TEST REPORT

Test Report No. : UL-RPT-RP-13926414-416-FCC

Applicant	:	TQ-Systems GmbH
Model No.	:	HPR Display V02
FCC ID	:	2ABQT-Q102
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 1.0
5. Result of the tested sample: **PASS**

Prepared by: Sercan, Usta
Title: Laboratory Engineer
Date: 21 March 2022

Approved by: Ajit, Phadtare
Title: Lead Test Engineer
Date: 21 March 2022

Deutsche Akkreditierungsstelle D-PL-19381-02-00

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

UL INTERNATIONAL GERMANY GMBH
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STU.CTECHLab@ul.com

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1. Customer Information

1.1.Applicant Information

Company Name:	TQ-Systems GmbH
Company Address:	Wildmoos 1, 82266 Inning am Ammersee, Germany
Company Phone No.:	+49 8153 9308-0
Company E-Mail:	info@tq-group.com
Contact Person:	Andreas Böhm
Contact E-Mail Address:	andreas.boehm@tq-group.com
Contact Phone No.:	+49 8153 9308-337

1.2.Manufacturer Information

Company Name:	FTA d.o.o.
Company Address:	Cesta Leona Dobrotinška 21a, SI-3230 Šentjur, Slovenia
Company Phone No.:	+386 3 746 19 35
Company E-Mail:	info@fta.si
Contact Person:	Blaž Šelekar
Contact E-Mail Address:	blaz.selekar@fta.si
Contact Phone No.:	+386 3 746 19 31

2. Summary of Testing

2.1. General Information

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

Applied Standards

Location

Location of Testing:	UL International Germany GmbH Hedelfinger Str. 61 70327 Stuttgart Germany
Test Firm Registration:	399704

Date information

Order Date:	29 July 2021
EUT arrived:	27 January 2022 & 08 February 2022
Test Dates:	04 February 2022 to 22 February 2022
EUT returned:	-/-

2.1.1.Summary of Test Results

Clause	Measurement	Complied	Did not comply	Not performed	Not applicable
Part 15.207	Transmitter AC Conducted Emissions	☒	☐	☐	☐
Part 15.247(a)(2)	Transmitter Minimum 6 dB Bandwidth	☒	☐	☐	☐
Part 15.35(c)	Transmitter Duty Cycle(1)	☒	☐	☐	☐
Part 15.247(e)	Transmitter Power Spectral Density	☐	☐	☒	☐
Part 15.247(b)(3)	Transmitter Maximum (Peak) Output Power	☒	☐	☐	☐
Part 15.247(d) & 15.209(a)	Transmitter Radiated Emissions	☒	☐	☐	☐
Part 15.247(d) & 15.209(a)	Transmitter Band Edge Radiated Emissions	☒	☐	☐	☐

Note(s):

1. The measurement was performed to assist in the calculation of the average measurements.
2. In accordance with ANSI C63.10-2013 Section 11.10.1, PSD is not required if the maximum conducted output power is less than the PSD limit of 8 dBm / 3 kHz. The PSD level is therefore deemed to be equal to the measured total output power.

2.2. 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

2.3. 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:	TQ-Systems
Model Name or Number:	HPR Display V02
Serial Number:	UL_CERT_RADIO_DTM_TX_01 *(Radiated RF Sample)*
Hardware Version Number:	0.1.10
Software Version Number:	Special DTM (Direct Test Mode) Transmit Firmware
FCC ID:	2ABQT-Q102

Brand Name:	TQ-Systems
Model Name or Number:	HPR Display V02
Serial Number:	UL_CERT_COND_DTM_TX_01 *(Conducted RF Sample)*
Hardware Version Number:	0.1.10
Software Version Number:	Special DTM (Direct Test Mode) Transmit Firmware
FCC ID:	2ABQT-Q102

3.2. Description of EUT

The equipment under test was an eBike Display Model: HPR Display V02 supporting Bluetooth Low Energy (BLE) & ANT+ (Proprietary) operations in 2.4 - 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 / Digital Transmission System		
Type of Unit:	Transceiver		
Power Supply Requirement(s):	Nominal	13.2 V DC / 0.2 A max	
Channel Spacing:	2 MHz		
Modulation:	GFSK		
Data Rate:	1 Mbps		
Measured Maximum Conducted Output Power:	2.69 dBm		
Declared Antenna Gain:	0 dBi		
Antenna Type:	Integral PCB Antenna		
Antenna Details:	Printed on PCB		
Transmit Frequency Range:	2402 MHz to 2480 MHz		
Transmit Channels Tested:	**Channel ID**	**RF Channel**	**Channel Frequency (MHz)**
	Bottom	37	2402
	Middle	19	2444
	Top	39	2480

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	Laboratory DC Power Supply	GW	GPS-1850D	7662217
2	Laboratory DC Power Supply	Conrad	PS-2403D	M42/CP 6320-01

B. Support Equipment (Manufacturer supplied)

Item	Description	Brand Name	Model Name or Number	Serial Number
1	Display Power Supply Cable (to EUT's red connector)	TQ-Systems	P/N:337384	N/A
2	Remote Connection Cable with Push Button (to EUT's green connector)	CHOGORI	N/A	N/A

4. Operation and Monitoring of the EUT during Testing

4.1. Operating Modes

The EUT was tested in the following operating mode(s):
☒ Continuously transmitting modulated carrier with combination of • Bluetooth Low Energy (BLE) | PRBS9 | 1 Mbps | Maximum Power Settings + 4 dBm (PWR 4)

4.2. Configuration and Peripherals

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

- The customer supplied test instructions 'HPR50.DCB.EMV-Test-Setup.0002.pdf', Rev 1.0, Issue Date 17.11.2021 was used to configure the EUT.

EUT Power Supply:

- The EUT was powered with 13.2 V DC via laboratory power supply.

Test Mode Activation:

- EUT has a button to set the channel of the test. By pressing this button required channel set to related test channel. EUT display shows the channel accordingly.
- EUT has external remote control with power control buttons. By pressing these buttons EUT set to maximum power and controlled from EUT display.
- The transmitter test modes were configured to maximum supported power settings (PWR 4).
- As the EUT continuous transmission of the EUT (D ≥ 98%) cannot be achieved and EUT was transmitting continuously with a constant Duty Cycle of 62.79 % (duty cycle variations are less than ±2%). Therefore, a Duty Cycle Correction Factor of 2.02 dB was added to all average measurements, to compute the corrected average values of the emissions that would have been measured had the test been performed at 100% Duty Cycle.

AC Conducted Line Measurements:

- The radiated EUT were used for AC conducted emissions measurements.

Conducted Measurements:

- All conducted measurements were carried out by using conducted sample SMA (Female) RF Cable soldered on the PCB by the customer. The maximum attenuation of 0.40 dB at the tested frequencies was added to a reference level offset to each of the conducted plots.

Radiated Measurements:

- The radiated sample with integrated antenna was used.
- 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 to 80 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 Measurement Software V10.60.10 was used for the radiated spurious emission 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:	M.Asim,Shahzad	**Test Date:**	15 February 2022
Test Sample Serial Number:	UL_CERT_RADIO_DTM_TX_01 *(Radiated RF Sample)*		
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):	24.9
Relative Humidity (%):	35.5

Settings of the Instrument

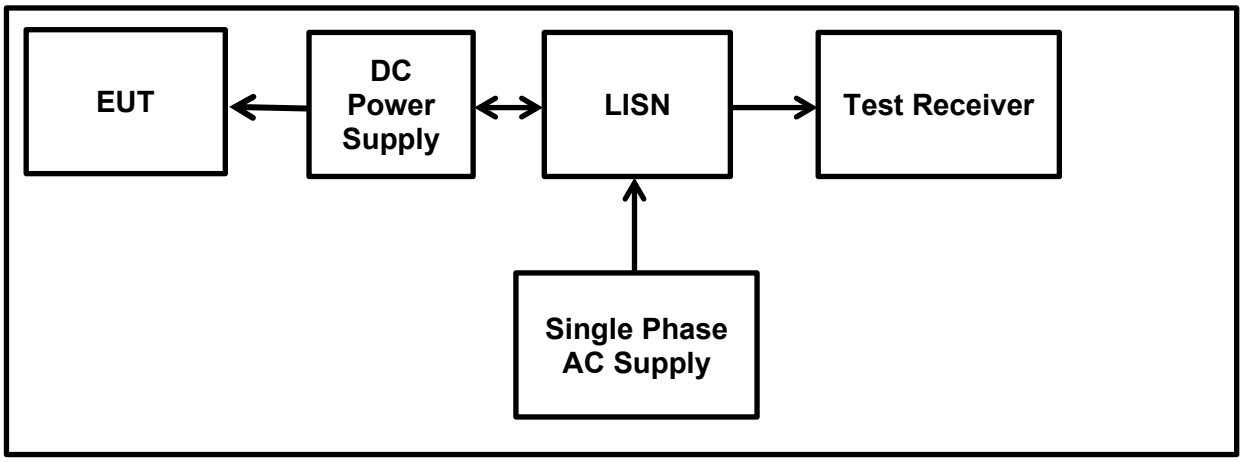
Detector	Quasi Peak/ Average Peak

Note(s):

1. The EUT was plugged into a DC Laboratory Power Supply. The Power Supply was connected to 120 VAC / 60 Hz single phase supply via a LISN.
2. In accordance with FCC KDB 174176 Q4, tests were performed with a 240 VAC 60 Hz single phase supply as this was within the voltage range marked on the 100-240 VAC~50/60 Hz power supply.
3. As a worst case the EUT was configured on BLE Bottom Channel 37 with PWR 4.
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 and found to be ambient or >20 dB below the applicable limit or below the measurement system noise floor.
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.

