Test Report No.: *Prüfbericht-Nr.:*	**US218Q3U 001**	**Order No.:** *Auftrags-Nr.:*	P00221745 234170610	Page 1 of 61 *Seite 1 von 61*
Client Reference No.: *Kunden-Referenz-Nr.:*	2239519	**Order date:** *Auftragsdatum:*	3/16/2021	
Client: *Auftraggeber:*	Whoop, Inc. 1325 Boylston Street, Unit 401, Boston MA 02215, USA			
Test item: *Prüfgegenstand:*	Whoop 4.0			
Identification/ Type No.: *Bezeichnung / Typ-Nr.*	WS40			
Order content: *Auftrags-Inhalt:*	Radio Compliance Test Report			
Test specification: *Prüfgrundlage:*	CFR 47 Part 15.247: 2021 and RSS 247: 2017			
Date of sample receipt: *Wareneingangsdatum:*	8/24/2021	See Test Setup Exhibit for Photos		
Test sample No: *Prüfmuster-Nr.:*	WS40			
Testing period: *Prüfzeitraum:*	8/25/2021- 9/1/2021			
Testing laboratory: *Prüflaboratorium:*	TUV Rheinland of North America 5015 Brandin Ct. Fremont, CA 94538			
Test result*: *Prüfergebnis*:*	Pass			

tested by: *geprüft von:*

authorized by: / *genehmigt von:*

Date: 10/1/2021 *Datum:*

Issue Date: 10/1/2021 *Ausstellungsdatum:*

Position / Stellung: Expert

Position / Stellung: Expert

Others / *Sonstiges*:

Condition of the test item at delivery: *Zustand des Prüfgegenstandes bei Anlieferung:* Test sample complete and undamaged

* Legend:	P(ass) = passed a.m. test specification(s)	F(ail) = failed a.m. test specification(s)	N/A = not applicable	N/T = not tested
** Legende:*	*P(ass) = entspricht o.g. Prüfgrundlage(n)*	*F(ail) = entspricht nicht o.g. Prüfgrundlage(n)*	*N/A = nicht anwendbar*	*N/T = nicht getestet*

Remarks
Anmerkungen

1	The equipment used during the specified testing period was calibrated according to our test laboratory calibration program. The equipment fulfils the requirements included in the relevant standards. The traceability of the test equipment used is ensured by compliance with the regulations of our management system. Detailed information regarding test conditions, equipment and measurement uncertainty is available in the test laboratory and could be provided on request. *Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben.* *Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden.*
2	As contractually agreed, this document has been signed digitally only. TUV Rheinland has not verified and unable to verify which legal or other pertaining requirements are applicable for this document. Such verification is within the responsibility of the user of this document. Upon request by its client, TUV Rheinland can confirm the validity of the digital signature by a separate document. Such request shall be addressed to our Sales department. An environmental fee for such additional service will be charged. *Wie vertraglich vereinbart, wurde dieses Dokument nur digital unterzeichnet. Der TÜV Rheinland hat nicht überprüft, welche rechtlichen oder sonstigen diesbezüglichen Anforderungen für dieses Dokument gelten. Diese Überprüfung liegt in der Verantwortung des Benutzers dieses Dokuments. Auf Verlangen des Kunden kann der TÜV Rheinland die Gültigkeit der digitalen Signatur durch ein gesondertes Dokument bestätigen. Diese Anfrage ist an unseren Vertrieb zu richten. Eine Umweltgebühr für einen solchen zusätzlichen Service wird erhoben.*
3	Test clauses with remark of * are subcontracted to qualified subcontractors and descripted under the respective test clause in the report. Deviations of testing specification(s) or customer requirements are listed in specific test clause in the report. *Prüfklausel mit der Note * wurden an qualifizierte Unterauftragnehmer vergeben und sind unter der jeweiligen Prüfklausel des Berichts beschrieben.* *Abweichungen von Prüfspezifikation(en) oder Kundenanforderungen sind in der jeweiligen Prüfklausel im Bericht aufgeführt.*
4	The test results contained in this report refer exclusively to the product(s) presented for testing. No liability may be assumed for models or products not referred to herein. This test report may not be published or duplicated in part without permission of the testing body. This test report by itself does not constitute authorization for the use of any TÜV Rheinland test mark. The report must not be used by the client to claim product certification, approval, or endorsement by A2LA.
5	Radio Compliance Emissions Test Report. The above product was found to be Compliant to the above test standard(s).

Test report no .: US218Q3U 001
Prüfbericht-Nr.:

Product description
Produktbeschreibung

1	**Product details:** *Produktdetails:*	Wearable Health monitor
2	**Dimensions / Weight:** *Maße / Gewicht:*	3.6 cm x 3 cm x 0.8 cm
3	**Operating elements:** *Bedienelemente:*	Battery Operated 4.4VDC, Transmit bands 2.402-2.4835 GHz.
4	**Equipment / Accessories:** *Ausstattung / Zubehör:*	HP Laptop
5	**Used materials:** *Verwendete Materialien:*	None.
6	**Other:** *Sonstiges:*	Test sample(s), as well sample information, description, product details and intended usage was provided by customer.
7	**Test sample obtaining:** *Prüfmusterbereitstellung:*	☒ Sending by customer ☐ Sampling by TÜV Rheinland Group ☐ others:

Revisions

Date mm/dd/yy	Name	Page Number of Change	Describe Change
09/10/2021	Rev. 0	N/A	Original Document
09/14/2021	Rev. 1	Page 1,6, 56 and 59	Updated Model No.
10/01/2021	Rev. 2	Page 33	Added RBW and VBW settings

TABLE OF CONTENTS

1 General Information

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.247: 2021 and RSS 247: 2017 based on the results of testing performed from August 25, 2021 through September 01, 2021 on Model WS40 manufactured by Whoop, Inc. 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 2402 MHz to 2480 MHz frequency band for Bluetooth, Low Energy is covered in this document.

1.3 Summary of Test Results

Table 1 - Summary of Test Results

Test	Test Method ANSI C 63.10 & C63.4	Worse Case (Measured)	Result
Maximum Output Power	CFR47 15.247 (b), RSS 247 Sect. 5.4 (d)	7.74 dBm @ 2402MHz Channel, 1Mbps	**Complied**
DTS Bandwidth (6dB)	CFR47 15.247 (a)(2), RSS 247 Sect. 5.2 (a)	0.688MHz @ 2440MHz Channel, 1Mbps	**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS 247 Sect. 5.2 (b)	-10.42 dBm/3kHz @ 2402MHz channel, 1Mbps	**Complied**
Out of Band Emissions: Non-Restricted	CFR47 15.247 (d), RSS 247 Sect.5.5	-40.56 dBc @ 2400 MHz, Lower Band Edge	**Complied**
Out of Band Emissions: Restricted	CFR47 15.205, RSS GEN Sect.8.10	-25.45dB margin @ 2484.02 MHz, Average	**Complied**
Transmitter Spurious Emissions	CFR47 15.209, CFR47 15.247 (d), RSS-GEN Sect.8.9	-5.59dB Margin @ 52.60MHz, Quasi Peak	**Complied**
AC Power Conducted Emission	CFR47 15.207, RSS-GEN Sect.8.8	-7.84 dB (Margin)	**Complied**
Note: This test report covers 2400 MHz to 2480 MHz band. Class B limits were applied where applicable.			

1.4 Special Accessories

No special accessories were necessary in order to achieve compliance.

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TUV Rheinland of North America EMC test facilities located at 1279 Quarry Lane, Ste. A, Pleasanton, CA, 94566, and 5015 Brandin Ct, Fremont, CA. 94538, are 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 (Pleasanton Registration No. US1131, Fremont Registration No. US1131). The laboratory Scopes of Accreditation include Title 47 CFR Parts 15, 18 and 90. The accreditations are updated every three years.

2.1.2 A2LA

TUV Rheinland of North America EMC test facilities are accredited by the American Association for Laboratory Accreditation (A2LA). The laboratories have been assessed and accredited by A2LA in accordance with ISO Standard 17025:2017 (Testing Certificate #3331.02). The Scope of Laboratory Accreditation includes emission and immunity testing. The accreditations are updated annually.

2.1.3 Industry Canada

The Pleasanton 5-meter Semi-Anechoic Chamber, Registration No. 2932M-1, has been accepted by Industry Canada to perform testing to 3 and 5 meters based on the test procedures described in ANSI C63.4-2014. The Fremont 10-meter Semi-Anechoic Chamber, Registration No. 2932D-1, has been accepted by Industry Canada to perform testing to 3 and 10 meters based on the test procedures described in ANSI C63.4-2014.

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. TUV Rheinland of North America EMC test facilities located at 1279 Quarry Lane, Ste. A, Pleasanton, CA, 94566, and 5051 Brandin Ct, Fremont, CA. 94538, have been assessed and approved in accordance with the Regulations for Voluntary Control Measures.

VCCI Registration No. for Pleasanton: A-0326

VCCI Registration No. for Fremont: A-0327

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 TUV 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 & EMC Software

Test facilities are located at 1279 Quarry Lane, Ste. A, Pleasanton, California 94566, U.S.A. and 5015 Brandin Ct, Fremont, CA. 94538, U.S.A. (Fremont is the Pleasanton Annex).

2.2.1 Emission Test Facility

The Semi-Anechoic Chambers and AC Line Conducted measurement facilities used to collect radiated and conducted emissions data have been constructed in accordance with ANSI C63.7:1992. The Fremont 10 meter semi-anechoic chamber has been measured in accordance with and verified to comply with the theoretical volumetric normalized site attenuation of ANSI C63.4-2014 and SVSWR requirements of CISPR 16-1-4 Consol. Ed. 3.0 (2010-04), at test distances of 3 and 10 meters. This site has been described in reports dated November 1st, 2006, submitted to the FCC, and accepted by letter dated November 28, 2006. The site is listed with the FCC and accredited by A2LA (Testing Certificate #3331.02). The Pleasanton 5 meter semi-anechoic chamber has been verified to comply with the theoretical volumetric normalized site attenuation of ANSI C63.4-2014 and SVSWR requirements of CISPR 16-1-4 Consol. Ed. 3.0 (2010-04) at a test distance of 3 meters. This site has been described in reports dated November 1st, 2006, submitted to the FCC, and accepted by letter dated November 28, 2006. The site is listed with the FCC and accredited by A2LA (Testing Certificate #3331.02).

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 7.3 m x 4.3 m x 4.1 m anechoic chamber.

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

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

2.2.3 EMC Software – Pleasanton and Fremont

Manufacturer	Name	Version	Test Type
Rohde & Schwarz	EMC32	10.40.10	Radiated Emissions
ETS-Lindgren	TILE	3.4.K.14 @ 4.0.A.5	Radiated & Conducted Emissions
Agilent	Agilent MXE	A.11.02	Radiated & Conducted Emissions
ETS-Lindgren	TILE	3.4.K.14	Radiated & Conducted Immunity
Thermo Electron - Keytek	CEWare32	4.00	EFT/Surge/Voltage Dips & Interrupt
Voltech	IEC61000-3	1.21.07RC2	Harmonic & Flicker

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.

The Expanded Uncertainty defines an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurement. The fraction may be viewed as the coverage probability or level of confidence of the interval.

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

Measurement Uncertainty Emissions

Per CISPR 16-4-2	**U_{lab}**	**U_{cispr}**
Radiated Disturbance @ 10 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 – 40 GHz	2.47 dB	4.93 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	1.09 dB	2.18 dB

Voltech PM6000A

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

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%.

Measurement Uncertainty – Radio Testing

The estimated combined standard uncertainty for frequency error measurements is ± 3.88 Hz
The estimated combined standard uncertainty for carrier power measurements is ± 0.70 dB.
The estimated combined standard uncertainty for adjacent channel power measurements is ± 1.47 dB.
The estimated combined standard uncertainty for modulation frequency response measurements is ± 0.46 dB.
The estimated combined standard uncertainty for transmitter conducted emission measurements is ± 2.06 dB

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 17025:2017. Equipment calibration records are kept on file at the test facility.

3 Product Information

3.1 Product Description

The primary function of the device is to monitor Heart rate via LEDs and also measure the skin temperature of the human tissue. These measurements are collected, processed and sent to a mobile phone to display the results.

3.2 Equipment Configuration

A description and justification of the equipment configuration is given in the EMC Test Plan. The EUT was tested as described in the EMC Test Plan and was configured and operated in a manner consistent with its intended use. The EUT was connected to rated power and allowed to warm up to normal operating conditions. The placement of the EUT system components was guided by the test standard and selected to represent typical installation conditions.

In the case of a 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 worse case radiation and place the EUT in the most susceptible state. There were no deviations from the description of the Equipment Configuration given in the EMC Test Plan.

3.3 Operating Mode

A description and justification of the operation mode is given in the EMC Test Plan.

In the case of a 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 worse case radiation and place the EUT in the most susceptible state. There were no deviations from the description of the Operation Mode given in the EMC Test Plan.

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, or 15.221.

3.4.1 Results

The Whoop 4.0 has 1 dedicated Bluetooth LDS Inverted F type antenna that has maximum gain of -6.93 dBi. It is not easily accessible to the end user.

It is integrated into the PCB of the device and is not easily accessible to the end user.

4. Emissions

Testing was performed in accordance with CFR 47 Part 15.247: 2021 and RSS 247: 2017. 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.

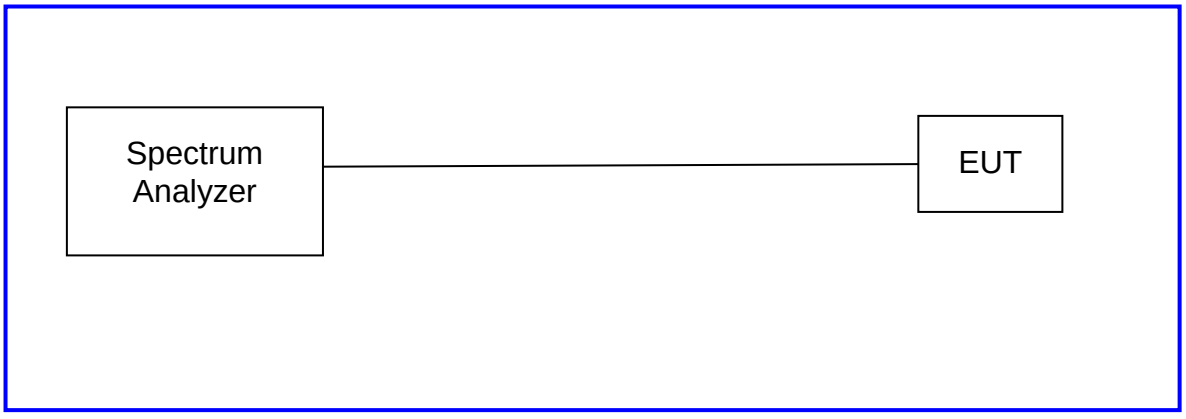
The maximum output power and harmonics shall not exceed CFR47 Part 15.247 (b) and RSS 247 Sect. 5.4.(d).

The maximum transmitted power in the frequency band 2400-2483.5 MHz: 1 W

4.1.1 Test Method

Conducted method was used to measure the channel power output. The worst findings were conducted on 3 channels in each operating range per CFR47 Part 15.247(b) and RSS 247 Sect. 5.4(d); 2400 MHz to 2483.5 MHz The worst mode results indicated below.

4.1.2 Test Setup: (Conducted)



4.1.3 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s). Worse case data for each mode reported below. Plots of highest power included for low, medium, and high channels.

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

Test Date: August 25, 2021	**Test By:** Rachana Khanduri
Test Method: Conducted Measurements	**Power Setting:** +8 dBm
Antenna Type: LDS Inverted F type antenna	**Max. Antenna Gain:** -6.93 dBi
Ambient Temp.: 21 °C	**Relative Humidity:** 37%

Bluetooth LE – RF Output Power

Data Rate	Operating Channel (MHz)	Measured Peak Output [dBm]	Limit [dBm]	Margin [dB]
1Mbps	2402	7.74	+30.00	-22.26
	2440	7.47	+30.00	-22.53
	2480	6.93	+30.00	-23.07

Note: The EUT transmitted at 100% duty cycle.

