313 West 12800 South, Suite 311
Draper, UT 84020
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Test Report

Certification

FCC ID	MHI-CONAPPWM2
Equipment Under Test	CONAPPWM2
Test Report Serial No	V056760_02
Dates of Test	November 23 & 24, 2020, December 1, 8, & 9, 2020, January 25, 2021, and April 28, 2021
Report Issue Date	April 28, 2021

Test Specifications:	Applicant:
FCC Part 15, Subpart E	CA Engineering 147 W. Election Road, Suite 200 Draper, UT 54020 U.S.A.

Testing
NVLAP Lab Code 100272-0

Certification of Engineering Report

This report has been prepared by VPI Laboratories, Inc. to document compliance of the device described below with the requirements of Federal Communications Commission (FCC) Part 15, Subpart E. This report may be reproduced in full. Partial reproduction of this report may only be made with the written consent of the laboratory. The results in this report apply only to the sample tested.

Applicant	CA Engineering
Manufacturer	Sub-Zero
Brand Name	Sub-Zero, Wolf, Cove
Model Number	CONAPPWM2
FCC ID	MHI-CONAPPWM2

On this 28th day of April 2021, I, individually and for VPI Laboratories, Inc., certify that the statements made in this engineering report are true, complete, and correct to the best of my knowledge, and are made in good faith.

Although NVLAP has accredited the VPI Laboratories, Inc. EMC testing facilities, this report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

VPI Laboratories, Inc.

Norman P Hansen

Radiated Emissions Testing by: Norman P. Hansen

Direct Connect Measurements by: Benjamin N. Antczak

Reviewed by: Jason Stewart

Revision History		
Revision	**Description**	**Date**
01	Original Report Release	April 28, 2021
02	Correcting Model Number	May 18, 2021

Table of Contents

1 Client Information

1.1 Applicant

Company Name	CA Engineering 147 W. Election Road, Suite 200 Draper, UT 84020 U.S.A.
Contact Name	James Stout
Title	Executive Vice President of Engineering

1.2 Manufacturer

Company Name	Sub-Zero, Inc. 4717 Hammersley Rd. PO Box 44130 Madison, WI 53744
Contact Name	Jonathan Shank
Title	Project Manager

2 Equipment Under Test (EUT)

2.1 Identification of EUT

Brand Name	Sub-Zero, Wolf, Cove
Model Number	CONAPPWM2
Serial Number	4020000035 and 4020000071
Dimensions (cm)	8 x 8 x 2.5

2.2 Description of EUT

The CONAPPWM2 are devices to provide an appliance with a WiFi connection to a WiFi network. The WiFi transceiver operates in both the 2.4 GHz ISM band and the 5 GHz UNII frequency bands. A BLE transceiver is also included for connecting to and configuring the WiFi connection. An XP Power VEL05US120-US-JA was used to power the device. The antenna is a trace on the PCB with a maximum gain of 3.5 dBi.

. Channel assignments, frequencies and maximum power settings are shown in the table below.

Channel	Frequency (MHz)	Maximum Power Setting
149	5745	16
153	5765	16
157	5785	16
161	5805	16
165	5825	16

2.2.1 Modes of Operation

EUT is intended to operate indoors as a client device. The EUT is not fixed and therefore incapable of fixed point-to-point architecture.

2.2.2 DFS Capabilities

This report covers the circuitry of the device operating in the UNII-3 band (5.725 GHz – 5.85 GHz). Operation in the UNII-3 band is not subject to DFS requirements.

2.3 EUT and Support Equipment

The EUT and support equipment used during the test are listed below.

Brand Name Model Number Serial Number	Description	Name of Interface Ports / Interface Cables
BN: Sub-Zero MN: CONAPPWM2 (Note 1) SN: 4020000035	BLE and WiFi network interface device	See Section 2.4

Notes: (1) EUT

2.4 Interface Ports on EUT

There are no interface ports on the EUT.

2.5 Modification Incorporated/Special Accessories on EUT

There were no modifications or special accessories required to comply with the specification.

2.6 Deviation from Test Standard

There were no deviations from the test specification.

2.7 Scope of This Report

This report covers the circuitry of the devices subject to FCC Part 15, Subpart E. with operation in the 5725 MHz to 5850 MHz frequency band. The circuitry of the device subject to FCC 15 Subpart B, FCC 15 Subpart C, and other requirements of FCC Part 15 Subpart E and was found to be compliant but are covered in separate reports.

3 Test Specification, Methods and Procedures

3.1 Test Specification

Title	FCC PART 15, Subpart E (47 CFR 15) 15.203, 15.207, 15.209, and 15.407
Purpose of Test	The tests were performed to demonstrate initial compliance
UNII References	KDB 789033 Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices Part 15, Subpart E KDB 905462 D02 UNII DFS Compliance Procedures New Rules v02

3.2 Methods & Procedures

3.2.1 §15.203 Antenna Requirement

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 in compliance 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 Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

3.2.2 §15.207 Conducted Limits

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency range (MHz)	Limit (dBμV)	
	Quasi-peak	Average
0.15 to 0.50*	66 to 56*	56 to 46*
0.50 to 5	56	46
5 to 30	60	50

*Decreases with the logarithm of the frequency.

Table 1: Limits for conducted emissions at mains ports of Class B ITE.

3.2.3 §15.407 Operation within the UNII Bands

Emission bandwidth is determined by measuring the width of the signal between points that are 26 dB down relative to the maximum level of the carrier center frequency.

Maximum conducted output power is the total transmit power delivered to all antennas, averaged across all symbols when operating at maximum power control level. If multiple modulation methods are possible, then the highest total transmit power in any mode is considered the maximum conducted output power.

Power spectral density is the total energy output per unit bandwidth from a transmitter operating at maximum power level divided by the total duration of transmission.

Measurements for UNII operation are taken over intervals of continuous transmissions. Measurements are taken using a minimum of resolution bandwidth of 1 MHz. If lower resolution bandwidths are used, measurement energies must be integrated to show the total power over 1 MHz. Emission limits are taken at the highest and lowest channels available to the manufacturer.

Although not covered in this test report, frequency stability must be ensured by manufacturer under all conditions of normal operation.

3.2.3.1 Power Limits in the Band 5150 – 5250 MHz ("UNII-1")

Access points operating either indoors or outdoors, maximum conducted output power over the frequency band 5.15 – 5.25 GHz ("UNII-1") shall not exceed 1 W (30 dBm) as long as the maximum antenna gain does not exceed 6 dBi. In addition, maximum power spectral density shall not exceed 17 dBm in any 1 MHz band. If maximum antenna gain exceeds 6 dBi, then the maximum conducted output power and maximum power spectral density shall be reduced by the amount (in dB) that the directional gain of the antenna exceeds 6 dBi.

Outdoor access points additionally may not exceed 125 mW (21 dBm) maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon.

Only fixed point-to-point access points may employ antennas with directional gain of up to 23 dBi without reducing conducted output power. However, for every 1 dB gain over 23 dBi, maximum conducted output power and maximum power spectral density must be reduced by 1 dB. The 23 dBi exception is only applicable to fixed, point-to-point access points, and is not acceptable for point to multi-point, omni-directional, or multi-point to point architectures.

Client devices shall not exceed conducted output power of 250 mW (24 dBm) as long as the maximum antenna gain does not exceed 6 dBi. In addition, maximum power spectral density shall not exceed 11 dBm for any 1 MHz band. If maximum antenna gain exceeds 6 dBi, then the maximum conducted output power and maximum power spectral density shall be reduced by the amount (in dB) that the directional gain of the antenna exceeds 6dBi.

Emissions outside the band 5.15 – 5.35 GHz shall not exceed an e.i.r.p. of -27 dBm/MHz.

3.2.3.2 Power Limits in the Bands 5250 – 5350 MHz and 5470 – 5725 MHz ("UNII-2")

Maximum conducted output power over the frequency bands 5.25-5.35 GHz and 5.47-5.725 GHz ("UNII-2A" and "UNII-2C," collectively, "UNII-2") shall not exceed the lesser of: 250 mW (24 dBm); or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz (MHz). Maximum power spectral density shall additionally not exceed 11 dBm in any 1 MHz band. If maximum antenna gain exceeds 6 dBi, then the maximum conducted output power and maximum power spectral density shall be reduced by the amount (in dB) that the directional gain of the antenna exceeds 6 dBi.

For transmitters operating in the UNII-2A band, emissions outside the band 5.15 – 5.35 GHz shall not exceed an e.i.r.p. of -27 dBm/MHz. For those transmitters operating in the UNII-2C band, emissions outside the UNII-2C band shall not exceed an e.i.r.p. of -27 dBm/MHz.

Transmitters operating in the UNII-2 bands for which e.i.r.p. exceeds 500 mW (27 dBm) must employ a transmit power control (TPC) mechanism, giving the device the capability of operating at least 6 dB below the mean EIRP of 30 dBm.

3.2.3.3 Power Limits in the Band 5725 – 5850 MHz ("UNII-3")

Maximum conducted output power over the frequency bands 5.725 – 5.85 GHz ("UNII-3") shall not exceed 1 W (30 dBm). Maximum power spectral density shall not exceed 30 dBm in any 500 kHz band. If maximum antenna gain exceeds 6 dBi, then the maximum conducted output power and maximum power spectral density shall be reduced by the amount (in dB) that the directional gain of the antenna exceeds 6 dBi. Fixed point-to-point operations may utilize antennas exceeding 6 dBi without reducing the transmitter conducted power; this exception is only applicable to fixed, point-to-point transmitters, and is not acceptable for point to multi-point, omni-directional, or multi-point to point architectures.

For transmitters operating in the UNII-3 band, emissions 75 MHz above or below the band-edge shall not exceed an e.i.r.p. of -27 dBm/MHz. For those emissions within 75M Hz and 25 MHz of the band-edge the limit increases linearly to 10 dBm/MHz. For those emissions within 25 MHz and 5 MHz of the band-edge the limit increases linearly to 15.6 dBm/MHz. For those emissions within 5 MHz of the band-edge the limit increases linearly to the band-edge to 27 dBm/MHz.

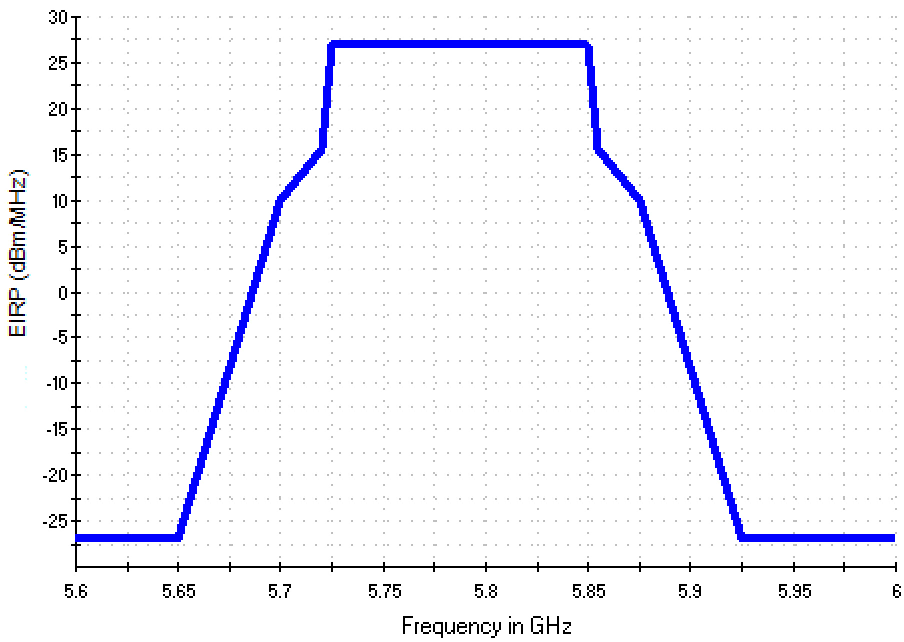


Figure 1. Emission limit for transmitters operating in the UNII-3 (5.725 – 5.850 GHz) band

Transmitters operating in the UNII-3 band shall also have a 6 dB bandwidth of at least 500 kHz.

3.2.3.4 Radar Detection Function of Dynamic Frequency Selection

UNII devices that operate with any part of their 26 dB emission bandwidth in the UNII-2 bands must employ a DFS radar detection mechanism to avoid co-channel operation with radar systems. Upon detection of radar signals, the channel must be flagged as containing a radar system and must not be utilized for at least 30 minutes ("Non-occupancy Period").

