313 West 12800 South, Suite 311
Draper, UT 84020
(801) 260-4040

Test Report

Certification

FCC ID	2BFEF-GWL1300
Equipment Under Test	WiTricity Brickyard PTU
Test Report Serial No	V072637_03
Dates of Test	February 7-12, 2024
Report Issue Date	March 15, 2024

Test Specifications:	Applicant:
FCC Part 15, Subpart C	WiTricity Corporation 57 Water Street Watertown, MA 02472 U.S.A.

TESTING
NVLAP LAB CODE 100272-0

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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 C. 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	WiTricity
Manufacturer	WiTricity
Brand Name	WiTricity
Model Number	Brickyard PTU
FCC ID	2BFEF-GWL1300

On this 15th day of March 2024, 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.

Tested by: Benjamin N. Antczak

Reviewed by: Jason Stewart

Revision History		
Revision	**Description**	**Date**
01	Original Report Release	March 15, 2024
02	Correcting Photograph 13	March 19, 2024
03	Correcting Applicant Address and Table in Section 5.1.1	March 21, 2024

Table of Contents

1 Client Information

1.1 Applicant

Company Name	WiTricity Corporation 57 Water Street Watertown, MA 02472 U.S.A.
Contact Name	Ky Sealy
Title	Engineering Fellow

1.2 Manufacturer

Company Name	WiTricity Corporation 2340 S. Heritage Dr., Ste. B Nibley, UT 84321 U.S.A.
Contact Name	Ky Sealy
Title	Engineering Fellow

2 Equipment Under Test (EUT)

2.1 Identification of EUT

Brand Name	WiTricity
Model Name	Brickyard (Halo) PTU
Model Number	190-001696-00 REV C 301-001696-01 REC C 00
Serial Number	IMS2959392300022
Dimensions (cm)	30 x 30 x 5

2.2 Description of EUT

The Brickyard (Halo) PTU is a part of the WiTricity Halo wireless battery charging system. Both parts of the system, the PTU (power transmit unit) and PRU (power receive unit) contain transmitter circuitry which operate in the 2.4GHz ISM band. The transmitter uses the BLE channel map and modulation schemes. The PTU uses a Witricity Brickard 190-001705-00 PCB antenna which is connected to the motherboard via coaxial cable. The Brickyard (Halo) also contains circuitry which operates at 85Khz to transfer power and is subject to and evaluated under FCC Part 18. EUT was powered by a Meanwell UHP-1500-115 switching power supply for testing.

BLE Transmitter Channel Plan (Channels Tested in Bold)

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
37	***2402***	9	2422	18	2442	28	2462
0	2404	10	2424	19	2444	29	2464
1	2406	38	2426	20	2446	30	2466
2	2408	11	2428	21	2448	31	2468
3	2410	12	2430	22	2450	32	2470
4	2412	13	2432	23	2452	33	2472
5	2414	14	2434	24	2454	34	2474
6	2416	15	2436	25	2456	35	2476
7	2418	16	2438	26	2458	36	2478
8	2420	***17***	***2440***	27	2460	***39***	***2480***

This report covers the transmitter circuitry of the PTU subject to FCC Part 15, Subpart C. The circuitry of the PRU subject to FCC part 15, Subpart C was found to be compliant and is covered in VPI Laboratories, Inc. report V072638_01. The circuitry of the device subject to FCC Part 18 was found to be compliant and is covered in VPI Laboratories, Inc. report V072639_01.

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: WiTricity MN: Brickyard (Halo) PTU (Note 1) SN: IMS2959392300022	BLE Transmitter	See Section 2.4
BN: Meanwell MN: UHP-1500-115 SN: GC277G7132	PSU	DC Power / Twisted Pair Conductors

Notes: (1) EUT

(2) Interface port connected to EUT (See Section 2.4)

The support equipment listed above was not modified in order to achieve compliance with this standard.

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.

3 Test Specification, Methods and Procedures

3.1 Test Specification

Title	FCC PART 15, Subpart C (47 CFR 15) 15.203, 15.207, and 15.231 Periodic operation in the 40.66 – 40.70 MHz and above 70 MHz
Purpose of Test	The tests were performed to demonstrate initial compliance

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 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 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

(a) Except as shown in paragraphs (b) and (c) of this section, 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.

(c) Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

3.2.3 §15.231

a) (a) The provisions of this section are restricted to periodic operation within the band 40.66-40.70 MHz and above 70 MHz. Except as shown in paragraph (e) of this section, the intentional radiator is restricted to the transmission of a control signal such as those used with alarm systems, door openers, remote switches, etc. Continuous transmissions, voice, video and the radio control of toys are not permitted. Data is permitted to be sent with a control signal. The following conditions shall be met to comply with the provisions for this periodic operation:

1) A manually operated transmitter shall employ a switch that will automatically deactivate the transmitter within not more than 5 seconds of being released.

2) A transmitter activated automatically shall cease transmission within 5 seconds after activation.

3) Periodic transmissions at regular predetermined intervals are not permitted. However, polling or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed if the total duration of transmissions does not exceed more than two seconds per hour for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed two seconds per hour.

4) Intentional radiators which are employed for radio control purposes during emergencies involving fire, security, and safety of life, when activated to signal an alarm, may operate during the pendency of the alarm condition.

5) Transmission of set-up information for security systems may exceed the transmission duration limits in paragraphs (a)(1) and (a)(2) of this section, provided such transmissions are under the control of a professional installer and do not exceed ten seconds after a manually operated switch is released or a transmitter is activated automatically. Such set-up information may include data.

b) In addition to the provisions of §15.205, the field strength of emission from intentional radiators operated under this section shall not exceed the following.

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emissions (microvolts/meter)
40.66 - 40.70	2,250	225
70 –130	1,250	125
130 – 174	1,250 to 3,750 **	125 to 375 **
174 – 260	3,750	375
260 – 470	3,750 to 12,500 **	375 to 1,250 **
Above 470	12,500	1,250

** Linear interpolations

Table 2: Limits for field strength of emissions from intentional radiators.

1) The above field strength limits are specified at a distance of 3 meters. The tighter limits apply at the band edges.

2) Intentional radiators operating under the provisions of this section shall demonstrate compliance with the limits on the field strength of emissions, as shown in the above table, based on the average value of the measured emissions. As an alternative, compliance with the limits in the above table may be based on the use of measurement instrumentation with a CISPR quasi-peak detector. The specific method of measurement employed shall be specified in the application for equipment authorization. If average emission measurements are employed, the provision in §15.35 for averaging pulsed emission and for limiting peak emissions apply. Further, compliance with the provisions of §15.205 shall be demonstrated using the measurement instrumentation specified in that section.

3) The limits on the field strength of the spurious emission in the above table are based on the fundamental frequency of the intentional radiator. Spurious emission shall be attenuated to the average (or, alternatively, CISPR quasi-peak) limits shown in this table or to the general limits shown in §15.209, whichever limit permits a higher field strength.

c) The bandwidth of the emission shall be no wider than 0.25% of the center frequency for devices operating above 70 MHz and below 900 MHz. For devices operating above 900 MHz, the emission shall be no wider than 0.5% of the center frequency. Bandwidth is determined at the points 20 dB down from the modulated carrier.

d) For devices operation within the frequency band 40.66-40.70 MHz, the bandwidth of the emission shall be confined within the band edges and the frequency tolerance of the carrier shall be ±0.01%. This frequency tolerance shall be maintained for a temperature variation of -20 degrees to +50 degrees C at normal supply voltage, and for a variation on the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

e) Intentional radiators may operate at a periodic rate exceeding that specified in paragraph (a) of this section and may be employed for any type of operation, including operation prohibited in paragraph (a) of this section, provided that intentional radiator complies with the provisions of paragraphs (b) through (d) of this section except the field strength table in paragraph (b) of this section is replaced by the following.

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emissions (microvolts/meter)
40.66 - 40.70	1,000	100
70 –130	500	50
130 – 174	500 to 1,500 **	50 to 150 **
174 – 260	1,500	150
260 – 470	1,500 to 5,000 **	150 to 500 **
Above 470	5,000	500

** Linear interpolations

Table 3: Limits for field strength of emissions from intentional radiators.

In addition, devices operated under the provisions of this paragraph shall be provided with a means for automatically limiting operation so that the duration of each transmission shall not be greater than one second and the silent periods between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds.

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, 2024. 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 and 47 CFR Part 15.

4 Operation of EUT During Testing

4.1 Operating Environment

Power Supply	120 VAC
AC Mains Frequency	60 Hz

4.2 Operating Modes

EUT was tested while transmitting continuously on the low, middle, and high power at the maximum output possible (setpoint +4dBm). EUT is floor-standing and cannot be operated otherwise. Therefore, EUT was only tested in the single orthogonal orientation. To simulate the placement of the antenna in the chassis, foam was used to position the antenna 2-3cm above the transmitter circuitry.

4.3 EUT Exercise Software

WiTricity Engineering Firmware was used to control the EUT for testing.

5 Summary of Test Results

5.1 FCC Part 15, Subpart C

5.1.1 Summary of Tests

Section	Environmental Phenomena	Frequency Range (MHz)	Result
15.203	Antenna Requirements	Structural requirement	Complied
15.207	Conducted Disturbance at Mains Ports	0.15 to 30	Complied
15.247(a)	Bandwidth Requirement	2400 to 2483.5	Complied
15.247(b)	Peak Output Power	2400 to 2483.5	Complied
15.247(d)	Radiated Spurious Emissions	1000 to 26500	Complied
15.247(e)	Peak Power Spectral Density	2400 to 2483.5	Complied

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.

When calculations in this report require EUT antenna gains, those values have been provided by the manufacturer unless otherwise noted.

6.2 Test Results

6.2.1 §15.203 Antenna Requirements

Describe the antenna and how it complies with the requirements.

