



FCC / ISED Test Report

For:

Georama, Inc. DBA QualSights

Model Name:

QS-CO-001

Product Description:

Electronic device for automatically tracking product usage or consumption

FCC ID: 2A2OVCO1

ISED ID: 28061-CO1

Applied Rules and Standards:

47 CFR Part 15.247 (DTS)

RSS-247 Issue 2 (DTSs) & RSS-Gen Issue 5

REPORT #: EMC_MPCON-004-21001_15.247_BTLE_DTS

DATE: 2022-03-29



A2LA Accredited

IC recognized #
3462B-1

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1 **Assessment**

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.247 of Title 47 of the Code of Federal Regulations and the relevant ISED Canada standard RSS-247.

No deviations were ascertained.

Company	Description	Model #
Georama, Inc. DBA QualSights	Electronic device for automatically tracking product usage or consumption	QS-CO-001

Responsible for Testing Laboratory:

2022-03-29	Compliance	Kevin Wang (EMC Lab Manager)	
Date	Section	Name	Signature

Responsible for the Report:

2022-03-29	Compliance	Kris Lazarov (EMC Engineer)	
Date	Section	Name	Signature

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
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
EMC Lab Manager:	Kevin Wang
Responsible Project Leader:	Sangeetha Sivaraman

2.2 Identification of the Client

Client Firm/Name:	Georama, Inc. DBA QualSights
Street Address:	2045 W Grand Ave Ste B, PMB 75887
City/Zip Code	Chicago, IL 60612
Country	USA

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as Client
Manufacturers Address:	
City/Zip Code	
Country	

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No:	QS-CO-001
HW Version :	Rev 001
SW Version :	1.14
FCC-ID :	2A20VCO1
ISED-ID:	28061-CO1
FWIN:	N/A
HVIN:	QS-CO-001
PMN:	QualSights Smart Coaster
Product Description:	Electronic device for automatically tracking product usage or consumption
Frequency Range / number of channels:	BLE - nominal band: 2400 MHz – 2483.5 MHz; Center to center: 2405 MHz (ch 5) – 2480 MHz (ch 80) Zigbee - single channel 11 at 2405 MHz
Radio Information:	Bluetooth Low Energy (BLE) Zigbee 802.15.4
Modes of Operation:	Bluetooth LE in both advertising and connected mode of operation Zigbee continuous transmission on ch 11
Antenna Information as declared:	max gain 1.3 dBi
Max. Peak Output Power:	Conducted Power 7.13 dBm
Power Supply/ Rated Operating Voltage Range:	3.7V typical / 4.2V max
Operating Temperature Range	-20°C to + 60°C
Other Radios included in the device:	Ultra Low Power 802.11b/g/n
Sample Revision	<input type="checkbox"/> Prototype Unit; <input type="checkbox"/> Production Unit; <input checked="" type="checkbox"/> Pre-Production

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	Engineering Sample 1	Rev 001	1.14	Radiated and AC Conducted Emissions
2	Engineering Sample 2	Rev 001	1.14	Conducted RF

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	USB Power Adapter	PSAI05R-050Q	PHIHONG	N/A

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#2	The radio of the EUT was configured to a fixed channel transmission with 100% duty cycle using software that is not available to the end user. The measurement equipment was connected to the 50 ohm RF port of the EUT.
2	EUT#1 + AE#1	The radio of the EUT was configured to a fixed channel transmission with 100% duty cycle using software that is not available to the end user. The internal antenna was connected. The EUT was connected to the AC mains through a USB charger.

3.5 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on low, mid and high channels, and 100% duty cycle. For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT according to the relevant requirements specified in FCC rules Part 15.247 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-247 of ISED Canada.

This test report is to support a request for new equipment authorization under the FCC ID: 2A2OVCO1 and ISED ID: 28061-CO1

Testing procedures are based on 558074 D01 15.247 Meas Guidance v05r02 – “GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES” - April 2, 2019, by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	NA	NP	Result
§15.247(a)(1) RSS-247 5.2(a)	Emission Bandwidth	Nominal	BTLE	■	□	□	Complies
§15.247(e) RSS-247 5.2(b)	Power Spectral Density	Nominal	BTLE	■	□	□	Complies
§15.247(b)(1) RSS-247 5.4(d)	Maximum Conducted Output Power and EIRP	Nominal	BTLE	■	□	□	Complies
§15.247(d) RSS-247 5.5	Band edge compliance Unrestricted Band Edges	Nominal	BTLE	■	□	□	Complies
§15.247; 15.209; 15.205 RSS-Gen 8.9; 8.10	Band edge compliance Restricted Band Edges	Nominal	BTLE	■	□	□	Complies
§15.247(d); §15.209 RSS-Gen 6.13	TX Spurious emissions- Radiated	Nominal	BTLE	■	□	□	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal	BTLE	■	□	□	Complies

Note: NA= Not Applicable; NP= Not Performed.

6 Measurement Uncertainty

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

Measurement System	EMC 1	EMC 2
Conducted emissions (mains port)	1.12 dB	0.46 dB
Radiated emissions (< 30 MHz)	3.66 dB	3.88 dB
(30 MHz – 1GHz)	3.17 dB	3.34 dB
(1 GHz – 3 GHz)	5.01 dB	4.45 dB
(>3 GHz)	4.0 dB	4.79 dB

6.1 Environmental Conditions During Testing:

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

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

6.2 Dates of Testing:

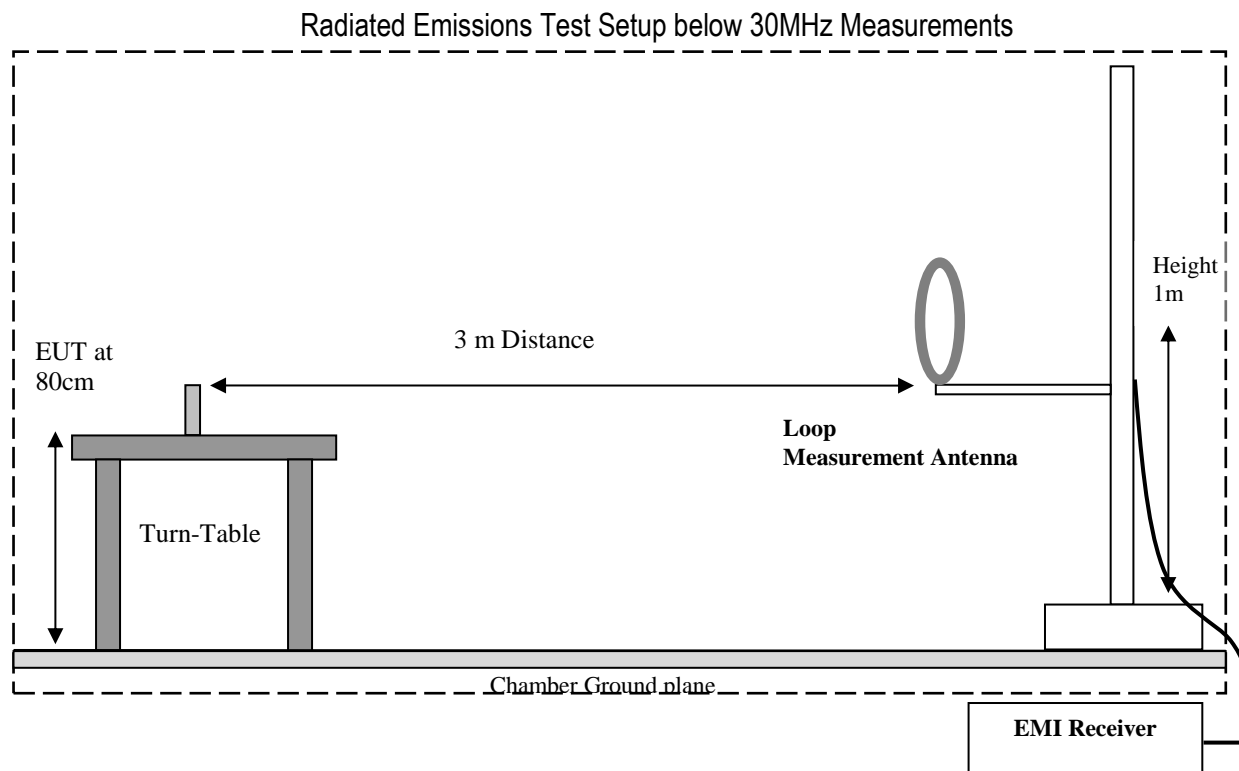
01/19/2022 – 02/20/2022

7 Measurement Procedures

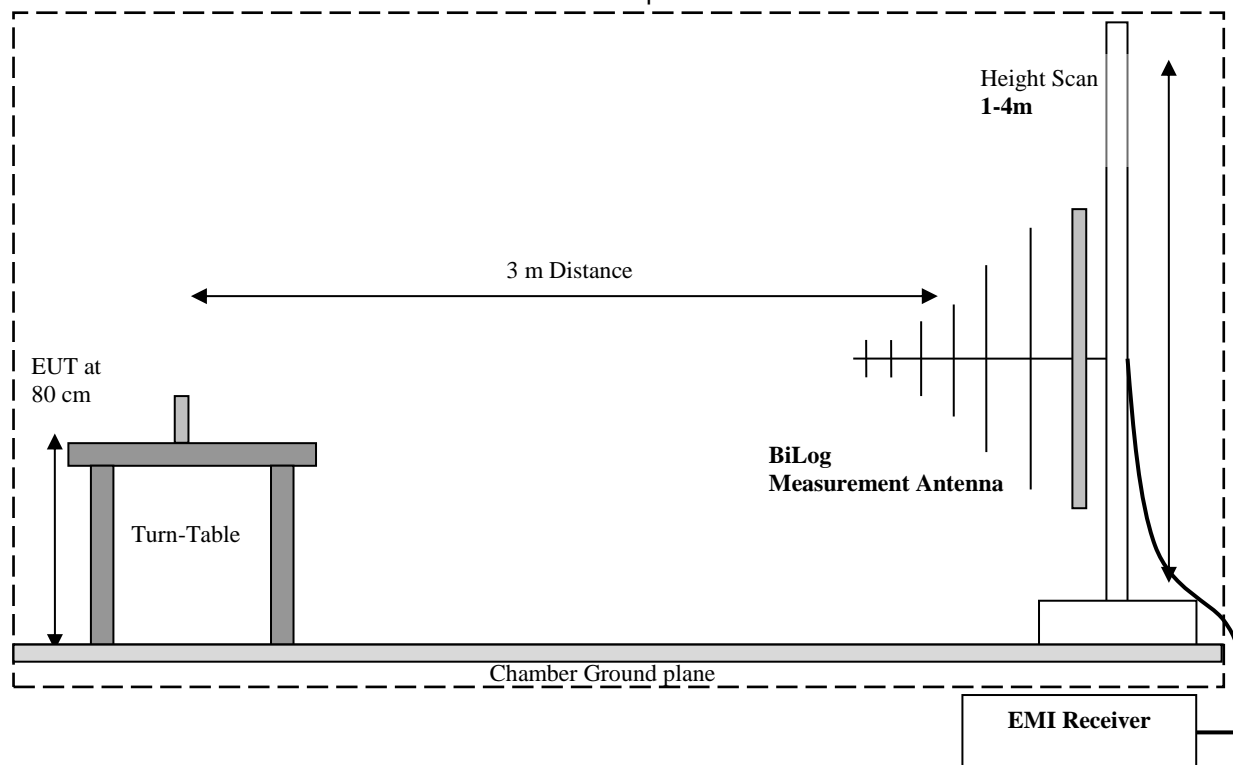
7.1 Radiated Measurement

The radiated measurement is performed according to ANSI C63.10 (2013)

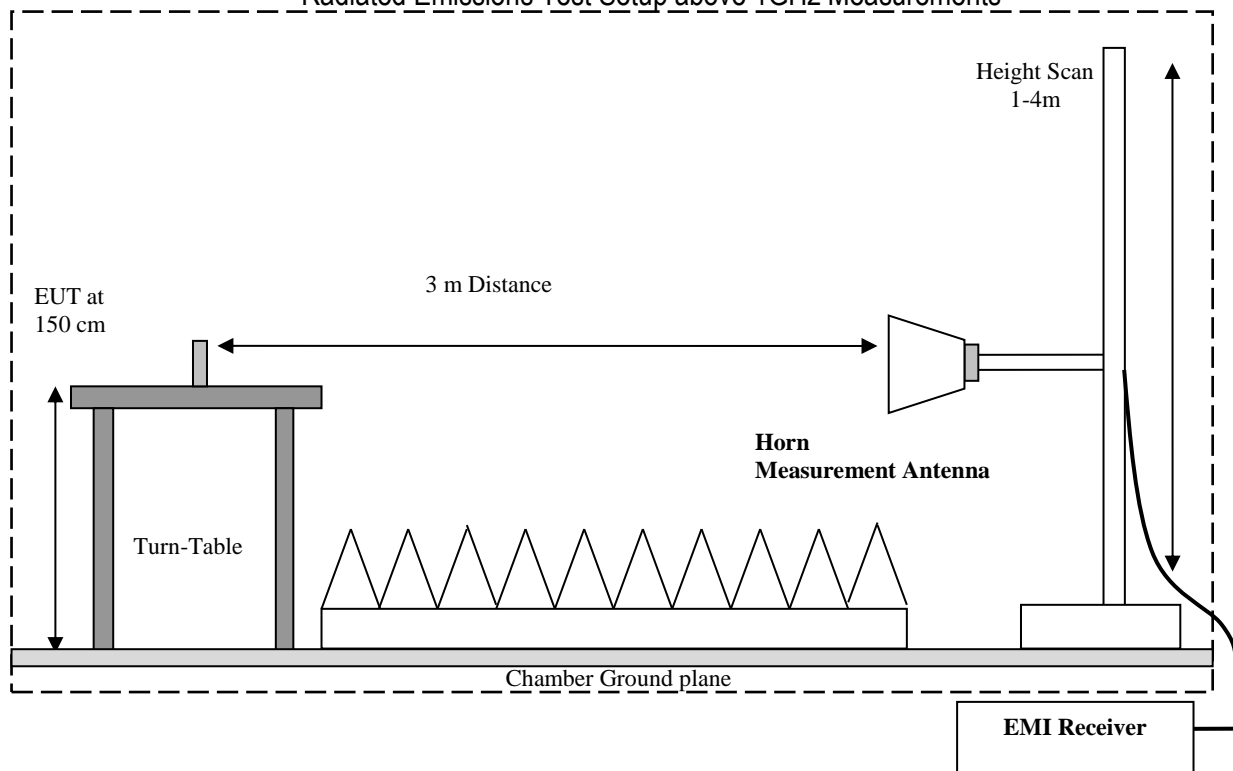
- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- 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 put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up 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 to cover frequencies up to 40 GHz.



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



7.1.1 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:

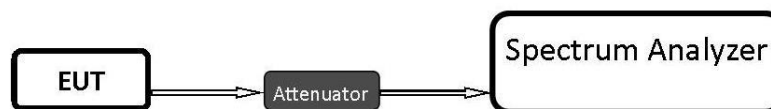
Frequency (MHz)	Measured SA (dB μ V)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dB μ V/m)
1000	80.5	3.5	14	98.0

7.2 Power Line Conducted Measurement Procedure

AC Power Line conducted emissions measurements performed according to: ANSI C63.4 (2014)

7.3 RF Conducted Measurement Procedure

Testing procedures are based on 558074 D01 15.247 Meas Guidance v05r02 – “GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES” - April 2, 2019, by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.



- Connect the equipment as shown in the above diagram.
- Adjust the settings of the SA (Rohde-Schwarz Spectrum Analyzer) to connect the EUT at the required mode of test.
- Measurements are to be performed with the EUT set to the low, middle and high channels and for worst case modulation schemes.

8 Test Result Data

8.1 Maximum Peak Conducted Output Power

8.1.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02

Spectrum Analyzer settings:

- $RBW \geq DTS \text{ bandwidth}$
- $VBW \geq 3 \times RBW$
- $Span \geq 3 \times RBW$
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Use peak marker function to determine the peak amplitude level

8.1.2 Limits:

Maximum Peak Output Power:

- FCC §15.247 (b)(1): 1 W
- IC RSS-247: 1 W

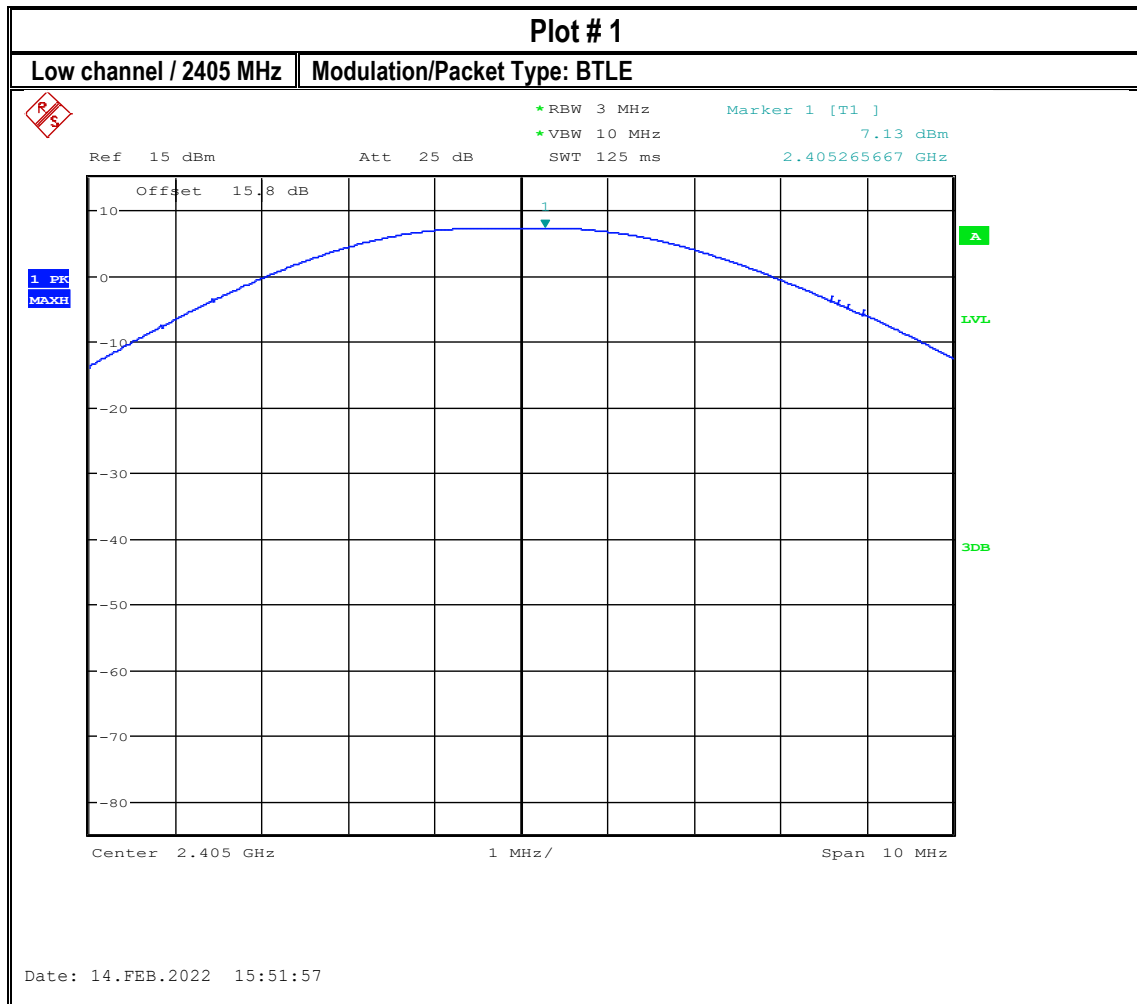
8.1.3 Test conditions and setup:

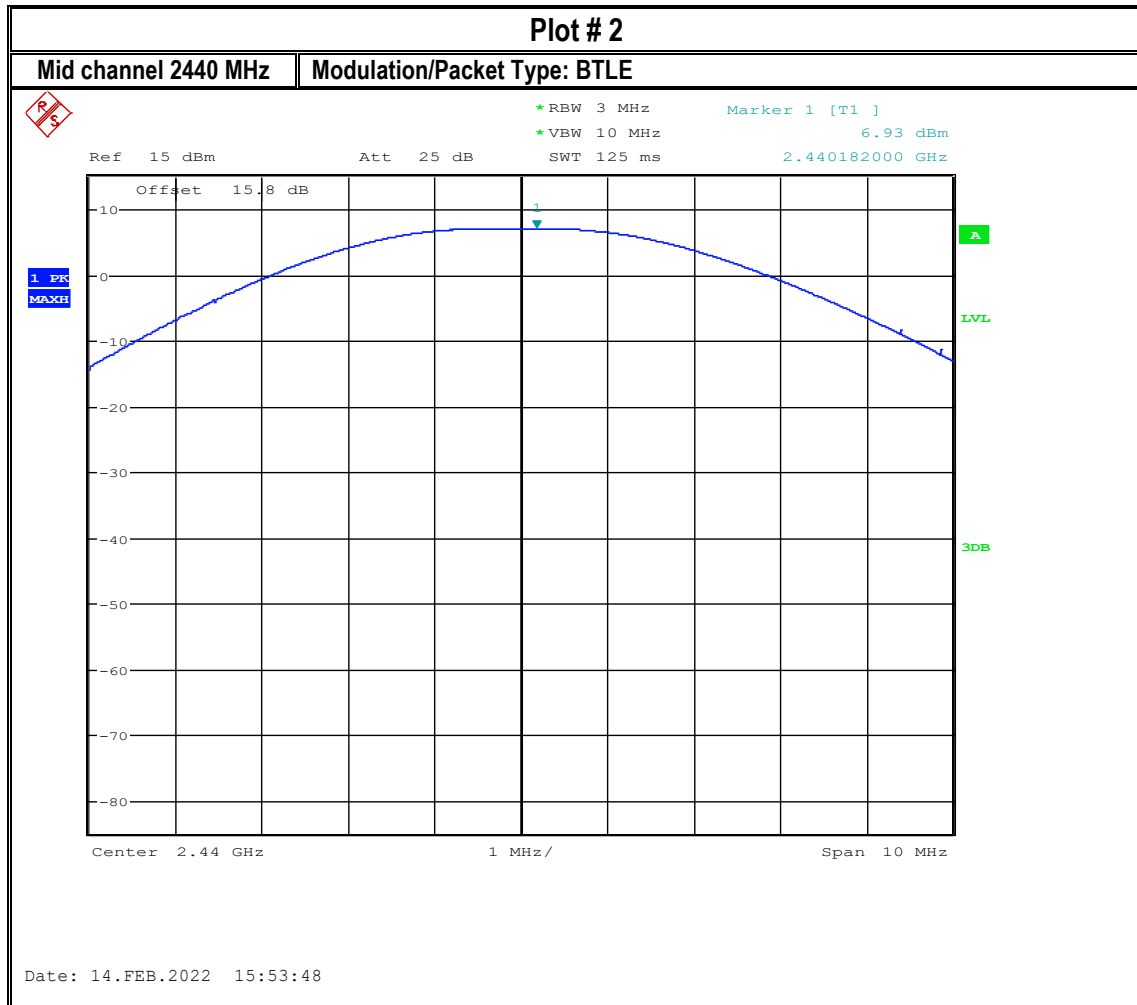
Ambient Temperature	EUT Set-Up #	EUT operating mode	Measurement Path Loss	Antenna Gain
23° C	1	GFSK continuous fixed channel	15.8 dB	1.3 dBi

8.1.4 Measurement result:

Plot #	Mode of Operation / Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	BLE 2405	7.13	8.43	30 (Pk) / 36 (EIRP)	Pass
2	BLE 2440	6.93	8.23	30 (Pk) / 36 (EIRP)	Pass
3	BLE 2480	6.6	7.9	30 (Pk) / 36 (EIRP)	Pass
4	Zigbee 2405	7.09	8.39	30 (Pk) / 36 (EIRP)	Pass

8.1.5 Measurement Plots:

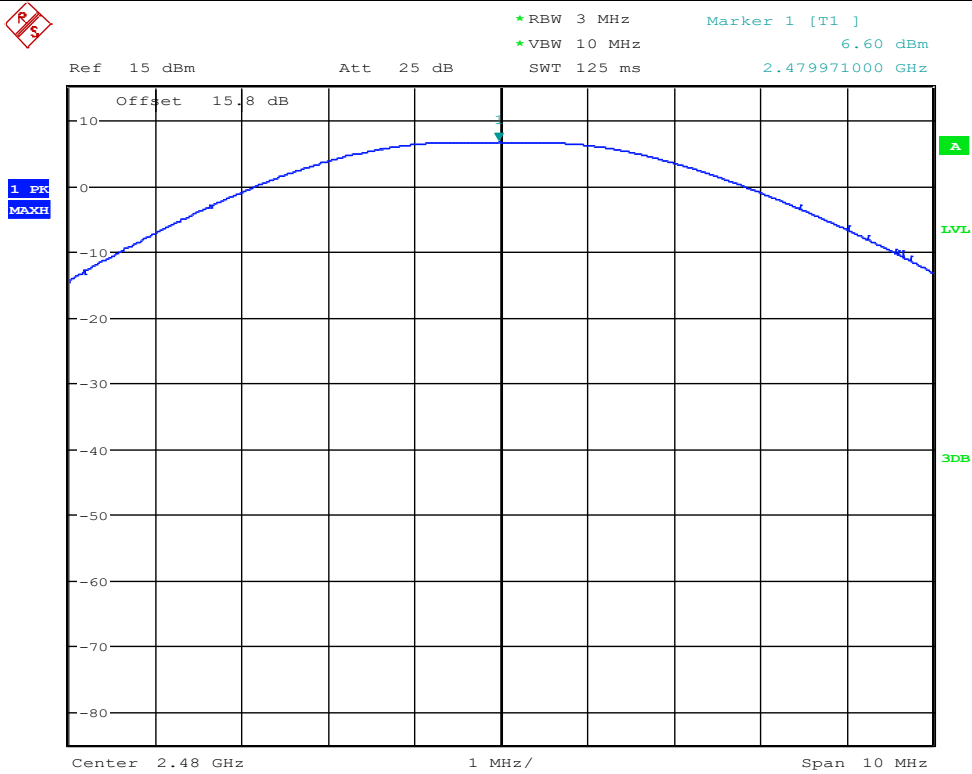




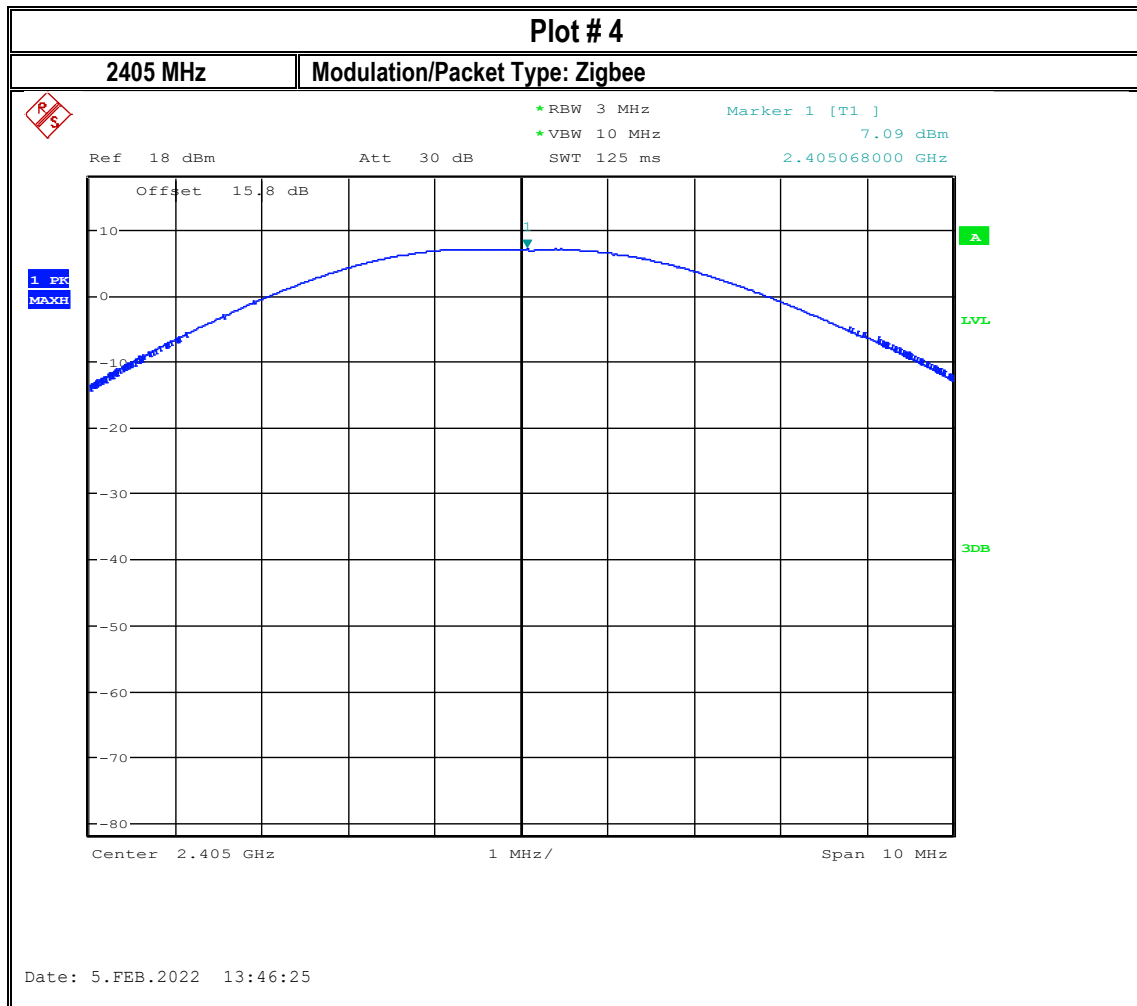
Plot # 3

High channel 2480 MHz

Modulation/Packet Type: BTLE



Date: 14.FEB.2022 15:55:08



8.2 Power Spectral Density

8.2.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02

Spectrum Analyzer settings for Peak PSD method:

- Set analyzer center frequency to DTS channel center frequency
- Set the span to 1.5 x DTS bandwidth
- Set RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
- Set the VBW $\geq 3 \times \text{RBW}$
- Detector = Peak
- Sweep time = Auto couple
- Trace mode = Max hold
- Allow trace to fully stabilize
- Use the peak marker function to determine the maximum amplitude level within the RBW
- If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat

8.2.2 Limits:

FCC§15.247(e) & RSS-247 5.2(b)

- For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

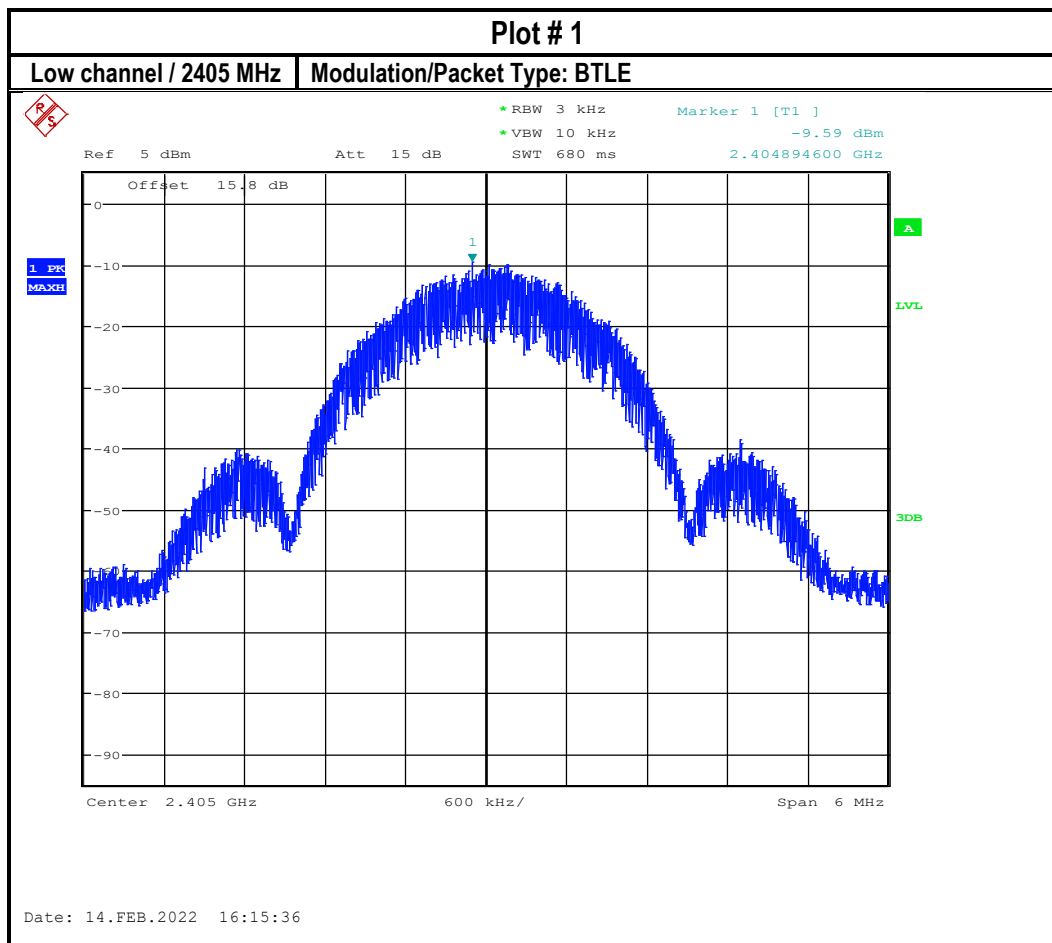
8.2.3 Test conditions and setup:

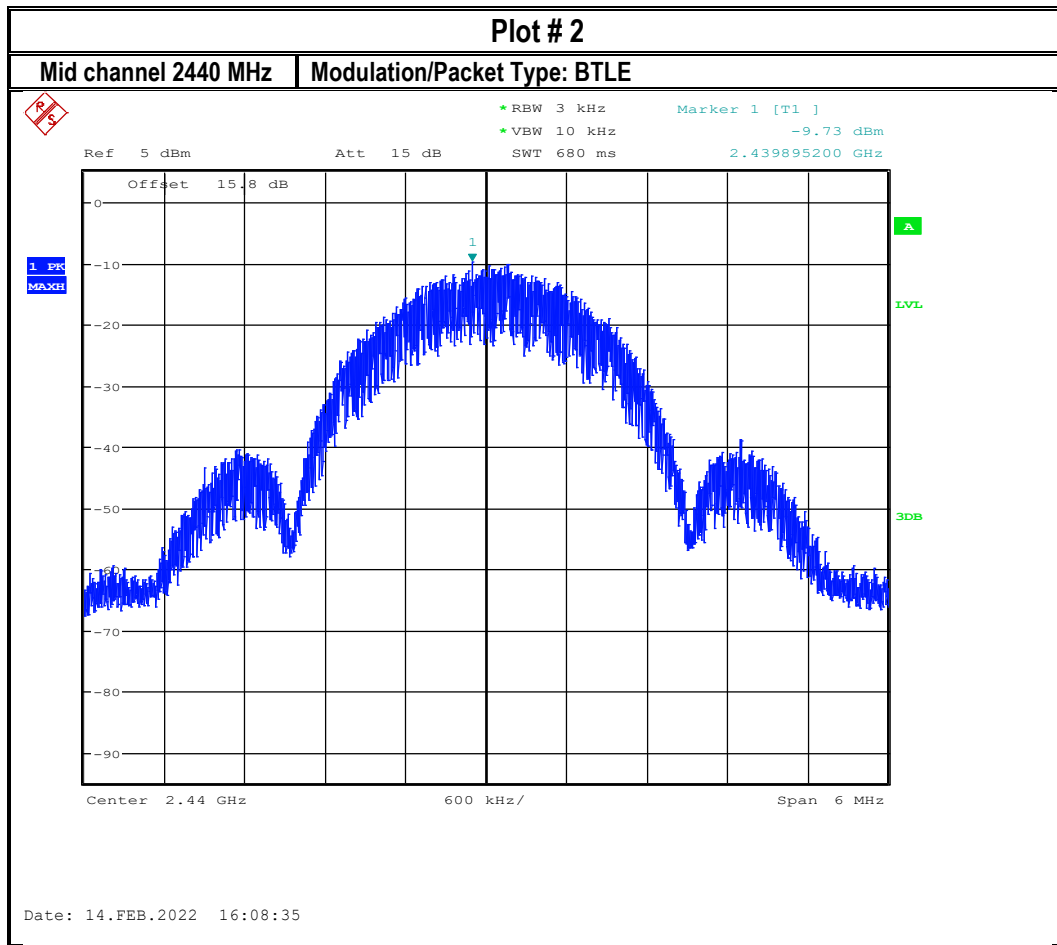
Ambient Temperature	EUT Set-Up #	EUT operating mode	Measurement Path Loss	Antenna Gain
23° C	1	GFSK continuous fixed channel	15.8 dB	1.3 dBi

