FCC / ISED Test Report

FOR: Digi Wireless Design Services, Inc.

Model Name: 51915

Product Description: Wireless module that connects to a sensor board and enables BLE communications with external gateway.

FCC ID: 2AQVA-ONVAPAN51915
IC ID: 24318-ONVPAN51915

Applied Rules and Standards:
47 CFR Part 2.1055 & 15.247 (DTS)
RSS-247 Issue 2 (DTSs) & RSS-Gen Issue 5

REPORT #: EMC_DIGII_045_18001_FCC_15.247_ISED_BLE_DTS

DATE: 11/13/2018

A2LA Accredited

IC recognized # 3462B-1

***CETECOM* Inc.**
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TABLE OF CONTENTS

1 Assessment

The following device as further described in section 3 of this report was evaluated for radiated and conducted spurious emissions for unlicensed radio according to criteria specified in FCC rules 15.247 of Title 47 of the Code of Federal Regulations and the relevant ISED Canada standard RSS-GEN and RSS-247.

No deviations were ascertained.

Company	Description	Model #
Digi Wireless Design Services, Inc.	Wireless module that connects to a sensor board and enables BLE communication with external gareway.	51915

Responsible for Testing Laboratory:

Date	Section	Name	Signature
11/13/2018	Compliance	Cindy Li (Lab Manager)	Cindy Li Digitally signed by Cindy Li DN: cn=Cindy Li, o=Cetecom Inc., ou=EMC, email=cindy.li@cetecom.com, c=US Date: 2018.11.13 15:58:09 -08'00'

Responsible for the Report:

Date	Section	Name	Signature
11/13/2018	Compliance	Issa Ghanma (EMC Engineer)	Digitally signed by: issa.ghanma@cetecom.com DN: CN = issa.ghanma@cetecom.com Date: 2018.11.13 15:24:28 -08'00'

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
Lab Manager:	Cindy Li
Responsible Project Leader:	Sangeetha Sivaraman

2.2 Identification of the Client

Applicant's Name:	Digi Wireless Design Services, Inc.
Street Address:	11001 Bren Rd E
City/Zip Code	Minnetonka, MN 55343
Country	USA

2.3 Identification of the Manufacturer

Manufacturer's Name:	Kimberly-Clark Professional
Manufacturers Address:	1400 Holcomb Bridge Road
City/Zip Code	Roswell, GA 30076
Country	USA

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Marketing name:	Onvation PAN Module
FWIN:	1.0
HVIN:	51915
PMN:	Onvation PAN Module
Frequency Range / number of channels:	Nominal band: 2400 MHz – 2483.5 MHz; Center to center: 2402 MHz (ch 0) – 2480 MHz (ch 39), 40 channels
Type(s) of Modulation:	Bluetooth low energy 4.0 GFSK modulation.
Modes of Operation:	Bluetooth LE in both advertising and connected mode of operation
Max. measured output Powers:	2.01 dBm
Antenna Information as declared:	KC TP, Maximum gain 4.04 dBi.
Power Supply/ Rated Operating Voltage Range:	Low 2.7 VDC, Nominal 3.0 VDC, High 3.3 VDC
Operating Temperature Range:	Low 0º C, Nominal 27º C, High 50º C
Other Radios included in the device:	NA
Sample Revision:	☐Prototype Unit; ☐Production Unit; ■Pre-Production
EUT Dimensions [cm]:	2.5 x 6.3
Weight [grams]:	6.5
EUT Diameter:	■ < 60 cm ☐ Other _____

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes / Comments
1	B28	1.0	1.0	Conducted Measurement / -
2	B36	1.0	1.0	Conducted Measurement / Variant unit
3	B29	1.0	1.0	Radiated Emissions / -
4	B34	1.0	1.0	Radiated Emissions / Variant unit

3.3 Accessory Equipment (AE) details

AE #	Comments
-	NA

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1	During the tests a “USB – 6 Pin Micro connector” cable was connected to the EUT. The cable is only for troubleshooting and configuring the EUT, and the EUT cannot keep transmitting on test mode configuration if the “6 Pin Micro connector” end of the cable is not connected to the EUT.
2	EUT#2	During the tests a “USB – 6 Pin Micro connector” cable was connected to the EUT. The cable is only for troubleshooting and configuring the EUT, and the EUT cannot keep transmitting on test mode configuration if the “6 Pin Micro connector” end of the cable is not connected to the EUT.
3	EUT#3	During the tests a “USB – 6 Pin Micro connector” cable was connected to the EUT. The cable is only for troubleshooting and configuring the EUT, and the EUT cannot keep transmitting on test mode configuration if the “6 Pin Micro connector” end of the cable is not connected to the EUT.

4	EUT#4	During the tests a "USB – 6 Pin Micro connector" cable was connected to the EUT. The cable is only for troubleshooting and configuring the EUT, and the EUT cannot keep transmitting on test mode configuration if the "6 Pin Micro connector" end of the cable is not connected to the EUT.

3.5 Mode of Operation details

Mode of Operation	Description of Operating modes	Additional Information
Op. 1	BLE GFSK	Putty terminal tool and special commands provided by the customer used to configure the EUT to: • Modulated TX carrier. • Low, Mid, High channel. • Max power. • Max duty cycle. • Data rate 1 Mbit/s or 2 Mbit/s. The commands will not be available to the end user. For Radiated measurements: The internal antenna was connected. For Conducted measurements: The measurements equipment was connected to 50 ohm RF port of the EUT.

3.6 Justification for Worst Case Mode of Operation

The worst case mode of operation has been determined by evaluating the conducted results.
During the testing process the EUT was tested with transmitter sets on low, mid and high channels, and worst case mode of duty cycle, output power and data rate.

For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT according to the relevant requirements specified in FCC rules 15.247 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-247 Issue 2 and RSS-GEN Issue 5 of ISED Canada.

This test report is to support a request for new equipment authorization under the:

- FCC ID: 2AQVA-ONVAPAN51915
- IC ID: 24318-ONVPAN51915

Testing procedures are based on 558074 D01 DTS Meas Guidance v04 – "GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER SECTION 15.247" - April 5, 2017, 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)(2) RSS-247 5.2(a)	Emission Bandwidth	Nominal	BT LE	■	☐	☐	Complies
§15.247(e) RSS-247 5.2(b)	Power Spectral Density	Nominal	BT LE	■	☐	☐	Complies
§15.247(b)(3) RSS-247 5.4(d)	Maximum Conducted Output Power and EIRP	Nominal	BT LE	■	☐	☐	Complies
§15.247(d) RSS-247 5.5	Band edge compliance Unrestricted Band Edges	Nominal	BT LE	■	☐	☐	Complies
§15.247; 15.209; 15.205 RSS-247 5.5; Gen 8.9; 8.10	Band edge compliance Restricted Band Edges	Nominal	BT LE	■	☐	☐	Complies
§15.247(d); §15.209 RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	BT LE	■	☐	☐	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	-	-	☐	■	☐	Note 1 Note 2

Note1: NA= Not Applicable; NP= Not Performed.
Note2: Device does not connect to AC main power.

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)

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:

07/24/2018 – 10/03/2018

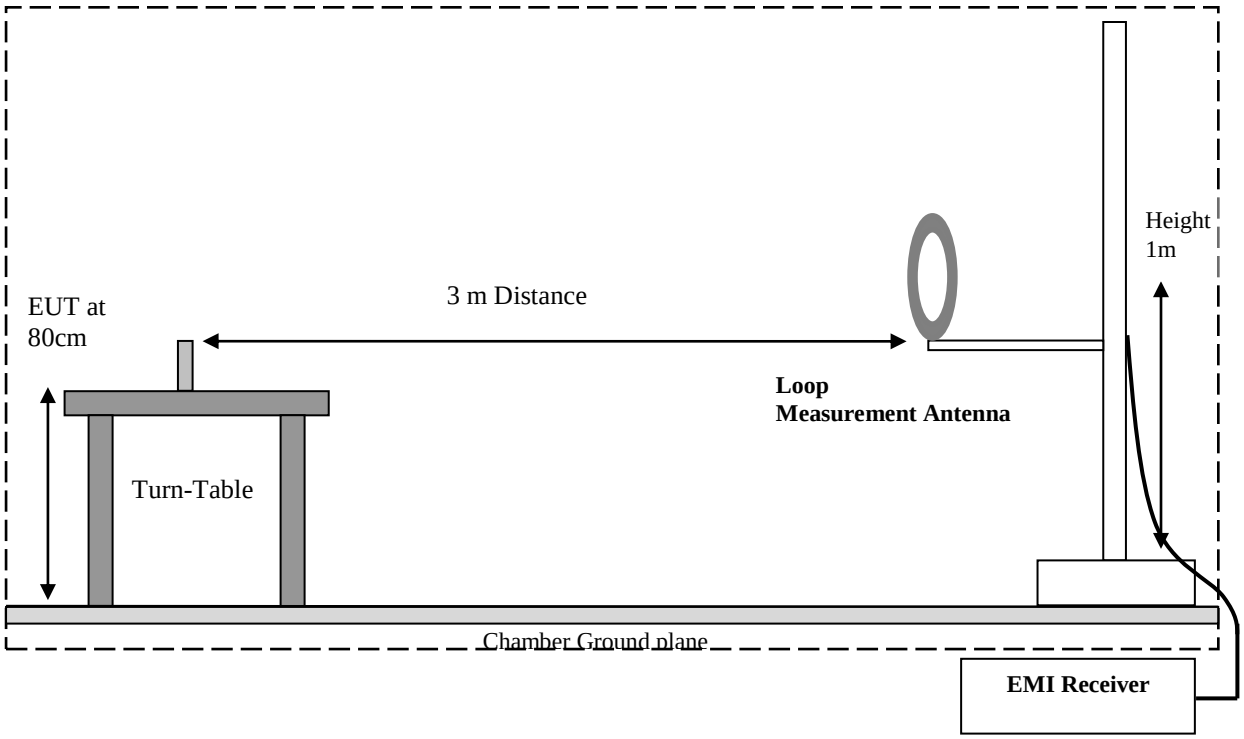
7 Measurement Procedures

7.1 Radiated Measurement

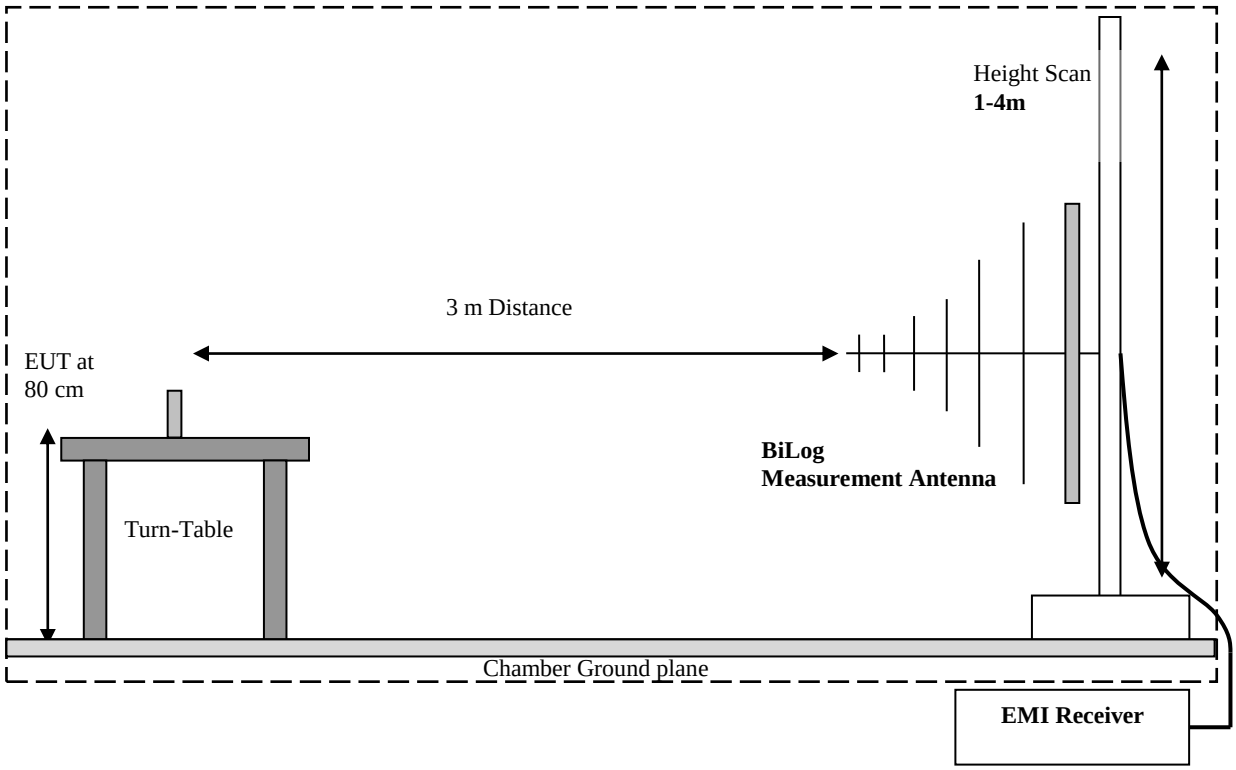
The radiated measurement is performed according to ANSI C63.10 (2013)

- 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.

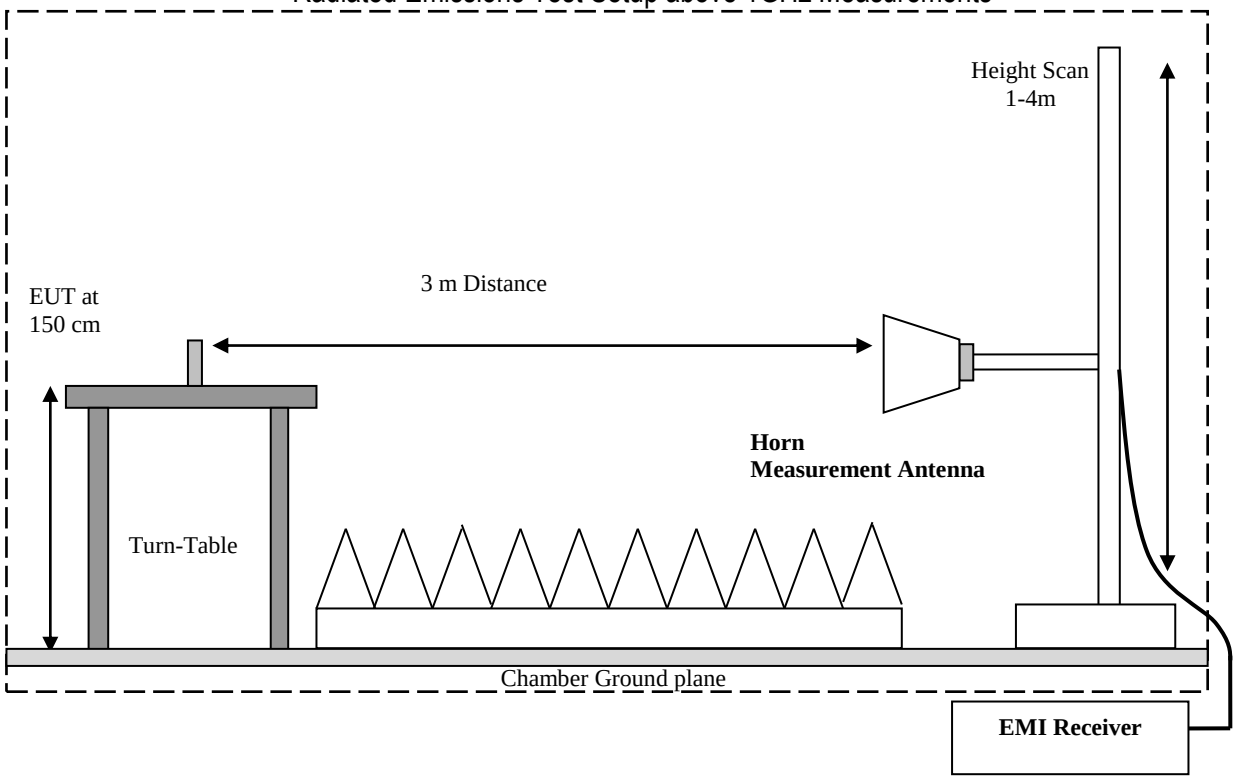
Radiated Emissions Test Setup below 30MHz Measurements



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 RF Conducted Measurement Procedure

Testing procedures are based on 558074 D01 DTS Meas Guidance v04 – "GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER SECTION 15.247" - April 5, 2017, 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 Emission Bandwidth 6dB and 99% Occupied Bandwidth

8.1.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings:

- 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.

8.1.2 Limits:

➢ FCC §15.247(a) (2):

- 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.

➢ RSS-247 5.2:

- DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:

  a. The minimum 6 dB bandwidth shall be 500 kHz.

8.1.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	1	Op.1	3.3v DC

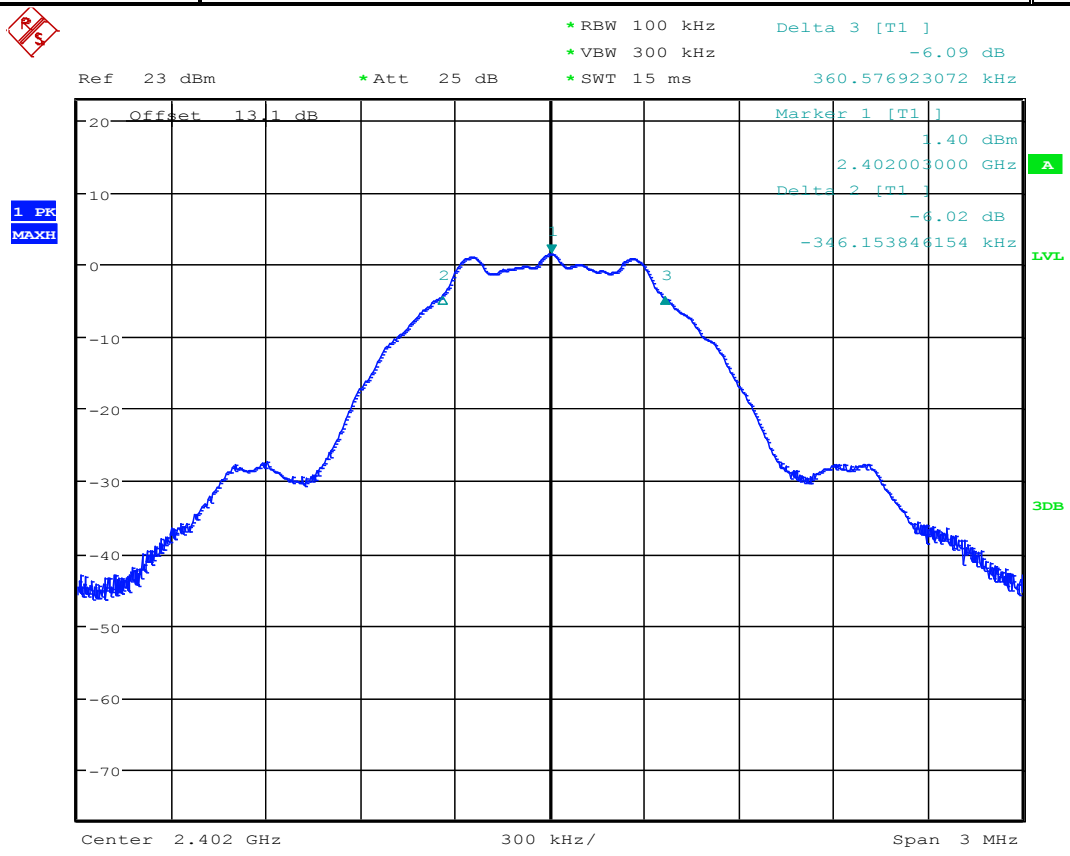
8.1.4 Measurement result:

Plot #	Frequency (MHz)	Data Rate (Mbit/s)	6dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
1	2402	1	0.71	> 0.5	Pass
2	2440	1	0.72	> 0.5	Pass
3	2480	1	0.72	> 0.5	Pass
4	2402	2	0.86	> 0.5	Pass
5	2440	2	0.82	> 0.5	Pass
6	2480	2	0.86	> 0.5	Pass

Plot #	Frequency (MHz)	Data Rate (Mbit/s)	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
7	2402	1	1.07	> 0.5	Pass
8	2440	1	1.08	> 0.5	Pass
9	2480	1	1.08	> 0.5	Pass
10	2402	2	1.83	> 0.5	Pass
11	2440	2	1.87	> 0.5	Pass
12	2480	2	1.89	> 0.5	Pass

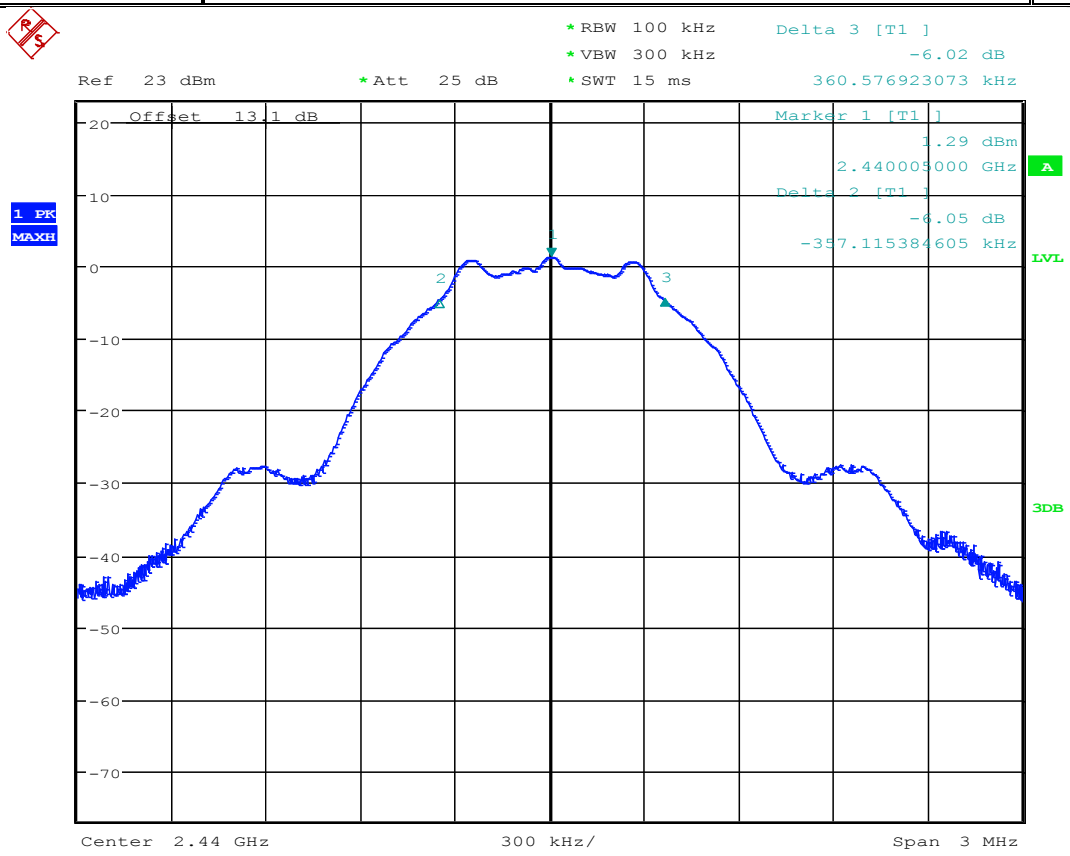
8.1.5 Measurement Plots:

Plot #1		
2402 MHz	Mode: BTLE	1 Mbit/s



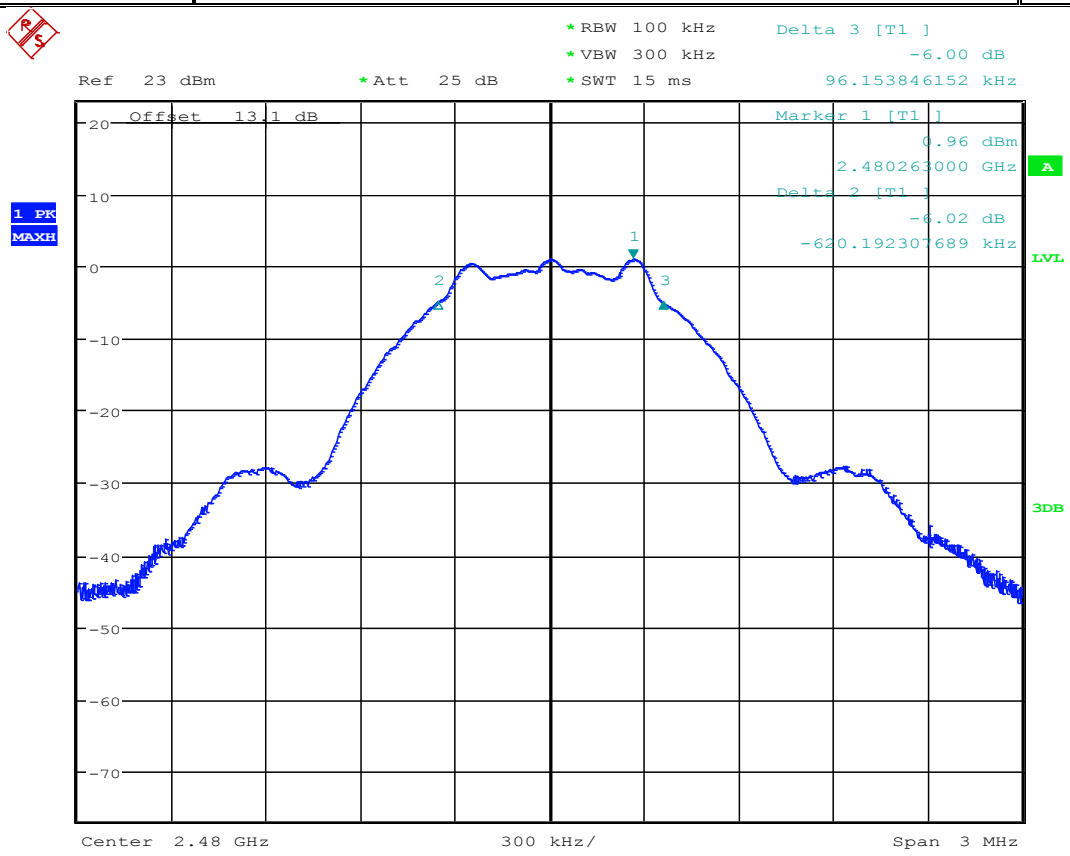
Plot #2

2440 MHz	Mode: BTLE	1 Mbit/s



Plot #3

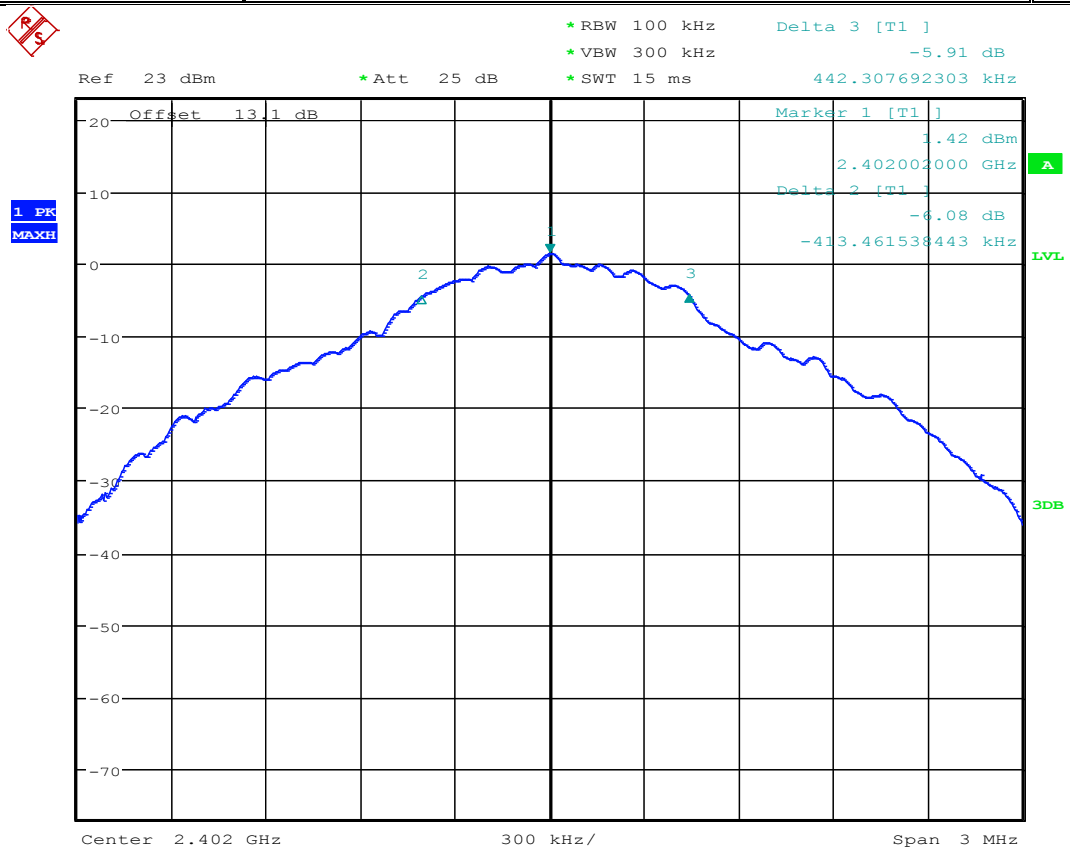
2480 MHz	Mode: BTLE	1 Mbit/s



Date: 25.JUL.2018 08:35:28

Plot #4

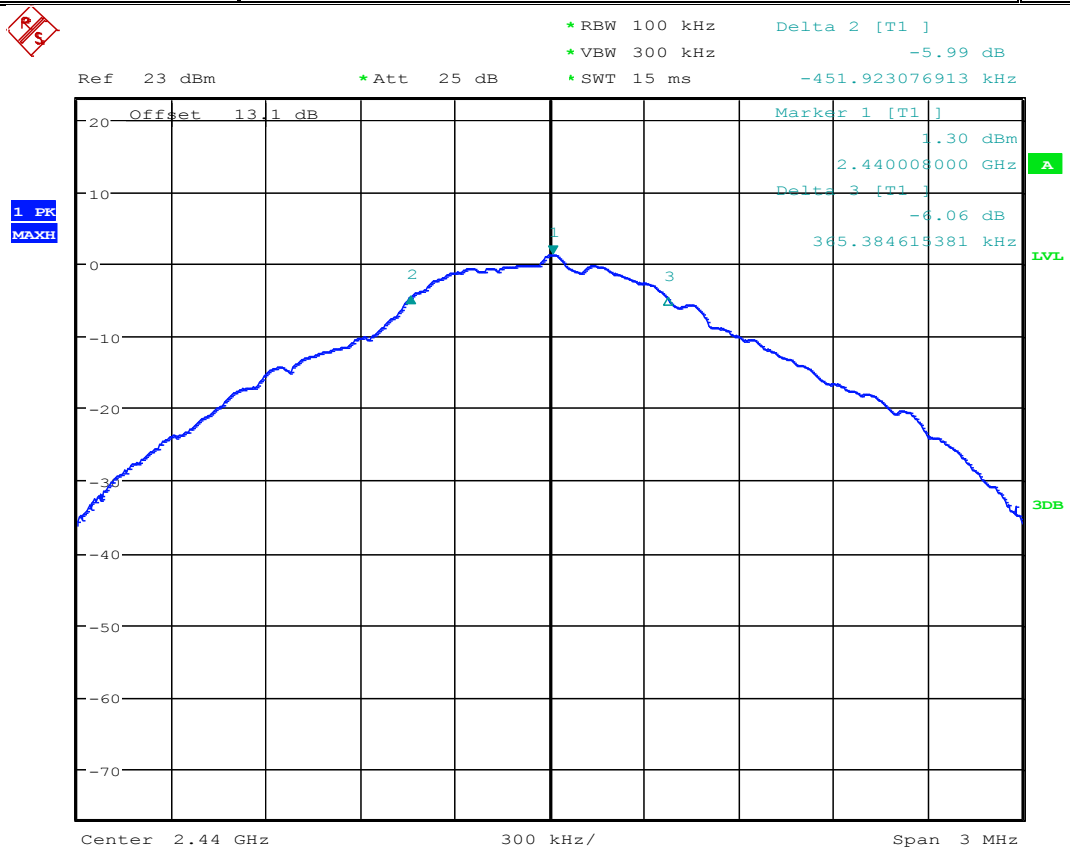
2402 MHz	Mode: BTLE	2 Mbit/s



Date: 25.JUL.2018 08:21:40

Plot #5

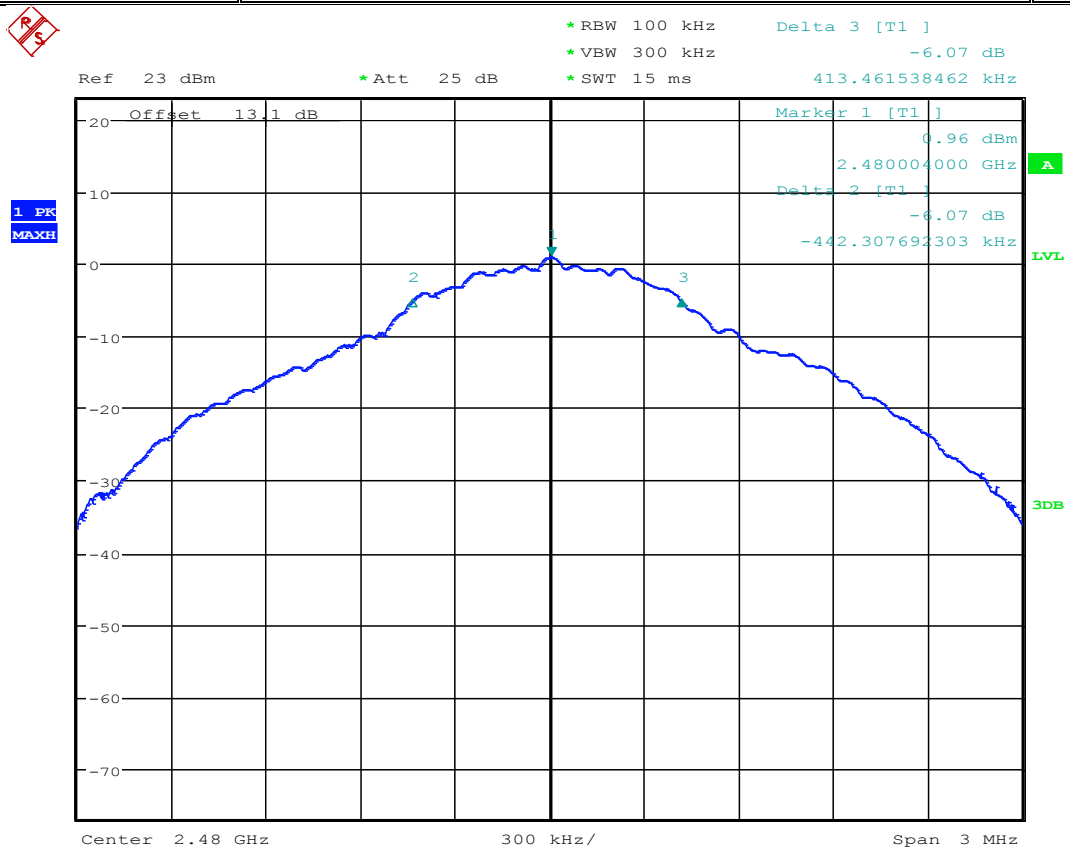
2440 MHz	Mode: BTLE	2 Mbit/s



Date: 25.JUL.2018 08:01:15

Plot #6

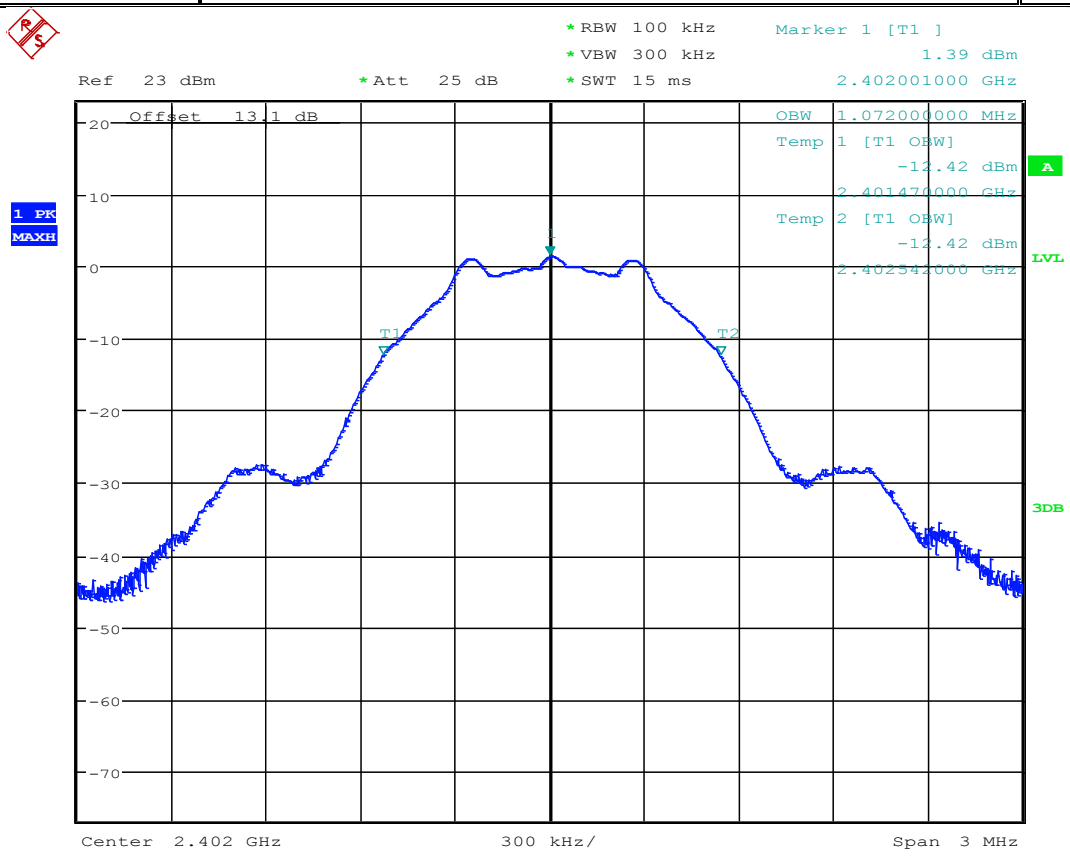
2480 MHz	Mode: BTLE	2 Mbit/s



Date: 25.JUL.2018 08:27:02

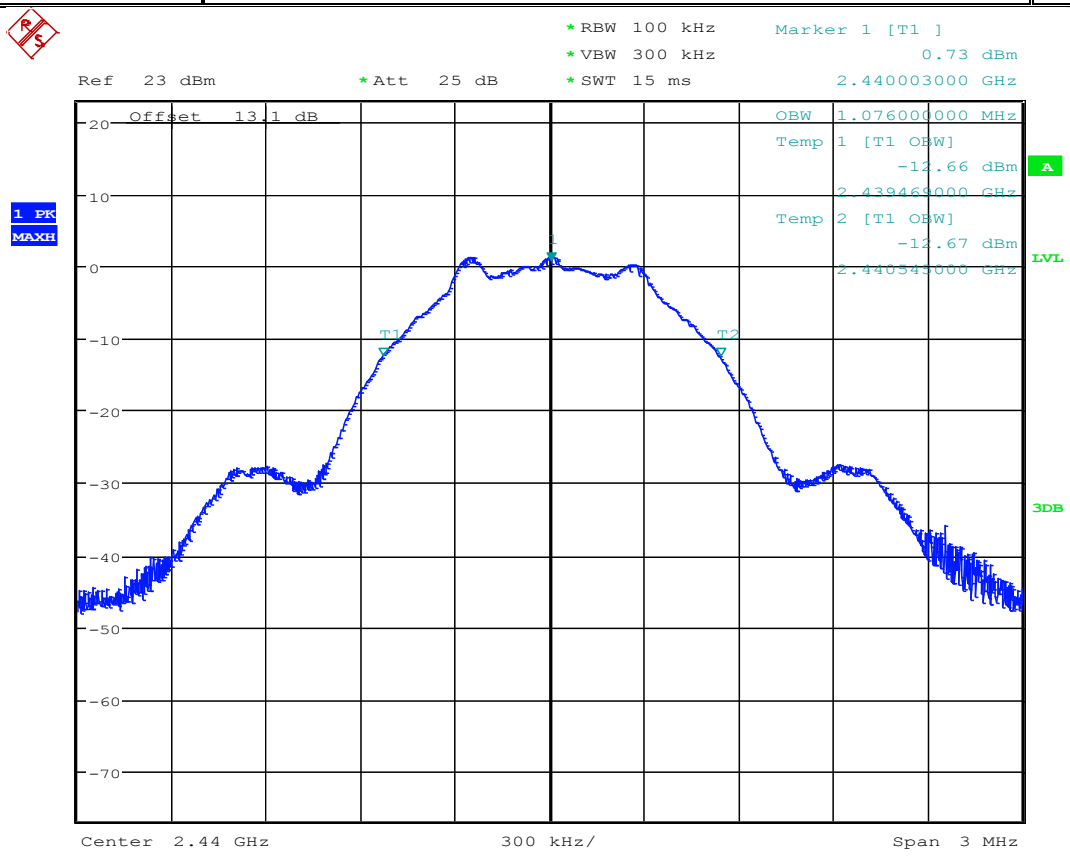
Plot #7

2402 MHz	Mode: BTLE	1 Mbit/s



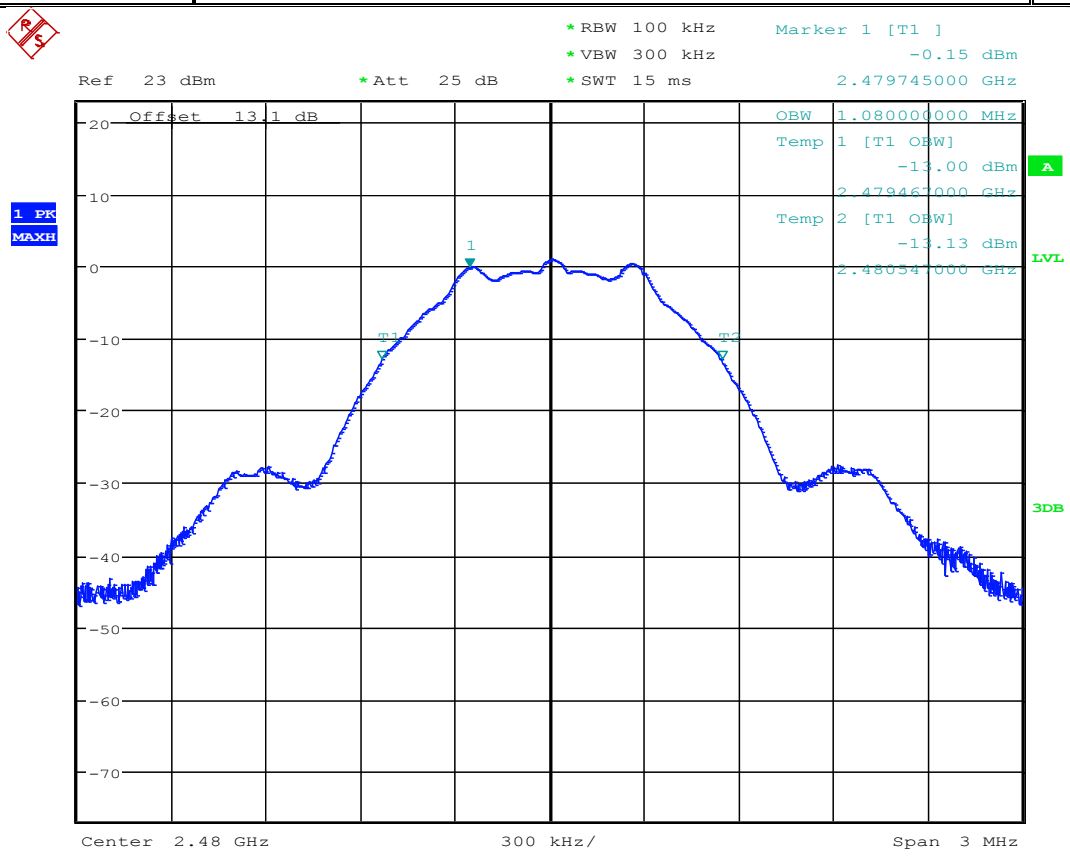
Plot #8

2440 MHz	Mode: BTLE	1 Mbit/s



Plot #9

2480 MHz	Mode: BTLE	1 Mbit/s



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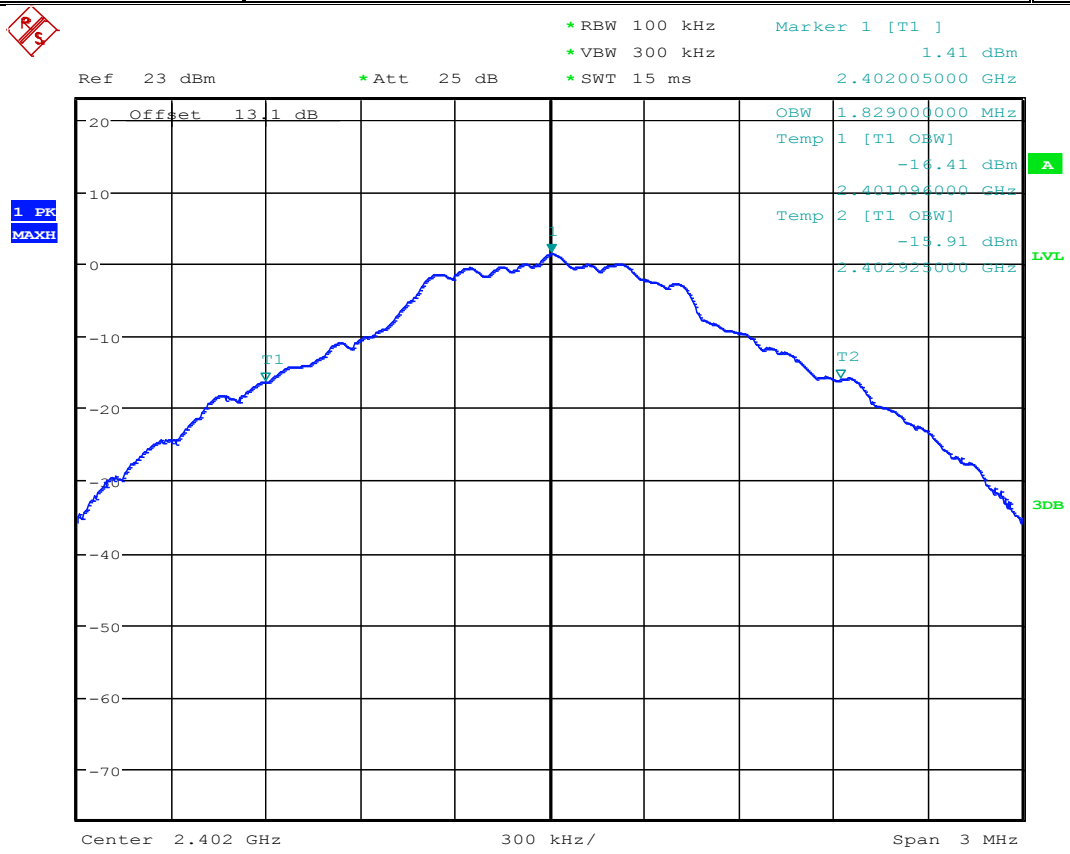
Plot #10

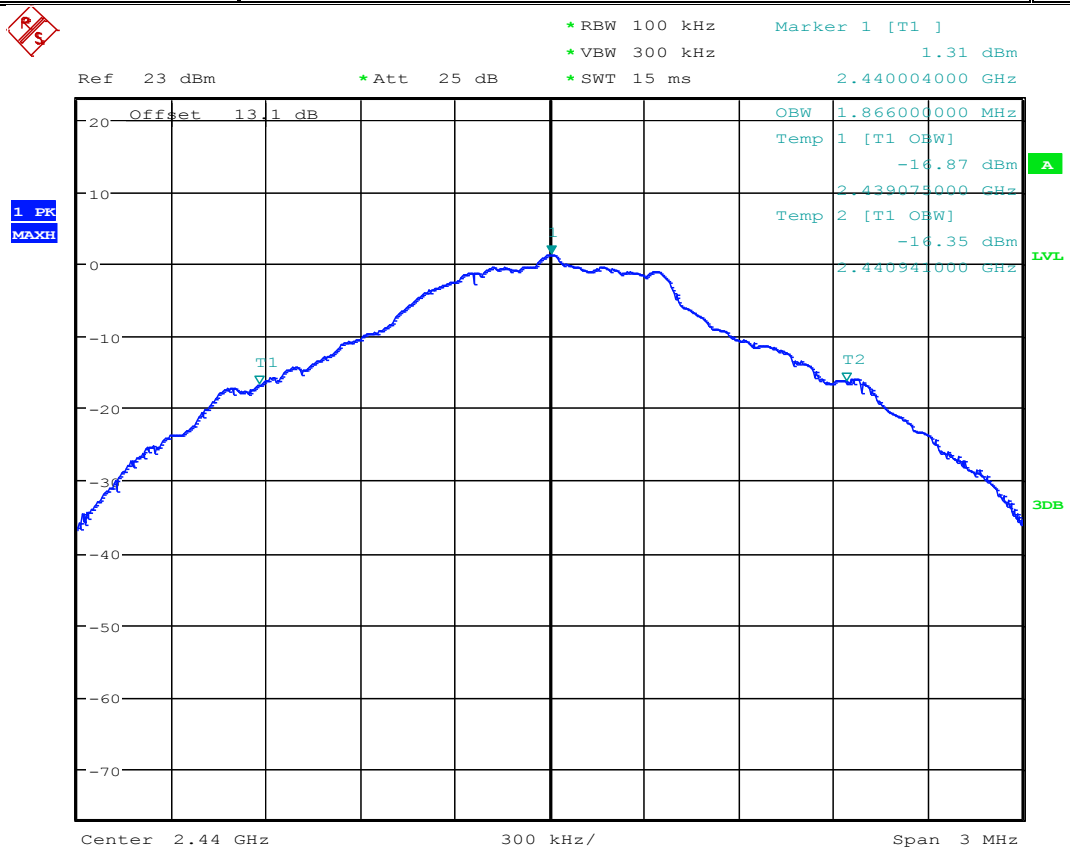
2402 MHz	Mode: BTLE	2 Mbit/s



Date: 25.JUL.2018 08:55:43

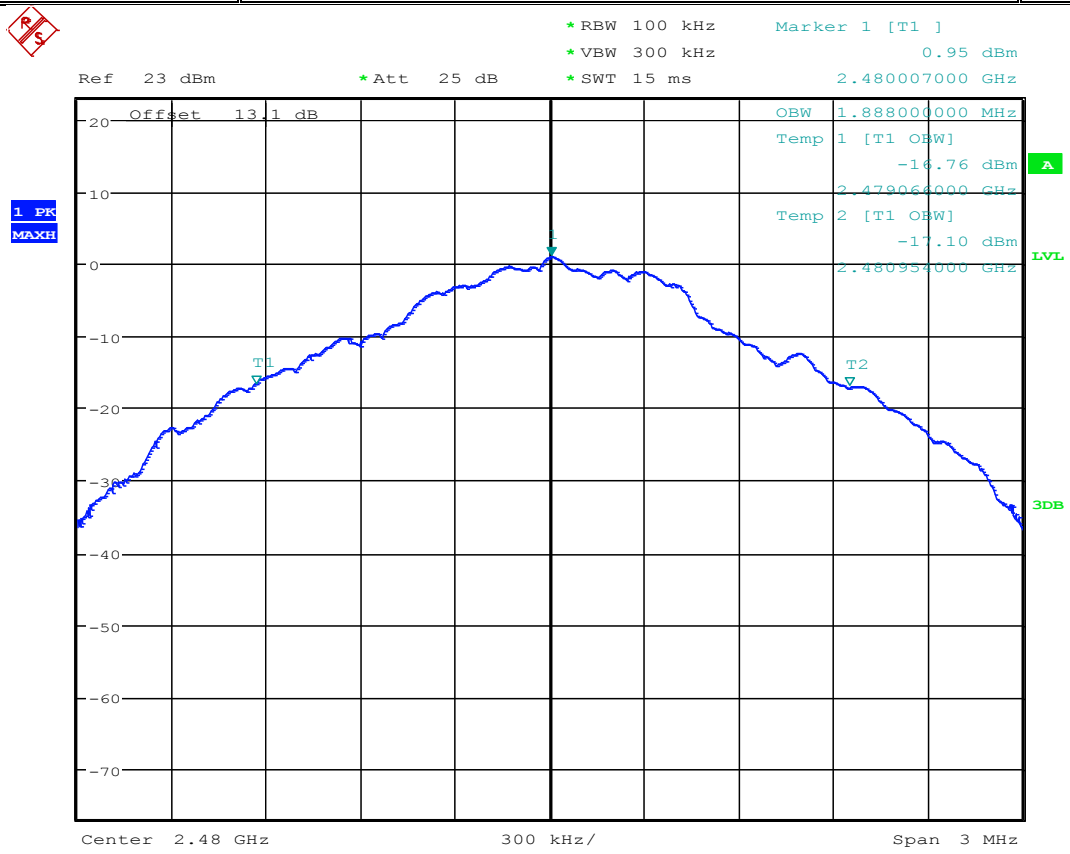
Plot #11

2440 MHz	Mode: BTLE	2 Mbit/s



Plot #12

2480 MHz	Mode: BTLE	2 Mbit/s



Date: 25.JUL.2018 08:45:47

8.1.6 Test conditions and setup:

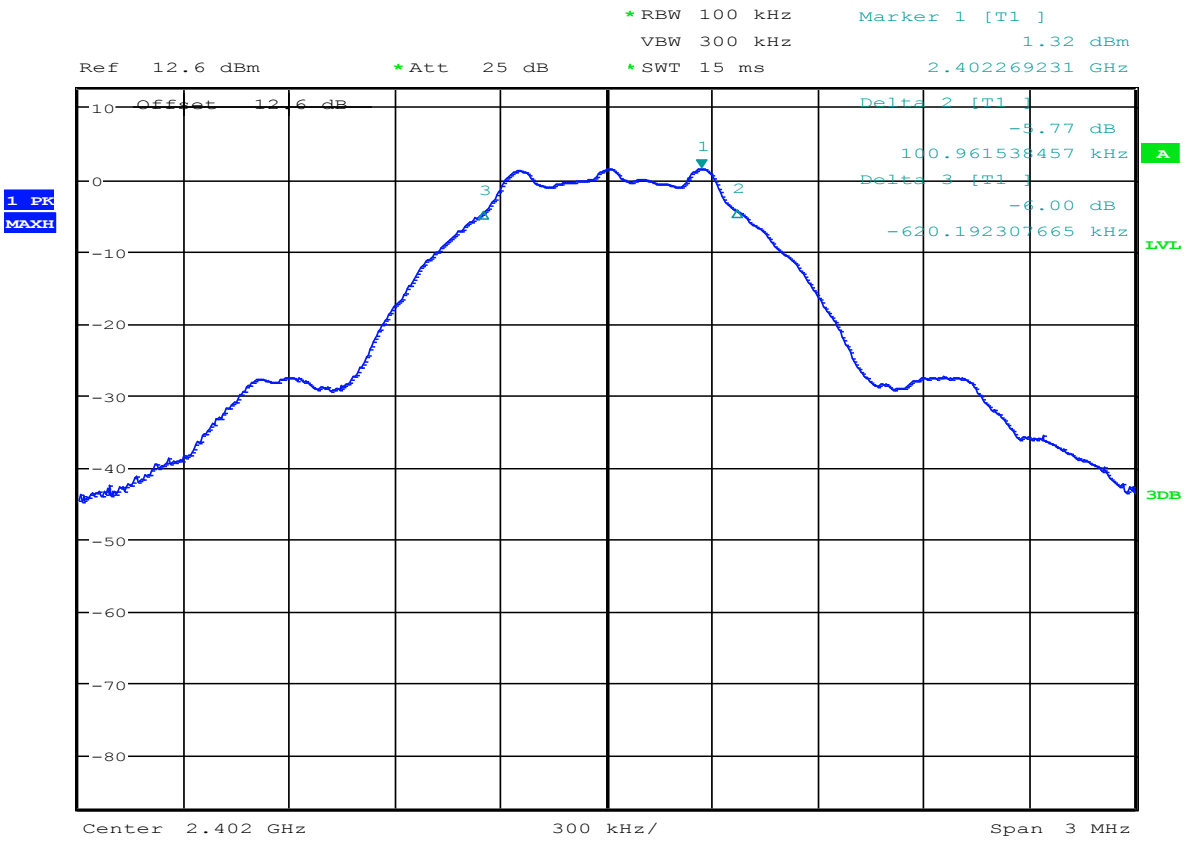
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	2	Op.2	3.3v DC

