Test Report Prepared By:

Electronics Test Centre
27 East Lake Hill
Airdrie, Alberta
Canada
T4A 2K3

sales@etc-mpbtech.com
http://www.etc-mpb.com

Telephone: 1-403-912-0037

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EMC testing of the INOVA Systems 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 Systems Corporation**

1769-120 Avenue NE
Calgary, Alberta
Canada
T3K 0S5

Telephone: 1-403-537-2134

Imran Akram
iakram@etc-mpbtech.com
EMC Technologist
Electronics Test Centre (Airdrie)

Marc Rousseau
marc.rousseau@mpbc.ca
QA Manager
Electronics Test Centre (Airdrie)

REVISION RECORD

ISSUE	DATE	AUTHOR	REVISIONS
DRAFT 1	2024-06-20	I. Akram	Initial draft submitted for review.
DRAFT 1	2024-09-06	I. Akram	Updated the FCC ID number
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 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:

Product Name:		Quantum Dual Band HyperQ Node
LoRa Radio	**Frequency Band**	902 – 928 MHz
	Frequency Range	902.3 – 908.5 MHz
	Mode of Operation	Hybrid 125KHz
	Max Transmit Power (Conducted)	17.4 dBm (0.055 W)
Associated LoRa Antennas		NIC Component Corporation MAN-F series Max Gain = -3.0dBi
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 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 (Internal Battery)**
2.3	Occupied Bandwidth	15.247(a)(1) 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) 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** (Fix Position)
2.11	Radiated Spurious Emission (Restricted Band)	15.205, 15.209 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** **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 ≥ 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*log (1/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 ≥ 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.

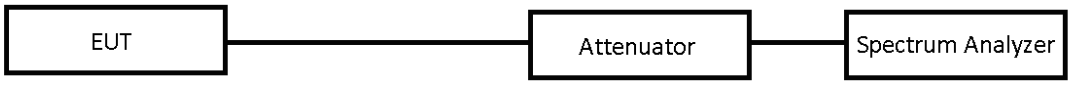
2.1.2 Test Equipment

Testing was performed with the following equipment:

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

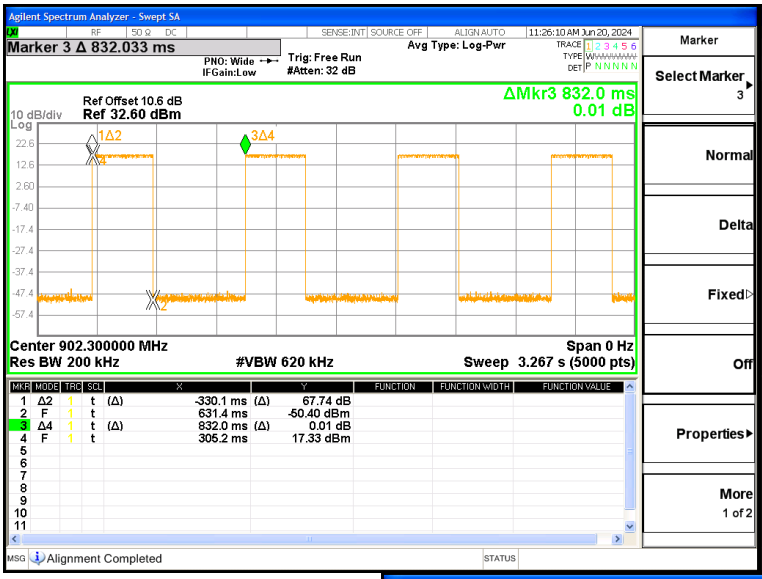
Test setup diagrams for Power testing:

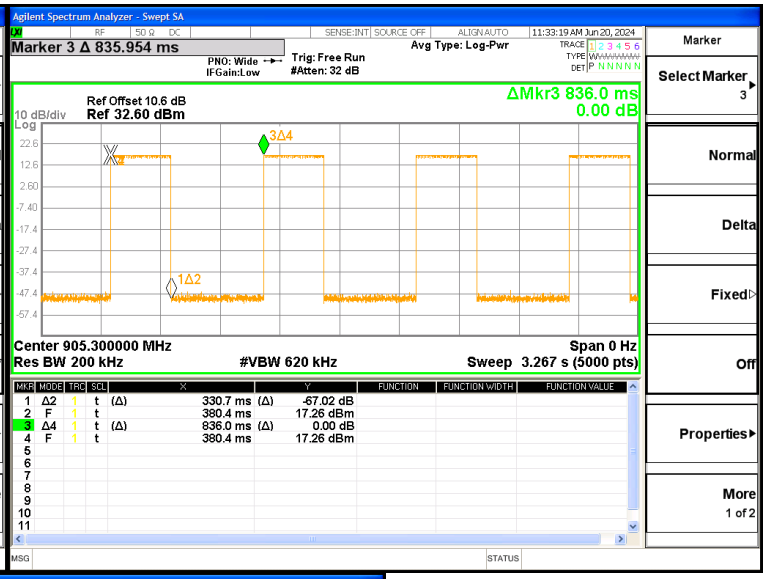
Conducted:

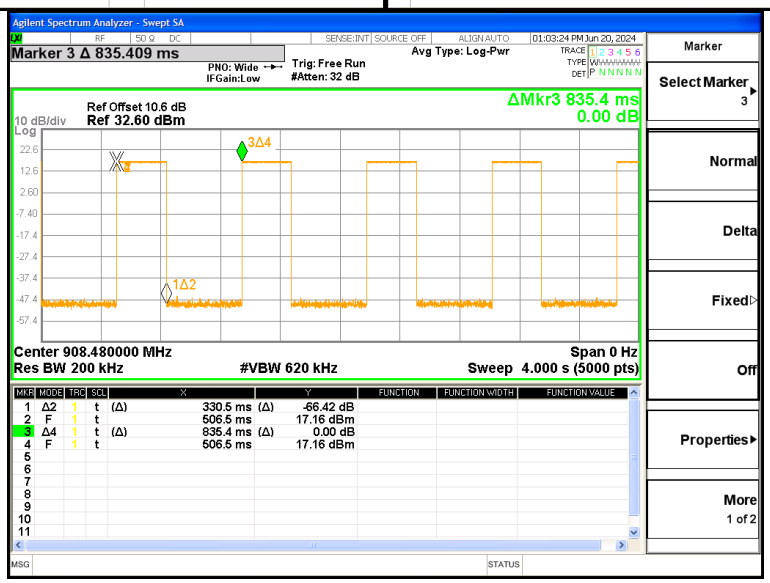


2.1.3 Duty Cycle

Channel	On time (ms)	Period (ms)	Duty Cycle DC= (on time/period) x100 (%)	Duty Factor 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** **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.	

2.3 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** **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 (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	

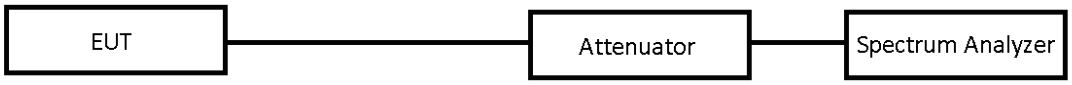
2.3.4 Test Sample Verification, Configuration & Modifications

The EUT was set to 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:

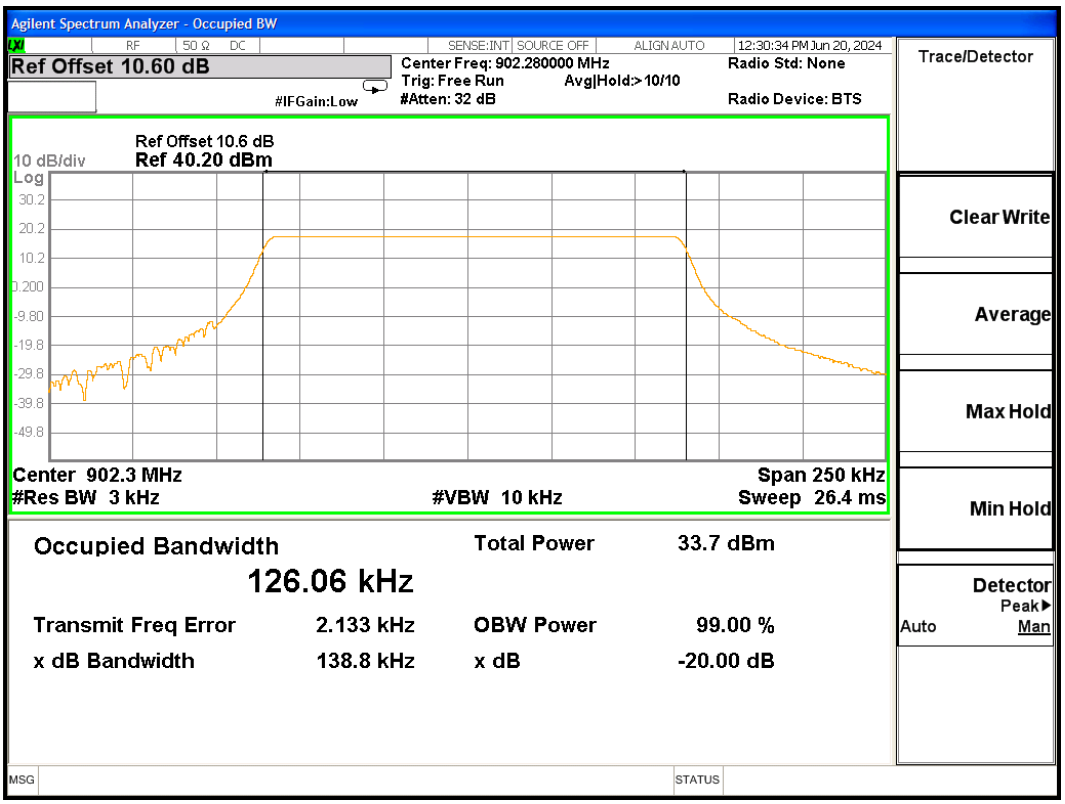


2.3.5 Channel Occupied Bandwidth Data:

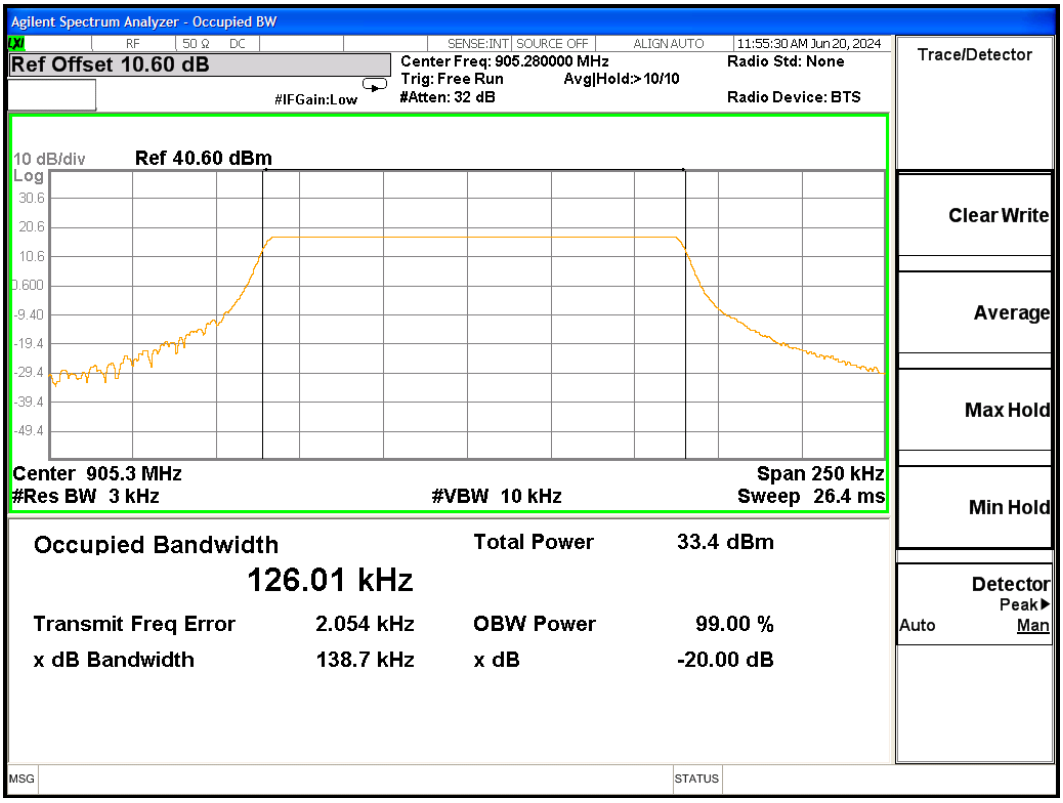
Mode of operation	Channel	Freq. [MHz]	Occupied BW [kHz]	20 dB BW [kHz]	Limit 20dB BW [KHz]
125KHz Hybrid	Low	902.3	126.06	138.8	≤ 500
	Mid	905.3	126.01	138.7	
	High	914.9	126.05	138.9	

Hybrid (125 KHz) Mode

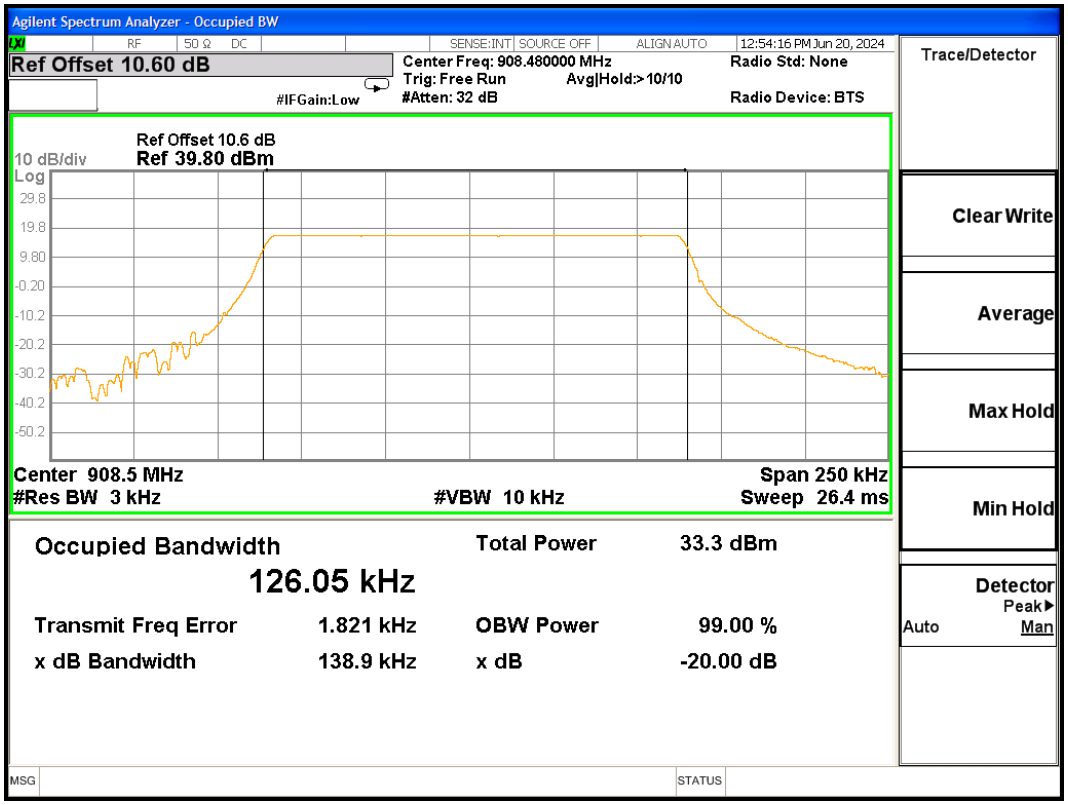
Screen Captures from the spectrum analyzer: Low Channel



