



TEST REPORT

Test Report No. : UL-RPT-RP12173937JD08A

Customer : Apple Inc.
Model No. : A1989
FCC ID : BCGA1989
Technology : *Bluetooth – Basic Rate & EDR*
Test Standard(s) : FCC Parts 15.209(a) & 15.247

Test Laboratory : UL VS LTD, Basingstoke, Hampshire, RG24 8AH, United Kingdom

1. This test report shall not be reproduced in full or partial, without the written approval of UL VS LTD.
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: 20 June 2018

Checked by: Sarah Williams
Sarah Williams
Senior Test Engineer, Radio Laboratory

Company Signatory: Ben Mercer
Ben Mercer
Senior Test Engineer, Radio Laboratory
UL VS LTD



The *Bluetooth*® word mark and logos are owned by the *Bluetooth SIG*, Inc. and any use of such marks by UL VS LTD is under licence. Other trademarks and trade names are those of their respective owners.

UL VS LTD

Pavilion A, Ashwood Park, Ashwood Way, Basingstoke, Hampshire, RG23 8BG, UK
Telephone: +44 (0)1256 312000
Facsimile: +44 (0)1256 312001

Customer Information

Company Name:	Apple Inc.
Address:	One Apple Park Way Cupertino, California 95014 U.S.A.
Contact Name:	Stuart Thomas

Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	20/06/2018	Initial Version	Sarah Williams

Table of Contents

Customer Information.....	2
Report Revision History	2
1. Attestation of Test Results.....	4
1.1. Description of EUT	4
1.2. General Information	4
1.3. Summary of Test Results	4
1.4. Deviations from the Test Specification	4
2. Summary of Testing.....	5
2.1. Facilities and Accreditation	5
2.2. Methods and Procedures	5
2.3. Calibration and Uncertainty	6
2.4. Test and Measurement Equipment	7
3. Equipment Under Test (EUT)	9
3.1. Identification of Equipment Under Test (EUT)	9
3.2. Modifications Incorporated in the EUT	9
3.3. Additional Information Related to Testing	10
3.4. Description of Available Antennas	10
3.5. Description of Test Setup	11
4. Antenna Port Test Results	14
4.1. Transmitter 20 dB Bandwidth	14
4.2. Transmitter Carrier Frequency Separation	18
4.3. Transmitter Number of Hopping Frequencies and Average Time of Occupancy	22
4.4. Transmitter Maximum Peak Output Power	24
5. Radiated Test Results.....	31
5.1. Transmitter Radiated Emissions <1 GHz	31
5.2. Transmitter Radiated Emissions >1 GHz	33
5.3. Transmitter Band Edge Radiated Emissions	36

1. Attestation of Test Results

1.1. Description of EUT

The equipment under test was a Laptop Computer with WLAN and *Bluetooth*.

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
Test Dates:	16 April 2018 to 29 April 2018

1.3. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.247(a)(1)	Transmitter 20 dB Bandwidth	Complied
Part 15.247(a)(1)	Transmitter Carrier Frequency Separation	Complied
Part 15.247(a)(1)(iii)	Transmitter Number of Hopping Frequencies and Average Time of Occupancy	Complied
Part 15.247(b)(1)	Transmitter Maximum Peak Output Power	Complied
Part 15.247(d) & 15.209(a)	Transmitter Radiated Emissions	Complied
Part 15.247(d) & 15.209(a)	Transmitter Band Edge Radiated Emissions	Complied

Note(s):

1. There are two vendors of the WiFi/*Bluetooth* radio modules, Vendor 1 and Vendor 2.

The WiFi/*Bluetooth* radio modules have the same mechanical outline (i.e. the same packaging dimension and pin layout), use the same on-board antenna matching circuit, have an identical antenna structure and are built and tested to conform to the same specification and to operate within the same tolerances.

Baseline testing was performed on the two vendors to determine the worst case.

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	X
Site 17	X

UL VS LTD is accredited by UKAS. 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

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

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
20 dB Bandwidth	2.4 GHz to 2.4835 GHz	95%	±4.59 %
Carrier Frequency Separation	2.4 GHz to 2.4835 GHz	95%	±4.59 %
Average Time of Occupancy	2.4 GHz to 2.4835 GHz	95%	±3.53 ns
Conducted Maximum Peak Output Power	2.4 GHz to 2.4835 GHz	95%	±1.13 dB
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±4.65 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.

2.4. Test and Measurement Equipment

Test Equipment Used for Transmitter 20 dB Bandwidth

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2037	Thermohygrometer	Testo	608-H1	45124925	27 Mar 2019	12
M1794	Spectrum Analyser	Rohde & Schwarz	FSU26	100027	28 Feb 2019	12
A2525	Attenuator	AtlanTecRF	AN18W5-10	832827#3	Calibrated before use	-
G0614	Signal Generator	Rohde & Schwarz	SMB100A	177687	08 May 2020	36
A2524	Attenuator	AtlanTecRF	AN18W5-10	832827#2	Calibrated before use	-

Test Equipment Used for Transmitter Carrier Frequency Separation, Number of Hopping Frequencies, Average Time of Occupancy & Maximum Peak Output Power

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2037	Thermohygrometer	Testo	608-H1	45124925	27 Mar 2019	12
M1873	Signal Analyser	Rohde & Schwarz	FSV30	103074	16 Jun 2018	12
A2525	Attenuator	AtlanTecRF	AN18W5-10	832827#3	Calibrated before use	-
G0614	Signal Generator	Rohde & Schwarz	SMB100A	177687	08 May 2020	36
A2524	Attenuator	AtlanTecRF	AN18W5-10	832827#2	Calibrated before use	-

Test and Measurement Equipment (continued)**Test Equipment Used for Transmitter Radiated Emissions**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	12 Mar 2019	12
M1273	Test Receiver	Rohde & Schwarz	ESIB26	100275	08 May 2018	12
G0453	Pre-amplifier	Sonoma	310N	230801	15 Jun 2018	12
A1834	Attenuator	Hewlett Packard	8491B	10444	14 Mar 2019	12
M2009	Thermohygrometer	Testo	608-H1	45046699	20 Jun 2018	12
K0002	3m RSE Chamber	Rainford EMC	N/A	N/A	07 Feb 2019	12
M2016	Thermohygrometer	Testo	608-H1	45046428	26 Feb 2019	12
M1630	Test Receiver	Rohde & Schwarz	ESU40	100233	03 Aug 2018	12
A2948	Pre Amplifier	Com-Power Corp	PAM-118A	551087	06 Apr 2019	12
A1818	Antenna	EMCO	3115	00075692	07 Feb 2019	12
A253	Antenna	Flann Microwave	128	12240-20	07 Feb 2019	12
A254	Antenna	Flann Microwave	139	14240-20	07 Feb 2019	12
A255	Antenna	Flann Microwave	519	16240-20	07 Feb 2019	12
A256	Antenna	Flann Microwave	400	18240-20	07 Feb 2019	12
A2895	Antenna	Schwarzbeck	BBHA 9170	9170-728	20 Feb 2019	12
A2130	High Pass Filter	AtlanTecRF	AFH-08000	80rJFBD06-002	21 Feb 2019	12
A2973	High Pass Filter	AtlanTecRF	AFH-03000	16080900032	24 Jan 2019	12

Test Equipment Used for Transmitter Band Edge Radiated Emissions

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2003	Thermohygrometer	Testo	608-H1	45046641	27 Feb 2019	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	20 Feb 2019	12
A2863	Pre Amplifier	Agilent	8449B	3008A02100	19 Feb 2019	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	18 Apr 2019	12
A2889	Antenna	Schwarzbeck	BBHA 9120 B	BBHA 9120 B 653	19 Feb 2019	12
A2916	Attenuator	AtlanTecRF	AN18W5-10	832827#1	21 Feb 2019	12
A2943	Attenuator	AtlanTecRF	AN18W5-06	208147#2	22 Feb 2019	12

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Apple
Model Name or Number:	A1989
Test Sample Serial Number:	C02W6005JTVL (<i>Conducted sample with RF port</i>)
Hardware Version:	EVT
Software Version:	17G2014
BT BB Version:	V35
FCC ID:	BCGA1989

Brand Name:	Apple
Model Name or Number:	A1989
Test Sample Serial Number:	C02W6011JTF2 (<i>Radiated sample #1</i>)
Hardware Version:	EVT
Software Version:	17G2014
BT BB Version:	V35
FCC ID:	BCGA1989

Brand Name:	Apple
Model Name or Number:	A1989
Test Sample Serial Number:	C02VR00RJH93 (<i>Radiated sample #2</i>)
Hardware Version:	EVT
Software Version:	17G2014
BT BB Version:	V35
FCC ID:	BCGA1989

3.2. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.3. Additional Information Related to Testing

Tested Technology:	<i>Bluetooth</i>				
Power Supply Requirement:	Nominal	3.8 VDC via 120 VAC 60 Hz AC/DC Adapter			
Type of Unit:	Transceiver				
Channel Spacing:	1 MHz				
Mode:	Basic Rate	Enhanced Data Rate			
Modulation:	GFSK	$\pi/4$ -DQPSK	8DPSK		
Packet Type: (Maximum Payload)	DH5	2DH5	3DH5		
Data Rate (Mbps):	1	2	3		
Maximum Conducted Output Power:	12.8 dBm				
Transmit Frequency Range:	2402 MHz to 2480 MHz				
Transmit Channels Tested:	Channel ID	Channel Number	Channel Frequency (MHz)		
	Bottom	0	2402		
	Middle	39	2441		
	Top	78	2480		

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	2.3

3.5. Description of Test Setup

Support Equipment

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

Description:	PHF
Brand Name:	Apple
Model Name or Number:	Apple EarPods
Serial Number:	Not marked or stated

Description:	USB-C Adapter
Brand Name:	Belkin
Model Name or Number:	F2CU040
Serial Number:	Not marked or stated

Description:	USB-C Power Adapter
Brand Name:	Apple
Model Name or Number:	A1718
Serial Number:	Not marked or stated

Description:	Type C USB Cable. Length 2.0 metres
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Operating Modes

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

- Continuously transmitting at maximum power on bottom, middle and top channels in Basic Rate (DH5 packets) or EDR (2DH5 or 3DH5 packets) as required.
- Continuously transmitting at maximum power in hopping mode on all channels in Basic Rate (DH5 packets) or EDR (2DH5 or 3DH5 packets) as required.

