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

Test Report

Certification

FCC ID	MZR-YRHCPZW4FM
Equipment Under Test	AYR-MOD-ZW4-USA
Test Report Serial No	V067194_02
Dates of Test	February 15 and 16, 2023
Report Issue Date	February 24, 2023

Test Specifications:	Applicant:
FCC Part 15, Subpart C Sections 15.203, 15.207, and 15.247	Master Lock Company 6744 S. Howell Avenue Oak Creek, WI 53154 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	Master Lock Company
Manufacturer	Master Lock Company
Brand Name	Yale
Model Name	AYR-MOD-ZW4-USA
FCC ID	MZR-YRHCPZW4FM

On this 24th day of February 2023, 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	February 24, 2023
02	Correction to FCC ID	May 28, 2024

Table of Contents

1 Client Information

1.1 Applicant

Company Name	Master Lock Company 6744 S. Howell Avenue Oak Creek, WI 53154 U.S.A.
Contact Name	Sidnei Stifelmann
Title	Senior Global Product Regulatory Compliance Manager

1.2 Manufacturer

Company Name	Master Lock Company 6744 S. Howell Avenue Oak Creek, WI 53154 U.S.A.
Contact Name	Sidnei Stifelmann
Title	Senior Global Product Regulatory Compliance Manager

2 Equipment Under Test (EUT)

2.1 Identification of EUT

Brand Name	Yale
Model Number	AYR-MOD-ZW4-USA
Serial Number	None
Dimensions (cm)	5 x 2 x 2

2.2 Description of EUT

The AYR-MOD-ZW4-USA is module containing a Z-wave LR transceiver that is used in Yale door locks. The AYR-MOD-ZW4-USA is powered by the batteries in the lock. For testing purposes, a Phihong PSA 05A-050QL6 power supply was used to power the AYR-MOD-ZW4-USA. The transceiver used 1 channel in the 902 MHz – 928 MHz ISM frequency band. The transceiver uses a PCB trace as an antenna with a gain of -1.26 as provided by the Manufacturer. The maximum power settings for the transceiver is shown below. Testing was performed using these settings.

Frequency (MHz)	Power Setting	Data Rate (kbps)	Modulation
912.0	155 raw	100	OQPSK

This report covers the circuitry of the devices subject to FCC Part 15, Subpart C. The circuitry of the device subject to FCC Subpart B and found to be compliant in VPI Laboratories, Inc. report V067190. Transceiver can transmit at three additional channels subject to §15.249 and found compliant in VPI Laboratories, Inc. report V067192.

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: Yale MN: AYR-MOD-ZW4-USA (Note 1) SN: None	Z-wave module for door locks	See Section 2.4

Notes: (1) EUT

2.4 Interface Ports on EUT

Name of Ports	No. of Ports Fitted to EUT	Cable Description/Length
Lock Interface	1	The EUT connects directly to the lock via an 8 pin header connector

2.5 Modification Incorporated/Special Accessories on EUT

No modifications were made to the EUT by the Client during testing 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 15.247 Limits and methods of measurement of radio interference characteristics of radio frequency devices.
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.

3.2.3 §15.247 Operation within the bands 902 – 928 MHz, 2400 – 2483.5 MHz, and 5725 – 5850 MHz

a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions.

1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400 – 2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudorandomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

   i. For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

   ii. Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

   iii. Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 non-overlapping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 non-overlapping channels are used.

2) Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

b) The maximum peak output power of the intentional radiator shall not exceed the following:

1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725 – 5850 MHz bands: 1 watt. As an alternative to a peak power measurement, compliance with the Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

c) Operation with directional antenna gains greater than 6 dBi.

1) Fixed point-to-point operation:

i. Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

ii. Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

iii. Fixed, point-to-point operation, as used in paragraphs (b)(4)(i) and (b)(4)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400-2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

i. Different information must be transmitted to each receiver.

ii. If the transmitter employs an antenna system that emits multiple directional beams but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna /antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

A. The directional gain shall be calculated as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

B. A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.

iii. If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.

iv. Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

e) For digitally modulated systems, 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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The digital modulation operation of the hybrid system, with the frequency hopping turned off, shall comply with the power density requirements of paragraph (d) of this section.

g) Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

i) Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See § 1.1307(b)(1) of this Chapter.

Note: Spread spectrum systems are sharing these bands on a noninterference basis with systems supporting critical Government requirements that have been allocated the usage of these bands, secondary only to ISM equipment operated under the provisions of Part 18 of this Chapter. Many of these Government systems are airborne radiolocation systems that emit a high EIRP which can cause interference to other users. Also, investigations of the effect of spread spectrum interference to U. S. Government operations in the 902-928 MHz band may require a future decrease in the power limits allowed for spread spectrum operation.

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, 2023. 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	5 VDC from batteries in normal use, for testing, an external DC power supply was used operating from 120 VAC/60 Hz

4.2 Operating Modes

The EUT was tested on 3 orthogonal axes and with the EUT constantly transmitting a modulated signal at the maximum power setting. The worst-case fundamental emissions were with the EUT standing on its long edge, and worst-case harmonic emissions were with the EUT place flat on the table. See Section 8 for reference photos.

4.3 EUT Exercise Software

CA Engineering software was used to control and exercise the transmitter.

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	902-928 (Center Frequency 912.0)	Complied
15.247(b)	Peak Output Power	902-928 (Center Frequency 912.0)	Complied
15.247(d)	Radiated Spurious Emissions	0.009 – 10000 (Center Frequency 912.0)	Complied
15.247(e)	Peak Power Spectral Density	902-928 (Center Frequency 912.0)	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.

6.2 Test Results

6.2.1 §15.203 Antenna Requirements

The EUT uses a meandering trace on the PCB as an antenna.

Result

The EUT complied with the specification.

6.2.2 §15.207 Conducted Emissions at AC Mains Ports

Hot Lead

Frequency (MHz)	Detector	Receiver Reading (dBµV)	Correction Factor (dB)	Measured Level (dBµV)	Class B Limit (dBµV)	Margin (dB)
0.24	Peak (Note 1)	29.1	9.8	39.0	52.0	-13.1
0.43	Peak (Note 1)	27.7	9.8	37.5	47.3	-9.8
0.53	Quasi-Peak (Note 2)	32.6	10.0	42.6	56.0	-13.5
0.53	Average (Note 2)	28.6	10.0	38.6	46.0	-7.5
0.94	Peak (Note 1)	25.1	9.8	35.0	46.0	-11.0
1.1	Peak (Note 1)	23.6	9.8	33.5	46.0	-12.5
1.7	Peak (Note 1)	22.6	9.9	32.5	46.0	-13.5
2.4	Peak (Note 1)	22.8	9.9	32.7	46.0	-13.3
3.0	Peak (Note 1)	21.7	9.9	31.6	46.0	-14.5
3.7	Peak (Note 1)	22.4	9.9	32.3	46.0	-13.7
4.4	Peak (Note 1)	22.0	9.9	31.9	46.0	-14.1
5.1	Peak (Note 1)	21.5	9.9	31.4	50.0	-18.6
18.6	Peak (Note 1)	15.6	10.4	26.0	50.0	-24.0

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.

