



TEST REPORT

Test Report No. : UL-RPT-RP-11645399-116FCC

Manufacturer : Casambi Technologies Oy
Model No. : CBM-002A
Technology : *Bluetooth* – Low Energy
Test Standard(s) : Partial testing of FCC Parts 15.209(a) & 15.247 (Radiated Testing only)

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 1.1– Supersede Version 1.0
5. Result of the tested sample: **PASS**

Prepared by: Abdoufataou Salifou
Title: Laboratory Engineer
Date: 17.10.2017

Approved by: Jakob Reschke
Title: Test Engineer
Date: 14.11.2017



Deutsche
Akkreditierungsstelle
D-PL-19381-02-00

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The tests reported herein have been performed in accordance with its' terms of accreditation.

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1. Customer Information

Company Name:	Casambi Technologies Oy
Company Address:	Linnoitustie 4, 02600 Espoo, Finland
Contact Person:	Kai Tötterman
Contact E-Mail Address:	kai.totterman@casambi.com
Contact Phone No.:	+358 45 137 9988

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
Test Firm Registration:	399704

Location

Location of Testing:	UL International Germany GmbH Hedelfinger Str. 61 70327 Stuttgart Germany
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Date information

Order Date:	16 February 2017
EUT arrived:	08 May 2017
Test Dates:	14 August 2017 to 13 October 2017
EUT returned:	-/-

2.2. Summary of Test Results

Clause	Measurement	Complied	Did not comply	Not performed	Not applicable
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 1}	☐	☐	☒	☐
Part 15.247(d)/15.209(a)	Transmitter Radiated Emissions	☒	☐	☐	☐
Part 15.247(d)/15.209(a)	Transmitter Band Edge Radiated Emissions	☒	☐	☐	☐
Part 15.207	Transmitter AC Conducted Emissions	☐	☐	☒	☐

Note(s):

1. Only the requested radiated measurements above were requested to be performed by the customer.

2.3. 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 DTS Meas Guidance v04 April 5, 2017
Title:	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247

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:	Casambi
Model Name or Number:	CBM-002A
Test Sample Serial Number:	Not marked or stated (<i>Radiated samples</i>)
Hardware Version Number:	CBM-002A: v1.1
Software Version Number:	20.1
FCC ID:	2ALA3-CBM002A

3.2. Description of EUT

The equipment under test was a Bluetooth Low Energy module.

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		
Channel Spacing:	2 MHz		
Modulation:	GFSK		
Data Rate:	1 Mbps		
Power Supply Requirement(s):	Nominal	3 VDC	
Maximum Conducted Output Power:	-/- dBm (1)		
Antenna Gain:	1.3 dBi		
Transmit Frequency Range:	2401 MHz to 2480 MHz		
Transmit Channels Tested:	Channel ID	RF Channel	Channel Frequency (MHz)
	Bottom	0	2401
	Middle	19	2440
	Top	39	2480

3.5. Support Equipment

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

Item	Description	Brand Name	Model Name or Number	Serial Number
1	Power Cable Length 2 metres	Not marked or stated	Not marked or stated	Not marked or stated
2	Laboratory Power Supply	Conrad Electronic Germany	PS -2403D	Not marked or stated
3	MP3 player	Apple	iPod Touch	CCQSCOZMGGK6

4. Operation and Monitoring of the EUT during Testing

4.1. Operating Modes

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

- ☒ Transmitting at maximum power in *Bluetooth* LE mode with modulation, maximum possible data length available.

4.2. Configuration and Peripherals

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

- The EUT was powered via a 3 VDC power supply for both conducted and radiated tests.
- Only radiated measurements were performed.
- The EUT was controlled in test mode using a software application Utility installed on the MP3 player supplied by the customer. The application was used to enable a continuous transmission and to select the test channels as required. The customer supplied a document containing the setup instructions "Casambi_radio_testing.pdf".
- The EUT radiated sample was used for measurement of Transmitter Radiated Emissions and Transmitter Band Edge Radiated Emissions.
- EMC32 V10.1.0 Software was used for the Radiated spurious emission measurement.

