



FCC / ISED Test Report

For:
CalAmp

Model:
HMU3640LB

Product Description:
Heavy Duty Telematics Gateway

FCC ID: APV-3640LB
IC: 5843C-3640LB

Applied Rules and Standards:
47 CFR Part 15.247 (DTS)
RSS-247 Issue 2 (DTSs) & RSS-Gen Issue 5

REPORT #: EMC_CALAM_136_23001_FCC_15_247

DATE: 2023-12-11



A2LA Accredited

IC recognized #
3462B

CETECOM Inc.

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

Phone: + 1 (408) 586 6200 ♦ Fax: + 1 (408) 586 6299 ♦ E-mail: contact@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⁽¹⁾..... 5

3.2 EUT SAMPLE DETAILS⁽¹⁾ 6

3.3 ACCESSORY EQUIPMENT (AE) DETAILS⁽¹⁾..... 6

3.4 TEST SAMPLE CONFIGURATION 6

3.5 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

6.3 DECISION RULE:..... 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..... 12

8.2 POWER SPECTRAL DENSITY 14

8.3 DUTY CYCLE..... 16

8.4 BAND EDGE COMPLIANCE 17

8.5 EMISSION BANDWIDTH 6dB AND 99% OCCUPIED BANDWIDTH..... 22

8.6 RADIATED TRANSMITTER SPURIOUS EMISSIONS AND RESTRICTED BANDS 25

9 TEST SETUP PHOTOS..... 39

10 TEST EQUIPMENT AND ANCILLARIES USED FOR TESTING 39

11 REVISION OF HISTORY 40



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.
CalAmp	Heavy Duty Telematics Gateway	HMU3640LB

Responsible for Testing Laboratory:

Arndt Stoecker

2023-12-11 Compliance (Director of Regulatory Services)

Date	Section	Name	Signature
------	---------	------	-----------

Responsible for the Report:

Cheng Song

2023-12-11 Compliance (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:	Arndt Stoecker
Responsible Project Leader:	Cathy Palacios

2.2 Identification of the Client

Applicant's Name:	CalAmp
Street Address:	2200 Faraday Ave #220
City/Zip Code	Carlsbad, CA 92008
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⁽¹⁾

Model No:	HMU3640LB
HW Version :	REV A
SW Version :	8.6L
FCC-ID :	APV-3640LB
IC:	5843C-3640LB
FVIN:	N/A
HVIN:	HMU3640LB
PMN:	HMU3640LB
Product Description:	Heavy Duty Telematics Gateway
Radio Information:	<u>Bluetooth:</u> <ul style="list-style-type: none"> • Chipset: TI SimpleLink™ CC2652R7 • 2400 MHz – 2483.5 MHz
Antenna Information as declared:	<u>Cellular:</u> <ul style="list-style-type: none"> • Taoglas PCS.06.A <u>Bluetooth:</u> <ul style="list-style-type: none"> • AVX/Ethertronics 1001312
Power Supply/ Rated Operating Voltage Range:	Battery powered only: 9-30 VDC
Operating Temperature Range	-30 C to 60 C
Other Radios included in the device:	<u>Cellular:</u> <ul style="list-style-type: none"> • Module: Quectel EG21-GL_D • FCC ID: XMR202212EG21GL; IC: 10224A-2022EG21GL • LTE, UMTS, GSM
Sample Revision	<input type="checkbox"/> Prototype Unit; <input type="checkbox"/> Production Unit; <input checked="" type="checkbox"/> Pre-Production

Note 1: Information provided by the customer

3.2 EUT Sample details⁽¹⁾

EUT #	Model Number	HW Version	SW Version	Notes/Comments
1	HMU3640LB	REV A	8.6L	Conducted RF
2	HMU3640LB	REV A	8.6L	Radiated and AC Conducted Emissions

Note 1: Information provided by the customer

3.3 Accessory Equipment (AE) details⁽¹⁾

AE #	Type	Model	Manufacturer	Serial Number
1	Vehicle Cable		CalAmp	

Note 1: Information provided by the customer

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1 + AE#1	The radio of the EUT was configured to a fixed channel transmission with highest possible 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#2 + AE#1	The radio of the EUT was configured to a fixed channel transmission with highest possible duty cycle using software that is not available to the end user. The internal antenna was connected.

3.5 Mode of Operation

Mode of Operation	Description of Operating modes	Additional Information
Op. 1	BLE	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.

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	Op. 1	■	□	□	Complies
§15.247(e) RSS-247 5.2(b)	Power Spectral Density	Nominal	Op. 1	■	□	□	Complies
§15.247(b)(1) RSS-247 5.4(d)	Maximum Conducted Output Power and EIRP	Nominal	Op. 1	■	□	□	Complies
§15.247(d) RSS-247 5.5	Band edge compliance Unrestricted Band Edges	Nominal	Op. 1	■	□	□	Complies
§15.247; 15.209; 15.205 RSS-Gen 8.9; 8.10	Band edge compliance Restricted Band Edges	Nominal	Op. 1	■	□	□	Complies
§15.247(d); §15.209 RSS-Gen 6.13	TX Spurious emissions- Radiated	Nominal	Op. 1	■	□	□	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal		■	□	□	Note 2

Note 1: NA= Not Applicable; NP= Not Performed.

Note 2: EUT does not utilize power from public mains.

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:

2023-09-25 – 2023-10-29

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.

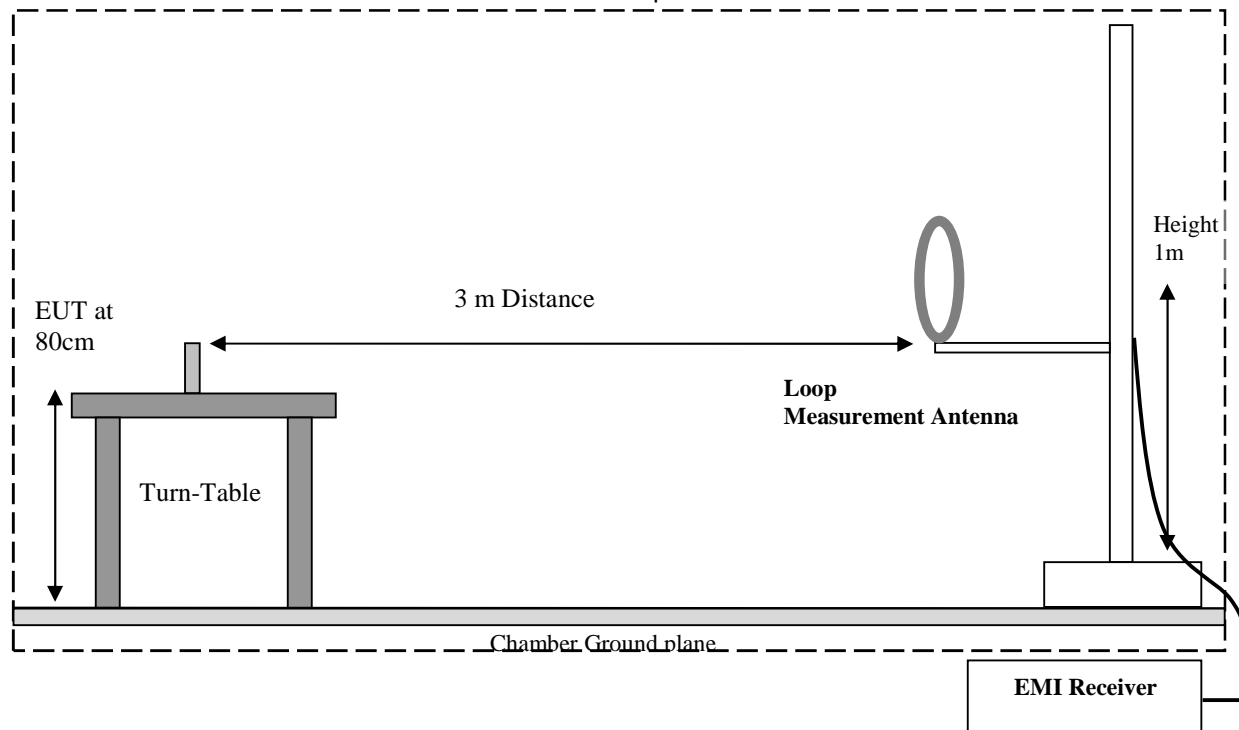
7 Measurement Procedures

7.1 Radiated Measurement

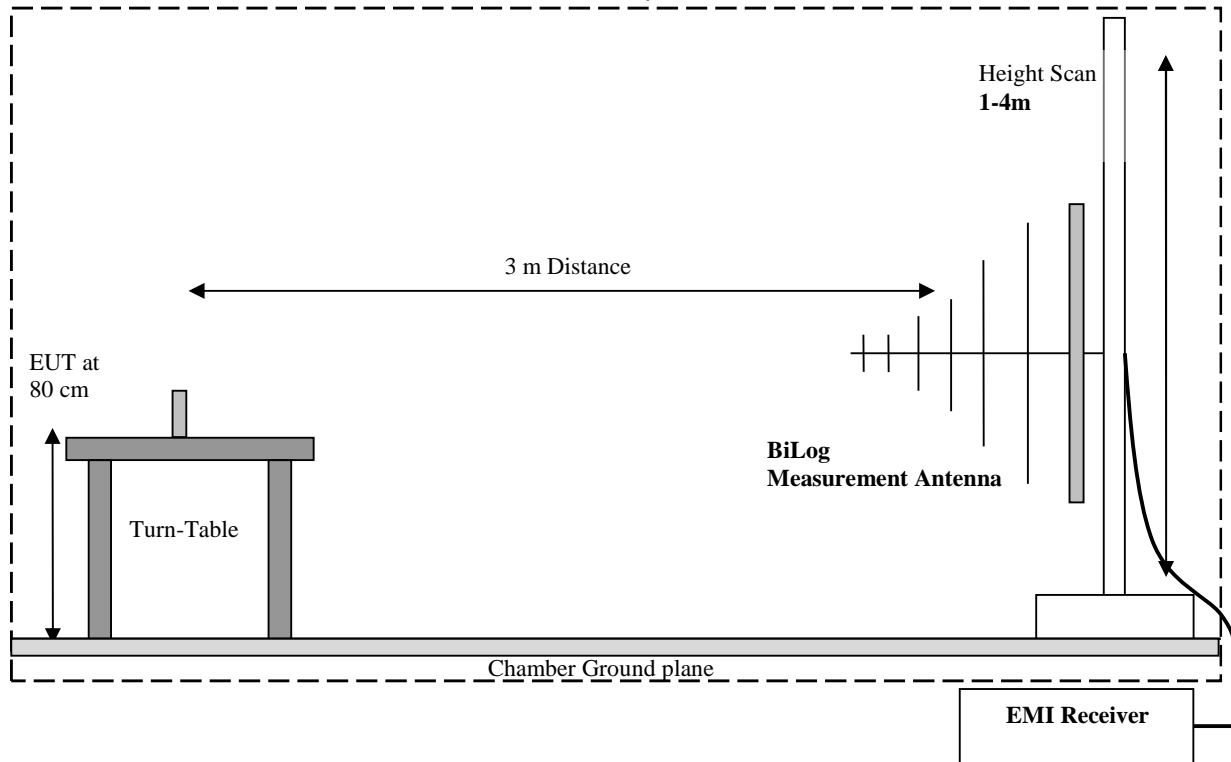
The radiated measurement is performed according to ANSI C63.10 (2013)

- 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.

