Emissions
Test Report

EUT Name: Tile Pro – Wireless Transceiver

Model No.: T6001W / T6001B

CFR 47 Part 15.247: 2017/RSS-247 Issue 2, LP0002:2018

Prepared for:

Tile, Inc.
2121 South El Camino Real, Suite 900
San Mateo CA 94403
Tel: (415) 902-9629

Prepared by:

TÜV Rheinland of North America, Inc.
1279 Quarry Lane
Pleasanton, CA 94566
Tel: (925) 249-9123
Fax: (925) 249-9124
http://www.TÜV.com/

Report/Reissue Date:	September 17, 2018
Job #	160199
Report Number:	31863512.001

Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
0	08/15/2018	Original Document	N/A
1	09/14/2018	Antenna Gain Update/TCB Updates	IA
2	09/17/2018	Updated Reference KDB number	IA

Note: Latest revision report will replace all previous reports.

Manufacturer:	Tile, Inc. 2121 South El Camino Real, Suite 900 San Mateo CA 94403
Name of Equipment:	Tile Pro – Wireless Transceiver
Model No.	T6001W / T6001B
Type of Equipment:	Intentional Radiator
Application of Regulations:	CFR 47 Part 15.247: 2017/RSS-247 Issue 2, LP0002:2018, LP0002:2018
Test Dates:	25 July 2018 to 1 Aug 2018

Guidance Documents:

Emissions: ANSI C63.10-2013, FCC KDB 558074 D01 v05

Test Methods:

Emissions: ANSI C63.10-2013, FCC KDB 558074 D01 v05

The electromagnetic compatibility test and documented data described in this report has been performed and recorded by TÜV Rheinland, in accordance with the standards and procedures listed herein. As the responsible authorized agent of the EMC laboratory, I hereby declare that the equipment described above has been shown to be compliant with the EMC requirements of the stated regulations and standards based on these results. If any special accessories and/or modifications were required for compliance, they are listed in the Executive Summary of this report.

This report must not be used to claim product endorsement by A2LA or any agency of the U.S. Government. This report shall not be reproduced except in full, without the written authorization of TÜV Rheinland of North America.

Abraham Avalos	Isaac Aguilar
Test Engineer Date: September 17, 2018	A2LA Signatory Date: September 17, 2018

Testing Cert #3331.02 **US1131** **2932M-1** **US0185**

1 Executive Summary *8*

1.1 Scope **8**

1.2 Purpose **8**

1.3 Summary of Test Results **9**

1.4 Special Accessories **9**

1.5 Equipment Modifications **9**

2 Laboratory Information *10*

2.1 Accreditations & Endorsements **10**

2.1.1 US Federal Communications Commission 10

2.1.2 NIST / A2LA 10

2.1.3 Canada – Industry Canada 10

2.1.4 Japan – VCCI 10

2.1.5 Acceptance by Mutual Recognition Arrangement 11

2.2 Test Facilities **11**

2.2.1 Emission Test Facility 11

2.2.2 Immunity Test Facility 11

2.3 Measurement Uncertainty **12**

2.3.1 Sample Calculation – radiated & conducted emissions 12

2.3.2 Measurement Uncertainty 12

2.3.3 Measurement Uncertainty Immunity 13

2.4 Calibration Traceability **13**

3 Product Information *14*

3.1 Product Description **14**

3.2 Equipment Configuration **14**

3.3 Operating Mode **14**

3.4 Unique Antenna Connector **15**

3.4.1 Results 15

3.5 Duty Cycle **16**

3.5.1 Results 16

4 Emissions *17*

4.1 Output Power Requirements **17**

4.1.1 Test Method 17

4.1.2 Results 18

4.2 Occupied Bandwidth **20**

4.2.1 Test Method 20

4.2.2 Results 21

4.3 Peak Power Spectral Density **23**

4.3.1 Test Method 23

4.3.2 Results 24

4.4 Out of Band Emissions 26
4.4.1 Test Method 26
4.4.2 Results 27

4.5 Transmit Spurious Emissions 30
4.5.1 Test Methodology 30
4.5.2 Transmitter Spurious Emission Limit 31
4.5.3 Test Results 31
4.5.4 Band-edge Data 33

4.6 AC Conducted Emissions 41
4.6.1 Test Methodology 41
4.6.2 Test Results 41

4.7 Maximum Permissible Exposure – Not Applicable 42
4.7.1 Test Methodology 42
4.7.2 FCC KDB 447498 D01v06 – General SAR Test Exclusion Guidance 42
4.7.3 EUT Operating Condition 42
4.7.4 Classification 42
4.7.5 Test Results 43

5 Test Equipment List 44

5.1 Equipment List 44

6 EMC Test Plan 45

6.1 Introduction 45

6.2 Customer 45

6.3 Equipment Under Test (EUT) 46

Table 1: Summary of Test Results 9
Table 2: RF Output Power at the Antenna Port – Test Results 18
Table 3: Occupied Bandwidth – Test Results 21
Table 4: Peak Power Spectral Density – Test Results 24
Table 5: Emissions at the Band-Edge – Test Results 27
Table 6: Transmit Spurious Emission at Band-Edge Requirements 32
Table 7: Customer Information 45
Table 8: EUT Specifications 46

1 Executive Summary

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.247: 2017/RSS-247 Issue 2, LP0002:2018, RSS-247 Issue 2 and LP0002:2018 based on the results of testing performed on 25 July 2018 to 29th July 2018 on the Tile Model T6001 manufactured by Tile Incorporated. This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components. This report is further intended to document changes and modifications to the EUT throughout its life cycle. All documentation will be included as a supplement.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report. The 2400 MHz to 2483.5 MHz frequency band is covered in this document.

1.3 Summary of Test Results

Table 1: Summary of Test Results

Test	Test Method ANSI C63.10: 2013	Result
Spurious Emission in Transmitted Mode	CFR47 15.209, CFR47 15.247 (d) RSS-Gen section 8.9 RSS-247 Section 5.5 LP0002 Section 2.8	**Complied**
Restricted Bands of Operation	CFR47 15.205 RSS-Gen Section 8.10 LP0002 Section 2.7	**Complied**
AC Power Conducted Emission	CFR47 15.207 RSS-Gen Section 8.8 LP0002 Section 2.3	**N/A**
Occupied Bandwidth	CFR47 15.247 (a) RSS-247 Section 5.2 a) LP0002 Section 3.10.1.6 (2)(A)	**Complied**
Maximum Output Power	CFR47 15.247 (b) RSS-247 Section 5.4 d) LP0002 Section 3.10.1.2 (1)(C)	**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS-247 Section 5.2 (b), LP0002 Section 3.10.1.6 (2) (B)	**Complied**
Out of Band Emission	CFR47 15.247 (d) RSS-247 Section 5.5 LP0002 Section 3.10.1.5 (1)	**Complied**
RF Exposure	CFR47 15.247 (i), 2.1093 RSS-102 Issue 5	**Note 2**

Note:

1) This test report covers 2400 MHz to 2483.5 MHz band.
2) RF Exposure covered in a separate report.

1.4 Special Accessories

None

1.5 Equipment Modifications

None

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TÜV Rheinland of North America at 1279 Quarry Ln, Pleasanton, CA 94566 is recognized by the commission for performing testing services for the general public on a fee basis. These laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (US1131). The laboratory scope of accreditation includes: Title 47 CFR Parts 15, 18, and 90. The accreditation is updated every 3 years.

2.1.2 NIST / A2LA

TÜV Rheinland of North America is accredited by the National Voluntary Laboratory Accreditation Program, which is administered under the auspices of the National Institute of Standards and Technology. The laboratory has been assessed and accredited in accordance with ISO Guide 17025:2005 (Lab Code Testing Cert #3331.02). The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 Canada – Industry Canada

TÜV Rheinland of North America at the 1279 Quarry Ln, Pleasanton, CA 94566 address is accredited by Industry Canada for performing testing services for the general public on a fee basis. This laboratory test facilities have been fully described in reports submitted to and accepted by Industry Canada (File Number 2932M). The accreditation is updated every 3 years.

2.1.4 Japan – VCCI

The Voluntary Control Council for Interference by Information Technology Equipment (VCCI) is a group that consists of Information Technology Equipment (ITE) manufacturers and EMC test laboratories. The purpose of the Council is to take voluntary control measures against electromagnetic interference from Information Technology Equipment, and thereby contribute to the development of a socially beneficial and responsible state of affairs in the realm of Information Technology Equipment in Japan. TÜV Rheinland of North America at 1279 Quarry Ln, Pleasanton, CA 94566 has been assessed and approved in accordance with the Regulations for Voluntary Control Measures.

VCCI Registration No. for Pleasanton: A-0268

2.1.5 Acceptance by Mutual Recognition Arrangement

The United States has an established agreement with specific countries under the Asia Pacific Laboratory Accreditation Corporation (APLAC) Mutual Recognition Arrangement. Under this agreement, all TÜV Rheinland at 1279 Quarry Ln, Pleasanton, CA 94566 test results and test reports within the scope of the laboratory NIST / A2LA accreditation will be accepted by each member country.

2.2 Test Facilities

All of the test facilities are located at 1279 Quarry Lane, Pleasanton, California 94566, USA. The 5015 Brandin Ct. Fremont CA 94538, USA location is considered a Pleasanton annex.

2.2.1 Emission Test Facility

The Semi-Anechoic chamber and AC Line Conducted measurement facility used to collect the radiated and conducted data has been constructed in accordance with ANSI C63.7:1992. The site has been measured in accordance with and verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2014, at a test distance of 3 and 5 meters. The site is listed with the FCC and accredited by A2LA (Lab Code Testing Cert #3331.02). The 3/5-meter semi-anechoic chamber used to collect the radiated data has been verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2014, at a test distance of 3 meter and 5 meters. A report detailing this site can be obtained from TÜV Rheinland of North America.

