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ETC Report #: i27e24a224_DTS Release 1 Report date: September 19, 2024

EMC testing of the INOVA System Corporation Quantum Dual Band HyperQ Node in accordance with FCC Part 15.247and 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

Test Personnel: Janet Mijares, Brendan Van Hee

Prepared for: **INOVA System Corporation**

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REVISION RECORD

ISSUE	DATE	AUTHOR	REVISIONS
DRAFT 1	2024-08-09	I. Akram	Initial draft submitted for review.
DRAFT 2	2024-09-06	I. Akram	Change FCC ID #
Release 1	2024-09-19	I. Akram	Sign Off

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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 new Authorization for Low-Power License-Exempt transmitters. All test procedures, limits, criteria, and results described in this report apply only to the INOVA System 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 System Corporation, located in Calgary, Alberta, Canada.

1.3 Test Sample Description

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

Product Name:	Quantum Dual Band HyperQ Node
Radio	BT
Frequency Band	2400 – 2483.5 MHz
Frequency Range	2402 – 2480 MHz
Operating Mode	BLE (DTS)
Max Transmit Power (Conducted)	0.0010351W (0.15 dBm)
Associated Antennas	STMicroelectronics AN5434 inverted F antenna Max Gain = 0.0dBi
Model#	FNL41075
Serial#	Q00800188, Q00800164
Power supply:	Battery Powered

Note: 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 feature 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 a continuous transmit mode ≥98% 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 SMA connector is soldered to the circuit board at the output of the radio to provide direct access to the radio output to connect spectrum analyzer and 10 dB pad was used between radio and spectrum analyzer for protection.
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 is tested in RX mode to cover FCC part 15 Sub Part 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	AC Main Conducted Emissions	15.207 / 15.109	Quantum Dual Band HyperQ Node	none	see § 2.1	**N/A** **(Internal Battery)**
2.2	6dB Bandwidth	15.247(a)	Quantum Dual Band HyperQ Node	none	see § 2.2	**Compliant**
2.3	Max Output Power	15.247(d)	Quantum Dual Band HyperQ Node	none	see § 2.3	**Compliant**
2.4	Band Edge	15.247(d)	Quantum Dual Band HyperQ Node	none	see § 2.4	**Compliant**
2.5	Power Spectral Density	15.247(e)	Quantum Dual Band HyperQ Node	none	see § 2.5	**Compliant**
2.6	Conducted Spurious Emissions (Non-Restricted Band)	15.247(d)	Quantum Dual Band HyperQ Node	none	see § 2.6	**Compliant**
2.7	EUT Position	ANSI C63.4	Quantum Dual Band HyperQ Node	none	see § 2.7	**Fix Position**
2.8	Radiated Spurious Emission (Restricted Band)	15.205, 15.209 15.247(d)	Quantum Dual Band HyperQ Node	none	see § 2.8	**Compliant**
2.9	Radiated Emission	15.109	Quantum Dual Band HyperQ Node	none	see § 2.9	**Compliant**
2.10	RF Exposure	15.247(i)	Quantum Dual Band HyperQ Node	none	see § 2.10	**Exempt**

Refer to the test data for applicable test conditions.

2.1 AC Main Power Line Conducted Emissions: N/A

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

2.2 6dB Bandwidth

Test Lab: Electronics Test Centre, Airdrie	**EUT: Quantum Dual Band HyperQ Node**
Test Personnel: Janet Mijares	**Standard: FCC PART 15.247**
Date: 2024-06-18 (21.7°C, 16% RH)	**Basic Standard: ANSI C63.10-2013** **FCC OET KDB 558074**

EUT status: Compliant

Specification: FCC Part 15.247 (a, 2), FCC 15.215 (c)

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

2.2.1 Test Guidance: ANSI C63.10-2013, Clause 11.8 / 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.

For DTS the spectrum analyzer is set for a frequency span ≥ (2 * OBW), ≤ (5 * OBW), selected to clearly display the channel. The RBW is set to 100 kHz. The VBW is set to ≥ (3 * RBW). The Peak detector is used, with the trace set to Max Hold.

The automated 99% BW function of the spectrum analyzer is engaged, and the 6 dB OBW and/or 20 dB OBW is measured with the x dB function.

2.2.2 Deviations From The Standard:

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

2.2.3 Test Equipment

Testing was performed with the following equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EMI receiver	Agilent	N9038A (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	

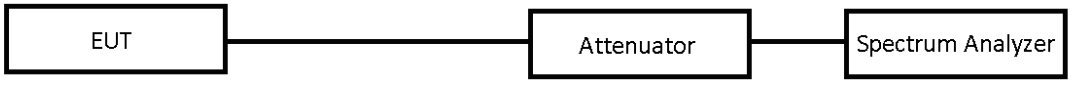
2.2.4 Test Sample Verification, Configuration & Modifications

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:

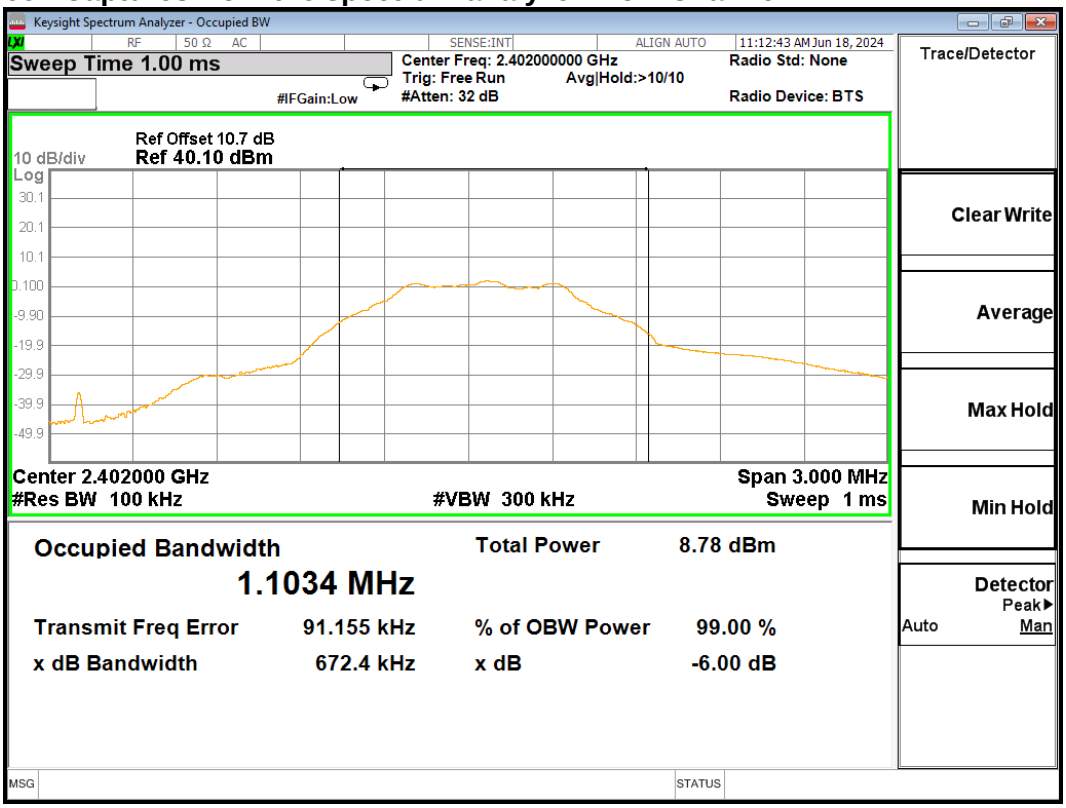
Conducted:



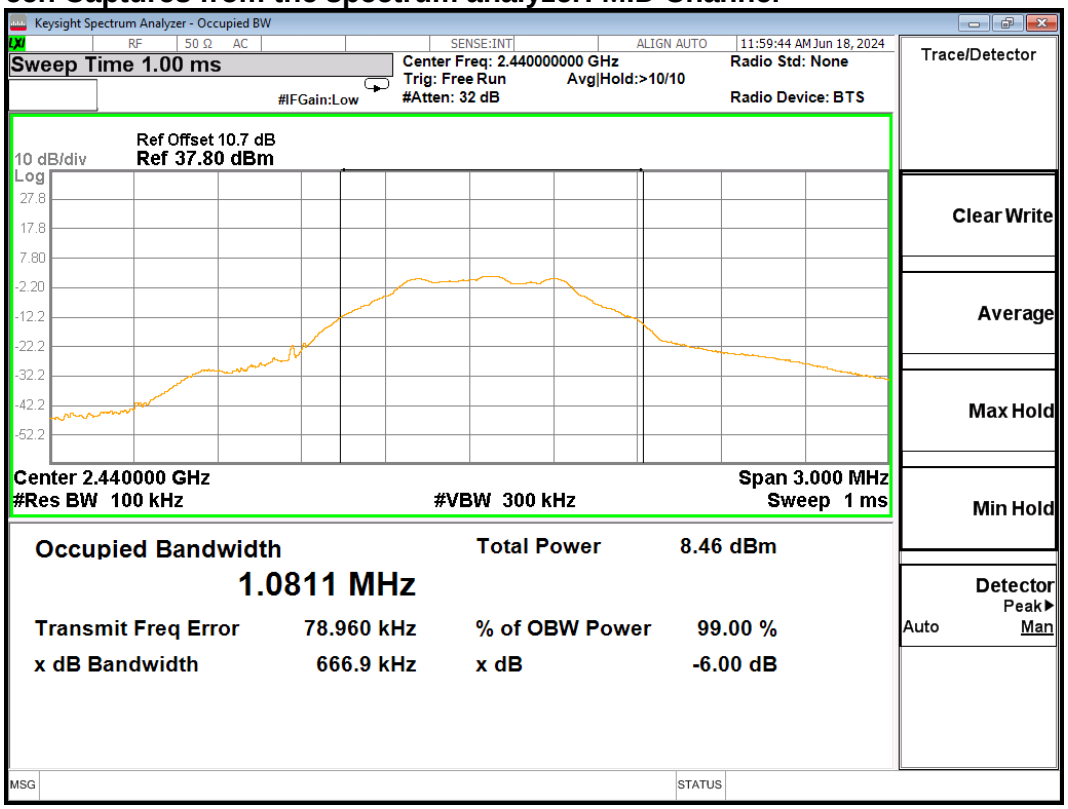
2.2.5 Channel Bandwidth Data:

Mode of operation	Channel	Freq. [MHz]	6 dB BW [MHz]	Limit BW [KHz]
BLE	Low	2402	672.4	≥ 500
	Mid	2440	666.9	
	High	2480	667.6	

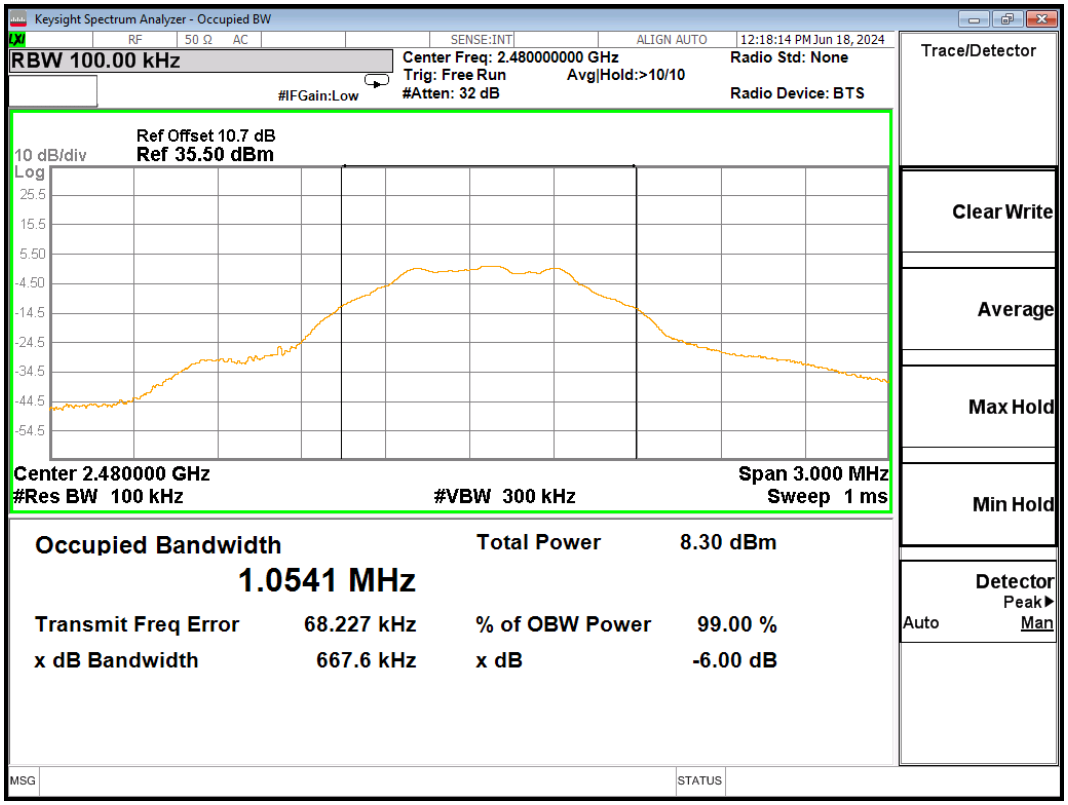
Screen Captures from the spectrum analyzer: Low Channel



Screen Captures from the spectrum analyzer: MID Channel



Screen Captures from the spectrum analyzer: High Channel



2.3 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: 2024-06-18 (21.7°C, 16% RH)	**Basic Standard: ANSI C63.10: 2013** **FCC OET KDB 558074**

EUT status: Compliant

Specification: FCC Part 15.247(b, 3)

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

2.3.1 Test Guidance: ANSI C63.10-2013, Clause 11.9.2.2.2/ 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-1 For LoRa DTS	
Span	≥ 1.5 times the OBW
RBW	1 – 5 % of the OBW, ≤ 1 MHz
VBW	≥ 3 x RBW
Number of Points in sweep	≥ 2 x Span / RBW
Sweep time	Auto
Detector	RMS (Power Averaging)
Sweep trigger	Free Run (Duty Cycle ≥98%)
Trace Average	100 traces in power Averaging (RMS)
Power measured	Integrated the spectrum across the OBW of the signal using the S/A band power measurement function, with band limit set equal to the OBW band edge.

