HEADQUARTERS: 914 WEST PATAPSCO AVENUE • BALTIMORE, MARYLAND 21230 • PHONE (410) 354-3300 • FAX (410) 354-3313

12/02/2020

Trackonomy
1828 Bering Drive
San Jose, CA 95112

Dear Saurabh Sanghai,

Enclosed is the EMC Wireless test report for compliance testing of the Trackonomy, FBW-2001 as tested to the requirements of Title 47 of the CFR, Ch. 1 (10-1-06 ed.), Part 15 Subpart C for Intentional Radiators.

Thank you for using the services of Eurofins E&E North America. If you have any questions regarding these results or if we can be of further service to you, please feel free to contact me.

Sincerely yours,
EUROFINS E&E NORTH AMERICA

Joel Huna
Documentation Department

Reference: (\Trackonomy\WIR107797-FCC247 Rev. 3)

Electromagnetic Compatibility Criteria
Test Report

for the

Trackonomy
FBW-2001

Tested under
the FCC Certification Rules
contained in
15.247 Subpart C for Intentional Radiators

Report: WIR107797-FCC247 Rev. 3

12/02/2020

Prepared For:

Trackonomy
1828 Bering Drive
San Jose, CA 95112

Prepared By:
Eurofins E&E North America
13501 McCallen Pass, Austin, TX 78753

Electromagnetic Compatibility Criteria
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the FCC Certification Rules
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15.247 Subpart C for Intentional Radiators

Adan Arab, Project Engineer
Electromagnetic Compatibility Lab

Joel Huna
Documentation Department

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules Part 15.247 under normal use and maintenance.

Jonathan Tavira,
Manager, Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
∅	08/26/2020	Initial Issue.
1	08/31/2020	Customer Comments.
2	11/23/2020	TCB Corrections.
3	12/02/2020	TCB Corrections.

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List of Terms and Abbreviations

AC	**A**lternating **C**urrent
ACF	**A**ntenna **C**orrection **F**actor
Cal	**Cal**ibration
d	**M**easurement **D**istance
dB	**D**eci**b**els
dBµA	**D**eci**b**els above one **micro**amp
dBµV	**D**eci**b**els above one **micro**volt
dBµA/m	**D**eci**b**els above one **micro**amp **per m**eter
dBµV/m	**D**eci**b**els above one **micro**volt **per m**eter
DC	**D**irect **C**urrent
E	**E**lectric Field
DSL	**D**igital **S**ubscriber **L**ine
ESD	**E**lectro**s**tatic **D**ischarge
EUT	**E**quipment **U**nder **T**est
f	**F**requency
FCC	**F**ederal **C**ommunications **C**ommission
GRP	**G**round **R**eference **P**lane
H	Magnetic Field
HCP	**H**orizontal **C**oupling **P**lane
Hz	**H**er**z**
IEC	**I**nternational **E**lectrotechnical **C**ommission
kHz	**k**ilo**h**ert**z**
kPa	**k**ilo**pa**scal
kV	**k**ilo**v**olt
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
MHz	**M**ega**h**ertz
µH	**microh**enry
µ	**microf**arad
µs	**micros**econds
NEBS	**N**etwork **E**quipment-**B**uilding **S**ystem
PRF	**P**ulse **R**epetition **F**requency
RF	**R**adio **F**requency
RMS	**R**oot-**M**ean-**S**quare
TWT	**T**raveling **W**ave **T**ube
V/m	**V**olts **per m**eter
VCP	**V**ertical **C**oupling **P**lane

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Trackonomy FBW-2001, with the requirements of Part 15, §15.247. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the FBW-2001. Trackonomy should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the FBW-2001, has been **permanently** discontinued.

B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15, §15.247, in accordance with Trackonomy, purchase order number T200416SS16. All tests were conducted using measurement procedure ANSI C63.10-2013.

FCC Reference 47 CFR Part 15.247:2020	Description	Compliance
Title 47 of the CFR, Part 15 §15.203	Antenna Requirement	Compliant
Title 47 of the CFR, Part 15 §15.247(a)(2)	6dB Occupied Bandwidth	Compliant
Title 47 of the CFR, Part 15 §15.247(b)	Peak Power Output	Compliant
Title 47 of the CFR, Part 15 §15.207(a)	Conducted Emission Limits	Not Applicable[1]
Title 47 of the CFR, Part 15 §15.247(d)	Conducted Spurious Emissions and restricted Bands of Operation (Conducted Band-edge)	Compliant
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	Radiated Spurious Emissions and Restricted Band of Operation (Radiated Band-edge)	Compliant
Title 47 of the CFR, Part 15; §15.247(e)	Peak Power Spectral Density	Compliant
Title 47 of the CFR, Part 15 §15.247(i)	Maximum Permissible Exposure (MPE)	Compliant
Not Applicable[1]: The EUT is battery Powered unit and Not Applicable to this requirement.		

Table 1. Executive Summary of EMC Part 15.247 ComplianceTesting

Eurofins MET Laboratories Inc. (Eurofins E&E North America) is part of the Eurofins Electrical & Electronics (E&E) global compliance network.

II. Equipment Configuration

A. Overview

Eurofins E&E North America was contracted by Trackonomy to perform testing on the FBW-2001, under Trackonomy's purchase order number T200416SS16.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Trackonomy, FBW-2001.

The results obtained relate only to the item(s) tested.

Model(s) Tested:	FBW-2001	
Model(s) Covered:	FBW-2001	
EUT Specifications:	Primary Power: 3 VDC	
	FCC ID: 2AXA8FWB2001	
	Type of Modulations:	GFSK
	Equipment Code:	DTS
	Peak RF Output Power:	2.78 dBm
	Transmitter Tune-Up Tolerance:	+/- 1.5 dB
	EUT Frequency Ranges:	2402-2480 MHz
	Antenna Type:	Custom PCB etched
	Antenna Gain:	0 dBi
	Firmware Version:	Functional Firmware v2.0
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35º C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Adan Arab	
Report Date(s):	12/02/2020	

Table 2. EUT Summary Table

B. References

CFR 47, Part 15, Subpart C	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies
ANSI C63.4:2014	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ISO/IEC 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices
KDB 558074 v0502	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247

Table 3. References

C. Test Site

Eurofins MET Laboratories Inc. (Eurofins E&E North America) is part of the Eurofins Electrical & Electronics (E&E) global compliance network.

All testing was performed at Eurofins E&E North America, 13501 McCallen Pass, Austin, TX 78753. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements were performed in a 10 meter semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at Eurofins E&E North America.

D. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
RF Frequencies	±4.52 Hz	2	95%
RF Power Conducted Emissions	±2.32 dB	2	95%
RF Power Conducted Spurious Emissions	±2.25 dB	2	95%
RF Power Radiated Emissions	±3.01 dB	2	95%

Table 4. Uncertainty Calculations Summary

E. Description of Test Sample

The Trackonomy FBW-2001, Equipment Under Test (EUT), is a FBW-2001.

F. Equipment Configuration

The EUT was set up as outlined in **Error! Reference source not found.**, Block Diagram of Test Setup. All cards, racks, etc., incorporated as part of the EUT is included in the following list.

Ref.ID	Slot#	Name/Description	Model Number	Part Number	Serial Number	Rev. #
1	--	FBW-2001	FWB-2001	--	R01	--
2	--	FBW-2001 With SMA Connector	FWB-2001	--	R02	--

Table 5. Equipment Configuration

G. Support Equipment

Support equipment necessary for the operation and testing of the EUT is included in the following list.

Ref. ID	Name / Description	Manufacturer	Model Number	*Customer Supplied Calibration Data
Programming Tablet	Tablet Device for OTA programming	Samsung	Galaxy Tab 8	N/A
The 'Customer Supplied Calibration Data' column will be marked as either not applicable, not available, or will contain the calibration date supplied by the customer.				

Table 6. Support Equipment

H. Ports and Cabling Information

Ref. ID	Port name on EUT	Cable Description or reason for no cable	Qty	Length as tested (m)	Max Length (m)	Shielded? (Y/N)	Termination Box ID & Port Name
1	EUT Antenna	RF Cable with SMA	1	0.1	0.1	Yes	Spectrum Analyzer

Table 7. Ports and Cabling Information

I. Mode of Operation

Functional Mode, The EUT is controlled using a Samsung Tablet Device for OTA programming through proprietary Trackonomy App. The EUT was then set to Transmit continuously with modulated or unmodulated and to select the operating frequency the following setting is used in Trackonomy App:

1. For continuous transmission, set Advertising Window to 0 and Scan/Sleep Window to 0
2. Set Mode by:
   a. CW1 – Continuous Wave without data
   b. CW2 – Continuous Wave with data
3. Set Channel by setting MS Data/Channel
   a. Valid Value range for BLE is (0 to 80). Low channel 02 (2402 MHz), Mid Channel 40 (2440 MHz) and High Channel 80 (2480 MHz).
4. Power Setting in the software as tested : 4 dBm

J. Method of Monitoring EUT Operation

Signal is emitted by DUT when activated.

K. Modifications

a) Modifications to EUT

No modifications were made to the EUT.

b) Modifications to Test Standard

No modifications were made to the test standard.

L. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Trackonomy upon completion of testing.

III. Electromagnetic Compatibility Criteria for Intentional Radiators

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.203 Antenna Requirement

Test Requirement: **§ 15.203:** 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 a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

The structure and application of the EUT were analyzed to determine compliance with Section 15.203 of the Rules. Section 15.203 states that the subject device must meet at least one of the following criteria:

a.) Antenna must be permanently attached to the unit.

b.) Antenna must use a unique type of connector to attach to the EUT.

c.) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

Results: The EUT as tested is compliant the criteria of §15.203. The FBW-2001 (EUT) uses a Custom PCB etched antenna of antenna gain 0 dBi as declared by the Manufacturer, that is permanently attached and can not be modified by the end user. The FBW-2001 (EUT) satisfies all requirements in 15.203.

Test Engineer(s): Adan Arab

Test Date(s): 08/10/2020

Duty Cycle Measurement:

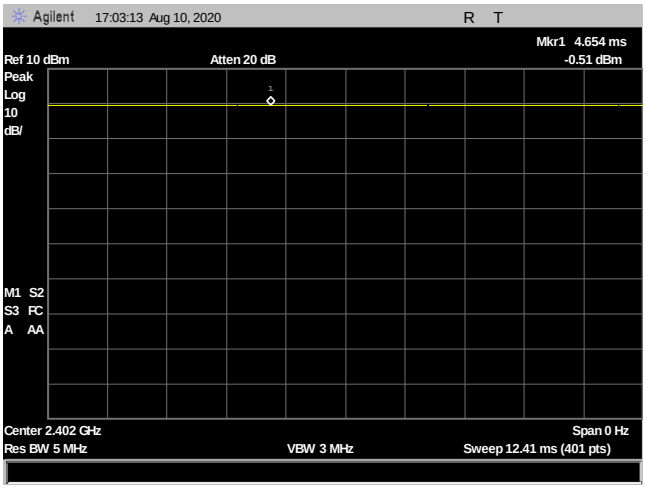

Figure 1: Duty Cycle Measurement, BLE, 2402 MHz - 100%

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(2) 6 dB Bandwidth

Test Requirements: **§ 15.247(a)(2):** Operation under the provisions of this section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

For systems using digital modulation techniques, the EUT may operate in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands. The minimum 6dB bandwidth shall be at least 500 kHz.

Test Procedure: The transmitter was on and transmitting at the highest output power. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW = 100kHz, VBW = 3*RBW. The 6 dB Bandwidth was measured and recorded. The measurements were performed on the low, mid and high channels.

Test Results The EUT was compliant with § 15.247 (a)(2).

The 6 dB Bandwidth was determined from the plots on the following pages.