Transmitter AC Conducted Spurious Emissions (continued)

Test setup:



Transmitter AC Conducted Spurious Emissions (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4

Results: Live / Quasi Peak / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.2051	Live	16.4	63.4	47.0	Complied
0.4971	Live	7.9	56.0	48.1	Complied
1.2659	Live	5.9	56.0	50.1	Complied
3.8316	Live	7.9	60.0	48.1	Complied
6.3006	Live	9	60.0	51.0	Complied
13.1222	Live	8.1	60.0	51.9	Complied

Results: Live / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.2051	Live	11.2	53.4	42.2	Complied
0.4971	Live	4.3	46.0	41.7	Complied
1.2659	Live	2.4	46.0	43.6	Complied
3.8316	Live	3.4	46.0	42.6	Complied
6.3006	Live	4.4	50.0	45.6	Complied
13.1222	Live	4.5	50.0	45.5	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

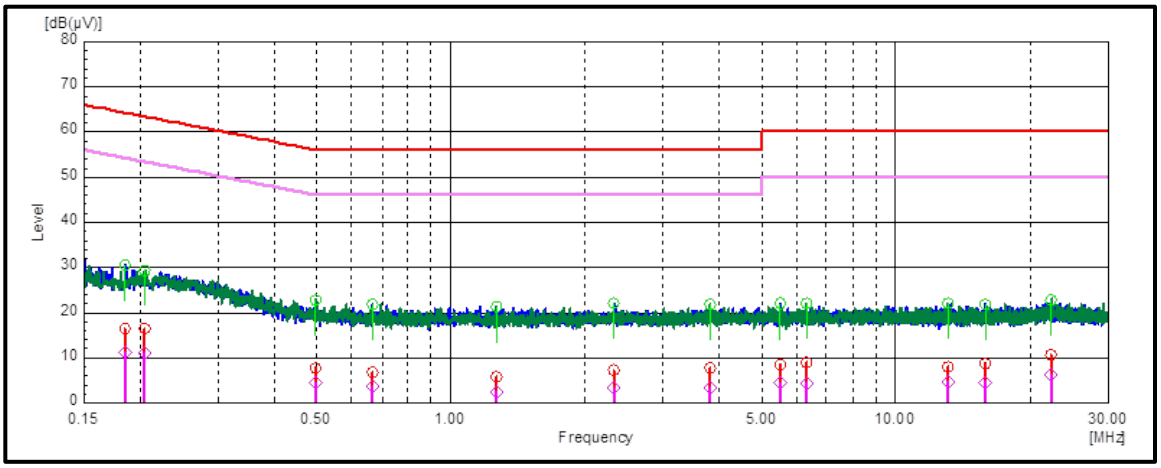
Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.1850	Neutral	16.4	64.3	47.9	Complied
0.6665	Neutral	6.7	56.0	49.3	Complied
2.3286	Neutral	7.3	56.0	48.7	Complied
5.5150	Neutral	8.4	60.0	51.6	Complied
15.8477	Neutral	8.6	60.0	51.4	Complied
22.3507	Neutral	10.7	60.0	49.3	Complied

Results: Neutral / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.1850	Neutral	11.2	54.3	43.1	Complied
0.6665	Neutral	3.5	46.0	42.5	Complied
2.3286	Neutral	3.4	46.0	42.6	Complied
5.5150	Neutral	4.3	46.0	45.7	Complied
15.8477	Neutral	4.5	50.0	45.5	Complied
22.3507	Neutral	6.2	50.0	43.8	Complied

Transmitter AC Conducted Spurious Emissions (continued)

Plot: BLE / PRBS9 / 1 Mbps / PWR 4 / 120 VAC 60 Hz



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

Result: Pass

Transmitter AC Conducted Spurious Emissions (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4

Results: Live / Quasi Peak / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.24870	Live	15.6	61.8	46.2	Complied
0.46613	Live	10.8	56.6	45.8	Complied
0.56232	Live	8.5	56.0	47.5	Complied
3.74349	Live	7.3	56.0	48.7	Complied
7.21944	Live	9.5	60.0	50.5	Complied
12.7515	Live	8.1	60.0	51.9	Complied

Results: Live / Average / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.24870	Live	10.7	51.8	41.1	Complied
0.46613	Live	4.3	46.6	42.3	Complied
0.56232	Live	3.5	46.0	42.5	Complied
3.74349	Live	3.4	46.0	42.6	Complied
7.21944	Live	5.3	50.0	44.7	Complied
12.7515	Live	4.5	50.0	45.5	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

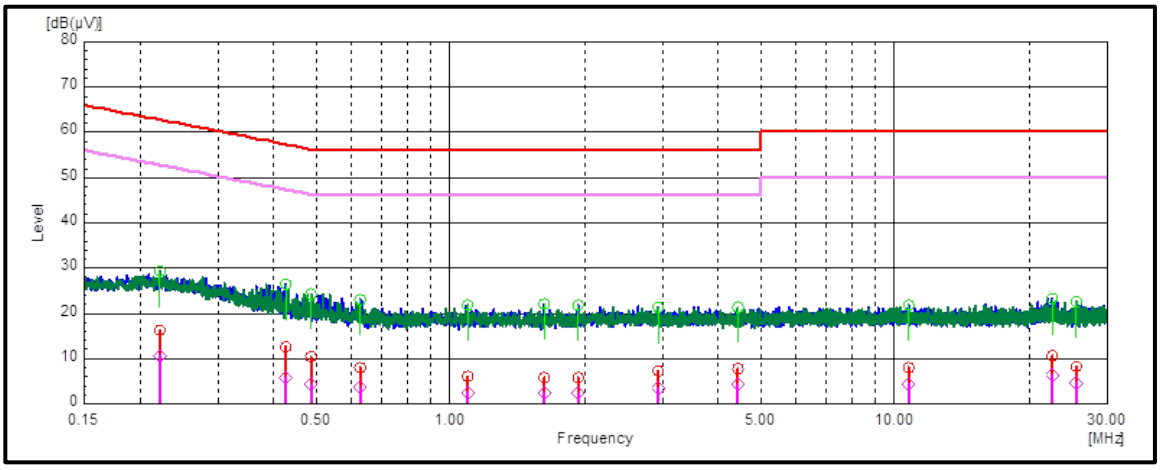
Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.18156	Neutral	16.2	64.4	48.2	Complied
0.41804	Neutral	12.6	57.5	44.9	Complied
0.44810	Neutral	11.9	56.9	45.0	Complied
1.19759	Neutral	5.9	56.0	50.1	Complied
2.15631	Neutral	7.3	56.0	48.7	Complied
21.30461	Neutral	11.1	60.0	48.9	Complied

Results: Neutral / Average / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.18156	Neutral	10.8	54.4	43.6	Complied
0.41804	Neutral	5.9	47.5	41.6	Complied
0.44810	Neutral	4.3	46.9	42.6	Complied
1.19759	Neutral	2.4	46.0	43.6	Complied
2.15631	Neutral	3.4	46.0	42.6	Complied
21.30461	Neutral	6.9	50.0	43.1	Complied

Transmitter AC Conducted Spurious Emissions (continued)

Plot: BLE / PRBS9 / 1 Mbps / PWR 4 / 240 VAC 50 Hz



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

Result: Pass

5.2.2. Transmitter Minimum 6 dB Bandwidth

Test Summary:

Test Engineer:	Sercan Usta	**Test Date:**	22 February 2022
Test Sample Serial Number:	UL_CERT_COND_DTM_TX_01 *(Conducted RF Sample)*		
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:

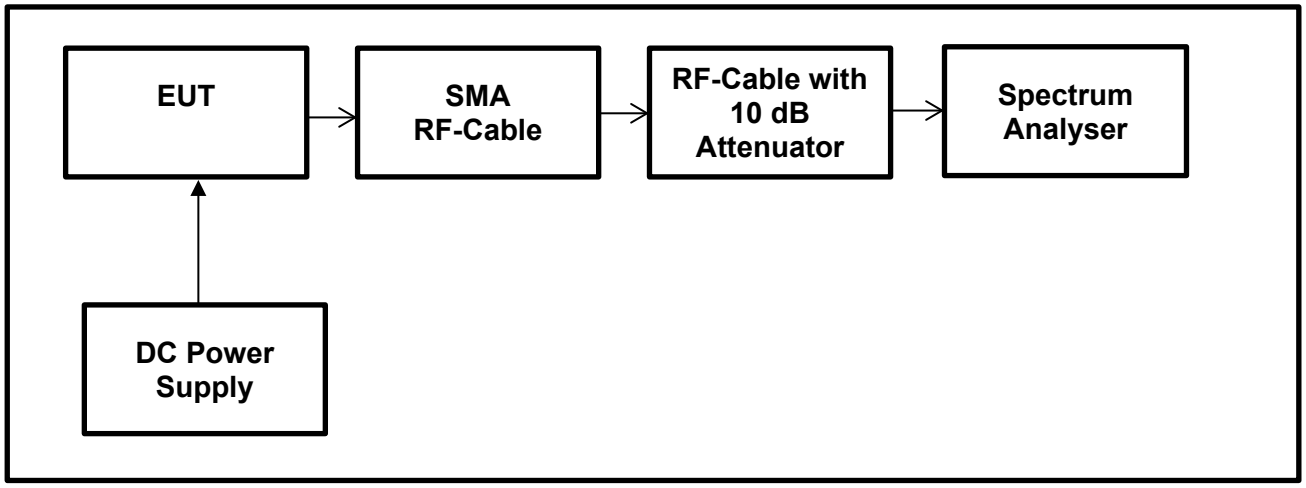
Temperature (°C):	25
Relative Humidity (%):	35

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 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 Cable soldered on PCB with maximum attenuation of 0.4 dB at the tested frequencies.
   - The RF cable attenuation maximum 0.6 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 11.0 dB was added to each of the at the tested frequencies conducted plots.

