



Radio Test Report

FCC CFR 47 Part 15.247
Industry Canada RSS-Gen, Issue 4
Industry Canada RSS-247, Issue 1

For:

Manufacturer: Delphi Electronics & Safety

Model Number: VRM

FCC ID: L2C0060TR
IC Certification Number: 3432A-0060TR

Test Report #: EMC_DELPH-004-15001_NA-BTLE

Date: February 25, 2016



CETECOM Inc.

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1 Assessment

The EUT, as identified in section 3 of this test report, was evaluated against the criteria specified in the following standards and no deviations were ascertained during the course of the tests performed.

Standard	Standard Title	Version
FCC CFR 47 Part 15.247	Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz	Current as of 2016-02-25
Industry Canada RSS-Gen	General Requirements for Compliance or Radio Apparatus	Issue 4, November 2014
Industry Canada RSS-247	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices	Issue 1, May 2015

Responsible for Testing Laboratory:

February 25, 2016 Compliance Franz Engert
(Compliance Manager)

 Digitally signed by Franz Engert
DN: cn=Franz Engert, c=US,
o=CETECOM, ou=Compliance,
email=franz.engert@cetecom.
com

Date	Section	Name	Signature
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Responsible for the Report:

February 25, 2016 Compliance Josie Sabado
(Test Lab Manager)



Date	Section	Name	Signature
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The test results of this test report relate exclusively to the test item specified in Section 3.

CETECOM Inc. USA does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CETECOM Inc. USA.

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name	CETECOM Inc.
Department	Compliance
Address	411 Dixon Landing Road Milpitas, CA 95035 USA
Telephone	+1 (408) 586-6200
Fax	+1 (408) 586-6299
Test Lab Manager	Franz Engert
Project Manager	James Devasia
Test Engineer	Josie Sabado

2.2 Identification of the Client and Manufacturer

	Client	Manufacturer
Company	Delphi Electronics & Safety	Same as client
Address	One Corporate Center M/S CTC4W Kokomo, IN 46904	
Country	USA	

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model Number	VRM
Product Description	In-Vehicle Entertainment System with 802.11 a/b/g/n/ac and Bluetooth LE
FCC ID	L2C0060TR
IC Certification Number	3432A-0060TR
Product Marketing Name (PMN)	VRM
Hardware Version Identification Number (HVIN)	VRM
Firmware Version Identification Number (FVIN)	N/A
Host Marketing Name (HMN)	N/A
Radio Evaluated in this Test Report	Bluetooth v4.1 (Bluetooth LE), Power Class 2
Bluetooth Frequency Range	2400 – 2483.5 MHz
Number of Bluetooth Channels	40, Ch 0 through Ch 39
Bluetooth Modulations	GFSK
Declared Bluetooth Maximum Output Power	0 dBm, +4 dB/-0 dB
Bluetooth Antenna Information	☒ Internal ☐ External Type: PiFA Maximum Peak Gain: 2.02 dBi
Power Source(s)	Vehicular DC
Operating Input Voltage Range	Low: 9 VDC Nominal: 14.4 VDC High: 16 VDC
Operating Temperature Range	Low: -40° C Nominal: 25° C High: 85° C
Other Radios Supported by the EUT	802.11 b/g/n (HT20); SISO 802.11 a/n (HT20, HT40)/ac (VHT20, VHT40, VHT80); SISO, MIMO using CDD
Test Sample Type	☐ Prototype ☒ Pre-Production ☐ Production
Dates of Testing	November 8, 2015; December 3-4, 2015

3.2 Identification of the Equipment Under Test

EUT #	Serial Number	SW Version	HW Version	Comments
1	REGULATORYSAMPLE01	1602.11	28531001AG	Radiated Unit
2	T210510006	1602.11	28531001AG	Conducted Unit

3.3 Identification of Test Support Equipment

The following equipment is used for testing purposes only.

TSE #	Type	Manufacturer	Model	Serial Number	Comments
1	Systems Analysis Interface Tool	DG Technologies	SAINT2	SZ2079	Radiated Testing
2	Power Supply & Product Interface	Delphi	N/A	N/A	Radiated Testing
3	Display Screen	Delphi	28420614A	73	Radiated Testing
4	Ethernet to USB Adapter	D-Link	DUB-E100	US1DB89000317	Radiated Testing
5	Laptop	Dell	Latitude E5500	6XRNYJ1	Radiated Testing
6	Systems Analysis Interface Tool	DG Technologies	SAINT2	SZ2053	Conducted Testing
7	Power Supply & Product Interface	Delphi	N/A	N/A	Conducted Testing
8	Display Screen	Delphi	28420614A	72	Conducted Testing
9	Ethernet to USB Adapter	D-Link	DUB-E100	US1DB89000251	Conducted Testing
10	Laptop	Dell	Latitude E5420	BW21LQ1	Conducted Testing

3.4 Identification of Test Support Software

The following software is provided by the client and used for testing purposes only. The end user does not have access to the software.

TSS #	Developer	Name	Version	Comments
1	Qualcomm Atheros	QCARCT	3.0.138.0	
2	Delphi	Chrysler IVE Simulator	1.0.2.2	
3	Delphi	Saint Bus Monitor 2	4.3.1.7	

3.5 Miscellaneous Testing Information

1. QCARCT is used to put the Bluetooth radio in a test mode. The software is used to set the channel. QCARCT is not accessible to the user under normal operations.
2. The EUT is normally powered by the DC battery supply of the vehicle. For testing, an AC/DC power supply is provided by Delphi.
3. The EUT is normally grounded when installed in a vehicle. For testing, the EUT was grounded to a ground plane and the ground plane was grounded to the anechoic chamber.

4 Summary of Measurement Results

Test Specification		Test Case	Pass	Fail	N/P	N/A	Result
FCC §15.247	IC RSS-247						
(a)(2)	5.2(1)	DTS Bandwidth	■	☐	☐	☐	Complies
(b)(3)	5.4	Transmitter Output Power and EIRP	■	☐	☐	☐	Complies
(e)	5.2(2)	Power Spectral Density	■	☐	☐	☐	Complies
(d)	5.5	Emissions in Non-Restricted Frequency Bands	■	☐	☐	☐	Complies
(d)	5.5	Emissions in Restricted Frequency Bands	■	☐	☐	☐	Complies
(d)	5.5	Band Edge	■	☐	☐	☐	Complies
§15.207	RSS-Gen, 7.2.2	AC Power Line Conducted Emissions	☐	☐	■	☐	See Note 2

Notes:

1. N/A = Not Applicable; N/P = Not Performed
2. AC power line conducted emissions is not required for vehicular devices.

5 Measurement Information

5.1 Measurement Procedure Standards

The following standards provided guidance for the measurement procedures used in this test report.

- ANSI C63.10 – 2013 : American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- FCC KDB 558074 D01 v03r03: Guidance for performing compliance measurements on digital transmission systems (DTS) operating under §15.247

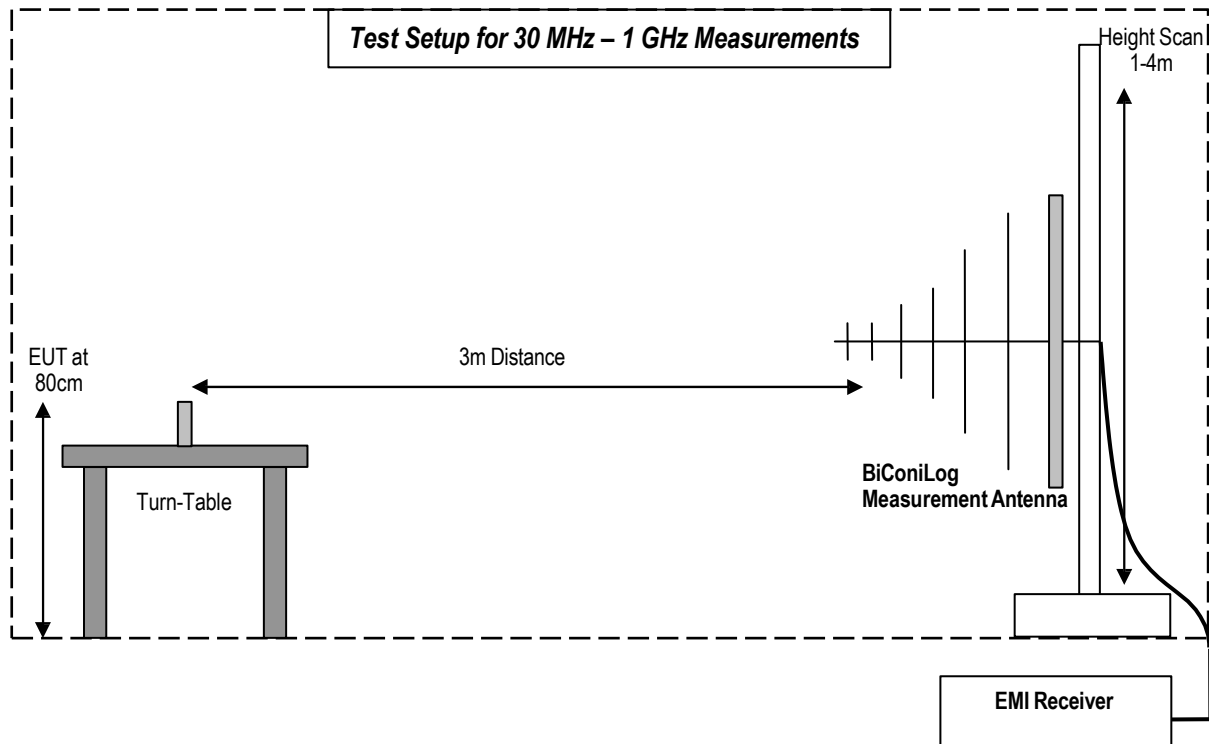
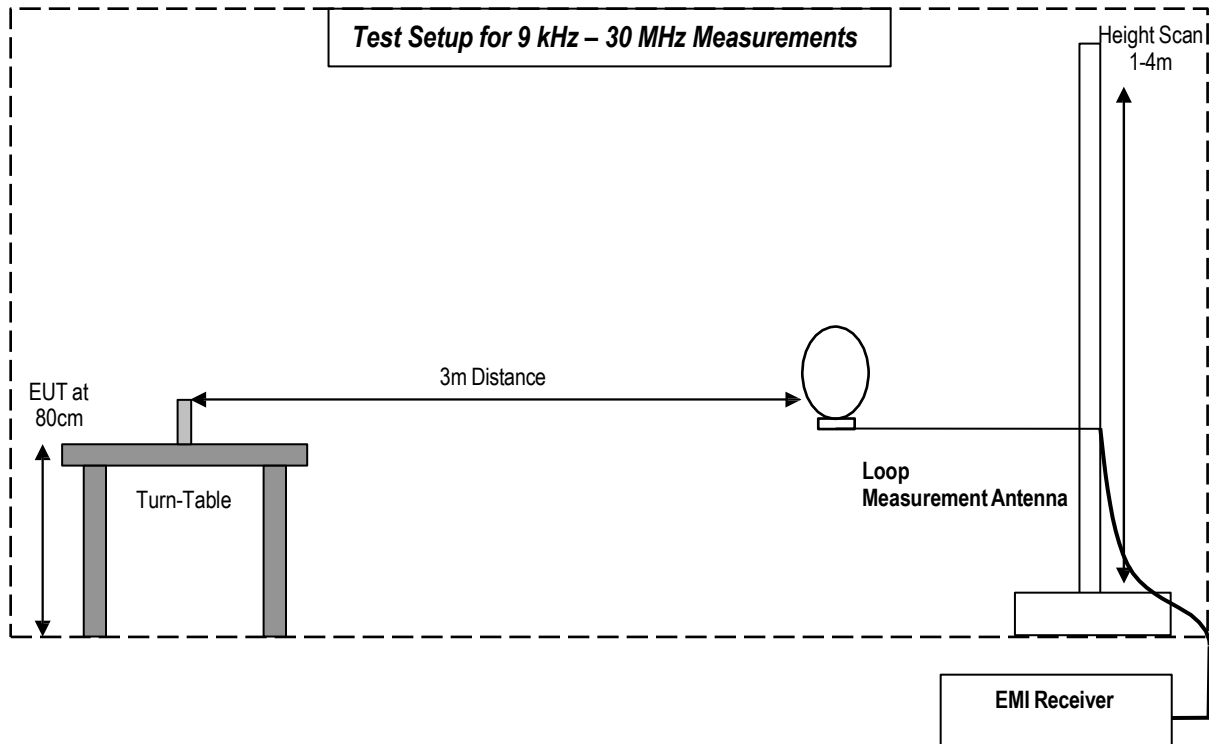
5.2 Radiated Measurements

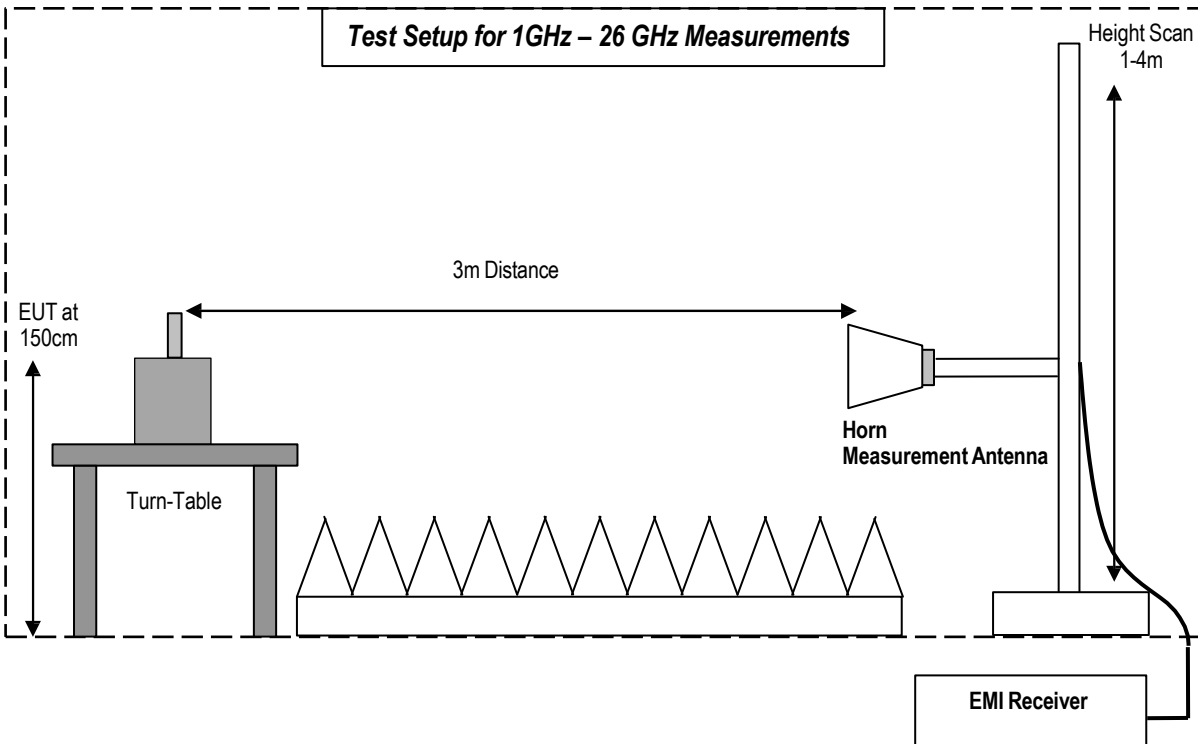
5.2.1 Radiated Measurements Procedure

Radiated measurement s is performed according to ANSI C63.10 (2013).

- The exploratory measurement is accomplished by running sweeps at 1 and 4m antenna heights over the required frequency range with R&S Test-SW EMC32 for both antenna polarizations. During each frequency scan the turntable rotates by no more than 10°.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then again maximized through a fine search in the frequency domain, maximized in the 360° range of the turntable, and maximized over the antenna height between 1 m and 4 m and for positioning of the EUT.
- The above procedure is repeated for transmissions in the low, mid, and high channels.
- In case there are no emissions above the noise floor level, only the maximum trace is reported as described above.
- The results are split into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used from 1 GHz to 40 GHz.
- All measurements are performed at 3 meter distance.

