



# TEST REPORT

**Test Report No. : UL-RPT-RP12592099-2516A**

**Manufacturer** : Plugwise B.V.  
**Model No.** : Stealth HA  
**FCC ID** : ZB9-16201  
**Technology** : Zigbee (IEEE 802.15.4)  
**Test Standard(s)** : FCC Parts 15.207, 15.209(a) & 15.247

1. This test report shall not be reproduced except in full, without the written approval of UL VS LTD.
2. The results in this report apply only to the sample(s) tested.
3. This 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:** 04 December 2019

**Checked by:**

Ben Mercer  
Senior Engineer, Radio Laboratory

**Company  
Signatory:**

Sarah Williams  
Senior Engineer, Radio Laboratory  
UL VS LTD



This laboratory is accredited by UKAS. The tests reported herein have been performed in accordance with its terms of accreditation.

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**UL VS LTD**

Unit 1-3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, UK  
Telephone: +44 (0)1256 312000  
Facsimile: +44 (0)1256 312001

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## **1. Customer Information**








<b>Company Name:</b>	Plugwise B.V.
<b>Address:</b>	Wattstraat 56 2171TR Sassenheim The Netherlands

## 2. Summary of Testing

### 2.1. General Information

<b>Specification Reference:</b>	47CFR15.247
<b>Specification Title:</b>	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.247
<b>Specification Reference:</b>	47CFR15.207 and 47CFR15.209
<b>Specification Title:</b>	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Sections 15.207 and 15.209
<b>Site Registration:</b>	621311
<b>Location of Testing:</b>	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
<b>Test Dates:</b>	06 February 2019 to 02 December 2019

### 2.2. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.207	Transmitter AC Conducted Emissions	
Part 15.247(a)(2)	Transmitter Minimum 6 dB Bandwidth	
Part 15.247(e)	Transmitter Power Spectral Density	Note 1
Part 15.247(b)(3)	Transmitter Maximum Peak Output Power	
Part 15.247(d)/15.209(a)	Transmitter Radiated Emissions	
Part 15.247(d)/15.209(a)	Transmitter Band Edge Radiated Emissions	
<b>Key to Results</b>		
 = Complied  = Did not comply		

#### Note(s):

- In accordance with ANSI C63.10 Section 11.10.1, PSD measurements are not required if the maximum conducted output power is less than the PSD limit of 8 dBm / 3 kHz. The PSD level is therefore deemed to be equal to the measured output power.

### **2.3. Methods and Procedures**

<b>Reference:</b>	ANSI C63.10-2013
<b>Title:</b>	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
<b>Reference:</b>	KDB 558074 D01 DTS Meas Guidance v05r02 April 2, 2019
<b>Title:</b>	Guidance for Compliance Measurements on Digital Transmission Systems, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating Under Section 15.247 of the FCC rules
<b>Reference:</b>	KDB 174176 D01 Line Conducted FAQ v01r01 June 3, 2015
<b>Title:</b>	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)**

<b>Brand Name:</b>	Plugwise
<b>Model Name or Number:</b>	Stealth HA
<b>Test Sample Serial Number:</b>	B19ABA ( <i>Conducted Sample #1</i> )
<b>Hardware Version:</b>	162-01
<b>Software Version:</b>	ETRX_PLUG_R0004 / 2016-11-21T02:00:00+02:00
<b>FCC ID:</b>	ZB9-16201

<b>Brand Name:</b>	Plugwise
<b>Model Name or Number:</b>	Stealth HA
<b>Test Sample Serial Number:</b>	13CAD4 ( <i>Conducted Sample #2</i> )
<b>Hardware Version:</b>	162-01
<b>Software Version:</b>	ETRX_PLUG_R0004 / 2016-11-21T02:00:00+02:00
<b>FCC ID:</b>	ZB9-16201

<b>Brand Name:</b>	Plugwise
<b>Model Name or Number:</b>	Stealth HA
<b>Test Sample Serial Number:</b>	B15549 ( <i>Radiated Sample</i> )
<b>Hardware Version:</b>	162-01
<b>Software Version:</b>	ETRX_PLUG_R0004 / 2016-11-21T02:00:00+02:00
<b>FCC ID:</b>	ZB9-16201

#### **3.2. Description of EUT**

The equipment under test was an energy measuring and switching device which incorporated Zigbee (IEEE802.15.4) functionality.

#### **3.3. Modifications Incorporated in the EUT**

No modifications were applied to the EUT during testing.

### **3.4. Additional Information Related to Testing**

<b>Technology Tested:</b>	IEEE 802.15.4 (Digital Transmission System)		
<b>Type of Unit:</b>	Transceiver		
<b>Modulation:</b>	O-QPSK		
<b>Data Rate:</b>	250 kb/s		
<b>Power Supply Requirement(s):</b>	Nominal	100 to 230 VAC	
<b>Maximum Conducted Output Power:</b>	6.7 dBm		
<b>Antenna Gain:</b>	5.1 dBi		
<b>Transmit Frequency Range:</b>	2405 MHz to 2480 MHz		
<b>Transmit Channels Tested:</b>	<b>Channel ID</b>	<b>Channel Number</b>	<b>Channel Frequency (MHz)</b>
	Bottom	11	2405
	Middle	18	2440
	Top	26	2480

### **3.5. Support Equipment**

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

<b>Description:</b>	Laptop PC
<b>Brand Name:</b>	Acer
<b>Model Name or Number:</b>	Aspire N17Q4
<b>Serial Number:</b>	NXGVEH003820005157600

<b>Description:</b>	USB Zigbee Stick
<b>Brand Name:</b>	Plugwise
<b>Model Name or Number:</b>	Zigbee Stick
<b>Serial Number:</b>	2B11BB



## **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 the bottom, middle and top channels as required.

### **4.2. Configuration and Peripherals**

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

- Controlled wirelessly over Zigbee using a bespoke application on the laptop PC supplied by the customer and a USB Zigbee stick. The application was used to enable continuous transmission and idle mode (enabled but not transmitting) and to select the test channels as required. Following test document sent from customer, "*Readme-RF-test mode instructions.pdf*".
- Radiated spurious emissions were performed with the EUT in its worst case orientation/position.
- There were no ports to terminate during radiated emissions testing.
- The EUT was powered from a 120 VAC 60 Hz single phase mains supply.
- The customer supplied an RF cable to the EUT in order to perform conducted measurements. The respective path loss was accounted for as an RF level offset.

## **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:	Stefan Ho	Test Date:	08 February 2019
Test Sample Serial Number:	B15549		

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

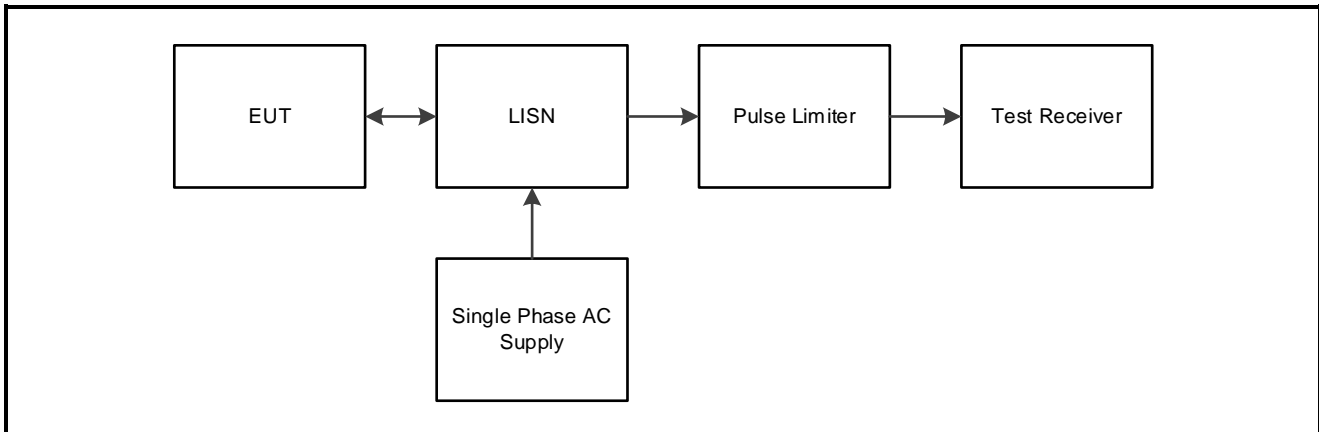
#### Environmental Conditions:

Temperature (°C):	20
Relative Humidity (%):	39

#### Note(s):

1. The EUT was connected to a 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 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 (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.1995	Live	52.7	63.6	10.9	Complied
0.2580	Live	49.9	61.5	11.6	Complied
0.3255	Live	46.7	59.6	12.9	Complied
0.4560	Live	42.0	56.8	14.8	Complied
0.6000	Live	38.1	56.0	17.9	Complied
0.8430	Live	31.7	56.0	24.3	Complied

**Results: Live / Average / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.1950	Live	37.4	53.8	16.4	Complied
0.2625	Live	36.7	51.4	14.7	Complied
0.3975	Live	32.8	47.9	15.1	Complied
0.4605	Live	28.6	46.7	18.1	Complied
0.5280	Live	27.1	46.0	18.9	Complied
0.8565	Live	21.9	46.0	24.1	Complied

**Results: Neutral / Quasi Peak / 120 VAC 60 Hz**

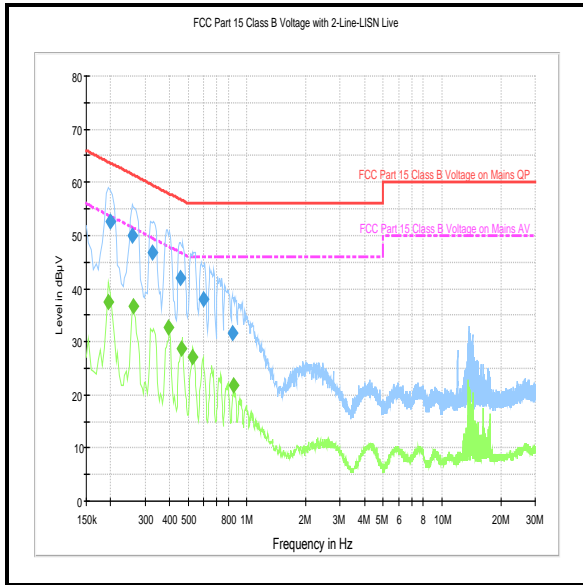
Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.195000	Neutral	53.0	63.8	10.8	Complied
0.258000	Neutral	49.8	61.5	11.7	Complied
0.321000	Neutral	46.5	59.7	13.2	Complied
0.469500	Neutral	41.3	56.5	15.2	Complied
0.609000	Neutral	35.9	56.0	20.1	Complied
0.843000	Neutral	29.3	56.0	26.7	Complied

**Results: Neutral / Average / 120 VAC 60 Hz**

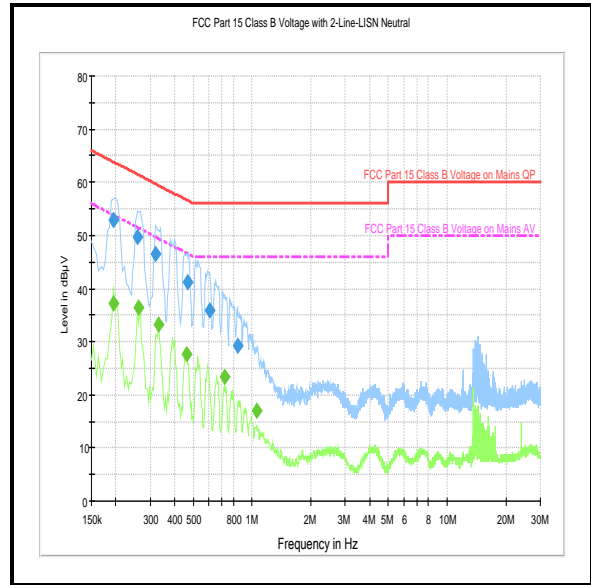
Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.195000	Neutral	37.1	53.8	16.7	Complied
0.262500	Neutral	36.5	51.4	14.9	Complied
0.330000	Neutral	33.3	49.5	16.2	Complied
0.460500	Neutral	27.7	46.7	19.0	Complied
0.726000	Neutral	23.4	46.0	22.6	Complied
1.059000	Neutral	17.0	46.0	29.0	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 (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.1905	Live	48.4	64.0	15.6	Complied
0.2580	Live	45.3	61.5	16.2	Complied
0.3210	Live	42.7	59.7	17.0	Complied
0.4020	Live	38.2	57.8	19.6	Complied
0.5910	Live	35.1	56.0	20.9	Complied
0.8565	Live	30.3	56.0	25.7	Complied

**Results: Live / Average / 240 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.1950	Live	31.9	53.8	21.9	Complied
0.2580	Live	30.6	51.5	20.9	Complied
0.3255	Live	28.4	49.6	21.2	Complied
0.3885	Live	27.2	48.1	20.9	Complied
0.5190	Live	24.9	46.0	21.1	Complied
0.8385	Live	21.4	46.0	24.6	Complied

**Results: Neutral / Quasi Peak / 240 VAC 60 Hz**

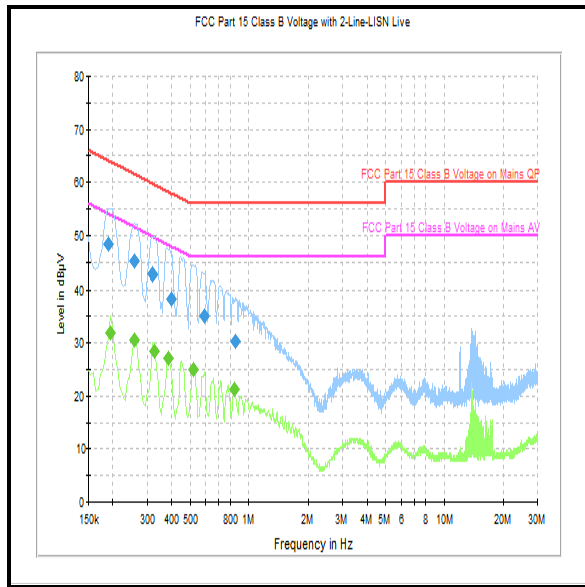
Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.1905	Neutral	48.2	64.0	15.8	Complied
0.2535	Neutral	44.7	61.6	16.9	Complied
0.3210	Neutral	42.2	59.7	17.5	Complied
0.3975	Neutral	38.9	57.9	19.0	Complied
0.5145	Neutral	35.9	56.0	20.1	Complied
0.5910	Neutral	33.7	56.0	22.3	Complied

**Results: Neutral / Average / 240 VAC 60 Hz**

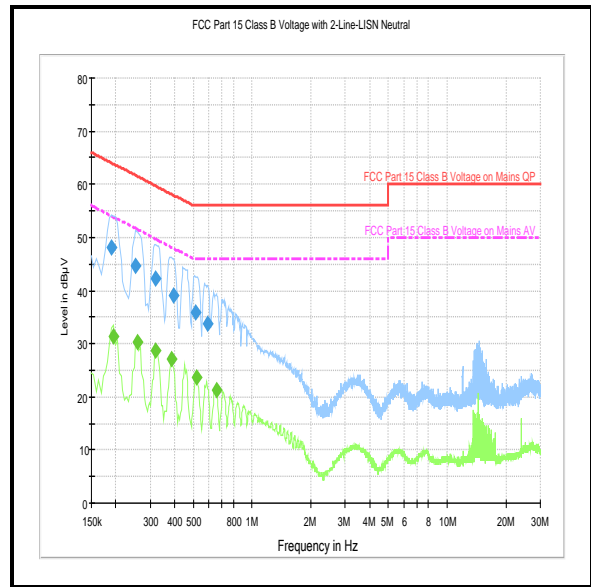
Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.1950	Neutral	31.4	53.8	22.4	Complied
0.2580	Neutral	30.3	51.5	21.2	Complied
0.3210	Neutral	28.8	49.7	20.9	Complied
0.3885	Neutral	27.2	48.1	20.9	Complied
0.5190	Neutral	23.7	46.0	22.3	Complied
0.6540	Neutral	21.2	46.0	24.8	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)
M2037	Thermohygrometer	Testo	608-H1	45124925	27 Mar 2019	12
M1273	Test Receiver	Rohde & Schwarz	ESIB26	100275	18 Dec 2019	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	06 Apr 2019	12
A649	Single Phase LISN	Rohde & Schwarz	ESH3-Z5	825562/008	23 Aug 2019	12

