



FCC / ISED Test Report

For:

IOSiX, LLC

Model Name:

IO-2110

Product Description:

OBD vehicle data interface with Bluetooth and WiFi connectivity

FCC ID: 2AICQ-2110

IC: 21520-2110

Applied Rules and Standards:

47 CFR Part 15.247 (DTS)

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

REPORT #: EMC_LOOMA-011-22001_15_247_BTLE_DTS

DATE: 12-12-2022



A2LA Accredited

IC recognized #
3462B-1

CETECOM Inc.

411 Dixon Landing Road • Milpitas, CA 95035 • U.S.A.

Phone: + 1 (408) 586 6200 • Fax: + 1 (408) 586 6299 • E-mail: info@cetecom.com • <http://www.cetecom.com>
CETECOM Inc. is a Delaware Corporation with Corporation number: 2905571

TABLE OF CONTENTS

| | |
|--|-----------|
| 1 ASSESSMENT..... | 3 |
| 2 ADMINISTRATIVE DATA..... | 4 |
| 2.1 IDENTIFICATION OF THE TESTING LABORATORY ISSUING THE EMC TEST REPORT | 4 |
| 2.2 IDENTIFICATION OF THE CLIENT | 4 |
| 2.3 IDENTIFICATION OF THE MANUFACTURER..... | 4 |
| 3 EQUIPMENT UNDER TEST (EUT)..... | 5 |
| 3.1 EUT SPECIFICATIONS | 5 |
| 3.2 EUT SAMPLE DETAILS..... | 6 |
| 3.3 ACCESSORY EQUIPMENT (AE) DETAILS..... | 6 |
| 3.4 TEST SAMPLE CONFIGURATION | 6 |
| 3.5 SOFTWARE USED TO CONFIGURE THE SAMPLES..... | 6 |
| 3.6 JUSTIFICATION FOR WORST CASE MODE OF OPERATION..... | 6 |
| 4 SUBJECT OF INVESTIGATION | 7 |
| 5 MEASUREMENT RESULTS SUMMARY | 7 |
| 6 MEASUREMENT UNCERTAINTY..... | 8 |
| 6.1 ENVIRONMENTAL CONDITIONS DURING TESTING:..... | 8 |
| 6.2 DATES OF TESTING:..... | 8 |
| 7 MEASUREMENT PROCEDURES..... | 9 |
| 7.1 RADIATED MEASUREMENT..... | 9 |
| 7.2 POWER LINE CONDUCTED MEASUREMENT PROCEDURE | 11 |
| 7.3 RF CONDUCTED MEASUREMENT PROCEDURE | 11 |
| 8 TEST RESULT DATA | 12 |
| 8.1 MAXIMUM PEAK CONDUCTED OUTPUT POWER AND DUTY CYCLE | 12 |
| 8.2 DUTY CYCLE..... | 16 |
| 8.3 POWER SPECTRAL DENSITY | 17 |
| 8.4 BAND EDGE COMPLIANCE | 21 |
| 8.5 EMISSION BANDWIDTH 6DB AND 99% OCCUPIED BANDWIDTH..... | 26 |
| 8.6 RADIATED TRANSMITTER SPURIOUS EMISSIONS AND RESTRICTED BANDS | 33 |
| 9 TEST SETUP PHOTOS..... | 46 |
| 10 TEST EQUIPMENT AND ANCILLARIES USED FOR TESTING | 46 |
| 11 HISTORY | 46 |

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 # |
|------------|---|---------|
| IOSiX, LLC | OBD vehicle data interface with Bluetooth and WiFi connectivity | IO-2110 |

Responsible for Testing Laboratory:

| 12-12-2022 | Compliance | Arndt Stoecker (Director of Regulatory Services) |
|------------|------------|---|
| Date | Section | Name |

Responsible for the Report:

| 12-12-2022 | Compliance | Kris Lazarov (Senior EMC Engineer) |
|------------|------------|---------------------------------------|
| Date | Section | Name |

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 |
| Director of Regulatory Services: | Arndt Stoecker |
| Responsible Project Leader: | Akanksha Baskaran |

2.2 Identification of the Client

| | |
|--------------------------|---------------------|
| Client Firm/Name: | IOSiX, LLC |
| Street Address: | 1161 Oak Valley Dr |
| City/Zip Code | Ann Arbor, MI 48108 |
| 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: | IO-2110 |
| HW Version : | 5.0b |
| SW Version : | 1.0 |
| FCC-ID : | 2AICQ-2110 |
| IC: | 21520-2110 |
| FWIN: | - |
| HVIN: | IO-2110 |
| PMN: | IO-2110 |
| Product Description: | OBD vehicle data interface with Bluetooth and WiFi connectivity |
| Frequency Range / number of channels: | Bluetooth (LE) - nominal band: 2400 MHz – 2483.5 MHz; Center to center: 2404 MHz (ch 0) – 2480 MHz (ch 39), 40 channels |
| Modes of Operation: | Bluetooth LE in both advertising and connected mode of operation |
| Antenna Information as declared: | Trace antenna Max gain 0.44 dBi |
| Max. Peak Output Power: | Conducted Power 6.3 dBm |
| Power Supply/ Rated Operating Voltage Range: | 5-27V DC |
| Operating Temperature Range | -40 C to 125 C |
| Other Radios included in the device: | 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 | 5.0b | 1.0 | Conducted |
| 2 | Engineering Sample 2 | 5.0b | 1.0 | Radiated |

3.3 Accessory Equipment (AE) details

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

3.4 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 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#2 | The radio of the EUT was configured to a fixed channel transmission using software that is not available to the end user. The internal antenna was connected. |

3.5 Software Used to Configure the Samples

- Software date: 2021.11.10
- Version: V2.8
- Storage location: https://www.espressif.com/sites/default/files/tools/ESP_RF_Test_EN.zip

3.6 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 the highest duty cycle possible. 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: 2AICQ-2110 and IC: 21520-2110.

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 DC | 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 | N/A | □ | ■ | □ | 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=2.

| 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:

10/17/2022 – 12/12/2022

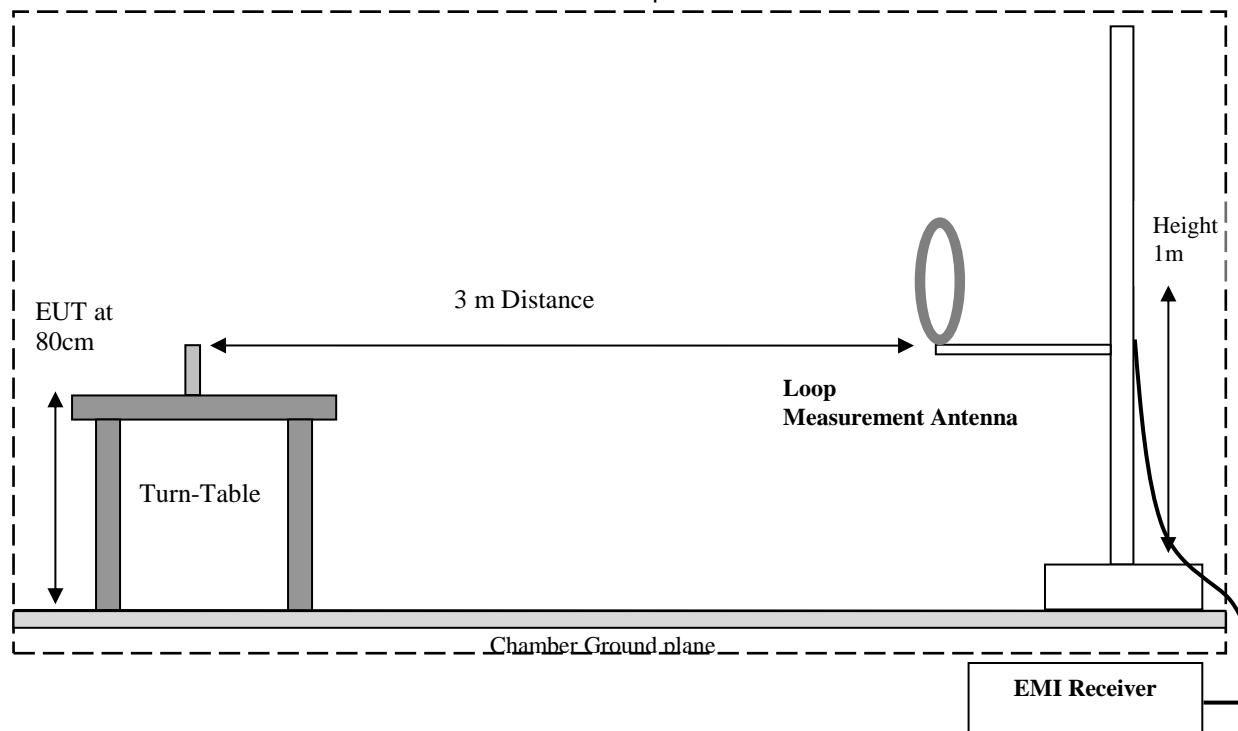
7 Measurement Procedures

7.1 Radiated Measurement

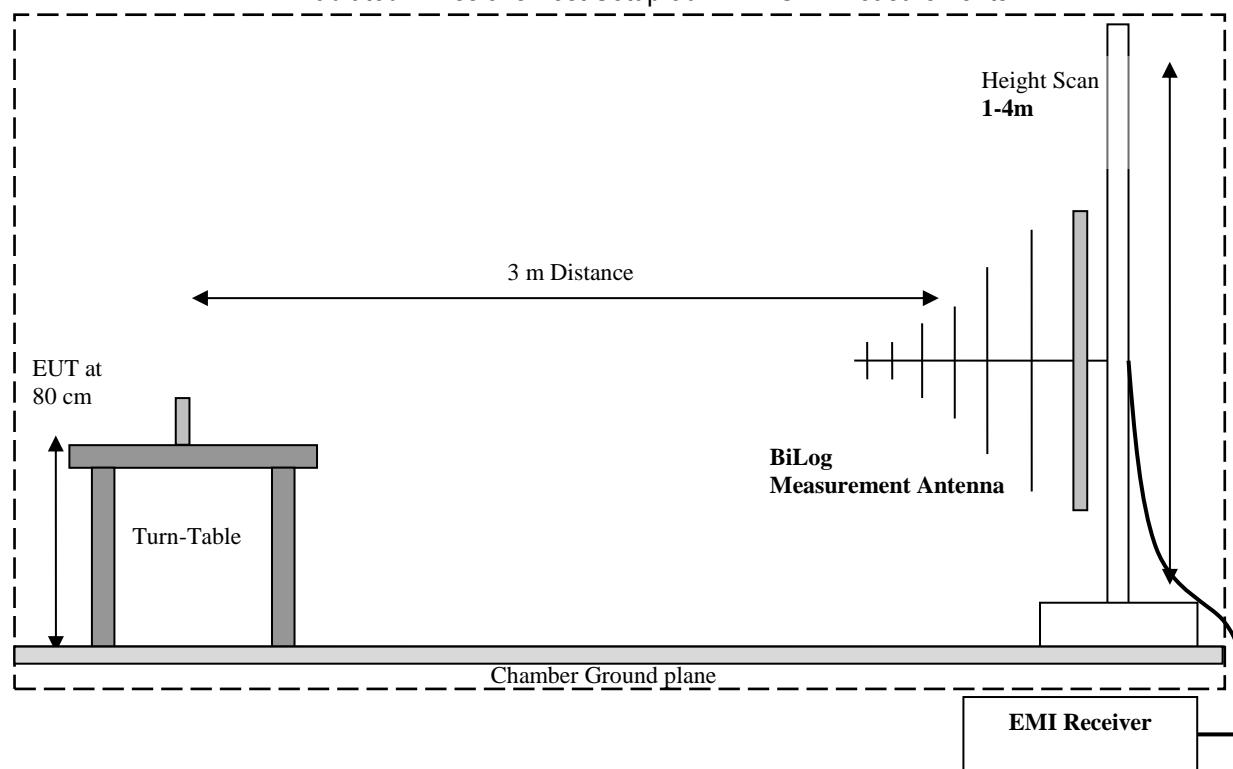
The radiated measurement is performed according to ANSI C63.10 (2013)

- 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.

