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**EMC testing of the INOVA Systems Corporation Quantum Dual Band HyperQ Node in accordance with FCC Part 15.247 and ANSI C63.10: 2013 as referenced by FCC OET KDB 558074 D01 15.247 Meas Guidance v05r02.**

**FCC ID: 2BHBH-95568866**

Test Dates: 2024-06-18 to 2024-06-21

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Prepared for: **INOVA Systems Corporation**

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## **1.0 INTRODUCTION**

### **1.1 Scope**

The purpose of this report is to present the results of compliance testing performed in accordance with FCC Part 15.247 and ANSI C63.10-2013 to gain FCC Authorization for Low-Power License-Exempt transmitters. All test procedures, limits, criteria, and results described in this report apply only to the INOVA Systems Corporation Quantum Dual Band HyperQ Node test sample, referred to herein as the EUT (Equipment Under Test).

The test sample has been provided by the customer.

This report does not imply product endorsement by the Electronics Test Centre, A2LA, nor any Canadian Government agency.

### **1.2 Applicant**

This test report has been prepared for INOVA Systems Corporation, located in Calgary, Alberta, Canada.

### **1.3 Test Sample Description**

As provided to ETC (Airdrie) by INOVA Systems Corporation:

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       |                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|-----------------------------------------------------------|
| <b>Product Name:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                       | Quantum Dual Band HyperQ Node                             |
| <b>LoRa Radio</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Frequency Band</b>                 | 902 – 928 MHz                                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Frequency Range</b>                | 902.3 – 908.5 MHz                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Mode of Operation</b>              | Hybrid 125KHz                                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Max Transmit Power (Conducted)</b> | 17.4 dBm (0.055 W)                                        |
| <b>Associated LoRa Antennas</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                       | NIC Component Corporation MAN-F series Max Gain = -3.0dBi |
| <b>Model#</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                       | FNL41075                                                  |
| <b>Serial#</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                       | Q00800188, Q00800164                                      |
| <b>Power supply:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                       | Battery Powered                                           |
| <b>Note:</b> There are two variants: model # FNL41075 with the geophone option and model # FNL41076 without this option. In FNL41076 model geophone connector is terminated with resistor. Both models enclosures are the same. Model #FNL41075 with extra features was selected for testing. All three channels (LOW, MID, and HIGH) for both LoRa and BLE radios are analyzed to determine the worst channels for each radio. Full emission scans are performed on the worst channels of each radio. Both radios are transmitting simultaneously during the spurious emission scans to cover the co-location test at the same time. |                                       |                                                           |

### **1.4 General Test Conditions**

The EUT was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. All inputs and outputs to and from other equipment associated with the EUT were adequately simulated. In order to meet the operational requirements during testing as per KDB 558074 D01 15.247 Meas Guidance v05r02 and ANSI C63.10-2013 clause 5.11 the device was programmed with a special firmware to transmit at maximum achievable duty cycle. Special firmware is strictly for testing purpose only and not available to end user. This special test case represents the worst-case duty cycle. For antenna port conducted emission spectrum analyzer is connected to the UFL connector of the radio via UFL to SMA Cable with 10dB Pad.

The environmental conditions are recorded during each test, and are reported in the relevant sections of this document.

## 1.5 Reference Standards

| Standards                              | Description                                                                                                                                                                              |
|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FCC, title 47 CFR § 15.247             | Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.                                                                                                              |
| FCC, title 47 CFR § 15.207             | Conducted limits for an intentional radiator that is designed to be connected to the public utility (AC) power line.                                                                     |
| FCC, title 47 CFR § 15.107             | Conducted limits for equipment that is designed to be connected to the public utility (AC) power line.                                                                                   |
| FCC, title 47 CFR § 15.209             | Radiated emission limits; general requirements                                                                                                                                           |
| FCC, title 47 CFR § 15.109             | Radiated emission limits; from unintentional radiators digital devices.                                                                                                                  |
| ANSI C63.10-2013                       | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices                                                                                           |
| ANSI C63.4-2014                        | American National Standard for Methods of Measurement of Radio – Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 KHz to 40 GHz                    |
| 558074 D01 15.247 Meas Guidance v05r02 | Guidance For Compliance Measurements On Digital Transmission System, Frequency Hopping Spread Spectrum System, And Hybrid System Devices Operating Under Section 15.247 Of The FCC Rules |

## 1.6 Test Methodology

Test methods are specified in the Basic Standard as referenced and/or modified by the Product Standard in the part of Section 2 of this report associated with each particular test case. EUT tested for RX mode to cover FCC Part 15 subpart B (digital Circuitry).

### 1.6.1 Variations in Test Methodology

Any variance in methodology or deviation from the reference Standard is documented in the part of Section 2 of this report associated with each particular Test Case.

### 1.6.2 Test Sample Verification, Configuration & Modifications

EUT setup, configuration, protocols for operation and monitoring of EUT functions, and any modifications performed in order to meet the requirements, are detailed in each Test Case of Section 2 of this report.

### 1.6.3 Uncertainty of Measurement:

The factors contributing to measurement uncertainty are identified and calculated in accordance with CISPR 16-4-2: 2011.

This uncertainty estimate represents an expended uncertainty expressed at approximately 95% confidence using a coverage factor of  $k = 2$ .

| Test Method                                   | Uncertainty |
|-----------------------------------------------|-------------|
| Radiated Emissions Level (9 KHz – 1 GHz)      | ±5.6 dB     |
| Radiated Emissions Level (1 GHz – 18 GHz)     | ±5.0 dB     |
| Radiated Emissions Level (18 GHz – 26.5 GHz)  | ±5.2 dB     |
| Conducted Emissions Level (150 KHz – 30 MHz)  | ±2.4 dB     |
| Uncertainty Conducted Power level             | ±0.5 dB     |
| Uncertainty Conducted Spurious emission level | ±0.6 dB     |
| Uncertainty for Bandwidth test                | ±1.5 %      |

## 2.0 TEST CONCLUSION

### STATEMENT OF COMPLIANCE

The customer equipment referred to in this report was found to comply with the requirements, as summarized below.

The EUT was subjected to the following tests. Compliance status is reported as **Compliant** or **Non-compliant**. **N/A** indicates the test was Not Applicable to the EUT.

The measurement uncertainty is not accounted for determination of the statement of compliance. The statement of compliance is based only on the measurement value recorded.

**Note:** Maintenance of compliance is the responsibility of the Manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the EUT with respect to the standards detailed in this test report.

The following table summarizes the tests performed in terms of the specification, class or performance criterion applied, and the EUT modification state.

| Test Case | Test Type                                                   | Specification                  | Test Sample                   | Modifications | Config.    | Result                    |
|-----------|-------------------------------------------------------------|--------------------------------|-------------------------------|---------------|------------|---------------------------|
| 2.1       | Duty Cycle                                                  | 15.247                         | Quantum Dual Band HyperQ Node | none          | see § 2.1  | 40%                       |
| 2.2       | AC Main Conducted Emissions                                 | 15.207 / 5.107                 | Quantum Dual Band HyperQ Node | none          | see § 2.2  | N/A<br>(Internal Battery) |
| 2.3       | Occupied Bandwidth                                          | 15.247(a)(1)<br>15.247(a)(2)   | Quantum Dual Band HyperQ Node | none          | see § 2.3  | Compliant                 |
| 2.4       | Max Output Average Power                                    | 15.247(b,2,3)                  | Quantum Dual Band HyperQ Node | none          | see § 2.4  | Compliant                 |
| 2.5       | Power Spectral Density                                      | 15.247(e)<br>15.247(f)         | Quantum Dual Band HyperQ Node | none          | see § 2.5  | Compliant                 |
| 2.6       | Band Edge                                                   | 15.247(d)                      | Quantum Dual Band HyperQ Node | none          | see § 2.6  | Compliant                 |
| 2.7       | Conducted Spurious Emission (Non-Restricted Band Operation) | 15.247(d)                      | Quantum Dual Band HyperQ Node | none          | see § 2.7  | Compliant                 |
| 2.8       | Minimum channel separation                                  | 15.247(a)(1)                   | Quantum Dual Band HyperQ Node | none          | see § 2.8  | Compliant                 |
| 2.9       | Average time of Occupancy for hybrid System                 | 15.247(f)                      | Quantum Dual Band HyperQ Node | none          | see § 2.9  | Compliant                 |
| 2.10      | EUT Position                                                | ANSI C63.4                     | Quantum Dual Band HyperQ Node | none          | see § 2.10 | N/A<br>(Fix Position)     |
| 2.11      | Radiated Spurious Emission (Restricted Band)                | 15.205,<br>15.209<br>15.247(d) | Quantum Dual Band HyperQ Node | none          | see § 2.11 | Compliant                 |
| 2.12      | Radiated Emission                                           | 15.109                         | Quantum Dual Band HyperQ Node | none          | see § 2.12 | Compliant                 |
| 2.13      | RF Exposure                                                 | 15.247(i)                      | Quantum Dual Band HyperQ Node | none          | see § 2.13 | Exempt                    |

Refer to the test data for applicable test conditions.

## 2.1 Duty Cycle

|                                            |                                                         |
|--------------------------------------------|---------------------------------------------------------|
| Test Lab: Electronics Test Centre, Airdrie | EUT: Quantum Dual Band HyperQ Node                      |
| Test Personnel: Janet Mijares              | Standard: FCC PART 15.247                               |
| Date: 2024-06-20 (20.7°C, 27.4% RH)        | Basic Standard: ANSI C63.10: 2013<br>FCC OET KDB 558074 |

**Duty Cycle LoRa = 39.7 %**

**Criteria:** All measurements are to be performed with EUT continuous transmit mode at 100% duty cycle or at least  $\geq 98\%$  duty cycle at its maximum control level; however, if 100% duty cycle cannot be achieved, an additional measurement of the transmitter duty cycle (D) are required for each tested mode of operation. (Duty Factor =  $10 \cdot \log(1/\text{duty cycle})$ ).

### 2.1.1 Test Guidance: ANSI C63.10-2013, Clause 11.6 / FCC OET KDB 558074 clause 6

This measurement is performed at low, mid and high frequencies, with modulation.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

- 1) Set the center frequency of the instrument to the center frequency of the transmission.
- 2) Set RBW  $\geq$  OBW if possible; otherwise, set RBW to the largest available value.
- 3) Set detector = peak or average.
- 4) The zero-span measurement method shall not be used unless both RBW and VBW are  $> 50/T$  and the number of sweep points across duration T exceeds 100.

### 2.1.2 Test Equipment

Testing was performed with the following equipment:

| Equipment              | Manufacturer | Model #                | Asset # | Cal. Date            | Cal. Due   |
|------------------------|--------------|------------------------|---------|----------------------|------------|
| EMI receiver           | Agilent      | N9038A<br>(FW A.25.05) | 6130    | 2023-08-11           | 2024-08-11 |
| Temp/Humidity          | Extech       | 42270                  | 5871    | 2024-04-08           | 2025-04-08 |
| Attenuator             | PCB          | BWS102W263             | 6932    | 2022-12-10           | 2025-12-10 |
| Coaxial Cables<br>(RF) | W.L. GORE    | PGR01R01036            | -       | Cal. before each use |            |
| DC Blocker             | Centric RF   | C0927 SMA              | 6987    | Cal. before each use |            |

**Test setup diagrams for Power testing:**

**Conducted:**



### 2.1.3 Duty Cycle

| Channel | On time (ms) | Period (ms) | Duty Cycle<br>DC= (on time/period) x100 (%) | Duty Factor<br>10log(1/Duty Cycle) (dB) |
|---------|--------------|-------------|---------------------------------------------|-----------------------------------------|
| Low     | 330.1        | 832         | 39.7                                        | 4.012                                   |
| MID     | 330.7        | 836         | 39.6                                        | 4.023                                   |
| High    | 330.5        | 835.4       | 39.6                                        | 4.023                                   |

**Comments:** Duty cycle is constant as variations are less than ±2%.



## 2.2 AC Main Power Line Conducted Emissions: N/A

|                                                                                                                |                                                                                                                                                           |
|----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Test Lab: Electronics Test Centre, Airdrie                                                                     | EUT: Quantum Dual Band HyperQ Node<br>Standard: FCC Part 15.207, FCC Part 15.107<br>Basic Standard: ANSI C63.10: 2013<br>Basic Standard: ANSI C63.4: 2014 |
| EUT status: N/A                                                                                                |                                                                                                                                                           |
| <b>Comments:</b> EUT is internal rechargeable battery powered. The unit is not operating during charging mode. |                                                                                                                                                           |

## 2.3 Occupied Bandwidth

|                                            |                                                        |
|--------------------------------------------|--------------------------------------------------------|
| Test Lab: Electronics Test Centre, Airdrie | EUT: Quantum Dual Band HyperQ Node                     |
| Test Personnel: Janet Mijares              | Standard: FCC PART 15.247                              |
| Date: 2024-06-20 (20.7°C, 27.4% RH)        | Basic Standard: ANSI C63.10-2013<br>FCC OET KDB 558074 |
| EUT status: Compliant                      |                                                        |

Specification: FCC Part 15.247 (a, 1, i)

Criteria: The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

### 2.3.1 Test Guidance: ANSI C63.10-2013, Clause 6.9.2 & 6.9.3/ FCC OET KDB 558074

This measurement is performed at low, mid and high frequencies, with modulation.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

| Use the following spectrum analyzer setting:                                                                                                        |                                                                  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| Span                                                                                                                                                | Between two time and five times the channel center frequency OBW |
| RBW                                                                                                                                                 | 1% to 5% of the OBW                                              |
| VBW                                                                                                                                                 | Approximately three times of RBW                                 |
| Sweep                                                                                                                                               | Auto Couple                                                      |
| Detector Function                                                                                                                                   | Peak                                                             |
| Trace                                                                                                                                               | Max Hold                                                         |
| Allow the trace to stabilize. The automated 99% BW function of the spectrum analyzer is engaged, 20dB bandwidth is measured with the X dB function. |                                                                  |

### 2.3.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

### 2.3.3 Test Equipment

Testing was performed with the following equipment:

| Equipment              | Manufacturer | Model #                | Asset # | Cal. Date            | Cal. Due   |
|------------------------|--------------|------------------------|---------|----------------------|------------|
| EMI receiver           | Agilent      | N9038A<br>(FW A.25.05) | 6130    | 2023-08-11           | 2024-08-11 |
| Temp/Humidity          | Extech       | 42270                  | 5871    | 2024-04-08           | 2025-04-08 |
| Attenuator             | PCB          | BWS102W263             | 6932    | 2022-12-10           | 2025-12-10 |
| Coaxial Cables<br>(RF) | W.L. GORE    | PGR01R01036            | -       | Cal. before each use |            |
| DC Blocker             | Centric RF   | C0927 SMA              | 6987    | Cal. before each use |            |

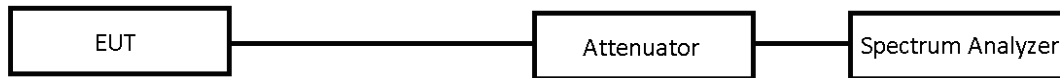
### 2.3.4 Test Sample Verification, Configuration & Modifications

The EUT was set to transmit continuously on a selected channel with test-specific software. The output was modulated as in normal operation.

The EUT met the requirements without modification.

Test setup diagrams for Occupied Bandwidth testing:

Conducted:

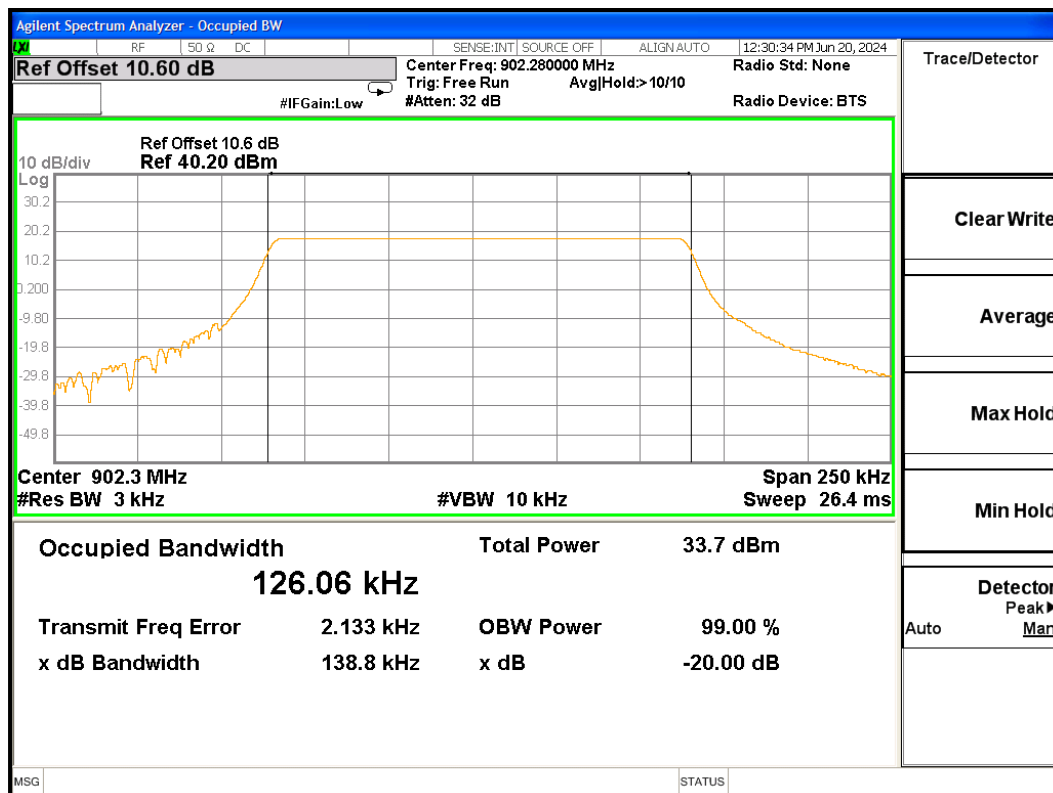


### 2.3.5 Channel Occupied Bandwidth Data:

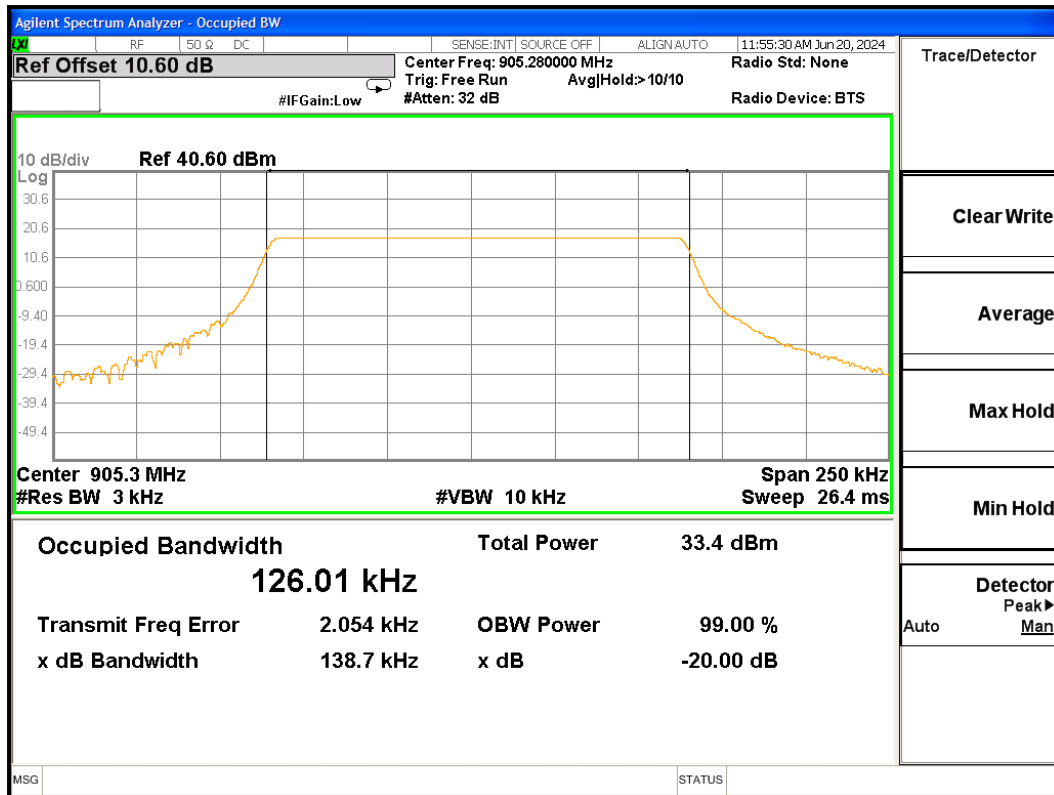
| Mode of operation | Channel | Freq. [MHz] | Occupied BW [kHz] | 20 dB BW [kHz] | Limit 20dB BW [KHz] |
|-------------------|---------|-------------|-------------------|----------------|---------------------|
| 125KHz Hybrid     | Low     | 902.3       | 126.06            | 138.8          | ≤ 500               |
|                   | Mid     | 905.3       | 126.01            | 138.7          |                     |
|                   | High    | 914.9       | 126.05            | 138.9          |                     |