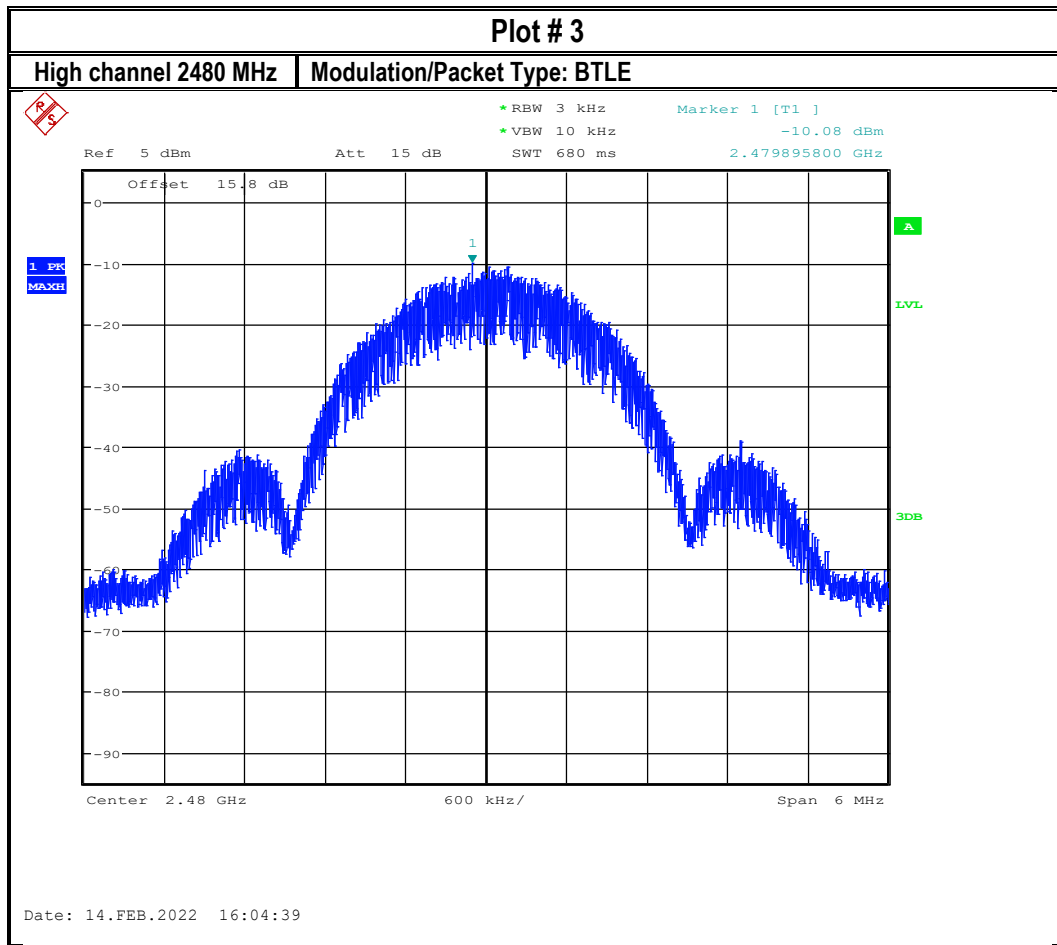
8.2.4 Measurement result:

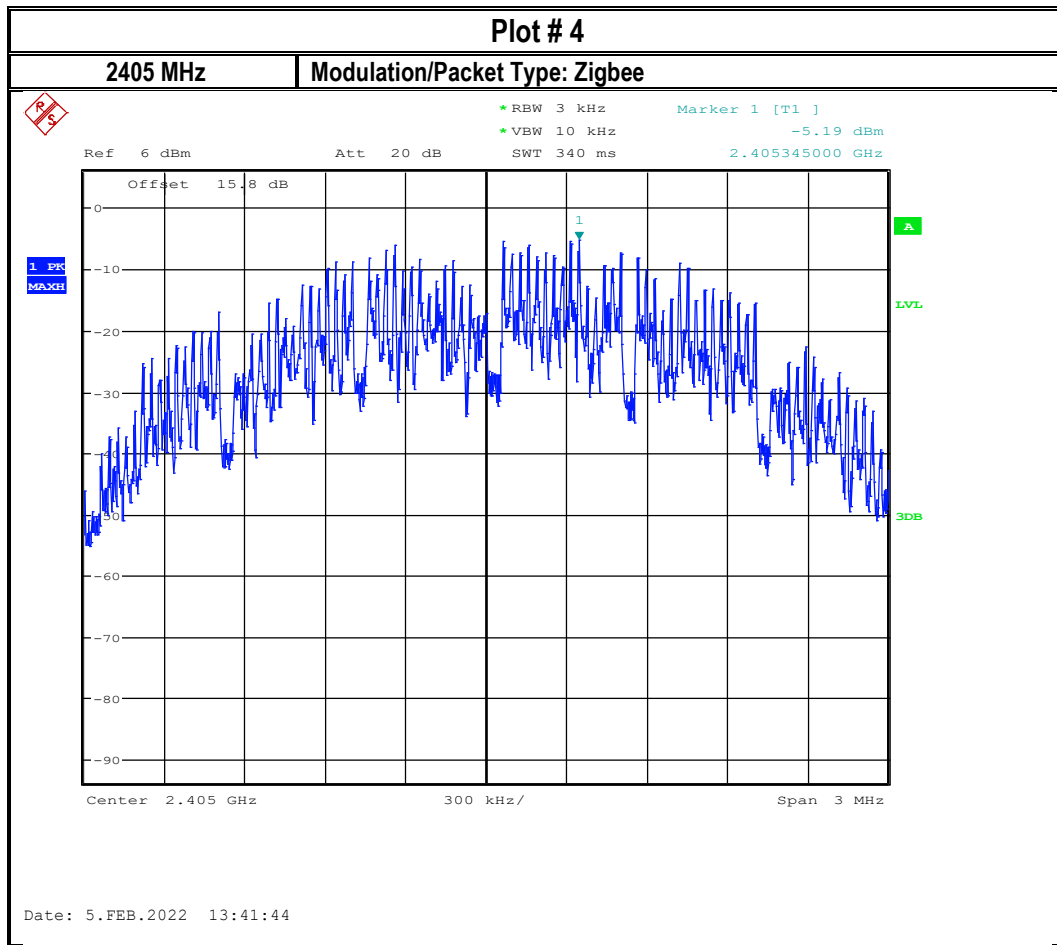
Plot #	Mode of Operation / Frequency (MHz)	Measured PSD (dBm/3 kHz)	Antenna Gain Corrected PSD (dBm/3 kHz)	Limit (dBm / 3 kHz)	Result
1	BLE 2405	-9.59	-8.29	8	Pass
2	BLE 2440	-9.73	-8.43	8	Pass
3	BLE 2480	-10.8	-9.5	8	Pass
4	Zigbee 2405	-5.19	-3.89	8	Pass

8.2.5 Measurement Plots:









8.3 Band Edge Compliance

8.3.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02

Spectrum Analyzer settings for band edge:

- Set the center frequency and span to encompass frequency range to be measured
- RBW = 100 kHz
- VBW $\geq 3 \times$ RBW
- Sweep Time: Auto couple
- Detector = Peak
- Trace = Max hold
- Allow trace to fully stabilize
- Use the peak marker function to determine the maximum amplitude level
- Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge

8.3.2 Limits non restricted band:

FCC§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. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

RSS-247 5/5

- 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 30dB instead of 20dB.

Spectrum Analyzer settings for restricted band:

- Peak measurements are made using a peak detector and RBW=1 MHz

8.3.3 Limits restricted band §15.247/15.209/15.205 and RSS-Gen 8.9/8.10

- *PEAK LIMIT= 74 dB μ V/m @3m =-21.23 dBm
- *AVG. LIMIT= 54 dB μ V/m @3m =-41.23 dBm
- Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205 & RSS-Gen 8.10
- Measurements with a peak detector were used to show compliance to average limits, thus showing compliance to both peak and average limits.

(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
10.495-0.505	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	2690-2900	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	Above 38.6
13.36-13.41			

8.3.4 Test conditions and setup:

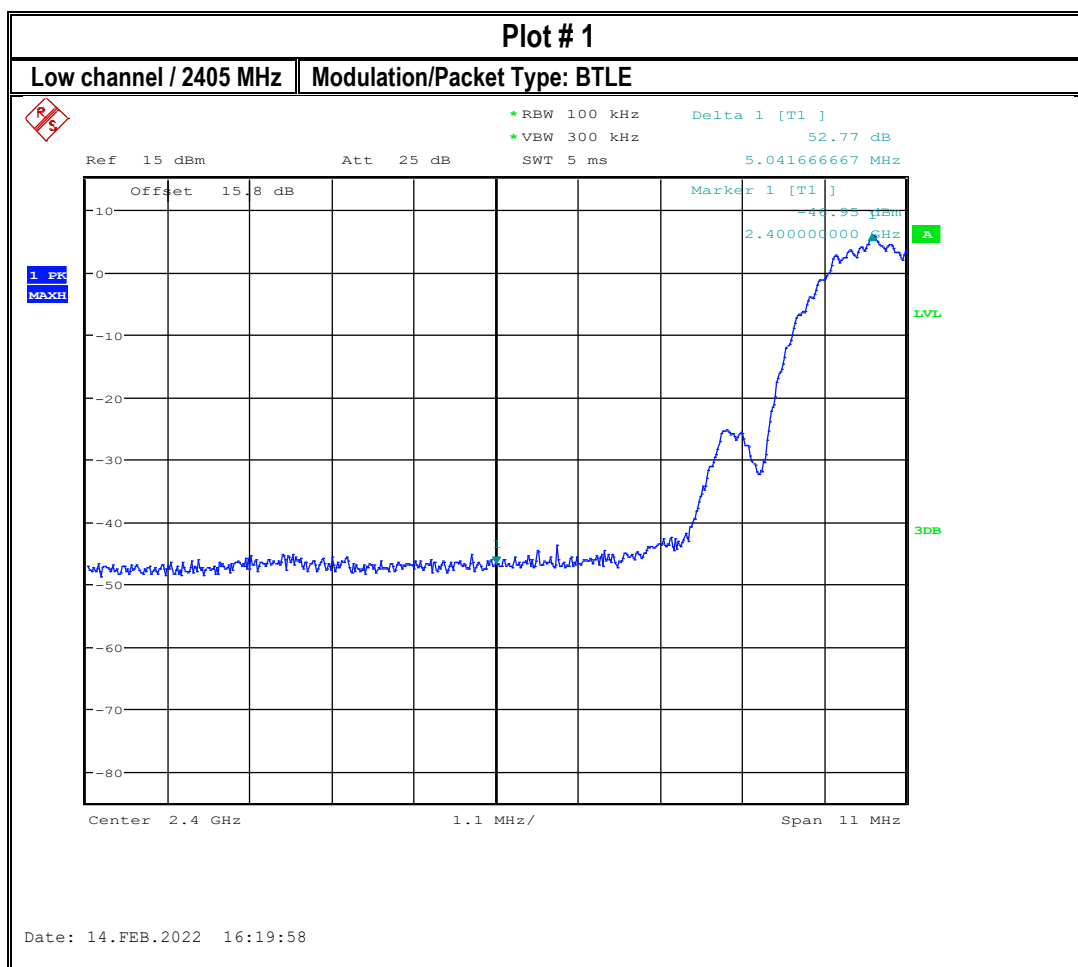
Ambient Temperature	EUT Set-Up #	EUT operating mode	Measurement Path Loss	Antenna Gain
23° C	1	GFSK continuous fixed channel	15.8 dB	1.3 dBi

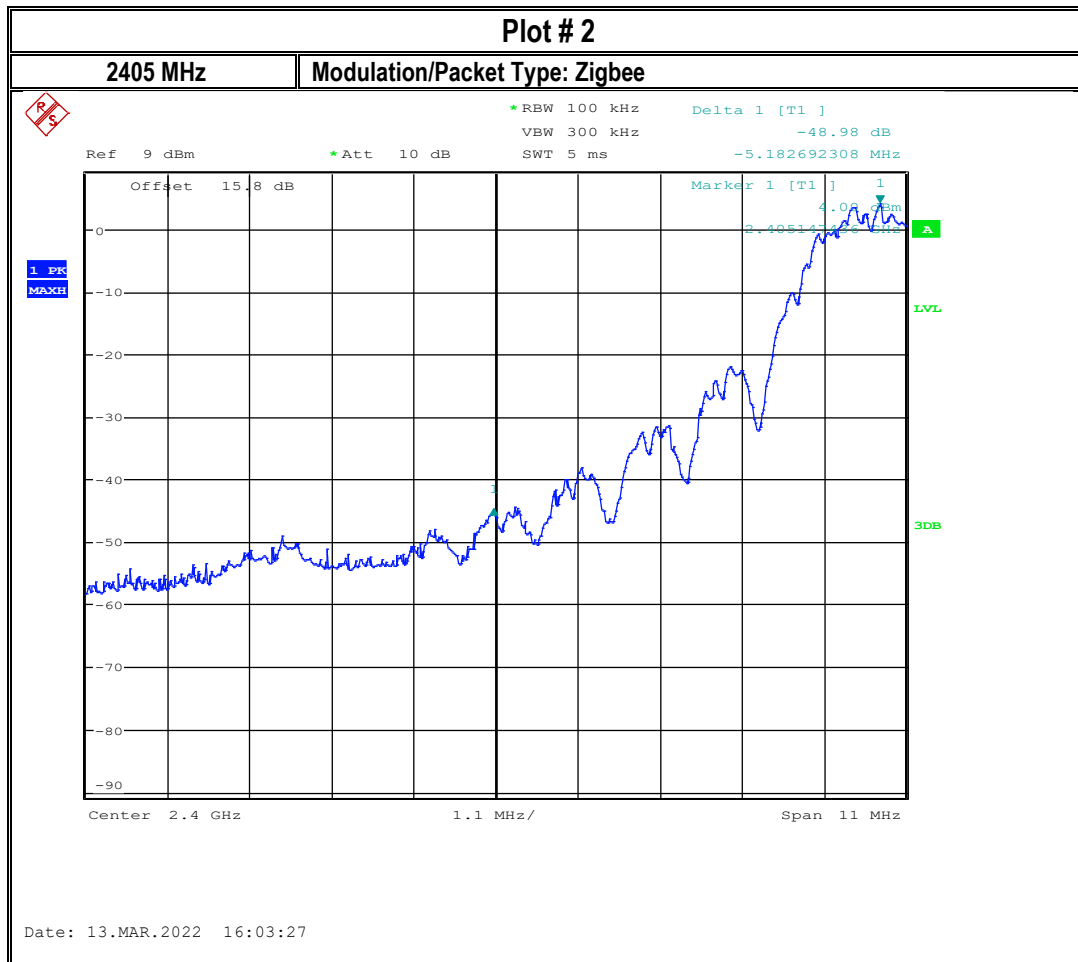
8.3.5 Measurement result:

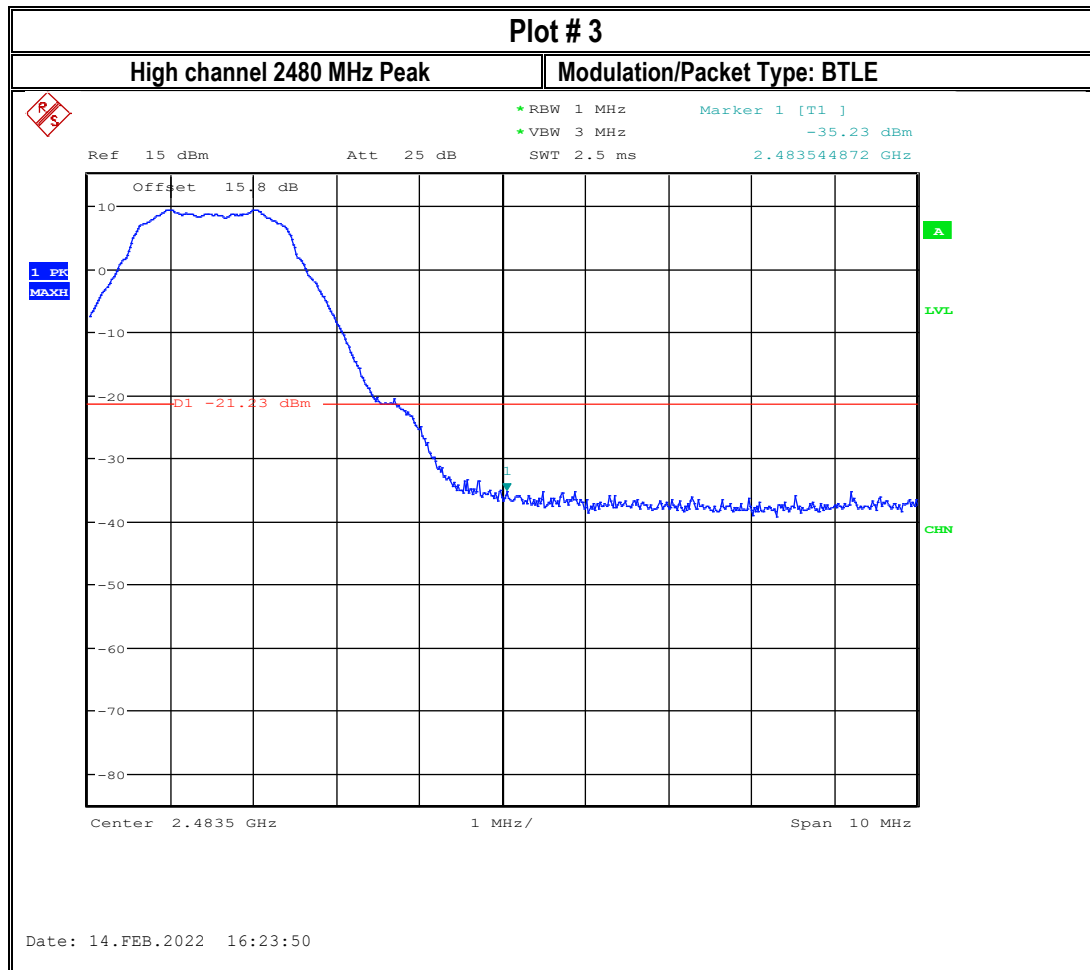
Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	BLE 2405	Lower, Non-restricted	53	20	Pass
2	Zigbee 2405	Lower, Non-restricted	49	20	Pass