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** **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	≥ 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 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 (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	

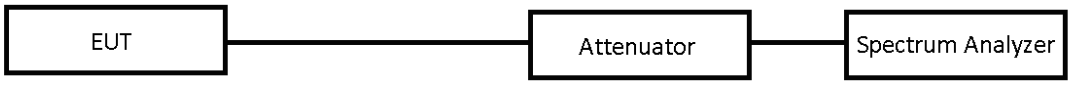
2.4.4 Test Sample Verification, Configuration & Modifications

The EUT was set to 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:

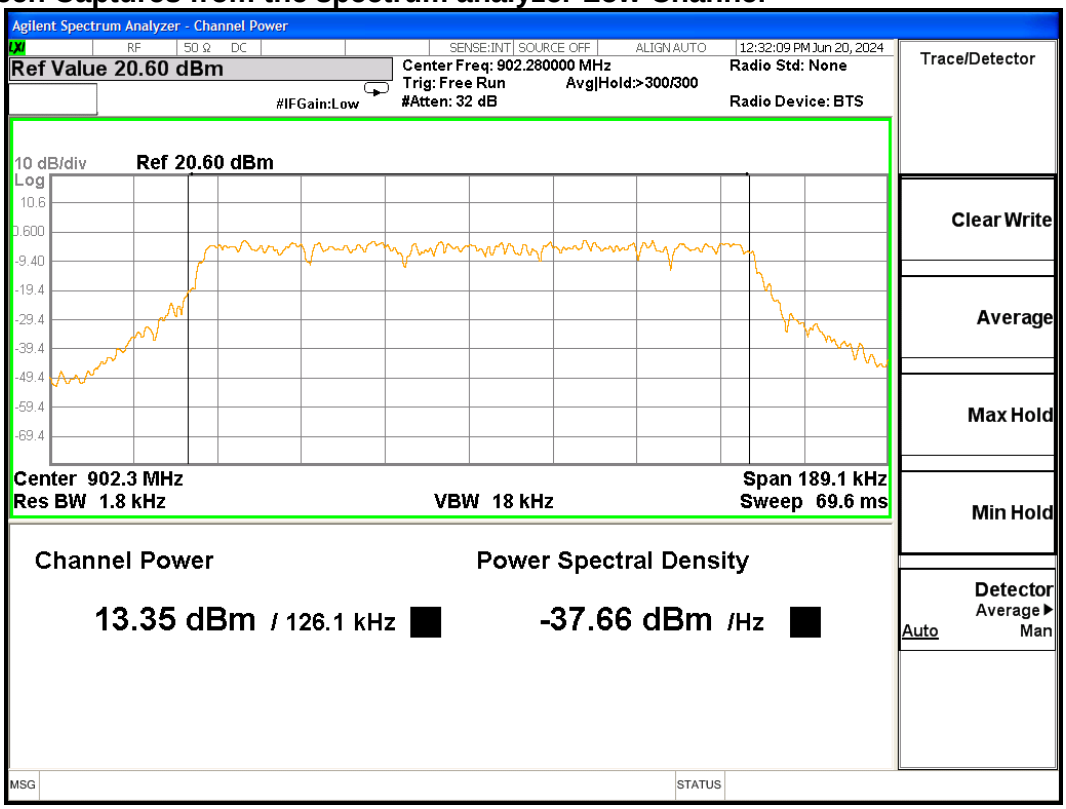
Conducted:



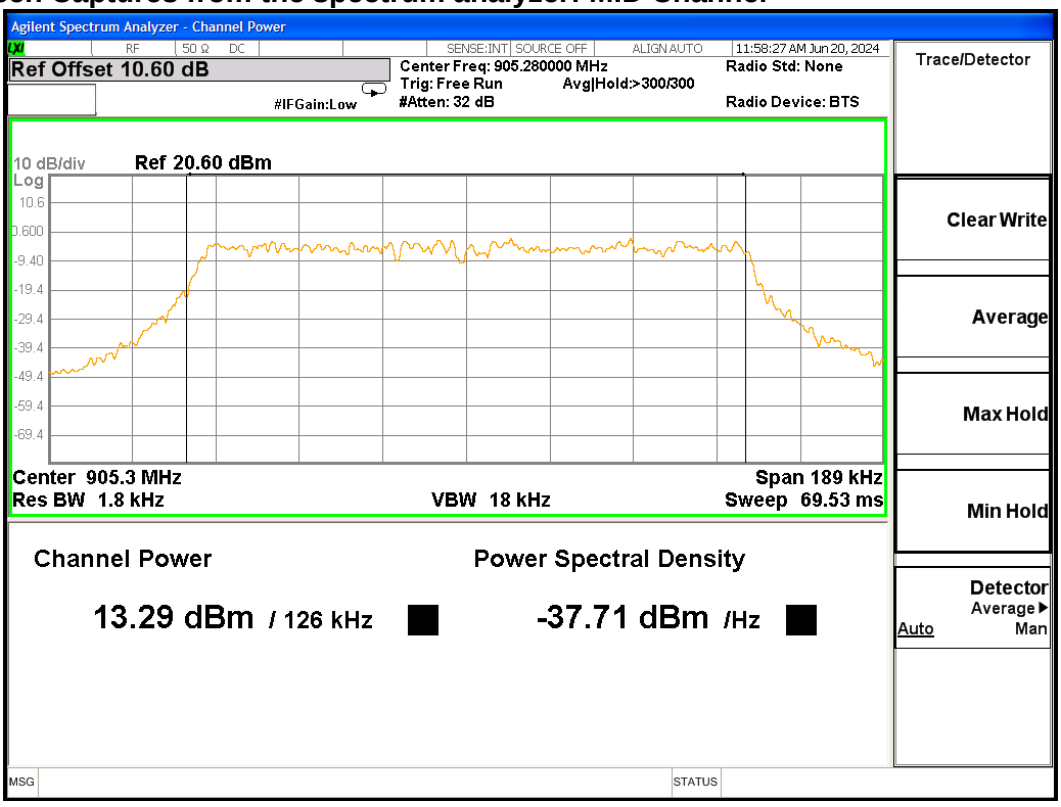
2.4.5 Max Output Power Data: DSS

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	

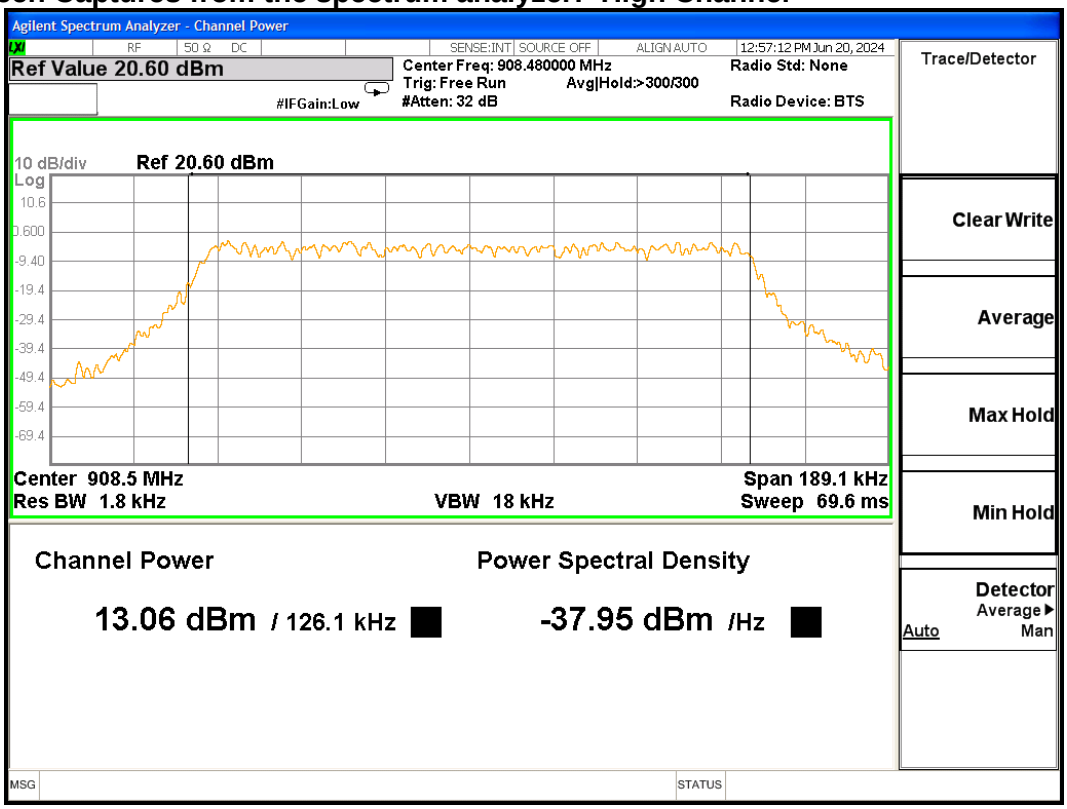
Screen Captures from the spectrum analyzer Low Channel



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	≥ 3 x 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 ≥ [2 x span / 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:

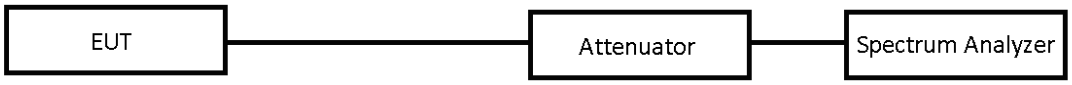
Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EMI receiver	Agilent	N9038A (FW A.25.05)	6130	2023-08-11	2024-08-11
Temp/Humidity	Extech	42270	5871	2024-04-08	2025-04-08
Attenuator	PCB	BWS102W263	6932	2022-12-10	2025-12-10
Coaxial Cables (RF)	W.L. GORE	PGR01R01036	-	Cal. before each use	
DC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

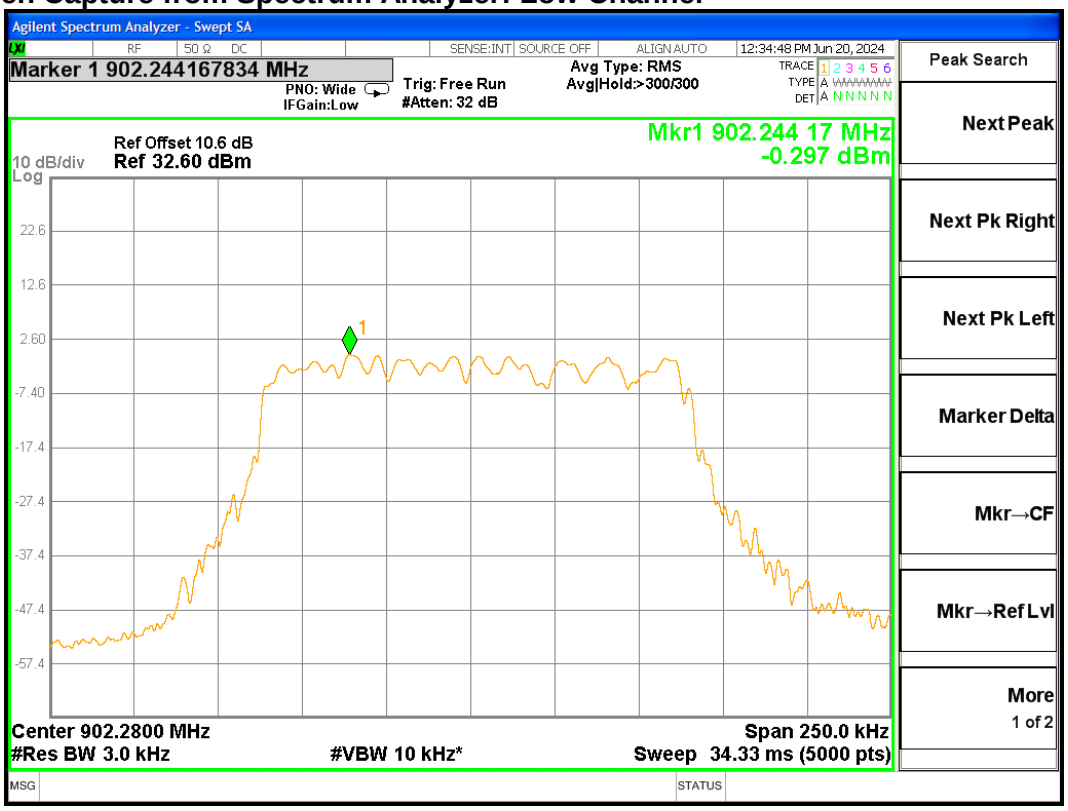
Test setup diagrams for Power Spectral Density testing:
Conducted:



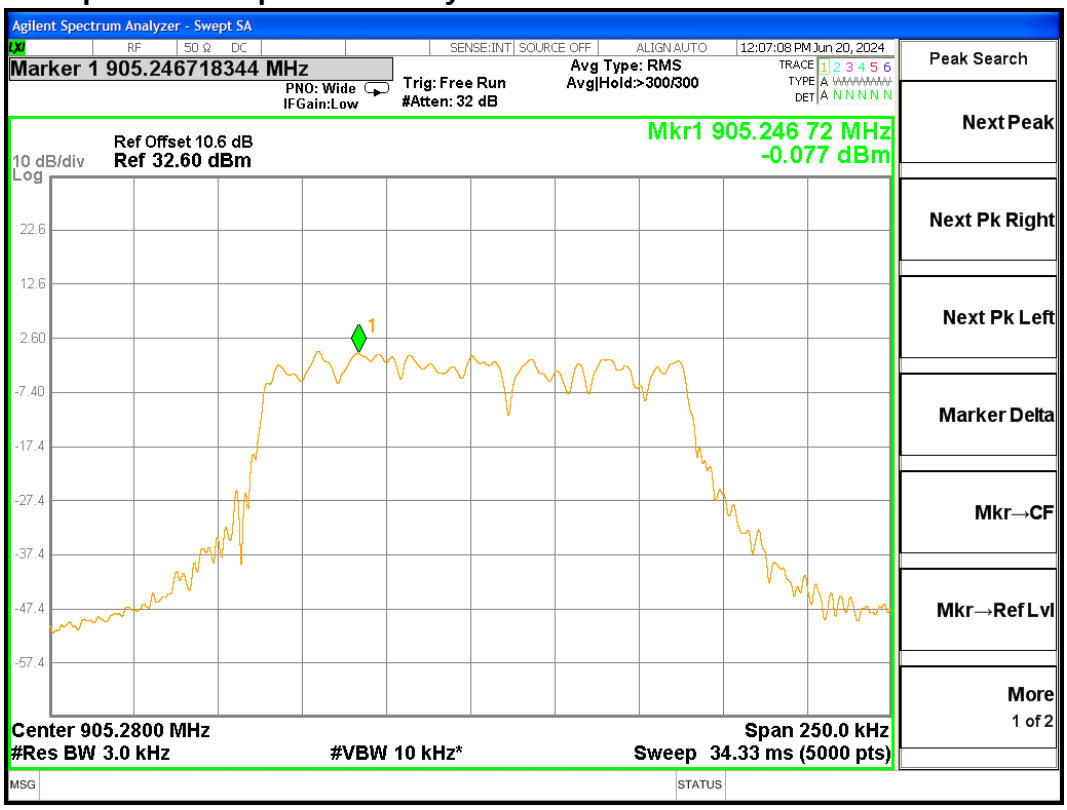
2.5.5 Average PSD Data

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	

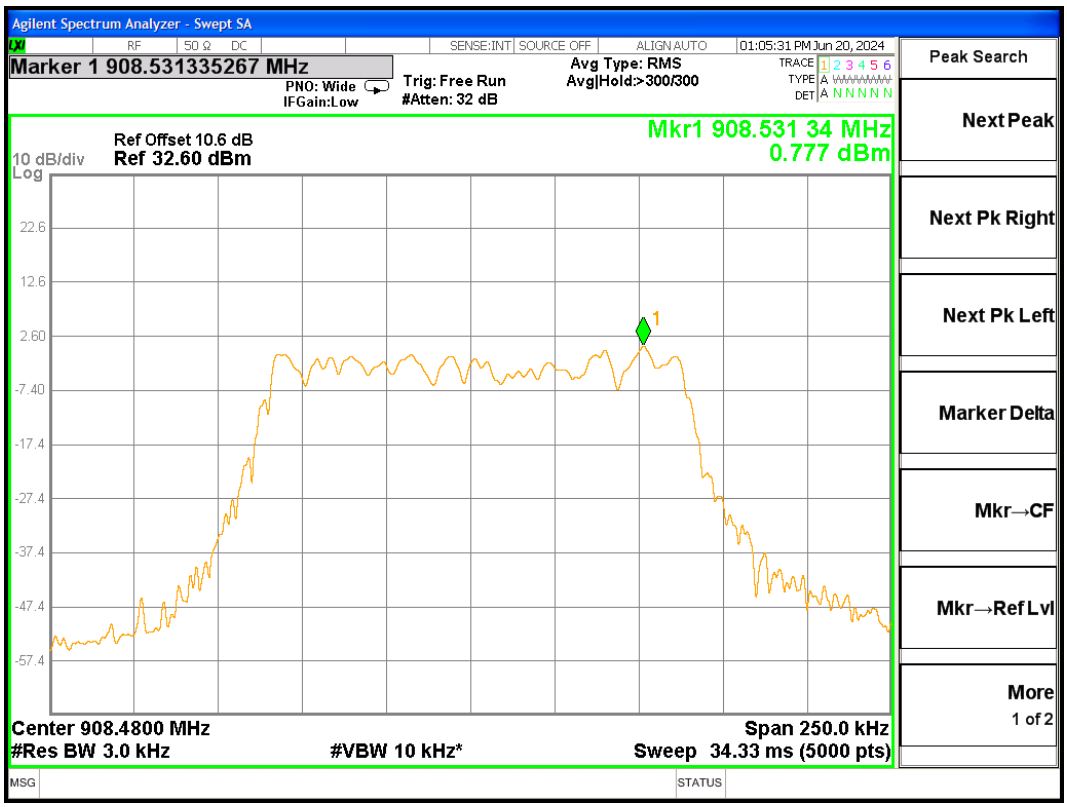
Screen Capture from Spectrum Analyzer: Low Channel



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 (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	

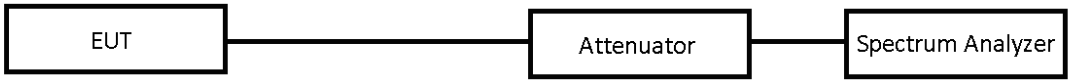
2.6.4 Test Sample Verification, Configuration & Modifications

The EUT was set to 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:

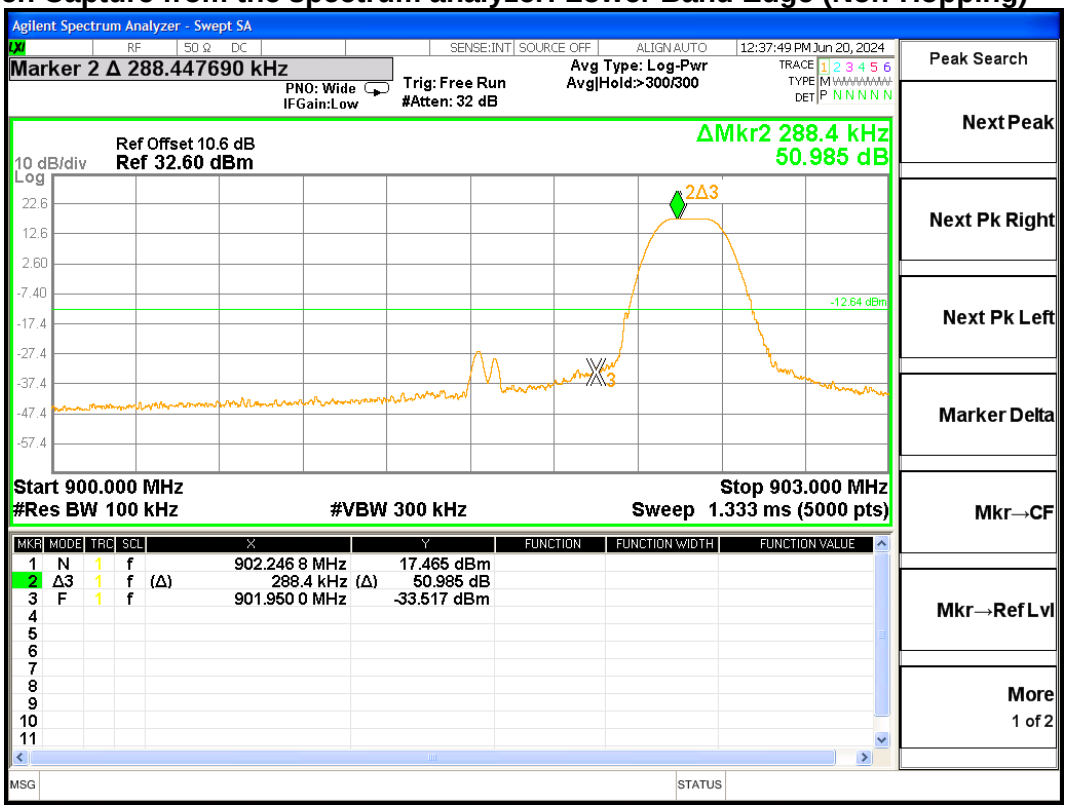


2.6.5 Band Edge Data

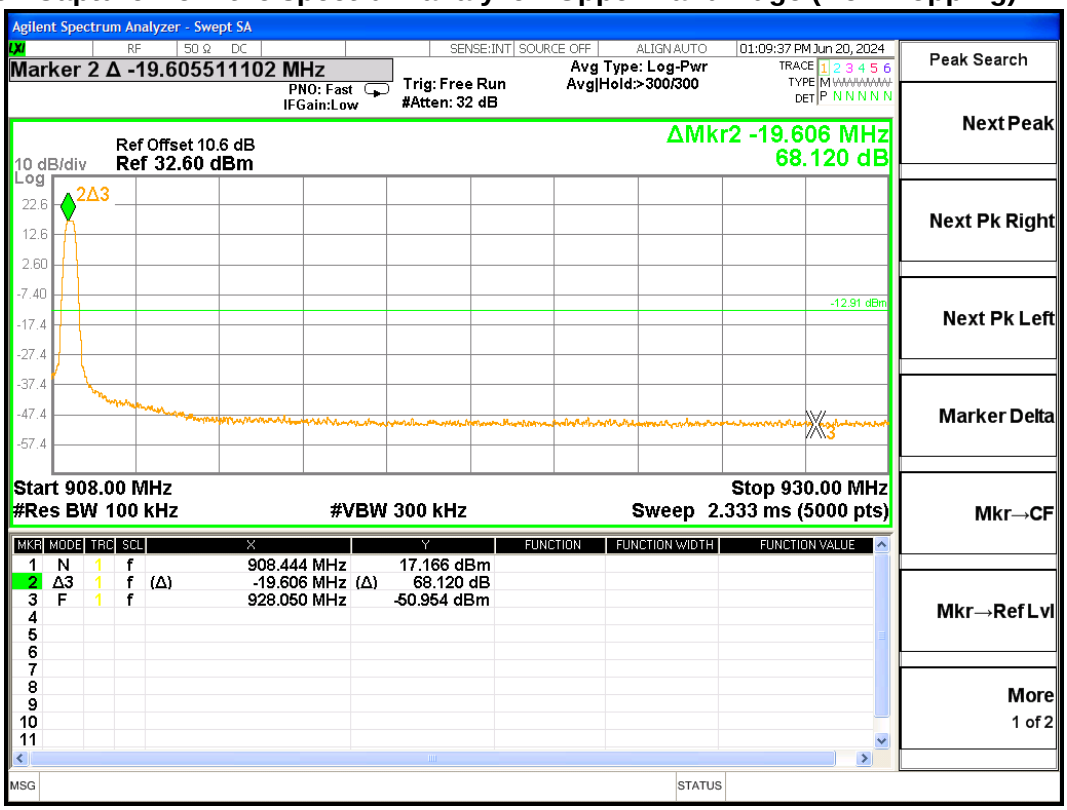
Worse Case Data

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

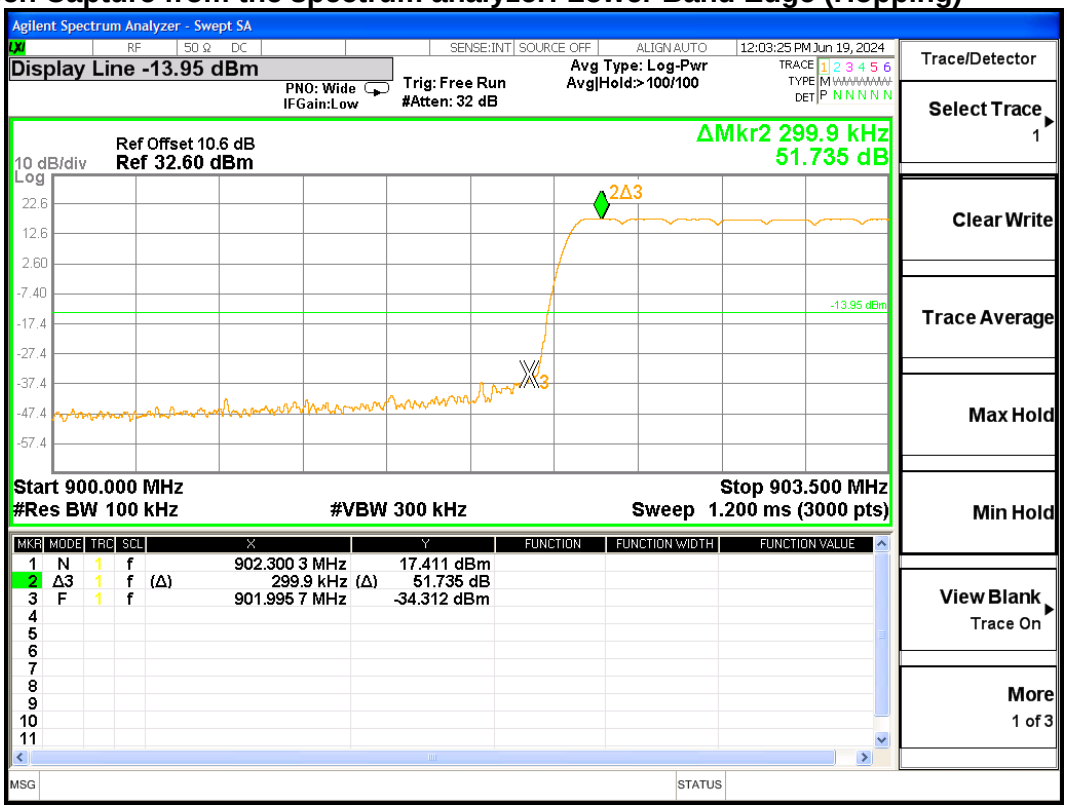
Screen Capture from the spectrum analyzer: Lower Band Edge (Non-Hopping)



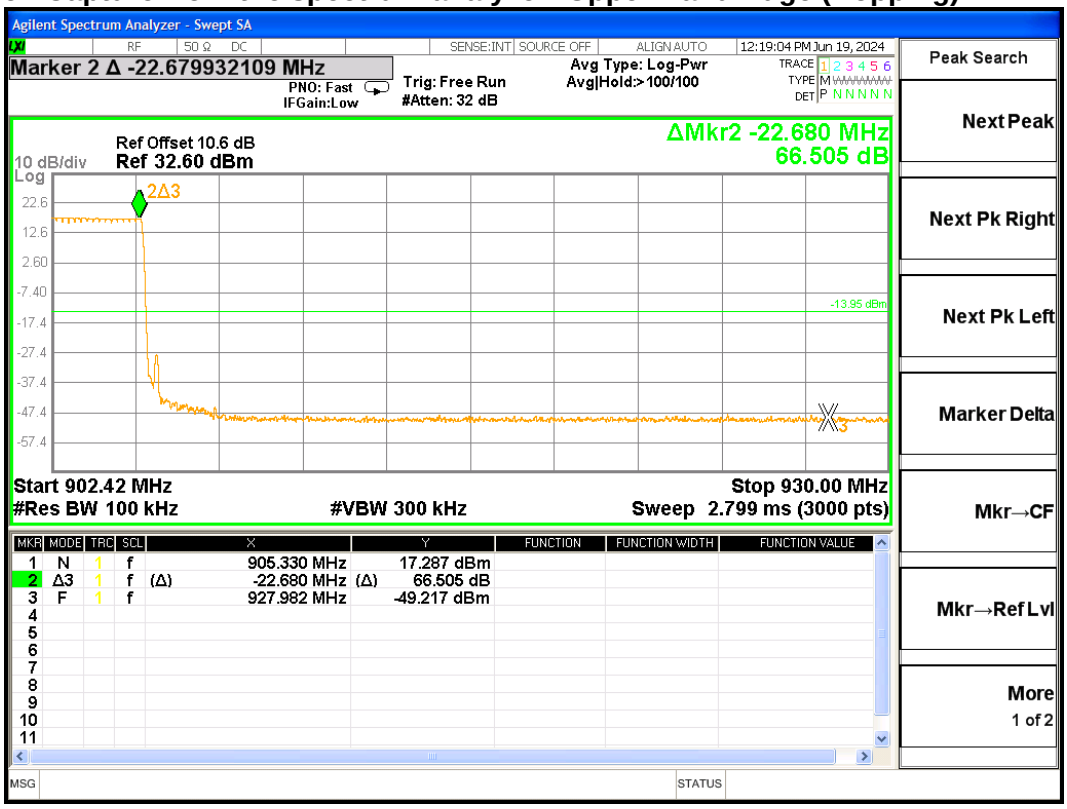
Screen Capture from the spectrum analyzer: Upper Band Edge (Non-Hopping)



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** **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:

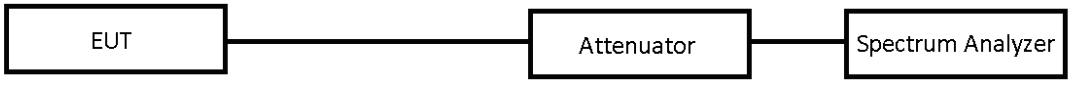
Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EMI receiver	Agilent	N9038A (FW A.25.05)	6130	2023-08-11	2024-08-11
Temp/Humidity	Extech	42270	5871	2024-04-08	2025-04-08
Attenuator	PCB	BWS102W263	6932	2022-12-10	2025-12-10
Coaxial Cables (RF)	W.L. GORE	PGR01R01036	-	Cal. before each use	
DC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

2.7.4 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.

