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## Test Report

### Certification

|                              |                           |
|------------------------------|---------------------------|
| <b>FCC ID</b>                | 2BPPE-AIRULORA0           |
| <b>Equipment Under Test</b>  | AirU Pro LoRa             |
| <b>Test Report Serial No</b> | V079457_01                |
| <b>Dates of Test</b>         | April 17 and May 19, 2025 |
| <b>Report Issue Date</b>     | June 24, 2025             |

| <b>Test Specifications:</b> | <b>Applicant:</b>   |
|-----------------------------|---|
| FCC Part 15, Subpart C      | TELLUS Networked Sensor Solutions<br>2319 Foothill Dr #140,<br>Salt Lake City, UT 84109<br>U.S.A. |



## Certification of Engineering Report

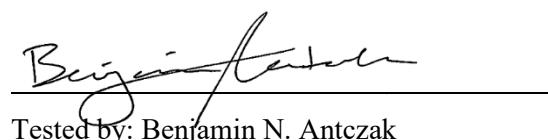
This report has been prepared by VPI Technology, Inc. to document compliance of the device described below with the requirements of Federal Communications Commission (FCC) Part 15, Subpart C. This report may be reproduced in full. Partial reproduction of this report may only be made with the written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

|                     |   |
|---------------------|---|
| <b>Applicant</b>    | TELLUS Networked Sensor Solutions, Inc.   |
| <b>Manufacturer</b> | TELLUS Networked Sensor Solutions, Inc.   |
| <b>Brand Name</b>   | TELLUS Networked Sensor Solutions, Tellus |
| <b>Model Number</b> | AirU Pro LoRa                             |
| <b>FCC ID</b>       | 2BPPE-AIRULORA0                           |

On this 24<sup>th</sup> day of June 2025, I, individually and for VPI Technology, 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 Technology, 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 US government.

VPI Technology, Inc.

  
\_\_\_\_\_  
Tested by: Benjamin N. Antczak

  
\_\_\_\_\_  
Reviewed by: Jason Stewart

| <b>Revision History</b> |                         |               |
|-------------------------|-------------------------|---------------|
| <b>Revision</b>         | <b>Description</b>      | <b>Date</b>   |
| 01                      | Original Report Release | June 24, 2025 |

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## 1 Client Information

### 1.1 Applicant

|                     |   |
|---------------------|---|
| <b>Company Name</b> | TELLUS Networked Sensor Solutions, Inc.<br>2319 Foothill Dr #140,<br>Salt Lake City, UT 84109<br>U.S.A. |
| <b>Contact Name</b> | Brett Rushlow   |
| <b>Title</b>        | Embedded Engineer   |

### 1.2 Manufacturer

|                     |   |
|---------------------|---|
| <b>Company Name</b> | TELLUS Networked Sensor Solutions, Inc.<br>2319 Foothill Dr #140,<br>Salt Lake City, UT 84109<br>U.S.A. |
| <b>Contact Name</b> | Brett Rushlow   |
| <b>Title</b>        | Embedded Engineer   |

## 2 Equipment Under Test (EUT)

### 2.1 Identification of EUT

|                                |  |
|--------------------------------|--|
| <b>Brand Name</b>              | Tellus                                     |
| <b>Model Number</b>            | AirU Pro LoRa                              |
| <b>Serial Number</b>           | Engineering Unit                           |
| <b>Dimensions (cm)</b>         | 20.0 x 14.0 x 7.6                          |
| <b>Peak Antenna Gain (dBi)</b> | 1.21 (Peak, Straight)<br>2.14 (Peak, Bent) |

### 2.2 Applicant Supplied Data

#### 2.2.1 Disclaimer

This test report contains Applicant supplied data that may change the validity of the results presented. VPI Technologies, Inc. does not maintain responsibility for the accuracy of the results from Taoglas datasheet report SPE-19-8-076/A.

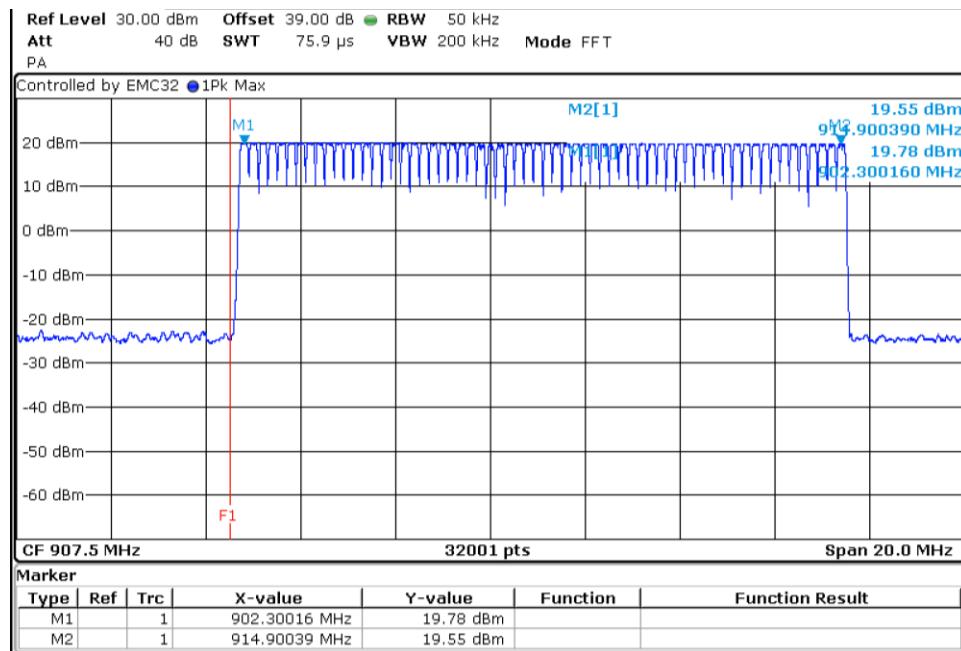
### 2.3 Description of EUT

The AirU Pro LoRa is an air quality monitor with a 902-928MHz LoRa transmitter. AirU Pro LoRa is powered by 5VDC 3A ITE PSU, FrontPower YL121-0503000HU. EUT also contains a certified module that is unused, Espressif ESP32-WROOM32E.

EUT uses 64 channels with center frequencies ranging from 902.3 MHz to 914.9 MHz. The following table and graph show the 64 channels and their center frequencies. Frequencies evaluated in this report are shown in bold.

| Chan. | F <sub>q</sub> (MHz) | Chan. | F <sub>q</sub> (MHz) | Chan.     | F <sub>q</sub> (MHz) | Chan. | F <sub>q</sub> (MHz) | Chan.     | F <sub>q</sub> (MHz) |
|-------|----------------------|-------|----------------------|-----------|----------------------|-------|----------------------|-----------|----------------------|
| 1     | <b>902.3</b>         | 14    | 904.9                | 27        | 907.5                | 40    | 910.1                | 53        | 912.7                |
| 2     | 902.5                | 15    | 905.1                | 28        | 907.7                | 41    | 910.3                | 54        | 912.9                |
| 3     | 902.7                | 16    | 905.3                | 29        | 907.9                | 42    | 910.5                | 55        | 913.1                |
| 4     | 902.9                | 17    | 905.5                | 30        | 908.1                | 43    | 910.7                | 56        | 913.3                |
| 5     | 903.1                | 18    | 905.7                | 31        | 908.3                | 44    | 910.9                | 57        | 913.5                |
| 6     | 903.3                | 19    | 905.9                | <b>32</b> | <b>908.5</b>         | 45    | 911.1                | 58        | 913.7                |
| 7     | 903.5                | 20    | 906.1                | 33        | 908.7                | 46    | 911.3                | 59        | 913.9                |
| 8     | 903.7                | 21    | 906.3                | 34        | 908.9                | 47    | 911.5                | 60        | 914.1                |
| 9     | 903.9                | 22    | 906.5                | 35        | 909.1                | 48    | 911.7                | 61        | 914.3                |
| 10    | 904.1                | 23    | 906.7                | 36        | 909.3                | 49    | 911.9                | 62        | 914.5                |
| 11    | 904.3                | 24    | 906.9                | 37        | 909.5                | 50    | 912.1                | 63        | 914.7                |
| 12    | 904.5                | 25    | 907.1                | 38        | 909.7                | 51    | 912.3                | <b>64</b> | <b>914.9</b>         |
| 13    | 904.7                | 26    | 907.3                | 39        | 909.9                | 52    | 912.5                |           |                      |

Table 1: Channel Plan and Evaluated Channels



Graph 1: EUT Channel Plot

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 was evaluated separately and found to be compliant and is covered in VPI Laboratories, Inc. report V079456\_01.

## 2.4 EUT and Support Equipment

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

| Brand Name<br>Model Number<br>Serial Number                      | Description                               | Name of Interface Ports / Interface Cables |
|--|---|--|
| BN: Tellus<br>MN: AirU Pro LoRa (Note 1)<br>SN: Engineering Unit | Air Quality Monitor with LoRa Transmitter | See Section 2.4                            |
| BN: Tellus<br>MN: AirU Pro LoRa (Note 1)<br>SN: N/A              | ITE Power Supply                          | Power / USB-C (Note 2)                     |

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.

## 2.5 Interface Ports on EUT

| Name of Ports | No. of Ports Fitted to EUT | Cable Description/Length                          |
|---------------|----------------------------|---|
| Power Input   | 1 of 1                     | USB C Permanantly Connected to ITE PSU / 2 meters |

## 2.6 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.

- 902-928MHz transmitter output power shall not be higher than 19dBm to comply with restricted band emissions above 1000MHz.

## 2.7 Deviation from Test Standard

There were no deviations from the test specification.

### 3 Test Specification, Methods and Procedures

#### 3.1 Test Specification

|                        |   |
|------------------------|---|
| <b>Title</b>           | FCC PART 15, Subpart C (47 CFR 15)<br>15.203, 15.207, and 15.247<br>Limits and methods of measurement of radio interference characteristics of radio frequency devices. |
| <b>Purpose of Test</b> | 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  $\mu$ H/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 (dB $\mu$ V) |           |
|-----------------------|--------------------|-----------|
|                       | 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 2: 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 Technology, Inc. is accredited by National Voluntary Laboratory Accreditation Program (NVLAP); NVLAP Lab Code: 100272-0, which is effective until September 30, 2025. VPI Technology, Inc. carries FCC Accreditation Designation Number US5263. VPI Technology main office is located at 313 W 12800 S, Suite 311, Draper, UT 84020. The testing was performed according to the procedures in ANSI C63.10-2013, KDB 558074, and 47 CFR Part 15.

## 4 Operation of EUT During Testing

### 4.1 Operating Environment

|                           |         |
|---------------------------|---------|
| <b>Power Supply</b>       | 120 VAC |
| <b>AC Mains Frequency</b> | 60 Hz   |

### 4.2 Operating Modes

The transmitter is a desktop device and tested on a single axis. EUT was tested while in a constant transmit mode at the upper, middle, and lower channels. For Channel Separation, Time of Occupancy, and Channel Usage tests, EUT was set to a normal operating mode. The articulating antenna was positioned for maximal coupling with test antenna's polarization for each radiated measurement. The AC mains voltage to the AC adapter was varied as required by §15.31(e) with no change seen in the voltage supplied to the transmitter or in transmitter characteristics.