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 (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	

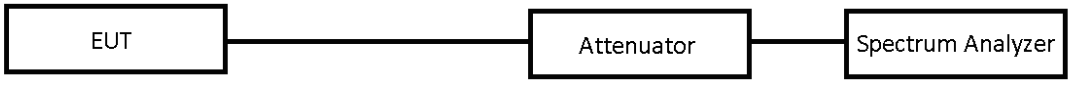
2.3.4 Test Sample Verification, Configuration & Modifications

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:

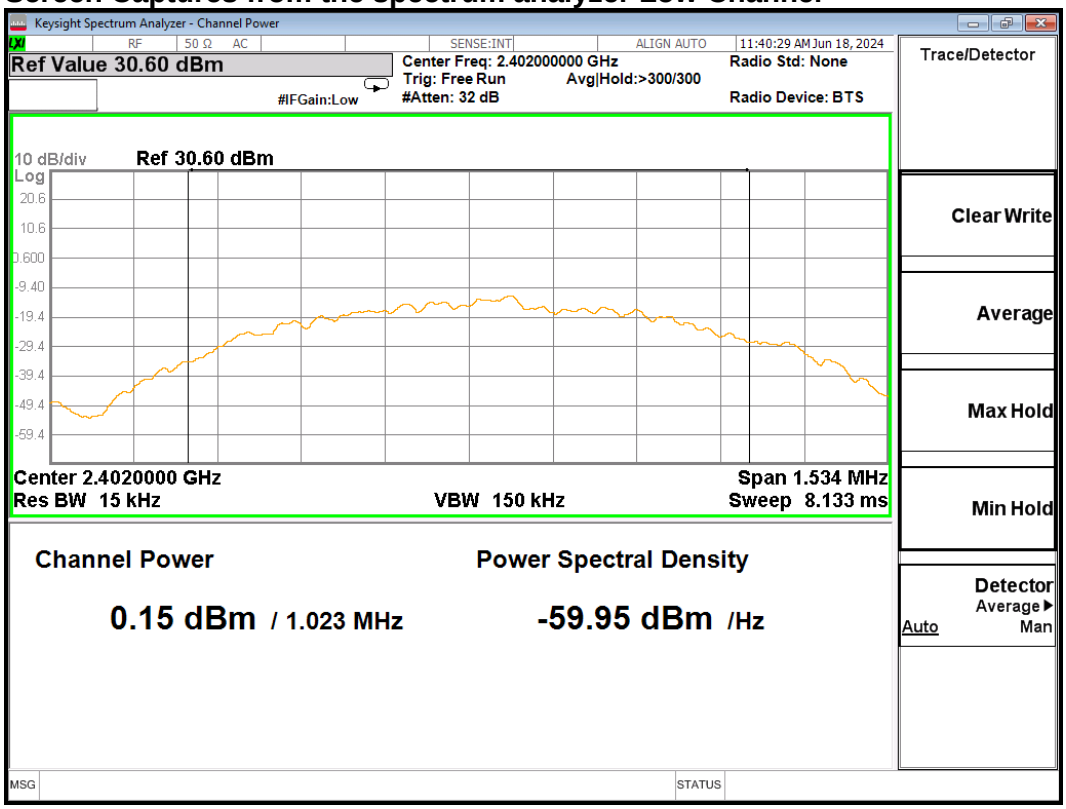
Conducted:



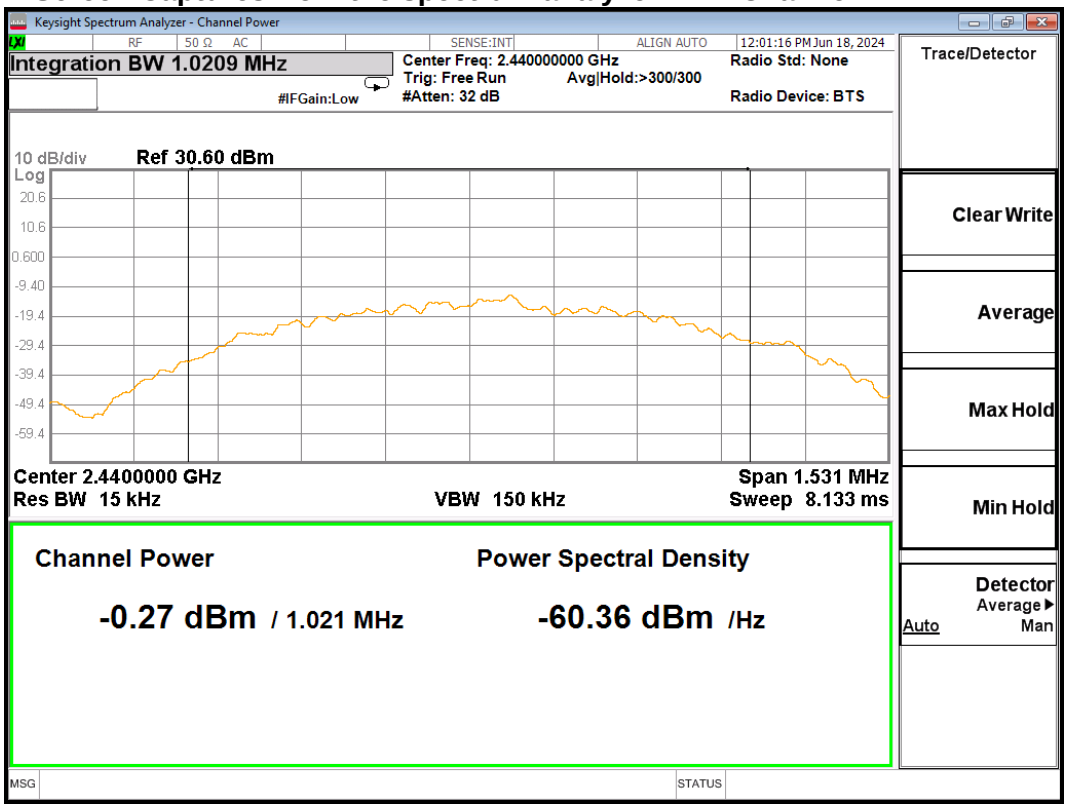
2.3.5 Max Average Output Power Data:

Mode of operation	Channel	Freq. [MHz]	Max Average Power [dBm]	Limit Power [dBm]
BLE	Low	2402	0.15	≤ 30 (1Watt)
	Mid	2440	-0.27	
	High	2480	-0.38	

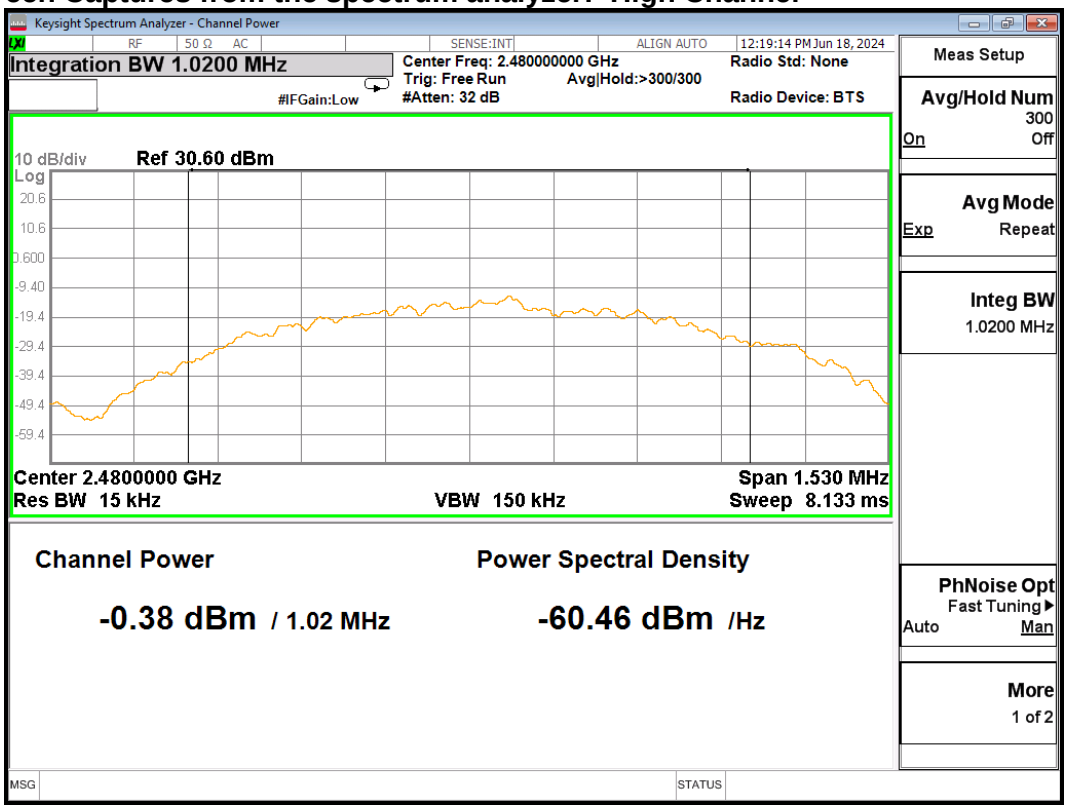
Screen Captures from the spectrum analyzer Low Channel



Screen Captures from the spectrum analyzer: MID Channel



Screen Captures from the spectrum analyzer: High Channel



2.4 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: 2024-06-18 (21.7°C, 16% RH)	**Basic Standard: ANSI C63.10: 2013 FCC OET KDB 558074**

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)).

2.4.1 Test Guidance: ANSI C63.10-2013 Clause 11.13.2 & 6.10.4, 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.

The spectrum analyzer is set for a frequency span to show the band edge and the nearest channel. The RBW is set to ≥ 100 kHz. The VBW is set to ≥ (RBW * 3). The Peak detector is used, with the trace set to Max Hold.

The attenuation is measured with the Marker Delta function.

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 (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	

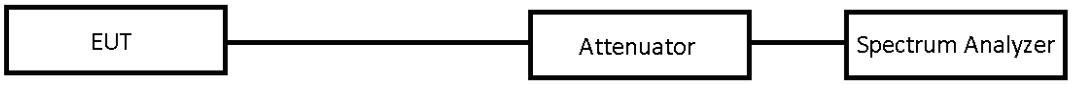
2.4.4 Test Sample Verification, Configuration & Modifications

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:

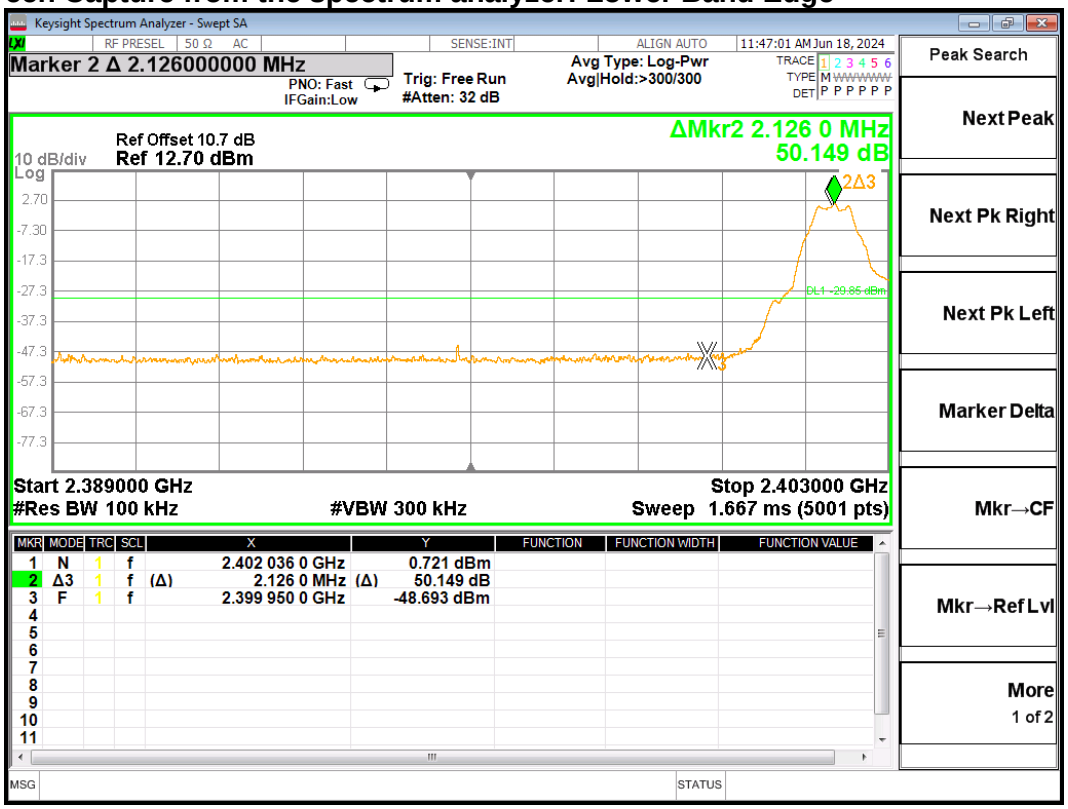


2.4.5 Band Edge Data

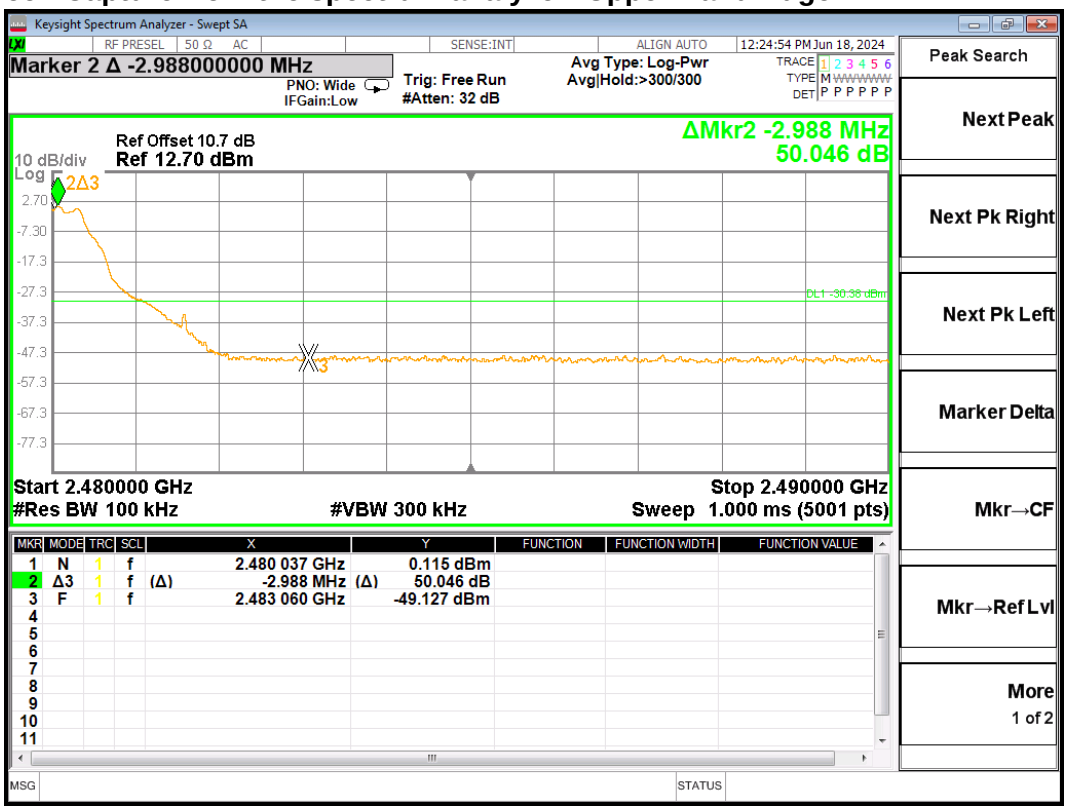
Worse Case Data

Mode of operation	Channel	Attenuation at Band Edge	Attenuation Limit at Band Edge
BLE	2402	50.149 dBc	≥ 30 dBc
	2480	50.046 dBc	

Screen Capture from the spectrum analyzer: Lower Band Edge



Screen Capture from the spectrum analyzer: Upper Band Edge



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: 2024-06-18 (21.7°C, 16% RH)	**Basic Standard: ANSI C63.10: 2013**

EUT status: Compliant

Specification: FCC Part 15.247(e)

Criteria For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

2.5.1 Test Guidance: ANSI C63.10-2013, Clause 11.10.3 / 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.

Method AVGPSD-1 For DTS	
Span	≥ 1.5 times the OBW
RBW	3 kHz ≤ RBW ≥ 100 kHz.
VBW	≥ 3 x RBW
Number of Points in sweep	≥ 2 x Span / RBW
Sweep time	auto couple
Detector	RMS (Power Averaging)
Sweep trigger	Free Run (Duty Cycle ≥98%)
Trace Average	Minimum 100 traces in power Averaging (RMS)
PSD measured	Use the peak marker function to determine the maximum amplitude level.
If the measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).	

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 (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	

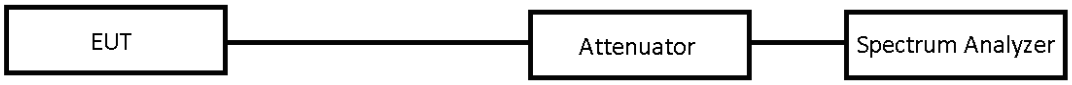
2.5.4 Test Sample Verification, Configuration & Modifications

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:

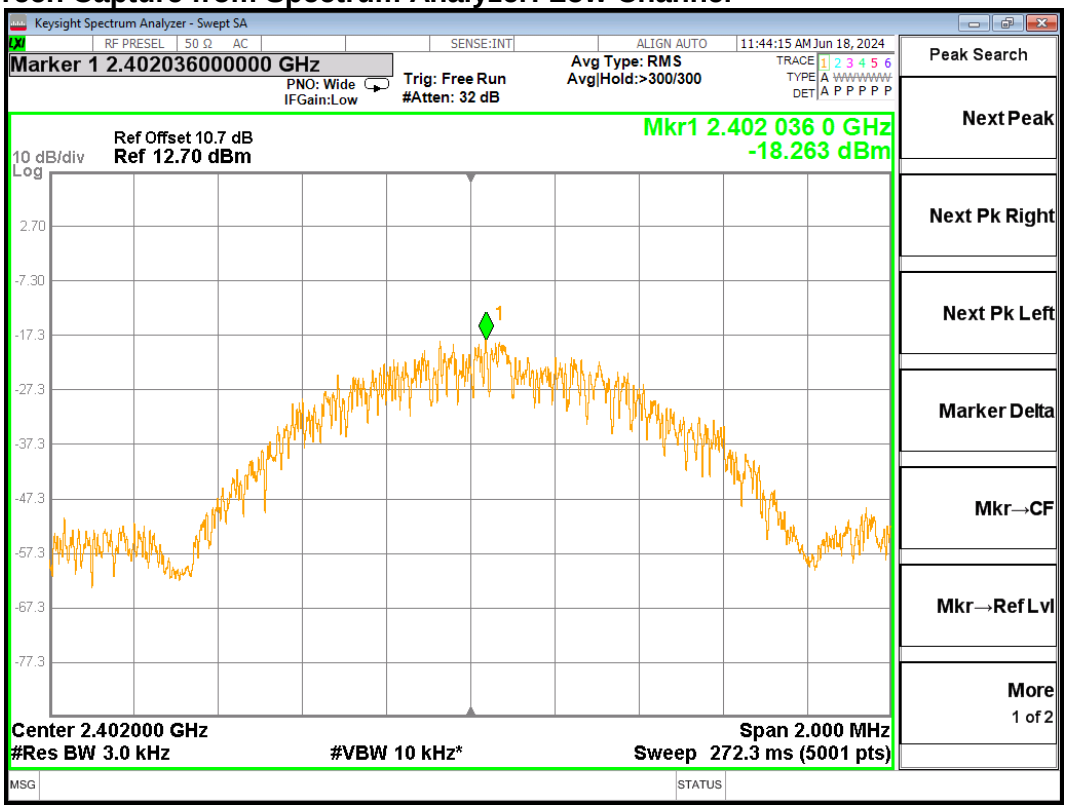
Conducted:



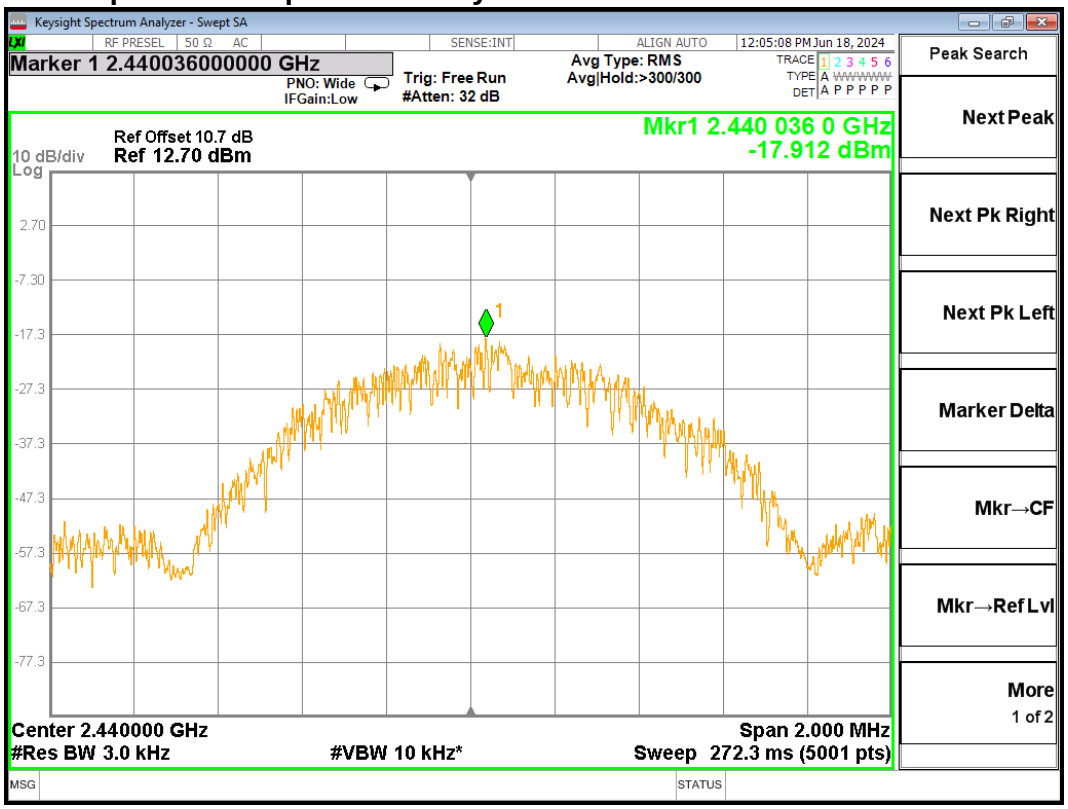
2.5.5 Average PSD Data

Mode	Channel	Frequency (MHz)	Average PSD (dBm)	Limit
BLE	Low	2402	-18.263	≤ 8 / 3KHz
	Mid	2440	-17.912	
	High	2480	-18.403	

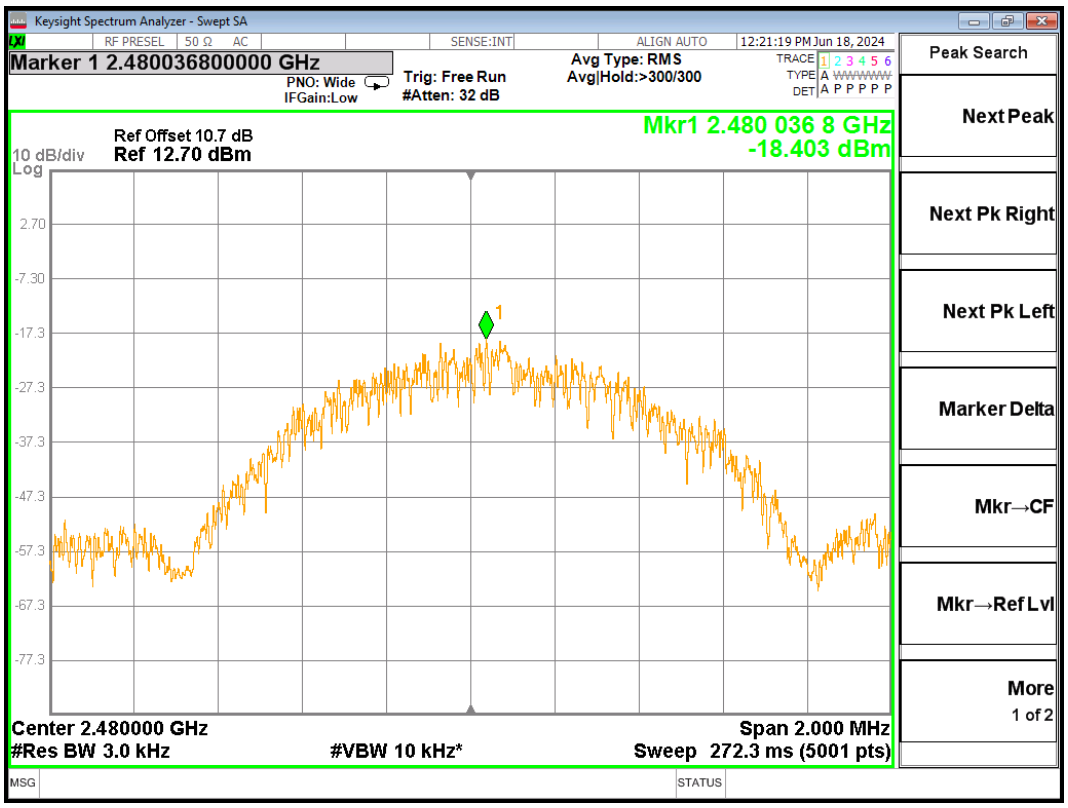
Screen Capture from Spectrum Analyzer: Low Channel



Screen Capture from Spectrum Analyzer: MID Channel



Screen Capture from Spectrum Analyzer: High Channel



2.6 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: 2024-06-18 (21.7°C, 16% RH)	**Basic Standard: ANSI C63.4-2014** **FCC OET KDB 558470 v04 DTS**

EUT status: Compliant

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.