Neutral Lead

Frequency (MHz)	Detector	Receiver Reading (dBµV)	Correction Factor (dB)	Measured Level (dBµV)	Class B Limit (dBµV)	Margin (dB)
0.44	Peak (Note 1)	24.5	9.8	34.3	47.1	-12.8

Frequency (MHz)	Detector	Receiver Reading (dBµV)	Correction Factor (dB)	Measured Level (dBµV)	Class B Limit (dBµV)	Margin (dB)
0.52	Peak (Note 1)	30.7	9.8	40.5	46.0	-5.5
0.90	Peak (Note 1)	21.5	9.8	31.4	46.0	-14.6
1.1	Peak (Note 1)	20.2	9.8	30.0	46.0	-16.0
1.5	Peak (Note 1)	19.1	9.9	28.9	46.0	-17.1
2.3	Peak (Note 1)	19.5	9.9	29.4	46.0	-16.6
3.8	Peak (Note 1)	19.5	9.9	29.4	46.0	-16.6
5.8	Peak (Note 1)	18.5	10.0	28.5	50.0	-21.6
9.4	Peak (Note 1)	16.4	10.1	26.5	50.0	-23.6
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

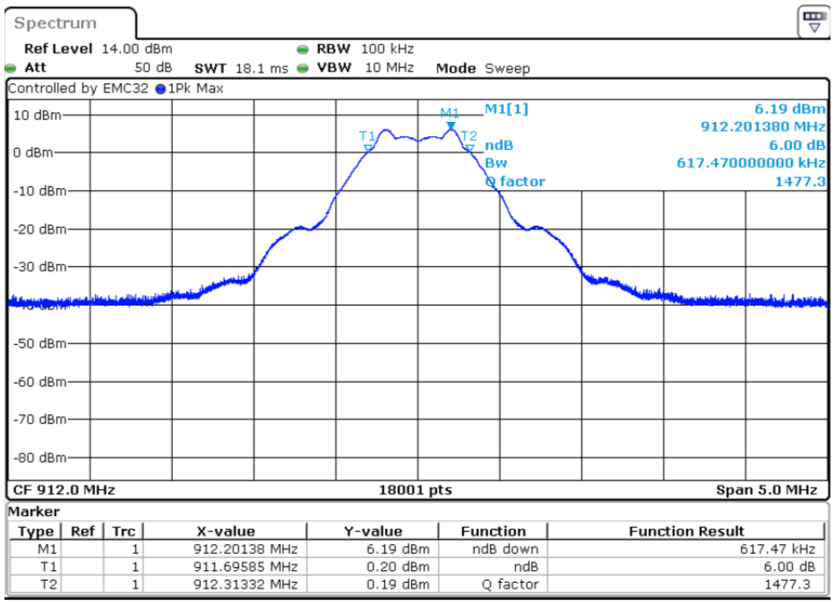
The EUT complied with the specification limit by a margin of 5.5 dB.

6.2.3 §15.247(a)(2) Emissions Bandwidth

Frequency (MHz)	Emissions 6 dB bandwidth (kHz)
912.0	617.5

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 plot below).



Graph 1: 912 MHz Fundamental Field Strength

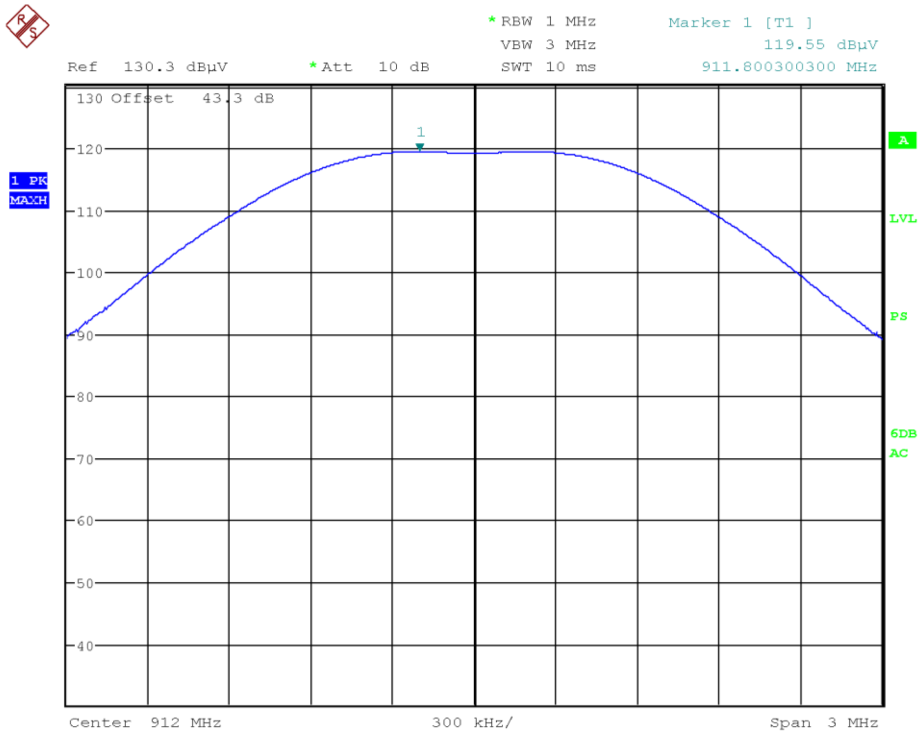
6.2.4 §15.247(b)(3) Peak Output Power

The maximum peak RF power measured using radiated methods. The field strength measurements were converted to EIRP using the equation 1.1 of FCC KDB 412172. The antenna gain was then subtracted from the calculated EIRP to give a calculated conducted power and compared to the limit of 1 Watt. The antenna has a maximum gain of -1.26 dBi.

Frequency (MHz)	Measured Field Strength (dBμV/m)	EIRP (mW)	EIRP (dBm)	Calculated Conducted Power (dBm)	Calculated Conducted Power (W)
912.0	119.6	273.6	24.4	25.7	0.3715

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 2: 912 MHz Fundamental Field Strength

6.2.5 §15.247(d) Spurious Emissions

Radiated Spurious Emissions

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 harmonic emissions. 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. Additional emissions from the digital circuitry and receivers of the EUT are shown in separate testing and found compliant in VPI Laboratories, Inc. report V067190_1.

Result

All emissions 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)
1824.0	Peak	Vertical	37.0	3.7	40.7	74.0	-33.3
1824.0	Average	Vertical	35.0	3.7	38.7	54.0	-15.3
1824.0	Peak	Horizontal	42.1	3.7	45.8	74.0	-28.2
1824.0	Average	Horizontal	41.1	3.7	44.8	54.0	-9.2
2736.0	Peak	Vertical	31.1	5.9	37.0	74.0	-37.0
2736.0	Average	Vertical	26.7	5.9	32.6	54.0	-21.4

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2736.0	Peak	Horizontal	32.9	5.9	38.8	74.0	-35.2
2736.0	Average	Horizontal	29.5	5.9	35.4	54.0	-18.6
3648.0	Peak	Vertical	29.7	8.6	38.3	74.0	-35.7
3648.0	Average	Vertical	26.2	8.6	34.9	54.0	-19.1
3648.0	Peak	Horizontal	29.3	8.6	37.9	74.0	-36.1
3648.0	Average	Horizontal	26.5	8.6	35.2	54.0	-18.8
4560.0	Peak	Vertical	30.7	9.5	40.2	74.0	-33.8
4560.0	Average	Vertical	26.3	9.5	35.8	54.0	-18.2
4560.0	Peak	Horizontal	31.4	9.5	40.9	74.0	-33.1
4560.0	Average	Horizontal	26.0	9.5	35.5	54.0	-18.5
5472.0	Peak	Vertical	30.8	11.2	42.1	74.0	-31.9
5472.0	Average	Vertical	25.5	11.2	36.7	54.0	-17.3
5472.0	Peak	Horizontal	29.5	11.2	40.8	74.0	-33.3
5472.0	Average	Horizontal	26.3	11.2	37.5	54.0	-16.5
6384.0	Peak	Vertical	29.3	12.3	41.6	74.0	-32.4
6384.0	Average	Vertical	26.4	12.3	38.7	54.0	-15.3
6384.0	Peak	Horizontal	31.2	12.3	43.5	74.0	-30.5
6384.0	Average	Horizontal	26.9	12.3	39.2	54.0	-14.8
7296.0	Peak	Vertical	29.0	15.4	44.4	74.0	-29.6
7296.0	Average	Vertical	25.6	15.4	40.9	54.0	-13.1
7296.0	Peak	Horizontal	29.0	15.4	44.4	74.0	-29.6
7296.0	Average	Horizontal	22.9	15.4	38.3	54.0	-15.7
8208.0	Peak	Vertical	28.1	17.5	45.6	74.0	-28.4
8208.0	Average	Vertical	25.8	17.5	43.3	54.0	-10.7
8208.0	Peak	Horizontal	28.5	17.5	46.0	74.0	-28.0
8208.0	Average	Horizontal	25.6	17.5	43.1	54.0	-11.0
9120.0	Peak	Vertical	24.6	19.4	44.0	74.0	-30.1
9120.0	Average	Vertical	21.4	19.4	40.8	54.0	-13.2
9120.0	Peak	Horizontal	27.3	19.4	46.7	74.0	-27.3
9120.0	Average	Horizontal	22.7	19.4	42.0	54.0	-12.0

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
*Emission is not in the restricted bands but was compared to the lower limit of the restricted bands.							