### 4.3 EUT Exercise Software

Tellus engineering firmware was flashed to put transmitter into constant transmit or normal hopping test modes.

## 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) | Channel Separation                   | 902-928                | Complied          |
| 15.247(a) | 20 dB Bandwidth                      | 902-928                | Complied          |
| 15.247(a) | Time of Occupancy                    | 902-928                | Complied          |
| 15.247(b) | Peak Output Power                    | 902-928                | Complied          |
| 15.247(d) | Radiated Spurious Emissions          | 902-928                | Complied          |
| 15.247(g) | Channel Usage                        | 902-928                | Complied          |
| 15.247(h) | Channel Intelligence/Avoidance       | 902-928                | Complied (Note 1) |

Note 1: Compliance with these requirements is shown in documents filed with the FCC at the time of Certification.

### 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

The EUT uses an articulating Taoglas TI.92.2113 antenna.

##### Result

The EUT complied with the specification.

#### 6.2.2 Conducted Emissions at Mains Ports Data

| Frequency (MHz) | Detector      | Receiver Reading (dB $\mu$ V) | Correction Factor (dB) | Measured Level (dB $\mu$ V) | Class B Limit (dB $\mu$ V) | Margin (dB) |
|-----------------|---------------|-------------------------------|------------------------|-----------------------------|----------------------------|-------------|
| 0.42            | Peak (Note 1) | 29.7                          | 10.3                   | 40.0                        | 47.5                       | -7.4        |
| 0.44            | Peak (Note 1) | 32.0                          | 10.3                   | 42.4                        | 47.1                       | -4.8        |
| 0.46            | Peak (Note 1) | 29.7                          | 10.3                   | 40.0                        | 46.8                       | -6.7        |
| 8.9             | Peak (Note 1) | 33.9                          | 10.5                   | 44.4                        | 50.0                       | -5.6        |
| 9.3             | Peak (Note 1) | 35.2                          | 10.5                   | 45.6                        | 50.0                       | -4.4        |
| 9.7             | Peak (Note 1) | 36.3                          | 10.5                   | 46.8                        | 50.0                       | -3.2        |
| 11.1            | Peak (Note 1) | 33.4                          | 10.5                   | 43.9                        | 50.0                       | -6.1        |

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.

Table 3: Conducted Emissions on the Hot Lead

| Frequency (MHz) | Detector      | Receiver Reading (dB $\mu$ V) | Correction Factor (dB) | Measured Level (dB $\mu$ V) | Class B Limit (dB $\mu$ V) | Margin (dB) |
|-----------------|---------------|-------------------------------|------------------------|-----------------------------|----------------------------|-------------|
| 0.44            | Peak (Note 1) | 28.8                          | 10.3                   | 39.1                        | 47.1                       | -8.0        |
| 8.8             | Peak (Note 1) | 30.3                          | 10.5                   | 40.7                        | 50.0                       | -9.3        |
| 9.3             | Peak (Note 1) | 31.8                          | 10.5                   | 42.3                        | 50.0                       | -7.7        |
| 9.6             | Peak (Note 1) | 34.3                          | 10.5                   | 44.8                        | 50.0                       | -5.2        |
| 9.7             | Peak (Note 1) | 33.4                          | 10.5                   | 43.8                        | 50.0                       | -6.2        |
| 9.9             | Peak (Note 1) | 33.0                          | 10.5                   | 43.4                        | 50.0                       | -6.6        |

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.

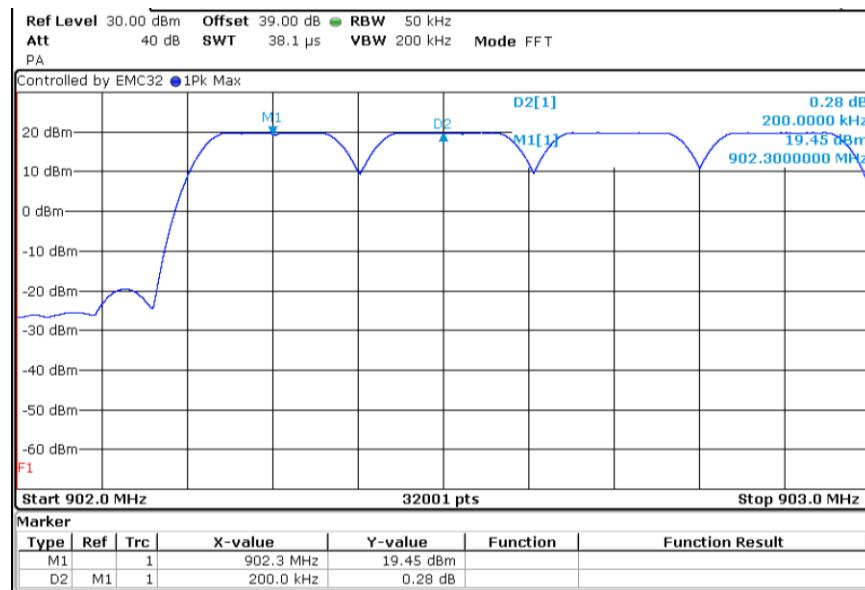
Table 4: Conducted Emissions on the Neutral Lead

## Result

The EUT complied with the specification limit by a margin of 3.2 dB.

### 6.2.3 §15.247(a) Channel Separation

The EUT must have the hopping channel carrier frequencies separated by 25 kHz or the 20 dB bandwidth, whichever is greater. The 20dB bandwidths are greater than 25kHz and are shown in section 6.2.4. A plot showing the channel separation is shown below.



Graph 2: Channel Separation Plot

## Result

The channel carrier frequency separation is 200 kHz, which is greater than the 20 dB bandwidth; therefore, the EUT complies with the specification.

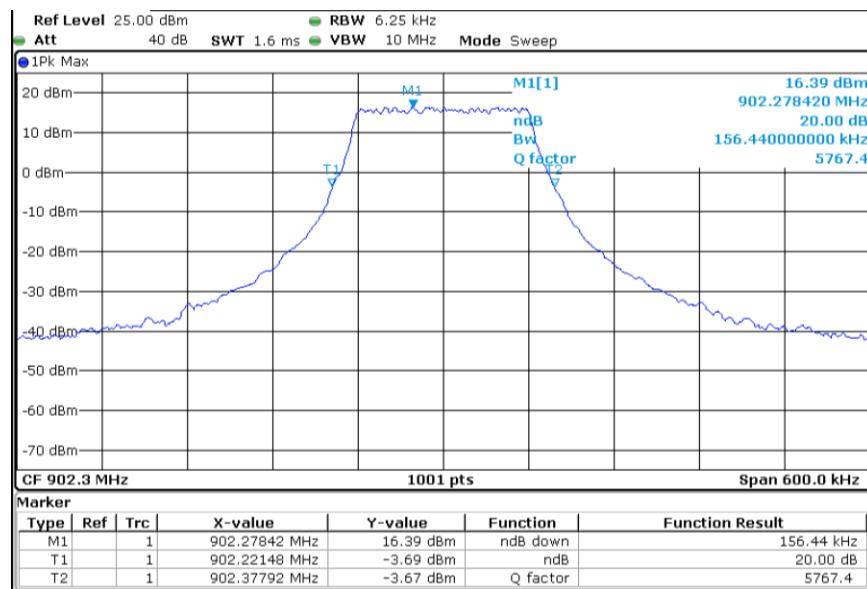
### 6.2.4 §15.247(a)(2) Emissions Bandwidth

The 20 dB bandwidth of the hopping channels is shown in the table and plots below.

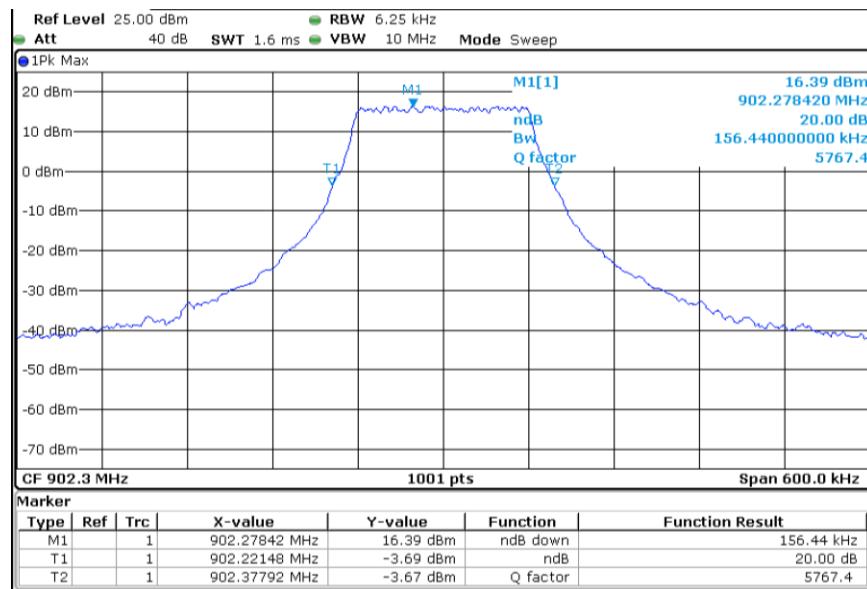
| Frequency (MHz) | Emissions 20 dB bandwidth (kHz) |
|-----------------|---------------------------------|
| 902.3           | 156.4                           |
| 908.5           | 154.1                           |
| 914.9           | 154.7                           |

## Result

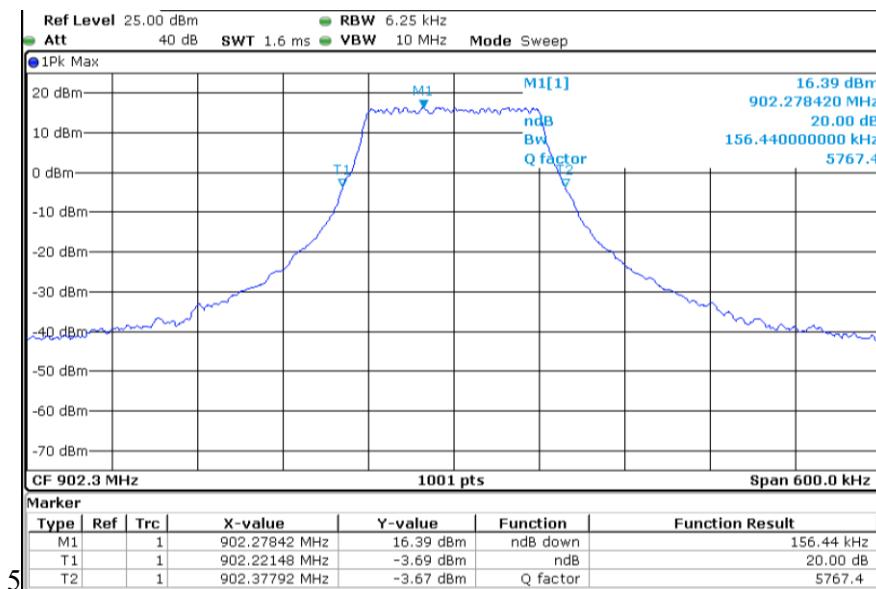
In the configuration tested, the 6 dB bandwidth was greater than 500 kHz; therefore, the EUT complied with the requirements of the specification (see spectrum analyzer plots below).



