




TEST REPORT


Test Report No. : UL-RPT-RP11913492-2216A V2.0

Manufacturer : Raspberry Pi (Trading) Ltd
Model No. : Raspberry Pi 3 Model B+
FCC ID : 2ABCB-RPI3BP
Technology : *Bluetooth* – Basic Rate & EDR
Test Standard(s) : FCC Parts 15.207, 15.209(a) & 15.247

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2. The results in this report apply only to the sample(s) tested.
3. The sample tested is in compliance with the above standard(s).
4. The test results in this report are traceable to the national or international standards.
5. Version 2.0 supersedes all previous versions.

Date of Issue: 06 March 2018

Checked by: 
Sarah Williams
Senior Test Engineer, Radio Laboratory

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



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1. Customer Information










Company Name:	Raspberry Pi (Trading) Ltd
Address:	30 Station Road Cambridge CB1 2JH United Kingdom

2. Summary of Testing

2.1. General Information

Specification Reference:	47CFR15.247
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.247
Specification Reference:	47CFR15.207 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:	209735
Location of Testing:	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
Test Dates:	28 November 2017 to 14 December 2017

2.2. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.207	Transmitter AC Conducted Emissions	
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	
Key to Results  = Complied  = Did not comply		

2.3. Methods and Procedures

Reference:	ANSI C63.10-2013
Title:	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Reference:	KDB 174176 D01 Line Conducted FAQ v01r01 June 3, 2015
Title:	AC Power-Line Conducted Emissions Frequently Asked Questions

2.4. Deviations from the Test Specification

For the measurements contained within this test report, there were no deviations from, additions to, or exclusions from the test specification identified above.

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Raspberry Pi
Model Name or Number:	Raspberry Pi 3 Model B+
Test Sample Serial Number:	Not marked or stated (<i>Radiated sample</i>)
Hardware Version:	V1.0
Software Version:	4.4
FCC ID:	2ABCB-RPI3BP

Brand Name:	Raspberry Pi
Model Name or Number:	Raspberry Pi 3 Model B+
Test Sample Serial Number:	Not marked or stated (<i>Conducted sample with RF port</i>)
Hardware Version:	V1.0
Software Version:	4.4
FCC ID:	2ABCB-RPI3BP

3.2. Description of EUT

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

3.3. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.4. 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:	11.6 dBm		
Antenna Gain:	3.5 dBi		
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

3.5. Support Equipment

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

Description:	LCD Monitor
Brand Name:	Asus
Model Name or Number:	PA238
Serial Number:	D9LMTF114809

Description:	USB Mouse
Brand Name:	Microsoft
Model Name or Number:	MS1119
Serial Number:	CN-093H7Y-73826-54B-03W0

Description:	USB Keyboard
Brand Name:	Microsoft
Model Name or Number:	600
Serial Number:	0065806454108

Support Equipment (continued)

Description:	Power Supply. 230 VAC Input / 5 VDC output
Brand Name:	Strontronics Ltd
Model Name or Number:	DSA-12CA-05
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. Quantity 1. Length 1.9 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

Description:	USB cable. Quantity 2. 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

Support Equipment (continued)

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

Description:	USB dongle
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

4. Operation and Monitoring of the EUT during Testing

4.1. 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.

4.2. 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 X 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 2 metre long HDMI cable.
- The keyboard and mouse were connected to the USB port on the EUT.
- The EUT radiated sample was used for AC conducted emissions and radiated spurious emissions tests.
- The EUT conducted sample was used for all other tests.

5. Measurements, Examinations and Derived Results

5.1. General Comments

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to *Section 6. Measurement Uncertainty* for details.

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

5.2. Test Results

5.2.1. Transmitter AC Conducted Spurious Emissions

Test Summary:

Test Engineer:	Doug Freegard	Test Date:	14 December 2017
Test Sample Serial Number:	Not marked or stated (<i>Radiated sample</i>)		

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

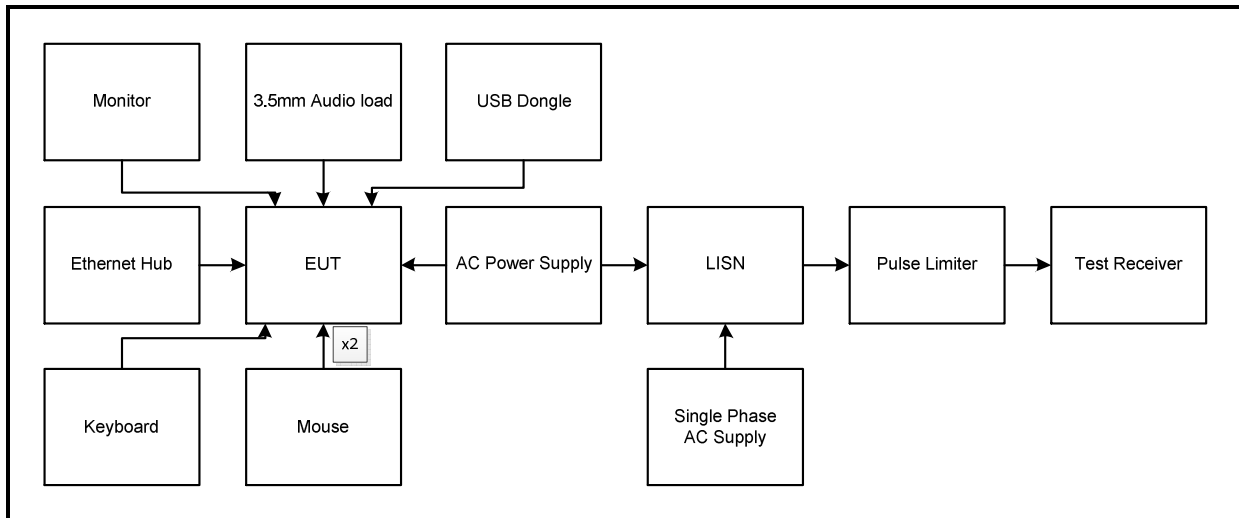
Environmental Conditions:

Temperature (°C):	22
Relative Humidity (%):	34

Note(s):

1. The EUT was connected to a DC power supply which supplied the unit with 5.0 VDC. The DC power supply 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 5.0 V DC 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.

Test setup:



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

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.150	Live	58.1	66.0	7.9	Complied
0.231	Live	52.8	62.4	9.6	Complied
0.281	Live	48.1	60.8	12.7	Complied
0.398	Live	43.7	57.9	14.2	Complied
0.677	Live	31.2	56.0	24.8	Complied
11.153	Live	26.8	60.0	33.2	Complied

Results: Live / Average / 120 VAC 60 Hz

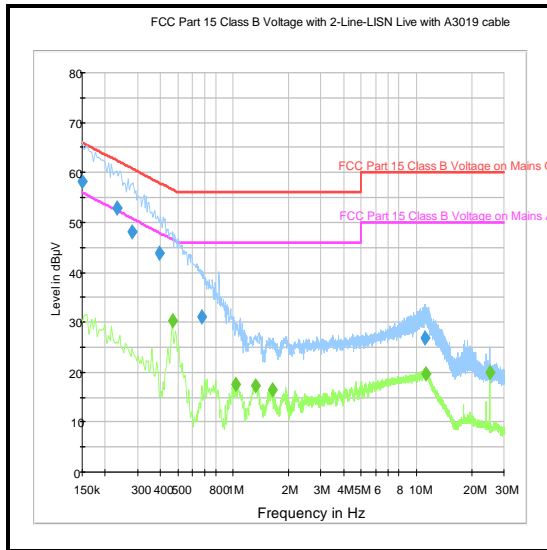
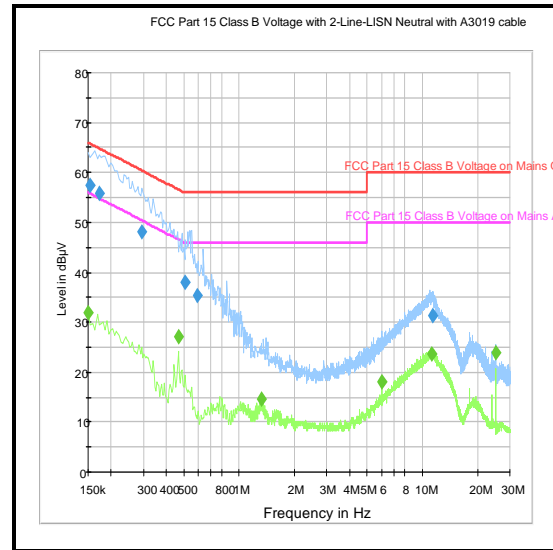
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.465	Live	30.4	46.6	16.2	Complied
1.037	Live	17.6	46.0	28.4	Complied
1.329	Live	17.2	46.0	28.8	Complied
1.644	Live	16.4	46.0	29.6	Complied
11.279	Live	19.7	50.0	30.3	Complied
25.058	Live	19.9	50.0	30.1	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.155	Neutral	57.3	65.8	8.5	Complied
0.173	Neutral	55.8	64.8	9.0	Complied
0.294	Neutral	48.0	60.4	12.4	Complied
0.510	Neutral	37.9	56.0	18.1	Complied
0.591	Neutral	35.3	56.0	20.7	Complied
11.351	Neutral	31.5	60.0	28.5	Complied

Results: Neutral / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.150	Neutral	31.8	56.0	24.2	Complied
0.465	Neutral	27.1	46.6	19.5	Complied
1.329	Neutral	14.6	46.0	31.4	Complied
6.014	Neutral	18.1	50.0	31.9	Complied
11.220	Neutral	23.6	50.0	26.4	Complied
25.058	Neutral	24.0	50.0	26.0	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 (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.150	Live	52.6	66.0	13.4	Complied
0.177	Live	50.4	64.6	14.2	Complied
0.272	Live	43.0	61.1	18.1	Complied
0.398	Live	35.0	57.9	22.9	Complied
1.460	Live	29.3	56.0	26.7	Complied
11.027	Live	27.4	60.0	32.6	Complied

Results: Live / Average / 240 VAC 60 Hz

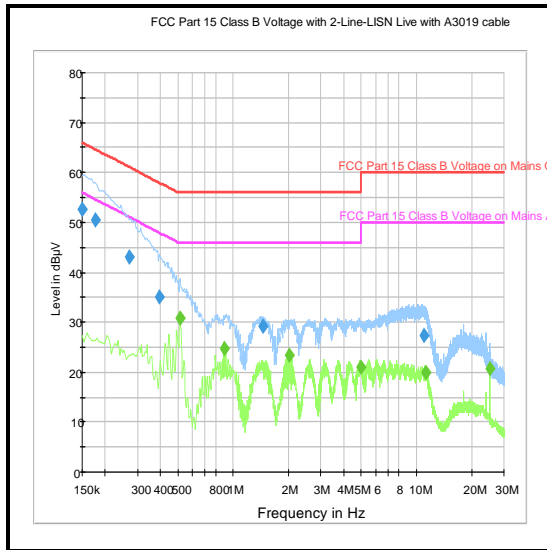
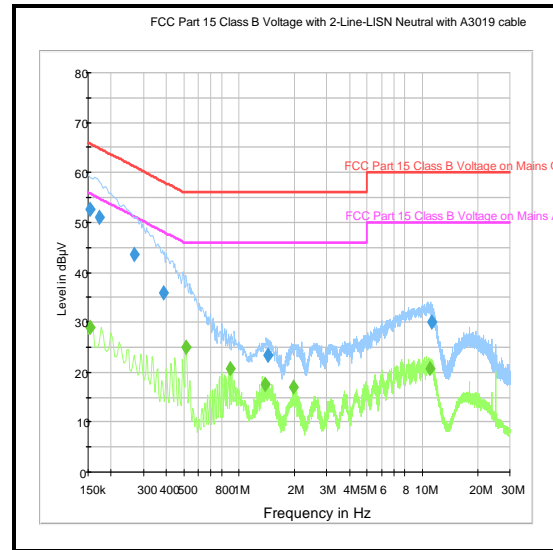
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.515	Live	30.9	46.0	15.1	Complied
0.893	Live	24.8	46.0	21.2	Complied
2.018	Live	23.3	46.0	22.7	Complied
4.943	Live	21.0	46.0	25.0	Complied
11.301	Live	19.9	50.0	30.1	Complied
25.058	Live	20.6	50.0	29.4	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.155	Neutral	52.6	65.8	13.2	Complied
0.173	Neutral	51.0	64.8	13.8	Complied
0.267	Neutral	43.7	61.2	17.5	Complied
0.389	Neutral	35.9	58.1	22.2	Complied
1.437	Neutral	23.4	56.0	32.6	Complied
11.180	Neutral	30.1	60.0	29.9	Complied

