eurofins | E&E

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

October 15, 2020

FreightLucid LLC
2525 N. Stemmons Frwy
Dallas, TX 75207

Dear Kumar Ramasundaram,

Enclosed is the EMC Wireless test report for compliance testing of the FreightLucid LLC, Hatch Sensor Unit 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: (\FreightLucid LLC\WIRS106561-FCC247 Rev 1)

A2LA ACCREDITED
TESTING CERT #0591.02

Certificates and reports shall not be reproduced except in full, without the written permission of Eurofins E&E North America While use of the A2LA logo in this report reflects Eurofins accreditation under these programs, the report must not be used by the client to claim product certification, approval, or endorsement by A2LA or any agency of the Federal Government. This letter of transmittal is not a part of the attached report.

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

Electromagnetic Compatibility Criteria
Test Report

for the

FreightLucid LLC
Hatch Sensor Unit

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

Report: WIRS106561-FCC247 Rev 1

October 15, 2020

Prepared For:

FreightLucid LLC
2525 N. Stemmons Frwy
Dallas, TX 75207

Prepared By:
Eurofins E&E North America
3162 Belick St., Santa Clara, CA 95054

 © 2020, Eurofins E&E North America

Electromagnetic Compatibility Criteria
Test Report

for the

FreightLucid LLC
Hatch Sensor Unit

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

Arsalan Hasan, 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.

Sandeep Brar,
Manager, Electromagnetic Compatibility Lab

 © 2020, Eurofins E&E North America

Report Status Sheet

Revision	Report Date	Reason for Revision
∅	September 15, 2020	Initial Issue.
1	October 15, 2020	TCB Updates

© 2020, Eurofins E&E North America

Table of Contents

I. Executive Summary **2**
A. Purpose of Test 3
B. Executive Summary 3

II. Equipment Configuration **4**
C. Overview 5
D. References 6
E. Test Site 6
F. Measurement Uncertainty 6
G. Description of Test Sample 7
H. Equipment Configuration 8
I. Support Equipment 8
J. Ports and Cabling Information 8
K. Mode of Operation 9
L. Method of Monitoring EUT Operation 9
M. Modifications 9
a) Modifications to EUT 9
b) Modifications to Test Standard 9
N. Disposition of EUT 9

III. Electromagnetic Compatibility Criteria for Intentional Radiators **10**
§ 15.203 Antenna Requirement 11
§ 15.247(a)(a) 6 dB and 99% Bandwidth 12
§ 15.247(b) Peak Power Output 14
§ 15.247(d) Radiated Spurious Emissions Requirements and Band Edge 16
§ 15.247(c) Spurious Emissions in Non-restricted Bands 26
§ 15.247(e) Peak Power Spectral Density 31
§ 15.247(i) Maximum Permissible Exposure 30

IV. Test Equipment **33**

 © 2020, Eurofins E&E North America

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**ert**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

© 2020, Eurofins E&E North America

I. Executive Summary

 © 2020, Eurofins E&E North America

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the FreightLucid LLC Hatch Sensor Unit, 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 Hatch Sensor Unit. FreightLucid LLC should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Hatch Sensor Unit, 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 FreightLucid LLC, purchase order number 10181308-2. All tests were conducted using measurement procedure ANSI C63.4-2014.

FCC Reference 47 CFR Part 15.247:2005	Description	Compliance
Title 47 of the CFR, Part 15 §15.203	Antenna Requirement	Compliant
Title 47 of the CFR, Part 15 §15.207(a)	Conducted Emission Limits	Not Applicable
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 §15.247(c)	Spurious Emissions in Non-restricted Bands	Compliant
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	Radiated Spurious Emissions Requirements	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

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.

© 2020, Eurofins E&E North America

II. Equipment Configuration

© 2020, Eurofins E&E North America

A. Overview

Eurofins E&E North America was contracted by FreightLucid LLC to perform testing on the Hatch Sensor Unit, under FreightLucid LLC's purchase order number 10181308-2.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the FreightLucid LLC, Hatch Sensor Unit.

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

Model(s) Tested:	Hatch Sensor Unit	
Model(s) Covered:	Hatch Sensor Unit	
EUT Specifications:	Primary Power: 3.6 VDC	
	FCC ID: 2AVGJTRHT01	
	Type of Modulations:	GFSK
	Equipment Code:	DTS
	Peak RF Output Power:	3.829 dBm
	EUT Frequency Ranges:	2402 – 2480 MHz
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:	Arsalan Hasan	
Report Date(s):	October 15, 2020	

Table 2. EUT Summary Table

© 2020, Eurofins E&E North America

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 17025:2005	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices
KDB 558074 v04	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, 3162 Belick St., Santa Clara, CA 95054. 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 (dB)	K	Confidence Level
Radiated Emissions, (30 MHz – 1 GHz)	±3.24	2	95%
Radiated Emissions, (1 - 6 GHz)	±3.92	2	95%
Conducted Emission	±3.53	2	95%
CEV Telecom Port	±2.44	2	95%

Table 4. Uncertainty Calculations Summary

© 2020, Eurofins E&E North America

E. Description of Test Sample

The FreightLucid LLC Hatch Sensor Unit, Equipment Under Test (EUT), is a smart sensor pack for railcar asset monitoring. It is battery powered with a life span of 6-10 years. It is intended to monitor the environmental conditions inside railcars and the integrity of the commodity being transported. Main Features: Measures commodity fill-level • Measures temperature, humidity, and pressure • Detects a full opening of the hatch cover Optional, Add-on Feature: • Detects a fully-latched hatch cover.