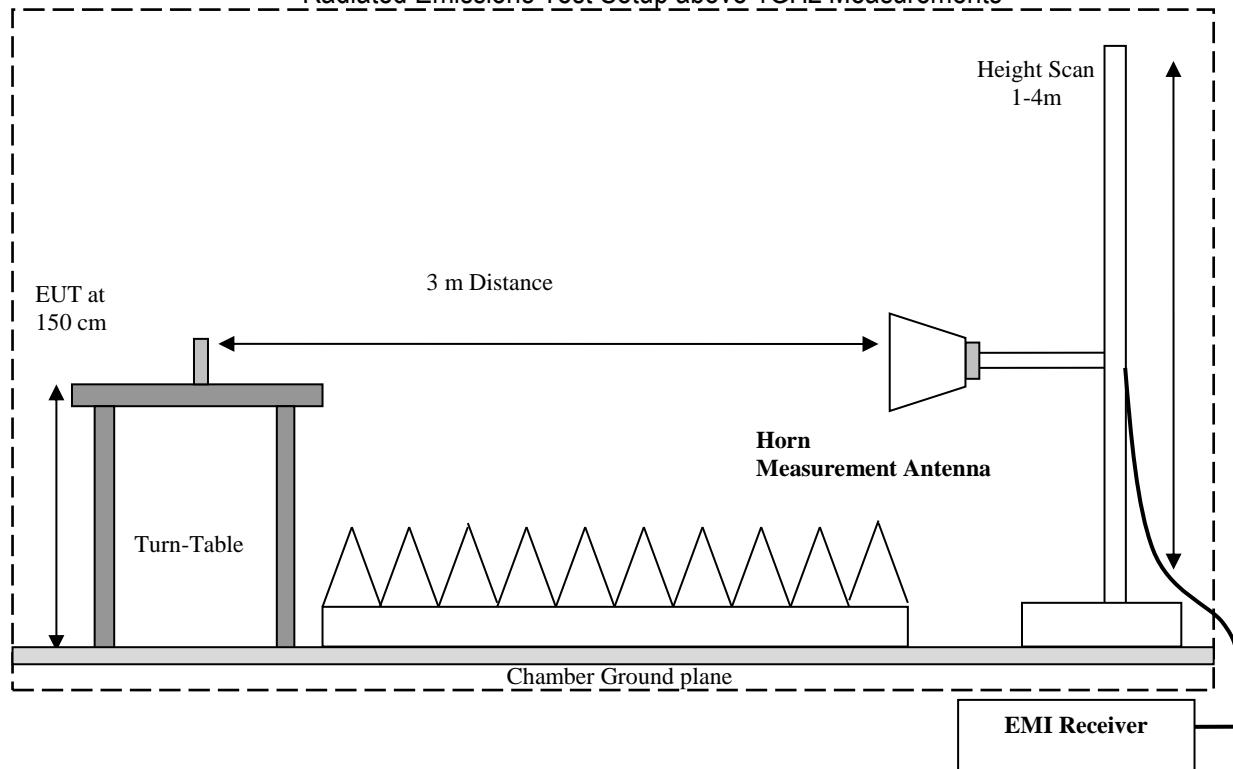
Radiated Emissions Test Setup below 30MHz Measurements



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:

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

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 and Duty Cycle

8.1.1 Measurement according to ANSI C63.10-2013 11.9.1.1

Spectrum Analyzer settings:

- RBW \geq DTS bandwidth
- VBW \geq 3 x RBW
- Span \geq 3 x 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)(3): 1 W
- IC RSS-247: 1 W

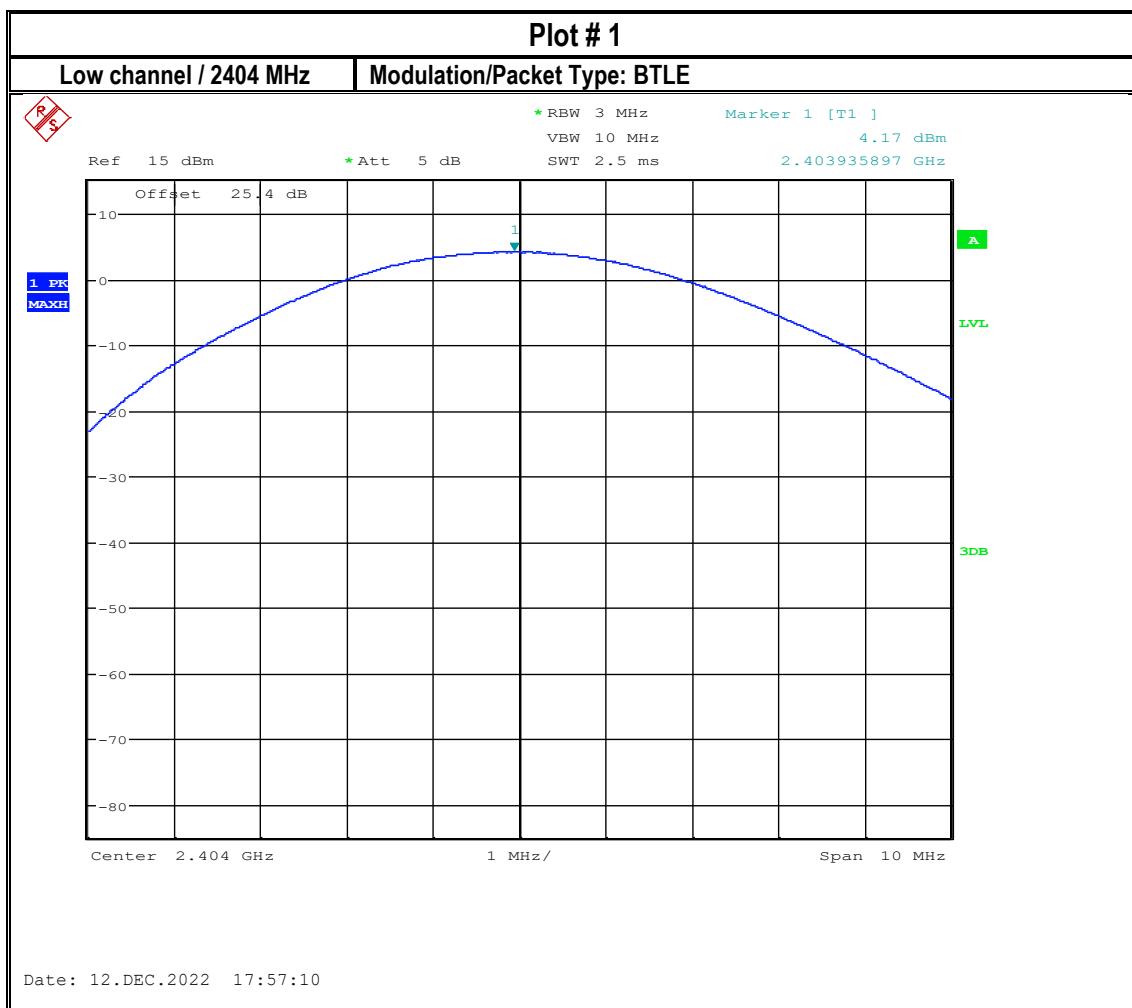
8.1.3 Test conditions and setup:

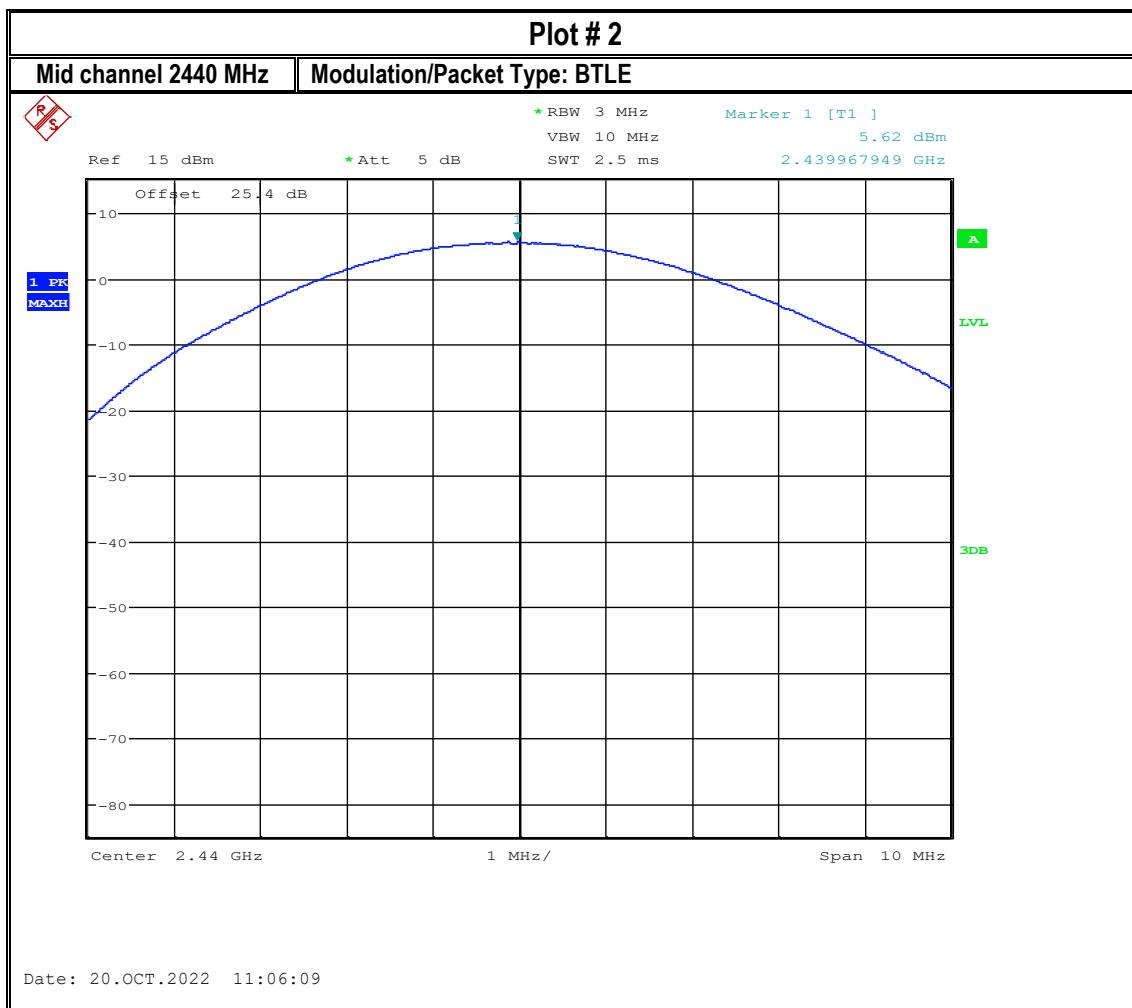
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Measurement Path Loss | Antenna Gain |
|---------------------|--------------|-------------------------------|-----------------------|--------------|
| 20° C | 1 | GFSK continuous fixed channel | 25.4 dB | 0.44 dBi |

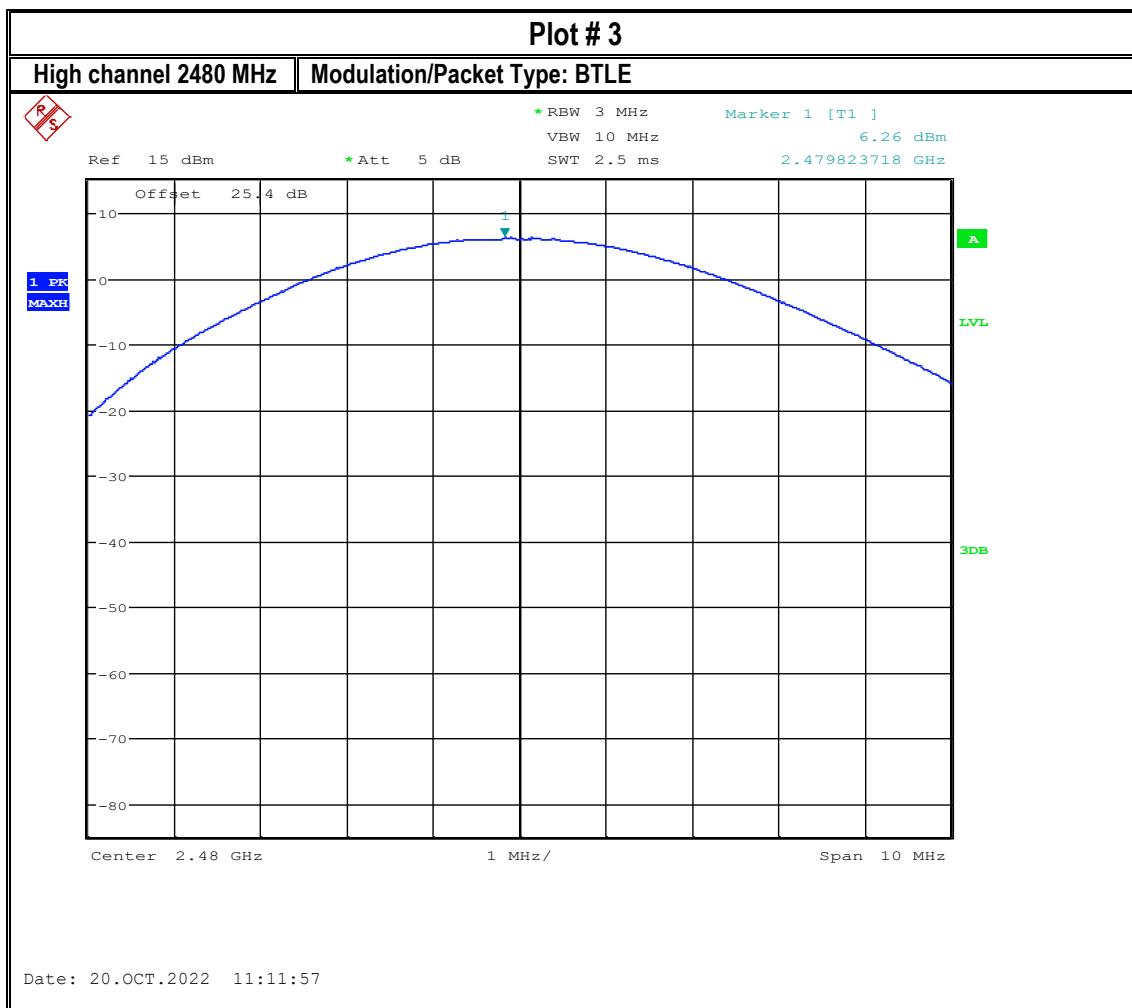
8.1.4 Measurement result:

| Plot # | Mode of Operation / Frequency (MHz) | Maximum Conducted Output Power (dBm) | Maximum Conducted Output Power (W) | Limit (W) | Result |
|--------|-------------------------------------|--------------------------------------|------------------------------------|-----------|--------|
| 1 | BLE 2404 | 4.17 | 0.002 | 1 | Pass |
| 2 | BLE 2440 | 5.62 | 0.004 | 1 | Pass |
| 3 | BLE 2480 | 6.26 | 0.005 | 1 | Pass |

