




TEST REPORT


Test Report No. : UL-RPT-RP10969487JD02A V2.0

Manufacturer : Playbrush Ltd
Model No. : PBR1
FCC ID : 2AF47PBR1
Technology : *Bluetooth* – Low Energy
Test Standard(s) : FCC Parts 15.209(a) & 15.247

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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 2.0 supersedes all previous versions.

Date of Issue: 13 November 2015

Checked by: 
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Engineer, Radio Laboratory

Issued by : 
pp
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Quality Manager,
UL VS LTD



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1. Customer Information







Company Name:	Playbrush Ltd
Address:	68 Edith Villas London W14 9AB United Kingdom

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:	47CFR15.209
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.209
Site Registration:	209735
Location of Testing:	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
Test Dates:	27 October 2015 to 09 November 2015

2.2. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.247(a)(2)	Transmitter Minimum 6 dB Bandwidth	
Part 15.247(e)	Transmitter Power Spectral Density	Note 1
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	
Key to Results		
 = Complied  = Did not comply		

Note(s):

- In accordance with FCC KDB 558074 Section 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.

2.3. 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 v03r03 June 9, 2015
Title:	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §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:	Playbrush
Model Name or Number:	PBR1
Test Sample Serial Number:	# 3 (<i>Radiated sample</i>)
Hardware Version:	V1
Software Version:	V1
FCC ID:	2AF47PBR1

Brand Name:	Playbrush
Model Name or Number:	PBR1
Test Sample Serial Number:	# 2 (<i>Conducted sample with RF port</i>)
Hardware Version:	V1
Software Version:	V1
FCC ID:	2AF47PBR1

3.2. Description of EUT

The equipment under test was a *Bluetooth LE* device that fits into a waterproof housing which transforms a toothbrush into a game controller.

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:	<i>Bluetooth</i> Low Energy (Digital Transmission System)		
Type of Unit:	Transceiver		
Channel Spacing:	2 MHz		
Modulation:	GFSK		
Data Rate:	1 Mbps		
Power Supply Requirement(s):	Nominal	4.1 VDC via rechargeable battery	
Maximum Conducted Output Power:	3.6 dBm		
Antenna Gain:	0.0 dBi		
Transmit Frequency Range:	2402 MHz to 2480 MHz		
Transmit Channels Tested:	Channel ID	RF Channel	Channel Frequency (MHz)
	Bottom	0	2402
	Middle	19	2440
	Top	39	2480

3.5. Support Equipment

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

Description:	Laptop Computer
Brand Name:	Lenovo
Model Name or Number:	E555
Serial Number:	Not stated

Description:	AC to DC adaptor
Brand Name:	Samsung
Model Name or Number:	ETA0U10UBE
Serial Number:	SC5CB01SS/7-E

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 a modulated carrier, maximum data length available and Pseudorandom Bit Sequence 9.

4.2. Configuration and Peripherals

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

- Transmit tests: The EUT was placed into BLE Test Mode using a laptop PC and application supplied by the customer. Bluetooth *Direct Test Mode* was selected, *Mode* was set to Transmit, *Payload Model* was PRBS9 and *Payload Length* was 37 bytes. The EUT *Channel* was set to *Single* and the test channel number set as required.
- The test application was *nRFgo Studio* (version 1.21.0.2) by Nordic Semiconductor ASA. The relevant instructions for using the tool on the EUT were contained within the document *DUT user manual.pdf* prepared October 2015.
- The EUT consisted of a pcb fitted with a micro-USB connector for charging purposes and powered by a coin type rechargeable battery
- During testing, the EUT was powered by a fully charged battery. The battery voltage was monitored throughout testing.
- The conducted sample was the PCB removed from the waterproof housing. The customer supplied a test jig that allowed a USB-B socket to interface to the EUT for serial communication. The test jig, made of PLA plastic, was also fitted with an SMA antenna port with a co-ax cable connected to the EUT in order to perform conducted measurements. This additional path loss was stated in band as 0.3 dB and was included in any path loss calculations.
- The radiated sample was connected to a test jig, made of PLA plastic. The EUT was powered by the internal battery whilst being charged from a 120 VAC to 5 VDC adaptor, via the micro-USB port.
- The EUT conducted sample was used for 6 dB bandwidth and maximum peak output power tests.

