



# TEST REPORT

**Test Report No. : UL-RPT-RP12700076-716A V2.0**

**Manufacturer** : Ubisense  
**Model No.** : UBIMOD31  
**FCC ID** : SEAMOD31  
**Technology** : Wide Band Transmitter  
**Test Standard(s)** : FCC Parts 15.207, 15.209 & 15.250

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. 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:** 24 June 2019

**Checked by:**

Ben Mercer  
Senior Test Engineer, Radio Laboratory

**Company Signatory:**

Sarah Williams  
Senior Test 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.

---

## 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

This page has been left intentionally blank.

**Table of Contents**

|                                                                    |           |
|--------------------------------------------------------------------|-----------|
| <b>1. Customer Information.....</b>                                | <b>4</b>  |
| <b>2. Summary of Testing.....</b>                                  | <b>5</b>  |
| 2.1. General Information                                           | 5         |
| 2.2. Summary of Test Results                                       | 5         |
| 2.3. Methods and Procedures                                        | 5         |
| 2.4. Deviations from the Test Specification                        | 5         |
| <b>3. Equipment Under Test (EUT) .....</b>                         | <b>6</b>  |
| 3.1. Identification of Equipment Under Test (EUT)                  | 6         |
| 3.2. Description of EUT                                            | 6         |
| 3.3. Modifications Incorporated in the EUT                         | 6         |
| 3.4. Additional Information Related to Testing                     | 6         |
| 3.5. Support Equipment                                             | 7         |
| <b>4. Operation and Monitoring of the EUT during Testing .....</b> | <b>8</b>  |
| 4.1. Operating Modes                                               | 8         |
| 4.2. Configuration and Peripherals                                 | 8         |
| <b>5. Measurements, Examinations and Derived Results .....</b>     | <b>9</b>  |
| 5.1. General Comments                                              | 9         |
| 5.2. Test Results                                                  | 10        |
| 5.2.1. Transmitter AC Conducted Spurious Emissions                 | 10        |
| 5.2.2. Transmitter -10 dB Bandwidth                                | 15        |
| 5.2.3. Transmitter Frequency Stability (Temperature Variation)     | 17        |
| 5.2.4. Transmitter Frequency Stability (Voltage Variation)         | 19        |
| 5.2.5. Transmitter Radiated Emissions Below 960 MHz                | 21        |
| 5.2.6. Transmitter Radiated Emissions Above 960 MHz                | 23        |
| 5.2.7. Transmitter Emissions Peak Level                            | 30        |
| <b>6. Measurement Uncertainty .....</b>                            | <b>32</b> |
| <b>7. Report Revision History .....</b>                            | <b>33</b> |
| <b>8. Appendix 1 .....</b>                                         | <b>34</b> |

**1. Customer Information**

|                      |                                                                                                |
|----------------------|------------------------------------------------------------------------------------------------|
| <b>Company Name:</b> | Ubisense                                                                                       |
| <b>Address:</b>      | St Andrew's House<br>St Andrew's Road<br>Chesterton,<br>Cambridge<br>CB4 1DL<br>United Kingdom |

## 2. Summary of Testing

### 2.1. General Information

|                                 |                                                                                                                                       |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <b>Specification Reference:</b> | 47CFR15.250                                                                                                                           |
| <b>Specification Title:</b>     | Code of Federal Regulations Volume 47 (Telecommunications):<br>Part 15 Subpart C (Intentional Radiators) - Section 15.250             |
| <b>Specification Reference:</b> | 47CFR15.207 and 47CFR15.209                                                                                                           |
| <b>Specification Title:</b>     | Code of Federal Regulations Volume 47 (Telecommunications):<br>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,<br>Basingstoke, Hampshire, RG24 8AH, United Kingdom                    |
| <b>Test Dates:</b>              | 22 February 2019 to 26 February 2019                                                                                                  |

### 2.2. Summary of Test Results

| FCC Reference (47CFR)                                                                                                                                                                                                        | Measurement                                  | Result                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|---------------------------------------------------------------------------------------|
| Part 15.207                                                                                                                                                                                                                  | Transmitter AC Conducted Emissions           |    |
| Part 15.250(a) & (b)                                                                                                                                                                                                         | Transmitter -10 dB Bandwidth                 |   |
| Part 15.250(a)                                                                                                                                                                                                               | Transmitter Frequency Stability              |  |
| Parts 15.250(d)(4) & 15.209(a)                                                                                                                                                                                               | Transmitter Radiated Emissions Below 960 MHz |  |
| Part 15.250(d)(1) & (2)                                                                                                                                                                                                      | Transmitter Radiated Emissions Above 960 MHz |  |
| Part 15.250(d)(3)                                                                                                                                                                                                            | Transmitter Emission Peak Level              |  |
| <b>Key to Results</b><br> = Complied  = Did not comply |                                              |                                                                                       |

### 2.3. Methods and Procedures

|                   |                                                                                                   |
|-------------------|---------------------------------------------------------------------------------------------------|
| <b>Reference:</b> | ANSI C63.10-2013                                                                                  |
| <b>Title:</b>     | American National Standard of Procedures for Compliance Testing of<br>Unlicensed Wireless Devices |
| <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>                | UBISENSE                                    |
| <b>Model Name or Number:</b>      | UBIMOD31                                    |
| <b>Test Sample Serial Number:</b> | 0011CE0000000ED6 ( <i>Radiated sample</i> ) |
| <b>Hardware Version Number:</b>   | ModeState1                                  |
| <b>Firmware Version Number:</b>   | Test Image                                  |
| <b>FCC ID:</b>                    | SEAMOD31                                    |

|                                   |                                              |
|-----------------------------------|----------------------------------------------|
| <b>Brand Name:</b>                | UBISENSE                                     |
| <b>Model Name or Number:</b>      | UBIMOD31                                     |
| <b>Test Sample Serial Number:</b> | 0011CE0000000ED7 ( <i>Conducted sample</i> ) |
| <b>Hardware Version Number:</b>   | ModeState1                                   |
| <b>Firmware Version Number:</b>   | Test Image                                   |
| <b>FCC ID:</b>                    | SEAMOD31                                     |

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

The Equipment Under Test was a location-tracking tag containing a wide band transmitter operating in the 5925 MHz to 7250 MHz band. The unit has an integral antenna and is normally powered by host equipment from a nominal 5.0 VDC supply.

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

No modifications were applied to the EUT during testing.

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

|                                  |                                                |                                |
|----------------------------------|------------------------------------------------|--------------------------------|
| <b>Tested Technology:</b>        | Wide Band Transmitter                          |                                |
| <b>Power Supply Requirement:</b> | Nominal                                        | 5.0 VDC via 120 VAC 60 Hz      |
| <b>Type of Unit:</b>             | Transmitter                                    |                                |
| <b>Type of Equipment:</b>        | Module                                         |                                |
| <b>Modulation:</b>               | OOK of a 1 Mpps (pulse-per-second) pulse train |                                |
| <b>Duty Cycle:</b>               | 100%                                           |                                |
| <b>Transmit Frequency Range:</b> | 5925 to 7250 MHz                               |                                |
| <b>Transmit Channel Tested:</b>  | <b>Channel ID</b>                              | <b>Channel Frequency (MHz)</b> |
|                                  | Single                                         | 6500                           |

**3.5. Support Equipment**

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

|                              |                       |
|------------------------------|-----------------------|
| <b>Description:</b>          | AC to DC Power Supply |
| <b>Brand Name:</b>           | XP Power              |
| <b>Model Name or Number:</b> | VER05US050-JA         |
| <b>Serial Number:</b>        | Not marked or stated  |

|                              |                            |
|------------------------------|----------------------------|
| <b>Description:</b>          | Power Cable. Length 1.8 m. |
| <b>Brand Name:</b>           | Not marked or stated       |
| <b>Model Name or Number:</b> | Not marked or stated       |
| <b>Serial Number:</b>        | 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):

- Constantly transmitting at full power with a wide band modulated pulse train representing the maximum possible data payload.

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

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

- The manufacturer pre-loaded test software/firmware prior to testing. This enabled the EUT to transmit in wide band test mode with a modulated pulse train. The customer supplied a document containing configuration instructions : 'Instructions for FCC\_IC Test Units.pdf'.
- For testing purposes the EUT was powered by 5 VDC via a 120 VAC 60 Hz XP power supply. The XP power supply was connected to the EUT via a multi pin connector.
- AC conducted emissions tests were performed with the XP power supply input connected to a 120 VAC 60 Hz single phase supply via a LISN. The XP power supply DC output was connected to the EUT via twin core cable and multi pin connector.
- Frequency stability measurements were performed using sample with serial number 0011CE0000000ED7. This sample was connected to a variable power supply in order to vary the voltage. This was monitored by a calibrated digital voltmeter throughout the test. All other measurements were performed using sample with serial number 0011CE0000000ED6.

