



Solutions

TEST REPORT

Test Report No.: UL-RPT-RP-14929091-116-FCC

Applicant * : Octagon I/O Ltd
Model No. * : Signal Live Hub
FCC ID * : 2A7VH-CSL-101
Technology * : Bluetooth – Low Energy
Test Standard(s) : **FCC Parts 15.207, 15.209(a) & 15.247**
For details of applied tests refer to test result summary

1. This test report shall not be reproduced in full or partial, without the written approval of UL International Germany GmbH.
2. The results in this report apply only to the sample tested.
3. The test results in this report are traceable to the national or international standards.
4. **Test Report Version 1.3 supersede Version 1.2 with immediate effect**
Test Report No. UL-RPT-RP-14929091-116-FCC Version 1.3, Issue Date 11 February 2025 replaces
Test Report No. UL-RPT-RP-14929091-116-FCC Version 1.2, Issue Date 11 February 2025, which is no longer valid.
5. Result of the tested sample: **Pass**
6. All information marked with a (*) were provided by customer / applicant or authorized representative

Prepared by: Muhammad Faiq Khan
Title: Project Engineer
Date: 11 February 2025

Approved by: Rachid, Acharkaoui
Title: Operations Manager
Date: 11 February 2025



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This laboratory is accredited by DAkkS.
The tests reported herein have been performed in
accordance with its' terms of accreditation.

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1. Customer Information *

1.1. Applicant Information

Company Name:	Octagon I/O Ltd
Company Address:	5.02A Mermaid House, London EC4V 3DS, United Kingdom
Contact Person:	Liliana Cortina
Contact E-Mail Address:	Liliana.cortina@converge.io
Contact Phone No.:	+44 (0)20 3808 3115

1.2. Manufacturer Information

Company Name:	Octagon I/O Ltd
Company Address:	5.02A Mermaid House, London EC4V 3DS, United Kingdom
Contact Person:	Liliana Cortina
Contact E-Mail Address:	Liliana.cortina@converge.io
Contact Phone No.:	+44 (0)20 3808 3115

2. Summary of Testing

2.1. General Information

Applied Standards

Specification Reference:	47CFR15.247
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.247
Specification Reference:	47CFR15.207 and 47CFR15.209
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Sections 15.207 and 15.209

Location

Location of Testing:	UL International Germany GmbH Hedelfinger Strasse. 61, 70327 Stuttgart, GERMANY
Registration Number:	399704

Date Information

Order Date:	11 August 2023
EUT arrived:	19 September 2023
Test Dates:	21 September 2023 to 09 November 2023
EUT returned:	-/-

2.2. Summary of Test Results

DIGITAL TRANSMISSION SYSTEMS (DTS): 2400-2483.5 MHz					
FCC Part 15 Clause	Compliance Test Description	Test Result			
		C	N.C.	N.P.	N.A.
15.207	Transmitter AC Power Line Conducted Emissions	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Part 15.247(a)(2)	Transmitter Minimum 6 dB Bandwidth	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Part 15.35(c)	Transmitter Duty Cycle ⁽¹⁾	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Part 15.247(e)	Transmitter Power Spectral Density	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Part 15.247(b)(3)	Transmitter Maximum (Peak) Output Power	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15.247(d) & 15.209(a)	Transmitter Radiated Emissions	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15.247(d) & 15.209(a)	Transmitter Band Edge Radiated Emissions	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C: COMPLIED N.C.: NOT COMPLIED N.P.: NOT PERFORMED N.A.: NOT APPLICABLE					
Decision rule: Where not otherwise specified or communicated in writing, statements of conformity (e.g. Pass/Fail) are established according to the following decision rule: considering the ILAC G8:2019 chapter 4.2.1 (simple acceptance rule). This leads to a maximum 50% of false accept or false reject when the measured value equals the tolerance limit. See ILAC-G8:09/2019 for further details.					

Note(s):

1. The measurement was performed to assist the average measurements.

2.3. Methods and Procedures

Reference:	ANSI C63.10-2013
Title:	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Reference:	FCC KDB 558074 D01 DTS Meas. Guidance v05r02 April 2, 2019
Title:	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
Reference:	FCC KDB 174176 D01 Line Conducted FAQ v01r01 June 3, 2015
Title:	AC Power-Line Conducted Emissions Frequently Asked Questions

2.4. Deviations from the Test Specification

For the measurements contained within this test report, there were no deviations from, additions to, or exclusions from the test specification identified above.

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT) *

Brand Name:	Converge
Model Name or Number:	Signal Live Hub
Serial Number:	N/A (<i>Radiated RF Test Sample</i>)
Hardware Version Number:	V1
Software Version Number:	N/A
FCC ID:	2A7VH-CSL-101

Brand Name:	Converge
Model Name or Number:	Signal Live Hub
Serial Number:	N/A (<i>Conducted RF Test Sample with SMA connector</i>)
Hardware Version Number:	V1
Software Version Number:	N/A
FCC ID:	2A7VH-CSL-101

3.2. Description of EUT *

The equipment under test was a Bluetooth to cellular gateway supporting Bluetooth Low Energy (BLE) operations in 2.400 - 2.4835 GHz ISM band.

3.3. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.4. Additional Information Related to Testing *

Technology Tested:	Bluetooth – Low Energy		
FCC Equipment Classification:	Digital Transmission System (DTS)		
Type of Unit:	Transceiver		
Operating Frequency Range:	2402 MHz to 2480 MHz		
Channel Spacing:	2 MHz		
Tested Data Rate(s) & Modulation(s):	1 Mbps	GFSK	
	2 Mbps	GFSK	
Antenna Type:	Ceramic Patch Antenna		
Antenna Details:	Internal Antenna		
Antenna Gain:	2 dBi		
Transmit Channels Tested:	Channel ID	RF Channel	Frequency (MHz)
	Bottom	0	2402
	Middle	19	2440
	Top	39	2480
Power Supply Requirement(s):	3.6 V DC / 3 A max via Internal Battery 200-240 V AC from Mains via AC DC adapter		
Highest internally generated clock and/ or oscillator frequency:	2.4 GHz (oscillator frequency for RF application) 64 kHz / MHz (oscillator frequency for internal functionality e.g. bus/ CPU clock etc.)		

3.5. Support Equipment

The following support equipment was used to exercise the EUT during testing:

A. Support Equipment (In-house)

Item	Description	Brand Name	Model Name or Number	Serial Number
1	Test Laptop with "nRF connect V3.7.1"	HP	ProBook 650	5CG614419V
2	AC/DC Power adapter	Samsung	EP-TA20EWE	R37J62G2F64DK3

B. Support Equipment (Manufacturer supplied) *

Item	Description	Brand Name	Model Name or Number	Serial Number
1	-/-	-/-	-/-	-/-

4. Operation and Monitoring of the EUT during Testing

4.1. Operating Modes

The EUT was tested in the following operating mode(s):

- ☒ BT-LE Test Mode: Continuously transmitting modulated carrier on Channel: Bottom / Middle / Top with combination of:
 - Bluetooth Low Energy (BLE) | PRBS9 | 1 Mbps | Maximum Power Settings*
 - Bluetooth Low Energy (BLE) | PRBS9 | 2 Mbps | Maximum Power Settings*

4.2. Configuration and Peripherals

The EUT was tested in the following configuration(s):

EUT Power Supply:

- The EUT was powered with 3.6 V DC via fully charged internal battery.

Test Mode Activation:

- The EUT can be connected with the Test laptop via USB-C cable supplied by the customer. The cables were only used to set the EUT in respective modes and was removed during measurements.
- The test modes were activated using the test software / Radio Tool "nRF Connect V 3.7.1" supplied by the customer. This test software / Radio Tool was installed on the test laptop to enable continuous transmission and to select the required power levels and the test channels.
- *There is an amplifier connected after the Radio module which amplifies the power of the Transmitted signal. The relation between configured power value and amplifier is not linear. The measurements were performed with -8 dBm set through the RF test app and the values measured at the output are after the amplification.

Conducted Measurements:

- All conducted measurements were carried out by using the EUT RF sample with SMA connector soldered on the PCB. The SMA RF connector's attenuation (maximum 1 dB@2.4GHz) was added to as a reference level offset to each of the conducted plots.

Radiated Measurements:

- The radiated samples with integrated antenna was used for radiated emission measurements.
- Before starting final radiated spurious emission measurements "worst case verification" with the EUT in Standing-position & Laying-position was performed by Lab.
- The EUT in Standing-position was found to be the worst case therefore this report includes relevant results.
- Radiated measurements below 30 MHz were performed with the EUT positioned on the turn table and rotating 360 degrees while the loop antenna height was set at 100 cm.
- Radiated measurements above 30 MHz were performed with the EUT positioned on the turn table and rotating 360 degrees while the antenna height varies from 1 to 4 m over the measurement frequency range.
- R&S® EMC32 V11.30.00 Software was used for the Radiated spurious emission measurements.

Duty Cycle Correction Details:

- As the continuous transmission of the EUT ($D \geq 98\%$) cannot be achieved and EUT was transmitting continuously with 56.92 duty cycle (+/- 2% tolerance) with 2 Mbps data rates. Therefore, duty cycle Correction Factor of 4.29 dB was added to all average measurements.

5. Measurements, Examinations and Derived Results

5.1. General Comments

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to Section 6 *Measurement Uncertainty* for details.

In accordance with DAkkS requirements all the measurement equipment is on a calibration schedule. All equipment was within the calibration period on the date of testing.

5.2. Test Results

5.2.1. Transmitter AC Conducted Spurious Emissions

Test Summary:

Test Engineer:	Muhammad Faiq Khan	Test Date:	18 October 2023
Test Sample Serial Number:	N/A (<i>Radiated RF Test Sample</i>)		
Test Site Identification	SR 7/8		

FCC Reference:	Part 15.207
Test Method Used:	ANSI C63.10 Section 6.2 / FCC KDB 174176 and notes below

Environmental Conditions:

Temperature (°C):	22
Relative Humidity (%):	43

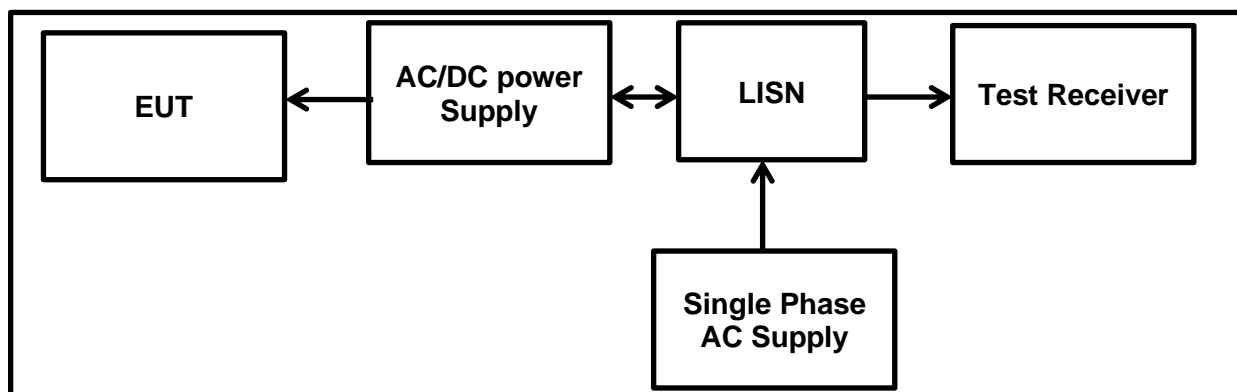
Settings of the Instrument

Detector	Quasi Peak/ Average
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Note(s):

1. In accordance with FCC KDB 174176 Q4, tests were also performed with a 240 VAC 60 Hz as this was within the voltage range marked on the 100-240 VAC~50/60 Hz power supply.
2. The EUT was powered via an external AC/DC power supply. The AC/DC power supply was connected with the LISN during the measurement.
3. The measurements were only performed with 2 Mbps data rate since it was found out to be the worst-case.
4. Pre-scans were performed, and markers placed on the highest live and neutral measured levels. Final measurements were performed on the marker frequencies and the results entered into the tables below.
5. The final measured value, for the given emission, in the table below incorporates the cable loss.
6. All other emissions shown on the pre-scan plot were investigated. Only the highest 6 emissions have been reported in the tables below in accordance with ANSI C63.10 section 6.2.5.
7. Measurements were performed in shielded room (SR7/ 8 Asset Number 1603671). The EUT was placed at a height of 80 cm above the reference ground plane and in a distance of 40 cm from the vertical ground plane at the edge of the table.
8. Measurement software used: Toyo EMI Software; CE measurement software EP5/CE Ver 4.0.1.

