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Test Report

Certification

FCC ID	SZV-EMDCU
Equipment Under Test	EMDCU
Test Report Serial No	V049983_01
Date of Test	November 13, 2019
Report Issue Date	November 14, 2019

Test Specifications:	**Applicant:**
FCC Part 15, Subpart C	EnOcean GmbH Kolpingring 18A Oberhaching 82041 Germany

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 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	EnOcean GmbH
Manufacturer	EnOcean GmbH
Brand Name	EnOcean
Model Number	EMDCU
FCC ID	SZV-EMDCU

On this 14th day of November 2019, 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: Norman P. Hansen

Reviewed by: Benjamin N. Antczak

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Revision History		
Revision	**Description**	**Date**
01	Original Report Release	November 14, 2019

Table of Contents

1 Client Information

1.1 Applicant

Company Name	EnOcean GmbH Kolpingring 18A Oberhaching 82041 Germany
Contact Name	Armin Anders
Title	Director Product Marketing

1.2 Manufacturer

Company Name	EnOcean GmbH Kolpingring 18A Oberhaching 82041 Germany
Contact Name	Armin Anders
Title	Director Product Marketing

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2 Equipment Under Test (EUT)

2.1 Identification of EUT

Brand Name	EnOcean
Model Number	EMDCU
Serial Number	None
Dimensions (cm)	11.0 x 6.0 x 2.5

2.2 Description of EUT

The EMDCU is a motion and illumination sensor with a 902.875 MHz transmitter for system interfacing. The EMDCU is powered by a solar cell with a CR2032 battery to assist in low light installations. The 902.875 MHz transmitter is a momentarily operated, pulsed emission device that sends 3 FSK modulated pulses out at each transmission. The antenna is a wire that is soldered to the PCB.

This report covers the transmitter circuitry of the devices subject to FCC Part 15, Subpart C. The circuitry of the device subject to FCC Subpart B was found to be compliant and is covered in VPI Laboratories, Inc. report V049982.

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: EnOcean MN: EMDCU (Note 1) SN: None	Motion and Illumination Sensor	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

The following modifications were made to the EUT by the Client during testing to comply with the specification. This report is not complete without an accompanying signed attestation, that the product will have all of the documented modifications incorporated into the product when manufactured and placed on the market.

- The power setting was changed to a setting of 12 in firmware and is not accessible to the user.

2.6 Deviation from Test Standard

There were no deviations from the test specification.

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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.

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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

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VPI Laboratories, Inc. is accredited by National Voluntary Laboratory Accreditation Program (NVLAP); NVLAP Lab Code: 100272-0, which is effective until September 30, 2020. VPI Laboratories, Inc. carries FCC Accreditation Designation Number US5263. VPI Laboratories main office is located at 313 W 12800 S, Draper, UT 84020. The testing was performed according to the procedures in ANSI C63.10-2013, KDB 558074, and 47 CFR Part 15.

4 Operation of EUT During Testing

Power Supply	3 VDC from solar cell, storage capacitor, and battery

4.1 Operating Modes

The transmitter was tested on 3 orthogonal axes while in a constant transmit mode. To make sure the EUT maintained full battery power throughout the testing, two AA batteries were connected to the EUT with two 10 cm wires soldered to the PCB.

4.2 EUT Exercise Software

Internal firmware was used to control the transmitter for testing.

5 Summary of Test Results

5.1 FCC Part 15, Subpart C

5.1.1 Summary of Tests

Part 15, Subpart C Reference	Test Performed	Frequency Range (MHz)	Result
15.203	Antenna Requirement	N/A	Complied
15.207	Emissions at the AC Mains	0.15 – 30	Not Applicable
15.231 (a)	Periodic Operation	902.875	Complied
15.231 (b)	Radiated Emissions	0.009 – 9030	Complied
15.231 (c)	Bandwidth	902.875	Complied
15.231 (d)	Frequency Stability	40.66 – 40.70	Not Applicable
15.231 (e)	Radiated Emissions – Reduced Field Strengths	0.009 – 9030	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 Results

6.2.1 §15.203 Antenna Requirements

The antenna is a wire soldered to the PCB inside the EUT housing.