2.2.2 Immunity Test Facility

ESD, EFT, Surge, PQF: These tests are performed in an environmentally controlled room with a 3.7 m x 4.8 m x 3.175 mm thick aluminum floor connected to PE ground.

For ESD testing, tabletop equipment is placed on an insulated mat with a surface resistivity of 10^9 Ohms/square on a 1.6 m x 0.8 m x 0.8 m high non-conductive table with a 3.175 mm aluminum top (Horizontal Coupling Plane). The HCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors. The Vertical Coupling Plane consists of an aluminum plate 50 cm x 50 cm x 3.175 mm thick. The VCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors.

For EFT, Surge, PQF, the HCP and VCP are removed.

RF Field Immunity testing is performed in a 7.3m x 4.3m x 4.1m anechoic chamber.

RF Conducted and Magnetic Field Immunity testing is performed on a 4.8m x 3.7m x 3.175mm thick aluminum ground plane.

All test areas allow a minimum distance of 1 meter from the EUT to walls or conducting objects.

2.3 Measurement Uncertainty

Two types of measurement uncertainty are expressed in this report, per *ISO Guide To The Expression Of Uncertainty In Measurement*, 1st Edition, 1995.

The Combined Standard Uncertainty is the standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities; it is equal to the positive square root of the sum of the variances or co-variances of these other quantities, weighted according to how the measurement result varies with changes in these quantities. The term *standard uncertainty* is the result of a measurement expressed as a standard deviation.

2.3.1 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBμV/m) = RAW - AMP + CBL + ACF

Where: RAW = Measured level before correction (dBμV)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)

25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

2.3.2 Measurement Uncertainty

Per CISPR 16-4-2	**U_{lab}**	**U_{cispr}**
Radiated Disturbance @ 5 meters		
30 – 1,000 MHz	2.25 dB	4.51 dB
Radiated Disturbance @ 3 meters		
30 – 1,000 MHz	2.26 dB	4.52 dB
1 – 6 GHz	2.12 dB	4.25 dB
6 – 18 GHz	2.47 dB	4.93 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	1.09 dB	2.18 dB

Disturbance Power		
30 MHz – 300 MHz	3.92 dB	4.3 dB

Voltech PM6000A

The estimated combined standard uncertainty for harmonic current and flicker measurements is ± 5.0%.	Per CISPR 16-4-2 Methods

2.3.3 Measurement Uncertainty Immunity

The estimated combined standard uncertainty for ESD immunity measurements is ± 8.2%.	Per IEC 61000-4-2
The estimated combined standard uncertainty for radiated immunity measurements is ± 4.10 dB.	Per IEC 61000-4-3
The estimated combined standard uncertainty for conducted immunity measurements with CDN is ± 3.66 dB	Per IEC 61000-4-6
The estimated combined standard uncertainty for power frequency magnetic field immunity is ± 2.9%.	Per IEC 61000-4-8

Thermo KeyTek EMC Pro

The estimated combined standard uncertainty for EFT fast transient immunity measurements is ± 2.6%.
The estimated combined standard uncertainty for surge immunity measurements is ± 2.6%.
The estimated combined standard uncertainty for voltage variation and interruption measurements is ± 1.74%.

The expanded uncertainty at a level of 95% confidence is obtained by multiplying the combined standard uncertainty by a coverage factor of 2. Compliance criteria are not based on measurement uncertainty.

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2005. Equipment calibration records are kept on file at the test facility.

3 Product Information

3.1 Product Description

The Tile T6001 Is a Bluetooth Tracker The device has the capability of operating in the following frequency bands 2.4 GHz.

3.2 Equipment Configuration

A description of the equipment configuration is given in the Test Plan Section. The EUT was tested as called for in the test standard and was configured and operated in a manner consistent with its intended use. The placement of the EUT system components was guided by the test standard and selected to represent typical installation conditions.

In the case of an EUT that can operate in more than one configuration, preliminary testing was performed to determine the configuration that produced maximum radiation.

The final configuration was selected to produce the worst case radiation for emissions testing.

3.3 Operating Mode

A description of the operation mode is given in the Test Plan Section. In the case of an EUT that can operate in more than one state, preliminary testing was performed to determine the operating mode that produced maximum radiation.

The final operating mode was selected to produce the worst case radiation for emissions testing. All tests were performed on the T6001W model.

3.4 Unique Antenna Connector

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of CFR47 Parts 15.211, 15.213, 15.217, 15.219, 15.221 and LP0002 Section 2.2.

3.4.1 Results

Tile T6001 has integral antenna which cannot be removed without making the device unusable for transmission.

3.5 Duty Cycle

The duty cycle of the device was determined before testing was performed in order to choose the appropriate test methodology. Duty cycle was measured with a spectrum analyzer in zero span and calculated as the percentage between the transmitters on time over the signal period.

Duty cycle % = (Transmitter on time/Signal Period)*100

3.5.1 Results

Mode	Frequency	Duty Cycle
BLE	2402 MHz	100%
BLE	2440 MHz	100%
BLE	2480 MHz	100%

4 Emissions

Testing was performed in accordance with CFR 47 Part 15.247: 2017/RSS-247 Issue 2. These test methods are listed under the laboratory's A2LA Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices. Procedures described in section 8 of the standard were used.

4.1 Output Power Requirements

The maximum output power requirement is the maximum equivalent isotropic radiated power delivering at the transmitting antenna under specified conditions of measurements in the presence of modulation.

The maximum output power and harmonics shall not exceed CFR47 Part 15.247 (b):2017, RSS 247: 2017 Sect. 5.4 d and LP0002 Section 3.10.1.2 (1)(C.

The maximum transmitted powers are

Band 2400-2483.5 MHz: the maximum peak conducted output power shall not exceed 1 W and the E.R.I.P shall not exceed 4 W.

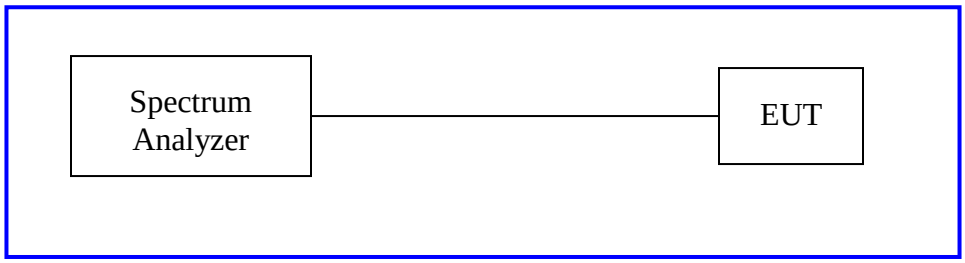
4.1.1 Test Method

The ANSI C63.10 section 11.9.1.1 conducted method was used to measure the channel power output. The measurements were conducted on 3 channels in each operating range per CFR47 Part 15.247(b): 2017 and LP0002:2018 2400 MHz to 2483.5 MHz. The device was connected to the spectrum analyzer with the following setting:

1. Span ≥ 1.5 times the OBW
2. Sweep Trigger = Free Run
3. RBW = RBW > DTS Bandwidth
4. VBW ≥ 3xRBW
5. Detector = Peak
6. Trace Mode = Max Hold
7. Sweep Time = auto couple

The trace was allowed to maximize and the peak search function was used to determine the maximum power. All measurement system losses have been accounted for and inputted into the analyzer.

Test Setup:



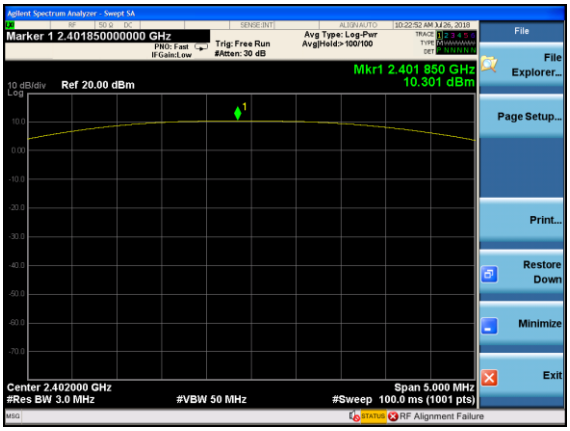
4.1.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

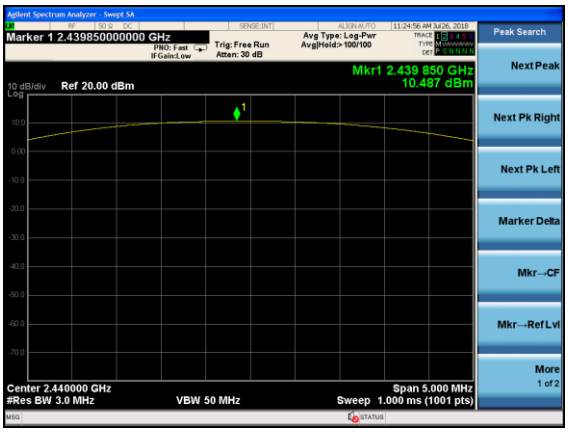
Table 2: RF Output Power at the Antenna Port – Test Results

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: PCB Trace		**Power Setting:** See test plan	
Max. Directional Gain: + 1.65 dBi			
Signal State: Modulated			
Ambient Temp.: 26° C		**Relative Humidity:**43%	
BLE			
Operating Channel (MHz)	**Limit [dBm]**	**Max Power [dBm]**	**Margin [dB]**
2402.00	30.00	10.3	19.7
2440.00	30.00	10.5	19.5
2480.00	30.00	10.9	19.1
Note: All insertion loss and corrections are accounted for in the measurement plots.			