8.1.7 Measurement result:

Plot #	Frequency (MHz)	Data Rate (Mbit/s)	6dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
1	2402	1	0.72	> 0.5	Pass
2	2440	1	0.72	> 0.5	Pass
3	2480	1	0.73	> 0.5	Pass
4	2402	2	0.89	> 0.5	Pass
5	2440	2	0.86	> 0.5	Pass
6	2480	2	0.82	> 0.5	Pass

8.1.8 Measurement Plots:

Plot #1		
2402 MHz	**Mode: BTLE**	**1 Mbit/s**



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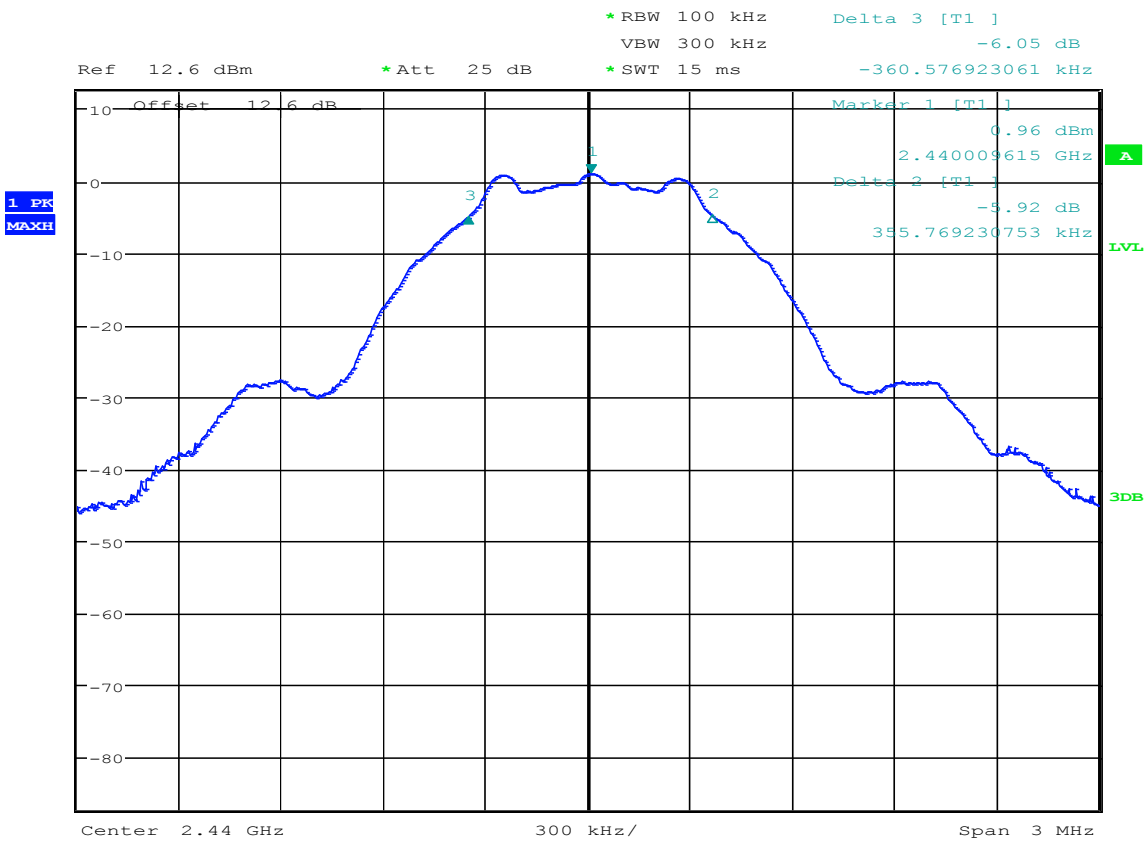
Date: 13.SEP.2018 10:43:38

Plot #2

2440 MHz	Mode: BTLE	1 Mbit/s



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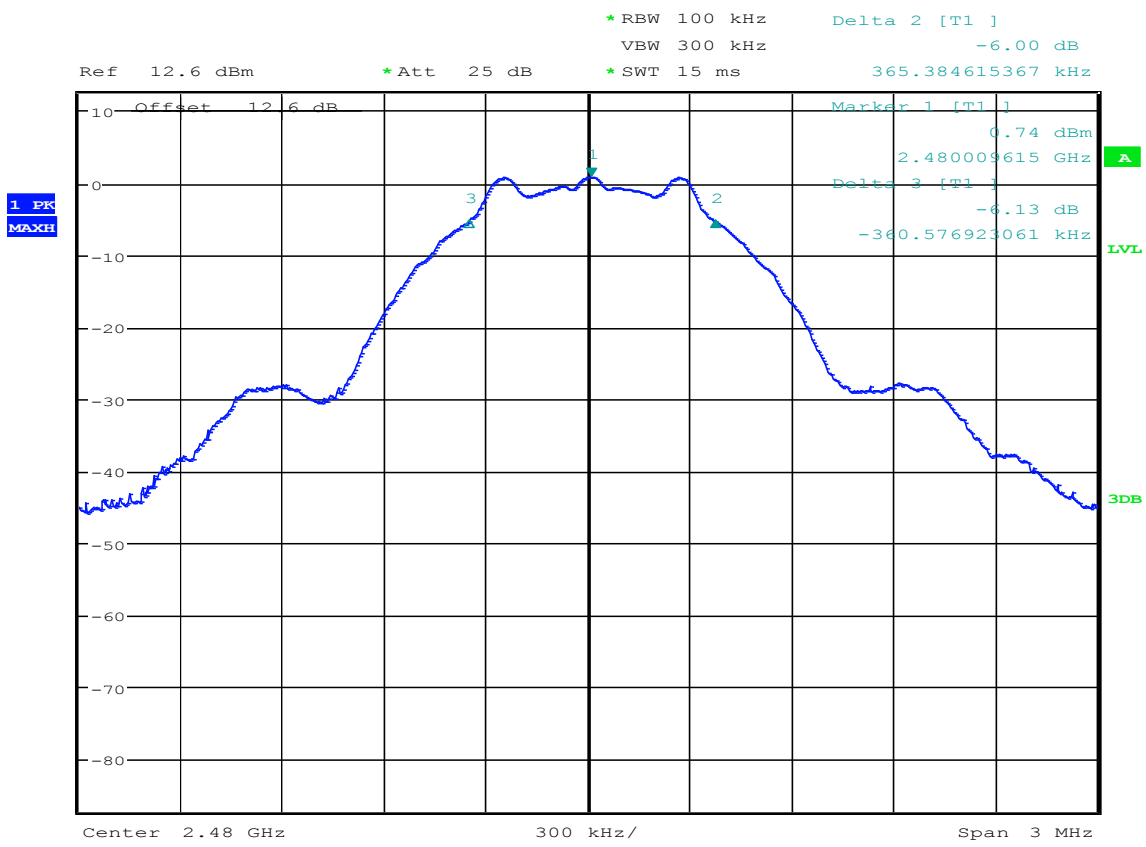
Plot #3

2480 MHz	Mode: BTLE	1 Mbit/s



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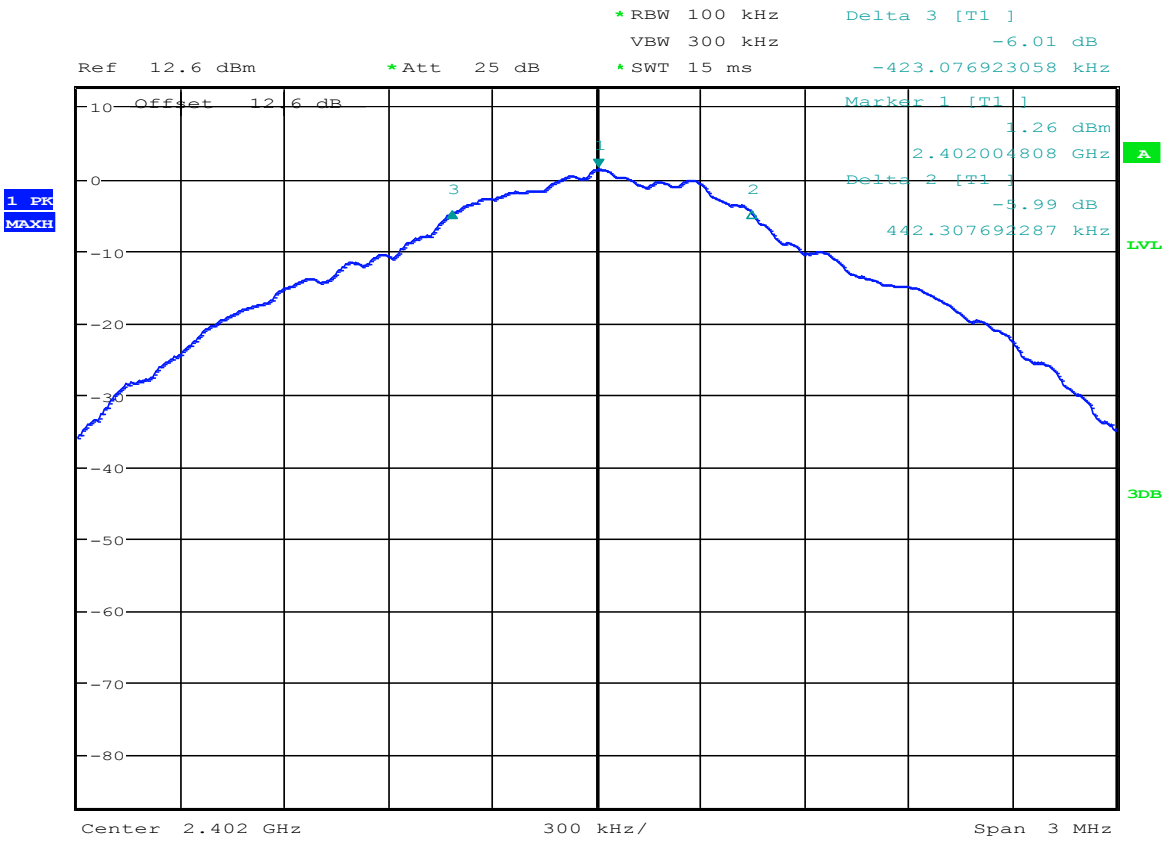
Date: 13.SEP.2018 12:21:27

Plot #4

2402 MHz	Mode: BTLE	2 Mbit/s



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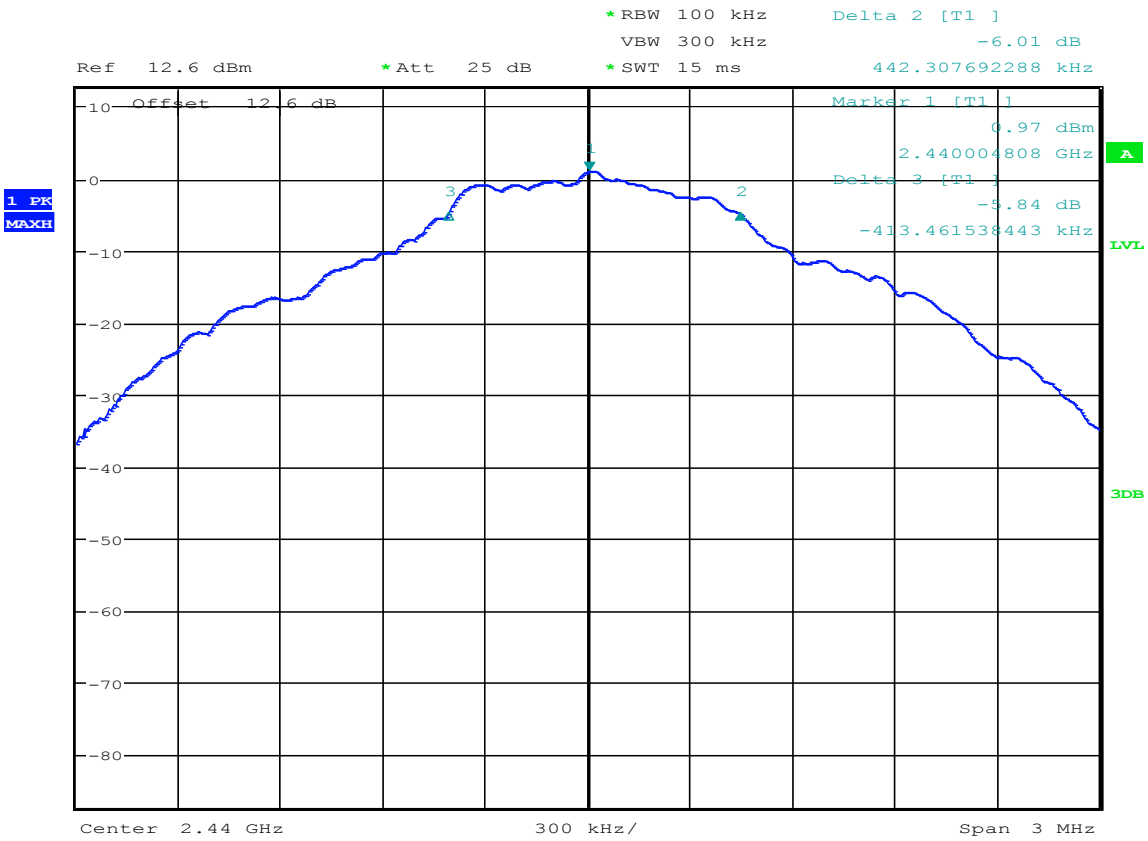
Plot #5

2440 MHz	Mode: BTLE	2 Mbit/s



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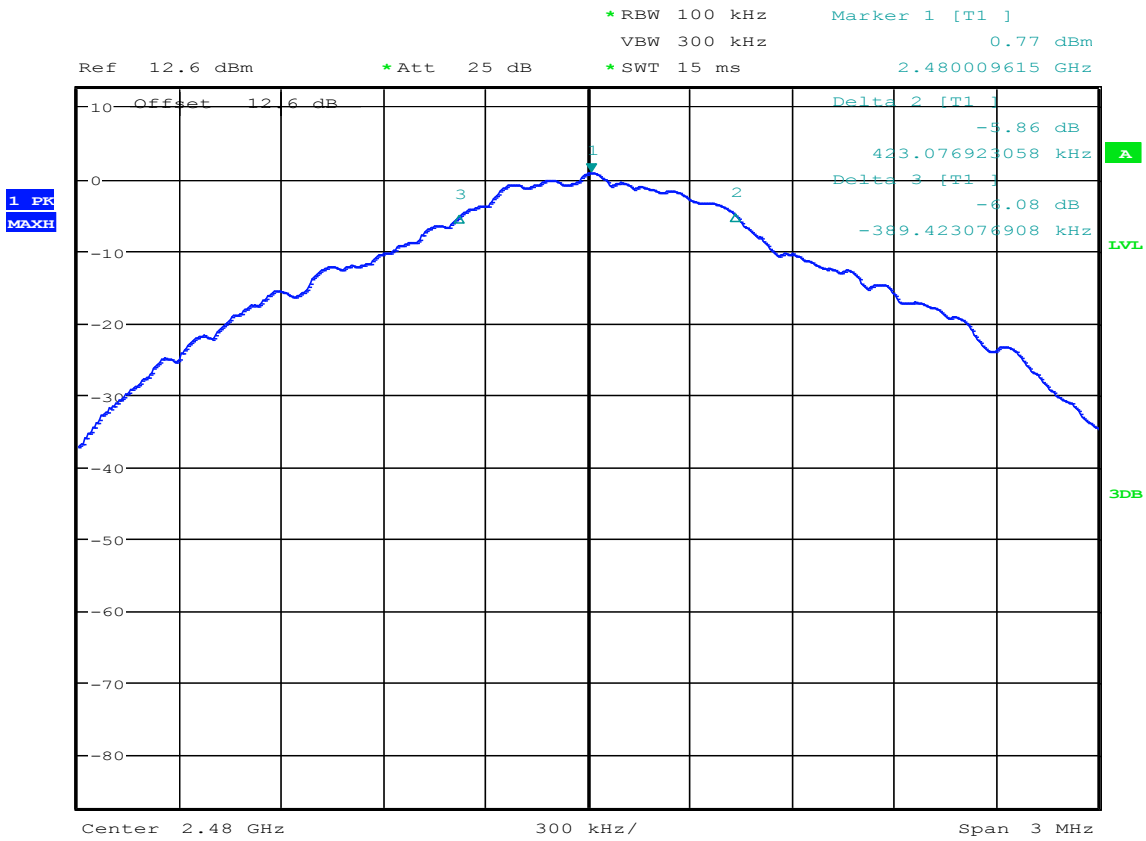
Plot #6

2480 MHz	Mode: BTLE	2 Mbit/s



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Date: 13.SEP.2018 12:18:02

8.2 Power Spectral Density

8.2.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

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) For digitally modulated systems, the 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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

➢ RSS-247 5.2

- b. The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

8.2.3 Test conditions and setup:

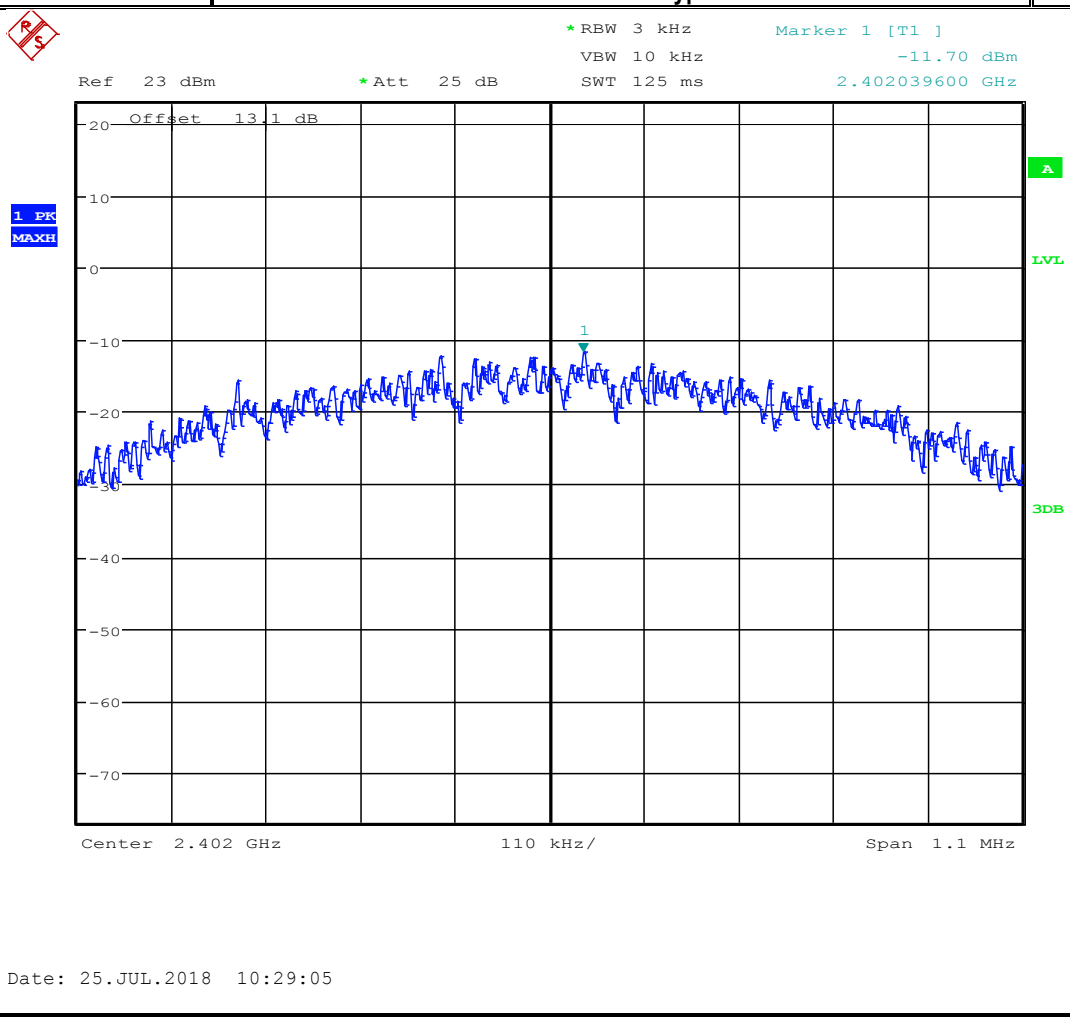
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	Op.1	3.3 VDC	4.04 dBi

8.2.4 Measurement result:

Plot #	Frequency (MHz)	Data Rate (Mbit/s)	Maximum Power Spectral Density (dBm/3 kHz)	PSD Adjusted for Antenna Gain (dBm/3 kHz)	Limit (dBm / 3 kHz)	Result
1	2402	1	-11.7	-7.66	8	Pass
2	2441	1	-11.67	-7.63	8	Pass
3	2480	1	-12.22	-8.18	8	Pass
4	2402	2	-11.84	-7.80	8	Pass
5	2441	2	-12.34	-8.20	8	Pass
6	2480	2	-11.17	-7.13	8	Pass

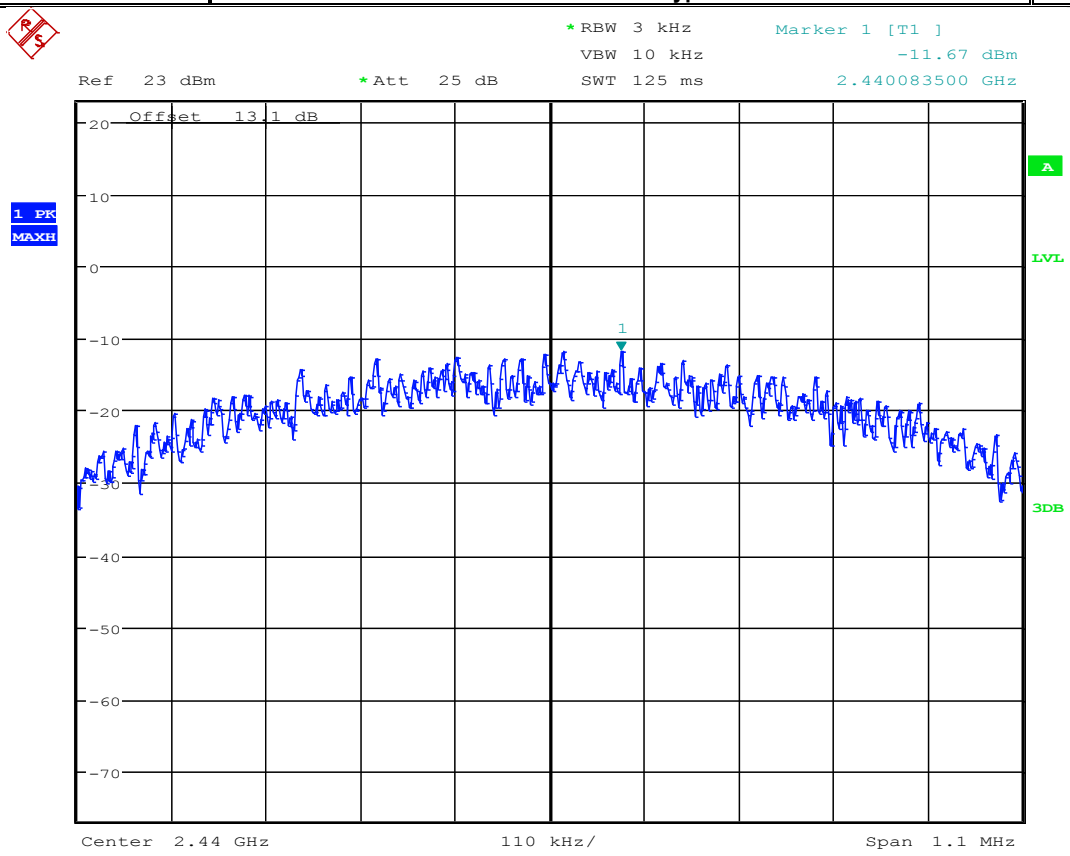
8.2.5 Measurement Plots:

Plot #1		
Low channel / 2402 MHz	**Modulation/Packet Type: BTLE**	**1 Mbit/s**



Plot #2

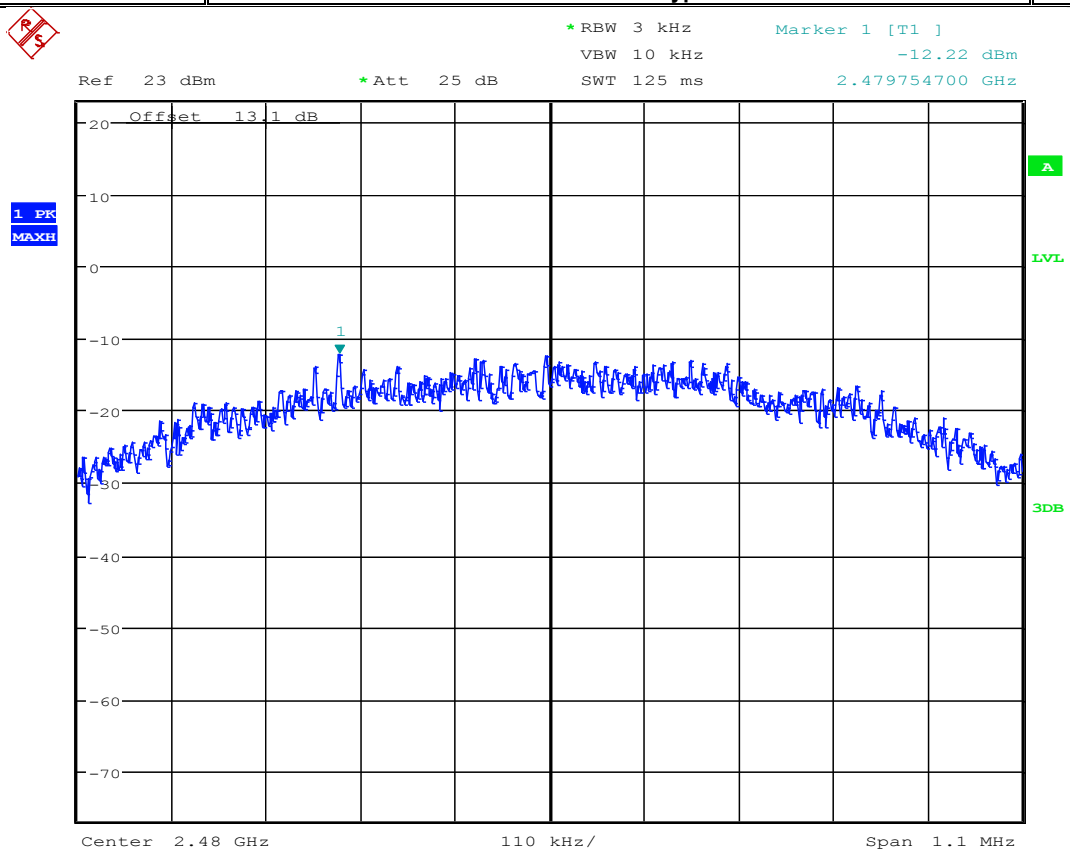
Mid channel 2440 MHz	Modulation/Packet Type: BTLE	1 Mbit/s



