FCC / ISED Test Report

For:
Compology Inc.

Model #:
SC01

Product Description:
Industrial container asset tracker/monitor.

FCC ID: 2AO44-SC01
IC ID: 23661-SC01

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

REPORT #: EMC_COMPO_017_20001_FCC_15.247_ISED_BLE_DTS

DATE: 6/29/2020

A2LA Accredited

IC recognized # 3462B-2

***CETECOM* Inc.**
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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.

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

Company	Description	Model #
Compology Inc.	Compology-SC01 Industrial container asset tracker/monitor.	SC01

Responsible for Testing Laboratory:

Date	Section	Name	Signature
6/29/2020	Compliance	Li, Cindy (EMC Lab Manager)	Cindy Li Digitally signed by cindy.li@cetecom.com DN: CN=cindy.li@cetecom.com Reason: I am approving this document Location: Date: 2020-07-01 12:22:38

Responsible for the Report:

Date	Section	Name	Signature
6/29/2020	Compliance	Ghanma, Issa (EMC Engineer)	Digitally signed by: Issa W Ghanma DN: CN = Issa W Ghanma email = issaghanma@cetecom.com C = US O = CETECOM Inc. OU = EMC Date: 2020.07.01 11:48:36 -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:	Li, Cindy
Responsible Project Leader:	Baskaran, Akanksha

2.2 Identification of the Client

Applicant's Name:	Compology Inc.
Street Address:	1045 Bryant Street, Suite 101
City/Zip Code	San Francisco, CA 94103
Country	USA

2.3 Identification of the Manufacturer

Manufacturer's Name:	AQS
Manufacturers Address:	47817 Fremont Blvd
City/Zip Code	Fremont, CA 94538
Country	USA

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No:	SC01
Product name:	SC01 SkyCamera.
FCC-ID :	2AO44-SC01
IC-ID:	23661-SC01
HW Version :	Rev04
SW Version :	Newman-0004
HVIN:	SC01
PMN:	SC01
FVIN:	newman-0004
HMN:	SC01
Product Description:	Industrial container asset tracker/monitor.
Radio information*1:	❖ BLE (transceiver): • Module name/number : Nordic nRF52840-QIAA-R7 • Max output power : +8 dBm • Modulation : GFSK • Frequencies : 2400 – 2483.5 MHz • Channel numbers : 0 – 39 • Bandwidth : 2 MHz • Antenna : Custom Micro-strip.
Antenna Information as declared:	Peak realized Gain: 2.04 dBi
Max. Measured Conducted Output Power:	7.6 dBm
Power Supply/ Rated Operating Voltage Range:	Low 2.5 V DC, Nominal 3.6 V DC, High 3.9 V DC

Operating Temperature Range:	Low -40º C, Nominal 20º C, High +85º C
Other Radios included in the device*1:	❖ NFC (transceiver): • Max output power : Set by reader • Modulation : ASK • Frequencies : 13.553 – 13.567 MHz • Channel numbers : N / A • Bandwidth : 14 KHz • Antenna : Custom FPC trace.
Sample Revision:	☐ Prototype Unit; ☐ Production Unit; ■ Pre-Production
Product dimensions [Inch]:	9 (H) x 3.625 (W) x 2.75 (D)

***1:** Client declared the device firmware prohibits simultaneous transmission between any of the transceivers.

3.2 EUT Sample details

EUT #	Device ID	HW Version	SW Version	Notes/Comments
1	SKYCAM02860020CF995B	Rev04	newman-0004	Conducted measurement
2	SKYCAM02860020C529F0	Rev04	newman-0004	Radiated measurement

3.3 Accessory Equipment (AE) details

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

❖ **Client declared:** There are no accessories provided with the device, only mounting hardware.

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	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	BLE	❖ Putty terminal used to communicate with the device, and sending commands provided by client, that will not be available to end-user, to configure the BLE radio: ▪ Maximum output power. ▪ Continuous transmission. ▪ Modulated signal. ▪ Switch between supported data rates: 250 Kbps, or 1 Mbps ▪ Select Tx channel(s): Low (0), Mid (19) and High (39)

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 highest possible duty cycle and output power.

For radiated measurements;

- All data in this report show the worst case of BLE radio, transmitting at the highest output power.
- 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 FCC ID: 2AO44-SC01 IC ID: 23661-SC01

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	BLE	■	☐	☐	Complies
§15.247(e) RSS-247 5.2(b)	Power Spectral Density	Nominal	BLE	■	☐	☐	Complies
§15.247(b)(1) RSS-247 5.4(d)	Maximum Conducted Output Power and EIRP	Nominal	BLE	■	☐	☐	Complies
§15.247(d) RSS-247 5.5	Band edge compliance Unrestricted Band Edges	Nominal	BLE	■	☐	☐	Complies
§15.247; 15.209; 15.205 RSS-Gen 8.9; 8.10	Band edge compliance Restricted Band Edges	Nominal	BLE	■	☐	☐	Complies
§15.247(d); §15.209 RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	BLE	■	☐	☐	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal	N/A	☐	■	☐	See note1 See note 2

Note1: NA= Not Applicable; NP= Not Performed.
Note2: This device is powered by internal 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 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:

5/29/2020 – 6/2/2020

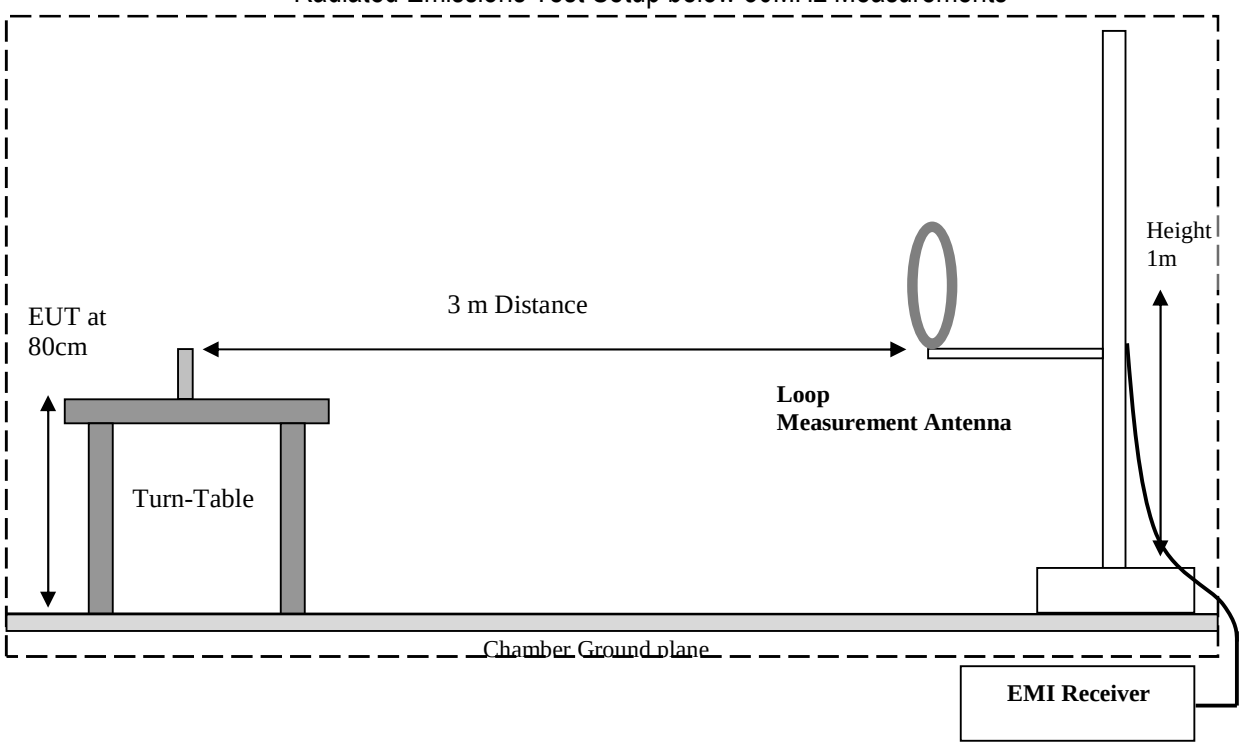
7 Measurement Procedures

7.1 Radiated Measurement

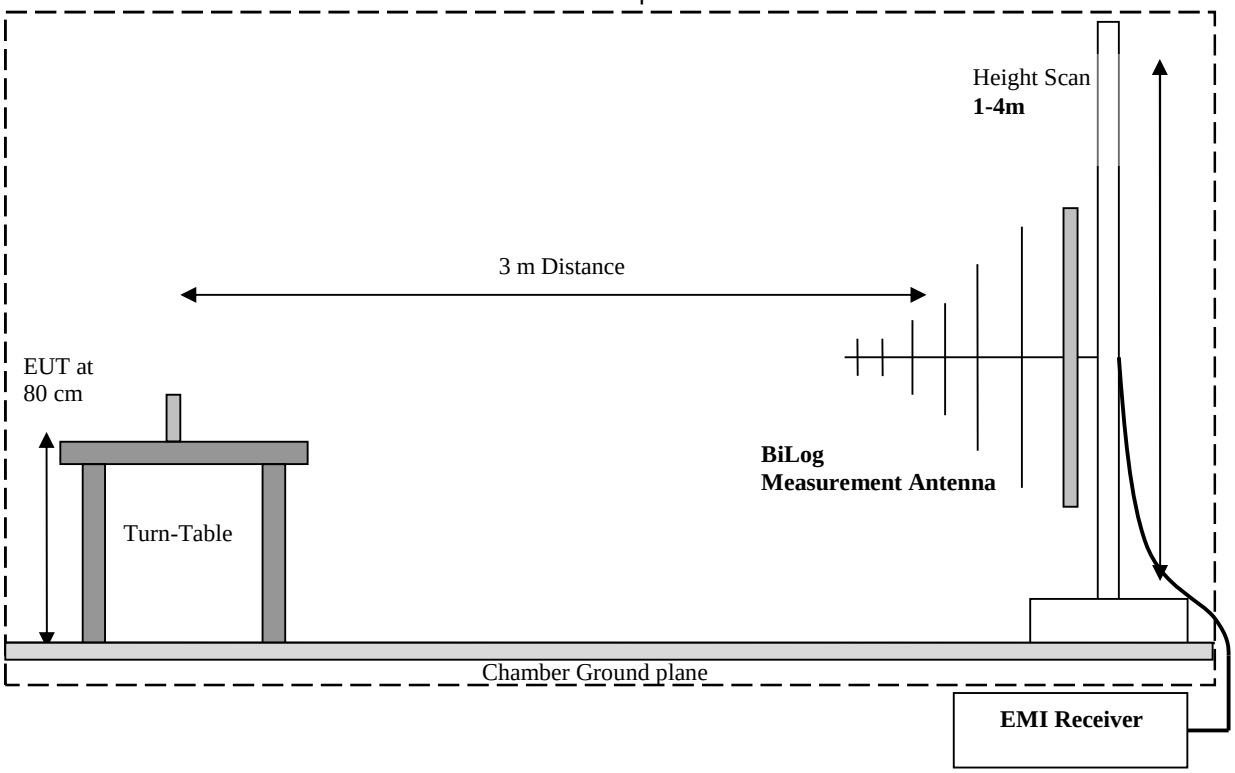
The radiated measurement is performed according to ANSI C63.10 (2013)

- 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 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.

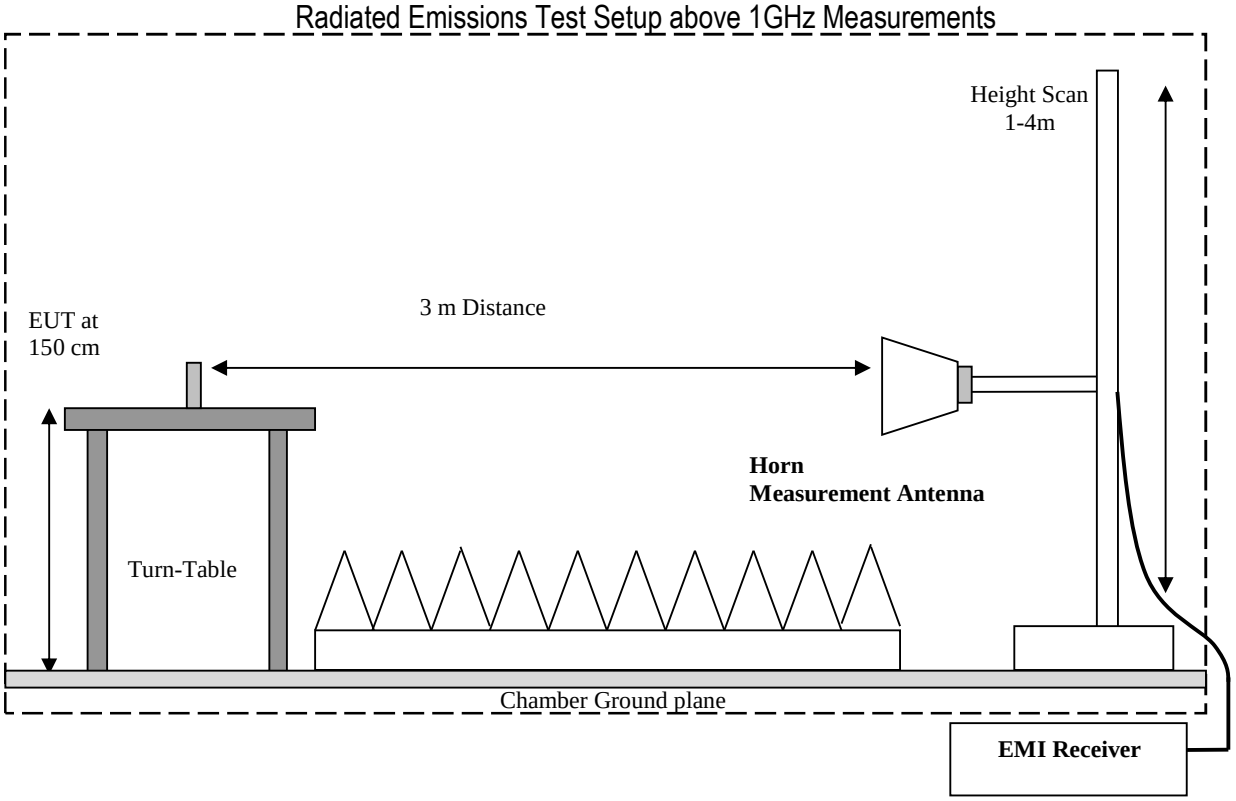
Radiated Emissions Test Setup below 30MHz Measurements



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:

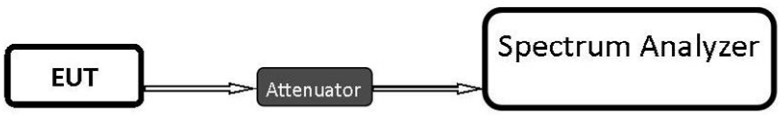
FS (dBµV/m) = Measured Value on SA (dBµV) + Cable Loss (dB) + Antenna Factor (dB/m)

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 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 FCC 558074 D01 15.247 Meas Guidance v05r02;

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 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:

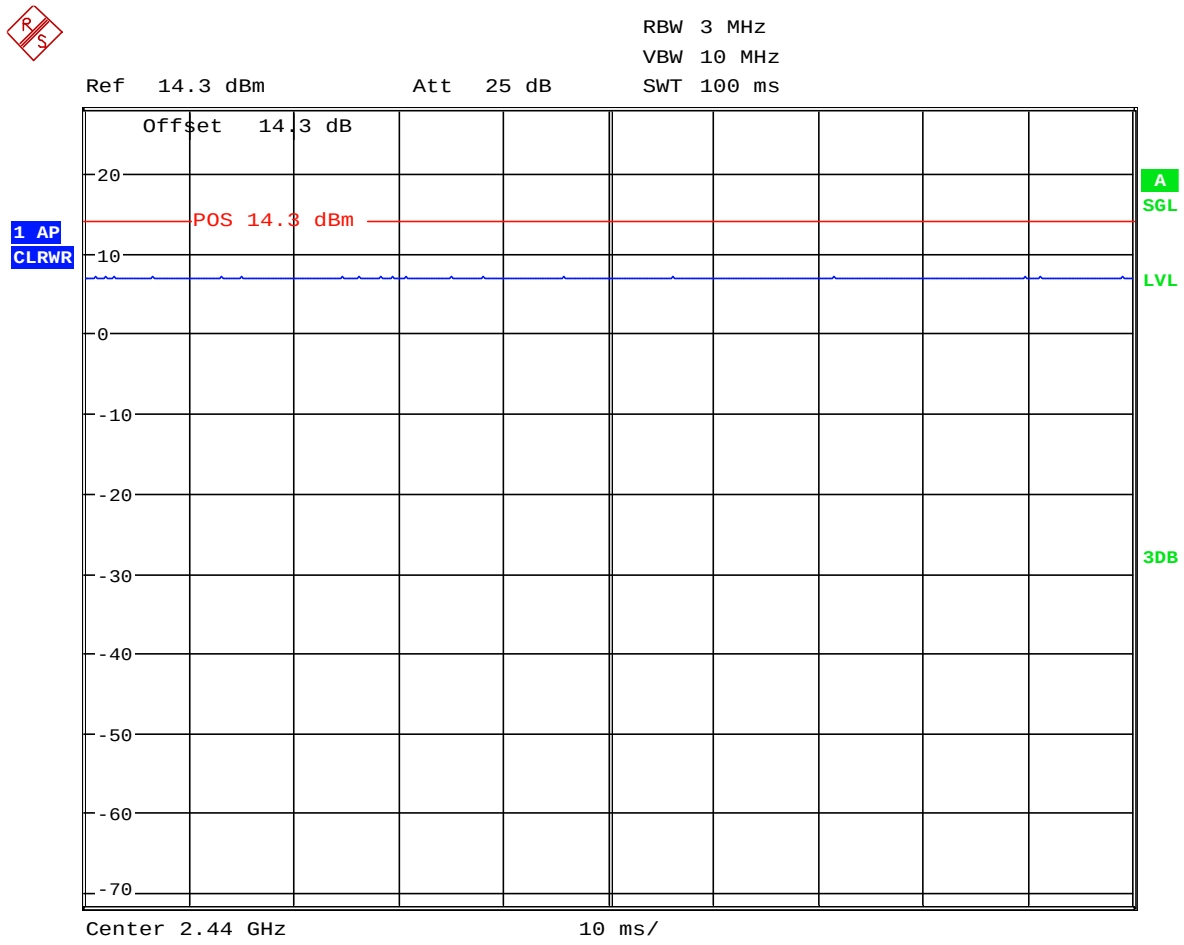
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23.8°C	1	Op.1	3.6 V DC

8.1.3 Measurement result:

Plot #	Mode	TX Frequency	Data Rate	Duty cycle
1	BLE	2440 MHz	250 Kbps	≥ 98.00 %
2	BLE	2440 MHz	1 Mbps	≥ 98.00 %

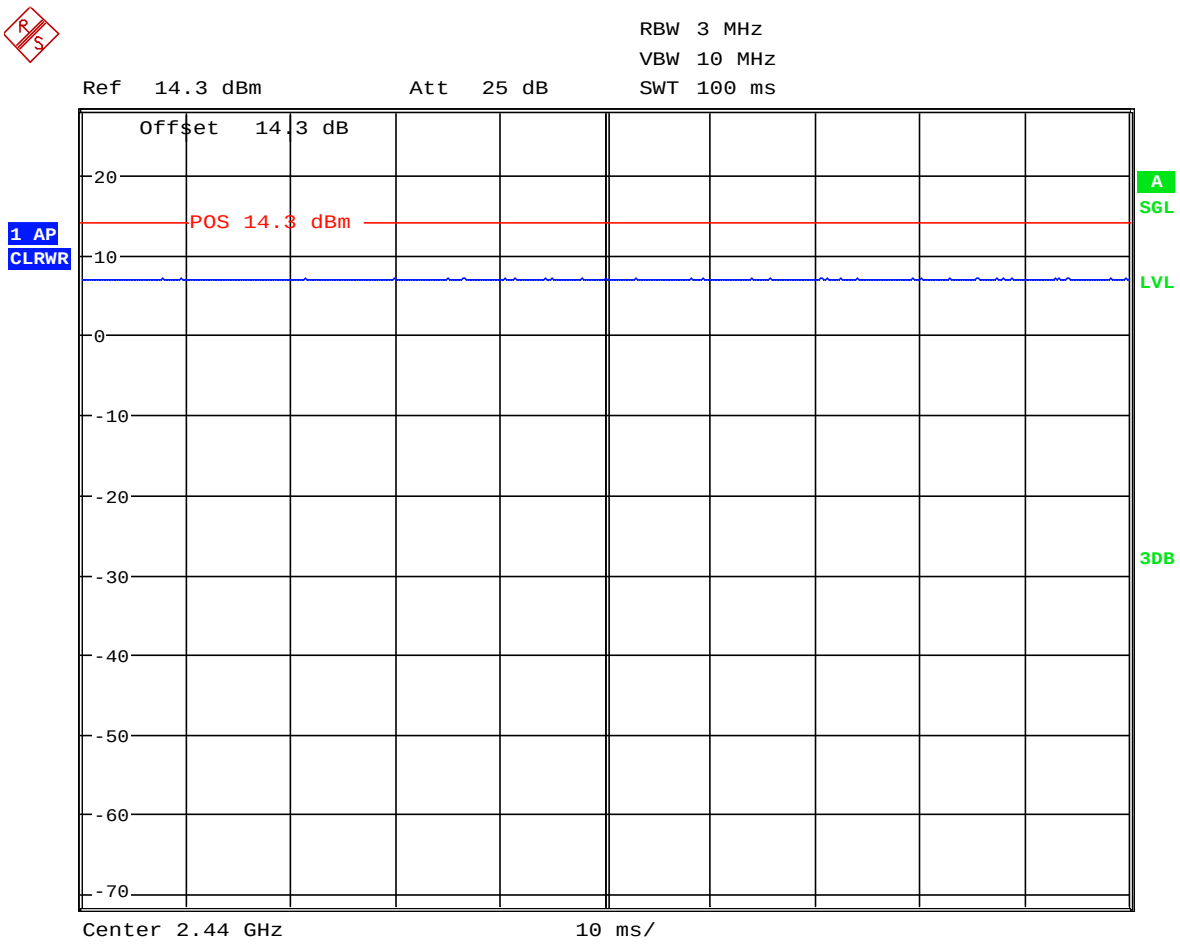
8.1.4 Measurement plots:

Plot # 1		
Tx Frequency: 2440 MHz	**Mode: BLE**	**Data rate: 250 Kbps**



Plot # 2

Tx Frequency: 2440 MHz	Mode: BLE	Data rate: 1 Mbps



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8.2 Emission Bandwidth 6dB and 99% Occupied Bandwidth

8.2.1 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.