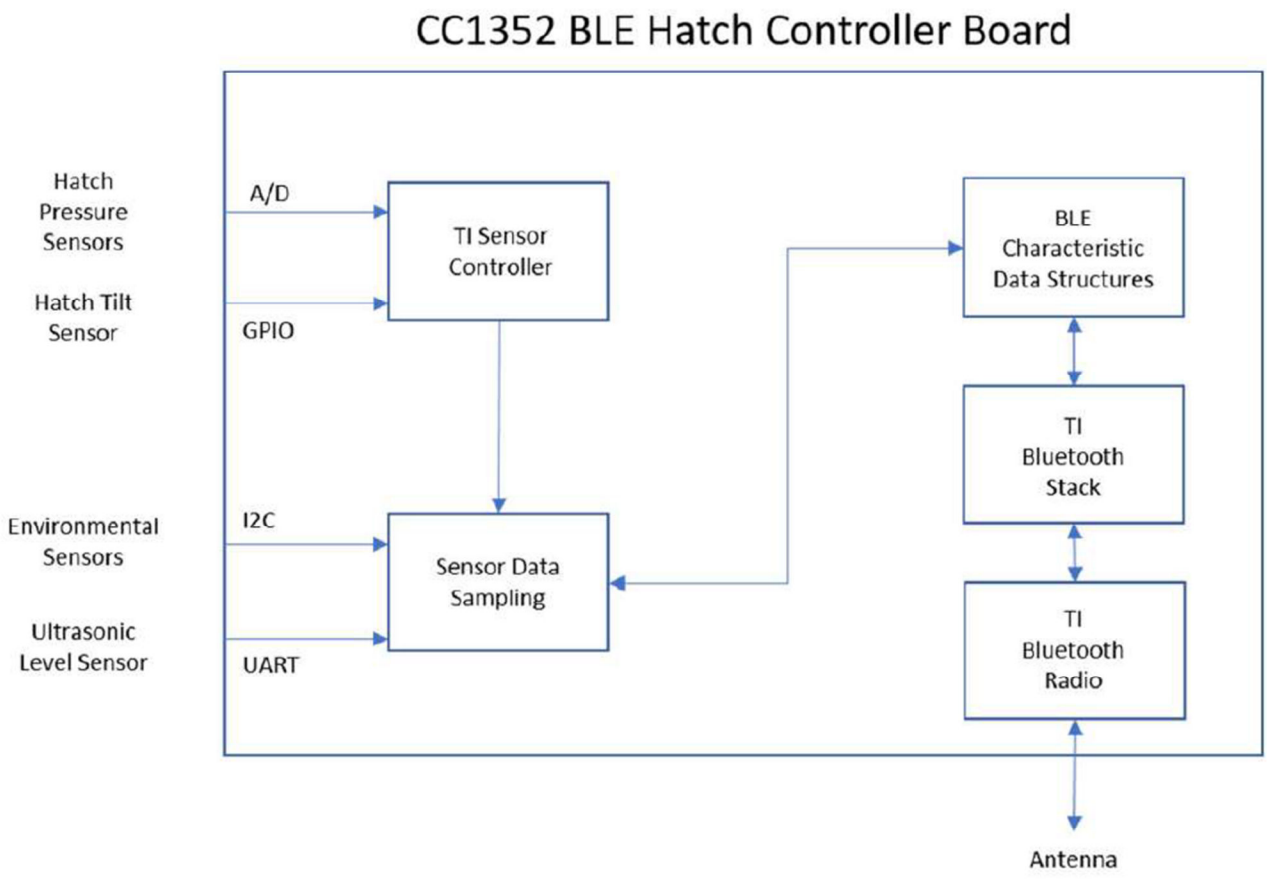


Figure 1. Block Diagram of Test Configuration

 © 2020, Eurofins E&E North America

F. Equipment Configuration

The EUT was set up as outlined in Figure 1, 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 (White / Light Almond)	Serial Number	Rev. #
01	N/A	Hatch Sensor Unit	TRHT-01	AA-900-0005	FCC UNIT 01	01

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
01	N/A	Freightlucid LLC	N/A	This device works alone without any support equipment
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
01	N/A	No cable. This is a wireless device using BLE protocol	0	0	0	N/A	N/A

Table 7. Ports and Cabling Information

 © 2020, Eurofins E&E North America

I. Mode of Operation

The device has the following modes - Sleep & Unpaired - Sleep & Paired - Active & reading values from sensors - Active & Paired.

J. Method of Monitoring EUT Operation

Use RF Studio to monitor the Bluetooth transmission of the device.

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 FreightLucid LLC upon completion of testing.

 © 2020, Eurofins E&E North America

III. Electromagnetic Compatibility Criteria for Intentional Radiators

© 2020, Eurofins E&E North America

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.

Test Engineer(s): Arsalan Hasan

Test Date(s): 07/14/2020

Antenna Type:	Manufacturer	Part No	Gain (dBi):	Impedance	Polarization
2.4GHz Cable Dipole	Taoglas	CBD01.07.0100C	3,24	50 Ω	Linear

Table 8. Antenna List

Figure 2. 2.4GHz Cable Antenna

 © 2020, Eurofins E&E North America

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): Arsalan Hasan

Test Date(s): 07/14/2020

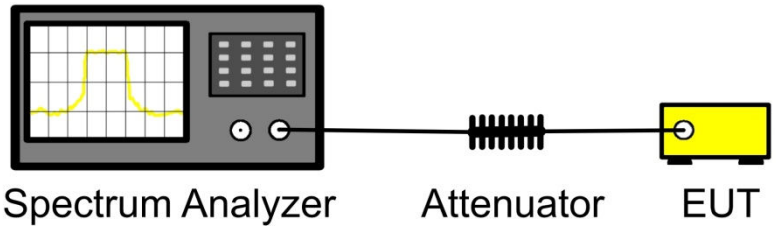


Figure 3. Block Diagram, Occupied Bandwidth Test Setup

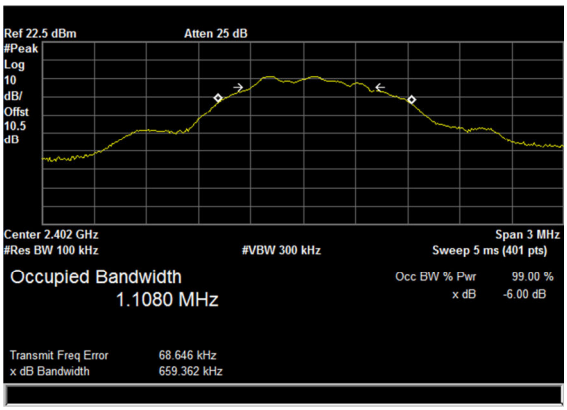
Occupied Bandwidth Test Results

Channel Carrier	Frequency (MHz)	Measurement of 6dB	Limit (MHz)
Low	2402	659.362 KHz	≥ 500
Mid	2442	640.267 KHz	≥ 500
High	2480	647.076 KHz	≥ 500

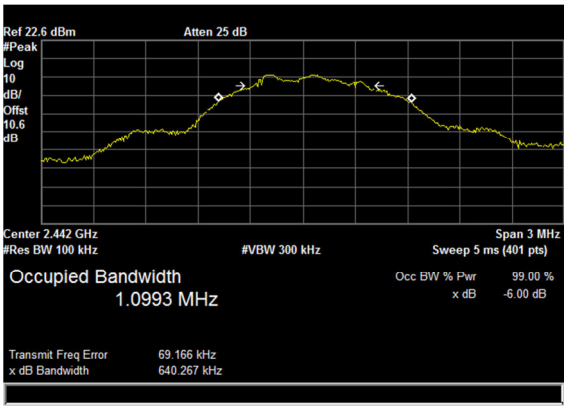
Table 9. 6 dB Occupied Bandwidth, Test Results

 © 2020, Eurofins E&E North America

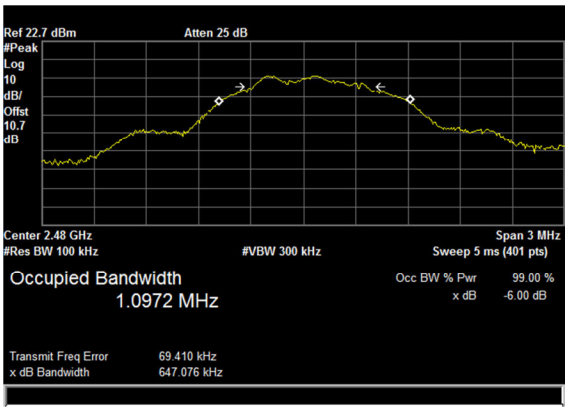
6 dB Occupied Bandwidth Test Results



Plot 1: 6 dB Bandwidth, BLE 2402MHz Low



Plot 2: 6 dB Bandwidth, BLE 2442MHz Mid



Plot 3: 6 dB Bandwidth, BLE 2480MHz High

© 2020, Eurofins E&E North America

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 10. 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 radiated setup, with the receive antenna placed 1m away from the EUT.