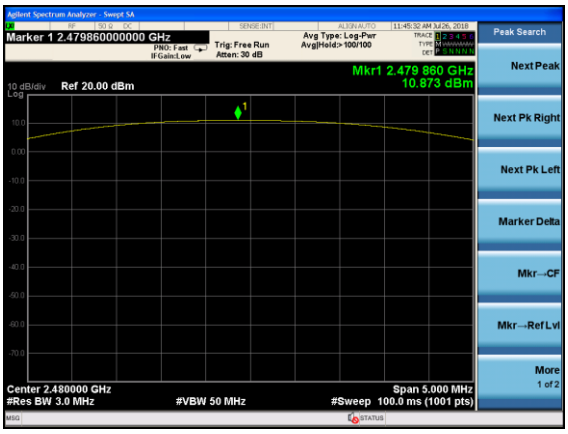
RF Output Power 2402 MHz



RF Output Power 2440 MHz



RF Output Power 2480 MHz



4.2 Occupied Bandwidth and DTS Bandwidth

The occupied bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

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

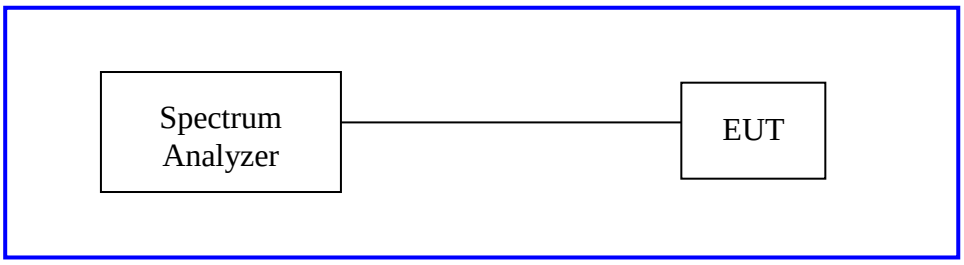
4.2.1 Test Method

The conducted method was used to measure the occupied bandwidth according to ANSI C63.10 section 11.8.2. The measurement was performed with modulation per CFR47 15.247(a) (2) 2017 on three channels operating between frequency range; 2400 MHz to 2483.5 MHz. The device was connected to the spectrum analyzer with the following setting:

1. RBW = 100 kHz
2. VBW = 3 x RBW
3. Detector = Peak
4. Sweep = auto couple

The trace was allowed to maximize and the peak emission was determined. For 99% occupied bandwidth, the spectrum analyzer's internal occupied bandwidth measurement function was used. For 6 dB bandwidth, the bandwidth was measured from the two outermost amplitude points that were attenuated by 6 dB. All measurement system losses have been accounted for and inputted into the analyzer.

Test Setup:



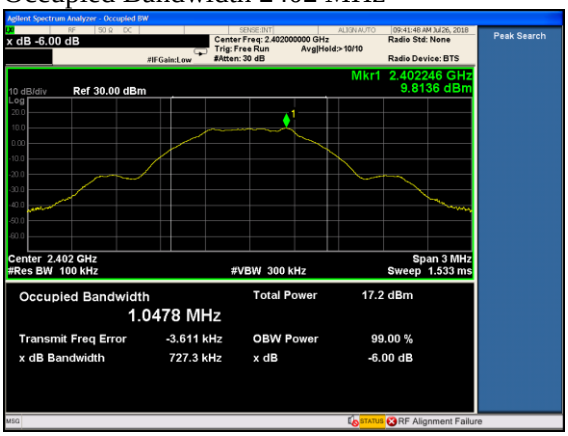
4.2.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

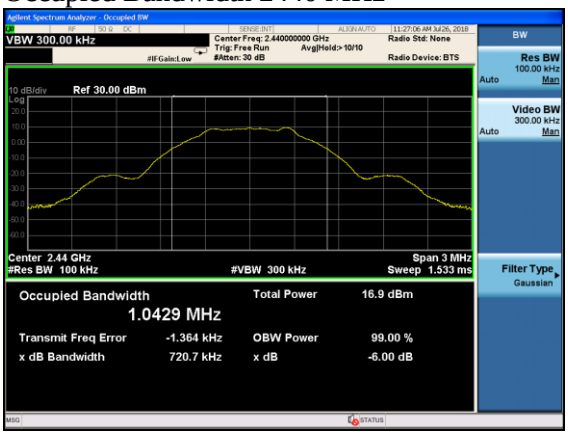
Table 3: Occupied Bandwidth – Test Results

Test Conditions: Conducted Measurement, Normal Temperature		
Antenna Type: PCB Trace		**Power Setting:** See test plan
Max. Directional Gain: + 1.65 dBi		
Signal State: Modulated		
Ambient Temp.: 26° C		**Relative Humidity:**43%
BLE		
Frequency (MHz)	**6dB Bandwidth (MHz)**	**Limit (MHz)**
2402	0.727	>0.500
2440	0.721	>0.500
2480	0.727	>0.500
Note: None		
Frequency (MHz)	**99% Bandwidth (MHz)**	**Limit (kHz)**
2402	1.05	N/A
2440	1.04	N/A
2480	1.05	N/A
Note: None		

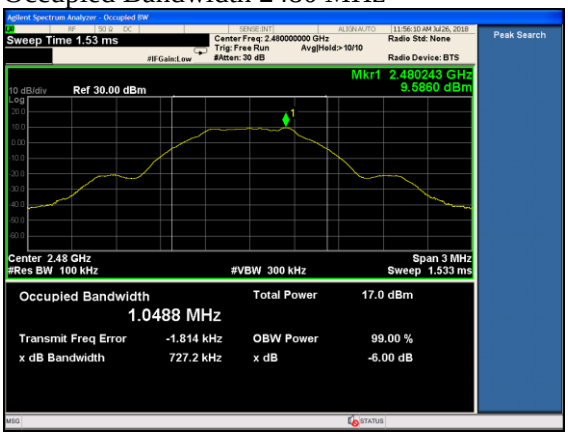
Occupied Bandwidth 2402 MHz



Occupied Bandwidth 2440 MHz



Occupied Bandwidth 2480 MHz



4.3 Peak Power Spectral Density

According to the CFR47 Part 15.247 (e), the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.3.1 Test Method

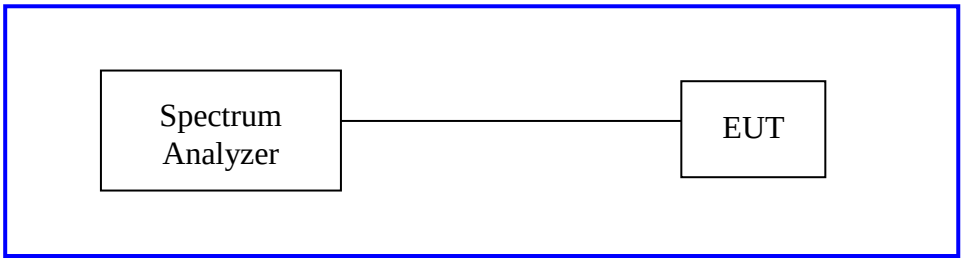
The conducted method was used to measure the channel power output per ANSI C63.10-2013 Section 11.10.2. The measurement was performed with modulation per CFR47 Part 15.247(e), RSS-247 section 5 and LP0002 3.10.1.6 (2)(B). The device was connected to the spectrum analyzer with the following setting:

1. Span = 1.5 x DTS Bandwidth (to start)
2. RBW = 3 kHz
3. VBW ≥ 3 x RBW
4. Detector = Peak
5. Sweep time = auto couple
6. Trace Mode = Max Hold

The trace is allowed to maximize and the peak marker function is used to find the peak power spectral density.

All measurement system losses have been accounted for and inputted into the analyzer.

Test Setup:



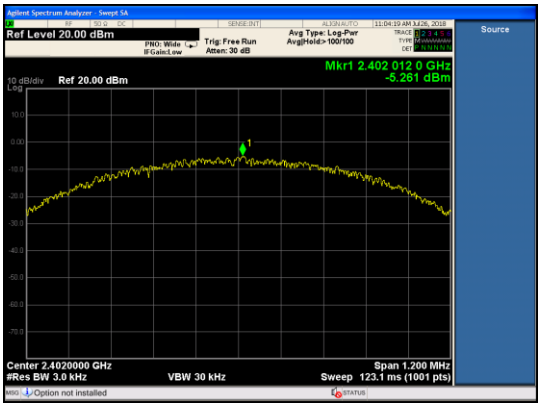
4.3.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

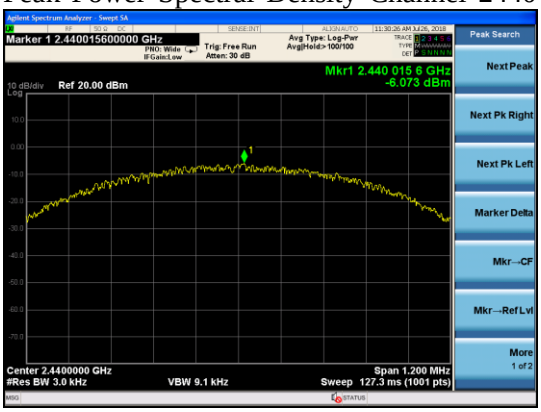
Table 4: Peak Power Spectral Density – Test Results

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: PCB Trace		**Power Setting:** See test plan	
Max. Directional Gain: + 1.65 dBi			
Signal State: Modulated			
Ambient Temp.: 26° C		**Relative Humidity:**43%	
BLE			
Frequency (MHz)	**Max PSD (dBm/3kHz)**	**Limit (dBm/3 kHz)**	**Margin [dB]**
2402	-5.26	8.00	13.26
2440	-6.07	8.00	14.07
2480	-6.13	8.00	14.13
Note: None			

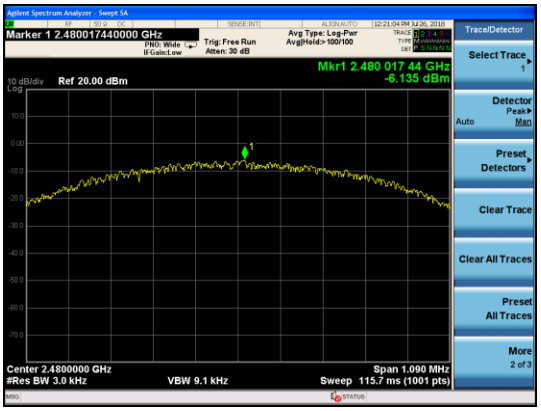
Peak Power Spectral Density Channel 2402



Peak Power Spectral Density Channel 2440



Peak Power Spectral Density Channel 2480



4.4 Out of Band Emissions

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR472.1051, 15.205, 15.209, 15.247(d), RSS-247 section 5 and LP0002 Section 3.10.1.5 (1).