Result

The EUT complied with the specification.

6.2.2 §15.207 Emissions at the AC Mains

Hot Lead:

Frequency (MHz)	Detector	Receiver Reading (dBµV)	Correction Factor (dB)	Measured Level (dBµV)	Class B Limit (dBµV)	Margin (dB)
0.20	Average (Note 2)	14.1	12.6	26.7	53.6	-27.0
0.20	Quasi-Peak (Note 2)	38.3	12.6	50.9	63.6	-12.7
0.60	Average (Note 2)	16.2	10.9	27.1	46.0	-18.9
0.60	Quasi-Peak (Note 2)	36.2	10.9	47.1	56.0	-8.9
2.4	Average (Note 2)	9.5	10.2	19.7	46.0	-26.3
2.4	Quasi-Peak (Note 2)	28.1	10.2	38.3	56.0	-17.7
4.6	Average (Note 2)	15.6	10.2	25.8	46.0	-20.2
4.6	Quasi-Peak (Note 2)	25.0	10.2	35.3	56.0	-20.7
18.4	Average (Note 2)	37.2	10.7	48.0	50.0	-2.1
18.4	Quasi-Peak (Note 2)	45.1	10.7	55.8	60.0	-4.2
27.0	Average (Note 2)	18.6	11.0	29.6	50.0	-20.4
27.0	Quasi-Peak (Note 2)	29.7	11.0	40.7	60.0	-19.3

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.

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Neutral Lead:

Frequency (MHz)	Detector	Receiver Reading (dBµV)	Correction Factor (dB)	Measured Level (dBµV)	Class B Limit (dBµV)	Margin (dB)
0.20	Average (Note 2)	11.2	12.6	23.8	53.6	-29.8
0.20	Quasi-Peak (Note 2)	38.0	12.6	50.6	63.6	-13.1
1.0	Average (Note 2)	12.3	10.5	22.8	46.0	-23.2
1.0	Quasi-Peak (Note 2)	31.6	10.5	42.2	56.0	-13.9
1.2	Average (Note 2)	11.8	10.4	22.2	46.0	-23.8
1.2	Quasi-Peak (Note 2)	31.2	10.4	41.6	56.0	-14.4
4.4	Average (Note 2)	18.9	10.2	29.1	46.0	-16.9
4.4	Quasi-Peak (Note 2)	31.3	10.2	41.6	56.0	-14.4
18.4	Average (Note 2)	35.7	10.8	46.5	50.0	-3.5
18.4	Quasi-Peak (Note 2)	46.9	10.8	57.7	60.0	-2.3
21.0	Average (Note 2)	30.1	10.8	40.9	50.0	-9.1
21.0	Quasi-Peak (Note 2)	37.2	10.8	48.0	60.0	-12.0

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 2.1 dB.

6.2.3 §15.247(a)(2) Emissions Bandwidth

Frequency (MHz)	Emissions 6 dB bandwidth (kHz)
2402	739.3
2440	752.5
2480	730.8

Result

In the configuration tested, the 6 dB bandwidth was greater than 500 kHz; therefore, the EUT complied with the requirements of the specification (see spectrum analyzer plots below).

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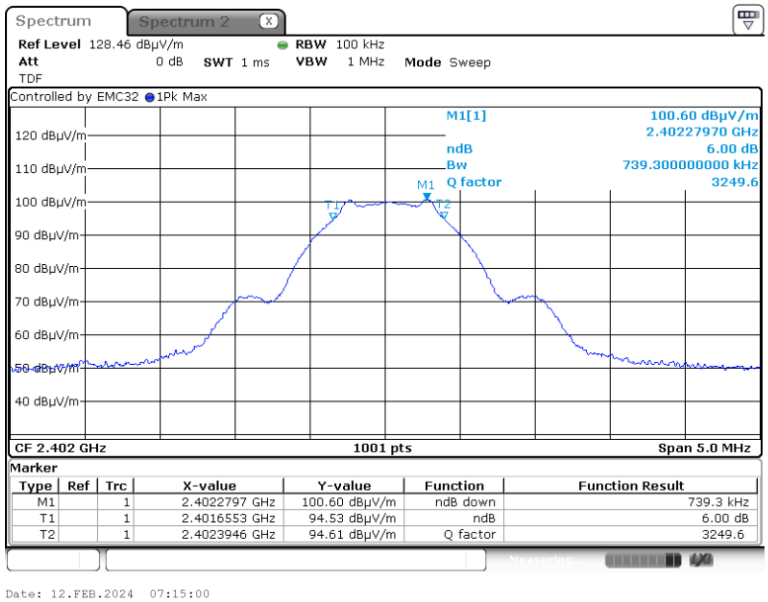
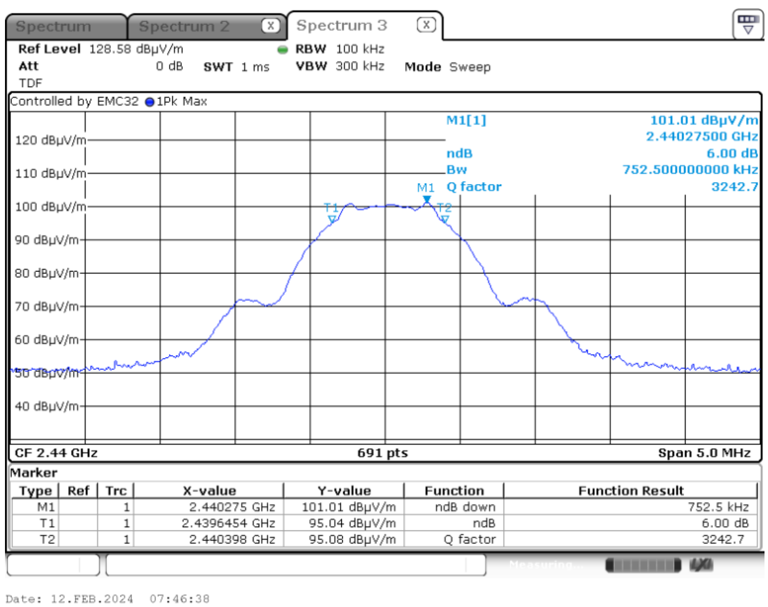


Graph 1: Lowest Channel Bandwidth



Graph 2: Middle Channel Bandwidth

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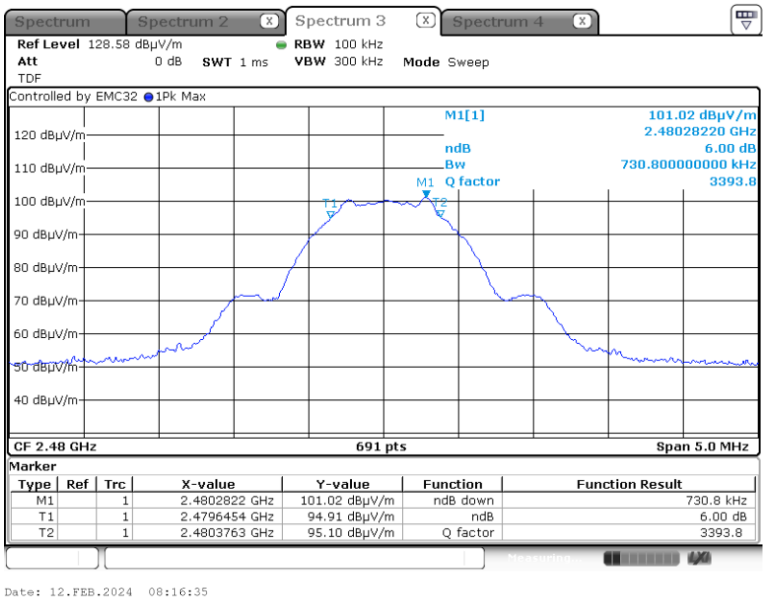


Graph 3: Highest Channel Bandwidth

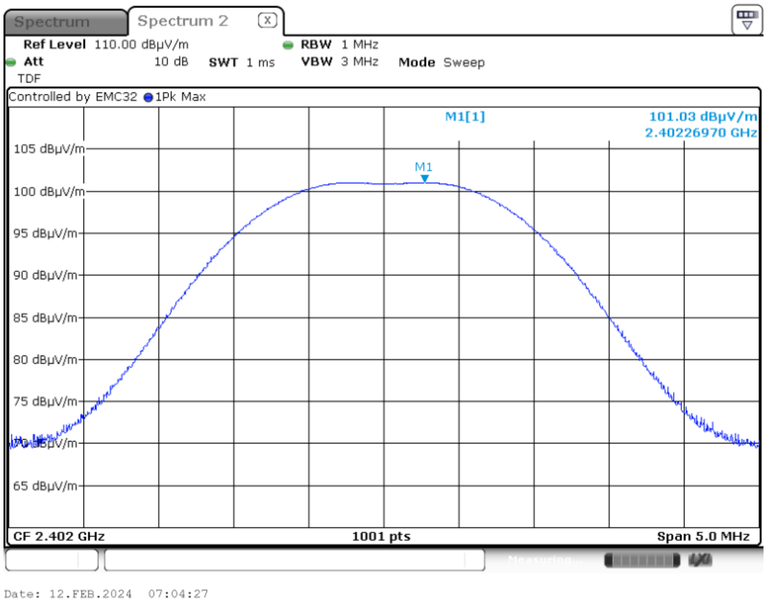
6.2.4 §15.247(b)(3) Peak Output Power

The maximum peak EIRP measured for this device was 6.71 dBm or 2.86 mW. The limit is 30 dBm or 1 Watt when using antennas with 6 dBi or less gain.

