FCC / ISED Test Report

For:
Motive Technologies, Inc.

Brand:
Motive Technologies, Inc.

Marketing Name:
Omnicam

Model Number:
OC-1

Product Description:
Is a vehicle camera, designed to be powered by vehicle power (12 or 24 V DC). It is designed to be always on and recording video while the vehicle is on. It will upload small video files to Motive back-end servers via LTE on request.

FCC ID: 2AQM7-OC1

IC: 24516-OC1

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

REPORT #: EMC_KPTRK_040_23001_FCC_15_247_ISED_BLE_DTS

DATE: 6/28/2023

A2LA Accredited

IC recognized # 3462B

CETECOM **Inc.**
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1 Assessment

The following equipment (as identified in section 3 of this test report) 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.

According to section 5 of this report, the overall result is Pass.

Company	Description	Model #
Motive Technologies, Inc.	Is a vehicle camera, designed to be powered by vehicle power (12 or 24 V DC). It is designed to be always on and recording video while the vehicle is on. It will upload small video files to Motive back-end servers via LTE on request.	OC-1

Responsible for Testing Laboratory:

Digitally signed by: Arndt Stoecker
DN: CN = Arndt Stoecker email = arndt.stoecker@cetecom.com C = US O = CETECOM Inc
Date: 2023.06.28 17:53:44 -07'00'

Date	Section	Name	Signature
6/28/2023	Compliance	Stoecker, Arndt (Director of Regulatory Services)	Arndt Stoecker

Responsible for the Report:

Digitally signed by: Issa Ghanma
DN: CN = Issa Ghanma email = Issa.Ghanma@cetecom.com C = US O = CETECOM, Inc. OU = EMC
Date: 2023.06.28 17:36:42 -07'00'

Date	Section	Name	Signature
6/28/2023	Compliance	Ghanma, Issa (Deputy Lab Manager)	

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 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:	Stoecker, Arndt
Responsible Project Leader:	Baskaran, Akanksha

2.2 Identification of the Client

Applicant's Name:	Motive Technologies, Inc.
Street Address:	55 Hawthorne St., Suite 400
City/Zip Code	San Francisco, CA 94105
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

Brand:	Motive Technologies, Inc.
Model No:	OC-1
Marketing name:	Omnicam
FCC-ID :	2AQM7-OC1
IC:	24516-OC1
HW Version :	1
SW Version :	0.7.2
HVIN:	OC-1
PMN:	Omnicam
Product Description:	Is a vehicle camera, designed to be powered by vehicle power (12 or 24 V DC). It is designed to be always on and recording video while the vehicle is on. It will upload small video files to Motive back-end servers via LTE on request.
Frequency Range/number of channels:	❖ BT LE v5.2 o Nominal band: 2400 MHz – 2483.5 MHz o Center to center: 2402 MHz (ch 0) – 2480 MHz (ch 39), 40 Channels
Radio information:	Bluetooth Low Energy Murata LBEE5XV1XZ • Technology: BLE Version 5.2 • Supported data rate: 1Mb/s, 2Mb/s
Max. Measured Conducted Output Power:	1M: +3.61 dBm 2M: +4.89 dBm
Power Supply/ Rated Operating Voltage Range:	12 or 24 V DC
Operating Temperature Range:	T min: -40 ºC / T Nom: 20 ºC / T max: +60 ºC
Other Radios included in the device:	❖ Cellular: Sierra Wireless RC7612 ❖ WLAN: Murata LBEE5XV1XZ
Antenna Information as declared:	❖ BLE/WLAN 0 o Type: Inverted-F Antenna o Max Gain 2.4 -2.48 GHz: 1.7 dBi
Sample Revision:	☐ Production Unit; ☑ Pre-Production
Product dimensions:	82mm tall x 82mm wide x 67mm deep
Note: The information of the EUT specifications in the table above is provided by the applicant.	

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	ACCS11AC240211	1	0.7.2	Conducted measurement
2	ACCS1BC332451	1	0.7.2	Radiated measurement

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	S/N	Notes/Comments
N/A	-	-	-	-	-

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test setup	Comments
1	EUT # 1	The measurement equipment was connected to the 50-ohm RF port of the EUT.
2	EUT # 2	The internal antenna was connected.

3.5 Mode of Operation details

Mode of Operation	Description of Operating modes	Additional Information
Op. 1	Bluetooth LE	❖ An Ethernet to USB 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 → +3 dBm • Continuous transmission • Modulated signal • Switch between supported data rates: 1Mb/s, 2Mb/s • Select TX channel(s) o Low → 2402 MHz o Mid → 2442 MHz o High → 2480 MHz
Op. 2	Bluetooth LE	❖ An Ethernet to USB 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 → +3 dBm • Continuous transmission • Modulated signal • Select data rate: 2Mb/s (worst case) • Select TX channel(s) o Low → 2402 MHz o Mid → 2442 MHz o High → 2480 MHz

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 possible duty cycle and output power.

For conducted measurements;

- All data in this report show the worst case of BLE radio transmitting at the highest output power representing the worst case of BLE transmission mode.
- All measurements were performed with a peak detector" and that the highest possible duty cycle was used for the testing.
- As per manufacturer declaration, duty cycles used are protocol-determined. Test tooling has no mechanism for setting a specific duty cycle.

For radiated measurements;

- All data in this report show the worst case of BLE radio transmitting at the highest output power representing the worst case of BLE transmission mode.
- All data in this report show 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 following:

- FCC ID: 2AQM7-OC1
- IC: 24516-OC1

4.1 Test methodology of applied standards

- FCC part 15, Subpart C §15.247
- FCC KDB 558074 D01 15.247 Meas Guidance v05r02
- RSS-247 issue 2 Feb. 2017
- RSS-Gen issue 5 April 2018
- ANSI C63.10:2013

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.2	☑	☐	☐	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal	-	☐	☐	☑	Note 1 Note 2

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

Note 2: The EUT is a vehicular device powered by DC mains (battery); hence this test is not applicable.

6 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with a 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

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 3 dB 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:

4/22/2023 – 5/26/2023

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.

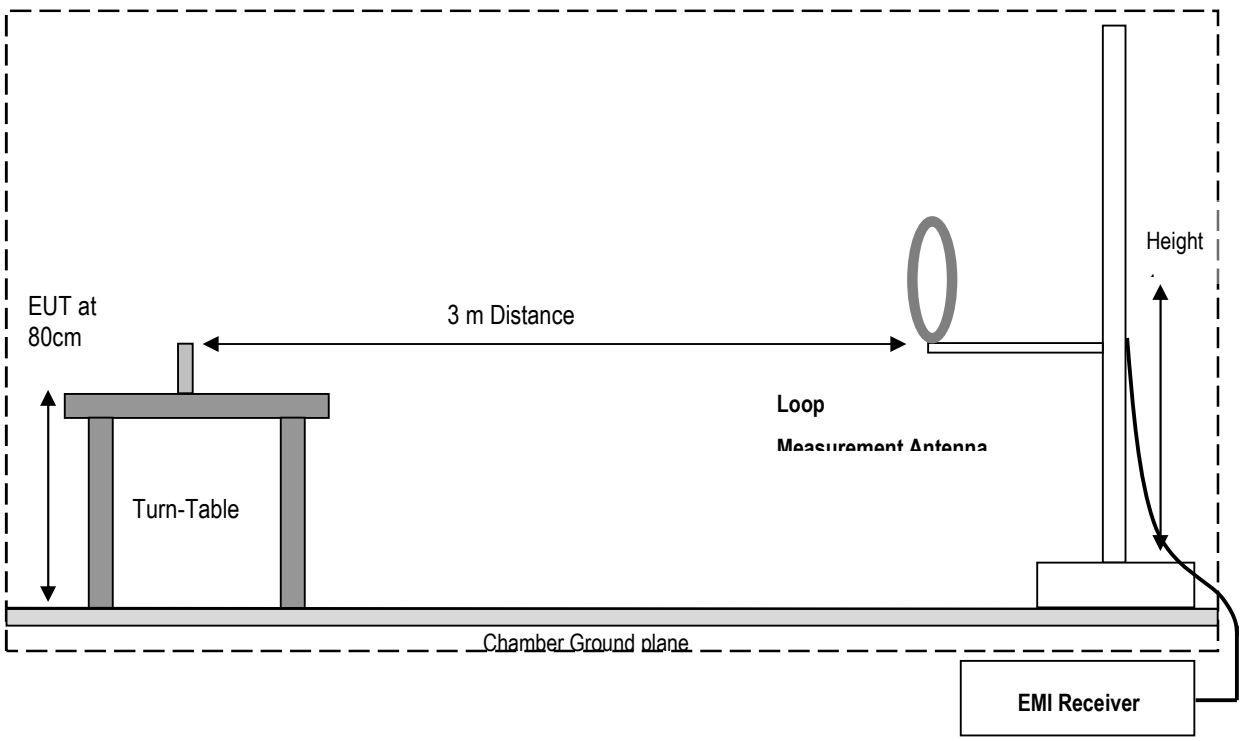
7 Measurement Procedures

7.1 Radiated Measurement

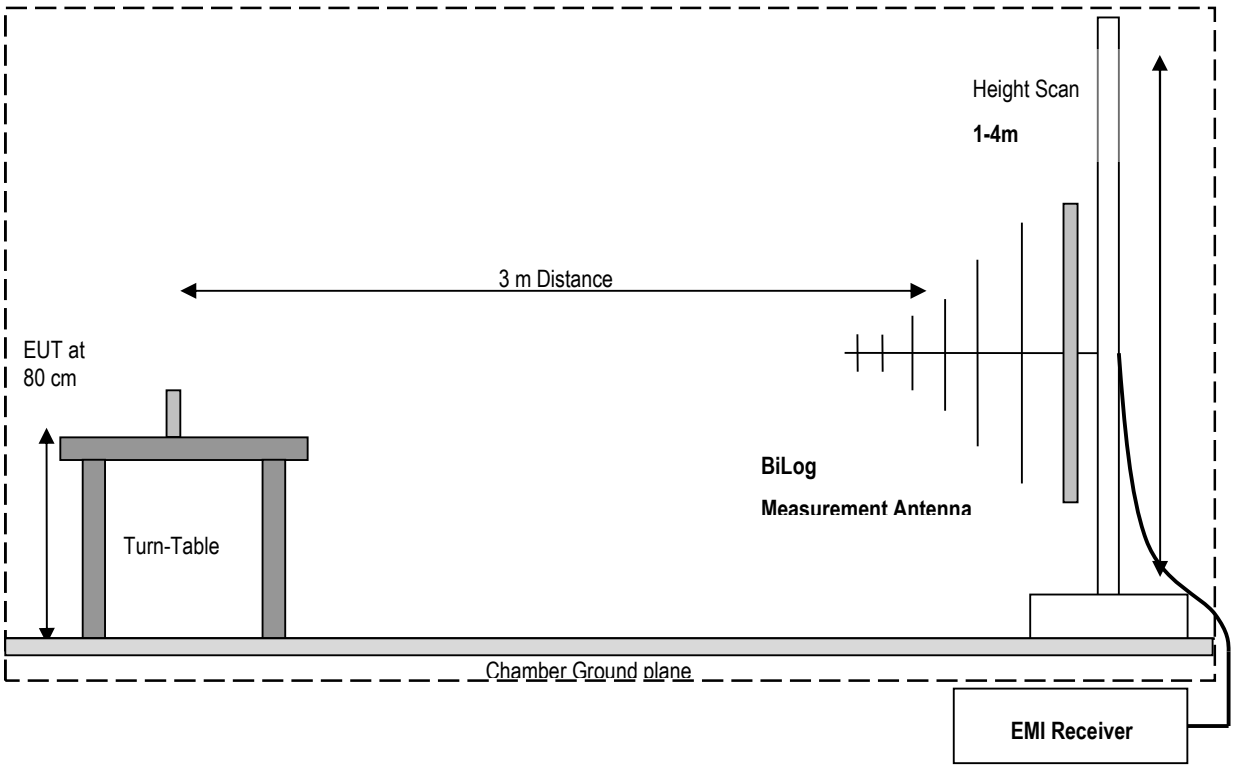
The radiated measurement is performed according to ANSI C63.10 (2013)

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 360º continuous measurement 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 highest six 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 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.

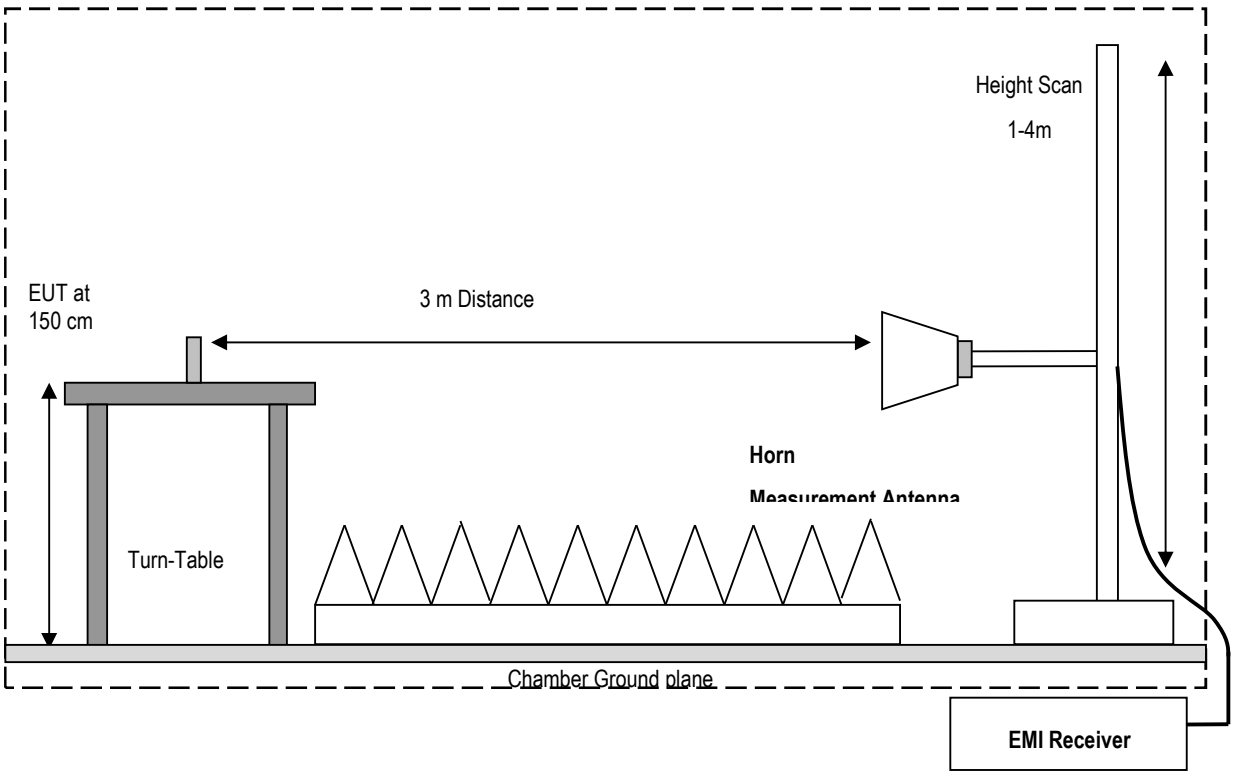
Radiated Emissions Test Setup below 30 MHz Measurements



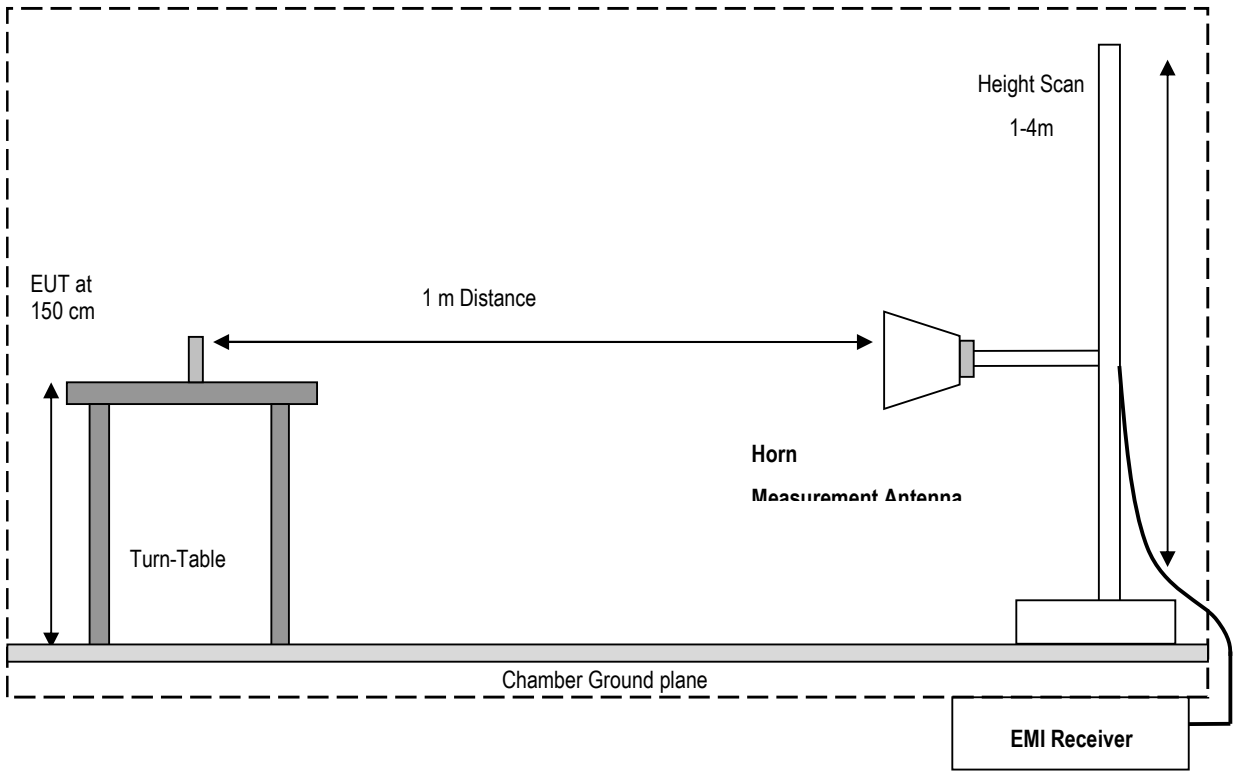
Radiated Emissions Test Setup 30 MHz-1 GHz Measurements