Test Engineer(s): Adan Arab

Test Date(s): 08/10/2020

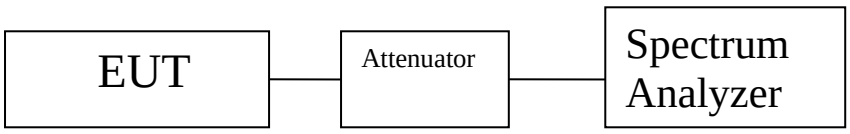

Figure 2. Block Diagram, Occupied Bandwidth Test Setup

Occupied Bandwidth Test Results

Occupied Bandwidth			
Mode	**Channel (MHz)**	**6 dB Bandwidth (MHz)**	**Limit (MHz)**
BLE	2402	1.394	≥0.500
BLE	2440	1.414	≥0.500
BLE	2480	1.408	≥0.500

Table 8. 6 dB Occupied Bandwidth, Test Results

6 dB Occupied Bandwidth Test Results

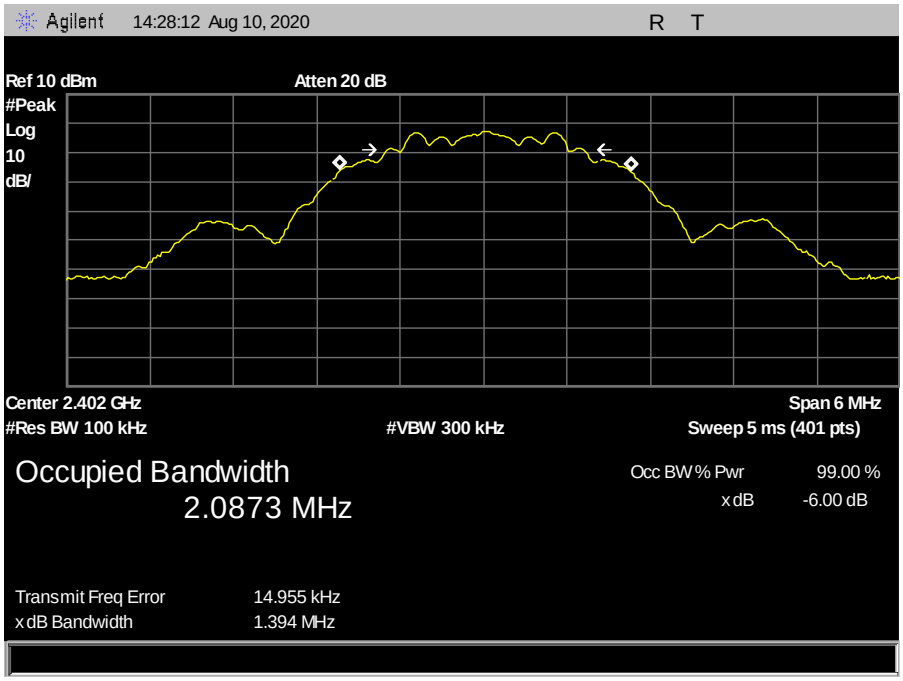

Figure 3: 6 dB Occupied Bandwidth, 2402 MHz - 1.394 MHz

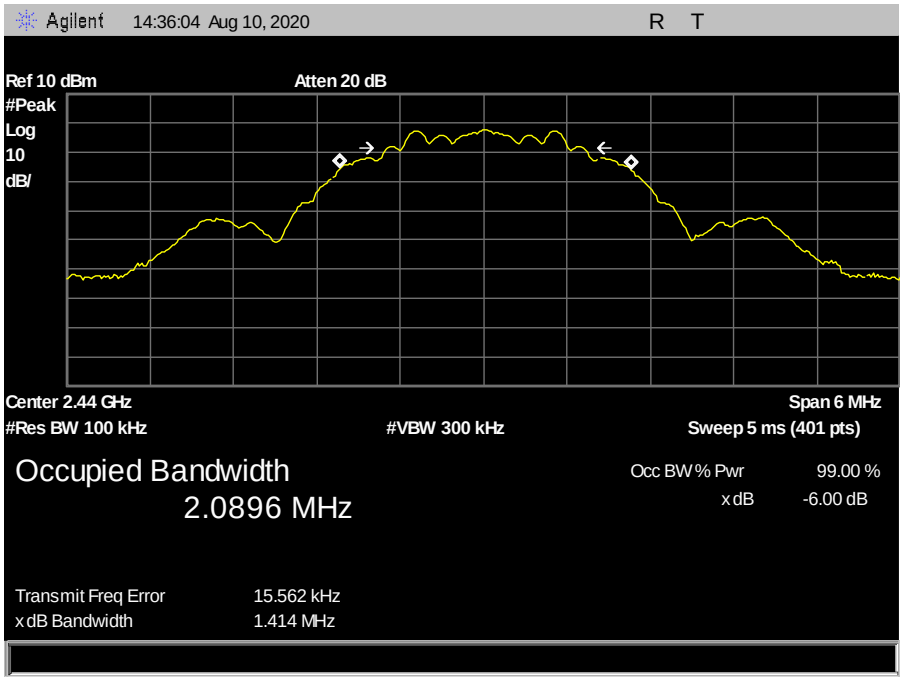

Figure 4: 6 dB Occupied Bandwidth, 2440 MHz - 1.414 MHz

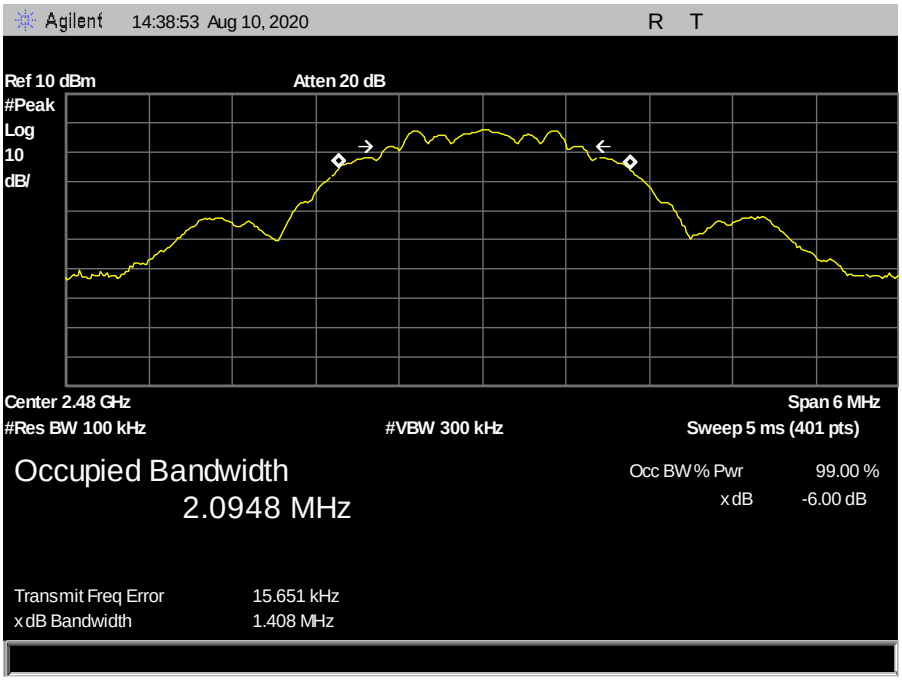

Figure 5: 6 dB Occupied Bandwidth, 2480 MHz - 1.408 MHz

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(b) Peak Power Output

Test Requirements: **§15.247(b):** The maximum peak output power of the intentional radiator shall not exceed the following:

Digital Transmission Systems (MHz)	Output Limit (Watts)
2400–2483.5	1.000

Table 9. Output Power Requirements from §15.247(b)

§15.247(c): if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values in the 9, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Test Procedure: The EUT was measured at the low, mid and high channels of each band at the maximum power level. Measurements were performed on a conducted setup as shown in the conducted tests setup photo.

Test Results: The EUT was compliant with the Peak Power Output limits of **§15.247(b)**.

Test Engineer(s): Adan Arab

Test Date(s): 08/10/2020

Peak Power Output Test Results:

Peak Conducted Output Power			
Mode	Frequency (MHz)	Peak Output Power (dBm)	Limit (dBm)
BLE	2402	1.99	30
BLE	2440	2.78	30
BLE	2480	2.59	30

Table 10. Peak Power Output, Test Results

Peak Power Output Test Plots:

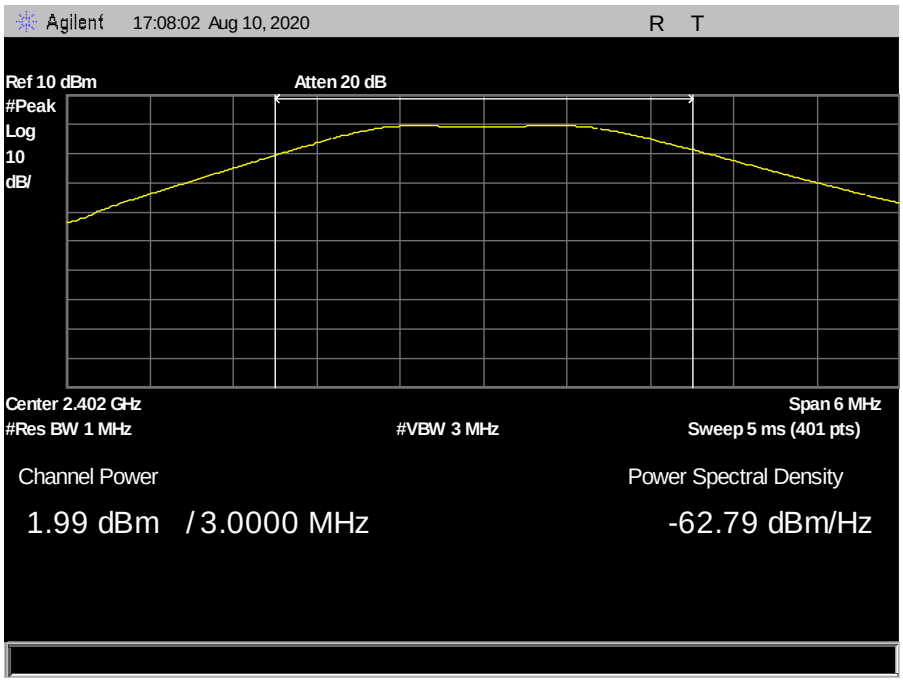

Figure 6: Conducted Output Power, 2402 MHz - (1.99 dBm)

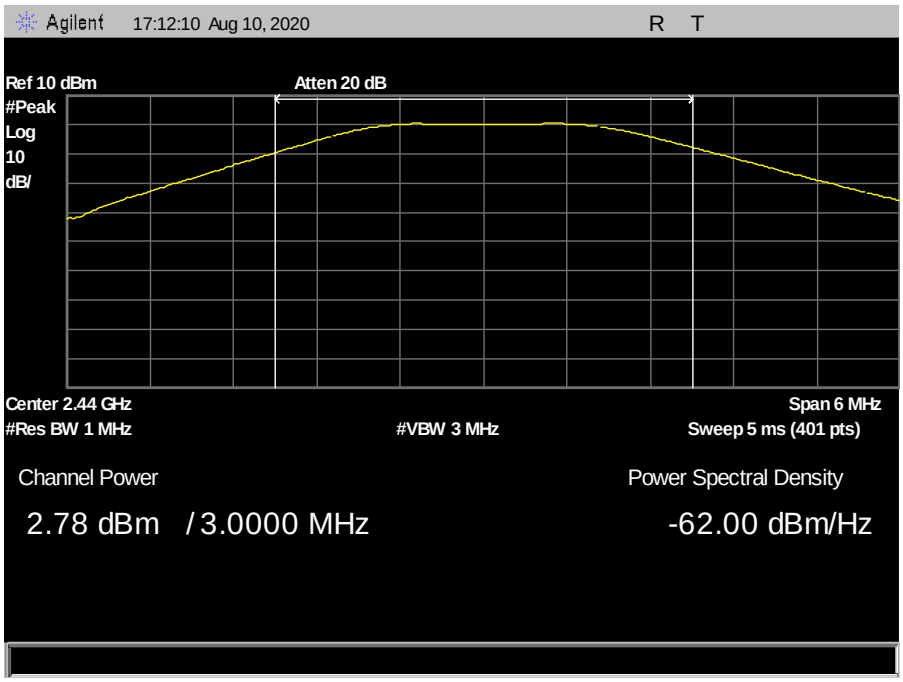

Figure 7: Conducted Output Power, 2440 MHz - (2.78 dBm)