**Test Measurement Software/Firmware Used**

Name	Version	Release Date
Rohde & Schwarz EMC32	6.30.0	2008

**5.2.2. Transmitter Minimum 6 dB Bandwidth**

**Test Summary:**

<b>Test Engineer:</b>	Stefan Ho	<b>Test Date:</b>	07 February 2019
<b>Test Sample Serial Number:</b>	B19ABA		

<b>FCC Reference:</b>	Part 15.247(a)(2)
<b>Test Method Used:</b>	FCC KDB 558074 Section 8.2 referencing ANSI C63.10 Section 11.8.1

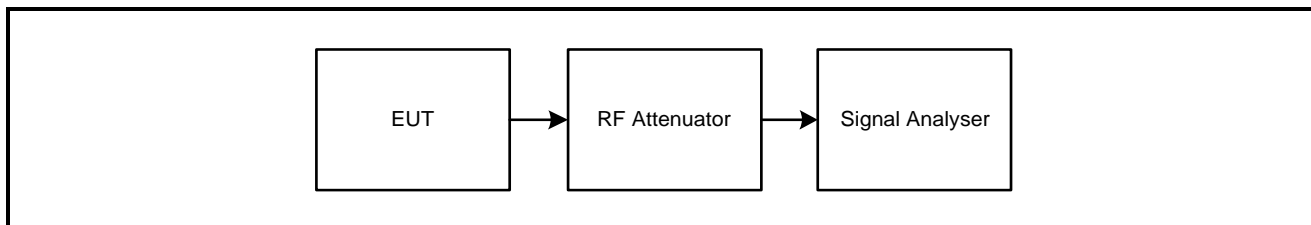
**Environmental Conditions:**

<b>Temperature (°C):</b>	22
<b>Relative Humidity (%):</b>	39

**Note(s):**

- 6 dB DTS bandwidth tests were performed using a signal analyser in accordance with ANSI C63.10 Section 11.8.1 Option 1 measurement procedure. The signal analyser resolution bandwidth was set to 100 kHz and video bandwidth to 300 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The DTS bandwidth was measured at 6 dB down from the peak of the signal.
- The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable.

**Test setup:**

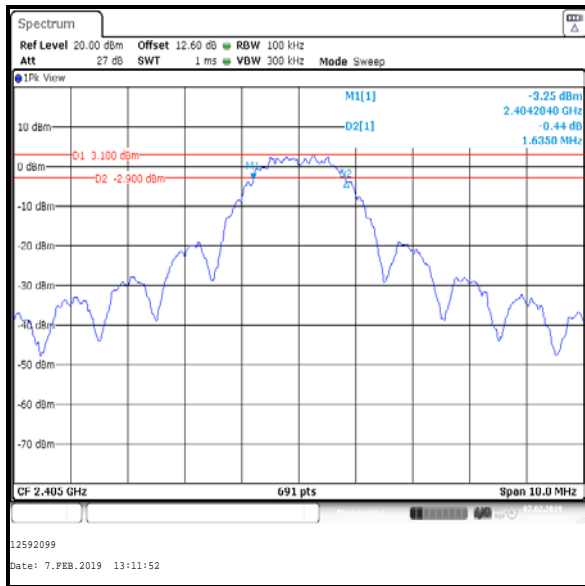




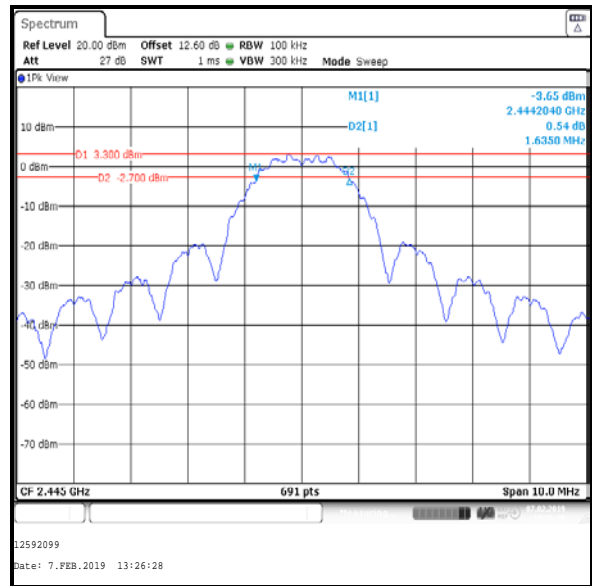
**Transmitter Minimum 6 dB Bandwidth (continued)**

**Results:**

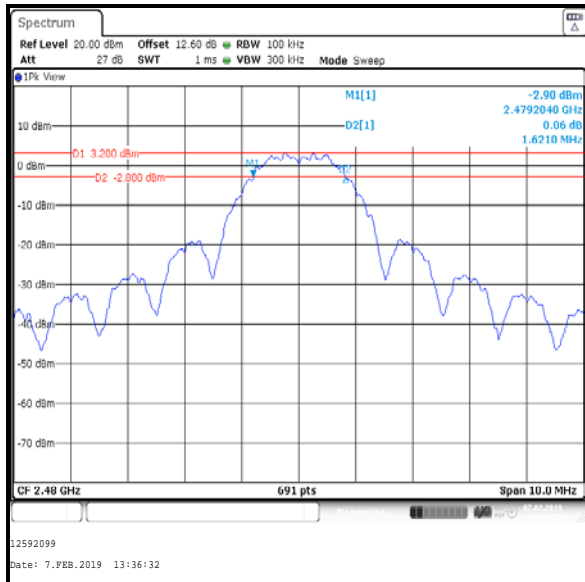
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	1635.000	≥500	1135.000	Complied
Middle	1635.000	≥500	1135.000	Complied
Top	1621.000	≥500	1121.000	Complied



Bottom Channel



Middle Channel



Top Channel

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

<b>Asset No.</b>	<b>Instrument</b>	<b>Manufacturer</b>	<b>Type No.</b>	<b>Serial No.</b>	<b>Date Calibration Due</b>	<b>Cal. Interval (Months)</b>
M2005	Thermohygrometer	Testo	608-H1	45046700	06 Jan 2020	12
M2036	Signal Analyser	Rohde & Schwarz	FSV30	101791	20 Apr 2019	12
G0628	Vector Signal Generator	Rohde & Schwarz	SMBV100A	261847	28 Sep 2020	36
A2524	Attenuator	AtlanTecRF	AN18W5-10	832827#2	Calibrated before use	-

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

<b>Test Engineer:</b>	Stefan Ho	<b>Test Date:</b>	16 July 2019
<b>Test Sample Serial Number:</b>	13CAD4		