All DFS devices must fulfil the Channel Move Time requirement, forcing all transmissions to cease operating on a channel within 10 seconds of detecting a radar signal. Transmissions may continue with normal traffic for a maximum of 200 ms after the detection of radar, but only control and management signals may exist after 200 ms to assist in the vacating of the occupied channel. Control and management signals are not allowed after 10 seconds.

Only DFS devices operating as a master device must fulfil the Channel Availability Check time requirement. Master devices must check if there are radar signals already operating on a channel before initiating transmission (or changing channels). If no radar signals are detected above the DFS detection threshold within 60 seconds, the channel may be utilized. Initial channel selection may be either randomly selected or manually selected.

The DFS detection threshold is -64 dBm for devices with a maximum e.i.r.p. between 200 mW and 1 W. Devices for which e.i.r.p. is less than 200 mW and for which maximum power spectral density is less than 10 dBm per 1 MHz band shall have a DFS threshold of -62 dBm.

Radar signals must be detected at 100 percent of the device's emission bandwidth. DFS detection threshold is the received power averaged over 1µs and referenced to a 0 dBi antenna.

Some standards such as IEEE 801.11.ax allow wideband transmissions that are "notched" or "punctured" upon radar detection (e.g., 160 MHz wideband transmissions wherein a 20 MHz portion of the bandwidth is not utilized). For such transmission schemes, the remaining emissions of the notched signal shall not bleed into the notch (i.e., 26 dB or 99% bandwidth is outside the notch). Channel closing and moving times must be met when notches are utilized.

3.2.4 UNII Band Channel Aggregation

EUTs which utilize "straddle" channels (Channel 50 at 160 MHz BW, Channel 138 at 80 MHz BW, Channel 142 at 40 MHz BW, or Channel 144 at 20 MHz BW) are subject to the requirements of the bands they straddle. For example, Channel 42 + 138 (80 MHz + 80 MHz) are distributed over (and straddle) the UNII-1 and UNII-2 bands.

Straddle channel 50 is considered operating in both UNII-1 and UNII-2A; straddle channels 138, 142, and 144 are considered operating in both UNII-2C and UNII-3.

3.2.4.1 Conducted Output Power in the Case of Channel Aggregation

For such transmissions, conducted output power is calculated as the summed power of segments located within the band, where the band edge replaces the -26 dB point of the straddling signal. In the example shown in Figure 1, power requirements must be met for both UNII-2 and UNII-3. While it is acceptable to sum the power of the entire transmission in a band (e.g., top-line $P_{U\text{-}NII\text{-}2C}$ and $P_{U\text{-}NII\text{-}3}$), individual measurements over the 26 dB bandwidth of each carrier frequency (or to the band edge) may also be summed ($P_A + P_B$ for UNII-2 band requirements and $P_{U\text{-}NII\ 3}$ for UNII-3 band requirements).

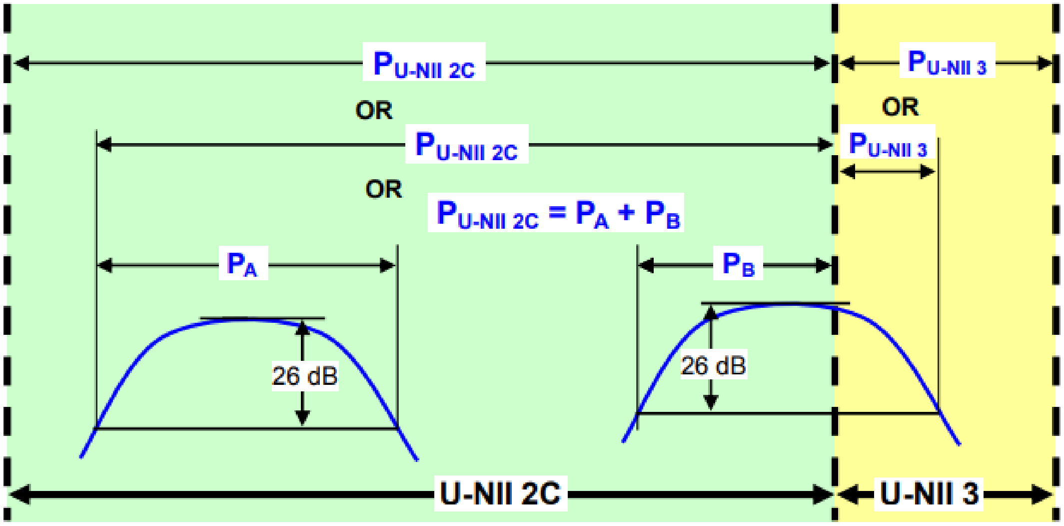


Figure 2. Conducted output power measurement examples (KDB 789033 D02 v02r01, p 21)

3.2.4.2 Emissions Bandwidths in the Case of Channel Aggregation

Emissions bandwidth is defined based upon overlap of the 26 dB bandwidths of each channel individually.

For those transmissions where the 26 dB bandwidths overlap, the emission bandwidth (EWB) is the difference between the outer -26 dB points.

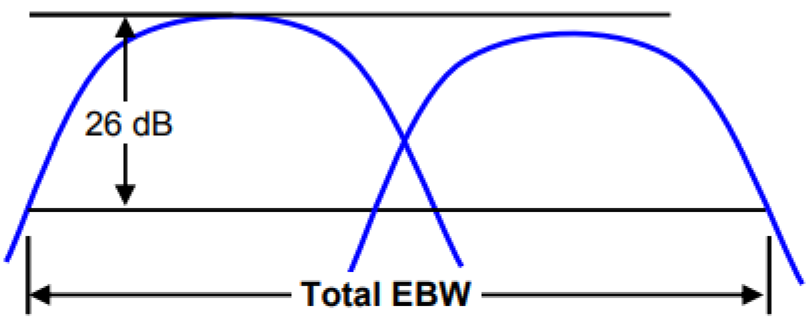


Figure 3. Overlapping emissions bandwidths (KDB 789033 D02 v02r01, p 18)

For those transmissions where the 26 dB bandwidths do not overlap, the emission bandwidth is the sum of the individual 26 dB bandwidths, and each segment is measured independently.

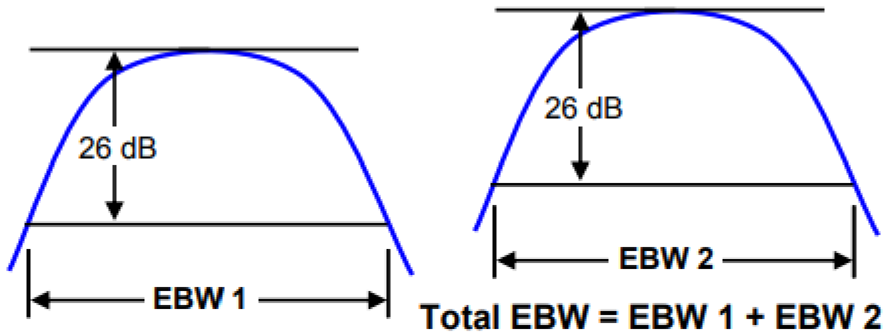


Figure 4. Non-overlapping emissions bandwidths (KDB 789033 D02 v02r01, p 18)

Finally, for those transmissions which cross into other UNII bands, the band boundary serves as one edge for that band, while the other edge is measured from the peak of the contiguous segment.

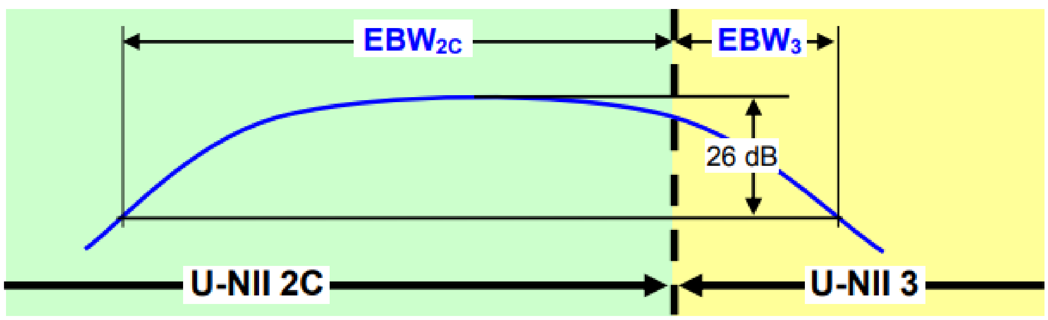


Figure 5. Non-overlapping emissions bandwidths (KDB 789033 D02 v02r01, p 19)

3.2.4.3 Additional Requirements for UNII Devices

UNII devices are subject to requirements imposed by the National Environmental Policy Act. Manufacturers are responsible for applying RF radiation exposure requirements specified in 47 CFR 1.1307(b), 2.1091, and 2.1093 as appropriate (47 CFR 15.407(f)). Such requirements include (but are not limited to) routine environmental evaluation for RF exposure prior to equipment authorization or use (47 CFR 1.1307(b)(2)(i)) and additional evaluation of RF radiation exposure for mobile and portable devices (47 CFR 2.1091 and 2.1093, respectively).

3.3 Test Procedure

VPI Laboratories, Inc. is accredited by National Voluntary Laboratory Accreditation Program (NVLAP); NVLAP Lab Code: 100272-0, which is effective until September 30, 2021. VPI Laboratories, Inc. carries FCC Accreditation Designation Number US5263. VPI Laboratories main office is located at 313 W 12800 S, Suite 311, Draper, UT 84020. The testing was performed according to the procedures in ANSI C63.10-2013, KDB 789033, and 47 CFR Part 15. Radiated testing was performed at the VPI Laboratories, Inc. Wanship Upper Open Area Test Site, located at 29145 Old Lincoln Highway, Wanship, UT. This location is listed on NVLAP scope under the lines for C63.4 and C63.10. Conducted testing was performed at VPI Laboratories main office.

4 Operation of EUT During Testing

4.1 Operating Environment

Power Supply	120 VAC/60 Hz

4.2 Operating Modes

The transmitter was tested while in a constant transmit mode at the upper, middle, and lower channels. The AC mains voltage to the AC adapter was varied as required by §15.31(e) with no change seen in the voltage supplied to the transmitter or in transmitter characteristics. The BLE transceiver was also set for continuous transmission at the maximum power setting for the specific mode.

4.3 EUT Exercise Software

CA Engineering firmware was used to exercise and control the transmitter for testing.

5 Summary of Test Results

5.1 FCC Part 15, Subpart E

Section	Environmental Phenomena	Frequency Range (MHz)	Result
15.205 (15.407(b)(9))	Spurious Emissions in Restricted Bands	0.009 - 40000	Complied
15.207 (15.407(b)(8))	Conducted Disturbance at Mains Ports	0.15 to 30	Complied
15.209 (15.407(b)(6))	General Field Strength Limits	0.009 - 40000	Complied
15.403	Emissions Bandwidth	5725 - 5850	Complied
15.407(e)	Minimum 6 dB Emission Bandwidth	5725 – 5850	Complied
15.407(a)(3)	Maximum Conducted Output Power	5725 - 5850	Complied
15.407(a)(1)(i)	EIRP above 30 Degrees	5150 – 5250	Note 2
15.407(a)(3)	Maximum Power Spectral Density	5725 - 5850	Complied
15.407(b)(4)	Unwanted Emissions	0.009 - 40000	Complied
Note 1: UNII-1 capable EUT does not operate outdoors and therefore requirement is not applicable.			

5.2 Result

In the configuration tested, the EUT complied with the requirements of the specification.

6 Measurements, Examinations and Derived Results

6.1 General Comments

This section contains the test results only. Details of the test methods used and a list of the test equipment used during the measurements can be found in Section 7 of this report.

6.2 Test Result

6.2.1 §15.203 Antenna Requirements

The EUT uses a trace on the PCB for an antenna. Maximum gain of the antenna is 3.5 dBi. The antenna is not user replaceable.

Result

In the configurations tested the EUT complied with the requirements of the specification.