Result

The EUT complied with the specification

6.2.2 §15.207 Emissions at the AC Mains

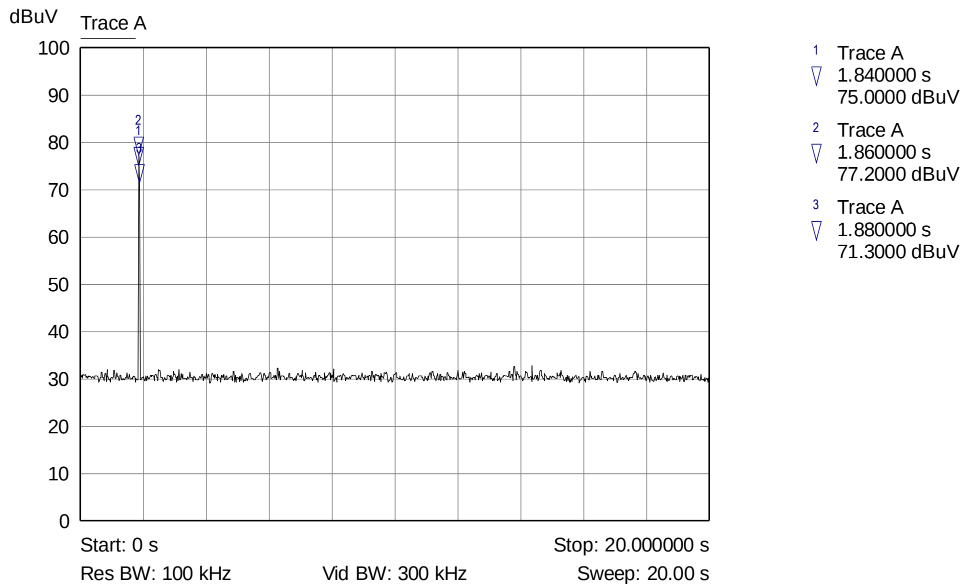
The EUT has no provision for connecting to the AC mains or a device that connects to the AC mains.

Result

This test is not applicable.

6.2.3 §15.231 (a)

1) The EUT is not manually activated.
2) The EUT is automatically activated. The EUT is active when changes in motion or illumination are sensed. The transmission ceases after 3 pulses are sent. See the plot below.



Graph 1: Plot Showing EUT ceases transmission within 5 seconds of activation if automatically activated

3) The EUT does not transmit at regular predetermined intervals.
4) The EUT may be used during an emergency that involves fire and safety of life.
5) The EUT must be paired to a receiver. A plot of the pairing emission is less than 10 seconds is shown below.

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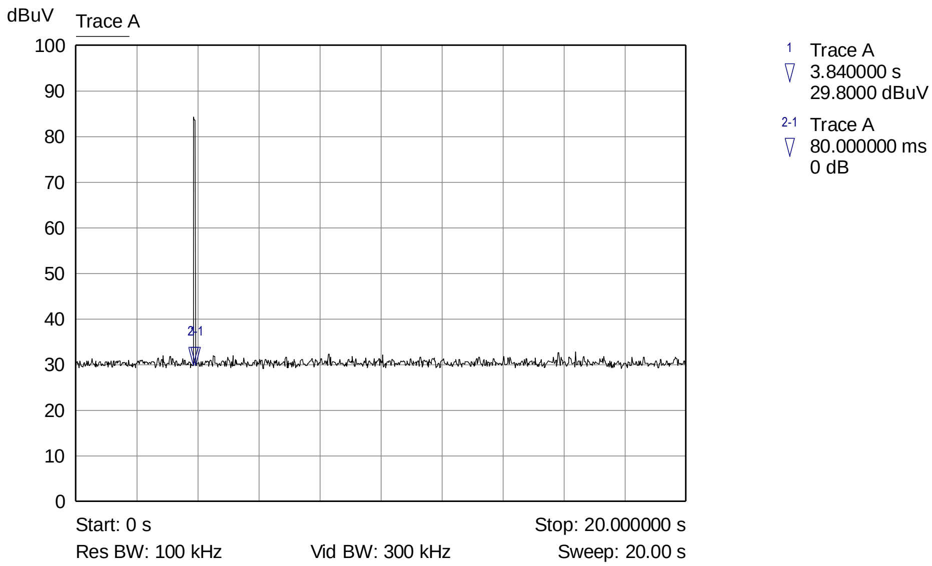


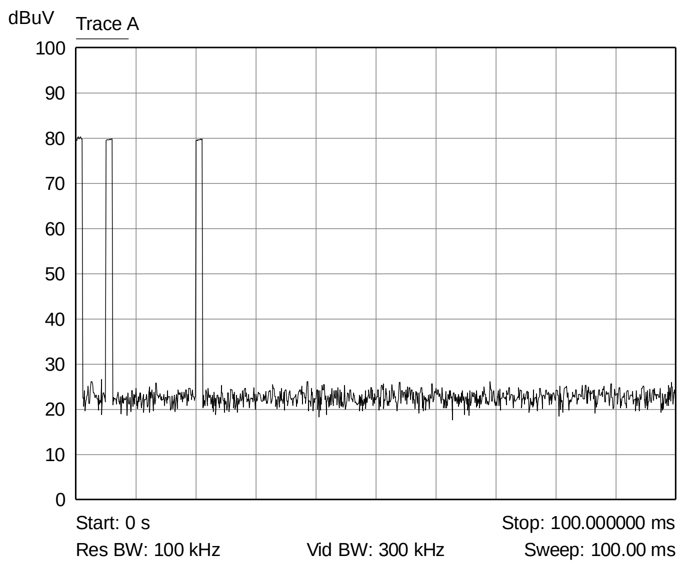
Graph 2: Plot Showing EUT Pairing Transmission

