



TEST REPORT

Test Report No. : UL-RPT-RP12663640-1216A

Customer : Raspberry Pi (Trading) Ltd

Model No. : Raspberry Pi 4 Model B

FCC ID : 2ABCB-RPI4B

Technology : *Bluetooth* – Basic Rate & EDR

Test Standard(s) : FCC Parts 15.207, 15.209(a) & 15.247

Test Laboratory : UL VS 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:

10 May 2019

Checked by:

Sarah Williams
Senior Test Engineer, Radio Laboratory

Company Signatory:

Ben Mercer
Senior Test Engineer, Radio Laboratory
UL VS LTD



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UL VS 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:	Raspberry Pi (Trading) Ltd
Address:	Maurice Wilkes Building Cowley Road Cambridge CB4 0DS United Kingdom

Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	10/05/2019	Initial Version	Sarah Williams

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1. Attestation of Test Results










1.1. Description of EUT

The Equipment Under Test was a single board computer. It contains a *Bluetooth*, 2.4 GHz and 5 GHz WLAN module powered from an AC/DC power supply. The antenna is integral.

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:	47CFR15.207 and 47CFR15.209
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Sections 15.207 and 15.209
Site Registration:	621311
Location of Testing:	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
Test Dates:	10 April 2019 to 23 April 2019

1.3. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.247(a)(1)	Transmitter 20 dB Bandwidth	
Part 15.247(a)(1)	Transmitter Carrier Frequency Separation	
Part 15.247(a)(1)(iii)	Transmitter Number of Hopping Frequencies and Average Time of Occupancy	
Part 15.247(b)(1)	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	
Part 15.207	Transmitter AC Conducted Emissions	
Key to Results  = Complied  = Did not comply		

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 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
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
Reference:	KDB 174176 D01 Line Conducted FAQ v01r01 June 3, 2015
Title:	AC Power-Line Conducted Emissions Frequently Asked Questions

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
AC Conducted Spurious Emissions	0.15 MHz to 30 MHz	95%	±2.40 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 Conducted Tests

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2039	Thermohygrometer	Testo	608-H1	45124922	06 Jan 2020	12
M1794	Spectrum Analyser	Rohde & Schwarz	FSU26	100027	18 Mar 2021	24
A2508	Attenuator	AtlanTecRF	AN18-10	821846#3	Calibrated before use	-
M199	Power Meter	Rohde & Schwarz	NRVS	827023/075	20 Apr 2020	24
M1267	Power Sensor	Rohde & Schwarz	NRV-Z52	100155	20 Apr 2020	24
G0615	Signal Generator	Rohde & Schwarz	SMBV100A	260473	08 May 2020	36

Test Equipment Used for Transmitter Radiated Emissions

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	06 Jan 2020	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	04 Oct 2019	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	01 Apr 2020	12
A3154	Pre-Amplifier	Com-Power	PAM-103	18020012	14 Sep 2019	12
A3155	Pre Amplifier	Com-Power	PAM-118A	18040037	14 Sep 2019	12
A3141	Pre Amplifier	Schwarzbeck	BBV 9718 B	00021	21 Nov 2019	12
A2896	Pre Amplifier	Schwarzbeck	BBV 9721	9721 – 023	08 Feb 2020	12
A553	Antenna	Chase	CBL6111A	1593	08 Oct 2019	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	03 Oct 2019	12
A3139	Antenna	Schwarzbeck	HWRD750	00027	04 Oct 2019	12
A2895	Antenna	Schwarzbeck	BBHA 9170	9170-728	08 Feb 2020	12
A2523	Attenuator	AtlanTechRF	AN18W5-10	832827#1	04 Mar 2020	12
A3093	High Pass Filter	AtlanTechRF	AFH-03000	18051800077	09 Apr 2020	12
A3095	High Pass Filter	AtlanTechRF	AFH-07000	18051600012	09 Apr 2020	12
A3085	Low Pass Filter	AtlanTechRF	ALH-02000	18051600014	09 Apr 2020	12

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

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	06 Jan 2020	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	04 Oct 2019	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	17 Apr 2019	12
A3155	Pre-Amplifier	Com-Power	PAM-118A	18040037	14 Sep 2019	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	03 Oct 2019	12
A2924	Attenuator	AtlanTechRF	AN18W5-20	832828#7	04 Mar 2020	12

Test Equipment Used for Transmitter AC Conducted Emissions

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2037	Thermohygrometer	Testo	608-H1	45124925	06 Jan 2020	12
A649	LISN	Rohde & Schwarz	ESH3-Z5	825562/008	23 Aug 2019	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	10 Apr 2020	12
M1273	Test Receiver	Rohde & Schwarz	ESIB 26	100275	18 Dec 2019	12

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Raspberry Pi
Model Name or Number:	Raspberry Pi 4 Model B
Test Sample Serial Number:	0000000020d6f686 (<i>Conducted sample #1</i>)
Hardware Version:	V1.0
Software Version:	V1.0
FCC ID:	2ABCB-RPI4B

Brand Name:	Raspberry Pi
Model Name or Number:	Raspberry Pi 4 Model B
Test Sample Serial Number:	000000003f9edf4a (<i>Radiated sample #1</i>)
Hardware Version:	V1.0
Software Version:	V1.0
FCC ID:	2ABCB-RPI4B

Brand Name:	Raspberry Pi
Model Name or Number:	Raspberry Pi 4 Model B
Test Sample Serial Number:	0000000027a0c96b (<i>Radiated sample #2</i>)
Hardware Version:	V1.0
Software Version:	V1.0
FCC ID:	2ABCB-RPI4B

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:	Bluetooth		
Power Supply Requirement:	Nominal	5.0 VDC	
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:	4.9 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	3.5

3.5. Description of Test Setup

Support Equipment

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

Description:	LCD Monitor
Brand Name:	Logik
Model Name or Number:	L22FE12A
Serial Number:	1309020661

Description:	USB Mouse
Brand Name:	Raspberry Pi
Model Name or Number:	RPI-MOUSE
Serial Number:	Not marked or stated

Description:	USB Keyboard
Brand Name:	Raspberry Pi
Model Name or Number:	RPI-KYB
Serial Number:	Not marked or stated

Description:	Power Supply. 100-230 VAC Input / 5 VDC output
Brand Name:	Belkin
Model Name or Number:	F7U011dr
Serial Number:	Not marked or stated

Description:	16 GB Micro SD card
Brand Name:	SanDisk
Model Name or Number:	HCI
Serial Number:	Not marked or stated

Description:	HDMI Cable Type A to Type D. Quantity 1. Length 1.05 metres
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	Ethernet cable. Quantity 1. Length 1.0 metres
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Support Equipment (continued)

Description:	USB cable. Quantity 3. Length 3.0 metres
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	USB Hub
Brand Name:	Hama
Model Name or Number:	00078498
Serial Number:	09825891600

Description:	Ethernet Router
Brand Name:	Netgear
Model Name or Number:	GS605
Serial Number:	1YG194390218E

Description:	HDMI Hub
Brand Name:	Sumvision
Model Name or Number:	Cyclone Micro
Serial Number:	SUM091104017

Description:	Cat 5 Ethernet Cable. Quantity 1. Length 2.0 metres
Brand Name:	AWN
Model Name or Number:	2835
Serial Number:	E87647

Description:	Test Laptop
Brand Name:	Lenovo
Model Name or Number:	L440
Serial Number:	R9-019EA1 14/04

Description:	Generic Headphones (ear buds)
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Support Equipment (continued)

Description:	USB Thumb Drive
Brand Name:	Sandisk
Model Name or Number:	Ultra flair USB 3.0
Serial Number:	BM182025896Z

Description:	USB Thumb Drive
Brand Name:	Sandisk
Model Name or Number:	Ultra flair USB 3.0
Serial Number:	BM190125896Z

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

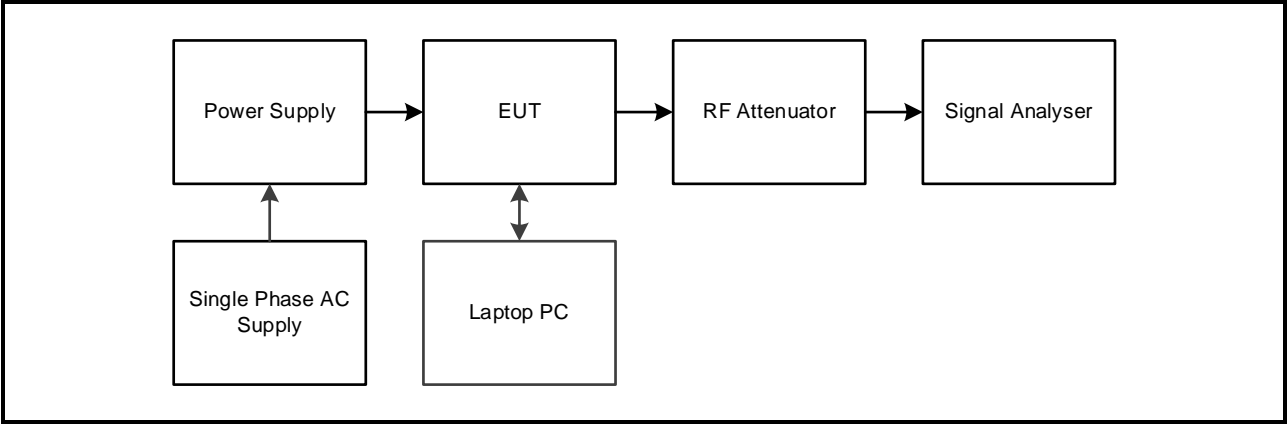
The EUT was tested in the following configuration(s):