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 UKAS 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 Minimum 6 dB Bandwidth

Test Summary:

Test Engineer:	Keith Tucker	Test Date:	27 October 2015
Test Sample Serial Number:	# 2		

FCC Reference:	Part 15.247(a)(2)
Test Method Used:	FCC KDB 558074 Section 8.1 Option 1

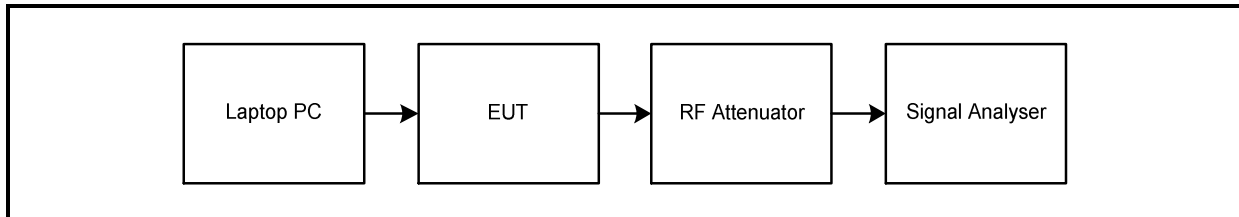
Environmental Conditions:

Temperature (°C):	24
Relative Humidity (%):	51

Note(s):

1. 6 dB DTS bandwidth tests were performed using a signal analyser in accordance with FCC KDB 558074 Section 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 signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable.

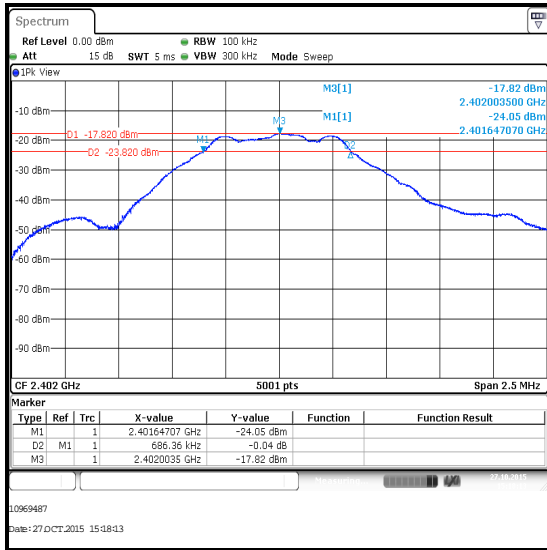
Test setup:



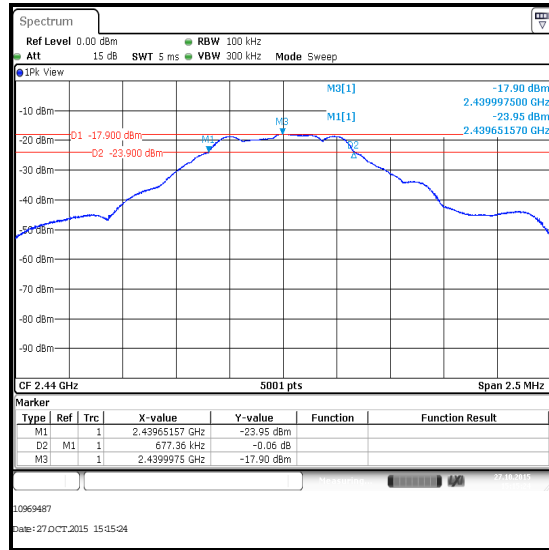
Transmitter Minimum 6 dB Bandwidth (continued)

Results:

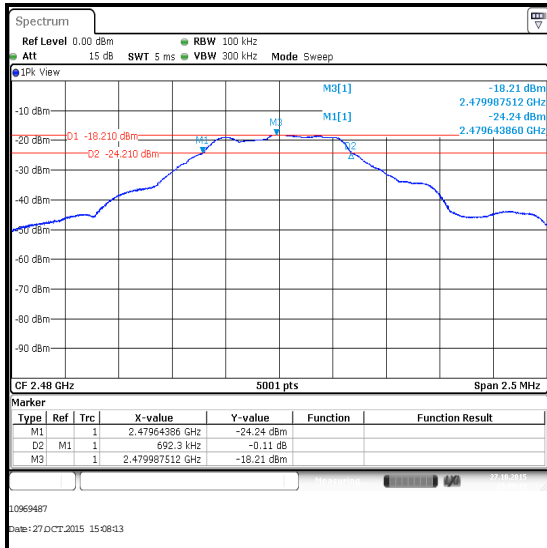
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	686.360	≥500	186.360	Complied
Middle	677.360	≥500	177.360	Complied
Top	692.300	≥500	192.300	Complied



Bottom Channel



Middle Channel



Top Channel

Transmitter Minimum 6 dB Bandwidth (continued)**Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1783	Thermohygrometer	JM Handelpunkt	30.5015.13	None stated	23 Apr 2016	12
A2521	Attenuator	AtlanTecRF	AN18-20	832797#2	Calibrated before use	-
M1883	Signal Analyser	Rohde & Schwarz	FSV30	103084	23 Jul 2016	12
G0614	Signal Generator	Rohde & Schwarz	SMB100A	177687	01 May 2017	36