Configuration and Peripherals

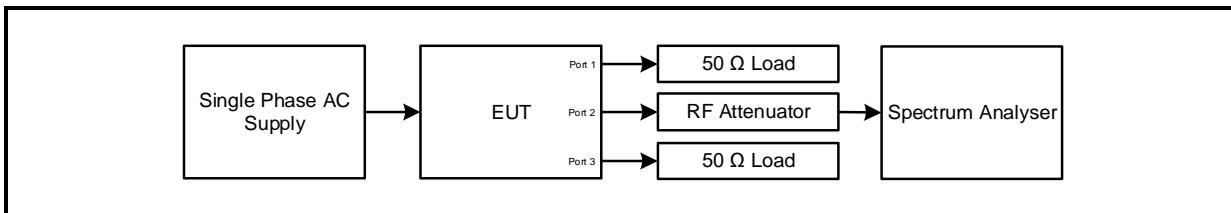
The EUT was tested in the following configuration(s):

- Controlled in test mode using a set of commands entered into a terminal application on the EUT. The commands were used to enable a continuous transmission and to select the test channels as required. The customer supplied a document containing the setup instructions 'EUT_BT_BTLE_CPM_SOP v1.0.docx'.
- The EUT was powered from a 120 VAC 60 Hz single phase mains supply.
- Transmitter radiated spurious emissions tests were performed with the EUT transmitting in DH5 packet type, as this mode was found to transmit the highest power.
- Transmitter radiated spurious emissions tests were performed with the AC Charger and PHF connected to the EUT.

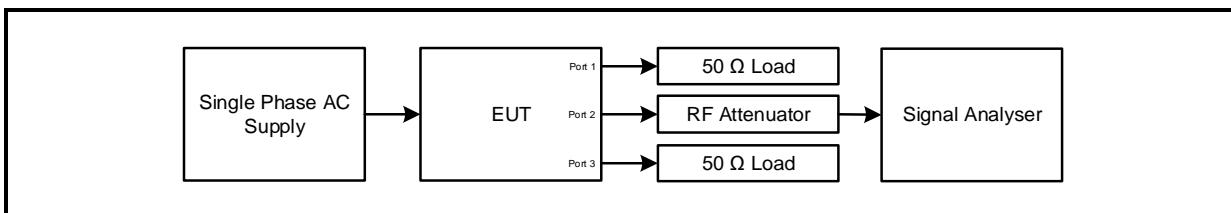
Test Setup Diagrams

Conducted Tests:

Test Setup for Transmitter 20 dB Bandwidth



Test Setup for Transmitter Carrier Frequency Separation, Number of Hopping Frequencies, Average Time of Occupancy & Maximum Peak Output Power



Radiated Tests:**Test Setup for Transmitter Radiated Emissions**

4. Antenna Port Test Results

4.1. Transmitter 20 dB Bandwidth

Test Summary:

Test Engineer:	Victor Carmon	Test Date:	16 April 2018
Test Sample Serial Number:	C02W6005JTVL		

FCC Reference:	Part 15.247(a)(1)
Test Method Used:	ANSI C63.10 Section 6.9.2

Environmental Conditions:

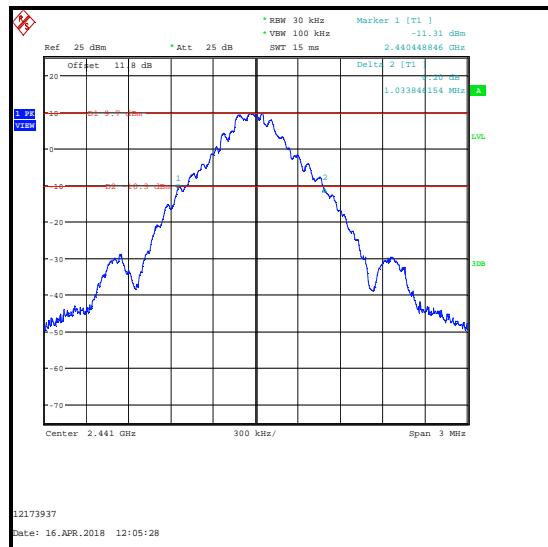
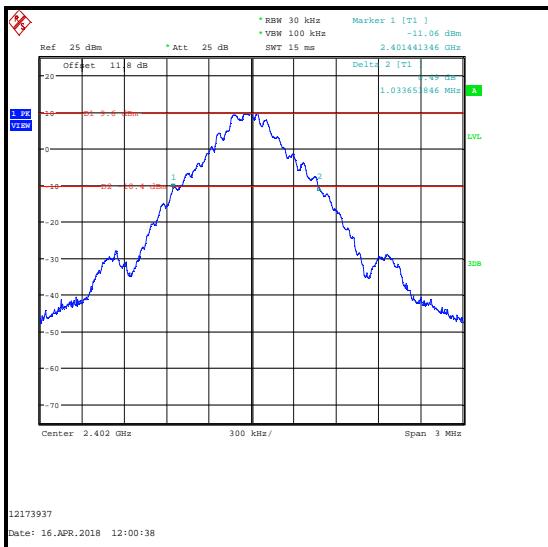
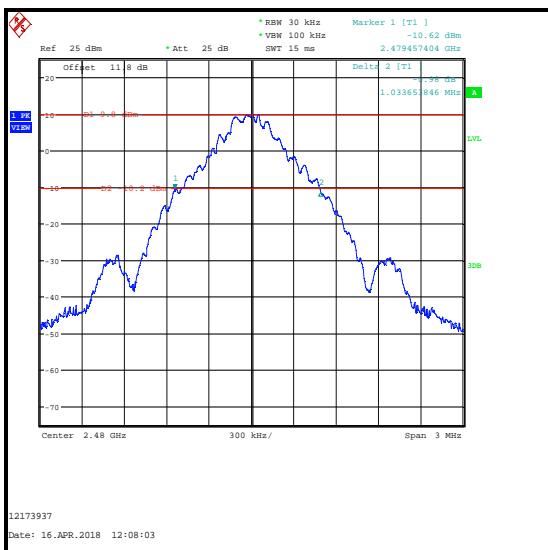
Temperature (°C):	21
Relative Humidity (%):	46

Note(s):

1. The spectrum analyser resolution bandwidth was set to 30 kHz and video bandwidth 100 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The span was set to 3.0 MHz. Normal and delta markers were placed 20 dB down from the peak of the carrier.
2. The spectrum analyser was connected to the RF port on the EUT using suitable attenuation and RF cable.

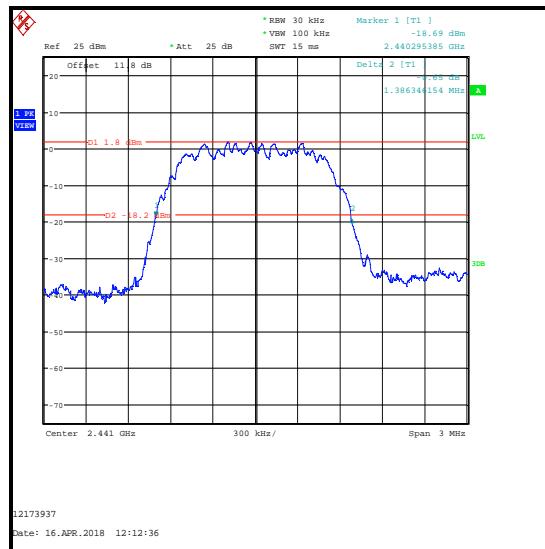
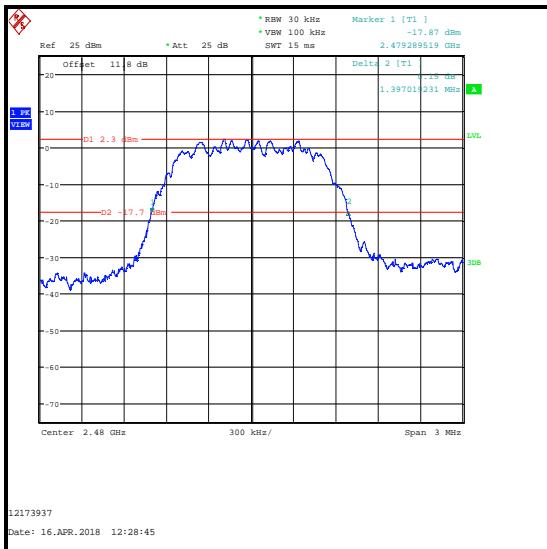
Transmitter 20 dB Bandwidth (continued)**Results DH5:**