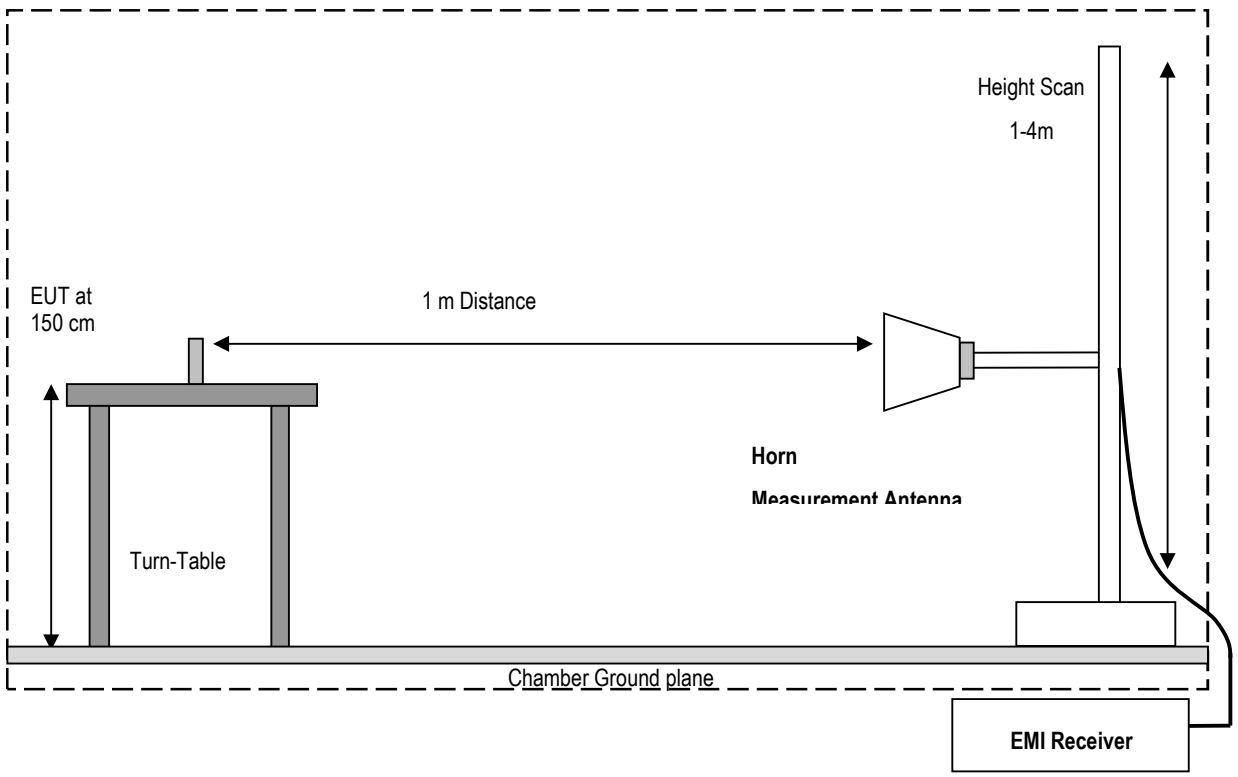
Radiated Emissions Test Setup above 1 GHz Measurements



Radiated Emissions Test Setup above 18 GHz Measurements



Radiated Emissions Test Setup above 18 GHz 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:

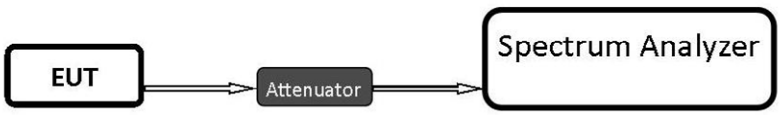
FS (dBµV/m) = Measured Value on SA (dBµV) + Cable Loss (dB) + Antenna Factor (dB/m)

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 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 Duty Cycle

8.1.1 Measurement according to ANSI C63.10 clause 11.6;

Measurements of duty cycle and transmission duration shall be performed using the following technique

b) The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the on-and off-times of transmitted signal.

1. Set the center frequency of the instrument to the center frequency of the transmission.
2. Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value.
3. Set VBW ≥ RBW. Set detector = peak or average.
4. The zero-span measurement method shall not be used unless both RBW and VBW are >50/T and the number of sweep points across duration T exceeds 100.

(For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if T ≥ 16.7 microseconds.)

8.1.2 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23.8°C	1	Op.1	12V DC

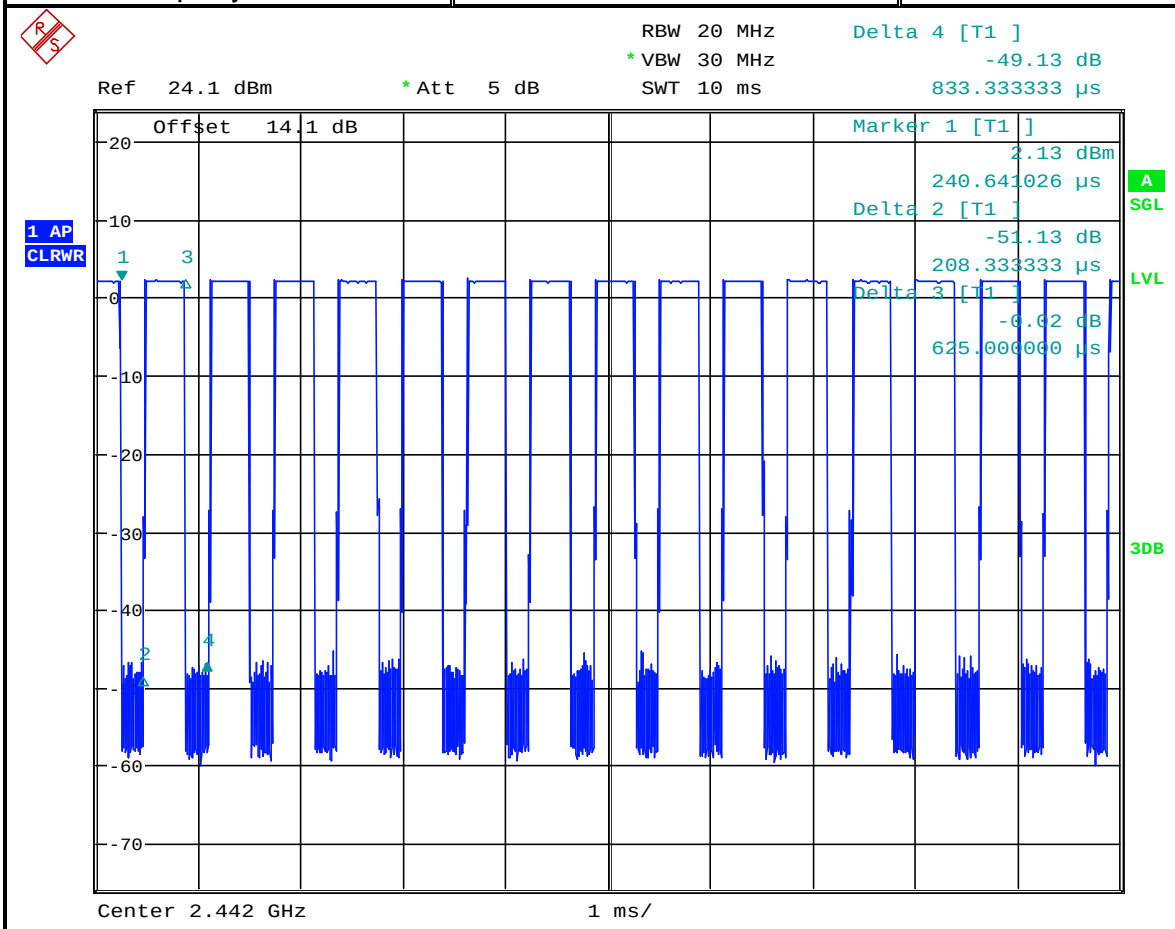
8.1.3 Measurement result:

Plot #	Mode	TX Frequency	Data Rate	Duty cycle
1	BLE	2442 MHz	1 Mb/s	63.84%
2	BLE	2442 MHz	2 Mb/s	32.37%

8.1.4 Measurement plots:

Plot # 1

Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 1 Mb/s



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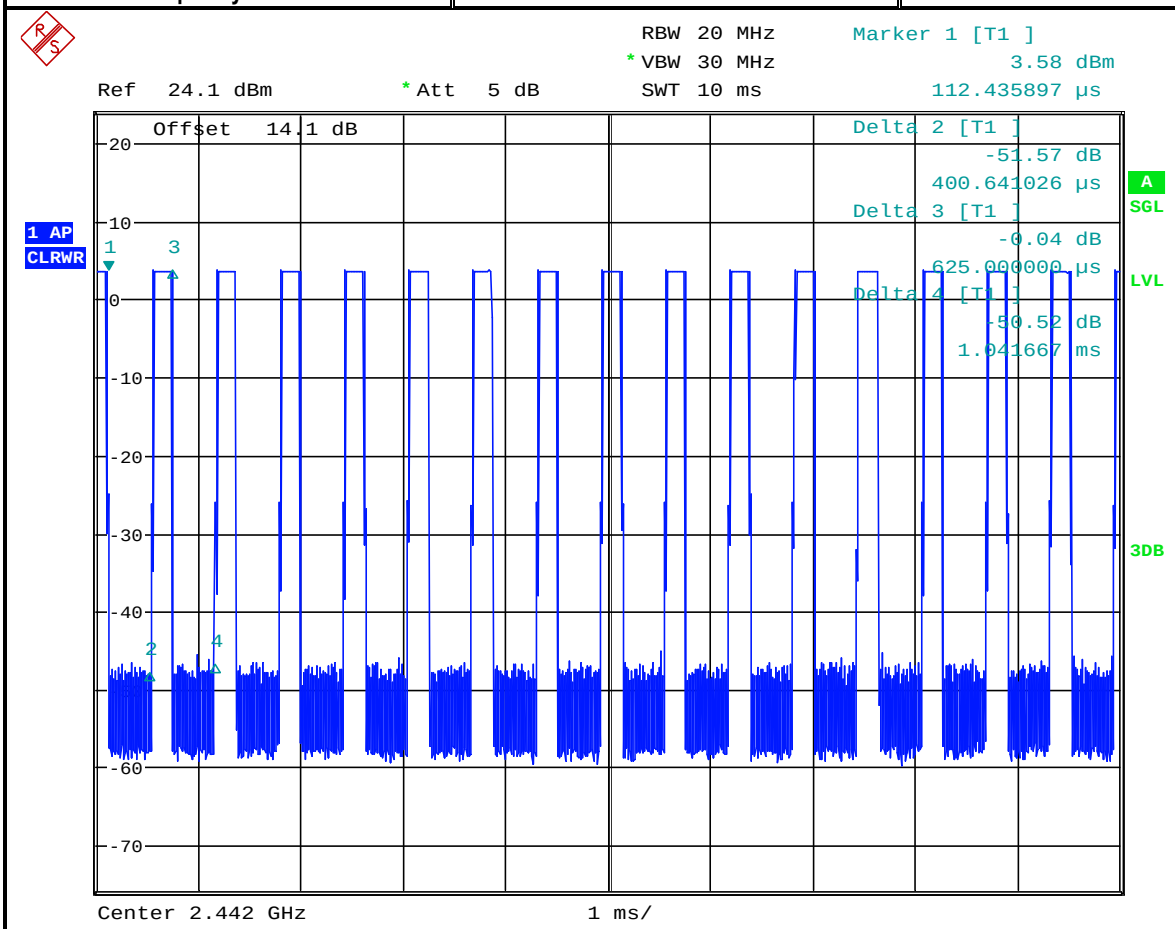
Plot # 2

Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 2 Mb/s



Date: 23.APR.2023 06:09:34

8.2 Emission Bandwidth 6dB and 99% Occupied Bandwidth

8.2.1 Measurement according to ANSI C63.10 clause 11.8

Spectrum Analyzer settings

6dB (DTS) Bandwidth

- Set RBW = 100 kHz
- Set the video bandwidth (VBW) ≥ 3 x 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) ≈ 3 x 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.

8.2.2 Limits:

FCC §15.247(a)(1)

- 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.

8.2.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23.8°C	1	Op.1	12V DC

8.2.4 Measurement result:

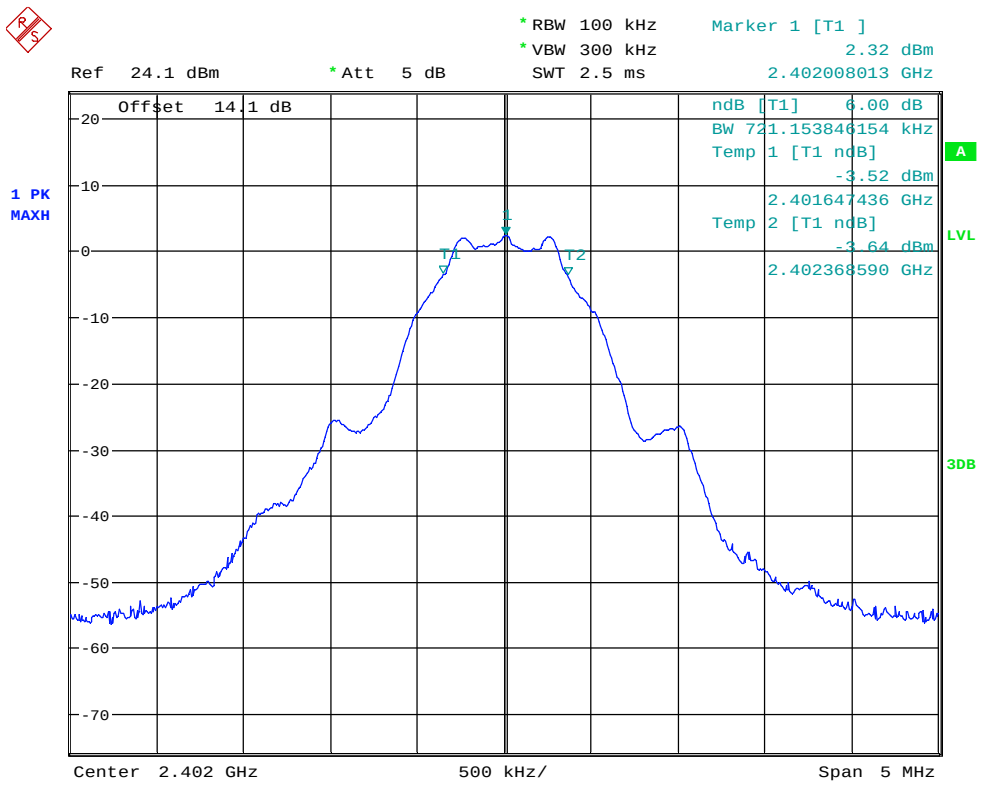
Plot #	Frequency (MHz)	Data rate	6dB Emission Bandwidth (MHz)	Limit (MHz)	Result
3	2402	1 Mb/s	0.72	> 0.5	Pass
4	2442		0.73	> 0.5	Pass
5	2480		0.74	> 0.5	Pass
6	2402	2 Mb/s	1.29	> 0.5	Pass
7	2442		1.29	> 0.5	Pass
8	2480		1.28	> 0.5	Pass

Plot #	Frequency (MHz)	Data rate	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
9	2402	1 Mb/s	1.10	> 0.5	Pass
10	2442		1.10	> 0.5	Pass
11	2480		1.10	> 0.5	Pass
12	2402	2 Mb/s	2.13	> 0.5	Pass
13	2442		2.13	> 0.5	Pass
14	2480		2.13	> 0.5	Pass

8.2.5 Measurement Plots:

6 dB Emission Bandwidth

Plot # 3		
Tx Frequency: 2402 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



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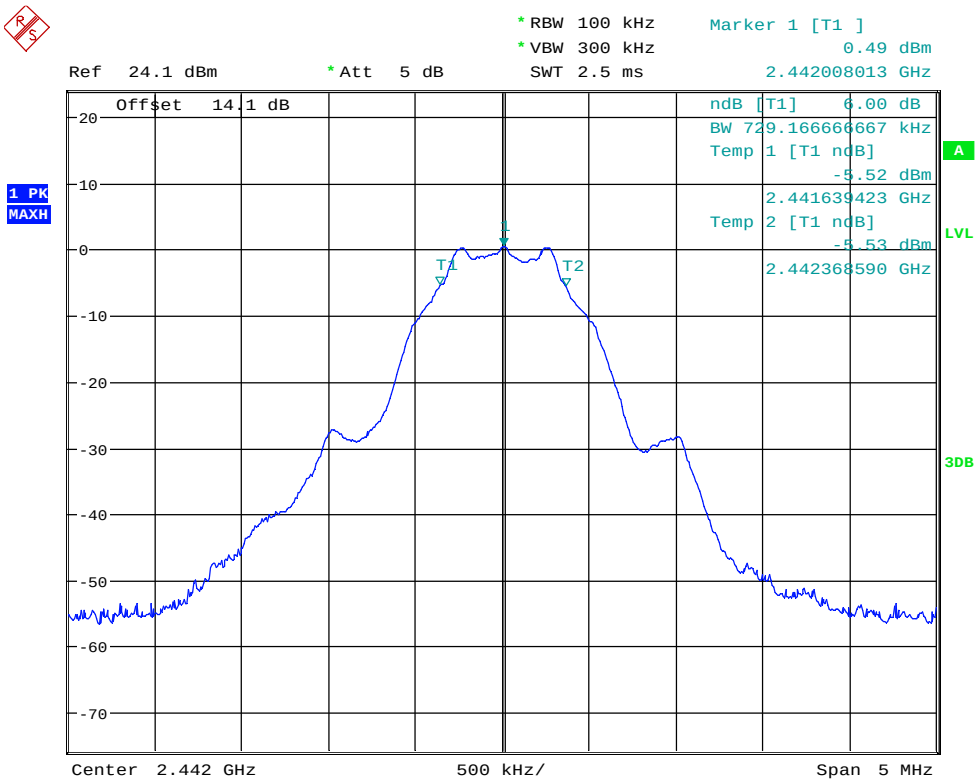
Plot # 4		
Tx Frequency: 2442 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



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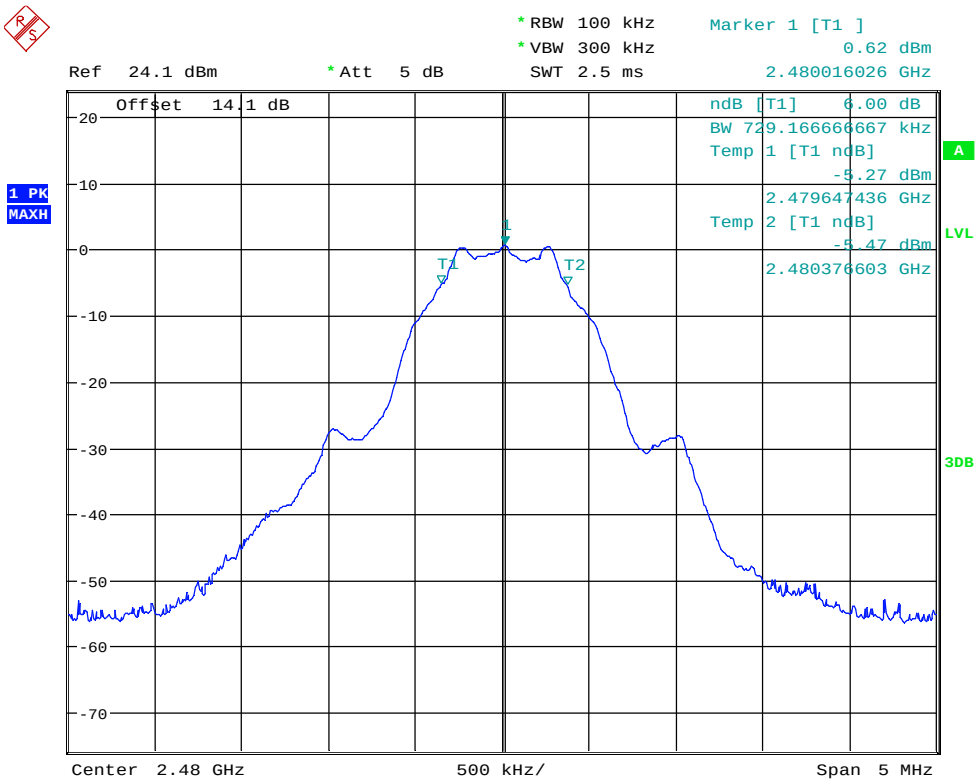
Plot # 5		
Tx Frequency: 2480 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