5.2.2. Transmitter Maximum Peak Output Power**Test Summary:**

Test Engineer:	Keith Tucker	Test Date:	27 October 2015
Test Sample Serial Number:	# 2		

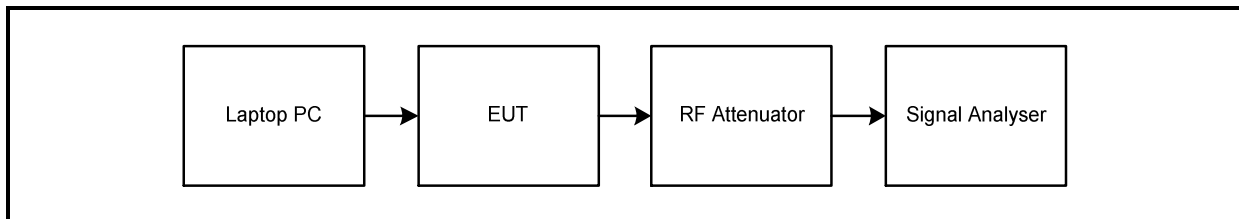
FCC Reference:	Part 15.247(b)(3)
Test Method Used:	FCC KDB 558074 Section 9.1.1

Environmental Conditions:

Temperature (°C):	24
Relative Humidity (%):	52

Note(s):

1. Conducted power tests were performed using a signal analyser in accordance with FCC KDB 558074 Section 9.1.1 with the RBW > *DTS bandwidth* procedure. A resolution bandwidth of 1 MHz was used and the video bandwidth was set to 3 MHz.
2. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF level offset was entered on the signal analyser to compensate for the loss of the attenuator and RF cables.
3. The conducted power was added to the declared antenna gain to obtain the EIRP.

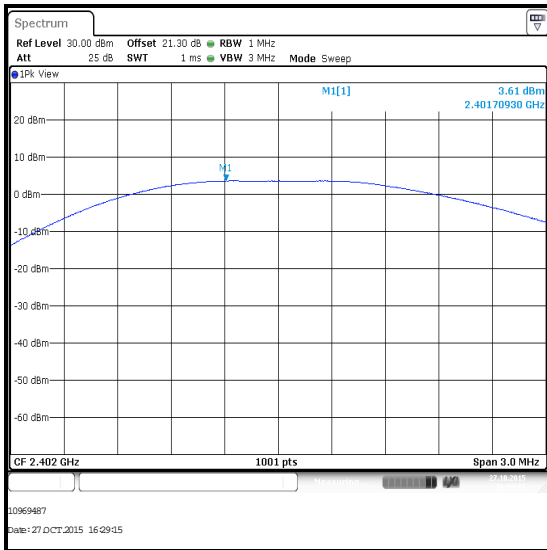
Test setup:

Transmitter Maximum Peak Output Power (continued)**Results:**

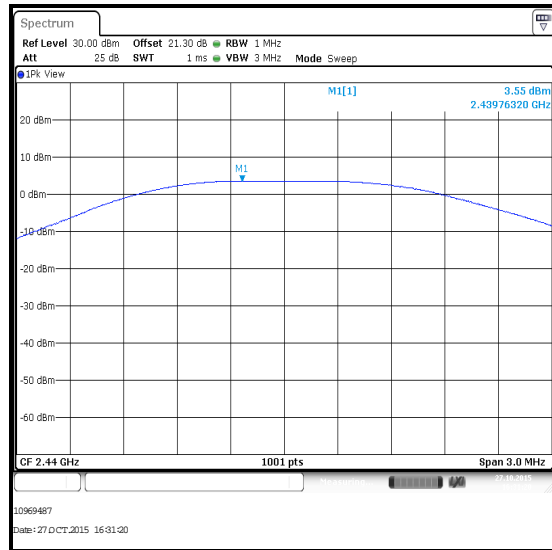
Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	3.6	30.0	26.4	Complied
Middle	3.6	30.0	26.4	Complied
Top	3.3	30.0	26.7	Complied

Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	3.6	0.0	3.6	36.0	32.4	Complied
Middle	3.6	0.0	3.6	36.0	32.4	Complied
Top	3.3	0.0	3.3	36.0	32.7	Complied

