FCC / ISED Test Report

For:
Xirgo Technologies Inc.

Model Name:
XT1520-1

Product Description:
The customer is in need of proximity beacons to be utilized in conjunction with the Marimba XT4971/5 devices installed on the customer's trailers. The proximity beacons will be mounted to distribution carts that are used to move packages between customer's facilities via trailer. The carts are loaded at one facility, loaded onto a trailer, transported and unloaded at a different facility.

FCC ID: GKM-1520-1
IC ID: 10281A-15201

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

REPORT #: EMC_XIRGO_164_21001_FCC_15.247_BTLE

DATE: 2021-07-26

A2LA Accredited

IC recognized #
3462B-1

***CETECOM* Inc.**
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CETECOM Inc. is a Delaware Corporation with Corporation number: 2905571

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1 Assessment

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

No deviations were ascertained.

Company	Description	Model #
Xirgo Technologies Inc.	The customer is in need of proximity beacons to be utilized in conjunction with the Marimba XT4971/5 devices installed on the customer's trailers. The proximity beacons will be mounted to distribution carts that are used to move packages between customer's facilities via trailer. The carts are loaded at one facility, loaded onto a trailer, transported and unloaded at a different facility.	XT1520-1

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2021-07-26	Compliance	Kevin Wang (EMC Lab Manager)	kevin.wang@cetecom.com Digitally signed by: kevin.wang@cetecom.com DN: CN = kevin.wang@cetecom.com Date: 2021.08.05 15:53:20 -07'00'

Responsible for the Report:

Date	Section	Name	Signature
2021-07-26	Compliance	Cheng Song (Associate Test Engineer)	cheng.song@cetecom.com Digitally signed by: cheng.song@cetecom.com DN: CN = cheng.song@cetecom.com Date: 2021.08.05 14:34:07 -07'00'

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
EMC Lab Manager:	Kevin Wang
Responsible Project Leader:	Akanksha Baskaran

2.2 Identification of the Client

Client's Name:	Xirgo Technologies, LLC
Street Address:	188 Camino Ruiz
City/Zip Code	Camarillo, CA 93012
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:	XT1520-1
HW Version :	1520-1-001
SW Version :	1520-1-01
FCC-ID :	GKM-1520-1
IC-ID:	10281A-15201
PMN	Vuvuzela Proximity Beacon
Product Description:	The customer is in need of proximity beacons to be utilized in conjunction with the Marimba XT4971/5 devices installed on the customer's trailers. The proximity beacons will be mounted to distribution carts that are used to move packages between customer's facilities via trailer. The carts are loaded at one facility, loaded onto a trailer, transported and unloaded at a different facility.
Radios included in the device:	Bluetooth Low Energy (BLE): • Manufacturer: Nordic Semiconductor • Module Name: Bluetooth 5.2 SoC supporting Bluetooth Low Energy • Module Number: nRF52810 • Modes of operation: LE 1 Mbps & LE 2 Mbps in advertising mode.
Antenna Information as Declared:	Main Antenna: • Type: PCB • Location: Internal • Maximum Gain: 3.3 dBi • Frequency Band: 2.4 GHz ISM
Max. Peak Output Power:	Conducted Power 5.2 dBm
Power Supply/ Rated Operating Voltage Range:	2 x AA Batteries
Operating Temperature Range	-20 ºC to 54 ºC
Sample Revision	☐Prototype Unit; ■Production Unit; ☐Pre-Production

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	212700017	1520-1-001	1520-1-01	Conducted RF
2	212700022	1520-1-001	1520-1-01	Radiated Emissions

3.3 Mode of Operation details

Mode of Operation	Description of Operating modes	Additional Information
Op. 1	BTLE(Conducted RF)	BTLE was configured to: • Mode : Transmitter • Tx Power: : 4dBm • Payload Mode: PRBS9 • Payload Length: 255 Bytes • Runtime: 0 ms • Channel(s) : o CH 0: 2402 MHz o CH 19: 2440 MHz o CH 39: 2480 MHz • PHY: o LE 1Mbps o LE 2Mbps
Op. 2	BTLE(Radiated Emissions)	BTLE was configured to: • Mode : Transmitter • Tx Power: : 4dBm • Payload Mode: PRBS9 • Payload Length: 255 Bytes • Runtime: 0 ms • Channel(s) : o CH 0: 2402 MHz o CH 19: 2440 MHz o CH 39: 2480 MHz • PHY: o LE 2Mbps

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1	Conducted RF
2	EUT#2	Radiated Emissions

3.5 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on low, mid and high channels, and highest possible duty cycle of 85.3% for LE 1 Mbps and 56.8% for LE 2 Mbps. For radiated measurements, only LE 2 Mbps which is the worst case was under test. 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:** GKM-1520-1
- **IC ID:** 10281A-15201

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

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	NA	NP	Result
§15.247(a)(1) RSS-247 5.2(a)	Emission Bandwidth	Nominal	BTLE	■	☐	☐	Complies
§15.247(e) RSS-247 5.2(b)	Power Spectral Density	Nominal	BTLE	■	☐	☐	Complies
§15.247(b)(1) RSS-247 5.4(d)	Maximum Conducted Output Power and EIRP	Nominal	BTLE	■	☐	☐	Complies
§15.247(d) RSS-247 5.5	Band edge compliance Unrestricted Band Edges	Nominal	BTLE	■	☐	☐	Complies
§15.247; 15.209; 15.205 RSS-Gen 8.9; 8.10	Band edge compliance Restricted Band Edges	Nominal	BTLE	■	☐	☐	Complies
§15.247(d); §15.209 RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	BTLE	■	☐	☐	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal	BTLE	☐	☐	■	Note 2

Note 1: NA= Not Applicable; NP= Not Performed.
Note 2: EUT powered by battery.

6 Measurement Uncertainty

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

Radiated measurement

9 kHz to 30 MHz	±2.5 dB (Magnetic Loop Antenna)
30 MHz to 1000 MHz	±2.0 dB (Biconilog Antenna)
1 GHz to 40 GHz	±2.3 dB (Horn Antenna)

Conducted measurement

150 kHz to 30 MHz	±0.7 dB (LISN)
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:

07/21/2021 - 07/23/2021

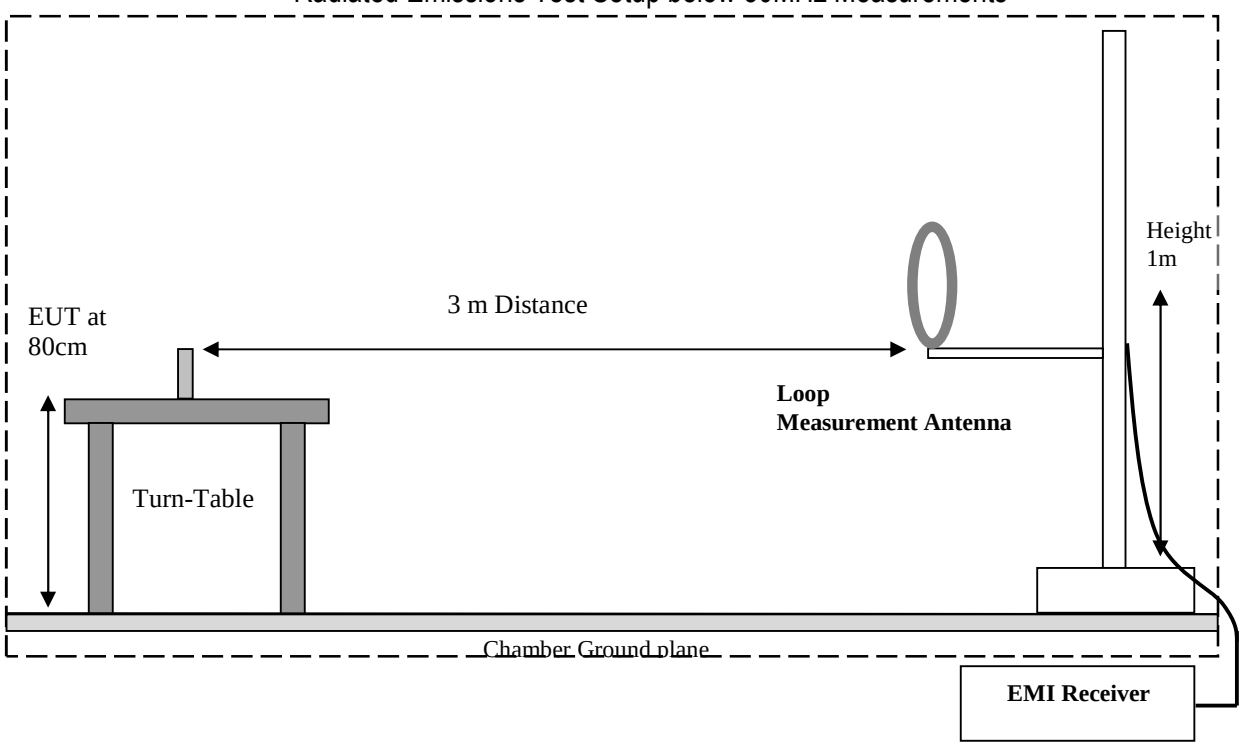
7 Measurement Procedures

7.1 Radiated Measurement

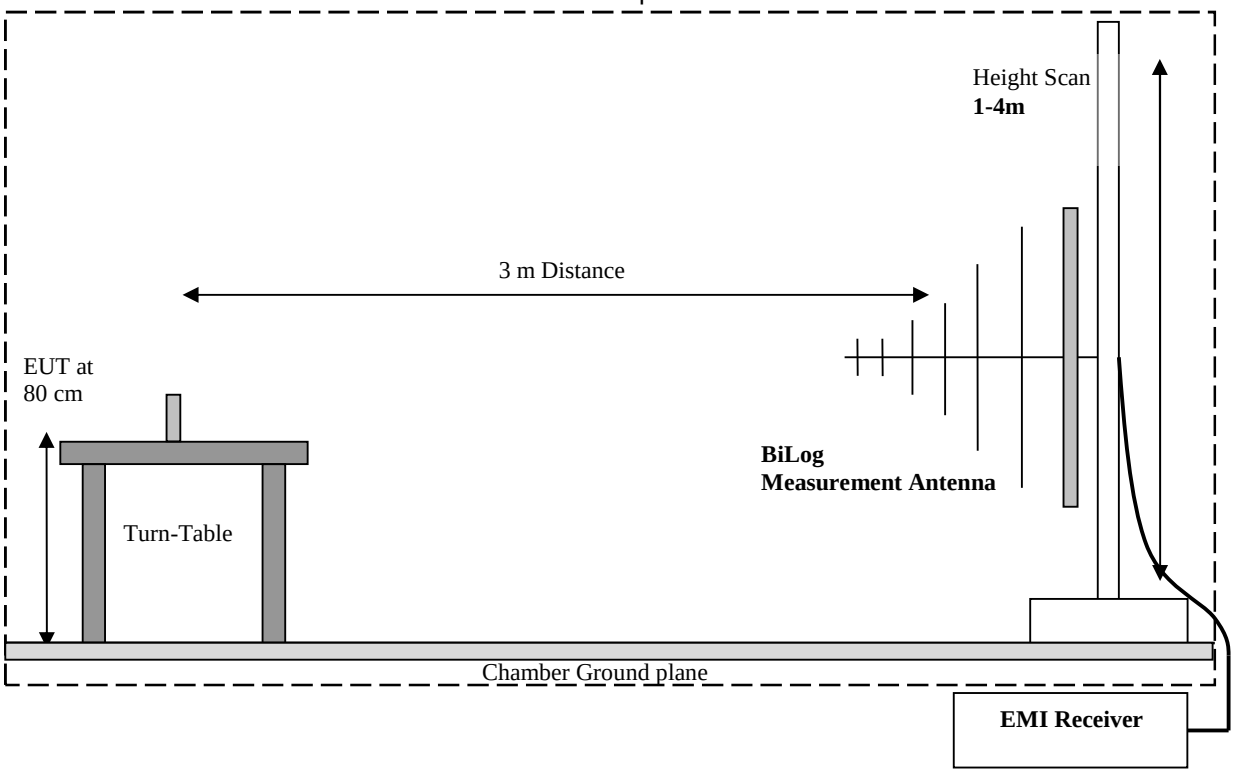
The radiated measurement is performed according to ANSI C63.10 (2013)

- 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.

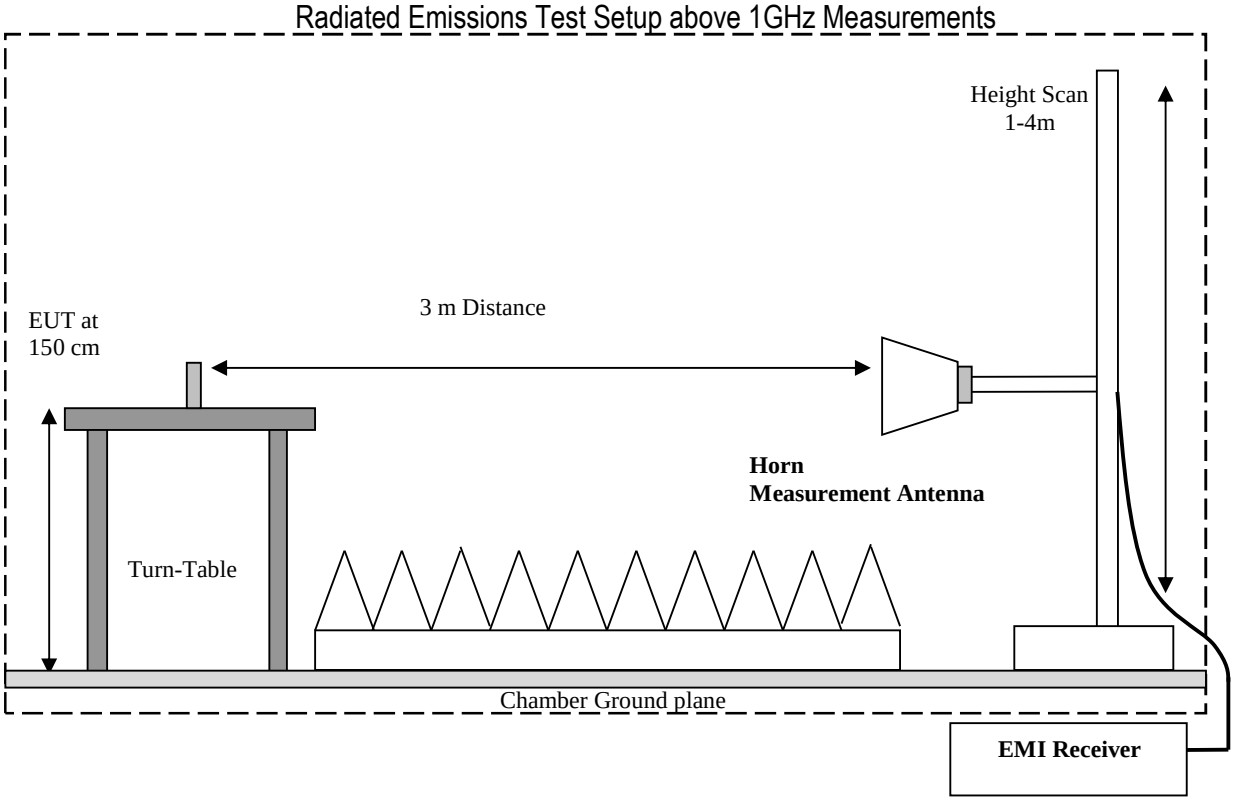
Radiated Emissions Test Setup below 30MHz Measurements



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

Example:

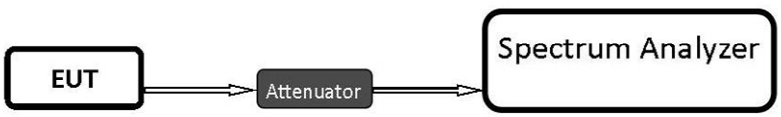
Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

7.2 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 ≥ 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

8.1.2 Limits:

Maximum Peak Output Power:

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

8.1.3 Test conditions and setup:

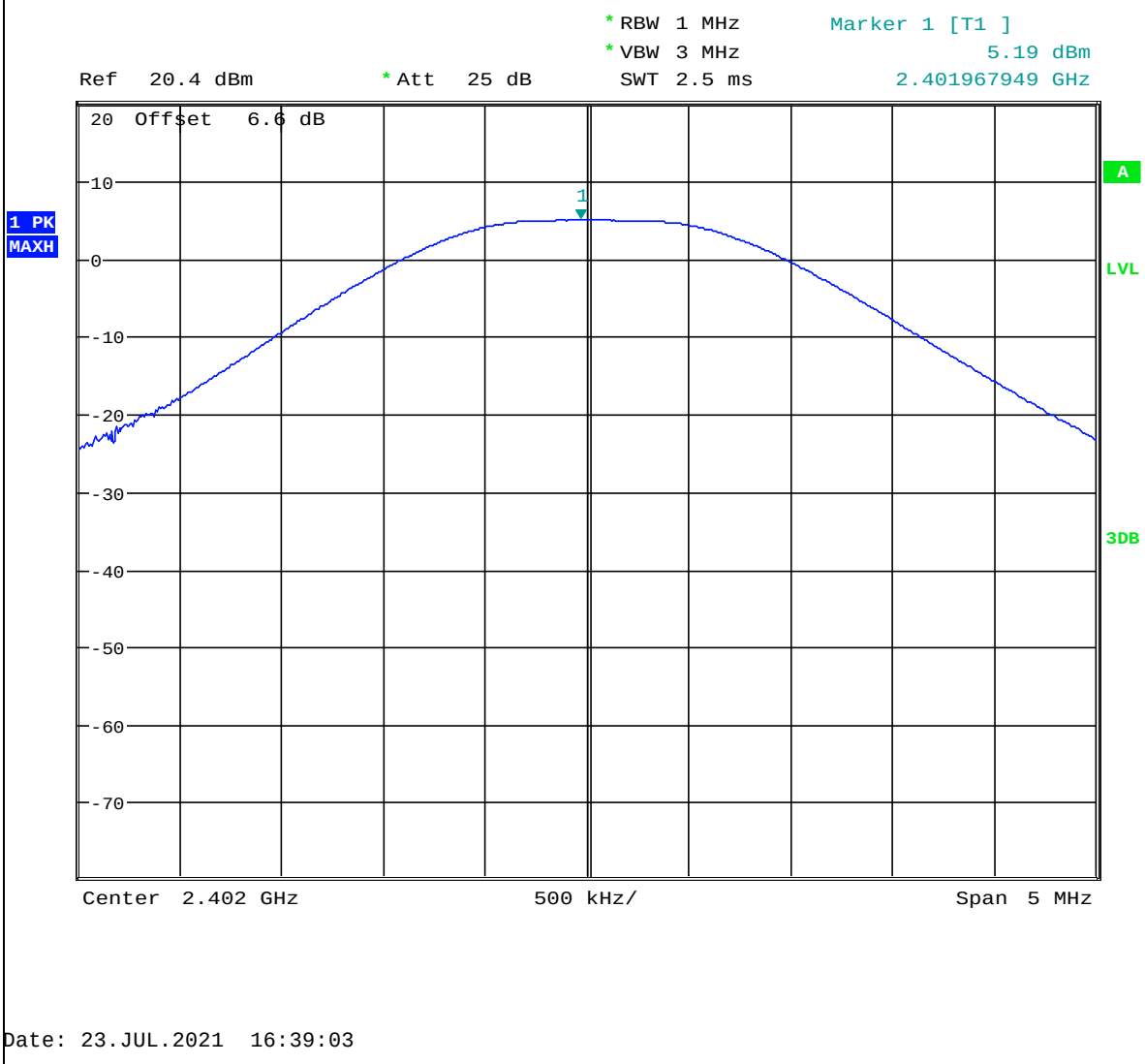
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	Op. 1	2 x AA Batteries	3.3 dBi

8.1.4 Measurement result:

Plot #	PHY	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	LE 1 Mbps	2402	5.19	8.49	30 (Pk) / 36 (EIRP)	Pass
2	LE 1 Mbps	2440	4.84	8.14	30 (Pk) / 36 (EIRP)	Pass
3	LE 1 Mbps	2480	4.57	7.87	30 (Pk) / 36 (EIRP)	Pass
4	LE 2 Mbps	2402	5.20	8.50	30 (Pk) / 36 (EIRP)	Pass
5	LE 2 Mbps	2440	4.85	8.15	30 (Pk) / 36 (EIRP)	Pass
5	LE 2 Mbps	2480	4.58	7.88	30 (Pk) / 36 (EIRP)	Pass

8.1.5 Measurement Plots:

Plot # 1	
BTLE CH 0: 2402 MHz	LE 1 Mbps



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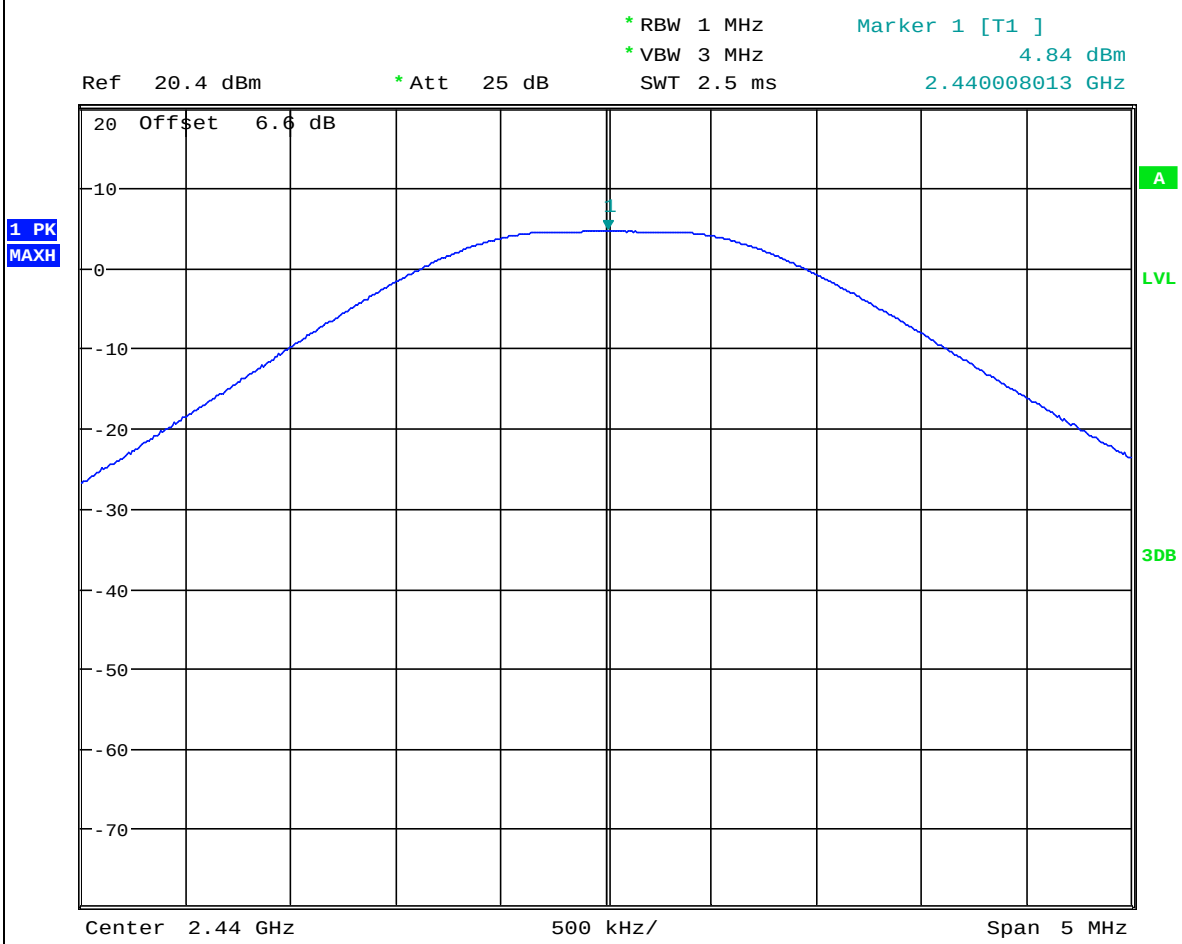
Plot # 2	
BTLE CH 19: 2440 MHz	**LE 1 Mbps**