Result

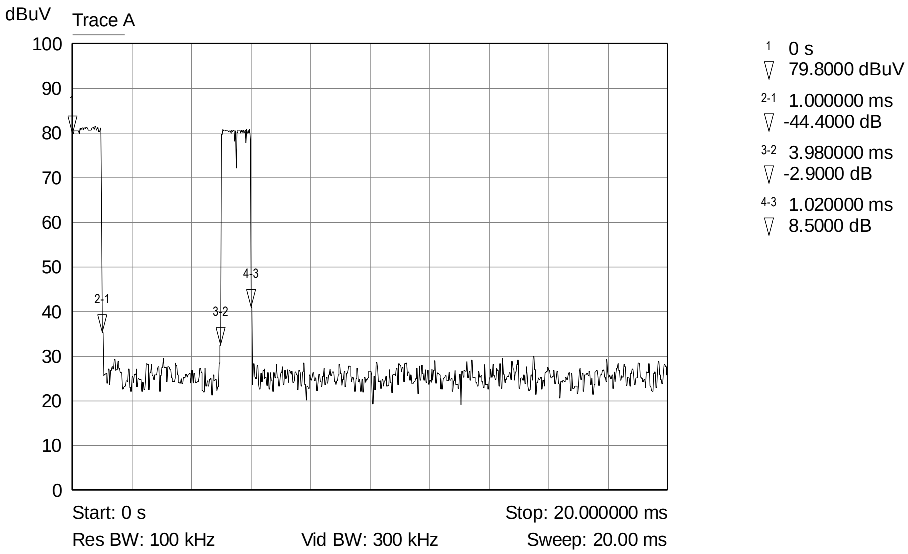
In the configuration tested, the EUT complied with the requirements of this section.

6.2.4 §15.35 (b) Averaging Factor

The EMDCU transmitter is a pulsed emission device using FSK modulation; therefore, the method of §15.35 for averaging a pulsed emission may be used. A timing diagram of the pulsed transmission, plots of the pulse train, and the average factor calculations are shown below.



Graph 3: Plot of the 100 ms Used for Average Factor Calculations



Graph 4: Plot Showing Pulse Width

Average factor calculation

The Average Factor will be calculated using 100 ms as specified in FCC §15.35(c). Each pulse has a maximum duration of 1.02 ms.

The Average Factor is calculated by the equation:

Average Factor = 20 log (on time/pulse train time)

Pulse train time = 100 ms

On time = 3 pulses x 1.02 ms = 3.06 ms

Average Factor = 20 log (3.06 / 100) = -30.3 dB

§15.35(b) specifies a 20 dB maximum between the peak and average measurements; therefore, a 20 dB averaging factor will be used.

6.2.5 §15.231 (b) Radiated Emissions Measurements

The EMDCU operates at 902.875 MHz, therefore; the average field strength of the fundamental must be less than 12500 µV/m (81.9 dBµV/m) at 3 meters. The maximum permitted field strength of any unwanted emission must be 20 dB below the maximum allowable fundamental field strength 61.9 dBµV/m).

Emissions in the restricted bands of §15.205 must meet the limits specified in §15.209.

Measurement Data Fundamental and Harmonic Emissions

The frequency range from the lowest frequency used in the device to the tenth harmonic of the highest fundamental frequency was investigated to measure any radiated emissions. Measurements were taken using Peak detection and then reduced by the Averaging Factor for comparison to the limits.

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EUT Placed Vertical on the Table – (Vertical Polarity)

Frequency (MHz)	Detector	Receiver Reading (dBμV)	Correction Factor (dB/m)	Averaging Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Delta (dB)
902.875	Peak	64.3	36.6	-20.0	80.9	81.9	-1.0
1805.750	Peak	38.3	1.2	-20.0	19.5	61.9	-42.4
2708.625*	Peak	35.1	4.2	-20.0	19.3	54.0	-34.7
3611.500*	Peak	38.3	6.8	-20.0	25.1	54.0	-28.9
4514.375*	Peak	38.7	7.7	-20.0	26.4	54.0	-27.6
5417.250*	Peak	40.9	9.4	-20.0	30.3	54.0	-23.7
6320.125	Peak	34.1	10.7	-20.0	24.8	61.9	-37.1
7223.000	Peak	34.3	13.8	-20.0	28.1	61.9	-33.8
8125.875*	Peak	32.2	16.5	-20.0	28.7	54.0	-25.3
9028.750*	Peak	31.0	18.6	-20.0	29.6	54.0	-24.4
*** Emissions within restricted bands**							

EUT Placed Vertical on the Table – (Horizontal Polarity)

Frequency (MHz)	Detector	Receiver Reading (dBμV)	Average Factor (dB)	Correction Factor (dB/m)	Field Strength (dBμV/m)	Limit (dBμV/m)	Delta (dB)
902.875	Peak	55.8	36.6	-20.0	72.4	81.9	-9.5
1805.750	Peak	35.6	1.2	-20.0	16.8	61.9	-45.1
2708.625*	Peak	36.1	4.2	-20.0	20.3	54.0	-33.7
3611.500*	Peak	37.3	6.8	-20.0	24.1	54.0	-29.9
4514.375*	Peak	40.3	7.7	-20.0	28.0	54.0	-26.0
5417.250*	Peak	43.7	9.4	-20.0	33.1	54.0	-20.9
6320.125	Peak	34.4	10.7	-20.0	25.1	61.9	-36.8
7223.000	Peak	37.4	13.8	-20.0	31.2	61.9	-30.7
8125.875*	Peak	31.9	16.5	-20.0	28.4	54.0	-25.6
9028.750*	Peak	30.8	18.6	-20.0	29.4	54.0	-24.6
*** Emissions within restricted bands**							