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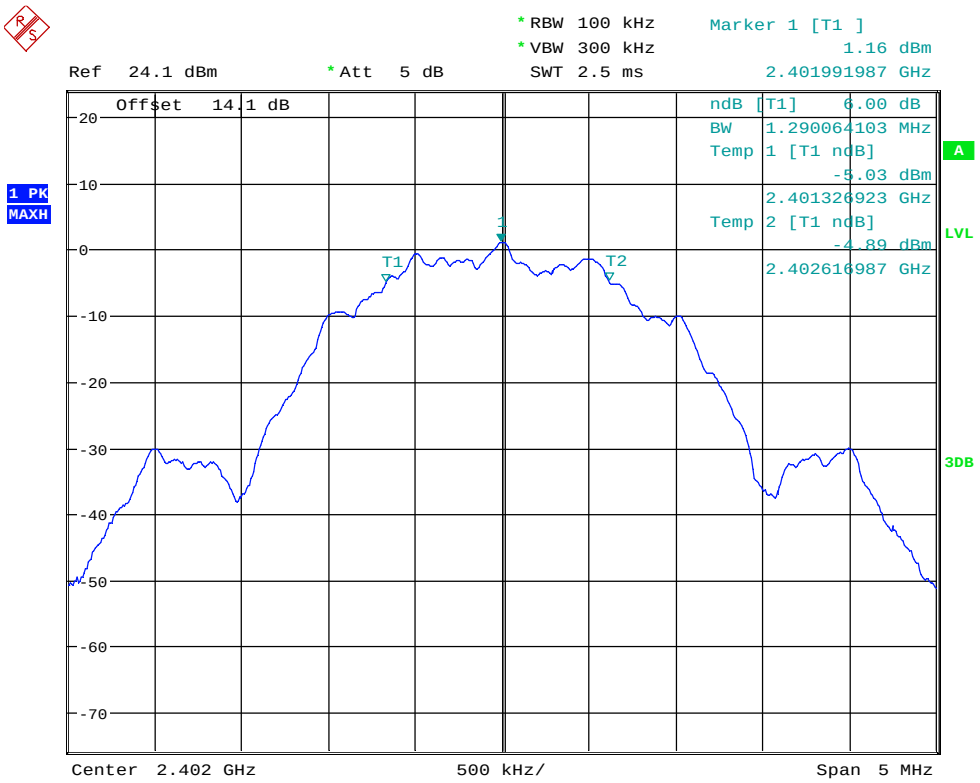
Plot # 6		
Tx Frequency: 2402 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



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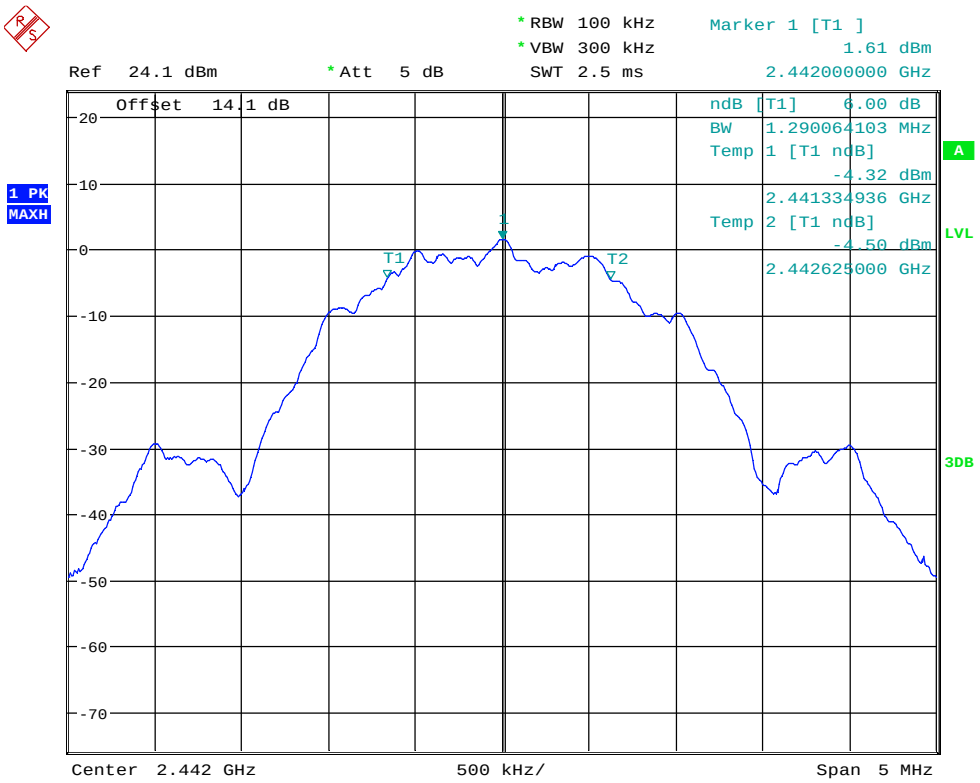
Plot # 7		
Tx Frequency: 2442 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



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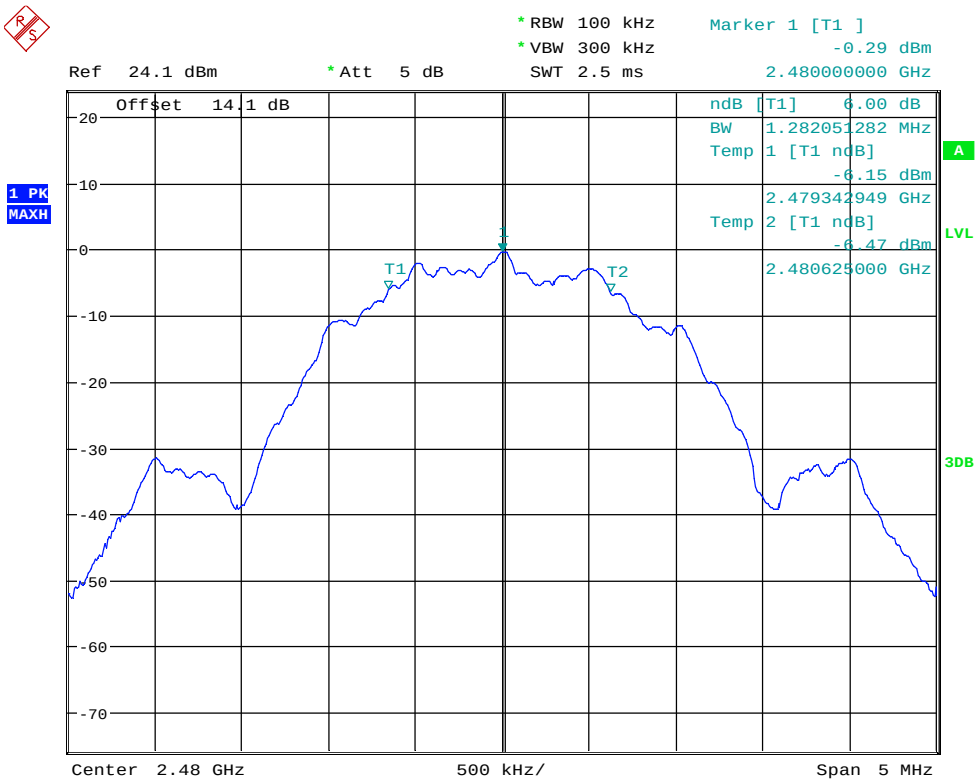
Plot # 8		
Tx Frequency: 2480 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



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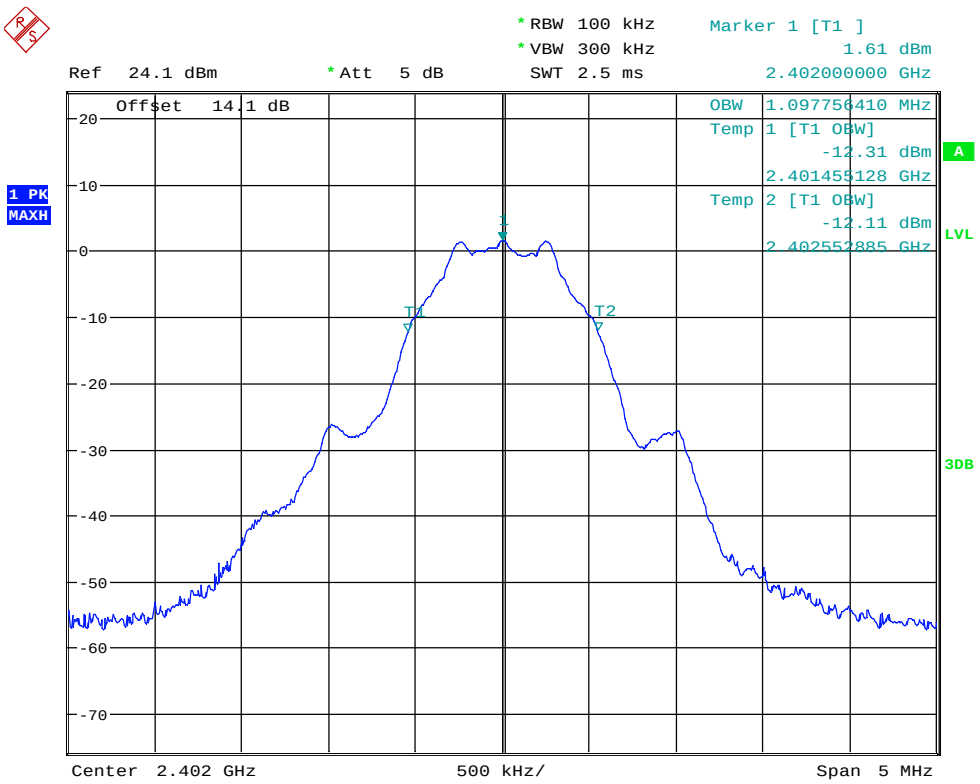
99% Occupied Bandwidth

Plot # 9		
Tx Frequency: 2402 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



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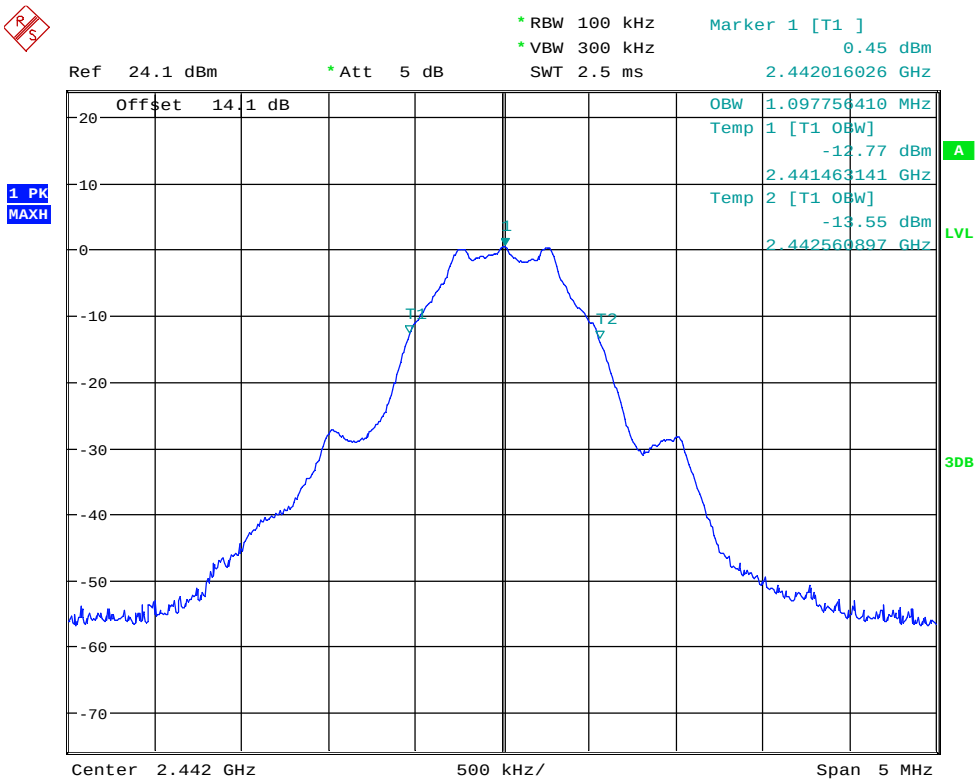
Plot # 10		
Tx Frequency: 2442 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



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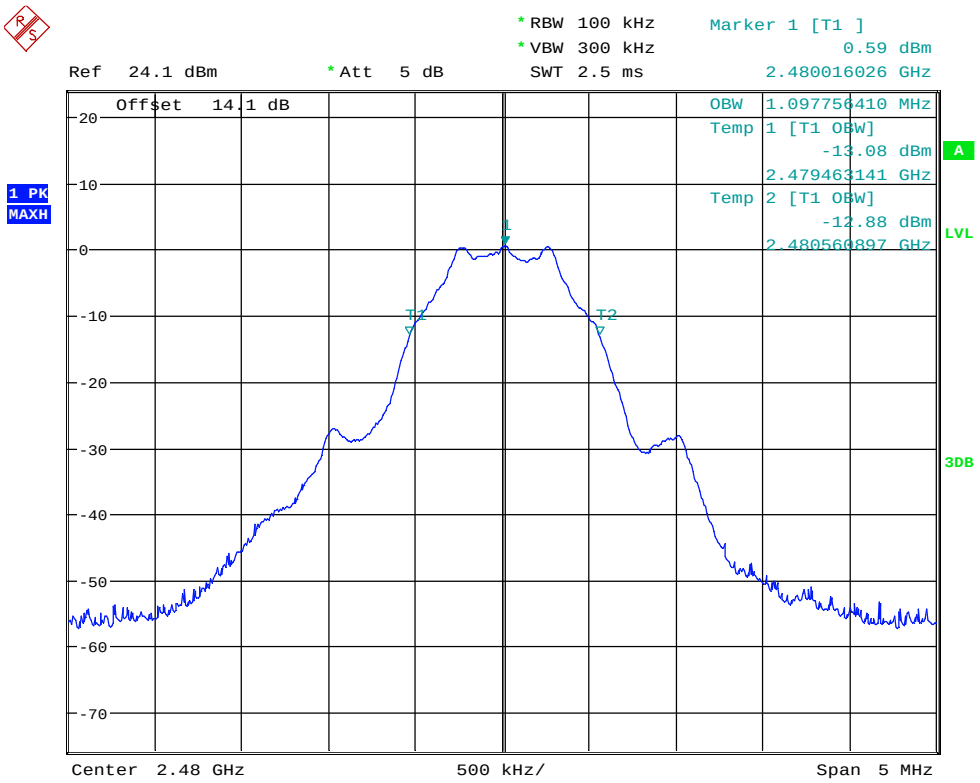
Plot # 11		
Tx Frequency: 2480 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



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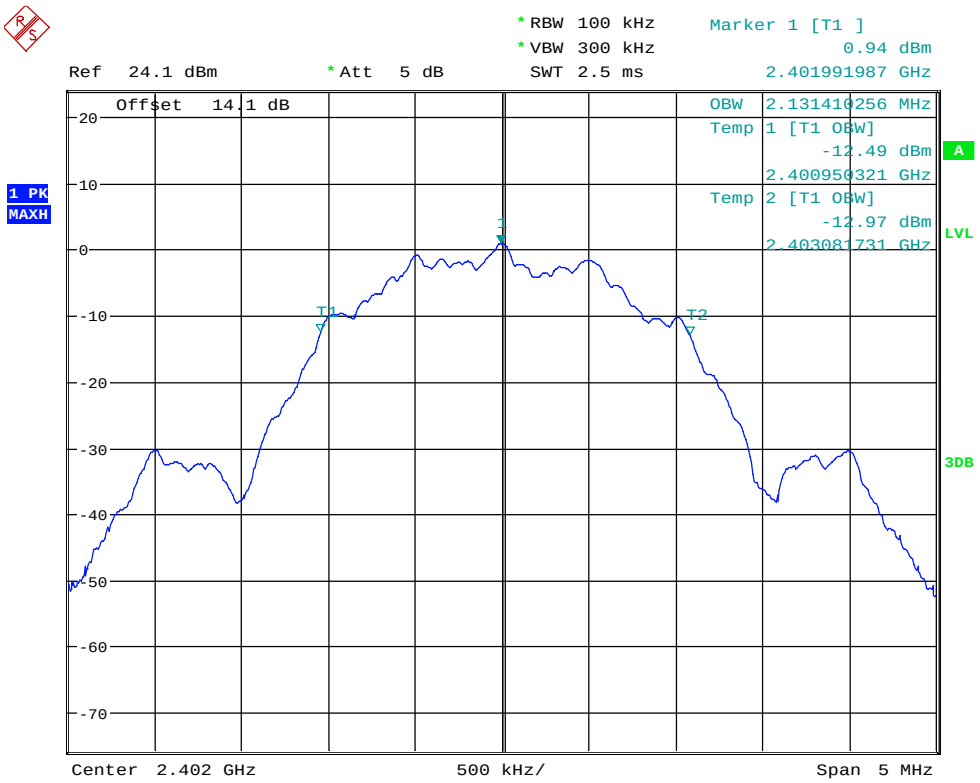
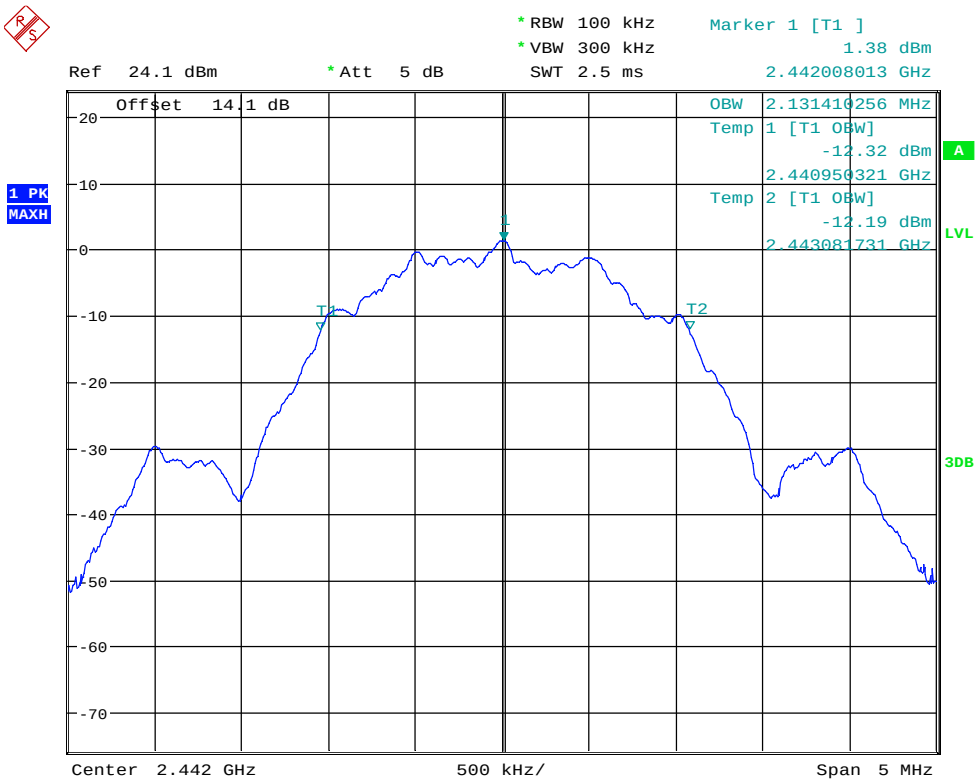
Plot # 12		
Tx Frequency: 2402 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