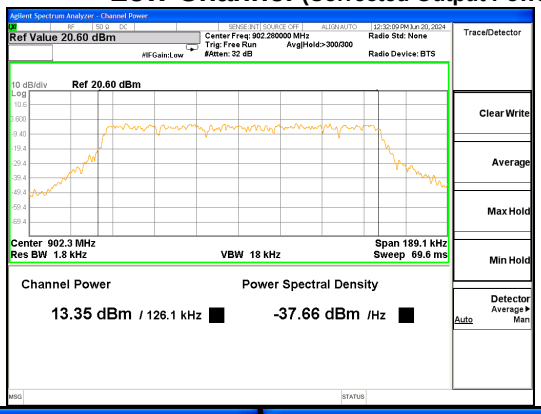
The EUT met the requirements without modification.

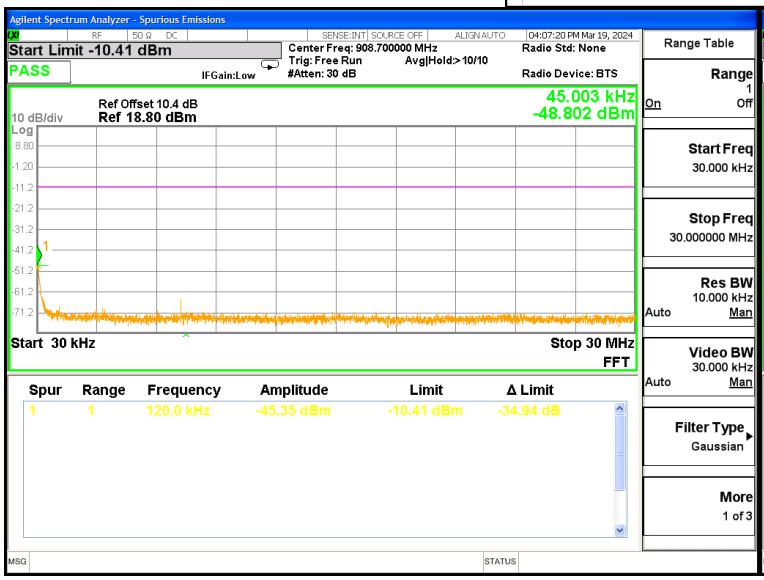
Test setup diagram for Conducted Spurious Emissions testing:

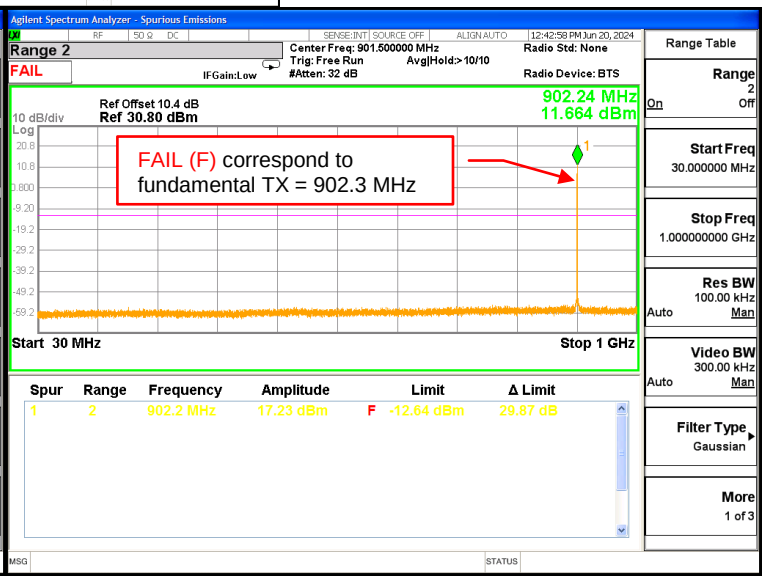


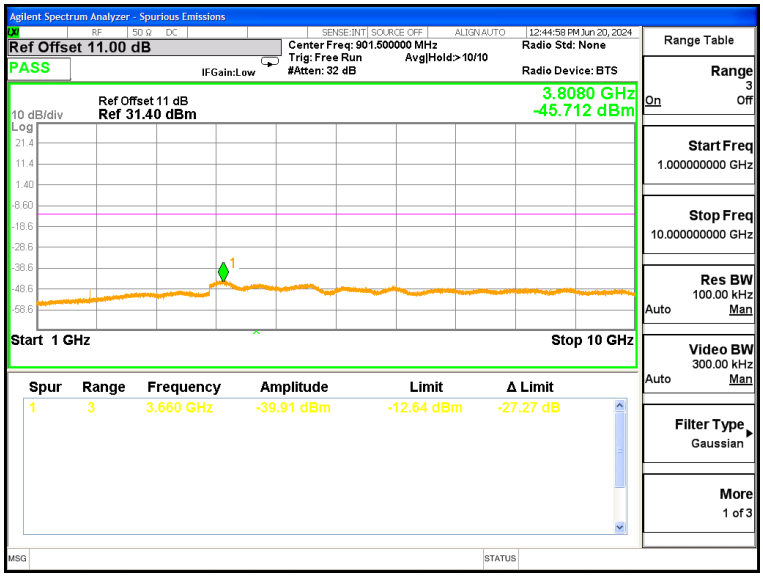
2.7.5 Conducted Emissions Data:

Low Channel (Corrected Output Power: 17.4 dBm)

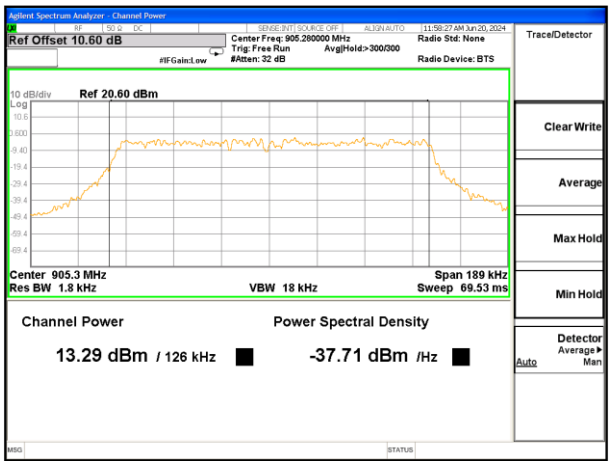


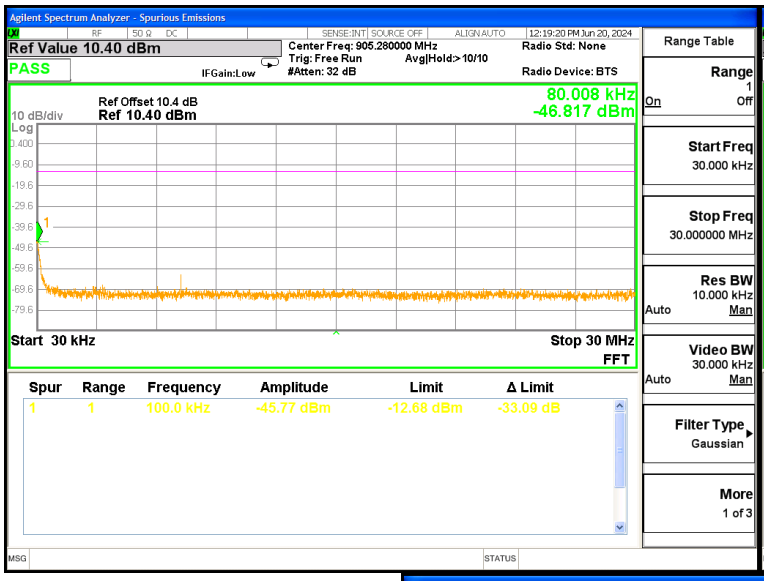


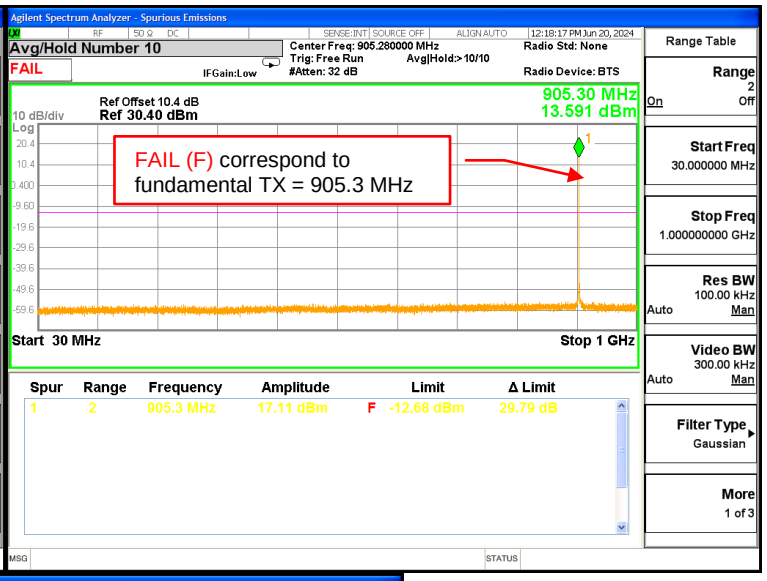


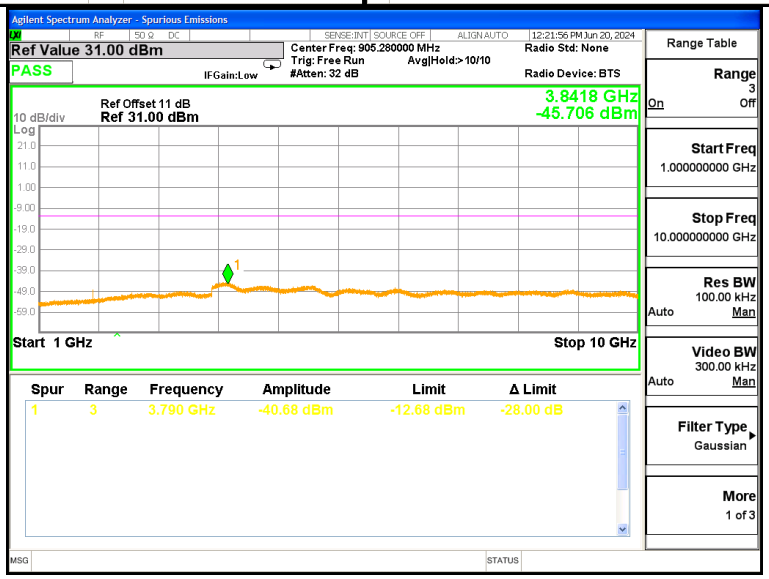


MID Channel (Corrected Output Power: 17.3 dBm)

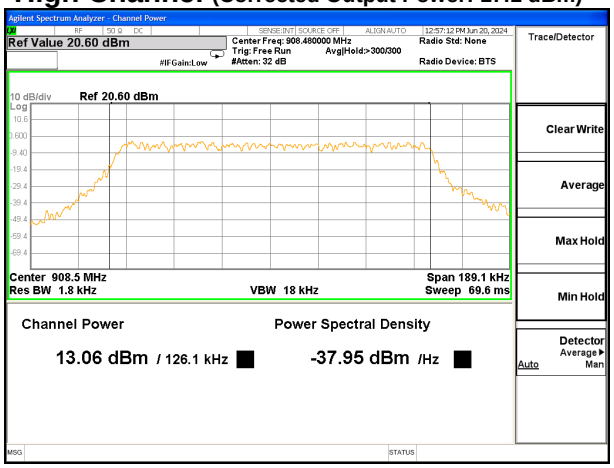


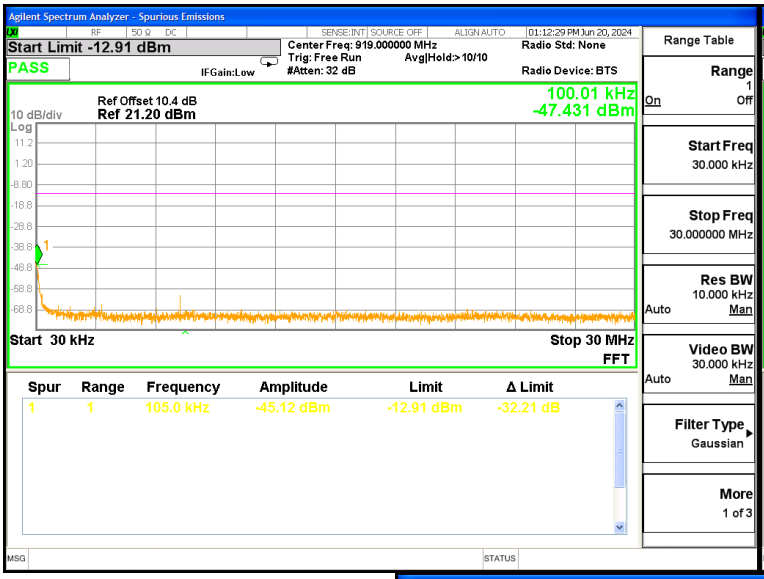


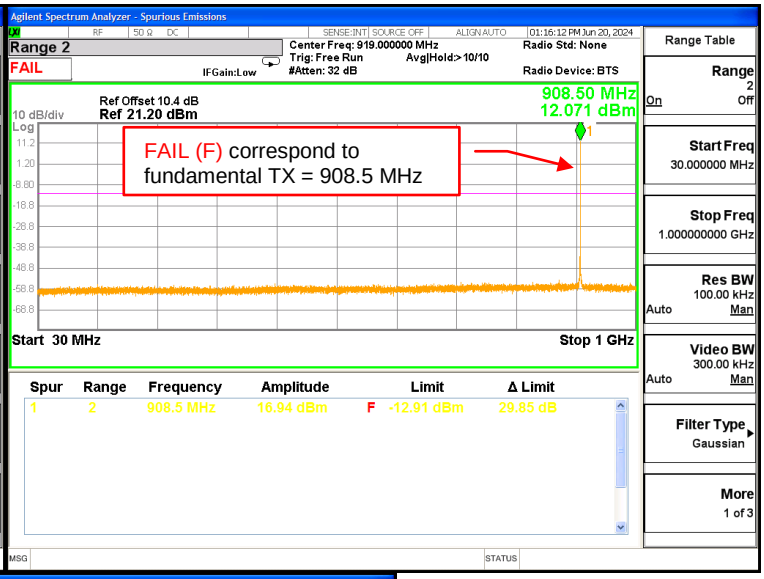


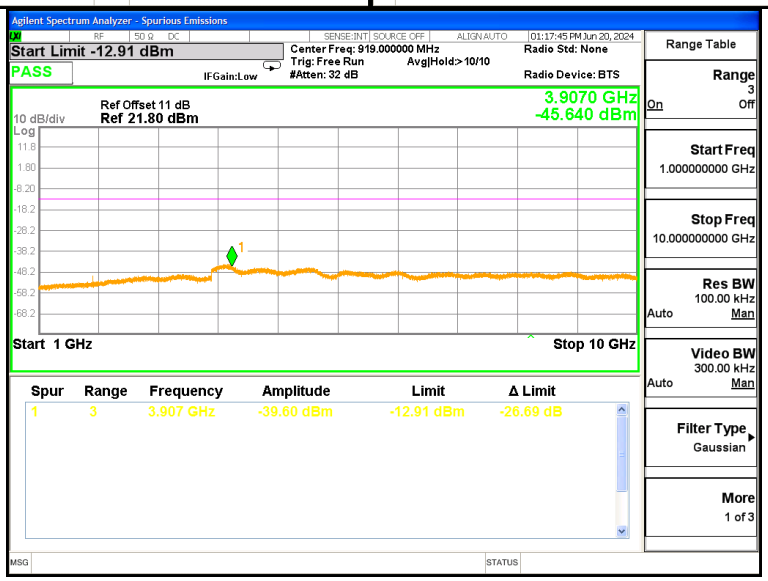


High Channel (Corrected Output Power: 17.1 dBm)