5.2.2 Radiated Measurement Block Diagrams





5.2.3 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

1. Measured reading in dB μ V
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

$$FS \text{ (dB}\mu\text{V/m)} = \text{Measured Value on SA (dB}\mu\text{V)} - \text{Cable Loss (dB)} + \text{Antenna Factor (dB/m)}$$

Example:

Frequency (MHz)	Measured SA (dB μ V)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dB μ V/m)
1000	80.5	3.5	14	98.0

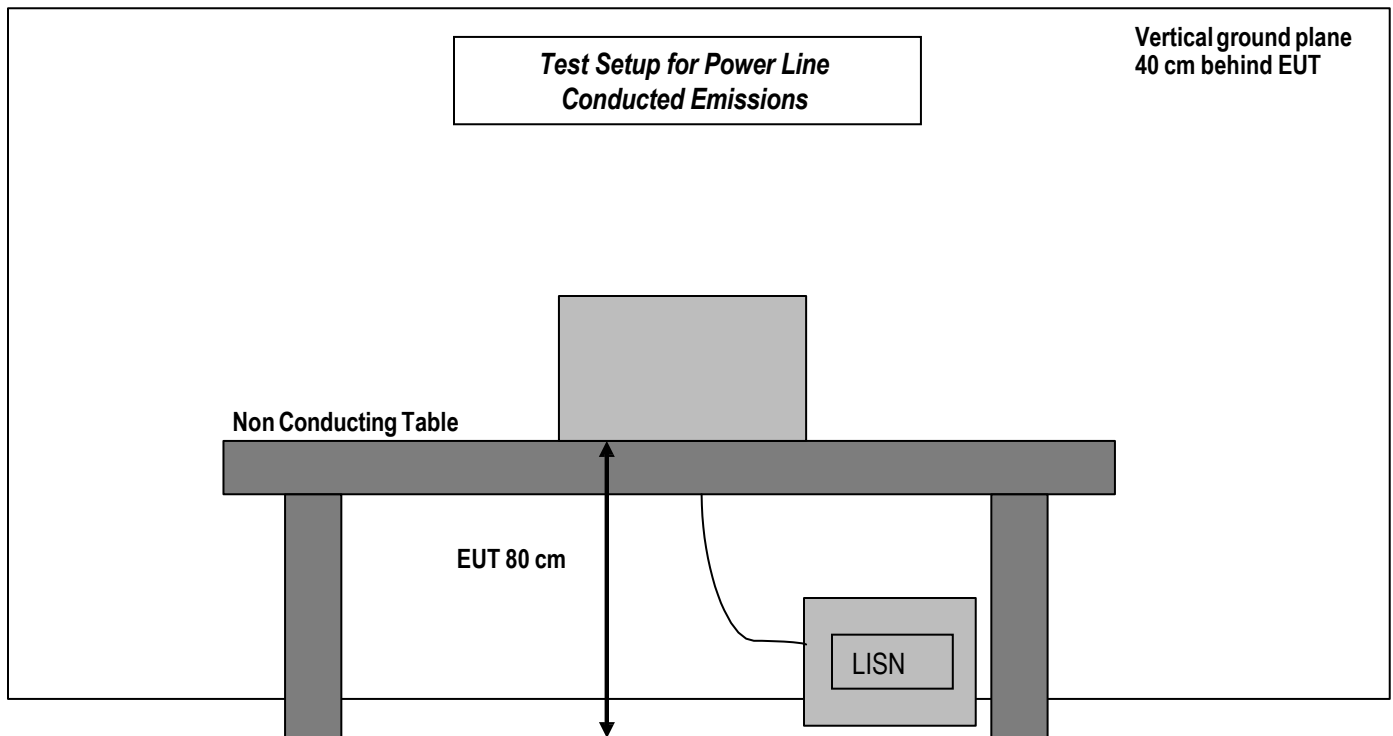
5.3 AC Power Line Conducted Emissions

5.3.1 AC Power Line Conducted Emissions Measurement Procedure

AC Power Line conducted emissions measurements are performed according to ANSI C63.10 (2013).

- The EUT and accessories are placed on a non-conducting table 80 cm above the horizontal ground plane and 40 cm from the vertical ground plane.
- Cables that hang closer than 40 cm to the ground plane are gathered into a 30 cm to 40 cm long bundle.
- The data ports of the EUT are exercised.
- The power cable of the EUT is connected to the LISN.
- The 6 highest emissions within 20 dB of the limit are noted.

5.3.2 AC Power Line Conducted Emissions Block Diagram



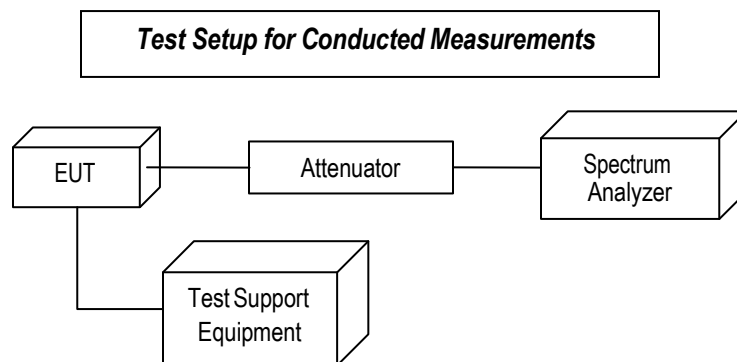
5.4 RF Conducted Measurements

5.4.1 RF Conducted Measurements Procedure

RF conducted measurements are performed according to ANSI C63.10 (2013).

- The antenna ports of the EUT are connected to the measurement equipment by an RF cable.
- The attenuation between the EUT and the measurement equipment is compensated in the measurement equipment.
- See plots for spectrum analyzer settings.

5.4.2 RF Conducted Measurements Block Diagram



5.5 Measurement Uncertainty

The following measurement uncertainty levels have been estimated for tests performed on the EUT, with 95% confidence interval (in dB delta to result), based on a coverage factor k=1.

	Uncertainty in dB Radiated <30 MHz	Uncertainty in dB Radiated 30 MHz – 1 GHz	Uncertainty in dB Radiated > 1 GHz	Uncertainty in dB Conducted Measurement
Standard Deviation k=1	2.48	1.94	2.16	0.64
95% Confidence Interval in dB	4.86	3.79	4.24	1.25
95% Confidence Interval in dB in delta to Result (rounded up to next decimal point)	+/- 2.5 dB	+/- 2.0 dB	+/- 2.3dB	+/- 0.7dB

5.6 Environmental Conditions During Testing

The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25°C
- Relative humidity: 40-60%

6 Measurement Results

6.1 DTS Bandwidth

6.1.1 Technical Standard References

FCC §15.247, Section (a) (2)

IC RSS-247, Section 5.2 (1)

KDB 558074, Section 8.0

6.1.2 Requirement

≥ 500 kHz

6.1.3 EUT Conditions

Frequency hopping off

6.1.4 Test Conditions

Measurements are according to FCC KDB 558074, section 8.1, Option 1.

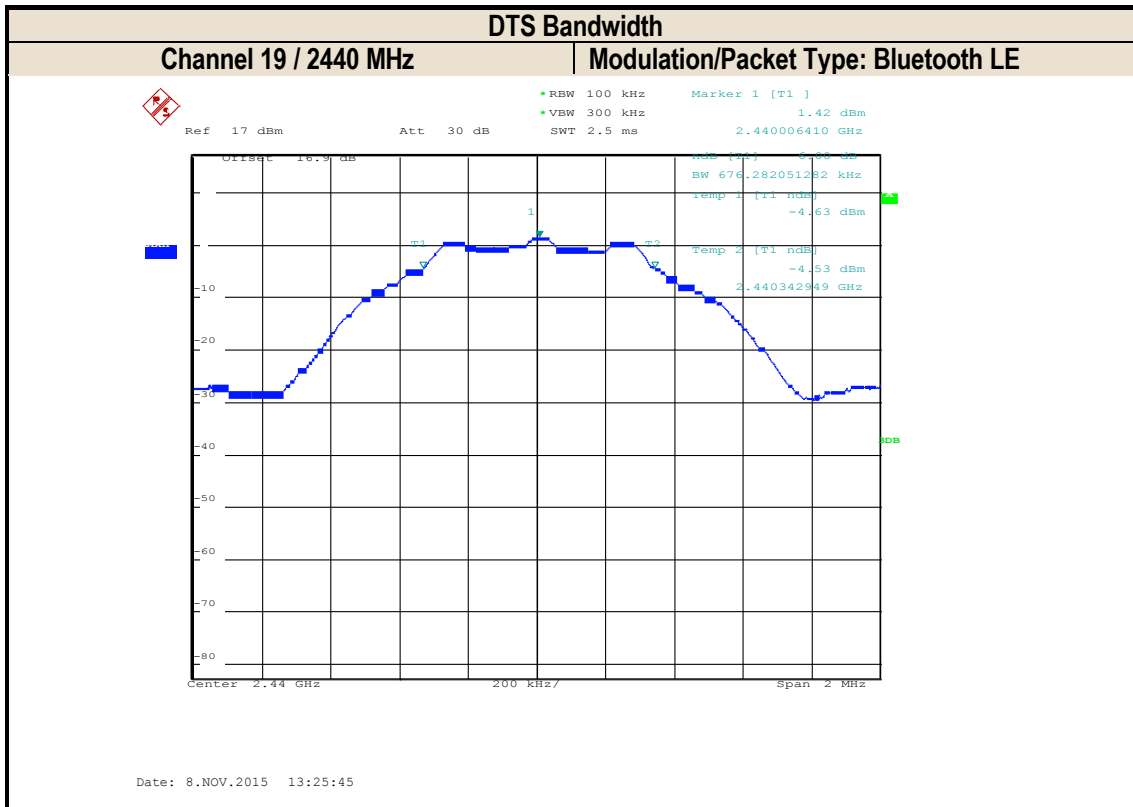
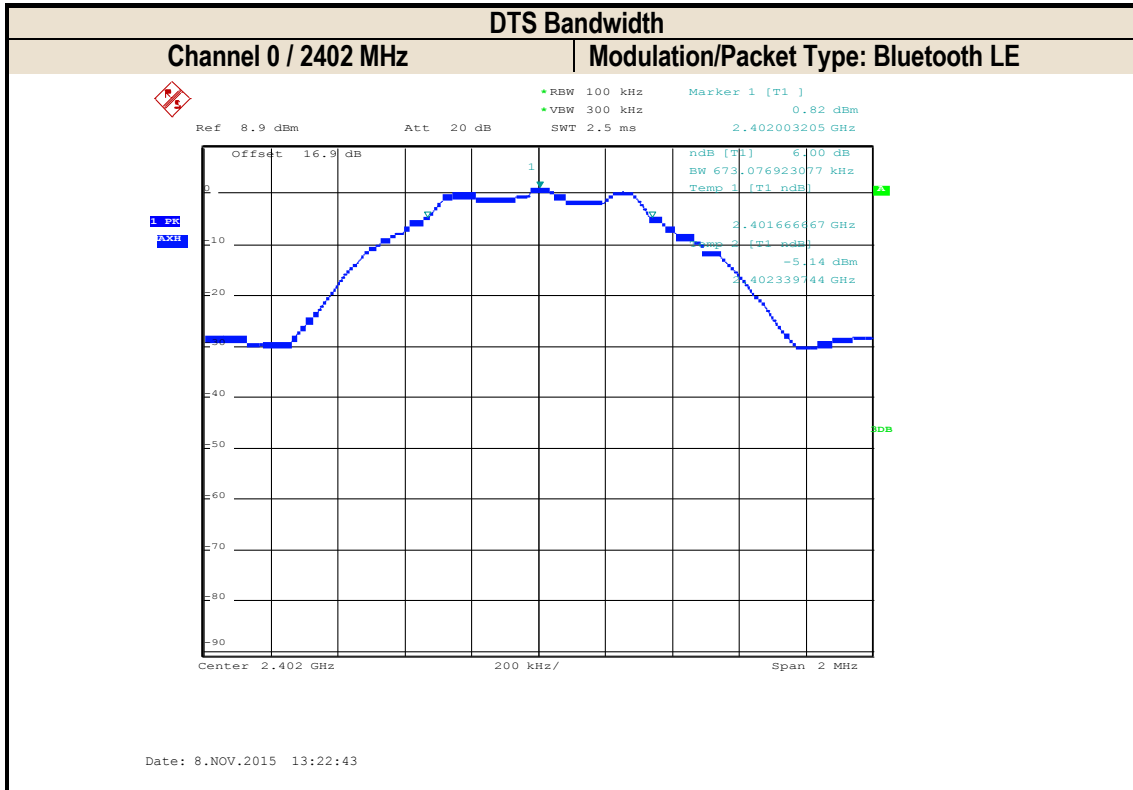
The bandwidth is measured 6 dB below the peak of the signal.

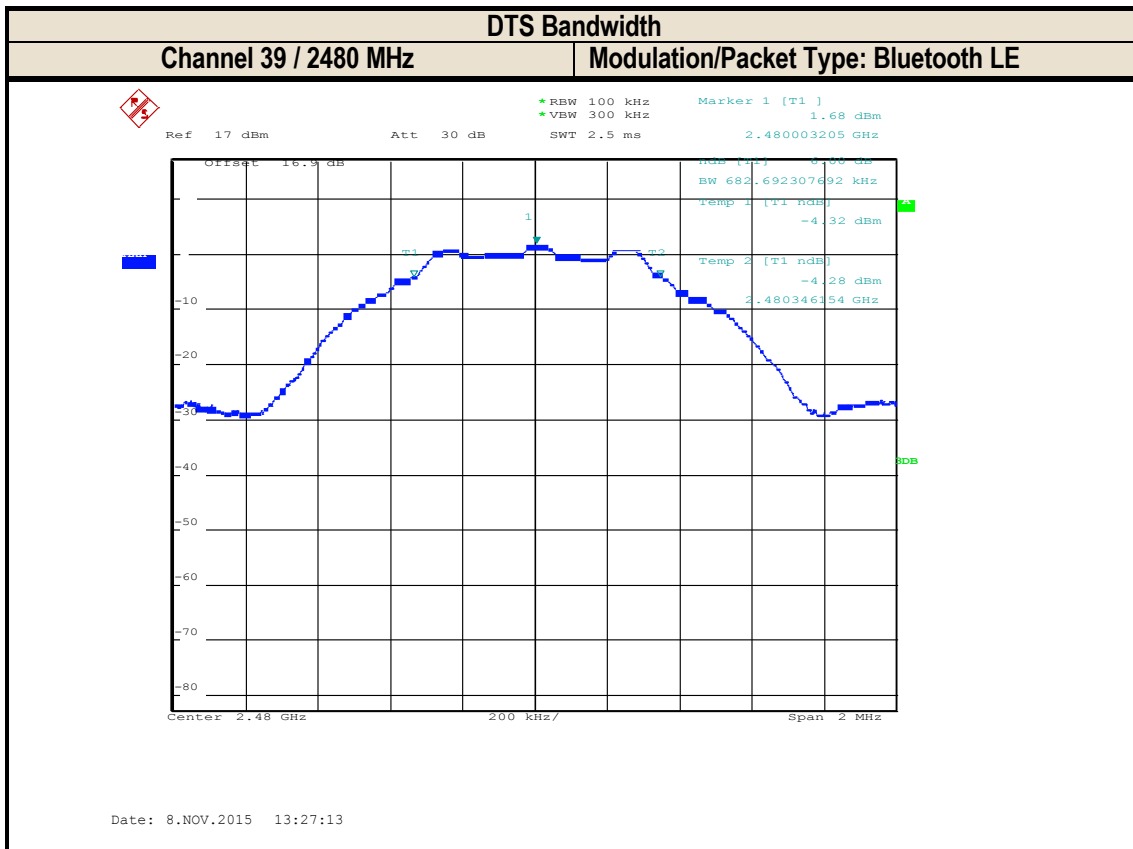
6.1.5 Test Results

Channel	Frequency (MHz)	DTS Bandwidth (kHz)
0	2402	673
19	2440	676
39	2480	683

6.1.6 Test Verdict

Pass

6.1.7 Test Plots



6.2 Transmitter Output Power and EIRP

6.2.1 Technical Standard References

FCC §15.247, Section (b) (3)

IC RSS-247, Section 5.4

KDB 558074, Section 9.0

6.2.2 Requirement

Conducted Output Power: 1 W (30 dBm)

EIRP: 4 W (36 dBm)

6.2.3 EUT Conditions

Frequency hopping off

6.2.4 Test Conditions

Measurements are according to FCC KDB 558074, section 9.1.1, maximum peak conducted output power measured with RBW $\geq$ DTS bandwidth.