6.2.2 §15.207 Conducted Emissions at AC Mains Ports

Frequency (MHz)	AC Mains Lead	Detector	Measured Level (dBμV)	Limit (dBμV)	Margin (dB)
1.03	Hot Lead	Peak (Note 1)	41.9	46.0	-4.1
3.46	Hot Lead	Quasi-Peak (Note 1)	39.4	46.0	-6.6
4.01	Hot Lead	Quasi-Peak (Note 1)	41.6	46.0	-4.4
4.24	Hot Lead	Quasi-Peak (Note 2)	44.3	56.0	-11.7
4.24	Hot Lead	Average (Note 2)	34.4	46.0	-11.6
4.49	Hot Lead	Quasi-Peak (Note 2)	45.4	56.0	-10.6
4.49	Hot Lead	Average (Note 2)	34.4	46.0	-11.6
4.69	Hot Lead	Quasi-Peak (Note 1)	41.6	46.0	-4.4
4.05	Neutral Lead	Quasi-Peak (Note 1)	37.6	46.0	-8.4
4.25	Neutral Lead	Quasi-Peak (Note 1)	39.9	46.0	-6.1
4.58	Neutral Lead	Quasi-Peak (Note 1)	39.3	46.0	-6.7
4.74	Neutral Lead	Peak (Note 1)	42.4	46.0	-3.6
9.50	Neutral Lead	Peak (Note 1)	41.7	50.0	-8.3
11.25	Neutral Lead	Peak (Note 1)	42.4	50.0	-7.6

Note 1: The reference detector used for the measurements was Quasi-Peak or Peak and the data was compared to the average limit; therefore, the EUT was deemed to meet both the average and quasi-peak limits.
Note 2: The reference detector used for the measurements was quasi-peak and average and the data was compared to the respective limits.

Result

The EUT complied with the specification limit by a margin of 3.6 dB.

6.2.3 Duty Cycle, Transmission Duration, and Maximum Power Control

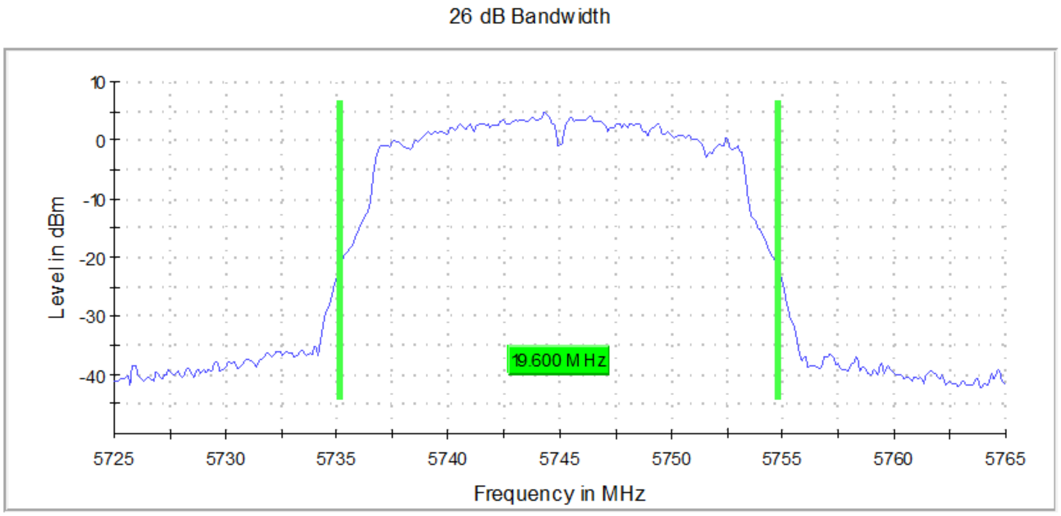
Where EUT was incapable of 100% duty cycle at maximum power control, correction factors are required. Duty cycle (DC) and transmission duration ("T") was tested for these modes of operation. and the Correction Factor ("CF") is determined by the equation $CF = 10 \times \log \frac{1}{DC}$, wherein DC is a decimal value between 0 and 1.