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

Test Engineer(s): Arsalan Hasan

Test Date(s): 07/15/2020

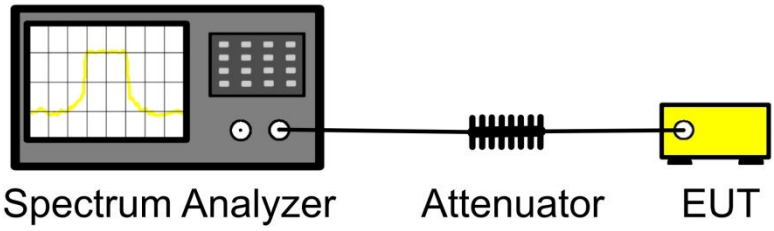


Figure 4. Peak Power Output, Test Setup

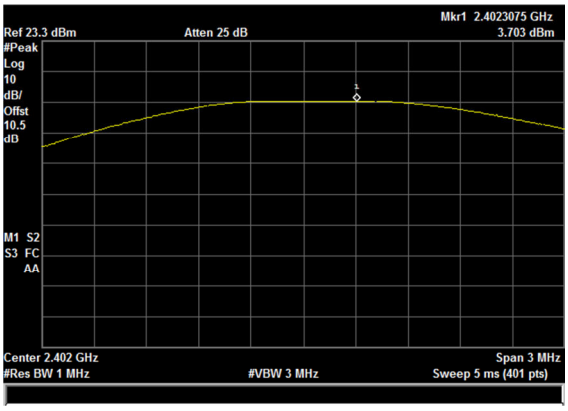
Peak Power Output Test Results

Channel	Frequency (MHz)	Measured Power (dBm)	Limit (dBm)
Low	2402	3.703	30
Mid	2445	3.748	30
High	2480	3.829	30

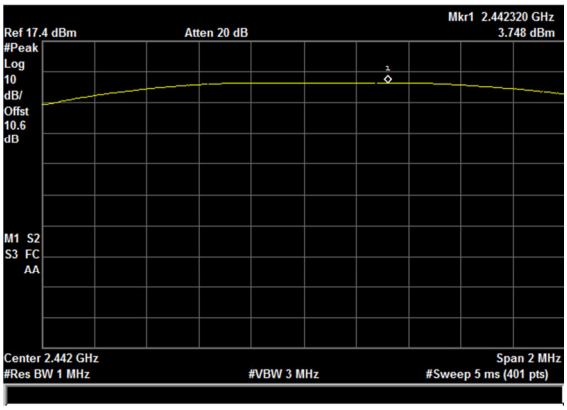
Table 11. Peak Power Output, Test Results

 © 2020, Eurofins E&E North America

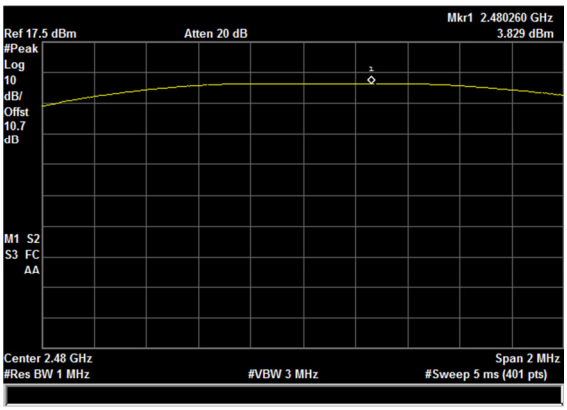
Peak Power Output Test Results



Plot 4: Peak Output Power, BLE, 2402MHz Low



Plot 5: Peak Output Power, BLE, 2442MHz Mid



Plot 6: Peak Output Power, BLE, 2480MHz High

© 2020, Eurofins E&E North America

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 12. Restricted Bands of Operation

[1] Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.
[2] Above 38.6

 © 2020, Eurofins E&E North America

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 13.

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 13. 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. Only noise floor was measured above 18 GHz.