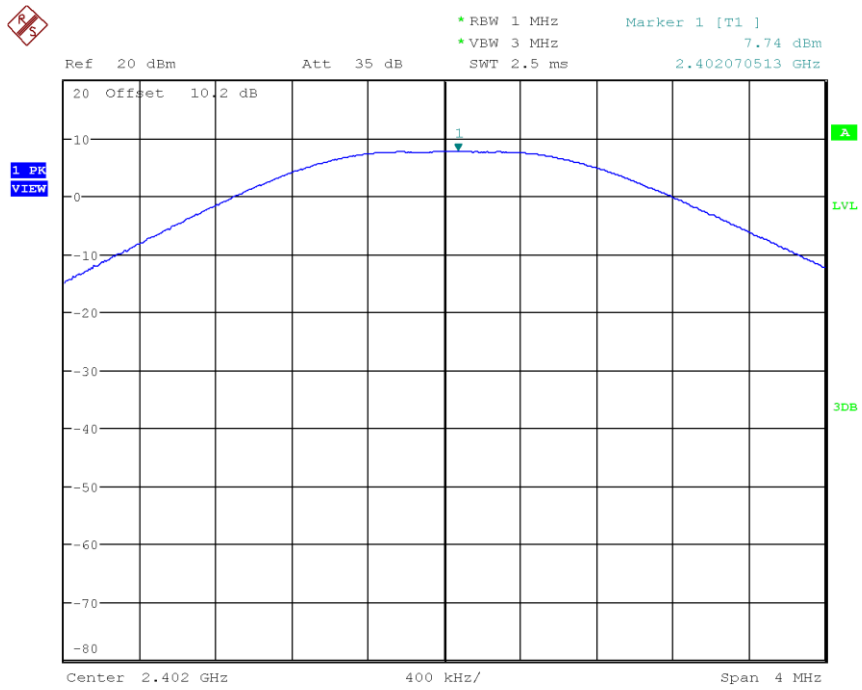


Figure 1: Maximum Conducted Power, 2402 MHz, 1Mbps

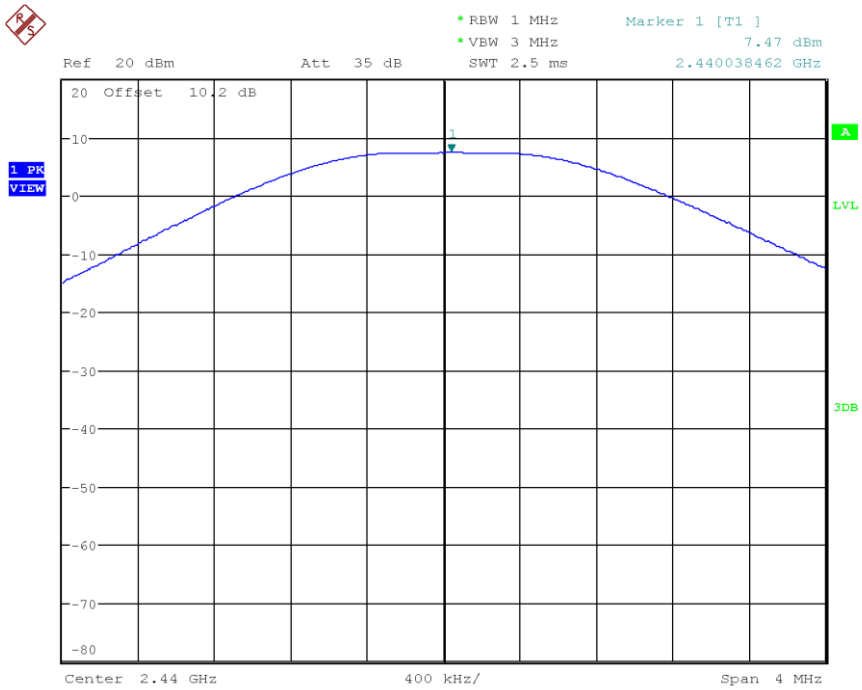


Figure 2: Maximum Conducted Power, 2440MHz, 1Mbps

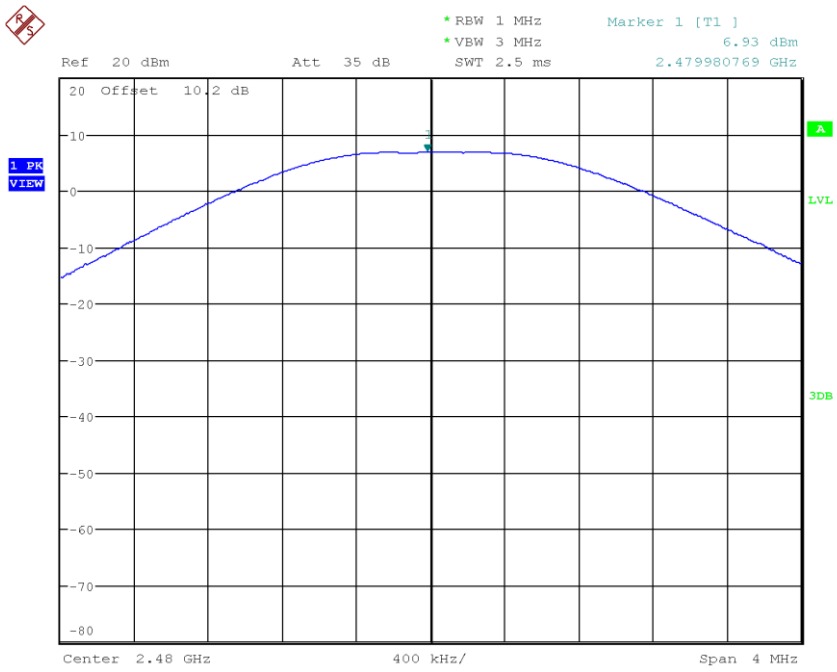


Figure 3: Maximum Conducted Power, 2480MHz, 1Mbps

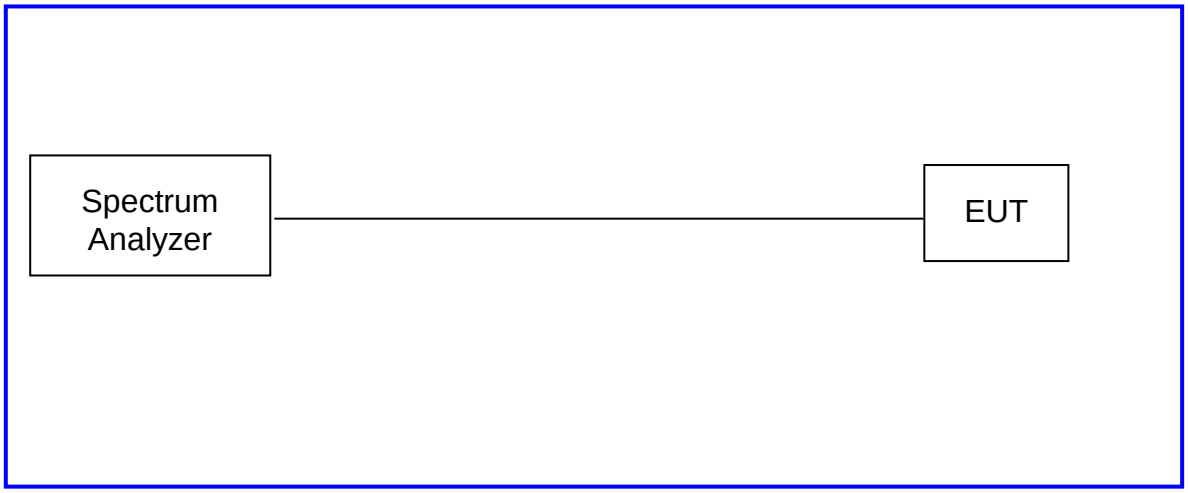
4.2 DTS Bandwidth (6dB) and Occupied Bandwidth

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 C63.10:2013 Section 11.8. The measurement was performed with modulation per CFR47 15.247 (a) (2) and RSS Gen Sect. 6.6. Measurements were performed on the low, middle and high channels of the operating frequency range; 2400 MHz to 2483.5 MHz.

4.2.2 Test Setup: (Conducted)



4.2.3 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 Date: August 25, 2021		**Test By:** Rachana Khanduri	
Test Method: Conducted Measurements		**Power Setting:** +8 dBm	
Antenna Type: LDS Inverted F type antenna		**Max. Antenna Gain:** -6.93 dBi	
Ambient Temp.: 21 °C		**Relative Humidity:** 37%	
Bluetooth LE – Occupied Bandwidth			
Data Rate	**Operating Channel (MHz)**	**99% Bandwidth (MHz)**	**6dB (DTS) Bandwidth (MHz)**
1Mbps	2402	1.053	0.692
	2440	1.053	0.688
	2480	1.058	0.692

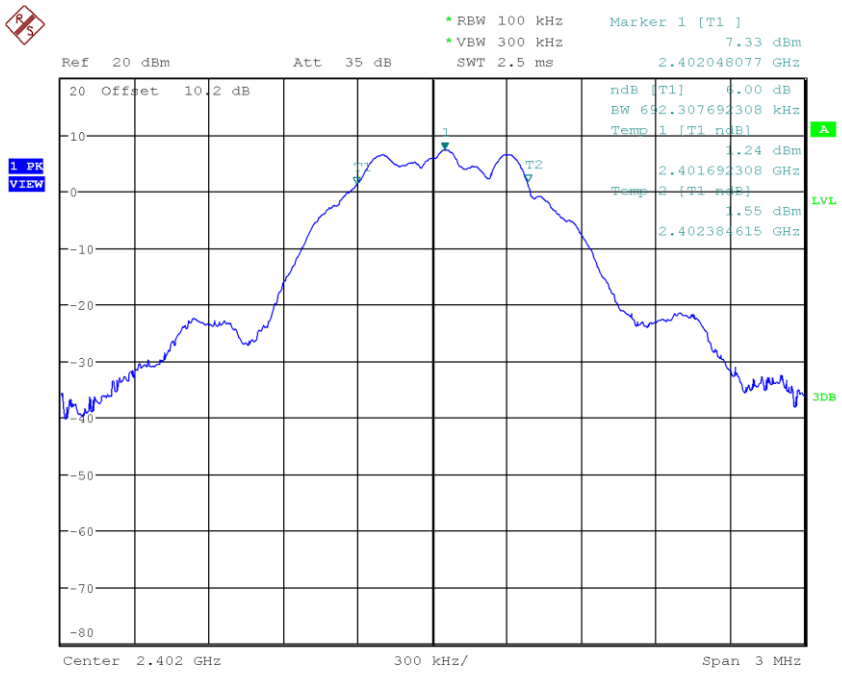


Figure 4: 2402MHz, 1Mbps, 6dB Bandwidth

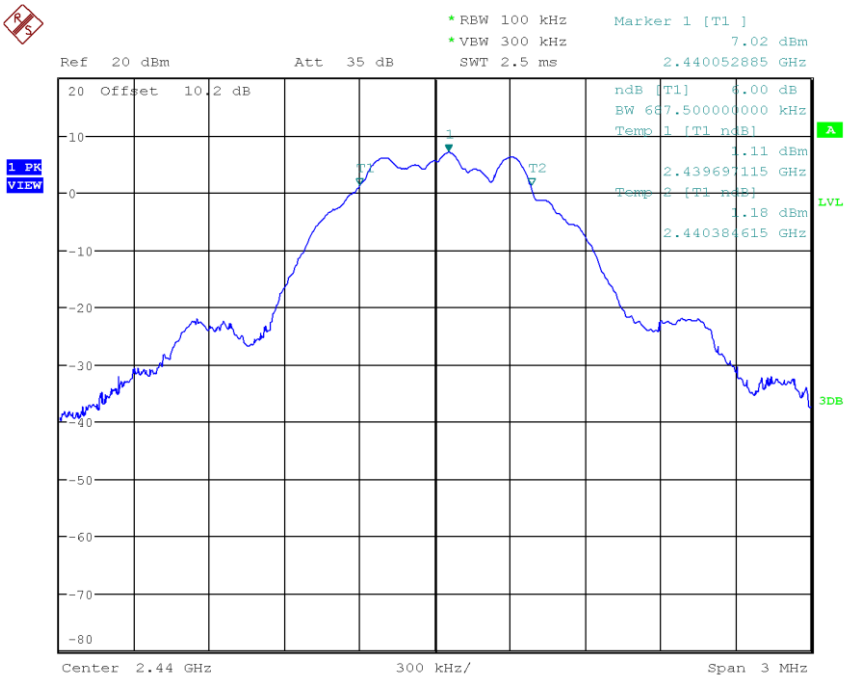


Figure 5: 2440MHz, 1Mbps, 6dB Bandwidth

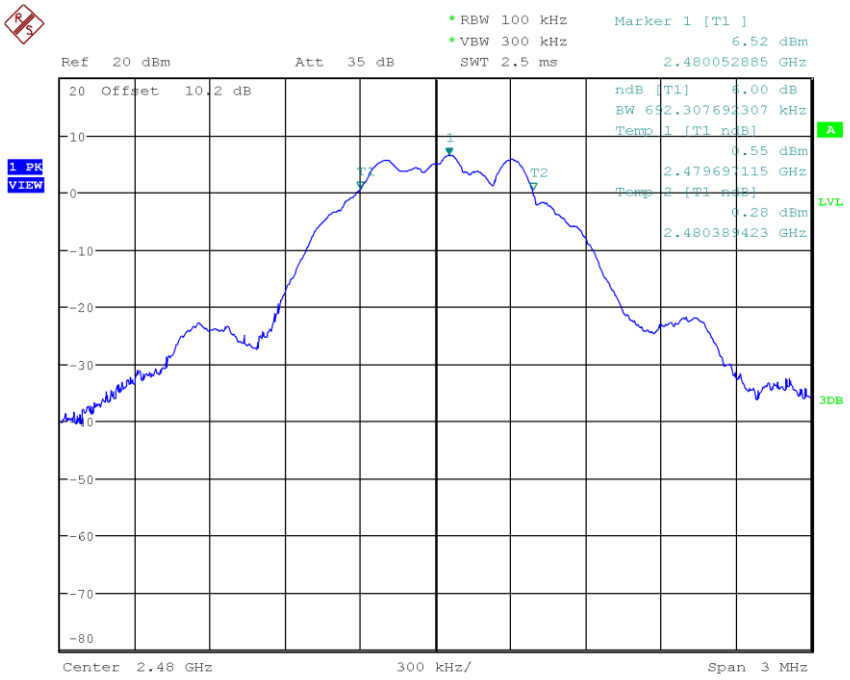


Figure 6: 2480MHz, 1Mbps, 6dB Bandwidth

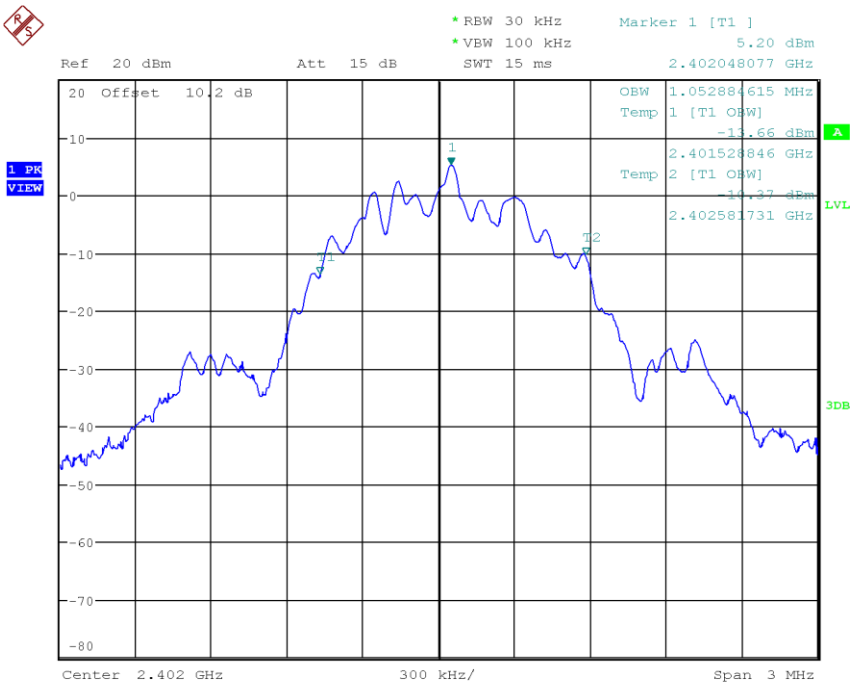


Figure 7: 2402MHz, 1Mbps, 99% Bandwidth

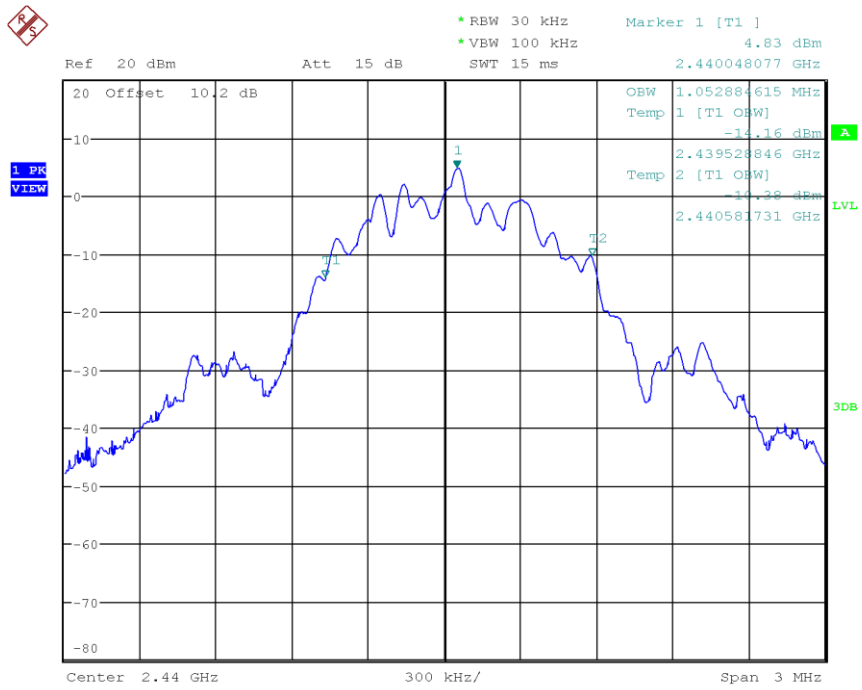


Figure 8: 2440MHz, 1Mbps, 99% Bandwidth

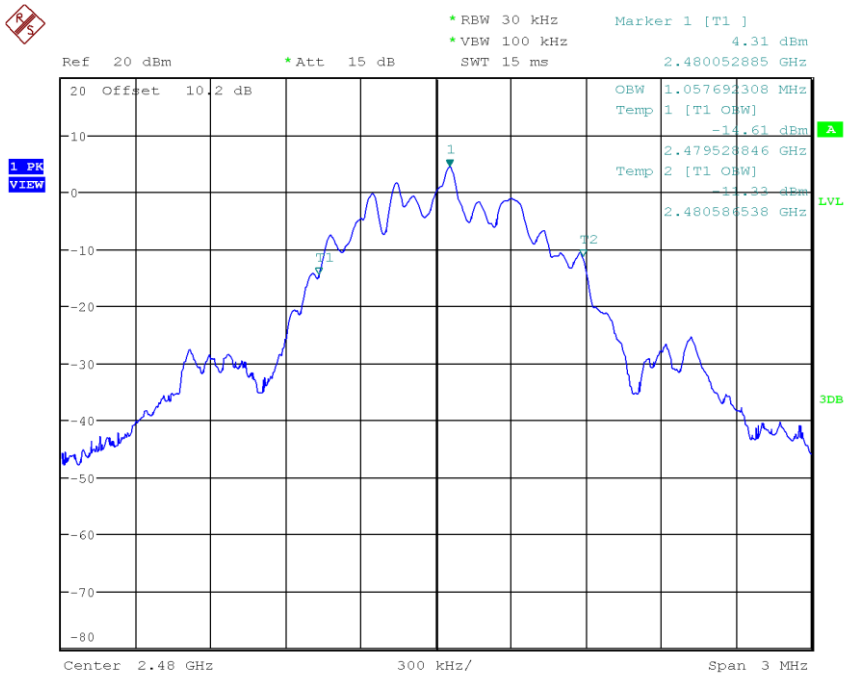


Figure 9: 2480MHz, 1Mbps, 99% Bandwidth

4.3 Peak Power Spectral Density

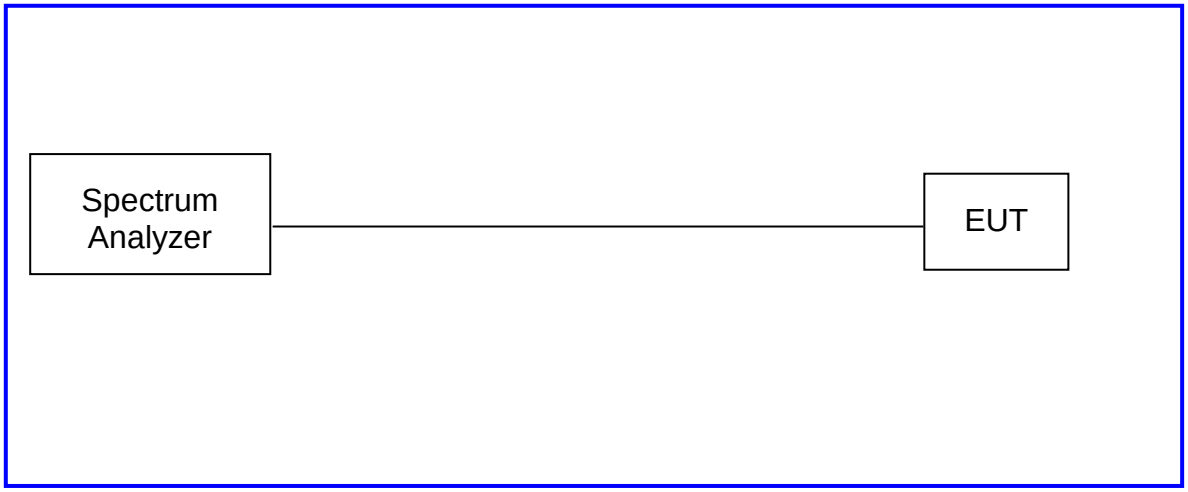
According to the CFR47 Part 15.247 (e) and RSS 247 Sect.5.2 (b), the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

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) and RSS 247 Sect.5.2 (b). The worst findings were conducted on 3 channels in each operating frequency range of 2400 MHz to 2483.5 MHz.

