TEST REPORT

Test Report No. : UL-RPT-RP13683656-516A

Customer	:	Loc8tor Ltd
Model No.	:	TH
FCC ID	:	TUW-PH
Technology	:	Proprietary (IEEE.802.15.4 based)
Test Standard(s)	:	FCC Parts 15.209(a) & 15.247
Test Laboratory	:	UL International (UK) Ltd, Basingstoke, Hampshire, RG24 8AH, United Kingdom

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2. The results in this report apply only to the sample(s) tested.
3. The sample tested is in compliance with the above standard(s).
4. The test results in this report are traceable to the national or international standards.
5. Version 1.0.

Date of Issue: 07 July 2022

Checked by:

Ben Mercer
Lead Project Engineer, Radio Laboratory

Company Signatory:

Sarah Williams
RF Operations Leader, Radio Laboratory

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UL International (UK) LTD
Unit 1-3 Horizon, Kingsland Business Park, Wade Road, Basingstoke, Hampshire, RG24 8AH, UK
Telephone: +44 (0)1256 312000
Facsimile: +44 (0)1256 312001

Customer Information

Company Name:	Loc8tor Ltd
Address:	Devonshire House Manor Way Borehamwood Herts WD6 1QQ United Kingdom

Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	07/07/2022	Initial Version	Ben Mercer

Table of Contents

1 Attestation of Test Results

1.1 Description of EUT

The Equipment Under Test was a tracking device used to identify the location of tags. The EUT utilisies a proprietary DSSS protocol in the 2.4 GHz frequency range.

1.2 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:	47CFR15.209
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) – Section 15.209
FCC Site Registration:	685609
FCC Lab. Designation No.:	UK2011
Location of Testing:	Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, G24 8AH, United Kingdom
Test Dates:	11 January 2022 to 12 January 2022

1.3 Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.35(c)	Transmitter Duty Cycle	Note 1
Part 15.247(a)(2)	Transmitter Minimum 6 dB Bandwidth	✓
Part 15.247(b)(3)	Transmitter Maximum Peak Output Power	✓
Part 15.247(e)	Transmitter Power Spectral Density	Note 2
Part 15.247(d) & 15.209(a)	Transmitter Radiated Emissions	✓
Part 15.247(d) & 15.209(a)	Transmitter Band Edge Radiated Emissions	✓
Key to Results ✓ = Complied ✗ = Did not comply		

Note(s):

1. The measurement was performed to assist in the calculation of the level of the emissions. The EUT cannot transmit continuously and sweep triggering/signal gating cannot be implemented.
2. In accordance with ANSI C63.10 Section 11.10.1, PSD measurements are 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 be equal to the measured output power.

1.4 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.

2 Summary of Testing

2.1 Facilities and Accreditation

The test site and measurement facilities used to collect data are located at Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom. The following table identifies which facilities were utilised for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

Site 1	X
Site 2	-
Site 17	-

UL International (UK) Ltd is accredited by the United Kingdom Accreditation Service (UKAS). UKAS is one of the signatories to the International Laboratory Accreditation Co-operation (ILAC) Arrangement for the mutual recognition of test reports. The tests reported herein have been performed in accordance with its terms of accreditation.

2.2 Methods and Procedures

Reference:	ANSI C63.10-2013
Title:	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Reference:	KDB 558074 D01 15.247 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

2.3 Calibration and Uncertainty

Measuring Instrument Calibration

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

Measurement Uncertainty & Decision Rule

Overview

No measurement or test can ever be perfect and the imperfections give rise to error of measurement in the results. Consequently the result of a measurement is only an approximation to the value of the measurand (the specific quantity subject to measurement) and is only complete when accompanied by a statement of the uncertainty of the approximation.

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

Decision Rule

The decision rule applied is based upon the accuracy method criteria. The measurement uncertainty is met and the result is considered in conformance with the requirement criteria if the observed value is within the prescribed limit.

Measurement Uncertainty

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	Range	Confidence Level (%)	Calculated Uncertainty
Radiated Duty Cycle	2.4 GHz to 2.4835 GHz	95%	±1.14 %
Radiated Minimum 6 dB Bandwidth	2.4 GHz to 2.4835 GHz	95%	±4.59 %
Radiated Power Sprectral Density	2.4 GHz to 2.4835 GHz	95%	±2.94 dB
Radiated Maximum Peak Output Power	2.4 GHz to 2.4835 GHz	95%	±2.94 dB
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±3.3 dB
Radiated Spurious Emissions	1 GHz to 25 GHz	95%	±2.94 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.