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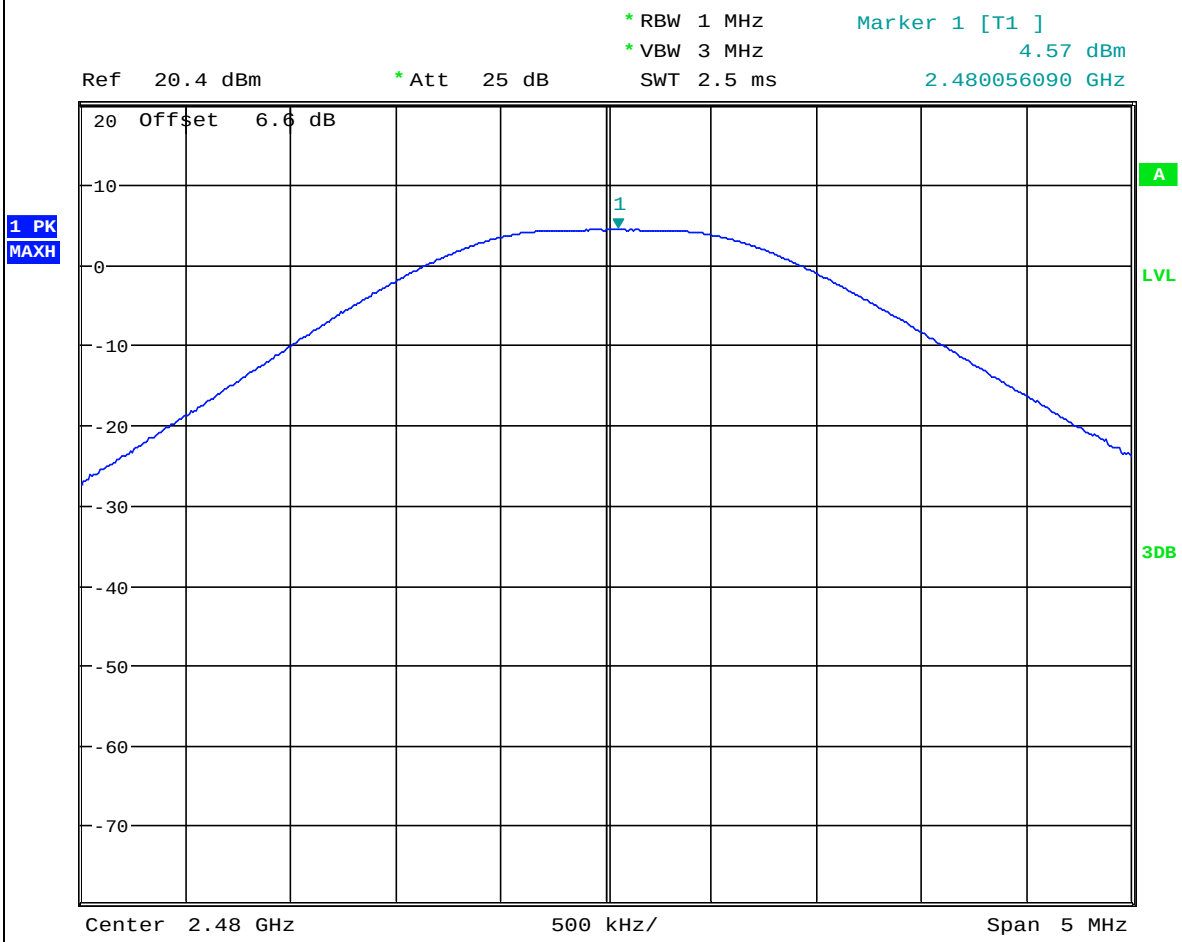
Plot # 3

BTLE CH 39: 2480 MHz	LE 1 Mbps



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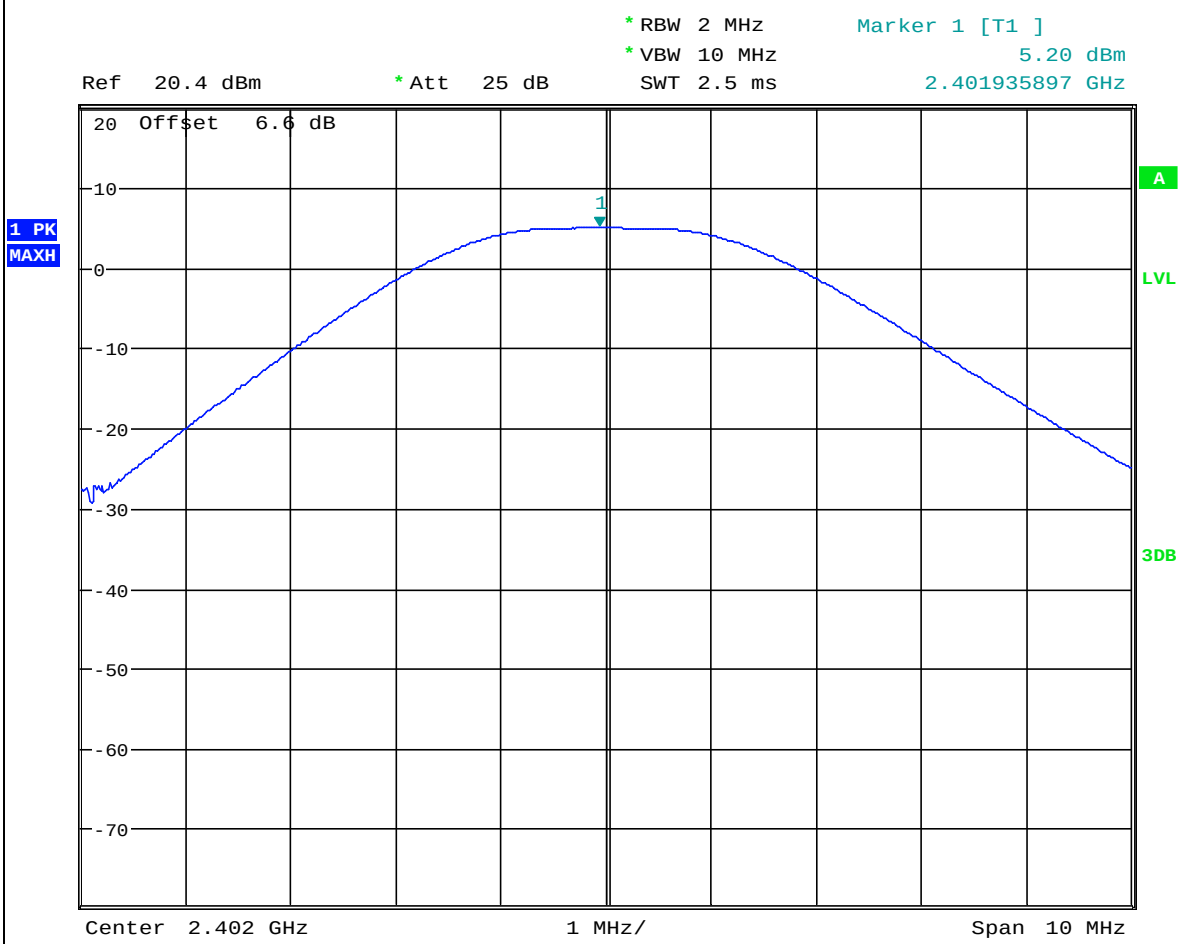
Plot # 4

BTLE CH 0: 2402 MHz	LE 2 Mbps



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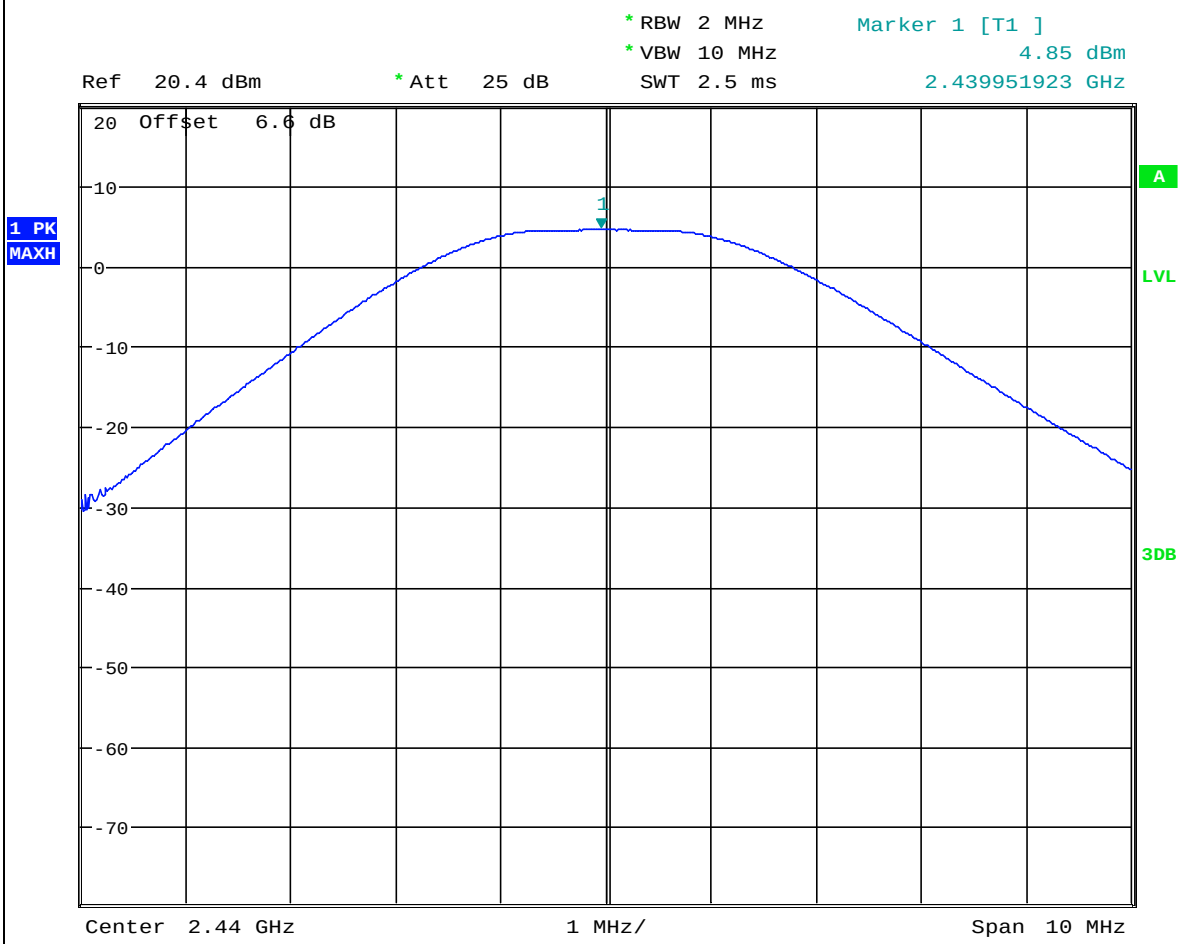
Plot # 5

BTLE CH 19: 2440 MHz	LE 2 Mbps



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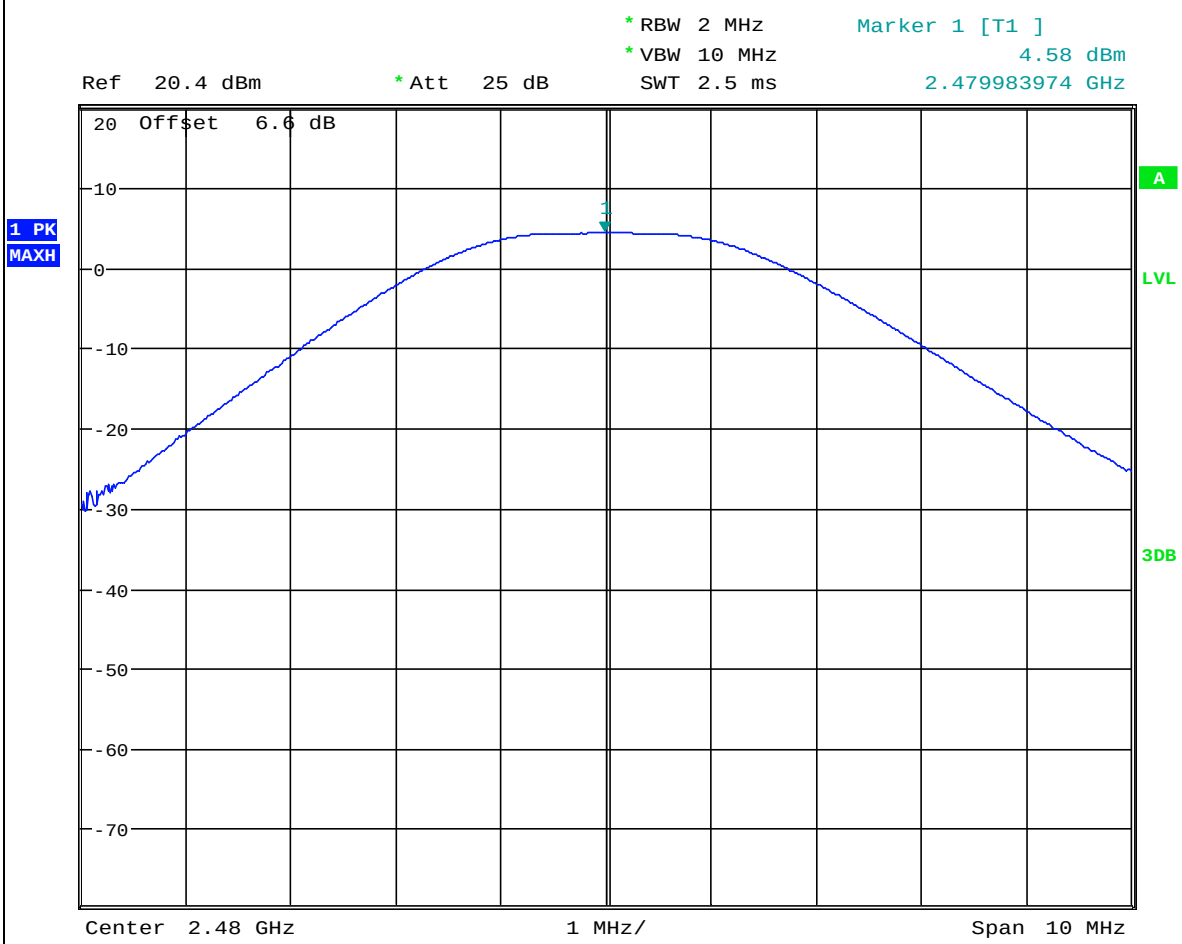
Plot # 6

BTLE CH 39: 2480 MHz	LE 2 Mbps



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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 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, 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:

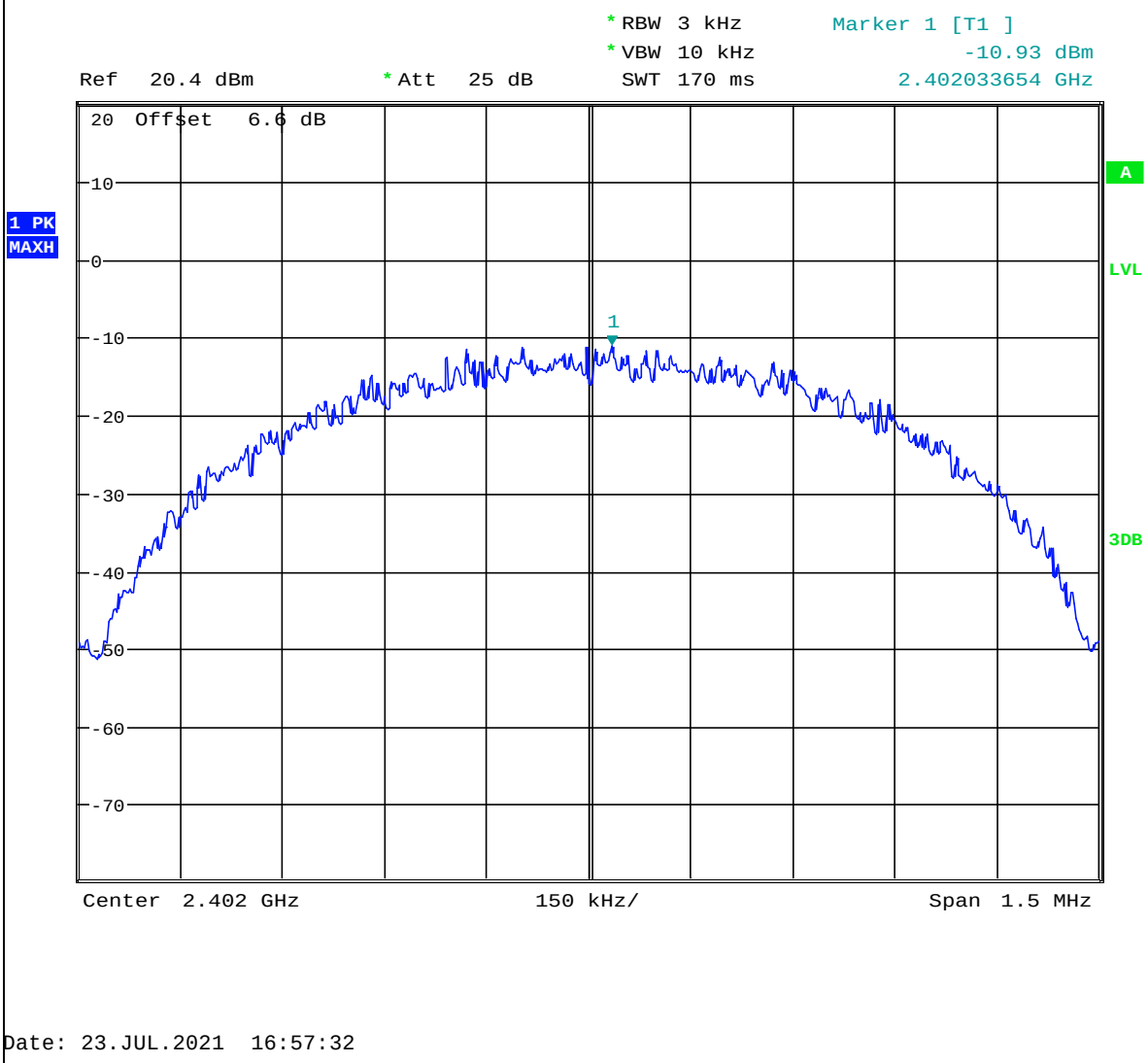
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	Op. 1	2 x AA Batteries	3.3 dBi

8.2.4 Measurement result:

Plot #	PHY	Frequency (MHz)	Maximum Power Spectral Density (dBm / 3 kHz)	Limit (dBm / 3 kHz)	Result
1	LE 1 Mbps	2402	-10.93	8	Pass
2	LE 1 Mbps	2440	-11.43	8	Pass
3	LE 1 Mbps	2480	-11.68	8	Pass
4	LE 2 Mbps	2402	-12.94	8	Pass
5	LE 2 Mbps	2440	-13.31	8	Pass
5	LE 2 Mbps	2480	-13.70	8	Pass

8.2.5 Measurement Plots:

Plot # 1	
BTLE CH 0: 2402 MHz	LE 1 Mbps



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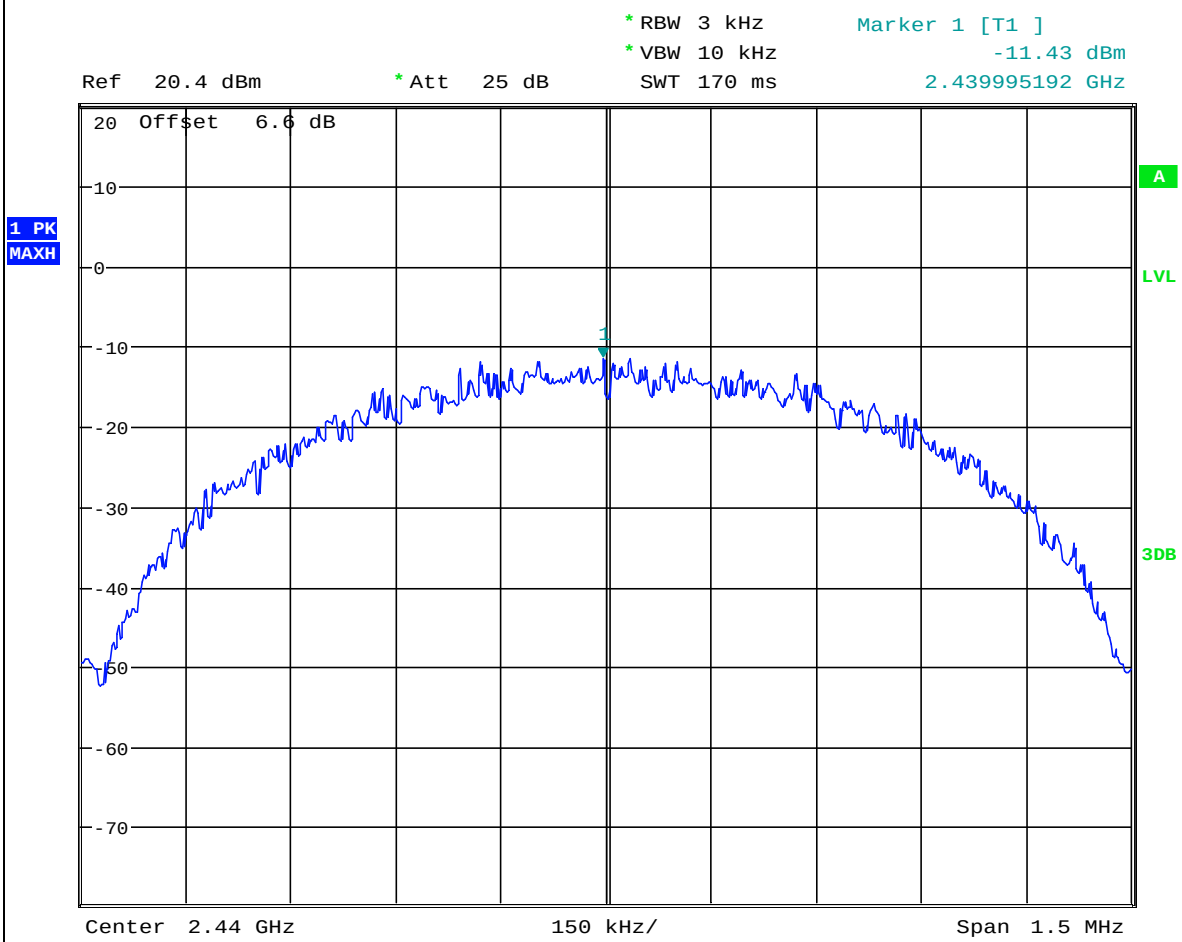
Plot # 2