Table 2: Transmitting at 912.0 MHz

Conducted Spurious Emissions

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 harmonic emissions. Emissions outside the restricted bands must be attenuated 20 dB from the peak fundamental when using a 100 kHz RBW. The peak conducted fundamental power was measured to be 4.9dBm, and harmonics must be attenuated below 4.9 – 20 = -15.1dBm.

Result

All harmonic emissions are attenuated by at least 20dB from the fundamental; therefore, the EUT complies with the specification.

Frequency (MHz)	Corrected Level (dBm)	Criteria (dBm)	Margin (dB)
1824.0	-47.8	-15.1	-32.7
2736.0	-61.0	-15.1	-45.9
3648.0	-74.5	-15.1	-59.4
4560.0	-77.6	-15.1	-62.5
5472.0	-66.7	-15.1	-51.6
6384.0	-75.1	-15.1	-60.0
7296.0	-76.9	-15.1	-61.8
8208.0	-65.8	-15.1	-50.7
9120.0	-81.2	-15.1	-66.1

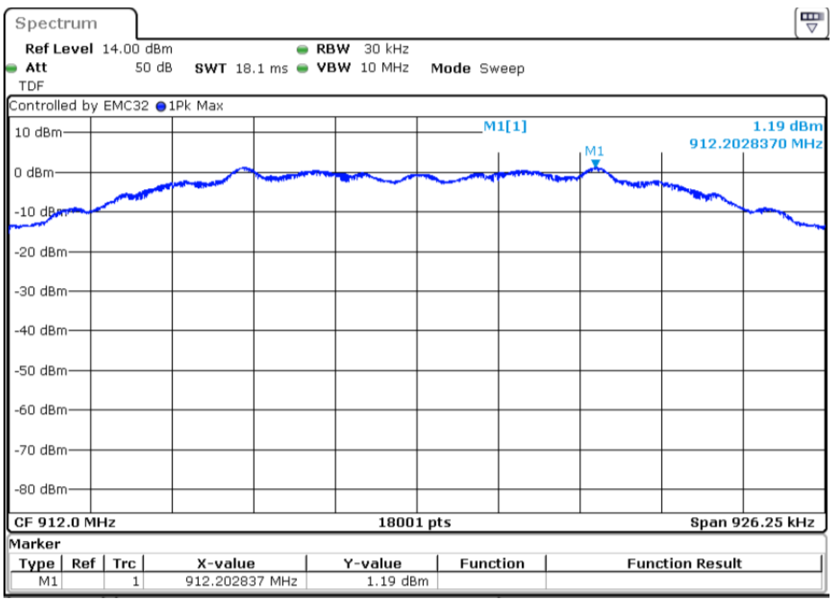
6.2.6 §15.247(e) Peak Power Spectral Density

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 are shown from antenna-port conducted measurements according to ANSI C63.10 method 11.10.2 with a RBW of 30kHz. EUT contains an antenna with maximum gain of -1.26dBi which is accounted for along with measurement cable loss via Transducer Factors.

Frequency (MHz)	Conducted Peak PSD (dBm)	Criteria (dBm)
912.0	1.2	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 3: PSD of EUT Transmitting at 912.0

6.3 Sample Field Strength Calculation

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.

$$Receiver\ Amplitude\ Reading\ =\ 20.8\ \mathrm{dB\mu V}$$
$$Correction\ Factor\ =\ 10.1 + 0.3\ =\ 10.4\ \mathrm{dB}$$
$$Conducted\ Emissions\ Value\ =\ 20.8 + 10.4\ =\ 31.2\ \mathrm{dB\mu V}$$

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	08/24/2022	08/24/2023
Spectrum Analyzer/ Signal Analyzer	Rohde & Schwarz	FSV40	V044352	03/08/2022	03/08/2023
LISN	Teseq	NNB 51	V045406	12/05/2022	12/05/2023
Conductance Cable Wanship Upper Site	VPI Labs	Cable J	V034832	12/23/2022	12/23/2023
EMC32 Test Software	Rohde & Schwarz	10.60.20	N/A	N/A	N/A