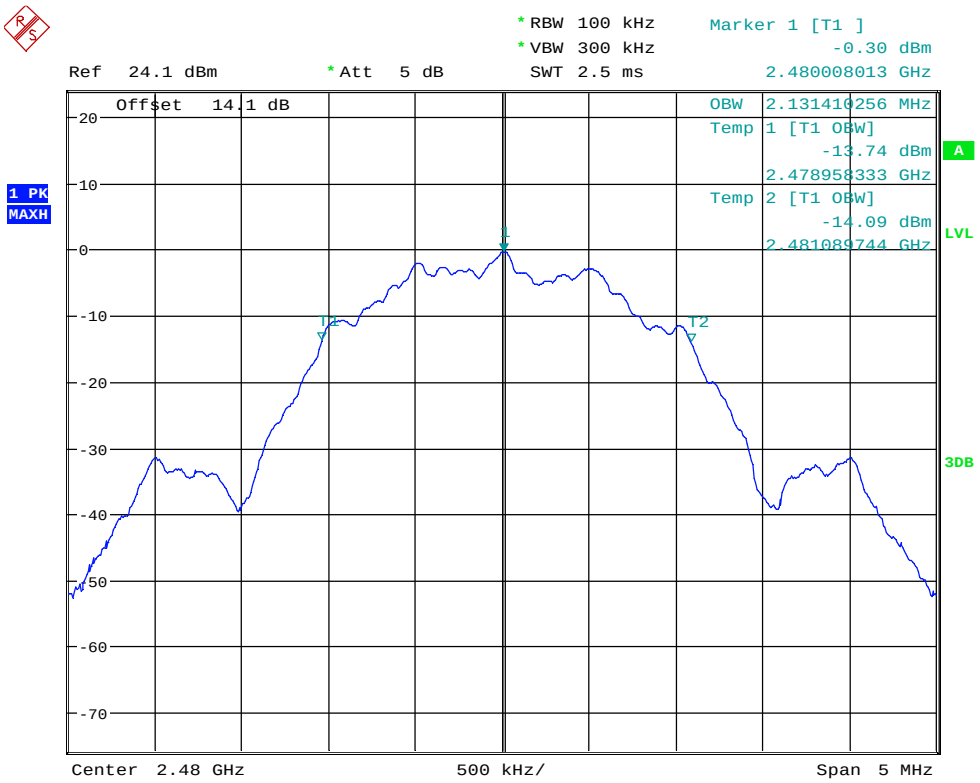
Date: 22.APR.2023 13:12:14

Plot # 13		
Tx Frequency: 2442 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



Date: 22.APR.2023 13:10:42

Plot # 14		
Tx Frequency: 2480 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



Date: 22.APR.2023 13:05:22

8.3 Maximum peak conducted output power

8.3.1 Measurement according to ANSI C63.10 clause 11.9.1.1 RBW ≥ DTS bandwidth

Spectrum Analyzer settings:

- RBW ≥ DTS bandwidth
- VBW ≥ 3 x RBW
- Span ≥ 3 x RBW
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Use peak marker function to determine the peak amplitude level

8.3.2 Limits:

Maximum Output Power:

- FCC §15.247 (b)(1): 1 W

8.3.3 Test conditions and setup:

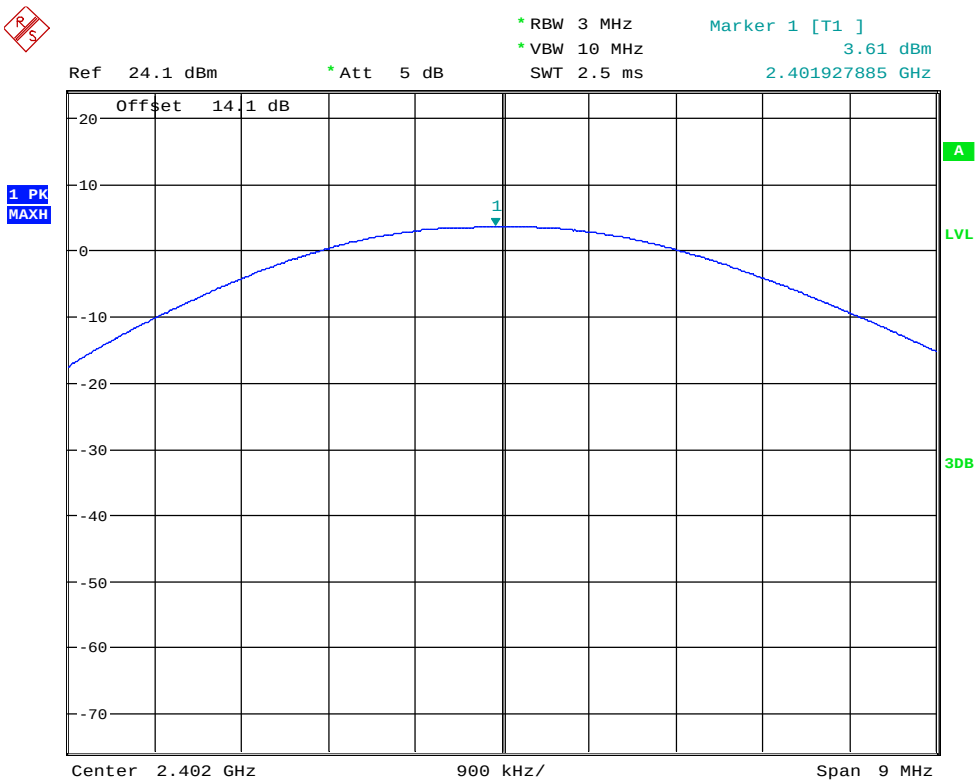
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8°C	1	Op.1	12V DC	1.7 dBi

8.3.4 Measurement result:

Plot #	Frequency (MHz)	Data rate	Output Power Conducted / EIRP (dBm)	Limit (dBm)	Result
15	2402	1 Mb/s	3.61 / 5.31	30 (Pk) / 36 (EIRP)	Pass
16	2442		2.32 / 4.02	30 (Pk) / 36 (EIRP)	Pass
17	2480		2.47 / 4.17	30 (Pk) / 36 (EIRP)	Pass
18	2402	2 Mb/s	4.48 / 6.18	30 (Pk) / 36 (EIRP)	Pass
19	2442		4.89 / 6.59	30 (Pk) / 36 (EIRP)	Pass
20	2480		2.54 / 4.24	30 (Pk) / 36 (EIRP)	Pass

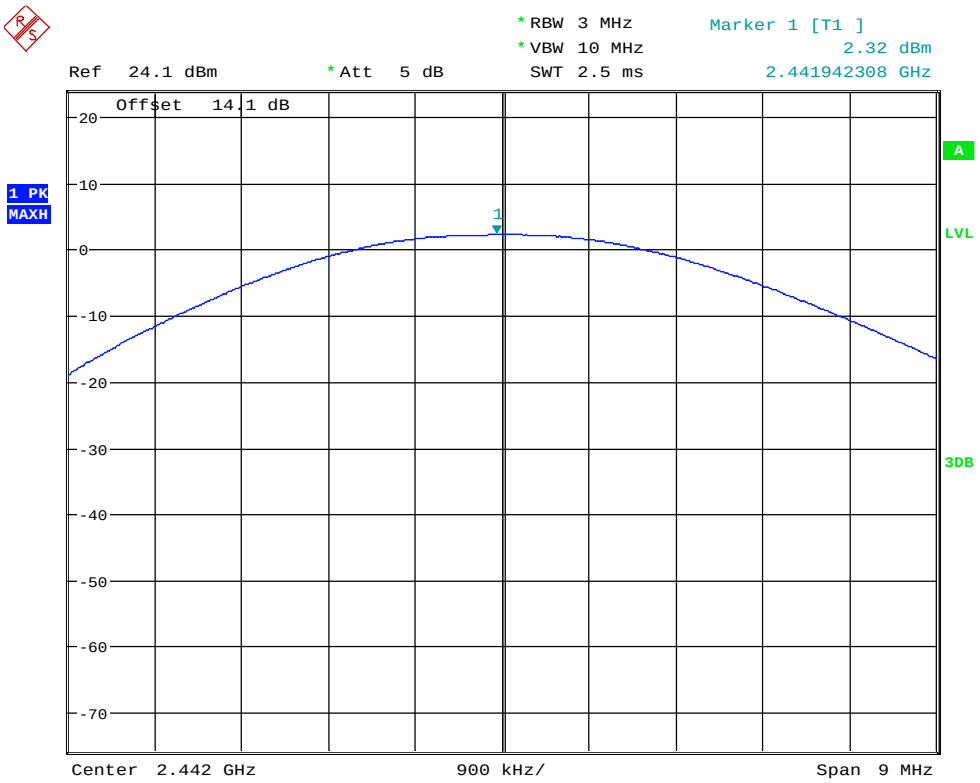
8.3.5 Measurement Plots:

Plot # 15		
Tx Frequency: 2402 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



Date: 22.APR.2023 13:22:45

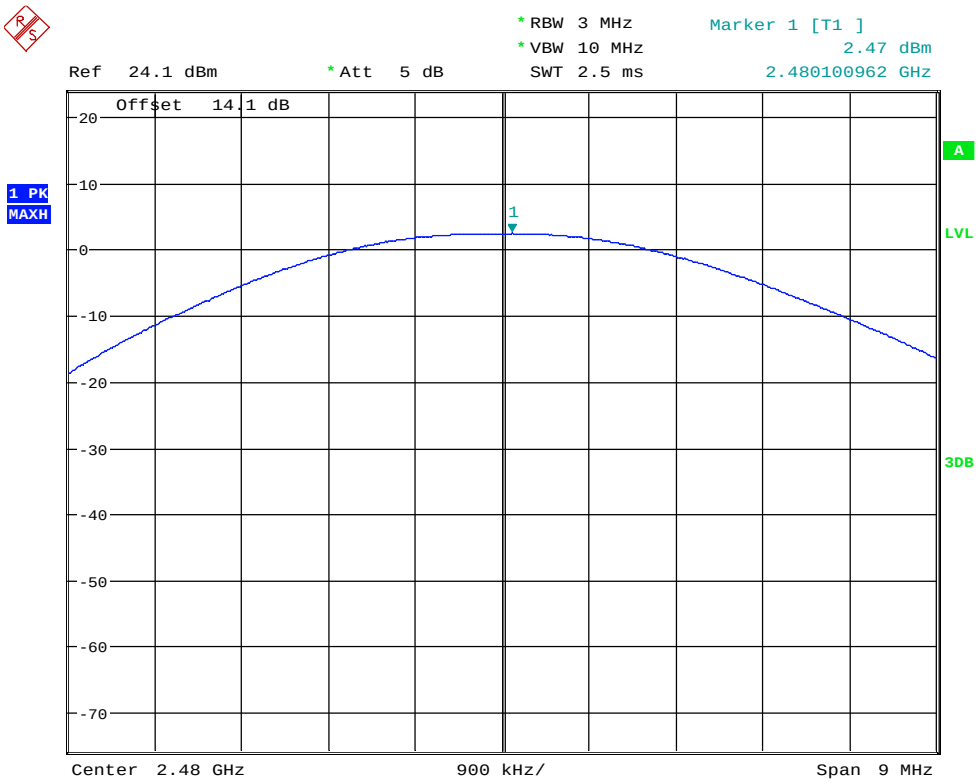
Plot # 16		
Tx Frequency: 2442 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



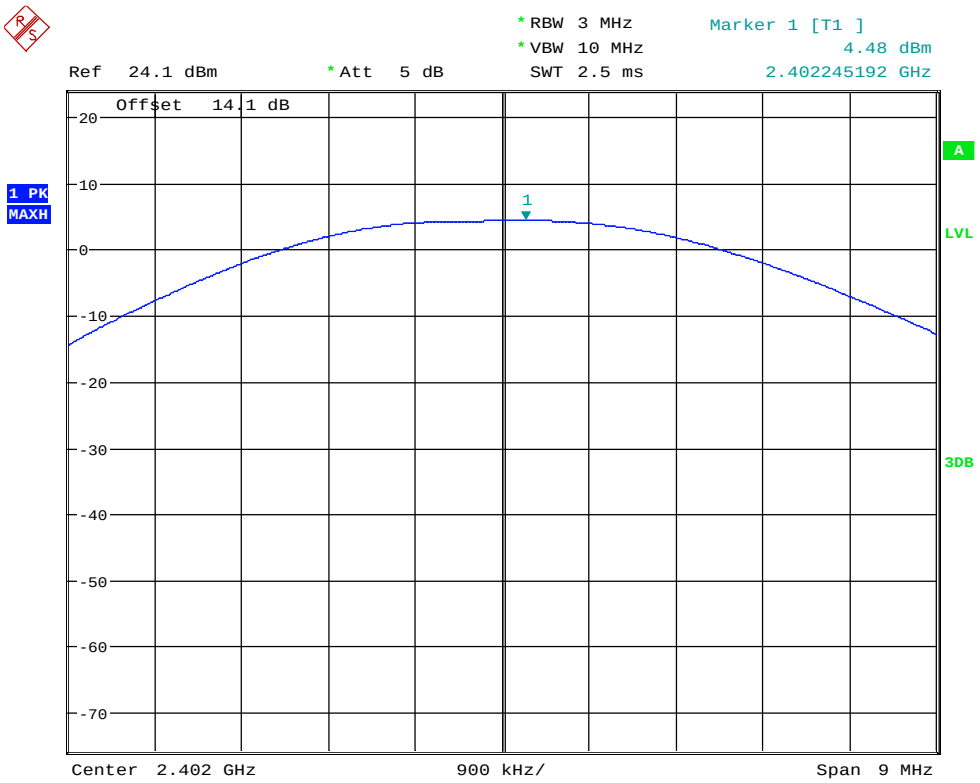
Date: 22.APR.2023 13:17:16

Plot # 17

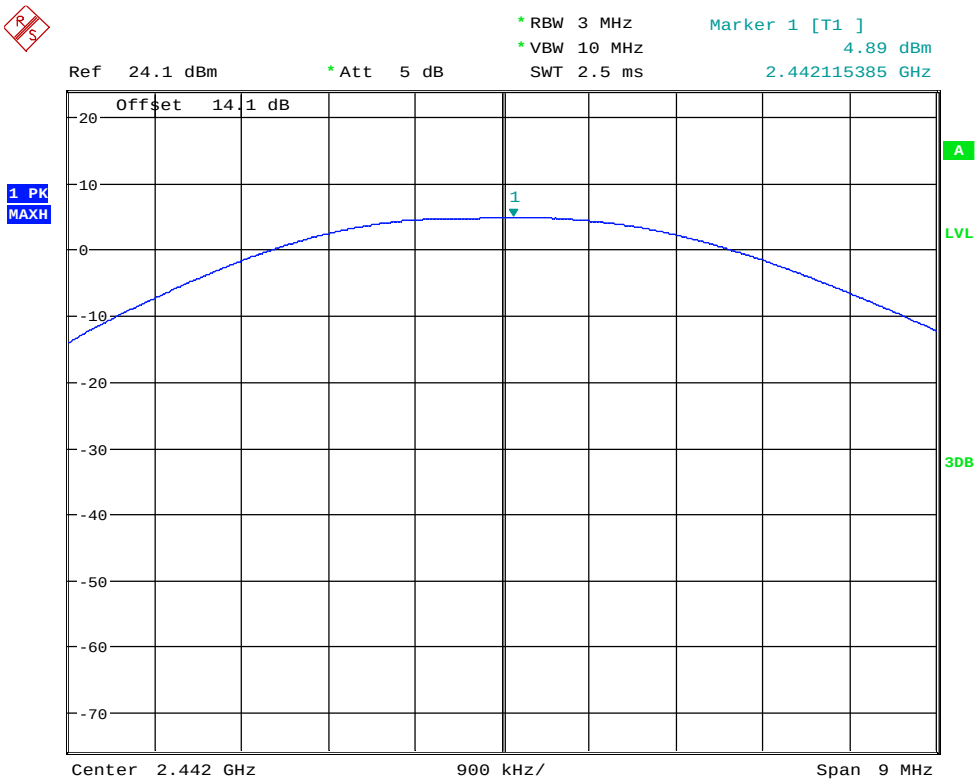
Tx Frequency: 2480 MHz	Mode: LE	Data rate: 1 Mb/s



Plot # 18		
Tx Frequency: 2402 MHz	**Mode: LE**	**Data rate: 2 Mb/s**

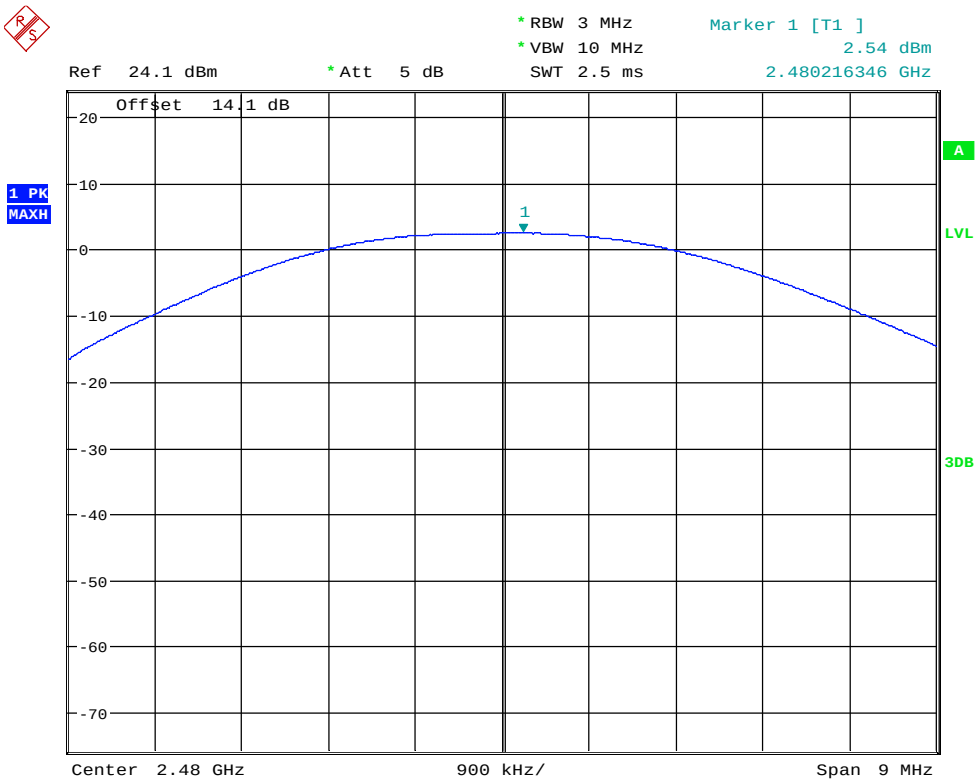


Plot # 19		
Tx Frequency: 2442 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



Date: 22.APR.2023 13:18:59

Plot # 20		
Tx Frequency: 2480 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



Date: 22.APR.2023 13:20:14

8.4 Power Spectral Density

8.4.1 Measurement according to ANSI C63.10 clause 11.10.2

ANSI C63.10 Subclause 11.10.2 Method PKPSD (peak PSD)

The following procedure shall be used if maximum peak conducted output power was used to determine compliance, and it is optional if the maximum conducted (average) output power was used to determine compliance:

- Set analyzer center frequency to DTS channel center frequency.
- Set the span to 1.5 times the DTS bandwidth.
- Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
- Set the VBW ≥ [3 x 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, then reduce RBW (but no less than 3 kHz) and repeat.