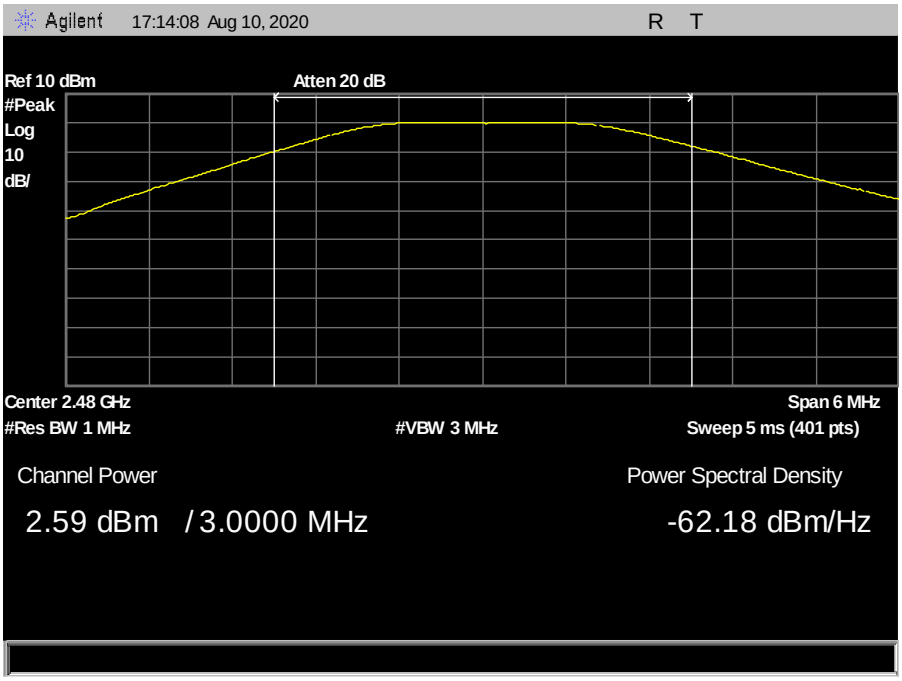

Figure 8: Conducted Output Power, 2480 MHz - (2.59 dBm)

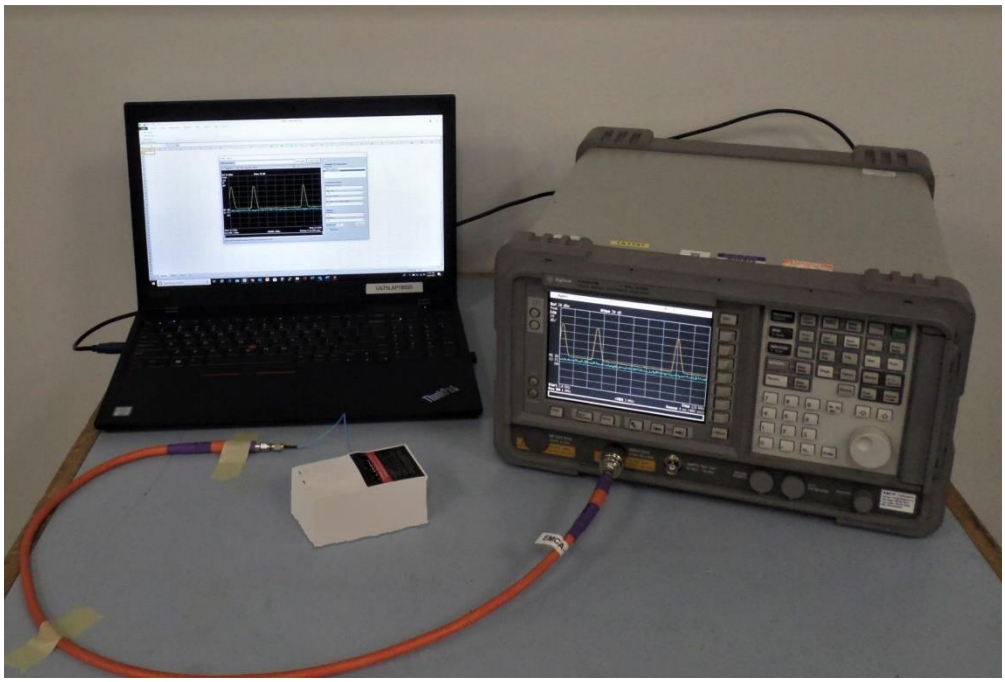

Figure 9: Conducted Measurement, Test Setup

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.209 Radiated Spurious Emissions Requirements and Band Edge

Test Requirements: **§15.247(d); §15.205:** Emissions outside the frequency band.

§15.205(a): Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090–0.110----------	16.42–16.423	399.9–410	4.5–5.15
[1] 0.495–0.505----------	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905----------	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128----------	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775----------	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775----------	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218----------	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825----------	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225----------	123–138	2200–2300	14.47–14.5
8.291–8.294----------	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366----------	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675----------	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475----------	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293----------	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025----------	240–285	3345.8–3358 36.	43–36.5
12.57675–12.57725----------	322–335.4	3600–4400	([2])

Table 11. Restricted Bands of Operation

[1] Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.

[2] Above 38.6

Test Requirement(s): **§ 15.209 (a):** Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in Table 12.

Frequency (MHz)	§ 15.209(a),Radiated Emission Limits (dBµV) @ 3m
30 - 88	40.00
88 - 216	43.50
216 - 960	46.00
Above 960	54.00

Table 12. Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)

Test Procedures: The transmitter was turned on. Measurements were performed of the low, mid and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line. For emissions below 1 GHz a peak detector measurement is used against Average limit, which is worst case.

Test Results: The EUT was compliant with the Radiated Spurious Emission limits of **§ 15.247(d) and § 15.209**.

Test Engineer(s): Adan Arab

Test Date(s): 08/10/2020

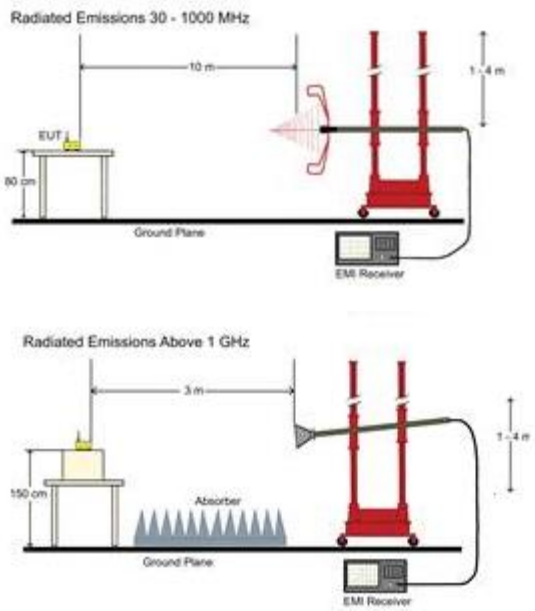

Figure 10: Radiated Emissions Test Setup

Radiated Spurious Emissions, Test Results

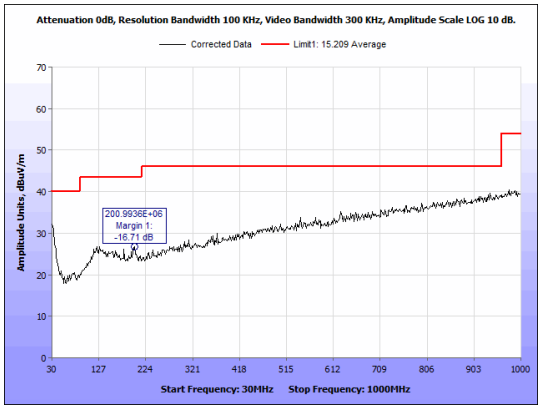

Figure 11: Radiated Emissions, 2402 MHz - 30-1000 MHz - Horizontal.

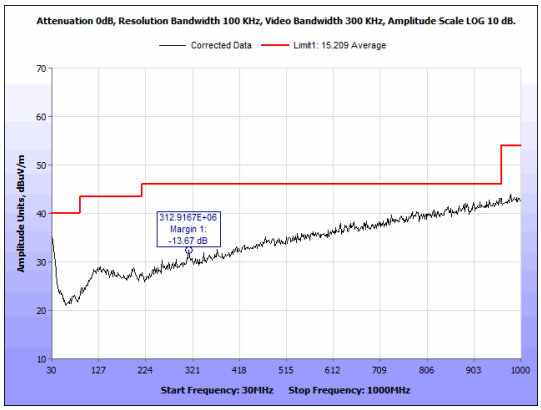

Figure 12: Radiated Emissions, 2402 MHz - 30-1000 MHz - Vertical.

Frequency (MHz)	Antenna polarity	Detector	Uncorrected Amplitude (dBuV)	RBW (KHz)	Distance Correction Factor (dB)	Antenna Factor (dB/m)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, 15.209 Average (dBuV/m)	Margin (dB)
200.9936	V	Peak	22.65	100	10.45	16.7	-23.01	26.79	43.5	-16.71
933.1571	V	Peak	21.07	100	10.45	27.1	-19.36	39.26	46	-6.74
948.7019	V	Peak	20.89	100	10.45	27.13	-19.24	39.23	46	-6.77
312.9167	H	Peak	26.42	100	10.45	17.7	-22.24	32.33	46	-13.67
954.9199	H	Peak	24.67	100	10.45	27.2	-19.19	43.13	46	-2.87
958.0288	H	Peak	24.48	100	10.45	27.3	-19.16	43.07	46	-2.93

Figure 13: Radiated Spurious Emissions, 2402 MHz - 30-1000 MHz

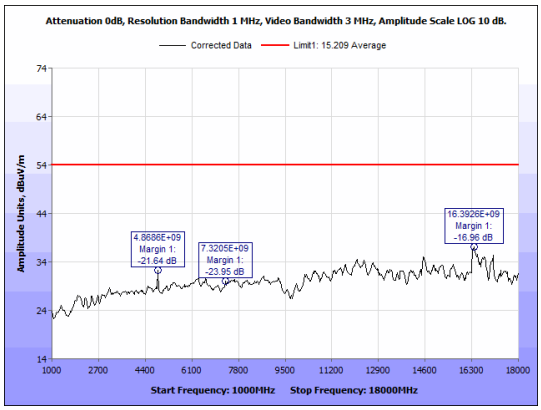

Figure 14: Radiated Emissions, 2402 MHz - 1-18 GHz - Average - Horizontal.

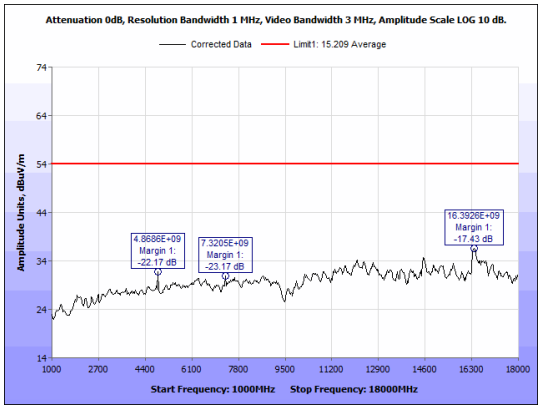

Figure 15: Radiated Emissions, 2402 MHz - 1-18 GHz - Average - Vertical.