2.4 Test and Measurement Equipment

Test Equipment Used for Transmitter Minimum 6 dB Bandwidth, Duty Cycle, Maximum Peak Output Power, Band Edge Radiated Emissions Tests

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	09 Dec 2022	12
K0001	3m RSE Chamber	Rainford EMC	N/A	N/A	06 Sep 2022	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	29 Apr 2022	12
A3179	Pre Amplifier	Agilent	8449B	3008A00934	24 Aug 2022	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	27 Aug 2022	12
A2523	Attenuator	AtlanTecRF	AN18W5-10	832827#1	03 Feb 2022	12

Test Equipment Used for Transmitter Radiated Emissions Tests

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	09 Dec 2022	12
K0001	3m RSE Chamber	Rainford EMC	N/A	N/A	06 Sep 2022	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	29 Apr 2022	12
A3179	Pre Amplifier	Agilent	8449B	3008A00934	24 Aug 2022	12
A3141	Pre Amplifier	Schwarzbeck	BBV 9718 B	00021	24 Aug 2022	12
A3154	Pre Amplifier	Com-Power	PAM-103	18020012	24 Aug 2022	12
A3265	Pre Amplifier	Schwarzbeck	BBV 9721	12345	16 Feb 2022	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	27 Aug 2022	12
A553	Antenna	Chase	CBL6111A	1593	23 Nov 2022	12
A3139	Antenna	Schwarzbeck	HWRD750	00027	27 Aug 2022	12
A2892	Antenna	Schwarzbeck	BBHA 9170	9170-727	02 Nov 2022	12
A2523	Attenuator	AtlanTecRF	AN18W5-10	832827#1	03 Feb 2022	12
A3083	Low Pass Filter	AtlanTecRF	AFL-01000	18010900076	03 Feb 2022	12
A3093	High Pass Filter	AtlanTecRF	AFH-0300	18051800077	03 Feb 2022	12
A3095	High Pass Filter	AtlanTecRF	AFH-07000	18051600012	03 Feb 2022	12

All test equipment was within the current or previous calibration period on the date of testing.

3 Equipment Under Test (EUT)

3.1 Identification of Equipment Under Test (EUT)

Brand Name:	Loc8tor
Model Name or Number:	TH
Test Sample Serial Number:	Not marked or stated *(Radiated Sample #1)*
Hardware Version:	Revision 5
Firmware Version:	V9
FCC ID:	TUW-PH

Brand Name:	Loc8tor
Model Name or Number:	TH
Test Sample Serial Number:	Not marked or stated *(Radiated Sample #2)*
Hardware Version:	Revision 5
Firmware Version:	V9
FCC ID:	TUW-PH

3.2 Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.3 Additional Information Related to Testing

Technology Tested:	IEEE 802.15.4 (Digital Transmission System)	
Type of Unit:	Transceiver	
Modulation:	DSSS	
Data Rate:	250 kbps	
Power Supply Requirement(s):	Nominal	3.0 VDC
Maximum Output Power:	3.1 dBm	
Transmit Frequency:	2435 MHz	
Transmit Channels Tested:	**Channel ID**	**Channel Frequency (MHz)**
	Single	2435

3.4 Description of Available Antennas

The radio utilizes an integrated antenna, with the following maximum gain:

Frequency Range (MHz)	Antenna Gain (dBi)
2400-2480	6.1

3.5 Description of Test Setup

No support equipment was used to exercise the EUT during testing.

Operating Modes

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

- Continously transmitting at maximum power with modulated carrier on a single channel.