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 Radiated Emissions

Test Summary:

Test Engineer:	Abdoufataou Salifou	Test Date:	18 August 2017 and 13 October 2017
Test Sample Serial Number:	Not marked or stated (<i>Radiated sample</i>)		
Test Site Identification	SR 1/2		

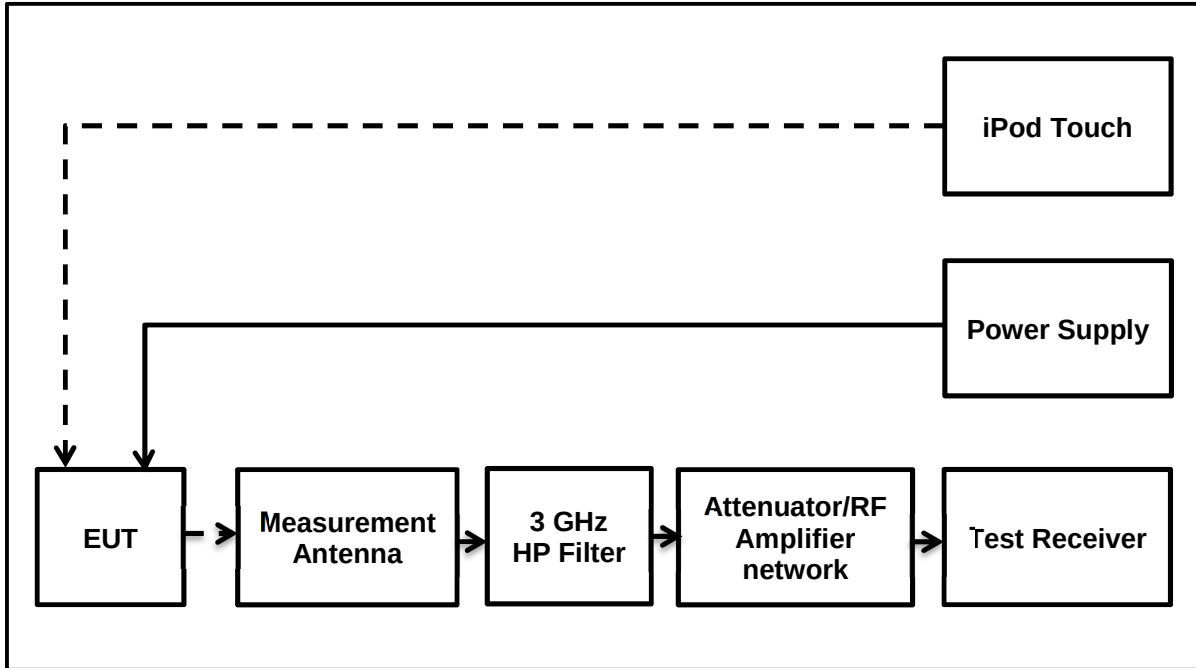
FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	ANSI C63.10 Sections 6.3 and 6.5
Frequency Range	30 MHz to 1000 MHz

Environmental Conditions:

Temperature (°C):	21
Relative Humidity (%):	37

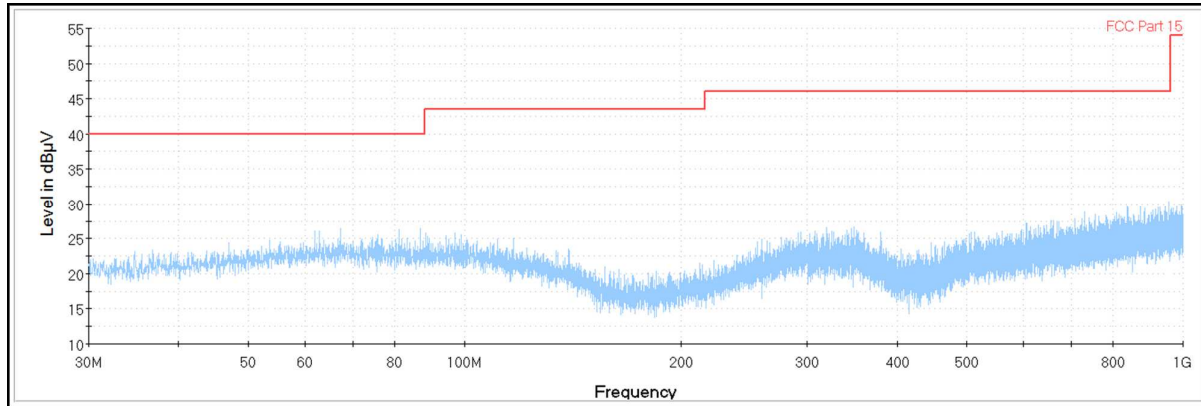
Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The 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 middle channel only.
3. No spurious emissions were detected above the noise floor of the measuring receiver therefore the highest peak noise floor reading of the measuring receiver was recorded as shown in the table below.
4. 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.
5. 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.

Transmitter Radiated Emissions (continued)**Test setup for radiated measurements:****Semi-anechoic chamber**

Transmitter Radiated Emissions (continued)**Results: Middle Channel**

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
955.916	Vertical	30.3	46.0	15.7	Complied



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:	Abdoufataou Salifou	Test Date:	14 August 2017 and 13 October 2017
Test Sample Serial Number:	Not marked or stated (<i>Radiated sample</i>)		
Test Site Identification	SR 1/2		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	FCC KDB 558074 Sections 11 & 12 referencing ANSI C63.10 Sections 6.3 and 6.6
Frequency Range	1 GHz to 25 GHz

Environmental Conditions:

Temperature (°C):	22
Relative Humidity (%):	40

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 emission shown on the 1 GHz to 4 GHz plot is the EUT fundamental.
3. Pre-scans above 1 GHz were performed in a semi anechoic chamber with absorber on the floor 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. 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.
4. 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.
5. The reference level for the emission in the non-restricted band was established by following KDB 558074 Section 11.2 procedure.
6. Maximum Power peak -20 dBc limit applies in non-restricted band as the conducted output power measurements were performed using a peak detector.

Transmitter Radiated Emissions (continued)**Results:****Results: Peak / Bottom Channel**

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
4802.666	Horizontal	56.3	74.1	17.8	Complied

Results: Average / Bottom Channel

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
4802.666	Horizontal	29.9	54.0	24.1	Complied

Results: Peak / Middle Channel

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
4881.000	Horizontal	56.7	74.6	17.9	Complied

Results: Average / Middle Channel

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
4881.000	Horizontal	30.3	54.0	23.7	Complied

Results: Peak / Top Channel

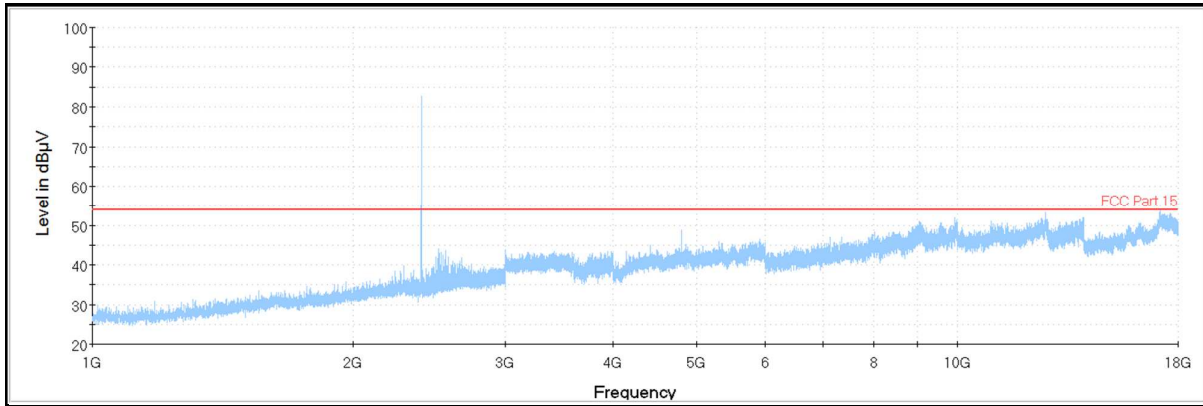
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
4960.666	Horizontal	55.8	75.1	19.3	Complied