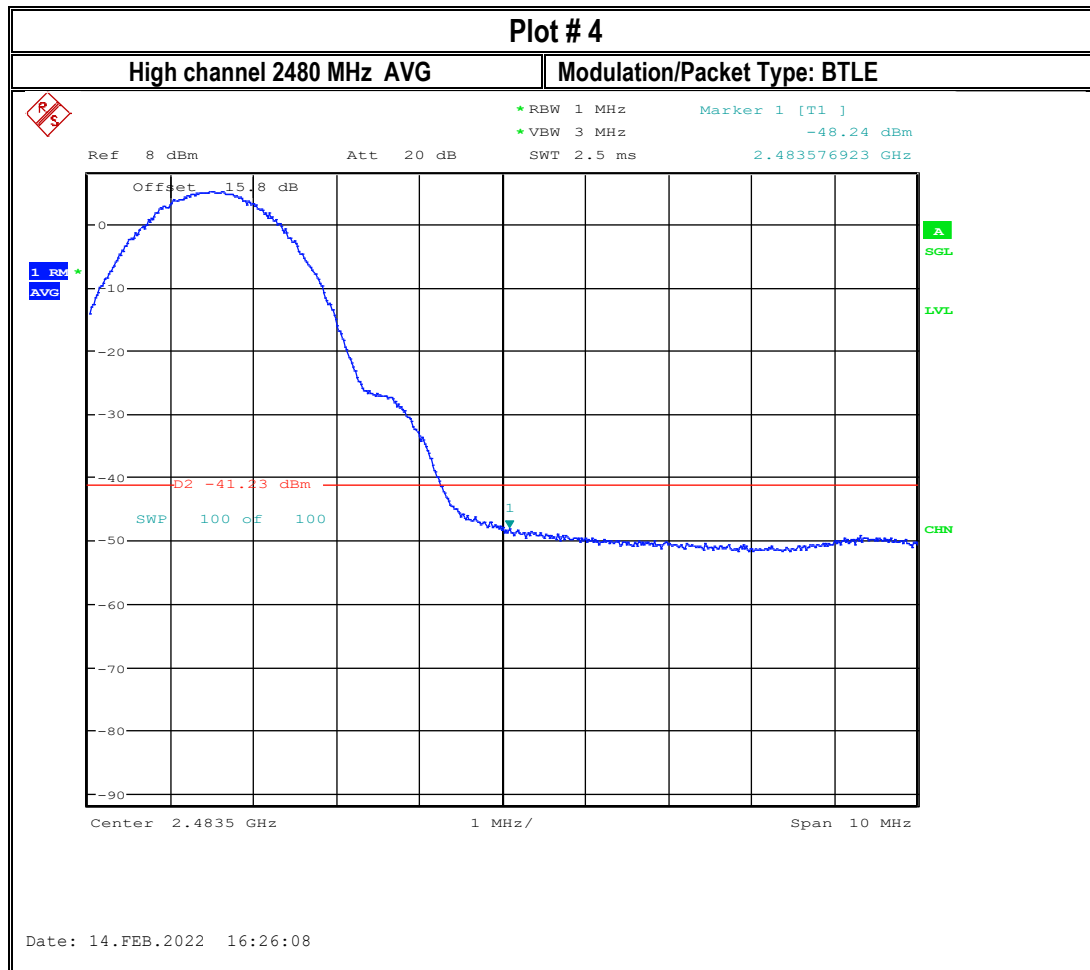
Plot #	Operating Mmode	Band Edge	Measured Peak Value (dBm)	Corrected by Antenna Gain (dBm)	Limit (dBm)	Result
3	BLE 2480	Upper Restricted Peak	-35.23	-33.23	-21.23 Peak	Pass
4	BLE 2480	Upper Restricted AVG	-48.22	-46.22	-41.23 AVG	Pass
5	Zigbee 2405	Upper Restricted Peak and AVG	-49.92	-47.92	-21.23 / -41.23	Pass

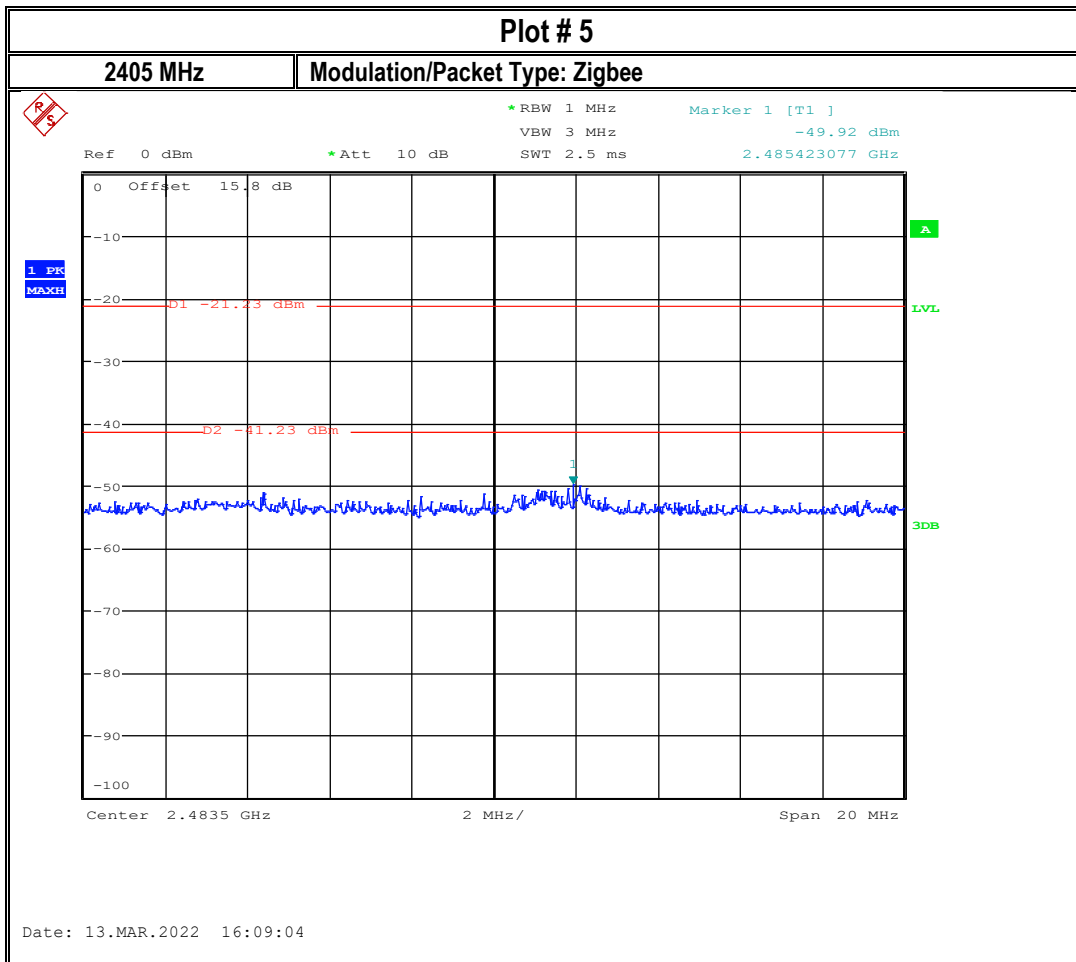
8.3.6 Measurement Plots:











8.4 Emission Bandwidth 6dB and 99% Occupied Bandwidth

8.4.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02

Spectrum Analyzer settings:

6dB (DTS) Bandwidth:

- Set RBW = 100 kHz
- Set the video bandwidth (VBW) $\geq 3 \times$ RBW
- Detector = Peak
- Trace mode = Max hold
- Sweep = Auto couple
- Allow the trace to stabilize
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

99% Occupied Bandwidth:

- Set frequency = nominal EUT channel center frequency
- Set Span = 1.5 x to 5.0 x OBW
- Set RBW = 1% to 5% of OBW
- Set the video bandwidth (VBW) $\approx 3 \times$ RBW
- Detector = Peak
- Trace mode = Max hold
- Sweep = Auto couple
- Allow the trace to stabilize
- Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth
- If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.

8.4.2 Limits:

FCC §15.247(a)(2) and RSS-247 5.2(a)

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

8.4.3 Test conditions and setup:

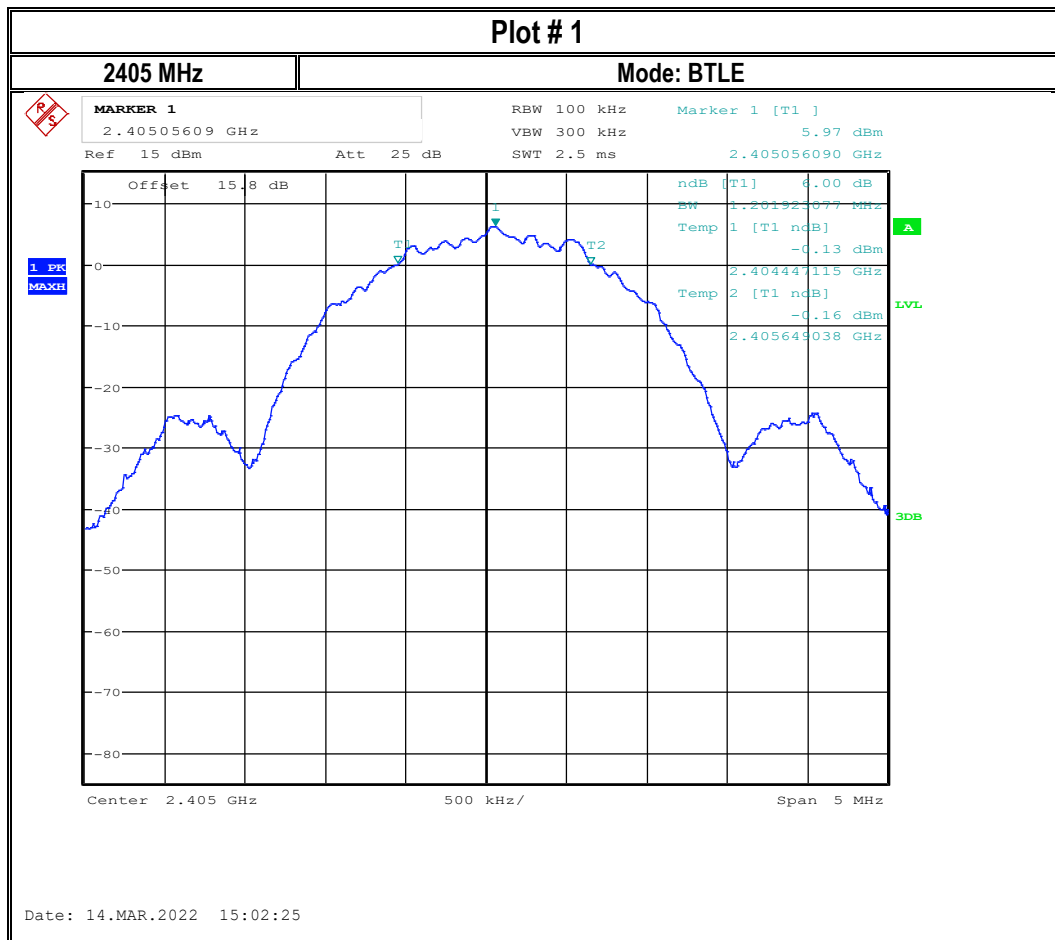
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	GFSK continuous fixed channel	3.7 VDC

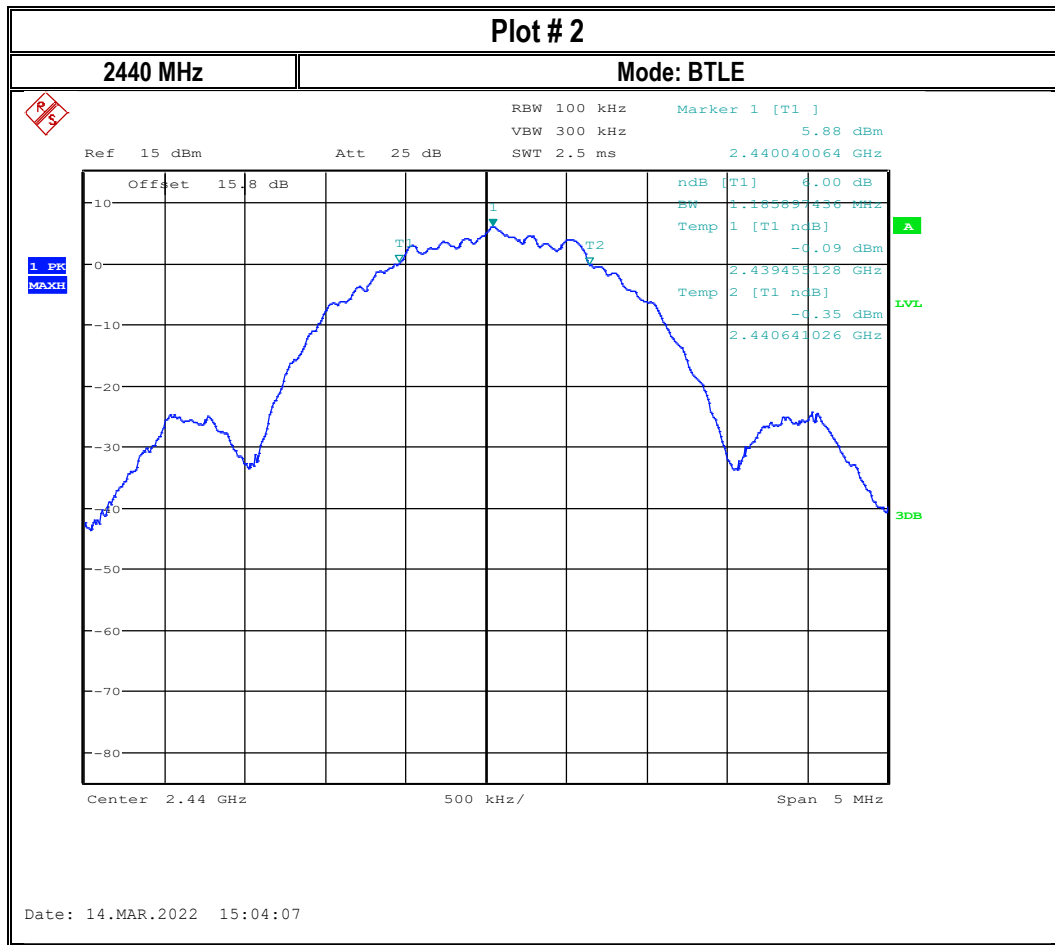
8.4.4 Measurement result:

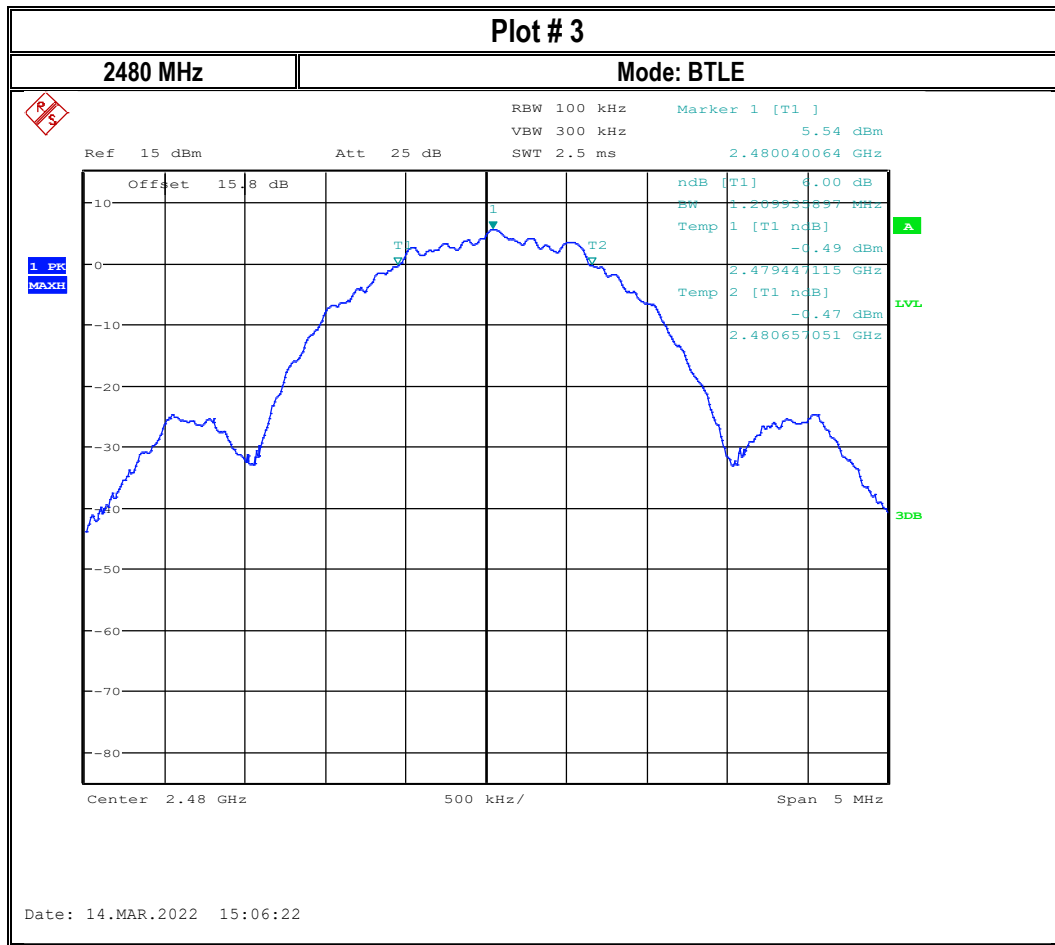
Plot #	Frequency (MHz)	6dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
1	BLE 2405	1.20	> 0.5	Pass
2	BLE 2440	1.10	> 0.5	Pass
3	BLE 2480	1.21	> 0.5	Pass
4	Zigbee 2405	1.57	> 0.5	Pass