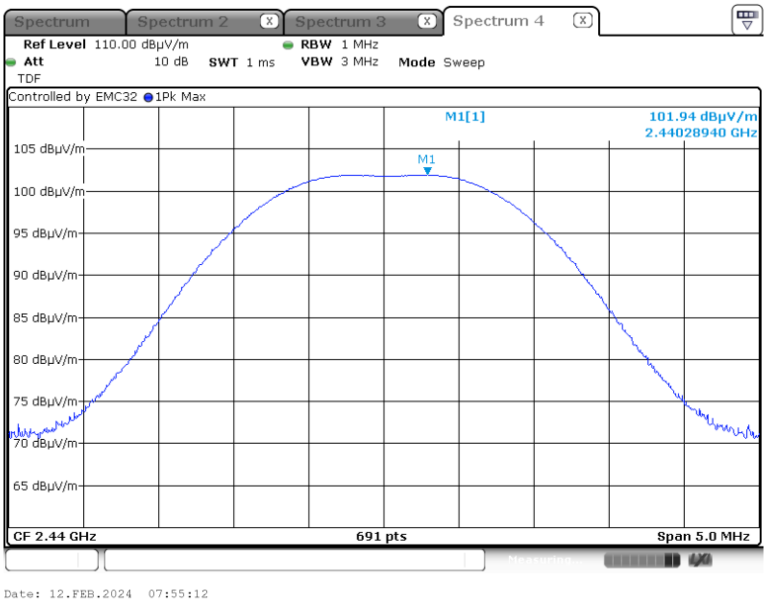
Frequency (MHz)	Measured Radiated Power (dBuV/m)	Measured EIRP (dBm)	Output Power (mW)
2402	101.03	5.80	2.32
2440	101.94	6.71	2.86
2480	101.47	6.24	2.57

Result

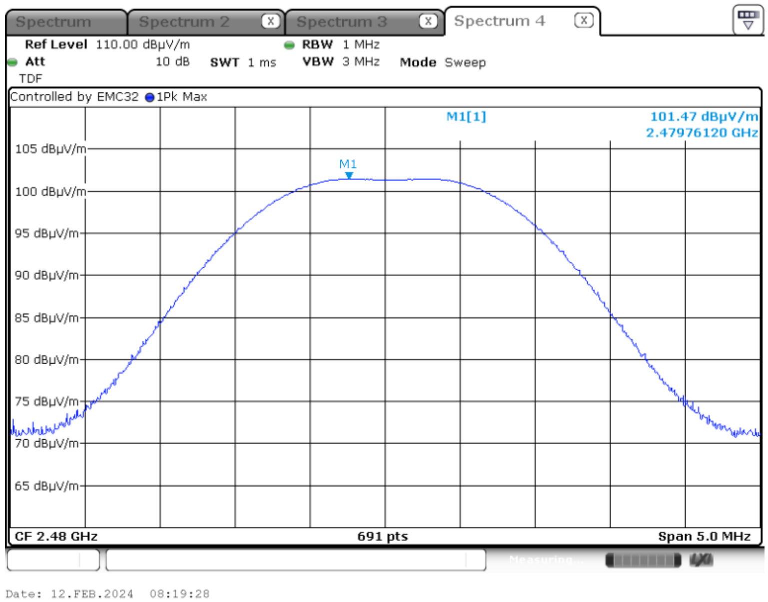
In the configuration tested, the RF peak output power was less than 1 Watt; therefore, the EUT complied with the requirements of the specification (see spectrum analyzer plots below).



Graph 4: Lowest Channel Output Power Plot



Graph 5: Middle Channel Output Power



Graph 6: Highest Channel Output Power Plot

6.2.5 §15.247(d) Spurious Emissions

Radiated Spurious Emissions in the Restricted Bands of §15.205

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. Tabular data for each of the spurious emissions is shown below for each of the units. Plots of the band edges are also shown.

Result

All emissions in the restricted bands of §15.205 met the limits specified in §15.209; therefore, the EUT complies with the specification.

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBµV)	Correction Factor (dB)	Field Strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
4803.5	Peak	Vertical	37.2	6.1	43.3	74.0	-30.7
4803.5	Average	Vertical	33.5	6.1	39.6	54.0	-14.4
4803.5	Peak	Horizontal	39.0	6.1	45.1	74.0	-28.9
4803.5	Average	Horizontal	35.9	6.1	42.0	54.0	-12.0
7206.6	Peak	Vertical	37.8	10.5	48.3	74.0	-25.7
7206.6	Average	Vertical	33.5	10.5	44.0	54.0	-10.0
7205.0	Peak	Horizontal	34.0	10.5	44.5	74.0	-29.5
7205.0	Average	Horizontal	27.7	10.5	38.3	54.0	-15.7

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Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
9608.0	Peak	Vertical	34.1	12.8	46.9	74.0	-27.1
9608.0	Average	Vertical	28.6	12.8	41.4	54.0	-12.6
9609.0	Peak	Horizontal	33.8	12.8	46.6	74.0	-27.4
9609.0	Average	Vertical	27.8	12.8	40.5	54.0	-13.5
12010.2	Peak	Vertical	32.7	16.2	49.0	74.0	-25.0
12010.2	Average	Vertical	26.2	16.2	42.4	54.0	-11.6
12015.4	Peak	Horizontal	33.6	16.2	49.8	74.0	-24.2
12015.4	Average	Horizontal	28.0	16.2	44.3	54.0	-9.8
14413.7	Peak	Vertical	30.3	20.6	50.9	74.0	-23.1
14413.7	Average	Vertical	24.8	20.6	45.4	54.0	-8.6
14408.1	Peak	Horizontal	30.6	20.6	51.1	74.0	-22.9
14408.1	Average	Horizontal	26.1	20.6	46.7	54.0	-7.3
16810.2	Peak	Vertical	31.3	18.8	50.0	74.0	-24.0
16810.2	Average	Vertical	25.8	18.8	44.5	54.0	-9.5
16814.4	Peak	Horizontal	32.5	18.8	51.3	74.0	-22.7
16814.4	Average	Horizontal	25.6	18.8	44.3	54.0	-9.7
19260.2	Peak	Vertical	39.0	15.7	54.7	74.0	-19.3
19260.2	Average	Vertical	27.0	15.7	42.7	54.0	-11.3
19265.2	Peak	Horizontal	38.5	15.7	54.2	74.0	-19.8
19265.2	Average	Horizontal	26.9	15.7	42.6	54.0	-11.4
21662.5	Peak	Vertical	37.3	17.5	54.8	74.0	-19.2
21662.5	Average	Vertical	25.6	17.5	43.1	54.0	-10.9
21666.1	Peak	Horizontal	37.6	17.5	55.1	74.0	-18.9
21666.1	Average	Horizontal	25.7	17.5	43.2	54.0	-10.8
24068.4	Peak	Vertical	37.0	20.7	57.8	74.0	-16.2
24068.4	Average	Vertical	25.5	20.7	46.2	54.0	-7.8
24068.6	Peak	Horizontal	37.4	20.7	58.2	74.0	-15.8
24068.6	Average	Horizontal	25.5	20.7	46.2	54.0	-7.8

Table 4: Transmitting at the Lowest Frequency

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4880.4	Peak	Vertical	36.4	6.1	42.5	74.0	-31.5
4880.4	Average	Vertical	32.8	6.1	38.9	54.0	-15.1
4879.9	Peak	Horizontal	37.5	6.1	43.6	74.0	-30.4
4879.9	Average	Horizontal	34.0	6.1	40.1	54.0	-13.9
7319.4	Peak	Vertical	40.6	10.9	51.5	74.0	-22.5
7319.4	Average	Vertical	35.9	10.9	46.9	54.0	-7.2
7320.5	Peak	Horizontal	34.1	10.9	45.0	74.0	-29.0
7320.5	Average	Horizontal	29.3	10.9	40.2	54.0	-13.8
9757.9	Peak	Vertical	33.5	12.6	46.2	74.0	-27.9
9757.9	Average	Vertical	27.7	12.6	40.3	54.0	-13.7
9760.7	Peak	Horizontal	32.7	12.6	45.3	74.0	-28.7
9760.7	Average	Vertical	27.3	12.6	39.9	54.0	-14.1
12185.7	Peak	Vertical	32.8	16.2	49.0	74.0	-25.0
12185.7	Average	Vertical	25.9	16.2	42.2	54.0	-11.8
12214.9	Peak	Horizontal	31.8	16.2	48.0	74.0	-26.0
12214.9	Average	Horizontal	26.9	16.2	43.2	54.0	-10.9
14648.9	Peak	Vertical	30.3	20.7	51.0	74.0	-23.0
14648.9	Average	Vertical	25.7	20.7	46.4	54.0	-7.6
14644.0	Peak	Horizontal	30.5	20.7	51.2	74.0	-22.8
14644.0	Average	Horizontal	26.2	20.7	46.9	54.0	-7.1
17080.0	Peak	Vertical	31.7	19.7	51.4	74.0	-22.6
17080.0	Average	Vertical	25.6	19.7	45.3	54.0	-8.7
17081.1	Peak	Horizontal	31.3	19.7	51.0	74.0	-23.0
17081.1	Average	Horizontal	25.7	19.7	45.4	54.0	-8.6
19559.7	Peak	Vertical	38.6	15.6	54.2	74.0	-19.8
19559.7	Average	Vertical	27.0	15.6	42.6	54.0	-11.4
19567.8	Peak	Horizontal	38.4	15.6	54.1	74.0	-20.0
19567.8	Average	Horizontal	27.0	15.6	42.6	54.0	-11.4
22003.3	Peak	Vertical	37.2	18.4	55.6	74.0	-18.5
22003.3	Average	Vertical	25.1	18.4	43.5	54.0	-10.5

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
22002.6	Peak	Horizontal	38.4	18.4	56.8	74.0	-17.2
22002.6	Average	Horizontal	25.1	18.4	43.5	54.0	-10.5
24444.1	Peak	Vertical	36.4	21.2	57.6	74.0	-16.5
24444.1	Average	Vertical	24.6	21.2	45.8	54.0	-8.2
24447.5	Peak	Horizontal	36.2	21.2	57.4	74.0	-16.6
24447.5	Average	Horizontal	24.6	21.2	45.8	54.0	-8.2