Test Setup:



Transmitter AC Conducted Spurious Emissions (continued)**Results: BLE | 1 Mbps | PRBS9 | Bottom Channel****Results: Live / Quasi Peak / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.17565	Live	36.20	64.70	28.50	Complied
0.68485	Live	26.10	56.00	29.90	Complied
0.75887	Live	28.70	56.00	27.30	Complied
2.50619	Live	22.50	56.00	33.50	Complied
3.17437	Live	21.10	56.00	34.90	Complied
13.95817	Live	16.40	60.00	43.60	Complied

Results: Live / Average / 120 VAC 60 Hz

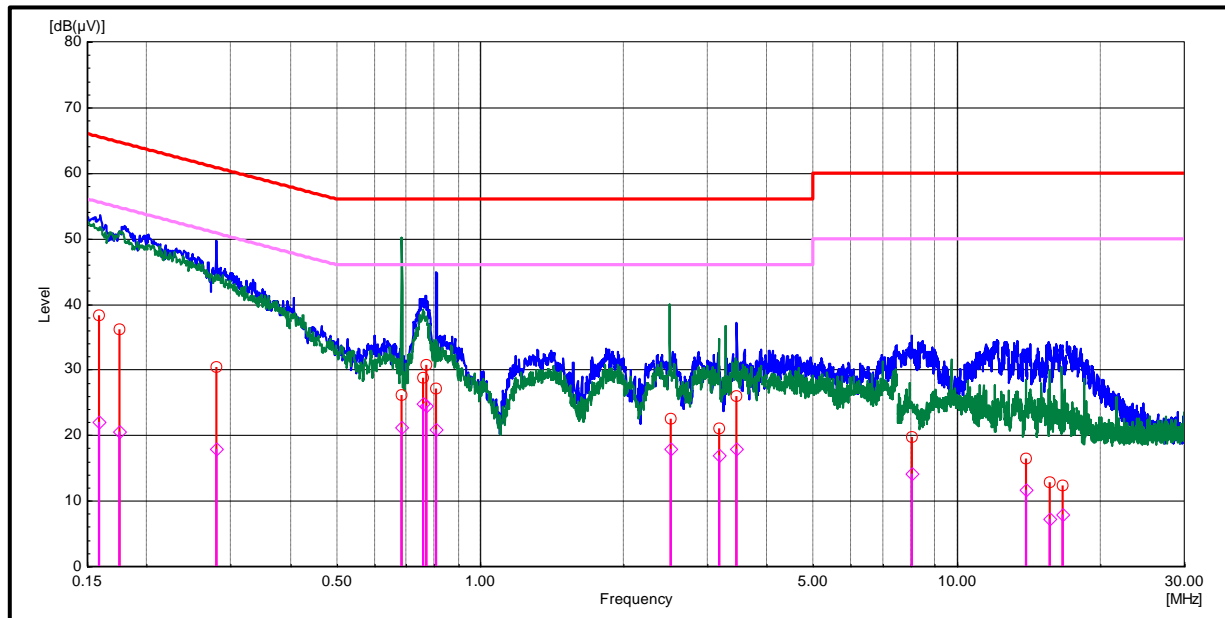
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.17565	Live	20.50	54.70	34.20	Complied
0.68485	Live	21.10	46.00	24.90	Complied
0.75887	Live	24.80	46.00	21.20	Complied
2.50619	Live	18.00	46.00	28.00	Complied
3.17437	Live	17.00	46.00	29.00	Complied
13.95817	Live	11.70	50.00	38.30	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.15882	Neutral	38.20	65.50	27.30	Complied
0.28061	Neutral	30.40	60.80	30.40	Complied
0.77107	Neutral	30.70	56.00	25.30	Complied
0.80761	Neutral	27.10	56.00	28.90	Complied
3.44988	Neutral	25.90	56.00	30.10	Complied
8.05456	Neutral	19.80	60.00	40.20	Complied

Transmitter AC Conducted Spurious Emissions (continued)**Results: BLE | 1 Mbps | PRBS9 | Bottom Channel****Results: Neutral / Average / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.15882	Neutral	22.10	55.50	33.40	Complied
0.28061	Neutral	17.80	50.80	33.00	Complied
0.77107	Neutral	24.40	46.00	21.60	Complied
0.80761	Neutral	20.90	46.00	25.10	Complied
3.44988	Neutral	18.00	46.00	28.00	Complied
8.05456	Neutral	14.20	50.00	35.80	Complied

Result: Pass**Plot: Live and Neutral Line / 120 VAC 60 Hz**

Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

Transmitter AC Conducted Spurious Emissions (continued)**Results: BLE | 1 Mbps | PRBS9 | Bottom Channel****Results: Live / Quasi Peak / 240 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.15427	Live	33.40	65.80	32.40	Complied
0.1781	Live	31.20	64.60	33.40	Complied
0.25573	Live	27.80	61.60	33.80	Complied
0.33365	Live	25.60	59.40	33.80	Complied
0.78791	Live	32.90	56.00	23.10	Complied
3.97689	Live	22.20	56.00	33.80	Complied

Results: Live / Average / 240 VAC 60 Hz

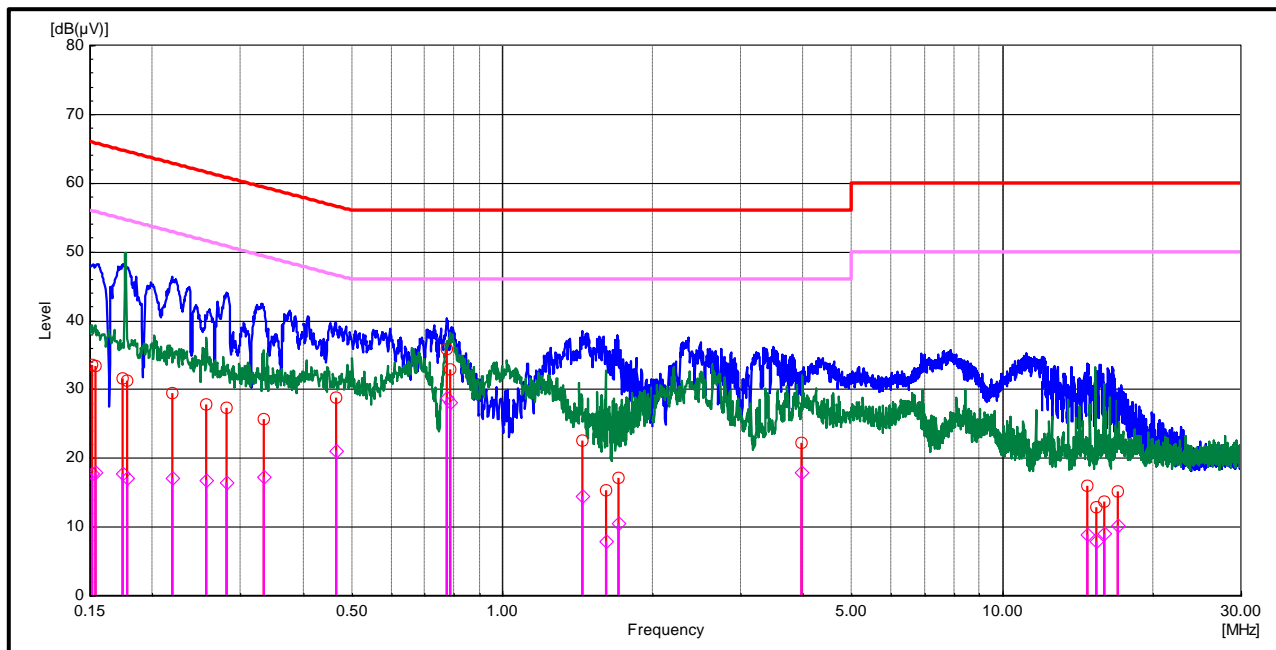
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.15427	Live	17.90	55.80	37.90	Complied
0.1781	Live	17.00	54.60	37.60	Complied
0.25573	Live	16.70	51.60	34.90	Complied
0.33365	Live	17.30	49.40	32.10	Complied
0.78791	Live	28.00	46.00	18.00	Complied
3.97689	Live	18.00	46.00	28.00	Complied

Transmitter AC Conducted Spurious Emissions (continued)**Results: BLE | 1 Mbps | PRBS9 | Bottom Channel****Results: Neutral / Quasi Peak / 240 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.15164	Neutral	33.50	65.90	32.40	Complied
0.17454	Neutral	31.60	64.70	33.10	Complied
0.21894	Neutral	29.40	62.90	33.50	Complied
0.28097	Neutral	27.20	60.80	33.60	Complied
0.46514	Neutral	28.70	56.60	27.90	Complied
0.77551	Neutral	35.90	56.00	20.10	Complied

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.21894	Neutral	17.10	52.90	35.80	Complied
0.28097	Neutral	16.50	50.80	34.30	Complied
0.46514	Neutral	21.00	46.60	25.60	Complied
0.77551	Neutral	28.70	46.00	17.30	Complied
1.44968	Neutral	14.50	46.00	31.50	Complied
1.70685	Neutral	10.50	46.00	35.50	Complied

Result: Pass

Transmitter AC Conducted Spurious Emissions (continued)**Results: BLE | 1 Mbps | PRBS9 | Bottom Channel****Plot: Live and Neutral Line / 240 VAC 60 Hz**

Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

5.2.2. Transmitter Duty Cycle**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	21 September 2023
Test Sample Serial Number:	N/A (Conducted RF Test Sample with SMA connector)		
Test Site Identification	SR 9		

FCC Reference:	Part 15.35(c)
Test Method Used:	FCC KDB 558074 Section 6.0 referencing ANSI C63.10 Section 11.6

Environmental Conditions:

Temperature (°C):	22.5
Relative Humidity (%):	61.9

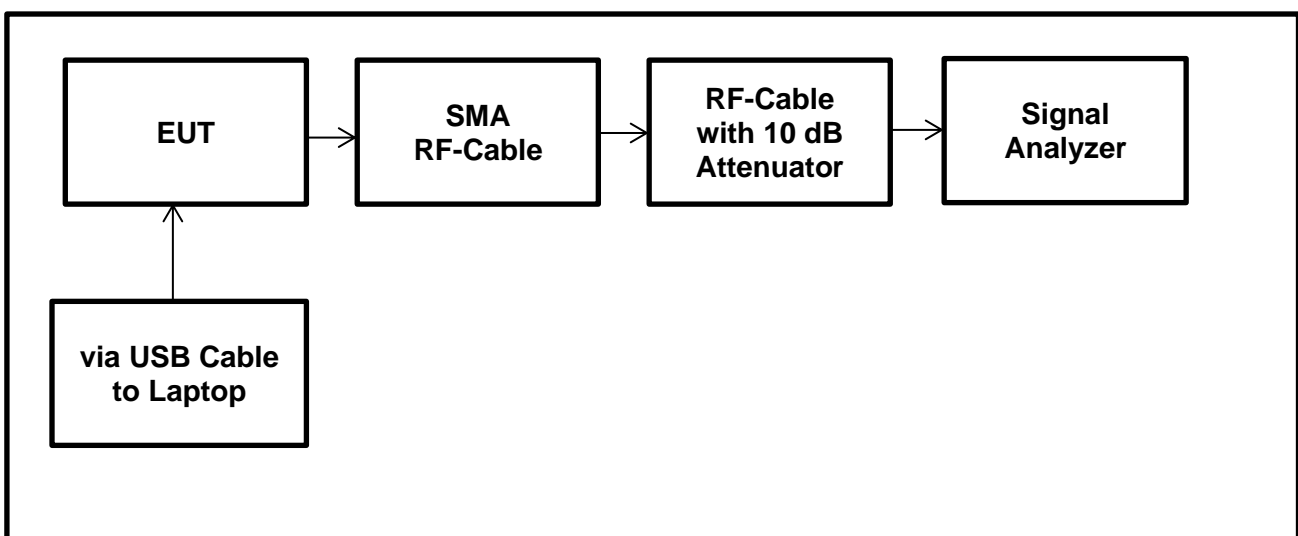
Note:

- The transmitter duty cycle was measured using a spectrum analyser in the time domain and calculated by using the following calculation:

$$\text{Duty Cycle (\%)} = 100 \times [\text{On Time (T}_{\text{ON}})] / [\text{Period(T}_{\text{ON}} + \text{T}_{\text{OFF}}) \text{ or } 100\text{ms whichever is the lesser}]$$

