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FCC CFR47 PART 15 SUBPART C & IC RSS-247

TEST REPORT

For

SOMFY SYSTEMS INC.

Sonesse 40 Zigbee Actuator
Model Number: 5141343 & 5141344

FCC ID: DWNSON40ZBAC
IC: 12049A-SON40ZBAC

Report Number: 0048-190820-03

Prepared for

SOMFY SYSTEMS INC.
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USA

Prepared by
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Date: 10/18/2019

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1. TEST RESULT CERTIFICATION

COMPANY NAME: **SOMFY SYSTEMS INC.**

EUT DESCRIPTION: **Sonesse 40 Zigbee Actuator**

MODEL: 5141343 & 5141344

DATE TESTED: 08/20/2019 to 10/18/2019

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
FCC Part 15.247 & IC RSS-247:Issue 2& RSS-Gen Issue 5	NO NON-COMPLIANCE NOTED

Test Summary

Testing Items Per FCC Part 2/ Part 15.247 & IC RSS-247 /RSS-Gen Standard Requirements for DTS Modulation	Section	Limit	Result
DTS Bandwidth	15.247(a) (2) RSS-247, 5.2(a)	>=500KHz	Complies
Peak Power Limit	15.247(b) (3) RSS-247, 5.4(d)	Conducted: 1W (30dBm) e.i.r.p. 4W(36dBm)	Complies
Peak Power Spectral Density	15.247(e) RSS-247, 5.2(b)	8dBm/3KHz	Complies
Emissions (Conducted)	15.247(d) RSS-247, 5.5	-20dB/-30dB	Complies
Spurious (Radiated)	15.205(a) RSS-247, 5.5	15.209/RSS-Gen	Complies
RF Safety*	1.1310/RSS-102	1.0/5.0 mW/cm^2	Complies

NOTE: * For mobile or fixed location transmitters, the minimum separation distance is 20 cm, even if calculations indicate that the MPE distance would be less.

Advanced Compliance Laboratory, Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note : This document reports conditions under which testing was conducted and results of tests performed. This document may not be altered or revised in any way unless done so by Advanced Compliance Laboratory, Inc. (ACL) and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by ACL, Advanced Compliance Laboratory,

Inc. will constitute fraud and shall nullify the document.

Approved & Released For ACL By:

Wei Li

Manager
Advanced Compliance Laboratory, Inc.

Tested By:

Edward Lee

EMC Engineer

2. EUT DESCRIPTION

The EUT for this certification is a low power transmitter, using digital modulation & operating in the 2400 MHz band.

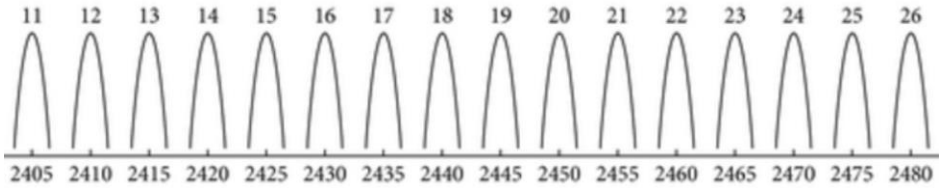
The transmitter has a maximum peak conducted output power as follows:

ZIGBEE Mode:

Frequency /Range (MHz)	Rated Power Selection	Tested Peak Power (dBm/W)*	Max. EIRP (W)
2405-2480	19dBm/0.0794W	18.47/ 0.07031	0.112

Frequency band: 2.400 to 2.4835 GHz
Channel spacing: 5 MHz
16 channels are available
Modulation: OQPSK
Coding: DSSS

PCB antenna gain: +2dBi



Bluetooth Low Energy (BLE) Mode:

Frequency /Range (MHz)	Rated Power Selection	Tested Peak Power (dBm/W)*	Max. EIRP (W)
2402-2480	10dBm/0.010W	9.87/ 0.0097	0.0154

Bluth Tooth Mode:

Frequency band: 2.400 to 2.4835 GHz
Channel spacing: 2 MHz
40 channels are available
Modulation: GFSK

PCB antenna gain: +2dBi

Channel List:

Channel number	Standard frequency & maximum tolerance
37 (Advertising chanel)	2402 MHz ±150 kHz
0	2404 MHz ±150 kHz
1	2406 MHz ±150 kHz
2	2408 MHz ±150 kHz
3	2410 MHz ±150 kHz
4	2412 MHz ±150 kHz
5	2414 MHz ±150 kHz
6	2416 MHz ±150 kHz
7	2418 MHz ±150 kHz
8	2420 MHz ±150 kHz
9	2422 MHz ±150 kHz
10	2424 MHz ±150 kHz
38 (Advertising chanel)	2426 MHz ±150 kHz
11	2428 MHz ±150 kHz
12	2430 MHz ±150 kHz
13	2432 MHz ±150 kHz
14	2434 MHz ±150 kHz
15	2436 MHz ±150 kHz
16	2438 MHz ±150 kHz
17	2440 MHz ±150 kHz

Channel number	Standard frequency & maximum tolerance
18	2442 MHz ±150 kHz
19	2444 MHz ±150 kHz
20	2446 MHz ±150 kHz
21	2448 MHz ±150 kHz
22	2450 MHz ±150 kHz
23	2452 MHz ±150 kHz
24	2454 MHz ±150 kHz
25	2456 MHz ±150 kHz
26	2458 MHz ±150 kHz
27	2460 MHz ±150 kHz
28	2462 MHz ±150 kHz
29	2464 MHz ±150 kHz
30	2466 MHz ±150 kHz
31	2468 MHz ±150 kHz
32	2470 MHz ±150 kHz
33	2472 MHz ±150 kHz
34	2474 MHz ±150 kHz
35	2476 MHz ±150 kHz
36	2478 MHz ±150 kHz
39 (Advertising chanel)	2480 MHz ±150 kHz

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.4-2014/C63.10-2013, FCC CFR 47 Part 2 & 15 & IC RSS-247:Issue 2& RSS-Gen Issue 5. Test procedure described in FCC "KDB 558074 D01 DTS Measurement Guidance " is used in this report.

4. FACILITIES AND ACCREDITATION

The test sites / measurement facilities for Advanced Compliance Laboratory, Inc.(ACL) to collect data are located at 210 Cougar Court, Hillsborough, New Jersey, USA. The sites are constructed in conformance with the requirements of ANSI C63.4, ANSI C63.7 and CISPR Publication 22. All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods".

This site is accepted by FCC to perform measurements under Part 15 or 18 (MRA#US5347) and also designated by IC as " site IC 3130". ACL is recognized by ISED as a wirless testing laboratory (CAB ID: US0100) . The NVLAP Lab code for accreditation of FCC EMC Test Method is: 200101-0. is accredited by NVLAP, Laboratory Code 200101-0. The full accreditation can be viewed at http://www.ac-lab.com.

NVLAP Lab Code: 200101-0

No part of this report may be used to claim or imply product endorsement by NVLAP or any agency of the US Government.

5. CALIBRATION AND UNCERTAINTY

5.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

5.2. MEASUREMENT UNCERTAINTY

The estimated uncertainty of the test result is given as following. The method of uncertainty calculation is provided in Advanced Compliance Lab. Doc. No. 0048-01-01.

	Prob. Dist.	Uncertainty(dB)	Uncertainty(dB)	Uncertainty(dB)
		30-1000MHz	1-6.5GHz	Conducted
Combined Std. Uncertainty u_c	norm.	±2.36	±2.99	±1.83

5.3. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Manufacturer	Model	Serial No.	Description	Last Cal mm/dd/yy	Cal Due Mm/dd/yy
Agilent	E4440A	US40420700	3Hz-26.5GHz Spec. Analyzer	17/06/18	17/06/20
R &S	ESPI	100018	9KHz-7GHz EMI Receiver	15/01/18	15/01/20
HP	HP8546A	3448A00290	9kHz to 6.5GHz EMI Receiver	25/09/18	25/09/20
EMCO	3104C	9307-4396	20-300MHz Biconical Antenna	12/11/17	12/11/19
EMCO	3146	9008-2860	200-1000MHz Log-Periodic Antenna	13/11/17	13/11/19
Electro-Meterics	ALR-25M/30	289	10KHz-30MHz Active Loop Antenna	28/05/18	28/05/20
EMCO	3115	4945	Double Ridge Guide Horn Antenna	28/11/17	28/11/19
R&S	SMH	8942280/010	Signal Generator	15/01/18	15/01/20
RES-NET	RFA500NFF30	0108	30dB in-line Power Attenuator	15/01/18	15/01/20

All Test Equipment Used is Calibrated, Traceable to NIST Standards.

6. SETUP OF EQUIPMENT UNDER TEST

SUPPORT EQUIPMENT

None.

TEST SETUP

Testing Frequency/Channel/Port Selection: **Zigbee Mode**

- Selected Channel Frequency = 2405MHz, 2440 MHz, 2480MHz
- For intentional radiator measurements, 2405/2440/2480 MHz transmitter was configured to transmit continuously. The EUT was powered by 120Vac

Testing Frequency/Channel/Port Selection: **BLE Mode**

- Selected Channel Frequency = 2402MHz, 2442 MHz, 2480MHz
- For intentional radiator measurements, 2402/2442/2480 MHz transmitter was configured to transmit continuously. The EUT was powered by 120Vac

Engineering Justification:
Difference between models:
5141343 & 5141344 are electronically identical. Model name difference is for marketing purpose only.

7. APPLICABLE LIMITS AND TEST RESULTS

7.1 6dB &99% BANDWIDTH

LIMIT

§15.247 (a) (2) & RSS-247 Sec.5.1(1): Min. 6dB DTS bandwidth should be no less than 500KHz.

TEST PROCEDURE *per FCC KDB 558074D01v05r02*

Measurement Procedure for Emission Bandwidth (DTS Bandwidth)	Applicable to this EUT
8.2 DTS BW Measurement Procedure per Subclause 11.8 of ANSI C63.10	☒

RESULTS

No non-compliance noted.

Zigbee Mode:

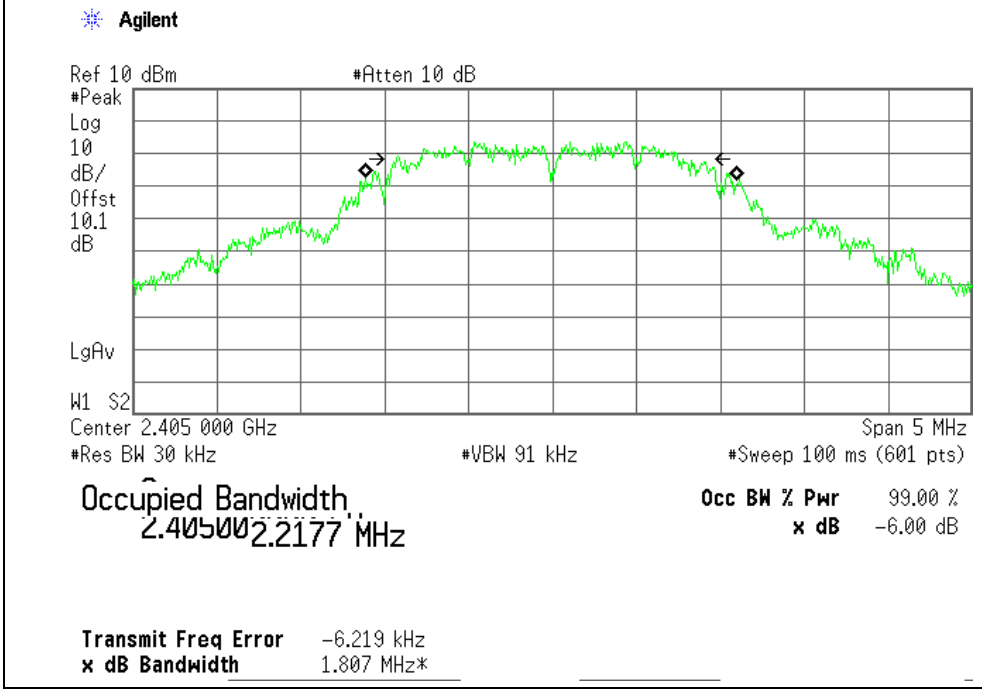
Channel	Frequency (MHz)	6dB Bandwidth (KHz)	99% Bandwidth (KHz)
L	2405	1807	2217.7
M	2445	1842	2220.7
H	2480	1821	2237.6

BLE Mode:

Channel	Frequency (MHz)	6dB Bandwidth (KHz)	99% Bandwidth (KHz)
L	2402	536.8	1071.1
M	2442	536.5	1070.3
H	2480	537.2	1072.8

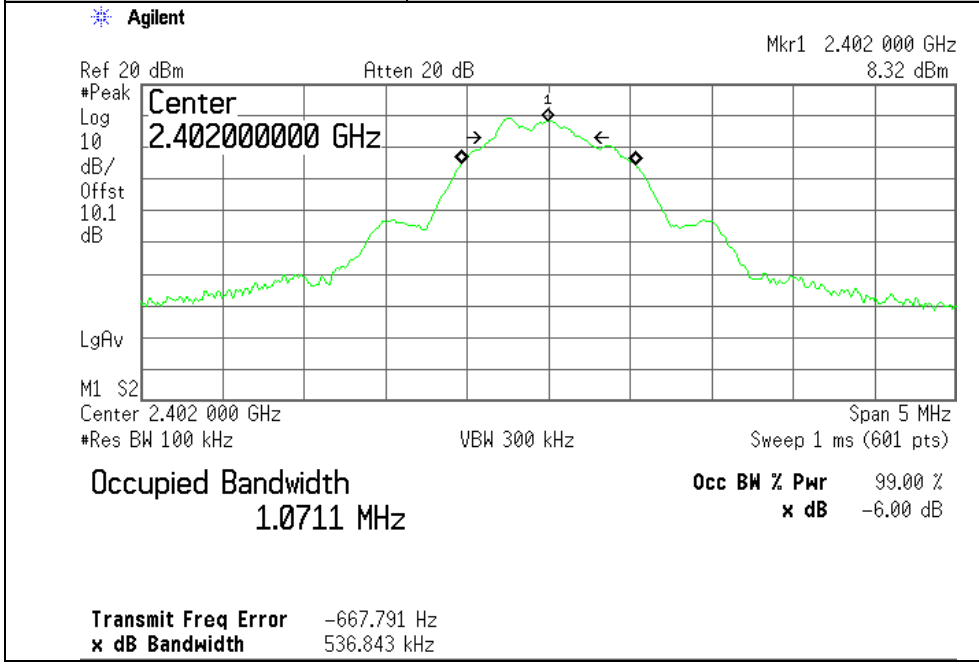
6dB & 99% BANDWIDTH_Zigbee Mode

Plot Name:	6dB & 99% Bandwidth Low CH



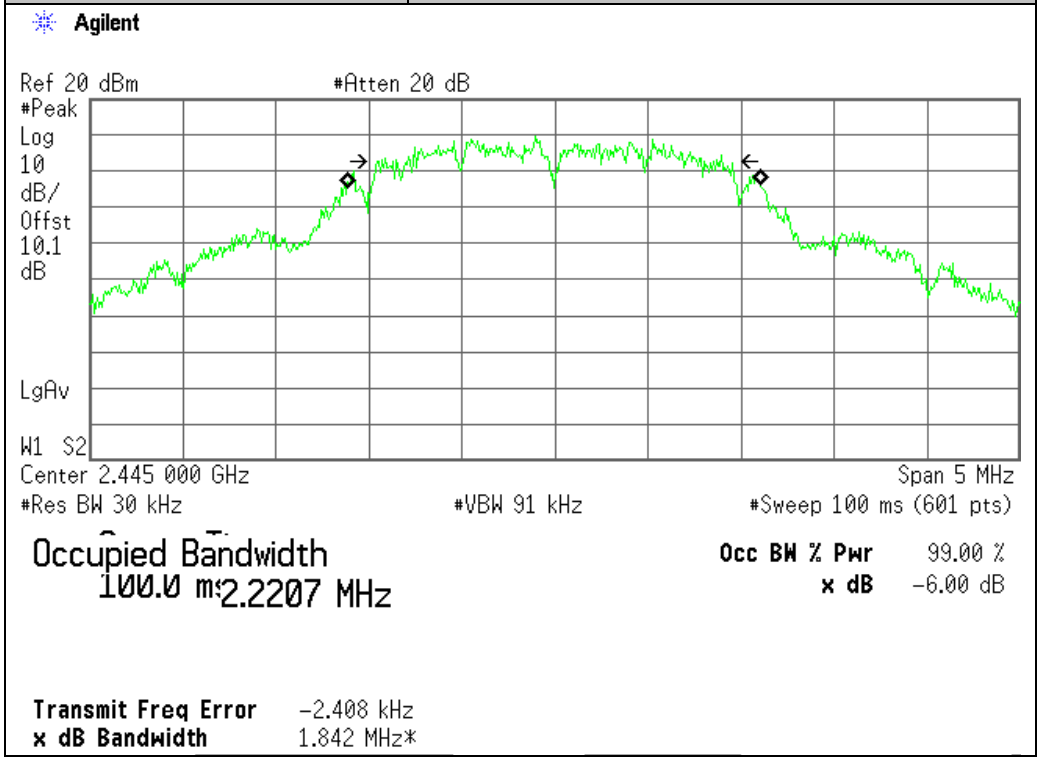
6dB & 99% BANDWIDTH _ Bluetooth Low Energy (BLE) Mode