8.2.2 Limits:

FCC §15.247(a)(1) and RSS-247 5.2(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	3.6 V DC

8.2.4 Measurement result:

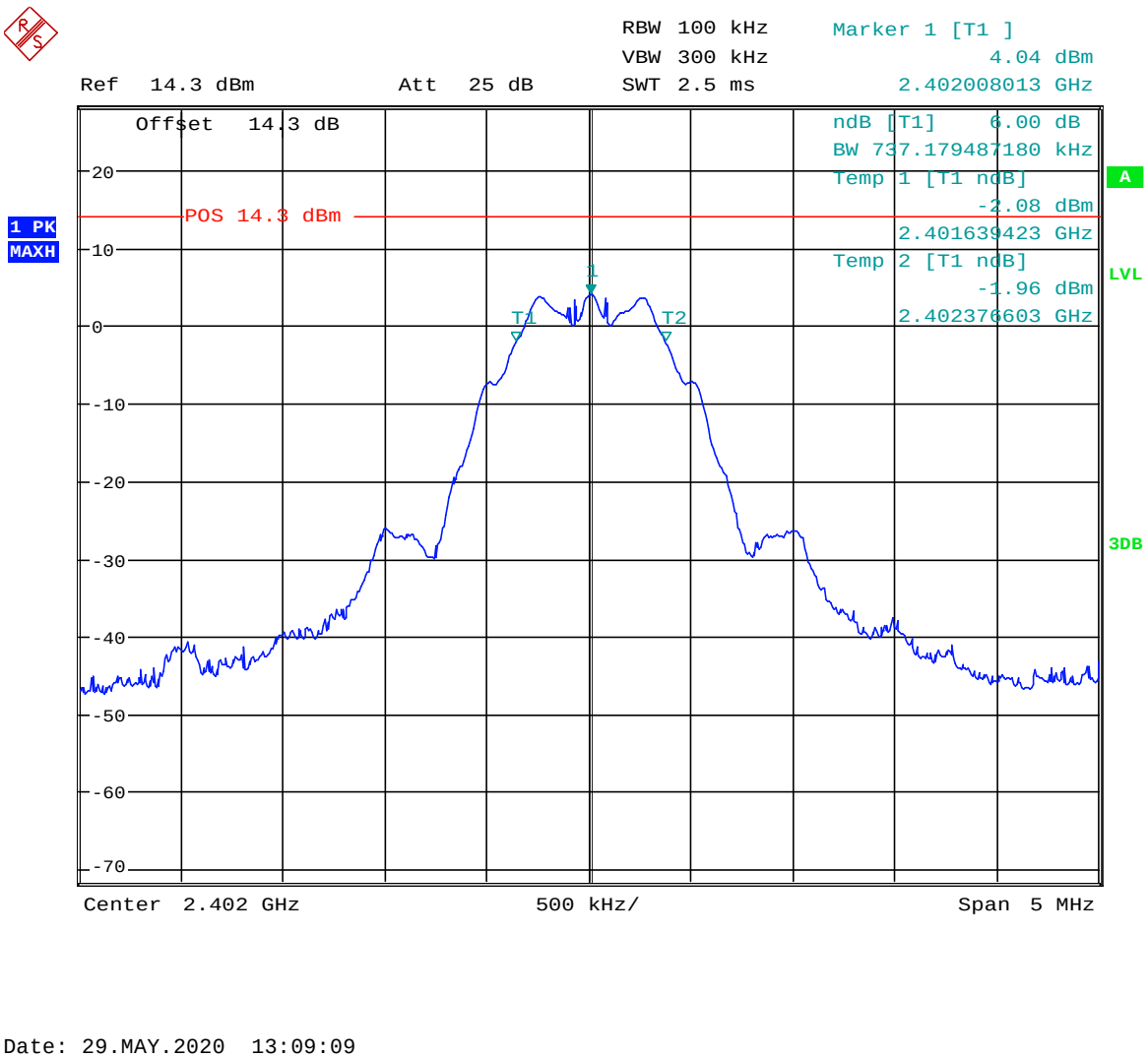
Plot #	Frequency (MHz)	Data rate	6dB Emission Bandwidth (MHz)	Limit (MHz)	Result
5	2402	250 Kbps	0.74	> 0.5	Pass
6	2442		0.74	> 0.5	Pass
7	2480		0.74	> 0.5	Pass
8	2402	1 Mbps	0.72	> 0.5	Pass
9	2442		0.72	> 0.5	Pass
10	2480		0.72	> 0.5	Pass

Plot #	Frequency (MHz)	Data rate	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
11	2402	250 Kbps	1.07	> 0.5	Pass
12	2440		1.07	> 0.5	Pass
13	2480		1.09	> 0.5	Pass
14	2402	1 Mbps	1.08	> 0.5	Pass
15	2442		1.07	> 0.5	Pass
16	2480		1.09	> 0.5	Pass

8.2.5 Measurement Plots:

6 dB Emission Bandwidth

Plot # 3		
Tx Frequency: 2402 MHz	**Mode: BLE**	**Data rate: 250 Kbps**



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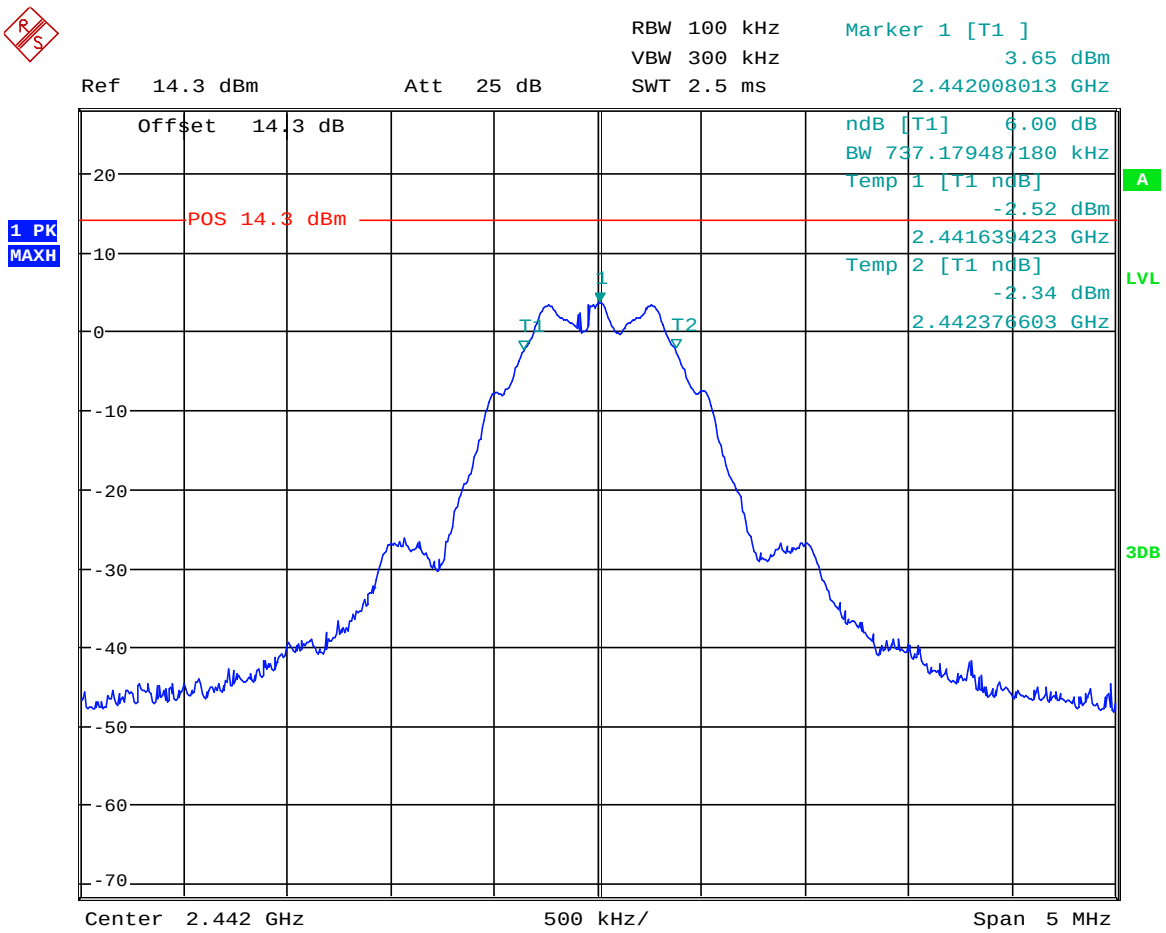
Plot # 4

Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 250 Kbps



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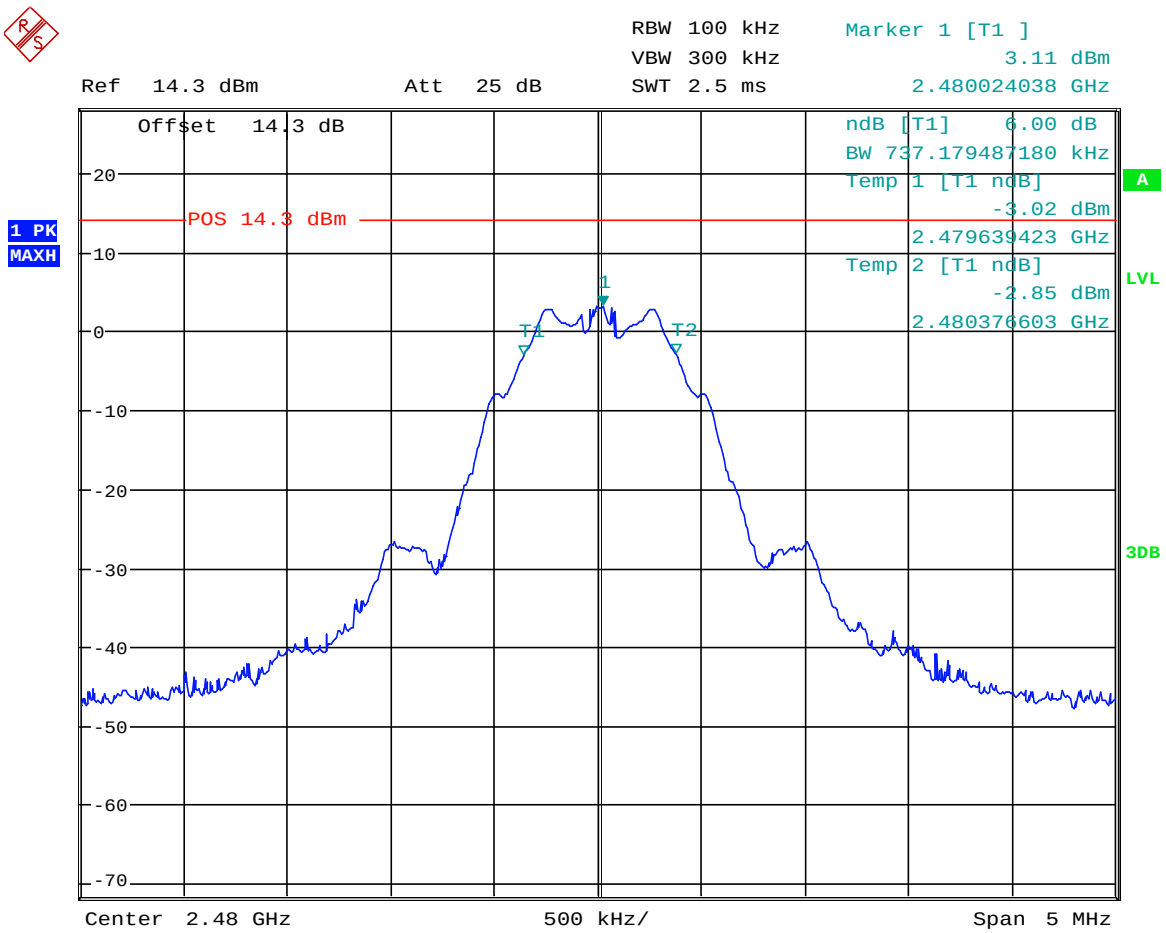
Plot # 5

Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 250 Kbps



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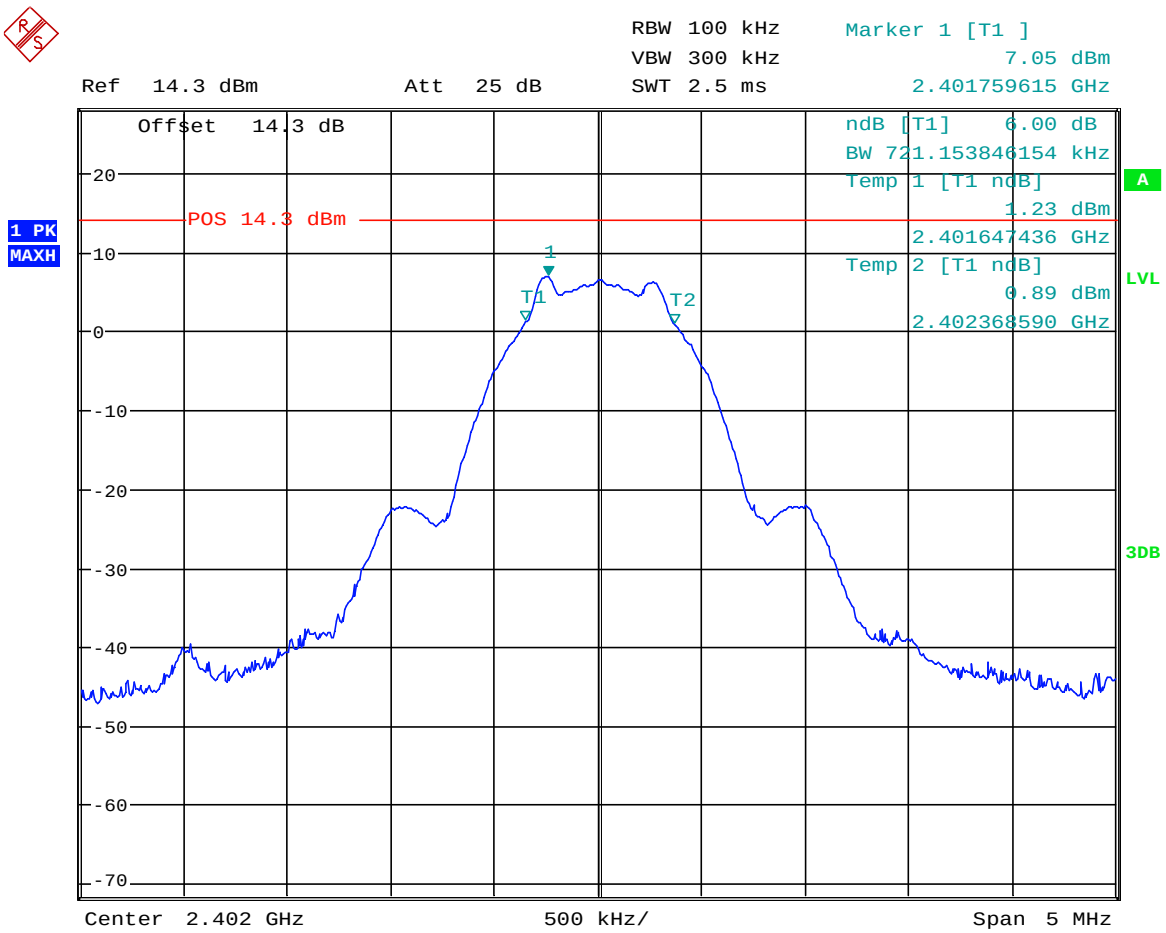
Plot # 6

Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 1 Mbps



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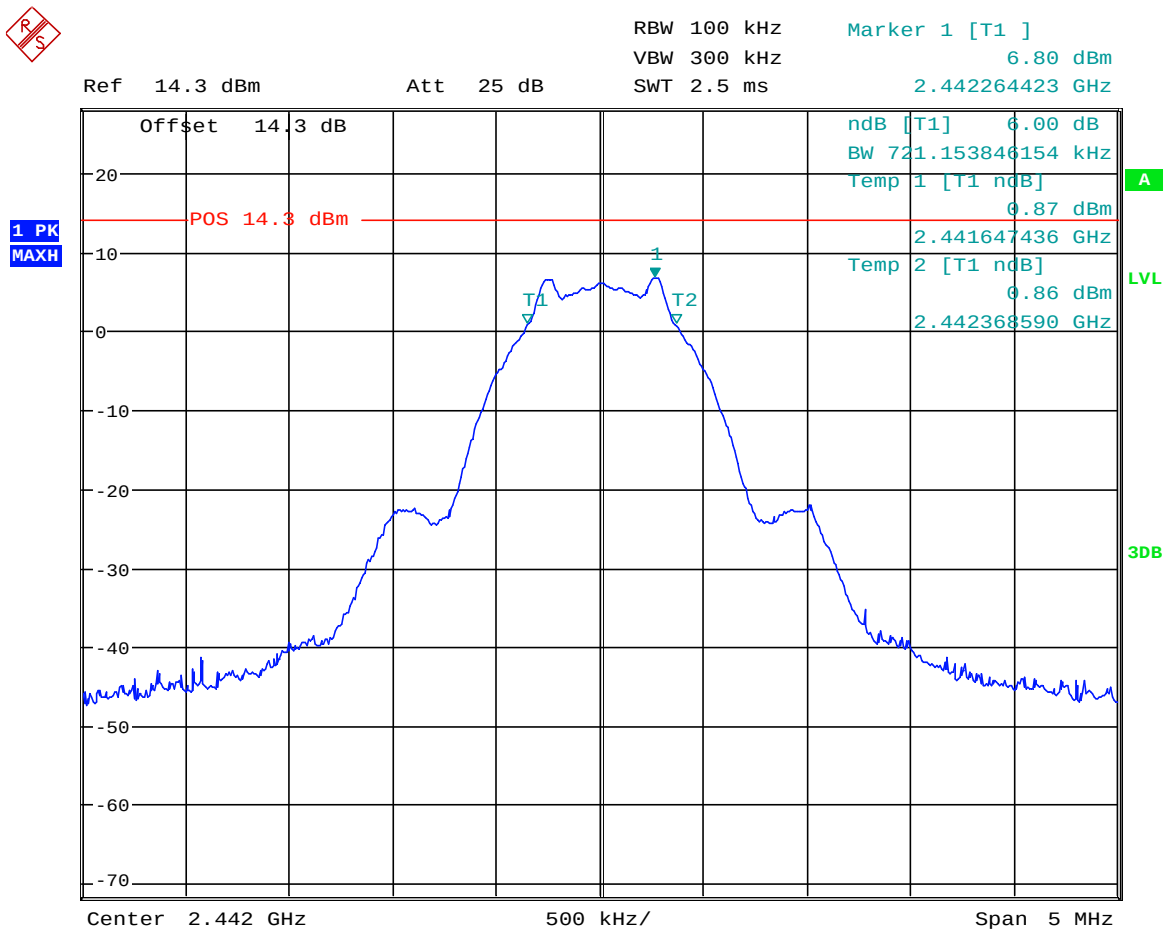
Plot # 7

Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 1 Mbps



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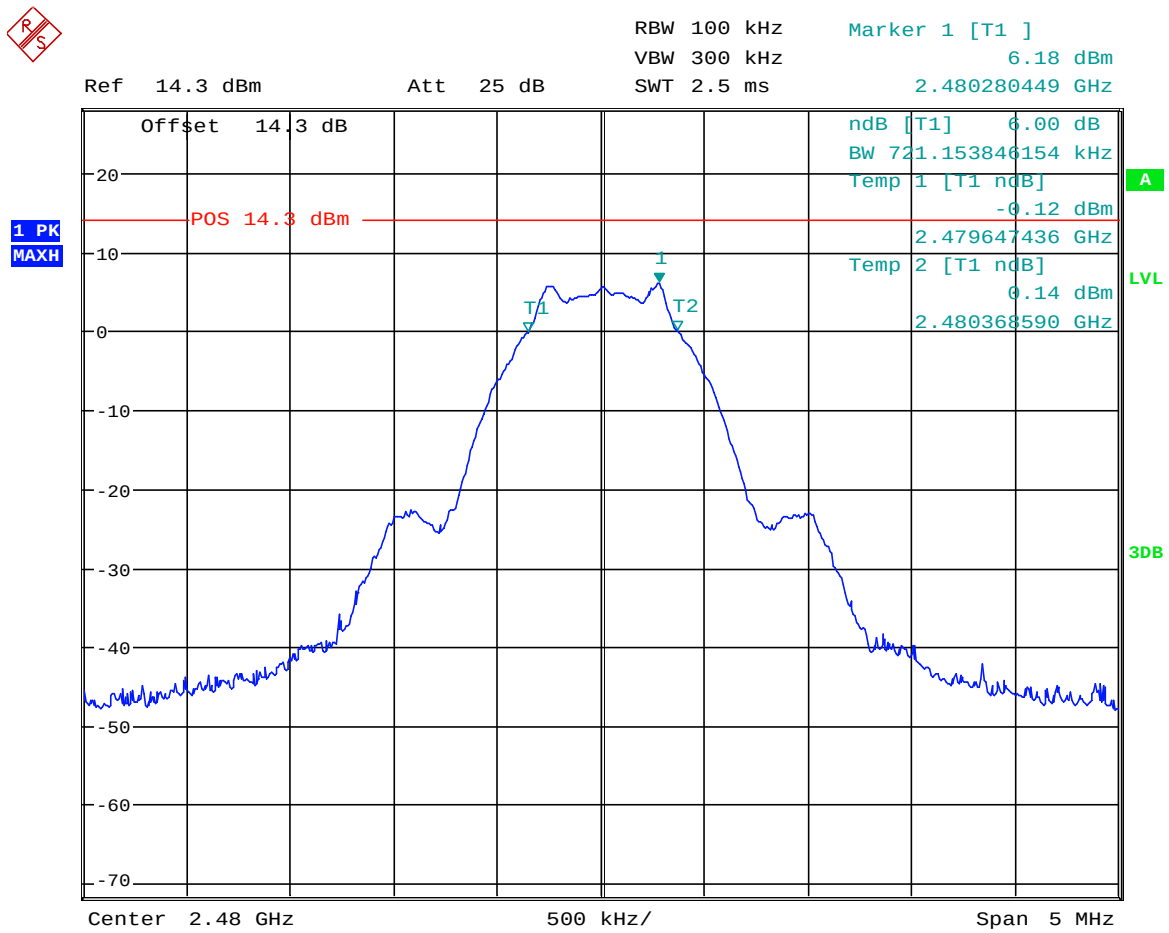
Plot # 8

Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 1 Mbps



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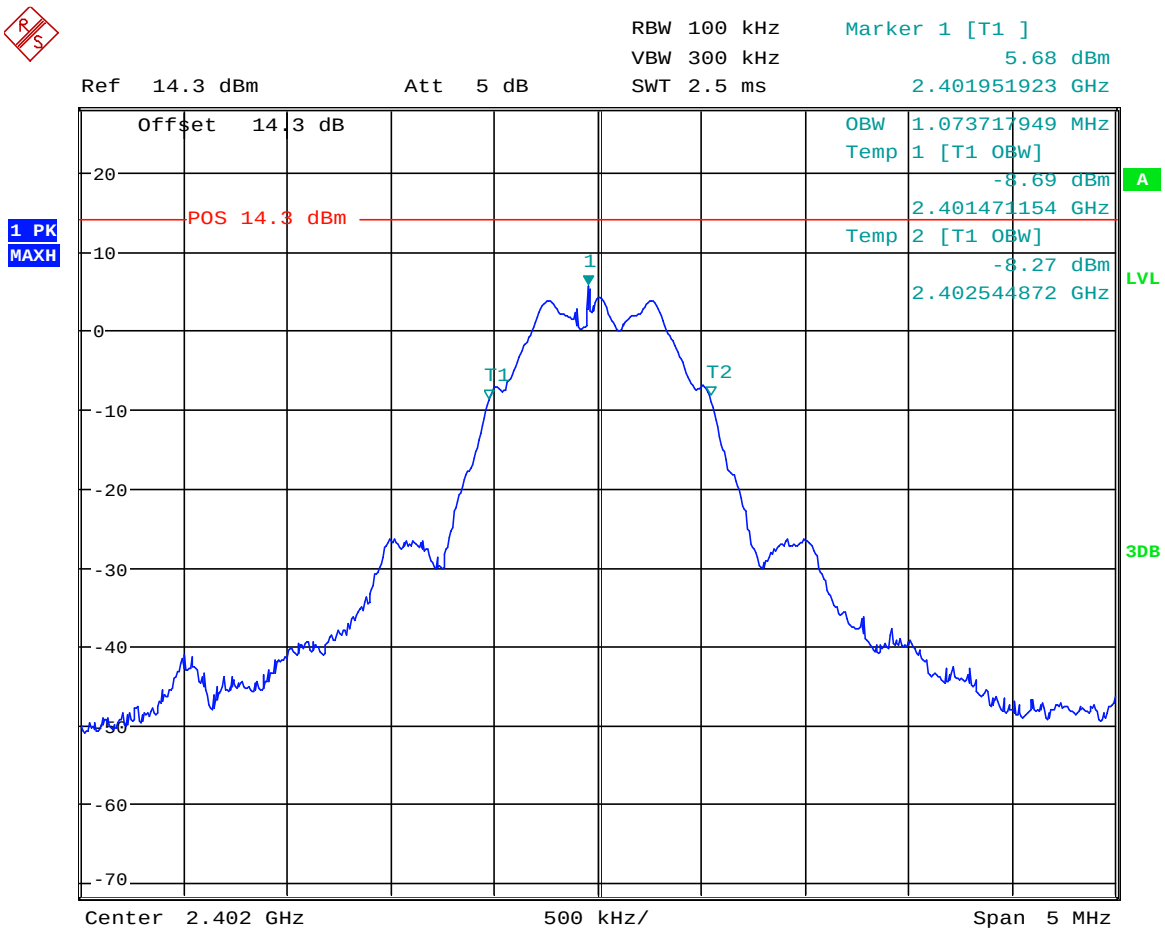
99% Occupied Bandwidth

Plot # 9		
Tx Frequency: 2402 MHz	**Mode: BLE**	**Data rate: 250 Kbps**



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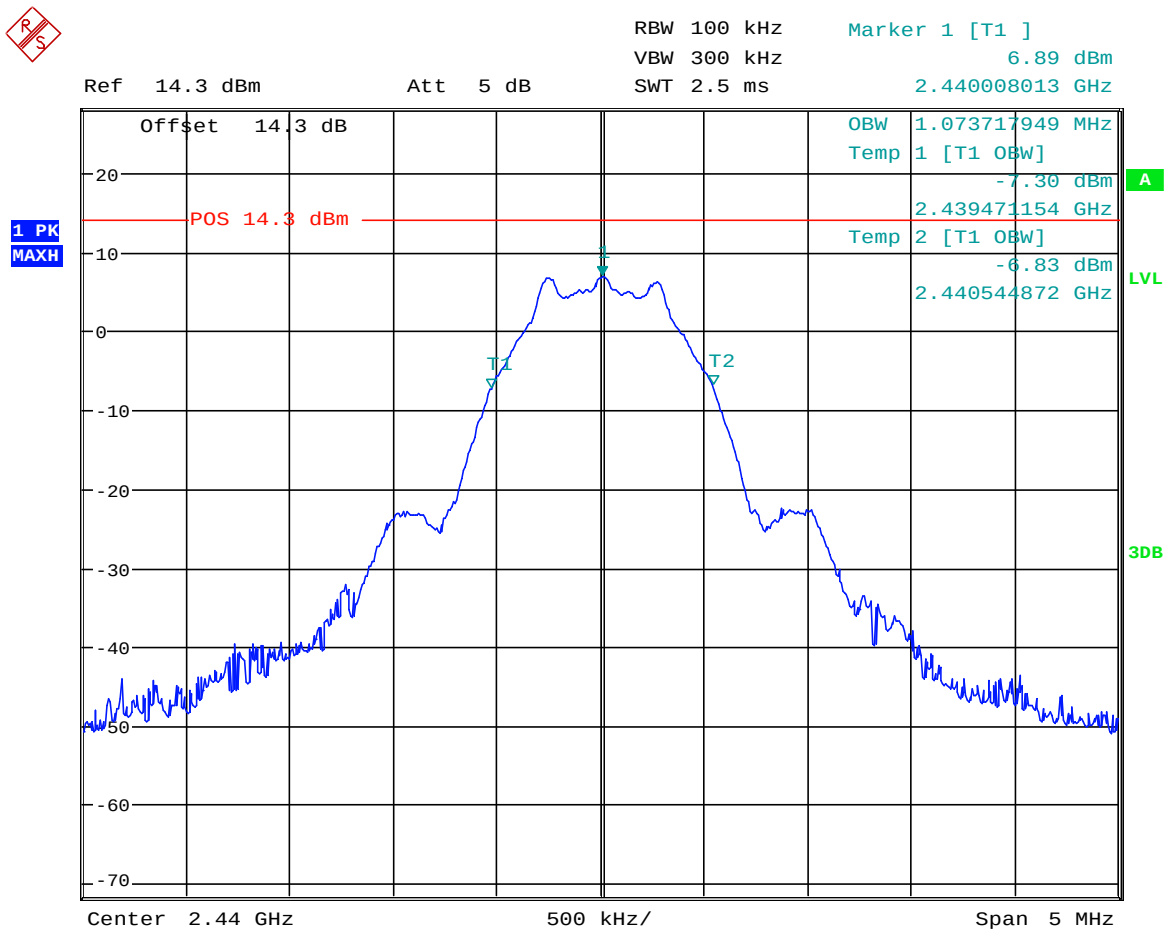
Plot # 10

Tx Frequency: 2440 MHz	Mode: BLE	Data rate: 250 Kbps



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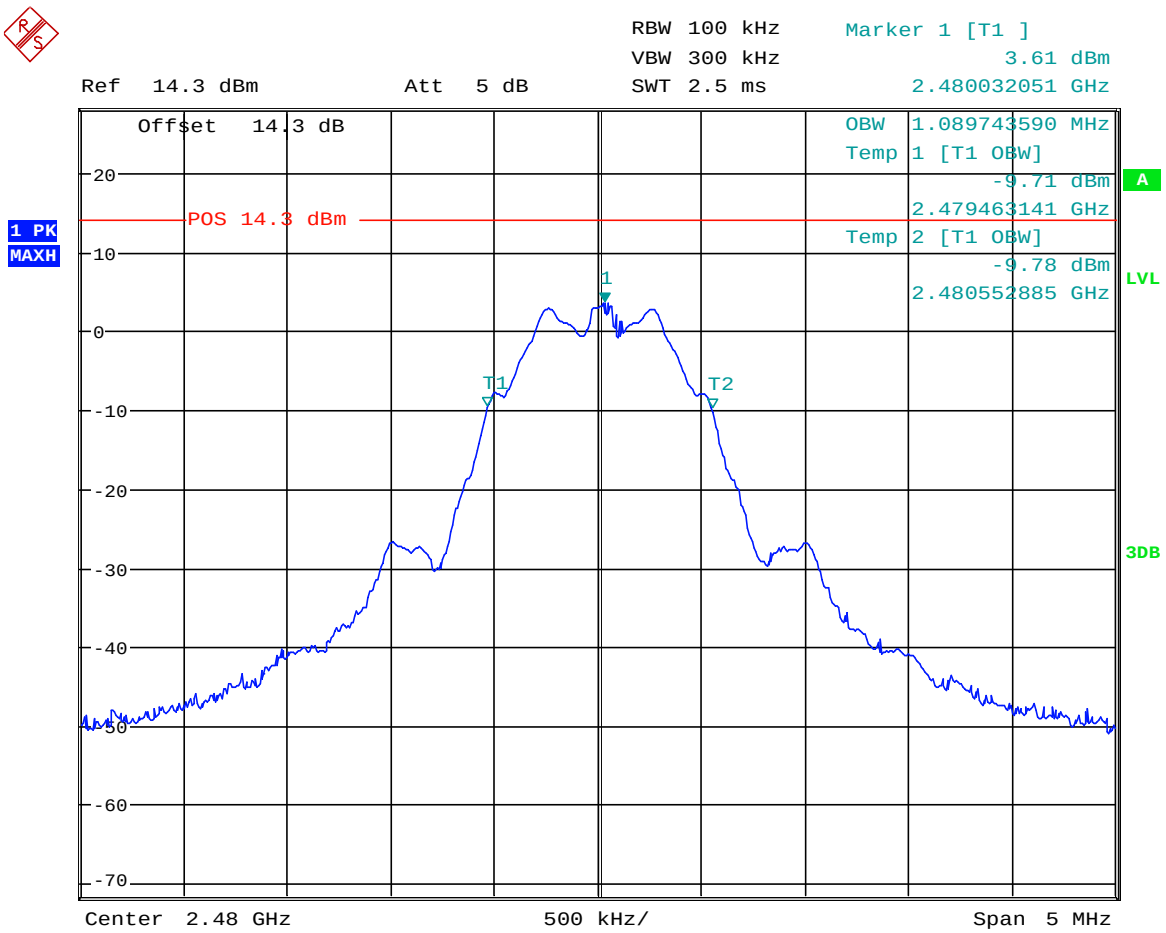
Plot # 11

Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 250 Kbps



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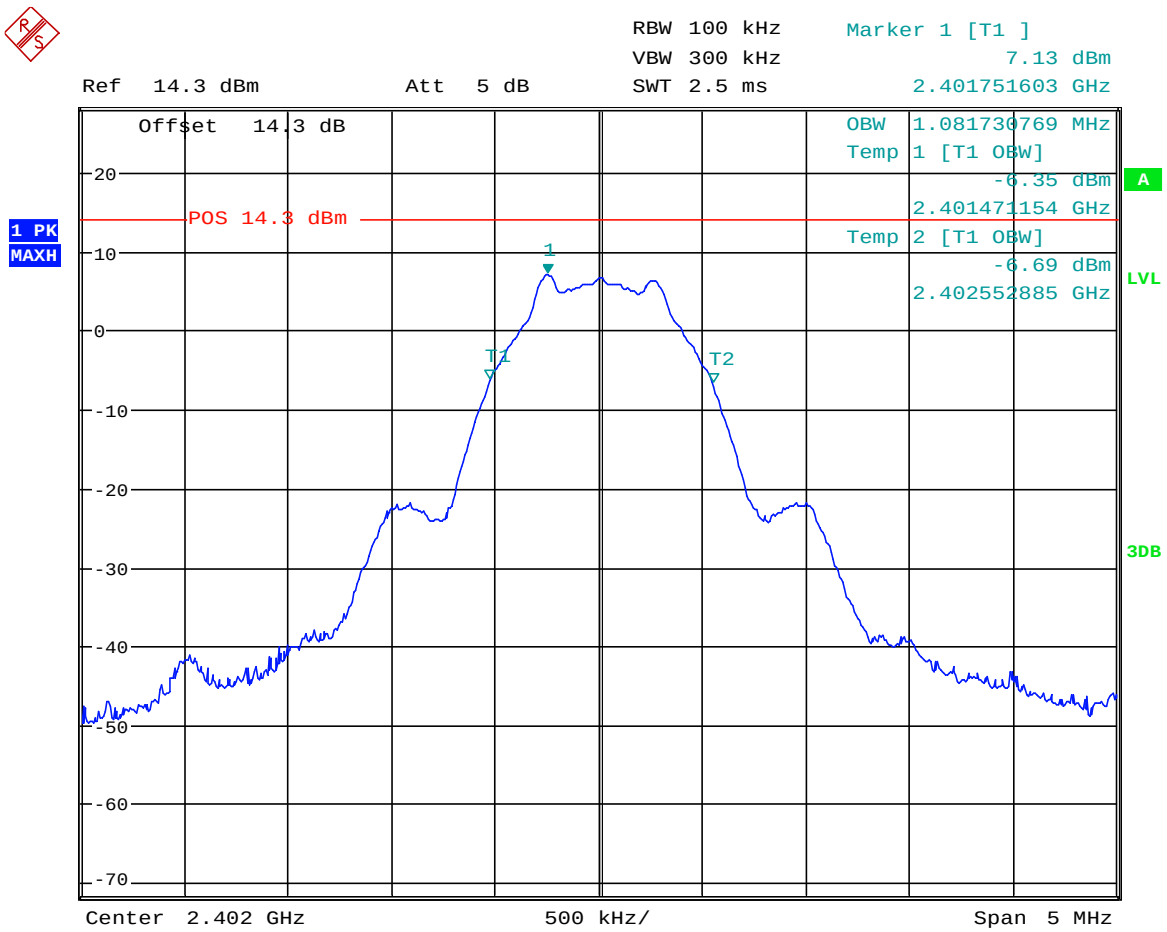
Plot # 12

Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 1 Mbps



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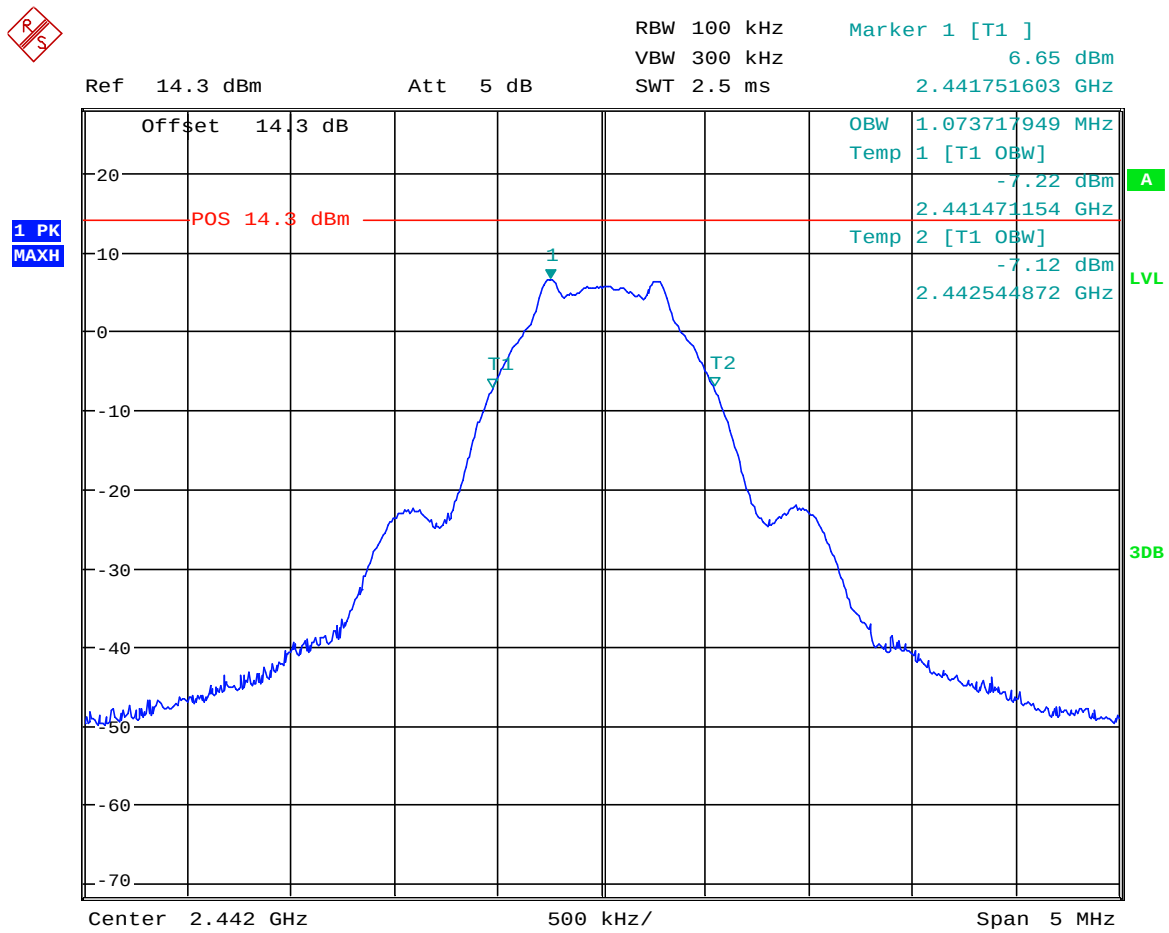
Plot # 13

Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 1 Mbps



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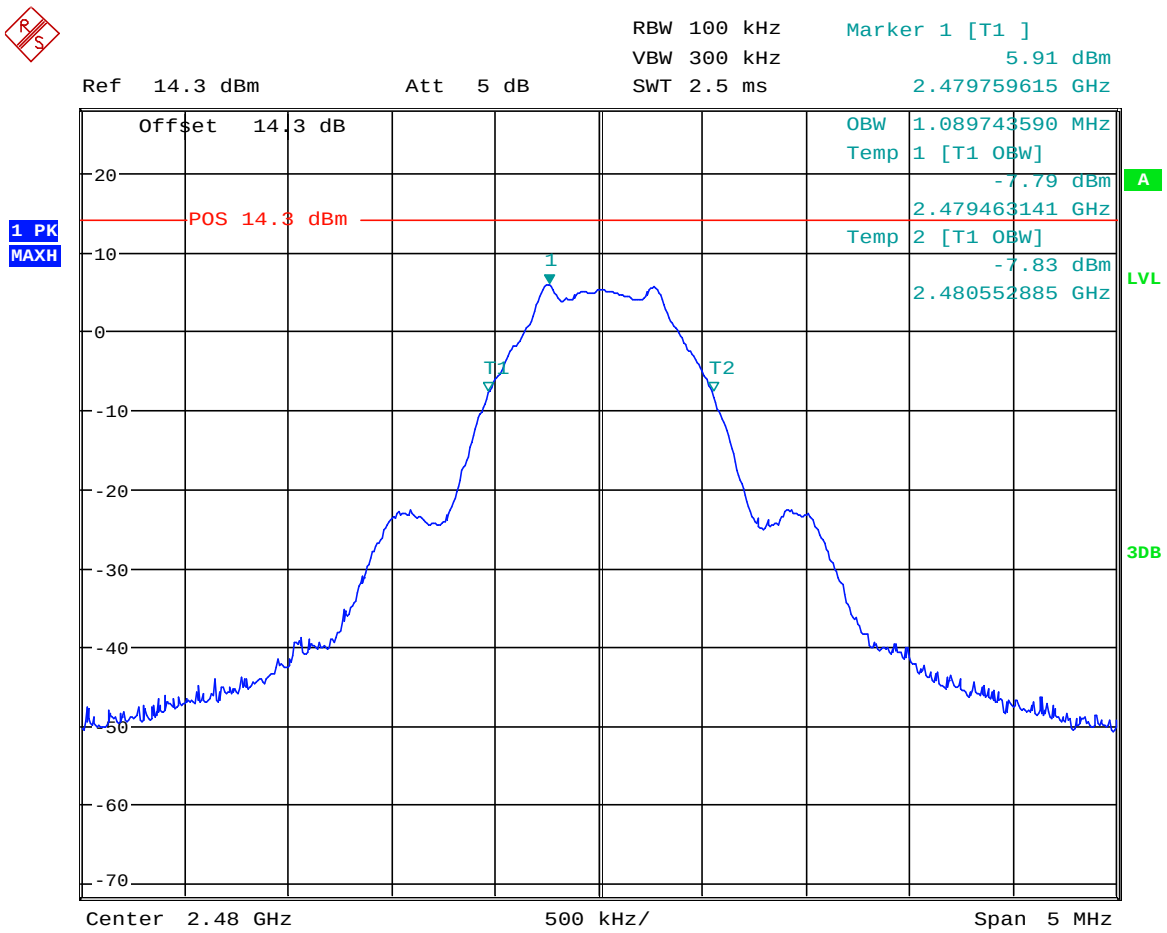
Plot # 14

Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 1 Mbps



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8.3 Maximum peak conducted output power

8.3.1 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

8.3.2 Limits:

Maximum Output Power:

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

8.3.3 Test conditions and setup:

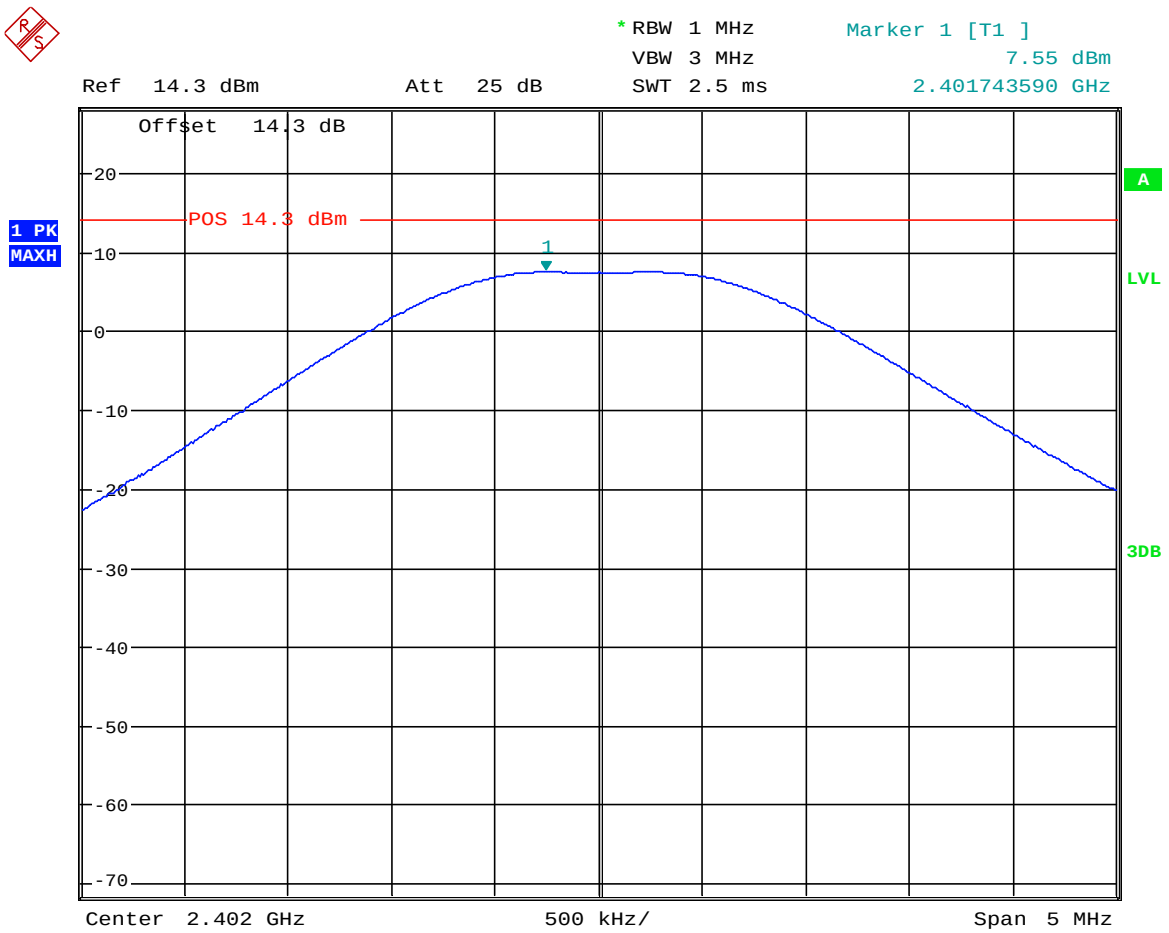
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8°C	1	Op.1	3.6 V DC	2.04 dBi

8.3.4 Measurement result:

Plot #	Frequency (MHz)	Data rate	Output Power Conducted / EIRP (dBm)	Limit (dBm)	Result
15	2402	250 Kbps	7.6 / 9.64	30 (Pk) / 36 (EIRP)	Pass
16	2442		7.1 / 9.14	30 (Pk) / 36 (EIRP)	Pass
17	2480		6.6 / 8.64	30 (Pk) / 36 (EIRP)	Pass
18	2402	1 Mbps	7.6 / 9.64	30 (Pk) / 36 (EIRP)	Pass
19	2442		7.1 / 9.14	30 (Pk) / 36 (EIRP)	Pass
20	2480		6.6 / 8.64	30 (Pk) / 36 (EIRP)	Pass

8.3.5 Measurement Plots:

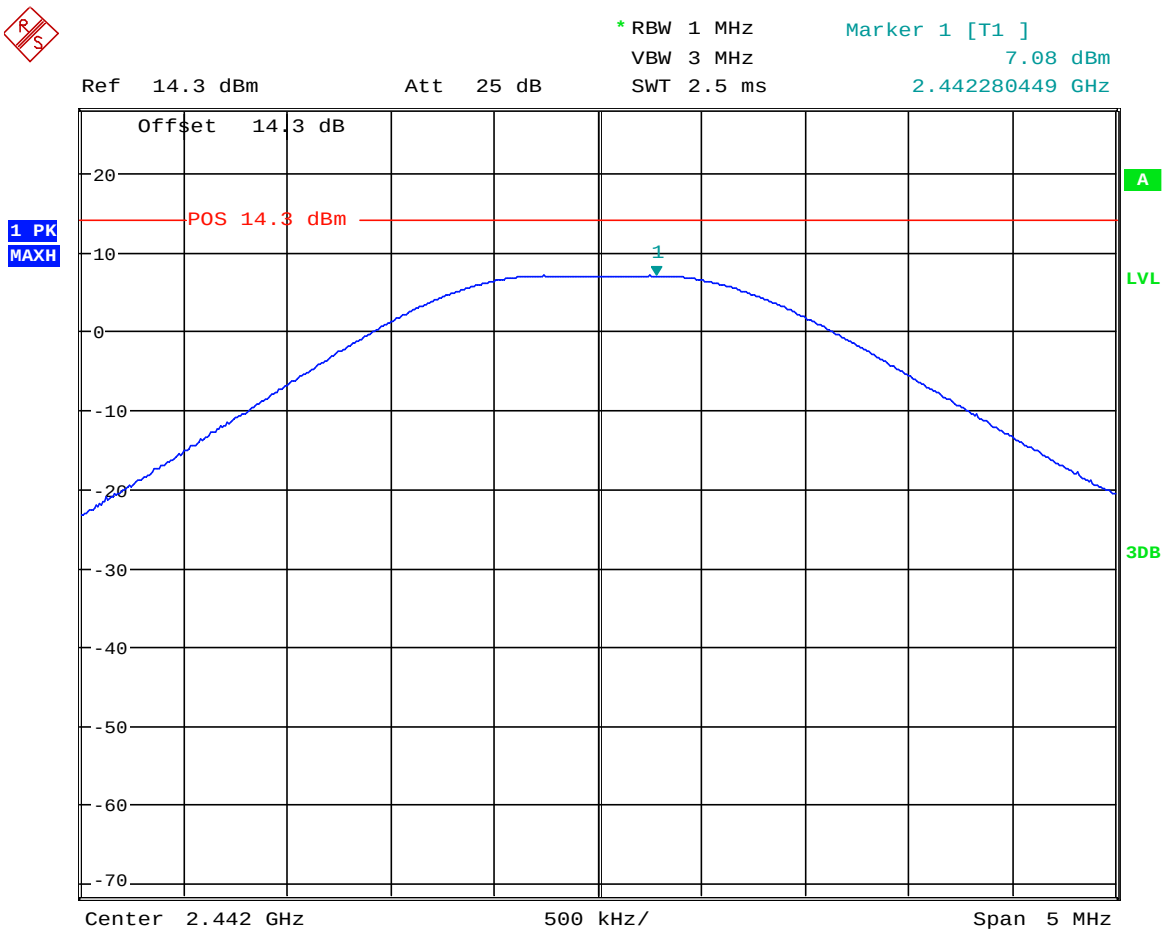
Plot # 15		
Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 250 Kbps



Date: 29.MAY.2020 13:32:18

Plot # 16

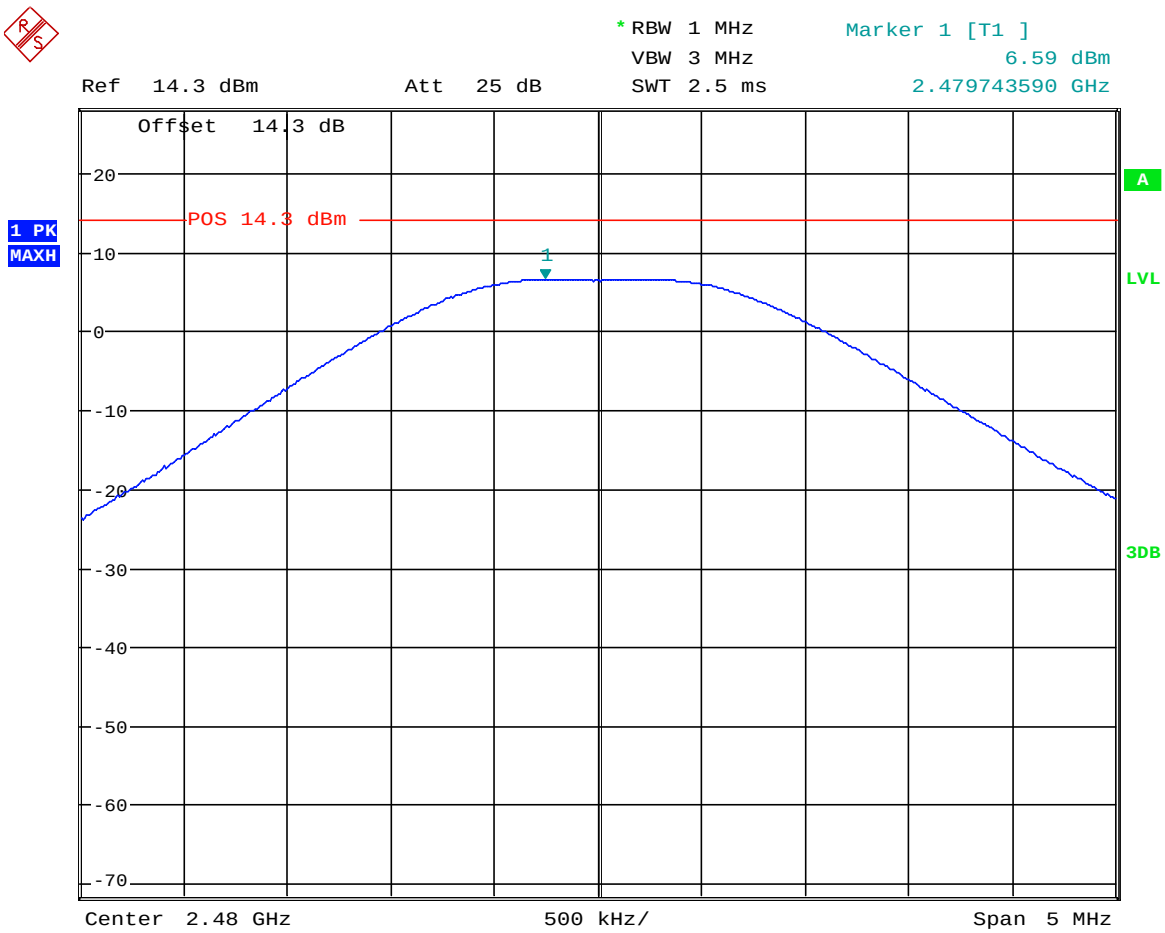
Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 250 Kbps



Date: 29.MAY.2020 13:28:03

Plot # 17

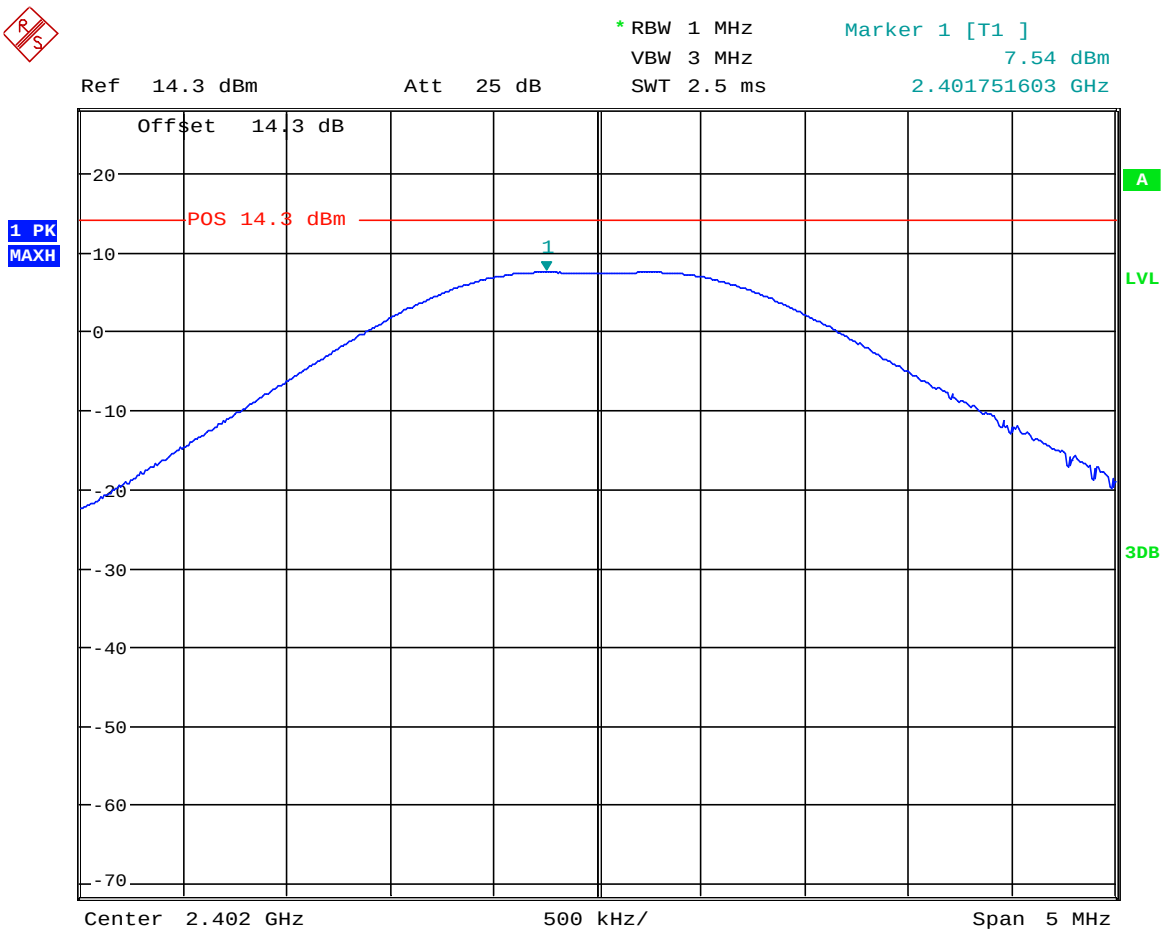
Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 250 Kbps



Date: 29.MAY.2020 13:26:31

Plot # 18

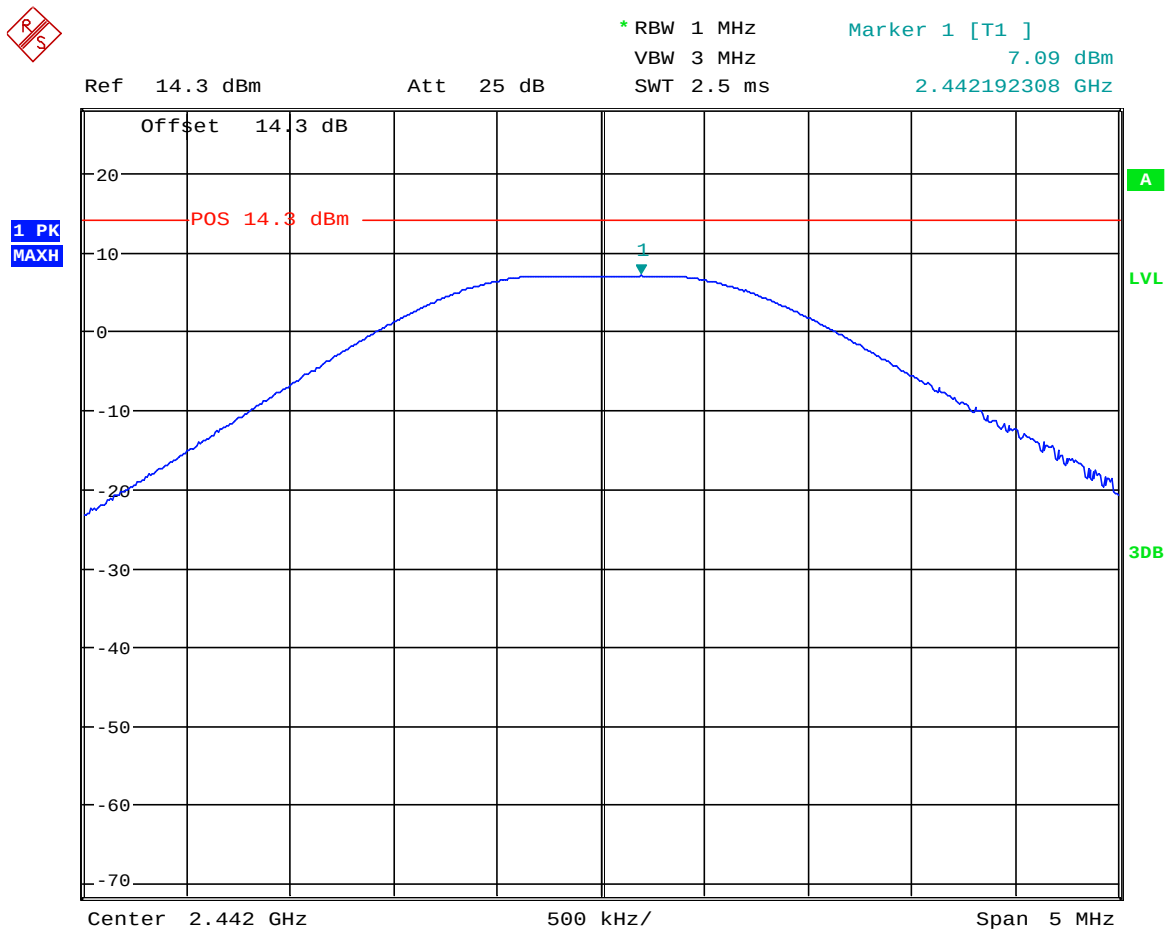
Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 1 Mbps



Date: 29.MAY.2020 13:30:51

Plot # 19

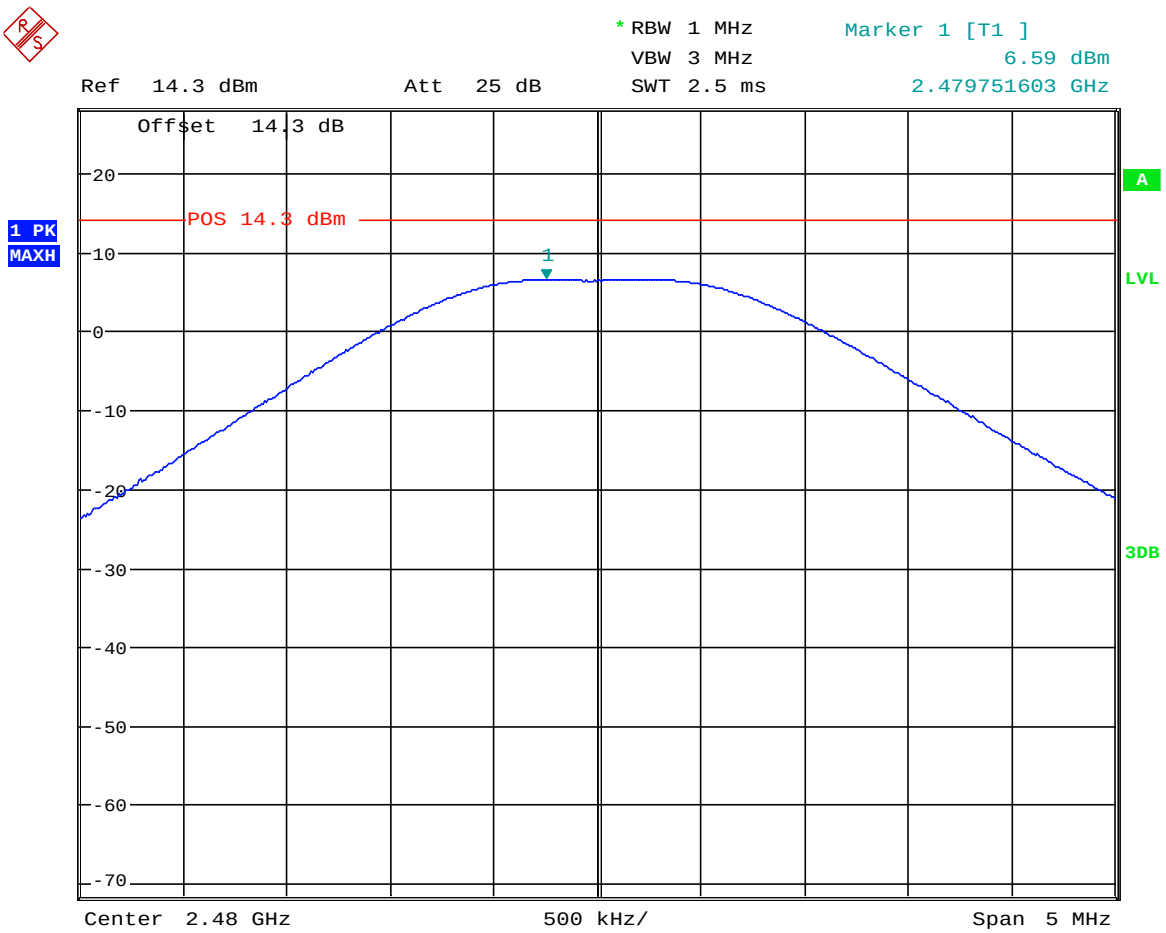
Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 1 Mbps