8.4.2 Limits:

FCC§15.247(e)

- 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.

8.4.3 Test conditions and setup:

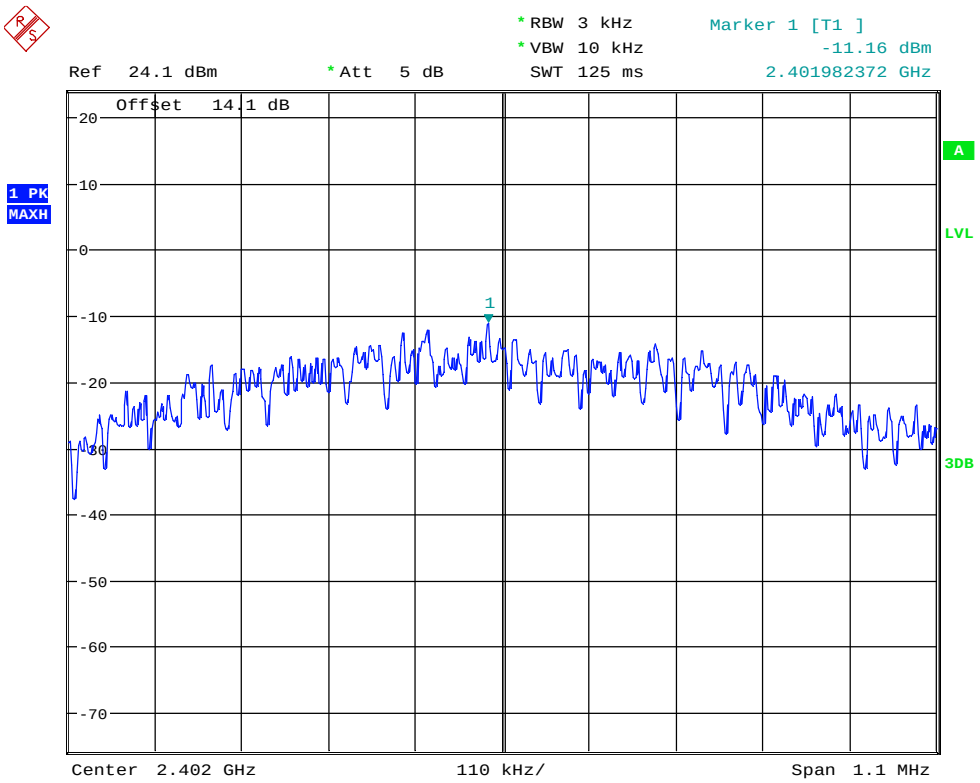
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8°C	1	Op.1	12V DC	1.7 dBi

8.4.4 Measurement result:

Plot #	Frequency (MHz)	Data rate	PSD (dBm / 3 KHz)	Limit (dBm / 3 kHz)	Result
21	2402	1 Mb/s	-11.16	8	Pass
22	2442		-12.45	8	Pass
23	2480		-12.24	8	Pass
24	2402	2 Mb/s	-13.85	8	Pass
25	2442		-13.47	8	Pass
26	2480		-16.0	8	Pass

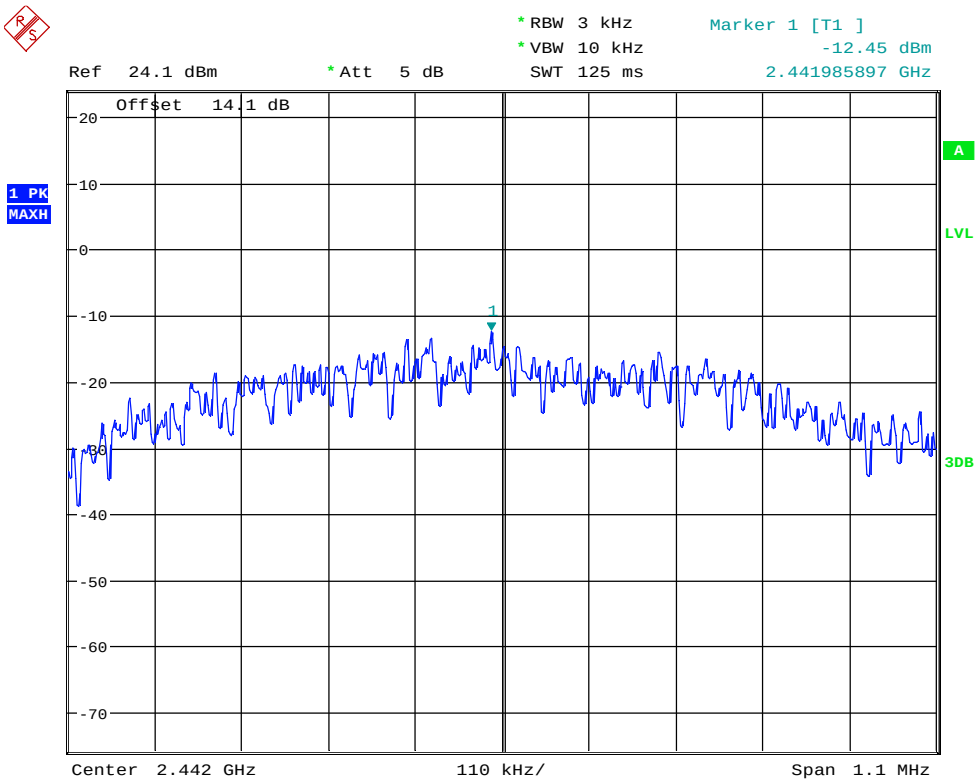
8.4.5 Measurement Plots:

Plot # 21		
Tx Frequency: 2402 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



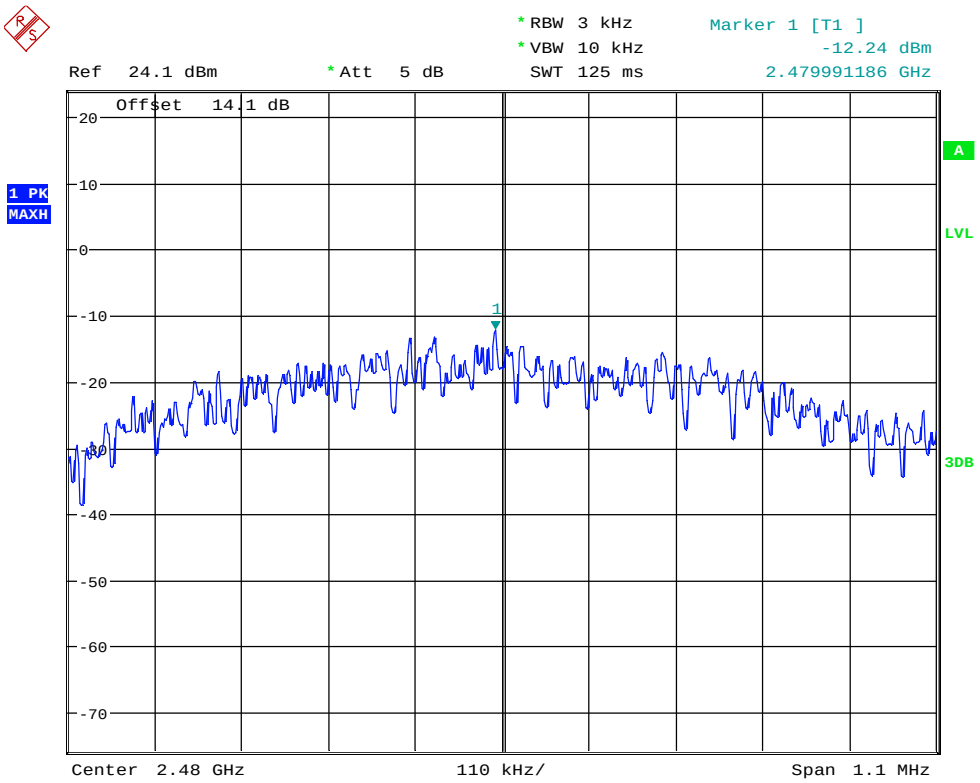
Date: 22.APR.2023 14:46:12

Plot # 22		
Tx Frequency: 2442 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



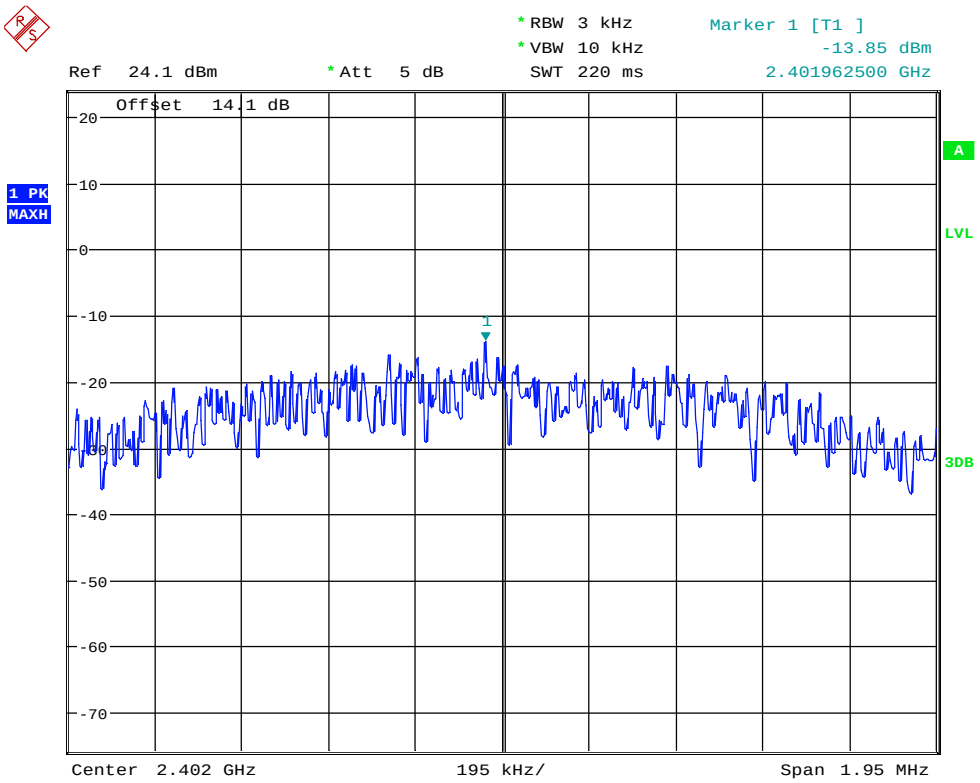
Date: 22.APR.2023 14:50:10

Plot # 23		
Tx Frequency: 2480 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



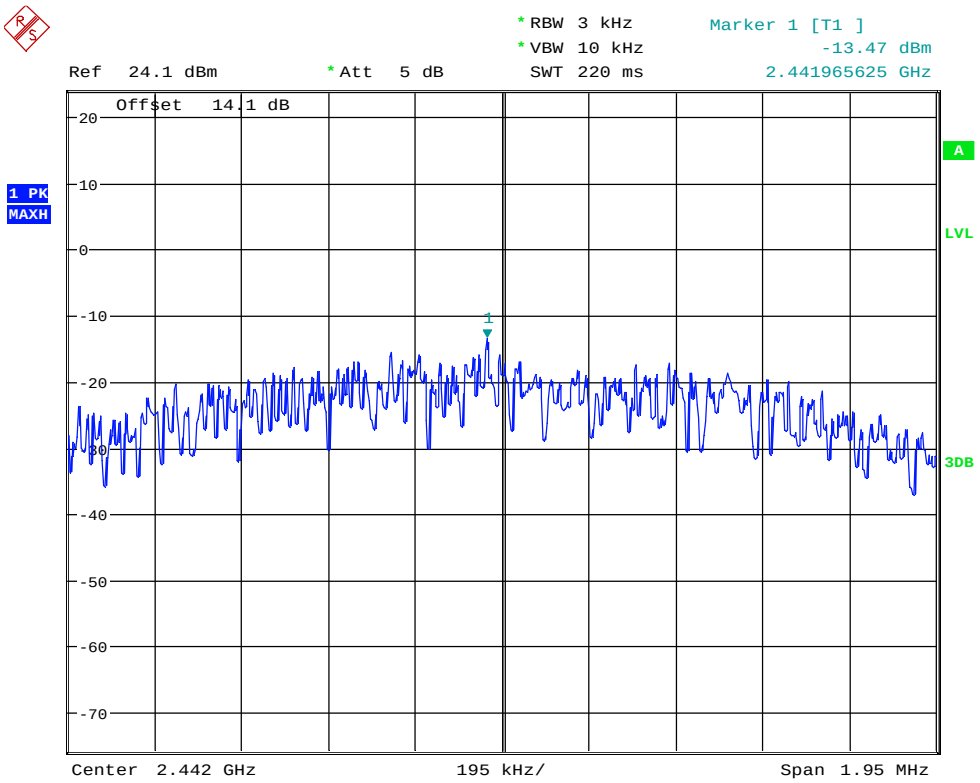
Date: 22.APR.2023 15:20:23

Plot # 24		
Tx Frequency: 2402 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



Date: 22.APR.2023 15:28:42

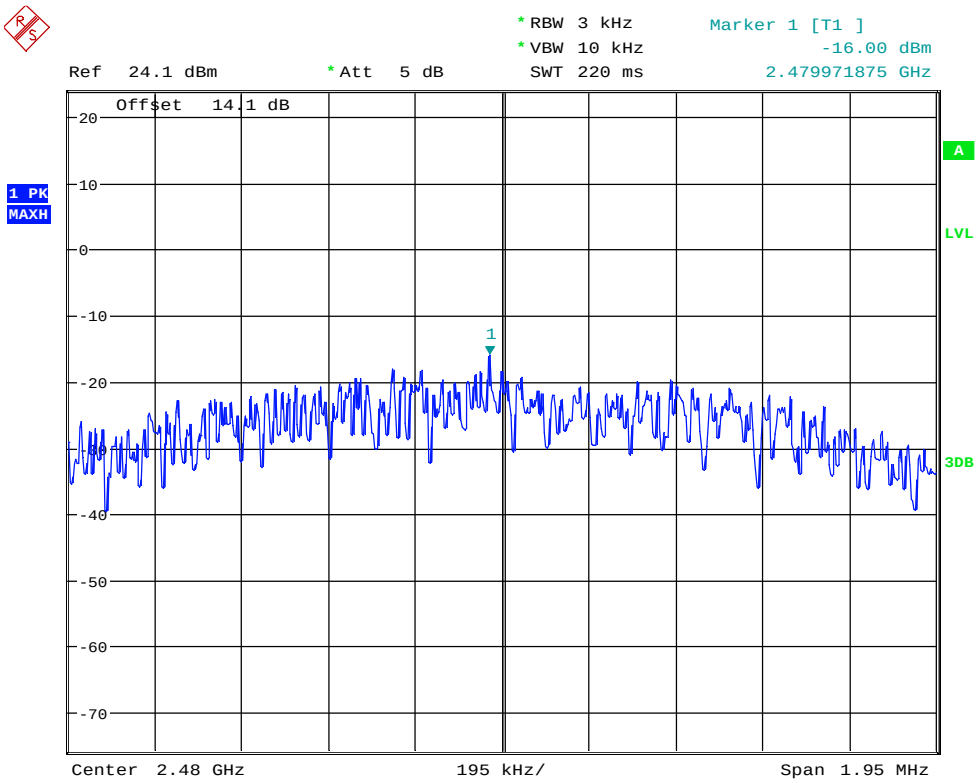
Plot # 25		
Tx Frequency: 2442 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



Date: 22.APR.2023 15:27:15

Plot # 26

Tx Frequency: 2480 MHz	Mode: LE	Data rate: 2 Mb/s



8.5 Band Edge Compliance

8.5.1 Emissions in non-restricted frequency bands

Measurement according to ANSI C63.10 clause 11.11 (Conducted)

- Set the center frequency and span to encompass frequency range to be measured
- RBW = 100 kHz
- VBW ≥ 3 x 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

8.5.2 Emissions in restricted frequency bands

Measurement according to ANSI C63.10 clause 11.12.1 (Radiated)

- RBW = 1 MHz
- Detector: Peak/RMS

8.5.3 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)).