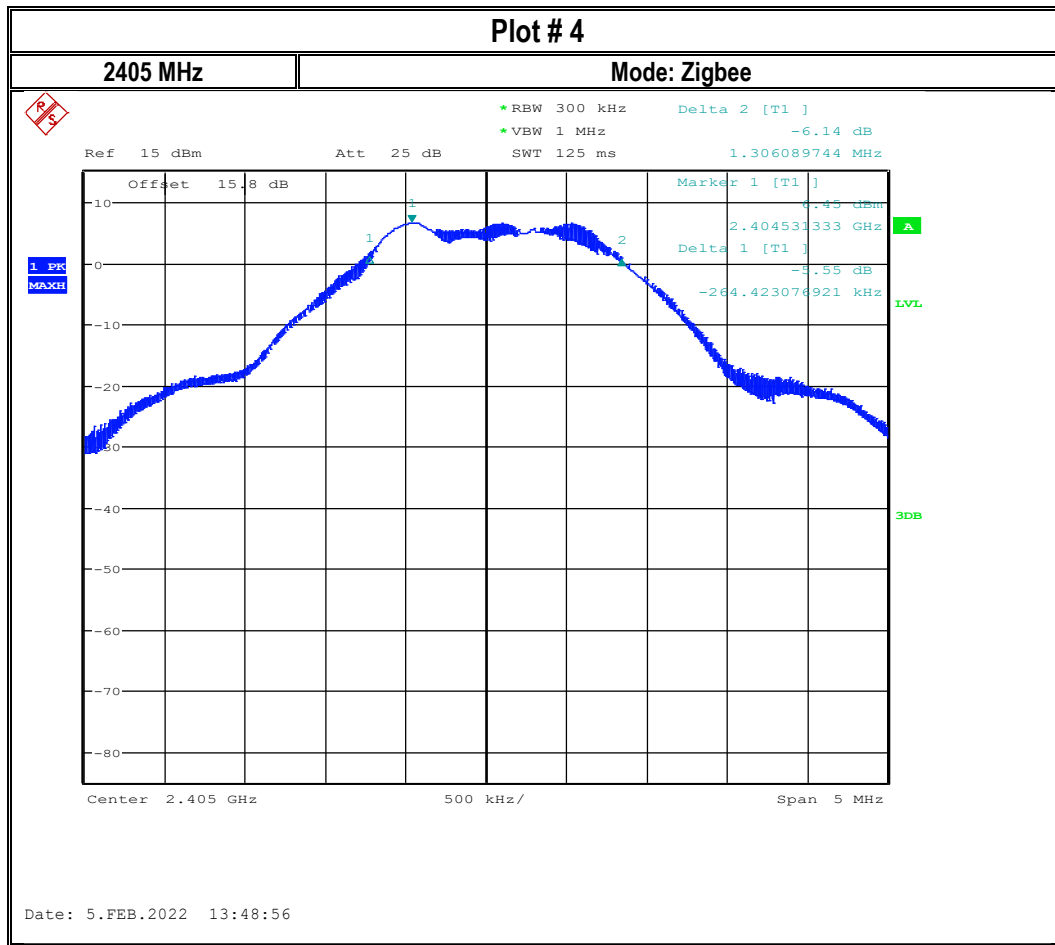
Plot #	Frequency (MHz)	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
5	BLE 2405	2.082	> 0.5	Pass
6	BLE 2440	2.088	> 0.5	Pass
7	BLE 2480	2.091	> 0.5	Pass
8	Zigbee 2405	2.37	> 0.5	Pass

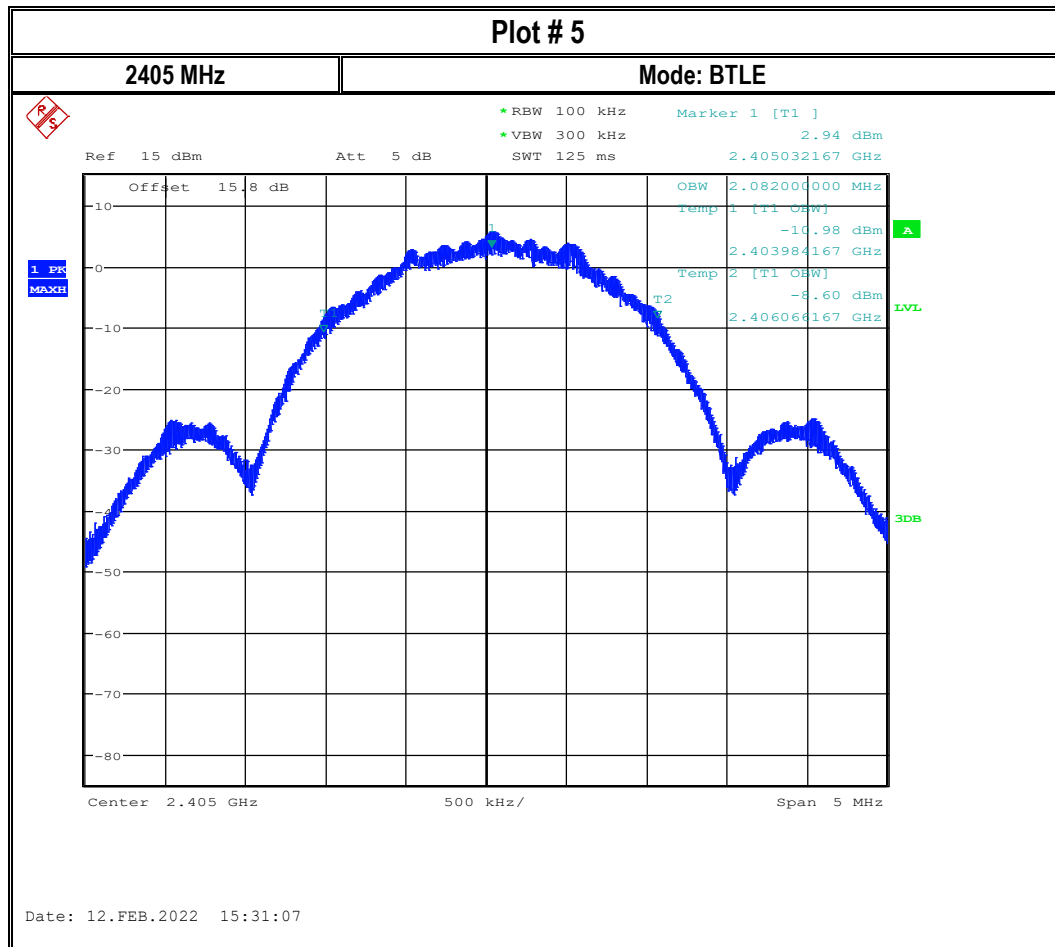
8.4.5 Measurement Plots:

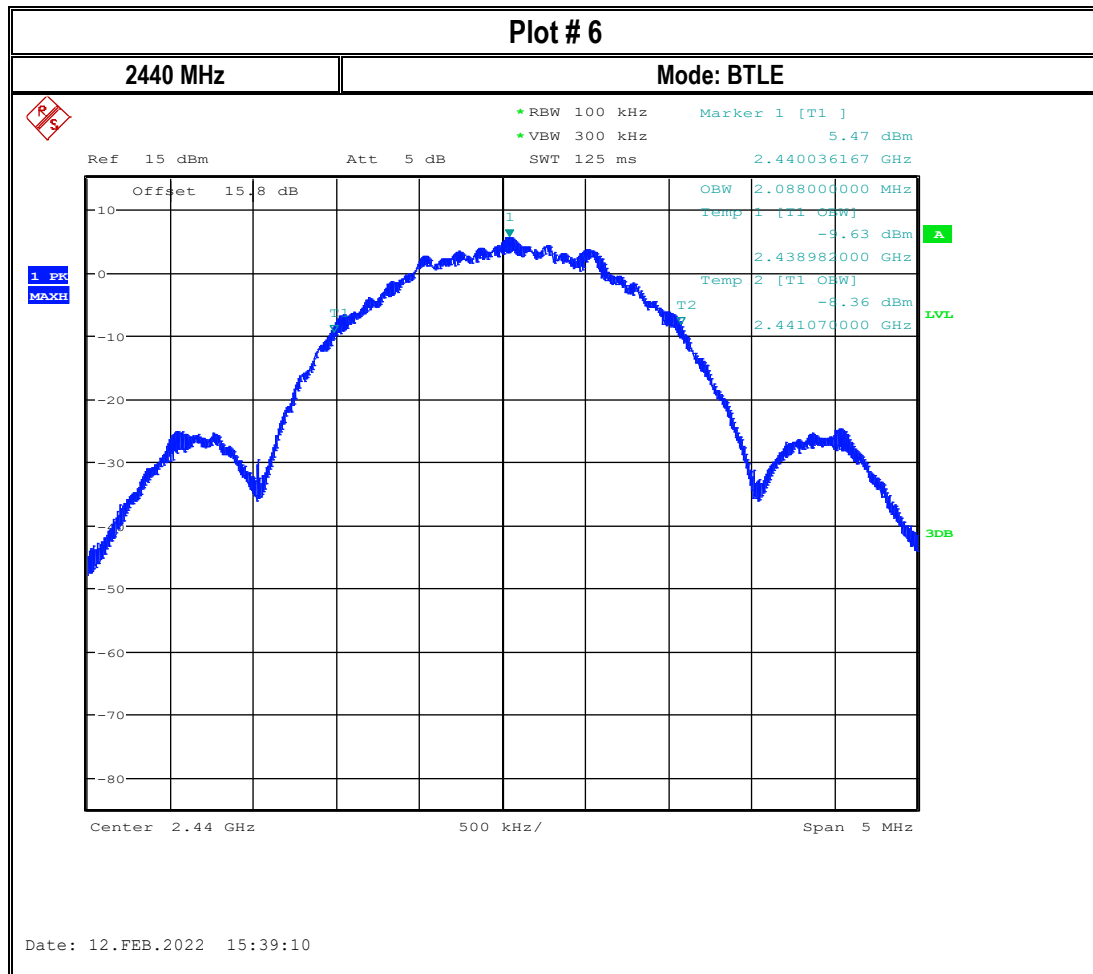




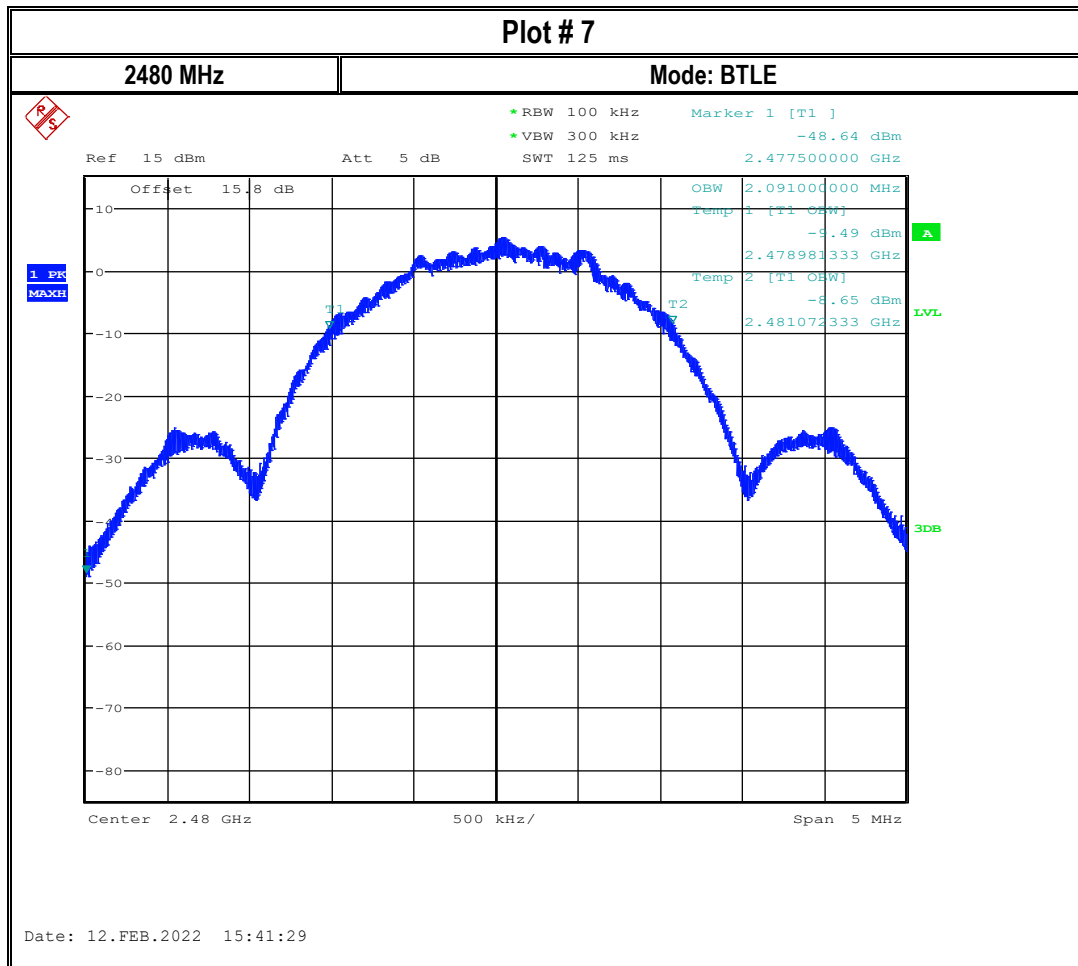


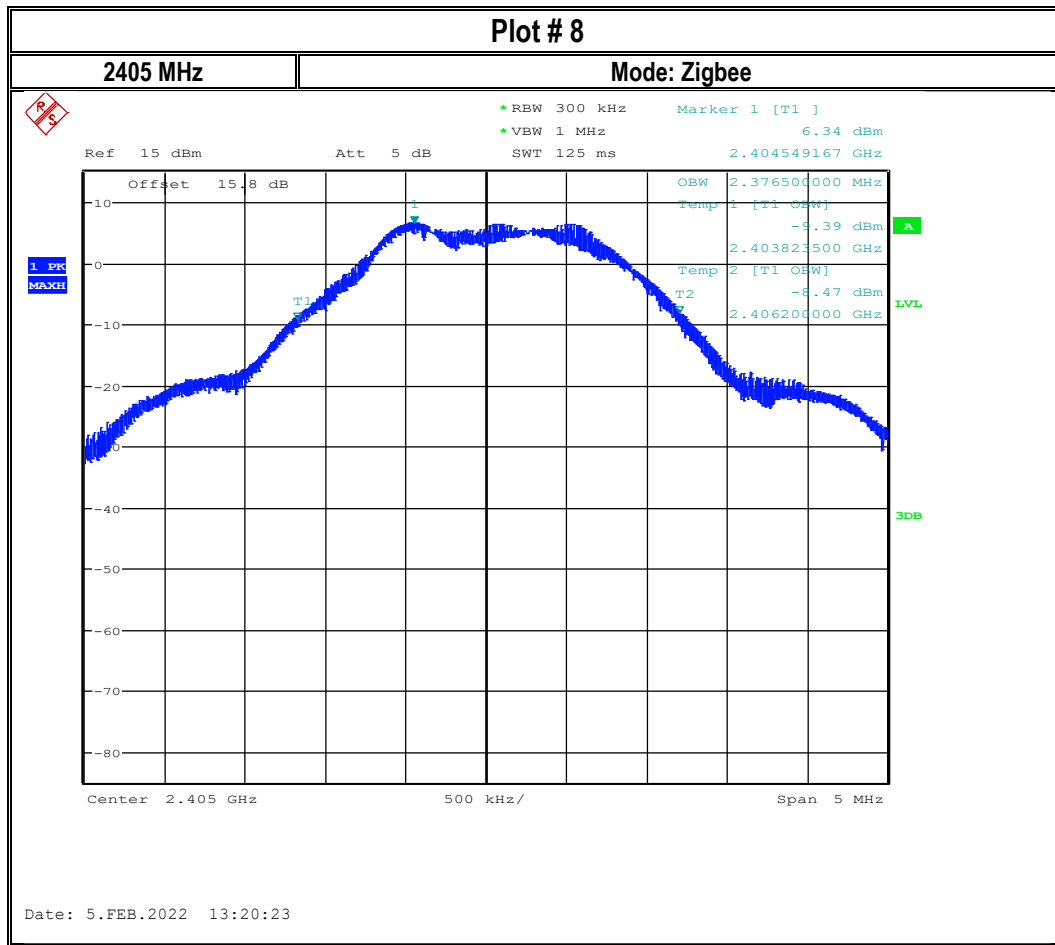






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8.5 Radiated Transmitter Spurious Emissions and Restricted Bands

8.5.1 Measurement according to ANSI C63.10 (2013)

Spectrum Analyzer Settings:

- Frequency = 9 KHz – 30 MHz
- RBW = 9 KHz
- Detector: Peak

- Frequency = 30 MHz – 1 GHz
- Detector = Peak / Quasi-Peak
- RBW= 120 KHz (<1GHz)

- Frequency > 1 GHz
- Detector = Peak / Average
- RBW = 1 MHz

- Radiated spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the lowest, middle and highest channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements.
- The highest (or worst-case) data rate shall be recorded for each measurement.
- For testing frequencies below 30 MHz at distance other than the specified in the standard, the limit conversion is calculated by using the FCC materials for the ANSI 63 committee issued on January, 27 1991.