Date: 29.MAY.2020 13:29:15

Plot # 20

Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 1 Mbps



Date: 29.MAY.2020 13:24:02

8.4 Power Spectral Density

8.4.1 Measurement according to FCC 558074 D01 15.247 Meas Guidance v05r02

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) & RSS-247 5.2(2)

- 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:

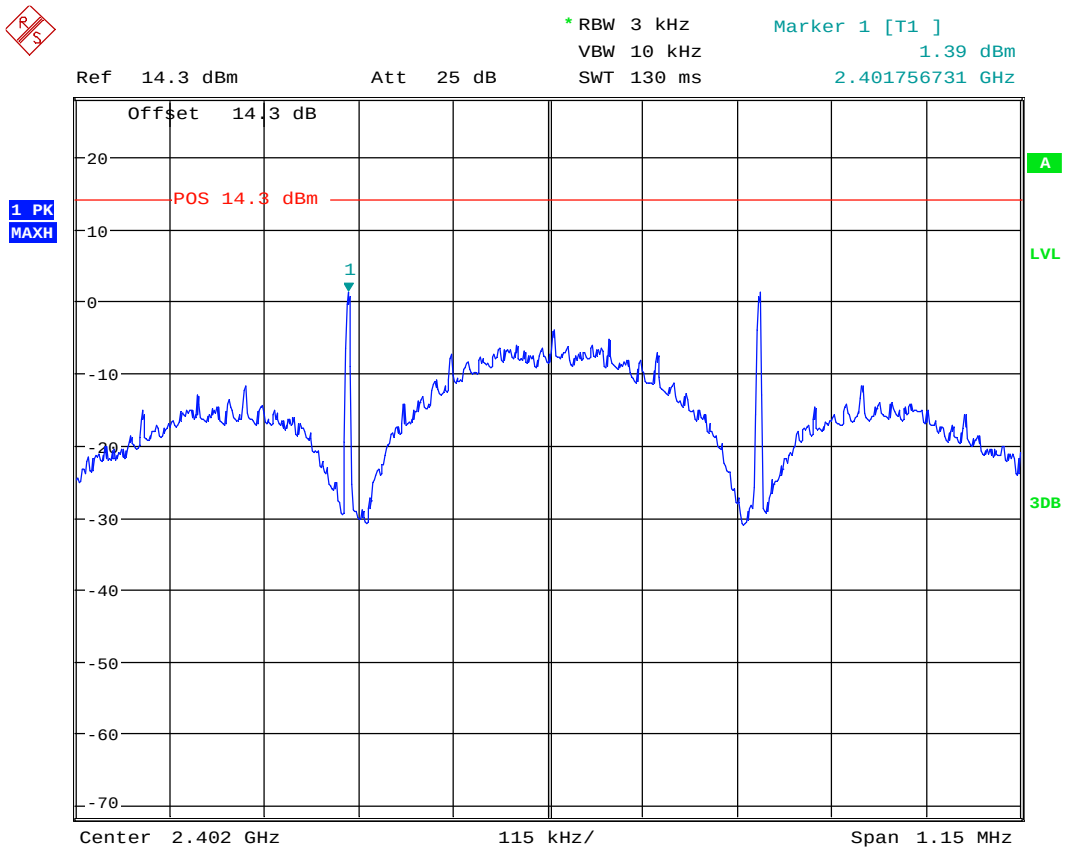
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8°C	1	Op.1	3.6 V DC	2.04 dBi

8.4.4 Measurement result:

Plot #	Frequency (MHz)	Data rate	PSD (dBm / 3 KHz)	Limit (dBm / 3 kHz)	Result
21	2402	250 Kbps	**1.39**	8	Pass
22	2442		0.95	8	Pass
23	2480		0.46	8	Pass
24	2402	1 Mbps	-4.98	8	Pass
25	2442		-5.85	8	Pass
26	2480		**-4.83**	8	Pass

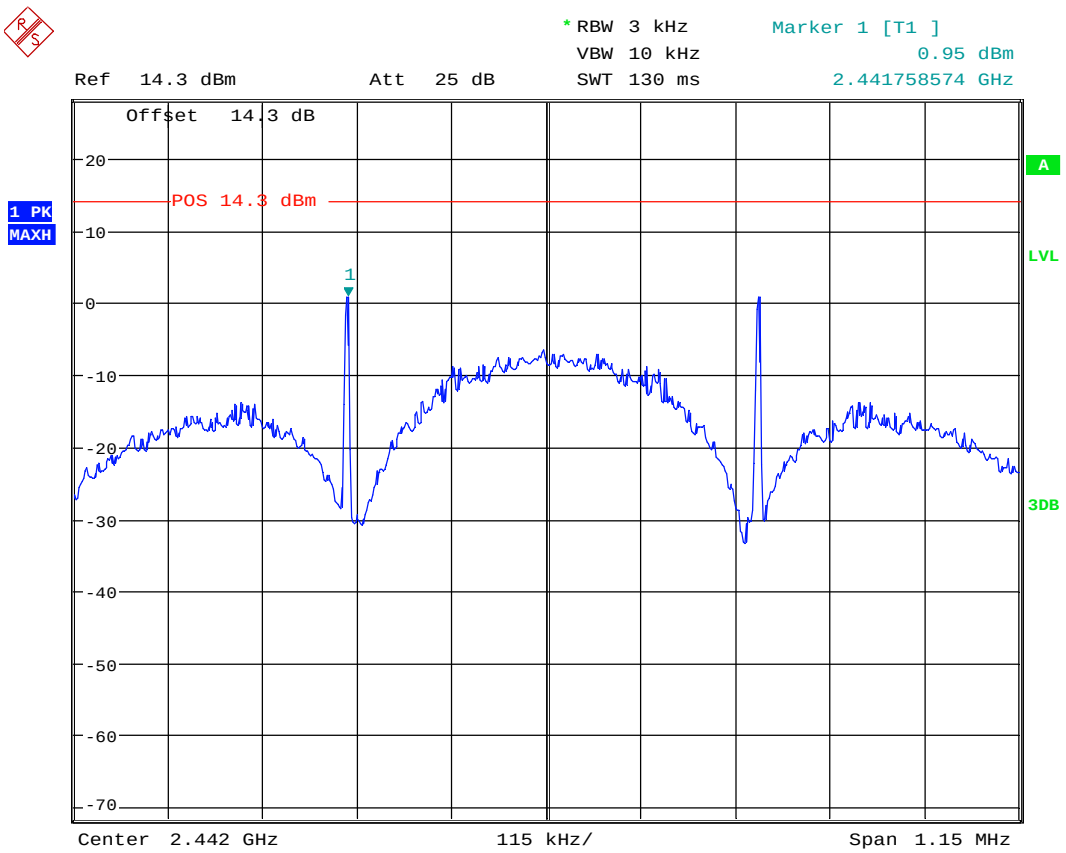
8.4.5 Measurement Plots:

Plot # 21		
Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 250 Kbps



Plot # 22

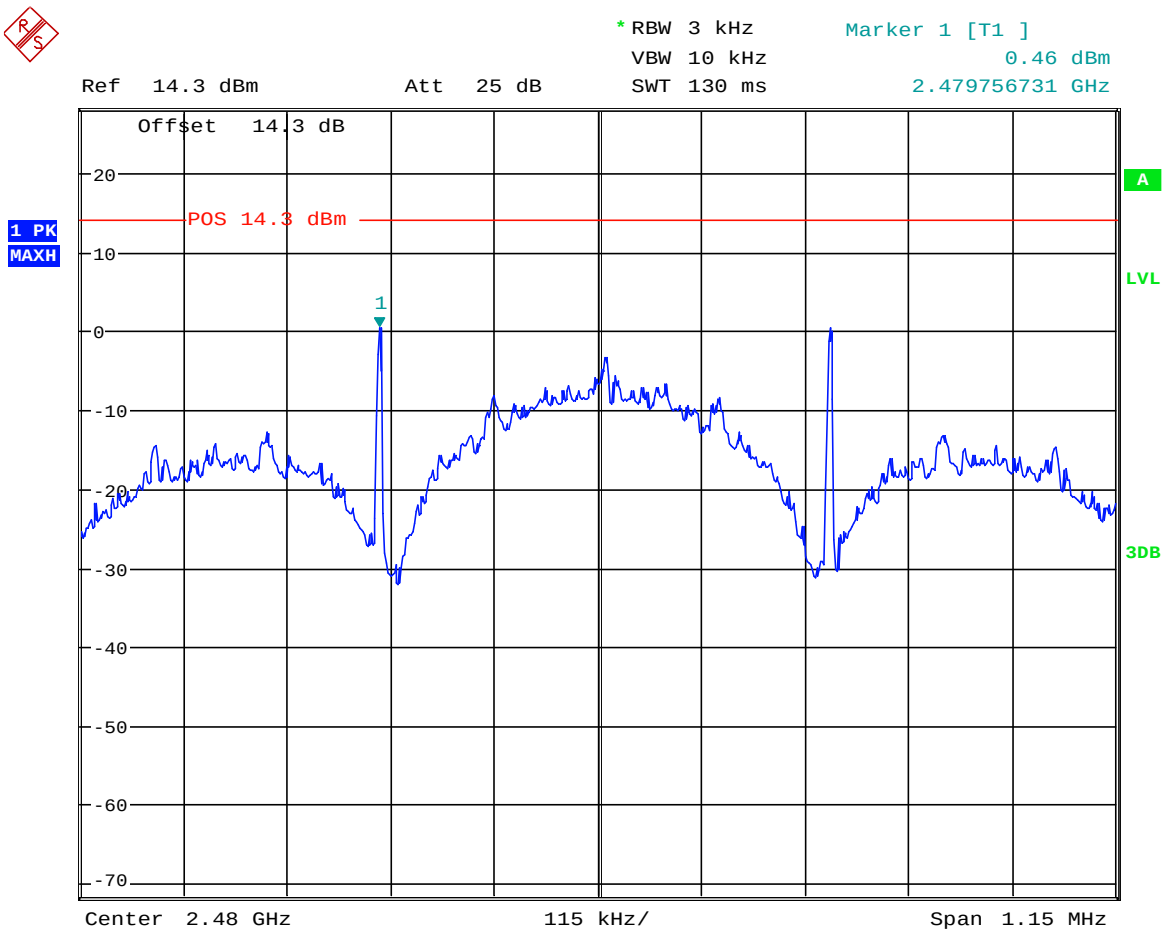
Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 250 Kbps



Date: 29.MAY.2020 13:56:37

Plot # 23

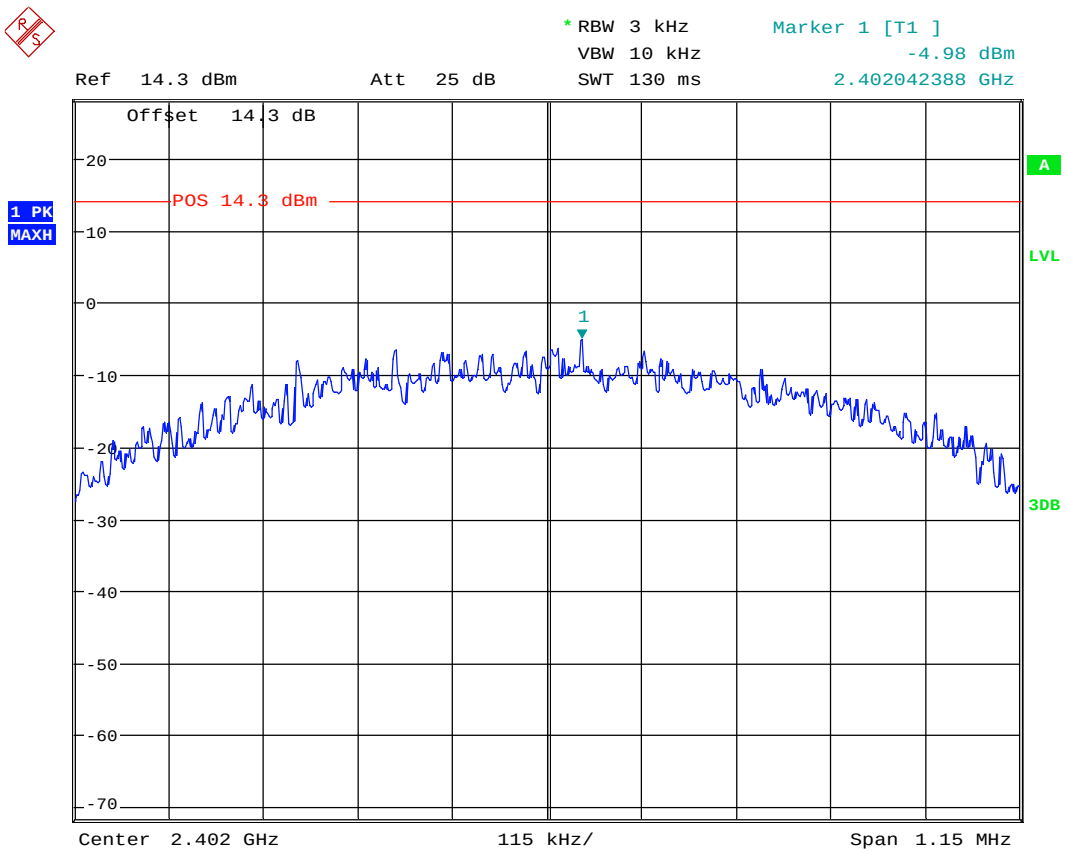
Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 250 Kbps



Date: 29.MAY.2020 14:03:21

Plot # 24

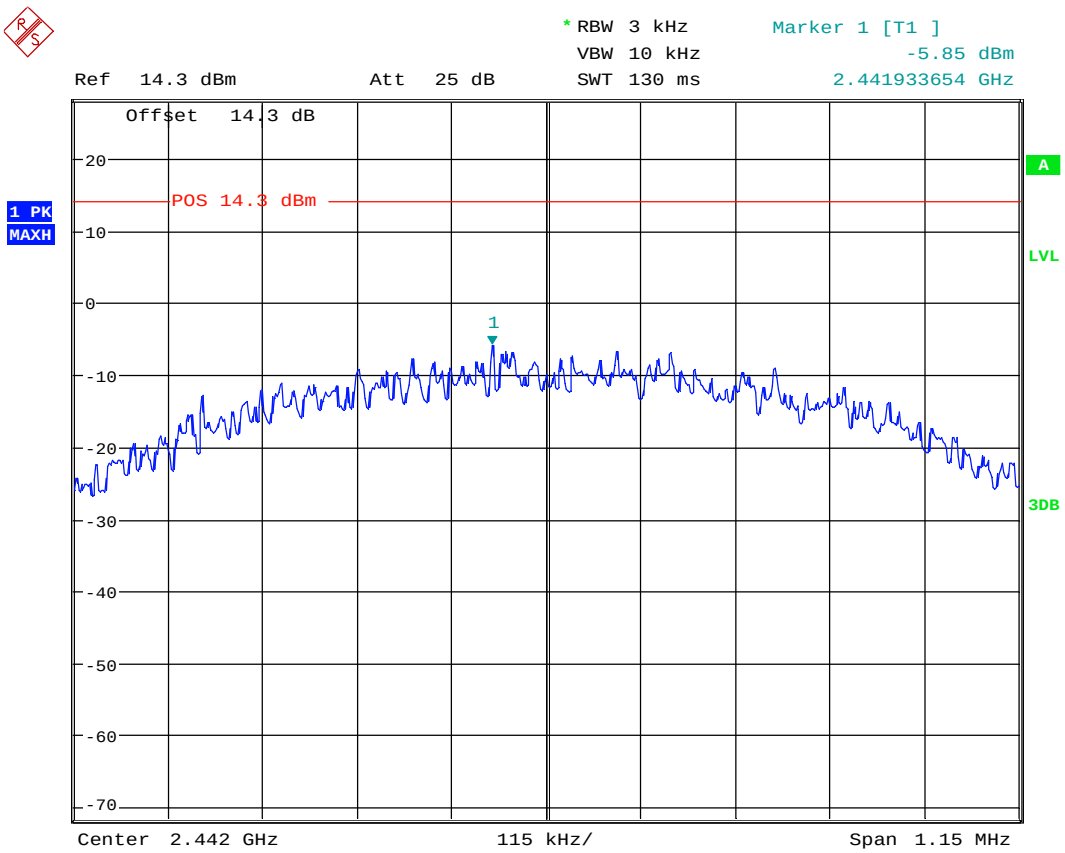
Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 1 Mbps



Date: 29.MAY.2020 13:50:05

Plot # 25

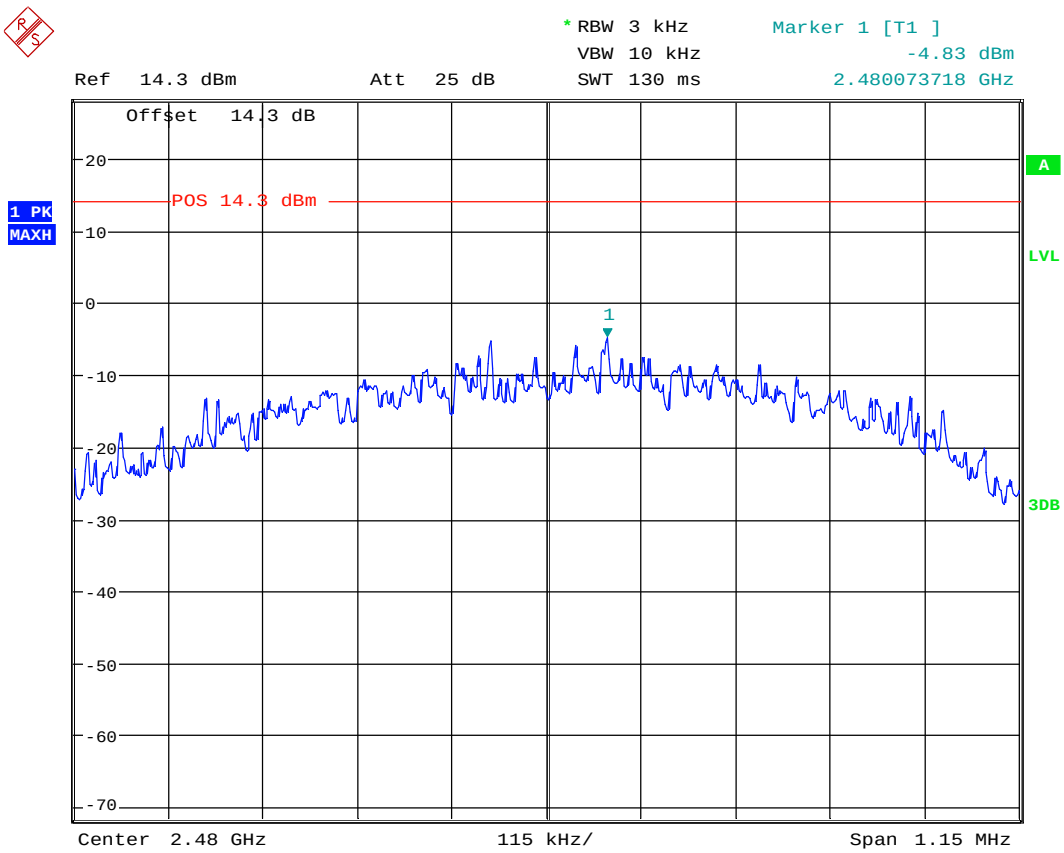
Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 1 Mbps



Date: 29.MAY.2020 13:58:51

Plot # 26

Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 1 Mbps



Date: 29.MAY.2020 14:00:59

8.5 Band Edge Compliance

8.5.1 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

8.5.2 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

8.5.3 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			

8.5.4 Test conditions and setup:

Non-Restricted Band:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8°C	1	Op.1	3.6 V DC	2.04 dBi

Restricted Band:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8°C	1	Op.1	3.6 V DC	2.04 dBi

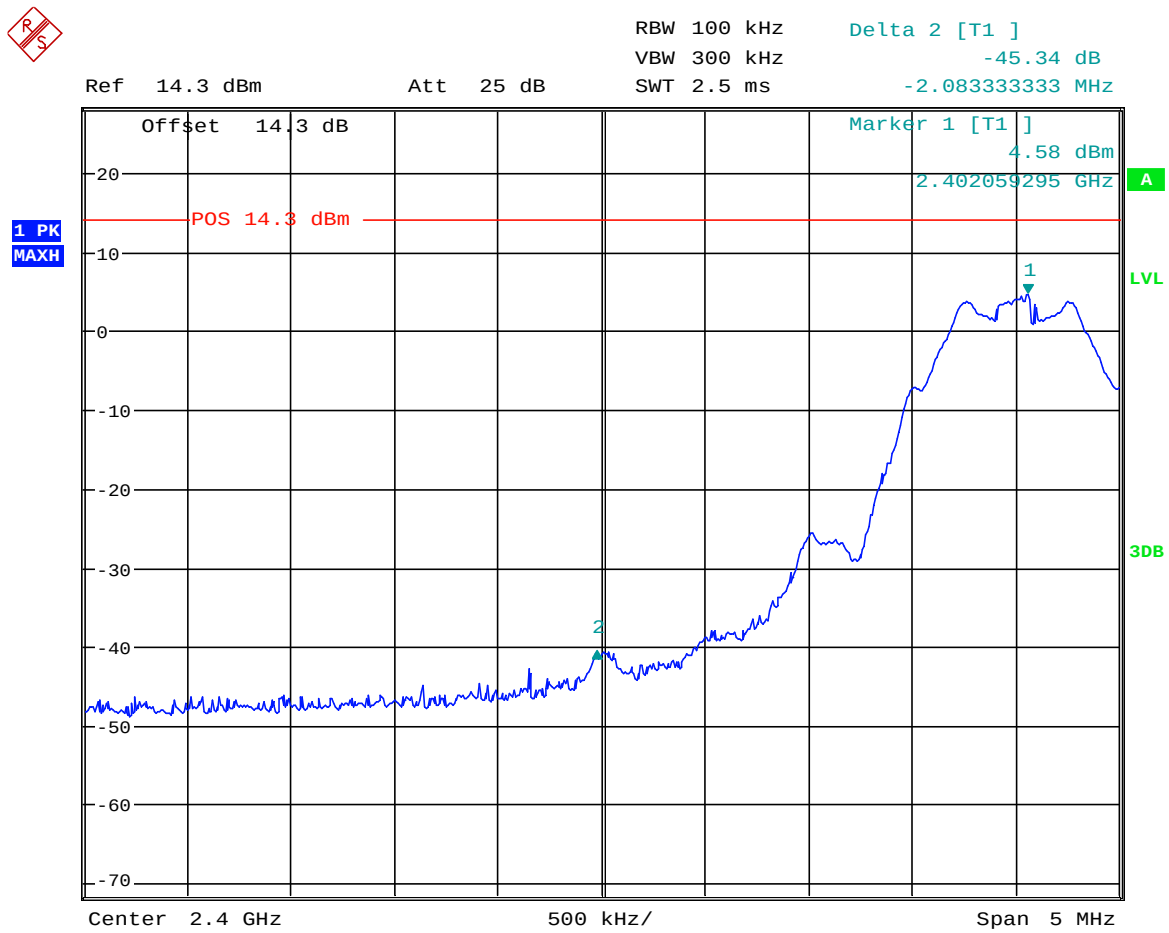
8.5.5 Measurement result:

Plot #	Data rate	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
27	250 Kbps	Lower, Non-restricted	-45.34	-20	Pass
28	1 Mbps	Lower, Non-restricted	-46.40	-20	Pass

Plot #	EUT operating mode	Band Edge	Measured Peak/AVG Value (dBm)	Corrected by Antenna Gain (dBm)	Limit (dBm)	Result
29	250 Kbps	Upper Restricted	Peak: -34.29	Peak: -32.25	Peak: -21.23	Pass
			AVG: -48.81	AVG: -46.77	AVG: -41.23	
30	1 Mbps	Upper Restricted	Peak: -32.86	Peak: -30.82	AVG: -21.23	Pass
			AVG: -46.88	AVG: -44.84	AVG: -41.23	

8.5.6 Measurement Plots:

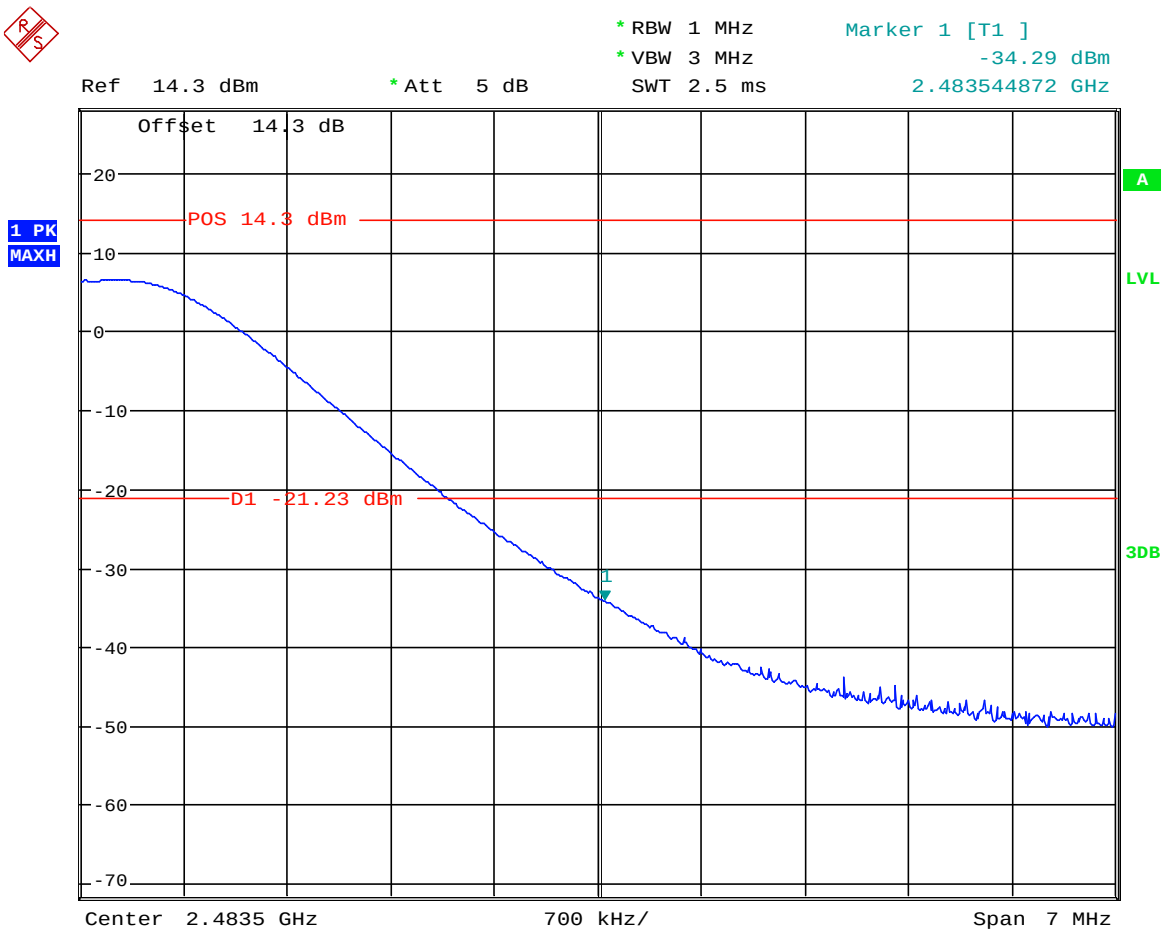
Plot # 27		
Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 250 Kbps



Date: 29.MAY.2020 14:09:51

Plot # 28

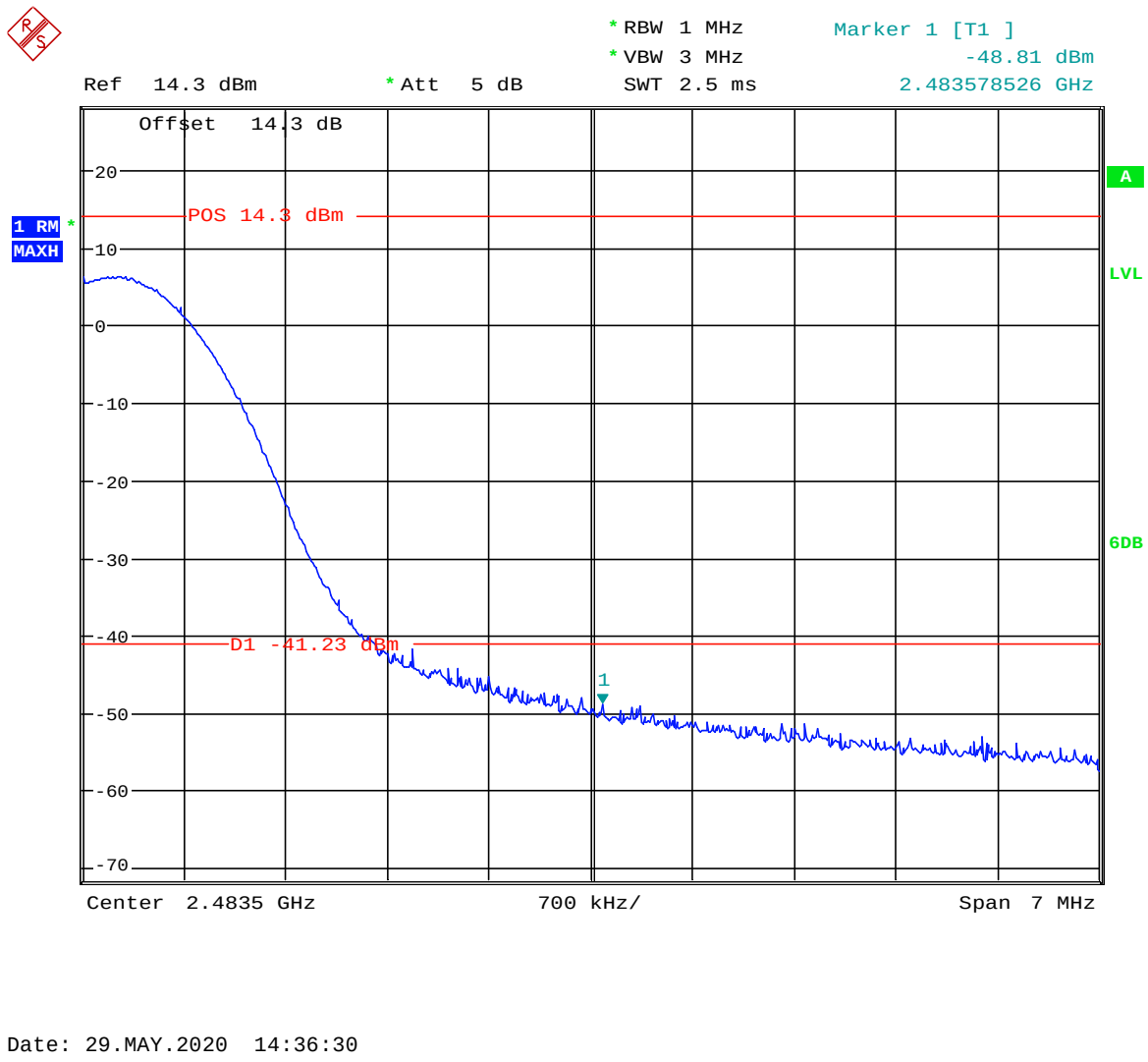
Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 250 Kbps



Date: 29.MAY.2020 14:33:20

Plot # 29

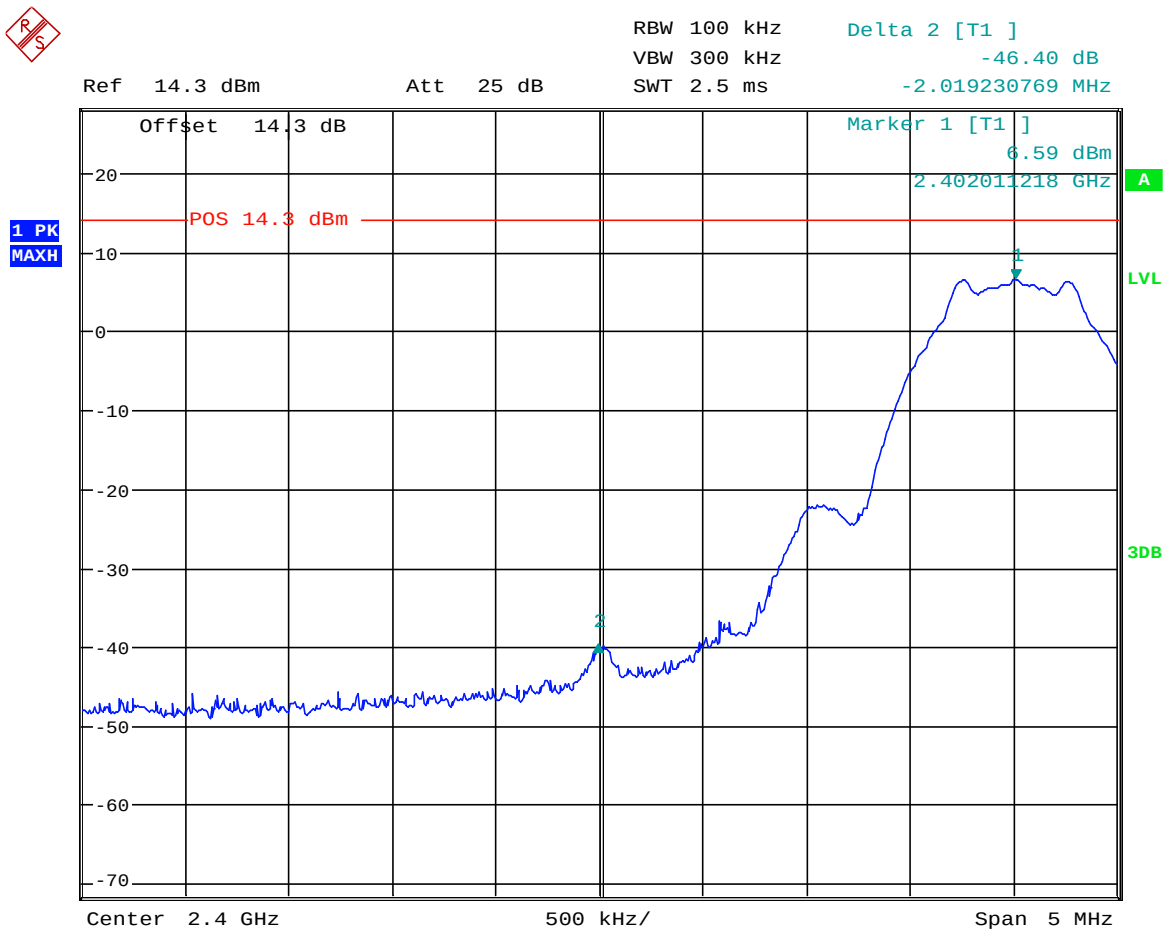
Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 250 Kbps



Date: 29.MAY.2020 14:36:30

Plot # 30

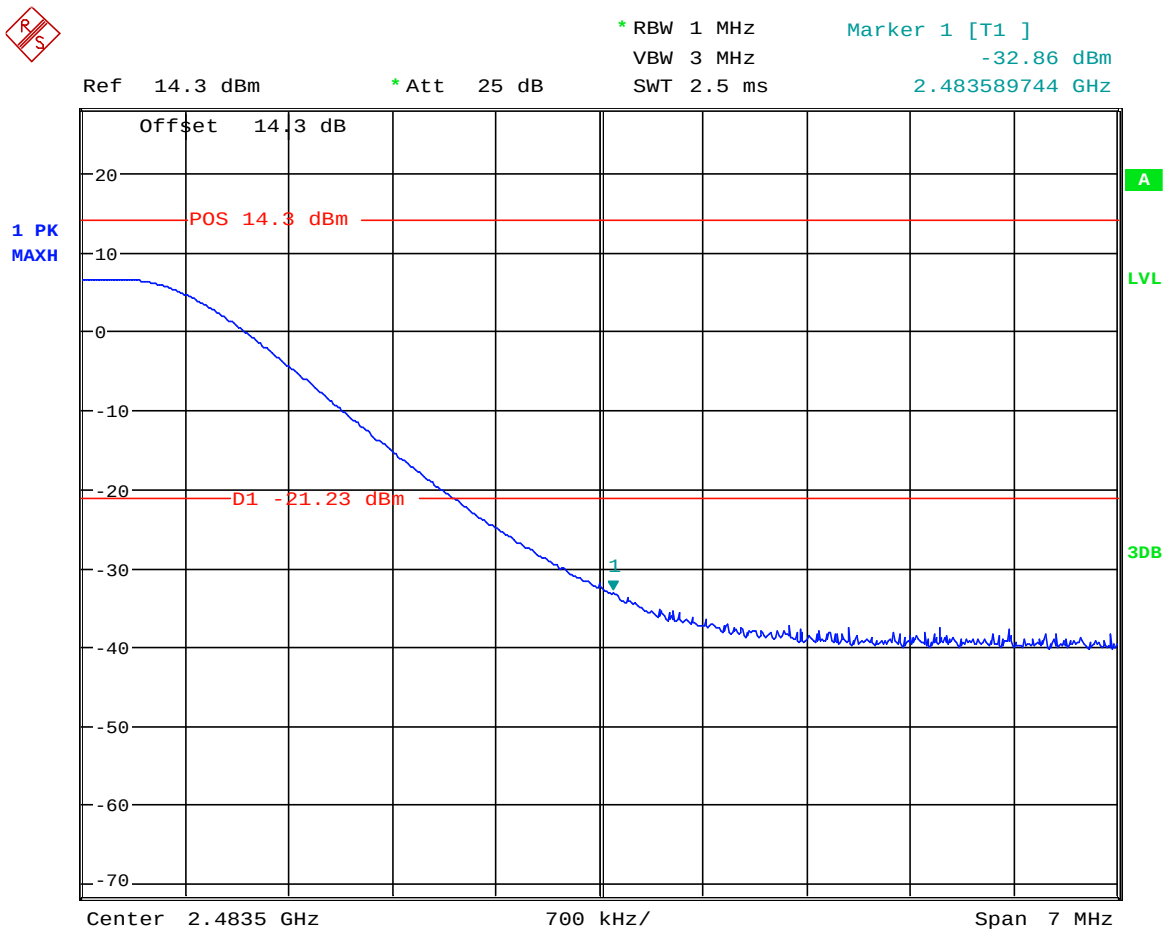
Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 1 Mbps



Date: 29.MAY.2020 14:12:34

Plot # 31

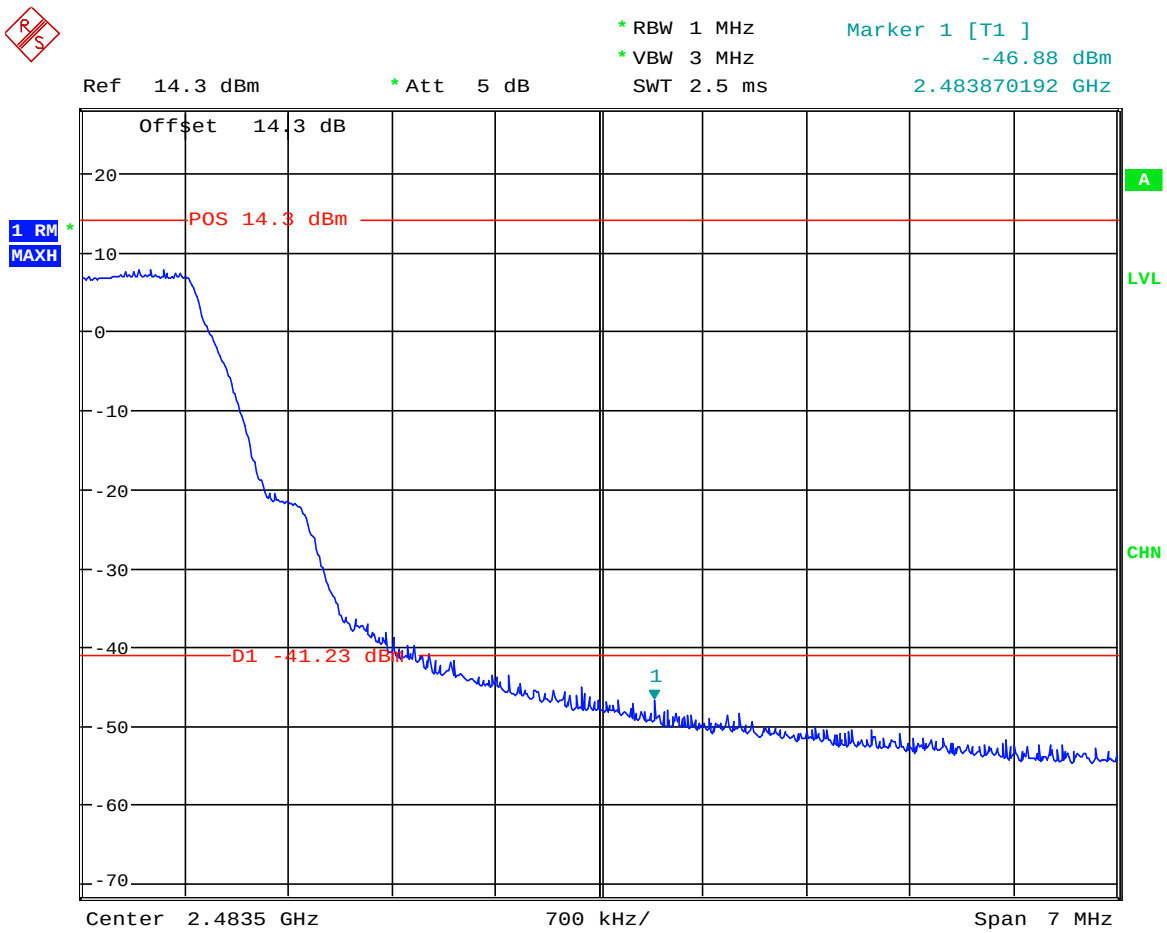
Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 1 Mbps



Date: 29.MAY.2020 14:19:35

Plot # 32

Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 1 Mbps



Date: 29.MAY.2020 14:29:17

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 Set-Up #	Power Input
23.8°C	2	3.6 V DC

8.6.4 Measurement result:

Plot #	Channel #	Scan Frequency	Limit	Result
33 – 35	Low	30 MHz – 18 GHz	See section 8.6.2	Pass
36 – 40	Mid	9 kHz – 26 GHz	See section 8.6.2	Pass
41 – 43	High	30 MHz – 18 GHz	See section 8.6.2	Pass