Results: Neutral / Average / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.155	Neutral	29.0	55.8	26.8	Complied
0.515	Neutral	24.9	46.0	21.1	Complied
0.893	Neutral	20.7	46.0	25.3	Complied
1.383	Neutral	17.4	46.0	28.6	Complied
1.977	Neutral	16.9	46.0	29.1	Complied
10.946	Neutral	20.7	50.0	29.3	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.

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2013	Thermohygrometer	Testo	608-H1	45046424	20 Jun 2018	12
A649	LISN	Rohde & Schwarz	ESH3-Z5	825562/008	09 Aug 2018	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	09 May 2018	12
M1263	Test Receiver	Rohde & Schwarz	ESIB7	100265	13 Nov 2018	12
A2953	Power Supply	Tacima	SC 5467	Not stated	Calibrated before use	-
M1229	Multimeter	Fluke	179	87640015	12 May 2018	12

5.2.2. Transmitter 20 dB Bandwidth**Test Summary:**

Test Engineer:	Doug Freegard	Test Dates:	04 December 2017 & 05 December 2017
Test Sample Serial Number:	Not marked or stated (<i>Conducted sample with RF port</i>)		

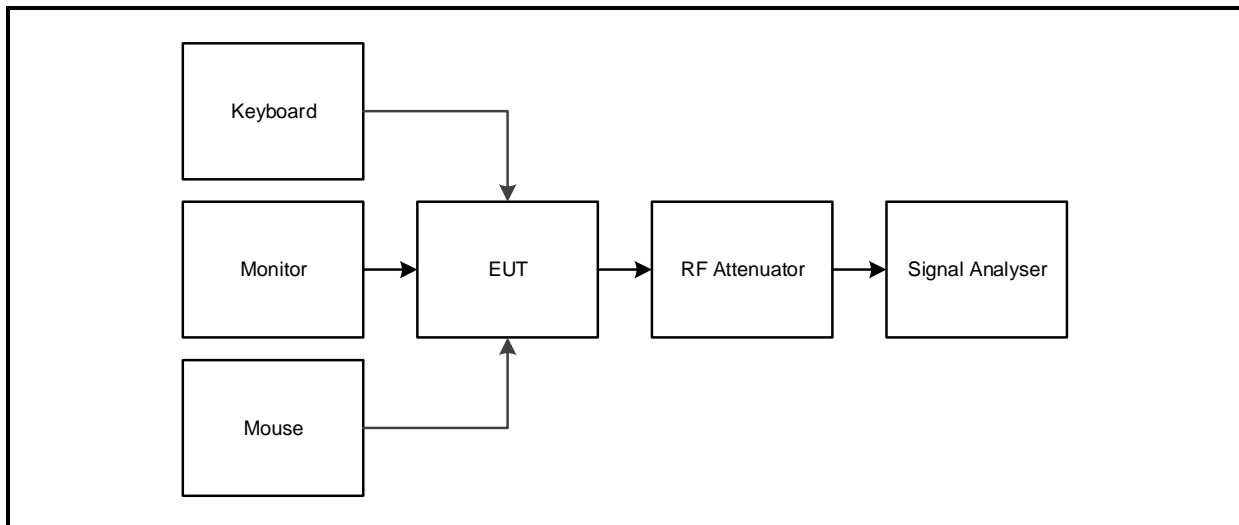
FCC Reference:	Part 15.247(a)(1)
Test Method Used:	ANSI C63.10 Section 6.9.2

Environmental Conditions:

Temperature (°C):	21 to 25
Relative Humidity (%):	32 to 38

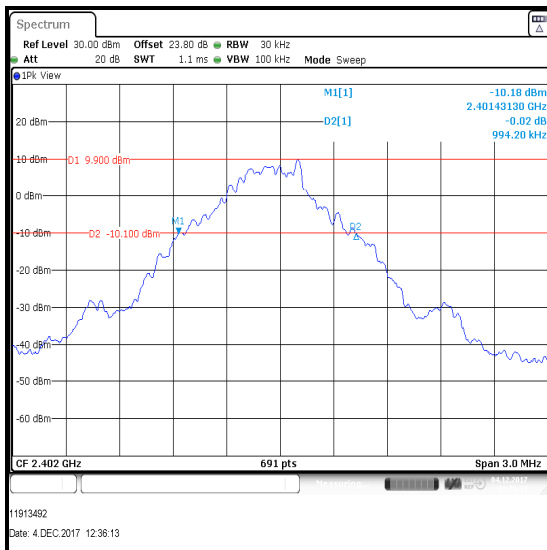
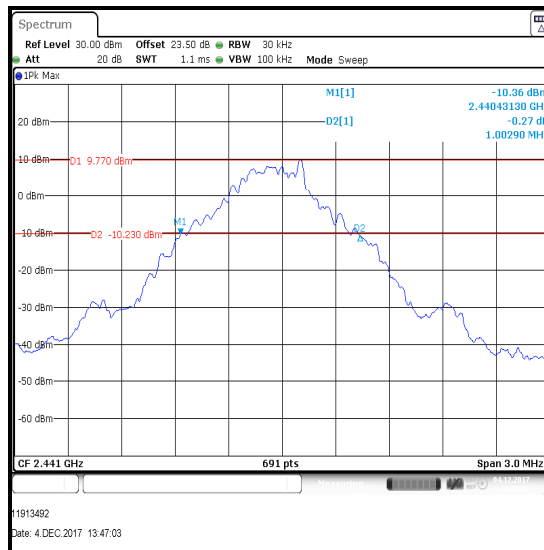
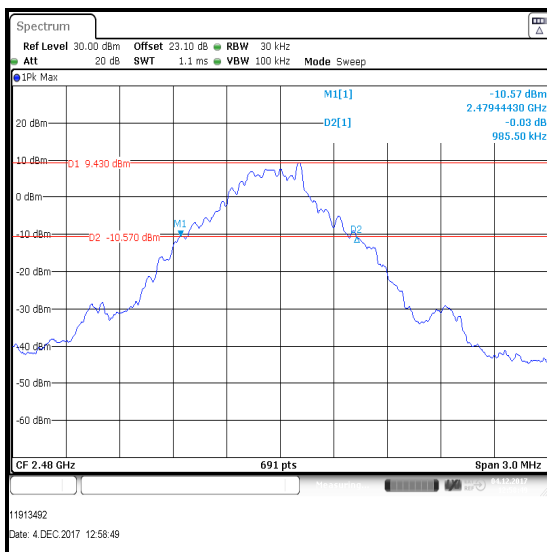
Note(s):

1. The signal 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 signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable.

Test setup:

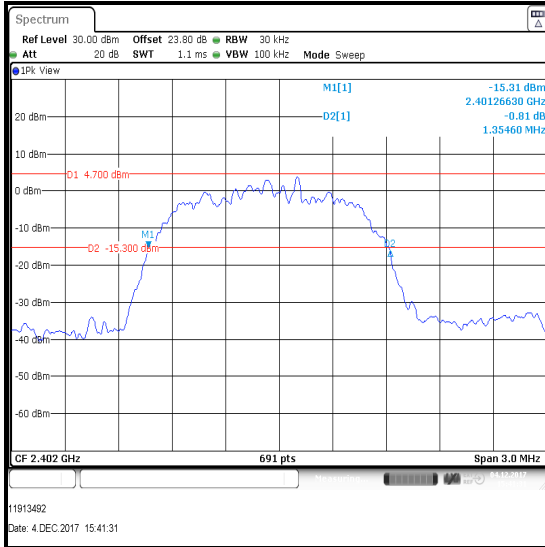
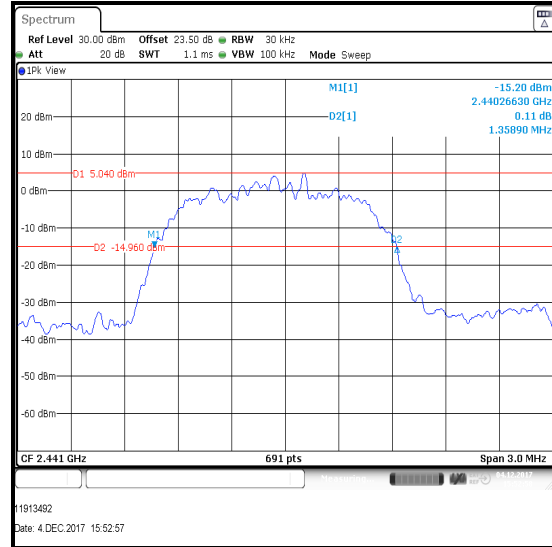
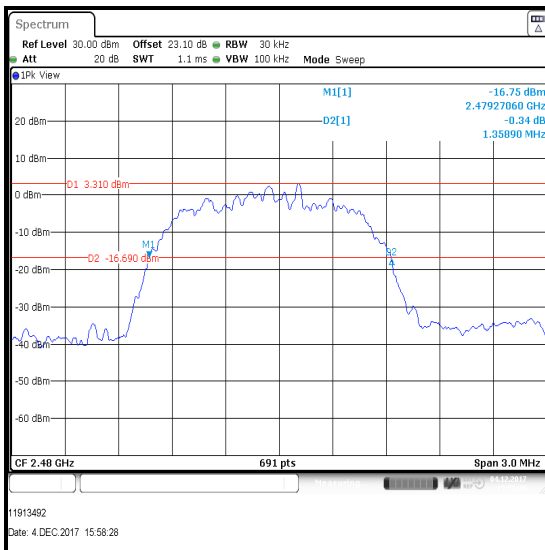
Transmitter 20 dB Bandwidth (continued)**Results DH5:**