Configuration and Peripherals

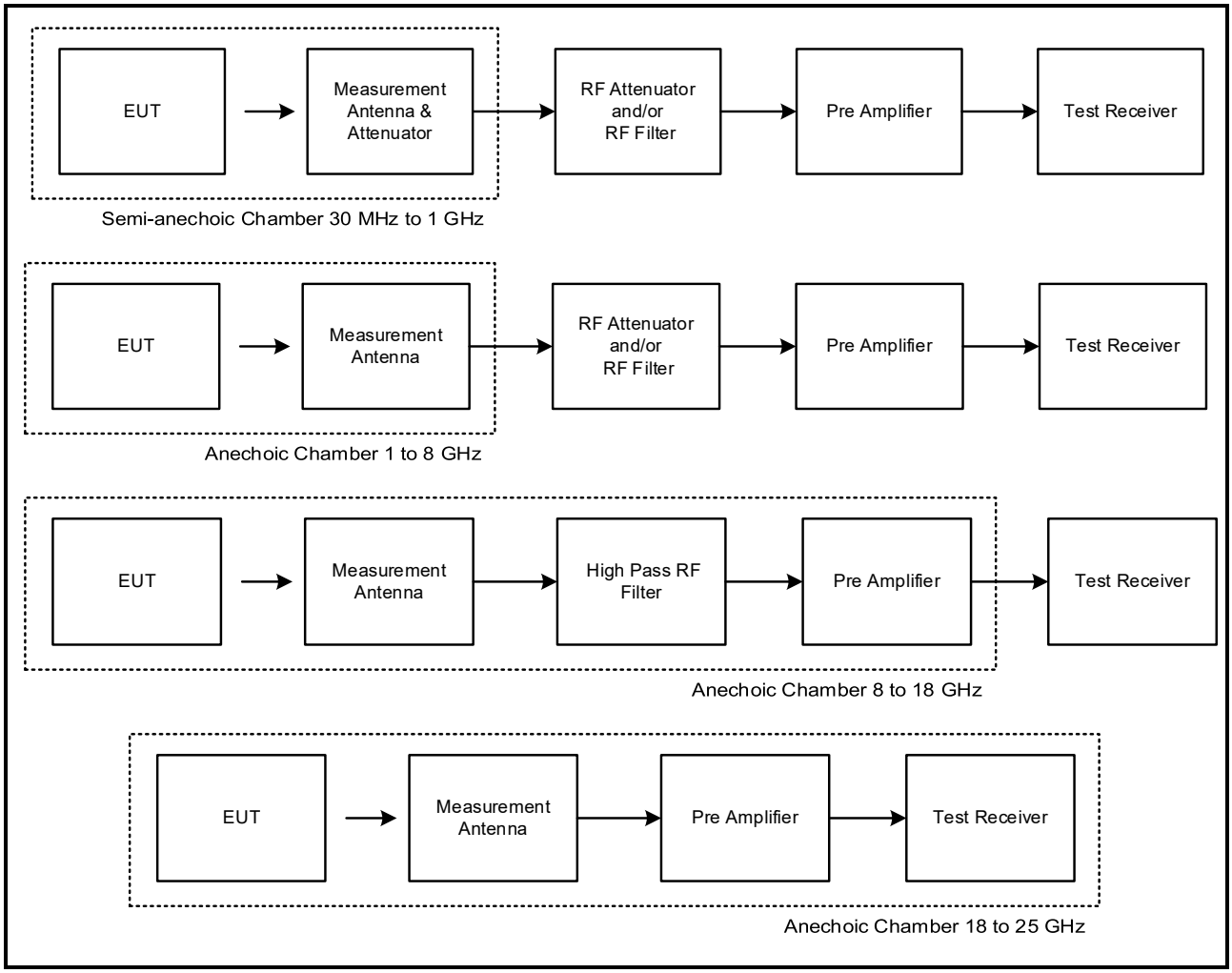
The EUT was tested in the following configuration(s):

- The EUT (Sample #1) was preconfigured to continuously transmit a 9-bit pseudorandom modulated carrier when connected to the internal batteries.
- The EUT (Sample #2) was preconfigured to transmit a 9-bit pseudorandom modulated carrier, one packet every 200ms, when connected to the internal batteries.
- The EUT was placed in the worst case position/orientation for the respective test.
- There were no ports to terminate.