BTLE CH 19: 2440 MHz	LE 1 Mbps



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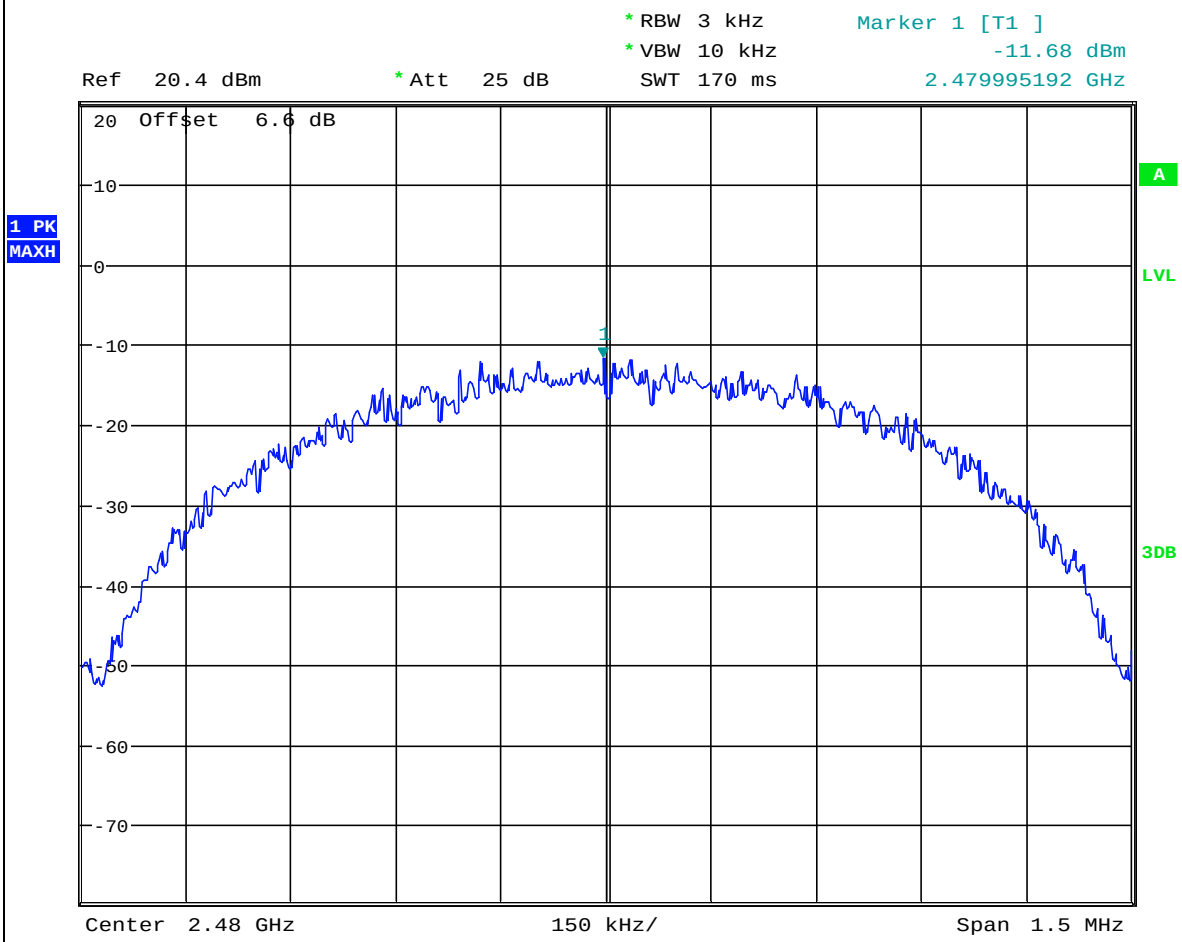
Plot # 3

BTLE CH 39: 2480 MHz	LE 1 Mbps



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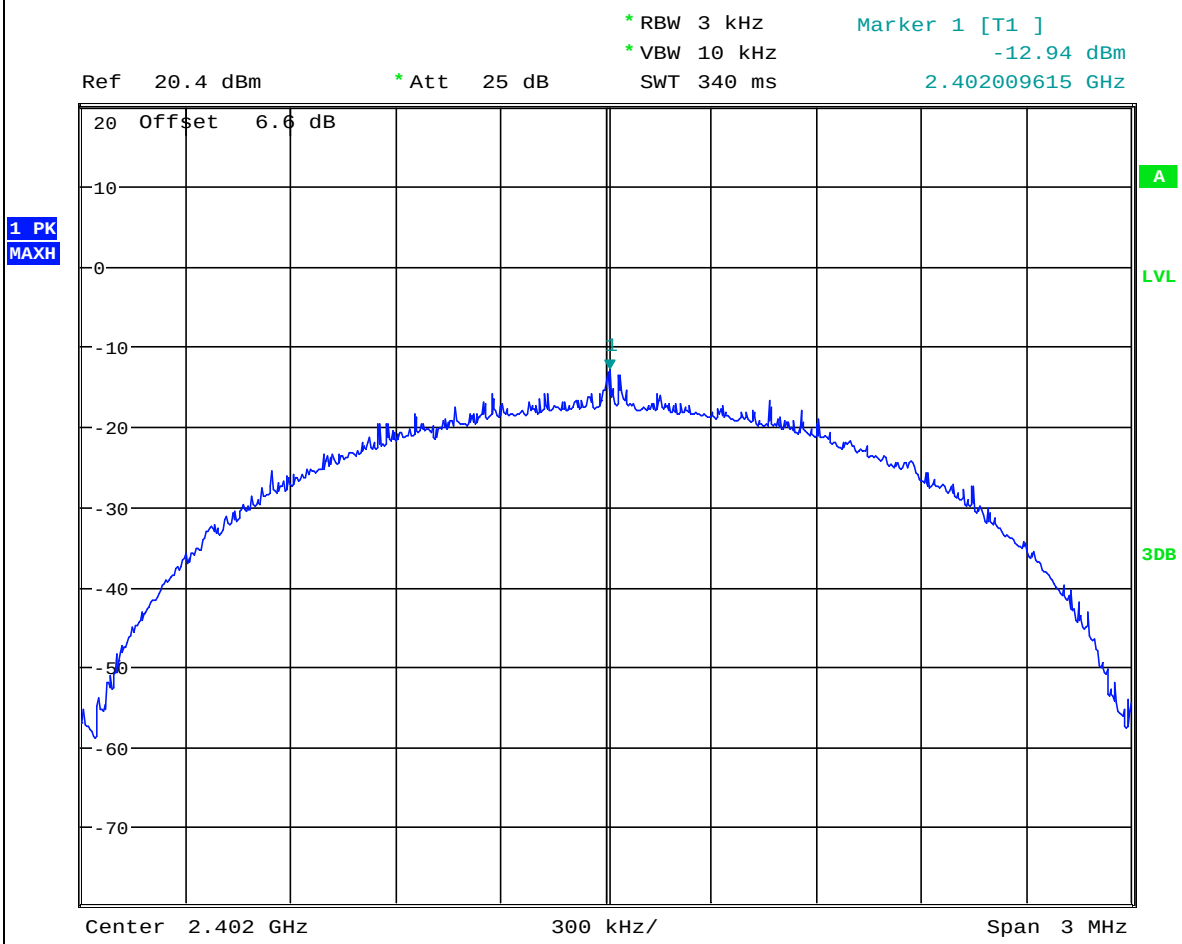
Plot # 4

BTLE CH 0: 2402 MHz	LE 2 Mbps



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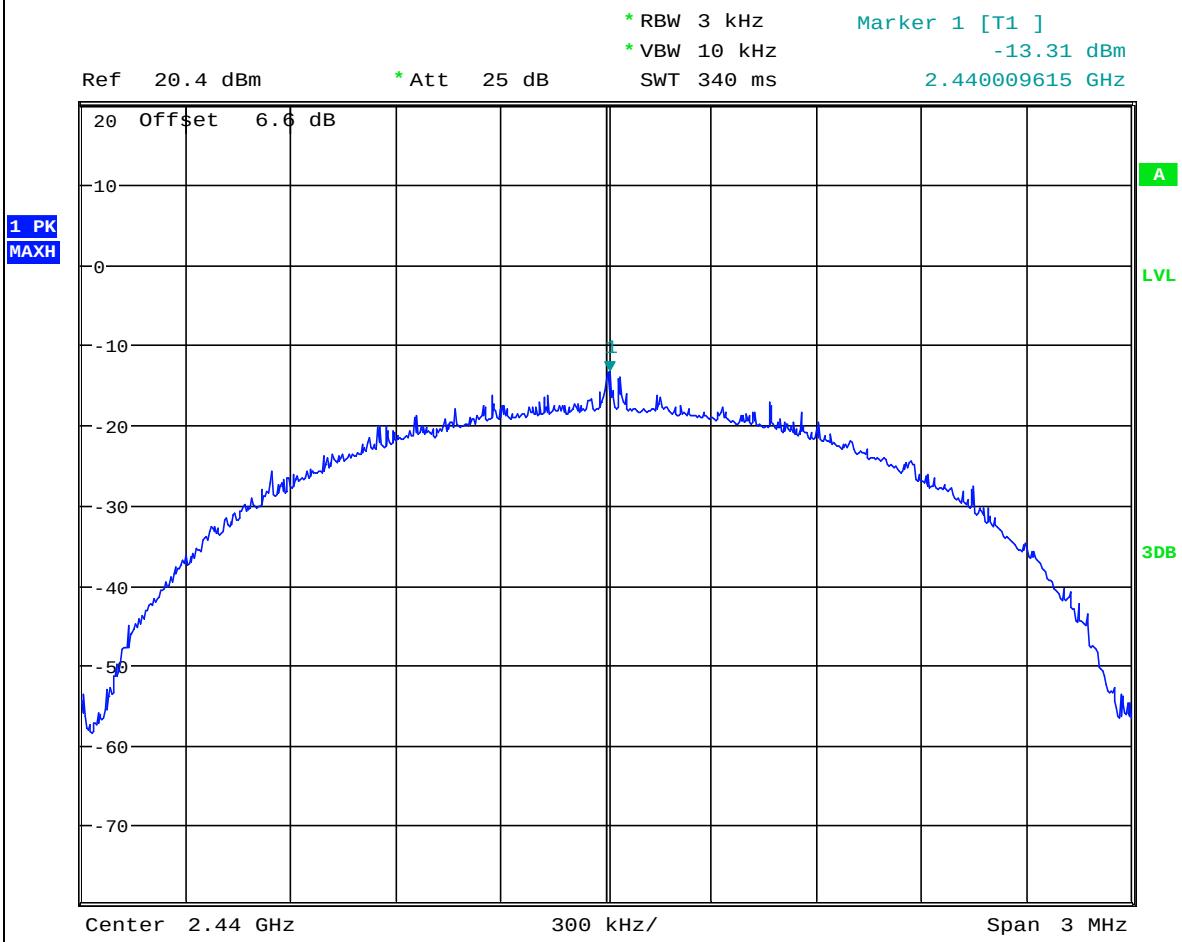
Plot # 5	
BTLE CH 19: 2440 MHz	**LE 2 Mbps**



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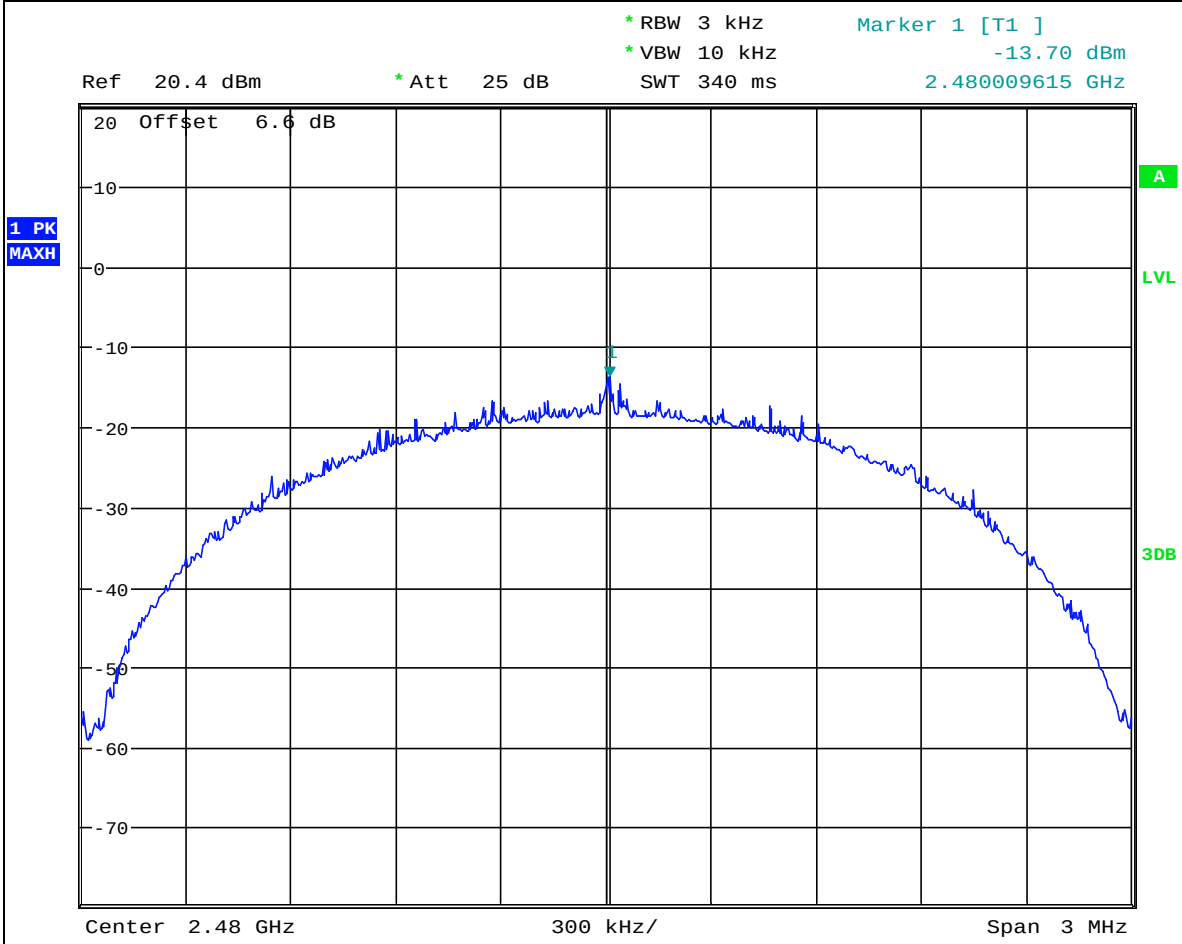
Plot # 6

BTLE CH 39: 2480 MHz	LE 2 Mbps



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8.3 Duty cycle

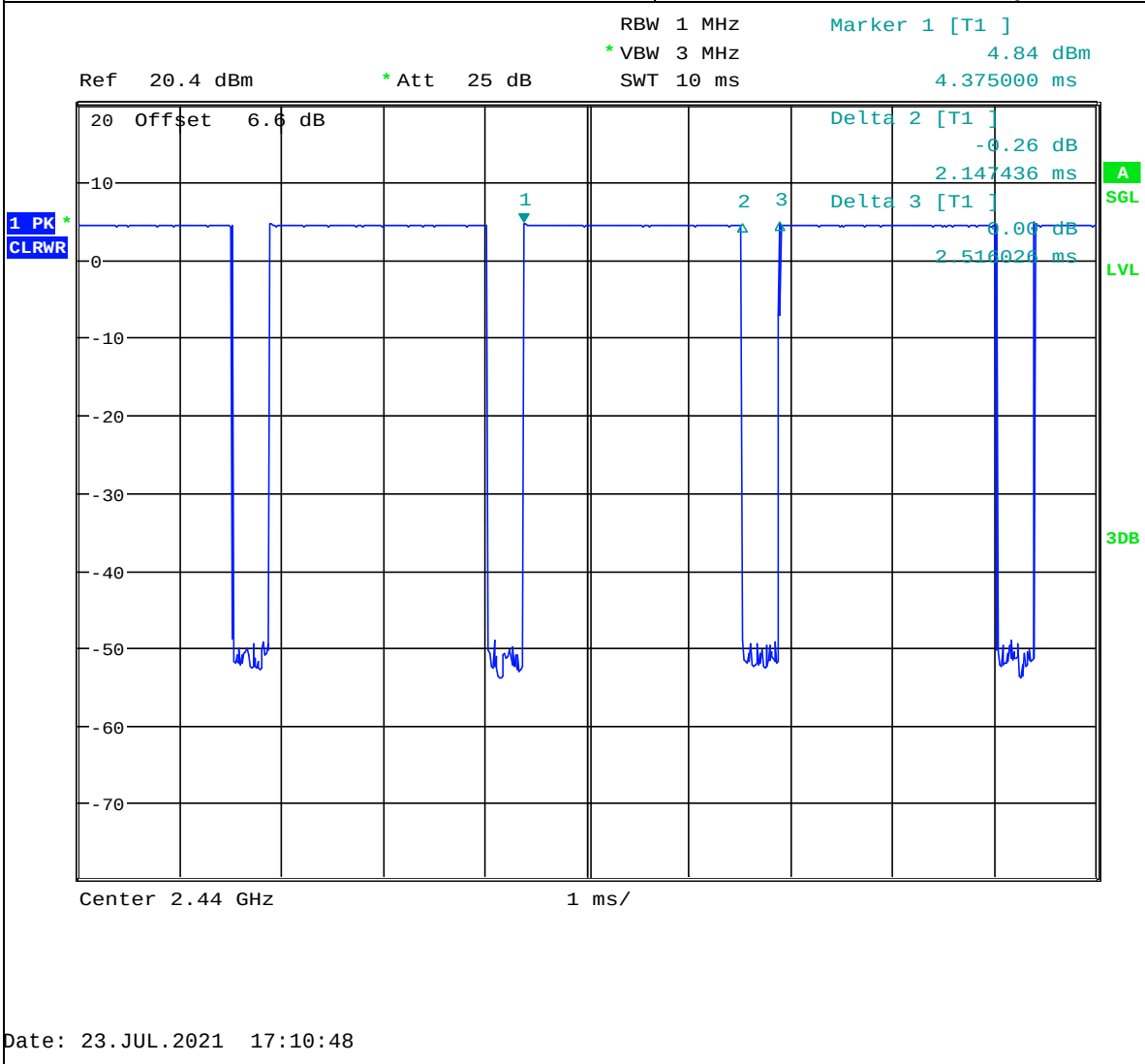
8.3.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02

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

Plot # 1	
BTLE CH 19: 2440 MHz	LE 1 Mbps



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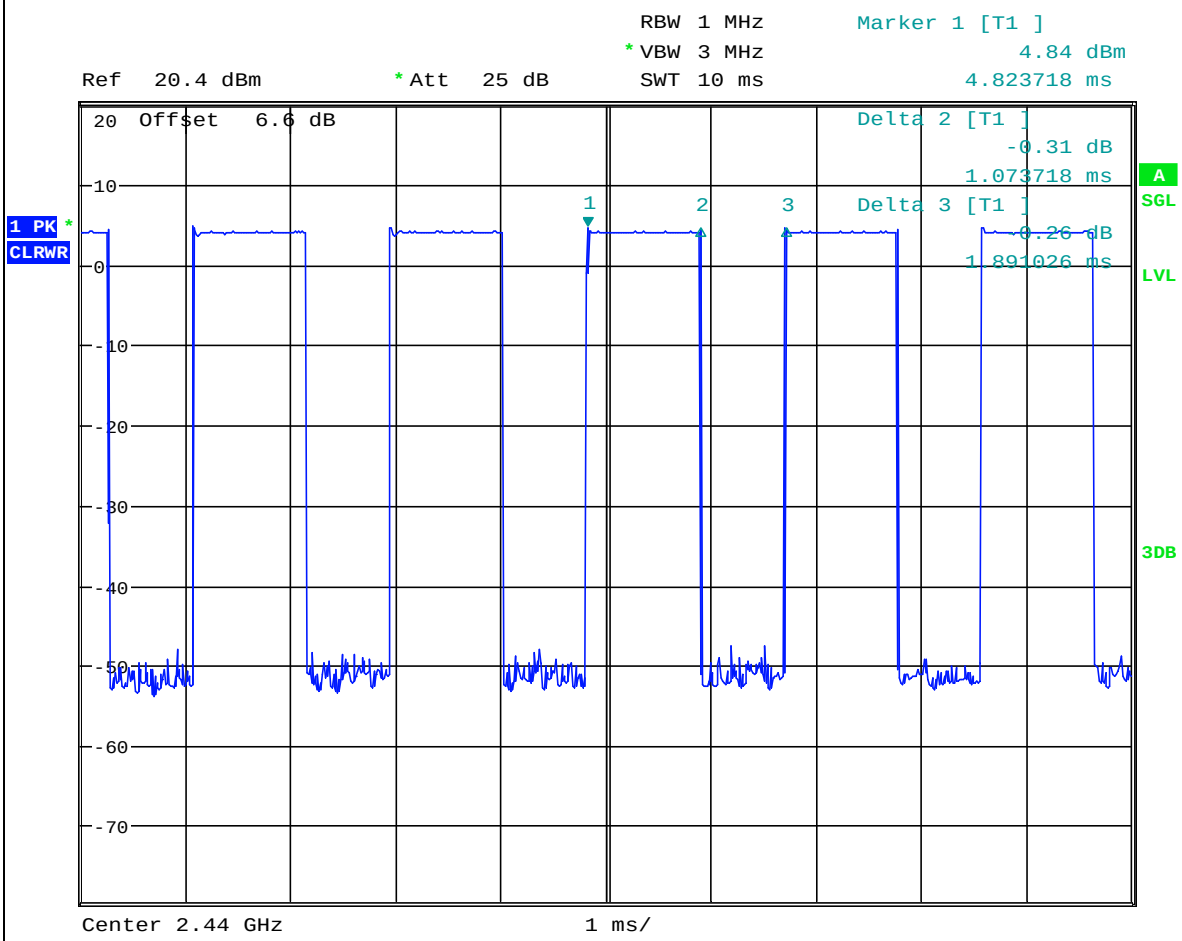
Duty cycle = 85.3%
Duty cycle correction factor = 10*log(1/0.853) = 0.69 dB

Plot # 2	
BTLE CH 19: 2440 MHz	**LE 2 Mbps**



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Duty cycle = 56.8%

Duty cycle correction factor = 10*log(1/0.568) = 2.46 dB

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 ≥ 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

8.4.2 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)).

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- In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30dB instead of 20dB.