Channel	20 dB Bandwidth (kHz)
Bottom	994.200
Middle	1002.900
Top	985.500

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

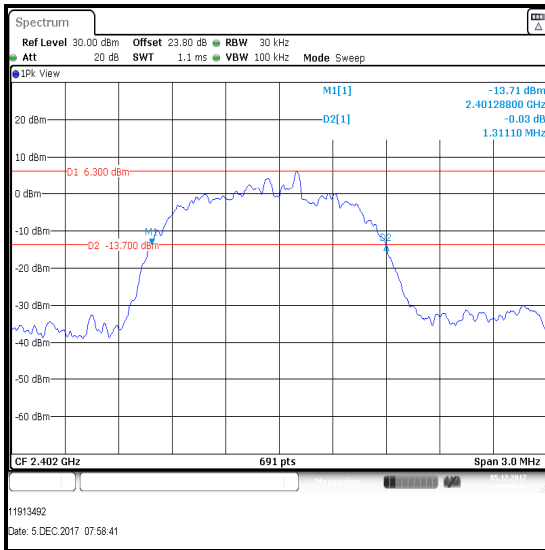
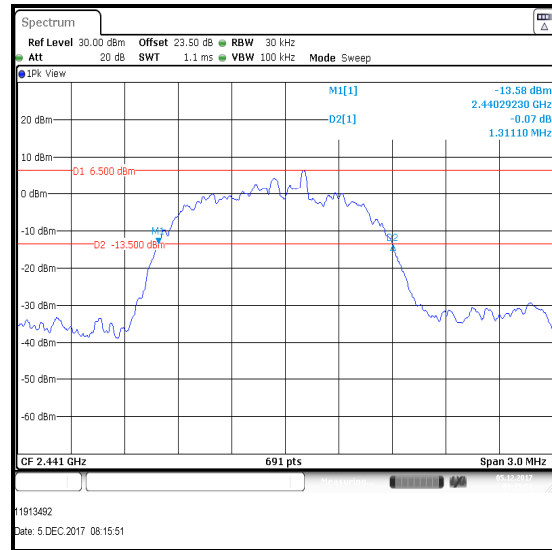
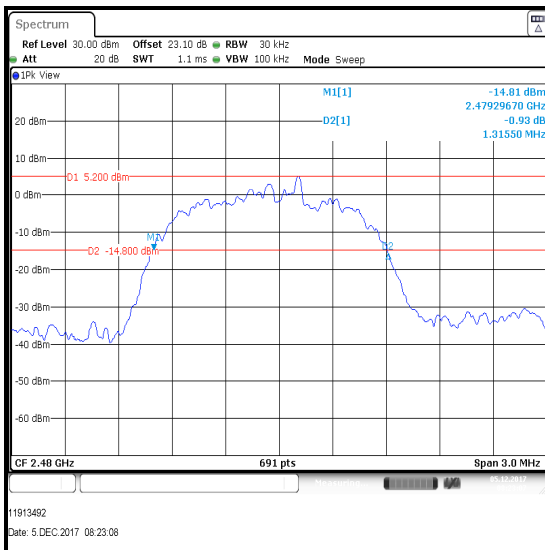
Transmitter 20 dB Bandwidth (continued)**Results 2DH5:**

Channel	20 dB Bandwidth (kHz)
Bottom	1354.600
Middle	1358.900
Top	1358.900

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

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

Channel	20 dB Bandwidth (kHz)
Bottom	1311.100
Middle	1311.100
Top	1315.500

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

Transmitter 20 dB Bandwidth (continued)**Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2002	Thermohygrometer	Testo	608-H1	45041825	22 Feb 2018	12
M1873	Signal Analyser	Rohde & Schwarz	FSV30	103074	13 Jun 2018	12
A2527	Attenuator	AtlanTecRF	AN18W5-20	832828#2	Calibrated before use	-
G0606	Signal Generator	Rohde & Schwarz	SMIQ 03B	832870 / 054	16 Feb 2018	12
M199	Power Meter	Rohde & Schwarz	NRVS	827023/075	11 Apr 2018	24
M1267	Power Sensor	Rohde & Schwarz	NRV-Z52	100155	15 Apr 2018	24

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

Test Engineer:	Doug Freegard	Test Date:	05 December 2017
Test Sample Serial Number:	Not marked or stated <i>(Conducted sample with RF port)</i>		

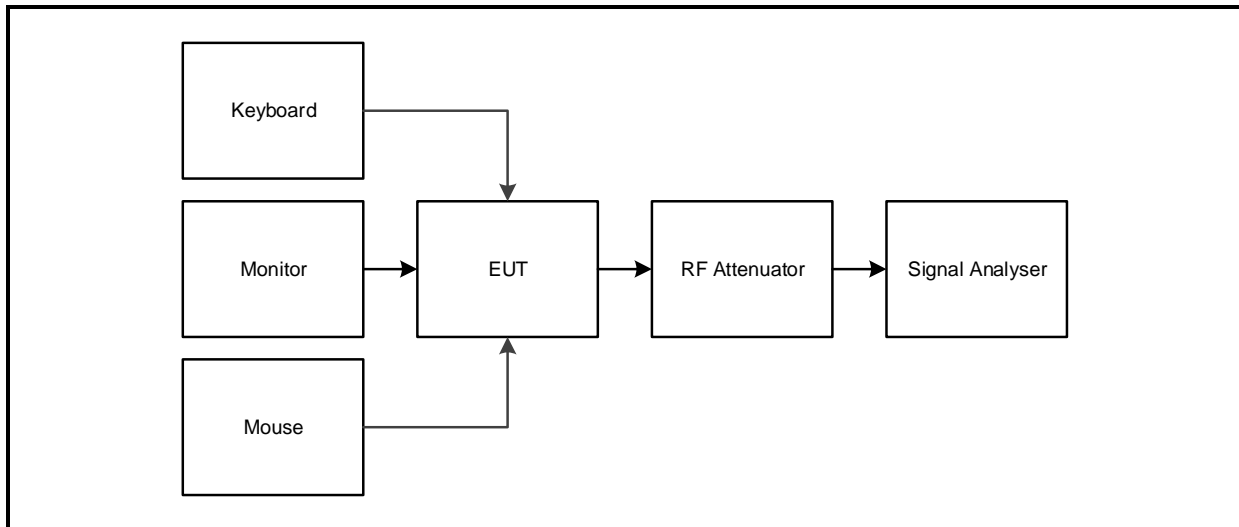
FCC Reference:	Part 15.247(a)(1)
Test Method Used:	ANSI C63.10 Section 7.8.2

Environmental Conditions:

Temperature (°C):	25
Relative Humidity (%):	32

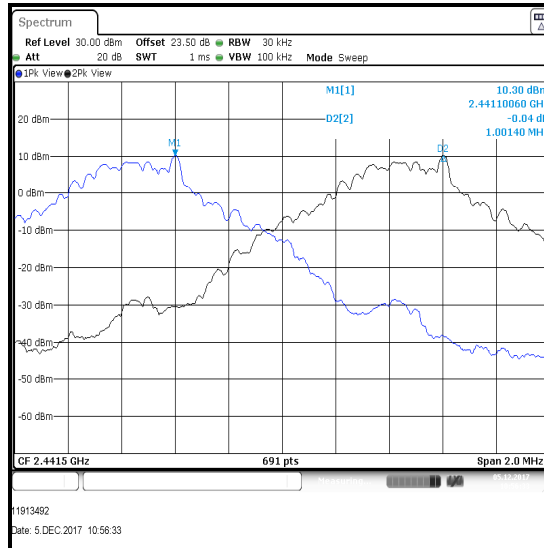
Note(s):

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

Test setup:

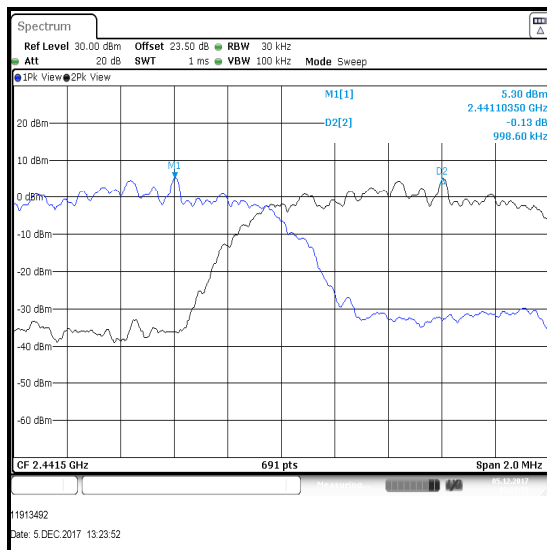
Transmitter Carrier Frequency Separation (continued)**Results: DH5**

Carrier Frequency Separation (kHz)	Limit ($2/3$ of 20 dB BW) (kHz)	Margin (kHz)	Result
1001.400	668.600	332.800	Complied



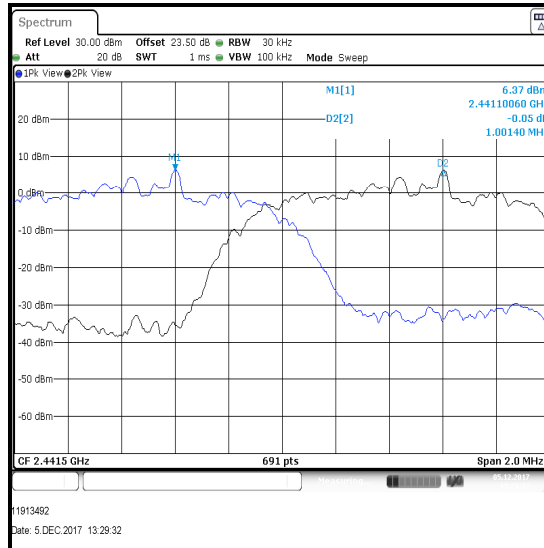
Results: 2DH5

Carrier Frequency Separation (kHz)	Limit (2/3 of 20 dB BW) (kHz)	Margin (kHz)	Result
998.600	905.933	92.667	Complied



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

Carrier Frequency Separation (kHz)	Limit ($2/3$ of 20 dB BW) (kHz)	Margin (kHz)	Result
1001.400	874.067	127.333	Complied

**Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2002	Thermohygrometer	Testo	608-H1	45041825	22 Feb 2018	12
M1873	Signal Analyser	Rohde & Schwarz	FSV30	103074	13 Jun 2018	12
A2527	Attenuator	AtlanTecRF	AN18W5-20	832828#2	Calibrated before use	-
G0606	Signal Generator	Rohde & Schwarz	SMIQ 03B	832870 / 054	16 Feb 2018	12
M199	Power Meter	Rohde & Schwarz	NRVS	827023/075	11 Apr 2018	24
M1267	Power Sensor	Rohde & Schwarz	NRV-Z52	100155	15 Apr 2018	24

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

Test Engineer:	Doug Freegard	Test Date:	05 December 2017
Test Sample Serial Number:	Not marked or stated <i>(Conducted sample with RF port)</i>		