### Hybrid (125 KHz) Mode

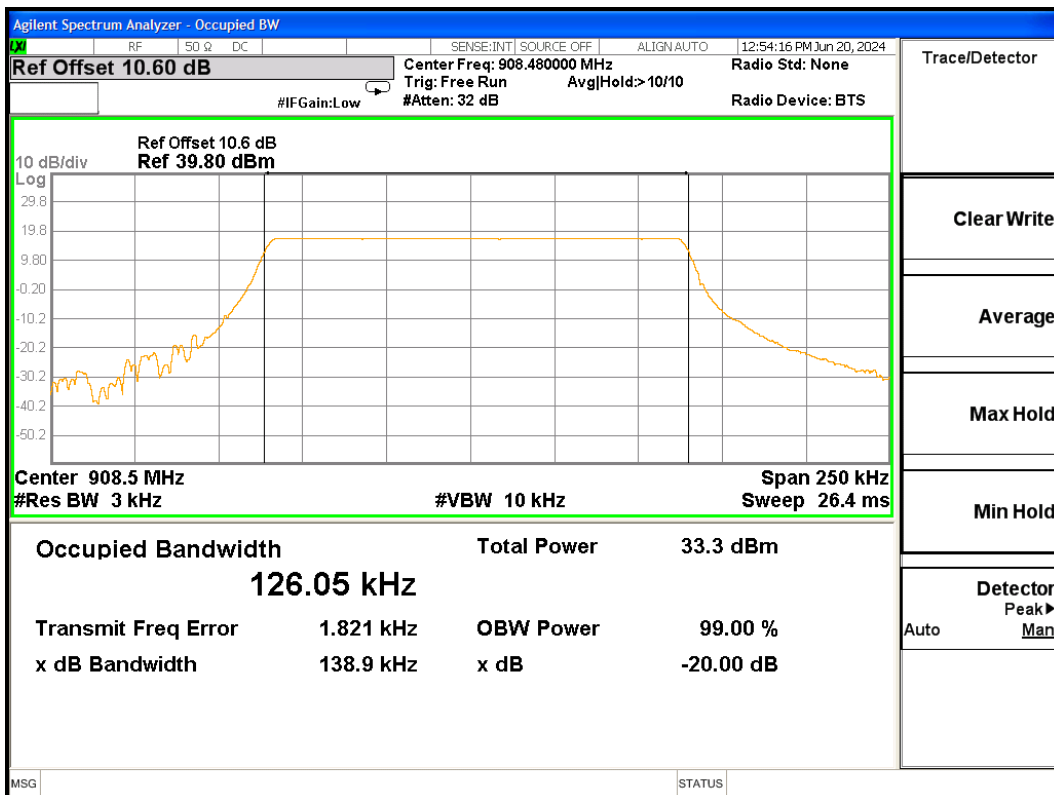
Screen Captures from the spectrum analyzer: Low Channel



## Screen Captures from the spectrum analyzer: MID Channel



## Screen Captures from the spectrum analyzer: High Channel



## 2.4 Max Average Output Power

|                                            |                                                         |
|--------------------------------------------|---------------------------------------------------------|
| Test Lab: Electronics Test Centre, Airdrie | EUT: Quantum Dual Band HyperQ Node                      |
| Test Personnel: Janet Mijares              | Standard: FCC PART 15.247                               |
| Date: 2024-06-20 (20.7°C, 27.4% RH)        | Basic Standard: ANSI C63.10: 2013<br>FCC OET KDB 558074 |
| EUT status: Compliant                      |                                                         |

### Specification: FCC Part 15.247(b, 3)

**Criteria** For hybrid system operating in the 902-928 MHz band: 1 watt

#### 2.4.1 Test Guidance: ANSI C63.10-2013, Clause 11.9.2.2.4 / FCC OET KDB 558074

This measurement is performed at low, mid and high frequencies, with modulation.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

| Output Power Method AVGSA-2 (Duty Cycle < 98%)             |                                                                                                                                                                                                                                                                                                                                                                     |
|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Measure the duty cycle D of the transmitter output signal. |                                                                                                                                                                                                                                                                                                                                                                     |
| Span                                                       | $\geq 1.5$ times the OBW                                                                                                                                                                                                                                                                                                                                            |
| RBW                                                        | 1 – 5 % of the OBW, $\leq 1$ MHz                                                                                                                                                                                                                                                                                                                                    |
| VBW                                                        | $\geq 3 \times$ RBW                                                                                                                                                                                                                                                                                                                                                 |
| Number of Points in sweep                                  | $\geq 2 \times$ Span / RBW                                                                                                                                                                                                                                                                                                                                          |
| Sweep time                                                 | Auto Couple                                                                                                                                                                                                                                                                                                                                                         |
| Detector                                                   | RMS (Power Averaging)                                                                                                                                                                                                                                                                                                                                               |
| Sweep trigger                                              | Free Run                                                                                                                                                                                                                                                                                                                                                            |
| Trace Average                                              | Minimum 100 traces in power Averaging (RMS) (Increased above 100 as needed such that the average accurately represents the true average over the ON and OFF periods of the transmitter)                                                                                                                                                                             |
| Power measured                                             | Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum. |
| Duty Cycle Correction Factor                               | Add $[10 \log (1 / D)]$ , where D is the duty cycle, to the measured power to compute the average power during the actual transmission times (because the measurement represents an average over both the ON and OFF times of the transmission). For example, add $[10 \log (1/0.25)] = 6$ dB if the duty cycle is 25%.                                             |

## 2.4.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

## 2.4.3 Test Equipment

Testing was performed with the following equipment:

| Equipment              | Manufacturer | Model #                | Asset # | Cal. Date            | Cal. Due   |
|------------------------|--------------|------------------------|---------|----------------------|------------|
| EMI receiver           | Agilent      | N9038A<br>(FW A.25.05) | 6130    | 2023-08-11           | 2024-08-11 |
| Temp/Humidity          | Extech       | 42270                  | 5871    | 2024-04-08           | 2025-04-08 |
| Attenuator             | PCB          | BWS102W263             | 6932    | 2022-12-10           | 2025-12-10 |
| Coaxial Cables<br>(RF) | W.L. GORE    | PGR01R01036            | -       | Cal. before each use |            |
| DC Blocker             | Centric RF   | C0927 SMA              | 6987    | Cal. before each use |            |

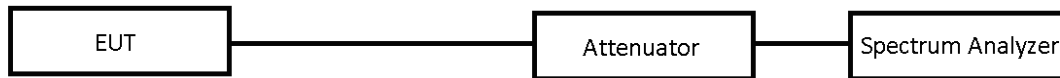
## 2.4.4 Test Sample Verification, Configuration & Modifications

The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation.

The EUT met the requirements without modification.

Test setup diagrams for Power testing:

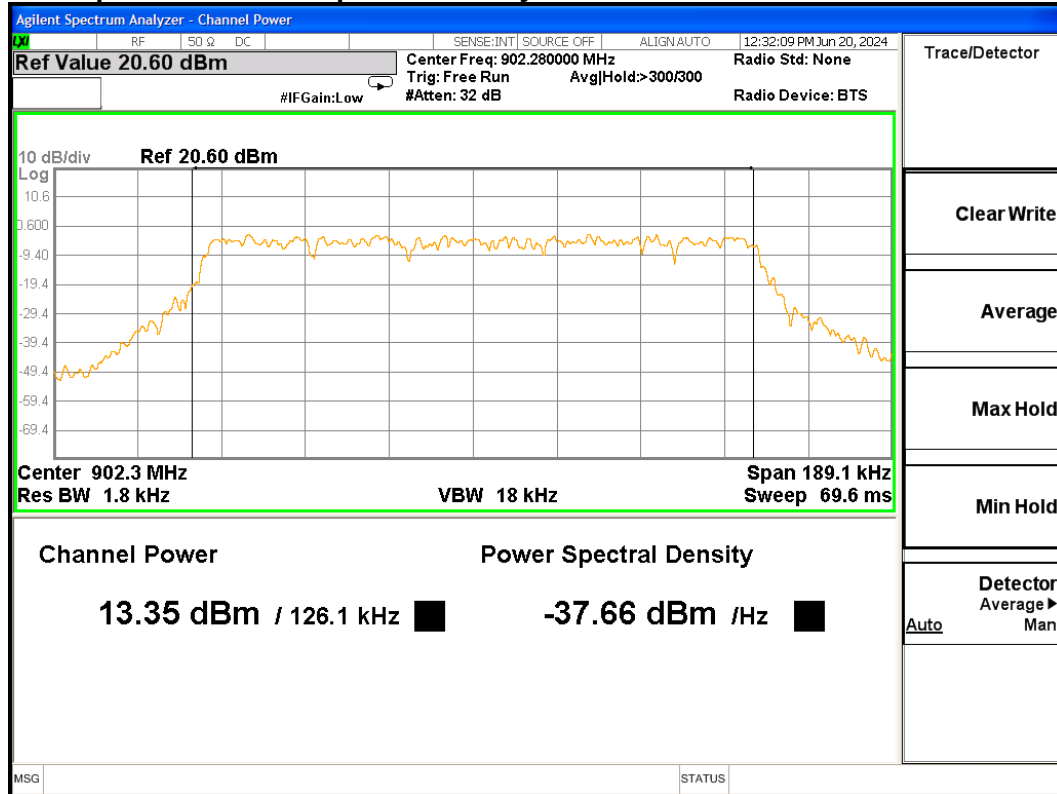
Conducted:



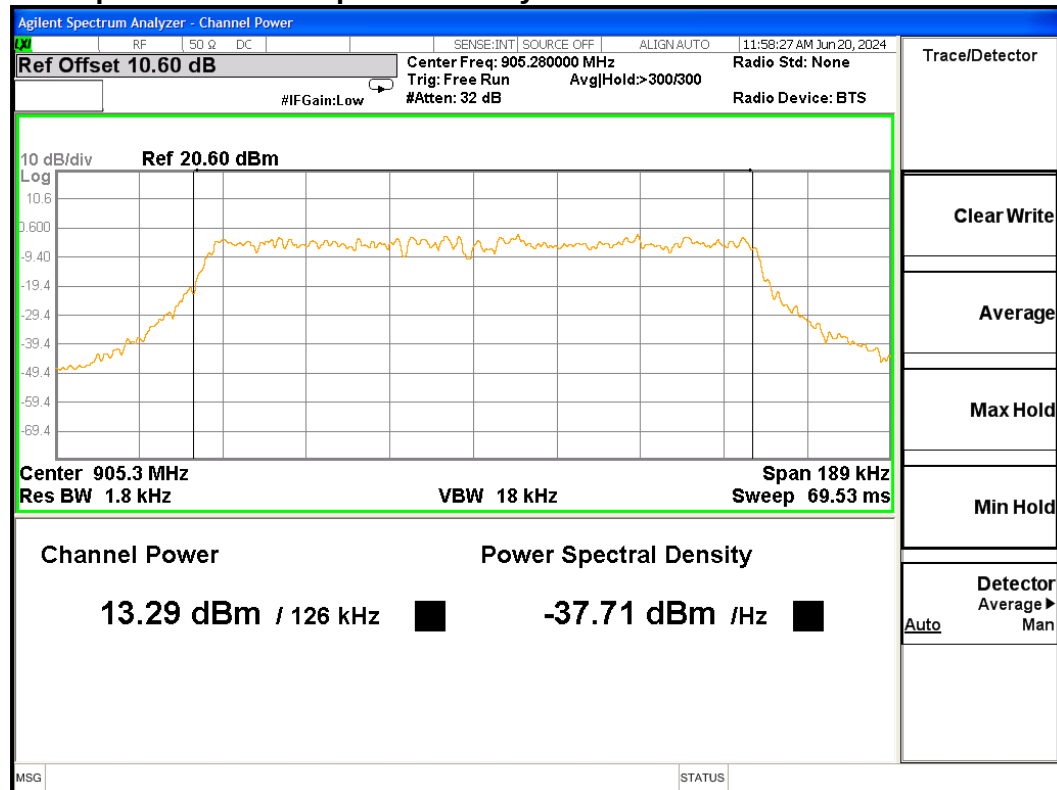
## 2.4.5 Max Output Power Data: DSS

| Mode of operation | Channel | Freq. [MHz] | Measured Average Power [dBm] | Duty Cycle Correction Factor (dB) | Corrected Average Power [dBm] | Limit Power [dBm] |
|-------------------|---------|-------------|------------------------------|-----------------------------------|-------------------------------|-------------------|
| 125KHz Hybrid     | Low     | 902.3       | 13.35                        | 4.012                             | 17.4                          | ≤ 30 (1Watt)      |
|                   | Mid     | 905.3       | 13.29                        | 4.023                             | 17.3                          |                   |
|                   | High    | 908.5       | 13.06                        | 4.023                             | 17.1                          |                   |

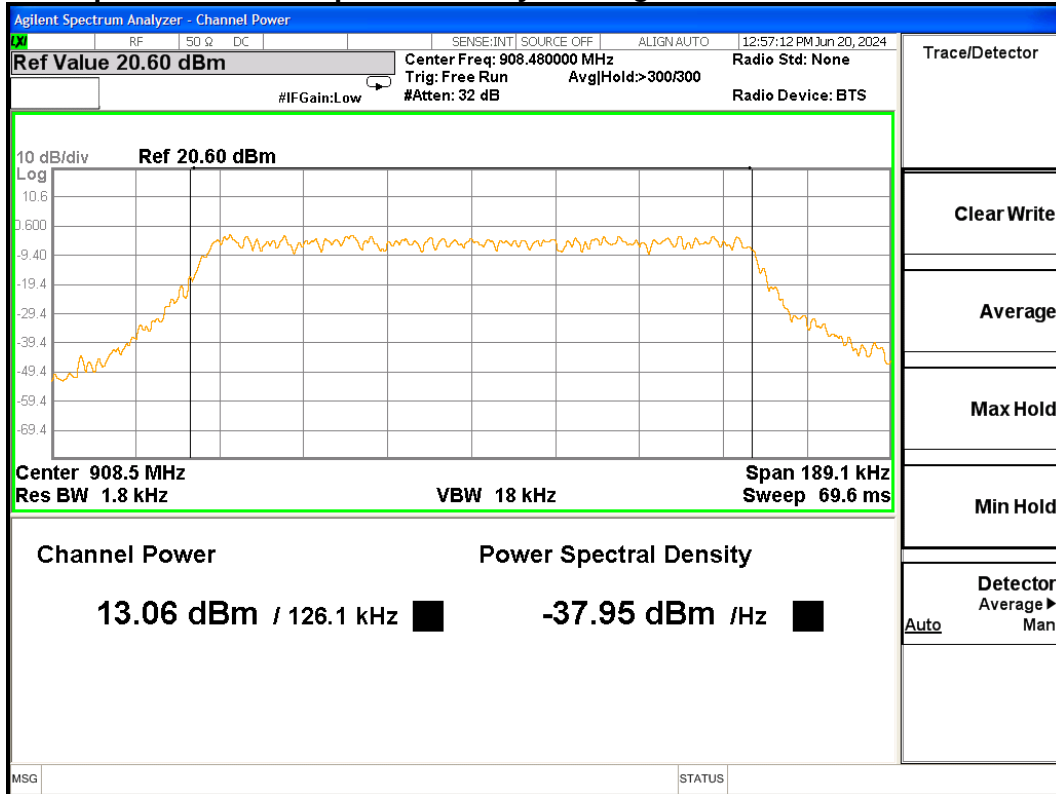
## Screen Captures from the spectrum analyzer Low Channel



## Screen Captures from the spectrum analyzer: MID Channel



## Screen Captures from the spectrum analyzer: High Channel



## 2.5 Power Spectral Density

|                                            |                                    |
|--------------------------------------------|------------------------------------|
| Test Lab: Electronics Test Centre, Airdrie | EUT: Quantum Dual Band HyperQ Node |
| Test Personnel: Janet Mijares              | Standard: FCC PART 15.247          |
| Date: 2024-06-20 (20.7°C, 27.4% RH)        | Basic Standard: ANSI C63.10: 2013  |

### EUT status: Compliant

#### Specification: FCC Part 15.247(f)

**Criteria** The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3kHz band during any time interval of continuous transmission.

#### 2.5.1 Test Guidance: ANSI C63.10-2013, Clause 11.10.5 / FCC OET KDB 558074

This measurement is performed at low, mid and high frequencies, in continuous transmission, with modulation.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

| Use the following Spectrum Analyzer settings                                                                                                                                                                |                                                                                                                                                              |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Measure the duty cycle (D) of the transmitter output signal                                                                                                                                                 |                                                                                                                                                              |
| Span                                                                                                                                                                                                        | At least 1.5 times the OBW of channel center Frequency                                                                                                       |
| RBW                                                                                                                                                                                                         | 3 KHz                                                                                                                                                        |
| VBW                                                                                                                                                                                                         | $\geq 3 \times \text{VBW}$                                                                                                                                   |
| Sweep                                                                                                                                                                                                       | Auto Couple                                                                                                                                                  |
| Detector Function                                                                                                                                                                                           | Power averaging (RMS) or Sample detector (when RMS not available.                                                                                            |
| Trace                                                                                                                                                                                                       | Employ trace average (rms) mode over a minimum of 100 traces.                                                                                                |
| Duty Cycle                                                                                                                                                                                                  | Add $[10 \log (1 / D)]$ , where D is the duty cycle measured in step a), to the measured PSD to compute the average PSD during the actual transmission time. |
| Ensure that the number of measurement points in the sweep $\geq [2 \times \text{span} / \text{RBW}]$ . Allow the trace to stabilize. Use the peak marker function to determine the maximum amplitude level. |                                                                                                                                                              |

#### 2.5.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

#### 2.5.3 Test Equipment

Testing was performed with this equipment:

| Equipment           | Manufacturer | Model #                | Asset # | Cal. Date            | Cal. Due   |
|---------------------|--------------|------------------------|---------|----------------------|------------|
| EMI receiver        | Agilent      | N9038A<br>(FW A.25.05) | 6130    | 2023-08-11           | 2024-08-11 |
| Temp/Humidity       | Extech       | 42270                  | 5871    | 2024-04-08           | 2025-04-08 |
| Attenuator          | PCB          | BWS102W263             | 6932    | 2022-12-10           | 2025-12-10 |
| Coaxial Cables (RF) | W.L. GORE    | PGR01R01036            | -       | Cal. before each use |            |
| DC Blocker          | Centric RF   | C0927 SMA              | 6987    | Cal. before each use |            |

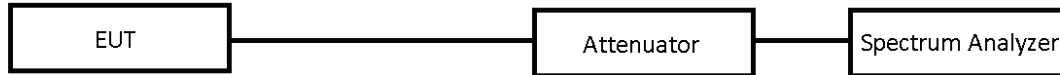
## 2.5.4 Test Sample Verification, Configuration & Modifications

The EUT was set to transmit continuously on a selected channel with test-specific software. The output was modulated as in normal operation.

The EUT met the requirements without modification.