Table 5: Transmitting at the Middle Frequency

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4959.8	Peak	Vertical	34.8	6.6	41.4	74.0	-32.6
4959.8	Average	Vertical	31.1	6.6	37.7	54.0	-16.4
4960.8	Peak	Horizontal	36.6	6.6	43.2	74.0	-30.8
4960.8	Average	Horizontal	33.8	6.6	40.4	54.0	-13.6
7441.2	Peak	Vertical	45.7	11.1	56.8	74.0	-17.2
7441.2	Average	Vertical	40.0	11.1	51.1	54.0	-2.9
7439.7	Peak	Horizontal	40.0	11.1	51.1	74.0	-22.9
7439.7	Average	Horizontal	36.2	11.1	47.3	54.0	-6.7
9919.8	Peak	Vertical	33.3	13.5	46.8	74.0	-27.2
9919.8	Average	Vertical	26.9	13.5	40.4	54.0	-13.6
9918.8	Peak	Horizontal	33.4	13.5	46.9	74.0	-27.1
9918.8	Average	Vertical	27.0	13.5	40.5	54.0	-13.5
12399.5	Peak	Vertical	32.8	16.3	49.1	74.0	-24.9
12399.5	Average	Vertical	25.8	16.3	42.1	54.0	-11.9
12404.7	Peak	Horizontal	33.0	16.4	49.3	74.0	-24.7
12404.7	Average	Horizontal	26.7	16.4	43.0	54.0	-11.0
14874.3	Peak	Vertical	31.0	20.4	51.4	74.0	-22.6
14874.3	Average	Vertical	26.0	20.4	46.4	54.0	-7.6
14879.9	Peak	Horizontal	30.1	20.4	50.5	74.0	-23.5
14879.9	Average	Horizontal	25.2	20.4	45.6	54.0	-8.4
17364.6	Peak	Vertical	29.7	22.0	51.7	74.0	-22.3

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
17364.6	Average	Vertical	24.1	22.0	46.1	54.0	-7.9
17363.5	Peak	Horizontal	30.3	22.0	52.3	74.0	-21.7
17363.5	Average	Horizontal	24.0	22.0	46.0	54.0	-8.0
19882.3	Peak	Vertical	40.7	15.7	56.4	74.0	-17.6
19882.3	Average	Vertical	27.7	15.7	43.4	54.0	-10.6
19886.1	Peak	Horizontal	39.8	15.7	55.6	74.0	-18.4
19886.1	Average	Horizontal	27.6	15.7	43.3	54.0	-10.7
22347.8	Peak	Vertical	37.7	19.6	57.3	74.0	-16.7
22347.8	Average	Vertical	25.4	19.6	45.0	54.0	-9.0
22345.3	Peak	Horizontal	37.6	19.6	57.2	74.0	-16.8
22345.3	Average	Horizontal	25.4	19.6	45.0	54.0	-9.0
24796.5	Peak	Vertical	38.1	22.2	60.3	74.0	-13.7
24796.5	Average	Vertical	25.9	22.2	48.1	54.0	-5.9
24797.4	Peak	Horizontal	37.6	22.2	59.9	74.0	-14.1
24797.4	Average	Horizontal	25.9	22.2	48.2	54.0	-5.8

Table 6: Transmitting at the Highest Frequency

No other emissions were seen in the restricted bands.

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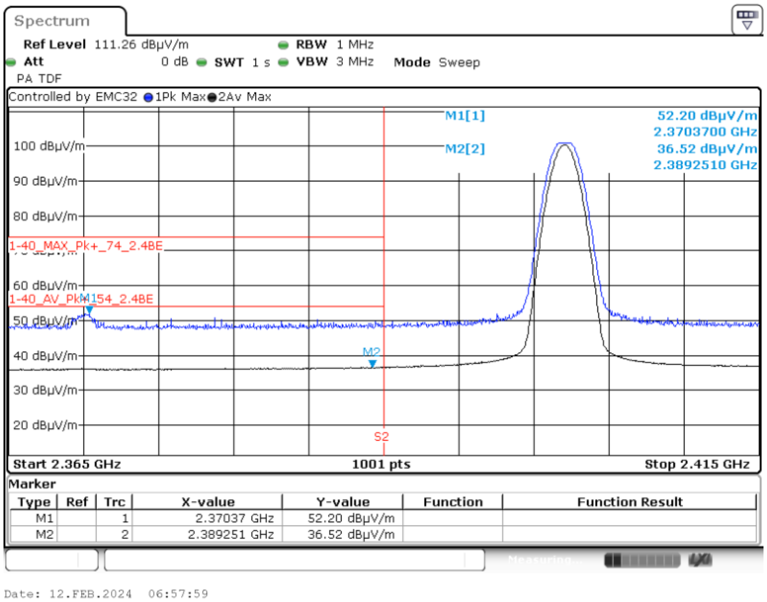
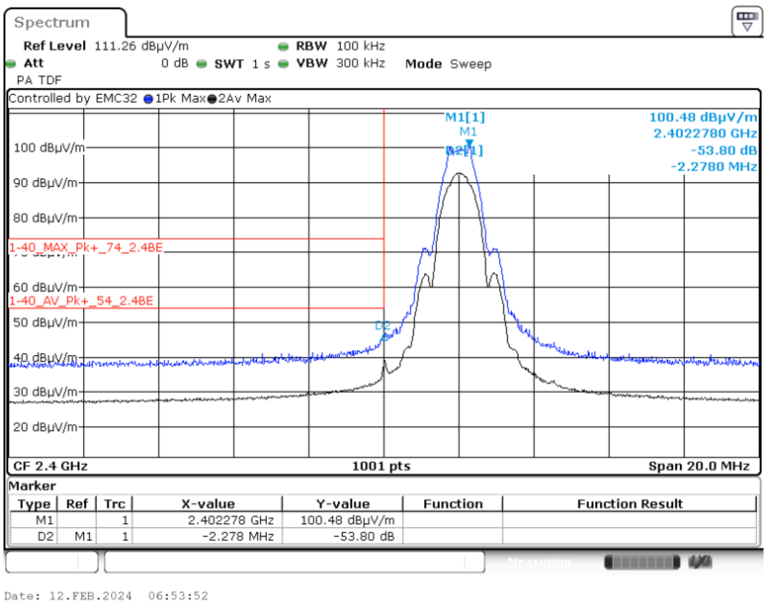
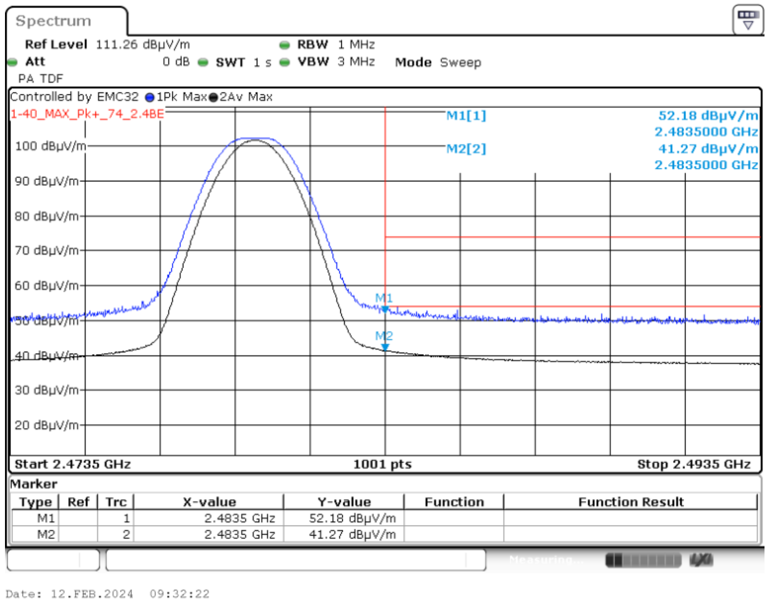


Graph 7: Radiated Lower Band Edge Plot (Restricted Band Edge)



Graph 8: Radiated Lower Band Edge Plot (Authorized Band Edge, C63.10 Method 6.10.4)



Graph 9: Radiated Upper Band Edge Plot (Restricted and Authorized Band Edge)

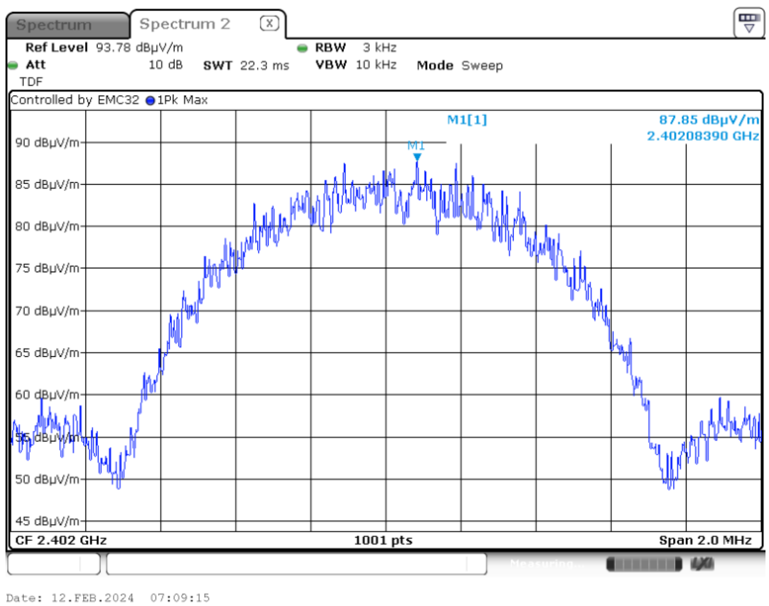
6.2.6 §15.247(e) Peak Power Spectral Density

The peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. Results of this testing are summarized.