Method PKPSD of “KDB 558074 – DTS Measurement Guidance v04” was used.

4.3.2 Test Setup: (Conducted)



4.3.3 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 Date: August 25, 2021	**Test By:** Rachana Khanduri
Test Method: Conducted Measurements	**Power Setting:** +8 dBm
Antenna Type: LDS Inverted F type antenna	**Max. Antenna Gain:** -6.93 dBi
Ambient Temp.: 21 °C	**Relative Humidity:** 37%

Bluetooth LE – Peak Power Spectral Density

Data Rate	Operating Channel (MHz)	Total PSD [dBm/kHz]	Limit [dBm/3kHz]	Margin [dB]
1Mbps	2402	-10.42	8.0dBm /3kHz	-18.42
	2440	-10.70	8.0dBm /3kHz	-18.70
	2480	-11.14	8.0dBm /3kHz	-19.14

Note: The EUT transmitted at 100% duty cycle.

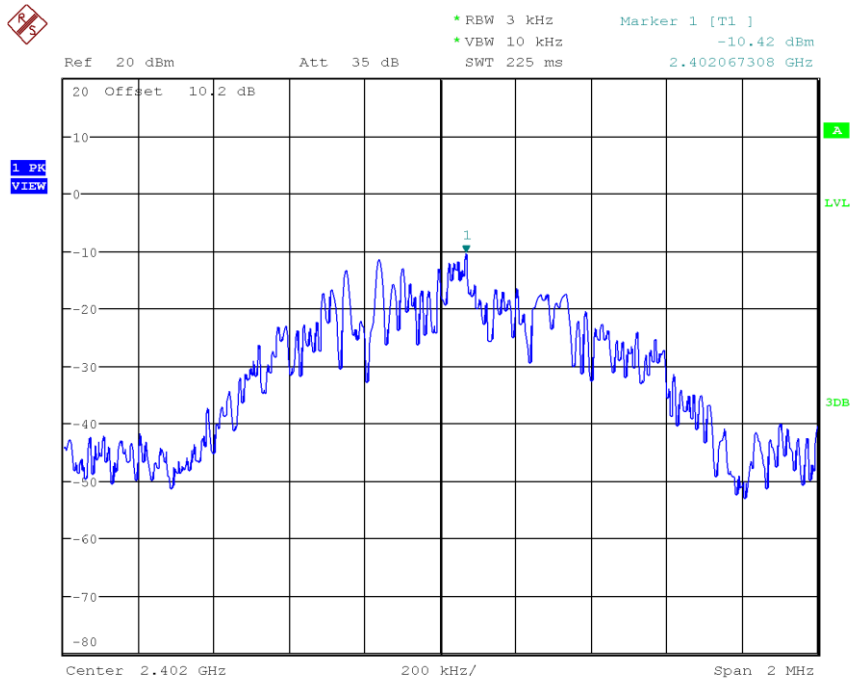


Figure 10: 2402 MHz, 1Mbps, PSD

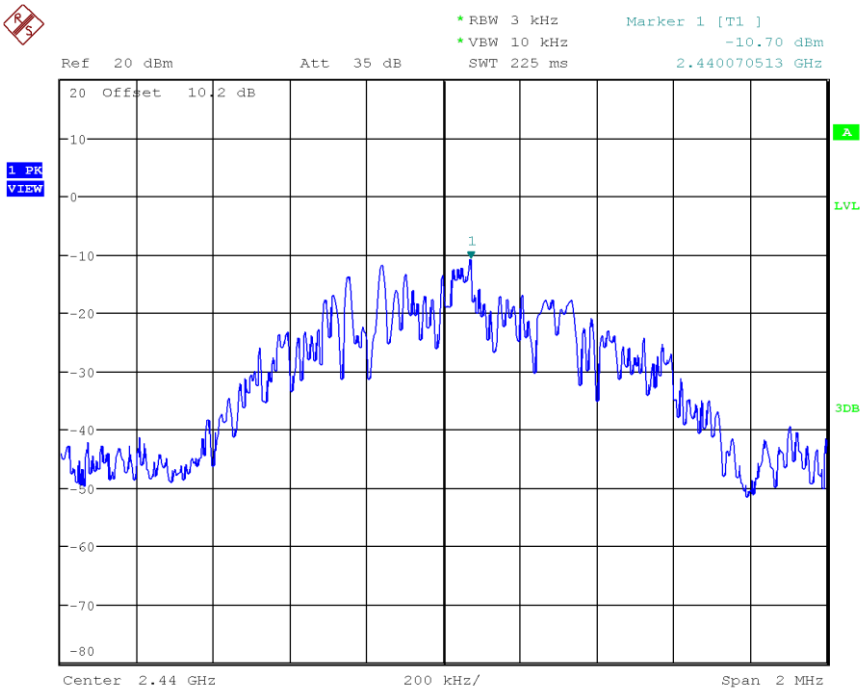


Figure 11: 2440 MHz, 1Mbps, PSD

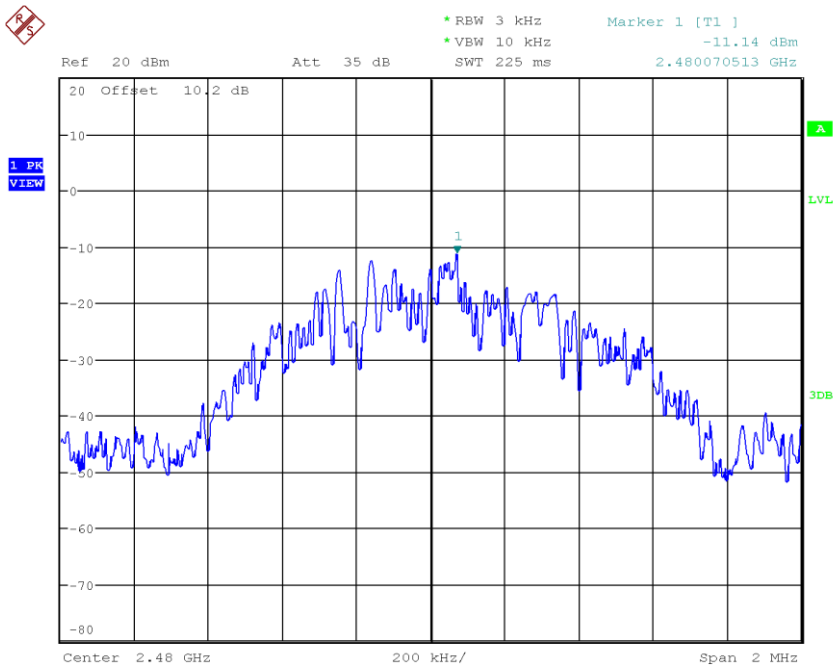


Figure 12: 2480MHz, 1Mbps, PSD

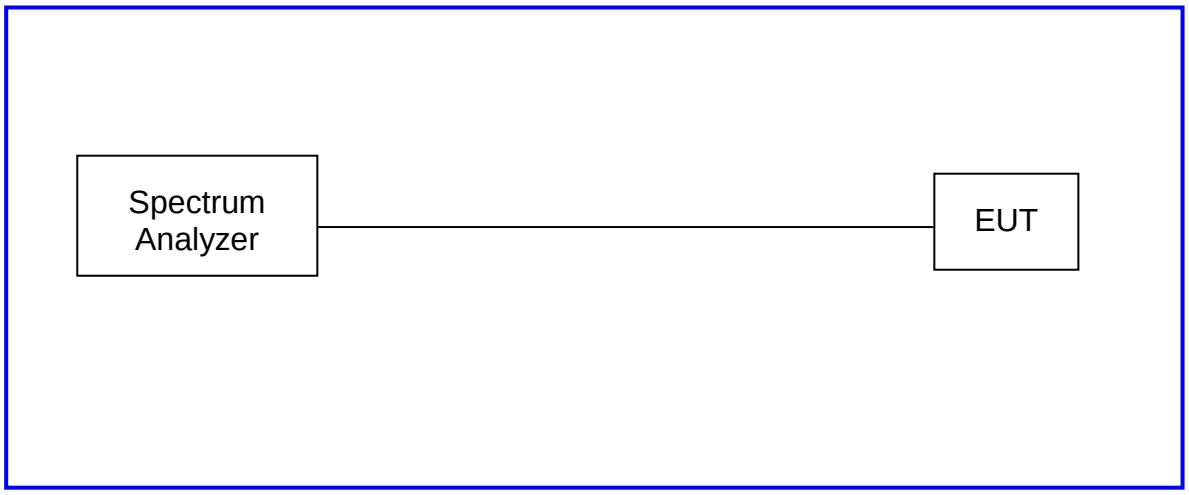
4.4 Out of Band Emissions: Non-Restricted Bands

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR47 15.205, 15.209, 15.247(d), RSS-247 Sect. 5.5, RSS-GEN Sect. 8.9 and 8.10.

4.4.1 Test Method

Conducted measurements per ANSI C63.10-2013 Sections 6.10, 11.11, 14.3.3 were used to measure the undesirable emission requirement in non-restricted bands. The measurement was performed with modulation. The measurement was conducted from 30MHz to 26.5GHz on 3 channels in each mode on the EUT. Band edge tests were conducted on the low and high channel of each mode. The worst case measurement of each mode is recorded in this report.

4.4.2 Test Setup: (Conducted)



4.4.3 Results

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

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

Test Date: August 25, 2021	**Test By:** Rachana Khanduri
Test Method: Conducted Measurements	**Power Setting:** +8 dBm
Antenna Type: LDS Inverted F type antenna	**Max. Antenna Gain:** -6.93 dBi
Ambient Temp.: 21 °C	**Relative Humidity:** 37%

Bluetooth LE – Emissions at the Band-Edge

Data Rate	Band Edge	Center Freq (MHz)	Out of Band Level (dBm)	20dBc Level (dBm)	Measured Freq (MHz)	Results
1Mbps	Low	2402	-40.56	-12.70	2400.0	Pass
	High	2480	-41.71	-13.51	2483.5	Pass

Note: dBc is defined as the level below the main carrier.
The band-edge level must be lower than the 20dBc level.

