FCC / ISED Test Report

FOR:
Compology

Model Name:
Oscar R12

Product Description:
Wireless dumpster fullness monitor

FCC ID: 2AO44-R12
IC ID: 23661-R12

Applied Rules and Standards:
47 CFR Part 15.247 (DTS)
RSS-247 Issue 2 (DTSs) & RSS-Gen Issue 4

REPORT #: EMC_COMPO_010_18001_15.247_ISED_BT_DTS

DATE: 03/09/2018

A2LA Accredited

IC recognized #
3462B-1

***CETECOM* Inc.**
411 Dixon Landing Road ◆ Milpitas, CA 95035 ◆ U.S.A.
Phone: + 1 (408) 586 6200 ◆ Fax: + 1 (408) 586 6299 ◆ E-mail: info@cetecom.com ◆ http://www.cetecom.com
CETECOM Inc. is a Delaware Corporation with Corporation number: 2905571

TABLE OF CONTENTS

1 ASSESSMENT 3

2 ADMINISTRATIVE DATA 4

2.1 IDENTIFICATION OF THE TESTING LABORATORY ISSUING THE EMC TEST REPORT 4
2.2 IDENTIFICATION OF THE CLIENT 4
2.3 IDENTIFICATION OF THE MANUFACTURER 4

3 EQUIPMENT UNDER TEST (EUT) 5

3.1 EUT SPECIFICATIONS 5
3.2 EUT SAMPLE DETAILS 6
3.3 ACCESSORY EQUIPMENT (AE) DETAILS 6
3.4 TEST SAMPLE CONFIGURATION 6
3.5 MODE OF OPERATION DETAILS 6
3.6 JUSTIFICATION FOR WORST CASE MODE OF OPERATION 6

4 SUBJECT OF INVESTIGATION 7

5 MEASUREMENT RESULTS SUMMARY 7

6 MEASUREMENT UNCERTAINTY 8

6.1 ENVIRONMENTAL CONDITIONS DURING TESTING: 8
6.2 DATES OF TESTING: 8

7 MEASUREMENT PROCEDURES 9

7.1 RADIATED MEASUREMENT 9
7.2 RF CONDUCTED MEASUREMENT PROCEDURE 11

8 TEST RESULT DATA 12

8.1 MAXIMUM PEAK CONDUCTED OUTPUT POWER 12
8.2 POWER SPECTRAL DENSITY 16
8.3 BAND EDGE COMPLIANCE 20
8.4 EMISSION BANDWIDTH 6DB AND 99% OCCUPIED BANDWIDTH 28
8.5 RADIATED TRANSMITTER SPURIOUS EMISSIONS AND RESTRICTED BANDS 35

9 TEST SETUP PHOTOS 49

10 TEST EQUIPMENT AND ANCILLARIES USED FOR TESTING 49

11 REVISION HISTORY 49

1 Assessment

The following device as further described in section 3 of this report was evaluated for radiated spurious emissions in simultaneous transmission of unlicensed and cellular radios according to 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.

Responsible for Testing Laboratory:

Date	Section	Name	Signature
03/09/2018	Compliance	James Donnellan (Lab Manager)	

Responsible for the Report:

Date	Section	Name	Signature
03/09/2018	Compliance	Issa Ghanma (EMC Engineer)	Digitally signed by ISSA GHANMA DN: cn=ISSA GHANMA, c=US, o=CETECOM Inc., email=issa.ghanma@cetecom.com Date: 2018.03.09 11:59:52 -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:	James Donnellan
Responsible Project Leader:	Laith Saman

2.2 Identification of the Client

Applicant's Name:	Compology
Street Address:	1045 Bryant St. Suite 101
City/Zip Code	San Francisco 94103
Country	USA
Contact Person:	Ben Chehebar
Phone No.	(914) 584-8103
e-mail:	ben@compology.com

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as Applicant
Manufacturers Address:	-------
City/Zip Code	-------
Country	-------

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No	R12
FWIN:	NA
HVIN:	R12
PMN:	Oscar R12
Product Description	Wireless dumpster fullness monitor
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 GFSK modulation.
Modes of Operation:	Bluetooth LE in both advertising and connected mode of operation
Max. measured output Powers:	6.81 dBm
Antenna Information as declared:	Internal Part Number: 2450AT43B100 Peak Gain: 1.3 dBi Average Gain: -0.5 dBi
Power Supply/ Rated Operating Voltage Range:	Low 2.5 VDC, Nominal 3.67 VDC, High 3.9 VDC
Operating Temperature Range	Low -20º C, Nominal 20º C, High 85º C
Other Radios included in the device:	**Cellular Module**: SARA-R410M-00B / Bands: E-UTRA FDD : Band 2, 4, 5, 12 FCC ID: XPY2AGQN4NNN / IC ID: 8595A-2AGQN4NNN **GPS**: U-blox EVA-M8M
Sample Revision	☐Prototype Unit; ■Production Unit; ☐Pre-Production
EUT Dimensions	5"x7.25"x2"
Weight	2lbs
EUT Diameter	■ < 60 cm ☐ Other _____

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	357591080056978	Rev_E	Oscar-0236	Conducted Measurement
2	02860016965Bs66	Rev_E	Oscar-0236	Radiated Emissions

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	Conducted Measurement
2	EUT#2	Radiated Measurement

3.5 Mode of Operation details

Mode of Operation	Description of Operating modes	Additional Information
Op. 1	BLE	Putty terminal tool used to configure the EUT to Low, Mid, High channel, Max power and Max duty cycle. The internal antenna was connected.

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 41.6% duty cycle.

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

4 Subject of Investigation

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

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

- FCC ID: 2AO44-R12
- IC ID: 23661-R12

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	BLE	■	☐	☐	Complies
§15.247(e) RSS-247 5.2(b)	Power Spectral Density	Nominal	BLE	■	☐	☐	Complies
§15.247(b)(3) 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	-	-	☐	■	☐	Note 2 Complies

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)

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:

02/27/2018 – 03/07/2018

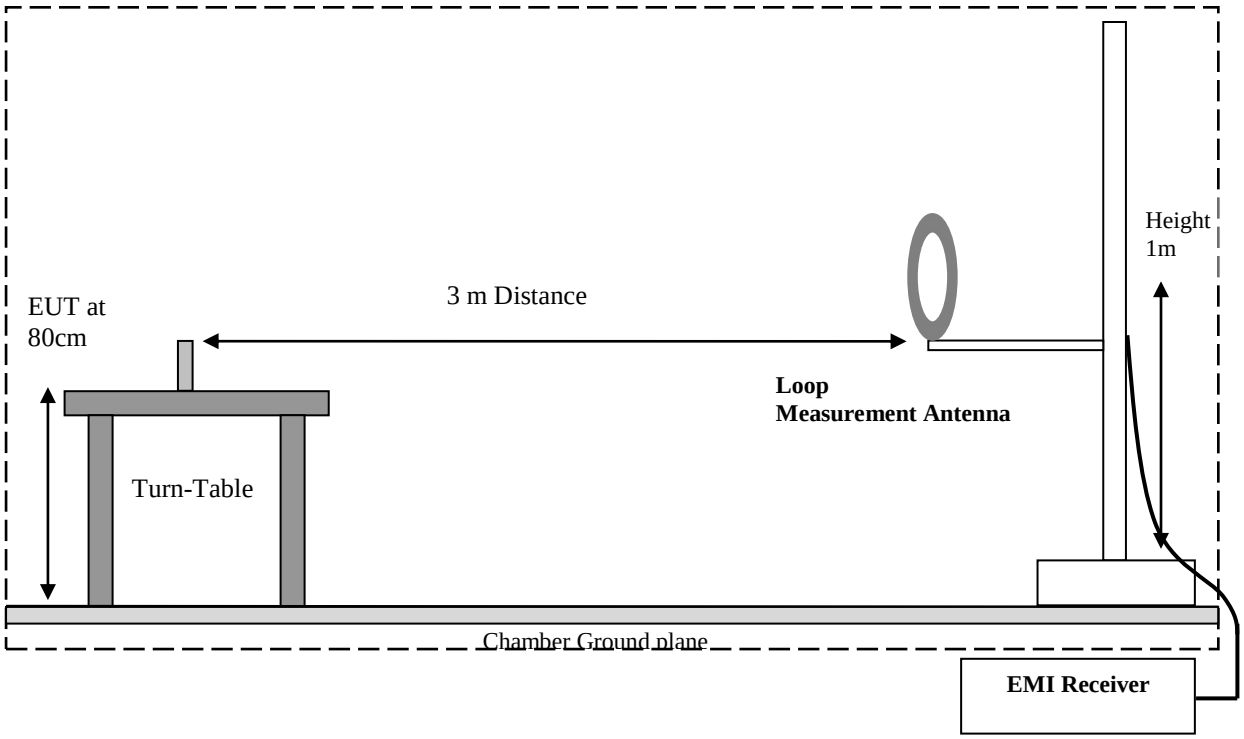
7 Measurement Procedures

7.1 Radiated Measurement

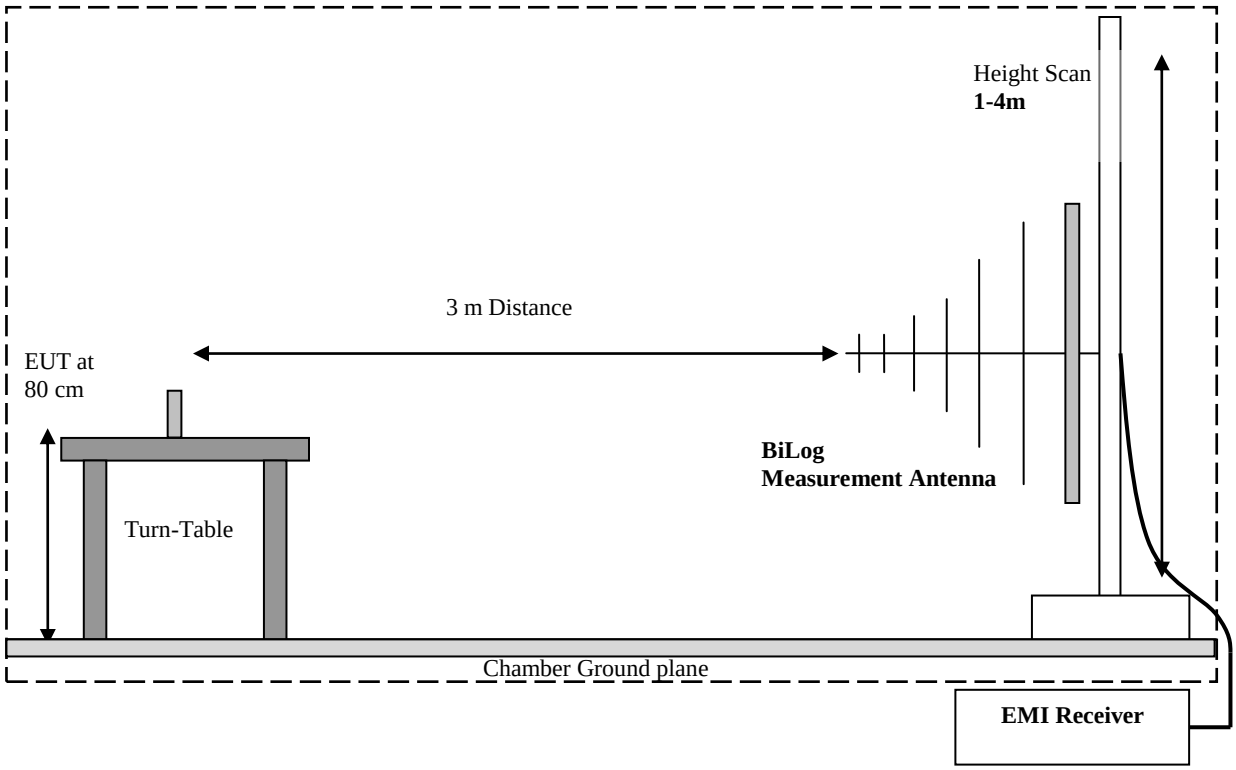
The radiated measurement is performed according to ANSI C63.10 (2013)

- 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.

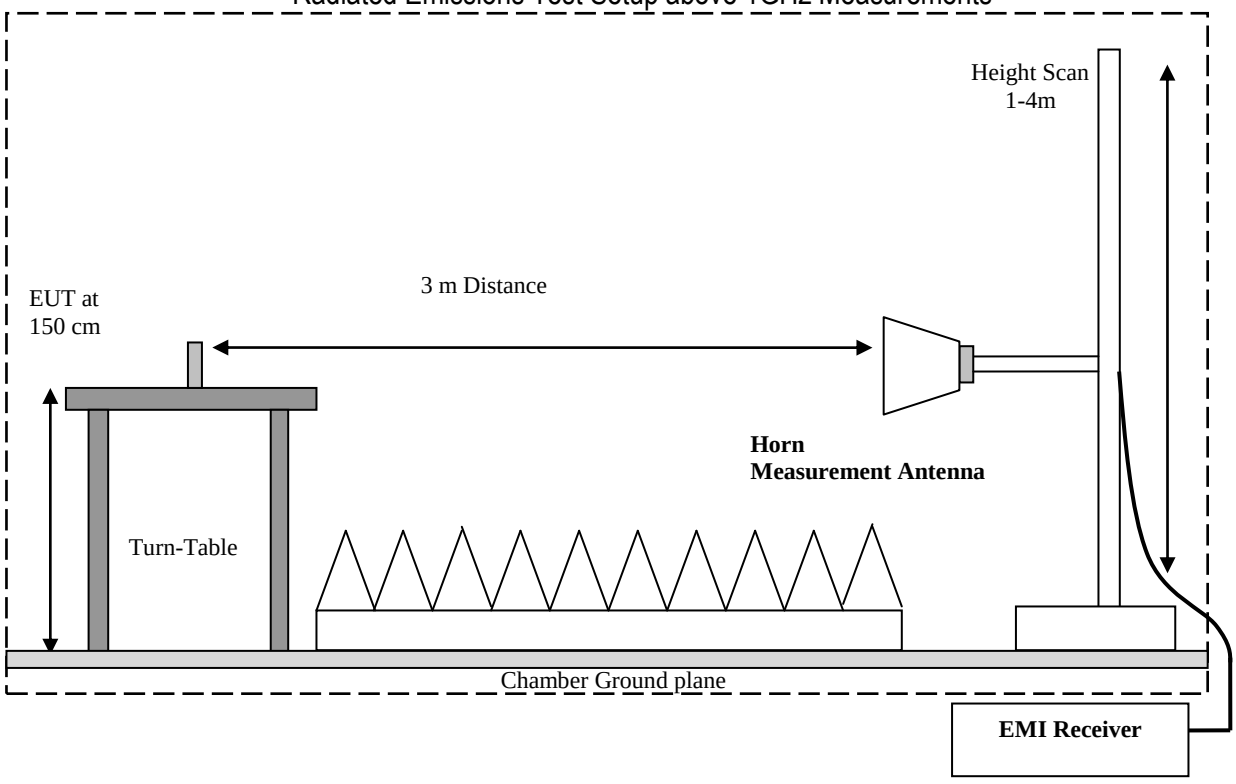
Radiated Emissions Test Setup below 30MHz Measurements



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:

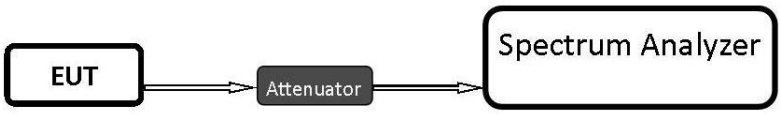
FS (dBµV/m) = Measured Value on SA (dBµV)- Cable Loss (dB)+ Antenna Factor (dB/m)

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 Maximum Peak Conducted Output Power

8.1.1 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

8.1.2 Limits:

Maximum Peak Output Power:

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

8.1.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	BT LE fixed channel	3.67 VDC	1.3 dBi

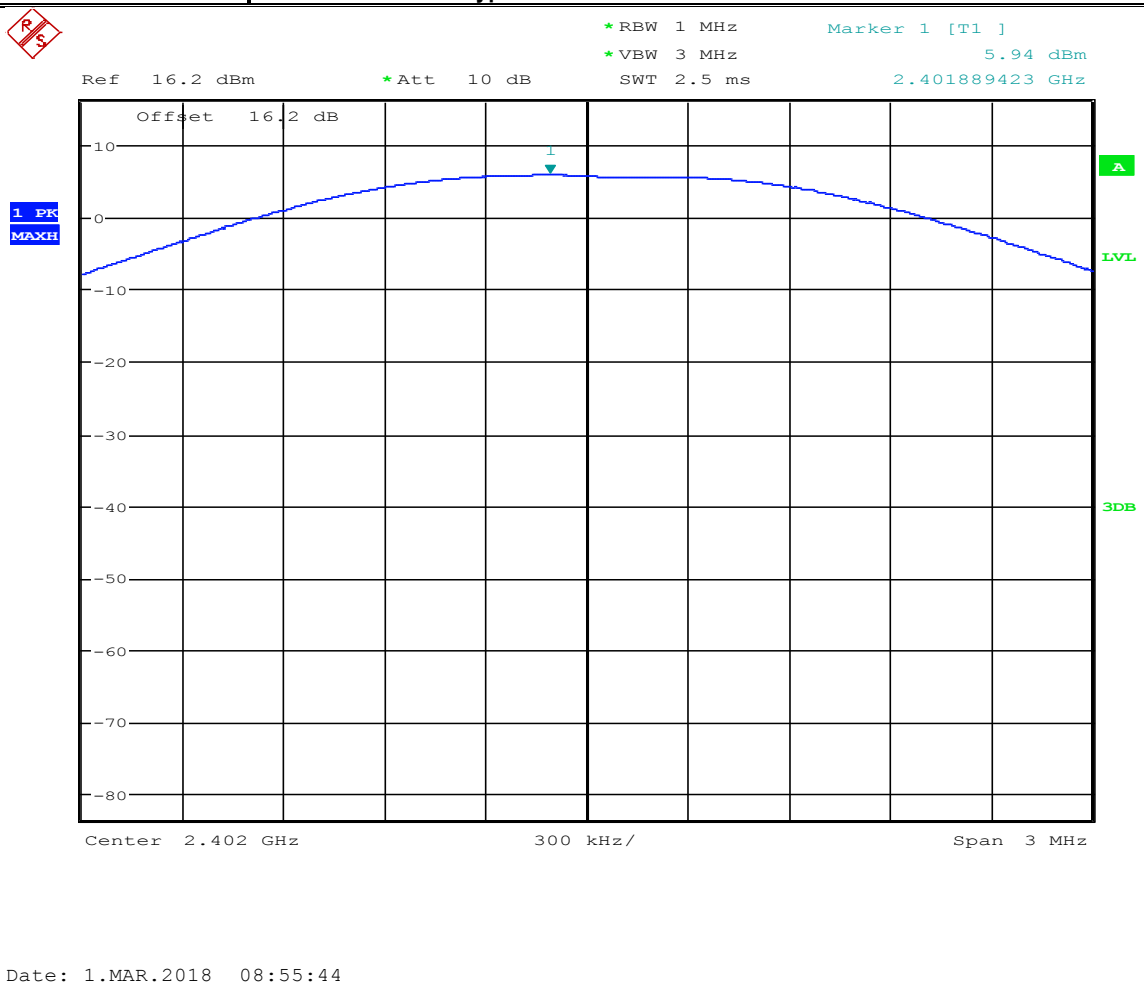
8.1.4 Measurement result:

Plot #	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	2402	5.94	7.24	30 (Pk) / 36 (EIRP)	Pass
2	2440	6.81	8.11	30 (Pk) / 36 (EIRP)	Pass
3	2480	6.60	7.90	30 (Pk) / 36 (EIRP)	Pass

8.1.5 Measurement Plots:

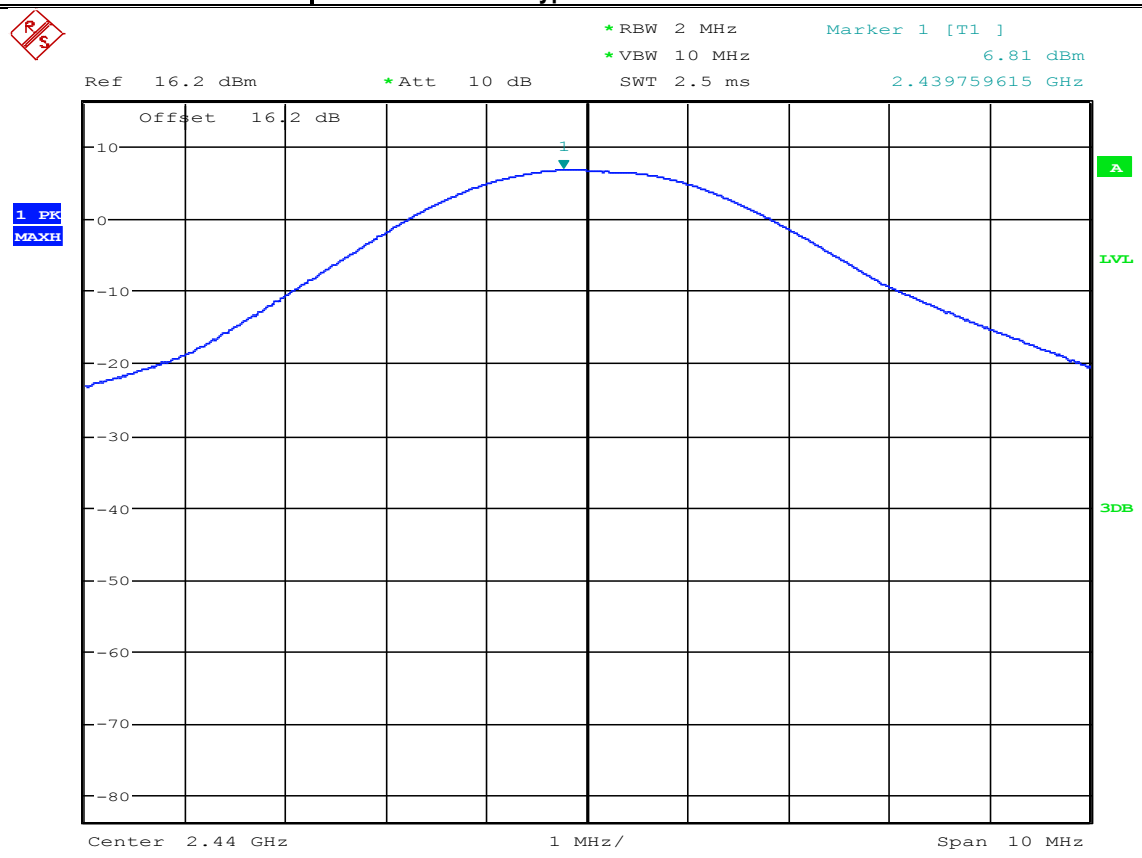
Plot #1

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



Plot #2

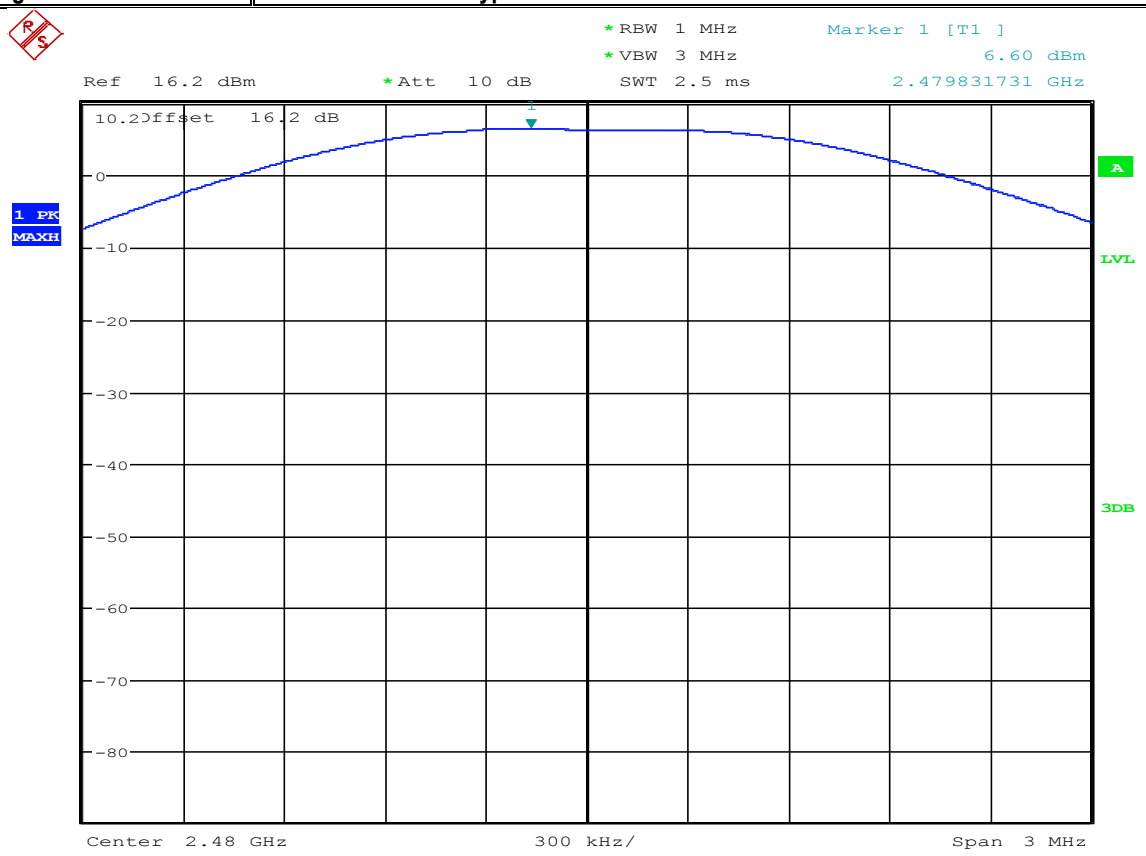
Mid channel 2440 MHz	Modulation/Packet Type: BTLE



Date: 1.MAR.2018 08:30:32

Plot #3

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



Date: 1.MAR.2018 09:11:19

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) & 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.

8.2.3 Test conditions and setup:

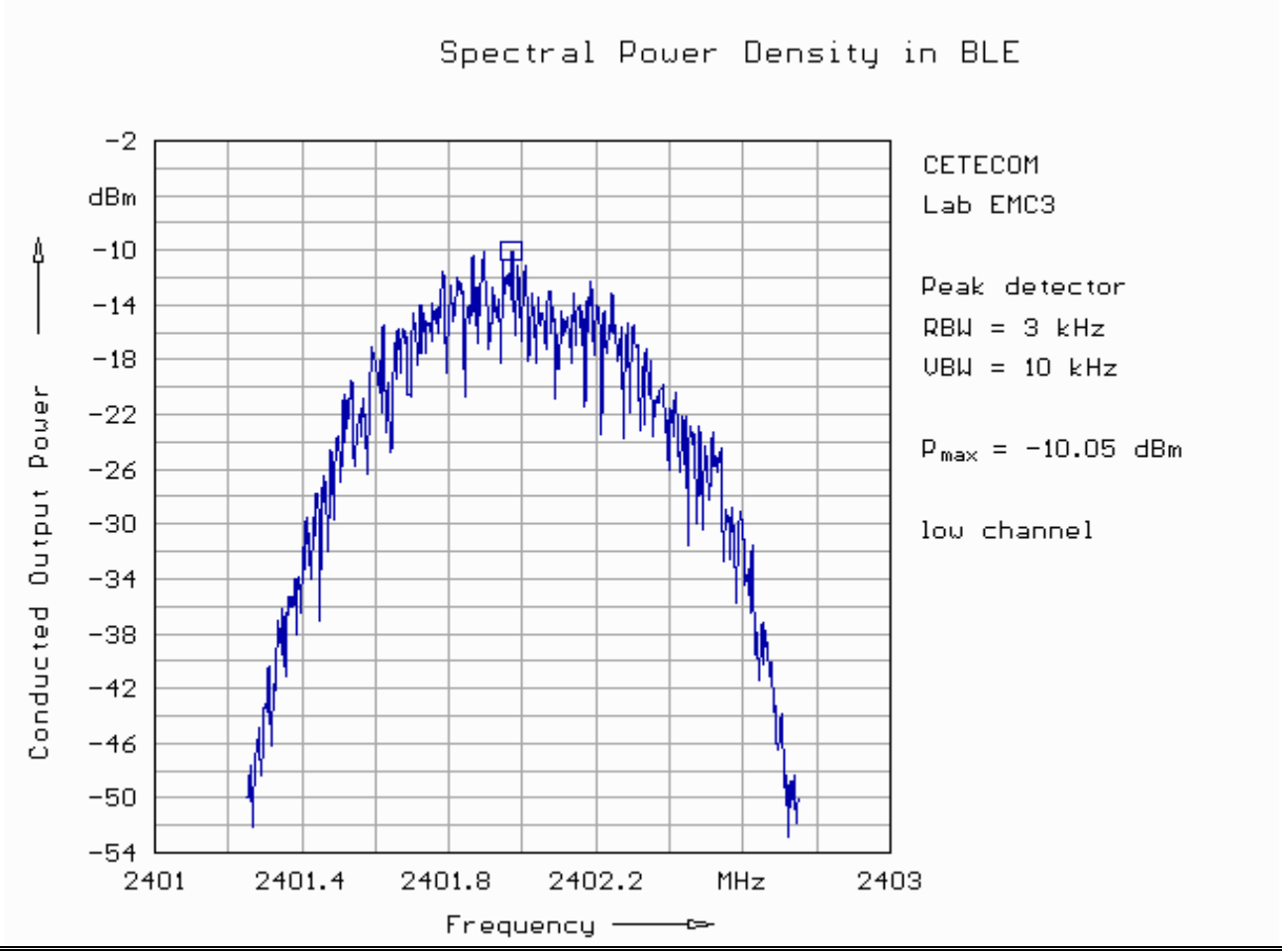
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	BT LE fixed channel	3.67 VDC	1.3 dBi