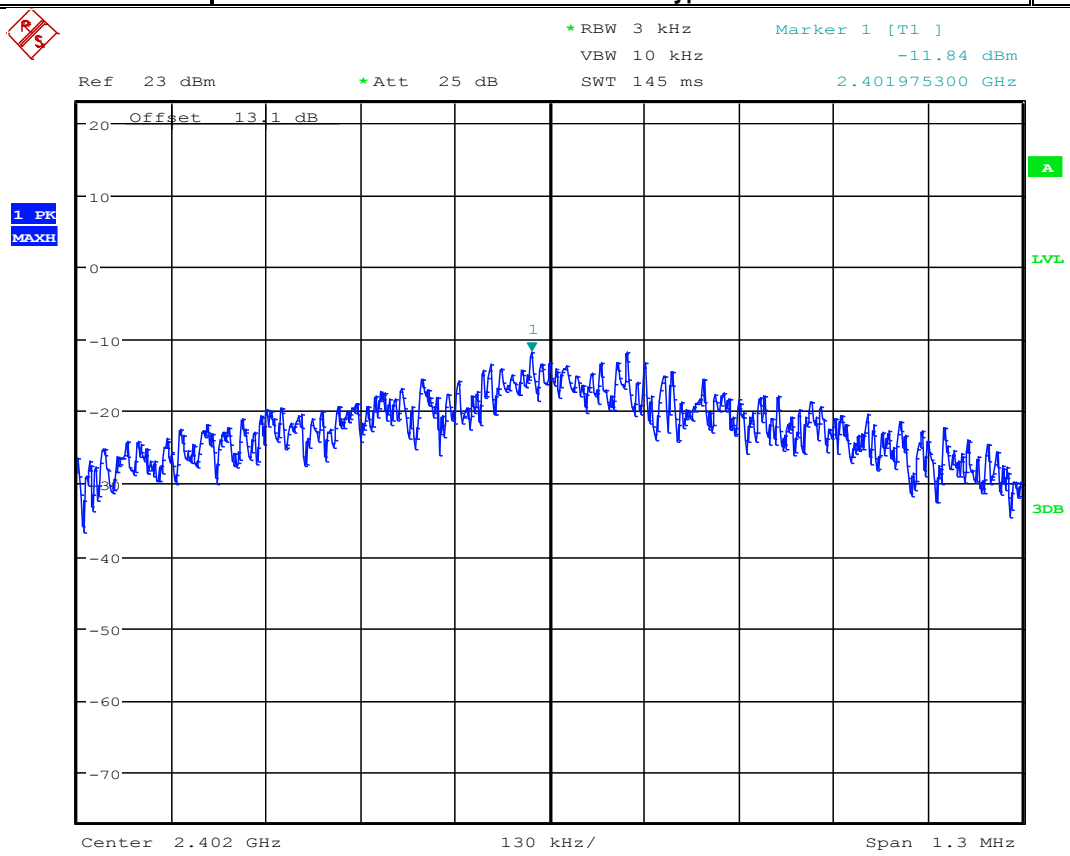
Date: 25.JUL.2018 10:17:17

Plot #3

High channel 2480 MHz	Modulation/Packet Type: BTLE	1 Mbit/s



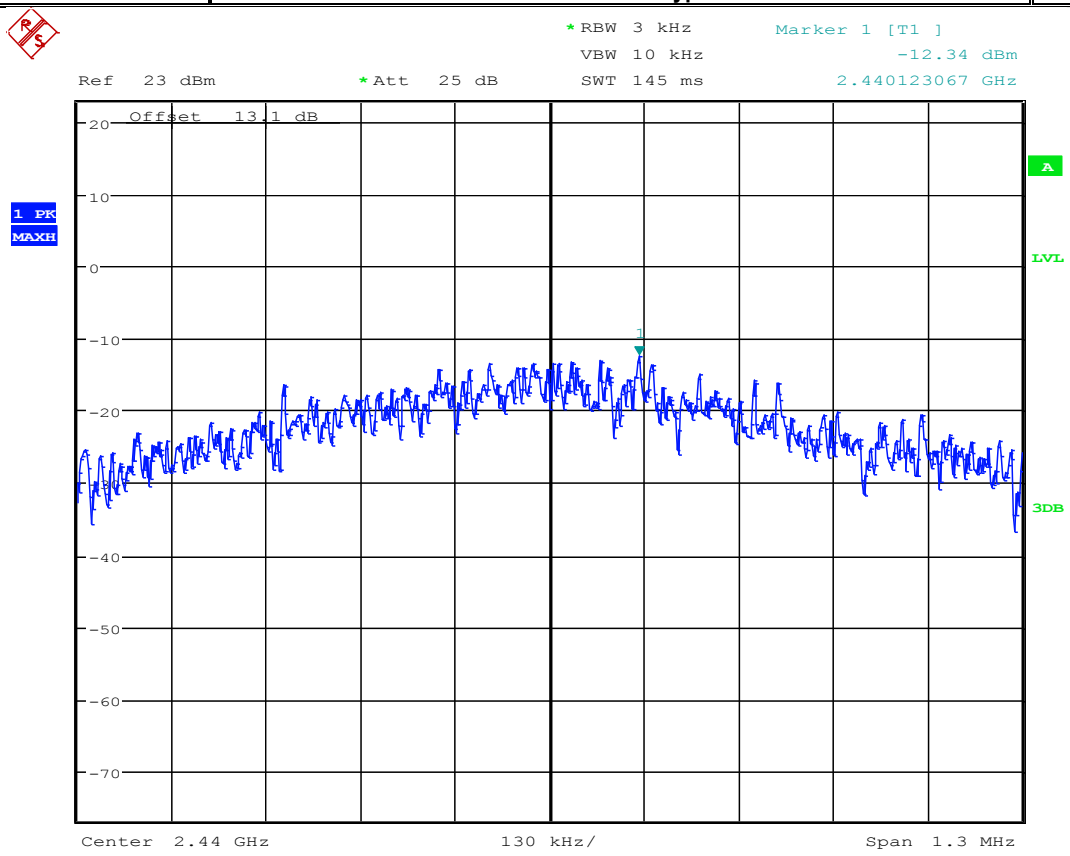
Plot #4		
Low channel / 2402 MHz	Modulation/Packet Type: BTLE	2 Mbit/s



Date: 25.JUL.2018 10:24:45

Plot #5

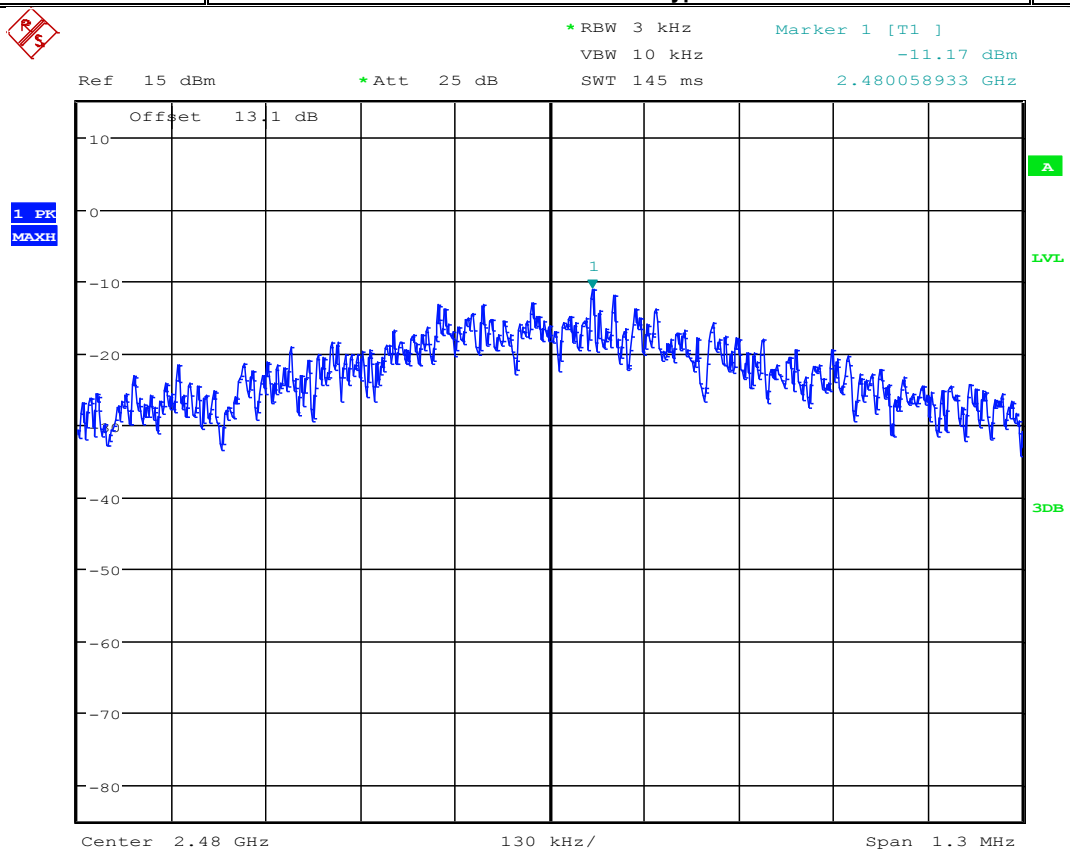
Mid channel 2440 MHz	Modulation/Packet Type: BTLE	2 Mbit/s



Date: 25.JUL.2018 10:19:17

Plot #6

High channel 2480 MHz	Modulation/Packet Type: BTLE	2 Mbit/s



8.2.6 Test conditions and setup:

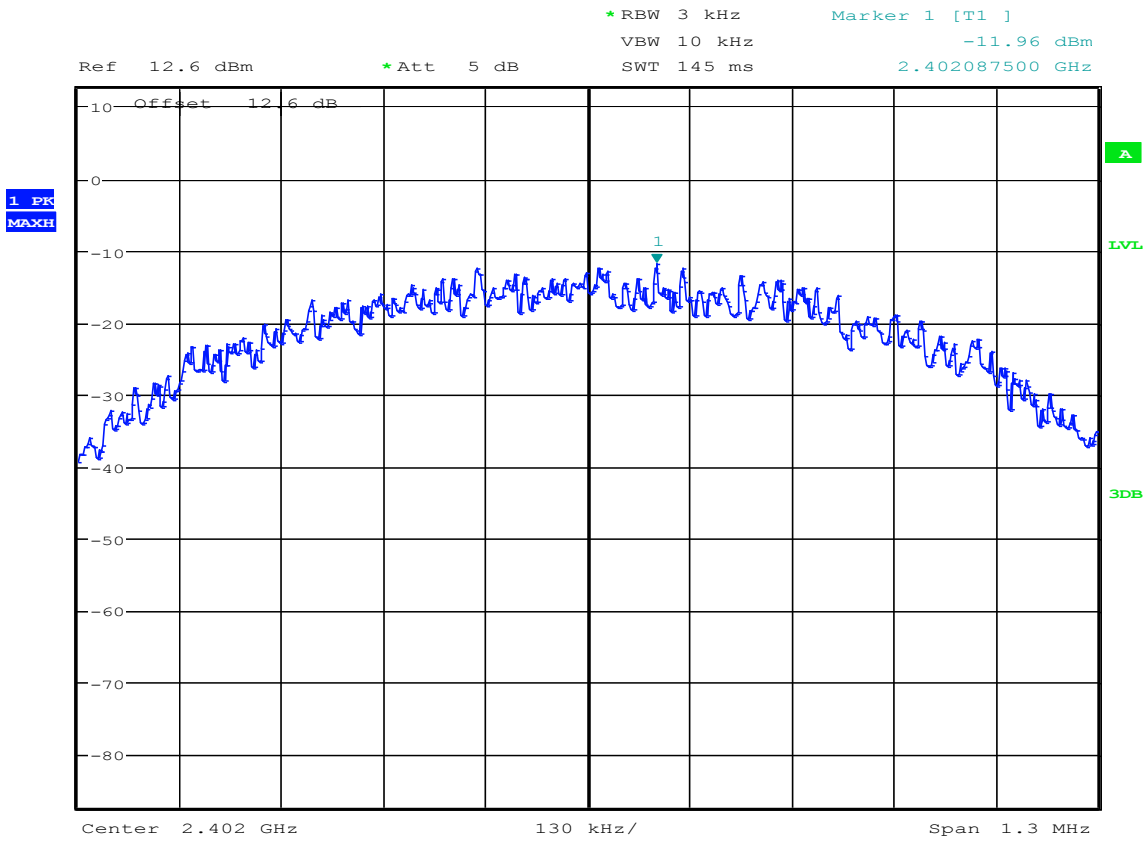
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	2	Op.2	3.3 VDC	-

8.2.7 Measurement result:

Plot #	Frequency (MHz)	Data Rate (Mbit/s)	Maximum Power Spectral Density (dBm/3 kHz)	PSD Adjusted for Antenna Gain (dBm/3 kHz)	Limit (dBm / 3 kHz)	Result
1	2402	1	-11.96	-7.92	8	Pass
2	2441	1	-11.89	-7.85	8	Pass
3	2480	1	-13.01	-8.97	8	Pass
4	2402	2	-12.57	-8.53	8	Pass
5	2441	2	-11.09	-7.05	8	Pass
6	2480	2	-11.26	-7.22	8	Pass

8.2.8 Measurement Plots:

Plot #1		
Low channel / 2402 MHz	**Modulation/Packet Type: BTLE**	**1 Mbit/s**

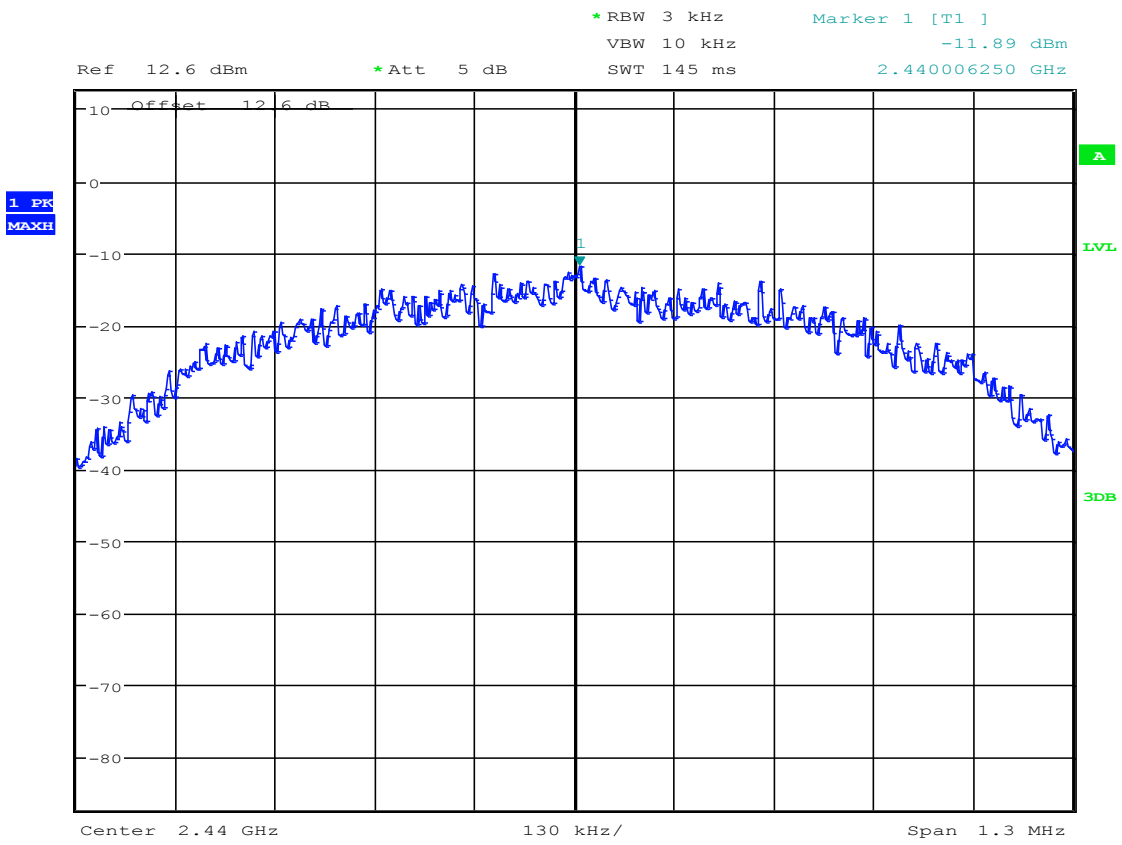


low

Date: 12.SEP.2018 16:28:34

Plot #2

Mid channel 2440 MHz	Modulation/Packet Type: BTLE	1 Mbit/s

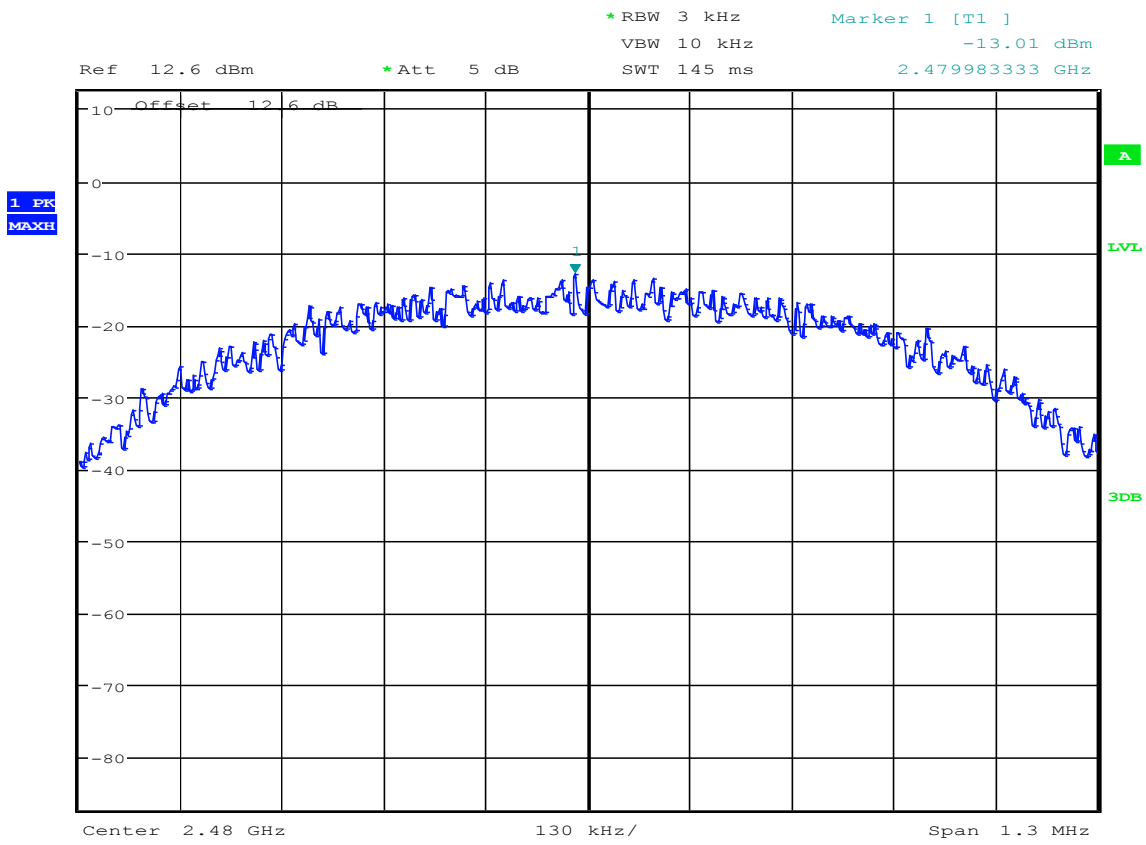


low

Date: 12.SEP.2018 16:25:05

Plot #3

High channel 2480 MHz	Modulation/Packet Type: BTLE	1 Mbit/s

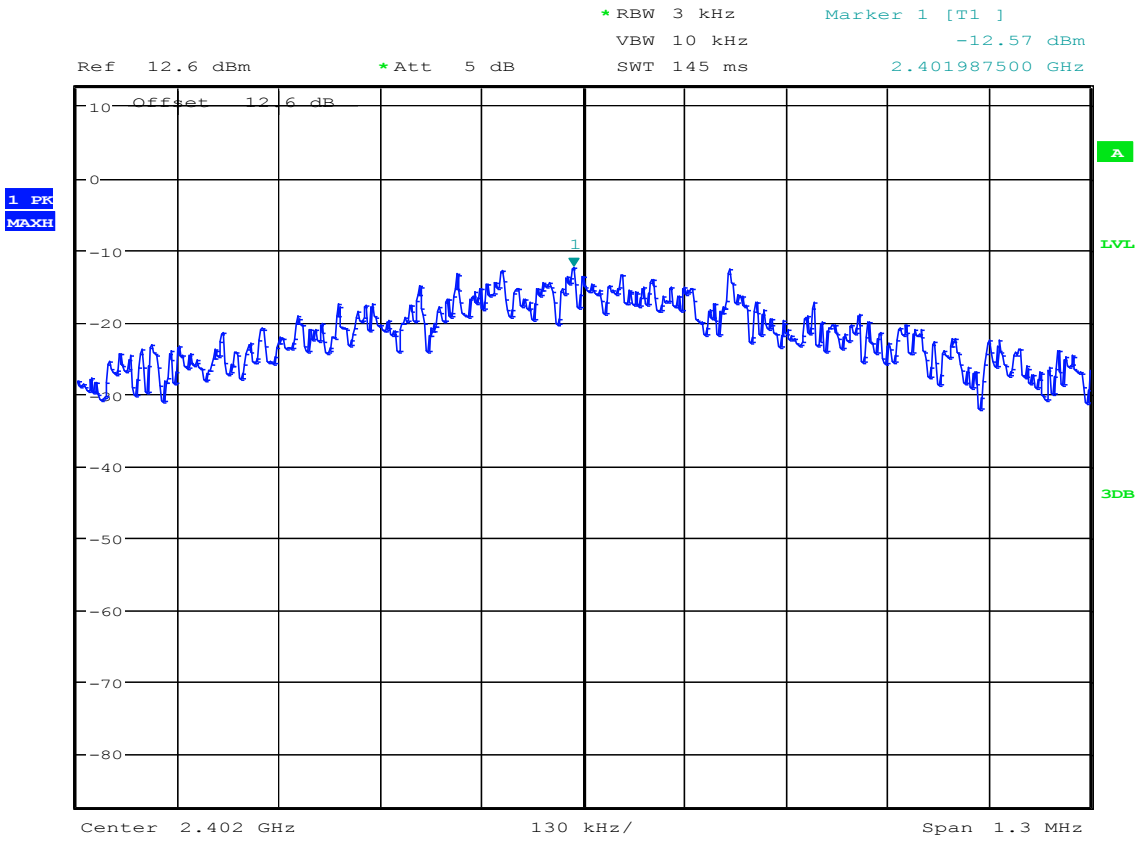


low

Date: 12.SEP.2018 16:23:52

Plot #4

Low channel / 2402 MHz	Modulation/Packet Type: BTLE	2 Mbit/s

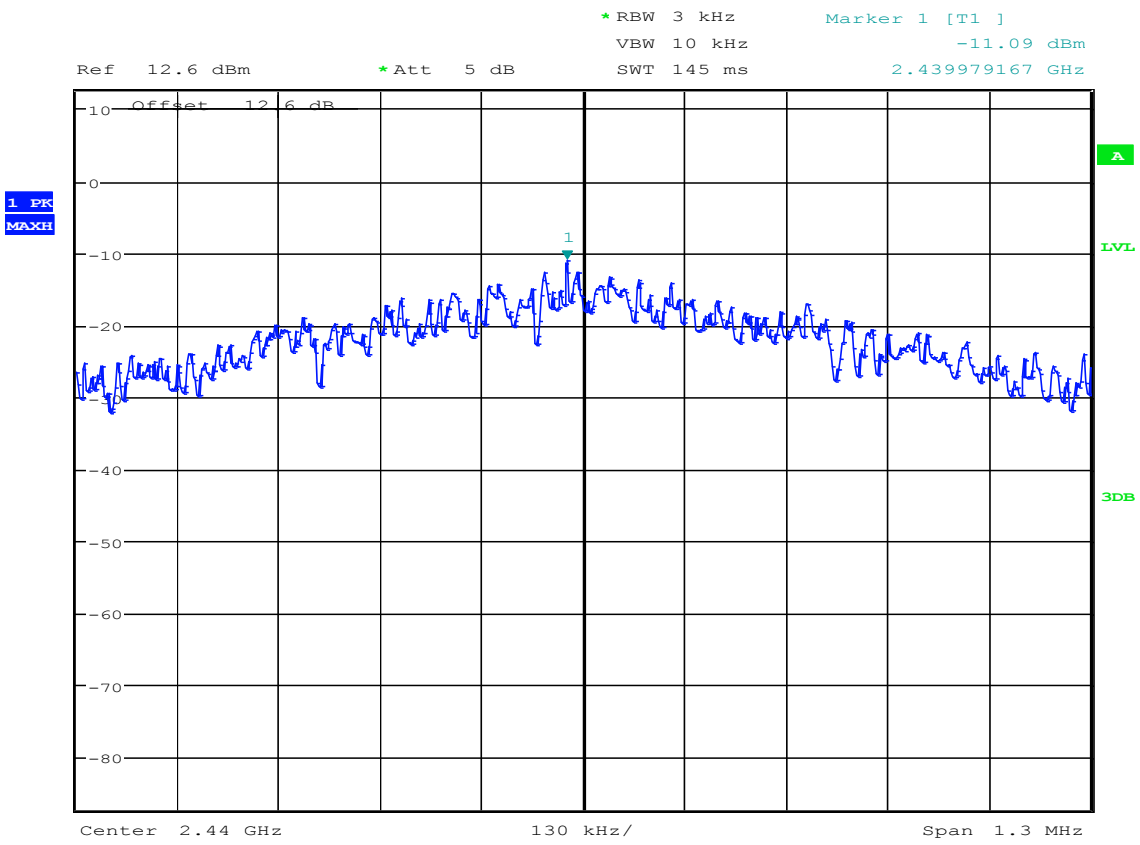


low

Date: 12.SEP.2018 16:27:49

Plot #5

Mid channel 2440 MHz	Modulation/Packet Type: BTLE	2 Mbit/s

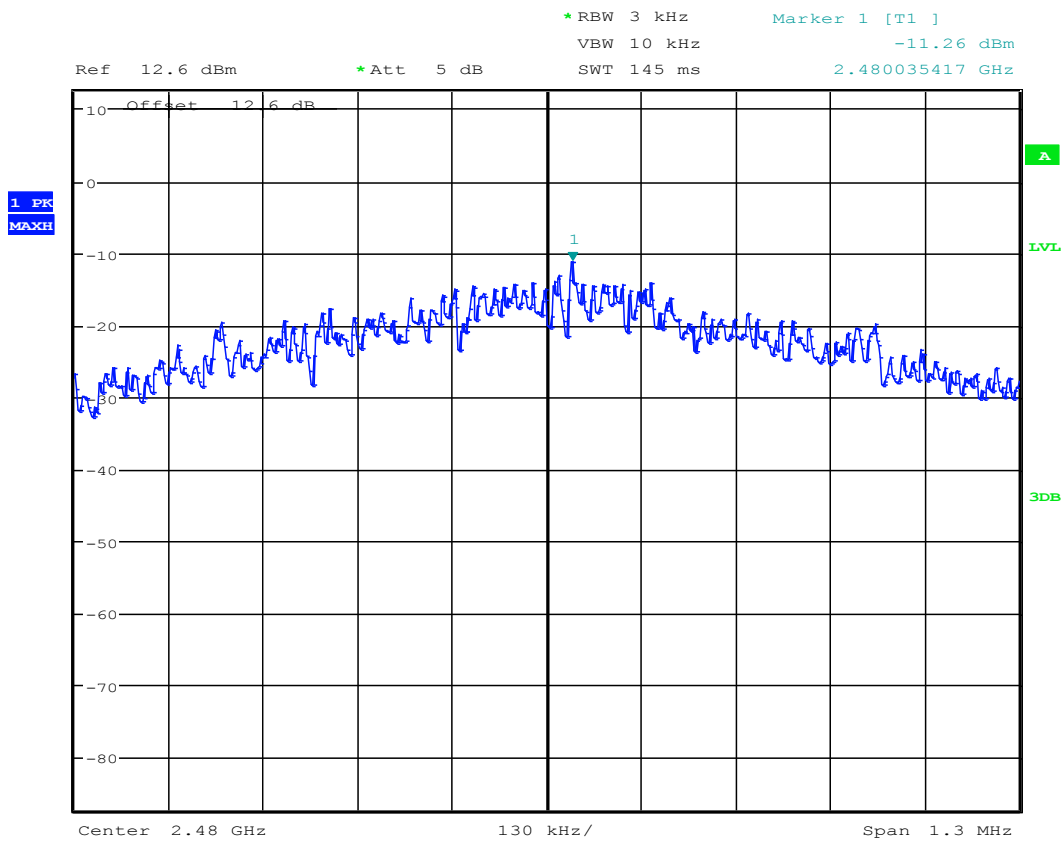


low

Date: 12.SEP.2018 16:25:54

Plot #6

High channel 2480 MHz	Modulation/Packet Type: BTLE	2 Mbit/s



low

Date: 12.SEP.2018 16:21:37

8.3 Maximum Peak Conducted Output Power

8.3.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

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 Peak Output Power:

- FCC §15.247 (b):
  - (3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

- IC RSS-247 5.4:
  - d. For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

  - As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

8.3.3 Test conditions and setup:

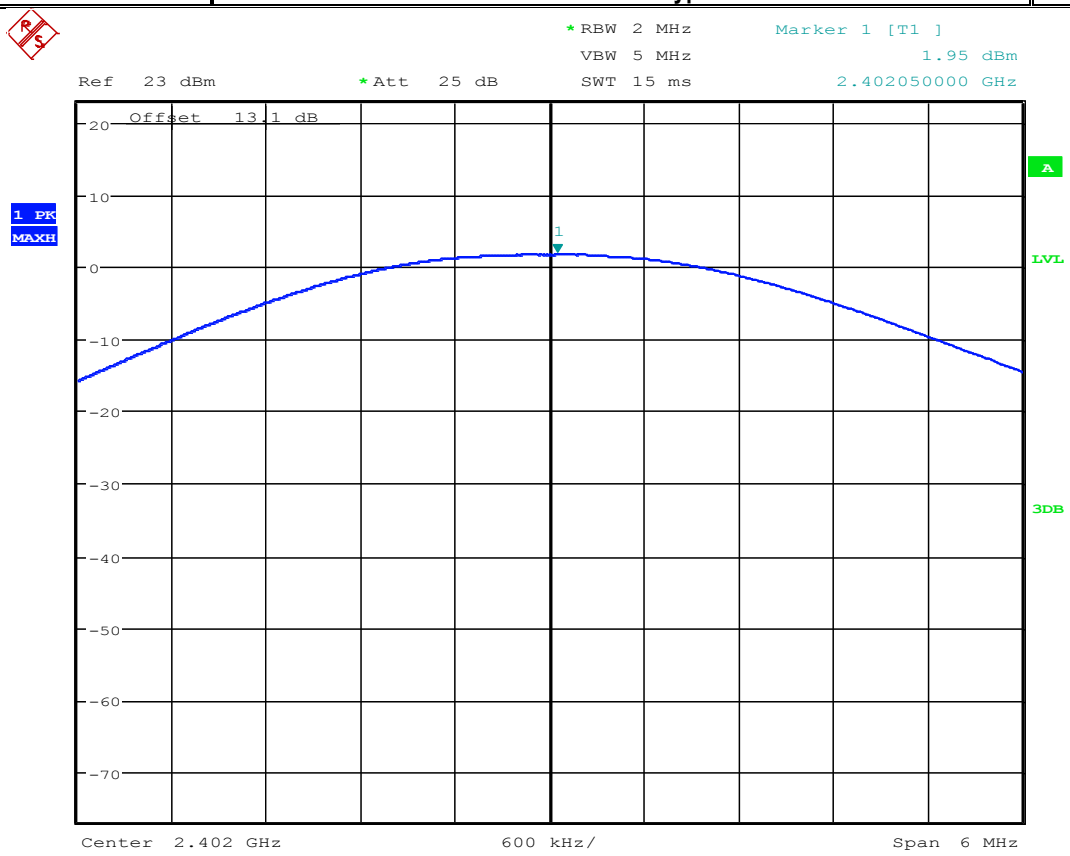
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	Op.1	3.3 VDC	4.04 dBi

8.3.4 Measurement result:

Plot #	Frequency (MHz)	Data Rate (Mbit/s)	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	2402	1	1.95	5.99	30 (Pk) / 36 (EIRP)	Pass
2	2441	1	1.82	5.86	30 (Pk) / 36 (EIRP)	Pass
3	2480	1	1.49	5.53	30 (Pk) / 36 (EIRP)	Pass
4	2402	2	1.96	6.0	30 (Pk) / 36 (EIRP)	Pass
5	2441	2	1.86	5.90	30 (Pk) / 36 (EIRP)	Pass
6	2480	2	1.51	5.55	30 (Pk) / 36 (EIRP)	Pass

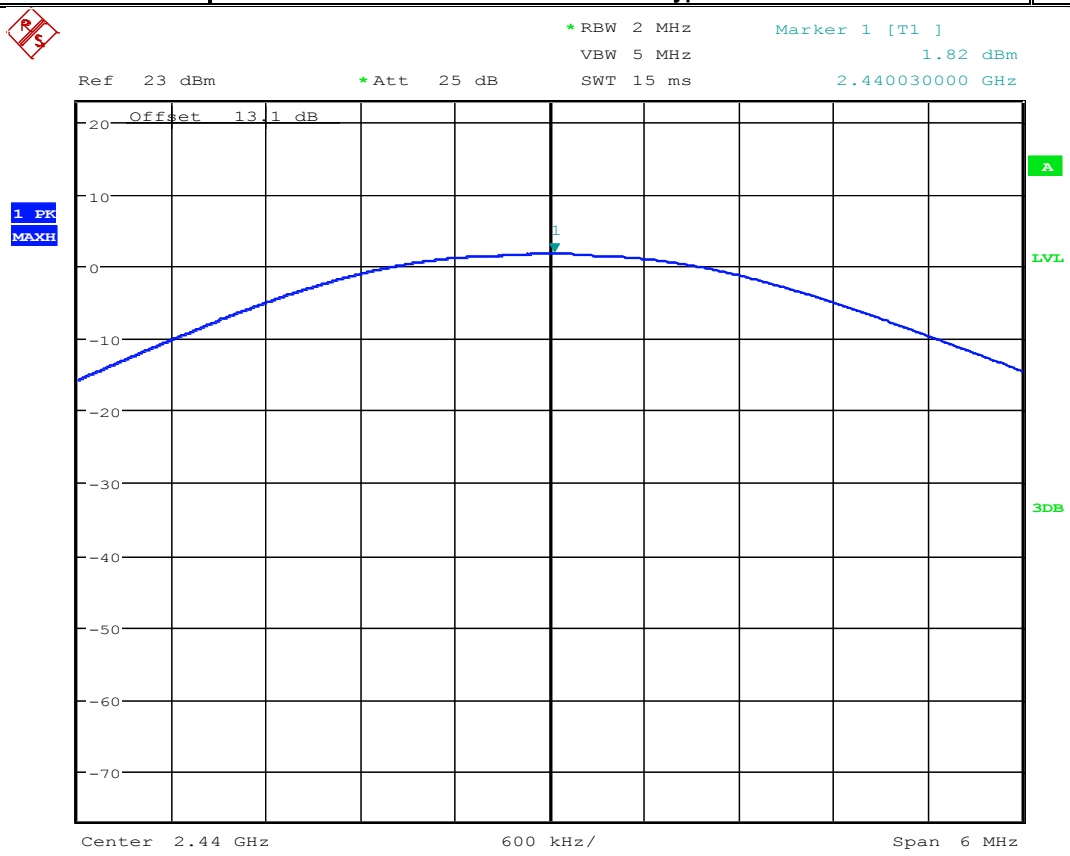
8.3.5 Measurement Plots:

Plot #1		
Low channel / 2402 MHz	**Modulation/Packet Type: BTLE**	**1 Mbit/s**



Plot #2

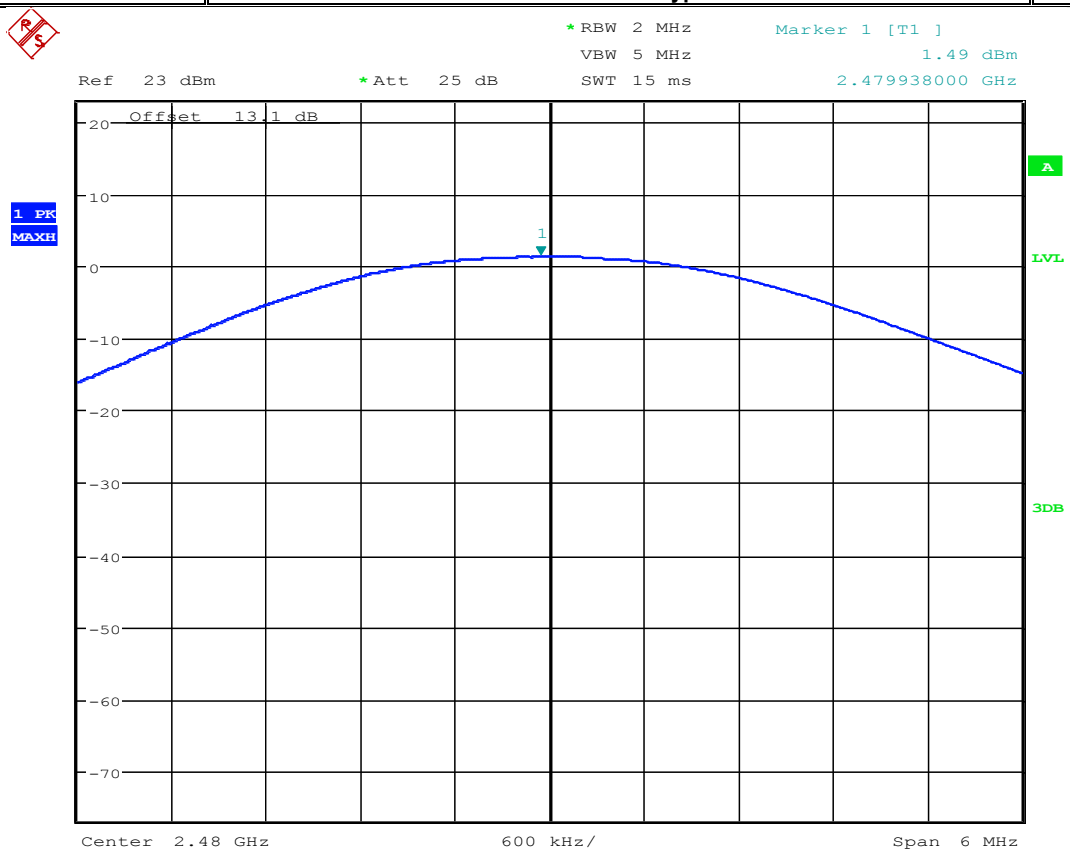
Mid channel 2440 MHz	Modulation/Packet Type: BTLE	1 Mbit/s



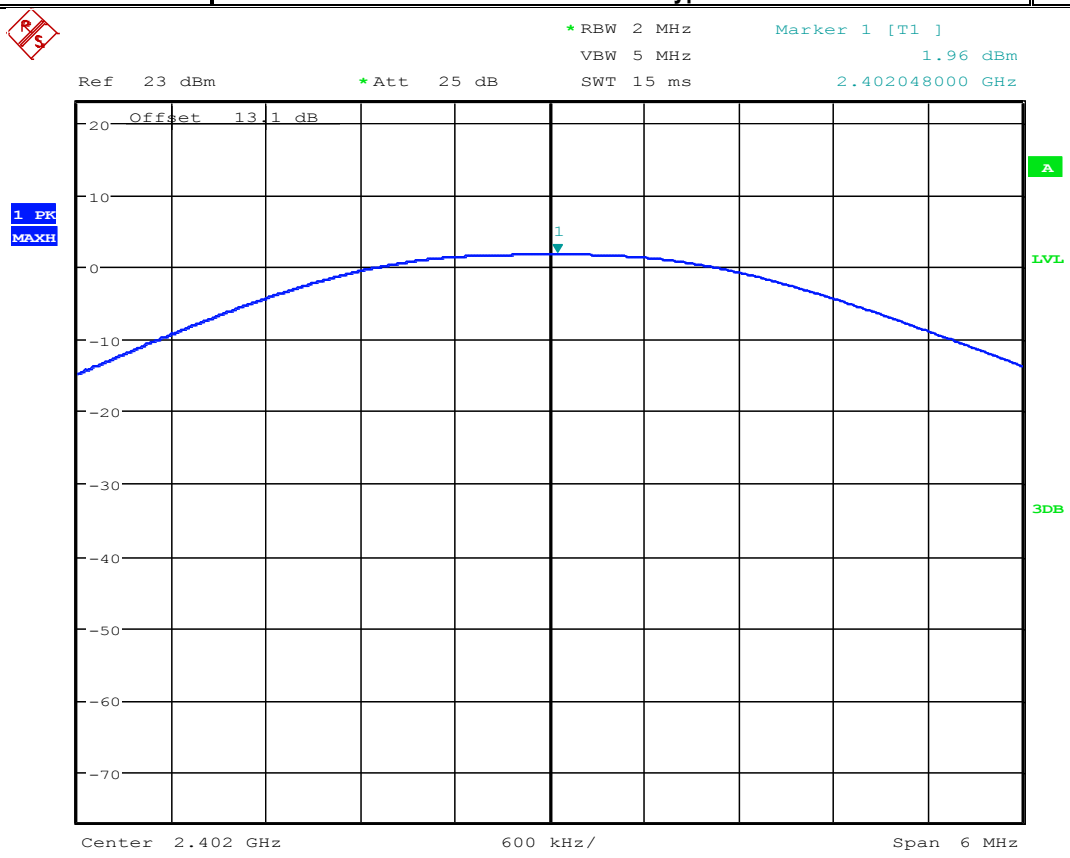
Date: 25.JUL.2018 09:29:44

Plot #3

High channel 2480 MHz	Modulation/Packet Type: BTLE	1 Mbit/s



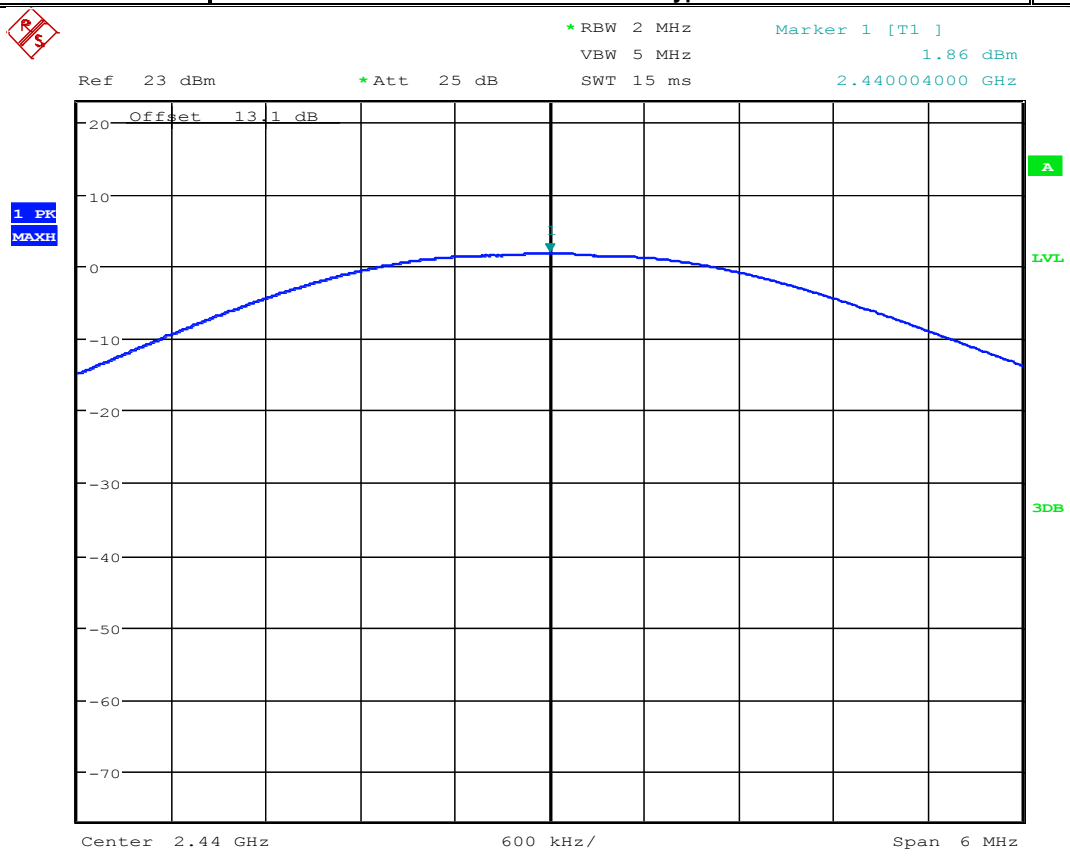
Plot #4		
Low channel / 2402 MHz	Modulation/Packet Type: BTLE	2 Mbit/s



Date: 25.JUL.2018 09:17:40

Plot #5

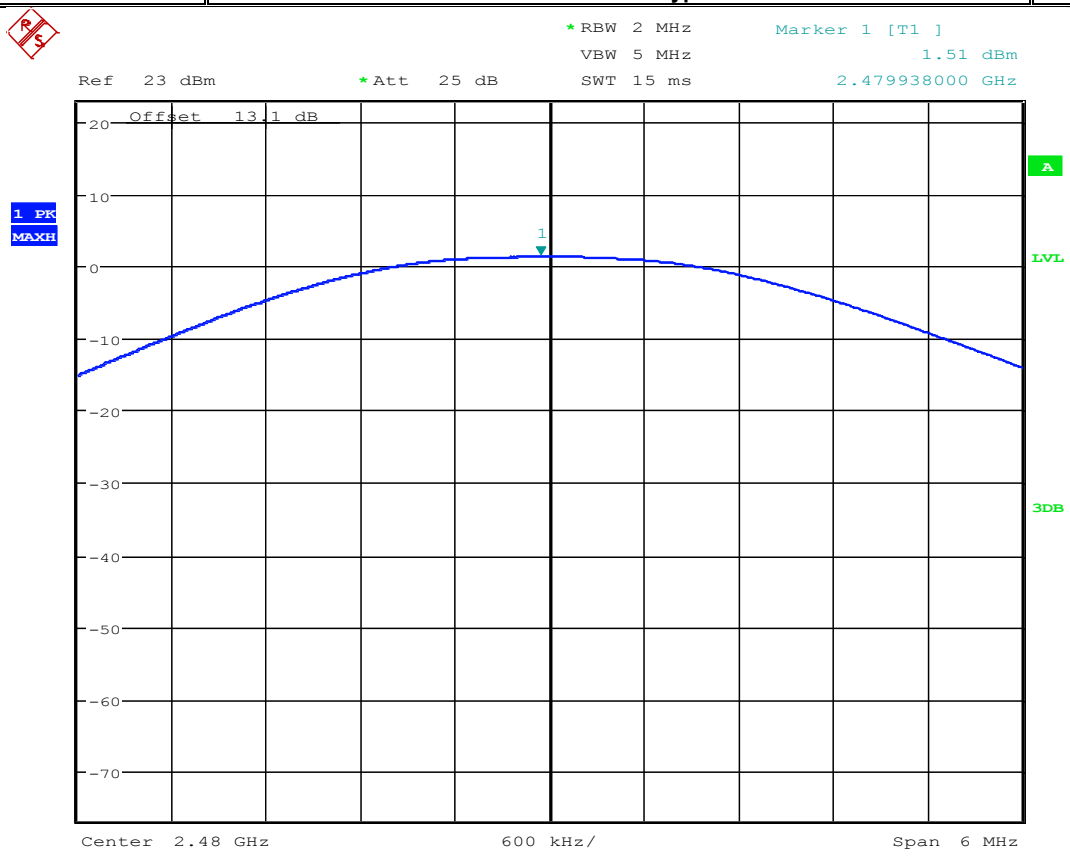
Mid channel 2440 MHz	Modulation/Packet Type: BTLE	2 Mbit/s



Date: 25.JUL.2018 09:36:37

Plot #6

High channel 2480 MHz	Modulation/Packet Type: BTLE	2 Mbit/s



8.3.6 Test conditions and setup:

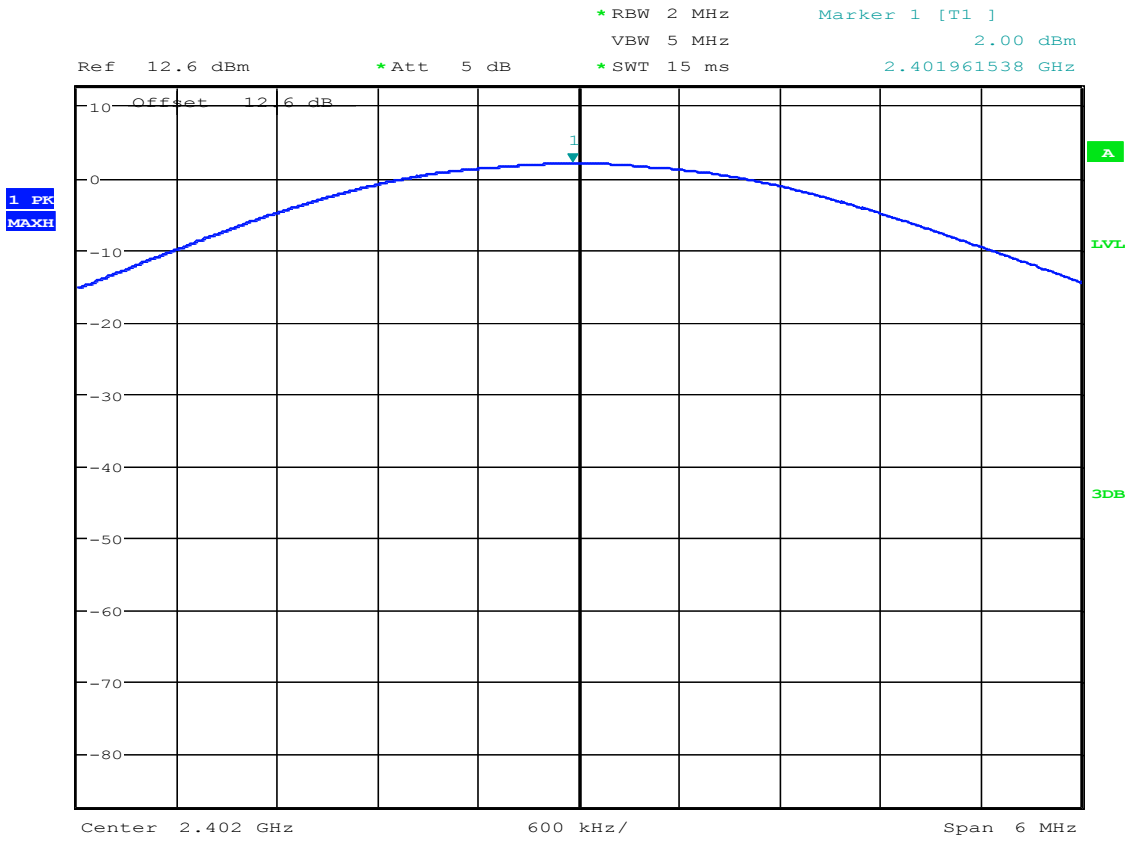
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	2	Op.2	3.3 VDC	4.04 dBi

8.3.7 Measurement result:

Plot #	Frequency (MHz)	Data Rate (Mbit/s)	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	2402	1	2.00	6.04	30 (Pk) / 36 (EIRP)	Pass
2	2441	1	1.70	5.74	30 (Pk) / 36 (EIRP)	Pass
3	2480	1	1.43	5.47	30 (Pk) / 36 (EIRP)	Pass
4	2402	2	2.01	6.05	30 (Pk) / 36 (EIRP)	Pass
5	2441	2	1.71	5.75	30 (Pk) / 36 (EIRP)	Pass
6	2480	2	1.42	5.46	30 (Pk) / 36 (EIRP)	Pass