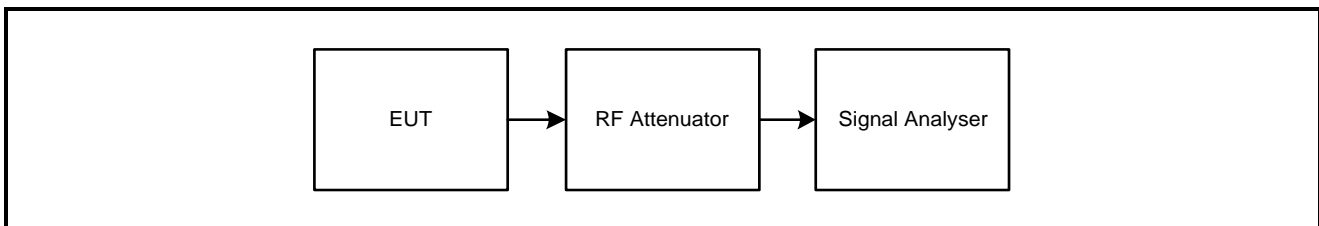
<b>FCC Reference:</b>	Part 15.247(b)(3)
<b>Test Method Used:</b>	FCC KDB 558074 Section 8.3.1.1 referencing ANSI C63.10 Section 11.9.1.1

**Environmental Conditions:**

<b>Temperature (°C):</b>	22
<b>Relative Humidity (%):</b>	39

**Note(s):**

1. Conducted power tests were performed using a signal analyser in accordance with ANSI C63.10 Section 11.9.1.1 RBW  $\geq$  DTS bandwidth procedure.
2. The signal analyser resolution bandwidth was set to 3 MHz 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 10 MHz. A marker was placed at the peak of the signal and the results recorded in the table below.
3. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF level offset was entered on the spectrum analyser to compensate for the loss of the attenuator and RF cable.
4. The conducted power was added to the declared antenna gain to obtain the EIRP.

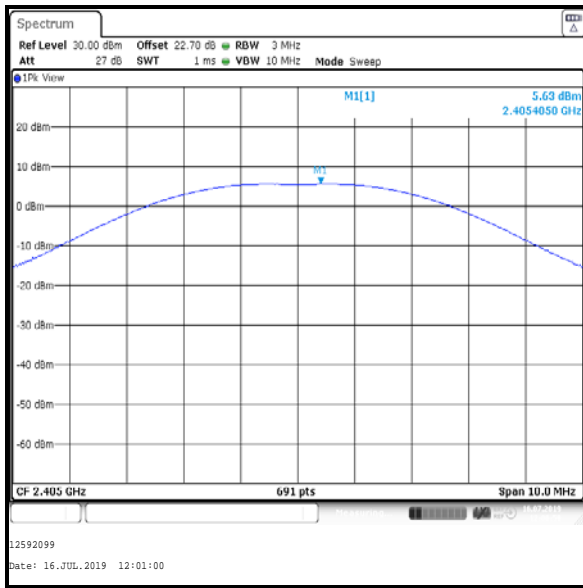
**Test setup:**

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

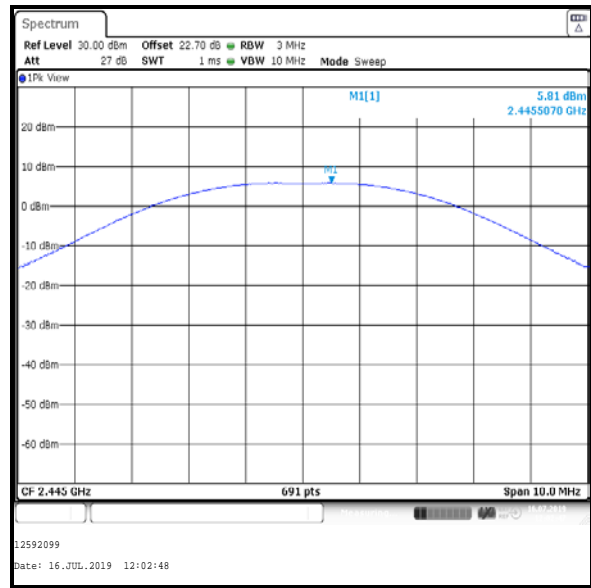
Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	5.6	30.0	24.4	Complied
Middle	5.8	30.0	24.2	Complied
Top	6.0	30.0	24.0	Complied

Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	5.6	5.1	10.7	36.0	25.3	Complied
Middle	5.8	5.1	10.9	36.0	25.1	Complied
Top	6.0	5.1	11.1	36.0	24.9	Complied

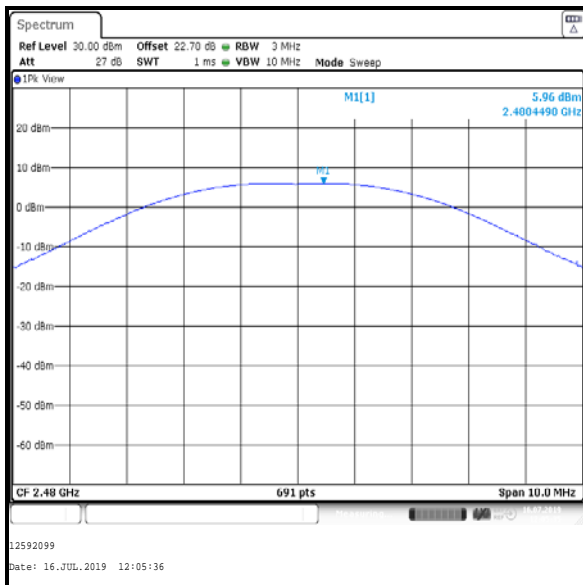
**Transmitter Maximum Peak Output Power (continued)**



**Bottom Channel**



**Middle Channel**



**Top Channel**

**Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2005	Thermohyrometer	Testo	608-H1	45046700	06 Jan 2020	12
M2036	Signal Analyser	Rohde & Schwarz	FSV30	101791	07 May 2020	12
G0628	Vector Signal Generator	Rohde & Schwarz	SMBV100A	261847	28 Sep 2020	36
A2946	Attenuator	AtlanTecRF	AN18W5-20	208146#1	Calibrated before use	-

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

<b>Test Engineers:</b>	Mohamed Toubella & Andrew Edwards	<b>Test Dates:</b>	07 February 2019 & 02 December 2019
<b>Test Sample Serial Number:</b>	B15549		

<b>FCC Reference:</b>	Parts 15.247(d) & 15.209(a)
<b>Test Method Used:</b>	ANSI C63.10 Sections 6.3, 6.4 and 6.5
<b>Frequency Range</b>	9 kHz to 1000 MHz