Results: Average / Top Channel

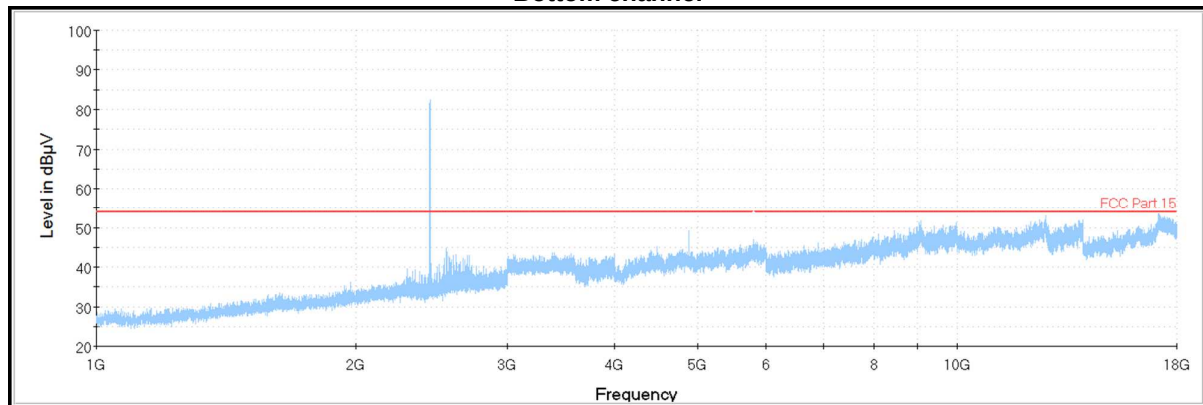
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
4960.666	Horizontal	29.4	54.0	24.6	Complied

Result: **Pass**

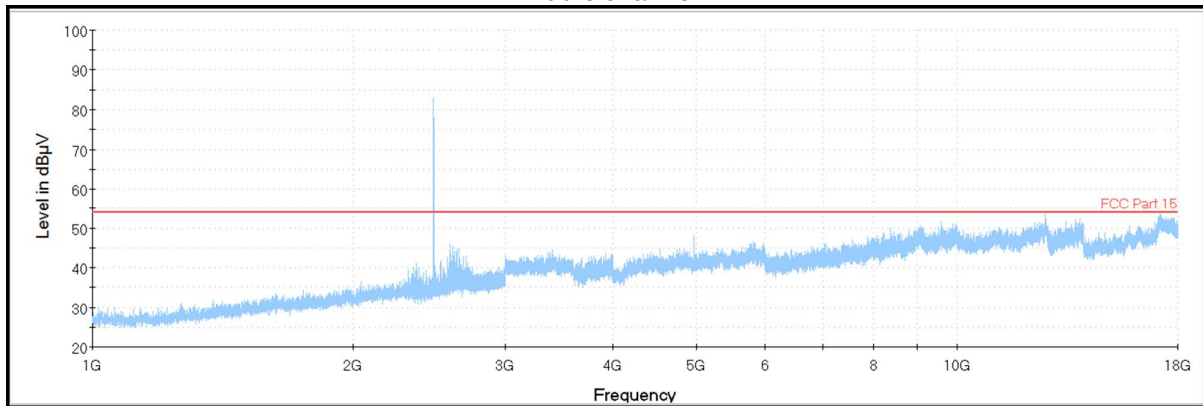
Transmitter Radiated Emissions (continued)