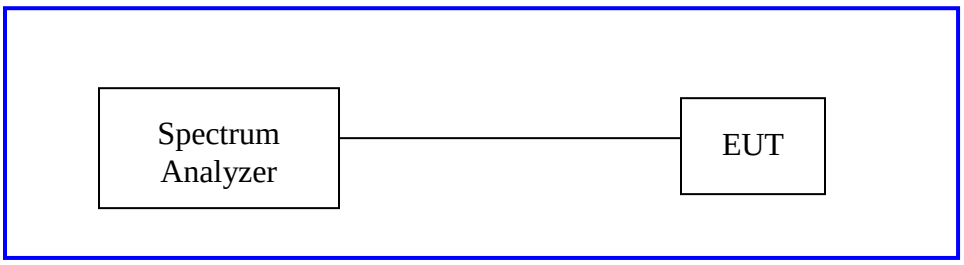
4.4.1 Test Method

ANSI C63.10 section 11.11 was used. The 20 dBc level was determined from the maximum PSD reference level procedure of section 11.11.2 of ANSI C63.10. The device was directly connected to a spectrum analyzer with the following settings:

1. Span set to encompass 30 MHz to the 10th harmonic of the fundamental
2. RBW = 100 kHz
3. VBW = 300 kHz
4. Detector Peak
5. Sweep Time = auto couple
6. Trace Mode = max hold

The trace was allowed to maximize and maximum emissions reported. All measurement system losses have been accounted for and inputted into the analyzer.

Test Setup:



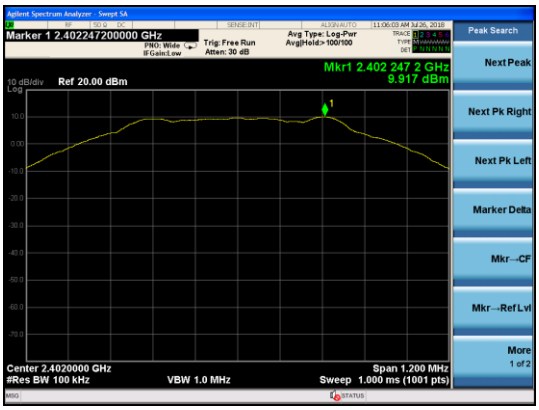
4.4.2 Results

As originally tested, the EUT was found to compliant to the requirements of the test standard(s).

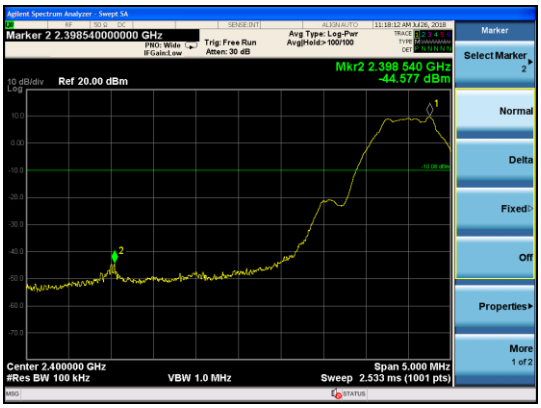
Table 5: Emissions at the Band-Edge – Test Results

Test Conditions: Conducted Measurement, Normal Temperature				
Antenna Type: PCB Trace			**Power Setting:** See test plan	
Max. Directional Gain: + 1.65				
Signal State: Modulated				
Ambient Temp.: 21° C			**Relative Humidity:** 36%	
Non-Restricted Frequency Band Emissions				
Freq. (MHz)	**Mode**	**Measured (dBm)**	**Limit (dBm)**	**Margin (dB)**
2402	BLE	-44.6	-10.1	34.6
2480	BLE	-49.0	-10.2	38.8
Note: 1. The worst case of each data rate is recorded.				

2402 MHz PSD Reference Level

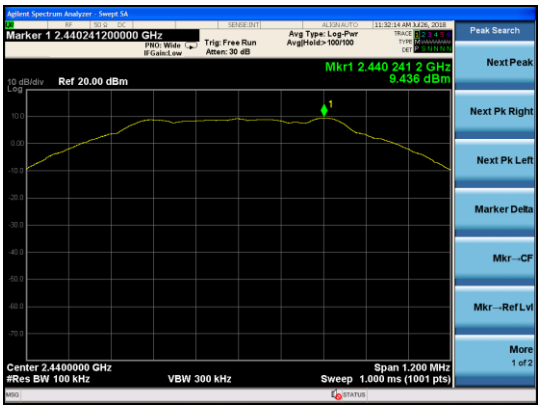


2402 MHz Conducted Bandedge



2402 MHz Conducted Spurious Emissions

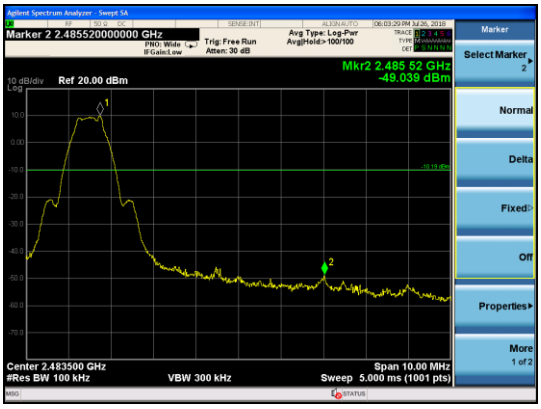
2440 MHz PSD Reference Level



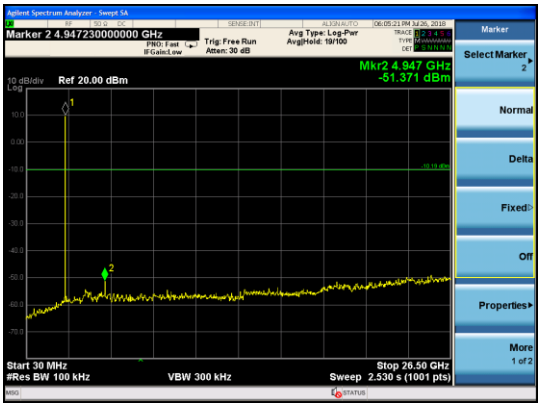
2440 MHz Conducted Spurious Emissions

2480 MHz Reference Level

2480 MHz Conducted Bandedge



2480 MHz Conducted Spurious Emissions



4.5 Transmit Spurious Emissions

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmit mode; per requirement of CFR47 15.205, 15.209, 15.247(d), RSS 247 Sect.5.5 and LP0002 Section 2.8.

4.5.1 Test Methodology

4.5.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization's.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm (<1 GHz) and 150cm (>1 GHz) above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

4.5.1.2 Final Test

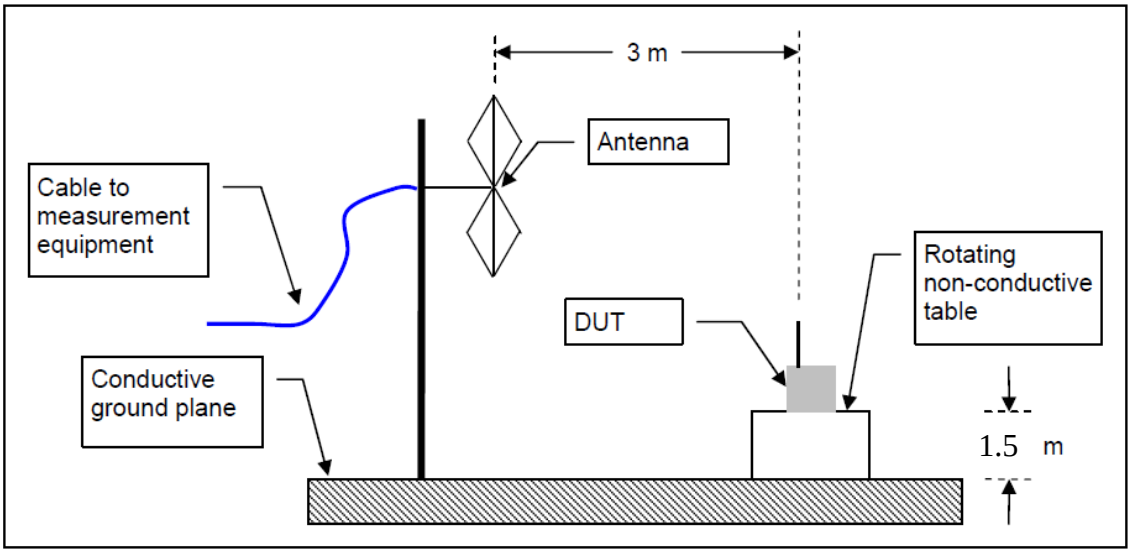
For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm (<1 GHz) and 150cm (>1 GHz) above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

4.5.1.3 Deviations

None.

Test Setup:



4.5.2 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209: 2018 and RSS Gen Sect. 8.9: 2018 and LP0002 Section 2.8: 2018.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490.....	2400/F(kHz)	300
0.490-1.705.....	24000/F(kHz)	30
1.705-30.0.....	30	30
30-88.....	100 **	3
88-216.....	150 **	3
216-960.....	200 **	3
Above 960.....	500	3

All harmonics and spurious emission which are outside of the restricted band shall be 20dB below the in-band emission.