Test setup diagrams for Power Spectral Density testing:

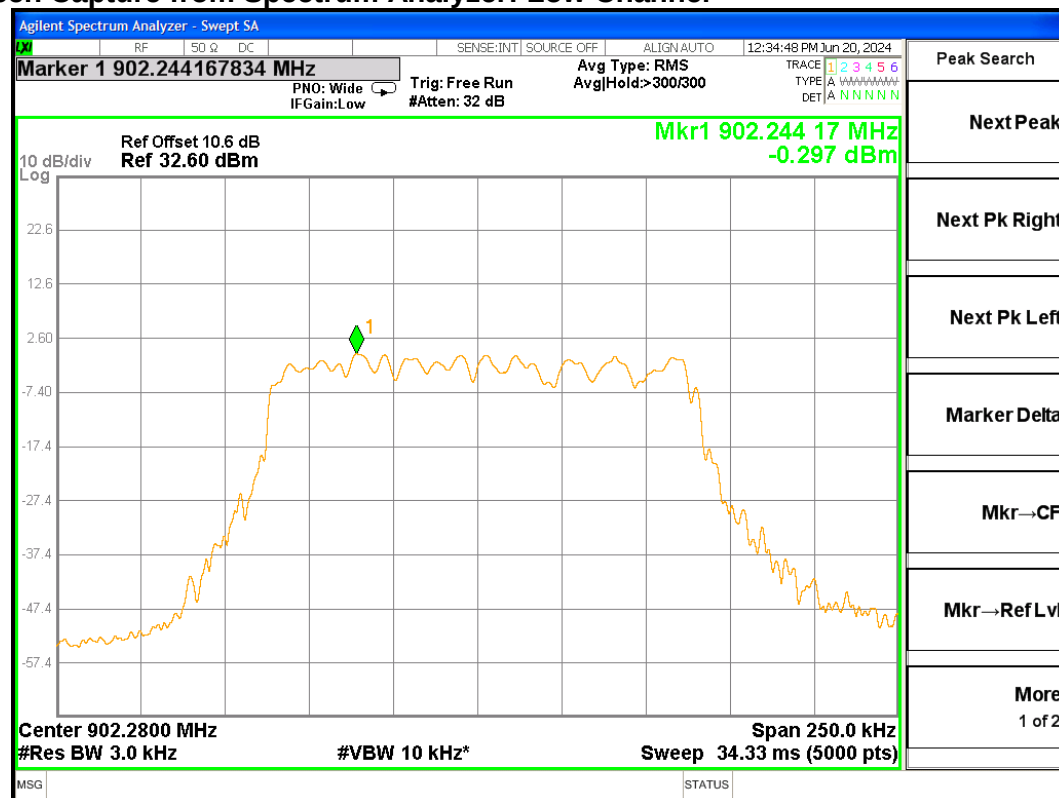
Conducted:



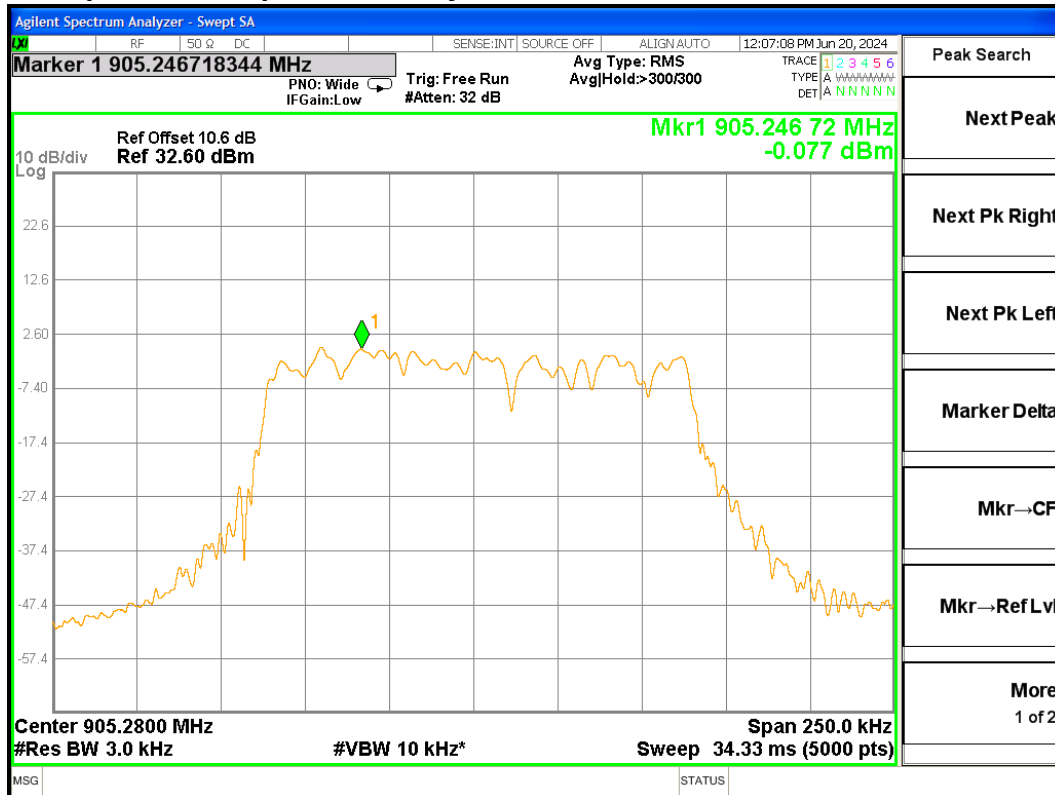
## 2.5.5 Average PSD Data

| Mode of operation | Channel | Freq. [MHz] | Measured PSD (dBm) | Duty Cycle (dB) | Corrected PSD (dBm) | PSD Limit (dBm) |
|-------------------|---------|-------------|--------------------|-----------------|---------------------|-----------------|
| LoRa 125 KHz      | Low     | 902.3       | -0.297             | 4.012           | 3.715               | ≤ 8 3KHz        |
|                   | Mid     | 905.3       | -0.077             | 4.023           | 3.946               |                 |
|                   | High    | 908.5       | 0.777              | 4.023           | 4.8                 |                 |

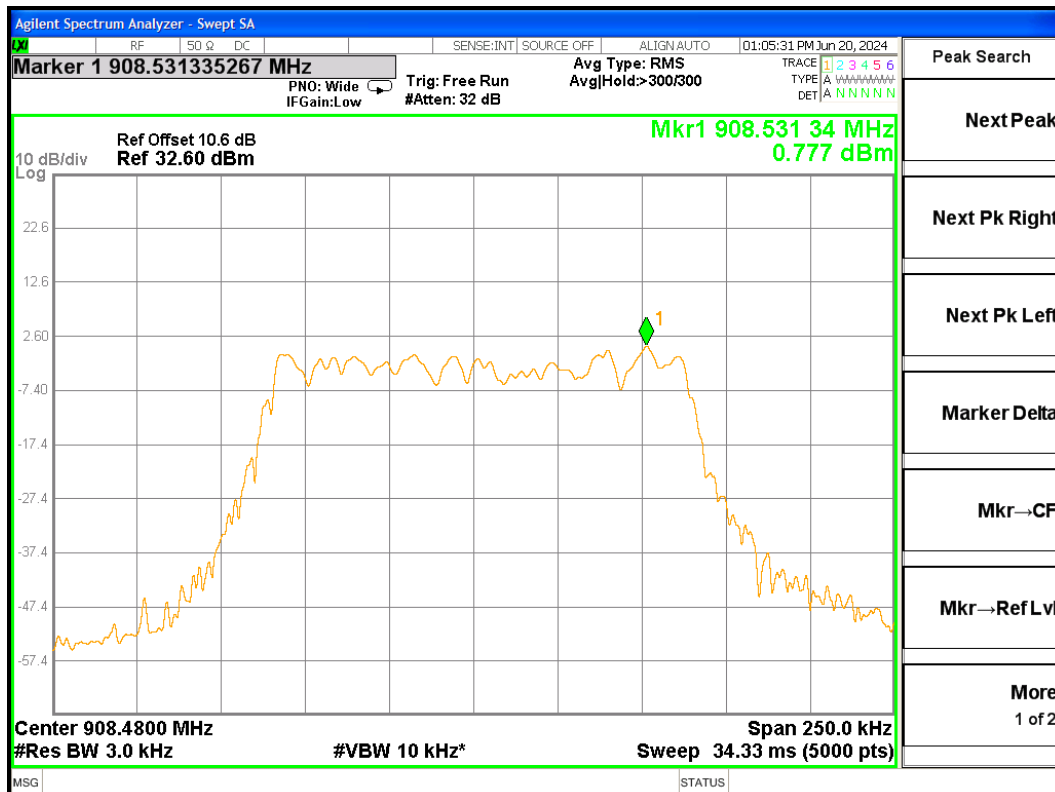
## Screen Capture from Spectrum Analyzer: Low Channel



## Screen Capture from Spectrum Analyzer: MID Channel



## Screen Capture from Spectrum Analyzer: High Channel



## 2.6 Band Edge Attenuation

|                                            |                                    |
|--------------------------------------------|------------------------------------|
| Test Lab: Electronics Test Centre, Airdrie | EUT: Quantum Dual Band HyperQ Node |
| Test Personnel: Janet Mijares              | Standard: FCC PART 15.247          |
| Date: 2024-06-19/20 (20.7°C, 27.4% RH)     | Basic Standard: ANSI C63.10: 2013  |

**EUT status: Compliant**

### Specification: FCC Part 15.247(d)

**Criteria:** 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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

### 2.6.1 Test Guidance: ANSI C63.10-2013 Clause 6.10.4 & 7.8.6, 6.10.6 / FCC OET KDB 558074

This measurement is performed at the low and high frequencies, with modulation.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

#### Use the following spectrum analyzer settings:

|                   |                                                                                                                                                                                                    |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Span              | Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation. |
| Attenuation       | Auto (at least 10 dB preferred).                                                                                                                                                                   |
| RBW               | 100 kHz                                                                                                                                                                                            |
| VBW               | 300 kHz                                                                                                                                                                                            |
| Sweep             | Coupled                                                                                                                                                                                            |
| Detector function | peak                                                                                                                                                                                               |
| Trace             | max hold                                                                                                                                                                                           |

Allow the trace to stabilize. Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.

## 2.6.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

## 2.6.3 Test Equipment

Testing was performed with the following equipment:

| Equipment              | Manufacturer | Model #                | Asset # | Cal. Date            | Cal. Due   |
|------------------------|--------------|------------------------|---------|----------------------|------------|
| EMI receiver           | Agilent      | N9038A<br>(FW A.25.05) | 6130    | 2023-08-11           | 2024-08-11 |
| Temp/Humidity          | Extech       | 42270                  | 5871    | 2024-04-08           | 2025-04-08 |
| Attenuator             | PCB          | BWS102W263             | 6932    | 2022-12-10           | 2025-12-10 |
| Coaxial Cables<br>(RF) | W.L. GORE    | PGR01R01036            | -       | Cal. before each use |            |
| DC Blocker             | Centric RF   | C0927 SMA              | 6987    | Cal. before each use |            |

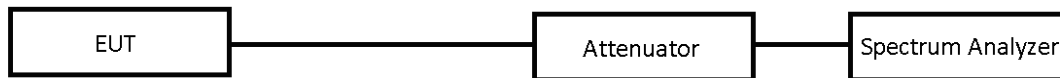
## 2.6.4 Test Sample Verification, Configuration & Modifications

The EUT was set to transmit continuously on a selected channel with test-specific software. The output was modulated as in normal operation.

The EUT met the requirements without modification.

### Test setup diagrams for Band Edge Attenuation testing:

Conducted:

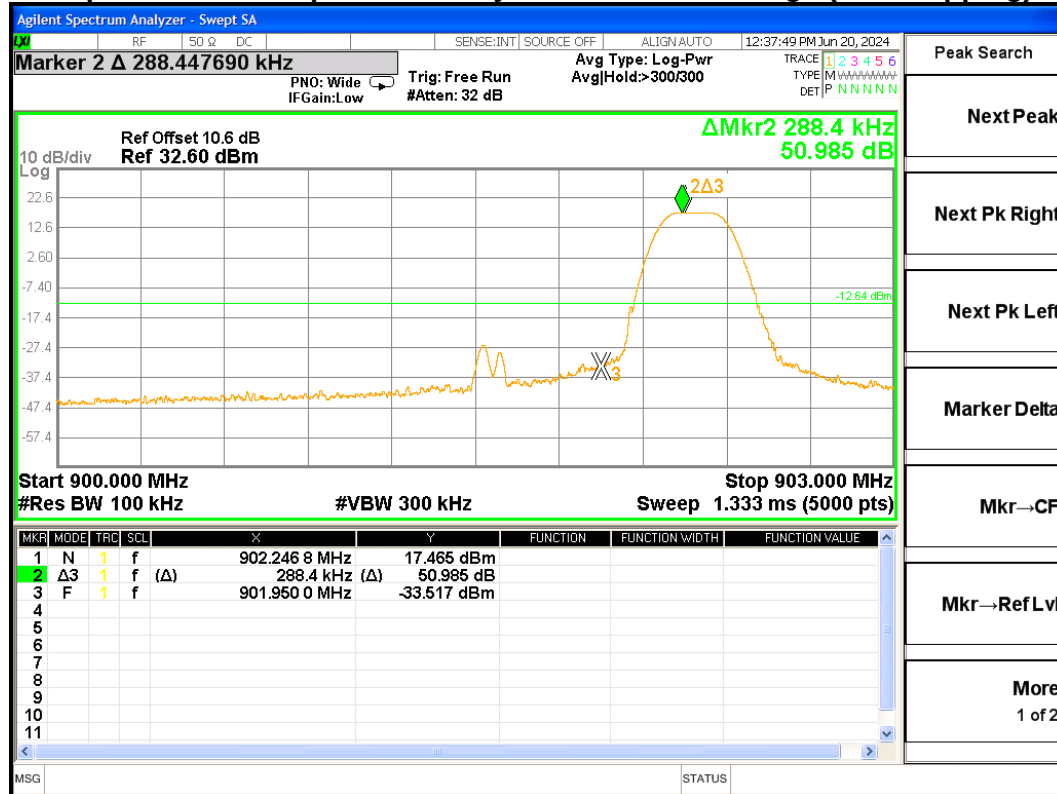


## 2.6.5 Band Edge Data

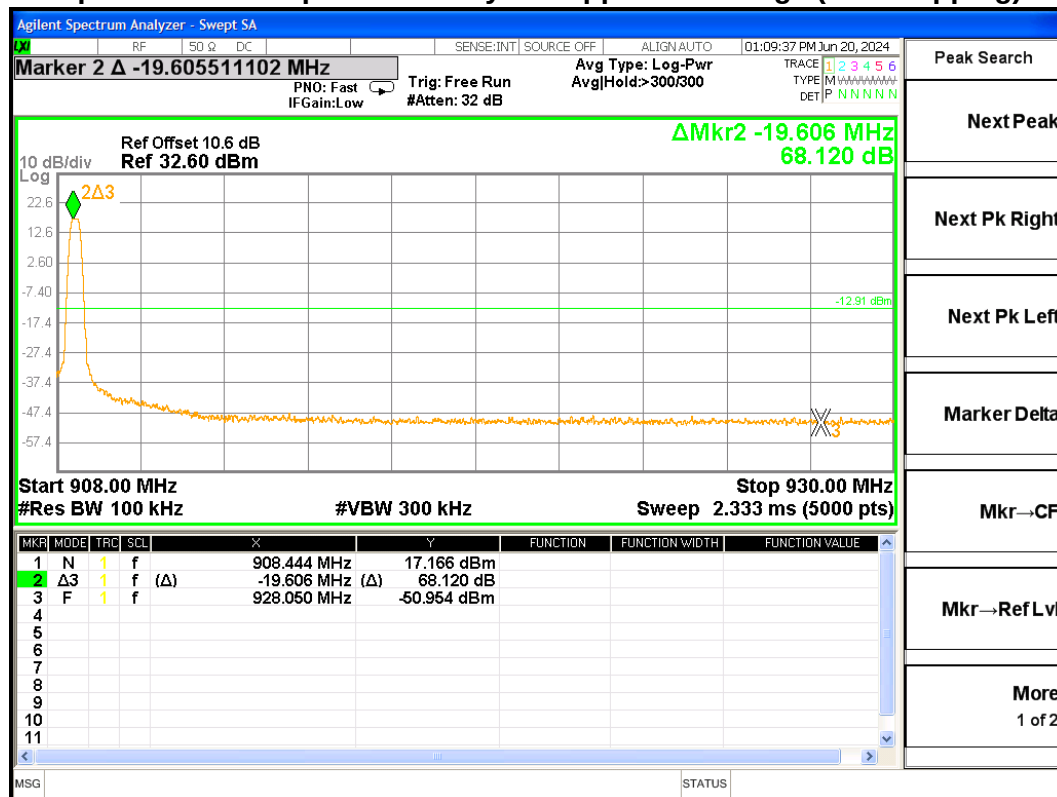
### Worse Case Data

| Mode of operation            | Channel | Attenuation at Band Edge | Attenuation Limit at Band Edge |
|------------------------------|---------|--------------------------|--------------------------------|
| Lora 125KHz<br>(Non-Hopping) | 902.3   | 50.985 dBc               | ≥30 dBc                        |
|                              | 908.5   | 68.120 dBc               |                                |
| Lora 125KHz<br>(Hopping)     | 902.3   | 51.735 dBc               |                                |
|                              | 908.5   | 66.505 dBc               |                                |

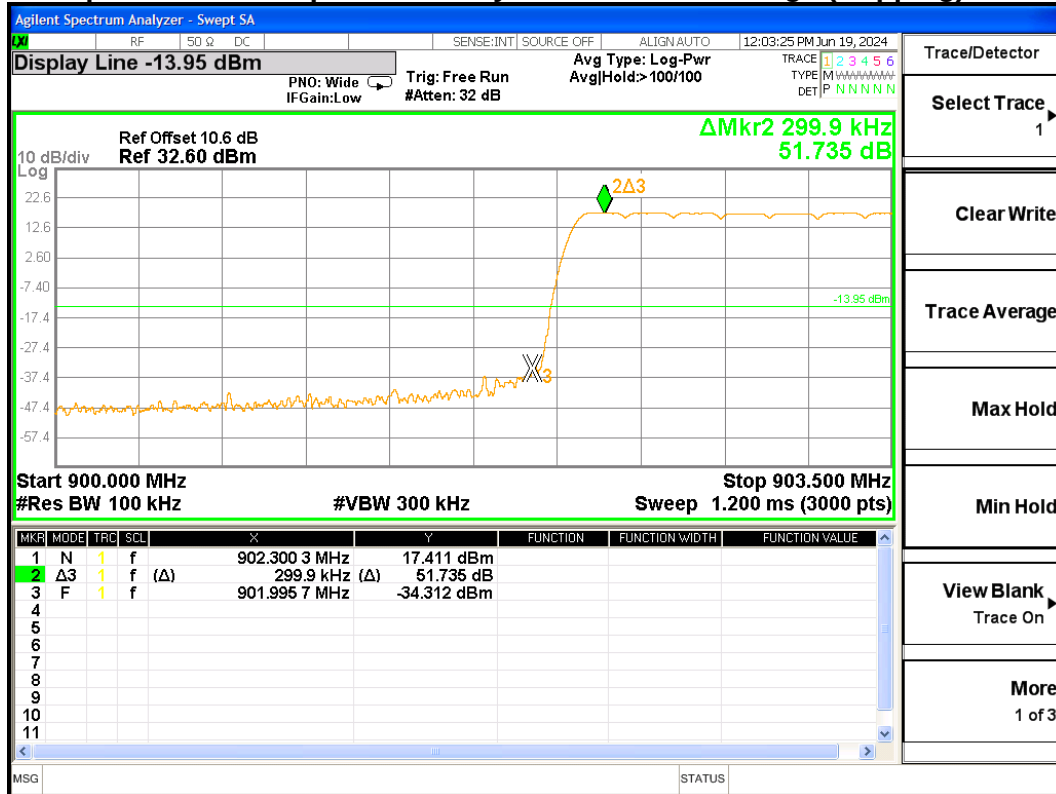
### Screen Capture from the spectrum analyzer: Lower Band Edge (Non-Hopping)



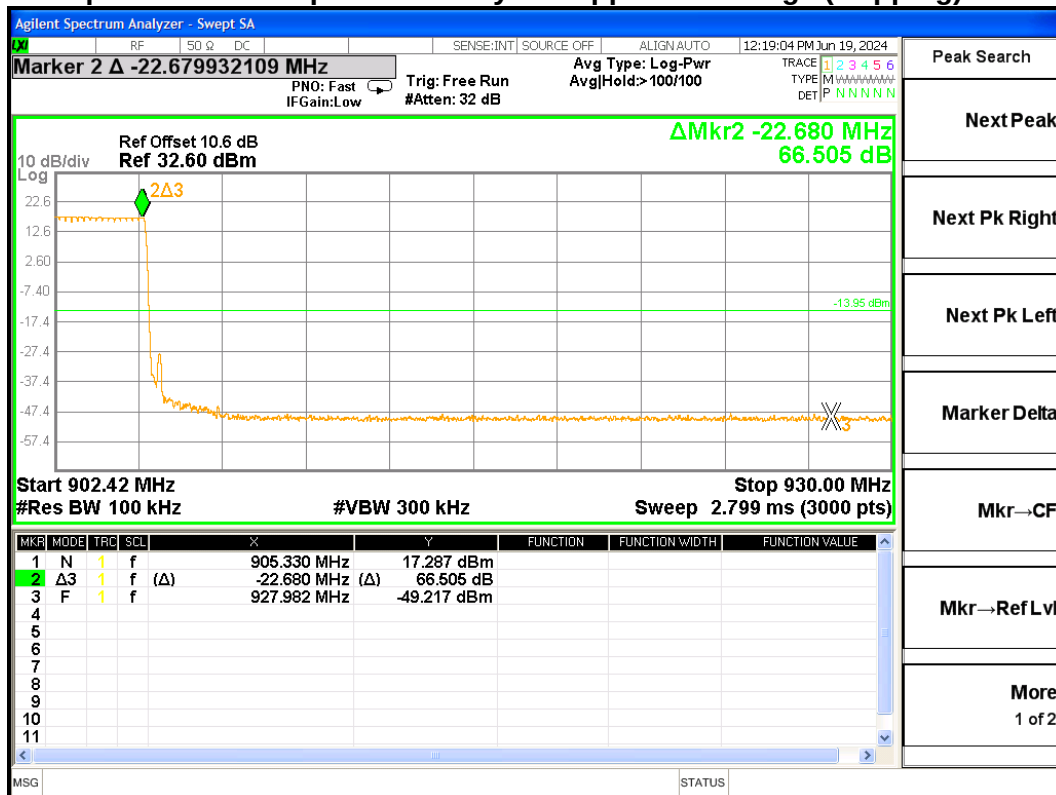
### Screen Capture from the spectrum analyzer: Upper Band Edge (Non-Hopping)



## Screen Capture from the spectrum analyzer: Lower Band Edge (Hopping)



## Screen Capture from the spectrum analyzer: Upper Band Edge (Hopping)



## 2.7 Conducted Spurious Emissions (Non- Restricted Band)

|                                            |                                                               |
|--------------------------------------------|---------------------------------------------------------------|
| Test Lab: Electronics Test Centre, Airdrie | EUT: Quantum Dual Band HyperQ Node                            |
| Test Personnel: Janet Mijares              | Standard: FCC PART 15.247                                     |
| Date: 2024-06-19 (20.7°C, 27.4% RH)        | Basic Standard: ANSI C63.4-2014<br>FCC OET KDB 558470 v04 DTS |

**EUT status: Compliant**

### Specification: FCC Part 15.247(d)

In any 100kHz 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.