Spectrum Analyzer settings for restricted band:

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

8.4.3 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
[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			

8.4.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	Op. 1	2 x AA Batteries	3.3 dBi

8.4.5 Measurement result:

Plot #	PHY	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	LE 1 Mbps	Lower, Non-restricted	-47.44	-20	Pass
2	LE 2 Mbps	Lower, Non-restricted	-32.84	-20	Pass

Plot #	PHY	Band Edge	Measured Peak Value (dBm)	Corrected by duty cycle	Corrected by Antenna Gain (dBm)	Limit (dBm)	Result
3	LE 1 Mbps	Lower Restricted Peak	-41.09	NA	-37.79	-21.23 Peak	Pass
4	LE 1 Mbps	Lower Restricted AVG	-53.90	-53.21	-49.91	-41.23 AVG	Pass
5	LE 1 Mbps	Upper Restricted Peak	-31.60	NA	-28.30	-21.23 Peak	Pass
6	LE 1 Mbps	Upper Restricted AVG	-53.26	-52.57	-49.27	-41.23 AVG	Pass
7	LE 2 Mbps	Lower Restricted Peak	-41.13	NA	-37.83	-21.23 Peak	Pass
8	LE 2 Mbps	Lower Restricted AVG	-55.66	-53.20	-49.90	-41.23 AVG	Pass
9	LE 2 Mbps	Upper Restricted Peak	-33.37	NA	-30.07	-21.23 Peak	Pass
10	LE 2 Mbps	Upper Restricted AVG	-51.88	-49.42	-46.12	-41.23 AVG	Pass

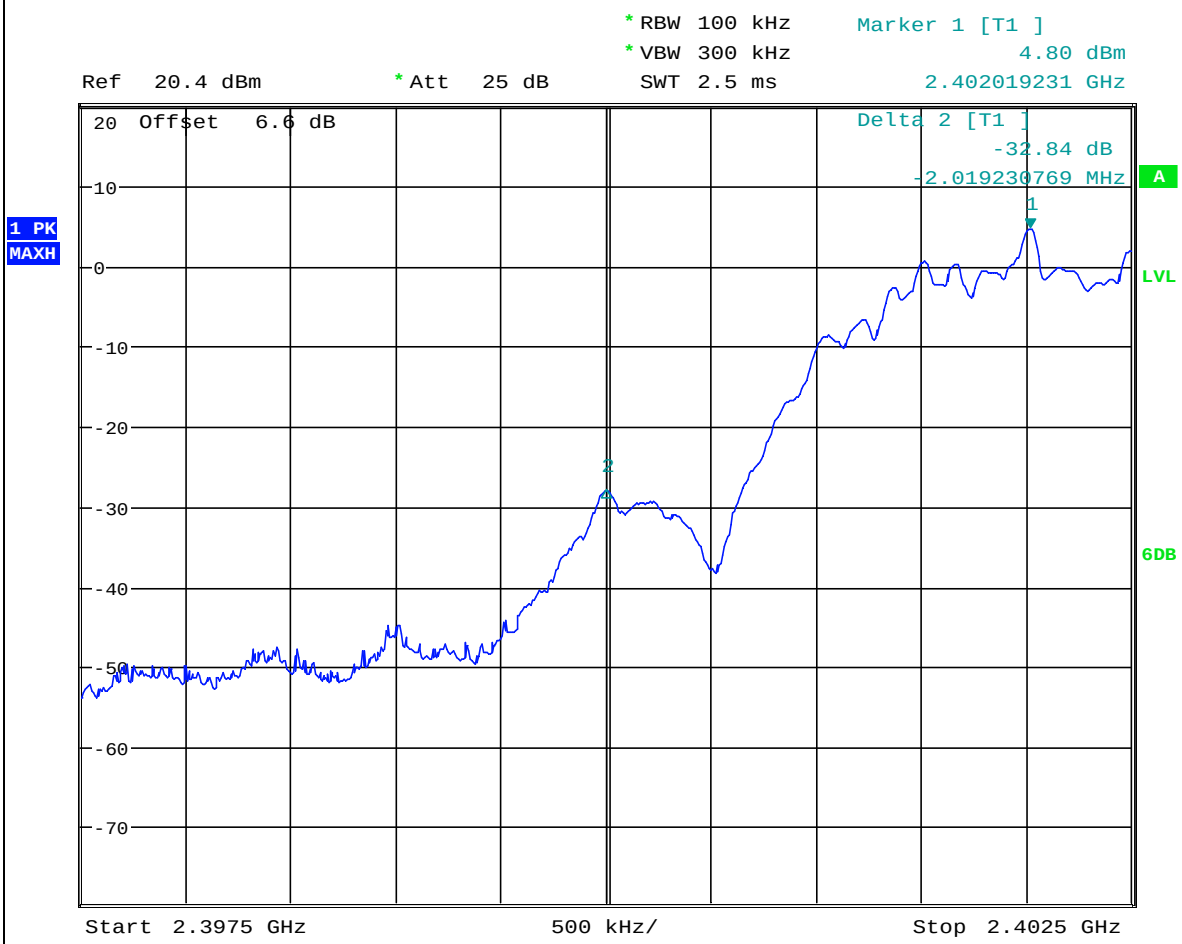
8.4.6 Measurement Plots:

Plot # 1	
Lower, Non-restricted	LE 1 Mbps

Date: 23.JUL.2021 16:27:17

Plot # 2

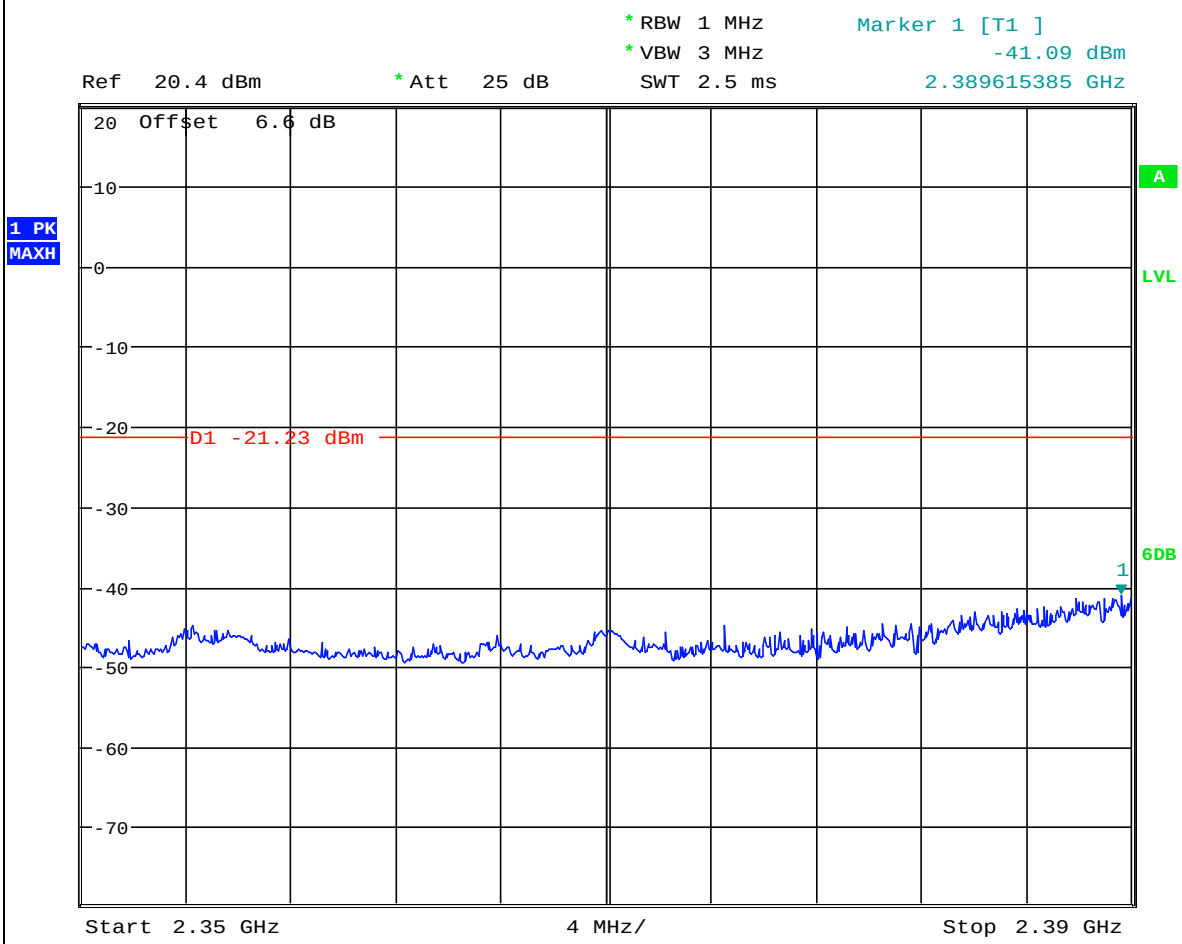
Lower, Non-restricted	LE 2 Mbps



Date: 23.JUL.2021 16:30:10

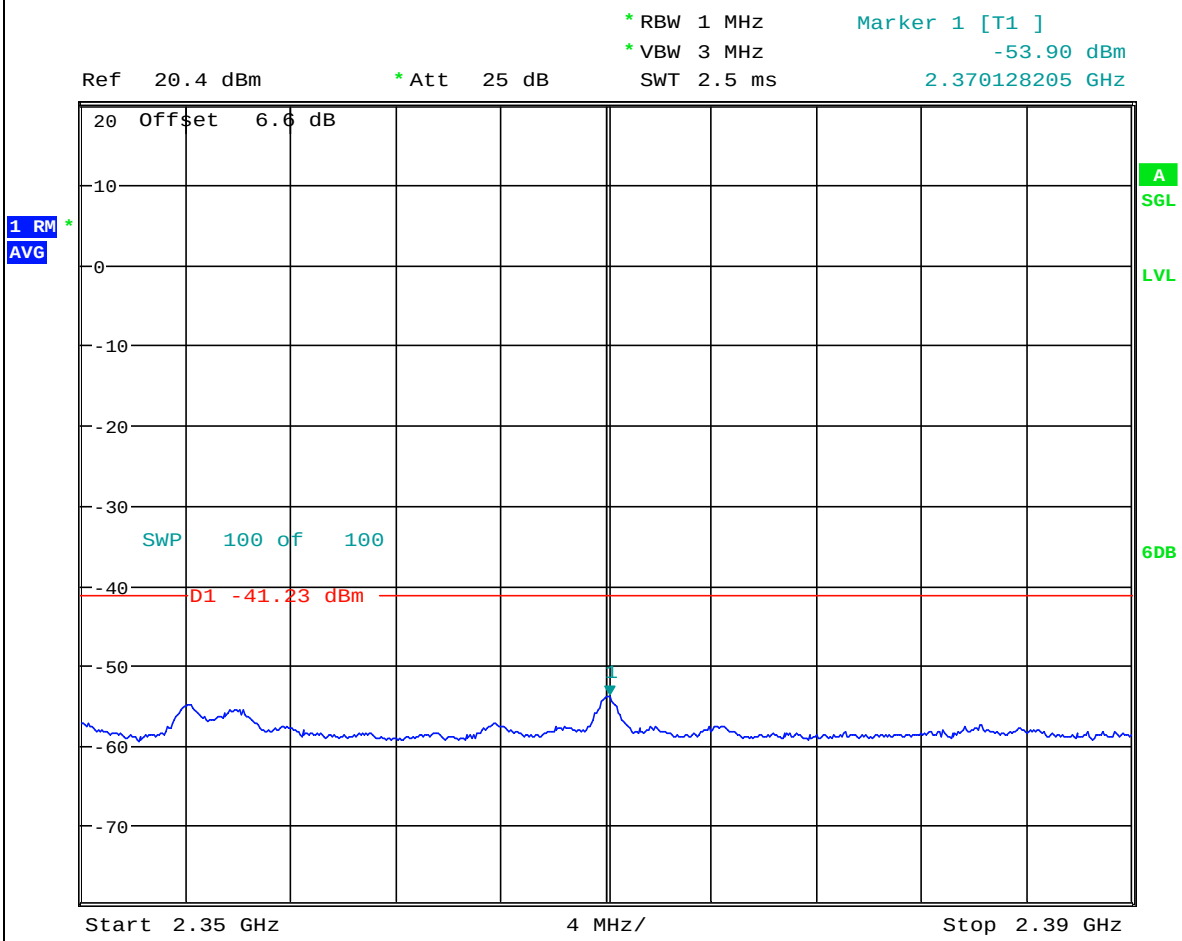
Plot # 3

Lower Restricted Peak	LE 1 Mbps



Date: 23.JUL.2021 16:13:33

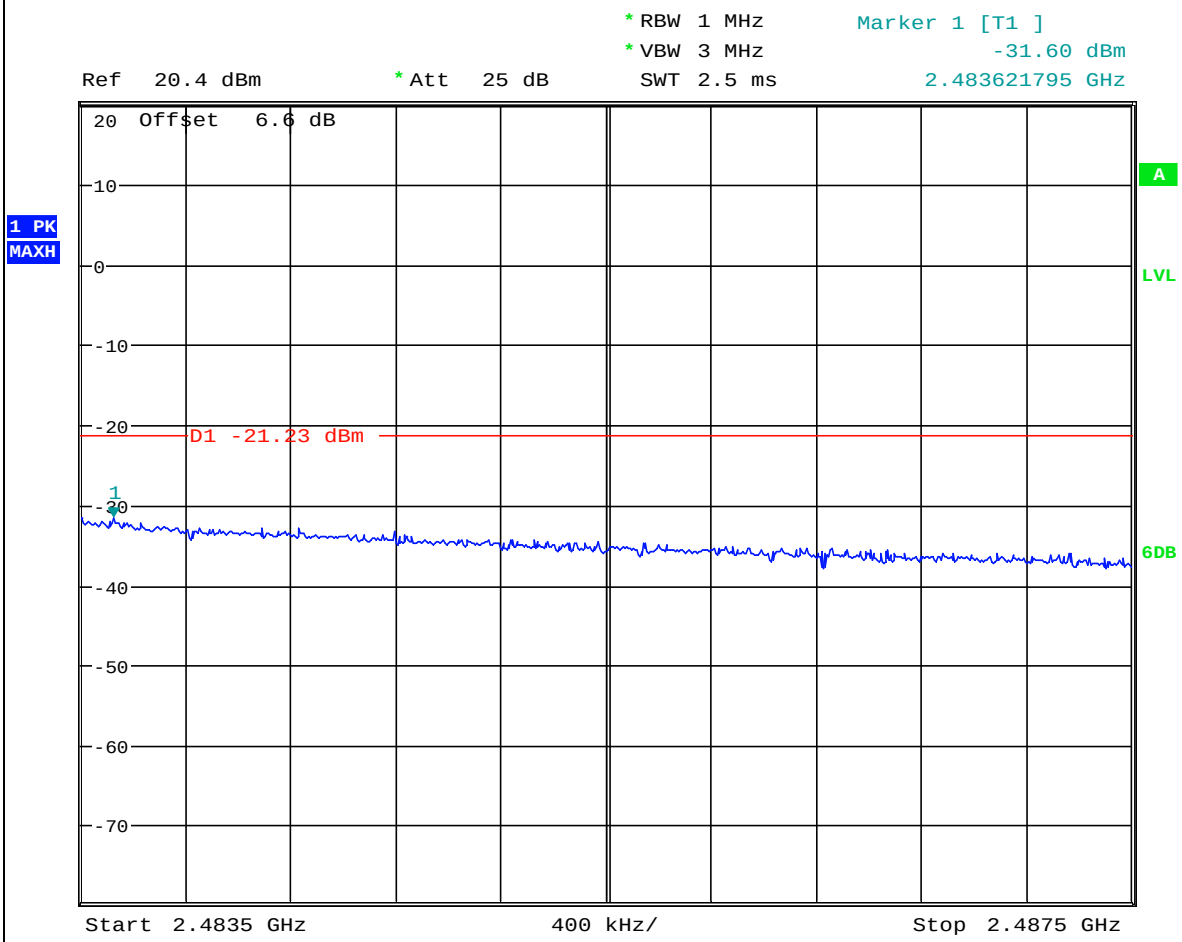
Plot # 4	
Lower Restricted AVG	LE 1 Mbps