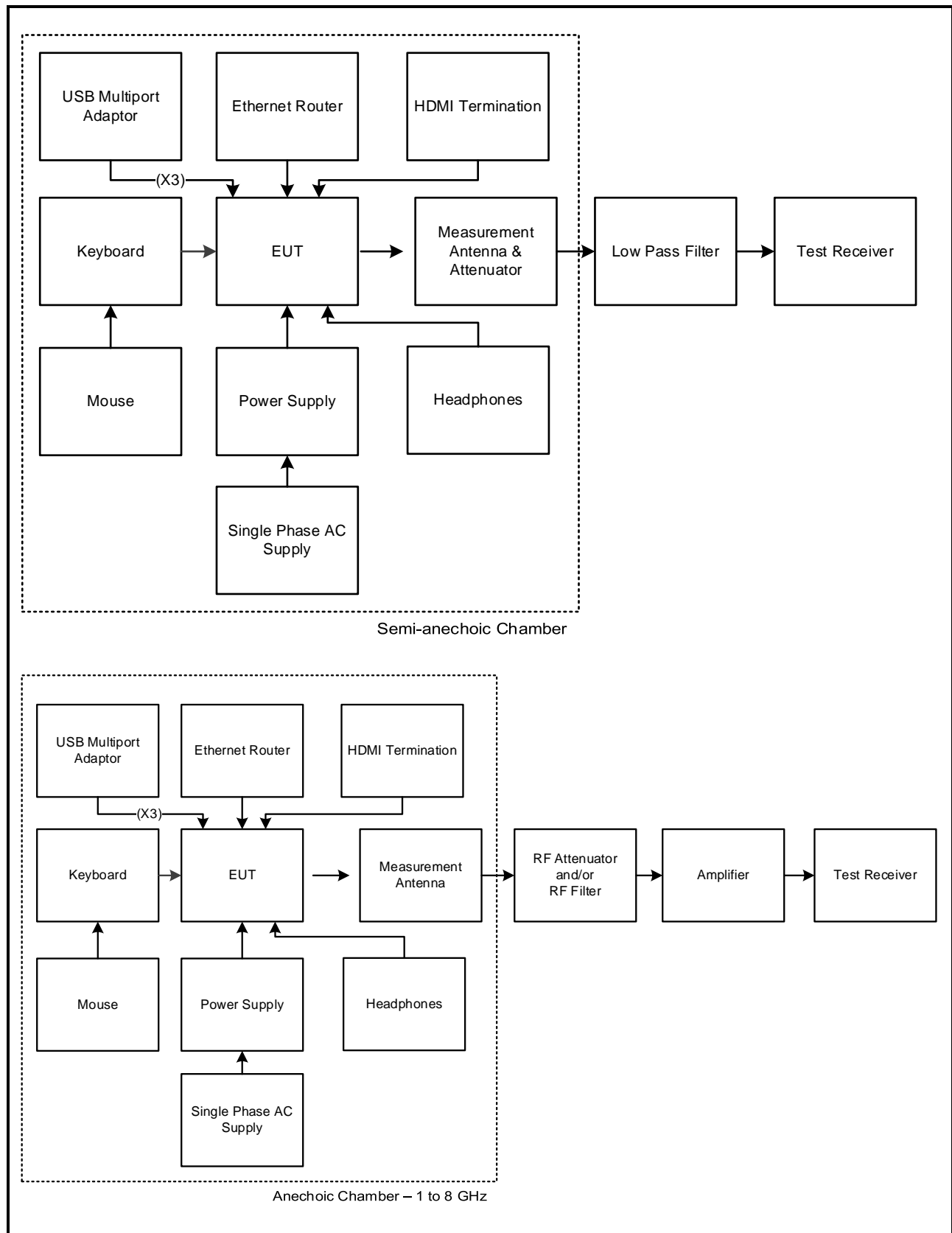
- The customer's test application and supplied instructions were used to place the EUT into *Bluetooth* test mode. The supplied commands were entered into the console menu on the EUT. Test commands stated in the `bt_testing.sh` file located on the `/home/pi` drive of the EUT were used to configure the EUT to enable a continuous transmission and to select the test channels as required.
- The EUT was powered via an AC/DC switch mode power supply.
- Both EDR/Basic rate modes were compared and tests were performed with the mode that presented the worst case result. For output power, bandwidth, band edge and channel separation, all modes were tested.
- AC conducted emissions test was tested with the EUT transmitting on the Middle channel using DH5 packet type, as this mode was found to transmit the highest power.
- Radiated spurious emissions were performed with the EUT in the Y plane (worst case) while connected to its power supply. Tests were performed with the EUT connected to its AC adaptor and USB cable. All other ports were terminated with suitable terminations.
- The LCD monitor was connected to the EUT using a 1.05 metre long HDMI cable.
- The keyboard and mouse were connected to the USB port on the EUT.

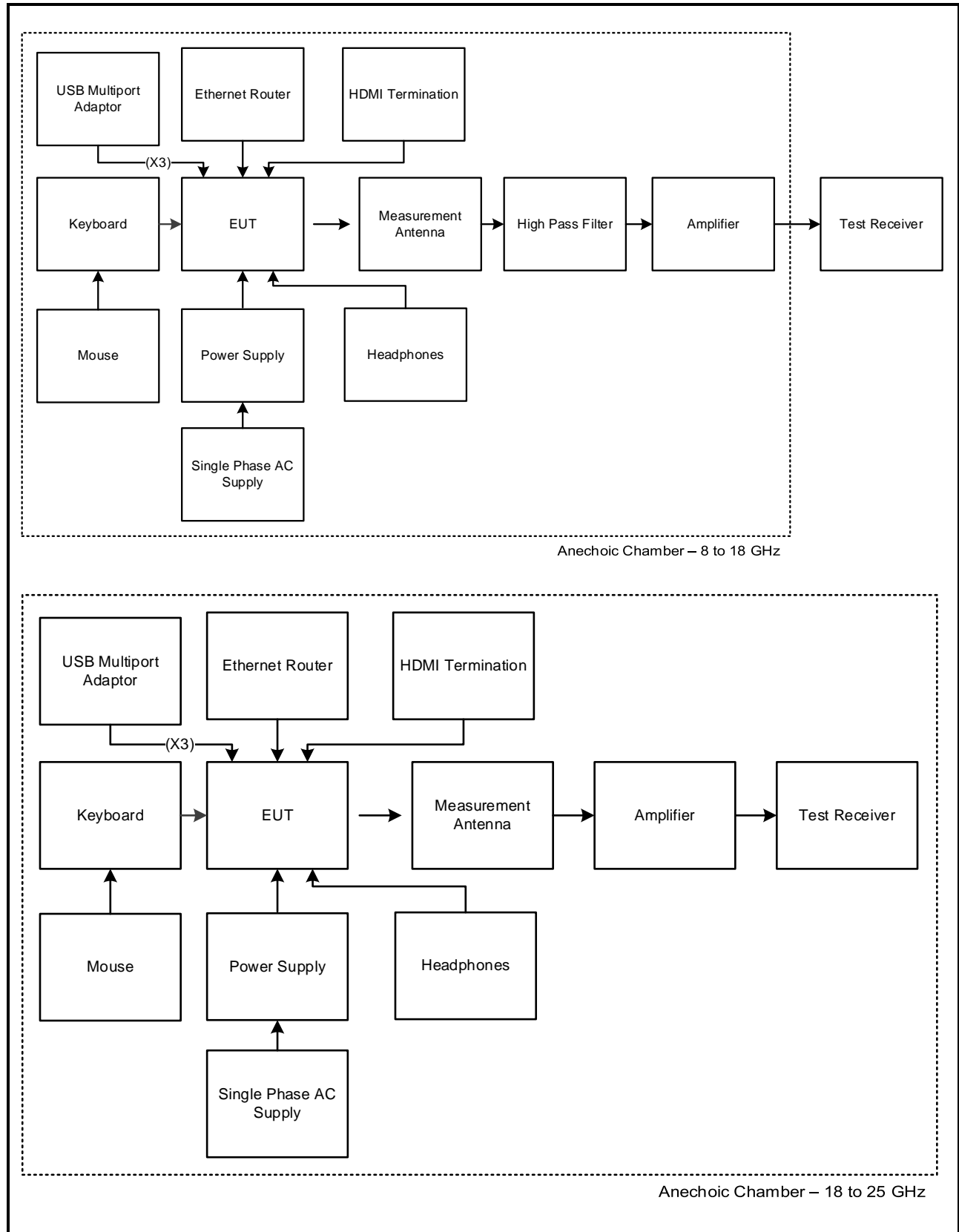
Test Setup Diagrams

Conducted Tests:

Test Setup for Transmitter 20 dB Bandwidth, Carrier Frequency Separation, Number of Hopping Frequencies and Average Time of Occupancy & Maximum Peak Output Power

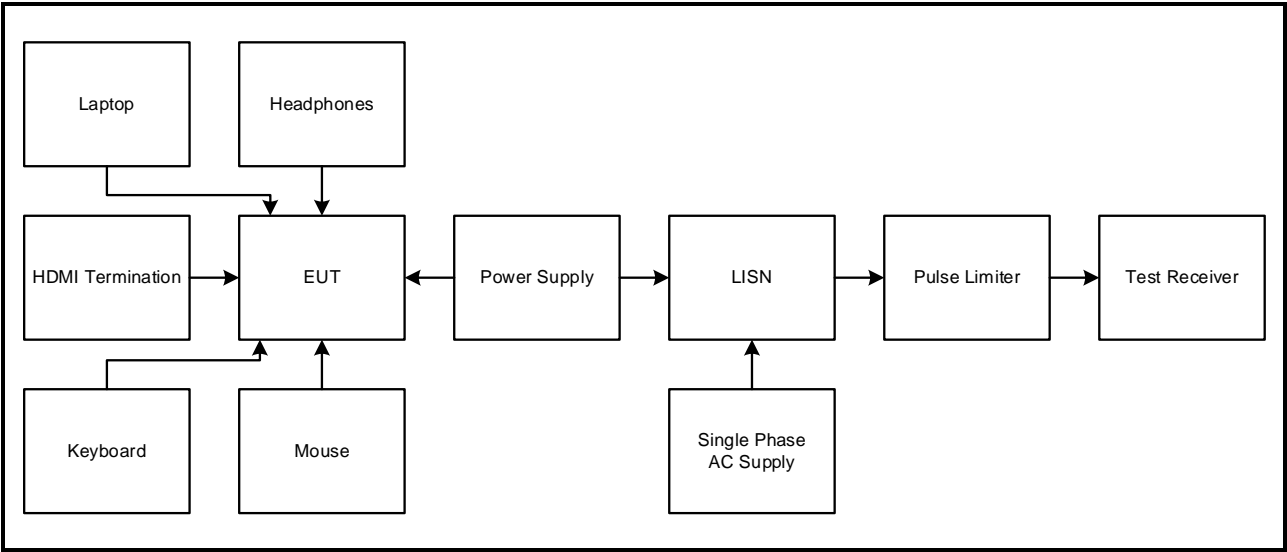


Test Setup Diagrams (continued)**Radiated Tests:****Test Setup for Transmitter Radiated Emissions**

Test Setup Diagrams (continued)**Test setup for radiated measurements (continued):**

Test Setup Diagrams (continued)

Test Setup for Transmitter AC Conducted Emissions



4. Antenna Port Test Results

4.1. Transmitter 20 dB Bandwidth

Test Summary:

Test Engineers:	Victor Carmon & Matthew Botfield	Test Date:	16 April 2019
Test Sample Serial Number:	0000000020d6f686		

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

Environmental Conditions:

Temperature (°C):	22
Relative Humidity (%):	43

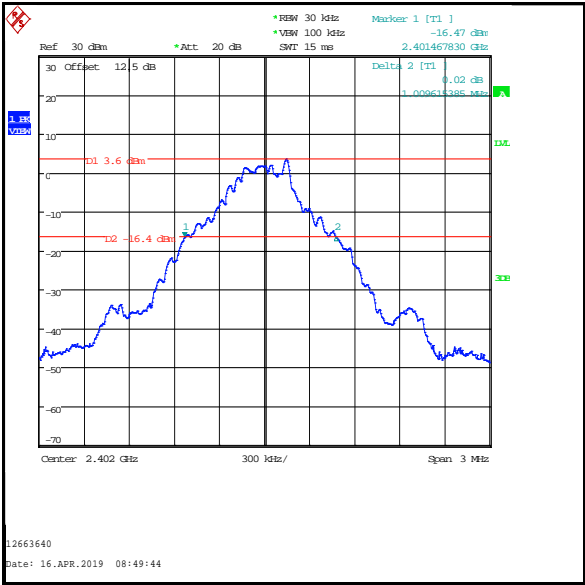
Note(s):

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 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.