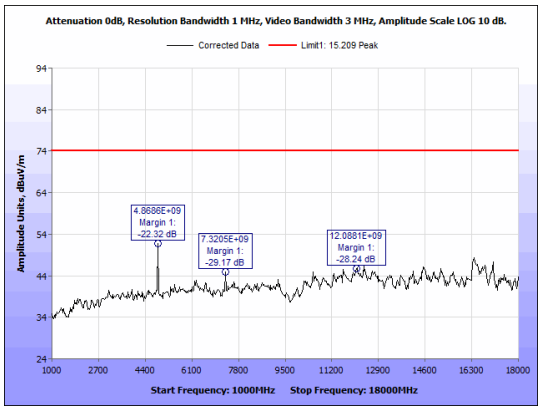

Figure 16: Radiated Emissions, 2402 MHz - 1-18 GHz - Peak - Horizontal.

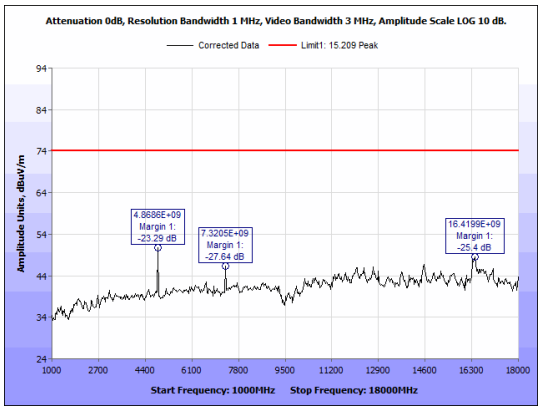

Figure 17: Radiated Emissions, 2402 MHz - 1-18 GHz - Peak - Vertical.

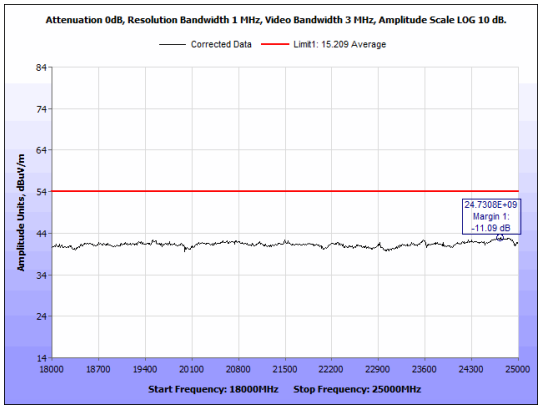

Figure 18: Radiated Emissions, 2402 MHz - 18-25 GHz - Average - Horizontal.

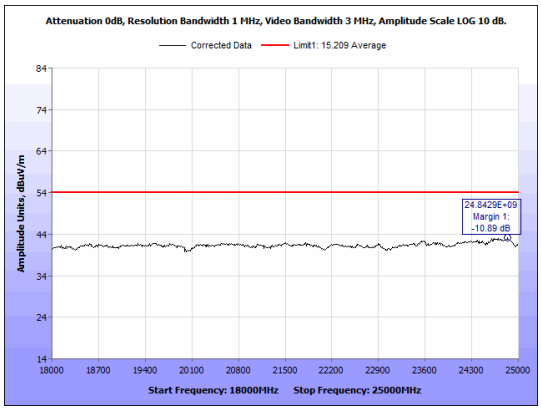

Figure 19: Radiated Emissions, 2402 MHz - 18-25 GHz - Average - Vertical.

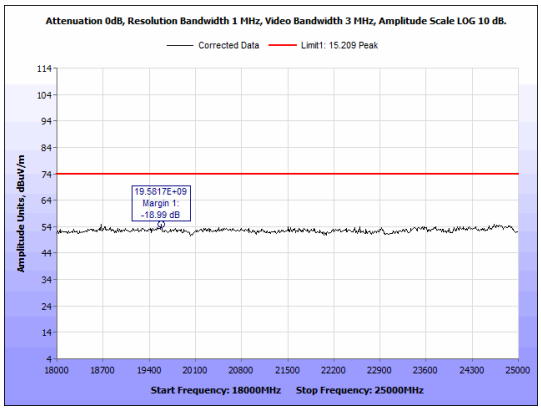

Figure 20: Radiated Emissions, 2402 MHz - 18-25 GHz - Peak - Horizontal.

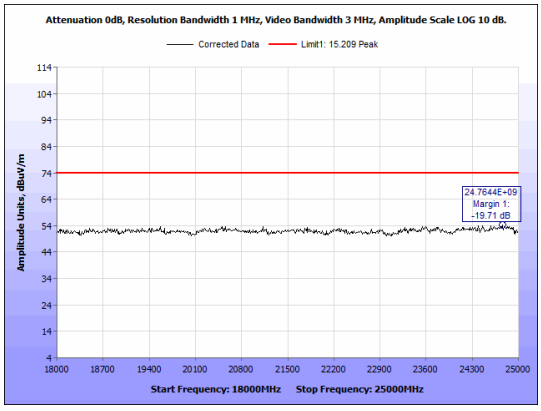

Figure 21: Radiated Emissions, 2402 MHz - 18-25 GHz - Peak - Vertical.

Frequency (GHz)	Uncorrected Amplitude (dBuV)	Antenna Polarity	Detector	RBW (MHz)	Antenna Factor (dB/m)	Preamp Factor (dB)	Corrected Amplitude (dBuV/m)	Limit 1, 15.209 Average (dBuV/m)	Limit 2, 15.209 Peak (dBuV/m)	Margin 1, (dB)	Margin 2, (dB)
16.3926	37.43	H	Average	1	40.63	-41.03	37.04	54	--	-16.96	--
16.3926	37.00	V	Average	1	40.6	-41.03	36.57	54	--	-17.43	--
4.8686	56.40	H	Peak	1	33.95	-38.67	51.68	--	74	--	-22.32
4.8686	55.56	V	Peak	1	33.81	-38.67	50.71	--	74	--	-23.29
24.7308	29.48	H	Average	1	45.38	-31.94	42.91	54	--	-11.09	--
24.8429	29.66	V	Average	1	45.38	-31.94	43.11	54	--	-10.89	--
19.5817	43.88	H	Peak	1	44.55	-33.42	55.01	--	74	--	-18.99
24.7644	40.85	V	Peak	1	45.38	-31.94	54.29	--	74	--	-19.71

Figure 22: Radiated Emissions, 2402 MHz - 18-25 GHz.

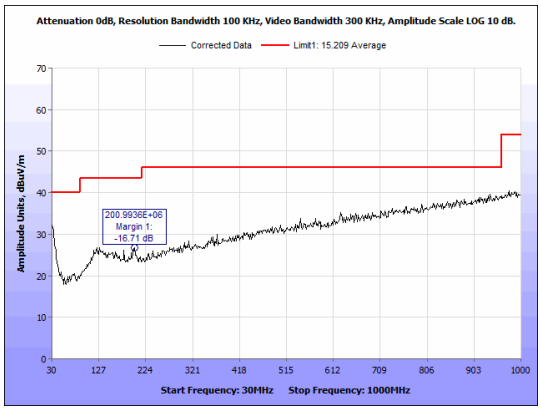

Figure 23: Radiated Emissions, 2440 MHz - 30-1000 MHz - Horizontal.

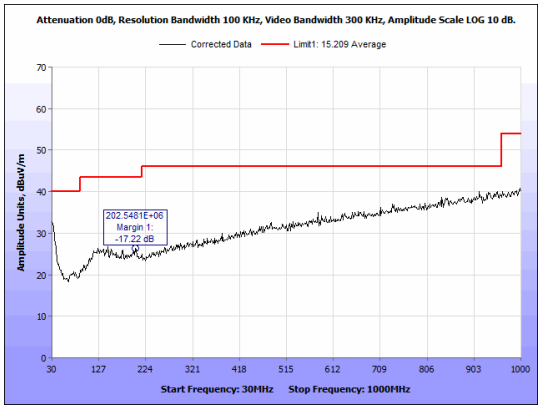

Figure 24: Radiated Emissions, 2440 MHz - 30-1000 MHz - Vertical.

Frequency (MHz)	Antenna polarity	Detector	Uncorrected Amplitude (dBuV)	RBW (KHz)	Distance Correction Factor (dB)	Antenna Factor (dB/m)	Preamp Factor (dB)	Corrected Amplitude (dBuV/m)	Limit, 15.209 Average (dBuV/m)	Margin (dB)
200.9936	H	Peak	22.65	100	10.45	16.7	-23.01	26.79	43.5	-16.71
936.2660	H	Peak	21.32	100	10.45	27.1	-19.32	39.55	46	-6.45
933.1571	H	Peak	21.07	100	10.45	27.1	-19.36	39.26	46	-6.74
202.5481	V	Peak	10.45	100	10.45	16.44	-22.97	26.28	43.5	-17.22
951.8109	V	Peak	21.65	100	10.45	27.2	-19.21	40.09	46	-5.91
914.5032	V	Peak	22.14	100	10.45	26.85	-19.51	39.93	46	-6.07

Figure 25: Radiated Spurious Emissions, 2440 MHz - 30-1000 MHz

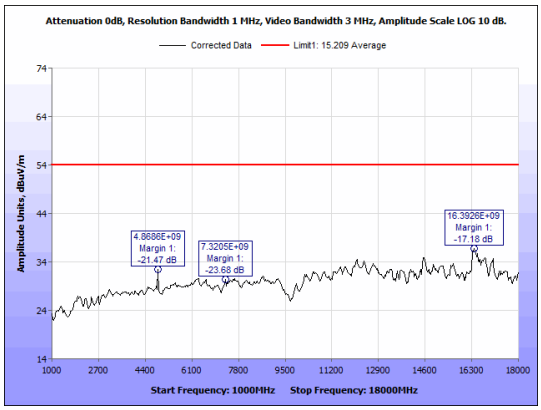

Figure 26: Radiated Emissions, 2440 MHz - 1-18 GHz - Average - Horizontal.

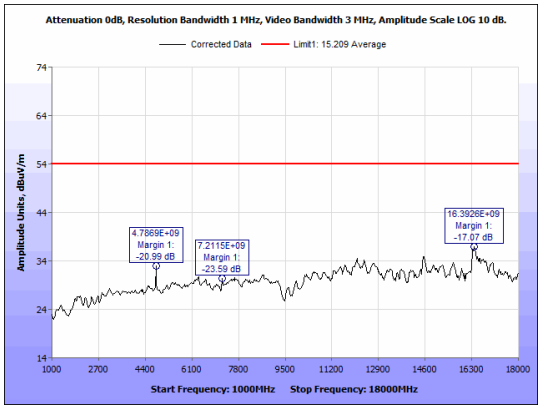

Figure 27: Radiated Emissions, 2440 MHz - 1-18 GHz - Average - Vertical.

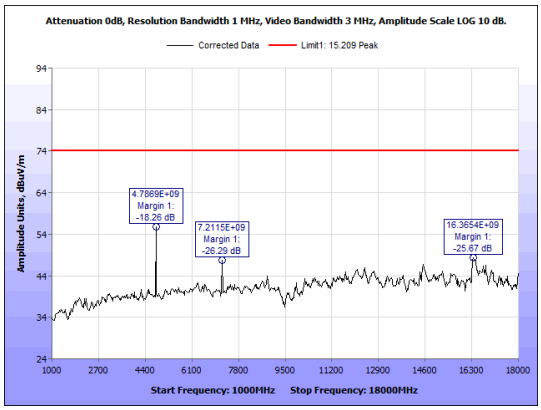

Figure 28: Radiated Emissions, 2440 MHz - 1-18 GHz - Peak - Vertical.