EIRP is calculated as

$$\text{EIRP} = \text{Conducted Peak Output Power} + \text{Antenna Gain}$$

6.2.5 Test Results

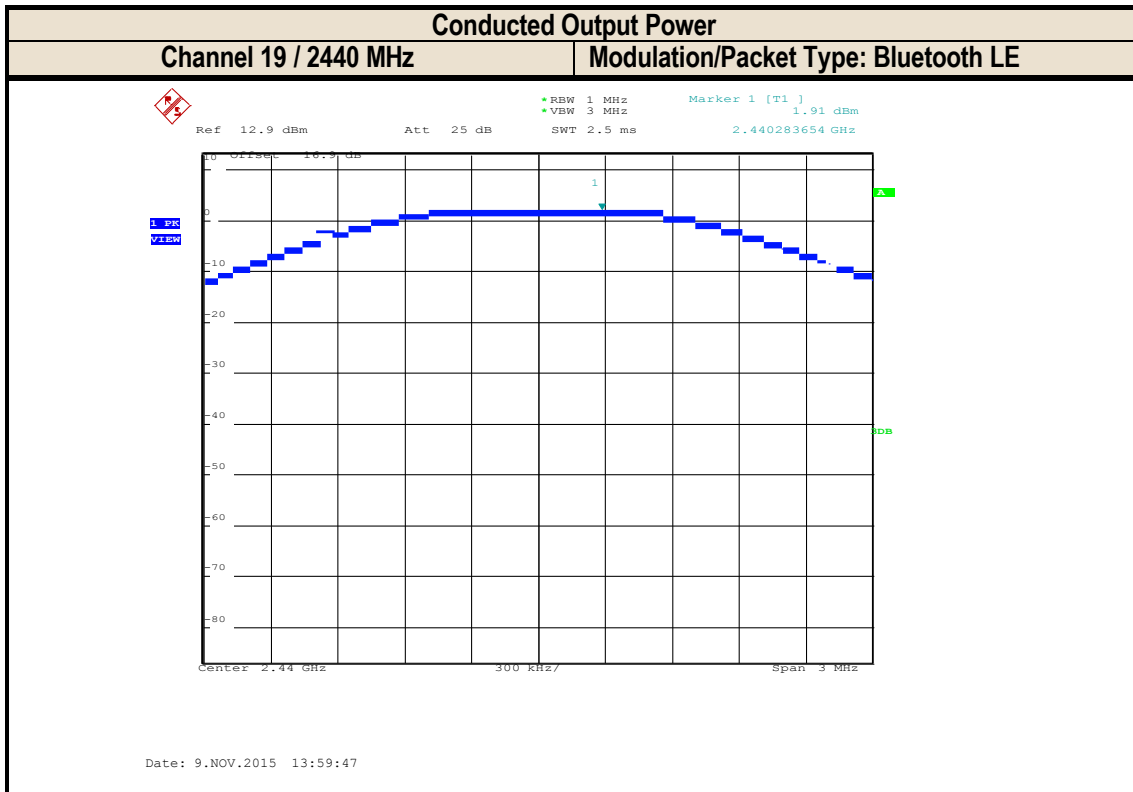
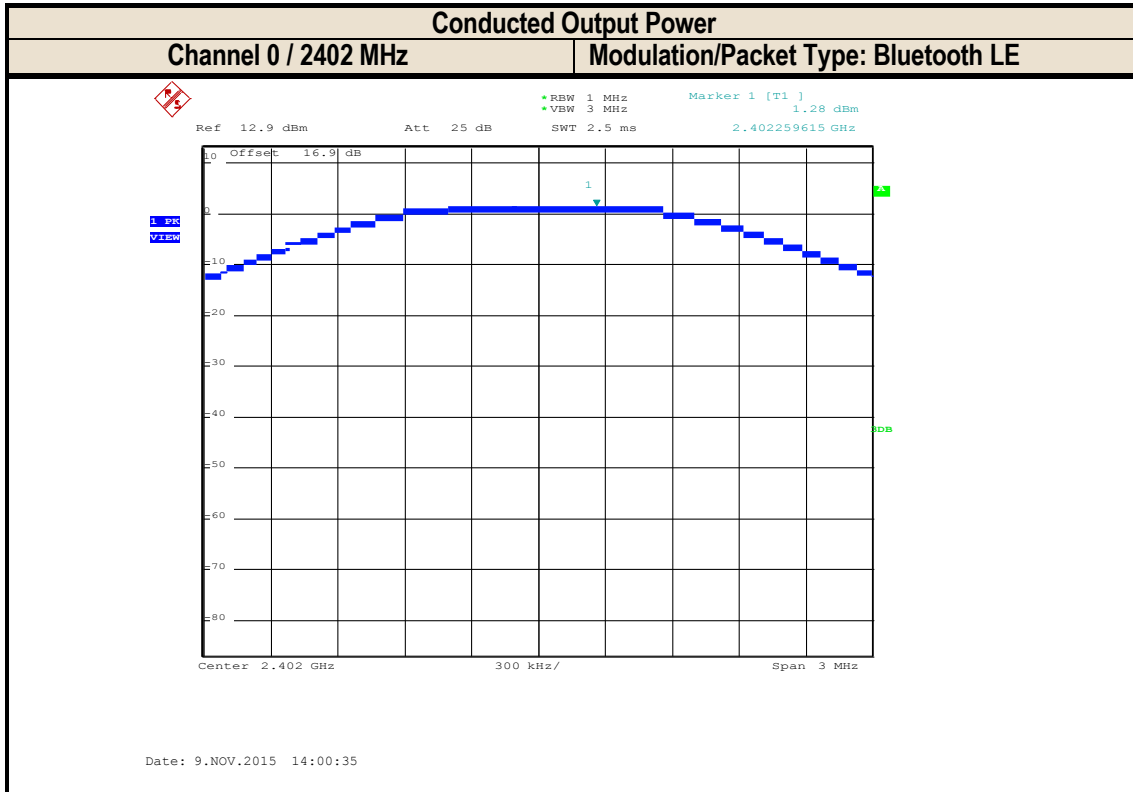
Maximum Antenna Gain: 2.02 dBi

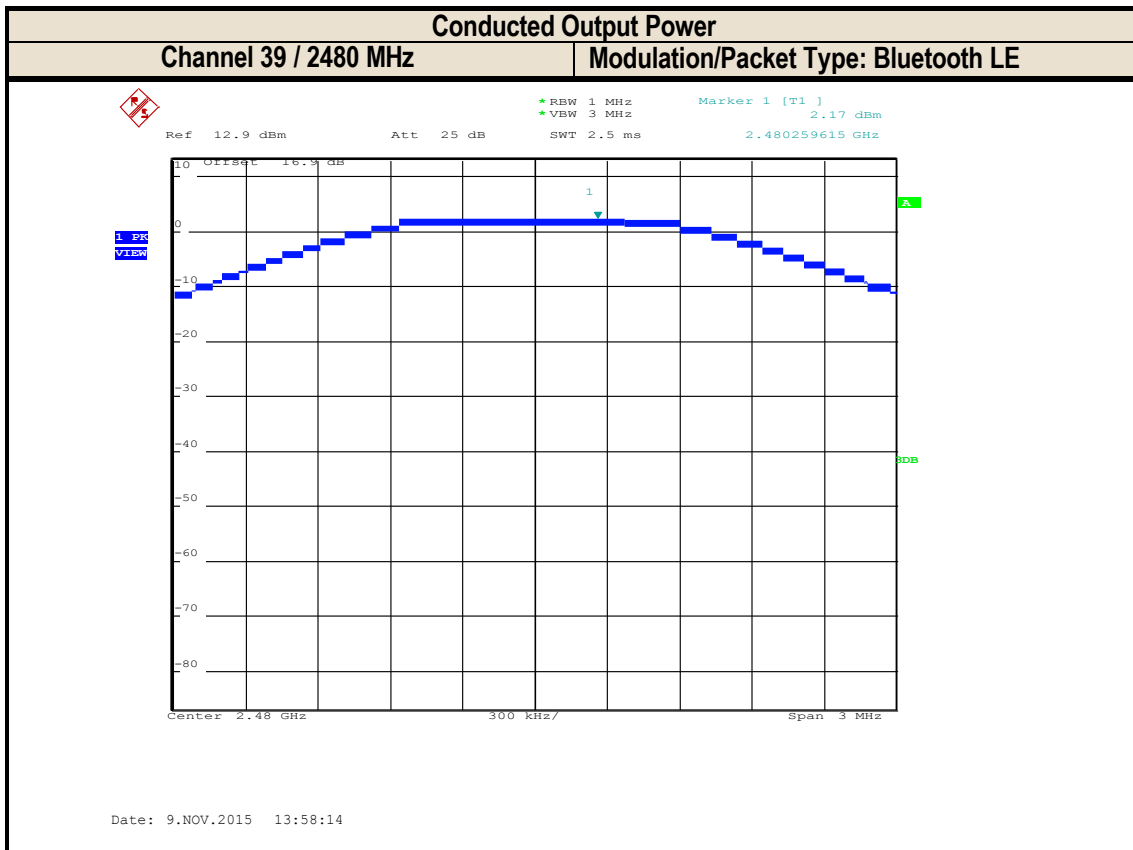
Channel	Frequency (MHz)	Measured Conducted Peak Output Power (dBm)	Calculated EIRP (dBm)
0	2402	1.28	3.3
19	2440	1.91	3.93
39	2480	2.17	4.19

6.2.6 Test Verdict

Pass

6.2.7 Test Plots





6.3 Power Spectral Density

6.3.1 Technical Standard References

FCC §15.247, Section (e)

IC RSS-247, Section 5.2 (2)

KDB 558074, Section 10.0

6.3.2 Requirement

8 dBm in any 3 kHz band

6.3.3 EUT Conditions

Frequency hopping off

6.3.4 Test Conditions

Measurements are according to FCC KDB 558074, section 10.2, method PKPSD (peak PSD).

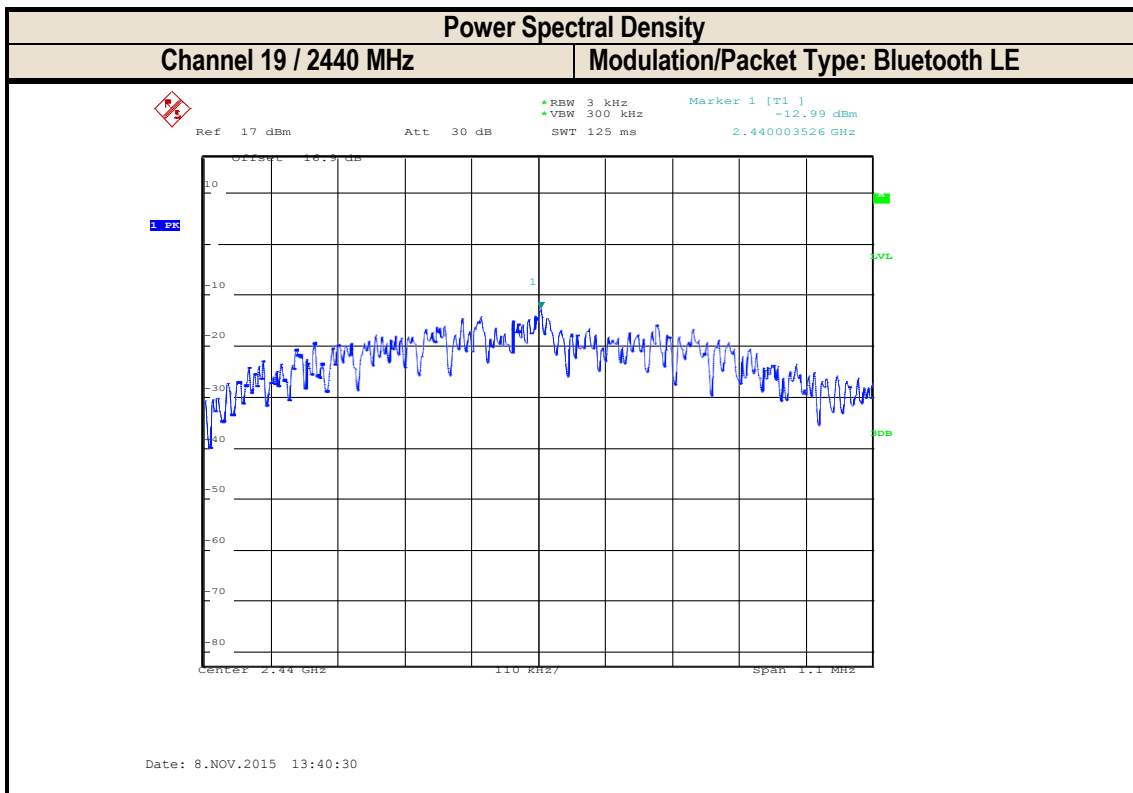
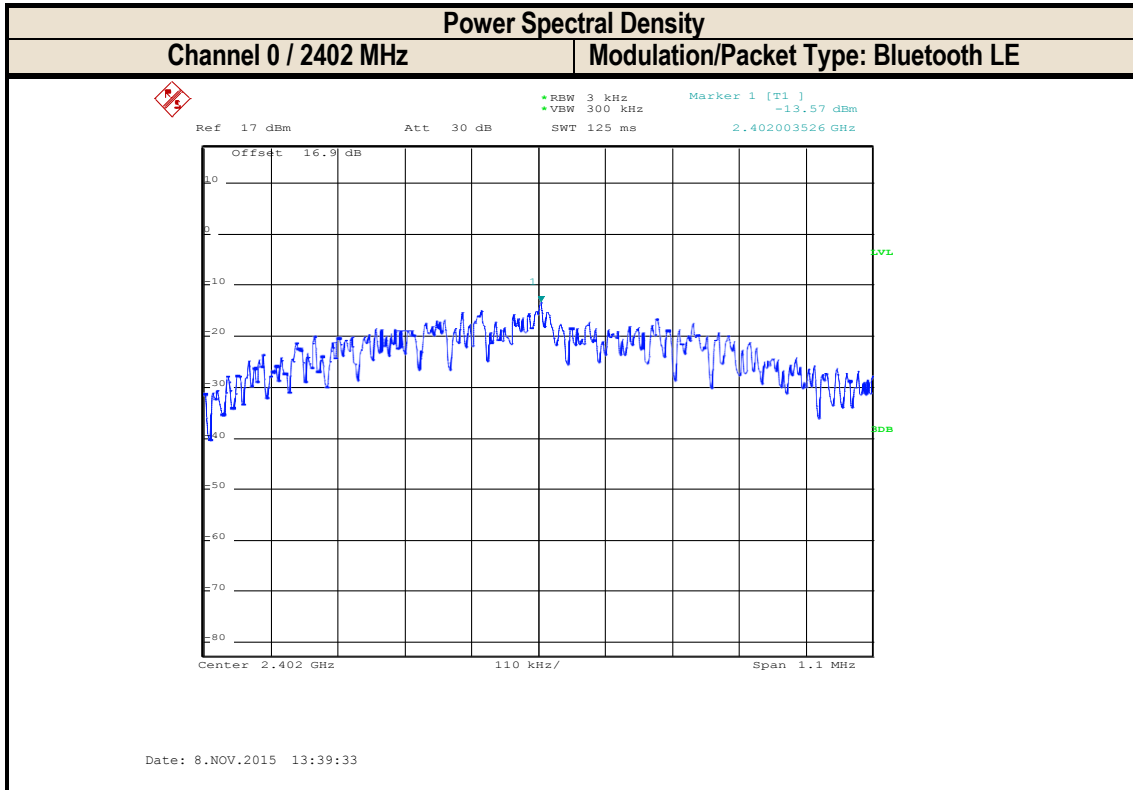
6.3.5 Test Results

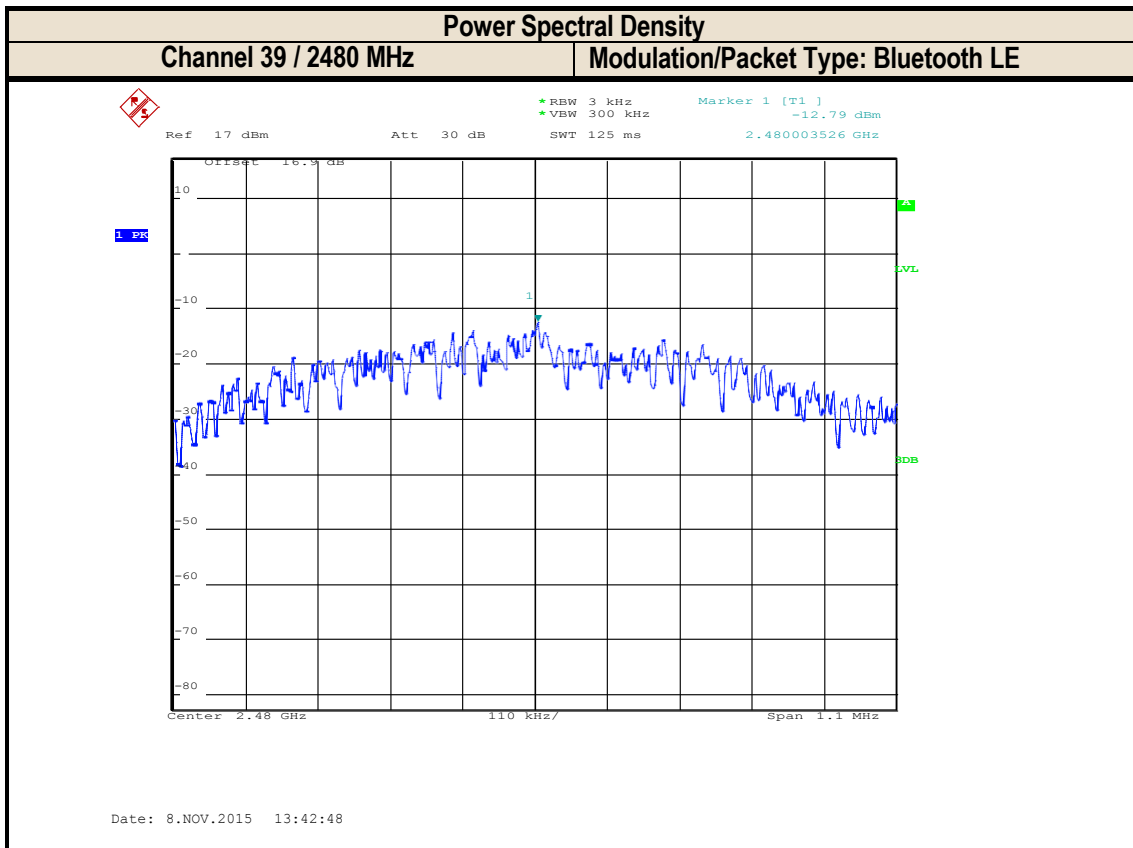
Channel	Frequency (MHz)	Power Spectral Density (dBm)
0	2402	-13.57
19	2440	-12.99
39	2480	-12.79

6.3.6 Test Verdict

Pass

6.3.7 Test Plots





6.4 Emissions in Non-Restricted Frequency Bands

6.4.1 Technical Standard References

FCC §15.247, Section (d)

IC RSS-247, Section 5.5

KDB 558074, Section 11.0

6.4.2 Requirement

- 20 dBc from the reference level

6.4.3 EUT Conditions

Frequency hopping off

6.4.4 Test Conditions

Measurements are according to FCC KDB 558074, section 11.0.

Emissions measurements are tested from 9 kHz to 25 GHz. The number of sweep points is increased to 30,001. If any emissions are within 10 dB of the limit, a smaller frequency span is used to zoom in to the emission.

Peaks above the limit are the transmit signal.