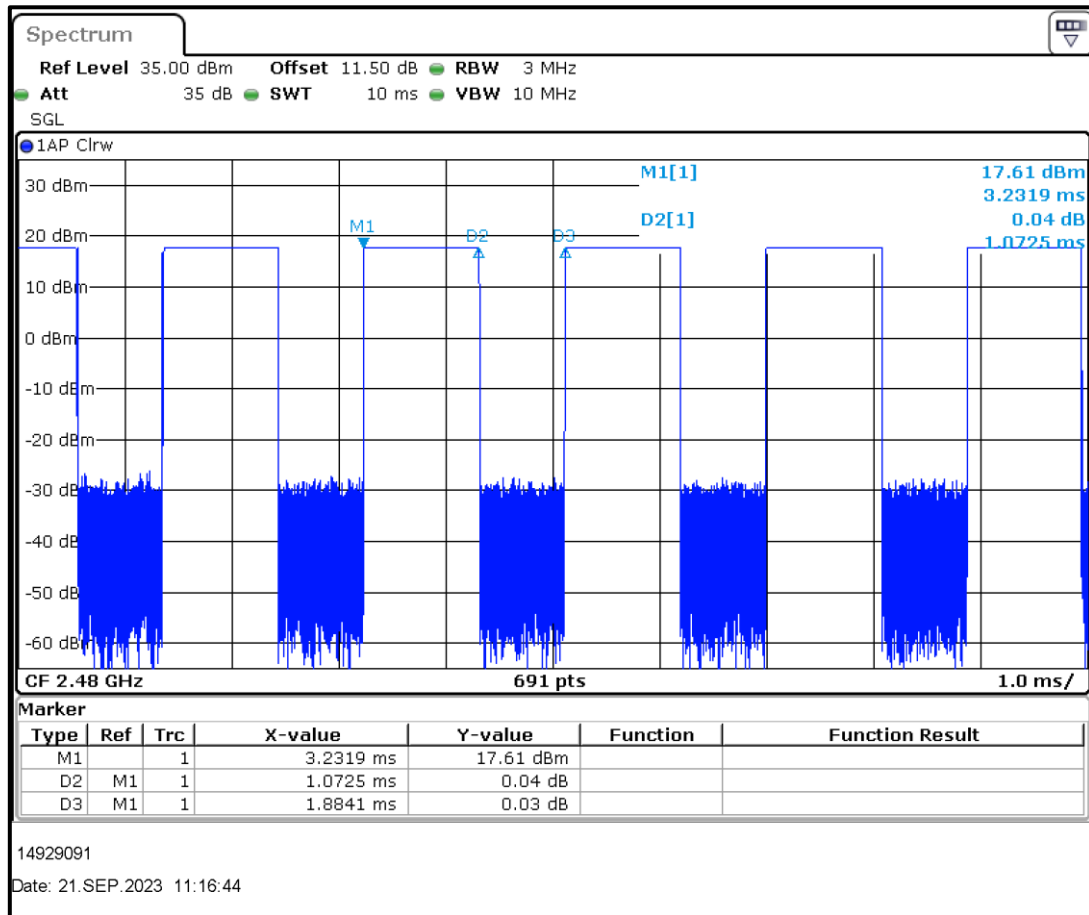
$$\text{Duty Cycle Correction Factor} = 10 \log 1 / [\text{On Time (T}_{\text{ON}})] / [\text{Period(T}_{\text{ON}} + \text{T}_{\text{OFF}}) \text{ or } 100\text{ms whichever is the lesser}]$$
- The measurements were only performed with 2 Mbps data rate since it was found out to be the worst-case.
- The RF port on the EUT was connected to the spectrum analyser using suitable attenuation and RF cable. The measured values takes into consideration the external attenuation correction factors.
 - The SMA (Female) RF Connector soldered on PCB with maximum attenuation of 1 dB at the tested frequencies.
 - The RF cable attenuation maximum 0.5 dB@2.4GHz from the EUT to Analyzer including the 10 dB attenuation at the input of Spectrum Analyzer

Therefore, total a reference level offset 11.50 dB was added to each of the at the tested frequencies conducted plots.

Test Setup:

Transmitter Duty Cycle (continued)**Results: BT-LE / 2 Mbps / PRBS9 / Top Channel**

Pulse On Time (T _{ON}) (ms)	Pulse Period (T _{ON} + T _{OFF}) (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
1.0725	1.8841	56.92	4.29

**Result: Pass**

5.2.3. Transmitter Minimum 6 dB Bandwidth

Test Summary:

Test Engineer:	Muhammad Faiq Khan	Test Date:	21 September 2023
Test Sample Serial Number:	N/A (Conducted RF Test Sample with SMA connector)		
Test Site Identification	SR 9		

FCC Reference:	Part 15.247(a)(2)
Test Method Used:	FCC KDB 558074 Section 8.2 referencing ANSI C63.10:2013 Section 11.8.1 Option 1

Environmental Conditions:

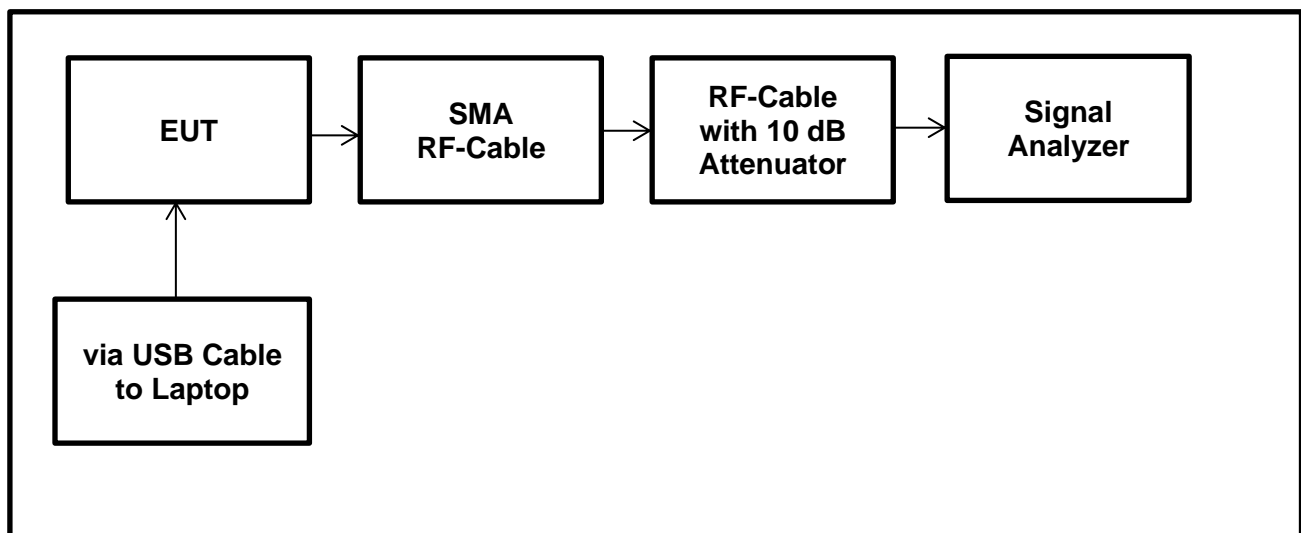
Temperature (°C):	22.5
Relative Humidity (%):	61.9

Notes:

1. The measurements were performed using the above configurations on the bottom, middle and top channels in accordance FCC KDB 558074 Section 8.2 referencing ANSI C63.10 Section 11.8 (11.8.1 Option 1 measurement procedure).
2. The spectrum analyser resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The DTS bandwidth was measured at 6 dB down from the peak of the signal.
3. The measurements were performed with 1Mbps and 2 Mbps data rate since it was found out to be the worst-case.
4. The RF port on the EUT was connected to the spectrum analyser using suitable attenuation and RF cable. The measured values takes into consideration the external attenuation correction factors.
 - The SMA (Female) RF Connector soldered on PCB with maximum attenuation of 1 dB at the tested frequencies.
 - The RF cable attenuation maximum 0.5 dB@2.4GHz from the EUT to Analyzer including the 10 dB attenuation at the input of Spectrum Analyzer

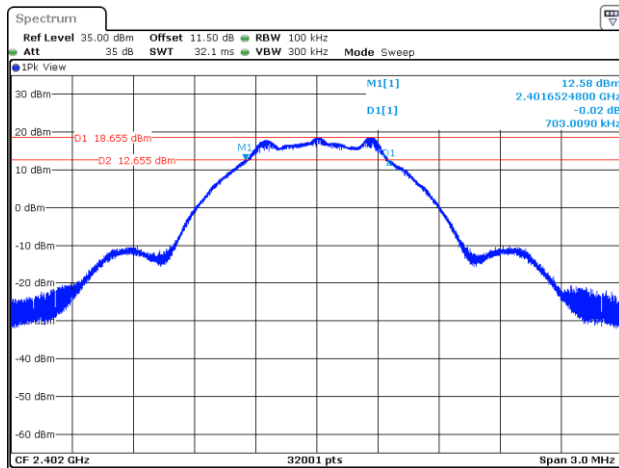
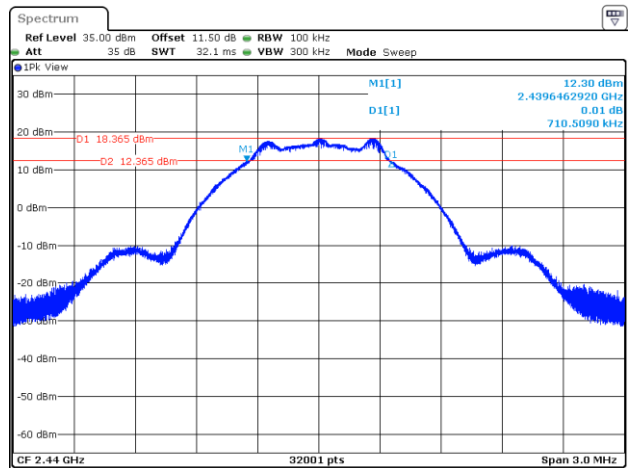
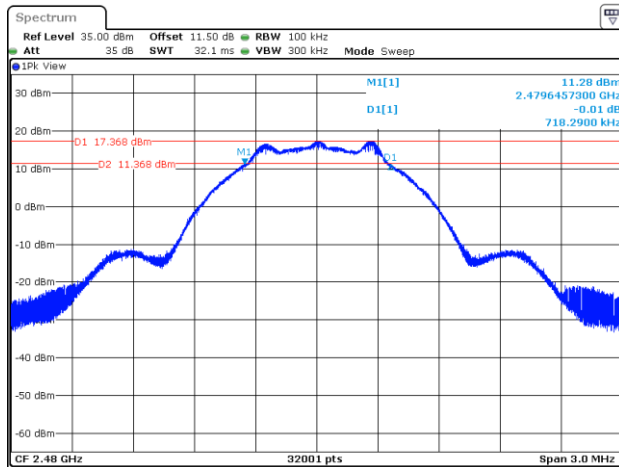
Therefore, total a reference level offset 11.50 dB was added to each of the at the tested frequencies conducted plots.