Graph 3: Lowest Channel 20dB Bandwidth



Graph 4: Middle Channel 20dB Bandwidth



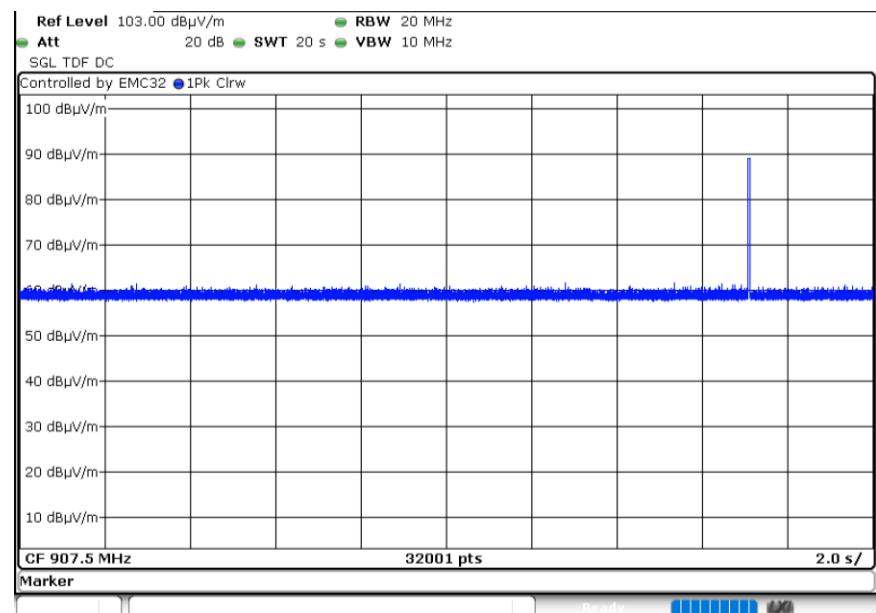
Graph 5: Highest Channel 20dB Bandwidth

## Result

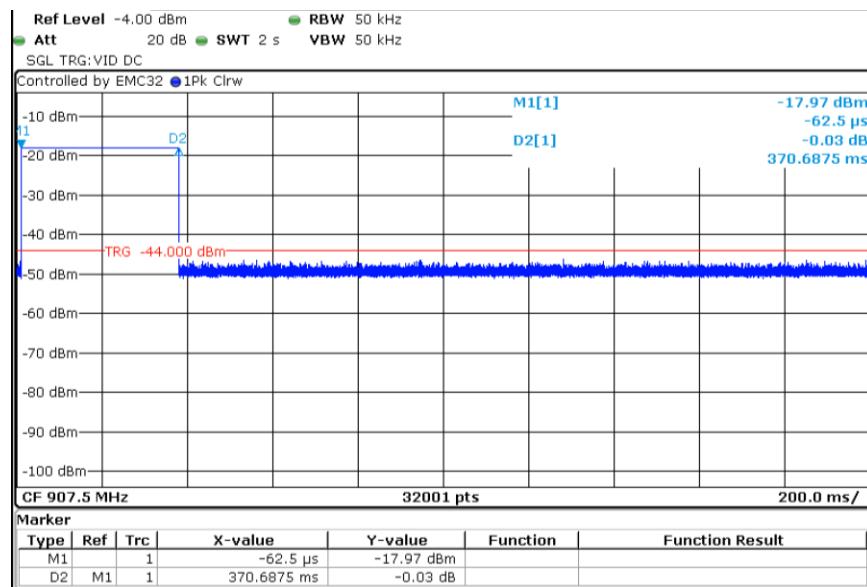
In the configuration tested, the channel bandwidth allows the channel separation of 200kHz to be compliant and is less than 500kHz; therefore, the EUT complied with the requirements of the specification.

### 6.2.5 §15.247(a) Channel Occupancy

The EUT uses 64 channels that have a bandwidth smaller than 250 kHz; therefore, the EUT must have an average time of occupancy on any frequency that is no greater than 0.4 seconds in a period of 20 seconds. See the plots below.



Graph 6: Timing Plot Showing a Single Transmission in a 20 second period.



**Graph 7: Timing Plot Showing a Single Transmission with a duration of 370.7ms**

## Result

The EUT complies with the specification as the EUT transmits on an individual channel for a maximum of 370.7 milliseconds in 20 seconds, less than the 0.4 seconds allowed by the specification.

### 6.2.6 §15.247(b)(3) Peak Output Power

The antenna used with the EUT has a gain of 2.14 dBi. The EUT uses 64 hopping channels. The limit for this device is 30 dBm or 1 Watt. Plots are shown below and the results of this testing are summarized in the table.

| Frequency (MHz) | Measurement (dBm) | Peak Output Power (mW) |
|-----------------|-------------------|------------------------|
| 902.3           | 17.54             | 56.8                   |
| 908.5           | 17.47             | 55.8                   |
| 914.9           | 17.81             | 60.4                   |

## Result

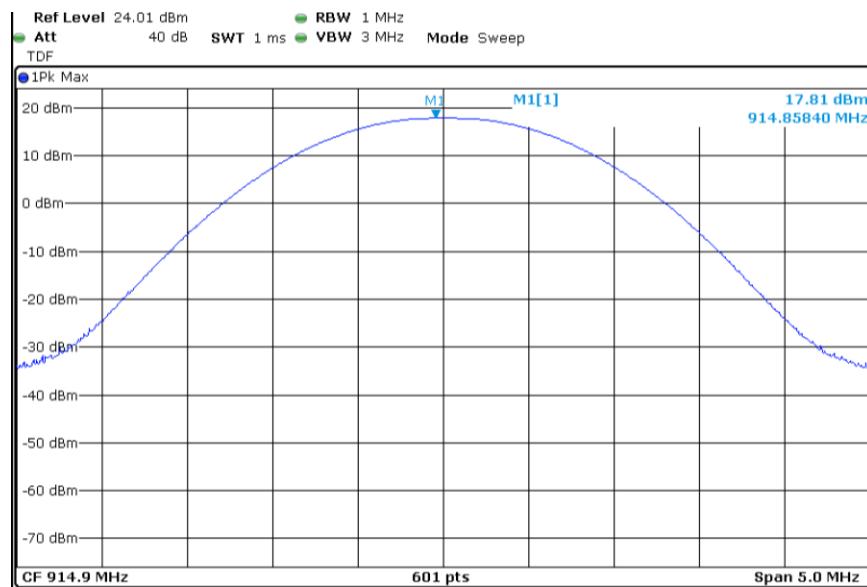
In the configuration tested, the RF peak output power was less than 1 Watt; therefore, the EUT complied with the requirements of the specification.



**Graph 8: Lowest Channel Output Power Plot**



**Graph 9: Middle Channel Output Power**



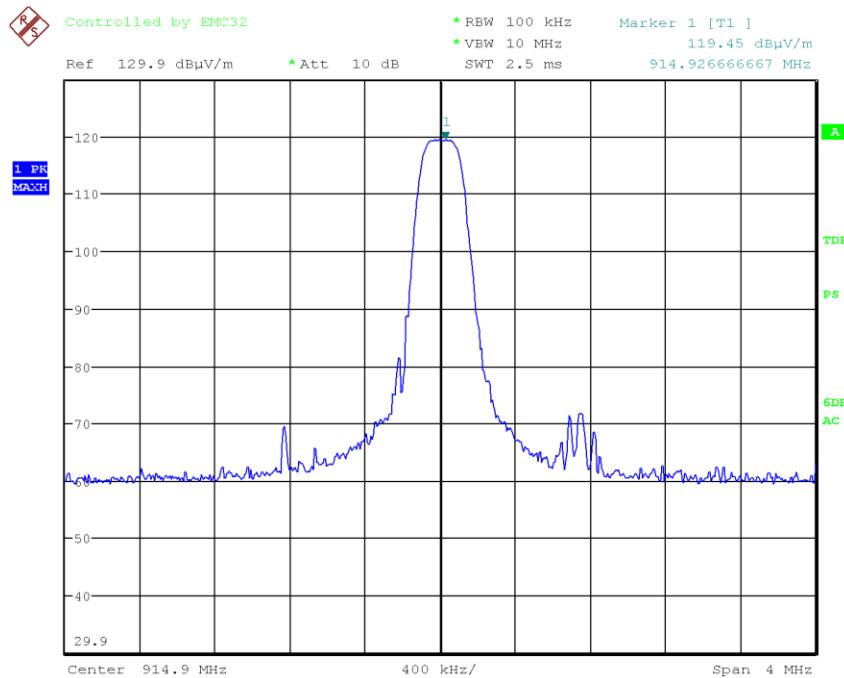
Graph 10: Highest Channel Output Power Plot

### 6.2.7 §15.247(d) Spurious Emissions

#### Radiated Spurious Emissions including 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 include measurements of any emission that fell into the restricted bands of §15.205. The emissions in the restricted bands must meet the limits specified in §15.209.

Spurious emissions that fall outside the restricted bands either met the limits of the restricted bands or were 20dB below the highest measured desired emission measured with a peak detector in a 100kHz BW, which was 119.45 dBm at 914.9MHz (antenna bent vertically).



### Graph 11: Highest Measured Desired Radiated Emission

The limit for peak spurious emissions falling outside the band is  $119.45 - 20 = 99.45$  dB $\mu$ V/m measured at 3 meters. Average measurements for spurious emissions outside the restricted bands are reported.

The tables show the worst-case emission measured from the EUT. The noise floor was a minimum of 6 dB below the limit. Tabular data for each of the spurious emissions is shown below for each of the units. A Plot of the lower band edge is also shown.