8.2.4 Measurement result:

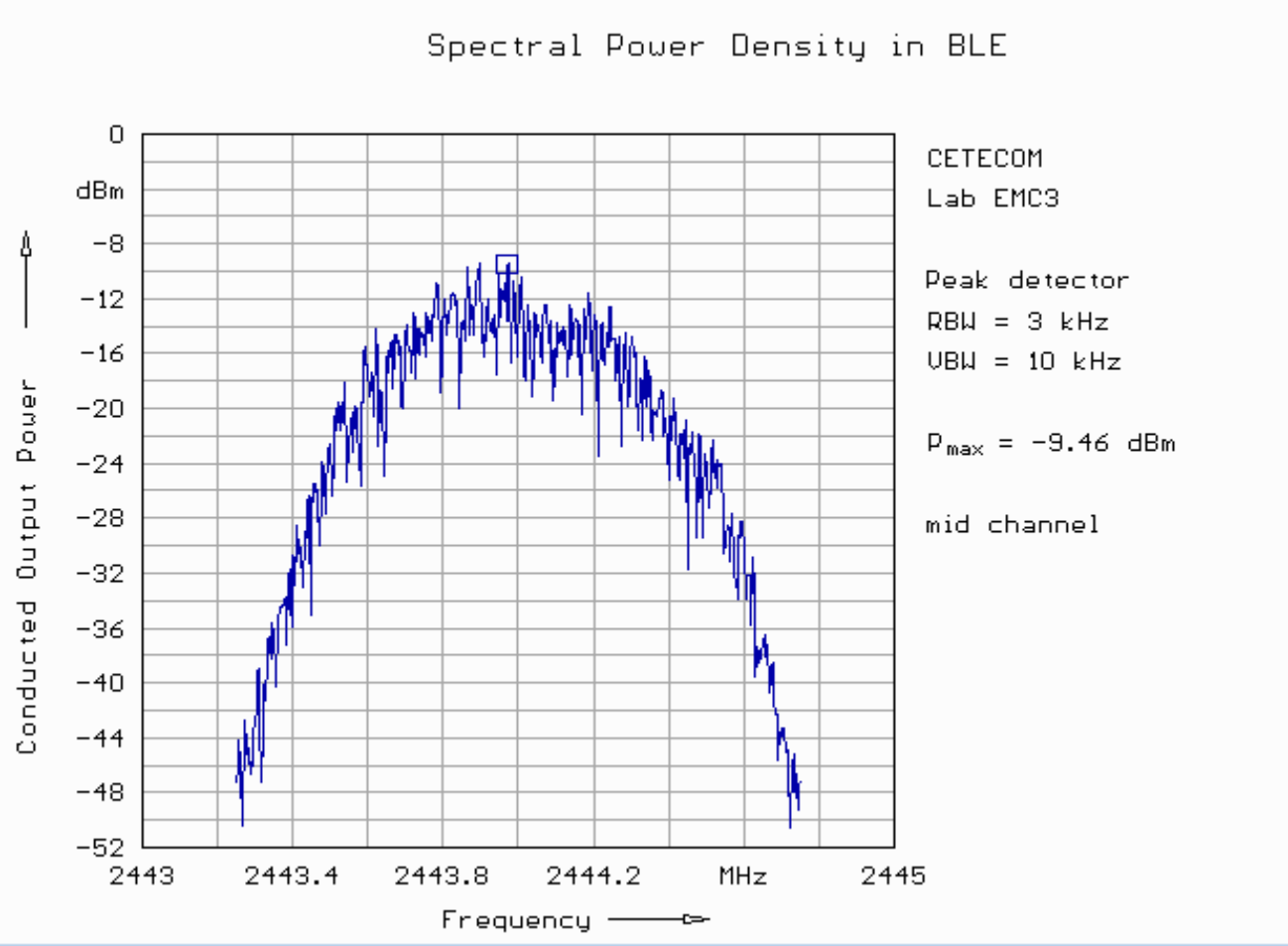
Plot #	Frequency (MHz)	Maximum Power Spectral Density (dBm/3 kHz)	PSD Adjusted for Antenna Gain (dBm/3 kHz)	Limit (dBm / 3 kHz)	Result
1	2402	-10.05	-8.75	8	Pass
2	2441	-9.46	-8.16	8	Pass
3	2480	-10.23	-8.93	8	Pass

8.2.5 Measurement Plots:

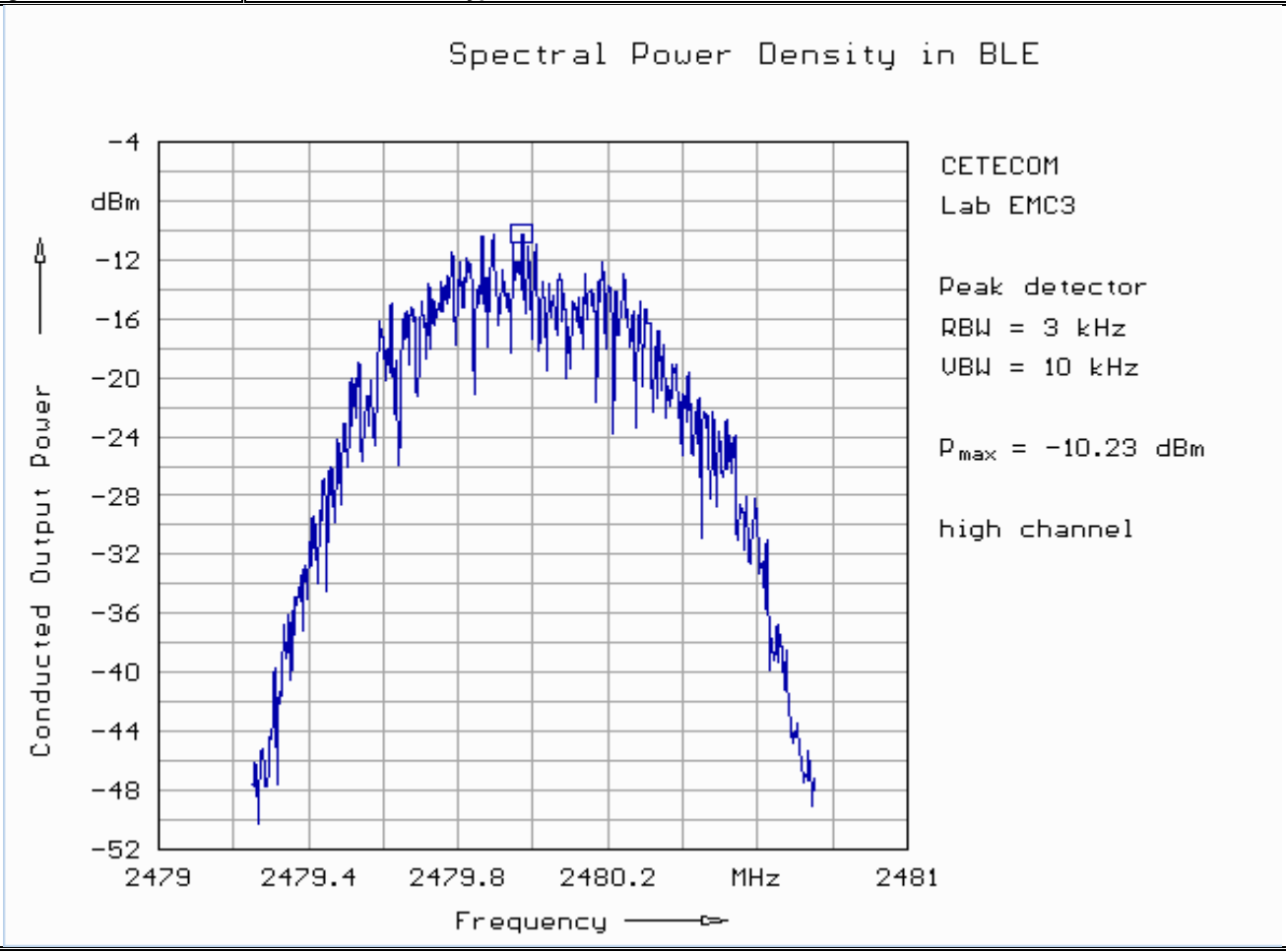
Plot #1	
Low channel / 2402 MHz	**Modulation/Packet Type: BTLE**



Plot #2	
Mid channel 2444 MHz	**Modulation/Packet Type: BTLE**



Plot #3	
High channel 2480 MHz	**Modulation/Packet Type: BTLE**



8.3 Band Edge Compliance

8.3.1 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

8.3.2 Limits non restricted band:

FCC§15.247 (d)

- In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

RSS-247 5/5

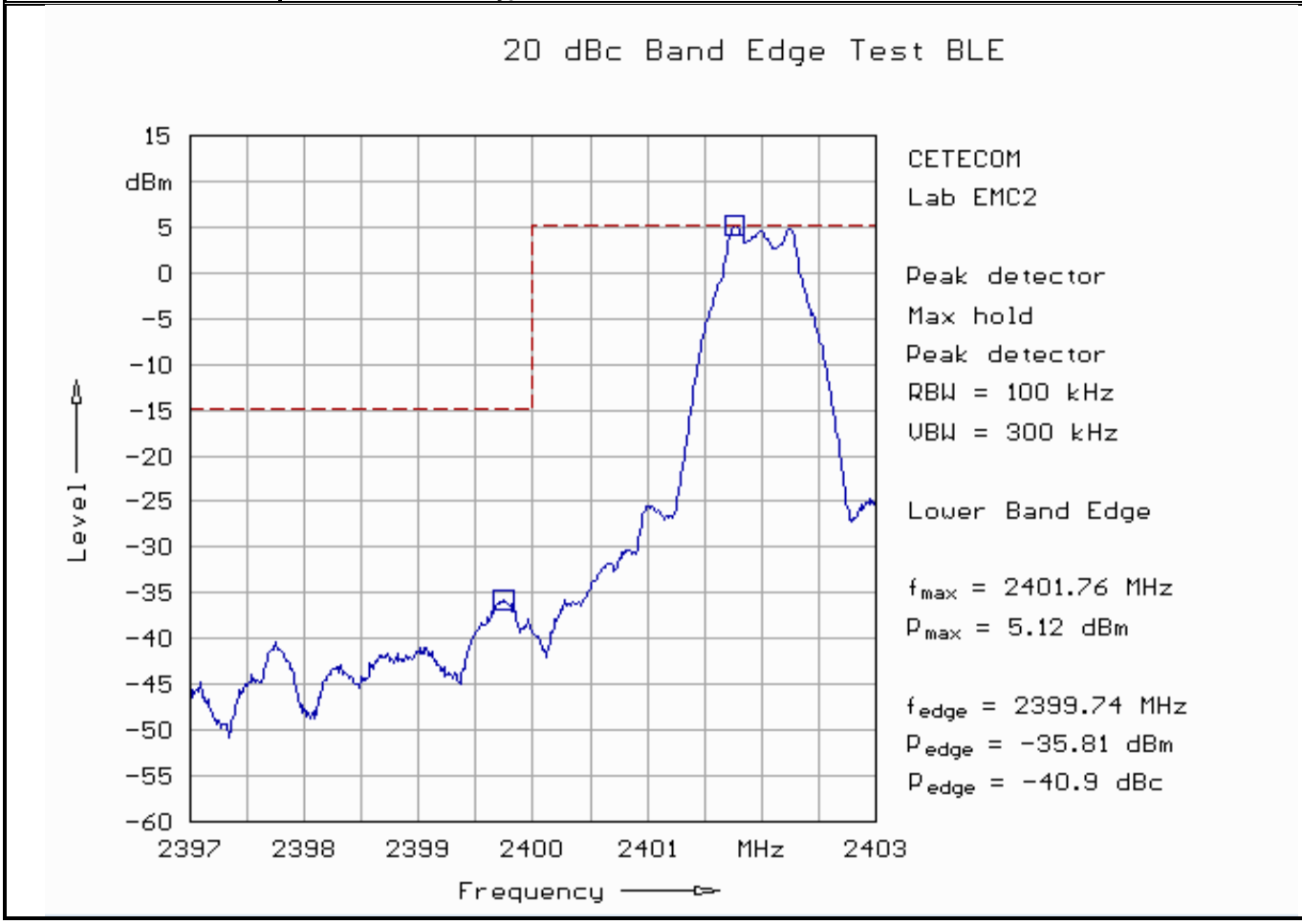
- In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains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

8.3.3 Measurement result:

Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	BT LE fixed channel	Lower, Non-restricted	-40.93	20	Pass

8.3.4 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

8.3.5 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			

8.3.6 Test conditions and setup:

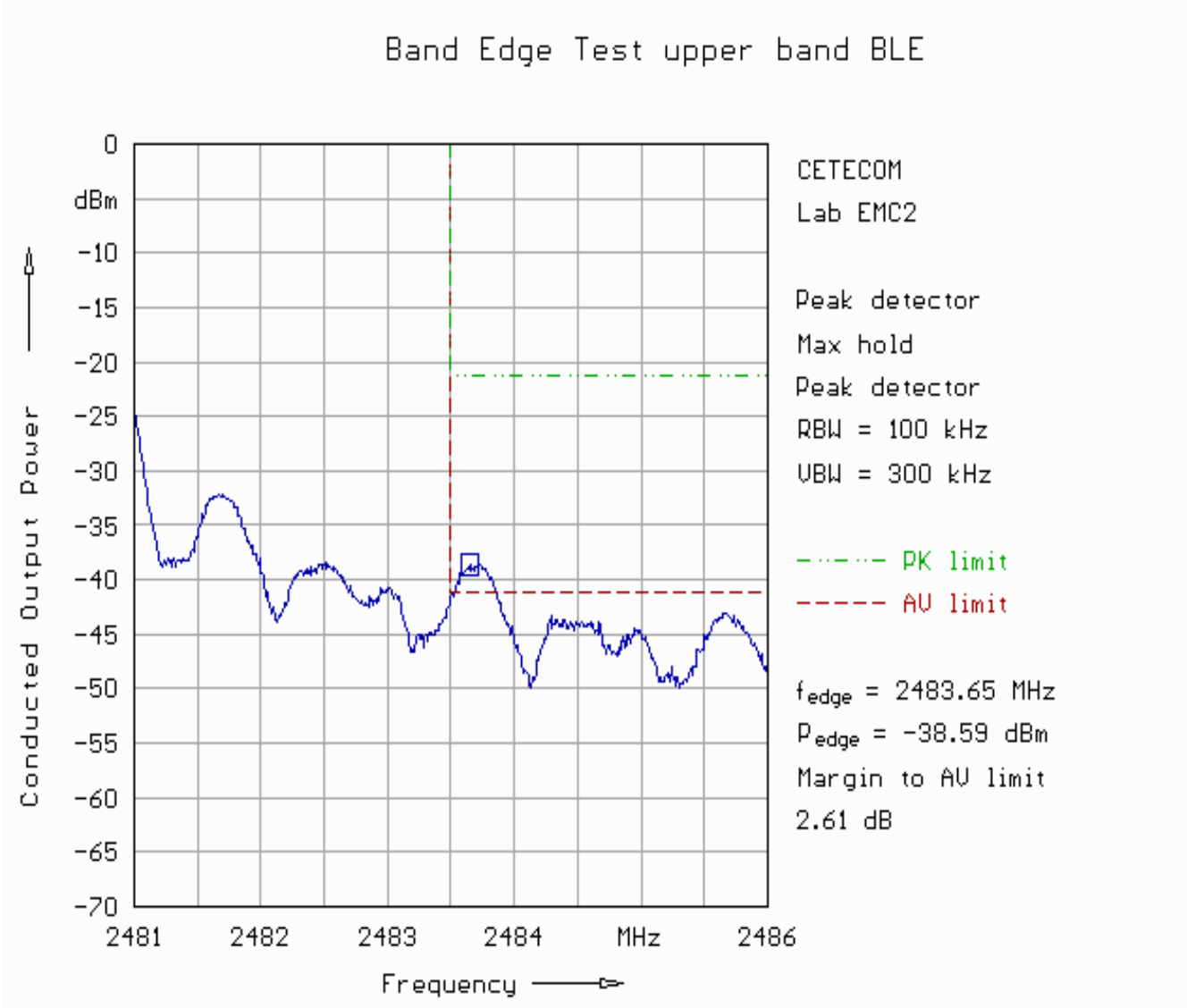
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	1	GFSK continuous fixed channel	3.7 VDC	3.5 dBi

8.3.7 Measurement result (Peak):

Plot #	EUT operating mode	Band Edge	Measured Peak Value (dBm)	Corrected by duty cycle	Corrected by Antenna Gain (dBm)	Limit (dBm)	Result
1	BT LE fixed channel	Upper Restricted Peak	-38.59	NA due to peak detector, and trace max hold	-17.36	-21.23 Peak	Pass

8.3.8 Measurement plot:

Plot #1	
High channel 2480 MHz Peak	**Modulation/Packet Type: BTLE**



8.3.9 Measurement result (AVG):

Plot #	EUT operating mode	Band Edge	Measured Peak Value (dBm)	Corrected by duty cycle	Corrected by Antenna Gain (dBm)	Limit (dBm)	Result
3	BT LE fixed channel	Upper Restricted Peak	-49.45	-45.64	-44.34	-41.23 AVG	Pass

- **According to 558074 D01 DTS:**

6.0 Duty cycle, transmission duration and maximum power control level

Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98 %). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized to ensure that measurements are made only during transmissions at the maximum power control level. Such sweep triggering/signal gating techniques will require knowledge of the minimum transmission duration (T) over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation. Sweep triggering/signal gating techniques can then be used if the measurement/sweep time of the analyzer can be set such that it does not exceed T at any time that data is being acquired (i.e., no transmitter off-time is to be considered).