8.3.8 Measurement Plots:

Plot #1		
Low channel / 2402 MHz	**Modulation/Packet Type: BTLE**	**1 Mbit/s**

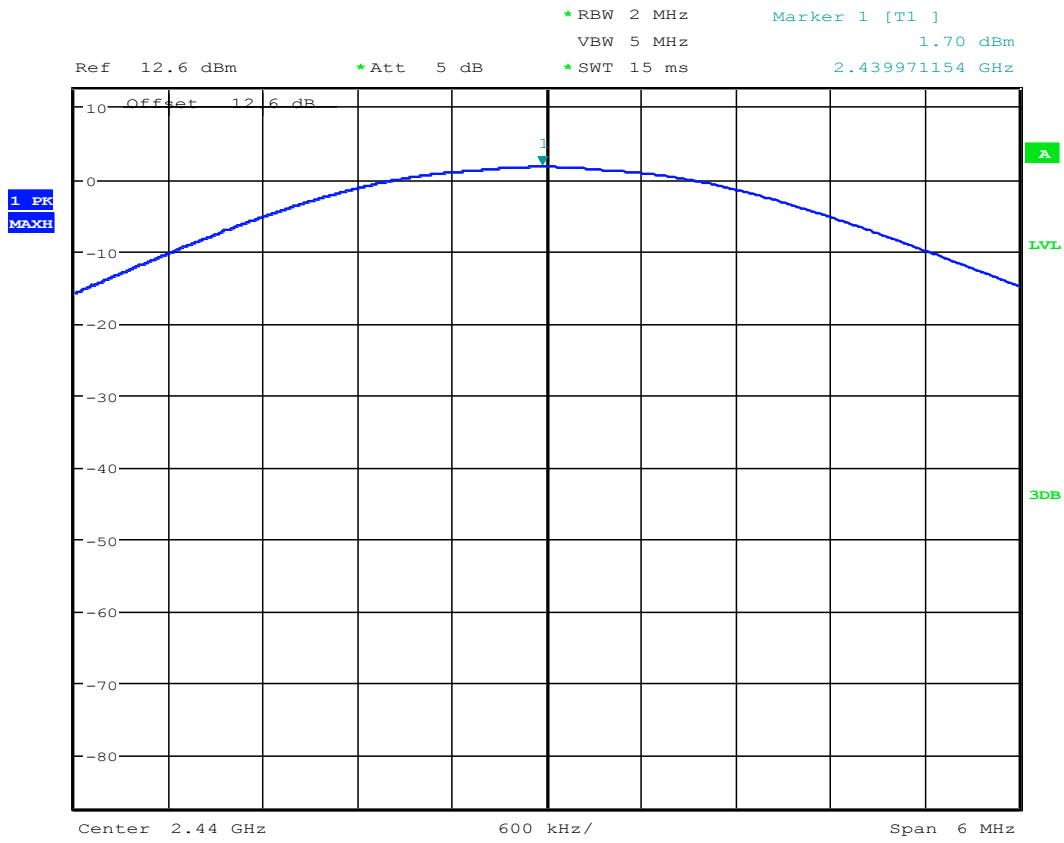


low

Date: 12.SEP.2018 16:11:20

Plot #2

Mid channel 2440 MHz	Modulation/Packet Type: BTLE	1 Mbit/s

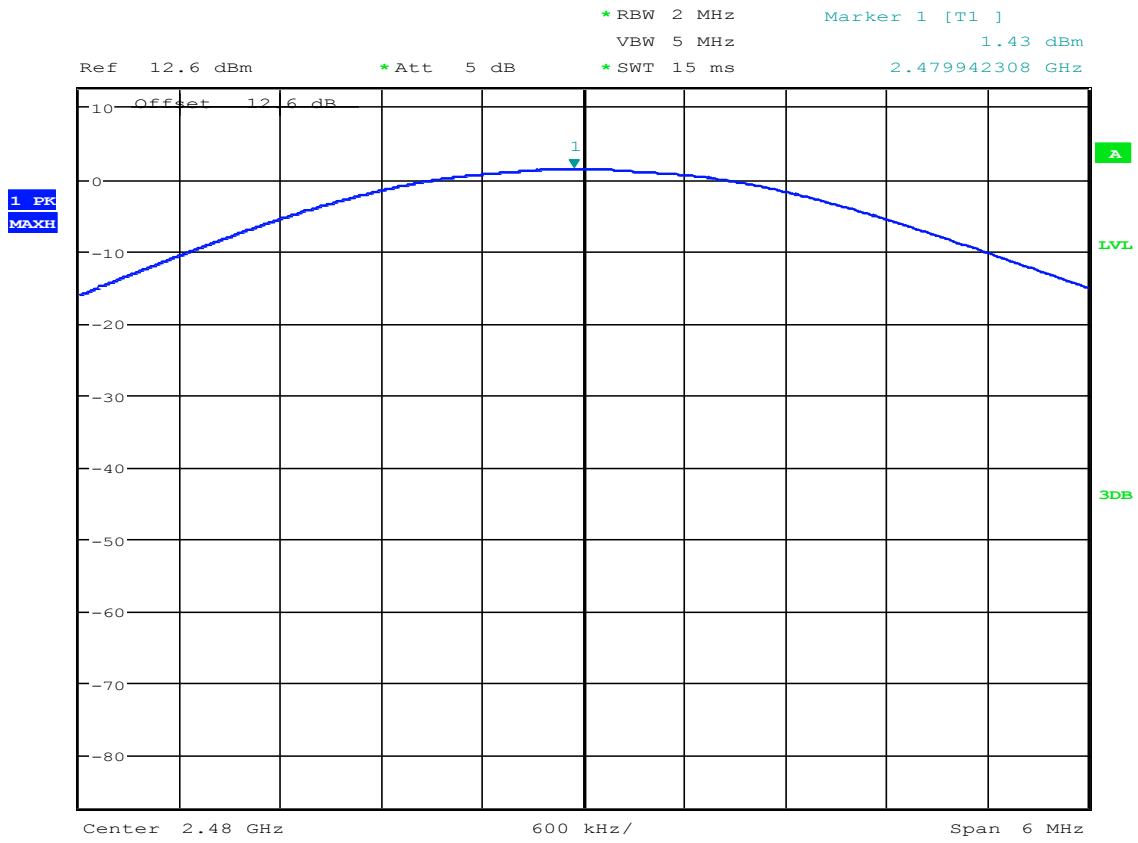


low

Date: 12.SEP.2018 16:07:00

Plot #3

High channel 2480 MHz	Modulation/Packet Type: BTLE	1 Mbit/s

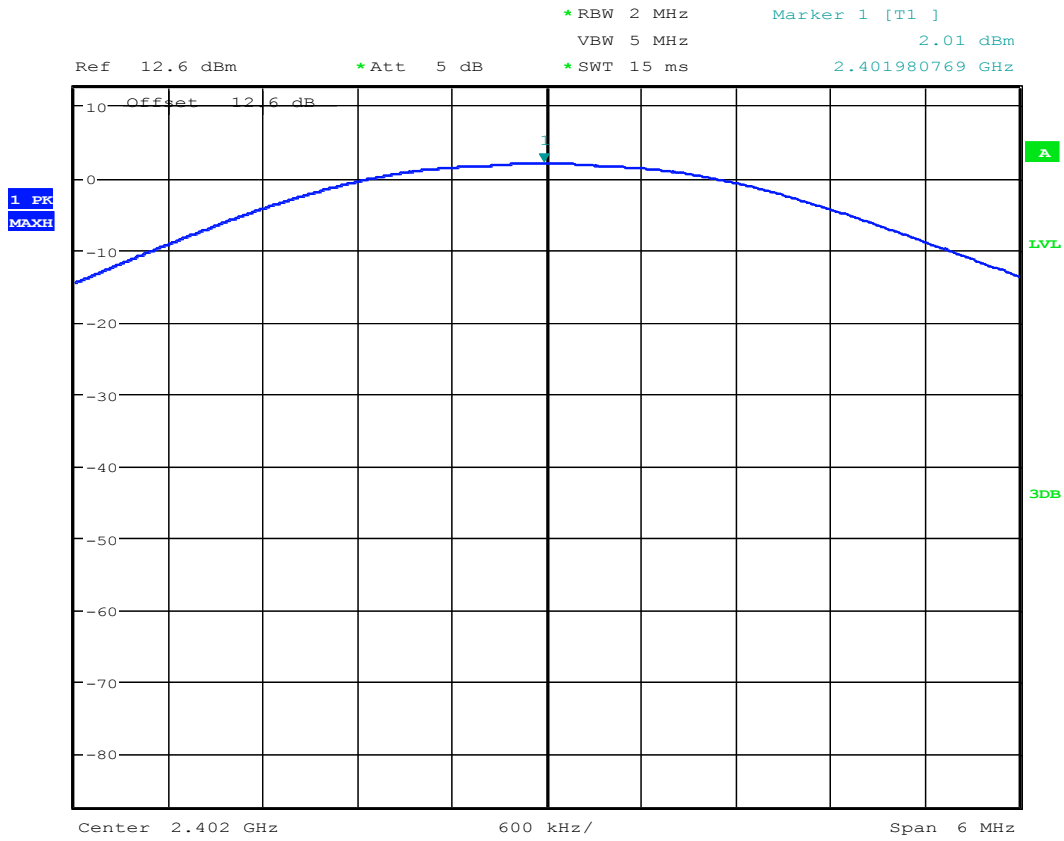


low

Date: 12.SEP.2018 16:15:41

Plot #4

Low channel / 2402 MHz	Modulation/Packet Type: BTLE	2 Mbit/s

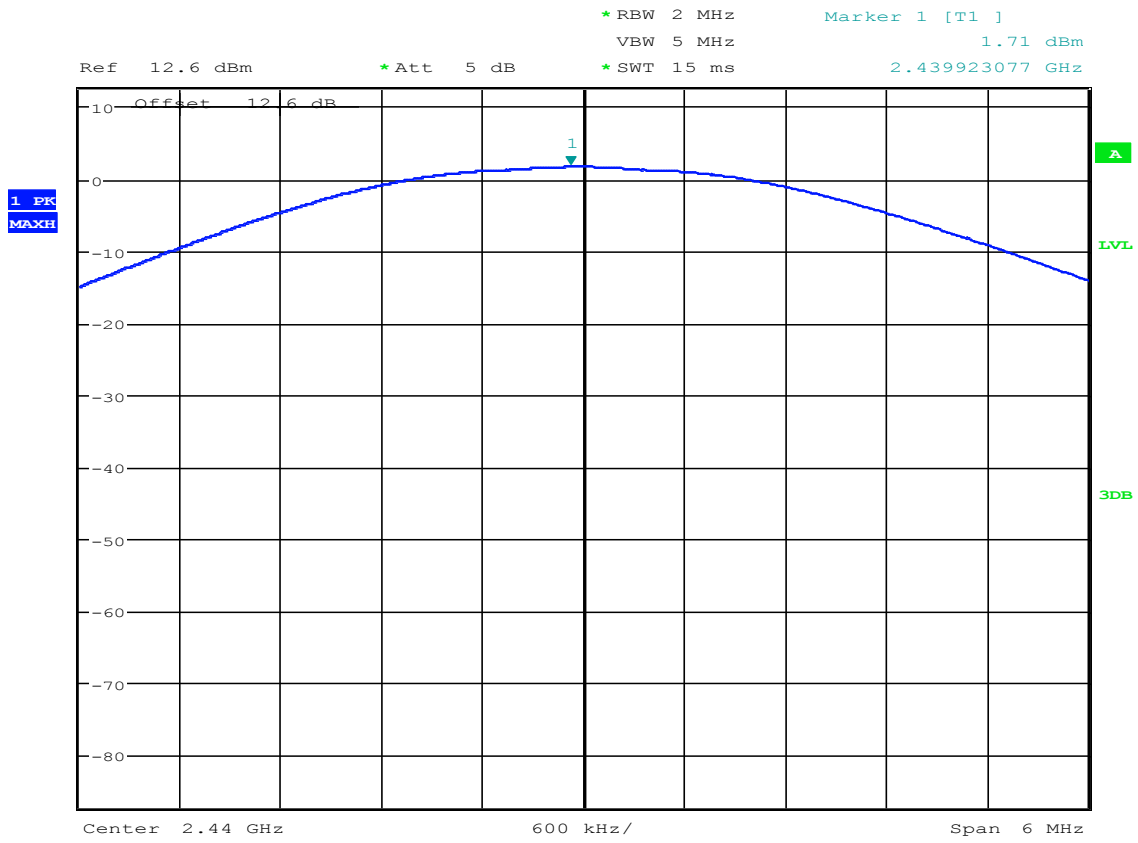


low

Date: 12.SEP.2018 16:12:36

Plot #5

Mid channel 2440 MHz	Modulation/Packet Type: BTLE	2 Mbit/s

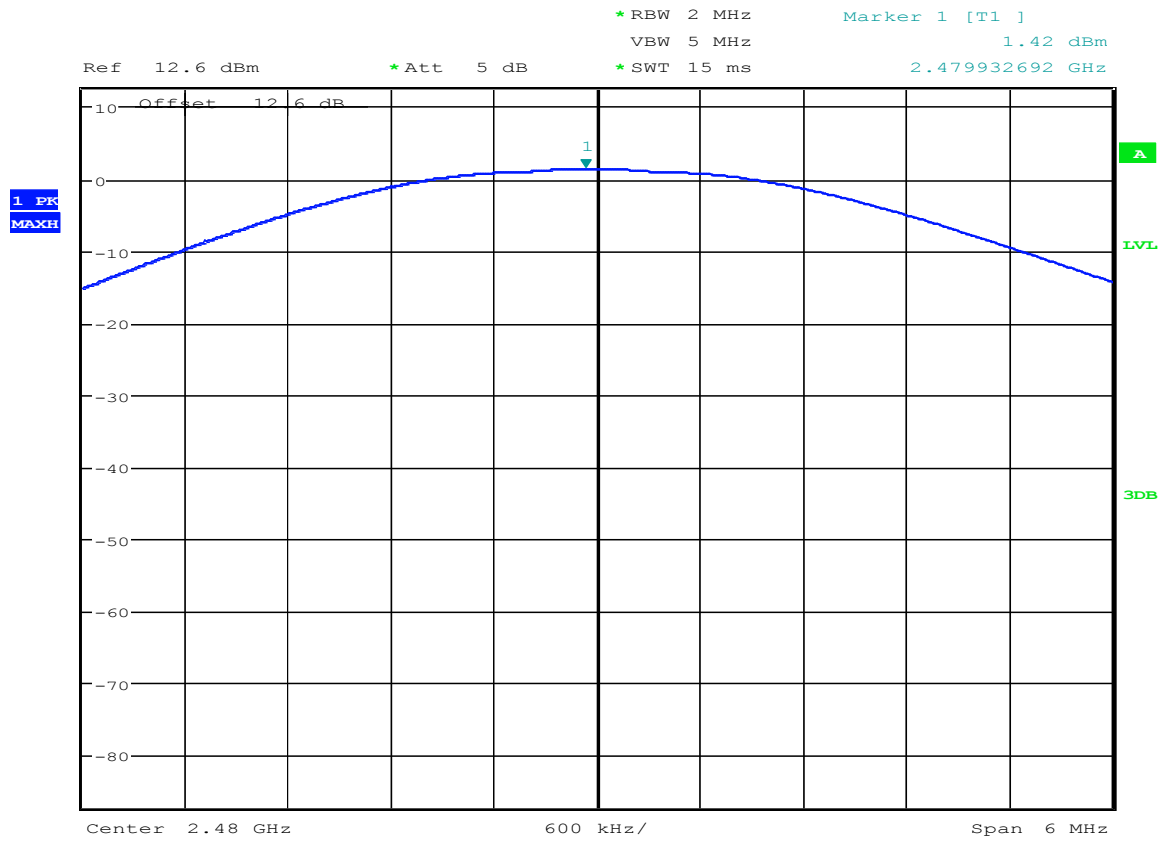


low

Date: 12.SEP.2018 16:05:41

Plot #6

High channel 2480 MHz	Modulation/Packet Type: BTLE	2 Mbit/s



low

Date: 12.SEP.2018 16:17:39

8.4 Band Edge Compliance

8.4.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

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)).

➢ RSS-247 5.5

- In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB.

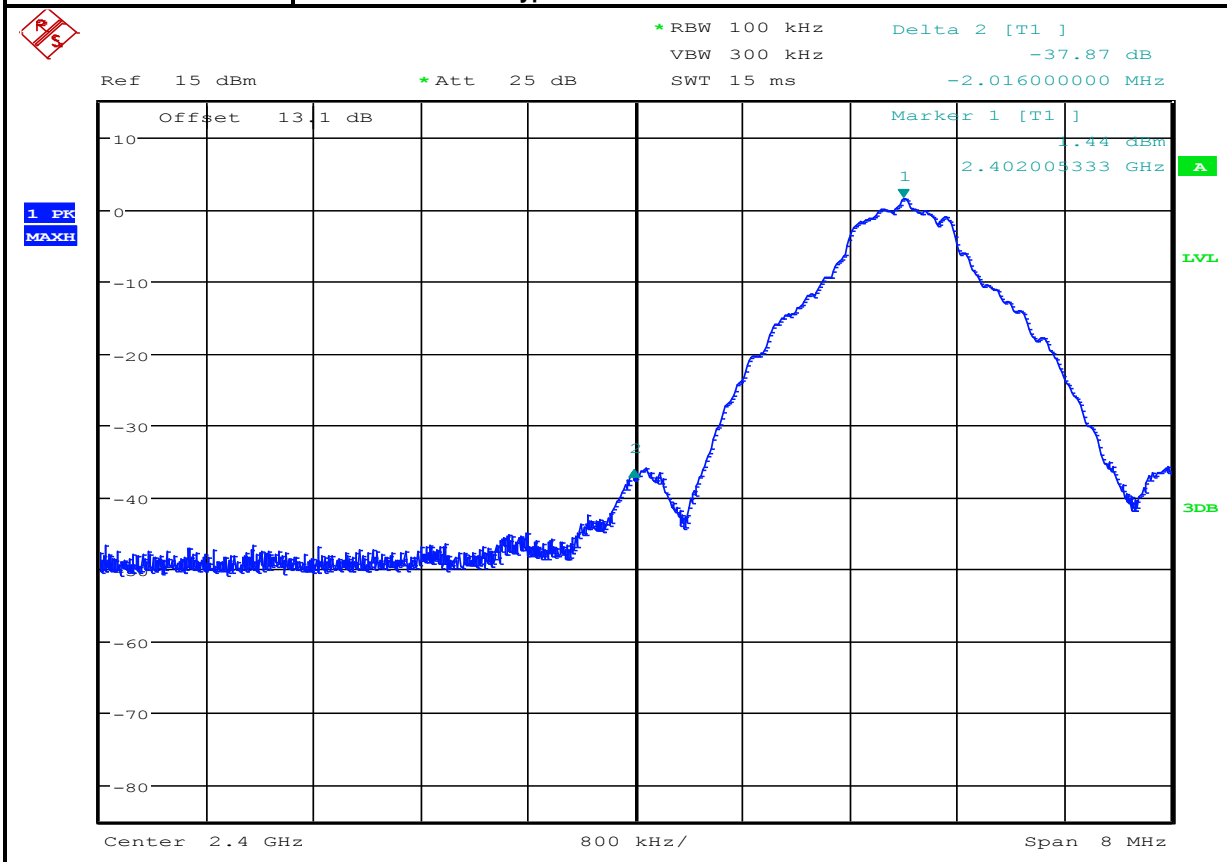
8.4.3 Measurement result:

Plot #	EUT Set-Up #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	1	Op.1	Lower, Non-restricted	-37.87	20	Pass

8.4.4 Measurement plots

Plot #1

Low channel / 2402 MHz | **Modulation/Packet Type: BTLE**



Spectrum Analyzer settings for restricted band:

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

8.4.5 Limits restricted band §15.247/15.209/15.205

- *PEAK LIMIT= 74 dBµV/m @3m =-21.23 dBm
- *AVG. LIMIT= 54 dBµV/m @3m =-41.23 dBm
- Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205 & 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			

8.4.6 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	Op.1	3.3 VDC	4.04 dBi

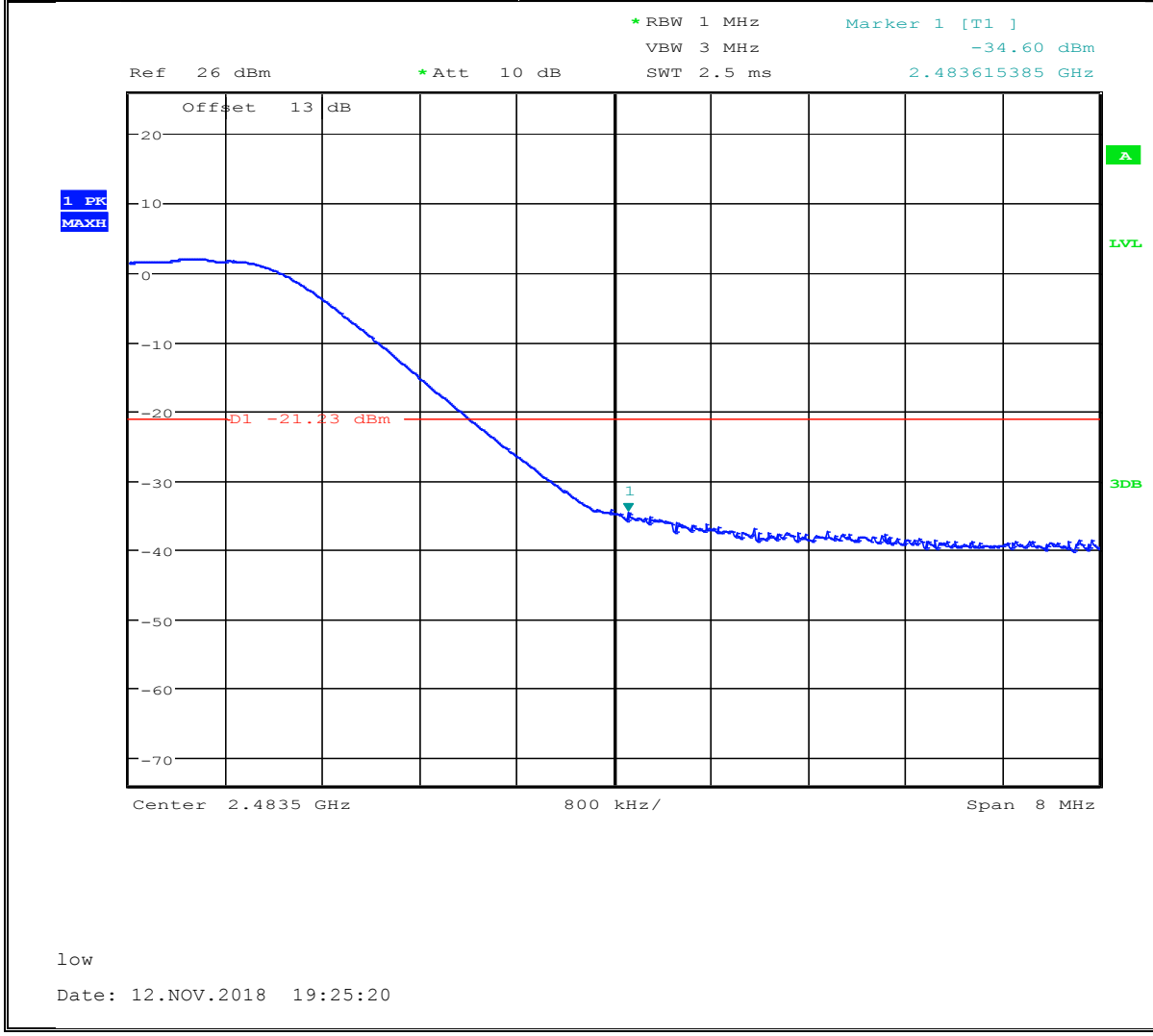
8.4.7 Measurement result (Peak):

Plot #	Band Edge	Measured Peak, Average Values (dBm)	Corrected by duty cycle	Corrected by Antenna Gain (dBm)	Limit (dBm)	Result
1	Upper Restricted Peak	-34.60	NA	-30.56	-21.23 Peak	Pass
2	Upper Restricted Average	-53.86	NA	49.82	-41.23 AVG	Pass

8.4.8 Measurement plot:

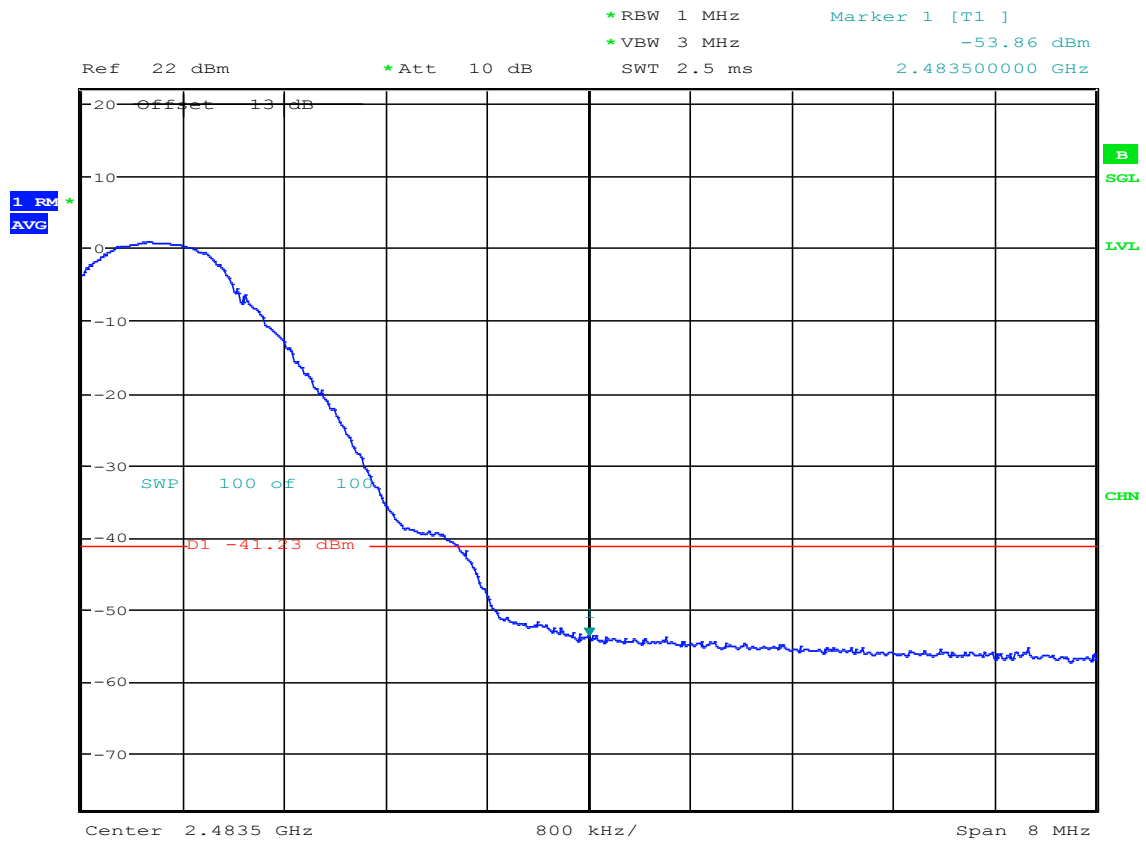
Plot #1

High channel 2480 MHz Peak | **Modulation/Packet Type: BTLE**



Plot #2

High channel 2480 MHz AVG	Modulation/Packet Type: BTLE



Date: 13.NOV.2018 13:31:38

8.5 Radiated Transmitter Spurious Emissions and Restricted Bands

8.5.1 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

8.5.2 Limits:

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)).