| Frequency (MHz) | Detector | Antenna Polarity | Receiver Reading (dB $\mu$ V) | Correction Factor (dB) | Field Strength (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) |
|-----------------|----------|------------------|-------------------------------|------------------------|-------------------------------|----------------------|-------------|
| 1804.5*         | Peak     | Vertical         | 61.9                          | -4.7                   | 57.2                          | 99.45                | -42.3       |
| 1804.5*         | Average  | Vertical         | 61.1                          | -4.7                   | 56.4                          | N/A                  | N/A         |
| 1804.7*         | Peak     | Horizontal       | 61.7                          | -4.7                   | 57.0                          | 99.45                | -42.4       |
| 1804.7*         | Average  | Horizontal       | 60.8                          | -4.7                   | 56.1                          | N/A                  | N/A         |
| 2706.7          | Peak     | Vertical         | 61.7                          | -1.2                   | 60.5                          | 74.0                 | -13.5       |
| 2706.9          | Average  | Vertical         | 50.8                          | -1.2                   | 49.6                          | 54.0                 | -4.4        |
| 2706.7          | Peak     | Horizontal       | 55.8                          | -1.2                   | 54.7                          | 74.0                 | -19.4       |
| 2706.9          | Average  | Horizontal       | 51.0                          | -1.2                   | 49.8                          | 54.0                 | -4.2        |
| 3608.9          | Peak     | Vertical         | 46.8                          | 2.8                    | 49.6                          | 74.0                 | -24.5       |
| 3609.1          | Average  | Vertical         | 41.9                          | 2.8                    | 44.7                          | 54.0                 | -9.3        |
| 3609.1          | Peak     | Horizontal       | 53.9                          | 2.8                    | 56.6                          | 74.0                 | -17.4       |
| 3609.1          | Average  | Horizontal       | 46.8                          | 2.8                    | 49.6                          | 54.0                 | -4.5        |
| 4511.5          | Peak     | Vertical         | 42.4                          | 4.8                    | 47.2                          | 74.0                 | -26.8       |
| 4511.6          | Average  | Vertical         | 34.1                          | 4.8                    | 38.9                          | 54.0                 | -15.2       |
| 4511.5          | Peak     | Horizontal       | 45.5                          | 4.8                    | 50.2                          | 74.0                 | -23.8       |
| 4511.5          | Average  | Horizontal       | 42.5                          | 4.8                    | 47.2                          | 54.0                 | -6.8        |
| 5413.7          | Peak     | Vertical         | 41.4                          | 7.4                    | 48.9                          | 74.0                 | -25.1       |
| 5413.8          | Average  | Vertical         | 34.7                          | 7.4                    | 42.1                          | 54.0                 | -11.9       |
| 5413.8          | Peak     | Horizontal       | 43.1                          | 7.4                    | 50.6                          | 74.0                 | -23.4       |
| 5413.8          | Average  | Horizontal       | 38.7                          | 7.4                    | 46.1                          | 54.0                 | -7.9        |
| 6315.7*         | Peak     | Vertical         | 36.5                          | 8.5                    | 45.1                          | 74.0                 | -28.9       |
| 6315.9*         | Average  | Vertical         | 28.1                          | 8.5                    | 36.6                          | 54.0                 | -17.4       |
| 6316.5*         | Peak     | Horizontal       | 38.2                          | 8.5                    | 46.7                          | 74.0                 | -27.3       |
| 6315.8*         | Average  | Horizontal       | 32.0                          | 8.5                    | 40.6                          | 54.0                 | -13.4       |
| 7218.0*         | Peak     | Vertical         | 35.7                          | 10.6                   | 46.3                          | 74.0                 | -27.7       |
| 7218.3*         | Average  | Vertical         | 24.3                          | 10.6                   | 34.9                          | 54.0                 | -19.1       |

| Frequency (MHz) | Detector | Antenna Polarity | Receiver Reading (dB $\mu$ V) | Correction Factor (dB) | Field Strength (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) |
|-----------------|----------|------------------|-------------------------------|------------------------|-------------------------------|----------------------|-------------|
| 7218.5*         | Peak     | Horizontal       | 37.5                          | 10.6                   | 48.0                          | 74.0                 | -26.0       |
| 7218.0*         | Average  | Horizontal       | 29.9                          | 10.6                   | 40.5                          | 54.0                 | -13.5       |
| 8118.9          | Peak     | Vertical         | 35.3                          | 11.6                   | 46.9                          | 74.0                 | -27.1       |
| 8120.6          | Average  | Vertical         | 23.8                          | 11.6                   | 35.4                          | 54.0                 | -18.6       |
| 8098.6          | Peak     | Horizontal       | 36.1                          | 11.7                   | 47.8                          | 74.0                 | -26.2       |
| 8120.4          | Average  | Horizontal       | 26.4                          | 11.6                   | 38.0                          | 54.0                 | -16.0       |
| 9028.2          | Peak     | Vertical         | 35.7                          | 12.6                   | 48.3                          | 74.0                 | -25.7       |
| 9023.2          | Average  | Vertical         | 22.4                          | 12.6                   | 35.0                          | 54.0                 | -19.0       |
| 9023.0          | Peak     | Horizontal       | 35.4                          | 12.6                   | 48.0                          | 74.0                 | -26.0       |
| 9022.5          | Average  | Horizontal       | 24.2                          | 12.6                   | 36.8                          | 54.0                 | -17.2       |

\*Emission falls outside the restricted bands of 15.205

Table 5: Transmitting at the Lowest Frequency

| Frequency (MHz) | Detector | Antenna Polarity | Receiver Reading (dB $\mu$ V) | Correction Factor (dB) | Field Strength (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) |
|-----------------|----------|------------------|-------------------------------|------------------------|-------------------------------|----------------------|-------------|
| 1817.1*         | Peak     | Vertical         | 62.8                          | -4.7                   | 58.1                          | 99.45                | -41.4       |
| 1817.1*         | Average  | Vertical         | 62.0                          | -4.7                   | 57.2                          | N/A                  | N/A         |
| 1817.0*         | Peak     | Horizontal       | 56.3                          | -4.7                   | 51.6                          | 99.45                | -47.9       |
| 1817.0*         | Average  | Horizontal       | 54.4                          | -4.7                   | 49.7                          | N/A                  | N/A         |
| 2725.5          | Peak     | Vertical         | 63.0                          | -1.2                   | 61.8                          | 74.0                 | -12.2       |
| 2725.6          | Average  | Vertical         | 51.9                          | -1.2                   | 50.7                          | 54.0                 | -3.3        |
| 2725.4          | Peak     | Horizontal       | 58.4                          | -1.2                   | 57.3                          | 74.0                 | -16.7       |
| 2725.5          | Average  | Horizontal       | 47.1                          | -1.2                   | 45.9                          | 54.0                 | -8.1        |
| 3633.9          | Peak     | Vertical         | 47.0                          | 2.9                    | 49.9                          | 74.0                 | -24.1       |
| 3634.0          | Average  | Vertical         | 43.1                          | 2.9                    | 46.0                          | 54.0                 | -8.0        |
| 3634.1          | Peak     | Horizontal       | 51.8                          | 2.9                    | 54.8                          | 74.0                 | -19.2       |
| 3634.1          | Average  | Horizontal       | 49.4                          | 2.9                    | 52.3                          | 54.0                 | -1.7        |
| 4542.6          | Peak     | Vertical         | 42.9                          | 4.8                    | 47.7                          | 74.0                 | -26.3       |
| 4542.5          | Average  | Vertical         | 34.3                          | 4.8                    | 39.1                          | 54.0                 | -14.9       |
| 4542.3          | Peak     | Horizontal       | 39.6                          | 4.8                    | 44.4                          | 74.0                 | -29.6       |
| 4542.5          | Average  | Horizontal       | 29.4                          | 4.8                    | 34.2                          | 54.0                 | -19.8       |

| Frequency (MHz) | Detector | Antenna Polarity | Receiver Reading (dB $\mu$ V) | Correction Factor (dB) | Field Strength (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) |
|-----------------|----------|------------------|-------------------------------|------------------------|-------------------------------|----------------------|-------------|
| 5450.7          | Peak     | Vertical         | 41.2                          | 7.6                    | 48.8                          | 74.0                 | -25.2       |
| 5451.0          | Average  | Vertical         | 34.4                          | 7.6                    | 42.0                          | 54.0                 | -12.0       |
| 5450.7          | Peak     | Horizontal       | 41.5                          | 7.6                    | 49.1                          | 74.0                 | -24.9       |
| 5450.9          | Average  | Horizontal       | 35.1                          | 7.6                    | 42.7                          | 54.0                 | -11.3       |
| 6359.1*         | Peak     | Vertical         | 37.6                          | 8.6                    | 46.2                          | 74.0                 | -27.8       |
| 6359.1*         | Average  | Vertical         | 25.9                          | 8.6                    | 34.4                          | 54.0                 | -19.6       |
| 6358.4*         | Peak     | Horizontal       | 37.9                          | 8.6                    | 46.5                          | 74.0                 | -27.5       |
| 6359.6*         | Average  | Horizontal       | 26.3                          | 8.6                    | 34.8                          | 54.0                 | -19.2       |
| 7266.8          | Peak     | Vertical         | 36.1                          | 10.8                   | 46.9                          | 74.0                 | -27.1       |
| 7268.0          | Average  | Vertical         | 23.7                          | 10.8                   | 34.6                          | 54.0                 | -19.4       |
| 7268.1          | Peak     | Horizontal       | 36.1                          | 10.9                   | 46.9                          | 74.0                 | -27.1       |
| 7268.1          | Average  | Horizontal       | 24.9                          | 10.9                   | 35.7                          | 54.0                 | -18.3       |
| 8177.2          | Peak     | Vertical         | 35.9                          | 11.5                   | 47.4                          | 74.0                 | -26.6       |
| 8176.4          | Average  | Vertical         | 23.2                          | 11.5                   | 34.7                          | 54.0                 | -19.3       |
| 8175.7          | Peak     | Horizontal       | 35.1                          | 11.5                   | 46.6                          | 74.0                 | -27.4       |
| 8176.4          | Average  | Horizontal       | 23.0                          | 11.5                   | 34.5                          | 54.0                 | -19.5       |
| 9075.2          | Peak     | Vertical         | 36.1                          | 12.6                   | 48.7                          | 74.0                 | -25.3       |
| 9085.0          | Average  | Vertical         | 22.4                          | 12.6                   | 35.0                          | 54.0                 | -19.1       |
| 9075.5          | Peak     | Horizontal       | 36.1                          | 12.6                   | 48.7                          | 74.0                 | -25.3       |
| 9085.2          | Average  | Horizontal       | 23.1                          | 12.6                   | 35.7                          | 54.0                 | -18.3       |

\*Emission falls outside the restricted bands of 15.205

Table 6: Transmitting at the Middle Frequency

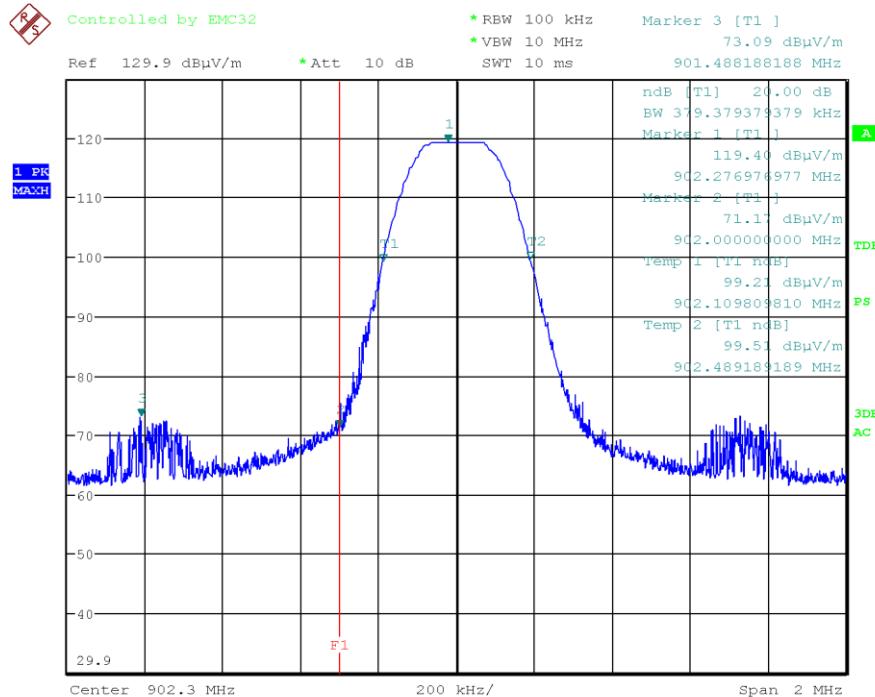
| Frequency (MHz) | Detector | Antenna Polarity | Receiver Reading (dB $\mu$ V) | Correction Factor (dB) | Field Strength (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) |
|-----------------|----------|------------------|-------------------------------|------------------------|-------------------------------|----------------------|-------------|
| 1829.9*         | Peak     | Vertical         | 65.8                          | -4.6                   | 61.2                          | 99.5                 | -38.2       |
| 1829.9*         | Average  | Vertical         | 65.3                          | -4.6                   | 60.7                          | N/A                  | N/A         |
| 1829.8*         | Peak     | Horizontal       | 60.7                          | -4.6                   | 56.1                          | 99.5                 | -43.4       |
| 1829.8*         | Average  | Horizontal       | 59.6                          | -4.6                   | 55.0                          | N/A                  | N/A         |
| 2744.8          | Peak     | Vertical         | 64.0                          | -1.1                   | 62.9                          | 74.0                 | -11.1       |
| 2744.7          | Average  | Vertical         | 53.1                          | -1.1                   | 52.0                          | 54.0                 | -2.0        |