8.1.5 Measurement Plots:







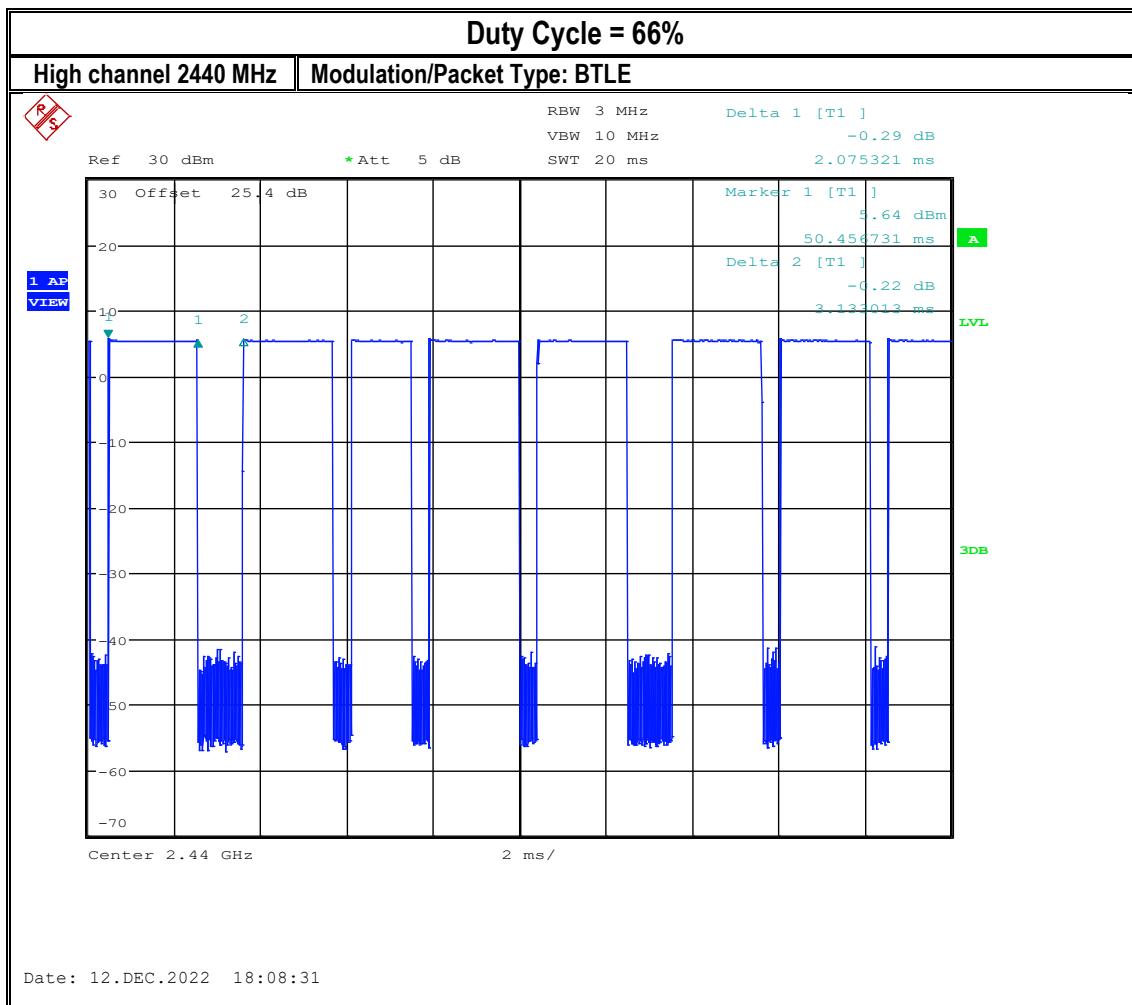
8.2 Duty cycle

8.2.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02

Spectrum Analyzer settings:

- Set the center frequency and of the instrument to the center frequency of the transmission
- Zero span
- Set RBW \geq OBW if possible; otherwise, set RBW to the largest available value
- Detector = Peak

8.2.2 Measurement result



8.3 Power Spectral Density

8.3.1 Measurement according to ANSI C63.10-2013 11.10.2.

Spectrum Analyzer settings:

- 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

8.3.2 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.

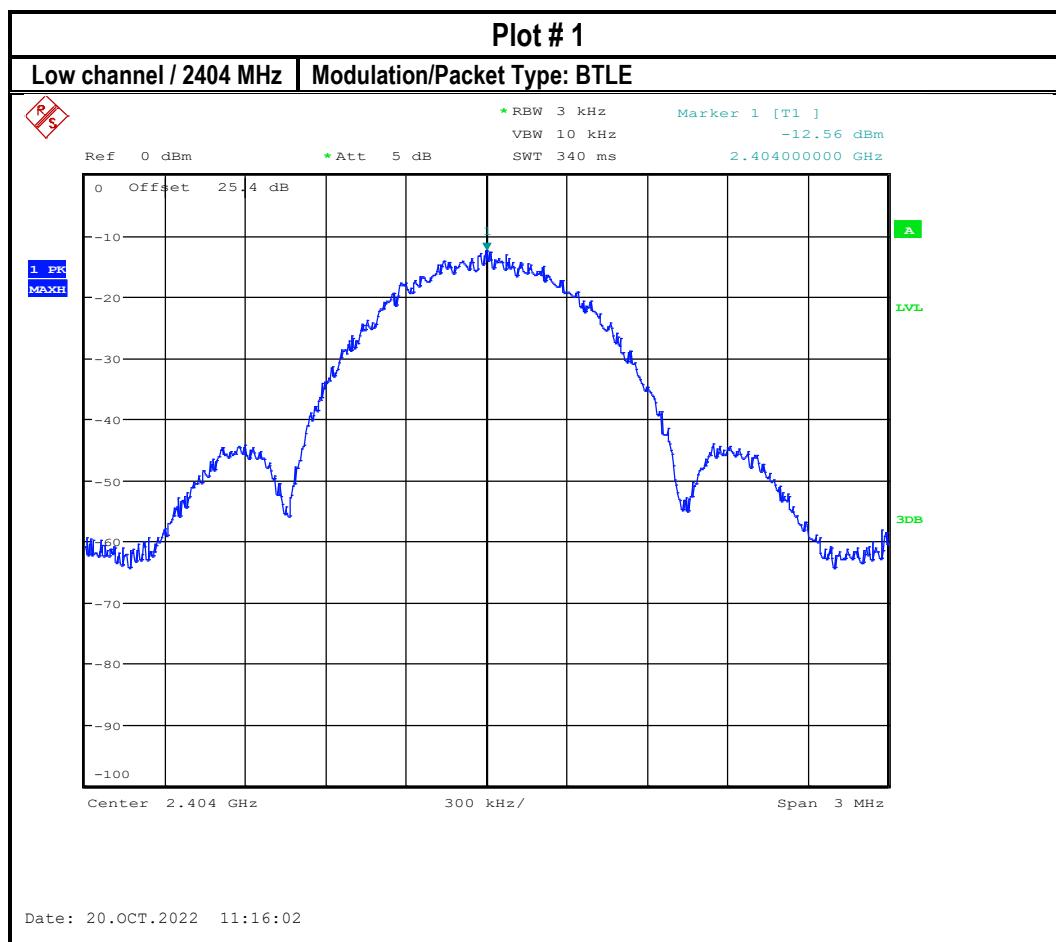
8.3.3 Test conditions and setup:

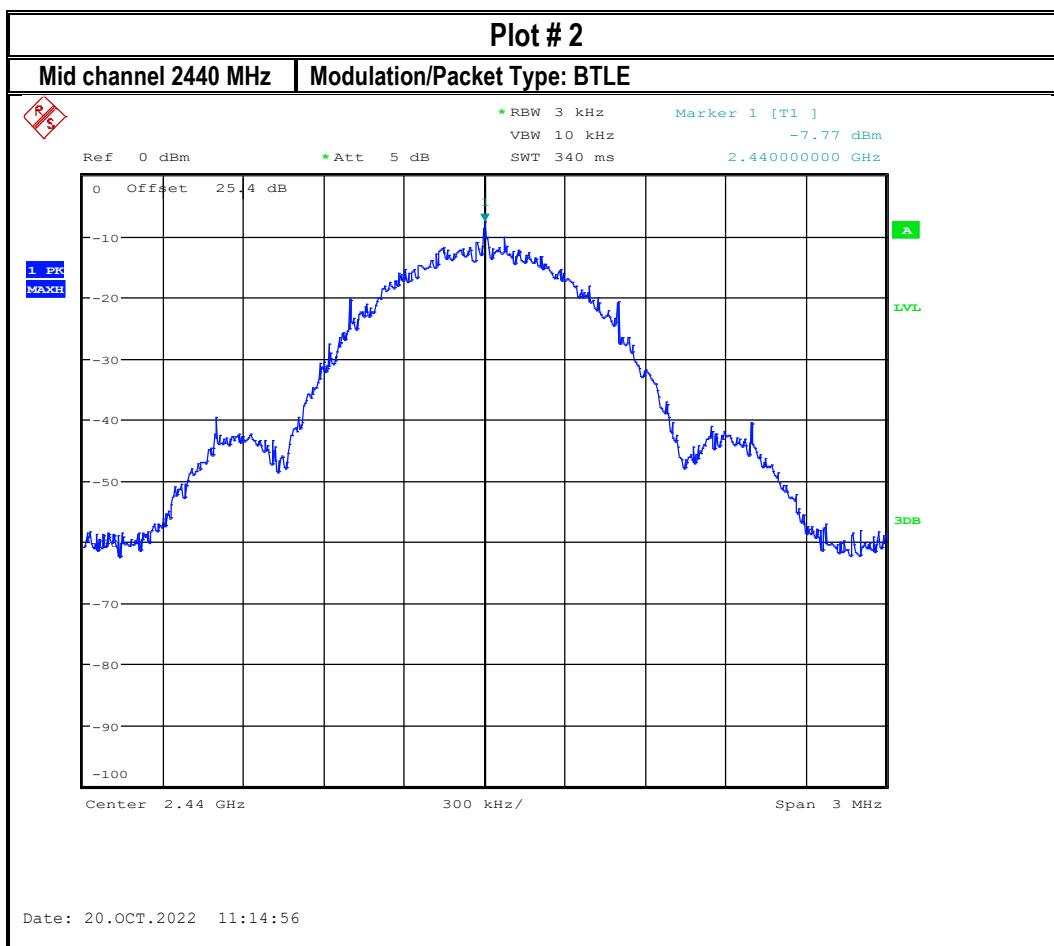
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Measurement Path Loss | Antenna Gain |
|---------------------|--------------|-------------------------------|-----------------------|--------------|
| 20° C | 1 | GFSK continuous fixed channel | 25.4 dB | 0.44 dBi |

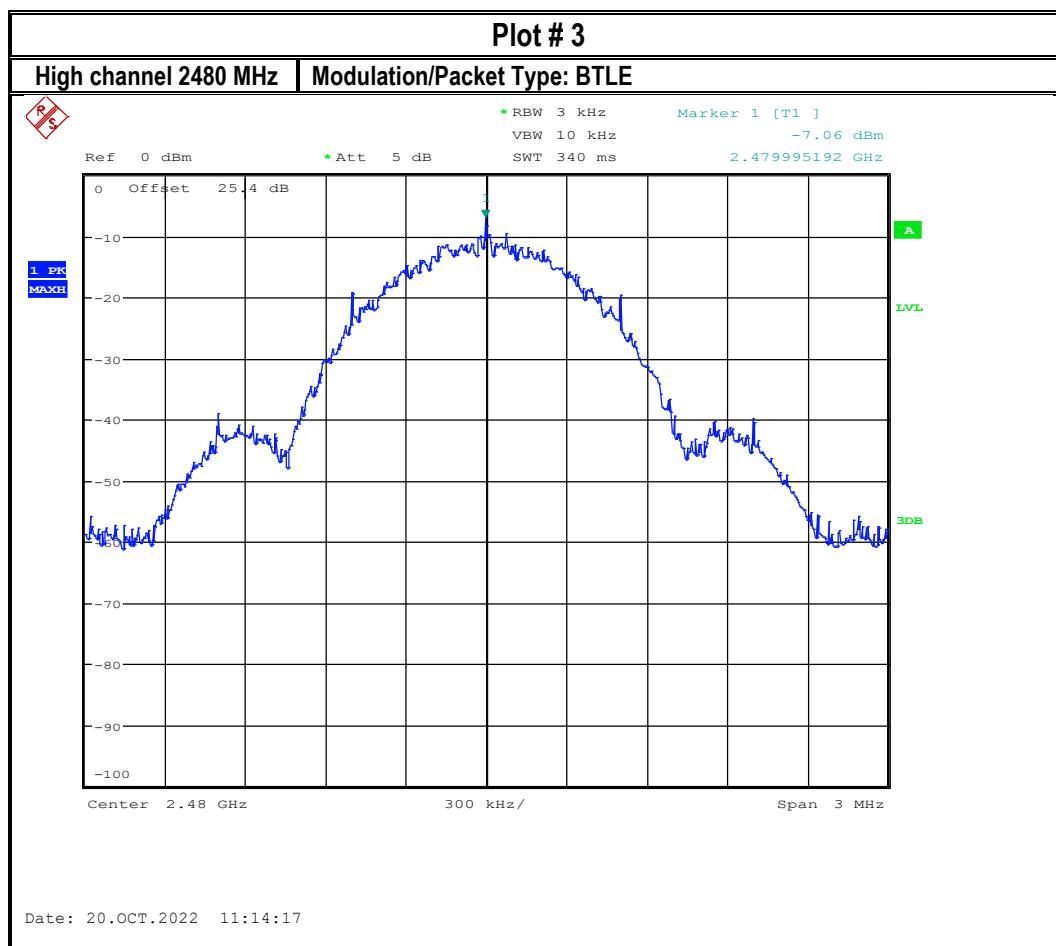
8.3.4 Measurement result:

| Plot # | Mode of Operation / Frequency (MHz) | Measured PSD (dBm/3 kHz) | Limit (dBm / 3 kHz) | Result |
|--------|-------------------------------------|--------------------------|-----------------------|--------|
| 1 | BLE 2404 | -12.56 | 8 | Pass |
| 2 | BLE 2440 | -7.77 | 8 | Pass |
| 3 | BLE 2480 | -7.06 | 8 | Pass |

8.3.5 Measurement Plots:







8.4 Band Edge Compliance

8.4.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02

- Lower non-restricted band edge was measured conducted
- Upper restricted band edge was measured radiated at 3 m distance

Spectrum Analyzer settings for non-restricted band edge ANSI 63.10 Section 11.11:

- 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

Spectrum Analyzer settings for restricted band radiated measurements ANSI 63.10 Section 11.12.1:

- RBW=1 MHz
- Detector Peak / RMS

8.4.2 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.