Test Setup Diagrams

Radiated Tests:

Test Setup for Transmitter Radiated Emissions



4 Radiated Test Results

4.1 Transmitter Duty Cycle

Test Summary:

Test Engineer:	John Ferdinand	**Test Date:**	12 January 2022
Test Sample Serial Number:	#2		

FCC Reference:	Part 15.35(c)
Test Method Used:	FCC KDB 558074 Section 6 referencing ANSI C63.10 Section 11.6

Environmental Conditions:

Temperature (°C):	20
Relative Humidity (%):	41

Note(s):

1. In order to assist with the determination of the average level of spurious emissions field strength, measurements were made of duty cycle to determine the transmission duration and the silent period time of the transmitter. The transmitter duty cycle was measured using a spectrum analyser in the time domain and calculated by using the following calculation:

   20 log (1 / (On Time / [Period or 100 ms whichever is the lesser])).

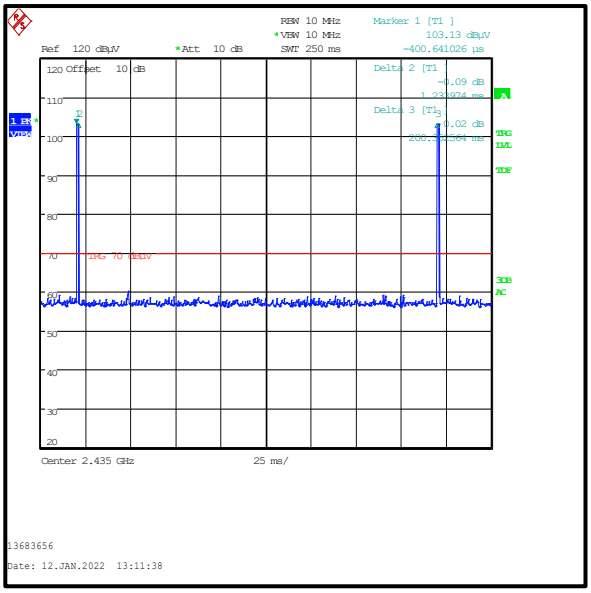
   Duty cycle: 20 log (1 / (1.226ms / 100ms)) = 38.2 dB

2. Sample #1 had a duty cycle of 100%.
3. The measurement was performed as a radiated test due to a conducted sample not being provided.

Transmitter Duty Cycle (continued)

Results:

Pulse Duration (ms)	Period (ms)	Duty Cycle (dB)
1.226	200.353	38.2



4.2 Transmitter Minimum 6 dB Bandwidth

Test Summary:

Test Engineer:	John Ferdinand	**Test Date:**	11 January 2022
Test Sample Serial Number:	#1		

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

Environmental Conditions:

Temperature (°C):	20
Relative Humidity (%):	42

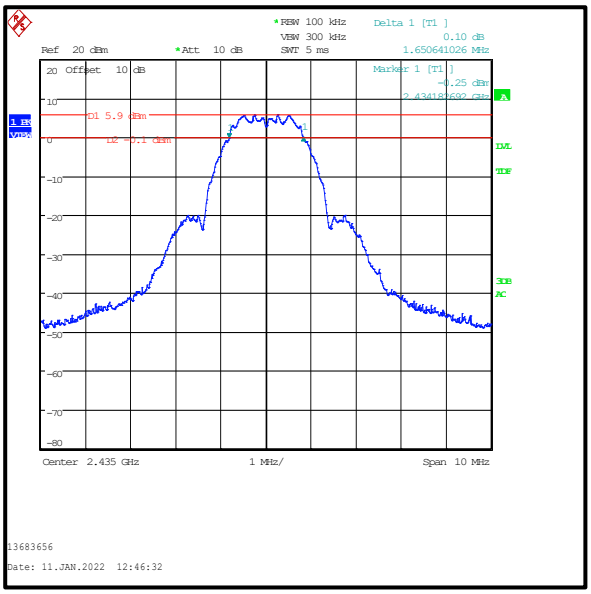
Note(s):

1. 6 dB DTS bandwidth tests were performed using a signal analyser in accordance with ANSI C63.10 Section 11.8.1 Option 1 measurement procedure. The signal 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.
2. The measurement was performed as a radiated test due to a conducted sample not being provided.