Channel	20 dB Bandwidth (kHz)
Bottom	1033.654
Middle	1033.846
Top	1033.654

**Bottom Channel****Middle Channel****Top Channel**

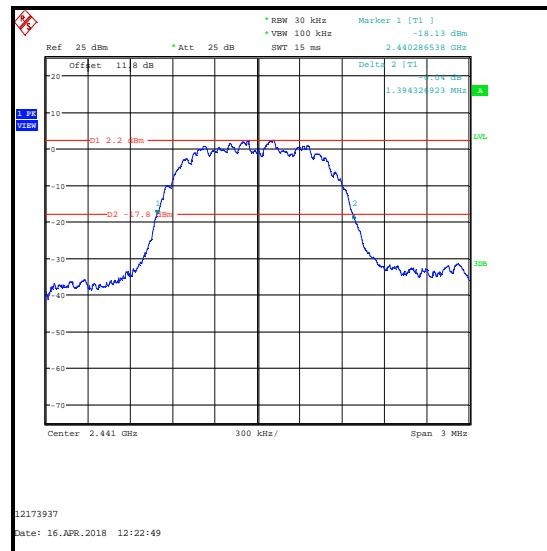
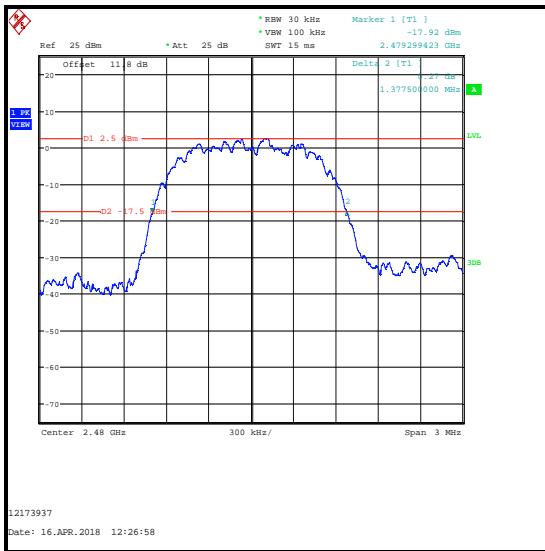
Transmitter 20 dB Bandwidth (continued)**Results 2DH5:**

Channel	20 dB Bandwidth (kHz)
Bottom	1399.038
Middle	1386.346
Top	1397.019

**Bottom Channel****Middle Channel****Top Channel**

Transmitter 20 dB Bandwidth (continued)**Results 3DH5:**

Channel	20 dB Bandwidth (kHz)
Bottom	1375.000
Middle	1394.327
Top	1377.500

**Bottom Channel****Top Channel****Middle Channel**

4.2. Transmitter Carrier Frequency Separation**Test Summary:**

Test Engineer:	Victor Carmon	Test Date:	16 April 2018
Test Sample Serial Number:	C02W6005JTVL		

FCC Reference:	Part 15.247(a)(1)
Test Method Used:	ANSI C63.10 Section 7.8.2

Environmental Conditions:

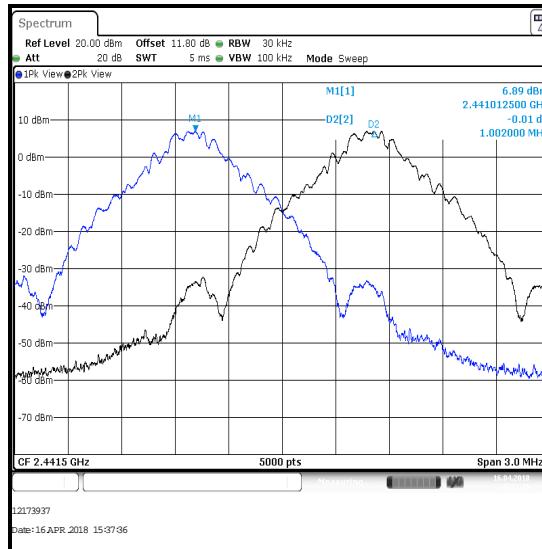
Temperature (°C):	22
Relative Humidity (%):	46

Note(s):

1. The 20 dB bandwidth measured for the middle channel operating at 2441 MHz was used to calculate the limit.

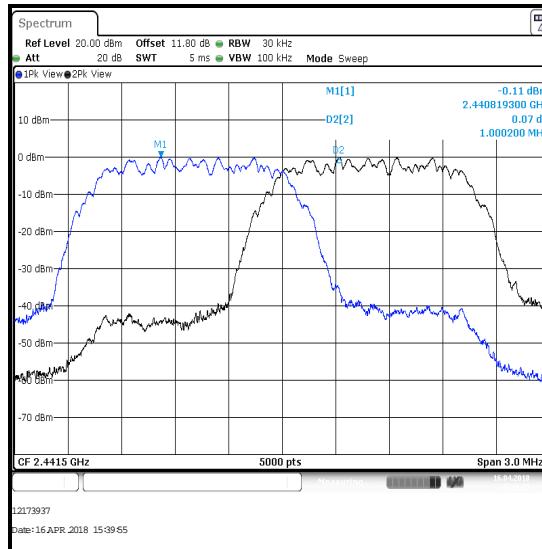
Transmitter Carrier Frequency Separation (continued)**Results: DH5**

Carrier Frequency Separation (kHz)	Limit ($\frac{2}{3}$ of 20 dB BW) (kHz)	Margin (kHz)	Result
1002.000	689.231	312.769	Complied



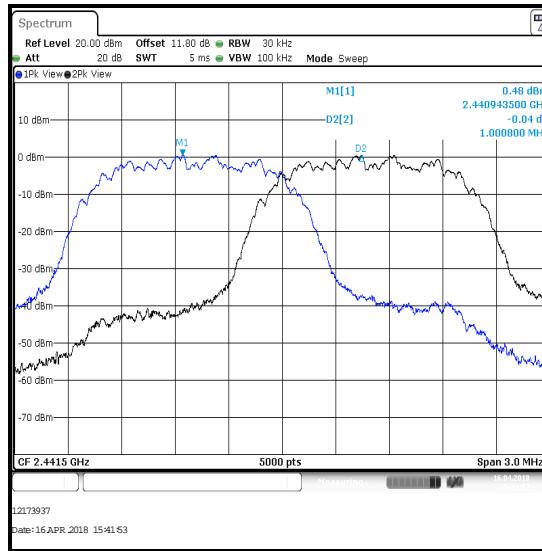
Transmitter Carrier Frequency Separation (continued)**Results: 2DH5**

Carrier Frequency Separation (kHz)	Limit (2/3 of 20 dB BW) (kHz)	Margin (kHz)	Result
1002.000	924.231	77.769	Complied



Transmitter Carrier Frequency Separation (continued)**Results: 3DH5**

Carrier Frequency Separation (kHz)	Limit (2/3 of 20 dB BW) (kHz)	Margin (kHz)	Result
1008.000	929.551	78.449	Complied



4.3. Transmitter Number of Hopping Frequencies and Average Time of Occupancy**Test Summary:**

Test Engineer:	Victor Carmon	Test Date:	16 April 2018
Test Sample Serial Number:	C02W6005JTVL		

FCC Reference:	Part 15.247(a)(1)(iii)
Test Method Used:	ANSI C63.10 Sections 7.8.3 & 7.8.4

Environmental Conditions:

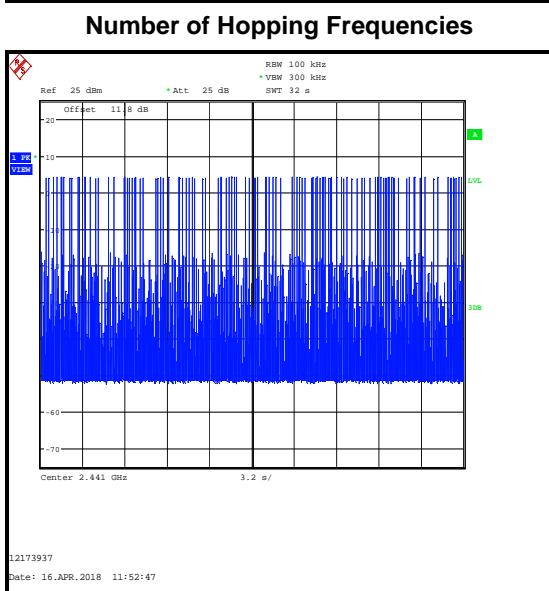
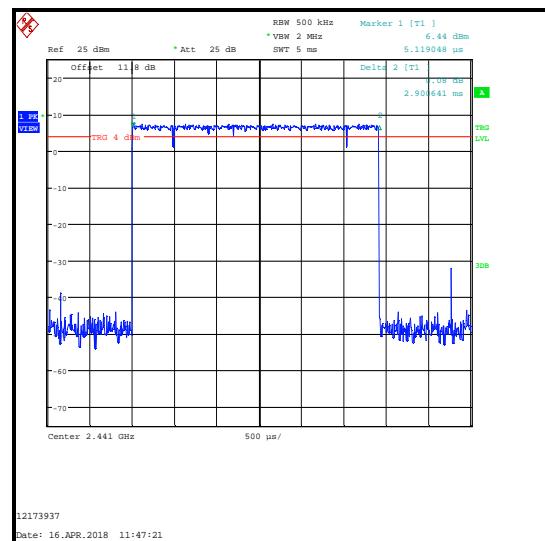
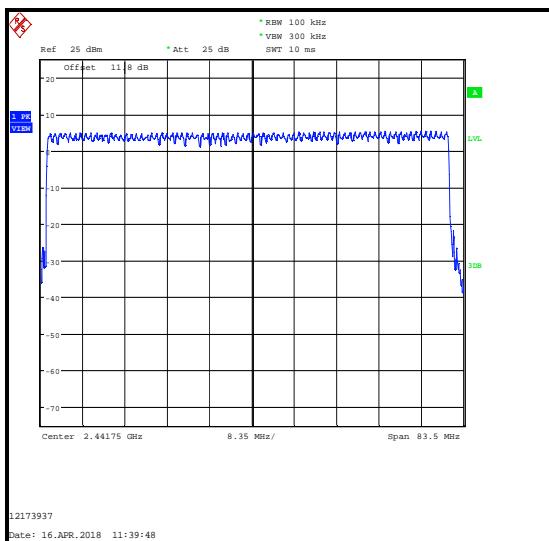
Temperature (°C):	22
Relative Humidity (%):	46