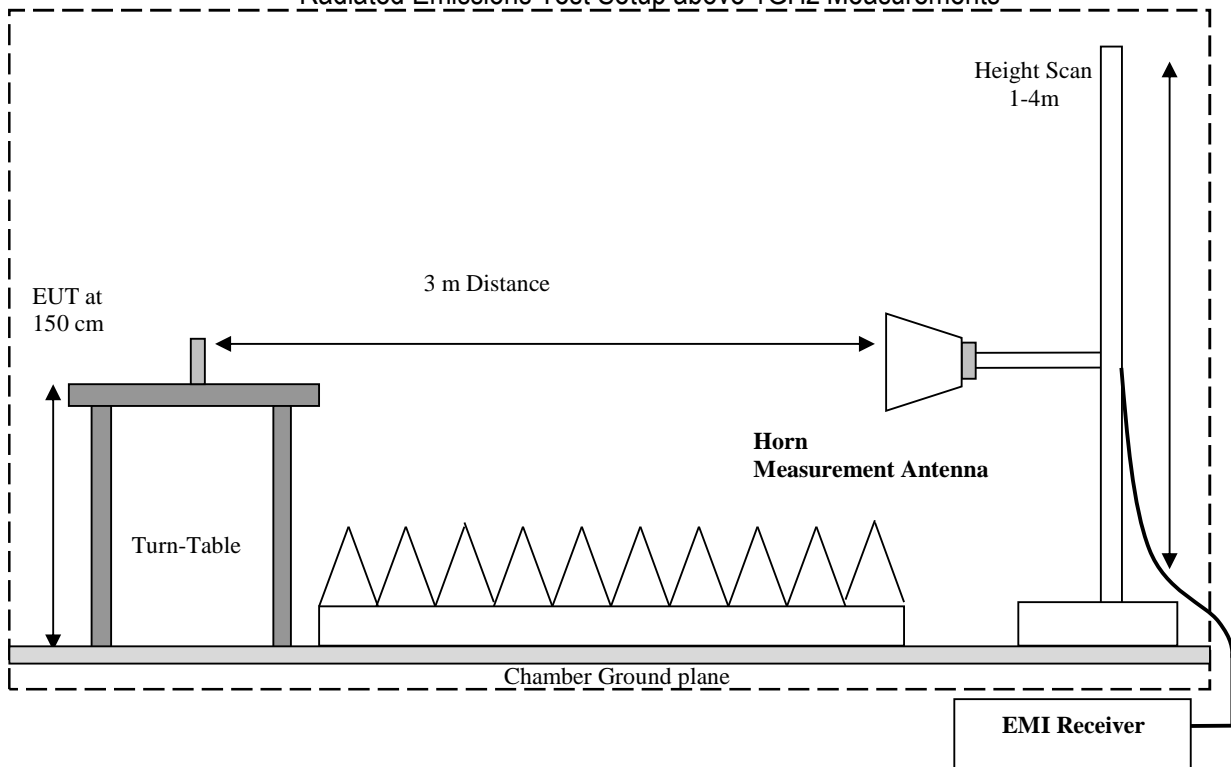
Radiated Emissions Test Setup below 30MHz Measurements



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 dBμV
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:

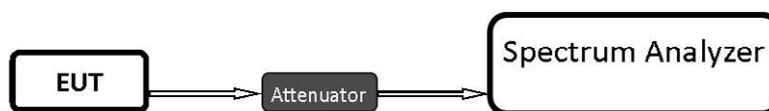
Frequency (MHz)	Measured SA (dBμV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBμV/m)
1000	80.5	3.5	14	98.0

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 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)(1): 1 W
- IC RSS-247: 1 W

8.1.3 Test conditions and setup:

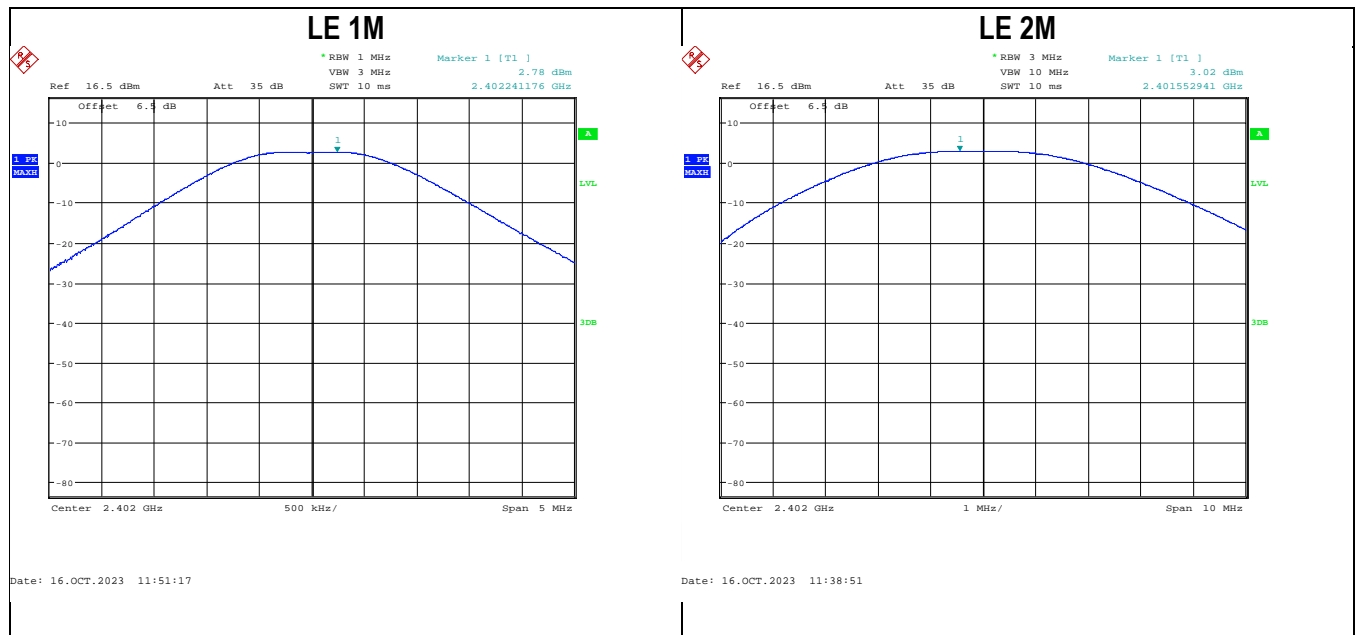
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	Op. 1	12 VDC	1.88 dBi



8.1.4 Measurement result:

Plot #	Frequency (MHz)	PHY	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	2402	LE 1M	2.78	4.66	30 (PK) / 36 (EIRP)	Pass
2	2440	LE 1M	2.61	4.49	30 (PK) / 36 (EIRP)	Pass
3	2480	LE 1M	2.45	4.33	30 (PK) / 36 (EIRP)	Pass
4	2402	LE 2M	3.02	4.9	30 (PK) / 36 (EIRP)	Pass
5	2440	LE 2M	2.73	4.61	30 (PK) / 36 (EIRP)	Pass
6	2480	LE 2M	2.42	4.3	30 (PK) / 36 (EIRP)	Pass

8.1.5 Measurement Plots:



Date: 16.OCT.2023 11:51:17

Date: 16.OCT.2023 11:38:51

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:

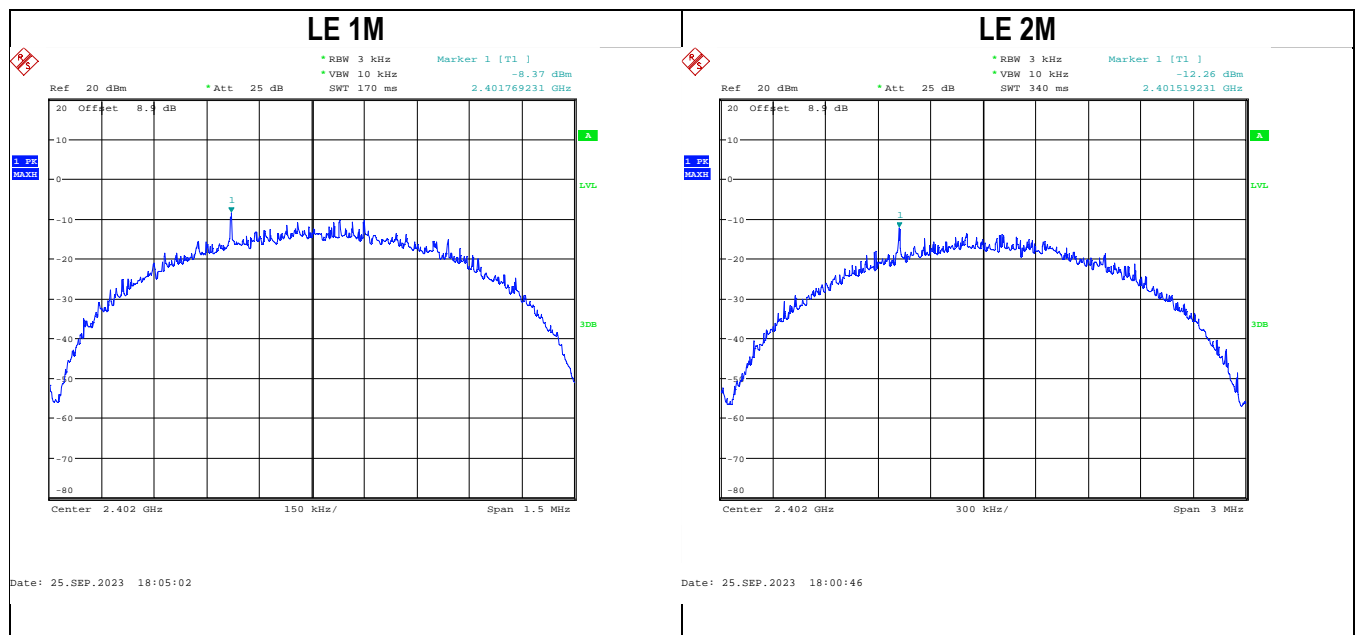
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	Op. 1	12 VDC	1.88 dBi