.Mode / Datarate	Duty Cycle	Correction Factor
N-Mode / DR: 4	11.2%	+9.5 dB

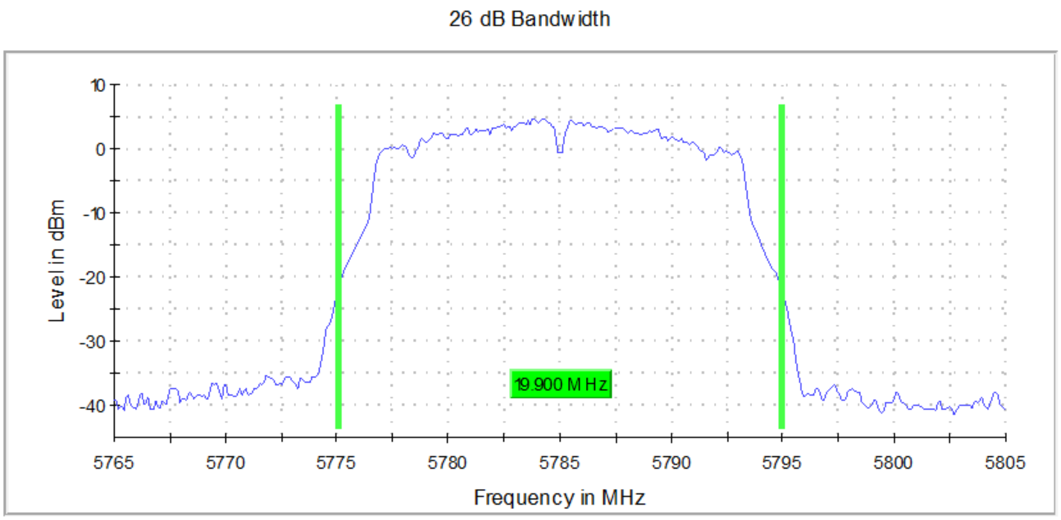
6.2.4 26 dB Emission Bandwidth

Frequency (MHz)	Emissions 26 dB bandwidth (MHz)
5745	19.6
5785	19.9
5825	19.9

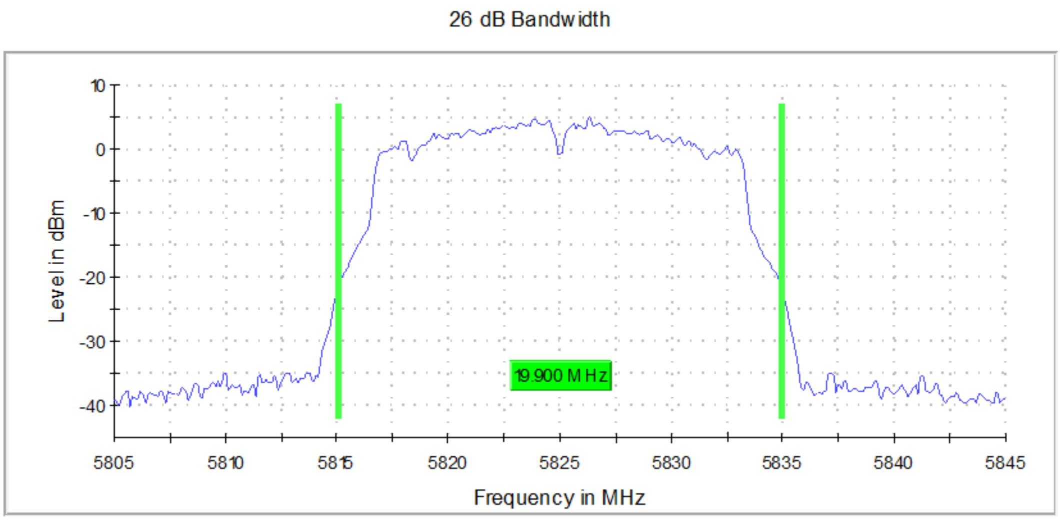
Table 2: 26 dB Emission Bandwidth



Graph 1: 26 dB Emissions Bandwidth Transmitting at 5745 MHz



Graph 2: 26 dB Emissions Bandwidth Transmitting at 5785 MHz

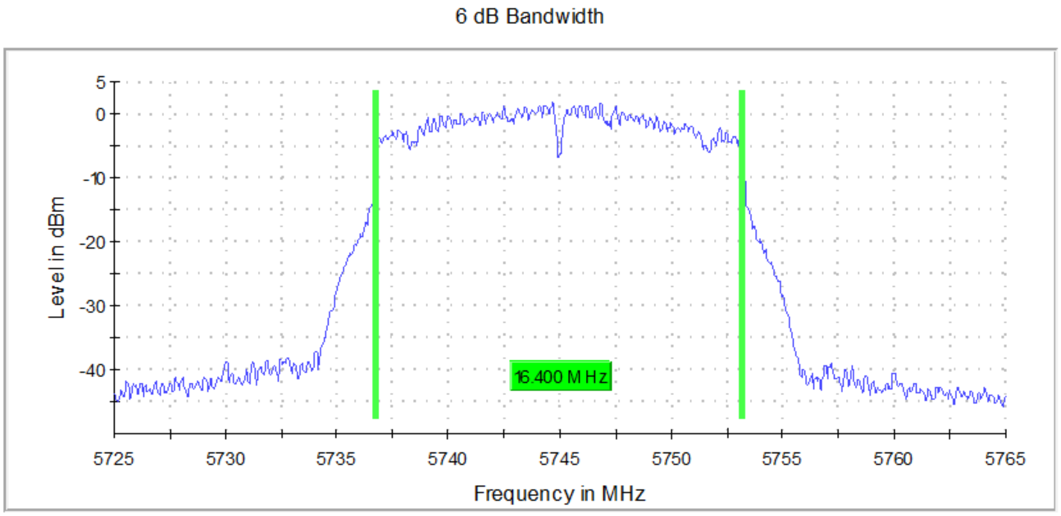


Graph 3: 26 dB Emissions Bandwidth Transmitting at 5825 MHz

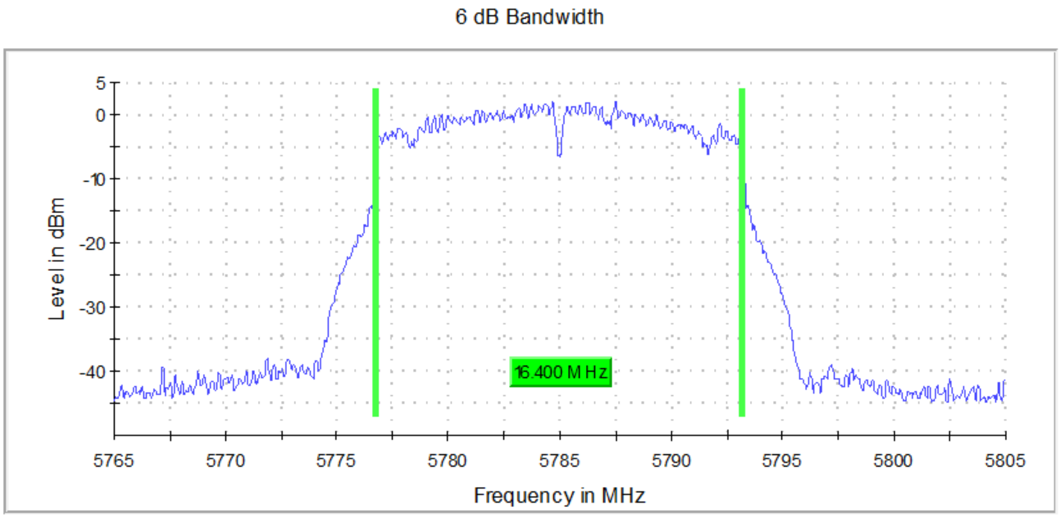
6.2.5 6 dB Emission Bandwidth

Frequency (MHz)	Emissions 6 dB bandwidth (MHz)
5745	16.4
5785	16.4
5825	16.4

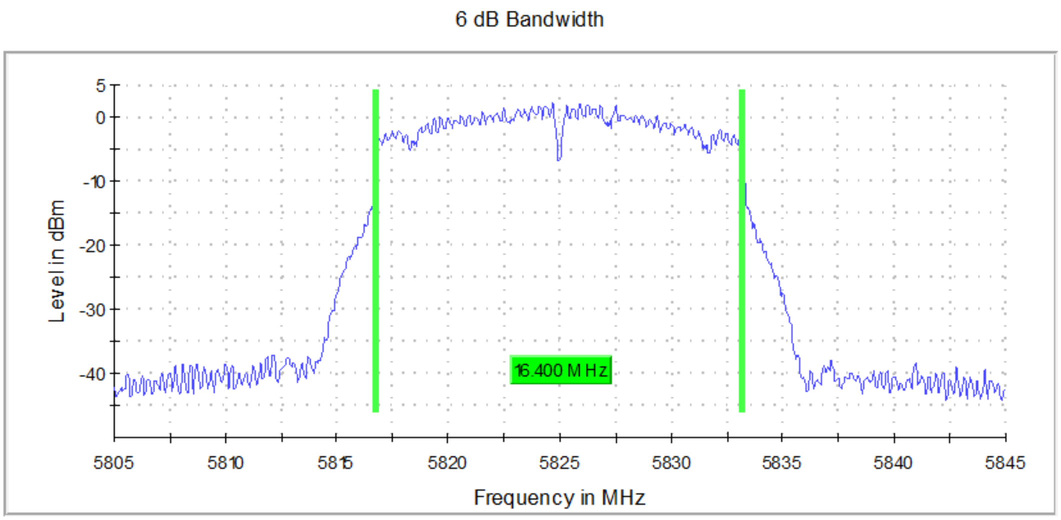
Table 3: 6 dB Emission Bandwidth



Graph 4: 6 dB Emissions Bandwidth Transmitting at 5745 MHz



Graph 5: 6 dB Emissions Bandwidth Transmitting at 5785 MHz



Graph 6: 6 dB Emissions Bandwidth Transmitting at 5825 MHz

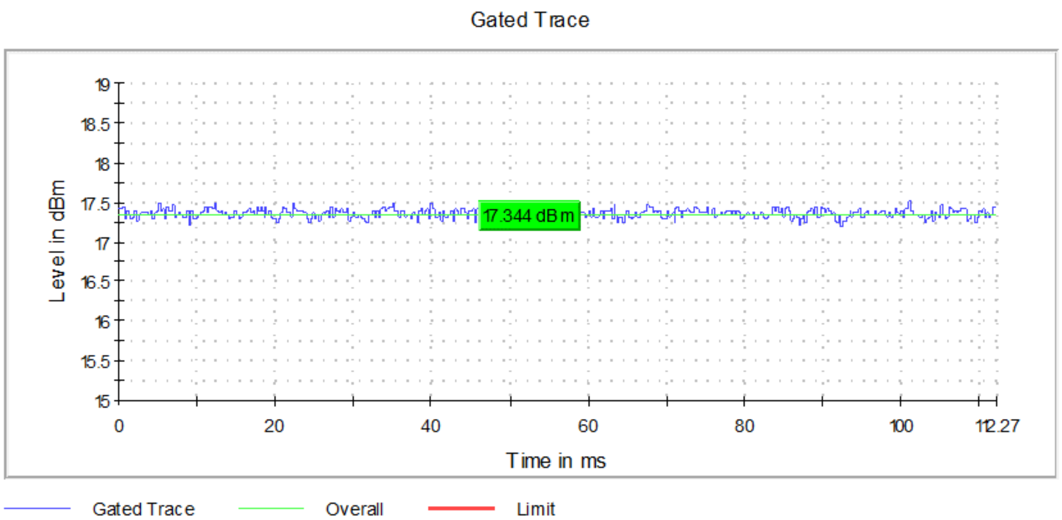
6.2.6 §15.407(a) Power Limits: Maximum Conducted Output Power

Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Margin (dB)
5745	17.3	30.0	-12.7
5785	17.4	30.0	-12.6
5825	17.2	30.0	-12.8

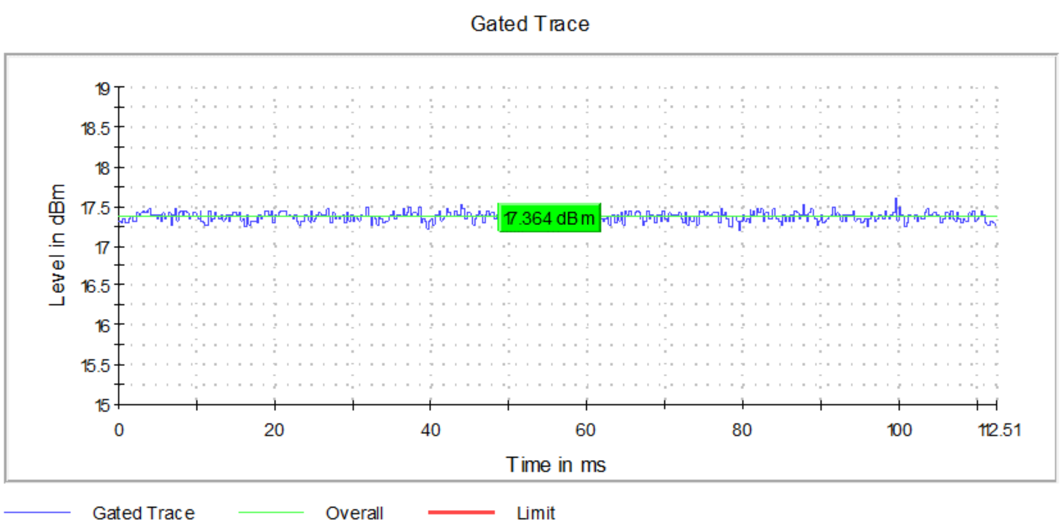
Table 4: Maximum Conducted Output Power (Method PM-G)

Result:

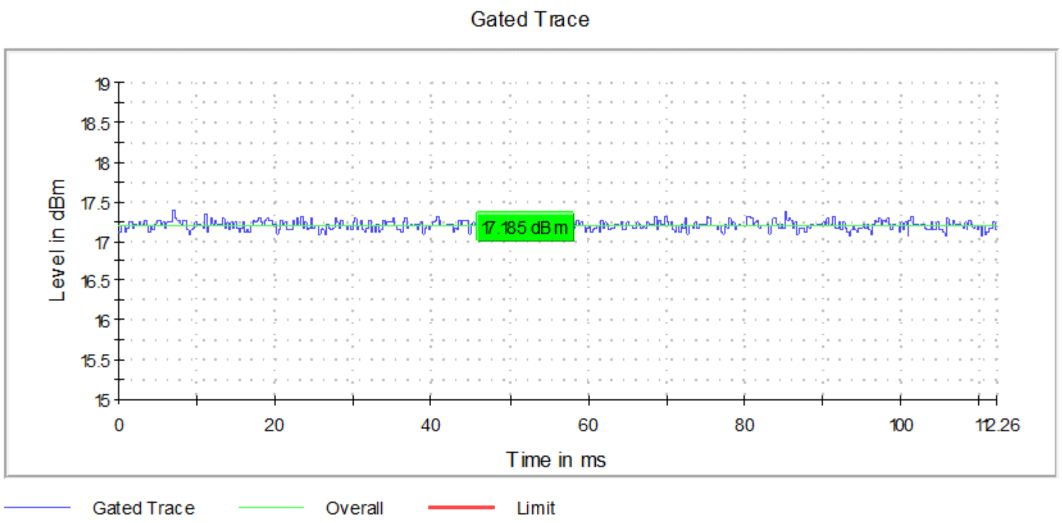
In the configurations tested the EUT complied with a margin of 12.6 dB.



Graph 7: Conducted Power Transmitting at 5745 MHz



Graph 8: Conducted Power Transmitting at 5785 MHz



Graph 9: Conducted Power Transmitting at 5825 MHz

6.2.7 §15.407(a) Power Limits: Maximum Power Spectral Density

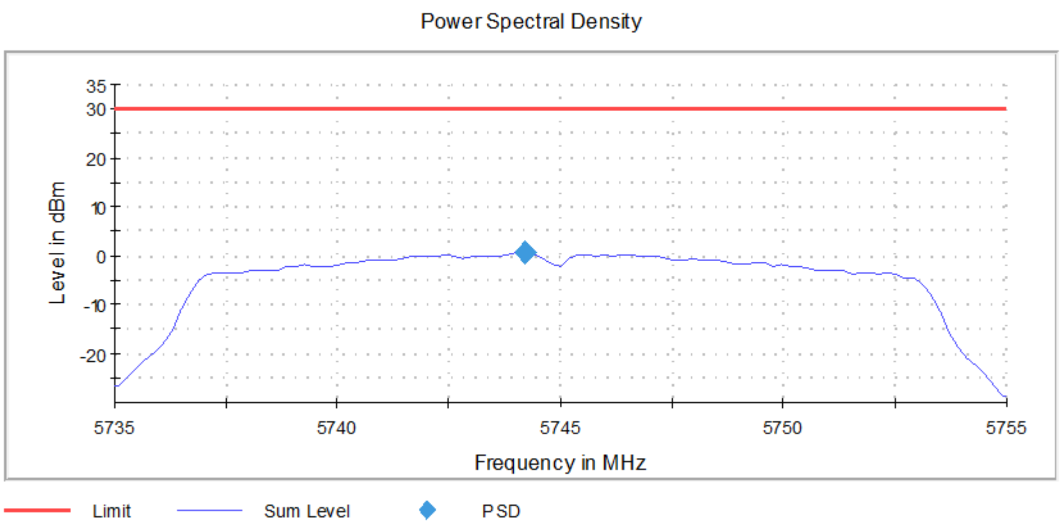
The following tables show the power spectral density per 500 kHz.

Frequency (MHz)	500 kHz PSD (dBm/500kHz)	Limit (dBm/500kHz)	Margin (dB)
5745	0.7	30.0	-29.3
5785	1.3	30.0	-28.7
5825	0.8	30.0	-29.2

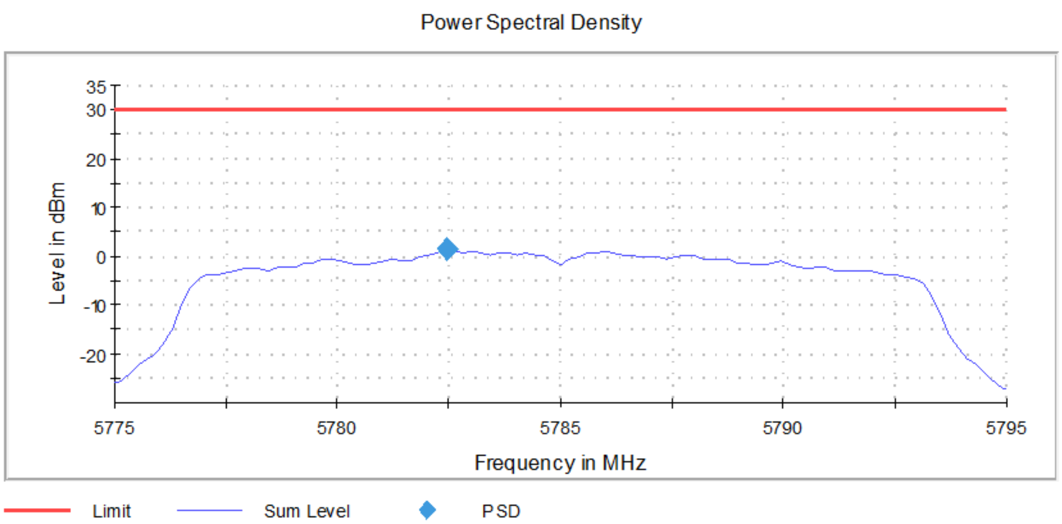
Table 5: Maximum Power Spectral Density

Result:

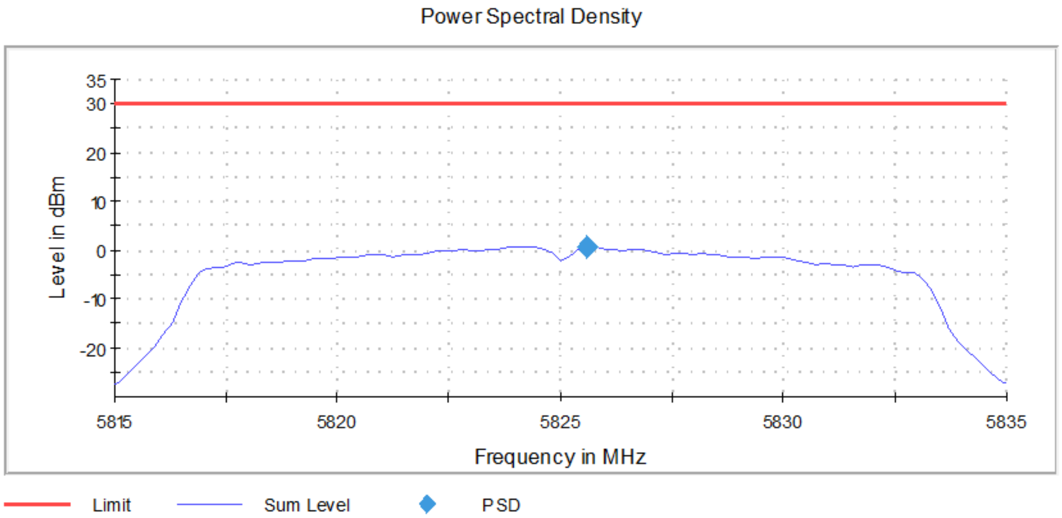
In the configurations tested, EUT complied with the requirements with a margin of 28.7 dB.