2.8 Channel Separation (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	**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: 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

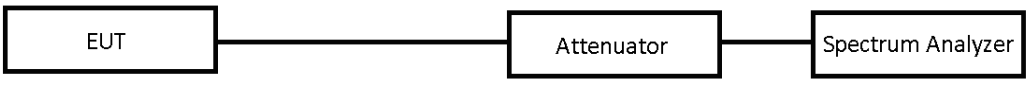
Testing was performed with the following equipment:

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

2.8.4 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:

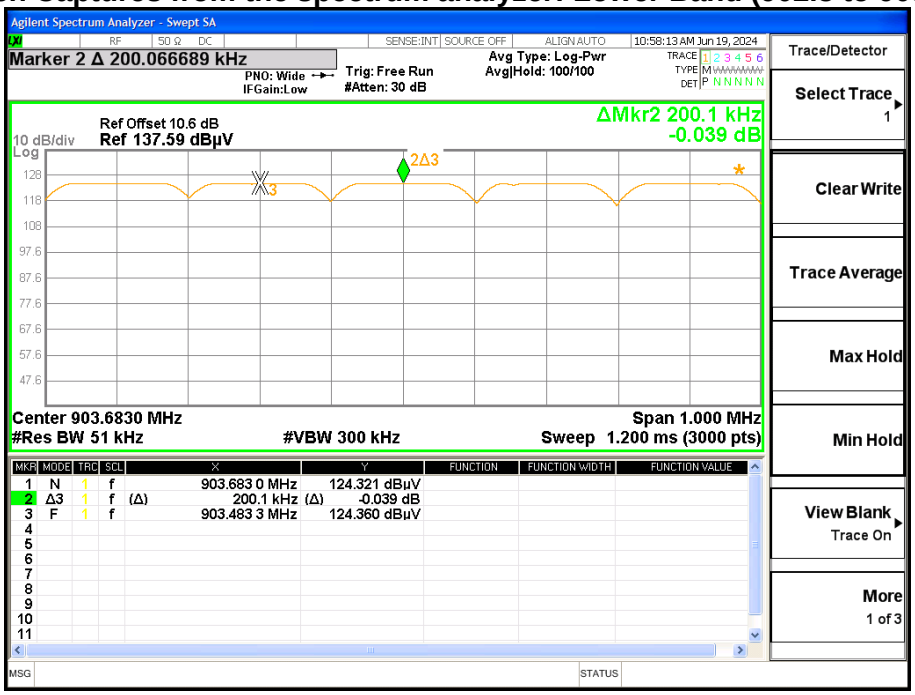


2.8.5 Channel Separation Data:

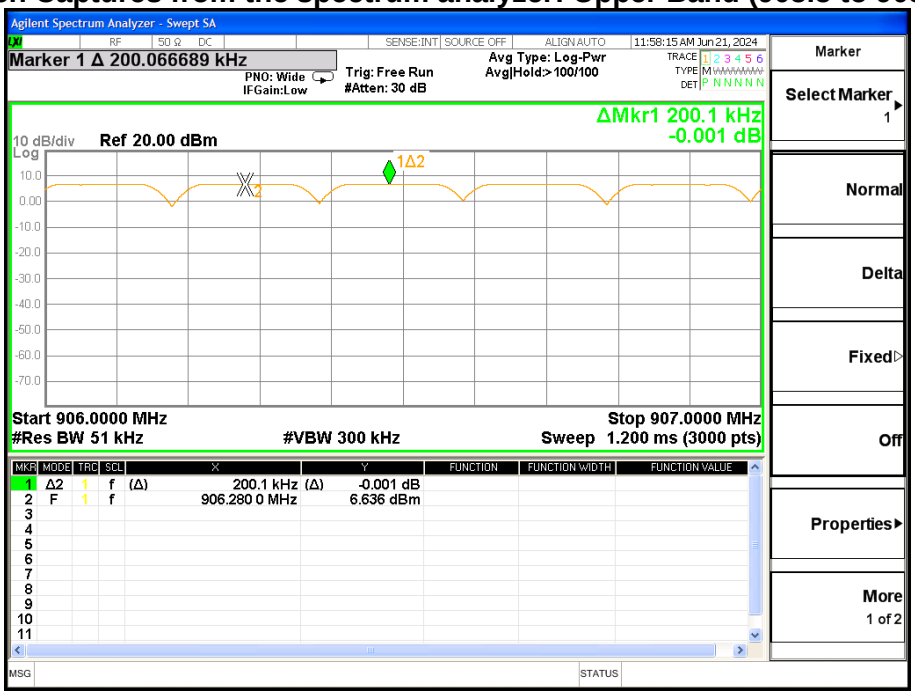
EUT can be configured to use either 16 channels in the lower band from 902.3 to 905.3 MHz or in the upper band from 905.5 to 908.5 MHz.

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 ≤ Channel spacing and where possible RBW should be set >> 1/T, where T is the expected dwell time per channel. VBW ≥ 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

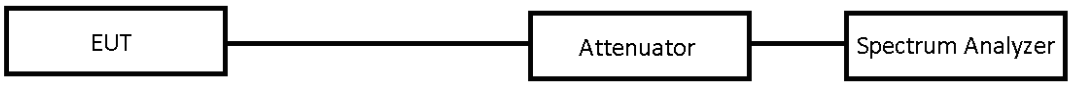
Testing was performed with the following equipment:

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

2.9.4 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:



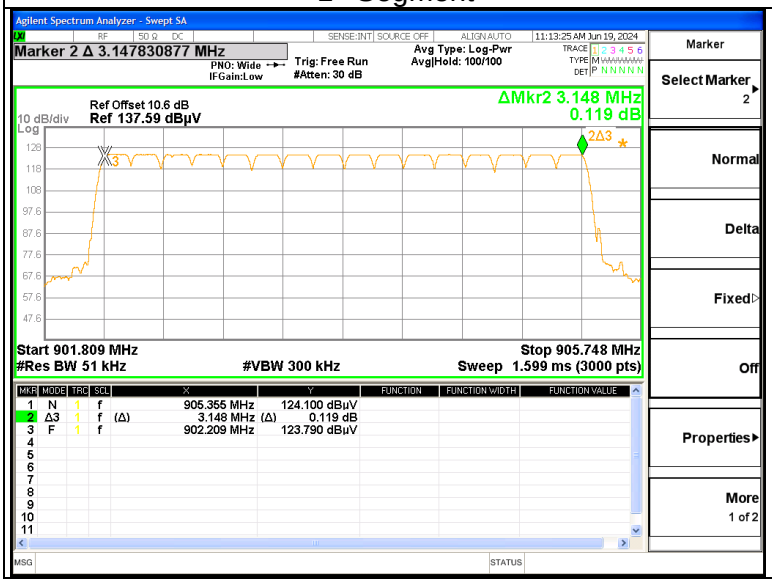
2.9.5 Dwell Time Data:

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.

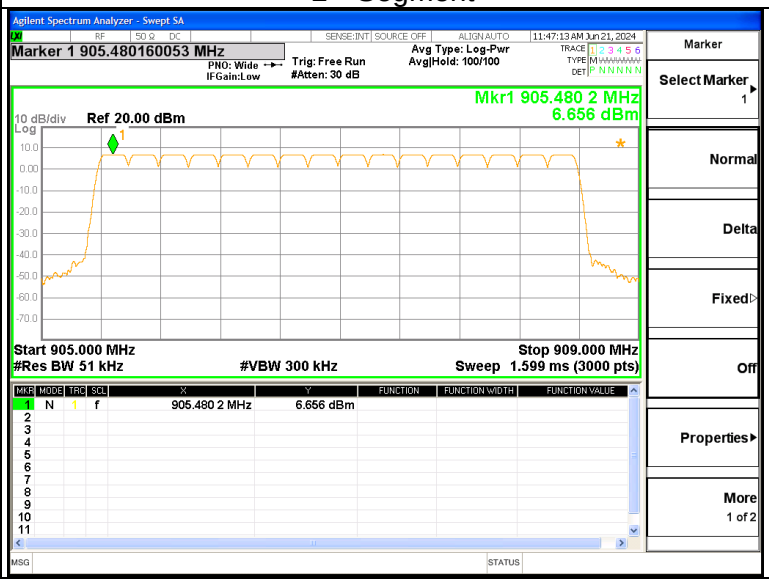
Segment	Measured Dwell time	Limit
1st (Lower Band)	200.6 ms	≤ 400ms
2nd (Upper Band)	207.0 ms	
Window of measurement is equal to number of hopping channels multiple by 400ms = **0.4 x 16 (For each segment)** = 6.4 Sec		

Measure numbers OF Channels= 16

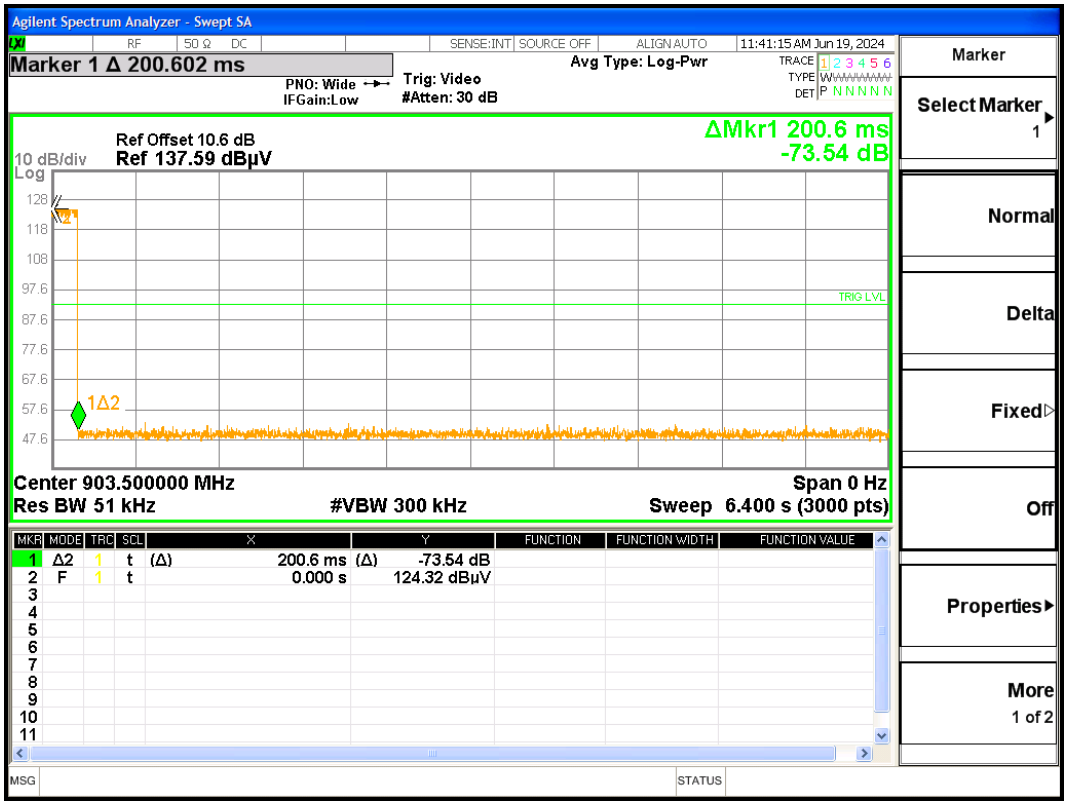
1st Segment



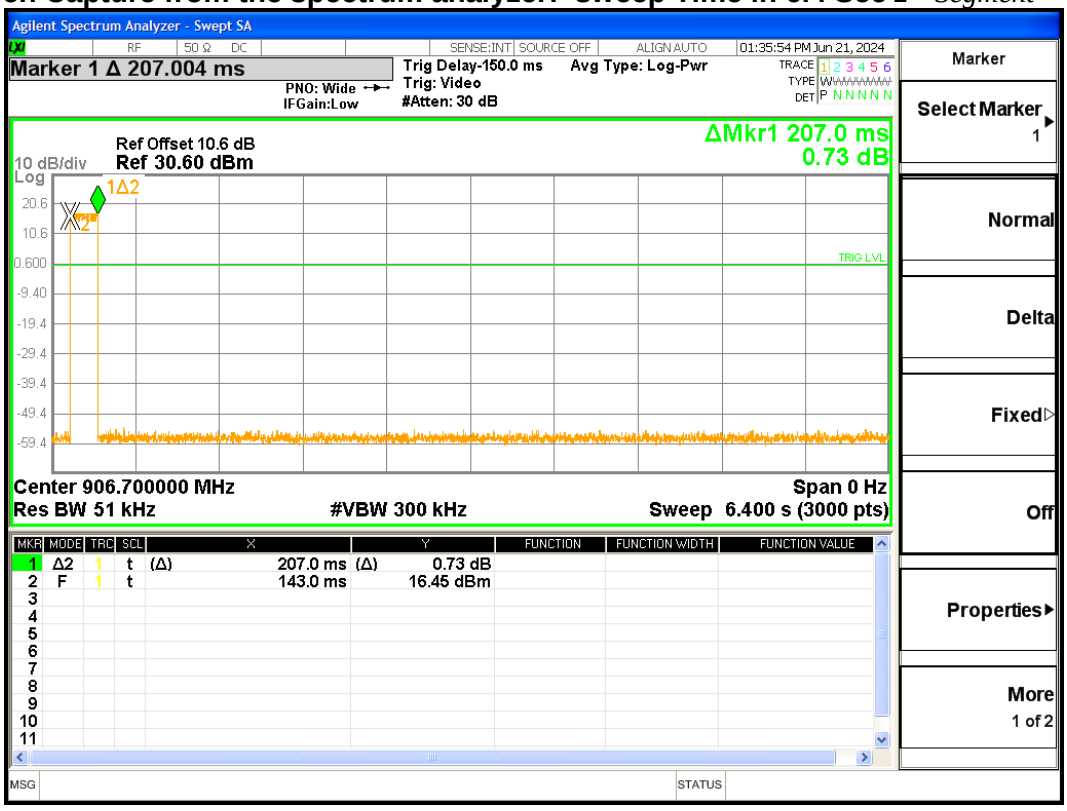
2nd Segment



Screen Capture from the spectrum analyzer: sweep Time in 6.4 Sec *1st Segment*



Screen Capture from the spectrum analyzer: sweep Time in 6.4 Sec *2nd Segment*

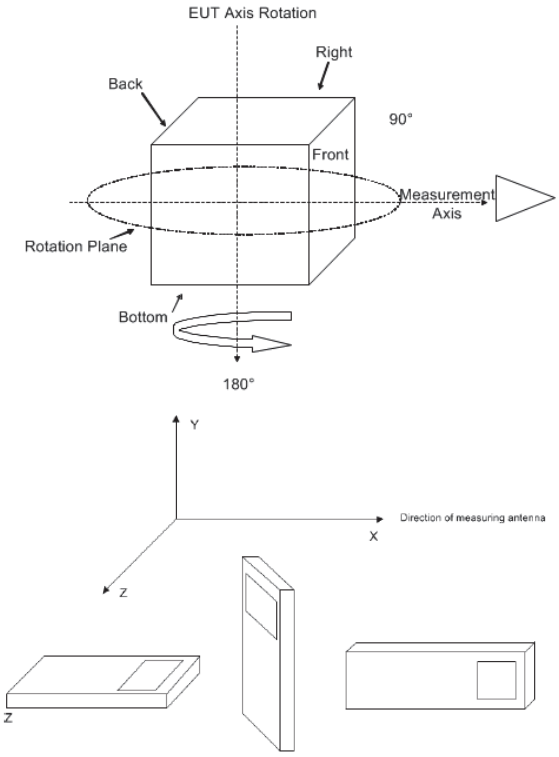


2.10 EUT Positioning Assessment – N/A

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.