Bottom channel



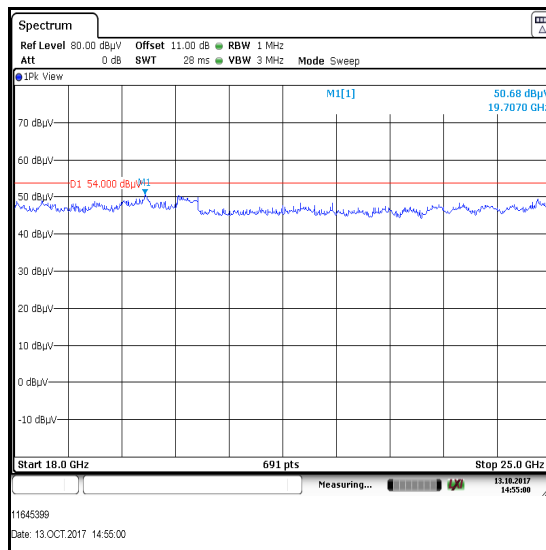
Middle channel



Top channel

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

Result: Pass

Transmitter Radiated Emissions (continued)**From 18 GHz to 25 GHz**

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

Result: Pass

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

Test Engineer:	Abdoufataou Salifou	Test Date:	14 September and 13 October 2017
Test Sample Serial Number:	Not marked or stated (<i>Radiated sample</i>)		
Test Site Identification	SR 1/2		

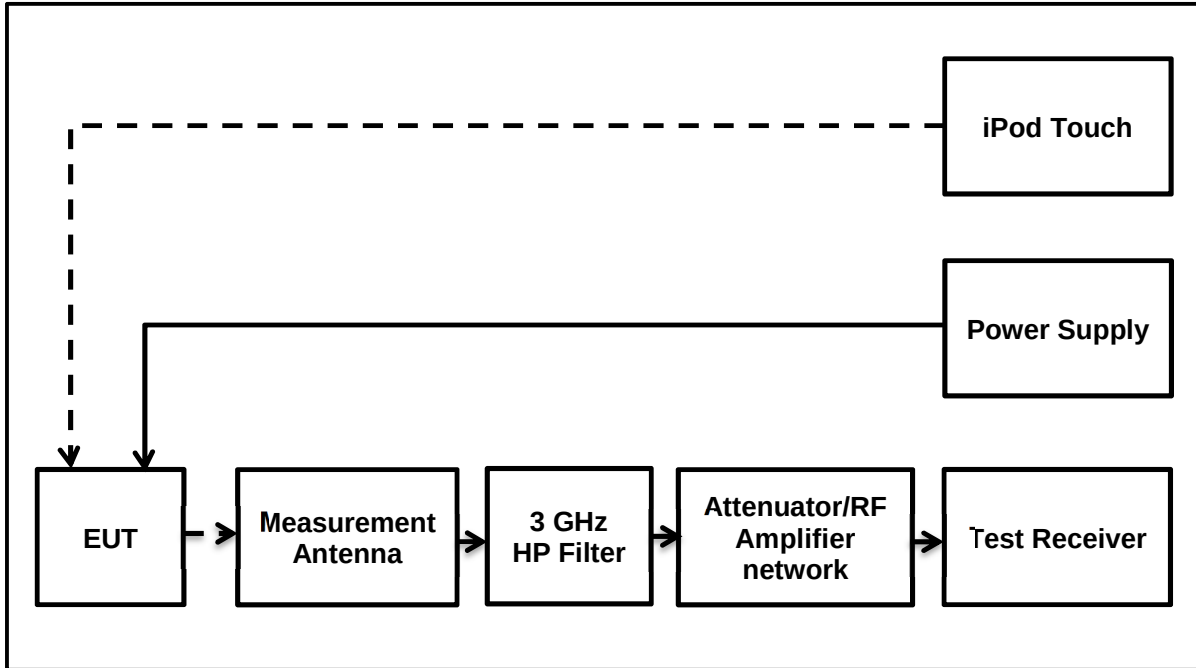
FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	ANSI C63.10 Section 6.10.4, 6.10.5 & KDB 558074 Section 11

