

TEST REPORT

Report Number: 103985132MPK-001
Project Number: G103985132
Original Issue Date: August 07, 2019
Revision Issue Date: March 26, 2020

Testing performed on
Philips Sonicare DiamondClean
Model Tested: HX991B, HX991W

FCC ID: 2ADZNHX991
IC: 20109-HX991

to

FCC Part 15 Subpart C (15.247)
Industry Canada RSS-247 Issue 2
FCC Part 15, Subpart B
Industry Canada ICES-003

For

Philips Oral Healthcare LLC

Test Performed by:
Intertek
1365 Adams Court
Menlo Park, CA 94025 USA

Test Authorized by:
Philips Oral Healthcare LLC
22100 Bothell Everett Highway
Bothell, WA 98021 USA

Prepared by:


Minh Ly

Date: August 07, 2019

Reviewed by:



Krishna K Vemuri

Date: August 07, 2019

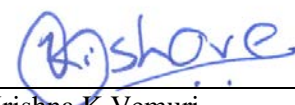
This report is for the exclusive use of Intertek's Client and is provided pursuant to the agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this report. Only the Client is authorized to copy or distribute this report and then only in its entirety. Any use of the Intertek name or one of its marks for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. The observations and test results in this report are relevant only to the sample tested. This report by itself does not imply that the material, product, or service is or has ever been under an Intertek certification program. This report must not be used to claim product endorsement by A2LA, NIST nor any other agency of the U.S. Government.

Report No. 103985132MPK-001	
Equipment Under Test:	Philips Sonicare DiamondClean
Trade Name:	Philips Oral Healthcare LLC
Model Tested Number:	HX991B, HX991W
Applicant:	Philips Oral Healthcare LLC
Contact:	Matthew Vasa
Address:	Philips Oral Healthcare LLC 22100 Bothell Everett Highway Bothell, WA 98021
Country:	USA
Tel. Number:	(425) 482-8367
Email:	matthew.vasa@philips.com
Applicable Regulation:	FCC Part 15 Subpart C (15.247) Industry Canada RSS-247 Issue 2 FCC Part 15, Subpart B Industry Canada ICES-003 Issue 6
Date of Test:	July 11 – 26, 2019

We attest to the accuracy of this report:



Mih Ly
Project Engineer



Krishna K Vemuri
Engineering Team Lead

TABLE OF CONTENTS

1.0 Summary of Tests 4

2.0 General Information 5

2.1 Product Description 5

2.2 Related Submittal(s) Grants 6

2.3 Test Facility 6

2.4 Test Methodology 6

2.5 Measurement Uncertainty 6

3.0 System Test Configuration 7

3.1 Support Equipment 7

3.2 Block Diagram of Test Setup 7

3.3 Justification 8

3.4 Software Exercise Program 8

3.5 Mode of Operation during Test 8

3.6 Modifications Required for Compliance 8

3.7 Additions, Deviations and Exclusions from Standards 8

4.0 Measurement Results 9

4.1 6-dB Bandwidth and 99% Occupied Bandwidth 9

4.2 Maximum Peak Conducted Output Power at Antenna Terminals 16

4.3 Maximum Power Spectral Density 20

4.4 Out of Band Antenna Conducted Emission 24

4.5 Transmitter Radiated Emissions 29

4.6 Radiated Emissions on Digital Parts 43

4.7 AC Line Conducted Emission 48

5.0 List of Test Equipment 49

6.0 Document History 50

Annex A - Duty Cycle Measurement 51

1.0 Summary of Tests

Test	Reference FCC	Reference Industry Canada	Result
RF Output Power	15.247(b)(3)	RSS-247, 5.4.d)	Complies
6 dB Bandwidth	15.247(a)(2)	RSS-247, 5.2.a)	Complies
Power Density	15.247(e)	RSS-247, 5.2.b)	Complies
Out of Band Antenna Conducted Emission	15.247(d)	RSS-247, 5.5	Complies
Transmitter Radiated Emissions	15.247(d), 15.209, 15.205	RSS-247, 5.5	Complies
AC Line Conducted Emission	15.207	RSS-GEN	Not Applicable – EUT is battery operated and does not operate while charging
Antenna Requirement	15.203	RSS-GEN	Complies (Internal Antenna)
Radiated Emissions	15.109	ICES-003	Complies
AC Line Conducted Emission	15.107	ICES-003	Not Applicable – EUT is battery operated and does not operate while charging

EUT receive date: July 11, 2019

EUT receive condition: The pre-production version of the EUT was received in good condition with no apparent damage. As declared by the Applicant, it is identical to the production units.

Test start date: July 11, 2019

Test completion date: July 26, 2019

The test results in this report pertain only to the item tested.

2.0 General Information

2.1 Product Description

Philips Oral Healthcare LLC supplied the following description of the EUT:

The HX991B/ HX991W is a battery powered rechargeable toothbrush with Bluetooth and NFC.

For more information, refer to the following product specification, declared by the manufacturer.

Information about the 2.4 GHz radio is presented below:

Applicant	Philips Oral Healthcare LLC
Model Tested No.	HX991B, HX991W
FCC Identifier	2ADZNHX991
IC Identifier	20109-HX991
Type of transmission	Digital Transmission System (DTS)
Rated RF Output	-1.93 dBm
Antenna(s) & Gain	Internal Antenna, Peak Gain: 0 dBi
Frequency Range	2402 – 2480 MHz
Type of modulation/data rate	GFSK 1MB/s
Number of Channel(s)	40, Channel 0-39
Applicant Name & Address	Philips Oral Healthcare LLC 22100 Bothell Everett Highway Bothell, WA 98021 USA

2.2 Related Submittal(s) Grants

None.

2.3 Test Facility

The test site used to collect the radiated data is site 1 (10-m semi-anechoic chamber). This test facility and site measurement data have been fully placed on file with the FCC, IC and A2LA accredited.

2.4 Test Methodology

Antenna conducted measurements were performed according to the FCC documents “Guidance for Performing Compliance Measurement on Digital Transmission Systems (DTS) Operating under §15.247” (KDB 558074 D01 DTS Meas Guidance v05r02), and RSS-247 Issue 2, RSS-GEN Issue 5.

Radiated emissions and AC mains conducted emissions measurements were performed according to the procedures in ANSI C63.10: 2013. Radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the "Data Sheet" of this report.

2.5 Measurement Uncertainty

Compliance with the limits was based on the results of the measurements and doesn't take into account the measurement uncertainty.

Estimated Measurement Uncertainty

Measurement	Expanded Uncertainty (k=2)		
	0.15 MHz – 1 GHz	1 GHz – 2.5 GHz	> 2.5 GHz
RF Power and Power Density – antenna conducted	-	0.7 dB	-
Unwanted emissions - antenna conducted	1.1 dB	1.3 dB	1.9 dB
Bandwidth – antenna conducted	-	30 Hz	-

Measurement	Expanded Uncertainty (k=2)			
	0.15 MHz – 30MHz	30 – 200 MHz	200 MHz – 1 GHz	1 GHz – 18 GHz
Radiated emissions	-	4.7	4.6	5.1 dB
AC mains conducted emissions	2.1 dB	-	-	-

3.0 System Test Configuration

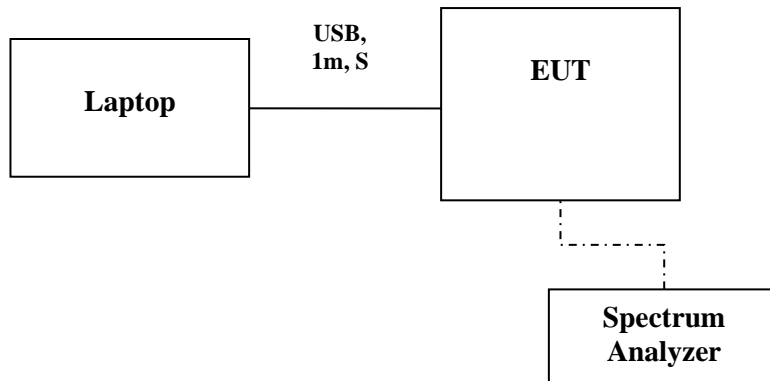
3.1 Support Equipment

Support Equipment		
Description	Manufacturer	Model Tested Number
Laptop	HP	ELITEBOOK 840

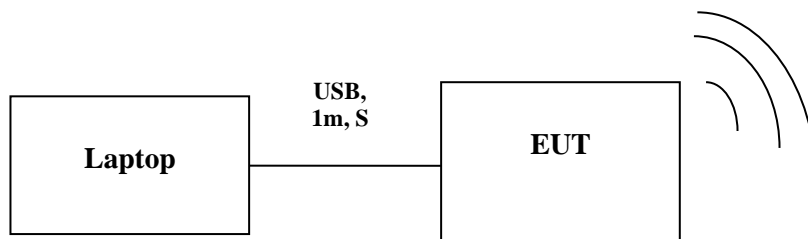
3.2 Block Diagram of Test Setup

Equipment Under Test			
Description	Manufacturer	Model	Serial Number
Radiated Sample	Philips Oral Healthcare LLC	HX991B	MPK1907111021-003
Conducted Sample	Philips Oral Healthcare LLC	HX991B	MPK1907111021-001

Antenna was removed and co-axial connector with a cable was installed for Conducted Measurements.



Radiated Measurements SETUP



S = Shielded	F = With Ferrite
U = Unshielded	m = Length in Meters

3.3 Justification

For radiated emission measurements the EUT is placed on a non-conductive table. The EUT was configured to continuously transmit. The highest clock frequency used in the EUT is less than 2.5 GHz.

Per manufacture, model HX991B (Black) and HX991W (White) are identical in hardware and material except for the different color.

3.4 Software Exercise Program

The EUT exercise program used during radiated and conducted testing was provided by Philips Oral Healthcare LLC

3.5 Mode of Operation during Test

Mode of operation during the tests was setup using a laptop which allows controlling the radio by test software. During the transmitter tests, the transmitter was setup to transmit maximum communication and RF power levels.

EUT was placed into transmit mode at the lowest (2402MHz) middle (2440MHz), and highest (2480MHz) channels.

3.6 Modifications Required for Compliance

No modifications were made by the manufacturer or Intertek to the EUT in order to bring the EUT into compliance.

3.7 Additions, Deviations and Exclusions from Standards

No additions, deviations or exclusions from the standard were made.

4.0 Measurement Results

4.1 6-dB Bandwidth and 99% Occupied Bandwidth
FCC Rule: 15.247(a)(2); RSS-247, 5.2.a) and RSS-GEN;

4.1.1 Requirement

The minimum 6-dB bandwidth shall be at least 500 kHz

4.1.2 Procedure

A spectrum analyzer was connected to the antenna port of the transmitter.

For FCC 6dB Channel Bandwidth the Procedure described in the FCC Publication KDB 558074 D01 Meas Guidance v05r02 was used to determine the DTS occupied bandwidth. Section 11.8.1 Option 1 of ANSI 63.10 was used.

1. Set RBW = 100 kHz.
2. Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize.
7. 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.

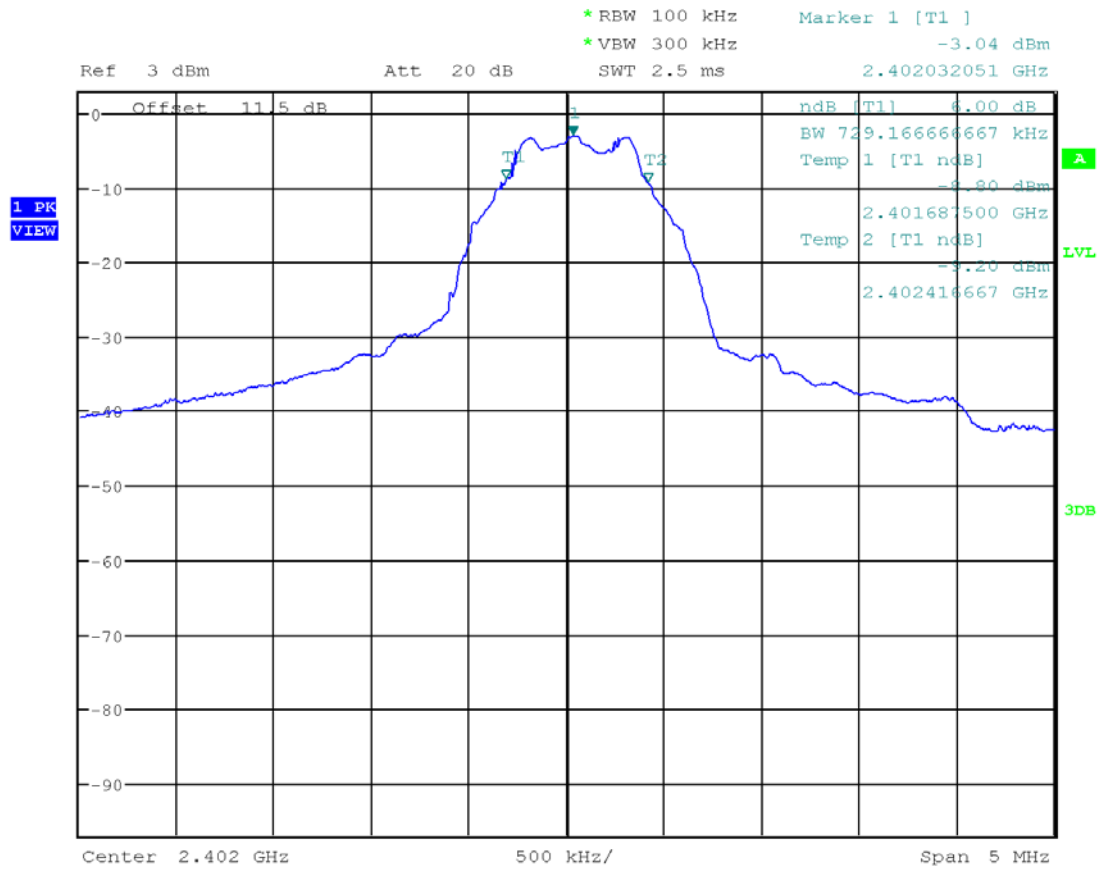
For 99% power bandwidth measurement, the bandwidth was determined by using the built-in 99% occupied bandwidth function of the spectrum analyzer. The resolution bandwidth is set to 1% of the selected span as is without being below 1%. The video bandwidth shall be set to 3 times the resolution bandwidth.