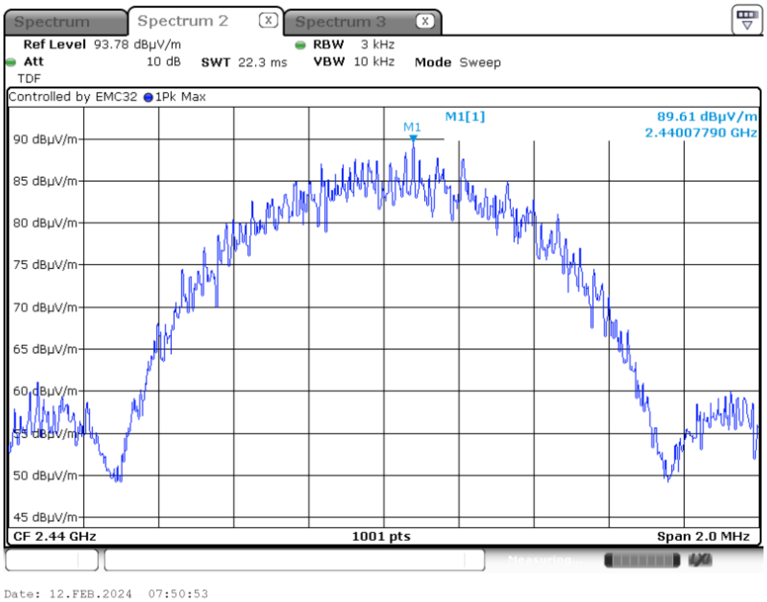
Frequency (MHz)	Radiated PSD (dBm)	Criteria (dBm)
2402	-7.38	8.0
2440	-5.62	8.0
2480	-7.58	8.0

Result

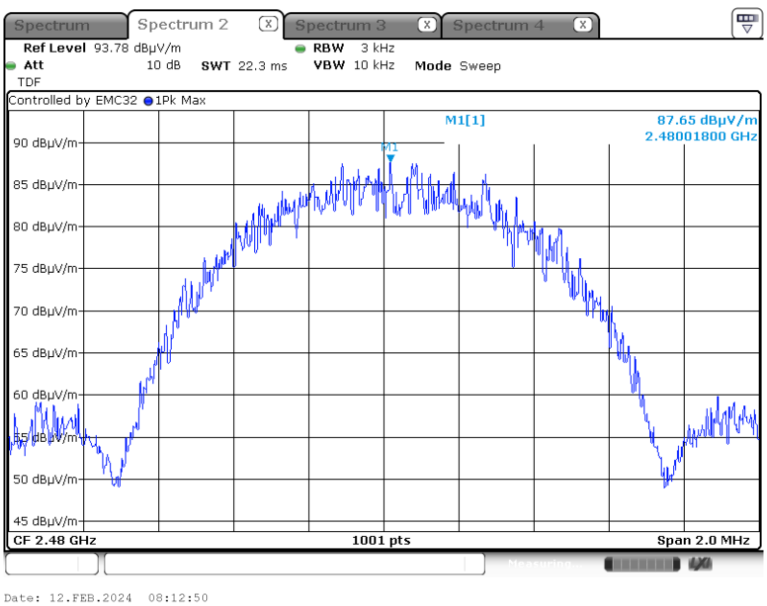
The maximum peak power spectral density was less than the limit of 8 dBm; therefore, the EUT complies with the specification.



Graph 10: Lowest Channel 3 kHz PSD Plot



Graph 11: Middle Channel 3 kHz PSD Plot



Graph 12: Highest Channel Output 3 kHz PSD Plot

6.3 Sample Measurement Calculations

6.3.1 Field Strength Calculations

The field strength is calculated by adding the *Correction Factor* (*Antenna Factor* + *Cable Factor*), to the measured level from the receiver. The receiver amplitude reading is compensated for any amplifier gain. The basic equation with a sample calculation is shown below:

Receiver Amplitude Reading=Receiver Reading-Amplifier Gain

Correction Factor=Antenna Factor + Cable Factor

Field Strength=Receiver Amplitude Reading + Correction Factor

Example

Assuming a *Receiver Reading* of 42.5 dBµV is obtained from the receiver, the *Amplifier Gain* is 26.5 dB the *Antenna Factor* is 4.5 dB, and the *Cable Factor* is 4.0 dB. The *Field Strength* is calculated by subtracting the *Amplifier Gain* and adding the *Correction Factor*, giving a *Field Strength* of 24.5 dBµV/m.

$$Receiver\ Amplitude\ Reading\ =\ 42.5 - 26.5\ =\ 16.0\ \mathrm{dB\mu V/m}$$

$$Correction\ Factor\ =\ 4.5 + 4.0\ =\ 8.5\ \mathrm{dB}$$

$$Field\ Strength\ =\ 16.0 + 8.5\ =\ 24.5\ \mathrm{dB\mu V/m}$$

6.3.2 Conducted Measurement Value Calculations

A conducted emission value is calculated by adding the *Correction Factor* (*LISN Transducer Factor* + *Cable Factor*) to the measured value from the receiver. The LISN contains an internal 10dB (nominal) attenuation accounted for in the LISN Transducer Factor. Amplifiers are not utilized for this measurement. The basic equation with a sample calculation is shown below:

Correction Factor = LISN Transducer Factor + Cable Factor

Conducted Emission Value = Receiver Amplitude Reading + Correction Factor

Example

Assuming a *Receiver Reading* of 20.8 dBµV is obtained from the receiver, *LISN Transducer Factor* is 10.1 dB, and the *Cable Factor* is 0.3 dB. The *Conducted Emissions Value* is calculated by adding the *Correction Factor*, giving a *Conducted Emissions Value* of 31.2 dBµV.

$$Receiver\ Amplitude\ Reading\ =\ 20.8\ \mathrm{dB\mu V}$$

$$Correction\ Factor\ =\ 10.1 + 0.3\ =\ 10.4\ \mathrm{dB}$$

$$Conducted\ Emissions\ Value\ =\ 20.8 + 10.4\ =\ 31.2\ \mathrm{dB\mu V}$$

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7 Test 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/Receiver	Rohde & Schwarz	ESU40	V033119	08/20/2023	08/20/2024
LISN	Teseq	NNB 51	V045405	12/05/2023	12/05/2024
Conductance Cable Wanship Upper Site	VPI Labs	Cable J	V034832	12/28/2023	12/28/2024
EMC32 Measurement Software	Rohde & Schwarz	10.60.20	N/A	N/A	N/A

Table 7: List of equipment used for conducted emissions testing at mains ports.

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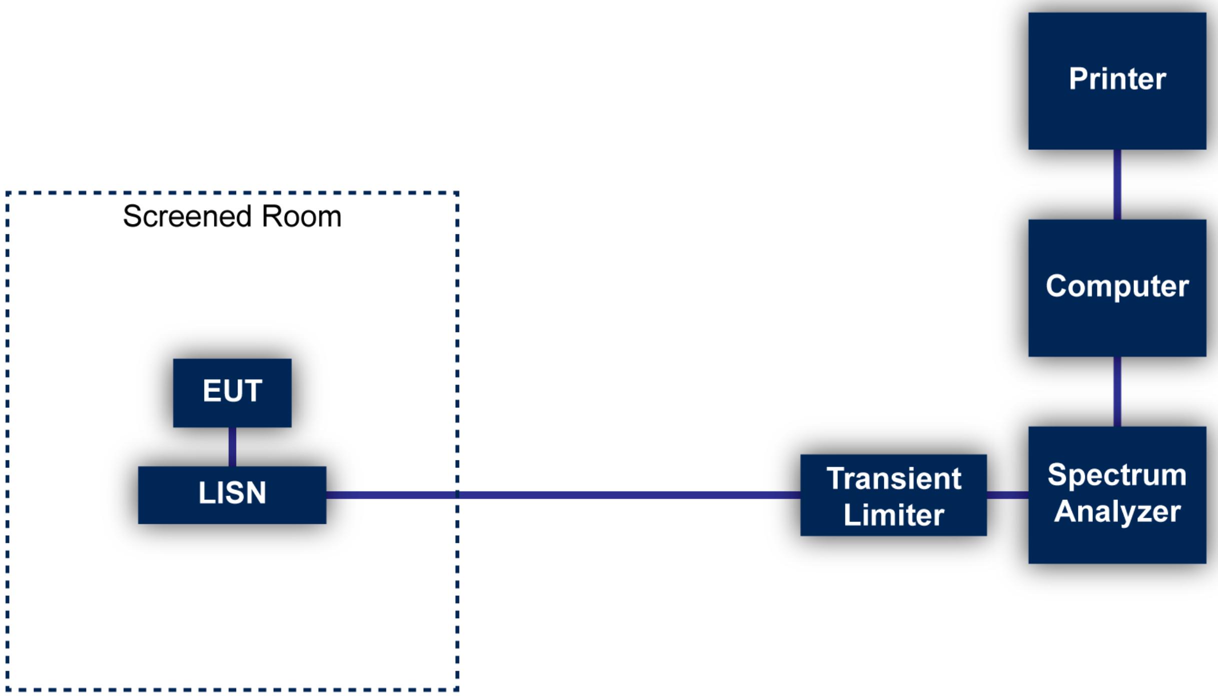


Figure 1: Conducted Emissions Test

7.2 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 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. For frequencies above 1000 MHz, a 1 MHz 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 distance of 3 and/or 1 meter 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	08/20/2023	08/20/2024
Spectrum Analyzer/ Signal Analyzer	Rohde & Schwarz	FSV40	V044352	03/08/2022	03/08/2024
Loop Antenna	EMCO	6502	V034216	04/27/2023	04/27/2024
Biconilog Antenna	EMCO	3142E	V057461	06/06/2023	06/06/2025
Power Amplifier	HP	8447E	V034189	12/28/2023	12/28/2024
Double Ridged Guide Antenna	EMCO	3115	V034413	01/25/2023	01/25/2025
High Frequency Amplifier	Miteq	AFS4-001018000-35-10P-4	V033997	12/28/2023	12/28/2024
900 MHz High Pass Filter	Micro-Tronics	HPM50108-03	V034185	12/28/2023	12/28/2024
2.4 GHz High Pass Filter	Micro-Tronics	HPM50111-03	V034183	12/28/2023	12/28/2024
2.4 GHz Notch Filter	Micro-Tronics	BRM50702-03	V034213	12/28/2023	12/28/2024
6’ High Frequency Cable	Microcoax	UFB197C-0-0720-000000	V033638	12/28/2023	12/28/2024
20’ High Frequency Cable	Microcoax	UFB197C-1-3120-000000	V033979	12/28/2023	12/28/2024
3 Meter Radiated Emissions Cable Wanship Upper Site	Microcoax	UFB205A-0-4700-000000	V033639	12/28/2023	12/28/2024
EMC32 Test Software	Rohde & Schwarz	10.60.20	N/A	N/A	N/A

Table 8: List of equipment used for radiated emissions testing.