2.6.1 Test Guidance: ANSI C63.10-2013, Clause 6.7

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.
The spectrum analyzer is stepped through the spectrum in frequency spans selected to ensure acceptable frequency resolution. The RBW is set to 100 kHz. The VBW is set to ≥ 300 kHz. The Peak detector is used, with the trace set to Max Hold.

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:

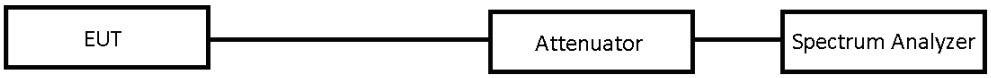
Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EMI receiver	Agilent	N9038A (FW A.25.05)	6130	2023-08-11	2024-08-11
Temp/Humidity	Extech	42270	5871	2024-04-08	2025-04-08
Attenuator	PCB	BWS102W263	6932	2022-12-10	2025-12-10
Coaxial Cables (RF)	W.L. GORE	PGR01R01036	-	Cal. before each use	
DC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

2.6.4 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:



2.6.65 Conducted Spurious Emissions Data (Non Restricted Band):

Low Channel

MID Channel


Integration BW 1.0209 MHz
Ref 30.60 dBm
Center 2.4400000 GHz
Res BW 15 kHz
VBW 150 kHz
Span 1.531 MHz
Sweep 8.133 ms
Channel Power
-0.27 dBm / 1.021 MHz
Power Spectral Density
-60.36 dBm /Hz
Ref Offset 10.40 dB
PASS
95.011 kHz
-51.052 dBm
Start 30 kHz
Stop 30 MHz
FFT
Start Limit -30.27 dBm
876.69 MHz
-56.630 dBm
Start 30 MHz
Stop 1 GHz
Ref Offset 11.00 dB
FAIL
2.4400 GHz
-1.2587 dBm
FAIL (F) correspond to
Fundamental Tx:2440 MHz
Start 1 GHz
Stop 10 GHz
Ref Offset 12.20 dB
16.296 GHz
-44.417 dBm
Start 10 GHz
Stop 18 GHz
Start Limit -30.27 dBm
25.880 GHz
-35.899 dBm
Start 18 GHz
Stop 26 GHz

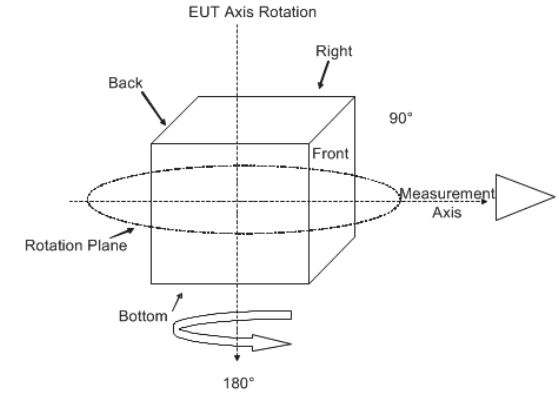
High Channel

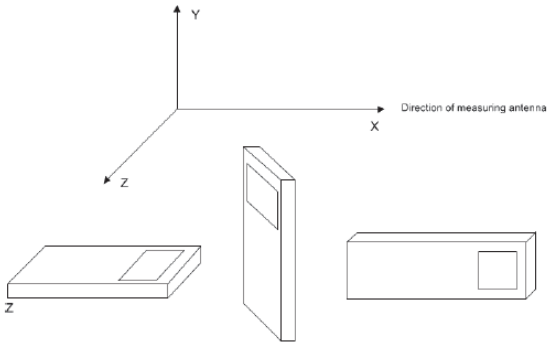
2.7 EUT Positioning Assessment

Test Lab: Electronics Test Centre, Airdrie	**EUT: Quantum Dual Band HyperQ Node**
Test Personnel:	**Standard: FCC PART 15.247**
Date:	**Basic Standard: ANSI C63.4-2014**
Comments: 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.





2.8 Radiated Spurious Emissions (within restricted band)

Test Lab: Electronics Test Centre, Airdrie

Test Personnel: Janet Mijares/Brendan Van Hee

Date: 2024-06-(19/15/18) (21.6° C,17.5 % RH)

EUT: Quantum Dual Band HyperQ Node

Standard: FCC PART 15.247/15.209

Basic Standard: ANSI C63.10-2013

EUT status: Compliant

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	12.290000 - 12.293000	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 – 1240.0000 ***	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

2.8.1 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 discreet 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.

2.8.2 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 (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
EMC Software	UL	Ver. 9.5	SW021	N/A	
EMI receiver	Agilent	N9038A (FW A.25.05)	6130	2023-08-11	2024-08-11
Loop Antenna (9KHz – 30MHz)	EMCO	6502	10868	2023-06-21	2025-06-21
Biconilog Antenna (30 – 1000 MHz)	AR	JB1	6905	2023-11-29	2025-11-29
DRG Horn (1 – 18 GHz)	EMCO	3115	19357	2022-10-05	2024-10-05
STD Horn (18-26 GHz)	Quinstar	QWH-KRPS00	6163	2022-10-10	2025-10-10
Humidity/Temp Logger	Extech Ins. Corp.	42270	5892	2024-04-08	2025-04-08
Pre-Amplifier (30 – 1400 MHz)	HP	8447D	9291	*2024-01-23	2025-01-23
L.N. Amplifier (1 – 18 GHz)	MITEQ	JS43-01001800-21-5P	4354	*2024-01-23	2025-01-23
L.N. Amplifier (18 – 26 GHz)	MITEQ	JS44-01002650-33-3P	6163	*2024-01-23	2025-01-23
RE Cable below 1GHz	Insulated Wire Inc.	KPS-1501A-3600-KPA-01102006	4419	*2024-01-23	2025-01-23
Re Cable Above 1 GHz	A.H. System Inc.	SAC-26G-8.23	6187	*2024-01-23	2025-01-23
0.9GHz Notch Filter	Microtronics	BRM20784	6947	*2024-01-23	2025-01-23

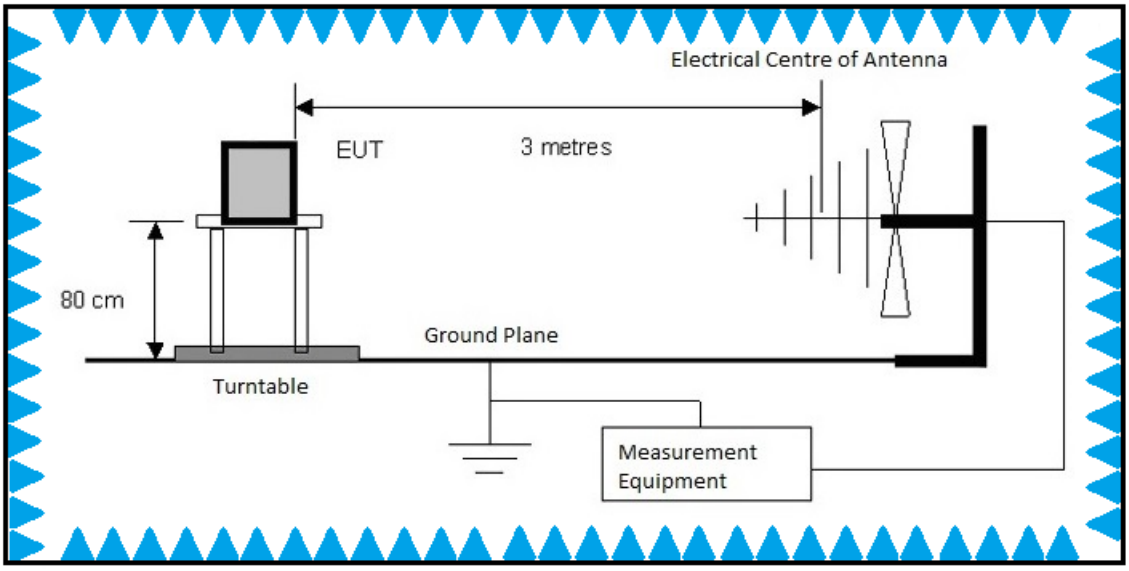
***** In-house verification

2.8.4 Test Sample Verification, Configuration & Modifications

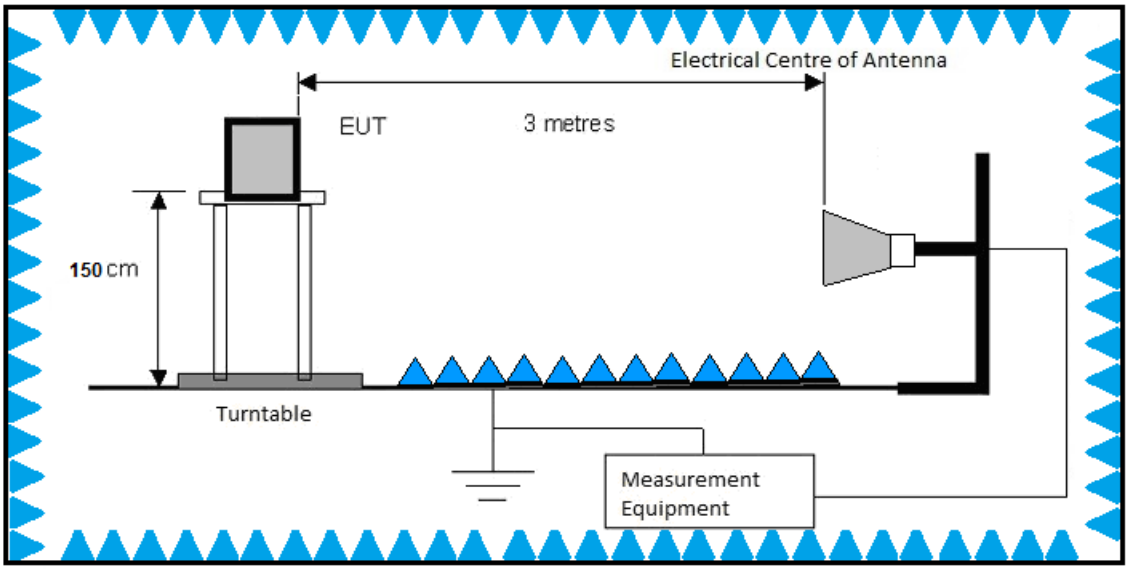
The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation. LoRa radio is transmitting at mid channel in ingle carrier configuration and high channel in dual carrier configurations.

The EUT met the requirements without modification.

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



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



2.8.5 Radiated Emissions Data: (LoRa & BLE 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 after the height and azimuth have been adjusted for maximum emission.
- Preliminary scans were performed for all channels in Transmit modes. The high band channel 2480 MHz was selected as the worst-case condition for detailed examination.
- In Transmit mode, the EUT was assessed up to 26.0 GHz.

Negative values for Delta indicate compliance.