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

Test Engineer(s): Arsalan Hasan

Test Date(s): 07/15/2020 & 9/28/2020

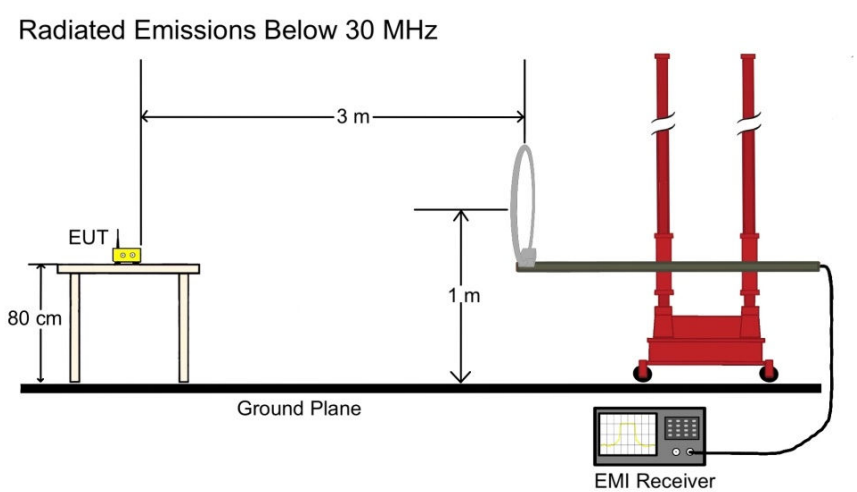


Figure 5: Radiated Emissions, Below 30MHz, Test Setup

 © 2020, Eurofins E&E North America

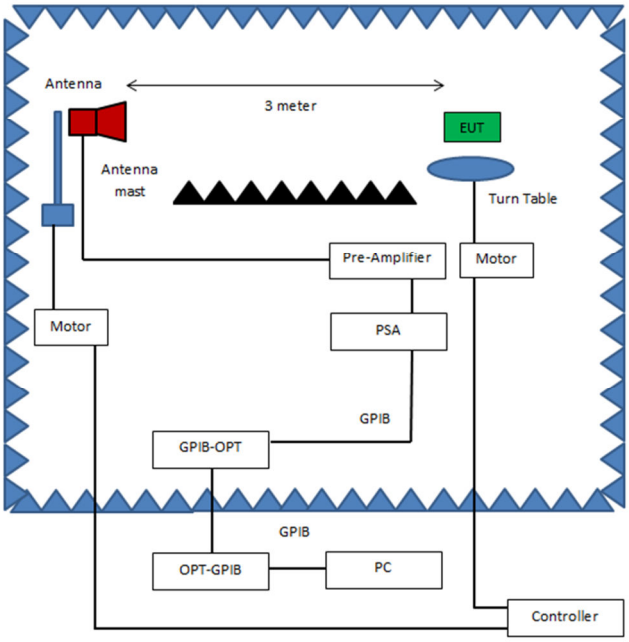


Figure 6: Radiated Emissions - Above 1GHz - Block Diagram

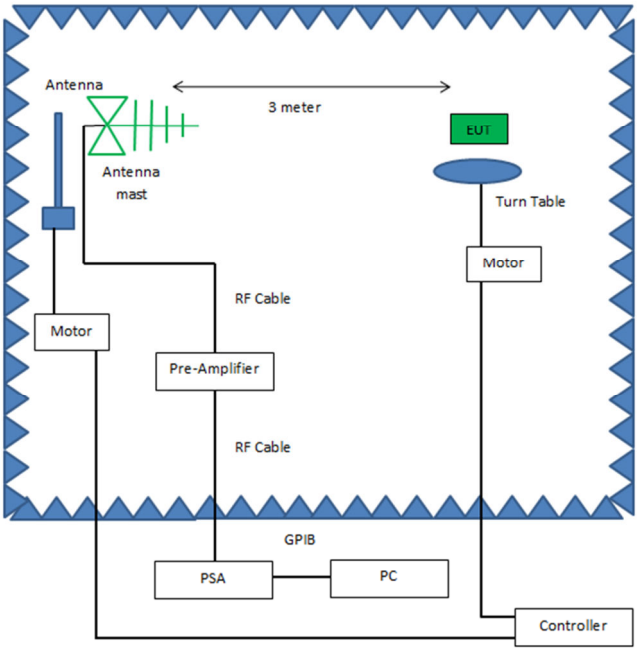
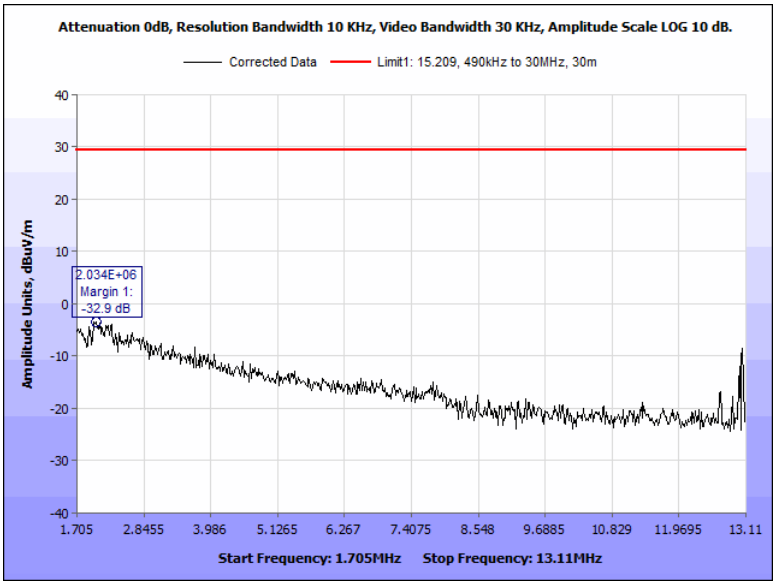


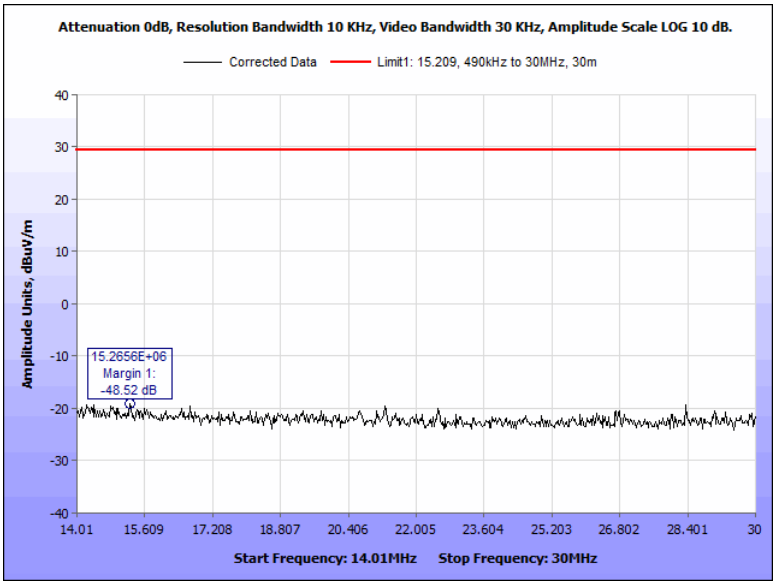
Figure 7: Radiated Emissions - Below 1GHz - Block Diagram

© 2020, Eurofins E&E North America

Radiated Spurious Emissions, Test Results



Plot 7: Radiated Spurious Emissions, Below 30MHz, Spot check for 12MHz Clock

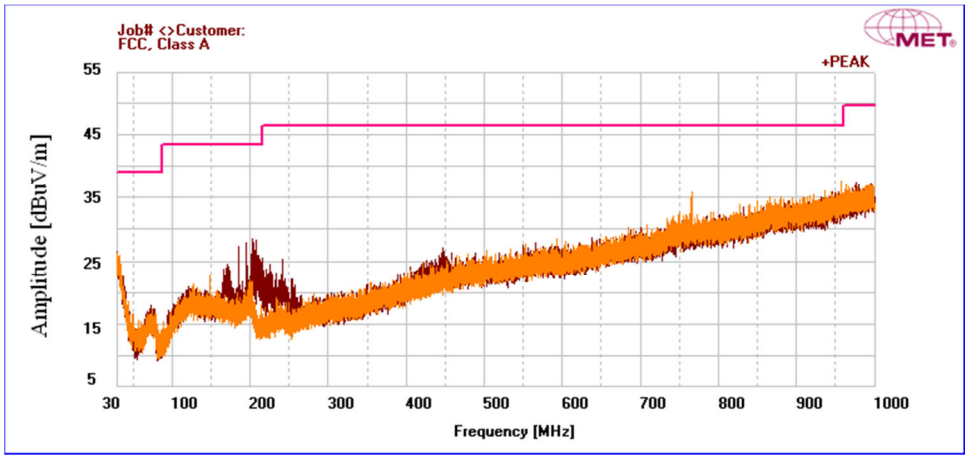


Plot 8: Radiated Spurious Emissions, Below 30MHz, Spot check for 24MHz Clock

© 2020, Eurofins E&E North America

Frequency (MHz)	EUT Azimuth (Degrees)	Antenna Polarity (H/V)	Antenna HEIGHT (m)	Uncorrected EMI Meter Reading (dBuV)	Antenna Correction Factor (dB/m) (+)	Cable Loss (dB) (+)	Distance Correction Factor (dB) (-)	Corrected Amplitude (dBuV/m)	Limit (dBuV/m)	Margin (dB)
213	153	H	1	41.24	15.43	29.765	0.00	26.905	43.5	-16.595
214	132	V	1	43.21	15.43	29.765	0.00	28.875	43.5	-14.625
218	186	H	1	37.54	17.65	29.659	0.00	25.531	46	-20.469
452	246	H	1	33.43	20.86	28.874	0.00	25.416	46	-20.584
539	142	V	1	32.43	23.62	28.432	0.00	27.618	46	-18.382
765	290	V	1	37.65	24.98	27.543	0.00	35.087	46	-10.913