Test Setup:



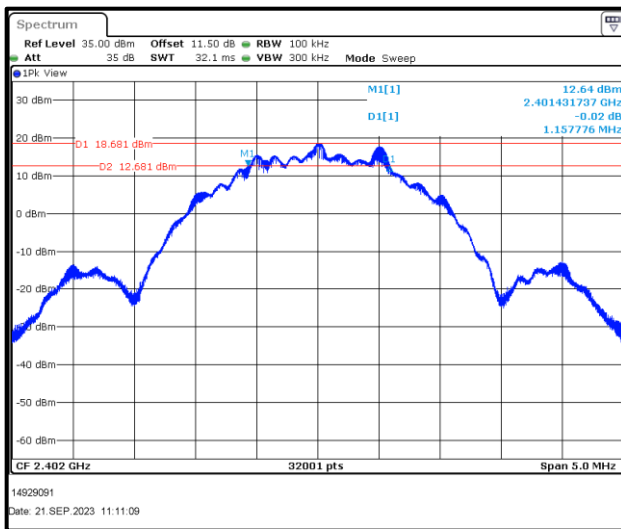
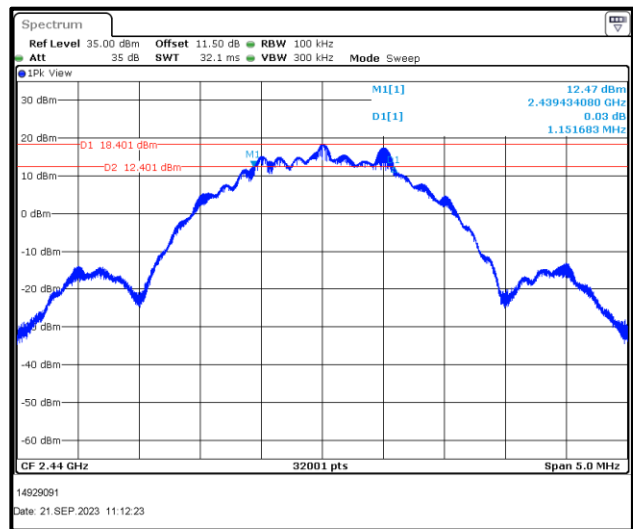
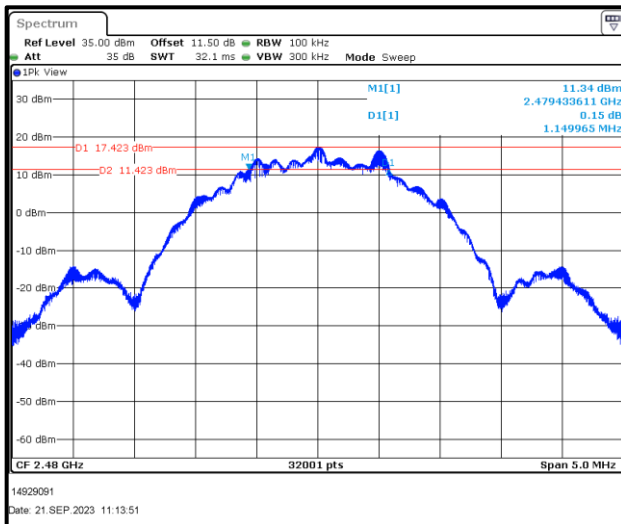
Transmitter Minimum 6 dB Bandwidth (continued)**Results: BT-LE / 1 Mbps / PRBS9**

Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	703.009	≥ 500	203.009	Complied
Middle	710.509	≥ 500	210.509	Complied
Top	718.290	≥ 500	218.290	Complied

**Bottom Channel****Middle Channel****Top Channel****Result: Pass**

Transmitter Minimum 6 dB Bandwidth (continued)**Results: BT-LE / 2 Mbps / PRBS9**

Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	1157.77	≥ 500	657.77	Complied
Middle	1151.68	≥ 500	651.68	Complied
Top	1149.96	≥ 500	649.96	Complied

**Bottom Channel****Middle Channel****Top Channel****Result: Pass**

5.2.4. Transmitter Power Spectral Density**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	21 September 2023
Test Sample Serial Number:	N/A (Conducted RF Test Sample with SMA connector)		
Test Site Identification	SR 9		

FCC Reference:	Part 15.247(e)
Test Method Used:	FCC KDB 558074 Section 8.4 referencing ANSI C63.10 Sections 11.10.2

Environmental Conditions:

Temperature (°C):	22.5
Relative Humidity (%):	61.9

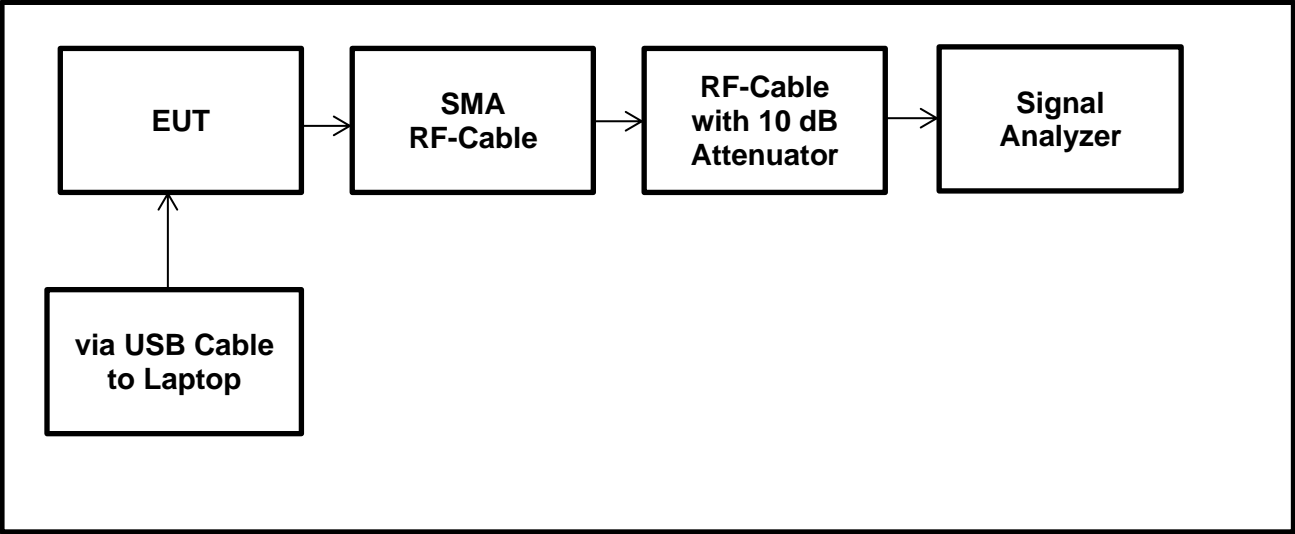
Notes:

- Final measurements were performed using the below configurations on the bottom, middle and top channels.
- The EUT was transmitting at < 98% duty cycle and testing was performed in accordance with ANSI C63.10 Section 11.10.2 Method PKPSD.
- The signal analyser resolution bandwidth was set to 3 kHz and video bandwidth 10 kHz. A Peak detector was used and sweep time was set to Auto. The span was set to 1.5 times the DTS bandwidth. The highest peak of the measured signal was recorded.
- The measurements were only performed with 2 Mbps data rate since it was found out to be the worst-case.
- The RF port on the EUT was connected to the spectrum analyser using suitable attenuation and RF cable. The measured values takes into consideration the external attenuation correction factors.
 - The SMA (Female) RF Connector soldered on PCB with maximum attenuation of 1 dB at the tested frequencies.
 - The RF cable attenuation maximum 0.5 dB@2.4GHz from the EUT to Analyzer including the 10 dB attenuation at the input of Spectrum Analyzer

Therefore, total a reference level offset 11.50 dB was added to each of the at the tested frequencies conducted plots.

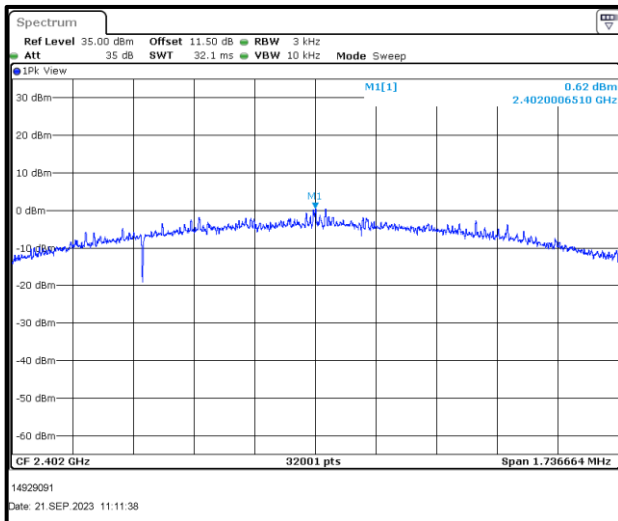
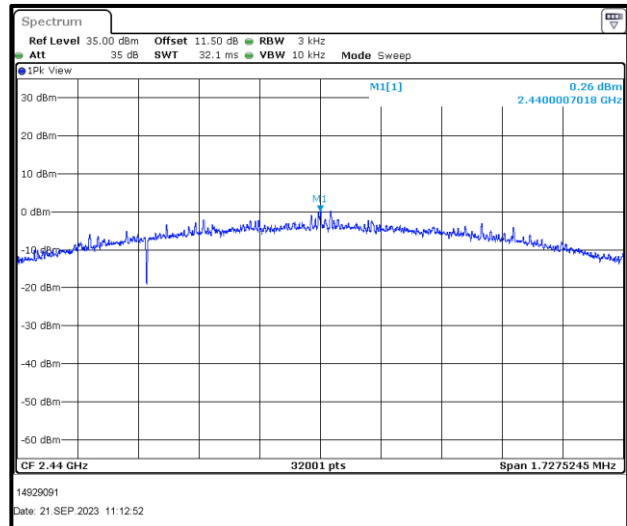
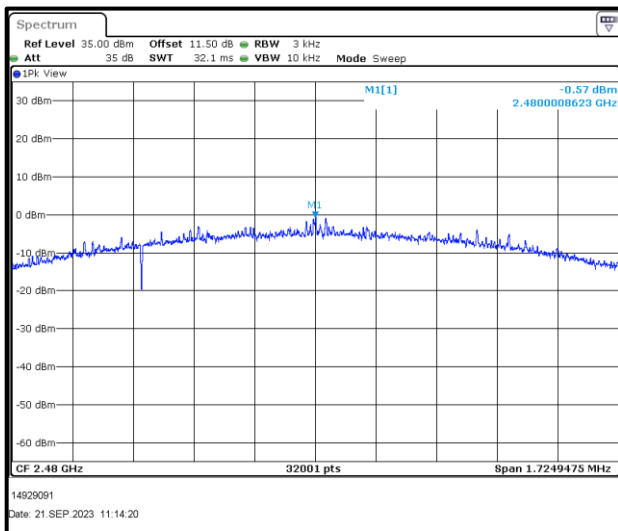
Transmitter Power Spectral Density (continued)

Test Setup:



Transmitter Power Spectral Density (continued)**Results: BT-LE / 2 Mbps / PRBS9**

Channel	Output Power (dBm/3 kHz)	Limit (dBm/3 kHz)	Margin (dB)	Result
Bottom	0.62	8.0	7.38	Complied
Middle	0.26	8.0	7.84	Complied
Top	-0.57	8.0	8.57	Complied

**Bottom Channel****Middle Channel****Top Channel****Result: Pass**

5.2.5. Transmitter Maximum (Peak) Output Power

Test Summary:

Test Engineer:	Muhammad Faiq Khan	Test Date:	21 September 2023
Test Sample Serial Number:	N/A (Conducted RF Test Sample with SMA connector)		
Test Site Identification	SR 9		

FCC Reference:	Part 15.247(b)(3)
Test Method Used:	FCC KDB 558074 Section 8.3.1.3 referencing ANSI C63.10 Sections 11.9.1.1

Environmental Conditions:

Temperature (°C):	22.5
Relative Humidity (%):	61.9

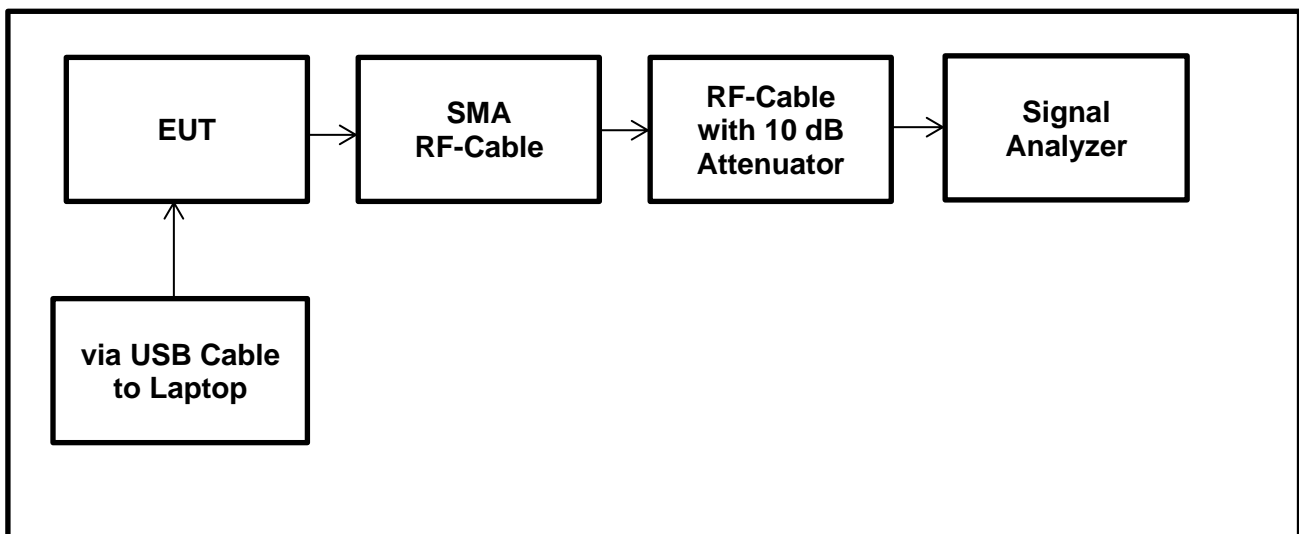
Notes:

- Final measurements were performed using the below configurations on the bottom, middle and top channels.
- The EUT was transmitting at <98% duty cycle and testing was performed in accordance with ANSI C63.10 Section 11.9.1.1 RBW \geq DTS bandwidth Method.
- The RF port on the EUT was connected to the spectrum analyser using suitable attenuation and RF cable. The measured values takes into consideration the external attenuation correction factors.
 - The SMA (Female) RF Connector soldered on PCB with maximum attenuation of 1 dB at the tested frequencies.
 - The RF cable attenuation maximum 0.5 dB@2.4GHz from the EUT to Analyzer including the 10 dB attenuation at the input of Spectrum Analyzer

Therefore, total a reference level offset 11.50 dB was added to each of the at the tested frequencies conducted plots.