Date: 23.JUL.2021 16:02:13

Plot # 5

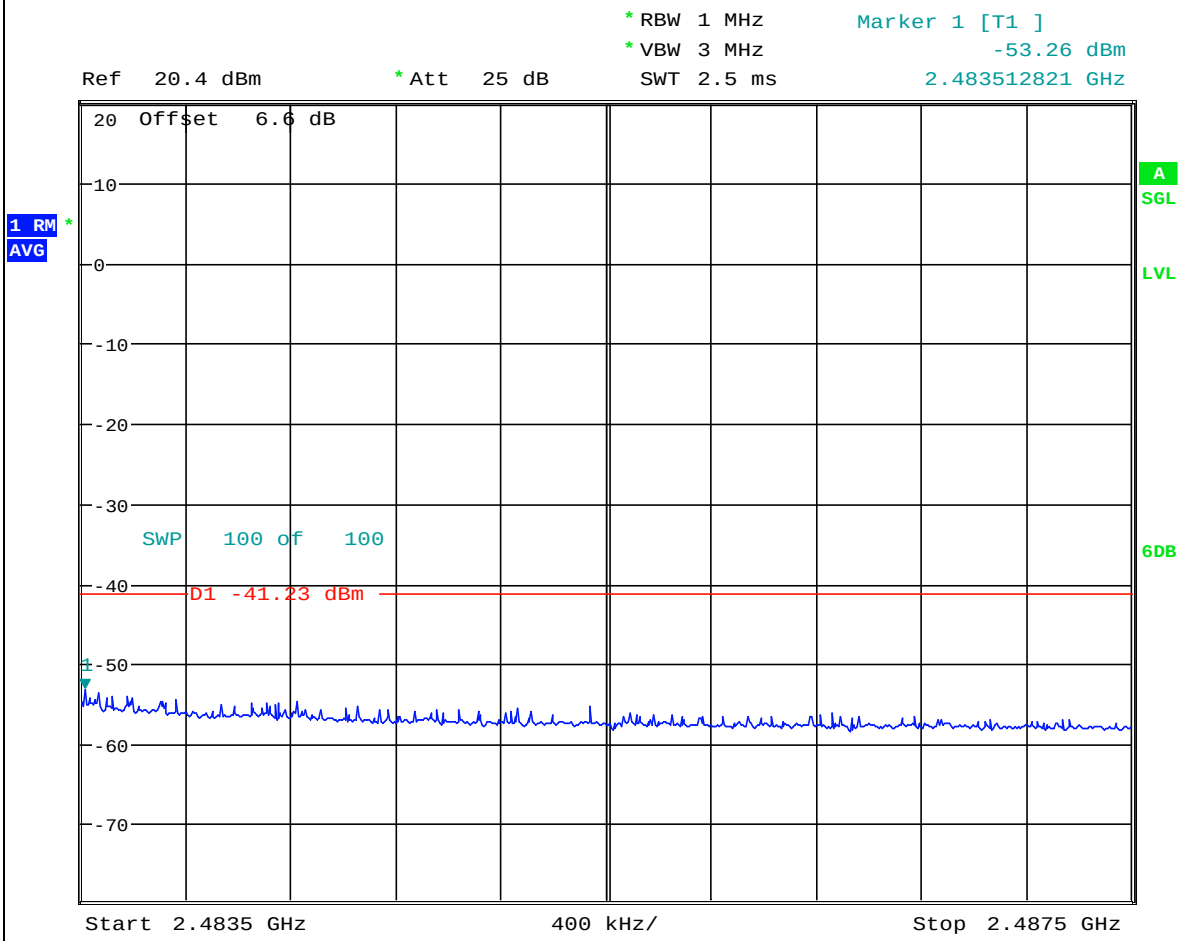
Upper Restricted Peak	LE 1 Mbps



Date: 23.JUL.2021 16:17:27

Plot # 6

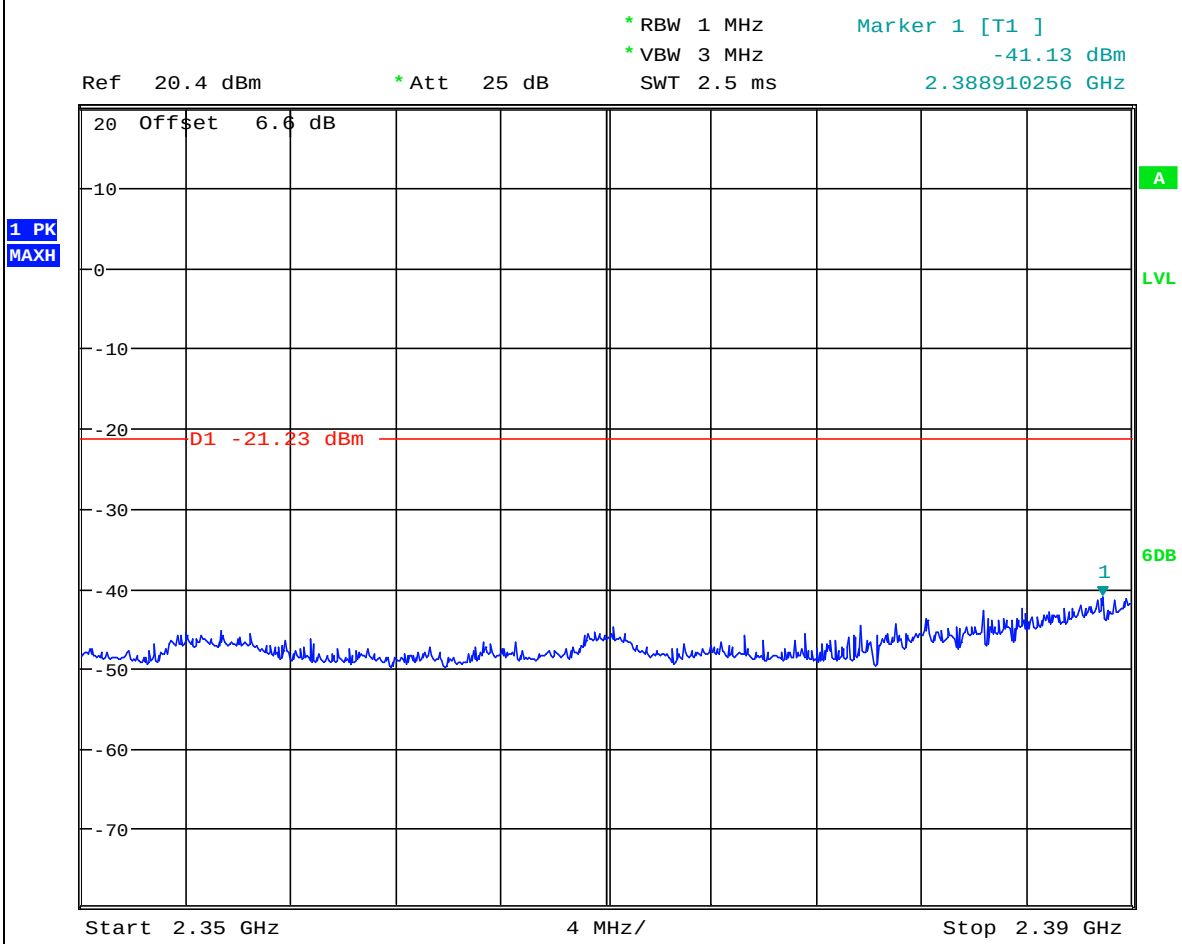
Upper Restricted AVG	LE 1 Mbps



Date: 23.JUL.2021 15:53:45

Plot # 7

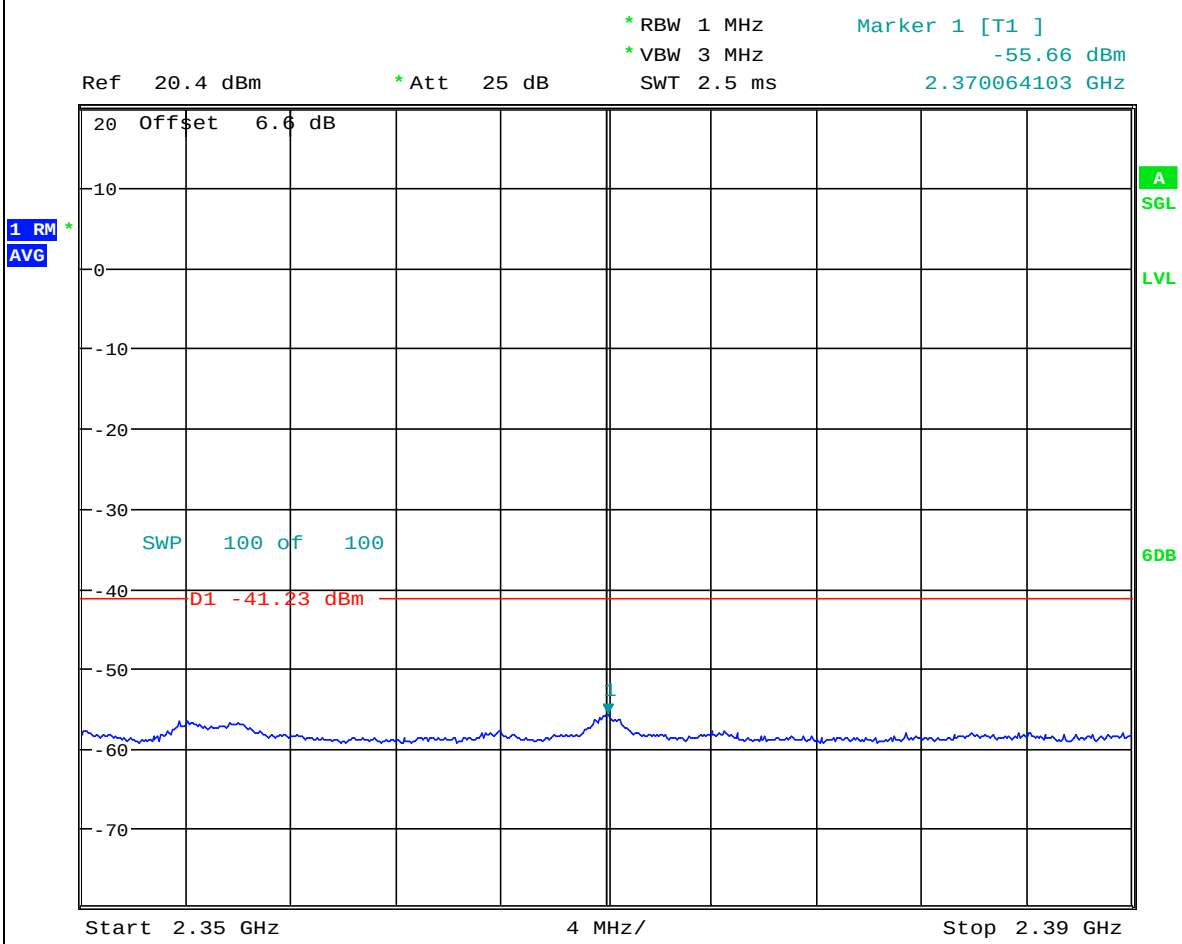
Lower Restricted Peak	LE 2 Mbps



Date: 23.JUL.2021 16:14:54

Plot # 8

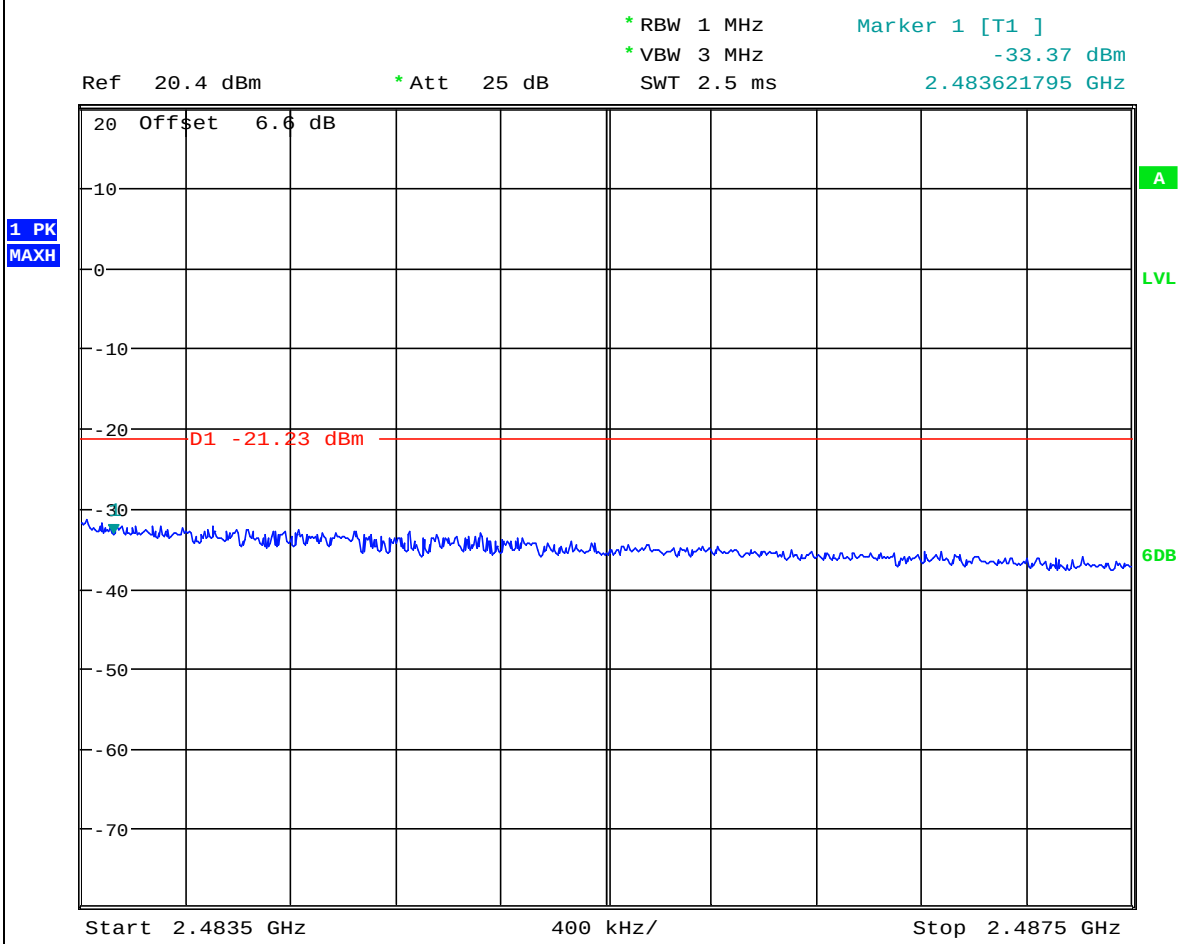
Lower Restricted AVG	LE 2 Mbps



Date: 23.JUL.2021 16:02:57

Plot # 9

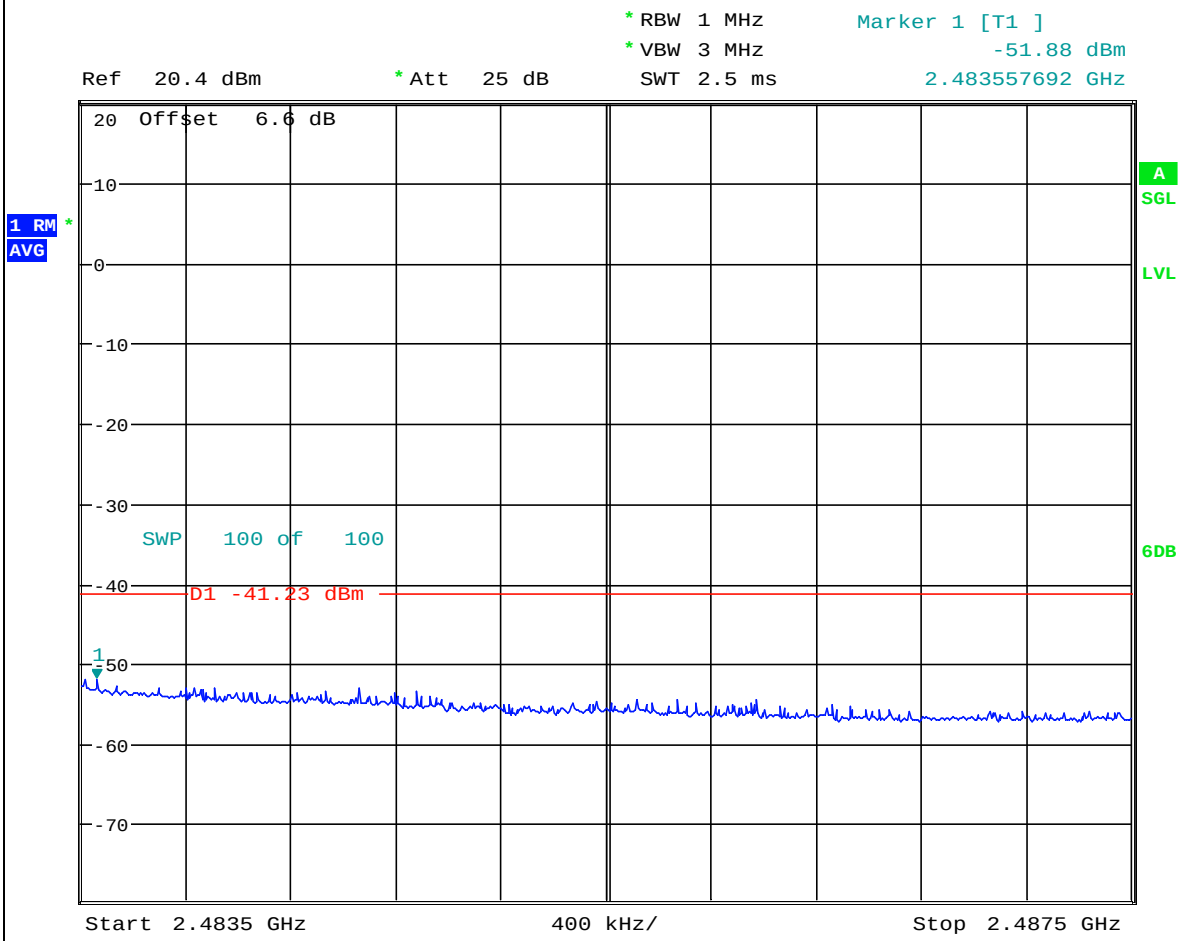
Upper Restricted Peak	LE 2 Mbps



Date: 23.JUL.2021 16:19:19

Plot # 10

Upper Restricted AVG	LE 2 Mbps



Date: 23.JUL.2021 15:51:42

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) ≥ 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.

8.5.2 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	2 x AA Batteries

8.5.4 Measurement result:

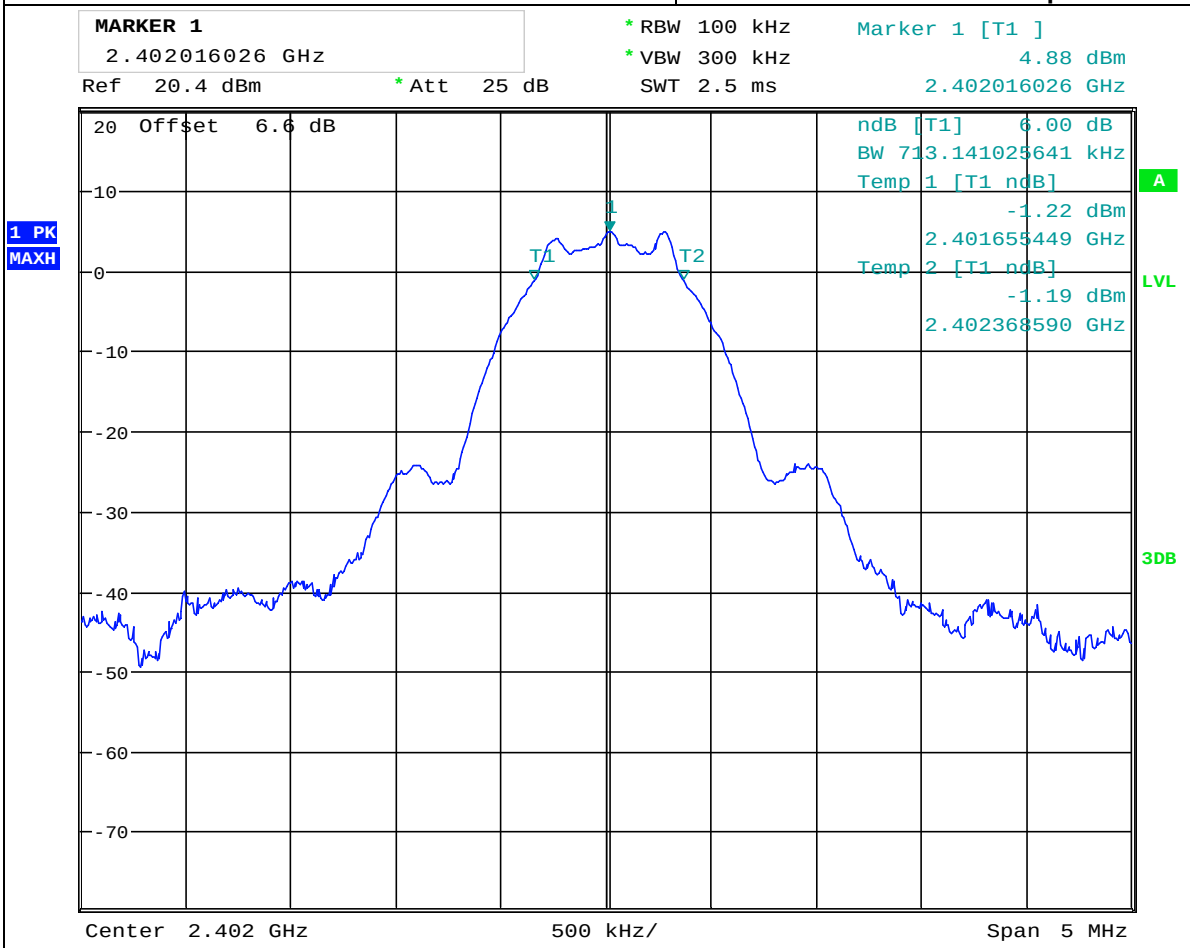
Plot #	PHY	Frequency (MHz)	6dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
1	LE 1 Mbps	2402	0.7131	> 0.5	Pass
2	LE 1 Mbps	2440	0.7051	> 0.5	Pass
3	LE 1 Mbps	2480	0.7051	> 0.5	Pass
4	LE 2 Mbps	2402	1.1699	> 0.5	Pass
5	LE 2 Mbps	2440	1.1859	> 0.5	Pass
6	LE 2 Mbps	2480	1.1699	> 0.5	Pass

Plot #	PHY	Frequency (MHz)	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
7	LE 1 Mbps	2402	1.0497	> 0.5	Pass
8	LE 1 Mbps	2440	1.0577	> 0.5	Pass
9	LE 1 Mbps	2480	1.0497	> 0.5	Pass
10	LE 2 Mbps	2402	2.0833	> 0.5	Pass
11	LE 2 Mbps	2440	2.0833	> 0.5	Pass
12	LE 2 Mbps	2480	2.0994	> 0.5	Pass

8.5.5 Measurement Plots:

6dB Emissions Bandwidth

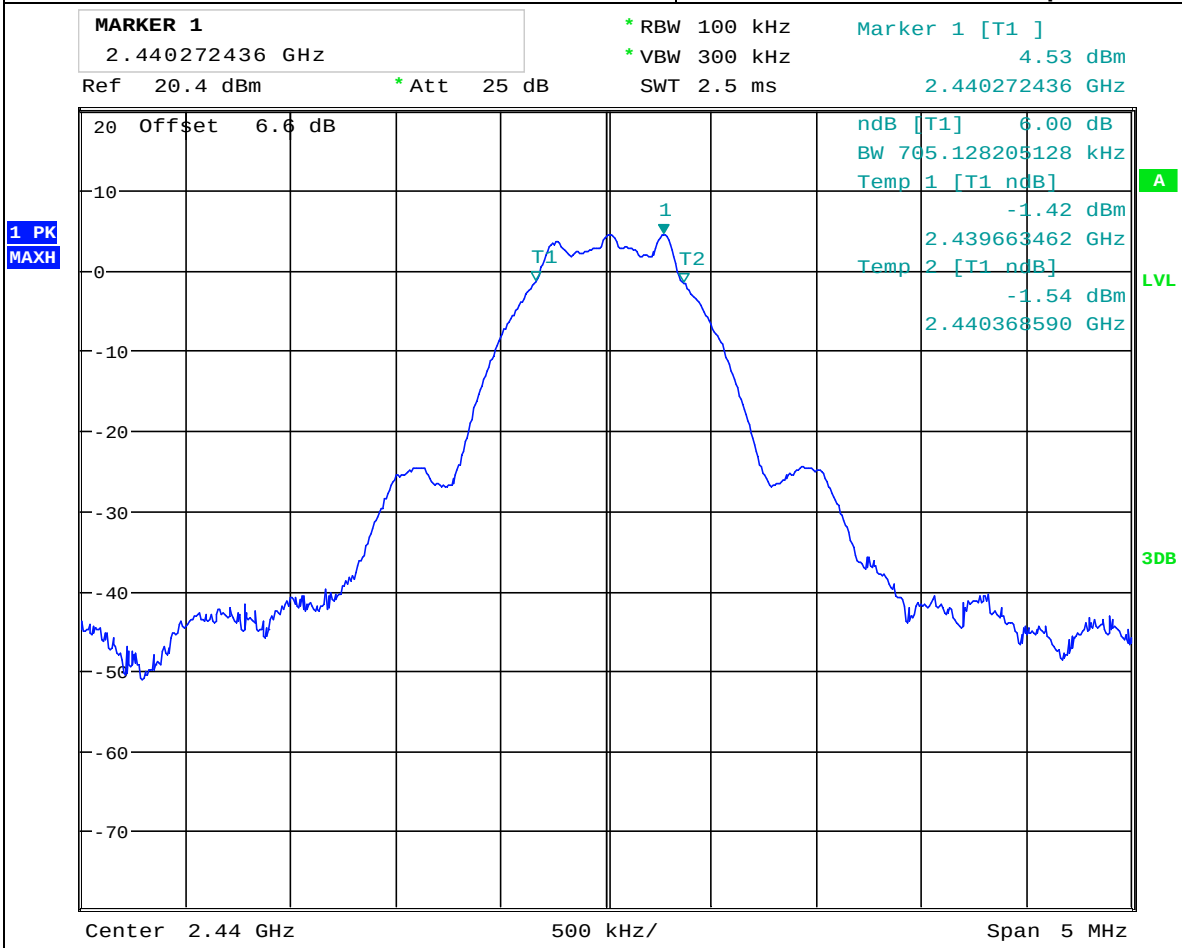
Plot # 1	
BTLE CH 0: 2402 MHz	**LE 1 Mbps**