Transmitter Minimum 6 dB Bandwidth (continued)

Results:

Channel	6 dB Bandwidth (MHz)	Limit (MHz)	Margin (MHz)	Result
Single	1.651	≥0.5	1.151	Complied



4.3 Transmitter Maximum Peak Output Power

Test Summary:

Test Engineer:	John Ferdinand	**Test Date:**	11 January 2022
Test Sample Serial Number:	#1		

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

Environmental Conditions:

Temperature (°C):	20
Relative Humidity (%):	41

Note(s):

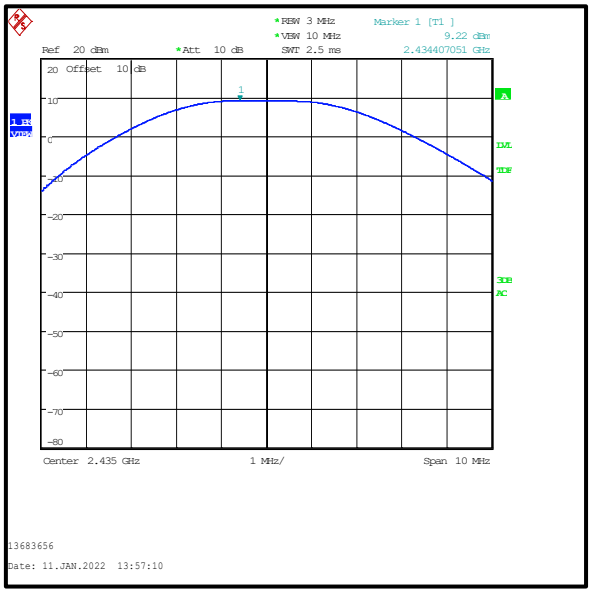
1. Measurements were performed using a test receiver in accordance with ANSI C63.10 Section 11.9.1.1 with the RBW ≥ DTS bandwidth procedure.
2. The test receiver resolution bandwidth was set to 3 MHz and video bandwidth of 10 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 10 MHz. A marker was placed at the peak of the signal and the results recorded in the tables below.
3. The measurement was performed as a radiated test due to a conducted sample not being provided.
4. The declated antenna gain was subtracted from the EIRP to obtain the conducted power.

Transmitter Maximum Peak Output Power (continued)

Results:

Channel	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Single	9.2	36.0	26.8	Complied

Channel	EIRP (dBm)	Declared Antenna Gain (dBi)	Conducted Power (dBm)	Conducted Power Limit (dBm)	Margin (dB)	Result
Single	9.2	6.1	3.1	30.0	26.9	Complied



4.4 Transmitter Radiated Emissions <1 GHz

Test Summary:

Test Engineer:	John Ferdinand	**Test Date:**	12 January 2022
Test Sample Serial Number:	#1		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	ANSI C63.10 Sections 6.3, 6.4, 6.5 and notes below
Frequency Range	30 MHz to 1000 MHz

Environmental Conditions:

Temperature (°C):	20
Relative Humidity (%):	41

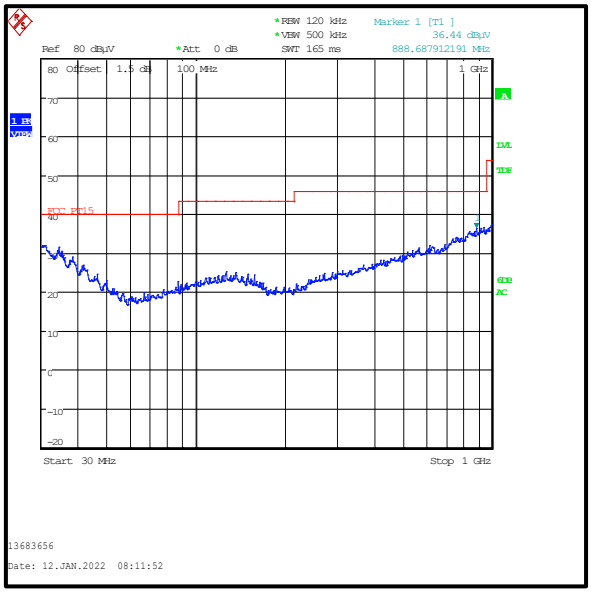
Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. All emissions shown on the pre-scan plots were investigated and found to be ambient, >20 dB below the applicable limit or below the measurement system noise floor. Therefore the highest peak noise floor reading of the measuring receiver was recorded in the table below.
3. Measurements below 1 GHz were performed in a semi-anechoic chamber (Asset Number K0017) 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.
4. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 120 kHz and video bandwidth 500 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.