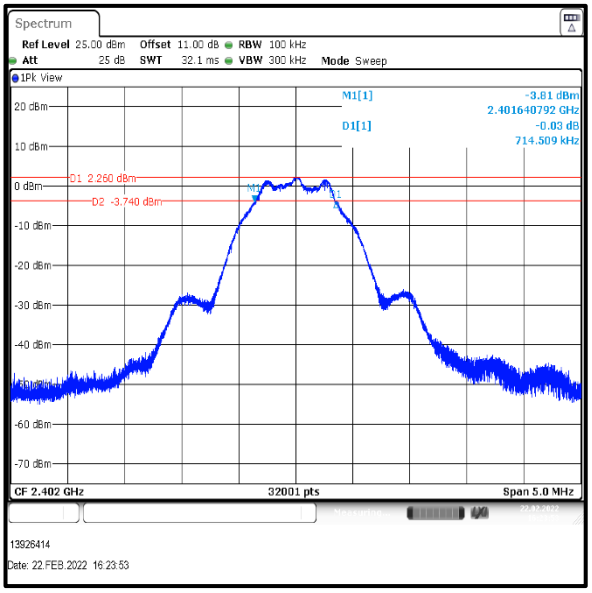
Test Setup :



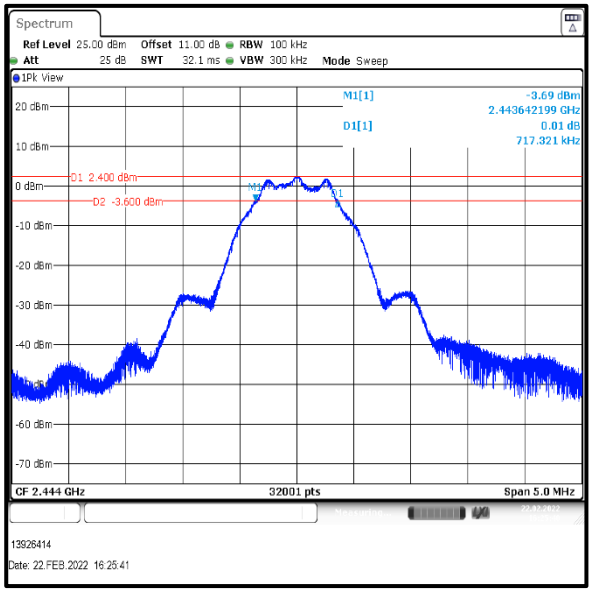
Transmitter Minimum 6 dB Bandwidth (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4

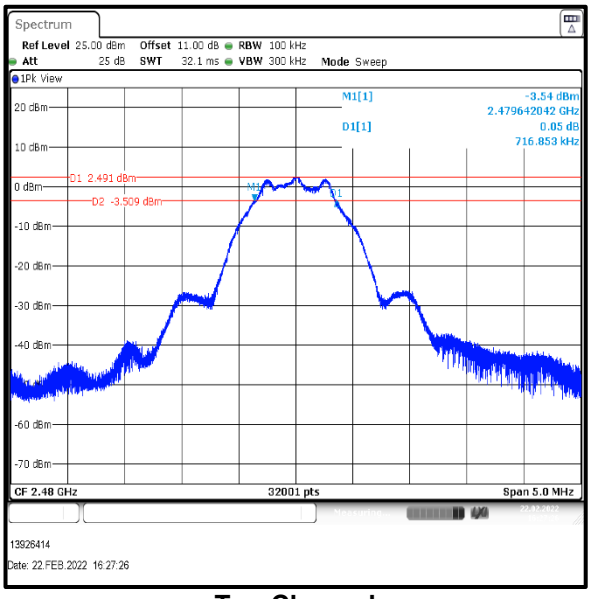
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	714.509	≥ 500	214.509	Complied
Middle	717.321	≥ 500	217.321	Complied
Top	716.853	≥ 500	216.853	Complied



Bottom Channel



Middle Channel



Top Channel

Result: Pass

5.2.3. Transmitter Duty Cycle

Test Summary:

Test Engineer:	Sercan Usta	**Test Date:**	09 February 2022
Test Sample Serial Number:	UL_CERT_COND_DTM_TX_01 *(Conducted RF Sample)*		
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):	24
Relative Humidity (%):	31

Notes:

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

   Duty Cycle (%) = 100 X [On Time (T_{ON})] / [Period(T_{ON}+ T_{OFF}) or 100ms whichever is the lesser]

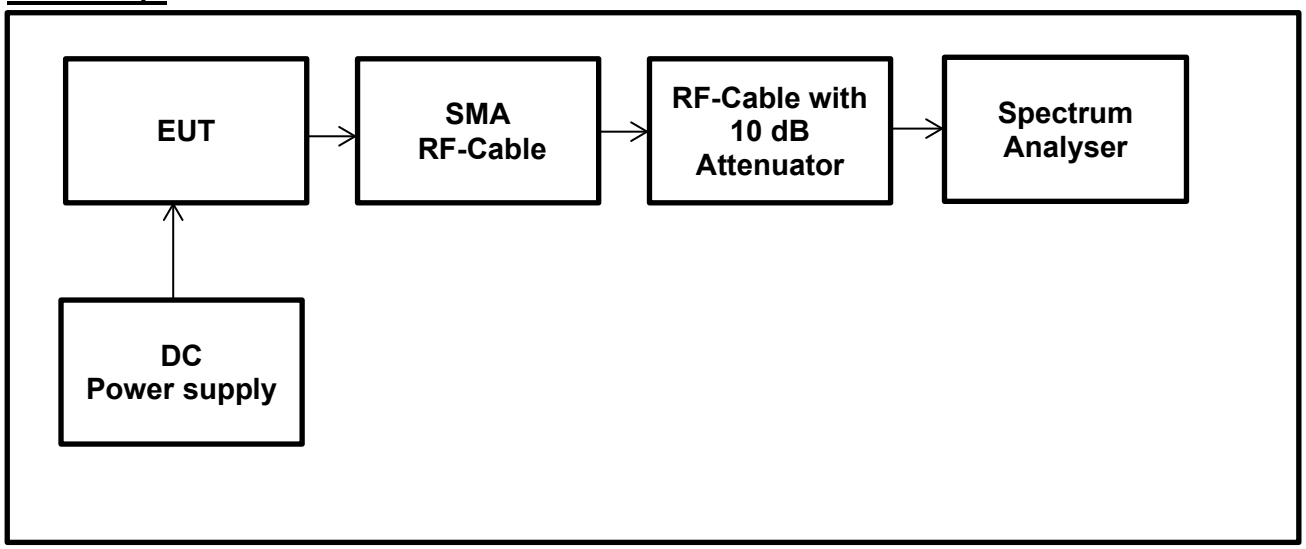
   Duty Cycle Correction Factor= 10 log 1 / [On Time (T_{ON})] / [Period(T_{ON}+ T_{OFF}) or 100ms whichever is the lesser]

2. 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 0.4 dB at the tested frequencies.
   - The RF cable attenuation maximum 0.6 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 11.0 dB was added to each of the at the tested frequencies conducted plots.

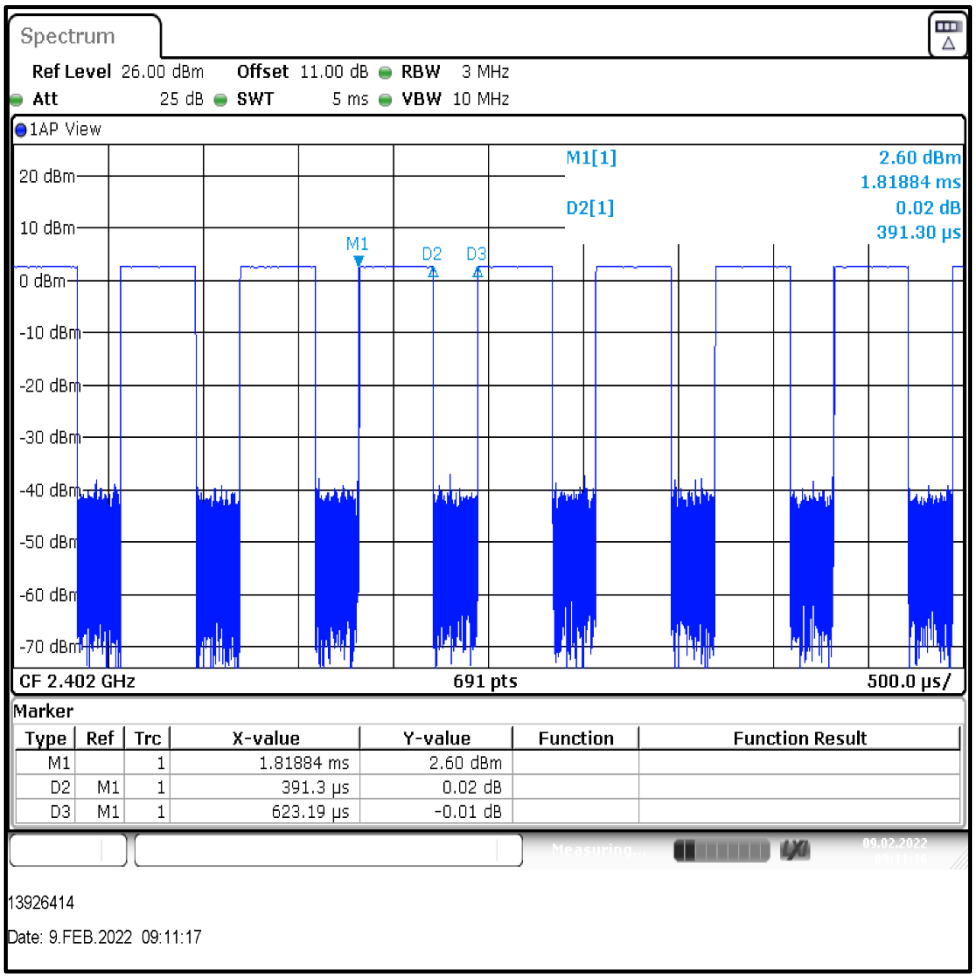
Test Setup:



Transmitter Duty Cycle (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4

Pulse On Time (T_{ON}) (µs)	Pulse Period (T_{ON} +T_{OFF}) (µs)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
391.30	623.19	62.79	2.02



Result: Pass

5.2.4. Transmitter Maximum (Peak) Output Power

Test Summary:

Test Engineer:	Sercan Usta	**Test Date:**	09 February 2022
Test Sample Serial Number:	UL_CERT_COND_DTM_TX_01 *(Conducted RF Sample)*		
Test Site Identification	SR 9		

FCC Reference:	Part 15.247(b)(3)
Test Method Used:	FCC KDB 558074 Section 8.3.1.1 referencing ANSI C63.10 Sections 11.9.1.1

Environmental Conditions:

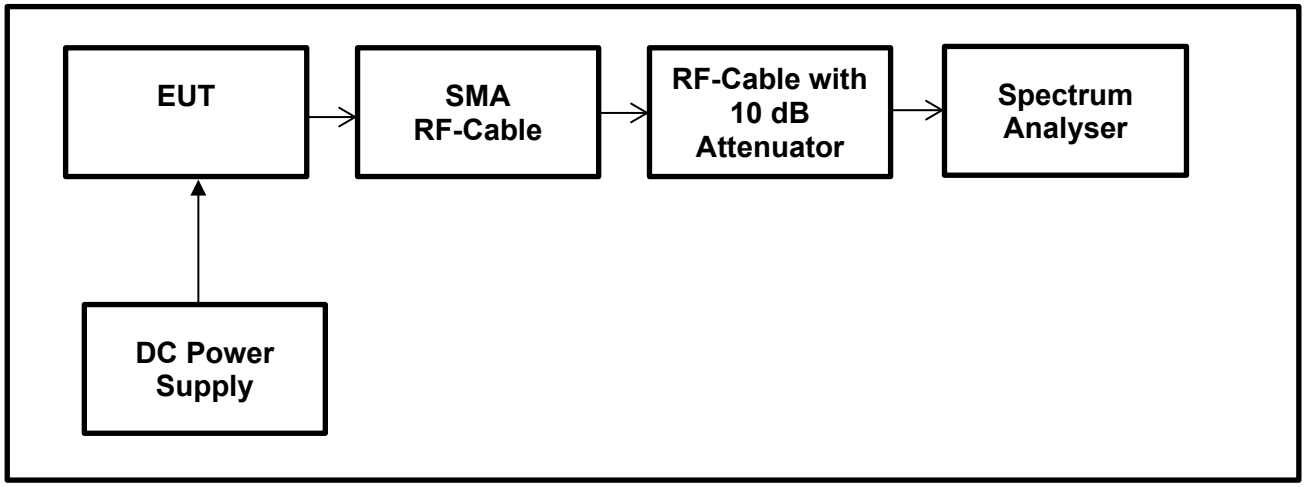
Temperature (°C):	24
Relative Humidity (%):	31

Notes:

1. Final measurements were performed using the below configurations on the bottom, middle and top channels.
2. The EUT was transmitting at <98% duty cycle and testing was performed in accordance with ANSI C63.10 Section 11.9.1.1 Method Maximum peak conducted output power.
3. 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 0.4 dB at the tested frequencies.
   - The RF cable attenuation maximum 0.6 dB@2.4GHz from the EUT to RF power meter including the 10 dB attenuation at the input of RF power meter.

   Therefore, total a reference level offset 11.0 dB was added to each of measured value at the tested frequencies.

Test Setup :



Transmitter Maximum (Peak) Output Power (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4

Conducted Power Limit Comparison

Channel	Conducted Peak Power (dBm)	Conducted Power Limit (dBm)	Margin (dB)	Result
Bottom	2.41	30.0	27.59	Complied
Middle	2.62	30.0	27.38	Complied
Top	2.69	30.0	27.31	Complied

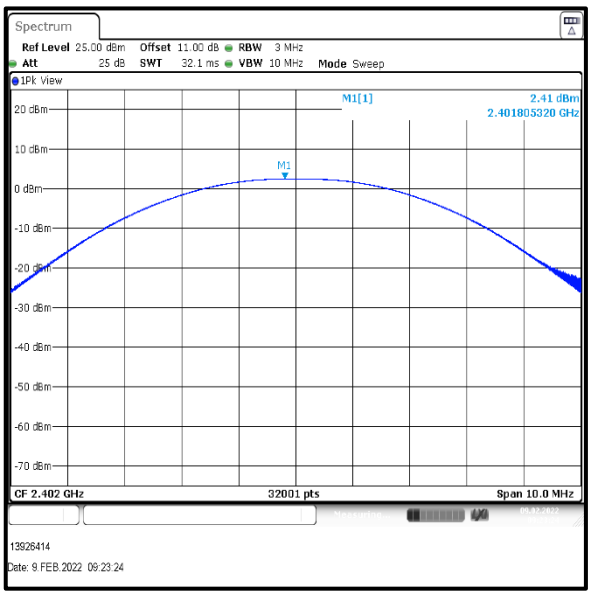
De Facto EIRP Limit Comparison

Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	2.41	0.0	2.41	36.0	33.59	Complied
Middle	2.62	0.0	2.62	36.0	33.38	Complied
Top	2.69	0.0	2.69	36.0	33.31	Complied

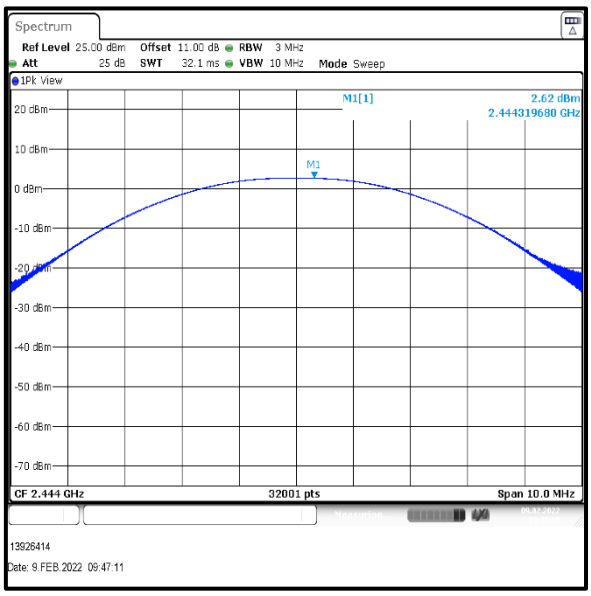
Result: Pass

Transmitter Maximum Peak Output Power (continued)

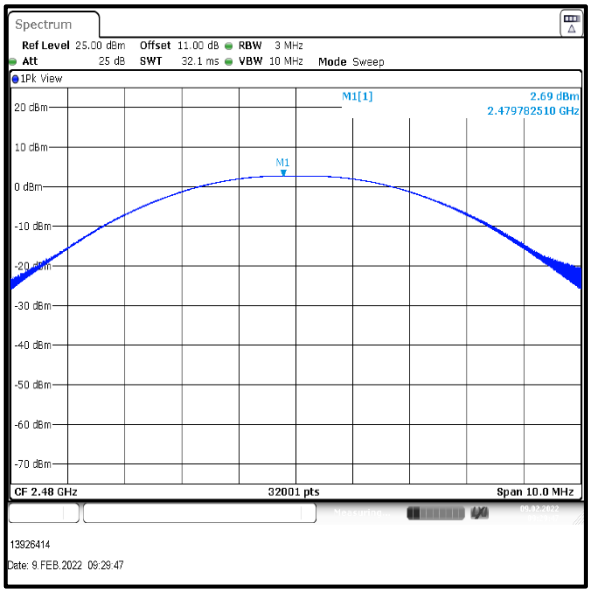
Results: BLE / PRBS9 / 1 Mbps / PWR 4



Bottom Channel



Middle Channel



Top Channel

5.2.5. Transmitter Radiated Emissions

Test Summary:

Test Engineer:	Sercan Usta	**Test Date:**	04 February 2022
Test Sample Serial Number:	UL_CERT_RADIO_DTM_TX_01 *(Radiated RF Sample)*		
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:

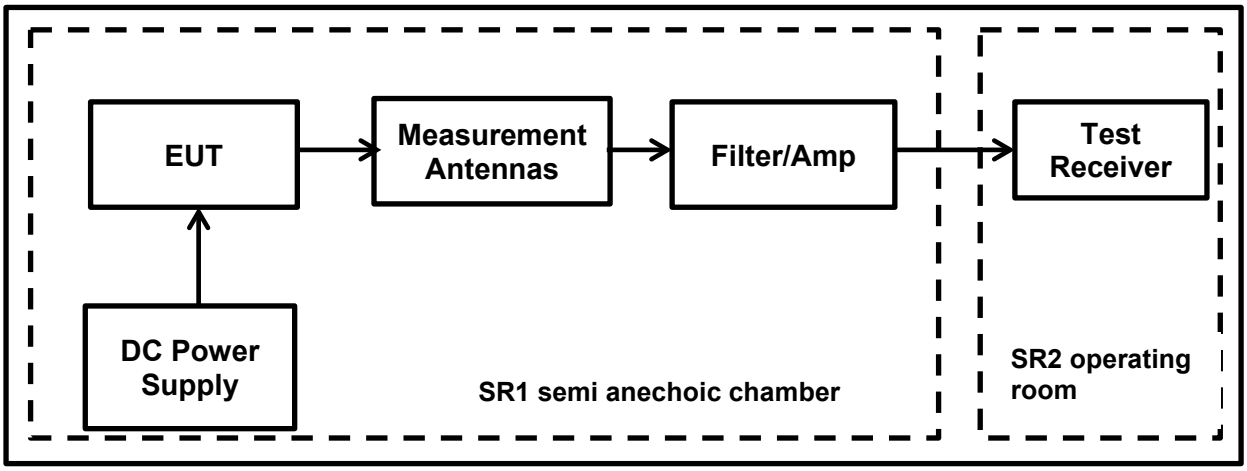
Temperature (°C):	23.3
Relative Humidity (%):	35.4

Note(s):

1. 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 a 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).
2. 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.
3. Therefore the limit values are extrapolated to a measurement distance of 3 m.
    - 9 kHz- 490 kHz: limits extrapolated from 300 m to 3 m by adding 80 dB at 40 dB/deacde.
    - 490kHz-1705 kHz: limits extrapolated from 30 m to 3 m by adding 40 dB at 40 dB /deacde.
4. 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 80 cm.
5. Pre-scans were performed and markers placed on the highest measured levels. The test receiver was set to:
    - Frequency range: 9 kHz-150kHz : RBW: 300 Hz /VBW: 1 kHz
    - Frequency range: 150 kHz – 30 MHz: RBW: 10 kHz /VBW: 30 kHz
    - Detector: Max-Peak detector
    - Trace Mode: Max Hold
6. The preliminary scans showed similar emission levels below 30 MHz, for each channel & modes of operation. Therefore, final radiated emissions measurements were performed with the EUT set to the Bottom channel only.
7. All emissions shown on the pre-scan plots were investigated and found to be below system noise floor.

Transmitter Radiated Emissions (continued)

Test Setup:

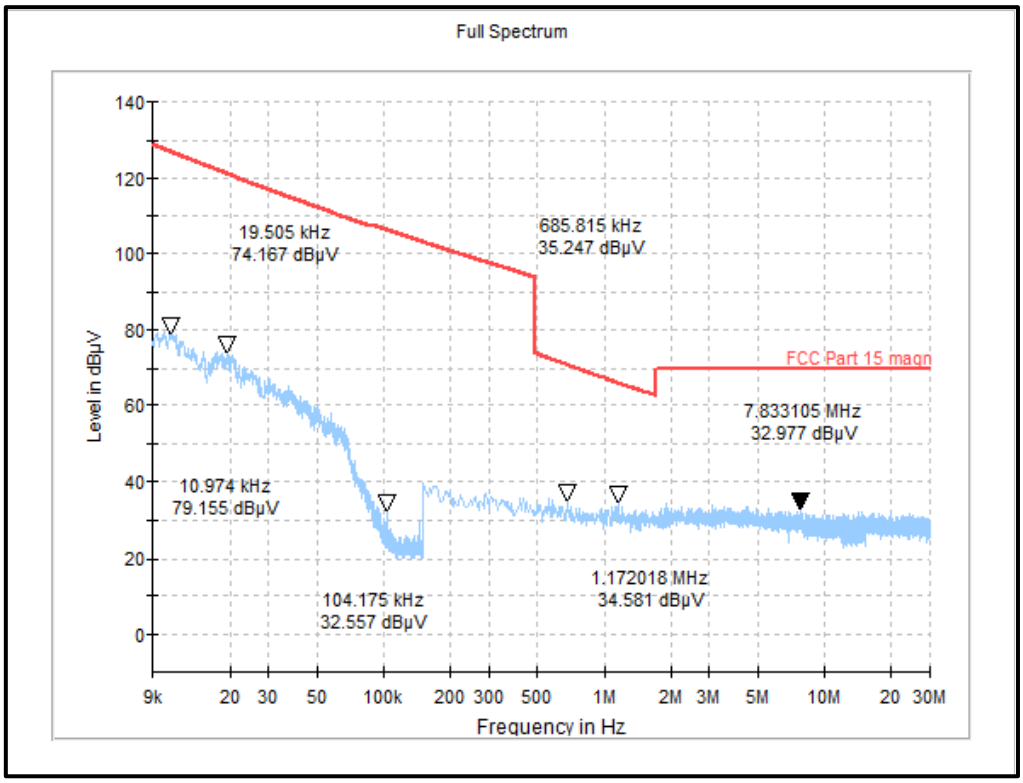


Transmitter Radiated Emissions (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4 / Bottom Channel

Frequency (MHz)	Loop Antenna Oriantation	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
No critical spurious emissions were found					

Plot: Radiated Transmitter spurious emission from 9 kHz – 30 MHz



Note: This plot is a pre-scan and for indication purposes only.
For final measurements,see accompanying table.

Result: Pass

Transmitter Radiated Emissions (continued)

Test Summary:

Test Engineer:	Sercan Usta	**Test Date:**	04 February 2022
Test Sample Serial Number:	UL_CERT_RADIO_DTM_TX_01 *(Radiated RF Sample)*		
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):	23.3
Relative Humidity (%):	38.9

Note(s):

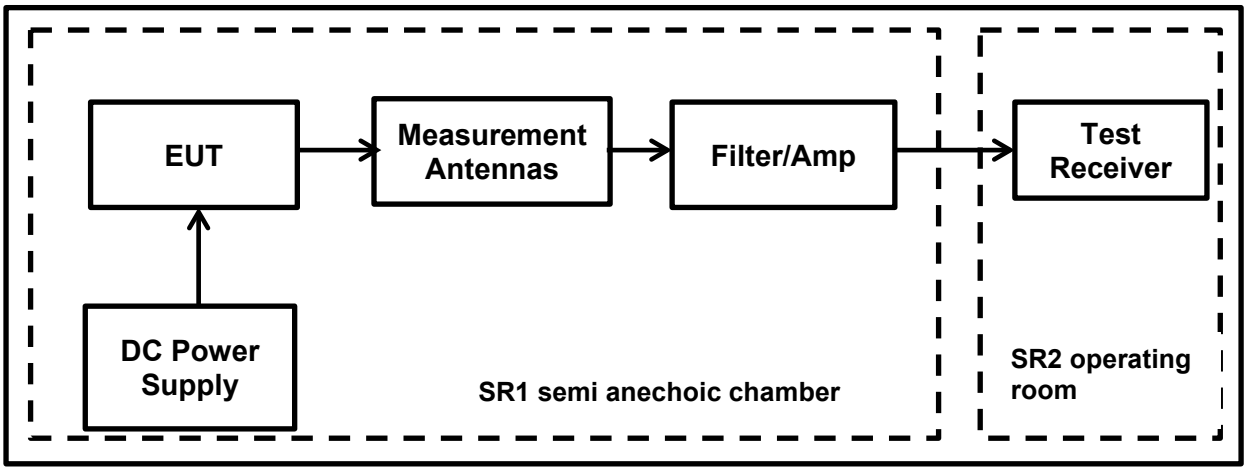
1. Measurements below 1 GHz were performed in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) at a distance of 3 m. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 m to 4 m.

2. 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.

3. The preliminary scans showed similar emission levels below 1 GHz, for each channel of operation. Therefore, final radiated emissions measurements were performed with the EUT set to the Bottom channel only.