Environmental Conditions:

Temperature (°C):	24
Relative Humidity (%):	40

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 FCC KDB 558074 Section 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 falls within a non-restricted band, only peak measurements are required. In accordance with FCC KDB 558074 Section 11.1, the test method in Section 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 conducted (average) output power was measured using an RMS detector in accordance with FCC KDB 558074 Section 9.2.2.4 an out-of-band limit line was placed 30 dB (FCC KDB 558074 Section 11.1(b)) below the peak level. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent non-restricted band of operation (where a higher level emission was present). Marker frequencies 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 their respective detectors. Markers were placed on the highest point on each trace.
6. The reference level was set to 118 dBµV in order to achieve sufficient headroom.

Transmitter Band Edge Radiated Emissions continued**Test setup for Band Edge Radiated Emissions Measurement****Semi-anechoic chamber**

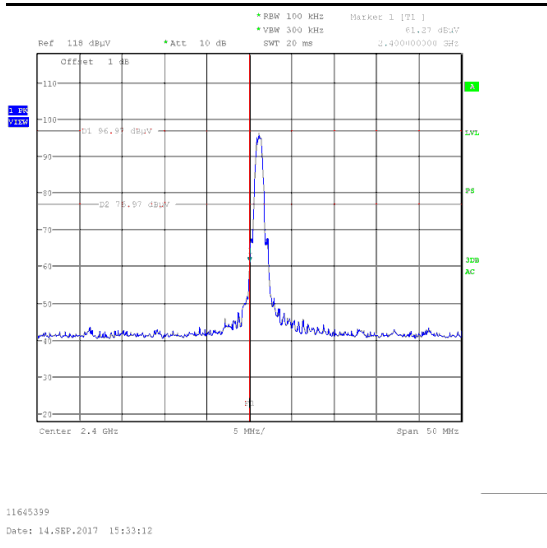
Results: Peak

Frequency (MHz)	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2400.0	61.3	77.0	15.7	Complied
2483.5	55.0	74.0	9.0	Complied

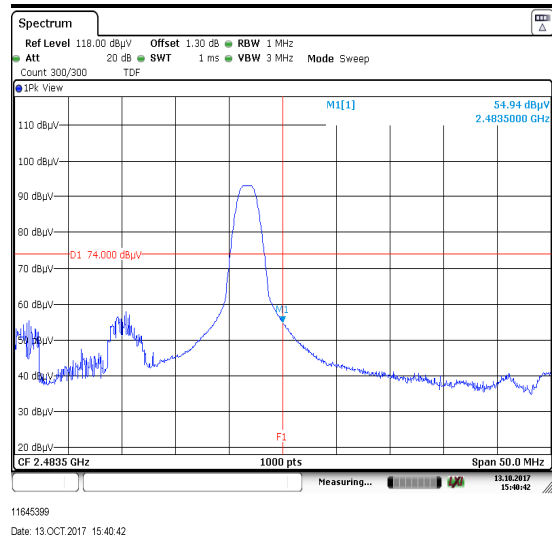
Results: Average

Frequency (MHz)	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	52.6	54.0	1.4	Complied