**Environmental Conditions:**

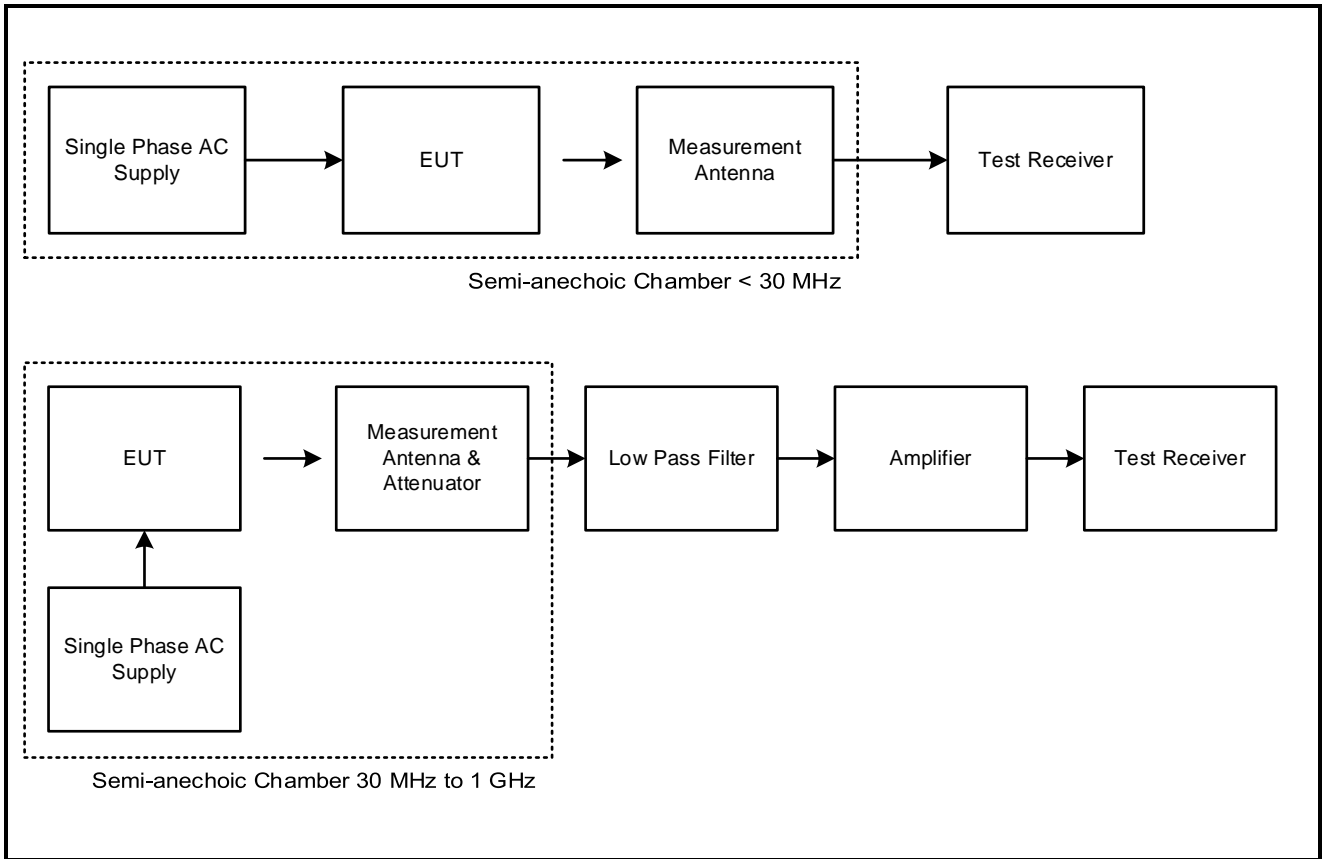
<b>Temperature (°C):</b>	21 to 23
<b>Relative Humidity (%):</b>	35 to 38

**Note(s):**

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The preliminary scans showed similar emission levels below 1 GHz, for each channel of operation. Therefore final radiated emissions measurements were performed with the EUT set to the middle channel only.
3. All other emissions were at least 20 dB below the appropriate limit or below the noise floor of the measurement system.
4. There are ambient emissions seen between 2 to 30 MHz on the pre-scan plot for 490 kHz to 30 MHz performed in the semi-anechoic chamber. A background scan between 490 kHz to 30 MHz is stored on the company server and is available for inspection upon request.
5. Measurements below 30 MHz were performed in a semi-anechoic chamber (Asset Number K0001) at 3 metres. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. The limit was extrapolated to 3 metres in accordance with ANSI C63.10 Section 6.4.4.2. Correlation data between the semi-anechoic chamber and an open-field test site is available upon request.
6. Measurements between 30 MHz to 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.
7. Pre-scans were performed, and markers placed on the highest measured levels. For measurements below 150 kHz: The test receiver resolution bandwidth was set to 300 Hz and video bandwidth 1 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. For measurements between 150 to 490 kHz: The test receiver resolution bandwidth was set to 10 kHz and video bandwidth 30 kHz. An average detector was used, sweep time was set to auto and trace mode was Max Hold. For measurements between 490 kHz to 30 MHz: The test receiver resolution bandwidth was set to 10 kHz and video bandwidth 30 kHz. A peak detector was used, sweep time was set auto and trace mode was Max Hold. For measurements between 30 MHz to 1 GHz: The test receiver resolution bandwidth was set to 120 kHz and video bandwidth 500 kHz. A peak detector was used, sweep time was set auto and trace mode was Max Hold.
8. 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 peak detector and Max hold enabled and span big enough to see the whole emission.

**Transmitter Radiated Emissions (continued)**

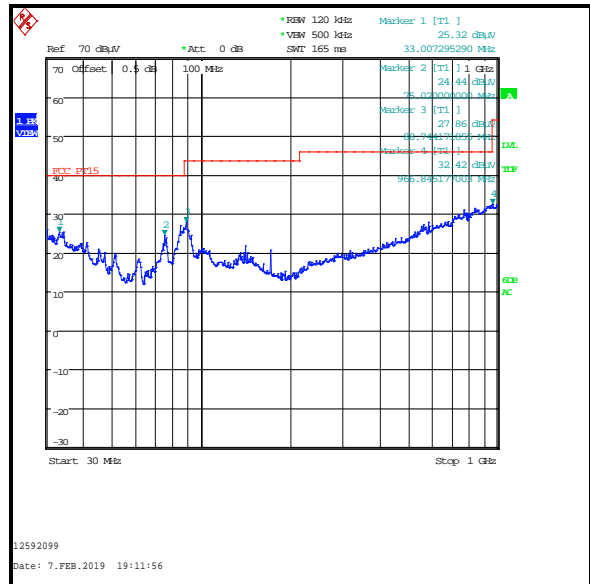
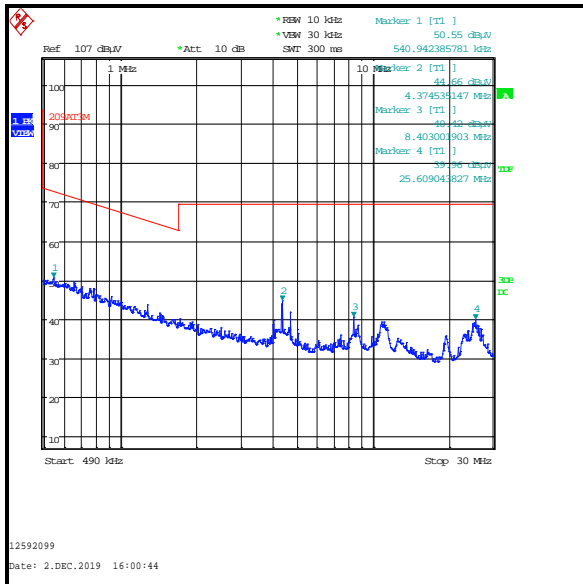
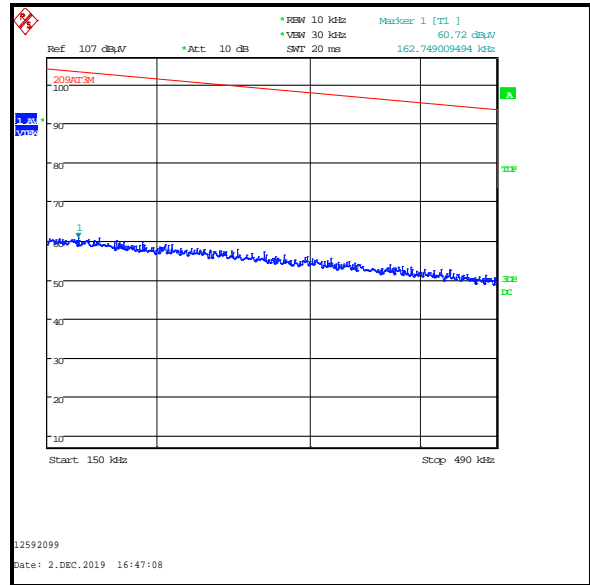
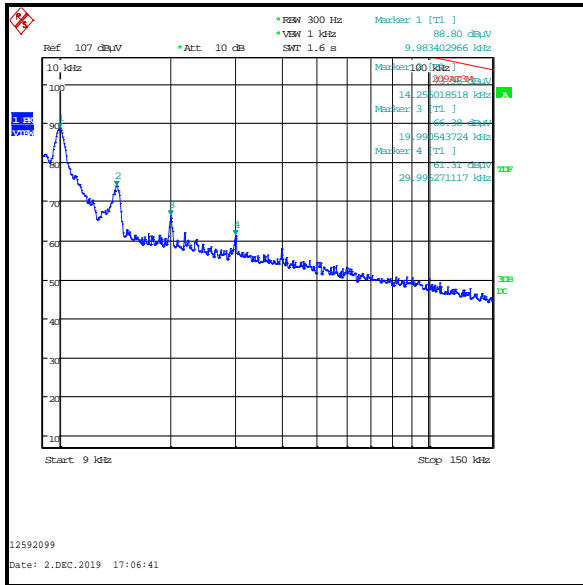
**Test setup for radiated measurements:**