2.11 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**

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

2.11.1 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 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.

2.11.2 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 (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 (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	*2024-01-21	*2025-01-23
Low Noise Amplifier (1 – 18 GHz)	MITEQ	JS43-01001800-21-5P	4354	*2024-01-21	*2025-01-23
RE Cable below 1GHz	Insulated Wire Inc.	KPS-1501A-3600-KPA-01102006	4419	*2024-01-21	*2025-01-23
Re Cable Above 1 GHz	A.H. System 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

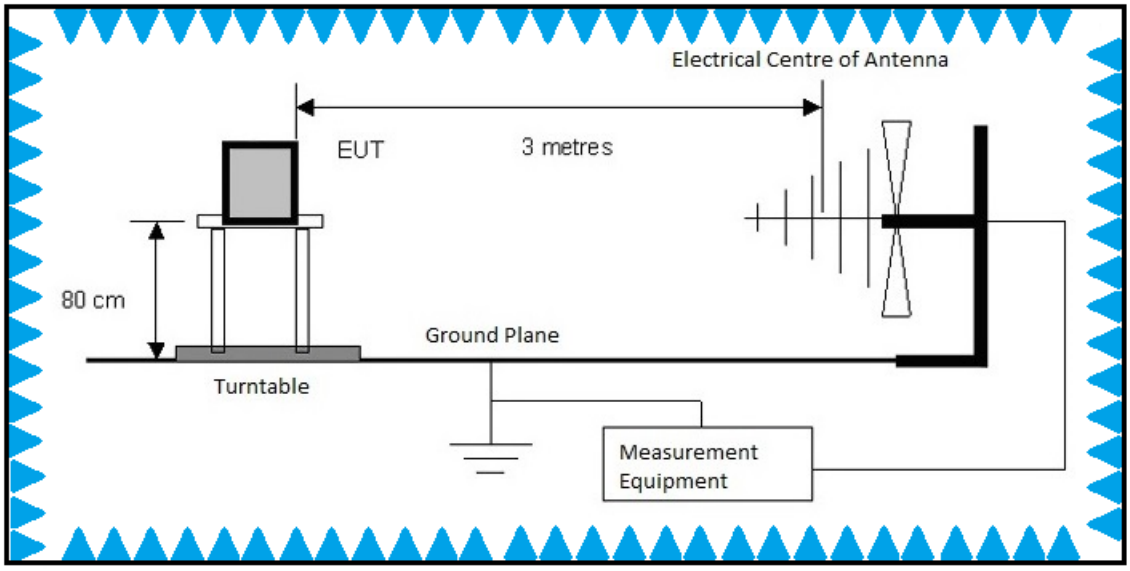
***** In-house verification

2.11.4 Test Sample Verification, Configuration & Modifications

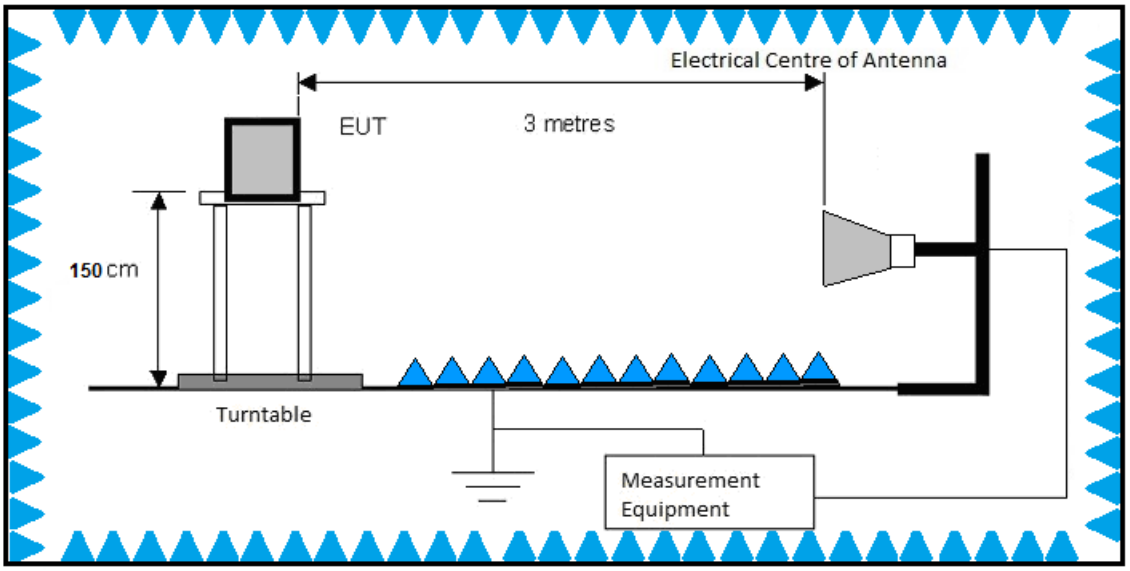
The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation. LoRa radio is transmitting at mid channel in ingle carrier configuration and high channel in dual carrier configurations.

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:

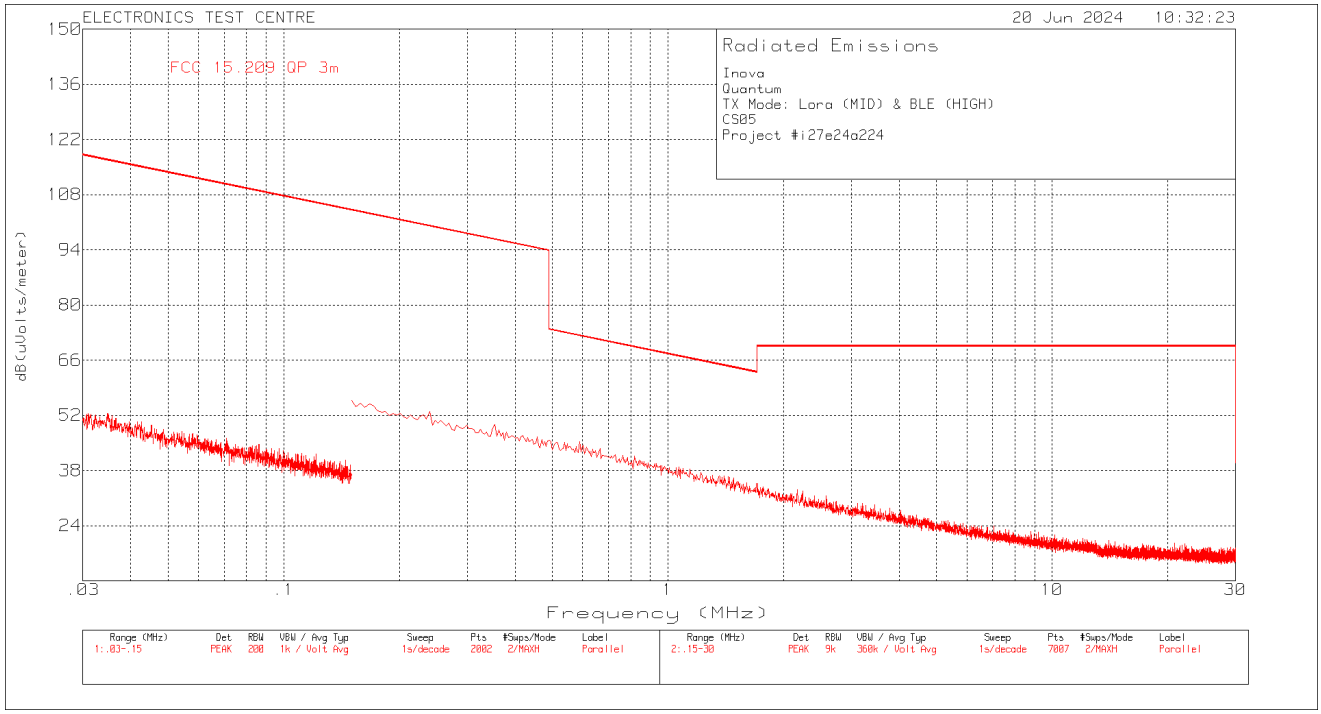
When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss. Measurements reported are the result of adjusting the turntable azimuth and antenna height to obtain the maximum EUT emission. This may produce a different reading than the plot trace. The plot is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

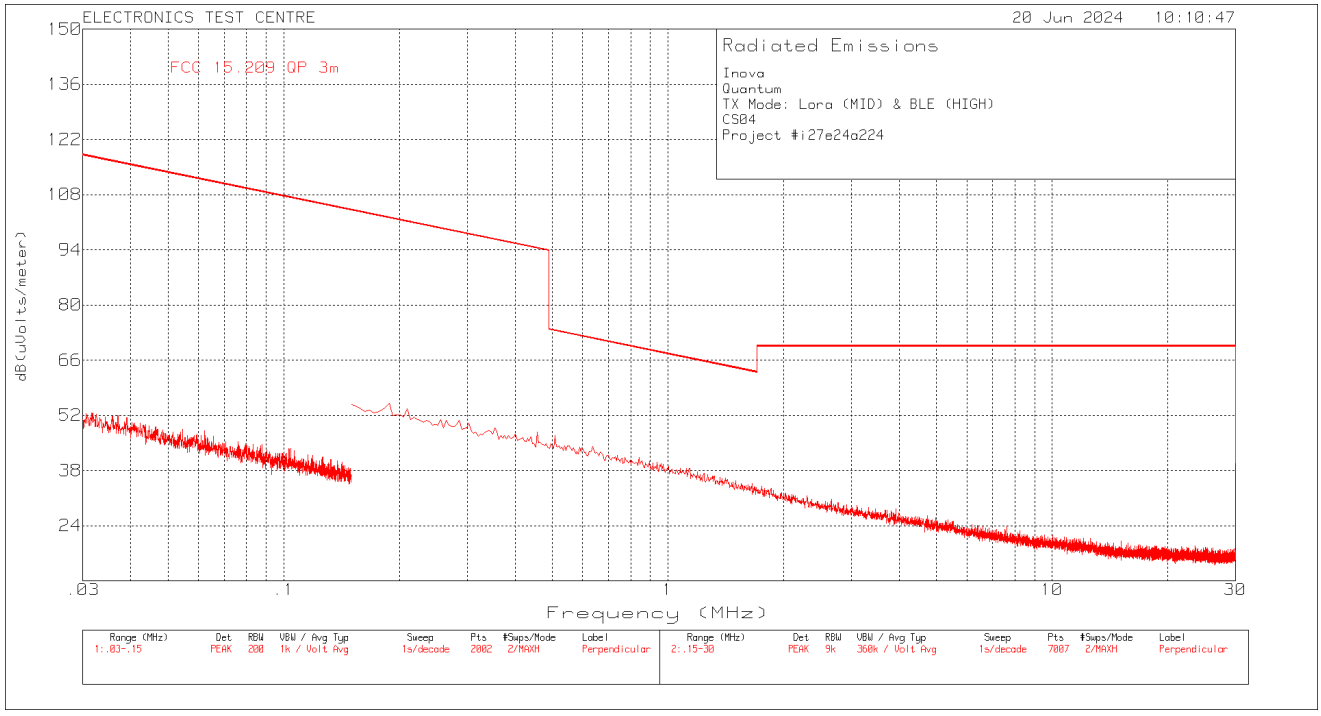
Freq. Marker	Freq. [GHz]	Raw reading[dBµv]	Det	Antenna Factor [dB/m]	Pre amp Gain [dB]	Corrected Reading [dBµv/m]	FCC 15.209 Limit [dBµv/m]	Delta [dB]	Azimuth [Deg]	Height [cm]	Polarization
1	0.10371	19.25	QP	16.1	-23.6	11.75	43.53	-31.78	125	156	Vertical
2	0.70263	20.05	QP	24.3	-19.1	25.25	46.03	-20.78	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**