4. All emissions shown on the pre-scan plots were investigated and found to be below system noise floor.

Test Setup:

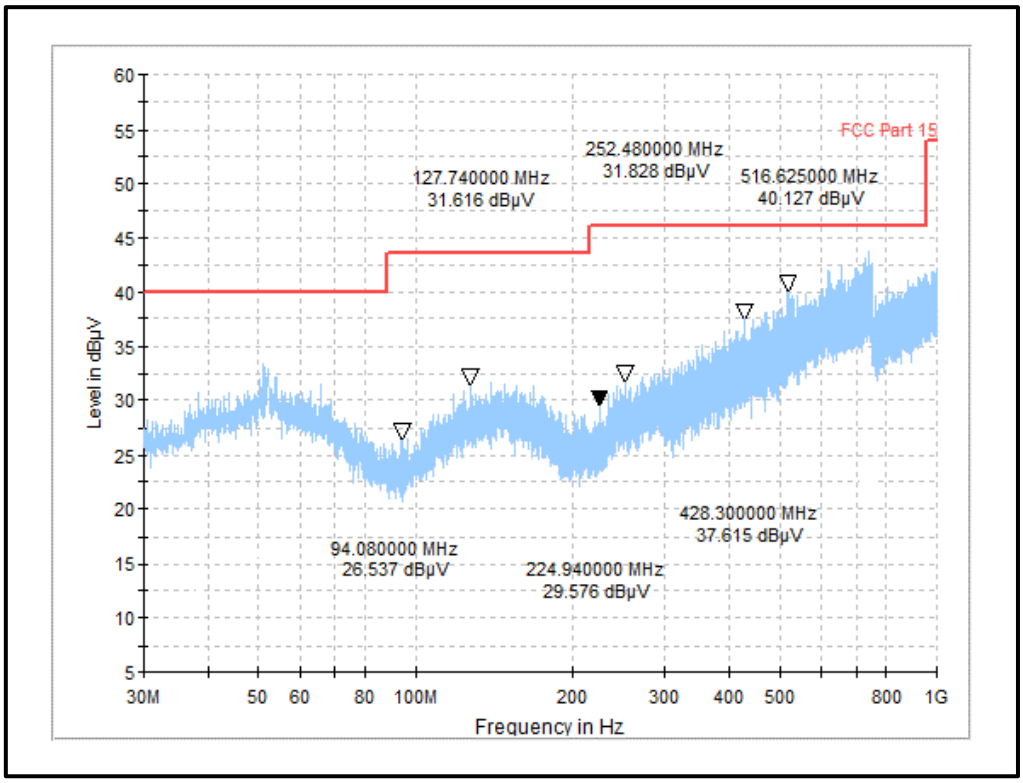


Transmitter Radiated Emissions (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4 / Bottom Channel

Frequency (MHz)	Antenna Polarization	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
No critical spurious emissions were found					

Plot: Radiated Transmitter spurious emission from 30 MHz – 1 GHz



Note: This plot is a pre-scan and for indication purposes only.
For final measurements, see accompanying table.

Result: Pass

Transmitter Radiated Emissions (continued)

Test Summary:

Test Engineer:	Sercan Usta	**Test Date:**	04 & 08 February 2022
Test Sample Serial Number:	UL_CERT_RADIO_DTM_TX_01 *(Radiated RF Sample)*		
Test Site Identification	SR 1/2		

FCC Reference:	Parts 15.247(d), 15.209(a) & 15.205(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:

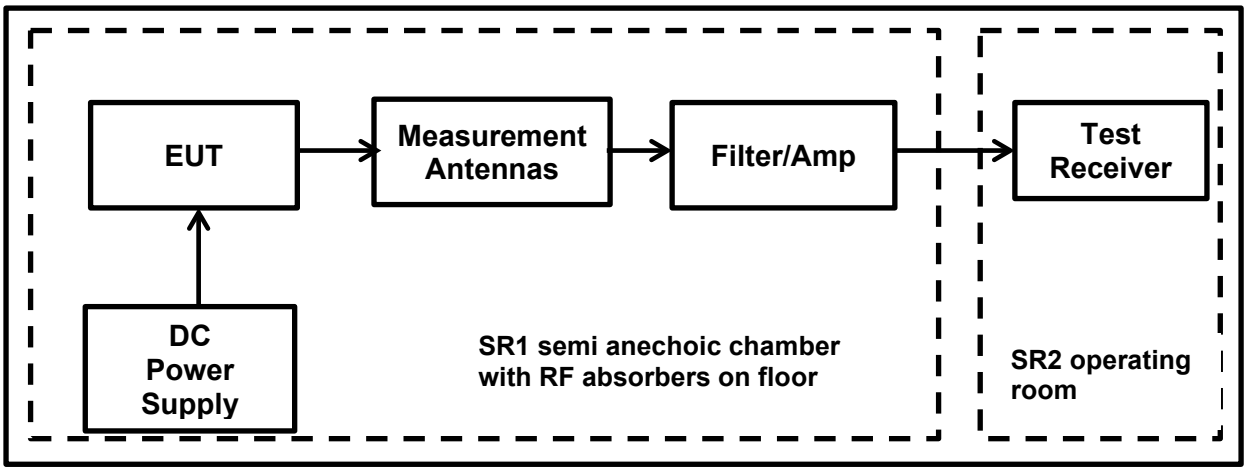
Temperature (°C):	23.3 & 24.8
Relative Humidity (%):	38.9 & 40.2

Note(s):

1. Pre-scans 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 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.
2. 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.
3. 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.
4. All emissions shown on the pre-scans were investigated and found to be below the noise floor of the measurement system.
5. The preliminary scans showed similar emission levels above 18 GHz, for each channel & modes of operation. Therefore final radiated emissions measurements were performed with the EUT set to the bottom channel only.
6. 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.
7. 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:



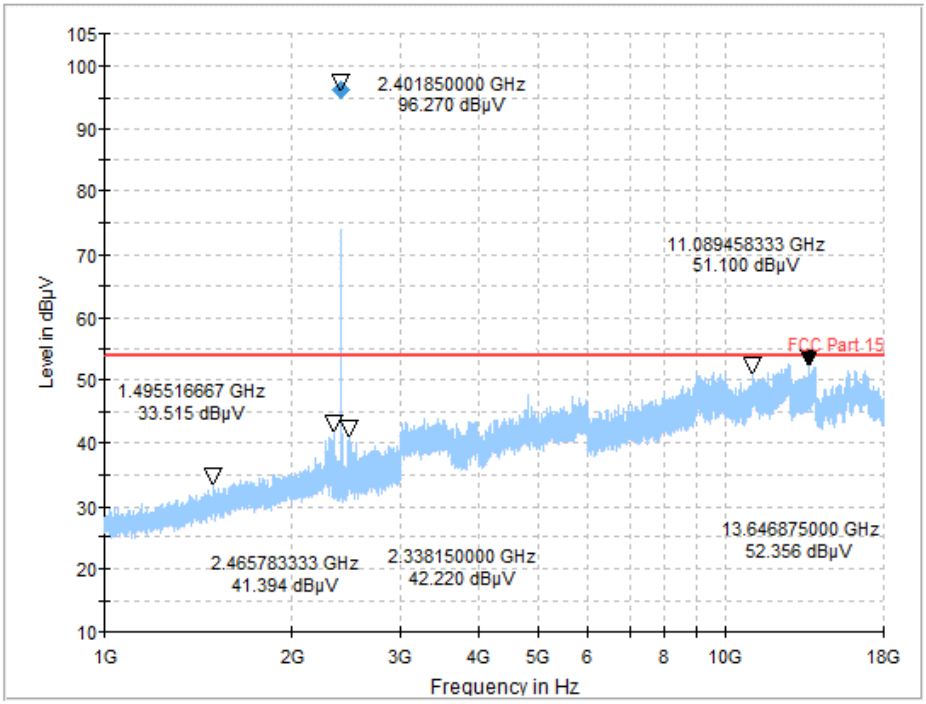
Transmitter Radiated Emissions (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4 / Bottom Channel

Frequency (MHz)	Antenna Polarization	MaxPeak Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
No critical spurious emissions were found					

Results: BLE / PRBS9 / 1 Mbps / PWR 4 / Bottom Channel

Plot: Radiated Transmitter spurious emission from 1 GHz – 18 GHz



Note: This plot is a pre-scan and for indication purposes only.
For final measurements,see accompanying table.

Result: Pass

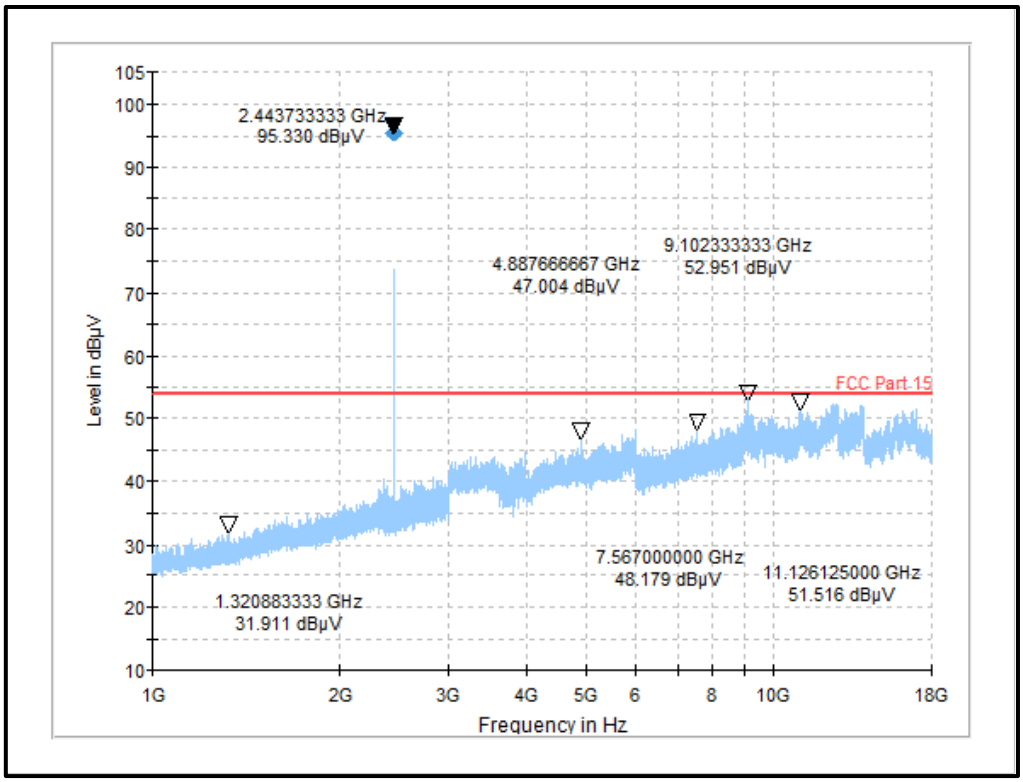
Transmitter Radiated Emissions (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4 / Middle Channel

Frequency (MHz)	Antenna Polarization	MaxPeak Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
No critical spurious emissions were found					

Results: BLE / PRBS9 / 1 Mbps / PWR 4 / Middle Channel

Plot: Radiated Transmitter spurious emission from 1 GHz – 18 GHz



Note: This plot is a pre-scan and for indication purposes only.
For final measurements,see accompanying table.