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

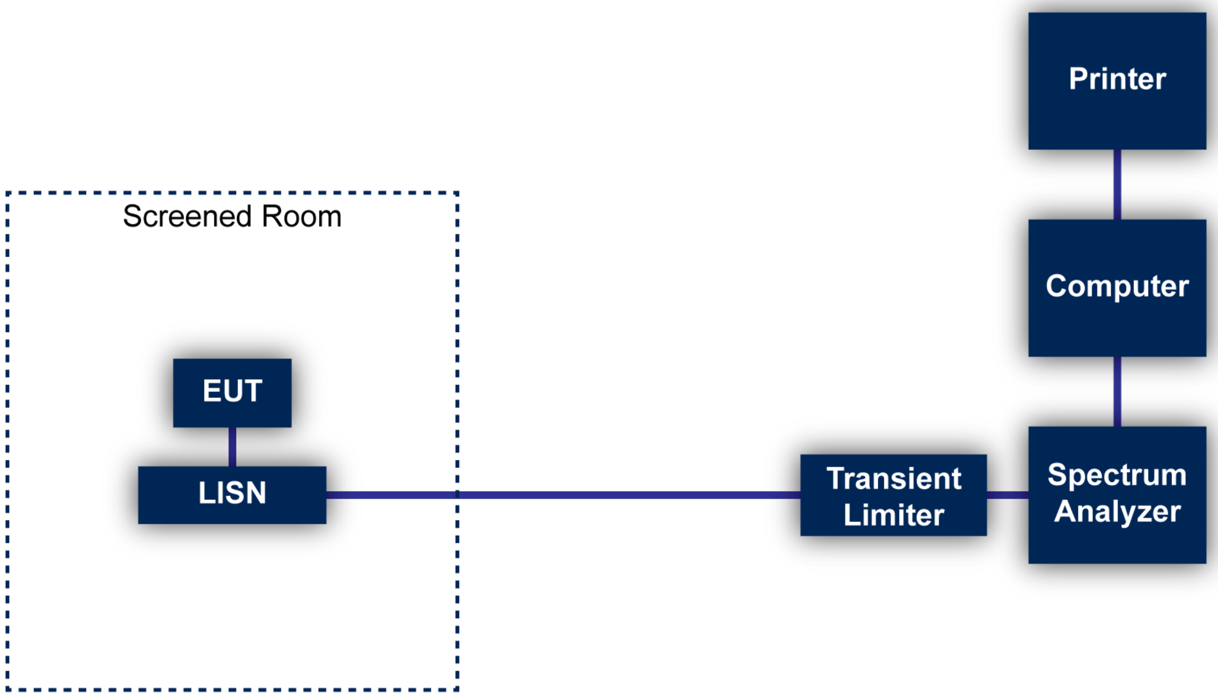


Figure 1: Conducted Emissions Test

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 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 distance of 3 meters 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	08/24/2022	08/24/2023
Spectrum Analyzer/ Signal Analyzer	Rohde & Schwarz	FSV40	V044352	03/08/2022	03/08/2024
Biconilog Antenna	EMCO	3142E	V057461	07/21/2021	07/21/2023
3142E Power Amplifier	EMCO	3142E-PA	V036056	05/19/2022	05/19/2023
Double Ridged Guide Antenna	EMCO	3115	V034413	01/25/2023	01/25/2025
High Frequency Amplifier	Miteq	AFS4-001018000-35-10P-4	V033997	12/23/2022	12/23/2023
6' High Frequency Cable	Microcoax	UFB197C-0-0720-000000	V033638	12/23/2022	12/23/2023
20' High Frequency Cable	Microcoax	UFB197C-1-3120-000000	V033979	12/23/2022	12/23/2023
3 Meter Radiated Emissions Cable Wanship Upper Site	Microcoax	UFB205A-0-4700-000000	V033639	12/23/2022	12/23/2023
10 Meter Radiated Emissions Cable Wanship Upper Site	VPI Labs	Cable L	V033649	12/23/2022	12/23/2023
EMC32 Test Software	Rohde & Schwarz	10.60.20	N/A	N/A	N/A

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

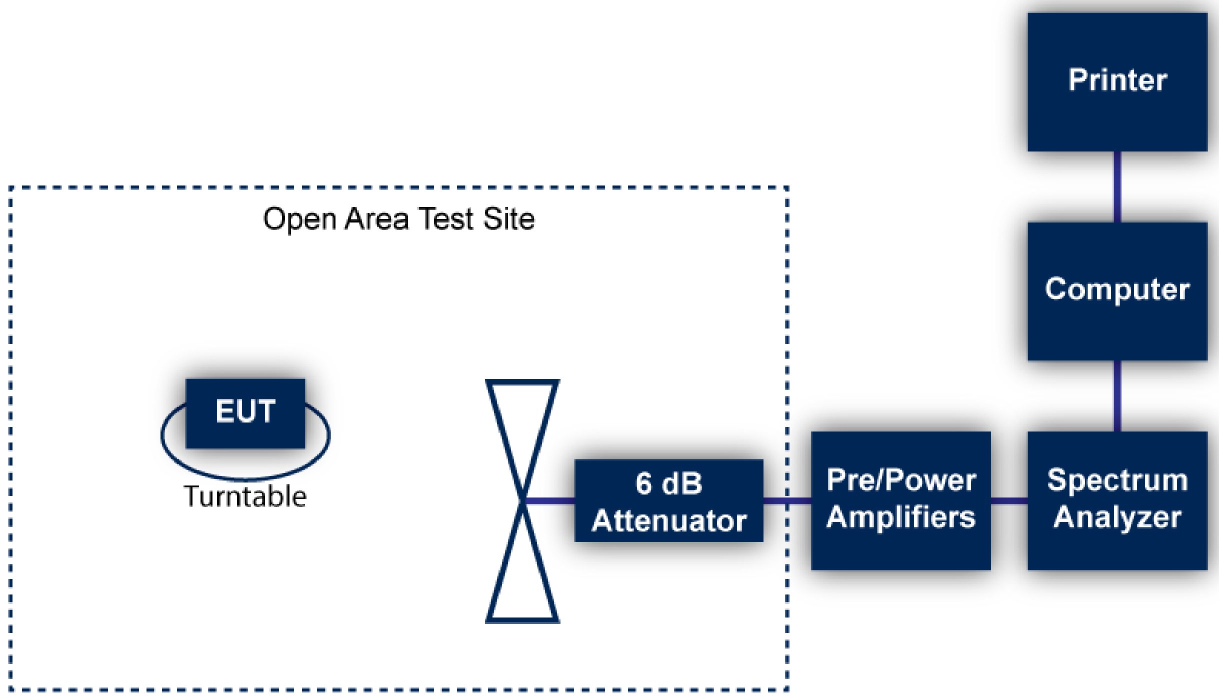


Figure 2: Radiated Emissions Test

7.3 Direct Connection at the Antenna Port Tests

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
Spectrum Analyzer/ Signal Analyzer	Rohde & Schwarz	FSV40	V044352	03/08/2022	03/08/2023
6 dB Attenuator	Pasternack	PE7004-6	V033645	12/23/2022	12/23/2023
“DUT 5” Cable	N/A	N/A	V034173	12/23/2022	12/23/2023

7.3.1 Test Configuration Block Diagram

Figure 3: Direct Connection at the Antenna Port Test

7.4 Equipment Calibration

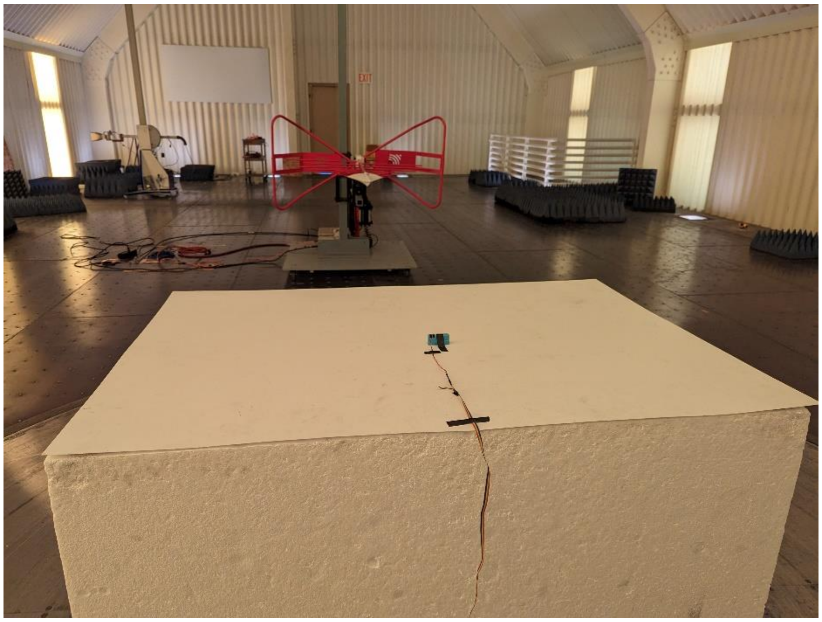
All applicable equipment is calibrated using either an independent calibration laboratory or VPI Laboratories, Inc. personnel at intervals defined in ANSI C63.4:2014 following outlined calibration procedures. All measurement instrumentation is traceable to the National Institute of Standards and Technology (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

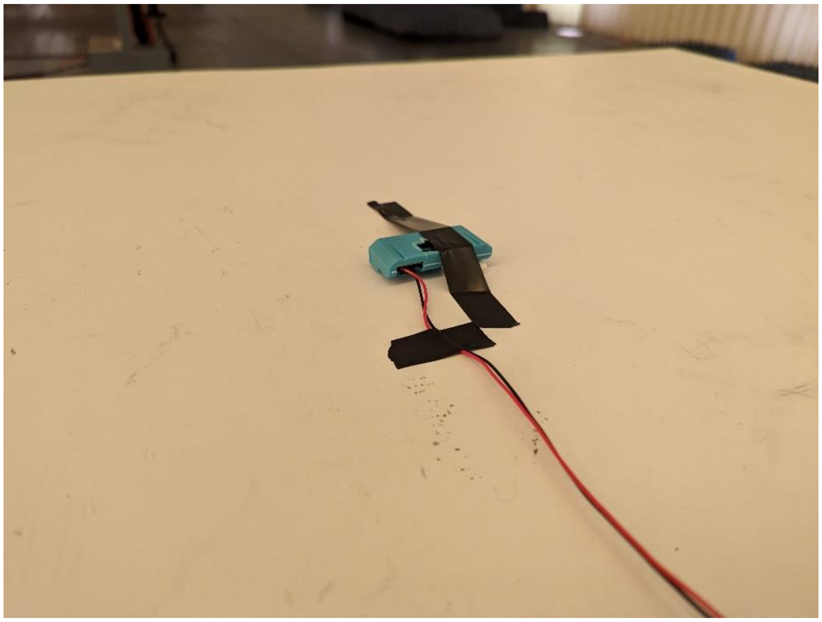
Photograph 1: Front View Radiated Emissions Worst-Case Configuration – 30 to 1000 MHz