Note(s):

1. Tests were performed to identify the average time of occupancy in number of channels (79) x 0.4 seconds. The calculated period is 31.6 seconds.
2. The signal analyser was set up for the Number of Hopping Frequencies measurement as follows: the resolution bandwidth was set to 100 kHz and video bandwidth of 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 83.5 MHz.
3. The signal analyser was set up for the Emission Width measurement as follows: the resolution bandwidth was set to 500 kHz and video bandwidth 2 MHz. A peak detector was used and sweep time was set to auto with a span of zero Hz. The signal analyser was set to trigger at 1 ms, with a marker placed at the start of the emission and a delta marker placed at the end of the emission. The emission width is recorded in the table below.
4. The signal analyser was set up for the Number of Hopping Frequencies in 32 seconds measurement as follows: the resolution bandwidth was set to 100 kHz and video bandwidth of 300 kHz. A peak detector was used and sweep time was set to 32 seconds. The EUT was set to transmit in a hopping frequency mode with zero span. The total number of hopping frequencies were recorded in the table below.
5. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable.

Transmitter Number of Hopping Frequencies and Average Time of Occupancy (continued)Results:

Emission Width (μs)	Number of Hops in 31.6 Seconds	Average Time of Occupancy (s)	Limit (s)	Margin (s)	Result
2900.641	114	0.331	0.400	0.069	Complied



Number of Hopping Frequencies in 32 s

4.4. Transmitter Maximum Peak Output Power

Test Summary:

Test Engineer:	Stefan Ho	Test Date:	17 April 2018
Test Sample Serial Number:	C02W6005JTVL		

FCC Reference:	Part 15.247(b)(1)
Test Method Used:	ANSI C63.10 Section 7.8.5

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	40

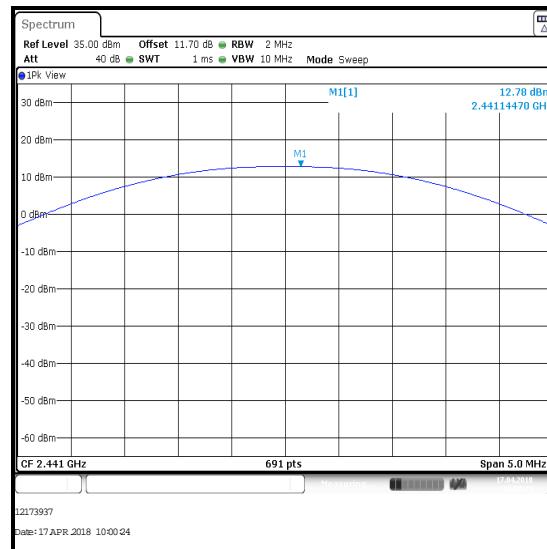
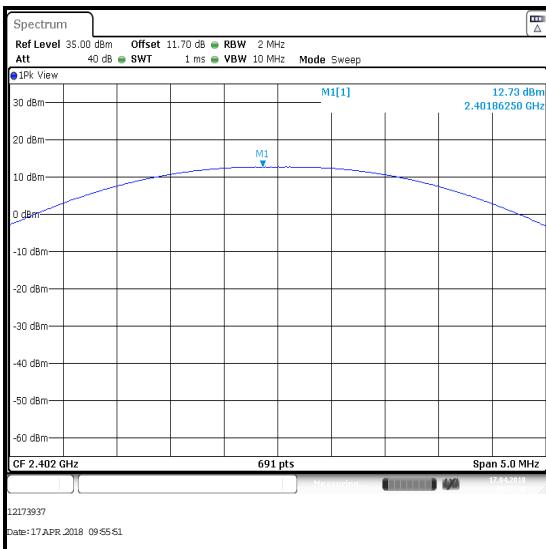
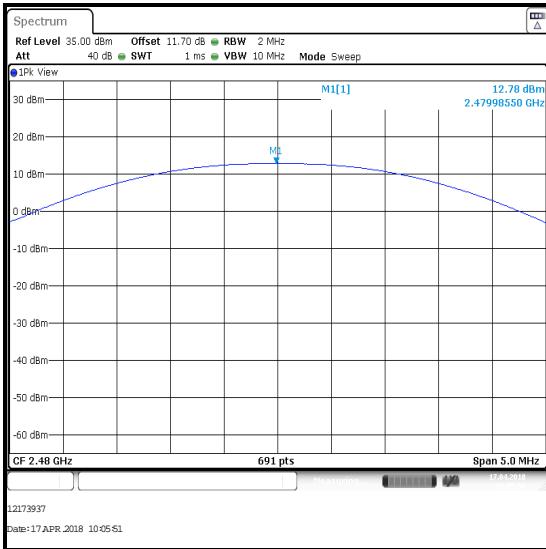
Note(s):

1. The signal analyser resolution bandwidth was set to 2 MHz (> 20 dB bandwidth) 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 5 MHz (approximately five times the 20 dB bandwidth). A marker was placed at the peak of the signal and the results recorded in the tables below.
2. The declared antenna gain was added to the conducted peak power to obtain the EIRP.
3. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF offset level was entered on the signal analyser to compensate for the loss of the attenuator and RF cable.

Transmitter Maximum Peak Output Power (continued)**Results: DH5**

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	12.7	30.0	17.3	Complied
Middle	12.8	30.0	17.2	Complied
Top	12.8	30.0	17.2	Complied

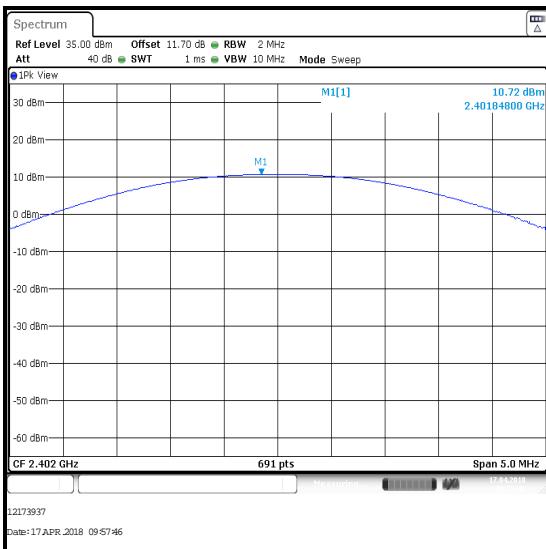
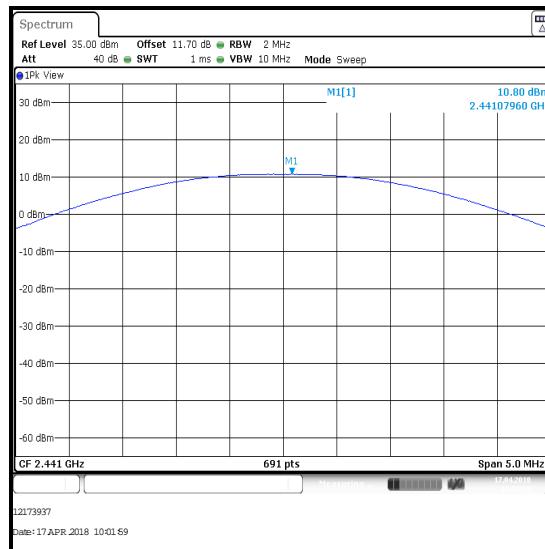
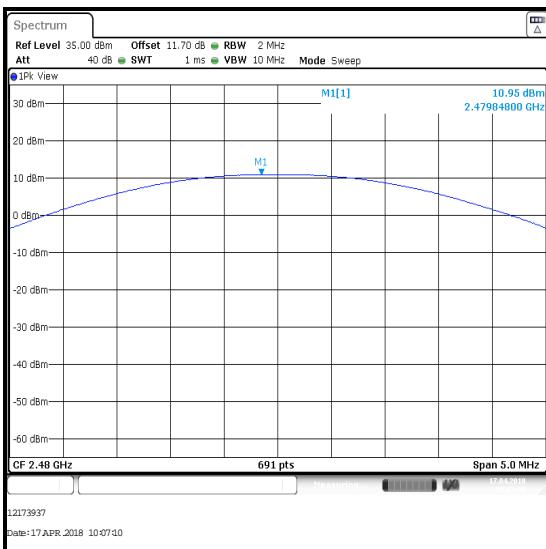
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	12.7	2.3	15.0	36.0	21.0	Complied
Middle	12.8	2.3	15.1	36.0	20.9	Complied
Top	12.8	2.3	15.1	36.0	20.9	Complied