Plot Name:	6dB & 99% Bandwidth Low CH



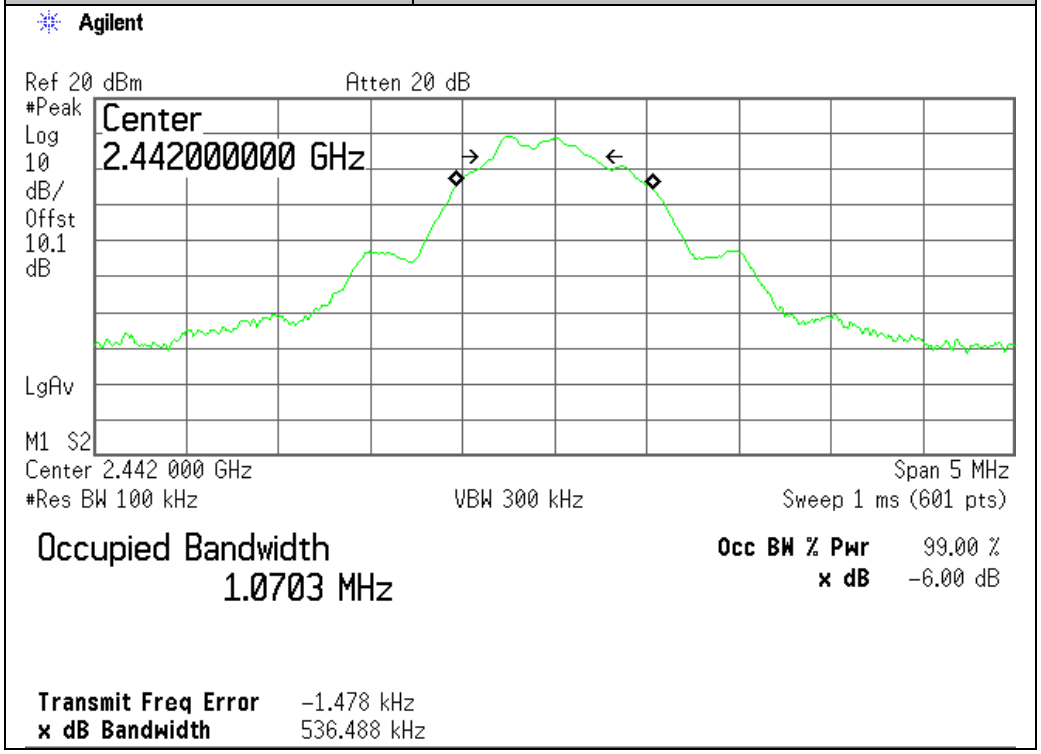
6dB & 99% BANDWIDTH_Zigbee Mode

Plot Name:	6dB & 99% Bandwidth Mid CH



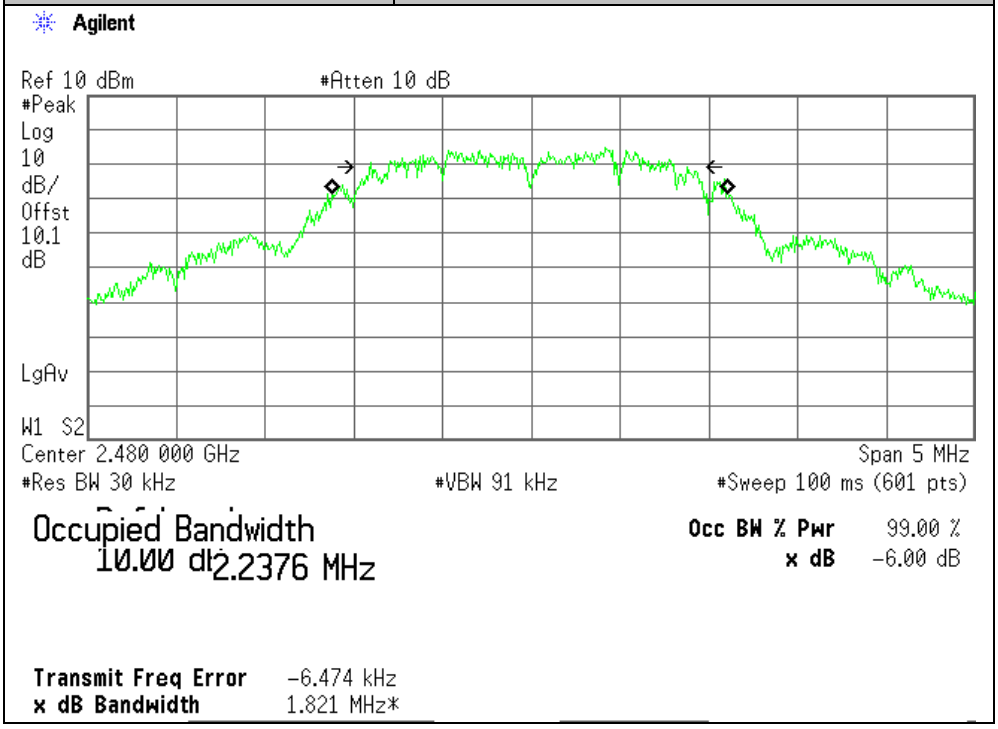
6dB & 99% BANDWIDTH _BLE Mode

Plot Name:	6dB & 99% Bandwidth Mid CH



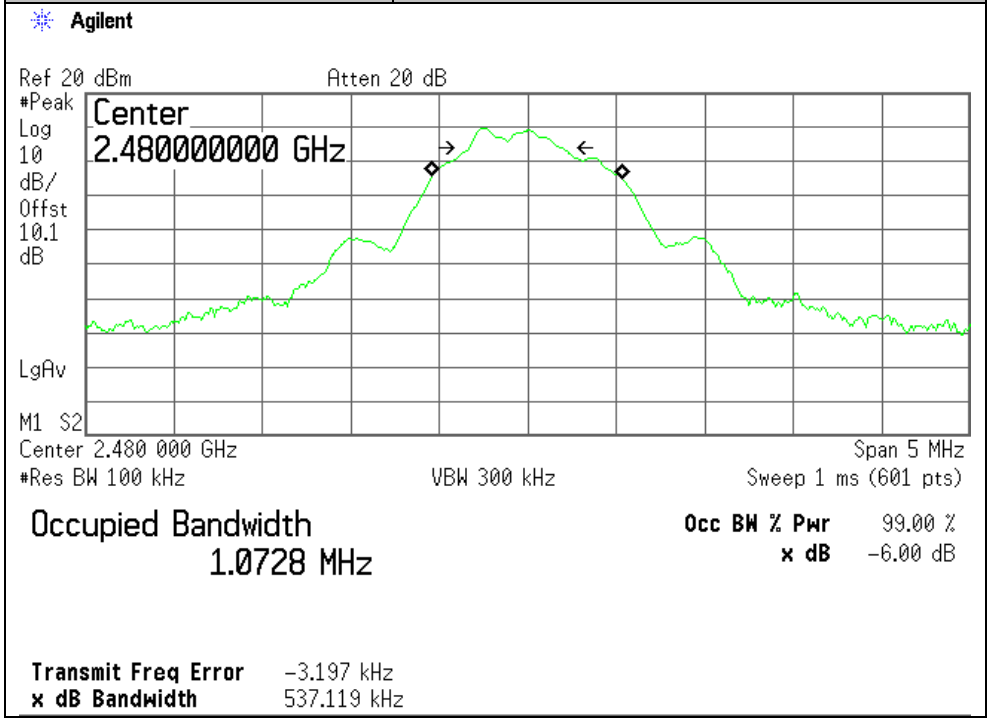
6dB & 99% BANDWIDTH_Zigbee Mode

Plot Name:	6dB & 99% Bandwidth Mid CH



6dB & 99% BANDWIDTH _BLE Mode

Plot Name:	6dB & 99% Bandwidth Mid CH



7.2 PEAK OUTPUT POWER

PEAK POWER LIMIT

§15.247 (b)(3) & RSS-247 Sec. 5.4(4)

The maximum peak conducted output power of the intentional radiator shall not exceed the following: For systems using digital modulation in the 900 MHz band: 1 Watt.

The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.

b(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Therefore, the applicable output power limit shall be calculated as follows:

Pout = 30 -(Gtx-6) for antenna gain ≤6dBi or
Pout = 30 -Floor[(Gtx-6)/3]
G_{Tx} = the maximum transmitting antenna directional gain in dBi.

TEST PROCEDURE *per FCC KDB 558074D01v05r02*

Measurement Procedure for Fundamental Emission Output Power*	**Applicable to this EUT**
8.3.1.1 Maximum Peak Conducted Output Power Level Measurement Procedure Option 1 (RBW≥DTS BW): Per Subclause 11.9.1.1 of ANSI C63.10	☒ **preferred**
8.3.1.2 Maximum Peak Conducted Output Power Level Measurement Procedure Option 2 (RBW<DTS BW) Integrated band power method: Prefer to use integrated average power measurement, as described in 8.3.2	☐
8.3.1.3 Maximum Peak Conducted Output Power Level Measurement Procedure Option 3: PKPM1 Peak-reading power meter method per Subclause 11.9.1.3 of ANSI C63.10	☐

* For measuring output power of a device transmitting a wide-band noise-like signal (i.e., digitally-modulated) where the peak power amplitude is a statistical parameter, the preferred methodology is to use integrated average power measurements, as described in 11.9.2 and 11.13.3 of ANSI C63.10.

No non-compliance noted.

OUTPUT PEAK POWER

Summary of Peak Power Testing Data:

Zigbee Mode

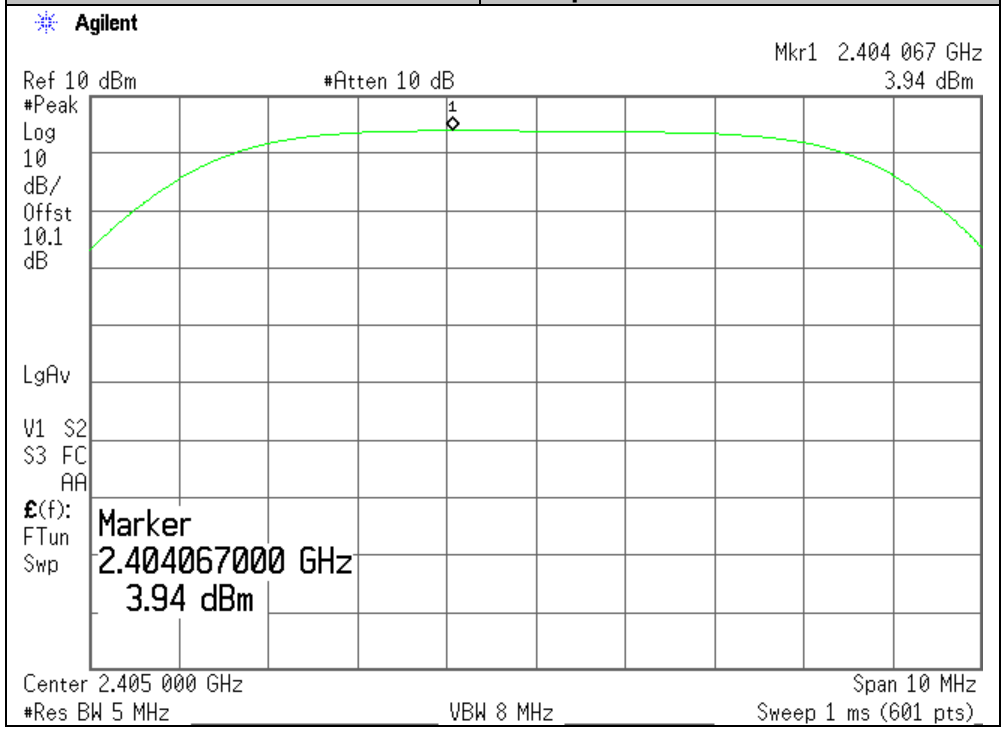
Channel	Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Margin (dB)
Low	2405	3.94	30	-26.06
Middle	2445	18.47	30	-11.53
High	2480	4.57	30	-25.46

BLEMode

Channel	Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Margin (dB)
Low	2402	9.22	30	-20.78
Middle	2440	9.46	30	-20.54
High	2480	9.87	30	-20.13

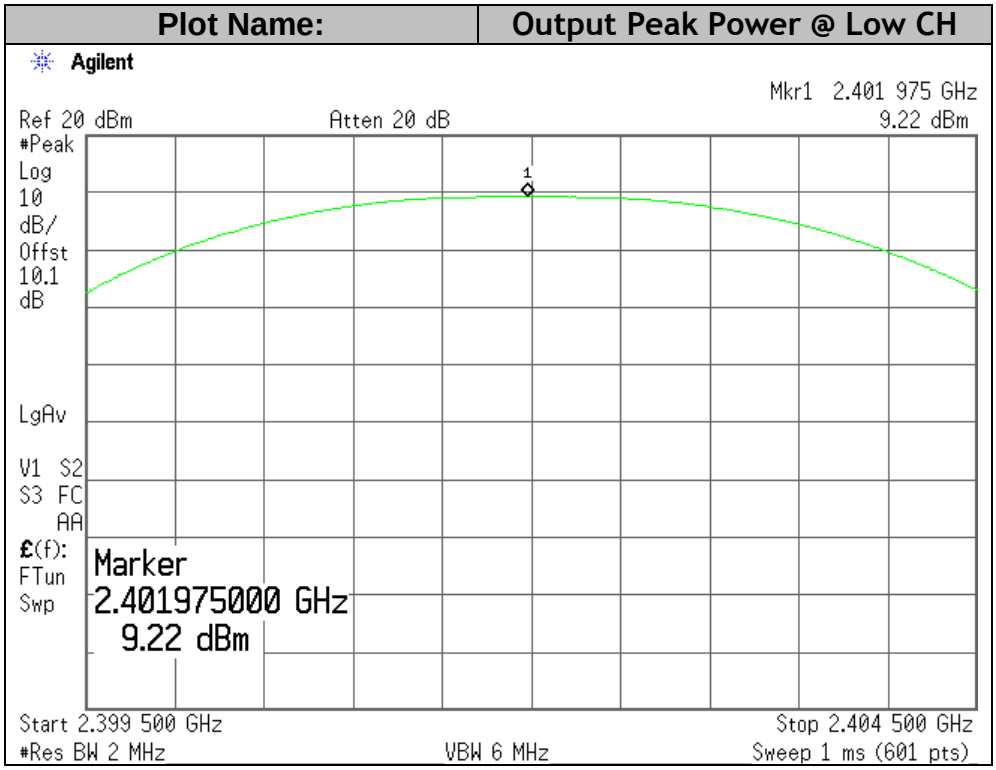
Zigbee Mode:

Plot Name:	Output Peak Power @ Low CH



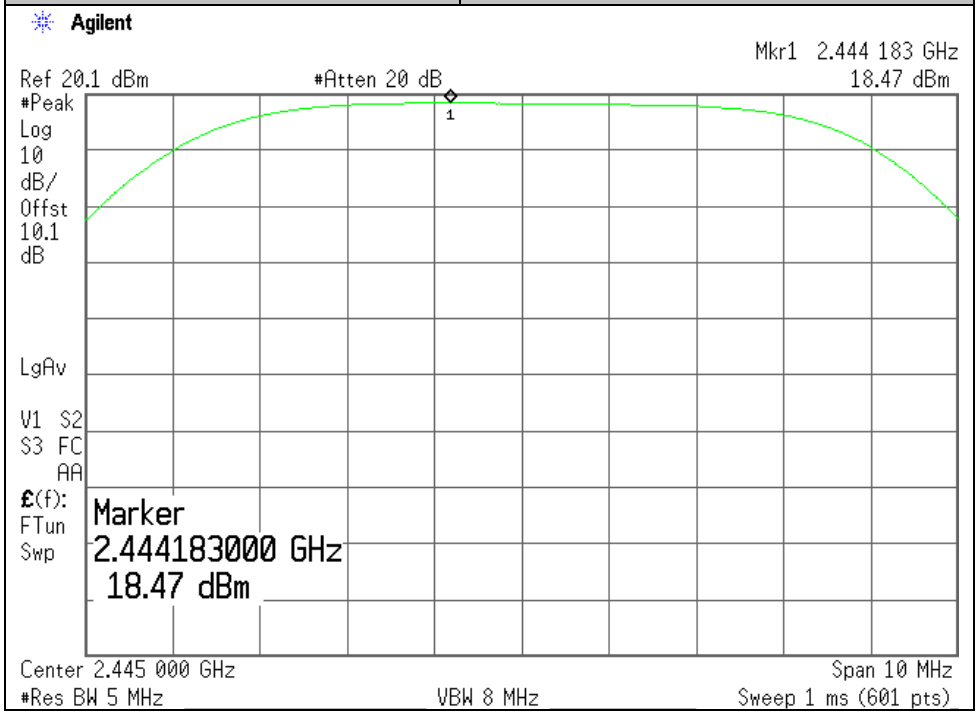
BLEMode:

Plot Name:	Output Peak Power @ Low CH

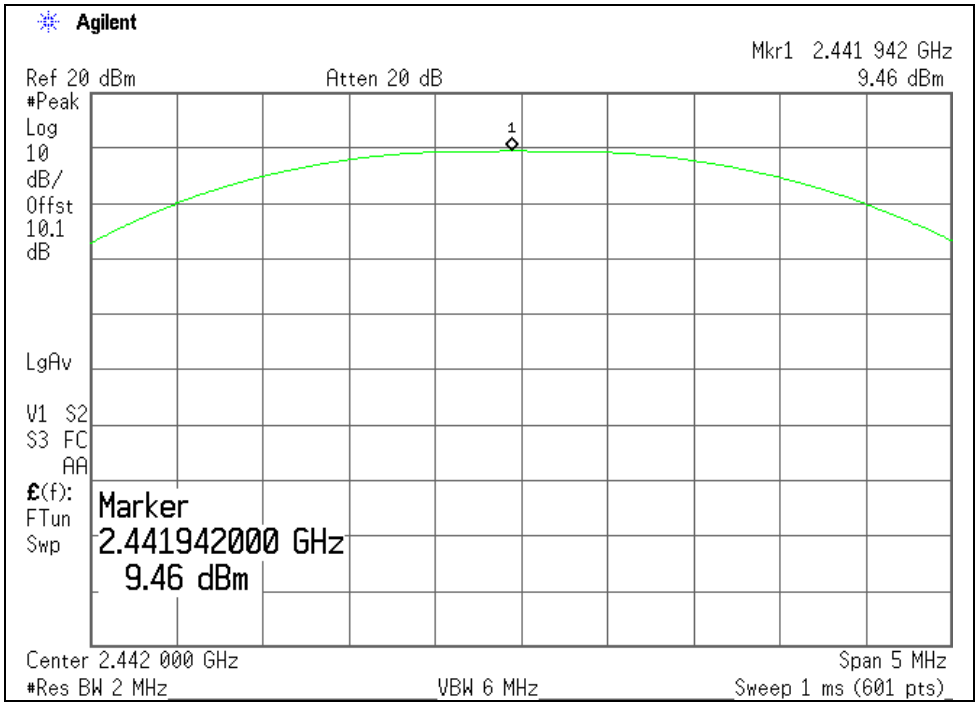


Zigbee Mode:

Plot Name:	Output Peak Power @ Mid CH

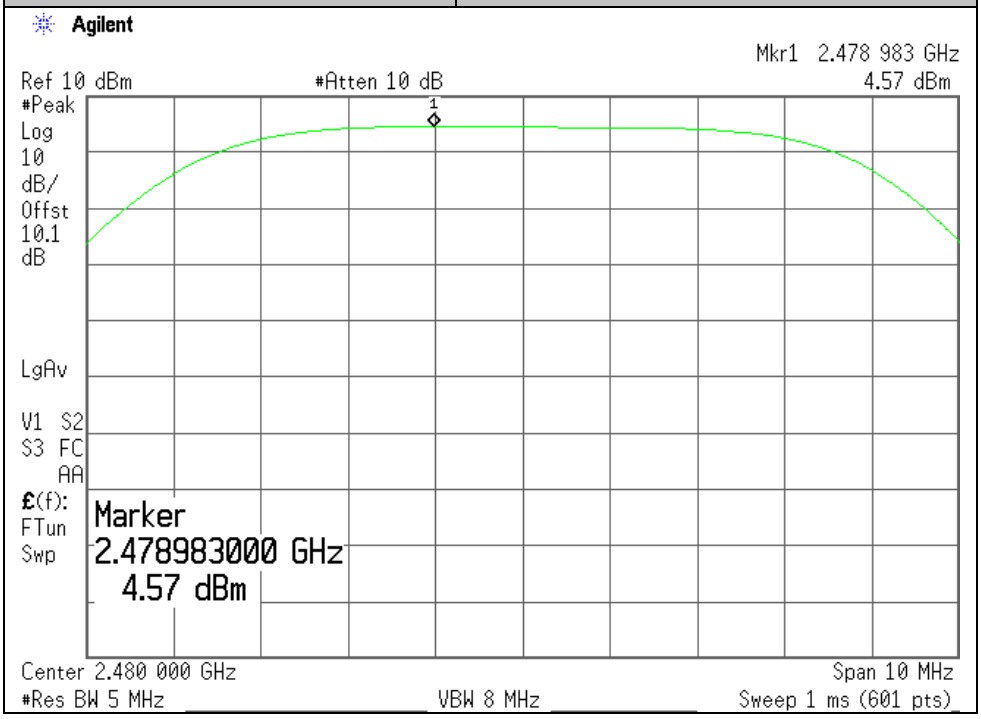


BLEMode:



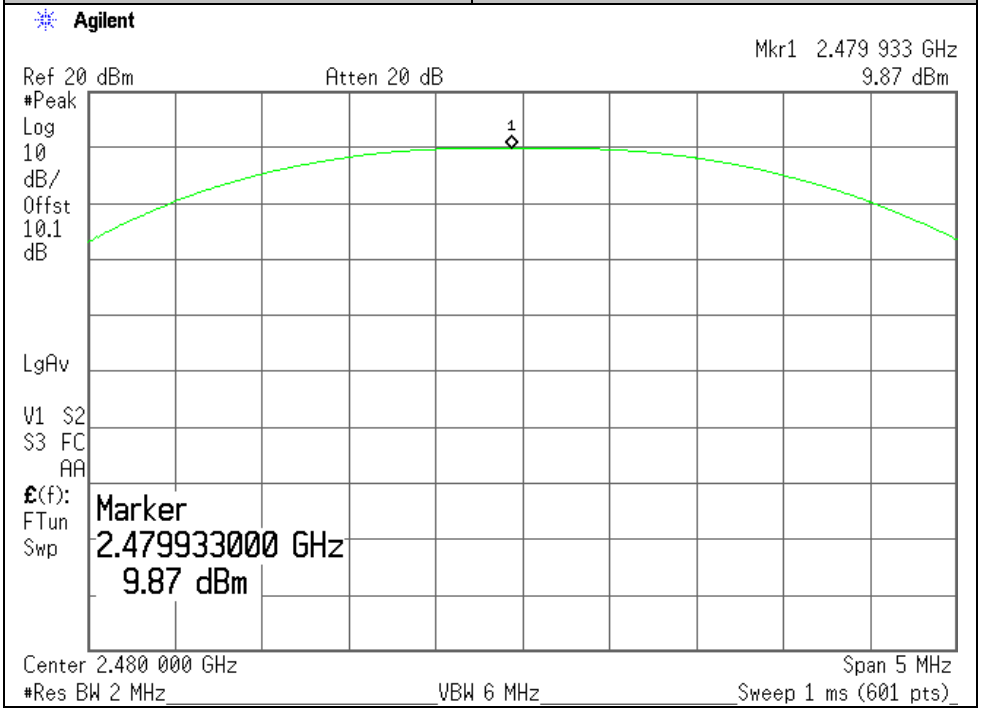
Zigbee Mode:

Plot Name:	Output Peak Power @ High CH



BLEMode:

Plot Name:	Output Peak Power @ High CH



7.3 MAXIMUM PERMISSIBLE EXPOSURE

LIMITS & RSS-102

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*($900/f^2$)	6
30–300	61.4	0.163	1.0	6
300–1500	.....	.....	f/300	6
1500–100,000	.....	.....	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*($180/f^2$)	30

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
30–300	27.5	0.073	0.2	30
300–1500	.....	.....	f/1500	30
1500–100,000	.....	.....	1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

LIMITS per RSS-102, Table 1 & Section 2.5

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance[4,5]

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

Per 2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:
• below 20 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
• at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz;
• at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
• at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2}\ f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;
• at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

CALCULATIONS

Given

$E = \sqrt{(30 * P * G) / d}$

and

$S = E \wedge 2 / 3770$

where

E = Field Strength in Volts/meter
P = Power in Watts
G = Numeric antenna gain
d = Distance in meters
S = Power Density in milliwatts/square centimeter

Combining equations and rearranging the terms to express the distance as a function of the remaining variables yields:

$d = \sqrt{((30 * P * G) / (3770 * S))}$

Changing to units of Power to mW and Distance to cm, using:

P(mW) = P (W) / 1000 and
d (cm) =100 * d (m)

yields

$d = 100 * \sqrt{((30 * (P / 1000) * G) / (3770 * S))}$
$d = 0.282 * \sqrt{(P * G / S)}$

where

d = distance in cm
P = Power in mW
G = Numeric antenna gain
S = Power Density in mW/cm^2

Substituting the logarithmic form of power and gain using: P (mW) = 10 ^ (P (dBm) / 10) and
G (numeric) = 10 ^ (G (dBi) / 10)

yields

$d = 0.282 * 10 \wedge ((P + G) / 20) / \sqrt{S}$ Equation (1)
$S = 0.0795 * 10 \wedge ((P + G)/10)/ d\wedge 2$ Equation (2)

where

d = MPE distance in cm
P = Power in dBm
G = Antenna Gain in dBi
S = Power Density Limit in mW/cm^2

Equation (1) and the measured peak power is used to calculate the MPE distance.
Equation (2) and the measured peak power is used to calculate the Power density.

APPLICABLE LIMITS for separation >= 20cm

FCC: From §1.1310 Table 1 (B), for Public S = 1.0 mW/cm^2 ; for Professional, S = 5.0 mW/cm^2
IC: With formula of 1.31 x 10^{-2} $f^{0.6834}$ W, more restricted EIRP limit value are 1.37W at 902MHz, 2.67W at 2400MHz.

RESULTS

No non-compliance noted:

---For FCC, the worst case for this EUT, P+G=18.47+2=20.47dBm, and d=20cm

Plug all three items into equation (2), yielding,

Power Density Limit (mV/cm^2)	Output Power (dBm)	Antenna] Gain (dBi)	Power Density (mW/cm^2)	Meet min. PD Limit
1.0/5.0	18.47	2	0.022	Yes

---For ISED, EUT max. e.r.i.p =0.112W (23.51dBm) < limit 2.67W

Therefore, all of results are below the FCC/ISED limit.

NOTE: For mobile or fixed location transmitters, the minimum separation distance between the antenna & radiating structures of the device and nearby persons is 20 cm, even if calculations indicate that the MPE distance would be less.

7.4 AVERAGE OUTPUT POWER

AVERAGE POWER LIMIT

Section 15.247 permits the maximum conducted (average) output power to be measured as an alternative to the maximum peak conducted output power for demonstrating compliance to the limit. When this option is exercised, the measured power is to be referenced to the OBW rather than the DTS bandwidth (see ANSI C63.10 for measurement guidance).

TEST PROCEDURE *per FCC KDB 558074D01v05r02*

Measurement Procedure for Fundamental Emission Output Power	Applicable to this EUT
8.3.2.2 Maximum Conducted (average) Output Power Level * Measurement Procedure Option 1 (Measurement using a spectrum analyzer (SA): per Subclause 11.9.2.2 of ANSI C63.10	☐
8.3.2.3 Maximum Conducted (average) Output Power Level * Measurement Procedure Option 2 (using a power meter(PM): per Subclause 11.9.2.3 of ANSI C63.10	☒

* Alternative method. EUT shall be configured to transmit continuously (min. 98% duty cycle at full power). The spectrum analyzer shall be set for bin-to-bin spacing ≤RBW/2.

The transmitter output is connected to a RF broadband power meter.

RESULTS

No non-compliance noted:

Zigbee Mode:

Channel	Frequency (MHz)	Average Power (dBm)
Low	2405	1.82
Middle	2445	7.21
High	2480	1.80

BLEMode:

Channel	Frequency (MHz)	Average Power (dBm)
Low	2402	1.23
Middle	2442	6.66
High	2480	1.39

7.5 PEAK POWER SPECTRAL DENSITY

LIMIT

§15.247 (e) & RSS-247 Sec. 5.2(2)
For direct sequence 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.

TEST PROCEDURE ***per FCC KDB 558074D01v05r02***

Measurement Procedure for Maximum Power Spectral Density in the Fundamental Emission	**Applicable to this EUT**
8.4 Measurement Procedure Method PKPSD (peak PSD) per Subclause 11.10.2 of ANSI C63.10	☒**preferred**
8.4 Measurement Procedure for Average PSD** (6 methods: AVGPSD-1 & Alt, AVGPSD-2 & Alt, AVGPSD-3 & Alt) per Subclause 11.10.3~11.10.8 of ANSI C63.10	☐

RESULTS

No non-compliance noted:

Summary of PPSD Testing Data:

Zigbee Mode:

Channel	**Frequency (MHz)**	**PPSD (dBm/3KHz)**	**Limit (dBm/3KHz)**	**Margin (dB)**
Low	2405	-11.22	8	-19.22
Middle	2440	2.74	8	-5.26
High	2480	-10.6	8	-18.6

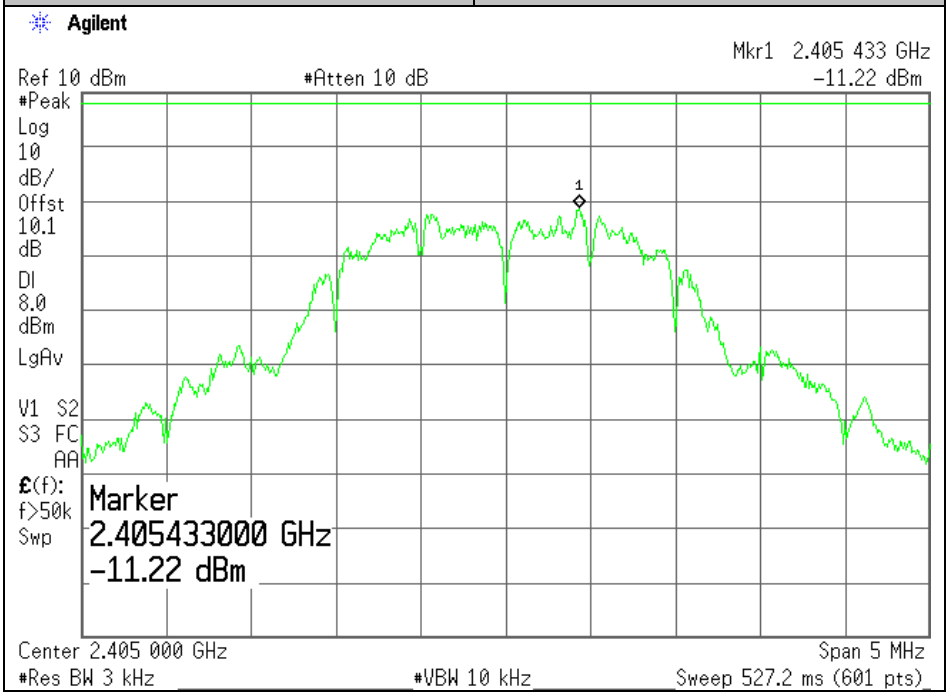
BlueTooth Mode:

Channel	**Frequency (MHz)**	**PPSD (dBm/3KHz)**	**Limit (dBm/3KHz)**	**Margin (dB)**
Low	2402	-7.0	8	-15.0
Middle	2442	-6.84	8	-14.84
High	2480	-6.39	8	-14.39

PEAK POWER SPECTRAL DENSITY

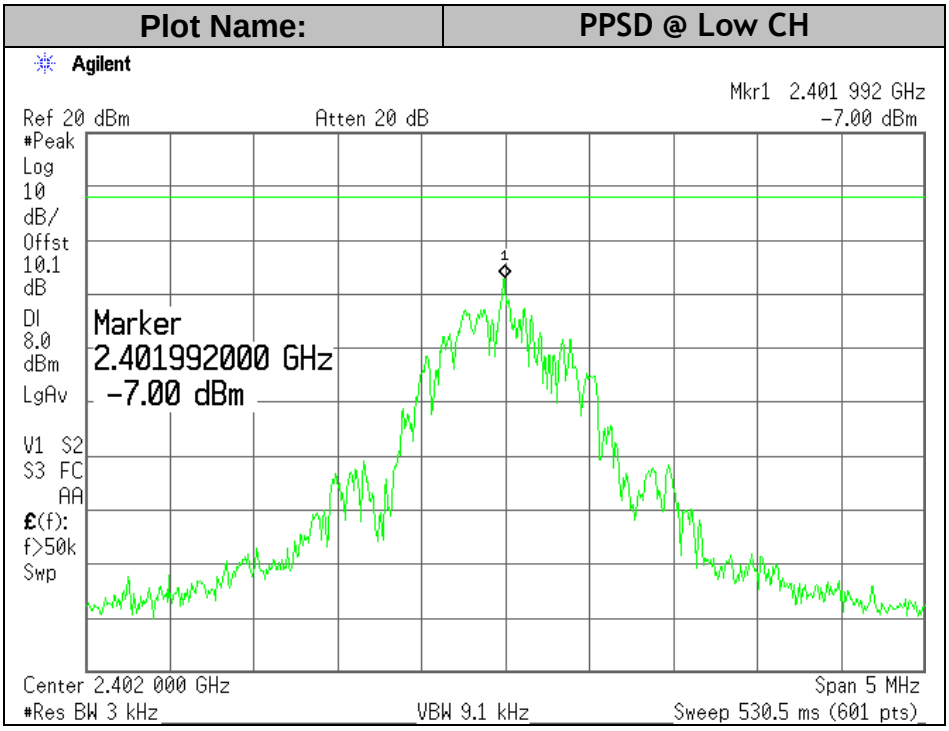
Zigbee Mode:

Plot Name:	PPSD @ Low CH



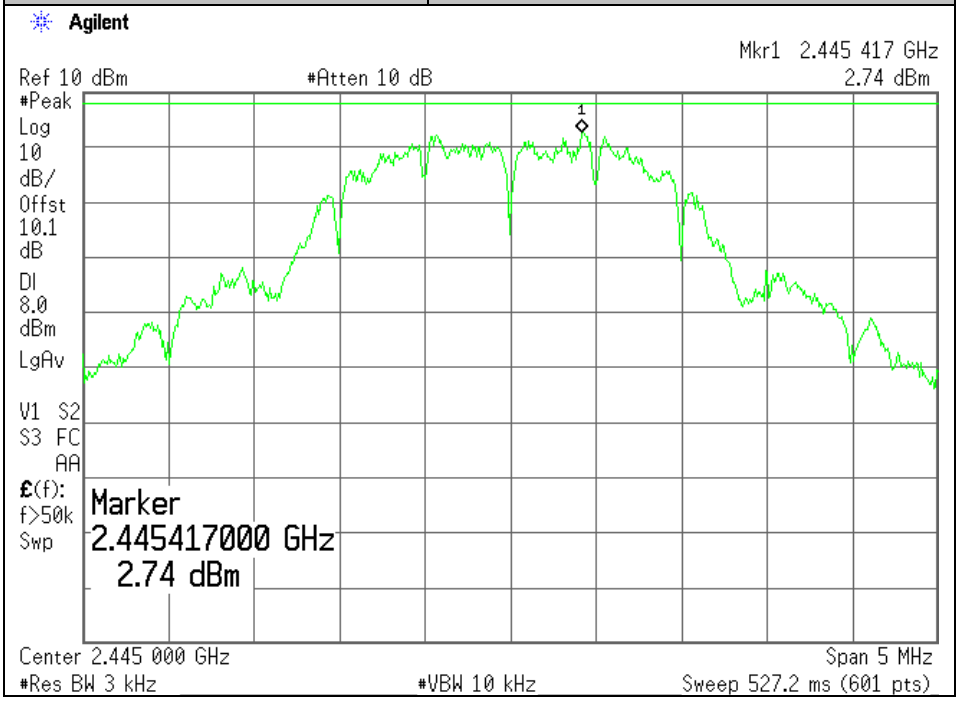
BLEMode:

Plot Name:	PPSD @ Low CH



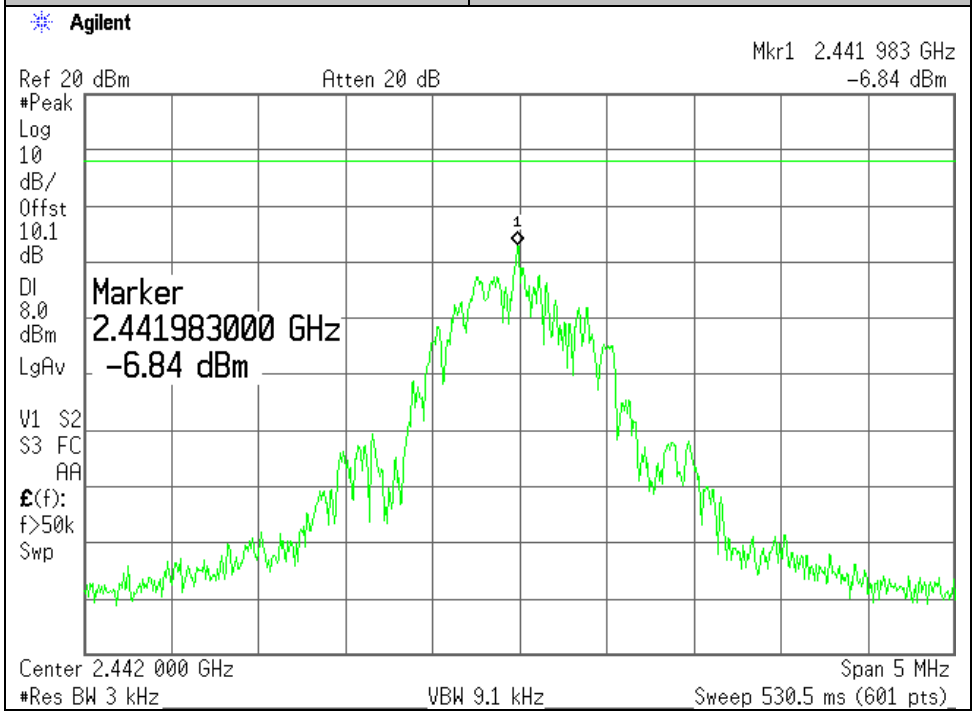
Zigbee Mode:

Plot Name:	PPSD @ Mid CH



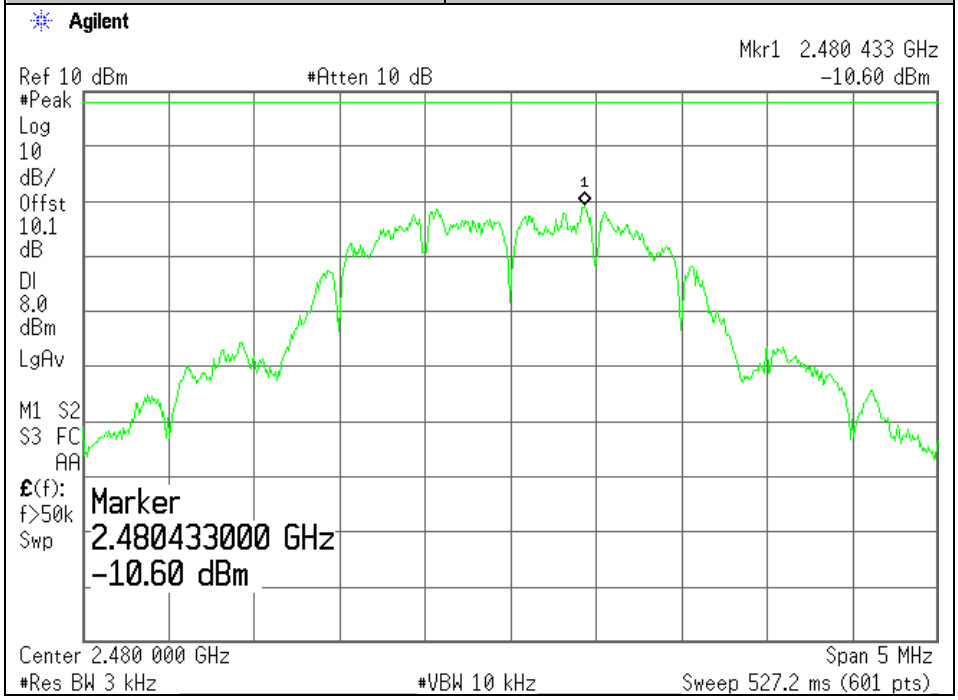
BLEMode:

Plot Name:	PPSD @ Mid CH



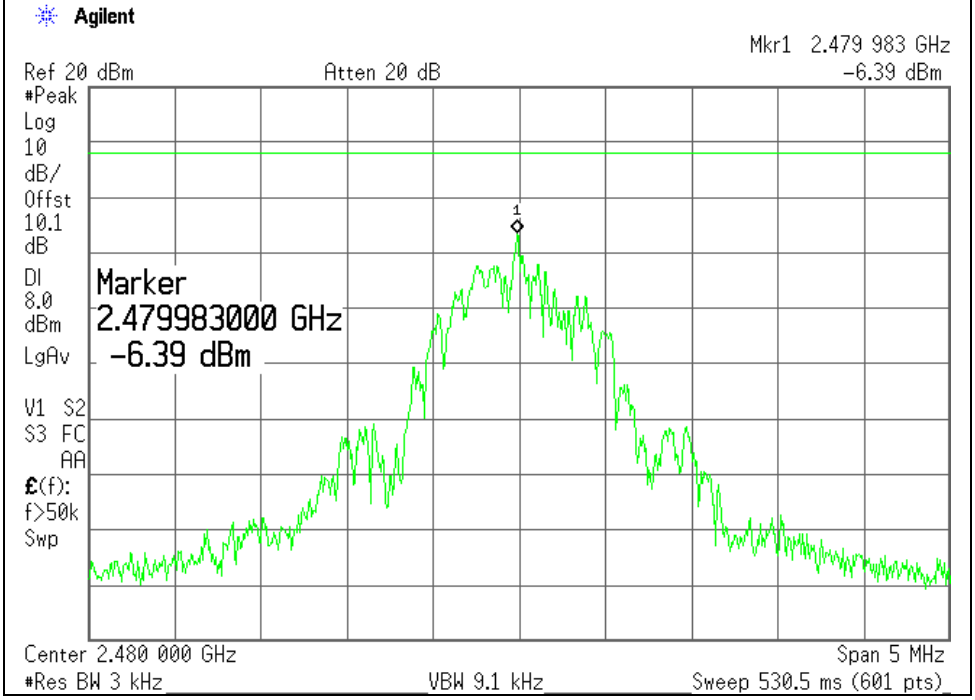
Zigbee Mode:

Plot Name:	PPSD @ High CH



BLEMode:

Plot Name:	PPSD @ High CH



7.6 CONDUCTED SPURIOUS EMISSIONS

LIMITS

§15.247 (d) & RSS-247 Sec. 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 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) & RSS-Gen 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) & RSS-Gen (see §15.205(c)).

TEST PROCEDURE ***per FCC KDB 558074D01v05r02,***

A. Section 8.5 DTS emissions in non-restricted frequency bands following the methods in Subclause 11.11 of ANSI C63.10

Conducted Measurement Procedure for Maximum Unwanted Emissions into Non-Restricted Frequency Bands	**Applicable to this EUT**	
	Peak Power limit: (-20dB)	**Average Power Limit: (-30dB)**
ANSI C63.10, Sec.11.11.1-11.11.2 Measurement Procedure-Reference Level (RBW=100KHz, VBW=300KHz)	☒	☐
ANSI C63.10, Sec. 11.11.3 Measurement Procedure- Emission level*	☒ **preferred**	☐

* Different attenuation limit shall be used based on the measurement method of fundamental emission power and PSD.

B. Section 8.6 DTS emissions in restricted frequency bands following the methods in Subclause 11.12 of ANSI C63.10

Antenna-Port Conducted Measurement Procedure for Maximum Unwanted Emissions into Restricted Frequency Bands**	**Applicable to this EUT**
ANSI C63.10, Sec.11.12.2.3 CISPR Quasi-Peak Measurement (CISPR 16)	☐
ANSI C63.10, Sec.11.12.2.4 Peak Power Measurement	☐
ANSI C63.10, Sec.11.12.2.5 Average Power Measurement (three options)***	☐

** To use this conducted testing method, per 12.2.2-12.2.6, the followings shall be taken as consideration:

1. Proper RBW and detector, per 15.35 a/b, shall be chosen in different frequency ranges;
2. **Maximum transmitter antenna gain (no less than 2dBi), G, shall be added to the measured power level to determine the EIRP;**
3. **Appropriate factor, A, shall be added to model worst case ground reflections: 6.0dB (f≤30MHz) and 4.7dB (f≤30 to 1000MHz)**
4. **Electric field strength can be obtained from the equation: E= EIRP-20log(d)+104.8+G (or 2.0) +A; Then compare to applicable limit;**
5. Unwanted emissions from EUT cabinet or casing shall be measured via radiated emission test method per C63.10 (in this case, the antenna port may be terminated properly).
6. Absolute peak power limit of -21.2dBm within the unwanted emission bandwidth shall be used for meeting 15.35(b) requirement;
7. Per 15.35(c), for pulse operation, Duty Cycle factor reduction can be applied for unwanted emissions that have the same pulse characteristics as does the fundamental emissions (such as harmonics) pulse operation

*** EUT shall be configured to transmit continuously (min. 98% duty cycle at full power). The spectrum analyzer shall be set for

bin-to-bin spacing ≤RBW/2.