## **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:             | Andrew Edwards   | Test Date: | 25 February 2019 |
| Test Sample Serial Number: | 0011CE0000000ED6 |            |                  |

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

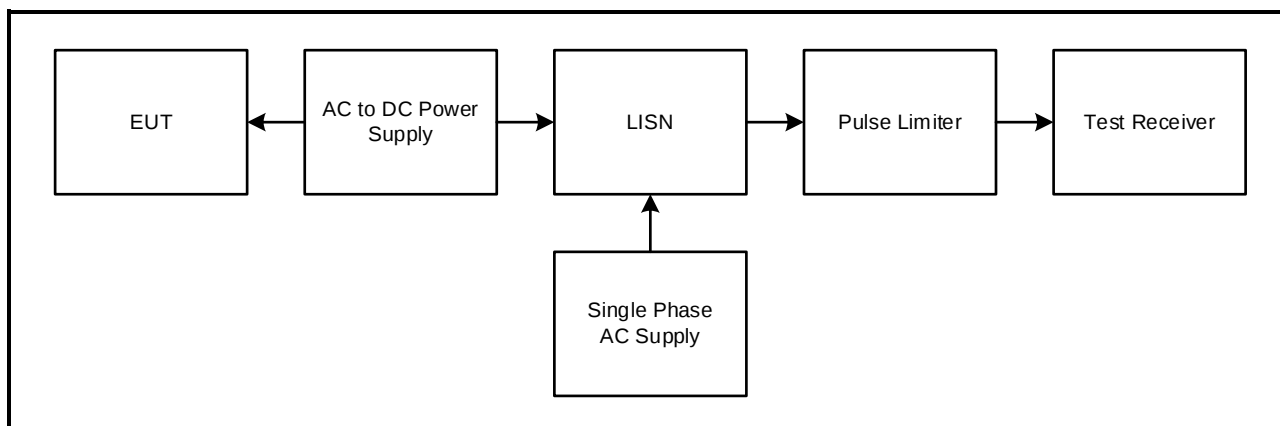
#### Environmental Conditions:

|                        |    |
|------------------------|----|
| Temperature (°C):      | 20 |
| Relative Humidity (%): | 36 |

#### Note(s):

1. The EUT was connected to the AC to DC power supply which 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 Diagram for Transmitter AC Conducted Emissions



**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   |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.357           | Live | 45.1               | 58.8               | 13.7        | Complied |
| 0.551           | Live | 30.4               | 56.0               | 25.6        | Complied |
| 0.956           | Live | 29.9               | 56.0               | 26.1        | Complied |
| 1.325           | Live | 29.2               | 56.0               | 26.8        | Complied |
| 2.445           | Live | 28.9               | 56.0               | 27.1        | Complied |
| 2.958           | Live | 28.9               | 56.0               | 27.1        | Complied |

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

| Frequency (MHz) | Line | Level (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Result   |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.357           | Live | 31.6               | 48.8               | 17.2        | Complied |
| 0.569           | Live | 20.5               | 46.0               | 25.5        | Complied |
| 0.915           | Live | 20.3               | 46.0               | 25.7        | Complied |
| 1.482           | Live | 20.2               | 46.0               | 25.8        | Complied |
| 2.040           | Live | 19.3               | 46.0               | 26.7        | Complied |
| 3.444           | Live | 18.3               | 46.0               | 27.7        | Complied |

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

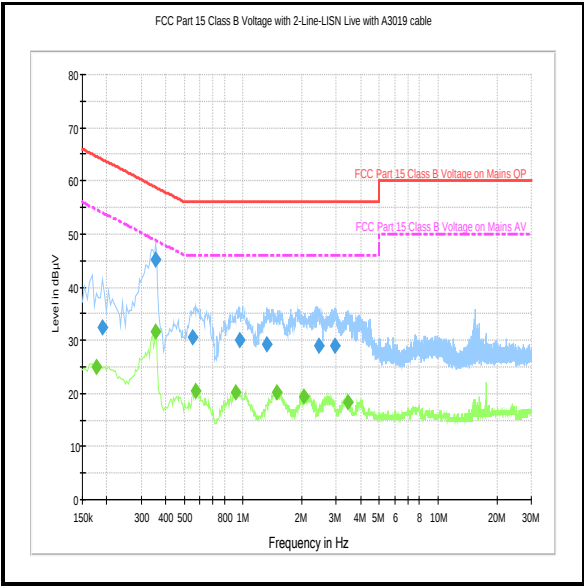
| Frequency (MHz) | Line    | Level (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Result   |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.335           | Neutral | 39.0               | 59.3               | 20.3        | Complied |
| 0.380           | Neutral | 27.4               | 58.3               | 30.9        | Complied |
| 0.645           | Neutral | 26.3               | 56.0               | 29.7        | Complied |
| 0.947           | Neutral | 27.3               | 56.0               | 28.7        | Complied |
| 1.464           | Neutral | 25.6               | 56.0               | 30.4        | Complied |
| 2.319           | Neutral | 24.3               | 56.0               | 31.7        | Complied |

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

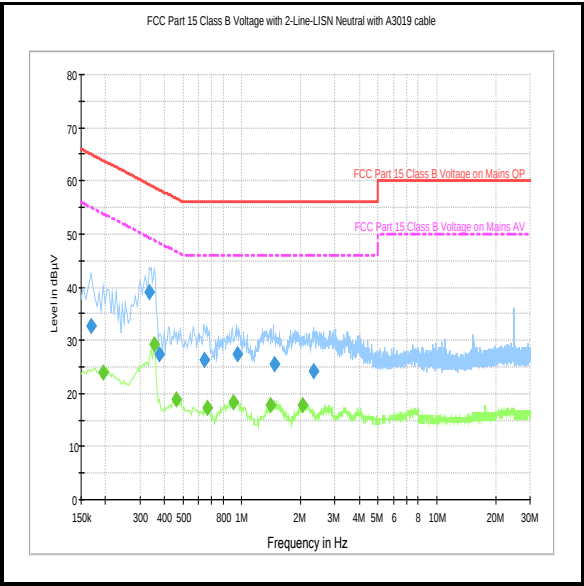
| Frequency (MHz) | Line    | Level (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Result   |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.357           | Neutral | 29.1               | 48.8               | 19.7        | Complied |
| 0.461           | Neutral | 18.9               | 46.7               | 27.8        | Complied |
| 0.668           | Neutral | 17.2               | 46.0               | 28.8        | Complied |
| 0.911           | Neutral | 18.3               | 46.0               | 27.7        | Complied |
| 1.401           | Neutral | 17.7               | 46.0               | 28.3        | Complied |
| 2.054           | Neutral | 17.7               | 46.0               | 28.3        | 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   |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.344           | Live | 46.1               | 59.1               | 13.0        | Complied |
| 0.407           | Live | 37.2               | 57.7               | 20.5        | Complied |
| 0.582           | Live | 35.6               | 56.0               | 20.4        | Complied |
| 0.695           | Live | 35.6               | 56.0               | 20.4        | Complied |
| 1.514           | Live | 35.3               | 56.0               | 20.7        | Complied |
| 2.423           | Live | 32.2               | 56.0               | 23.8        | Complied |

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

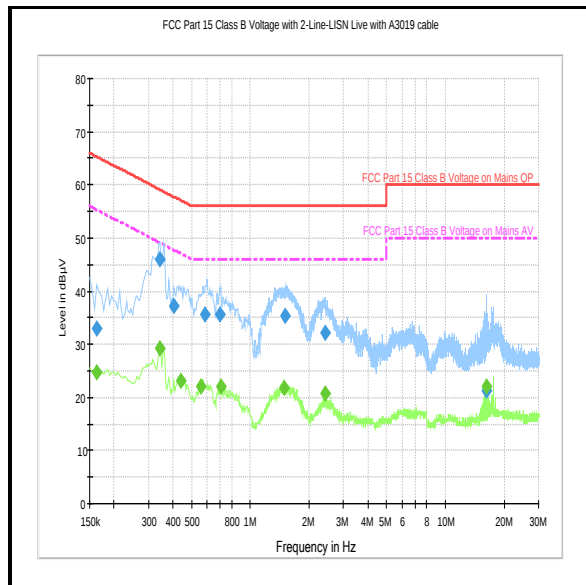
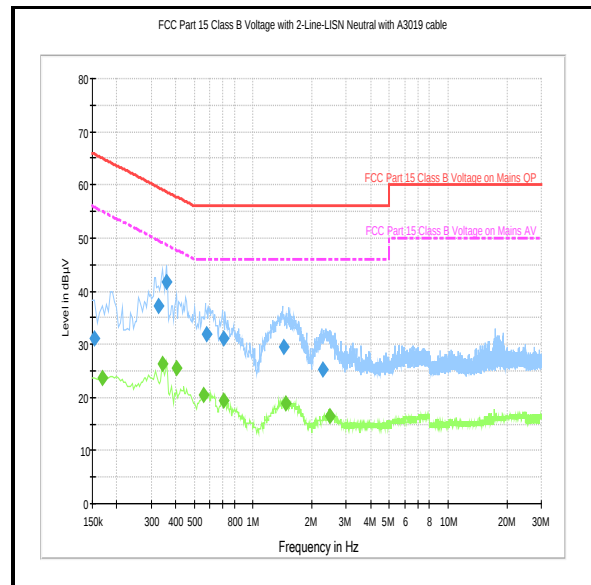
| Frequency (MHz) | Line | Level (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Result   |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.344           | Live | 29.1               | 49.1               | 20.0        | Complied |
| 0.443           | Live | 23.0               | 47.0               | 24.0        | Complied |
| 0.560           | Live | 22.1               | 46.0               | 23.9        | Complied |
| 0.704           | Live | 22.0               | 46.0               | 24.0        | Complied |
| 1.496           | Live | 21.8               | 46.0               | 24.2        | Complied |
| 2.414           | Live | 20.7               | 46.0               | 25.3        | Complied |

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

| Frequency (MHz) | Line    | Level (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Result   |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.326           | Neutral | 37.2               | 59.6               | 22.4        | Complied |
| 0.362           | Neutral | 41.6               | 58.7               | 17.1        | Complied |
| 0.578           | Neutral | 31.8               | 56.0               | 24.2        | Complied |
| 0.704           | Neutral | 31.2               | 56.0               | 24.8        | Complied |
| 1.428           | Neutral | 29.6               | 56.0               | 26.4        | Complied |
| 2.265           | Neutral | 25.3               | 56.0               | 30.7        | Complied |

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

| Frequency (MHz) | Line    | Level (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Result   |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.344           | Neutral | 26.3               | 49.1               | 22.8        | Complied |
| 0.407           | Neutral | 25.5               | 47.7               | 22.2        | Complied |
| 0.560           | Neutral | 20.4               | 46.0               | 25.6        | Complied |
| 0.704           | Neutral | 19.4               | 46.0               | 26.6        | Complied |
| 1.473           | Neutral | 18.8               | 46.0               | 27.2        | Complied |
| 2.463           | Neutral | 16.5               | 46.0               | 29.5        | 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   | 06 Jan 2020          | 12                     |
| M1273     | Test Receiver    | Rohde & Schwarz | ESIB26   | 100275     | 18 Dec 2019          | 12                     |
| A649      | LISN             | Rohde & Schwarz | ESH3-Z5  | 825562/008 | 23 Aug 2019          | 12                     |
| A1830     | Pulse Limiter    | Rohde & Schwarz | ESH3-Z2  | 100668     | 06 Apr 2019          | 12                     |