When continuous transmission cannot be achieved and sweep triggering/signal gating cannot be implemented, alternate procedures are provided that can be used to measure the average power; however, they will require an additional measurement of the transmitter duty cycle. Within this guidance document, the duty cycle refers to the fraction of time over which the transmitter is on and is transmitting at its maximum power control level. The duty cycle is considered to be constant if variations are less than ± 2 %, otherwise the duty cycle is considered to be non-constant.

The term “maximum power control level” is intended to distinguish between operating power levels of the EUT and differences in power levels of individual symbols that occur with some modulation types such as quadrature amplitude modulation (QAM). During testing, the EUT is not required to transmit continuously at its highest possible symbol power level. Rather, it should transmit all of the symbols and should do so at the highest power control level (i.e., highest operating power level) of the EUT.

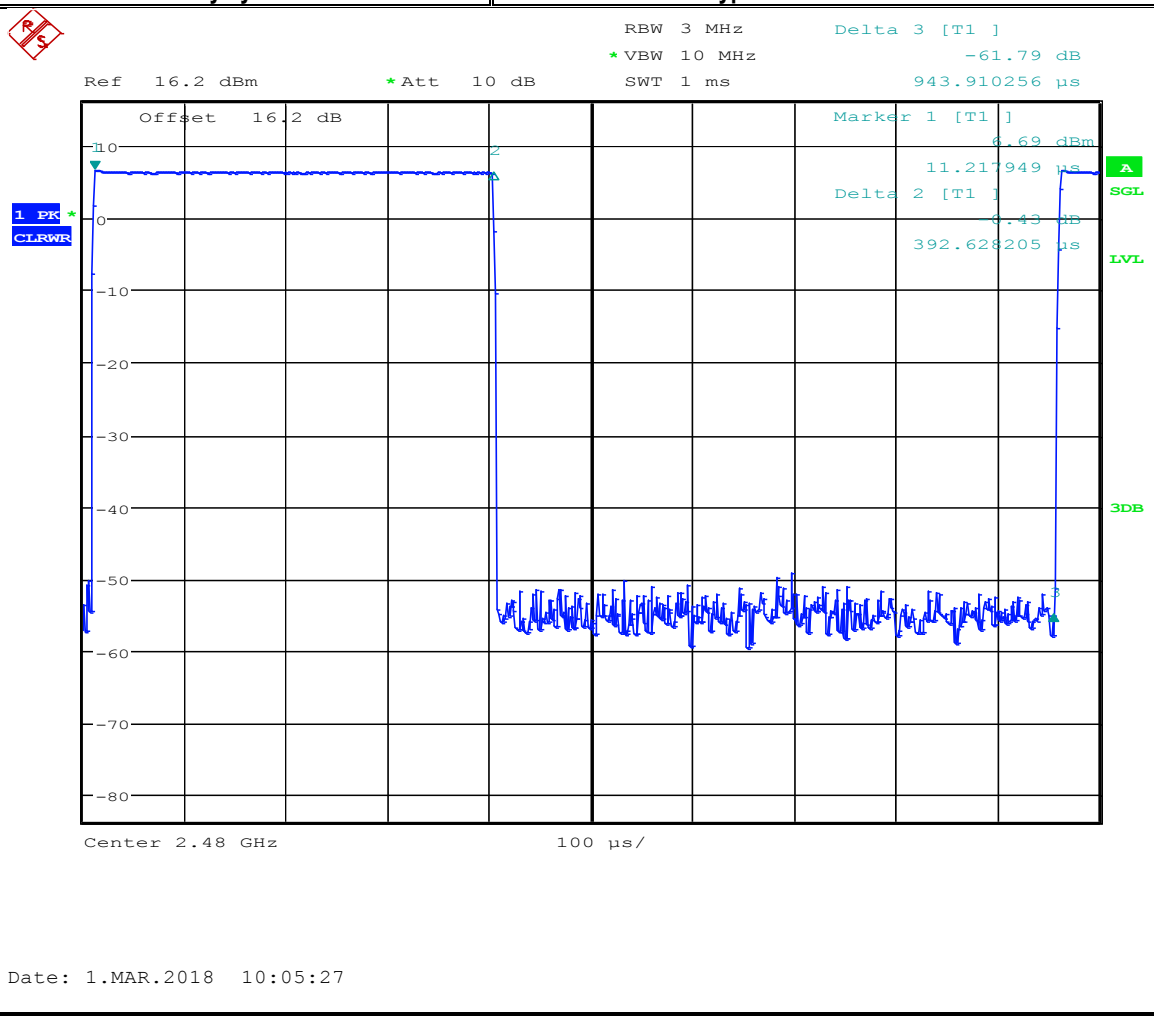
Measurements of duty cycle and transmission duration shall be performed using one of the following techniques:

a) A diode detector and an oscilloscope that together have sufficiently short response time to permit accurate measurements of the on- and off-times of the transmitted signal.
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 the 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.

- **Duty cycle calculation**:

(392.6 / 943.9) * 100 = 41.6%

Plot #2	
Duty cycle	**Modulation/Packet Type: BTLE**



13.3.2 Trace averaging across on- and off-times of the EUT transmissions followed by duty cycle correction

If continuous transmission of the EUT (i.e., duty cycle ≥ 98 %) cannot be achieved and the duty cycle is constant (i.e., duty cycle variations are less ± 2 %), then the following procedure may be used to measure the average power of unwanted emissions within 2 MHz of the authorized band edge:
a) The EUT shall be configured to operate at the maximum achievable duty cycle.
b) Measure the duty cycle, x, of the transmitter output signal as described in Section 6.0.
c) Set instrument center frequency to the frequency of the emission to be measured.
d) Set span to 2 MHz
e) RBW = 100 kHz.
f) VBW ≥ 3 X RBW.
g) Detector = RMS, if span/(# of points in sweep) ≤ (RBW/2). Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If this condition cannot be satisfied, then the detector mode shall be set to peak.
h) Averaging type = power (i.e., RMS).
1) As an alternative, the detector and averaging type may be set for linear voltage averaging.
2) Some instruments require linear display mode in order to use linear voltage averaging. Log or dB averaging shall not be used.
i) Sweep time = auto.
j) Perform a trace average of at least 100 traces.
k) Compute the power by integrating the spectrum over 1 MHz using the instrument's band power measurement function with band limits set equal to the emission frequency ($f_{emission}$ ± 0.5 MHz). If the spectrum analyzer does not have a band power function, then sum the amplitude levels (in power units) at 100 kHz intervals extending across the 1 MHz spectrum defined by ($f_{emission}$ ± 0.5 MHz). 558074 D01 DTS Meas Guidance v04 Page 23

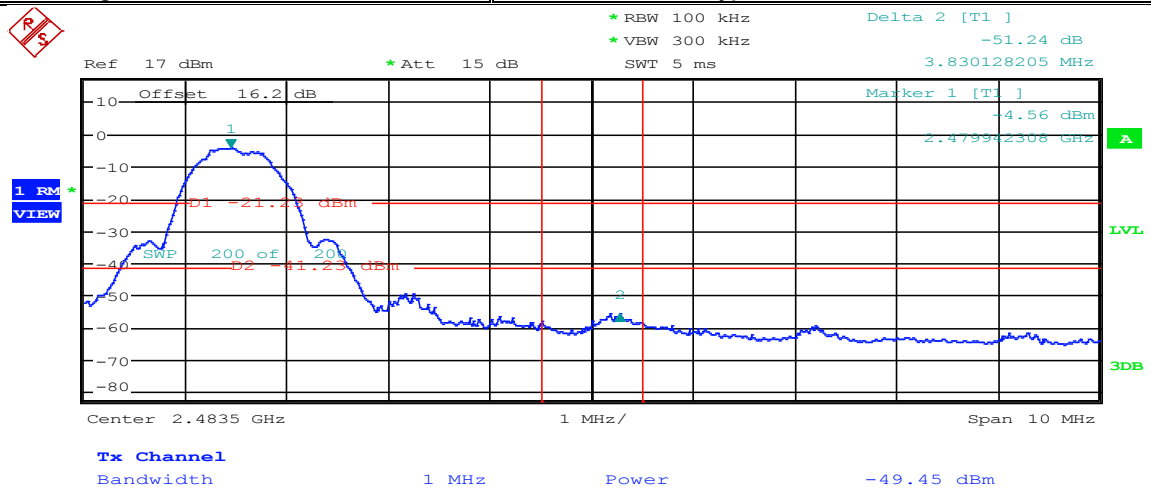
l) A correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100 % duty cycle. The correction factor is computed as follows:
1) If power averaging (RMS) mode was used in step f), then the applicable correction factor is 10 log(1/x), where x is the duty cycle.
2) If linear voltage averaging mode was used in step f), then the applicable correction factor is 20 log(1/x), where x is the duty cycle.
3) If a specific emission is demonstrated to be continuous (≥ 98 % duty cycle) rather than turning on and off with the transmit cycle, then no duty cycle correction is required for that emission.
NOTE: Reduction of the measured emission amplitude levels to account for operational duty factor is **not** permitted. Compliance is based on emission levels occurring during transmission, but is **not** based on an average across on- and off-times of the transmitter.

- **Appling duty cycle correction factor:**

10 * log(1 / 0.416) = 3.81 dBm

Plot #2

High channel 2480 MHz AVG	Modulation/Packet Type: BTLE



Date: 1.MAR.2018 07:45:01

8.4 Emission Bandwidth 6dB and 99% Occupied Bandwidth

8.4.1 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.

8.4.2 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.

8.4.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	1	BT LE fixed channel	3.67 VDC

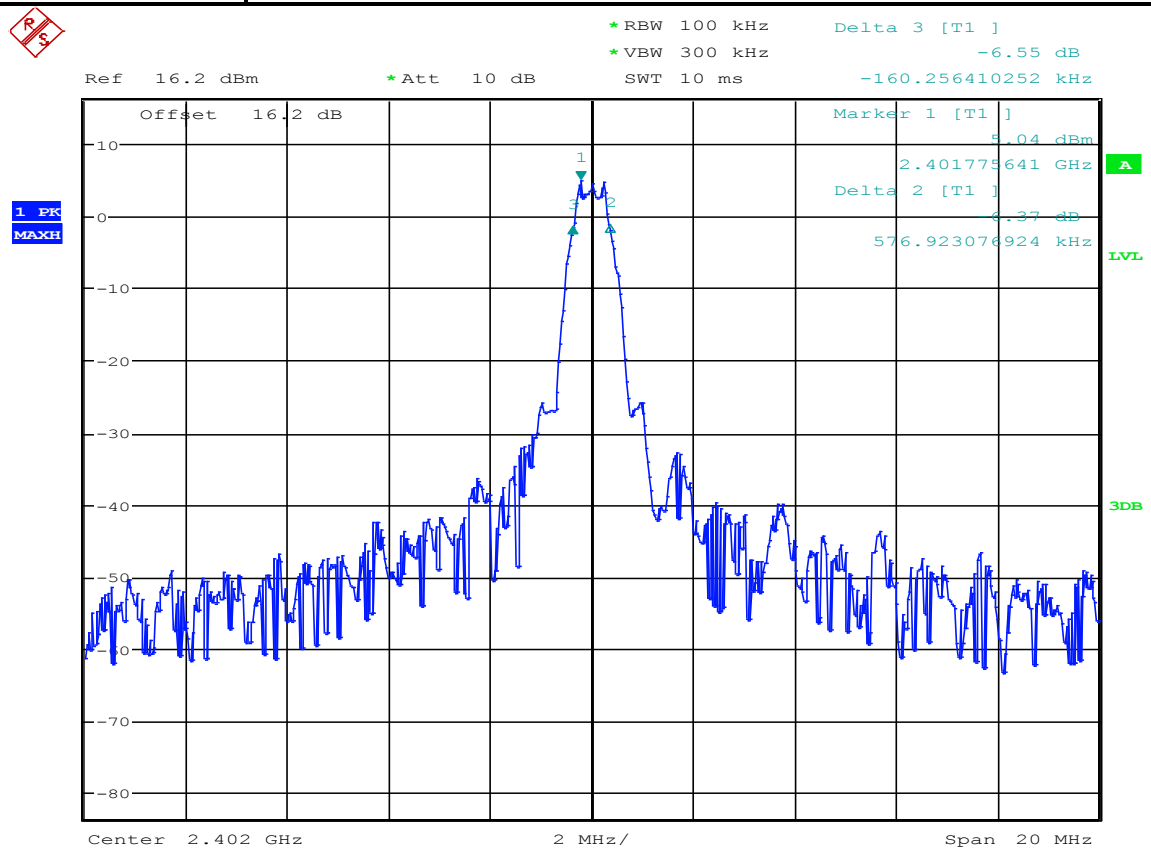
8.4.4 Measurement result:

Plot #	Frequency (MHz)	6dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
1	2402	0.737	> 0.5	Pass
2	2440	0.753	> 0.5	Pass
3	2480	0.727	> 0.5	Pass

Plot #	Frequency (MHz)	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
4	2402	1.06	> 0.5	Pass
5	2444	1.07	> 0.5	Pass
6	2480	1.08	> 0.5	Pass