### 2.7.1 Test Guidance: ANSI C63.10-2013, Clause 6.7, 7.8.8 / 558074 D01 15.247 Measurement Guidance v05r02

This measurement is performed at the low, mid and high frequencies, with modulation. The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

Use the following spectrum analyzer settings:

|                   |                                                                                |
|-------------------|--------------------------------------------------------------------------------|
| Span              | Set the center frequency and span to encompass frequency range to be measured. |
| RBW               | 100 kHz                                                                        |
| VBW               | 300 kHz                                                                        |
| Sweep             | Auto Coupled                                                                   |
| Detector function | peak                                                                           |
| Trace             | max hold                                                                       |

Allow the trace to stabilize. Use the peak marker function to determine the maximum amplitude level. Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) is attenuated by at least the minimum requirements specified in

### 2.7.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

### 2.7.3 Test Equipment

Testing was performed with the following equipment:

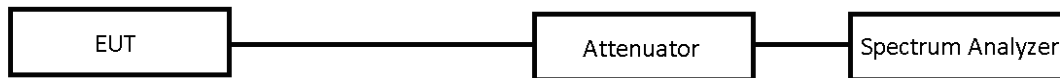
| Equipment              | Manufacturer | Model #                | Asset # | Cal. Date            | Cal. Due   |
|------------------------|--------------|------------------------|---------|----------------------|------------|
| EMI receiver           | Agilent      | N9038A<br>(FW A.25.05) | 6130    | 2023-08-11           | 2024-08-11 |
| Temp/Humidity          | Extech       | 42270                  | 5871    | 2024-04-08           | 2025-04-08 |
| Attenuator             | PCB          | BWS102W263             | 6932    | 2022-12-10           | 2025-12-10 |
| Coaxial Cables<br>(RF) | W.L. GORE    | PGR01R01036            | -       | Cal. before each use |            |
| DC Blocker             | Centric RF   | C0927 SMA              | 6987    | Cal. before each use |            |

### 2.7.4 Test Sample Verification, Configuration & Modifications

The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation.

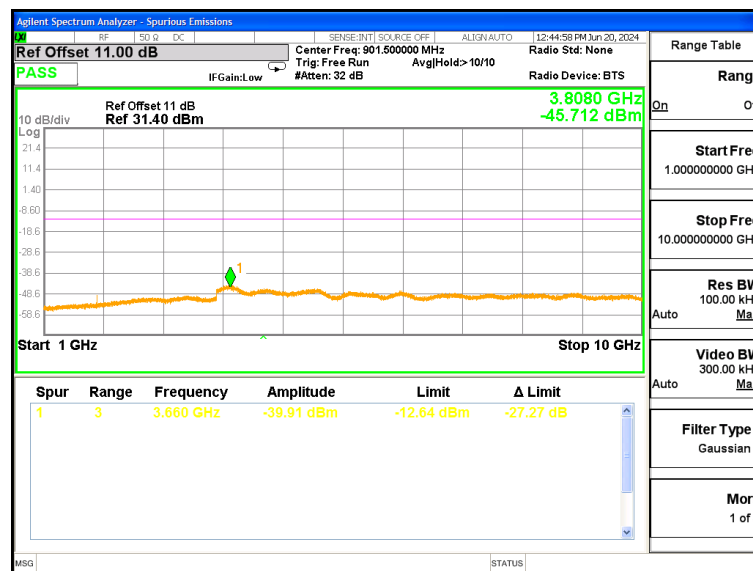
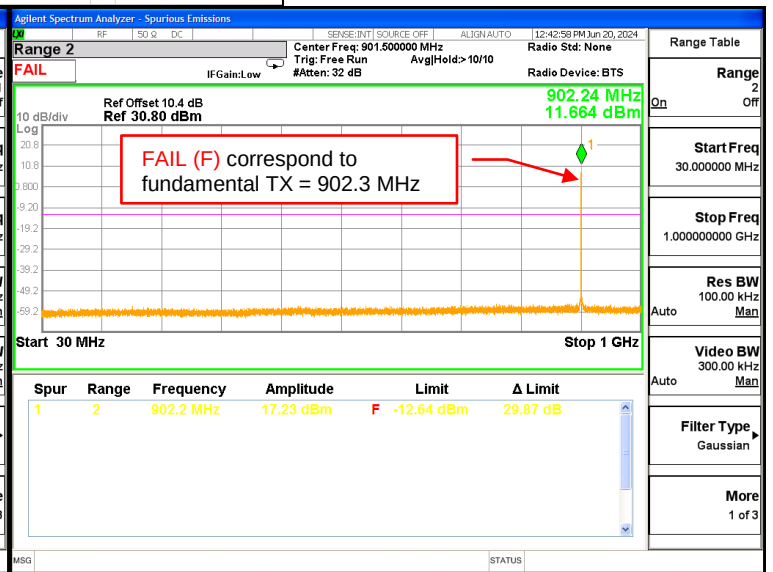
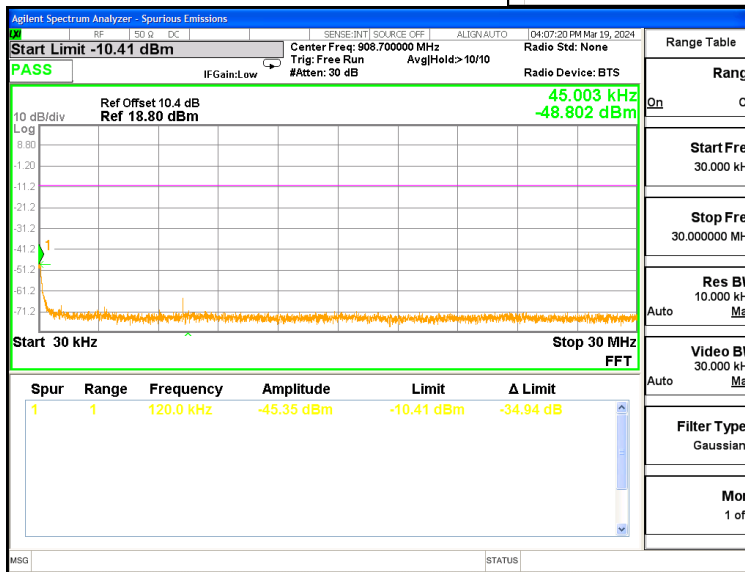
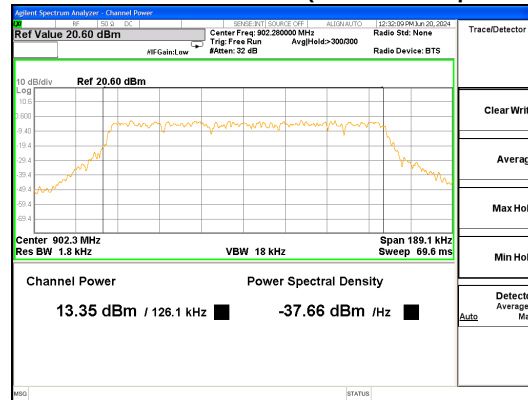
The EUT met the requirements without modification.

Test setup diagram for Conducted Spurious Emissions testing:

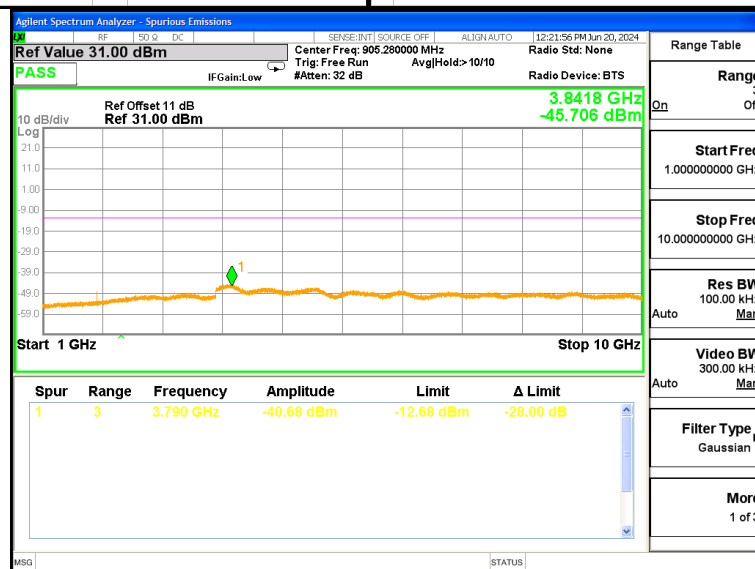
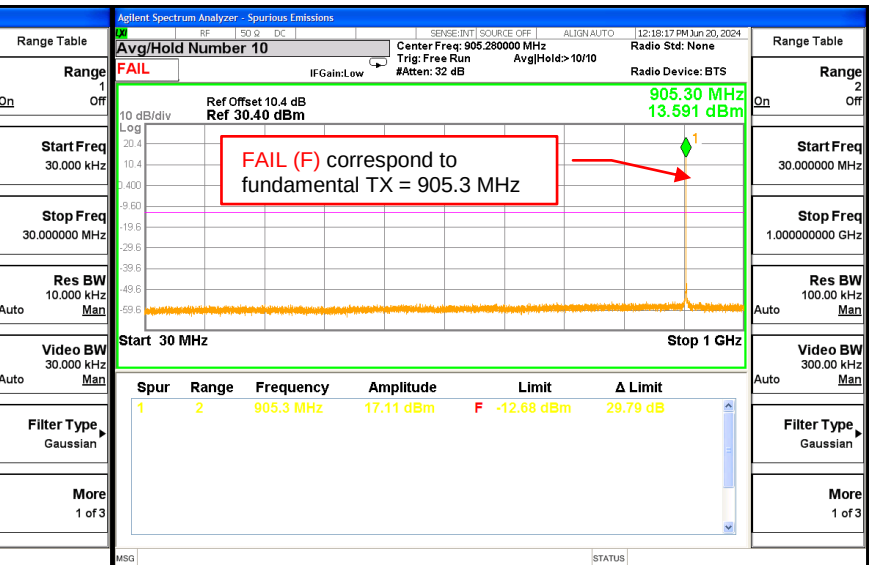
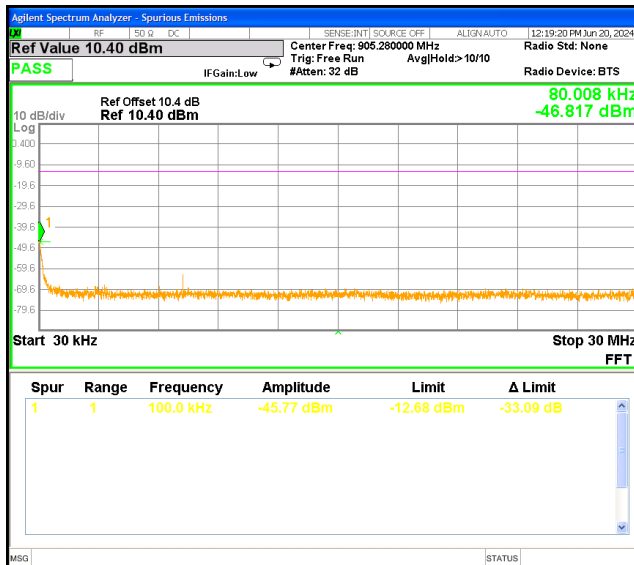
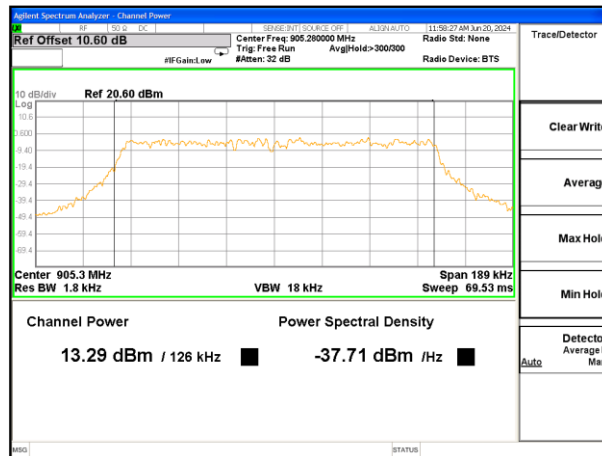


## 2.7.5 Conducted Emissions Data:

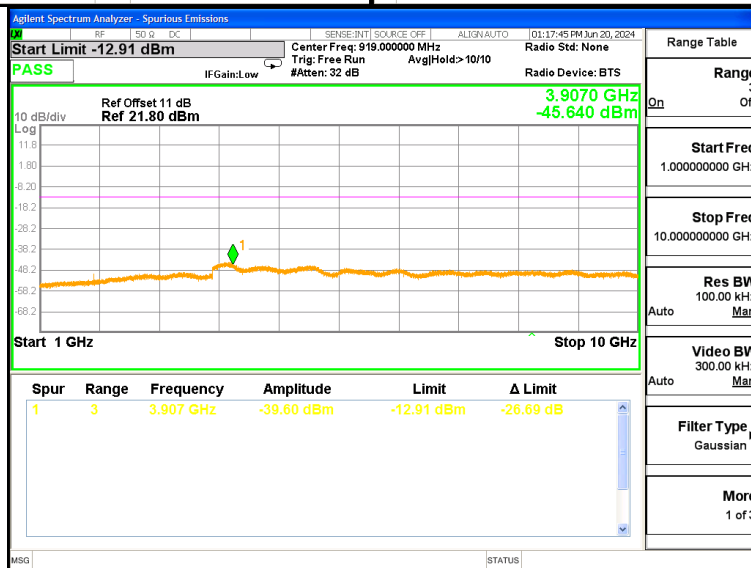
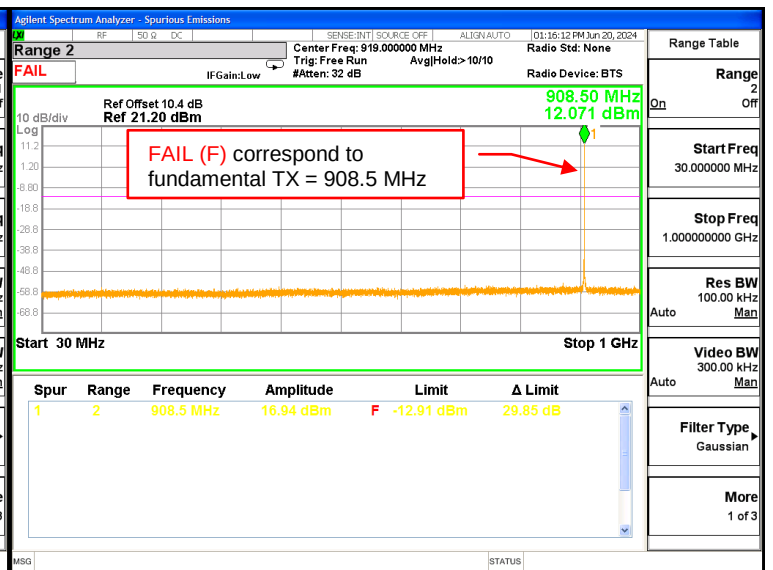
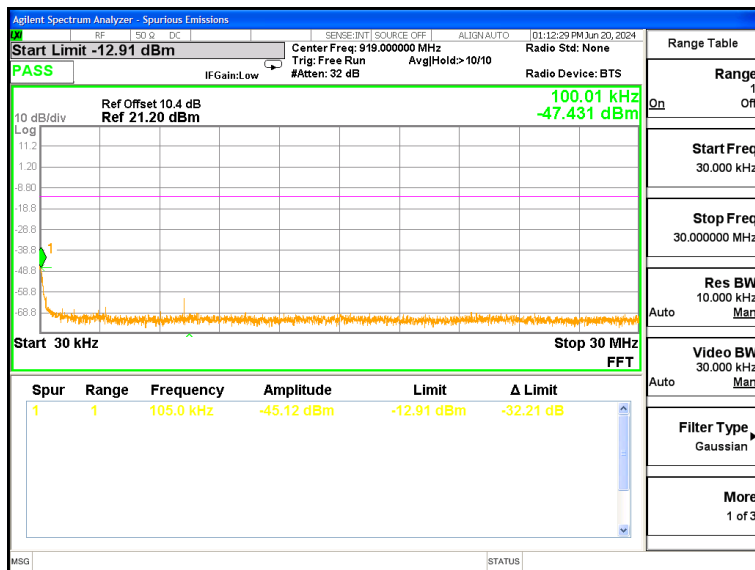
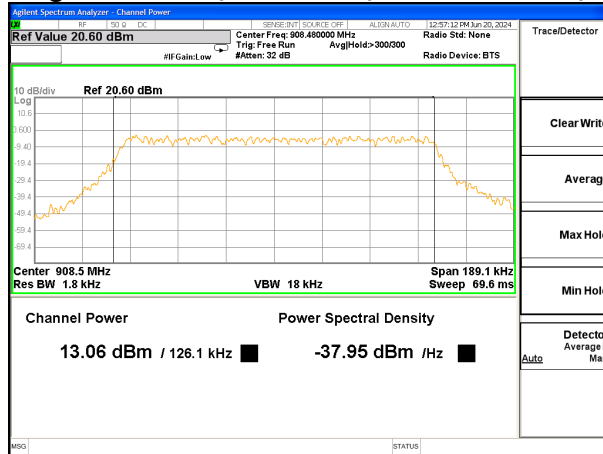
### Low Channel (Corrected Output Power: 17.4 dBm)



MID Channel (Corrected Output Power: 17.3 dBm)



### High Channel (Corrected Output Power: 17.1 dBm)



## 2.8 Channel Separation (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie

Test Personnel: Janet Mijares / Brendan Van Hee

Date: 2024-06-19/21 (20.7°C, 27.4% RH)

EUT: Quantum Dual Band HyperQ Node

Standard: FCC Part 15.247

Basic Standard: ANSI C63.10: 2013

**EUT status: Compliant**

### Specification: FCC Part 15.247(a, 1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20dB bandwidth of the hopping channel, whichever is greater.

#### 2.8.1 Test Guidance: ANSI 63.10 Clause 7.8.2 / 558074 D01 15.247 Measurement Guidance v05r02

This measurement is performed with the EUT transmitter frequency hopping function active.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

The spectrum analyzer is set for a frequency span wide enough to capture at least two adjacent channels. The RBW is set to at least 1% of the span. The Peak detector is used, with the trace set to Max Hold. Channel Separation is displayed with the Marker Delta function.