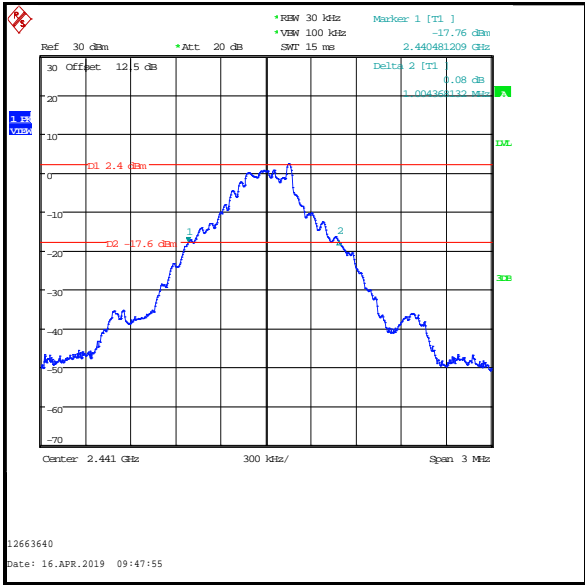
Transmitter 20 dB Bandwidth (continued)

Results DH5:

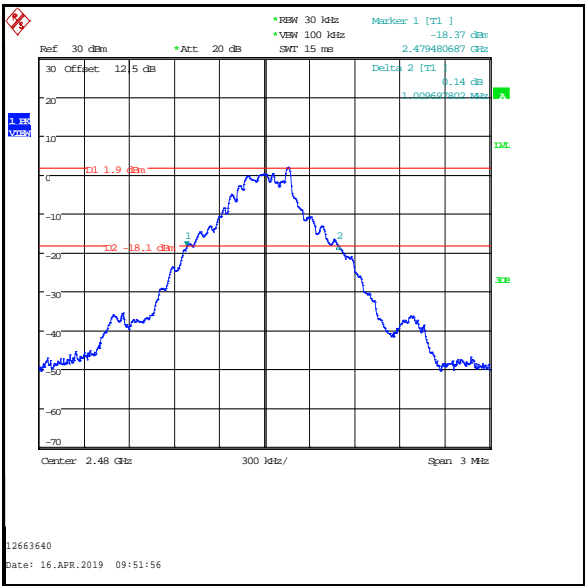
Channel	20 dB Bandwidth (kHz)
Bottom	1009.615
Middle	1004.368
Top	1009.698



Bottom Channel



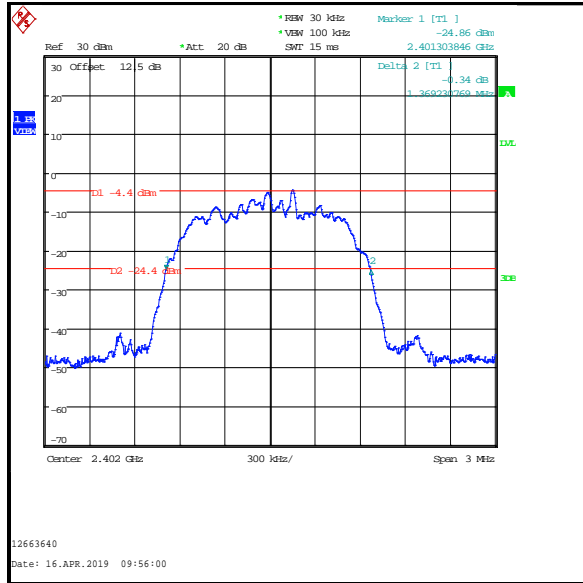
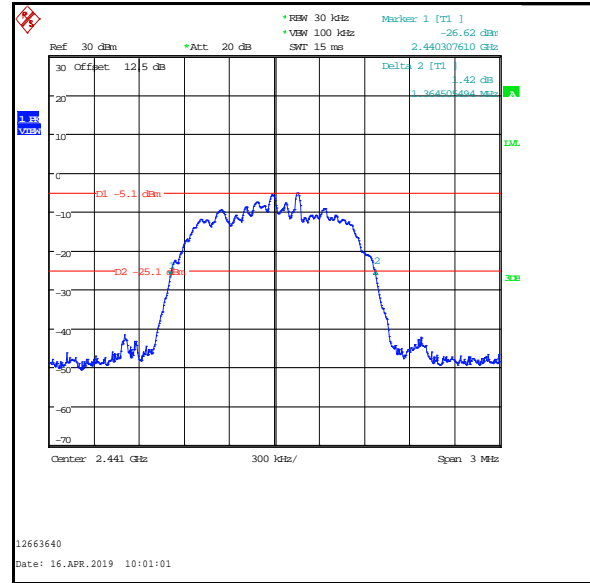
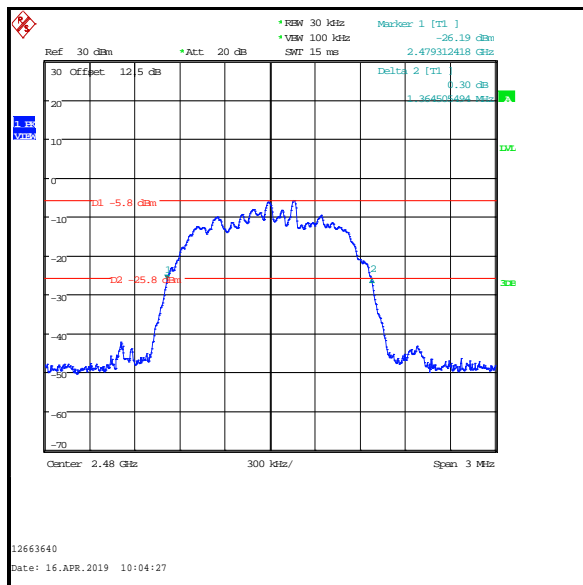
Middle Channel



Top Channel

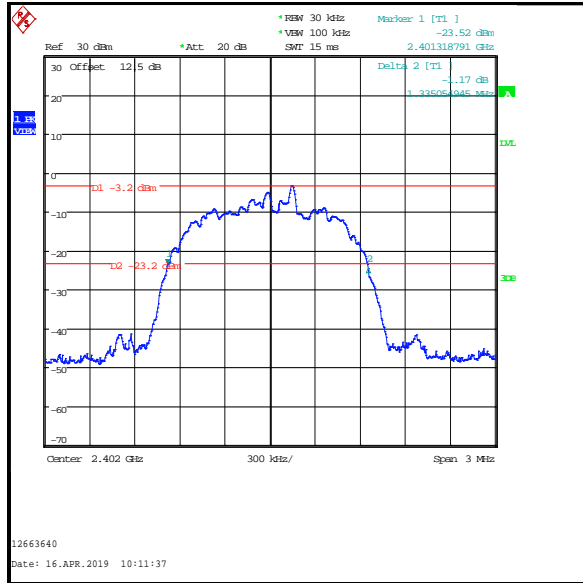
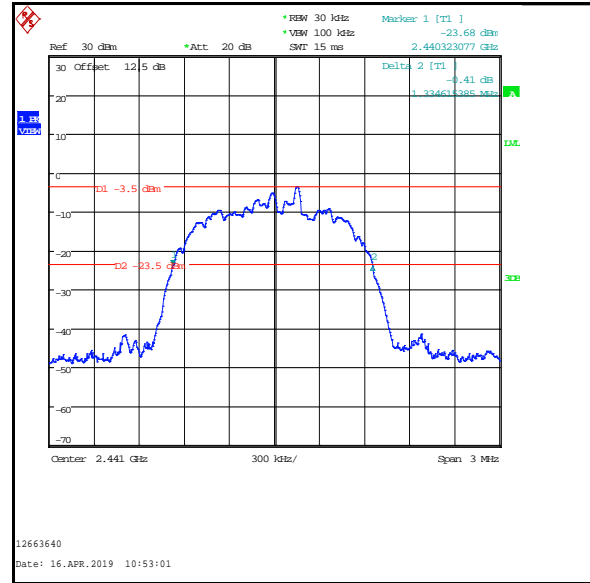
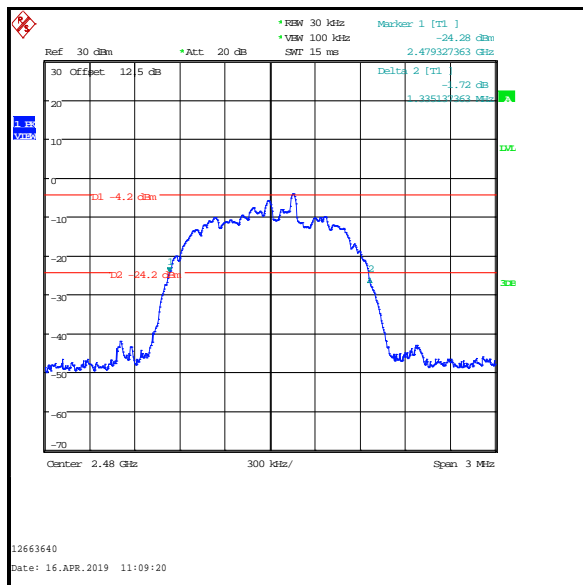
Transmitter 20 dB Bandwidth (continued)**Results 2DH5:**

Channel	20 dB Bandwidth (kHz)
Bottom	1369.231
Middle	1364.505
Top	1364.505

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

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

Channel	20 dB Bandwidth (kHz)
Bottom	1335.055
Middle	1334.615
Top	1335.137

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

4.2. Transmitter Carrier Frequency Separation

Test Summary:

Test Engineers:	Victor Carmon & Matthew Botfield	Test Date:	16 April 2019
Test Sample Serial Number:	0000000020d6f686		

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

Environmental Conditions:

Temperature (°C):	22
Relative Humidity (%):	43

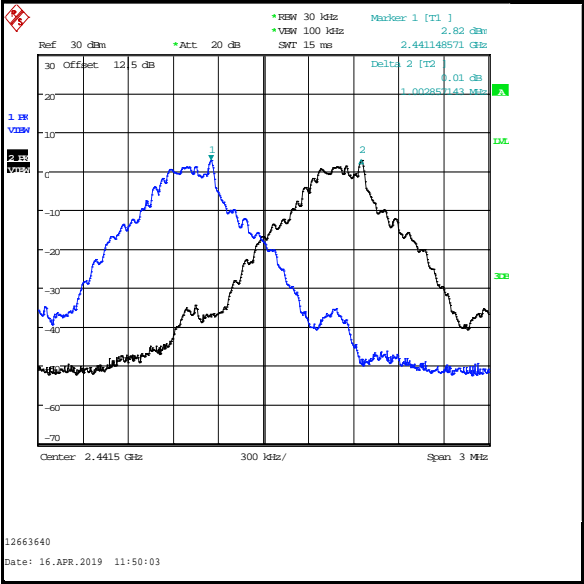
Note(s):

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)

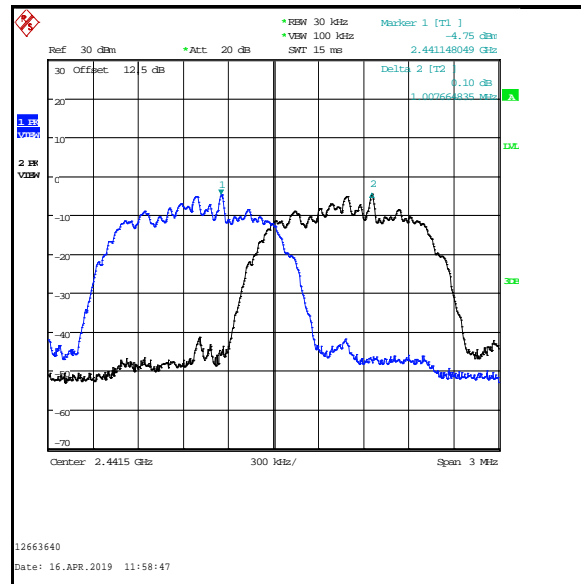
Results: DH5

Carrier Frequency Separation (kHz)	Limit (2/3 of 20 dB BW) (kHz)	Margin (kHz)	Result
1002.857	669.579	333.278	Complied