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EUT Placed Flat on the Table – (Vertical Polarity)

Frequency (MHz)	Detector	Receiver Reading (dBμV)	Correction Factor (dB/m)	Averaging Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Delta (dB)
902.875	Peak	56.8	36.6	-20.0	73.4	81.9	-8.5
1805.750	Peak	35.3	1.2	-20.0	16.5	61.9	-45.4
2708.625*	Peak	35.1	4.2	-20.0	19.3	54.0	-34.7
3611.500*	Peak	36.9	6.8	-20.0	23.7	54.0	-30.3
4514.375*	Peak	40.2	7.7	-20.0	27.9	54.0	-26.1
5417.250*	Peak	43.9	9.4	-20.0	33.3	54.0	-20.7
6320.125	Peak	34.2	10.7	-20.0	24.9	61.9	-37.0
7223.000	Peak	34.7	13.8	-20.0	28.5	61.9	-33.4
8125.875*	Peak	32.2	16.5	-20.0	28.7	54.0	-25.3
9028.750*	Peak	31.1	18.6	-20.0	29.7	54.0	-24.3
*** Emissions within restricted bands**							

EUT Placed Flat on the Table – (Horizontal Polarity)

Frequency (MHz)	Detector	Receiver Reading (dBμV)	Average Factor (dB)	Correction Factor (dB/m)	Field Strength (dBμV/m)	Limit (dBμV/m)	Delta (dB)
902.875	Peak	61.1	36.6	-20.0	77.7	81.9	-4.2
1805.750	Peak	38.6	1.2	-20.0	19.8	61.9	-42.1
2708.625*	Peak	36.3	4.2	-20.0	20.5	54.0	-33.5
3611.500*	Peak	36.8	6.8	-20.0	23.6	54.0	-30.4
4514.375*	Peak	37.4	7.7	-20.0	25.1	54.0	-28.9
5417.250*	Peak	41.1	9.4	-20.0	30.5	54.0	-23.5
6320.125	Peak	34.4	10.7	-20.0	25.1	61.9	-36.8
7223.000	Peak	34.2	13.8	-20.0	28.0	61.9	-33.9
8125.875*	Peak	31.5	16.5	-20.0	28.0	54.0	-26.0
9028.750*	Peak	31.2	18.6	-20.0	29.8	54.0	-24.2
*** Emissions within restricted bands**							

EUT Placed On Edge on the Table – (Vertical Polarity)

Frequency (MHz)	Detector	Receiver Reading (dBμV)	Correction Factor (dB/m)	Averaging Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Delta (dB)
902.875	Peak	57.3	36.6	-20.0	73.9	81.9	-8.0
1805.750	Peak	36.7	1.2	-20.0	17.9	61.9	-44.0
2708.625*	Peak	35.6	4.2	-20.0	19.8	54.0	-34.2
3611.500*	Peak	38.8	6.8	-20.0	25.6	54.0	-28.4
4514.375*	Peak	40.0	7.7	-20.0	27.7	54.0	-26.3
5417.250*	Peak	42.2	9.4	-20.0	31.6	54.0	-22.4
6320.125	Peak	33.9	10.7	-20.0	24.6	61.9	-37.3
7223.000	Peak	36.6	13.8	-20.0	30.4	61.9	-31.5
8125.875*	Peak	31.9	16.5	-20.0	28.4	54.0	-25.6
9028.750*	Peak	31.1	18.6	-20.0	29.7	54.0	-24.3
*** Emissions within restricted bands**							

EUT Placed On Edge on the Table – (Horizontal Polarity)

Frequency (MHz)	Detector	Receiver Reading (dBμV)	Average Factor (dB)	Correction Factor (dB/m)	Field Strength (dBμV/m)	Limit (dBμV/m)	Delta (dB)
902.875	Peak	61.0	36.6	-20.0	77.6	81.9	-4.3
1805.750	Peak	36.5	1.2	-20.0	17.7	61.9	-44.2
2708.625*	Peak	35.5	4.2	-20.0	19.7	54.0	-34.3
3611.500*	Peak	40.0	6.8	-20.0	26.8	54.0	-27.2
4514.375*	Peak	40.2	7.7	-20.0	27.9	54.0	-26.1
5417.250*	Peak	43.1	9.4	-20.0	32.5	54.0	-21.5
6320.125	Peak	33.8	10.7	-20.0	24.5	61.9	-37.4
7223.000	Peak	33.4	13.8	-20.0	27.2	61.9	-34.7
8125.875*	Peak	31.5	16.5	-20.0	28.0	54.0	-26.0
9028.750*	Peak	31.1	18.6	-20.0	29.7	54.0	-24.3
*** Emissions within restricted bands**							

6.2.6 §15.231 (c) 20 dB Bandwidth

The bandwidth of the emission must not be wider than 0.5% of the center frequency. The center frequency is 902.875 MHz, therefore the bandwidth must not be wider than 4514.375 kHz. The EMDCU bandwidth was 286 kHz. See spectrum analyzer plot below.