**Test Measurement Software/Firmware Used**

| Name                  | Version | Release Date |
|-----------------------|---------|--------------|
| Rohde & Schwarz EMC32 | 6.30.0  | 2018         |

**5.2.2. Transmitter -10 dB Bandwidth****Test Summary:**

|                                   |                  |                   |                  |
|-----------------------------------|------------------|-------------------|------------------|
| <b>Test Engineer:</b>             | Andrew Edwards   | <b>Test Date:</b> | 22 February 2019 |
| <b>Test Sample Serial Number:</b> | 0011CE0000000ED6 |                   |                  |

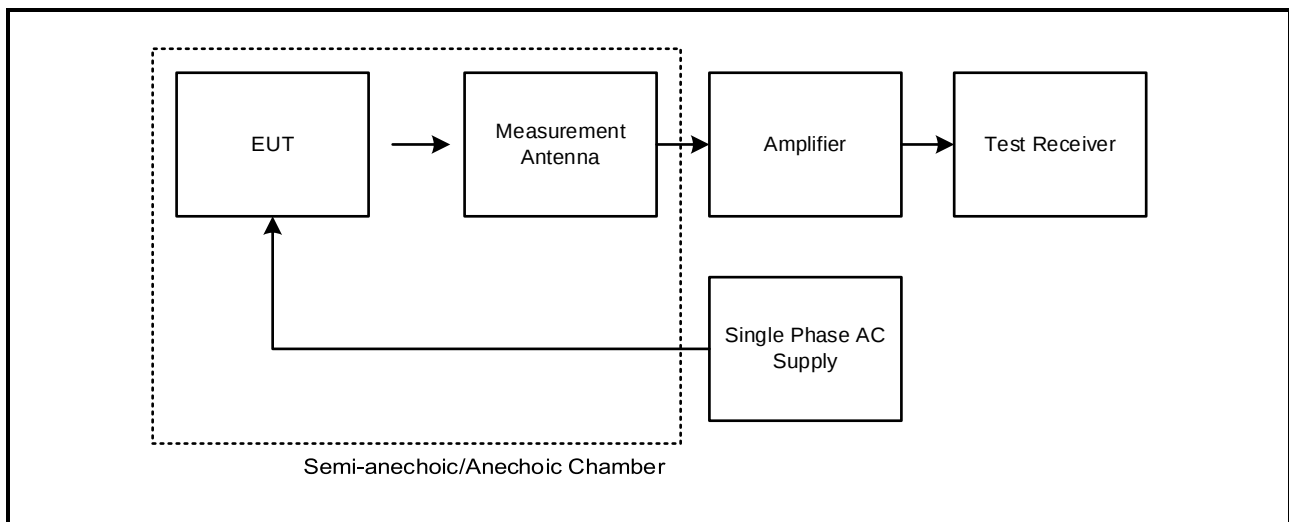
|                          |                                              |
|--------------------------|----------------------------------------------|
| <b>FCC Reference:</b>    | Part 15.250(a) & (b)                         |
| <b>Test Method Used:</b> | Part 15.250(e)(4) & ANSI C63.10 Section 10.1 |

**Environmental Conditions:**

|                               |    |
|-------------------------------|----|
| <b>Temperature (°C):</b>      | 23 |
| <b>Relative Humidity (%):</b> | 41 |

**Note(s):**

1. The -10 dB bandwidth was measured using a peak detector in a 1 MHz resolution bandwidth and a video bandwidth greater than or equal to the resolution bandwidth. Markers were placed on the lower and upper -10 dB points and the frequencies recorded.
2. The -10 dB Bandwidth was calculated in accordance with ANSI C63.10 section 10.1

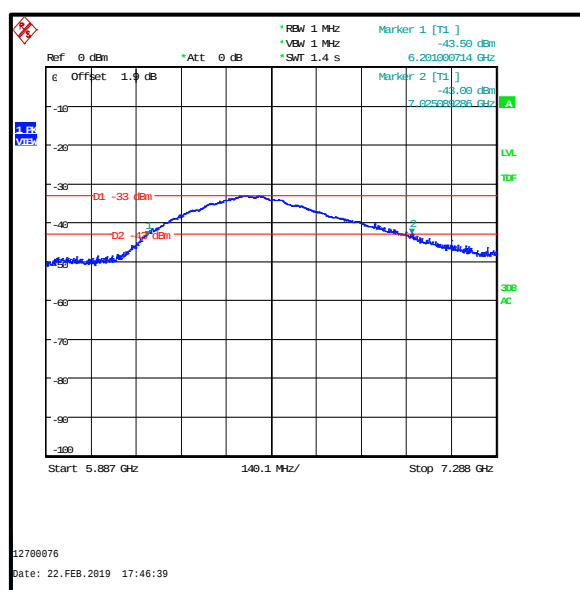
**Test Setup Diagram for Transmitter -10 dB Bandwidth**

**Transmitter -10 dB Bandwidth (continued)****Results: 15.250(a)**

| Lower -10 dB Frequency (MHz) | Upper -10 dB Frequency (MHz) | Lower Limit (MHz) | Upper Limit (MHz) | Result   |
|------------------------------|------------------------------|-------------------|-------------------|----------|
| 6201.001                     | 7025.089                     | 5925              | 7250              | Complied |

**Results: 15.250(b)**

| -10 dB Bandwidth (MHz) | Limit (MHz) | Margin (MHz) | Result   |
|------------------------|-------------|--------------|----------|
| 824.088                | >50         | 774.088      | Complied |

**Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No.    | Serial No.      | Date Calibration Due | Cal. Interval (Months) |
|-----------|------------------|-----------------|-------------|-----------------|----------------------|------------------------|
| M2003     | Thermohygrometer | Testo           | 608-H1      | 45046641        | 06 Jan 2020          | 12                     |
| K0017     | 3m RSE Chamber   | Rainford EMC    | N/A         | N/A             | 16 Feb 2020          | 12                     |
| M1995     | Test Receiver    | Rohde & Schwarz | ESU40       | 100428          | 10 Aug 2019          | 12                     |
| A2948     | Pre-Amplifier    | COM-POWER       | PAM-118A    | 551087          | 12 Feb 2020          | 12                     |
| A2889     | Antenna          | Schwarzbeck     | BBHA 9120 B | BBHA 9120 B 653 | 12 Feb 2020          | 12                     |

**5.2.3. Transmitter Frequency Stability (Temperature Variation)****Test Summary:**

|                                   |                  |                    |                  |
|-----------------------------------|------------------|--------------------|------------------|
| <b>Test Engineer:</b>             | Stefan Ho        | <b>Test Dates:</b> | 26 February 2019 |
| <b>Test Sample Serial Number:</b> | 0011CE0000000ED7 |                    |                  |

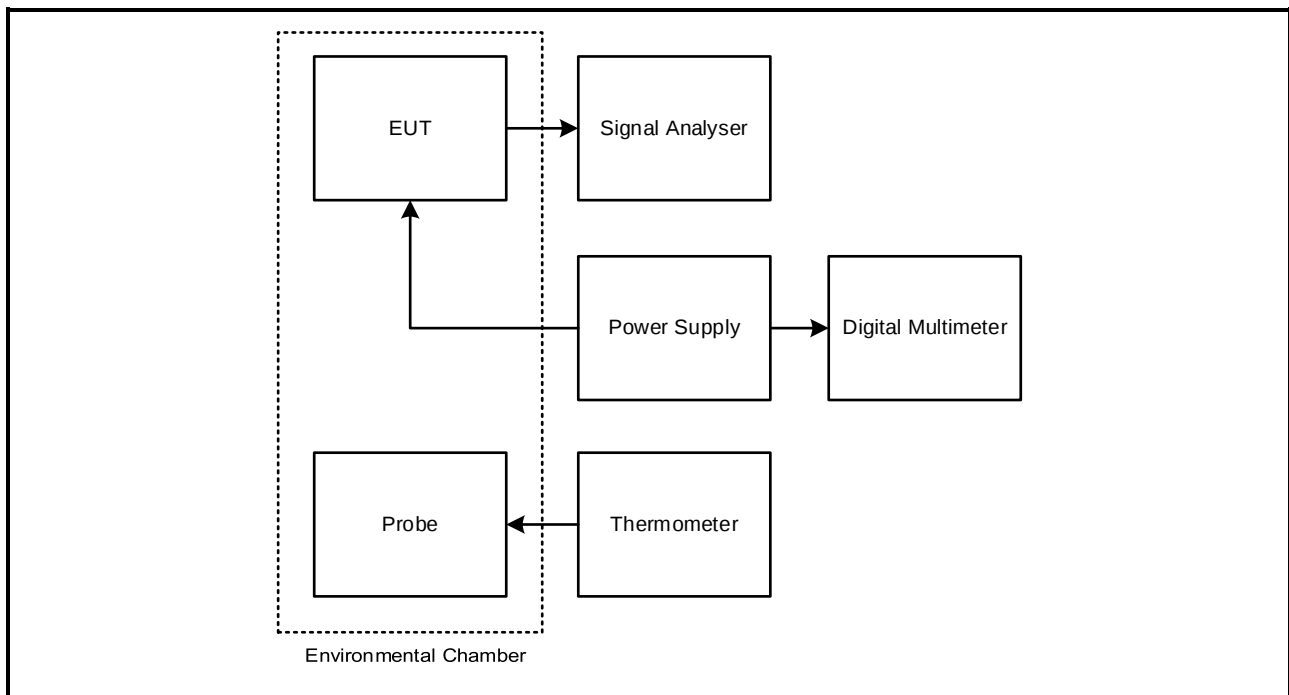
|                          |                                   |
|--------------------------|-----------------------------------|
| <b>FCC Reference:</b>    | Part 15.250(a)                    |
| <b>Test Method Used:</b> | Part 15.250(e)(4) and Notes below |

**Environmental Conditions:**

|                                       |    |
|---------------------------------------|----|
| <b>Ambient Temperature (°C):</b>      | 21 |
| <b>Ambient Relative Humidity (%):</b> | 33 |

**Note(s):**

1. The -10 dB bandwidth was measured using a peak detector in a 1 MHz resolution bandwidth and a video bandwidth greater than or equal to the resolution bandwidth. -10 dB points were measured at the manufacturer's stated minimum and maximum temperatures of -40°C and +85°C. Markers were placed on the lower and upper -10 dB points and the results recorded in the table below.
2. A sufficient stabilisation period was allowed at each temperature level and temperature was monitored throughout the test with a calibrated digital thermometer.
3. 5.0 VDC was the nominal voltage used throughout the test.
4. Result plots are archived on the UL VS LTD IT server and available for inspection if required.