4.1.3 Test Result

Frequency (MHz)	6-dB bandwidth FCC 15.247 & RSS-GEN	Occupied bandwidth, RSS-GEN	Plot
MHz	kHz	MHz	
2402	729.1	--	1.1
	--	1.065	1.4
2440	721.1	--	1.2
	--	1.057	1.5
2480	729.1	--	1.3
	--	1.057	1.6

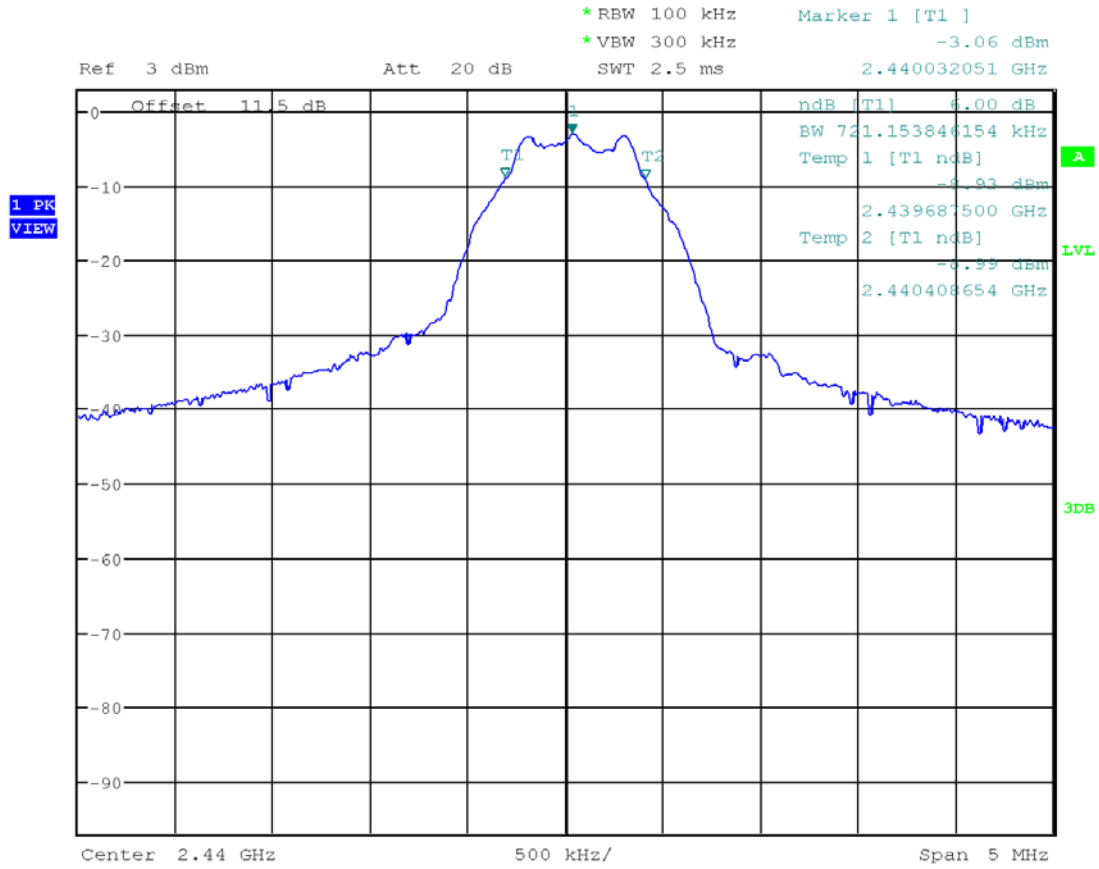
Tested By	Test Date
Minh Ly	July 15, 2019

Plot 1. 1



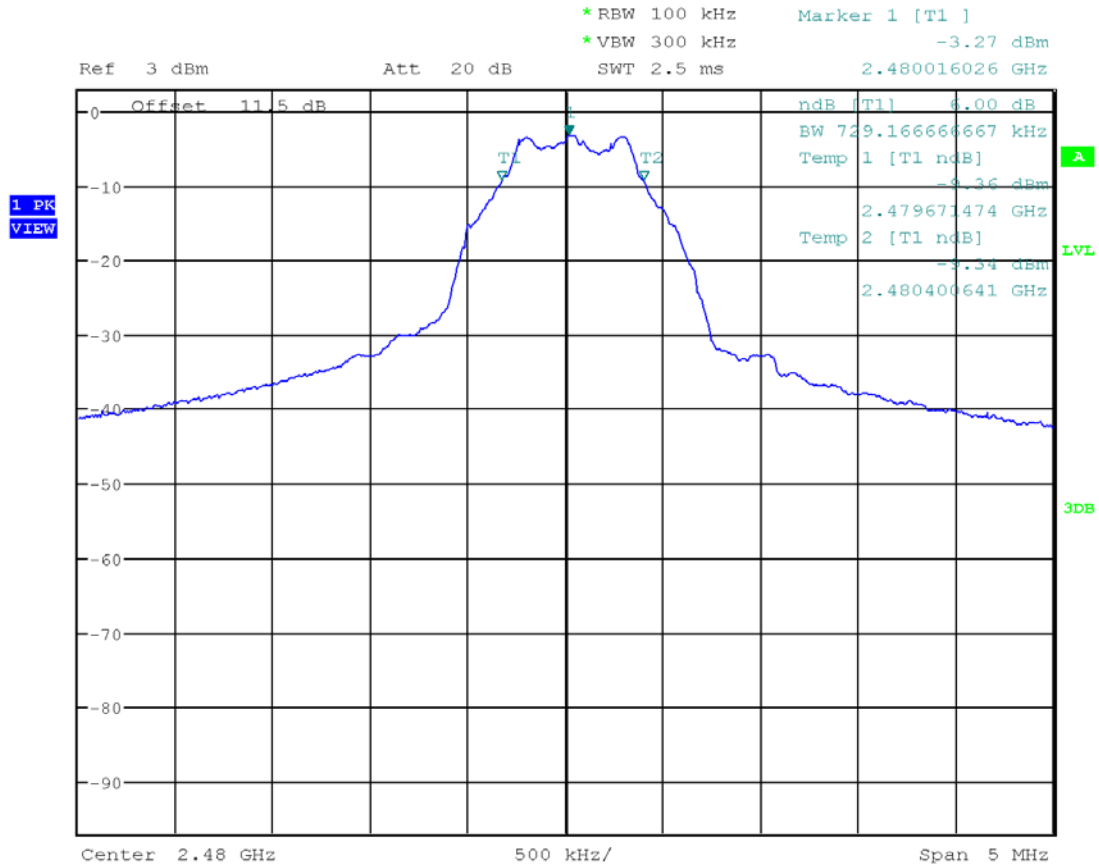
Date: 15.JUL.2019 16:53:25

Plot 1.2



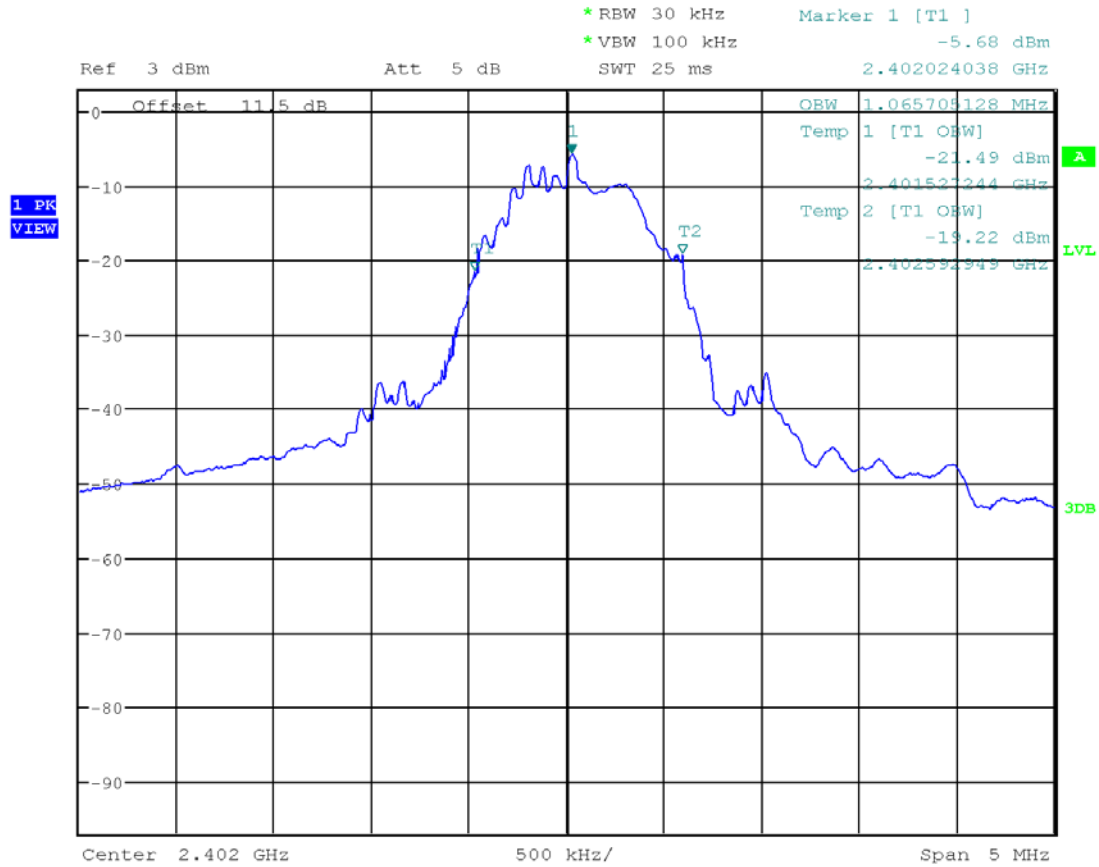
Date: 15.JUL.2019 16:54:18

Plot 1.3



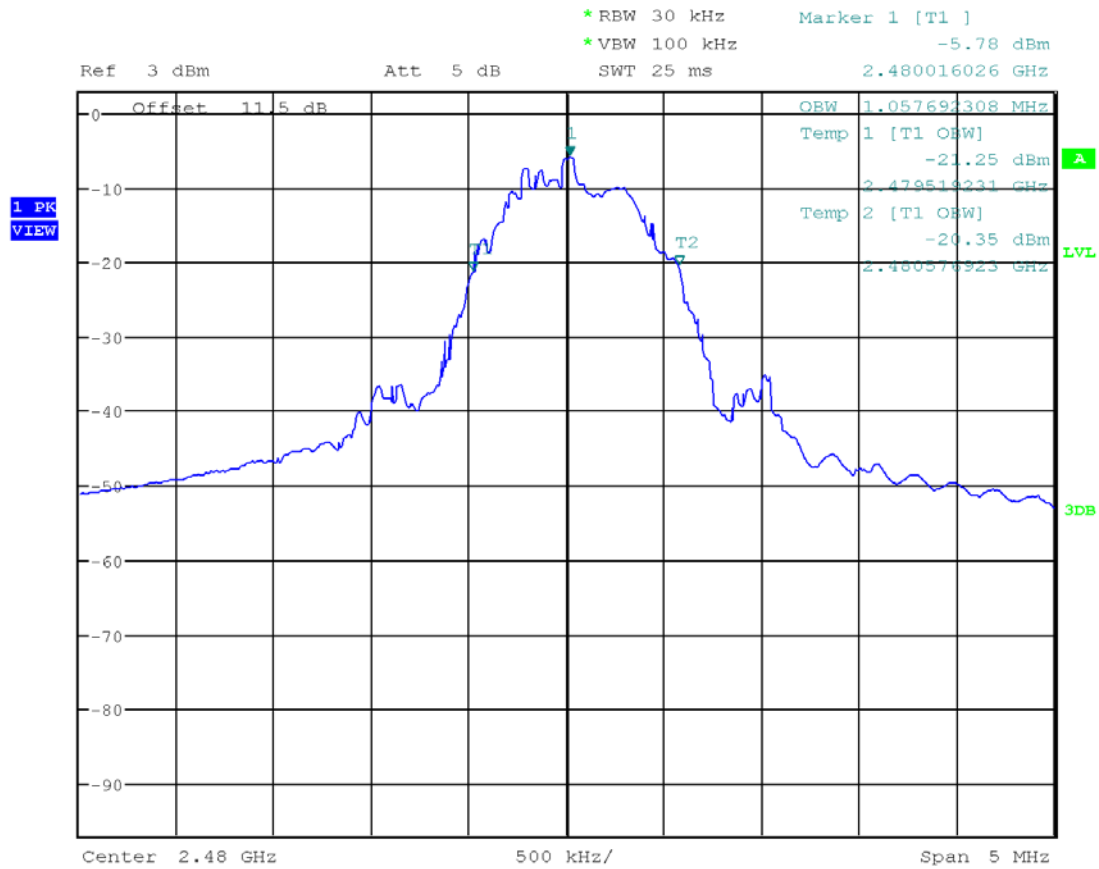
Date: 15.JUL.2019 16:55:47

Plot 1.4



Date: 15.JUL.2019 16:57:55

Plot 1.6



Date: 15.JUL.2019 16:56:52

4.2 Maximum Peak Conducted Output Power at Antenna Terminals
FCC Rule: 15.247(b)(3); RSS-247, 5.4.d);

4.2.1 Requirement

For antennas with gains of 6 dBi or less, maximum allowed transmitter output is 1 watt or 30 dBm. For antennas with gains greater than 6 dBi, transmitter output level must be decreased appropriately, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

4.2.2 Procedure

The procedure described in FCC Publication KDB 558074 D01 Meas Guidance v05r02 was used. Specifically, section 11.9.1.1 $RBW \geq DTS$ bandwidth in ANSI 63.10.

1. Set the $RBW \geq DTS$ Bandwidth
2. Set the $VBW \geq 3 \times RBW$
3. Set the $span \geq 3 \times RBW$
4. Detector = Peak
5. Sweep time = Auto couple
6. Trace mode = Max Hold
7. Allow trace to fully stabilize
8. Use peak marker function to determine the peak amplitude level.

A spectrum analyzer was connected to the antenna port of the transmitter.

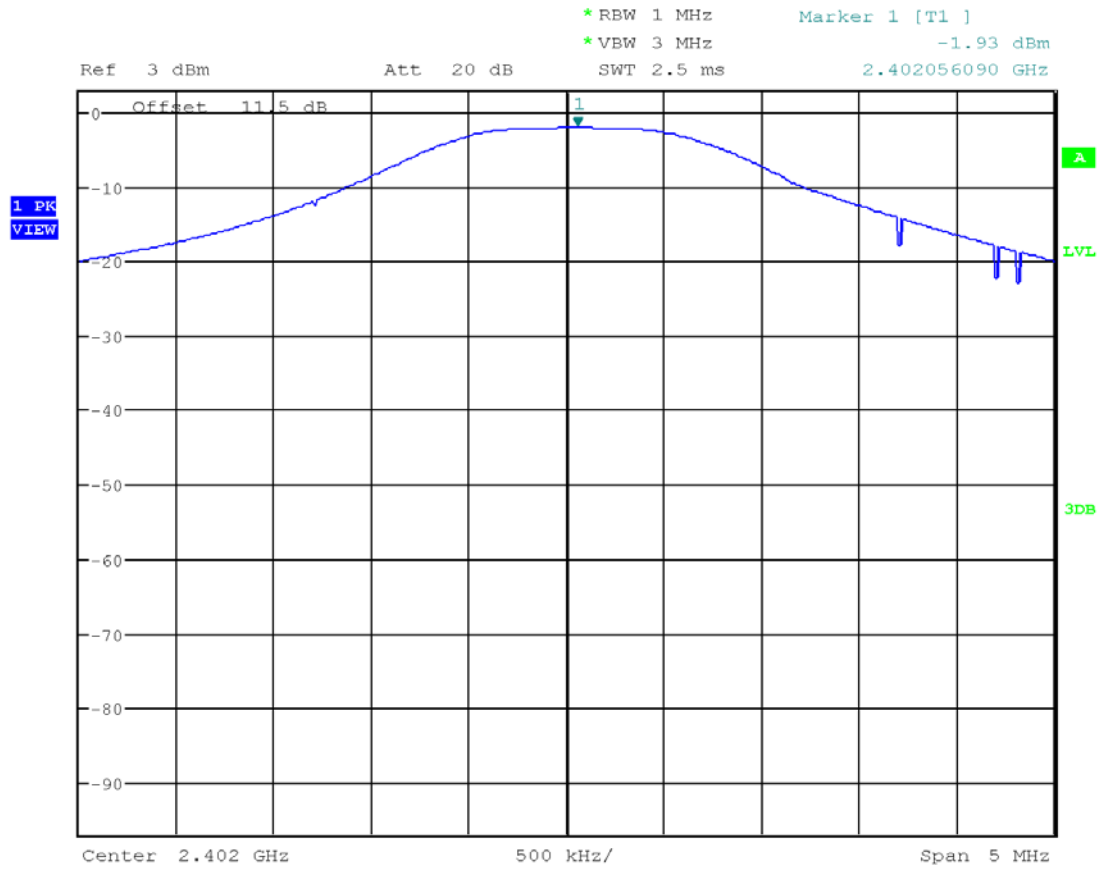
4.2.3 Test Result

Refer to the following plots 2.1 – 2.3 for the test details.

