



FCC / ISED Test Report

For:

Universal Audio, Inc.

Model Name:

GPM-LION

Product Description:

Guitar Effects Pedal

FCC ID: 2AXKQ2077

ISED: 26610-2077

Applied Rules and Standards:

47 CFR Part 15.247 (DTS)

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

REPORT #: EMC_UNIVE_031_23001_15_247_BTLE_DTS_Rev1

DATE: 2023-09-29



A2LA Accredited

IC recognized #
3462B

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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 Name	Product Description	Model No.
Universal Audio, Inc.	Guitar Effects Pedal	GPM-LION

Responsible for Testing Laboratory:

Arndt Stoecker

2023-09-29

Compliance

(Director of Regulatory Services)

Date	Section	Name	Signature
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Responsible for the Report:

Art Thammanavarat

2023-09-29

Compliance

(Senior EMC Engineer)

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
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:	Arndt Stoecker
Responsible Project Leader:	Cathy Palacios

2.2 Identification of the Client

Applicant's Name:	Universal Audio, Inc.
Street Address:	4585 Scotts Valley Drive
City/Zip Code	Scotts Valley, CA 95066
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

Product Description:	Guitar Effects Pedal
Model Name :	GPM-LION
HW Version :	10007488
SW Version :	1.1.5
FCC-ID :	2AXKQ2077
IC :	26610-2077
Frequency Range / number of channels:	Nominal band: 2400 MHz – 2483.5 MHz; Center to center: 2402 MHz (ch 0) – 2480 MHz (ch 39), 40 channels
Bands/Modes Supported	<u>Bluetooth Modules</u> Model Name : Nordic NRF52810_QCAA-R <u>Wireless Technologies</u> BLE 5.0
Modes of Operation:	Bluetooth LE in both advertising and connected mode of operation
Antenna Information as declared:	max gain 0 dBi
Max. Peak Output Power:	Original Power: 3.22 dBm *
Other Radios included in the device	N/A
Power Supply/ Rated Operating Voltage Range	100-240 VAC
Operating Temperature Range	-10 °C to 40 °C
Sample Revision	☐ Production ☒ Pre-Production
EUT Dimensions	147mm x 91mm x 65mm
Weight	605 grams
EUT Diameter	☒ < 60 cm ☐ Other _____

* Note: Please refer to section 8.1 for power verification to compare with Original Power.

3.2 EUT Sample details

EUT #	Model Number	HW Version	SW Version	Serial Number
1	GPM-LION	10007488	1.1.5	23212077000121

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	N/A	N/A	N/A	N/A

3.4 Support Equipment (SE) details

SE #	Type	Model	Manufacturer	Serial Number
1	Power Supply	PSAC12R-090	Phihong	N/A
2	Mobile Phone	iPod Touch	Apple	N/A
3	Headphones	VHP-100	VCLT	N/A
4	12-Channel Mic/Line Mixer	1202-VLZPRO	Mackie	(21)BU93853
5	Notebook PC	UX325E	ASUS	12M

3.5 Test Setup Configurations

Set-up #	EUT / SE used for set-up	Comments
1	EUT1 + SE1 + SE2 + SE3 + SE4 + SE5	EUT in fully functional mode, while BLE radio active

3.6 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1	The radio of the EUT was configured to a fixed channel transmission with highest possible duty cycle, USB-Type C adaptor provided by the client used to communicate with the device and send commands, that will not be available to the end-user to configure the BLE radio to: • Maximum output power setting $\pm$ +4 dBm • Continuous transmission • Modulated signal • Select data rate: 2Mb/s (worst case) • Select TX channel(s) ○ Low $\pm$ 2402 MHz ○ Mid $\pm$ 2442 MHz ○ High $\pm$ 2480 MHz

3.7 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 highest possible 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: 2AXKQ2077 IC ID: 26610-2077.

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 1: NA= Not Applicable

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 $k=2$.

Radiated measurement

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

RF conducted measurement ± 0.5 dB

According to TR 102 273 a multiplicative propagation of error is assumed for RF measurement systems. For this reason the RMS method is applied to dB values and not to linear values as appropriate for additive propagation of error. Also used: <http://physics.nist.gov/cuu/Uncertainty/typeb.html>. The above calculated uncertainties apply to direct application of the Substitution method. The Substitution method is always used when the EUT comes closer than 3dB to the limit.

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:

2023-08-02 – 2023-08-17

6.3 Decision Rule:

Cetecom advanced follows ILAC G8:2019 chapter 4.2.1 (Simple Acceptance Rule).

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3. The measurement uncertainty is mentioned in this test report, See chapter 9, but is not taken into account – neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong.

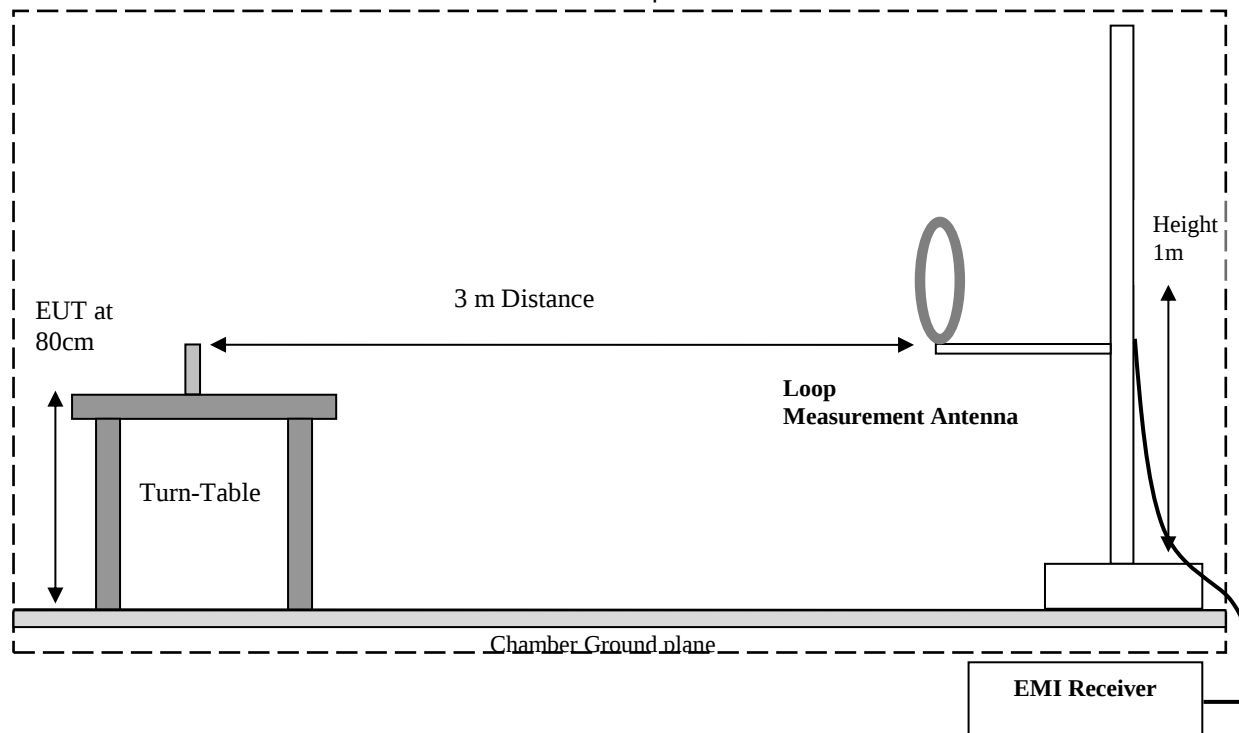
7 Measurement Procedures

7.1 Radiated Measurement

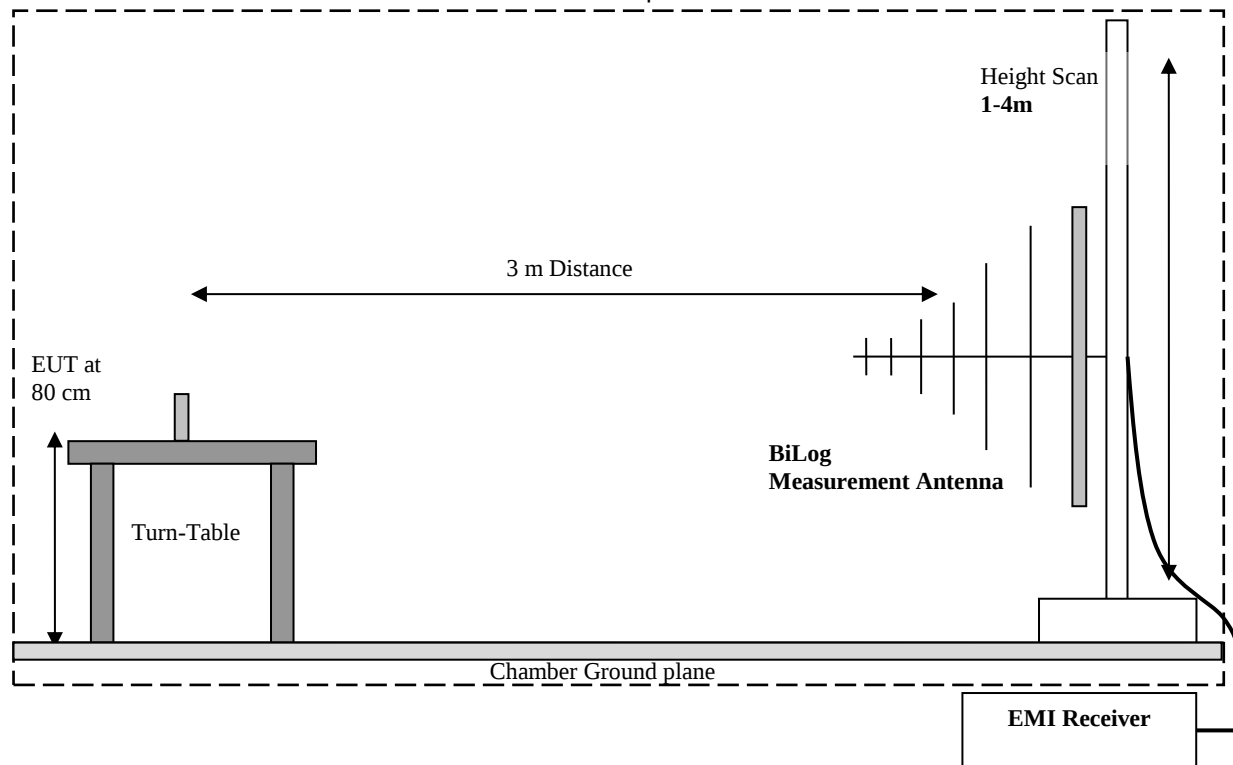
The radiated measurement is performed according to ANSI C63.10 (2013)

- 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.

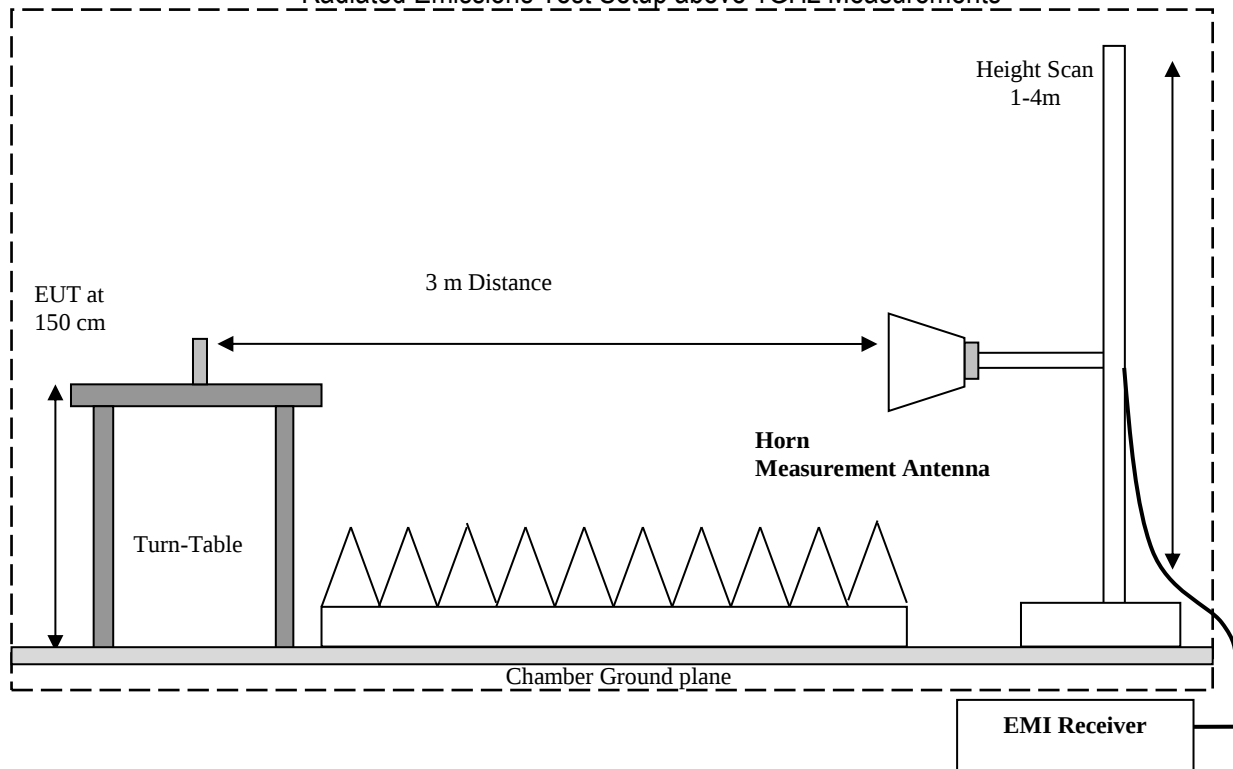
Radiated Emissions Test Setup below 30MHz Measurements



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:

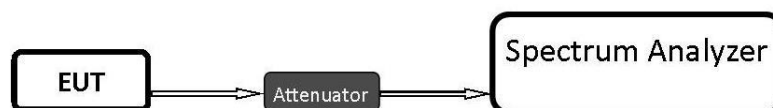
Frequency (MHz)	Measured SA (dB μ V)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dB μ V/m)
1000	80.5	3.5	14	98.0

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 Verification.

8.1.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02

Spectrum Analyzer settings:

- $RBW \geq DTS$ 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

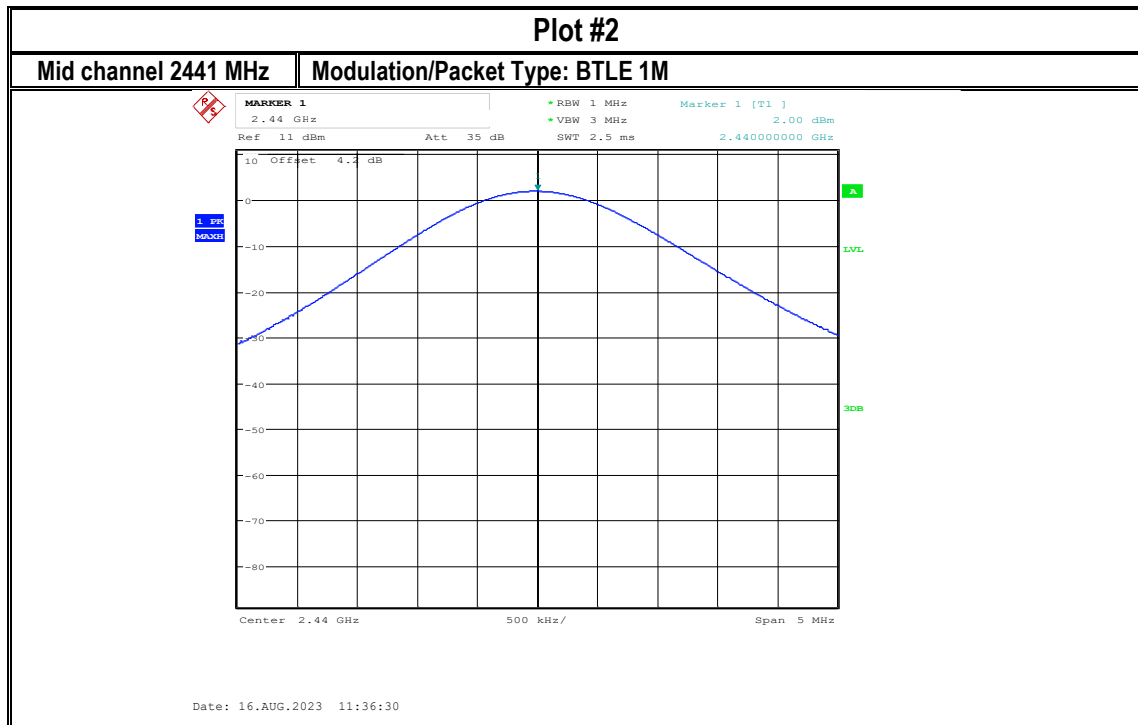
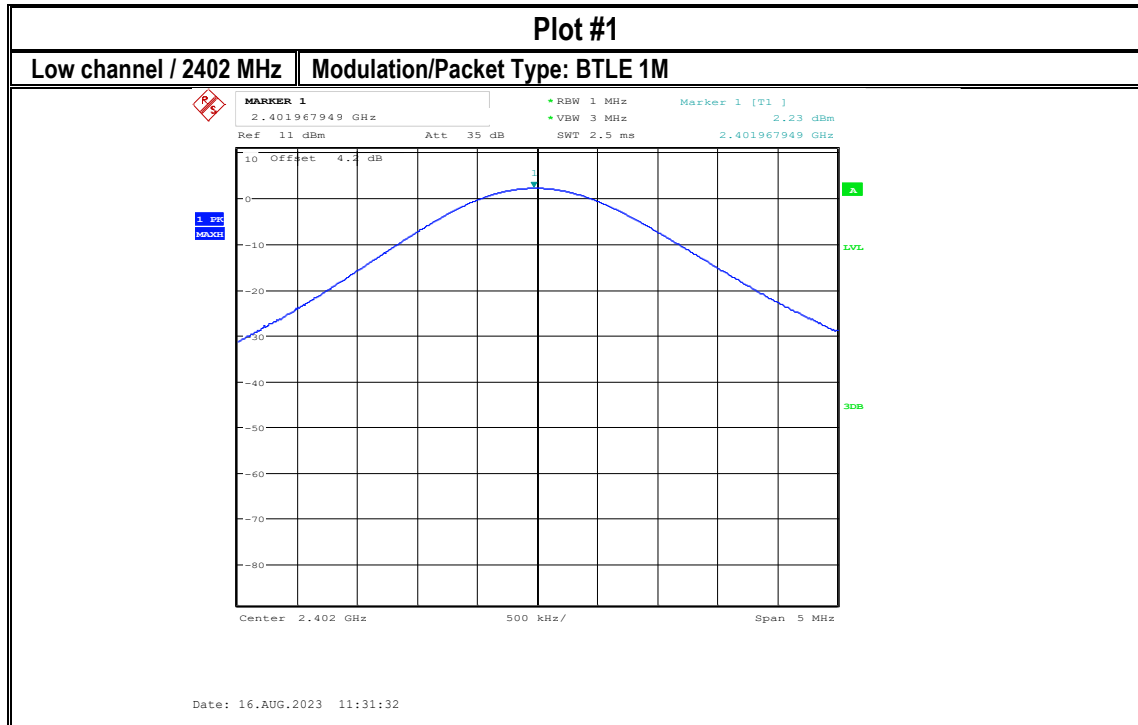
8.1.3 Test conditions and setup:

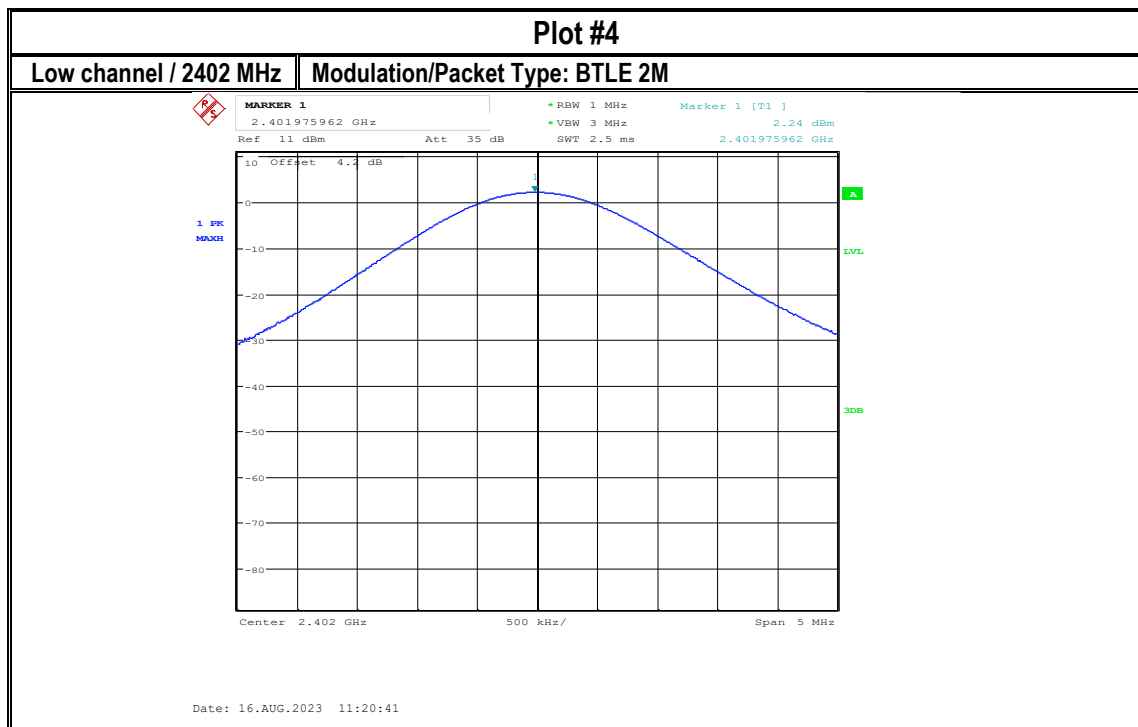
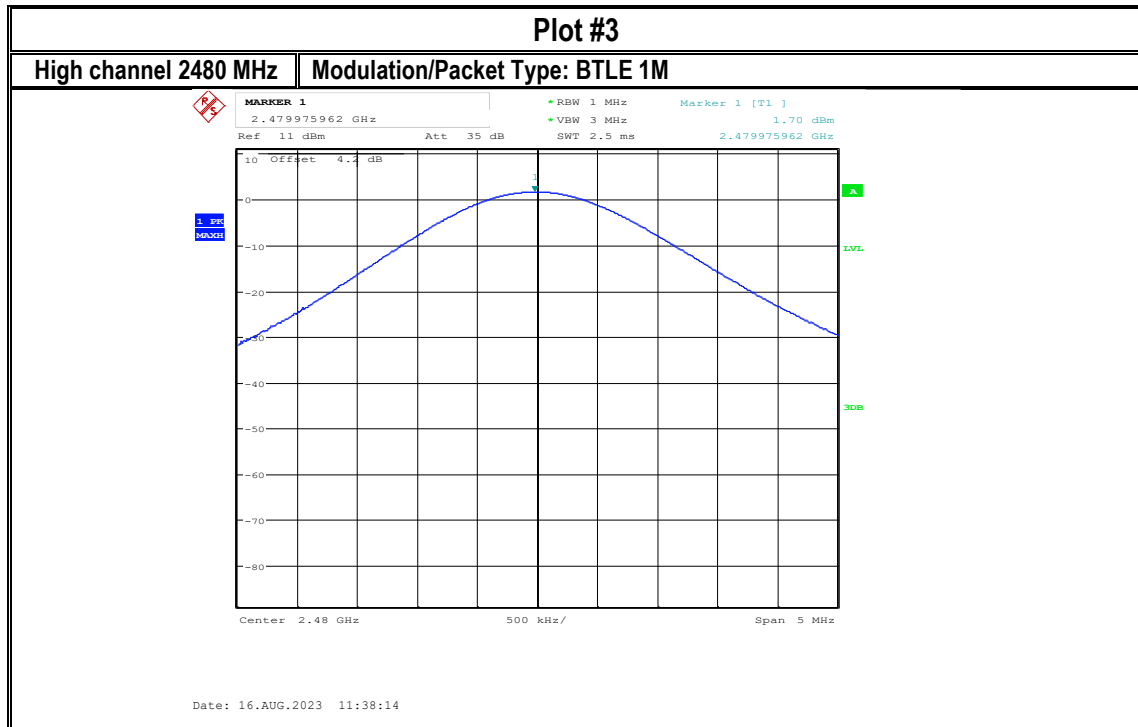
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
24° C	1	BT LE	120 VAC To 9 VDC	0 dBi

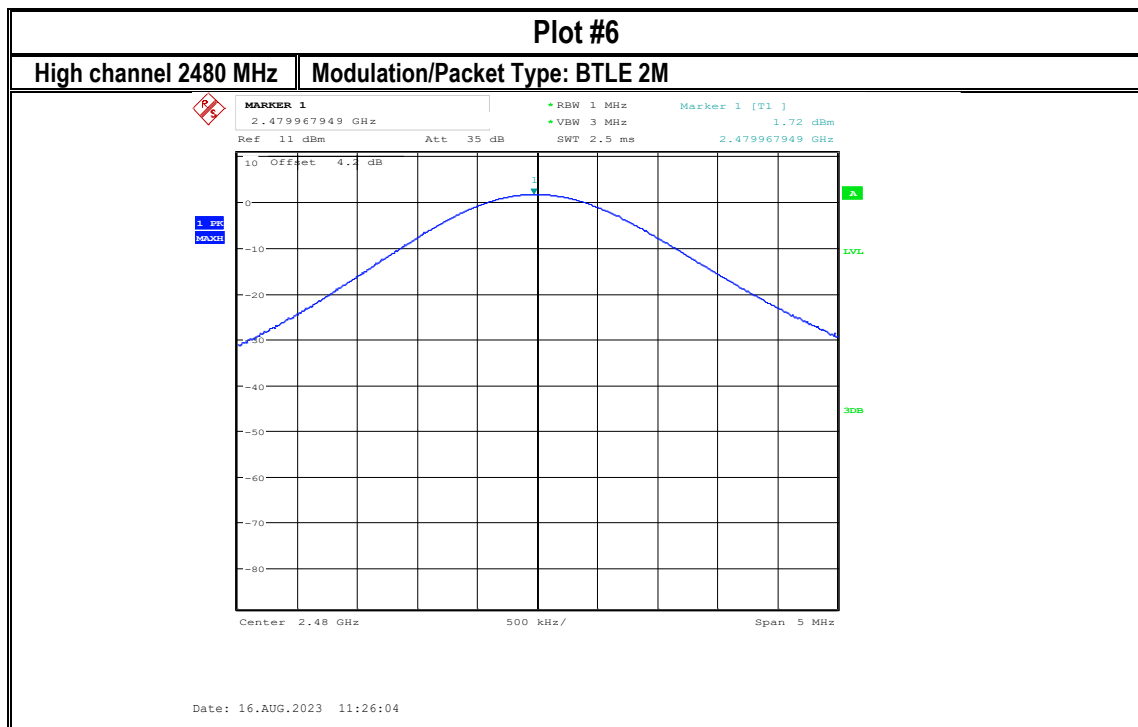
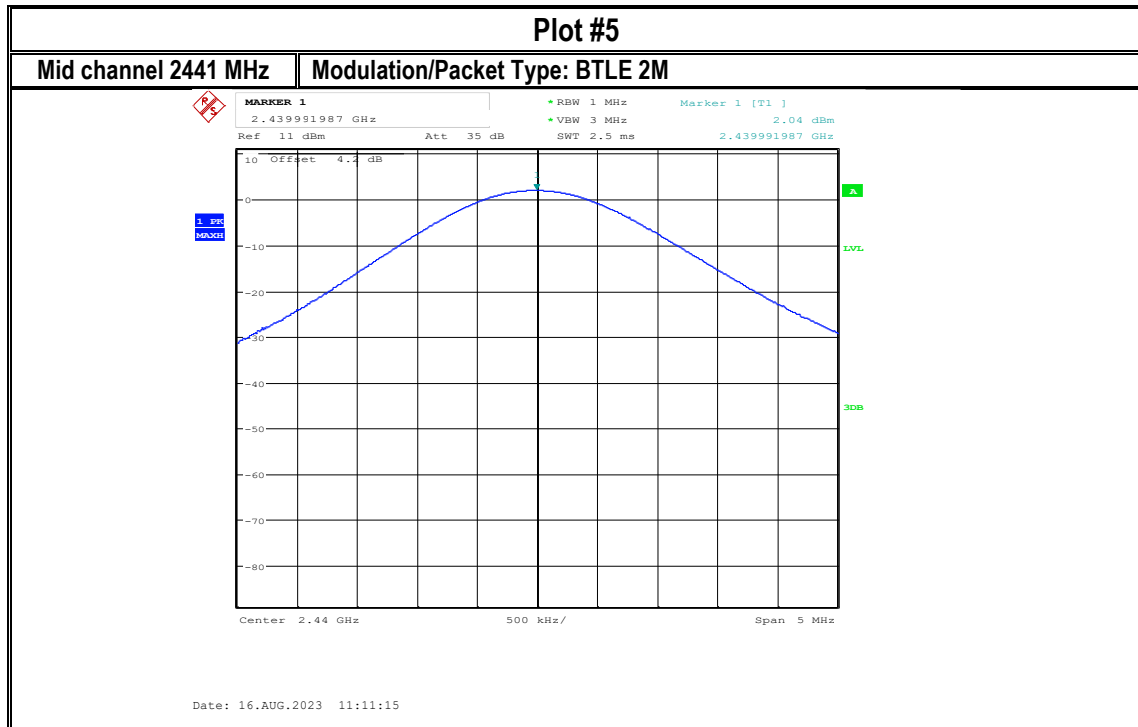
8.1.4 Measurement result:

Plot #	PHY	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	1Mbit/s	2402	2.23	2.23	30 (Pk) / 36 (EIRP)	Pass
2	1Mbit/s	2441	2.00	2.00	30 (Pk) / 36 (EIRP)	Pass
3	1Mbit/s	2480	1.70	1.70	30 (Pk) / 36 (EIRP)	Pass
4	2Mbit/s	2402	2.24	2.24	30 (Pk) / 36 (EIRP)	Pass
5	2Mbit/s	2441	2.04	2.04	30 (Pk) / 36 (EIRP)	Pass
6	2Mbit/s	2480	1.72	1.72	30 (Pk) / 36 (EIRP)	Pass

8.1.5 Measurement Plots:







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.

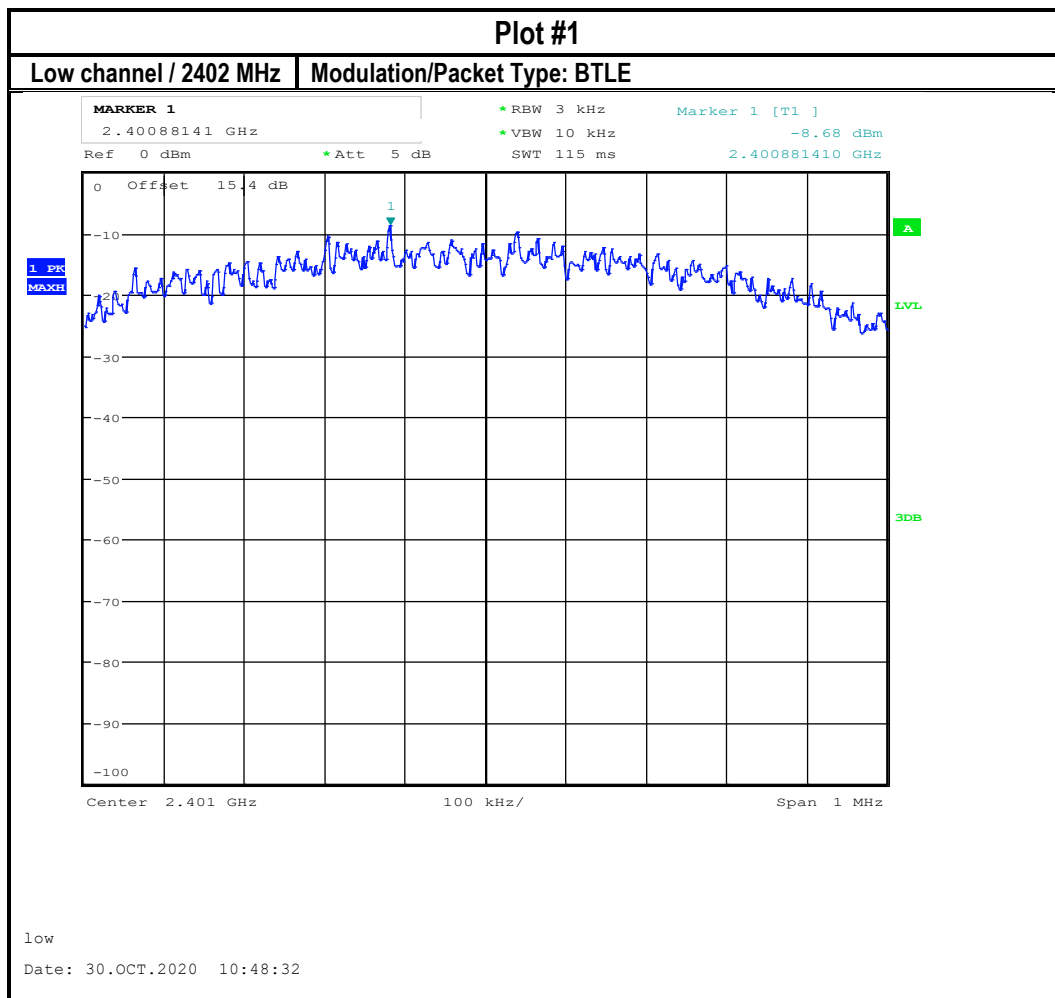
8.2.3 Test conditions and setup:

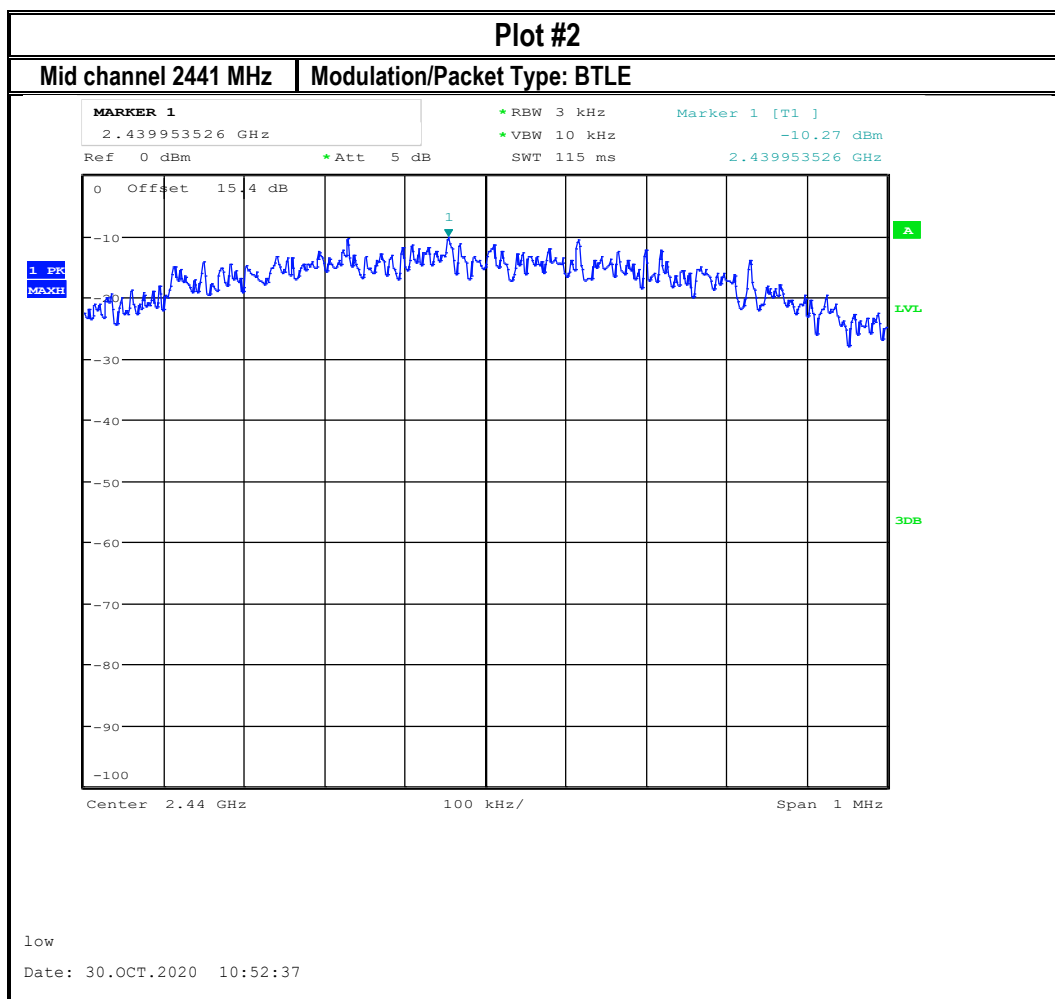
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	GFSK at 1MB	9 VDC	0 dBi