| Frequency (MHz) | Detector | Antenna Polarity | Receiver Reading (dB $\mu$ V) | Correction Factor (dB) | Field Strength (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) |
|-----------------|----------|------------------|-------------------------------|------------------------|-------------------------------|----------------------|-------------|
| 2744.7          | Peak     | Horizontal       | 59.9                          | -1.1                   | 58.8                          | 74.0                 | -15.2       |
| 2744.7          | Average  | Horizontal       | 47.5                          | -1.1                   | 46.4                          | 54.0                 | -7.6        |
| 3659.7          | Peak     | Vertical         | 47.9                          | 3.1                    | 51.0                          | 74.0                 | -23.0       |
| 3659.6          | Average  | Vertical         | 43.4                          | 3.1                    | 46.6                          | 54.0                 | -7.5        |
| 3659.4          | Peak     | Horizontal       | 51.6                          | 3.1                    | 54.7                          | 74.0                 | -19.3       |
| 3659.7          | Average  | Horizontal       | 48.1                          | 3.1                    | 51.2                          | 54.0                 | -2.8        |
| 4574.6          | Peak     | Vertical         | 43.3                          | 4.9                    | 48.2                          | 74.0                 | -25.8       |
| 4574.5          | Average  | Vertical         | 35.3                          | 4.9                    | 40.2                          | 54.0                 | -13.8       |
| 4574.8          | Peak     | Horizontal       | 39.8                          | 4.9                    | 44.7                          | 74.0                 | -29.3       |
| 4574.5          | Average  | Horizontal       | 30.3                          | 4.9                    | 35.2                          | 54.0                 | -18.8       |
| 5489.4*         | Peak     | Vertical         | 41.4                          | 7.6                    | 49.1                          | 74.0                 | -25.0       |
| 5489.2*         | Average  | Vertical         | 35.6                          | 7.6                    | 43.2                          | 54.0                 | -10.8       |
| 5489.7*         | Peak     | Horizontal       | 40.9                          | 7.6                    | 48.5                          | 74.0                 | -25.5       |
| 5489.4*         | Average  | Horizontal       | 34.6                          | 7.6                    | 42.3                          | 54.0                 | -11.8       |
| 6405.6*         | Peak     | Vertical         | 37.3                          | 8.5                    | 45.8                          | 74.0                 | -28.2       |
| 6404.1*         | Average  | Vertical         | 26.4                          | 8.5                    | 34.9                          | 54.0                 | -19.1       |
| 6404.1*         | Peak     | Horizontal       | 37.1                          | 8.5                    | 45.6                          | 74.0                 | -28.4       |
| 6404.4*         | Average  | Horizontal       | 26.7                          | 8.5                    | 35.2                          | 54.0                 | -18.8       |
| 7319.8          | Peak     | Vertical         | 35.8                          | 11.1                   | 46.9                          | 74.0                 | -27.1       |
| 7319.5          | Average  | Vertical         | 24.9                          | 11.1                   | 36.0                          | 54.0                 | -18.0       |
| 7319.0          | Peak     | Horizontal       | 35.9                          | 11.1                   | 47.0                          | 74.0                 | -27.0       |
| 7319.2          | Average  | Horizontal       | 25.7                          | 11.1                   | 36.8                          | 54.0                 | -17.2       |
| 8236.9          | Peak     | Vertical         | 35.6                          | 11.8                   | 47.4                          | 74.0                 | -26.6       |
| 8234.0          | Average  | Vertical         | 23.1                          | 11.8                   | 34.9                          | 54.0                 | -19.1       |
| 8237.8          | Peak     | Horizontal       | 35.7                          | 11.8                   | 47.5                          | 74.0                 | -26.5       |
| 8234.2          | Average  | Horizontal       | 23.1                          | 11.8                   | 34.8                          | 54.0                 | -19.2       |
| 9145.3          | Peak     | Vertical         | 35.7                          | 12.4                   | 48.1                          | 74.0                 | -25.9       |
| 9148.5          | Average  | Vertical         | 22.8                          | 12.4                   | 35.2                          | 54.0                 | -18.8       |
| 9151.5          | Peak     | Horizontal       | 35.6                          | 12.4                   | 48.0                          | 74.0                 | -26.0       |
| 9148.8          | Average  | Horizontal       | 23.8                          | 12.4                   | 36.2                          | 54.0                 | -17.8       |

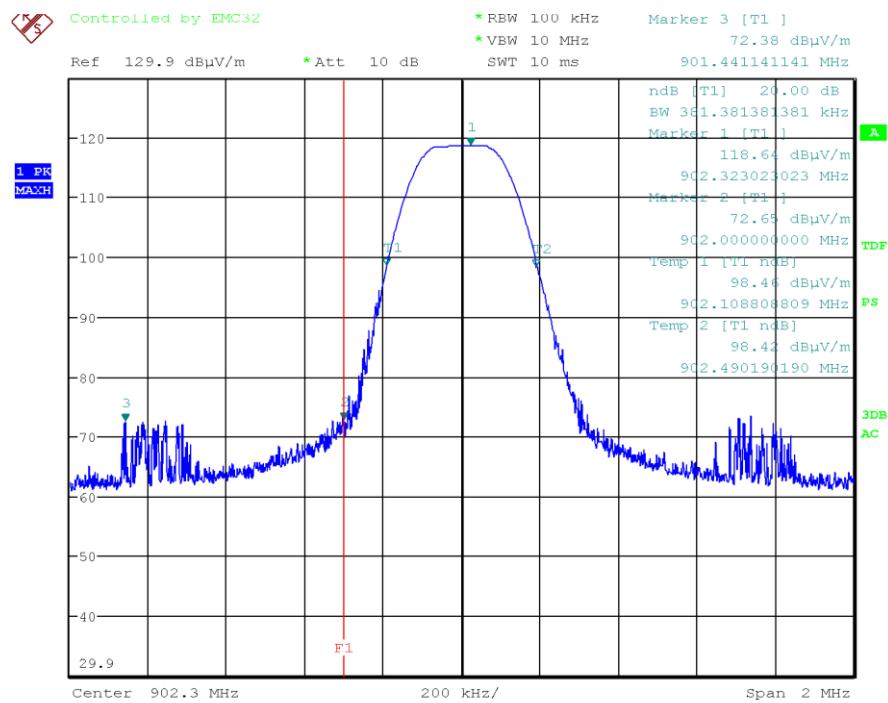
| Frequency (MHz)  | Detector | Antenna Polarity | Receiver Reading (dB $\mu$ V) | Correction Factor (dB) | Field Strength (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) |
|--|----------|------------------|-------------------------------|------------------------|-------------------------------|----------------------|-------------|
| *Emission falls outside the restricted bands of 15.205 |          |                  |                               |                        |                               |                      |             |

Table 7: Transmitting at the Highest Frequency

No other emissions were seen in the restricted bands



Graph 12: Lower Band Edge Plot (EUT Antenna Vertical, Measurement Antenna Vertical)



**Graph 13: Lower Band Edge Plot (EUT Antenna Horizontal, Measurement Antenna Horizontal)**

## Result

The radiated spurious emissions in the restricted bands met the limits specified in §15.209 and radiated spurious emissions falling outside those bands were attenuated more than 20dB from the highest desired emission; therefore, the EUT complies with the specification

## 6.3 Sample Measurement Calculations

### 6.3.1 Filed 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. When an average measurement requires an average measurement correction value, it is also accounted for. The basic equation with a sample calculation is shown below:

$$\text{Receiver Amplitude Reading} = \text{Receiver Reading} - \text{Amplifier Gain}$$

$$\text{Correction Factor} = \text{Antenna Factor} + \text{Cable Factor}$$

$$\text{Field Strength} = \text{Receiver Amplitude Reading} + \text{Correction Factor} [+ \text{Average Correction Value}]$$

#### Example

Assuming a *Receiver Reading* of 42.5 dB $\mu$ V 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 dB $\mu$ V/m.

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

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

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

### 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:

$$\text{Correction Factor} = \text{LISN Transducer Factor} + \text{Cable Factor}$$

$$\text{Conducted Emission Value} = \text{Receiver Amplitude Reading} + \text{Correction Factor}$$

#### Example

Assuming a *Receiver Reading* of 20.8 dB $\mu$ V 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 dB $\mu$ V.

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

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

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

## 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      | 12/02/2024               | 12/02/2025              |
| Spectrum Analyzer/ Signal Analyzer   | Rohde & Schwarz | FSV40        | V044352      | 03/05/2024               | 03/05/2026              |
| LISN                                 | Teseq           | NNB 51       | V045406      | 12/19/2024               | 12/19/2025              |
| Conductance Cable Wanship Upper Site | VPI Labs        | Cable J      | V034832      | 12/19/2024               | 12/19/2025              |
| EMC32 Measurement Software           | Rohde & Schwarz | 10.60.20     | N/A          | N/A                      | N/A                     |