Table 14: Radiated Emissions Data 30MHz – 1GHz

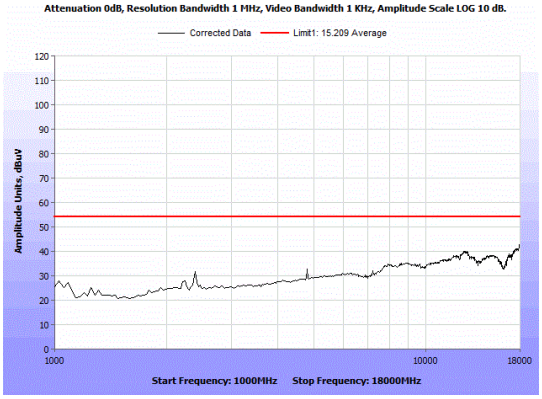


Plot 9: Radiated Emissions, BLE, 30 MHz - 1 GHz,

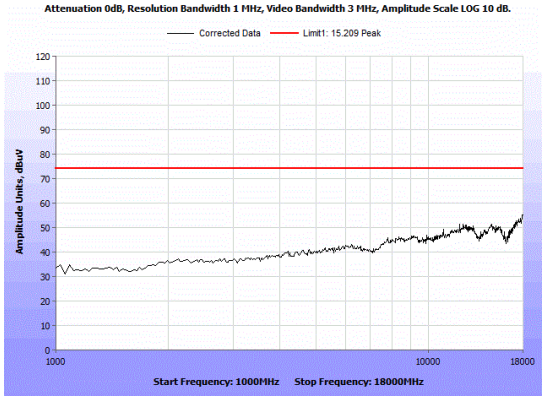
Horizontal

Vertical

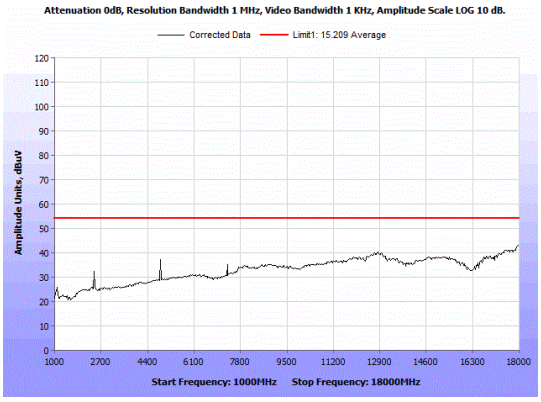
© 2020, Eurofins E&E North America



Plot 10: BLE, Radiated Spurious Emissions, 2402MHz, Average. (Vertical – Worst Case)

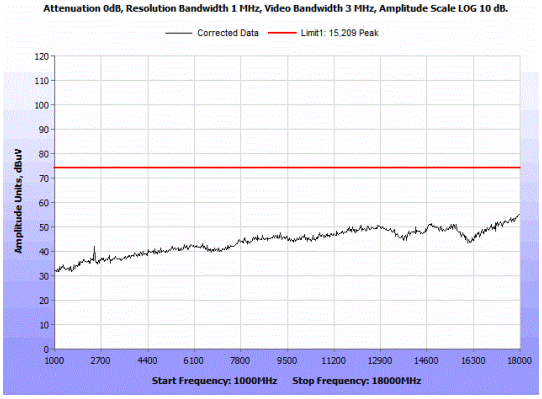


Plot 11: Radiated Spurious Emissions, BLE, 2402MHz, Peak. (Vertical – Worst Case)

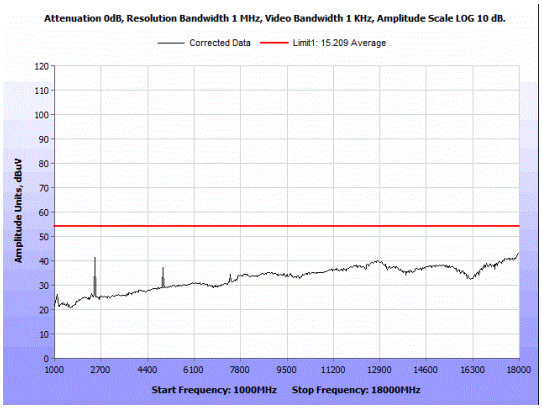


Plot 12: Radiated Spurious Emissions, BLE, 2442MHz, Average. (Vertical – Worst Case)

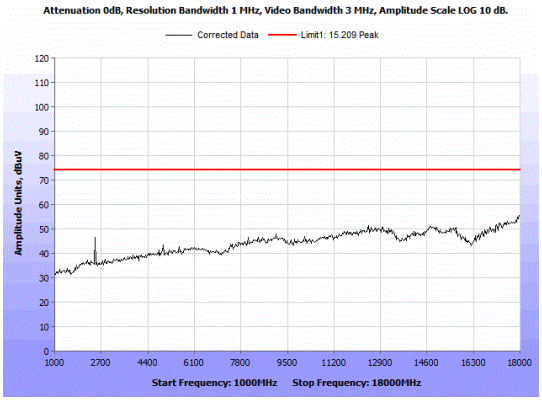
© 2020, Eurofins E&E North America



Plot 13: Radiated Spurious Emissions, BLE, 2442MHz, Peak. (Vertical – Worst Case)



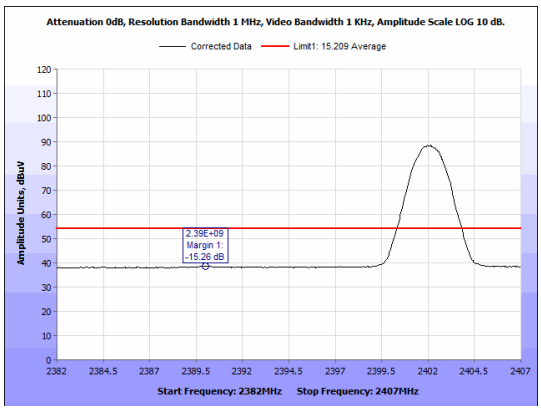
Plot 14: Radiated Spurious Emissions, BLE, 2480MHz, Average. (Vertical – Worst Case)



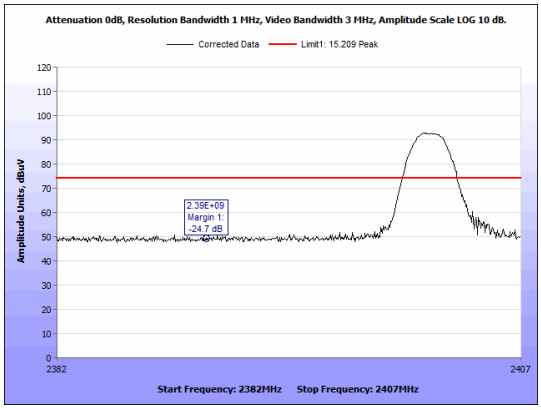
Plot 15: Radiated Spurious Emissions, BLE, 2480MHz, Peak. (Vertical – Worst Case)

© 2020, Eurofins E&E North America

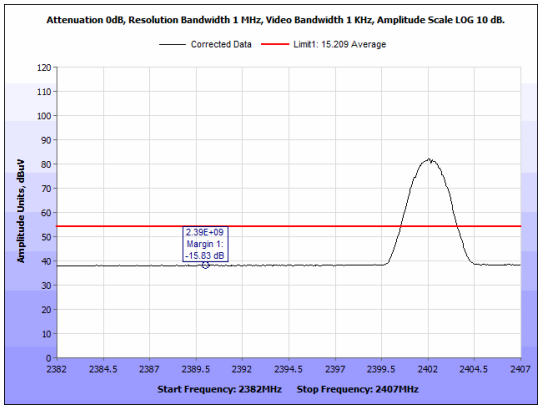
Radiated Band Edge Measurements



Plot 16: Radiated Band Edge, BLE, Low Channel 2402Mhz, Horizontal Average.

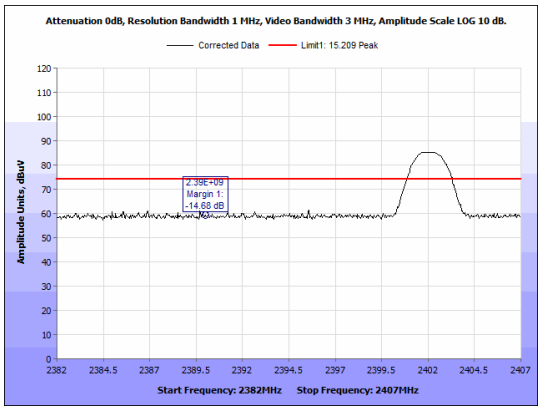


Plot 17: Radiated Band Edge, BLE, Low Channel 2402Mhz, Horizontal Peak.