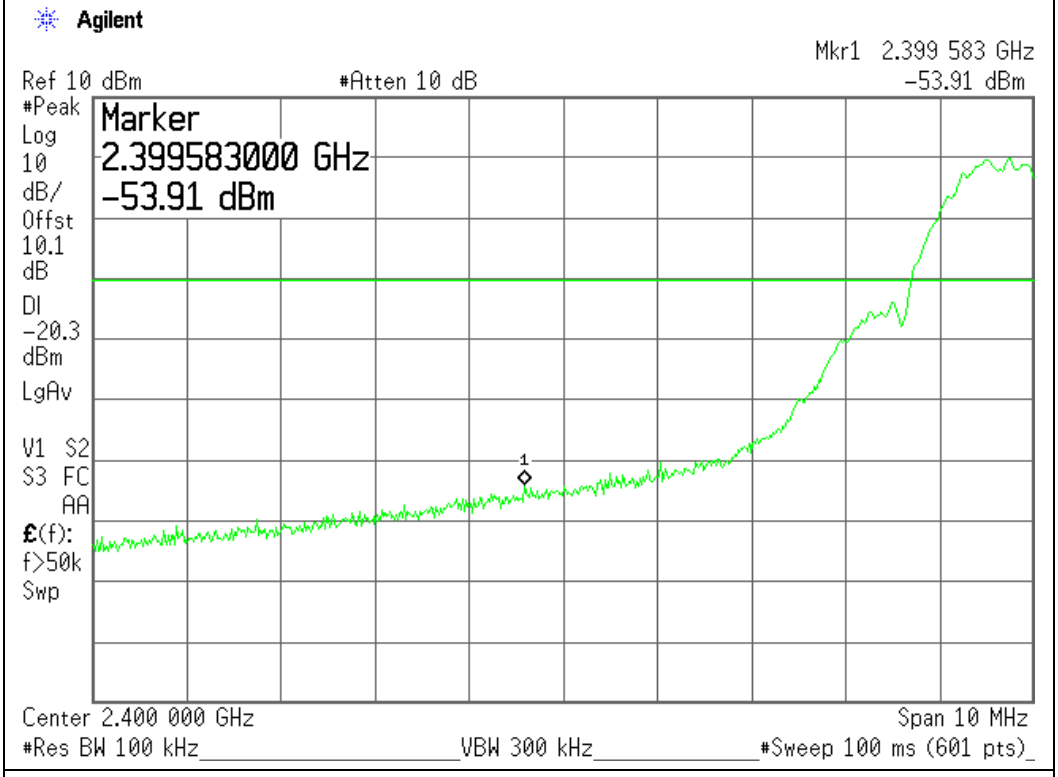
C. ***Section 8.7 DTS band-edge emission measurements following the methods in Subclause 11.13 of ANSI C63.10***

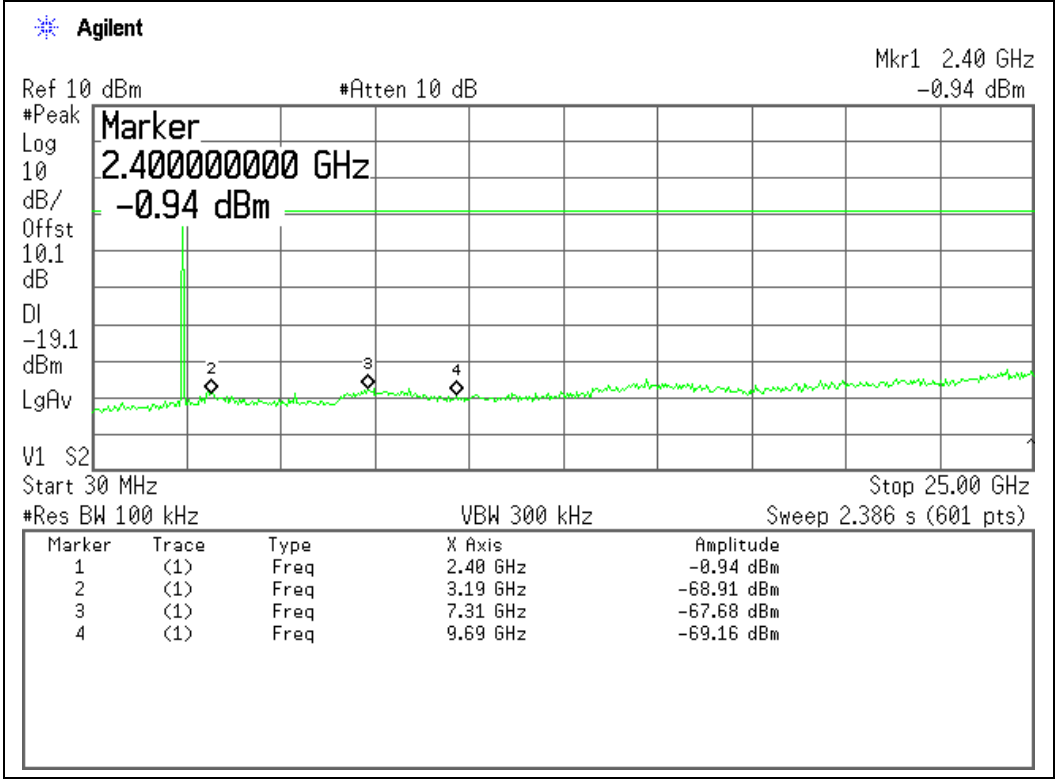
Conducted Band-edge measurements	**Applicable to this EUT**
ANSI C63.10, Sec.11.13.2 Band-Edge Marker-Delta Method (per ANSI C63.10, Sec. 6.10.6) (within 2MHz)	☐
ANSI C63.10, Sec. 11.13.3.2~5 Band-Edge Integration Method (peak / average)	☒

RESULTS:

Zigbee Mode:

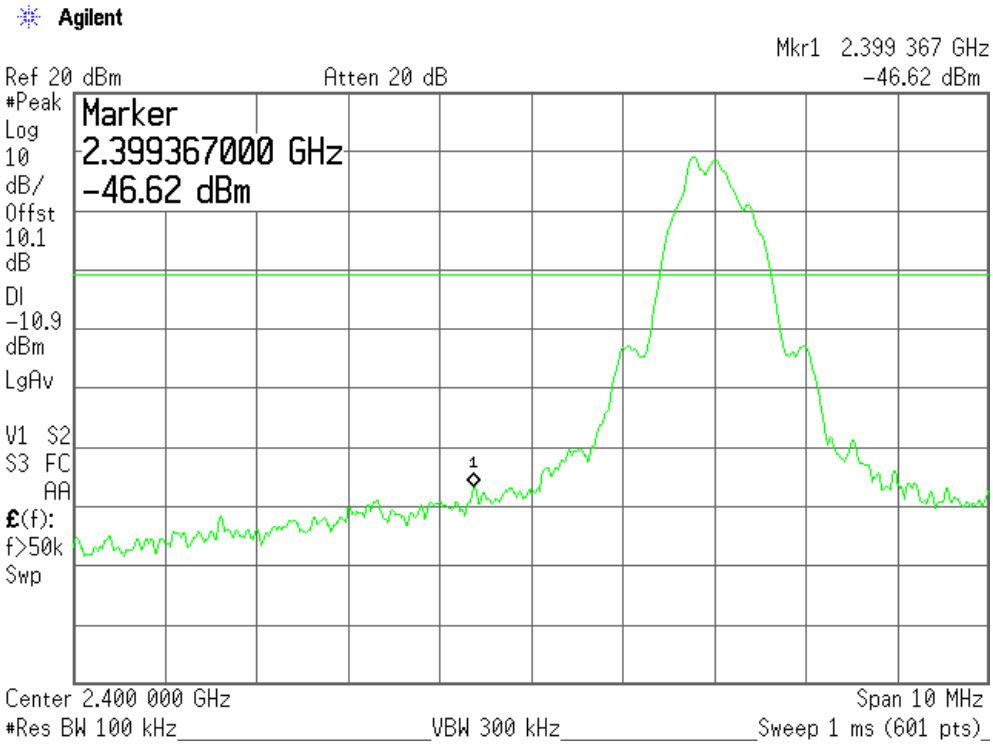
Plot Name:	Conducted Spurious @ Low CH

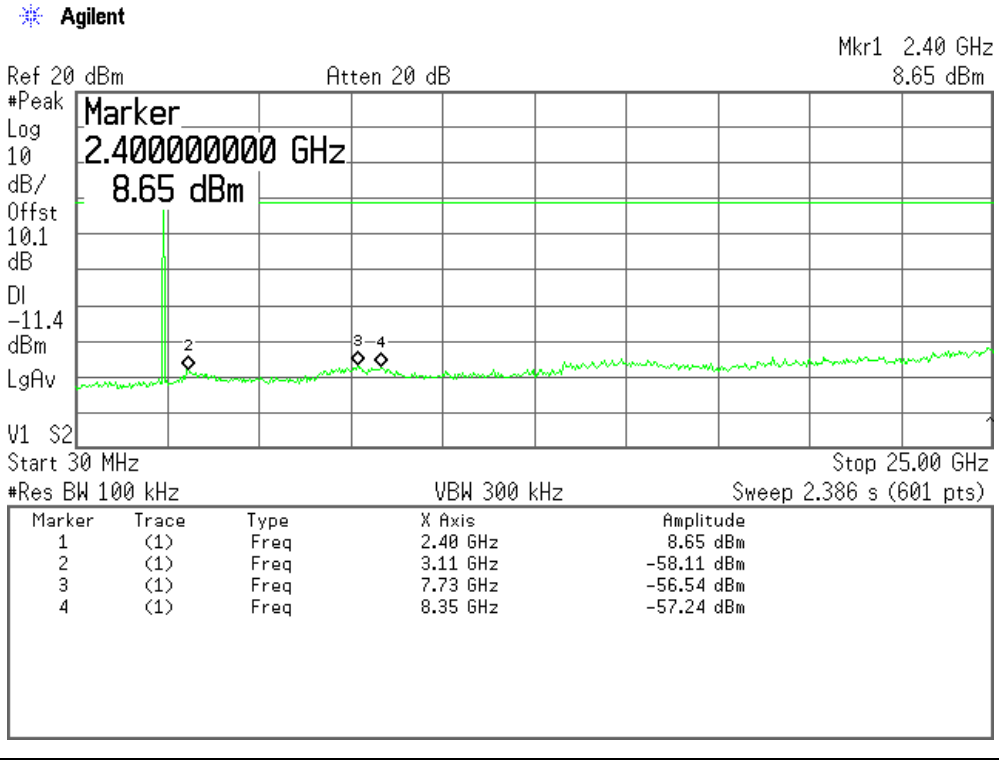




BLEMode:

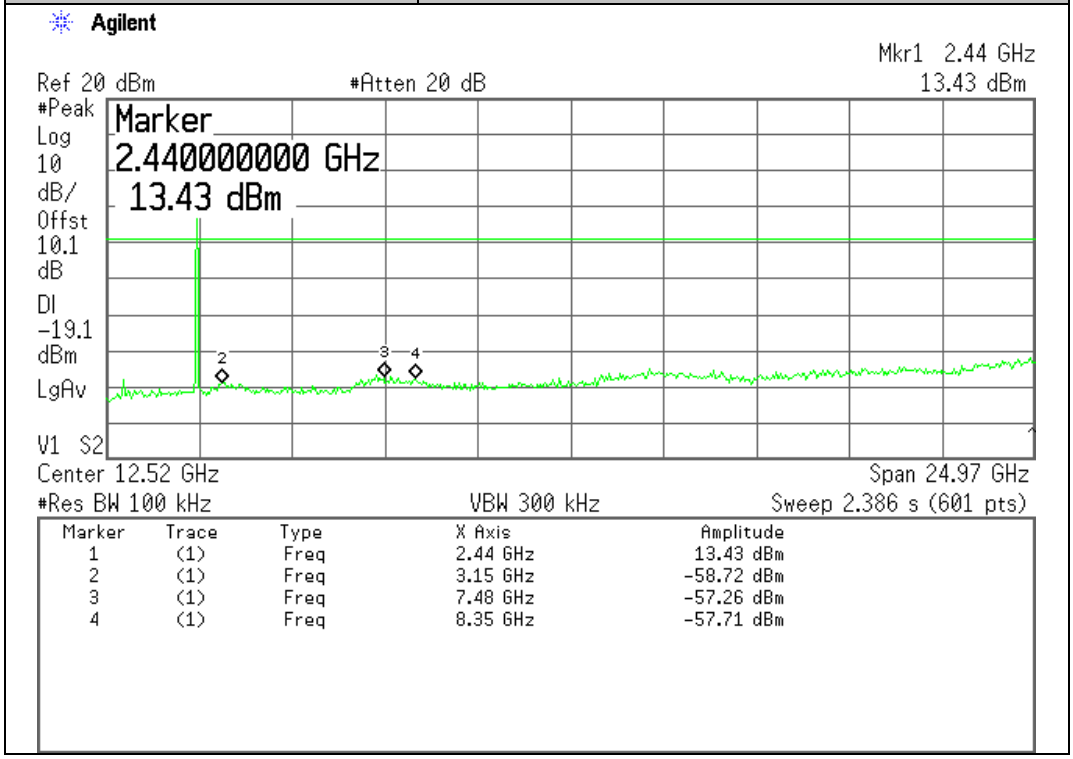
Plot Name:	Conducted Spurious @ Low CH



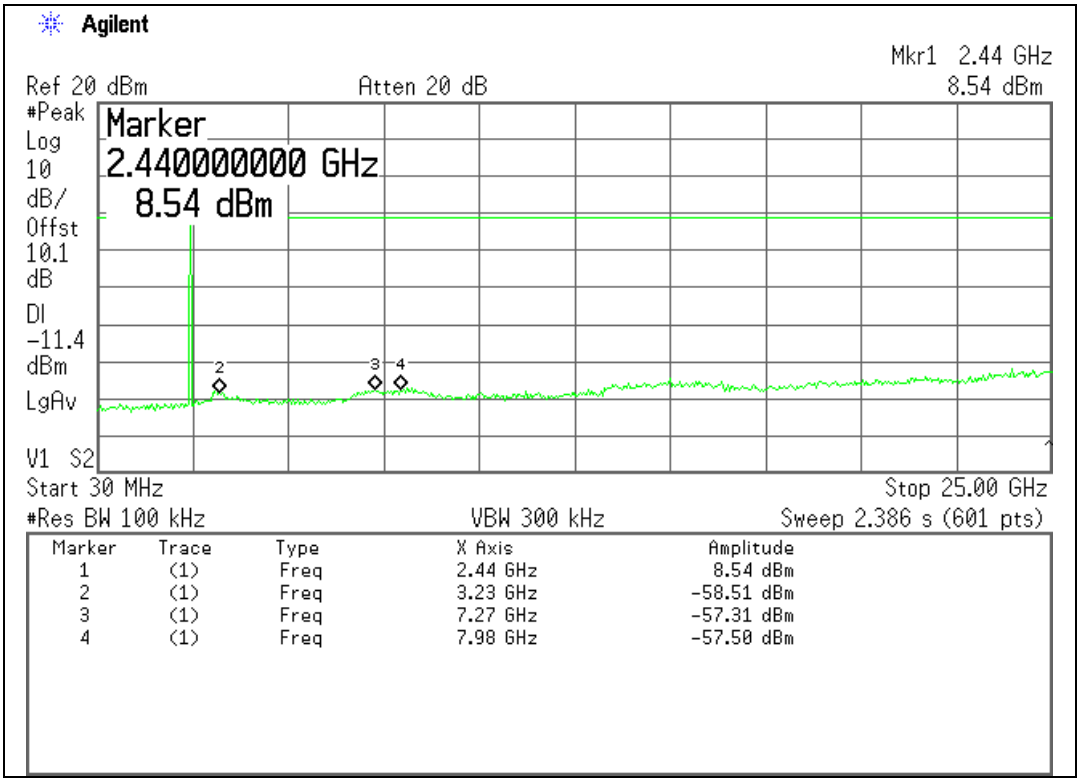


Zigbee Mode:

Plot Name:	Conducted Spurious @ Mid CH

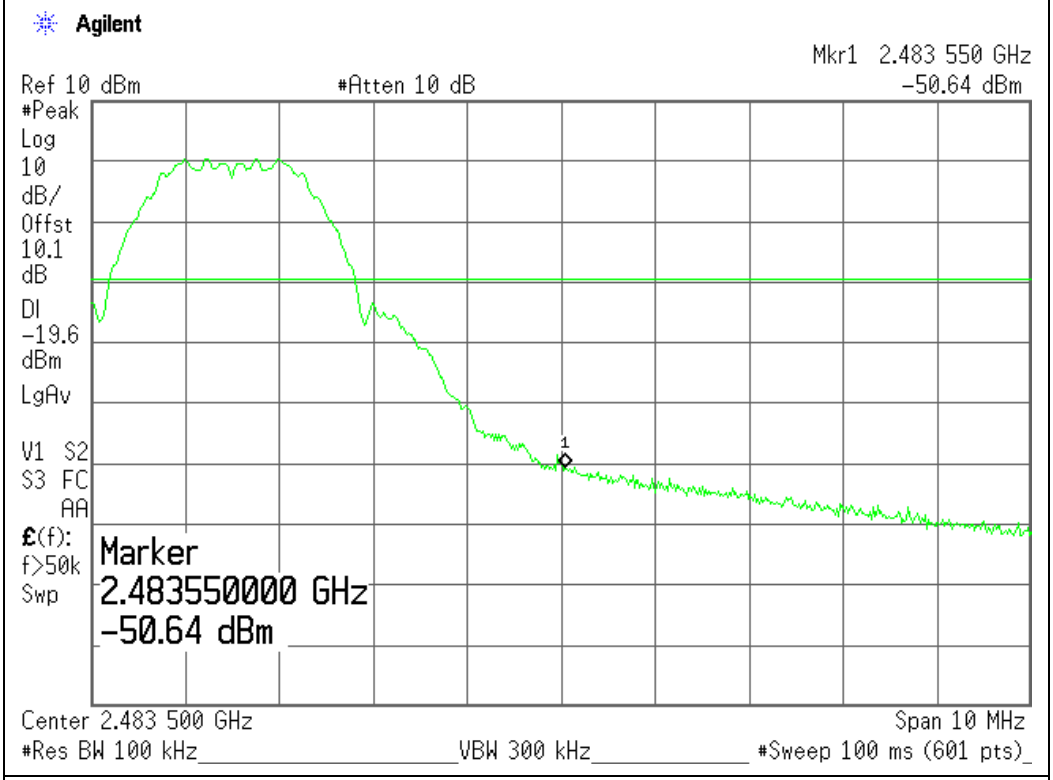


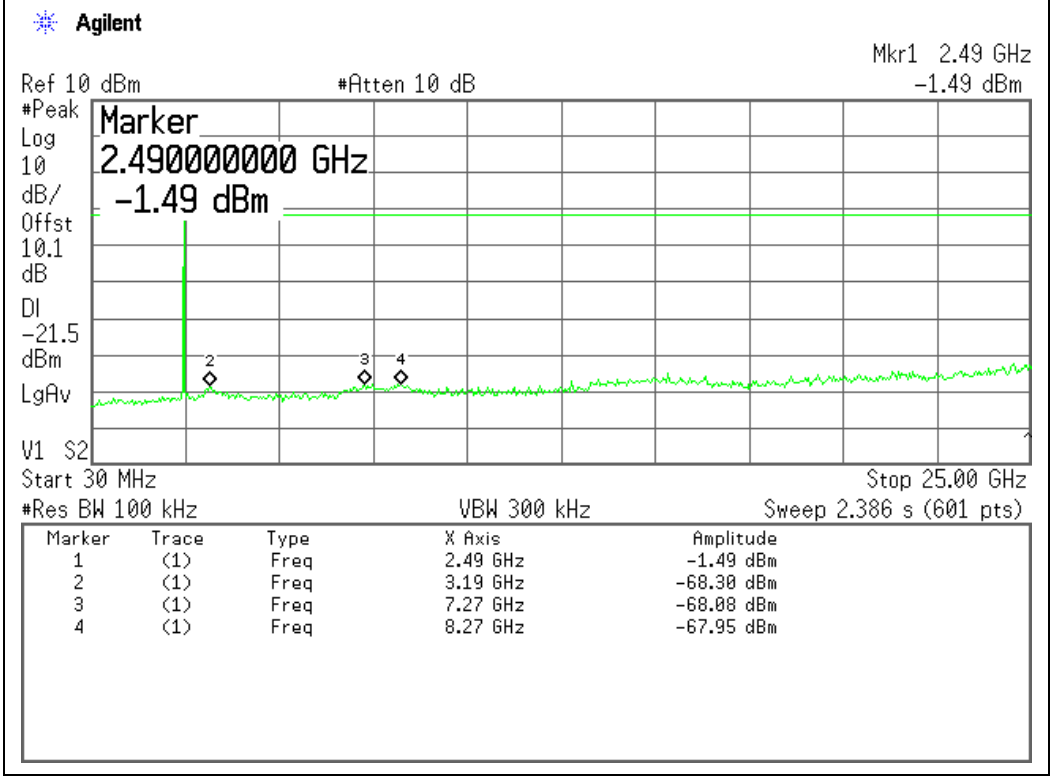
BLEMode:



Zigbee Mode:

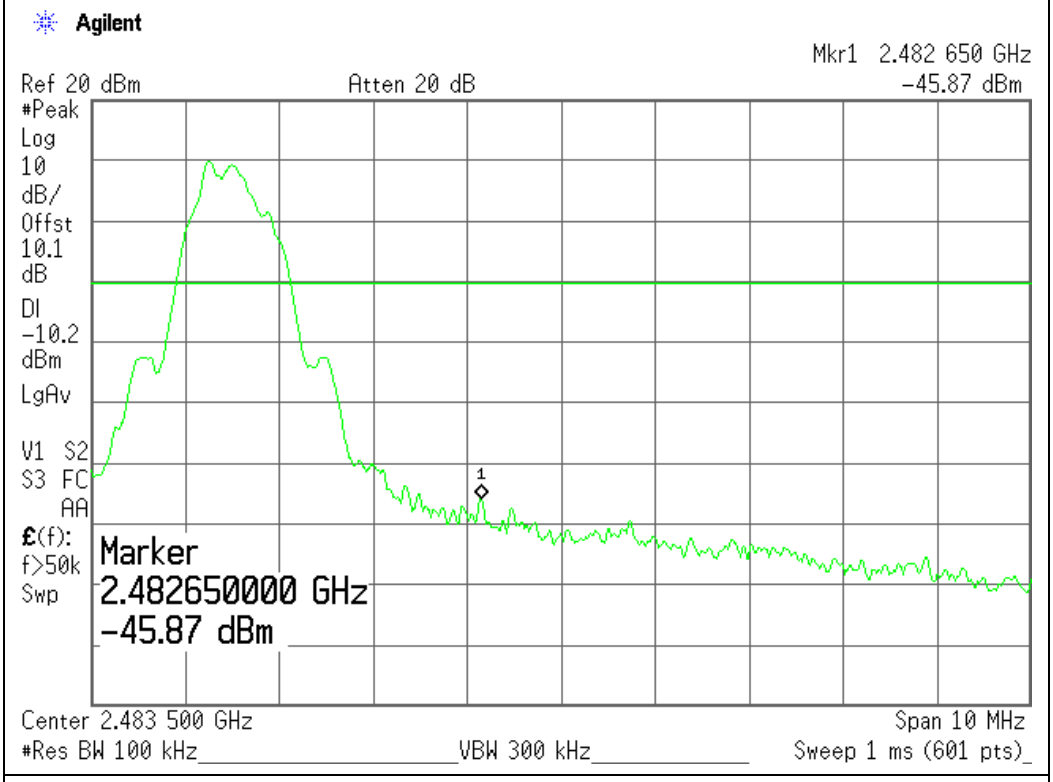
Plot Name:	Conducted Spurious @ high CH

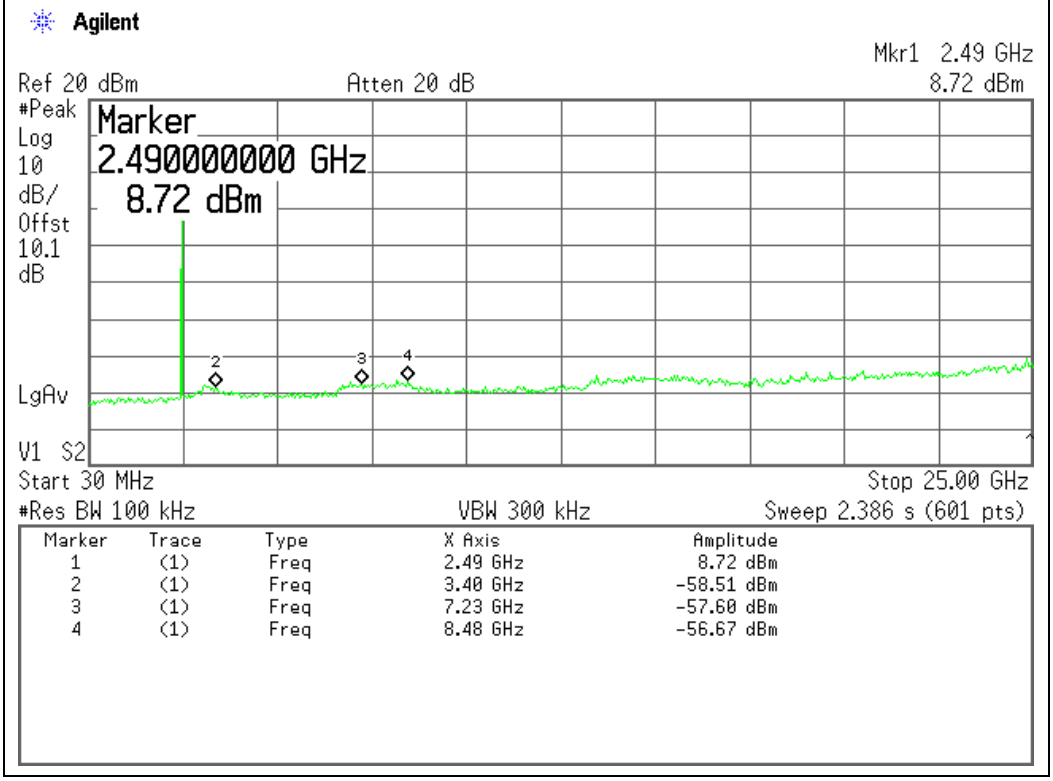




BLEMode:

Plot Name:	Conducted Spurious @ high CH





7.7 RADIATED EMISSIONS

7.7.1. TRANSMITTER RADIATED SPURIOUS EMISSIONS

LIMITS

§15.205 (a) RSS-102 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	[2]
13.36-13.41			

[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.
[2] Above 38.6

§15.205 (b) Except as provided in paragraphs (d) and (e), the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209 & RSS-Gen. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 & RSS-Gen shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 & RSS-Gen shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

§15.209 (a) & RSS-Gen 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 (MHz)	Field Strength (microvolts /meter	Measurement Distance (meters)
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

§15.209 (b) & RSS-Gen In the emission table above, the tighter limit applies at the band edges.

TEST PROCEDURE *per FCC KDB 558074D01v05r02 Sec.* 8.6 DTS emissions in restricted frequency bands following the method in Subclause 11.12.2.7 of ANSI C63.10 (Radiated method)
Also see Sec. 8.1 c)3): Additional measurement procedures and the allowance for duty cycle for DTS device out-of-band measurements in a restricted band for protocol-limited devices.

The EUT is set to transmit in a continuous mode. Established procedures in C63.4/C63.10 for performing radiated measurements shall be used. For cabinet emission measurements, the EUT transmit antenna may be replaced with a termination matching the nominal impedance of the antenna. For portable devices, the EUT was tested in three orthogonal planes.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak. For measurements above 1 GHz the resolution bandwidth is set to 1 MHz, and then the video bandwidth is set to 1 MHz for peak measurements and 10 Hz for average measurements.

The radio spectrum was investigated from the lowest frequency generated within the device (without going below 9 kHz) up to the 10^{th} harmonic of the rated transmitted emission. The emissions are investigated with the transmitter set to the lowest, middle, and highest channels.

The emissions are investigated with the transmitter set to the lowest, middle, and highest channels, if applicable. The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

RESULTS

No non-compliance noted.

7.7.2. TRANSMITTER RADIATED EMISSIONS DATA

(HARMONICS & SPURIOUS falling in restricted bands listed in Sec.15.205 and non-restricted bands *)

HARMONICS AND SPURIOUS EMISSIONS (>1GHz & <=1GHz)

Zigbee Mode:

Low Channel Harmonics/Spurious

Freq. (MHz)	Position (H,V) X	Dist. (m)	D Corr (dB)	Peak@3m (dBuV/m)	Avg@3m (dBuV/m)	PK Lim (dBuV/m)	QP/Avg.Lim (dBuV/m)	PK Mar (dBuV/m)	QP/Avg.Mar. (dBuV/m)
4810	H,X	3		42.1	33.5	74	54	-31.9	-20.5
7215	H,X	3		-	-	74	54		
4810	V,X	3		44.6	34.0	74	54	-29.4	-20.0
7215	V,X	3		--	-	74	54		

Middle Channel Harmonics/Spurious

Freq. (MHz)	Position (H,V) X	Dist. (m)	D Corr (dB)	Peak@3m (dBuV/m)	Avg@3m (dBuV/m)	PK Lim (dBuV/m)	QP/Avg.Lim (dBuV/m)	PK Mar (dBuV/m)	QP/Avg.Mar. (dBuV/m)
4884	H,X	3		47.7	38.3	74	54	-26.3	-15.7
7326	H,X	3		51.7	42.5	74	54	-22.3	-11.5
4884	V,X	3		53.1	43.9	74	54	-20.9	-10.1
7326	V,X	3		51.4	42.2	74	54	-22.6	-11.8

High Channel Harmonics/Spurious

Freq. (MHz)	Position (H,V) X	Dist. (m)	D Corr (dB)	Peak@3m (dBuV/m)	Avg@3m (dBuV/m)	PK Lim (dBuV/m)	QP/Avg.Lim (dBuV/m)	PK Mar (dBuV/m)	QP/Avg.Mar. (dBuV/m)
4960	H,X	3		41.7	32.6	74	54	-32.3	-21.4
7440	H,X	3		-	-	74	54		
4960	V,X	3		44.3	33.8	74	54	-29.7	-20.2
7440	V,X	3		-	-	74	54		

* Data shown above represents the worst case in all applicable EUT orientations. No other significant emissions were found in the rest frequency range. For spurious in restricted band, the limit is per 15.209 & RSS-Gen. For the others, by measuring the field strength of fundamental (peak) with 100KHz RBW, the limit is 20dB below that level (here it is higher than the limit in 15.209 & RSS-Gen). In this case, all non-fundamental emission points are below 15.209 & RSS-Gen limit, so there is NO additional concern for non-restriction band limit compliance.
** QP reading.

BLEMode:

Low Channel Harmonics/Spurious

Freq. (MHz)	Position (H,V) X	Dist. (m)	D Corr (dB)	Peak@3m (dBuV/m)	Avg@3m (dBuV/m)	PK Lim (dBuV/m)	QP/Avg .Lim (dBuV/m)	PK Mar (dBuV/m)	QP/Avg.Mar. (dBuV/m)
4804	H,X	3		46.0	37.4	74	54	-28	-16.6
7206	H,X	3		-	-	74	54		
4804	V,X	3		48.7	38.1	74	54	-25.3	-15.9
7206	V,X	3		--	-	74	54		

Middle Channel Harmonics/Spurious

Freq. (MHz)	Position (H,V) X	Dist. (m)	D Corr (dB)	Peak@3m (dBuV/m)	Avg@3m (dBuV/m)	PK Lim (dBuV/m)	QP/Avg .Lim (dBuV/m)	PK Mar (dBuV/m)	QP/Avg.Mar. (dBuV/m)
4890	H,X	3		43.6	34.4	74	54	-30.4	-19.6
7335	H,X	3		-	-	74	54		
4890	V,X	3		48.0	38.8	74	54	-26.0	-15.2
7335	V,X	3		-	-	74	54		

High Channel Harmonics/Spurious

Freq. (MHz)	Position (H,V) X	Dist. (m)	D Corr (dB)	Peak@3m (dBuV/m)	Avg@3m (dBuV/m)	PK Lim (dBuV/m)	QP/Avg .Lim (dBuV/m)	PK Mar (dBuV/m)	QP/Avg.Mar. (dBuV/m)
4960	H,X	3		45.6	36.5	74	54	-28.4	-17.5
7440	H,X	3		-	-	74	54		
4960	V,X	3		48.2	37.7	74	54	-25.8	-16.3
7440	V,X	3		-	-	74	54		

* Data shown above represents the worst case in all applicable EUT orientations. No other significant emissions were found in the rest frequency range. For spurious in restricted band, the limit is per 15.209 & RSS-Gen. For the others, by measuring the field strength of fundamental (peak) with 100KHz RBW, the limit is 20dB below that level (here it is higher than the limit in 15.209 & RSS-Gen). In this case, all non-fundamental emission points are below 15.209 & RSS-Gen limit, so there is NO additional concern for non-restriction band limit compliance.
** QP reading.

Band Edge Data for EUT

In addition, the band-edge requirements are also verified.

Testing procedure per KDB 558074D01:

The measurement of unwanted emissions at the edge of the authorized frequency bands can be complicated by the capture of RF energy from the fundamental emission within the RBW passband. The following techniques are permitted for use in performing a measurement of the unwanted emission level at the band edges.

10.2.5.1 Marker-Delta Method

The marker-delta method, as described in KDB 913591 and in C63.10, can be used to perform measurements of the unwanted emissions level at the band-edges.

10.2.5.2 Integrated Power Measurement

A narrower resolution bandwidth can be used at the band edge to improve the measurement accuracy provided that the measurement is subsequently integrated to the relevant bandwidth specification (e.g., 100 kHz within non-restricted bands and 1 MHz within restricted frequency bands).

Results:

The testing results for worst case based on pretesting results are shown as following and comply with the band-edge requirements for 2400-2483.5MHz DTS per FCC Part 15.247. EUT antenna with max gain was used for this testing.

- H=Measurement antenna horizontal position
- V= Measurement antenna vertical position
- Using conventional manner for measuring the radiated emissions that are removed by more than two measurement bandwidths from band-edge, such as the emissions in the restricted band 2310-2390MHz & 2483.5-2500MHz, etc.
- Using conventional manner or if needed, using “delta” measurement technique for measuring the radiated emissions that are up to two measurement bandwidths removed from band-edge, such as the restricted band that begins at 2483.5MHz.
- The worst case for different EUT orientations was chosen for final data collection based on pre-scan testing results.