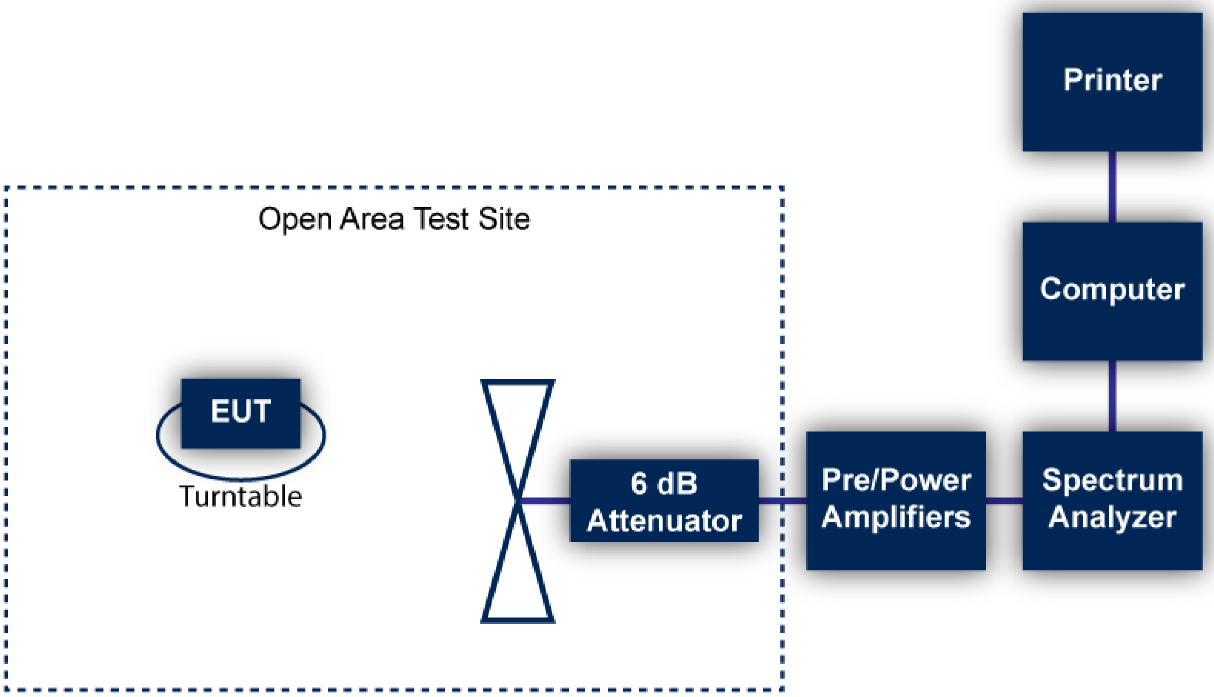


Figure 2: Radiated Emissions Test

7.3 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.

7.4 Measurement Uncertainty

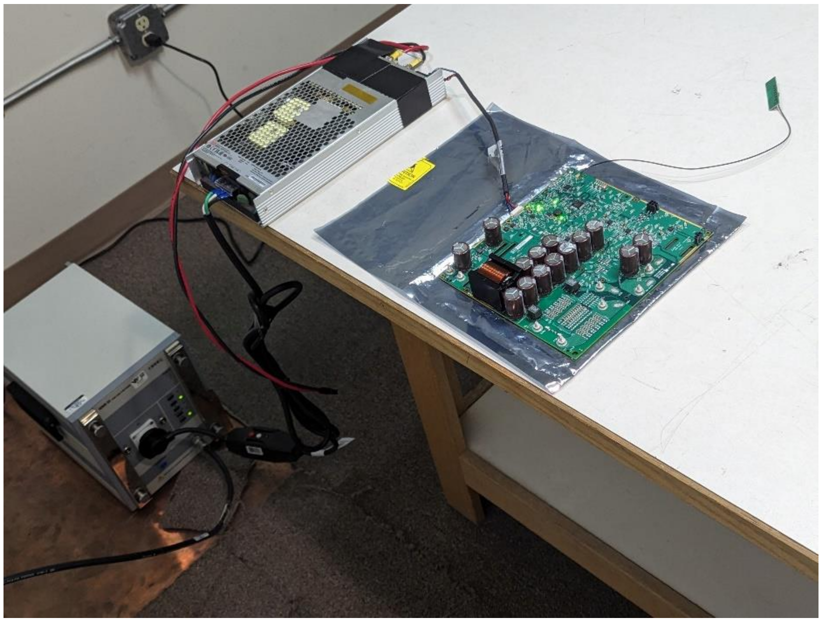
Test	Uncertainty (±dB)	Confidence (%)
Conducted Emissions	2.8	95
Radiated Emission (9 kHz to 30 MHz)	3.3	95
Radiated Emissions (30 MHz to 1 GHz)	3.4	95
Radiated Emissions (1 GHz to 18 GHz)	5.0	95
Radiated Emissions (18 GHz to 40 GHz)	4.1	95

8 Photographs

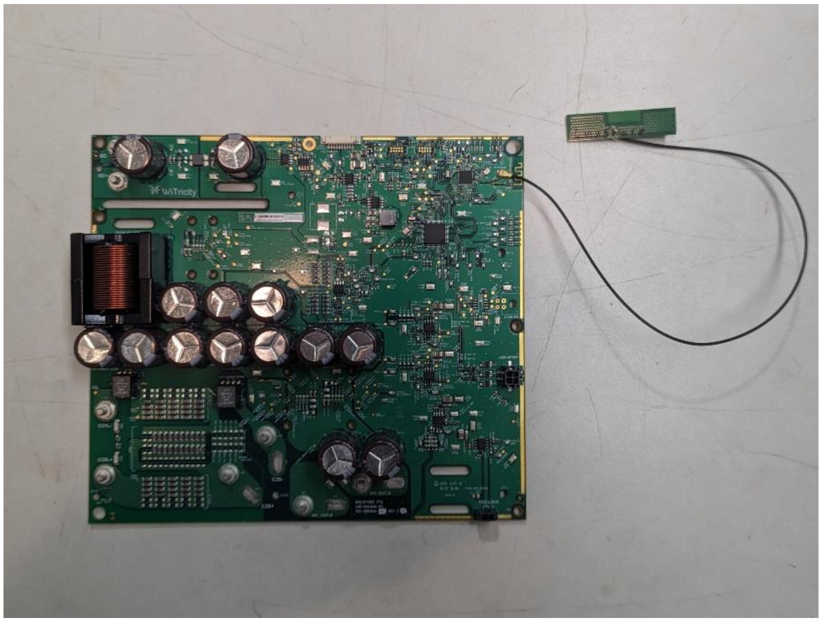
Photograph 1: Front View Radiated Emissions Worst-Case Configuration

Photograph 2: Back View Radiated Emissions Worst-Case Configuration

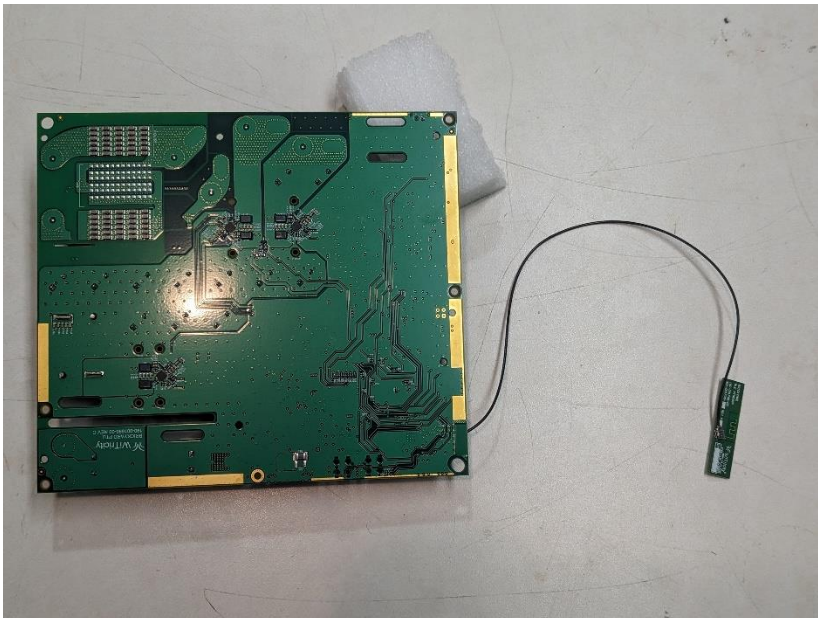
Photograph 3: Front View Conducted Emissions Worst-Case Configuration