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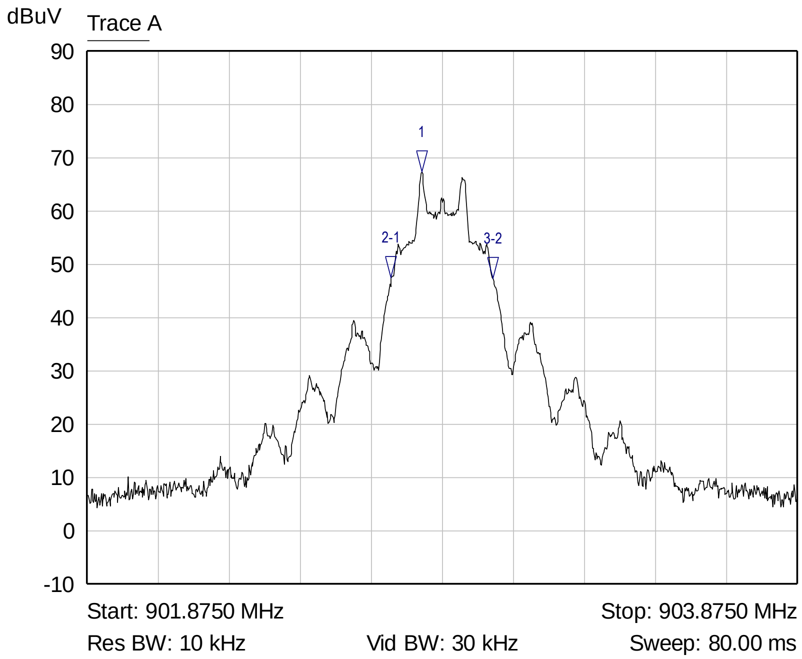


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	902.8170 MHz	67.27 dBuV	
2-1 ▽	Trace A	-86.0000 kHz	-19.84 dB	
3-2 ▽	Trace A	286.0000 kHz	-0.05 dB	

Graph 5: Bandwidth Plot

Result

In the configuration tested, the EUT complied with the requirements of this section.

6.3 Sample Field Strength Calculation

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:

$$Receiver\ Amplitude\ Reading = Receiver\ Reading - Amplifier\ Gain$$

$$Correction\ Factor = Antenna\ Factor + Cable\ Factor$$

$$Field\ Strength = Receiver\ Amplitude\ Reading + Correction\ Factor + Averaging\ Factor$$

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, the *Cable Factor* is 4.0 dB, and the *Averaging Factor* is -6.0. The *Field Strength* is calculated by subtracting the *Amplifier Gain* and adding the *Correction Factor* and *Averaging Factor*, giving a *Field Strength* of 18.5 dBμV/m.

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

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

$$Averaging\ Factor = -6.0$$

$$Field\ Strength\ =\ 16.0 + 8.5 + (-6.0)\ =\ 18.5\ \mathrm{dB\mu V/m}$$

7 Test Procedures and Test Equipment

7.1 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. 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	08/01/2019	08/01/2020
Spectrum Analyzer	Hewlett Packard	8566B	V048078	05/26/2019	05/26/2020
Quasi-Peak Detector	Hewlett Packard	85650A	V039474	05/02/2018	05/02/2020
Loop Antenna	EMCO	6502	V034216	02/11/2019	02/11/2021
Biconilog Antenna	EMCO	3142E-PA	V035736	07/05/2018	07/05/2020
Double Ridged Guide Antenna	EMCO	3115	V033469	04/13/2018	04/13/2020
High Frequency Amplifier	Miteq	AFS4-001018000-35-10P-4	V033997	01/08/2019	01/08/2020
6’ High Frequency Cable	Microcoax	UFB197C-0-0720-000000	V033638	01/08/2019	01/08/2020

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
20' High Frequency Cable	Microcoax	UFB197C-1-3120-000000	V033979	01/08/2019	01/08/2020
3 Meter Radiated Emissions Cable Wanship Upper Site	Microcoax	UFB205A-0-4700-000000	V033639	01/08/2019	01/08/2020
Test Software (FCC)	VPI Labs	Revision 01	V035673	N/A	N/A