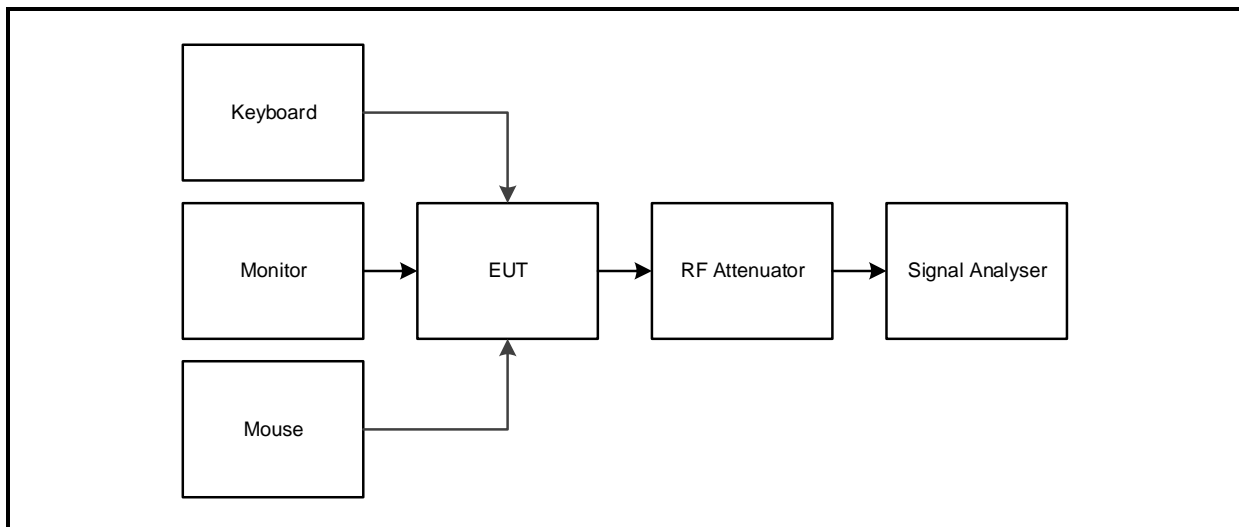
FCC Reference:	Part 15.247(a)(1)(iii)
Test Method Used:	ANSI C63.10 Sections 7.8.3 & 7.8.4

Environmental Conditions:

Temperature (°C):	25
Relative Humidity (%):	32

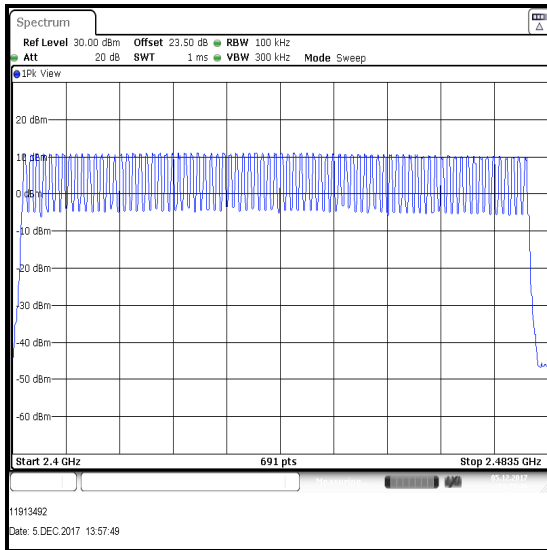
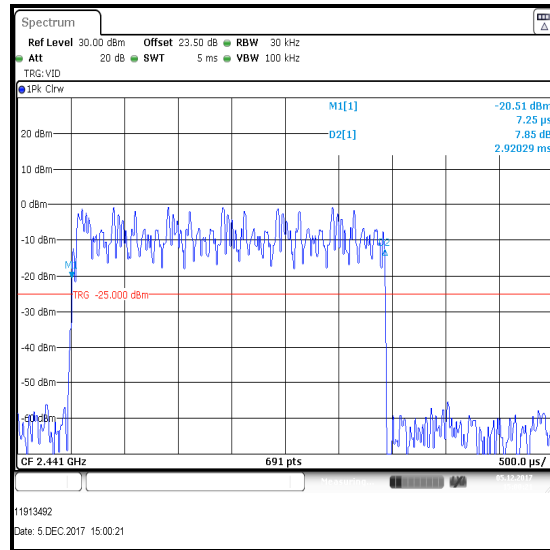
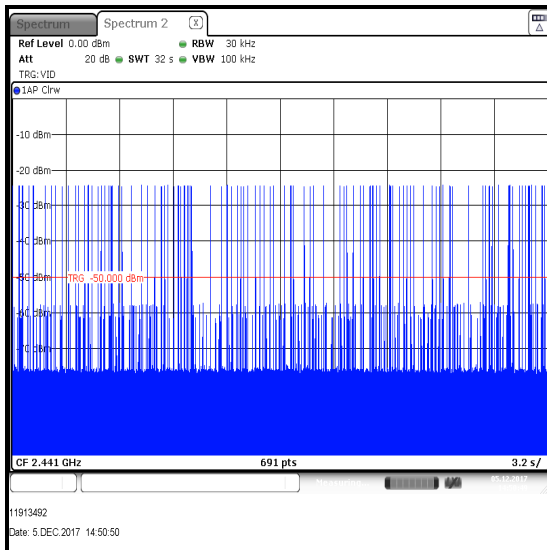
Note(s):

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 30 kHz and video bandwidth of 100 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 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 signal 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 signal 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 was recorded in the table below.
5. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable.

Test setup:

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
2920.290	114	0.333	0.4	0.067	Complied

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

Transmitter Number of Hopping Frequencies and Average Time of Occupancy (continued)**Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2002	Thermohygrometer	Testo	608-H1	45041825	22 Feb 2018	12
M1873	Signal Analyser	Rohde & Schwarz	FSV30	103074	13 Jun 2018	12
A2527	Attenuator	AtlanTecRF	AN18W5-20	832828#2	Calibrated before use	-
G0606	Signal Generator	Rohde & Schwarz	SMIQ 03B	832870 / 054	16 Feb 2018	12
M199	Power Meter	Rohde & Schwarz	NRVS	827023/075	11 Apr 2018	24
M1267	Power Sensor	Rohde & Schwarz	NRV-Z52	100155	15 Apr 2018	24

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

Test Engineer:	Doug Freegard	Test Date:	05 December 2017
Test Sample Serial Number:	Not marked or stated (<i>Conducted sample with RF port</i>)		

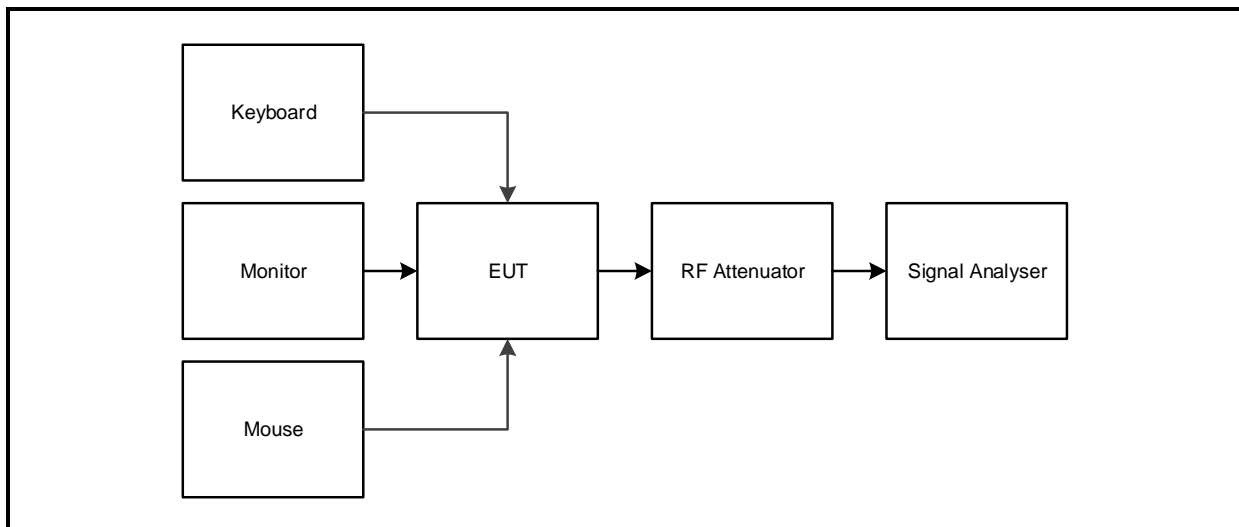
FCC Reference:	Part 15.247(b)(1)
Test Method Used:	ANSI C63.10 Section 7.8.5

Environmental Conditions:

Temperature (°C):	25
Relative Humidity (%):	32

Note(s):

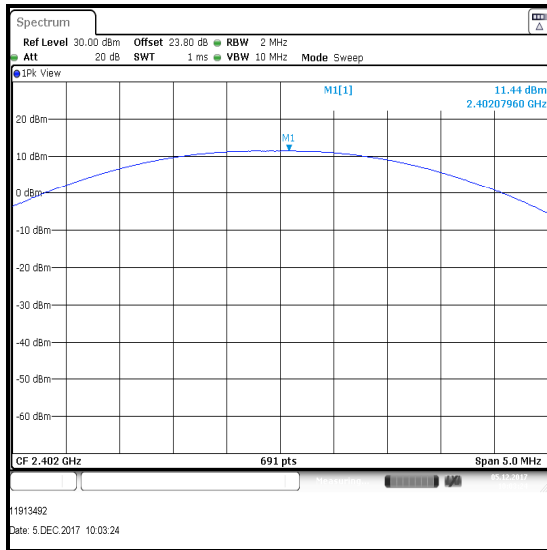
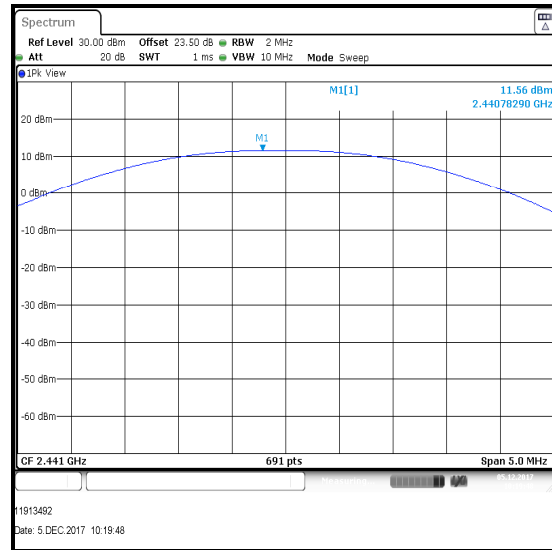
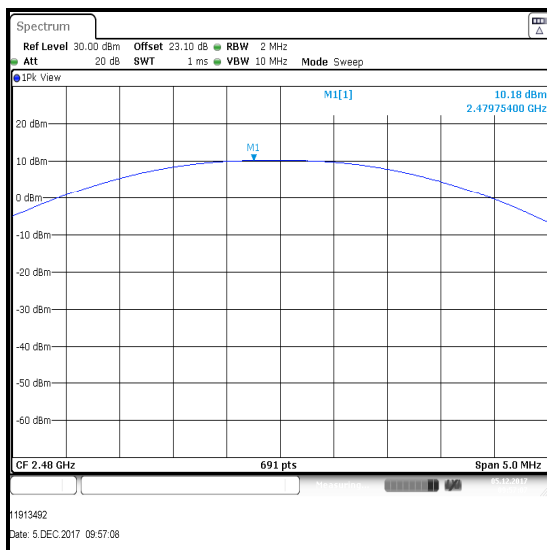
1. The signal analyser resolution bandwidth was set to 2 MHz (>20 dB bandwidth) and video bandwidth of 10 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 5.0 MHz (approximately five times the 20 dB bandwidth). A marker was placed at the peak 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.