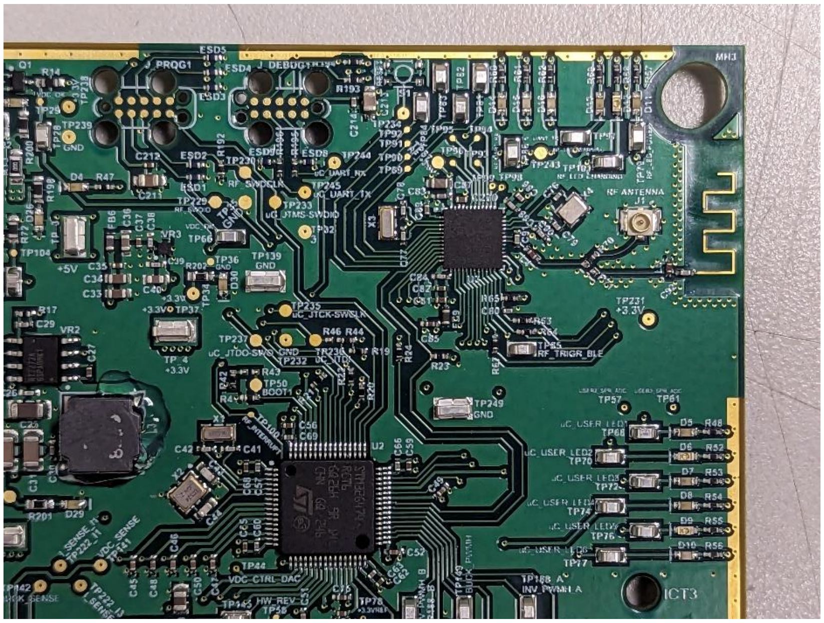
Photograph 4: Back View Conducted Emissions Worse-Case Configuration



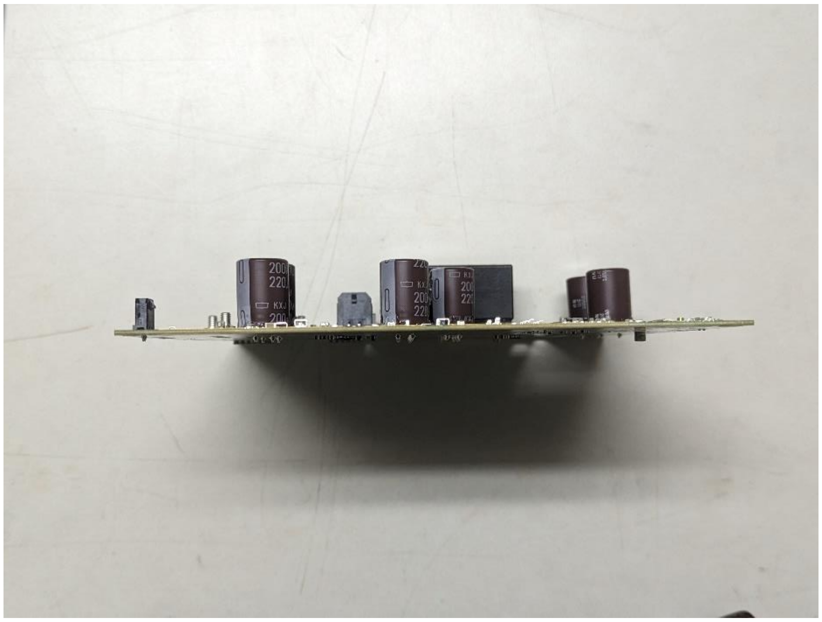
Photograph 5: Front View of the EUT



Photograph 6: Back View of the EUT



Photograph 7: Closeup View of the RF Circuitry



Photograph 8: Side 1 of the Main Board with RF Circuitry

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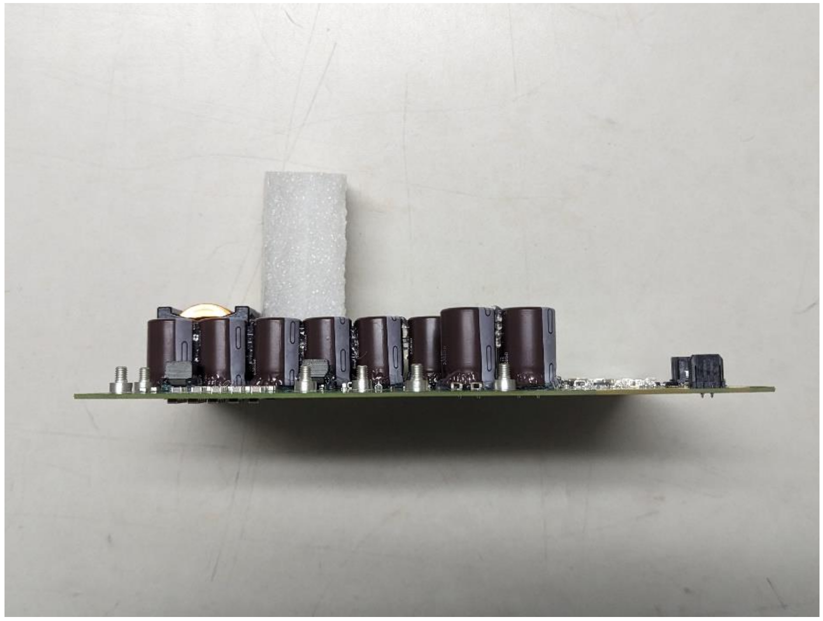
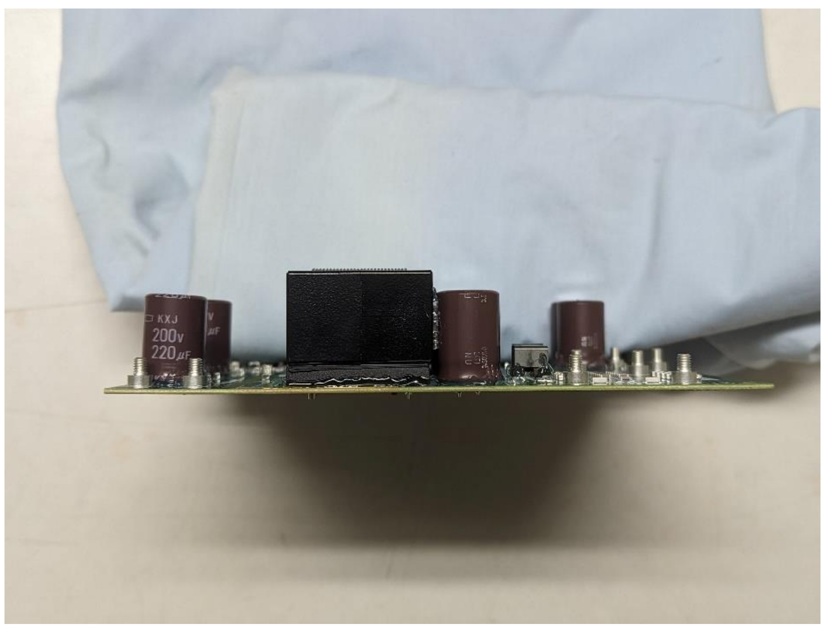


Photograph 9: Side 2 of the Main Board with RF Circuitry



Photograph 10: Side 3 of the Main Board with RF Circuitry

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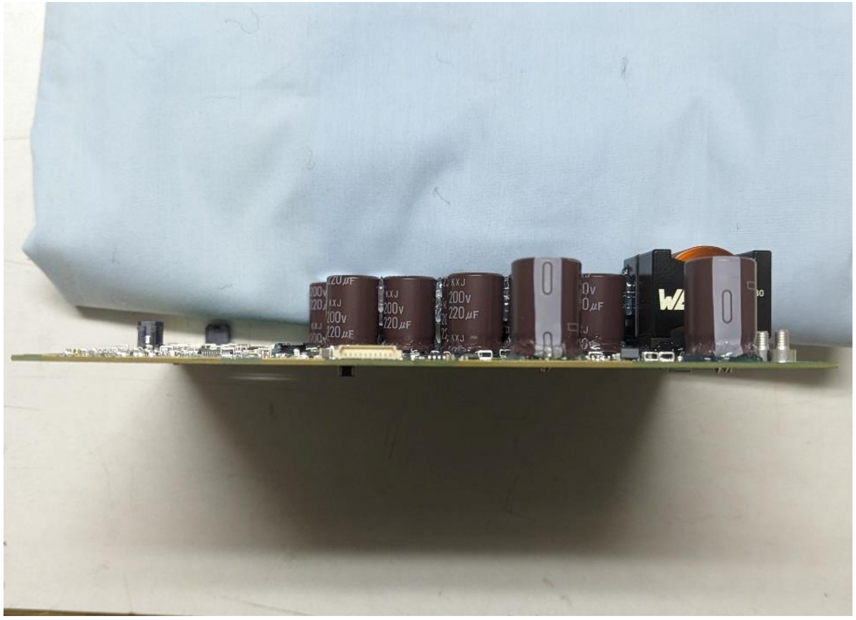
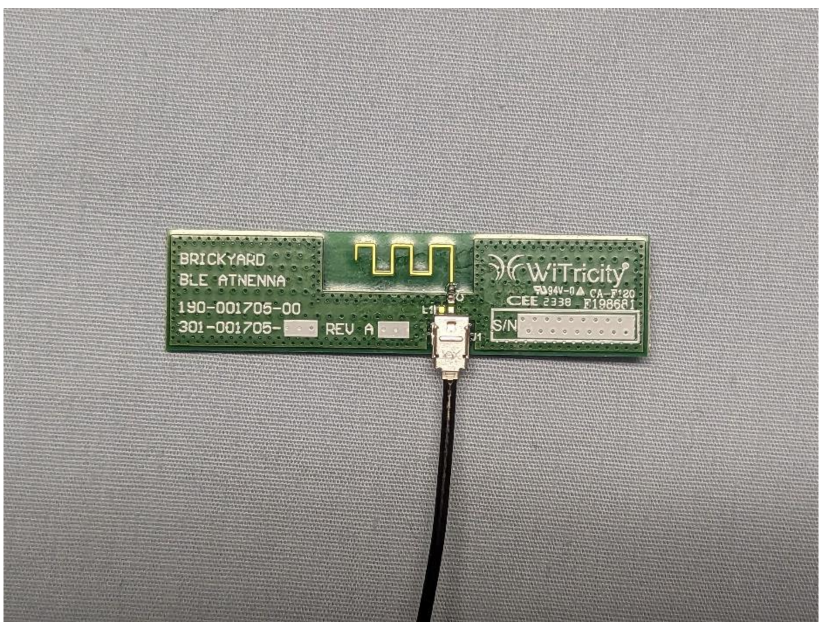
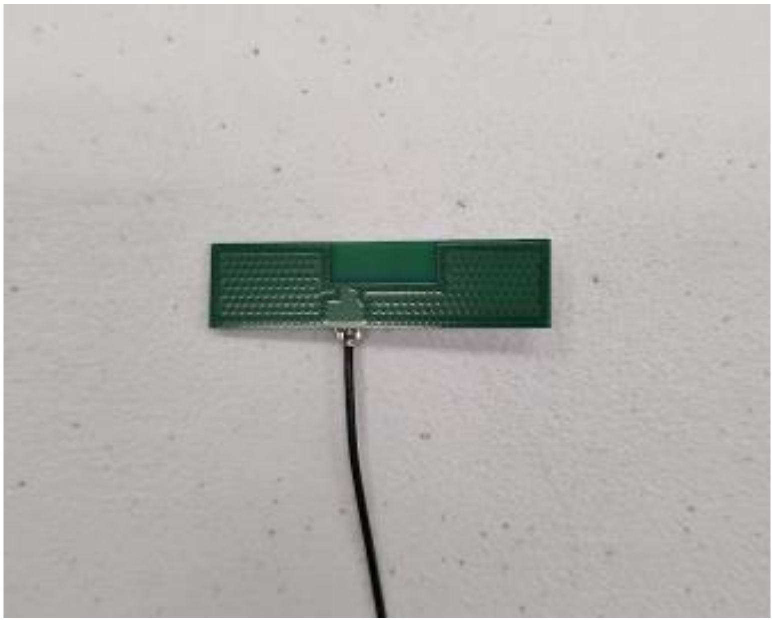