8.2.4 Measurement result:

Plot #	Frequency (MHz)	PHY	Maximum Power Spectral Density (dBm/3 kHz)	Limit (dBm / 3 kHz)	Result
1	2402	LE 1M	-8.37	8	Pass
2	2440	LE 1M	-9.09	8	Pass
3	2480	LE 1M	-9.37	8	Pass
4	2402	LE 2M	-12.26	8	Pass
5	2440	LE 2M	-12.32	8	Pass
6	2480	LE 2M	-12.43	8	Pass

8.2.5 Measurement Plots:





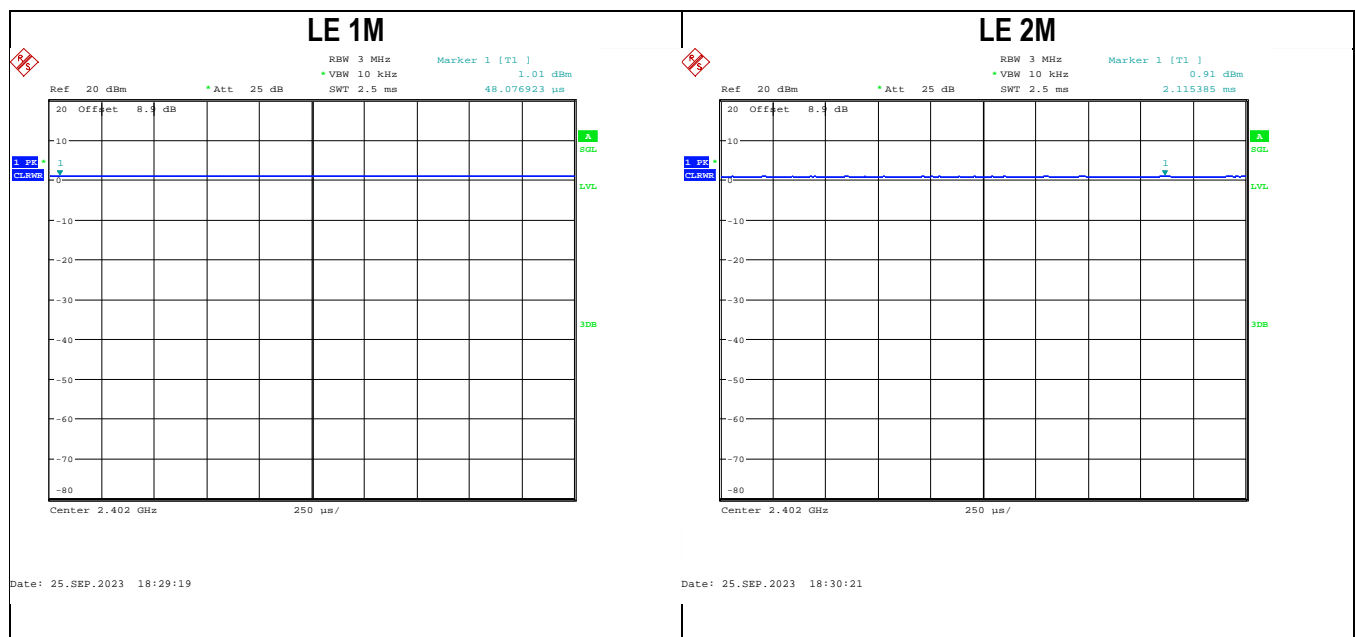
8.3 Duty cycle

8.3.1 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 >=OBW if possible; otherwise, set RBW to the largest available value
- Detector = Peak or average

8.3.2 Measurement result



Duty cycle = 100%

8.4 Band Edge Compliance

8.4.1 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

8.4.2 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.

Spectrum Analyzer settings for restricted band:

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



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

- *PEAK LIMIT= 74 dBµV/m @3m =-21.23 dBm
- *AVG. LIMIT= 54 dBµV/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			

8.4.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1, 2	Op. 1	12 VDC	1.88 dBi

8.4.5 Measurement result:

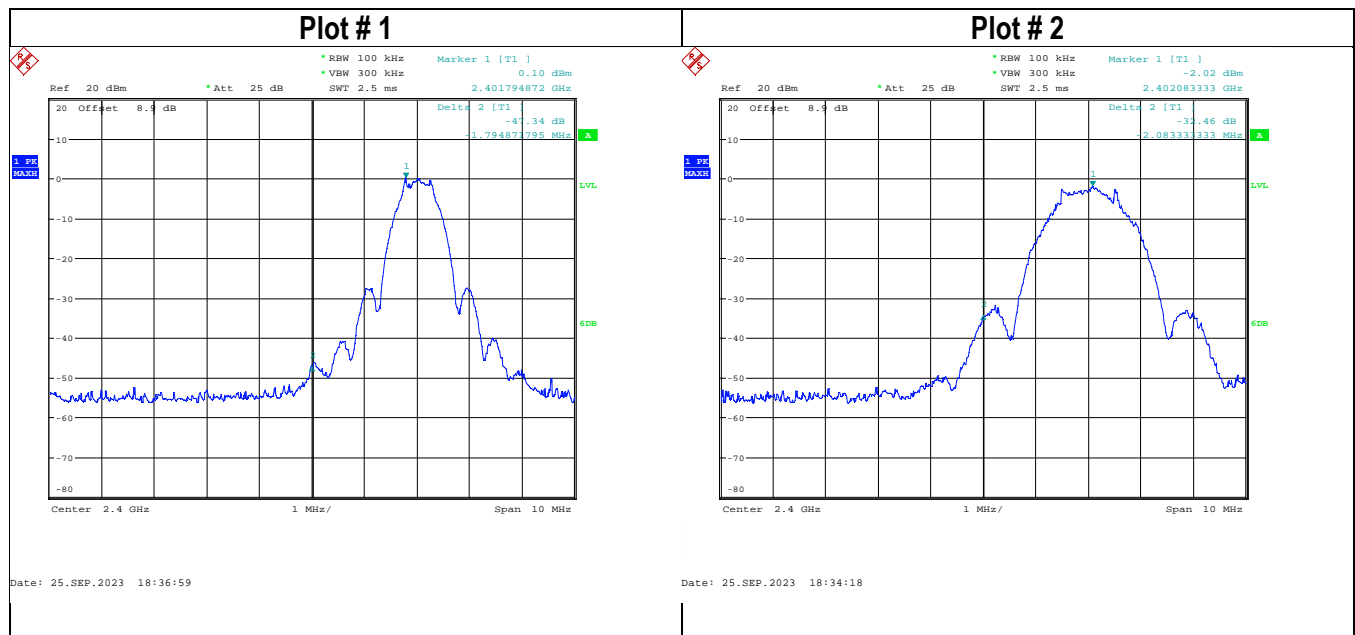
Plot #	EUT Set-Up #	PHY	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	1	LE 1M	Lower, Non-restricted	47.34	> 20	Pass
2	1	LE 2M	Lower, Non-restricted	32.46	> 20	Pass



Plot #	EUT Set-Up #	PHY	Band Edge Radiated (dBμV/m)	Limit (dBμV/m)	Result
3	2	LE 1M	PK: 37.60	PK: 74	Pass
			AVG: 24.90	AVG: 54	
4	2	LE 2M	PK: 45.40	PK: 74	Pass
			AVG: 33.26	AVG: 54	

Note: Radiated testing setup refer section 7.1.

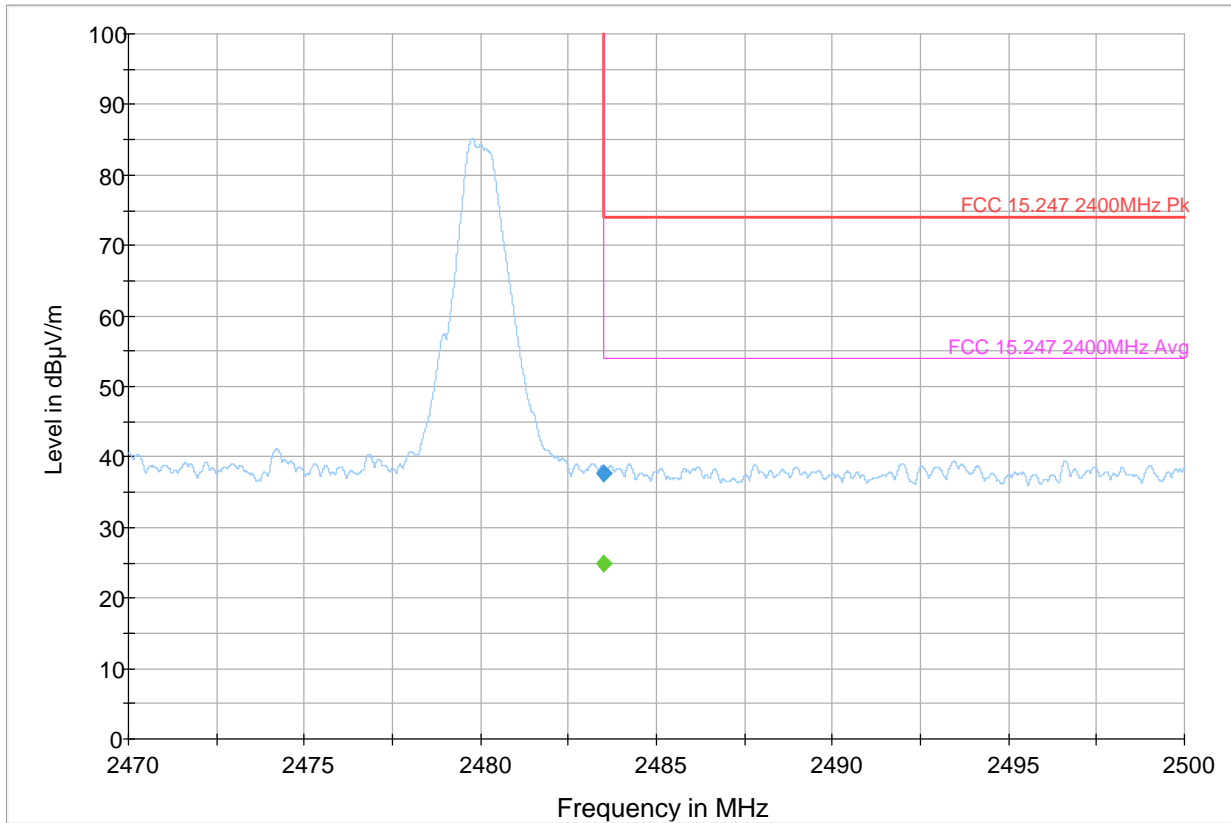
8.4.6 Measurement Plots:





Plot # 3

Frequency	MaxPeak (dBµV/m)	CAverage	Limit (dBµV/m)	Margin	Measurement	Bandwidth	Height	Polarization	Azimuth	Correction (dB/m)	Signature	Preamplifier	Trace Correction	Raw Rec
2483.500	---	24.90	54.00	29.10	500.0	1000.000	133.0	V	155.0	6.0	-	0.0	28.5	19.0
2483.500	37.60	---	74.00	36.40	500.0	1000.000	133.0	V	155.0	6.0	-	0.0	28.5	31.6

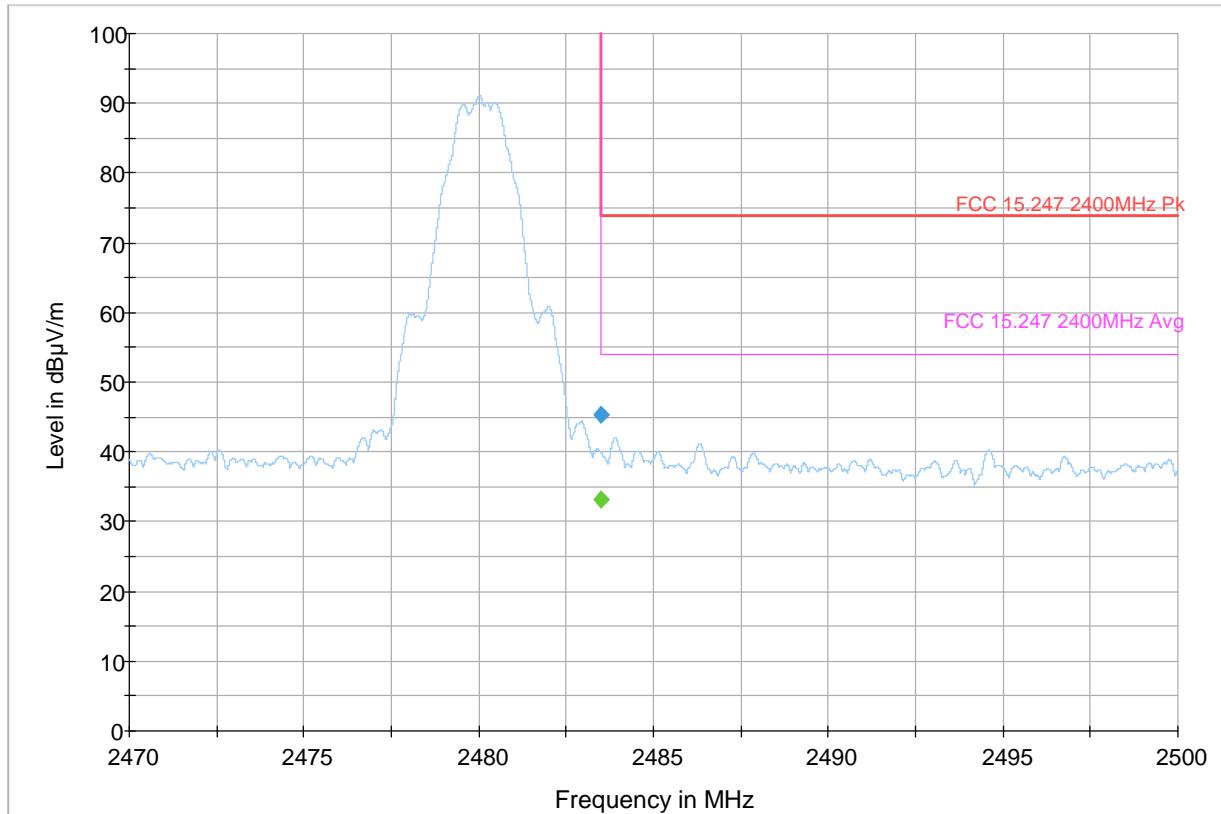


— AVG_MAXH — PK+_MAXH — FCC 15.247 2400MHz Pk
— FCC 15.247 2400MHz Avg ◆ Final_Result PK+ ◆ Final_Result CAV



Plot # 4

Frequency	MaxPeak (dBµV/m)	CAverage	Limit (dBµV/m)	Margin	Measurement	Bandwidth	Height	Polarization	Azimuth	Correction (dB/m)	Signature	Preamplifier	Trace Correction	Raw Rec
2483.502	---	33.26	54.00	20.74	500.0	1000.000	142.0	H	52.0	6.0	-	0.0	28.5	27.3
2483.502	45.40	---	74.00	28.60	500.0	1000.000	142.0	H	52.0	6.0	-	0.0	28.5	39.5



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

8.5 Emission Bandwidth 6dB and 99% Occupied Bandwidth

8.5.1 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.

8.5.2 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	Power Input
22° C	1	Op. 1	12 VDC

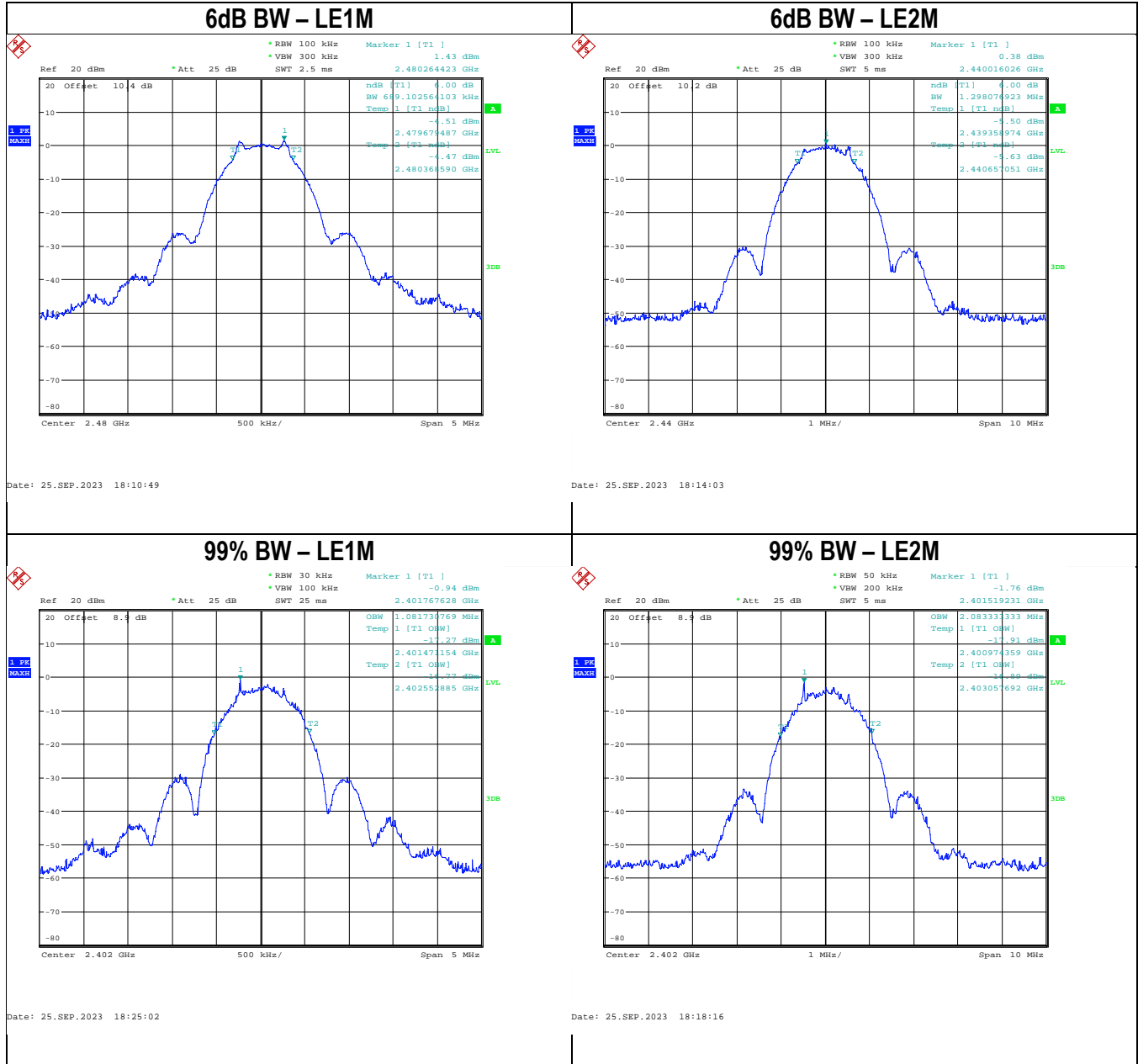
8.5.4 Measurement result:

Plot #	Frequency (MHz)	PHY	6dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
1	2402	LE 1M	0.705	> 0.5	Pass
2	2440	LE 1M	0.729	> 0.5	Pass
3	2480	LE 1M	0.689	> 0.5	Pass
4	2402	LE 2M	1.346	> 0.5	Pass
5	2440	LE 2M	1.298	> 0.5	Pass
6	2480	LE 2M	1.426	> 0.5	Pass

Plot #	Frequency (MHz)	PHY	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
7	2402	LE 1M	1.082	NA	Pass
8	2440	LE 1M	1.098	NA	Pass
9	2480	LE 1M	1.098	NA	Pass
10	2402	LE 2M	2.083	NA	Pass
11	2440	LE 2M	2.083	NA	Pass
12	2480	LE 2M	2.083	NA	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 (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