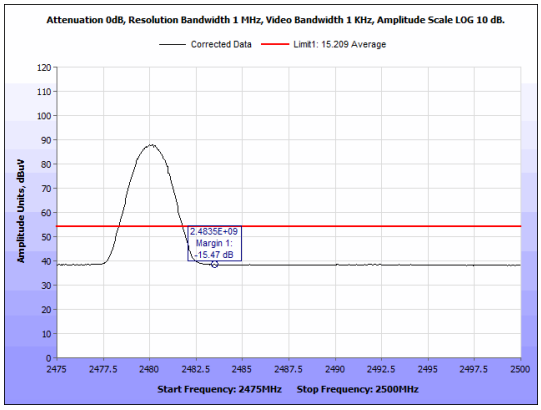


Plot 18: Radiated Band Edge, BLE, Low Channel 2402Mhz, Vertical Average.

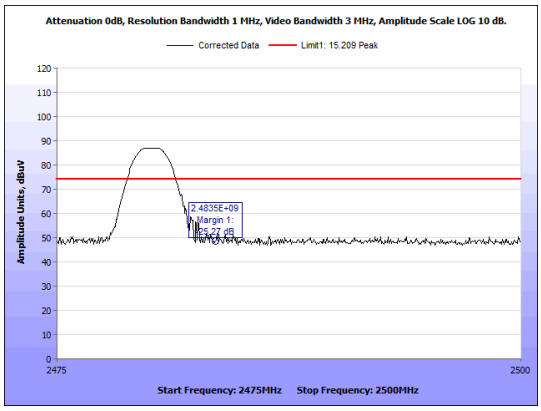
© 2020, Eurofins E&E North America



Plot 19: Radiated Band Edge, BLE, Low Channel 2402Mhz, Vertical Peak.

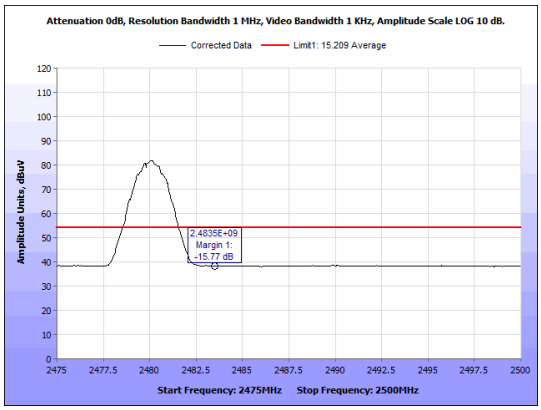


Plot 20: Radiated Band Edge, BLE, High Channel 2480Mhz, Horizontal Average.

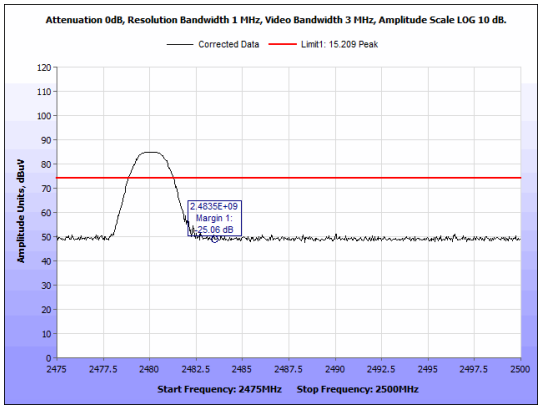


Plot 21: Radiated Band Edge, BLE, High Channel 2480Mhz, Horizontal Peak.

© 2020, Eurofins E&E North America



Plot 22: Radiated Band Edge, BLE, High Channel 2480Mhz, Vertical Average.



Plot 23: Radiated Band Edge, BLE, High Channel 2480Mhz, Vertical Peak.

© 2020, Eurofins E&E North America

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.

Since the EUT had an integral antenna, conducted measurements could not be performed. Measurements needed to be taken radiated. An antenna was located 1 m away from the EUT and plots were taken. The EUT was rotated through all three orthogonal axes. The plots were corrected for both antenna correction factor and cable lost.

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

Test Engineer(s): Arsalan Hasan

Test Date(s): 07/14/2020

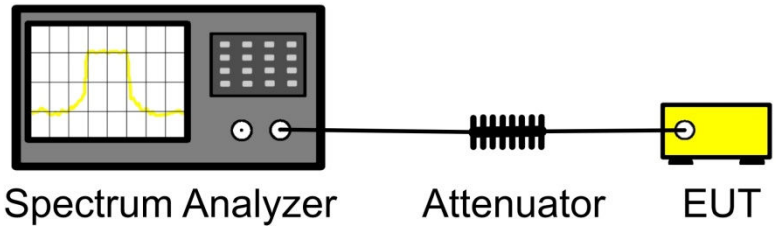
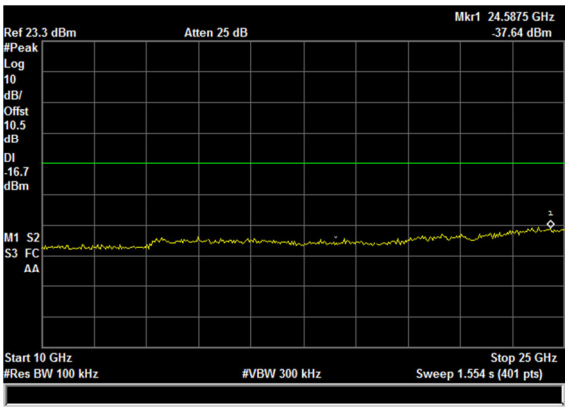


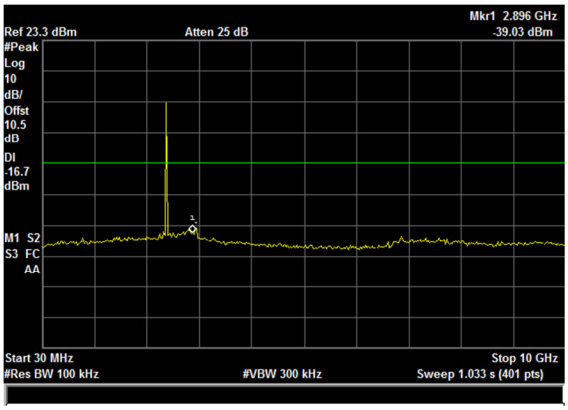
Figure 8. Conducted Spurious Emissions, Test Setup

© 2020, Eurofins E&E North America

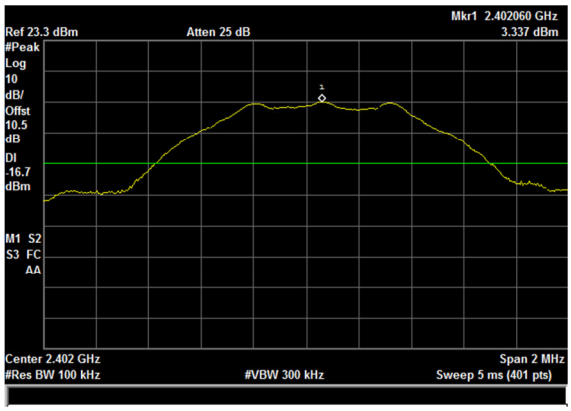
Spurious Emissions in Non-restricted Bands, Test Results