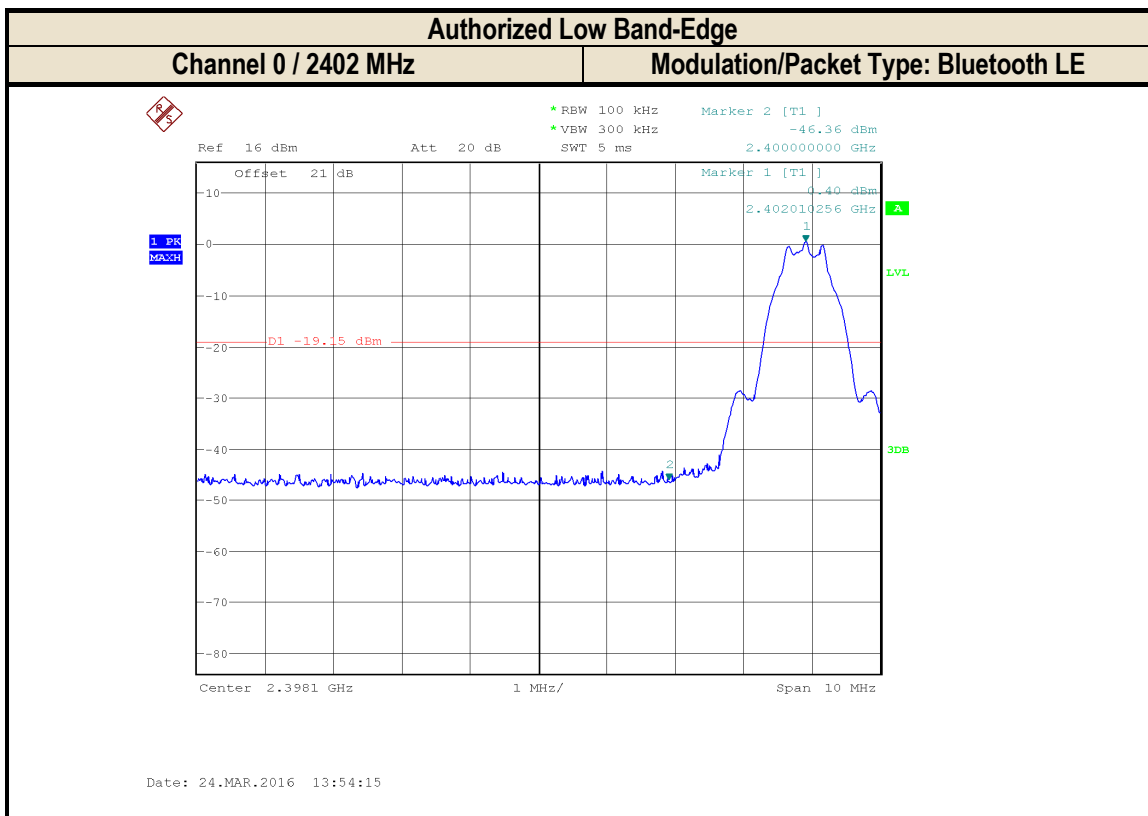
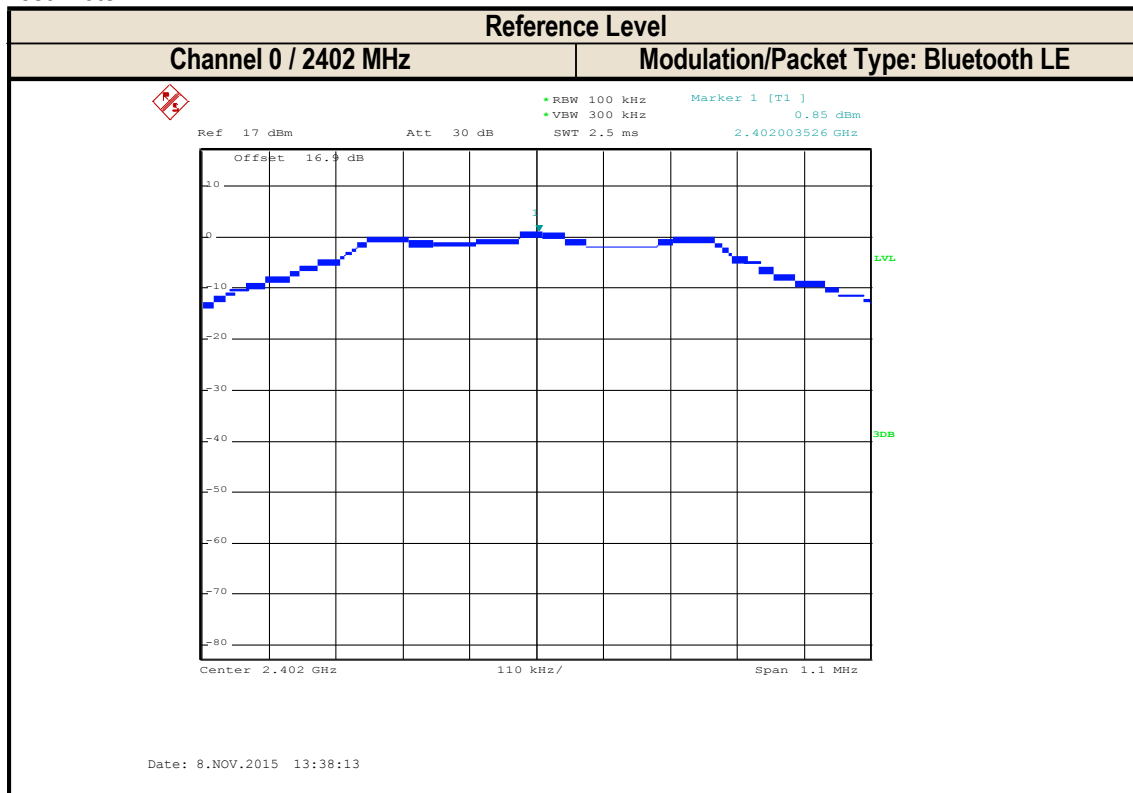
6.4.5 Test Results

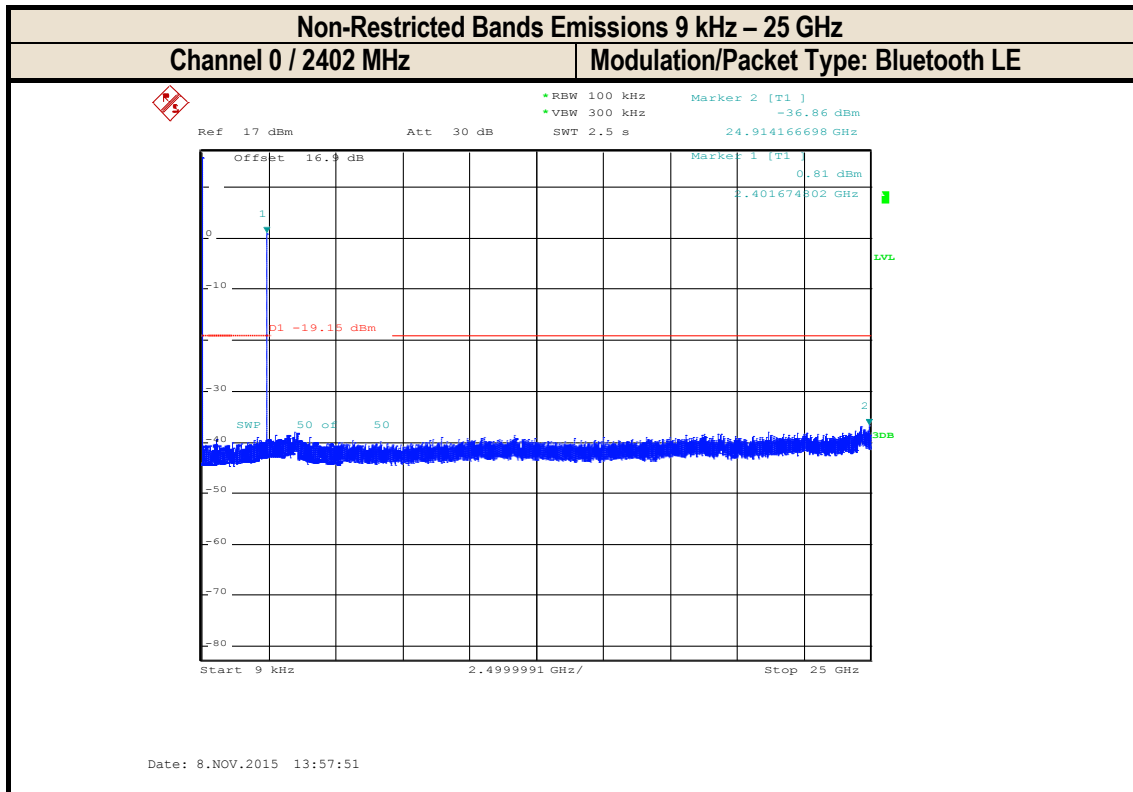
The following table lists the worst case emissions where worst case is defined as the emission with the smallest margin to the limit.

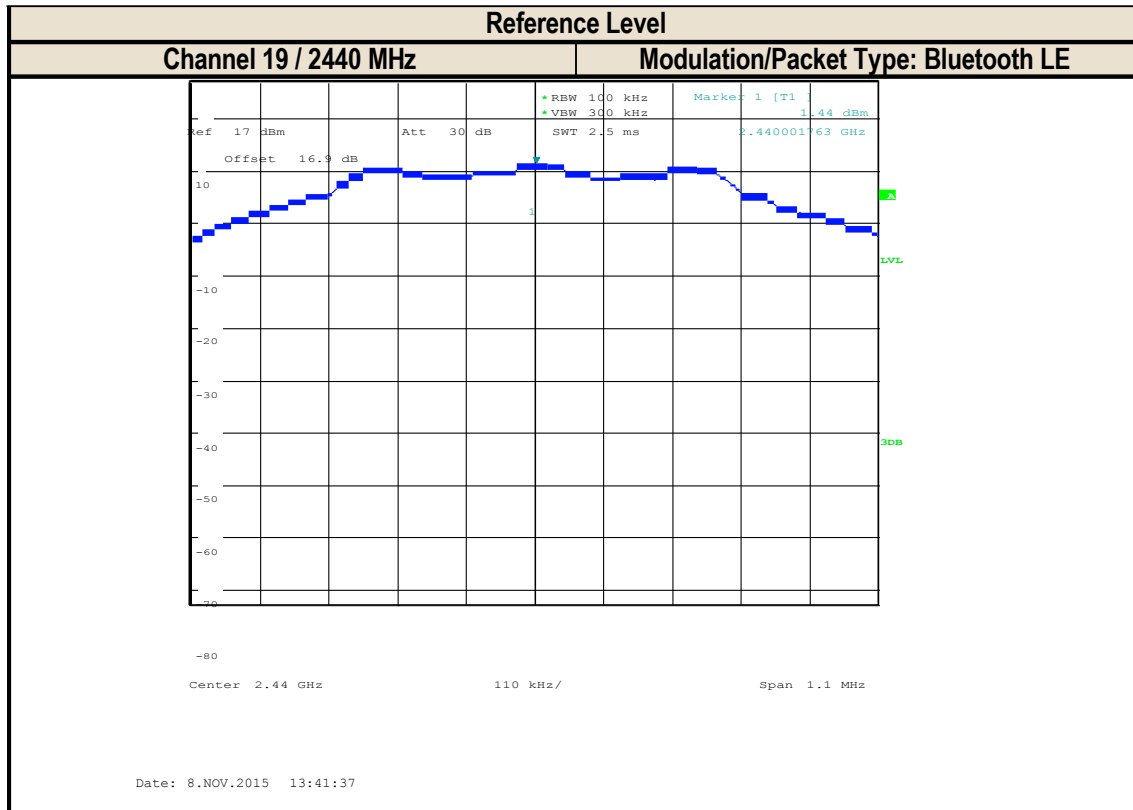
Channel	Frequency (MHz)	Reference Level (dBm)	Worst Case Spurious Emission Frequency (MHz)	Worst Case Spurious Emission Level (dBm)
0	2402	0.85	Noise Floor	Noise Floor
19	2440	1.44	Noise Floor	Noise Floor
39	2480	1.72	Noise Floor	Noise Floor

6.4.6 Test Verdict

Pass

6.4.7 Test Plots

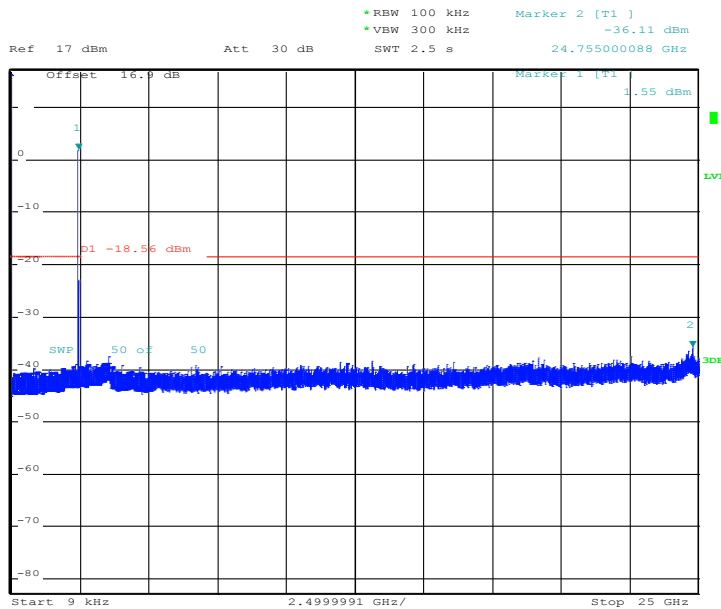




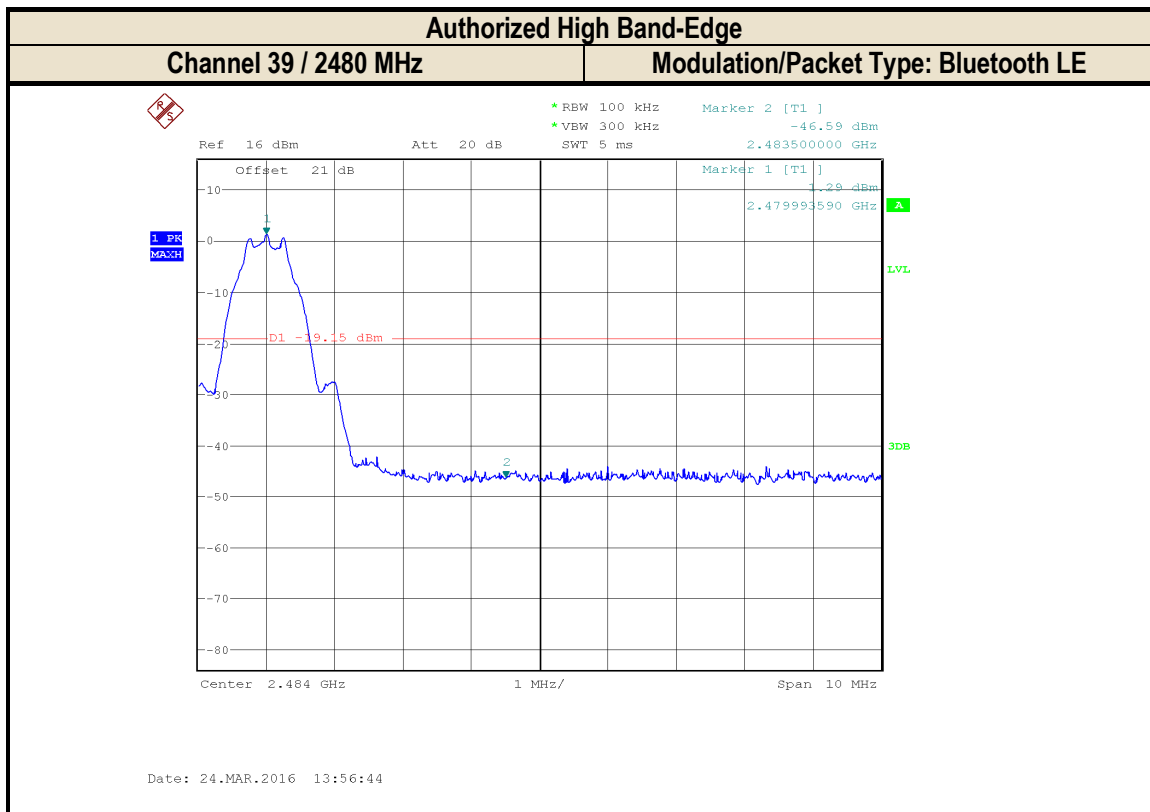
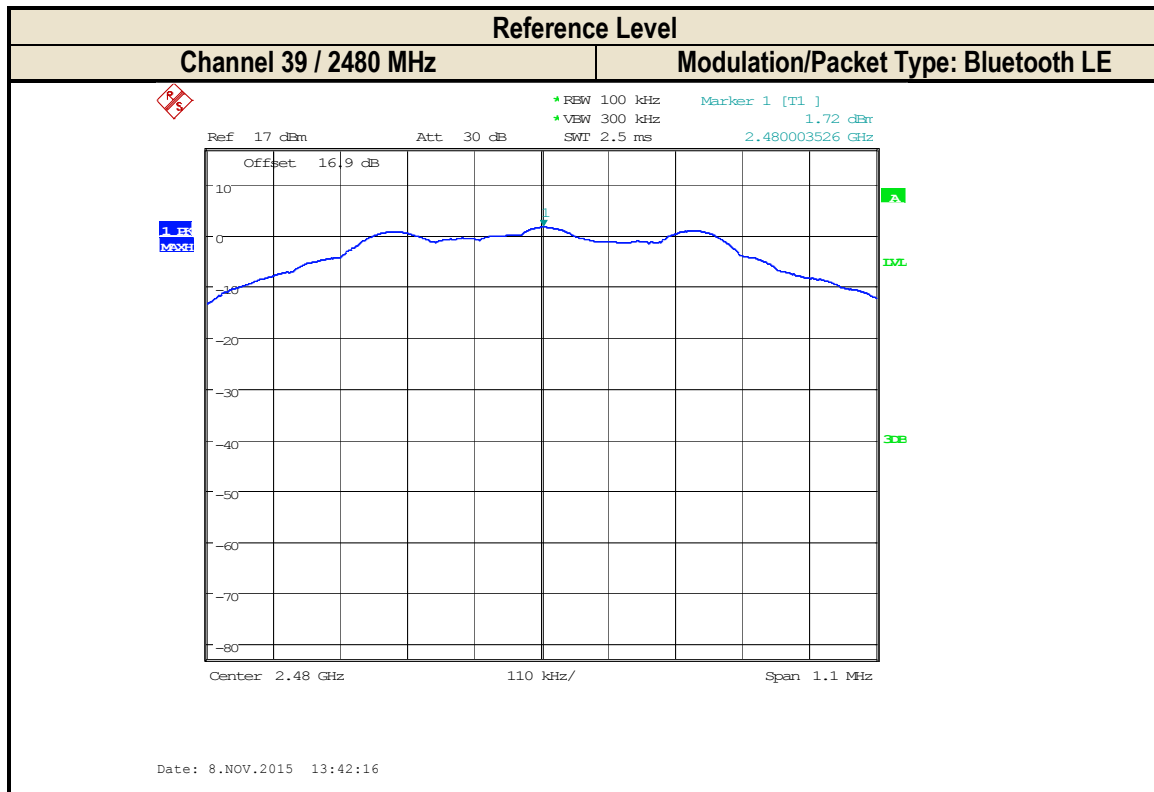
Non-Restricted Bands Emissions 9 kHz – 25 GHz