Transmitter Radiated Emissions (continued)

Results: Peak

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
888.688	Vertical	36.4	46.0	9.6	Complied



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

4.5 Transmitter Radiated Emissions >1 GHz

Test Summary:

Test Engineer:	John Ferdinand	**Test Dates:**	11 January 2022 & 12 January 2022
Test Sample Serial Number:	#1		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	FCC KDB 558074 Sections 8.1 c)3), 8.5 & 8.6 referencing ANSI C63.10 Sections 6.3, 6.6, 11.11 & 11.12
Frequency Range	1 GHz to 25 GHz

Environmental Conditions:

Temperature (°C):	20
Relative Humidity (%):	40 to 41

Note(s):

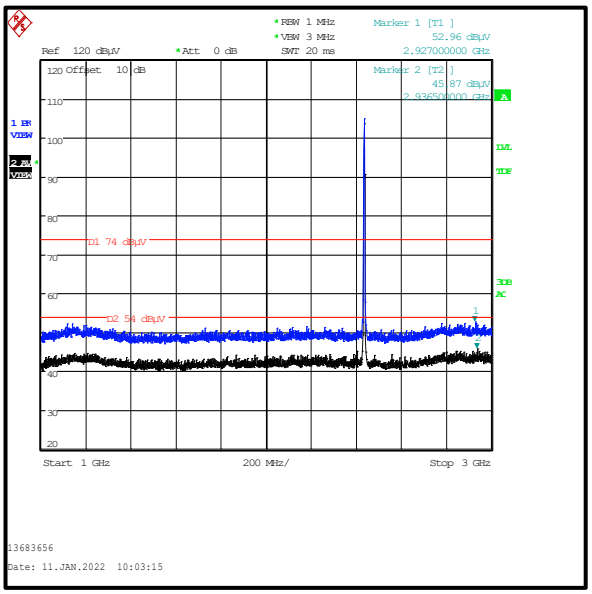
1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. All other emissions shown on the pre-scans were investigated and found to be ambient, >20 dB below the applicable limit or below the noise floor of the measurement system.
3. The emission shown on the 1 GHz to 3 GHz plot is the EUT fundamental.
4. Pre-scans above 1 GHz were performed in a fully anechoic chamber (Asset Number K0017) at a distance of 3 metres. The EUT was placed at a height of 1.5 metres above the test chamber floor in the centre of the chamber turntable. All measurement antennas were placed at a fixed height of 1.5 metres above the test chamber floor, in line with the EUT. Final measurements were performed in a fully anechoic chamber (Asset Number K0017) at a distance of 3 metres. 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 metre to 4 metres.
5. 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. Peak and average measurements were performed with their respective detectors during the pre-scan measurements.
6. The reference level for the emission in the non-restricted band was established by following KDB 558074 Section 11.2 procedure.
7. * -20 dBc limit.
8. ** 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.

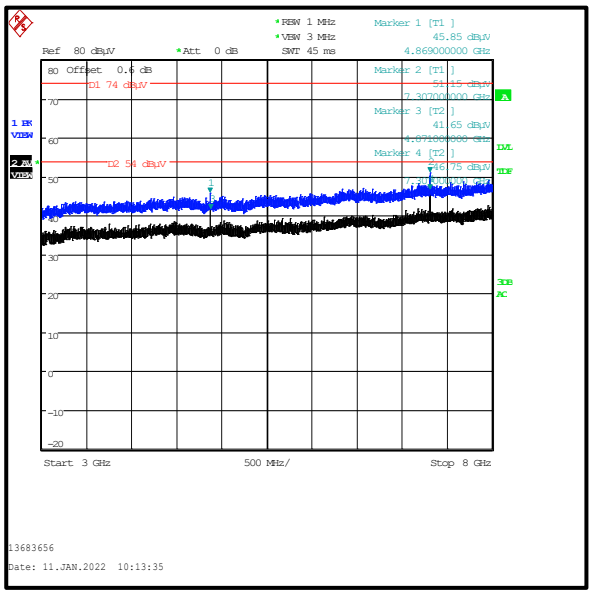
Transmitter Radiated Emissions (continued)