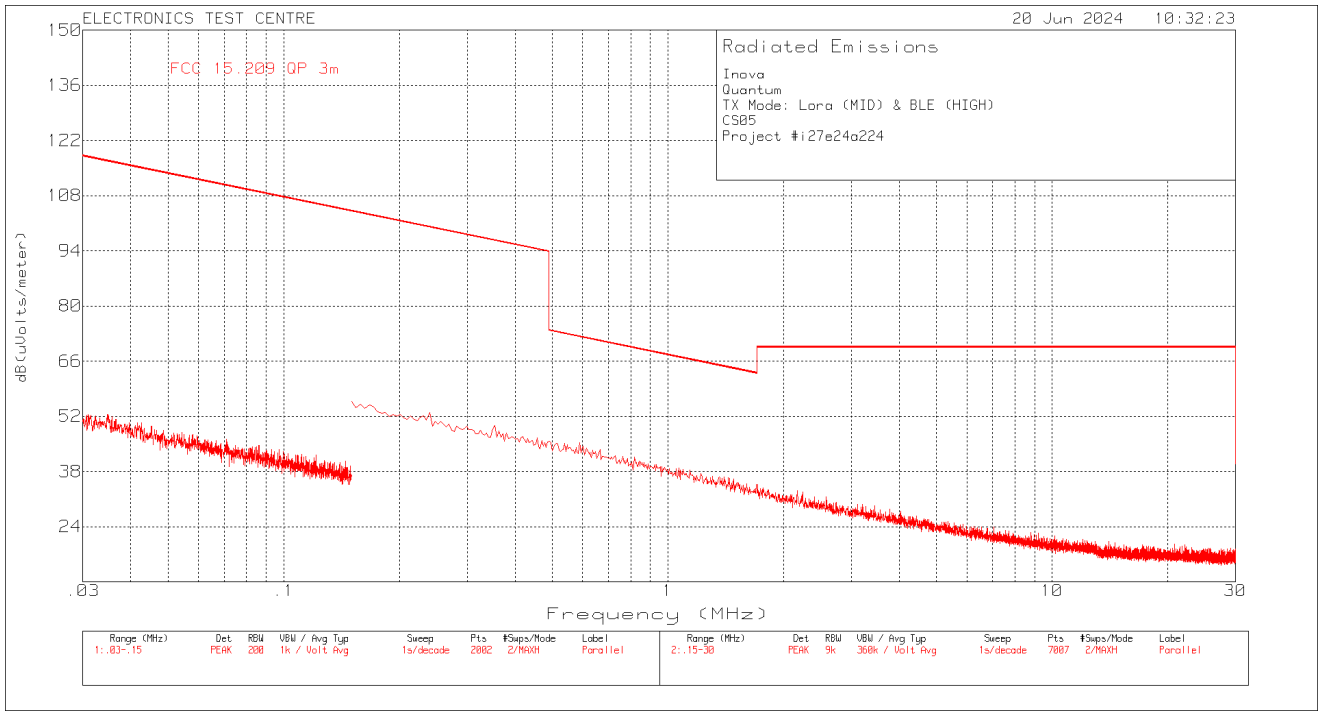
Freq. Marker	Freq. [GHz]	Raw reading[dBµv]	Det	Antenna Factor [dB/m]	Pre amp Gain [dB]	Corrected Reading [dBµv/m]	FCC 15.209 Limit [dBµv/m]	Delta [dB]	Azimuth [Deg]	Height [cm]	Polarization
1	0.10371	19.25	QP	16.1	-23.6	11.75	43.53	-31.78	125	156	Vertical
2	0.70263	20.05	QP	24.3	-19.1	25.25	46.03	-20.78	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
11	*12.40	33.25	PK	39.3	-21.4	51.15	74	-22.85	179	362	Horizontal
11	*12.40	20.42	AV	39.3	-21.4	38.32	54	-15.68	179	362	Horizontal
12	14.55	28.29	PK	42.5	-20.8	49.99	> 20dBc	48.85dBc	219	355	Horizontal
13	*17.92	25.2	PK	46.8	-16.3	55.7	74	-18.3	5	163	Horizontal
13	*17.92	13.0	AV	46.8	-16.3	43.5	54	-10.5	5	163	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

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
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
23	*12.40	34.24	PK	39.3	-21.4	52.14	74	-21.86	224	284	Vertical
23	*12.40	21.6	AV	39.3	-21.4	39.5	54	-14.5	224	284	Vertical
24	14.53	28.25	PK	42.5	-20.8	49.95	> 20dBc	41.95dBc	14	359	Vertical
25	*17.72	25.58	PK	45.1	-16.5	54.18	74	-19.82	353	368	Vertical
25	*17.72	12.82	AV	45.1	-16.5	41.42	54	-12.58	353	368	Vertical

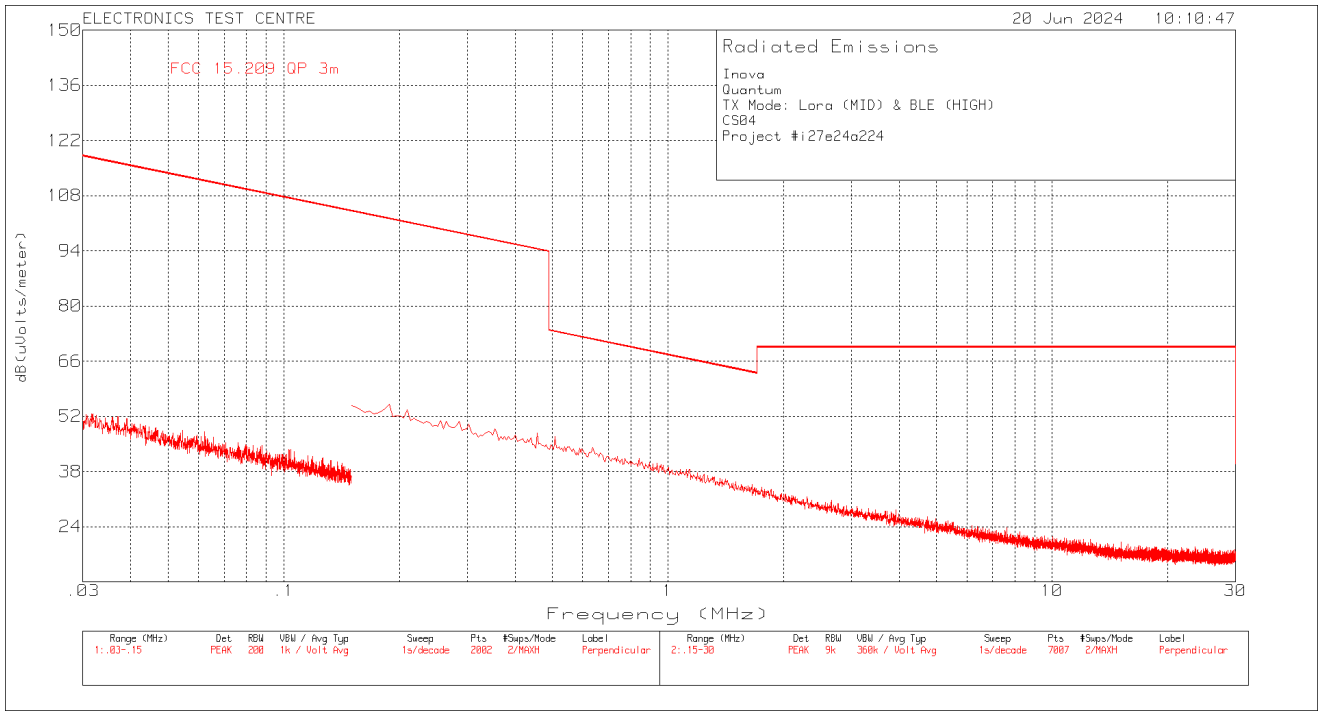
QP: Quasi-Peak Detector**, PK:** Peak Detector**, AV:** Average Detector,

*** Spurious Emission in Restricted Band**

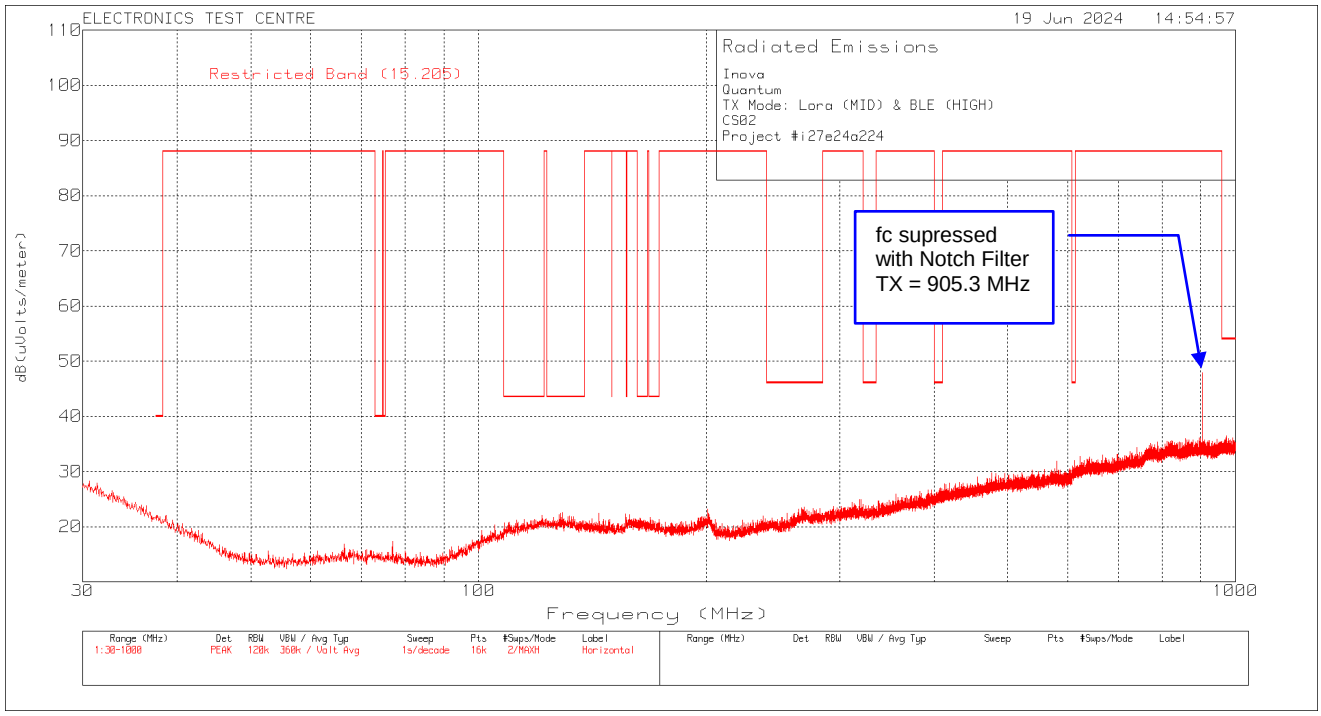
Plot of Radiated Emissions: Parallel



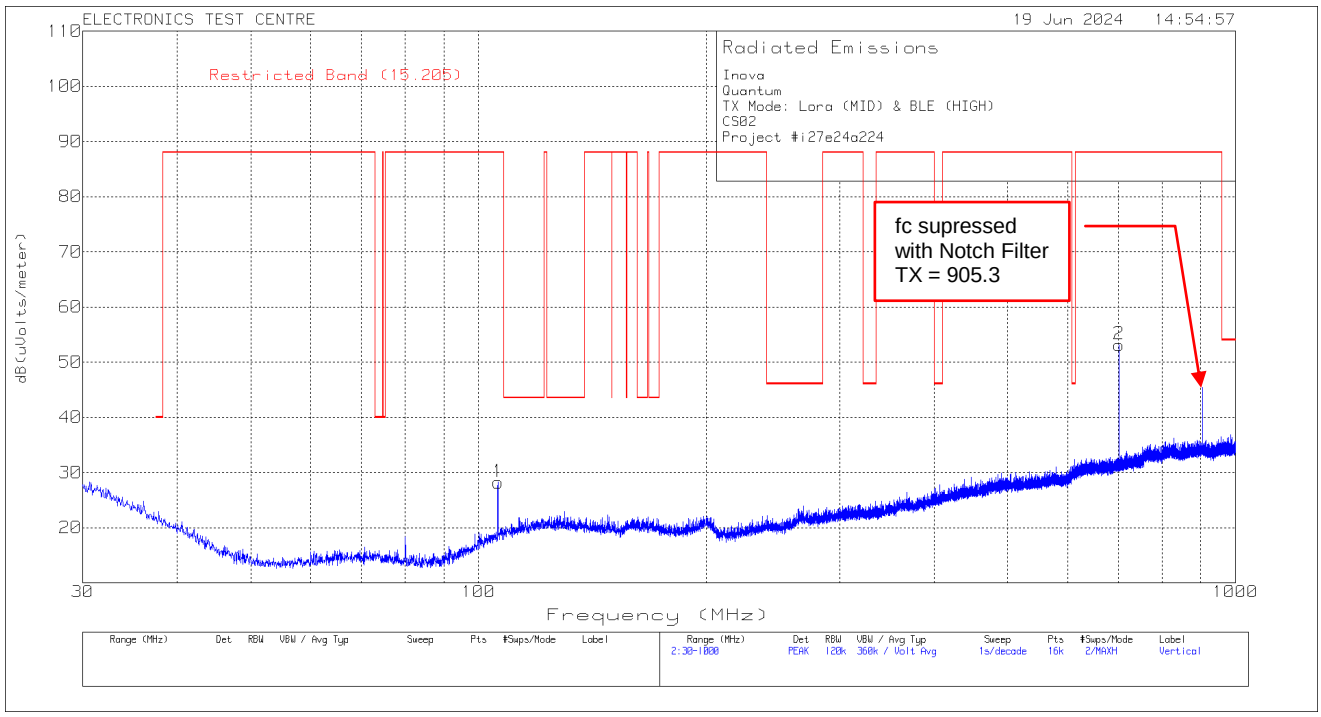
Plot of Radiated Emissions: Perpendicular