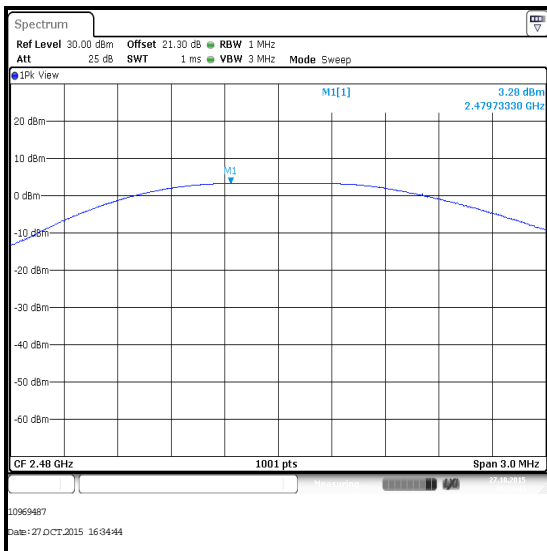
Transmitter Maximum Peak Output Power (continued)



Bottom Channel



Middle Channel



Top Channel

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1783	Thermohyrometer	JM Handelpunkt	30.5015.13	None stated	23 Apr 2016	12
A2521	Attenuator	AtlanTecRF	AN18-20	832797#2	Calibrated before use	-
M1883	Signal Analyser	Rohde & Schwarz	FSV30	103084	23 Jul 2016	12
G0614	Signal Generator	Rohde & Schwarz	SMB100A	177687	01 May 2017	36

5.2.3. Transmitter Radiated Emissions**Test Summary:**

Test Engineer:	Kiren Mistry	Test Date:	09 November 2015
Test Sample Serial Number:	# 3		

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:

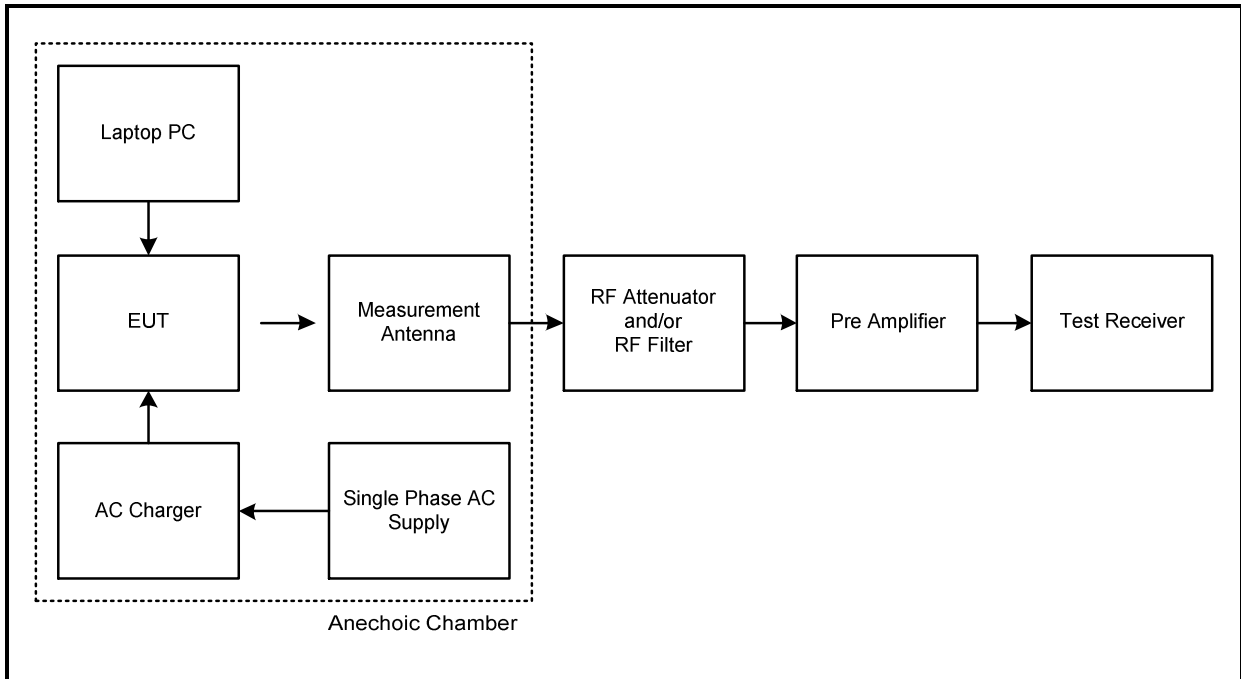
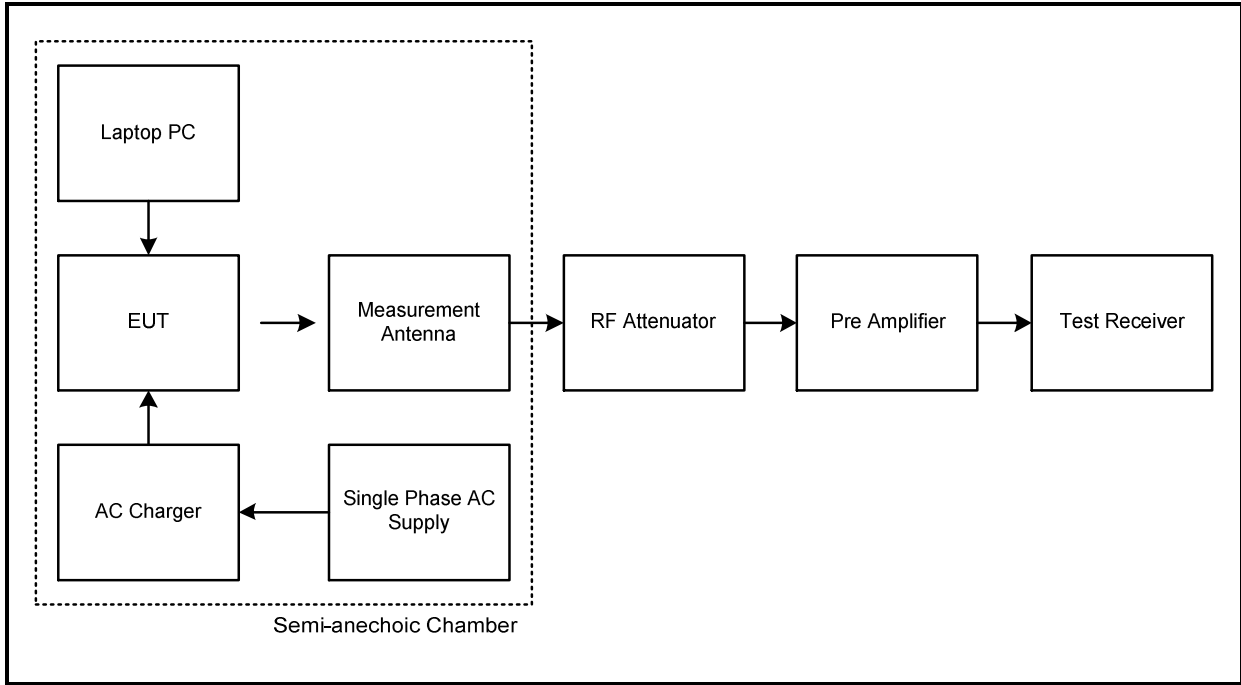
Temperature (°C):	22
Relative Humidity (%):	42