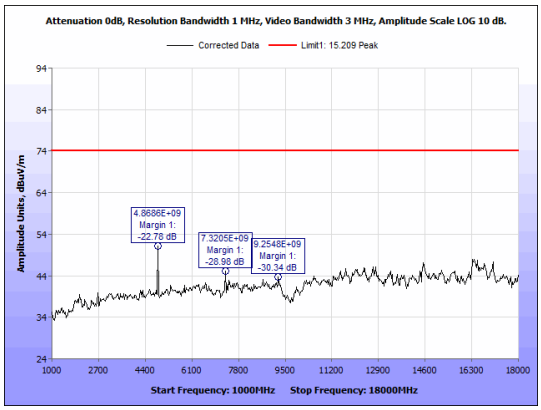

Figure 29: Radiated Emissions, 2440 MHz - 1-18 GHz - Peak - Horizontal.

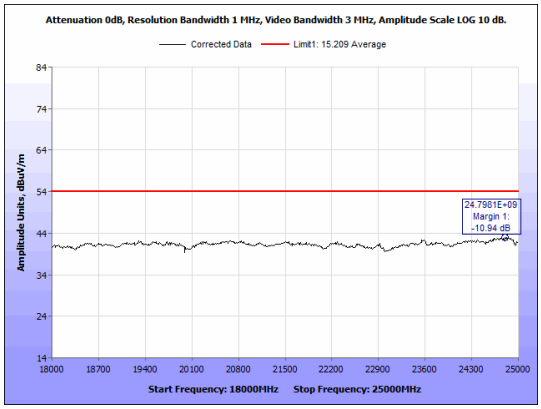

Figure 30: Radiated Emissions, 2440 MHz - 18-25 GHz - Average - Horizontal.

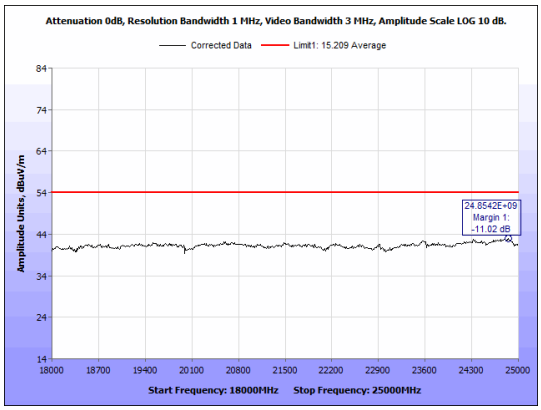

Figure 31: Radiated Emissions, 2440 MHz - 18-25 GHz - Average - Vertical.

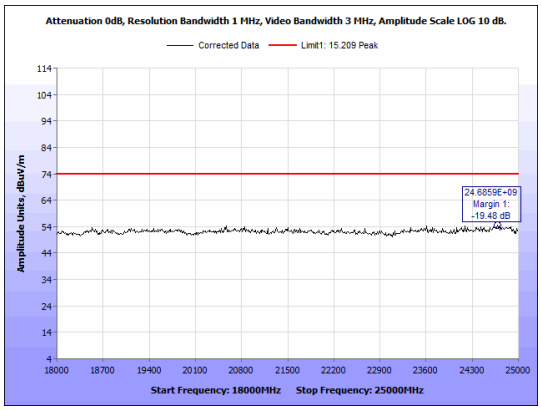

Figure 32: Radiated Emissions, 2440 MHz - 18-25 GHz - Peak - Horizontal.

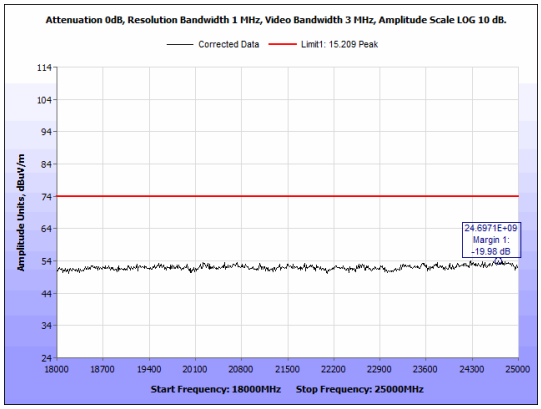

Figure 33: Radiated Emissions, 2440 MHz - 18-25 GHz - Peak - Vertical.

Frequency (GHz)	Uncorrected Amplitude (dBuV)	Antenna Polarity	Detector	RBW (MHz)	Antenna Factor (dB/m)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit 1, 15.209 Average (dBuV/m)	Limit 2, 15.209 Peak (dBuV/m)	Margin 1, (dB)	Margin 2, (dB)
16.3926	37.25	H	Average	1	40.6	-41.03	36.82	54	--	-17.18	--
16.3926	37.36	V	Average	1	40.6	-41.03	36.93	54	--	-17.07	--
4.8686	55.71	H	Peak	1	33.97	-38.46	55.74	--	74	--	22.78
4.7869	60.23	V	Peak	1	33.97	-38.46	55.74	--	74	--	-18.26
24.7981	29.6	H	Average	1	45.4	-31.94	43.06	54	--	-10.94	--
24.8542	29.53	V	Average	1	45.38	-31.94	42.98	54	--	-11.02	--
24.6859	41.11	H	Peak	1	45.37	-31.95	54.52	--	74	--	-19.48
24.6971	40.58	V	Peak	1	45.39	-31.95	54.02	--	74	--	-19.98

Figure 34: Radiated Emissions, 2440 MHz - 18-25 GHz.

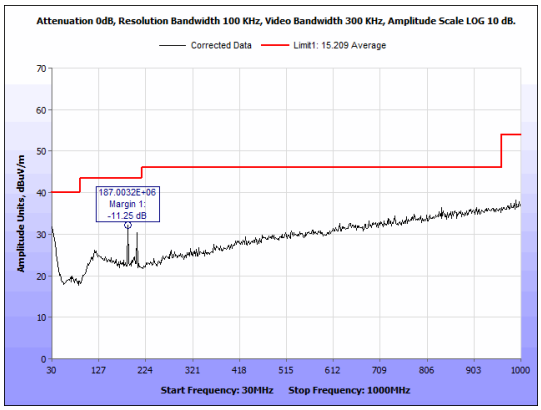

Figure 35: Radiated Emissions, 2480 MHz - 30-1000 MHz - Horizontal.

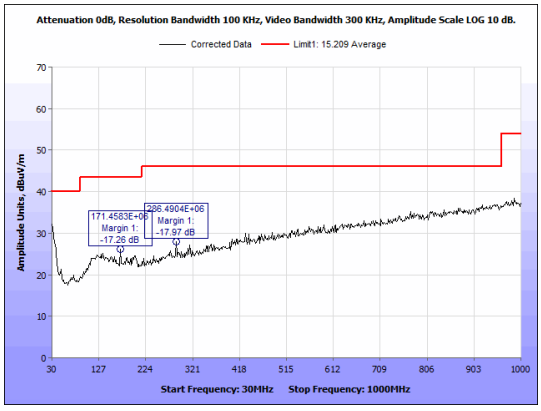

Figure 36: Radiated Emissions, 2480 MHz - 30-1000 MHz - Vertical.

Frequency (MHz)	Antenna polarity	Detector	Uncorrected Amplitude (dBuV)	RBW (KHz)	Distance Correction Factor (dB)	Antenna Factor (dB/m)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit, 15.209 Average (dBuV/m)	Margin (dB)
187.0032	H	Peak	29.71	100	10.45	15.1	-23.01	32.25	43.5	-11.25
30.0000	H	Peak	21.33	100	10.45	24.9	-24.82	31.86	40	-8.14
31.5545	H	Peak	21.11	100	10.45	23.96	-24.72	30.8	40	-9.2
171.4583	V	Peak	23.3	100	10.45	15.6	-23.12	26.24	43.5	-17.26
286.4904	V	Peak	22.89	100	10.45	17.3	-22.61	28.03	46	-17.97
30.0000	V	Peak	21.51	100	10.45	25	-24.82	32.14	40	-7.86

Figure 37: Radiated Spurious Emissions, 2480 MHz - 30-1000 MHz

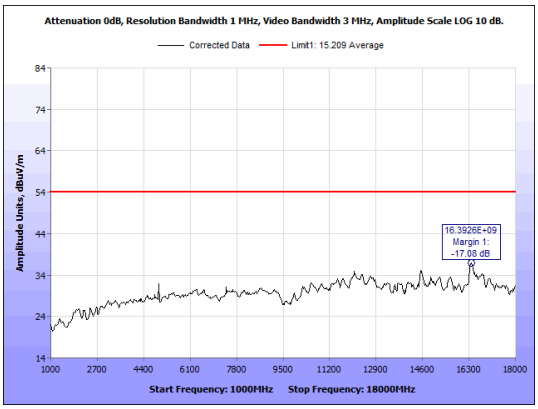

Figure 38: Radiated Emissions, 2480 MHz - 1-18 GHz - Average - Horizontal.

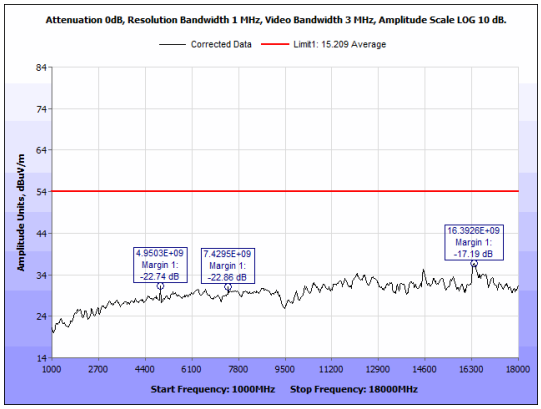

Figure 39: Radiated Emissions, 2480 MHz - 1-18 GHz - Average - Vertical.

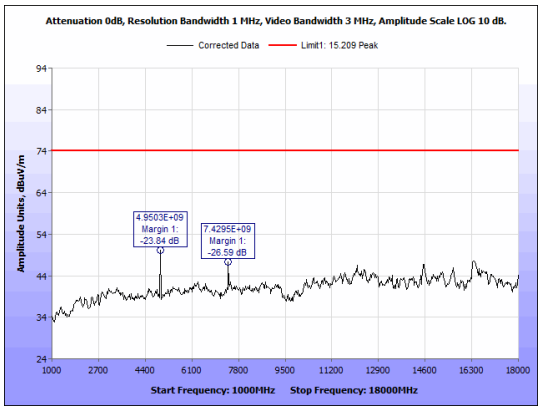

Figure 40: Radiated Emissions, 2480 MHz - 1-18 GHz - Peak - Horizontal.

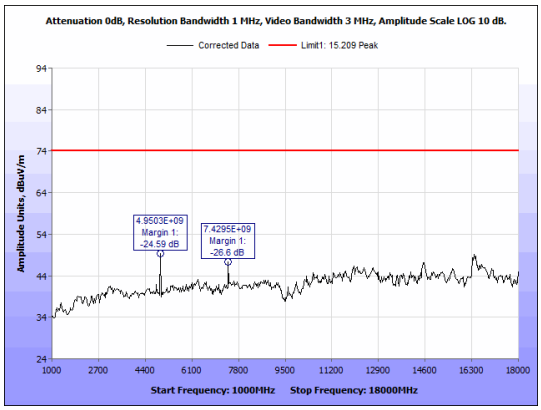

Figure 41: Radiated Emissions, 2480 MHz - 1-18 GHz - Peak - Vertical.