**Test Setup Diagram for Transmitter Frequency Stability (Temperature Variation)**

**Transmitter Frequency Stability (Temperature Variation) (continued)****Results:**

| Temperature | Lower -10 dB Frequency (MHz) | Upper -10 dB Frequency (MHz) | Lower Limit (MHz) | Upper Limit (MHz) | Result   |
|-------------|------------------------------|------------------------------|-------------------|-------------------|----------|
| -40°C       | 6197.900                     | 7008.300                     | 5925              | 7250              | Complied |
| 21°C        | 6197.900                     | 6964.900                     | 5925              | 7250              | Complied |
| 85°C        | 6190.600                     | 6928.870                     | 5925              | 7250              | Complied |

**Test Equipment Used:**

| Asset No. | Instrument            | Manufacturer    | Type No.      | Serial No. | Date Calibration Due  | Cal. Interval (Months) |
|-----------|-----------------------|-----------------|---------------|------------|-----------------------|------------------------|
| M1835     | Signal Analyser       | Rohde & Schwarz | FSV30         | 103050     | 19 Mar 2019           | 12                     |
| A2524     | Attenuator            | AtlanTecRF      | AN18W5-10     | 832827#2   | Calibrated before use | -                      |
| M1815     | Environmental Chamber | Votsch          | VT4002        | 521/83083  | Calibrated before use | -                      |
| M2053     | Thermometer           | Fluke           | 52II          | 4232071WS  | 16 Aug 2019           | 12                     |
| M2002     | Thermohygrometer      | Testo           | 608-H1        | 45041825   | 06 Jan 2020           | 12                     |
| S0577     | DC power supply       | TTI             | CPX400S       | 436670     | Calibrated before use |                        |
| M1818     | Multimeter            | Fluke           | 79 Series III | 71811580   | 19 Apr 2019           | 12                     |

**5.2.4. Transmitter Frequency Stability (Voltage Variation)****Test Summary:**

|                            |                  |            |                  |
|----------------------------|------------------|------------|------------------|
| Test Engineer:             | Stefan Ho        | Test Date: | 26 February 2019 |
| Test Sample Serial Number: | 0011CE0000000ED7 |            |                  |

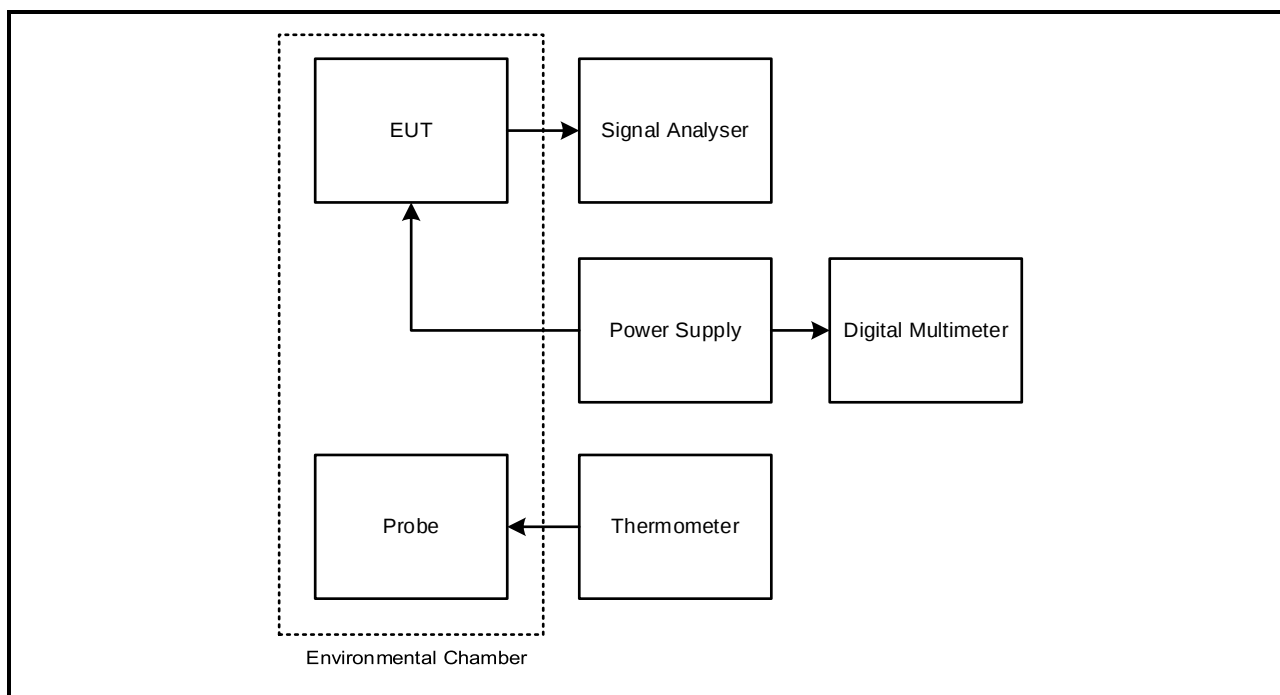
|                   |                                    |
|-------------------|------------------------------------|
| FCC Reference:    | Part 15.250(a)                     |
| Test Method Used: | Parts 15.250(e)(4) and Notes below |

**Environmental Conditions:**

|                        |    |
|------------------------|----|
| Temperature (°C):      | 21 |
| Relative Humidity (%): | 33 |

**Note(s):**

1. The -10 dB bandwidth was measured using a peak detector in a 1 MHz resolution bandwidth and a video bandwidth greater than or equal to the resolution bandwidth. -10 dB points were measured at the manufacturer's stated minimum, nominal and maximum voltages. Markers were placed on the lower and upper -10 dB points and the results recorded in the table below.
2. Voltage was monitored throughout the test with a calibrated digital voltmeter.
3. Result plots are archived on the UL VS LTD IT server and available for inspection if required.

**Test Setup Diagram for Transmitter Frequency Stability (Voltage Variation)**

**Transmitter Frequency Stability (Voltage Variation) (continued)****Results:**

| Voltage (DC) | Lower -10 dB Frequency (MHz) | Upper -10 dB Frequency (MHz) | Lower Limit (MHz) | Upper Limit (MHz) | Result   |
|--------------|------------------------------|------------------------------|-------------------|-------------------|----------|
| 2.30         | 6197.900                     | 6964.900                     | 5925              | 7250              | Complied |
| 5.00         | 6197.900                     | 6964.900                     | 5925              | 7250              | Complied |
| 5.25         | 6197.900                     | 6957.600                     | 5925              | 7250              | Complied |

**Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No.      | Serial No. | Date Calibration Due  | Cal. Interval (Months) |
|-----------|------------------|-----------------|---------------|------------|-----------------------|------------------------|
| M1835     | Signal Analyser  | Rohde & Schwarz | FSV30         | 103050     | 19 Mar 2019           | 12                     |
| A2524     | Attenuator       | AtlanTecRF      | AN18W5-10     | 832827#2   | Calibrated before use | -                      |
| S0577     | DC power supply  | TTI             | CPX400S       | 436670     | Calibrated before use | -                      |
| M1818     | Multimeter       | Fluke           | 79 Series III | 71811580   | 19 Apr 2019           | 12                     |
| M2002     | Thermohygrometer | Testo           | 608-H1        | 45041825   | 06 Jan 2020           | 12                     |

**5.2.5. Transmitter Radiated Emissions Below 960 MHz****Test Summary:**

|                                   |                  |                   |                  |
|-----------------------------------|------------------|-------------------|------------------|
| <b>Test Engineer:</b>             | Andrew Edwards   | <b>Test Date:</b> | 22 February 2019 |
| <b>Test Sample Serial Number:</b> | 0011CE0000000ED6 |                   |                  |

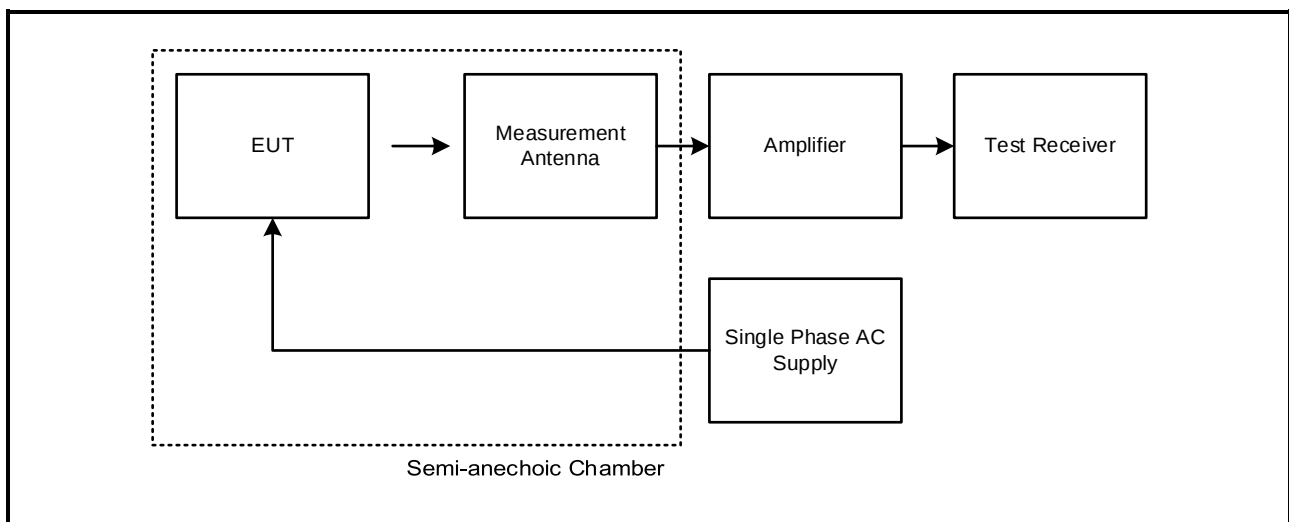
|                          |                                  |
|--------------------------|----------------------------------|
| <b>FCC Reference:</b>    | Parts 15.250(d)(4) & 15.209(a)   |
| <b>Test Method Used:</b> | ANSI C63.10 Sections 6.3 and 6.5 |
| <b>Frequency Range</b>   | 30 MHz to 960 MHz                |