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

8.5.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	3	Op.3	3.3 VDC

8.5.4 Measurement result:

Plot #	Channel #	Scan Frequency	Highest emission in dB	Frequency of highest emission in MHz	Limit	Result
1 – 3	Low	30 MHz – 18 GHz	58.16	12001.8	See section 8.6.2	Pass
4 – 8	Mid	9 kHz – 26 GHz	56.08	7319.06	See section 8.6.2	Pass
9 – 11	High	30 MHz – 18 GHz	56.39	12401.7	See section 8.6.2	Pass

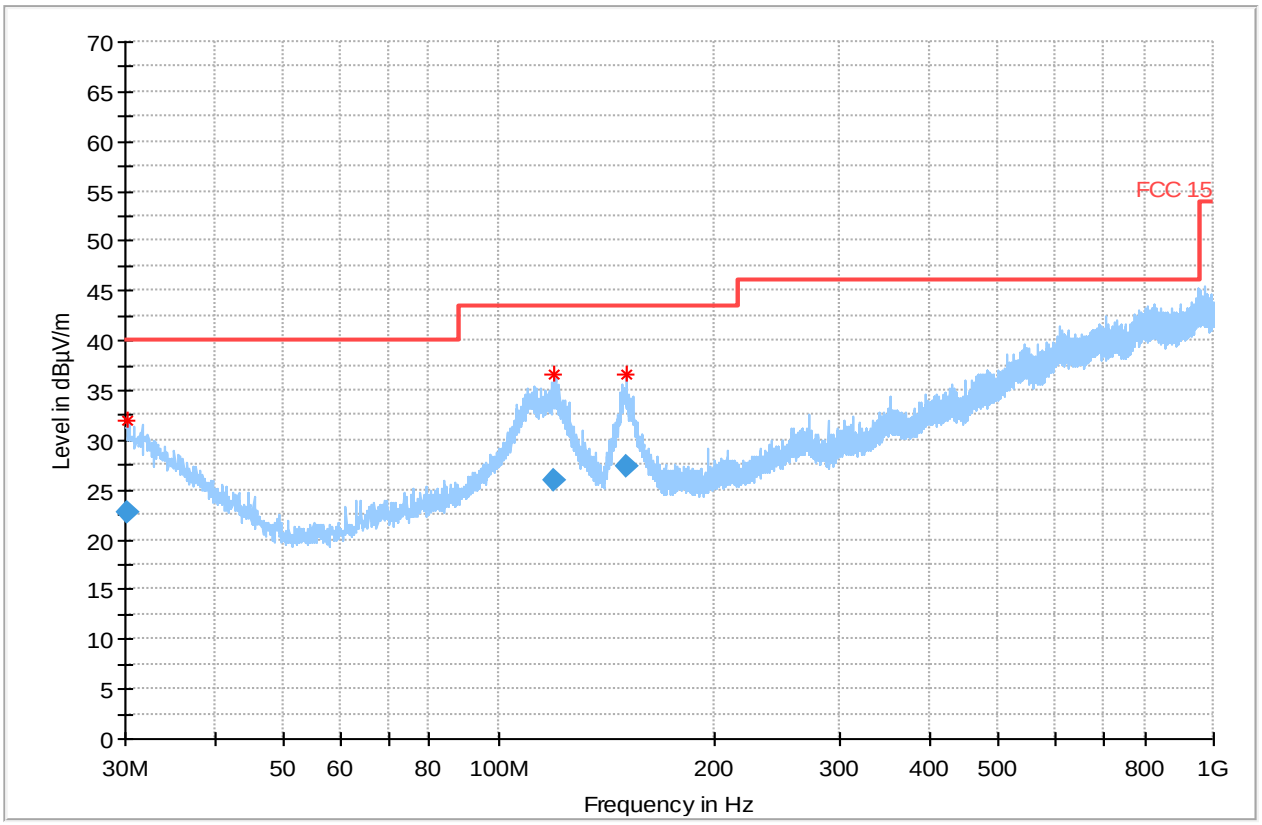
8.5.5 Measurement Plots:

Plot #1 Radiated Emissions: 30MHz – 1GHz

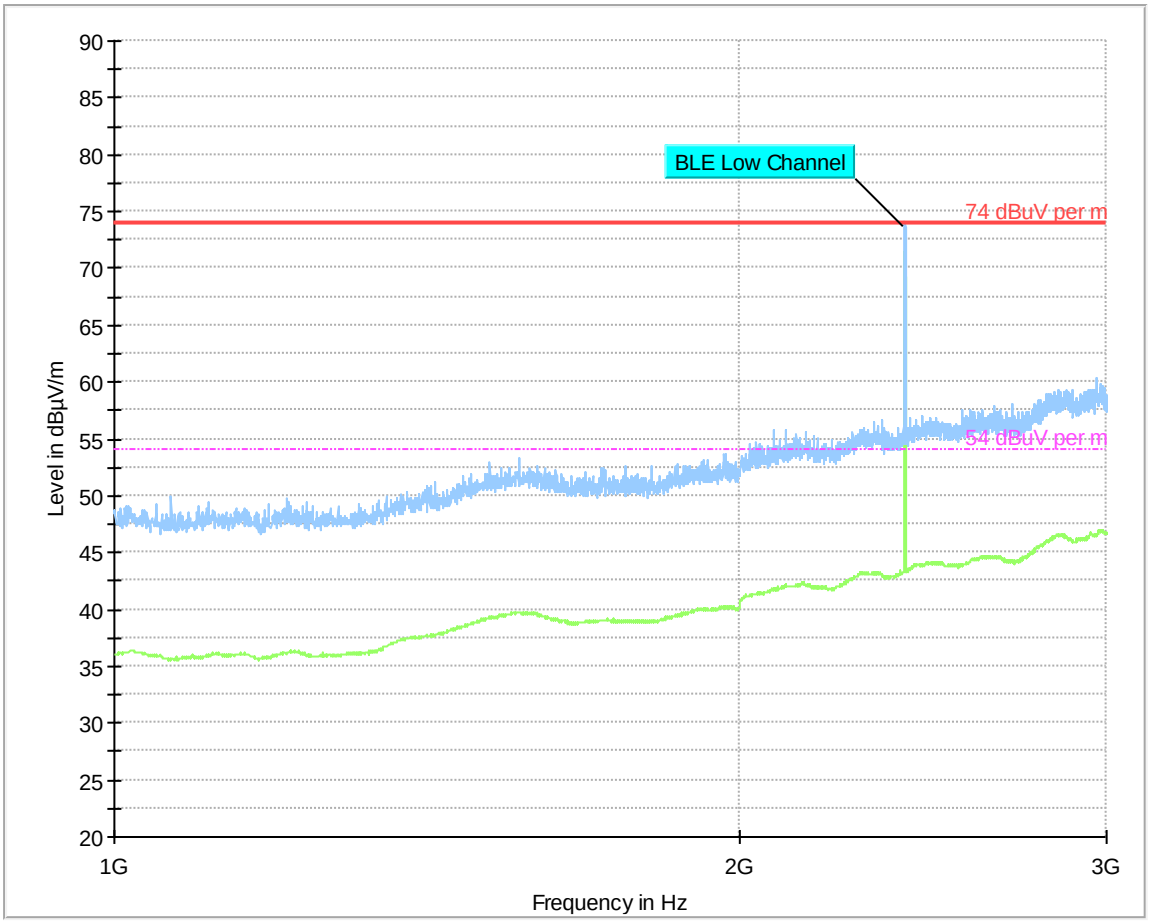
Modulation: BT LE | **Channel: Low**

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
30.180000	22.66	40.00	17.34	200.0	120.000	157.0	H	126.0	20.4
119.400000	26.03	43.52	17.49	200.0	120.000	221.0	V	100.0	24.6
150.480000	27.28	43.52	16.25	200.0	120.000	325.0	H	180.0	24.3



Plot # 2 Radiated Emissions: 1 – 3GHz	
Modulation: BT LE	**Channel: Low**

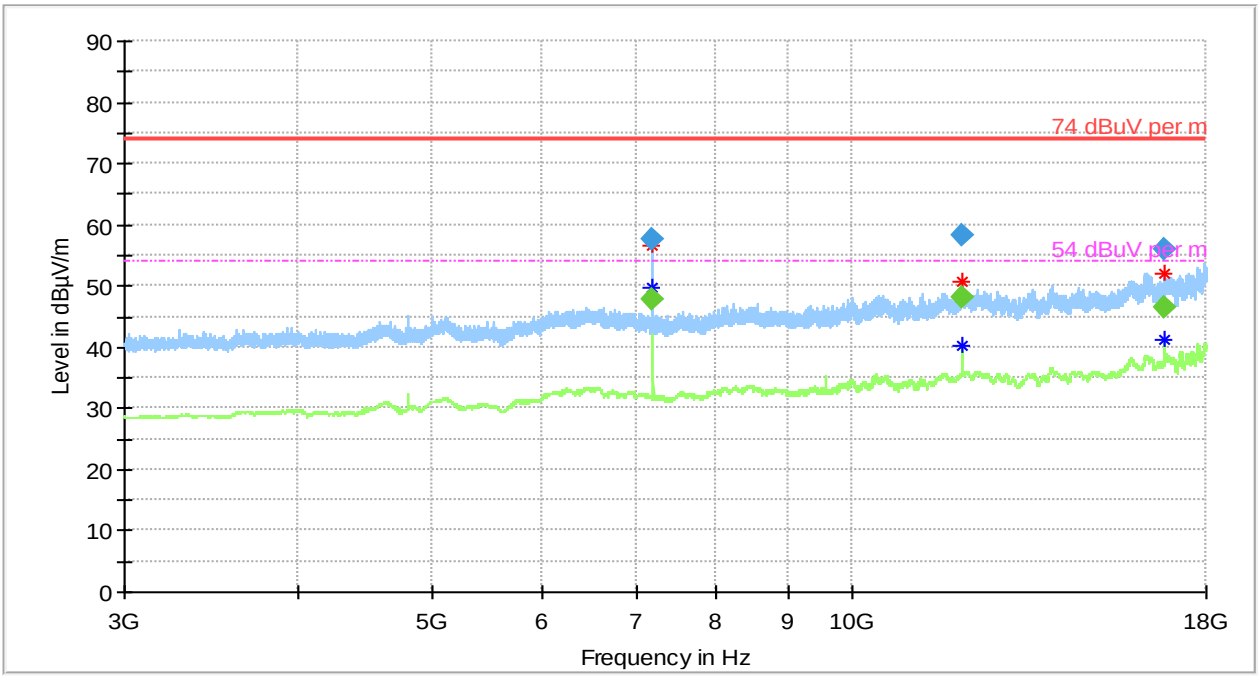


Plot # 3 Radiated Emissions: 3 – 18GHz

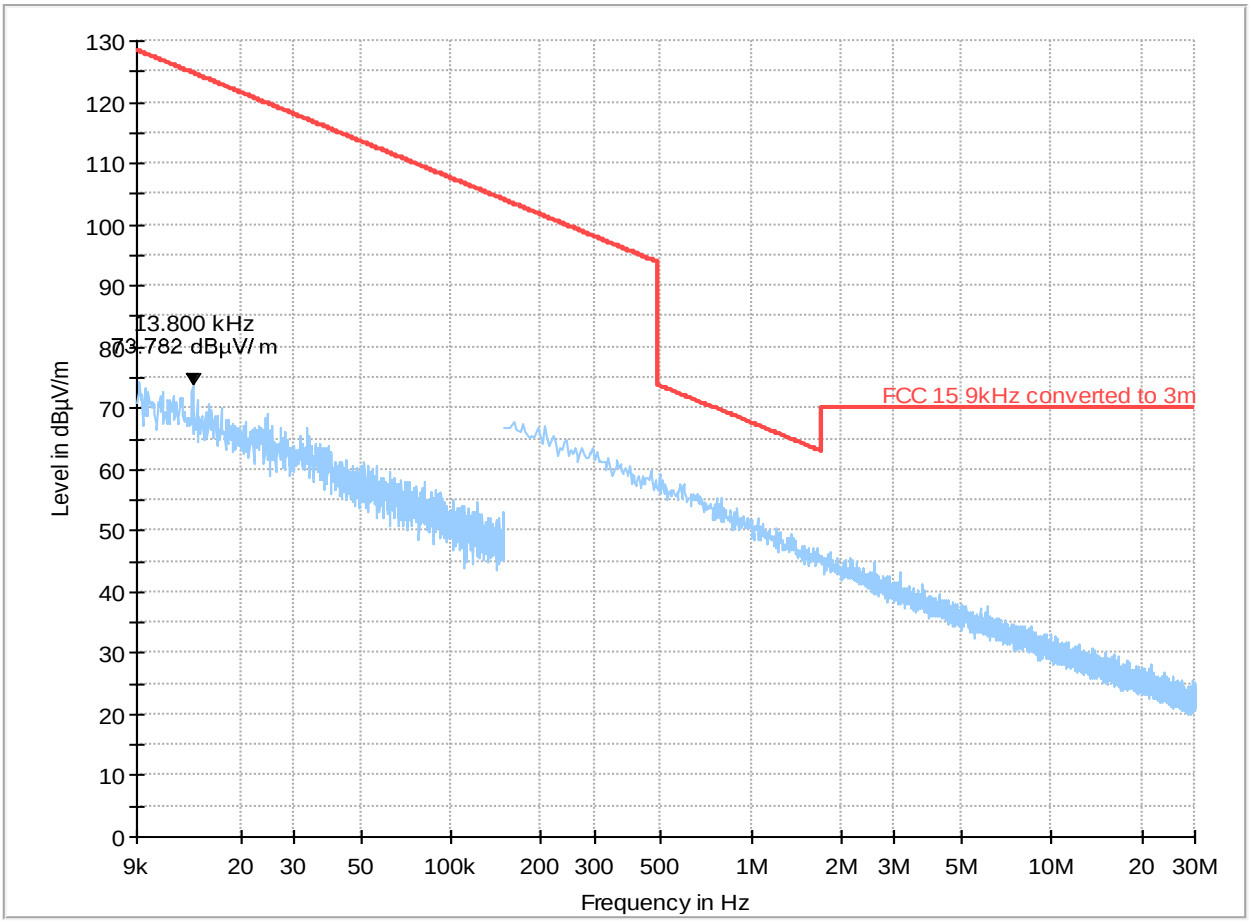
Modulation: BT LE | **Channel: Low**

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
7200.000000	---	47.83	54.00	6.17	100.0	1000.000	153.0	V	223.0
7201.060000	57.44	---	74.00	16.56	100.0	1000.000	309.0	V	223.0
12001.500000	---	48.27	54.00	5.73	100.0	1000.000	316.0	H	243.0
12001.800000	58.16	---	74.00	15.84	100.0	1000.000	317.0	H	242.0
16798.000000	---	46.49	54.00	7.51	100.0	1000.000	207.0	H	154.0
16802.380000	56.10	---	74.00	17.90	100.0	1000.000	210.0	H	150.0



Plot # 4 Radiated Emissions: 9KHz – 30MHz	
Modulation: BT LE	**Channel: Mid**

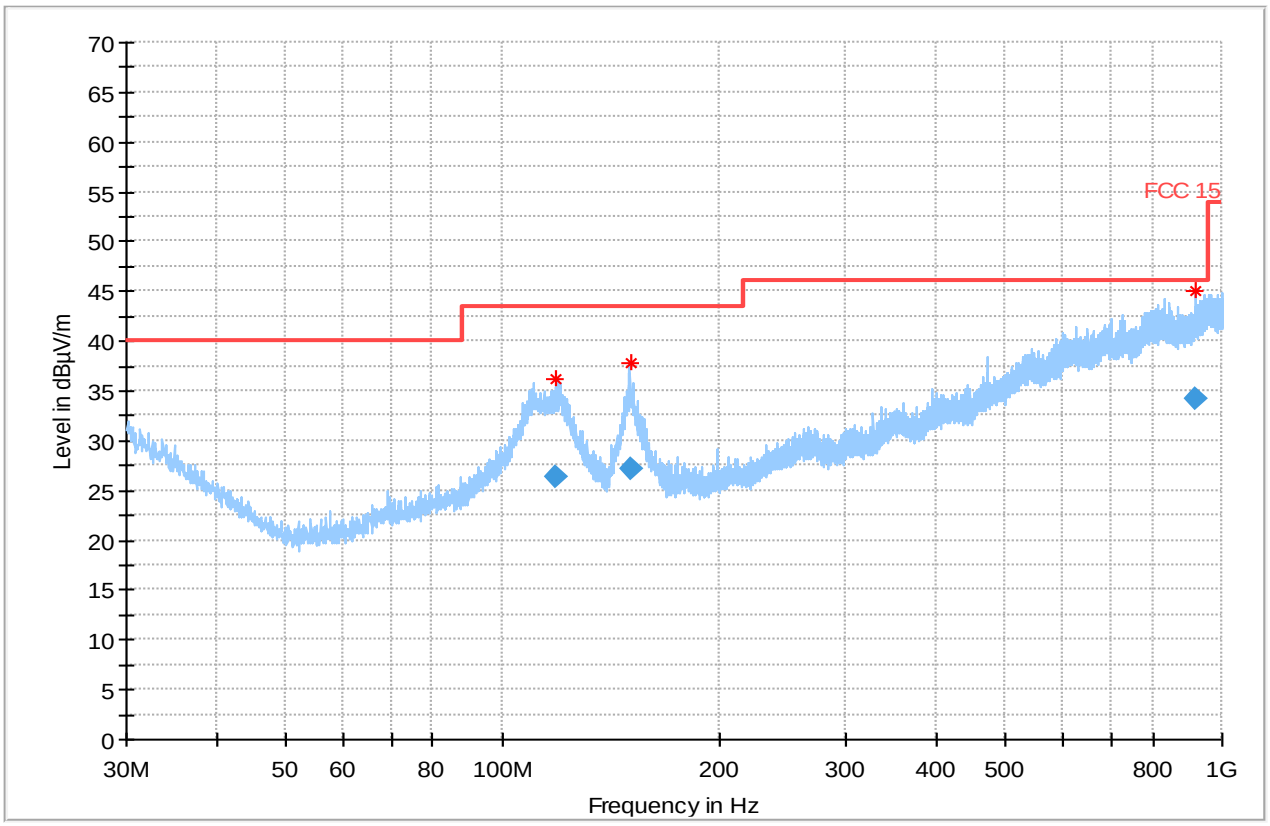


Plot #5 Radiated Emissions: 30MHz – 1GHz

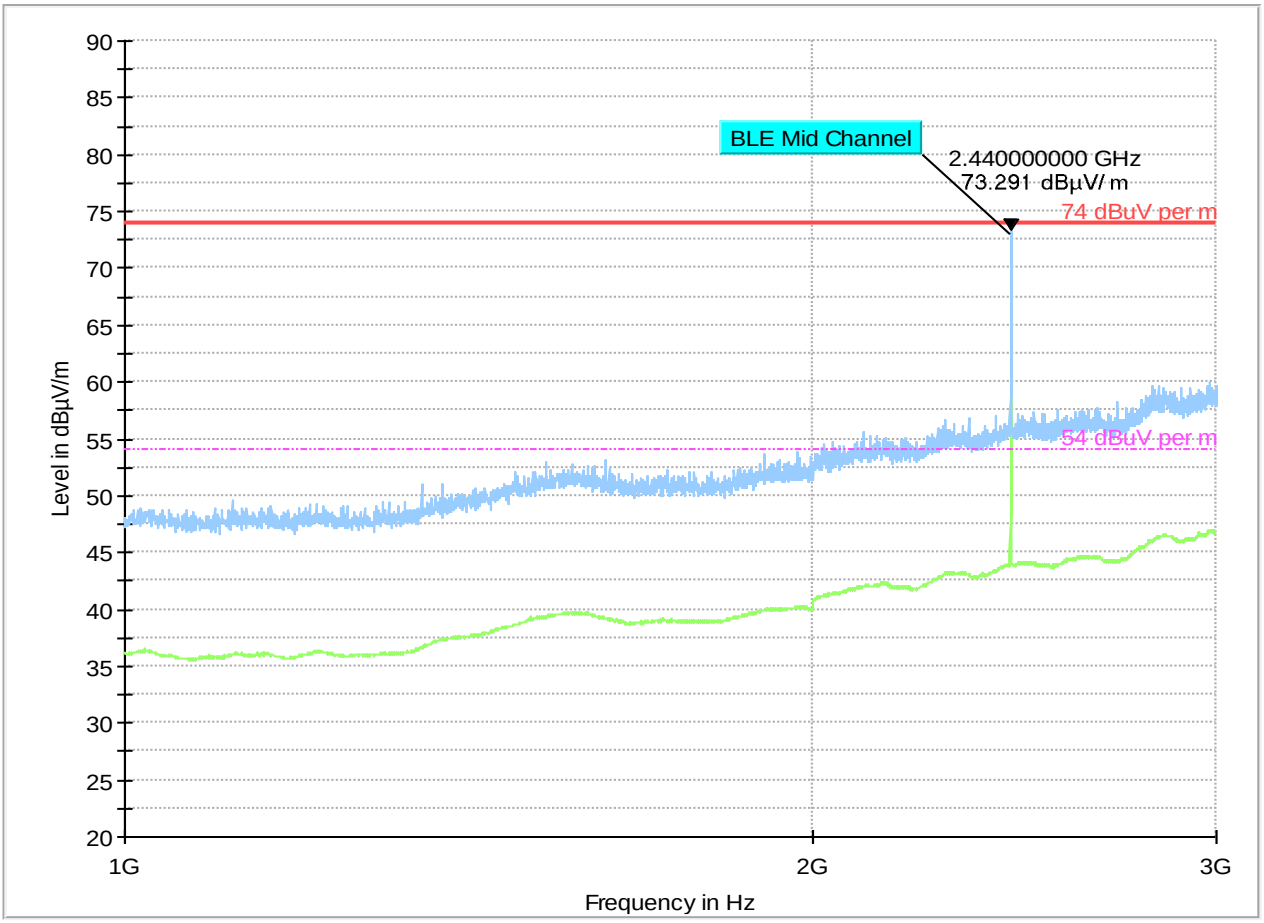
Modulation: BT LE | **Channel: Mid**

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
118.560000	26.42	43.52	17.10	200.0	120.000	181.0	V	129.0	24.3
150.360000	27.16	43.52	16.36	200.0	120.000	283.0	H	251.0	24.4
917.340000	34.16	46.02	11.86	200.0	120.000	322.0	H	130.0	29.6



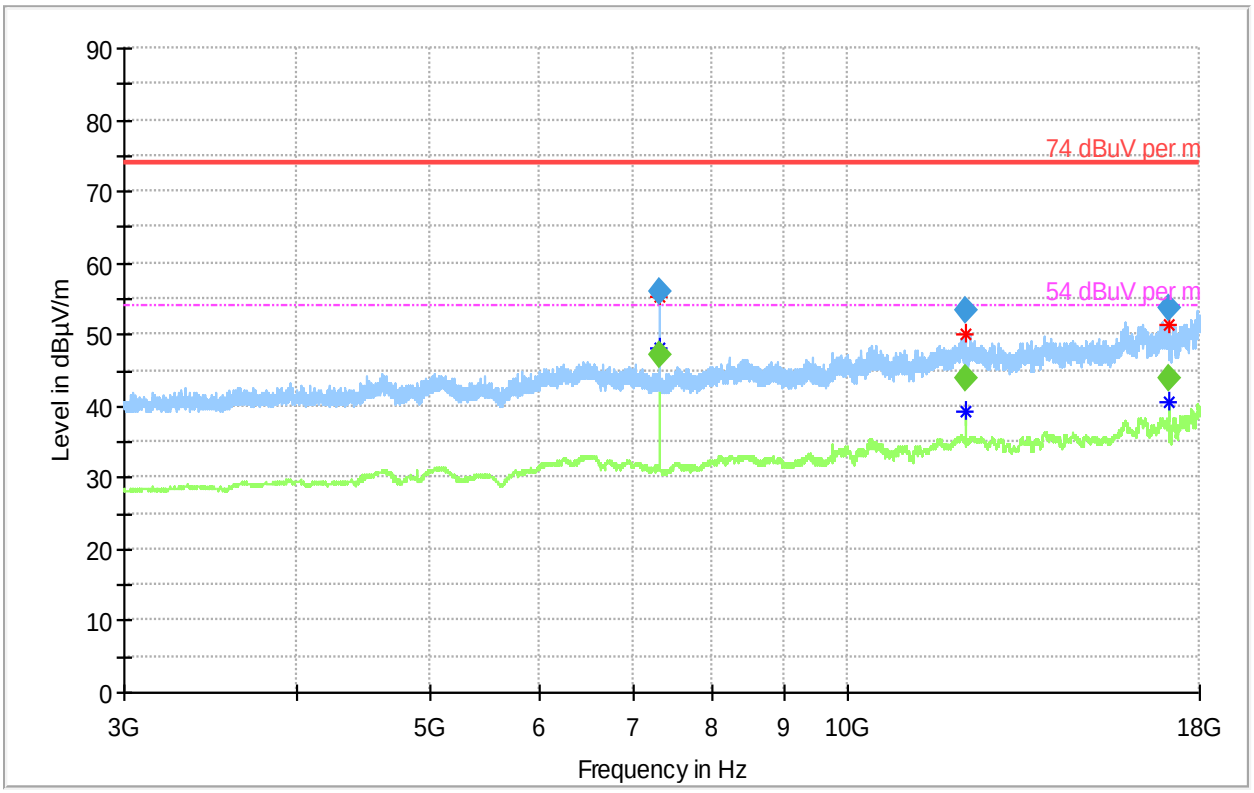
Plot #6 Radiated Emissions: 1 – 3GHz	
Modulation: BT LE	**Channel: Mid**



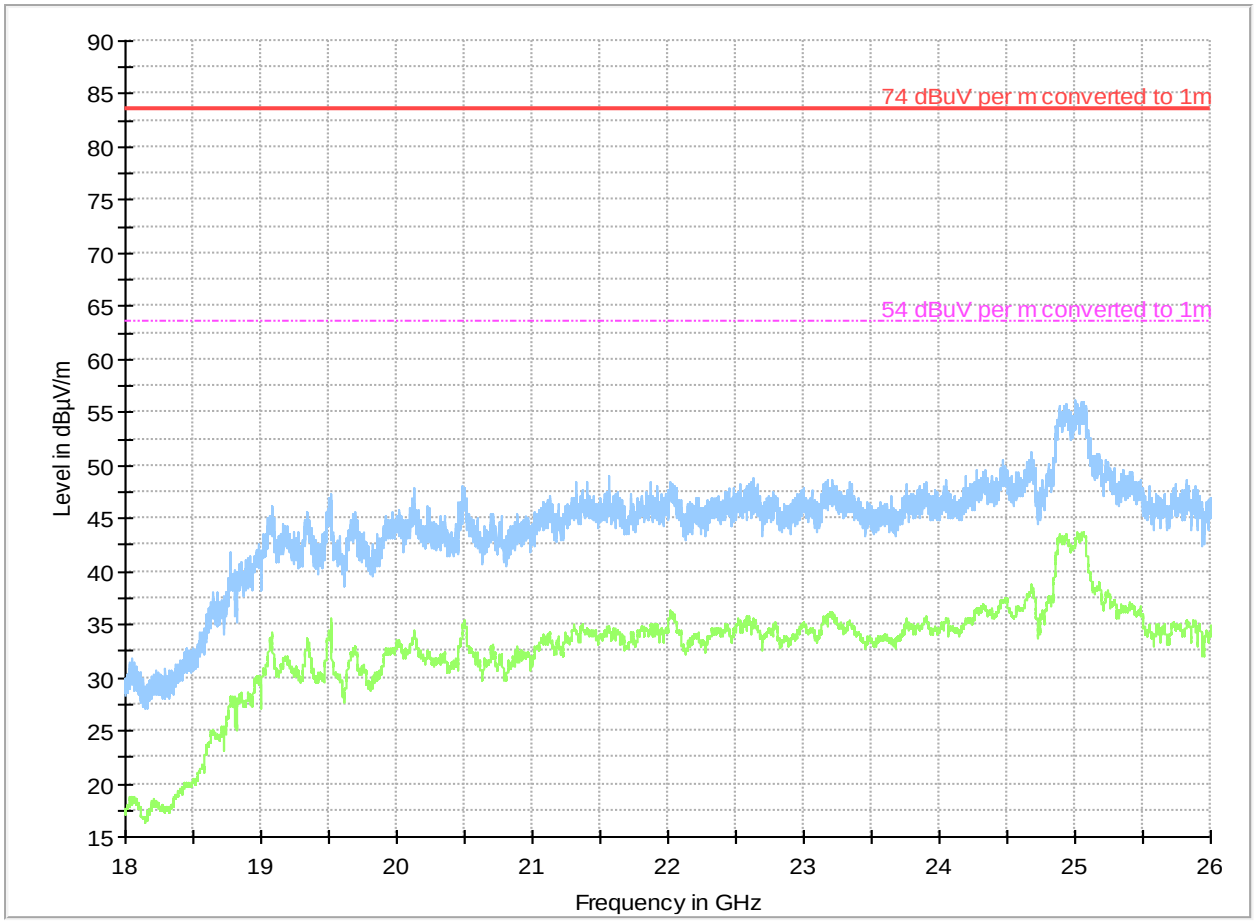
Plot #7 Radiated Emissions: 3 – 18GHz	
Modulation: BT LE	**Channel: Mid**

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
7319.060000	56.08	---	74.00	17.92	100.0	1000.000	140.0	V	212.0
7319.500000	---	47.13	54.00	6.87	100.0	1000.000	140.0	V	212.0
12198.500000	---	43.89	54.00	10.11	100.0	1000.000	325.0	V	147.0
12201.820000	53.43	---	74.00	20.57	100.0	1000.000	325.0	V	147.0
17077.900000	53.74	---	74.00	20.26	100.0	1000.000	199.0	H	152.0
17078.000000	---	43.98	54.00	10.02	100.0	1000.000	197.0	H	133.0