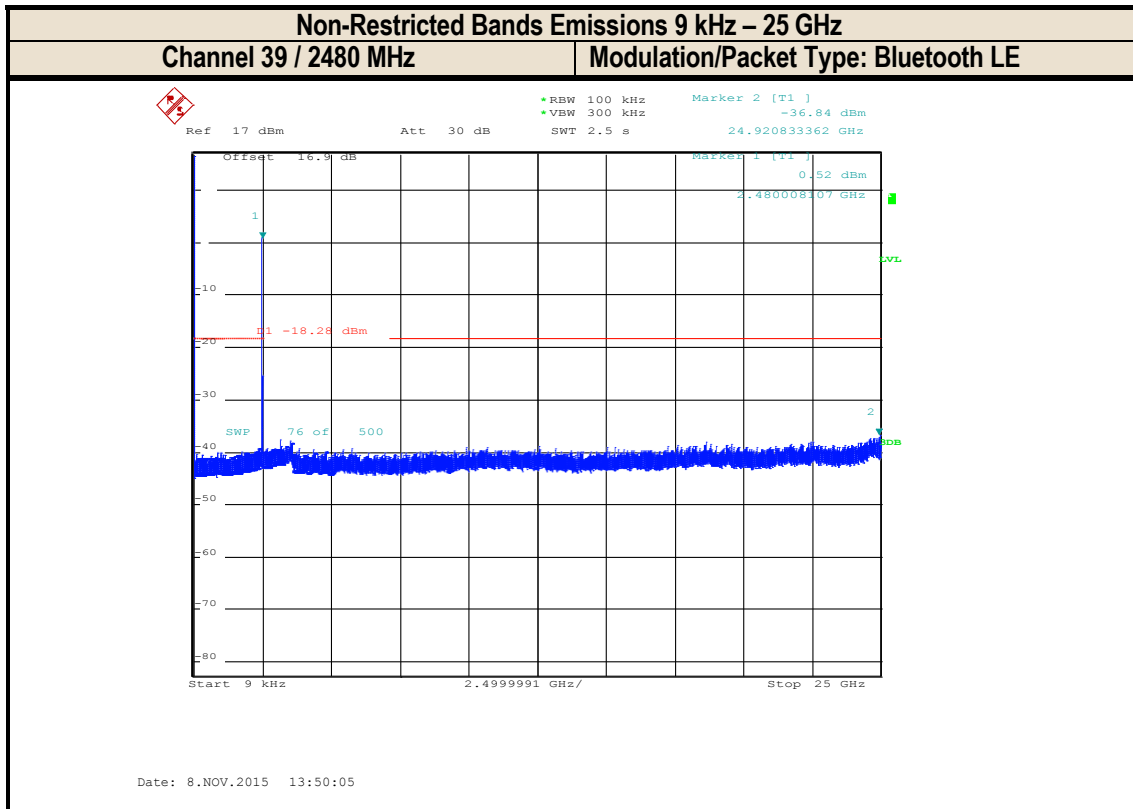
Channel 19 / 2440 MHz

Modulation/Packet Type: Bluetooth LE



Date: 8.NOV.2015 13:54:00





6.5 Emissions in Restricted Frequency Bands

6.5.1 Technical Standard References

FCC §15.247, Section (d)
IC RSS-247, Section 5.5
KDB 558074, Section 12.0

6.5.2 Requirement

The limits are extrapolated to a 3 meter measurement distance as described in the following table.

Frequency	Detector Type	Standard Field Strength Limit ($\mu\text{V/m}$)	Extrapolated Field Strength Limit at 3 m (dB $\mu\text{V/m}$)
9 – 490 kHz	Quasi-Peak	2400 / F(kHz) @ 300 m	128.5 – 93.8
490 kHz – 1.705 MHz	Quasi-Peak	24000 / F(kHz) @ 30 m	73.8 – 63
1.705 – 30 MHz	Quasi-Peak	30 @ 30 m	69.5
30 – 88 MHz	Quasi-Peak	100 @ 3 m	40
88 -216 MHz	Quasi-Peak	150 @ 3 m	43.5
216 – 960 MHz	Quasi-Peak	200 @ 3 m	46
Above 960 MHz	Average Peak	500 @ 3 m ---	54 74

6.5.3 EUT Conditions

Frequency hopping off

6.5.4 Test Conditions

Measurements are according to FCC KDB 558074, section 12.1.

Measurements 9 kHz to 30 MHz and 18 GHz to 26 GHz are tested with mid channel transmitting. Measurements 30 MHz to 18 GHz is tested with low, mid, and high channels transmitting.

Receiver Settings			
Frequency Range	9 kHz – 30 MHz	30 MHz – 1 GHz	1 GHz – 26 GHz
RBW	9 kHz	120 kHz	1 MHz
Sweep Time	Auto	Auto	Auto
Step Size	5 kHz	100 kHz	1 MHz
Detection Mode	Peak	Peak	Peak and Average
Trace Mode	Max Hold	Max Hold	Max Hold

The source of spurious emissions 30 MHz to 1 GHz is determined to come from support test equipment.

6.5.5 Test Results

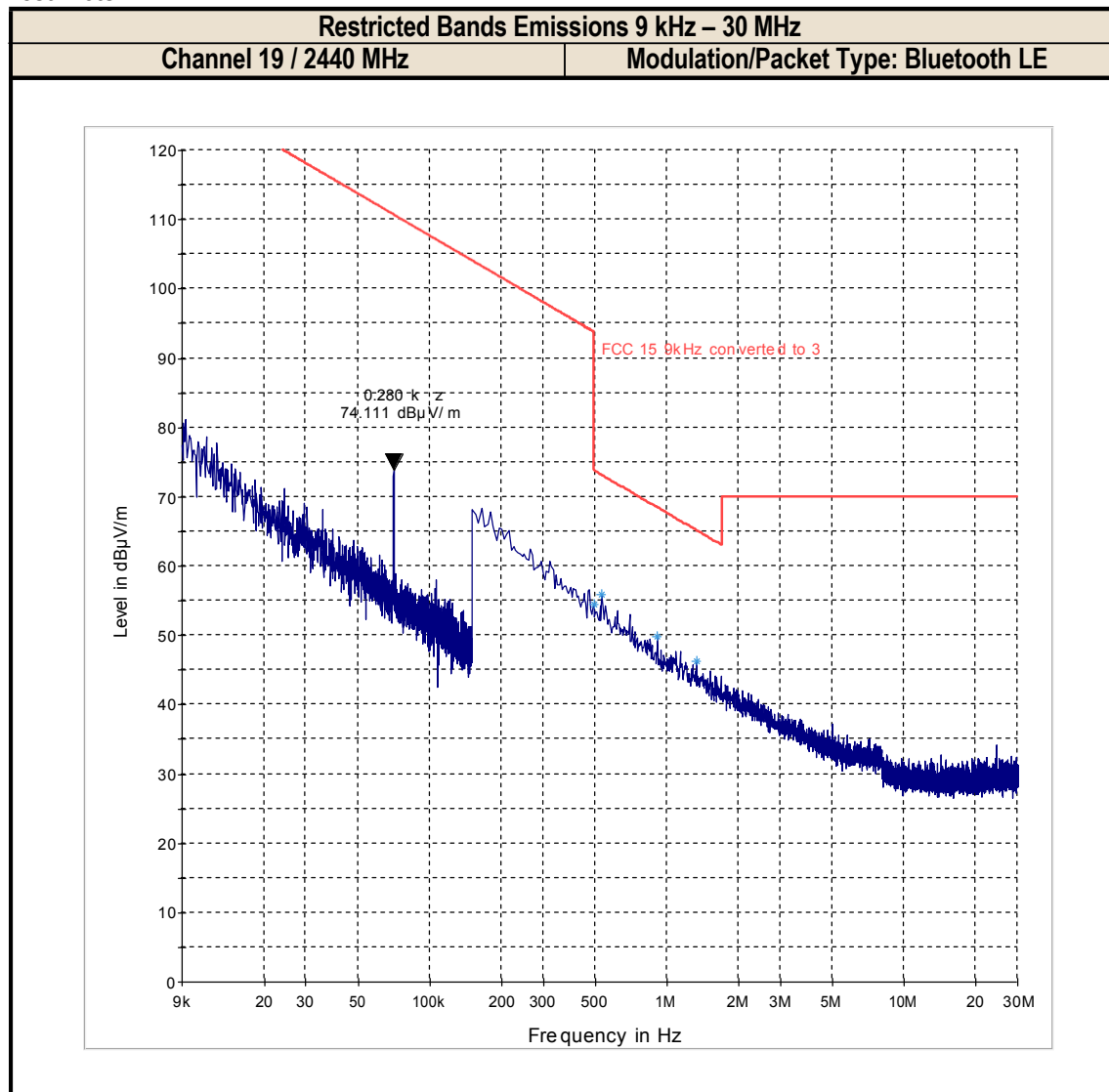
The following table lists the worst case emissions where worst case is defined as the emission with the smallest margin to the limit.

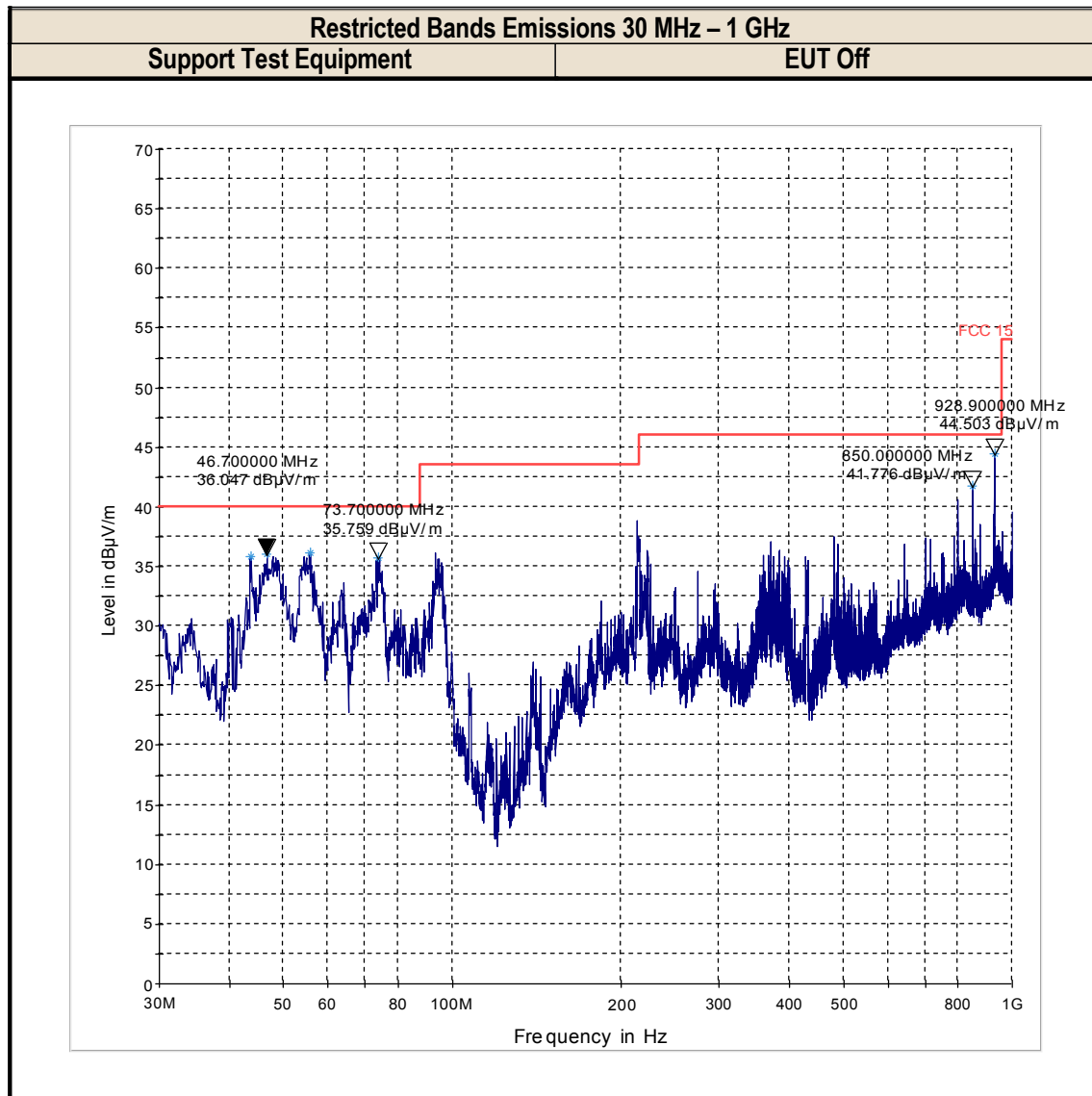
Channel	Frequency (MHz)	Detector	Worst Case Spurious Emission Frequency	Worst Case Spurious Emission Level	Margin to the Limit
0	2402	Average	1287 MHz	38.785 dB μ V/m	15.2 dB
19	2440	Average	1594 MHz	40.723 dB μ V/m	13.3 dB
39	2480	Average	2131 MHz	43.075 dB μ V/m	10.9 dB