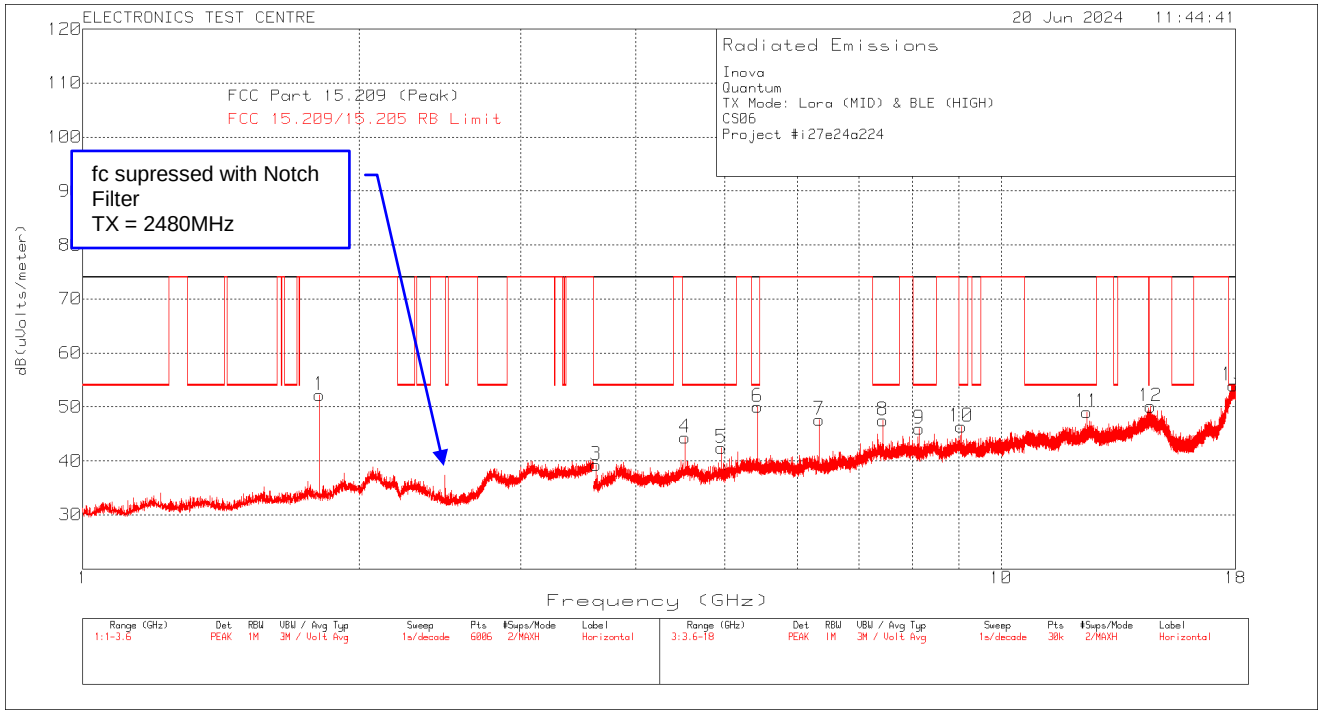
Plot of Radiated Emissions: Horizontal polarization



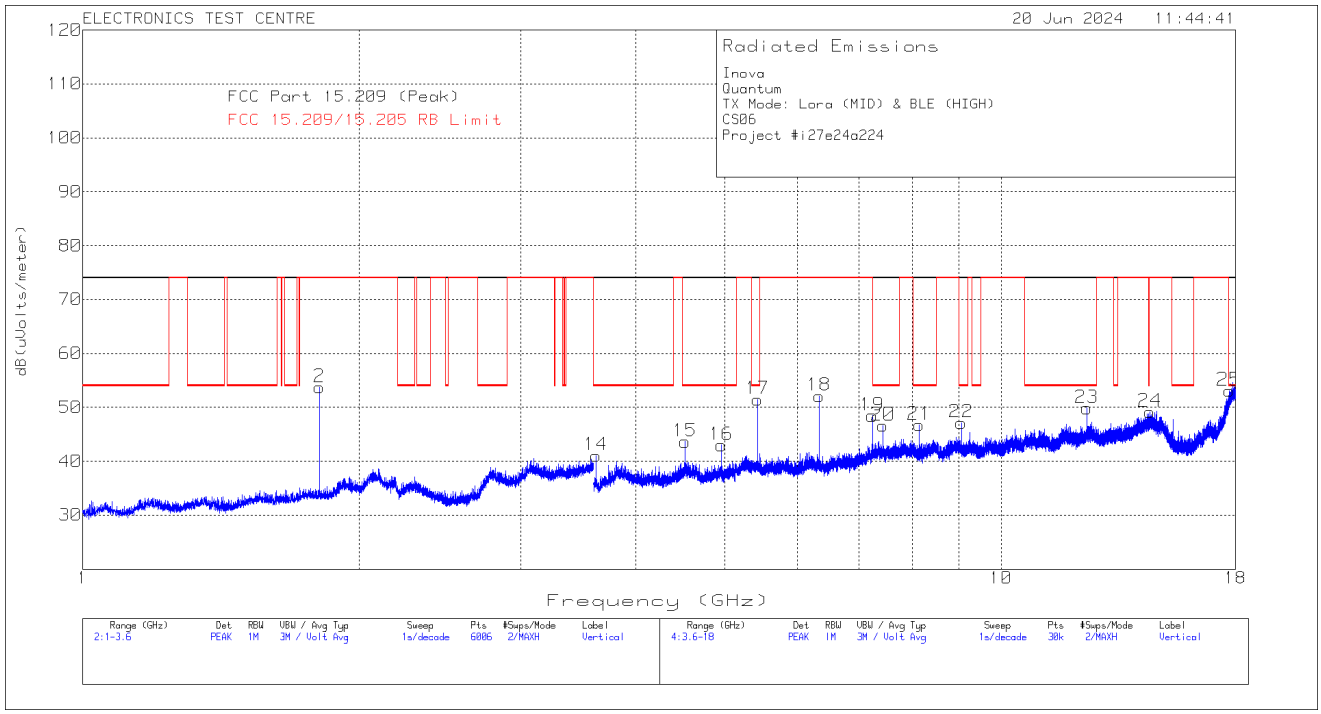
Plot of Radiated Emissions: Vertical polarization



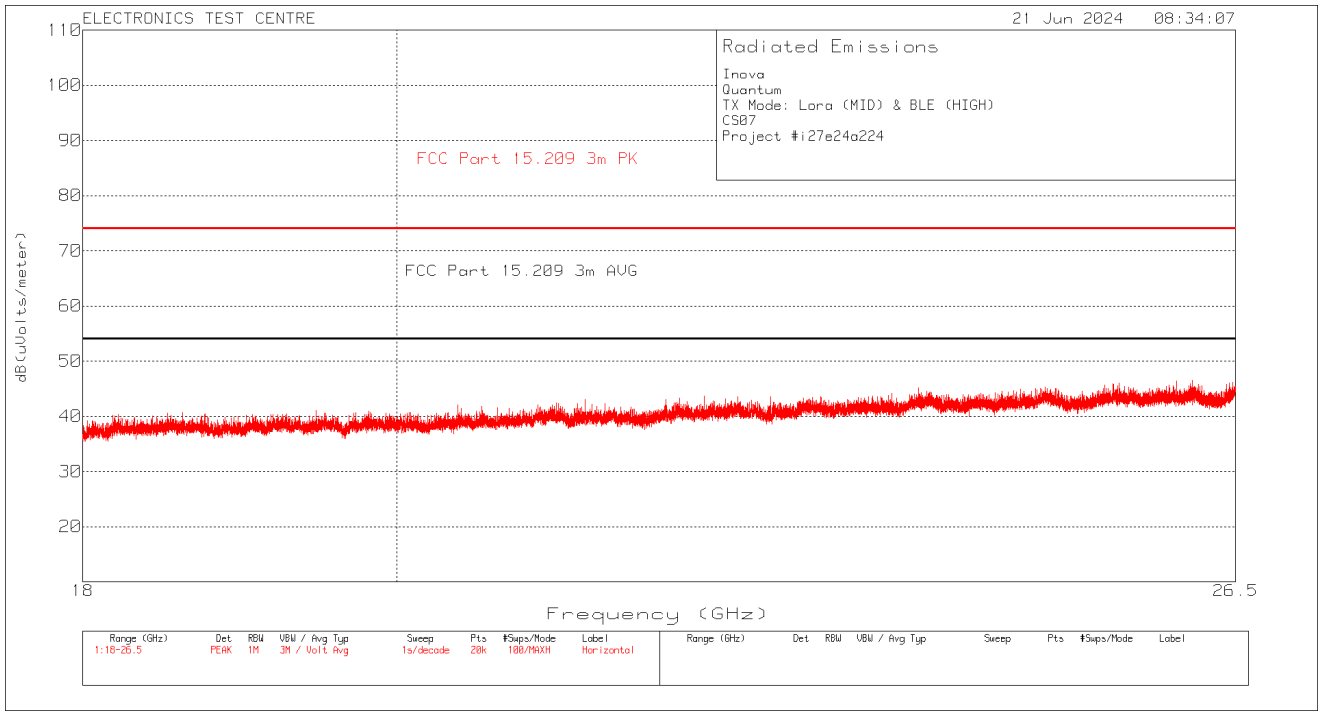
Plot of Radiated Emissions: Horizontal polarization



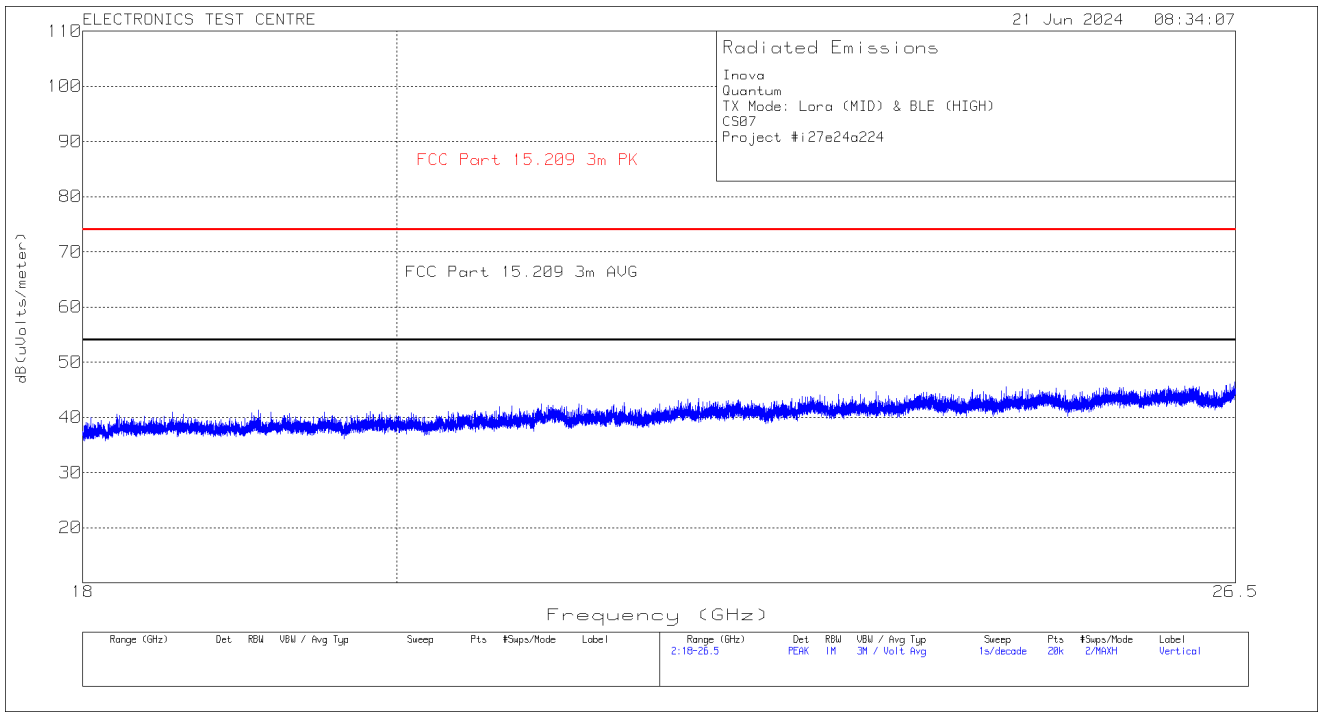
Plot of Radiated Emissions: Vertical polarization



Plot of Radiated Emissions: Horizontal polarization



Plot of Radiated Emissions: Vertical polarization



2.9 Radiated Emissions (RX Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: Quantum Dual Band HyperQ Node**
Test Personnel: Janet Mijares/Brendan Van Hee	**Standard: FCC Part 15.109**
Date: 2024-06-(19/20/21) (21.0° C,15.2 % RH)	**Basic Standard: ANSI C63.4: 2014**
	Class: A

EUT status: Compliant

Frequency (MHz)	FCC Part 15.109 Class A Limit (3m)
30 – 88	50 (dBµV/m)
88 – 216	53.52 (dBµV/m)
216 – 960	56.44 (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.