Frequency	Conducted Power (peak)		Plot
	MHz	dBm	
2402	-1.93	0.643	2.1
2440	-2.03	0.628	2.2
2480	-2.22	0.601	2.3

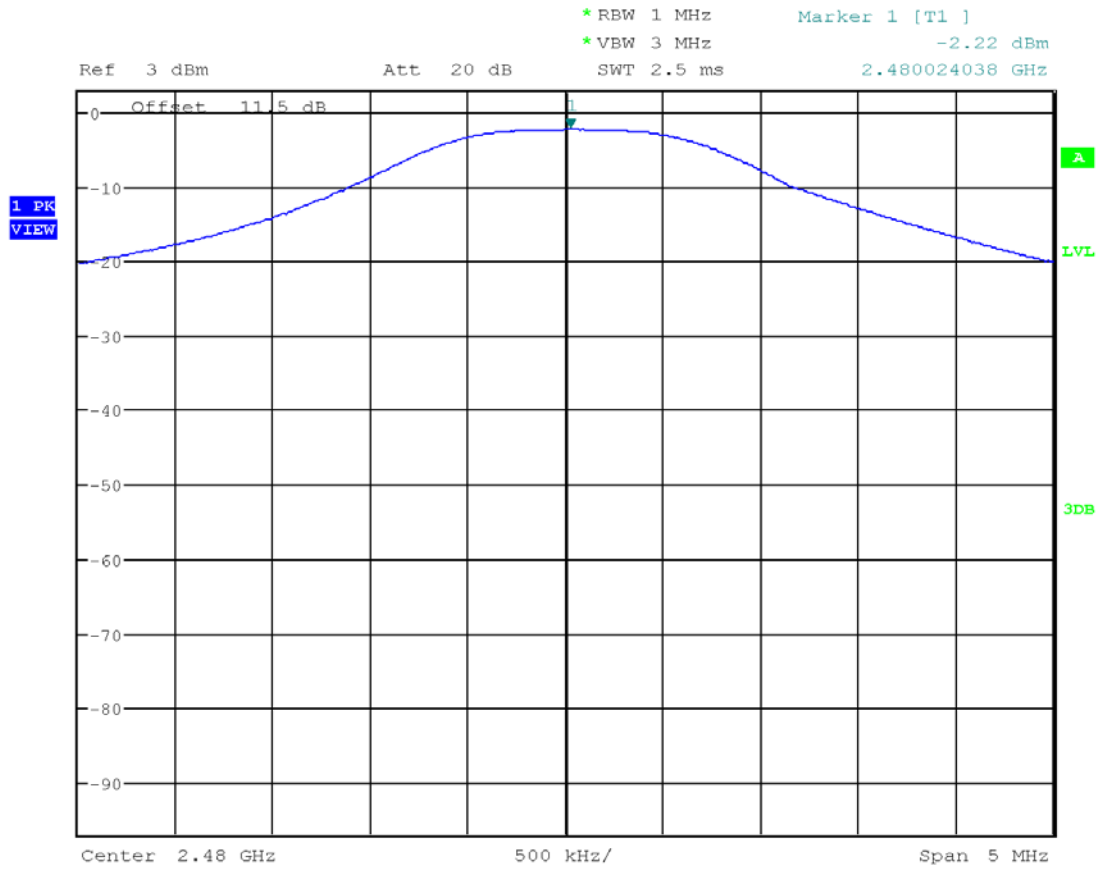
Tested By	Test Date
Minh Ly	July 15, 2019

Plot 2. 1



Date: 15.JUL.2019 16:45:24

Plot 2.3



Date: 15.JUL.2019 16:47:55

4.3 Maximum Power Spectral Density
FCC: 15.247 (e); RSS-247, 5.2.b);

4.3.1 Requirement

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna should not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.3.2 Procedure

A spectrum analyzer was connected to the antenna port of the transmitter.

The procedure described in FCC Publication KDB 558074 D01 Meas Guidance v05r02, specifically section 11.10.2 Method PKPSD (peak PSD) of ANSI 63.10.

1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the *DTS bandwidth*.
3. Set the RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
4. Set the VBW $\geq 3 \times \text{RBW}$.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

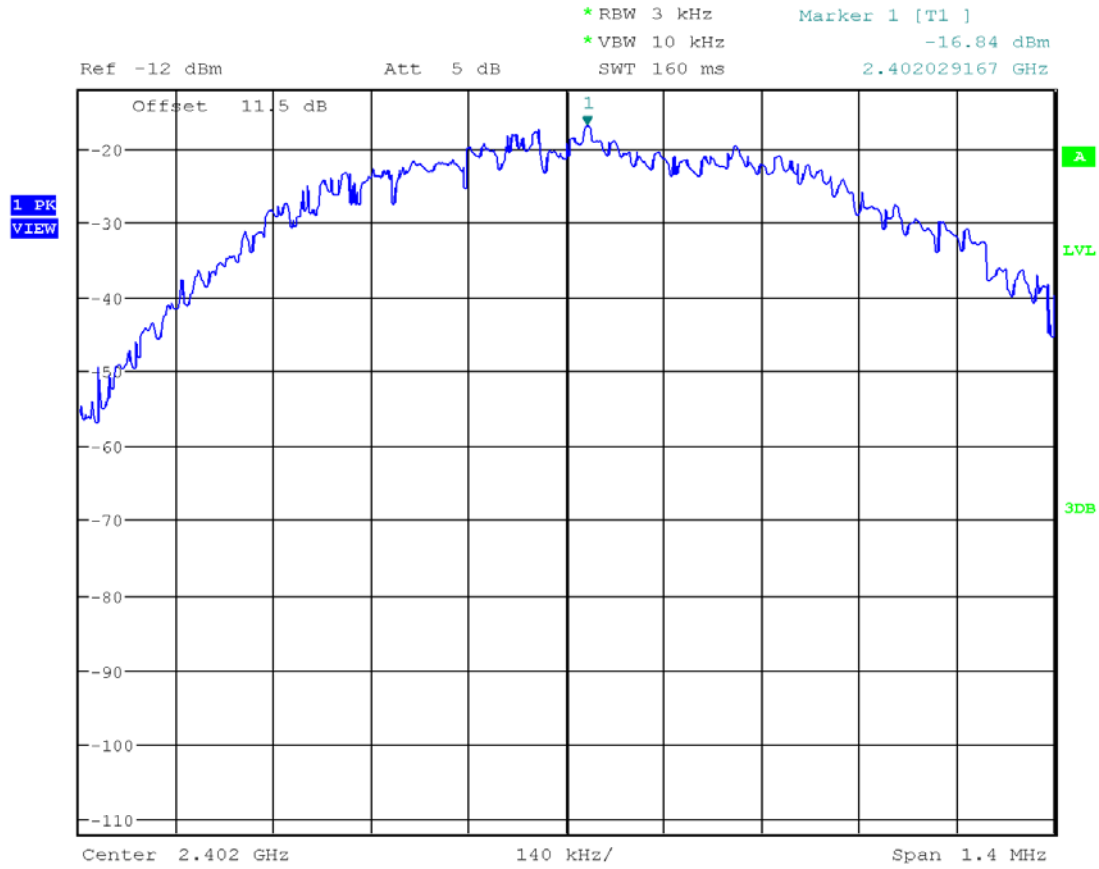
4.3.3 Test Result

Refer to the following plots for the test result

Frequency, MHz	Maximum Power Spectral Density dBm	Maximum Power Spectral Density Limit dBm	Margin dB	Plot
2402	-16.8	8.0	-24.8	3.1
2440	-17.0	8.0	-25.0	3.2
2480	-17.3	8.0	-25.3	3.3

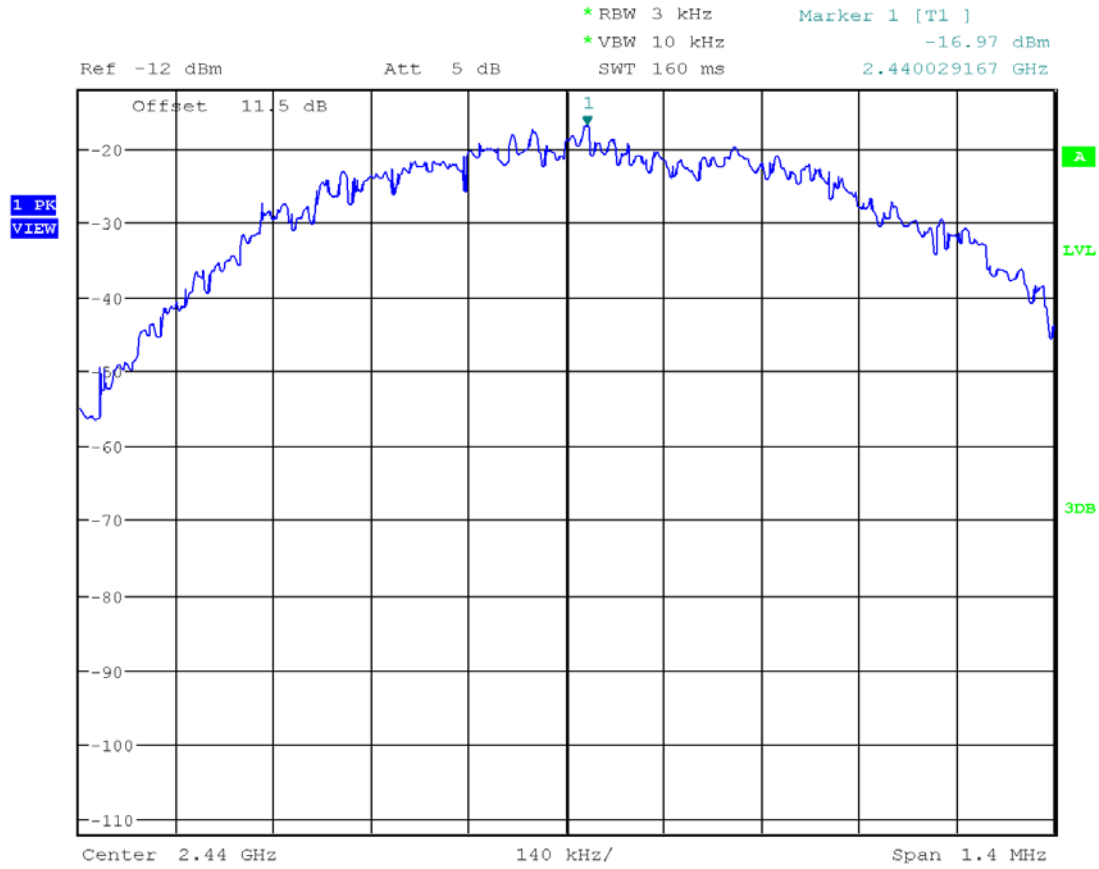
Tested By	Test Date
Minh Ly	July 02, 2019

Plot 3. 1



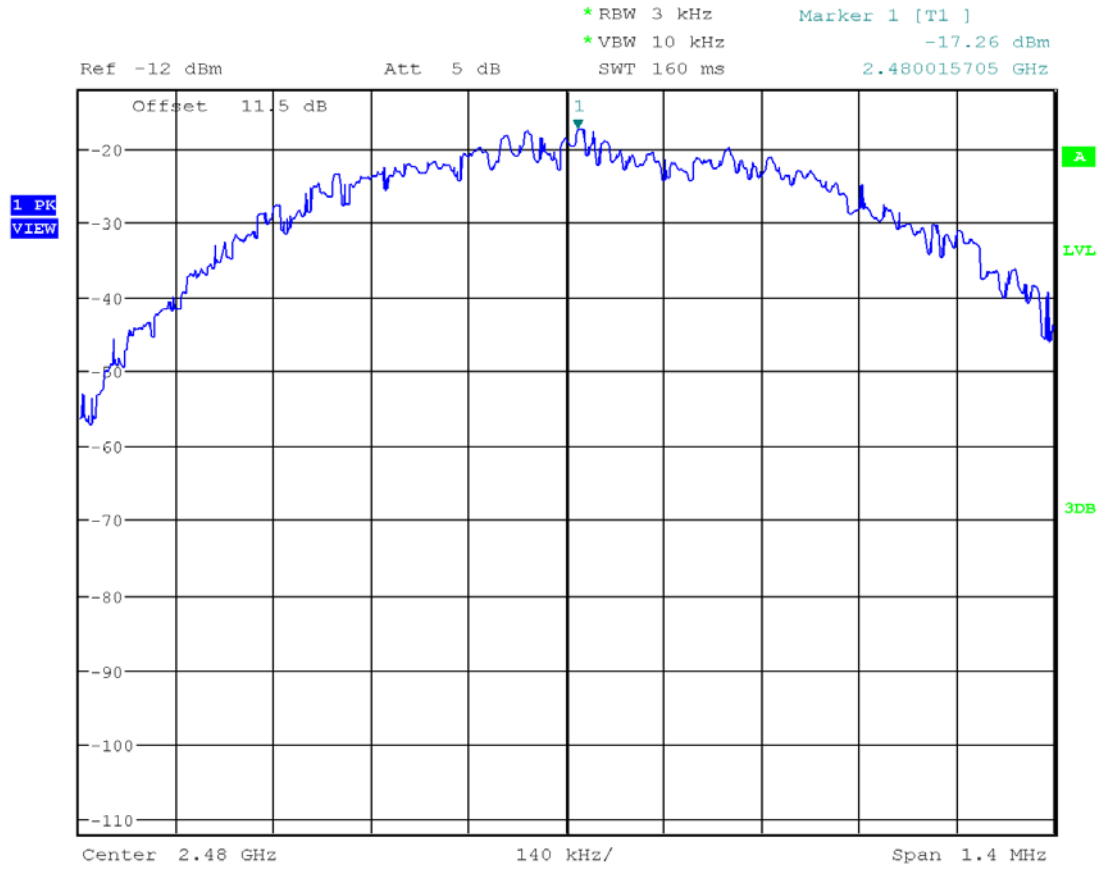
Date: 15.JUL.2019 16:50:57

Plot 3.2



Date: 15.JUL.2019 16:50:15

Plot 3.3



Date: 15.JUL.2019 16:49:24

4.4 Out of Band Antenna Conducted Emission
FCC: 15.247(d); RSS-247, 5.5;

4.4.1 Requirement

In any 100 kHz bandwidth outside the EUT pass-band, the RF power shall be below the maximum in-band 100 kHz emissions by at least 20 dB (if peak power of in-band emission is measured) or 30 dB (if average power of in-band emission is measured).