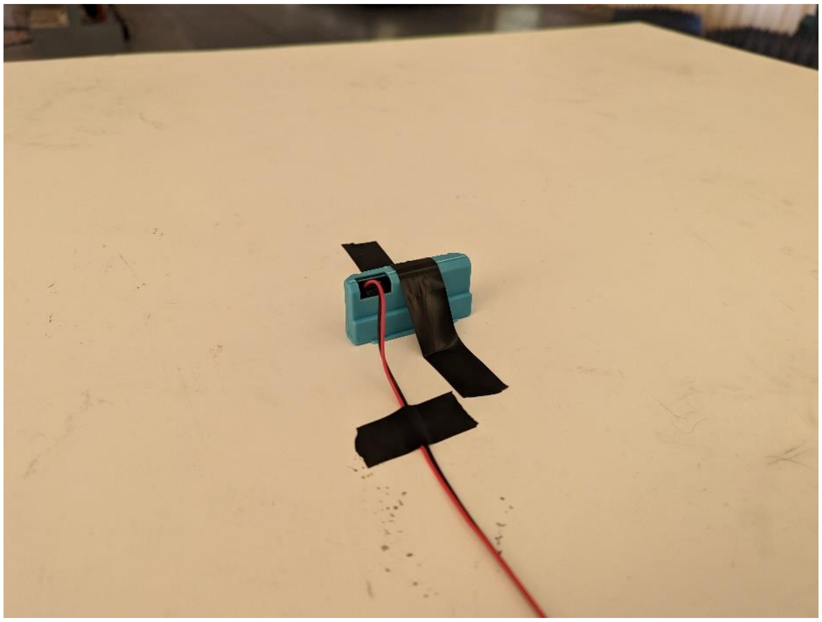
Photograph 2: Back View Radiated Emissions Worst-Case Configuration – 30 to 1000 MHz

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

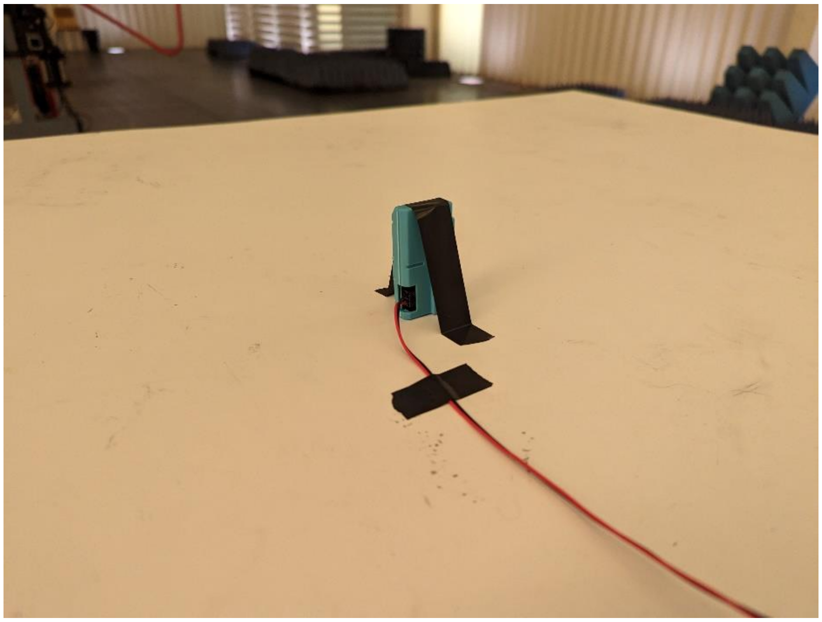
Photograph 4: Back View Radiated Emissions Worst-Case Configuration – Above 1000 MHz