**Environmental Conditions:**

|                               |    |
|-------------------------------|----|
| <b>Temperature (°C):</b>      | 24 |
| <b>Relative Humidity (%):</b> | 42 |

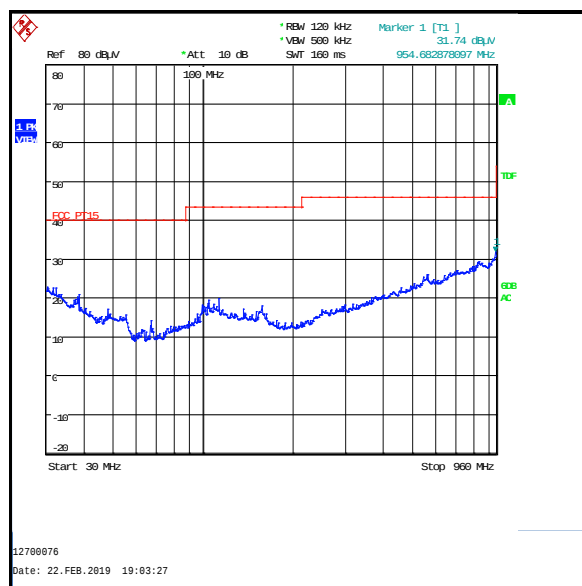
**Note(s):**

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. No spurious emissions were detected above the noise floor of the measuring receiver, therefore the highest peak noise floor reading of the measuring receiver was recorded in the table below.
3. 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.
4. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 120 kHz and video bandwidth 500 kHz. The sweep time was set to auto. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.

**Test Setup Diagram for Transmitter Radiated Emissions Below 960 MHz**

**Transmitter Radiated Emissions Below 960 MHz (continued)****Results: Peak**

| Frequency (MHz) | Antenna Polarity | Level (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Result   |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 954.683         | Vertical         | 31.7                 | 46.0                 | 14.3        | Complied |

**Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|-----------|------------------|-----------------|----------|------------|----------------------|------------------------|
| M2003     | Thermohygrometer | Testo           | 608-H1   | 45046641   | 06 Jan 2020          | 12                     |
| K0017     | 3m RSE Chamber   | Rainford EMC    | N/A      | N/A        | 16 Feb 2020          | 12                     |
| M1995     | Test Receiver    | Rohde & Schwarz | ESU40    | 100428     | 10 Aug 2019          | 12                     |
| A3167     | Pre-Amplifier    | COM-POWER       | PAM-103  | 18020010   | 11 Feb 2020          | 12                     |
| A3161     | Antenna          | Teseq           | CBL6111D | 50859      | 17 Dec 2019          | 12                     |
| A3113     | Attenuator       | AtlanTecRF      | AN18-06  | 219706#3   | 17 Dec 2019          | 12                     |

**5.2.6. Transmitter Radiated Emissions Above 960 MHz****Test Summary:**

|                                   |                  |                    |                                        |
|-----------------------------------|------------------|--------------------|----------------------------------------|
| <b>Test Engineer:</b>             | Andrew Edwards   | <b>Test Dates:</b> | 22 February 2019 &<br>26 February 2019 |
| <b>Test Sample Serial Number:</b> | 0011CE0000000ED6 |                    |                                        |

|                          |                                                          |
|--------------------------|----------------------------------------------------------|
| <b>FCC Reference:</b>    | Part 15.250(d)(1)(2)                                     |
| <b>Test Method Used:</b> | Part 15.250(e)(1) & ANSI C63.10 Sections 6.3, 6.6 & 10.3 |
| <b>Frequency Range</b>   | 960 MHz to 40 GHz                                        |

**Environmental Conditions:**

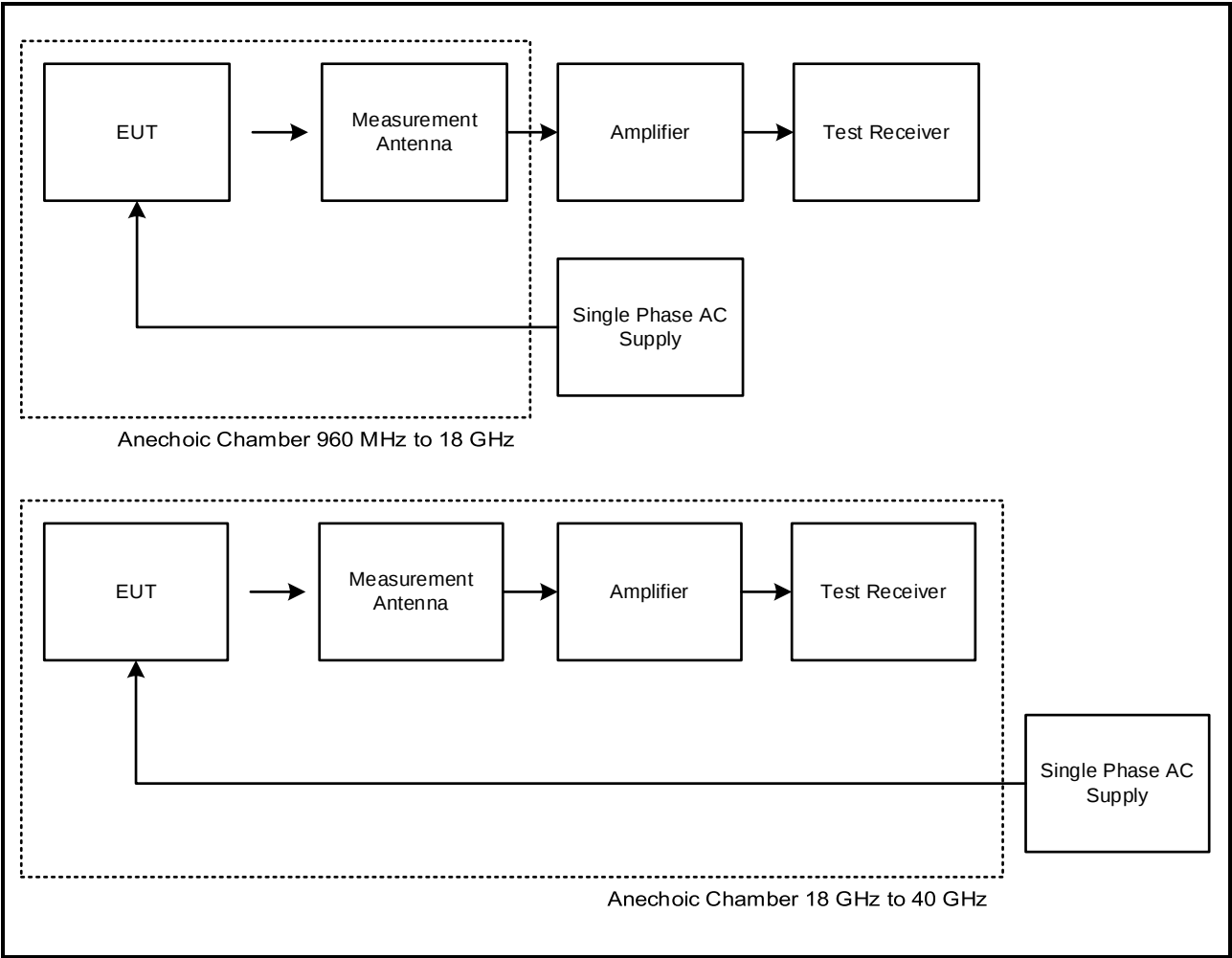
|                               |          |
|-------------------------------|----------|
| <b>Temperature (°C):</b>      | 23 to 24 |
| <b>Relative Humidity (%):</b> | 35 to 45 |

**Note(s):**

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The emission shown on the 5.887 GHz to 7.288 GHz plot at approximately 6509 MHz is the EUT fundamental.
3. No spurious emissions were detected above the noise floor of the measuring receiver therefore the highest noise floor reading of the measuring receiver was recorded in the table below.
4. In certain frequency ranges it was not possible to perform the measurements at the required distance due to the level of the measurement system noise floor compared with the limit. Therefore the test distance was reduced and a correction offset was applied to the measurements.
5. Pre-scans below 1 GHz were performed in a fully anechoic chamber (Asset Number K0017) at a distance of 2 metres. The EUT was placed at a height of 80 cm above the test chamber floor in the centre of the chamber turntable. The measurement antennas were placed at a fixed height of 1.5 metres above the test chamber floor, in line with the EUT.
6. Pre-scans above 1 GHz were performed in a fully anechoic chamber (Asset Numbers K0002 and K0017) at a distance between 0.15 to 3 metres (the test distance for each range is stated in Appendix 1 of this test report). The EUT was placed at a height of 1.5 metres above the test chamber floor in the centre of the chamber turntable. All measurement antennas were placed at a fixed height of 1.5 metres above the test chamber floor, in line with the EUT. Final measurements above 1 GHz were performed in a semi-anechoic chamber (Asset Number K0017) at a distance of 3 metres. The EUT was placed at a height of 1.5 metres 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 1 MHz. The sweep time was set in accordance with FCC Part 15.250(e)(1).
8. Due to limitations of the test receiver it was necessary to overlap the start and stop frequencies of pre-scan measurement ranges to satisfy the sweep point requirement in FCC Part 15.250(e)(1). Pre-scan measurements < 1 GHz were performed between 799 MHz to 1 GHz; a frequency line has been placed at 960 MHz to indicate the actual measurement start frequency. Appendix 1 of this report details the frequency range, sweep points and sweep time used.