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

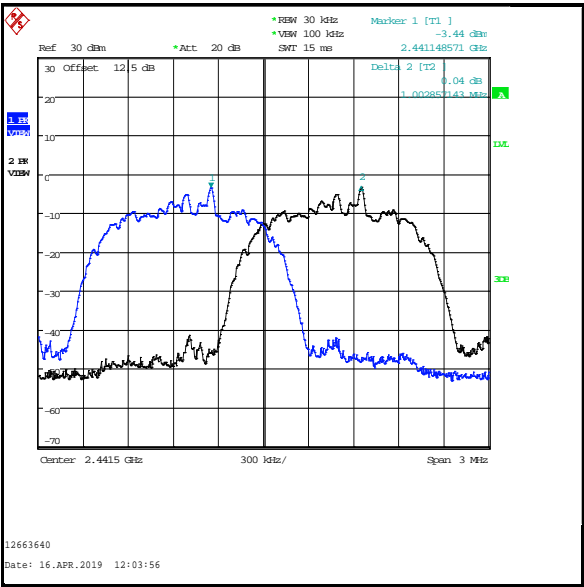
Carrier Frequency Separation (kHz)	Limit ($2/3$ of 20 dB BW) (kHz)	Margin (kHz)	Result
1007.665	909.670	97.995	Complied



Transmitter Carrier Frequency Separation (continued)

Results: 3DH5

Carrier Frequency Separation (kHz)	Limit (2/3 of 20 dB BW) (kHz)	Margin (kHz)	Result
1002.857	889.743	113.114	Complied



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

Test Engineers:	Victor Carmon & Matthew Botfield	Test Date:	16 April 2019
Test Sample Serial Number:	0000000020d6f686		

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

Environmental Conditions:

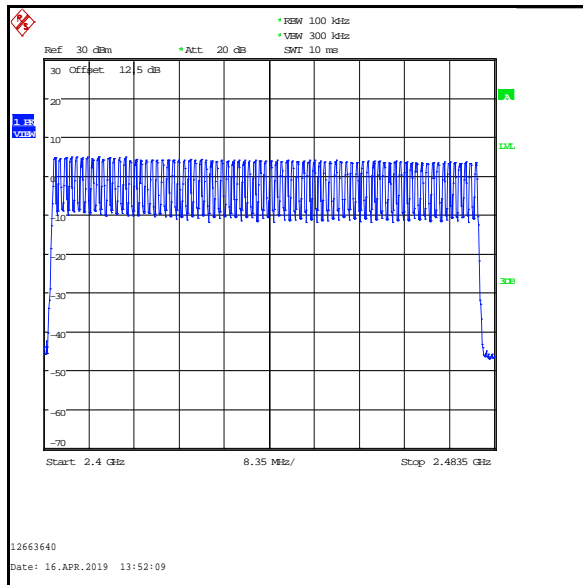
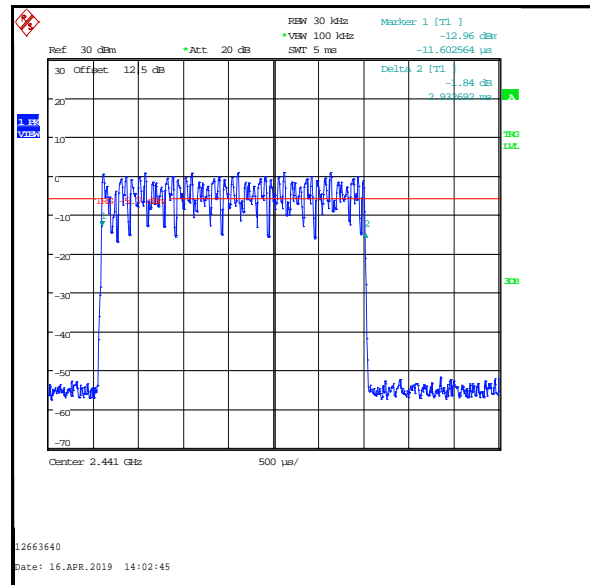
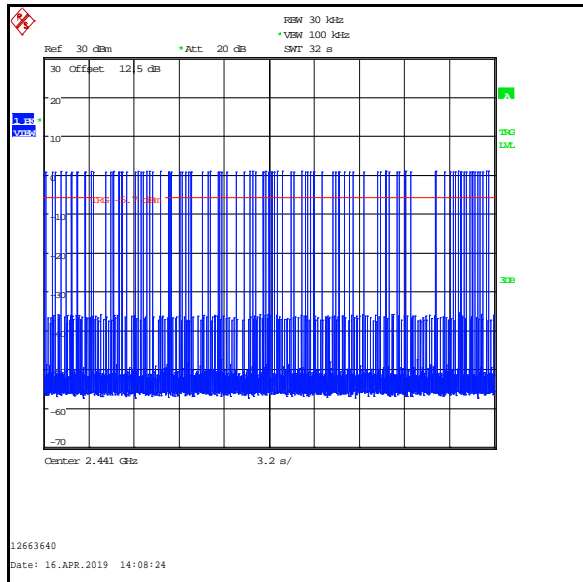
Temperature (°C):	22
Relative Humidity (%):	43

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 spectrum 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 spectrum analyser was set up for the Emission Width measurement as follows: the resolution bandwidth was set to 30 kHz and video bandwidth of 100 kHz. A peak detector was used and sweep time was set to auto with a span of zero Hz. The spectrum analyser was set to trigger at 0.5 ms, with a marker placed at the start of the emission and a delta marked place at the end of the emission. The emission width is recorded in the table below
4. The spectrum analyser was set up for the Number of Hopping Frequencies in 32 seconds measurement as follows: the resolution bandwidth was set to 30 kHz and video bandwidth of 100 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 spectrum 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 (μ s)	Number of Hops in 31.6 Seconds	Average Time of Occupancy (s)	Limit (s)	Margin (s)	Result
2932.692	109	0.320	0.4	0.080	Complied

**Number of Hopping Frequencies****Emission Width****Number of Hopping Frequencies in 32 s**

4.4. Transmitter Maximum Peak Output Power

Test Summary:

Test Engineers:	Victor Carmon & Matthew Botfield	Test Date:	16 April 2019
Test Sample Serial Number:	0000000020d6f686		

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

Environmental Conditions:

Temperature (°C):	22
Relative Humidity (%):	43

Note(s):

1. The spectrum 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 for DH5 and 6.5 MHz 2DH5 and 3DH5 (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 spectrum analyser was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF offset level was entered on the spectrum analyser to compensate for the loss of the attenuator and RF cable.

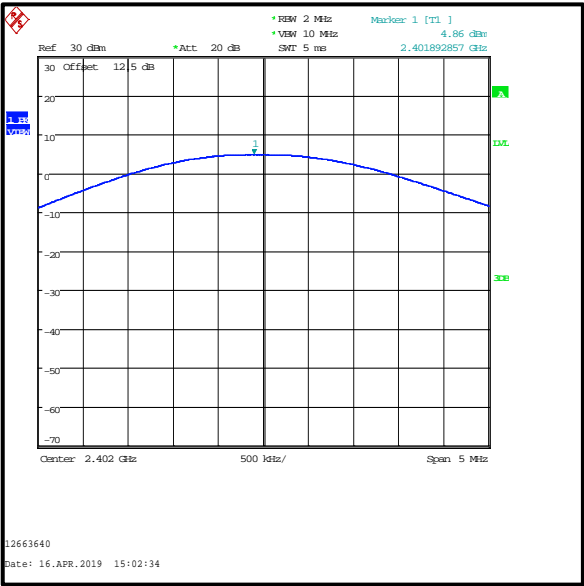
Transmitter Maximum Peak Output Power (continued)**Results: DH5**

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	4.9	30.0	25.1	Complied
Middle	4.2	30.0	25.8	Complied
Top	3.6	30.0	26.4	Complied

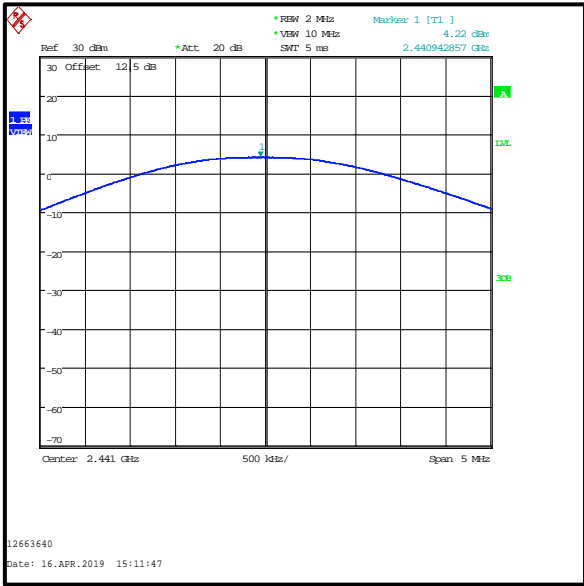
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	4.9	3.5	8.4	36.0	27.6	Complied
Middle	4.2	3.5	7.7	36.0	28.3	Complied
Top	3.6	3.5	7.1	36.0	28.9	Complied

Transmitter Maximum Peak Output Power (continued)

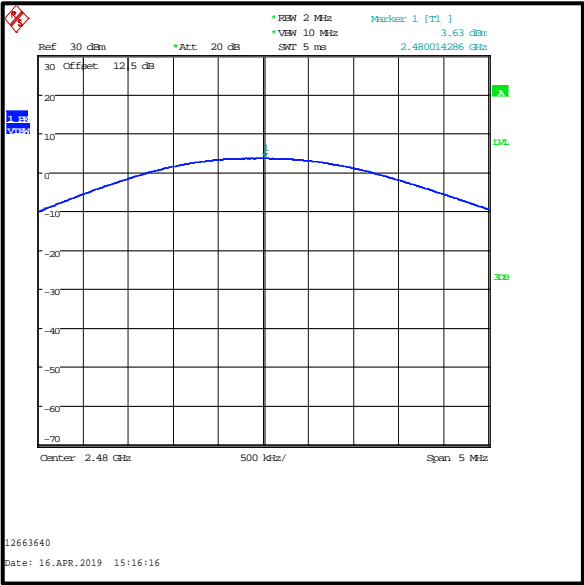
Results: DH5



Bottom Channel



Middle Channel



Top Channel

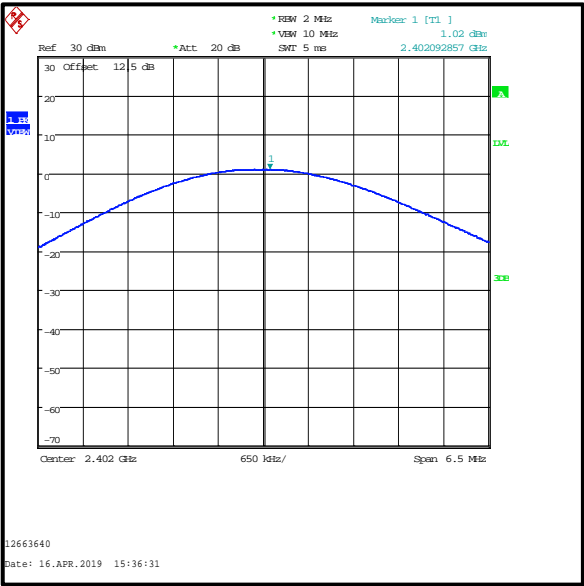
Transmitter Maximum Peak Output Power (continued)**Results: 2DH5**