4.4.3.1 Band Edge - conducted

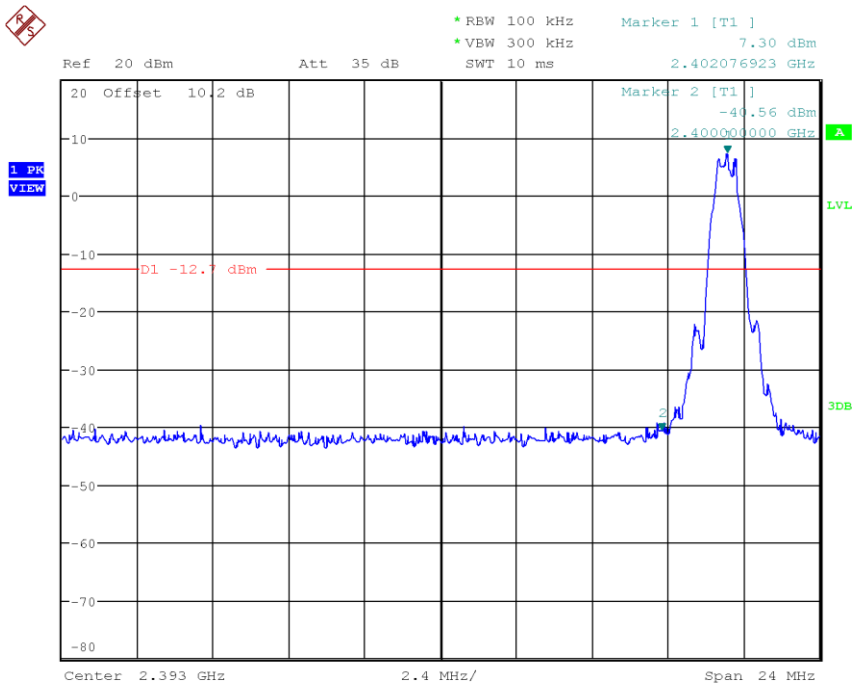


Figure 13: 2402MHz, 1Mbps, Lower Band Edge

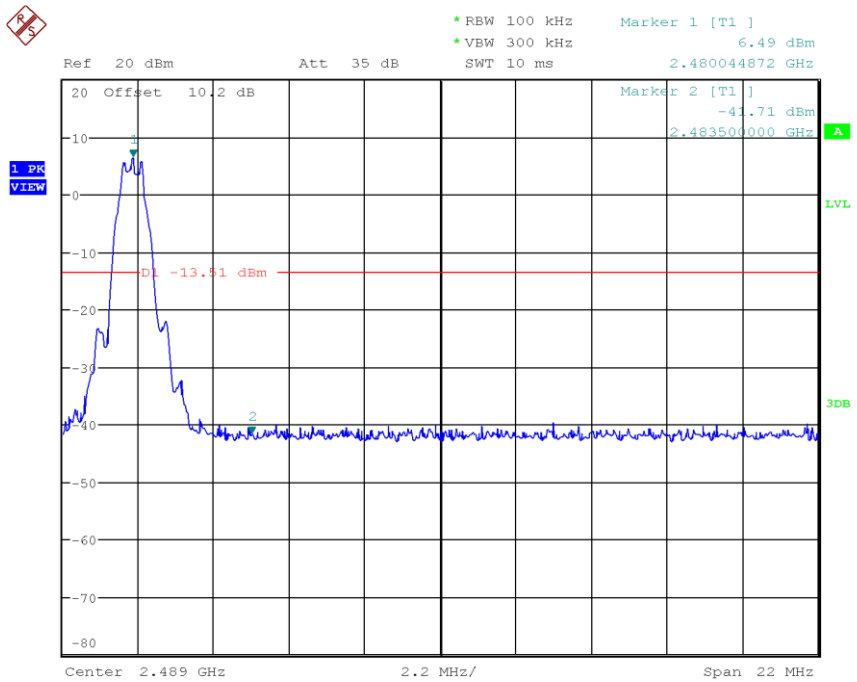


Figure 14: 2480MHz, 1Mbps Upper Band Edge

4.4.3.2 Conducted Spurious

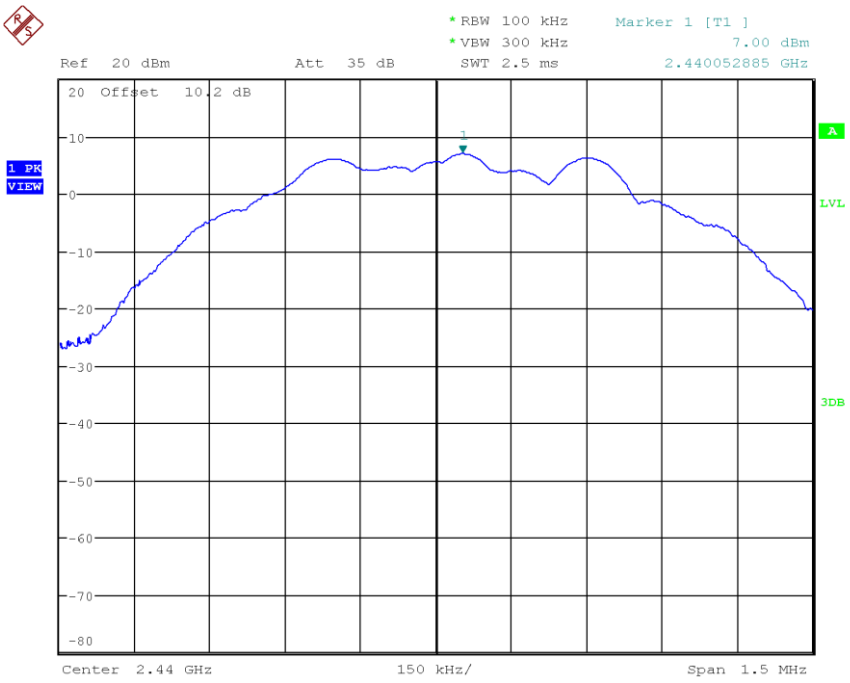


Figure 15: 1Mbps Ref Measurement

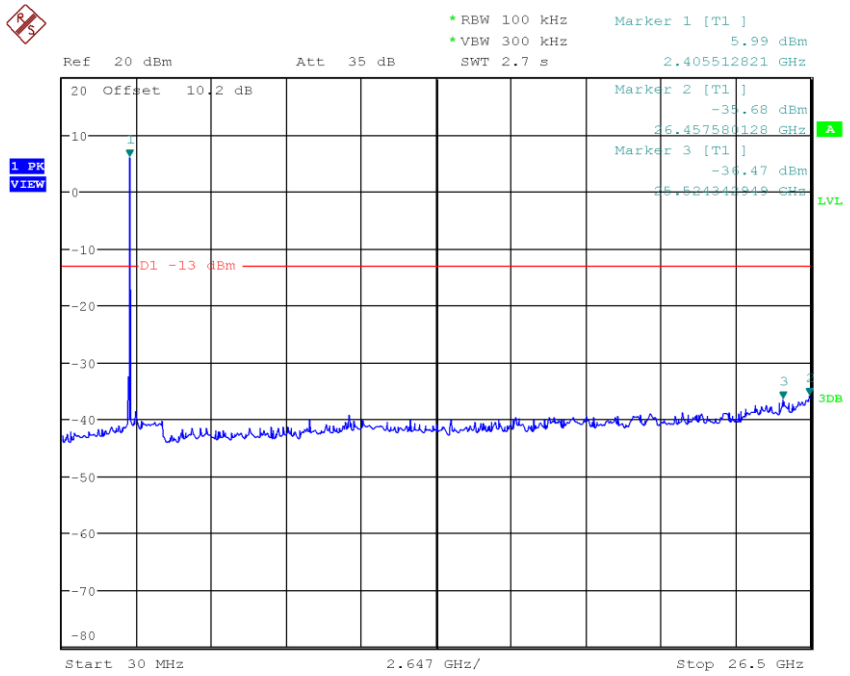


Figure 16: Conducted Emissions, 2402 MHz, 1Mbps

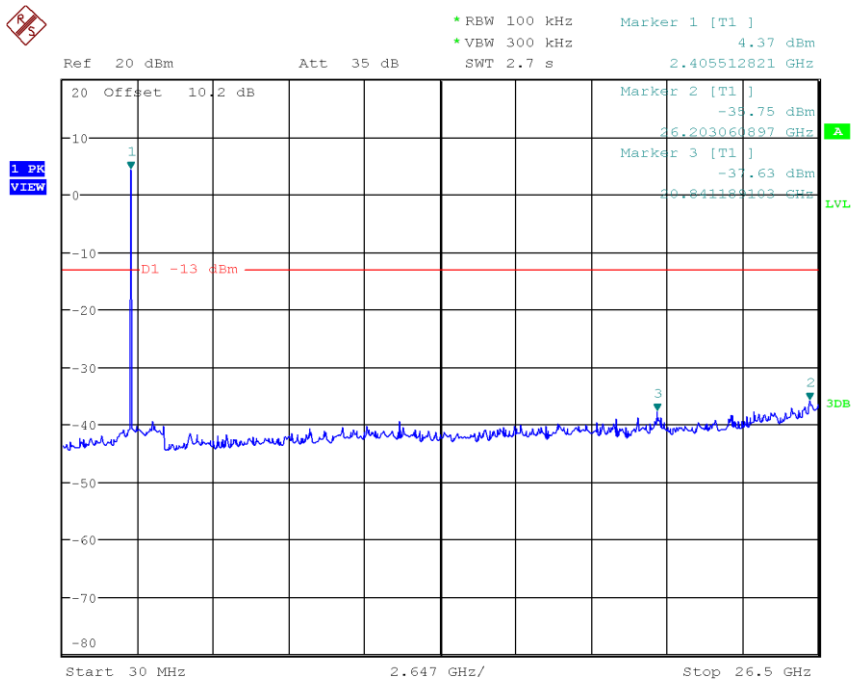


Figure 17: Conducted Emissions, 2440 MHz, 1Mbps

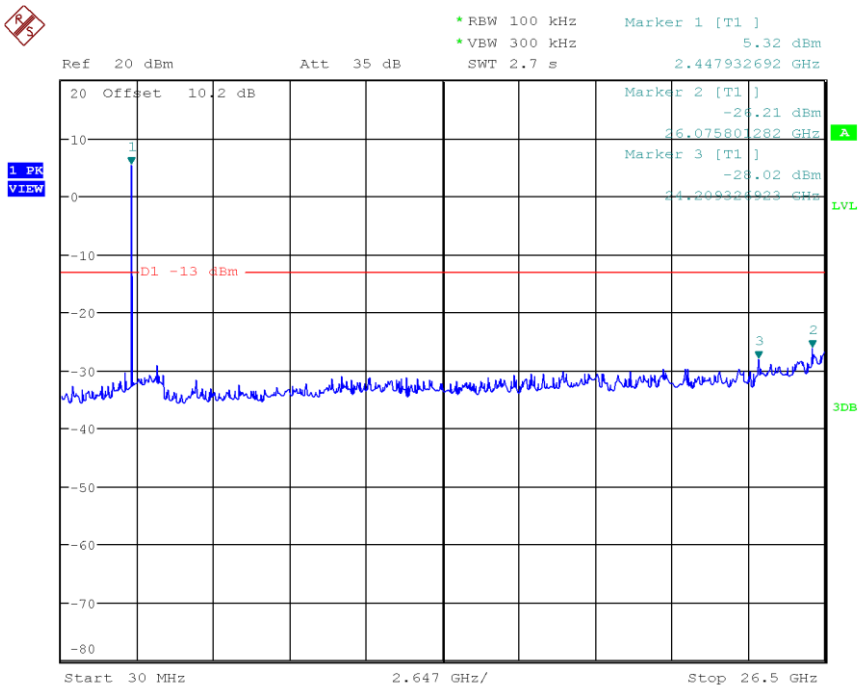


Figure 18: Conducted Emissions, 2480 MHz, 1Mbps

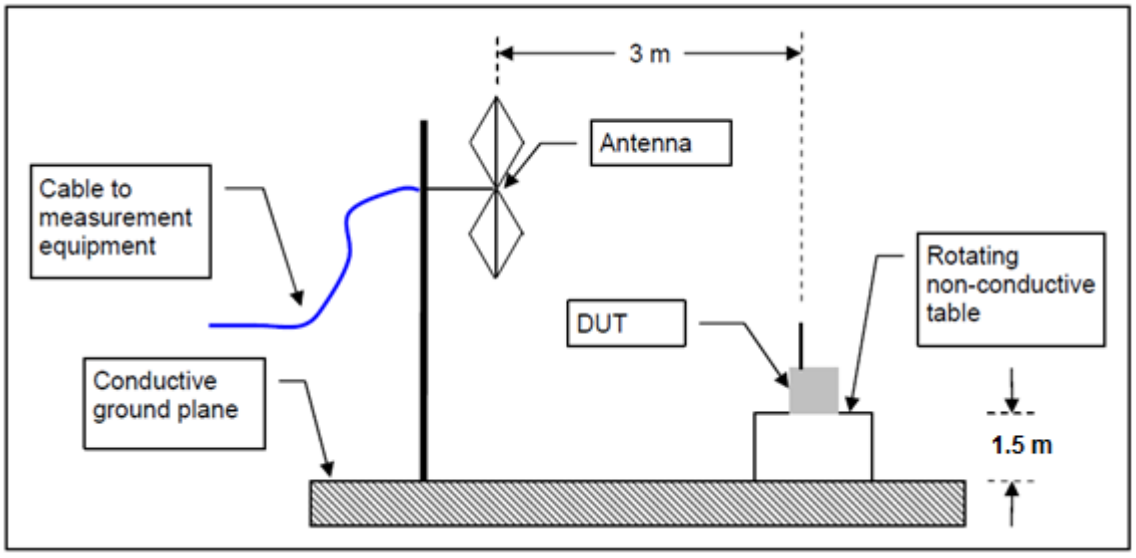
4.5 Out of Band Emissions: Restricted Band Edge

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR47 15.205, 15.209, 15.247(d), RSS-247 Sect. 5.5, RSS-GEN Sect. 8.9 and 8.10.

4.5.1 Test Method

Radiated measurements per ANSI C63.10-2013 Section 6.10.5 were used to measure the undesirable emission requirement in restricted bands. Peak points were found and RMS Average was taken for each point found. The measurement was performed with modulation. All channels were tested at highest power settings.
RBW is set to 1MHz, VBW is set to 3MHz.

4.5.2 Test Setup



The DUT was stimulated by manufacturer provided test software that is not available to the end user.

4.5.3 Test Results

Test Conditions: Radiated Measurement, Normal Temperature and Voltage
Antenna Type: LDS Inverted F type antenna
Power Setting: +8dBm
Max. Antenna Gain: -6.93dBi
Test Performed by: Rachana Khanduri

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2371.388800	---	27.44	54.00	26.56	1000.000	216.0	H	181.0	-2.6
2371.388800	43.35	---	74.00	30.65	1000.000	216.0	H	181.0	-2.6
2388.793600	---	27.51	54.00	26.49	1000.000	232.0	V	226.0	-2.5
2388.793600	43.25	---	74.00	30.75	1000.000	232.0	V	226.0	-2.5

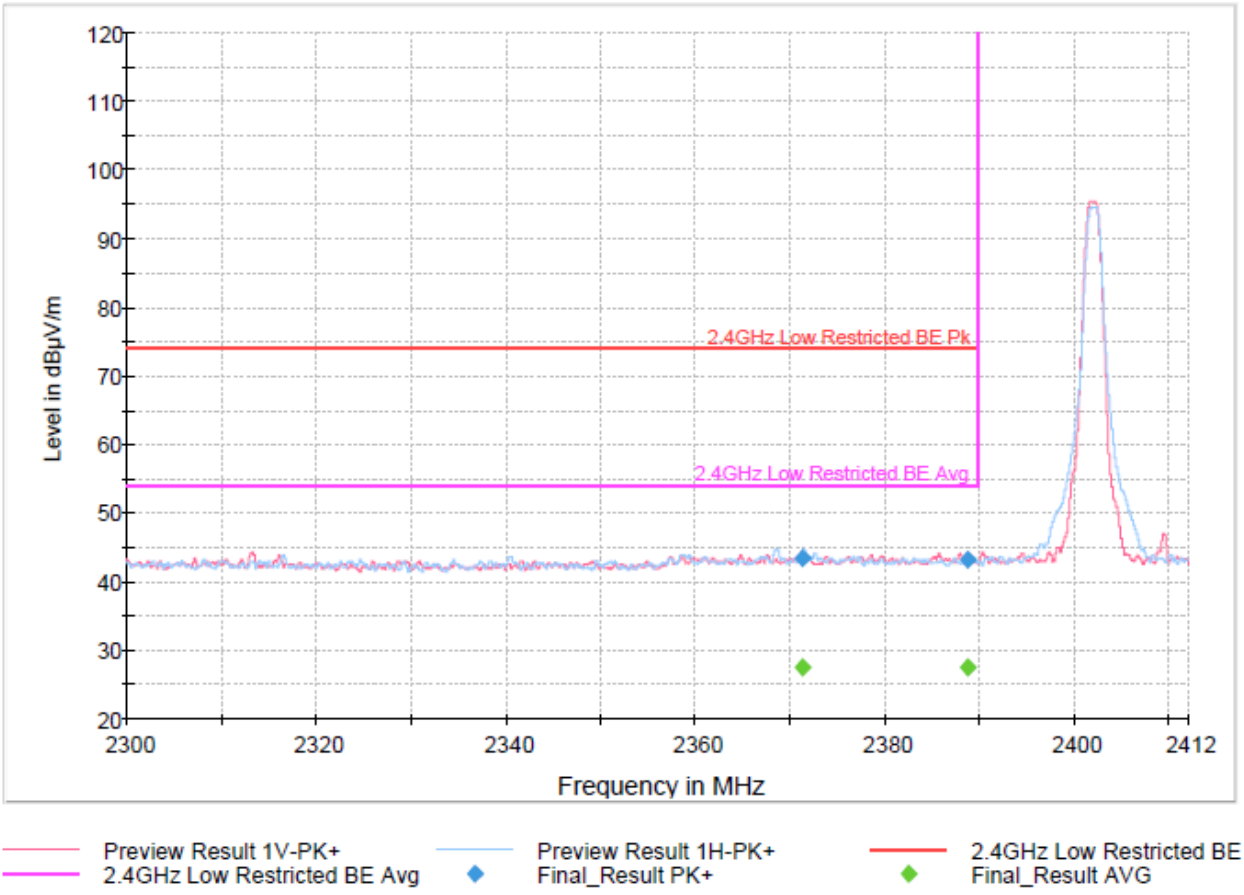


Figure 19: Restricted Band Edge, Low, 2402MHz, 1 Mbps

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2484.024800	---	28.55	54.00	25.45	1000.000	100.0	H	49.0	-1.9
2484.024800	43.98	---	74.00	30.02	1000.000	100.0	H	49.0	-1.9
2487.350600	---	28.61	54.00	25.39	1000.000	155.0	V	133.0	-1.9
2487.350600	44.38	---	74.00	29.62	1000.000	155.0	V	133.0	-1.9

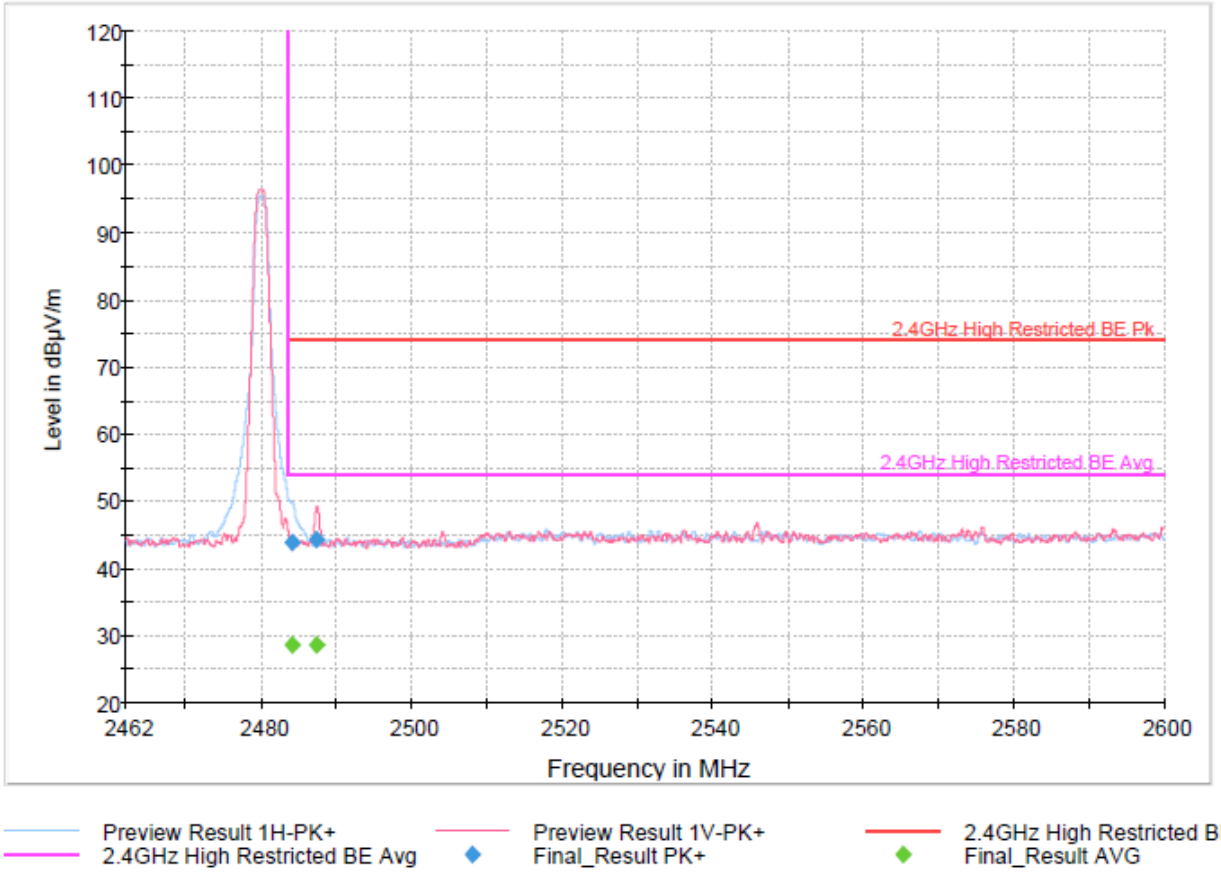


Figure 20: Restricted Band Edge, High, 2480MHz, 1 Mbps

4.6 Transmitter 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, RSS-GEN Sect. 8.9 and 8.10.

4.6.1 Test Methodology

4.6.1.1 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 Figure 2: ted 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.

Pre-scans were performed to determine the worst data rate / chains.

4.6.1.2 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.

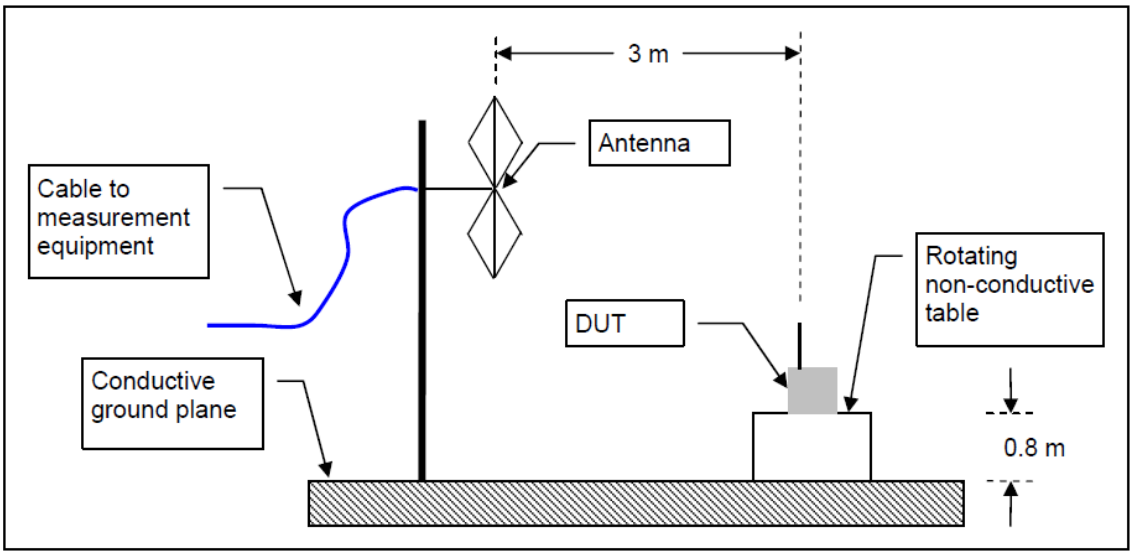
4.6.1.3 Deviations

None.

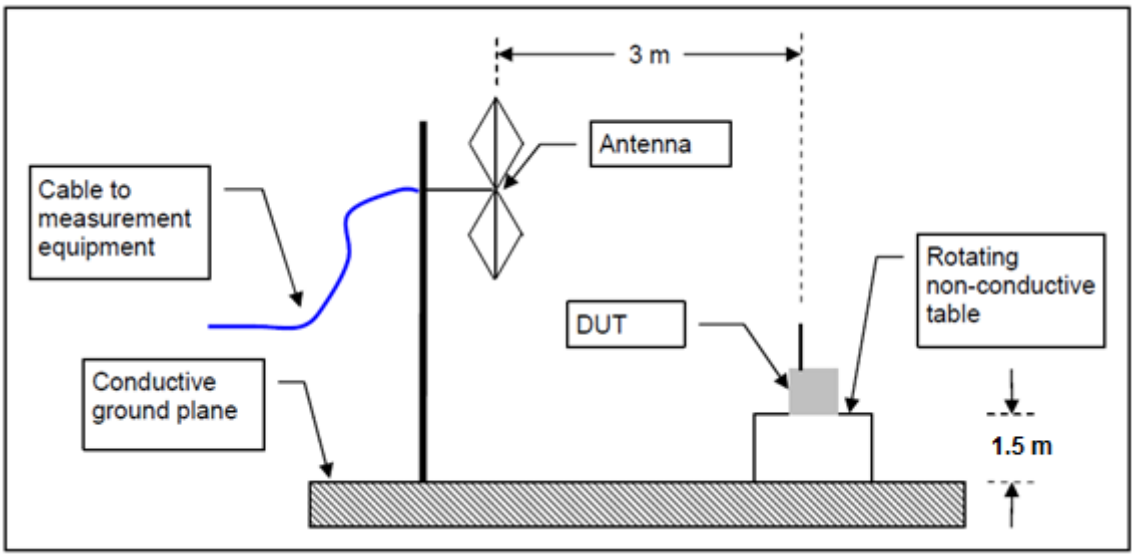
4.6.2 Test Setup:

All tests were conducted at full power on low, middle, and high channels. The DUT was stimulated by manufacturer provided test software that is not available to the end user.