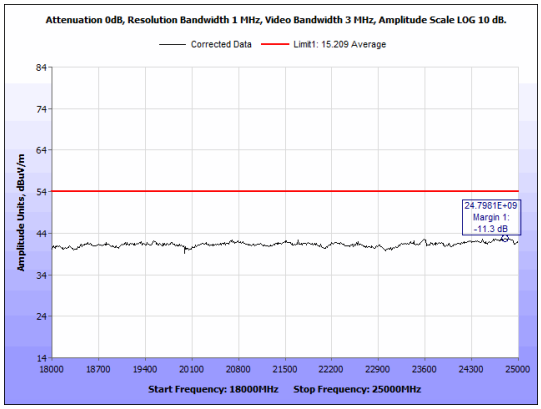

Figure 42: Radiated Emissions, 2480 MHz - 18-25 GHz - Average - Horizontal.

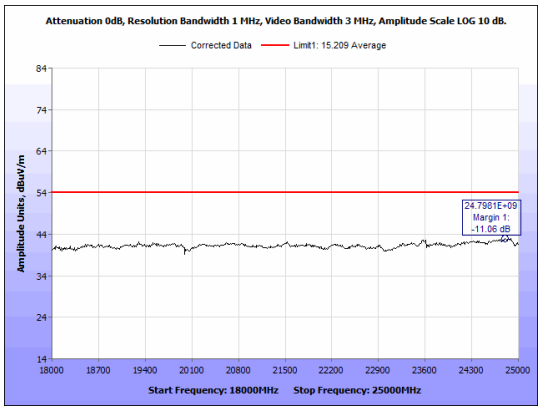

Figure 43: Radiated Emissions, 2480 MHz - 18-25 GHz - Average - Vertical.

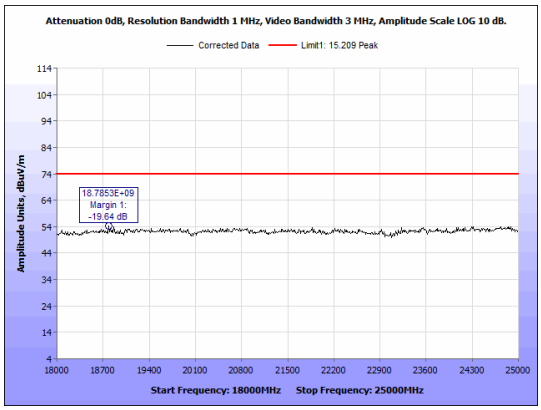

Figure 44: Radiated Emissions, 2480 MHz - 18-25 GHz - Peak - Horizontal.

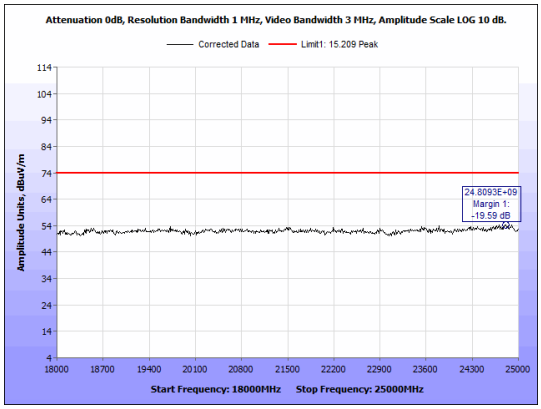

Figure 45: Radiated Emissions, 2480 MHz - 18-25 GHz - Peak - Vertical.

Frequency (GHz)	Uncorrected Amplitude (dBuV)	Antenna Polarity	Detector	RBW (MHz)	Antenna Factor (dBuV)	Preamp Factor (dB)	Corrected Amplitude dBuV/m	Limit 1, 15.209 Average (dBuV/m)	Limit 2, 15.209 Peak (dBuV/m)	Margin 1, (dB)	Margin 2, (dB)
16.3926	37.32	H	Average	1	40.63	-41.03	36.92	54	--	-17.08	--
16.3926	37.25	H	Average	1	40.6	-41.03	36.81	54	--	-17.19	--
4.9503	55.09	H	Peak	1	33.87	-38.8	50.16	--	74	--	-23.84
4.9503	54.45	V	Peak	1	33.76	-38.8	49.41	--	74	--	-24.59
24.7981	29.24	H	Average	1	45.4	-39.94	42.7	54	--	11.3	--
24.7981	29.51	V	Average	1	45.38	-39.94	42.94	54	--	-11.06	--
18.7853	42.58	H	Peak	1	44.26	-32.38	54.36	--	74	--	-19.64
24.8093	40.97	V	Peak	1	45.38	-31.94	54.41	--	74	--	-19.59

Figure 46: Radiated Emissions, 2480 MHz - 18-25 GHz.

Radiated Band Edge Measurements

Test Procedures: The transmitter was turned on. Measurements were performed of the low and high Channels. The EUT was rotated orthogonally through all three axes. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line.

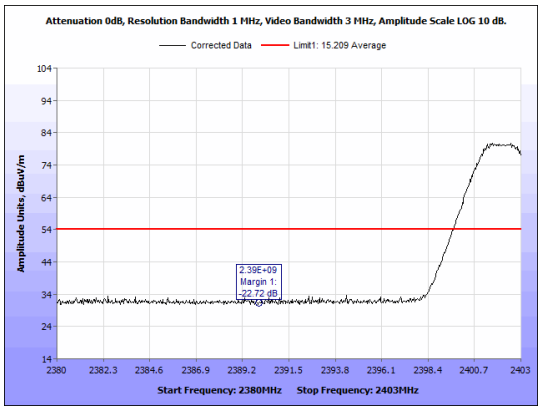

Figure 47: Radiated Band Edge, 2402 MHz - Average - Horizontal.

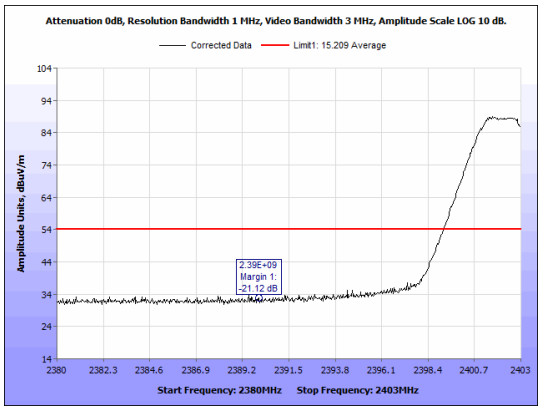

Figure 48: Radiated Band Edge, 2402 MHz - Average - Vertical.

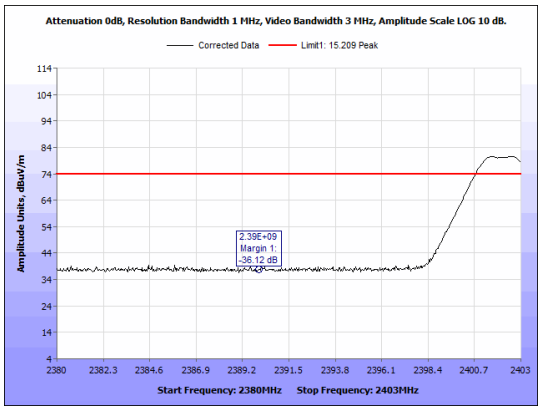

Figure 49: Radiated Band Edge, 2402 MHz - Peak - Horizontal.

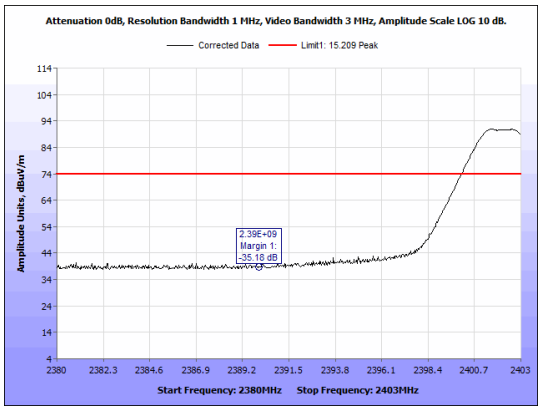

Figure 50: Radiated Band Edge, 2402 MHz - Peak - Vertical.

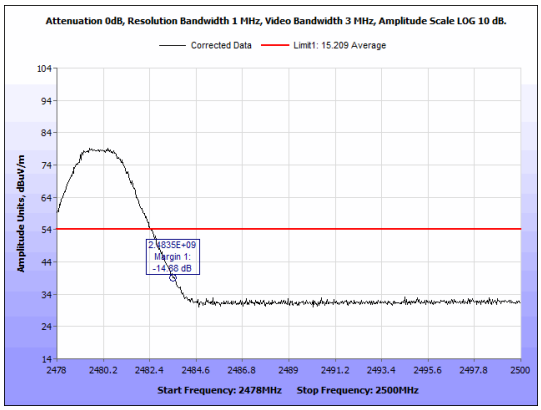

Figure 51: Radiated Band Edge, 2480 MHz - Average - Horizontal.

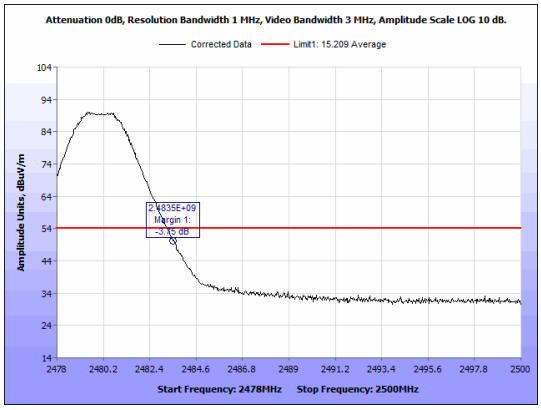

Figure 52: Radiated Band Edge, 2480 MHz - Average - Vertical.

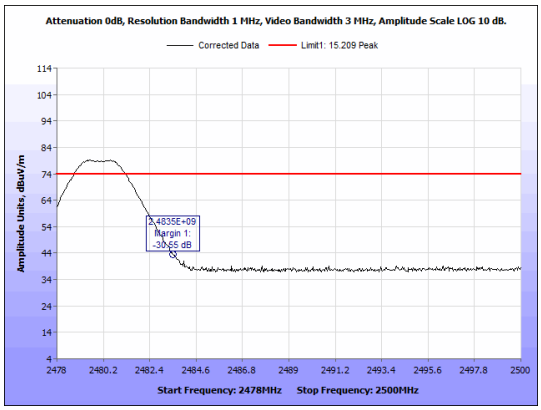

Figure 53: Radiated Band Edge, 2480 MHz - Peak - Horizontal.

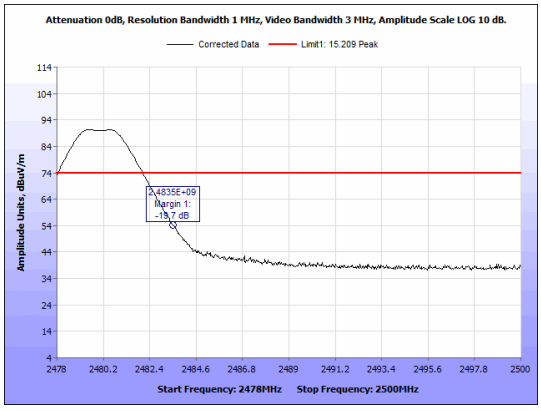

Figure 54: Radiated Band Edge, 2480 MHz - Peak - Vertical.

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) Spurious Emissions in Non-restricted Bands

Test Requirement: **15.247(d)** In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Test Procedure: For intentional radiators with a digital device portion which operates below 10 GHz, the spectrum was investigated as per §15.33(a)(1) and §15.33(a)(4); i.e., the lowest RF signal generated or used in the device up to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

Conducted measurements were performed. The test result and plots are shown below.

Test Results: The EUT was compliant with the Spurious Emission limits of **§15.247(d)**.