**Transmitter Radiated Emissions (continued)**

**Results: Middle Channel**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
75.058	Horizontal	26.1	40.0	13.9	Complied



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



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

<b>Asset No.</b>	<b>Instrument</b>	<b>Manufacturer</b>	<b>Type No.</b>	<b>Serial No.</b>	<b>Date Calibration Due</b>	<b>Cal. Interval (Months)</b>
M2040	Thermohygrometer	Testo	608-H1	45124934	06 Jan 2020	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	16 Oct 2020	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	01 Apr 2020	12
A3154	Pre-Amplifier	Com-Power	PAM-103	18020012	14 Sep 2019	12
A3198	Magnetic Loop Antenna	ETS-Lindgren	6502	00221887	27 Mar 2020	12
A553	Antenna	Chase	CBL6111A	1593	08 Oct 2019	12
A3112	Attenuator	AtlanTechRF	AN18-06	219706#2	08 Oct 2019	12
A3085	Low Pass Filter	AtlanTechRF	AFL-02000	18051600014	29 Jun 2019	12

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

<b>Test Engineer:</b>	Mohamed Toubella & Andrew Harding	<b>Test Date:</b>	06 February 2019 to 11 March 2019
<b>Test Sample Serial Number:</b>	B15549		

<b>FCC Reference:</b>	Parts 15.247(d) & 15.209(a)
<b>Test Method Used:</b>	FCC KDB 558074 Sections 8.1 c)3), 8.5 & 8.6 referencing ANSI C63.10 Sections 6.3, 6.6, 11.11 & 11.12
<b>Frequency Range</b>	1 GHz to 25 GHz

**Environmental Conditions:**

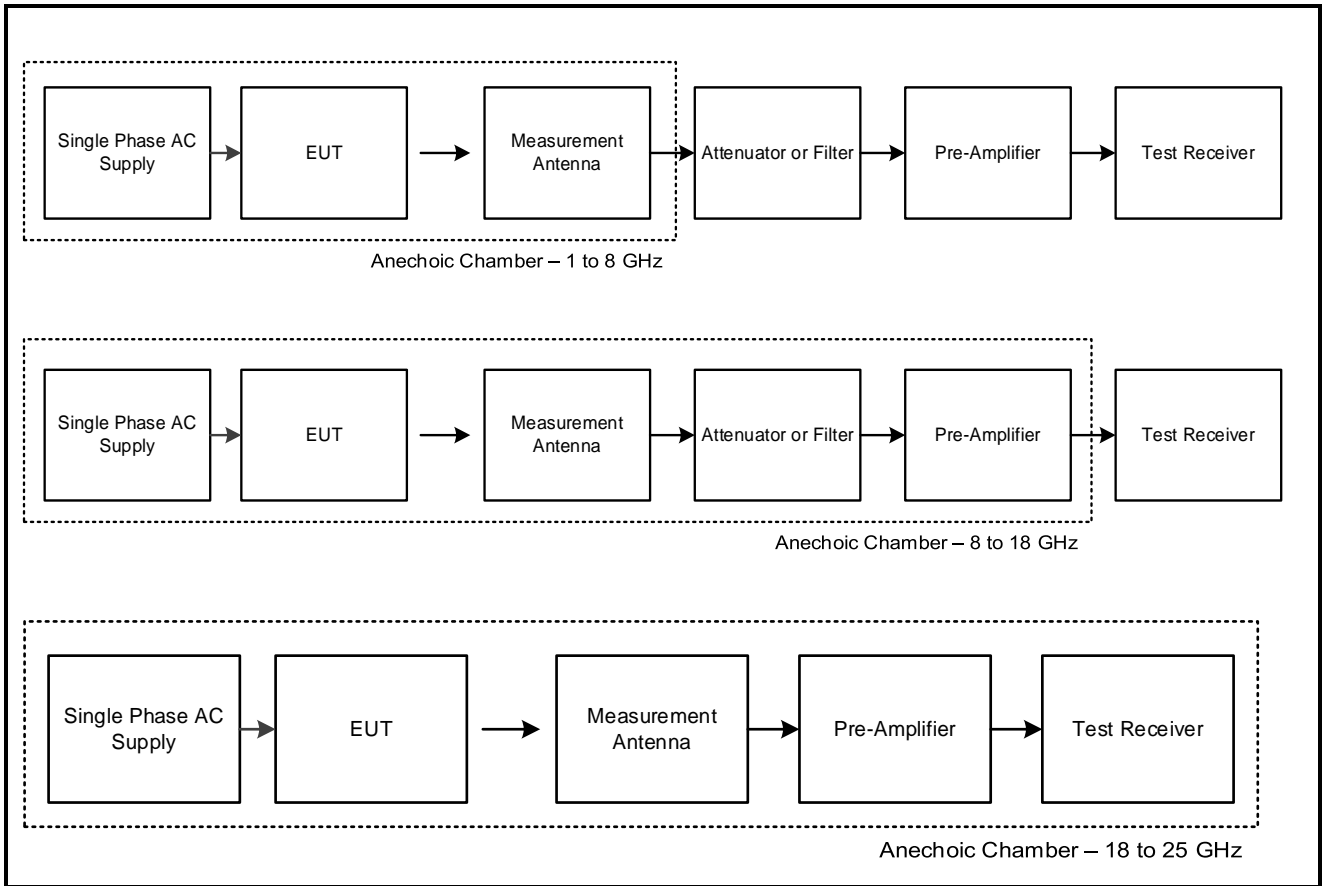
<b>Temperature (°C):</b>	23 to 24
<b>Relative Humidity (%):</b>	35 to 39

**Note(s):**

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. All other emissions shown on the pre-scan plot were investigated and found to be ambient or >20 dB below the applicable limit or below the measurement system noise floor.
3. The emission shown on the 1 GHz to 3 GHz plot is the EUT fundamental.
4. 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 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 m above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
5. Pre-scans were performed and markers placed on the highest measured levels the test receiver was set up as followed: a RBW set to 1 MHz, the VBW set to 3, with the sweep time set to auto couple. Peak and average measurements were performed with their own appropriate detectors during the pre-scan measurements.
6. \*Emissions in restricted bands: In accordance with C63.10 section 6.6.4.3, Note 1, where the peak detected amplitude was shown to comply with the average limit, an average measurement was not performed.
7. The reference level for the emission in the non-restricted band was established by following ANSI C63.10 Section 11.11.2 procedure.
8. \*\* -20 dBc limit applies in non-restricted bands as the conducted output power measurements were performed using a peak detector.