Plot #8 Radiated Emissions: 18 – 26GHz	
Modulation: BT LE	**Channel: Mid**

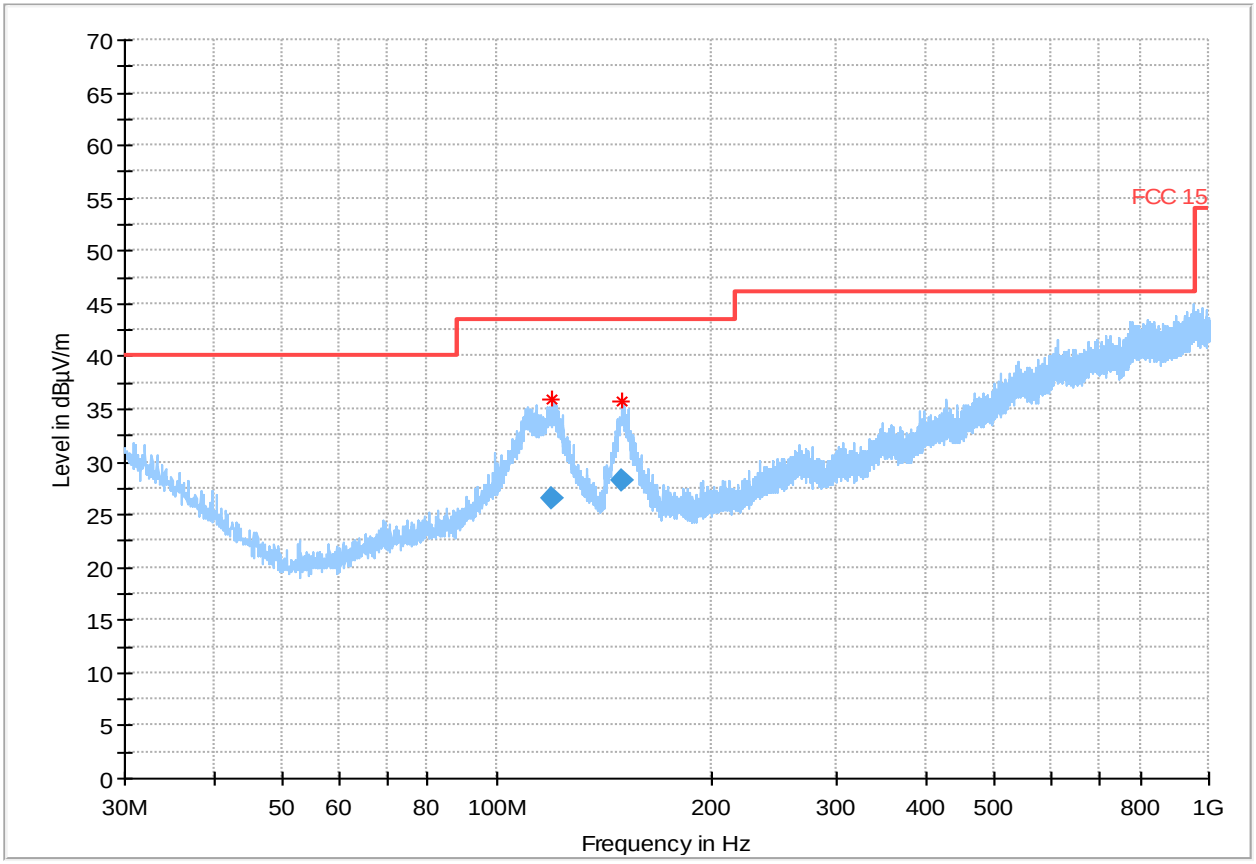


Plot #9 Radiated Emissions: 30MHz – 1GHz

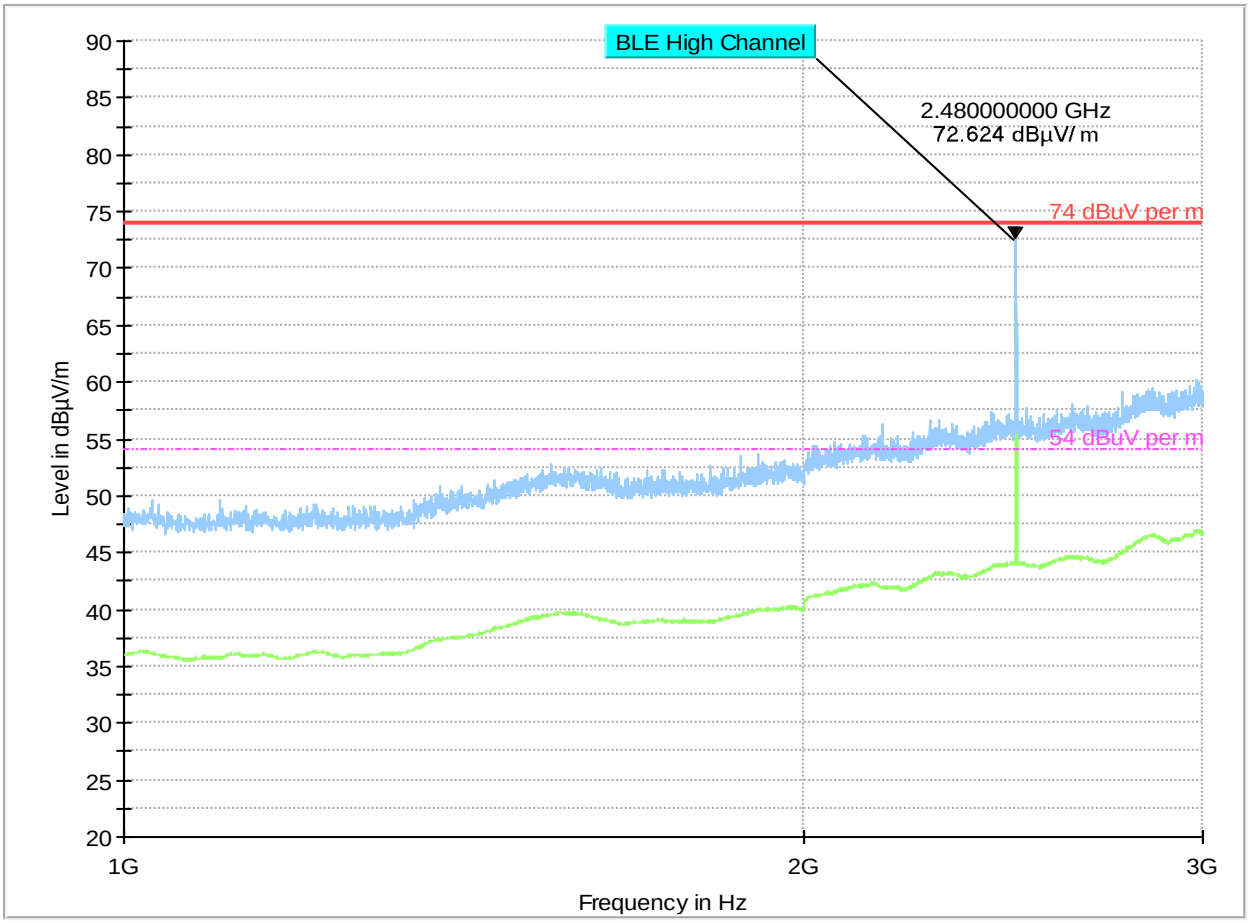
Modulation: BT LE | **Channel: High**

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
119.340000	26.56	43.52	16.96	200.0	120.000	325.0	V	55.0	24.5
150.180000	28.21	43.52	15.32	200.0	120.000	315.0	H	89.0	24.5



Plot # 10 Radiated Emissions: 1 – 3GHz	
Modulation: BT LE	**Channel: High**

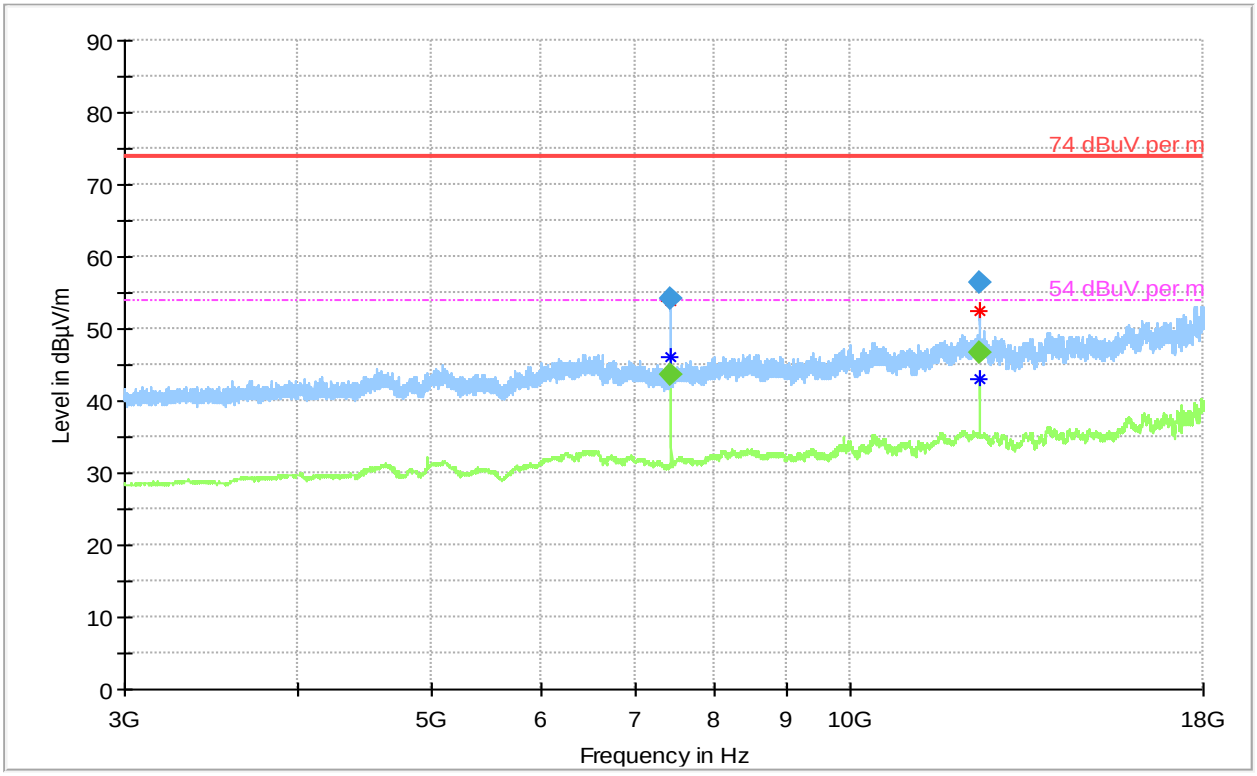


Plot #11 Radiated Emissions: 3 – 18GHz

Modulation: BT LE | **Channel: High**

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
7439.060000	54.08	---	74.00	19.92	100.0	1000.000	150.0	V	213.0
7440.000000	---	43.60	54.00	10.40	100.0	1000.000	151.0	V	213.0
12401.500000	---	46.71	54.00	7.29	100.0	1000.000	197.0	H	158.0
12401.700000	56.39	---	74.00	17.61	100.0	1000.000	197.0	H	158.0



8.5.6 Test conditions and setup:

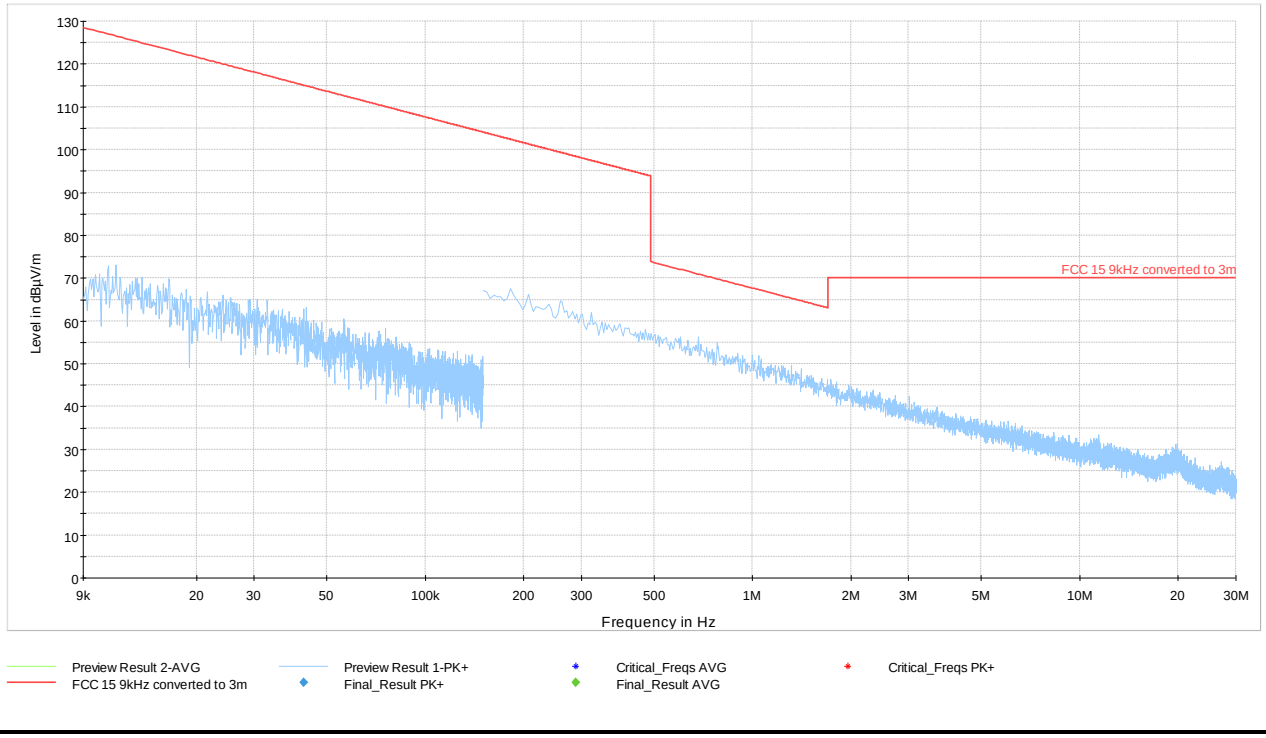
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	4	Op.4	3.3 VDC

8.5.7 Measurement result:

Plot #	Channel #	Scan Frequency	Highest emission in dB	Frequency of highest emission in MHz	Limit	Result
4 – 8	Mid	9 kHz – 26 GHz	51.35	7205	See section 8.6.2	Pass

8.5.8 Measurement Plots:

Plot # 4 Radiated Emissions: 9KHz – 30MHz	
Modulation: BT LE	**Channel: Low**

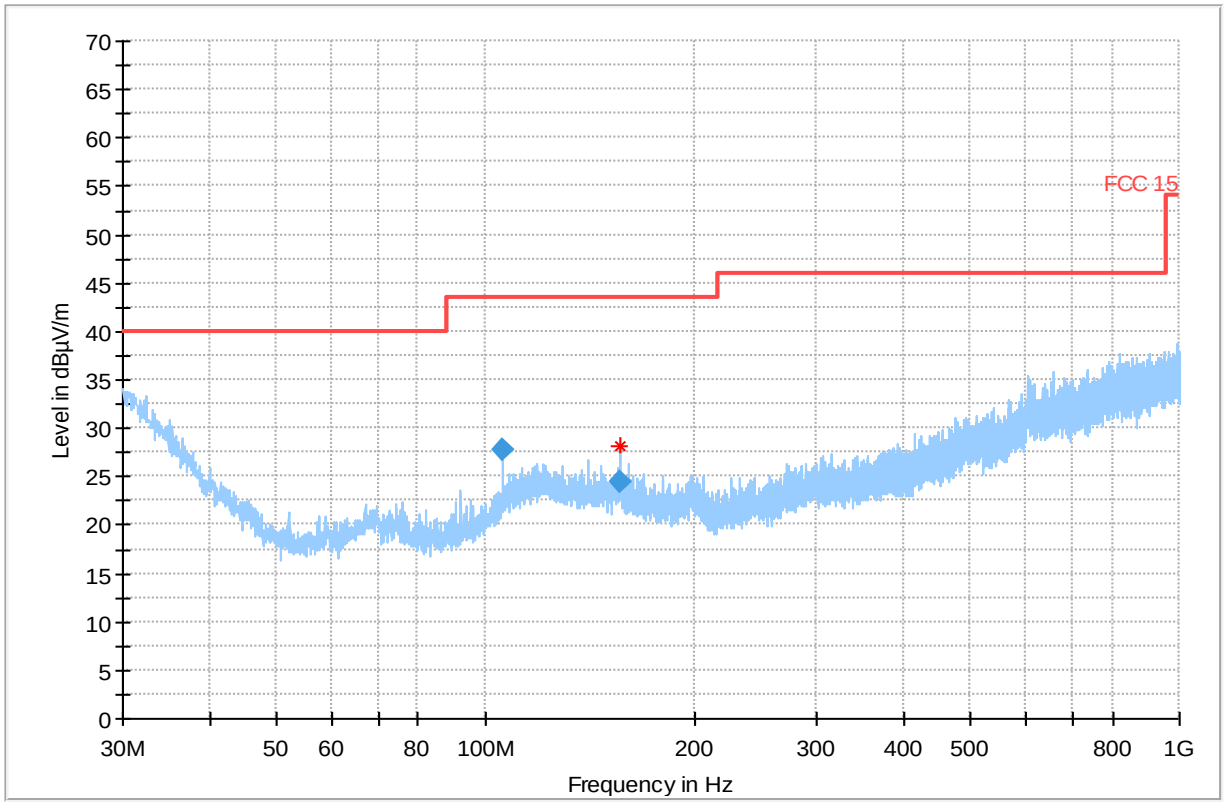


Plot #1 Radiated Emissions: 30MHz – 1GHz

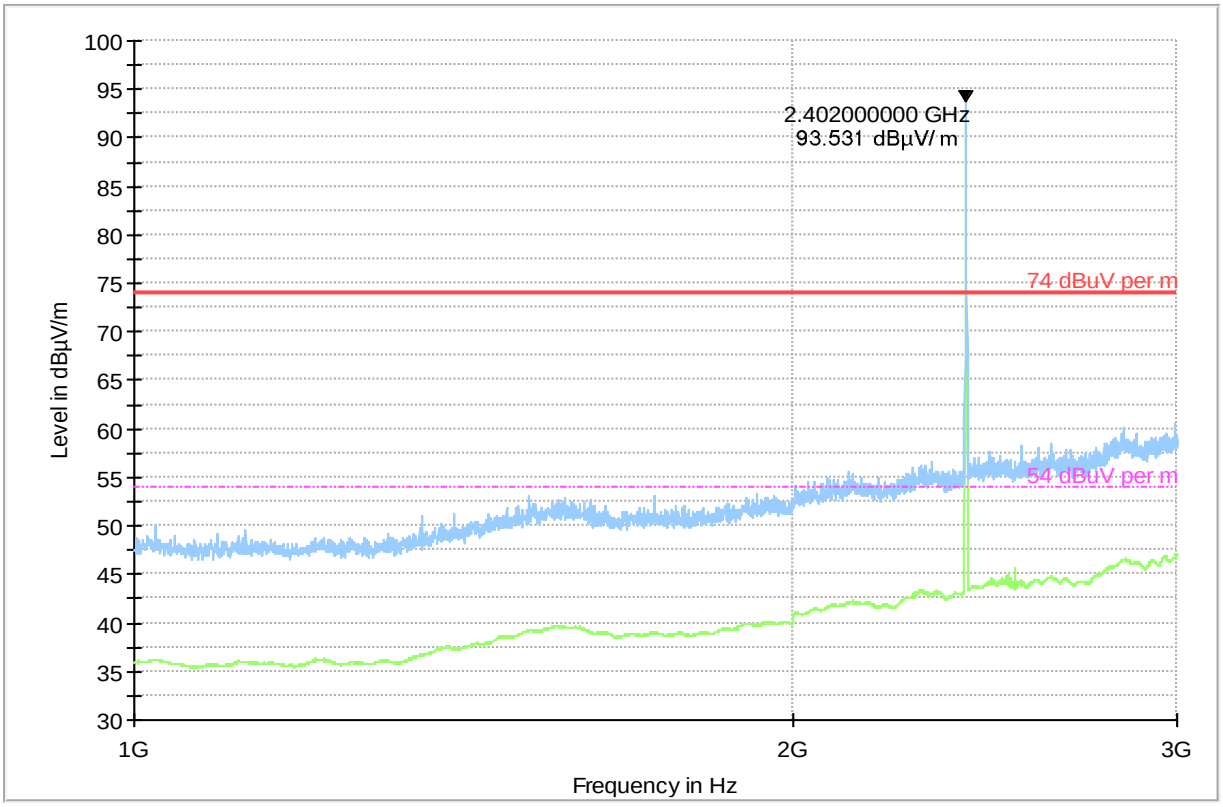
Modulation: BT LE | **Channel: Low**

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
105.726109	27.82	43.52	15.70	200.0	120.000	164.0	H	234.0	21.1	10:10:38 AM - 9/20/2018
156.217261	24.53	43.52	18.99	200.0	120.000	152.0	H	210.0	21.8	10:12:24 AM - 9/20/2018



Plot # 2 Radiated Emissions: 1 – 3GHz	
Modulation: BT LE	**Channel: Low**

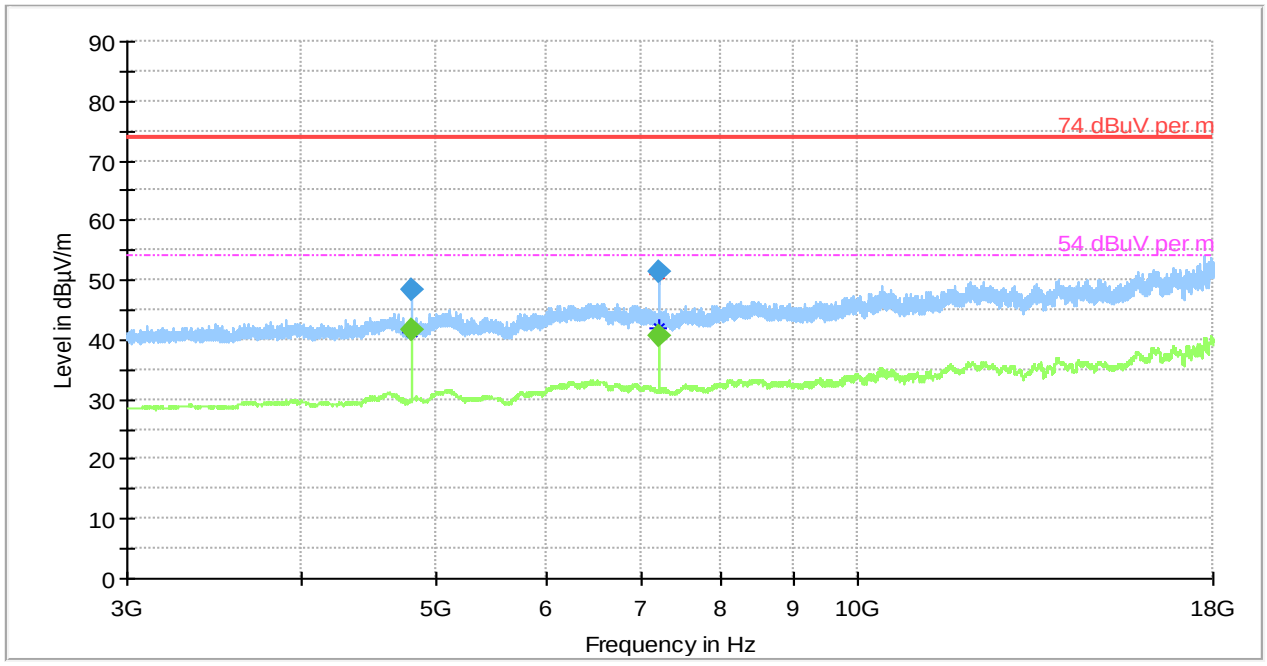


Plot # 3 Radiated Emissions: 3 – 18GHz

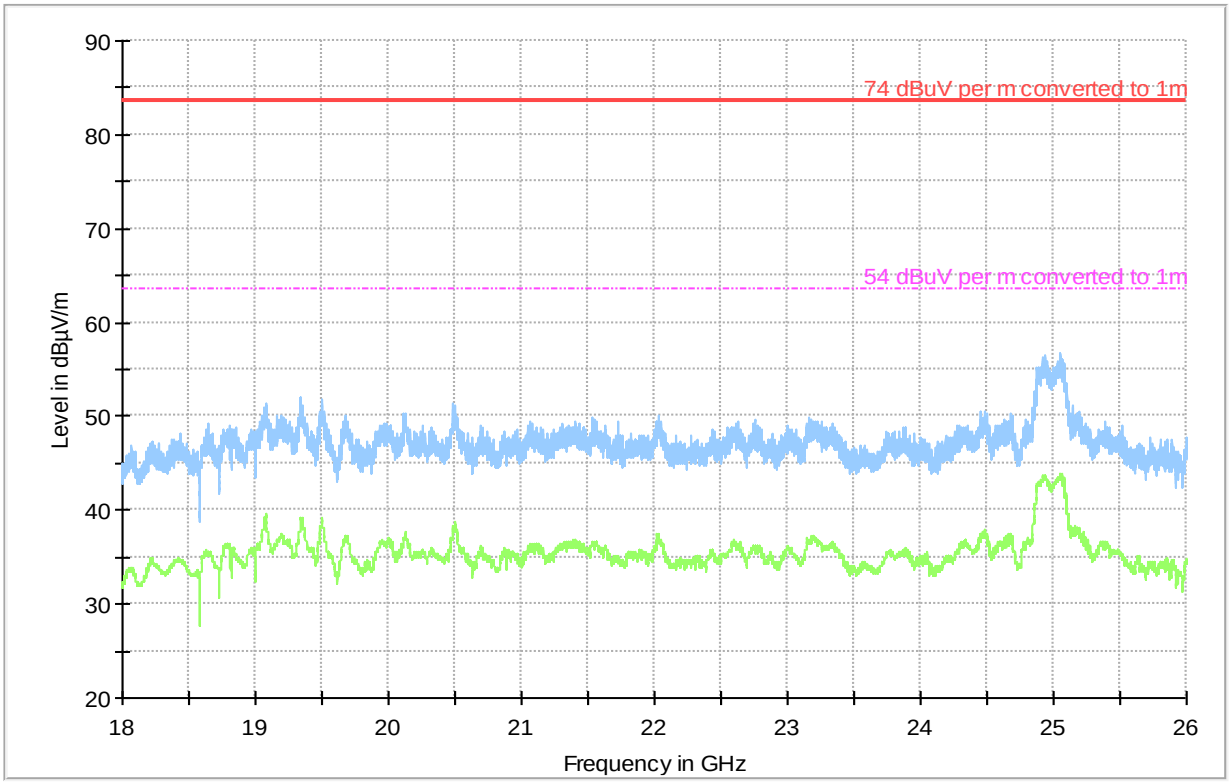
Modulation: BT LE | **Channel: Low**

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
4804.00000	---	41.55	54.00	12.45	100.0	1000.000	153.0	H	-145.0	-5.1	11:36:57 AM - 9/20/2018
4804.02000	48.33	---	74.00	25.67	100.0	1000.000	153.0	H	-144.0	-5.1	11:31:11 AM - 9/20/2018
7205.04000	51.35	---	74.00	22.65	100.0	1000.000	153.0	V	161.0	-0.4	11:34:07 AM - 9/20/2018
7206.00000	---	40.63	54.00	13.37	100.0	1000.000	152.0	V	161.0	-0.4	11:39:49 AM - 9/20/2018



Plot #8 Radiated Emissions: 18 – 26GHz	
Modulation: BT LE	**Channel: Low**



9 Test setup photos

Setup photos are included in supporting file name: "EMC_DIGII_045_18001_FCC_ISED_BLE_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
ACTIVE LOOP	ETS.LINDGREN	6507	00161344	3 YEARS	10/26/2017
BOLOG ANTENNA	EMCO	3142E	166067	3 YEARS	06/27/2017
HORN ANTENNA	ETS.LINDGREN	3115	00035114	3 YEARS	07/31/2017
HORN ANTENNA	ETS.LINDGREN	3117	00245984	3 YEARS	01/26/2018
HORN ANTENNA	ETS.LINDGREN	3116	00070497	3 YEARS	10/31/2017
SIGNAL ANALYZER	R&S	FSU26	200065	2 YEARS	07/03/2017
TEST RECEIVER	R&S	ESU.EMI	100256	3 YEARS	01/31/2018
COMPACT DIGITAL BAROMETER	CONTROL COMPANY	35519-055	91119547	2 YEARS	06/20/2017
THRMOMETER HUMIDIY	DICKSON	TM320	16253639	3 YEARS	11/02/2017

Note: Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels. Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated "N/A" for cal status either do not specifically require calibration or is internally characterized before use.

11 Revision History

Date	Report Name	Changes to report	Report prepared by
11/13/2018	EMC_DIGII_045_18001_FCC_15.247_ISED_BLE_DTS	Initial Version	Issa Ghanma