Test setup:

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

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	11.4	30.0	18.6	Complied
Middle	11.6	30.0	18.4	Complied
Top	10.2	30.0	19.8	Complied

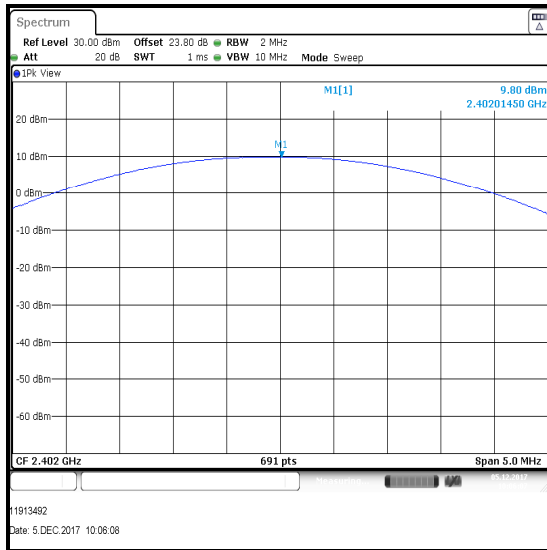
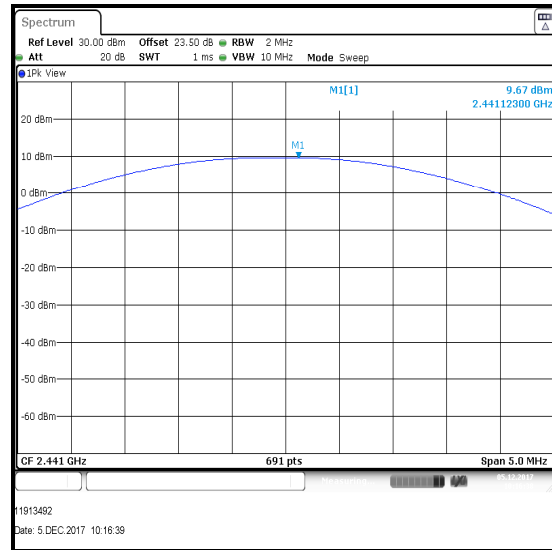
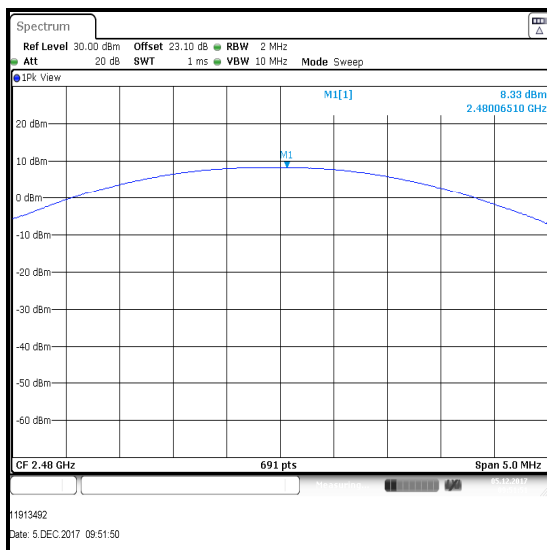
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	11.4	3.5	14.9	36.0	21.1	Complied
Middle	11.6	3.5	15.1	36.0	20.9	Complied
Top	10.2	3.5	13.7	36.0	22.3	Complied

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	9.8	21.0	11.2	Complied
Middle	9.7	21.0	11.3	Complied
Top	8.3	21.0	12.7	Complied

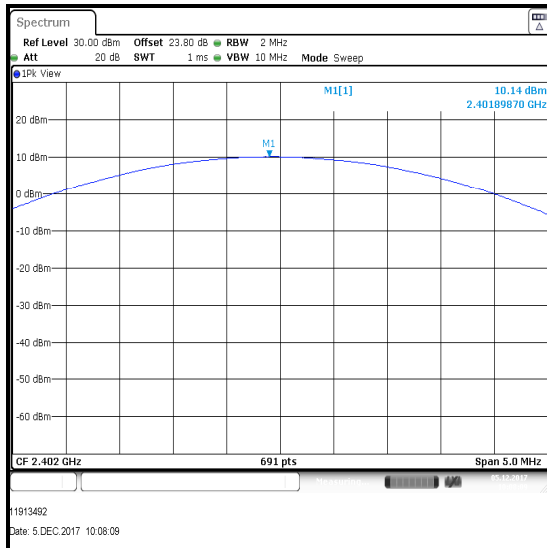
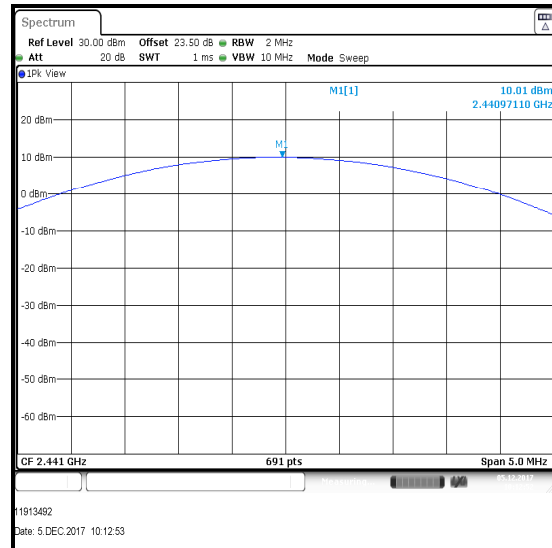
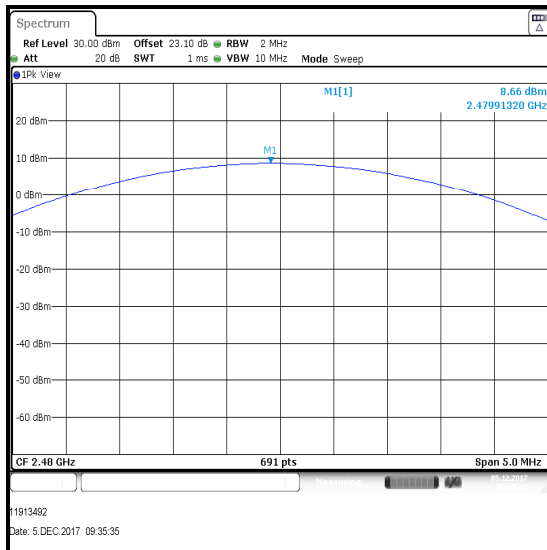
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	9.8	3.5	13.3	27.0	13.7	Complied
Middle	9.7	3.5	13.2	27.0	13.8	Complied
Top	8.3	3.5	11.8	27.0	15.2	Complied

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	10.1	21.0	10.9	Complied
Middle	10.0	21.0	11.0	Complied
Top	8.7	21.0	12.3	Complied

Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	10.1	3.5	13.6	27.0	13.4	Complied
Middle	10.0	3.5	13.5	27.0	13.5	Complied
Top	8.7	3.5	12.2	27.0	14.8	Complied

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

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2002	Thermohygrometer	Testo	608-H1	45041825	22 Feb 2018	12
M1873	Signal Analyser	Rohde & Schwarz	FSV30	103074	13 Jun 2018	12
A2527	Attenuator	AtlanTecRF	AN18W5-20	832828#2	Calibrated before use	-
G0606	Signal Generator	Rohde & Schwarz	SMIQ 03B	832870 / 054	16 Feb 2018	12
M199	Power Meter	Rohde & Schwarz	NRVS	827023/075	11 Apr 2018	24
M1267	Power Sensor	Rohde & Schwarz	NRV-Z52	100155	15 Apr 2018	24

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

Test Engineer:	David Doyle	Test Date:	30 November 2017
Test Sample Serial Number:	Not marked or stated (<i>Radiated sample</i>)		

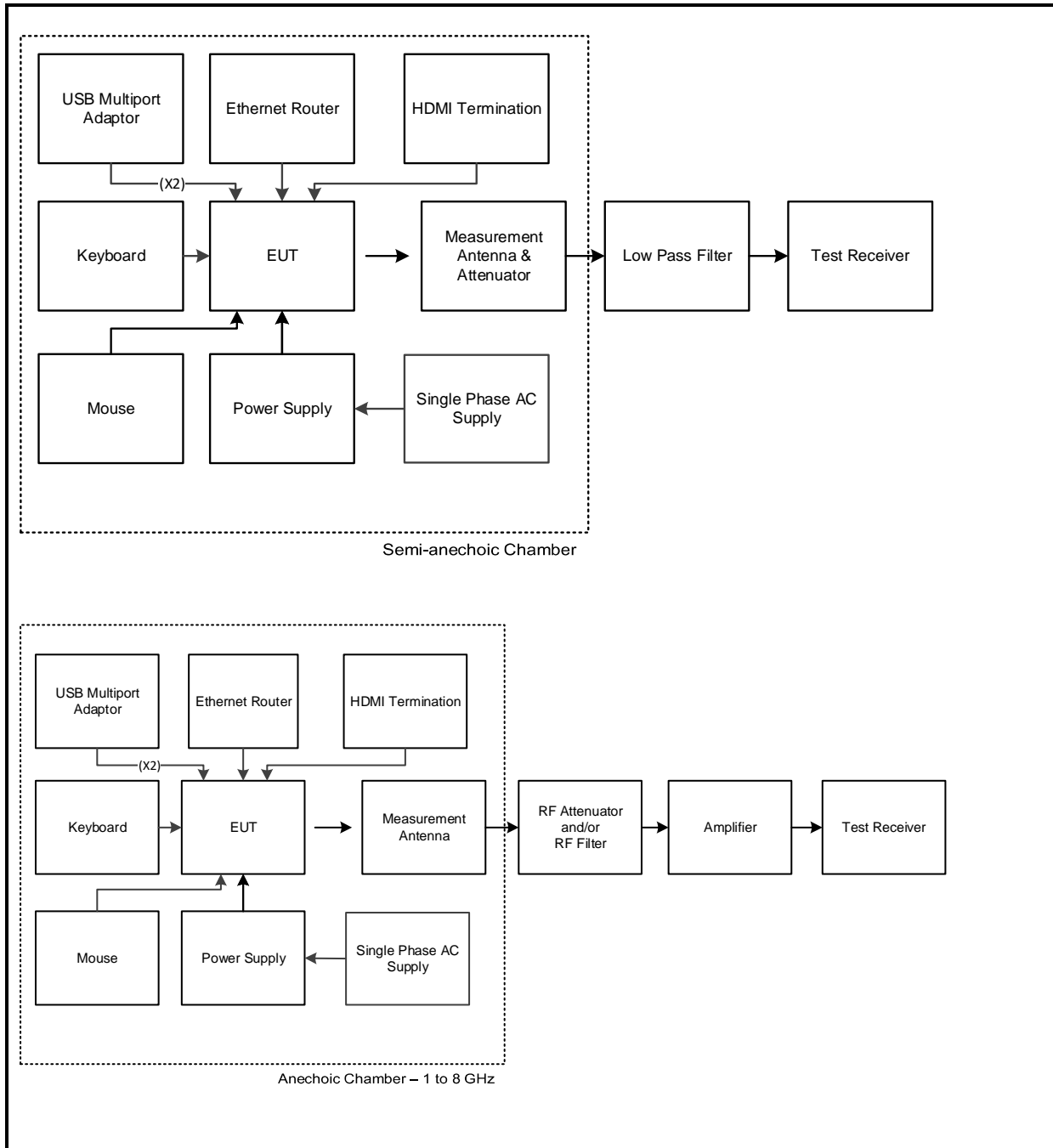
FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	ANSI C63.10 Sections 6.3 and 6.5
Frequency Range	30 MHz to 1000 MHz