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

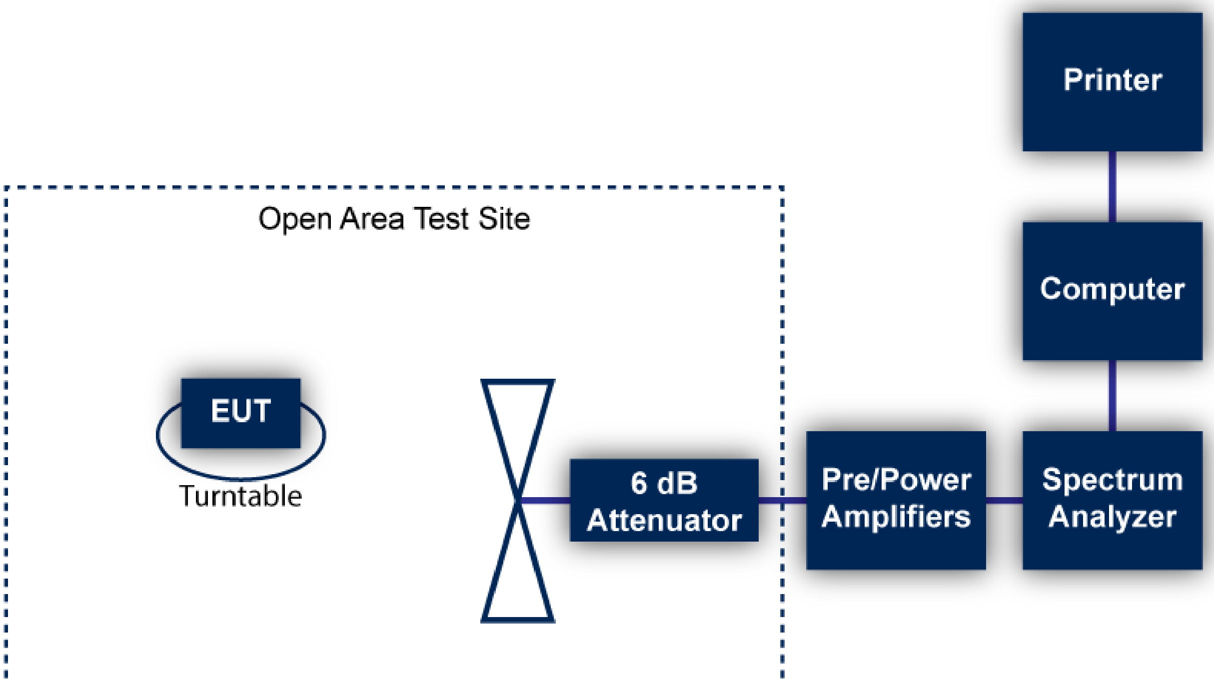


Figure 1: Radiated Emissions Test

7.2 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.

7.3 Measurement Uncertainty

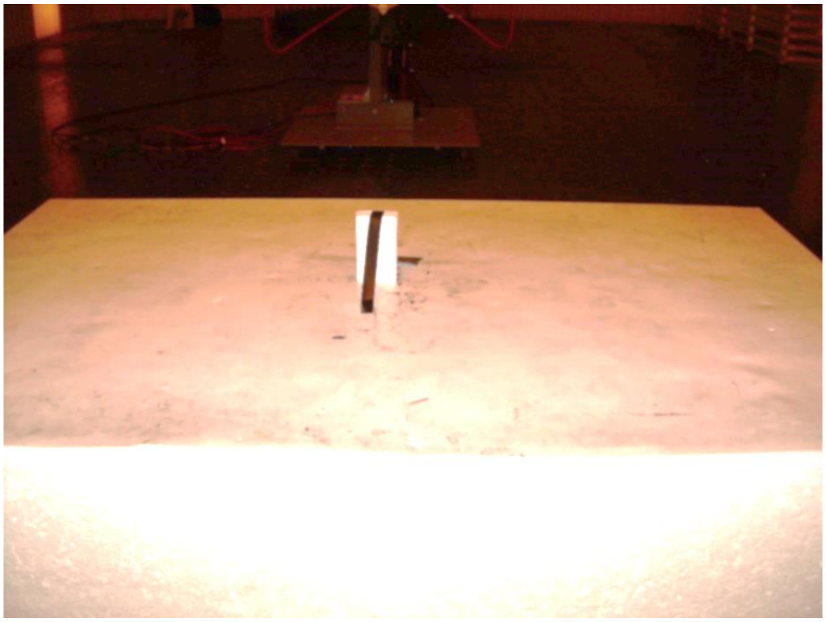
Test	Uncertainty (±dB)	Confidence (%)
Conducted Emissions	2.8	95
Radiated Emission (9 kHz to 30 MHz)	3.3	95

PROPRIETARY

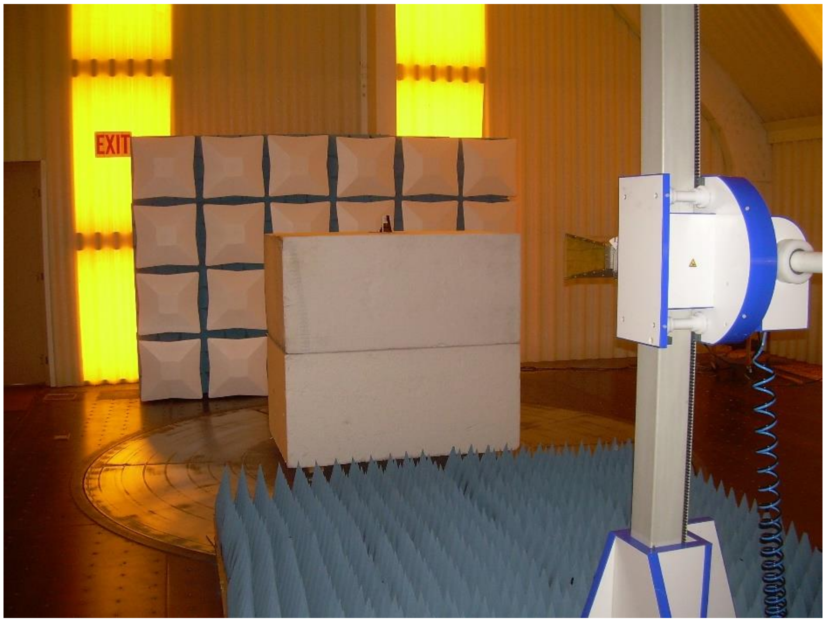
Test	Uncertainty (±dB)	Confidence (%)
Radiated Emissions (30 MHz to 1 GHz)	3.4	95
Radiated Emissions (1 GHz to 18 GHz)	5.0	95
Radiated Emissions (18 GHz to 40 GHz)	4.1	95