#### 2.8.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

#### 2.8.3 Test Equipment

Testing was performed with the following equipment:

| Equipment              | Manufacturer | Model #                | Asset # | Cal. Date            | Cal. Due   |
|------------------------|--------------|------------------------|---------|----------------------|------------|
| EMI receiver           | Agilent      | N9038A<br>(FW A.25.05) | 6130    | 2023-08-11           | 2024-08-11 |
| Temp/Humidity          | Extech       | 42270                  | 5871    | 2024-04-08           | 2025-04-08 |
| Attenuator             | PCB          | BWS102W263             | 6932    | 2022-12-10           | 2025-12-10 |
| Coaxial Cables<br>(RF) | W.L. GORE    | PGR01R01036            | -       | Cal. before each use |            |
| DC Blocker             | Centric RF   | C0927 SMA              | 6987    | Cal. before each use |            |

#### 2.8.4 Test Sample Verification, Configuration & Modifications

SMA connector is soldered to the circuit board at the output of the radio to provide direct access to the radio output

#### EUT configuration for Channel Separation testing:

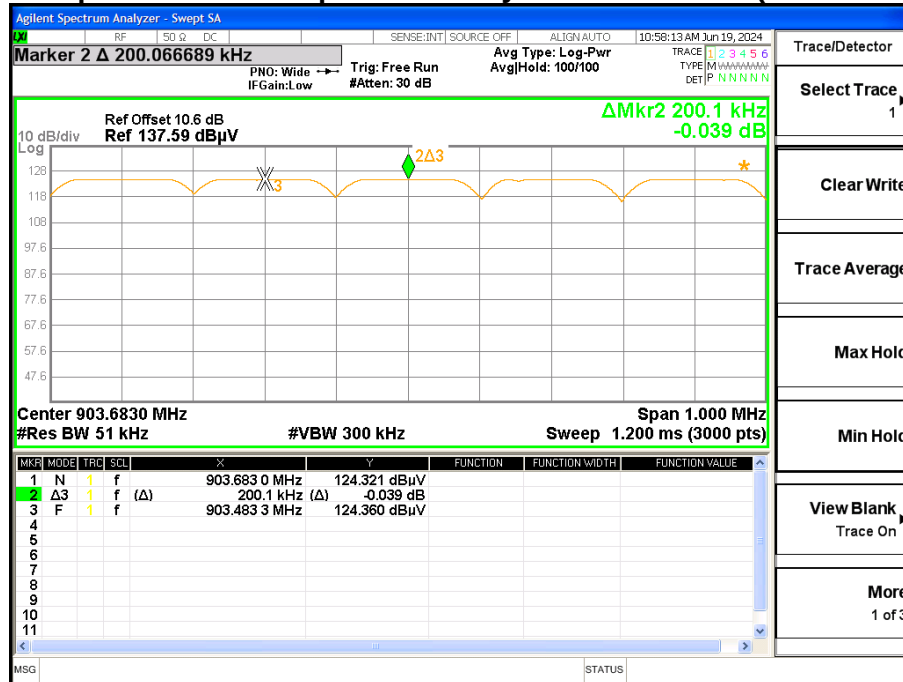


## 2.8.5 Channel Separation Data:

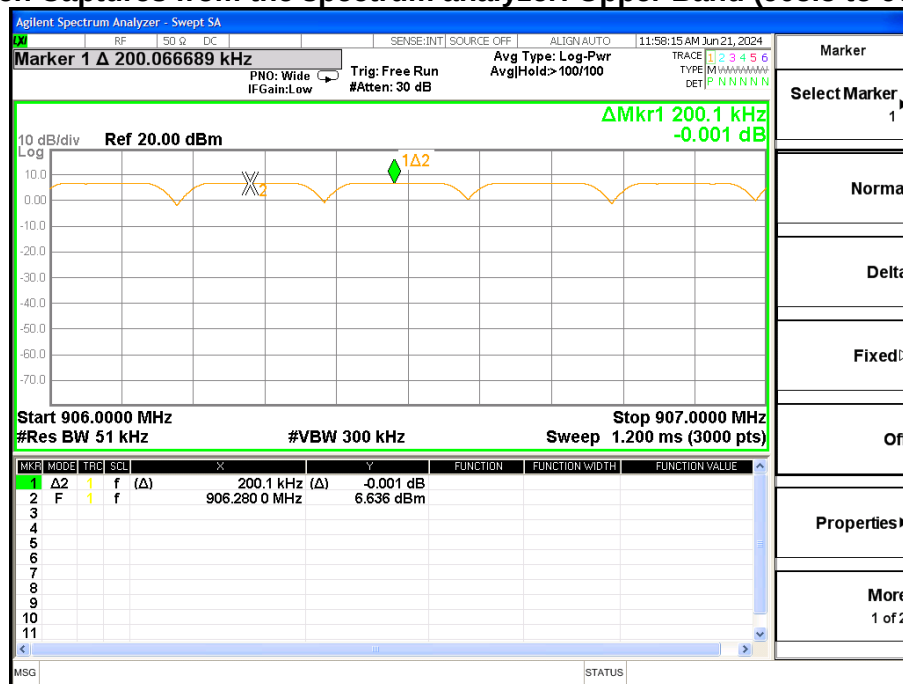
EUT can be configured to use either 16 channels in the lower band from 902.3 to 905.3 MHz or in the upper band from 905.5 to 908.5 MHz.

Channel separation measured = 200 KHz

### Screen Captures from the spectrum analyzer: Lower Band (902.3 to 905.3 MHz)



### Screen Captures from the spectrum analyzer: Upper Band (905.5 to 908.5 MHz)



## 2.9 Time of Occupancy (Hybrid Mode)

|                                                 |                                    |
|-------------------------------------------------|------------------------------------|
| Test Lab: Electronics Test Centre, Airdrie      | EUT: Quantum Dual Band HyperQ Node |
| Test Personnel: Janet Mijares / Brendan Van Hee | Standard: FCC PART 15.247          |
| Date: 2024-06-19/21 (20.7°C, 27.4% RH)          | Basic Standard: ANSI C63.10: 20013 |
| EUT status: Compliant                           |                                    |

### Specification: FCC Part 15.247 (f)

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

#### 2.9.1 Test Guidance: ANSI 63.10 Clause 7.8.4 / 558074 D01 15.247 Measurement Guidance v05r02

This measurement is performed with the EUT frequency hopping function active.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

The spectrum analyzer is set for Peak detection over a 0 Hz frequency span (time domain) centered on a hopping channel. The RBW shall be  $\leq$  Channel spacing and where possible RBW should be set  $\gg 1/T$ , where T is the expected dwell time per channel. VBW  $\geq$  RBW. The sweep time is adjusted to clearly capture one transmission. The Dwell time is measured with the Marker Delta function.

Another sweep is set to capture enough transmission events to calculate the number of events within the specified period of time. The Peak detector is used, with the trace set to Max Hold.

#### 2.9.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

#### 2.9.3 Test Equipment

Testing was performed with the following equipment:

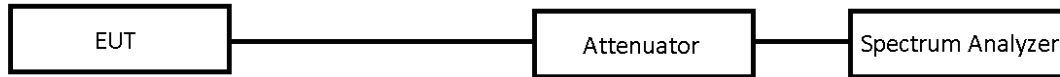
| Equipment              | Manufacturer | Model #                | Asset # | Cal. Date            | Cal. Due   |
|------------------------|--------------|------------------------|---------|----------------------|------------|
| EMI receiver           | Agilent      | N9038A<br>(FW A.25.05) | 6130    | 2023-08-11           | 2024-08-11 |
| Temp/Humidity          | Extech       | 42270                  | 5871    | 2024-04-08           | 2025-04-08 |
| Attenuator             | PCB          | BWS102W263             | 6932    | 2022-12-10           | 2025-12-10 |
| Coaxial Cables<br>(RF) | W.L. GORE    | PGR01R01036            | -       | Cal. before each use |            |
| DC Blocker             | Centric RF   | C0927 SMA              | 6987    | Cal. before each use |            |

## 2.9.4 Test Sample Verification, Configuration & Modifications

The EUT was operating in normal mode.

The EUT met the requirements without modification.

### EUT configuration for Dwell Time testing:



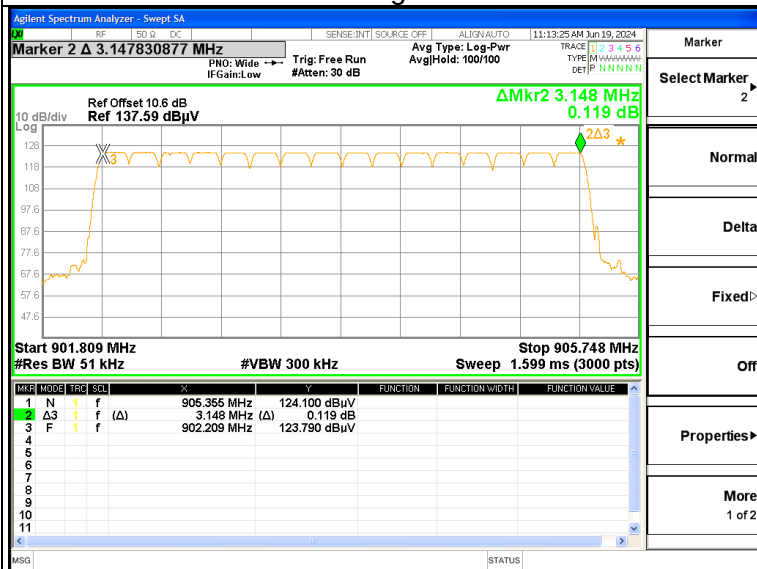
## 2.9.5 Dwell Time Data:

EUT can be configured to use either 16 channels in the lower band from 902.3 to 905.3 MHz or in the upper band from 905.5 to 908.5 MHz.

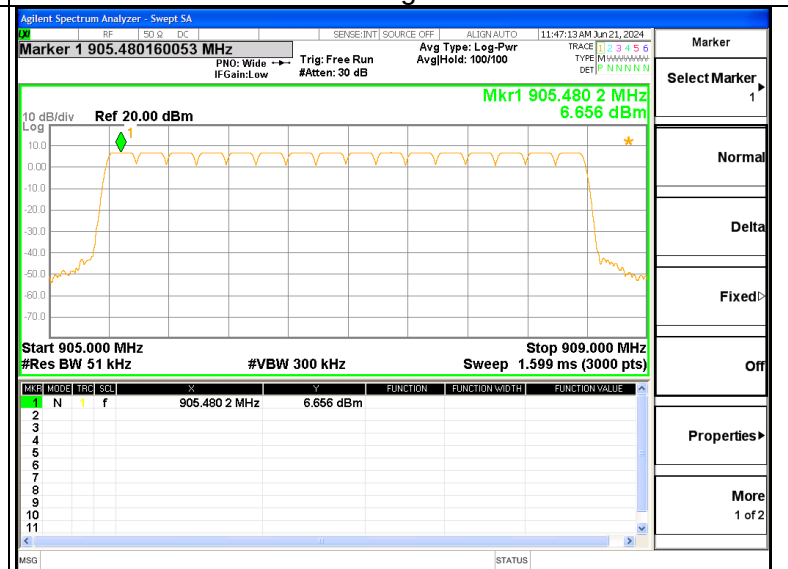
| Segment                                                                                                                          | Measured Dwell time | Limit   |
|----------------------------------------------------------------------------------------------------------------------------------|---------------------|---------|
| 1 <sup>st</sup> (Lower Band)                                                                                                     | 200.6 ms            | ≤ 400ms |
| 2 <sup>nd</sup> (Upper Band)                                                                                                     | 207.0 ms            |         |
| Window of measurement is equal to number of hopping channels multiple by 400ms<br>= <b>0.4 x 16 (For each segment)</b> = 6.4 Sec |                     |         |

### Measure numbers OF Channels= 16

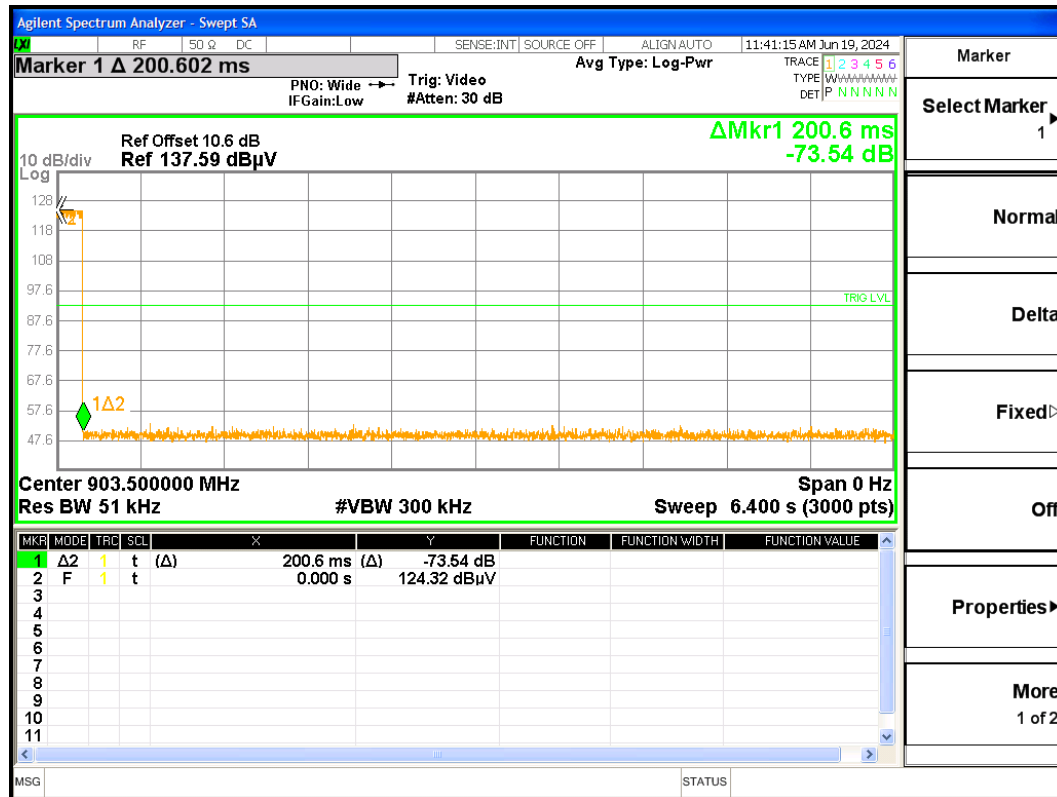
#### 1<sup>st</sup> Segment



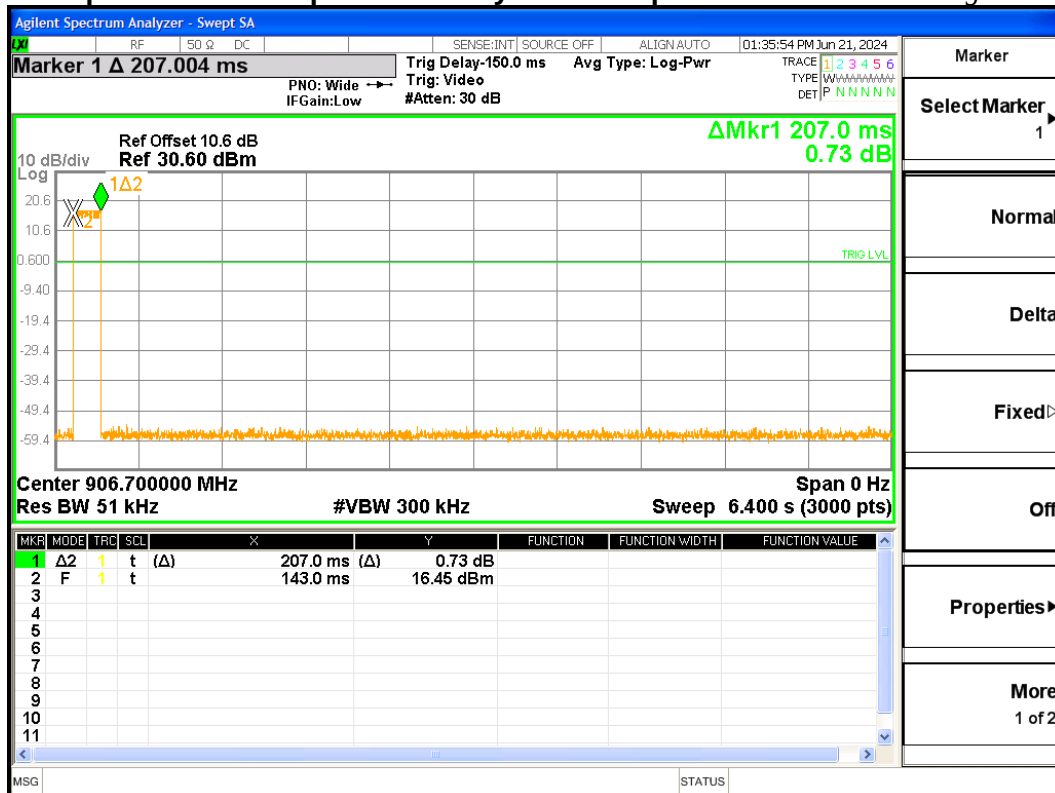
#### 2<sup>nd</sup> Segment



Screen Capture from the spectrum analyzer: sweep Time in 6.4 Sec 1<sup>st</sup> Segment



Screen Capture from the spectrum analyzer: sweep Time in 6.4 Sec 2<sup>nd</sup> Segment

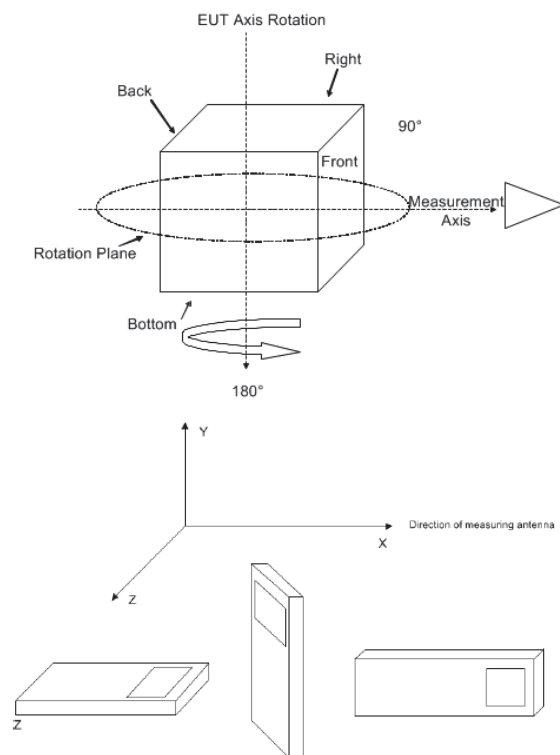


## 2.10 EUT Positioning Assessment – N/A

|                                                                       |                                           |
|-----------------------------------------------------------------------|-------------------------------------------|
| <b>Test Lab:</b> Electronics Test Centre, Airdrie                     | <b>EUT:</b> Quantum Dual Band HyperQ Node |
| <b>Test Personnel:</b>                                                | <b>Standard:</b> FCC PART 15.247          |
| <b>Date:</b>                                                          | <b>Basic Standard:</b> ANSI C63.4-2014    |
| <b>Comments:</b> N/A (EUT be mounted vertically at Fix one position.) |                                           |

### Specification: ANSI C63.4-2014, Clause 6.3.2.1

Portable, small, lightweight, or modular devices that may be handheld, worn on the body, or placed on a table during operation shall be positioned on a non-conducting platform, the top of which is 80 cm above the reference ground plane. The preferred area occupied by the EUT arrangement is 1 m by 1.5 m, but it may be larger or smaller to accommodate various sized EUTs (see Figure 6, Figure 7, and Figure 9). For testing purposes, ceiling- and wall-mounted devices also shall be positioned on a tabletop (see also 6.3.4 and 6.3.5). In making any tests involving handheld, body-worn, or ceiling-mounted equipment, it is essential to recognize that the measured levels may be dependent on the orientation (attitude) of the three orthogonal axes of the EUT. Thus, exploratory tests as specified in 8.3.1 shall be carried out for various axes orientations to determine the attitude having maximum or near-maximum emission level.



## 2.11 Radiated Spurious Emissions within restricted band

|                                            |                                    |
|--------------------------------------------|------------------------------------|
| Test Lab: Electronics Test Centre, Airdrie | EUT: Quantum Dual Band HyperQ Node |
| Test Personnel: Janet Mijares              | Standard: FCC PART 15.247/15.209   |
| Date: 2024-06-(19/20) (20.7° C, 27.4% RH)  | Basic Standard: ANSI C63.10-2013   |
| <b>EUT status: Compliant</b>               |                                    |

### Specification: FCC PART 15.247(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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

### Restricted Bands of Operation:

| MHz                   | MHz                     | MHz                   | MHz                    | MHz                   | GHz                   | GHz                   |
|-----------------------|-------------------------|-----------------------|------------------------|-----------------------|-----------------------|-----------------------|
| 0.0900000 – 0.1100000 | 8.2910000 - 8.2940000   | 16.804250 - 16.804750 | 162.01250 - 167.17000  | 1660.0000 – 1710.0000 | 3.6000000 – 4.4000000 | 14.470000 – 14.500000 |
| 0.4950000 - 0.5050000 | 8.3620000 - 8.3660000   | 25.500000 - 25.670000 | 167.72000 - 173.20000  | 1718.8000 – 1722.2000 | 4.5000000 – 5.1500000 | 15.350000 – 16.200000 |
| 2.1735000 - 2.1905000 | 8.3762500 - 8.3867500   | 37.500000 - 38.250000 | 240.00000 – 285.00000  | 2200.0000 – 2300.0000 | 5.3500000 – 5.4600000 | 17.700000 – 21.400000 |
| 4.1250000 - 4.1280000 | 8.4142500 - 8.4147500   | 73.000000 - 74.600000 | 322.00000 - 335.40000  | 2310.0000 – 2390.0000 | 7.2500000 – 7.7500000 | 22.010000 – 23.120000 |
| 4.1772500 - 4.1777500 | 12.2900000 - 12.2930000 | 74.800000 - 75.200000 | 399.90000 – 410.00000  | 2483.5000 – 2500.0000 | 8.0250000 – 8.5000000 | 23.600000 – 24.000000 |
| 4.2072500 - 4.2077500 | 12.519750 - 12.520250   | 108.00000 - 121.94000 | 608.00000 – 614.00000  | 2655.0000 – 2900.0000 | 9.0000000 – 9.2000000 | 31.200000 – 31.800000 |
| 5.6770000 - 5.6830000 | 12.576750 - 12.577250   | 123.00000 - 138.00000 | 960.00000 – 1240.00000 | 3260.0000 – 3267.0000 | 9.3000000 – 9.5000000 | 36.430000 – 36.500000 |
| 6.2150000 - 6.2180000 | 13.360000 - 13.410000   | 149.90000 - 150.05000 | 1300.0000 – 1427.0000  | 3332.0000 – 3339.0000 | 10.600000 – 12.700000 | Above 38.600000       |
| 6.2677500 - 6.2682500 | 16.420000 - 16.423000   | 156.52475 - 156.52525 | 1435.0000 – 1626.5000  | 3345.8000 – 3358.0000 | 13.250000 – 13.400000 |                       |
| 6.3117500 - 6.3122500 | 16.694750 - 16.695250   | 156.70000 - 156.90000 | 1645.5000 – 1646.5000  | 3500.0000 – 3600.0000 |                       |                       |

US only

Canada 108 – 138 MHz

Canada 960 – 1427 MHz

Canada only

### 2.11.1 Test Guidance: ANSI C63.10-2013, Clause 13.4.2

From 9 kHz to 150 kHz (resolution bandwidth of 200 Hz) and from 150 kHz to 30 MHz (resolution bandwidth 9 kHz) measurements are performed with a loop antenna (as per KDB 460108).