Result: Pass

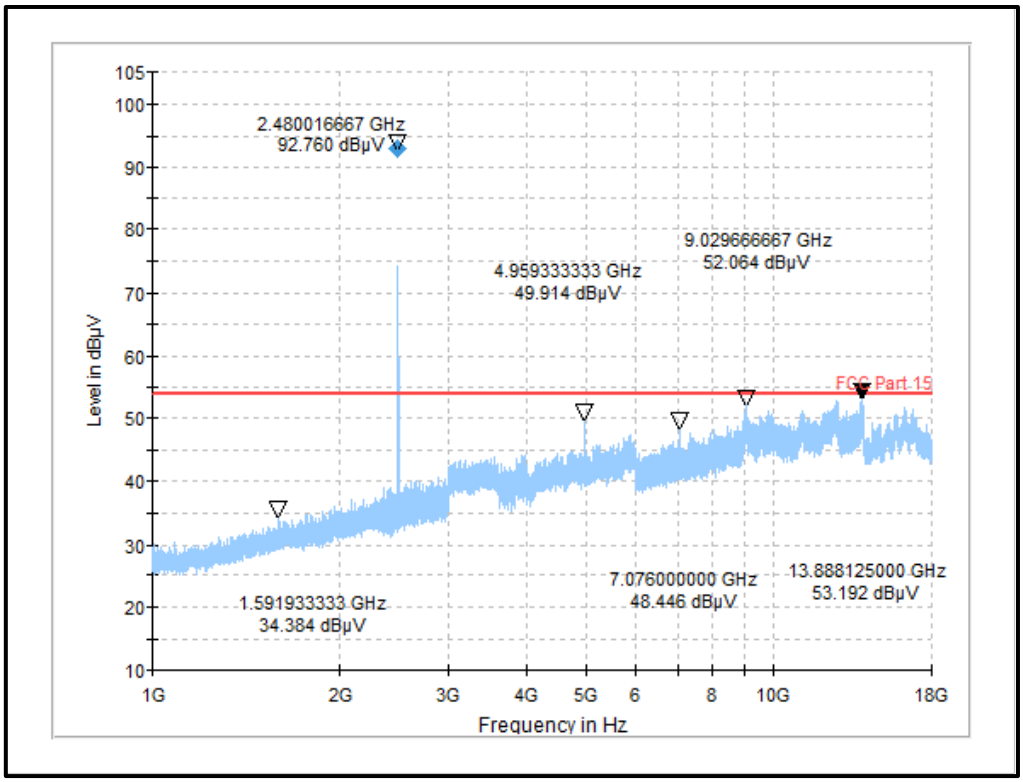
Transmitter Radiated Emissions (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4 / Top Channel

Frequency (MHz)	Antenna Polarization	MaxPeak Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
No critical spurious emissions were found					

Results: BLE / PRBS9 / 1 Mbps / PWR 4 / Top Channel

Plot: Radiated Transmitter spurious emission from 1 GHz – 18 GHz



Note: This plot is a pre-scan and for indication purposes only.
For final measurements,see accompanying table.

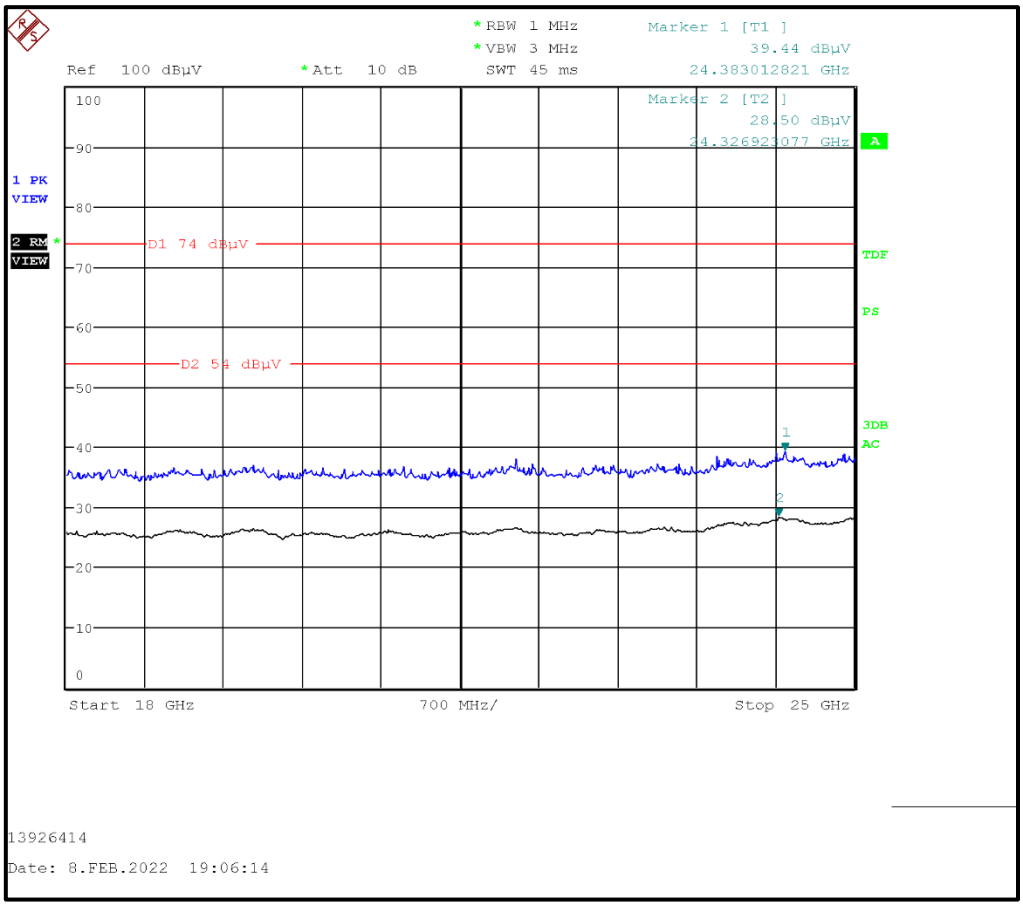
Result: Pass

Transmitter Radiated Emissions (continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4 / Bottom Channel

Frequency (MHz)	Antenna Polarization	MaxPeak Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
No critical spurious emissions were found					

Plot: Radiated Transmitter spurious emission from 18 GHz – 25 GHz



Note: This plot is a pre-scan and for indication purposes only.
For final measurements,see accompanying table.

Result: Pass

5.2.6. Transmitter Band Edge Radiated Emissions

Test Summary:

Test Engineer:	Sercan Usta	**Test Date:**	04 February 2022
Test Sample Serial Number:	UL_CERT_RADIO_DTM_TX_01 *(Radiated RF Sample)*		
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):	23.3
Relative Humidity (%):	38.9

Note(s):

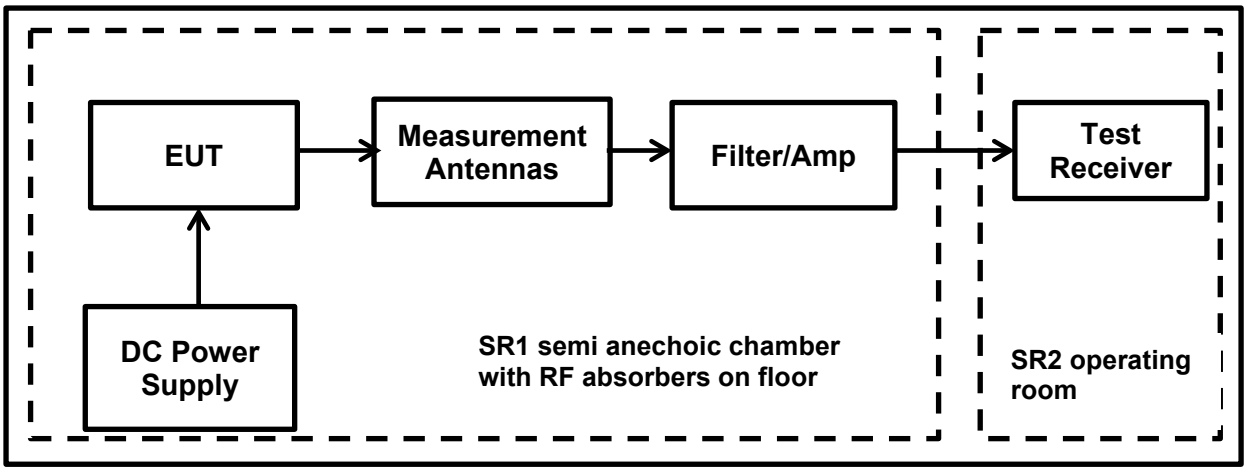
1. The measurments were in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) with RF absorbers on the floor at a distance of 3 m. The EUT was placed at a height of 1.5 m above the test chamber floor in the centre of the chamber turntable. Maximum emission levels were determined by height searching 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 a sufficient length of time 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 EUT continuous transmission of the EUT ($D \geq 98\%$) cannot be achieved and the duty cycle is constant (duty cycle variations are less than ±2%), the restricted band average measurements were performed in accordance with ANSI C63.10 Section 11.12.2.5.2.
6. 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. A RMS detector in power averaging mode was used. The test receiver was left to sweep for a sufficient length of time 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.