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 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. All emissions shown on the pre-scans were investigated and found to be ambient, or > 20 dB below the appropriate limit or below the noise floor of the measurement system, 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.
6. Final measurements were performed on the marker frequencies and the results entered into the table below. The test receiver resolution bandwidth was set to 120 kHz, using a CISPR quasi-peak detector and span big enough to see the whole emission.

Transmitter Radiated Emissions (continued)

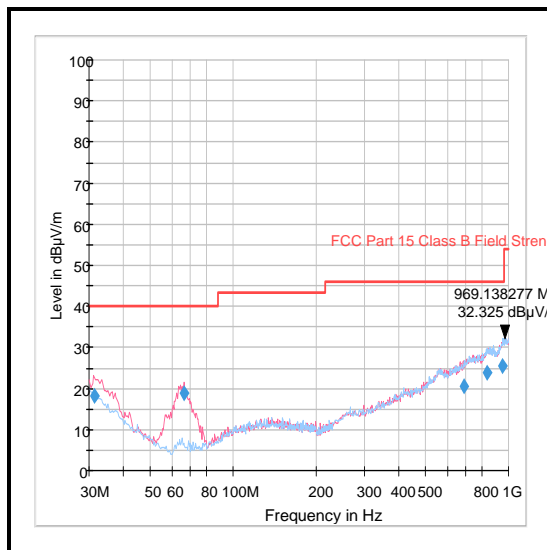
Test setup for radiated measurements:



Transmitter Radiated Emissions (continued)

Results: Middle Channel

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
969.138	Horizontal	32.3	54.0	21.7	Complied



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

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1945	Thermohygrometer	JM Handelspunkt	30.5015.01	0112	23 Apr 2016	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	19 Mar 2016	12
G0543	Amplifier	Sonoma	310N	230801	10 Feb 2016	3
M1273	Test Receiver	Rohde & Schwarz	ESIB 26	100275	12 Mar 2016	12
A490	Antenna	Chase	CBL6111A	1590	30 Apr 2016	12
A1834	Attenuator	Hewlett Packard	8491B	10444	05 Mar 2016	12