4.5.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and test plan.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

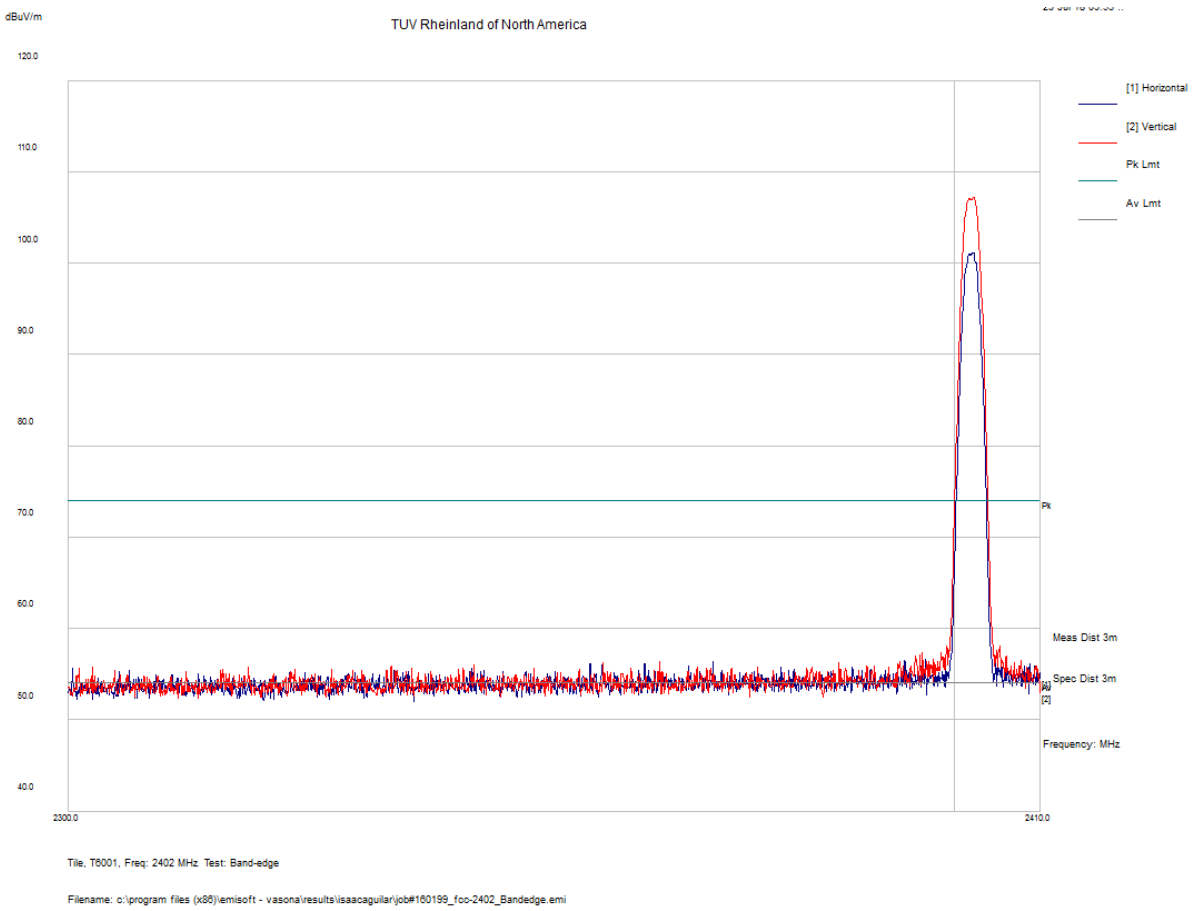
Table 6: Transmit Spurious Emission at Band-Edge Requirements

Test Conditions: Conducted Measurement, Normal Temperature									
Antenna Type: PCB Trace						**Power Setting:** See test plan			
Max. Directional Gain: + 1.65 dBi									
Signal State: Modulated									
Ambient Temp.: 21° C						**Relative Humidity:** 36%			
Band-Edge Results									
Frequency (MHz)	**Raw (dBµV/m)**	**Detector**	**Cable Loss (dB)**	**Antenna Factor (dBi)**	**Level (dBµV/m)**	**Pol (H/V)**	**Height (cm)**	**Limit (dBµV/m)**	**Margin (dBµV/m)**
BLE									
2390	26.7	Peak	1.46	28.24	56.41	V	245	74	17.6
2390	17.46	Ave	1.47	28.32	47.24	H	250	54	6.76
2483.5	28.24	Peak	1.51	28.4	58.15	V	250	74	15.85
2483.5	17.71	Ave	1.52	28.4	47.14	H	150	54	6.86

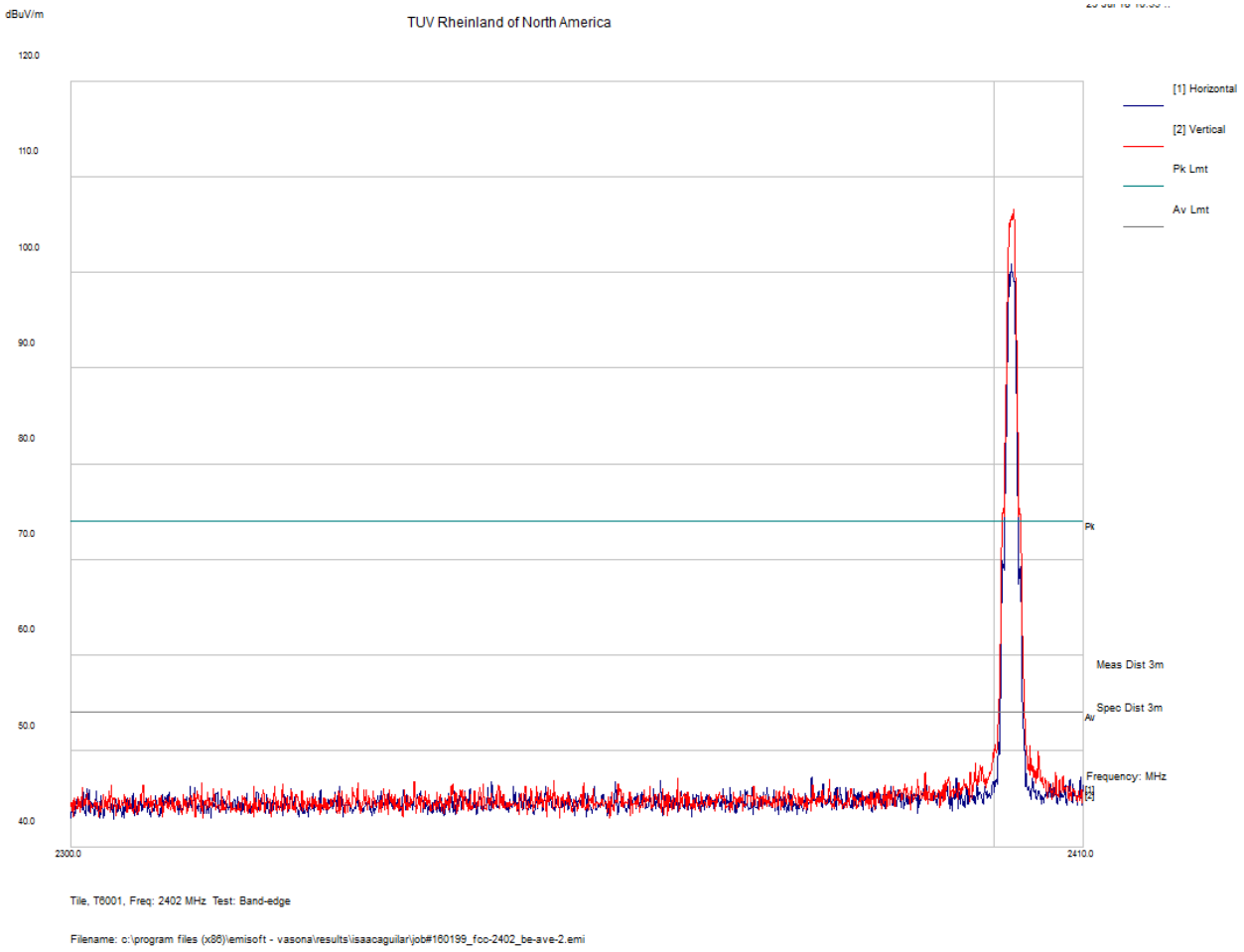
Note: 1. The emissions were measured at the adjacent restricted band of the fundamental signal.
2. All the band-edge measurements met the restricted band requirements of CFR47 15.205.