Date: 23.JUL.2021 17:22:48

Plot # 2

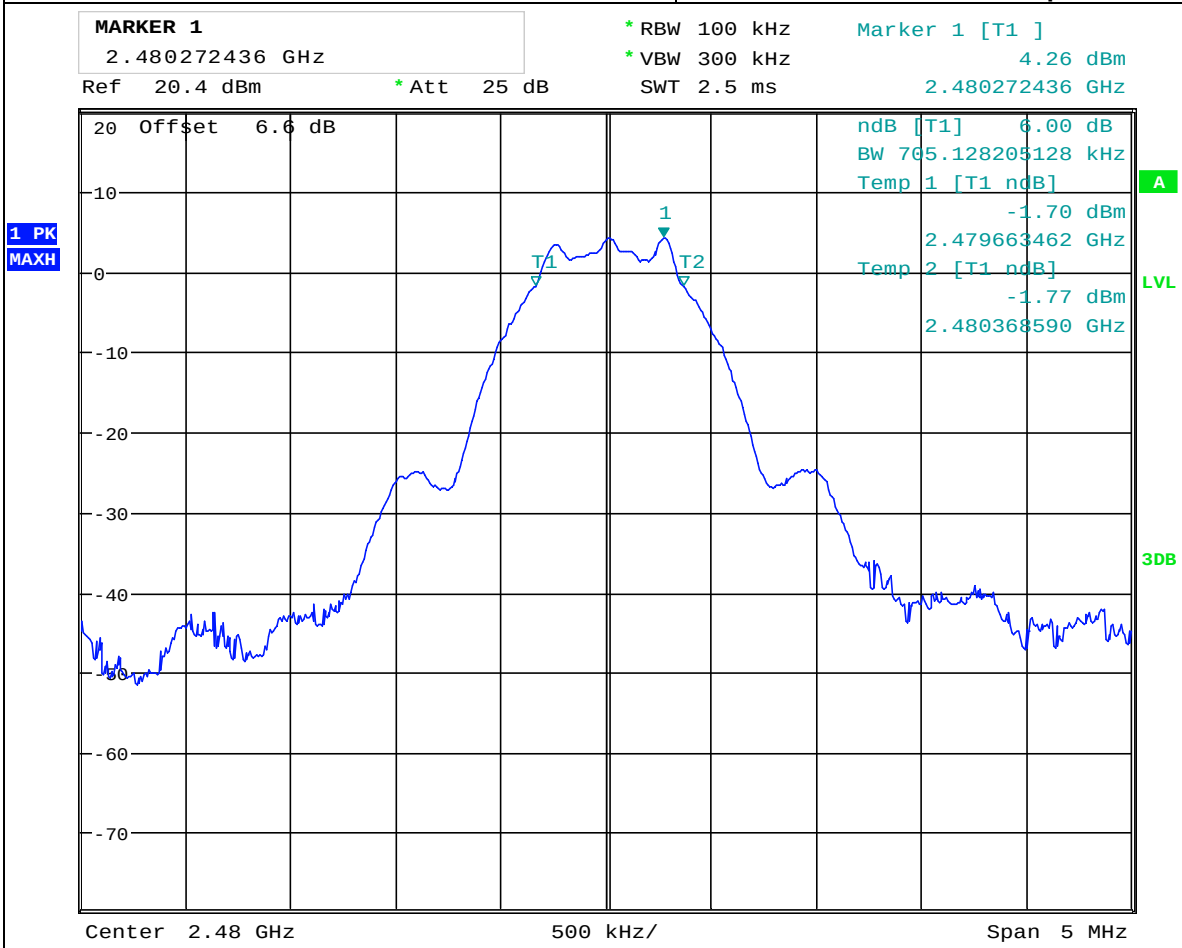
BTLE CH 19: 2440 MHz	LE 1 Mbps



Date: 23.JUL.2021 17:24:45

Plot # 3

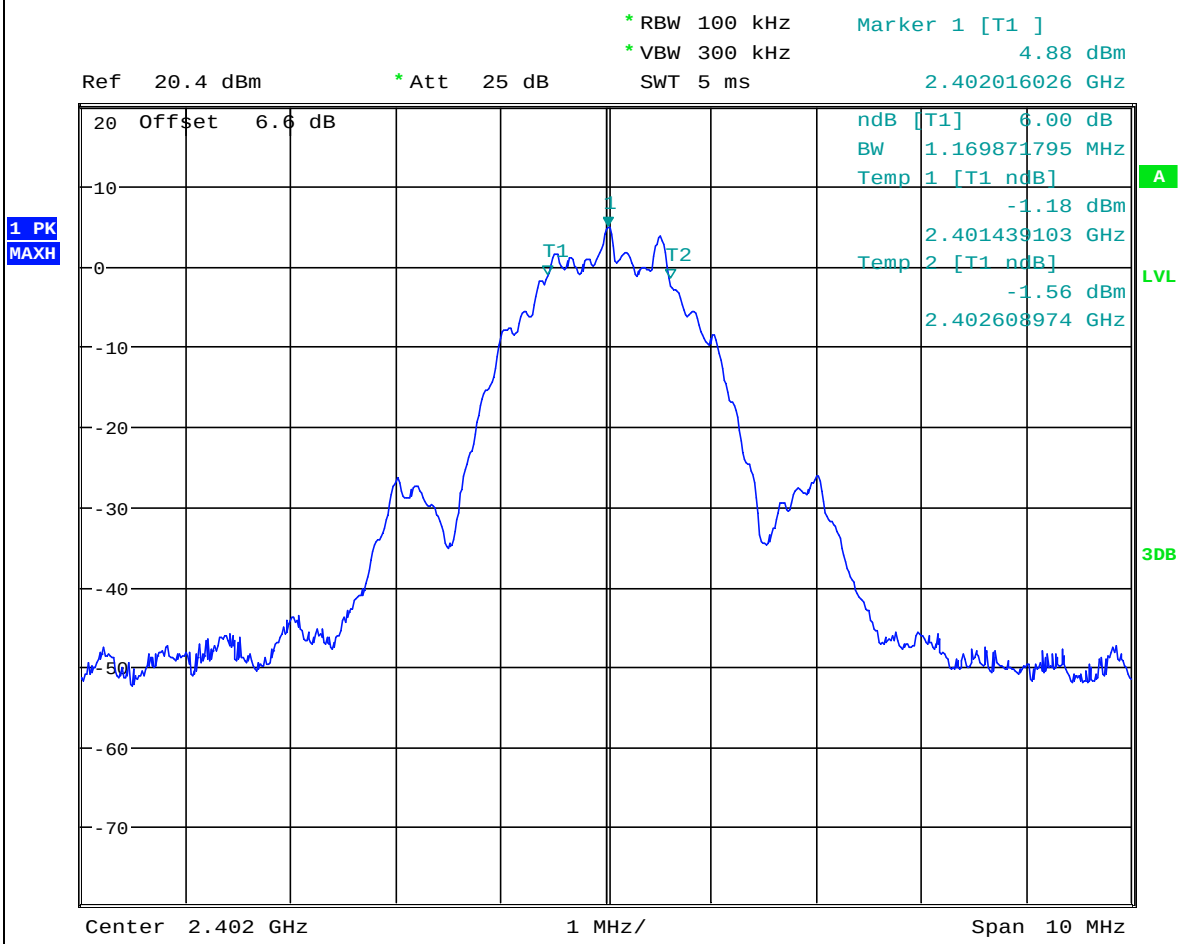
BTLE CH 39: 2480 MHz	LE 1 Mbps



Date: 23.JUL.2021 17:26:27

Plot # 4

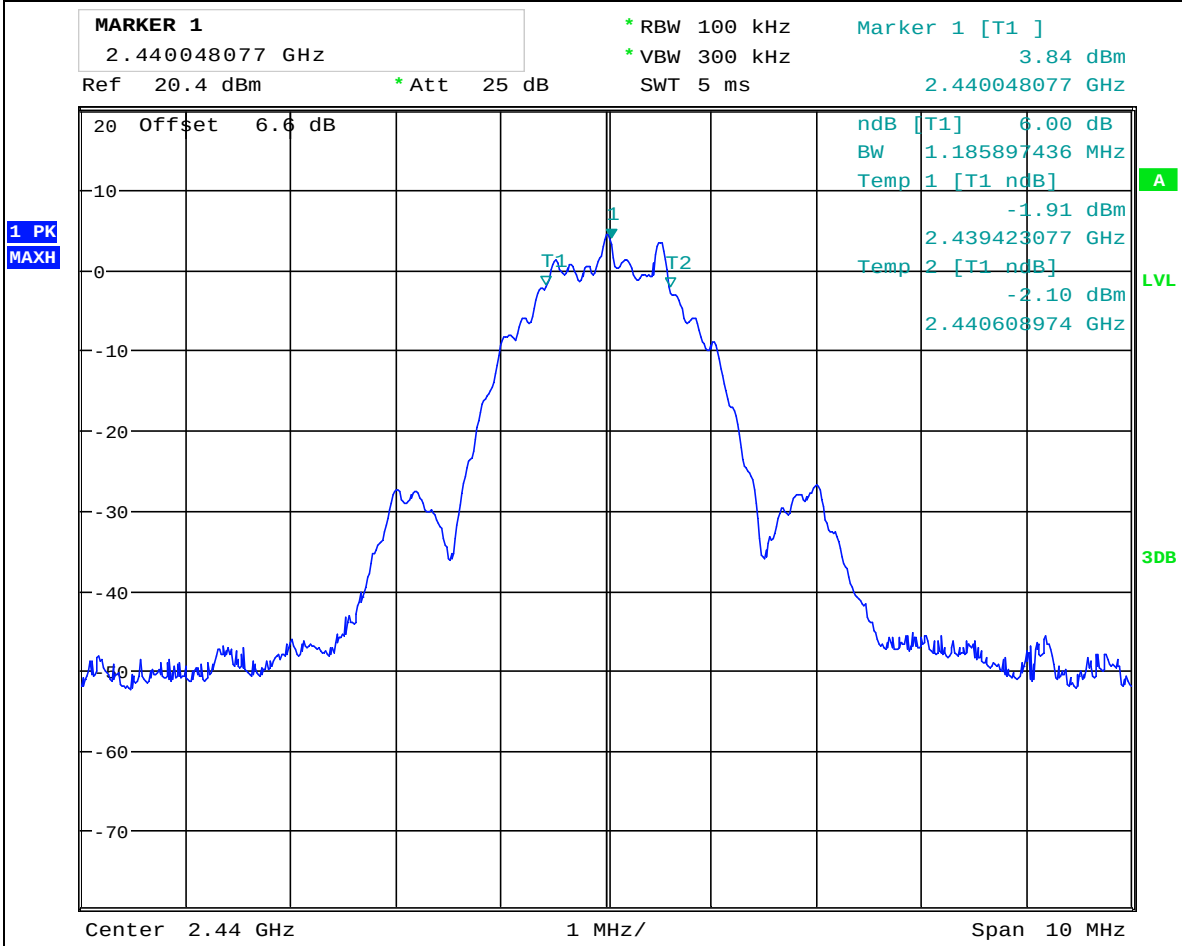
BTLE CH 0: 2402 MHz	LE 2 Mbps



Date: 23.JUL.2021 17:28:44

Plot # 5

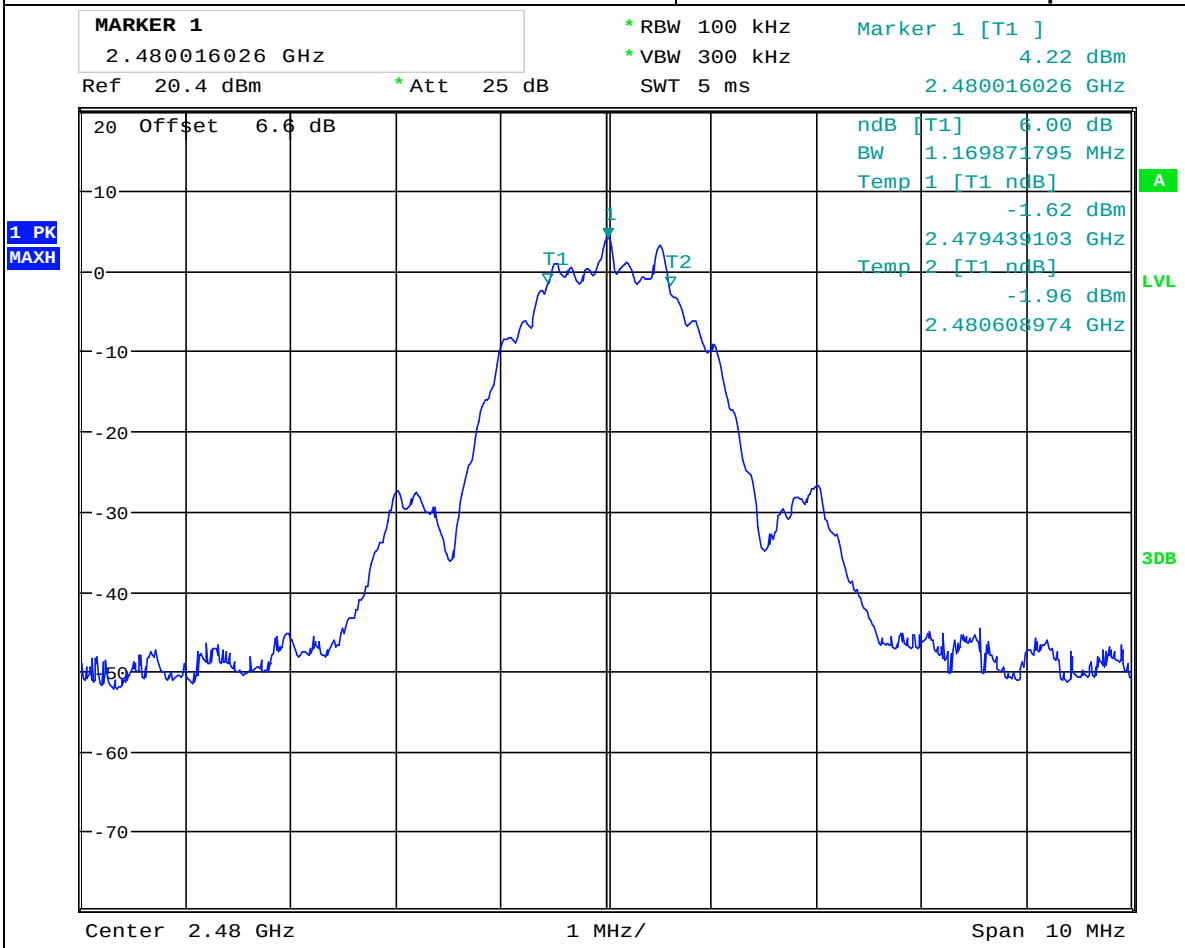
BTLE CH 19: 2440 MHz	LE 2 Mbps



Date: 23.JUL.2021 17:30:25

Plot # 6

BTLE CH 39: 2480 MHz	LE 2 Mbps

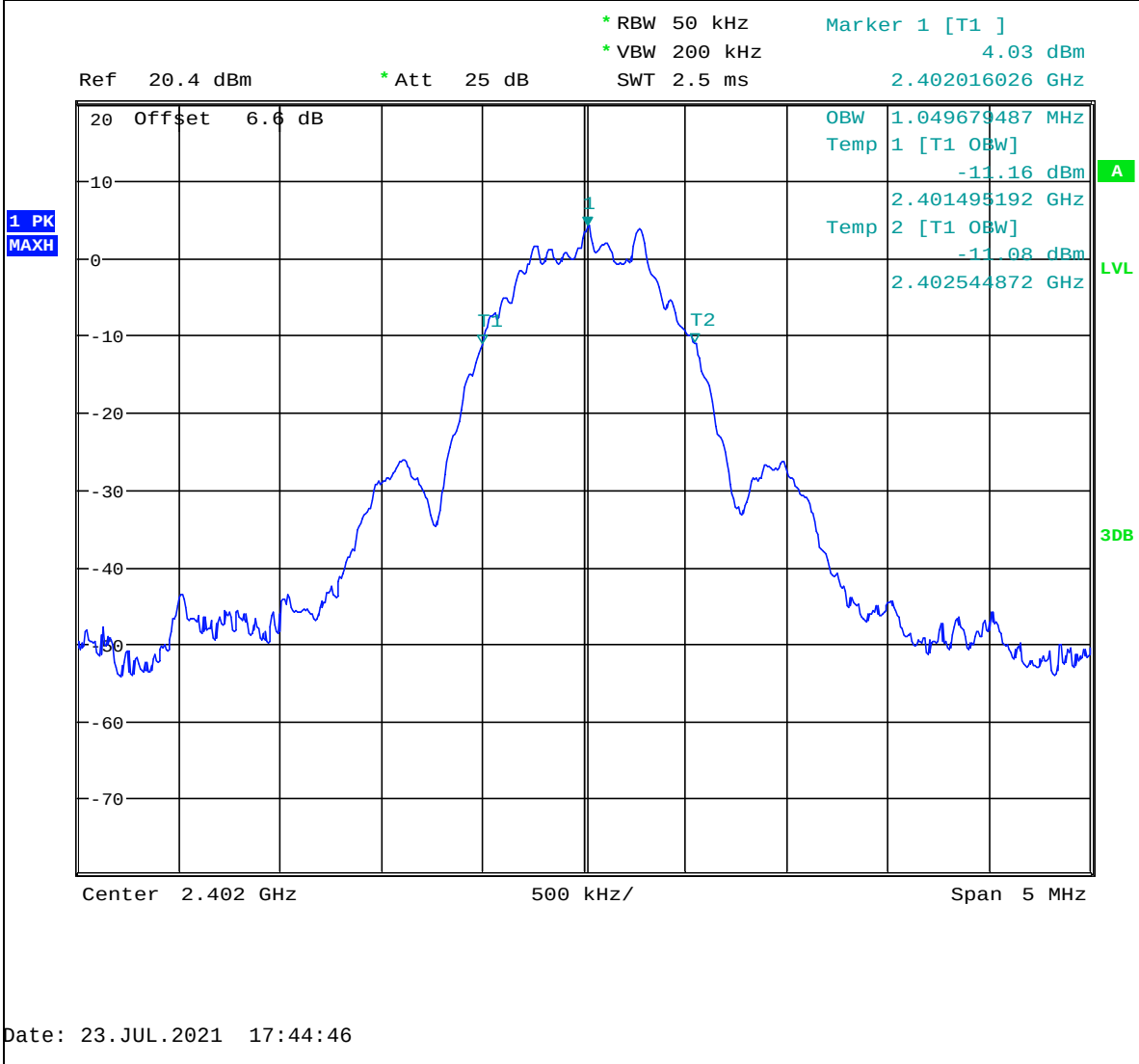


Date: 23.JUL.2021 17:31:45

99% Occupied Bandwidth

Plot # 7

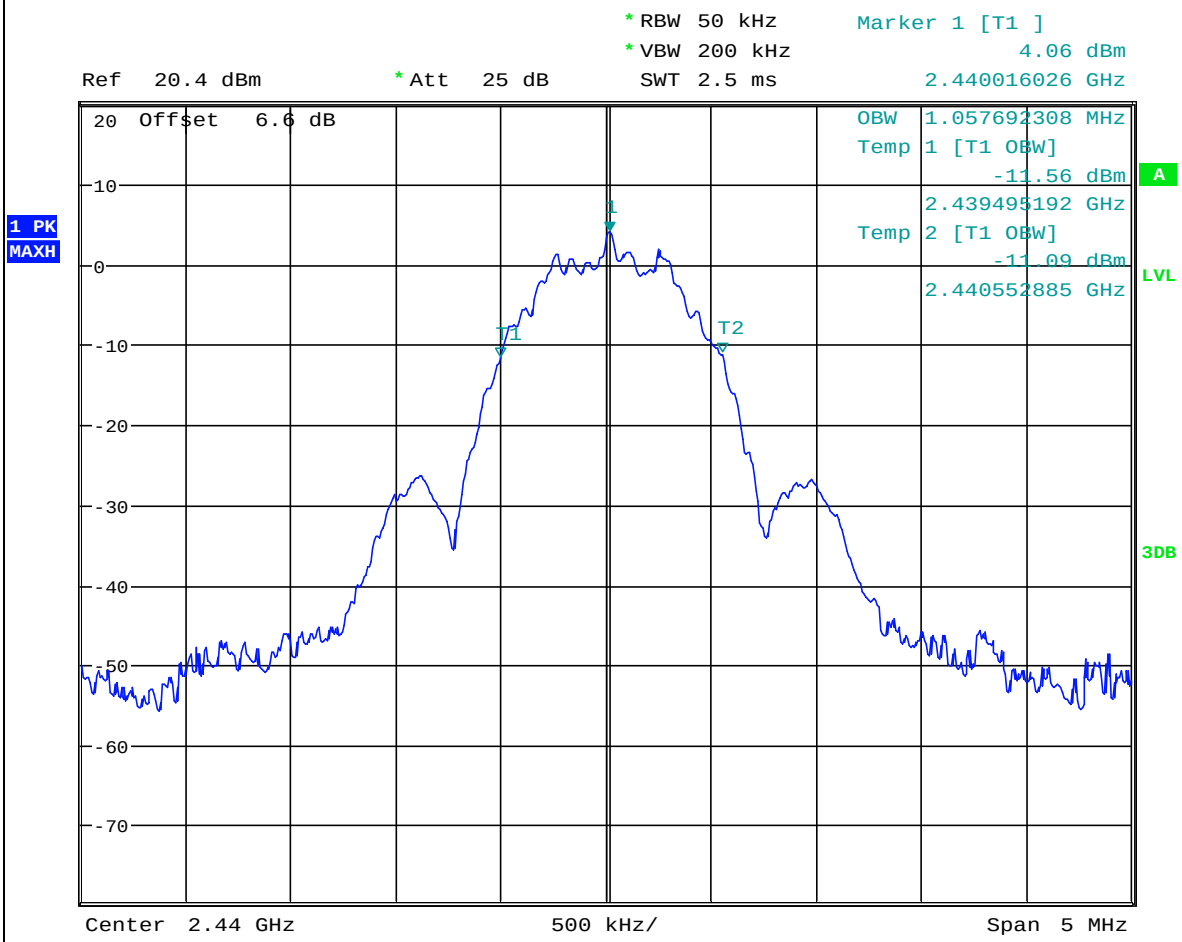
BTLE CH 0: 2402 MHz	LE 1 Mbps



Date: 23.JUL.2021 17:44:46

Plot # 8

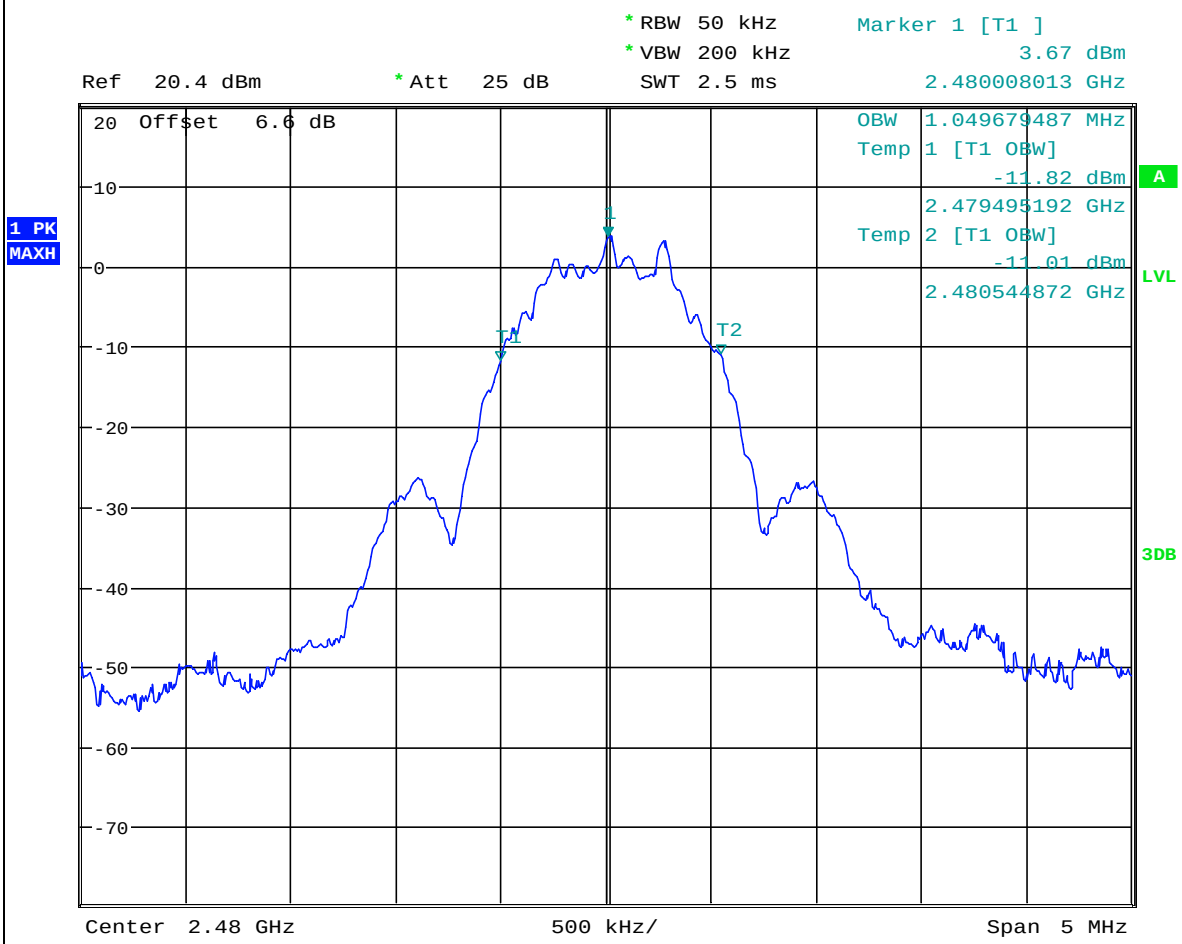
BTLE CH 19: 2440 MHz	LE 1 Mbps



Date: 23.JUL.2021 17:46:30

Plot # 9

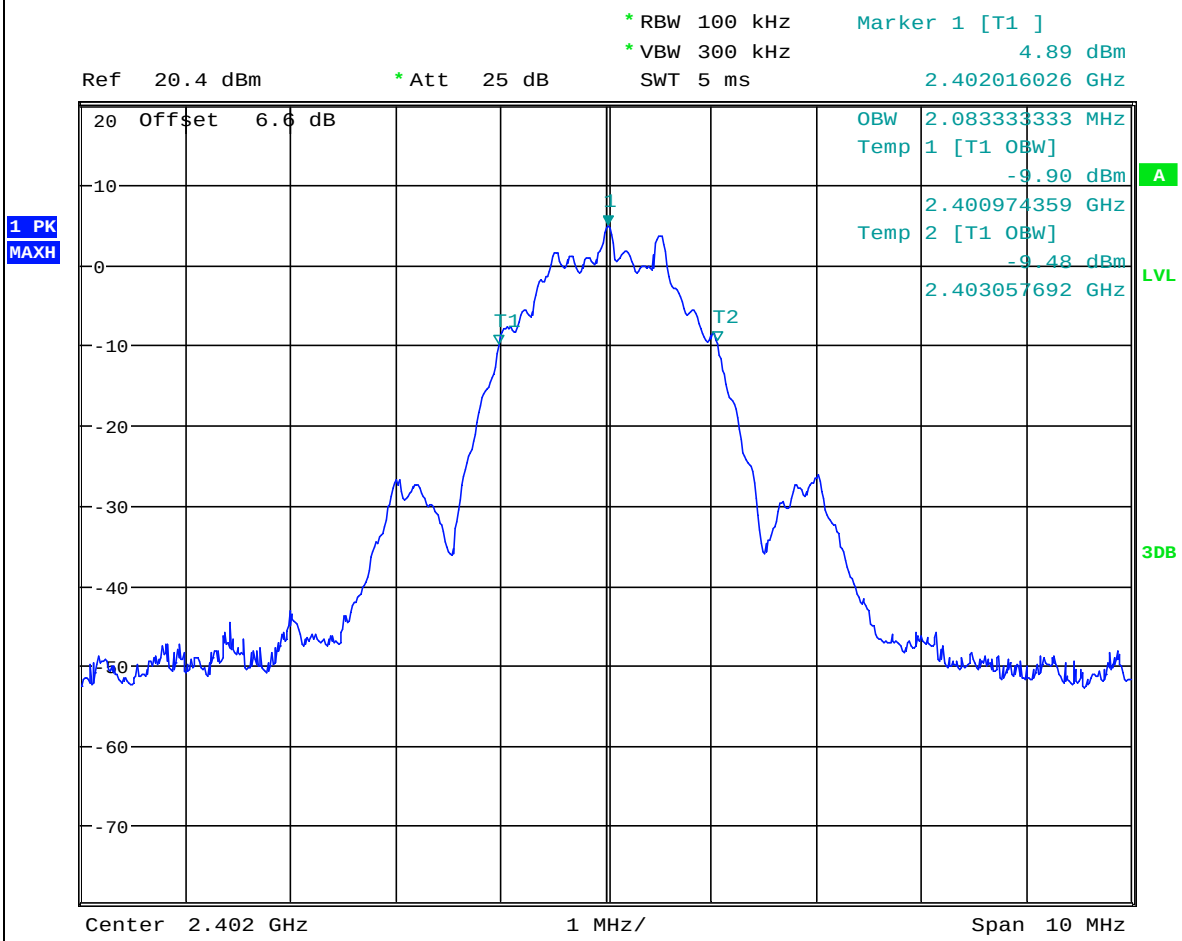
BTLE CH 39: 2480 MHz	LE 1 Mbps



Date: 23.JUL.2021 17:48:10

Plot # 10

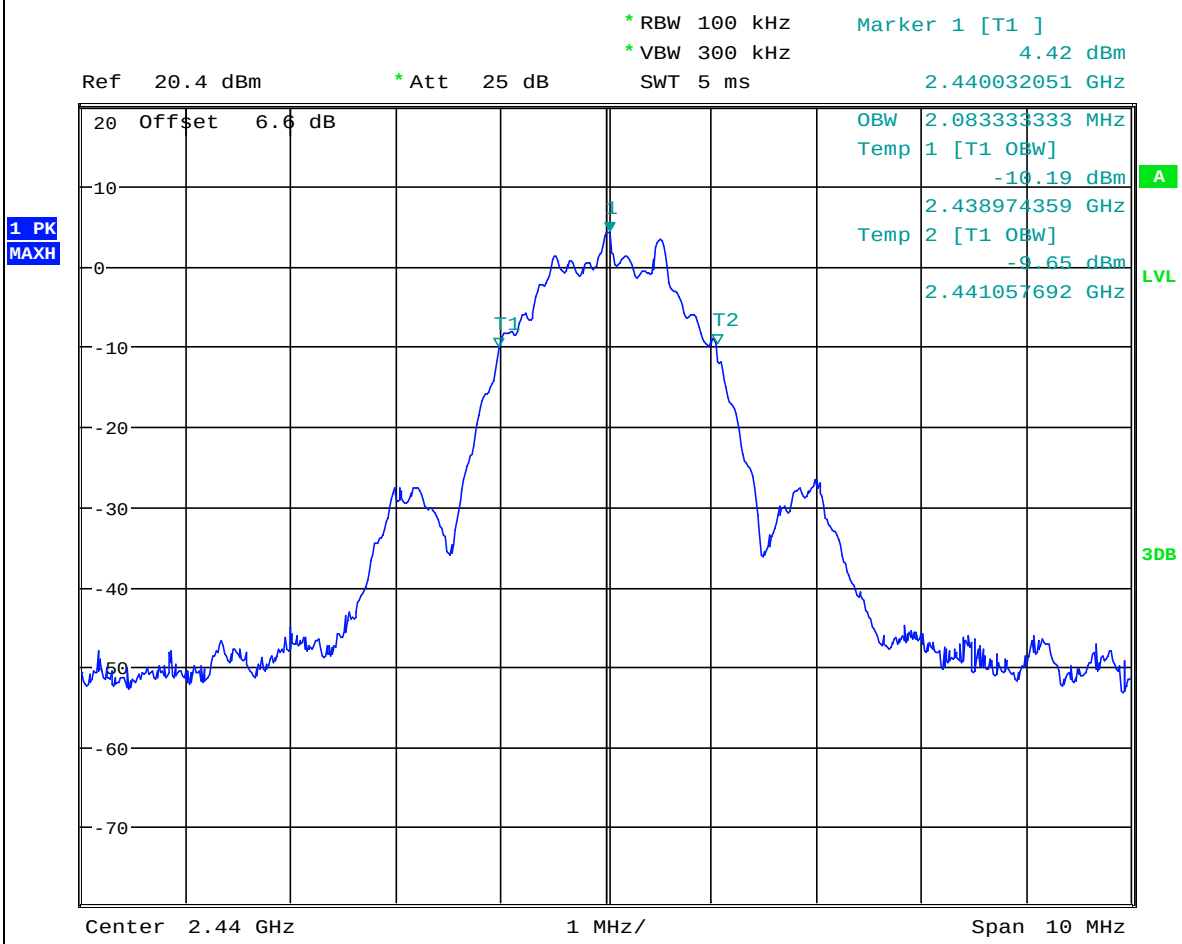
BTLE CH 0: 2402 MHz	LE 2 Mbps



Date: 23.JUL.2021 17:50:35

Plot # 11

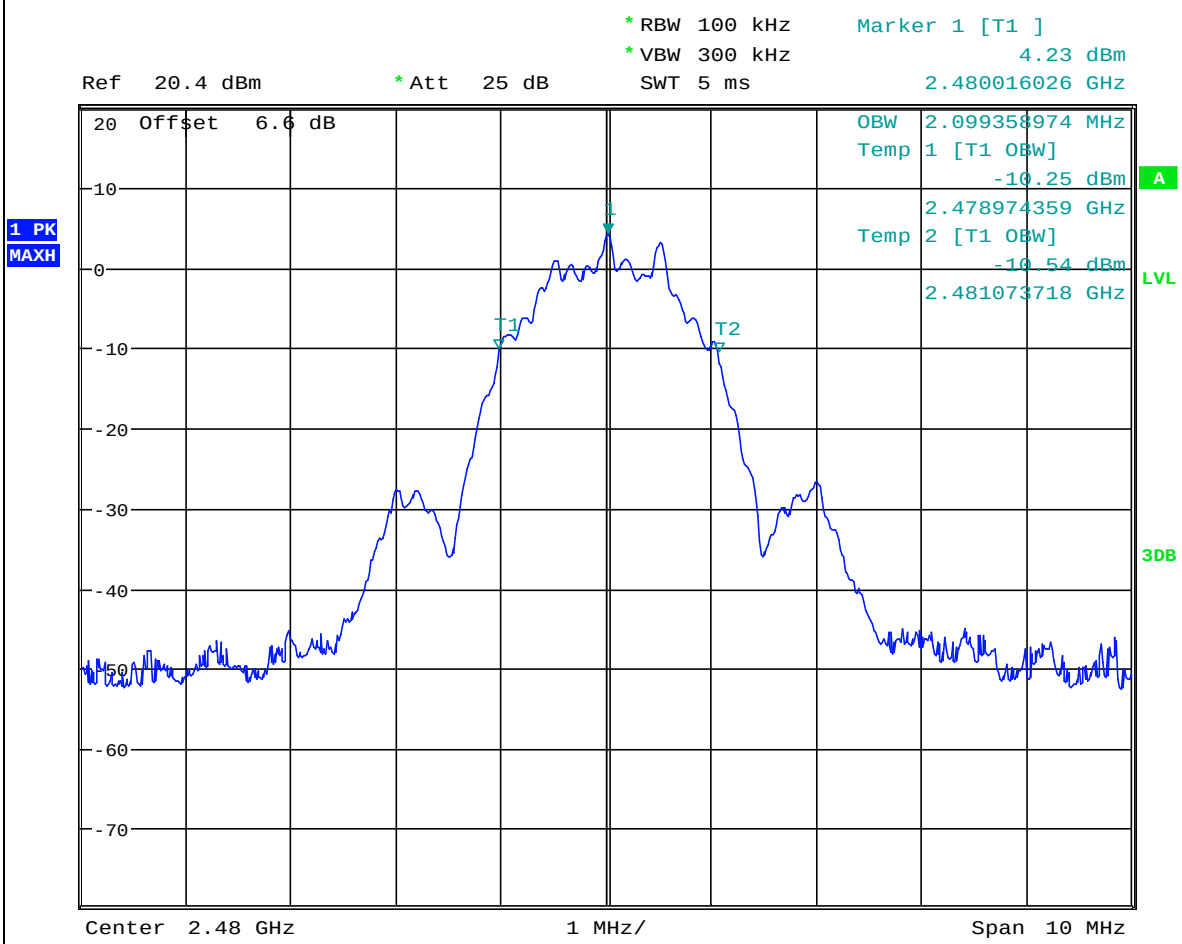
BTLE CH 19: 2440 MHz	LE 2 Mbps



Date: 23.JUL.2021 17:52:08

Plot # 12

BTLE CH 39: 2480 MHz	LE 2 Mbps



Date: 23.JUL.2021 17:53:25

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
[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 Set-Up #	EUT operating mode	Power Input
23° C	2	Op. 2	2 x AA Batteries

8.6.4 Measurement result:

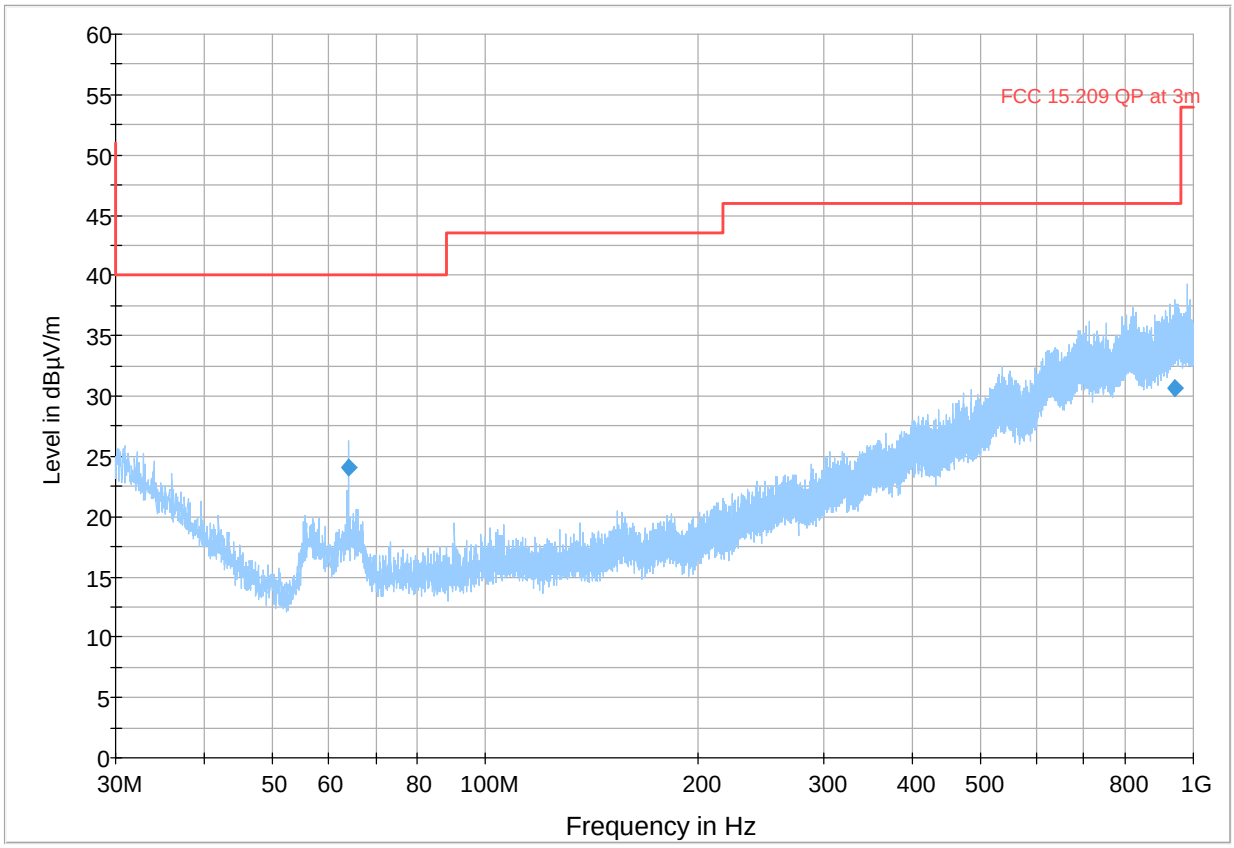