EUT Duty Cycle Factor:

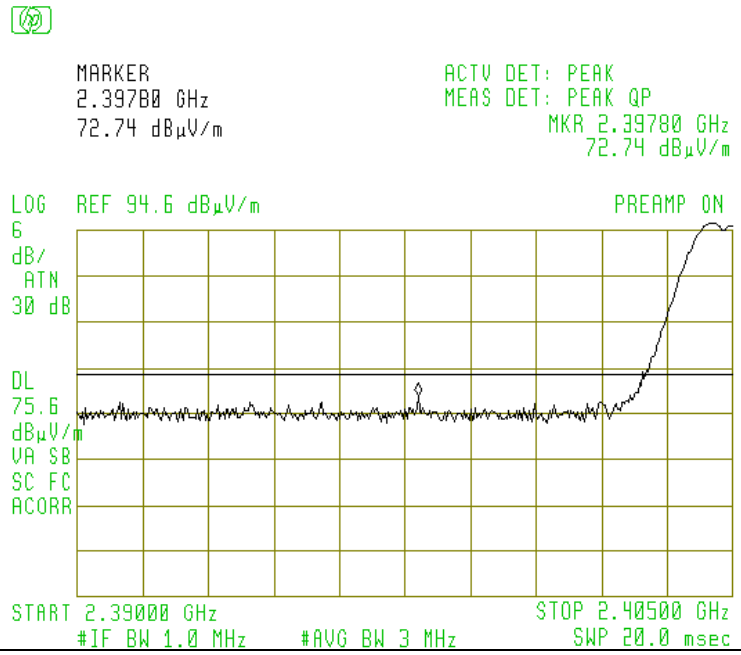
The computed worst-case value for an 802.15.4-compliant ZigBee stack, which is 66. Note that the 66% measurement assumes worst-case values achieved in several randomization functions, so real-world application performance will almost certainly be less than this number. TX duty cycle percentage (P), the correction/relaxation factor (F) applied to your harmonics emissions will be based on the following formula: $F = 20 * \log(P/100)$. For example, a 66% TX duty cycle yields a duty cycle correction factor of -3.6 dB = 20 * log (0.66).

It may not need to use the Duty Cycling correction factor if the output power from the 2.4GHz radio is low.

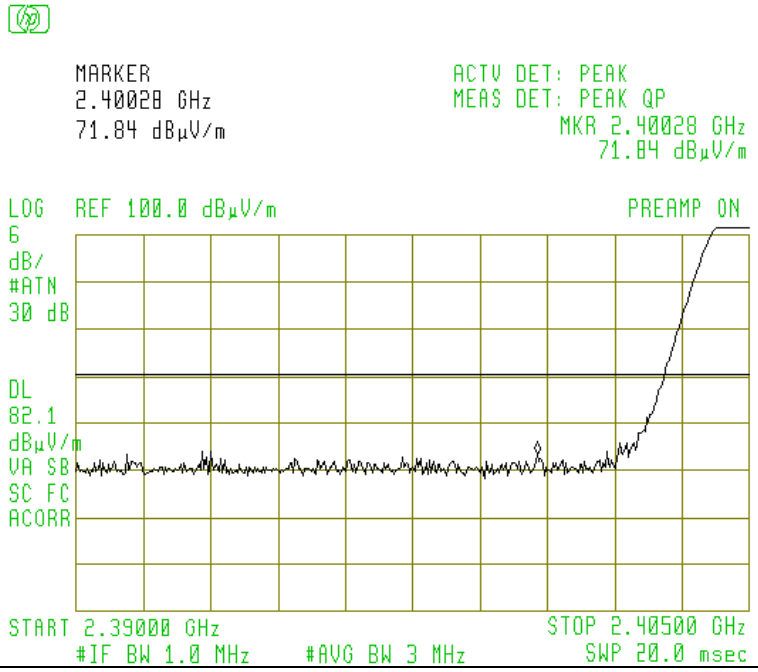
The following plots show band edge spurious are below the limit in FCC 15.247, 15.209 & RSS-247, RSS-Gen

Zigbee Mode:

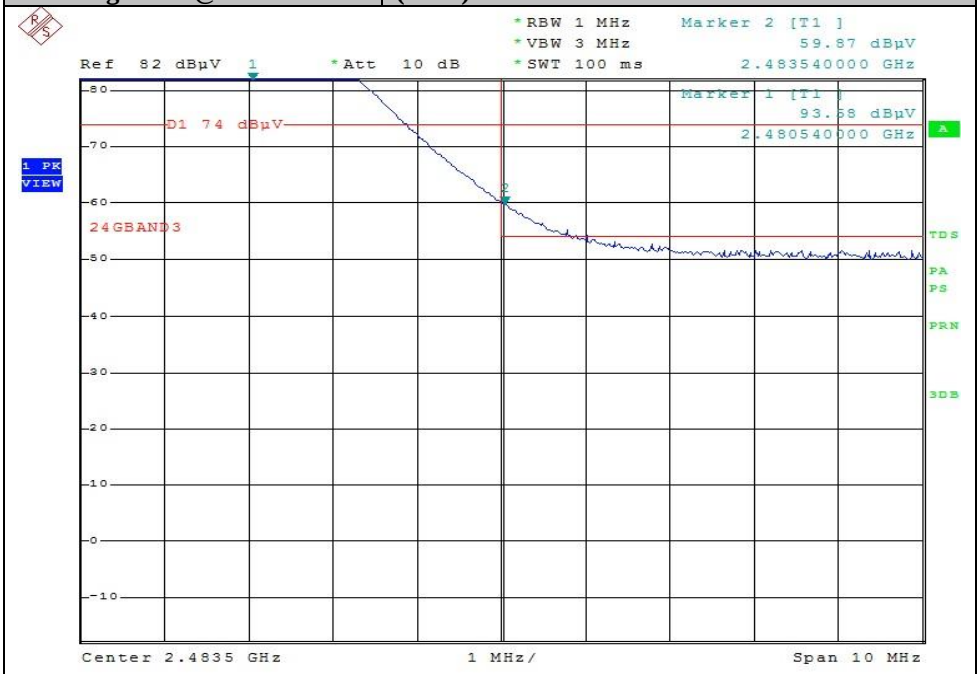
Plot Name: Radiated Emission Bandedge Test @ 2400MHz	Spurious @ Lower Band-edge_Horizontal



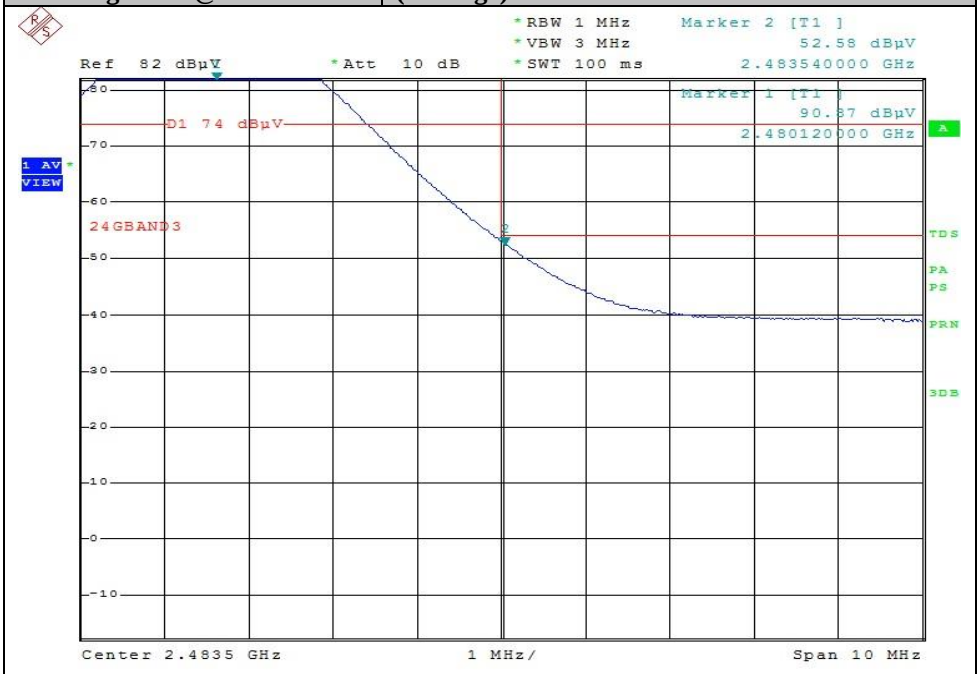
Plot Name: Radiated Emission Bandedge Test @ 2400MHz	Spurious @ Lower Band-edge_Vertical



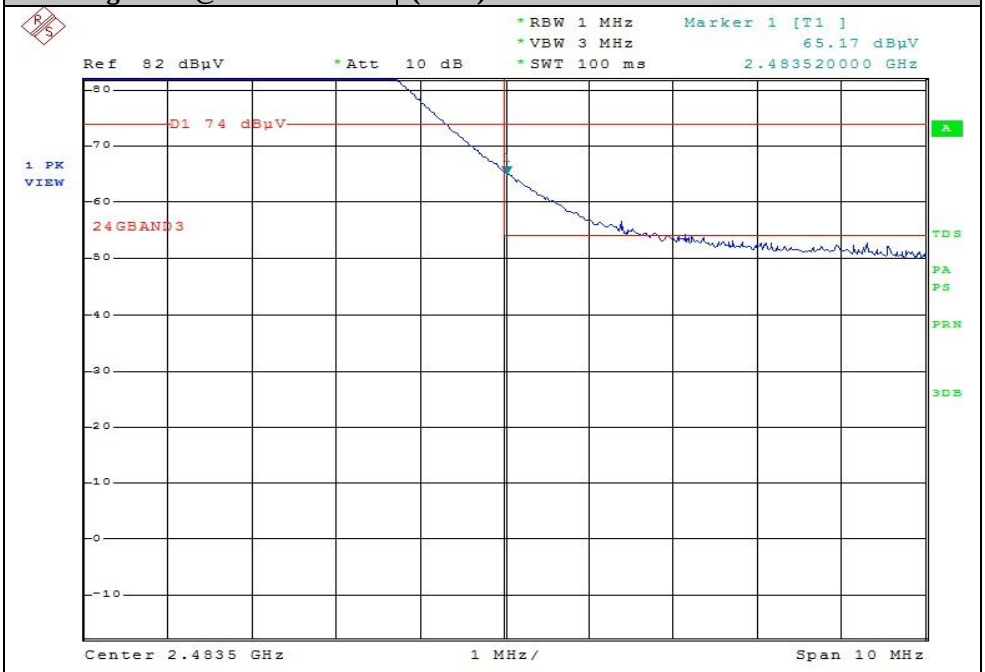
Plot Name: Radiated Emission Bandedge Test @ 2483.5MHz	Spurious @ High Band-edge_Horizontal (Peak)



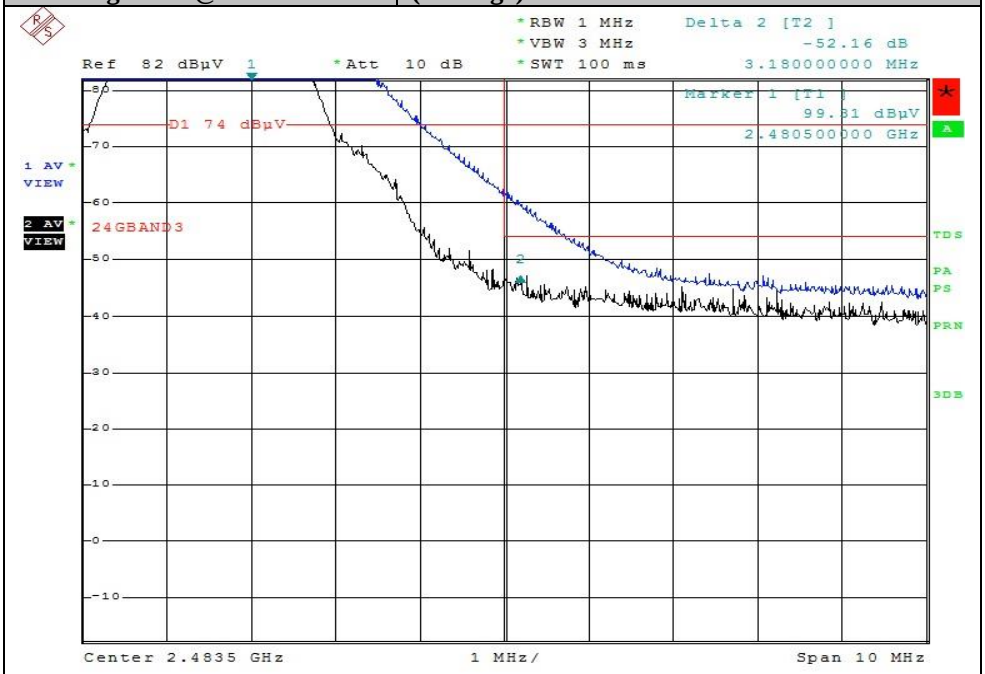
Plot Name: Radiated Emission Bandedge Test @ 2483.5MHz	Spurious @ High Band-edge_Horizontal (Average)



Plot Name: Radiated Emission Bandedge Test @ 2483.5MHz	Spurious @ High Band-edge_Vertical (Peak)



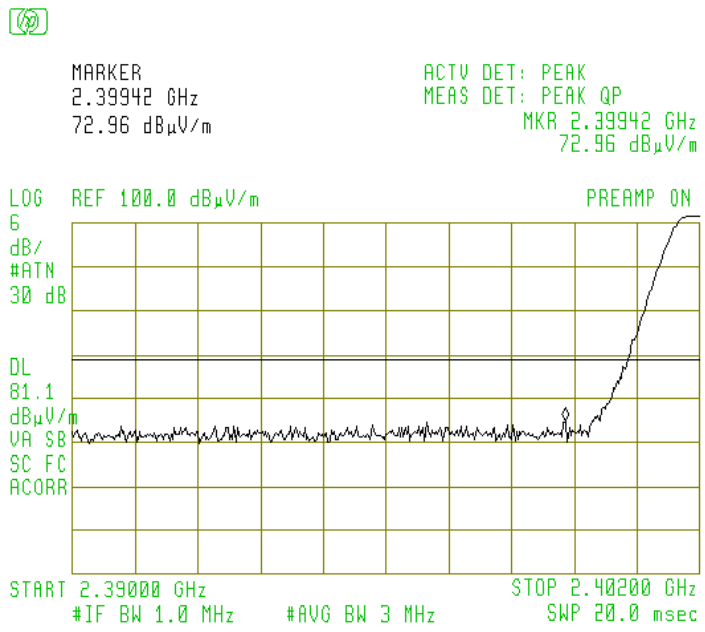
Plot Name: Radiated Emission Bandedge Test @ 2483.5MHz	Spurious @ High Band-edge_Vertical (Average)



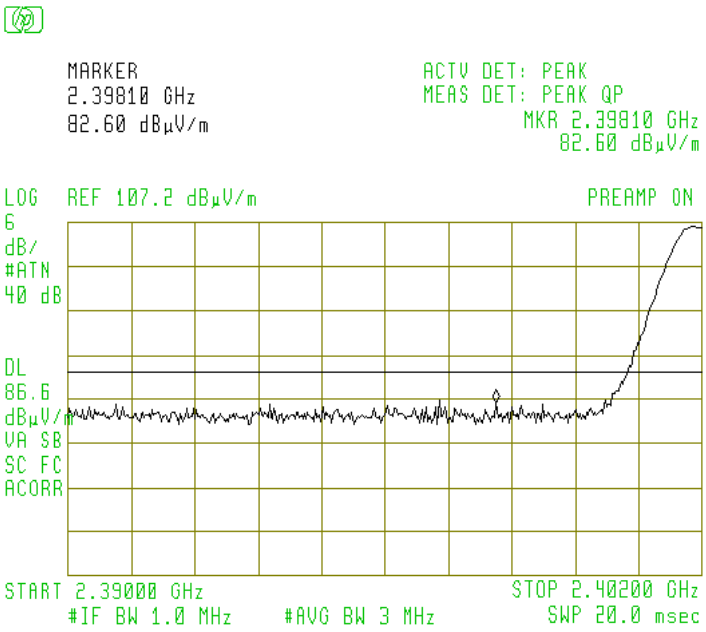
Max. average reading=99.31-52.16=46.7dBuV/m under the limit 54dBuV/m

BLEMode:

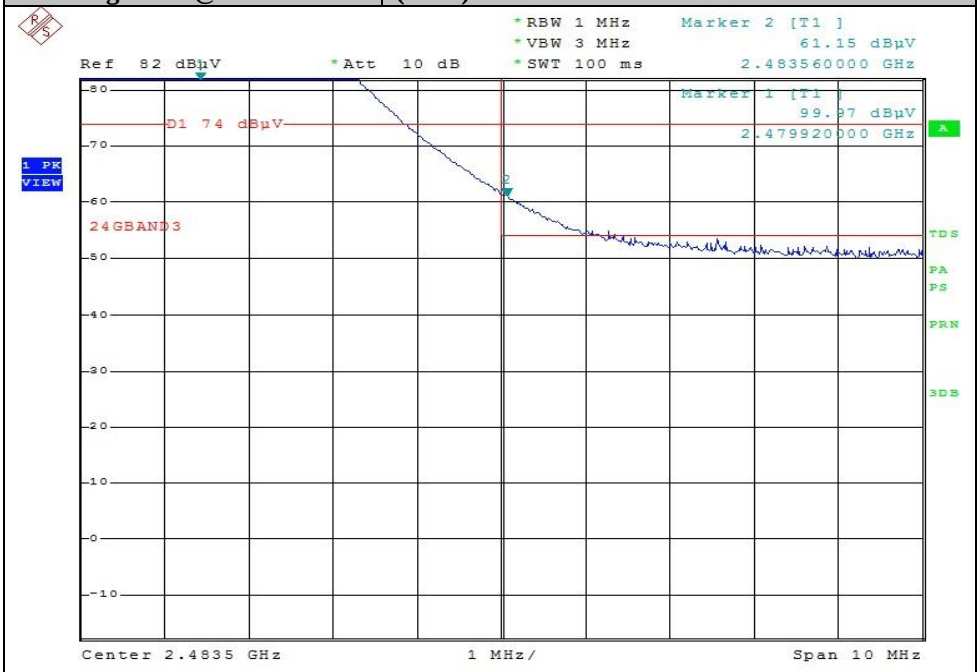
Plot Name: Radiated Emission Bandedge Test @ 2400MHz	Spurious @ Lower Band-edge_Horizontal



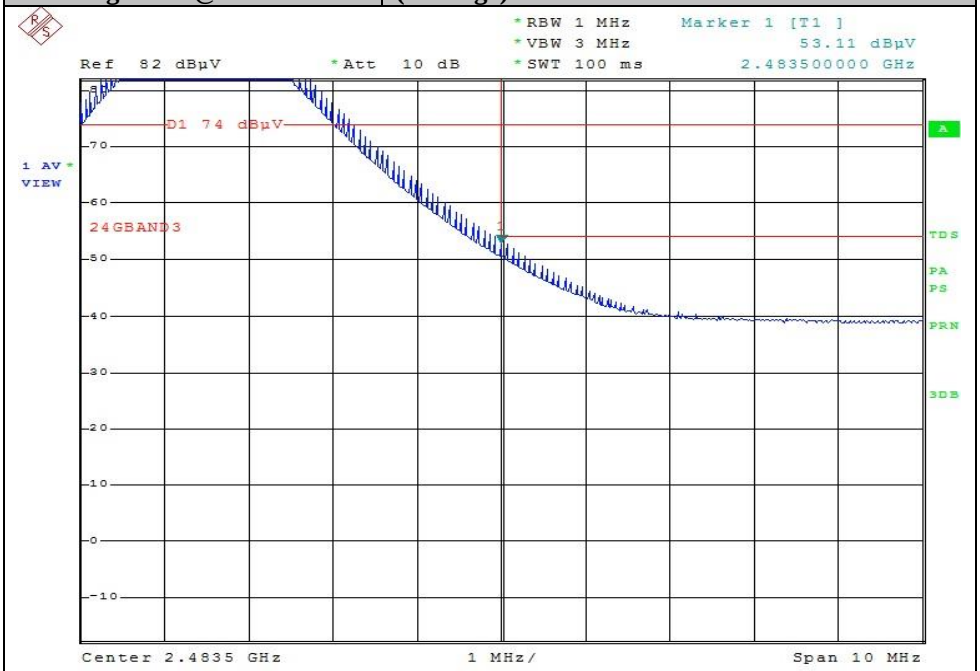
Plot Name: Radiated Emission Bandedge Test @ 2400MHz	Spurious @ Lower Band-edge_Vertical



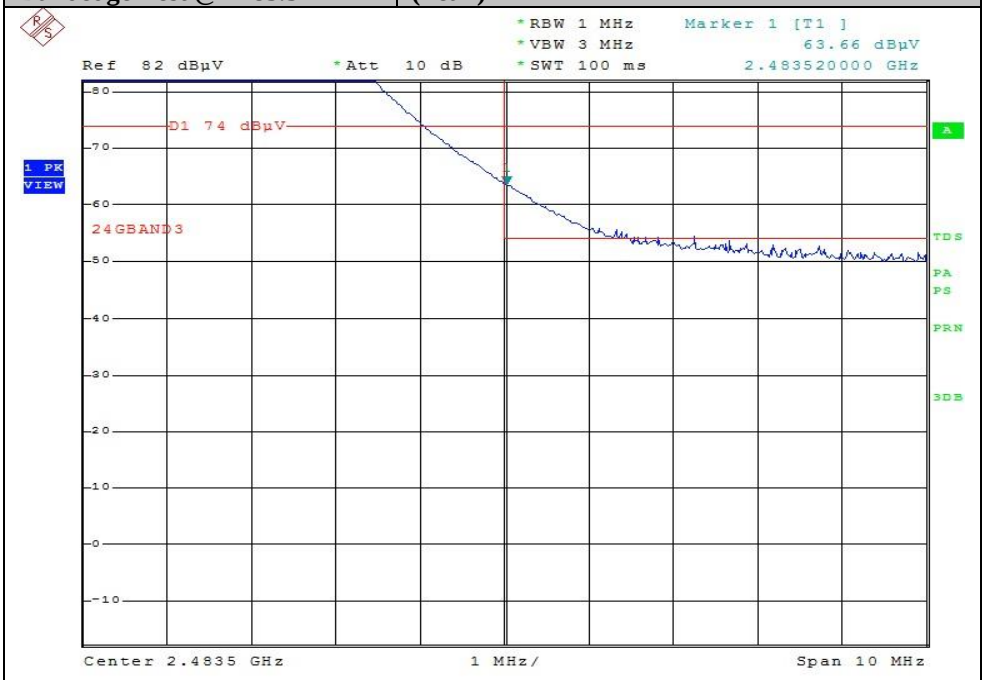
Plot Name: Radiated Emission Bandedge Test @ 2483.5MHz	Spurious @ High Band-edge_Horizontal (Peak)



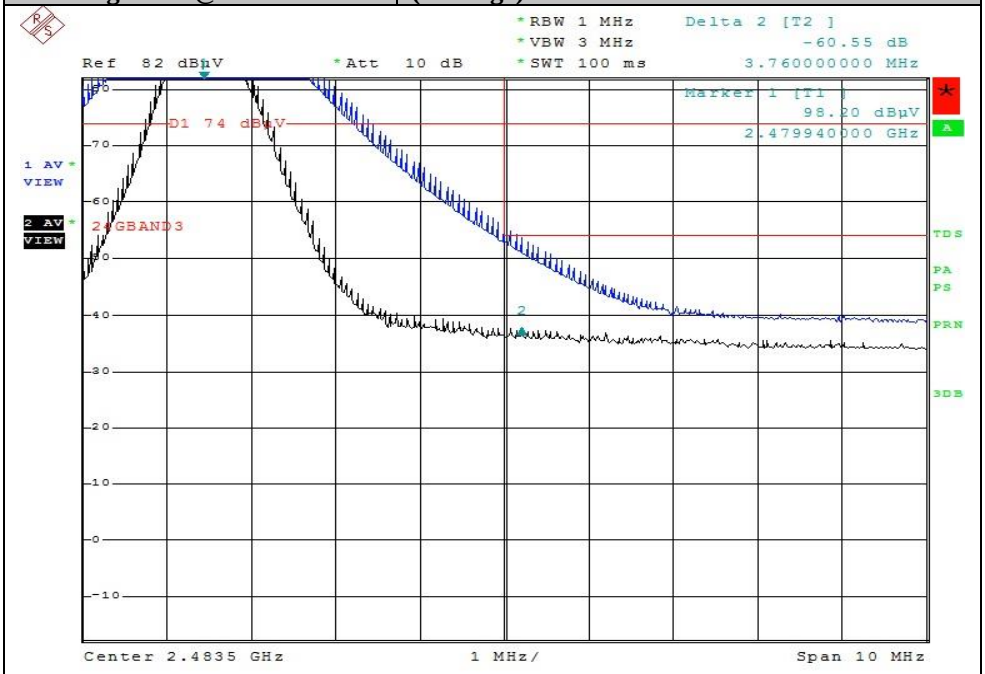
Plot Name: Radiated Emission Bandedge Test @ 2483.5MHz	Spurious @ High Band-edge_Horizontal (Average)



Plot Name: Radiated Emission Bandedge Test @ 2483.5MHz	Spurious @ High Band-edge_Vertical (Peak)



Plot Name: Radiated Emission Bandedge Test @ 2483.5MHz	Spurious @ High Band-edge_Vertical (Average)



Max. average reading=99.20-60.55=37.75dBuV/m under the limit 54dBuV/m

7.8 CONDUCTED EMISSION

7.8.1 Test Methods and Conditions

The EUT was under normal operational mode during the conducted emission test. EMI Receiver was scanned from 150KHz to 30MHz with maximum hold mode for maximum emission. Recorded data was sent to the plotter to generate output in linear format. At the input of the spectrum analyzer, a HP transient limiter is inserted for protective purpose. This limiter has a 10 dB attenuation in the range of 150KHZ to 30MHZ. That factor was automatically compensated by the receiver, so the readings are the corrected readings. The reference of the plot is the CISPR 22 Class B limit in following plots.

Conducted Emission Technical Requirements				
	Class A		**Class B**	
Frequency Range	**Quasi-Peak dBuV**	**Average dBuV**	**Quasi-Peak DBuV**	**Average dBuV**
150kHz –0.5MHz	79 (8912uV)	66 (1995uV)	66-56	56-46
0.5MHz-30MHz	73 (4467uV)	60 (1000uV)	---	---
0.5MHz- 5MHz	---	---	56	46 (250uV)
5MHz-30MHz	---	---	60	50

Emissions that have peak values close to the specification limit (if any) are also measured in the quasi-peak/average mode to determine compliance.

7.8.2 Test Data

The following plots show the neutral and line conducted emissions for the standard operation.

Highest Data for AC Line Conducted Emissions						
Frequency (MHz)	0.15 (Line)	0.34 (Line)	0.79 (Line)	0.17 (Neutral)	0.7 (Neutral)	0.81 (Neutral)
Peak Reading (dBuV)	39.18	33.52	32.51	37.15	34.57	34.69
Average Reading (dBuV*)						

* no need to show the average reading if the peak value is under average limit.

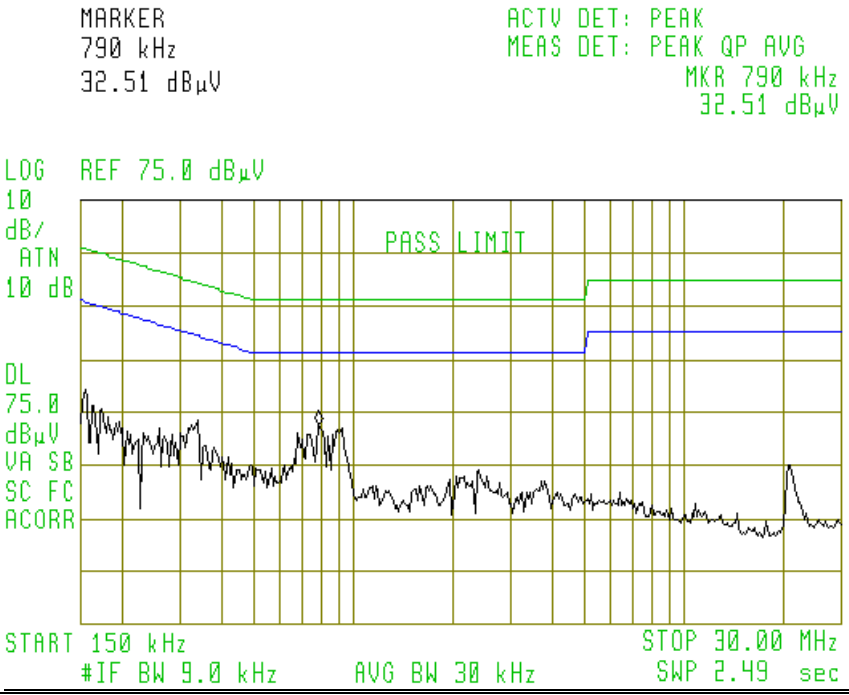
Test Personnel:

Tester Signature: _____

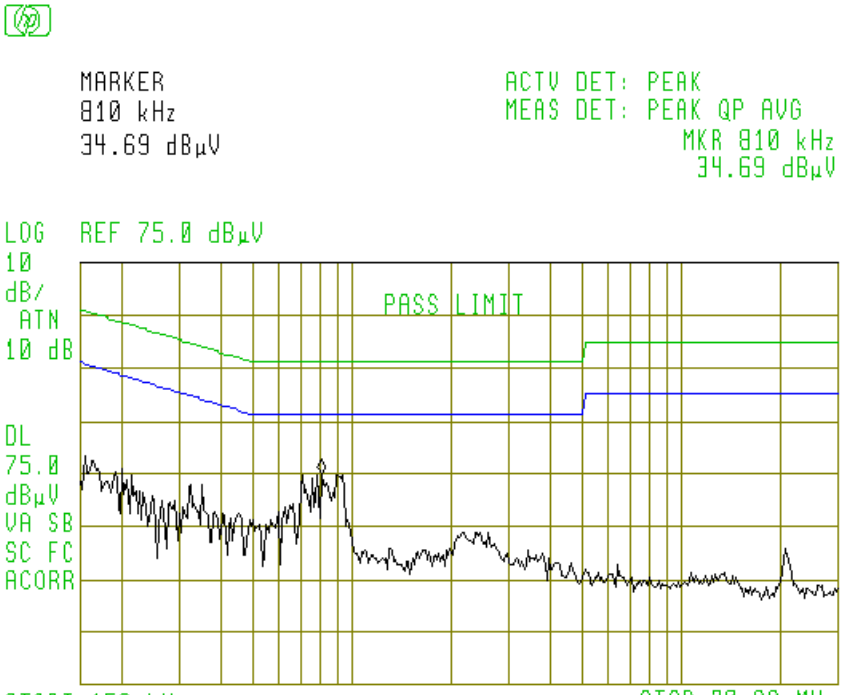
Edward Lee

Typed/Printed Name: _____ Date: : 10/18/19

LINE :150kHz- 30MHz



Neutral :150kHz- 30MHz



7.9 EUT RECEIVING MODE VERIFICATION

Radiated Test Data for Receiving Mode

Frequency (MHz)	Polarity (H,V))	Antenna Height (m)	Azimuth (Degree)	Peak Reading at 3m (2) (dBuV/m)	Peak Reading After Correction (dBuV/m)	FCC/IC 3m Limit (1) (dBuV/m)	Difference (dBuV/m)
175.8	H	1.8	180	33.5		43.5	-10.00
189.8	H	1.8	180	34.4		43.5	-9.1
478	H	1.0	135	35.1		46.5	-11.4
790	H	1.0	045	40.1		46.5	-6.4
910	H	1.0	045	41.8		46.5	-4.7
178.8	V	1.2	135	33.9		43.5	-9.6
192.8	V	1.1	000	35.1		43.5	-8.4
870	V	1.1	000	41.0		46.5	-5.5
910	V	1.1	270	41.3		46.5	-5.2

(1) Receiving mode spurious emissions shall be lower than the limit defined in FCC Sec. 15.209 & IC RSS-GEN.
(2) If the peak reading is less than the FCC/IC quasi-peak or average limit, it'll be not necessary to show the measured/ calculated quasi-peak or average reading.

Radiated Test Data for Digital Circuitry Operation Mode

Frequency (MHz)	Polarity (H,V))	Antenna Height (m)	Azimuth (Degree)	Peak Reading at 3m (2) (dBuV/m)	Peak Reading After Correction (dBuV/m)	FCC/IC 3m Limit (1) (dBuV/m)	Difference (dBuV/m)

NOT APPLICABLE