8.5.4 Limits restricted band §15.247/15.209/15.205

- *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
- 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
[1]0.495-0.505	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			

8.5.5 Test conditions and setup:

Restricted and Non-Restricted Band

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8°C	1	Op.1	12V DC	1.7 dBi

8.5.6 Measurement result:

2390 – 2400 MHz

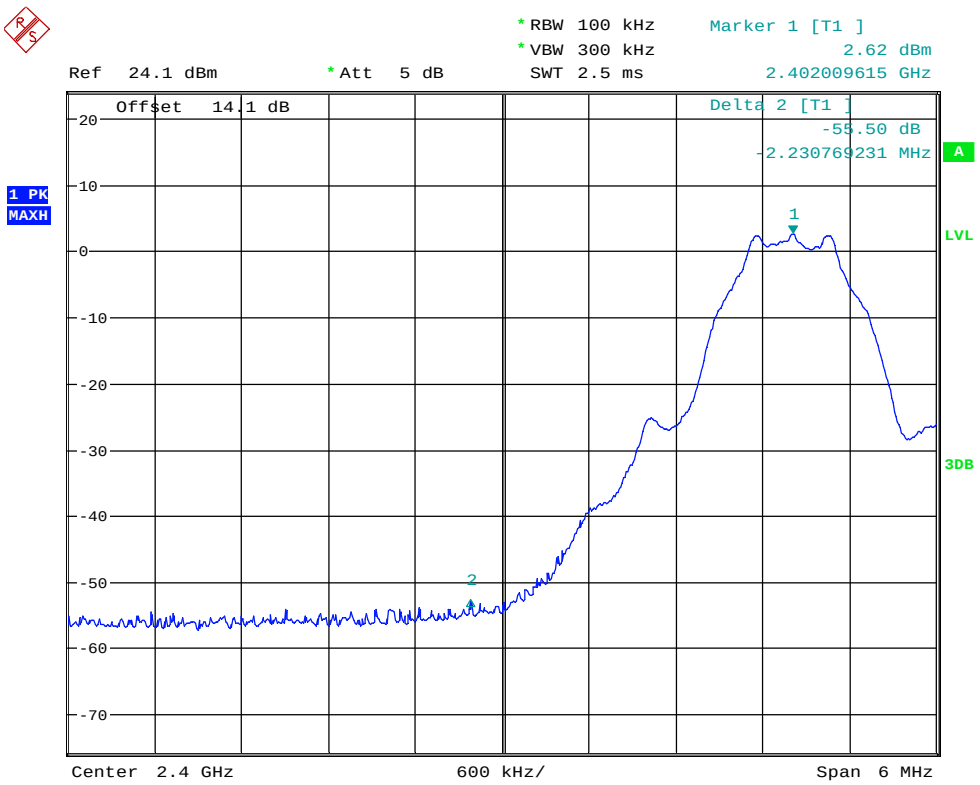
Plot #	Frequency (MHz)	Data rate	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
27	2402	1 Mb/s	Lower, Non-restricted	-55.50	-20	Pass
28	2402	2 Mb/s	Lower, Non-restricted	-31.14	-20	Pass

2483.5 – 2500 MHz

Plot #	TX Frequency (MHz)	Data rate	Band Edge	Measured Value (dBµV/m) @3m	Limit (dBµV/m) @3m	Result
29	2480	2 Mb/s	Upper Restricted (AVG)	29.0	54	Pass
30	2480		Upper Restricted (Peak)	46.32	74	Pass

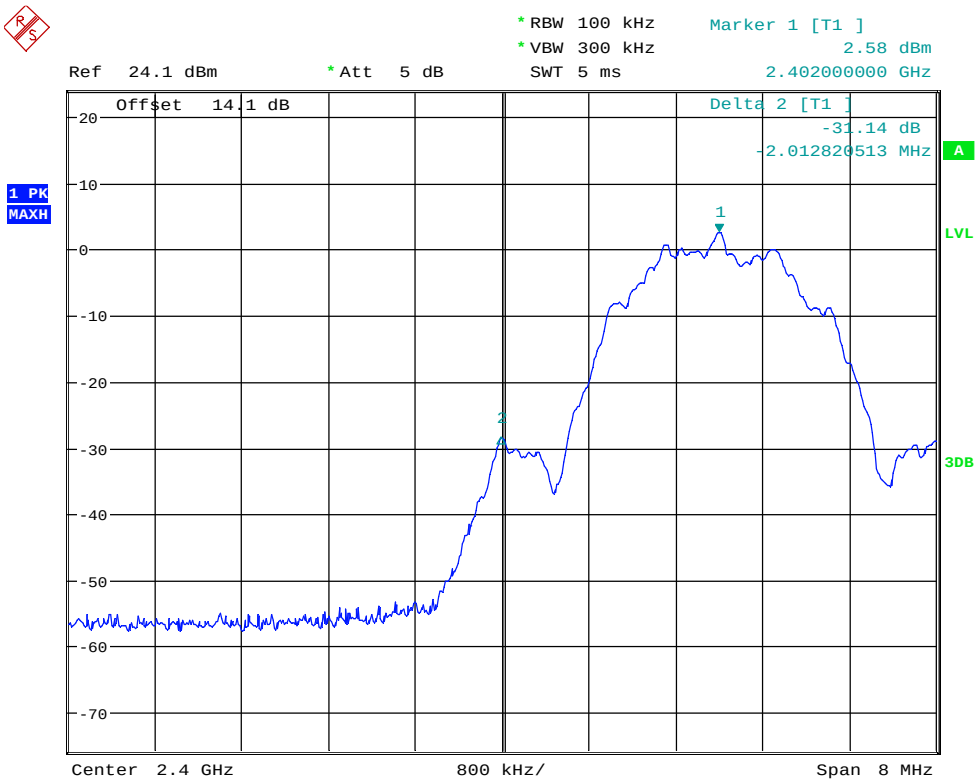
8.5.7 Measurement Plots:

Plot # 27		
Tx Frequency: 2480 MHz	**Mode: LE**	**Data rate: 1 Mb/s**



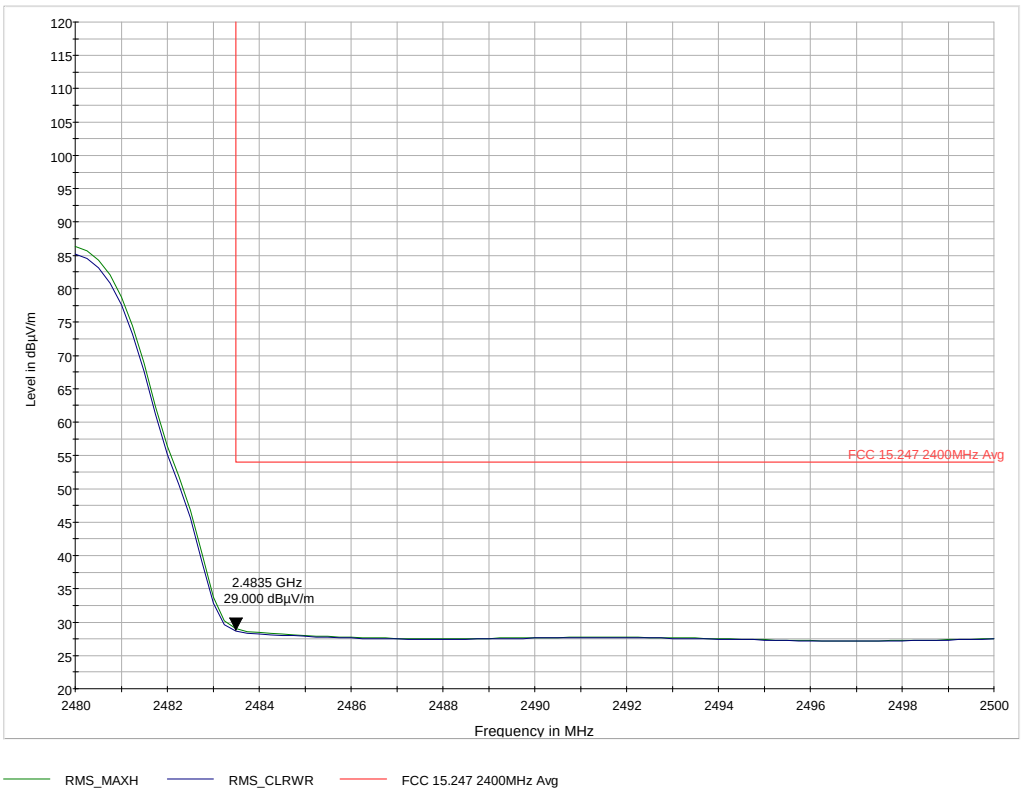
Date: 22.APR.2023 15:37:59

Plot # 28		
Tx Frequency: 2402 MHz	**Mode: LE**	**Data rate: 2 Mb/s**

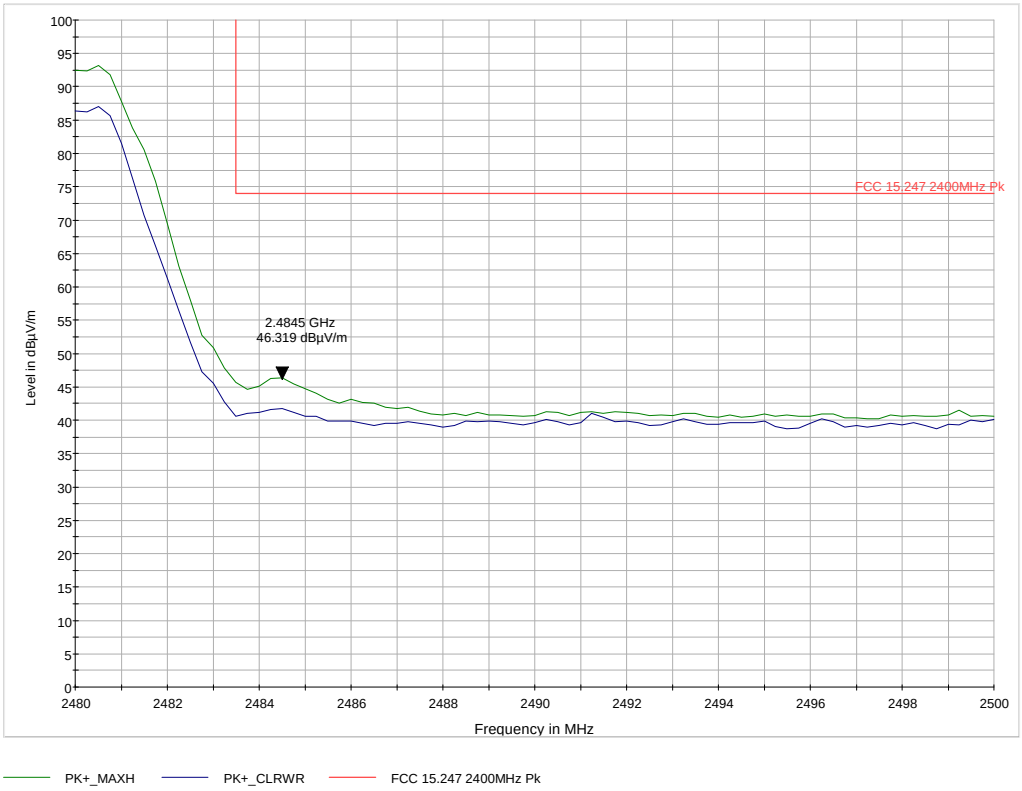


Date: 22.APR.2023 15:34:43

Plot # 29		
Tx Frequency: 2442 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



Plot # 30		
Tx Frequency: 2480 MHz	**Mode: LE**	**Data rate: 2 Mb/s**



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 at distance other than the specified in the standard, the limit conversion is calculated by using 40 dB/decade extrapolation factor as follow: Conversion factor (CF) = 40 log (D/d) = 40 log (300m / 3m) = 80dB

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
[1]0.495-0.505	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 operating mode	Power supply	Antenna Gain
23°C	Op.2	12V DC	1.7 dBi

8.6.4 Measurement result:

EUT Set-Up #	Plot #	Channel #	Scan Frequency	Lowest margin emission [dBµV/m] @ 3m	Limit	Result
2	9 – 11	Low	30 MHz – 18 GHz	29.03	See section 8.2.2	Pass
	12 – 16	Mid	9 kHz – 26 GHz	42.30	See section 8.2.2	Pass
	17 – 19	High	30 MHz – 18 GHz	32.68	See section 8.2.2	Pass

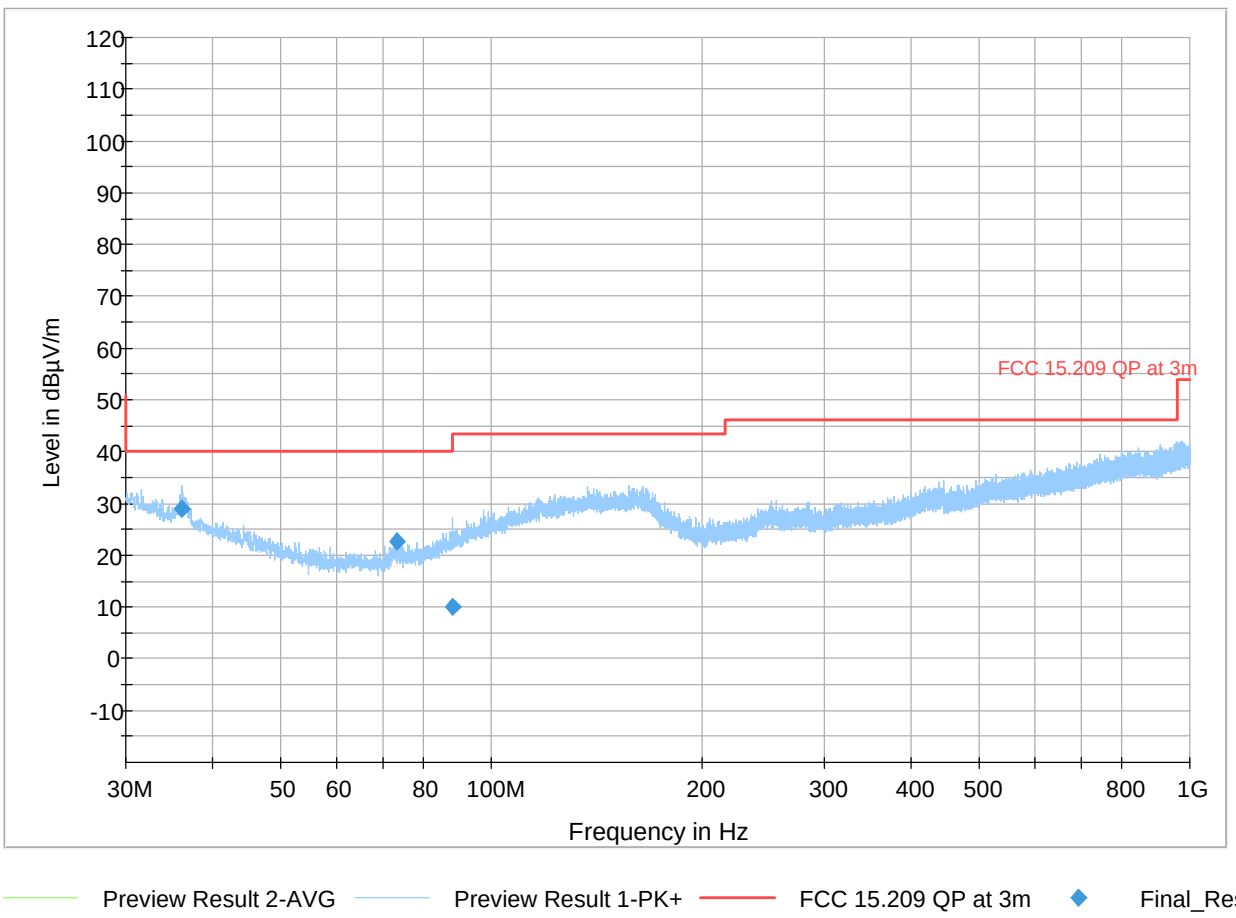
8.6.5 Measurement Plots:

Plot # 31 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 2402 MHz	PHY: 2M

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBµV)
36.11	29.03	40.00	10.97	500.0	120.0	100.0	V	6.0	-14.2	-35.3	0.0	21.1	43.2
73.19	22.59	40.00	17.41	500.0	120.0	100.0	V	337.0	-21.8	-35.1	0.0	13.3	44.4
88.05	9.99	43.50	33.51	500.0	120.0	100.0	H	61.0	-18.3	-35.1	0.0	16.8	28.3

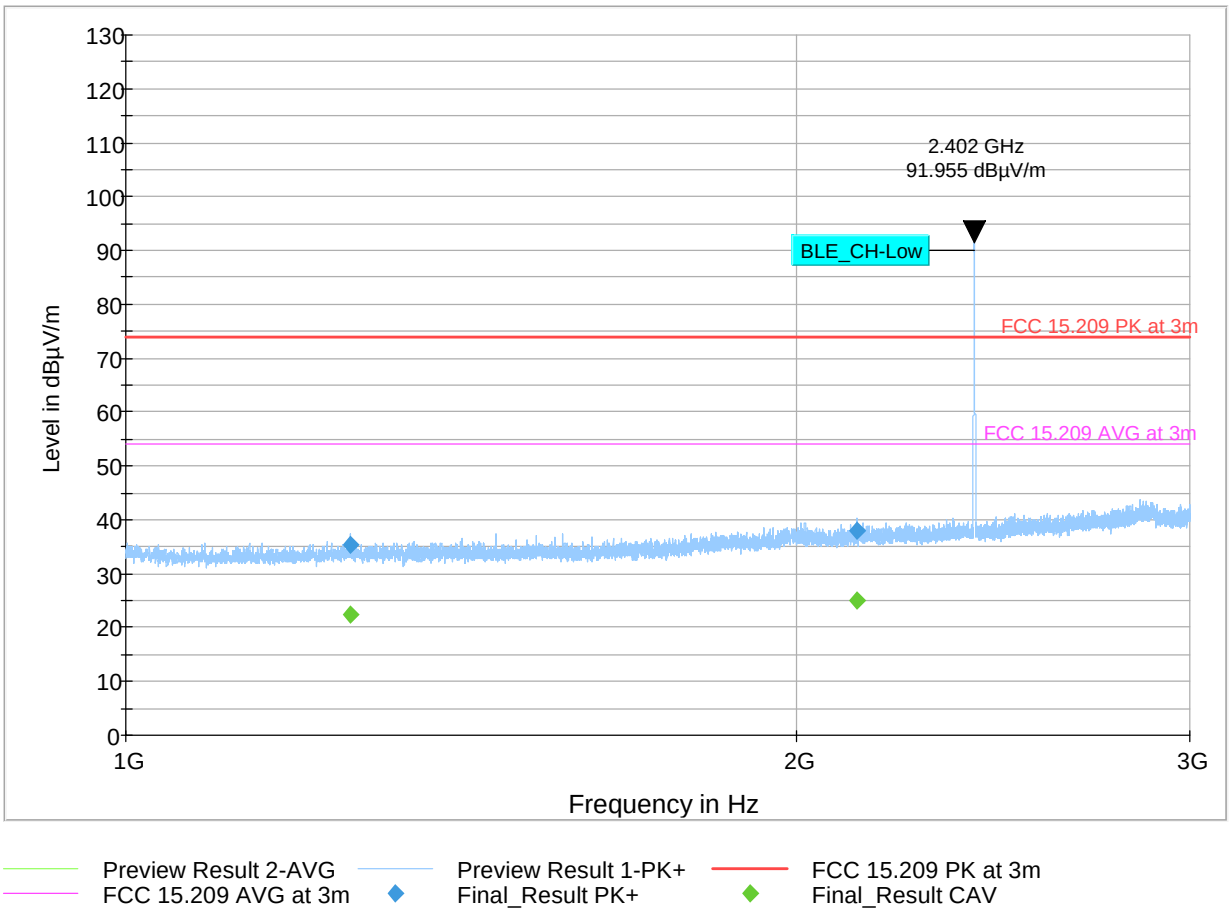


Plot # 32 Radiated Emissions: 1 – 3 GHz

Tx Frequency: 2402 MHz	PHY: 2M

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)
1261.57	---	22.45	53.98	31.53	500.0	1000.0	117.0	H	25.0	2.9
1261.57	35.31	---	73.98	38.67	500.0	1000.0	117.0	H	25.0	2.9
2126.86	---	25.08	53.98	28.90	500.0	1000.0	177.0	H	291.0	5.3
2126.86	37.99	---	73.98	35.99	500.0	1000.0	177.0	H	291.0	5.3