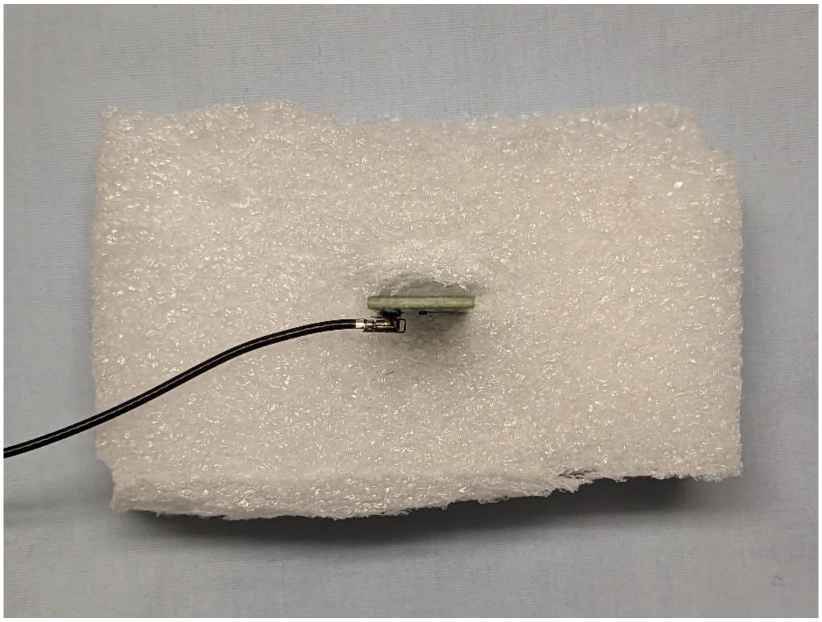
Photograph 11: Side 4 of the Main Board with RF Circuitry



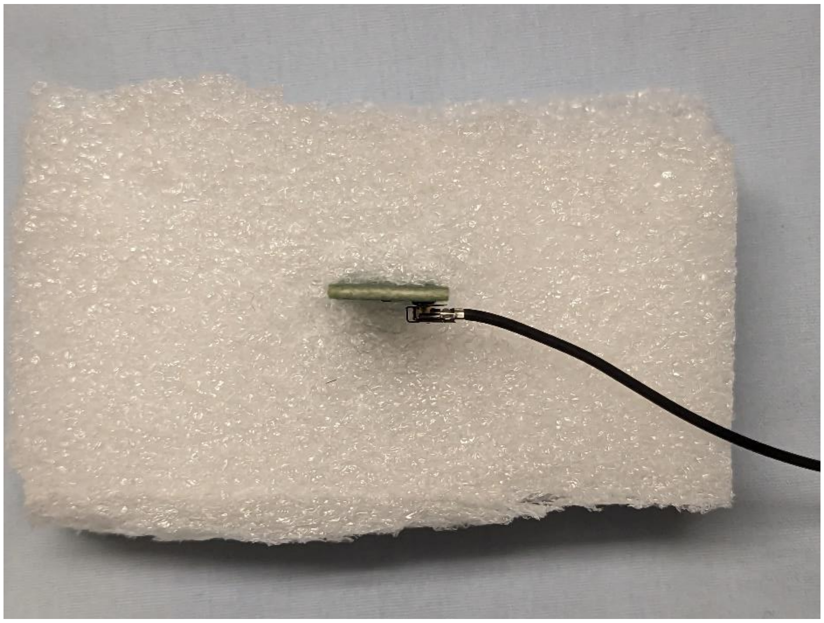
Photograph 12: Front View of the Antenna Board



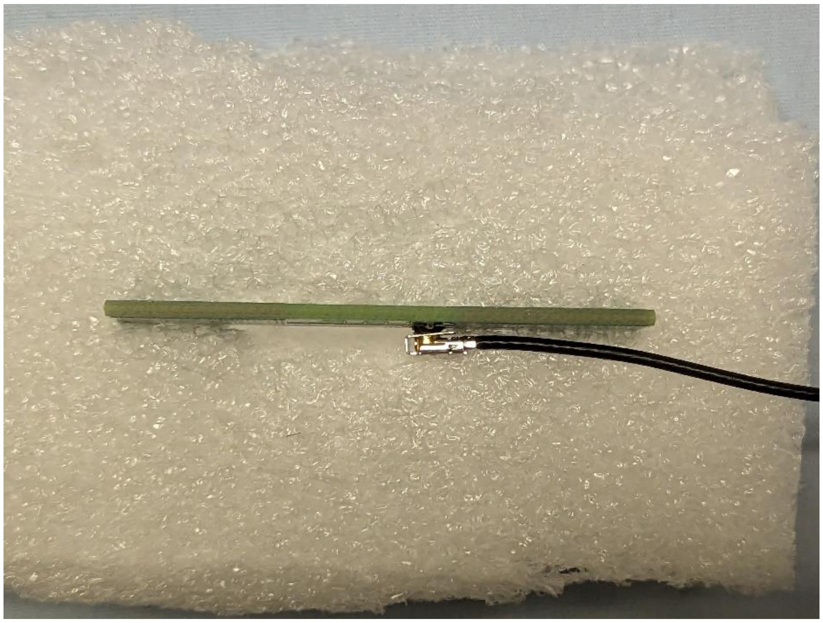
Photograph 13: Back View of the Antenna Board



Photograph 14: Side 1 of the Antenna Board

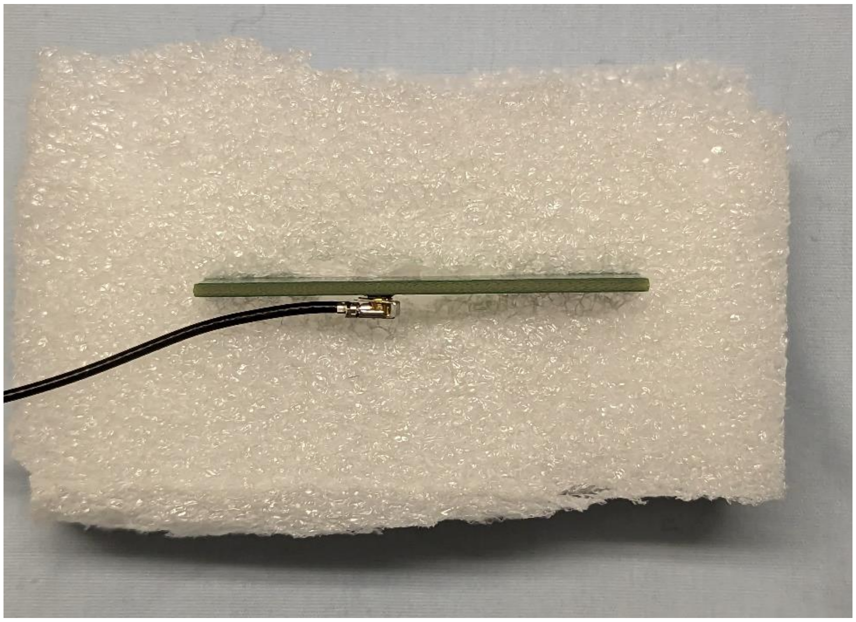


Photograph 15: Side 2 of the Antenna Board



Photograph 16: Side 3 of the Antenna Board

PROPRIETARY



Photograph 17: Side 4 of the Antenna Board

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