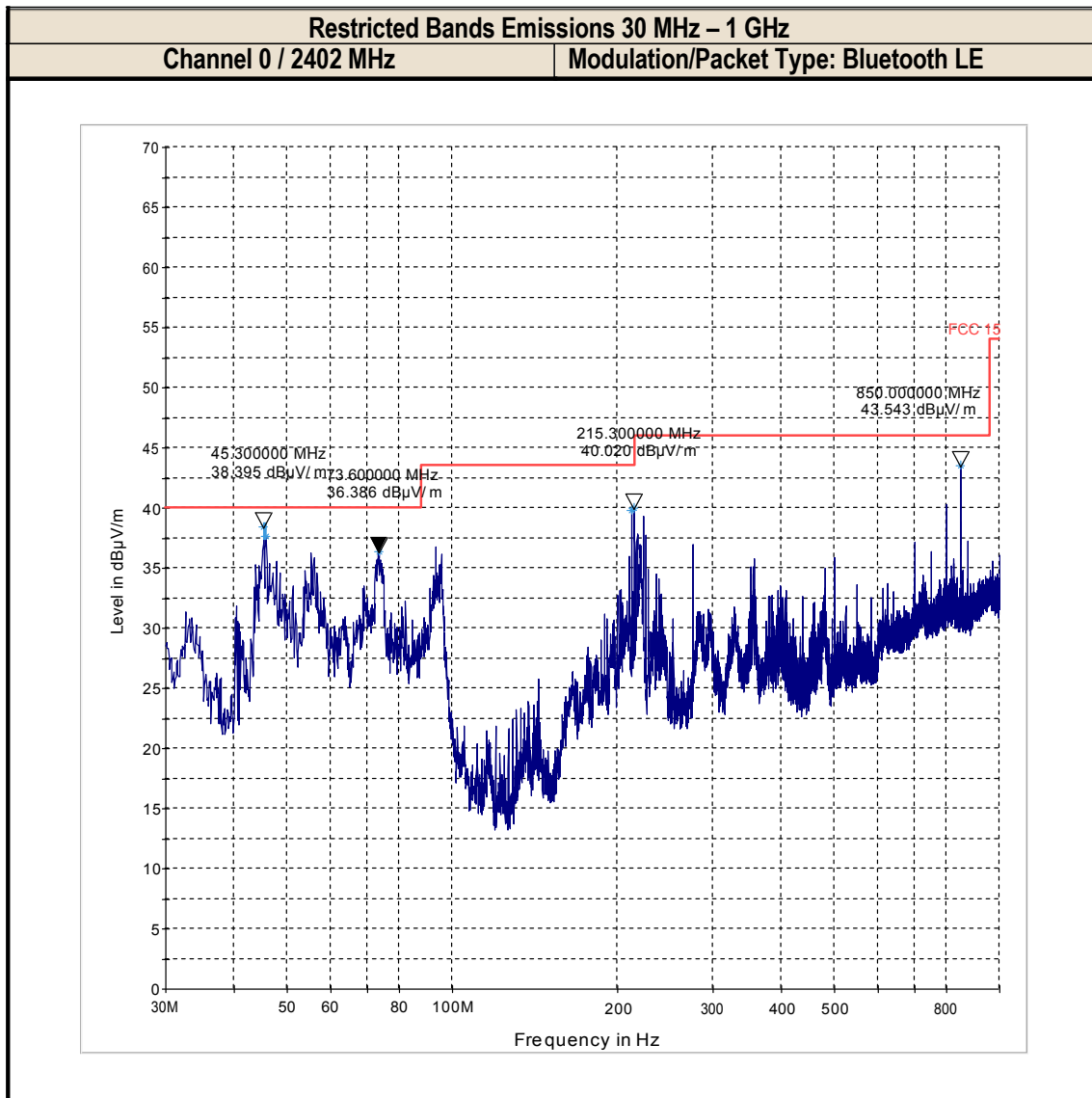
6.5.6 Test Verdict

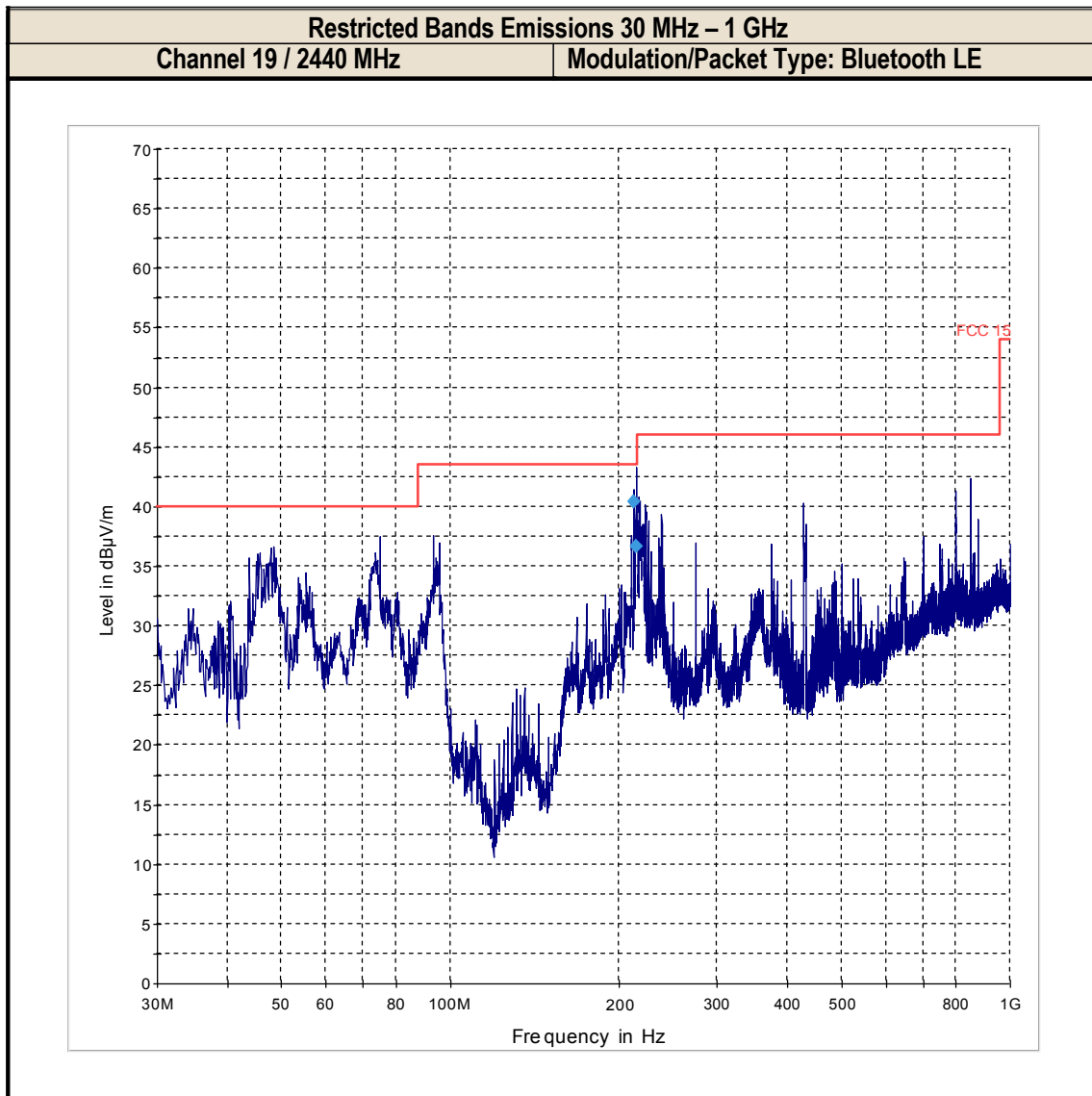
Pass

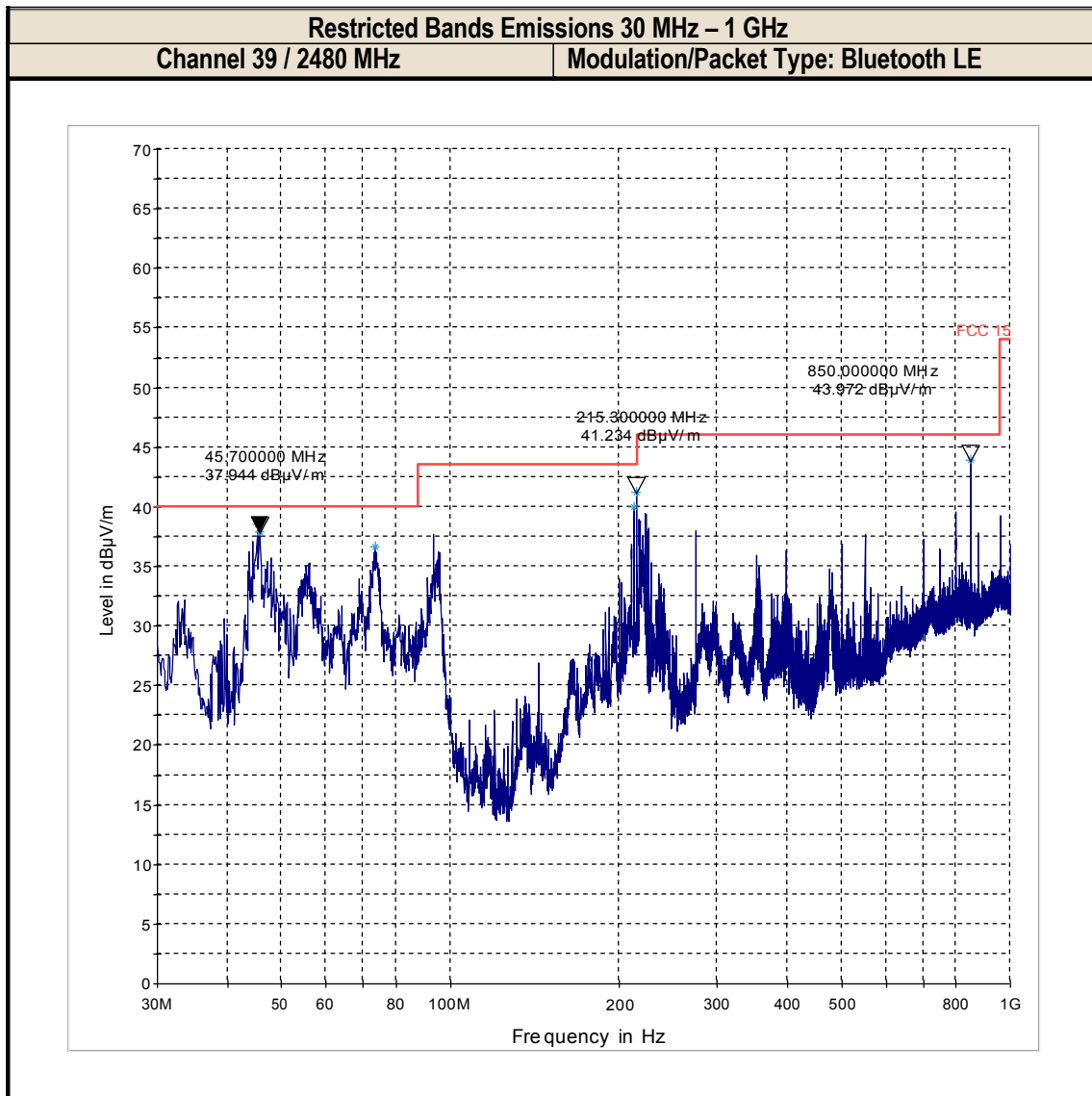
6.5.7 Test Plots









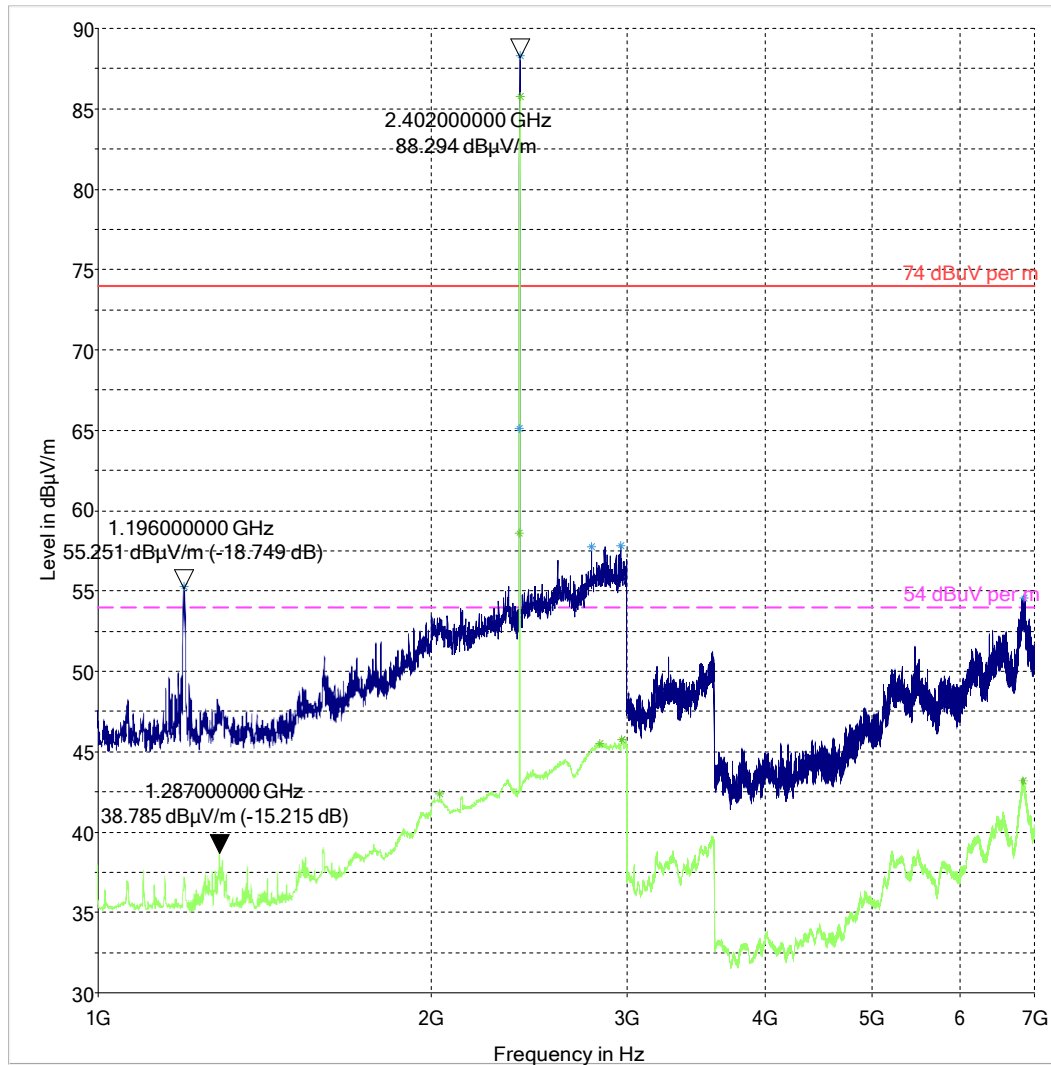


Restricted Bands Emissions 1 GHz – 7 GHz**Channel 0 / 2402****Modulation/Packet Type: Bluetooth LE**

Peak above the limit is the carrier frequency.

Green measurement trace is the average measurement. Pink limit line is the average limit.

Blue measurement trace is the peak measurement. Red limit line is the peak limit.