Test Engineer(s): Adan Arab

Test Date(s): 08/10/2020

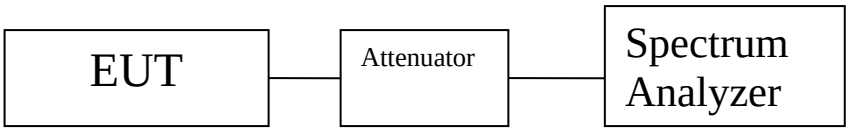

Figure 55: Block Diagram, Conducted Spurious Emissions Test Setup

Spurious Emissions in Non-restricted Bands, Test Results

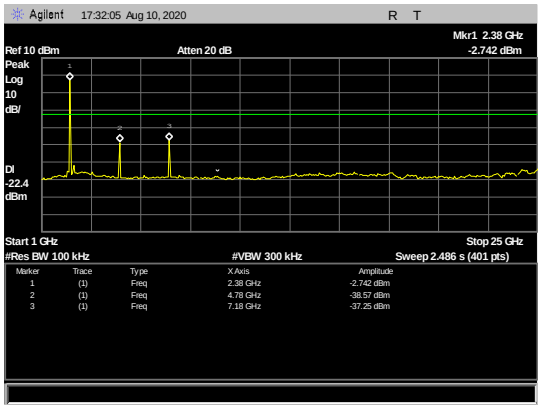

Figure 56: Conducted Spurious Emissions, 2402 MHz - 1-25 GHz

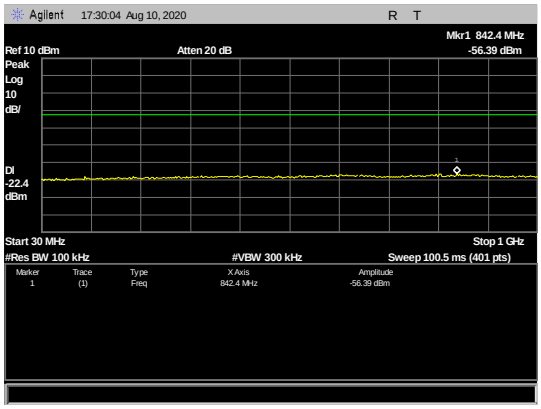

Figure 57: Conducted Spurious Emissions, 2402 MHz - 30-10000 MHz

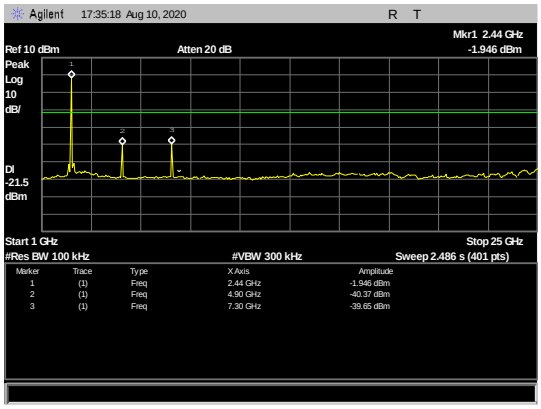

Figure 58: Conducted Spurious Emissions, 2440 MHz - 1-25 GHz

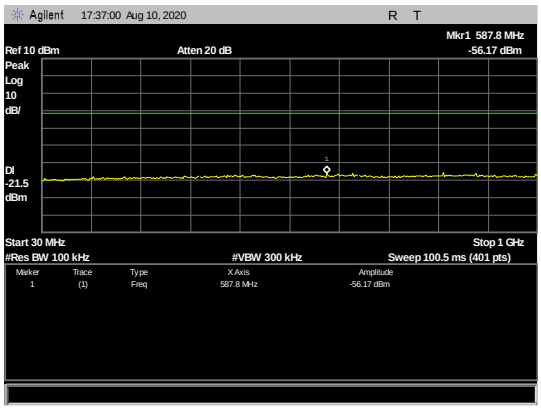

Figure 59: Conducted Spurious Emissions, 2440 MHz - 30-10000 MHz

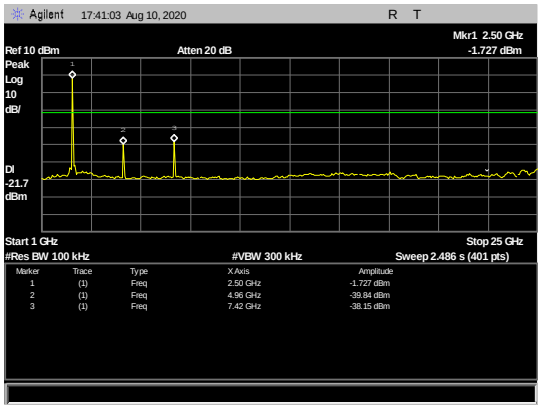

Figure 60: Conducted Spurious Emissions, 2480 MHz - 1-25 GHz

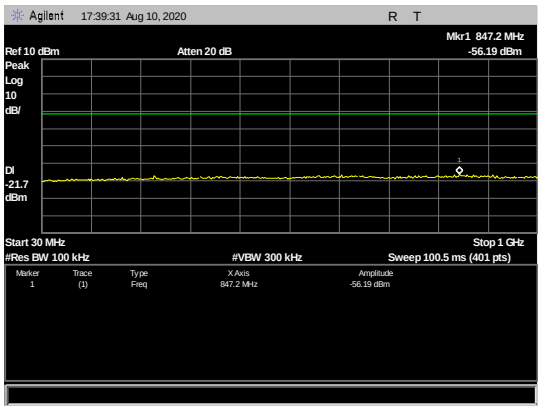

Figure 61: Conducted Spurious Emissions, 2480 MHz - 30-10000 MHz

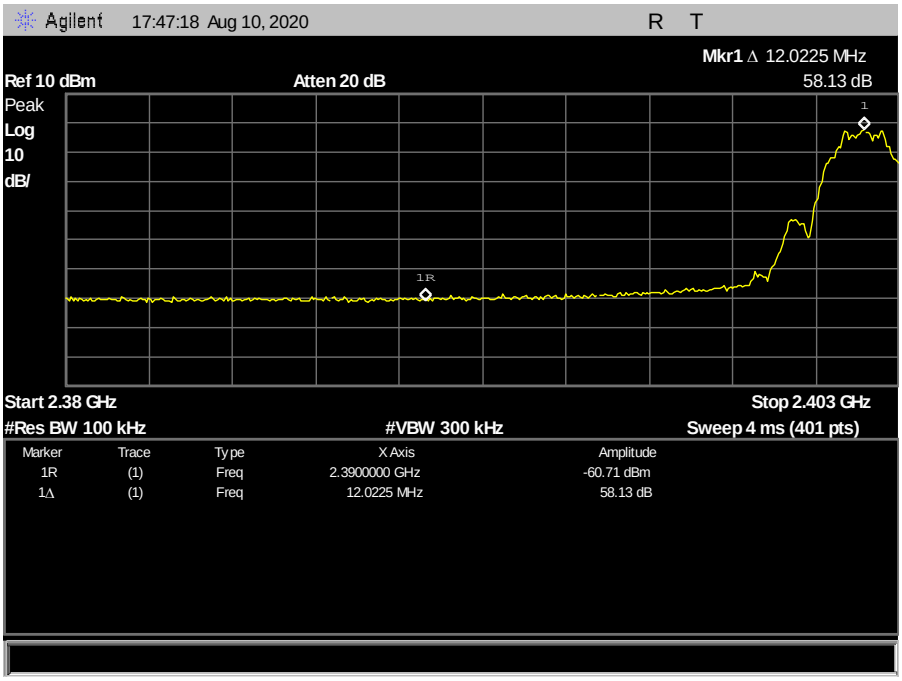

Figure 62: Conducted Band Edge, 2402 MHz

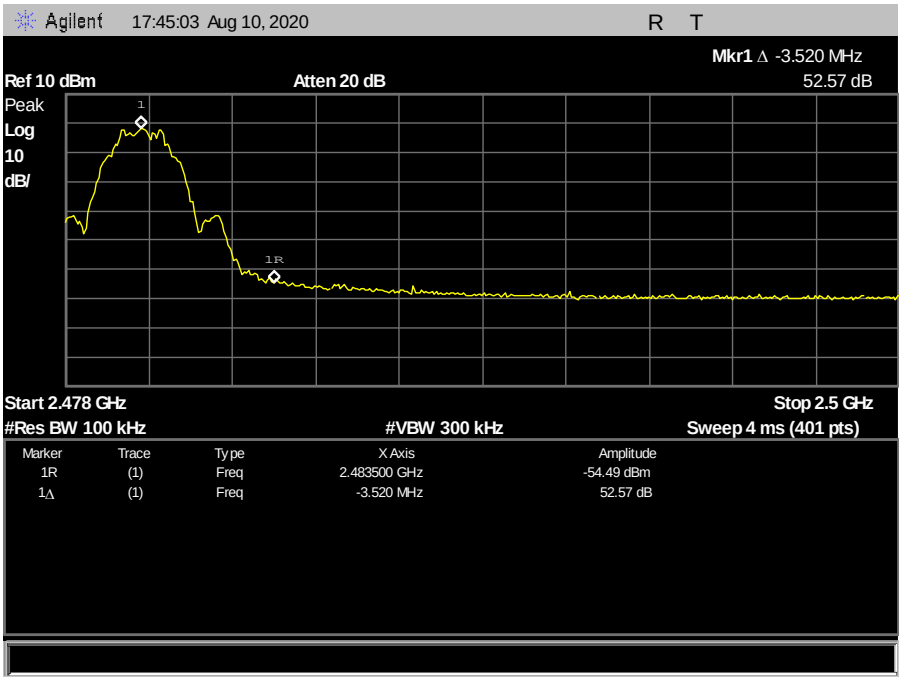

Figure 63: Conducted Band Edge, 2480 MHz

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(e) Peak Power Spectral Density

Test Requirements: **§15.247(e):** For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

Test Procedure: The power level was set to the maximum level throughout each of the 100 sweeps of power averaging. The RBW was set to 3 kHz and a VBW set to 9 kHz or greater. The spectrum analyzer was set to an auto sweep time and a peak detector was used. Measurements were carried out at the low, mid and high channels. Measurements were performed on a radiated setup, with the receive antenna placed 1m away from the EUT.

Test Results: The EUT was compliant with the peak power spectral density limits of **§ 15.247 (e)**.

The peak power spectral density was measured and test result and plots are on the following page(s).