Graph 10: Power Spectral Density Transmitting at 5745 MHz



Graph 11: Power Spectral Density Transmitting at 5785 MHz



Graph 12: Power Spectral Density Transmitting at 55825 MHz

6.2.8 §15.247(b) Undesirable Emissions – Restricted Bands

The frequency range from the lowest frequency generated or used in the device to the tenth harmonic of the highest fundamental emission was investigated to measure any radiated emissions in the restricted bands. The following tables show measurements of any emission that fell into the restricted bands of §15.205. The tables show the worst-case emission measured from the EUT. For frequencies above 18.0 GHz, a measurement distance of 1 meter was used. The noise floor was a minimum of 6 dB below the limit. The emissions in the restricted bands must meet the limits specified in §15.209. The spurious emissions were tested at the highest power setting used by any channel in the band (setting of 20). The band edges at the restricted bands were measured using the power settings that will be used in manufacturing. Tabular data and plots are shown below.

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
11490.0	Peak	Vertical	6.1	47.3	53.4	74.0	-20.6
11490.0	Average	Vertical	-5.5	47.3	41.8	54.0	-12.2
11490.0	Peak	Horizontal	5.8	47.3	53.1	74.0	-20.9
11490.0	Average	Horizontal	-3.5	47.3	43.8	54.0	-10.2

Table 6: Transmitting at the Lowest Frequency (Channel 149)

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
11570.0	Peak	Vertical	5.8	47.4	53.2	74.0	-20.8
11570.0	Average	Vertical	-5.8	47.4	41.6	54.0	-12.4
11570.0	Peak	Horizontal	5.3	47.4	52.7	74.0	-21.3
11570.0	Average	Horizontal	-5.5	47.4	41.9	54.0	-12.1

Table 7: Transmitting at the Middle Frequency (Channel 157)

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
11650.0	Peak	Vertical	5.2	47.5	52.7	74.0	-21.3
11650.0	Average	Vertical	-5.9	47.5	41.6	54.0	-12.4
11650.0	Peak	Horizontal	4.6	47.5	52.1	74.0	-21.9
11650.0	Average	Horizontal	-6.7	47.5	40.8	54.0	-13.2

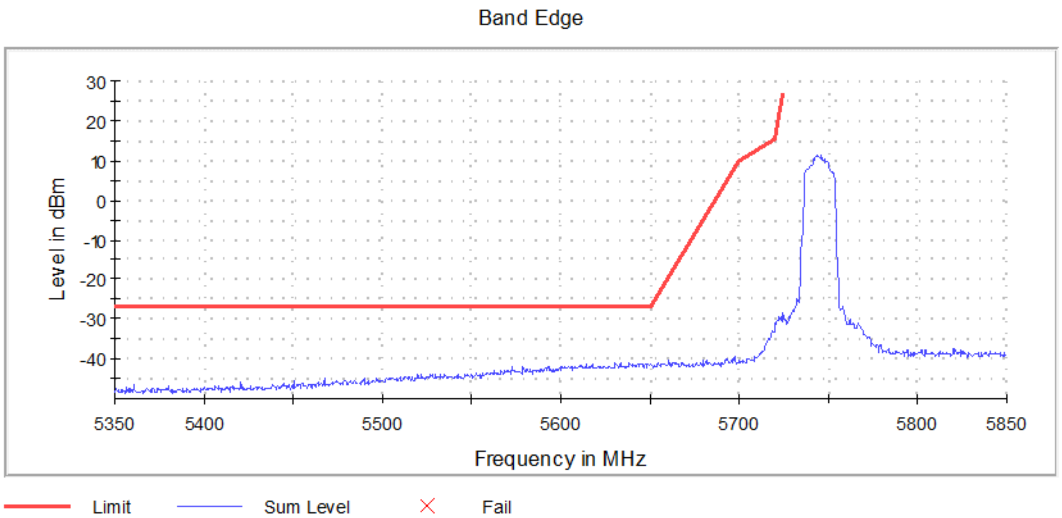
Table 8: Transmitting at the Highest Frequency (Channel 165)

Result

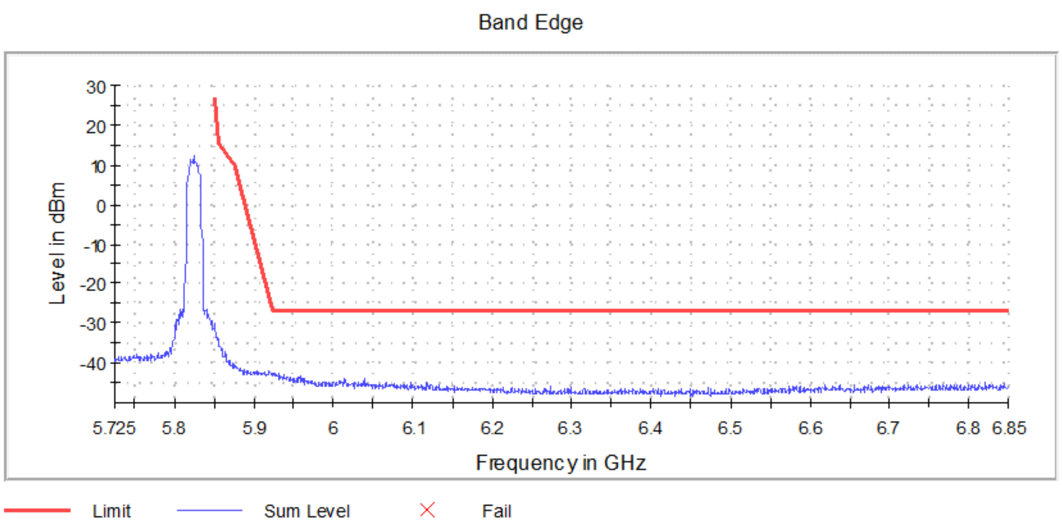
The EUT complied with the specification limit as all emissions met the limits of 15.209.

6.2.9 §15.407(b) Undesirable Emissions – Out-of-Band and Spurious Domains

Out-Of-Band Domain Measurements

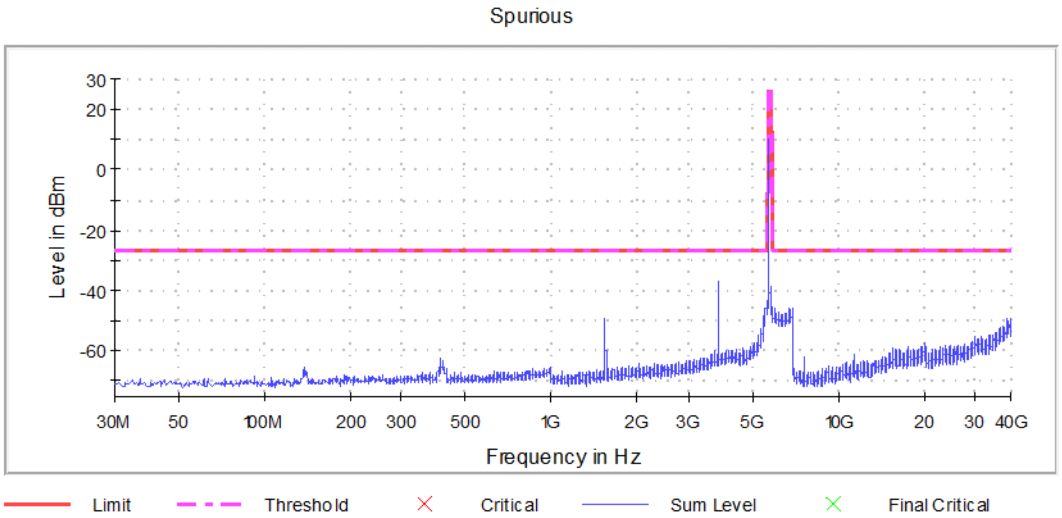


Graph 13: Lower Band Edge Channel 149 Transmitting (5745 MHz)

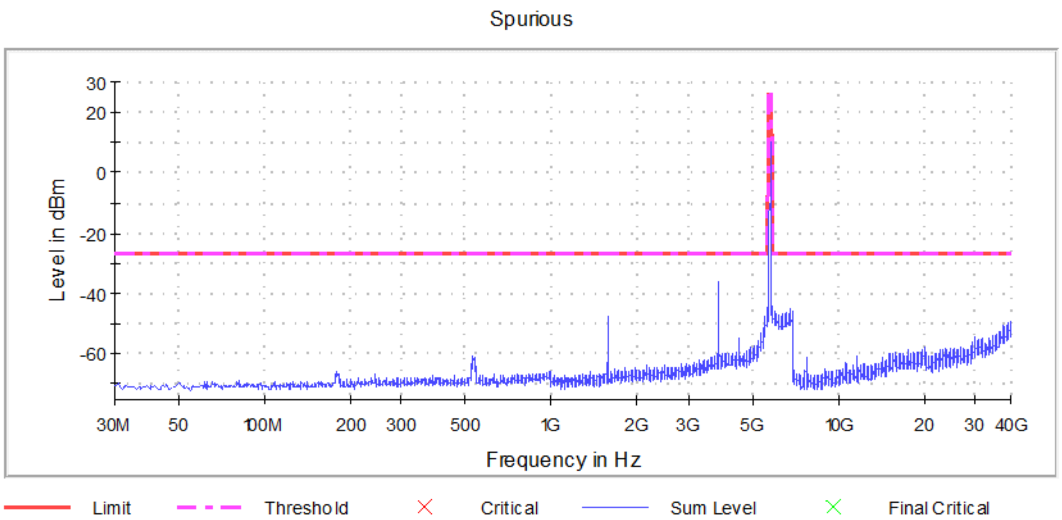


Graph 14: Upper Band Edge Channel 165 Transmitting (5825 MHz)

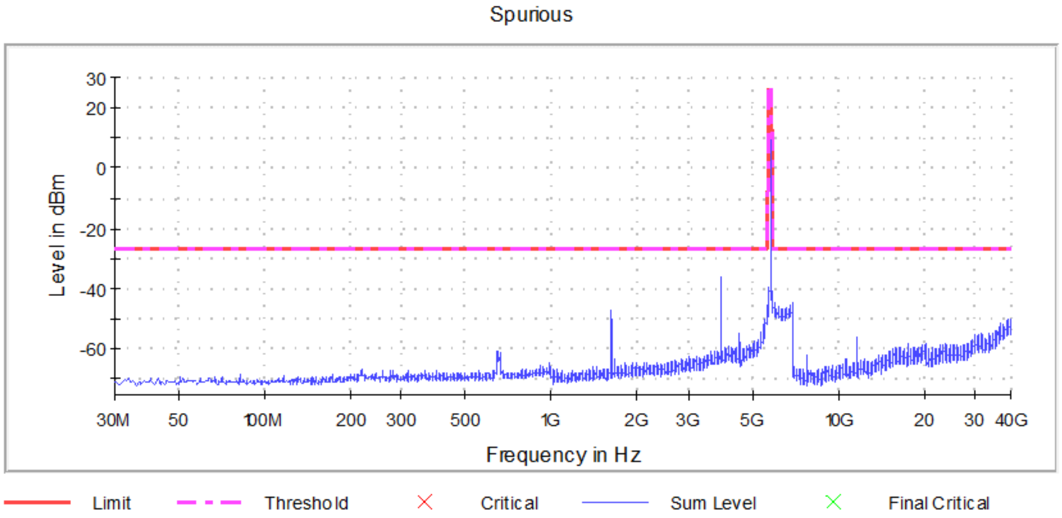
Spurious Domain Measurements



Graph 15: Spurious Emissions Channel 149 Transmitting (5745 MHz)



Graph 16: Spurious Emissions Channel 157 Transmitting (5785 MHz)



Graph 17: Spurious Emissions Channel 165 Transmitting (5825 MHz)

Result

The EUT complied with all undesirable emission requirements of 15.407(b).

7 Procedures and Test Equipment

7.1 Conducted Emissions at Mains Ports

The conducted emissions at mains and telecommunications ports from the EUT were measured using a spectrum analyzer with a quasi-peak adapter for peak, quasi-peak and average readings. The quasi-peak adapter uses a bandwidth of 9 kHz, with the spectrum analyzer's resolution bandwidth set at 100 kHz, for readings in the 150 kHz to 30 MHz frequency ranges.

The conducted emissions at mains ports measurements are performed in a screen room using a (50 Ω/50 μH) Line Impedance Stabilization Network (LISN).

Where mains flexible power cords are longer than 1 m, the excess cable is folded back and forth as far as possible so as to form a bundle not exceeding 0.4 m in length.

Where the EUT is a collection of devices with each device having its own power cord, the point of connection for the LISN is determined from the following rules:

- Each power cord, which is terminated in a mains supply plug, shall be tested separately.
- Power cords, which are not specified by the manufacturer to be connected via a host unit, shall be tested separately.
- Power cords which are specified by the manufacturer to be connected via a host unit or other power supplying equipment shall be connected to that host unit and the power cords of that host unit connected to the LISN and tested.
- Where a special connection is specified, the necessary hardware to effect the connection is supplied by the manufacturer for the testing purpose.
- When testing equipment with multiple mains cords, those cords not under test are connected to an artificial mains network (AMN) different than the AMN used for the mains cord under test.