Restricted Bands Emissions 1 GHz – 7 GHz

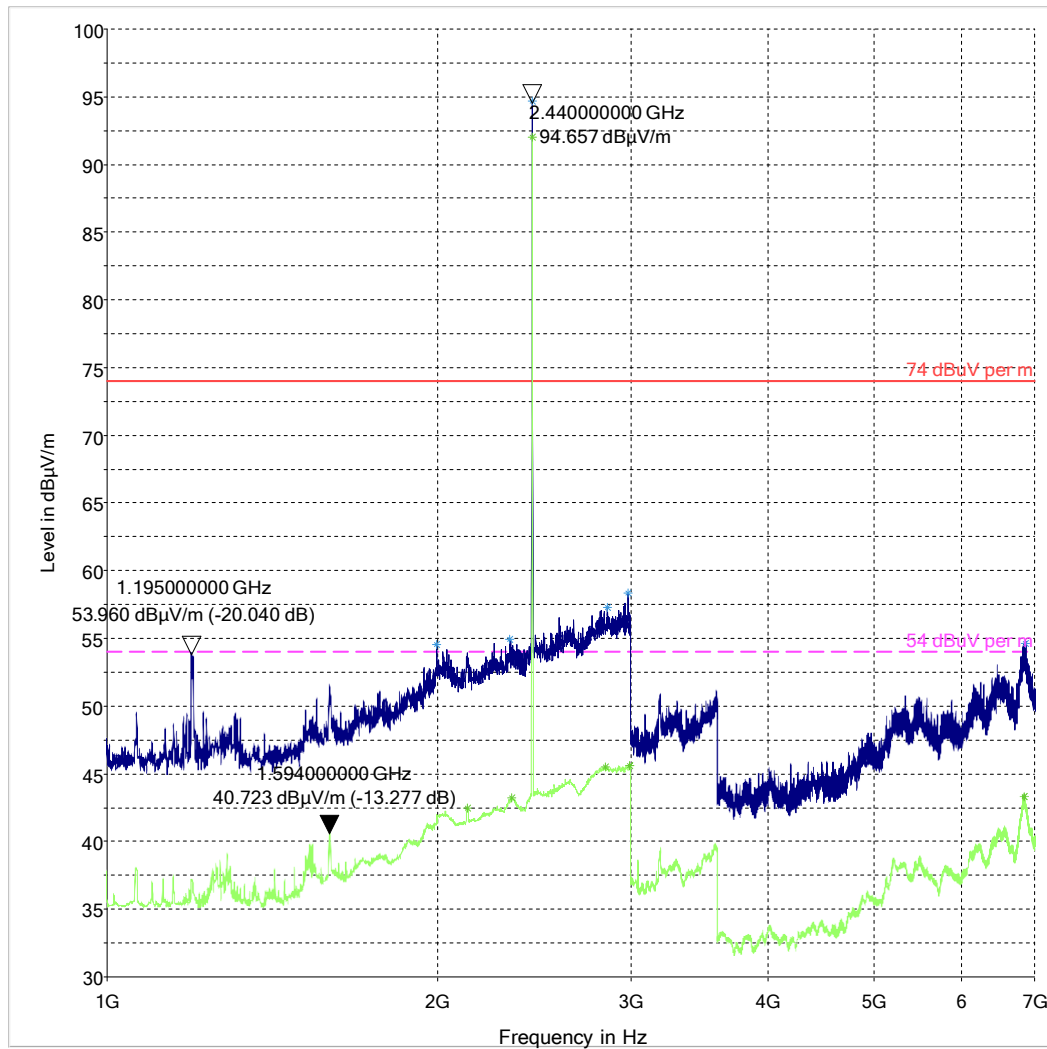
Channel 19 / 2440

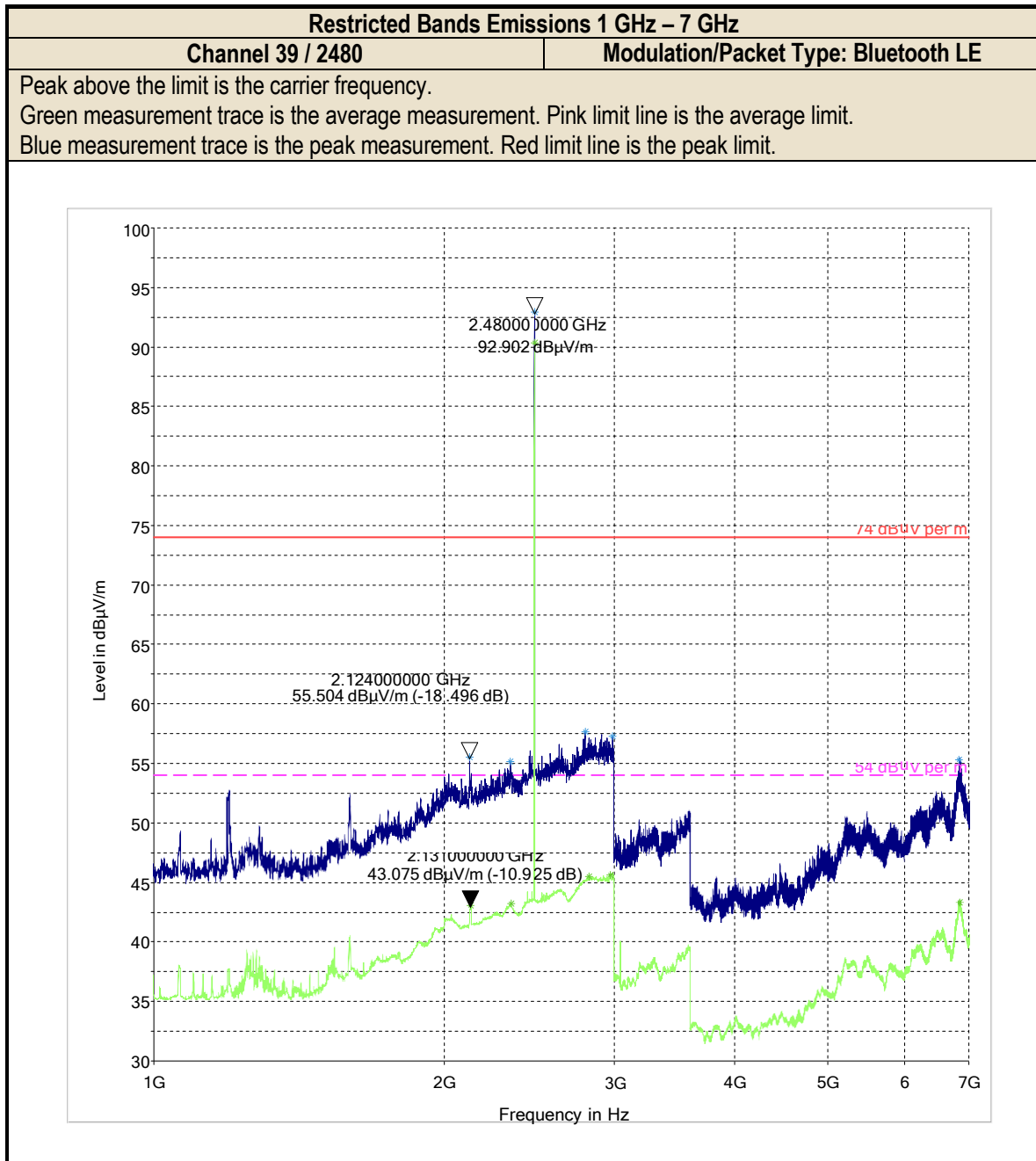
Modulation/Packet Type: Bluetooth LE

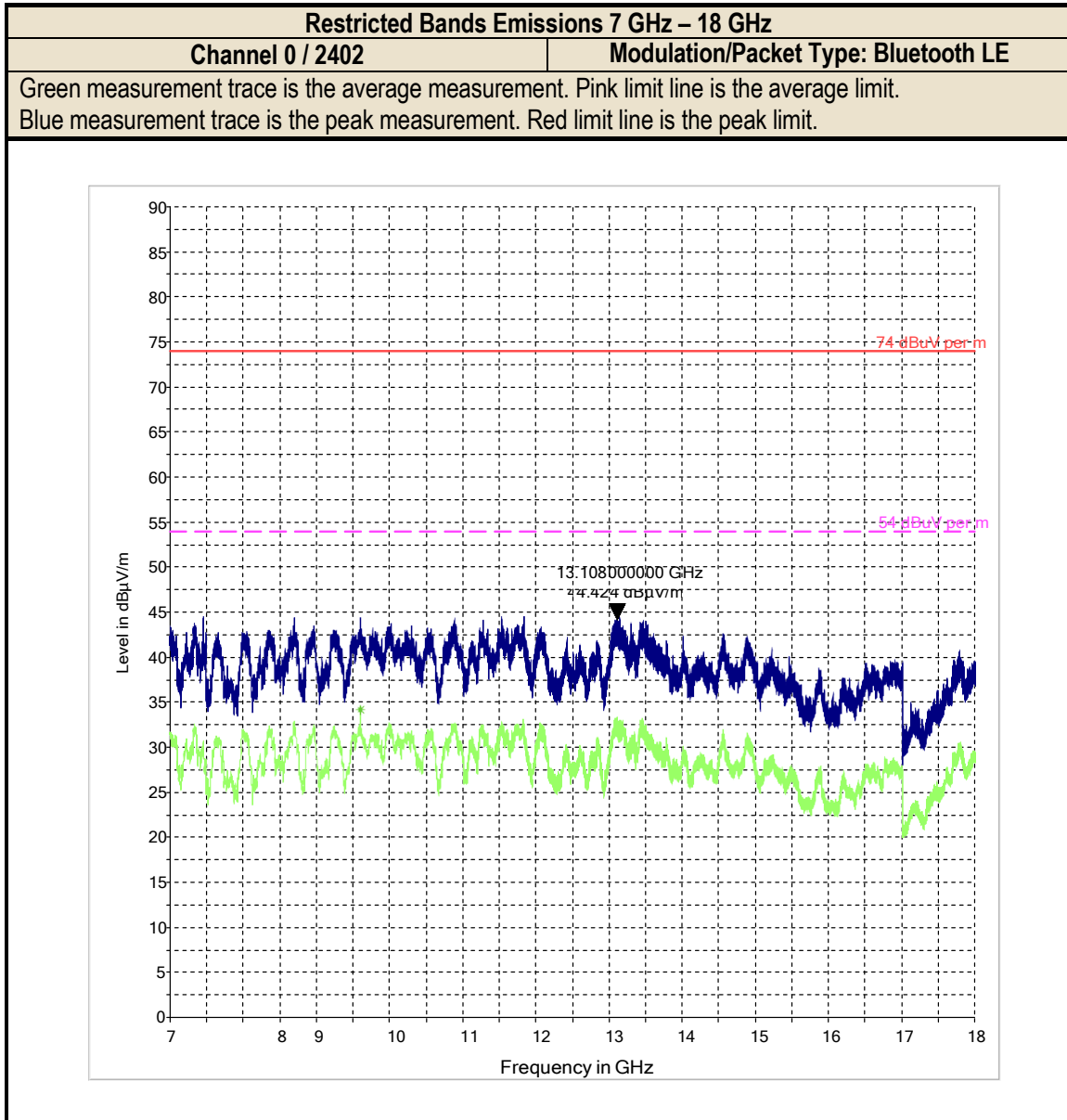
Peak above the limit is the carrier frequency.

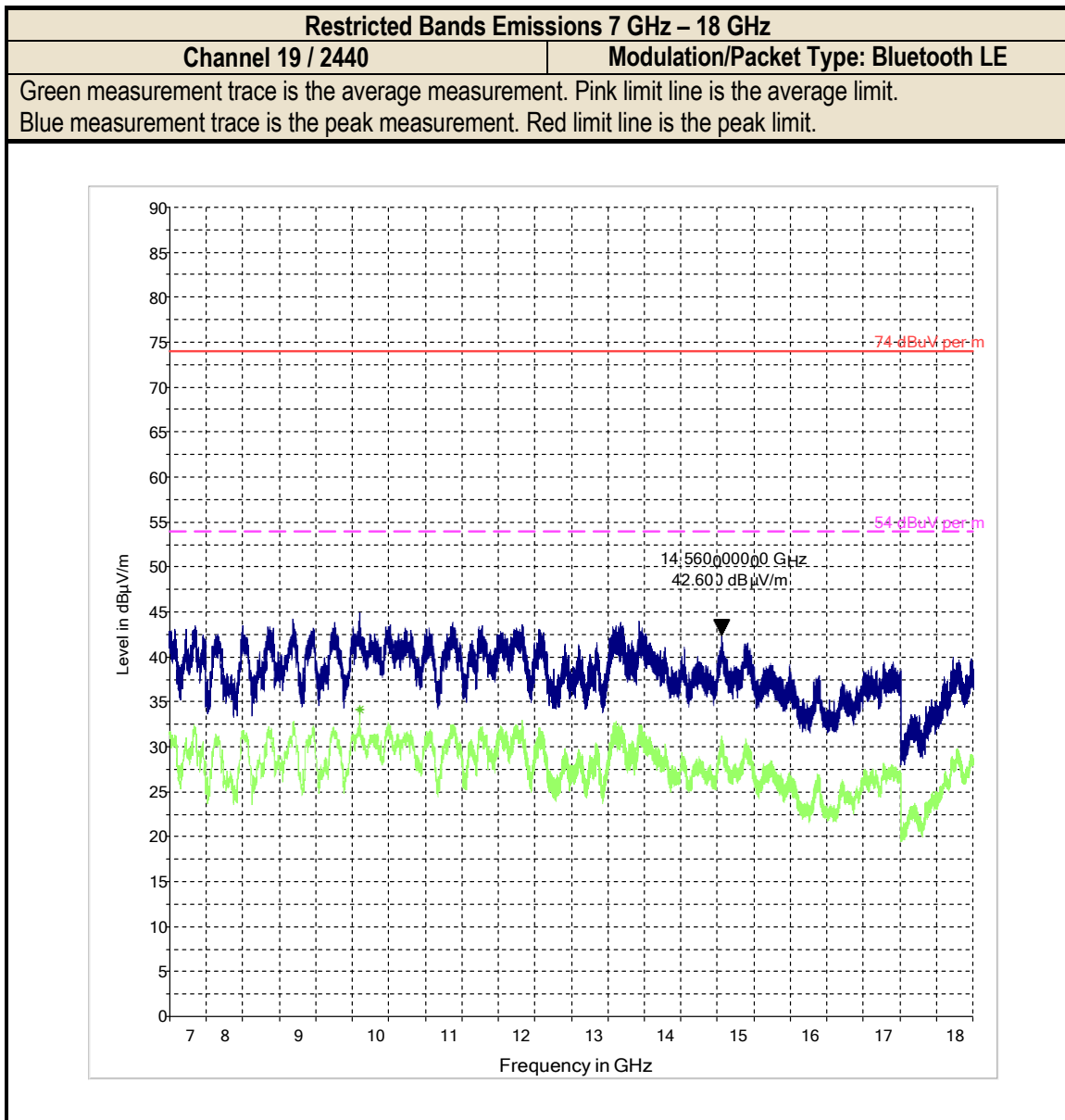
Green measurement trace is the average measurement. Pink limit line is the average limit.

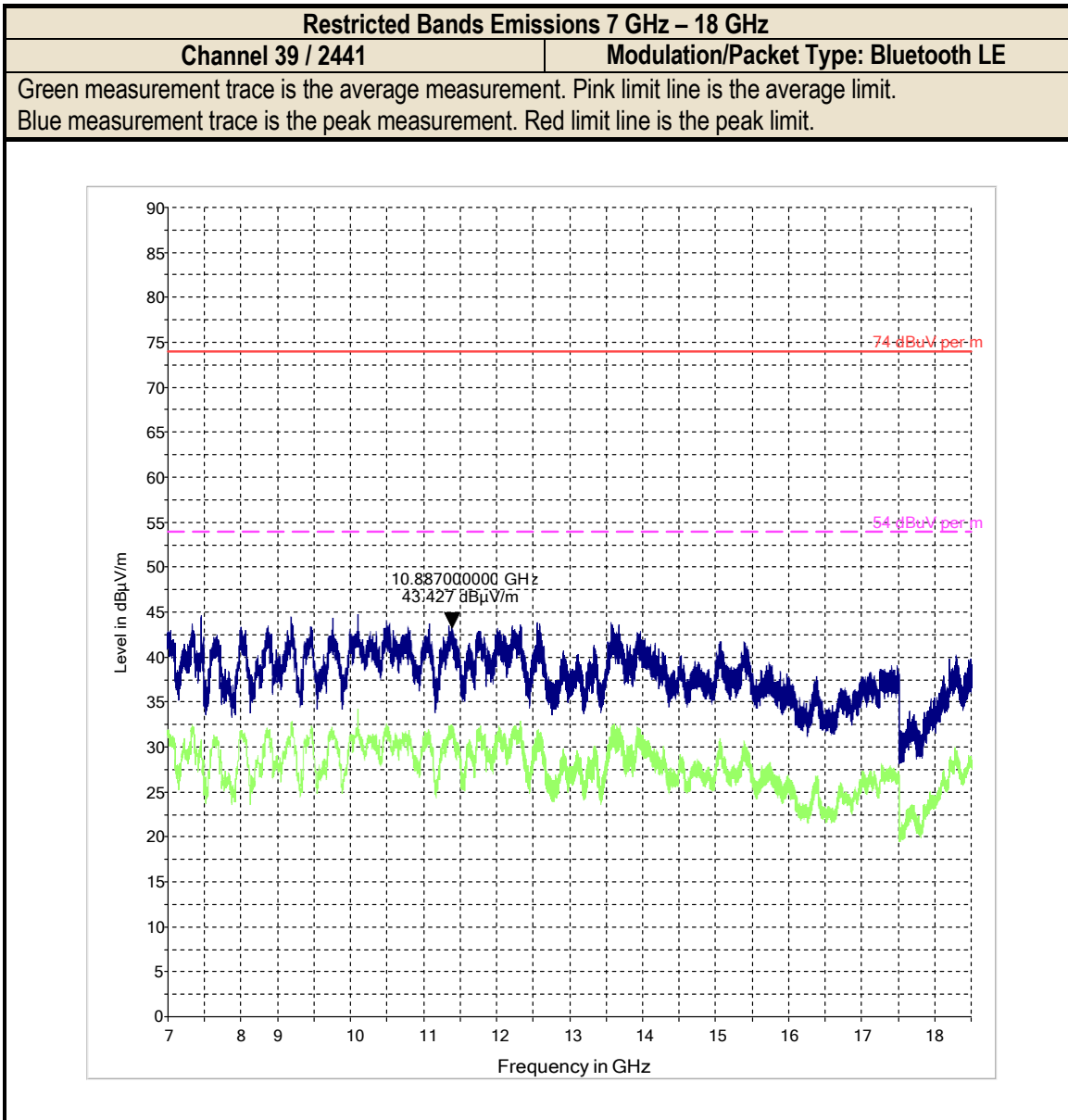
Blue measurement trace is the peak measurement. Red limit line is the peak limit.

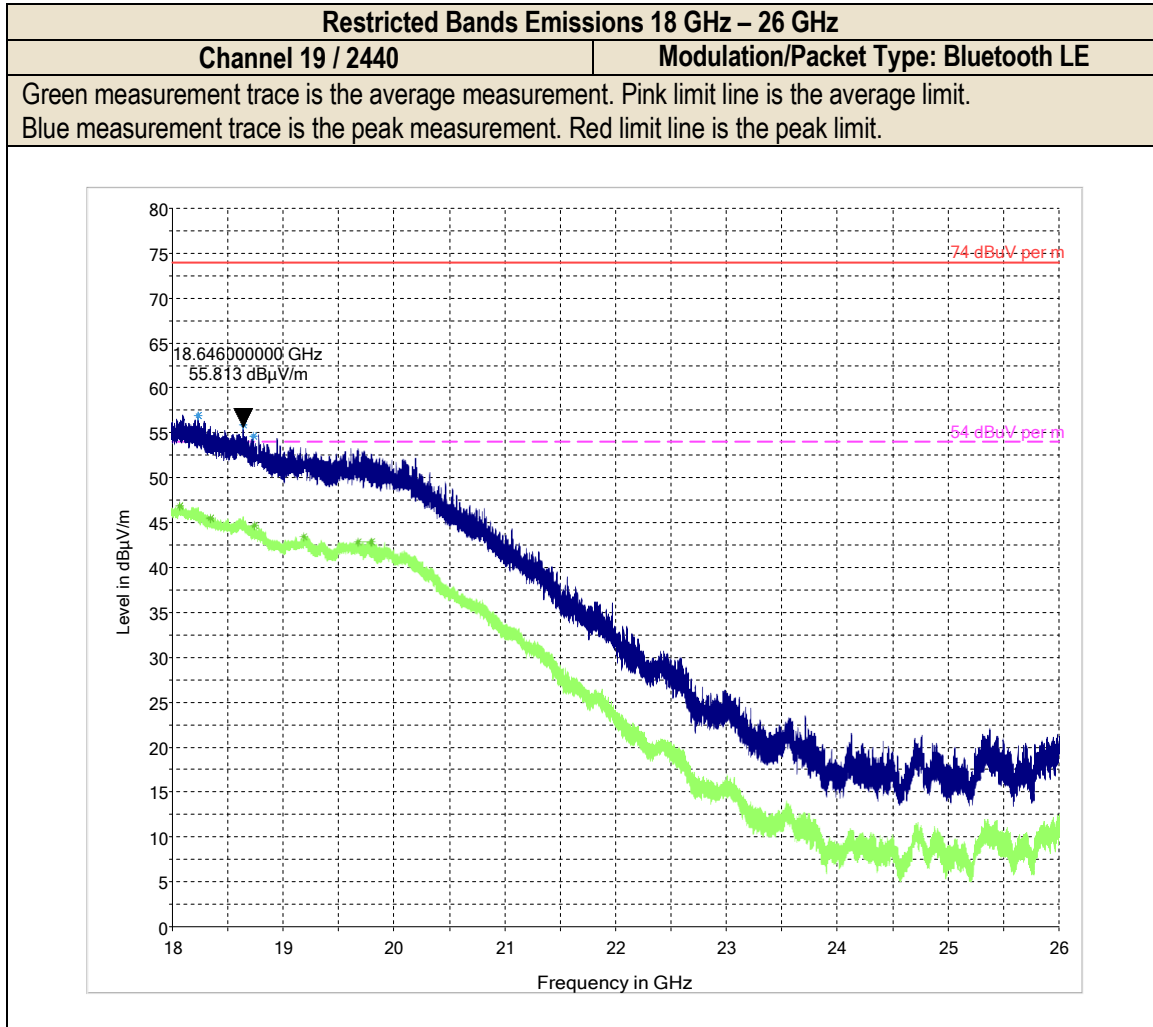












6.6 Restricted Band Edge**6.6.1 Technical Standard References**

FCC §15.247, Section (d)

IC RSS-247, Section 5.5

KDB 558074, Section 13.0

ANI C63.10, Section 11.13

6.6.2 Requirement

Frequency (MHz)	Band Edge Limit at 3 meters (dBμV/m)	
	Average	Peak
≤ 2390	54	74
≥ 2483.5	54	74

The band edge at 2483.5 MHz applies to FCC only.

6.6.3 EUT Conditions

Frequency hopping off

6.6.4 Test Conditions

Measurements are according to ANSI C63.10, section 11.13.1.