30MHz-1GHz



1-26GHz



4.6.3 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209: 2015 and RSS Gen Sect. 8.9 and 8.10: 2014.

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

4.6.4 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.

Frequencies below 30MHz and above 18GHz were investigated and no emissions were found above the noise floor. Both horizontal and vertical polarities were investigated. The results show only the worst case.

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

Note: The 2.4 GHz notch filter was used to protect the front end of the pre-amp.

4.6.4.1 Measurement Results:

Final Result

Frequency (MHz)	QuasiPeak (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
52.603200	---	38.83	---	---	10000.0	120.000	100.0	V	120.0	-10.8
52.603200	34.41	---	40.00	5.59	10000.0	120.000	100.0	V	120.0	-10.8
139.818040	18.10	---	43.52	25.42	10000.0	120.000	100.0	V	302.0	-16.8
139.818040	---	27.16	---	---	10000.0	120.000	100.0	V	302.0	-16.8
279.005320	---	38.29	---	---	10000.0	120.000	100.0	V	169.0	-11.6
279.005320	34.09	---	46.02	11.93	10000.0	120.000	100.0	V	169.0	-11.6
347.967280	27.70	---	46.02	18.32	10000.0	120.000	100.0	V	234.0	-9.4
347.967280	---	36.01	---	---	10000.0	120.000	100.0	V	234.0	-9.4
395.907880	23.04	---	46.02	22.98	10000.0	120.000	100.0	V	169.0	-8.5
395.907880	---	32.05	---	---	10000.0	120.000	100.0	V	169.0	-8.5
989.872680	20.43	---	53.98	33.55	10000.0	120.000	100.0	V	156.0	0.1
989.872680	---	28.55	---	---	10000.0	120.000	100.0	V	156.0	0.1

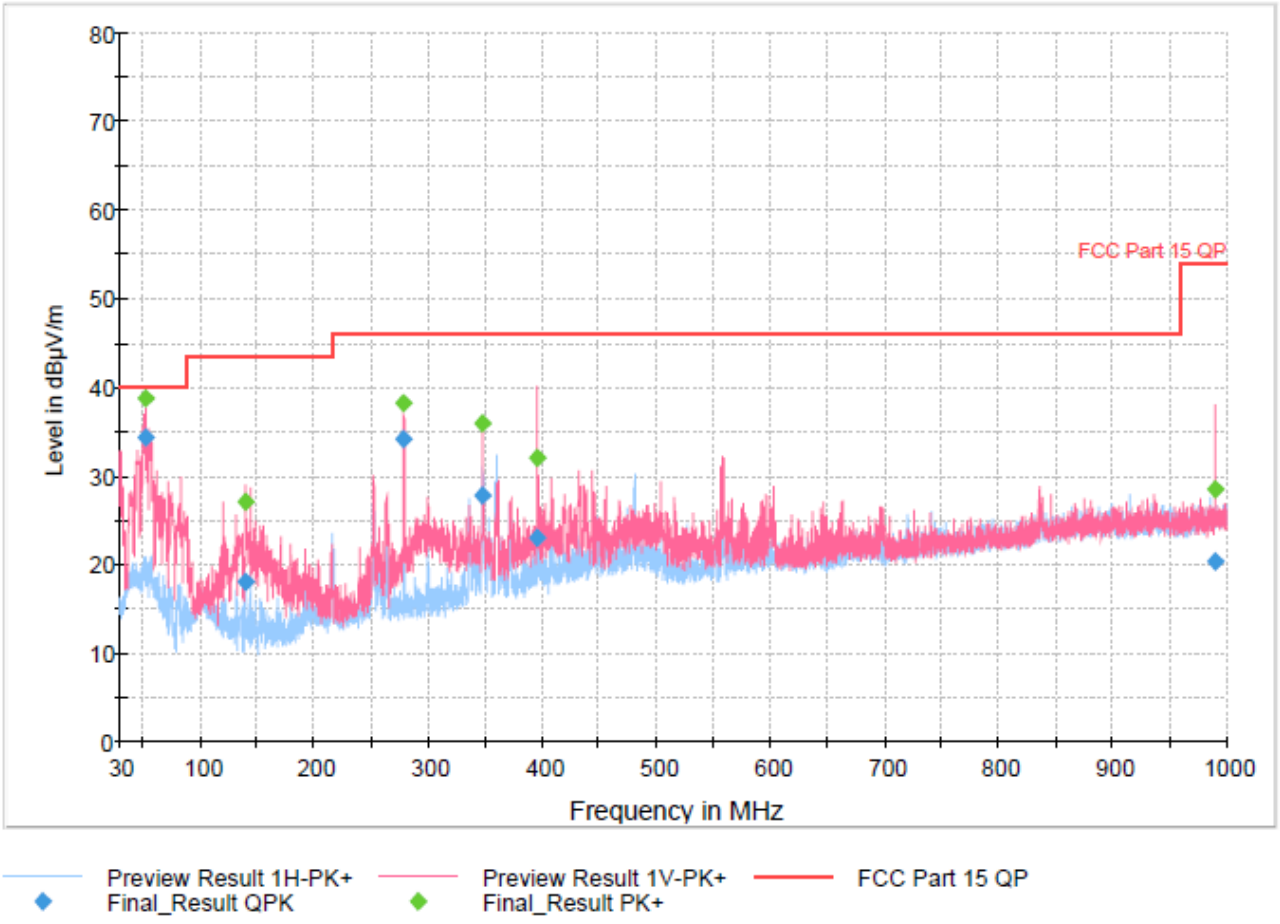


Figure 21: Radiated Spurious Emissions 30MHz – 1GHz, 2402MHz, 1Mbps

Final Result

Frequency (MHz)	QuasiPeak (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
51.223920	35.07	---	40.00	4.93	10000.0	120.000	100.0	V	93.0	-10.7
51.223920	---	39.35	---	---	10000.0	120.000	100.0	V	93.0	-10.7
71.995000	25.82	---	40.00	14.18	10000.0	120.000	105.0	V	31.0	-16.2
71.995000	---	30.44	---	---	10000.0	120.000	105.0	V	31.0	-16.2
144.055440	27.39	---	43.52	16.13	10000.0	120.000	100.0	V	87.0	-16.9
144.055440	---	34.28	---	---	10000.0	120.000	100.0	V	87.0	-16.9
279.178680	34.78	---	46.02	11.24	10000.0	120.000	100.0	V	87.0	-11.6
279.178680	---	39.21	---	---	10000.0	120.000	100.0	V	87.0	-11.6
396.085160	---	22.20	---	---	10000.0	120.000	100.0	V	172.0	-8.5
396.085160	13.48	---	46.02	32.54	10000.0	120.000	100.0	V	172.0	-8.5
990.200800	---	28.83	---	---	10000.0	120.000	104.0	V	173.0	0.1
990.200800	20.06	---	53.98	33.92	10000.0	120.000	104.0	V	173.0	0.1

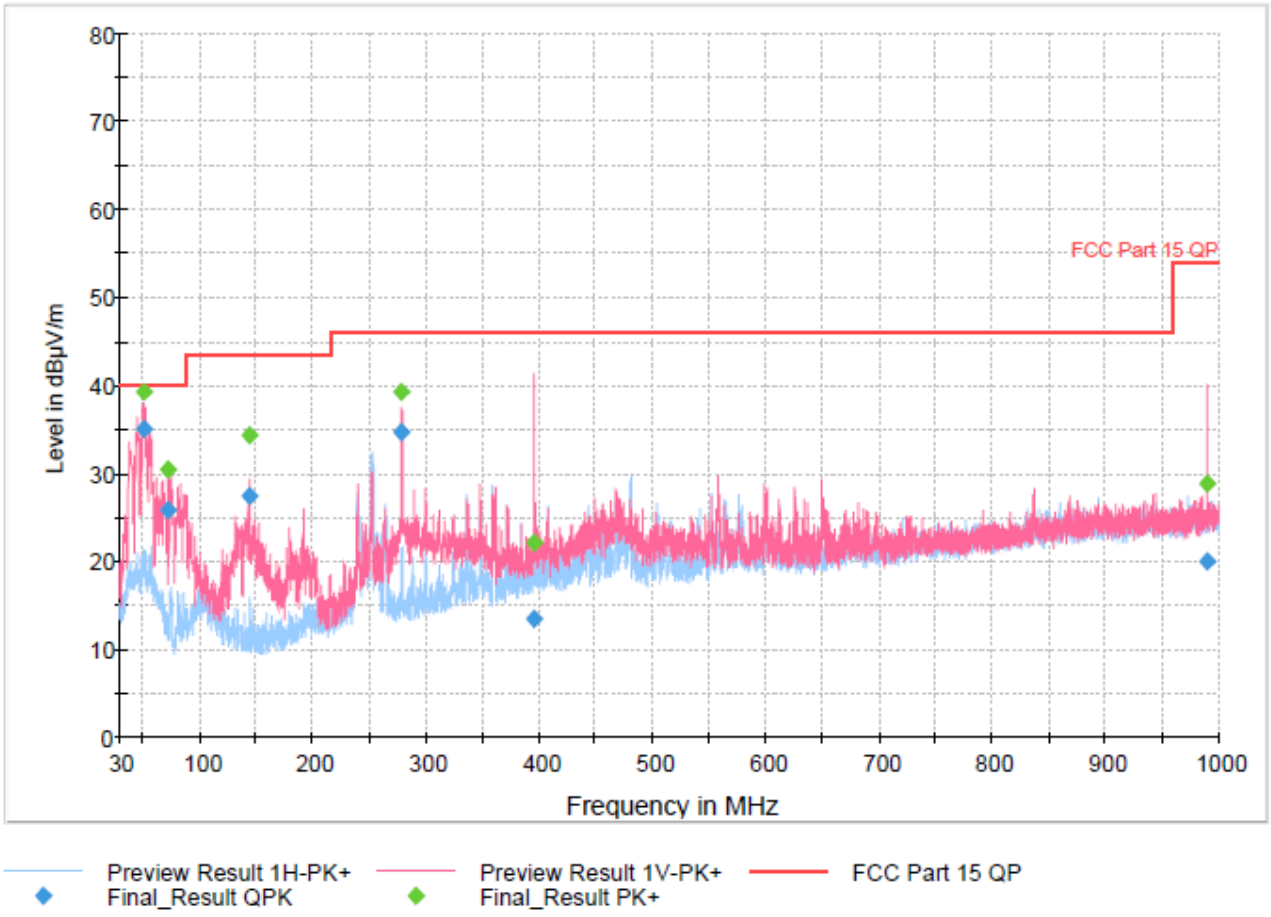


Figure 22: Radiated Spurious Emissions 30MHz – 1GHz, 2440MHz, 1Mbps

Final Result

Frequency (MHz)	QuasiPeak (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.701360	---	33.61	---	---	10000.0	120.000	100.0	V	-5.0	-14.5
30.701360	29.04	---	40.00	10.96	10000.0	120.000	100.0	V	-5.0	-14.5
51.125520	---	37.89	---	---	10000.0	120.000	100.0	V	123.0	-10.7
51.125520	33.34	---	40.00	6.66	10000.0	120.000	100.0	V	123.0	-10.7
252.864960	23.51	---	46.02	22.51	10000.0	120.000	100.0	V	-2.0	-12.0
252.864960	---	33.43	---	---	10000.0	120.000	100.0	V	-2.0	-12.0
278.896000	34.20	---	46.02	11.82	10000.0	120.000	100.0	V	119.0	-11.6
278.896000	---	38.66	---	---	10000.0	120.000	100.0	V	119.0	-11.6
395.781040	13.38	---	46.02	32.64	10000.0	120.000	100.0	V	163.0	-8.5
395.781040	---	21.55	---	---	10000.0	120.000	100.0	V	163.0	-8.5
990.064360	20.15	---	53.98	33.83	10000.0	120.000	100.0	V	159.0	0.1
990.064360	---	28.82	---	---	10000.0	120.000	100.0	V	159.0	0.1

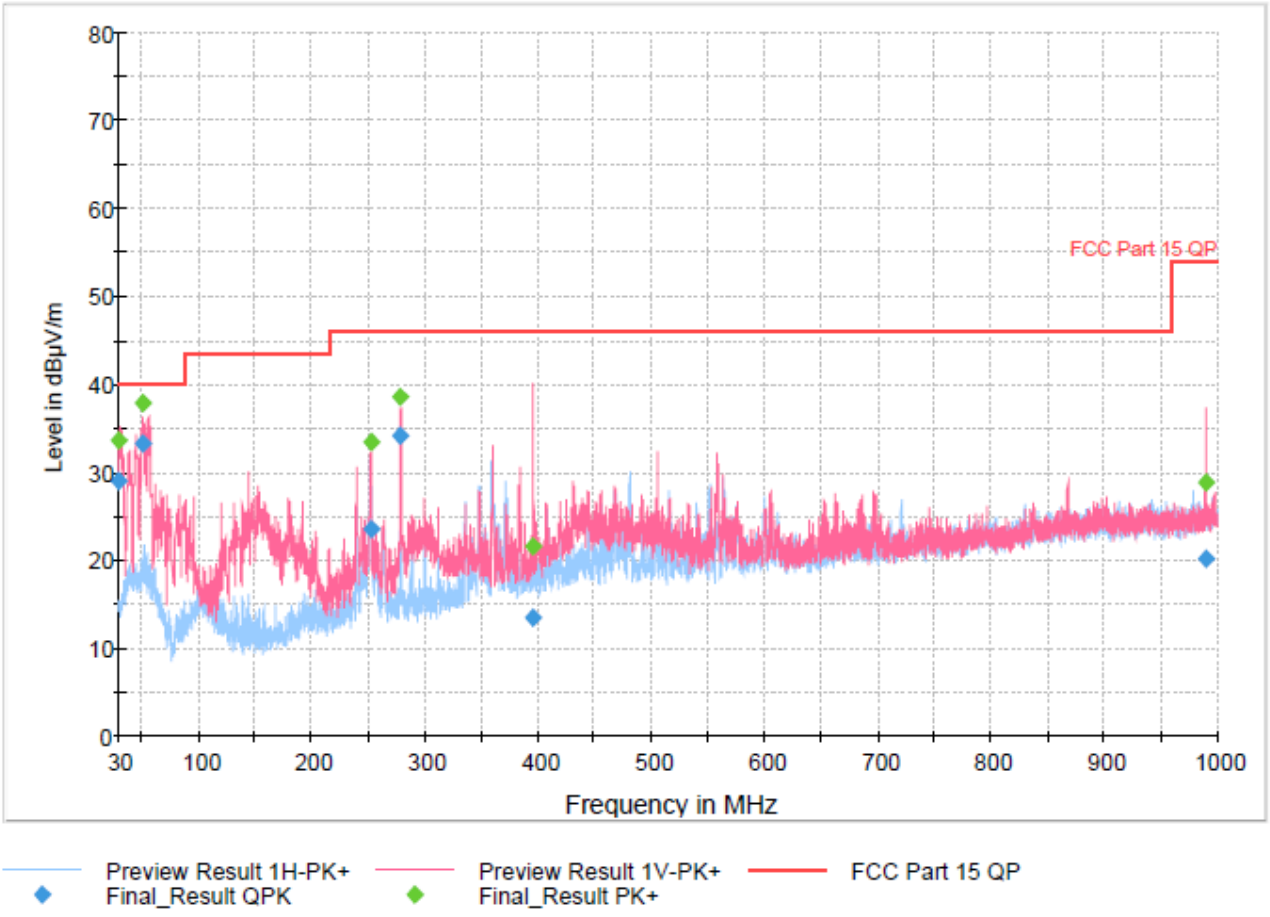


Figure 23: Radiated Spurious Emissions 30MHz – 1GHz, 2480MHz, 1Mbps

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4819.450000	41.44	---	74.00	32.56	1000.000	250.0	H	241.0	5.4
4819.450000	---	27.05	54.00	26.95	1000.000	250.0	H	241.0	5.4
7205.323029	43.21	---	74.00	30.79	1000.000	100.0	V	49.0	8.1
7205.323029	---	28.98	54.00	25.02	1000.000	100.0	V	49.0	8.1
10923.538000	---	32.99	54.00	21.01	1000.000	104.0	V	84.0	10.8
10923.538000	46.91	---	74.00	27.09	1000.000	104.0	V	84.0	10.8
13643.008971	---	36.35	54.00	17.65	1000.000	100.0	V	24.0	13.6
13643.008971	50.05	---	74.00	23.95	1000.000	100.0	V	24.0	13.6
17571.256029	55.29	---	74.00	18.71	1000.000	153.0	H	45.0	18.8
17571.256029	---	41.31	54.00	12.69	1000.000	153.0	H	45.0	18.8
17990.000000	---	41.37	54.00	12.63	1000.000	103.0	V	342.0	19.9
17990.000000	54.96	---	74.00	19.04	1000.000	103.0	V	342.0	19.9