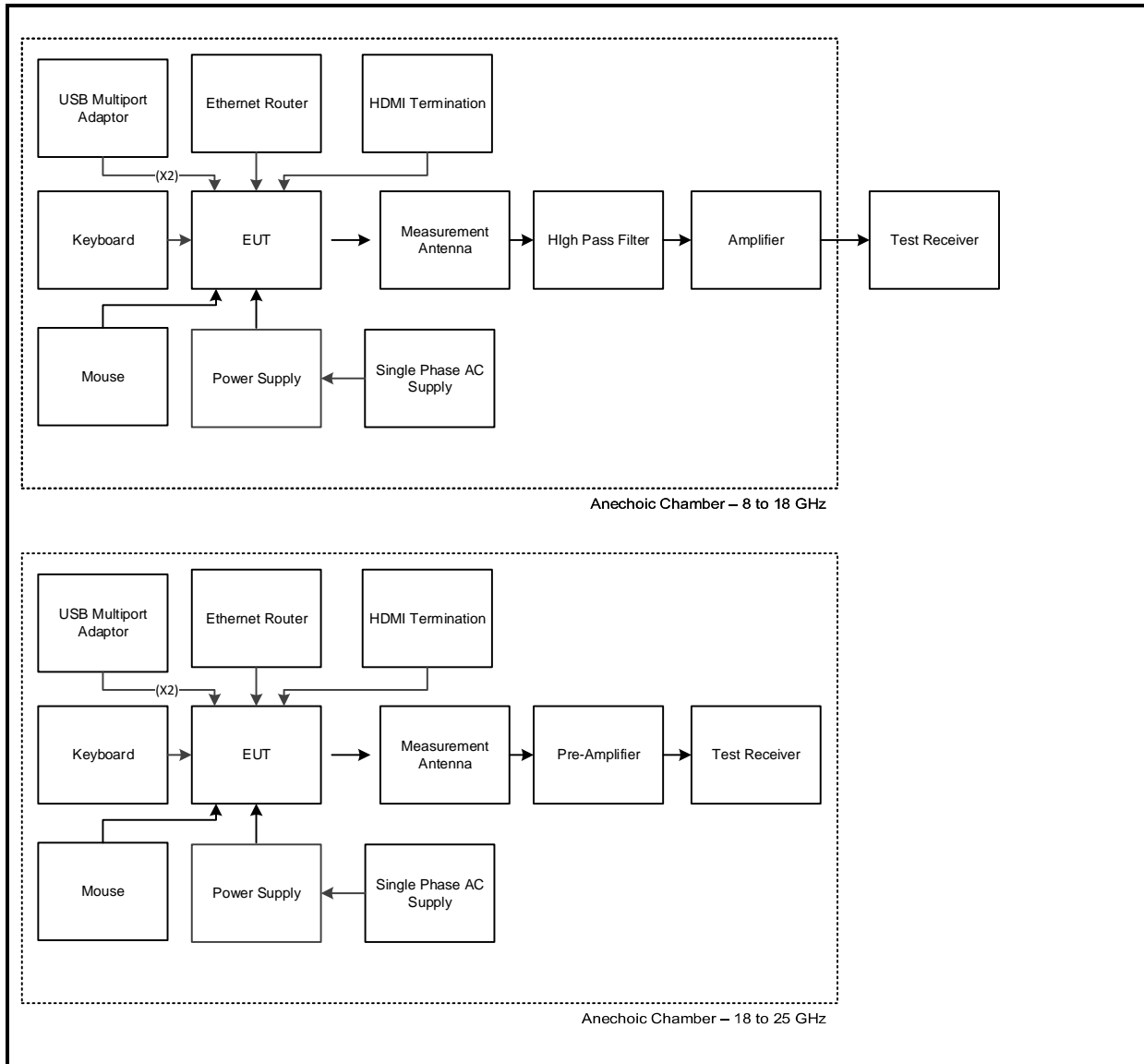
Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	31

Note(s):

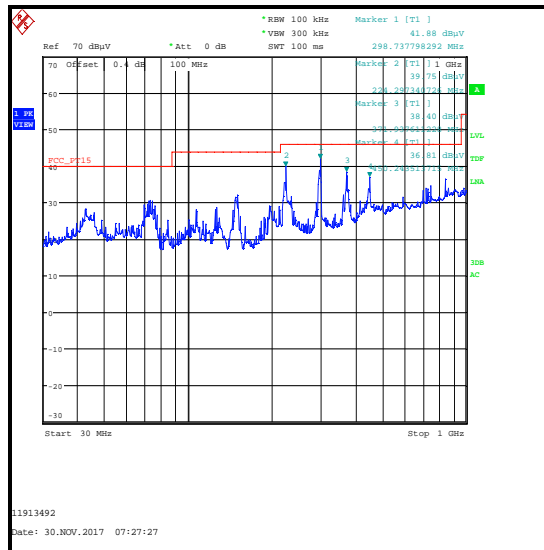
1. Transmitter radiated spurious emissions tests were performed with the EUT transmitting in DH5 mode as this was found to transmit the highest power and therefore deemed worst case.
2. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
3. The 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.
4. 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 measurement system noise floor and therefore not recorded.
5. Measurements below 1 GHz were performed in a semi-anechoic chamber (Asset Number K0017) at a distance of 3 metres. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
6. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. The sweep time was set to auto. 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 big enough to see the whole emission.

Transmitter Radiated Emissions (continued)**Test setup for radiated measurements:**

Transmitter Radiated Emissions (continued)**Test setup for radiated measurements (continued):**

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
126.442	Horizontal	25.6	43.5	17.9	Complied



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

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2003	Thermohygrometer	Testo	608-H1	45046641	22 Feb 2018	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	14 Apr 2018	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	13 Apr 2018	12
A2888	Antenna	Schwarzbeck	VULB 9163	9163-941	25 Apr 2018	12
A2147	Attenuator	AtlanTecRF	AN18-06	09020206-06	25 Apr 2018	12
A2131	Low Pass Filter	AtlanTecRF	AFL-0200	JFB 1004-002	27 Feb 2018	12

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

Test Engineer:	David Doyle	Test Date:	29 November 2017
Test Sample Serial Number:	Not marked or stated (<i>Radiated sample</i>)		

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):	23
Relative Humidity (%):	32

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.
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 K0017) at a distance of 3 metres. The EUT was placed at a height of 1.5 metres above the test chamber floor in the centre of the chamber turntable. All measurement antennas were placed at a fixed height of 1.5 metres above the test chamber floor, in line with the EUT. Final measurements above 1 GHz 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
4803.529	Vertical	51.8*	54.0	2.2	Complied

Results: Middle Channel / DH5

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
4882.336	Vertical	50.0*	54.0	4.0	Complied

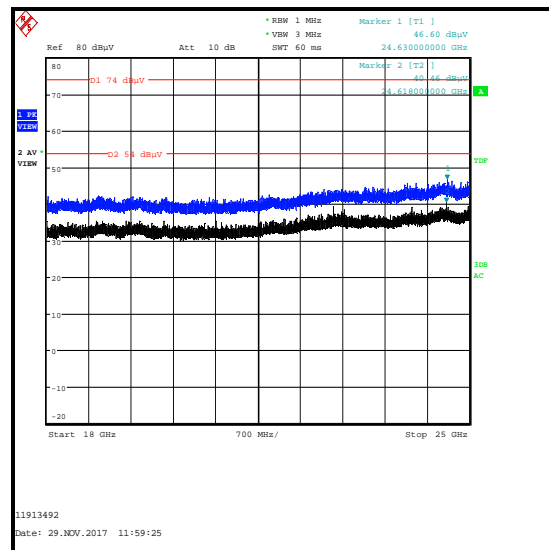
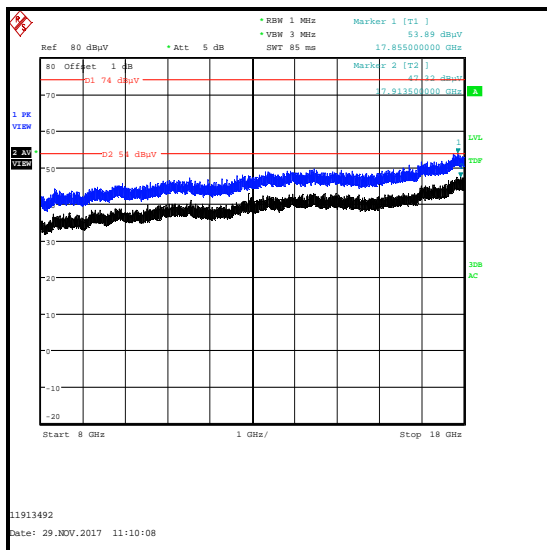
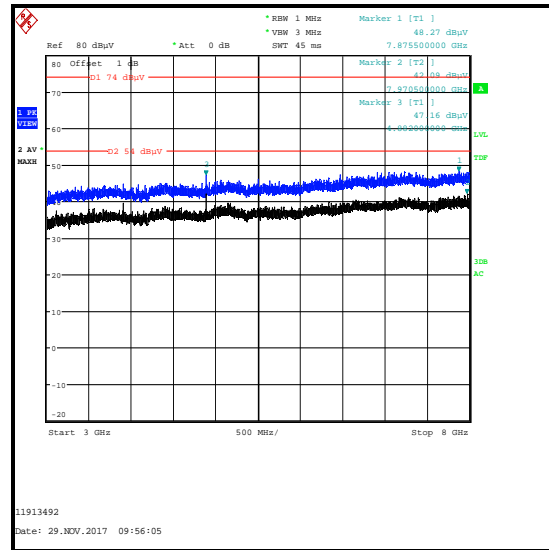
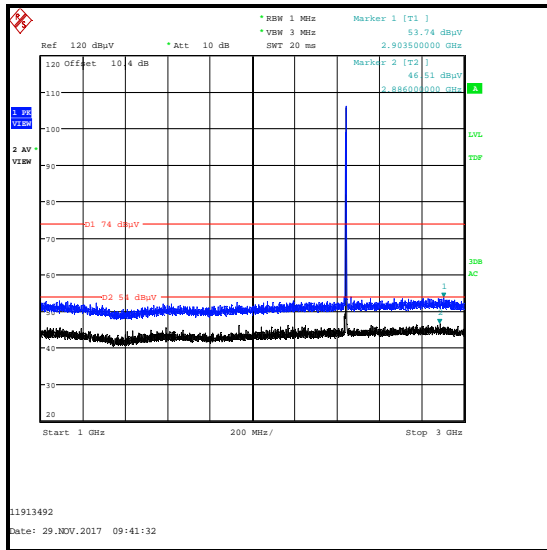
Results: Top Channel / DH5

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
4959.450	Vertical	47.8*	54.0	6.2	Complied

Results: Hopping Mode / DH5

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
4804.286	Vertical	52.6*	54.0	1.4	Complied

Transmitter Radiated Emissions (continued)