**Table 8: List of equipment used for conducted emissions testing at mains ports.**

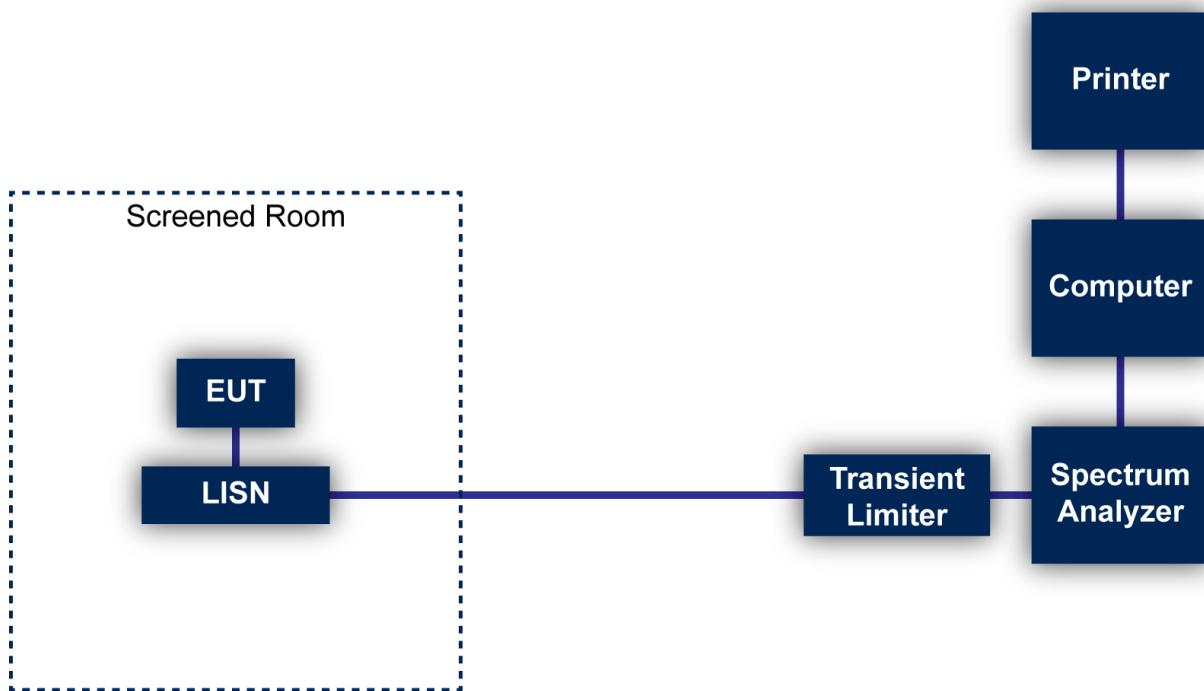


Figure 1: Conducted Emissions Test

## 7.2 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/Receiver        | Rohde & Schwarz | ESU40        | V033119      | 12/02/2024               | 12/02/2025              |
| Spectrum Analyzer/Signal Analyzer | Rohde & Schwarz | FSV40        | V044352      | 03/05/2024               | 03/05/2026              |
| “DUT 5” Cable                     | N/A             | N/A          | N/A          | 12/19/2024               | 12/19/2025              |
| EMC32 Test Software               | Rohde & Schwarz | 11.60        | N/A          | N/A                      | N/A                     |

### 7.2.1 Test Configuration Block Diagram



Figure 2: Direct Connection at the Antenna Port Test

### 7.3 Radiated Emissions

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

A preamplifier with a fixed gain 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 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      | 12/02/2024               | 12/02/2025              |
| Spectrum Analyzer/ Signal Analyzer | Rohde & Schwarz | FSV40                   | V044352      | 03/05/2024               | 03/05/2026              |
| Loop Antenna                       | EMCO            | 6502                    | V034216      | 04/27/2025               | 04/27/2027              |
| Biconilog Antenna                  | EMCO            | 3142E                   | V057461      | 07/06/2023               | 07/06/2025              |
| Power Amplifier                    | HP              | 8447E                   | V034189      | 12/19/2024               | 12/19/2025              |
| Double Ridged Guide Antenna        | EMCO            | 3115                    | V034413      | 01/25/2025               | 01/25/2027              |
| Standard Gain Horn                 | ETS-Lindgren    | 3160-09                 | V034223      | ICO                      | ICO                     |
| High Frequency Amplifier           | Miteq           | AFS4-001018000-35-10P-4 | V033997      | 12/19/2024               | 12/19/2025              |
| 900 MHz High Pass Filter           | Micro-Tronics   | HPM50108-03             | V034185      | 12/19/2024               | 12/19/2025              |

| Type of Equipment                                   | Manufacturer    | Model Number          | Asset Number | Date of Last Calibration | Due Date of Calibration |
|---|-----------------|-----------------------|--------------|--------------------------|-------------------------|
| 2.4 GHz High Pass Filter                            | Micro-Tronics   | HPM50111-03           | V034183      | 12/19/2024               | 12/19/2025              |
| 2.4 GHz Notch Filter                                | Micro-Tronics   | BRM50702-03           | V034213      | 12/19/2024               | 12/19/2025              |
| 6' High Frequency Cable                             | Microcoax       | UFB197C-0-0720-000000 | V033638      | 12/19/2024               | 12/19/2025              |
| 20' High Frequency Cable                            | Microcoax       | UFB197C-1-3120-000000 | V033979      | 12/19/2024               | 12/19/2025              |
| 3 Meter Radiated Emissions Cable Wanship Upper Site | Microcoax       | UFB205A-0-4700-000000 | V033639      | 12/19/2024               | 12/19/2025              |
| EMC32 Test Software                                 | Rohde & Schwarz | 10.60.20              | N/A          | N/A                      | N/A                     |

Table 9: List of equipment used for radiated emissions testing.

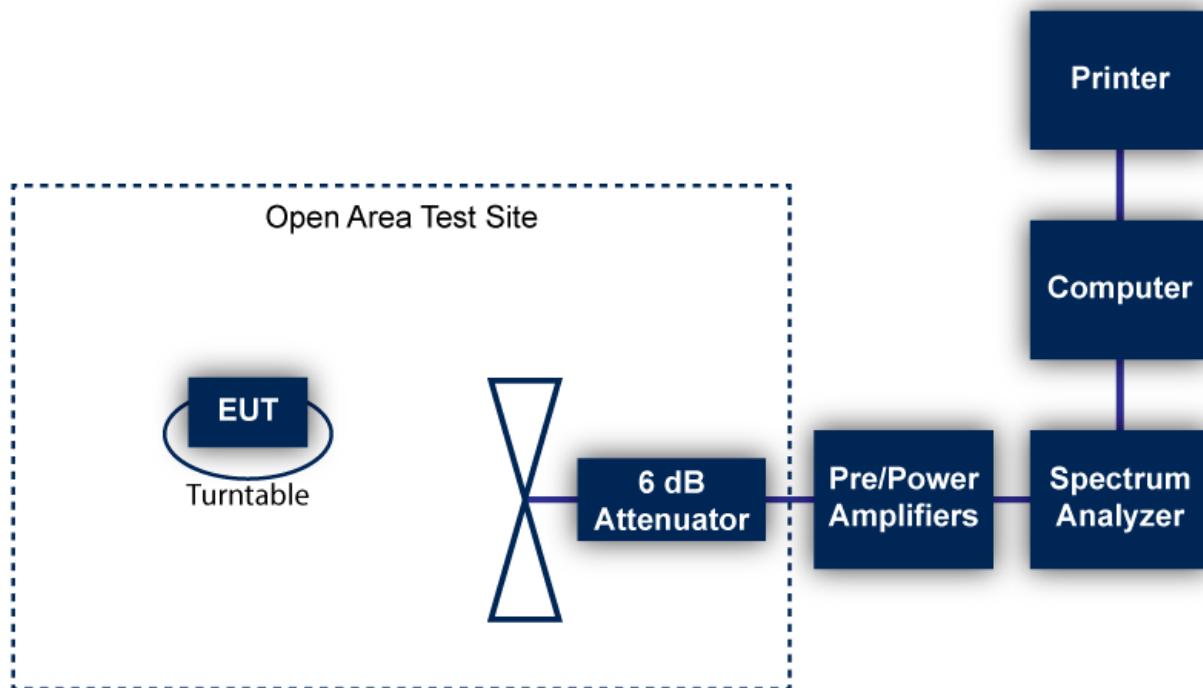


Figure 3: Radiated Emissions Test

## 7.4 Equipment Calibration

All applicable equipment is calibrated using either an independent calibration laboratory or VPI Technology, 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 ( $\pm$ 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 – Frequencies Below 1000 MHz**



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



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



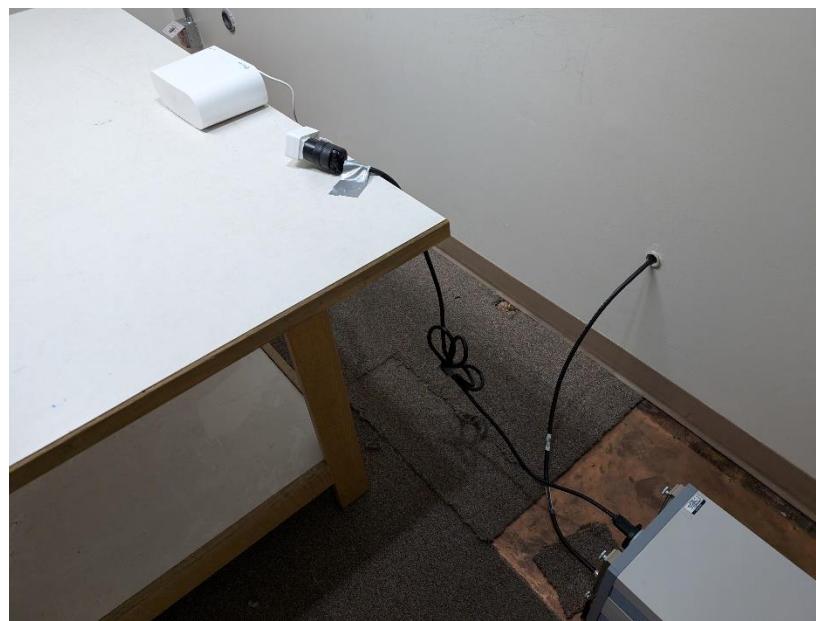
**Photograph 4: Back View Radiated Emissions Worst-Case Configuration – Frequencies Above 1000 MHz**



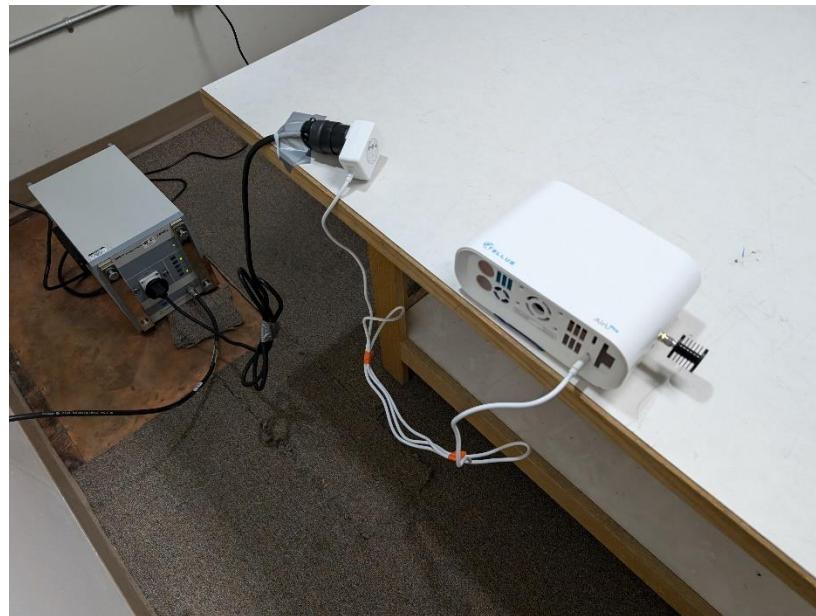
**Photograph 5: View of Horizontal EUT Antenna Orientation – Frequencies Below 1000 MHz**