**Transmitter Radiated Emissions Above 960 MHz (continued)**

**Test Setup Diagrams Radiated Emissions Above 960 MHz**

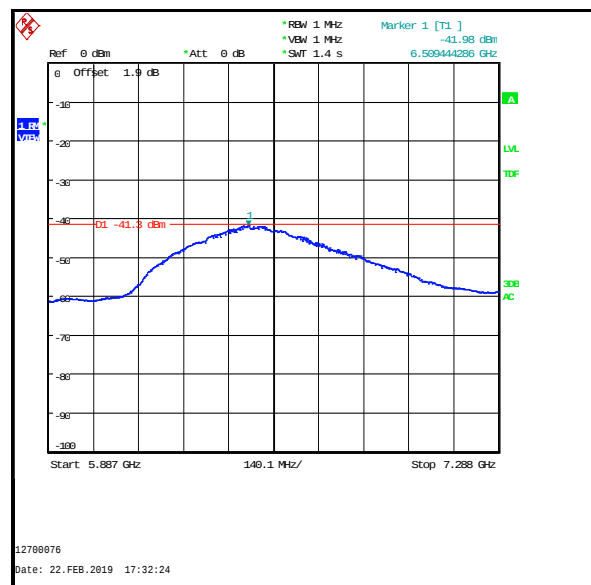
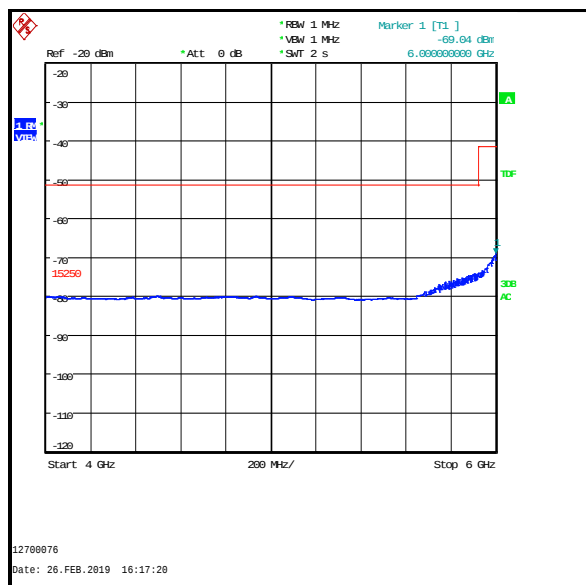
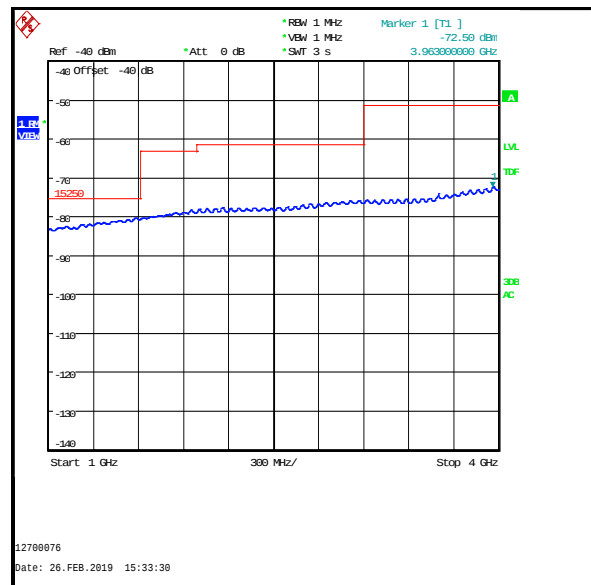
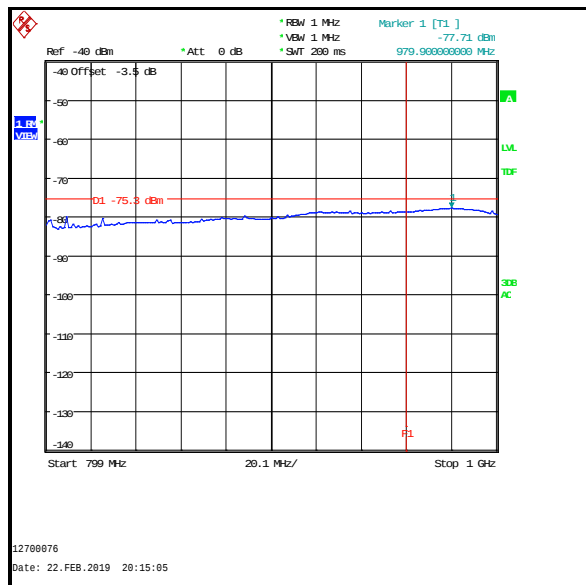


**Transmitter Radiated Emissions Above 960 MHz (continued)****Results: Part 15.250(d)(1)**

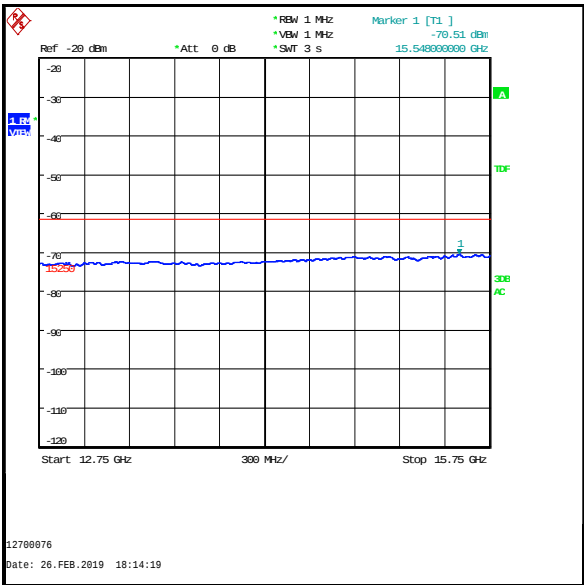
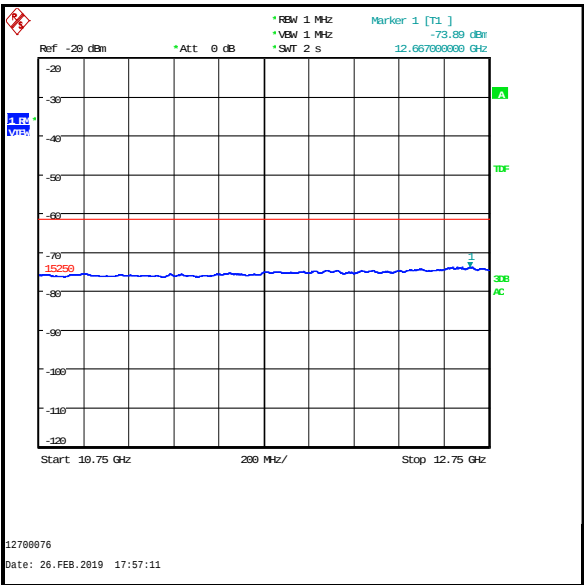
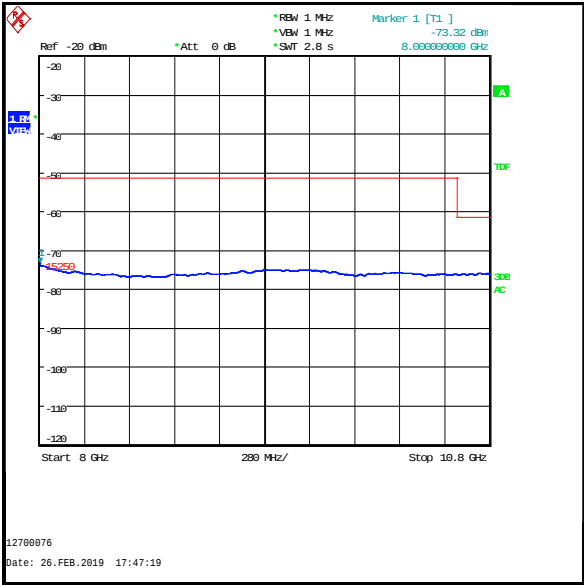
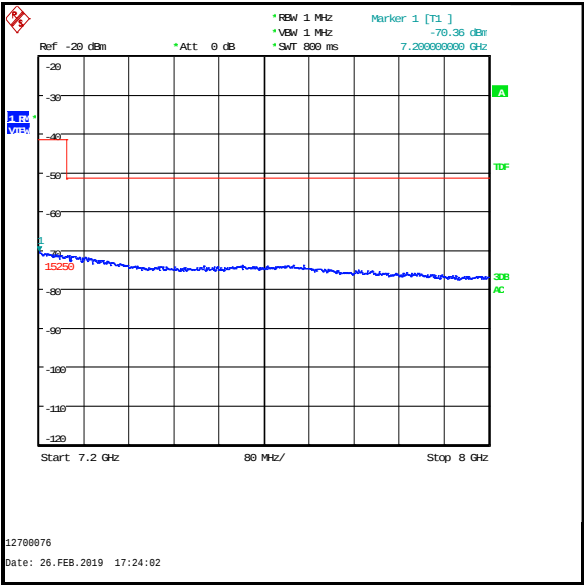
| Frequency (MHz) | Antenna Polarity | RMS Level (dBm) | Limit (dBm) | Margin (dB) | Result   |
|-----------------|------------------|-----------------|-------------|-------------|----------|
| 6509.444        | Vertical         | -42.0           | -41.3       | 0.7         | Complied |