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)

4.4.2 Procedure

The procedure described in FCC Publication KDB 558074 D01 Meas Guidance v05r02, specifically section 11.11 DTS Emissions in non-restricted frequency bands of ANSI 63.10.

A spectrum analyzer was connected to the antenna port of the transmitter.

1. Set the RBW = 100 kHz.
2. Set the VBW $\geq 3 \times$ RBW.
3. Detector = peak.
4. Sweep time = auto couple.
5. Trace mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum amplitude level.

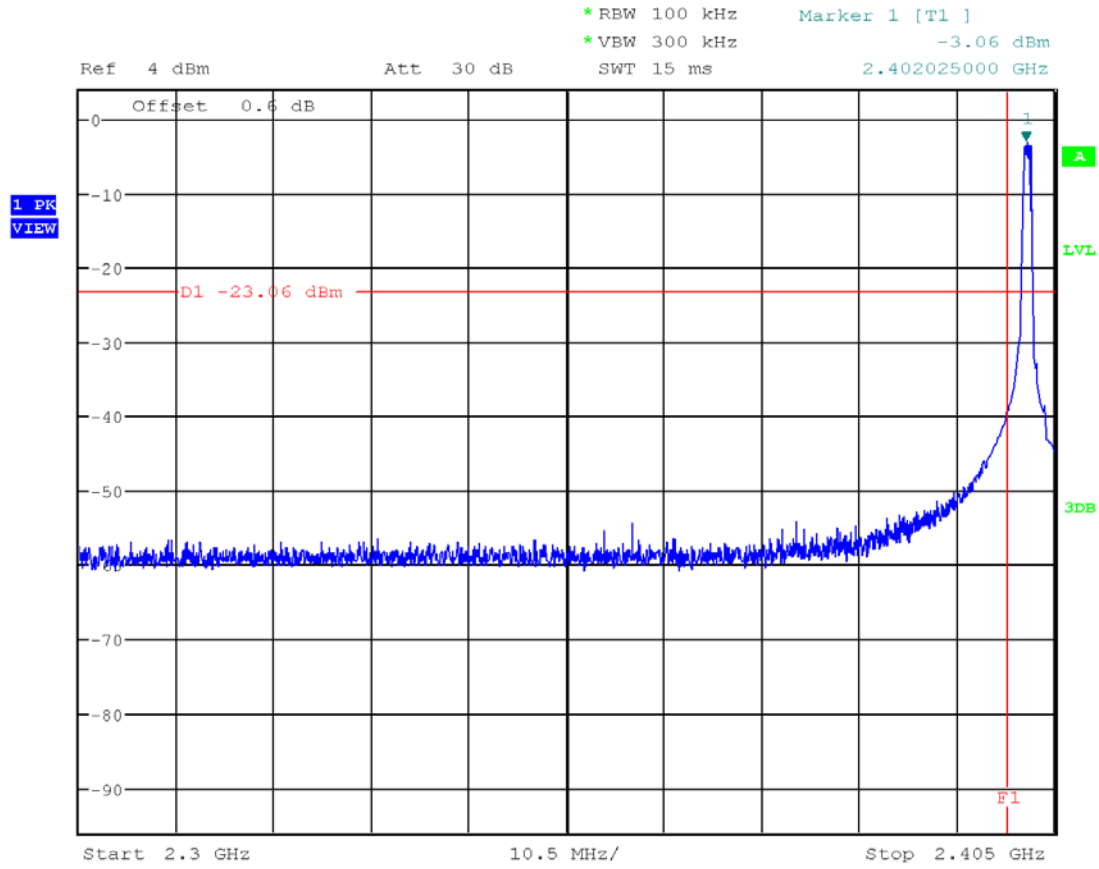
The unwanted emissions were measured from 30 MHz to 25 GHz. Plots below are corrected for cable loss and then compared to the limits.

4.4.3 Test Result

Refer to the following plots 4.1 – 4.5 for unwanted conducted emissions. The plot shows -20dB attenuation limit line.

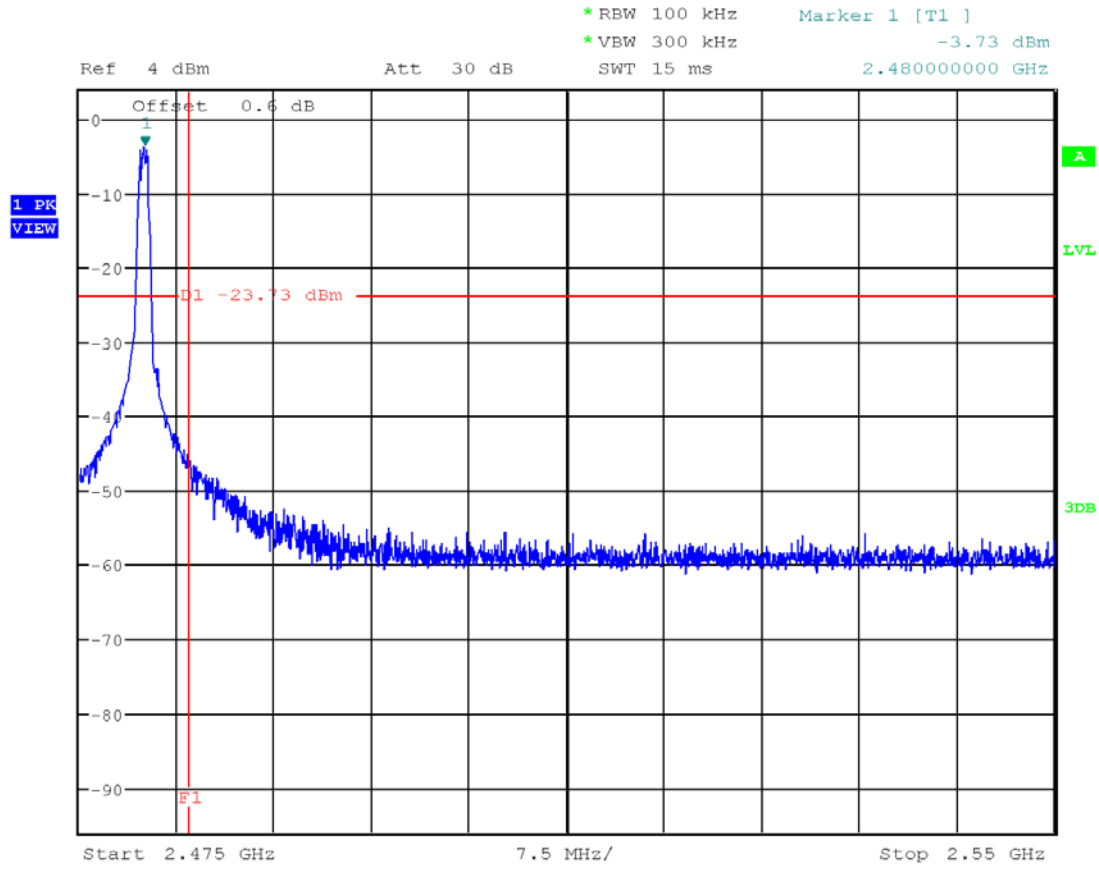
Tested By	Test Date
Minh Ly	July 16, 2019

Tx @ Low Channel, 2400 MHz Band Edge
Plot 4.1



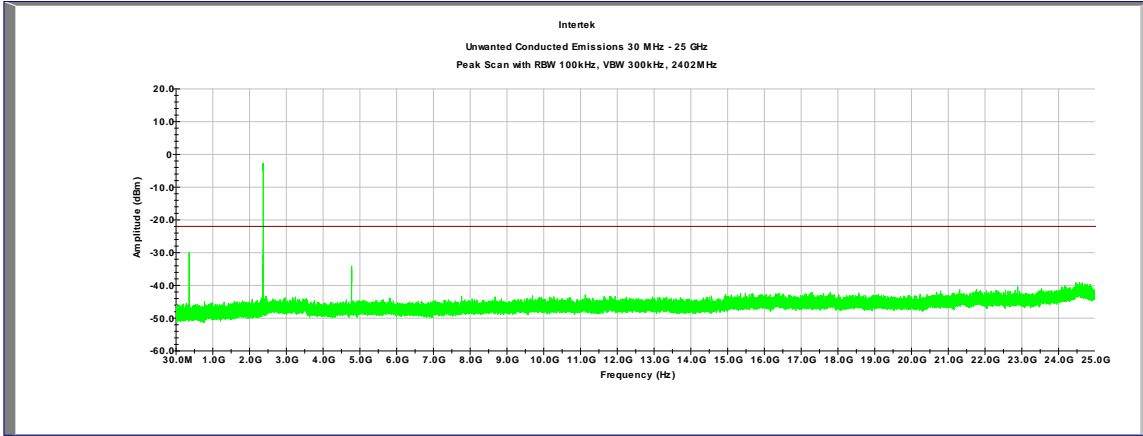
Date: 26.JUL.2019 15:52:45

Tx @ Low Channel, 2483.5 MHz Band Edge
Plot 4.2

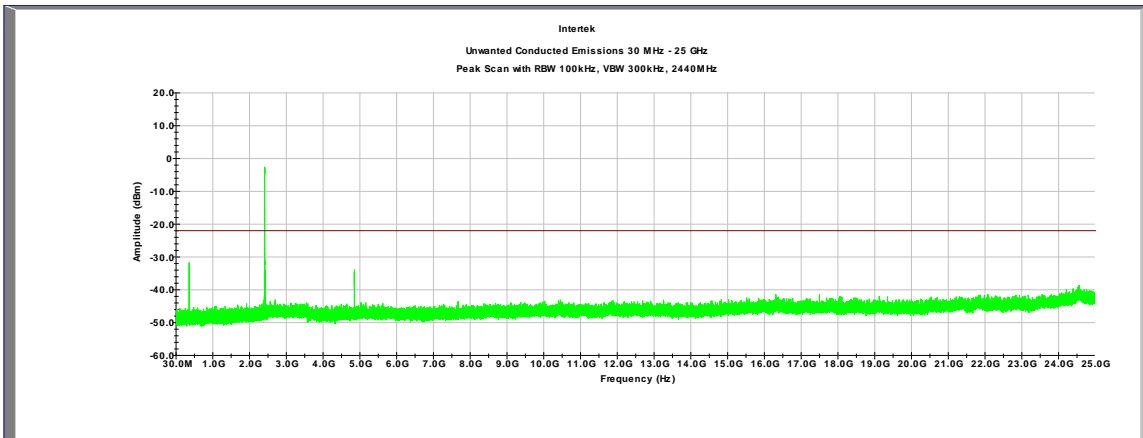


Date: 26.JUL.2019 15:51:02

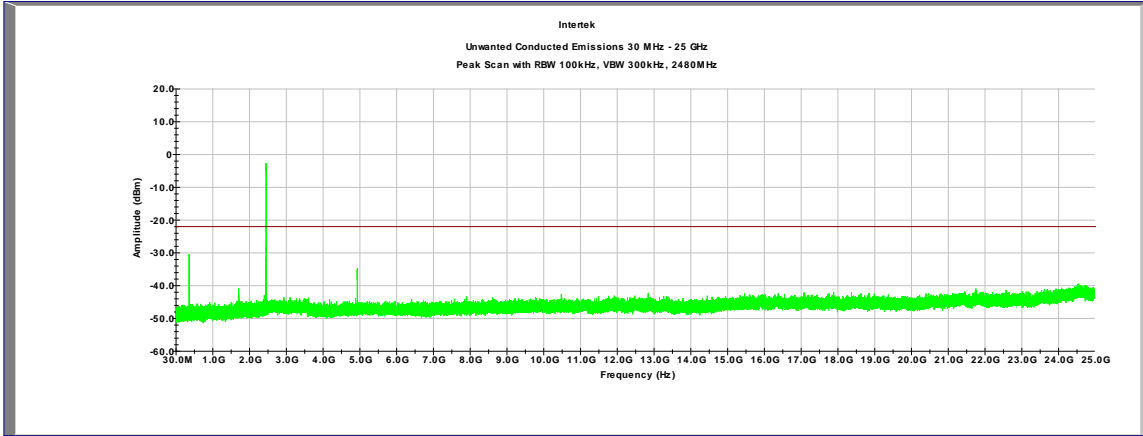
Tx @ Low Channel, 2402 MHz
30MHz -26GHz Conducted Spurious
Plot 4.3



Tx @ Mid Channel, 2440 MHz
30MHz -26GHz Conducted Spurious
Plot 4.4



Tx @ High Channel, 2480 MHz
30MHz -26GHz Conducted Spurious
Plot 4.5



4.5 Transmitter Radiated Emissions
FCC Rules: 15.247(d), 15.209, 15.205; RSS-247, 5.5;

4.5.1 Requirement

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)).

For out of band radiated emissions (except for frequencies in restricted bands), in any 100 kHz bandwidths outside the EUT pass-band, the RF power shall be at least 20dB (peak) or 30 dB (average) below that of the maximum in-band 100 kHz emissions.

4.5.2 Procedure

Radiated emission measurements were performed from 30 MHz to 25 GHz according to the procedure described in ANSI C63.10: 2013. Spectrum Analyzer Resolution Bandwidth is 100 kHz or greater for frequencies 30 MHz to 1000 MHz, 1 MHz for frequencies above 1000 MHz. Above 1000 MHz Peak and Average measurements were performed.

The EUT is placed on a plastic turntable that is 80 cm in height for below 1000MHz and 1.5m in height for above 1GHz. If the EUT attaches to peripherals, they are connected and operational (as typical as possible). During testing, all cables were manipulated to produce worst-case emissions. The signal is maximized through rotation. The antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters.

Radiated emissions are taken at 3 meters for frequencies above 1 GHz and at 10 meters for frequencies below 1 GHz.

Measurements made from 1 GHz to 18GHz had a 2.4-2.5GHz notch filter in place. A preamp was used from 30MHz to 26GHz.

All measurements were made with a Peak Detector and compared to QP limits for 30MHz – 1GHz and Average limits for 1GHz – 26GHz.

Average measurement in restricted frequency bands were measured according to the procedure described in ANSI C63.10:2013 Section 11.12.2.25.2.

Radiated measurements were performed on different orientation of the EUT. Data is presented with the worst-case configuration (the configuration which resulted in the highest emission levels).

4.5.3 Field Strength Calculation

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$FS = RA + AF + CF - AG$; if measurement is performed at a distance other than specified in the rule, a Distance Correction Factor (DCF) shall be added.

Where FS = Field Strength in dB(μ V/m)

RA = Receiver Amplitude (including preamplifier) in dB(μ V); AF = Antenna Factor in dB(1/m)

CF = Cable Attenuation Factor in dB; AG = Amplifier Gain in dB

Assume a receiver reading of 52.0 dB(μ V) is obtained. The antennas factor of 7.4 dB(1/m) and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving field strength of 32 dB(μ V/m). This value in dB(μ V/m) was converted to its corresponding level in μ V/m.