Test Engineer: Adan Arab

Test Date: 08/10/2020

Peak Power Spectral Density Test Results:

Mode	Channel (MHz)	Power Density (dBm)	Limit (dBm/KHz)
BLE	2402	-2.371	8
BLE	2440	-1.475	8
BLE	2480	-1.733	8

Table 13. Peak Power Spectral Density, Test Results

Peak Power Spectral Density

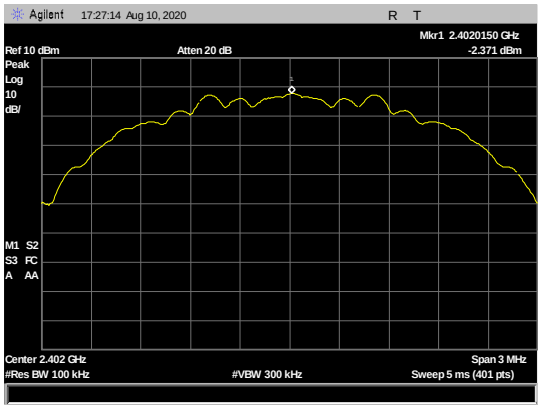

Figure 64: Power Spectral Density, 2402 MHz - (-2.371 dBm)

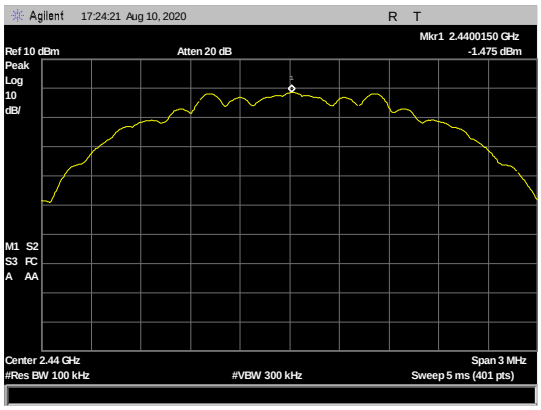

Figure 65: Power Spectral Density, 2440 MHz - (-1.475 dBm)

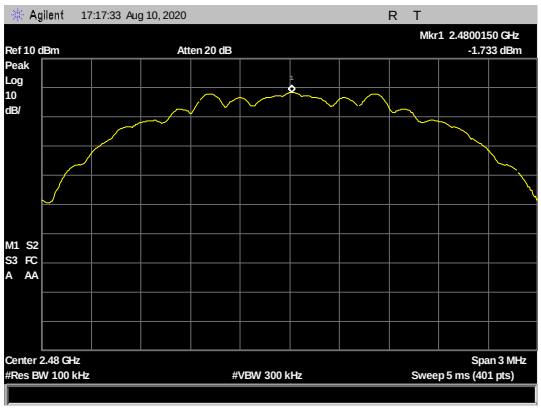

Figure 66: Power Spectral Density, 2480 MHz - (-1.733 dBm)

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(i) Maximum Permissible Exposure

RF Exposure Requirements: **§1.1307(b)(1) and §1.1307(b)(2):** Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

RF Radiation Exposure Limit: **§1.1310:** As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

MPE Limit: EUT's operating frequencies @ 2400-2483.5 MHz; **Limit for Uncontrolled exposure: 1 mW/cm^2 or 10 W/m^2**

Equation from page 18 of OET 65, Edition 97-01

$$S = PG / 4\pi R^2 \quad \text{or} \quad R = \sqrt{(PG / 4\pi S)}$$

where, S = Power Density (mW/cm^2)
P = Power Input to antenna (mW)
G = Antenna Gain (numeric value)

The maximum target output power of the transmitter is 4 dBm. The target power was adjusted for the maximum Tune-Up tolerance of 1.5 dB and the evaluation was performed using the Maximum Tune-Up Power 5.5 dBm.

Mode	Frequency Range (MHz)	Antenna gain		Maximum Tune-Up Power		Evaluation Distance (cm)	Power Density (mW/cm^2)	MPE Limit (mW/cm^2)
		(dBi)	(Numeric)	(dBm)	(mW)			
Bluetooth Low Energy	2402-2480	0	1	5.5	3.55	20	0.00705	1

Figure: RF Human Exposure, Test Results

The transmitter meets the exemption limit when used at distances of at least 20cm in accordance with the standard.

IV. Test Equipment

Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2017.

MET Asset #	Equipment	Manufacturer	Model	Last Cal Date	Cal Due Date
1A1191	Temp, Humidity, and Pressure Recorder	Omega	OM-CP-PRHTemp2000	1/31/2020	1/31/2021
1A1141	Spectrum Analyzer	Agilent Technologies	E4407B	08/05/2019	09/05/2020
1A1083	EMI Test Receiver	Rohde & Schwarz	ESU40	10/10/2019	10/10/2020
1A1147	Bilog Antenna (30-1000 MHz)	Sunol Sciences Corp	JB3	06/05/2019	12/05/2020
1A1183	Double Ridged Waveguide Antenna (1-18 GHz)	ETS Lindgren	3117	06/01/2020	06/01/2022
1A1161	DRG Horn Antenna	ETS Lindgren	3116C-PA	06/03/2020	06/03/2022
1A1176	Active Loop Antenna	ETS-Lindgren	6502	06/02/2020	06/02/2021
1A1099	1A1099	Generator	COM-Power Corp	SEE NOTE	
1A1044	1A1044	Generator	COM-Power Corp	SEE NOTE	
1A1088	PRE-AMP	ROHDE & SCHWARZ	TS-PR1	SEE NOTE	
1A1080	MULTI-DEVICE CONTROLLER	ETS-EMCO	2090	SEE NOTE	
1A1073	MULTI-DEVICE CONTROLLER	ETS-EMCO	2090	SEE NOTE	
1A1180	PRE-AMP	MITEQ	AMF-7D-01001800-22-10P	SEE NOTE	
1A1106	10M SEMI-ANECHOIC CHAMBER	LINDGREN	N/a	SEE NOTE	

Table 14. Test Equipment List

Note: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.

V. Certification & User's Manual Information

Certification & User's Manual Information

A. Certification Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart I — Marketing of Radio frequency devices:

§ 2.801 Radio-frequency device defined.

As used in this part, a radio-frequency device is any device which in its operation is capable of Emitting radio-frequency energy by radiation, conduction, or other means. Radio- frequency devices include, but are not limited to:

(a) The various types of radio communication transmitting devices described throughout this chapter.

(b) The incidental, unintentional and intentional radiators defined in Part 15 of this chapter.

(c) The industrial, scientific, and medical equipment described in Part 18 of this chapter.

(d) Any part or component thereof which in use emits radio-frequency energy by radiation, conduction, or other means.

§ 2.803 Marketing of radio frequency devices prior to equipment authorization.

(a) Except as provided elsewhere in this chapter, no person shall sell or lease, or offer for sale or lease (including advertising for sale or lease), or import, ship or distribute for the purpose of selling or leasing or offering for sale or lease, any radio frequency device unless:

(1) In the case of a device subject to certification, such device has been authorized by the Commission in accordance with the rules in this chapter and is properly identified and labeled as required by §2.925 and other relevant sections in this chapter; or

(2) In the case of a device that is not required to have a grant of equipment authorization issued by the Commission, but which must comply with the specified technical standards prior to use, such device also complies with all applicable administrative (including verification of the equipment or authorization under a Declaration of Conformity, where required), technical, labeling and identification requirements specified in this chapter.

(d) Notwithstanding the provisions of paragraph (a) of this section, the offer for sale solely to business, commercial, industrial, scientific or medical users (but not an offer for sale to other parties or to end users located in a residential environment) of a radio frequency device that is in the conceptual, developmental, design or pre-production stage is permitted prior to equipment authorization or, for devices not subject to the equipment authorization requirements, prior to a determination of compliance with the applicable technical requirements *provided* that the prospective buyer is advised in writing at the time of the offer for sale that the equipment is subject to the FCC rules and that the equipment will comply with the appropriate rules before delivery to the buyer or to centers of distribution.

(e)(1) Notwithstanding the provisions of paragraph (a) of this section, prior to equipment authorization or determination of compliance with the applicable technical requirements any radio frequency device may be operated, but not marketed, for the following purposes and under the following conditions:

(i) Compliance testing;

(ii) Demonstrations at a trade show provided the notice contained in paragraph (c) of this section is displayed in a conspicuous location on, or immediately adjacent to, the device;

(iii) Demonstrations at an exhibition conducted at a business, commercial, industrial, scientific or medical location, but excluding locations in a residential environment, provided the notice contained in paragraphs (c) or (d) of this section, as appropriate, is displayed in a conspicuous location on, or immediately adjacent to, the device;

(iv) Evaluation of product performance and determination of customer acceptability, provided such operation takes place at the manufacturer's facilities during developmental, design or pre-production states; or

(v) Evaluation of product performance and determination of customer acceptability where customer acceptability of a radio frequency device cannot be determined at the manufacturer's facilities because of size or unique capability of the device, provided the device is operated at a business, commercial, industrial, scientific or medical user's site, but not at a residential site, during the development, design or pre-production stages.

(e)(2) For the purpose of paragraphs (e)(1)(iv) and (e)(1)(v) of this section, the term *manufacturer's facilities* includes the facilities of the party responsible for compliance with the regulations and the manufacturer's premises, as well as the facilities of other entities working under the authorization of the responsible party in connection with the development and manufacture, but not the marketing, of the equipment.

(f) For radio frequency devices subject to verification and sold solely to business, commercial, industrial, scientific and medical users (excluding products sold to other parties or for operation in a residential environment), parties responsible for verification of the devices shall have the option of ensuring compliance with the applicable technical specifications of this chapter at each end user's location after installation, provided that the purchase or lease agreement includes a proviso that such a determination of compliance be made and is the responsibility of the party responsible for verification of the equipment.

Certification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart J — Equipment Authorization Procedures:

§ 2.901 Basis and Purpose

(a) In order to carry out its responsibilities under the Communications Act and the various treaties and international regulations, and in order to promote efficient use of the radio spectrum, the Commission has developed technical standards for radio frequency equipment and parts or components thereof. The technical standards applicable to individual types of equipment are found in that part of the rules governing the service wherein the equipment is to be operated.[1] *In addition to the technical standards provided, the rules governing the service may require that such equipment be verified by the manufacturer or importer*, be authorized under a Declaration of Conformity, or receive an equipment authorization from the Commission by one of the following procedures: certification or registration.

(b) The following sections describe the verification procedure, the procedure for a Declaration of Conformity, and the procedures to be followed in obtaining certification from the Commission and the conditions attendant to such a grant.

§ 2.907 Certification.

(a) Certification is an equipment authorization issued by the Commission, based on representation and test data submitted by the applicant.

(b) Certification attaches to all units subsequently marketed by the grantee which are identical (see Section 2.908) to the sample tested except for permissive changes or other variations authorized by the Commission pursuant to Section 2.1043.

[1] In this case, the equipment is subject to the rules of Part 15. More specifically, the equipment falls under Subpart B (of Part 15), which deals with unintentional radiators.

Certification & User's Manual Information

§ 2.948 Description of measurement facilities.

(a) Each party making measurements of equipment that is subject to an equipment authorization under Part 15 or Part 18 of this chapter, regardless of whether the measurements are filed with the Commission or kept on file by the party responsible for compliance of equipment marketed within the U.S. or its possessions, shall compile a description of the measurement facilities employed.

(1) If the measured equipment is subject to the verification procedure, the description of the measurement facilities shall be retained by the party responsible for verification of the equipment.

(i) If the equipment is verified through measurements performed by an independent laboratory, it is acceptable for the party responsible for verification of the equipment to rely upon the description of the measurement facilities retained by or placed on file with the Commission by that laboratory. In this situation, the party responsible for the verification of the equipment is not required to retain a duplicate copy of the description of the measurement facilities.

(ii) If the equipment is verified based on measurements performed at the installation site of the equipment, no specific site calibration data is required. It is acceptable to retain the description of the measurement facilities at the site at which the measurements were performed.

(2) If the equipment is to be authorized by the Commission under the certification procedure, the description of the measurement facilities shall be filed with the Commission's Laboratory in Columbia, Maryland. The data describing the measurement facilities need only be filed once but must be updated as changes are made to the measurement facilities or as otherwise described in this section. At least every three years, the organization responsible for filing the data with the Commission shall certify that the data on file is current.

Certification & User's Manual Information

1. Label and User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart A — General:

§ 15.19 Labeling requirements.

(a) In addition to the requirements in Part 2 of this chapter, a device subject to certification or verification shall be labeled as follows:

(1) Receivers associated with the operation of a licensed radio service, e.g., FM broadcast under Part 73 of this chapter, land mobile operation under Part 90, etc., shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

(2) A stand-alone cable input selector switch, shall bear the following statement in a conspicuous location on the device:

This device is verified to comply with Part 15 of the FCC Rules for use with cable television service.

(3) All other devices shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

(4) Where a device is constructed in two or more sections connected by wires and marketed together, the statement specified under paragraph (a) of this section is required to be affixed only to the main control unit.

(5) When the device is so small or for such use that it is not practicable to place the statement specified under paragraph (a) of this section on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

§ 15.21 Information to user.

The user's manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Verification & User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart B — Unintentional Radiators:

§ 15.105 Information to the user.

(a) For a Class A digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at own expense.

(b) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

– Reorient or relocate the receiving antenna.

– Increase the separation between the equipment and receiver.

– Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

– Consult the dealer or an experienced radio/TV technician for help.

End of Report