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

Transmitter Radiated Emissions (continued)**Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2003	Thermohygrometer	Testo	608-H1	45046641	22 Feb 2018	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	14 Feb 2018	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	13 Apr 2018	12
A2863	Pre Amplifier	Agilent	8449B	3008A02100	11 Apr 2018	12
A2891	Pre Amplifier	Schwarzbeck	BBV 9718	9718-306	11 Apr 2018	12
A2893	Pre Amplifier	Schwarzbeck	BBV 9721	9721-021	11 Apr 2018	12
A2889	Antenna	Schwarzbeck	BBHA 9120 B	BBHA 9120 B 653	11 Apr 2018	12
A2890	Antenna	Schwarzbeck	HWRD 750	014	11 Apr 2018	12
A2892	Antenna	Schwarzbeck	BBHA 9170	9170-727	11 Apr 2018	12
A2916	Attenuator	AtlanTecRF	AN18W5-10	832827#1	03 Mar 2018	12
A2914	High Pass Filter	AtlanTecRF	AFH-03000	2155	06 Mar 2018	12
A2947	High Pass Filter	AtlanTecRF	AFH-07000	1601900001	18 May 2018	12
M1269	Multimeter	Fluke	179	90250210	02 May 2018	12
S0538	Bench Power Supply	TTI	PL154	250135	Calibrated before use	-

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

Test Engineer:	David Doyle	Test Dates:	28 November 2017 & 01 December 2017
Test Sample Serial Number:	Not marked or stated (<i>Radiated sample</i>)		

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

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	32 to 36

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 falls within 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 falls within 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
2394.551	Vertical	50.1	87.3*	37.2	Complied
2400.0	Vertical	48.3	87.3*	39.0	Complied
2483.5	Vertical	57.7	74.0	16.3	Complied

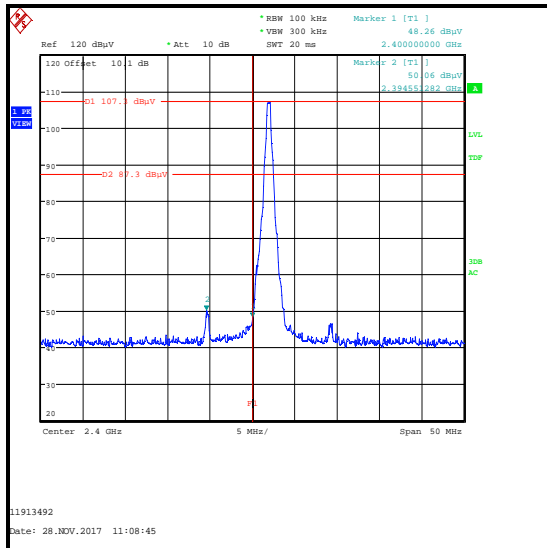
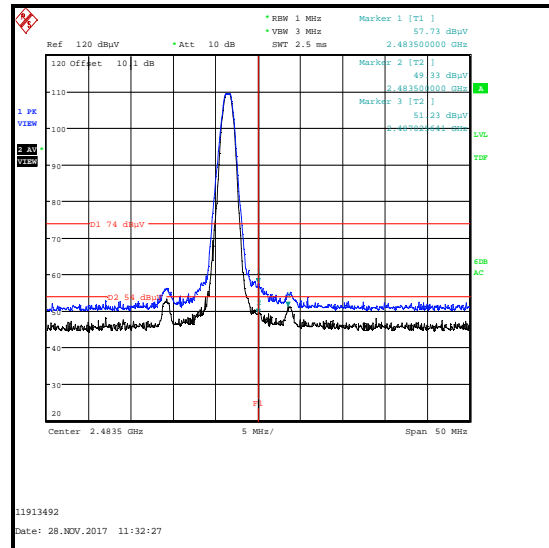
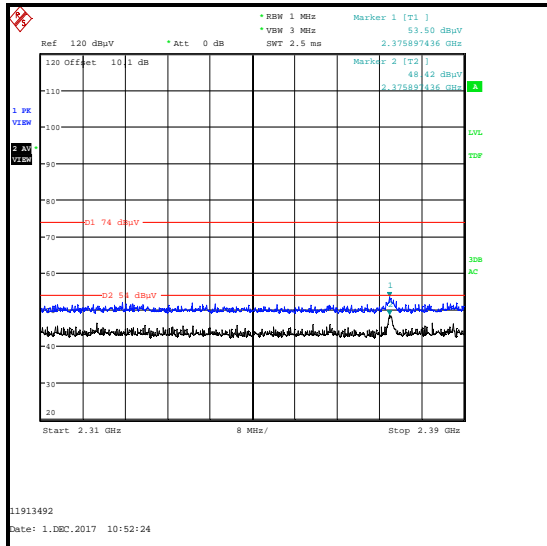
Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	49.3	54.0	4.7	Complied
2487.026	Vertical	51.2	54.0	2.8	Complied

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
2375.897	Vertical	53.5	74.0	20.5	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
2375.897	Vertical	48.4	54.0	5.6	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
2399.439	Vertical	48.2	87.1*	38.9	Complied
2400.0	Vertical	46.5	87.1*	40.6	Complied
2483.5	Vertical	52.9	74.0	21.1	Complied
2483.821	Vertical	55.2	74.0	18.8	Complied

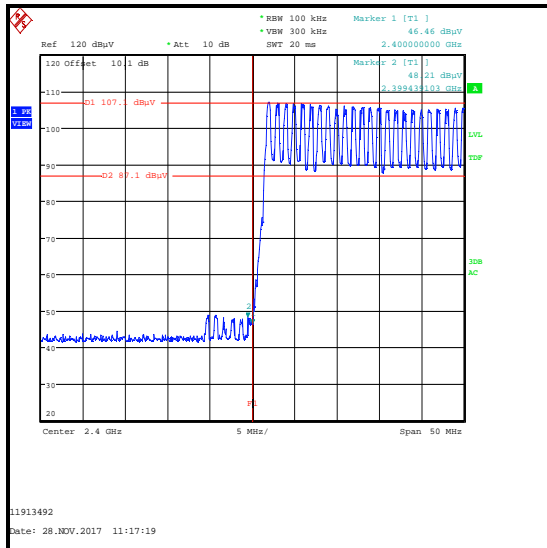
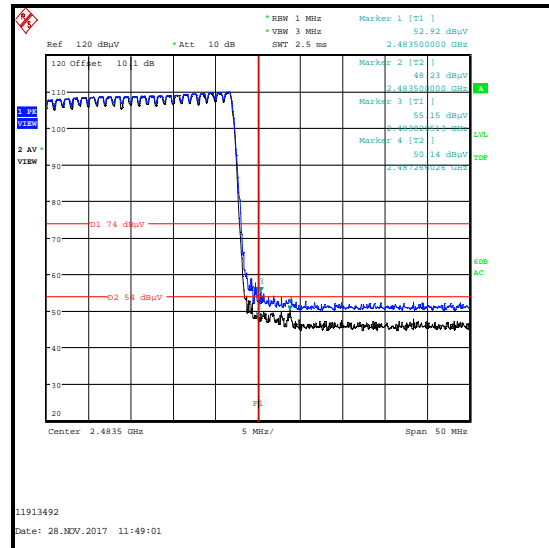
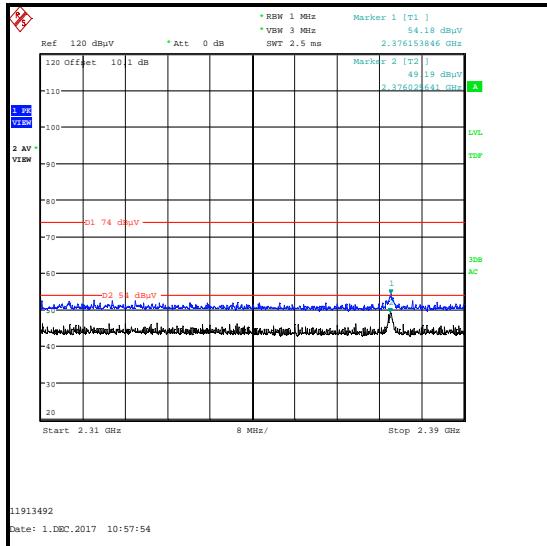
Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	48.2	54.0	5.8	Complied
2487.266	Vertical	50.1	54.0	3.9	Complied

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
2376.154	Vertical	54.2	74.0	19.8	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	Vertical	49.2	54.0	4.8	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
2399.920	Vertical	48.3	83.1*	34.8	Complied
2400.0	Vertical	47.3	83.1*	35.8	Complied
2483.5	Vertical	52.5	74.0	21.5	Complied
2483.580	Vertical	54.6	74.0	19.4	Complied

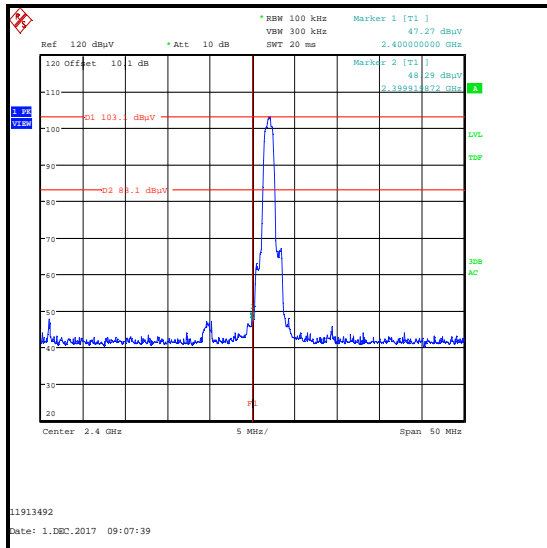
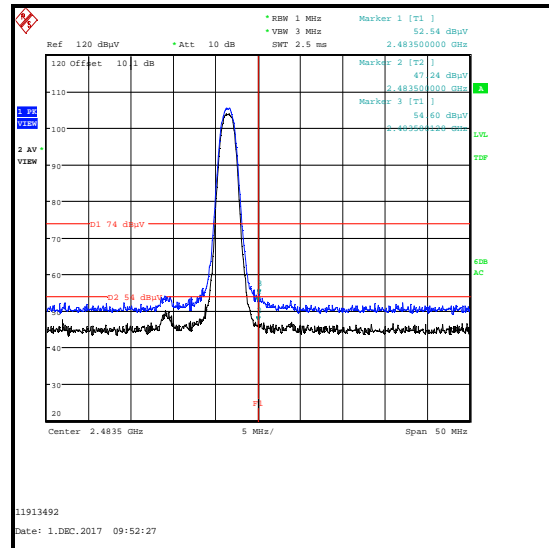
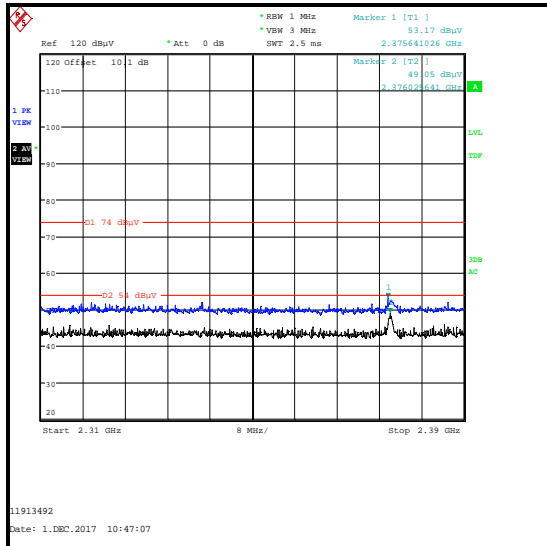
Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	47.2	54.0	6.8	Complied

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
2375.641	Vertical	53.2	74.0	20.8	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	Vertical	49.1	54.0	4.9	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
2400.0	Vertical	45.0	83.0*	38.0	Complied
2483.5	Vertical	51.6	74.0	22.4	Complied