RA = 52.0 dB(μ V)

AF = 7.4 dB(1/m)

CF = 1.6 dB

AG = 29.0 dB

$FS = 52.0 + 7.4 + 1.6 - 29.0 = 32$ dB(μ V/m).

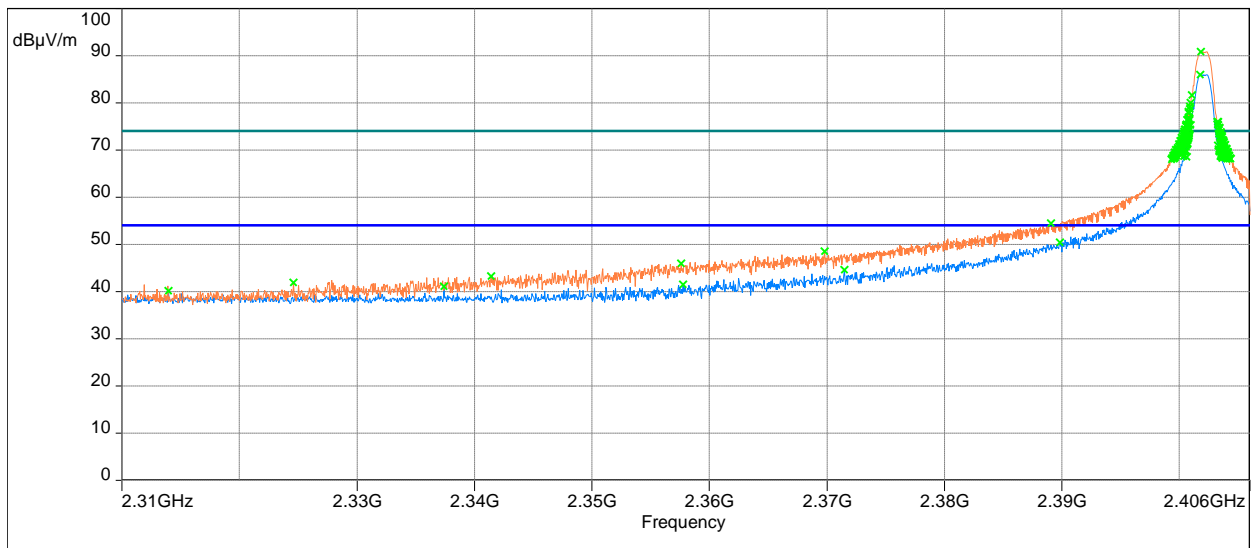
Level in μ V/m = Common Antilogarithm [(32 dB μ V/m)/20] = 39.8 μ V/m.

4.5.4 Test Results

Tested By	Test Date
Minh Ly	July 11 - 26, 2019

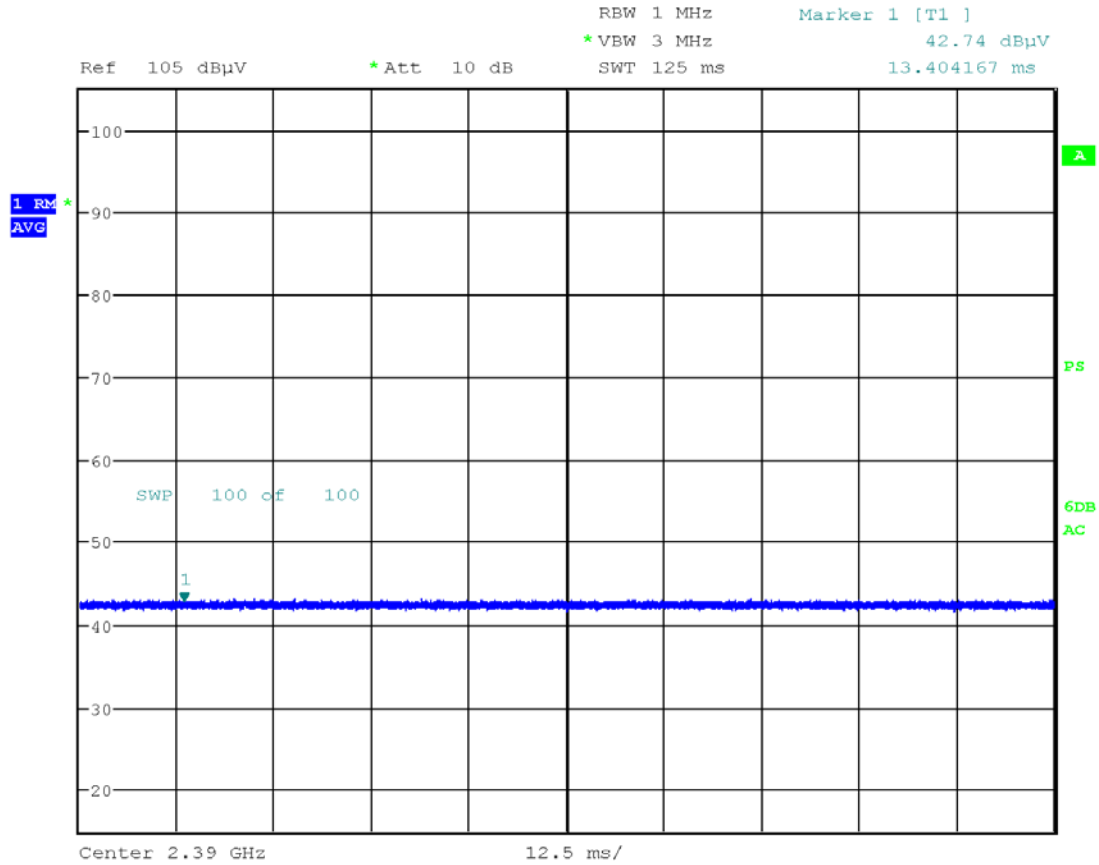
**Out-of-Band Radiated spurious emissions at the Band-edge @3m distance
2310–2390 MHz, Peak Scan with Average Limit
EUT in Horizontal Position**

- FCC Part 15/FCC Part 15.209 1GHz to 40GHz - Average/3.0m/
- FCC Part 15/FCC Part 15.209 1GHz to 40GHz - Peak/3.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- x Peak (Peak /Lim. Peak) (Horizontal)
- x Peak (Peak /Lim. Peak) (Vertical)



Model: ; Client: ; Comments: ; Test Date: 07/26/2019 20:33

Band Edge Measurement at 2390MHz, Horizontal

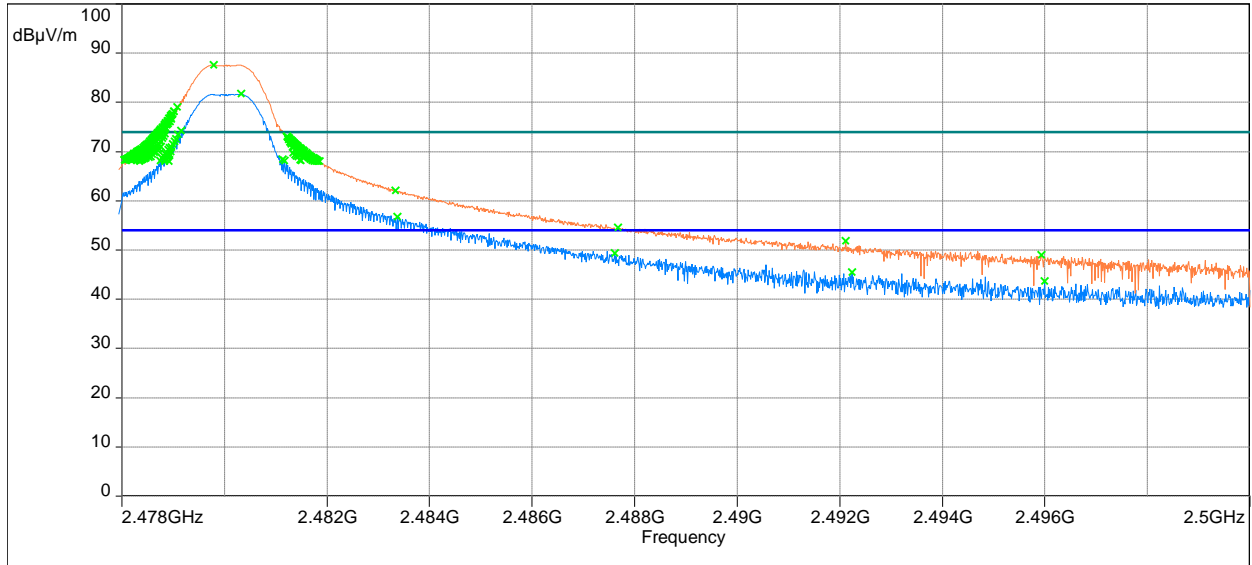


Date: 26.JUL.2019 20:36:10

Frequency (MHz)	Average (dBμV/m)	Ave Limit (dBμV/m)	Margin (dB)	Angle (°)	Height (m)	Polarity	Raw (dBuV)	Correction (dB)
2390.0	27.6	54	-26.4	83	1.91	Horizontal	42.74	-15.14

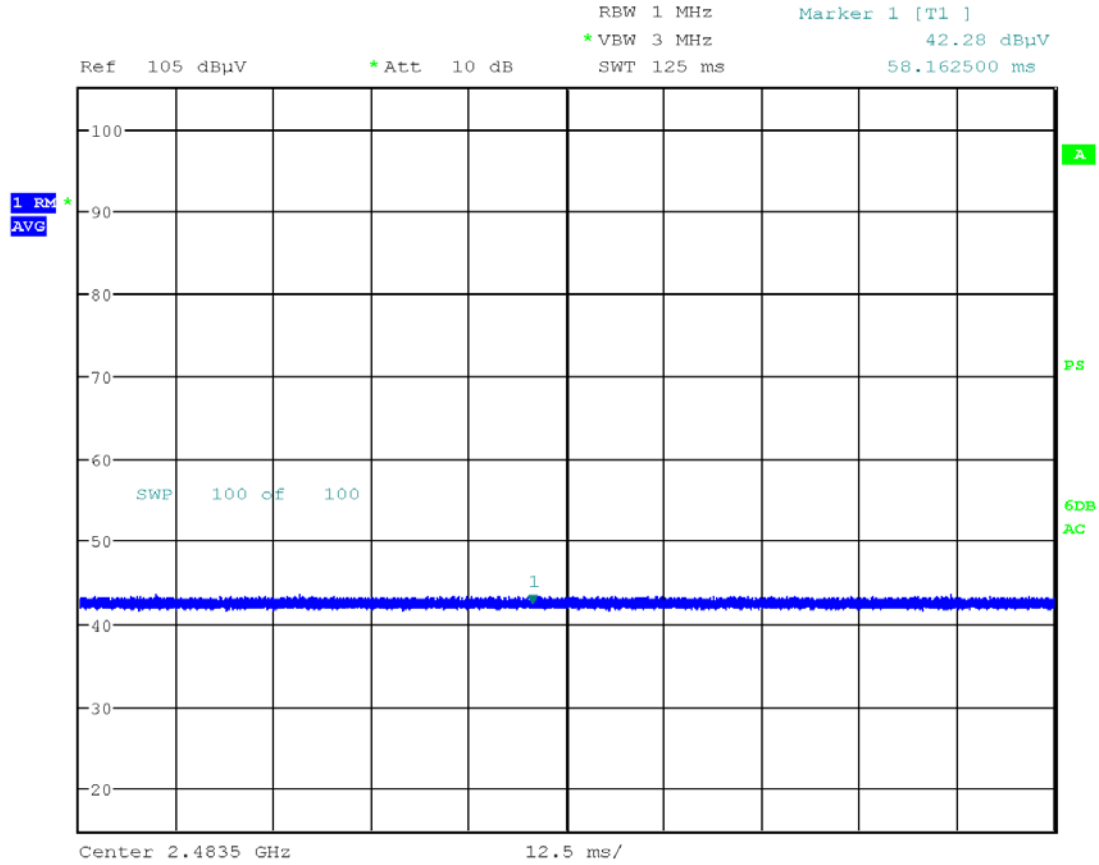
**Out-of-Band Radiated spurious emissions at the Band-edge @3m distance
2483.5–2500 MHz, Peak Scan with Average Limit
EUT in Horizontal Position**

- FCC Part 15/FCC Part 15.209 1GHz to 40GHz - Average/3.0m/
- FCC Part 15/FCC Part 15.209 1GHz to 40GHz - Peak/3.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- x Peak (Peak /Lim. Peak) (Horizontal)
- x Peak (Peak /Lim. Peak) (Vertical)



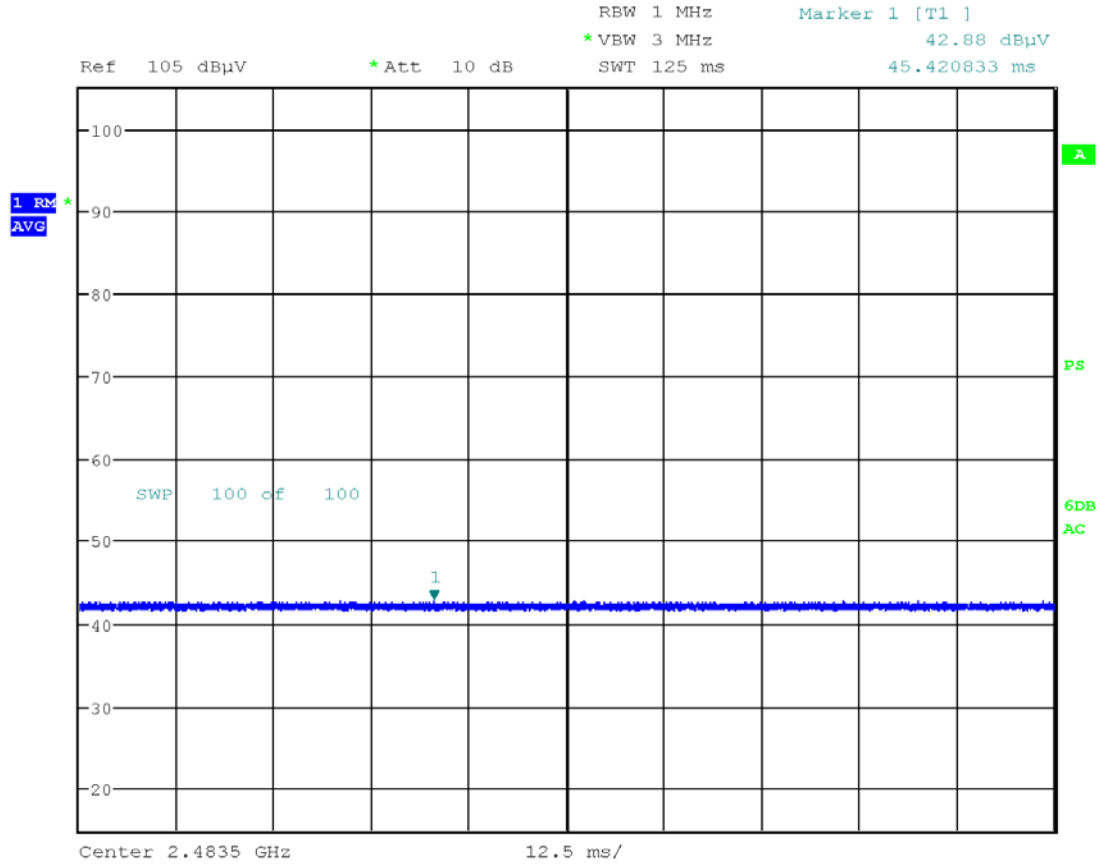
Model: ; Client: ; Comments: ; Test Date: 07/26/2019 20:07