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

Test Engineer:	Kiren Mistry	Test Date:	03 November 2015
Test Sample Serial Number:	# 3		

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):	23
Relative Humidity (%):	42

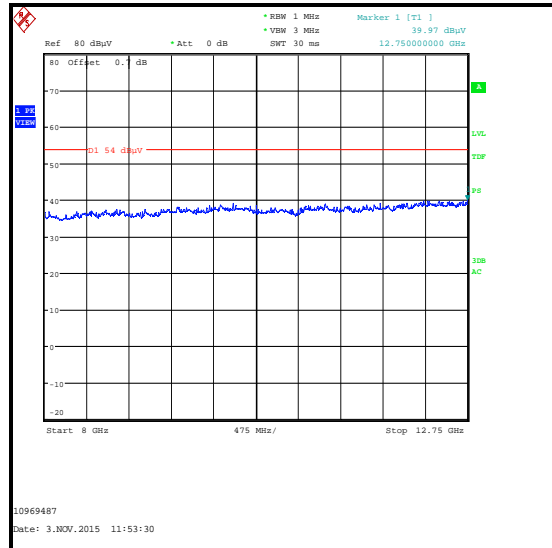
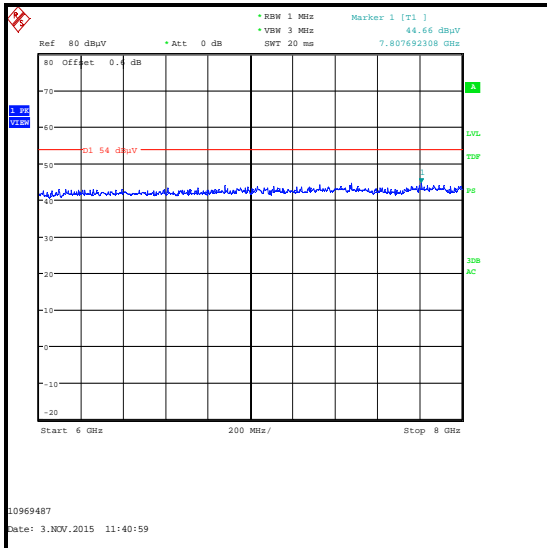
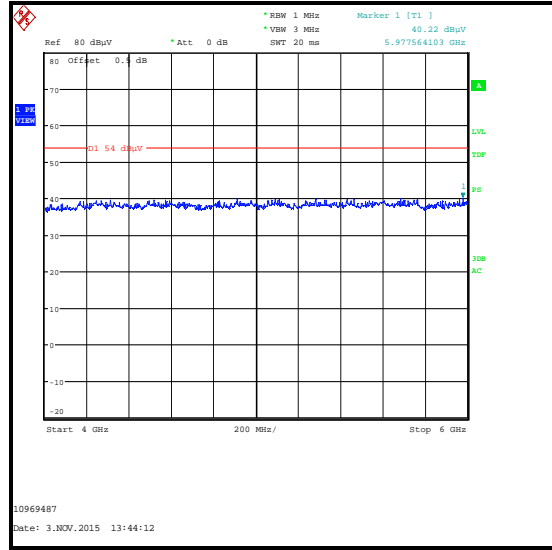
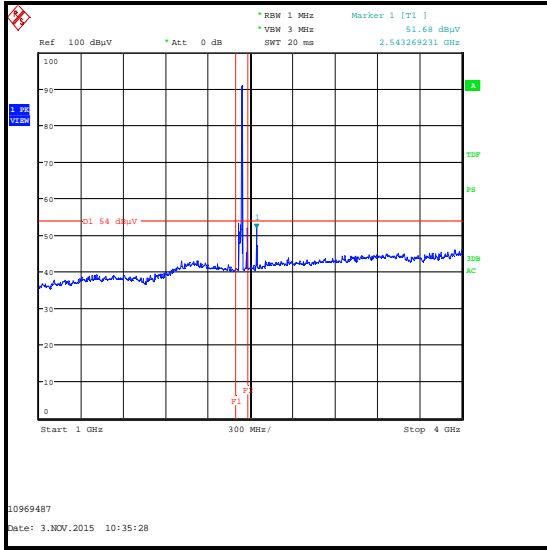
Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. 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.
3. The emission shown on the 1 GHz to 4 GHz plot is the EUT fundamental.
4. Pre-scans above 1 GHz were performed in a fully anechoic chamber (Asset Number K0002) 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 above 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 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.
6. 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.