**Transmitter Radiated Emissions (continued)**

**Test setup for radiated measurements:**



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

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
4811.240	Vertical	51.6	54.0*	2.4	Complied
7216.426	Vertical	56.7	74.0	17.3	Complied
9622.005	Vertical	52.3	73.0**	20.7	Complied

**Results: Average / Bottom Channel**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
7213.542	Vertical	48.9	54.0	5.1	Complied

**Results: Peak / Middle Channel**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
4889.080	Vertical	55.6	74.0	18.4	Complied
7333.840	Vertical	56.2	74.0	17.8	Complied
9781.984	Vertical	43.9	73.0**	29.1	Complied

**Results: Average / Middle Channel**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
4889.080	Vertical	48.8	54.0	5.2	Complied
7333.840	Vertical	47.8	54.0	6.2	Complied

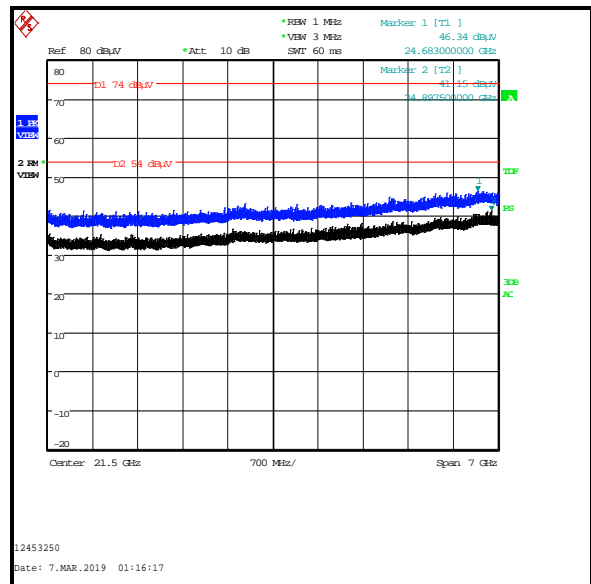
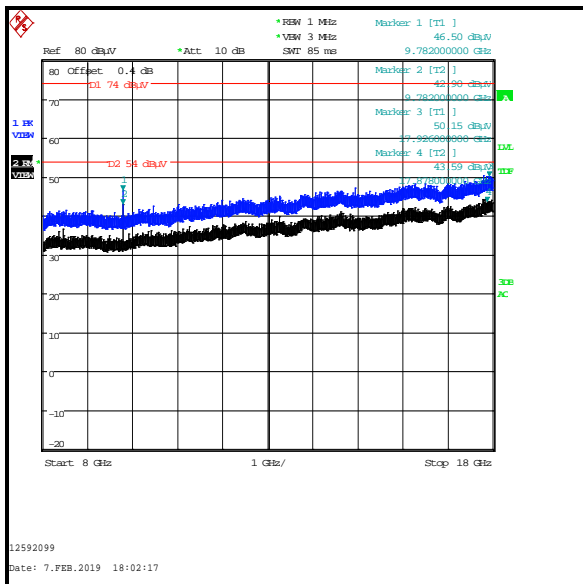
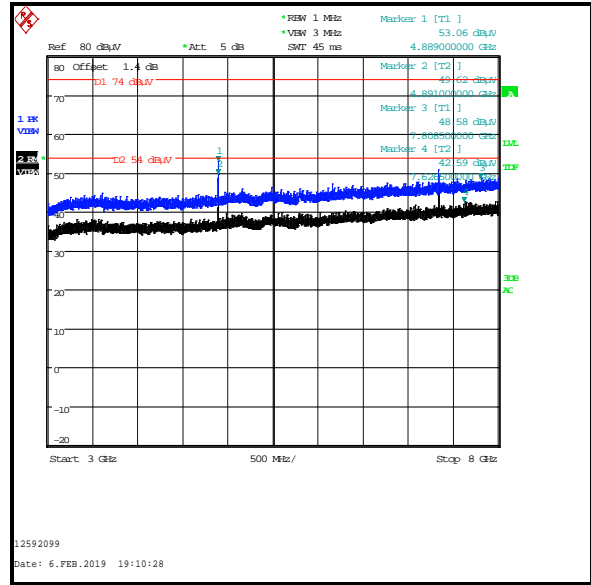
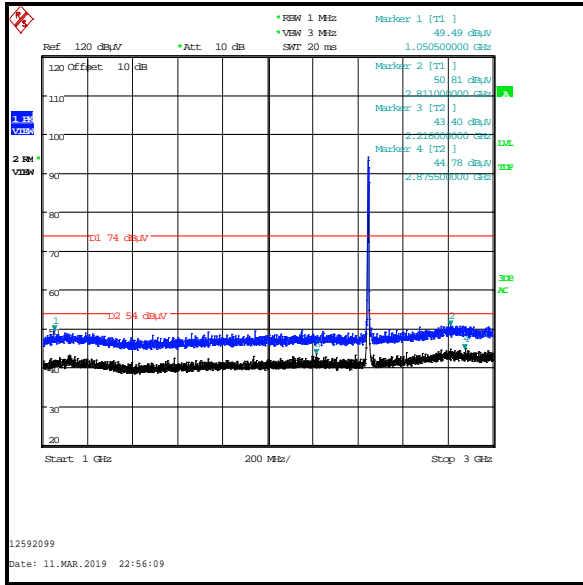
**Results: Peak / Top Channel**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
4960.994	Vertical	59.4	74.0	14.6	Complied
7441.442	Vertical	46.4	54.0*	7.6	Complied
9926.504	Vertical	44.3	73.0**	28.7	Complied

**Results: Average / Top Channel**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
4960.994	Vertical	48.6	54.0	5.4	Complied
7441.571	Vertical	36.0	54.0	18.0	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:**

<b>Asset No.</b>	<b>Instrument</b>	<b>Manufacturer</b>	<b>Type No.</b>	<b>Serial No.</b>	<b>Date Calibration Due</b>	<b>Cal. Interval (Months)</b>
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	Amplifier	Com-Power	PAM-118A	18040037	14 Sep 2019	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	03 Oct 2019	12
A2523	Attenuator	AtlanTechRF	AN18W5-10	832827#1	23 Nov 2019	12
A3093	High Pass Filter	AtlanTechRF	AFH-03000	18051800077	29 Jun 2019	12
A3139	Antenna	Schwarzbeck	HWRD750	00027	04 Oct 2019	12
A3095	High Pass Filter	AtlanTechRF	AFH-07000	18051600012	29 Jun 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
A2895	Antenna	Schwarzbeck	BBHA 9170	9170-728	08 Feb 2020	12
M2040	Thermohygrometer	Testo	608-H1	45124934	06 Jan 2020	12

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

<b>Test Engineer:</b>	Mohamed Toubella & Andrew Harding	<b>Test Dates:</b>	06 February 2019 & 07 February 2019
<b>Test Sample Serial Number:</b>	000D6F0005-B15549		

<b>FCC Reference:</b>	Parts 15.247(d) & 15.209(a)
<b>Test Method Used:</b>	KDB 558074 Section 8.7 referencing ANSI C63.10 Section 11.11, 11.12 & 11.13

**Environmental Conditions:**

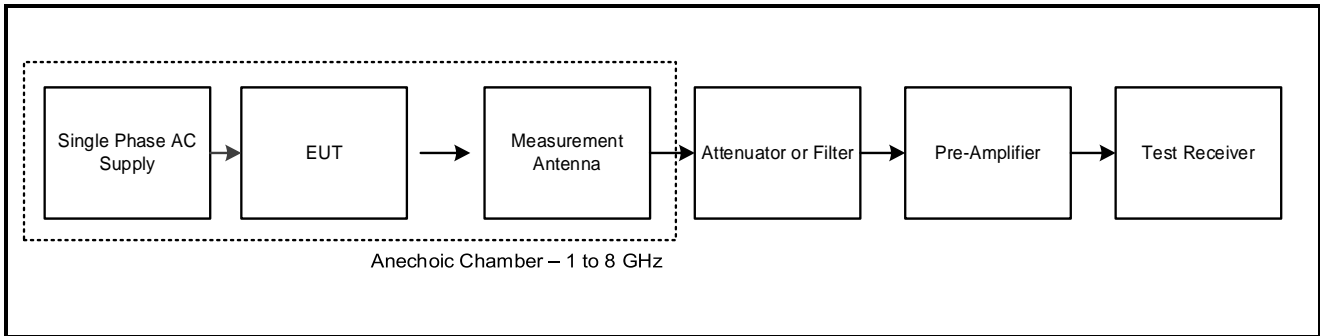
<b>Temperature (°C):</b>	23 to 24
<b>Relative Humidity (%):</b>	38 to 39