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	1.0	21.0	20.0	Complied
Middle	0.3	21.0	20.7	Complied
Top	-0.4	21.0	21.4	Complied

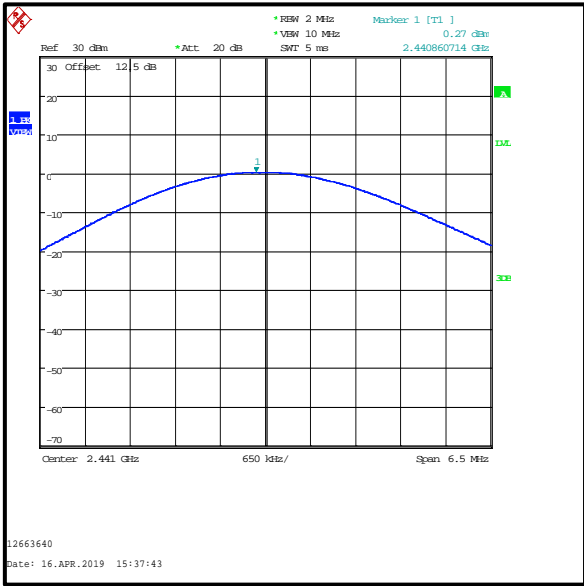
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	1.0	3.5	4.5	27.0	22.5	Complied
Middle	0.3	3.5	3.8	27.0	23.2	Complied
Top	-0.4	3.5	3.1	27.0	23.9	Complied

Transmitter Maximum Peak Output Power (continued)

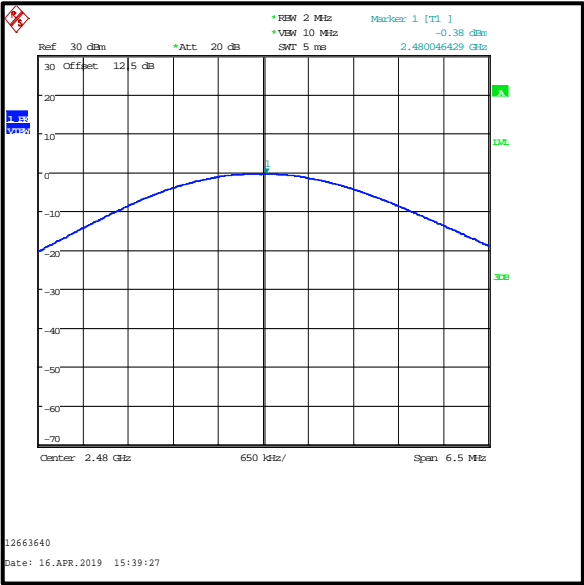
Results: 2DH5



Bottom Channel



Middle Channel



Top Channel

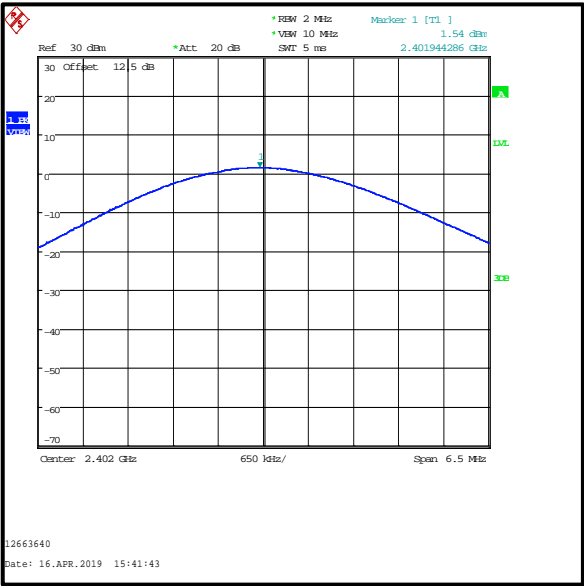
Transmitter Maximum Peak Output Power (continued)**Results: 3DH5**

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	1.5	21.0	19.5	Complied
Middle	0.8	21.0	20.2	Complied
Top	0.2	21.0	20.8	Complied

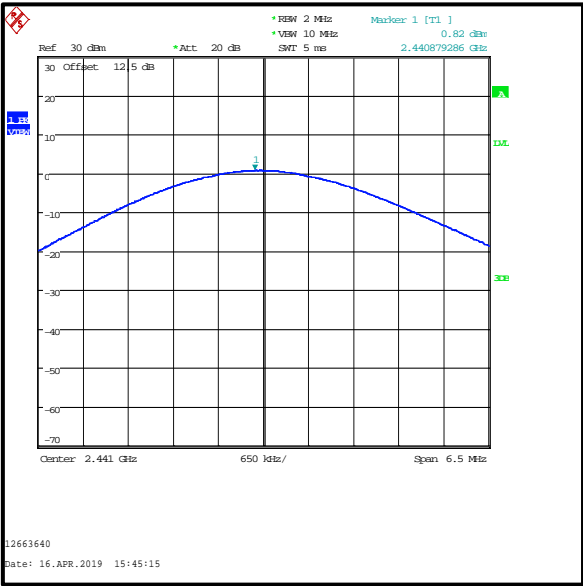
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	1.5	3.5	5.0	27.0	22.0	Complied
Middle	0.8	3.5	4.3	27.0	22.7	Complied
Top	0.2	3.5	3.7	27.0	23.3	Complied

Transmitter Maximum Peak Output Power (continued)

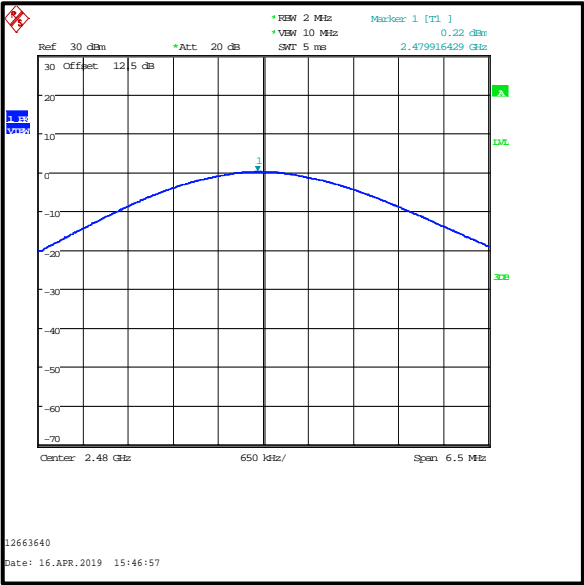
Results: 3DH5



Bottom Channel



Middle Channel



Top Channel

5. Radiated Test Results

5.1. Transmitter Radiated Emissions <1 GHz

Test Summary:

Test Engineer:	David Doyle	Test Date:	11 April 2019
Test Sample Serial Number:	000000003f9edf4a		

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:

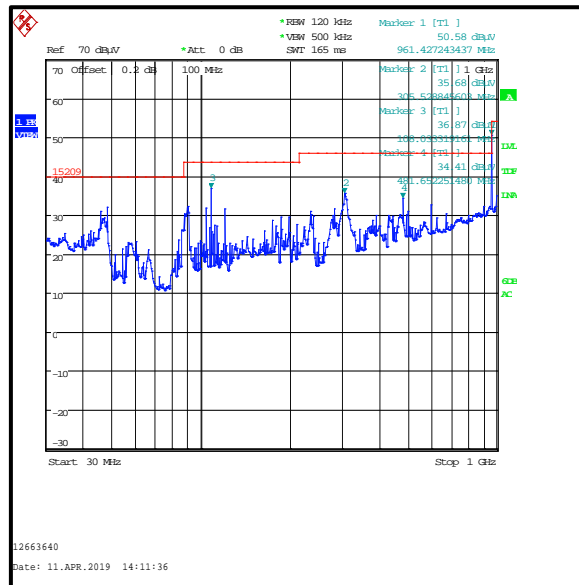
Temperature (°C):	19
Relative Humidity (%):	38

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 other 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.
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 middle 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: Quasi-Peak / DH5**

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
108.263	Horizontal	35.8	43.5	7.7	Complied
120.288	Horizontal	33.5	43.5	10.0	Complied
278.347	Horizontal	32.6	46.0	13.4	Complied
960.279	Horizontal	49.7	54.0	4.3	Complied



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

5.2. Transmitter Radiated Emissions >1 GHz

Test Summary:

Test Engineer:	David Doyle	Test Dates:	10 April 2019 to 12 April 2019
Test Sample Serial Number:	000000003f9edf4a		

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):	19 to 20
Relative Humidity (%):	38 to 41

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. 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.
5. All other 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.
6. Pre-scans above 1 GHz were performed in a fully anechoic chamber (Asset Number K0001) 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 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.
7. 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.

Transmitter Radiated Emissions (continued)**Results: Bottom Channel / DH5**

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
3843.150	Horizontal	47.9	54.0	6.1	Complied
4724.721	Vertical	51.9	54.0	2.1	Complied

Results: Middle Channel / DH5

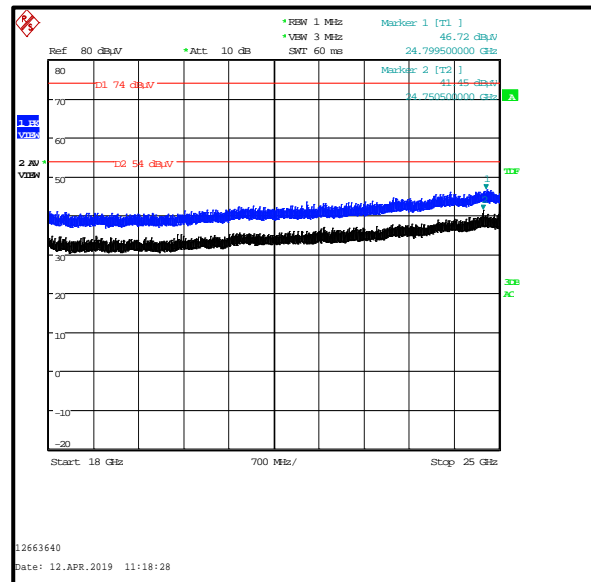
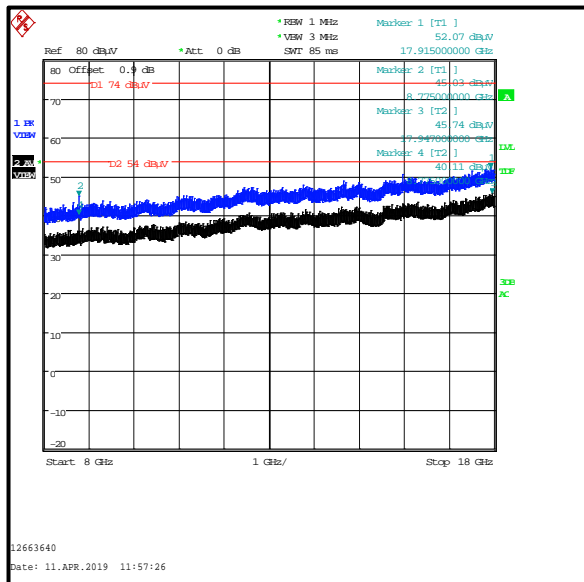
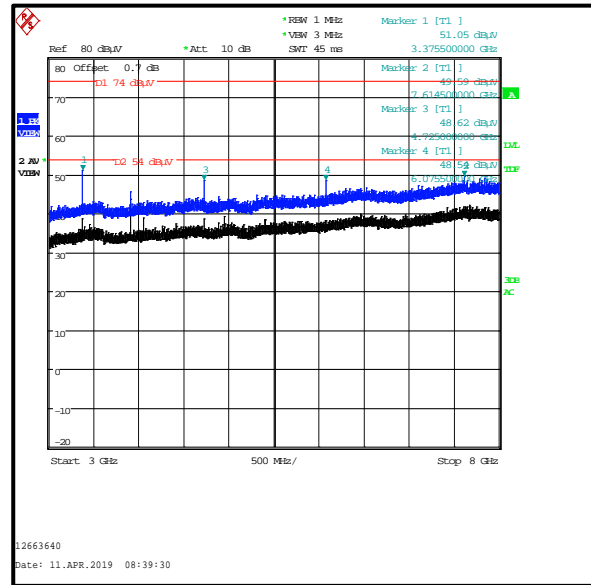
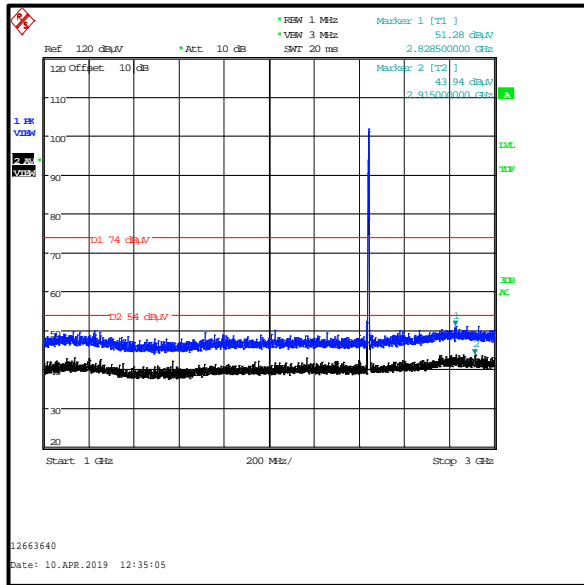
Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
3905.429	Horizontal	47.8	54.0	6.2	Complied
4724.971	Vertical	51.7	54.0	2.3	Complied