8.6.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	2	Op. 1	12 VDC

8.6.4 Measurement result:

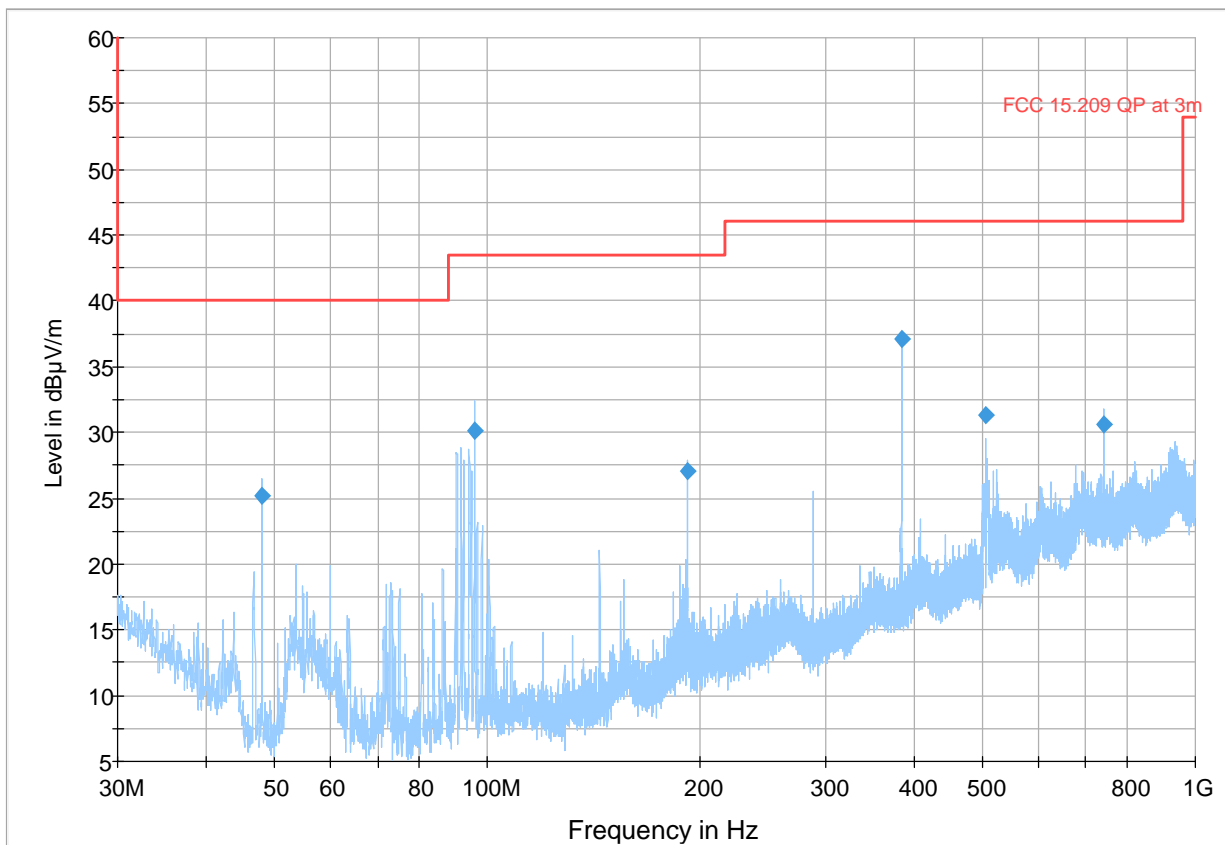
Plot #	Channel #	Scan Frequency	Limit	Result
1-3	Low	30 MHz – 18 GHz	See section 8.6.2	Pass
4-8	Mid	9 kHz – 26 GHz	See section 8.6.2	Pass
9-11	High	30 MHz – 18 GHz	See section 8.6.2	Pass



8.6.5 Measurement Plots:

Plot # 1

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
47.977	25.164	40.00	14.84	500.0	120.000	122.0	V	250.0	-21.3
95.992	30.115	43.50	13.38	500.0	120.000	155.0	V	126.0	-19.7
192.022	27.084	43.50	16.42	500.0	120.000	121.0	H	242.0	-17.3
384.018	37.141	46.02	8.88	500.0	120.000	132.0	H	180.0	-10.4
506.302	31.275	46.02	14.75	500.0	120.000	145.0	V	-26.0	-7.8
742.497	30.566	46.02	15.45	500.0	120.000	206.0	H	65.0	-3.7

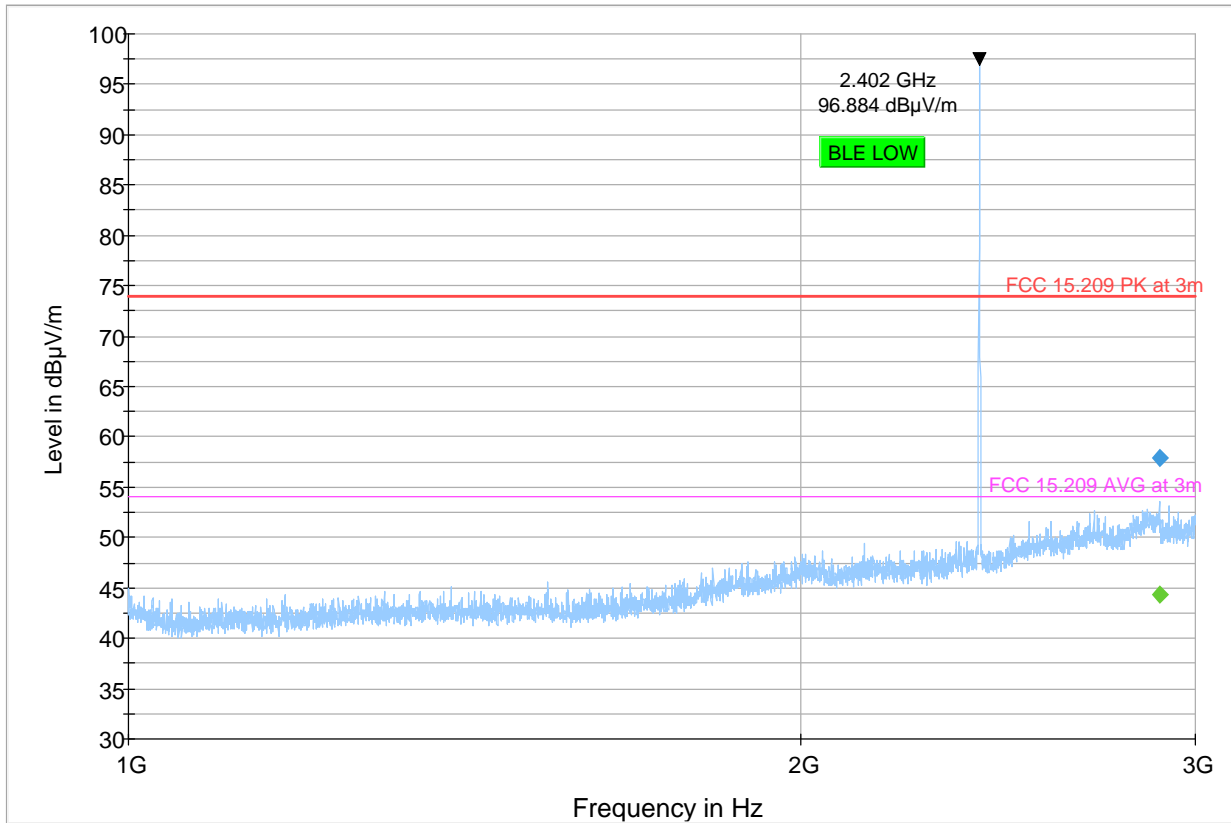


— Preview Result 1-PK+ — FCC 15.209 QP at 3m ◆ Final_Result QPK



Plot # 2

Frequency	MaxPeak (dBµV/m)	CAverage	Limit (dBµV/m)	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m)	Sig Pat	Pream p	Trd Corr.	Raw Rec
2889.429	---	44.37	53.98	9.61	500.0	1000.000	284.0	H	-22.0	35.0	5.7	0.0	29.3	9.4
2889.429	57.90	---	73.98	16.08	500.0	1000.000	284.0	H	-22.0	35.0	5.7	0.0	29.3	22.9

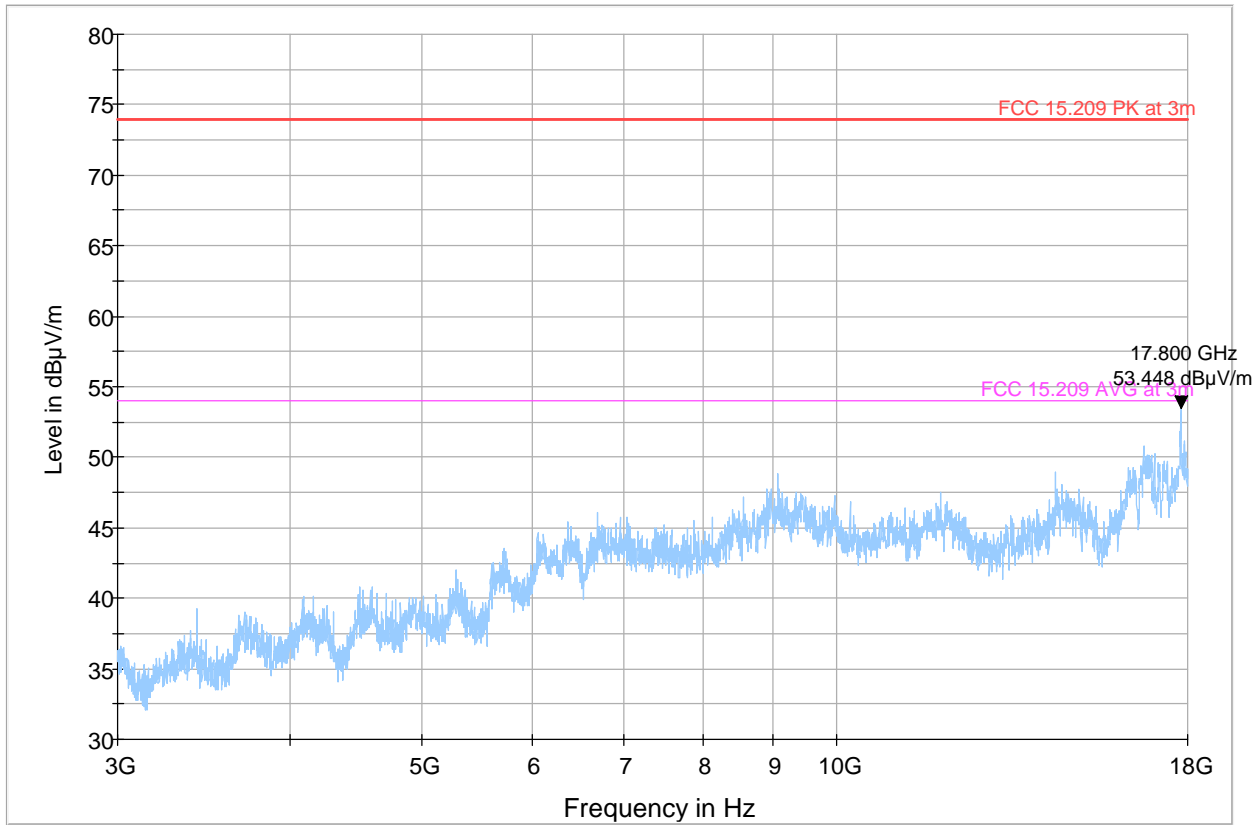


— AVG_MAXH
 — PK+_MAXH
 — FCC 15.209 PK at 3m
— FCC 15.209 AVG at 3m
 ◆ Final_Result PK+
 ◆ Final_Result CAV