8.4.5 Measurement Plots:

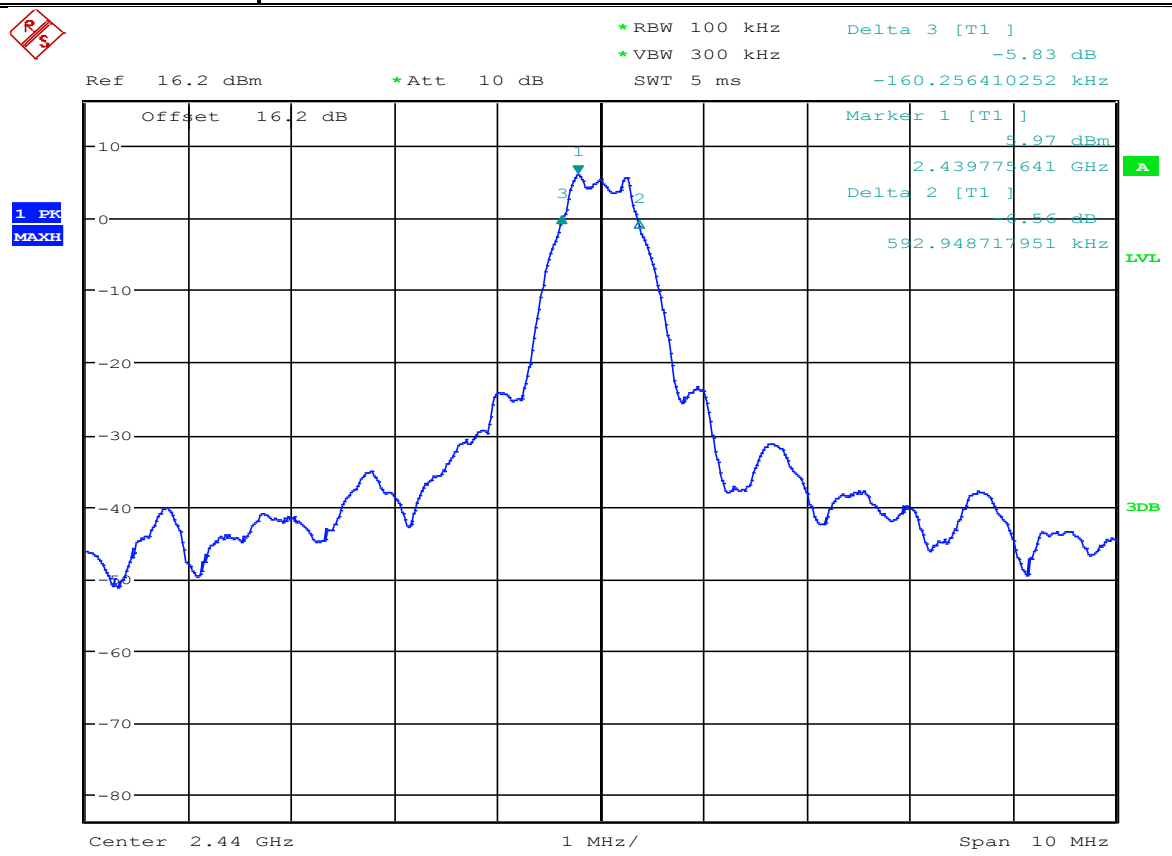
Plot #1	
2402 MHz	Mode: BTLE



Date: 1.MAR.2018 08:53:24

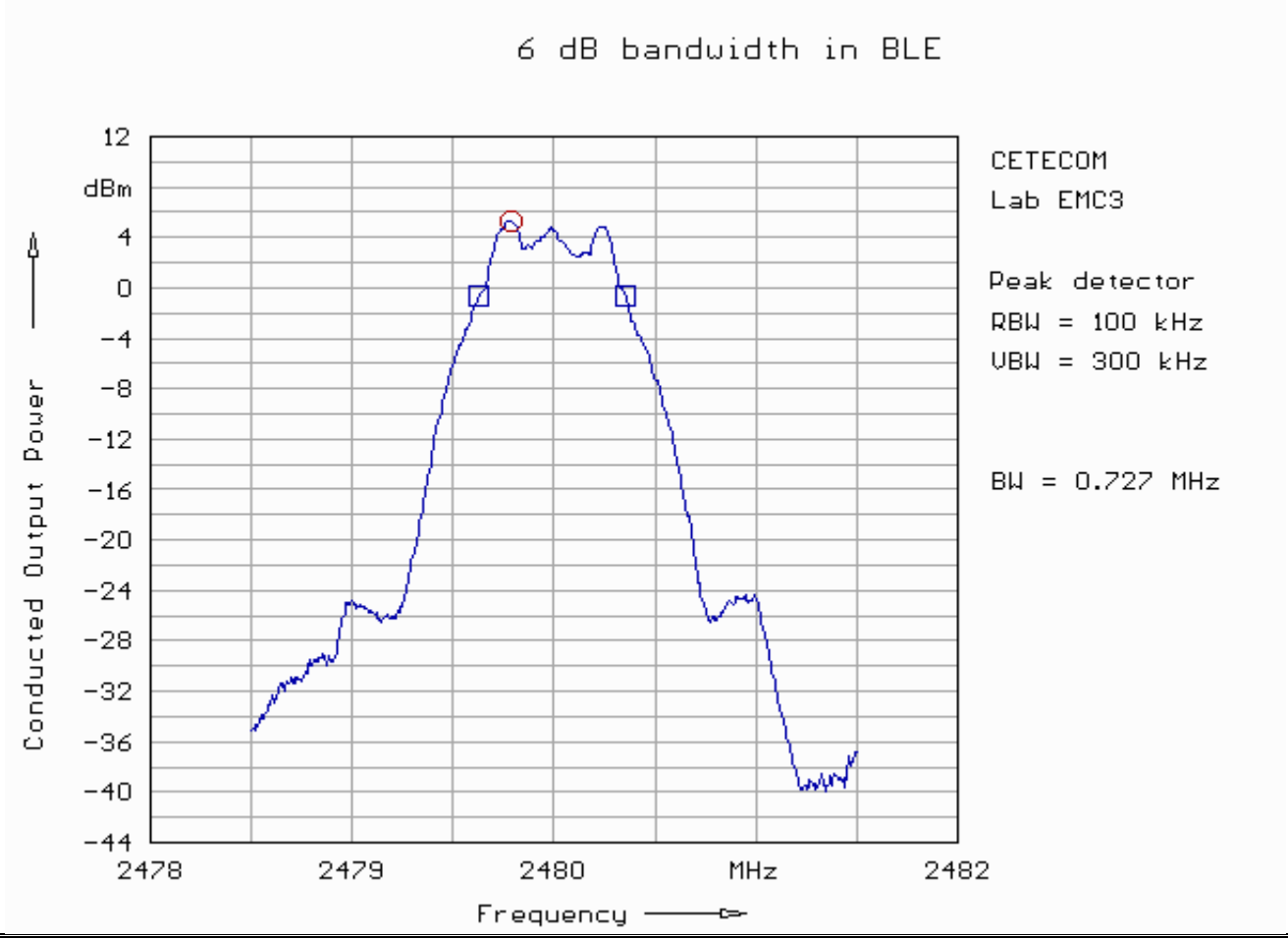
Plot #2

2440 MHz	Mode: BTLE

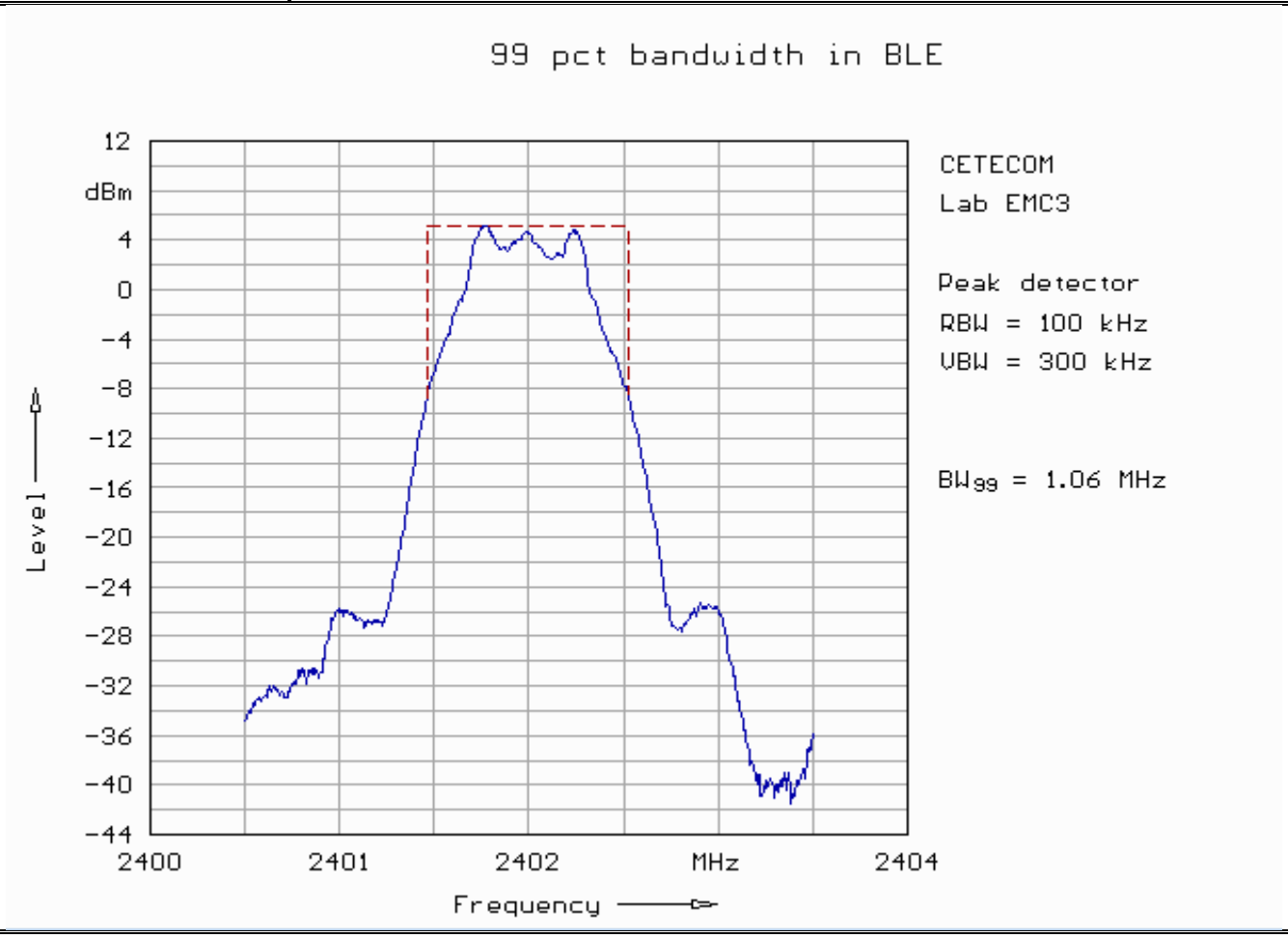


Date: 1.MAR.2018 08:38:12

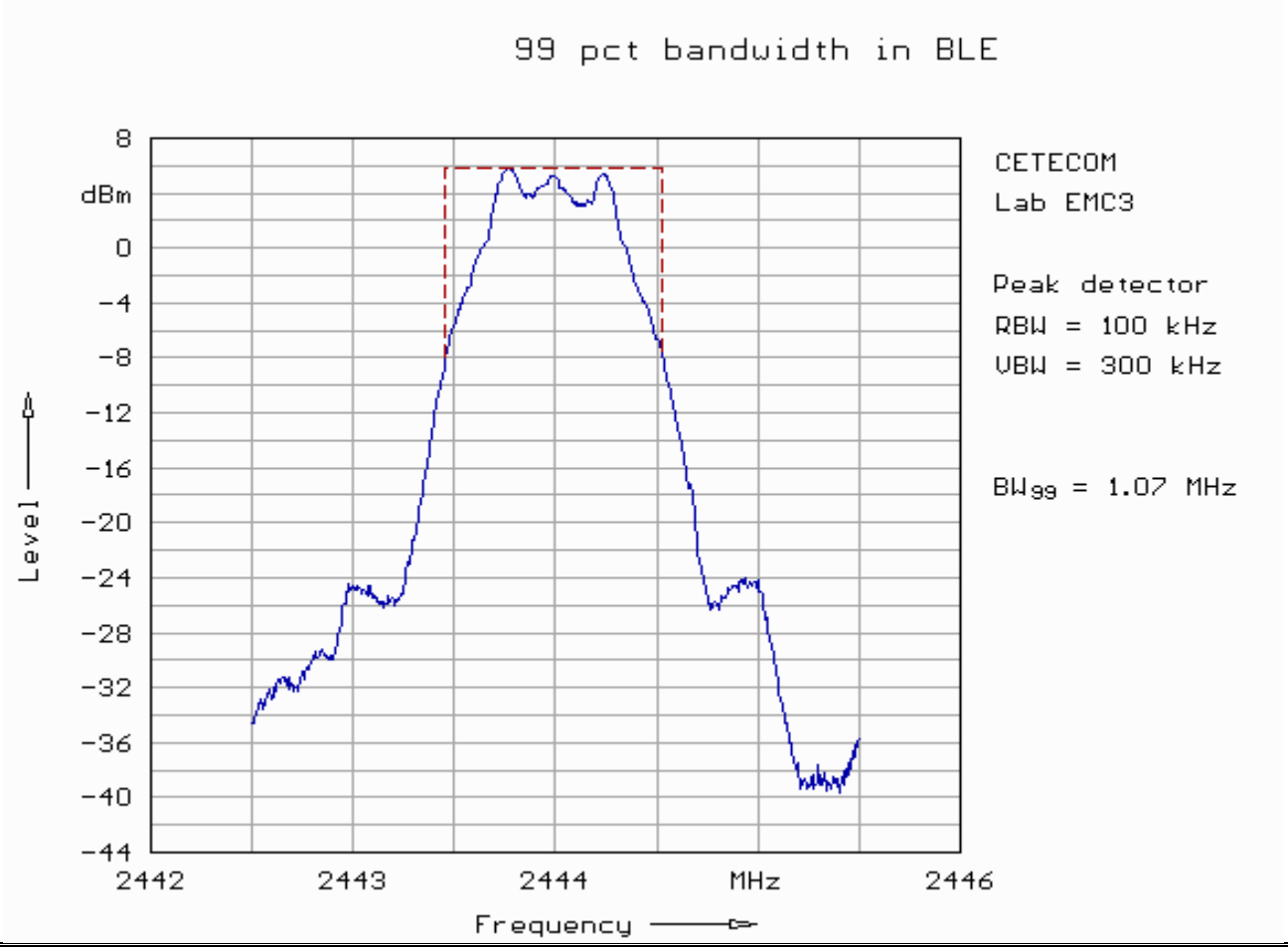
Plot #3	
2480 MHz	**Mode: BTLE**



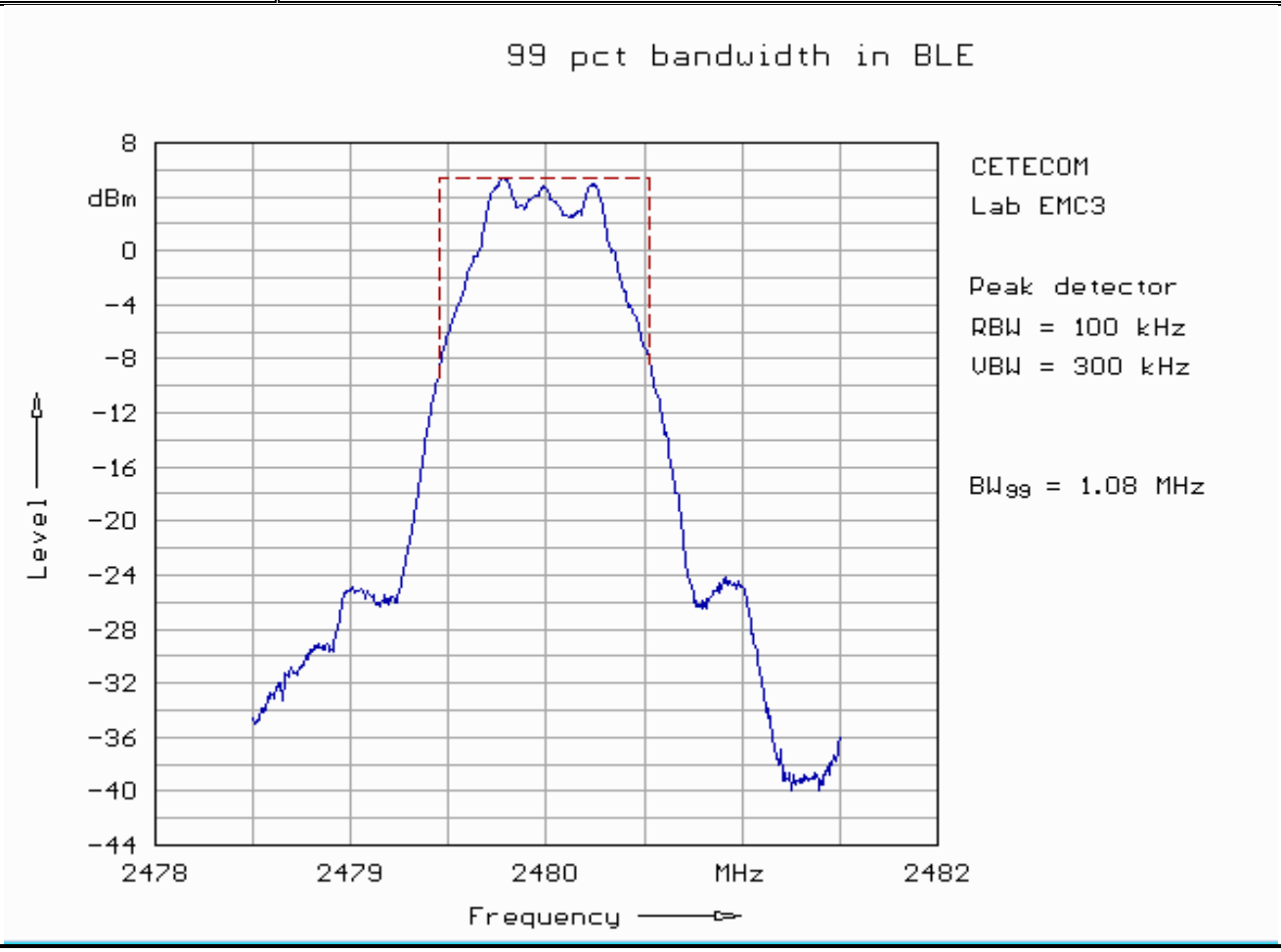
Plot #4	
2402 MHz	**Mode: BTLE**



Plot #5	
2444 MHz	**Mode: BTLE**



Plot #6	
2480 MHz	**Mode: BTLE**



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