Plot #	Channel #	Scan Frequency	Result
1-3	Low	30 MHz – 18 GHz	Pass
4-8	Mid	9 kHz – 26 GHz	Pass
9-11	High	30 MHz – 18 GHz	Pass

8.6.5 Measurement Plots:

Plot # 1

BTLE CH 0: 2402 MHz | **LE 2 Mbps**

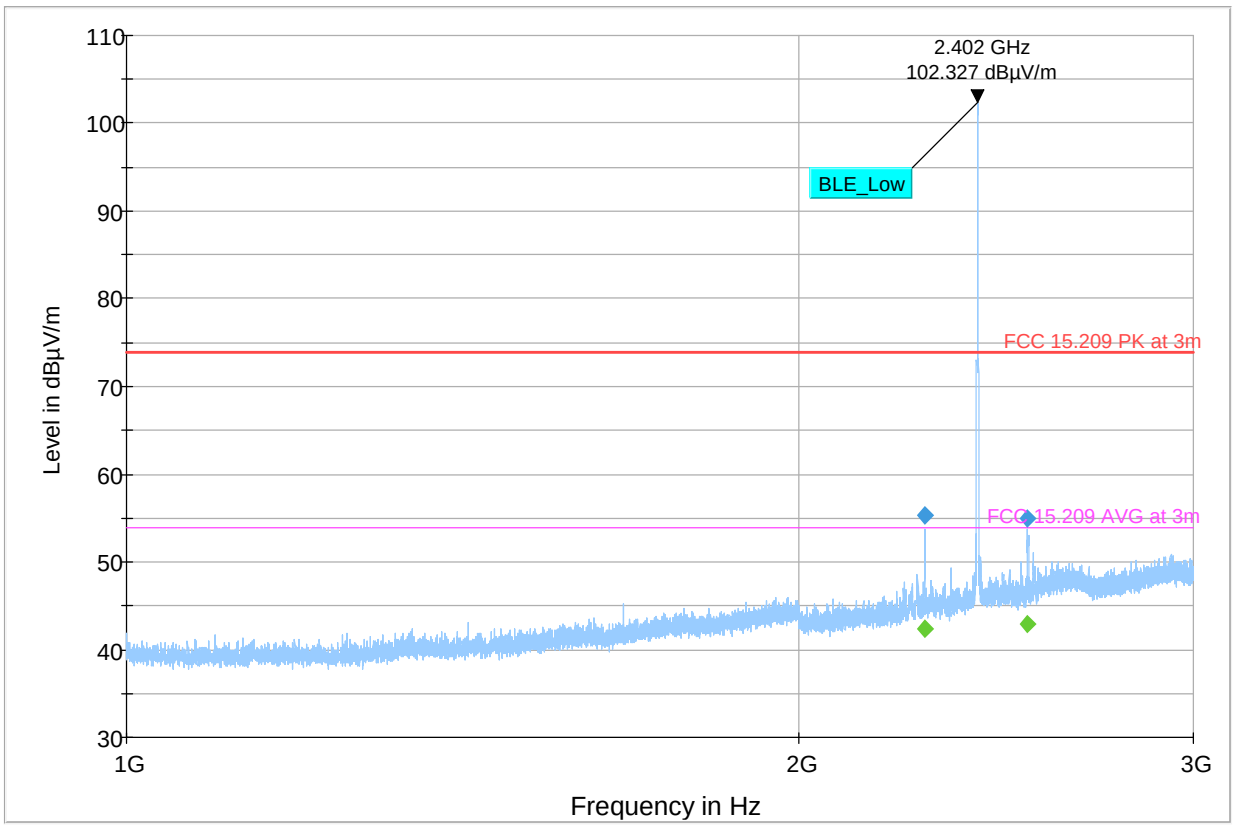
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
63.982	24.07	40.00	15.93	500.0	120.000	140.0	H	275.0	10.8	
942.802	30.69	46.02	15.33	500.0	120.000	298.0	H	321.0	30.8	



Plot # 2

BTLE CH 0: 2402 MHz | LE 2 Mbps

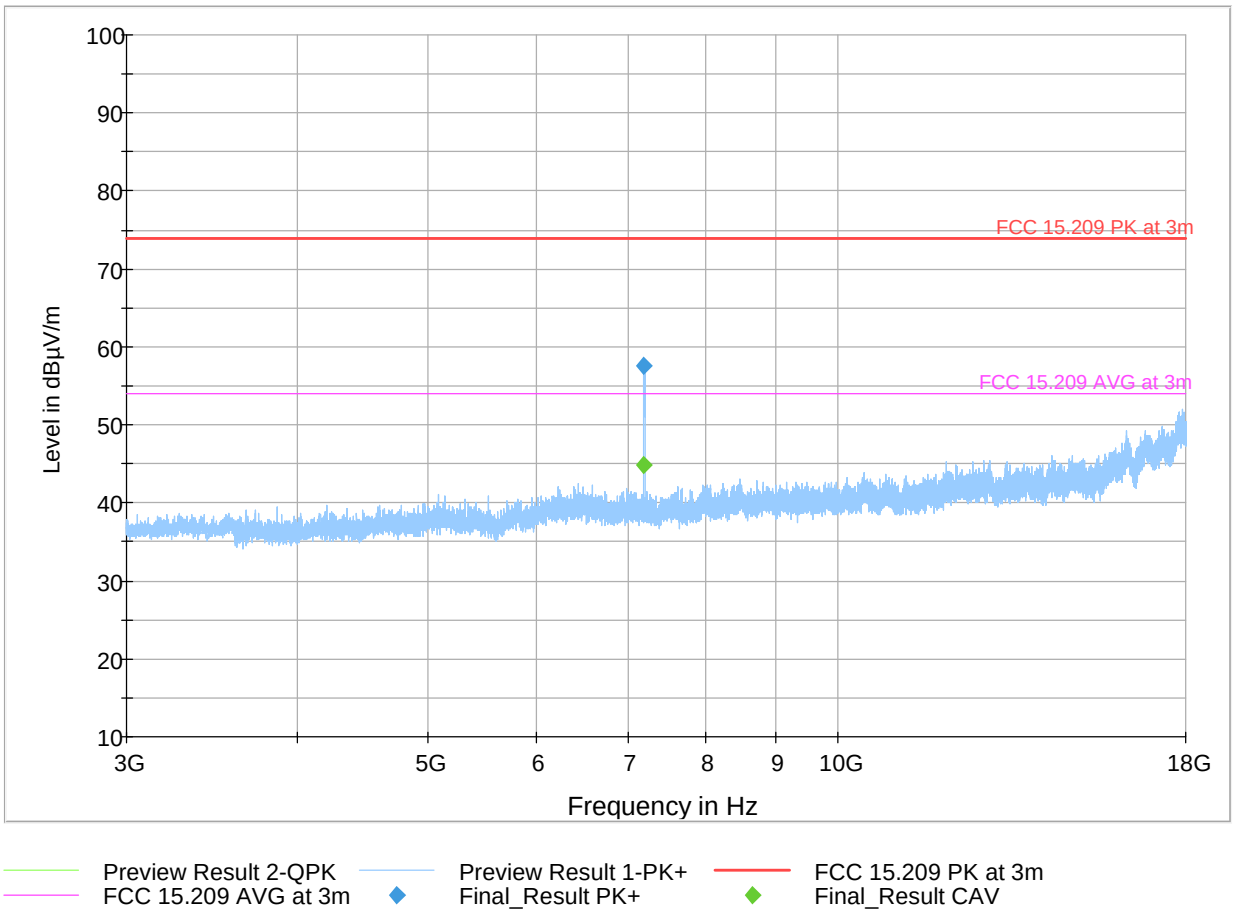
Frequency	MaxPeak (dBµV/m	CAverage	Limit (dBµV/m	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m	Comment
2274.571	---	42.38	53.98	11.60	500.0	1000.000	152.0	H	132.0	9.0	
2274.571	55.31	---	73.98	18.67	500.0	1000.000	152.0	H	132.0	9.0	
2529.571	---	42.95	53.98	11.03	500.0	1000.000	253.0	H	123.0	9.9	
2529.571	55.00	---	73.98	18.98	500.0	1000.000	253.0	H	123.0	9.9	



Plot # 3

BTLE CH 0: 2402 MHz | **LE 2 Mbps**

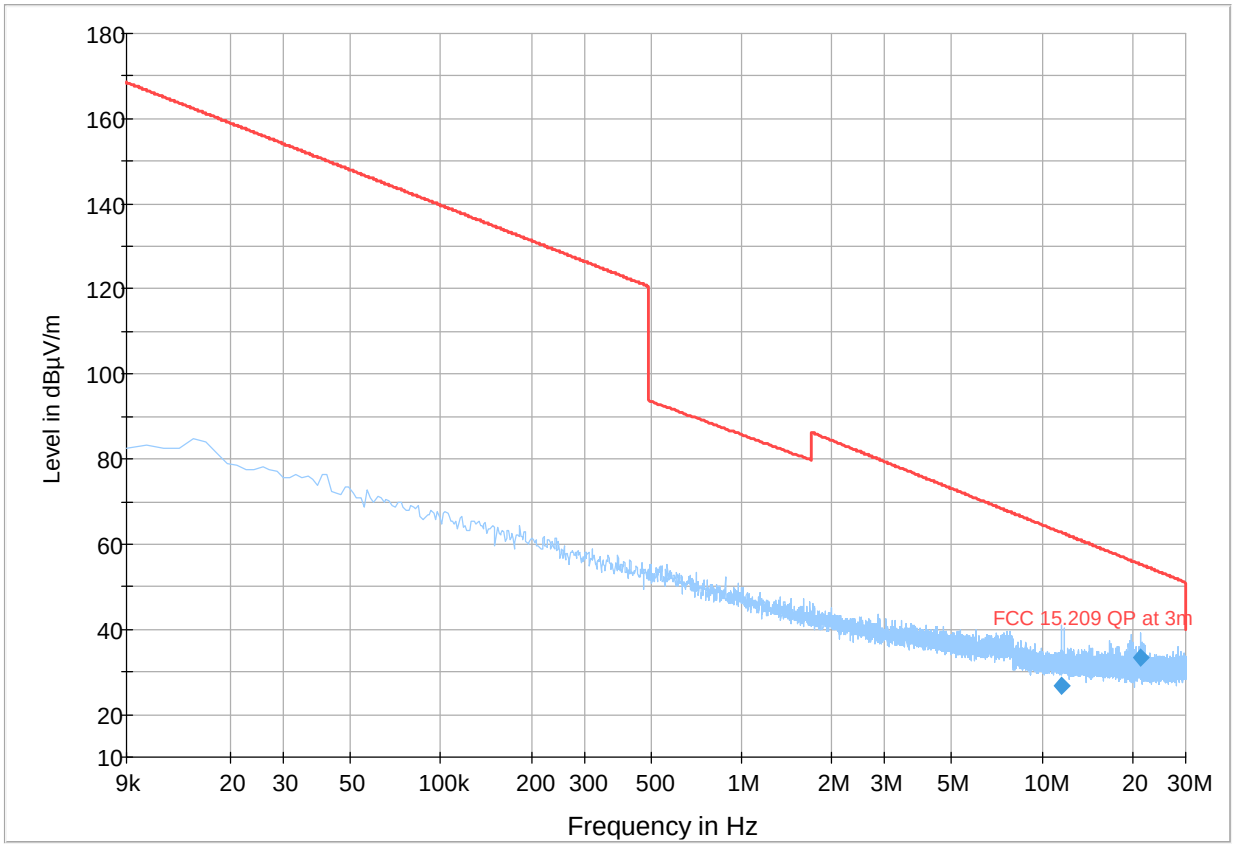
Frequency	MaxPeak (dBµV/m	CAverage	Limit (dBµV/m	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m	Comment
7204.500	---	44.90	53.98	9.08	500.0	1000.000	152.0	V	197.0	-0.6	
7204.500	57.60	---	73.98	16.38	500.0	1000.000	152.0	V	197.0	-0.6	



Plot # 4

BTLE CH 19: 2440 MHz — LE 2 Mbps

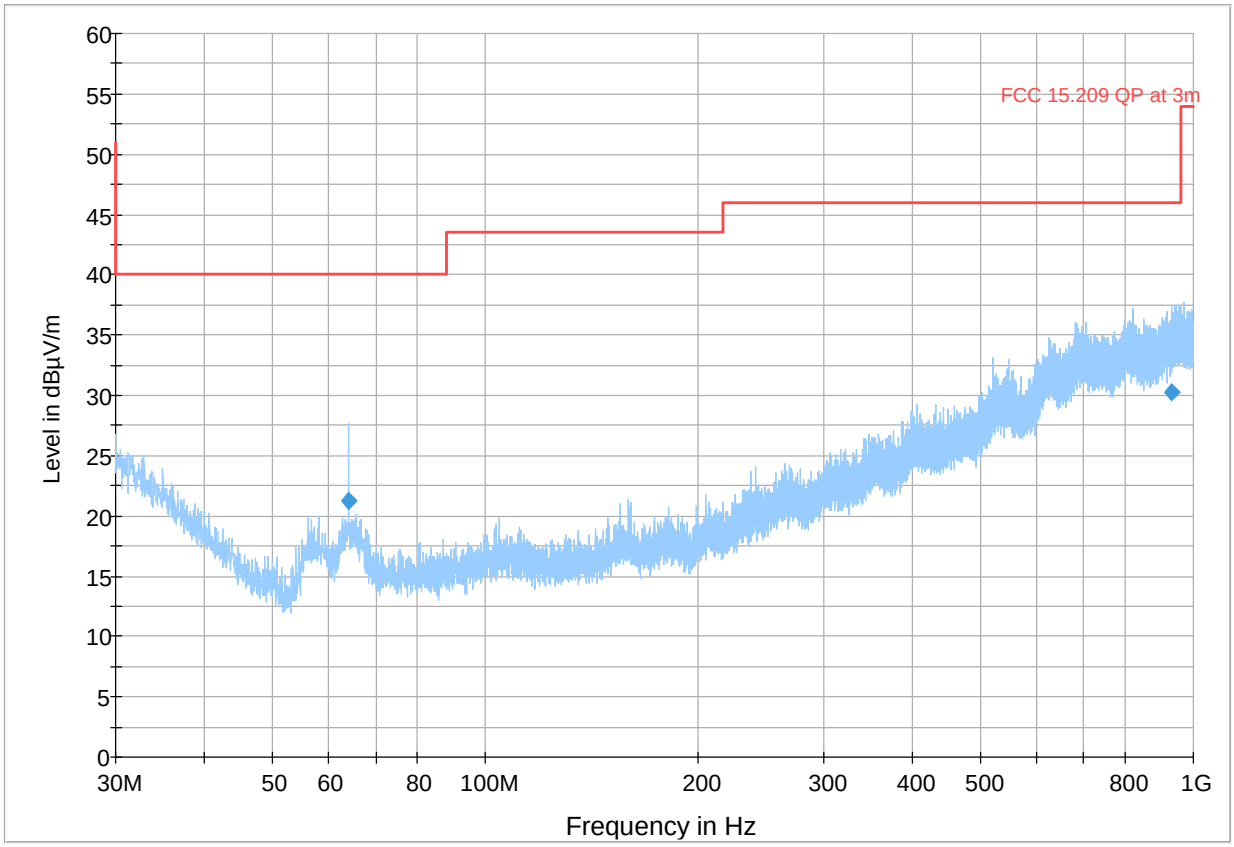
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
11.637	26.74	62.70	35.95	500.0	9.000	163.0	V	55.0	17.4	
21.348	33.50	55.23	21.73	500.0	9.000	140.0	V	183.0	16.7	