From 30 MHz to 1000 MHz, measurements are performed with a broadband biconilog antenna and a resolution bandwidth of 120 kHz.

Above 1000 MHz, measurements are performed with a DRG Horn antenna or a Standard Gain horn, and a resolution bandwidth of 1 MHz. The EUT is raised to 150 cm above the ground plane, and the area between the EUT and the antenna mast is covered with RF absorbent material.

The scan is performed at discrete increments of turntable azimuth and antenna height, which are selected in accordance with the applicable standard in order to assure capture of frequencies of interest. Optimization is performed based on the scan data.

Frequencies having peak emissions within 10dB of the limits are optimized. The EUT is rotated in azimuth over 360 degrees and the direction of maximum emission is noted.

Antenna height is varied from 1 – 4 meters at this azimuth to obtain the maximum emission. Then the maximum level is measured with the appropriate detector and recorded. Up to 1 GHz, measurements are performed with a Quasi-Peak detector. Above 1 GHz, measurements are recorded with Peak and/or Average detectors, as applicable.

### 2.11.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

### 2.11.3 Test Equipment

Testing was performed with the following equipment:

| Equipment                            | Manufacturer           | Model #                         | Asset # | Cal. Date<br>(yyyy-mm-dd) | Cal. Due<br>(yyyy-mm-dd) |
|--------------------------------------|------------------------|---------------------------------|---------|---------------------------|--------------------------|
| EMC Software                         | UL                     | Ver. 9.5                        | SW021   | N/A                       |                          |
| EMI receiver                         | Agilent                | N9038A<br>(FW A.25.05)          | 6130    | 2023-08-11                | 2024-08-11               |
| Loop Antenna<br>(9KHz – 30MHz)       | EMCO                   | 6502                            | 10868   | 2023-06-21                | 2025-06-21               |
| Biconilog Antenna<br>(30 – 1000 MHz) | AR                     | JB1                             | 6905    | 2023-11-29                | 2025-11-29               |
| DRG Horn<br>(1000 – 18000 MHz)       | EMCO                   | 3115                            | 19357   | 2022-10-05                | 2024-10-05               |
| Humidity/Temp<br>Logger              | Extech Ins.<br>Corp.   | 42270                           | 5892    | 2024-04-08                | 2025-04-08               |
| Pre-Amplifier<br>(30 – 1400 MHz)     | HP                     | 8447D                           | 9291    | *2024-01-21               | *2025-01-23              |
| Low Noise Amplifier<br>(1 – 18 GHz)  | MITEQ                  | JS43-01001800-21-<br>5P         | 4354    | *2024-01-21               | *2025-01-23              |
| RE Cable below<br>1GHz               | Insulated Wire<br>Inc. | KPS-1501A-3600-<br>KPA-01102006 | 4419    | *2024-01-21               | *2025-01-23              |
| Re Cable Above 1<br>GHz              | A.H. System<br>Inc.    | SAC-26G-8.23                    | 6187    | *2024-01-21               | *2025-01-23              |
| 0.9GHz Notch Filter                  | Microtronics           | BRM20784                        | 6947    | *2024-01-21               | *2025-01-23              |

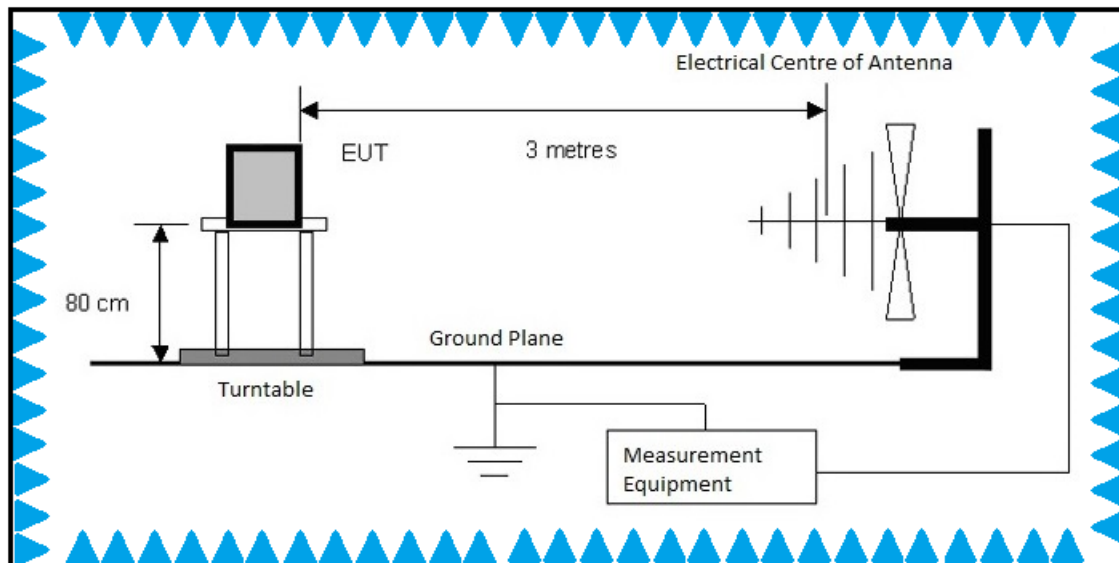
\* In-house verification

#### 2.11.4 Test Sample Verification, Configuration & Modifications

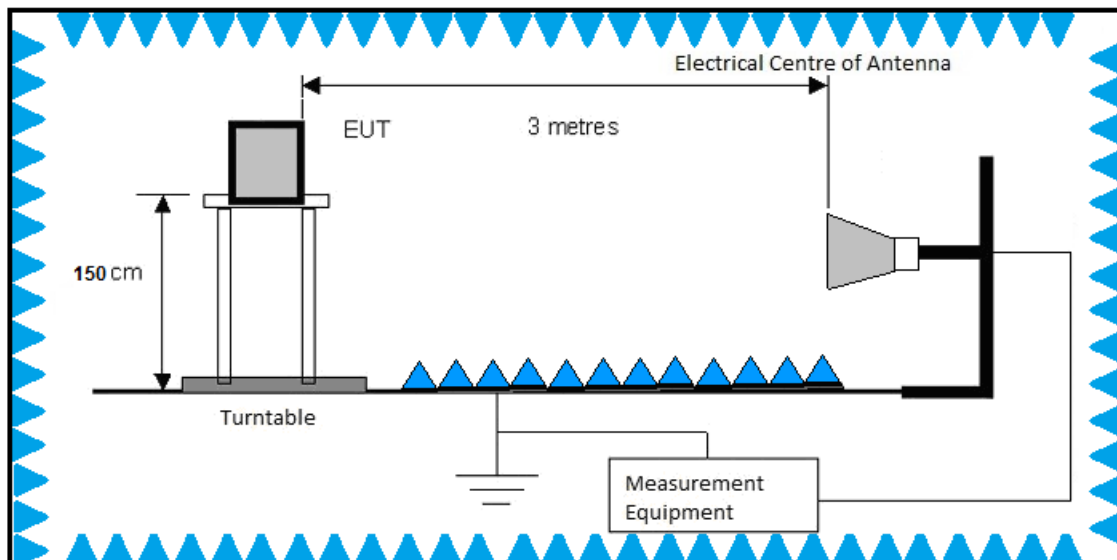
The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation. LoRa radio is transmitting at mid channel in single carrier configuration and high channel in dual carrier configurations.

The EUT met the requirements without modification. Power cable is soldered to the battery terminal to connect the DC power supply during radiated emission.

##### Test setup diagram for Radiated Spurious Emissions testing (below 1GHz):



##### Test setup diagram for Radiated Spurious Emissions testing (above 1GHz):



### 2.11.5 Radiated Emissions Data: Lora and BLE radio transmitting simultaneously

The emissions data are presented in tabular form, showing turntable azimuth, antenna height and polarization, the uncorrected spectrum analyzer reading, the correction factors applied, the net result, the value of the limit at the frequency investigated, and the Delta between the result and the limit.

Meter Reading in dBμV + Antenna Factor in dB/m + Gain/Loss Factor in dB = Corrected Field Strength in dBμV/m.

Delta = Field Strength – Limit

#### Notes:

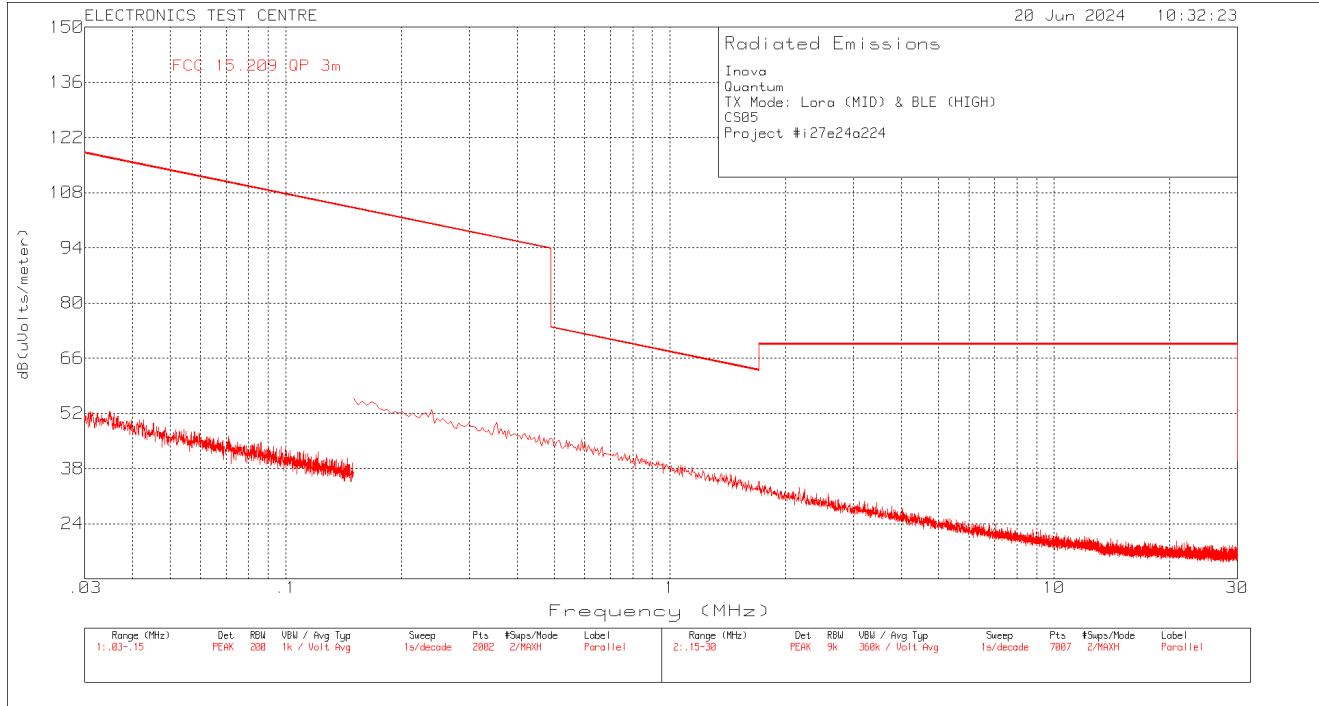
When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss. Measurements reported are the result of adjusting the turntable azimuth and antenna height to obtain the maximum EUT emission. This may produce a different reading than the plot trace. The plot is a Peak Hold function obtained at discreet increments of height and azimuth, while the reported measurement is obtained with the appropriate Quasi Peak or Average detector using max hold function after the height and azimuth have been adjusted for maximum emission. Preliminary scans were performed for all channels in Transmit modes. The LoRa Mid channel and BLE High channel were selected as the worst-case condition for detailed examination. In Transmit mode both radios are transmitting simultaneously and the EUT was assessed up to 26.5 GHz. In this LoRa DSS report emission data reported up to 10GHz.

Negative values for Delta indicate compliance.

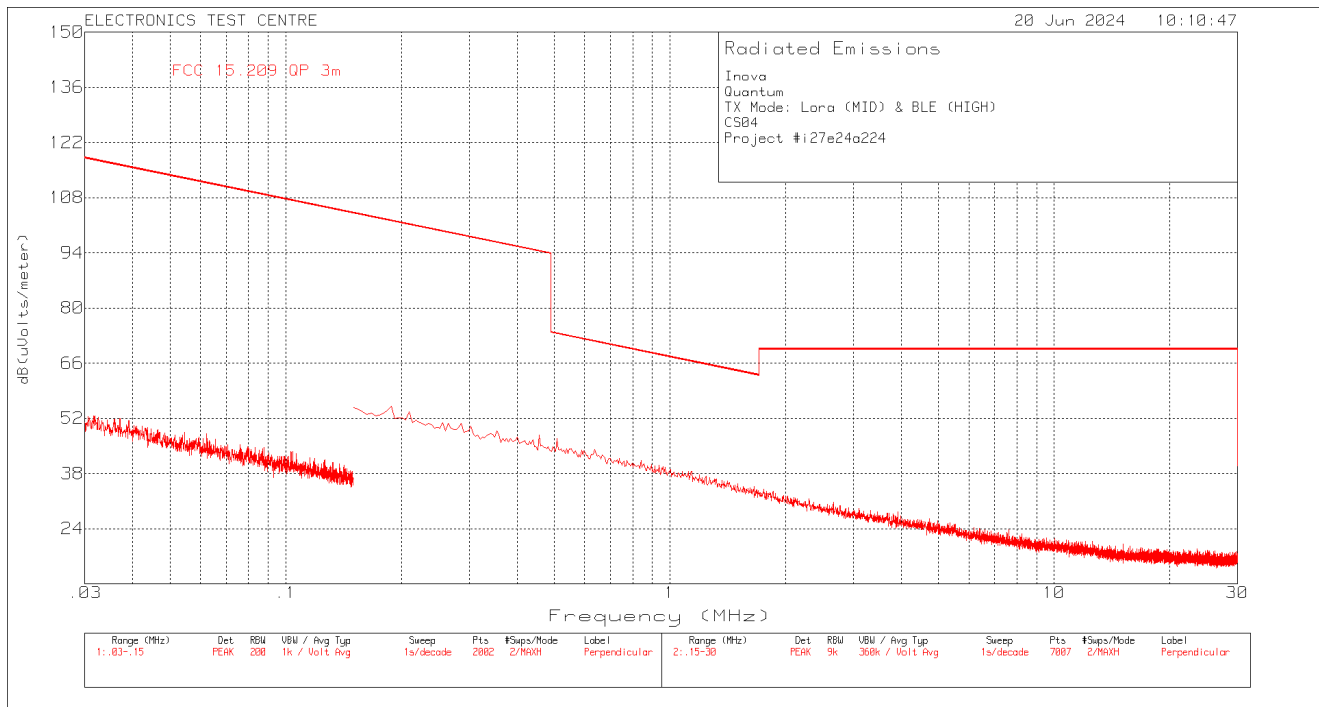
| Freq. Marker | Freq. [GHz] | Raw reading [dBμv] | Det | Antenna Factor [dB/m] | Pre amp Gain [dB] | Corrected Reading [dBμv/m] | FCC 15.209 Limit [dBμv/m] | Delta [dB] | Azimuth [Deg] | Height [cm] | Polarization |
|--------------|-------------|--------------------|-----|-----------------------|-------------------|----------------------------|---------------------------|------------|---------------|-------------|--------------|
| 1            | 0.10371     | 19.25              | QP  | 16.1                  | -23.6             | 11.75                      | 43.53                     | -31.78     | 125           | 156         | Vertical     |
| 2            | 0.70263     | 20.05              | QP  | 24.3                  | -19.1             | 25.25                      | 46.03                     | -20.78     | 106           | 156         | Vertical     |
| 1            | 1.8105      | 60.32              | PK  | 27.5                  | -33.3             | 54.52                      | > 20dBc                   | 44.32dBc   | 166           | 385         | Horizontal   |
| 2            | 1.8105      | 60.49              | PK  | 27.5                  | -33.3             | 54.69                      | > 20dBc                   | 37.21dBc   | 229           | 397         | Vertical     |
| 3            | *3.6209     | 44.31              | PK  | 31.6                  | -32.8             | 43.11                      | 74                        | -30.89     | 157           | 393         | Horizontal   |
| 3            | *3.6209     | 36.35              | AV  | 31.6                  | -32.8             | 35.15                      | 54                        | -18.85     | 157           | 393         | Horizontal   |
| 4            | *4.5264     | 45.81              | PK  | 32.5                  | -31.5             | 46.81                      | 74                        | -27.19     | 133           | 306         | Horizontal   |
| 4            | *4.5264     | 39.78              | AV  | 32.5                  | -31.5             | 40.78                      | 54                        | -13.22     | 133           | 306         | Horizontal   |
| 5            | *4.9601     | 43.67              | PK  | 33.1                  | -30.9             | 45.87                      | 74                        | -28.13     | 10            | 239         | Horizontal   |
| 5            | *4.9601     | 33.15              | AV  | 33.1                  | -30.9             | 35.35                      | 54                        | -18.65     | 10            | 239         | Horizontal   |
| 6            | *5.4314     | 51.2               | PK  | 34                    | -28.7             | 56.5                       | 74                        | -17.5      | 128           | 280         | Horizontal   |
| 6            | *5.4314     | 41.57              | AV  | 34                    | -28.7             | 46.87                      | 54                        | -7.13      | 128           | 280         | Horizontal   |
| 7            | 6.337       | 44.15              | PK  | 34.4                  | -27.9             | 50.65                      | > 20dBc                   | 48.19dBc   | 258           | 223         | Horizontal   |
| 8            | *7.4398     | 38.42              | PK  | 36.6                  | -26.5             | 48.52                      | 74                        | -25.48     | 197           | 291         | Horizontal   |
| 8            | *7.4398     | 27.51              | AV  | 36.6                  | -26.5             | 37.61                      | 54                        | -16.39     | 197           | 291         | Horizontal   |
| 9            | *8.1475     | 38.13              | PK  | 36.4                  | -24.9             | 49.63                      | 74                        | -24.37     | 130           | 288         | Horizontal   |
| 9            | *8.1475     | 28.9               | AV  | 36.4                  | -24.9             | 40.4                       | 54                        | -13.6      | 130           | 288         | Horizontal   |
| 10           | *9.0533     | 35.03              | PK  | 37.2                  | -24.4             | 47.83                      | 74                        | -26.17     | 241           | 380         | Horizontal   |
| 10           | *9.0533     | 24.56              | AV  | 37.2                  | -24.4             | 37.36                      | 54                        | -16.64     | 241           | 380         | Horizontal   |
| 14           | *3.6211     | 44.71              | PK  | 31.6                  | -32.8             | 43.51                      | 74                        | -30.49     | 89            | 260         | Vertical     |
| 14           | *3.6211     | 39.96              | AV  | 31.6                  | -32.8             | 37.76                      | 54                        | -16.24     | 89            | 260         | Vertical     |
| 15           | *4.5266     | 44.39              | PK  | 32.5                  | -32.8             | 45.39                      | 74                        | -28.61     | 173           | 289         | Vertical     |
| 15           | *4.5266     | 37.8               | AV  | 32.5                  | -32.8             | 38.8                       | 54                        | -15.20     | 173           | 289         | Vertical     |
| 16           | *4.9591     | 40.78              | PK  | 33.1                  | -30.9             | 42.98                      | 74                        | -31.02     | 301           | 100         | Vertical     |
| 16           | *4.9591     | 27.66              | AV  | 33.1                  | -30.9             | 29.86                      | 54                        | -24.14     | 301           | 100         | Vertical     |
| 17           | *5.4314     | 50.75              | PK  | 34                    | -28.7             | 56.05                      | 74                        | -17.95     | 259           | 146         | Vertical     |
| 17           | *5.4314     | 41.84              | AV  | 34                    | -28.7             | 47.14                      | 54                        | -6.86      | 259           | 146         | Vertical     |
| 18           | 6.34        | 48.28              | PK  | 34.4                  | -28.7             | 54.78                      | > 20dBc                   | 37.12dBc   | 303           | 136         | Vertical     |
| 19           | 7.24        | 40.22              | PK  | 36.2                  | -27.9             | 49.62                      | > 20dBc                   | 42.28dBc   | 74            | 347         | Vertical     |
| 20           | *7.44       | 37.57              | PK  | 36.6                  | -26.5             | 47.67                      | 74                        | -26.33     | 344           | 330         | Vertical     |
| 20           | *7.44       | 26.63              | AV  | 36.6                  | -26.5             | 36.73                      | 54                        | -17.27     | 344           | 330         | Vertical     |
| 21           | *8.15       | 39.65              | PK  | 36.4                  | -24.9             | 51.15                      | 74                        | -22.85     | 351           | 340         | Vertical     |
| 21           | *8.15       | 30.26              | AV  | 36.4                  | -24.9             | 41.76                      | 54                        | -12.24     | 351           | 340         | Vertical     |
| 22           | *9.053      | 37.19              | PK  | 37.2                  | -24.4             | 49.99                      | 74                        | -24.01     | 275           | 346         | Vertical     |
| 22           | *9.053      | 27.26              | AV  | 37.2                  | -24.4             | 40.06                      | 54                        | 13.94      | 275           | 346         | Vertical     |