8 Photographs

Photograph 1 – Front View Radiated Emissions Worst-Case Configuration – Below 1000 MHz



Photograph 2 – Back View Radiated Emissions Worst-Case Configuration – Below 1000 MHz



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

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

Photograph 5 – Vertical Placement

Photograph 6 – On Edge Placement

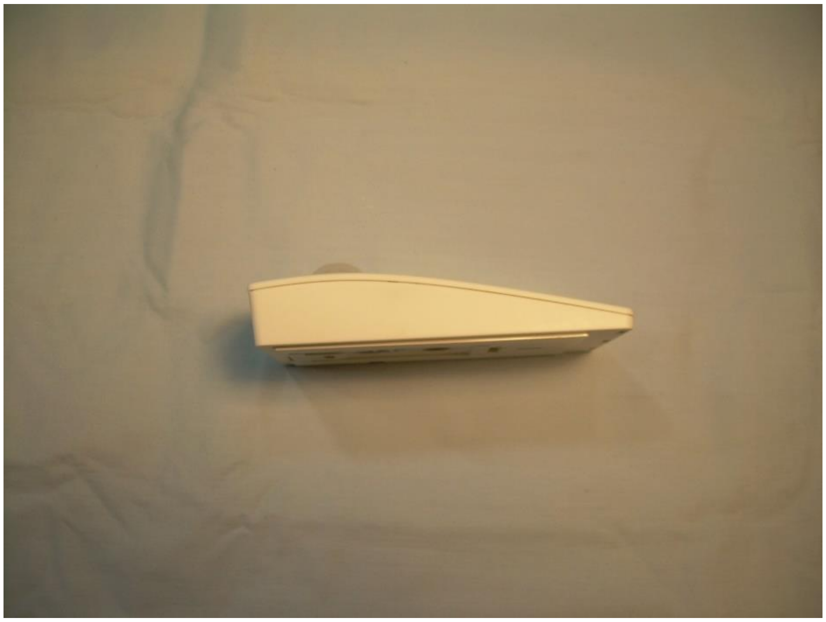
Photograph 7 – Flat Placement

Photograph 8 - Front View of the EUT

Photograph 9 - Back View of the EUT