Plot # 3

Frequency	MaxPeak (dBµV/m)	CAverage	Limit (dBµV/m)	Margin	Measurement	Bandwidth	Height	Polarization	Azimuth	Correction (dB/m)	Signature Pattern	Preamplifier	Trace Correction	Raw Record
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

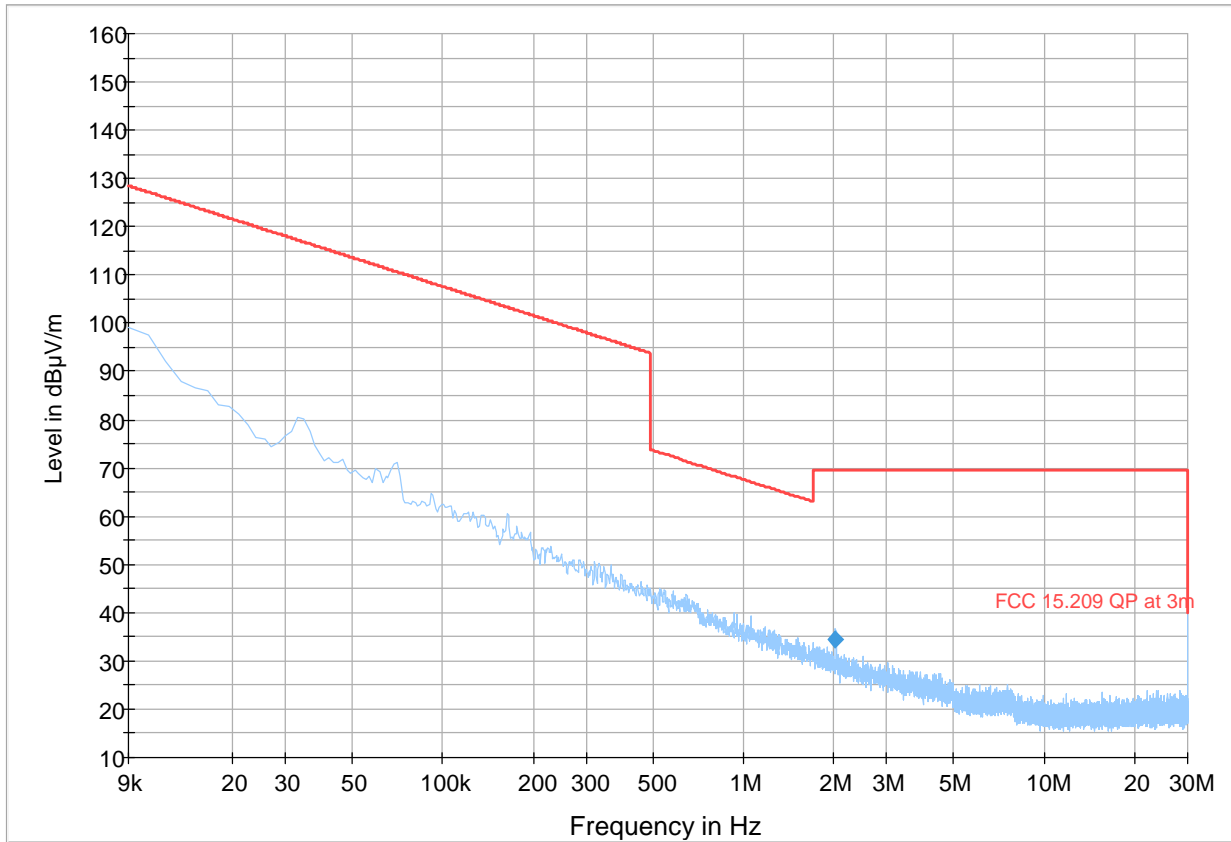


- AVG_MAXH
- FCC 15.209 AVG at 3m
- PK+_MAXH
- ◆ Final_Result PK+
- FCC 15.209 PK at 3m
- ◆ Final_Result CAV



Plot # 4

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2.027	34.496	69.50	35.00	500.0	9.000	121.0	V	-36.0	14.0

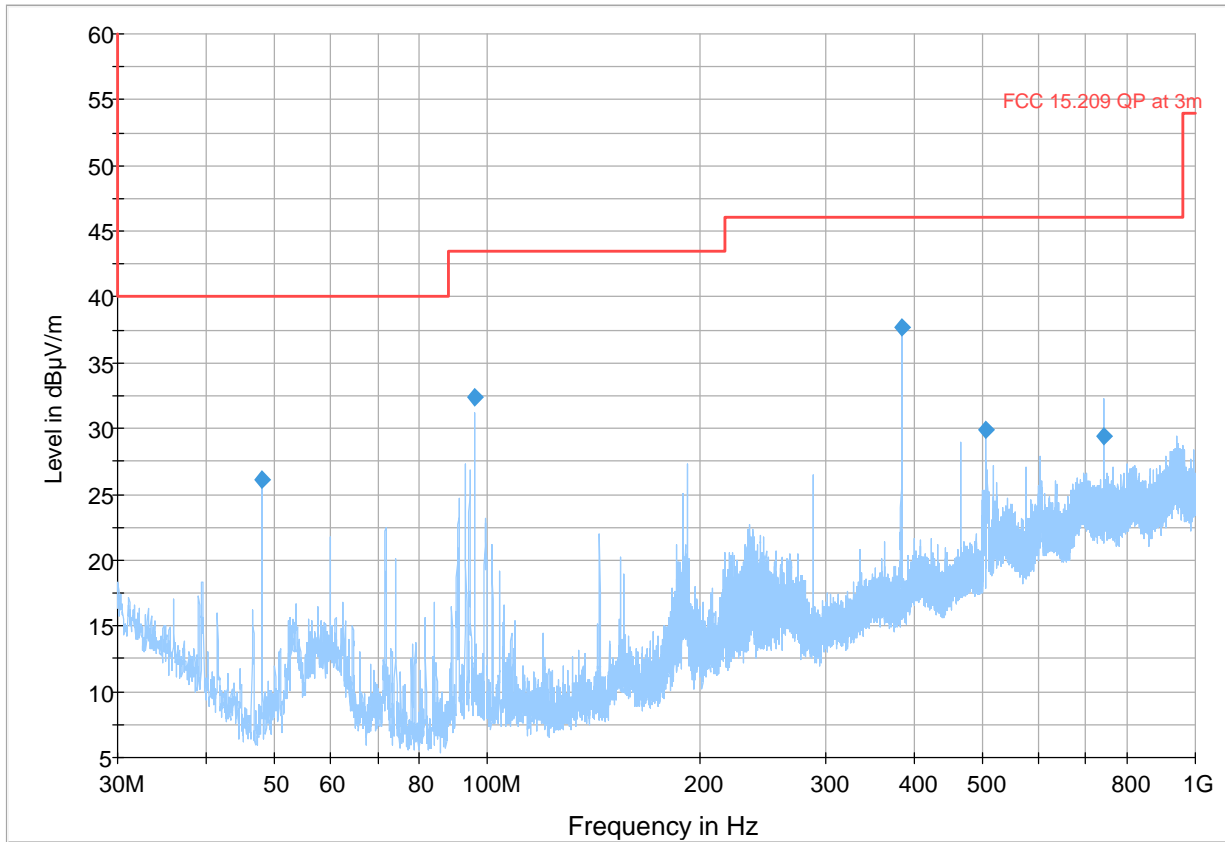


— Preview Result 1-PK+
 — FCC 15.209 QP at 3m
 ◆ Final_Result QPK



Plot # 5

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
47.977	26.097	40.00	13.90	500.0	120.000	122.0	V	219.0	-21.3
95.992	32.325	43.50	11.17	500.0	120.000	155.0	V	145.0	-19.7
384.018	37.670	46.02	8.35	500.0	120.000	132.0	H	181.0	-10.4
506.302	29.957	46.02	16.06	500.0	120.000	151.0	V	7.0	-7.8
742.497	29.384	46.02	16.64	500.0	120.000	319.0	H	240.0	-3.7

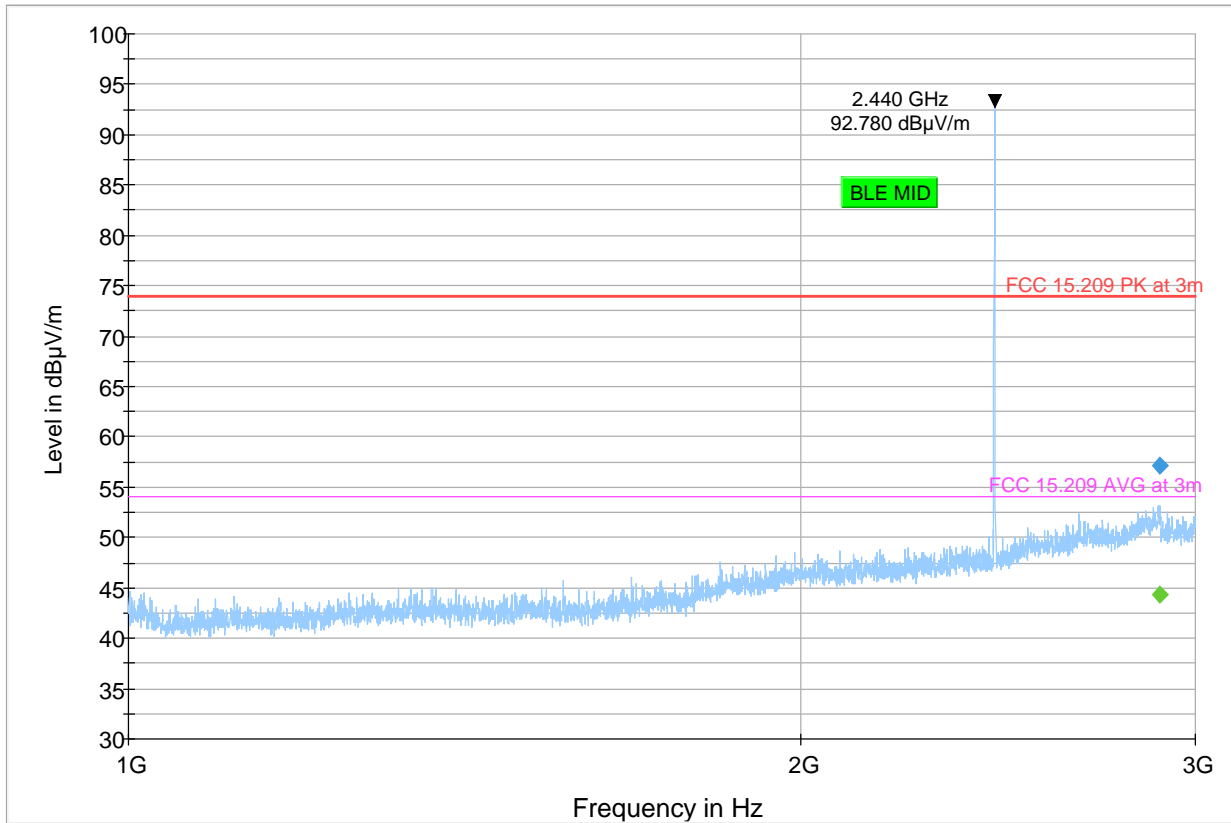


— Preview Result 1-PK+ — FCC 15.209 QP at 3m ◆ Final_Result QPK



Plot # 6

Frequency	MaxPeak (dBµV/m)	CAverage	Limit (dBµV/m)	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m)	Sig Pat	Preamp	Trd Corr.	Raw Rec
2891.286	---	44.38	53.98	9.59	500.0	1000.000	107.0	H	193.0	35.0	5.7	0.0	29.3	9.4
2891.286	57.07	---	73.98	16.91	500.0	1000.000	107.0	H	193.0	35.0	5.7	0.0	29.3	22.1