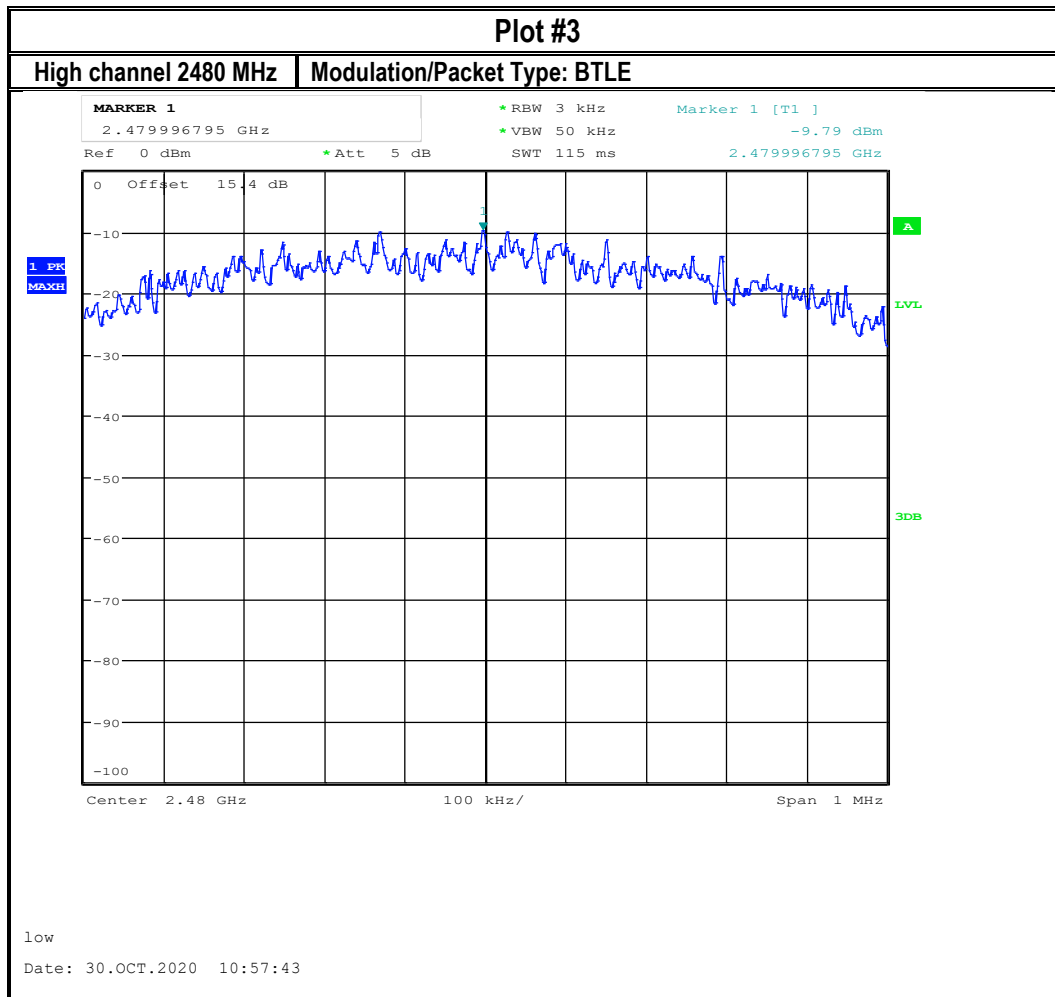
8.2.4 Measurement result:

Plot #	Frequency (MHz)	Maximum Power Spectral Density (dBm/3 kHz)	Limit (dBm / 3 kHz)	Result
1	2402	-8.68	8	Pass
2	2441	-10.27	8	Pass
3	2480	-9.97	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)).

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- 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:

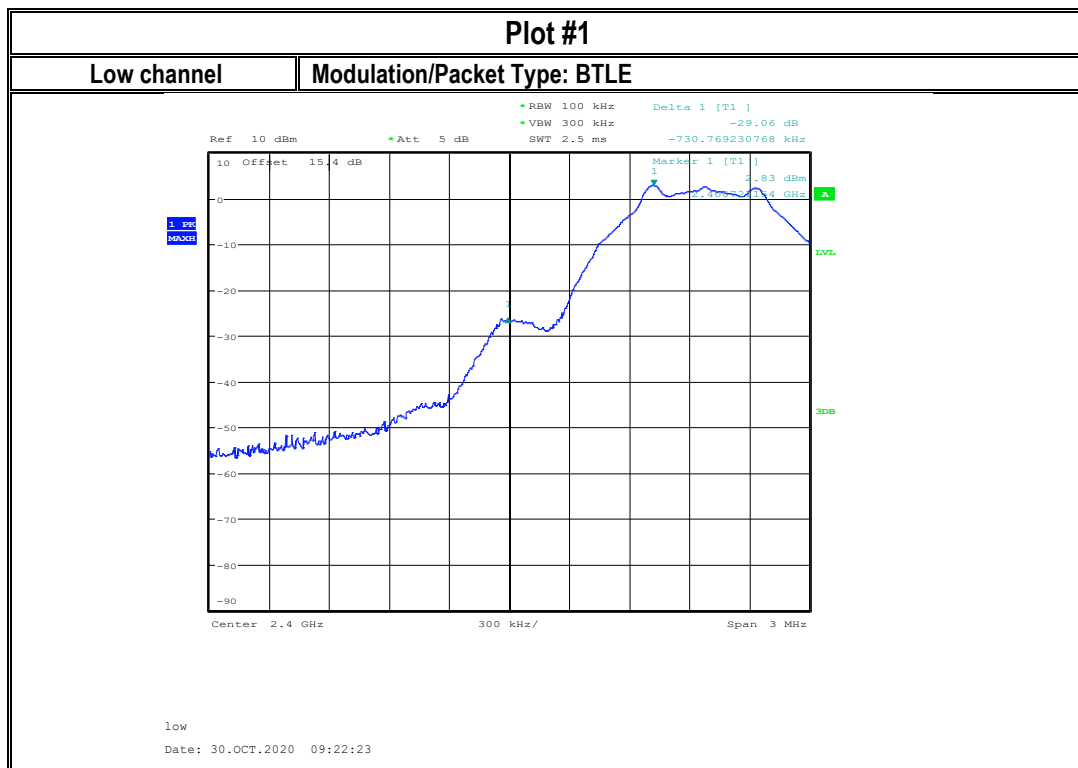
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
24° C	1	BT LE	120 VAC To 9 VDC	0 dBi

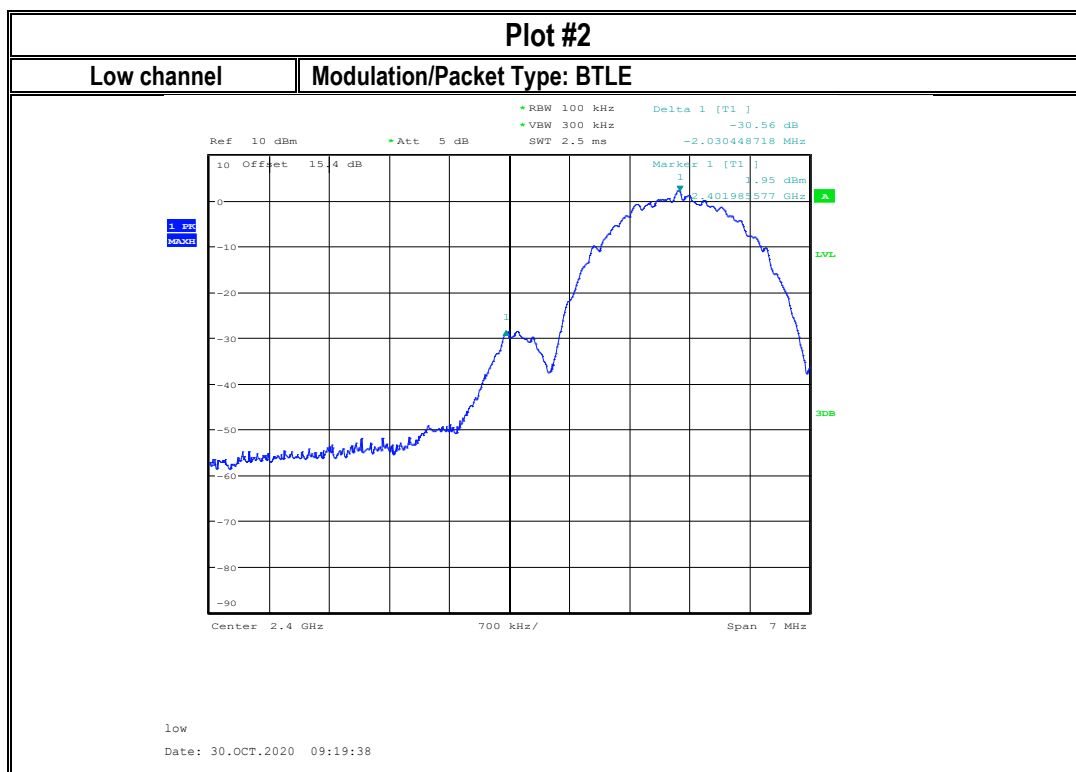
8.3.5 Measurement result:

Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	GFSK @ 1MB	Lower, Non-restricted	-29.06	-20	Pass
2	GFSK @ 2MB	Lower, Non-restricted	-30.56	-20	Pass

Plot #	EUT operating mode	Band Edge	Measured Value (dB μ V/m)	Limit (dB μ V/m)	Result
3	GFSK @ 1MB	Upper Restricted Peak	39.69	74 Peak	Pass
		Upper Restricted AVG	27.28	54 AVG	Pass
4	GFSK @ 2MB	Upper Restricted Peak	38.70	74 Peak	Pass
		Upper Restricted AVG	25.95	54 AVG	Pass

8.3.6 Measurement Plots:





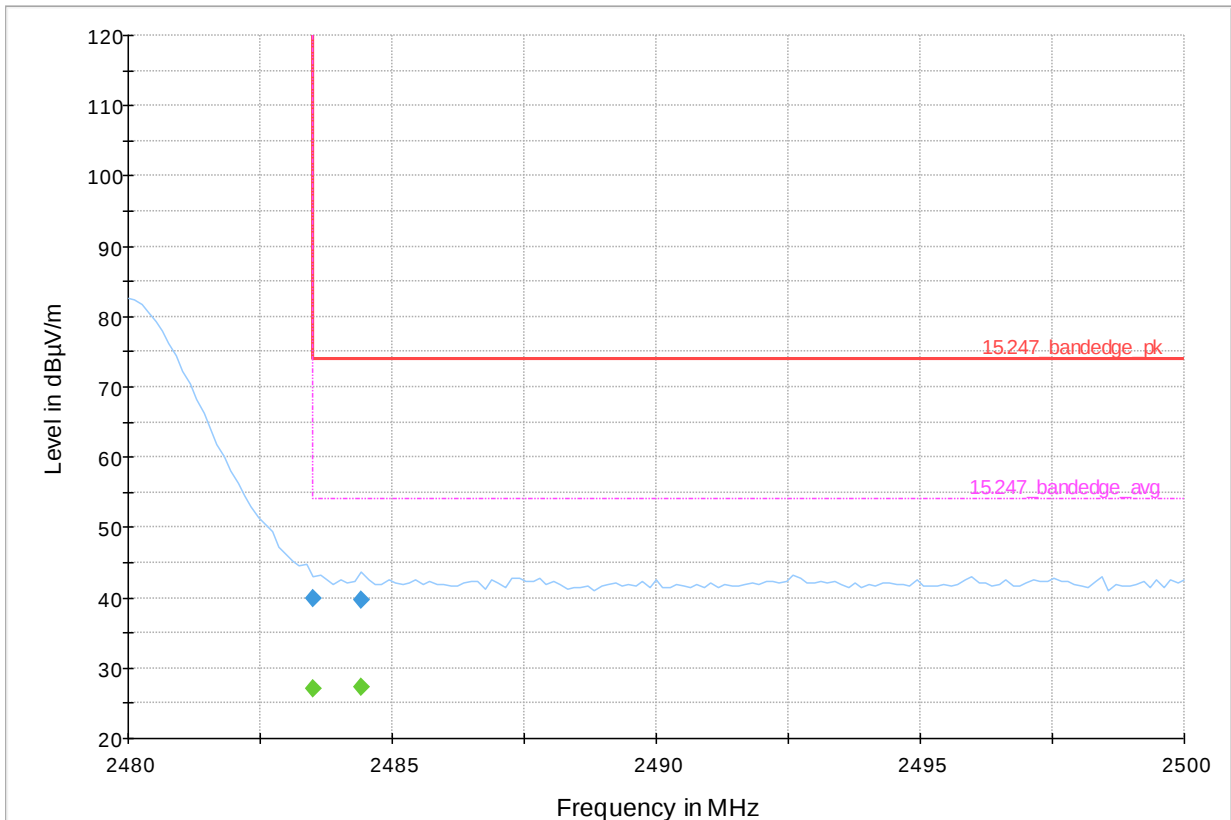
Plot #3

High channel / 2480 MHz

Modulation/Packet Type: BTLE

Final Result

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)	Comment
2483.506	39.957	---	74.00	34.04	500.0	1000.000	184.0	V	4.0	7.1	
2483.506	---	27.086	54.00	26.91	500.0	1000.000	184.0	V	4.0	7.1	
2484.416	39.685	---	74.00	34.32	500.0	1000.000	165.0	V	42.0	7.1	
2484.416	---	27.275	54.00	26.72	500.0	1000.000	165.0	V	42.0	7.1	



—◆— Preview Result 1-PK+ Final_Result PK+
 —◆— 15.247_bandedge_pk Final_Result CAV
 —◆— 15.247_bandedge_avg

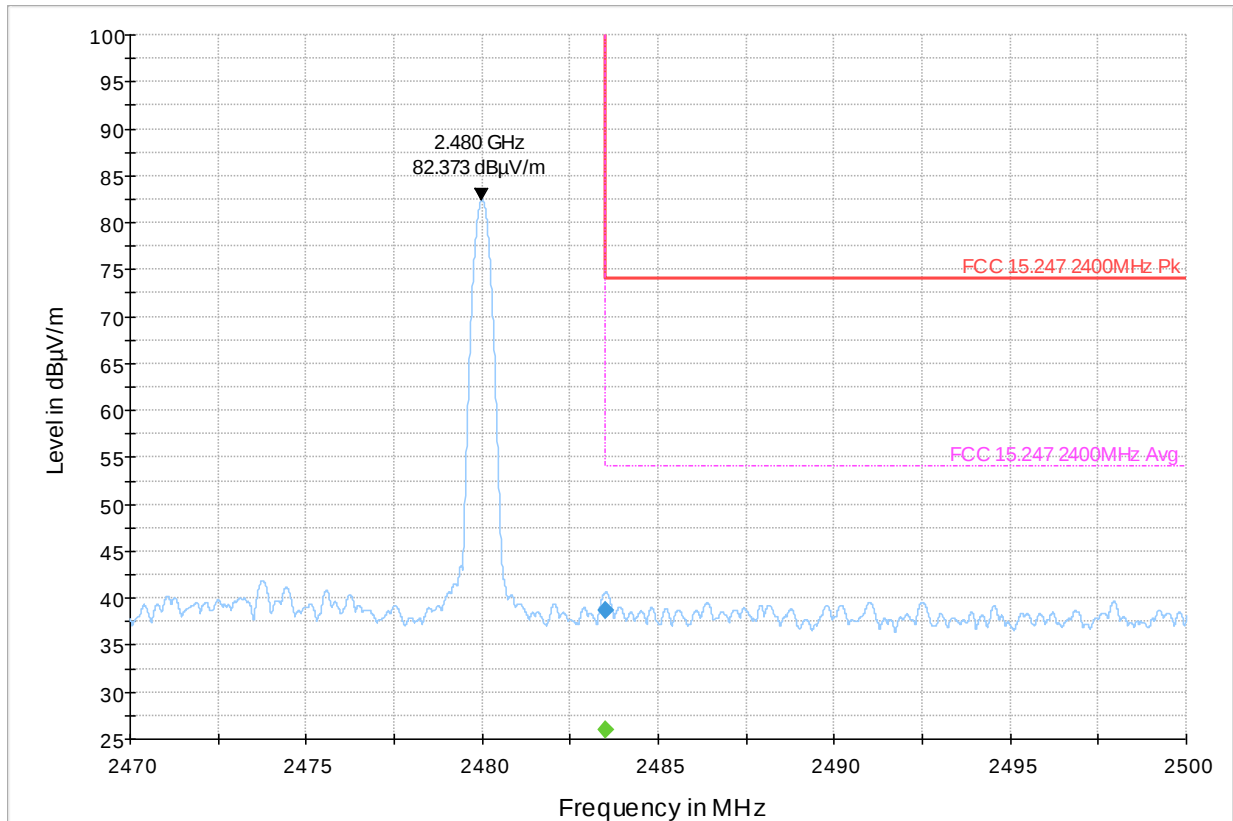
Plot #4

High channel / 2480 MHz

Modulation/Packet Type: BTLE

Final Result

Frequency	MaxPeak (dBμV/m)	CAverage	Limit (dBμV/m)	Margin	Measurement	Bandwidth	Height	Polarization	Azimuth	Correction (dB/m)	Signal Pattern	Preamplifier	Trd Corr.	Raw Rec
2483.509	---	25.95	54.00	28.05	500.0	1000.000	199.0	V	181.0	6.0	-	0.0	28.5	20.0
2483.509	38.70	---	74.00	35.30	500.0	1000.000	199.0	V	181.0	6.0	-	0.0	28.5	32.8