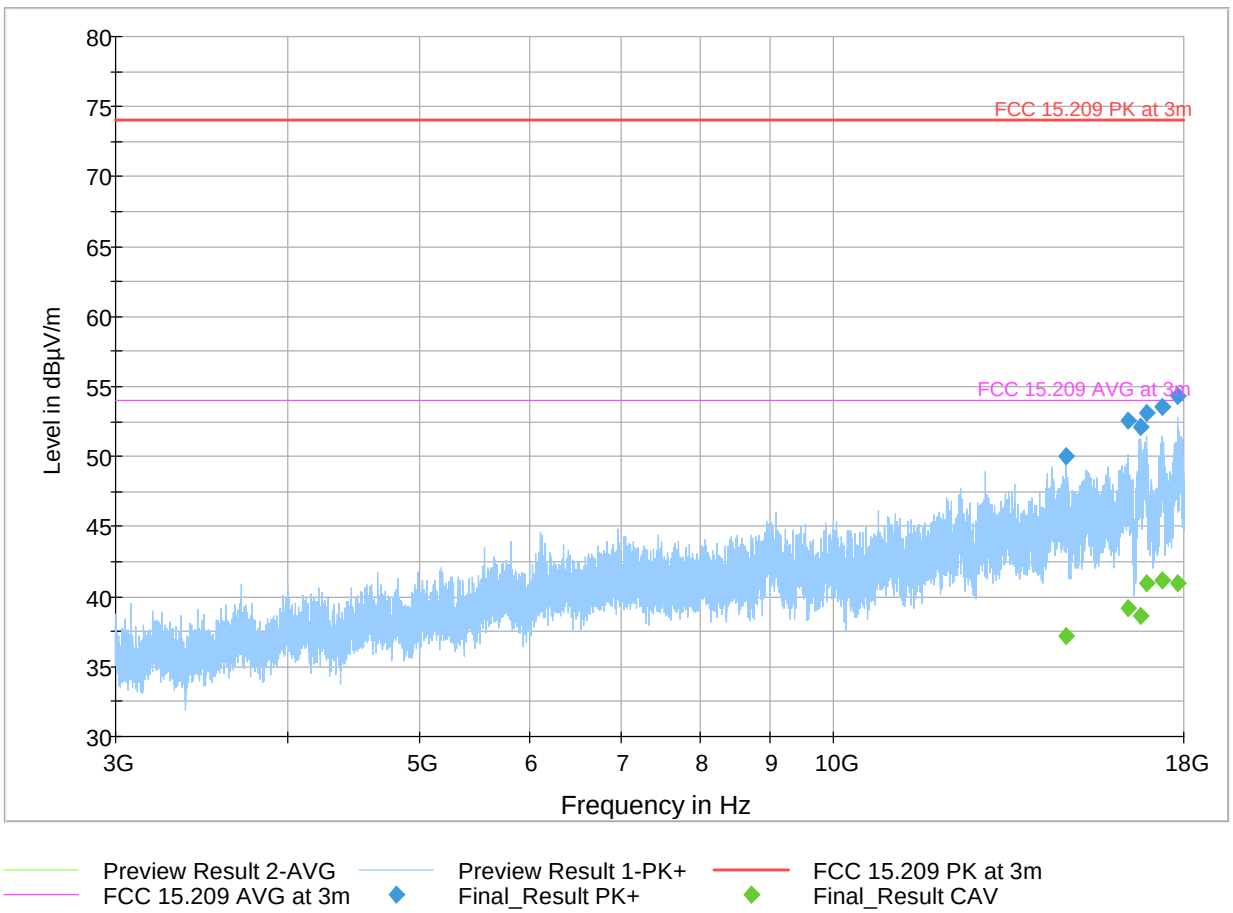


Plot # 33 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 2402 MHz	PHY: 2M

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)
14773.25	50.03	---	73.98	23.95	500.0	1000.0	187.0	V	-90.0	9.1
14773.25	---	37.14	53.98	16.84	500.0	1000.0	187.0	V	-90.0	9.1
16403.50	---	39.20	53.98	14.78	500.0	1000.0	311.0	H	202.0	14.0
16403.50	52.61	---	73.98	21.37	500.0	1000.0	311.0	H	202.0	14.0
16737.25	---	38.61	53.98	15.37	500.0	1000.0	107.0	V	166.0	13.5
16737.25	52.08	---	73.98	21.90	500.0	1000.0	107.0	V	166.0	13.5
16891.50	53.11	---	73.98	20.87	500.0	1000.0	350.0	V	130.0	14.3
16891.50	---	40.94	53.98	13.04	500.0	1000.0	350.0	V	130.0	14.3
17358.50	53.61	---	73.98	20.37	500.0	1000.0	197.0	V	-64.0	15.9
17358.50	---	41.22	53.98	12.76	500.0	1000.0	197.0	V	-64.0	15.9
17801.75	54.31	---	73.98	19.67	500.0	1000.0	310.0	H	259.0	17.8
17801.75	---	40.94	53.98	13.04	500.0	1000.0	310.0	H	259.0	17.8

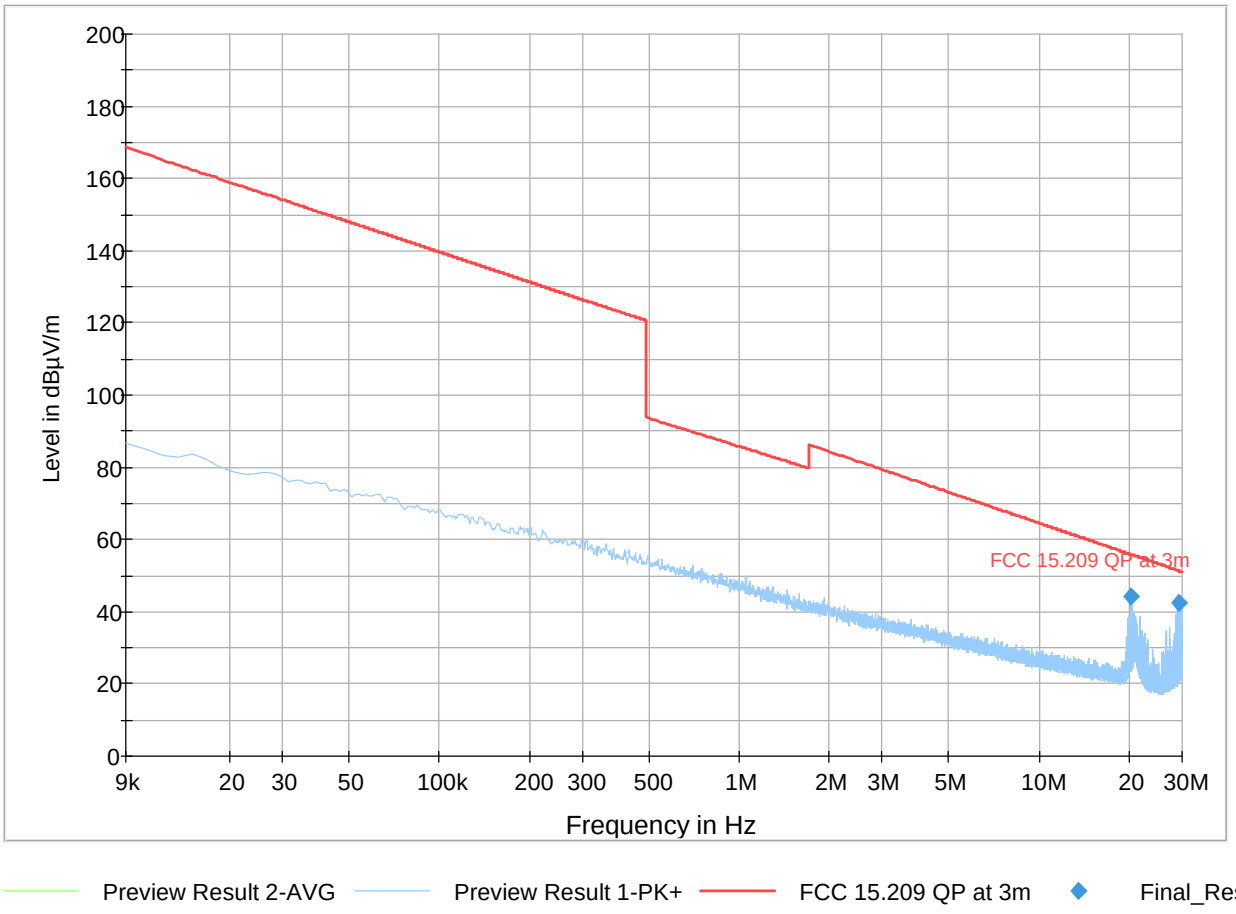


Plot # 34 Radiated Emissions: 9 KHz – 30 MHz

Tx Frequency: 2440 MHz	PHY: 2M

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
20.26	44.31	55.87	11.56	500.0	9.0	100.0	H	222.0	16.5
29.24	42.30	51.36	9.06	500.0	9.0	100.0	H	291.0	15.9

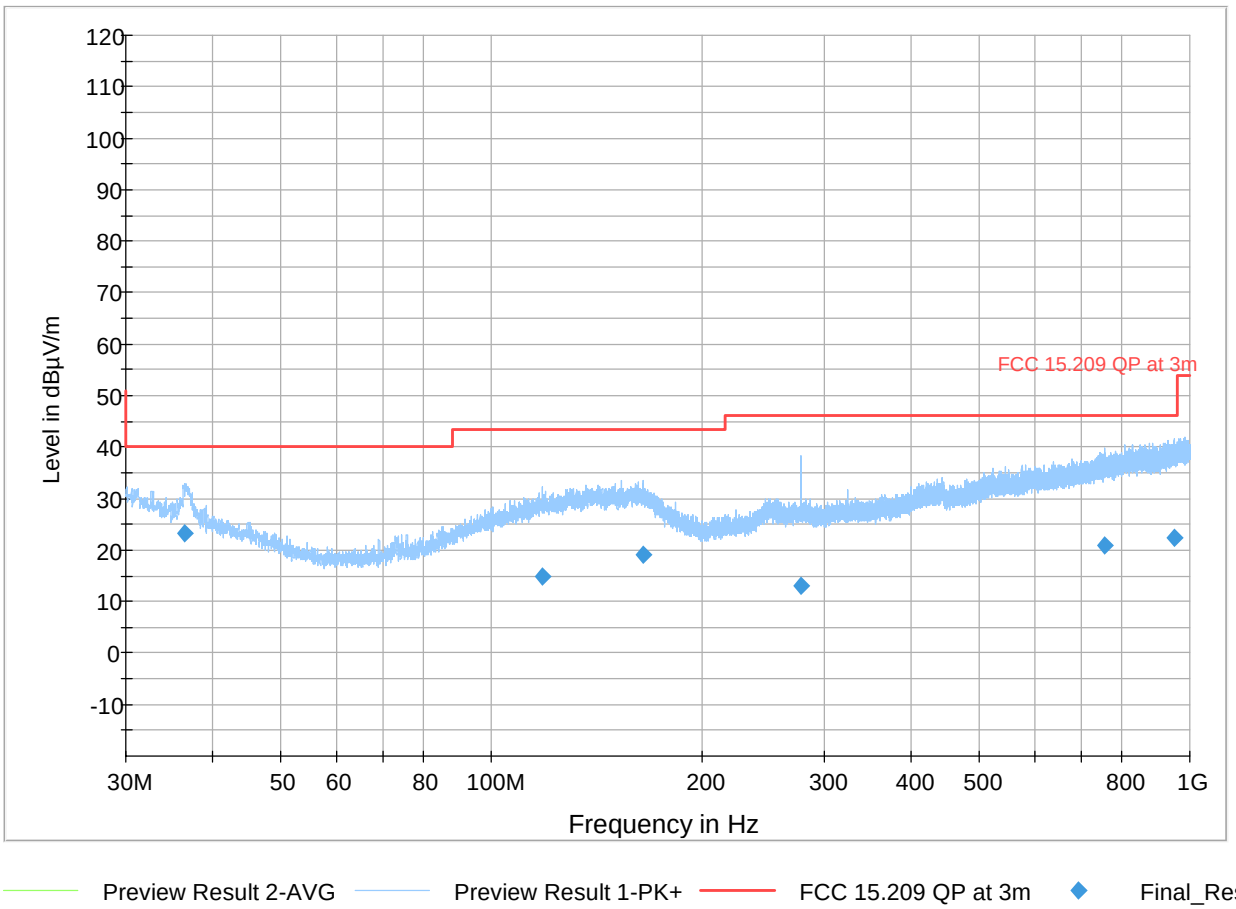


Plot # 35 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 2440 MHz	PHY: 2M

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBµV)
36.45	23.29	40.00	16.71	500.0	120.0	264.0	V	82.0	-14.3	-35.2	0.0	20.9	37.6
118.22	14.78	43.50	28.72	500.0	120.0	193.0	H	252.0	-11.5	-35.0	0.0	23.5	26.3
164.64	19.07	43.50	24.43	500.0	120.0	107.0	V	182.0	-9.6	-34.6	0.0	25.0	28.7
277.37	12.96	46.02	33.06	500.0	120.0	116.0	H	86.0	-14.2	-34.2	0.0	20.0	27.2
755.88	20.92	46.02	25.10	500.0	120.0	184.0	H	137.0	-4.5	-32.6	0.0	28.1	25.4
949.27	22.38	46.02	23.64	500.0	120.0	117.0	H	74.0	-2.7	-32.1	0.0	29.4	25.1

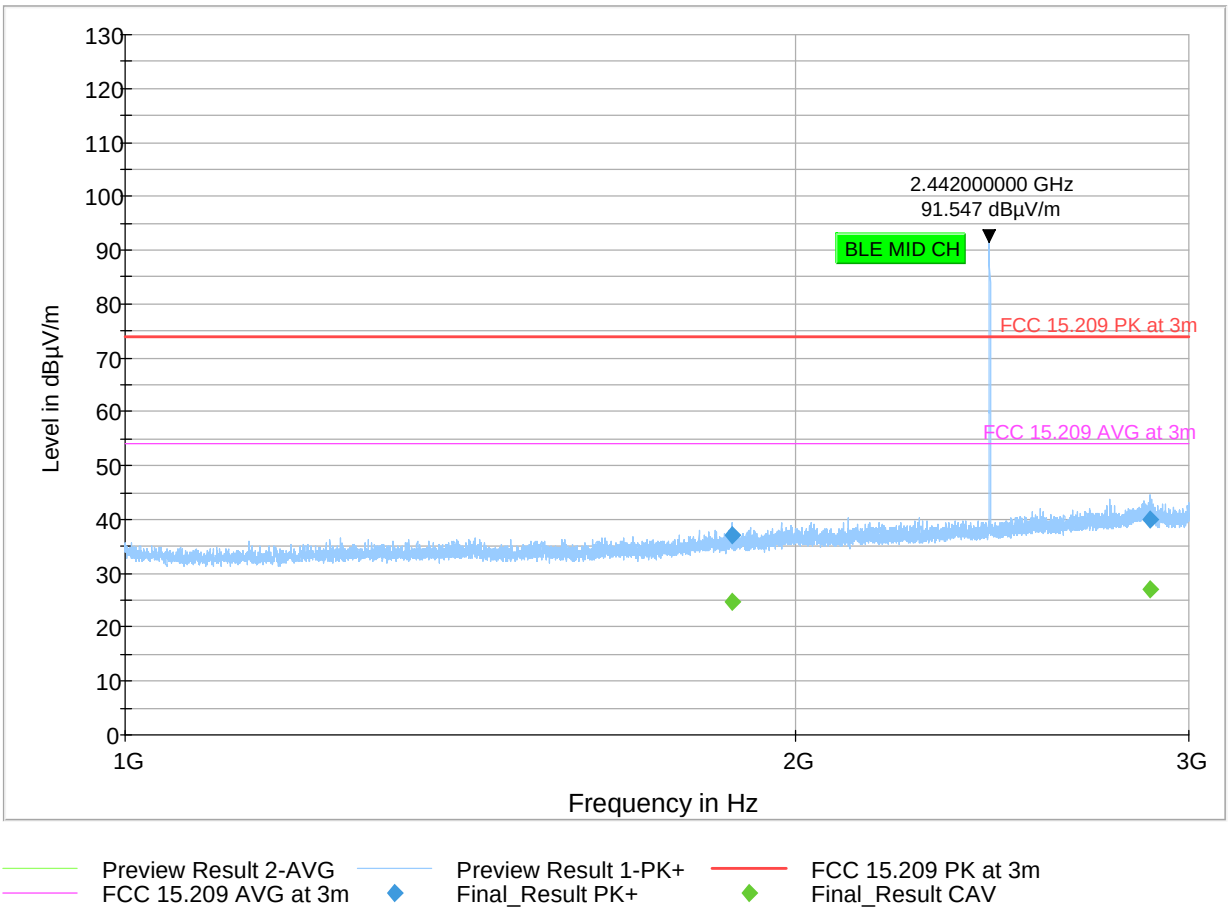


Plot # 36 Radiated Emissions: 1 – 3 GHz

Tx Frequency: 2440 MHz	PHY: 2M

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)
1870.86	---	24.60	53.98	29.38	500.0	1000.0	311.0	V	94.0	4.5
1870.86	37.12	---	73.98	36.86	500.0	1000.0	311.0	V	94.0	4.5
2880.86	---	26.99	53.98	26.99	500.0	1000.0	164.0	V	208.0	8.1
2880.86	39.86	---	73.98	34.12	500.0	1000.0	164.0	V	208.0	8.1