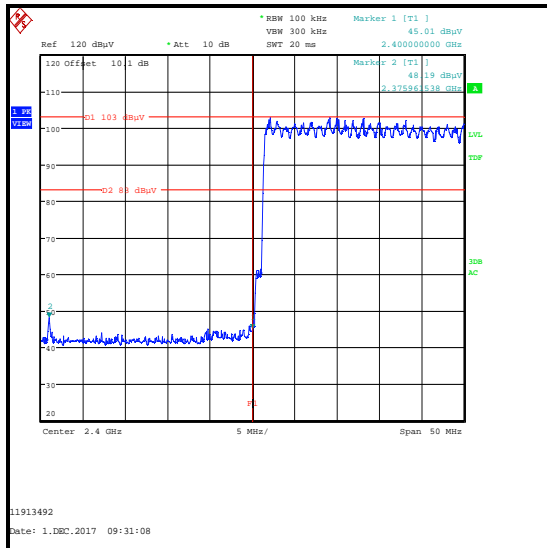
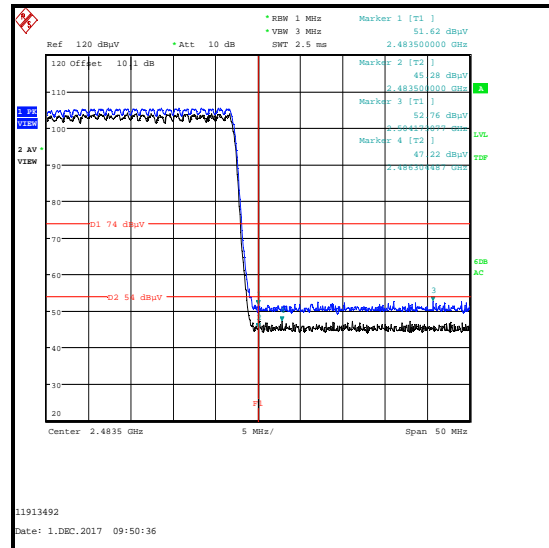
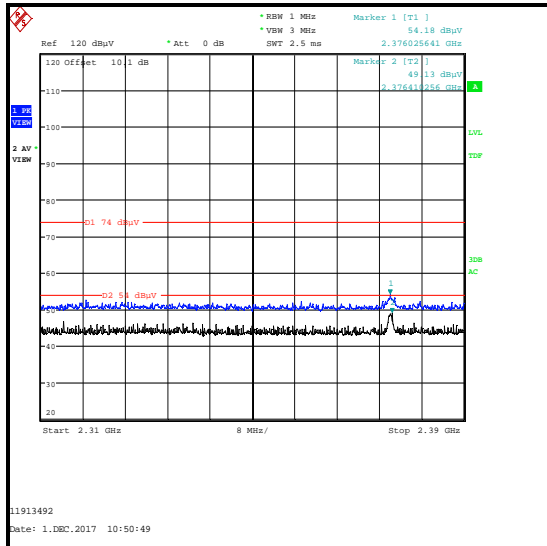
Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	45.3	54.0	8.7	Complied
2486.304	Vertical	47.2	54.0	6.8	Complied

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
2376.026	Vertical	54.2	74.0	19.8	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	Vertical	49.1	54.0	4.9	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	Vertical	48.7	82.7*	34.0	Complied
2483.5	Vertical	52.3	74.0	21.7	Complied
2483.821	Vertical	54.5	74.0	19.5	Complied

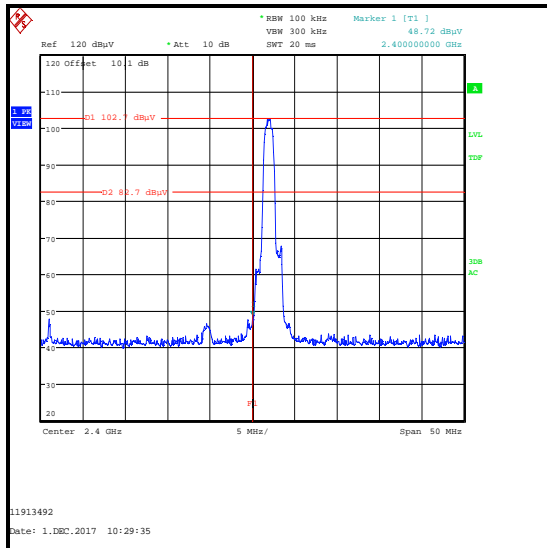
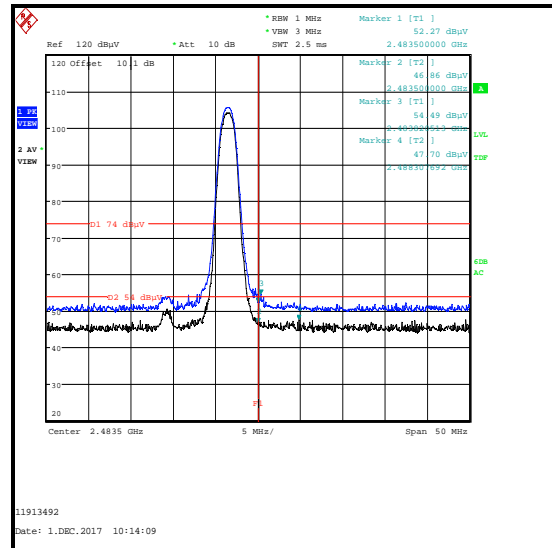
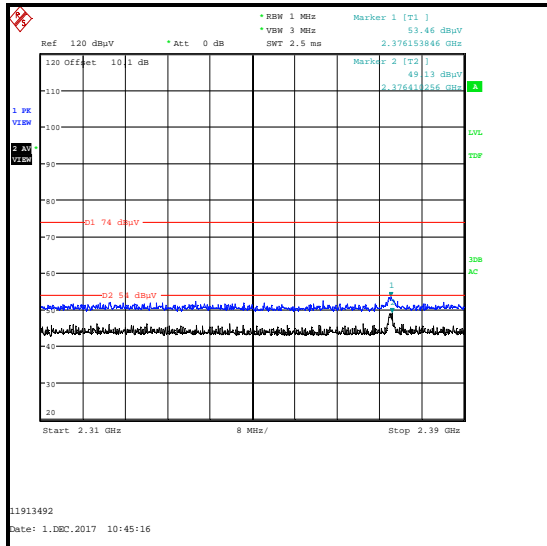
Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	46.9	54.0	7.1	Complied
2488.308	Vertical	47.7	54.0	6.3	Complied

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
2376.154	Vertical	53.5	74.0	20.5	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	Vertical	49.1	54.0	4.9	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	Vertical	44.0	83.0*	39.0	Complied
2483.5	Vertical	51.2	74.0	22.8	Complied
2483.740	Vertical	52.8	74.0	21.2	Complied

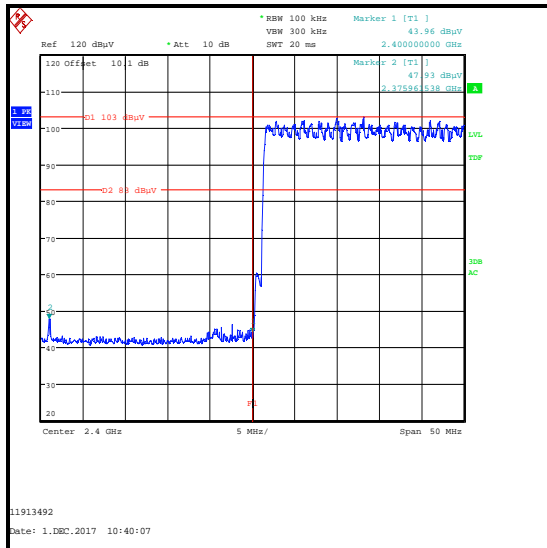
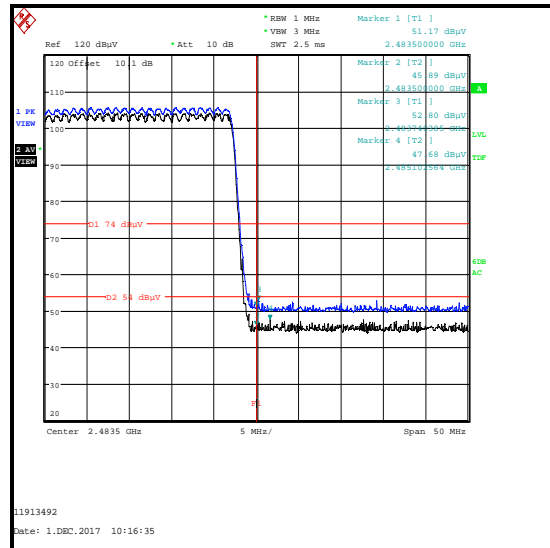
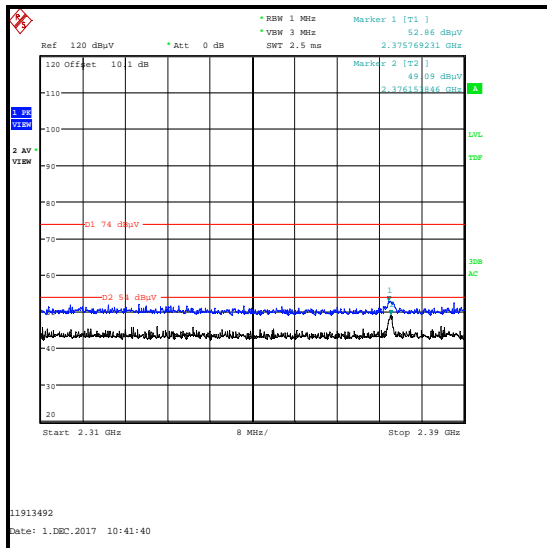
Frequency (MHz)	Antenna Polarity	Average Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
2483.5	Vertical	45.9	54.0	8.1	Complied
2485.103	Vertical	47.7	54.0	6.3	Complied

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
2375.769	Vertical	52.9	74.0	21.1	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
2376.154	Vertical	49.1	54.0	4.9	Complied

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / 3DH5****Lower Band Edge****Upper Band Edge****2310 MHz to 2390 MHz Restricted Band****Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2003	Thermohygrometer	Testo	608-H1	45046641	22 Feb 2018	12
K0017	3m RSE Chamber	Rainford	N/A	N/A	14 Apr 2018	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	13 Apr 2018	12
A2863	Pre-Amplifier	Agilent	8449B	3008A02100	11 Apr 2018	12
A2889	Antenna	Schwarzbeck	BBHA 9120 B	BBHA 9120 B 653	11 Apr 2018	12
A2916	Attenuator	AtlanTecRF	AN18W5-10	832827#1	03 Mar 2018	12

6. Measurement Uncertainty

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

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

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
AC Conducted Spurious Emissions	0.15 MHz to 30 MHz	95%	±4.69 dB
Conducted Maximum Peak Output Power	2.4 GHz to 2.4835 GHz	95%	±1.13 dB
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
20 dB Bandwidth	2.4 GHz to 2.4835 GHz	95%	±4.59 %
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±5.65 dB
Radiated Spurious Emissions	1 GHz to 26.5 GHz	95%	±2.94 dB

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty the published guidance of the appropriate accreditation body is followed.

7. Report Revision History

Version Number	Revision Details		
	Page No(s)	Clause	Details
1.0	-	-	Initial Version
2.0	38	-	Test setup diagram added

--- END OF REPORT ---