Plot 24: Conducted Spurious Emission, BLE. low channel 10GHz-25GHz

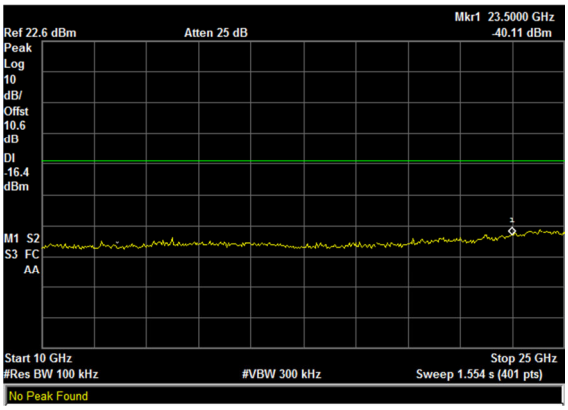


Plot 25: Conducted Spurious Emissions, BLE, low channel 30MHZ-10GHz

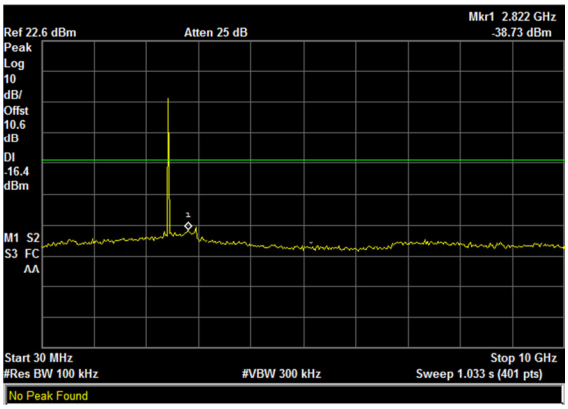


Plot 26: Conducted Spurious Emission, BLE, low channel reference

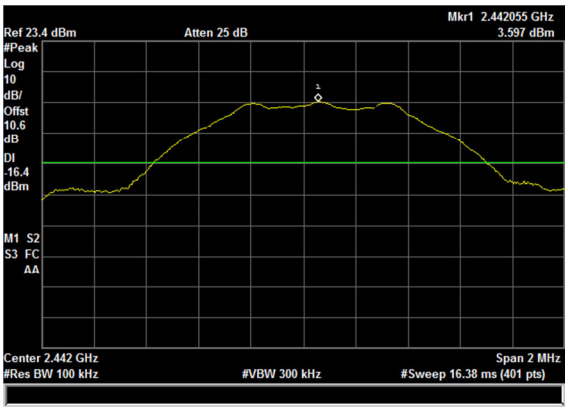
© 2020, Eurofins E&E North America



Plot 27: Conducted Spurious Emission, BLE, mid channel 10GHz-25GHz

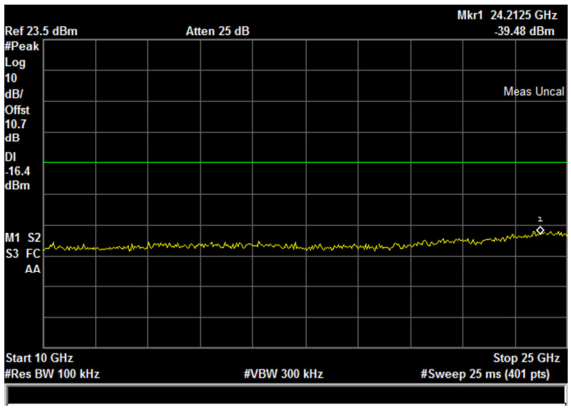


Plot 28: Conducted Spurious Emission, BLE, mid channel 30MHz-10GHz

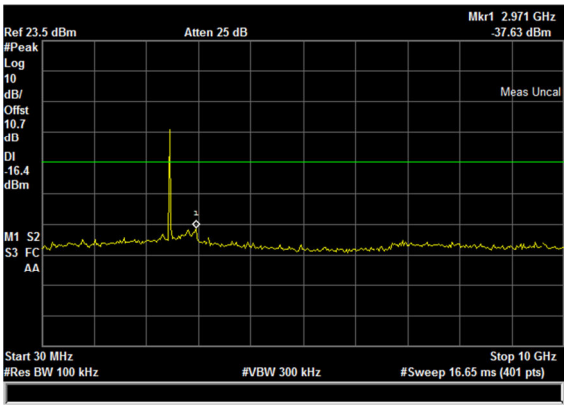


Plot 29: Conducted Spurious Emission, BLE, mid channel reference

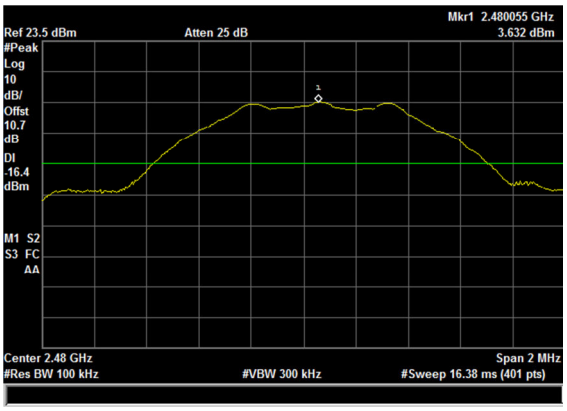
© 2020, Eurofins E&E North America



Plot 30: Conducted Spurious Emission, BLE, high channel 10GHz-25GHz

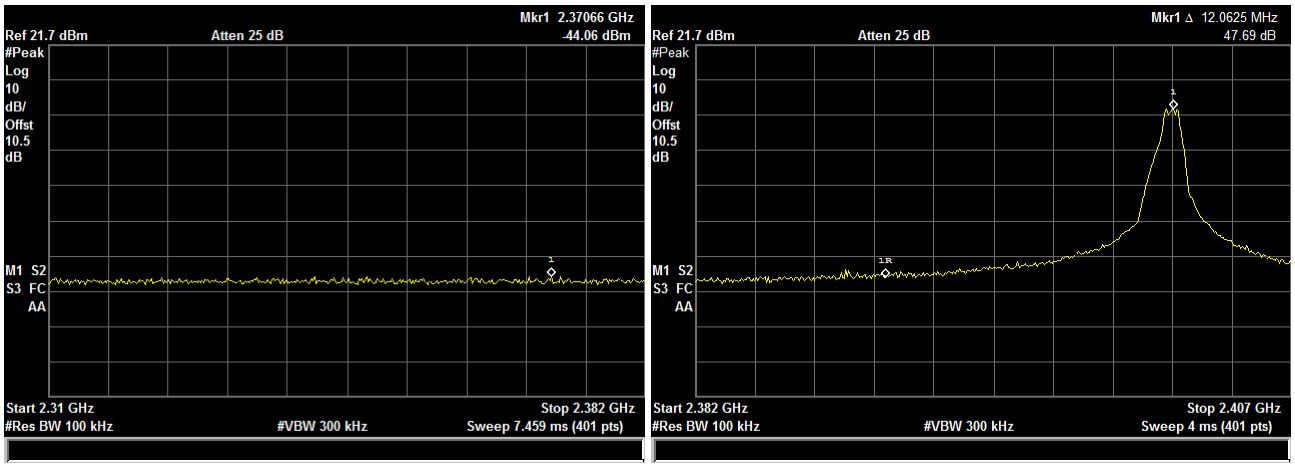


Plot 31: Conducted Spurious Emission, BLE high channel 30MHZ-10GHz

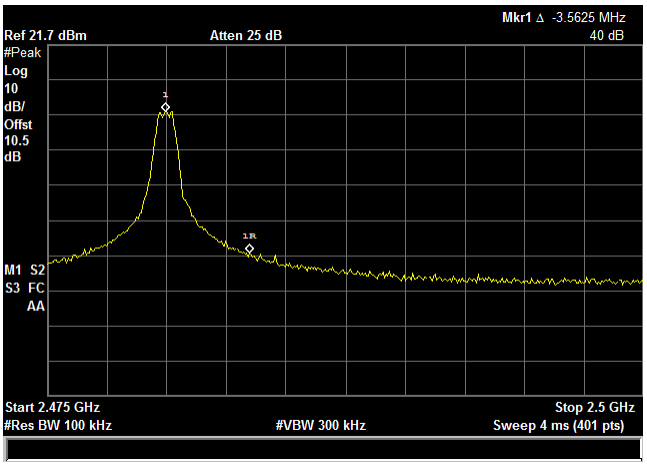


Plot 32: Conducted Spurious Emission, BLE high channel reference

© 2020, Eurofins E&E North America



Plot 33: RF Conducted Band Edge, 2402MHz Low Channel



Plot 34: RF Conducted Band Edge, 2480MHz High Channel

© 2020, Eurofins E&E North America

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 determined from plots on the following page(s).

Test Engineer: Arsalan Hasan

Test Date: 07/14/2020

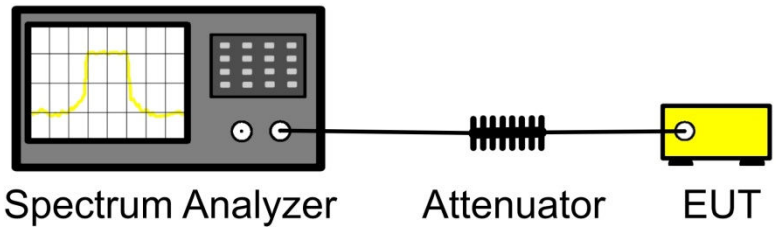


Figure 9. Power Spectral Density, Test Setup

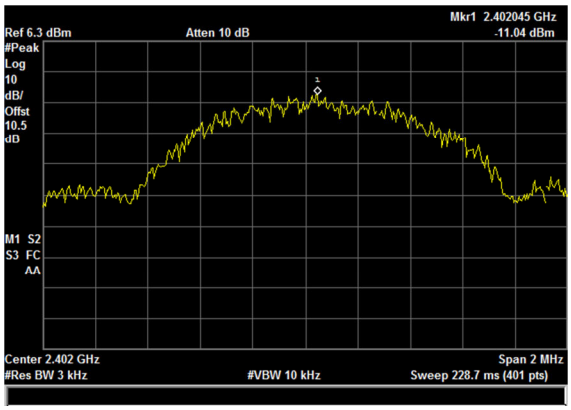
Peak Power Spectral Density Test Results

Channel	Frequency (MHz)	PSD (dBm)	LIMIT (dBm)
Low	2402	-11.04	8
Mid	2442	-11.01	8
High	2480	-11.11	8

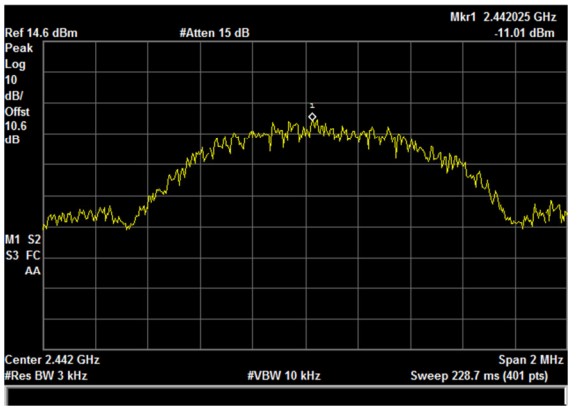