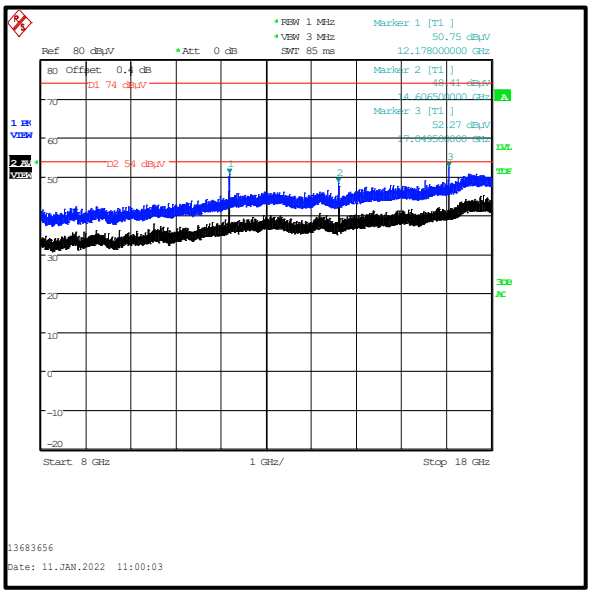
Results: Peak

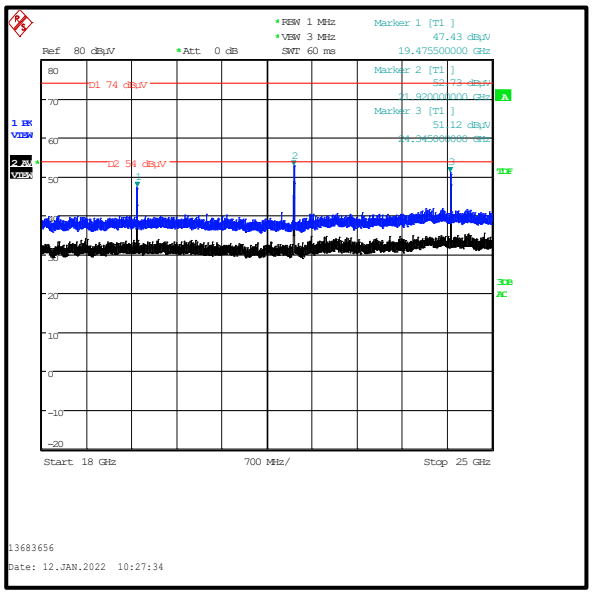
Frequency (MHz)	Antenna Polarity	Peak Level (dBμV/m)	Average Limit (dBμV/m)	Margin (dB)	Result
4871.551	Vertical	48.1	54.0**	5.9	Complied
7306.667	Vertical	51.8	54.0**	2.2	Complied
12172.388	Horizontal	51.6	54.0**	2.4	Complied
19484.356	Vertical	49.2	54.0**	4.8	Complied

Transmitter Radiated Emissions (continued)









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

4.6 Transmitter Band Edge Radiated Emissions

Test Summary:

Test Engineer:	John Ferdinand	**Test Date:**	11 January 2022
Test Sample Serial Number:	#1		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	KDB 558074 Section 8.7 referencing ANSI C63.10 Sections 11.11, 11.12 & 11.13

Environmental Conditions:

Temperature (°C):	20
Relative Humidity (%):	42

Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The maximum peak conducted output power was previously measured. In accordance with ANSI C63.10 Section 11.11.1(a), the lower band edge measurement was performed with a peak detector and the -20 dBc limit applied.
3. As the lower band edge is adjacent to a non-restricted band, only peak measurements are required. In accordance with ANSI C63.10 Section 11.11.1, the test method in Section 11.11.3 was followed: 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. As the maximum peak conducted output power was measured using a peak detector in accordance with ANSI C63.10 Section 11.9.1.1 an out-of-band limit line was placed 20 dB (ANSI C63.10 Section 11.11.1(a)) below the peak level. A marker was placed on the band edge spot frequencies. Marker frequency and levels were recorded.
4. As the upper band edge is adjacent to 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. An RMS detector was used, sweep time was set to auto and trace mode was trace averaging over 300 sweeps. 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.
5. 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 peak and RMS detectors respectively. Markers were placed on the highest point on each trace.
6. * -20 dBc limit.