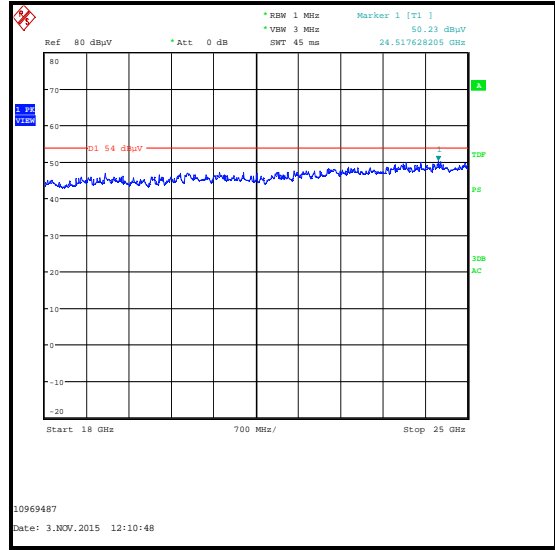
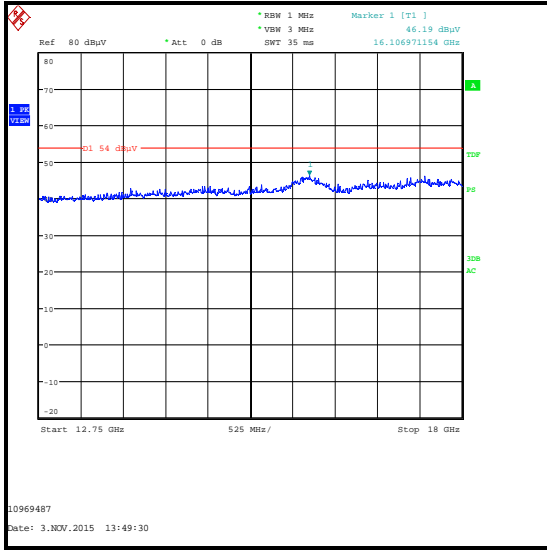
Results: Peak / Bottom Channel

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2381.756	Horizontal	53.2	54.0	0.8	Complied

Transmitter Radiated Emissions (continued)



Transmitter Radiated Emissions (continued)



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

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1656	Thermohygrometer	JM Handelspunkt	30.5015.13	None stated	23 Apr 2016	12
K0002	3m RSE Chamber	Rainford EMC	N/A	N/A	01 May 2016	12
A1534	Pre Amplifier	Hewlett Packard	3449B	3008A00405	21 Dec 2015	12
M1874	Test Receiver	Rohde & Schwarz	ESU26	100553	12 Jun 2016	12
A1818	Antenna	EMCO	3115	00075692	20 Dec 2015	12
A253	Antenna	Flann Microwave	12240-20	128	20 Dec 2015	12
A254	Antenna	Flann Microwave	14240-20	139	20 Dec 2015	12
A255	Antenna	Flann Microwave	16240-20	519	20 Dec 2015	12
A256	Antenna	Flann Microwave	18240-20	400	20 Dec 2015	12
A436	Antenna	Flann Microwave	20240-20	330	20 Dec 2015	12
A1975	High Pass Filter	AtlanTecRF	AFH-03000	090424010	17 Apr 2016	12

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

Test Engineer:	Kiren Mistry	Test Date:	03 November 2015
Test Sample Serial Number:	# 3		

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):	23
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 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. 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.
4. * -20 dBc limit.
5. The reference level was set to 115 dB μ V in order to achieve sufficient headroom.

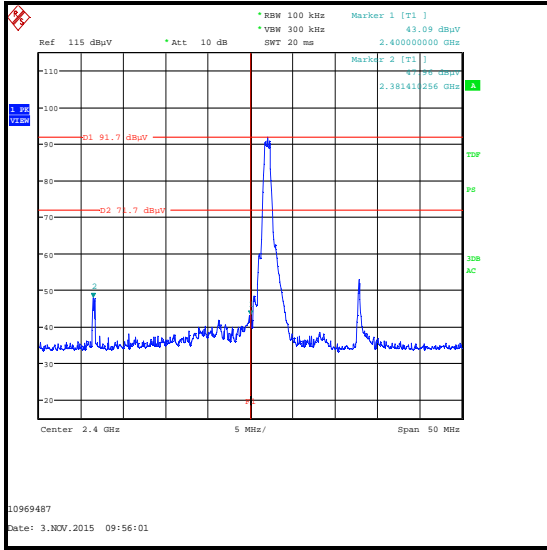
Transmitter Band Edge Radiated Emissions (continued)**Results: Peak**

Frequency (MHz)	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2351.795	53.4	74.0	20.6	Complied
2381.410	48.0	74.0	26.0	Complied
2381.538	55.2	74.0	18.8	Complied
2400.0	43.1	71.7*	28.6	Complied
2483.5	50.9	74.0	23.1	Complied
2508.500	52.6	70.3*	17.7	Complied