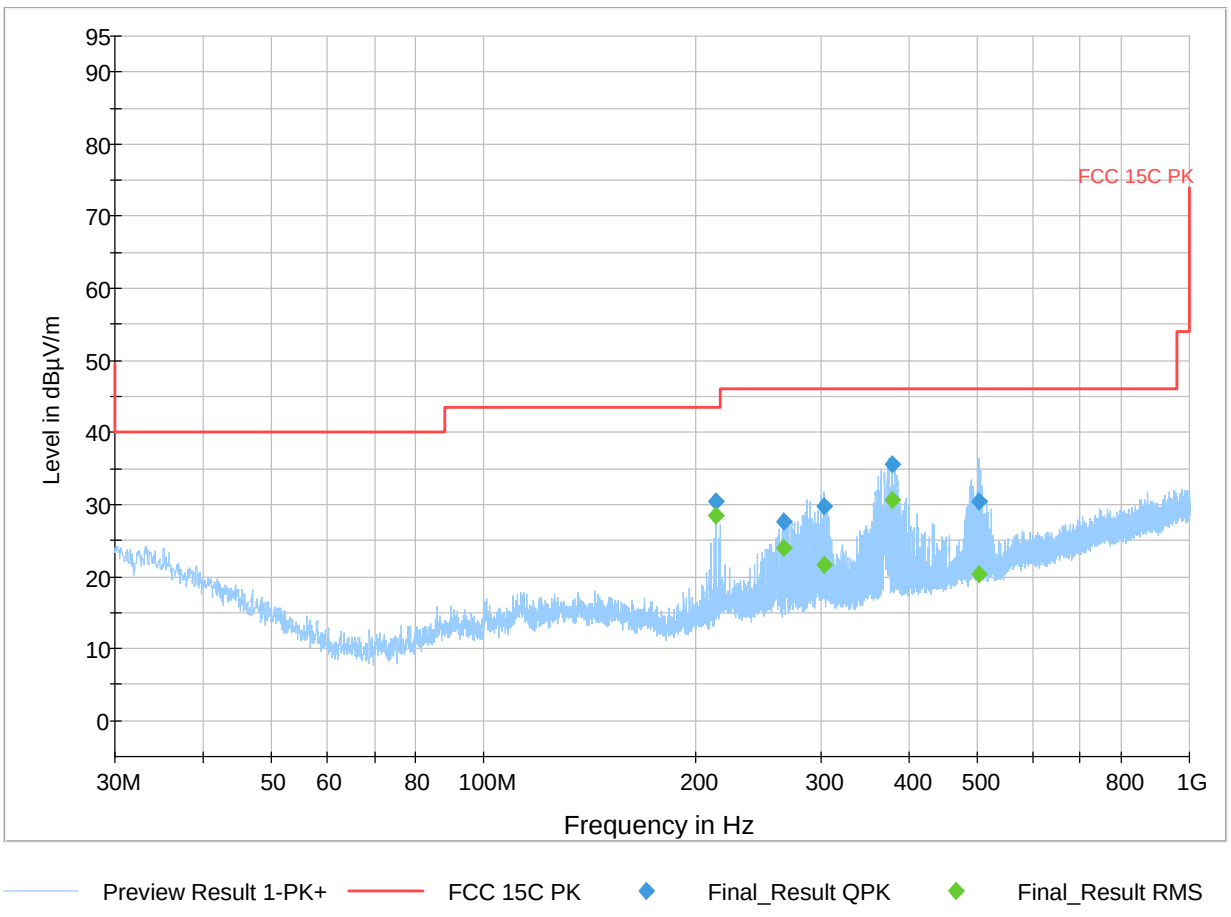
8.6.5 Measurement Plots:

Plot # 33 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 1 Mbps

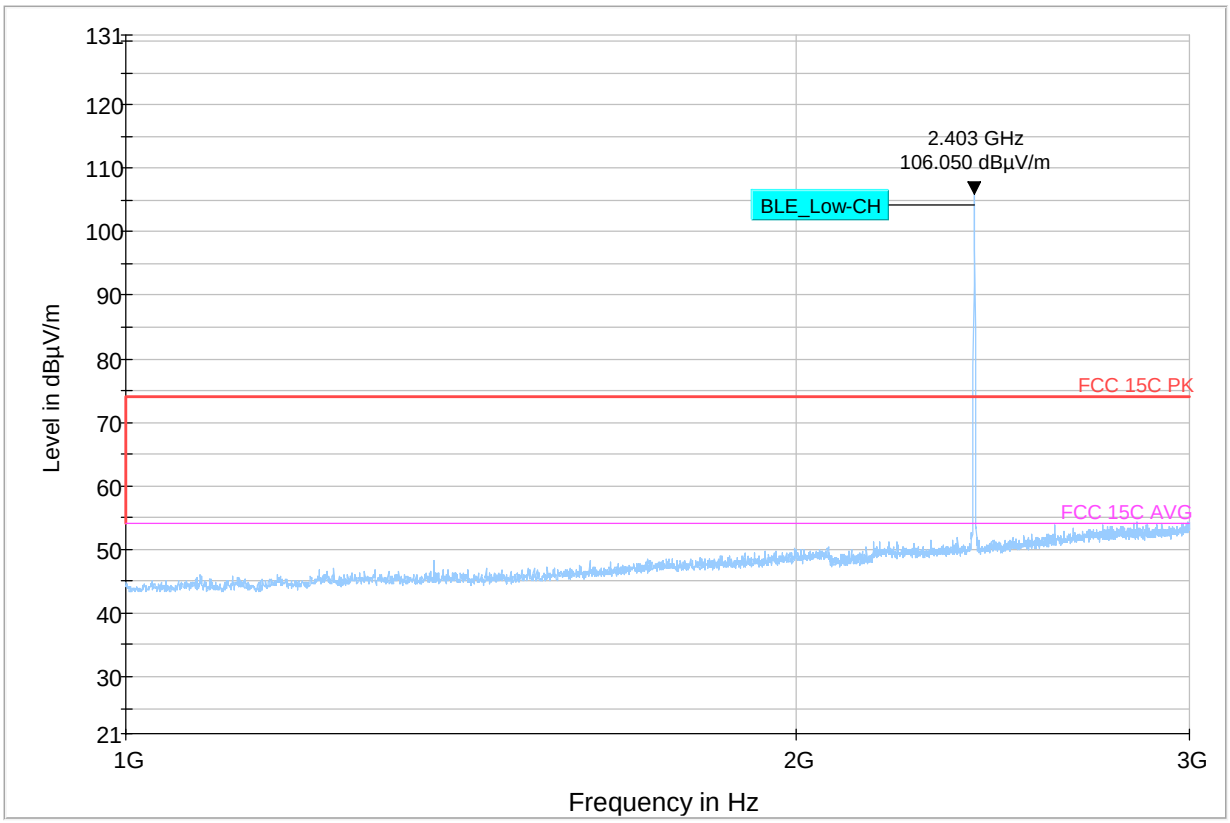
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB/m)
213.395	---	28.58	---	---	500.0	120.000	167.0	H	-18.9
213.395	30.49	---	43.50	13.01	500.0	120.000	167.0	H	-18.9
265.995	27.56	---	46.00	18.44	500.0	120.000	107.0	H	-17.8
265.995	---	23.96	---	---	500.0	120.000	107.0	H	-17.8
303.606	---	21.63	---	---	500.0	120.000	100.0	H	-17.0
303.606	29.71	---	46.00	16.29	500.0	120.000	100.0	H	-17.0
379.161	---	30.54	---	---	500.0	120.000	100.0	H	-15.0
379.161	35.48	---	46.00	10.52	500.0	120.000	100.0	H	-15.0
502.118	30.35	---	46.00	15.65	500.0	120.000	276.0	H	-12.1
502.118	---	20.40	---	---	500.0	120.000	276.0	H	-12.1



Plot # 34 Radiated Emissions: 1 – 3 GHz

Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 1 Mbps

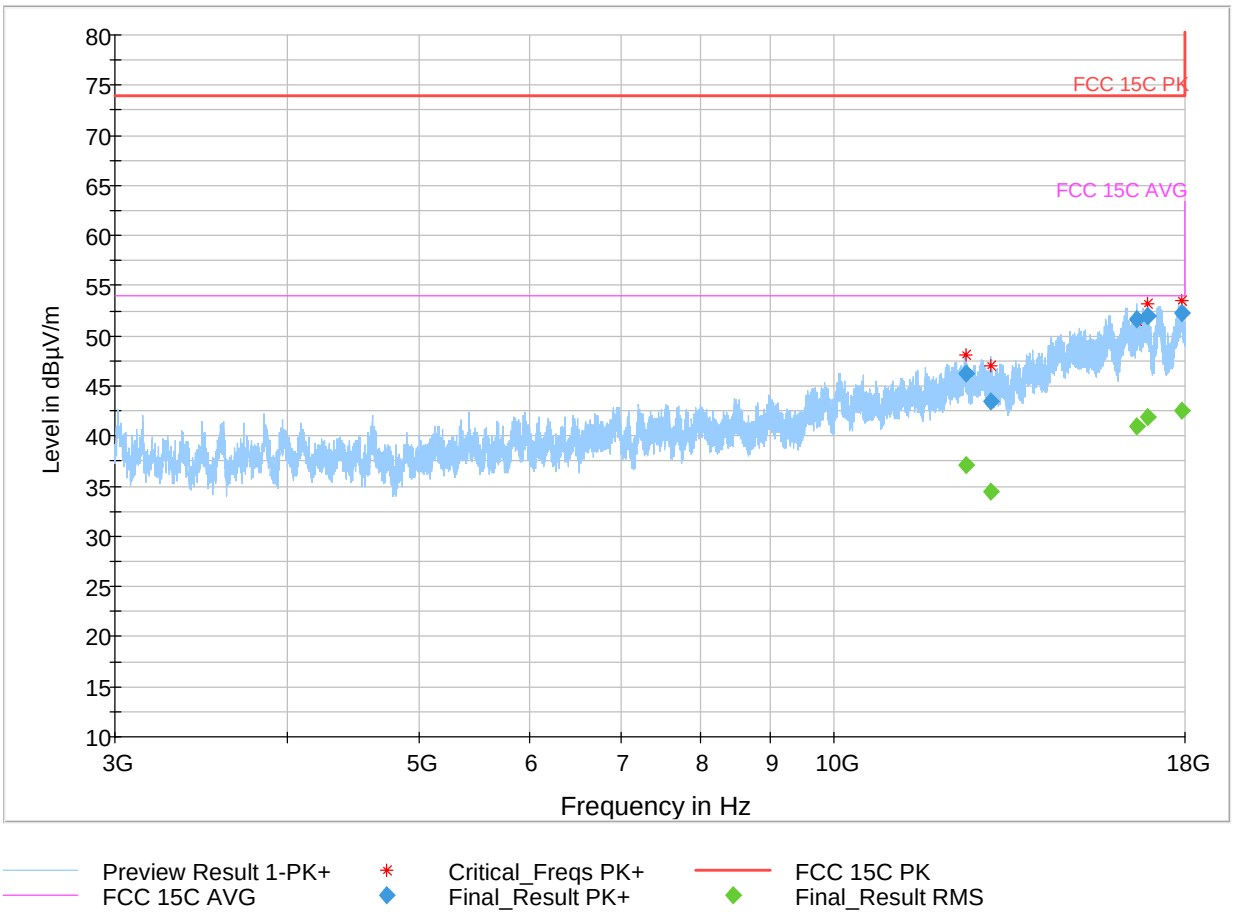


Plot # 35 Radiated Emissions: 3 – 18 GHz

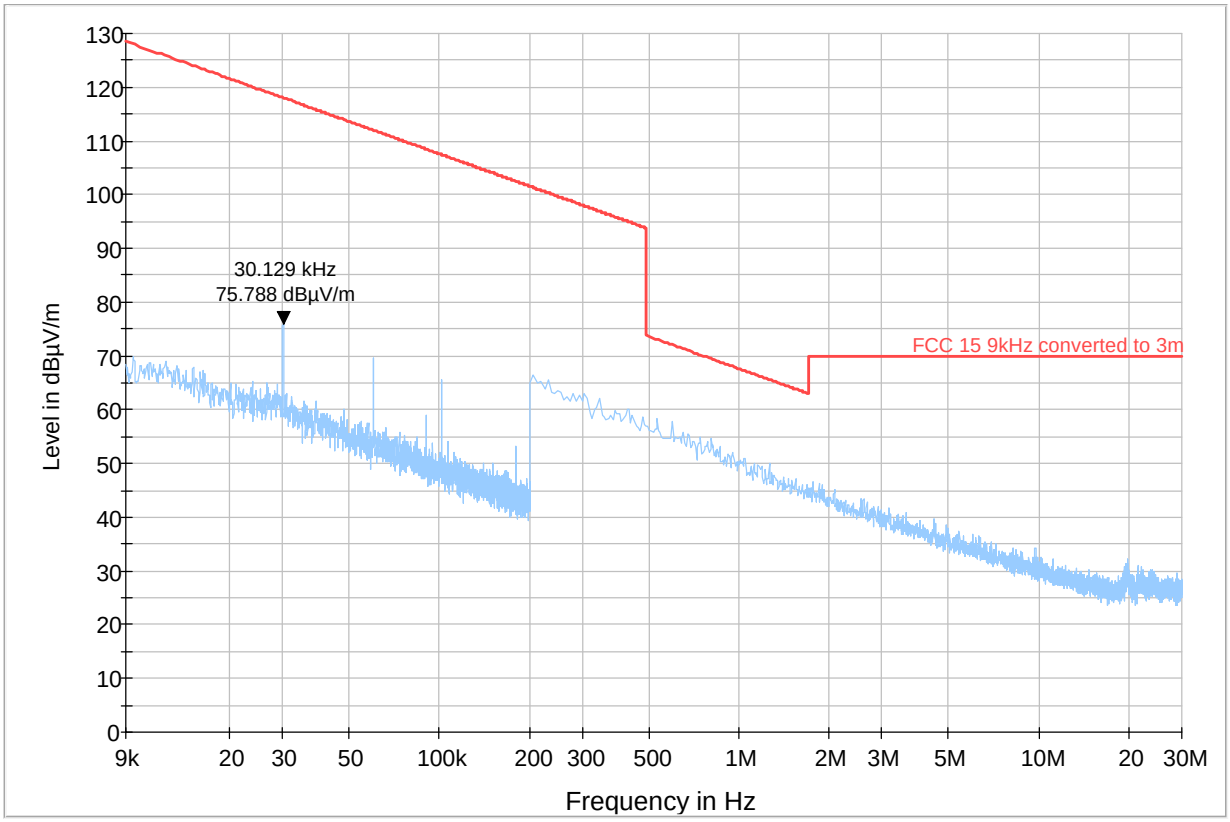
Tx Frequency: 2402 MHz	Mode: BLE	Data rate: 1 Mbps

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB/m)	Comment
12463.302533	46.26	---	73.98	27.72	10.0	1000.000	192.0	H	5.6	3:30:59 PM - 6/2/2020
12463.302533	---	37.14	53.98	16.84	10.0	1000.000	192.0	H	5.6	3:30:59 PM - 6/2/2020
12995.135967	---	34.51	53.98	19.47	10.0	1000.000	299.0	H	5.7	3:24:42 PM - 6/2/2020
12995.135967	43.51	---	73.98	30.47	10.0	1000.000	299.0	H	5.7	3:24:42 PM - 6/2/2020
16626.990700	51.62	---	73.98	22.36	10.0	1000.000	181.0	V	10.5	3:34:13 PM - 6/2/2020
16626.990700	---	41.05	53.98	12.93	10.0	1000.000	181.0	V	10.5	3:34:13 PM - 6/2/2020
16894.316467	51.94	---	73.98	22.04	10.0	1000.000	340.0	V	12.0	3:37:22 PM - 6/2/2020
16894.316467	---	41.92	53.98	12.06	10.0	1000.000	340.0	V	12.0	3:37:23 PM - 6/2/2020
17925.270533	52.24	---	73.98	21.74	10.0	1000.000	147.0	H	13.7	3:27:47 PM - 6/2/2020
17925.270533	---	42.58	53.98	11.40	10.0	1000.000	147.0	H	13.7	3:27:48 PM - 6/2/2020



Plot # 36 Radiated Emissions: 9 KHz – 30 MHz		
Tx Frequency: 2442 MHz	**Mode: BLE**	**Data rate: 1 Mbps**

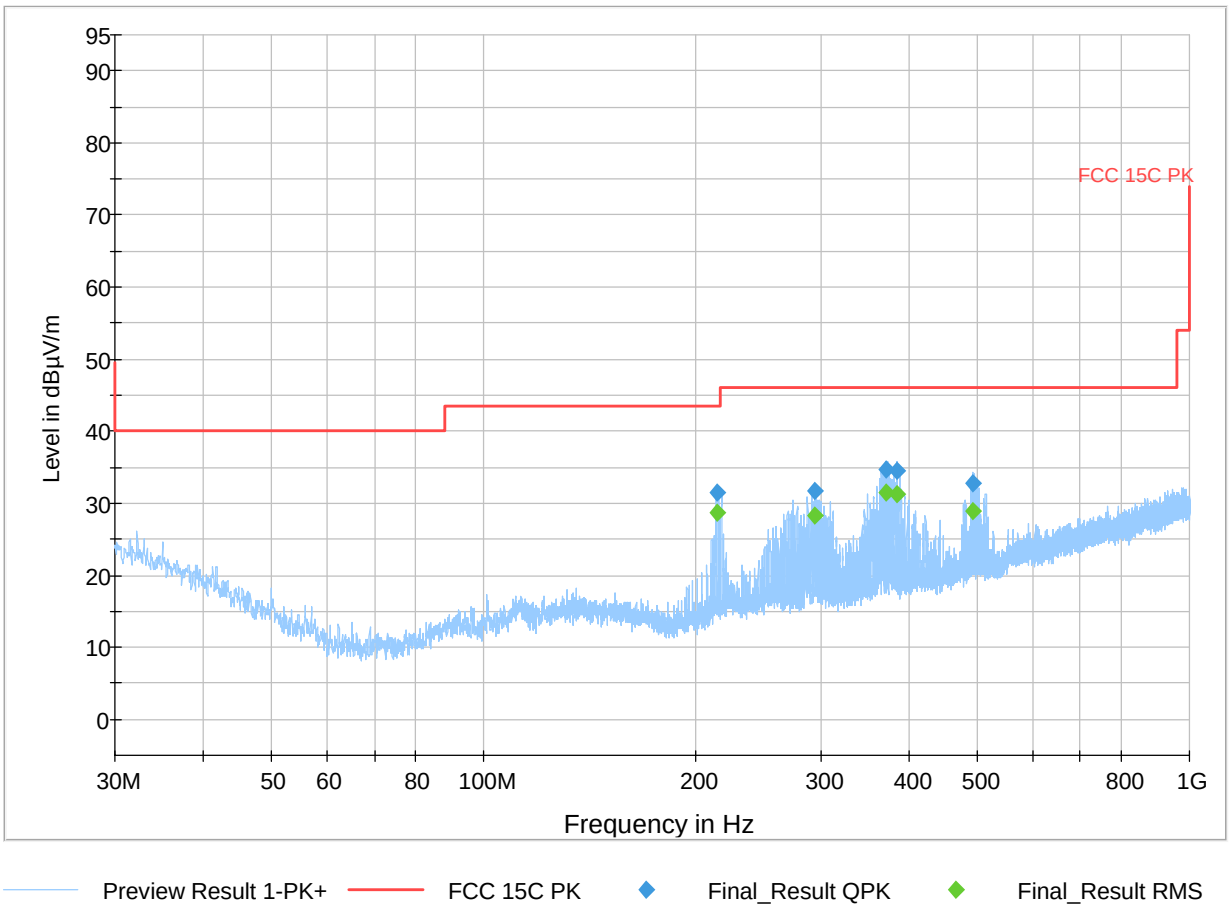


Plot # 37 Radiated Emissions: 30 MHz – 1 GHz

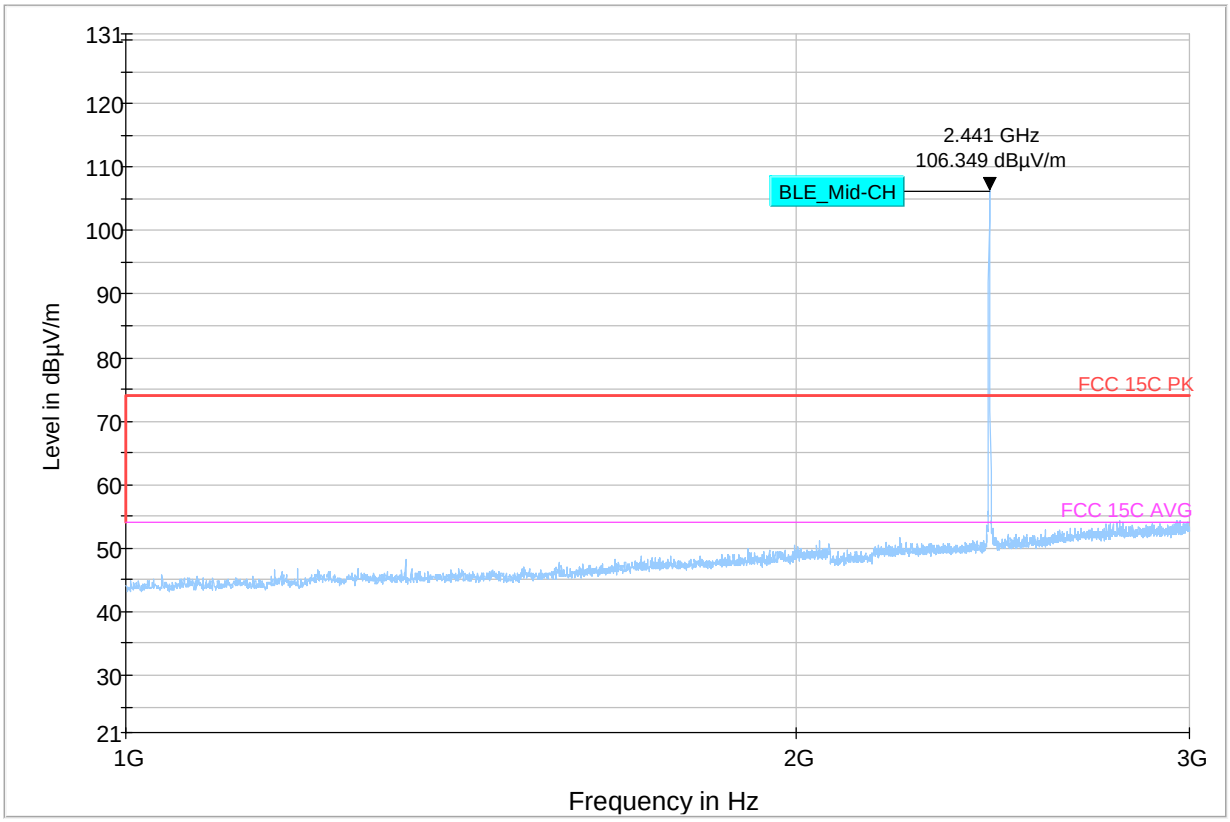
Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 1 Mbps