**Results: Part 15.250(d)(2)**

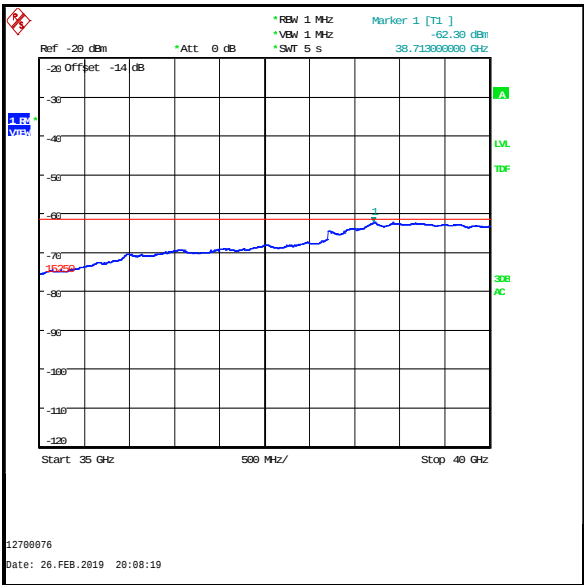
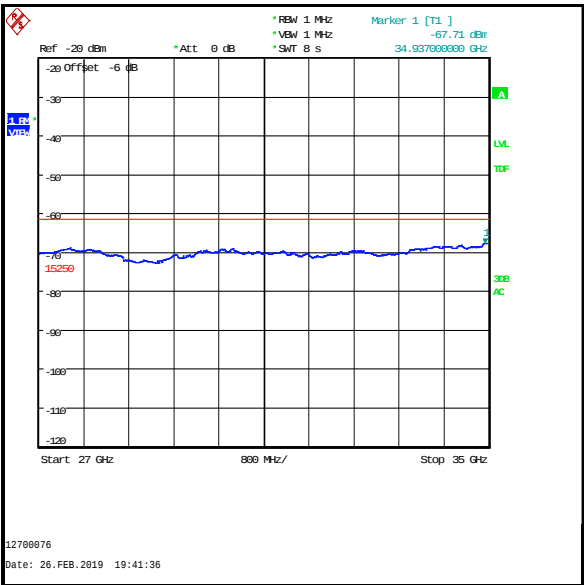
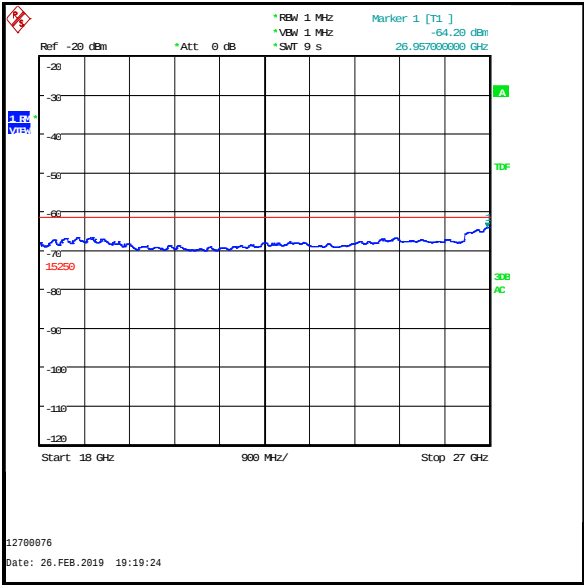
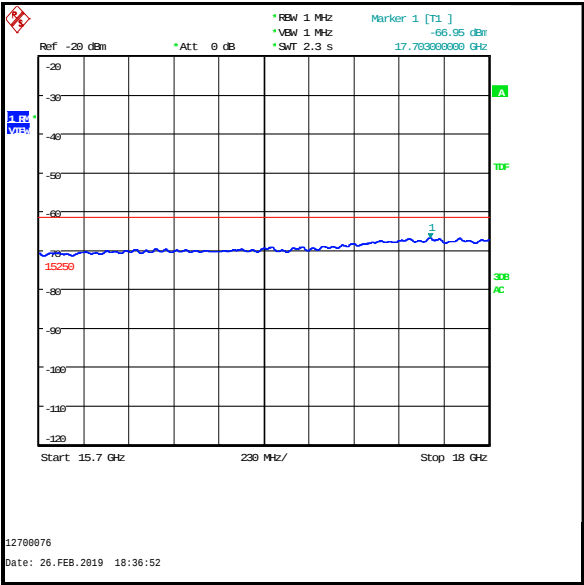
| Frequency (MHz) | Antenna Polarity | RMS Level (dBm) | Limit (dBm) | Margin (dB) | Result   |
|-----------------|------------------|-----------------|-------------|-------------|----------|
| 1239.525        | Vertical         | -91.3           | -85.3       | 6.0         | Complied |
| 1586.200        | Vertical         | -89.3           | -85.3       | 4.0         | Complied |



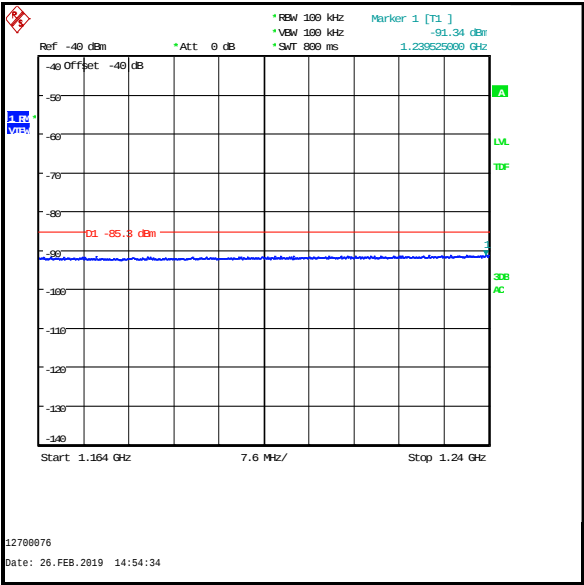
Transmitter Radiated Emissions Above 960 MHz (continued)



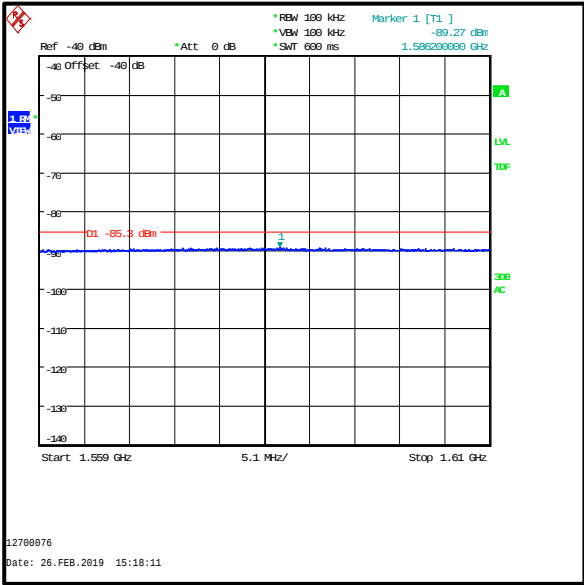
Transmitter Radiated Emissions Above 960 MHz (continued)



Transmitter Radiated Emissions Above 960 MHz (continued)



1164 to 1240 MHz  
-85.3 dBm limit / 100 kHz resolution bandwidth



1559 to 1610 MHz  
-85.3 dBm limit / 100 kHz resolution bandwidth

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

**Transmitter Radiated Emissions Above 960 MHz (continued)****Test Equipment Used:**

| Asset No. | Instrument           | Manufacturer    | Type No.    | Serial No.      | Date Calibration Due  | Cal. Interval (Months) |
|-----------|----------------------|-----------------|-------------|-----------------|-----------------------|------------------------|
| M2016     | Thermohygrometer     | Testo           | 608-H1      | 45046428        | 06 Jan 2020           | 12                     |
| K0002     | 3m RSE Chamber       | Rainford EMC    | N/A         | N/A             | 08 Feb 2020           | 12                     |
| M1874     | Test Receiver        | Rohde & Schwarz | ESU26       | 100553          | 04 Dec 2019           | 12                     |
| A3056     | Pre-Amplifier        | COM-POWER       | PAM-118A    | 18040040        | 08 Feb 2020           | 12                     |
| A2896     | Pre-Amplifier        | Schwarzbeck     | BBV 9721    | 9721 - 023      | 08 Feb 2020           | 12                     |
| A1818     | Antenna              | EMCO            | 3115        | 00075692        | 08 Feb 2020           | 12                     |
| A253      | Antenna              | Flann Microwave | 12240-20    | 128             | 08 Feb 2020           | 12                     |
| A254      | Antenna              | Flann Microwave | 14240-20    | 139             | 08 Feb 2020           | 12                     |
| A255      | Antenna              | Flann Microwave | 16240-20    | 519             | 08 Feb 2020           | 12                     |
| A256      | Antenna              | Flann Microwave | 18240-20    | 400             | 08 Feb 2020           | 12                     |
| A2895     | Antenna              | Schwarzbeck     | BBHA 9170   | 9170-728        | 08 Feb 2020           | 12                     |
| M2003     | Thermohygrometer     | Testo           | 608-H1      | 45046641        | 06 Jan 2020           | 12                     |
| K0017     | 3m RSE Chamber       | Rainford EMC    | N/A         | N/A             | 16 Feb 2020           | 12                     |
| M1995     | Test Receiver        | Rohde & Schwarz | ESU40       | 100428          | 10 Aug 2019           | 12                     |
| A2948     | Pre-Amplifier        | COM-POWER       | PAM-118A    | 551087          | 12 Feb 2020           | 12                     |
| A2889     | Antenna              | Schwarzbeck     | BBHA 9120 B | BBHA 9120 B 653 | 12 Feb 2020           | 12                     |
| G0614     | Signal Generator     | Rohde & Schwarz | SMB100A     | 177687          | 08 May 2020           | 36                     |
| A3097     | Antenna              | Link Microtek   | AM1-18HA    | 15275           | 30 Aug 2021           | 36                     |
| M1435     | Power Meter          | Hewlett Packard | 437B        | 3125U14631      | 03 May 2019           | 12                     |
| M1011     | Power Sensor         | Hewlett Packard | 8485D       | 2847A00141      | 05 Jul 2019           | 12                     |
| M1649     | Reference Attenuator | Hewlett Packard | 11708A      | 26584           | 02 Jul 2019           | 12                     |
| A2943     | Attenuator           | AtlanTecRF      | AN18W5-06   | 208147#2        | Calibrated Before Use | -                      |