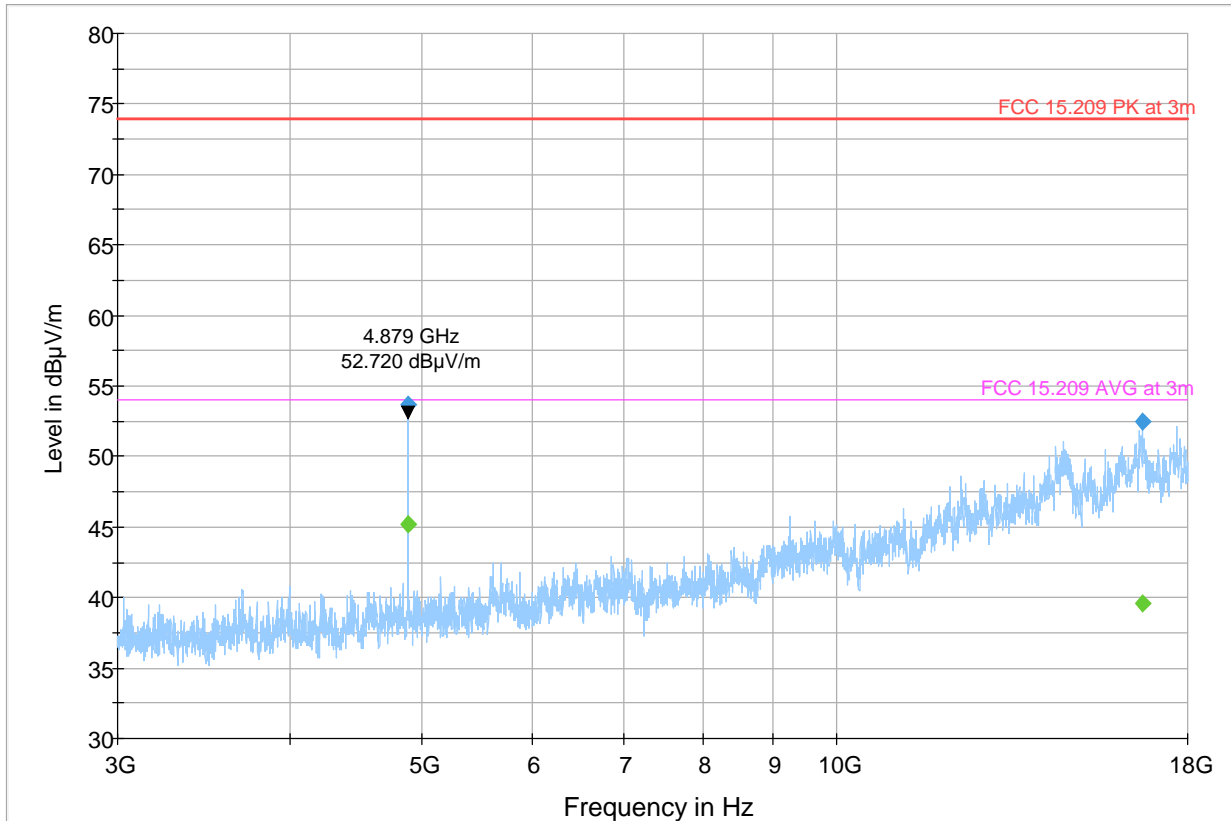


- AVG_MAXH
- FCC 15.209 AVG at 3m
- PK+_MAXH
- ◆ Final_Result PK+
- FCC 15.209 PK at 3m
- ◆ Final_Result CAV



Plot # 7

Frequency	MaxPeak (dBµV/m)	CAverage	Limit (dBµV/m)	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m)	Sig Pat	Pream p	Trd Corr.	Raw Rec
4879.000	53.73	---	73.98	20.25	500.0	1000.000	283.0	V	215.0	-4.1	7.7	-45.9	34.1	57.8
4879.000	---	45.21	53.98	8.77	500.0	1000.000	283.0	V	215.0	-4.1	7.7	-45.9	34.1	49.3
16696.500	52.42	---	73.98	21.56	500.0	1000.000	143.0	V	-27.0	14.9	15.7	-42.1	41.3	37.6
16696.500	---	39.56	53.98	14.42	500.0	1000.000	143.0	V	-27.0	14.9	15.7	-42.1	41.3	24.7

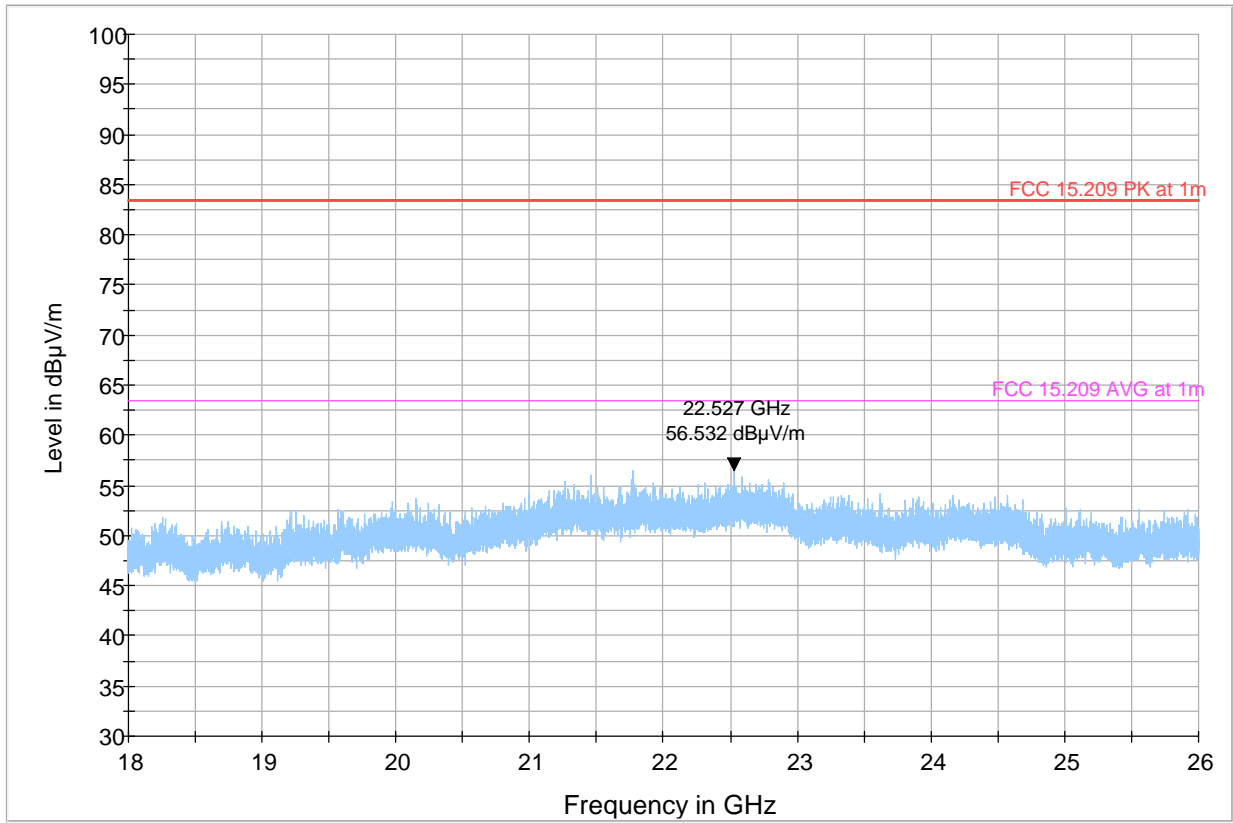


- AVG_MAXH
- FCC 15.209 AVG at 3m
- PK+_MAXH
- ◆ Final_Result PK+
- FCC 15.209 PK at 3m
- ◆ Final_Result CAV



Plot # 8

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)
---	---	---	---	---	---	---	---		---	---

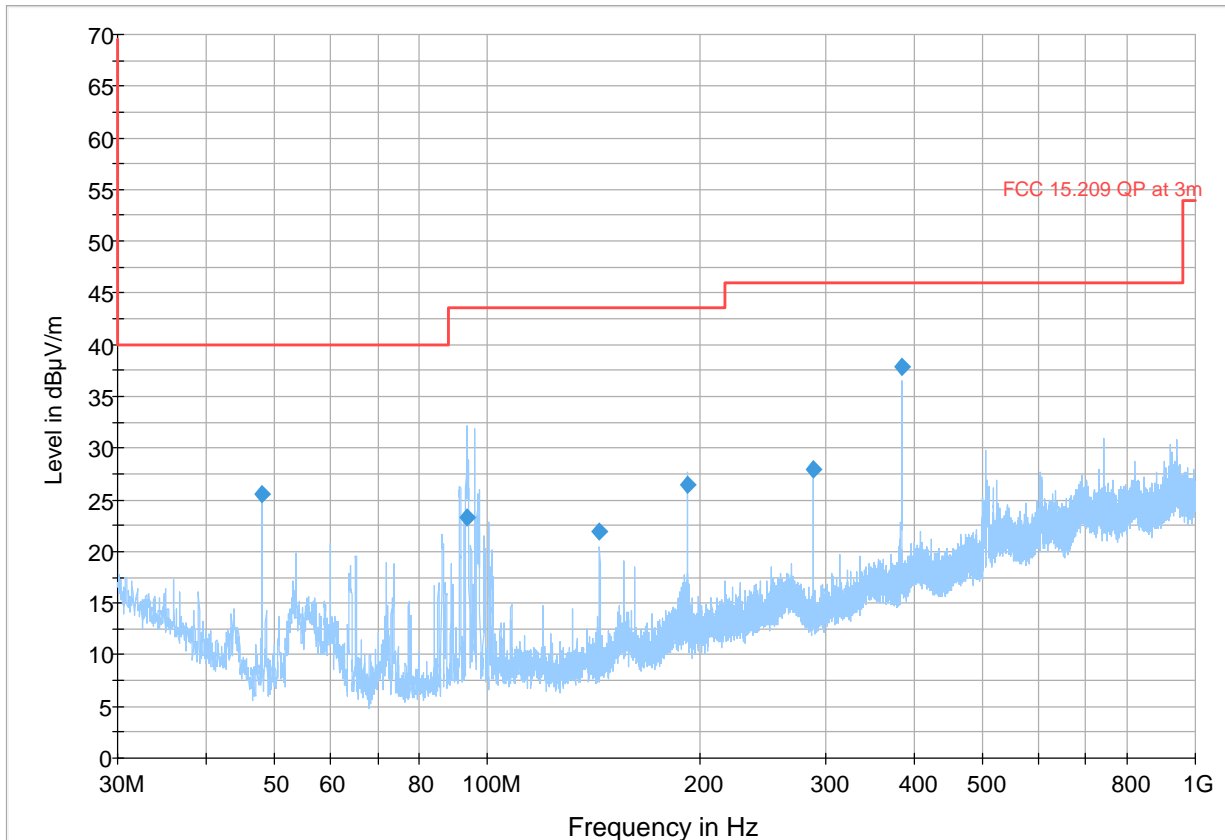


- Preview Result 1-PK+ * Critical_Freqs PK+
- FCC 15.209 AVG at 1m ◆ Final_Result PK+
- FCC 15.209 PK at 1m ◆ Final_Result CAV