Transmitter Maximum Peak Output Power (continued)**Results: DH5****Bottom Channel****Middle Channel****Top Channel**

Transmitter Maximum Peak Output Power (continued)**Results: 2DH5**

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	10.7	21.0	10.3	Complied
Middle	10.8	21.0	10.2	Complied
Top	11.0	21.0	10.0	Complied

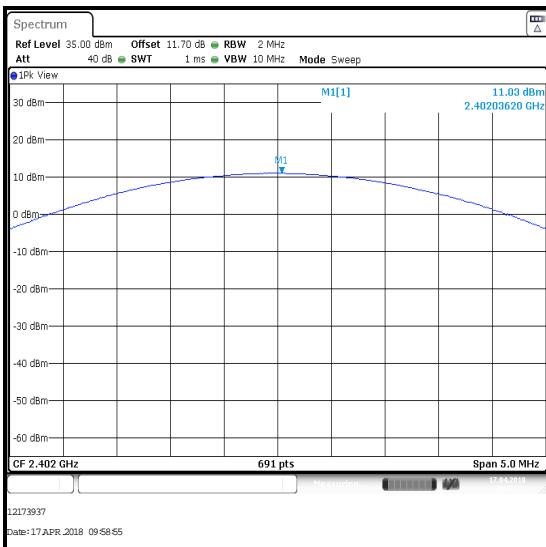
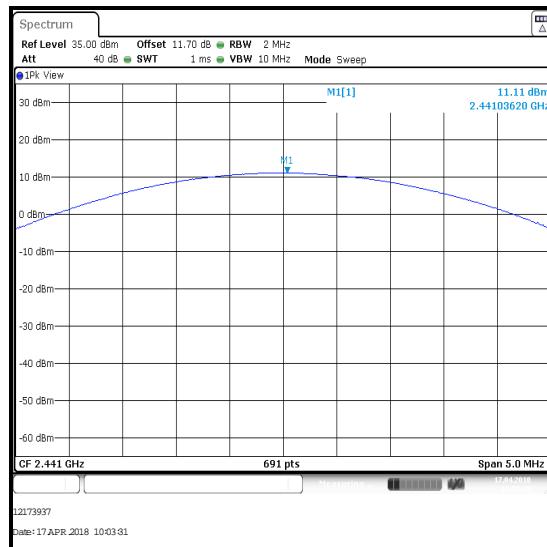
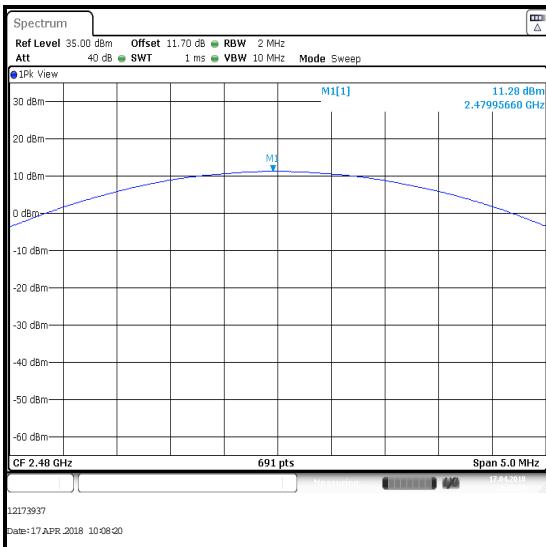
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	10.7	2.3	13.0	27.0	14.0	Complied
Middle	10.8	2.3	13.1	27.0	13.9	Complied
Top	11.0	2.3	13.3	27.0	13.7	Complied

Transmitter Maximum Peak Output Power (continued)**Results: 2DH5****Bottom Channel****Middle Channel****Top Channel**

Transmitter Maximum Peak Output Power (continued)**Results: 3DH5**

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	11.0	21.0	10.0	Complied
Middle	11.1	21.0	9.9	Complied
Top	11.3	21.0	9.7	Complied

Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	11.0	2.3	13.3	27.0	13.7	Complied
Middle	11.1	2.3	13.4	27.0	13.6	Complied
Top	11.3	2.3	13.6	27.0	13.4	Complied

Transmitter Maximum Peak Output Power (continued)**Results: 3DH5****Bottom Channel****Middle Channel****Top Channel**

5. Radiated Test Results

5.1. Transmitter Radiated Emissions <1 GHz

Test Summary:

Test Engineer:	James O'Reilly	Test Date:	29 April 2018
Test Sample Serial Number:	C02VR00RJH93		

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:

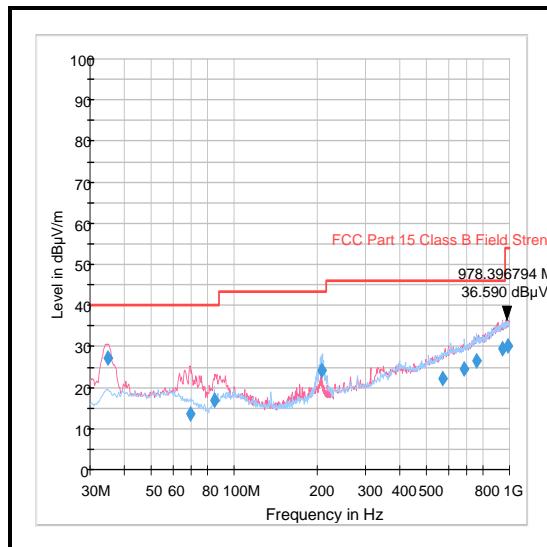
Temperature (°C):	23
Relative Humidity (%):	42

Note(s):

1. Transmitter radiated spurious emissions tests were performed with the EUT transmitting in DH5 mode as this was found to transmit the highest power and therefore deemed worst case.
2. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
3. All 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. Therefore the highest peak noise floor reading of the measuring receiver was recorded in the table below.
4. 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 top channel only.
5. 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.
6. 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.
7. 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 wide enough to see the whole emission.

Transmitter Radiated Emissions (continued)**Results: Peak / DH5**

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
978.397	Vertical	36.6	54.0	17.4	Complied



5.2. Transmitter Radiated Emissions >1 GHz

Test Summary:

Test Engineer:	Marco Zunarelli	Test Dates:	19 April 2018 & 20 April 2018
Test Sample Serial Number:	C02W6011JTF2		

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

Environmental Conditions:

Temperature (°C):	25 to 26
Relative Humidity (%):	43 to 45

Note(s):

1. Transmitter radiated spurious emissions tests were performed with the EUT transmitting in DH5 mode as this was found to transmit the highest power and therefore deemed worst case.
2. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
3. The emission shown on the 1 GHz to 3 GHz plot is the EUT fundamental at 2441 MHz.
4. No spurious emissions were detected above the noise floor of the measuring receiver therefore the highest peak and average noise floor readings of the measuring receiver were recorded as shown in the tables below.
5. 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.
6. 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 own appropriate detectors during the pre-scan measurements.