**5.2.7. Transmitter Emissions Peak Level****Test Summary:**

|                                   |                  |                   |                  |
|-----------------------------------|------------------|-------------------|------------------|
| <b>Test Engineer:</b>             | Andrew Edwards   | <b>Test Date:</b> | 22 February 2019 |
| <b>Test Sample Serial Number:</b> | 0011CE0000000ED6 |                   |                  |

|                          |                                                |
|--------------------------|------------------------------------------------|
| <b>FCC Reference:</b>    | Part 15.250(d)(3)                              |
| <b>Test Method Used:</b> | Part 15.250(e)(2) & ANSI C63.10 Section 10.3.6 |

**Environmental Conditions:**

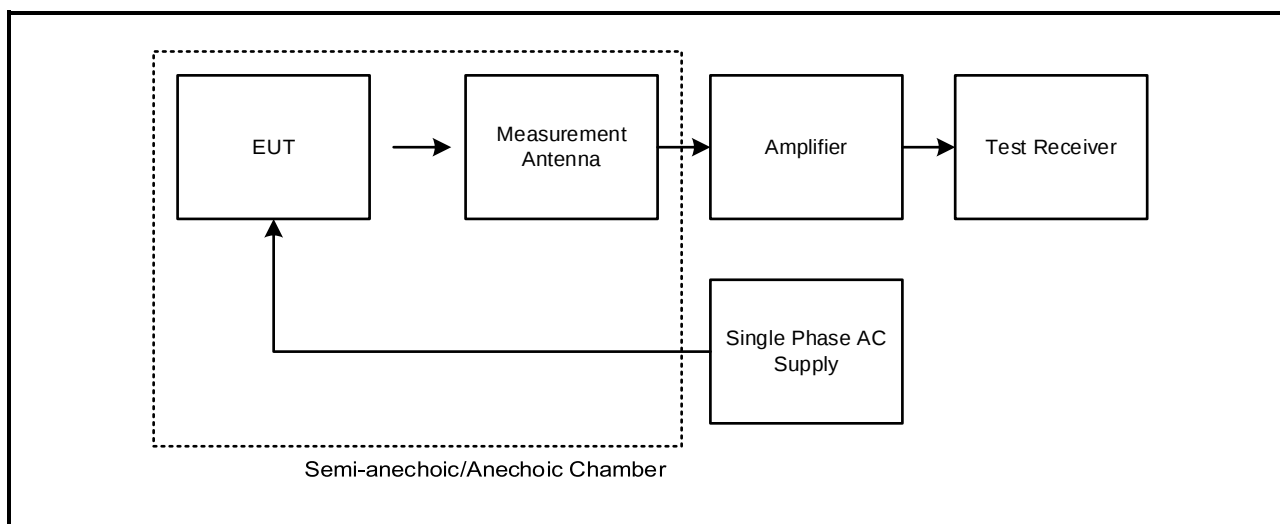
|                               |    |
|-------------------------------|----|
| <b>Temperature (°C):</b>      | 24 |
| <b>Relative Humidity (%):</b> | 41 |

**Note(s):**

1. The test receiver was set to the maximum available resolution bandwidth of 10 MHz and video bandwidth of 10 MHz. The measurement span was set to 1401 MHz and a sweep time of 1.4s with 1401 sweep points were used. The test receiver was set to the centre frequency of the peak signal. A peak detector and max hold function were used.
2. The measurement was performed using a 10 MHz RBW and in accordance with Part 15.250(d)(3) the limit has been calculated as:

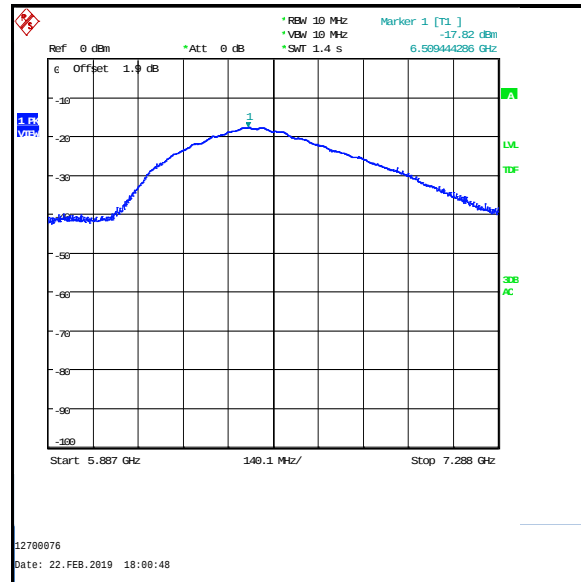
$$20 \text{ Log (RBW/50) dBm}$$

$$20 * \text{Log (10/50)} = -14.0 \text{ dBm/10 MHz}$$

**Test Setup Diagram for Transmitter Emissions Peak Level**

**Transmitter Emissions Peak Level (continued)****Results:**

| Frequency FM (MHz) | Antenna Polarity | Level (dBm/10 MHz) | Limit (dBm/10 MHz) | Margin (dB) | Result   |
|--------------------|------------------|--------------------|--------------------|-------------|----------|
| 6509.444           | Vertical         | -17.8              | -14.0              | 3.8         | Complied |

**Test Equipment Used:**

| Asset No. | Instrument           | Manufacturer    | Type No.    | Serial No.      | Date Calibration Due  | Cal. Interval (Months) |
|-----------|----------------------|-----------------|-------------|-----------------|-----------------------|------------------------|
| M2003     | Thermohygrometer     | Testo           | 608-H1      | 45046641        | 06 Jan 2020           | 12                     |
| K0017     | 3m RSE Chamber       | Rainford EMC    | N/A         | N/A             | 16 Feb 2020           | 12                     |
| M1995     | Test Receiver        | Rohde & Schwarz | ESU40       | 100428          | 10 Aug 2019           | 12                     |
| A2948     | Pre-Amplifier        | COM-POWER       | PAM-118A    | 551087          | 12 Feb 2020           | 12                     |
| A2889     | Antenna              | Schwarzbeck     | BBHA 9120 B | BBHA 9120 B 653 | 12 Feb 2020           | 12                     |
| A2889     | Antenna              | Schwarzbeck     | BBHA 9120 B | BBHA 9120 B 653 | 12 Feb 2020           | 12                     |
| G0614     | Signal Generator     | Rohde & Schwarz | SMB100A     | 177687          | 08 May 2020           | 36                     |
| A3097     | Antenna              | Link Microtek   | AM1-18HA    | 15275           | 30 Aug 2021           | 36                     |
| M1435     | Power Meter          | Hewlett Packard | 437B        | 3125U14631      | 03 May 2019           | 12                     |
| M1011     | Power Sensor         | Hewlett Packard | 8485D       | 2847A00141      | 05 Jul 2019           | 12                     |
| M1649     | Reference Attenuator | Hewlett Packard | 11708A      | 26584           | 02 Jul 2019           | 12                     |
| A2943     | Attenuator           | AtlanTecRF      | AN18W5-06   | 208147#2        | Calibrated Before Use | -                      |

## 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%                  | ±2.40 dB               |
| Transmitter -10 dB Bandwidth     | 5.925 GHz to 7.250 GHz | 95%                  | ±4.59 %                |
| Frequency Stability              | 5.925 GHz to 7.250 GHz | 95%                  | ±4.59 %                |
| Radiated Spurious Emissions      | 30 MHz to 1 GHz        | 95%                  | ±4.65 dB               |
| Radiated Spurious Emissions      | 1 GHz to 40 GHz        | 95%                  | ±2.54 dB               |
| Transmitter Emissions Peak Level | 5.925 GHz to 7.250 GHz | 95%                  | ±2.54 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            | 1, 6, 8          | 3.2, 3.4, 4.1, 4.2 | Replaced references to 'Ultra Wide Band' with 'Wide Band Transmitter'. |

## 8. Appendix 1

In accordance with FCC 15.250(e)(1), the test receiver span, sweep time and sweep points must be set to achieve a 1 ms dwell time over each 1 MHz segment. The test receiver settings used during testing are detailed in the table below.

### Using a 1 MHz Bandwidth

| Frequency Range (GHz) | Span (MHz) | Sweep Points | Sweep Time (s) | Test Distance (m) |
|-----------------------|------------|--------------|----------------|-------------------|
| 0.03 to 0.96          | 930 MHz    | 625          | Auto coupled   | 3.0               |
| 0.799 to 1            | 201        | 201          | 0.2            | 2.0               |
| 1 to 4                | 3000       | 3001         | 3.0            | 1.0               |
| 4 to 6                | 2000       | 2001         | 2.0            | 1.0               |
| 5.887 to 7.288        | 1401       | 1401         | 1.4            | 3.0               |
| 7.2 to 8              | 800        | 801          | 0.8            | 1.0               |
| 8 to 10.8             | 2800       | 2801         | 2.8            | 1.0               |
| 10.75 to 12.75        | 2000       | 2001         | 2.0            | 1.0               |
| 12.75 to 15.75        | 3000       | 3001         | 3.0            | 1.0               |
| 15.7 to 18            | 2300       | 2301         | 2.3            | 1.0               |
| 18 to 27              | 9000       | 9001         | 9.0            | 1.0               |
| 27 to 35              | 8000       | 8001         | 8.0            | 0.5               |
| 35 to 40              | 5000       | 5001         | 5.0            | 0.2               |

### Using a 100 kHz Bandwidth

| Frequency Range (GHz) | Span (MHz) | Sweep Points | Sweep Time (s) | Test Distance (m) |
|-----------------------|------------|--------------|----------------|-------------------|
| 1.164 to 1.24         | 76         | 801          | 0.8            | 1.0               |
| 1.559 to 1.61         | 51         | 601          | 0.6            | 1.0               |

--- END OF REPORT ---