AVG_MAXH
 FCC 15.247 2400MHz Avg
 PK+_MAXH
 Final_Result PK+
 FCC 15.247 2400MHz Pk
 Final_Result CAV

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:

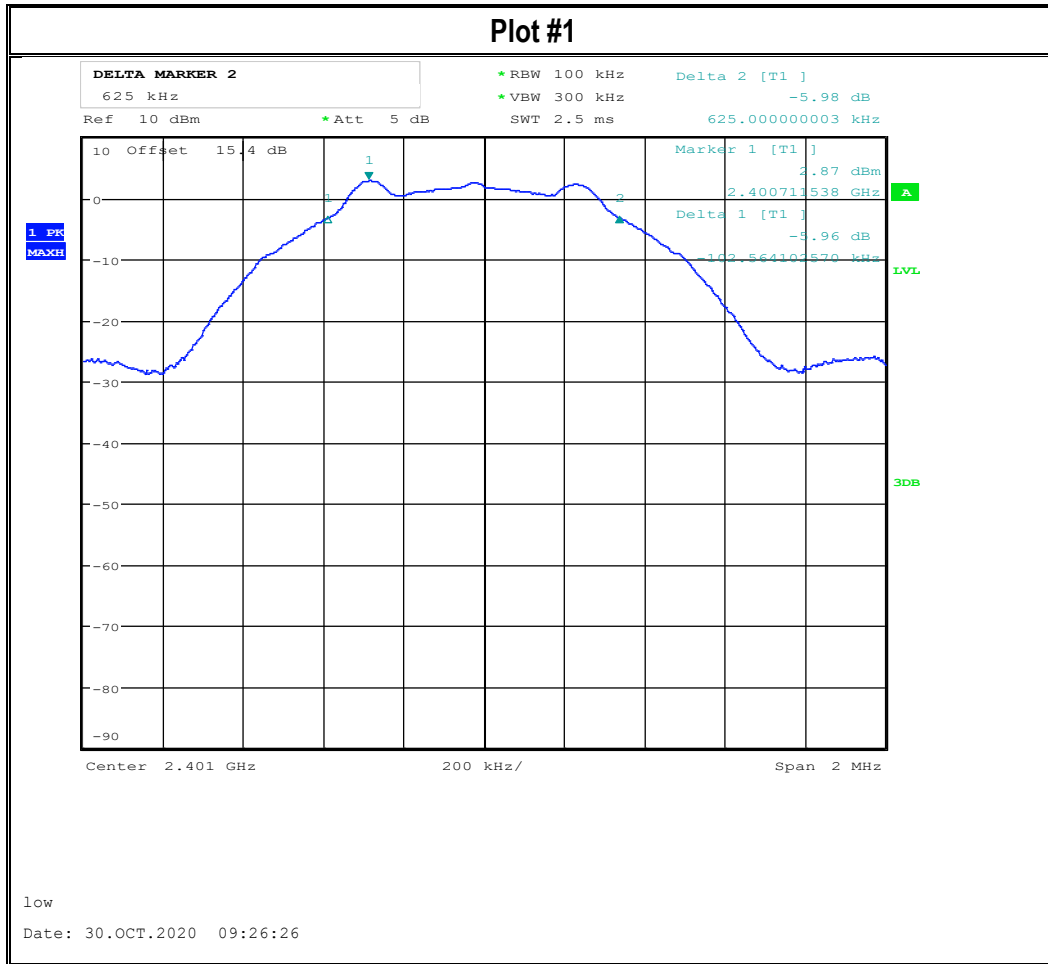
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	1	GFSK @ 1MB, and 2MB	9 VDC

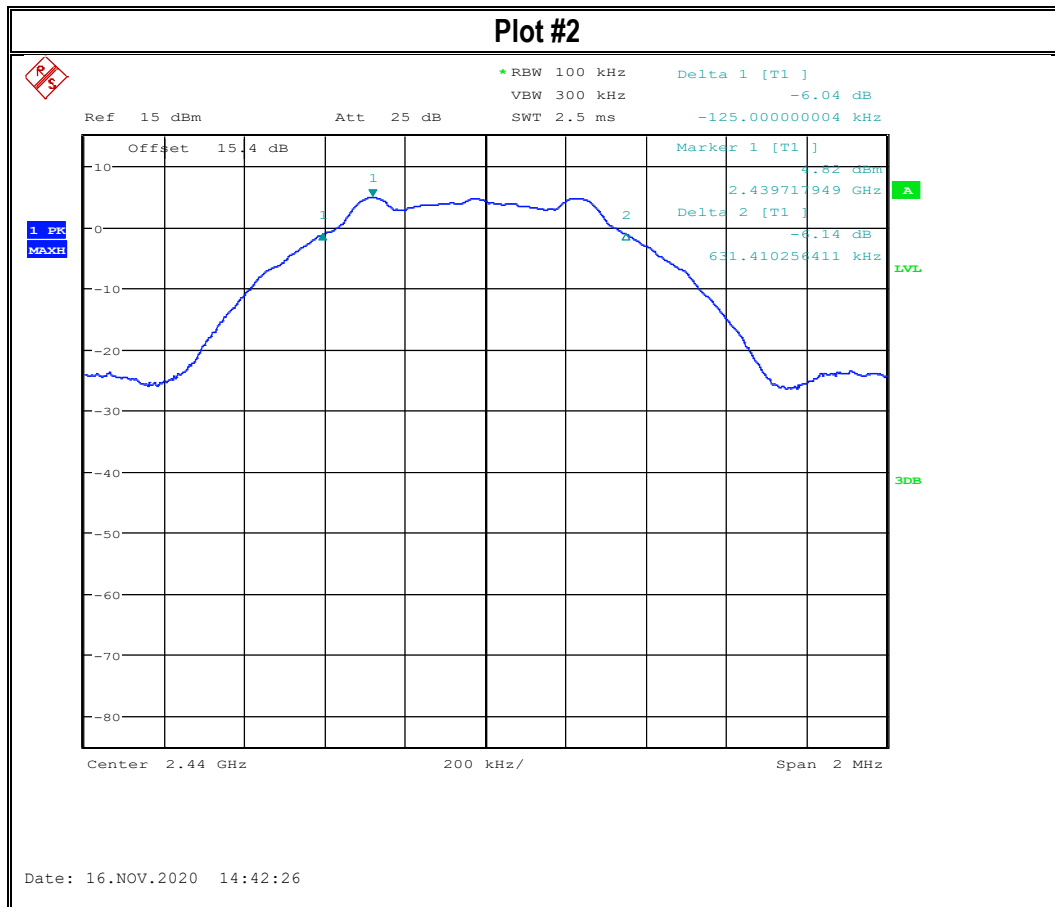
8.4.4 Measurement result:

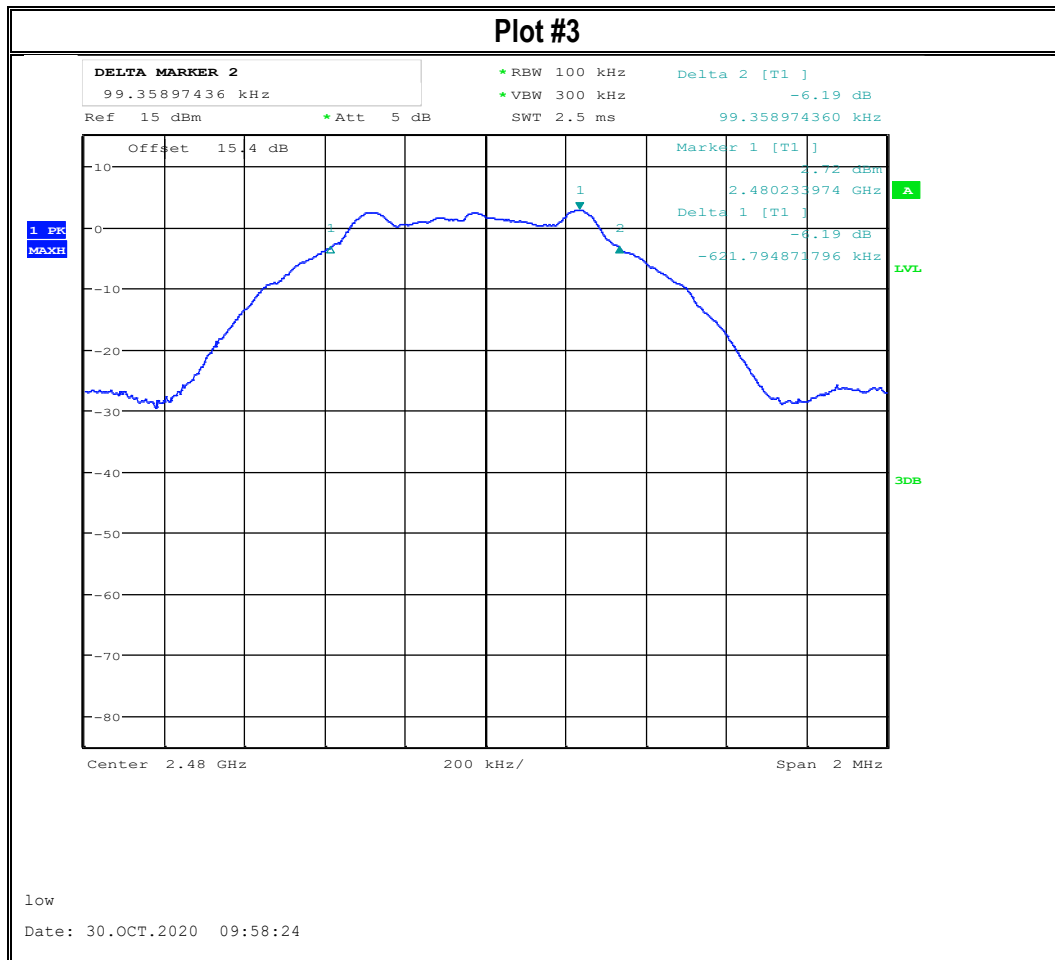
Plot #	EUT operating mode	Channel	6dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
1	GFSK @ 1MB	Low	0.727	> 0.5	Pass
2	GFSK @ 1MB	Mid	0.756	> 0.5	Pass
3	GFSK @ 1MB	High	0.721	> 0.5	Pass
4	GFSK @ 2MB	Low	1.458	> 0.5	Pass
5	GFSK @ 2MB	Mid	1.338	> 0.5	Pass
6	GFSK @ 2MB	High	1.378	> 0.5	Pass

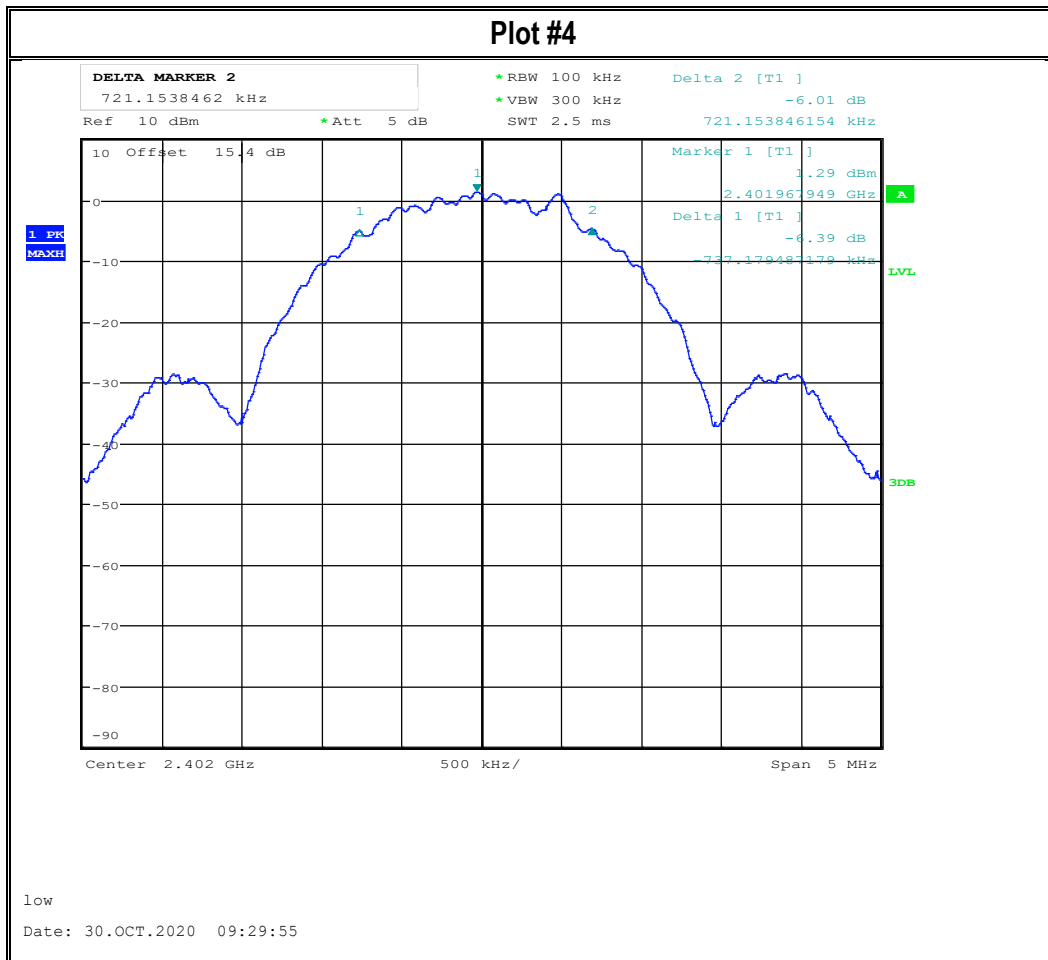
Plot #	EUT operating mode	Channel	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
7	GFSK @ 1MB	Low	1.073	> 0.5	Pass
8	GFSK @ 1MB	Mid	1.073	> 0.5	Pass
9	GFSK @ 1MB	High	1.070	> 0.5	Pass
10	GFSK @ 2MB	Low	2.099	> 0.5	Pass
11	GFSK @ 2MB	Mid	2.099	> 0.5	Pass
12	GFSK @ 2MB	High	2.099	> 0.5	Pass

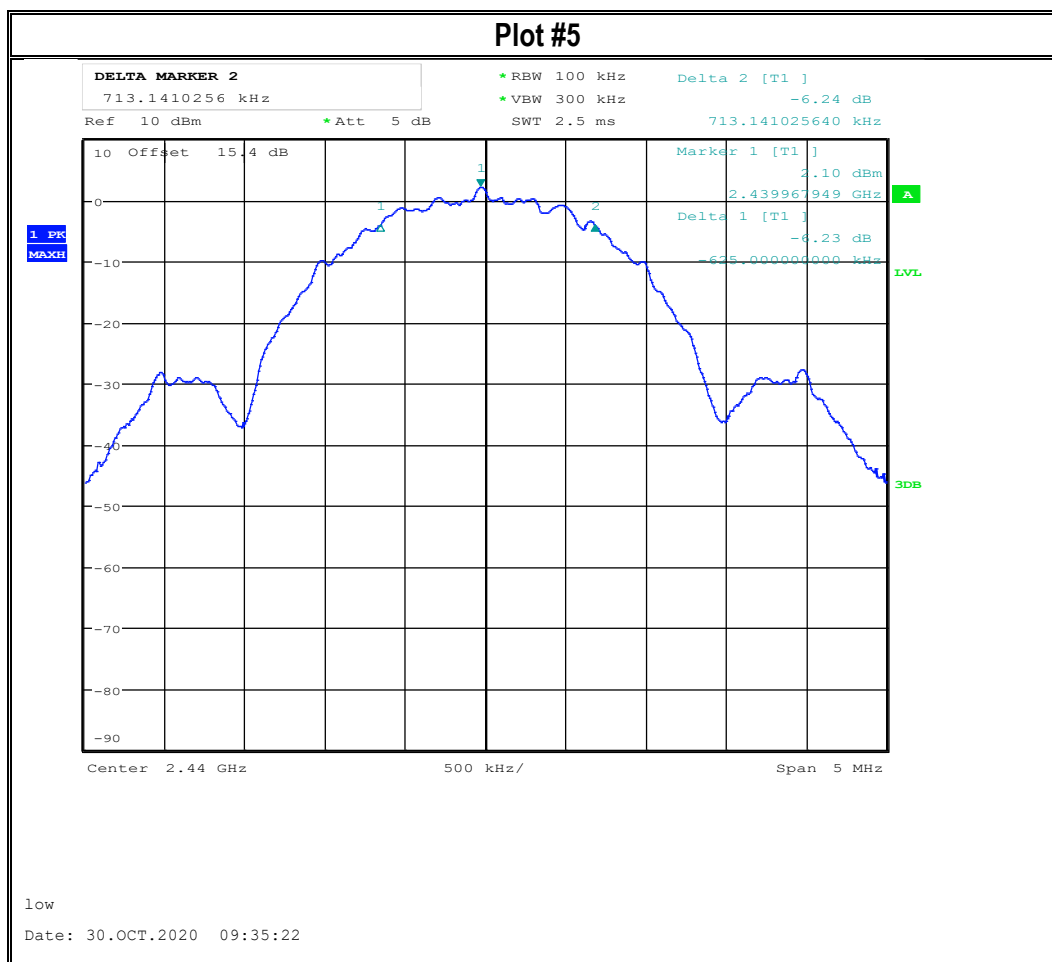
8.4.5 Measurement Plots:

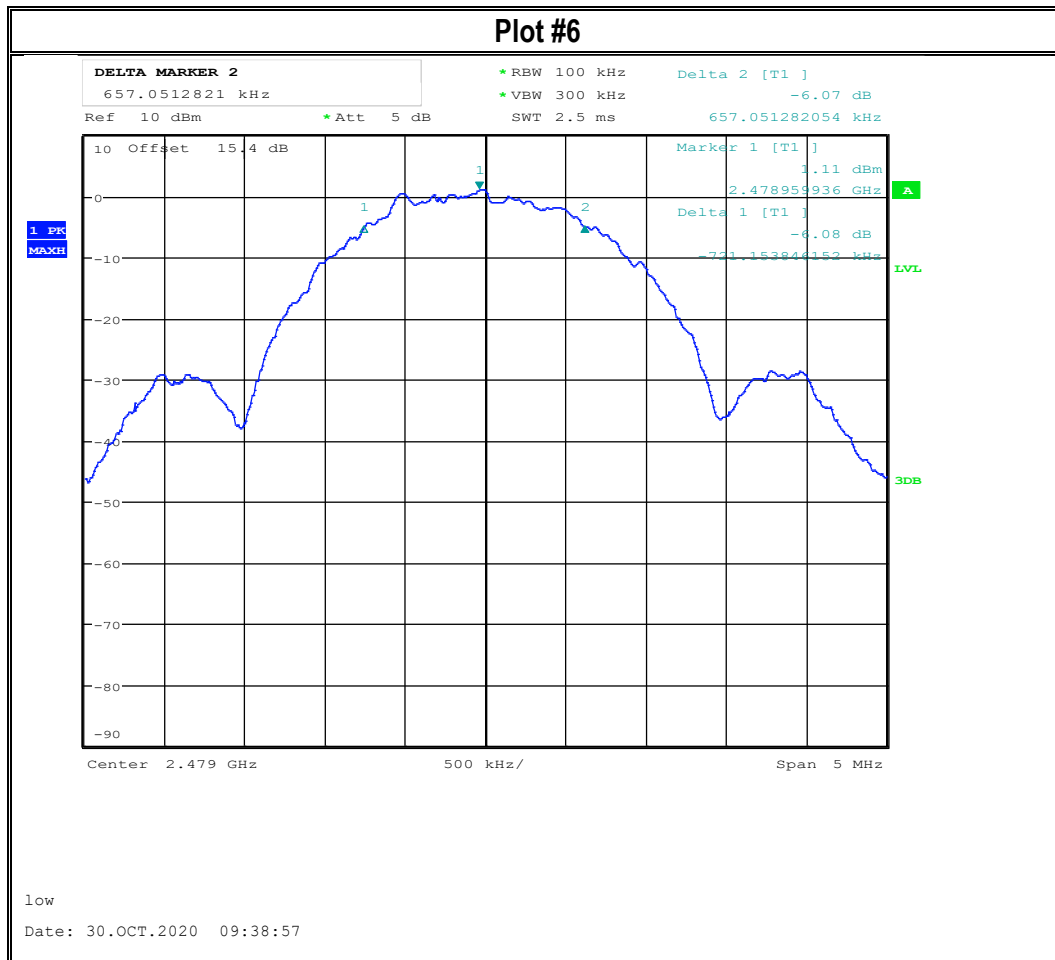


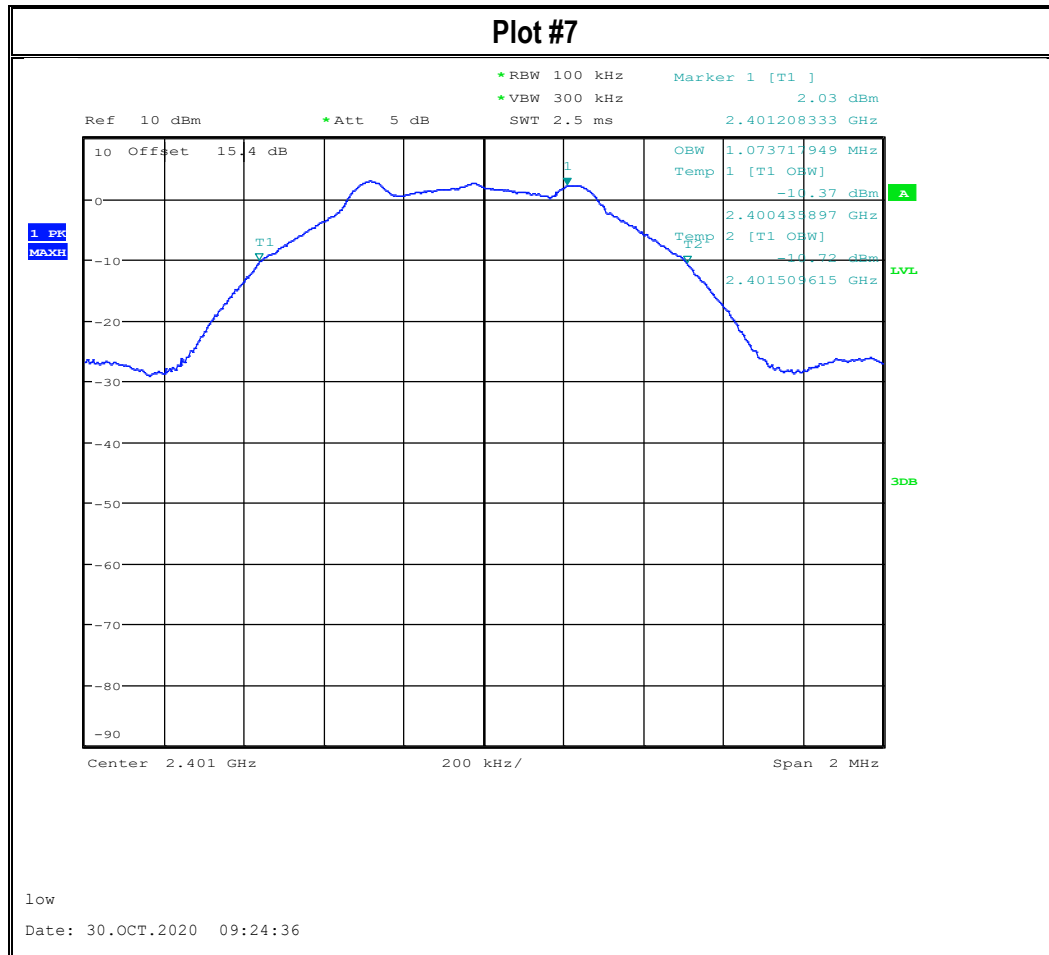


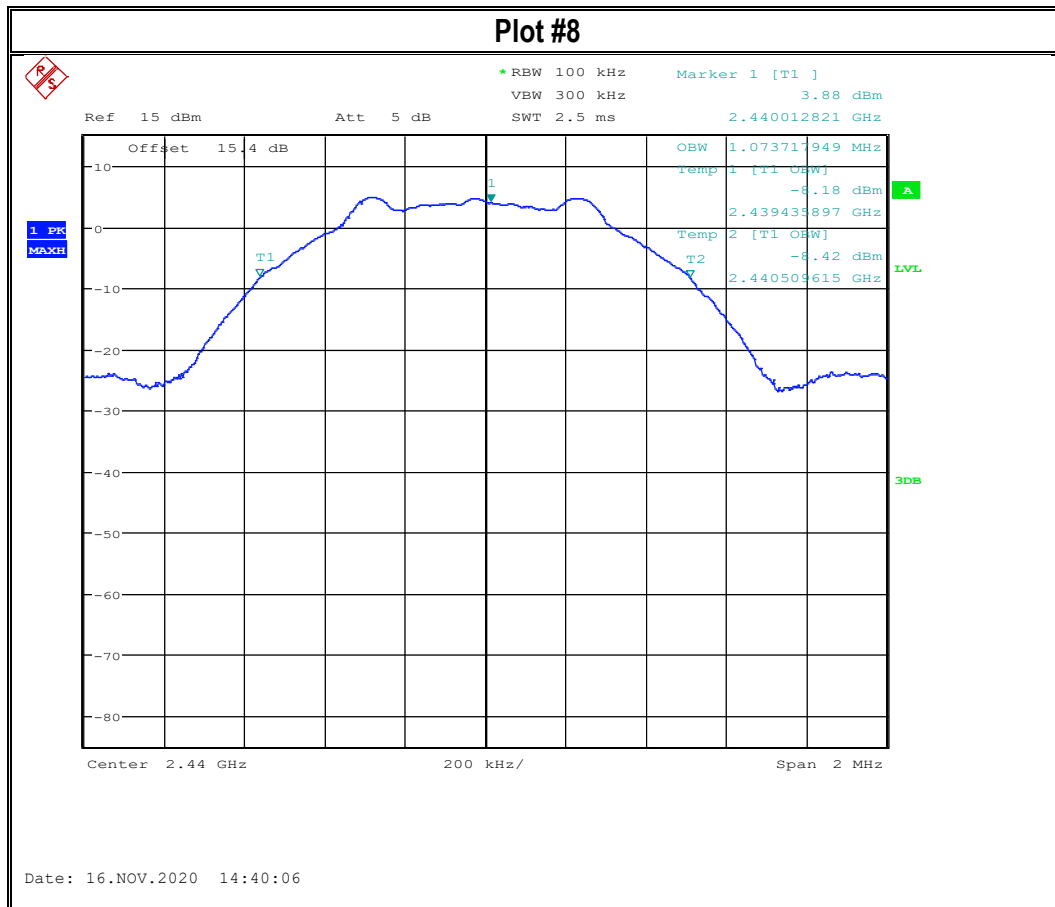


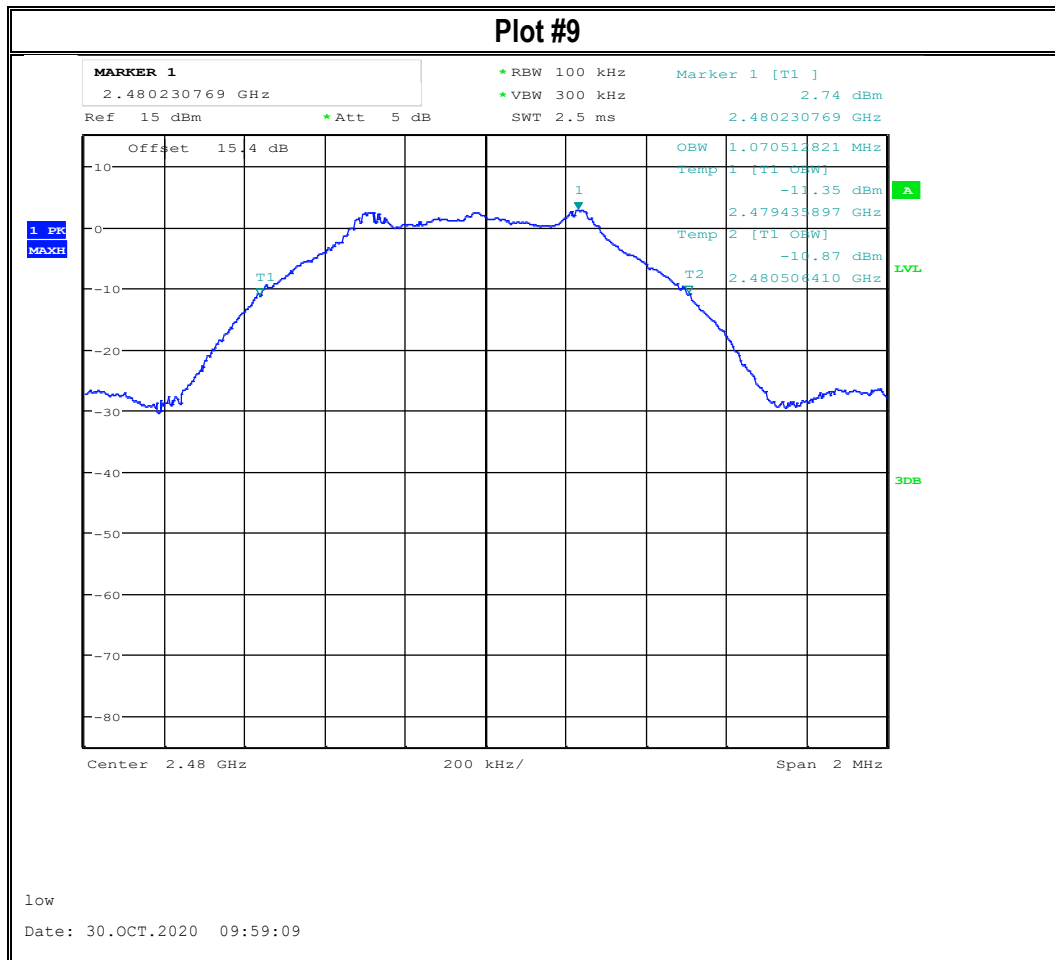


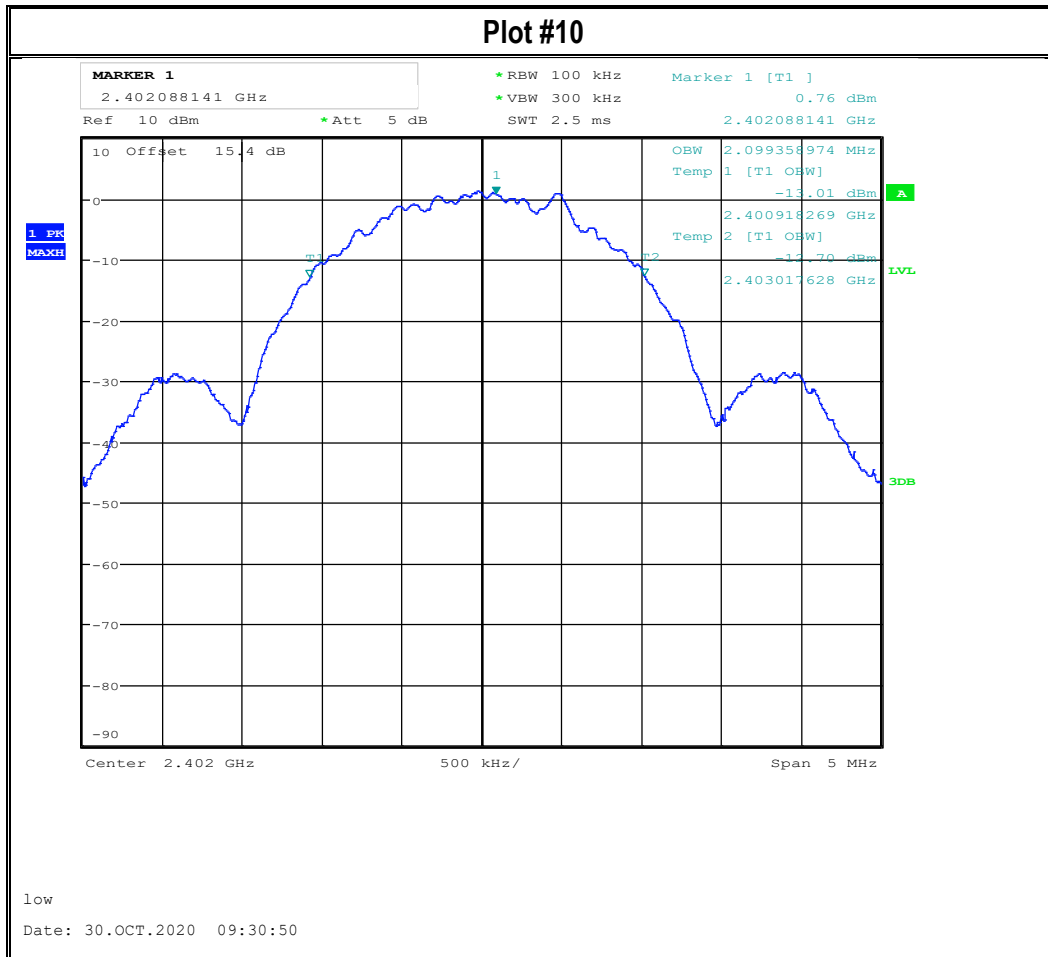


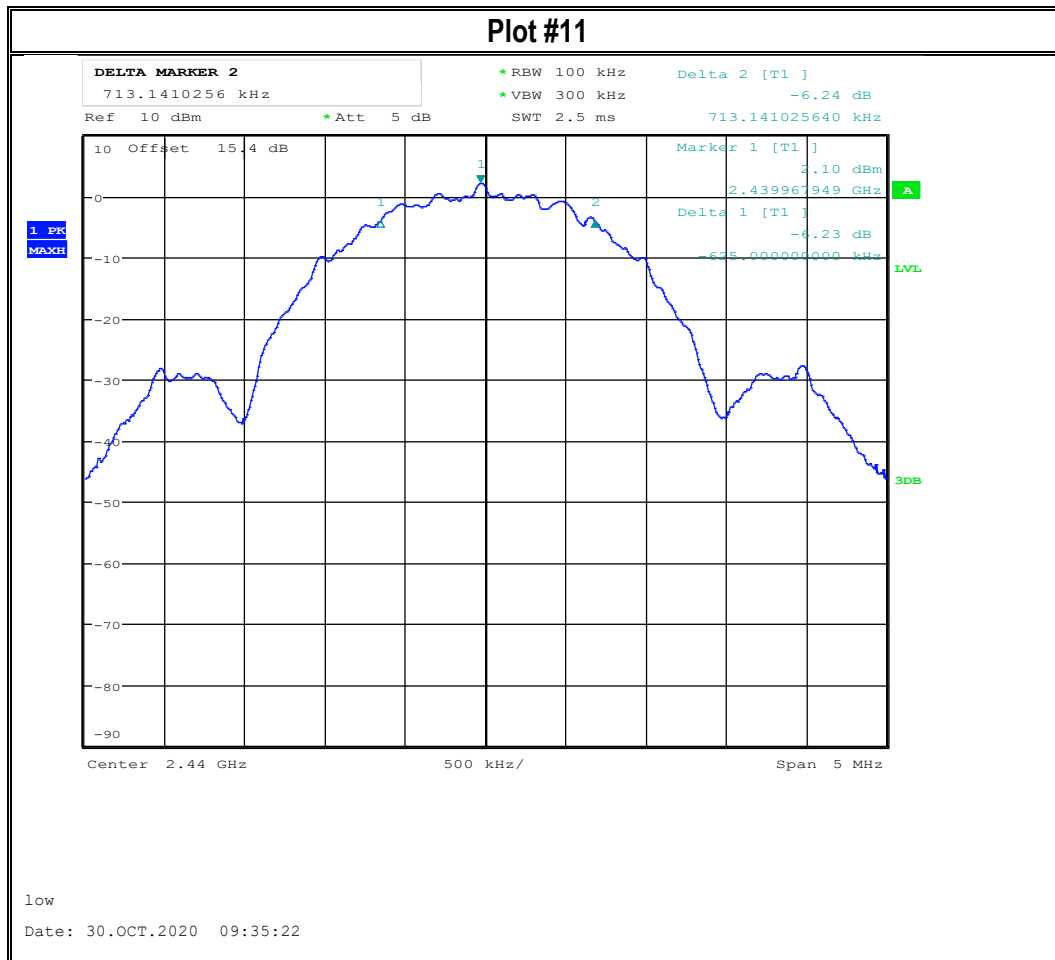


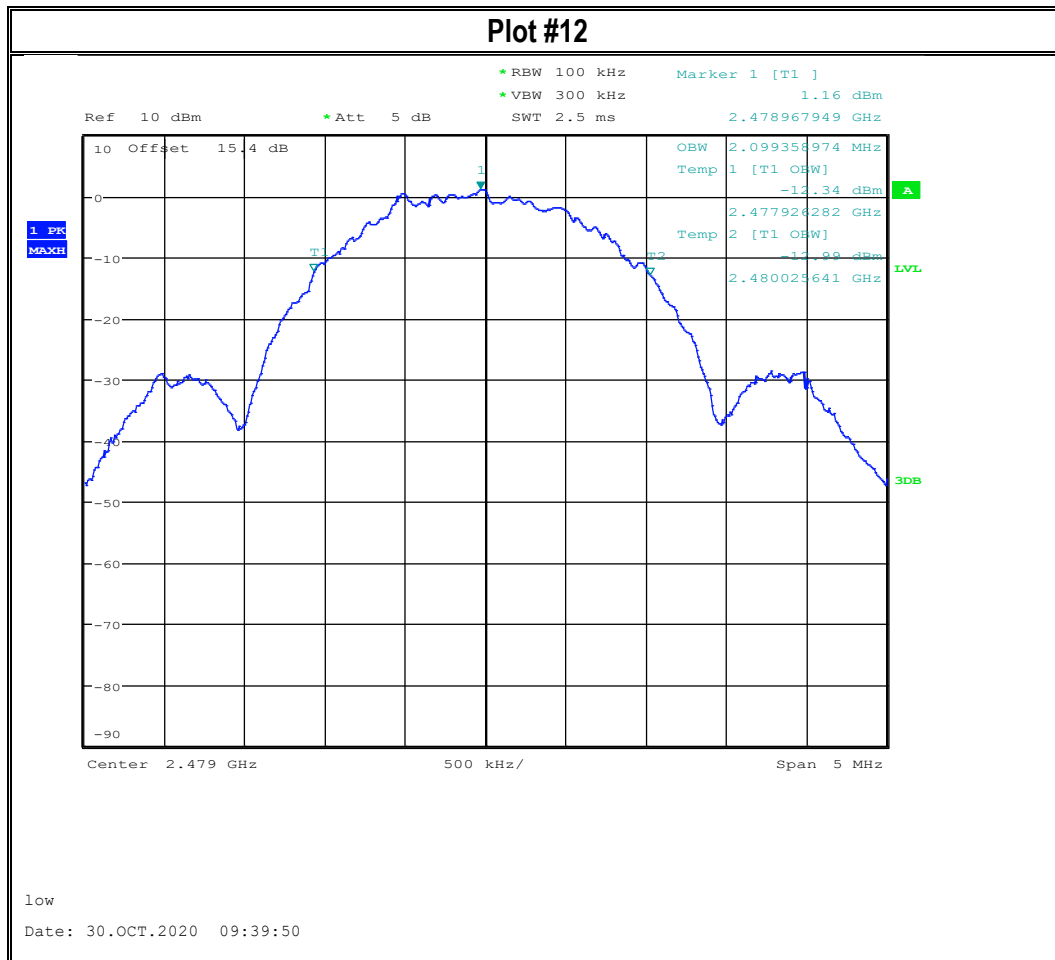












8.5 Radiated Transmitter Spurious Emissions and Restricted Bands

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
24° C	1	BT LE continuous fixed channel	120 Vac

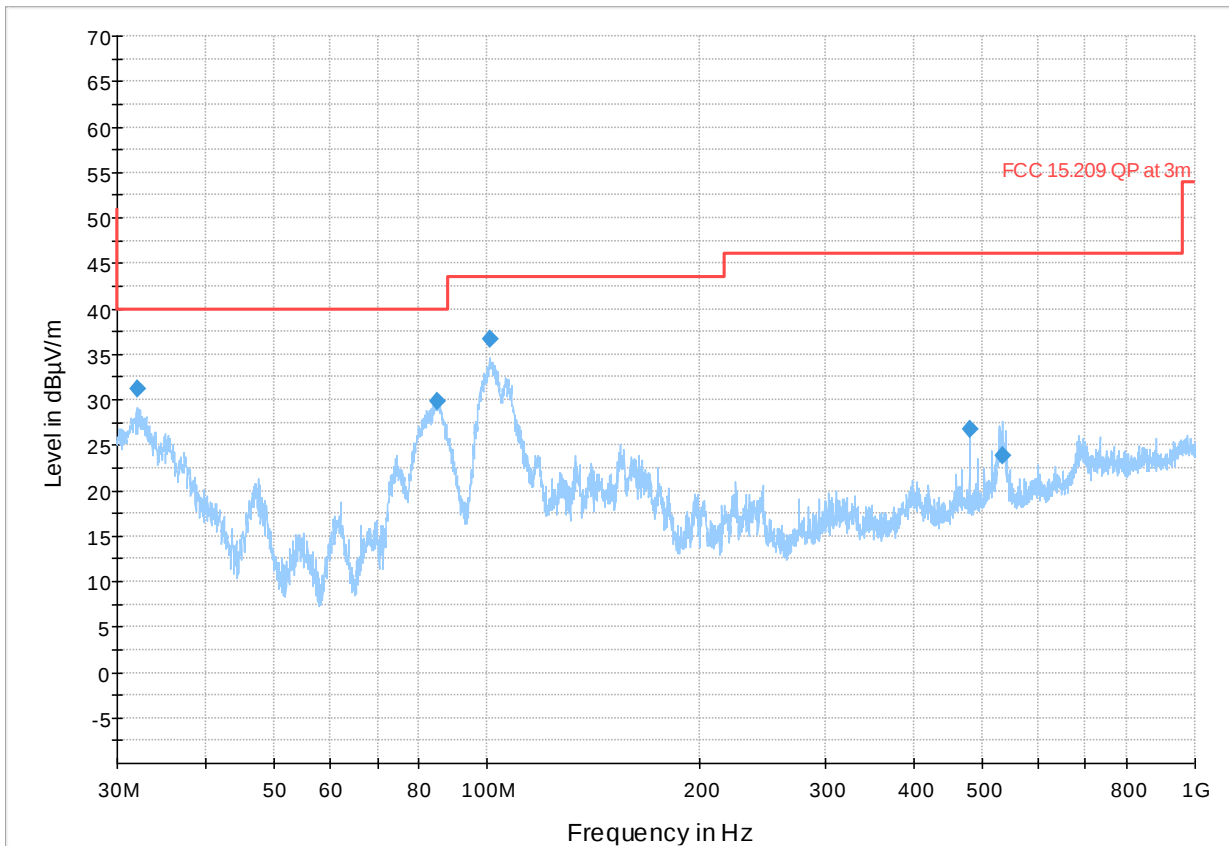
8.5.4 Measurement result:

Plot #	Channel #	Scan Frequency	Limit	Result
1-3	Low	30 MHz – 18 GHz	See section 8.6.2	Pass
4-8	Mid	9 kHz – 26 GHz	See section 8.6.2	Pass
9-11	High	30 MHz – 18 GHz	See section 8.6.2	Pass

8.5.5 Measurement Plots:

Plot # 1 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 2402 MHz						GFSK 2M							
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path	Preamp (dB)	Trd Corr.	Raw Rec
31.964	31.26	40.00	8.74	500.0	120.000	100.0	V	316.0	-12.2	-35.3	0.0	23.1	43.5