- The declared antenna gain was added to conducted power to obtain the relevant EIRP values.

Test Setup:



Transmitter Maximum Peak Output Power (continued)**Results: BT-LE / 1 Mbps / PRBS9**

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	18.73	30.00	11.27	Complied
Middle	18.44	30.00	11.56	Complied
Top	17.47	30.00	12.53	Complied

Results EIRP: BT-LE / 1 Mbps / PRBS9

Channel	Conducted Peak Power (dBm)	Declared Stitched Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	18.73	2.0	20.73	36.00	15.27	Complied
Middle	18.44	2.0	20.44	36.00	15.56	Complied
Top	17.47	2.0	19.47	36.00	16.53	Complied

Result: Pass**Results: BT-LE / 2 Mbps / PRBS9**

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	18.94	30.00	11.06	Complied
Middle	18.65	30.00	11.35	Complied
Top	17.75	30.00	12.25	Complied

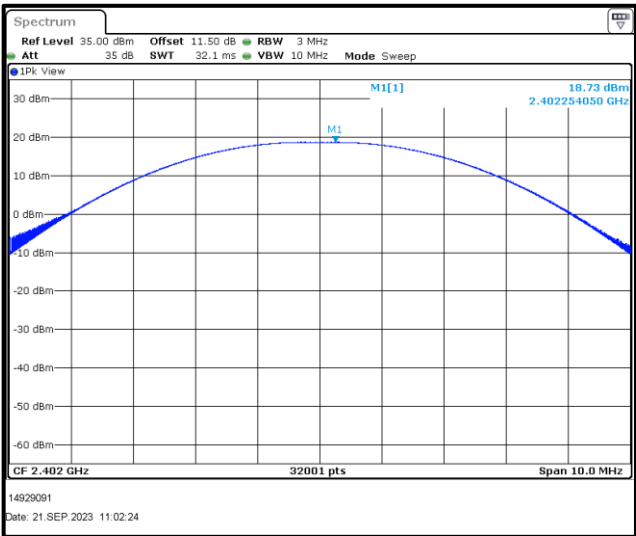
Results EIRP: BT-LE / 2 Mbps / PRBS9

Channel	Conducted Peak Power (dBm)	Declared Stitched Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	18.94	2.0	20.94	36.00	15.06	Complied
Middle	18.65	2.0	20.65	36.00	15.35	Complied
Top	17.75	2.0	19.75	36.00	16.25	Complied

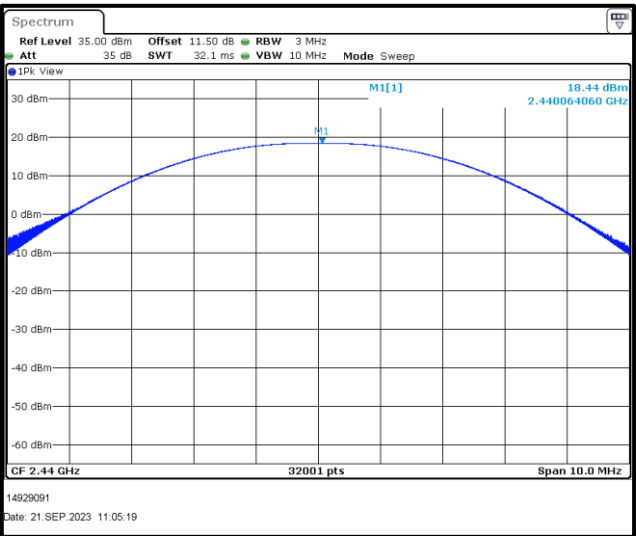
Result: Pass

Transmitter Maximum Peak Output Power (continued)

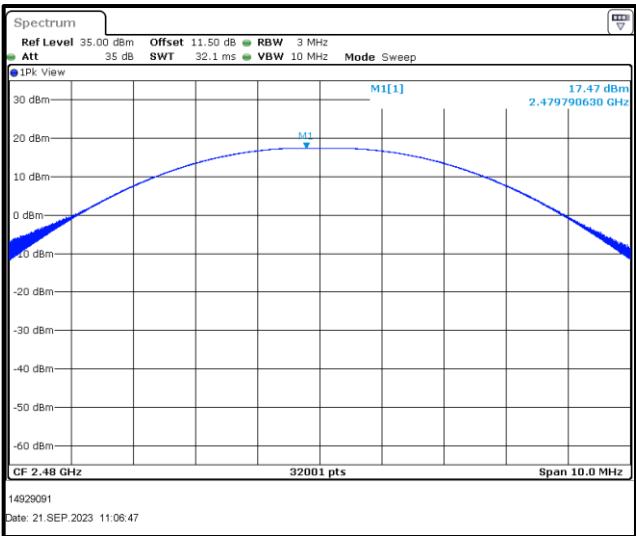
Plots: BT-LE / 1 Mbps / PRBS9



Bottom Channel



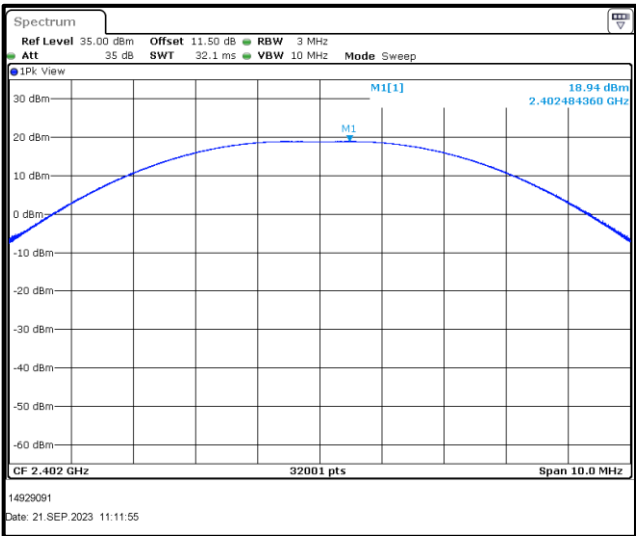
Middle Channel



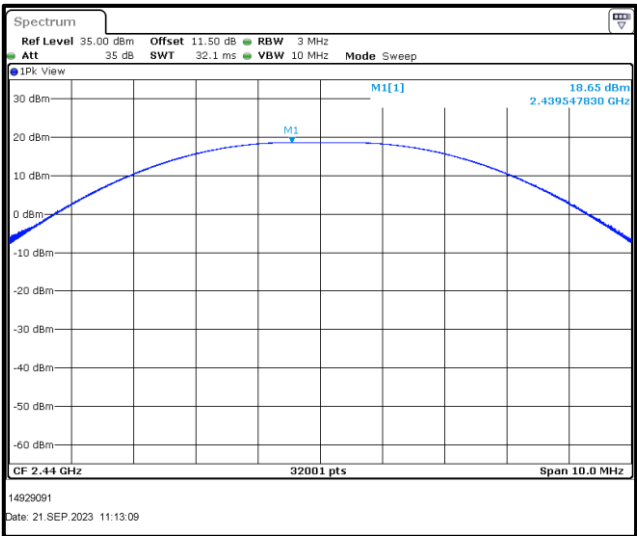
Top Channel

Transmitter Maximum Peak Output Power (continued)

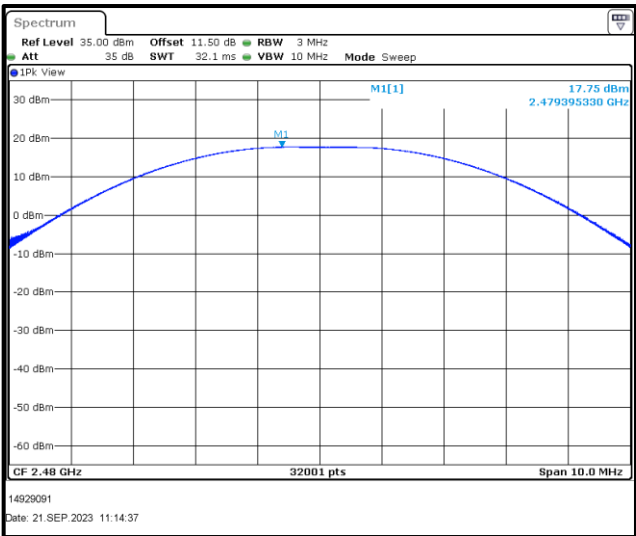
Plots: BT-LE / 2 Mbps / PRBS9



Bottom Channel



Middle Channel



Top Channel

5.2.6. Transmitter Radiated Emissions

Test Summary:

Test Engineer:	Muhammad Faiq Khan	Test Date:	12 October 2023
Test Sample Serial Number:	N/A (<i>Radiated RF Test Sample</i>)		
Test Site Identification	SR 1/2		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	FCC KDB 558074 Sections 8.5 & 8.6 referencing ANSI C63.10 Sections 11.11 and 11.12 ANSI C63.10:2013 Sections 6.3 and 6.4
Frequency Range	9 kHz to 30 MHz

Environmental Conditions:

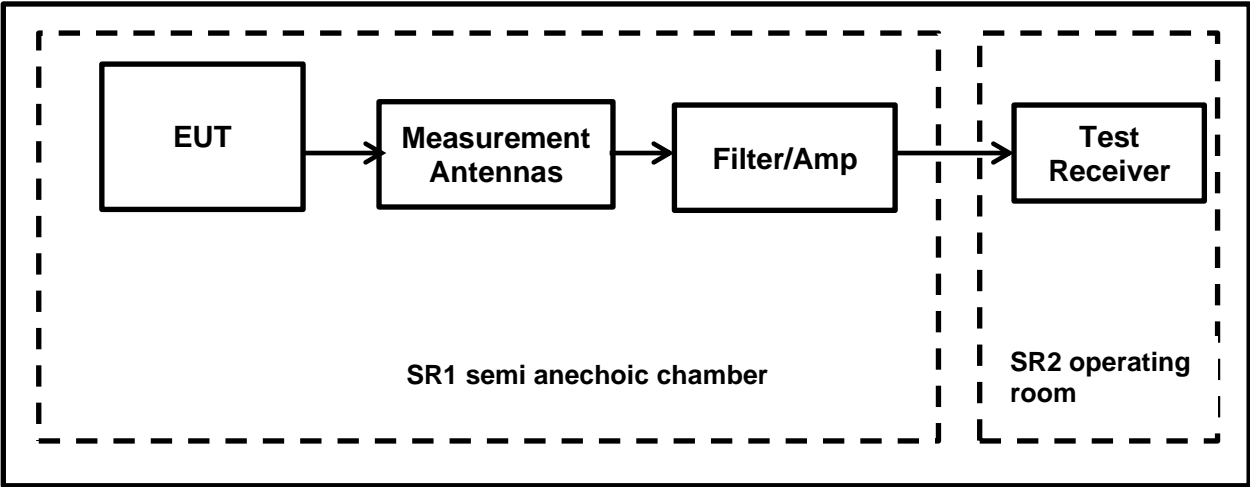
Temperature (°C):	24.3
Relative Humidity (%):	44.2

Notes:

- In accordance with FCC KDB 414788 D01 Radiated Test Site & ANSI C63.10 clause 5.2 an alternative test site that can demonstrate equivalence to an open area test site may be used. Therefore, the measurement was performed in a Semi Anechoic Chamber. (The OATS / SAC comparison data is available upon request).
- The limits are specified at a test distances of 30 and 300 metres. However, as specified in FCC Section 15.31 (f)(2) & ANSI C63.10 clause 6.4.3, measurements may be performed at a closer distance and the measured level extrapolated to the specified measurement distance using the method described in clauses 6.4.4, specifically sub-clause 6.4.4.1 which specifies that the measured level shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 40 dB/decade. Therefore, measurements were performed at a measurement distance of 3 m.
- The measured values at 3 m were extrapolated to the required measurement distances of 300 m and 30 m and compared the specified limits at those distances as follows:
 - 9 kHz- 490 kHz: measured value extrapolated from 3 m to 300 m by subtracting 80 dB at 40 dB /decade.
 - 490 kHz-30 MHz: measured value extrapolated from 3 m to 30 m by subtracting 40 dB at 40 dB /decade.
 The results table shows both the measured levels at 3 m and the same measurement values extrapolated to the actual measurement distance for the limits specified at 30 and 300 metres. Conversely, the limit line shown on the spectrum plot was extrapolated to 3 m from 300 m and 30 m using the 40 dB /decade rule.
- Measurements below 30 MHz were performed in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) at a distance of 3 m. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. The measurement loop antenna height was 100 cm.
- The EUT was configured with the following mode as it had the highest power and widest bandwidth:
 - BT-LE | 2 Mbps | PRBS9 | Bottom Channel
- The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
- Pre-scans were performed, and markers placed on the highest measured levels. The test receiver was set to:
 - Frequency range: 9 kHz-150 kHz: RBW: 1 kHz /VBW: 3 kHz
 - Frequency range: 150 kHz – 30 MHz: RBW: 10 kHz /VBW: 30 kHz
 - Detector: Peak detector
 - Trace Mode: Max Hold

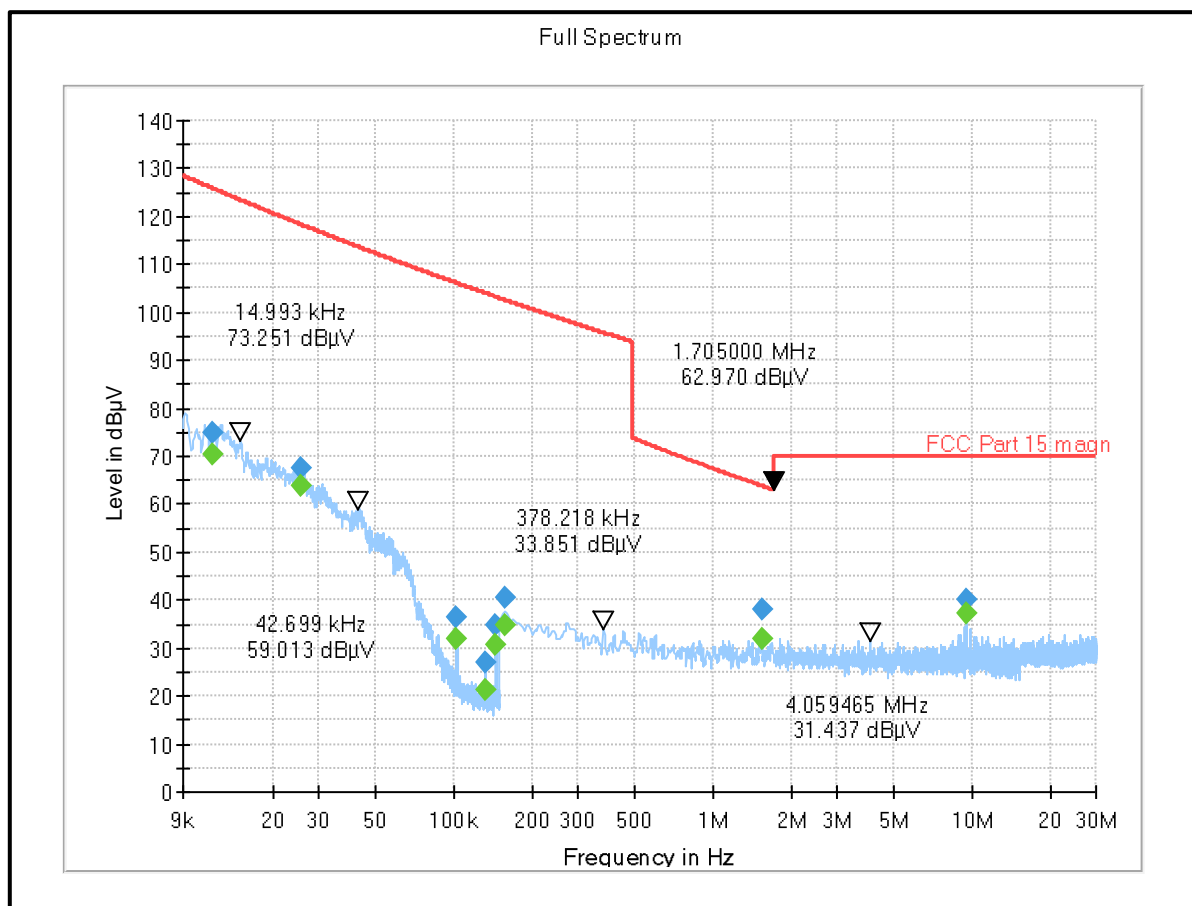
Transmitter Radiated Emissions (continued)

Test Setup:



Transmitter Radiated Emissions (continued)**Results: BT-LE / 2 Mbps / PRBS9 / Bottom Channel**

Frequency (MHz)	Loop Antenna Orientation	MaxPeak Level at 3 m(dBμV/m)	MaxPeak Emission Level extrapolated (dBmV/m)	Limit (dBμV/m)	Margin (dB)	Result
0.011679	90° to EUT	75.11	-4.89	45.89	50.78	Complied
0.025568	90° to EUT	67.56	-12.44	38.36	50.80	Complied
0.101708	90° to EUT	36.33	-43.67	26.16	69.83	Complied
0.131106	0° to EUT	26.94	-53.06	24.06	77.12	Complied
0.145206	0° to EUT	34.64	-45.36	23.23	68.59	Complied
0.156615	0° to EUT	40.49	-39.51	22.62	62.13	Complied
1.532.535	90° to EUT	37.99	-2.01	23.83	25.84	Complied
9.467.995	90° to EUT	40.08	0.08	30.00	29.92	Complied

Plot: 9 kHz – 30 MHz: BT-LE / 2 Mbps / PRBS9 / Bottom Channel**Result: Pass**

Transmitter Radiated Emissions (continued)**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	12 October 2023
Test Sample Serial Number:	N/A (<i>Radiated RF Test Sample</i>)		
Test Site Identification	SR 1/2		

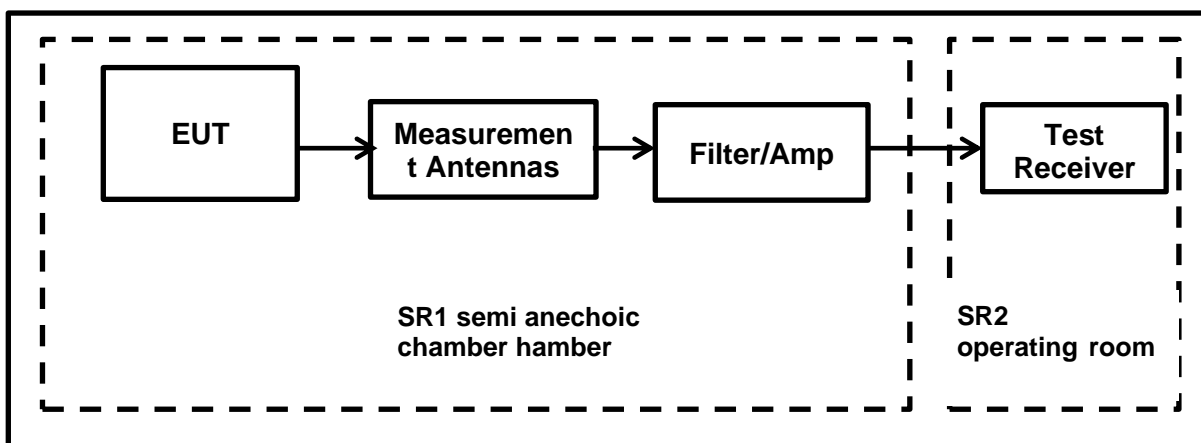
FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	FCC KDB 558074 Sections 8.5 & 8.6 referencing ANSI C63.10 Sections 11.11 and 11.12 ANSI C63.10:2013 Sections 6.3 and 6.5
Frequency Range:	30 MHz to 1000 MHz

Environmental Conditions:

Temperature (°C):	24.3
Relative Humidity (%):	44.2

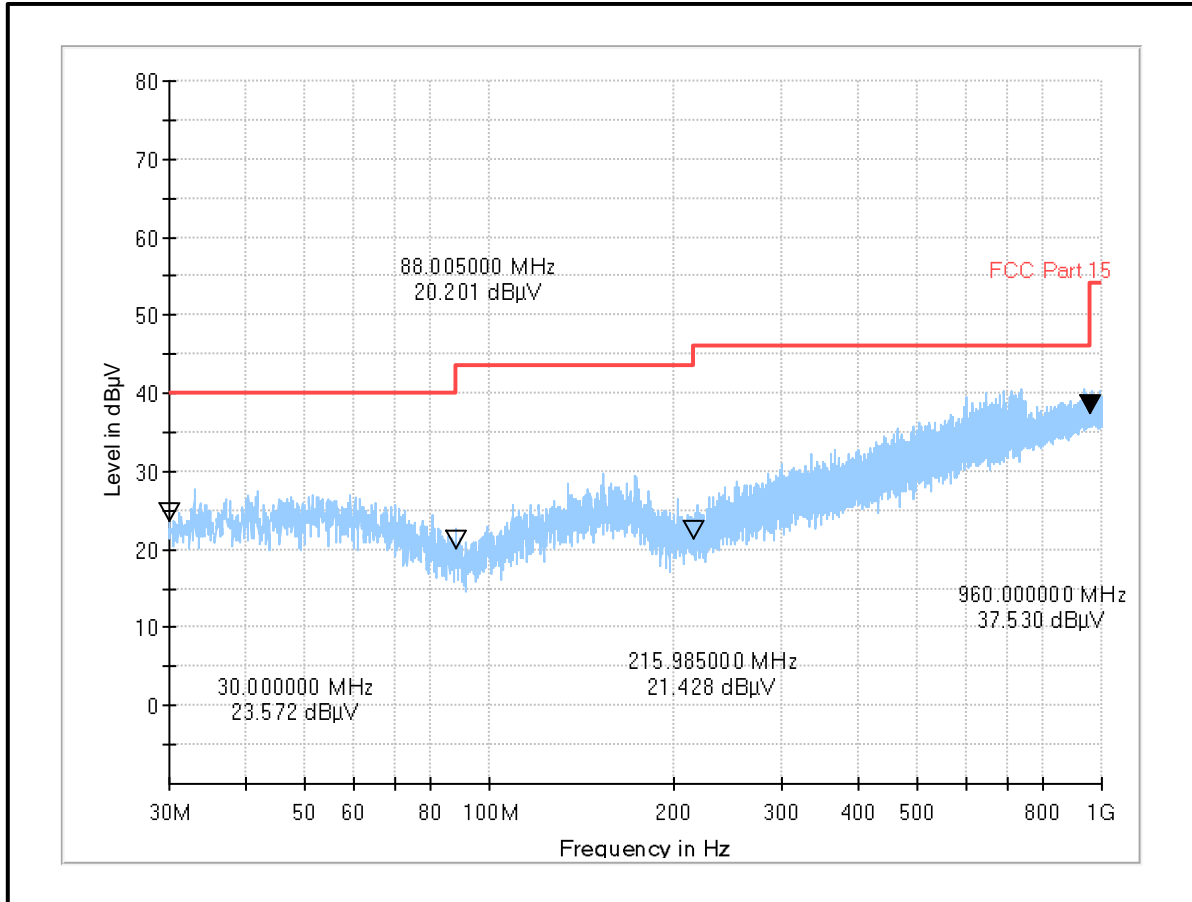
Note(s):

- Measurements below 1 GHz were performed in a semi-anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
- The EUT was configured with the following mode as it had the highest power and widest bandwidth:
 - BT-LE | 2 Mbps | PRBS9 | Bottom Channel
- Pre-scans were performed, and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.
- The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
- All other emissions shown on the pre-scan plot were investigated and found to be below the measurement system noise floor.