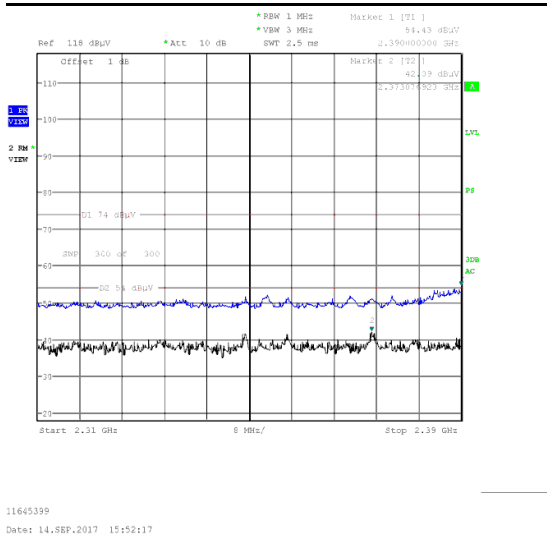
Transmitter Band Edge Radiated Emissions continued



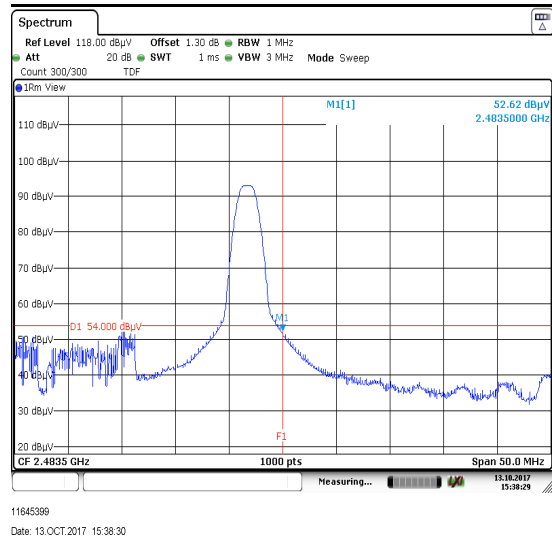
Lower Band Edge Peak Measurement



Upper Band Edge Peak Measurement



2310 MHz to 2390 MHz Restricted Band Plot



Upper Band Edge Average Measurement

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	Range	Confidence Level (%)	Calculated Uncertainty
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±2.53 dB
Radiated Spurious Emissions	1 GHz to 26.5 GHz	95%	±2.53 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 No.	Calibration Date	Cal. Cycle
350	Rohde & Schwarz	Receiver, EMI Test	ESIB7	836697/014	7/13/2017	12
377	Bonn Elektronik	Amplifier, Low Noise Pre	BLMA 0118-1A	025294B	7/11/2017	12
423	Bonn Elektronik	Amplifier, Low Noise Pre	BLMA 1840-1A	055929	7/12/2017	12
460	Deisl	Turntable	DT 4250 S		n/a	n/a
465	Schwarzbeck	Antenna, Trilog Broadband	VULB 9168	9168-240	8/8/2016	36
496	Rohde & Schwarz	Antenna, log. - periodical	HL050	100297	7/20/2016	24
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	7/12/2017	12
608	Rohde & Schwarz	Switch Matrix	OSP 120	101227	4/8/2014	60
614	Wainwright Instruments	Highpass Filter 3GHz	WHKX10-	1	Lab verification	n/a
615	Wainwright Instruments	Highpass Filter 1GHz	WHKX12-	3	Lab verification	n/a
620	Bonn Elektronik	pre-amplifier	BLNA 0110-01N	1510111	7/12/2017	24
628	Maturo	Antenna mast	CAM 4.0-P	224/19590716	n/a	n/a
629	Maturo	Kipheinrichtung	KE 2.5-R-M	MAT002	n/a	n/a

8. Report Revision History

Version Number	Revision Details		
	Page No(s)	Clause	Details
1.0	-	-	Initial Version
1.1	7, 12, 14, 19,23	5.2.1, 5.2.2	Setup diagram, test dates and equipment list was updated

--- END OF REPORT ---