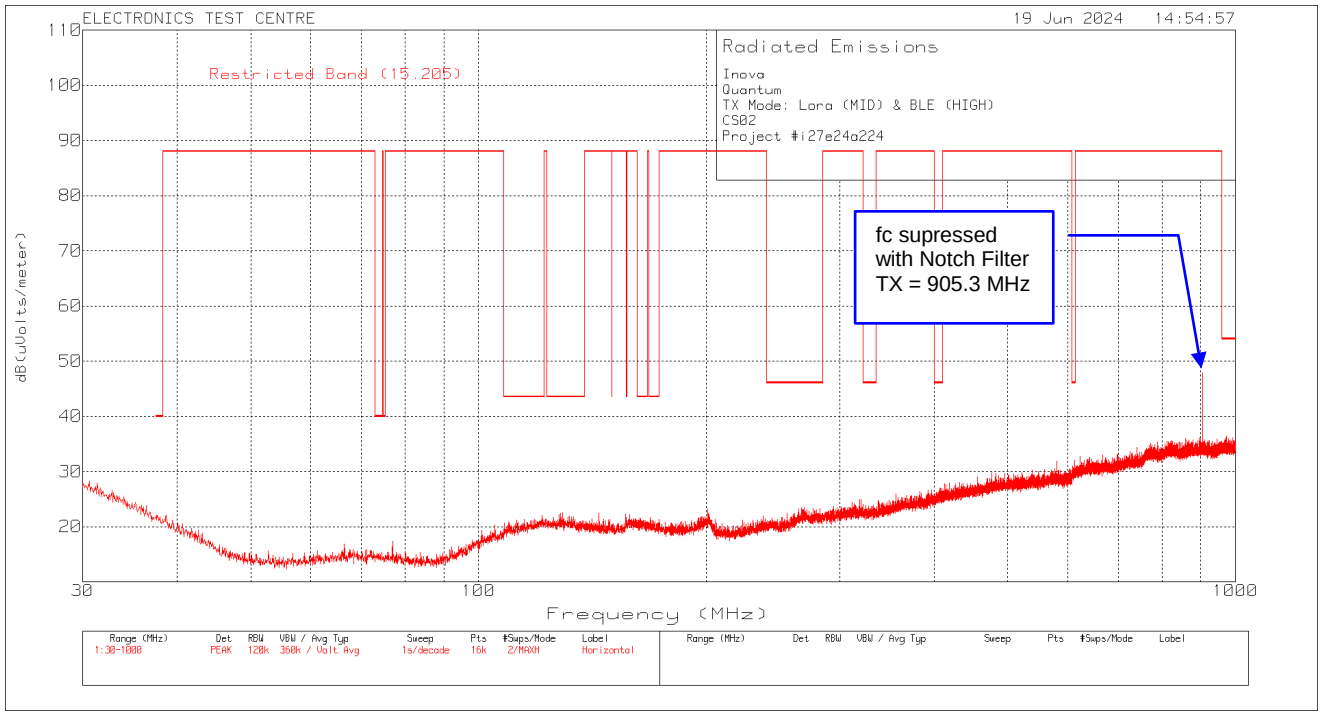
Plot of Radiated Emissions: Parallel



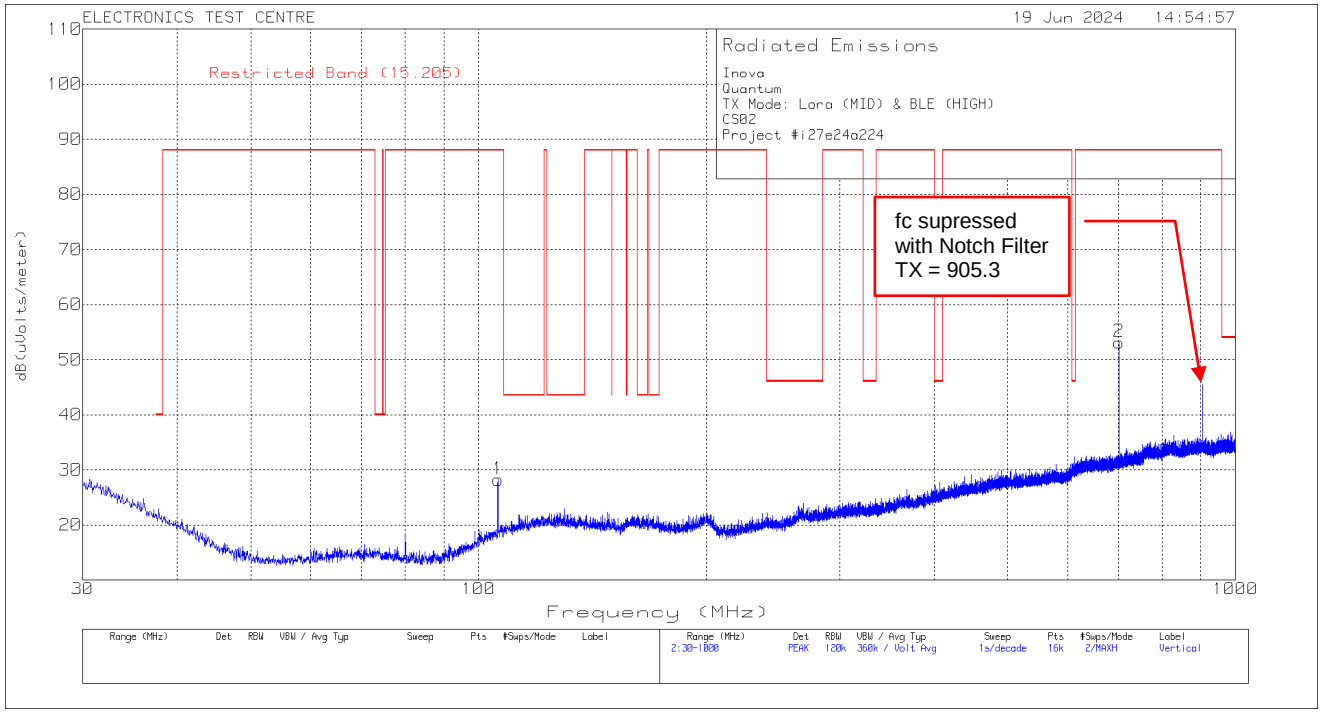
Plot of Radiated Emissions: Perpendicular



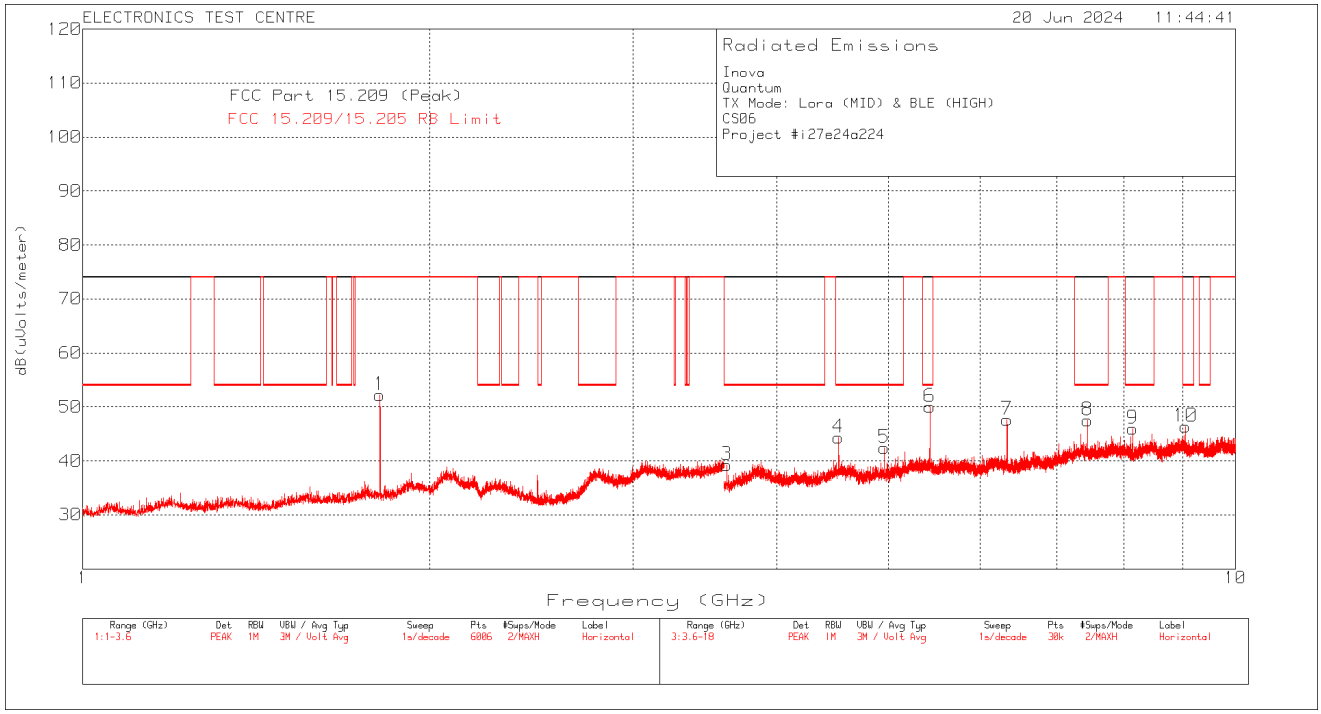
Plot of Radiated Emissions: Horizontal Polarization



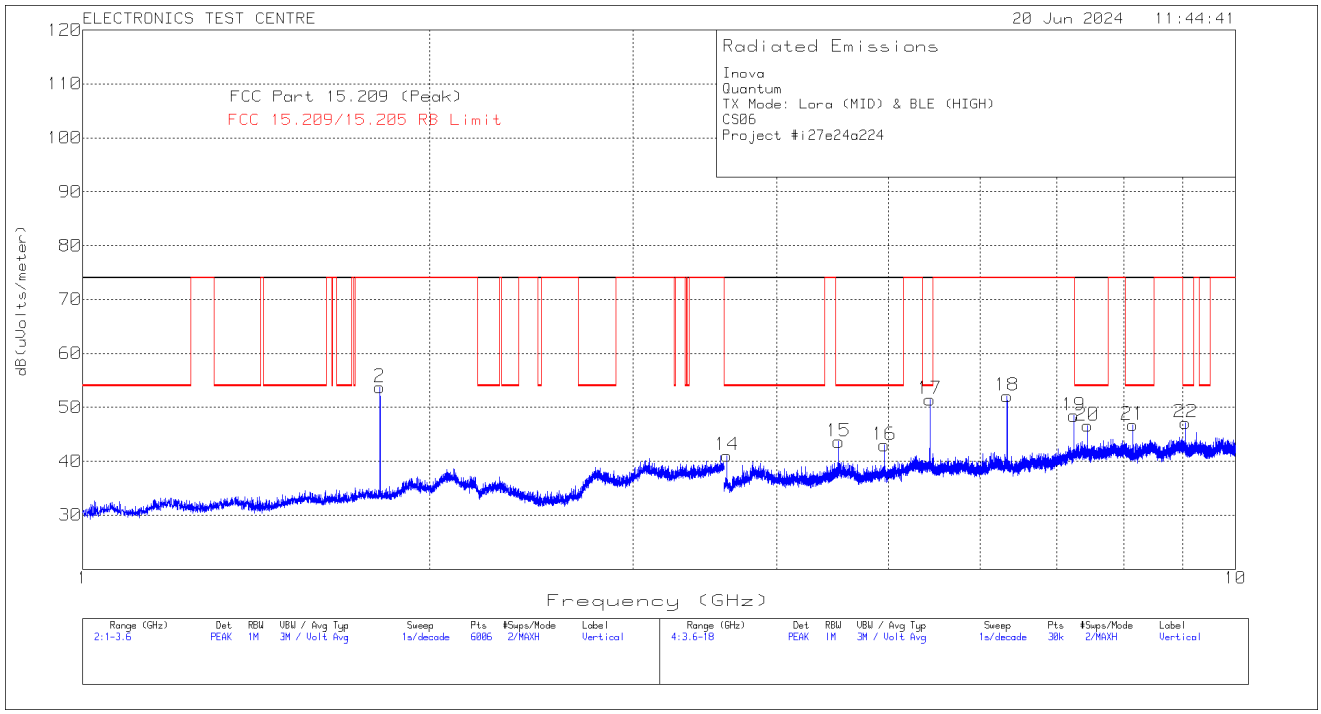
Plot of Radiated Emissions: Vertical Polarization



Plot of Radiated Emissions: Horizontal Polarization



Plot of Radiated Emissions: Vertical Polarization



2.12 Radiated Emissions (RX Mode)

Test Lab: Electronics Test Centre, Airdrie **Test Personnel: Janet Mijares** **Date: 2024-06-(19/20/21) (21.3°C, 24.6%RH)**	**EUT: Quantum Dual Band HyperQ Node** **Standard: FCC Part 15.109** **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	56.02 (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 (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

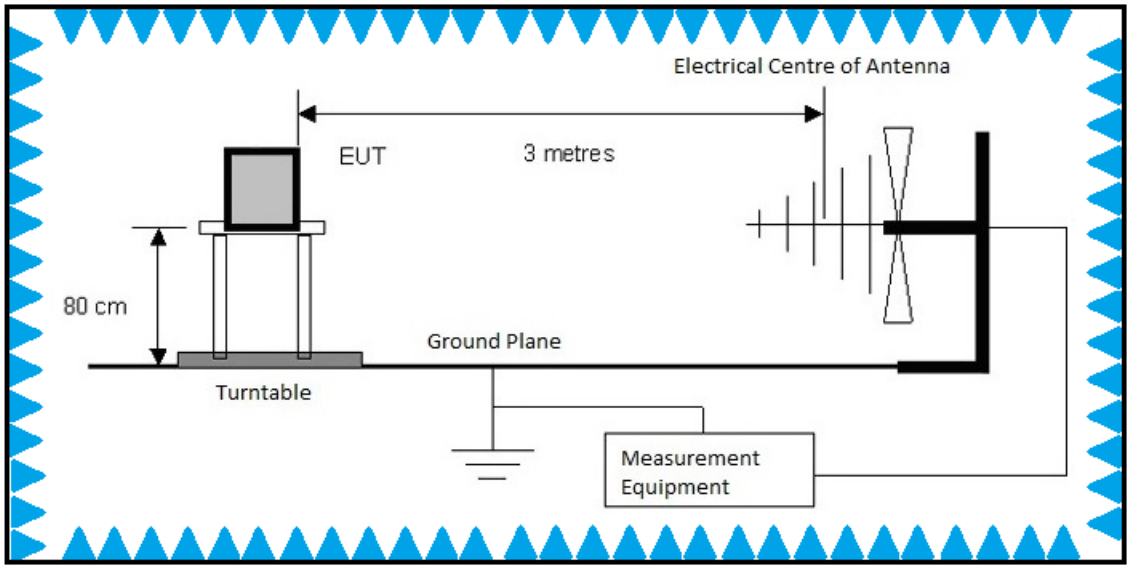
***** In-house verification

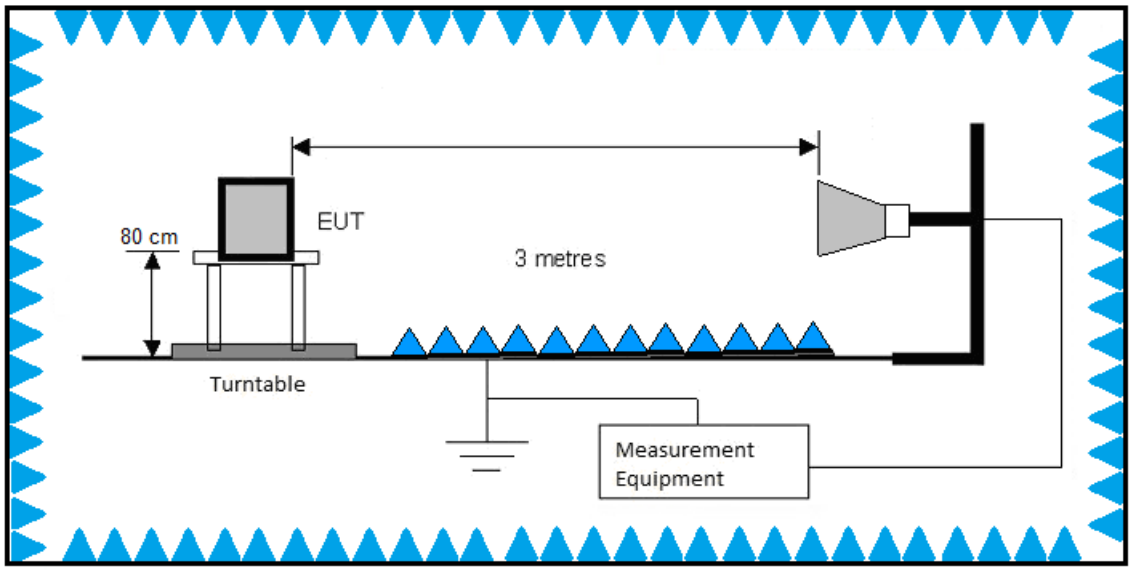
2.12.4 Test Sample Verification, Configuration & Modifications

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:




80 cm
EUT
3 metres
Turntable
Measurement
Equipment

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:

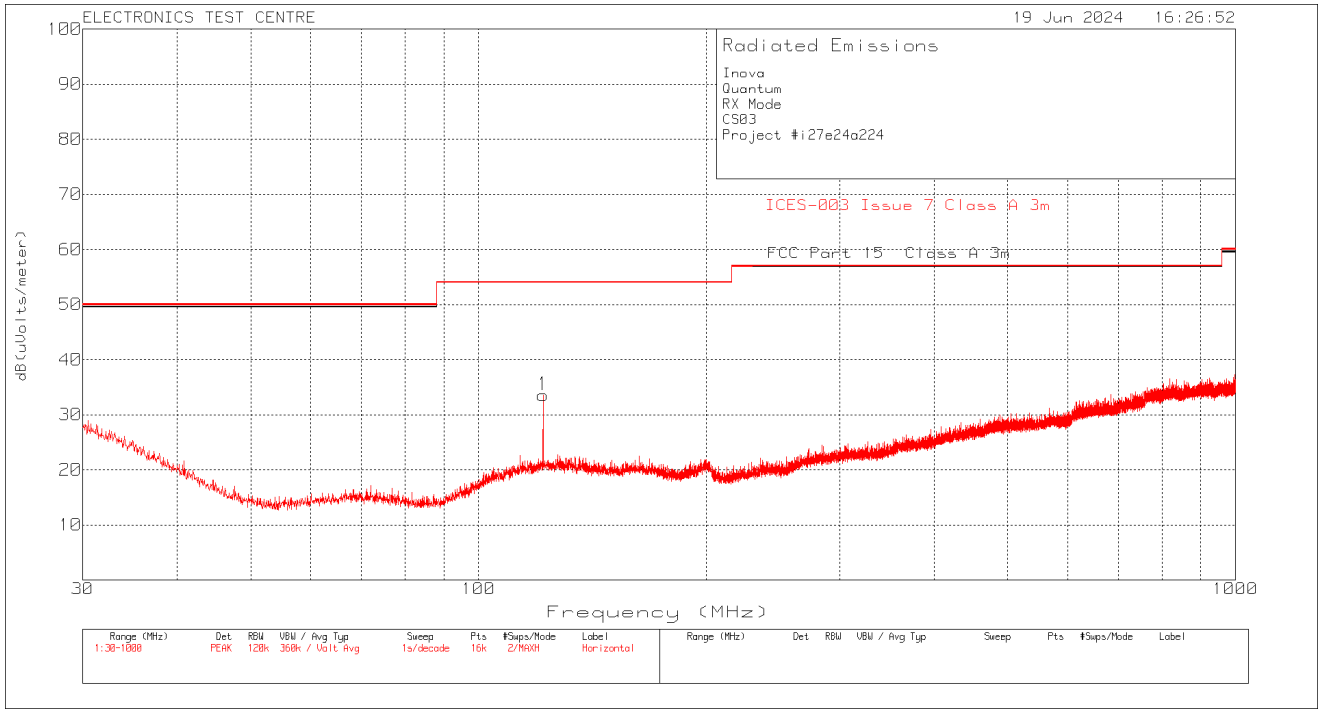
When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss. Measurements reported are the result of adjusting the turntable azimuth and antenna height to obtain the maximum EUT emission. This may produce a different reading than the plot trace. The plot is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

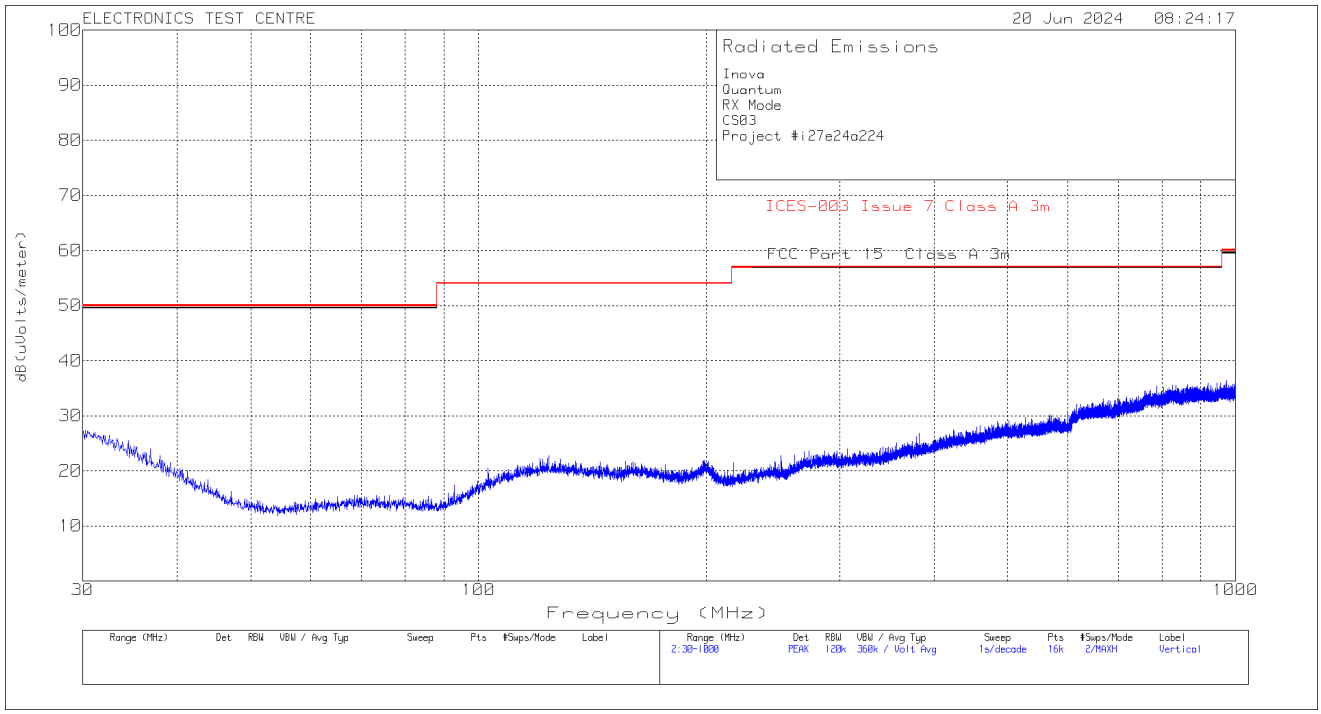
Freq. Marker	Freq. [GHz]	Raw reading[dBµv]	Det	Antenna Factor [dB/m]	Pre amp Gain [dB]	Corrected Reading [dBµv/m]	FCC Class A Limit [dBµv/m]	Delta [dB]	Azimuth [Deg]	Height [cm]	Polarization
1	121.1	18.51	QP	17.9	-23.4	13.01	53.98	-40.97	308	127	Horizontal
2	2401.1	26.46	AV	28.5	-33.4	21.56	60	-38.44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

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

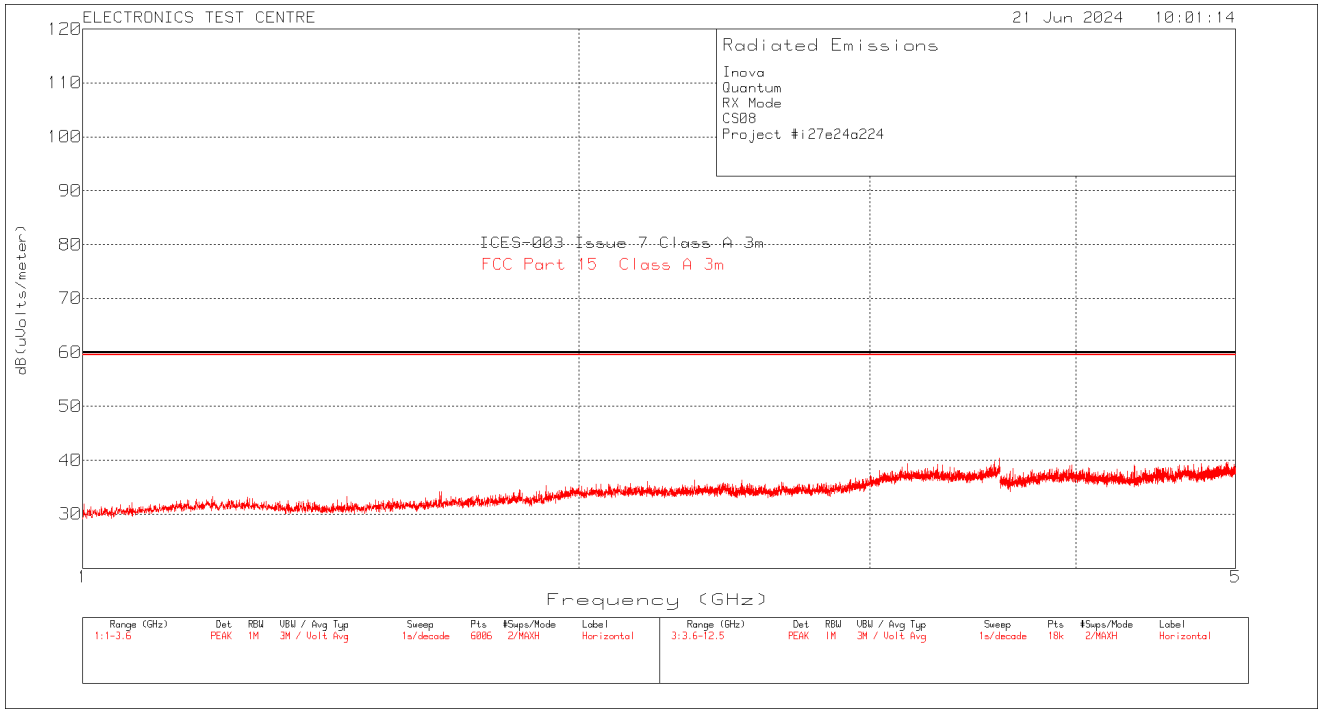
Plot of Radiated Emissions: Horizontal Polarization



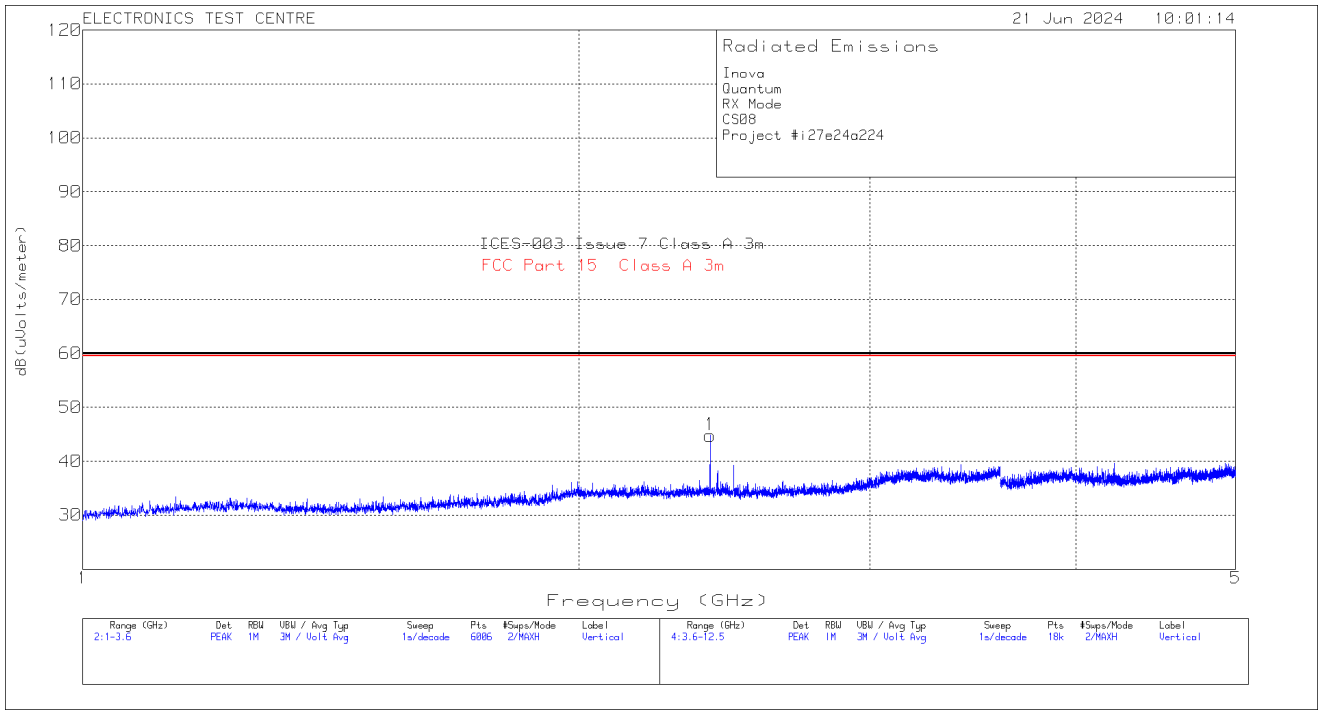
Plot of Radiated Emissions: Vertical Polarization



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

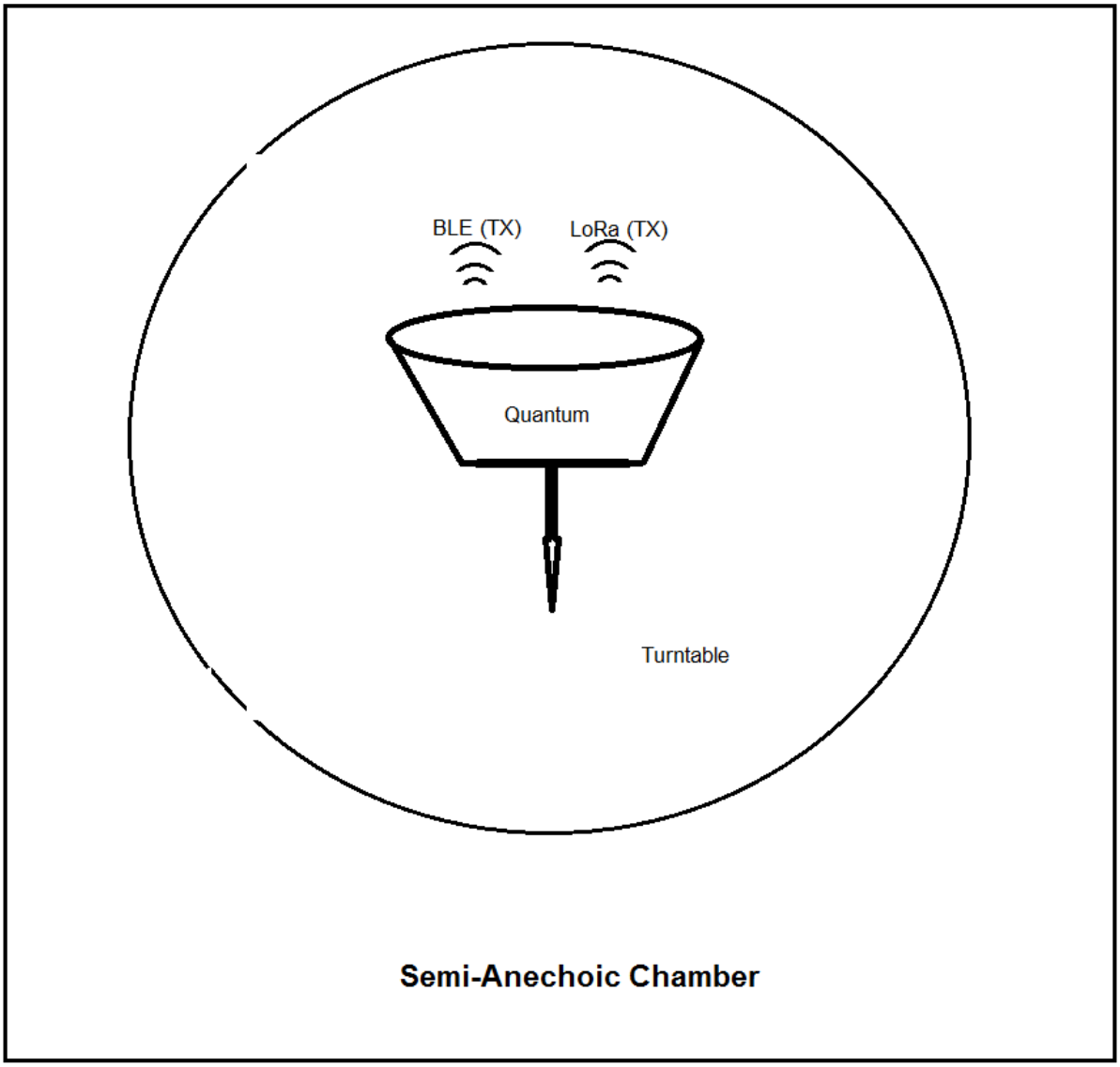
The Quantum Dual Band HyperQ Node was placed at the center of the test chamber turntable on top of an 80-cm high polystyrene foam table below 1GHz and at 1.5m high polystyrene foam table above 1 GHz for transmits mode and 80cm high for RX mode. There is no external grounding.

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



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