4.5.4 Band-edge Data

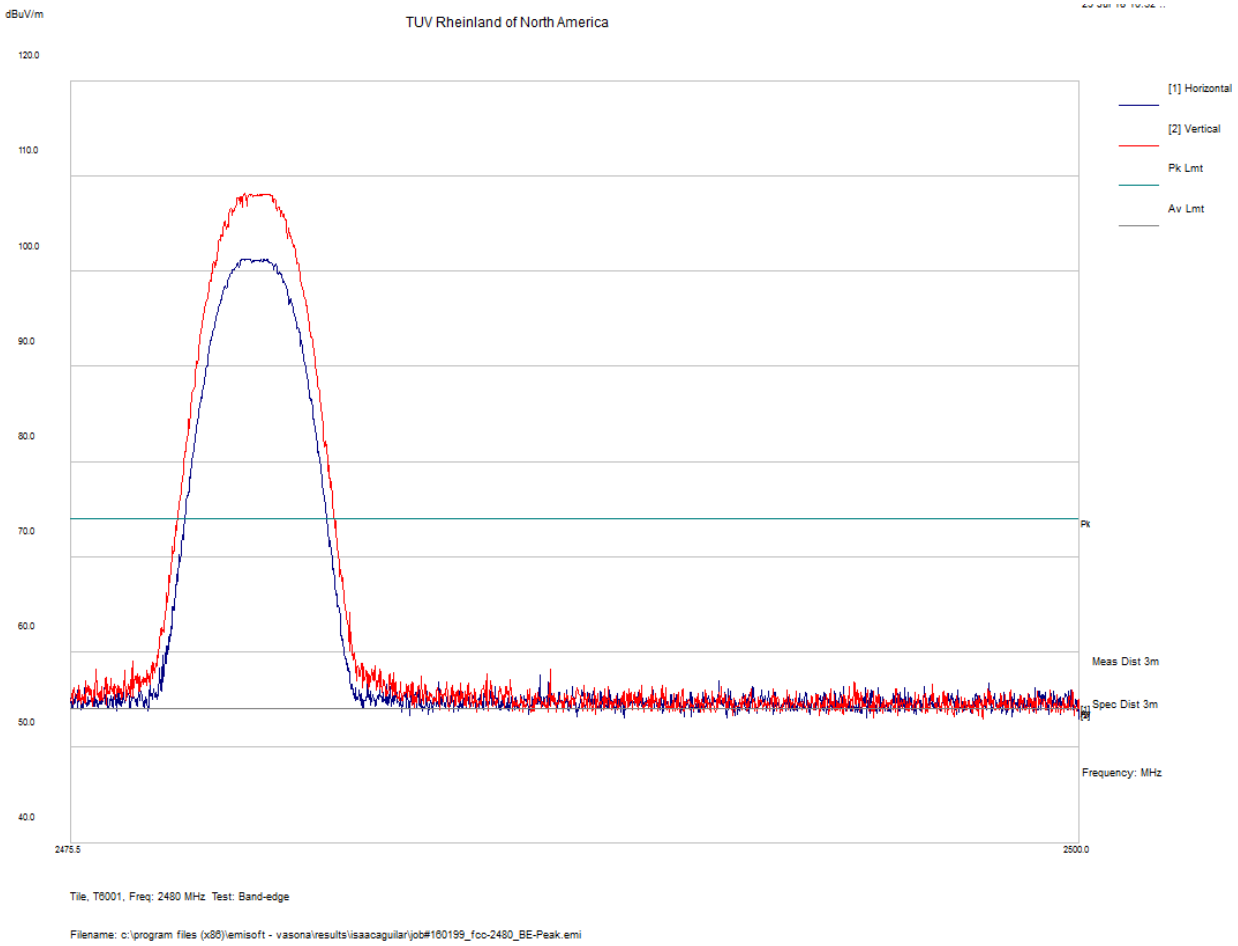
2402 MHz – Peak Horizontal/Vertical



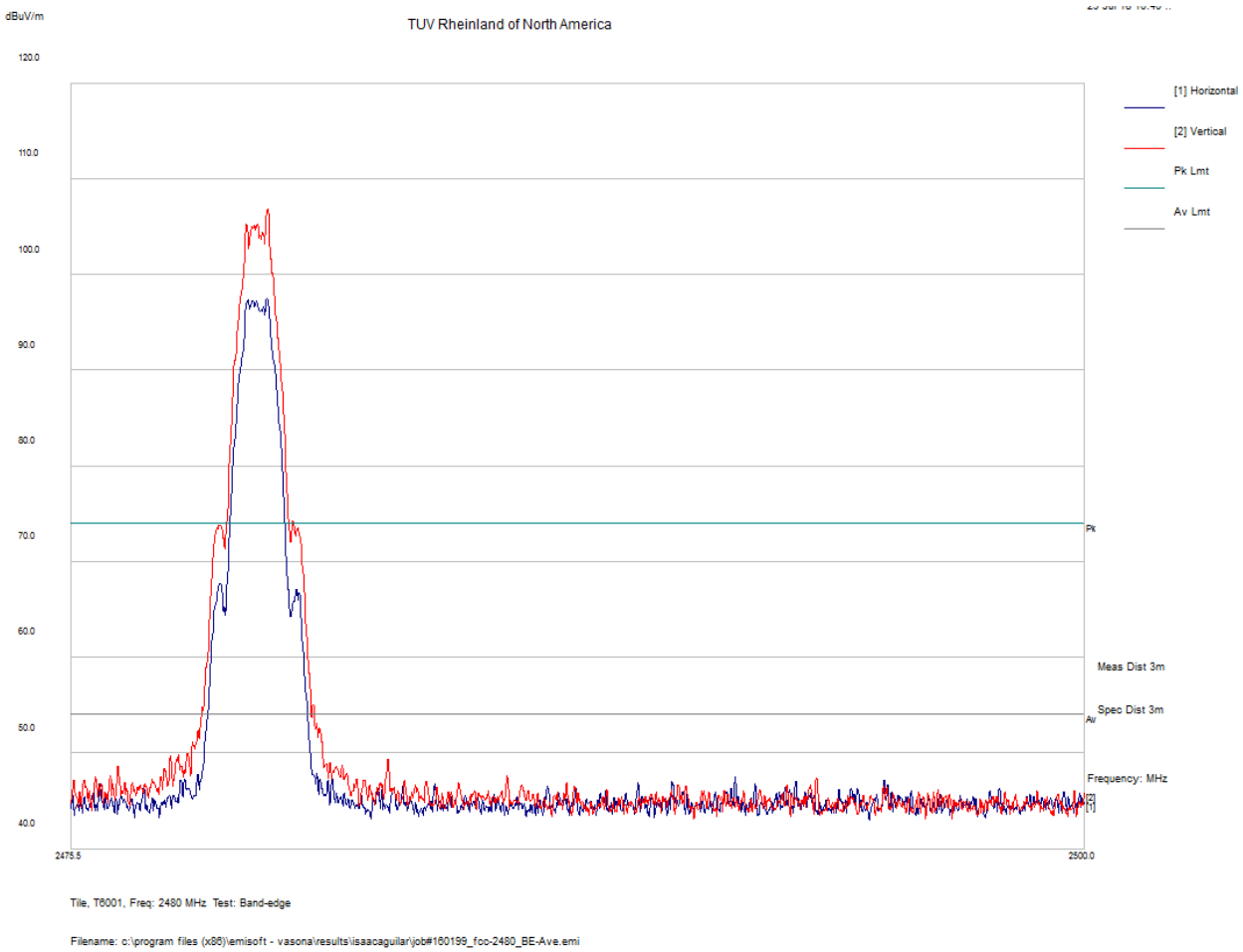
2402 MHz – Average Horizontal/Vertical



2480 MHz – Peak Horizontal/Vertical



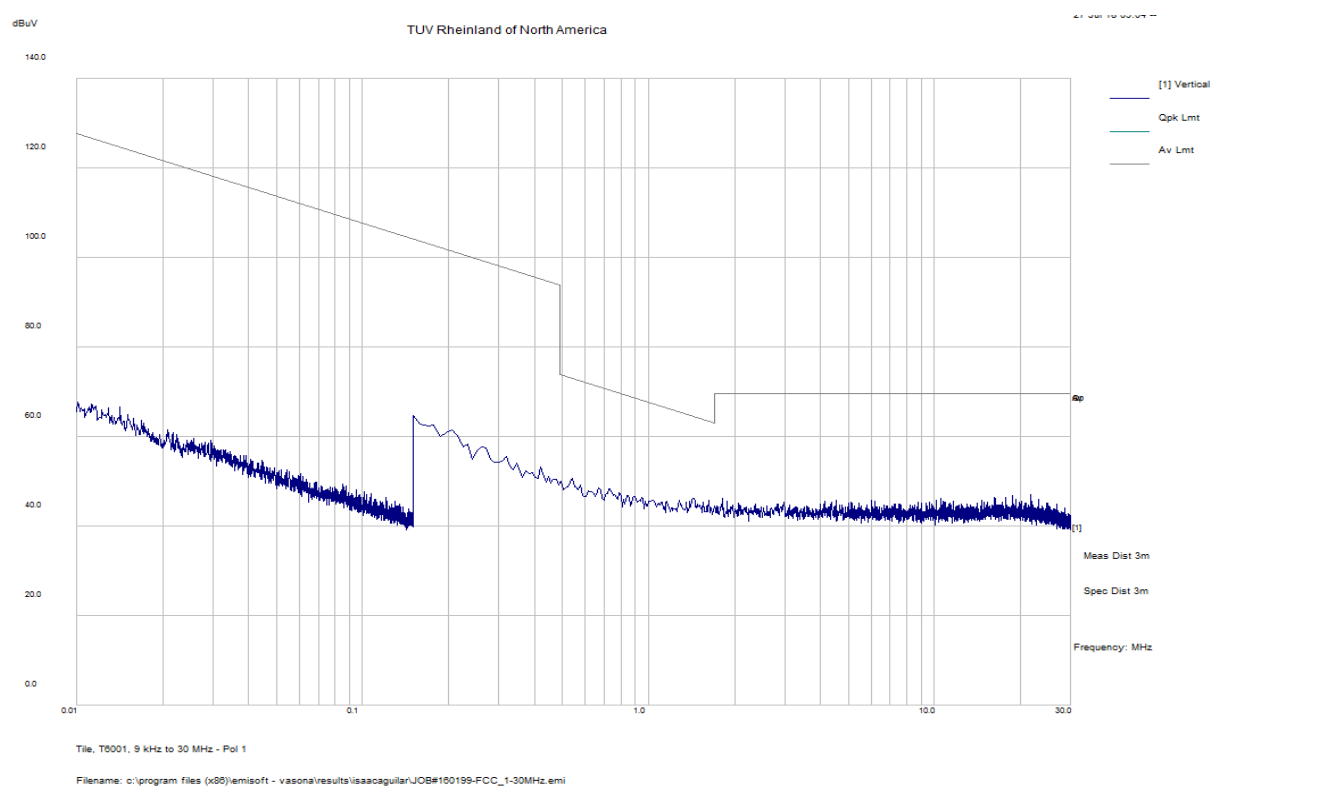
2480 MHz – Peak Horizontal/Vertical



SOP 1 Radiated Emissions		Tracking #	Page 1 of 4
EUT Name	T6001	**Date**	July 27, 2018
EUT Model	T6001W / T6001B	**Temp / Hum in**	23.6 C
EUT Serial	N/A	**Temp / Hum out**	43%
EUT Config.	Bluetooth Low Energy – 2480 MHz	**Line AC / Freq**	N/A
Standard	§15.209	**RBW / VBW**	N/A
Dist/Ant Used	3 meter/Loop Antenna	**Performed by**	Abraham Avalos