**Note(s):**

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The maximum peak conducted output power was previously measured. In accordance with ANSI C63.10 Section 11.11.1(a), the lower band edge measurement was performed with a peak detector and the -20 dBc limit applied.
3. As the lower band edge is adjacent to a non-restricted band, only peak measurements are required. In accordance with ANSI C63.10 Section 11.11.1, the test method in Section 11.11.3 was followed: the test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The test receiver was left to sweep for a sufficient length of time in order to maximise the carrier level and out-of-band emissions. A marker and corresponding reference level line were placed on the peak of the carrier. As the maximum peak conducted output power was measured using a peak detector in accordance with ANSI C63.10 Section 11.9.1.1 an out-of-band limit line was placed 20 dB (ANSI C63.10 Section 11.11.1(a)) below the peak level. A marker was placed on the band edge spot frequencies. Marker frequency and levels were recorded.
4. As the upper band edge is adjacent to a restricted band both peak and average measurements were recorded by placing a marker at the edge of the band. For peak measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. For average measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. An RMS detector was used, sweep time was set to auto and trace mode was trace averaging over 300 sweeps. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent restricted band of operation (where a higher level emission was present). Marker frequencies and levels were recorded
5. There is a restricted band 10 MHz below the lower band edge. The test receiver was set up as follows: the RBW set to 1 MHz, the VBW set to 3 MHz, with the sweep time set to auto couple. Peak and average measurements were performed with their respective detectors. Markers were placed on the highest point on each trace.
6. \* -20 dBc limit.
7. \*\* For improved accuracy the upper band edge average measurement was tested using the integration method stated in ANSI C63.10 Section 11.13.3.

**Transmitter Band Edge Radiated Emissions (continued)**

**Test setup for radiated measurements:**



**Results: Peak**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
2400.000	Vertical	51.5	73.0*	21.5	Complied
2483.500	Vertical	62.7	74.0	11.3	Complied

**Results: Average**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
2483.500	Vertical	50.9**	54.0	3.1	Complied

**Results: 2310 MHz to 2390 MHz Restricted Band / Peak**

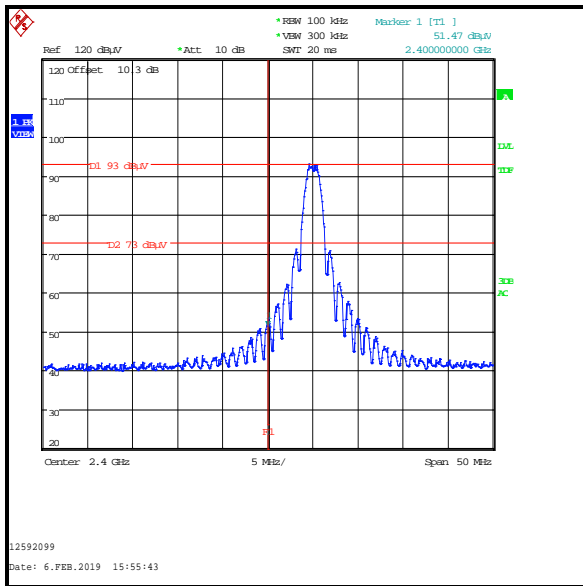
Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
2387.436	Vertical	51.9	74.0	22.1	Complied

**Results: 2310 MHz to 2390 MHz Restricted Band / Average**

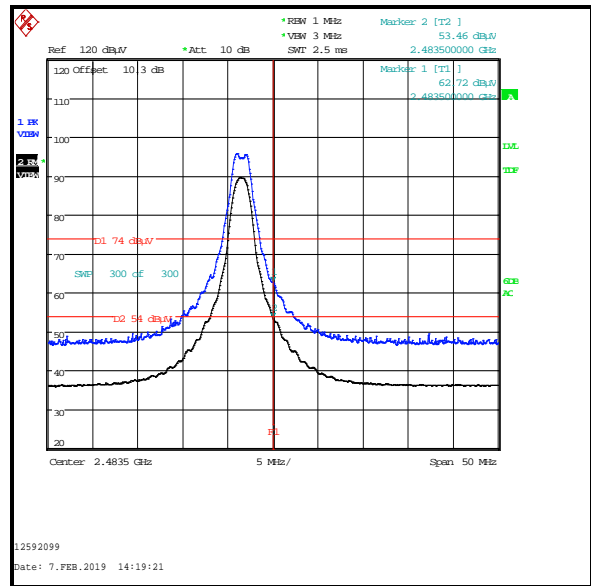
Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
2390.00	Vertical	40.2	54.0	13.8	Complied



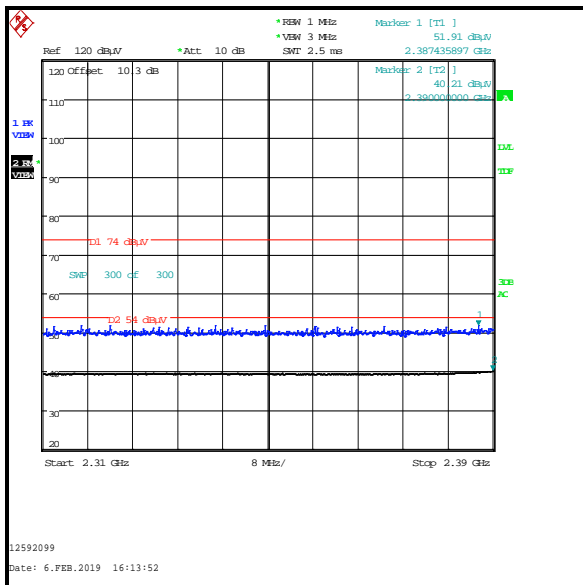
**Transmitter Band Edge Radiated Emissions (continued)**



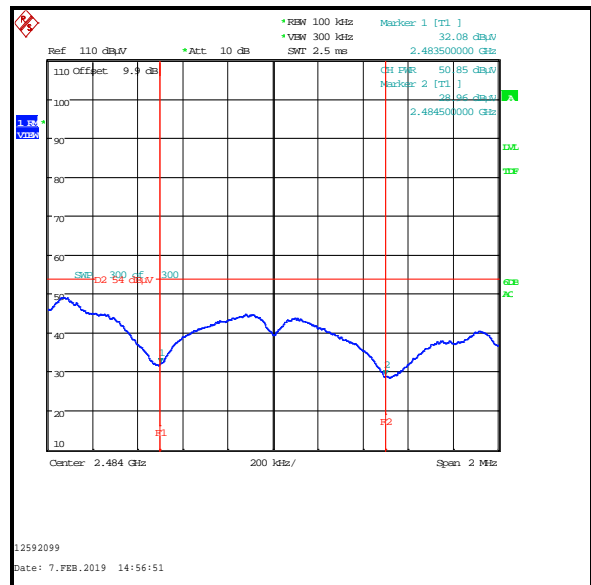
**Lower Band Edge Peak Measurement**



**Upper Band Edge Measurement**



**2310 MHz to 2390 MHz Restricted Band Plot**



**Upper Band Edge Average Measurement – Integration Method**

**Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohyrometer	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
A2523	Attenuator	AtlanTechRF	AN18W5-10	832827#1	23 Nov 2019	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".

<b>Measurement Type</b>	<b>Range</b>	<b>Confidence Level (%)</b>	<b>Calculated Uncertainty</b>
AC Conducted Spurious Emissions	0.15 MHz to 30 MHz	95%	±1.96 dB
Conducted Maximum Peak Output Power	2.4 GHz to 2.4835 GHz	95%	±1.13 dB
Spectral Power Density	2.4 GHz to 2.4835 GHz	95%	±1.13 dB
Minimum 6 dB Bandwidth	2.4 GHz to 2.4835 GHz	95%	±4.59 %
Radiated Spurious Emissions	9 kHz to 30 MHz	95%	±4.39 dB
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±4.65 dB
Radiated Spurious Emissions	1 GHz to 25 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	-	5.2.4	9 kHz to 30 MHz measurements added.
	-	-	Editorial updates.

--- END OF REPORT ---