Test Setup:

Transmitter Radiated Emissions (continued)**Results: BT-LE / 2 Mbps / PRBS9 / Bottom Channel**

Frequency (MHz)	MaxPeak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Antenna Polarization	Result
No critical emissions were detected					

Plot: 30 MHz – 1GHz: BT-LE / 2 Mbps / PRBS9 / Bottom Channel**Result: Pass**

Transmitter Radiated Emissions (continued)**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	12 October 2023
Test Sample Serial Number:	N/A (<i>Radiated RF Test Sample</i>)		
Test Site Identification	SR 1/2		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	FCC KDB 558074 Sections 8.5 & 8.6 referencing ANSI C63.10 Sections 11.11 and 11.12 ANSI C63.10:2013 Sections 6.3 and 6.6
Frequency Range:	1 GHz to 25 GHz

Environmental Conditions:

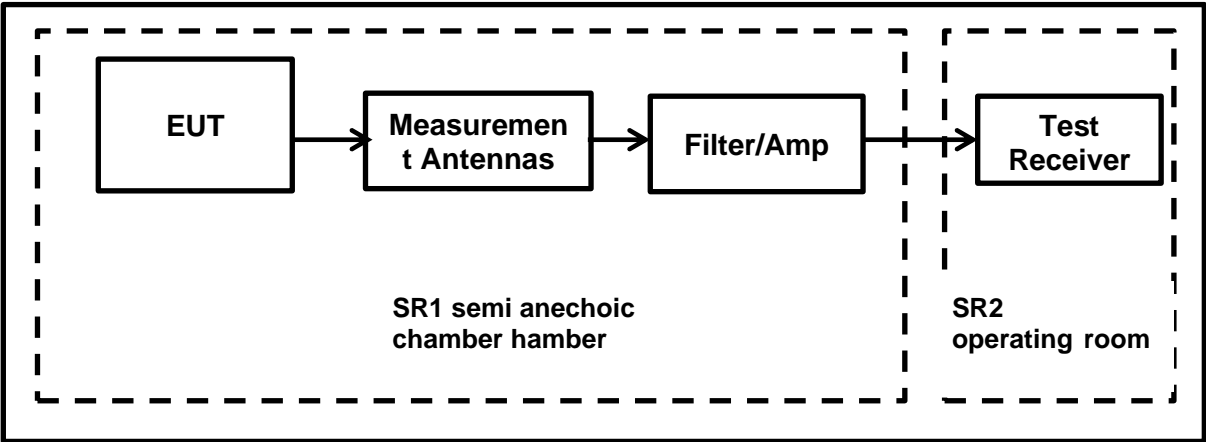
Temperature (°C):	24.3
Relative Humidity (%):	44.2

Notes:

- Pre-scans above 1 GHz were performed in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) with RF absorbers on the floor at a distance of 3 m. The EUT was placed at a height of 1.5 m above the test chamber floor in the centre of the chamber turntable. All measurement antennas were placed at a fixed height of 1.5 m above the test chamber floor, in line with the EUT. Final measurements above 1 GHz were performed in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) with absorber on the floor at a distance of 3 m. The EUT was placed at a height of 1.5 m above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 m to 4 m.
- The EUT was configured with the following mode as it had the highest power and widest bandwidth:
 - BT-LE | 2 Mbps | PRBS9 | Bottom Channel
- Pre-scans were performed, and a marker placed on the highest measured level of the appropriate plot. The test receiver resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz the sweep time was set to auto.
- The emissions shown at frequencies approximately 2.4 GHz to 2.4835 GHz on the 1 GHz to 18 GHz plots are the EUT fundamental for the tested channel.
- *In accordance with ANSI C63.10 Section 6.6.4.3 (Note 1), if the peak measured value complies with the average limit, it is unnecessary to perform an average measurement."
- The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
- In accordance with ANSI C63.10-2013 Section 5.3.3 & 6.5.3 measurements above 18 GHz were performed at closer distance (1 m); because at specified measurement distance (3m) for compliance the instrumentation noise floor was typically close to the radiated emission limit.
- For frequency range between 18 GHz and 25 GHz, no critical emissions were found. All emissions shown on the pre-scans were investigated and found to be below the noise floor of the measurement system.

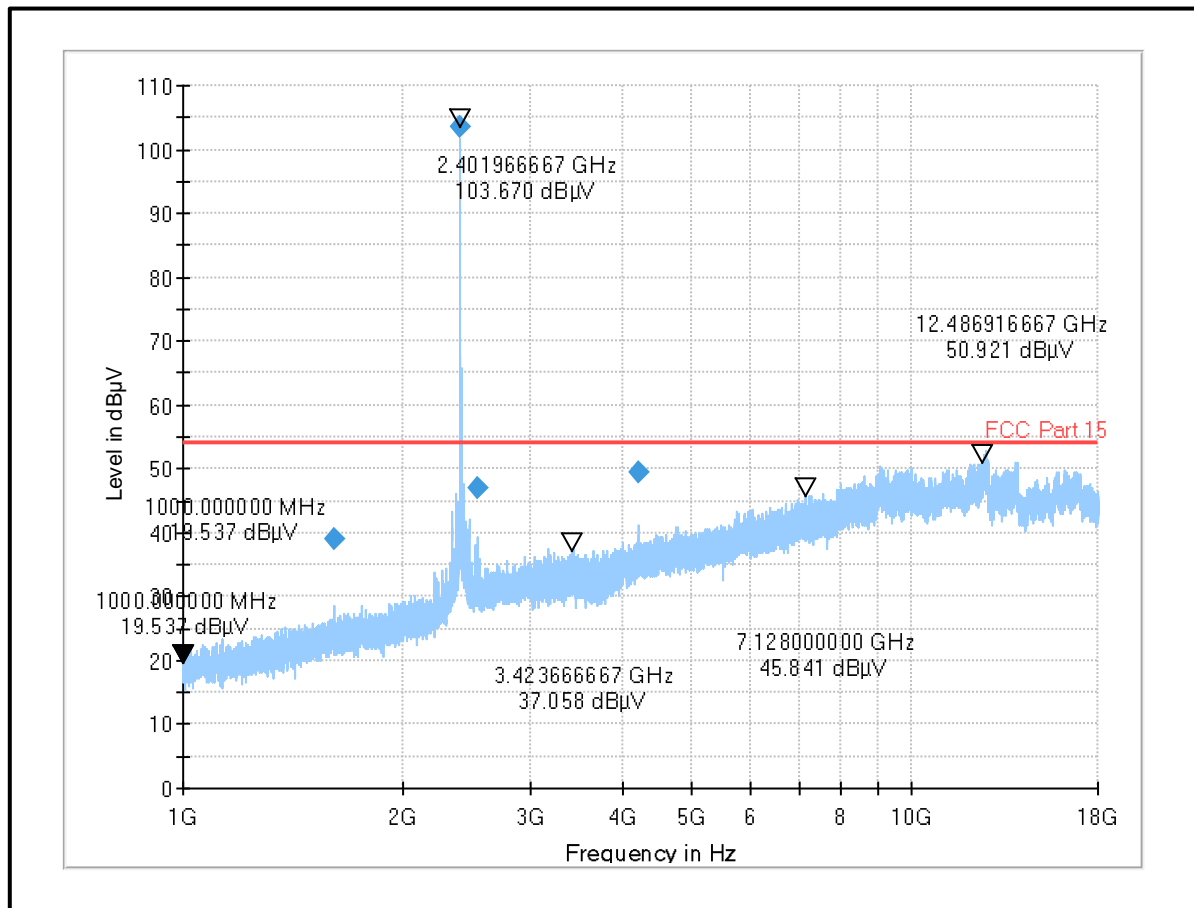
Transmitter Radiated Emissions (continued)

Test Setup:

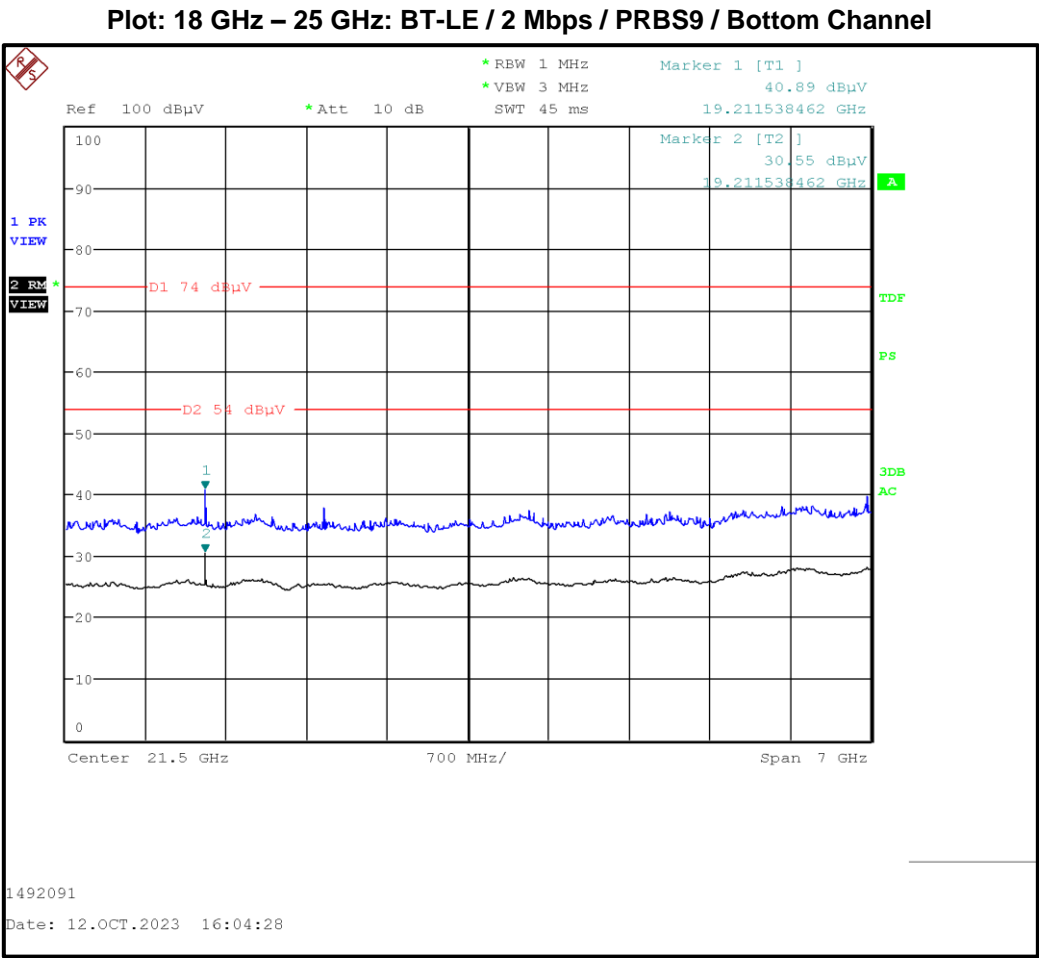


Transmitter Radiated Emissions (continued)**Results: BT-LE / 2 Mbps / PRBS9 / Bottom Channel**

Frequency (MHz)	MaxPeak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Antenna Polarization	Result
1607.533333	38.93	54.00	15.07	Horizontal	Complied
4206.666667	49.60	54.00	4.40	Horizontal	Complied
2529.950000	47.04	54.00	6.96	Horizontal	Complied

Plot: 1 GHz – 18 GHz: BT-LE / 2 Mbps / PRBS9 / Bottom Channel**Result: Pass**

Transmitter Radiated Emissions (continued)
Results: BT-LE / 2 Mbps / PRBS9 / Bottom Channel



Result: Pass

5.2.7. Transmitter Band Edge Radiated Emissions**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	09 November 2023
Test Sample Serial Number:	N/A (<i>Radiated RF Test Sample</i>)		
Test Site Identification	SR 1/2		

FCC Reference:	Parts 15.247(d), 15.209(a) & 15.205(a)
Test Method Used:	DTS emissions in non-restricted frequency bands: FCC KDB 558074 Section 8.5 referencing ANSI C63.10:2013 Sections 11.11
	DTS emissions in restricted frequency bands: FCC KDB 558074 Section 8.6 referencing ANSI C63.10:2013 Sections 11.12
	ANSI C63.10:2013 Sections 6.10.4, 6.10.5

Environmental Conditions:

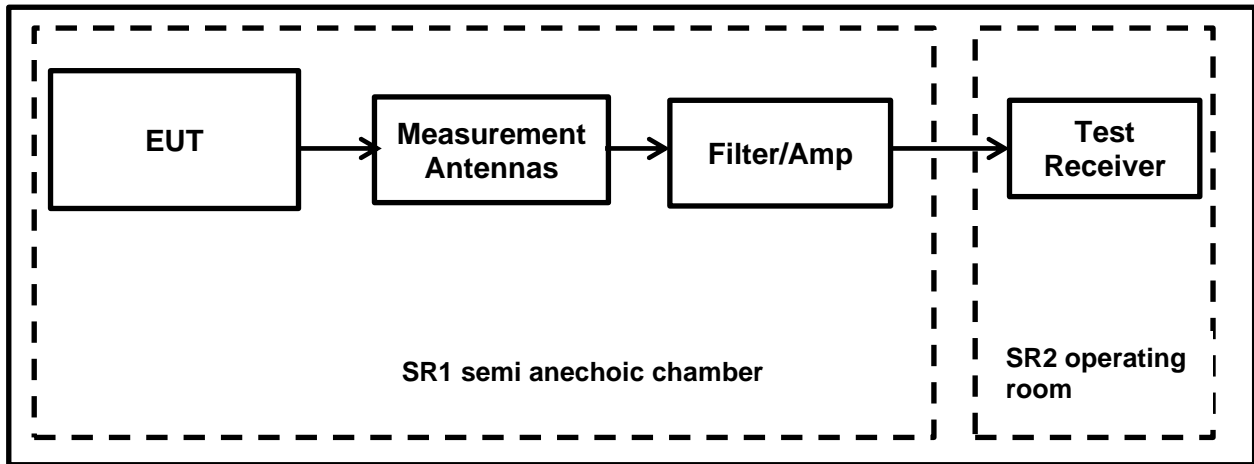
Temperature (°C):	22.3
Relative Humidity (%):	45.9