**Photograph 6: Back View Radiated Emissions Worst-Case Configuration – Frequencies Above 1000 MHz**



**Photograph 7: Front View Conducted Emissions Worst-Case Configuration**



**Photograph 8: Back View Conducted Emissions Worst-Case Configuration**



**Photograph 9: Front and Top View of the EUT Enclosure**



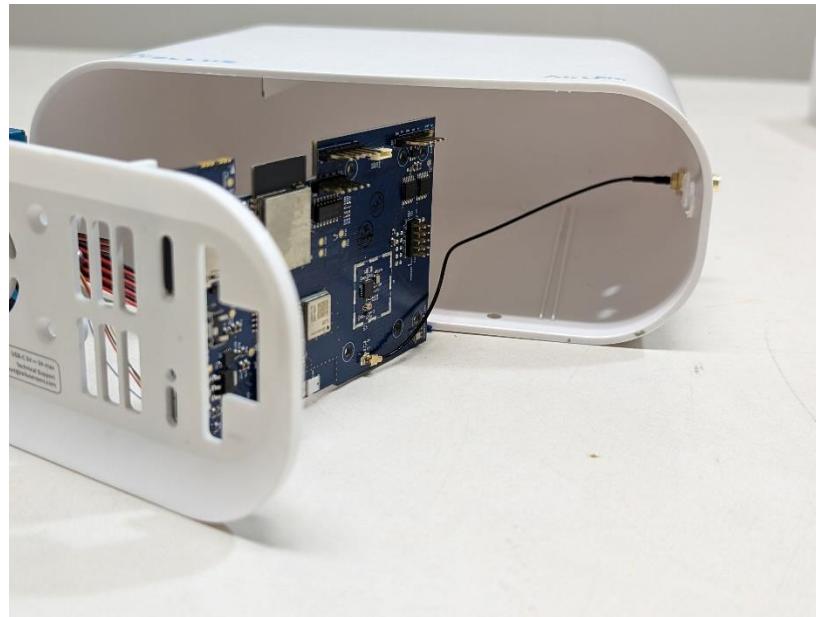
**Photograph 10: Back and Bottom View of the EUT Enclosure**



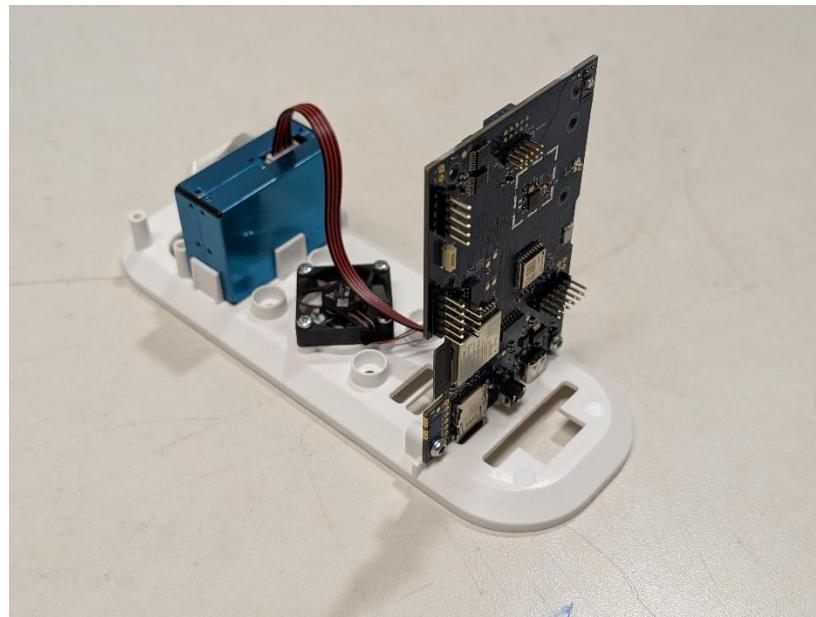
**Photograph 11: Side 1 View of the EUT Enclosure**



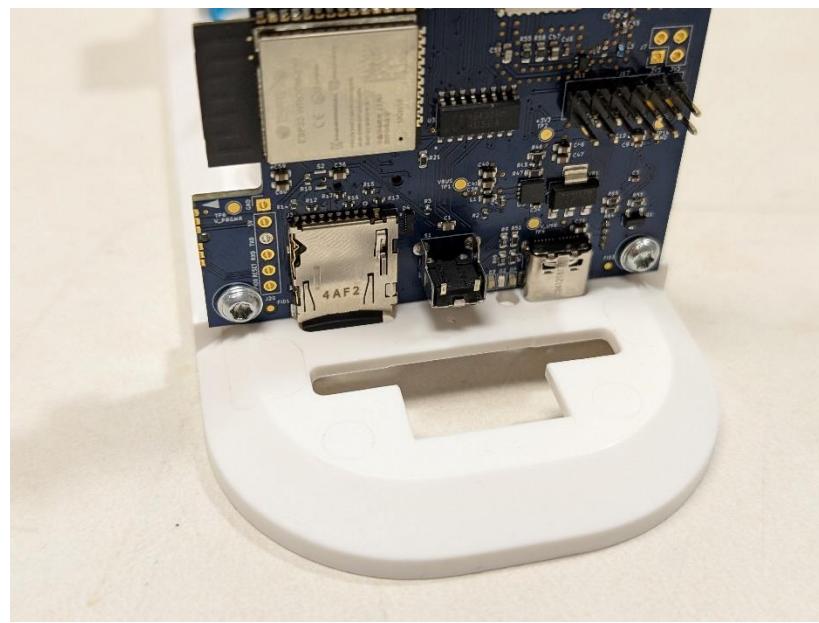
**Photograph 12: Side 2 View of the EUT Enclosure**



**Photograph 13: PCB Placement in Enclosure Showing Antenna Connection to Enclosure**



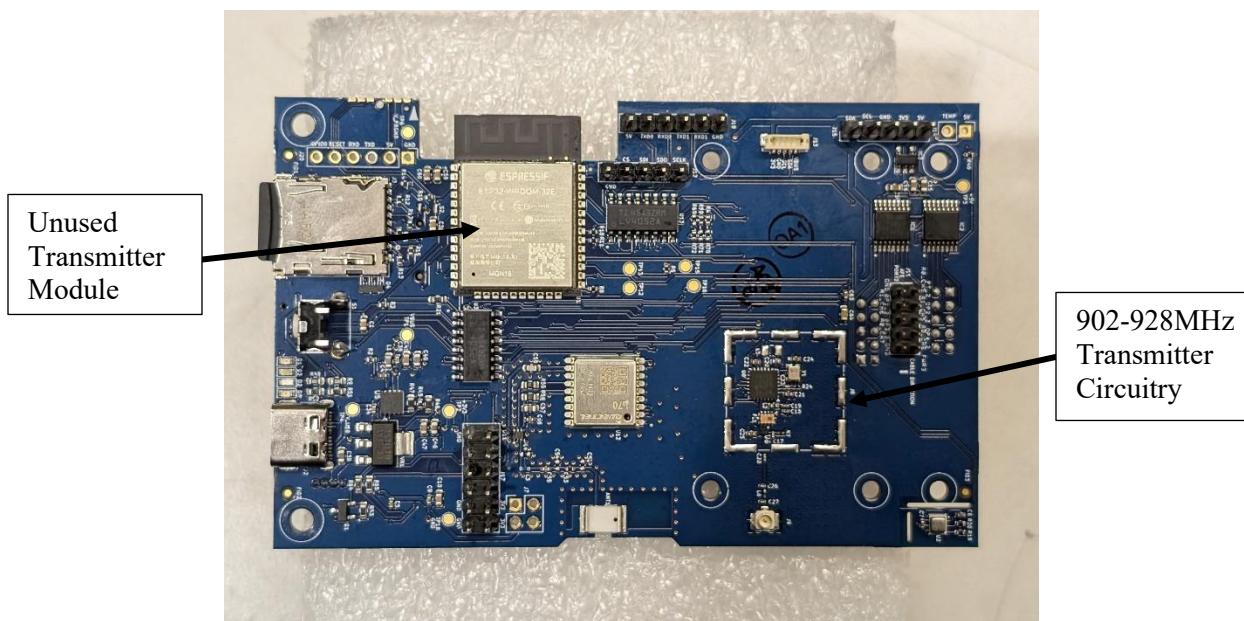
**Photograph 14: PCB Placement in Enclosure Rear**



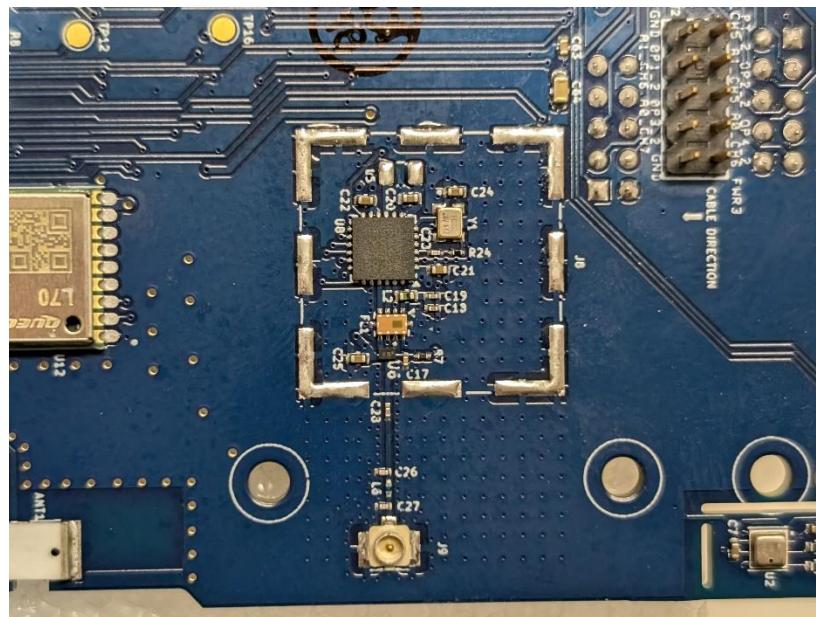
**Photograph 15: PCB Placement in Enclosure Rear Showing EUT Fastened to Enclosure**



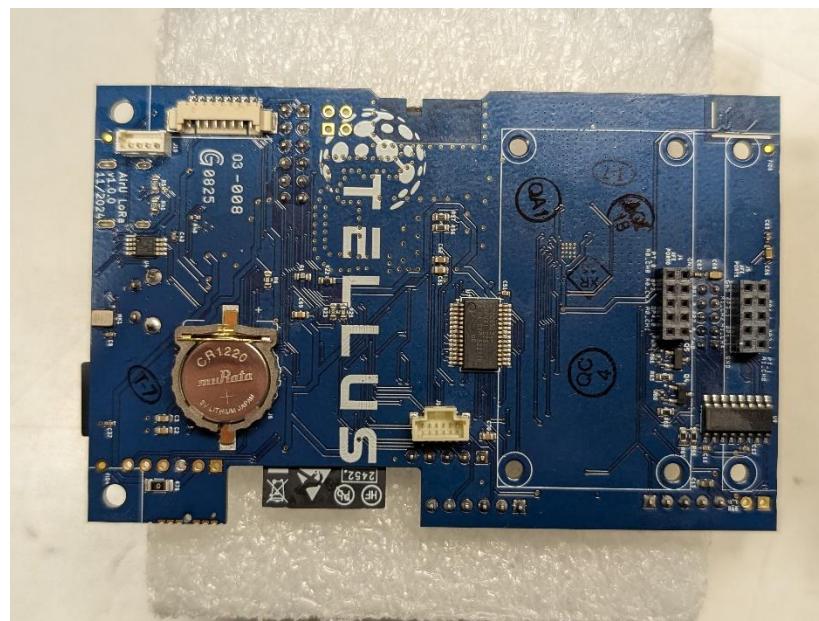
**Photograph 16: PCB Placement in Enclosure Rear Showing EUT Unfastened**