Transmitter Band Edge Radiated Emissions (continued)

Results: Peak

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2395.994	Vertical	43.1	81.7*	38.6	Complied
2400.000	Vertical	40.8	81.7*	40.9	Complied
2483.500	Vertical	50.8	74.0	23.2	Complied
2520.675	Vertical	52.2	74.0	21.8	Complied

Results: Average

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.5	Vertical	44.8	54.0	9.2	Complied
2504.653	Vertical	46.5	54.0	7.5	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

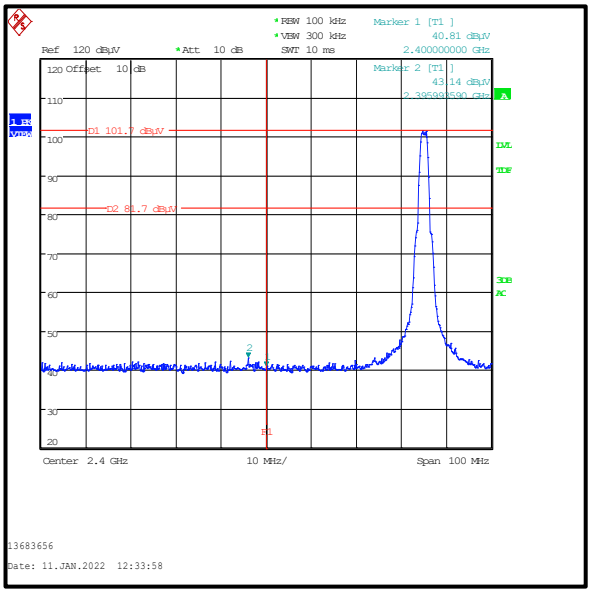
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2318.333	Vertical	52.4	74.0	21.6	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

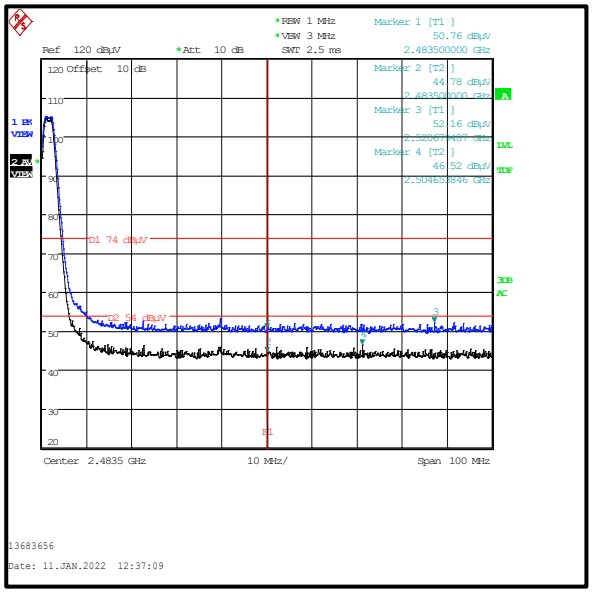
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2330.000	Vertical	46.5	54.0	7.5	Complied

Transmitter Band Edge Radiated Emissions (continued)

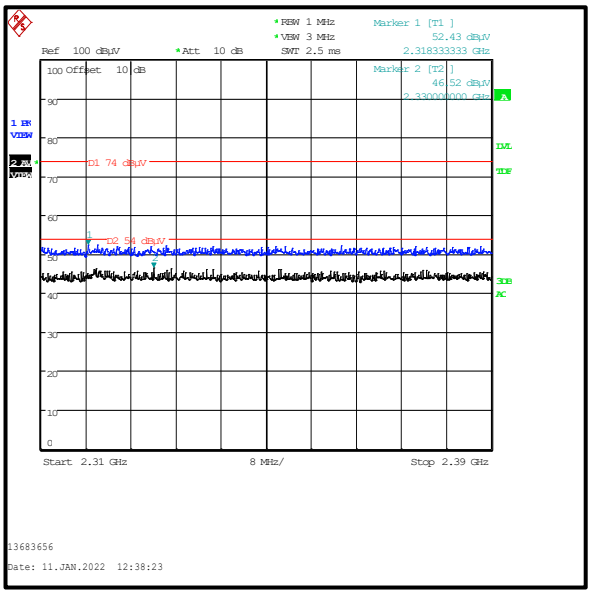
Results:



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

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