2.9.1 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.

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

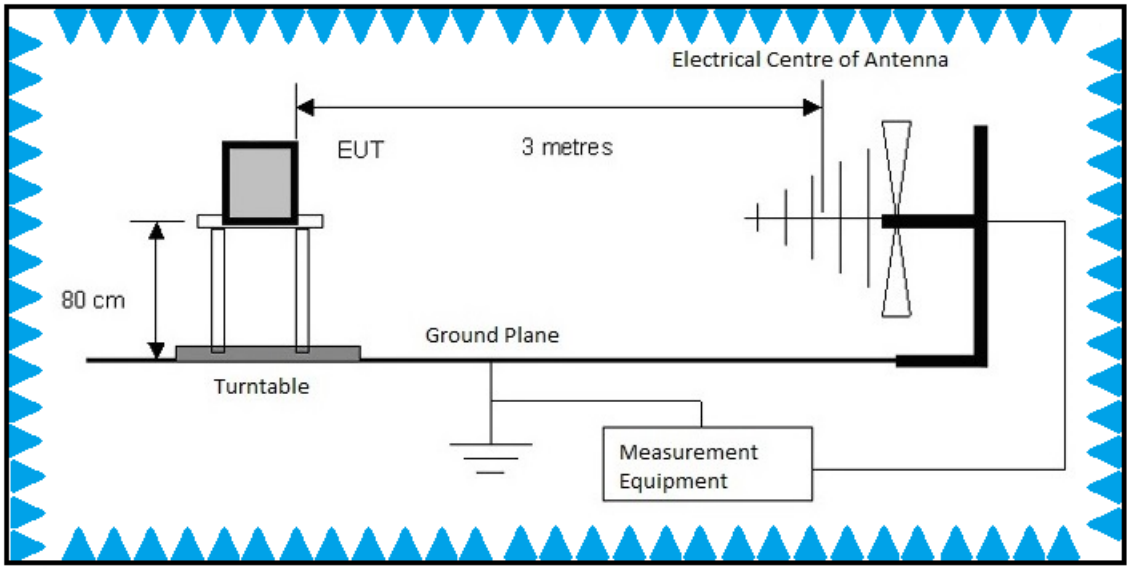
***** In-house verification.

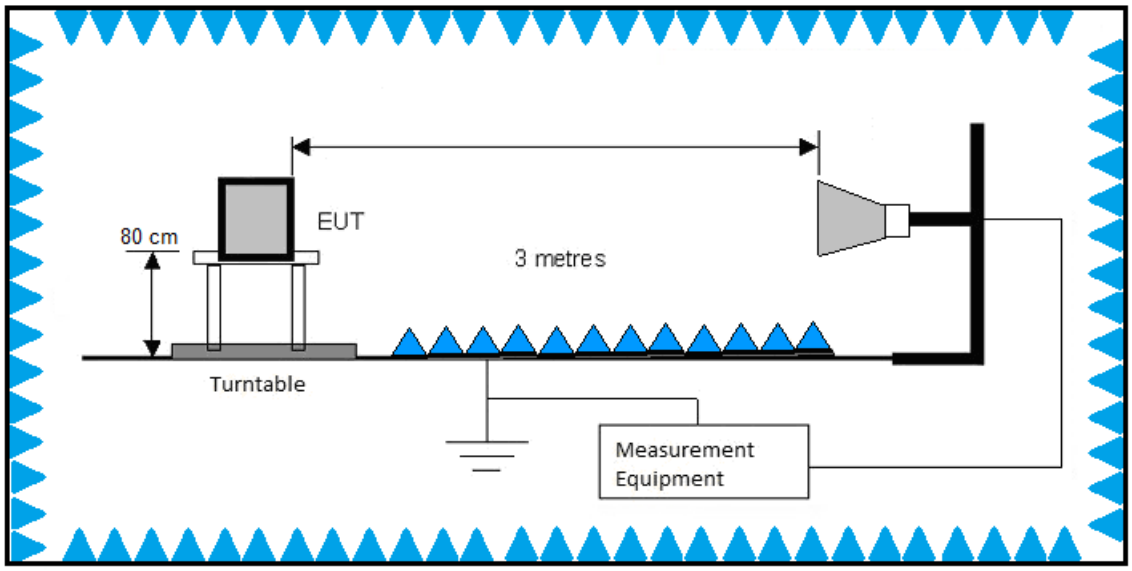
2.9.4 Test Sample Verification, Configuration & Modifications

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. Power cable is soldered to the battery terminal to connect the DC power supply during radiated emission.

EUT RX configuration Block Diagram for Radiated Emissions testing:





2.9.5 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:

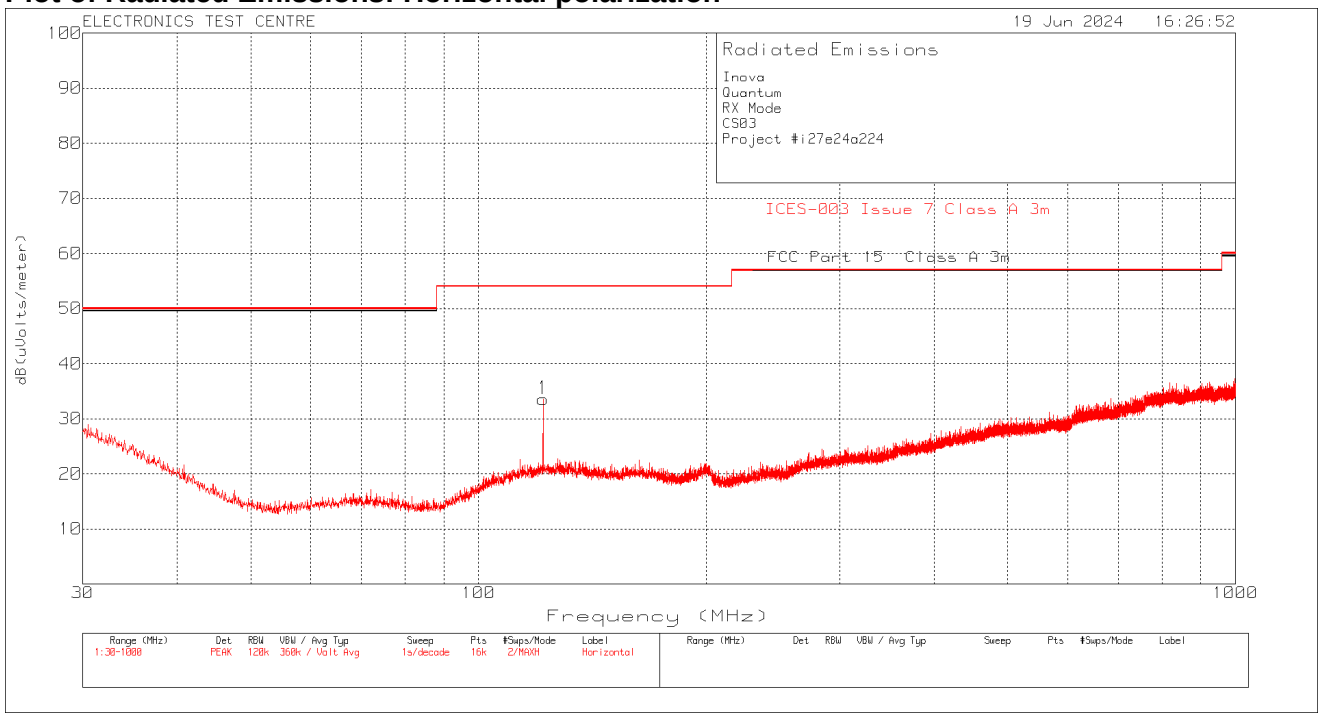
When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss. Measurements reported are the result of adjusting the turntable azimuth and antenna height to obtain the maximum EUT emission. This may produce a different reading than the plot trace. The plot is 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.

Negative values for Delta indicate compliance.

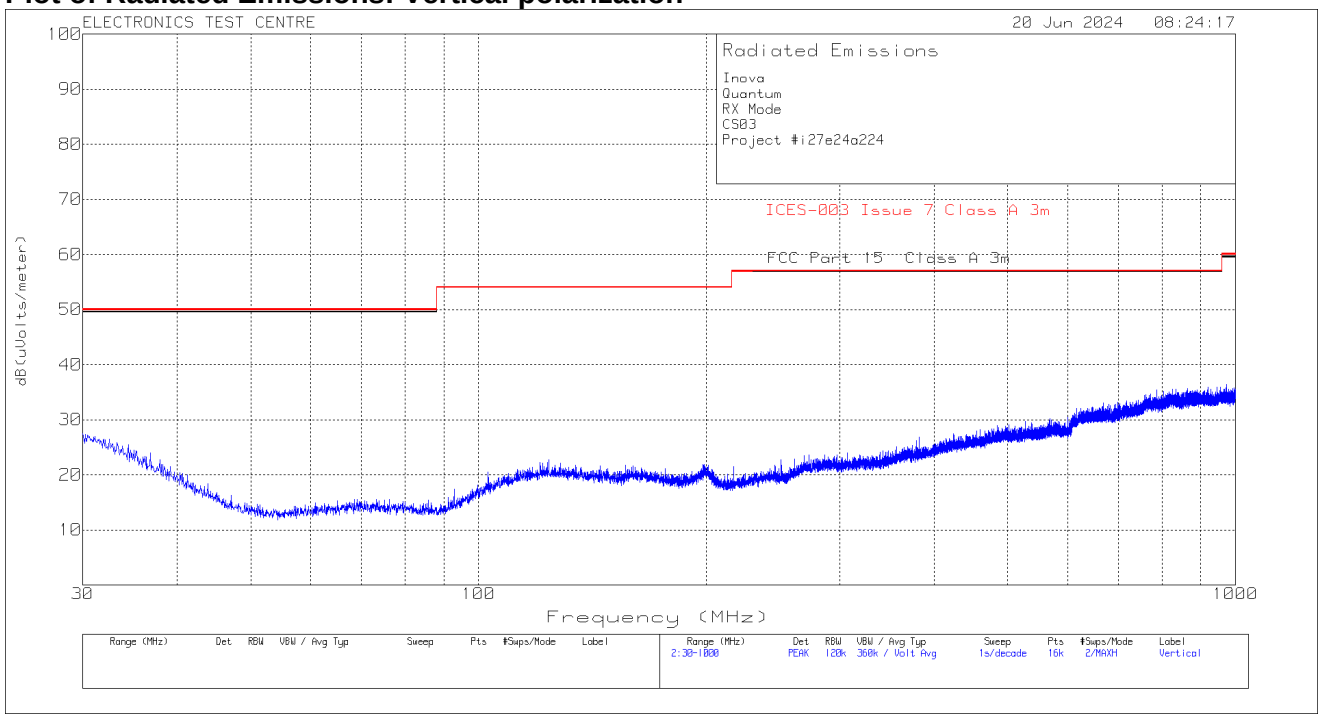
Freq. Marker	Freq. [GHz]	Raw reading[dBµv]	Det	Antenna Factor [dB/m]	Pre amp Gain [dB]	Corrected Reading [dBµv/m]	FCC Class A Limit [dBµv/m]	Delta [dB]	Azimuth [Deg]	Height [cm]	Polarization
1	0.1211	18.51	QP	17.9	-23.4	13.01	53.98	-40.97	308	127	Horizontal
1	2.4011	26.46	AV	28.5	-33.4	21.56	60	-38.44	231	282	Vertical