For testing, desktop EUT are placed on a non-conducting table at least 0.8 meters from the metallic floor and placed 40 cm from the vertical coupling plane (copper plating in the wall behind EUT table). Floor standing equipment is placed directly on the earth grounded floor.

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
Spectrum Analyzer	Hewlett Packard	8566B	V034141	05/12/2020	05/12/2021
Quasi-Peak Detector	Hewlett Packard	85650A	V033345	05/11/2020	05/11/2022
LISN	Teseq	NNB 51	V045406	08/20/2020	08/20/2021
Conductance Cable Wanship Upper Site	VPI Labs	Cable J	V034832	01/12/2021	01/12/2022
Filter	VPI Labs	47038	V047038	01/12/2021	01/12/2022
Test Software (AC)	VPI Labs	Revision 01	V035674	N/A	N/A

Table 2: List of equipment used for conducted emissions testing at mains ports.

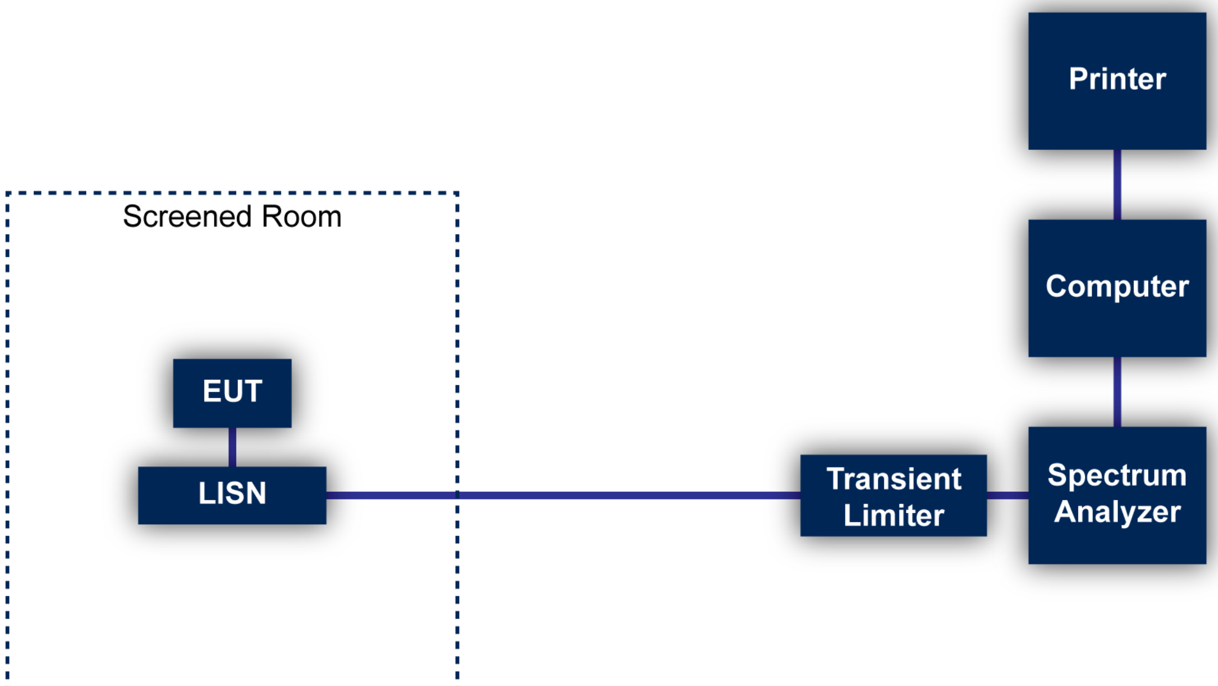


Figure 1: Mains Conducted Emissions Test

7.2 Direct Connection at the Antenna Port Test

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
Spectrum Analyzer	Rohde & Schwarz	FSU40	V044352	03/13/2020	03/13/2021
Signal Generator	Rohde & Schwarz	SMB100A	V044485	03/16/2020	03/16/2021
Vector Signal Generator	Rohde & Schwarz	SMBV100A	V044217	04/01/2019	04/01/2021
40GHz Switch Extension	Rohde & Schwarz	OSP-150	V044486	03/24/2020	03/24/2022
40GHz Switch Base Unite	Rohde & Schwarz	OSP-120	V044487	04/30/2020	04/30/2022

Table 3: List of equipment used for conducted emissions testing at antenna ports.

7.2.1 Test Configuration Block Diagram

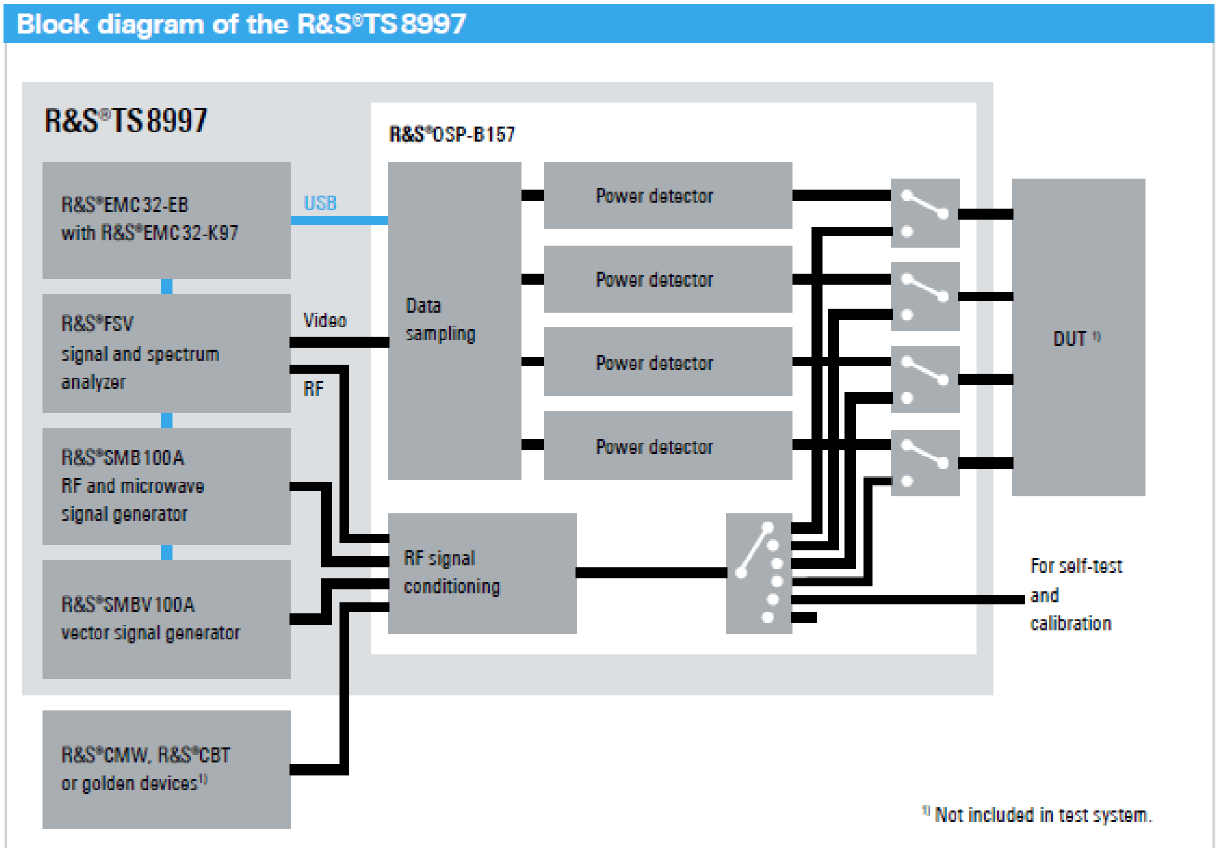


Figure 2: Direct Connection at the Antenna Port Test

7.3 Radiated Emissions

The radiated emissions from the EUT were measured using a spectrum analyzer with a quasi-peak adapter for peak and quasi-peak readings.

A preamplifier with a fixed gain of 51 dB was used to increase the sensitivity of the measuring instrumentation. The quasi-peak adapter uses a bandwidth of 120 kHz, with the spectrum analyzer's resolution bandwidth set at 1 MHz, for readings in the 30 to 1000 MHz frequency ranges. For frequencies below 30 MHz, a 9 kHz resolution Bandwidth was used.

A loop antenna was used to measure frequencies below 30 MHz. A biconilog antenna was used to measure the frequency range of 30 to 1000 MHz, at a distance of 3 meters from the EUT. The readings obtained by these antennas are correlated to the levels obtained with a tuned dipole antenna by adding antenna factors. A double-ridged guide antenna was used to measure the emissions at frequencies above 1000 MHz at a 3 meter or 1 meter distance from the EUT.

The configuration of the EUT was varied to find the maximum radiated emission. The EUT was connected to the peripherals listed in Section 2.3 via the interconnecting cables listed in Section 2.4. A technician manually manipulated these interconnecting cables to obtain worst-case radiated emissions. The EUT was rotated 360 degrees, and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission. Where there were multiple interface ports all of the same type, cables are either placed on all of the ports or cables added to these ports until the emissions do not increase by more than 2 dB.

Desktop EUT are measured on a non-conducting table 0.8 meters above the ground plane. For frequencies above 1000 MHz, the EUT is placed on a table 1.5 meters above the ground plane. The table is placed on a turntable, which is level with the ground plane. For equipment normally placed on floors, the equipment shall be placed directly on the turntable.

For radiated emissions testing that is performed at distances closer than the specified distance; an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
Spectrum Analyzer/Receiver	Rohde & Schwarz	ESU40	V033119	08/05/2020	08/05/2021
Spectrum Analyzer	Hewlett Packard	8566B	V034141	05/12/2020	05/12/2021
Quasi-Peak Detector	Hewlett Packard	85650A	V033345	05/11/2020	05/11/2022
Loop Antenna	EMCO	6502	V034216	02/03/2021	02/03/2023
Biconilog Antenna	EMCO	3142E-PA	V035736	06/24/2020	06/24/2022
Double Ridged Guide Antenna	EMCO	3115	V034194	03/09/2019	03/09/2021
Standard Gain Horn	ETS-Lindgren	3160-09	V034223	ICO	ICO
Standard Gain Horn	ETS-Lindgren	3160-10	V034224	ICO	ICO
High Frequency Amplifier	Miteq	AFS4-001018000-35-10P-4	V033997	01/12/2021	01/12/2022
High Frequency Amplifier	L3-Narda-Miteq	AMF-6F-18004000-37-8P	V042464	01/12/2021	01/12/2022
5.8 GHz High Pass Filter	Micro-Tronics	HPM50105	V034198	01/12/2021	01/12/2022
6’ High Frequency Cable	Microcoax	UFB197C-0-0720-000000	V033638	01/12/2021	01/12/2022
20’ High Frequency Cable	Microcoax	UFB197C-1-3120-000000	V033979	01/12/2021	01/12/2022
3 Meter Radiated Emissions Cable Wanship Upper Site	Microcoax	UFB205A-0-4700-000000	V033639	01/12/2021	01/12/2022
Test Software (FCC)	VPI Labs	Revision 01	V035673	N/A	N/A

Table 4: List of equipment used for radiated emissions testing.