Receiver Settings	
RBW	1 MHz
Sweep Time	Auto
Step Size	< 200 kHz
Detection Mode	Peak and Average
Trace Mode	Max Hold

6.6.5 Test Results

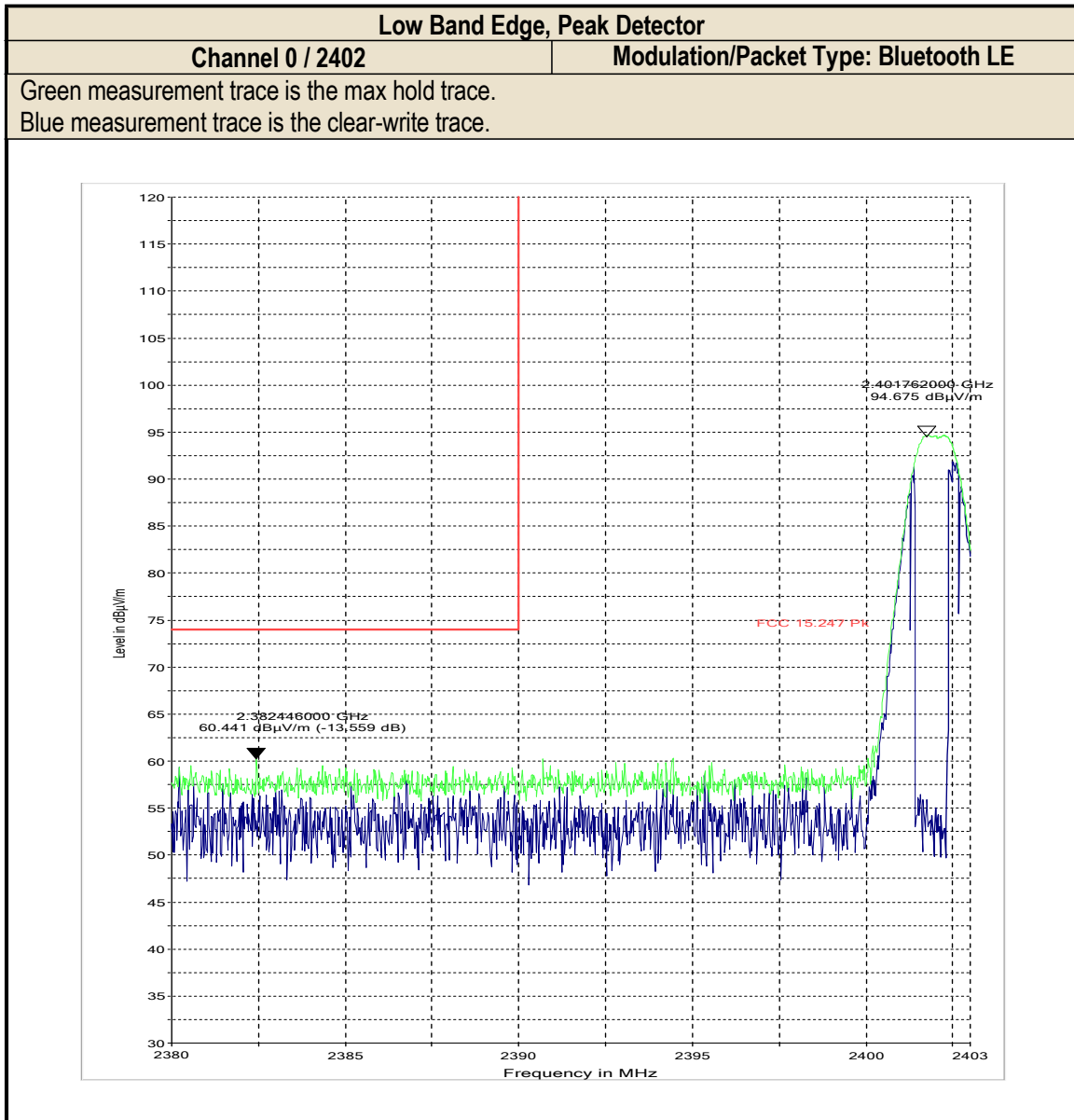
The following table lists the worst case emissions where worst case is defined as the emission with the smallest margin to the limit.

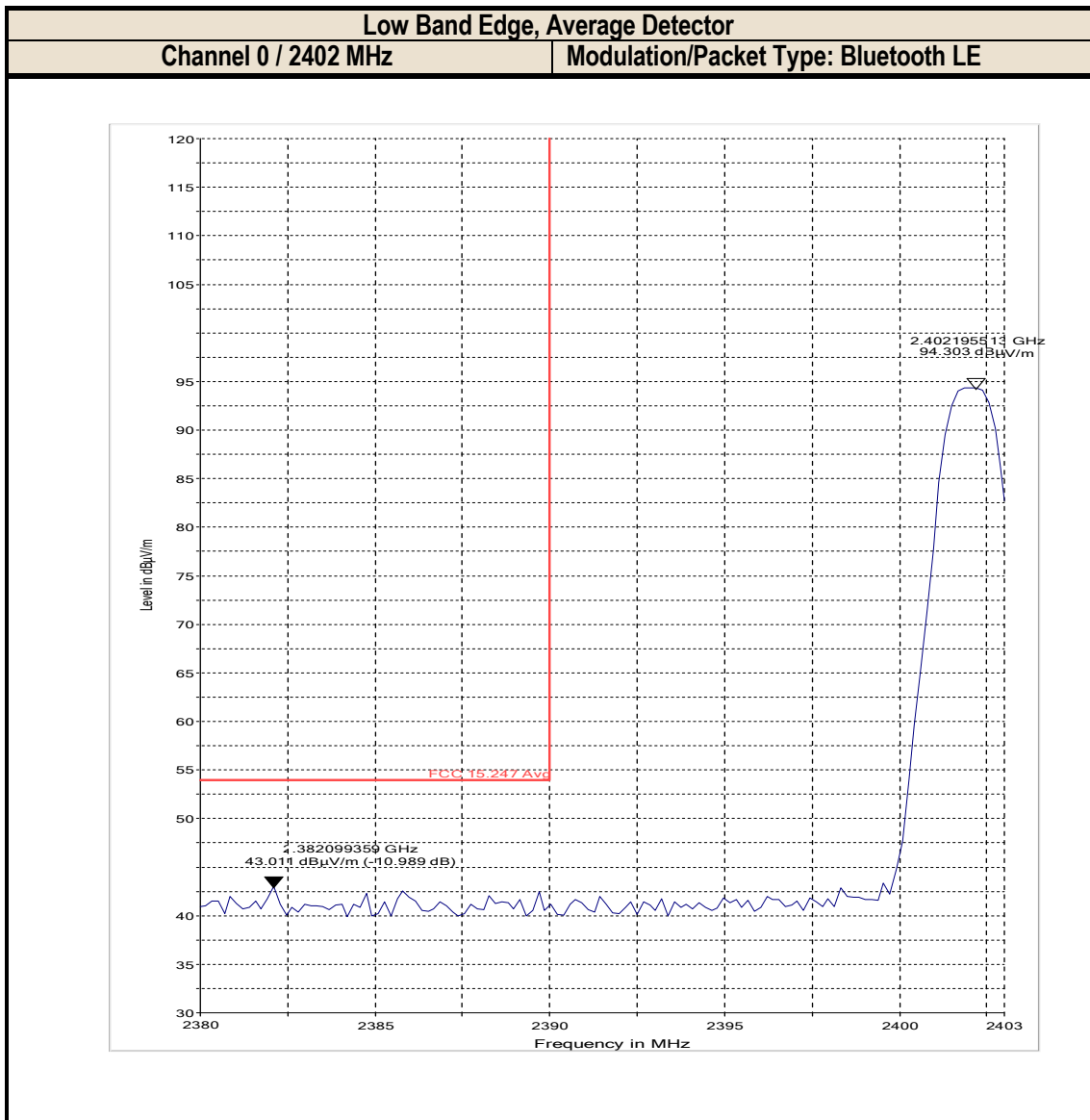
Channel	Frequency (MHz)	Detector	Worst Case Spurious Emission Frequency (MHz)	Worst Case Spurious Emission Level (dBμV/m)
0	2402	Peak/Avg	Noise Floor	Noise Floor
39	2480	Peak/Avg	Noise Floor	Noise Floor

6.6.6 Test Verdict

Pass

6.6.7 Test Plots

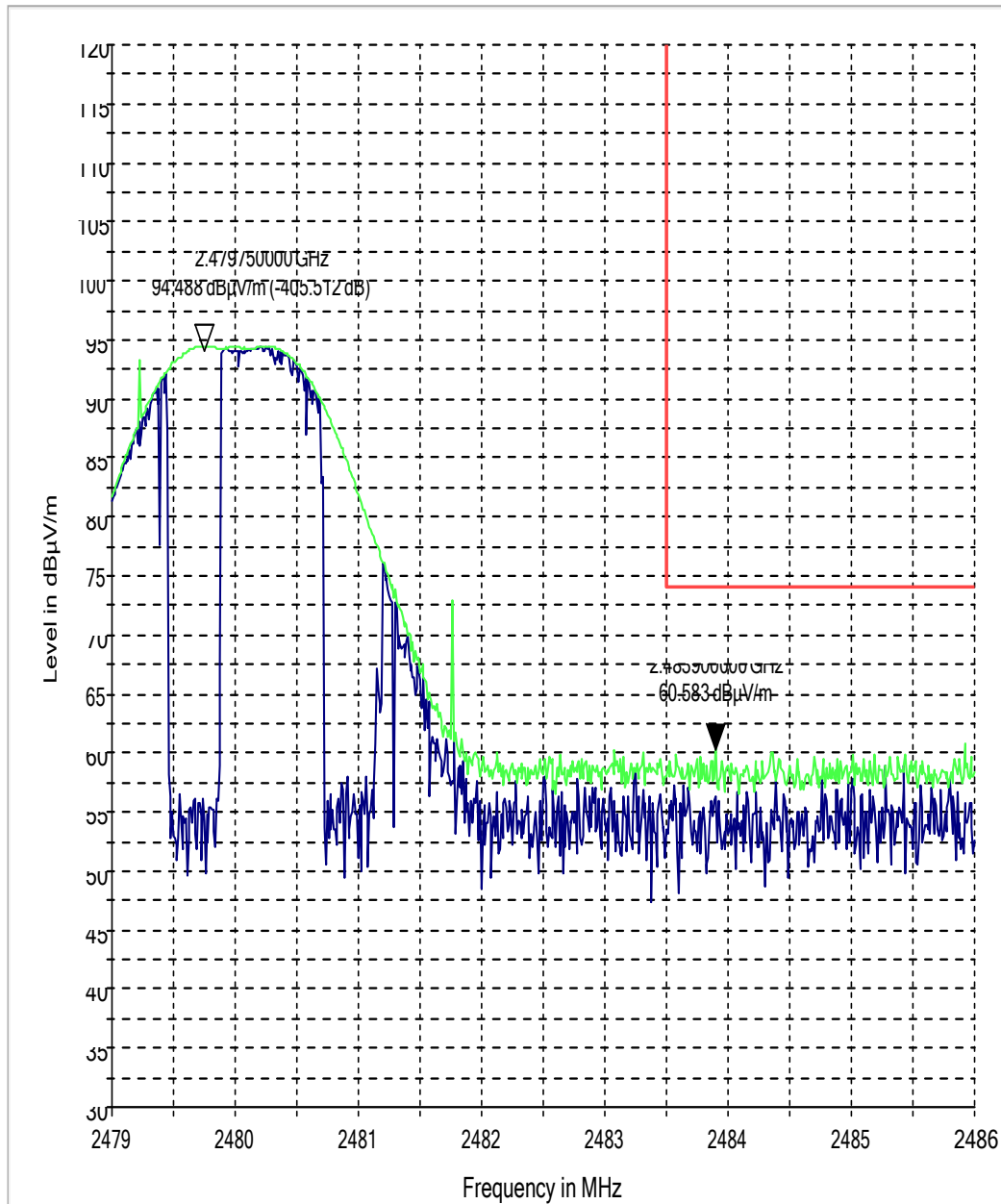


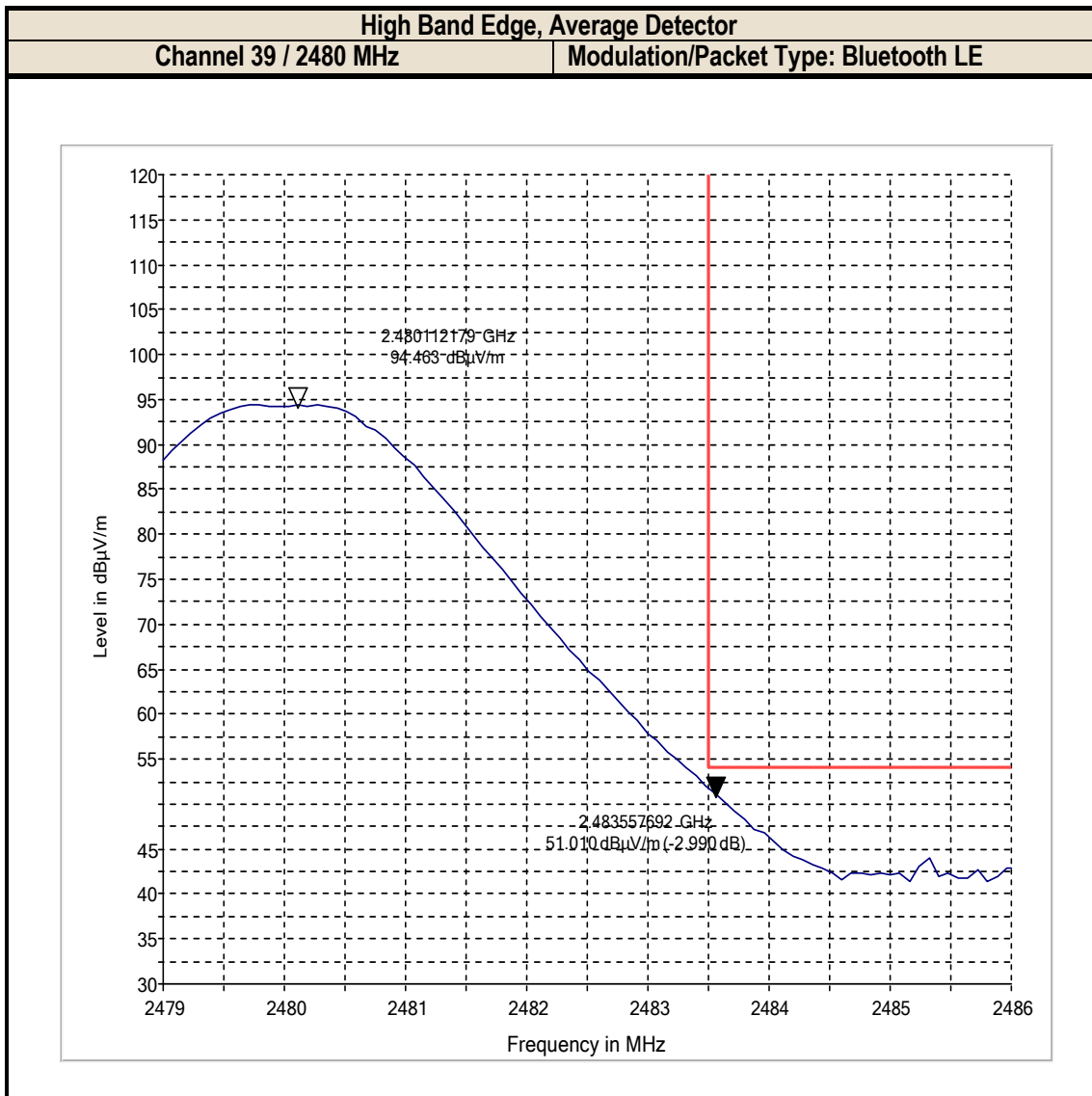


High Band Edge, Peak Detector**Channel 39 / 2480****Modulation/Packet Type: Bluetooth LE**

Green measurement trace is the max hold trace.

Blue measurement trace is the clear-write trace.





7 Test Equipment and Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial Number	Cal Date	Cal Interval
Turn table	EMCO	2075	N/A	N/A	N/A
MAPS Position Controller	ETSLindgren	2092	0004-1510	N/A	N/A
Antenna Mast	ETSLindgren	2171B	N/A	N/A	N/A
Relay Switch Unit	Rohde&Schwarz	RSU	338964/001	N/A	N/A
1500MHz HP Filter	Filtek	HP12/1700	14c48	N/A	N/A
2800 MHz HP Filter	Filtek	HP12/2800	14C47	N/A	N/A
6200 MHz HP Filter	Micro-tronics	HPM50106	1	N/A	N/A
Pre-Amplifier	Miteq	JS40010260	340125	N/A	N/A
Pre-Amplifier	Rohde&Schwarz	TS-PR18	100053	N/A	N/A
Communication Antenna	Kathrein	IBP5-900/1940	N/A	N/A	N/A
15 dB Attenuator	Huber & Suhner	N/A	N/A	N/A	N/A
Antenna Biconilog	EMCO	3142E	166067	6/14/2014	3 years
Antenna Horn	EMCO	3115	35111	7/24/2015	3 years
Antenna Horn	ETSLindgren	3116	70497	7/22/2015	3 years
Antenna Loop 6512	ETSLindgren	6512	49838	3/13/2014	3 years
Digital Barometer	Control Company	35519-055	91119547	4/7/2015	2 Years
Receiver ESU40	R&S	ESU40	100251	6/29/2015	3 years
Spectrum Analyzer	R&S	FSU26	200065	7/4/2015	3 years
Thermometer Humidity	Dickson	TM320	5280063	7/29/2015	1 Year

Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels.

Calibration due dates, unless defined specifically, falls on the last day of the month.

Items indicated "N/A" for cal date or interval either do not specifically require calibration or is internally characterized before use.

The calibrations of the test apparatus are commissioned to and performed by an accredited calibration laboratory. The calibration intervals are determined in accordance with ISO/IEC 17025. In addition to the external calibrations, the laboratory executes comparison measurements and verifications with other calibrated test systems or effective verifications. Weekly chamber inspections and range calibrations are performed.

8 Report History

Date	Report Name – Changes to Report	Report Prepared By
February 25, 2016	EMC_DELPH-004-15001_NA-BTLE 1. Initial Report	J. Sabado