Transmitter Band Edge Radiated Emissions (continued)

Note(s): (continued)

7. 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.
8. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
9. ** As the EUT continuous transmission of the EUT (D ≥ 98%) cannot be achieved and EUT was transmitting continuously with a constant Duty Cycle of 62.79 % (duty cycle variations are less than ±2%). Therefore, a Duty Cycle Correction Factor of 2.02 dB was added to all average measurements, to compute the corrected average values of the emissions that would have been measured had the test been performed at 100% Duty Cycle.

Test Setup:



Transmitter Band Edge Radiated Emissions (Continued)

Results: BLE / PRBS9 / 1 Mbps / PWR 4

Results: Lower Band Edge / Peak

Frequency (MHz)	Peak Level (dBµV/m)	-20 dBc Limit (dBµV/m)	Margin (dB)	Result
2399.59	47.72	75.41	27.69	Complied
2400.00	45.73	75.41	29.68	Complied

Results: Lower Band Edge / *2310 to 2390 MHz Restricted Band* / Peak

Frequency (MHz)	Peak Level (dBµV/m)	Peak Limit (dBµV/m)	Margin (dB)	Result
2389.74	53.27	74.00	20.73	Complied

Results: Lower Band Edge / *2310 to 2390 MHz Restricted Band* / Average

Frequency (MHz)	Average Level (dBµV/m)	Duty Cycle Correction Factor (dB)	Corrected Average Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
2338.08	44.90	2.02	46.92**	54.00	5.20	Complied

Results: Upper Band Edge / Peak

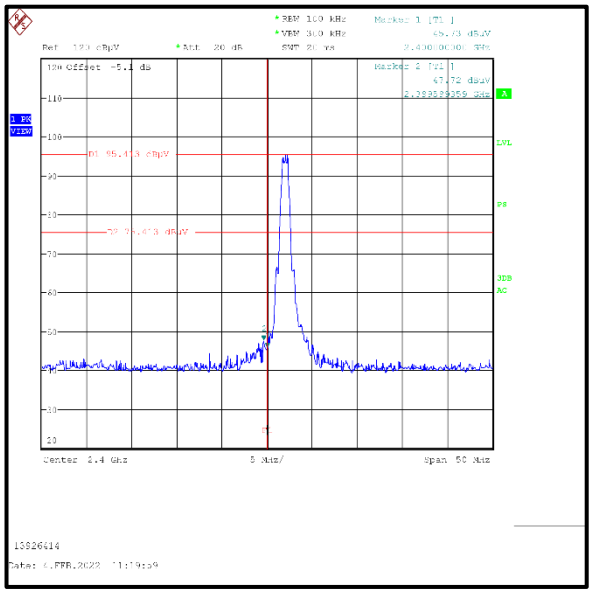
Frequency (MHz)	Peak Level (dBµV/m)	Peak Limit (dBµV/m)	Margin (dB)	Result
2483.50	57.53	74.00	16.47	Complied
2483.76	57.37	74.00	16.63	Complied

Results: Upper Band Edge / Average

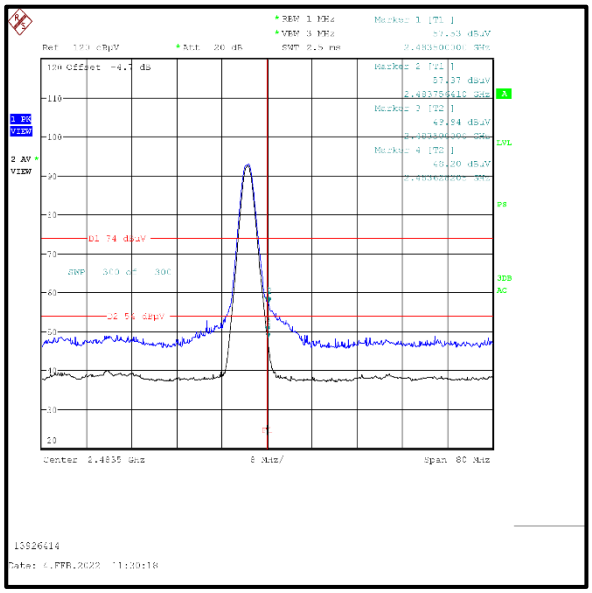
Frequency (MHz)	Average Level (dBµV/m)	Duty Cycle Correction Factor (dB)	Corrected Average Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
2483.50	49.94	2.02	51.96**	54.00	2.04	Complied
2483.62	48.20	2.02	50.22**	54.00	3.78	Complied

Transmitter Band Edge Radiated Emissions (Continued)

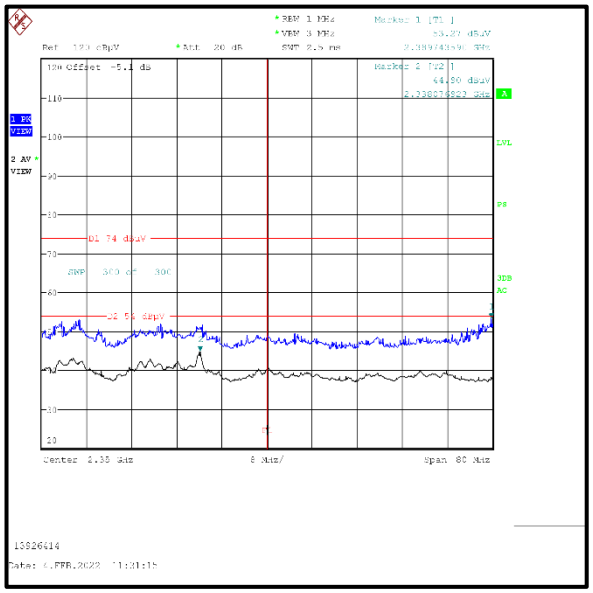
Results: BLE / PRBS9 / 1 Mbps / PWR 4



Lower Band Edge Peak Measurement



Upper Band Edge Measurement



Restricted Band Edge Measurement

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
AC Conducted Spurious Emissions	95%	±2.49 dB
Conducted Maximum Peak Output Power	95%	±0.59 dB
Radiated Spurious Emissions	95%	±3.10 dB
Band Edge Radiated Emissions	95%	±3.10 dB
Transmitter Duty Cycle	95%	±3.4%
Minimum 6 dB Bandwidth	95%	±0.87 %

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	10/07/2020	36
377	BONN Elektronik	Amplifier, Low Noise Pre	BLMA 0118-1A	025294B	16/07/2021	12
423	Bonn Elektronik	Amplifier, Low Noise Pre	BLMA 1840-1A	55929	16/07/2021	12
460	Deisel	Turntable	DT 4250 S	n/a	n/a	n/a
452	Schwarzbeck	Antenna, Trilog Broadband	VULB 9168	9168-240	02/09/2020	24
496	Rohde & Schwarz	Antenna, log. - periodical	HL050	100297	05/08/2020	36
607	Schwarzbeck	Antenna broadband horn antenna	BBHA 9170	9170-561	15/10/2019	36
587	Maturo	antenna mast, tilting	TAM 4.0-E	011/7180311	n/a	n/a
588	Maturo	Controller	NCD	029/7180311	n/a	n/a
591	Rohde & Schwarz	Receiver	ESU 40	100244/040	28/06/2021	12
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
1603665	Siemens Matsushita Components	semi-anechoic chamber SR1/ 2	-/-	B83117-A1421-T161	n/a	n/a

Test site: SR 7/8

ID	Manufacturer	Type	Model	Serial	Calibration Date	Cal. Cycle (months)
23	Rohde & Schwarz	Artificial Mains Network	ESH3-Z5	831767/013	14/07/2021	12
349	Rohde & Schwarz	Receiver, EMI Test	ESIB7	836697/009	13/07/2021	12
-/-	Testo	Thermo-Hygrometer	608-H1	08	lab verification	n/a
327	SPS	AC/DC power distribution system	PAS 5000	A2464 00/1 0200	lab verification	n/a

Test site: SR 9

ID	Manufacturer	Type	Model	Serial	Calibration Date	Cal. Cycle (months)
-/-	Huber+Suhner	10 dB Attenuator	0047	-/-	lab verification	n/a
637	Rohde & Schwarz	Spectrum Analyzer	FSV40	101587	13/07/2021	12
636	Rohde & Schwarz	Switching Unit Power Meter	OSP-B157W8	101698	13/07/2021	12
-/-	Testo	Thermo-Hygrometer	608-H1	07	lab verification	n/a
-/-	Huber+Suhner	RF Cable -OSP120-DUT1	ST18/SMAm/SMAm/72	605505	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

8. Report Revision History

Version Number	Revision Details		
	Page No(s)	Clause	Details
1.0	41	-	Initial Version

--- END of Test Report ---