**QP:** Quasi- Peak **PK:** Peak Detector **AV:** Average Detector. \* Spurious Emission in Restricted Band

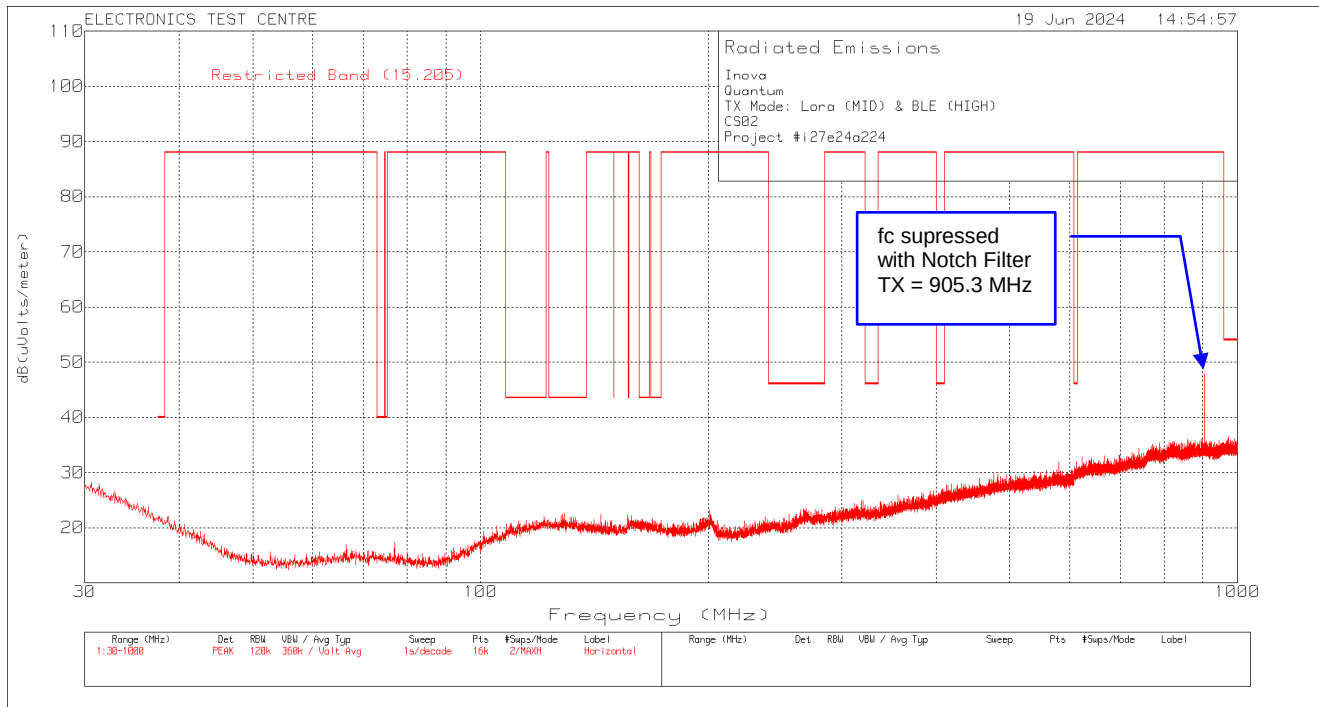
## Plot of Radiated Emissions: Parallel



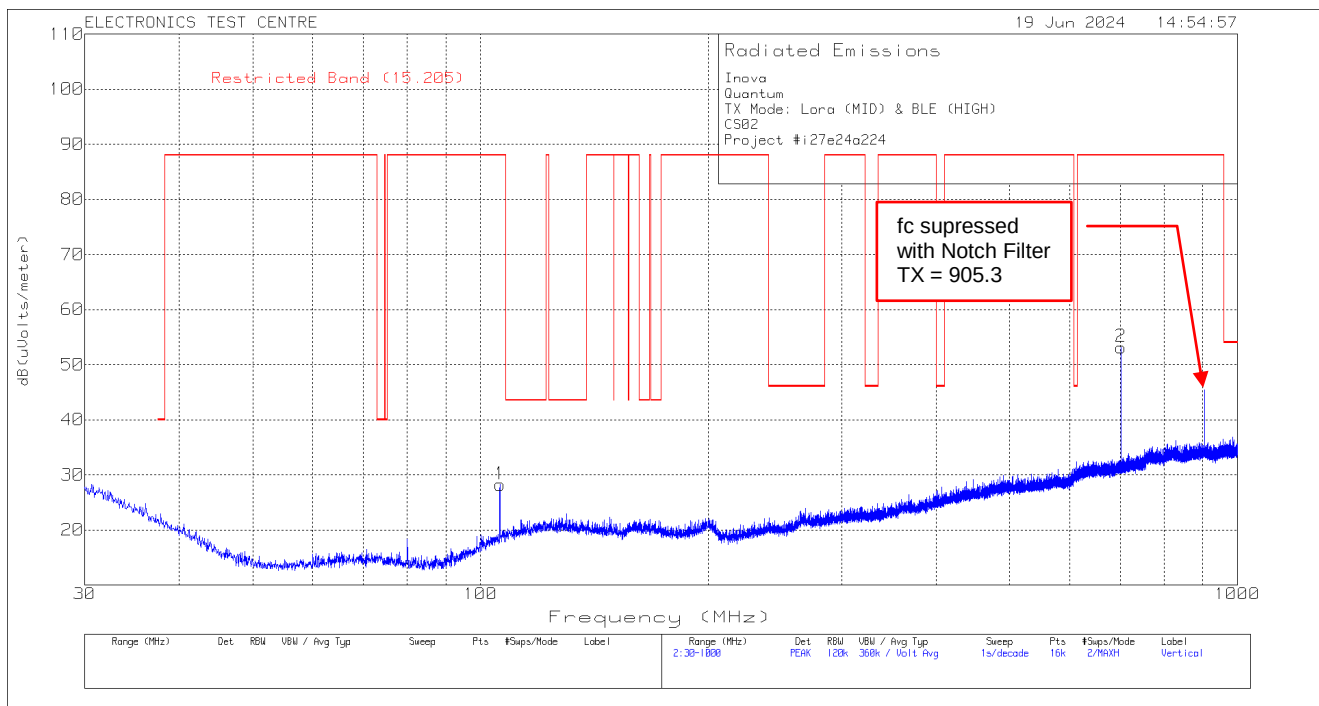
## Plot of Radiated Emissions: Perpendicular



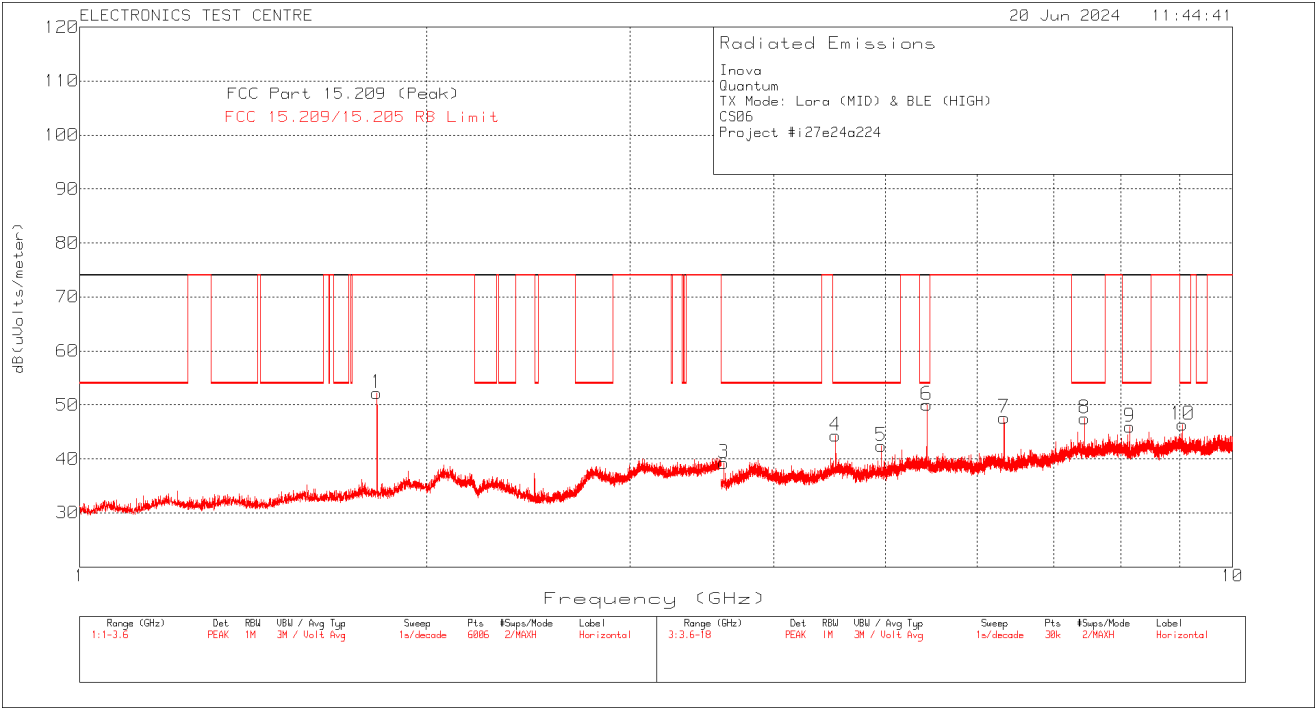
## Plot of Radiated Emissions: Horizontal Polarization



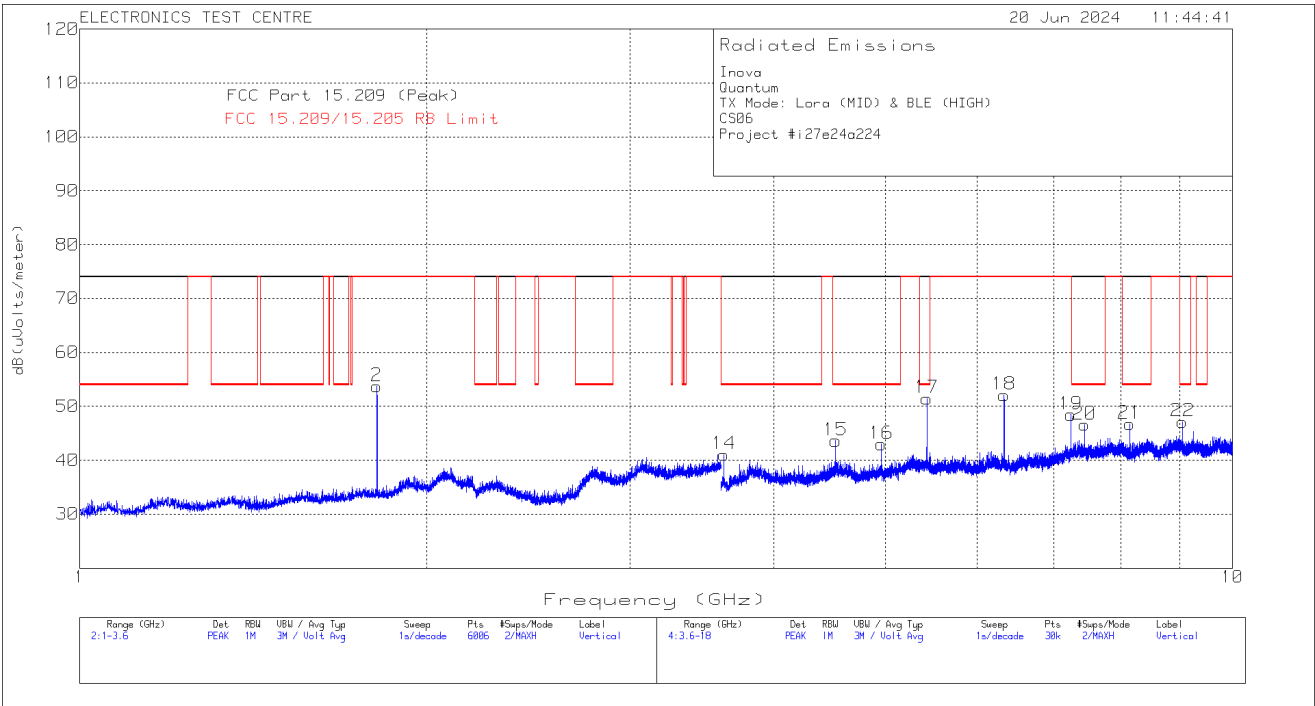
## Plot of Radiated Emissions: Vertical Polarization



Plot of Radiated Emissions: Horizontal Polarization



Plot of Radiated Emissions: Vertical Polarization



## 2.12 Radiated Emissions (RX Mode)

|                                                                                                                           |                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Test Lab: Electronics Test Centre, Airdrie<br>Test Personnel: Janet Mijares<br>Date: 2024-06-(19/20/21) (21.3°C, 24.6%RH) | EUT: Quantum Dual Band HyperQ Node<br>Standard: FCC Part 15.109<br>Basic Standard: ANSI C63.4: 2014<br>Class: A |
| EUT status: Compliant                                                                                                     |                                                                                                                 |

| Frequency (MHz) | FCC Part 15.109<br>Class A Limit (3m) |
|-----------------|---------------------------------------|
| 30 – 88         | 50 (dBµV/m)                           |
| 88 – 216        | 53.52 (dBµV/m)                        |
| 216 – 960       | 56.02 (dBµV/m)                        |
| Above 960       | 59.54 (dBµV/m)                        |

**Criteria:** The radiated emissions produced by a device, measured at a distance of 3 meters, shall not exceed the limits as specified.

### 2.12.1 Test Guidance:

From 30 MHz to 1000 MHz, measurements are performed with a broadband biconilog antenna and a resolution bandwidth of 120 kHz.

Above 1000 MHz, measurements are performed with a DRG Horn antenna or a Standard Gain horn, and a resolution bandwidth of 1 MHz.

The scan is performed at discreet increments of turntable azimuth and stepped antenna height, with peak detector and Max Hold function which are selected in accordance with the applicable standard in order to assure capture of frequencies of interest. Optimization is performed based on the scan data.

After the pre-scan is completed, the frequencies of interest are optimized. The EUT is rotated in azimuth over 360 degrees and the direction of maximum emission is noted.

Antenna height is varied from 1 – 4 meters at this azimuth to obtain the maximum emission. Then the maximum level is measured with the appropriate detector and recorded. This may produce a different reading than the pre-scan trace. Up to 1 GHz, measurements are performed with a Quasi-Peak detector. Above 1 GHz, measurements are recorded with Peak and/or Average detectors, as applicable.

### 2.12.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

### 2.12.3 Test Equipment

Testing was performed with the following equipment:

| Equipment                            | Manufacturer           | Model #                         | Asset # | Cal. Date<br>(yyyy-mm-dd) | Cal. Due<br>(yyyy-mm-dd) |
|--------------------------------------|------------------------|---------------------------------|---------|---------------------------|--------------------------|
| EMC Software                         | UL                     | Ver. 9.5                        | SW021   | N/A                       |                          |
| EMI receiver                         | Agilent                | N9038A<br>(FW A.25.05)          | 6130    | 2023-08-11                | 2024-08-11               |
| Biconilog Antenna<br>(30 – 1000 MHz) | AR                     | JB1                             | 6905    | 2023-11-29                | 2025-11-29               |
| DRG Horn<br>(1000 – 18000 MHz)       | EMCO                   | 3115                            | 19357   | 2022-10-05                | 2024-10-05               |
| Humidity/Temp<br>Logger              | Extech Ins.<br>Corp.   | 42270                           | 5892    | 2024-04-08                | 2025-04-08               |
| Pre-Amplifier<br>(30 – 1400 MHz)     | HP                     | 8447D                           | 9291    | *2024-01-23               | 2025-01-23               |
| Low Noise Amplifier<br>(1 – 18 GHz)  | MITEQ                  | JS43-01001800-21-<br>5P         | 4354    | *2024-01-23               | 2025-01-23               |
| RE Cable below<br>1GHz               | Insulated Wire<br>Inc. | KPS-1501A-3600-<br>KPA-01102006 | 4419    | *2024-01-23               | 2025-01-23               |
| Re Cable Above 1<br>GHz              | A.H. System<br>Inc.    | SAC-26G-8.23                    | 6187    | *2024-01-23               | 2025-01-23               |

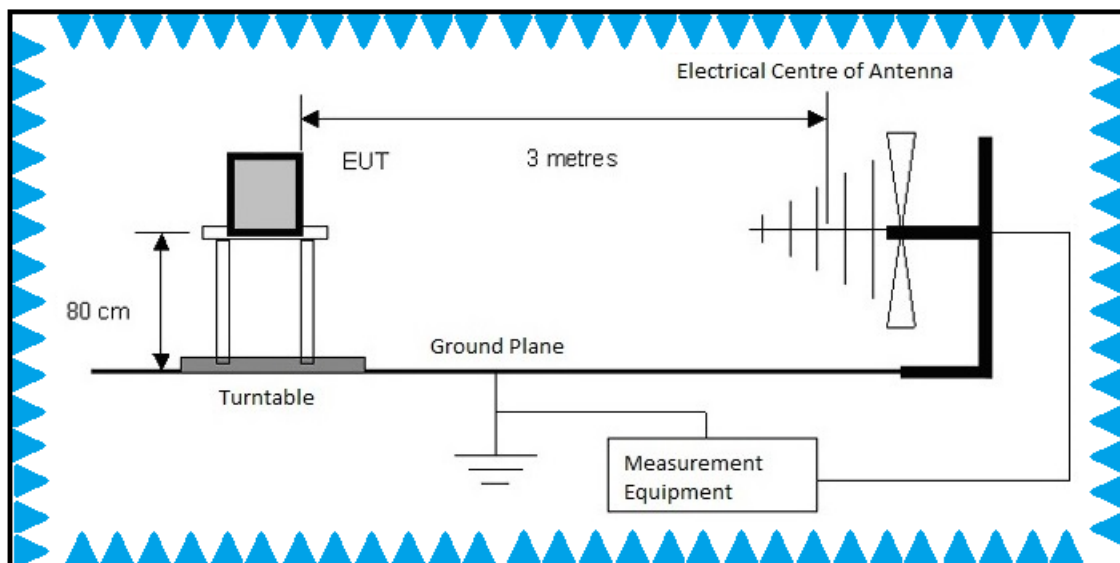
\* In-house verification

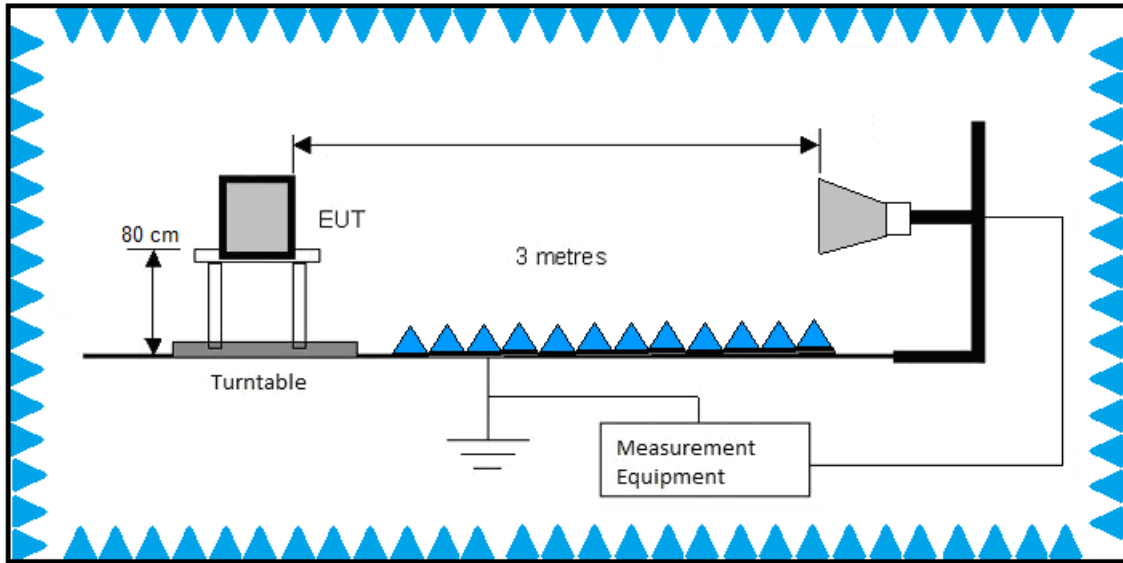
### 2.12.4 Test Sample Verification, Configuration & Modifications

To cover the unintentional radiated emission. The EUT was configured in receive mode. Unit was placed at the center of turntable in semi-anechoic chamber 80cm above the ground plane and at a distance of 3m from the test receive antenna.