Note(s):

1. The measurements were in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) with RF absorbers on the floor at a distance of 3 m. The EUT was placed at a height of 1.5 m above the test chamber floor in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 m to 4 m
2. As the lower band edge falls within a non-restricted band, measurements were performed in accordance with FCC KDB 558074 Section 8.5 referencing ANSI C63.10 Section 11.11. Since maximum conducted (Peak) output power was previously measured in accordance with ANSI C63.10 Section 11.11.1(a) lower band edge measurement was performed with a peak detector and the -20 dBc limit applied.
3. As the lower band edge falls within a non-restricted band, only peak measurements are required. The test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The test receiver was left to sweep for 300 sweeps in order to maximise the carrier level and out-of-band emissions. A marker and corresponding reference level line were placed on the peak of the carrier. Marker frequencies and levels were recorded.
4. The restricted band peak measurements were performed in accordance with ANSI C63.10 Section 11.12.2.4.
5. As the upper band edge falls within a restricted band both peak and average measurements were recorded by placing a marker at the edge of the band. For peak measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. For average measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz and RMS detector in linear power averaging mode was used. The test receiver was left to sweep for 300 sweeps in order to maximise the carrier level and out-of-band emissions. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent restricted band of operation (where a higher-level emission was present). Marker frequencies and levels were recorded.
6. There is a restricted band 10 MHz below the lower band edge. The test receiver was set up as follows: the RBW set to 1 MHz, the VBW set to 3 MHz, with the sweep time set to auto couple. Peak and average measurements were performed with their respective detectors. Markers were placed on the highest point on each trace.

Transmitter Band Edge Radiated Emissions (continued)**Note(s): (continued)**

7. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
8. The measurements were only performed with 2 Mbps data rate since it is the widest data rate and was found out to be the worst-case w.r.t to output power.
9. As the continuous transmission of the EUT ($D \geq 98\%$) cannot be achieved and EUT was transmitting continuously with 56.92 duty cycle (+/- 2% tolerance) with 2 Mbps data rates. Therefore, duty cycle Correction Factor of 4.29 dB was added to all average measurements.

Test Setup:

Transmitter Band Edge Radiated Emissions (continued)**Results: BT-LE / 2 Mbps / PRBS9****Results: Lower Band Edge / Peak**

Frequency (MHz)	Peak Level (dB μ V/m)	-20 dBc Limit (dB μ V/m)	Margin (dB)	Result
2399.91	62.54	77.42	14.88	Complied
2400.00	64.84	77.42	12.58	Complied

Results: 2310 to 2390 MHz Restricted Band / Peak

Frequency (MHz)	Peak Level (dB μ V/m)	Peak Limit (dB μ V/m)	Margin (dB)	Result
2382.17	53.33	74.00	20.67	Complied

Results: 2310 to 2390 MHz Restricted Band / Average

Frequency (MHz)	Average Level (dB μ V/m)	Duty Cycle Correction Factor (dB)	Corrected Average Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2370.00	44.50	4.29	48.89	54.00	5.11	Complied

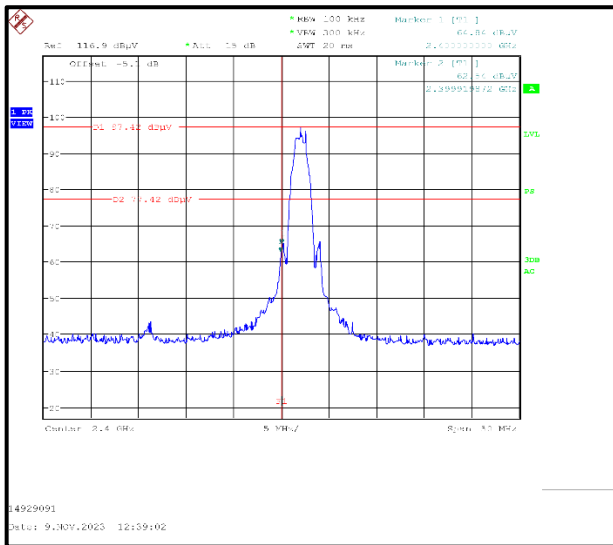
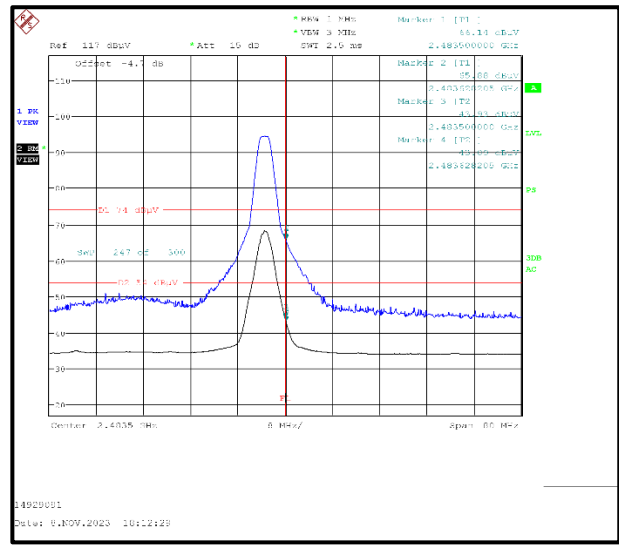
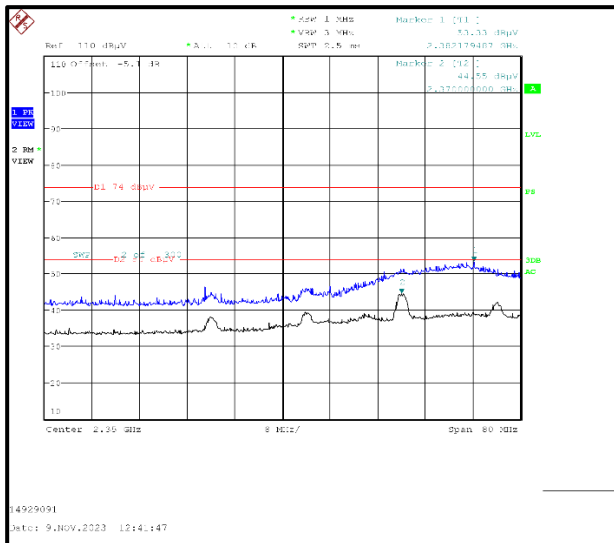
Results: Upper Band Edge / Peak

Frequency (MHz)	Peak Level (dB μ V/m)	Peak Limit (dB μ V/m)	Margin (dB)	Result
2483.50	66.14	74.00	7.86	Complied
2483.62	65.88	74.00	8.12	Complied

Results: Upper Band Edge / Average

Frequency (MHz)	Average Level (dB μ V/m)	Duty Cycle Correction Factor (dB)	Corrected Average Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2483.50	43.93	4.29	48.22	54.00	5.78	Complied
2483.62	43.00	4.29	47.29	54.00	6.71	Complied

Result: Pass

Transmitter Band Edge Radiated Emissions (continued)**Results: BT-LE / 2 Mbps / PRBS9****Lower Band Edge Peak Measurement****Upper Band Edge Peak & Average Measurement****2310 MHz to 2390 MHz Restricted Band****Result: Pass**

6. Measurement Uncertainty

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

The uncertainty of the result may need to be taken into account when interpreting the measurement results.

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor such that a confidence level of approximately 95% is maintained. For the purposes of this document “approximately” is interpreted as meaning “effectively” or “for most practical purposes”.

Measurement Type	Confidence Level (%)	Calculated Uncertainty
Minimum 6 dB Bandwidth	95%	±0.87 %
Transmitter Duty Cycle	95%	±3.4%
Conducted Maximum Peak Output Power	95%	±0.59 dB
Power spectral density	95%	±0.59 dB
Radiated Spurious Emissions	95%	±3.10 dB
Band Edge Radiated Emissions	95%	±3.10 dB

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty the published guidance of the appropriate accreditation body is followed.

7. Used equipment

Test site: SR 1/2

ID	Manufacturer	Type	Model	Serial	Calibration Date	Cal. Cycle (months)
1	Rohde & Schwarz	Antenna, Loop	HFH2-Z2	831247/012	18/07/2023	36
377	BONN Elektronik	Amplifier, Low Noise Pre	BLMA 0118-1A	025294B	18/07/2023	12
460	Deisel	Turntable	DT 4250 S	n/a	n/a	n/a
465	Schwarzbeck	Antenna, Trilog Broadband	VULB 9168	9168-240	02/09/2020	43
496	Rohde & Schwarz	Antenna, log. - periodical	HL050	100297	22/08/2022	24
588	Maturo	Controller	NCD	029/7180311	n/a	n/a
591	Rohde & Schwarz	Receiver	ESU 40	100244/040	13/07/2023	12
669	Rohde & Schwarz	EMI Test Receiver	ESW 44	103087	13/07/2023	18
607	Schwarzbeck	Antenna broadband horn antenna	BBHA 9170	9170-561	15/10/2019	55
608	Rohde & Schwarz	Switch Matrix	OSP 120	101227	lab verification	n/a
628	Maturo	Antenna mast	CAM 4.0-P	224/19590716	n/a	n/a
629	Maturo	Kippeinrichtung	KE 2.5-R-M	MAT002	n/a	n/a
-/-	Testo	Thermo-Hygrometer	608-H1	01	lab verification	n/a
328	SPS	AC/DC power distribution system	PAS 5000	A2464 00/2 0200	lab verification	n/a
1603665	Siemens Matsushita Components	semi-anechoic chamber SR1/ 2	-/-	B83117-A1421-T161	n/a	n/a
681	Maturo	Antenna mast, tilting	BAM4.5-P	402/0718.1	n/a	n/a

Test site: SR 9

ID	Manufacturer	Type	Model	Serial	Calibration Date	Cal. Cycle (months)
445	Huber & Suhner	RF Attenuator (10 dB)	6810.17.AC	--	lab verification	12
637	Rohde & Schwarz	Spectrum Analyzer	FSV40	101587	12/07/2023	12
-/-	Testo	Thermo-Hygrometer	608-H1	07	lab verification	n/a
-/-	Huber & Suhner	RF Cable (up to 18 GHz)	-/-	-/-	lab verification	n/a
327	SPS	AC/DC power distribution system	PAS 5000	A2464 00/1 0200	lab verification	n/a
1603668	Siemens Matsushita Components	shielded room		B83117-B1422-T161	n/a	n/a

Test site: SR 7/8

ID	Manufacturer	Type	Model	Serial No.	Calibration Date	Cal. Cycle
22	Rohde & Schwarz	Artificial Mains	ESH3-Z5	831767/014	18.07.2023	12
23	Rohde & Schwarz	Artificial Mains	ESH3-Z5	831767/013	18.07.2023	12
215	Rohde & Schwarz	Artificial Mains Network	ESH2-Z5	879675/002	18.07.2023	24
349	Rohde & Schwarz	Receiver, EMI Test	ESIB7	836697/009	18.07.2023	12
351	Rohde & Schwarz	network, Artificial Mains	ESH3-Z5	862770/018	18.07.2023	12

8. Report Revision History

Version Number	Revision Details		
	Page No(s)	Clause	Details
1.0	-	-	Initial Version
1.1	12-15	5.2.1	Result updated according to comment
	20	5.2.4	Result added according to comment
	29, 32, 34	5.2.6	Notes updated
	43	7	Equipment calibration information updated
1.2	9,12,13,14,15,16,18,20,21,24,26,27,28,29,31,32,33,34,36,37,40,41	-	Correction of power level
Test Report Version 1.3 supersede Version 1.2 with immediate effect Test Report No. UL-RPT-RP-14929091-116-FCC Version 1.3, Issue Date 11 February 2025 replaces Test Report No. UL-RPT-RP-14929091-116-FCC Version 1.2, Issue Date 12 JUNE 2024, which is no longer valid.			
1.3	Page No(s)	Clause	Details
	20,21,24,26-28	-	Correction of power level

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