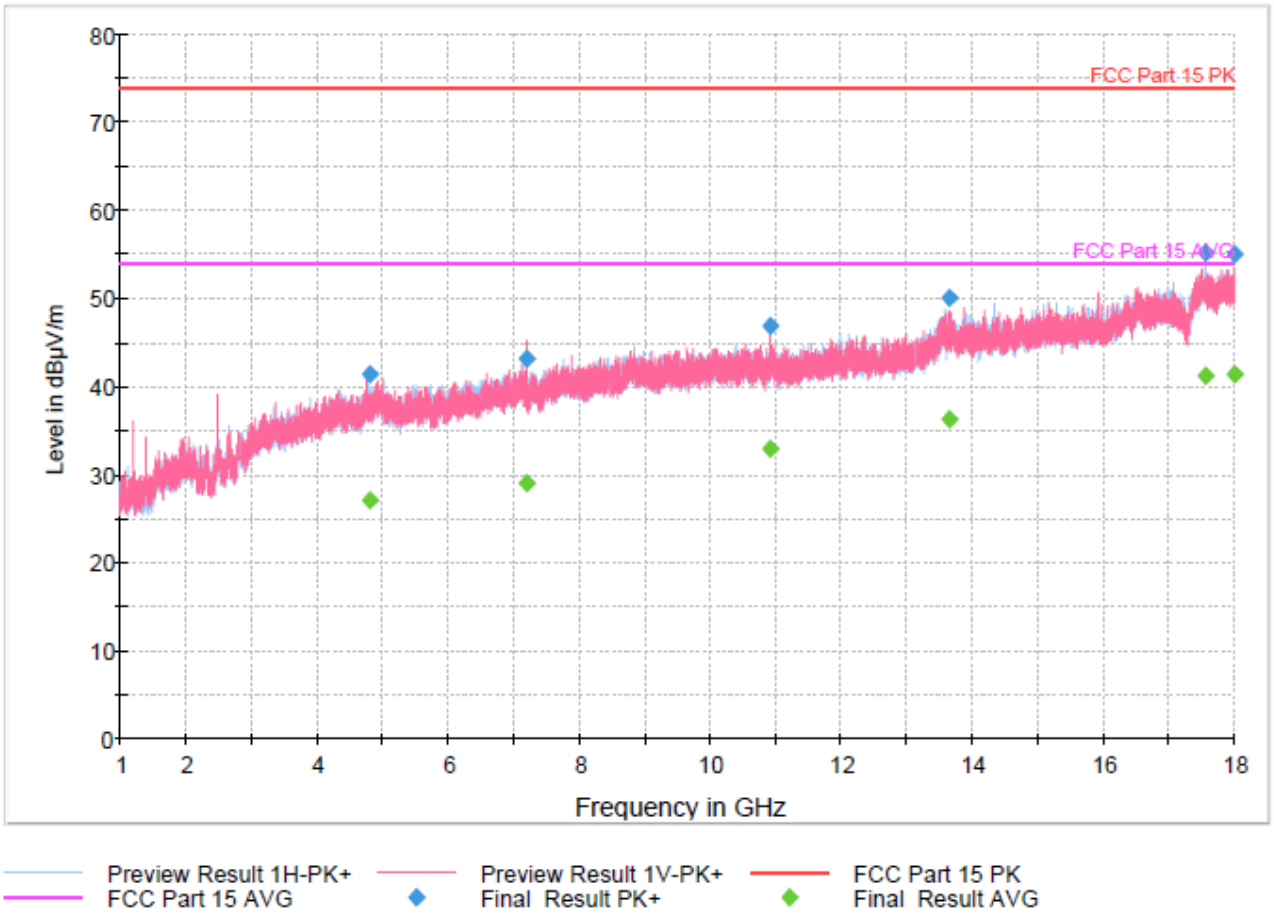


Figure 24: Radiated Spurious Emissions 1GHz - 18GHz, 2402MHz, 1Mbps

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4755.417000	41.01	---	74.00	32.99	1000.000	100.0	H	186.0	5.4
4755.417000	---	26.91	54.00	27.09	1000.000	100.0	H	186.0	5.4
7319.368971	---	29.95	54.00	24.05	1000.000	154.0	H	92.0	7.9
7319.368971	43.58	---	74.00	30.42	1000.000	154.0	H	92.0	7.9
10957.302029	---	32.84	54.00	21.16	1000.000	153.0	H	37.0	11.0
10957.302029	46.66	---	74.00	27.34	1000.000	153.0	H	37.0	11.0
13504.398000	50.65	---	74.00	23.35	1000.000	236.0	V	67.0	13.3
13504.398000	---	37.01	54.00	16.99	1000.000	236.0	V	67.0	13.3
17530.000000	---	41.53	54.00	12.47	1000.000	103.0	V	223.0	18.9
17530.000000	55.22	---	74.00	18.78	1000.000	103.0	V	223.0	18.9
17847.500971	55.21	---	74.00	18.79	1000.000	100.0	V	50.0	19.5
17847.500971	---	41.41	54.00	12.59	1000.000	100.0	V	50.0	19.5

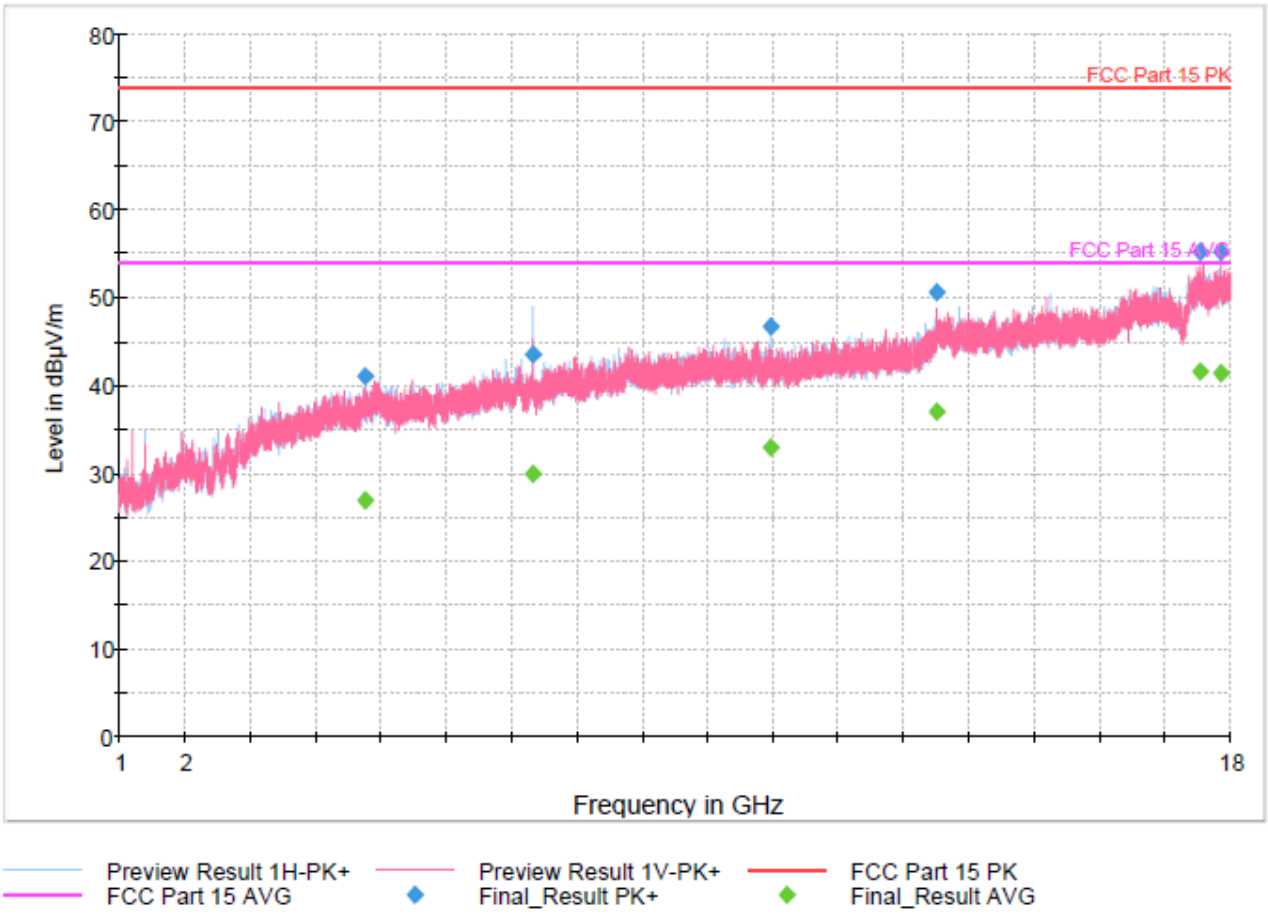


Figure 25: Radiated Spurious Emissions 1GHz - 18GHz, 2440MHz, 1Mbps

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4946.500000	41.86	---	74.00	32.14	1000.000	154.0	H	189.0	5.7
4946.500000	---	27.61	54.00	26.39	1000.000	154.0	H	189.0	5.7
7440.000000	---	28.77	54.00	25.23	1000.000	100.0	V	217.0	8.1
7440.000000	42.30	---	74.00	31.70	1000.000	100.0	V	217.0	8.1
10429.370029	---	32.56	54.00	21.44	1000.000	234.0	H	236.0	10.7
10429.370029	45.97	---	74.00	28.03	1000.000	234.0	H	236.0	10.7
13544.842000	50.29	---	74.00	23.71	1000.000	235.0	V	62.0	13.3
13544.842000	---	36.58	54.00	17.42	1000.000	235.0	V	62.0	13.3
17545.827029	55.34	---	74.00	18.66	1000.000	236.0	V	-2.0	18.9
17545.827029	---	41.56	54.00	12.44	1000.000	236.0	V	-2.0	18.9
17874.893971	---	41.33	54.00	12.67	1000.000	150.0	V	63.0	19.5
17874.893971	54.62	---	74.00	19.38	1000.000	150.0	V	63.0	19.5

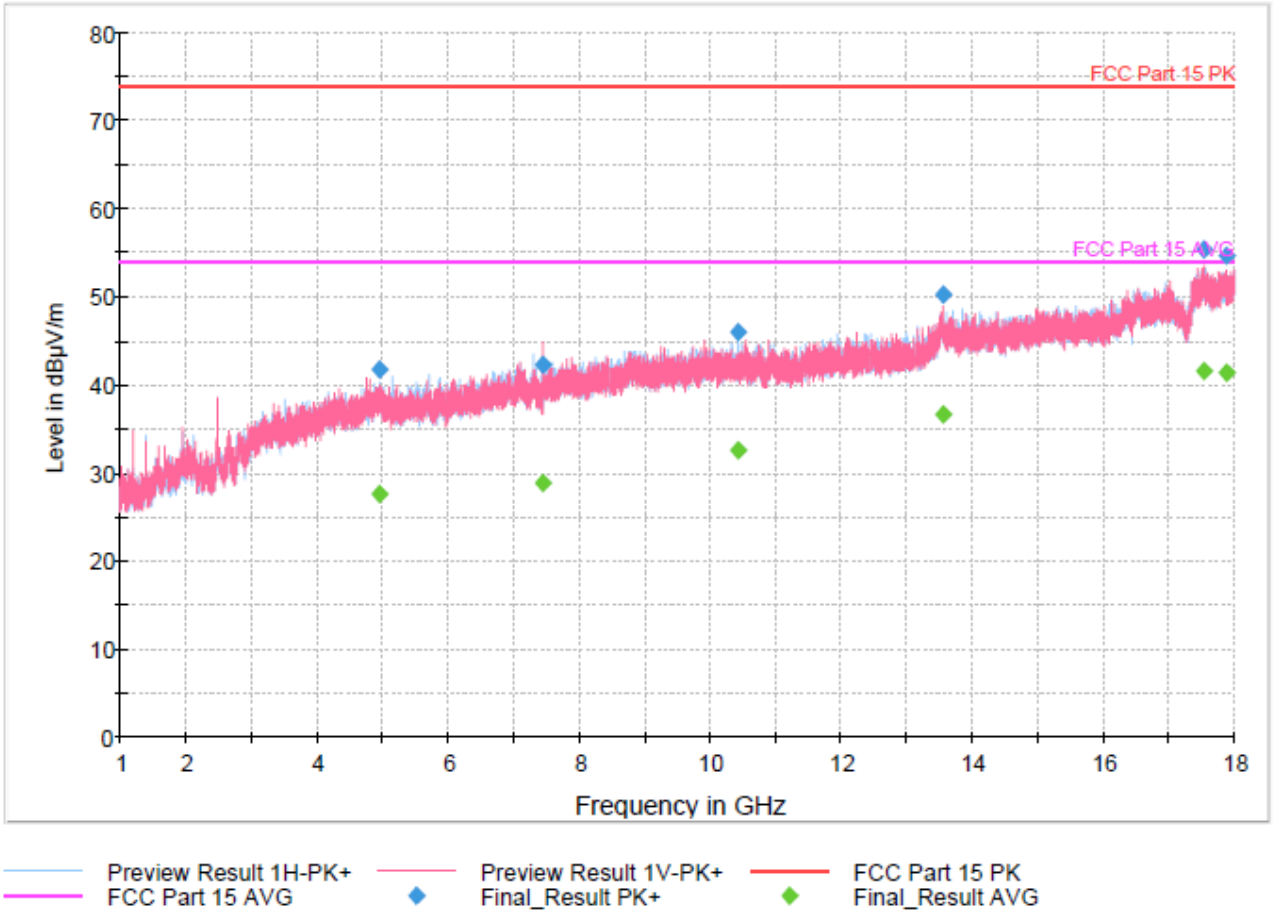


Figure 26: Radiated Spurious Emissions 1GHz - 18GHz, 2480MHz, 1Mbps

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
18114.919235	---	35.10	54.00	18.90	1000.000	100.0	H	147.0	-3.1
18114.919235	49.46	---	74.00	24.54	1000.000	100.0	H	147.0	-3.1
19488.778588	47.98	---	74.00	26.02	1000.000	155.0	H	23.0	-1.0
19488.778588	---	34.49	54.00	19.51	1000.000	155.0	H	23.0	-1.0
20870.795089	48.10	---	74.00	25.90	1000.000	153.0	V	149.0	0.3
20870.795089	---	34.86	54.00	19.14	1000.000	153.0	V	149.0	0.3
22494.795089	48.34	---	74.00	25.66	1000.000	100.0	H	169.0	0.8
22494.795089	---	35.08	54.00	18.92	1000.000	100.0	H	169.0	0.8
24631.323529	---	35.57	54.00	18.43	1000.000	105.0	H	194.0	2.5
24631.323529	49.14	---	74.00	24.86	1000.000	105.0	H	194.0	2.5
25899.728971	49.69	---	74.00	24.31	1000.000	106.0	V	169.0	4.6
25899.728971	---	35.74	54.00	18.26	1000.000	106.0	V	169.0	4.6

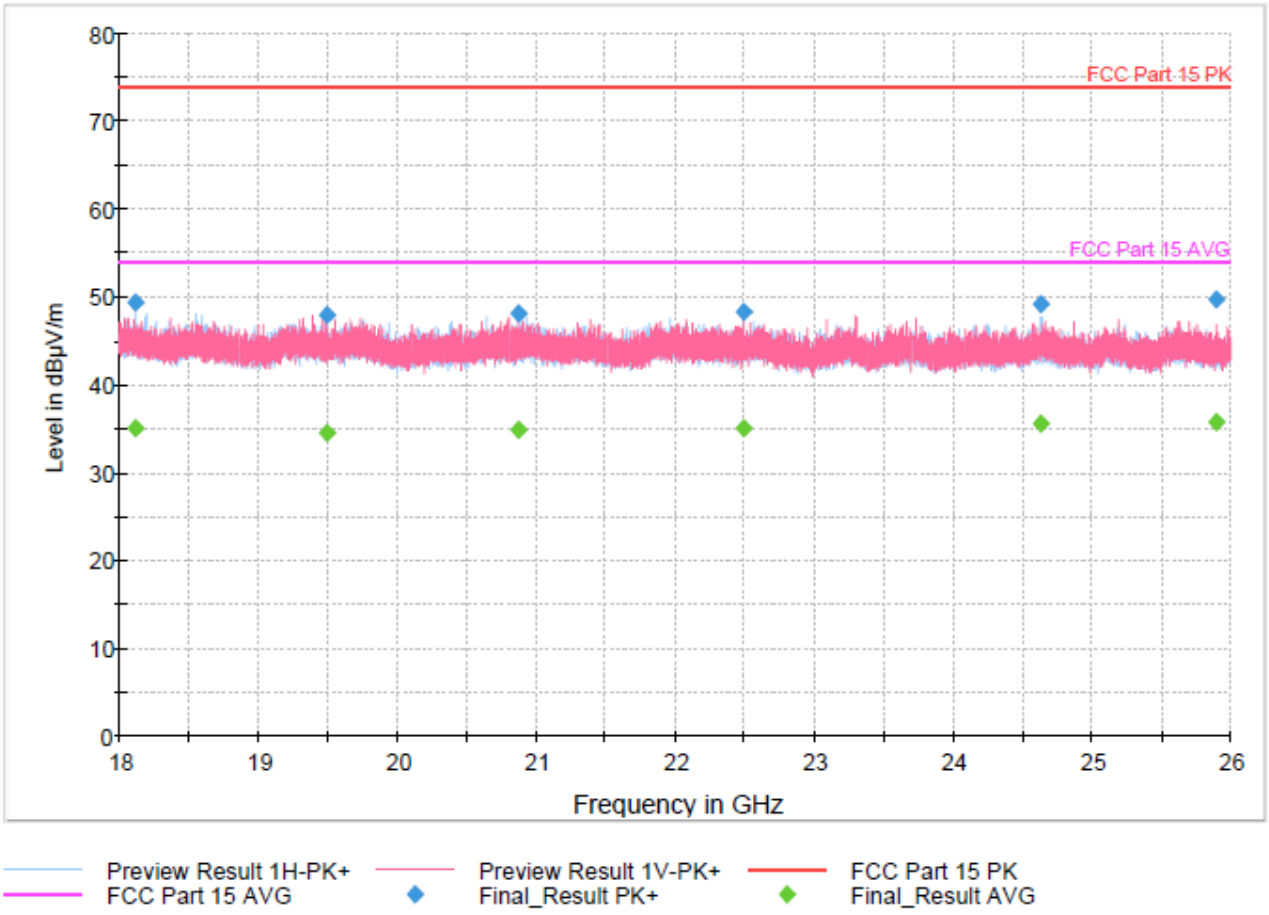


Figure 27: Radiated Spurious Emissions 18GHz - 26GHz, 2402MHz, 1Mbps

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
18127.030383	48.62	---	74.00	25.38	1000.000	158.0	V	-5.0	-3.1
18127.030383	---	34.96	54.00	19.04	1000.000	158.0	V	-5.0	-3.1
20327.557853	---	34.99	54.00	19.01	1000.000	155.0	V	338.0	0.0
20327.557853	49.02	---	74.00	24.98	1000.000	155.0	V	338.0	0.0
21894.167206	49.37	---	74.00	24.63	1000.000	150.0	H	252.0	0.9
21894.167206	---	35.66	54.00	18.34	1000.000	150.0	H	252.0	0.9
23288.677442	---	34.83	54.00	19.17	1000.000	100.0	H	27.0	1.1
23288.677442	48.47	---	74.00	25.53	1000.000	100.0	H	27.0	1.1
24528.996736	48.76	---	74.00	25.24	1000.000	106.0	H	21.0	2.2
24528.996736	---	35.10	54.00	18.90	1000.000	106.0	H	21.0	2.2
25656.883471	49.26	---	74.00	24.74	1000.000	100.0	H	69.0	4.5
25656.883471	---	35.76	54.00	18.24	1000.000	100.0	H	69.0	4.5