Photograph 5: Laying Flat Placement on the Table

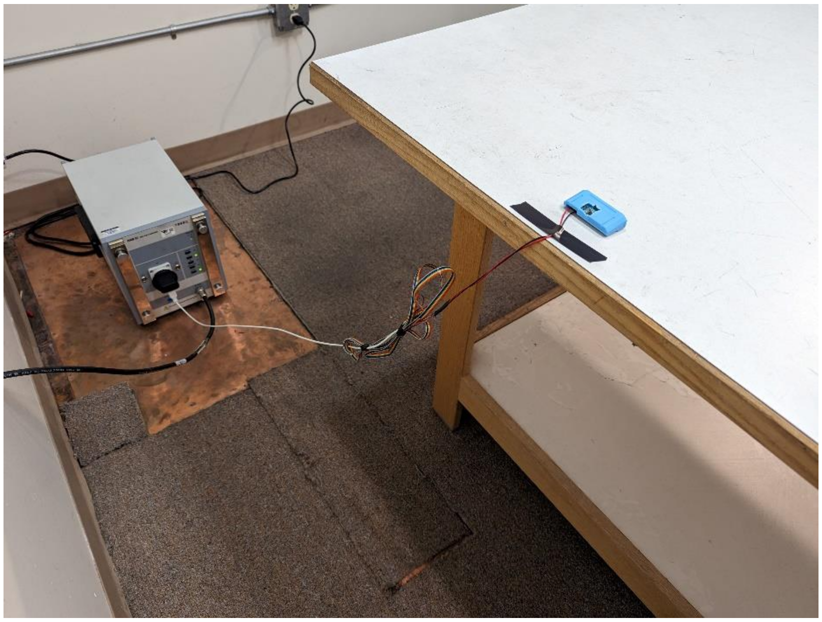


Photograph 6: On Long Edge Placement on the Table

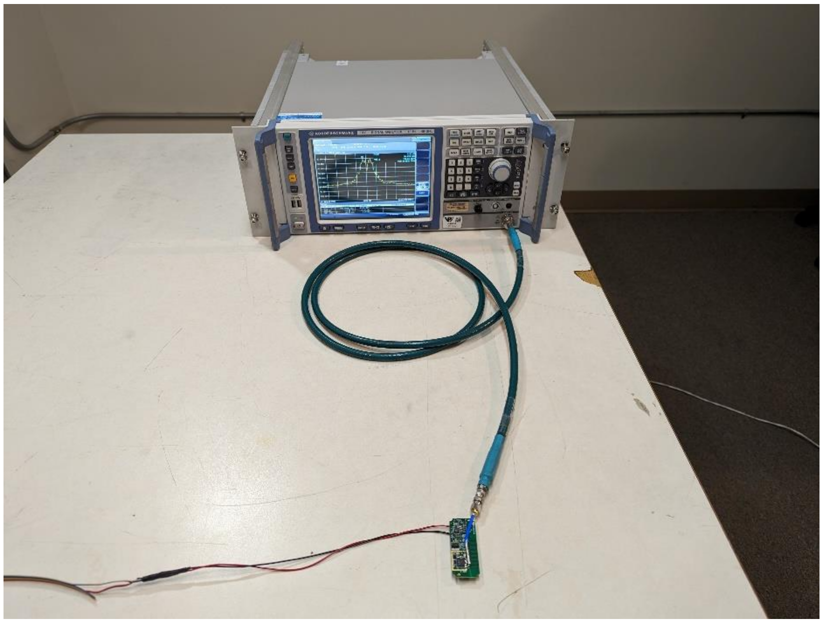


Photograph 7: On Short Edge Placement on the Table

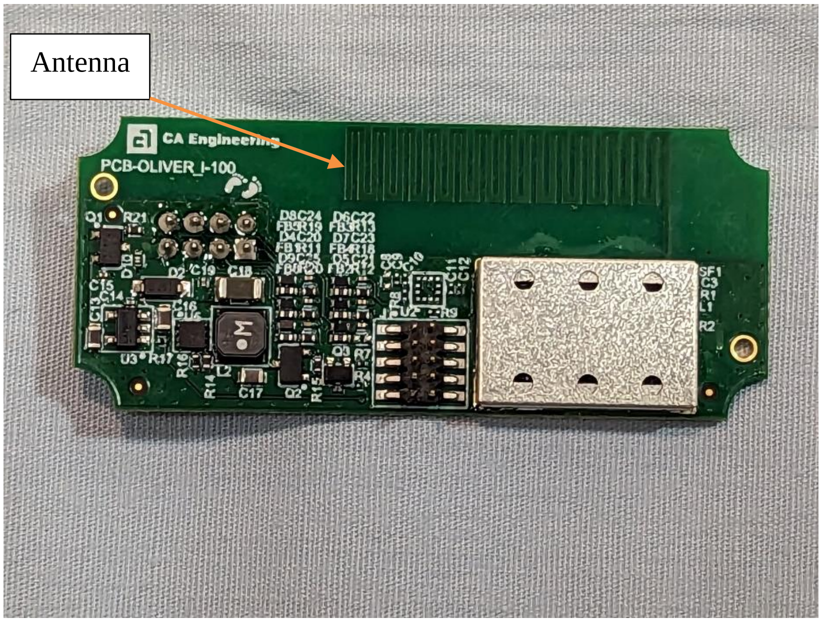
Photograph 8: Front View Conducted Emissions Worst-Case Configuration



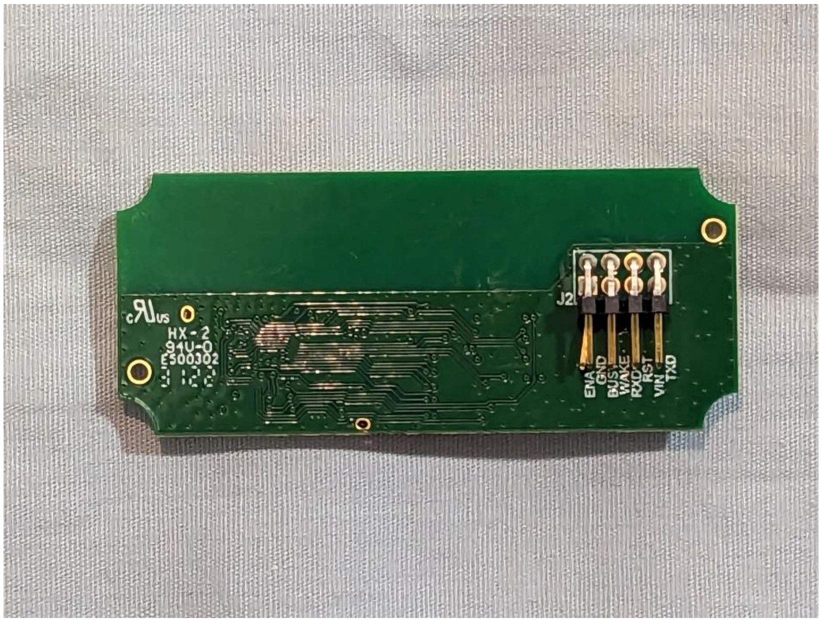
Photograph 9: Back View Conducted Emissions Worst-Case Configuration



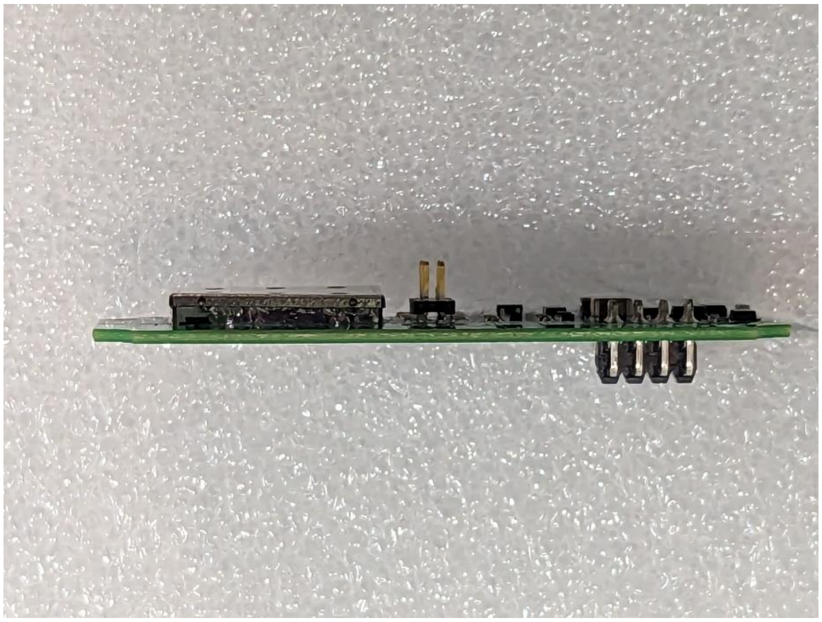
Photograph 10: View of Conducted Measurements Test Setup at the Antenna Port



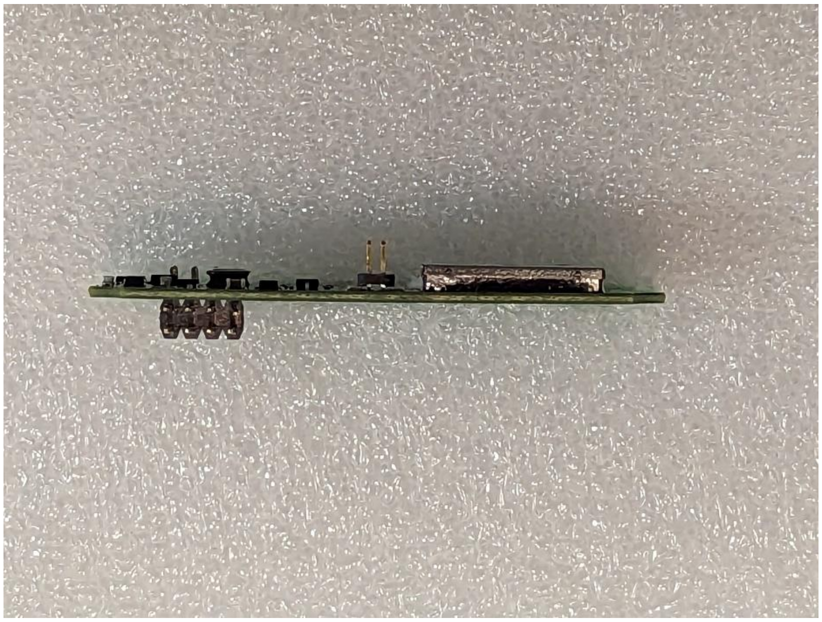
Photograph 11: Top View of the EUT with RF Shield In Place