Results: Top Channel / DH5

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
3967.993	Horizontal	47.6	54.0	6.4	Complied
4725.193	Vertical	51.3	54.0	2.7	Complied

Results: Hopping Mode / DH5

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
3870.683	Horizontal	47.8	54.0	6.2	Complied
4725.036	Vertical	51.8	54.0	2.2	Complied

Transmitter Radiated Emissions (continued)

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

5.3. Transmitter Band Edge Radiated Emissions

Test Summary:

Test Engineer:	David Doyle	Test Date:	10 April 2019
Test Sample Serial Number:	000000003f9edf4a		

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

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. 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
2394.151	Horizontal	46.5	78.8*	32.3	Complied
2400.0	Horizontal	40.2	78.8*	38.6	Complied
2483.5	Horizontal	50.8	74.0	23.2	Complied
2484.061	Horizontal	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	Horizontal	46.5	54.0	7.5	Complied
2484.141	Horizontal	49.4	54.0	4.6	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

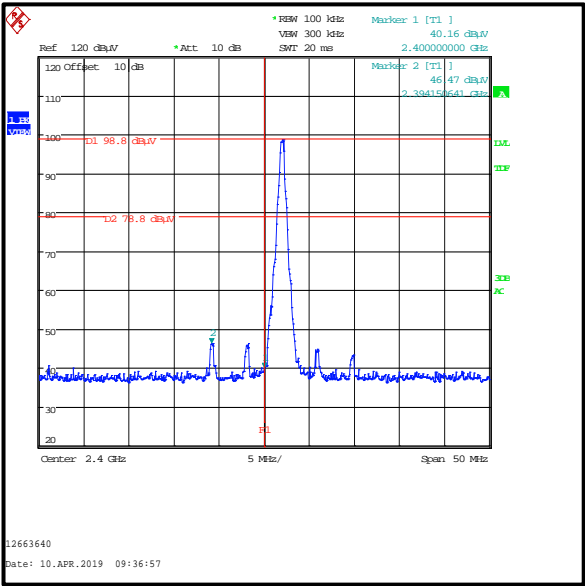
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2384.231	Horizontal	52.3	74.0	21.7	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

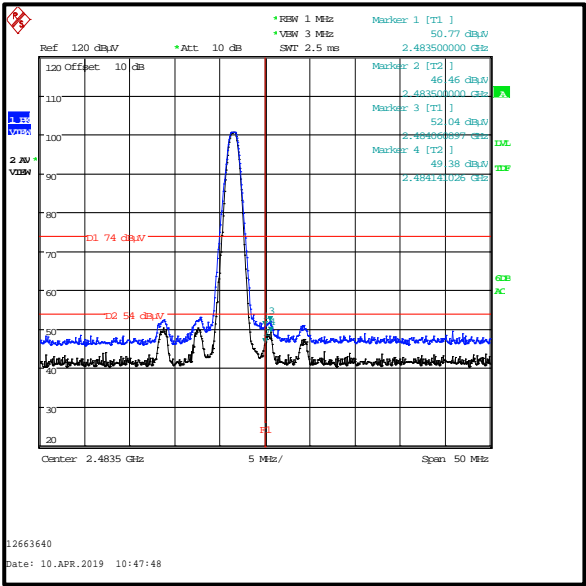
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2348.205	Horizontal	44.6	54.0	9.4	Complied

Transmitter Band Edge Radiated Emissions (continued)

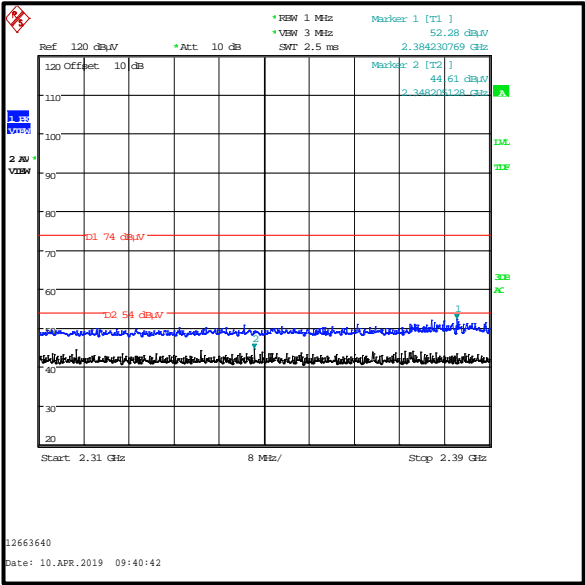
Results: Static Mode / DH5



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
2394.071	Horizontal	46.4	78.8*	32.4	Complied
2400.0	Horizontal	44.3	78.8*	34.5	Complied
2483.5	Horizontal	49.9	74.0	24.1	Complied
2483.740	Horizontal	52.1	74.0	21.9	Complied

Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Horizontal	46.4	54.0	7.6	Complied
2483.740	Horizontal	48.1	54.0	5.9	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

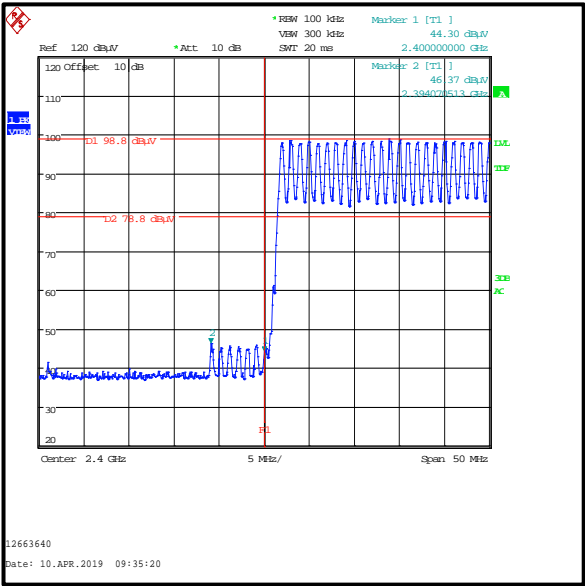
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2379.359	Horizontal	51.6	74.0	22.4	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

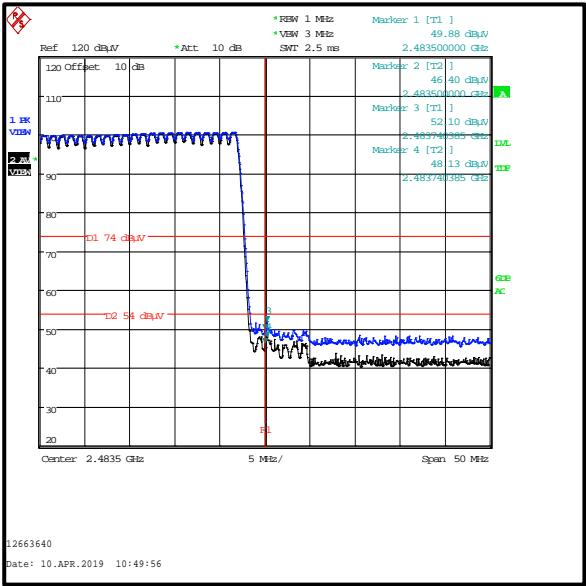
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2376.410	Horizontal	45.1	54.0	8.9	Complied

Transmitter Band Edge Radiated Emissions (continued)

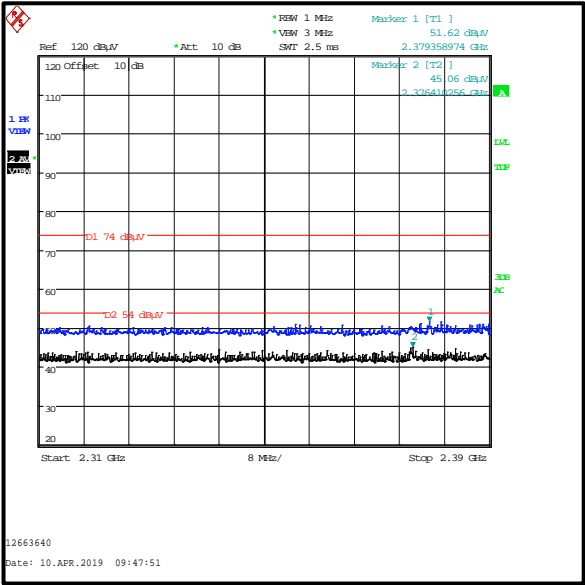
Results: Hopping Mode / DH5



Lower Band Edge



Upper 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
2394.071	Horizontal	42.6	71.1*	28.5	Complied
2400.0	Horizontal	39.0	71.1*	32.1	Complied
2483.5	Horizontal	48.3	74.0	25.7	Complied
2484.141	Horizontal	48.9	74.0	25.1	Complied

Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Horizontal	43.5	54.0	10.5	Complied
2484.221	Horizontal	44.6	54.0	9.4	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

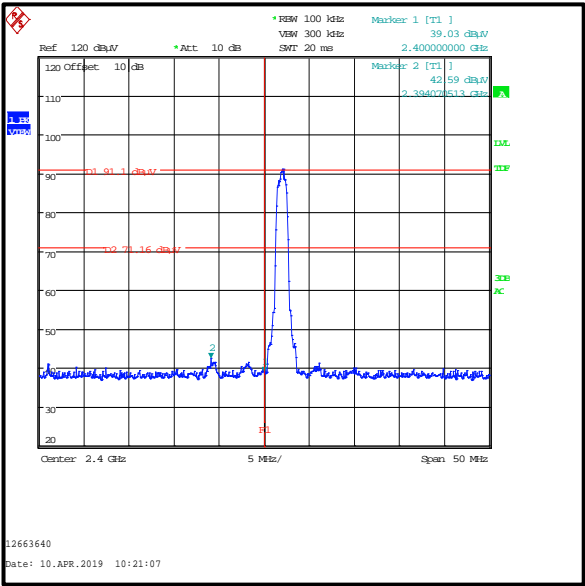
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2388.846	Horizontal	51.9	74.0	22.1	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