QP: Quasi- Peak Detector
PK: Peak Detector
AV: Average Detector

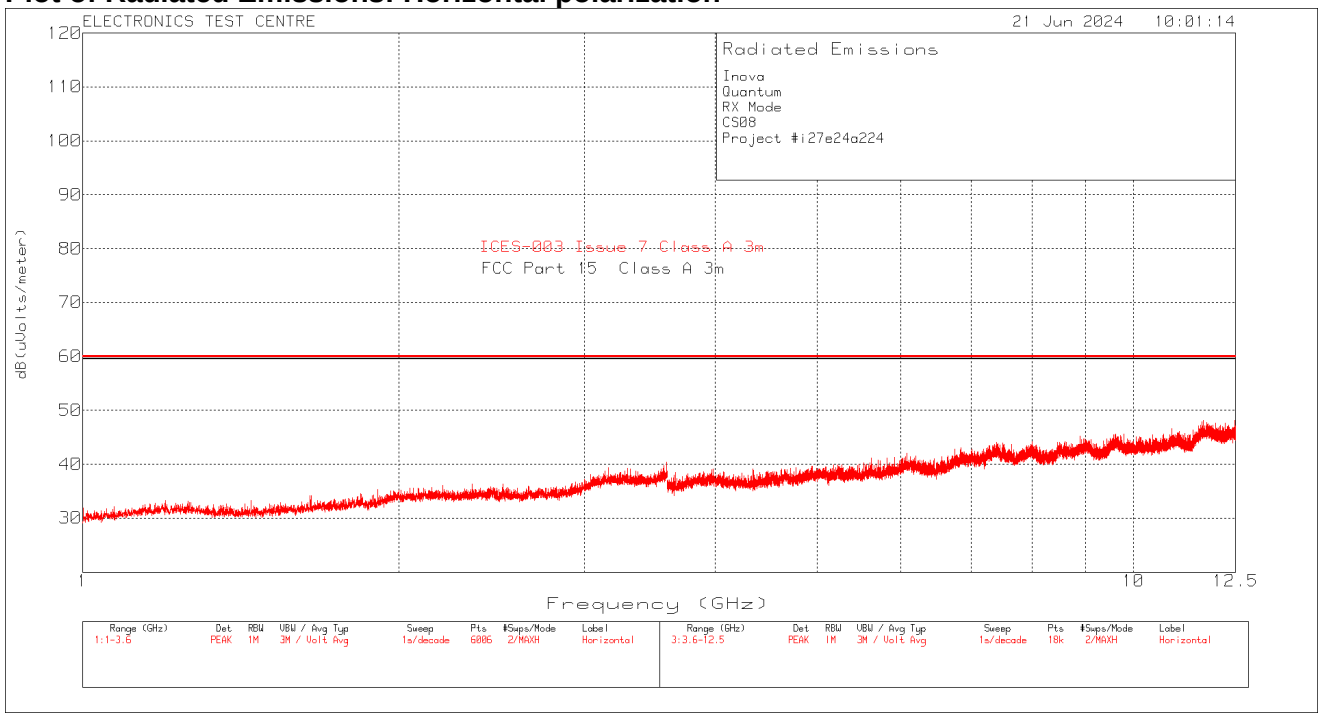
Plot of Radiated Emissions: Horizontal polarization



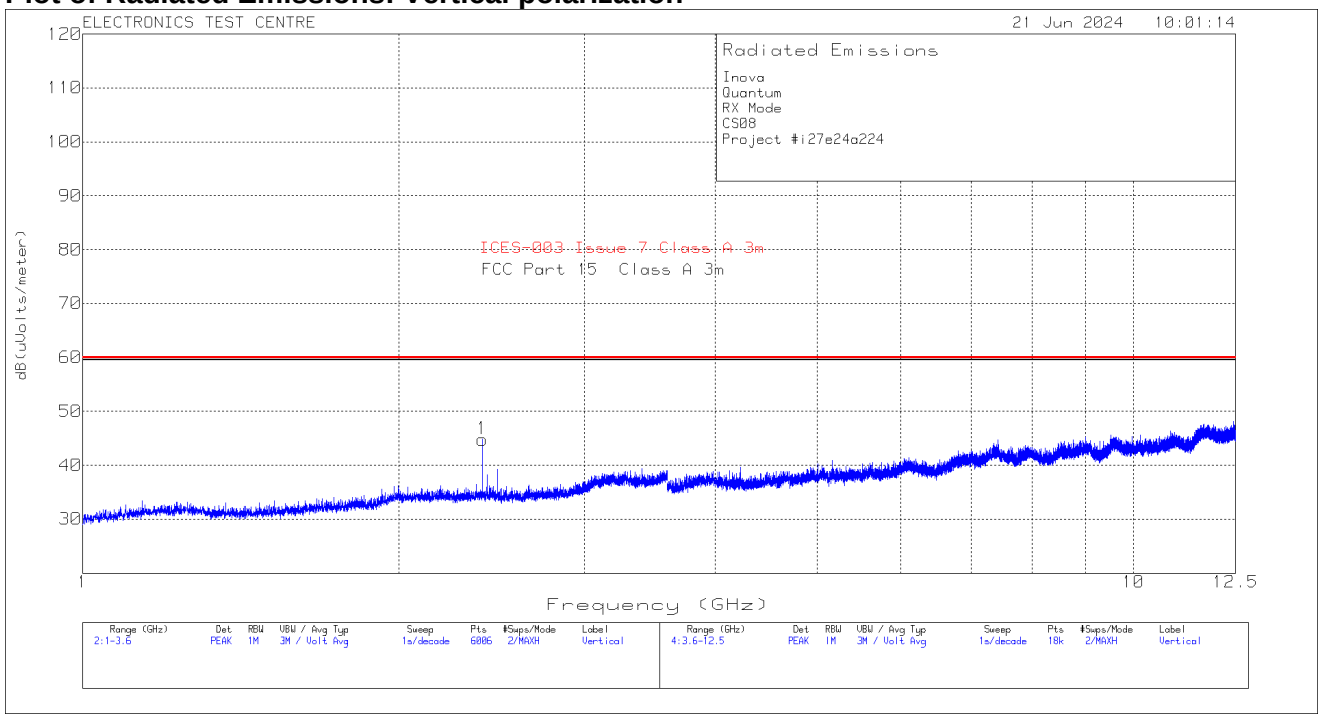
Plot of Radiated Emissions: Vertical polarization



Plot of Radiated Emissions: Horizontal polarization



Plot of Radiated Emissions: Vertical polarization



2.10 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.

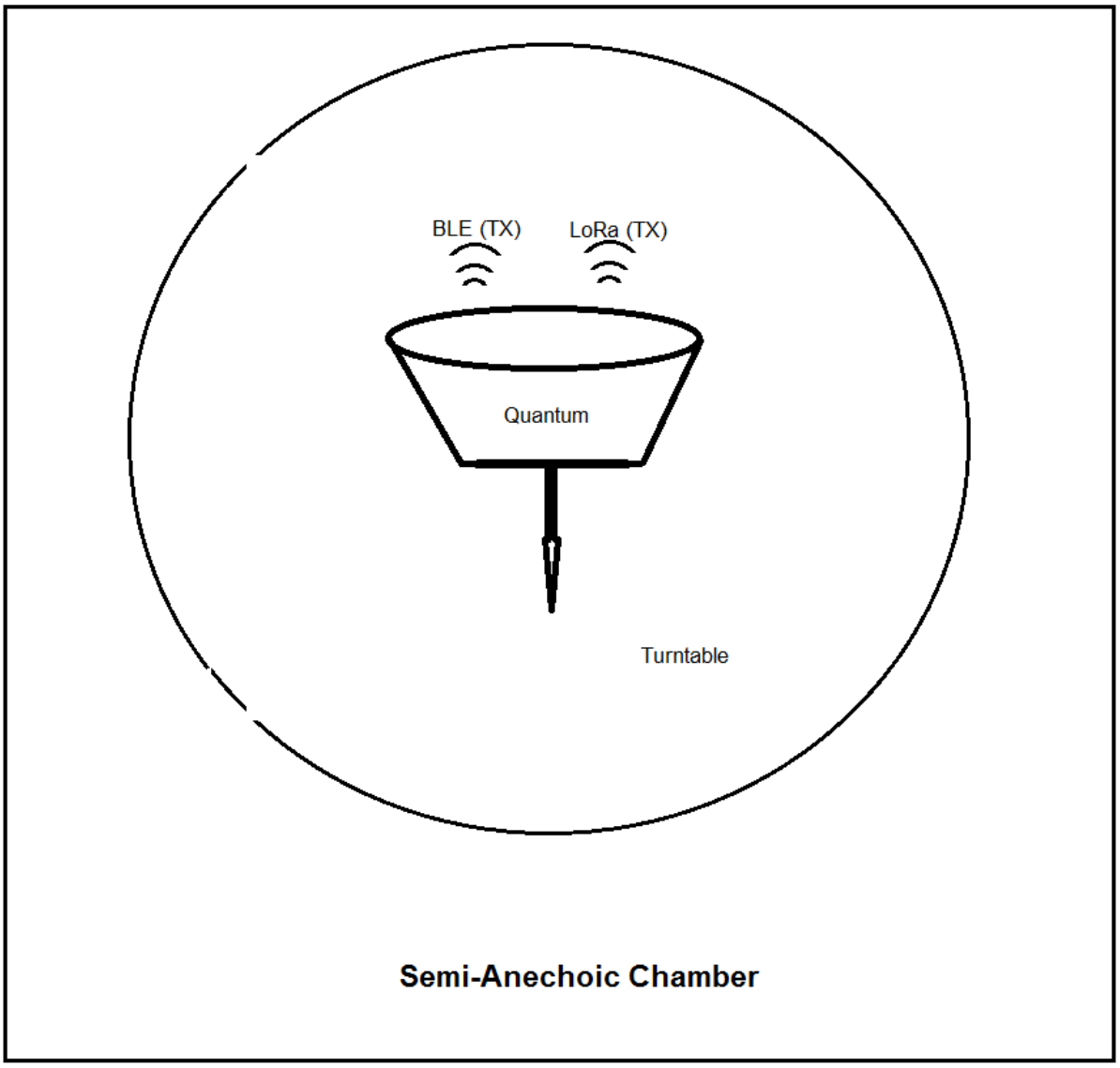
3.2 Grounding Plan

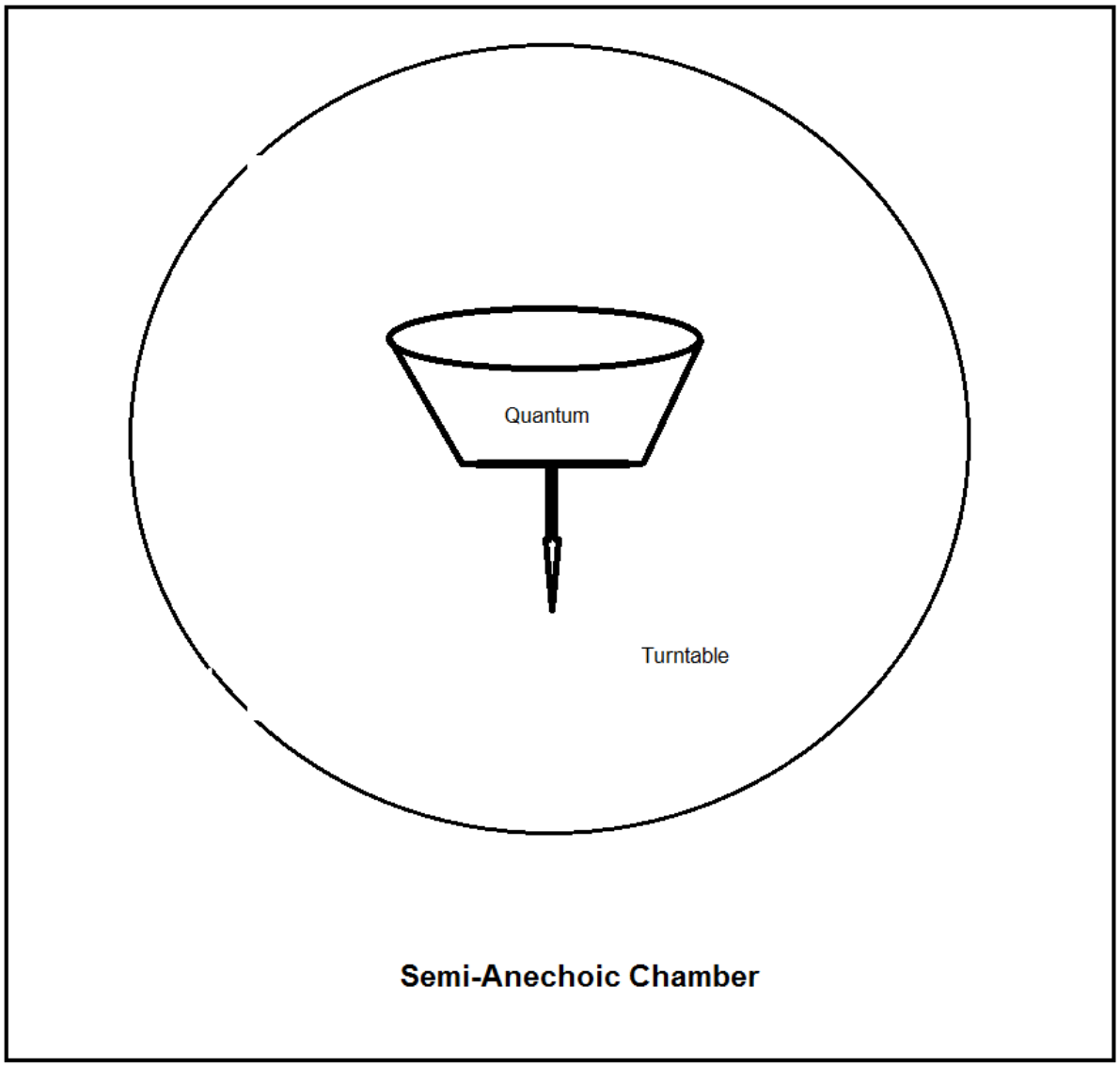
The Quantum Dual Band HyperQ Node was placed at the center of the test chamber turntable on top of an 80-cm high polystyrene foam table below 1GHz and at 1.5m high polystyrene foam table above 1 GHz for transmits mode and 80cm high for RX mode. No provision is made within the Quantum Dual Band HyperQ Node for an earth ground connection.

3.3 Power Supply

Power supplied via internal rechargeable Li-ion battery 7.2V 6.7Ah 48.24Wh pack.

Appendix A – Test Setup Block Diagram




Quantum
Turntable
Semi-Anechoic Chamber

End of Document