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

- *PEAK LIMIT= 74 dB μ V/m
- *AVG. LIMIT= 54 dB μ V/m
- Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205 & RSS-Gen 8.10
- (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 | | | |

8.4.4 Test conditions and setup:

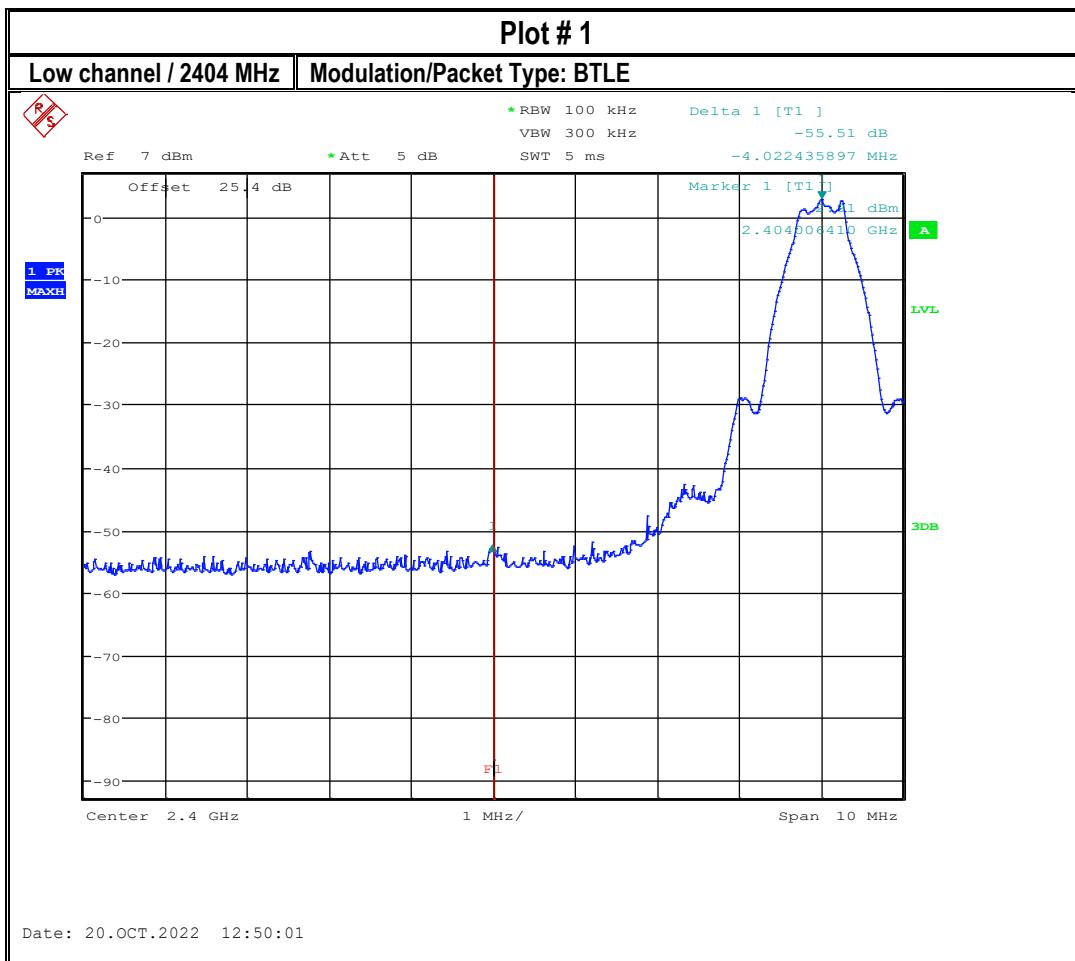
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Measurement Path Loss |
|---------------------|--------------|-------------------------------|-----------------------|
| 20° C | 1, 2 | GFSK continuous fixed channel | 25.4 dB |

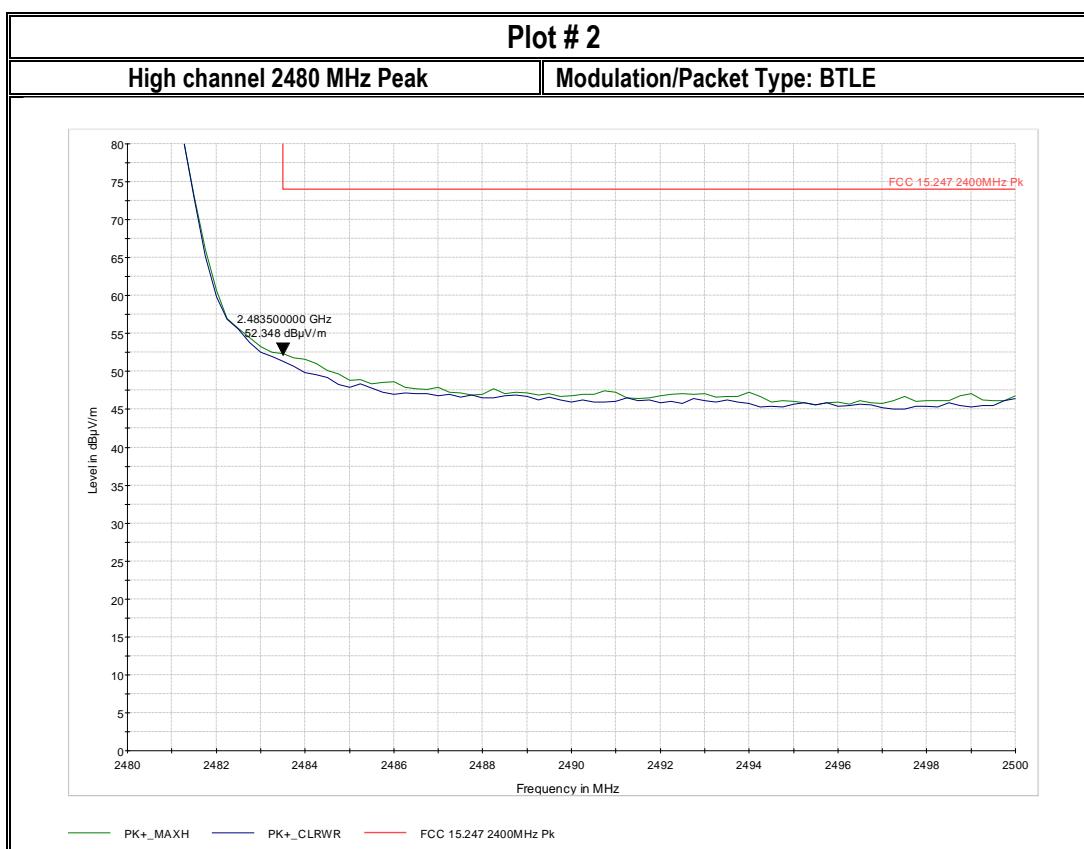
8.4.5 Measurement result:

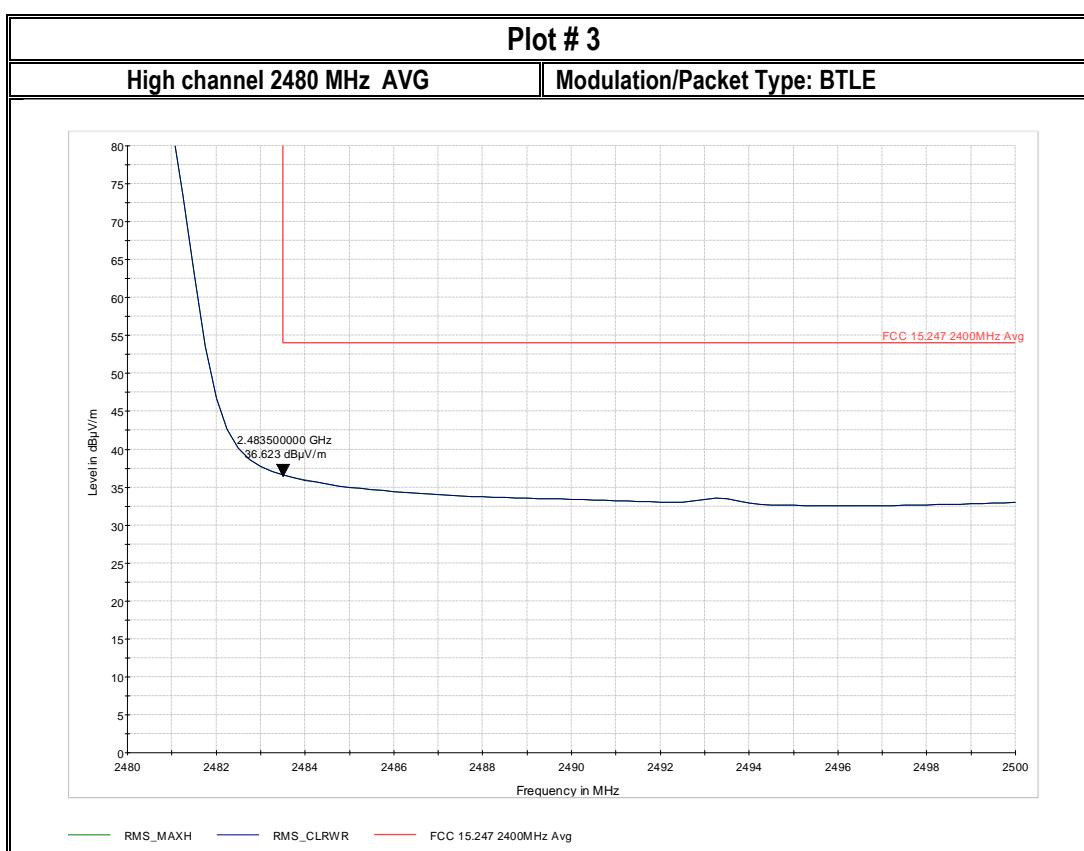
| Plot # | EUT operating mode | Band Edge | Band Edge Delta (dBc) | Limit (dBc) | Result |
|--------|--------------------|-----------------------|-----------------------|-------------|--------|
| 1 | BLE 2404 | Lower, Non-restricted | 55.51 | > 20 | Pass |

| Plot # | Operating Mode | Band Edge | Measured Radiated Value (dB μ V/m) | Limit (dB μ V/m) | Result |
|--------|----------------|-----------------------|--|----------------------|--------|
| 2 | BLE 2480 | Upper Restricted Peak | 52.35 | 74 Peak | Pass |
| 3 | BLE 2480 | Upper Restricted AVG | 36.63 | 54 AVG | Pass |

8.4.6 Measurement Plots:







8.5 Emission Bandwidth 6dB and 99% Occupied Bandwidth

8.5.1 Measurement according to ANSI C63.10-2013 11.8.

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.

8.5.2 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.

8.5.3 Test conditions and setup:

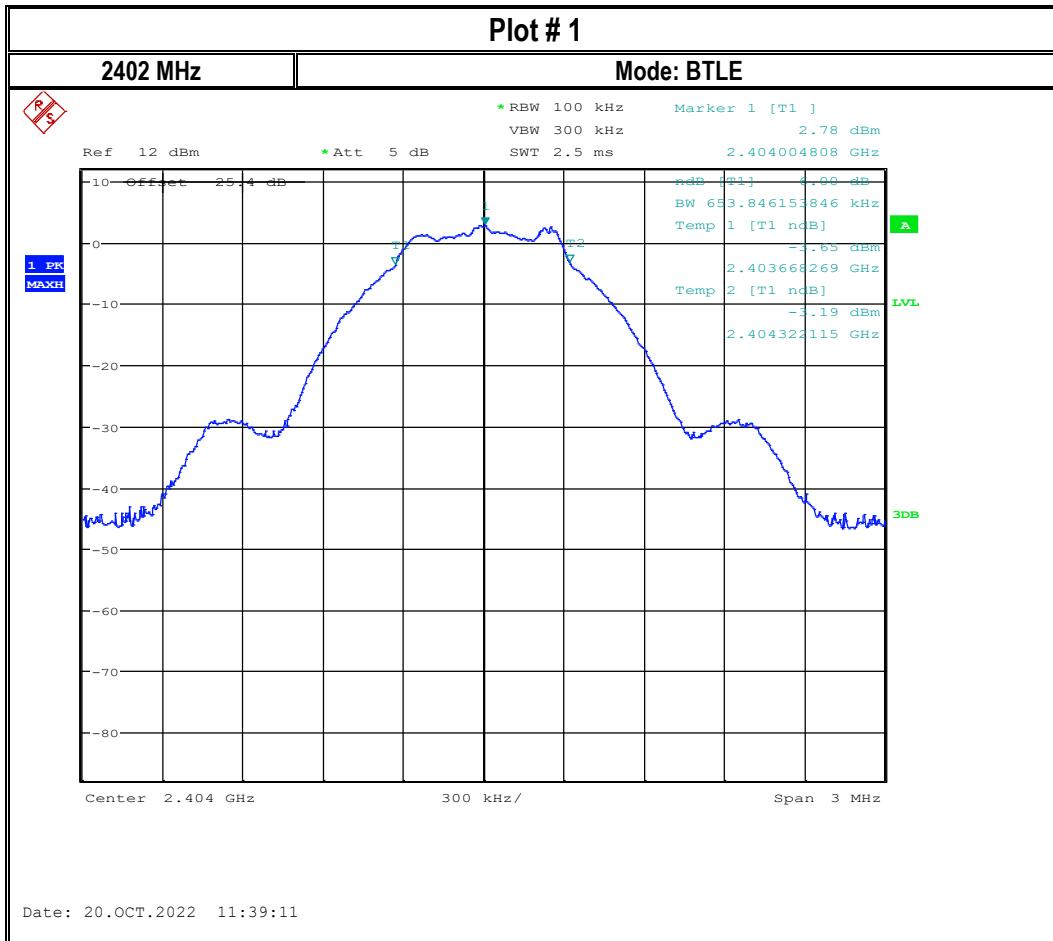
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Measurement Path Loss |
|---------------------|--------------|-------------------------------|-----------------------|
| 20° C | 1 | GFSK continuous fixed channel | 25.4 dB |