84.926	29.85	40.00	10.15	500.0	120.000	107.0	V	310.0	-19.2	-35.1	0.0	15.9	49.0
100.907	36.66	43.50	6.84	500.0	120.000	100.0	V	309.0	-14.8	-35.0	0.0	20.2	51.4
479.983	26.76	46.02	19.27	500.0	120.000	177.0	V	207.0	-9.8	-33.5	0.0	23.7	36.6
534.643	23.84	46.02	22.18	500.0	120.000	100.0	H	139.0	-8.8	-33.1	0.0	24.4	32.6



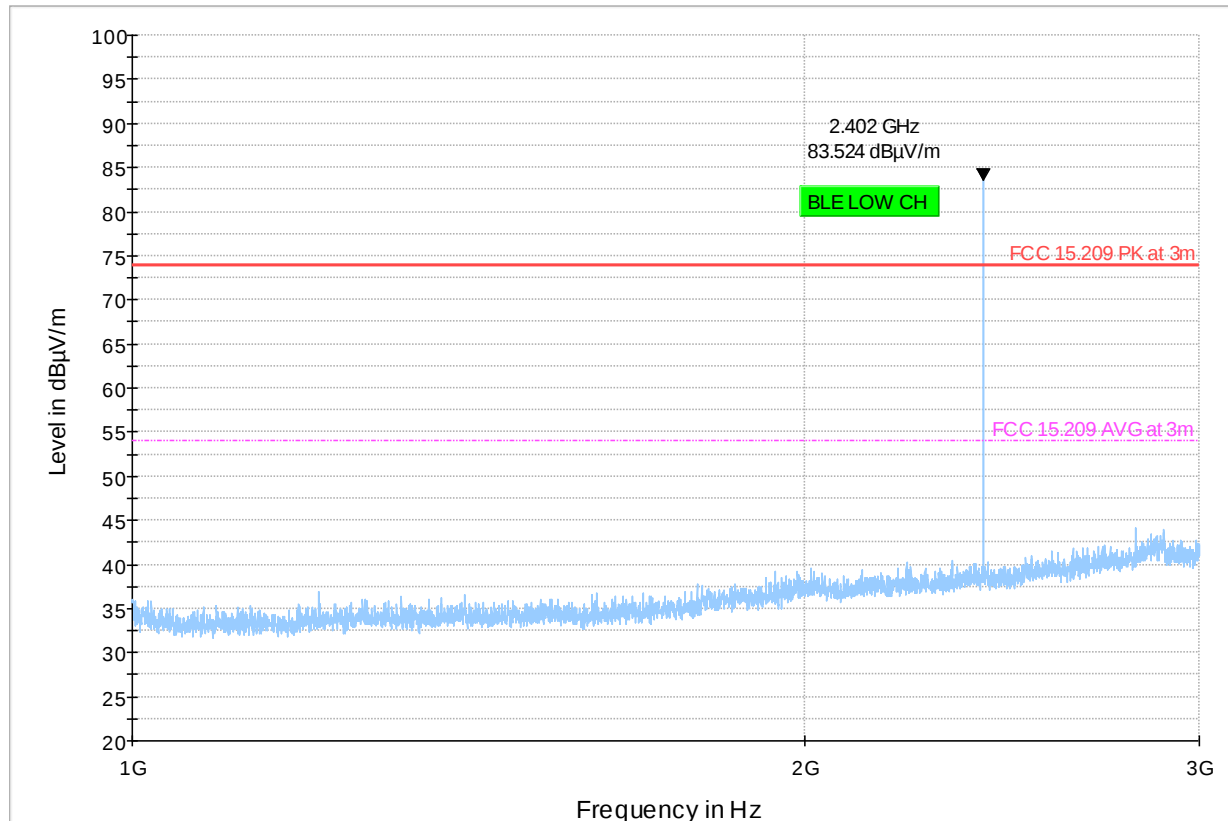
— AVG_MAXH — PK+_MAXH — FCC 15.209 QP at 3m ◆ Final_Result QPK

Plot # 2 Radiated Emissions: 1 – 3 GHz

Tx Frequency: 2402 MHz

GFSK 2M

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path	Preamp (dB)	Trd Corr.	Raw Rec
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---



AVG_MAXH
FCC 15.209 AVG at 3m

PK+_MAXH
Final_Result PK+

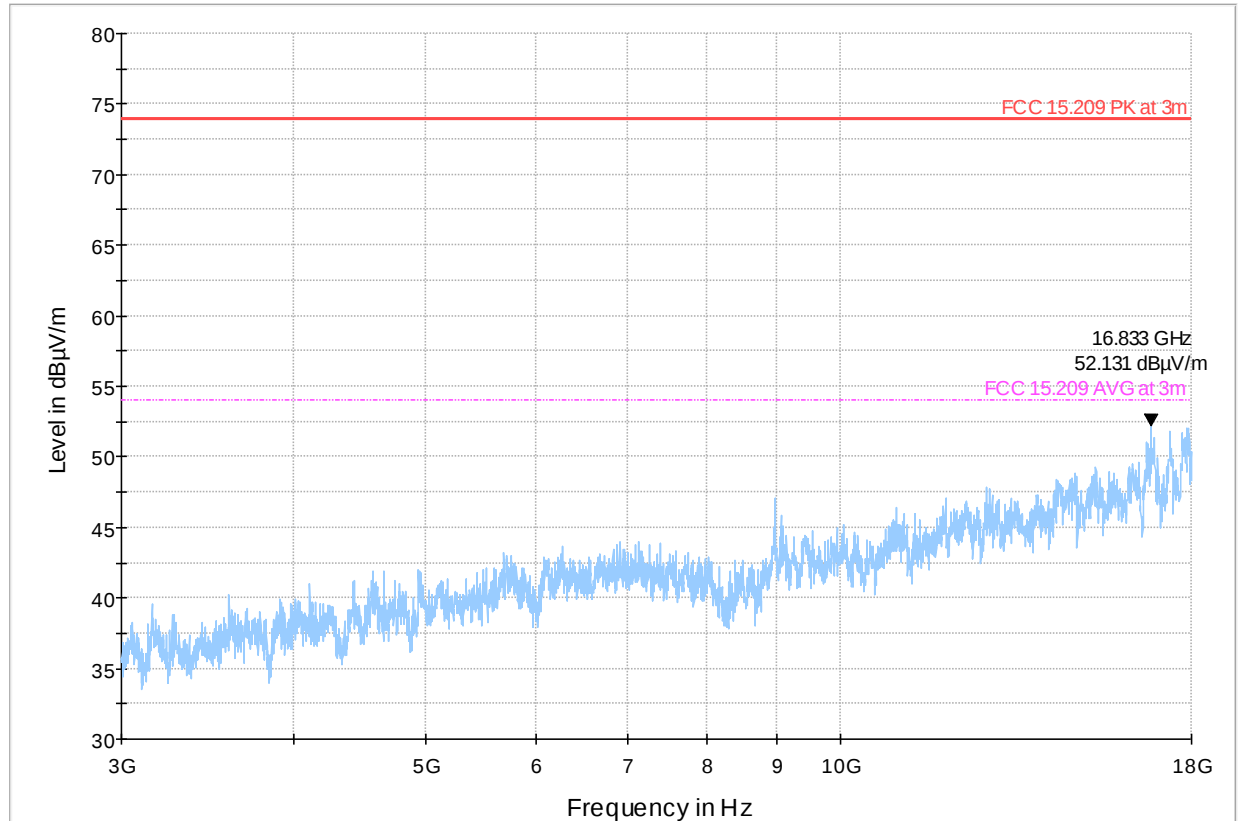
FCC 15.209 PK at 3m
Final_Result CAV

Plot # 3 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 2402 MHz

GFSK 2M

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path	Preamp (dB)	Trd Corr.	Raw Rec
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---