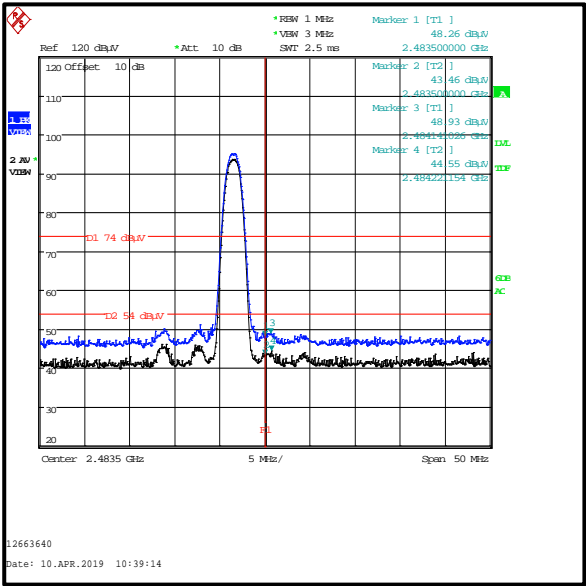
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2386.282	Horizontal	44.7	54.0	9.3	Complied

Transmitter Band Edge Radiated Emissions (continued)

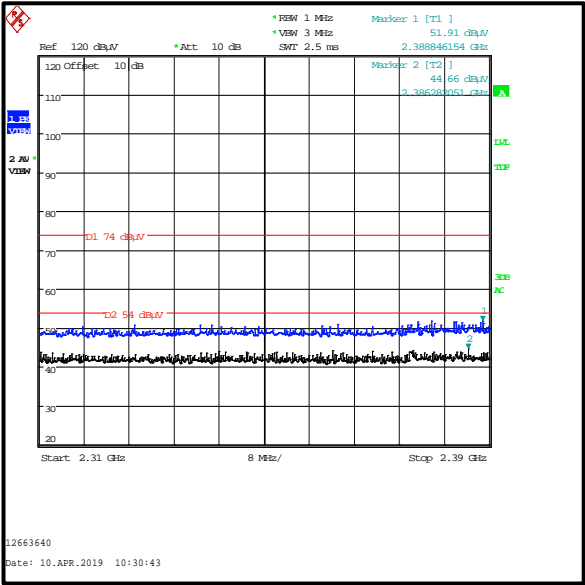
Results: Static Mode / 2DH5



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
2395.353	Horizontal	41.0	71.6*	30.6	Complied
2400.0	Horizontal	39.2	71.6*	32.4	Complied
2483.5	Horizontal	46.3	74.0	27.7	Complied

Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Horizontal	41.8	54.0	12.2	Complied
2484.141	Horizontal	45.3	54.0	8.7	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

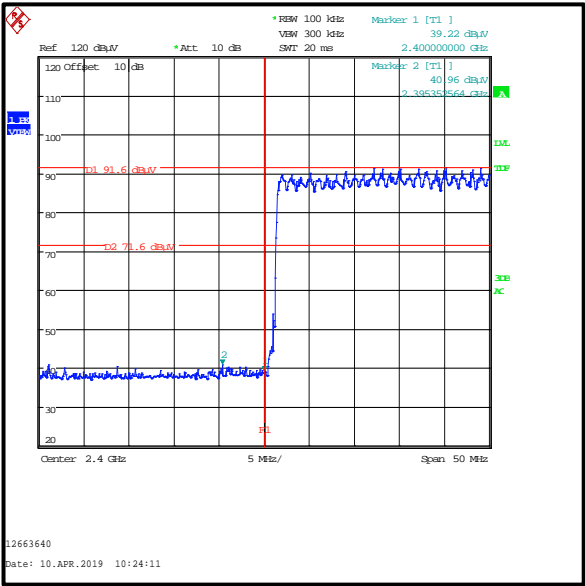
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2380.385	Horizontal	53.1	74.0	20.9	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

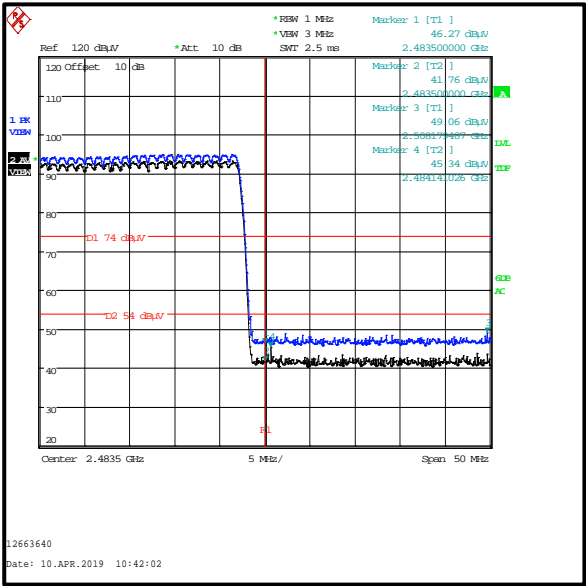
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2376.026	Horizontal	46.1	54.0	7.9	Complied

Transmitter Band Edge Radiated Emissions (continued)

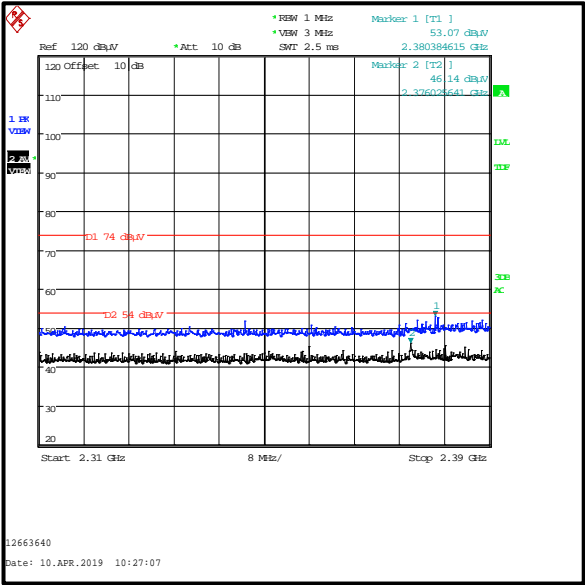
Results: Hopping Mode / 2DH5



Lower Band Edge



Upper 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
2400.0	Horizontal	39.1	71.3*	32.2	Complied
2483.5	Horizontal	48.0	74.0	26.0	Complied
2483.981	Horizontal	48.3	74.0	25.7	Complied

Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Horizontal	44.2	54.0	9.8	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

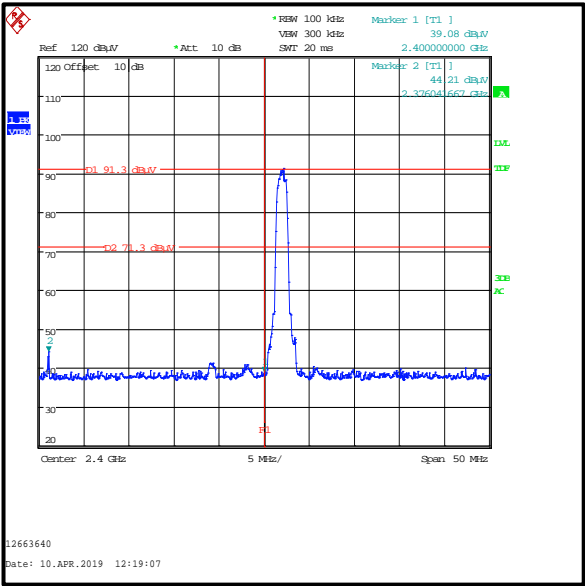
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2382.692	Horizontal	53.6	74.0	20.4	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

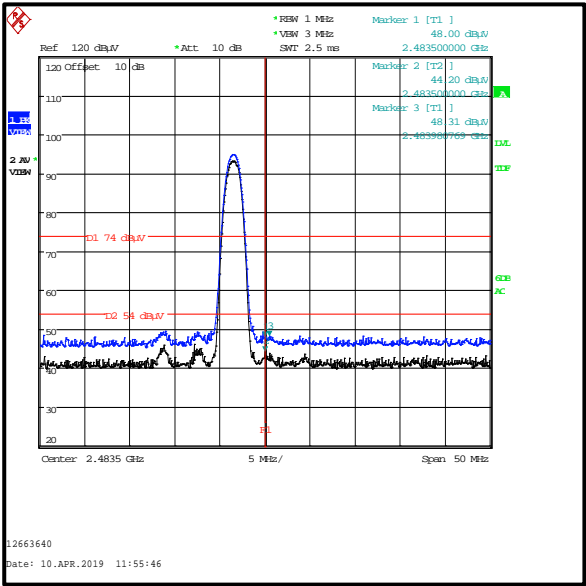
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2376.154	Horizontal	46.3	54.0	7.7	Complied

Transmitter Band Edge Radiated Emissions (continued)

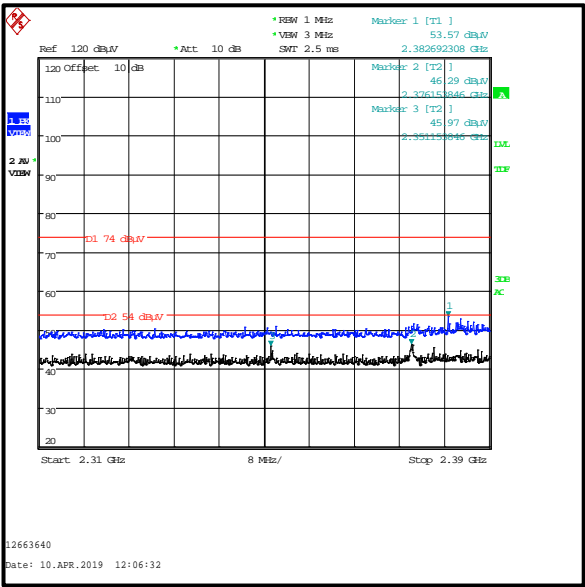
Results: Static Mode / 3DH5



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

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
2400.0	Horizontal	40.2	71.7*	31.5	Complied
2483.5	Horizontal	46.9	74.0	27.1	Complied
2484.462	Horizontal	48.9	74.0	25.1	Complied

Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Horizontal	42.1	54.0	11.9	Complied
2490.471	Horizontal	44.1	54.0	9.9	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

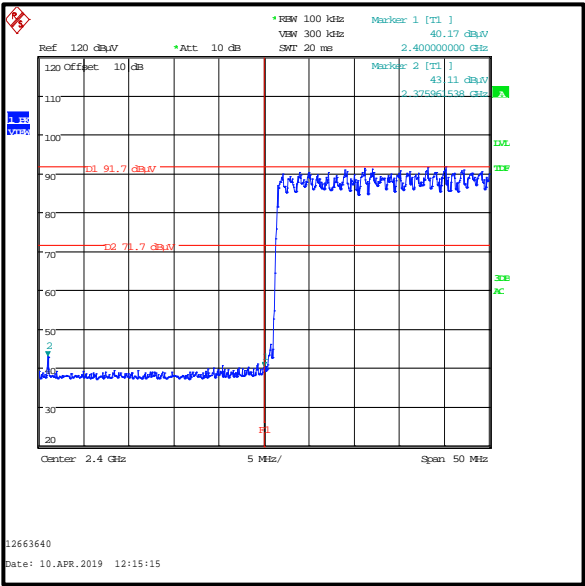
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2380.385	Horizontal	52.5	74.0	21.5	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