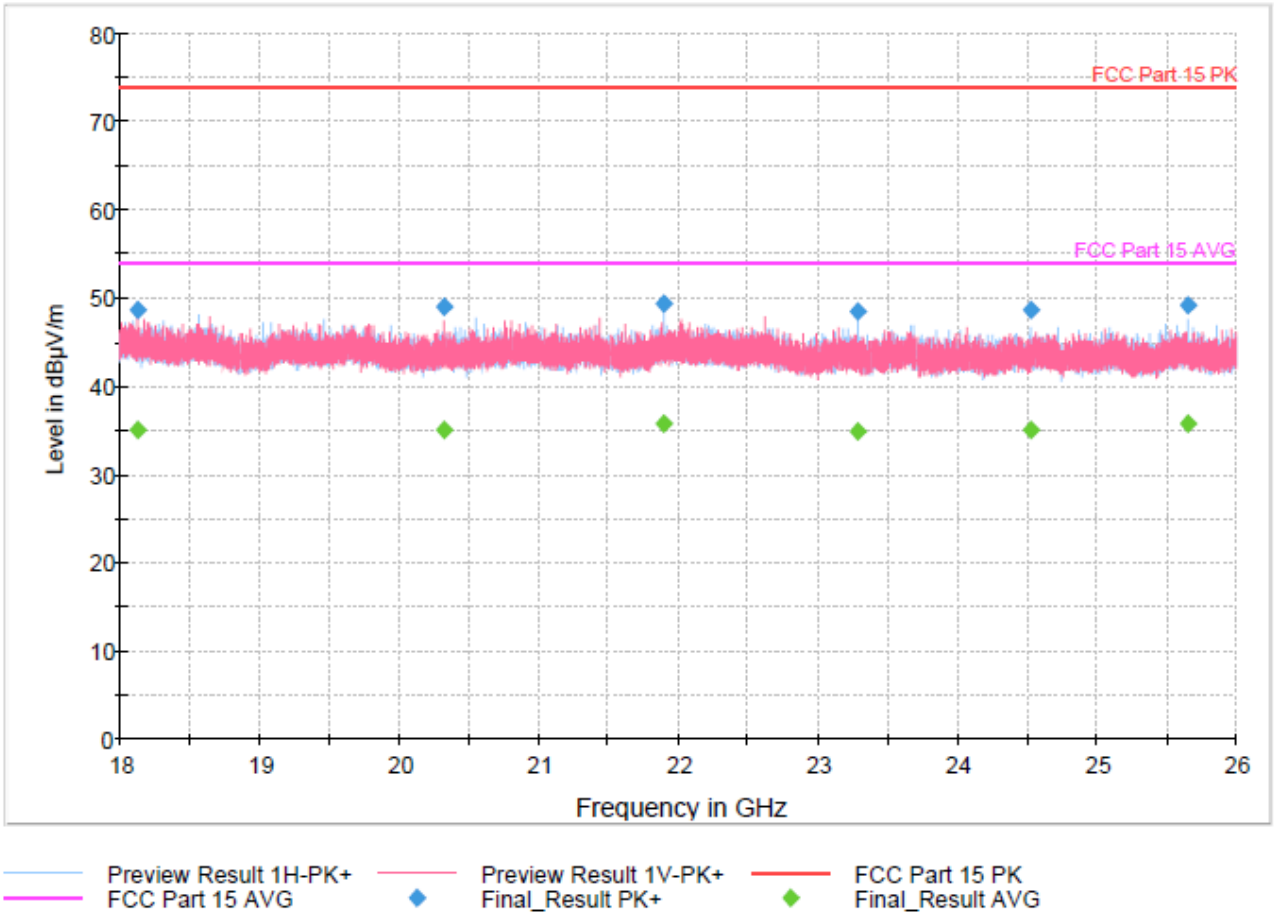


Figure 28: Radiated Spurious Emissions 18GHz - 26GHz, 2440MHz, 1Mbps

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
18233.204911	48.54	---	74.00	25.46	1000.000	105.0	V	64.0	-2.9
18233.204911	---	34.94	54.00	19.06	1000.000	105.0	V	64.0	-2.9
19552.012735	---	34.50	54.00	19.50	1000.000	103.0	H	304.0	-1.0
19552.012735	47.60	---	74.00	26.40	1000.000	103.0	H	304.0	-1.0
22051.014529	---	35.62	54.00	18.38	1000.000	150.0	H	-2.0	0.6
22051.014529	49.94	---	74.00	24.06	1000.000	150.0	H	-2.0	0.6
23554.324500	---	34.52	54.00	19.48	1000.000	105.0	V	32.0	1.3
23554.324500	47.71	---	74.00	26.29	1000.000	105.0	V	32.0	1.3
25138.761941	48.87	---	74.00	25.13	1000.000	106.0	V	354.0	3.4
25138.761941	---	35.51	54.00	18.49	1000.000	106.0	V	354.0	3.4
25820.263735	---	35.41	54.00	18.59	1000.000	103.0	H	97.0	4.5
25820.263735	48.81	---	74.00	25.19	1000.000	103.0	H	97.0	4.5

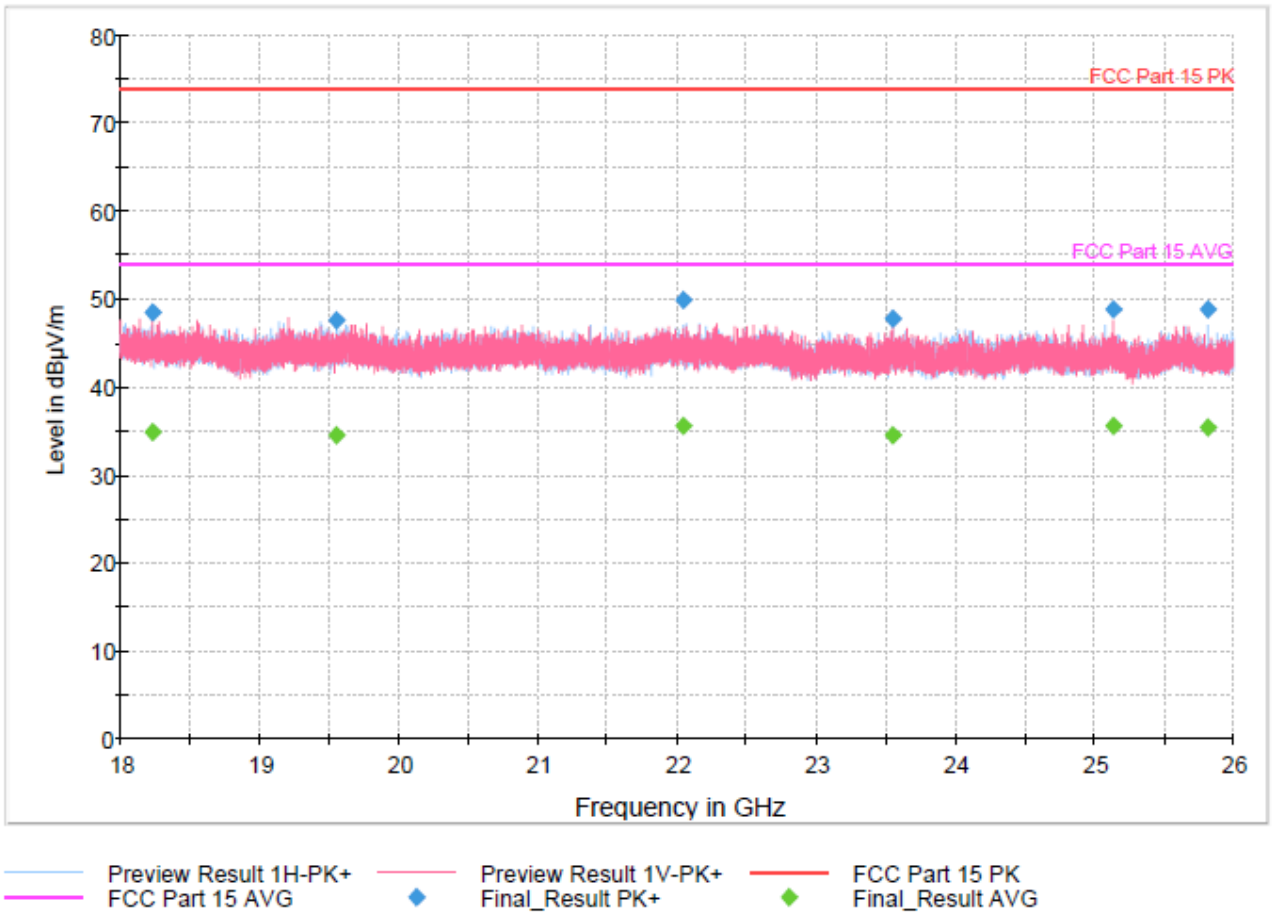


Figure 29: Radiated Spurious Emissions 18GHz - 26GHz, 2480MHz, 1Mbps

4.7 AC Conducted Emissions

Testing was performed in accordance with ANSI C63.10: 2013. 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: 2021 and RSS Gen: 2019 Sect. 8.8.

4.7.1 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.

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.

4.7.1.1 Deviations

There were no deviations from this test methodology.

4.7.2 Test Results

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

Table 6: AC Conducted Emissions – Test Results

Test Conditions: Conducted Measurement at Normal Conditions only		
Antenna Type: LDS Inverted F type antenna	**Antenna Gain:** -6.93dBi	
AC Power: 120 VAC/60 Hz	**Configuration:** Tabletop	
Configuration	**Frequency Range**	**Test Result**
Line 1 (Live)	0.15 to 30 MHz	Pass
Line 2 (Neutral)	0.15 to 30 MHz	Pass

Note: The EUT is DC powered by a battery. Conducted Emissions testing was performed with the EUT battery pack connected to the strap and is being charged through an AC port And EUT battery pack connected with the laptop. The Bluetooth radio is operating in all these configurations.

Figure 30 Live line and Figure 33 Neutral Line shows the emissions over average and quasi peak limits are from the charger which operate at 13.56MHz frequency.

4.7.2.1 Live Line

Configuration: EUT battery pack connected to the strap and is being charged through an AC

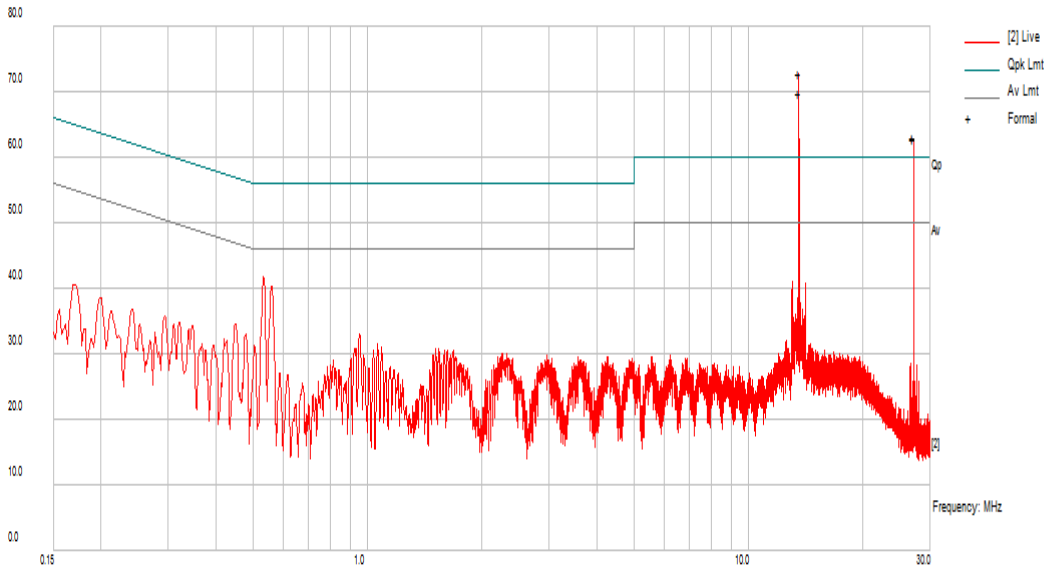


Figure 30: AC Conducted Emissions 150 kHz to 30 MHz-Live Line – Charger only, Bluetooth radio is off.

Note: The transmitter fundamental 13.56 MHz is from charger. Blutooth Radio is off.

Frequency MHz	Raw dBuV	Cable Loss	Factors dB	Level dBuV	Measurement Type	Line	Limit dBuV	Margin dB	Pass /Fail
0.530285	29.37	10.11	0.03	39.52	Quasi Peak	Live	56	-16.48	Pass
0.554842	30.22	10.11	0.03	40.36	Quasi Peak	Live	56	-15.64	Pass
13.03561	28.46	10.39	-0.03	38.81	Quasi Peak	Live	60	-21.19	Pass
1.059944	17.22	10.12	0.03	27.37	Quasi Peak	Live	56	-28.63	Pass
0.15203	21.75	11.08	0.09	32.92	Quasi Peak	Live	65.89	-32.97	Pass
27.64772	15.62	10.64	-0.29	25.97	Quasi Peak	Live	60	-34.03	Pass
0.530285	23.58	10.11	0.03	33.73	Average	Live	46	-12.27	Pass
0.554842	24.94	10.11	0.03	35.08	Average	Live	46	-10.92	Pass
13.03561	23.93	10.39	-0.03	34.29	Average	Live	50	-15.71	Pass
1.059944	5.61	10.12	0.03	15.76	Average	Live	46	-30.24	Pass
0.15203	4.78	11.08	0.09	15.95	Average	Live	55.89	-39.94	Pass
27.64772	5.37	10.64	-0.29	15.72	Average	Live	50	-34.28	Pass

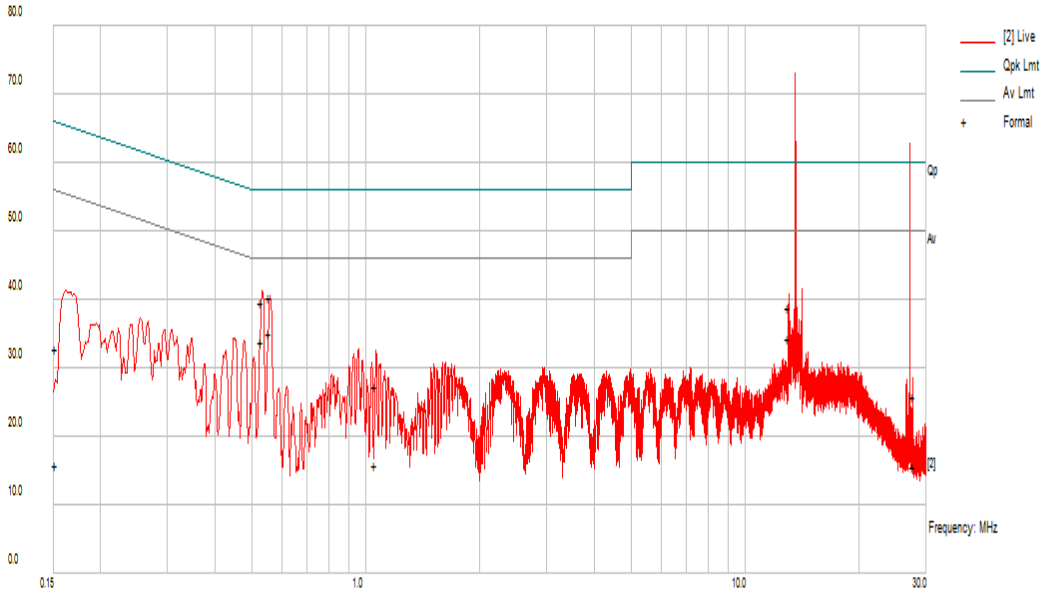


Figure 31: AC Conducted Emissions 150 kHz to 30 MHz- Live Line, Bluetooth Radio is On

Note: The emission over average and quasi peak limit is not from Bluetooth. Meet FCC Class B limit.

Configuration: EUT battery pack connected with the laptop.

Frequency MHz	Raw dBuV	Cable Loss	Factors dB	Level dBuV	Measurement Type	Line	Limit dBuV	Margin dB	Pass /Fail
0.151122	39.09	11.13	0.09	50.31	Quasi Peak	Live	65.94	-15.63	Pass
3.394393	22.12	10.2	0.03	32.35	Quasi Peak	Live	56	-23.65	Pass
0.220974	27.72	10.2	0.06	37.98	Quasi Peak	Live	62.78	-24.8	Pass
1.765655	13.64	10.14	0.03	23.82	Quasi Peak	Live	56	-32.18	Pass
7.792774	19.29	10.29	0.02	29.6	Quasi Peak	Live	60	-30.4	Pass
13.56073	29.13	10.4	-0.04	39.5	Quasi Peak	Live	60	-20.5	Pass
27.12121	28.85	10.63	-0.28	39.2	Quasi Peak	Live	60	-20.8	Pass
0.151122	18.5	11.13	0.09	29.73	Average	Live	55.94	-26.21	Pass
3.394393	7.08	10.2	0.03	17.3	Average	Live	46	-28.7	Pass
0.220974	14.77	10.2	0.06	25.03	Average	Live	52.78	-27.75	Pass
1.765655	1.69	10.14	0.03	11.87	Average	Live	46	-34.13	Pass
7.792774	13.22	10.29	0.02	23.53	Average	Live	50	-26.47	Pass
13.56073	27.97	10.4	-0.04	38.33	Average	Live	50	-11.67	Pass
27.12121	28.65	10.63	-0.28	39	Average	Live	50	-11	Pass

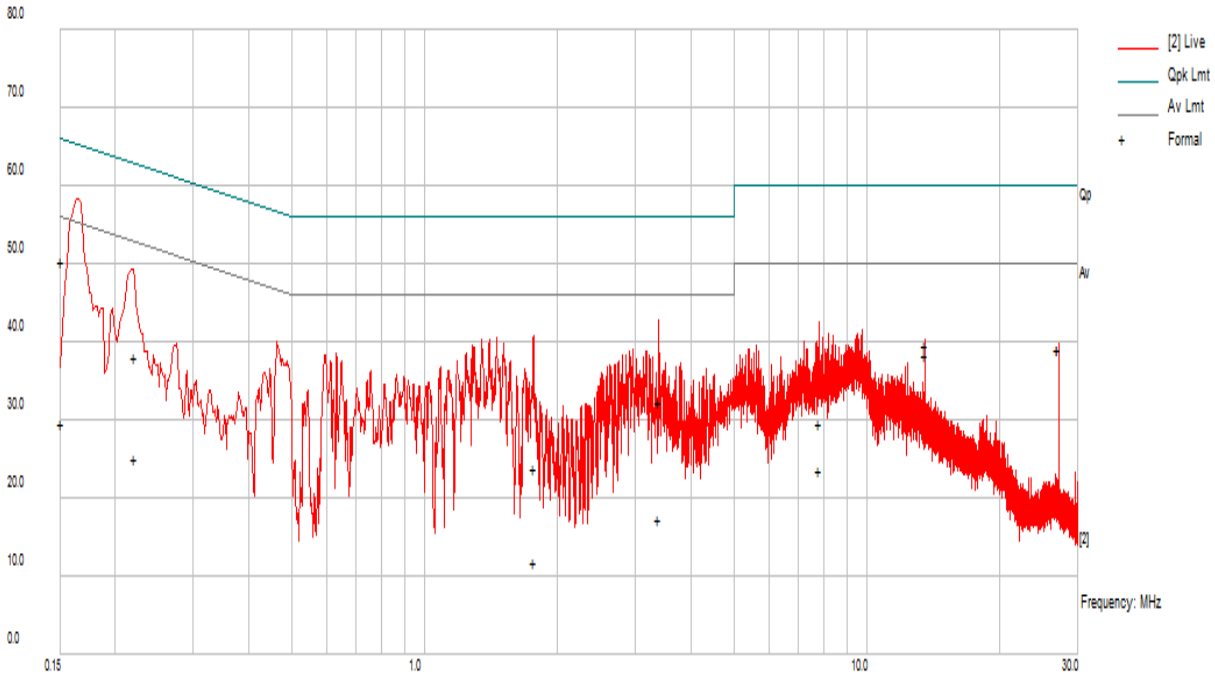


Figure 32: AC Conducted Emissions 150 kHz to 30 MHz- Live Line

4.7.2.2 Neutral Line

Configuration: EUT battery pack connected to the strap and is being charged through an AC