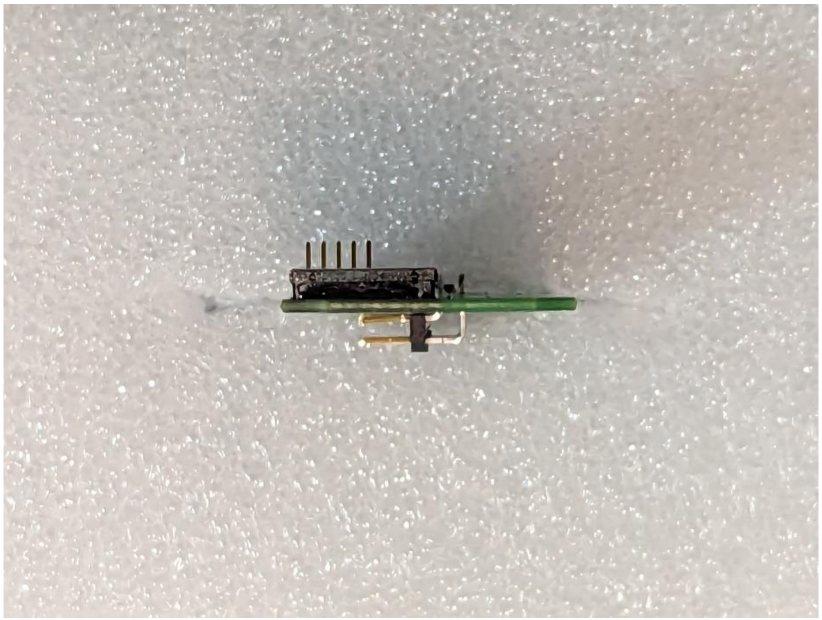
Photograph 12: Bottom View of the EUT



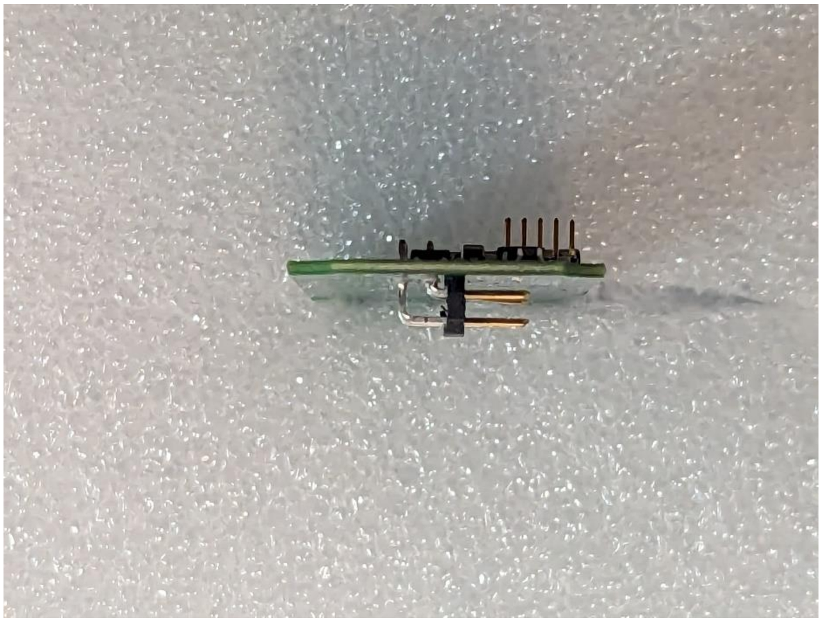
Photograph 13: Long Edge View 1



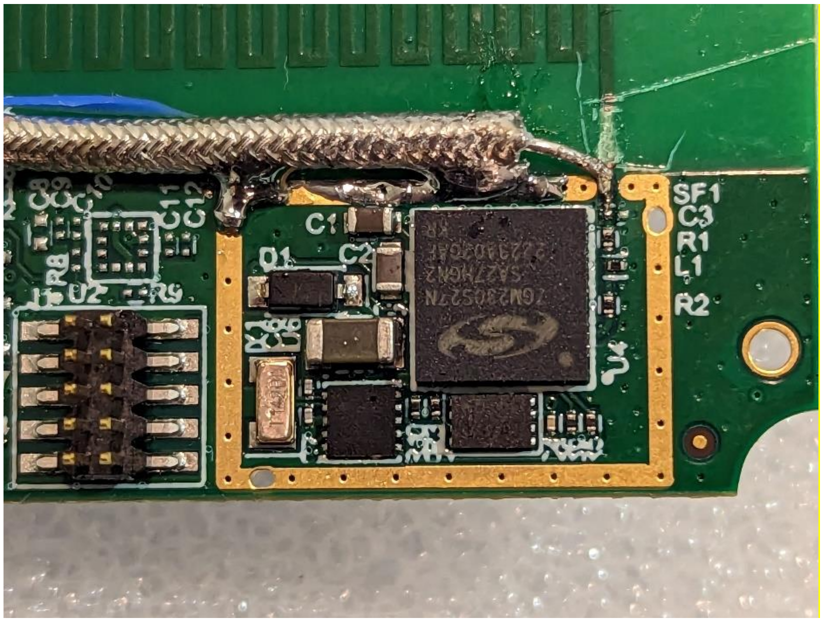
Photograph 14: Long Edge View 2



Photograph 15: Short Edge View 1

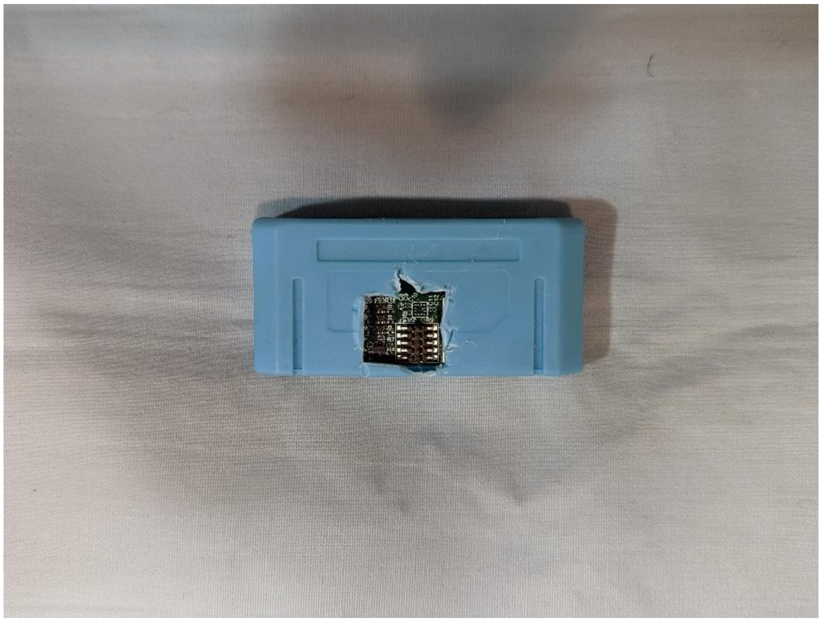


Photograph 16: Short Edge View 2

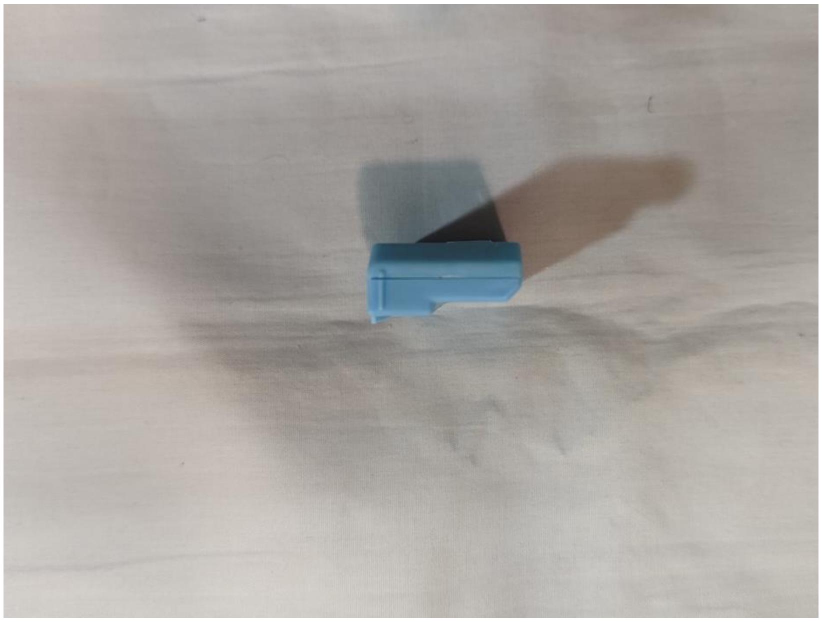


Photograph 17: View of the Circuitry Under the RF Shield

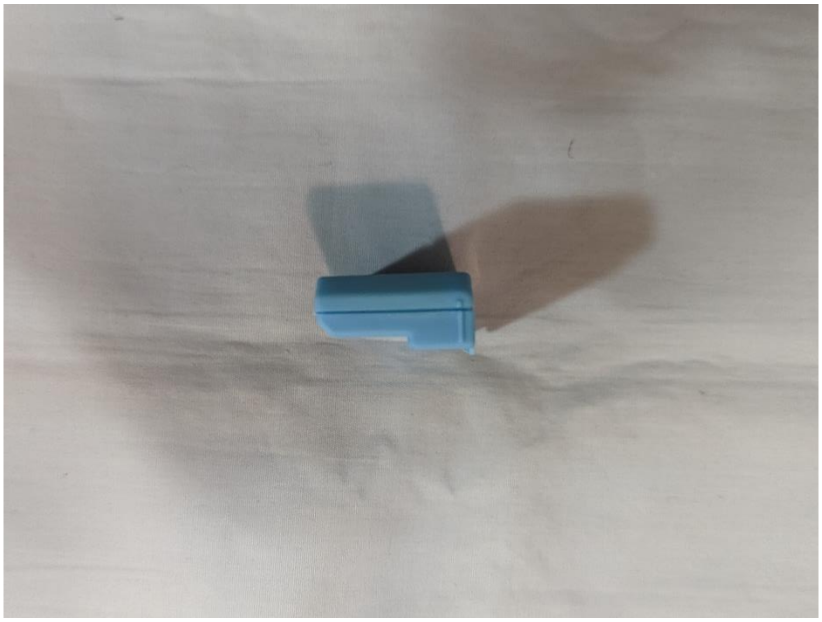
Photograph 18: Front View of the EUT in the Housing