9kHz – 30 MHz Transmit at 2480 MHz

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
21.677775	34.26	2.47	10.16	46.89	Peak [Scan]	V	136	216	69.5	-22.61
0.669925	35.81	2.27	10.3	48.38	Peak [Scan]	V	136	6	71.08	-22.7
23.1023	33.54	2.48	9.88	45.9	Peak [Scan]	V	136	92	69.5	-23.6



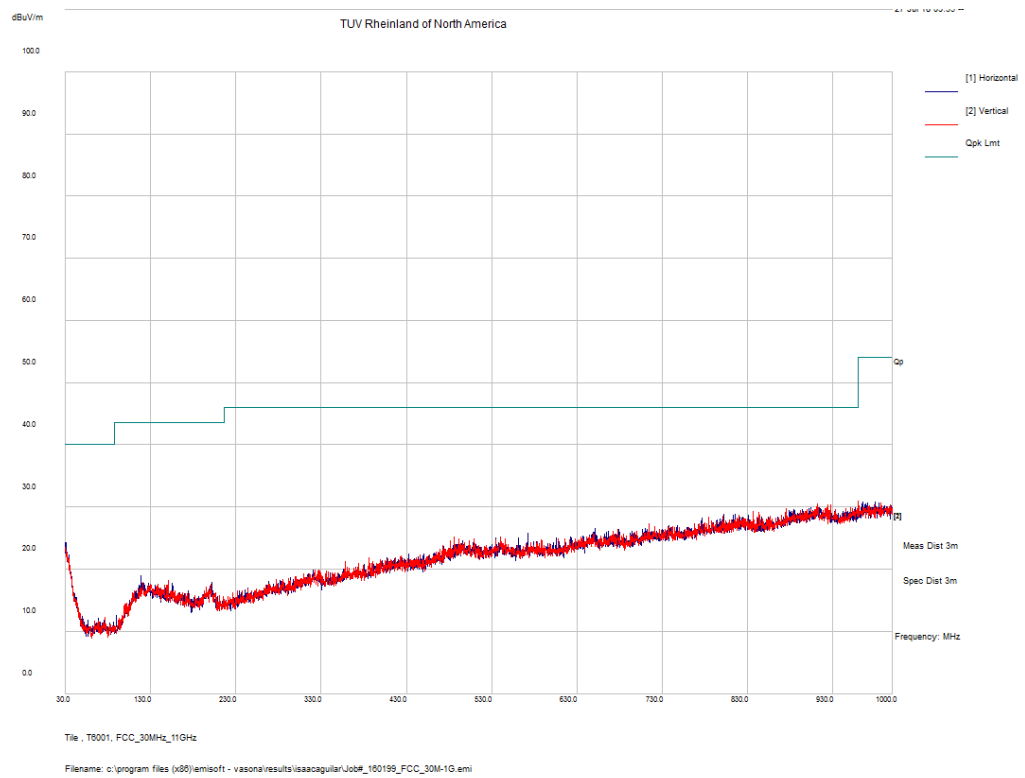
Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note: Worst case configuration was tested and report. Worst case configuration was determined by max power and PSD.

SOP 1 Radiated Emissions		Tracking #	Page 2 of 11
EUT Name	T6001	**Date**	July 27, 2018
EUT Model	T6001W / T6001B	**Temp / Hum in**	23.6 C
EUT Serial	N/A	**Temp / Hum out**	43%
EUT Config.	Bluetooth Low Energy – 2480 MHz	**Line AC / Freq**	N/A
Standard	§15.209	**RBW / VBW**	N/A
Dist/Ant Used	3 meter/Bi-Log Antenna	**Performed by**	Abraham Avalos

30 MHz – 1 GHz Transmit at 2480 MHz

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
959.99	29.32	5.06	-3.45	30.93	Peak [Scan]	V	200	252.00	46.00	-15.07
30.00	28.28	2.49	-6.48	24.29	Peak [Scan]	H	100	237.00	40.00	-15.71



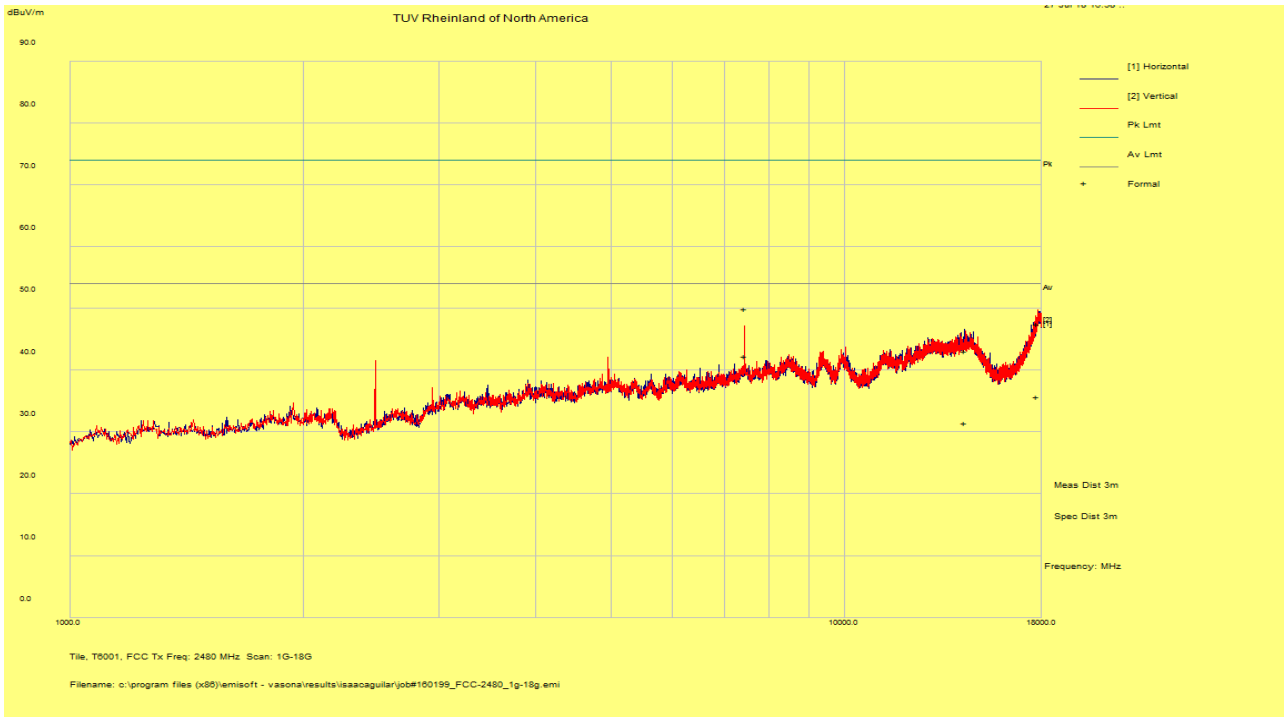
Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note: Worst case configuration was tested and report. Worst case configuration was determined by max power and PSD.

SOP 1 Radiated Emissions		Tracking #	Page 3 of 11
EUT Name	T6001	**Date**	July 27, 2018
EUT Model	T6001W / T6001B	**Temp / Hum in**	23.6 C
EUT Serial	N/A	**Temp / Hum out**	43%
EUT Config.	Bluetooth Low Energy – 2480 MHz	**Line AC / Freq**	N/A
Standard	§15.209	**RBW / VBW**	N/A
Dist/Ant Used	3 meter/Bi-Log Antenna	**Performed by**	Abraham Avalos

1 GHz – 18 GHz Transmit at 2462 MHz

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
7439.302743	60.31	2.7	-13.11	49.9	Peak Max	V	122	230	74	-24.1
7439.302743	52.73	2.7	-13.11	42.33	Average Max	V	122	230	54	-11.67
14314.143	49.22	3.68	-9.76	43.14	Peak Max	H	171	269	74	-30.86
14314.143	37.54	3.68	-9.76	31.46	Average Max	H	171	269	54	-22.54
17784.846	35.6	4.25	-4.06	35.79	Average Max	V	202	236	54	-18.22
17784.846	47.31	4.25	-4.06	47.49	Peak Max	V	202	236	74	-26.51