8.5.2 Limits:

FCC §15.247

- 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. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

FCC §15.209 & RSS-Gen 8.9

- Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency of emission (MHz)	Field strength (μV/m)	Measurement Distance (m)	Field strength @ 3m (dBμV/m)
0.009–0.490	2400/F(kHz) / -----	300	-
0.490–1.705	24000/F(kHz) / -----	30	-
1.705–30.0	30 / (29.5)	30	-
30–88	100	3	40 dBμV/m
88–216	150	3	43.5 dBμV/m
216–960	200	3	46 dBμV/m
Above 960	500	3	54 dBμV/m

FCC §15.205 & RSS-Gen 8.10

- 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
10.495-0.505	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	2690-2900	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	Above 38.6
13.36-13.41			

- Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

*PEAK LIMIT= 74 dBμV/m

*AVG. LIMIT= 54 dBμV/m

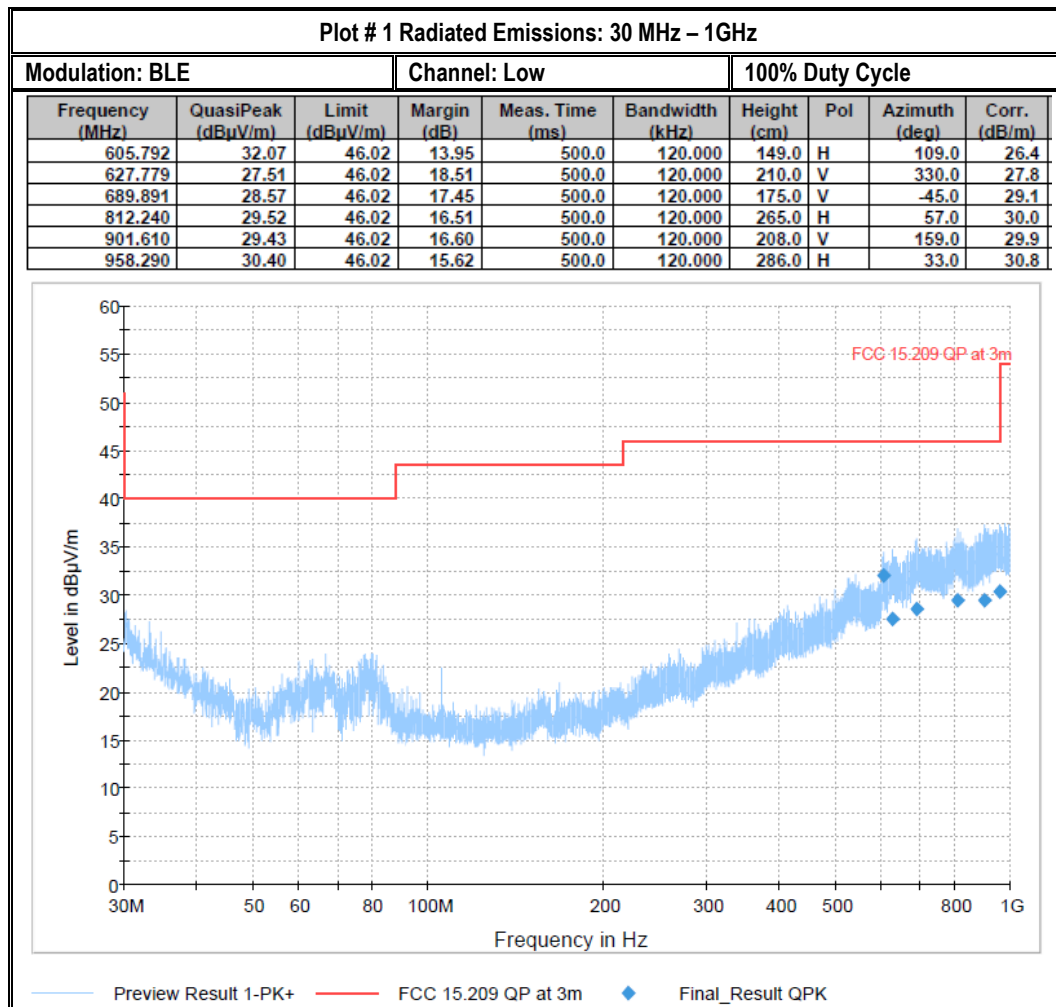
8.5.3 Test conditions and setup:

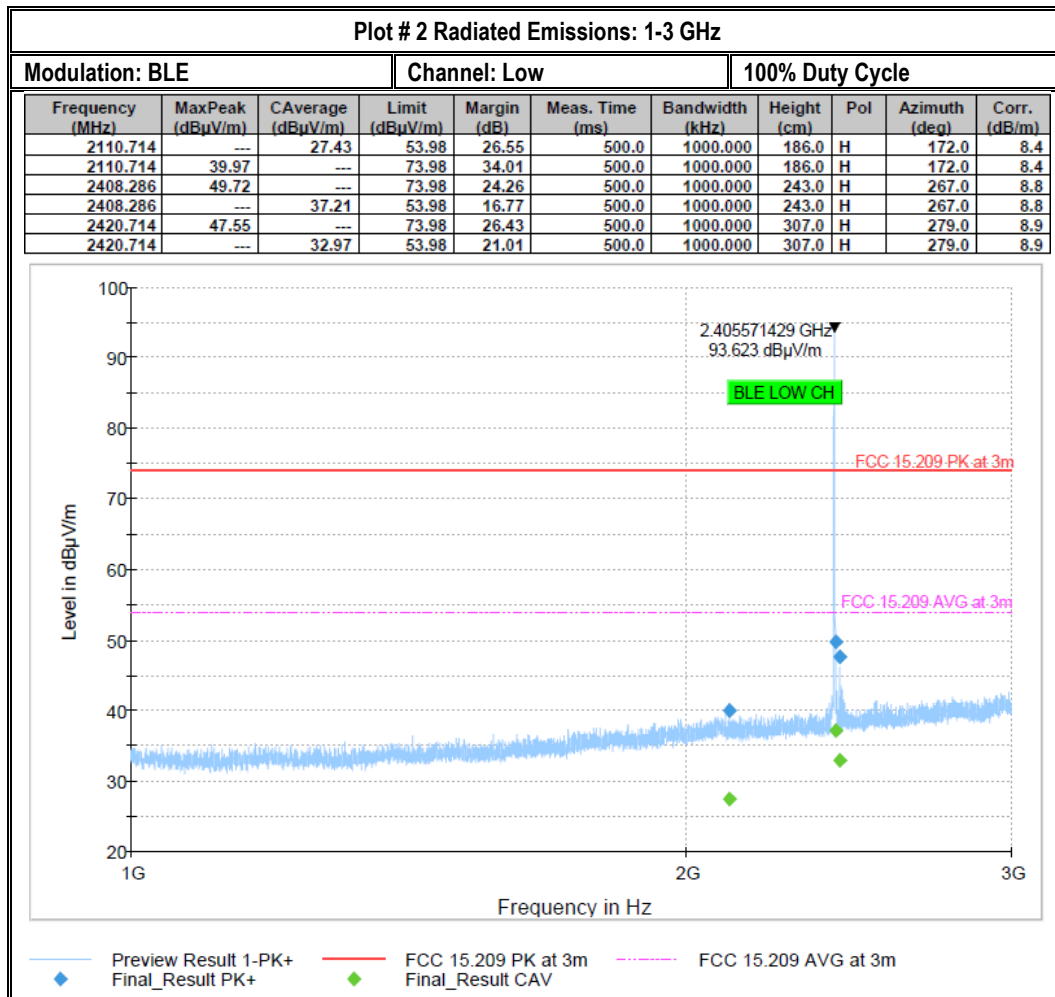
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	2	GFSK continuous fixed channel	110V 60Hz

8.5.4 Measurement result:

Plot #	Channel #	Scan Frequency	Limit	Result
1-3	Low	30 MHz – 18 GHz	See section 8.5.2	Pass
4-8	Mid	9 kHz – 26 GHz	See section 8.5.2	Pass
9-11	High	30 MHz – 18 GHz	See section 8.5.2	Pass
12-16	Zigbee	9 kHz – 26 GHz	See section 8.5.2	Pass

8.5.5 Measurement Plots:





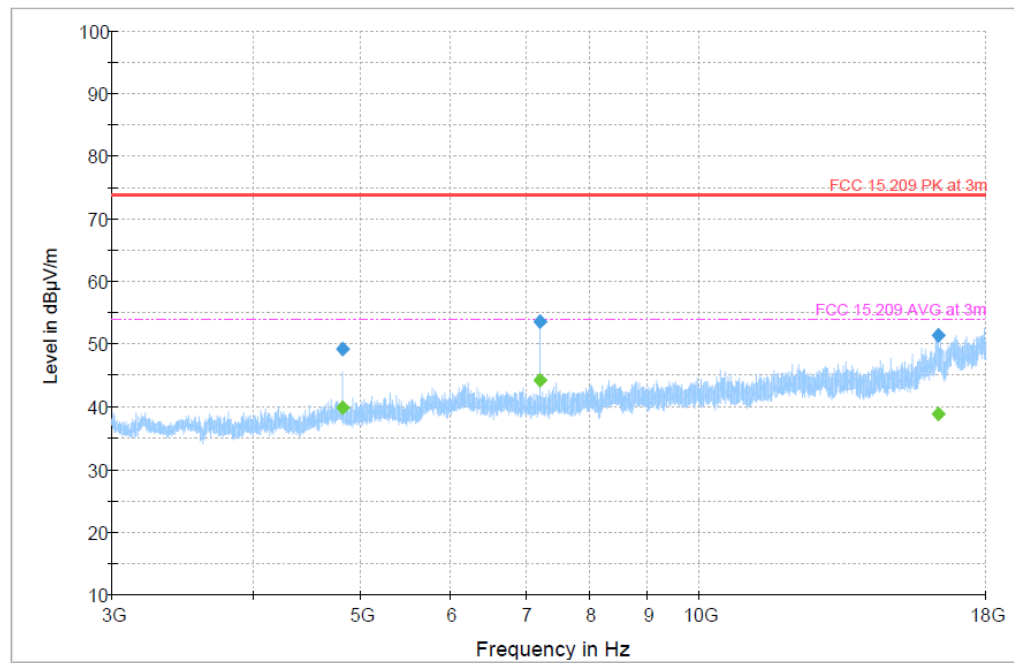
Plot # 3 Radiated Emissions: 3-18 GHz

Modulation: BLE

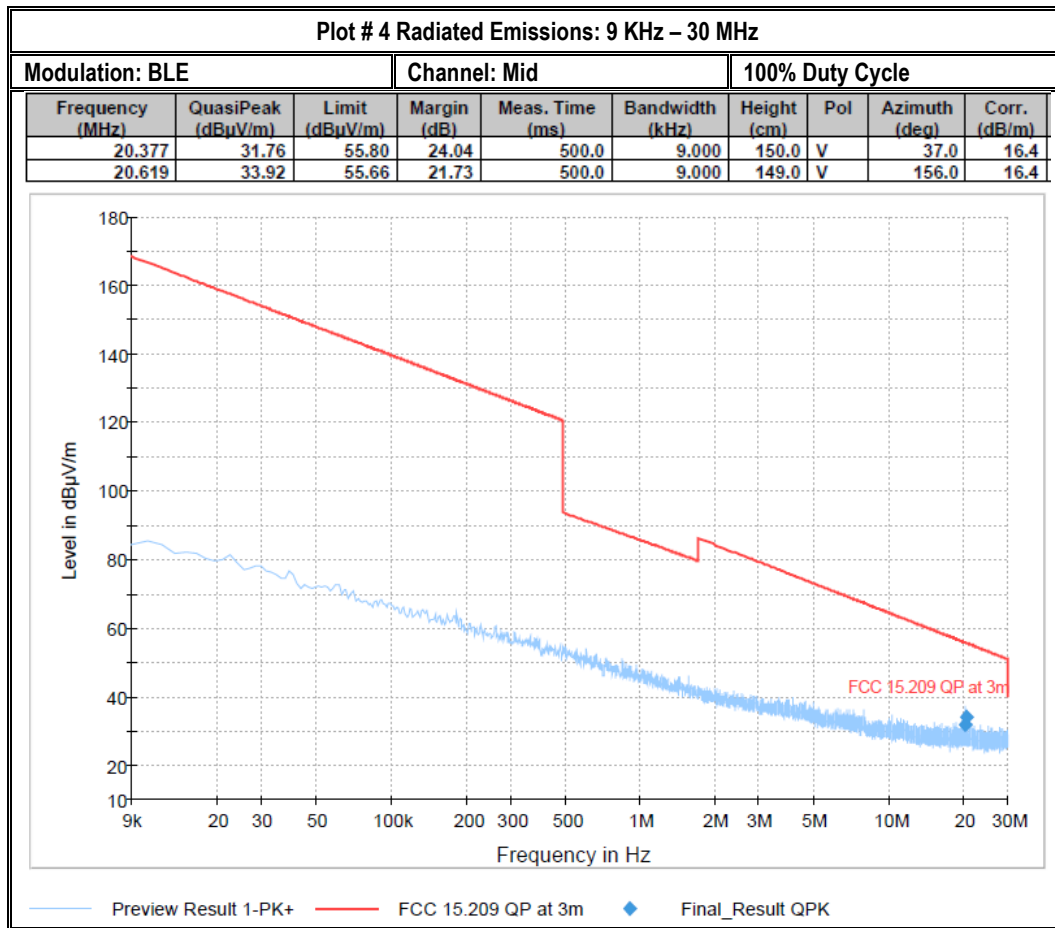
Channel: Low

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBuV/m)	CAverage (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4810.000	---	39.92	53.98	14.05	500.0	1000.000	150.0	H	314.0	-2.7
4810.000	49.18	---	73.98	24.80	500.0	1000.000	150.0	H	314.0	-2.7
7216.500	53.56	---	73.98	20.42	500.0	1000.000	309.0	V	259.0	1.1
7216.500	---	44.16	53.98	9.82	500.0	1000.000	309.0	V	259.0	1.1
16324.500	51.35	---	73.98	22.63	500.0	1000.000	240.0	V	3.0	12.2
16324.500	---	38.86	53.98	15.12	500.0	1000.000	240.0	V	3.0	12.2



Preview Result 1-PK+ Final_Result PK+ FCC 15.209 PK at 3m Final_Result CAV FCC 15.209 AVG at 3m



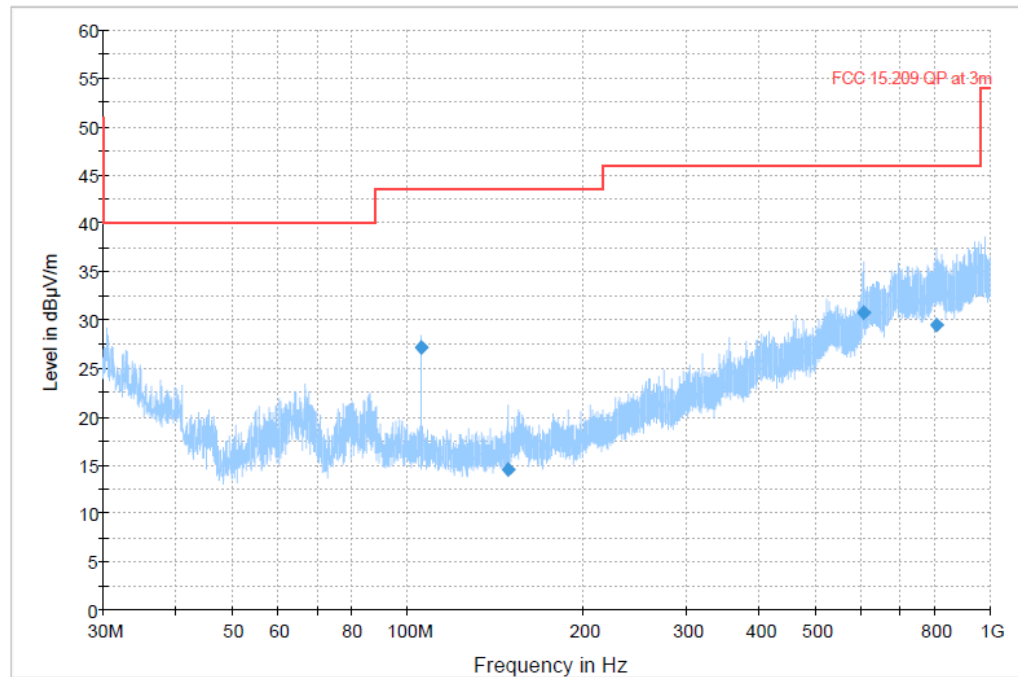
Plot # 5 Radiated Emissions: 30 MHz – 1GHz

Modulation: BLE

Channel: Mid

100% Duty Cycle

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
105.725	27.11	43.50	16.39	500.0	120.000	150.0	V	305.0	13.2
148.502	14.56	43.50	28.94	500.0	120.000	231.0	H	130.0	13.5
605.339	30.71	46.02	15.31	500.0	120.000	149.0	H	19.0	26.3
809.201	29.47	46.02	16.55	500.0	120.000	173.0	H	54.0	30.0