- 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:

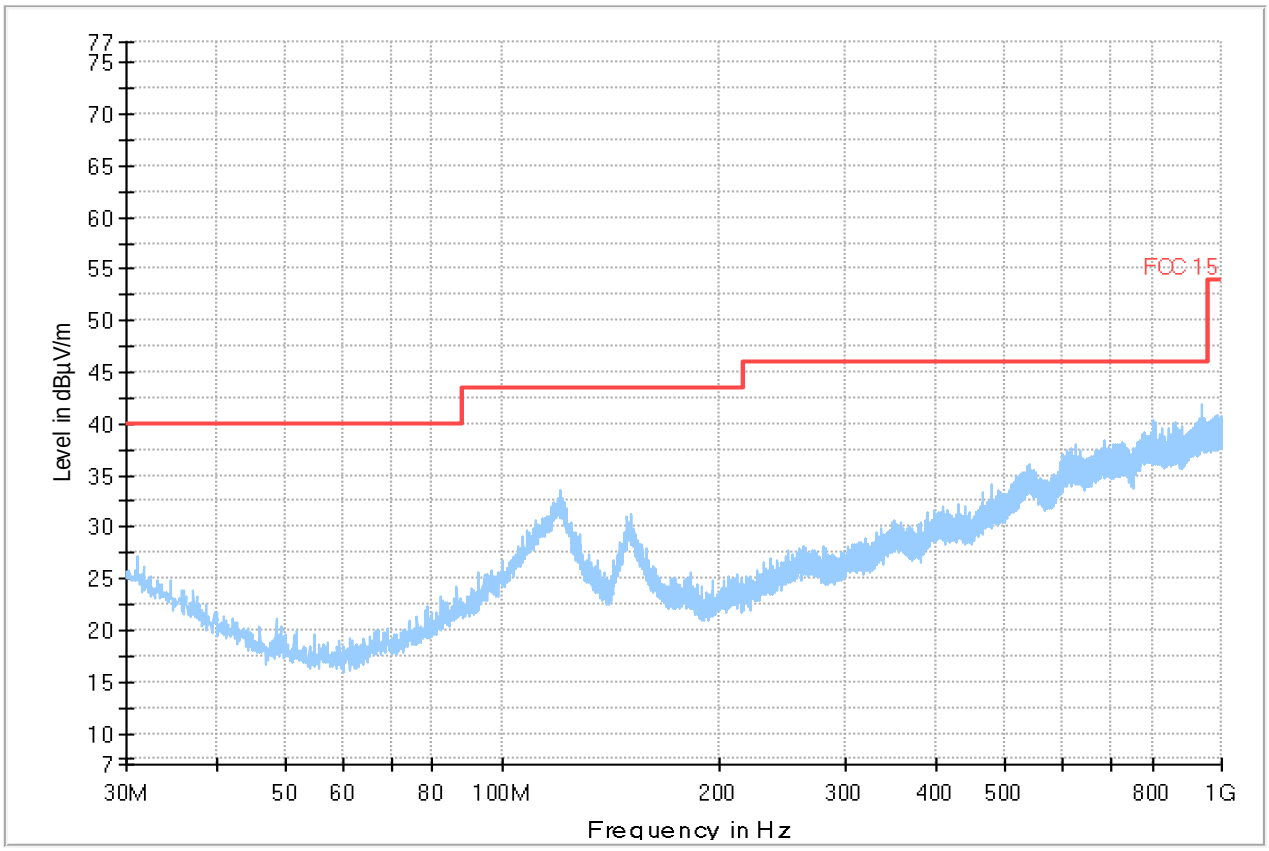
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	2	BLE	3.67 VDC

8.5.4 Measurement result:

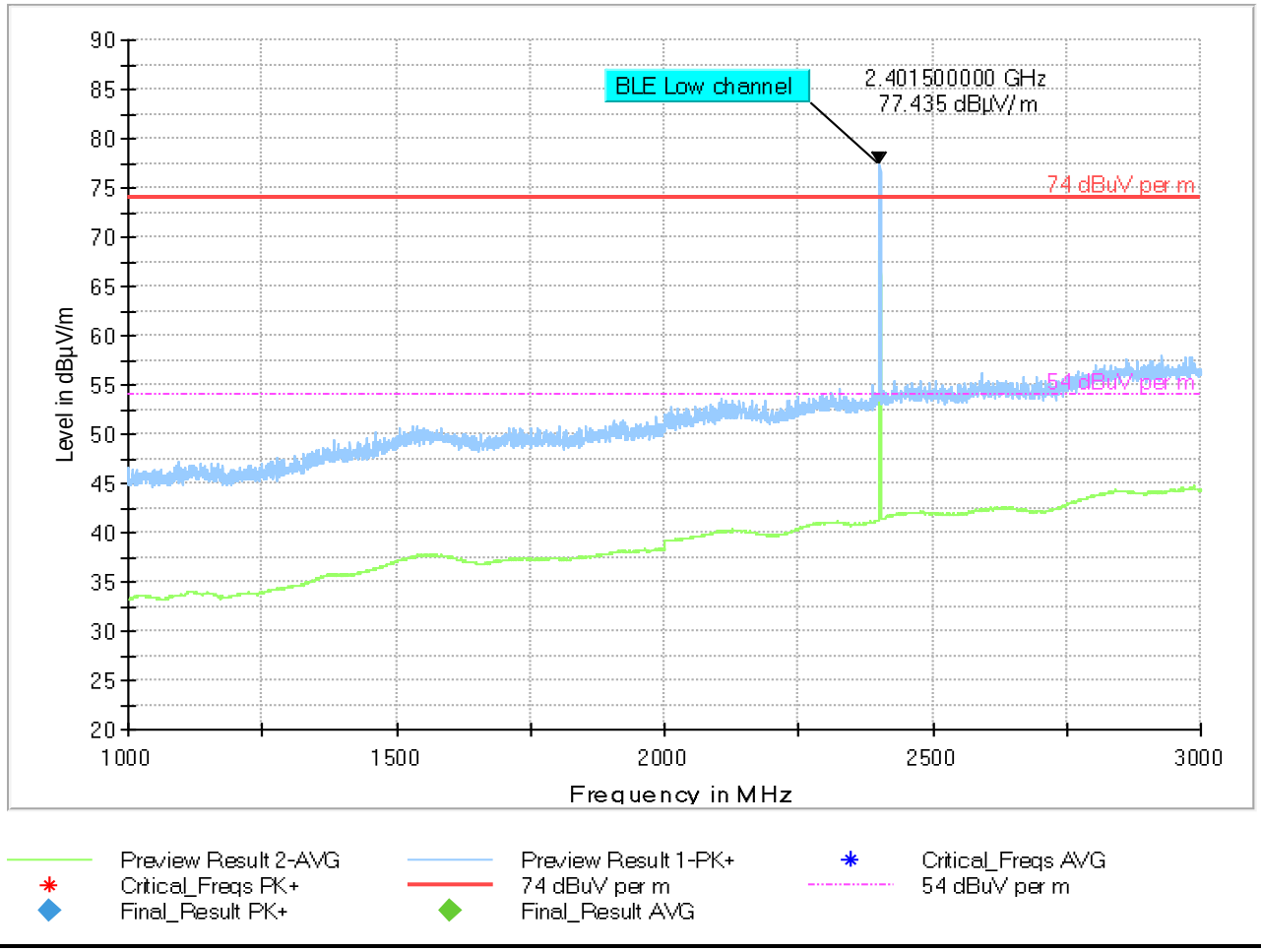
Plot #	Channel #	Scan Frequency	Highest emission in dB	Frequency of highest emission in MHz	Limit	Result
1 – 3	Low	30 MHz – 18 GHz	54.4	16812	See section 7.5.2	Pass
4 – 8	Mid	9 kHz – 40 GHz	57.12	17078	See section 7.5.2	Pass
9 – 11	High	30 MHz – 18 GHz	56.37	17358	See section 7.5.2	Pass