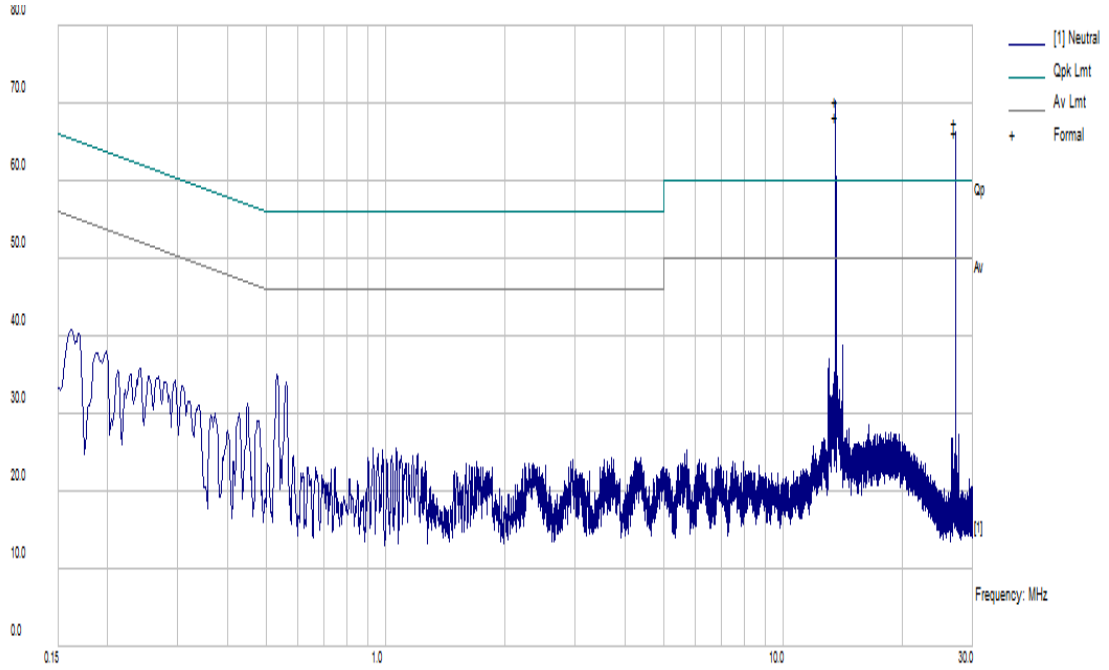


Figure 33: AC Conducted Emissions 150 kHz to 30 MHz Neutral Line-Charger only,Bluetooth radio is off.

Note: The transmitter fundamental 13.56 MHz is from charger. Blutooth Radio is off.

Frequency MHz	Raw dBuV	Cable Loss	Factors dB	Level dBuV	Measurement Type	Line	Limit dBuV	Margin dB	Pass /Fail
0.529108	21.15	10.11	0.03	31.3	Quasi Peak	Neutral	56	-24.7	Pass
13.0106	26.8	10.39	-0.03	37.15	Quasi Peak	Neutral	60	-22.85	Pass
14.10938	27.41	10.41	-0.04	37.78	Quasi Peak	Neutral	60	-22.22	Pass
0.550389	23.43	10.11	0.03	33.57	Quasi Peak	Neutral	56	-22.43	Pass
0.16678	28.28	10.5	0.08	38.86	Quasi Peak	Neutral	65.12	-26.26	Pass
0.247822	24.46	10.17	0.05	34.69	Quasi Peak	Neutral	61.83	-27.14	Pass
0.529108	10.55	10.11	0.03	20.7	Average	Neutral	46	-25.3	Pass
13.0106	15.61	10.39	-0.03	25.97	Average	Neutral	50	-24.03	Pass
14.10938	16.19	10.41	-0.04	26.56	Average	Neutral	50	-23.44	Pass
0.550389	15.9	10.11	0.03	26.05	Average	Neutral	46	-19.95	Pass
0.16678	14.23	10.5	0.08	24.81	Average	Neutral	55.12	-30.31	Pass
0.247822	7.28	10.17	0.05	17.51	Average	Neutral	51.83	-34.32	Pass

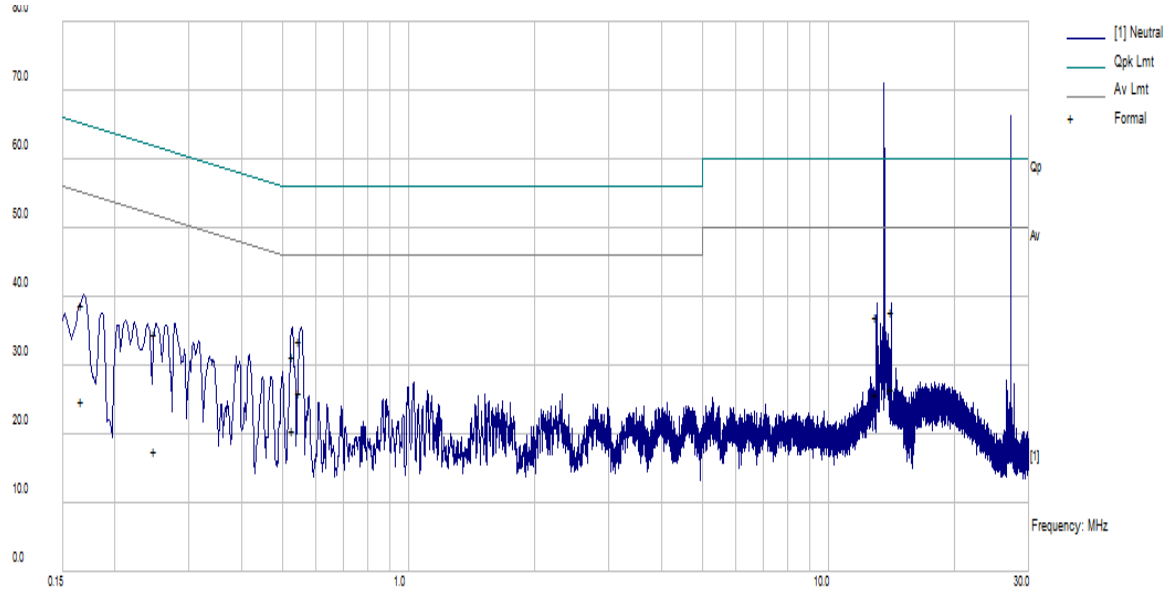


Figure 34: AC Conducted Emissions 150 kHz to 30 MHz- Neutral Line, Bluetooth Radio is On

Note: The emission over average and quasi peak limit is not from Bluetooth. Meet FCC Class B limit.

Configuration: EUT battery pack connected with the laptop.

Frequency MHz	Raw dBuV	Cable Loss	Factors dB	Level dBuV	Measurement Type	Line	Limit dBuV	Margin dB	Pass /Fail
0.21104	45.05	10.21	0.07	55.32	Quasi Peak	Neutral	63.16	-7.84	Pass
0.211509	44.96	10.21	0.06	55.23	Quasi Peak	Neutral	63.15	-7.92	Pass
9.832341	26.67	10.32	0	36.99	Quasi Peak	Neutral	60	-23.01	Pass
9.668565	29.57	10.32	0	39.88	Quasi Peak	Neutral	60	-20.12	Pass
1.647794	5.09	10.14	0.03	15.26	Quasi Peak	Neutral	56	-40.74	Pass
0.24403	28.22	10.18	0.05	38.45	Quasi Peak	Neutral	61.96	-23.51	Pass
27.12092	30.18	10.63	-0.28	40.53	Quasi Peak	Neutral	60	-19.47	Pass
13.55975	29.63	10.4	-0.04	40	Quasi Peak	Neutral	60	-20	Pass
0.21104	32.36	10.21	0.07	42.64	Average	Neutral	53.16	-10.53	Pass
0.211509	31.59	10.21	0.06	41.86	Average	Neutral	53.15	-11.28	Pass
9.832341	18.17	10.32	0	28.49	Average	Neutral	50	-21.51	Pass
9.668565	18.55	10.32	0	28.87	Average	Neutral	50	-21.13	Pass
1.647794	-3.95	10.14	0.03	6.22	Average	Neutral	46	-39.78	Pass
0.24403	16.69	10.18	0.05	26.92	Average	Neutral	51.96	-25.04	Pass
27.12092	29.95	10.63	-0.28	40.3	Average	Neutral	50	-9.7	Pass
13.55975	29.51	10.4	-0.04	39.88	Average	Neutral	50	-10.12	Pass

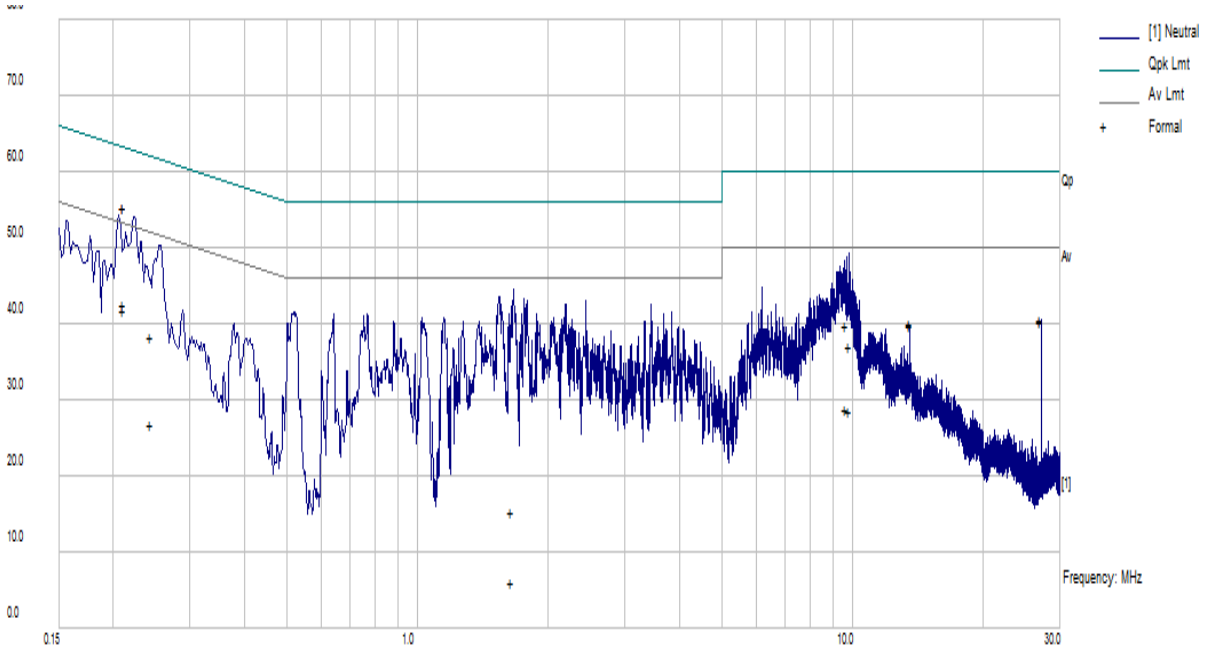


Figure 35: AC Conducted Emissions 150 kHz to 30 MHz- Neutral Line

5 Test Equipment Use List

5.1 Equipment List

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal mm/dd/yyyy	Next Cal mm/dd/yyyy
Analyzer/EMI Receiver	Rohde & Schwarz	ESW, 2Hz-44GHz	5000-2455-0027	02/28/2021	02/28/2022
Trilog Antenna	Rohde & Schwarz	VULB 9162	A102606	02/27/2021	02/27/2022
Preamplifier, 30MHz – 8 GHz	Rohde & Schwarz	TS-PR8	102353	02/26/2021	02/26/2022
Horn, 1-18GHz	Rohde & Schwarz	HF907	20-817094-C	09/10/2020	09/10/2021
Preamplifier, 1-18GHz	Rohde & Schwarz	TS-PR18	101649	03/23/2021	03/23/2022
Horn, 18-40GHz	Rohde & Schwarz	180-442-KF	132596-01	04/17/2020	04/17/2022
Preamplifier, 18 – 40GHz	Rohde & Schwarz	TS-PR1840	100067	02/27/2020	02/27/2022
Spectrum Analyzer	Rohde & Schwarz	FSU26.5	200050	02/24/2021	02/24/2022
Base station simulator	Rohde & Schwarz	CMW500	1201.0002K50	02/22/2020	02/22/2022
Environmental Chamber	Espec	BTZ-133	0613436	N/A (See Note)	
1.6 GHz Low Pass Filter	K&L Microwave	8L120-X1600-0/09135-0249	UA691-35	N/A (See Note)	
2.4GHz Band Pass Filter	Micro-Tronics	BRM50702	009	N/A (See Note)	
Note: Equipment is characterized before use.					

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 (information supplied by the customer and can affect the validity of results) so that the test laboratory may perform the requested testing.

6.2 Customer

The information in the following tables is required, as it should appear in the final test report.

Table 7 – Customer Information

Company Name	Whoop, Inc.
Address	1325 Boylston Street, Unit 401
City, State, Zip	Boston, MA 02215
Country	U.S.A.

Table 8 – Contact Information

Name	Jordon Halteman
E-mail	Halteman@whoop.com
Phone	(617) 670-1074

6.3 Equipment Under Test (EUT)

The information provided in the following table should be listed as it should appear in the final report. For those products that have only a model name, list the model number as *non-applicable* and vice-versa.

Table 9 – EUT Designation

Product Name	Whoop 4.0
Model No.	WS40
Product Description	Wearable Health monitor

6.3.1 Product Specifications

The information provided in the following table should be listed as it should appear in the final report.

Table 10 – EUT Specifications*

EUT Specification	
AC Power Input	100-240 VAC, 50/60Hz (AC Charger)
DC Power Input	4.4VDC (powered by battery)
Environment	Indoor/Outdoor
Operating Temperature Range:	-20 to 60 degrees C
Multiple Feeds:	☐ Yes and how many ☒ No
Product Marketing Name (PMN)	Whoop 4.0
Hardware Version Identification Number (HVIN)	WS40
Firmware Version Identification Number (FVIN)	N/A
Operating Mode	Bluetooth Low Energy
Transmitter Frequency Band	2402 MHz to 2483.5 MHz
Power Setting @ Operating Channel	+8 dBm (max)
Antenna Type	LDS Inverted F type antenna
Peak Antenna Gain (dBi)	-6.93 dBi
Modulation Type	☐ AM ☐ FM ☐ DSSS ☐ OFDM ☒ Other describe: GFSK
Date Rate	1 Mbps and 2 Mbps
TX/RX Chain (s)	1
Directional Gain Type	☒ Uncorrelated ☒ No Beam-Forming ☐ Other describe:
Type of Equipment	☐ Table Top ☐ Wall-mount ☐ Floor standing cabinet ☒ Other: Wearable Smartwatch
Note: *All EUT specifications are provided by the manufacturer or the TUV direct customer. Information supplied by the customer and can affect the validity of results.	

Table 11: Antenna Information

Number	Antenna Type	Description	Max Gain (dBi)
1	LDS Inverted F type antenna	Internal	-6.93

Table 12: 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?
USB Cable	Serial to USB	☐ Yes	☒ Metric: <3.0m	☒ N/A
Note: Cable required for EUT configuration for regulatory test mode. 3pin to USB cable not utilized within final product. EUT powered by battery during test.				

Table 13: Accessory Equipment

Equipment	Manufacturer	Model	Serial	Comment
USB to Serial Connector cable	N/A (generic)	N/A (generic)	N/A	Used between test cases to configure EUT operational test mode.
Note: None.				

Table 14: Ancillary Equipment (used for test purposes only)

Equipment	Manufacturer	Model	Serial	Used for
Laptop	HP	13-aw2003dx	5CD1134HQD	Setup EUT operating channels via serial connection to EUT
Note: None.				

6.3.2 Configuration(s)

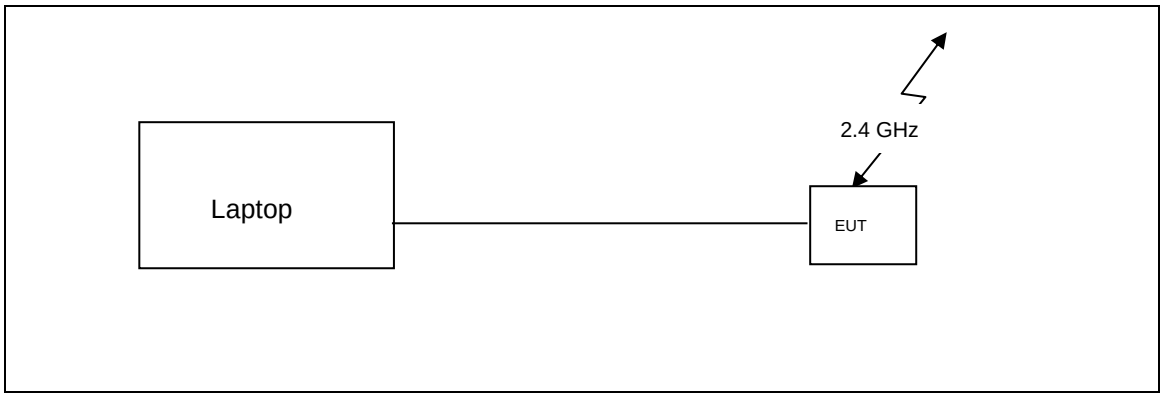


Figure 36: Block Diagram of EUT Setup - Radiated

Note: 1. The EUT was connected to the USB Port of the supporting laptop for configuration and control.
2. SMA cable was in place of the antenna for conducted measurement test purposes only.

Table 15: Description of Sample used for Testing

Device	Sample Model Number	Configuration	Used For
Whoop 4.0	WS40	Radiated Sample	Radiated Emissions, Radiated Band Edge
	WS40, WB40	Conducted Sample	Transmit Power, Occupied Bandwidth, Out of Band Emission, PSD, Duty Cycle

Table 16: Description of Test Configuration used for Radiated Measurement.

Device	Antenna	Mode	Setup Description
Whoop 4.0	LDS Inverted F type antenna	Transmit/ Receive	EUT Flat
Note: EUT was tested on its X-Axis as this was worse case			

6.4 Test Specifications

The information provided in the following table should be provided as you would like the product to be evaluated if different from the requirements of the standard.

Table 17 - Test Specifications

Emissions and Immunity	
Standard	**Requirement**
CFR 47 Part 15.247: 2021	All
RSS 247 Issue 2, 2017	All

--- Ende des Prüfberichts / *End of Test Report* ---