Plot # 9

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
47.977	25.545	40.00	14.46	500.0	120.000	121.0	V	213.0	-21.3
93.406	23.293	43.50	20.21	500.0	120.000	121.0	V	192.0	-19.8
144.007	21.971	43.50	21.53	500.0	120.000	122.0	V	52.0	-18.8
191.990	26.511	43.50	16.99	500.0	120.000	131.0	H	252.0	-17.3
288.020	27.990	46.02	18.03	500.0	120.000	136.0	H	184.0	-13.8
384.018	37.808	46.02	8.21	500.0	120.000	136.0	H	184.0	-10.4

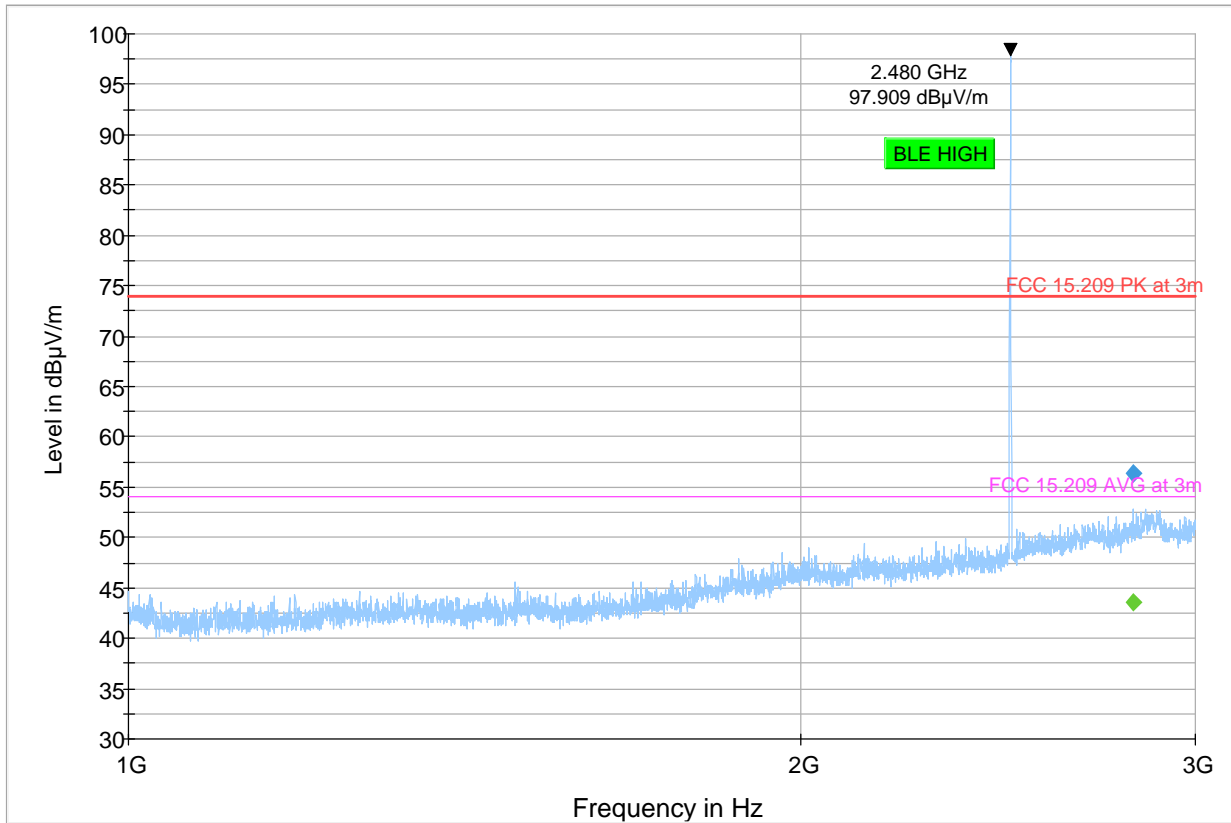


— Preview Result 1-PK+
 — FCC 15.209 QP at 3m
 ◆ Final_Result QPK



Plot # 10

Frequency	MaxPeak (dBµV/m)	CAverage	Limit (dBµV/m)	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m)	Sig Pat	Pream p	Trd Corr.	Raw Rec
2814.143	56.32	---	73.98	17.66	500.0	1000.000	124.0	V	159.0	34.6	5.5	0.0	29.0	21.7
2814.143	---	43.50	53.98	10.48	500.0	1000.000	124.0	V	159.0	34.6	5.5	0.0	29.0	8.9

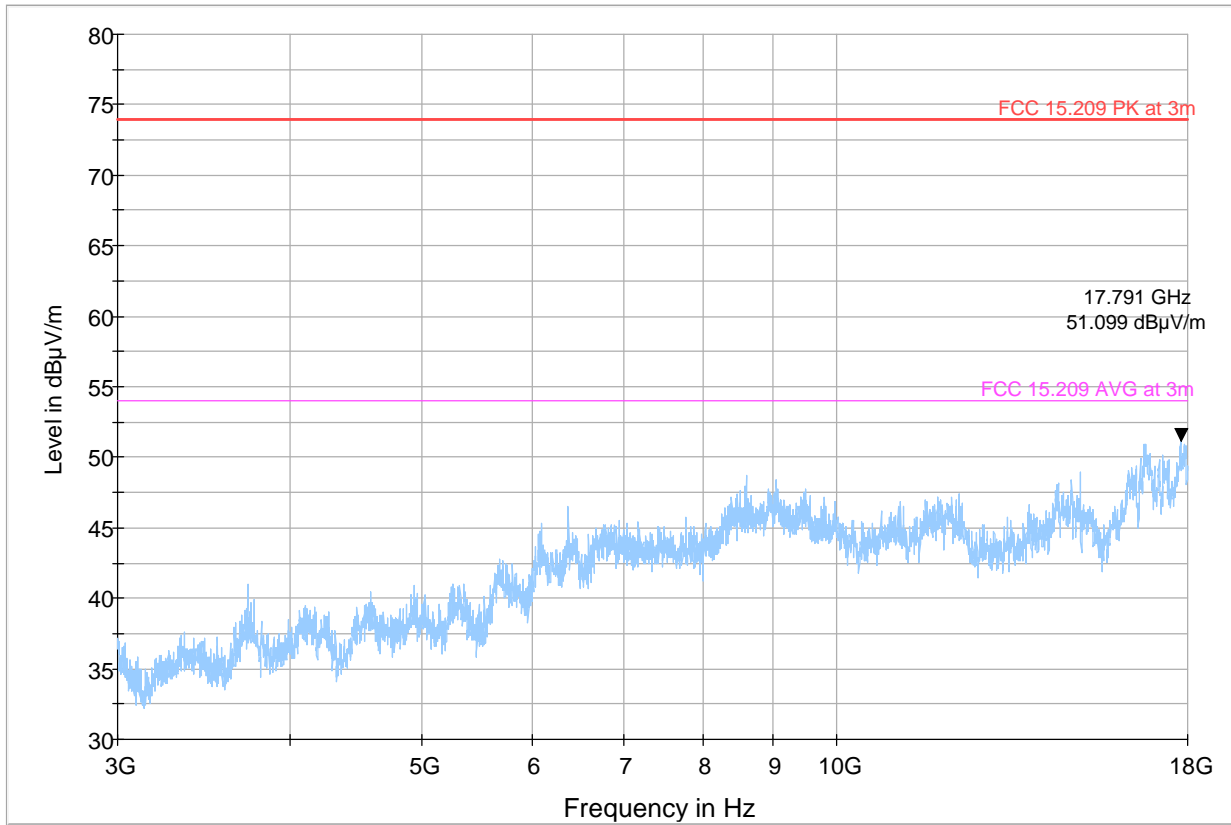


- AVG_MAXH
- FCC 15.209 AVG at 3m
- PK+_MAXH
- ◆ Final_Result PK+
- FCC 15.209 PK at 3m
- ◆ Final_Result CAV



Plot # 11

Frequency	MaxPeak (dBµV/m)	CAverage	Limit (dBµV/m)	Margin	Measurement	Bandwidth	Height	Polarization	Azimuth	Correction (dB/m)	Signature	Preamplifier	Trade-off Correction	Raw Record
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---



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



9 Test setup photos

Setup photos are included in supporting file name: "EMC_CALAM_136_23001_FCC_Setup_Photos"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
PASSIVE LOOP ANTENNA	EMCO	6512	00164698	2 YEARS	9/6/2023
BILOG ANTENNA	A.H. SYSTEMS	BiLA2G	569	2 YEARS	10/30/2023
HORN ANTENNA	EMCO	3115	00035111	2 YEARS	10/26/2023
HORN ANTENNA	ETS LINDGREN	3117-PA	00169547	2 YEARS	9/25/2023
HORN ANTENNA	ETS LINDGREN	3116C-PA	00169535	2 YEARS	10/26/2023
ESW.EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW44	101715	2 YEARS	10/24/2023

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 Revision of History

Date	Report Name	Changes to report	Prepared by
2023-12-11	EMC_CALAM_136_23001_FCC_15_247	Initial Version	Cheng Song

<<< The End >>>