— Preview Result 1-PK+ — FCC 15.209 QP at 3m ◆ Final_Result QPK

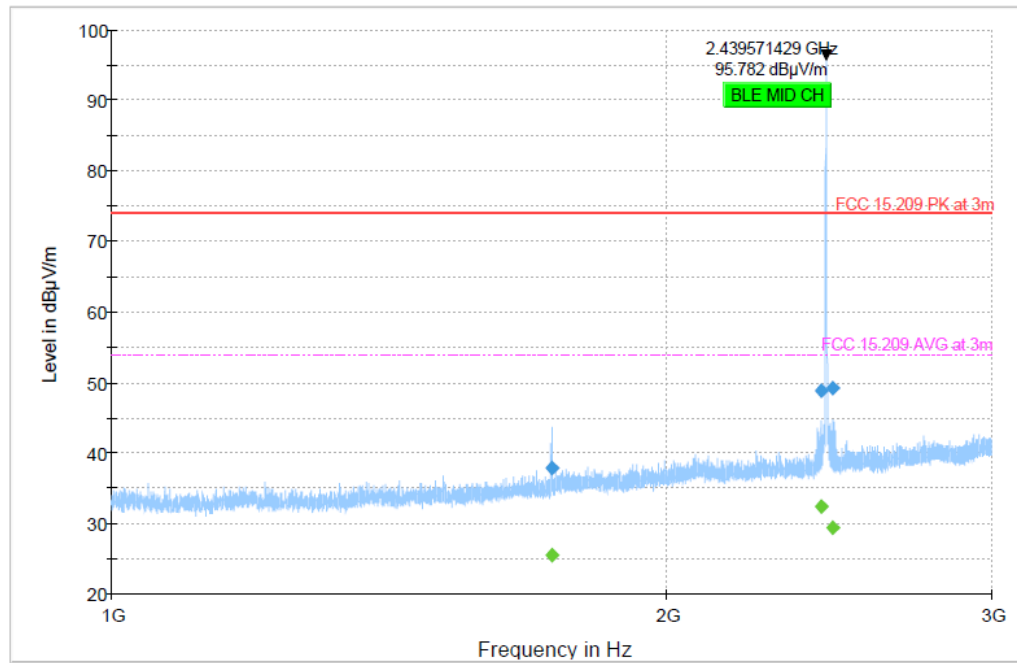
Plot # 6 Radiated Emissions: 1-3 GHz

Modulation: BLE

Channel: Mid

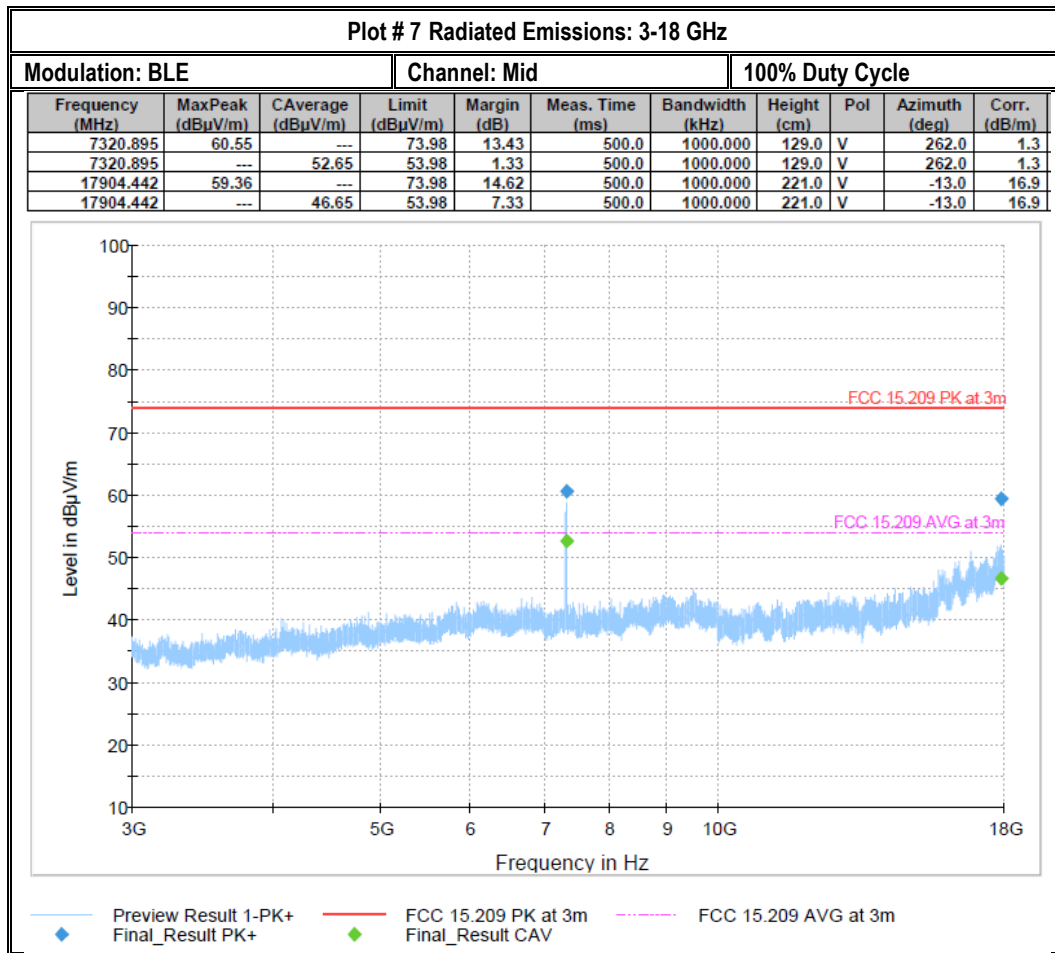
100% Duty Cycle

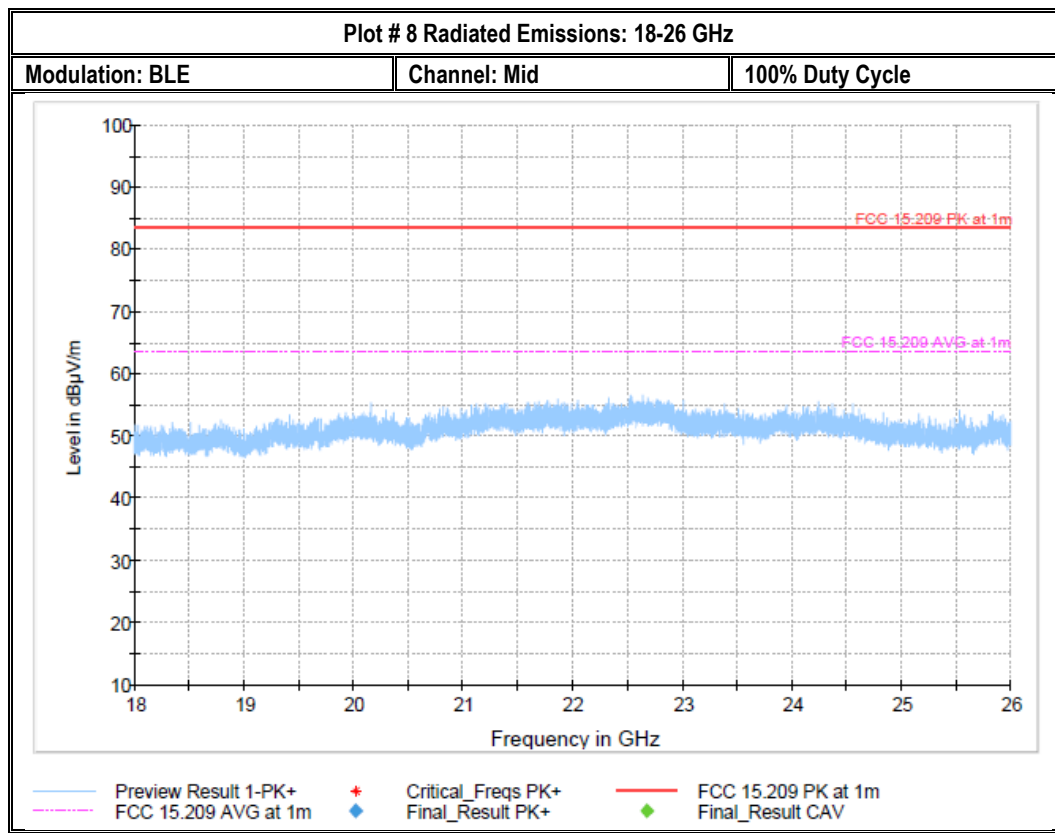
Frequency (MHz)	MaxPeak (dBuV/m)	CAverage (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1733.000	---	25.42	53.98	28.56	500.0	1000.000	298.0	V	45.0	6.0
1733.000	37.89	---	73.98	36.09	500.0	1000.000	298.0	V	45.0	6.0
2423.429	48.91	---	73.98	25.07	500.0	1000.000	243.0	H	272.0	9.0
2423.429	---	32.48	53.98	21.50	500.0	1000.000	243.0	H	272.0	9.0
2461.571	49.15	---	73.98	24.83	500.0	1000.000	267.0	H	319.0	9.4
2461.571	---	29.41	53.98	24.57	500.0	1000.000	267.0	H	319.0	9.4

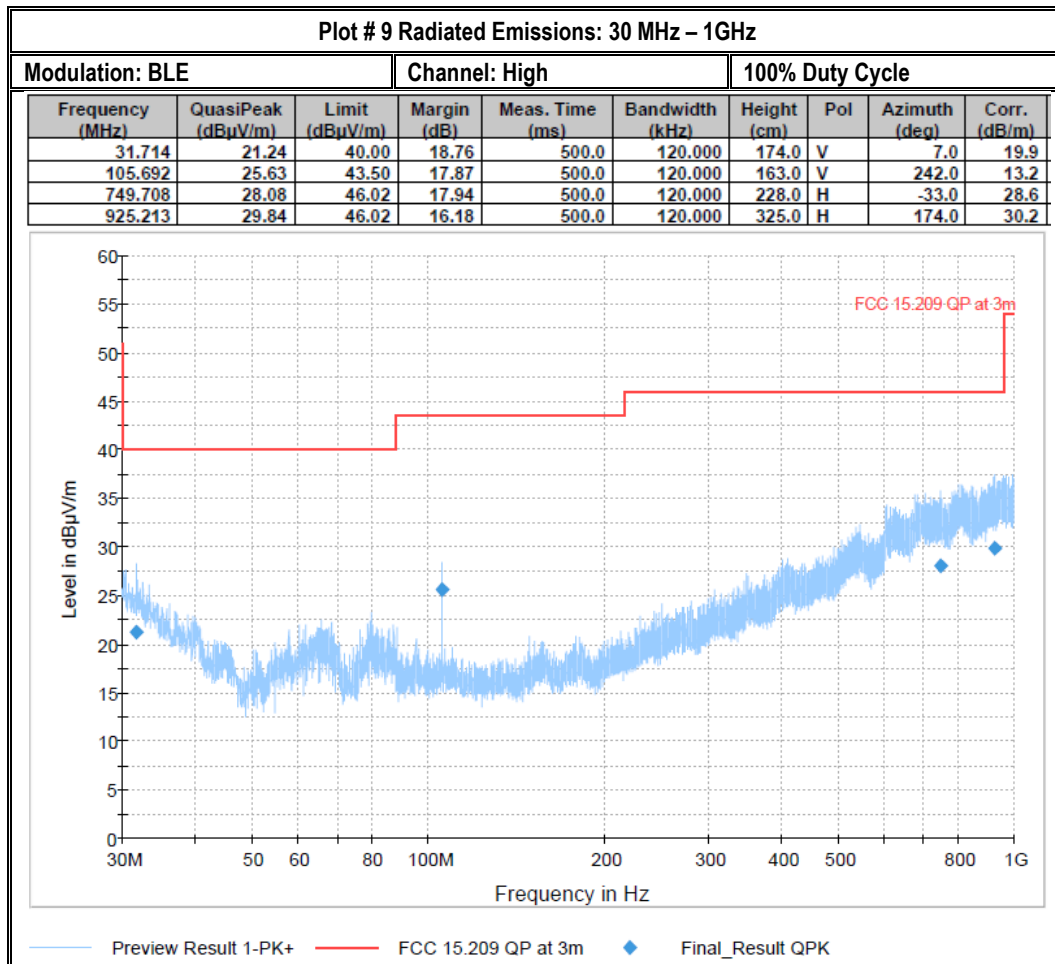


◆ Preview Result 1-PK+ Final_Result PK+ ◆ FCC 15.209 PK at 3m Final_Result CAV

— FCC 15.209 AVG at 3m







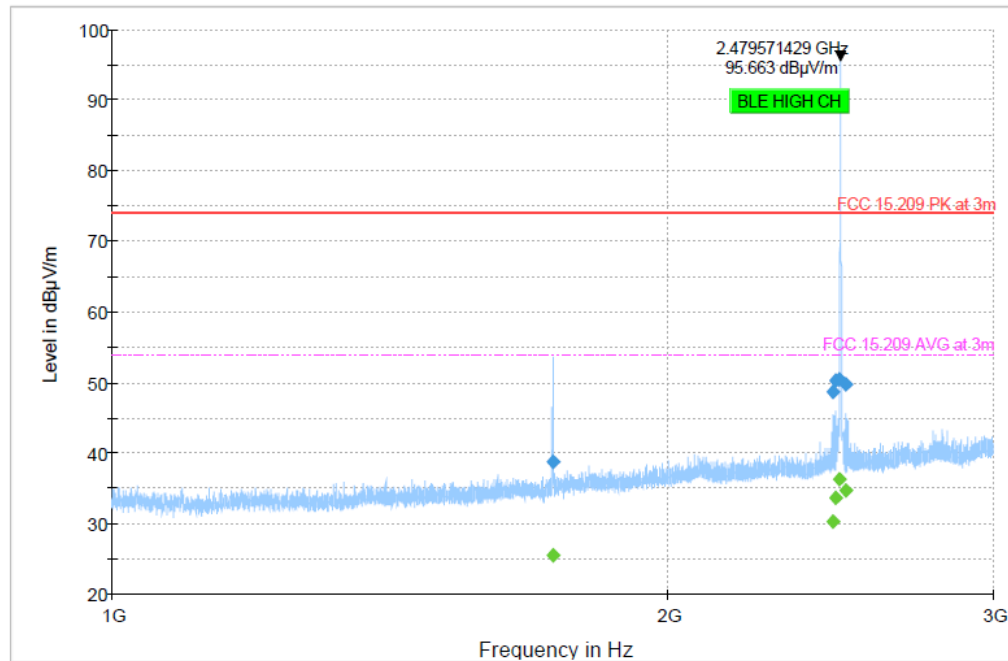
Plot # 10 Radiated Emissions: 1-3 GHz

Modulation: BLE

Channel: High

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBuV/m)	CAverage (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1733.429	38.71	---	73.98	35.27	500.0	1000.000	308.0	V	310.0	6.0
1733.429	---	25.43	53.98	28.55	500.0	1000.000	308.0	V	310.0	6.0
2455.143	---	30.30	53.98	23.68	500.0	1000.000	261.0	H	313.0	9.3
2455.143	48.67	---	73.98	25.31	500.0	1000.000	261.0	H	313.0	9.3
2463.429	50.31	---	73.98	23.66	500.0	1000.000	263.0	H	299.0	9.4
2463.429	---	33.61	53.98	20.37	500.0	1000.000	263.0	H	299.0	9.4
2475.714	50.40	---	73.98	23.58	500.0	1000.000	174.0	H	298.0	9.5
2475.714	---	36.27	53.98	17.71	500.0	1000.000	174.0	H	298.0	9.5
2495.857	49.65	---	73.98	24.33	500.0	1000.000	206.0	H	319.0	9.7
2495.857	---	34.77	53.98	19.21	500.0	1000.000	206.0	H	319.0	9.7



Preview Result 1-PK+ Final_Result PK+ FCC 15.209 PK at 3m Final_Result CAV FCC 15.209 AVG at 3m

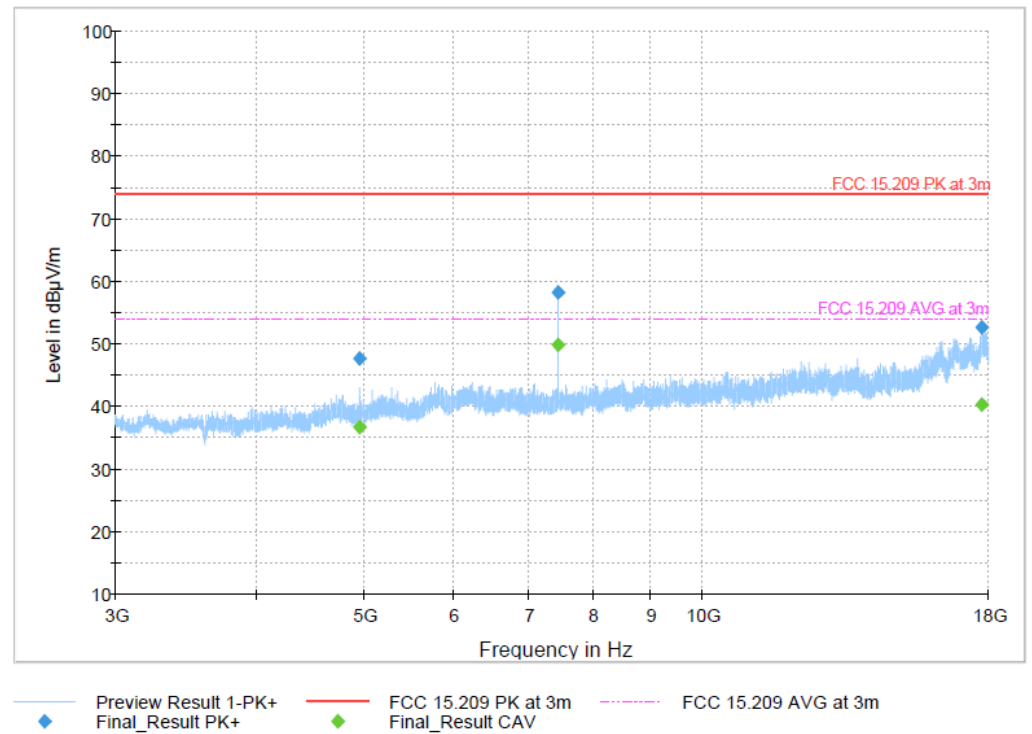
Plot # 11 Radiated Emissions: 3-18 GHz

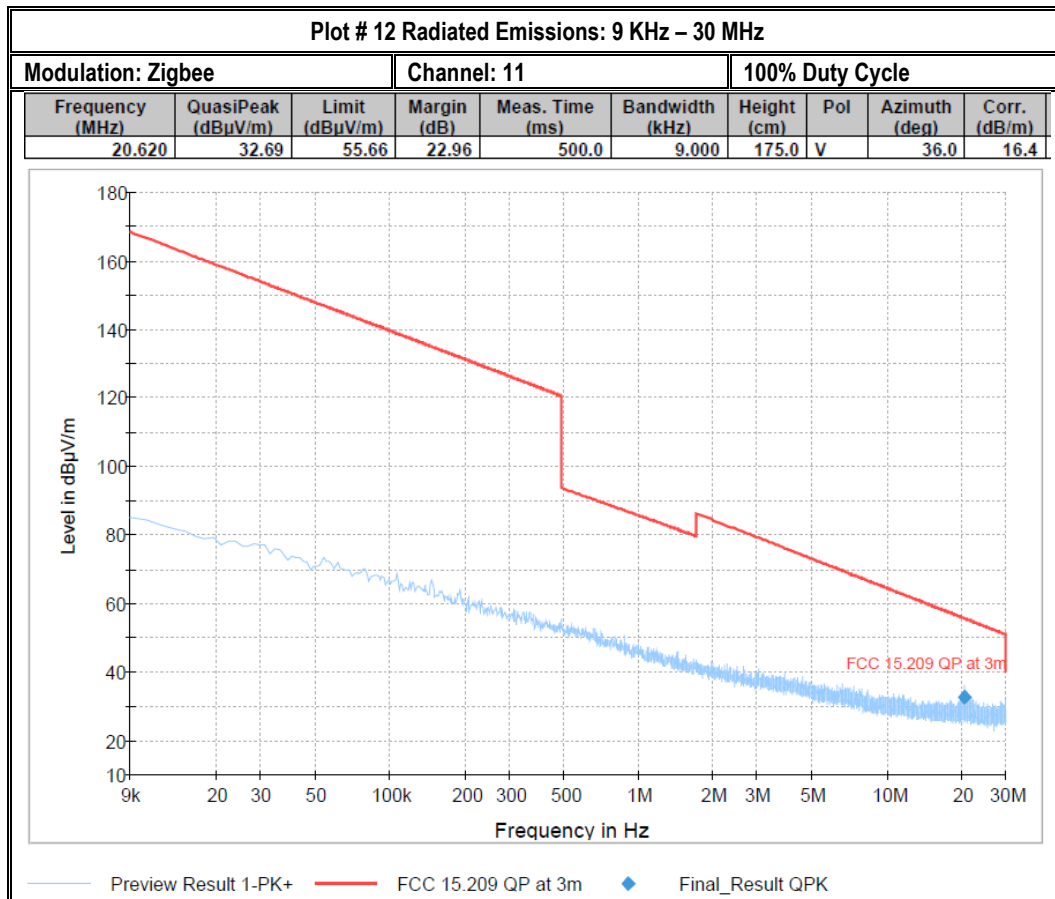
Modulation: BLE

Channel: High

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4959.000	47.65	---	73.98	26.33	500.0	1000.000	287.0	H	315.0	-3.1
4959.000	---	36.77	53.98	17.21	500.0	1000.000	287.0	H	315.0	-3.1
7441.500	58.11	---	73.98	15.87	500.0	1000.000	175.0	V	269.0	1.5
7441.500	---	49.73	53.98	4.25	500.0	1000.000	175.0	V	269.0	1.5
17747.000	---	40.28	53.98	13.70	500.0	1000.000	315.0	H	273.0	15.9
17747.000	52.56	---	73.98	21.42	500.0	1000.000	315.0	H	273.0	15.9