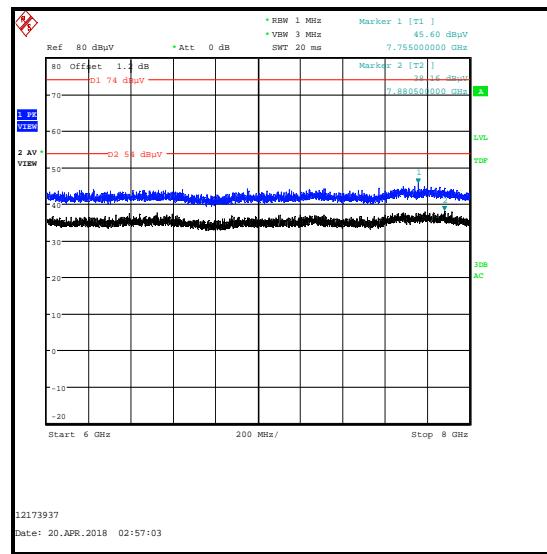
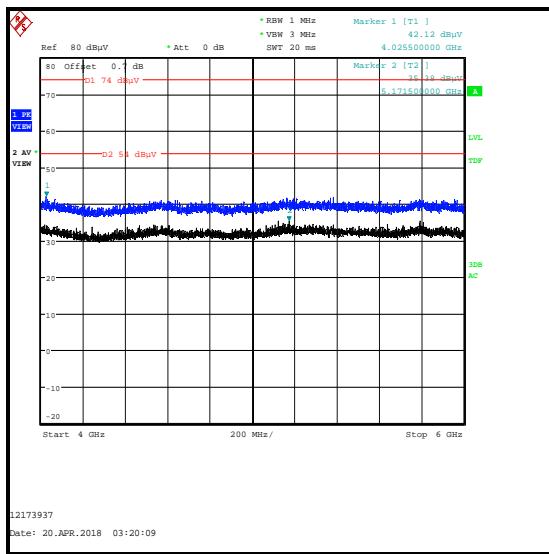
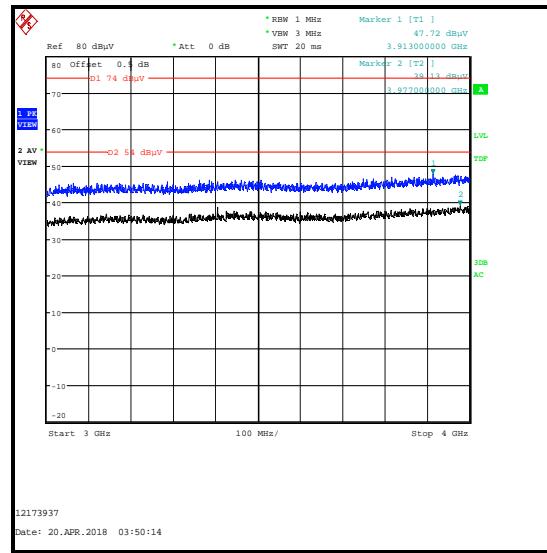
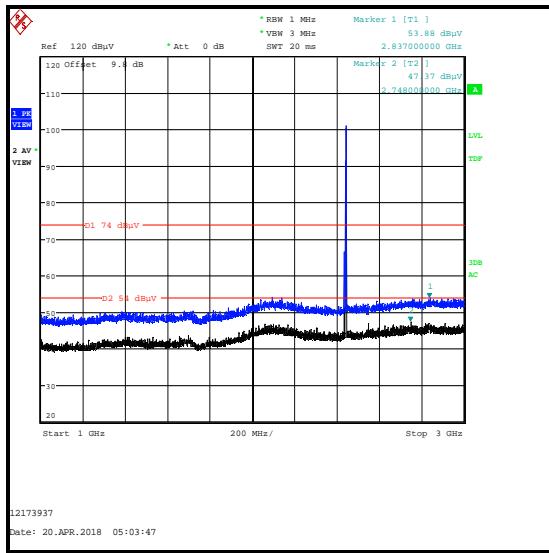
Results: Peak / Middle Channel / DH5

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2837.000	Vertical	53.9	74.0	20.1	Complied

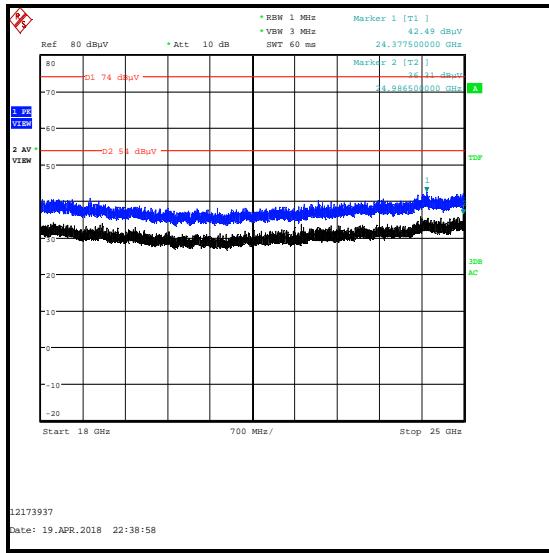
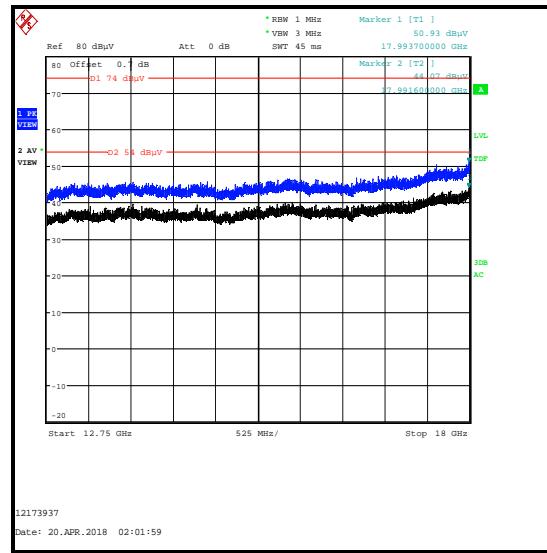
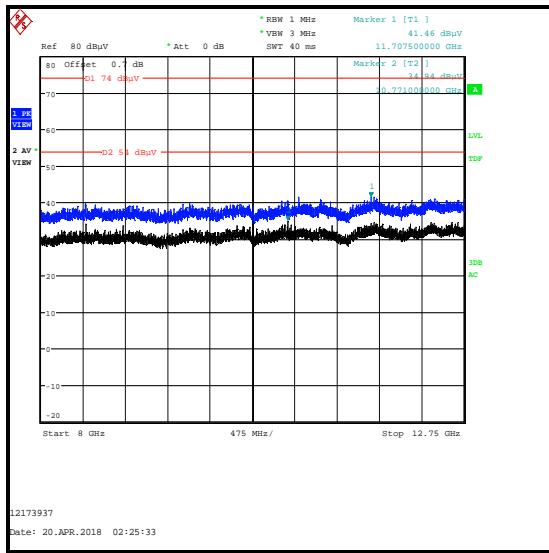
Results: Average / Middle Channel / DH5

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2748.000	Vertical	47.4	54.0	6.6	Complied

Transmitter Radiated Emissions (continued)



Transmitter Radiated Emissions (continued)



5.3. Transmitter Band Edge Radiated Emissions

Test Summary:

Test Engineers:	Alan Withers & John Ferdinand	Test Date:	27 April 2018
Test Sample Serial Number:	C02VR00RJH93		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	ANSI C63.10 Section 6.10

Environmental Conditions:

Temperature (°C):	22 to 24
Relative Humidity (%):	40 to 45

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 lower band edge is adjacent to a non-restricted band. 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. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent band (where a higher level emission was present). Marker frequencies and levels were recorded.
3. The upper band edge is adjacent to a restricted band. The test receiver resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz. Peak and average measurements were performed with their respective detectors, 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 was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent band (where a higher level emission was present). Marker frequencies and levels were recorded.
4. 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.
5. * -20 dBc limit.

Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / DH5**

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2400.0	Vertical	44.1	86.3*	42.2	Complied
2483.5	Vertical	51.8	74.0	22.2	Complied
2483.660	Vertical	52.6	74.0	21.4	Complied

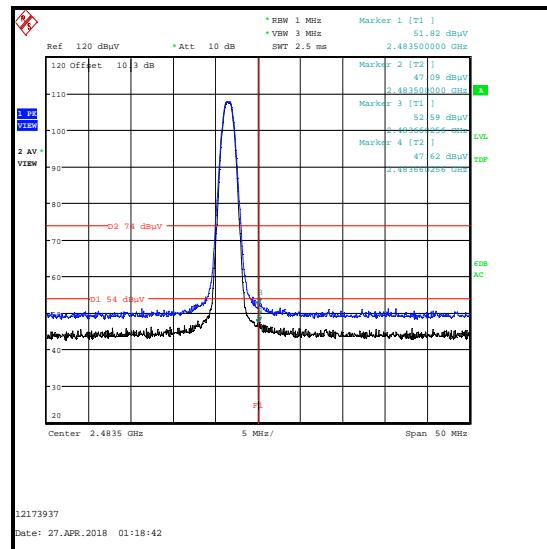
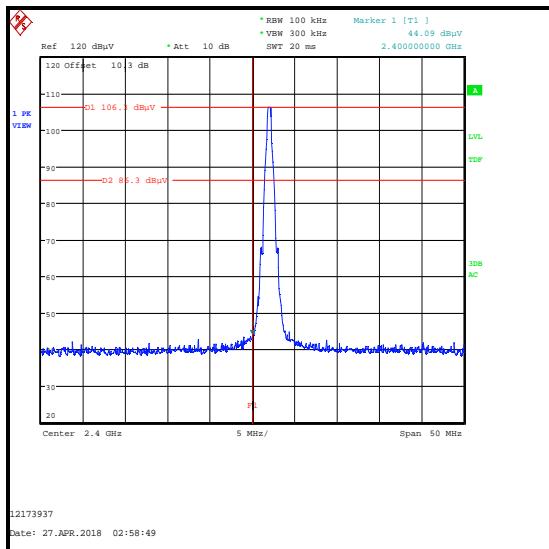
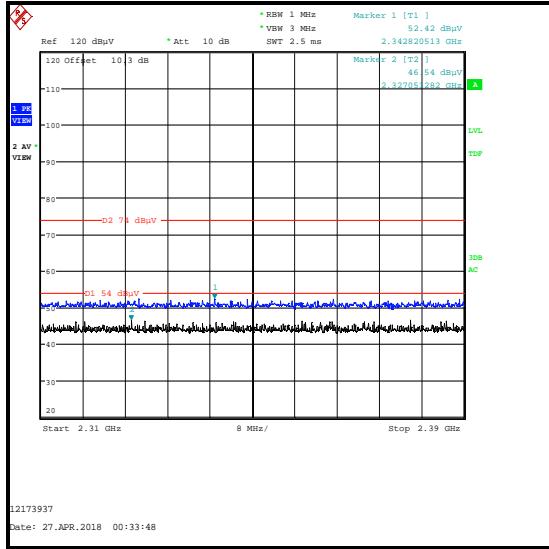
Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	47.1	54.0	6.9	Complied
2483.660	Vertical	47.6	54.0	6.4	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2342.821	Vertical	52.4	74.0	21.6	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2327.051	Vertical	46.5	54.0	7.5	Complied

Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / DH5****Lower Band Edge****Upper Band Edge****2310 MHz to 2390 MHz Restricted Band**

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / DH5**

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2399.920	Vertical	45.1	83.4*	38.3	Complied
2400.0	Vertical	44.6	83.4*	38.8	Complied
2483.5	Vertical	48.8	74.0	25.2	Complied
2491.192	Vertical	51.0	74.0	23.0	Complied

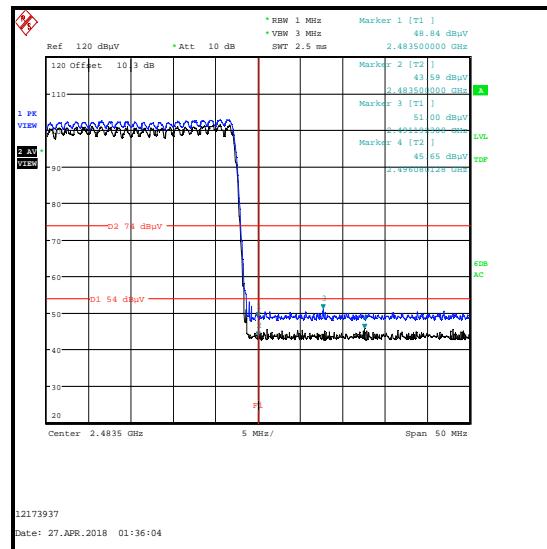
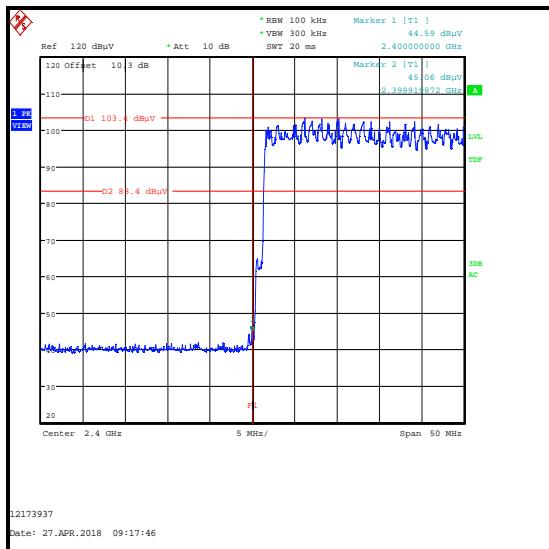
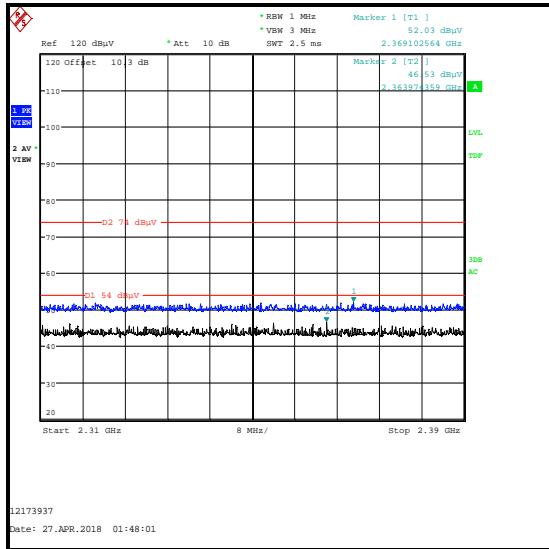
Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	43.6	54.0	10.4	Complied
2496.080	Vertical	45.7	54.0	8.3	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2369.103	Vertical	52.0	74.0	22.0	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2363.974	Vertical	46.5	54.0	7.5	Complied

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / DH5****Lower Band Edge****2310 MHz to 2390 MHz Restricted Band**

Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / 2DH5**

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2400.0	Vertical	49.2	83.3*	34.1	Complied
2483.5	Vertical	51.6	74.0	22.4	Complied
2483.981	Vertical	52.0	74.0	22.0	Complied

Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	45.5	54.0	8.5	Complied
2483.981	Vertical	46.6	54.0	7.4	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

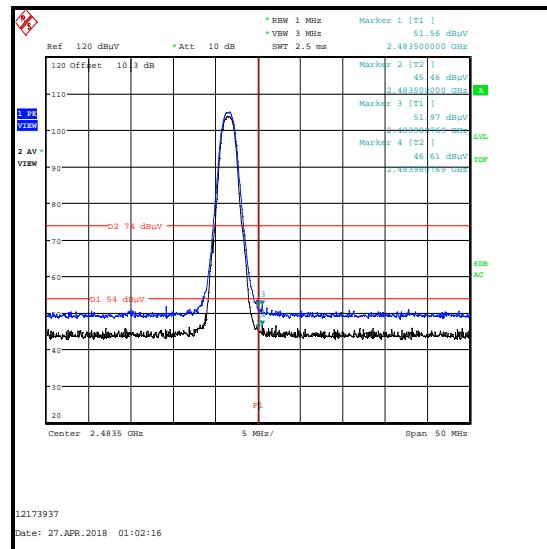
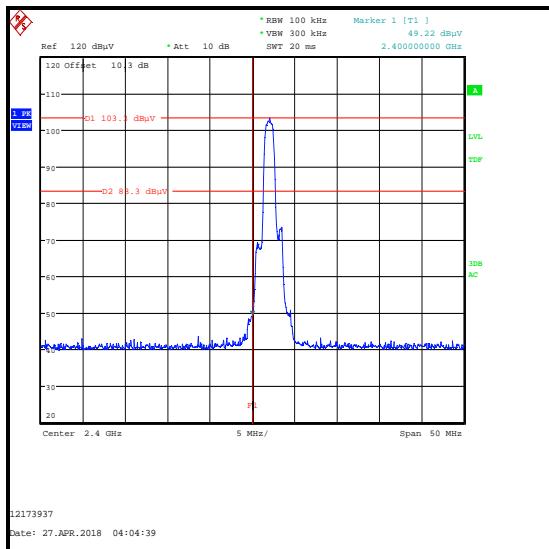
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2390.000	Vertical	52.8	74.0	21.2	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2385.256	Vertical	46.8	54.0	7.2	Complied

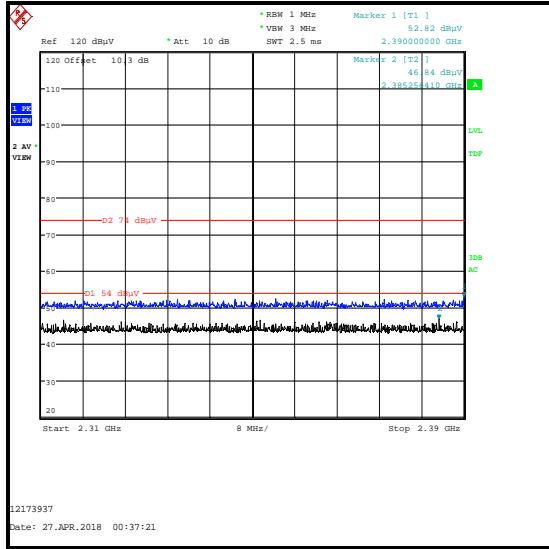
Transmitter Band Edge Radiated Emissions (continued)

Results: Static Mode / 2DH5



Lower Band Edge

Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / 2DH5**

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2379.567	Vertical	42.5	87.3*	44.8	Complied
2400.0	Vertical	43.0	87.3*	44.3	Complied
2483.5	Vertical	50.6	74.0	23.4	Complied
2483.821	Vertical	53.6	74.0	20.4	Complied