The EUT met the requirements without modification.

#### EUT RX configuration Block Diagram for Radiated Emissions testing:





### 2.12.5 Radiated Emissions Data maximization:

The emissions data are presented in tabular form, showing turntable azimuth, antenna height and polarization, the uncorrected spectrum analyzer reading, the correction factors applied, the net result, the value of the limit at the frequency investigated, and the Delta between the result and the limit.

**Meter Reading in dBμV + Antenna Factor in dB/m + Gain/Loss Factor in dB = Corrected Field Strength in dBμV/m.**

**Delta = Field Strength – Limit**

#### Notes:

When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss. Measurements reported are the result of adjusting the turntable azimuth and antenna height to obtain the maximum EUT emission. This may produce a different reading than the plot trace. The plot is a Peak Hold function obtained at discreet increments of height and azimuth, while the reported measurement is obtained with the appropriate Quasi Peak or Average detector after the height and azimuth have been adjusted for maximum emission. In receive mode the EUT was assessed up to 12.5 GHz. In this LoRa report emission data reported up to 5.0GHz.

**Negative values for Delta indicate compliance.**

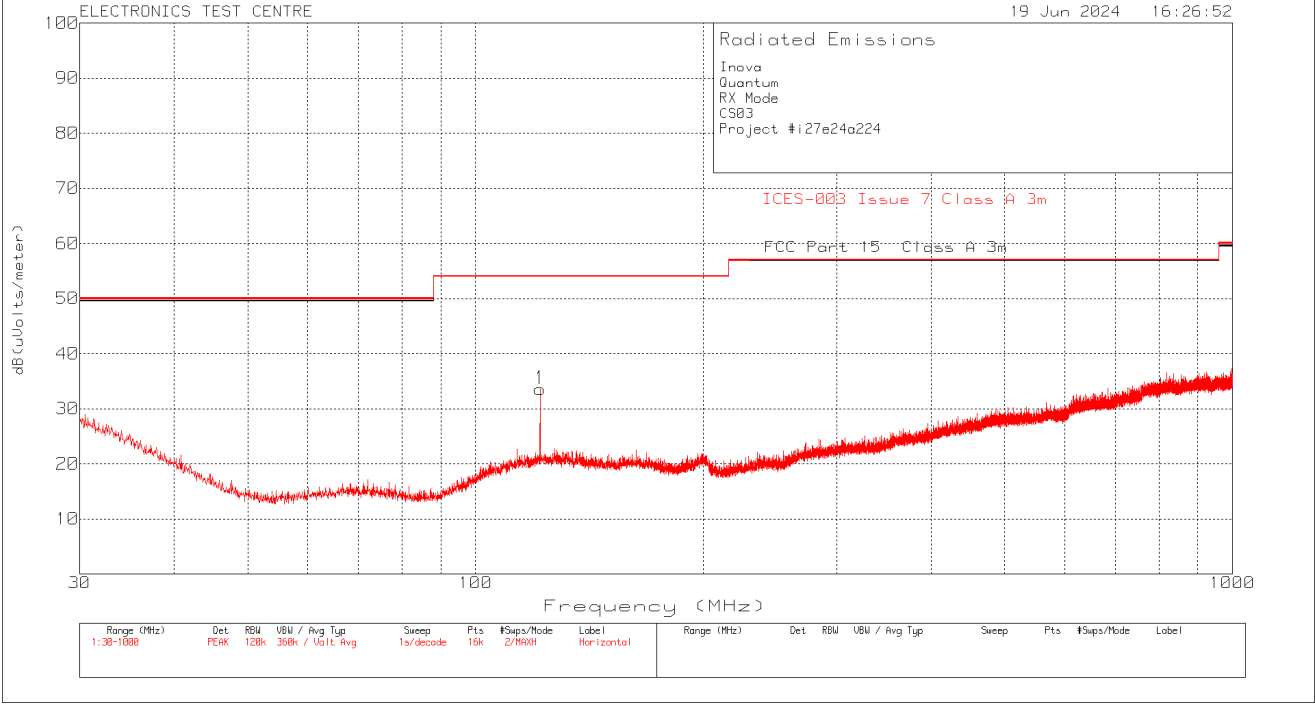
| Freq. Marker | Freq. [GHz] | Raw reading[ dBμV] | Det | Antenna Factor [dB/m] | Pre amp Gain [dB] | Corrected Reading [dBμV/m] | FCC Class A Limit [dBμV/m] | Delta [dB] | Azimuth [Deg] | Height [cm] | Polarization |
|--------------|-------------|--------------------|-----|-----------------------|-------------------|----------------------------|----------------------------|------------|---------------|-------------|--------------|
| 1            | 121.1       | 18.51              | QP  | 17.9                  | -23.4             | 13.01                      | 53.98                      | -40.97     | 308           | 127         | Horizontal   |
| 2            | 2401.1      | 26.46              | AV  | 28.5                  | -33.4             | 21.56                      | 60                         | -38.44     | 231           | 282         | Vertical     |

**QP**: Quasi- Peak Detector

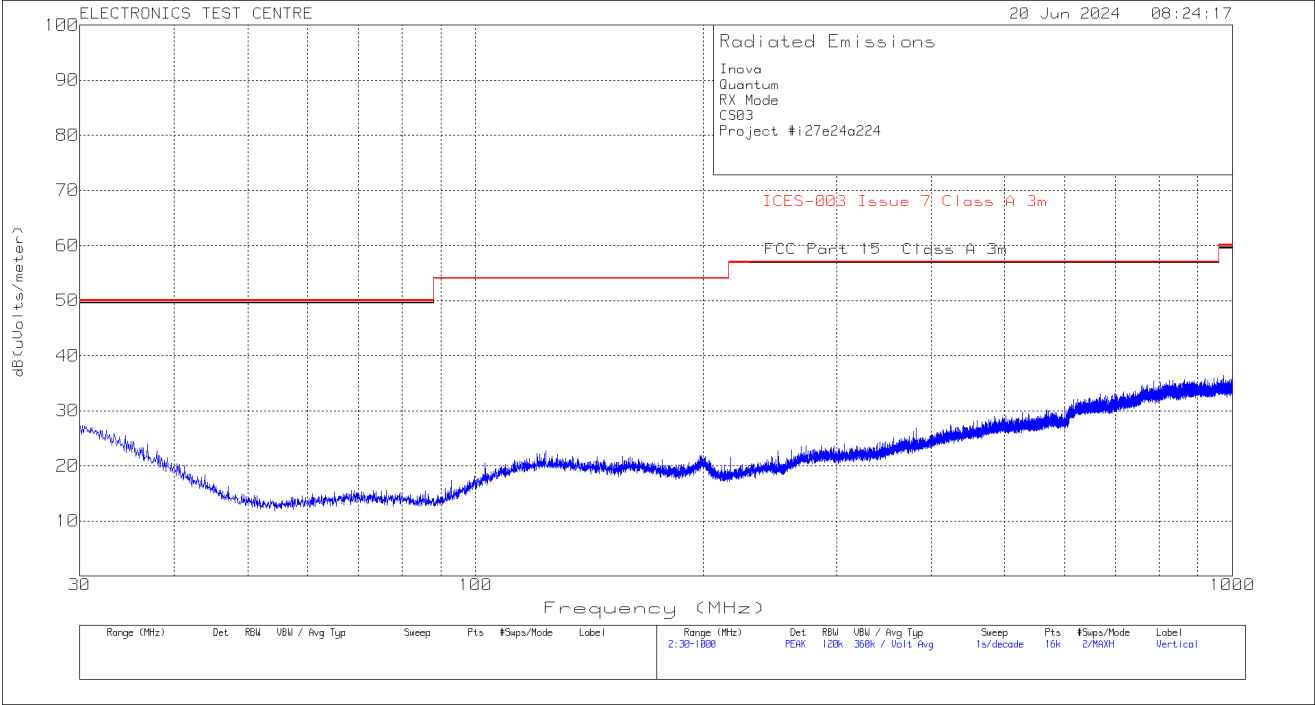
**PK**: Peak Detector

**AV**: Average Detector.

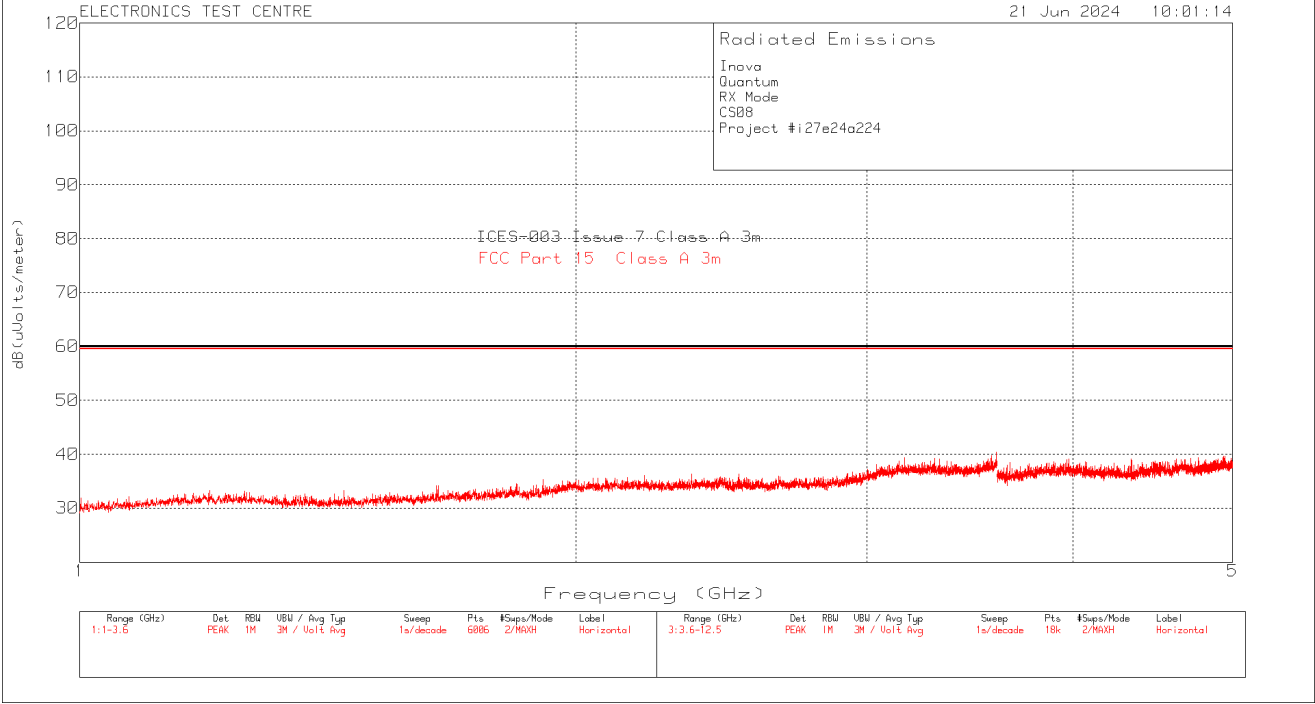
Plot of Radiated Emissions: Horizontal Polarization



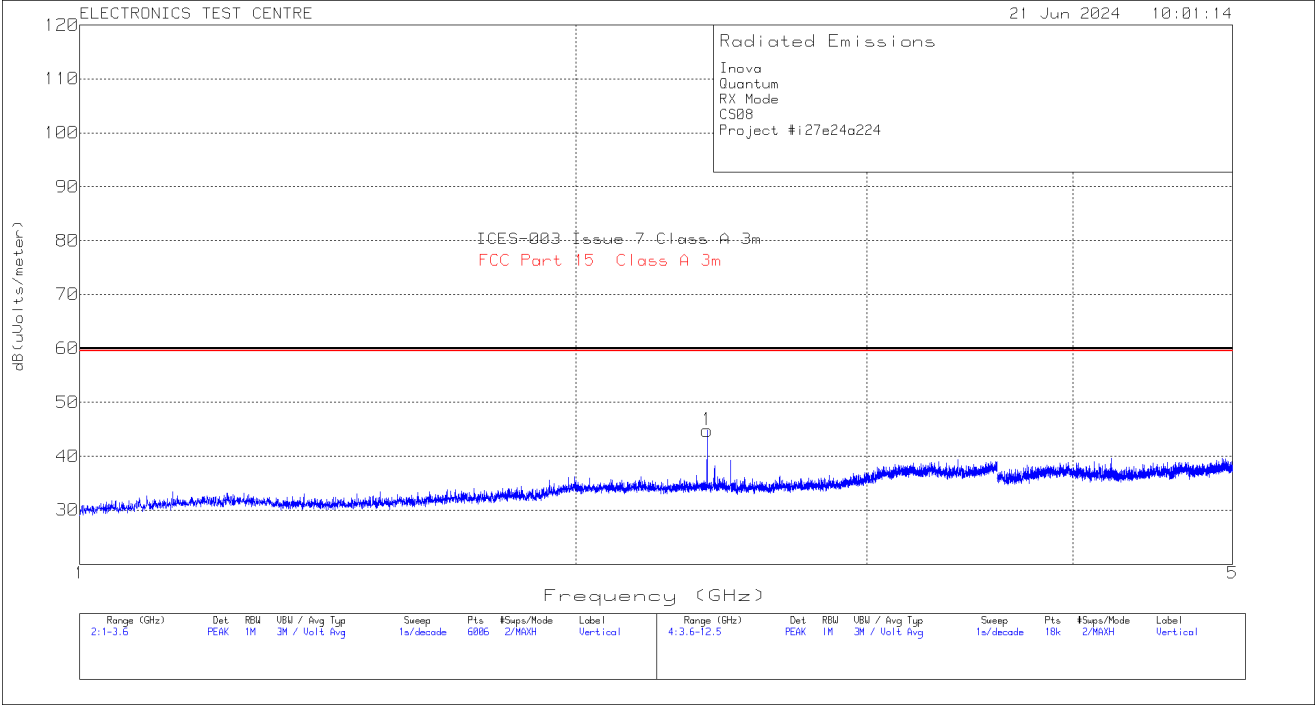
Plot of Radiated Emissions: Vertical Polarization



Plot of Radiated Emissions: Horizontal Polarization



Plot of Radiated Emissions: Vertical Polarization



## 2.13 RF Exposure

Test Lab: Electronics Test Centre, Airdrie

EUT: Quantum Dual Band HyperQ Node

Test Personnel:

Standard: FCC PART 15.247

Date:

**EUT status: Exempt from SAR evaluation**

**Compliant:** RF exposure assessment to be provided in a separate Exhibit.

## **3.0 TEST FACILITY**

### **3.1 Location**

The Quantum Dual Band HyperQ Node was tested at the Electronics Test Centre laboratory located in Airdrie, Alberta, Canada. The Radio Frequency Anechoic Chamber (RFAC), identified as Chamber 1, has a usable working space measuring 10.6 m long x 7.3 m wide x 6.5 m high.

The test site is registered with Industry Canada per registration file # 2046A. This site is also listed with the FCC under Registration Number CA2046.

The floor, walls and ceiling consist of annealed steel panels. The walls and ceiling are covered with ferrite tile, augmented by RF absorbant foam material on the end wall nearest the turntable, and on the adjacent walls and the ceiling. The chamber floor supports a 15 cm high internal floor, constructed of annealed steel panels, that forms the ground plane, and is bonded to the chamber walls.

The 3-m diameter turntable is flush-mounted with the floor. A sub-floor cable-way is provided to route cables between the turntable pit and EUT support equipment located in the Control Room. Cables reach the EUT through an opening in the centre of the turntable.

Test instrumentation and EUT support equipment is located in the Control Room, consisting of two shielded vestibules joined together at the side of the main room. Cables are routed through bulkhead panels between the rooms and the test chamber as required. Power feeds are routed into the main room and vestibules through line filters providing at least 100 dB of attenuation between 10 kHz and 10 GHz.

Either floor mounted or table-top equipment can be tested at this facility.

### **3.2 Grounding Plan**

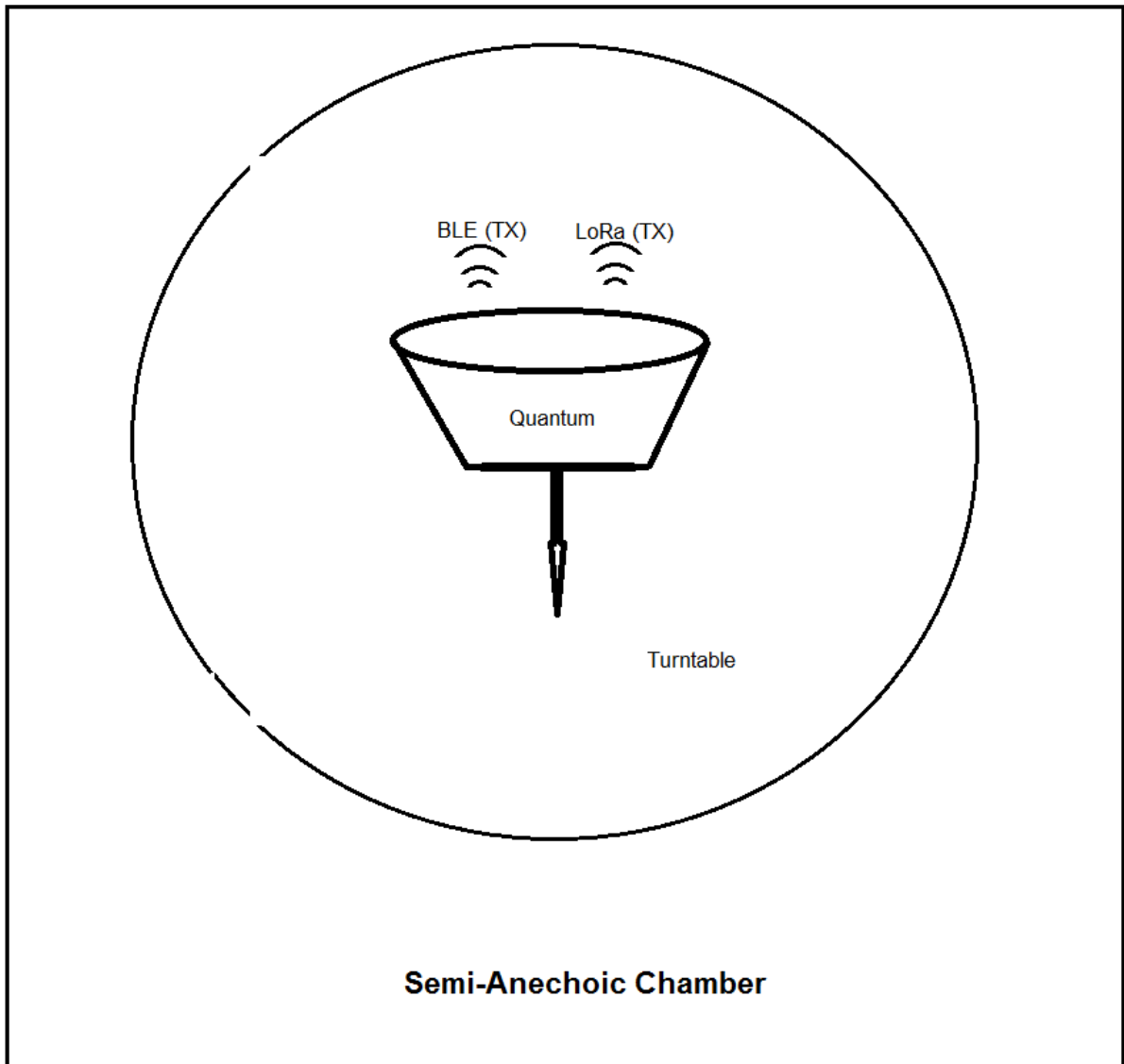
The Quantum Dual Band HyperQ Node was placed at the center of the test chamber turntable on top of an 80-cm high polystyrene foam table below 1GHz and at 1.5m high polystyrene foam table above 1 GHz for transmits mode and 80cm high for RX mode. There is no external grounding.

### **3.3 Power Supply**

For radiated emission and antenna port conducted emission power was supplied via internal rechargeable Li-ion battery 7.2V 6.7Ah 48.24Wh pack.

## Appendix A – Test Setup Block Diagram

### TX MODE



**End of Document**