Photograph 19: Back View of the EUT in the Housing

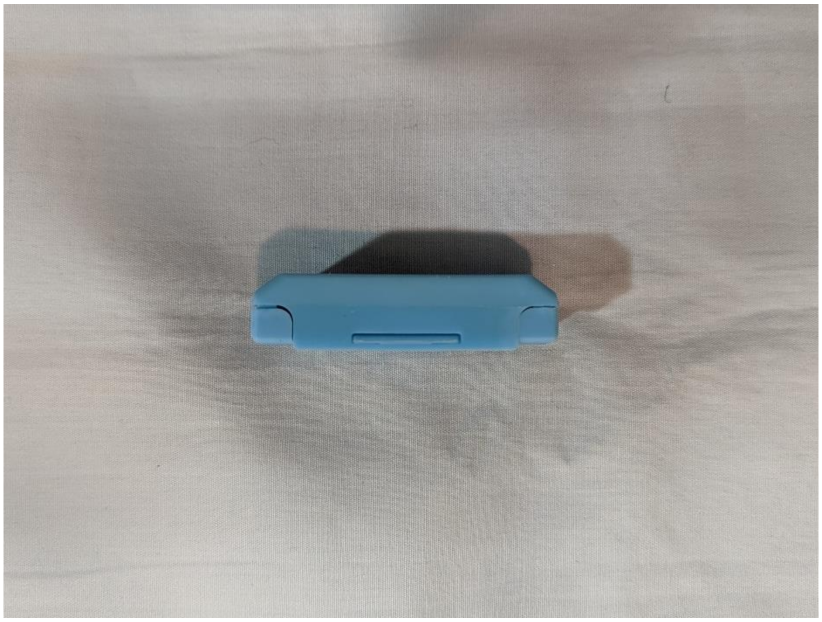


Photograph 20: Side View of the EUT in the Housing

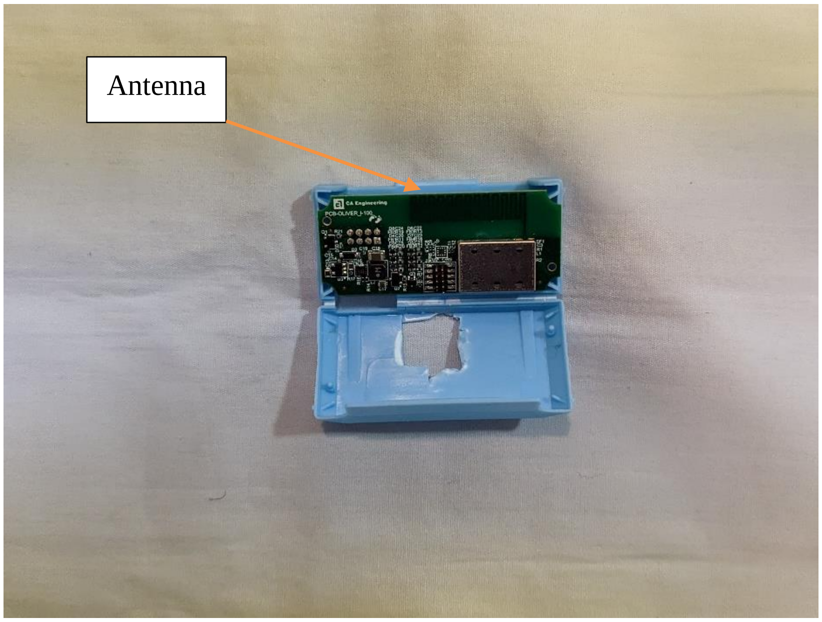


Photograph 21: Side View of the EUT in the Housing

Photograph 22: Side View of the EUT in the Housing

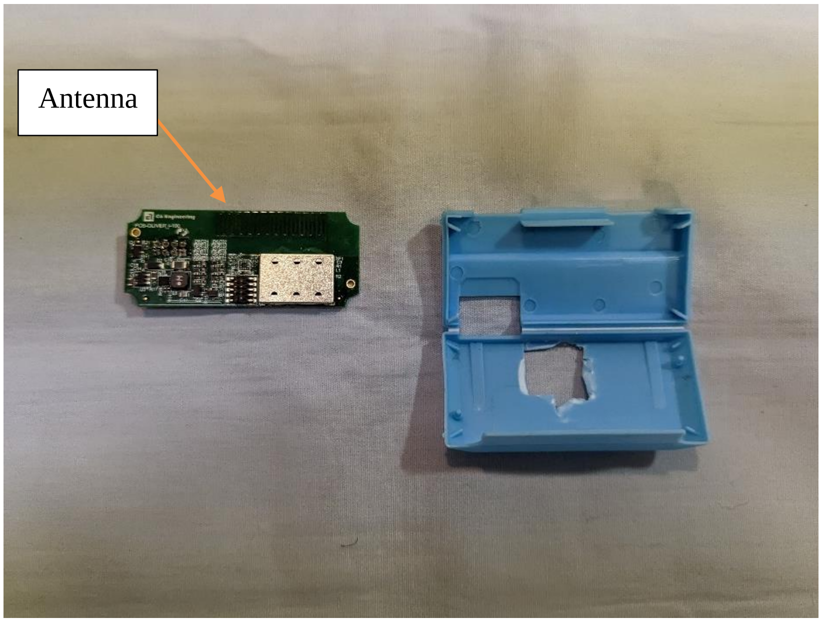


Photograph 23: Side View of the EUT in the Housing



Photograph 24: View 1 of the EUT in the Housing

Photograph 25: View 2 of the EUT in the Housing



Photograph 26: View of the EUT and the Housing

--- End of Report ---