Table 15: Peak Power Spectral Density, Test Results

 © 2020, Eurofins E&E North America

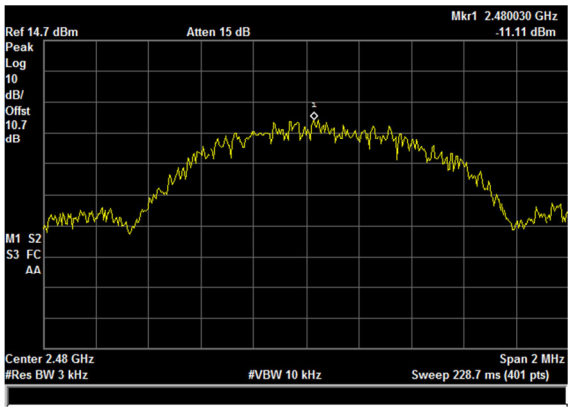
Peak Power Spectral Density



Plot 35: Power Spectral Density, BLE, 2402MHz Low



Plot 36: Power Spectral Density, BLE, 2442MHz Mid



Plot 37: Power Spectral Density, BLE, 2480MHz High

© 2020, Eurofins E&E North America

IV. Test Equipment

© 2020, Eurofins E&E North America

Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2005.

ASSET #	NOMENCLATURE	MANUFACTURER	MODEL	LAST CAL	CAL DUE
1S2399	TURNTABLE CONTROLLER	SUNOL SCIENCE	SC99V	FUNCTIONAL VERIFY	
1S3928	EMI TESTER RECEIVER	ROHDE & SCHWARZ	ESR26	03/04/2020	03/04/2021
1S2600	BILOG ANTENNA	TESEQ	CBL6112D	03/19/2019	03/19/2021
1S3983	LOOP ANTENNA	ETS-LINDGREN	6512	09/26/2019	09/26/2021
1S2486	5 METER CHAMBER CONTROL ROOM	PANASHIELD	5 METER CONTROL ROOM	FUNCTIONAL VERIFY	
1S3926	1MHZ STEP, 1GHZ COMBO GENERATOR	COM-POWER CORP	CGO-501	FUNCTIONAL VERIFY	
1S4067	DIGITAL BAROMETER	CONTROL CO	6530	06/22/2020	06/22/2022
1S2481	10 METER CHAMBER	ETS-LINGREN	DKE-8X8 DBL	FUNCTIONAL VERIFY	
1S380	EMI RECEIVER	NARDA SAFETY TEST SOLUTIONS	PMM 9010F	8/23/2020	8/23/2021
1S245	COMB GENERATOR (RADIATED)	COM-POWER	GG510	FUNCTIONAL VERIFY	
1S2599	LASER PROBE INTERFACE	AMPLIFIER RESEARCH	F1700	FUNCTIONAL VERIFY	
1S2603	DOUBLE RIDGED WAVEGUIDE HORN	ETS-LINDGREN	3117	09/18/2018	09/18/2020
1S2000	SPECTRUM ANALYZER	AGILENT	E4448A	11/06/2019	11/06/2020
1S3818	DRG HORN ANTENNA	A.H. SYSTEMS, INC	SAS-574	09/24/2018	09/24/2020

Table 16: Test Equipment List

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

© 2020, Eurofins E&E North America

End of Report

 © 2020, Eurofins E&E North America