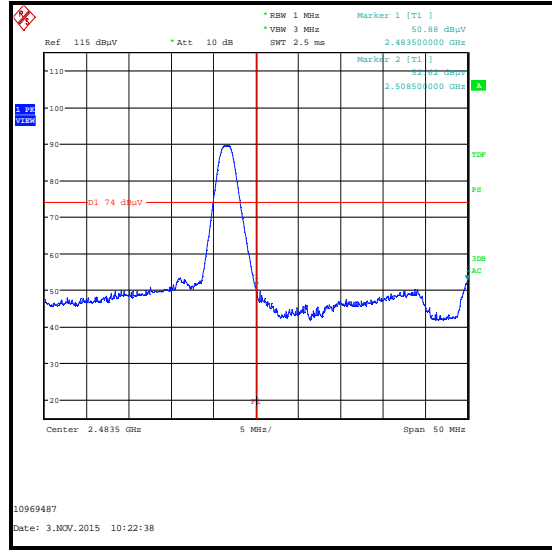
Results: Average

Frequency (MHz)	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2351.667	42.4	54.0	11.6	Complied
2381.410	42.1	54.0	11.9	Complied
2483.5	45.8	54.0	8.2	Complied

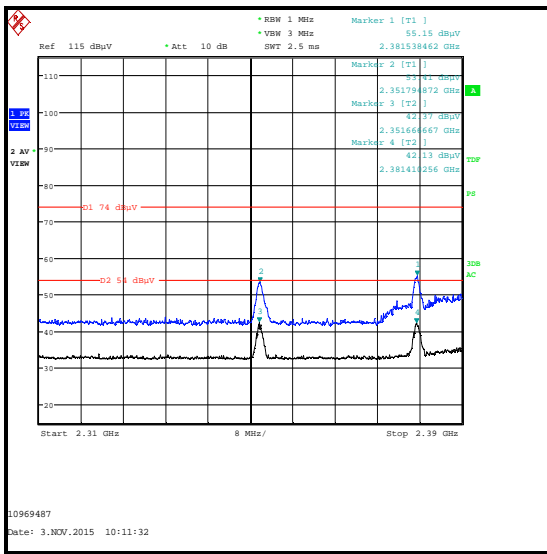
Transmitter Band Edge Radiated Emissions (continued)



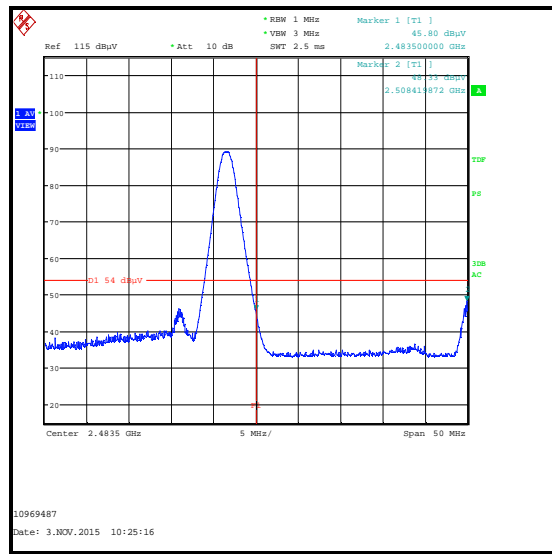
Lower Band Edge Peak Measurement



Upper Band Edge Peak Measurement



2310 MHz to 2390 MHz Restricted Band Plot



Upper Band Edge Average Measurement

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1656	Thermohygrometer	JM Handelspunkt	30.5015.13	None stated	23 Apr 2016	12
K0002	3m RSE Chamber	Rainford EMC	N/A	N/A	01 May 2016	12
A1534	Pre Amplifier	Hewlett Packard	3449B	3008A00405	21 Dec 2015	12
M1874	Test Receiver	Rohde & Schwarz	ESU26	100553	12 Jun 2016	12
A1818	Antenna	EMCO	3115	00075692	20 Dec 2015	12

6. Measurement Uncertainty

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 measured (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.

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
Conducted Maximum Peak Output Power	2.4 GHz to 2.4835 GHz	95%	±1.13 dB
Minimum 6 dB Bandwidth	2.4 GHz to 2.4835 GHz	95%	±3.92 %
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±5.65 dB
Radiated Spurious Emissions	1 GHz to 26.5 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.

7. Report Revision History

Version Number	Revision Details		
	Page No(s)	Clause	Details
1.0	-	-	Initial Version
2.0	-	-	Sections 3.2 & 4.2 updated

--- END OF REPORT ---