8.5.5 Measurement Plots:

Plot #1 Radiated Emissions: 30MHz – 1GHz	
Modulation: BT LE	**Channel: Low**



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

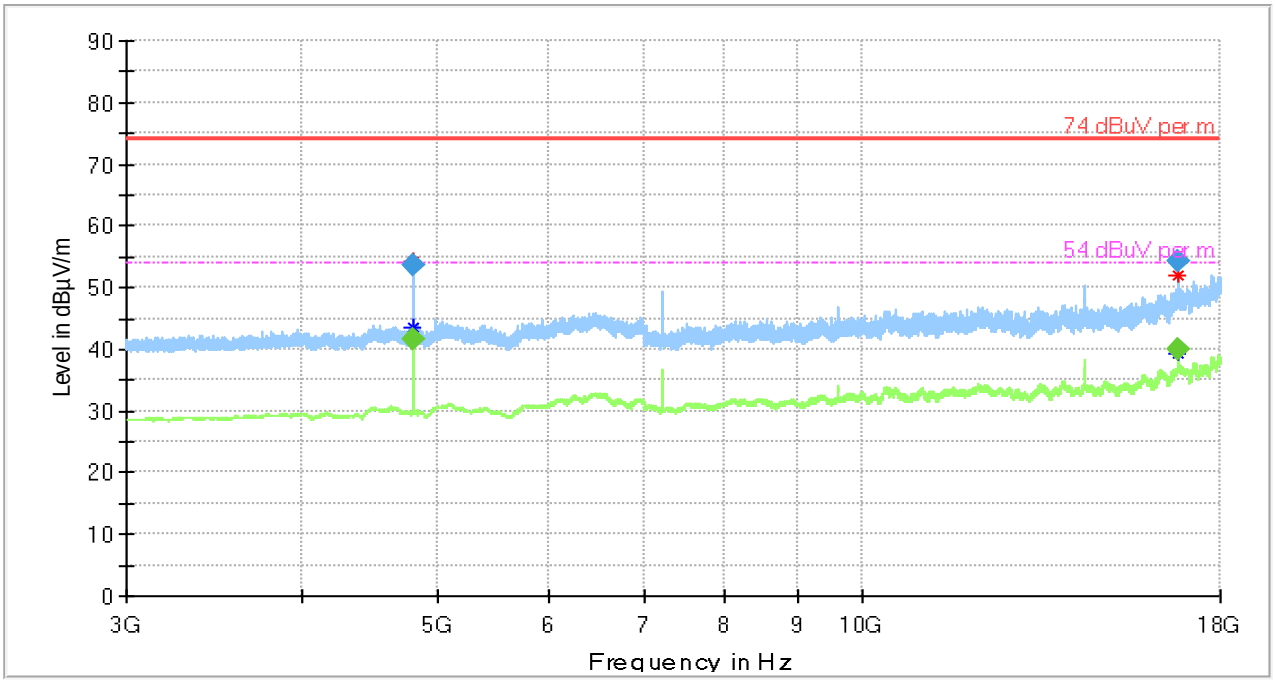


Plot # 3 Radiated Emissions: 3 – 18GHz

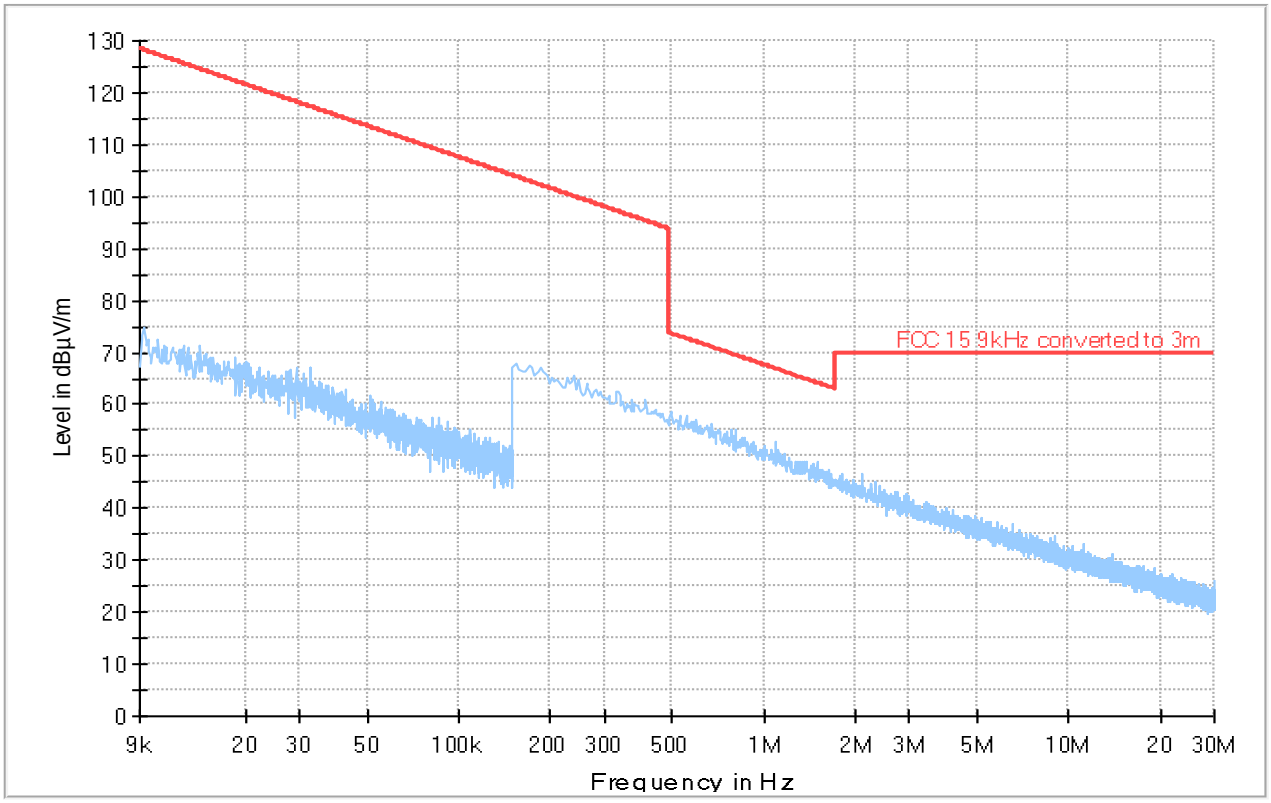
Modulation: BT LE | **Channel: Low**

Final_Result

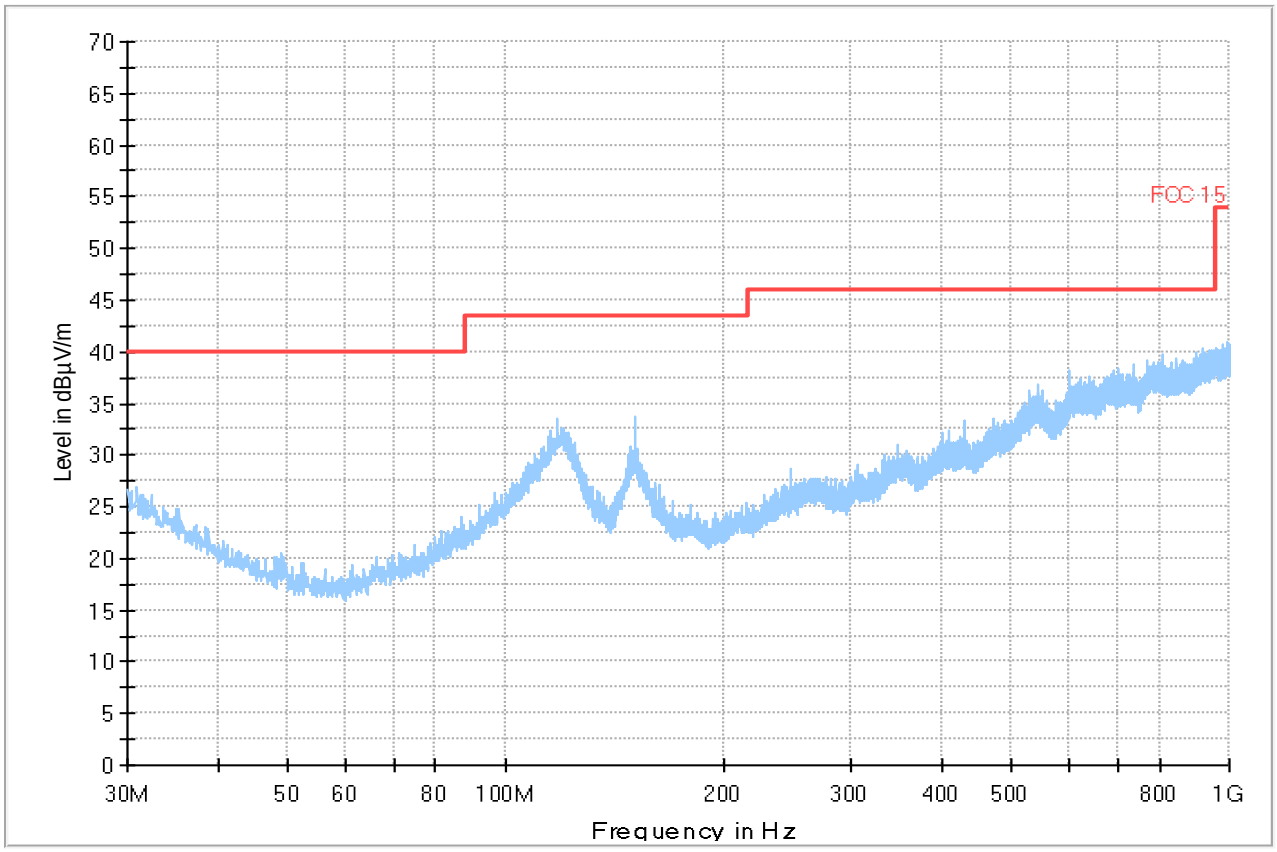
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4803.460000	53.62	---	74.00	20.38	100.0	1000.000	155.0	V	206.0	-5.1
4804.000000	---	41.64	54.00	12.36	100.0	1000.000	181.0	V	205.0	-5.1
16812.000000	---	40.02	54.00	13.98	100.0	1000.000	198.0	V	317.0	11.3
16812.100000	54.40	---	74.00	19.61	100.0	1000.000	140.0	V	314.0	11.3



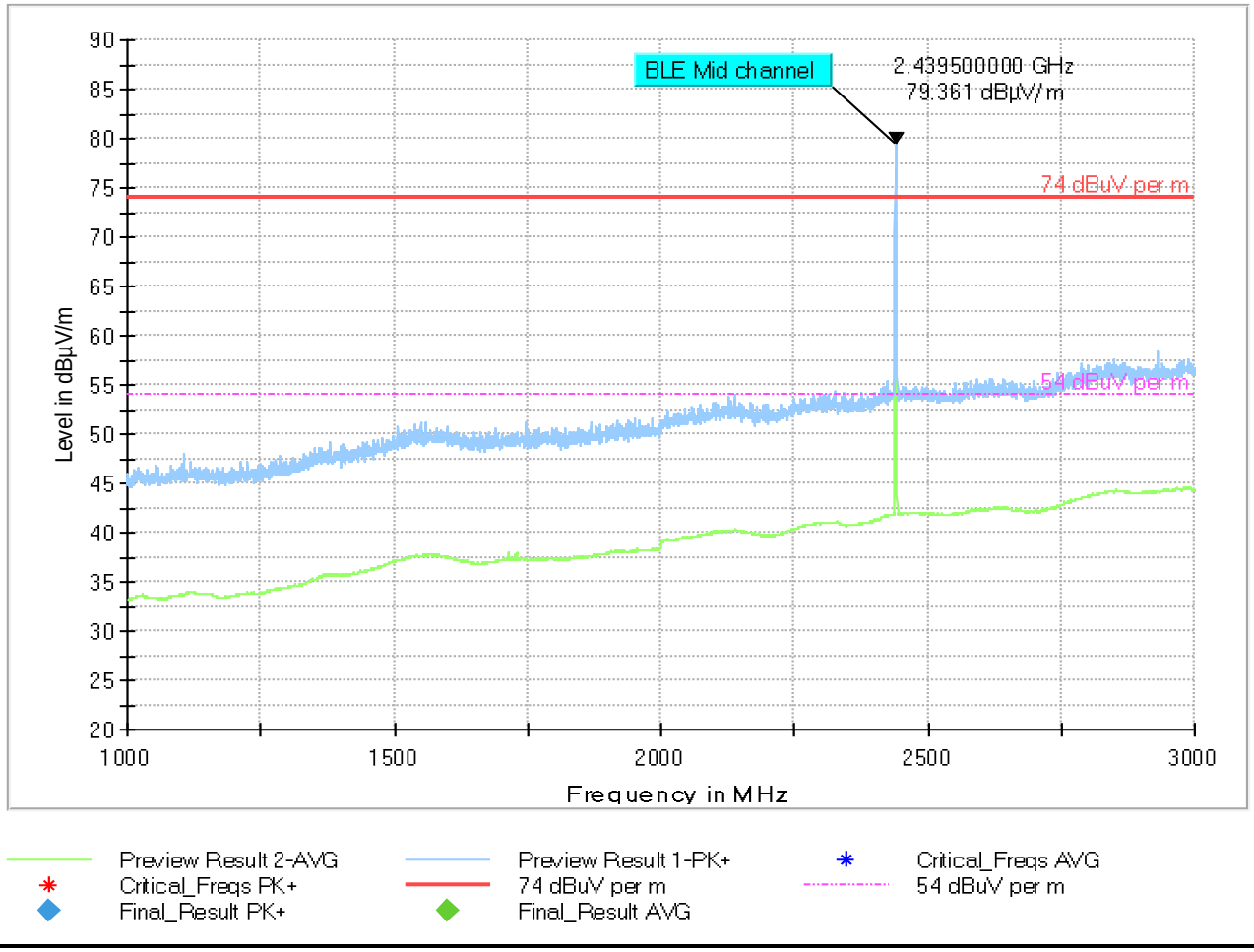
Plot # 4 Radiated Emissions: 9KHz – 30MHz	
Modulation: BT LE	**Channel: Mid**