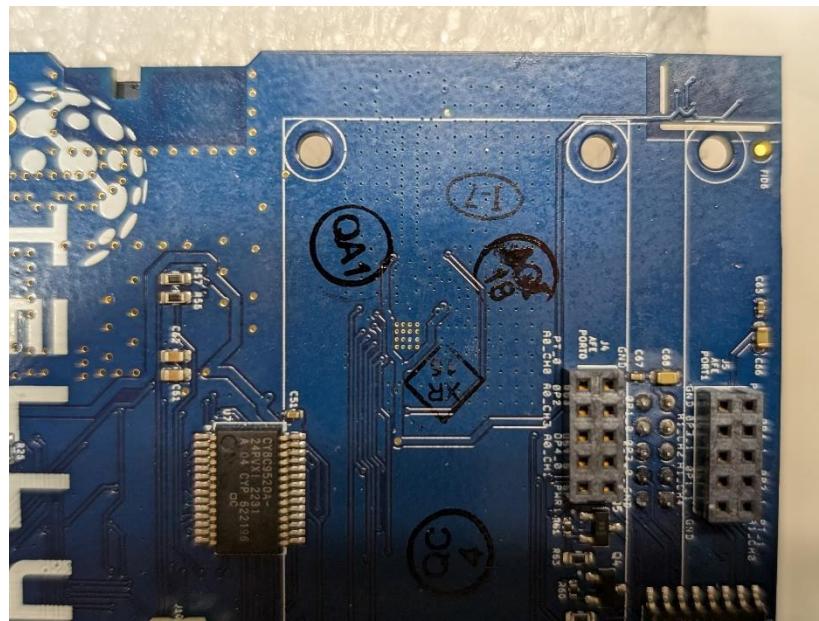
**Photograph 17: PCB Front View**



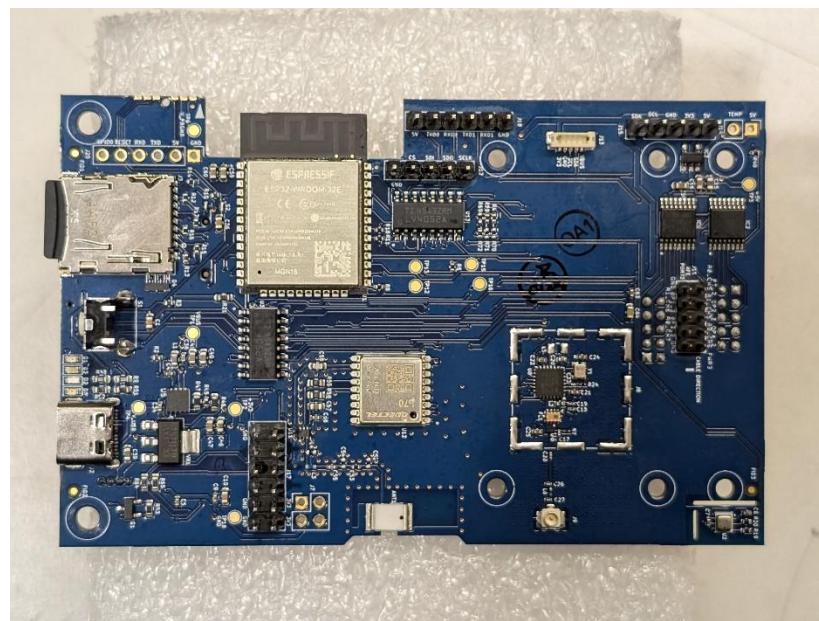
**Photograph 18: Closeup of Radio Circuitry**



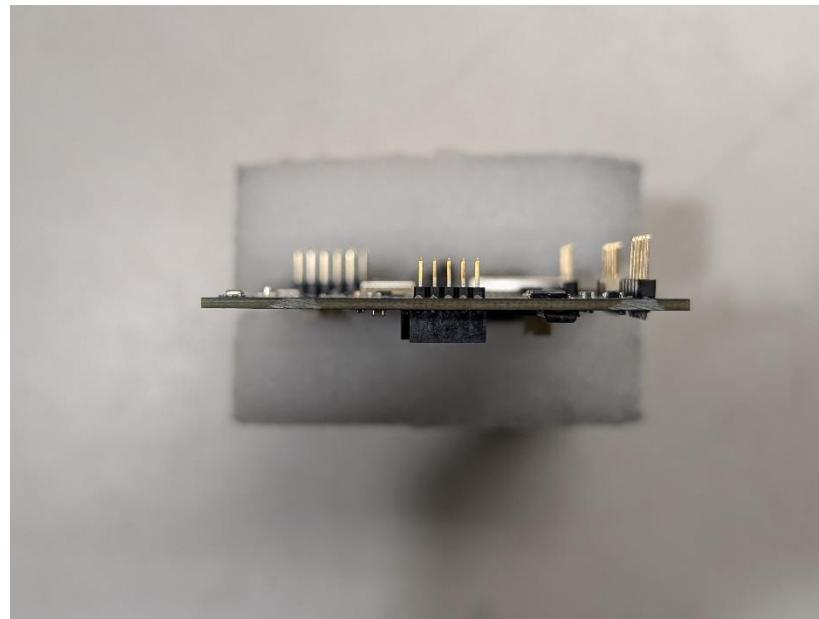
**Photograph 19: PCB Back View**



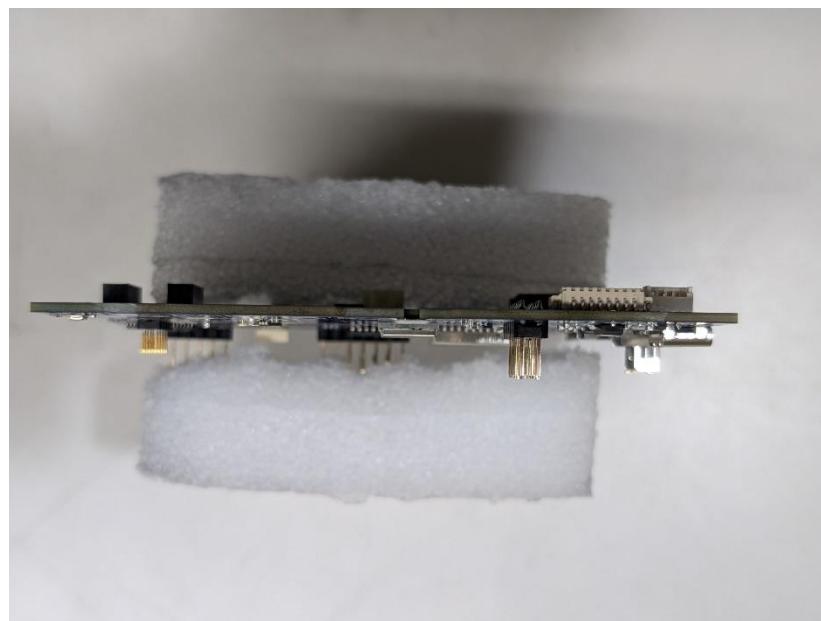
**Photograph 20: Closeup of Back of Radio Circuitry**



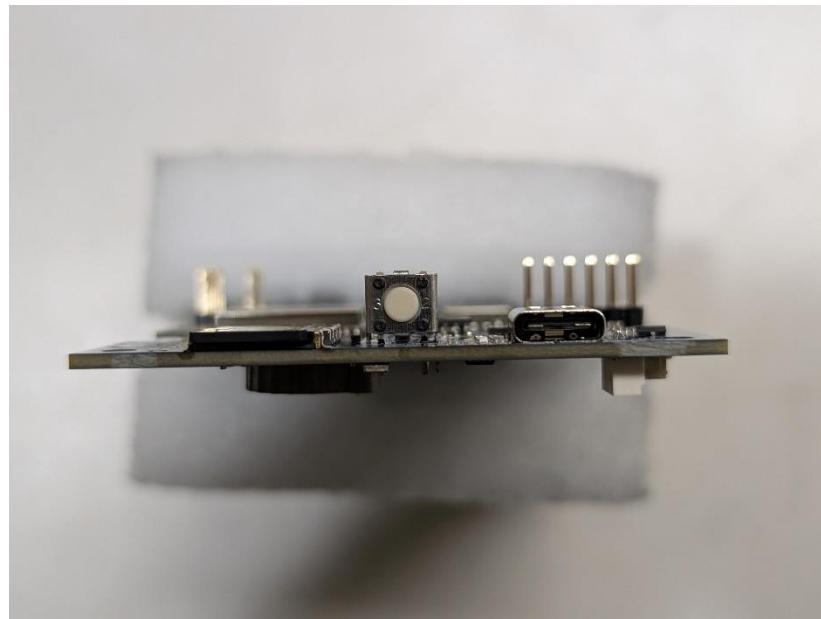
**Photograph 21: PCB Front View**



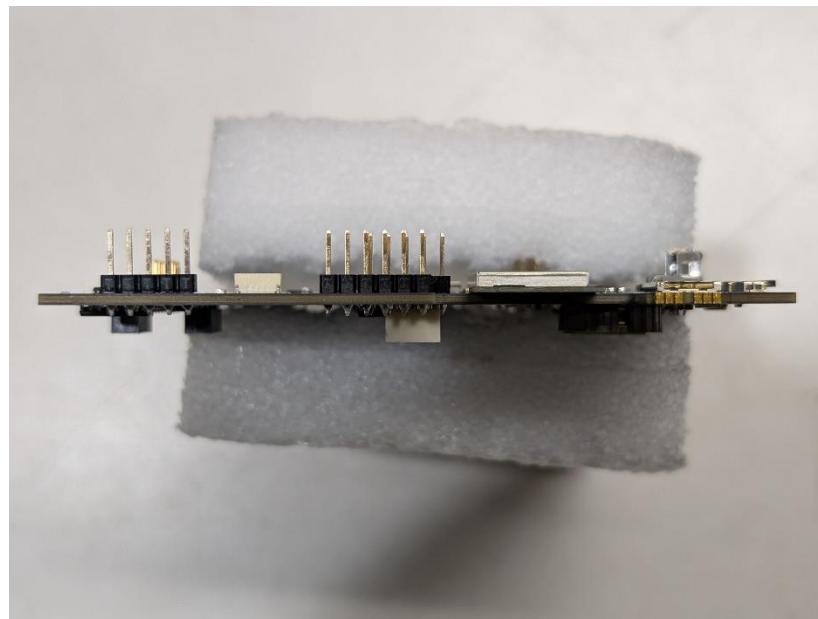
**Photograph 22: Edge 1 of PCB**



**Photograph 23: Edge 2 of PCB**



**Photograph 24: Edge 3 of PCB**



**Photograph 25: Edge 4 of PCB**



**Photograph 26: View of the Power Supply Used for Testing**

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--- End of Report ---