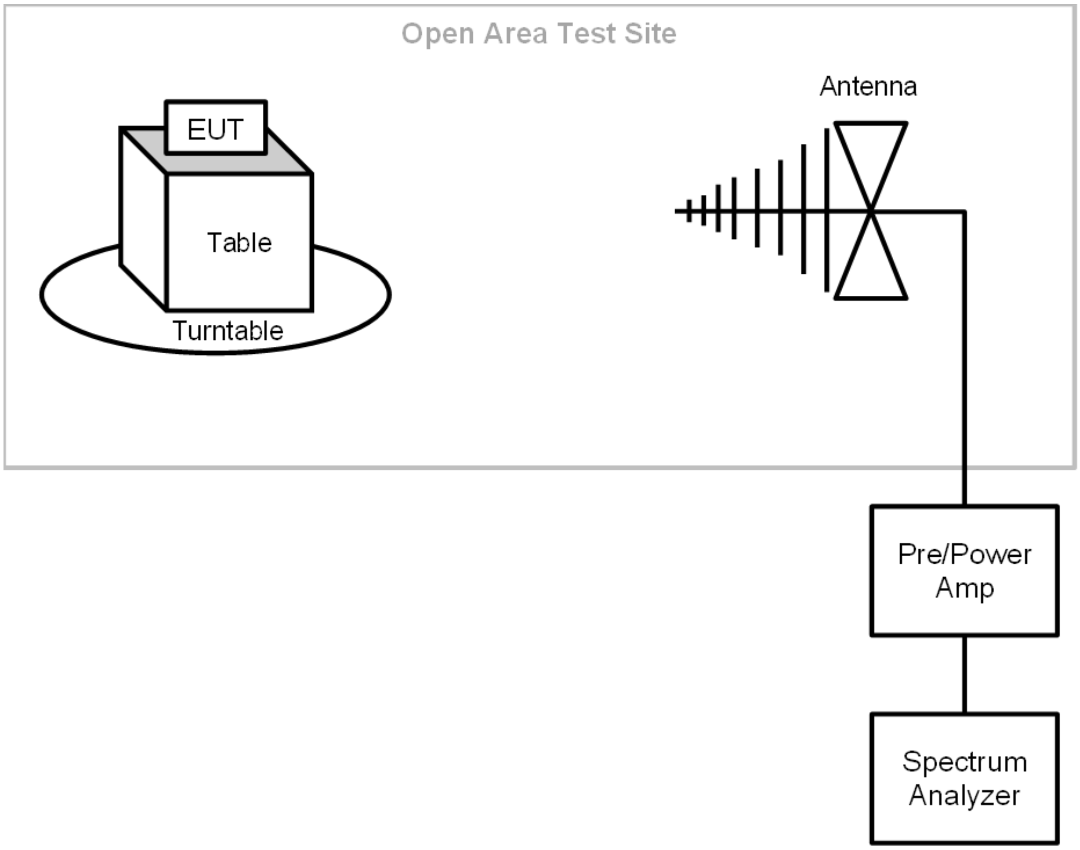


Figure 3: Radiated Emissions Below 1GHz Test

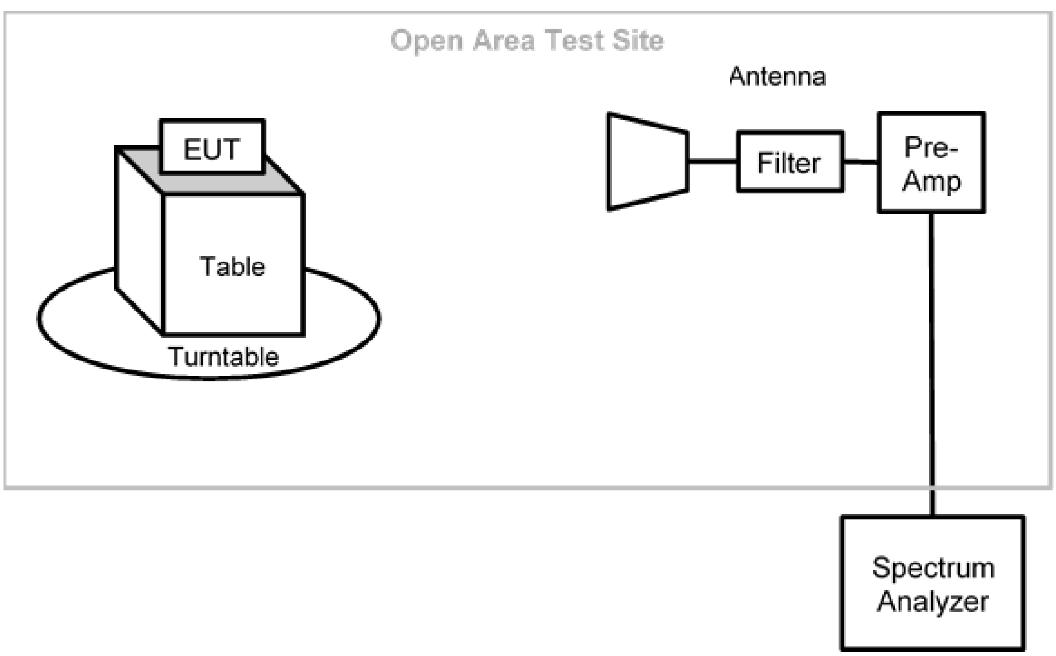


Figure 4: Radiated Emissions Above 1GHz Test

7.4 Equipment Calibration

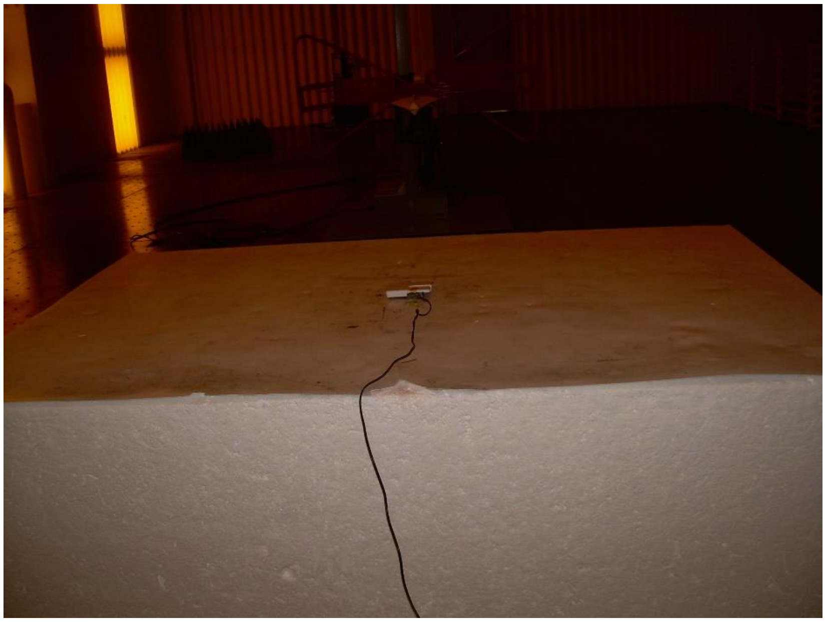
All applicable equipment is calibrated using either an independent calibration laboratory or VPI Laboratories, Inc. personnel at intervals defined in ANSI C63.4:2014 following outlined calibration procedures. All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to tractability is on file and is available for examination upon request.

7.5 Measurement Uncertainty

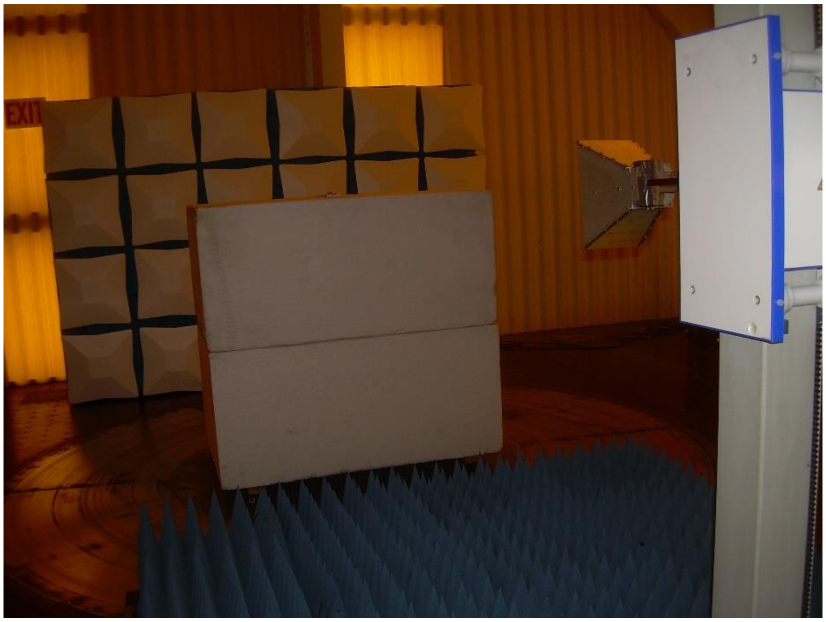
Test	Uncertainty (±dB)	Confidence (%)
Conducted Emissions	2.8	95
Radiated Emission (9 kHz to 30 MHz)	3.3	95
Radiated Emissions (30 MHz to 1 GHz)	3.4	95
Radiated Emissions (1 GHz to 18 GHz)	5.0	95
Radiated Emissions (18 GHz to 40 GHz)	4.1	95

8 Photographs

Photograph 1: Front View Radiated Emissions Worst-Case Configuration – 30 to 1000 Mhz

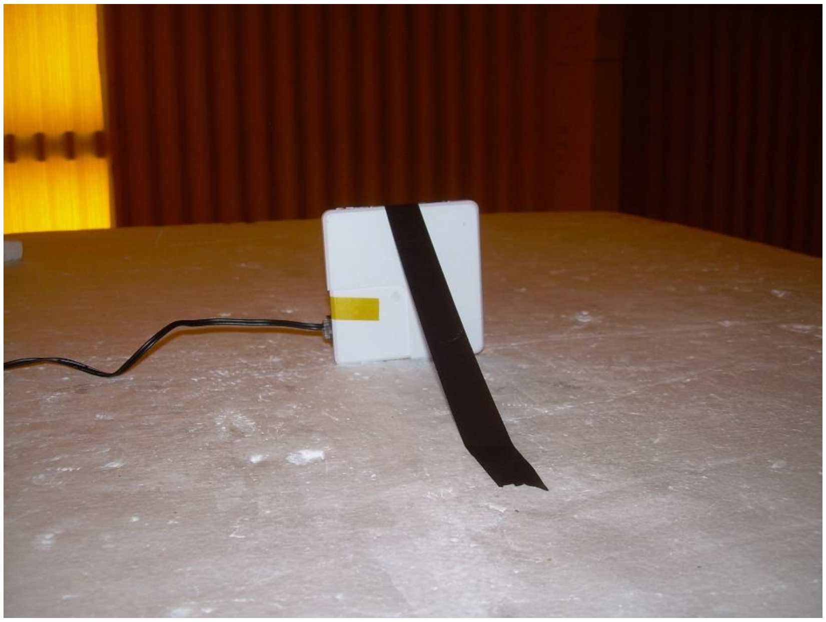


Photograph 2: Back View Radiated Emissions Worst-Case Configuration – 30 to 1000 MHz

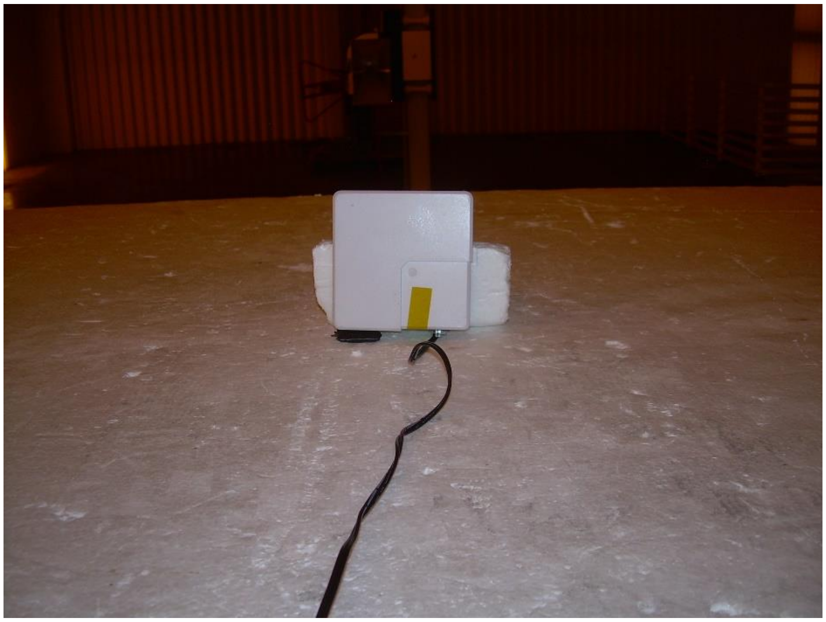


Photograph 3: Front View Radiated Emissions Worst-Case Configuration – Above 1000 MHz