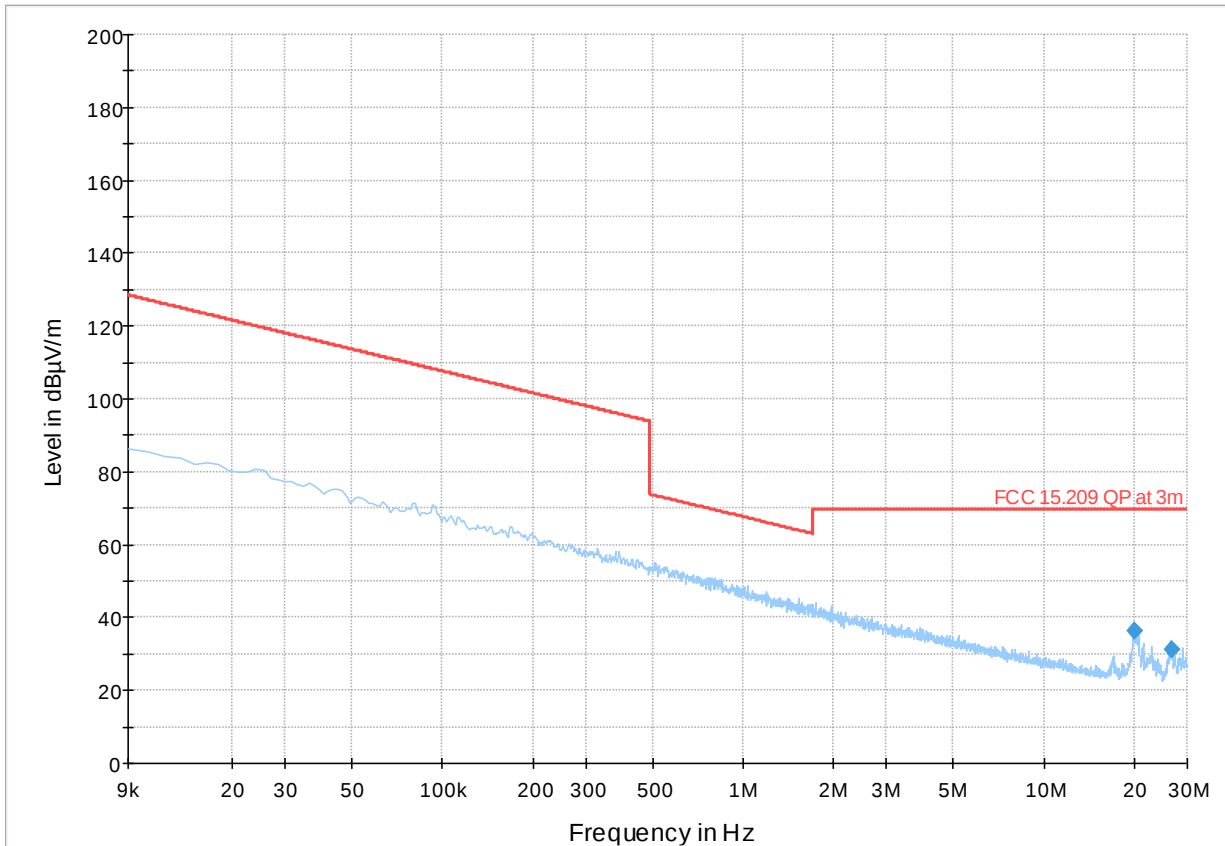
— AVG_MAXH
--- FCC 15.209 AVG at 3m
 — PK+_MAXH
◆ Final_Result PK+
 — FCC 15.209 PK at 3m
◆ Final_Result CAV

Plot # 4 Radiated Emissions: 9 KHz – 30 MHz

Tx Frequency: 2440 MHz

GFSK 2M

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
19.934	36.14	69.50	33.36	500.0	9.000	100.0	V	-34.0	16.5
26.532	31.14	69.50	38.36	500.0	9.000	100.0	V	176.0	16.0



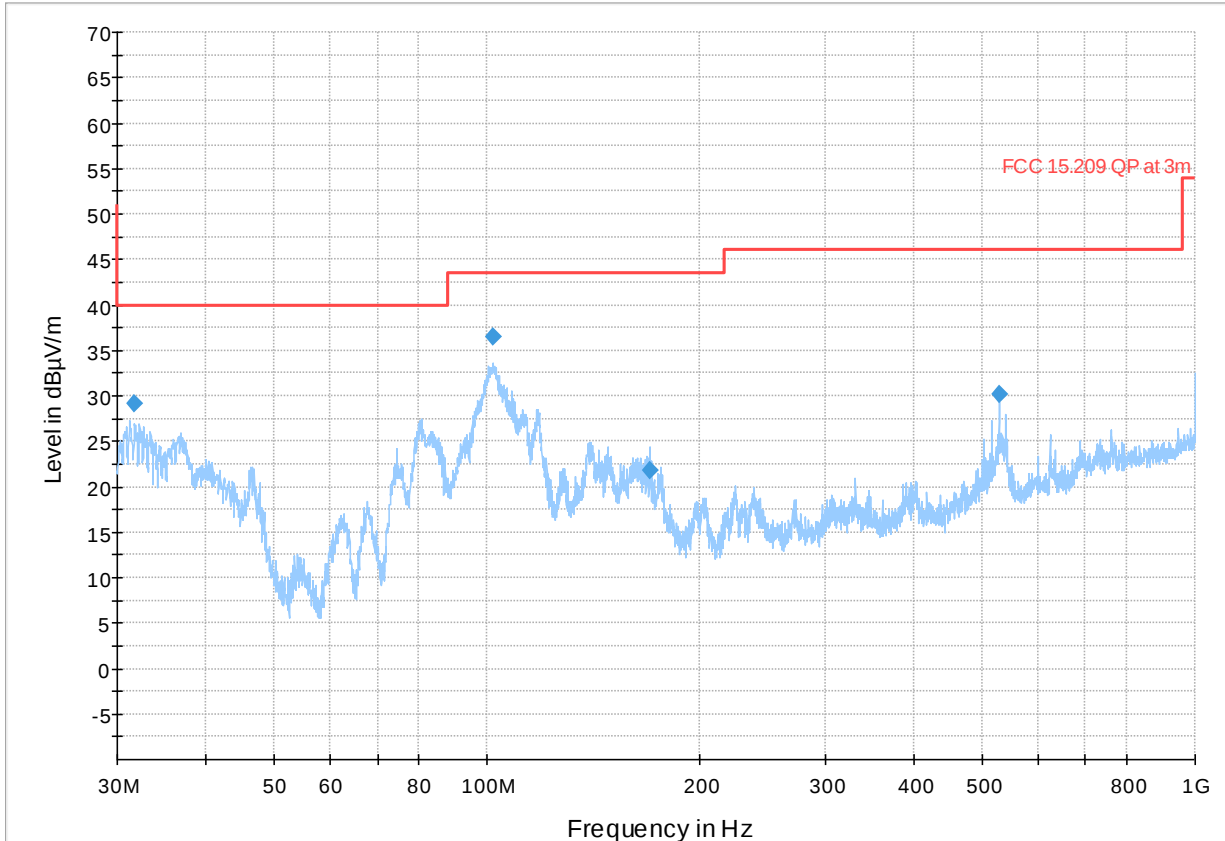
— AVG_MAXH — PK+_MAXH — FCC 15.209 QP at 3m ◆ Final_Result QPK

Plot # 5 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 2440 MHz

GFSK 2M

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path	Preamp (dB)	Trd Corr.	Raw Rec
31.770	29.13	40.00	10.87	500.0	120.000	100.0	V	275.0	-12.1	-35.3	0.0	23.2	41.3
101.756	36.57	43.50	6.93	500.0	120.000	100.0	V	263.0	-14.6	-35.0	0.0	20.4	51.1
169.607	21.80	43.50	21.70	500.0	120.000	210.0	V	50.0	-10.5	-34.6	0.0	24.2	32.3
527.998	30.10	46.02	15.92	500.0	120.000	100.0	H	53.0	-8.8	-33.3	0.0	24.5	38.9



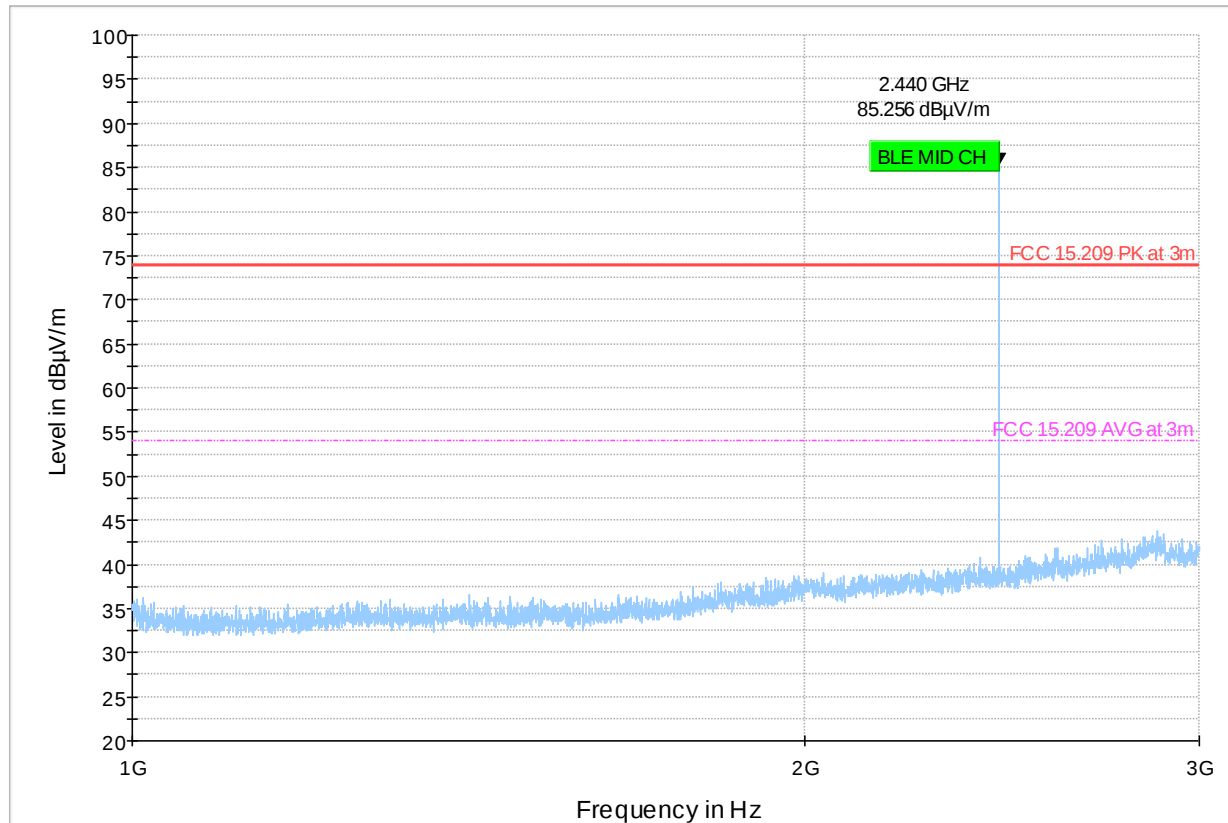
AVG_MAXH PK+_MAXH FCC 15.209 QP at 3m Final_Result QPK

Plot # 6 Radiated Emissions: 1 – 3 GHz

Tx Frequency: 2440 MHz

GFSK 2M

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path	Preamp (dB)	Trd Corr.	Raw Rec
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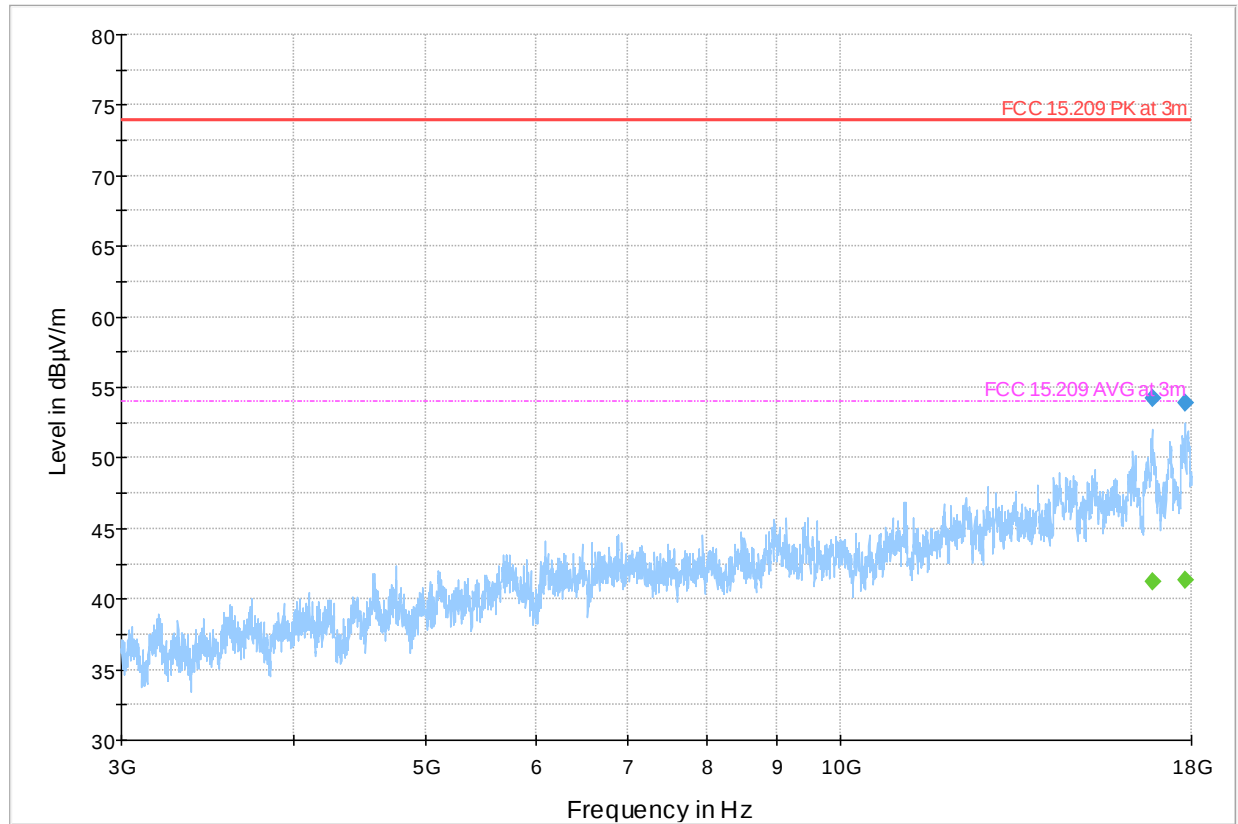
— AVG_MAXH
— FCC 15.209 AVG at 3m
 ◆ PK+_MAXH
◆ Final_Result PK+
 — FCC 15.209 PK at 3m
◆ Final_Result CAV

Plot # 7 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 2440 MHz

GFSK 2M

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path	Preamp (dB)	Trd Corr.	Raw Rec
16847.000	54.24	---	73.98	19.74	500.0	1000.000	350.0	V	24.0	14.4	15.9	0.0	-1.6	39.9
16847.000	---	41.24	53.98	12.74	500.0	1000.000	350.0	V	24.0	14.4	15.9	0.0	-1.6	26.9
17806.250	53.94	---	73.98	20.04	500.0	1000.000	150.0	H	167.0	17.8	16.1	0.0	1.7	36.1
17806.250	---	41.33	53.98	12.64	500.0	1000.000	150.0	H	167.0	17.8	16.1	0.0	1.7	23.5



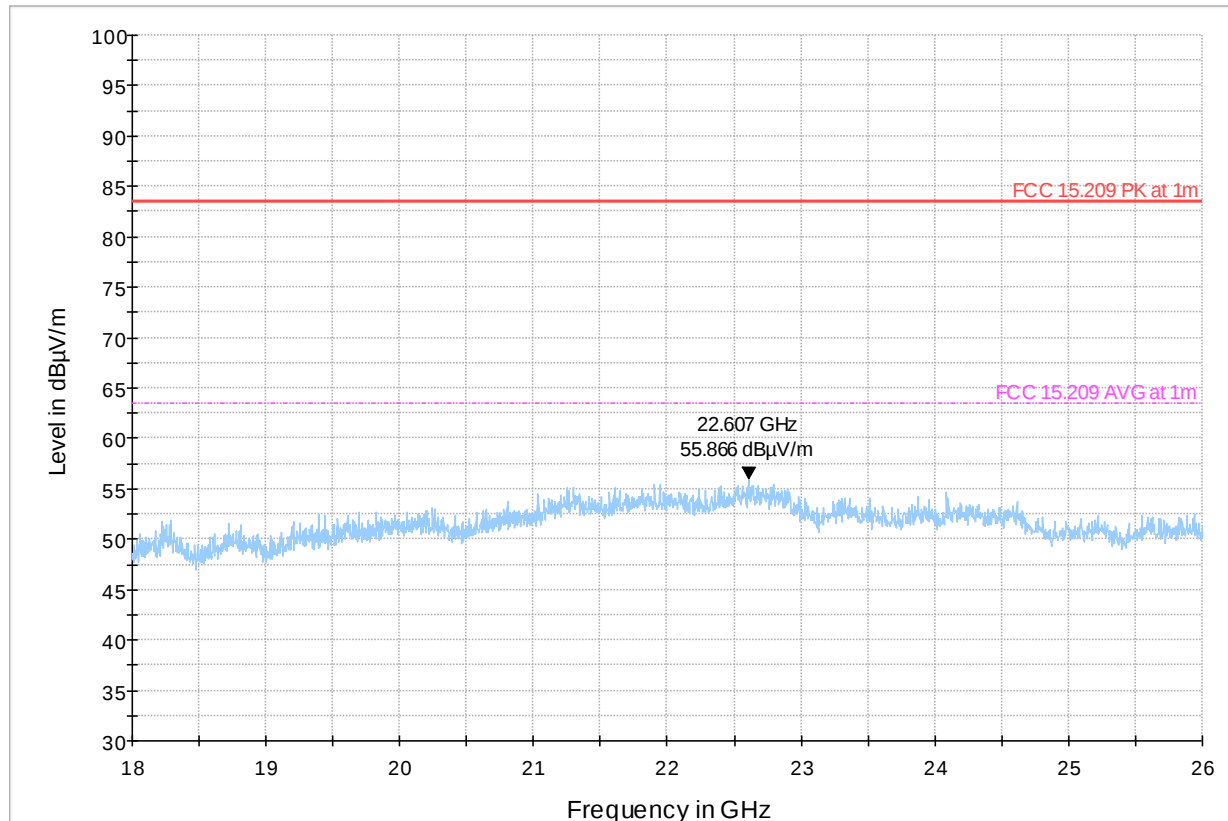
— AVG_MAXH ◆ PK+_MAXH — FCC 15.209 PK at 3m
--- FCC 15.209 AVG at 3m ◆ Final_Result CAV

Plot # 8 Radiated Emissions: 18 – 26 GHz

Tx Frequency: 2440 MHz

GFSK 2M

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path	Preamp (dB)	Trd Corr.	Raw Rec
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---