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB/m)
213.730350	31.55	---	43.50	11.95	500.0	120.000	183.0	H	-18.8
213.730350	---	28.72	---	---	500.0	120.000	183.0	H	-18.8
294.290600	31.72	---	46.00	14.28	500.0	120.000	114.0	H	-17.7
294.290600	---	28.26	---	---	500.0	120.000	114.0	H	-17.7
371.610322	---	31.56	---	---	500.0	120.000	100.0	H	-15.1
371.610322	34.72	---	46.00	11.28	500.0	120.000	100.0	H	-15.1
384.736006	---	31.18	---	---	500.0	120.000	100.0	H	-14.8
384.736006	34.42	---	46.00	11.58	500.0	120.000	100.0	H	-14.8
493.298886	---	28.81	---	---	500.0	120.000	256.0	H	-12.5
493.298886	32.75	---	46.00	13.25	500.0	120.000	256.0	H	-12.5



Plot # 38 Radiated Emissions: 1 – 3 GHz		
Tx Frequency: 2442 MHz	**Mode: BLE**	**Data rate: 1 Mbps**

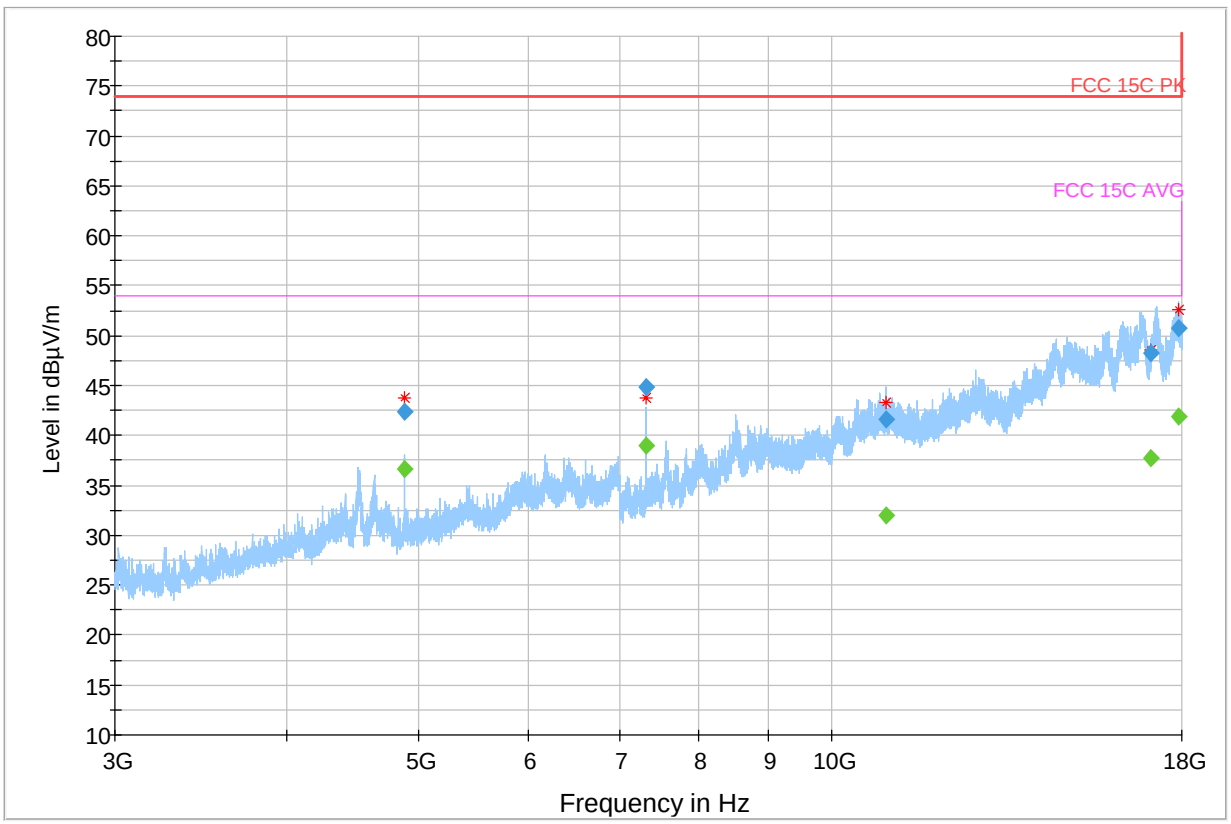


Plot # 39 Radiated Emissions: 3 – 18 GHz

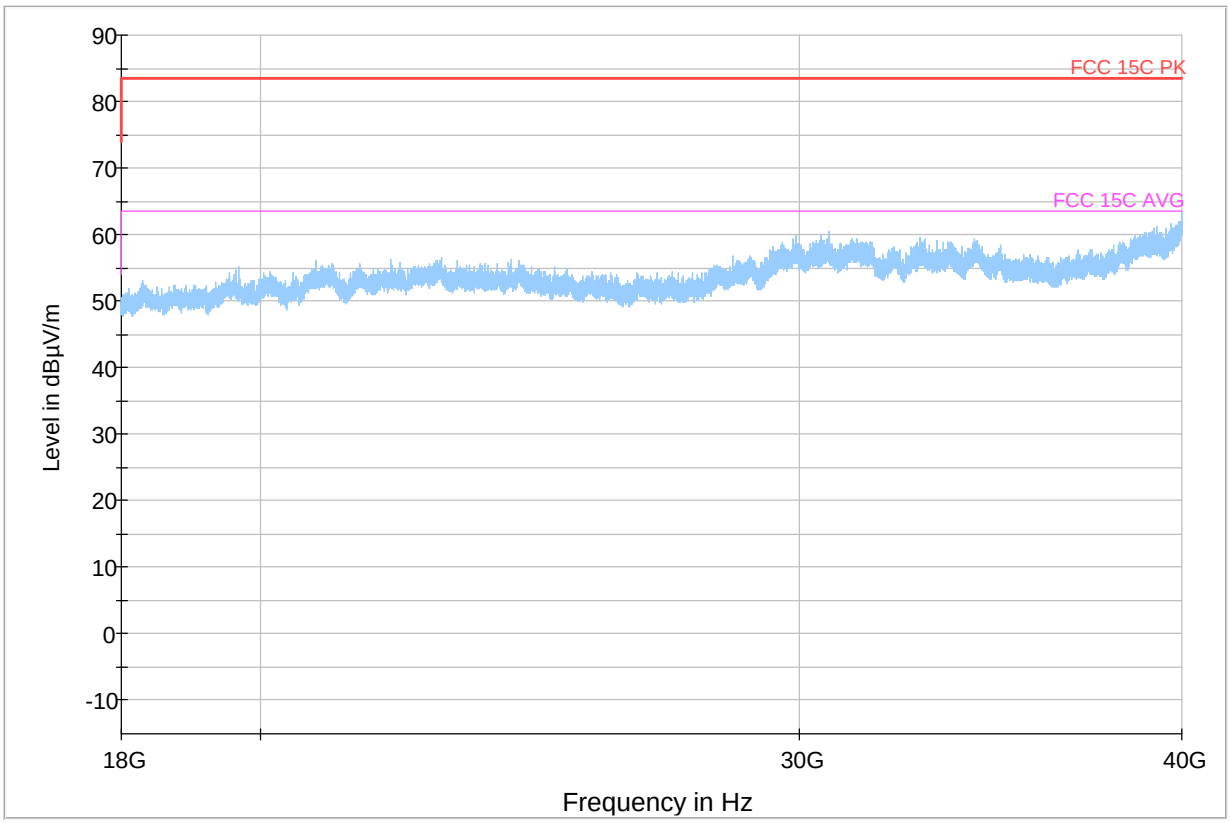
Tx Frequency: 2442 MHz	Mode: BLE	Data rate: 1 Mbps

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB/m)	Comment
4879.464	42.29	---	73.99	31.70	500.0	1000.000	266.0	H	-5.7	1:27:32 PM - 6/2/2020
4879.464	---	36.56	53.98	17.42	500.0	1000.000	266.0	H	-5.7	1:27:32 PM - 6/2/2020
7319.606	---	38.98	53.98	15.00	500.0	1000.000	241.0	V	-2.7	1:36:26 PM - 6/2/2020
7319.606	44.89	---	73.99	29.10	500.0	1000.000	241.0	V	-2.7	1:36:26 PM - 6/2/2020
10950.437	41.53	---	73.98	32.46	10.0	1000.000	224.0	V	3.5	1:50:36 PM - 6/2/2020
10950.437	---	31.93	53.98	22.05	10.0	1000.000	224.0	V	3.5	1:50:36 PM - 6/2/2020
17069.579	48.24	---	73.98	25.74	10.0	1000.000	279.0	H	9.6	1:30:09 PM - 6/2/2020
17069.579	---	37.78	53.98	16.20	10.0	1000.000	279.0	H	9.6	1:30:09 PM - 6/2/2020
17919.455	50.73	---	73.98	23.25	10.0	1000.000	234.0	V	13.7	1:33:23 PM - 6/2/2020
17919.455	---	41.91	53.98	12.07	10.0	1000.000	234.0	V	13.7	1:33:23 PM - 6/2/2020



Plot # 40 Radiated Emissions: 18 – 40 GHz		
Tx Frequency: 2442 MHz	**Mode: BLE**	**Data rate: 1 Mbps**

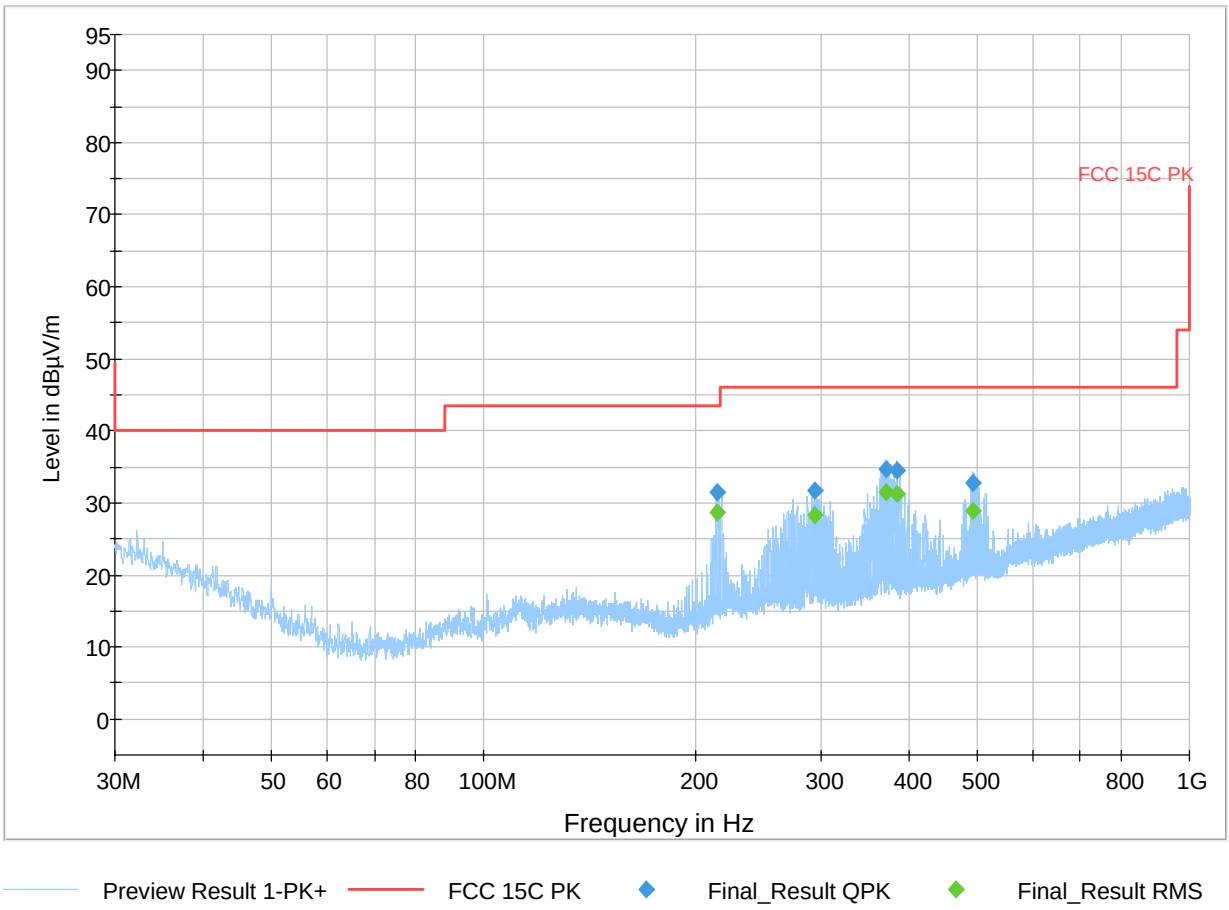


Plot # 41 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 1 Mbps

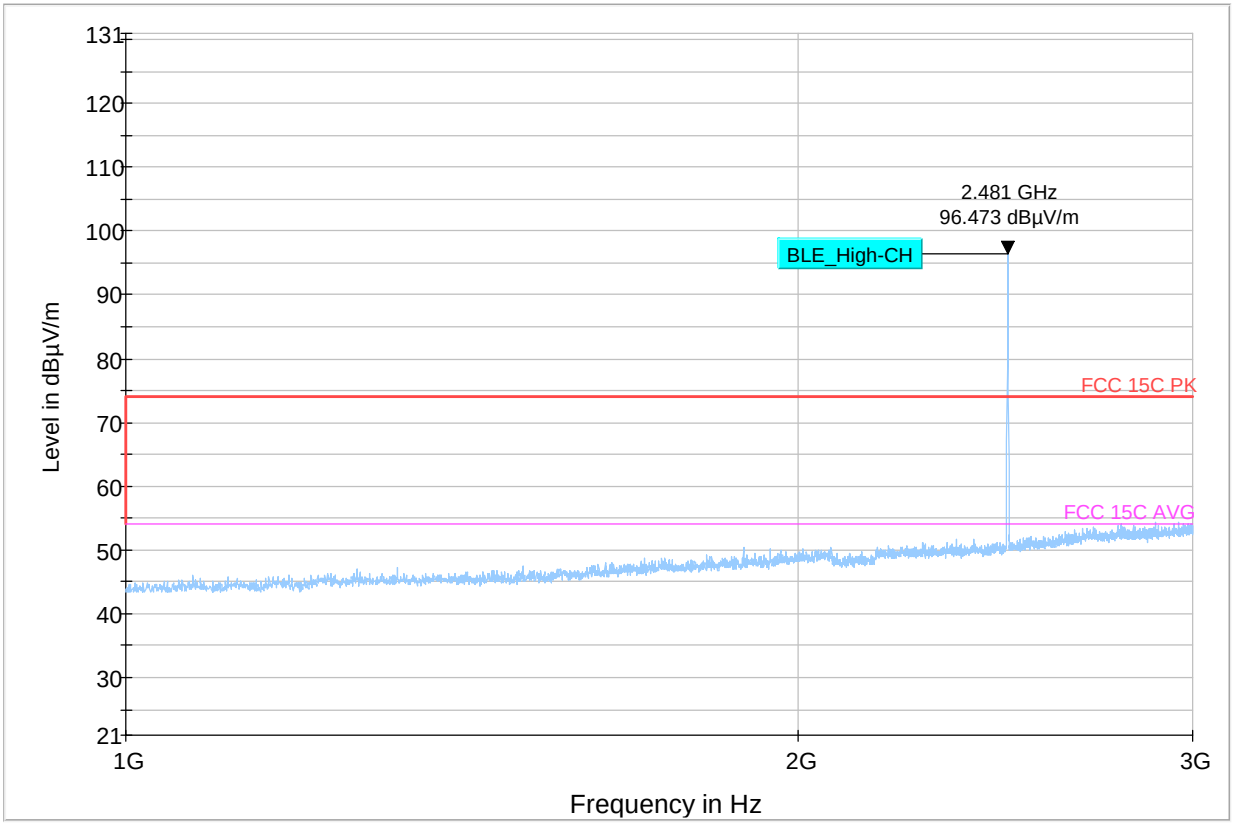
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB/m)
213.730	31.55	---	43.50	11.95	500.0	120.000	183.0	H	-18.8
213.730	---	28.72	---	---	500.0	120.000	183.0	H	-18.8
294.290	31.72	---	46.00	14.28	500.0	120.000	114.0	H	-17.7
294.290	---	28.26	---	---	500.0	120.000	114.0	H	-17.7
371.610	---	31.56	---	---	500.0	120.000	100.0	H	-15.1
371.610	34.72	---	46.00	11.28	500.0	120.000	100.0	H	-15.1
384.736	---	31.18	---	---	500.0	120.000	100.0	H	-14.8
384.736	34.42	---	46.00	11.58	500.0	120.000	100.0	H	-14.8
493.2988	---	28.81	---	---	500.0	120.000	256.0	H	-12.5
493.2988	32.75	---	46.00	13.25	500.0	120.000	256.0	H	-12.5



Plot # 42 Radiated Emissions: 1 – 3 GHz

Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 1 Mbps

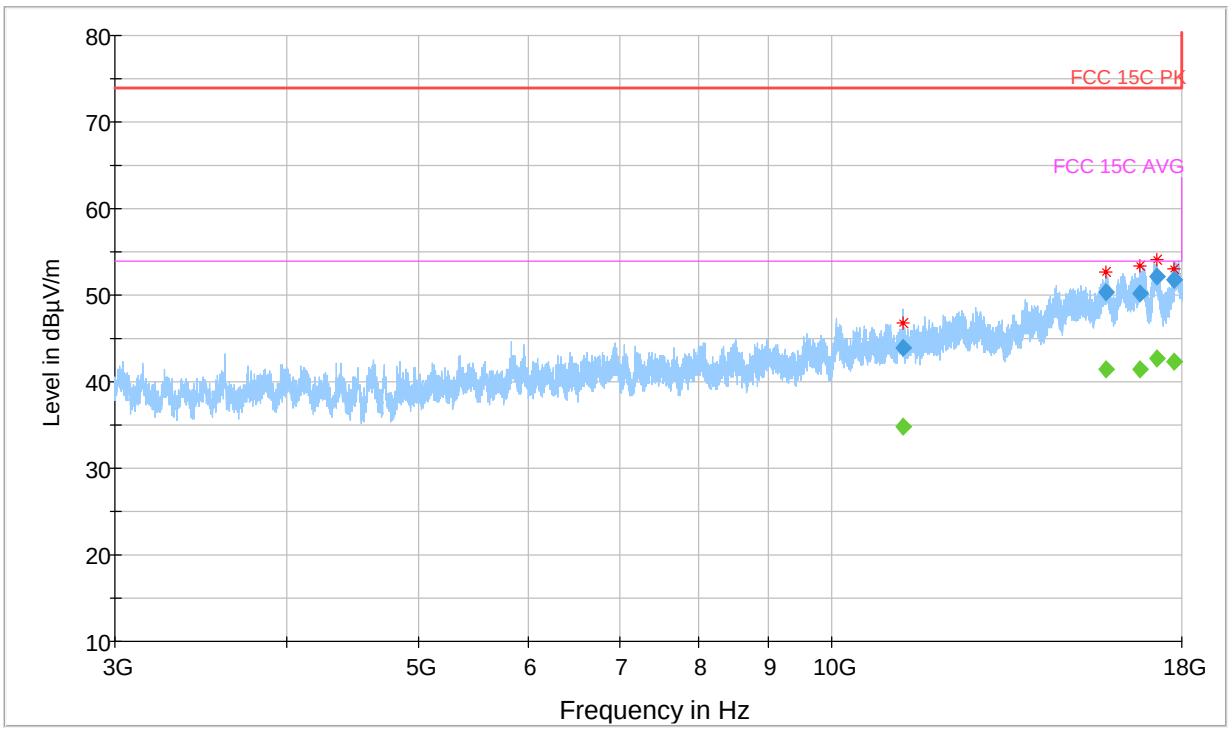


Plot # 43 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 2480 MHz	Mode: BLE	Data rate: 1 Mbps

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB/	Comment
11266.49060	---	34.79	53.98	19.19	10.0	1000.000	100.0	H	3.4	3:02:06 PM - 6/2/2020
11266.49060	43.93	---	73.98	30.05	10.0	1000.000	100.0	H	3.4	3:02:06 PM - 6/2/2020
15845.79933	---	41.38	53.98	12.60	10.0	1000.000	294.0	H	10.1	3:05:03 PM - 6/2/2020
15845.79933	50.31	---	73.98	23.67	10.0	1000.000	294.0	H	10.1	3:05:03 PM - 6/2/2020
16768.47450	50.26	---	73.98	23.72	10.0	1000.000	252.0	V	12.2	3:10:38 PM - 6/2/2020
16768.47450	---	41.44	53.98	12.54	10.0	1000.000	252.0	V	12.2	3:10:38 PM - 6/2/2020
17256.83200	---	42.70	53.98	11.28	10.0	1000.000	256.0	V	13.4	3:13:59 PM - 6/2/2020
17256.83200	52.13	---	73.98	21.85	10.0	1000.000	256.0	V	13.4	3:13:59 PM - 6/2/2020
17781.55680	51.71	---	73.98	22.27	10.0	1000.000	306.0	V	12.7	3:07:56 PM - 6/2/2020
17781.55680	---	42.36	53.98	11.62	10.0	1000.000	306.0	V	12.7	3:07:56 PM - 6/2/2020



9 Test setup photos

Setup photos are included in supporting file name:
"EMC_COMPO_017_20001_FCC_15.247_ISED_BLE_DTS_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	10/26/2017
BILOG ANTENNA	TESEO	CBL 6141B	41106	3 YEARS	11/01/2017
HORN ANTENNA	EMCO	3115	00035111	3 YEARS	04/17/2019
HORN ANTENNA	ETS LINDGREN	3117	00169547	3 YEARS	08/08/2017
HORN ANTENNA	ETS LINDGREN	3116C	00169535	3 YEARS	09/24/2017
SIGNAL ANALYZER	R&S	FSV 40	101022	3 YEARS	07/16/2019
Spectrum Analyzer	R&S	FSU26	200065	3 YEARS	07/16/2019
THERMOMETER HUMIDITY MONITOR	CONTROL COMPANY	36934-164	181230565	2 YEARS	01/10/2019

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	Report prepared by
7/1/2020	EMC_COMPO_017_20001_FCC_15.247_ISED_BLE_DTS	Initial Version	Issa Ghanma

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