Photograph 4: Flat Configuration



Photograph 5: On Edge Configuration

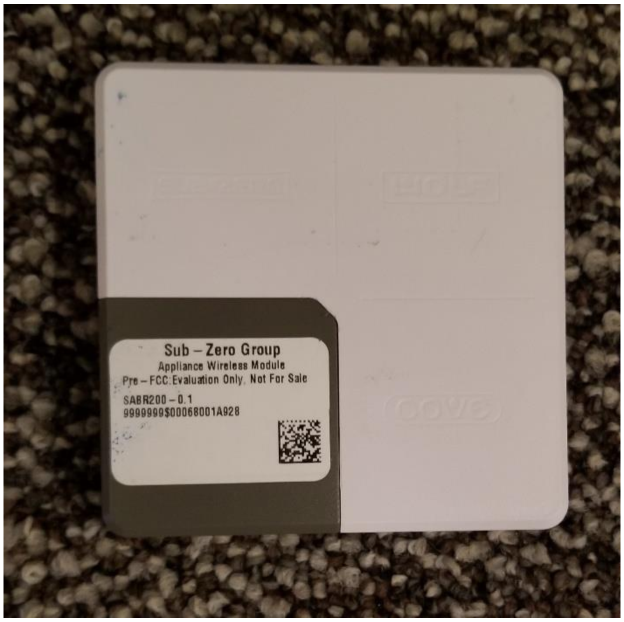


Photograph 6: Vertical Configuration

Photograph 7: Front View Conducted Emissions Worst-Case Configuration

Photograph 8: Back View Conducted Emissions Worst-Case Configuration

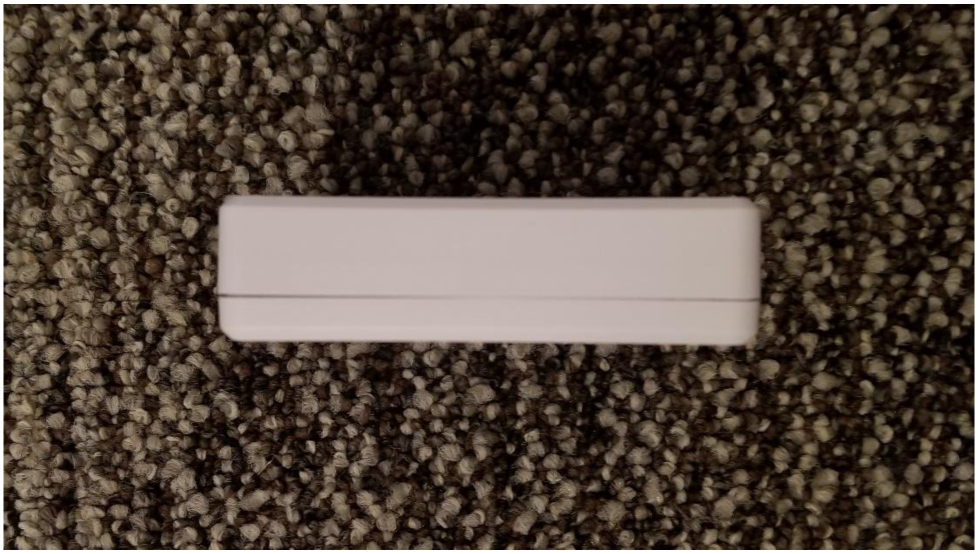
Photograph 9: Top View of the EUT



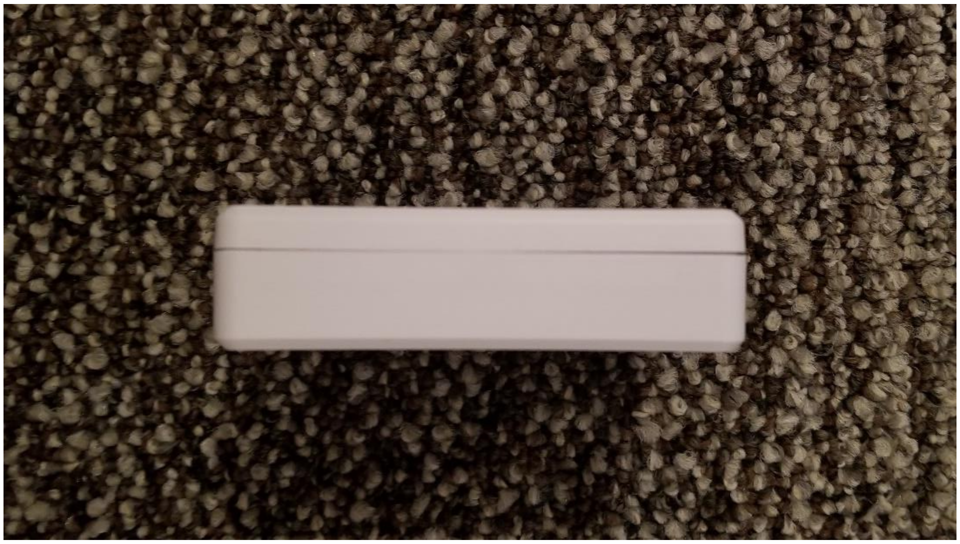
Photograph 10: Bottom View of the EUT

Photograph 11: Back View of the EUT

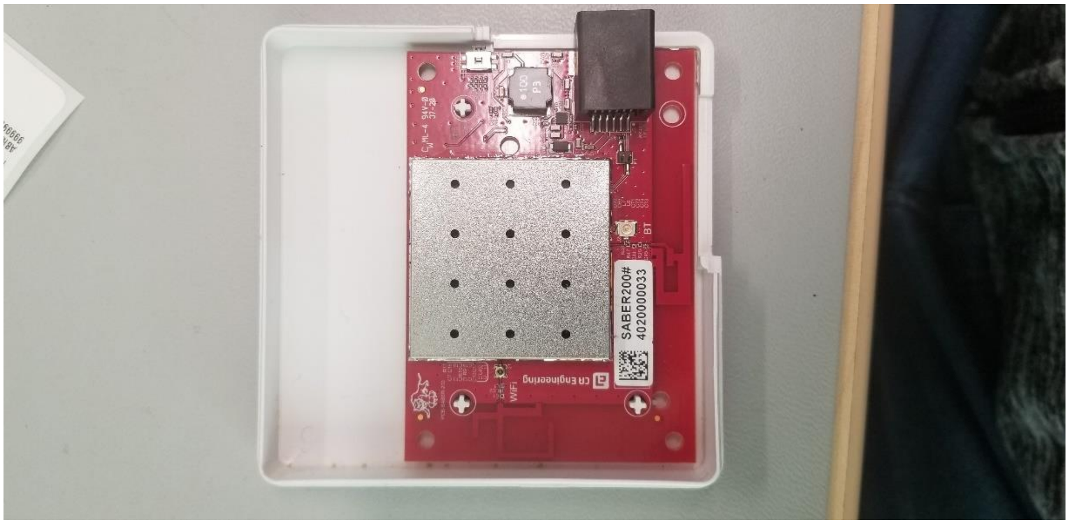
Photograph 12: Front View of the EUT



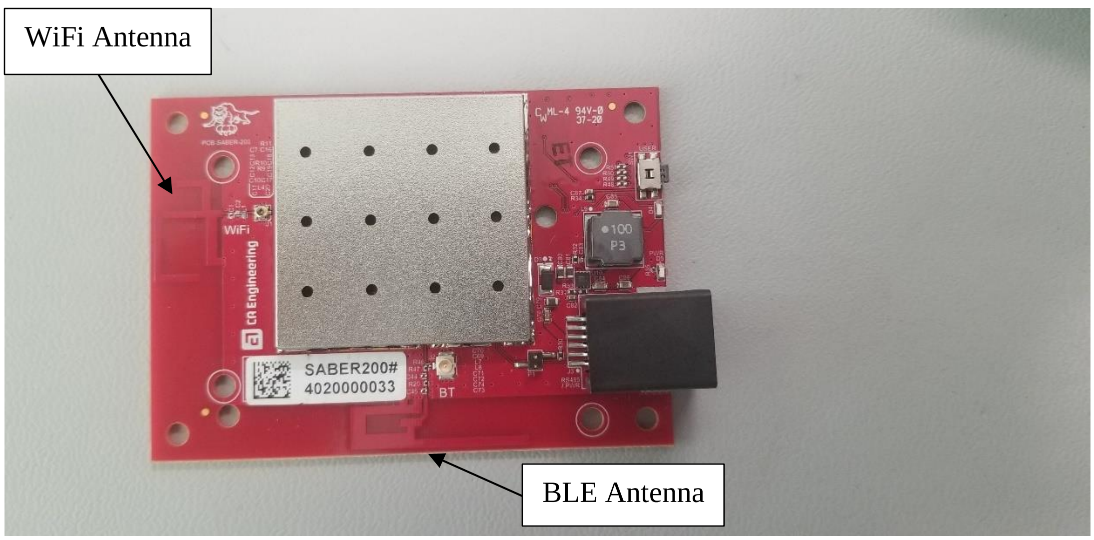
Photograph 13: Side View of the EUT



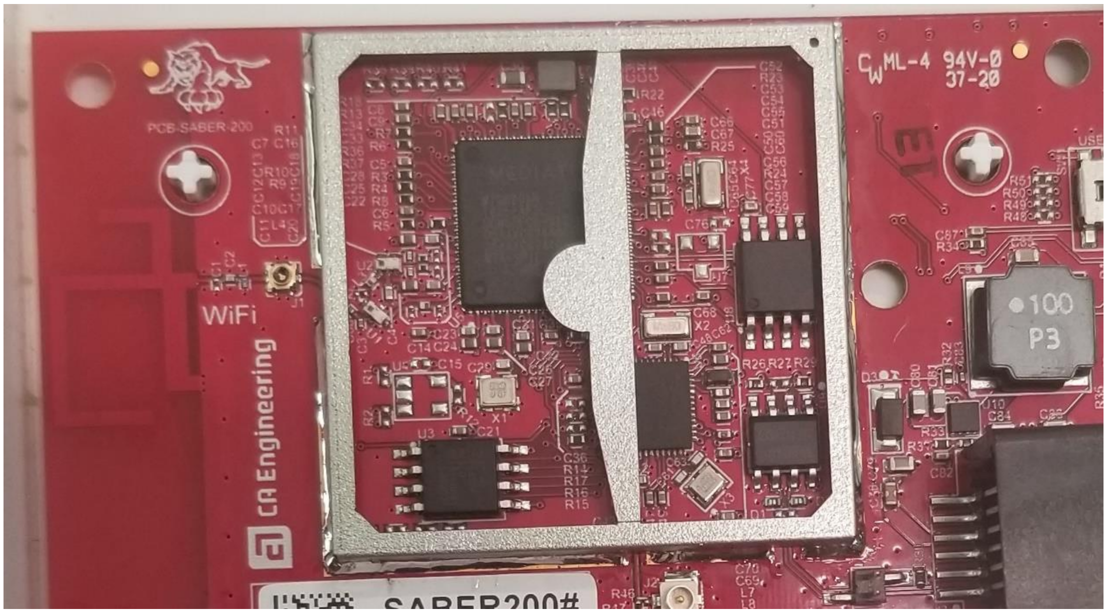
Photograph 14: Side View of the EUT



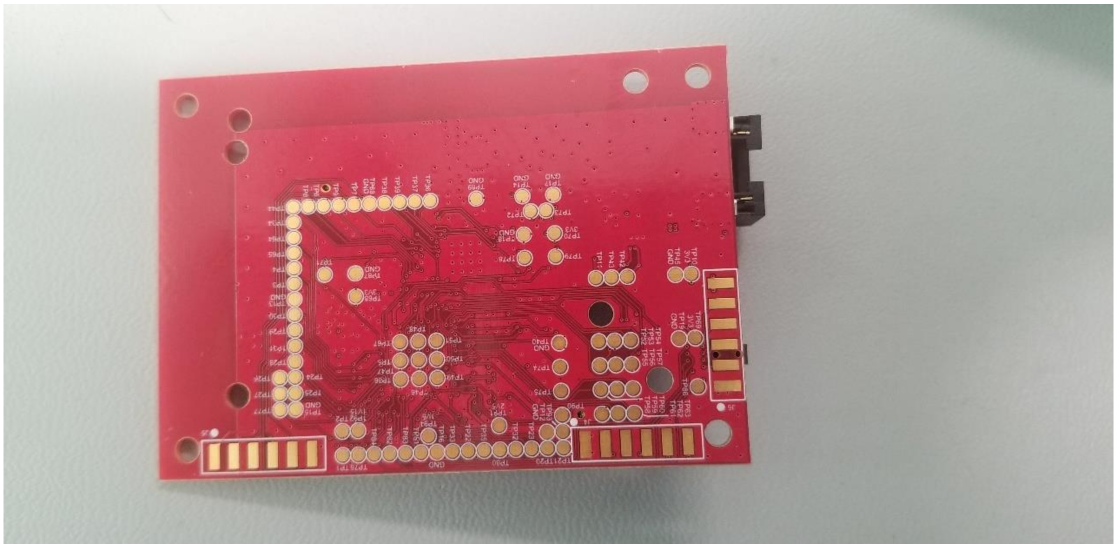
Photograph 15: View with the Housing Opened



Photograph 16: View of the Top Side of the PCB



Photograph 17: View of the Circuitry Under the RF Shield



Photograph 18: Bottom Side of the PCB

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