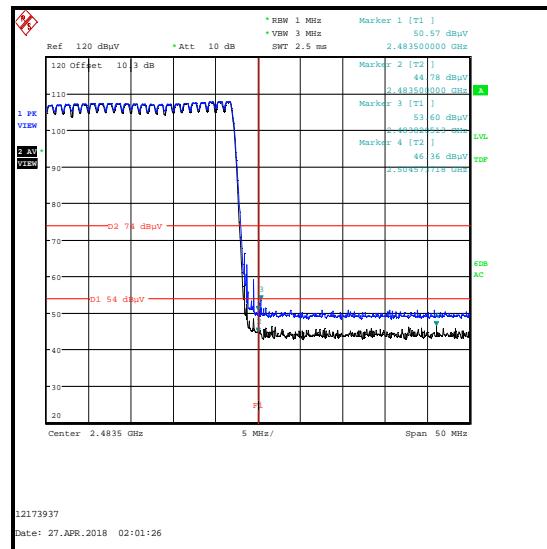
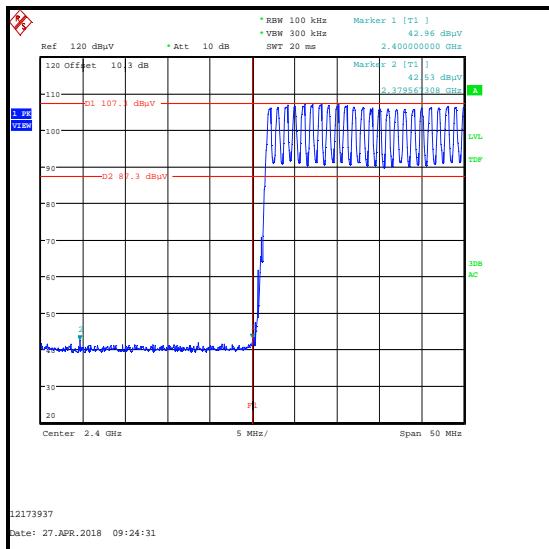
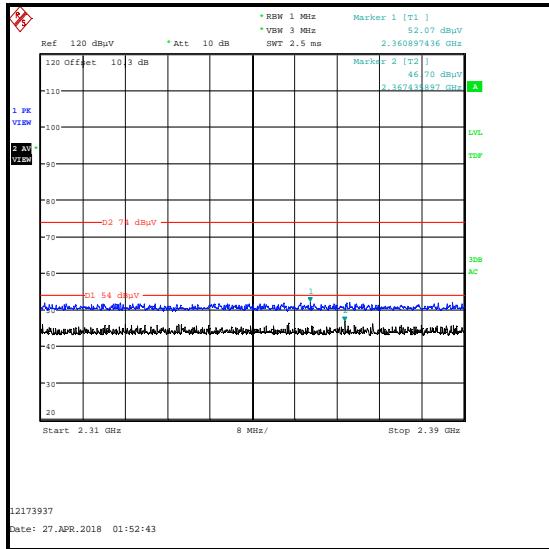
Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	44.8	54.0	9.2	Complied
2504.574	Vertical	46.4	54.0	7.6	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2360.897	Vertical	52.1	74.0	21.9	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2367.436	Vertical	46.7	54.0	7.3	Complied

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / 2DH5****Lower Band Edge****2310 MHz to 2390 MHz Restricted Band**

Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / 3DH5**

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2399.679	Vertical	48.3	81.3*	33.0	Complied
2400.0	Vertical	47.3	81.3*	34.0	Complied
2483.5	Vertical	52.0	74.0	22.0	Complied

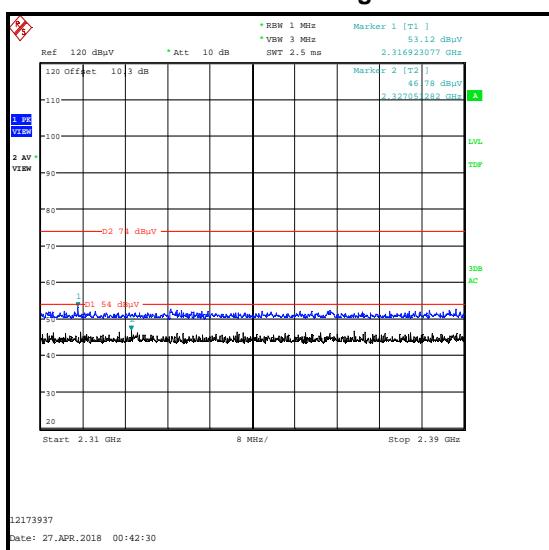
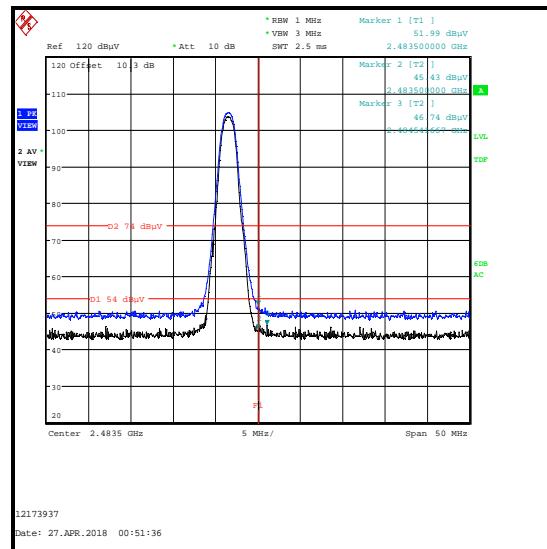
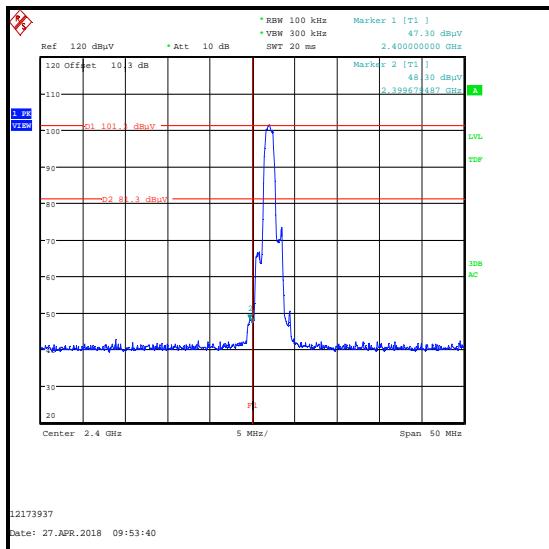
Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	45.4	54.0	8.6	Complied
2484.542	Vertical	46.7	54.0	7.3	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2316.923	Vertical	53.1	74.0	20.9	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2327.051	Vertical	46.8	54.0	7.2	Complied

Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / 3DHS**

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / 3DH5**

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2394.631	Vertical	43.4	87.2*	43.8	Complied
2400.0	Vertical	41.7	87.2*	45.5	Complied
2483.5	Vertical	49.1	74.0	24.9	Complied
2483.821	Vertical	51.6	74.0	22.4	Complied

Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	44.4	54.0	9.6	Complied
2507.058	Vertical	47.0	54.0	7.0	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

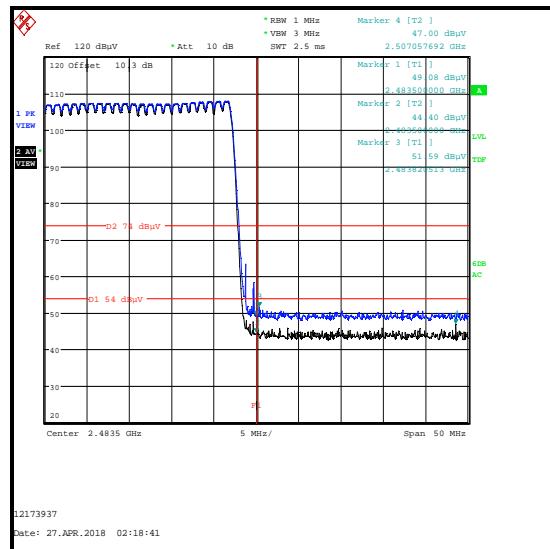
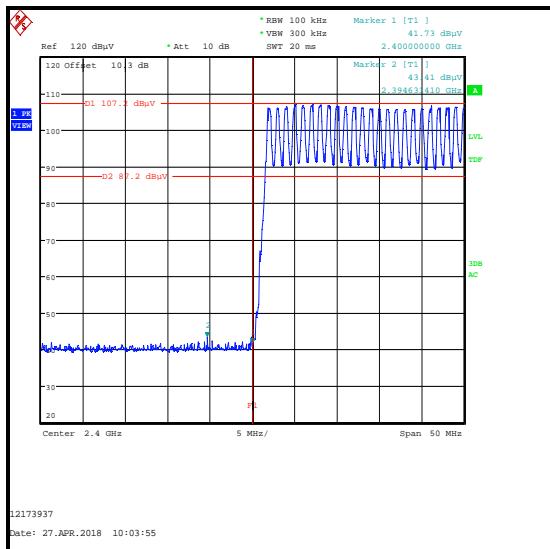
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2312.821	Vertical	50.7	74.0	23.3	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2364.615	Vertical	45.2	54.0	8.8	Complied

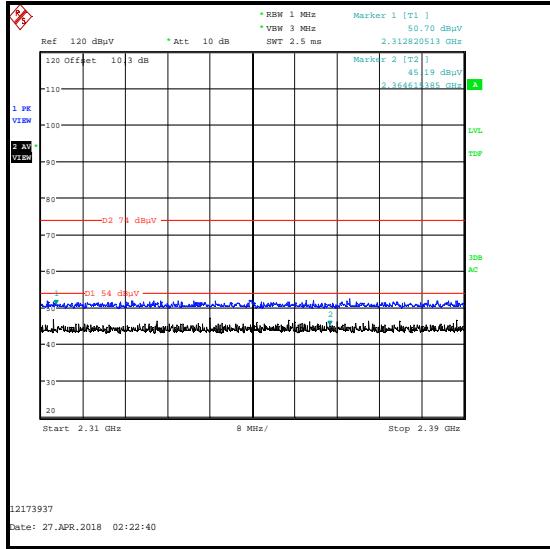
Transmitter Band Edge Radiated Emissions (continued)

Results: Hopping Mode / 3DH5



Lower Band Edge

Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

--- END OF REPORT ---