Plot # 5

BTLE CH 19: 2440 MHz — LE 2 Mbps

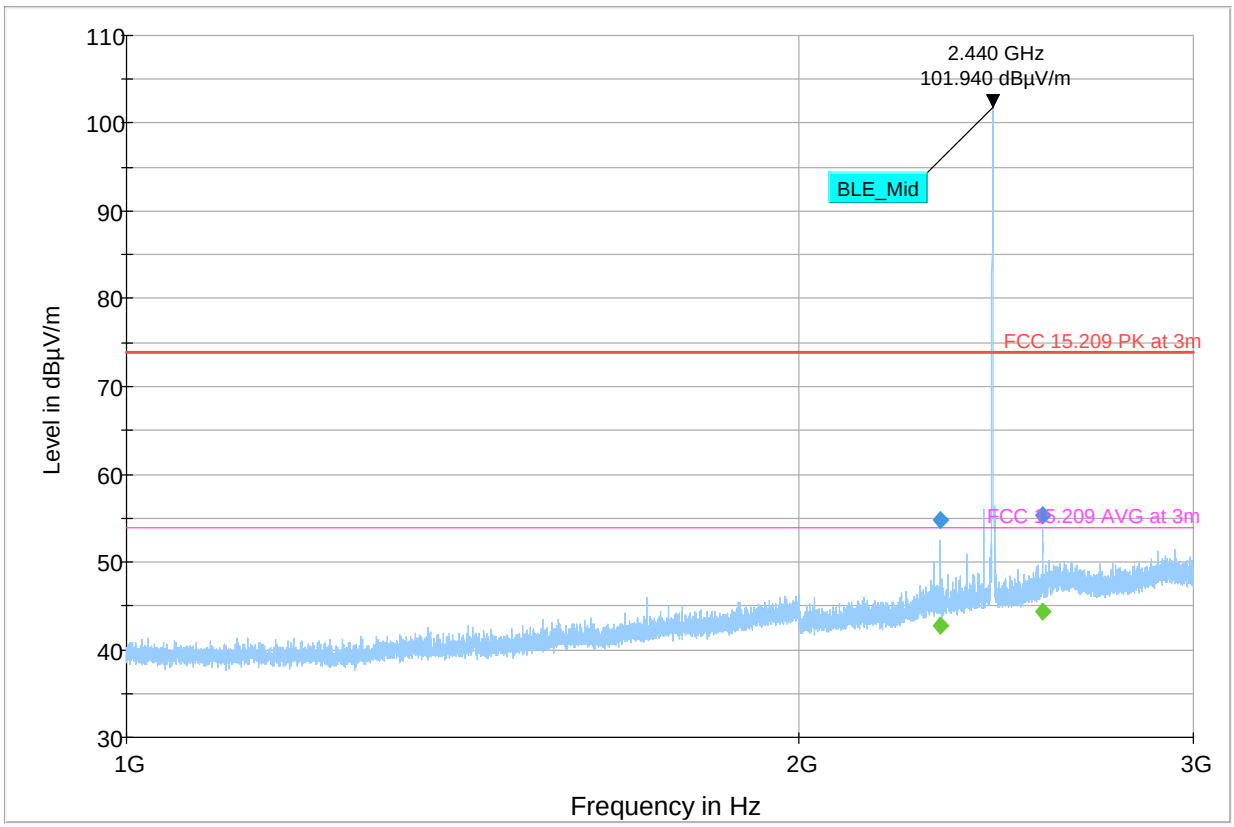
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
63.982	21.27	40.00	18.73	500.0	120.000	183.0	V	15.0	10.8	
932.747	30.30	46.02	15.72	500.0	120.000	292.0	V	308.0	30.4	



Plot # 6

BTLE CH 19: 2440 MHz | **LE 2 Mbps**

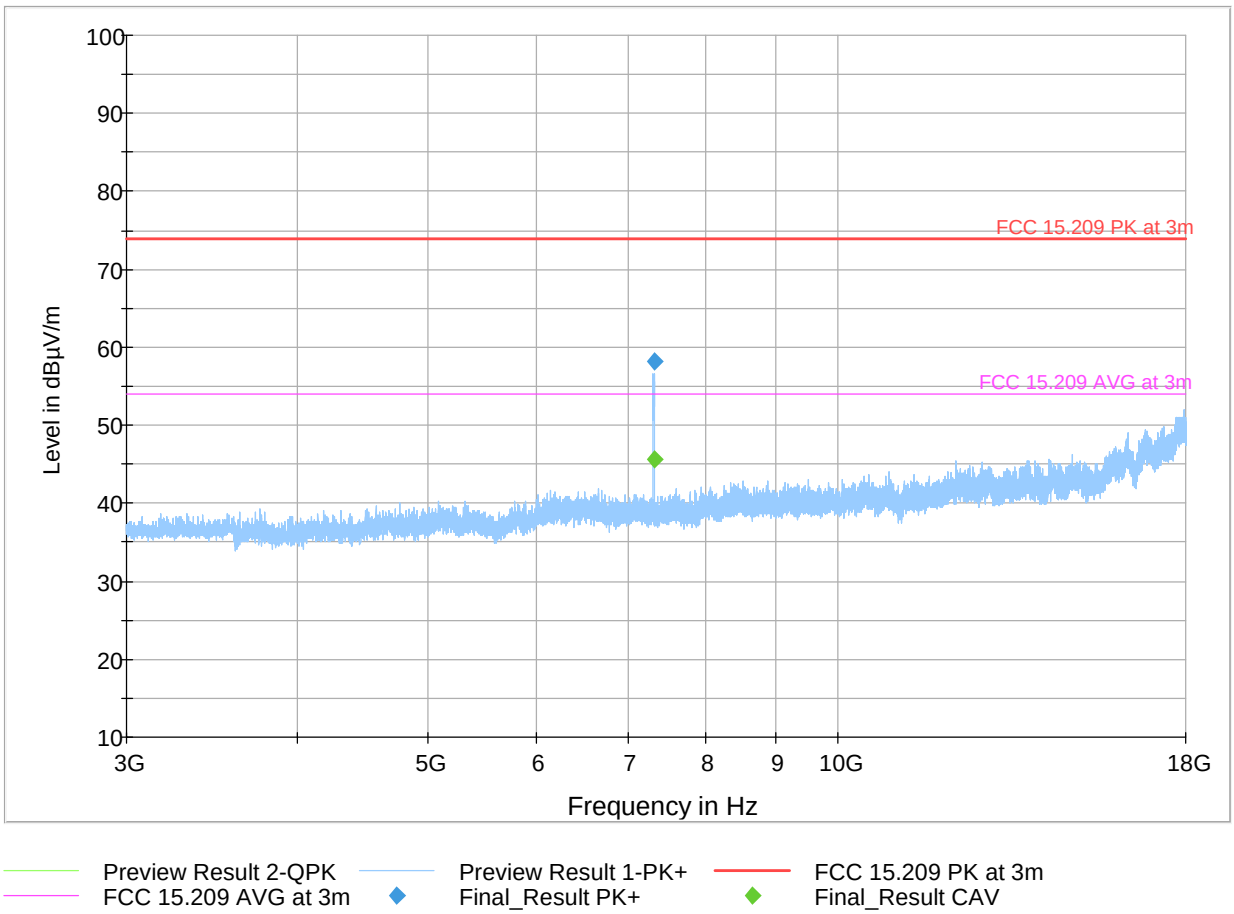
Frequency	MaxPeak (dBµV/m	CAverage	Limit (dBµV/m	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m	Comment
2311.571	54.79	---	73.98	19.19	500.0	1000.000	198.0	H	276.0	9.2	
2311.571	---	42.75	53.98	11.23	500.0	1000.000	198.0	H	276.0	9.2	
2568.143	---	44.34	53.98	9.64	500.0	1000.000	172.0	H	265.0	10.2	
2568.143	55.33	---	73.98	18.65	500.0	1000.000	172.0	H	265.0	10.2	



Plot # 7

BTLE CH 19: 2440 MHz | **LE 2 Mbps**

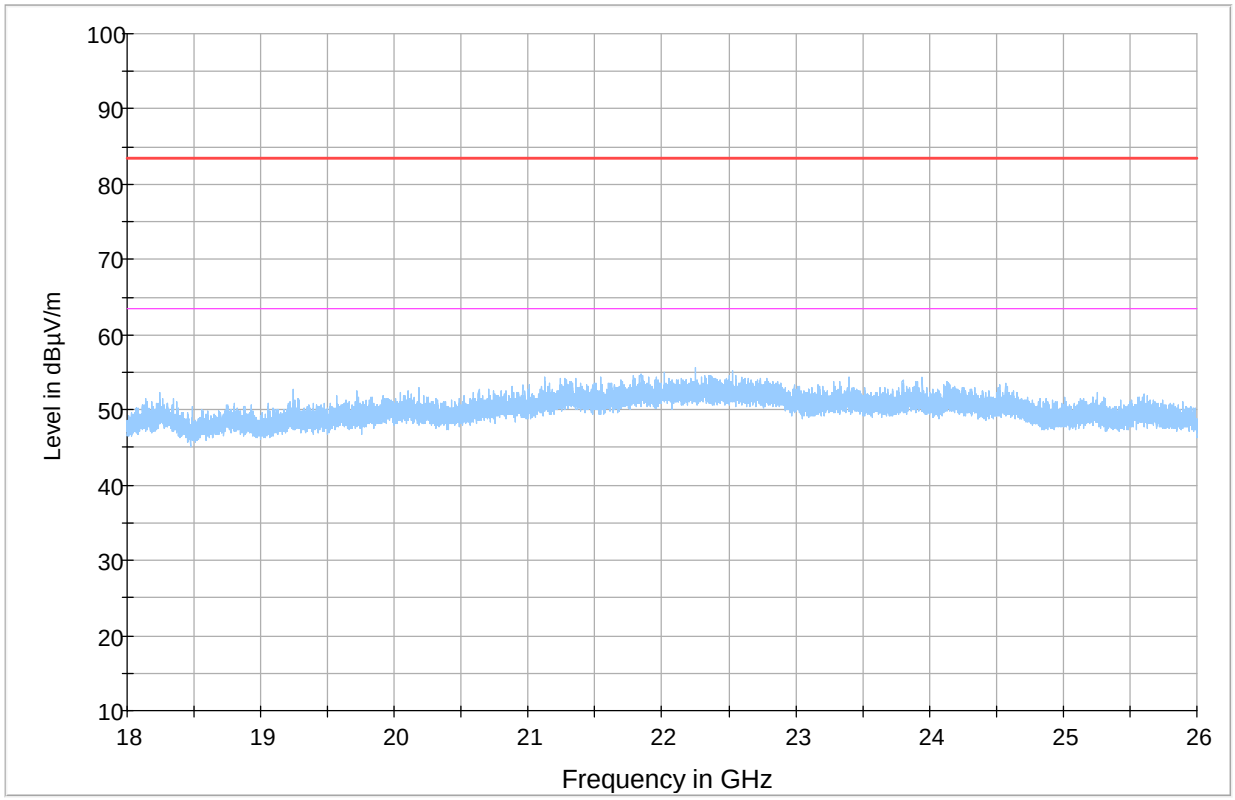
Frequency	MaxPeak (dBµV/m	CAverage	Limit (dBµV/m	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m	Comment
7321.500	---	45.57	53.98	8.41	500.0	1000.000	140.0	V	119.0	-0.5	
7321.500	58.24	---	73.98	15.74	500.0	1000.000	140.0	V	119.0	-0.5	



Plot # 8

BTLE CH 19: 2440 MHz | **LE 2 Mbps**

Frequency	MaxPeak (dBµV/m	CAverage	Limit (dBµV/m	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m	Comment
---	---	---	---	---	---	---	---		---	---	

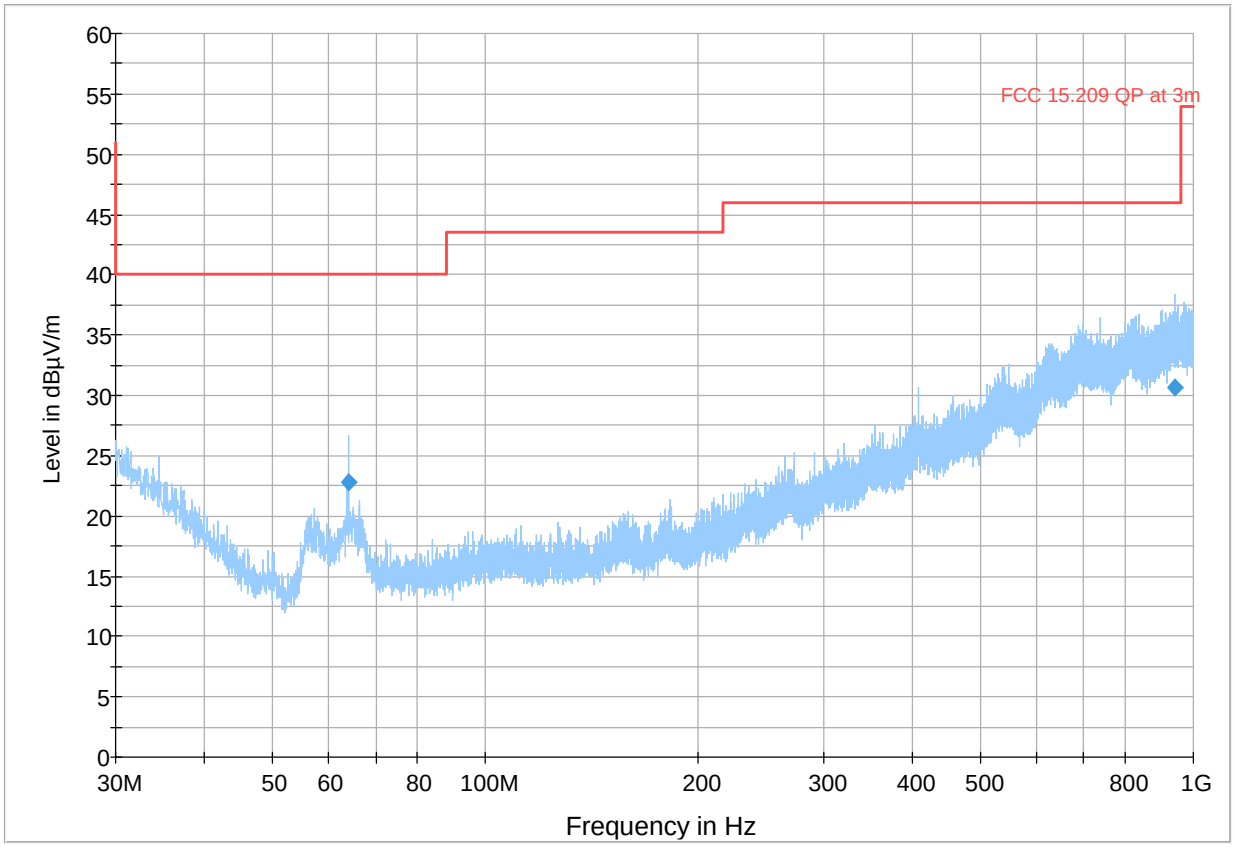


Preview Result 2-AVG
Preview Result 1-PK+
Critical_Freqs AVG
Critical_Freqs PK+
FCC 15.209 PK at 1m
FCC 15.209 AVG at 1m
Final_Result PK+
Final_Result CAV

Plot # 9

BTLE CH 39: 2480 MHz — LE 2 Mbps

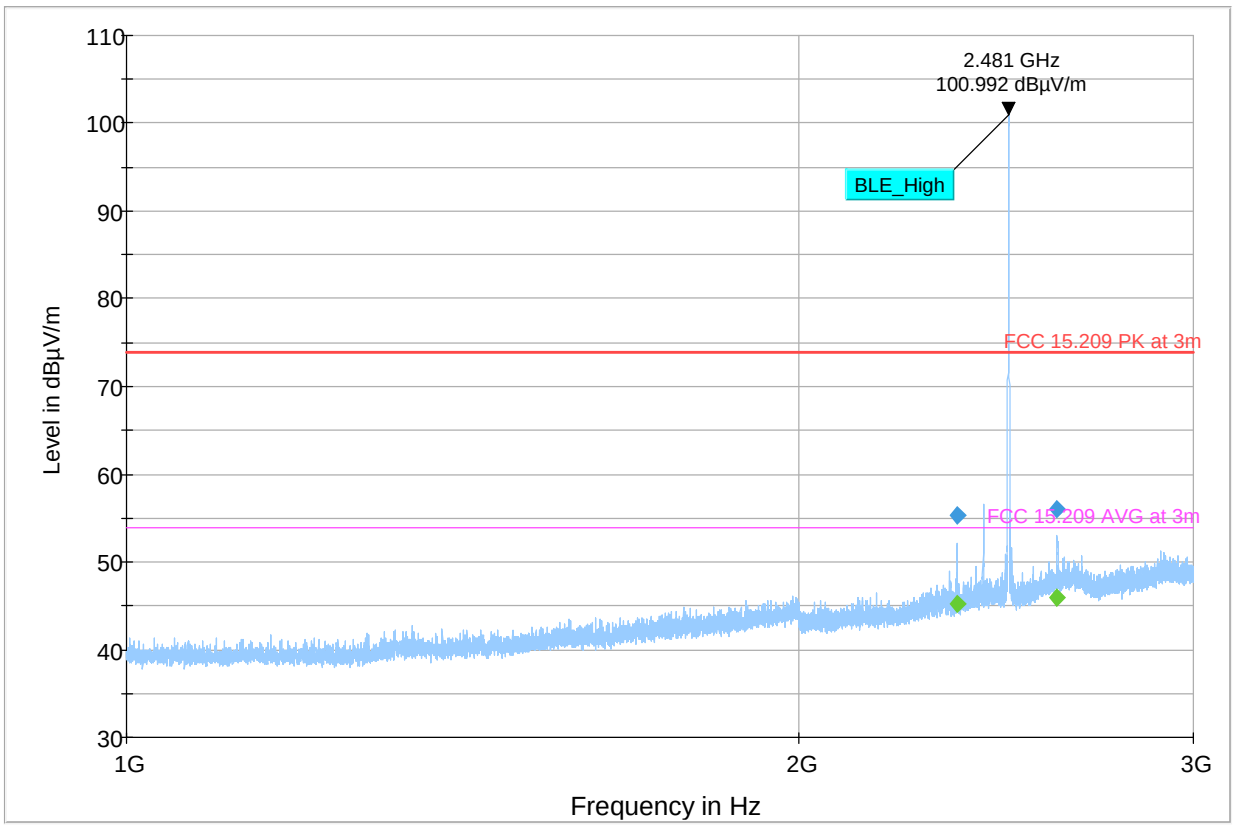
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
63.982	22.73	40.00	17.27	500.0	120.000	140.0	V	201.0	10.8	
940.377	30.68	46.02	15.34	500.0	120.000	152.0	V	341.0	30.7	



Plot # 10

BTLE CH 39: 2480 MHz | LE 2 Mbps

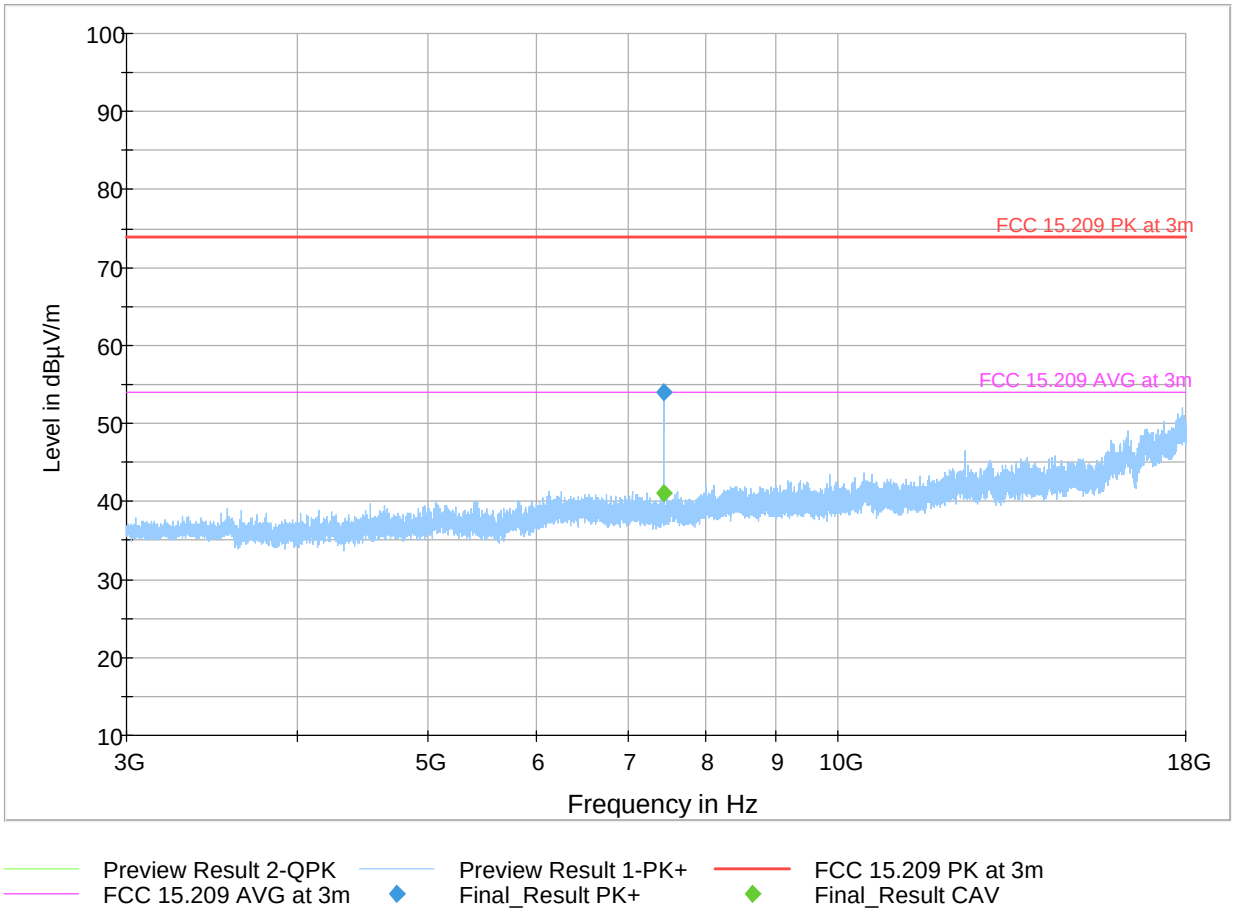
Frequency	MaxPeak (dBµV/m	CAverage	Limit (dBµV/m	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m	Comment
2351.857	55.39	---	73.98	18.59	500.0	1000.000	140.0	H	287.0	9.2	
2351.857	---	45.29	53.98	8.69	500.0	1000.000	140.0	H	287.0	9.2	
2608.000	---	45.93	53.98	8.05	500.0	1000.000	315.0	H	285.0	10.5	
2608.000	56.04	---	73.98	17.94	500.0	1000.000	315.0	H	285.0	10.5	



Plot # 11

BTLE CH 39: 2480 MHz | **LE 2 Mbps**

Frequency	MaxPeak (dBµV/m	CAverage	Limit (dBµV/m	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m	Comment
7441.500	---	41.08	53.98	12.90	500.0	1000.000	173.0	H	207.0	-0.2	
7441.500	54.08	---	73.98	19.90	500.0	1000.000	173.0	H	207.0	-0.2	



9 Test setup photos

Setup photos are included in supporting file name:
"EMC_XIRGO_164_21001_FCC_15.247_BTLE_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Name/Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
Biconilog Antenna	ETS Lindgren	3142E	166067	3 years	03/20/2020
Horn Antenna	ETS Lindgren	3115	35114	3 years	10/10/2020
Horn Antenna	ETS Lindgren	3117-PA	215984	3 years	08/08/2020
Active Loop Antenna	ETS Lindgren	6507	161344	3 years	10/30/2020
Horn Antenna	ETS Lindgren	3116C	70497	3 years	11/23/2020
Spectrum Analyzer	R&S	ESU40	100251	3 years	07/16/2019
Spectrum Analyzer	R&S	FSU26	200065	3 years	07/03/2020
Thermometer Humidity Monitor	Dickson	TM320	5280063	3 years	11/02/2020

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	Report Name	Changes to report	Prepared by
2021-07-26	EMC_XIRGO_164_21001_FCC_15.247_BTLE	Initial Version	Cheng Song

<<< The End >>>