Band Edge Measurement at 2483.5MHz, Vertical



Date: 26.JUL.2019 20:13:46

Band Edge Measurement at 2483.5MHz, Horizontal



Date: 26.JUL.2019 20:16:03

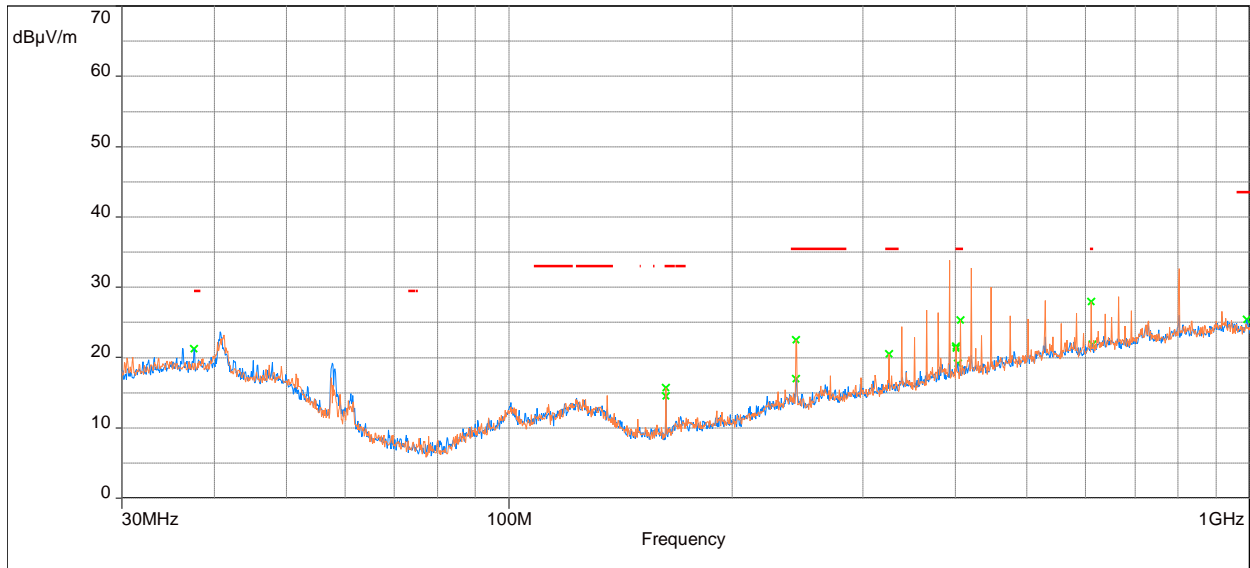
Frequency (MHz)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Angle (°)	Height (m)	Polarity	Raw (dBuV)	Correction (dB)
2483.5	28.2	54.0	-25.8	356.0	1.59	Horizontal	42.9	-14.7
2483.5	27.6	54.0	-26.4	345.0	2.10	Vertical	42.3	-14.7

Out-of-Band Radiated Spurious Emissions

Test Results: 15.209 Radiated Spurious Emissions Low Channel, Tx at 2402MHz

Radiated Spurious Emissions 30 MHz - 1000 MHz

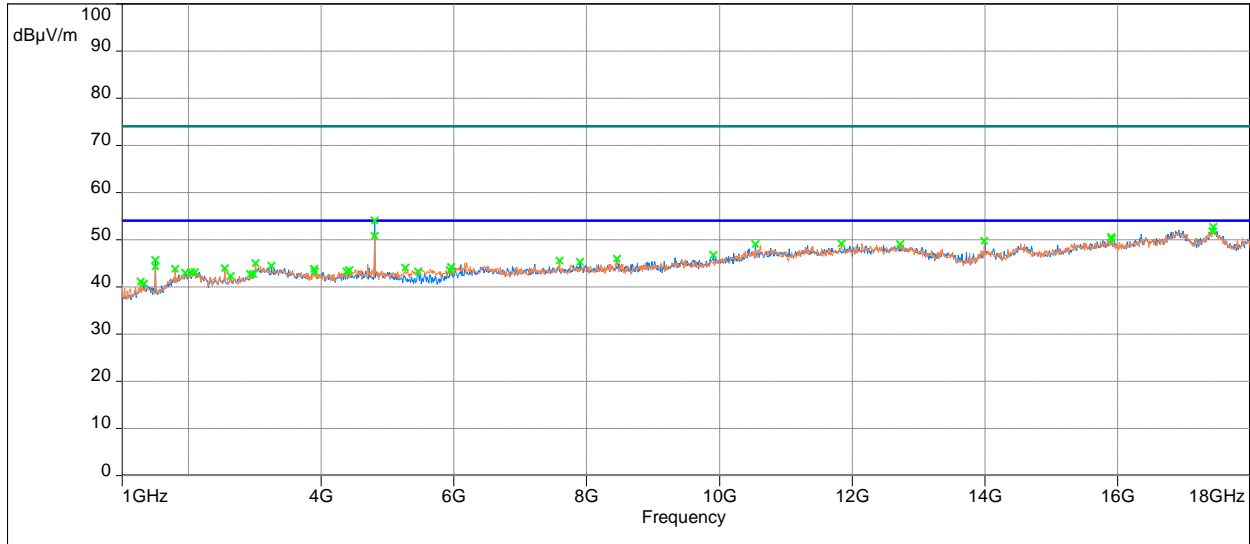
- FCC Part 15/FCC Part 15.205/15.209, 30MHz-1GHz - QPeak/10.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- x Peak (Peak /Lim. QPeak) (Horizontal)
- x Peak (Peak /Lim. QPeak) (Vertical)



Model: ; Client: ; Comments: ; Test Date: 07/26/2019 21:08

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Avg & Peak Limit

- FCC Part 15/FCC Part 15.209 1GHz to 40GHz - Average/3.0m/
- FCC Part 15/FCC Part 15.209 1GHz to 40GHz - Peak/3.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- x Peak (Peak /Lim. Peak) (Horizontal)
- x Peak (Peak /Lim. Peak) (Vertical)



Model: ; Client: ; Comments: ; Test Date: 07/26/2019 17:36

Freq. MHz	Ave @3m dB(uV/m)	Ave Limit@3m dB(µV/m)	Ave Margin dB	Azimuth deg	Height m	Polarity	Raw	Correction dB
4804	53.2	54.0	-0.8	97	2.69	Vertical	60.94	-7.77

Note: Measurements were performed in X, Y, Z planes of the EUT and worst cast data was presented. Final average measurements were performed using section 11.12.2.5.2 of ANSI 63.10; when utilizing 11.12.2.5.2, the Trace mode was set to Max Hold and the measurement correction factor in 11.12.2.5.2 i) is not added (reference KDB 558074 D01 DTS Meas Guidance v05r02; FAQ #3(b)).

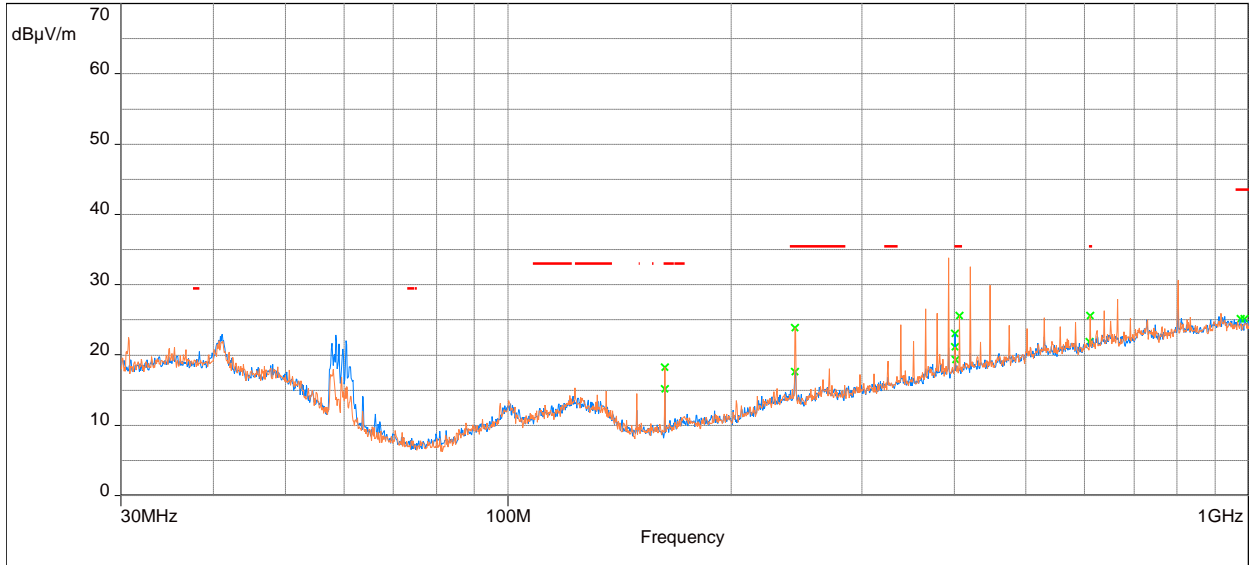
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

Note: FS@3m = RA + Correction
Correction = AF + CF – Preamp

Test Results: 15.209 Radiated Spurious Emissions Mid Channel, Tx at 2440MHz

Radiated Spurious Emissions 30 MHz - 1000 MHz

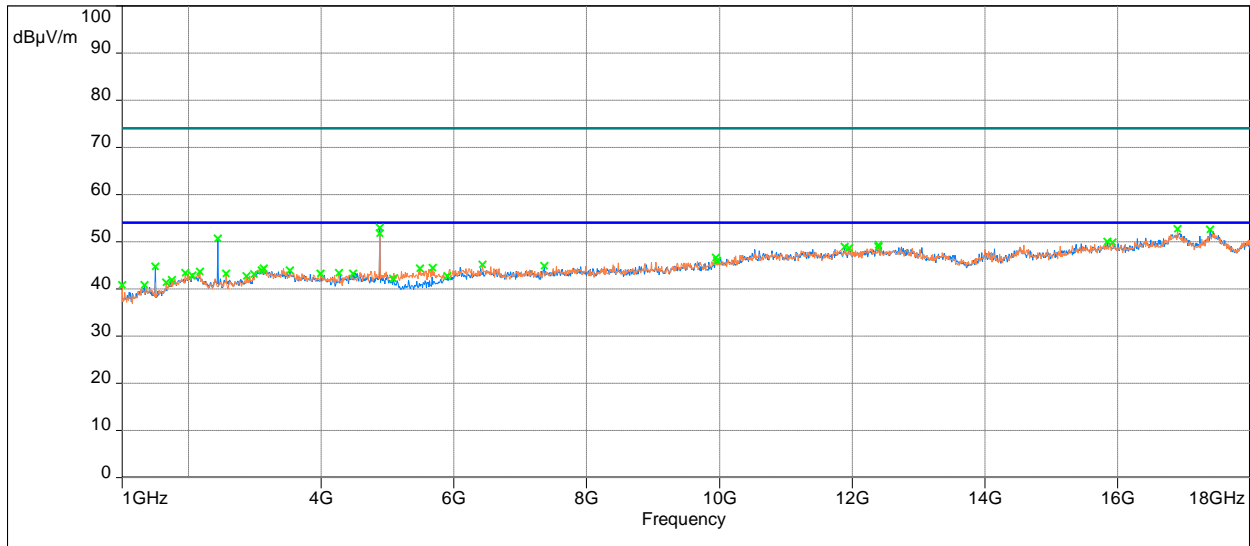
- FCC Part 15/FCC Part 15.205/15.209, 30MHz-1GHz - QPeak/10.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- x Peak (Peak /Lim. QPeak) (Horizontal)
- x Peak (Peak /Lim. QPeak) (Vertical)



Model: ; Client: ; Comments: ; Test Date: 07/26/2019 21:15

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Avg & Peak Limit

- FCC Part 15/FCC Part 15.209 1GHz to 40GHz - Average/3.0m/
- FCC Part 15/FCC Part 15.209 1GHz to 40GHz - Peak/3.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- x Peak (Peak /Lim. Peak) (Horizontal)
- x Peak (Peak /Lim. Peak) (Vertical)



Model: ; Client: ; Comments: ; Test Date: 07/26/2019 18:05

Freq. MHz	Ave @3m dB(uV/m)	Ave Limit@3m dB(µV/m)	Ave Margin dB	Azimuth deg	Height m	Polarity	Raw	Correction dB
4880.0	51.2	54.0	-2.8	88.0	2.32	Vertical	59.05	-7.89

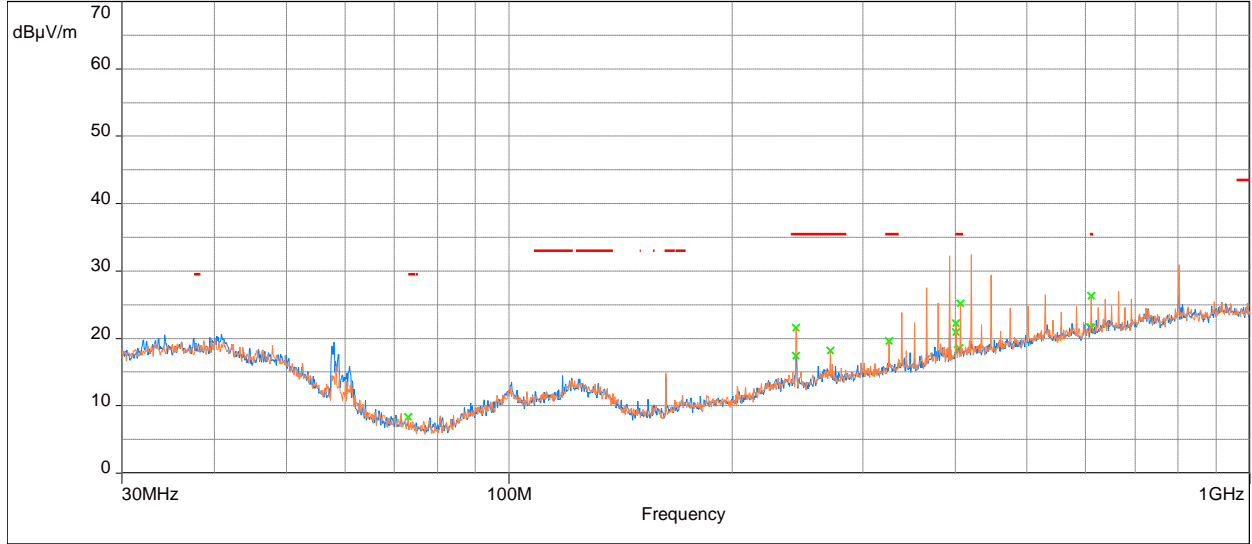
Note: Measurements were performed in X, Y, Z planes of the EUT and worst cast data was presented. Final average measurements were performed using section 11.12.2.5.2 of ANSI 63.10; when utilizing 11.12.2.5.2, the Trace mode was set to Max Hold and the measurement correction factor in 11.12.2.5.2 i) is not added (reference KDB 558074 D01 DTS Meas Guidance v05r02; FAQ #3(b)).

Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

Note: FS@3m = RA + Correction
Correction = AF + CF – Preamp

Radiated Spurious Emissions 30 MHz - 1000 MHz

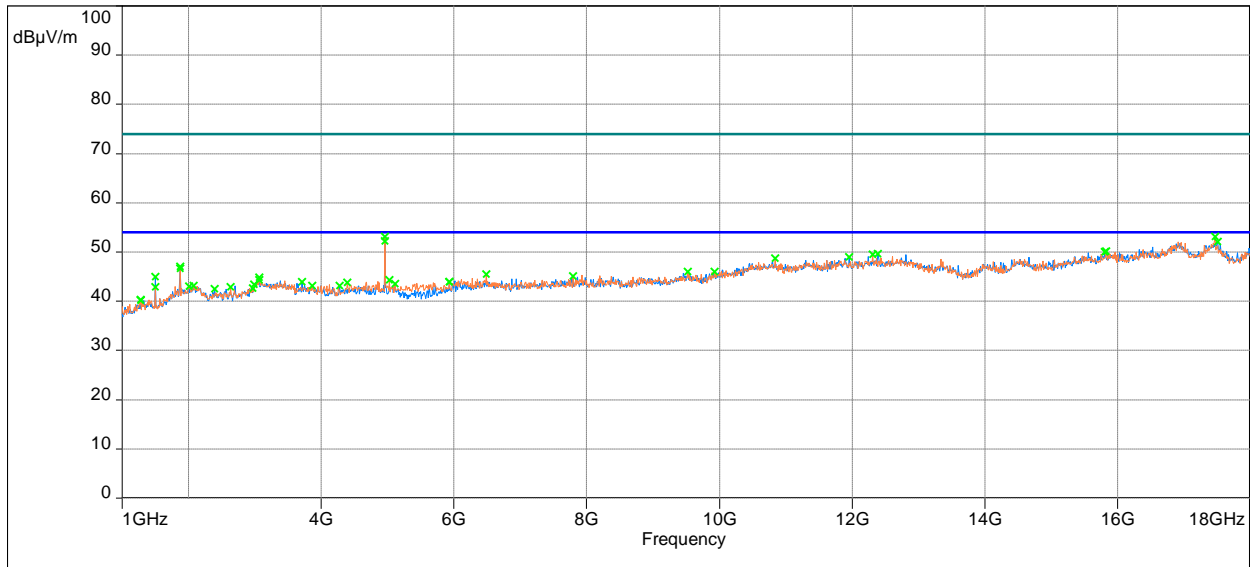
- FCC Part 15/FCC Part 15.205/15.209, 30MHz-1GHz - QPeak/10.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- Peak (Peak /Lim. QPeak) (Horizontal)
- Peak (Peak /Lim. QPeak) (Vertical)



Model: ; Client: ; Comments: ; Test Date: 07/26/2019 21:24

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Avg & Peak Limit

- FCC Part 15/FCC Part 15.209 1GHz to 40GHz - Average/3.0m/
- FCC Part 15/FCC Part 15.209 1GHz to 40GHz - Peak/3.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- x Peak (Peak /Lim. Peak) (Horizontal)
- x Peak (Peak /Lim. Peak) (Vertical)



Model: ; Client: ; Comments: ; Test Date: 07/26/2019 18:31

Freq. MHz	Ave @3m dB(uV/m)	Ave Limit@3m dB(µV/m)	Ave Margin dB	Azimuth deg	Height m	Polarity	Raw	Correction dB
4960.0	53.1	54.0	-0.9	86	1.88	Horizontal	60.81	-7.75

Note: Measurements were performed in X, Y, Z planes of the EUT and worst cast data was presented. Final average measurements were performed using section 11.12.2.5.2 of ANSI 63.10; when utilizing 11.12.2.5.2, the Trace mode was set to Max Hold and the measurement correction factor in 11.12.2.5.2 i) is not added (reference KDB 558074 D01 DTS Meas Guidance v05r02; FAQ #3(b)).

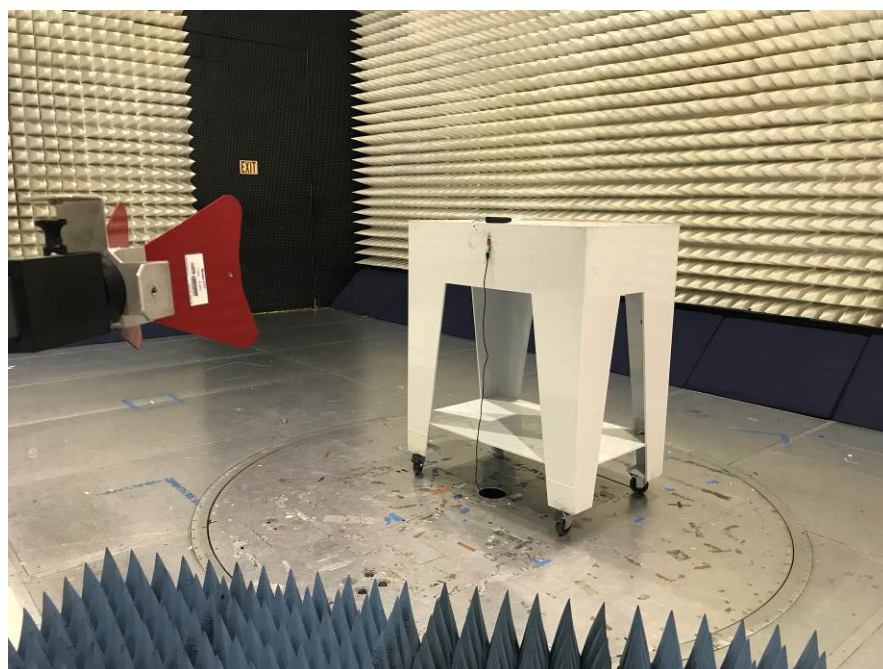
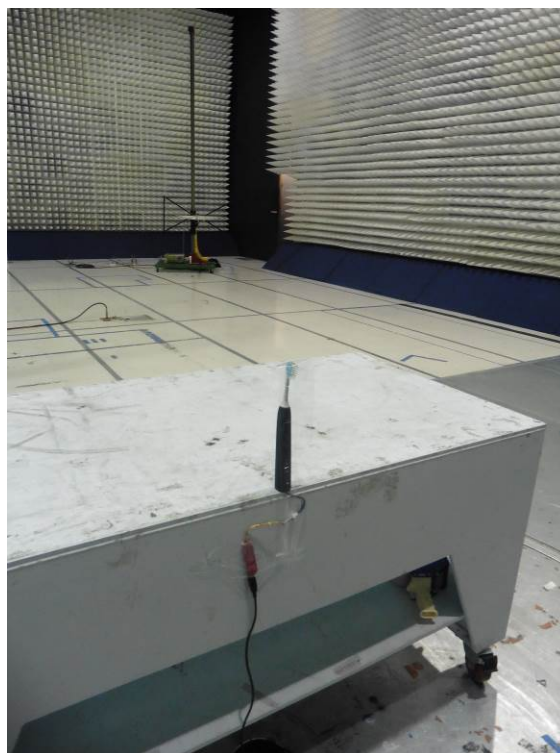
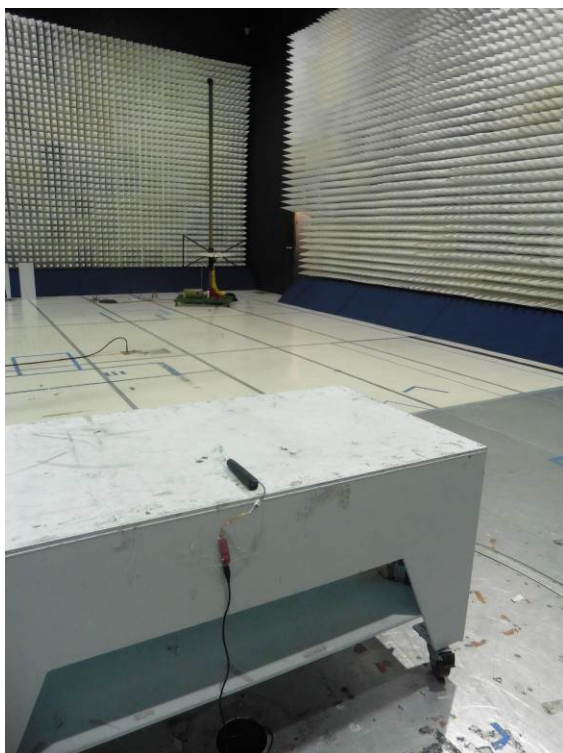
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

Note: FS@3m = RA + Correction
Correction = AF + CF – Preamp

Results	Complies by 0.8dB
----------------	--------------------------

4.5.5 Test Setup Configuration

The following photographs show the testing configurations used.



4.6 Radiated Emissions on Digital Parts
FCC Ref: 15.109, ICES 003, RSS Gen

4.6.1 Test Limit

Limits for Electromagnetic Radiated Emissions FCC Section 15.109(b), ICES 003*, RSS GEN

Frequency (MHz)	Class A at 10m dB(μV/m)	Class B at 3m dB(μV/m)
30-88	39	40.0
88-216	43.5	43.5
216-960	46.4	46.0
Above 960	49.5	54.0

* According to FCC Part 15.109(g) an alternative to the radiated emission limits shown above, digital devices may be shown to comply with the limit of CISPR Pub. 22

4.6.2 Procedure

Radiated measurements were taken. 120 kHz resolution bandwidth was used from 30 MHz - 1 GHz. 1 MHz resolution bandwidth was used for measurements done above 1 GHz. All plots are corrected for cable loss, antenna factor, and preamp.

Radiated emission measurements were performed from 30 MHz to 18000 MHz. The data on the following pages list the significant emission frequencies, the limit and the margin of compliance.

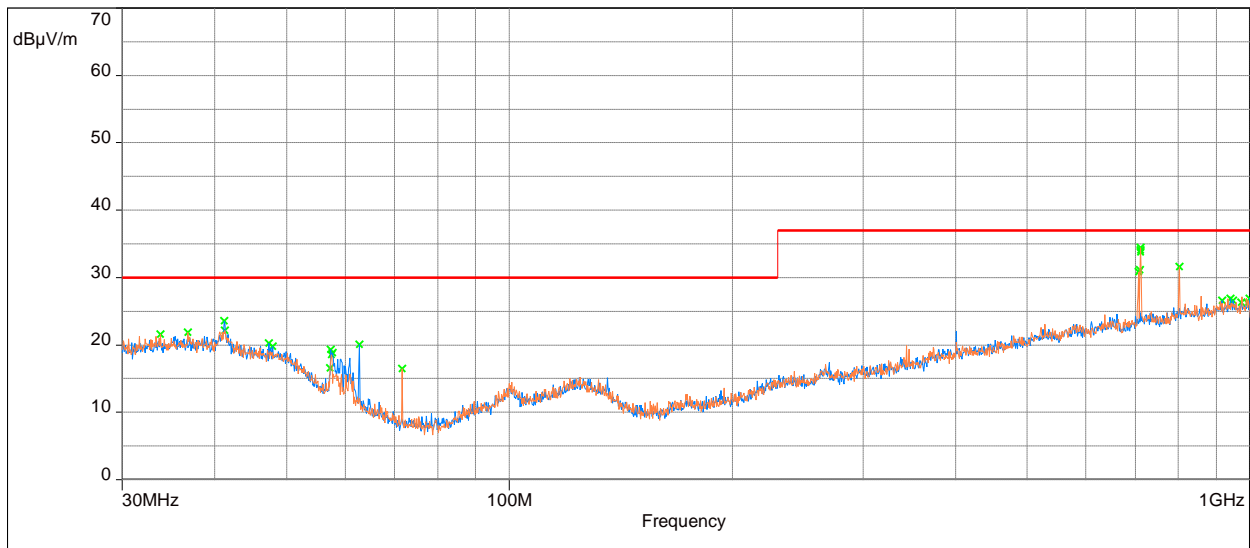
Measurements recorded in this section were made with the Transmitter in standby mode (RF Off).

4.6.3 Test Results

The EUT met the radiated disturbance requirements of FCC Part 15, Subpart B and ICES-003 Industry Canada for a Class B device.

FCC Part 15 Subpart B, ICES-003 Radiated Disturbance, 30MHz-1GHz

- CISPR Limit/CISPR Limit 30M-1GHz QP B - QPeak/10.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- x Peak (Peak /Lim. QPeak) (Horizontal)
- x Peak (Peak /Lim. QPeak) (Vertical)

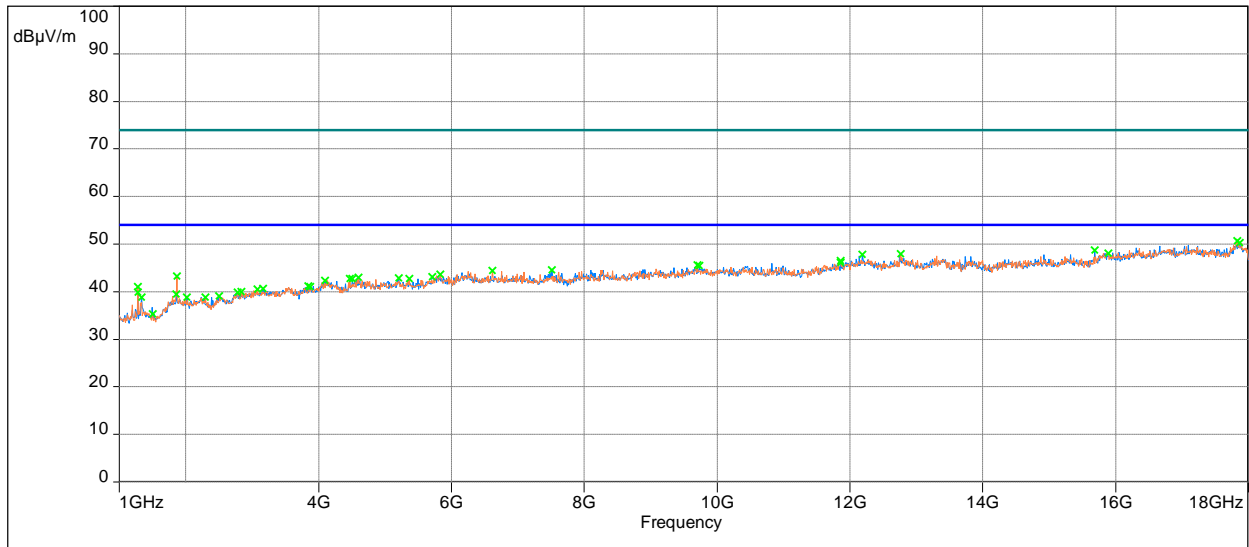


Model: ; Client: ; Comments: ; Test Date: 07/15/2019 17:49

Frequency (MHz)	FS @10m dB(µV/m)	Limit @10m dB(µV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity	RA (dBuV)	Correction (dB)
41.220	23.5	30.0	-6.5	298.3	4.0	Vertical	30.2	-6.6
41.252	22.2	30.0	-7.8	180.5	4.0	Horizontal	28.8	-6.6
47.363	20.3	30.0	-9.7	354.8	1.0	Vertical	28.0	-7.7
62.721	20.0	30.0	-10.0	354.8	1.0	Vertical	36.1	-16.1
710.940	34.0	37.0	-3.0	215.8	1.0	Horizontal	36.6	-2.6
801.829	31.6	37.0	-5.4	294.5	1.0	Horizontal	33.2	-1.6