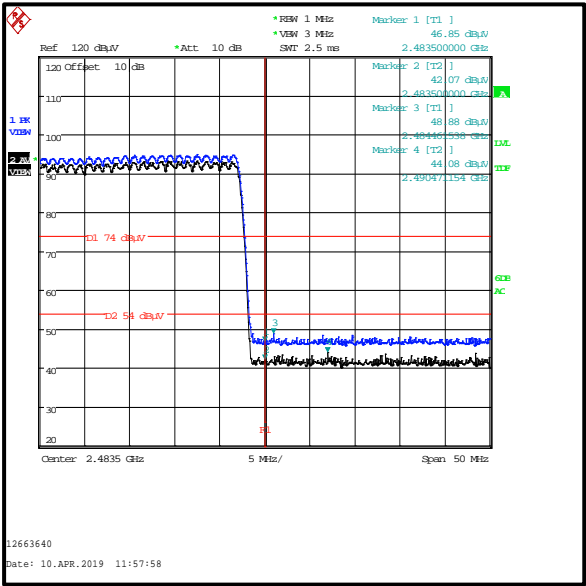
Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2376.410	Horizontal	46.0	54.0	8.0	Complied

Transmitter Band Edge Radiated Emissions (continued)

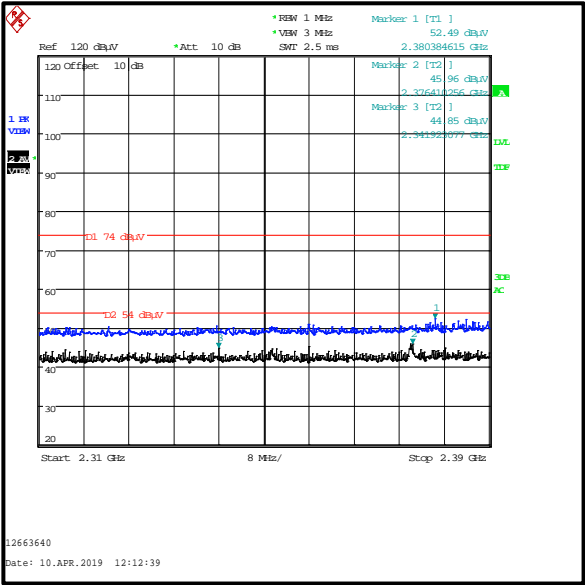
Results: Hopping Mode / 3DH5



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

6. AC Power Line Conducted Emissions Test Results

6.1. Transmitter AC Conducted Spurious Emissions

Test Summary:

Test Engineer:	Victor Carmon	Test Dates:	18 April 2019 & 23 April 2019
Test Sample Serial Number:	0000000027a0c96b		

FCC Reference:	Part 15.207
Test Method Used:	ANSI C63.10 Section 6.2 / FCC KDB 174176 and notes below

Environmental Conditions:

Temperature (°C):	21 to 23
Relative Humidity (%):	43 to 45

Note(s):

1. The EUT was connected to the AC to DC switch mode power supply which was connected to 120 VAC 60 Hz single phase supply via a LISN.
2. In accordance with FCC KDB 174176 Q4, tests were performed with a 240 VAC 60 Hz single phase supply as this was within the voltage range marked on the EUT's power supply.
3. A pulse limiter was fitted between the LISN and the test receiver.
4. Pre-scans were performed and markers placed on the highest live and neutral measured levels. Final measurements were performed on the marker frequencies and the results entered into the tables below.

Transmitter AC Conducted Spurious Emissions (continued)**Results: Live / Quasi Peak / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.150	Live	53.9	66.0	12.1	Complied
0.191	Live	50.3	64.0	13.7	Complied
0.276	Live	43.5	60.9	17.4	Complied
0.362	Live	37.3	58.7	21.4	Complied
11.747	Live	27.3	60.0	32.7	Complied
14.348	Live	23.3	60.0	36.7	Complied

Results: Live / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.155	Live	28.8	55.8	27.0	Complied
0.195	Live	25.7	53.8	28.1	Complied
0.447	Live	25.4	46.9	21.5	Complied
0.515	Live	25.9	46.0	20.1	Complied
11.963	Live	20.3	50.0	29.7	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

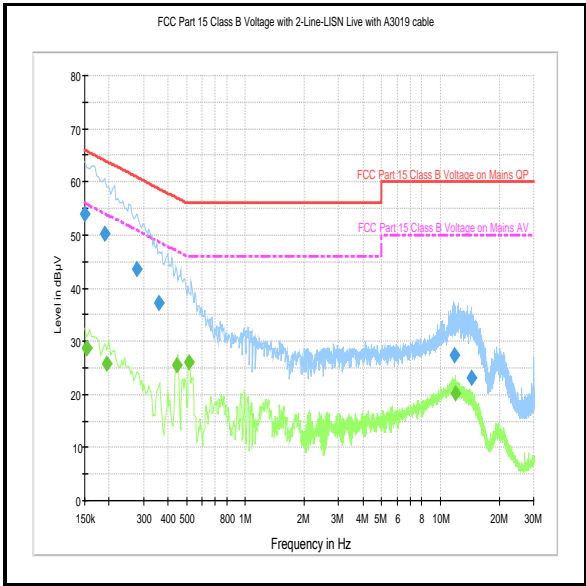
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.150	Neutral	52.7	66.0	13.3	Complied
0.186	Neutral	49.3	64.2	14.9	Complied
0.281	Neutral	41.1	60.8	19.7	Complied
11.922	Neutral	30.5	60.0	29.5	Complied
15.509	Neutral	26.2	60.0	33.8	Complied
16.755	Neutral	20.6	60.0	39.4	Complied

Results: Neutral / Average / 120 VAC 60 Hz

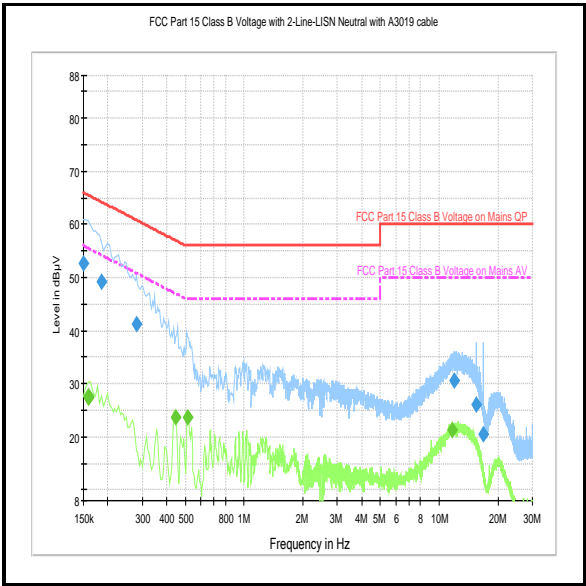
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.159	Neutral	27.6	55.5	27.9	Complied
0.447	Neutral	23.7	46.9	23.2	Complied
0.515	Neutral	23.6	46.0	22.4	Complied
11.715	Neutral	21.4	50.0	28.6	Complied

Transmitter AC Conducted Spurious Emissions (continued)

Results: 120 VAC 60 Hz



Live



Neutral

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

Transmitter AC Conducted Spurious Emissions (continued)**Results: Live / Quasi Peak / 240 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.150	Live	38.3	66.0	27.7	Complied
0.510	Live	35.7	56.0	20.3	Complied
1.271	Live	29.3	56.0	26.7	Complied
5.204	Live	26.5	60.0	33.5	Complied
11.648	Live	26.7	60.0	33.3	Complied

Results: Live / Average / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.168	Live	23.8	55.1	31.3	Complied
0.371	Live	23.7	48.5	24.8	Complied
0.501	Live	25.0	46.0	21.0	Complied
0.762	Live	23.5	46.0	22.5	Complied
1.190	Live	22.0	46.0	24.0	Complied
11.594	Live	21.2	50.0	28.8	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

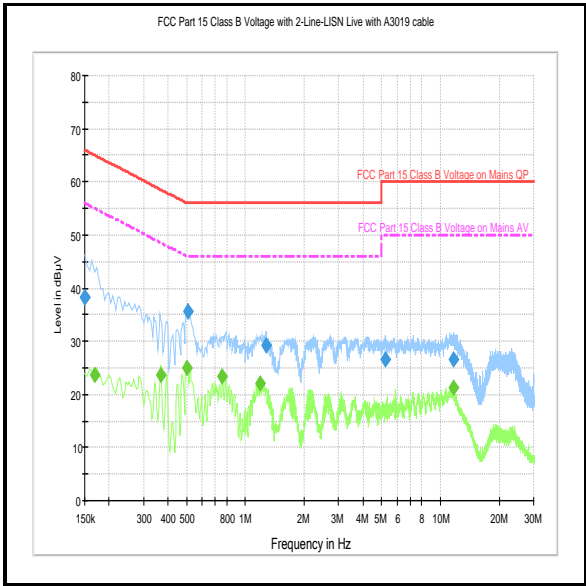
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.150	Neutral	35.4	66.0	30.6	Complied
0.159	Neutral	34.5	65.5	31.0	Complied
0.510	Neutral	36.2	56.0	19.8	Complied
0.708	Neutral	31.9	56.0	24.1	Complied
7.188	Neutral	24.0	60.0	36.0	Complied
10.275	Neutral	26.9	60.0	33.1	Complied

Results: Neutral / Average / 240 VAC 60 Hz

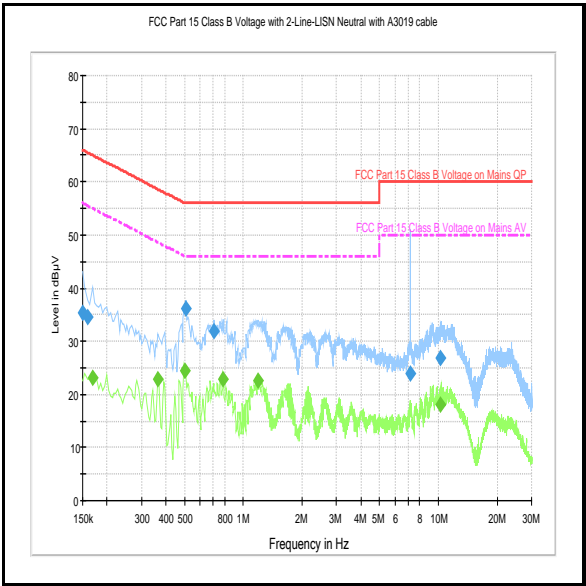
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.168	Neutral	23.1	55.1	32.0	Complied
0.366	Neutral	22.9	48.6	25.7	Complied
0.501	Neutral	24.5	46.0	21.5	Complied
0.789	Neutral	23.0	46.0	23.0	Complied
1.185	Neutral	22.5	46.0	23.5	Complied
10.271	Neutral	18.0	50.0	32.0	Complied

Transmitter AC Conducted Spurious Emissions (continued)

Results: 240 VAC 60 Hz



Live



Neutral

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

--- END OF REPORT ---