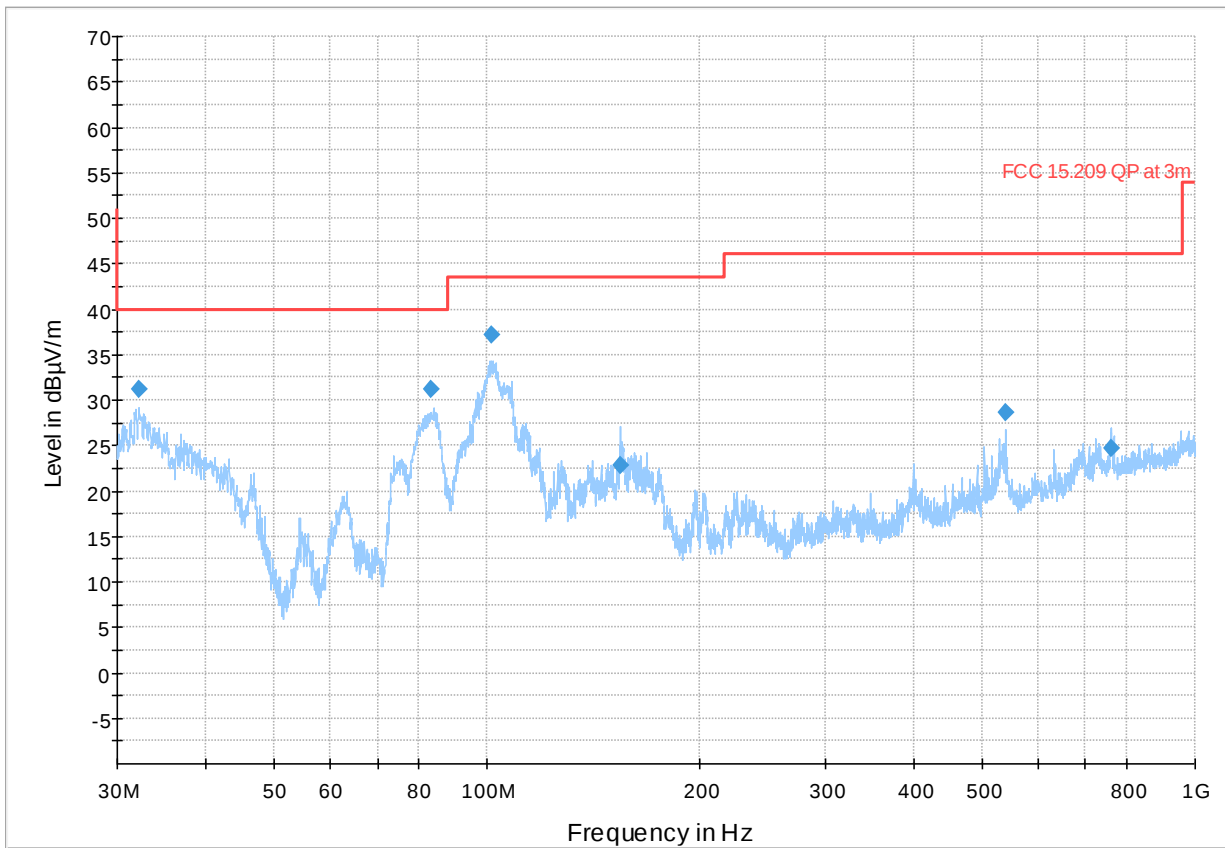
— AVG_MAXH
— FCC 15.209 AVG at 1m
 — PK+_MAXH
◆ Final_Result PK+
 — FCC 15.209 PK at 1m
◆ Final_Result CAV

Plot # 9 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 2480 MHz

GFSK 2M

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path	Preamp (dB)	Trd Corr.	Raw Rec
32.255	31.16	40.00	8.84	500.0	120.000	100.0	V	312.0	-12.4	-35.3	0.0	22.9	43.5
83.350	31.19	40.00	8.81	500.0	120.000	100.0	V	118.0	-19.7	-35.1	0.0	15.4	50.9
101.562	37.15	43.50	6.35	500.0	120.000	100.0	V	255.0	-14.6	-35.0	0.0	20.4	51.8
154.281	22.76	43.50	20.74	500.0	120.000	125.0	V	-40.0	-9.8	-34.8	0.0	25.0	32.5
539.953	28.55	46.02	17.47	500.0	120.000	100.0	H	56.0	-8.6	-33.1	0.0	24.5	37.1
760.750	24.62	46.02	21.40	500.0	120.000	100.0	V	251.0	-4.8	-32.6	0.0	27.8	29.4



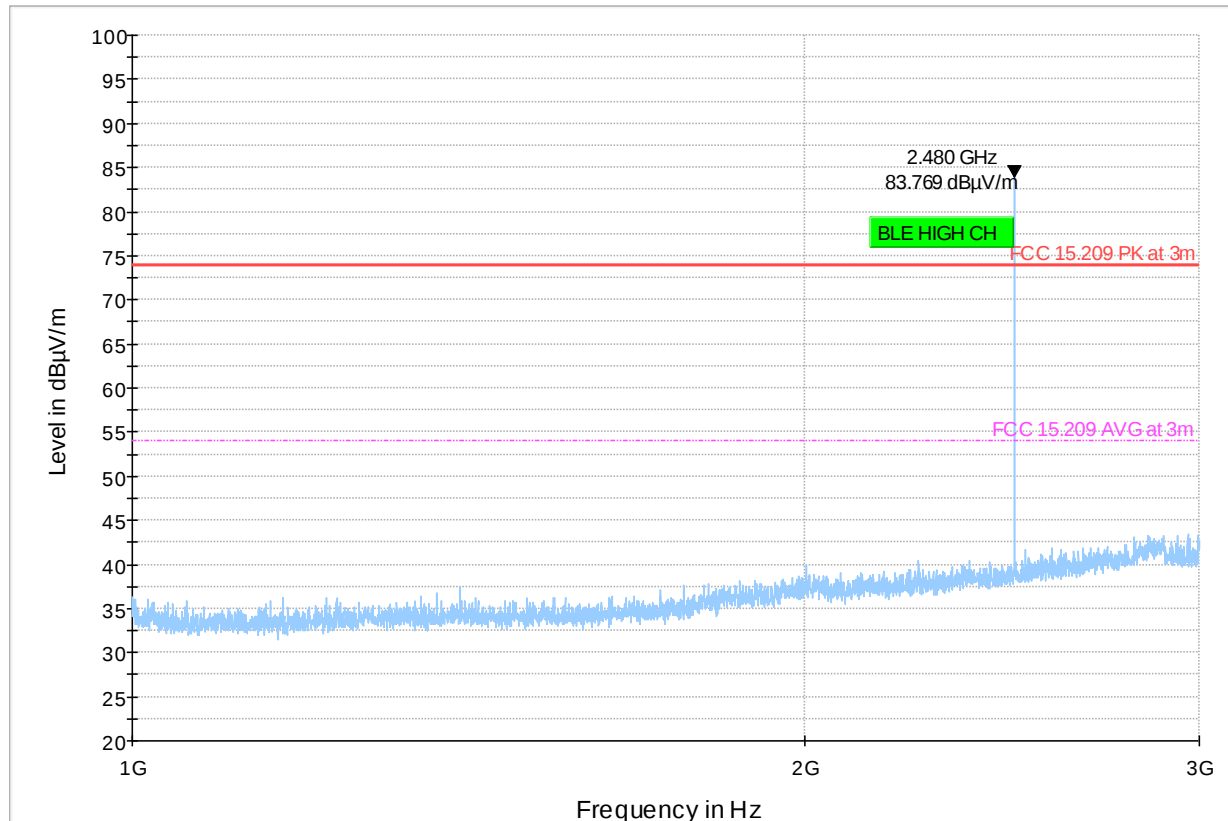
— AVG_MAXH — PK+_MAXH — FCC 15.209 QP at 3m ◆ Final_Result QPK

Plot # 10 Radiated Emissions: 1 – 3 GHz

Tx Frequency: 2480 MHz

GFSK 2M

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path	Preamp (dB)	Trd Corr.	Raw Rec
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---



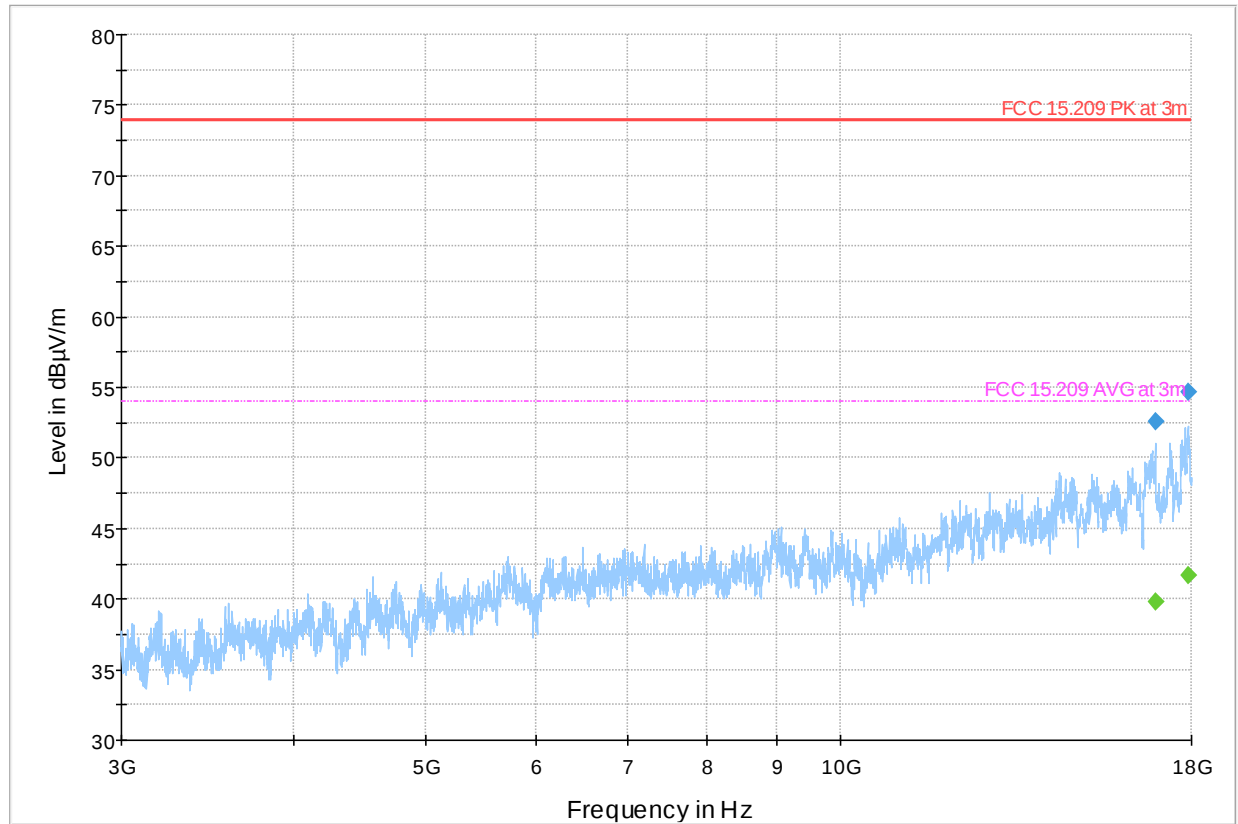
— AVG_MAXH
— FCC 15.209 AVG at 3m
 ◆ PK+_MAXH
◆ Final_Result PK+
 — FCC 15.209 PK at 3m
◆ Final_Result CAV

Plot # 11 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 2480 MHz

GFSK 2M

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path	Preamp (dB)	Trd Corr.	Raw Rec
16937.500	---	39.79	53.98	14.19	500.0	1000.000	246.0	H	111.0	13.6	16.5	0.0	-2.8	26.2
16937.500	52.62	---	73.98	21.36	500.0	1000.000	246.0	H	111.0	13.6	16.5	0.0	-2.8	39.0
17888.750	---	41.68	53.98	12.30	500.0	1000.000	152.0	V	212.0	18.2	16.2	0.0	2.1	23.4
17888.750	54.66	---	73.98	19.32	500.0	1000.000	152.0	V	212.0	18.2	16.2	0.0	2.1	36.4



AVG_MAXH
FCC 15.209 AVG at 3m

PK+_MAXH
Final_Result PK+

FCC 15.209 PK at 3m
Final_Result CAV

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 $^{\circ}$ C	EUT Set-Up #	EUT operating mode	Power line (L1, L2, L3, N)	Power Input
24 $^{\circ}$ C	1	BT LE continuous fixed channel	Line & Neutral	110V / 60Hz

8.6.4 Measurement Result:

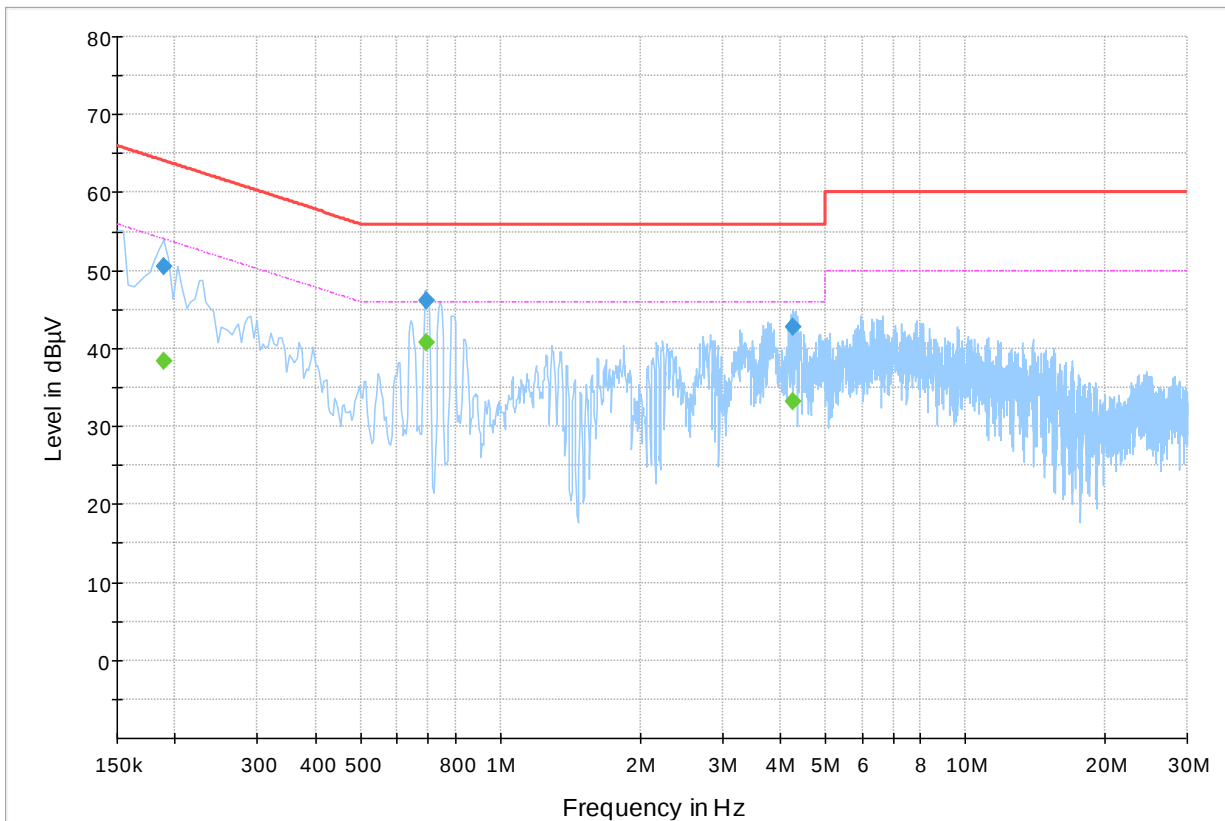
Plot #	Port	EUT Set-Up #:	EUT operating mode	Scan Frequency	Limit	Result
12	AC Mains	1	BT LE continuous fixed channel	150 kHz – 30 MHz	See section 8.7.2	Pass

8.6.5 Measurement Plots:

Plot # 12 AC Conducted Emissions: 150 KHz – 30 MHz

Final_Result

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.190	---	38.340	54.06	15.72	500.0	9.000	L1	GND	10.4
0.190	50.511	---	64.06	13.55	500.0	9.000	L1	GND	10.4
0.694	---	40.700	46.00	5.30	500.0	9.000	L1	GND	10.0
0.694	46.176	---	56.00	9.82	500.0	9.000	L1	GND	10.0
4.268	---	33.298	46.00	12.70	500.0	9.000	L1	GND	10.1
4.268	42.813	---	56.00	13.19	500.0	9.000	L1	GND	10.1



◆ Preview Result 1-PK+ Final_Result QPK
◆ EN 55032 Voltage on Mains QP Final_Result CAV
--- EN 55032 Voltage on Mains AV

9 Test setup photos

Setup photos are included in supporting file name: "EMC_UNIVE_031_23001_15.247_FCC_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
HORN ANTENNA	EMCO	3115	00035111	3 YEARS	09/30/2021
TEST RECEIVER	R&S	ESU40	100251	3 YEARS	09/13/2021
DIGITAL THERMOMETER	CONTROL COMPANY	36934-164	181230565	3 YEARS	10/20/2021
LISN	FCC	N/A	08014	3 YEARS	08/31/2021

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.

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
ACTIVE LOOP ANTENNA	ETS LINDGREN	6507	00161344	3 YEARS	10/30/2020
BILOG ANTENNA	A.H. SYSTEMS	BiLA2G	569	3 YEARS	11/16/2021
HORN ANTENNA	ETS LINDGREN	3117-PA	00169547	3 YEARS	9/1/2020
HORN ANTENNA	ETS LINDGREN	3116C-PA	00169535	3 YEARS	9/23/2020
ESW.EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW44	101715	3 YEARS	9/14/2021

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
2023-09-13	EMC_Project_Name_15.247_BTLE_DTS	Initial Version	Art Thammanavarat
2023-09-29	EMC_Project_Name_15.247_BTLE_DTS_Rev1	<u>Report Revised Base on TCB's Feedback.</u> 1. Section 3.1: Added Original Output Power and Note. 2. Section 5: Updated Table. 3. Section 8.2: Added Power Spectral Density 4. Section 8.3: Added Band Edge Compliance. 5. Section 8.4: Added Emission Bandwidth.	Art Thammanavarat

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