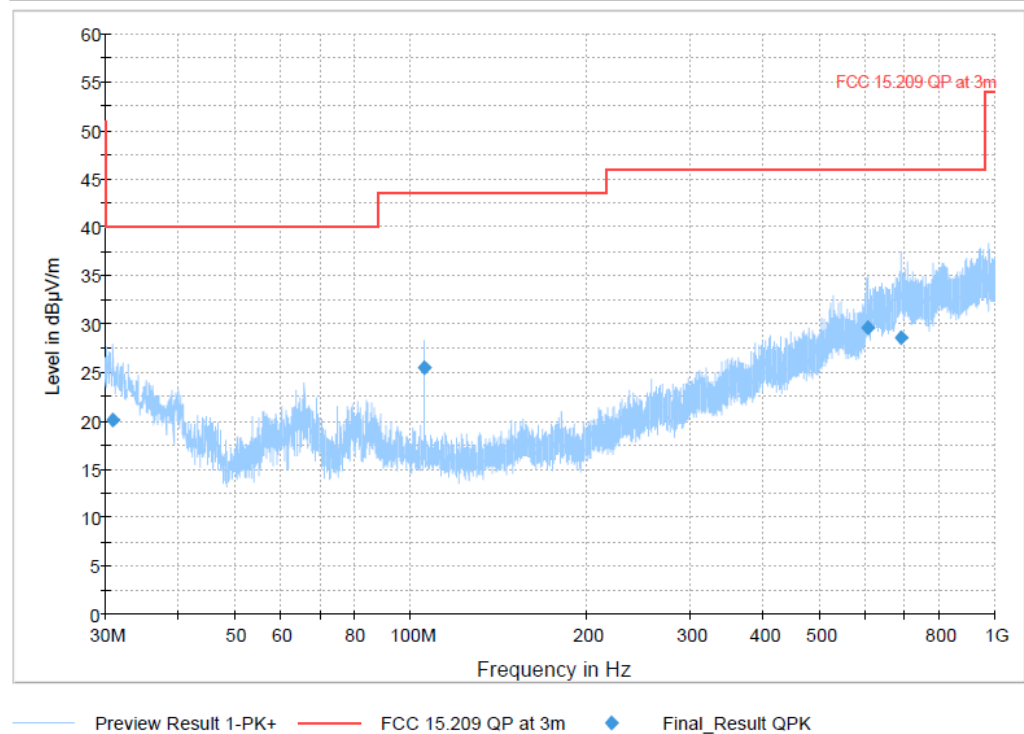
Plot # 13 Radiated Emissions: 30 MHz – 1GHz

Modulation: Zigbee

Channel: 11

100% Duty Cycle

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.905	20.15	40.00	19.85	500.0	120.000	260.0	V	83.0	20.4
105.692	25.52	43.50	17.98	500.0	120.000	163.0	V	202.0	13.2
605.921	29.59	46.02	16.43	500.0	120.000	237.0	H	260.0	26.4
692.284	28.59	46.02	17.43	500.0	120.000	218.0	V	303.0	29.1



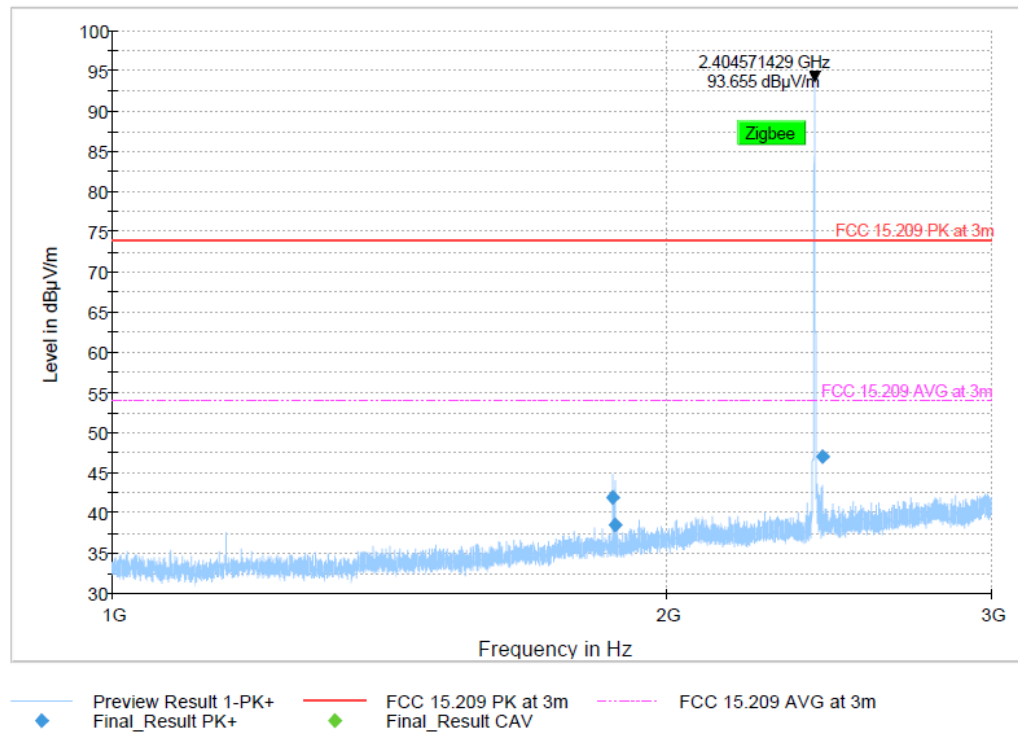
Plot # 14 Radiated Emissions: 1-3 GHz

Modulation: Zigbee

Channel: 11

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBuV/m)	CAverage (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1869.000	41.90	---	73.98	32.08	500.0	1000.000	325.0	V	311.0	6.8
1869.000	---	26.54	53.98	27.44	500.0	1000.000	325.0	V	311.0	6.8
1873.571	---	25.88	53.98	28.10	500.0	1000.000	325.0	V	69.0	6.9
1873.571	38.56	---	73.98	35.42	500.0	1000.000	325.0	V	69.0	6.9
2429.714	46.99	---	73.98	26.99	500.0	1000.000	305.0	H	268.0	9.0
2429.714	---	29.98	53.98	24.00	500.0	1000.000	305.0	H	268.0	9.0



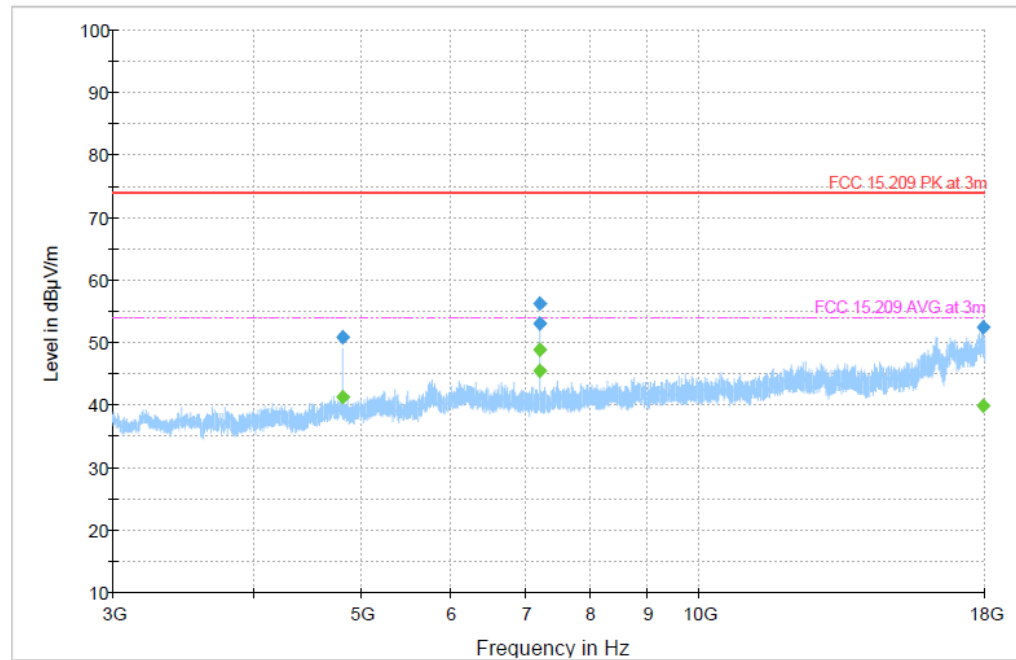
Plot # 15 Radiated Emissions: 3-18 GHz

Modulation: Zigbee

Channel: 11

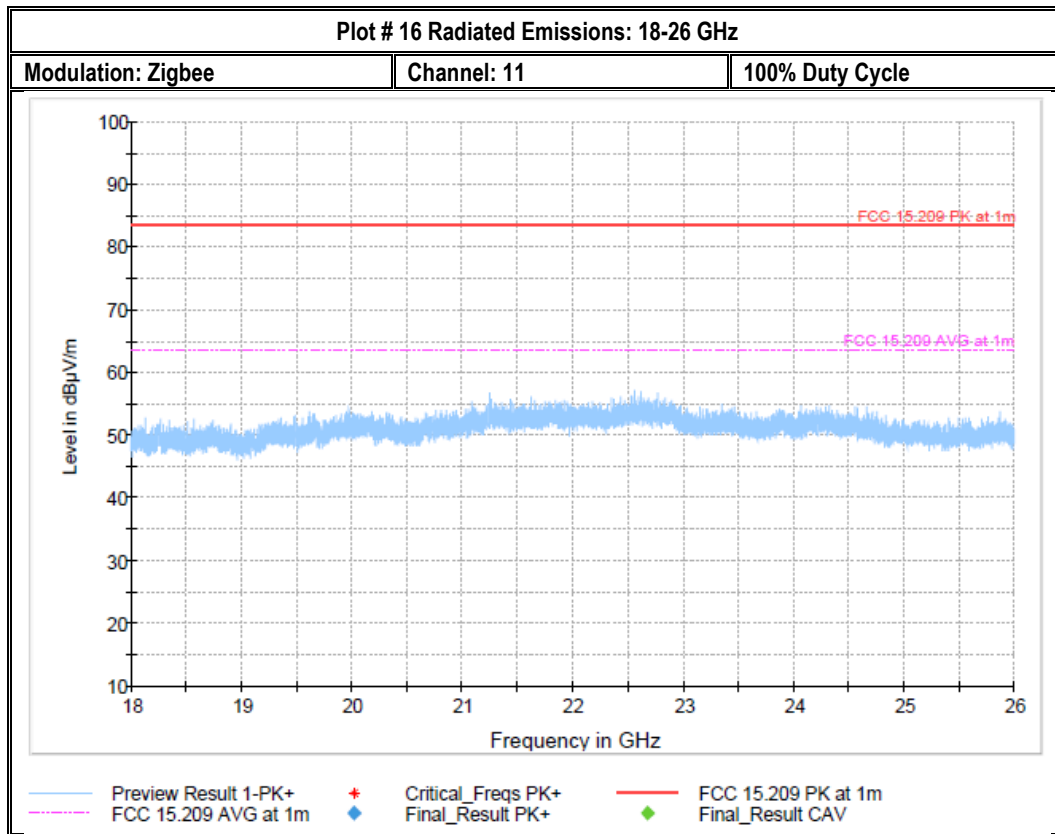
100% Duty Cycle

Frequency (MHz)	MaxPeak (dBuV/m)	CAverage (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4809.000	---	41.34	53.98	12.64	500.0	1000.000	163.0	H	321.0	-2.7
4809.000	50.89	---	73.98	23.09	500.0	1000.000	163.0	H	321.0	-2.7
7214.000	53.03	---	73.98	20.95	500.0	1000.000	286.0	V	273.0	1.1
7214.000	---	45.39	53.98	8.58	500.0	1000.000	286.0	V	273.0	1.1
7216.500	---	48.90	53.98	5.08	500.0	1000.000	175.0	V	274.0	1.1
7216.500	56.21	---	73.98	17.77	500.0	1000.000	175.0	V	274.0	1.1
17961.000	52.37	---	73.98	21.61	500.0	1000.000	198.0	V	18.0	16.4
17961.000	---	39.97	53.98	14.01	500.0	1000.000	198.0	V	18.0	16.4



◆ Preview Result 1-PK+ Final_Result PK+ ◆ FCC 15.209 PK at 3m Final_Result CAV

— FCC 15.209 PK at 3m — FCC 15.209 AVG at 3m



8.6 AC Power Line Conducted Emissions

8.6.1 Measurement according to ANSI C63.4

Analyzer Settings:

- RBW = 9 KHz (CISPR Bandwidth)
- Detector: Peak / Average for Pre-scan
- Quasi-Peak/Average for Final Measurements

8.6.2 Limits: §15.207 & RSS-Gen 8.8

FCC §15.207(a) & RSS-Gen 8.8

- Except as shown in paragraphs (b) and (c) of this section of the CFR, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table (1), as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between frequency ranges.

Frequency of emission (MHz)	Conducted limit (dB μ V)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases with the logarithm of the frequency.

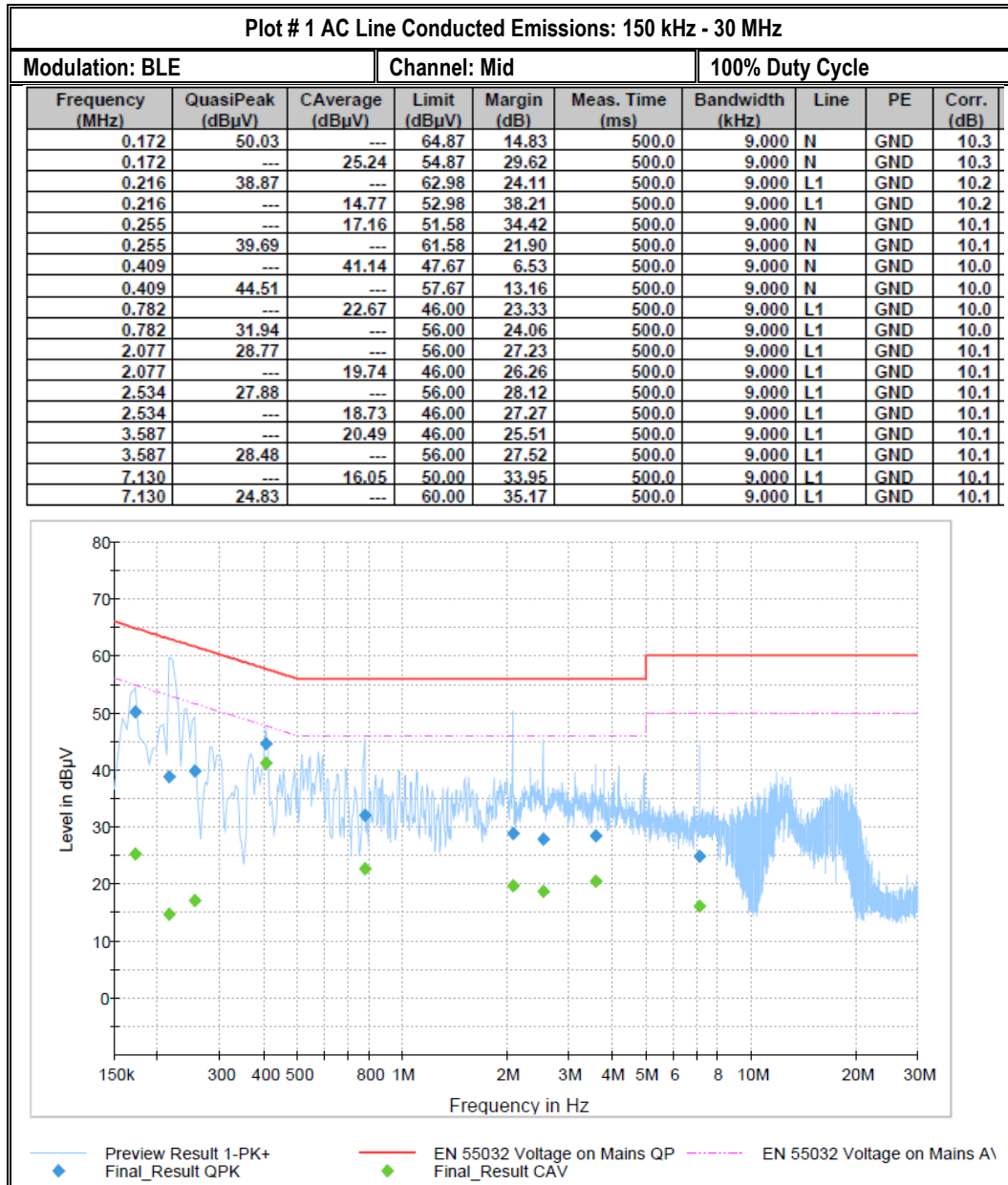
8.6.3 Test conditions and setup:

Ambient Temperature ©	EUT Set-Up #	EUT operating mode	Power line (L1, L2, L3, N)	Power Input
22° C	1	BLE continuous fixed channel	Line & Neutral	110V / 60Hz

8.6.4 Measurement Result:

Plot #	Port	EUT Set-Up #:	EUT operating mode	Scan Frequency	Limit	Result
1	AC Mains	1	BLE continuous fixed channel	150 kHz – 30 MHz	See section 8.6.2	Pass

8.6.5 Measurement Plots:



9 Test setup photos

Setup photos are included in supporting file name: "EMC_MPCON-004-21001_15.247_DTS_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Name/Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
EMI Receiver	Rohde & Schwarz	ESU 40	100251	3 Years	9/13/2021
Signal Analyzer	Rohde & Schwarz	FSV40	101022	3 Years	9/14/2021
Active Loop antenna	ETS Lindgren	6507	161344	3 Years	10/30/2020
Loop antenna	ETS Lindgren	6512	49383	3 Years	7/27/2020
Biconlog Antenna	EMCO	3142E	166067	3 years	3/12/2020
Horn Antenna	EMCO	3115	35114	3 years	8/10/2020
Horn Antenna	ETS Lindgren	3117-PA	215984	3 years	1/31/2021
Horn Antenna	ETS Lindgren	3116C-PA	169535	3 years	9/30/2020
LISN	FCC	FCC-LISN-50-25-2-08	8014	3 Years	8/31/2021
10db Pulse Limiter	Rohde & Schwarz	ESH3-Z2	102473	3 Years	8/25/2020
Digital Thermometer	Control Company	36934-164	191871986	3 Years	10/20/2021
Digital Barometer	VWR	10510-922	200236891	3 Years	4/13/2020

Note: 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 status either do not specifically require calibration or is internally characterized before use.

11 History

Date	Template Revision	Changes to report	Prepared by	Approved by
2022-03-29	EMC_MPCON-004-21001_15.247_BTLE_DTS	Initial Version	Kris Lazarov	

<<< The End >>>