FCC Part 15 Subpart B, ICES-003 Radiated Disturbance, 1GHz-18GHz, Peak Detector

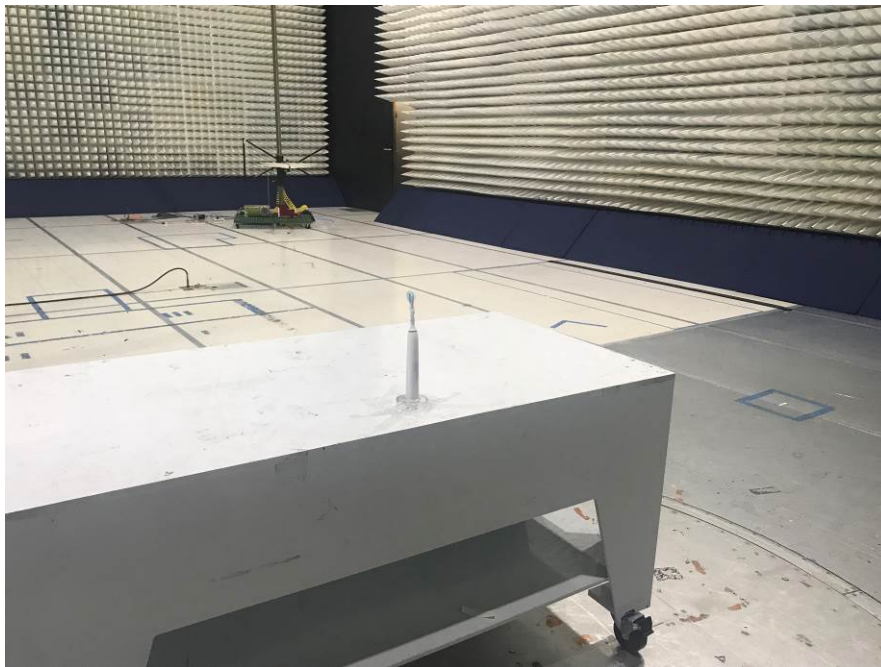
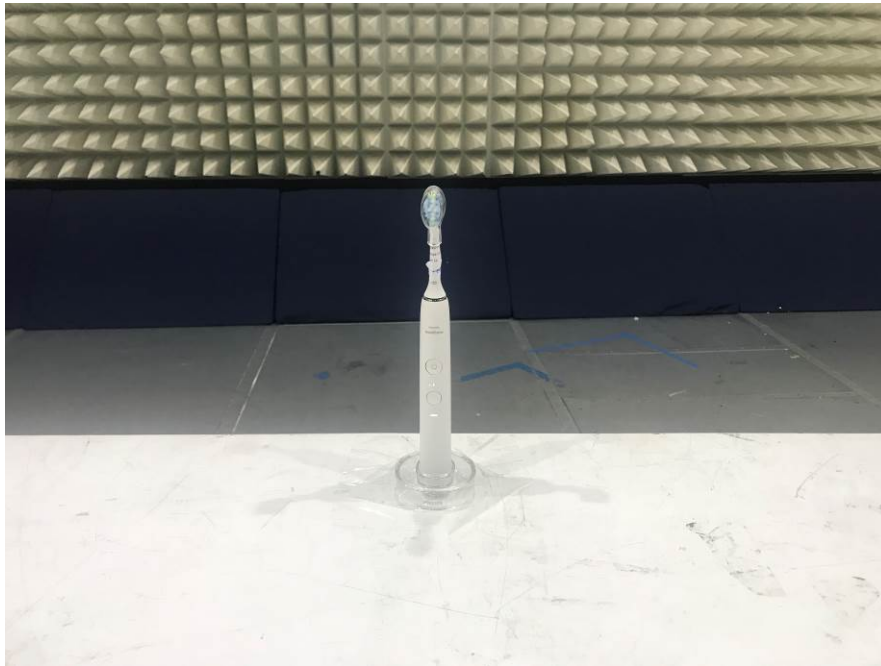
- FCC Part 15/FCC Part 15.109 30M-40GHz B - Average/3.0m/
- FCC Part 15/FCC Part 15.109 30M-40GHz B - QPeak/3.0m/
- FCC Part 15/FCC Part 15.109 30M-40GHz B - Peak/3.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- x Peak (Peak /Lim. Peak) (Horizontal)
- x Peak (Peak /Lim. Peak) (Vertical)



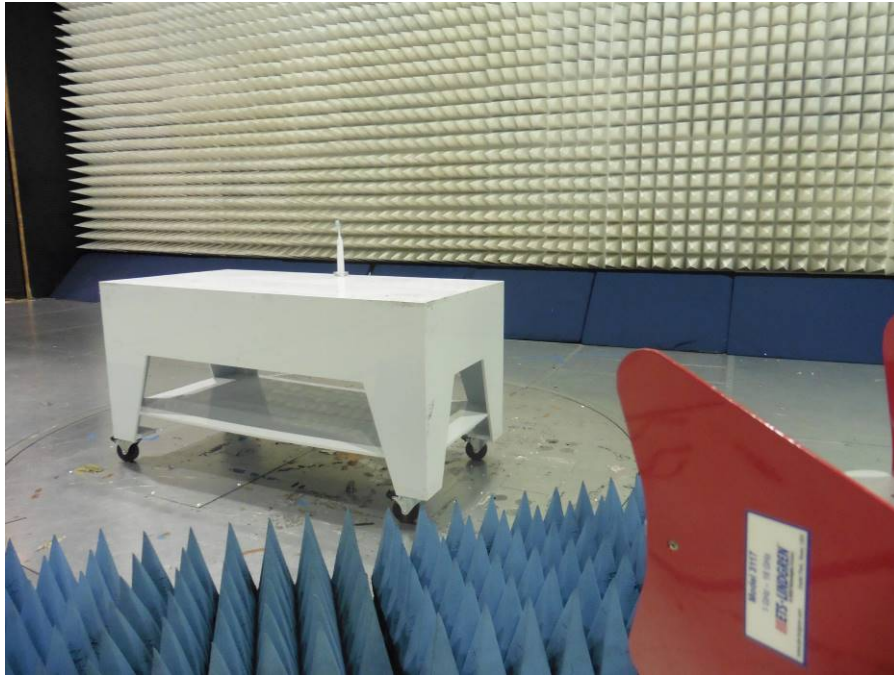
Model: ; Client: ; Comments: ; Test Date: 07/16/2019 17:16

Result: Complies by 3.0 dB for FCC Part 15 Subpart B and ICES-003

4.6.4 Setup Photographs:



4.6.4 Setup Photographs (Continued)



4.7 AC Line Conducted Emission
FCC Rule 15.207, FCC 15.107

4.7.1 Requirement

Frequency Band MHz	Class B Limit dB(μ V)		Class A Limit dB(μ V)	
	Quasi-Peak	Average	Quasi-Peak	Average
0.15-0.50	66 to 56 *	56 to 46 *	79	66
0.50-5.00	56	46	73	60
5.00-30.00	60	50	73	60

Note: *Decreases linearly with the logarithm of the frequency. At the transition frequency the lower limit applies.

4.7.2 Procedure

Measurements are carried out using quasi-peak and average detector receivers in accordance with CISPR 16. An AMN is required to provide a defined impedance at high frequencies across the power feed at the point of measurement of terminal voltage and also to provide isolation of the circuit under test from the ambient noise on the power lines. An AMN as defined in CISPR 16 shall be used.

The EUT is located so that the distance between the boundary of the EUT and the closest surface of the AMN is 0.8m.

Where a flexible mains cord is provided by the manufacturer, this shall be 1m long or if in excess of 1m, the excess cable is folded back and forth as far as possible so as to form a bundle not exceeding 0.4m in length.

The EUT is arranged and connected with cables terminated in accordance with the product specification.

Conducted disturbance is measured between the phase lead and the reference ground, and between the neutral lead and the reference ground. Both measured values are reported.

The EUT, where intended for tabletop use, is placed on a table whose top is 0.8m above the ground plane. A vertical, metal reference plane is placed 0.4m from the EUT. The vertical metal reference-plane is at least 2m by 2m. The EUT shall be kept at least 0.8m from any other metal surface or other ground plane not being part of the EUT. The table is constructed of non-conductive materials. Its dimensions are 1m by 1.5m, but may be extended for larger EUT.

Floor standing EUT are placed on a horizontal metal ground plane and isolated from the ground plane by resting on an insulating material. The metal ground plane extends at least 0.5m beyond the boundaries of the EUT and has minimum dimensions of 2m by 2m.

EUT was placed in transmission mode then tested for conducted emissions per 15.207 to ensure the device complies with 15.207. After, the EUT RF was powered off and was measured to show compliance with the 15.107 limits.

4.7.3 Test Results

Not applicable. The EUT is battery powered only.

5.0 List of Test Equipment

Measurement equipment used for emission compliance testing utilized the equipment on the following list:

Equipment	Manufacturer	Model Tested/Type	Asset #	Cal Int	Cal Due
Spectrum Analyzer	Rohde and Schwarz	FSU	ITS 00913	12	03/26/20
EMI Receiver	Rohde and Schwarz	ESR7	ITS 01607	12	10/23/19
Pre-Amplifier (18-40GHz)	Miteq	TTA1840-35-S-M	ITS 01393	12	02/08/20
Active Horn Antenna	ETS-Lindgren	3117-PA	ITS 01636	12	01/17/20
Horn Antenna (10-40 GHz)	ETS-Lindgren	3116C	ITS 01376	12	04/15/20
Bi-Log Antenna	Antenna Research	LPB-2513	ITS 00355	12	04/24/20
Pre-Amplifier	Sonoma Instrument	310N	ITS 00415	12	04/17/20
RE Cable	TRU Corporation	TRU CORE 300	ITS 01462	12	09/17/19
RE Cable	TRU Corporation	TRU CORE 300	ITS 01465	12	09/17/19
RE Cable	TRU Corporation	TRU CORE 300	ITS 01470	12	09/17/19
RF Cable	TRU Corporation	TRU CORE 300	ITS 01342	12	12/05/19
Notch Filter	MICRO-TRONICS	BRM50702	ITS 01166	12	05/14/20
RF Cable	Mega Phase	EMC1-K1K1-236	ITS 01537	12	02/20/20
10 dB Attenuator	Mini Circuits	BW-S10W5+	ITS 01582	12	10/07/19
RF Cable	Mega Phase	TM40-K1K1-59	ITS 01156	12	02/20/20

No Calibration required

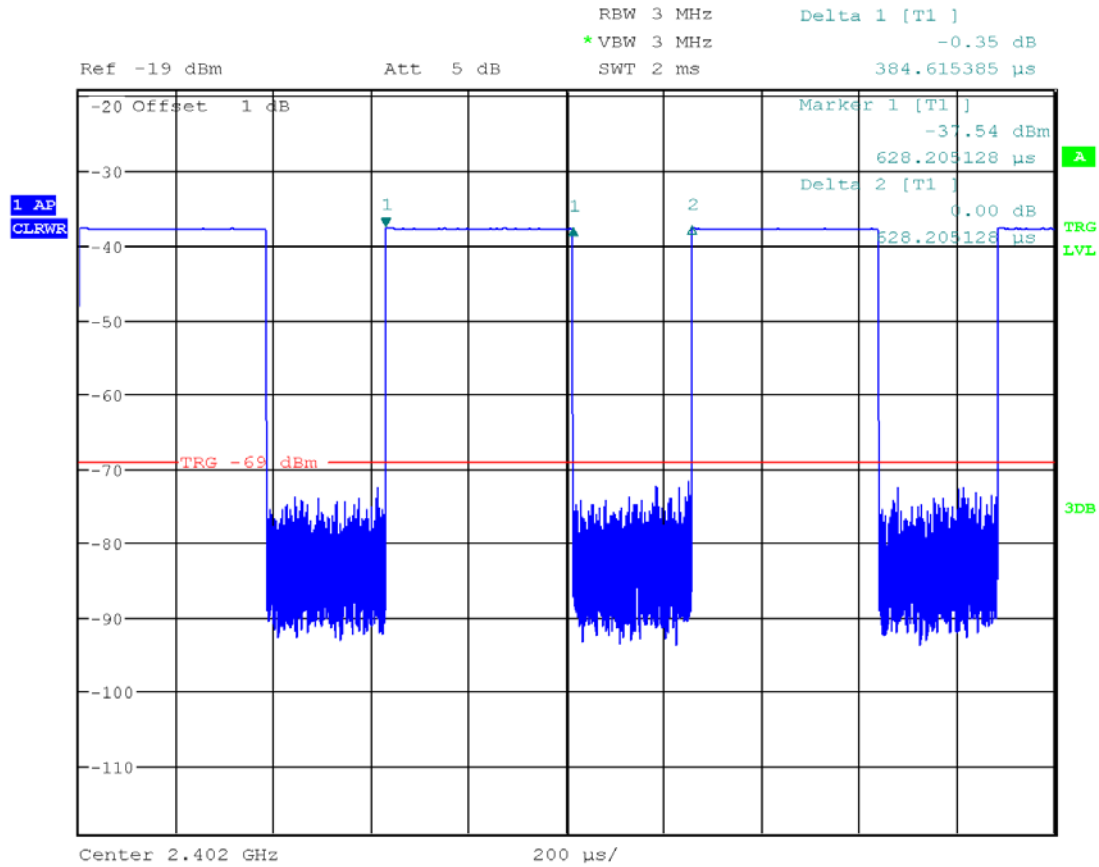
Software used for emission compliance testing utilized the following:

Name	Manufacturer	Version	Template/Profile
Tile	Quantum Change	3.4.K.22	Conducted Spurious_30M-26GHz
BAT-EMC	Nexio	3.17.0.10	Philips, ML_07-2019.bpp
RS Commander	Rohde Schwarz	1.6.4	Not Applicable (Screen grabber)

6.0 Document History

Revision/ Job Number	Writer Initials	Reviewers Initials	Date	Change
1.0 / G103985132	ML	KV	August 07, 2019	Original document
2.0 / G103985132	ML	KV	March 26, 2020	Added Radiated Band Edge on pages 31-35.

Annex A - Duty Cycle Measurement



Date: 24.JUL.2019 18:36:28

Duty Cycle:

$$DC = 384.6 / 628.2 = 0.61 \text{ or } 61\%$$

Duty Cycle Correction Factor δ (dB) for power averaging:

$$\delta = 10 \log (1/DC) = 2.13 \text{ dB (power average/RMS)}$$