Plot #5 Radiated Emissions: 30MHz – 1GHz	
Modulation: BT LE	**Channel: Mid**



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

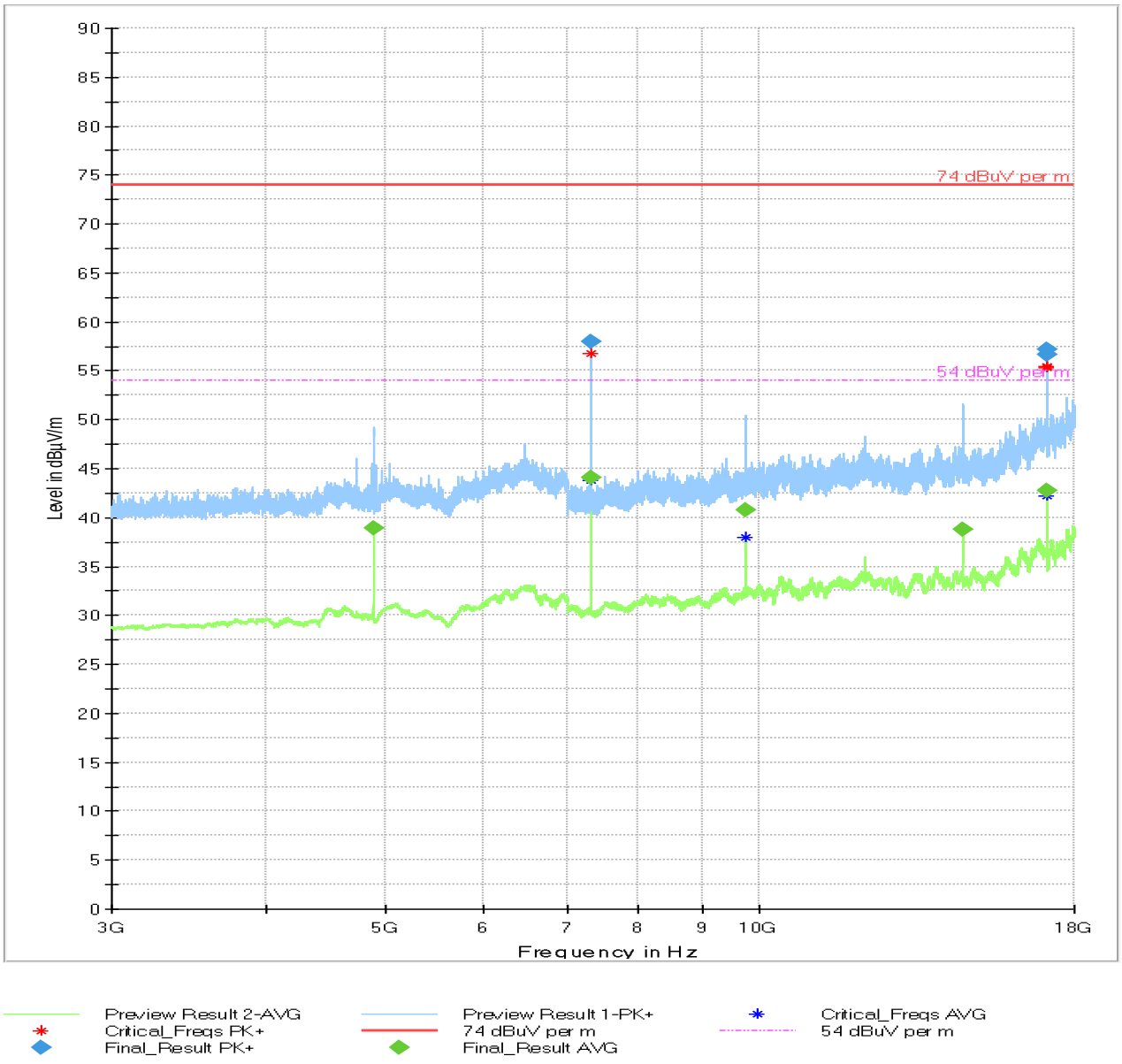


Plot #7 Radiated Emissions: 3 – 18GHz

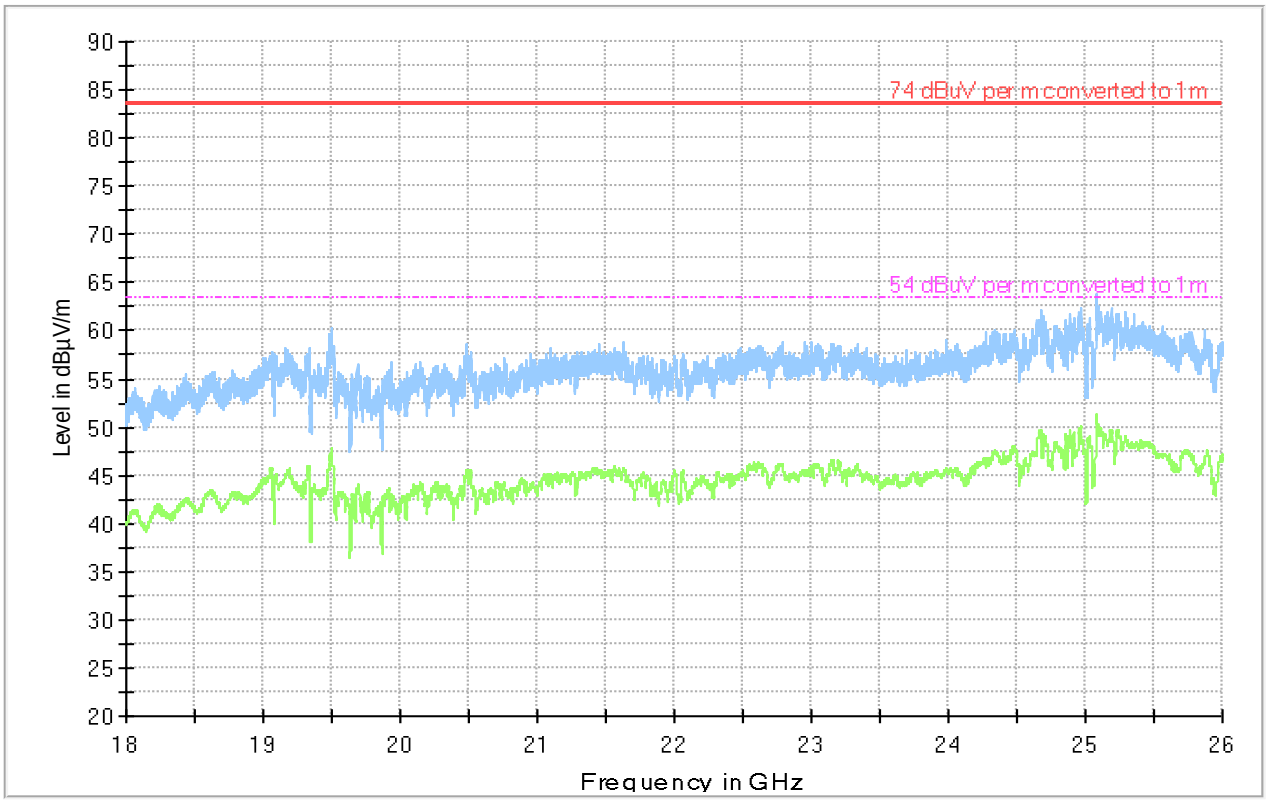
Modulation: BT LE | **Channel: Mid**

Final_Result

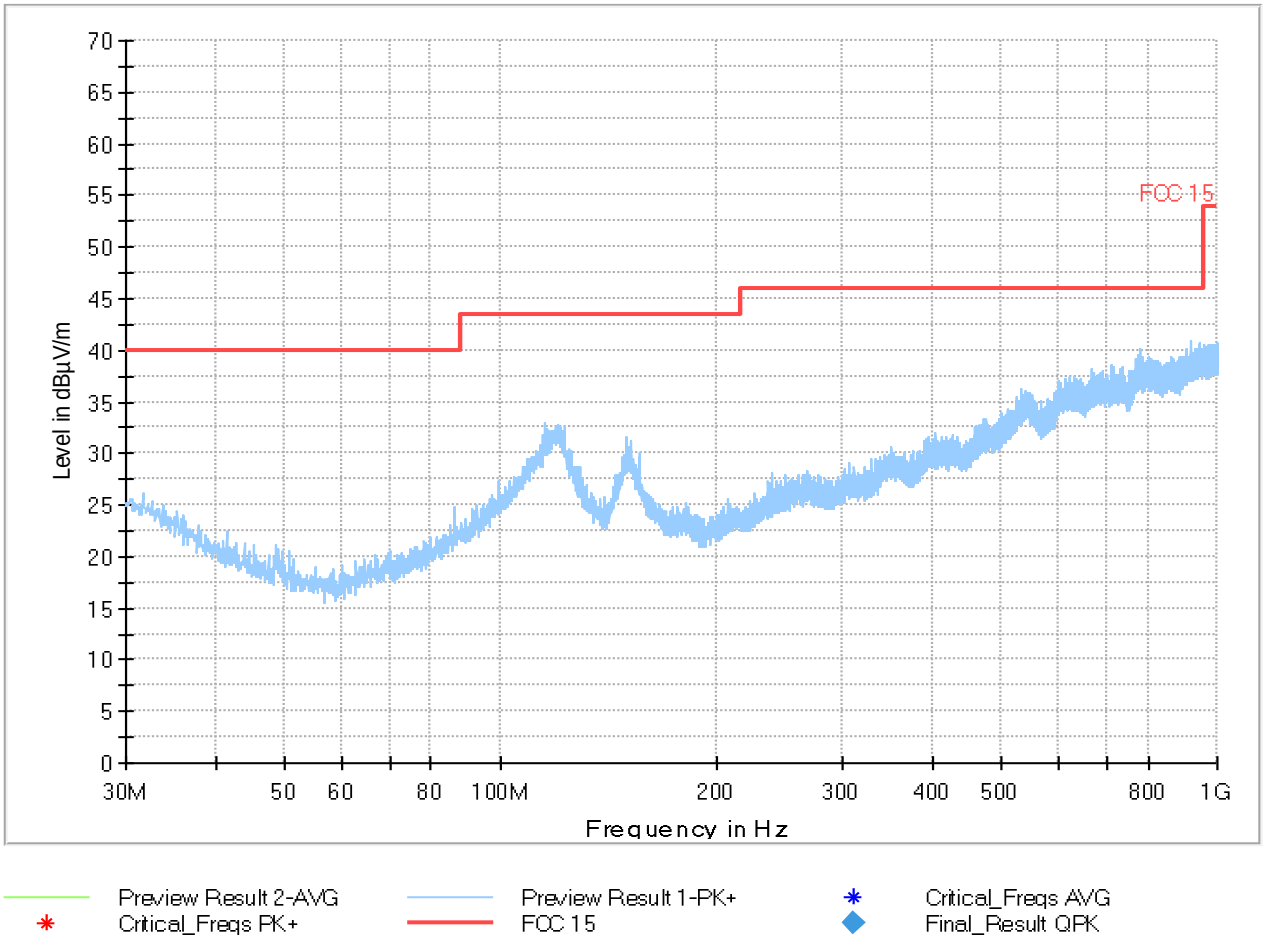
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4880.000000	---	38.86	54.00	15.14	100.0	1000.000	207.0	V	230.0	-5.3
7319.180000	58.00	---	74.00	16.00	100.0	1000.000	223.0	V	216.0	-0.6
7320.500000	---	44.11	54.00	9.89	100.0	1000.000	216.0	V	212.0	-0.6
9759.000000	---	40.74	54.00	13.26	100.0	1000.000	206.0	V	249.0	2.3
14638.500000	---	38.73	54.00	15.27	100.0	1000.000	153.0	V	209.0	4.9
17078.000000	---	42.73	54.00	11.27	100.0	1000.000	155.0	V	323.0	10.9
17078.100000	57.12	---	74.00	16.88	100.0	1000.000	155.0	V	322.0	10.9
17081.560000	56.69	---	74.00	17.31	100.0	1000.000	140.0	V	322.0	10.9



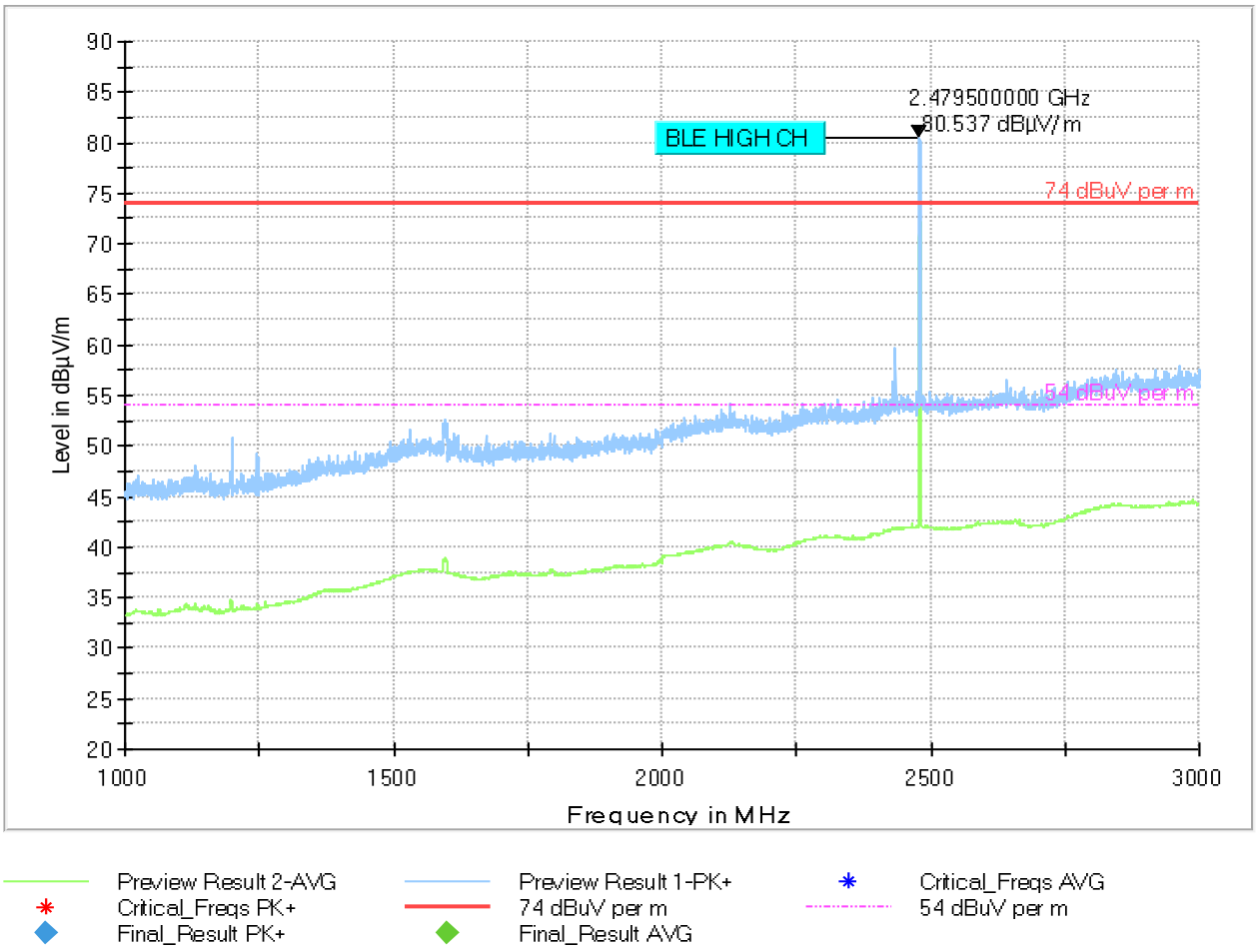
Plot #8 Radiated Emissions: 18 – 40GHz	
Modulation: BT LE	**Channel: Mid**



Plot #9 Radiated Emissions: 30MHz – 1GHz	
Modulation: BT LE	**Channel: High**



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

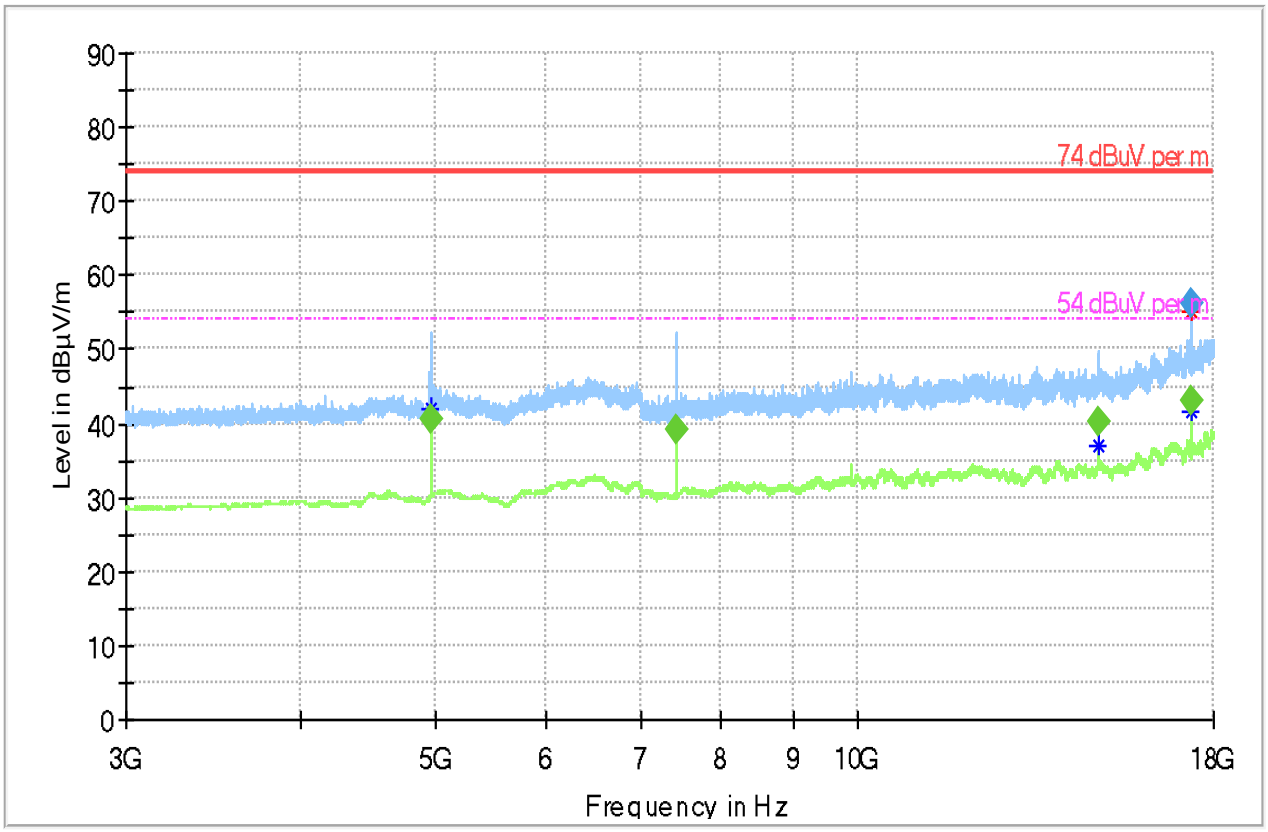


Plot #11 Radiated Emissions: 3 – 18GHz

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)	Corr. (dB)
4960.000000	---	40.55	54.00	13.45	100.0	1000.000	225.0	V	204.0	-4.8
7440.500000	---	39.16	54.00	14.84	100.0	1000.000	140.0	H	233.0	-0.2
14878.500000	---	40.17	54.00	13.83	100.0	1000.000	153.0	V	107.0	6.0
17358.000000	---	42.98	54.00	11.02	100.0	1000.000	196.0	V	317.0	12.2
17358.100000	56.37	---	74.00	17.63	100.0	1000.000	153.0	H	325.0	12.2



9 Test setup photos

Setup photos are included in supporting file name: "EMC_COMPO_010_18001_FCC_ISED_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
ACTIVE LOOP	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
SIGNAL ANALYZER	R&S	FSU26	200256	2 YEARS	07/04/2017
SIGNAL ANALYZER	R&S	FSU26	200302	2 YEARS	07/05/2017
TEST RECEIVER	R&S	ESU.EMI	100256	3 YEARS	01/31/2018
COMPACT DIGITAL BAROMETER	CONTROL COMPANY	35519-055	91119547	1 YEARS	06/05/2017
THRMOMETER HUMIDIY	DICKSON	TM320	16253639	1 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
03/09/2018	EMC_COMPO_010_18001_15.247_ISED_BT_DTS	Initial Version	Issa Ghanma