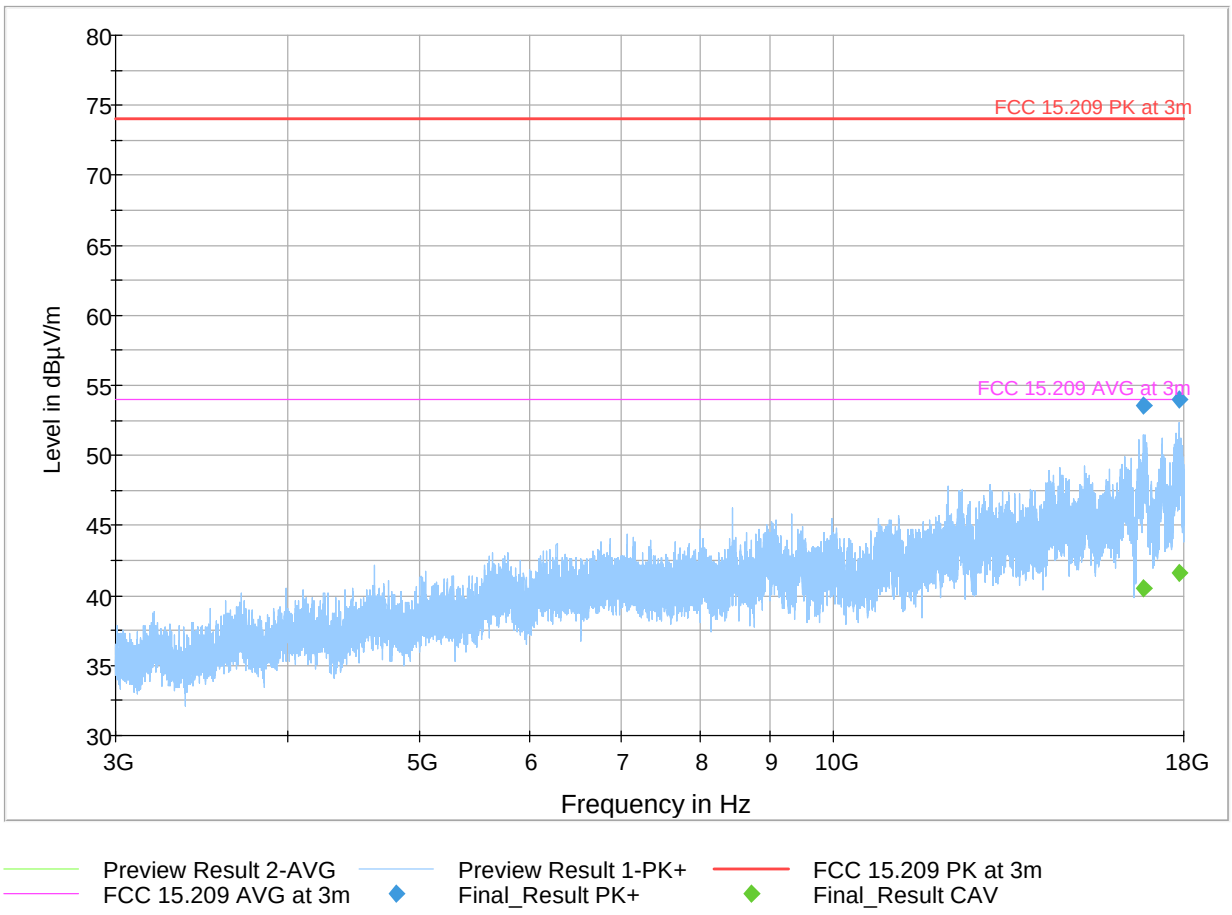


Plot # 37 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 2440 MHz	PHY: 2M

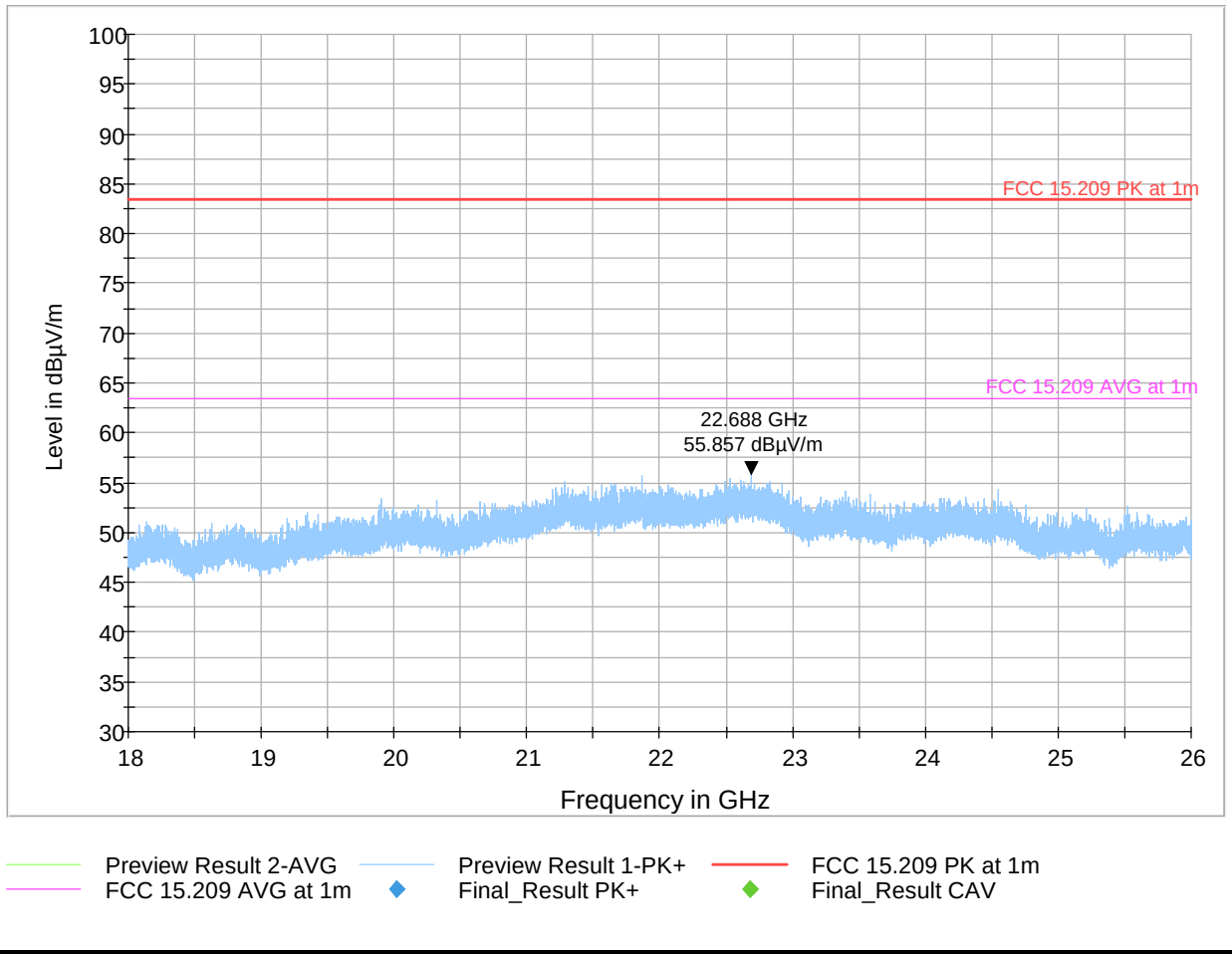
Final_Result

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)
16840.75	---	40.48	53.98	13.50	500.0	1000.0	134.0	H	-68.0	14.4
16840.75	53.59	---	73.98	20.39	500.0	1000.0	134.0	H	-68.0	14.4
17876.00	---	41.60	53.98	12.38	500.0	1000.0	341.0	H	173.0	18.2
17876.00	53.98	---	73.98	20.00	500.0	1000.0	341.0	H	173.0	18.2



Plot # 38 Radiated Emissions: 18 – 26 GHz

Tx Frequency: 2440 MHz	PHY: 2M

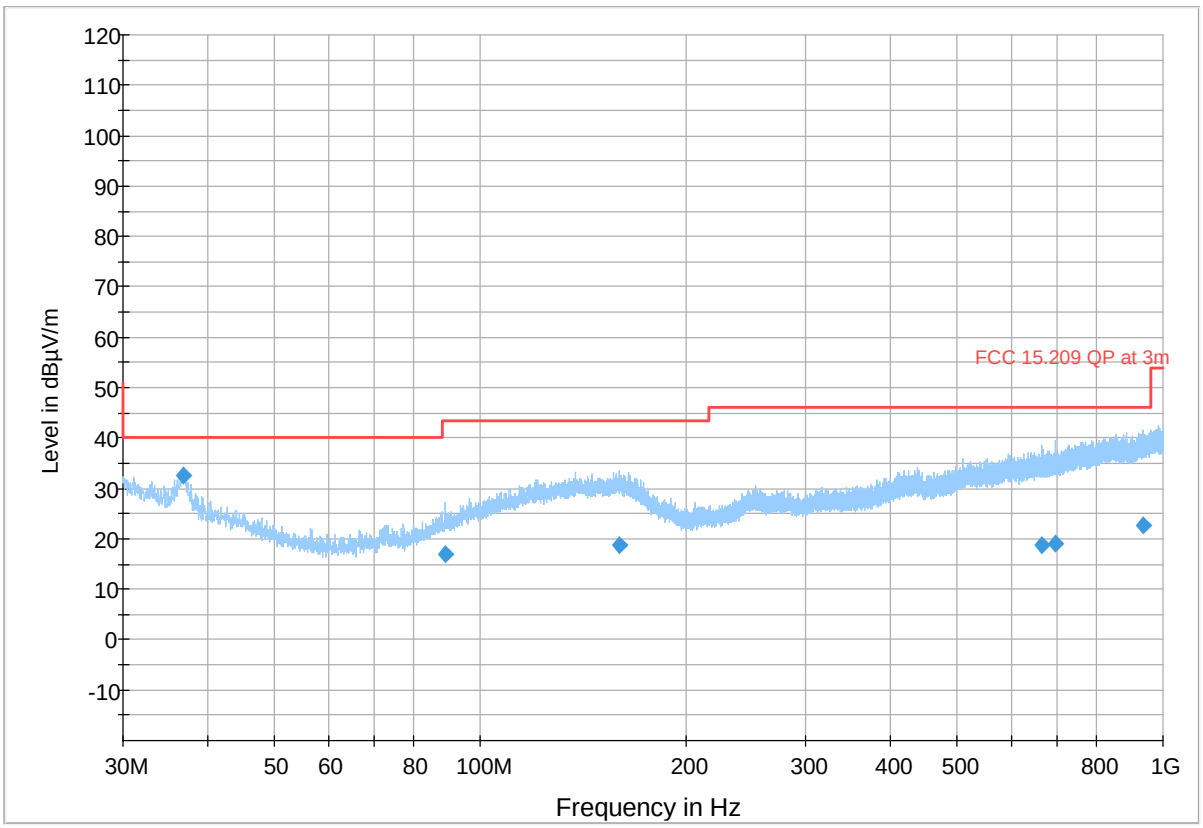


Plot # 39 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 2480 MHz	PHY: 2M

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBµV)
36.84	32.68	40.00	7.32	500.0	120.0	100.0	V	4.0	-14.5	-35.2	0.0	20.7	47.2
88.95	17.01	43.50	26.49	500.0	120.0	100.0	V	-16.0	-18.0	-35.0	0.0	17.1	35.0
159.74	18.88	43.50	24.62	500.0	120.0	275.0	V	148.0	-9.2	-34.7	0.0	25.5	28.1
663.92	18.61	46.02	27.41	500.0	120.0	254.0	V	328.0	-6.7	-32.7	0.0	26.0	25.3
695.64	19.00	46.02	27.02	500.0	120.0	134.0	V	25.0	-6.4	-32.8	0.0	26.4	25.4
936.73	22.52	46.02	23.50	500.0	120.0	167.0	V	28.0	-2.7	-32.1	0.0	29.4	25.2

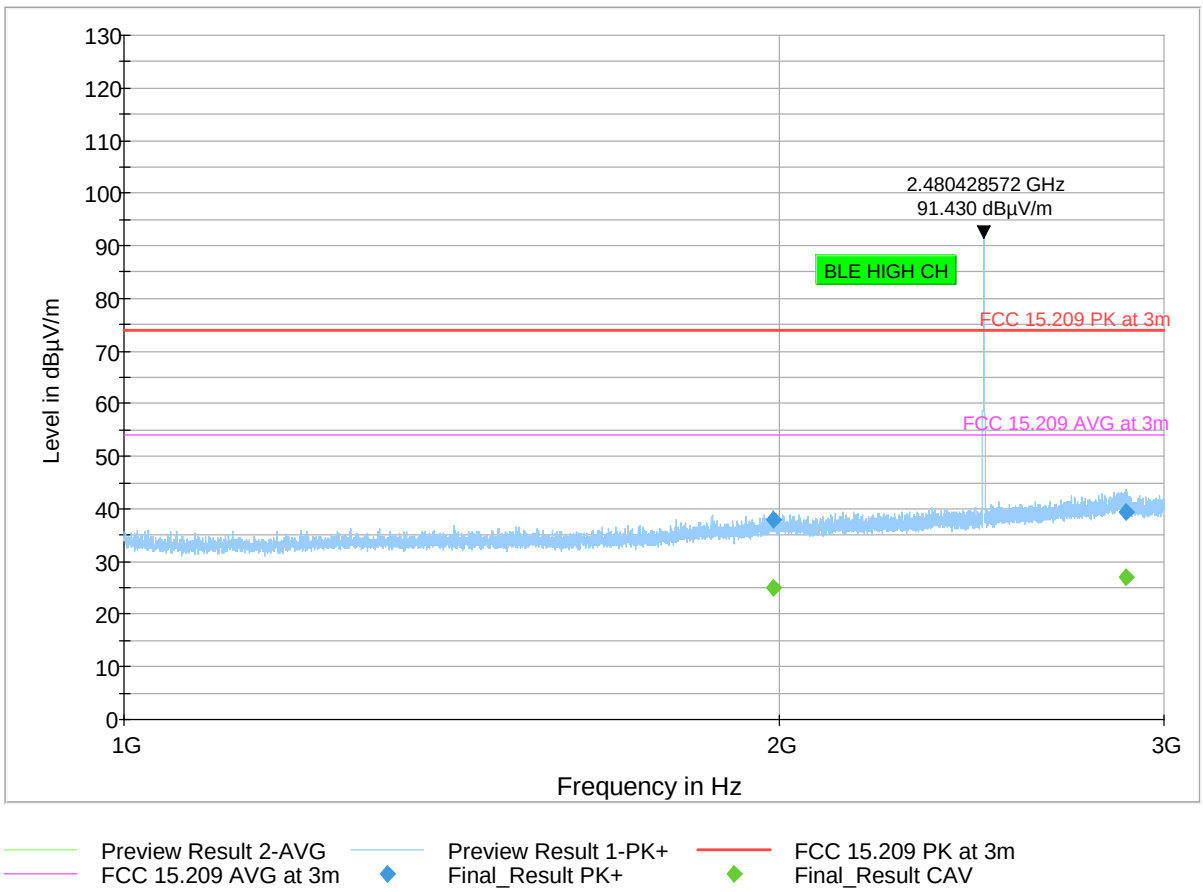


Plot # 40 Radiated Emissions: 1 – 3 GHz

Tx Frequency: 2480 MHz	PHY: 2M

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)
1986.86	37.90	---	73.98	36.08	500.0	1000.0	142.0	V	222.0	5.0
1986.86	---	25.06	53.98	28.92	500.0	1000.0	142.0	V	222.0	5.0
2882.86	39.48	---	73.98	34.50	500.0	1000.0	125.0	H	-33.0	8.1
2882.86	---	27.12	53.98	26.86	500.0	1000.0	125.0	H	-33.0	8.1

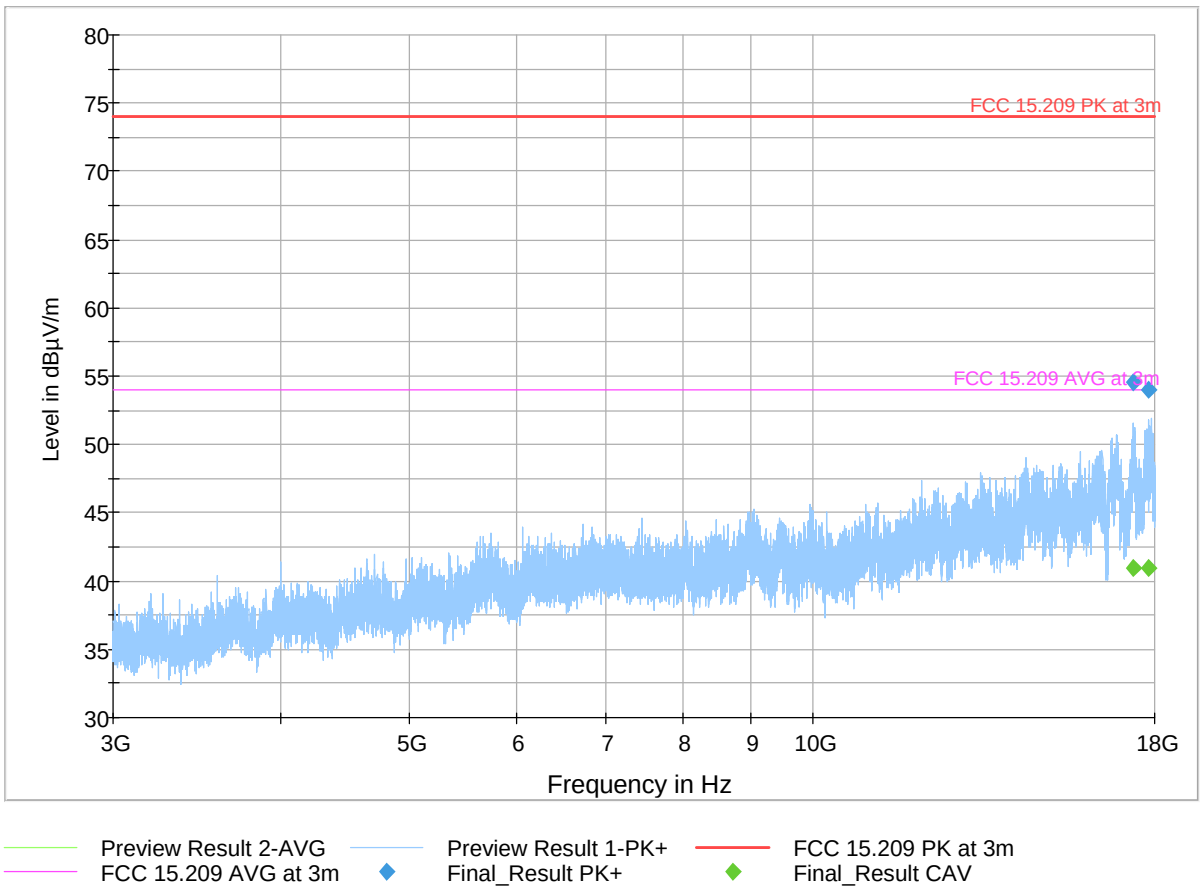


Plot # 41 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 2480 MHz	PHY: 1M

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)
17371.50	---	40.98	53.98	13.00	500.0	1000.0	328.0	V	15.0	15.9
17371.50	54.56	---	73.98	19.42	500.0	1000.0	328.0	V	15.0	15.9
17802.00	---	41.00	53.98	12.98	500.0	1000.0	160.0	V	136.0	17.8
17802.00	54.03	---	73.98	19.95	500.0	1000.0	160.0	V	136.0	17.8



9 Test setup photos

Setup photos are included in supporting file name: "EMC_KPTRK_040_23001_FCC_ISED_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
ACTIVE LOOP ANTENNA	ETS LINDGREN	6507	00161344	3 YEARS	10/30/2020
BICONILOG ANTENNA	ETS Lindgren	3142E	00166067	3 YEARS	6/8/2022
HORN ANTENNA	EMCO	3115	00035114	3 YEARS	8/10/2020
HORN ANTENNA	ETS LINDGREN	3117-PA	00215984	3 YEARS	1/31/2021
HORN ANTENNA	ETS LINDGREN	3116C-PA	00169535	3 YEARS	9/23/2020
EMI RECEIVER	R&S	ESU40	100251	3 YEARS	9/13/2021
SPECTRUM ANALYZER	R&S	FSU26	200065	3 YEARS	8/25/2021
DIGITAL THERMOMETER	CONTROL COMPANY	36934-164	191871986	3 YEARS	10/20/2021

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 are internally characterized before use.

11 History

Date	Report Name	Changes to report	Report prepared by
6/28/2023	EMC_KPTRK_040_23001_FCC_15.247_ISED_BLE_DTS	Initial Version	Issa Ghanma

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