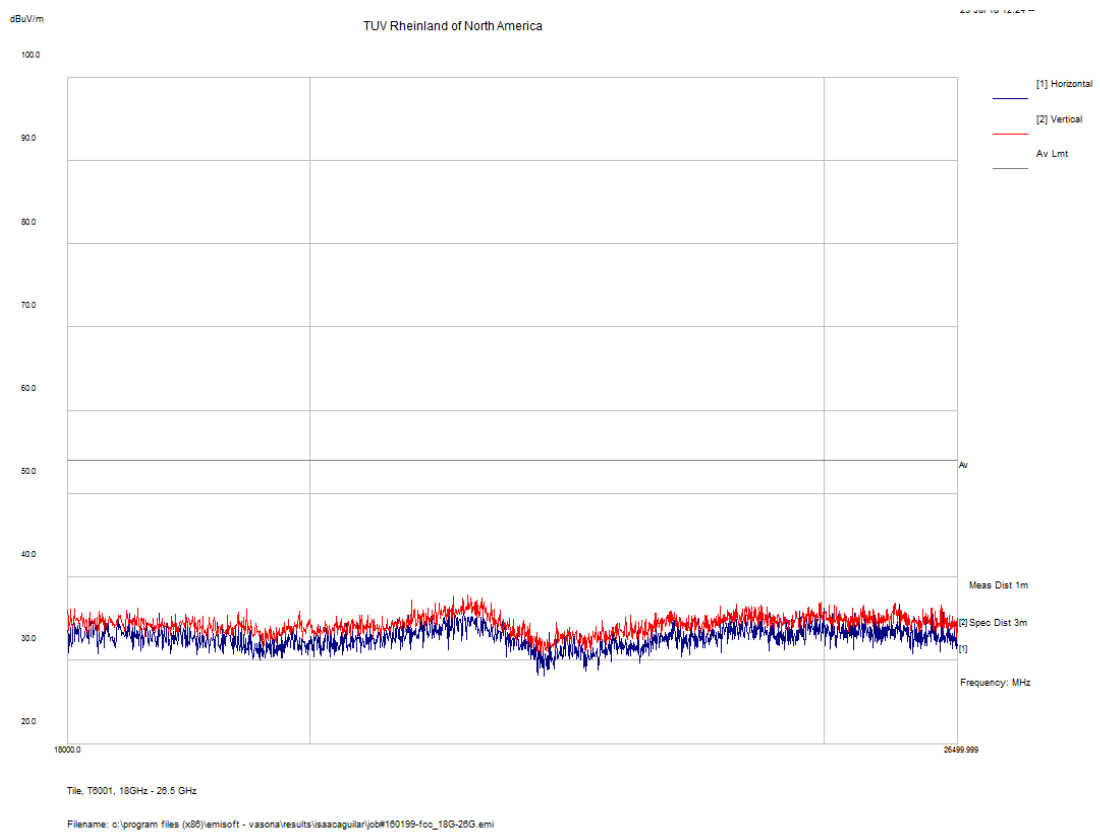
Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note: Worst case configuration was tested and report. Worst case configuration was determined by max power and PSD.

SOP 1 Radiated Emissions		Tracking #	Page 4 of 11
EUT Name	T6001	**Date**	July 29, 2018
EUT Model	T6001W / T6001B	**Temp / Hum in**	20.6 C
EUT Serial	N/A	**Temp / Hum out**	38.8%
EUT Config.	Bluetooth Low Energy – 2480 MHz	**Line AC / Freq**	N/A
Standard	§15.209	**RBW / VBW**	N/A
Dist/Ant Used	3 meter/Bi-Log Antenna	**Performed by**	Abraham Avalos

1 – 18 GHz Transmit at 2462 MHz

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB
21421.25	39.62	7.7	-9.51	37.81	Peak [Scan]	V	150	166	54	-16.19
24969.999	41.82	8.17	-13.01	36.99	Peak [Scan]	V	150	130	54	-17.01



Spec Margin = E-Field AVG - Limit, E-Field AVG = FIM AVG+ Total CF ± Uncertainty
Total CF= AF+ Cable Loss AF= Antenna factor + Preamp

Note: Worst case configuration was tested and report. Worst case configuration was determined by max power and PSD.

4.6 AC Conducted Emissions

Testing was performed in accordance with ANSI C63.4:2014. These test methods are listed under the laboratory's A2LA Scope of Accreditation.

This test measures the levels emanating from the EUT's AC input port, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

The AC conducted emissions of equipment under test shall not exceed the values in CFR47 Part 15.207: 2017 and RSS Gen: 2017 Sect. 8.8.

4.6.1 Test Methodology

A test program that controls instrumentation and data logging was used to automate the AC Power Line Conducted emission test procedure. The frequency range of interest was divided into sub-ranges such as to yield a frequency resolution of 9 kHz. Each phase and neutral of the AC power line were measured with respect to ground. Measurements were performed using a set of 50µH / 50Ω LISNs.

Testing is performed in Lab 5. The setup photographs clearly identify which site was used. The vertical ground plane used in the semi-anechoic chamber is a 2m x 2m solid aluminum frame and panel, and it is bonded to the horizontal ground plane.

In the case of tabletop equipment, the EUT is placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane and 40cm from a vertical ground reference plane. The rear of the EUT was positioned flush with the backside of the table and directly over the LISNs. The power and I/O cables were routed over the edge of the table and bundled approximately 40cm from the ground plane. Support equipment was powered from a separate LISN.

4.6.1.1 Deviations

There were no deviations from this test methodology.

4.6.2 Test Results

No testing is required because EUT is battery powered and not connected to AC mains.

4.7 Maximum Permissible Exposure – Not Applicable

4.7.1 Test Methodology

In this section, we try to prove the safety of radiation harmfulness to the human body for our product. The KDB 447498 D01v06 General RF Exposure Guidance is followed. The Gain of the antenna used in this calculation is declared by the manufacturer, and the maximum average power input to the antenna is measured. Using the general SAR test exclusion guidance in Section 4.3 of KDB 447498 D01v06, we show that the device meets the SAR exclusion threshold found in Appendix A of KDB 447498 D01v06 and the SAR exemption limits found in table 1 of RSS-102 Issue 5.

ISED accepts the KDB 447498 D01v06 Procedure.

4.7.2 FCC KDB 447498 D01v06 – General SAR Test Exclusion Guidance

The SAR exclusion threshold conditions are listed:
1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by the following formula:

$$\text{Exclusion Threshold} = [\ P / d\ ] * [\sqrt{f}]$$

Where

P = max power of channel (including tune-up tolerance) in mW
d = min. test separation distance in mm
f = the RF channel transmit frequency in GHz
Power and distance are rounded to the nearest mW and mm before calculation
The result is rounded to one decimal place for comparison

<u>Limits:</u> ≤ 3.0 for 1-g SAR ≤ 7.5 for 10-g extremity SAR

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

4.7.3 EUT Operating Condition

The software provided by Manufacturer enabled the EUT to transmit data at lowest, middle and highest channel individually.

4.7.4 Classification

The antenna of the product, under normal condition, is less than 20cm away from the body of the user. This device is classified as a **Portable Device**.

4.7.5 Test Results

1. **FCC:**
   1.1. Max Conducted Power: 10.9 dBm @ 2480 MHz
   1.2. Maximum Antenna Gain: 1.65 dBi
   1.3. Separation distance: 5 mm
   1.4. Threshold Level: 6.5 W GHz/m
      1.4.1. The device meets that SAR exclusion threshold for extremity use. Does not meet the body used case.

2. **ISED:**
   2.1. Maximum Power: 10.9 dBm @ 2480 MHz
   2.2. Maximum Antenna Gain: 1.65 dBi
   2.3. Separation Distance: 5 mm
   2.4. Threshold Level: 4 mW (as per RSS-102 Section 2.5.1)
      2.4.1. The device doesn't meet the minimum requirement for SAR exclusion. SAR must be performed.

5 Test Equipment List

5.1 Equipment List

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal mm/dd/yyyy	Next Cal mm/dd/yyyy
Receiver	Agilent	N9038A	MY52260210	01/22/2018	01/22/2019
Receiver	Agilent	N9038A	MY51210195	01/24/2018	01/24/2019
Horn Antenna	Sunol Sciences	DRH-118	A040806	11/11/2017	11/11/2018
Bi-log Antenna	Sunol Sciences	JB3	A061907	11/20/2017	11/20/2018
Active Loop Antenna	EMCO	6502	00062531	05/17/2017	05/17/2019
Active Horn Antenna	Com-Power	LI-215	12100	01/24/2018	01/24/2019
Directional Coupler	Agilent	87301D Opt 240	14044A	N/A	N/A
Amplifier	MiTeq	TTA1800-30-HG	1842452	01/13/2018	01/13/2019
Amplifier	Hewlett-Packard	8447D	2944A06715	01/26/2018	01/26/2019
Notch Filter	Micro-Tronics	BRM50702	037	N/A	N/A

6 EMC Test Plan

6.1 Introduction

This section provides a description of the Equipment Under Test (EUT), configurations, operating conditions, and performance acceptance criteria. It is an overview of information provided by the manufacturer so that the test laboratory may perform the requested testing.

6.2 Customer

Table 7: Customer Information

Company Name	Tile, Inc.
Address	2121 South El Camino Real, Suite 900
City, State, Zip	San Mateo CA 94403
Country	USA
Phone	(415) 902-9629

6.3 Equipment Under Test (EUT)

Table 8: EUT Specifications

EUT Specifications	
Dimensions	4.1 cm x 4.1 cm x 0.8 cm
DC Input	3 VDC
Operating Temperature Range:	-10º to +60º Celsius
Multiple Feeds:	☐ Yes and how many ☒ No
Hardware Version	08-00W00JD
Part Number	N/A
RF Software Version	05.03.07.9
Bluetooth Low Energy	
Operating Mode	BLE
Transmitter Frequency Band	2.4 GHz – 2.4835 GHz
Antenna Type	PCB Trance Antenna
Antenna Gain	1.65 dBi
Modulation Type	☐ AM ☐ FM ☐ DSSS ☒ GFSK ☐ Other describe: 16QAM and 64 QAM
Data Rate	1 Megabyte
TX/RX Chain (s)	Single; no beam forming
Directional Gain Type	☐ Uncorrelated ☐ Beam-Forming ☒ Other describe:
Type of Equipment	☐ Table Top ☐ Wall-mount ☐ Floor standing cabinet ☒ Other: Bluetooth Tracker
Note: None.	

Table 14: Interface Specifications

Interface Type	Cabled with what type of cable?	Is the cable shielded?	Maximum potential length of the cable?	Metallic (M), Coax (C), Fiber (F), or Not Applicable?
N/A		☐ No	☐ Metric: 1.5 m	☒ N/A

Table 15: Supported Equipment

Equipment	Manufacturer	Model	Serial	Used for
N/A				
Note: None.				

Table 16: Description of Sample used for Testing

Device	Serial Number	Configuration	Used For
T6001	0000T6001	Radiated & Conducted	Bluetooth Tracking

END OF REPORT