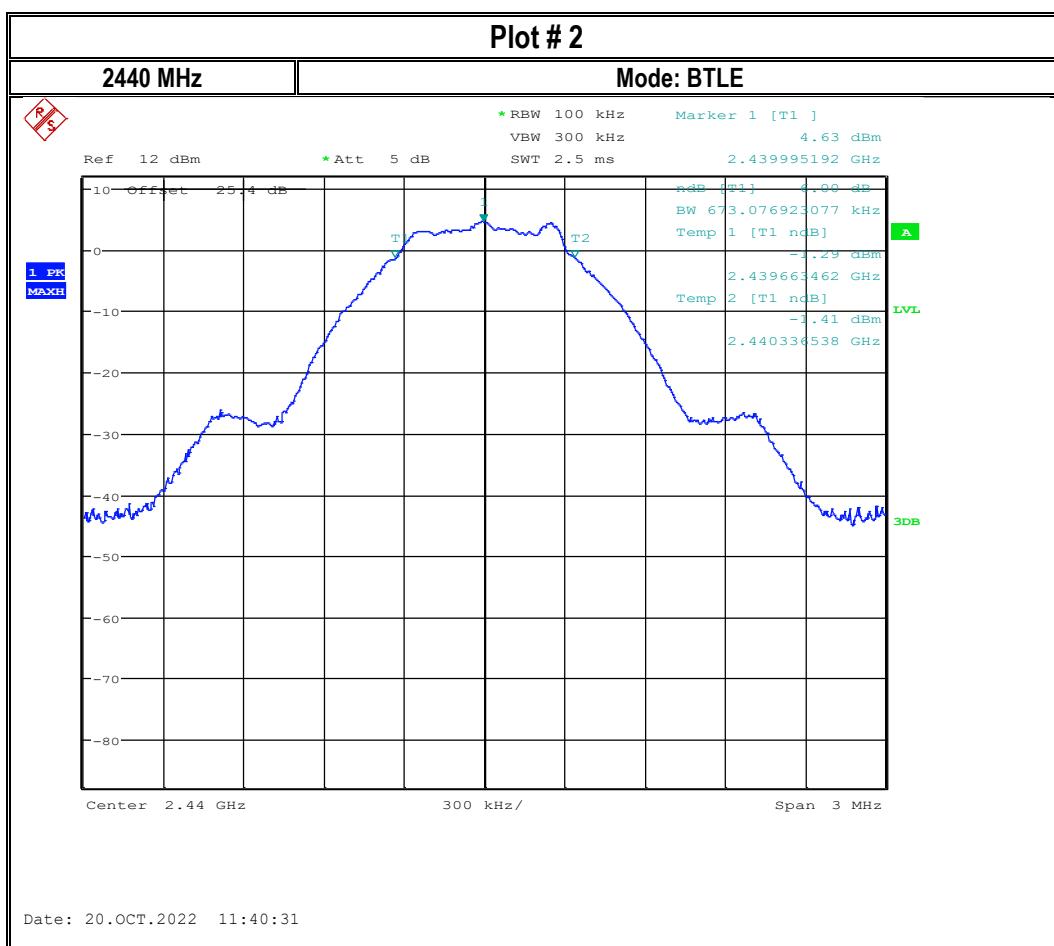
8.5.4 Measurement result:

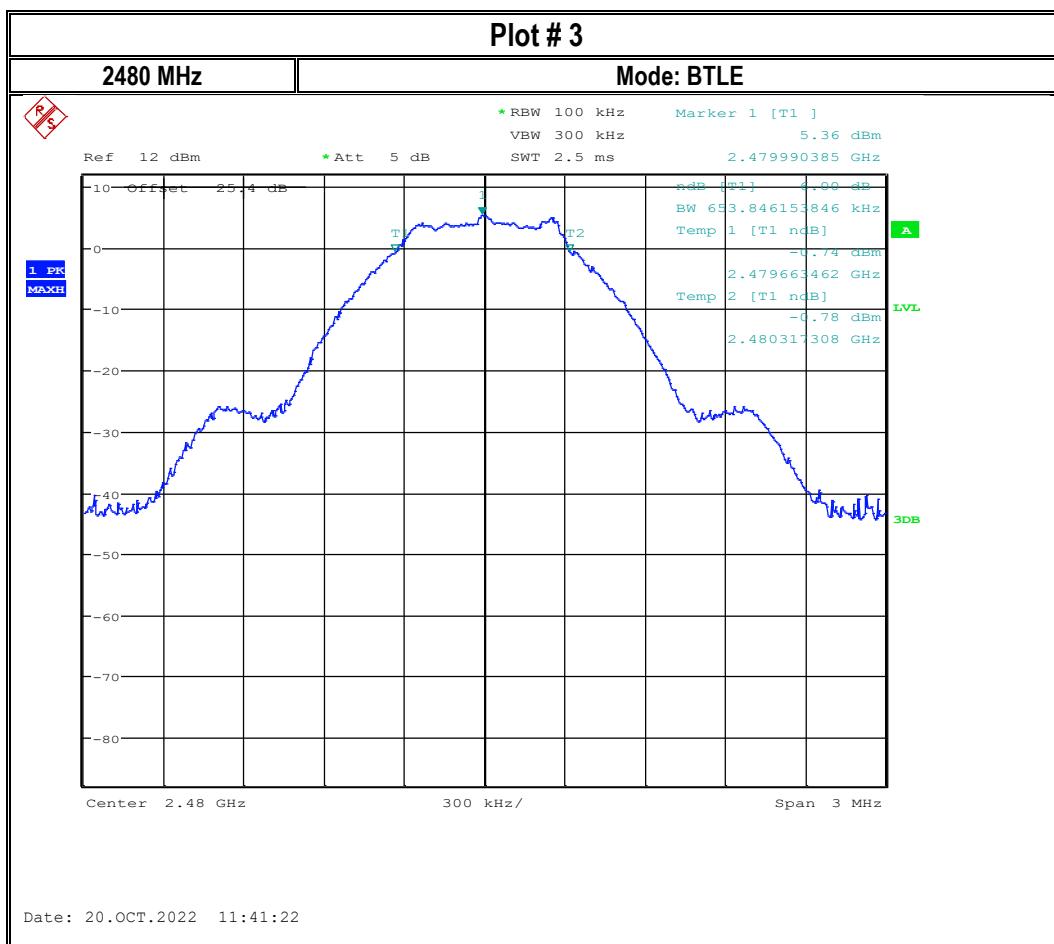
| Plot # | Frequency (MHz) | 6dB Emissions Bandwidth (MHz) | Limit (MHz) | Result |
|--------|-----------------|-------------------------------|-------------|--------|
| 1 | BLE 2404 | 0.654 | > 0.5 | Pass |
| 2 | BLE 2440 | 0.673 | > 0.5 | Pass |
| 3 | BLE 2480 | 0.654 | > 0.5 | Pass |

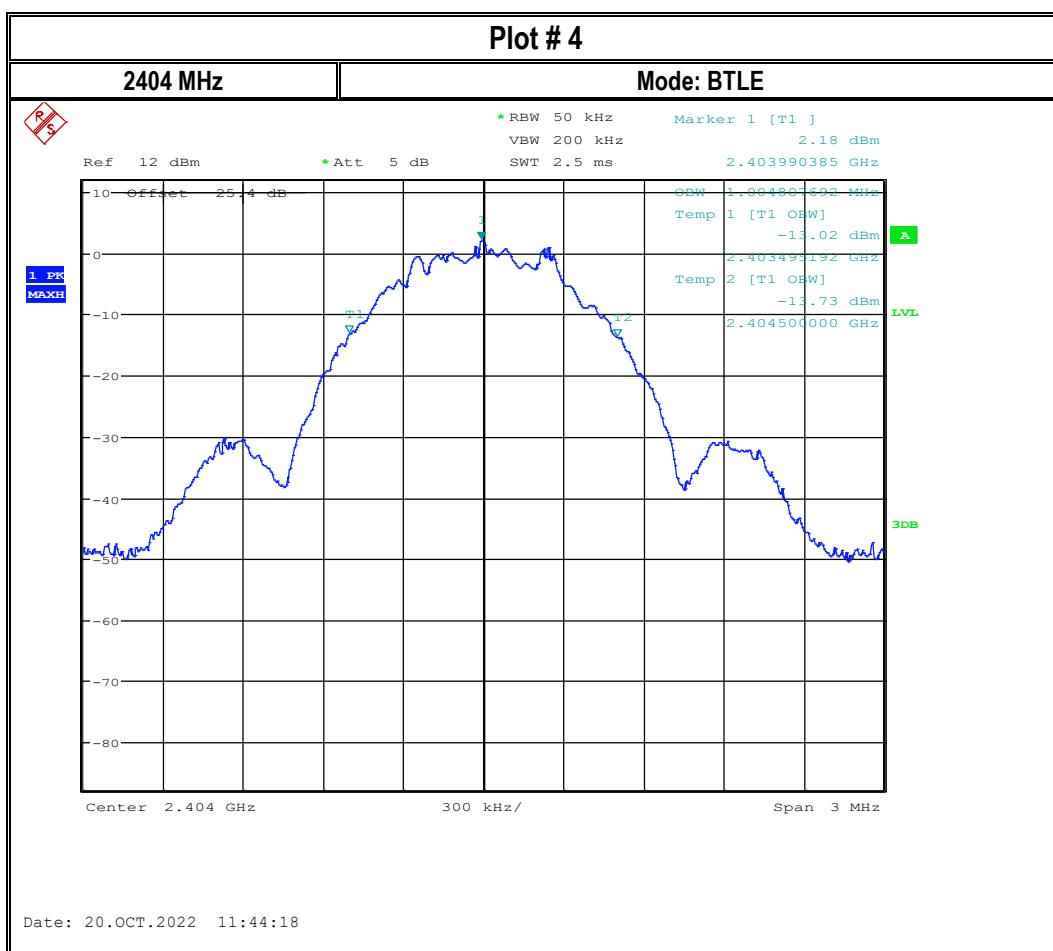
| Plot # | Frequency (MHz) | 99% Occupied Bandwidth (MHz) | Limit (MHz) | Result |
|--------|-----------------|------------------------------|-------------|--------|
| 4 | BLE 2404 | 1.005 | > 0.5 | Pass |
| 5 | BLE 2440 | 1.010 | > 0.5 | Pass |
| 6 | BLE 2480 | 1.019 | > 0.5 | Pass |

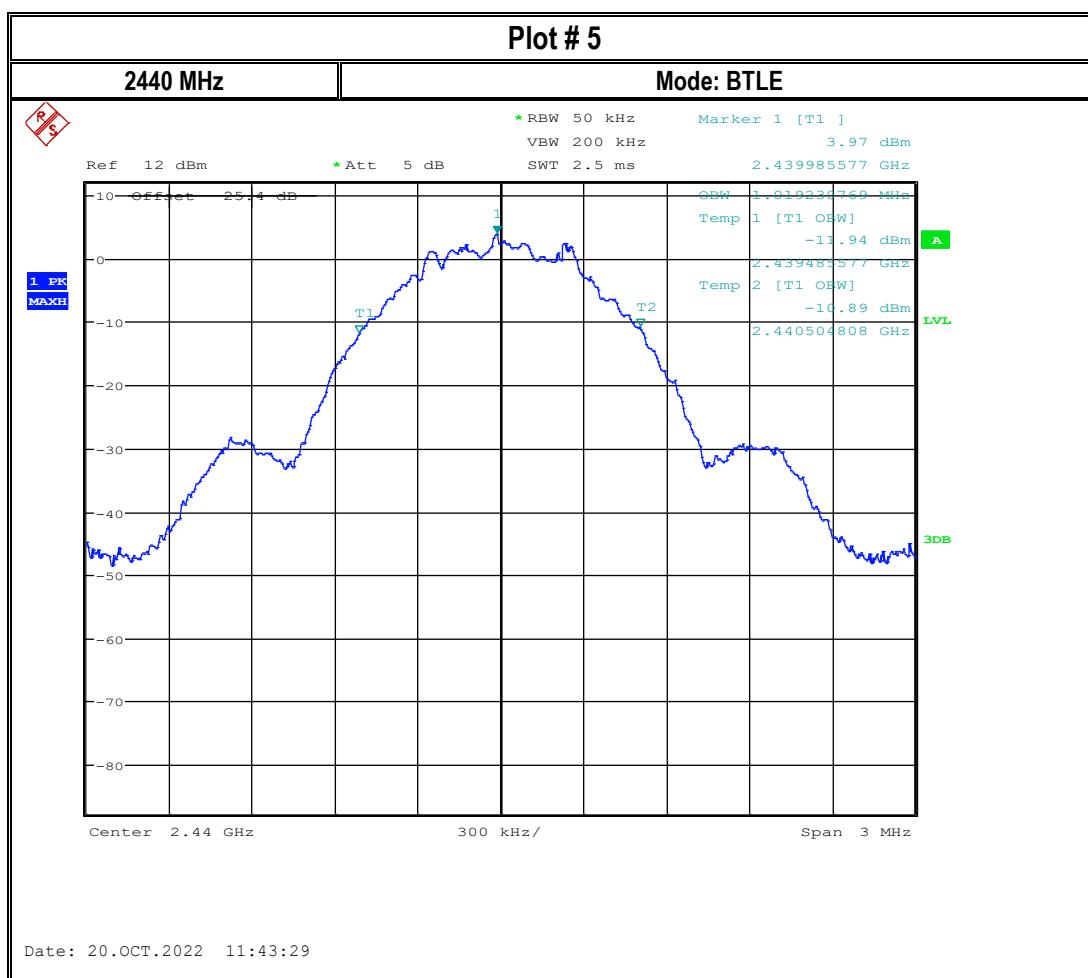
8.5.5 Measurement Plots:

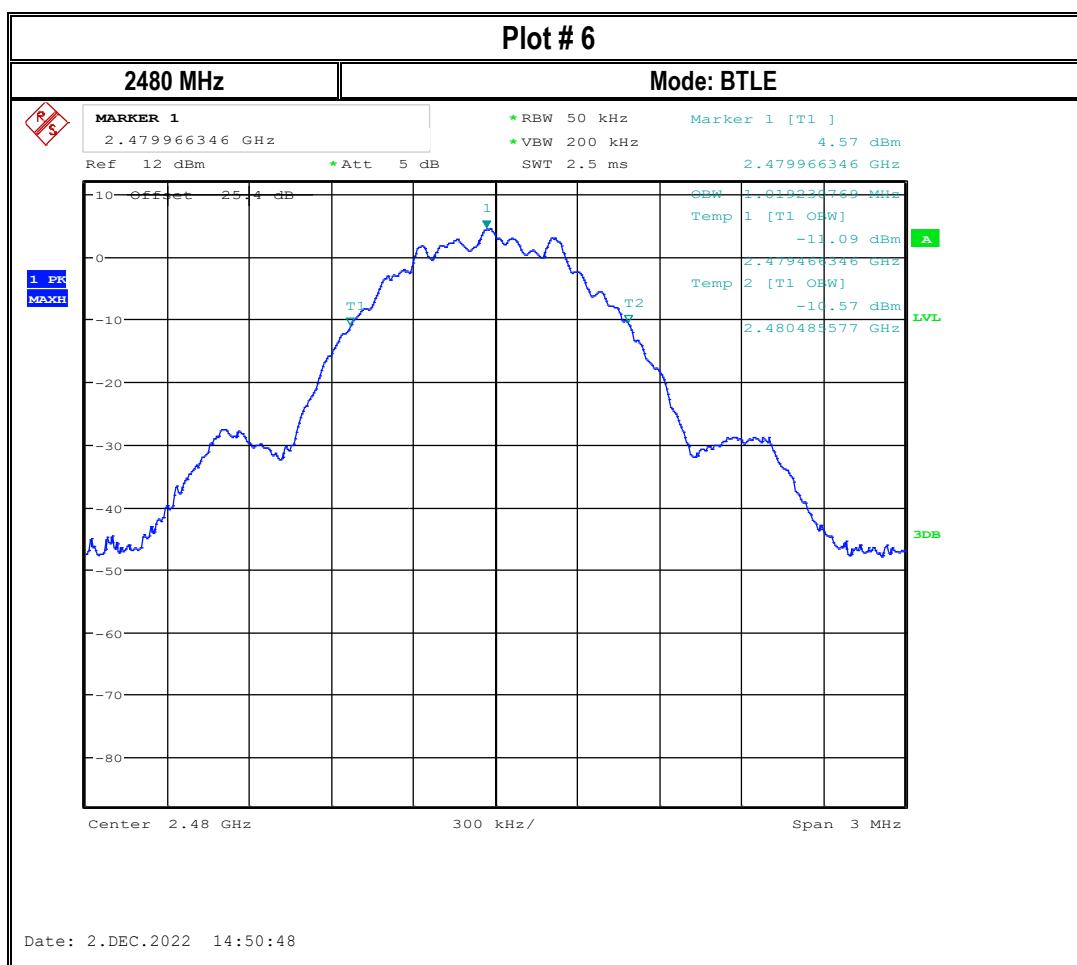












8.6 Radiated Transmitter Spurious Emissions and Restricted Bands

8.6.1 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.

8.6.2 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 (μ V/m) | Measurement Distance (m) | Field strength @ 3m (dB μ V/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 dB μ V/m |
| 88–216 | 150 | 3 | 43.5 dB μ V/m |
| 216–960 | 200 | 3 | 46 dB μ V/m |
| Above 960 | 500 | 3 | 54 dB μ V/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 dB μ V/m

*AVG. LIMIT= 54 dB μ V/m

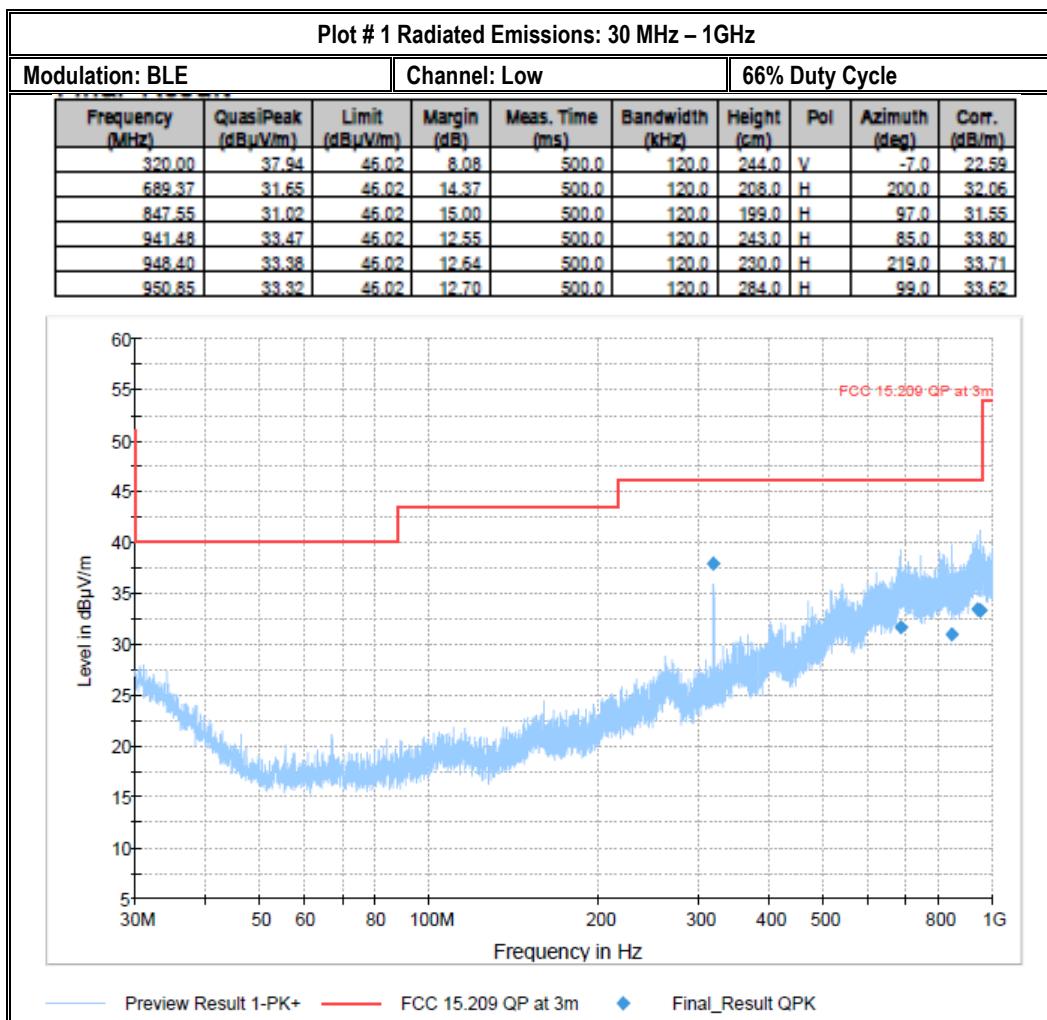
8.6.3 Test conditions and setup:

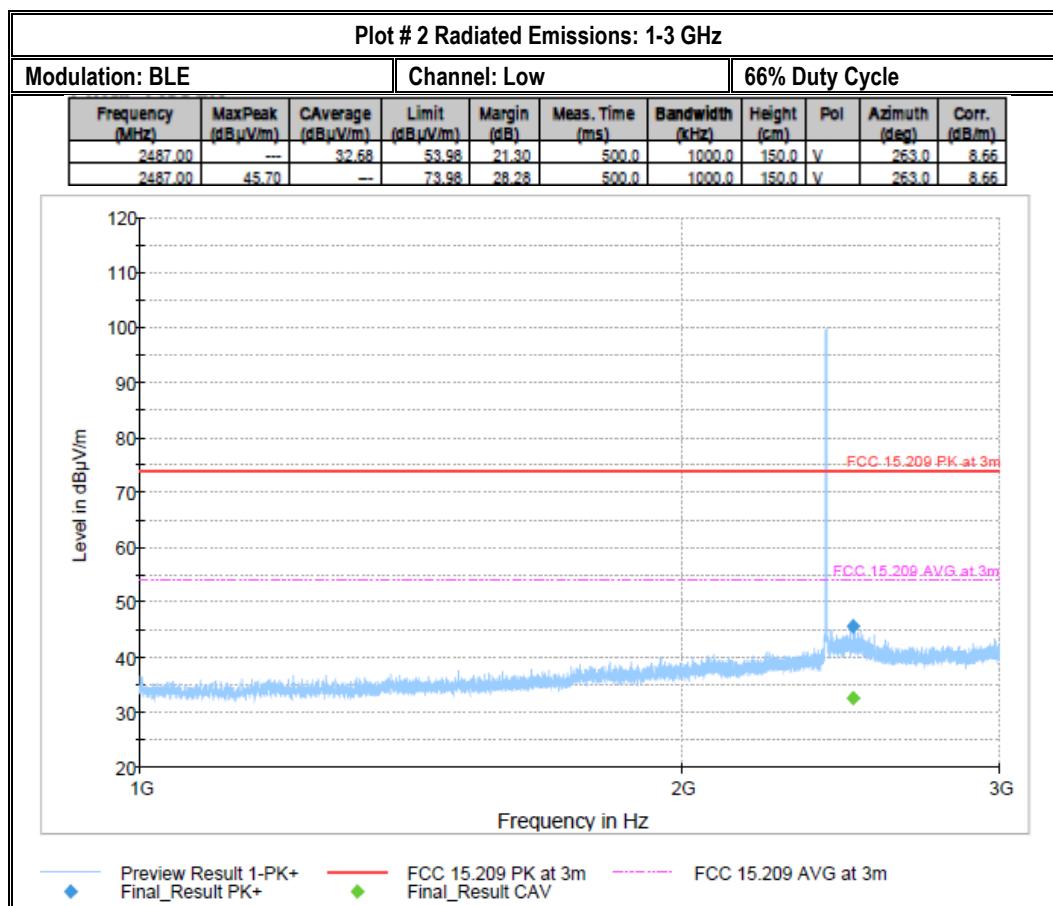
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input |
|---------------------|--------------|-------------------------------|-------------|
| 20° C | 2 | GFSK continuous fixed channel | 7 VDC |

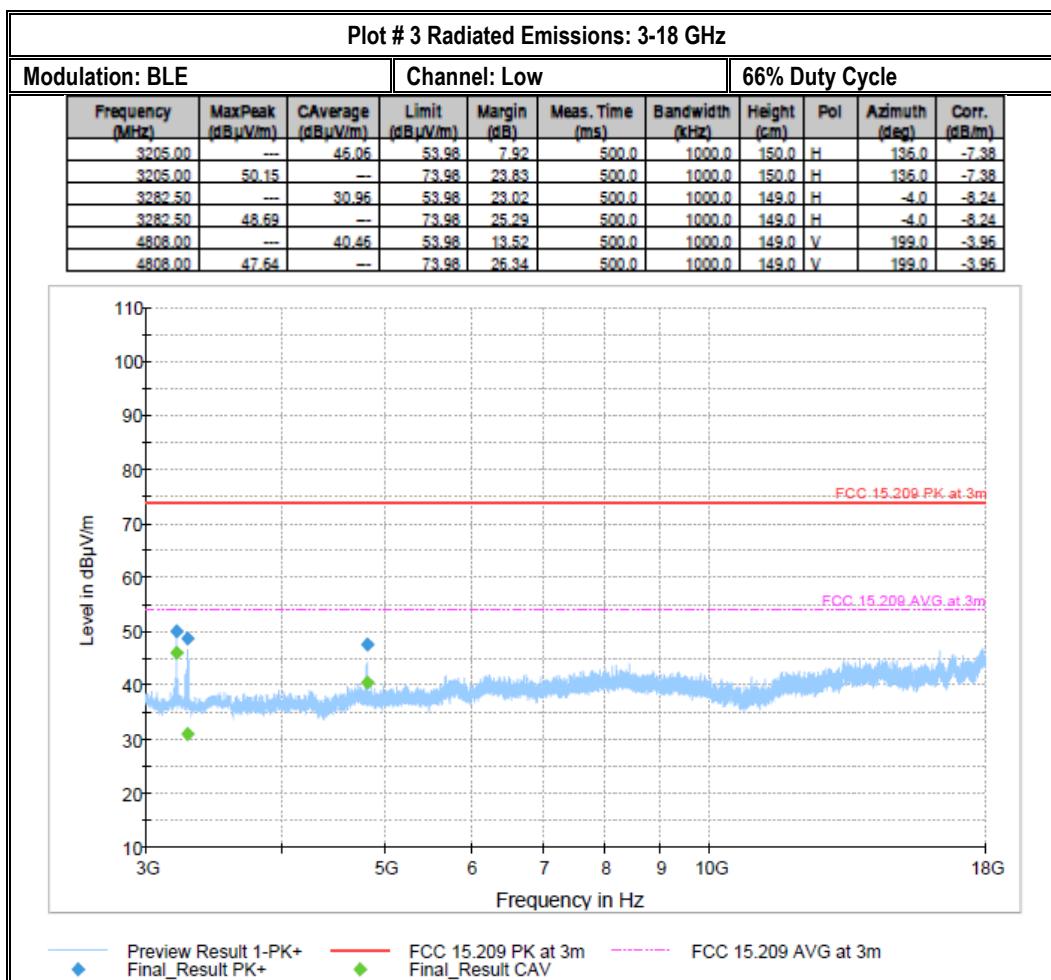
8.6.4 Measurement result:

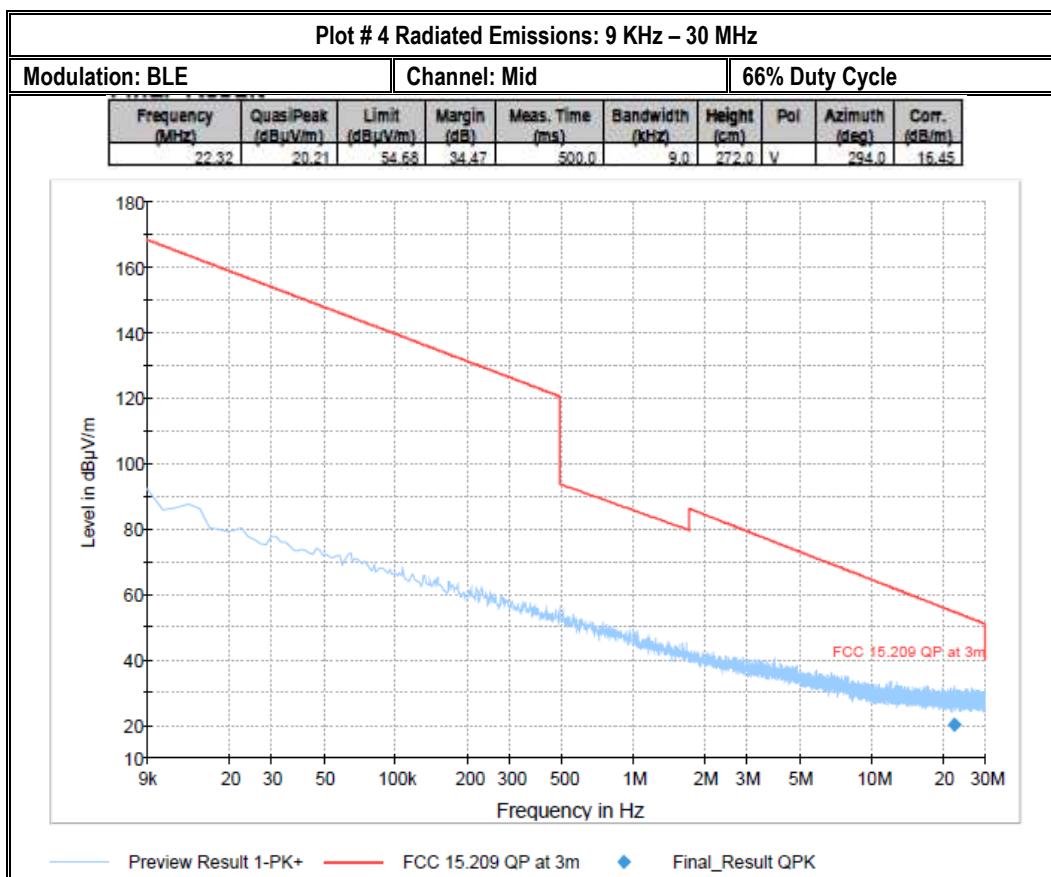
| Plot # | Channel # | Scan Frequency | Limit | Result |
|--------|-----------|-----------------|-------------------|--------|
| 1-3 | Low | 30 MHz – 18 GHz | See section 8.5.2 | Pass |
| 4-8 | Mid | 9 kHz – 26 GHz | See section 8.5.2 | Pass |
| 9-11 | High | 30 MHz – 18 GHz | See section 8.5.2 | Pass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

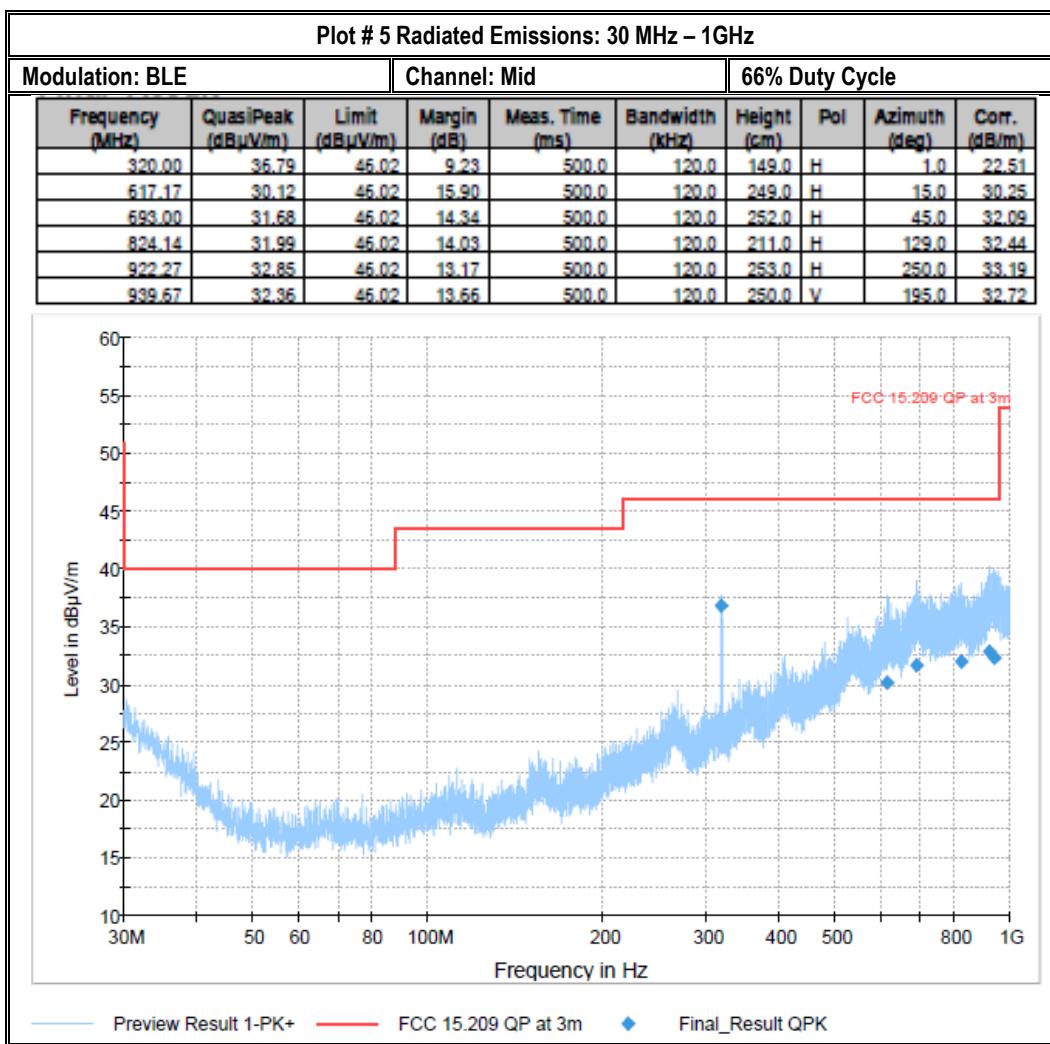
8.6.5 Measurement Plots:

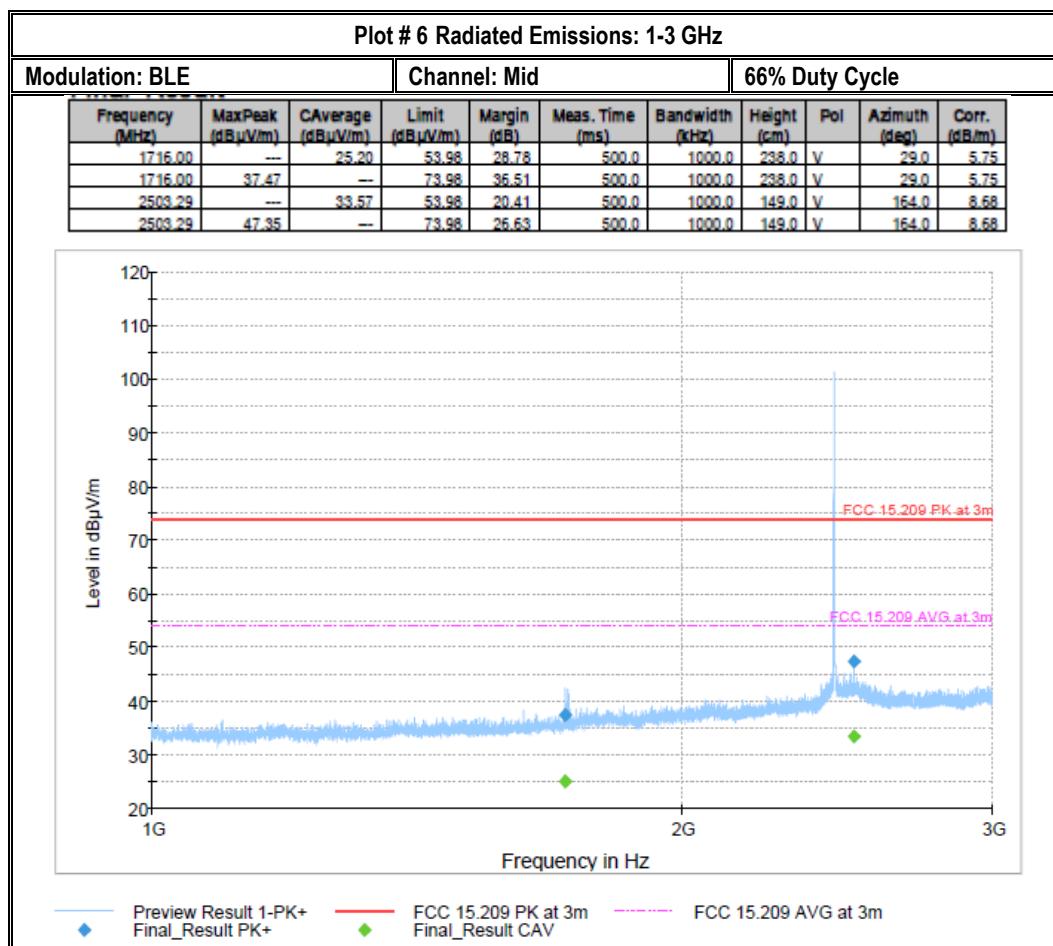


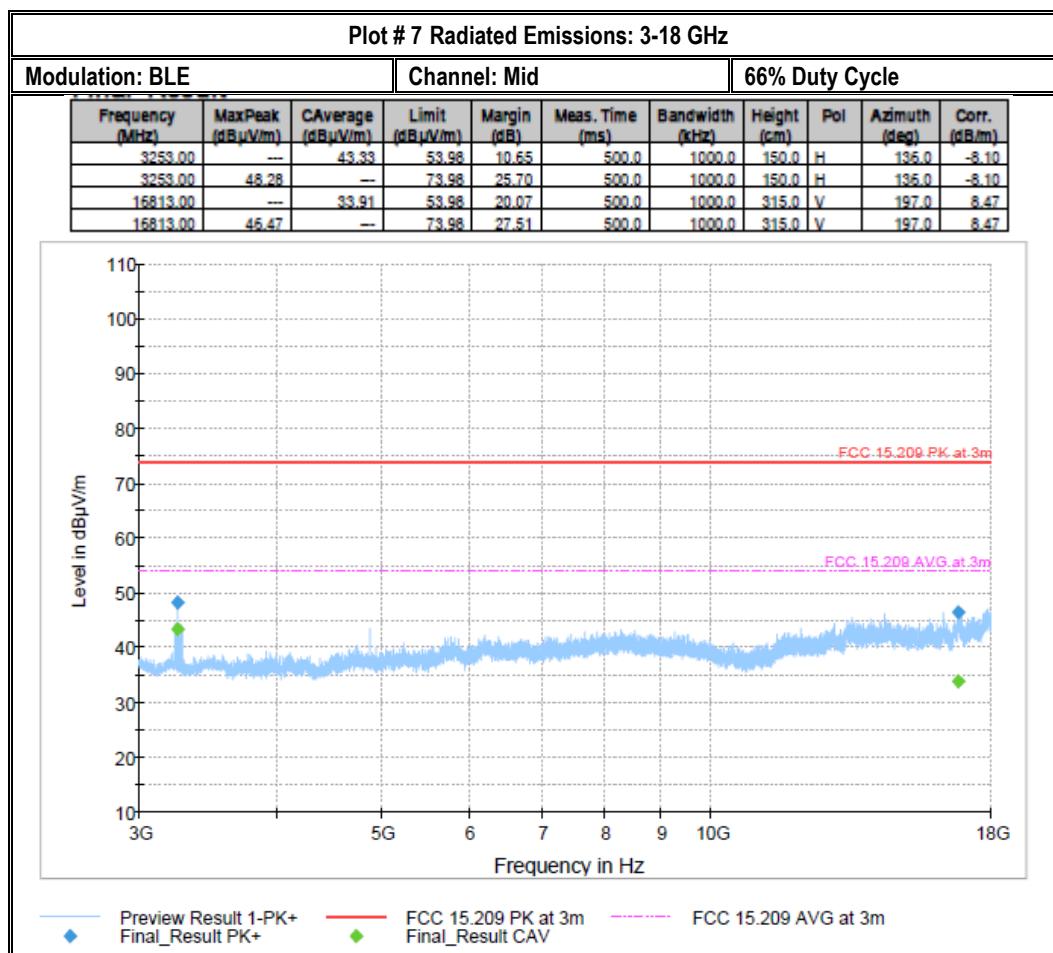


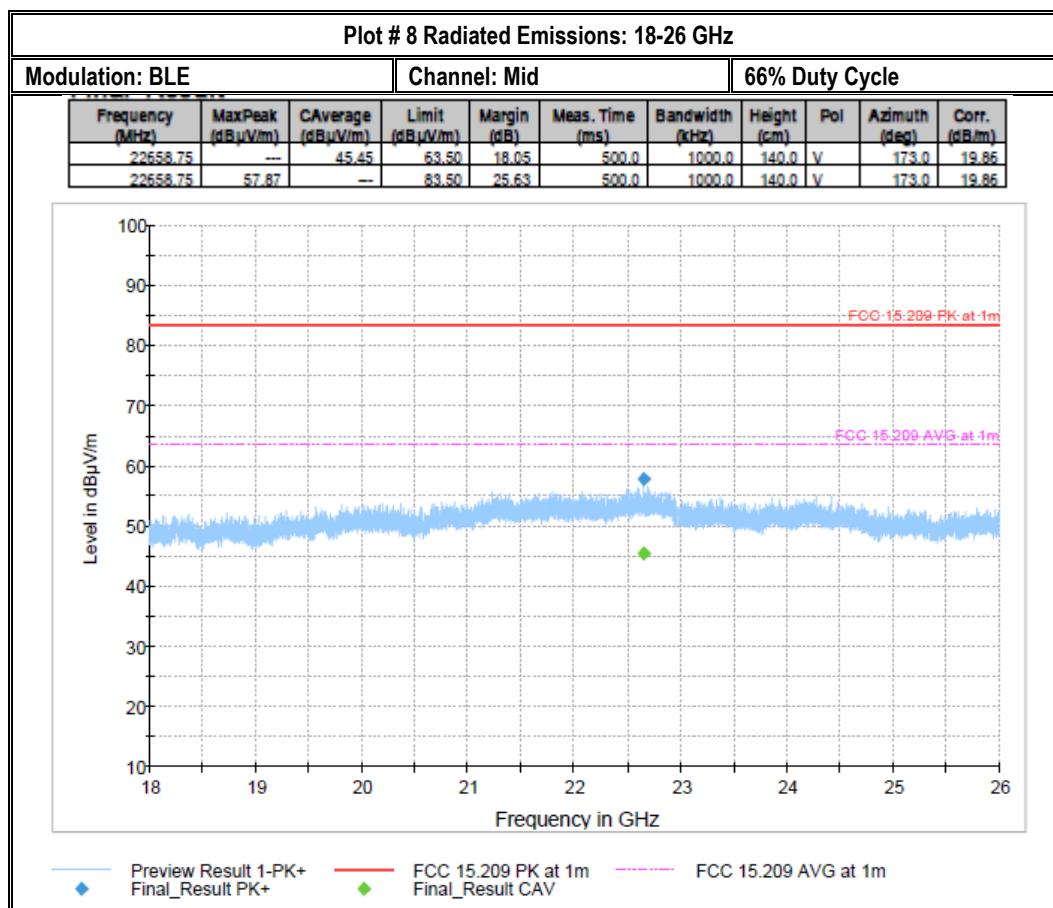


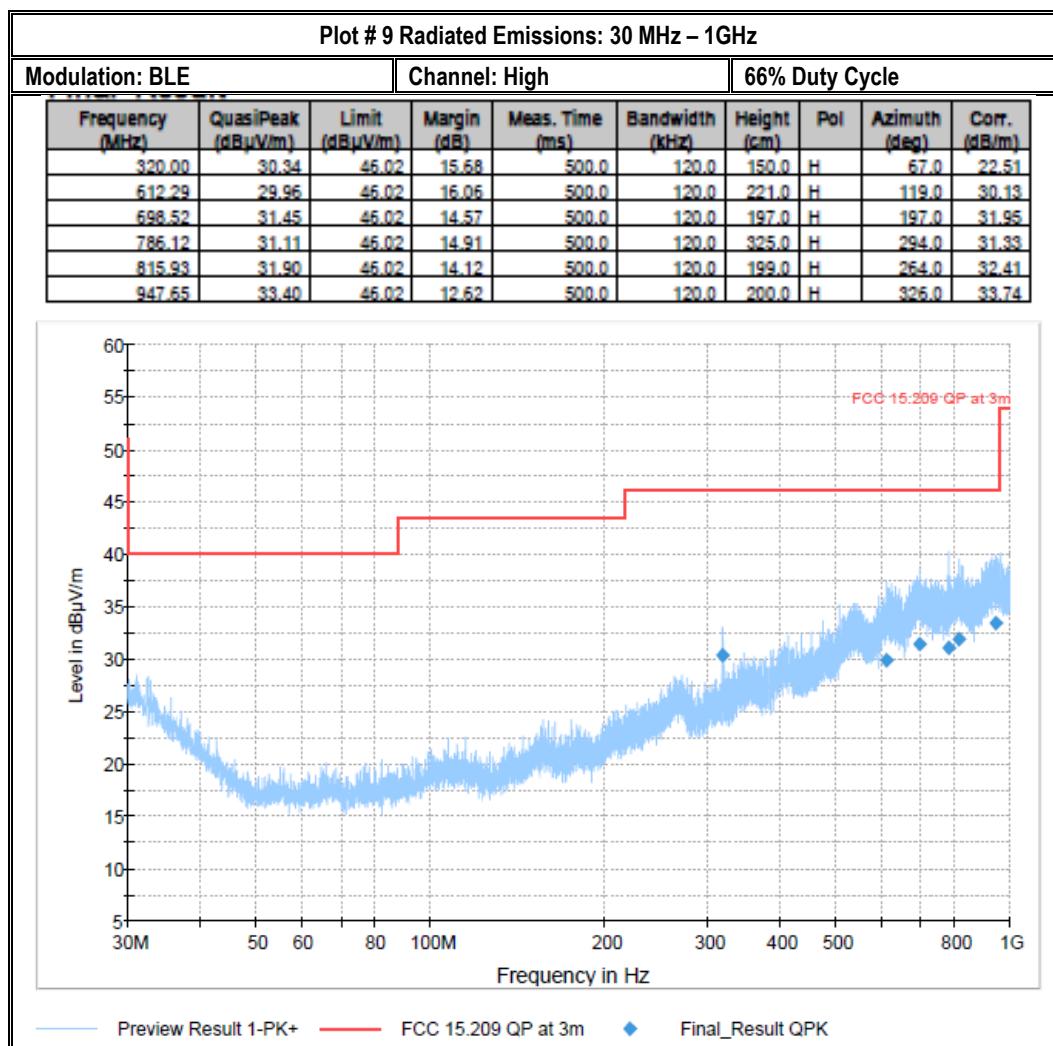


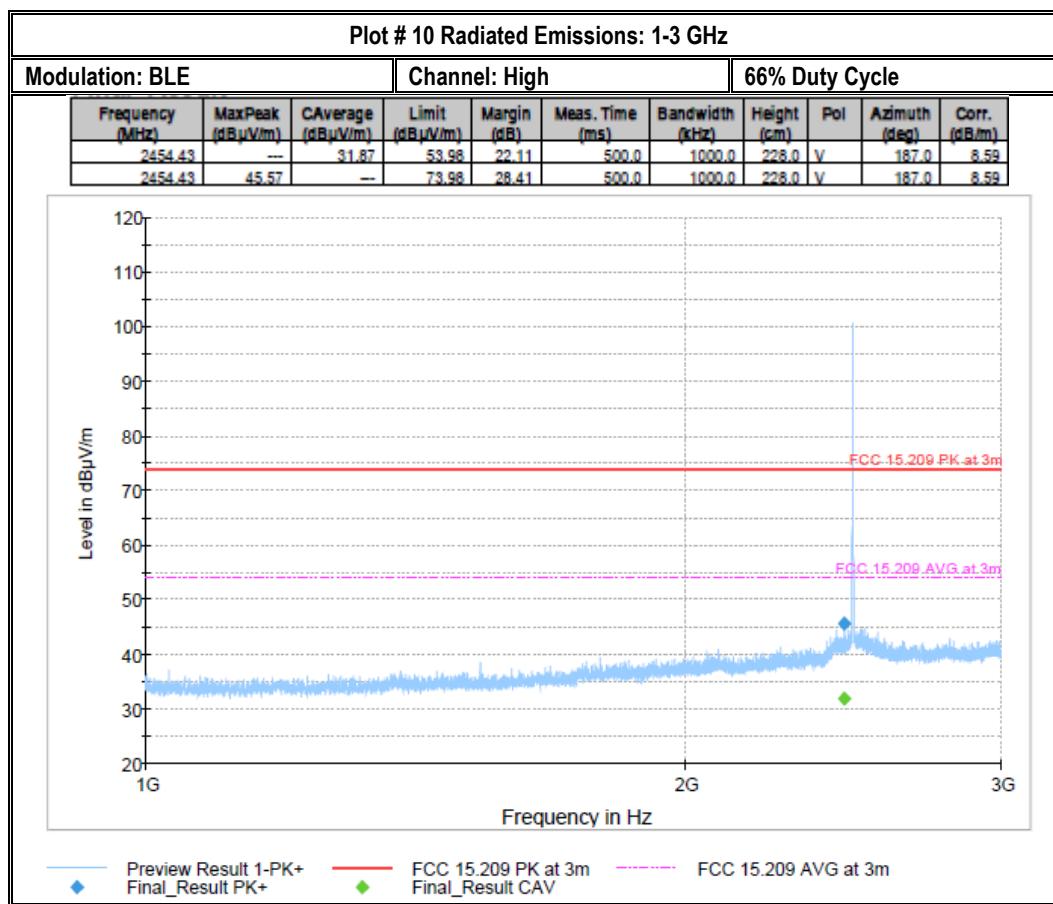


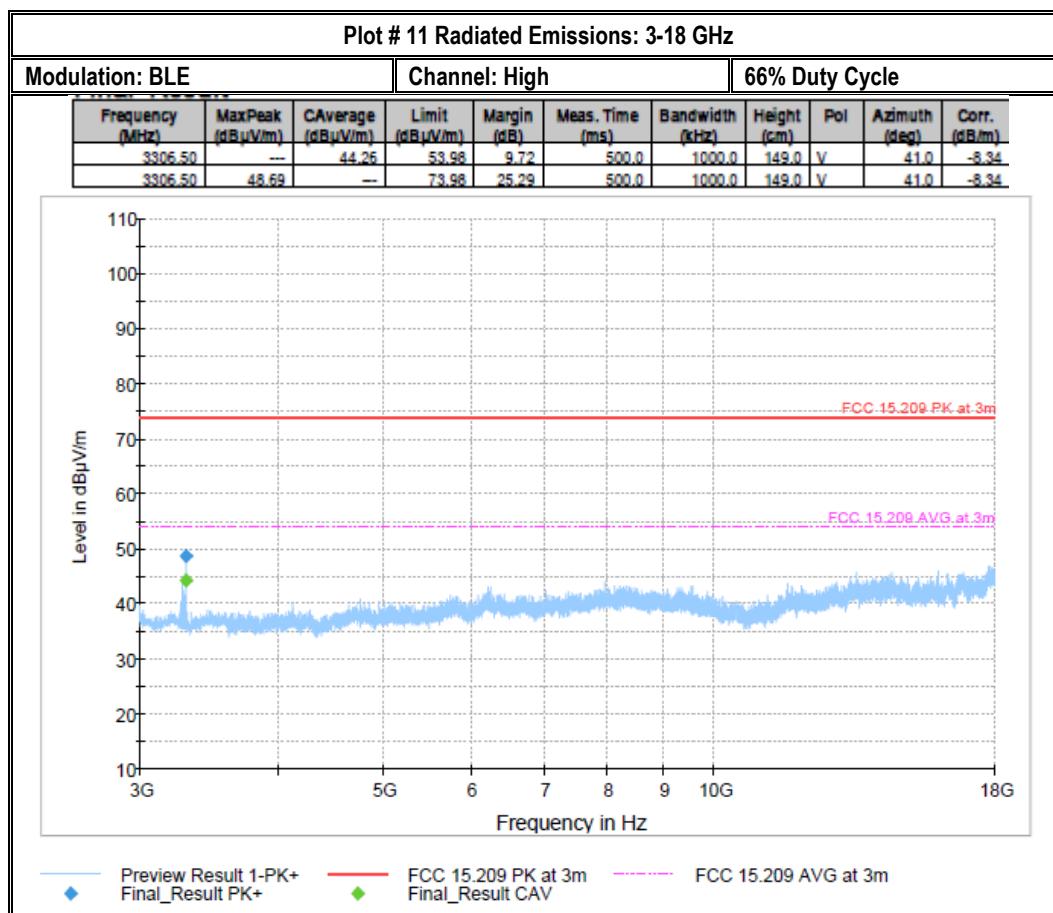












9 Test setup photos

Setup photos are included in supporting file name: "EMC_LOOMA-011-22001_15.247_RSE_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 | ESW44 | 101715 | 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 |
| Biconlog Antenna | AH systems | BiLA2G | 569 | 3 years | 12/1/2020 |
| Horn Antenna | EMCO | 3115 | 35111 | 3 years | 9/30/2021 |
| Horn Antenna | ETS Lindgren | 3117-PA | 169547 | 3 years | 9/1/2020 |
| Horn Antenna | ETS Lindgren | 3116C-PA | 169535 | 3 years | 9/30/2020 |
| Digital Thermometer | Control Company | 36934-164 | 191872028 | 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 |
|------------|-------------------------------------|-------------------|--------------|
| 12-12-2022 | EMC_LOOMA-011-22001_15_247_BTLE_DTS | Initial Version | Kris Lazarov |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

<<< The End >>>