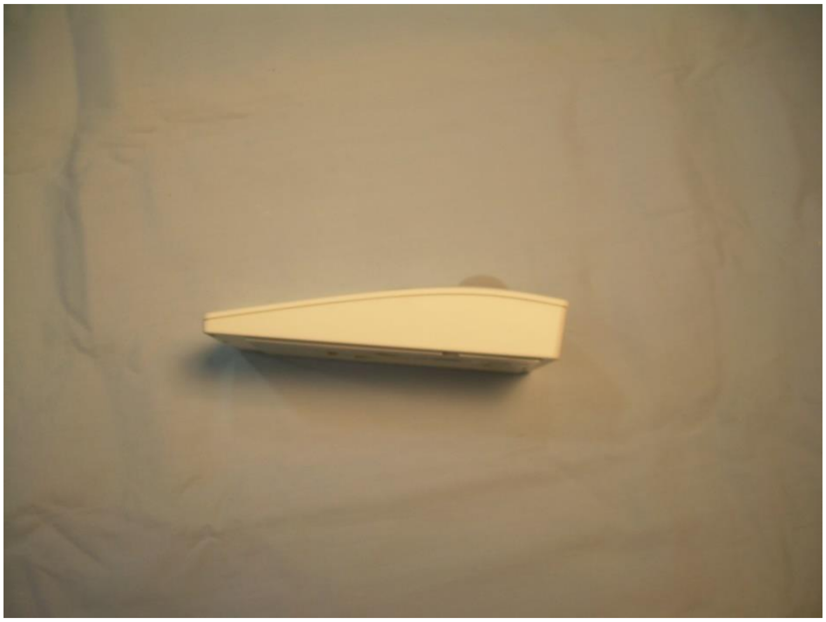
Photograph 10 – Top View of the EUT

Photograph 11 - Bottom View of the EUT

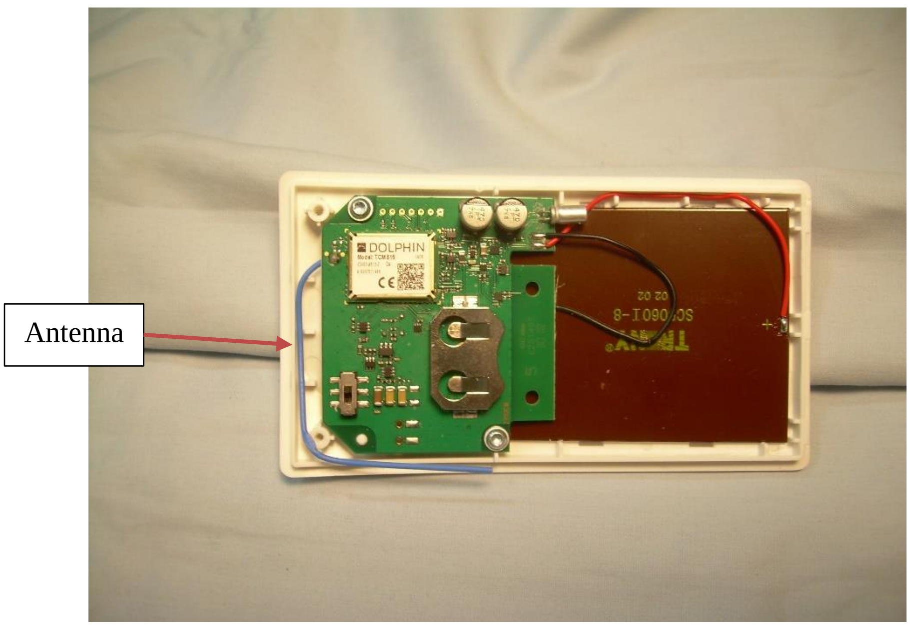


Photograph 12 – Left Side View of the EUT

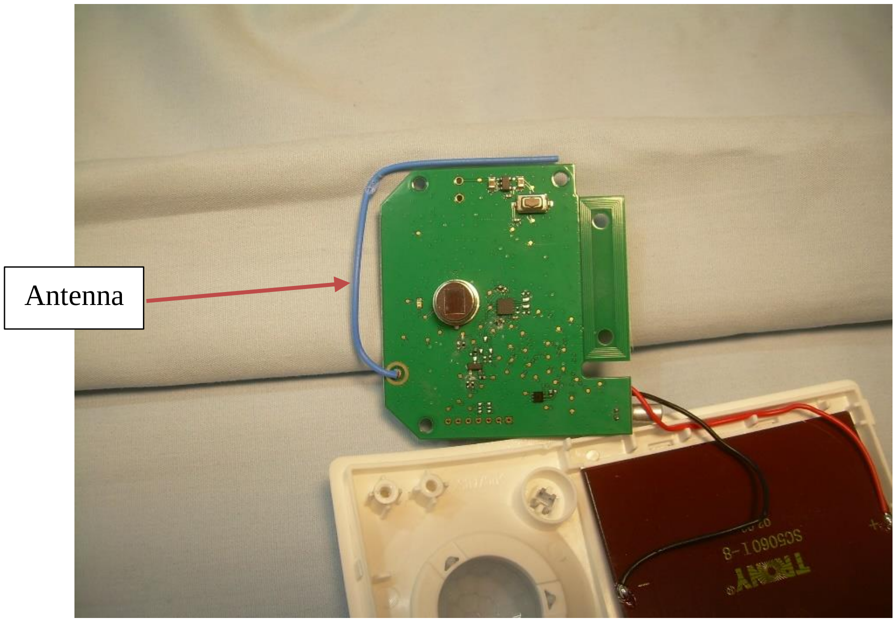
PROPRIETARY



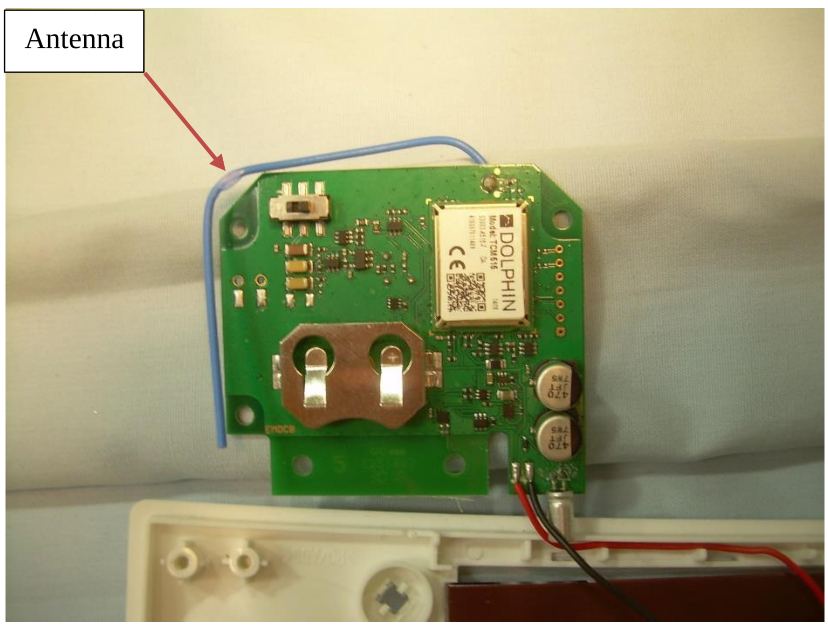
Photograph 13 – Right Side View of the EUT



Photograph 14 – Internal View of the EUT



Photograph 15 – View of the Front Side of the PCB



Photograph 16 – View of the Back Side of the EUT

--- End of Report ---