



## Radio Test Report

**Eccel Technology Ltd**

**Action Cam User Interface RFID Unit**

**000443**

47 CFR Part 15.225 Effective Date 1st October 2018

DXC: Part 15 Low Power Communication Device Transmitter

Test Date: 5th June 2020 to 30th June 2020

Report Number: 06-12244-1-20 Issue 02

Supersedes report: 06-12244-1-20 issue 01

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## Certificate of Test 12244-1

The equipment noted below has been fully tested by R.N. Electronics Limited and, where appropriate, conforms to the relevant subpart of 47 CFR Part 15C. This is a certificate of test only and should not be confused with an equipment authorisation. Other standards may also apply.

|                                                         |                                                                                                               |
|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Equipment:                                              | Action Cam User Interface RFID Unit                                                                           |
| Model Number:                                           | 000443                                                                                                        |
| Unique Serial Number:                                   | 000001                                                                                                        |
| Applicant:                                              | Eccel Technology Ltd<br>198 Station Road, Glenfield<br>Leicester, Leicestershire<br>LE3 8GT                   |
| Full measurement results are detailed in Report Number: | 06-12244-1-20 Issue 02                                                                                        |
| Test Standards:                                         | 47 CFR Part 15.225 Effective Date 1st October 2018<br>DXX: Part 15 Low Power Communication Device Transmitter |

### NOTE:

Certain tests were not performed based upon manufacturer's declarations. Certain other requirements are subject to manufacturer declaration only and have not been tested/verified. For details refer to section 3 of this report.

### DEVIATIONS:

No deviations have been applied.

This certificate relates only to the unit tested as identified by a unique serial number and in the condition at the time it was tested. It does not relate to any other similar equipment and performance of the product before or after the test cannot be guaranteed. Whilst every effort is made to assure quality of testing, type tests are not exhaustive and although no non-conformances may be found, this doesn't exclude the possibility of unit not meeting the intentions of the standard or the requirements of the Federal Regulations, particularly under different conditions to those during testing. Any compliance statements are made reliant on (a) the application of the product and use of the assigned band being acceptable to the FCC and (b) the modes of operation as instructed to us by the Customer based on their specific knowledge of the application and functionality of the EUT. Statements of compliance, where measurements were made, do not include the measurement uncertainty. The measurement uncertainty, where stated, is the expanded uncertainty based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

Date Of Test: 5th June 2020 to 30th June 2020

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2360

## 0 Revision History

| Issue Number | Revision History                                                                 | Page Reference(s) |
|--------------|----------------------------------------------------------------------------------|-------------------|
| 01           | First Issue                                                                      | -                 |
| 02           | <i>Updated report issued date</i>                                                | 5                 |
|              | <i>Added 15.205 and 15.209 references to table</i>                               | 10                |
|              | <i>Edited text to confirm use of suitable antenna load per FCC requirements.</i> | 13                |
|              | <i>Added extra radiated emissions photo</i>                                      | 68                |

## 1 Contents

|      |                                                                        |    |
|------|------------------------------------------------------------------------|----|
| 0    | Revision History.....                                                  | 3  |
| 1    | Contents.....                                                          | 4  |
| 2    | Equipment under test (EUT) .....                                       | 5  |
| 2.1  | Equipment specification .....                                          | 5  |
| 2.2  | Configurations for testing.....                                        | 6  |
| 2.3  | Functional description .....                                           | 7  |
| 2.4  | Modes of operation .....                                               | 7  |
| 2.5  | Emissions configuration .....                                          | 8  |
| 3    | Summary of test results.....                                           | 10 |
| 4    | Specifications .....                                                   | 11 |
| 4.1  | Relevant standards .....                                               | 11 |
| 4.2  | Deviations .....                                                       | 11 |
| 4.3  | Tests at extremes of temperature & voltage .....                       | 11 |
| 4.4  | Test fixtures .....                                                    | 11 |
| 5    | Tests, methods and results.....                                        | 12 |
| 5.1  | AC power line conducted emissions .....                                | 12 |
| 5.2  | Radiated emissions 9 - 150 kHz .....                                   | 16 |
| 5.3  | Radiated emissions 150 kHz - 30 MHz .....                              | 18 |
| 5.4  | Radiated emissions 30 MHz -1 GHz .....                                 | 21 |
| 5.5  | Radiated emissions above 1 GHz .....                                   | 24 |
| 5.6  | Intentional radiator field strength .....                              | 25 |
| 5.7  | Occupied bandwidth.....                                                | 27 |
| 5.8  | Spectrum mask .....                                                    | 30 |
| 5.9  | Frequency stability .....                                              | 32 |
| 6    | Plots/Graphical results.....                                           | 34 |
| 6.1  | AC power line conducted emissions.....                                 | 34 |
| 6.2  | Radiated emissions 9 - 150 kHz .....                                   | 40 |
| 6.3  | Radiated emissions 150 kHz - 30 MHz .....                              | 42 |
| 6.4  | Radiated emissions 30 MHz -1 GHz.....                                  | 44 |
| 6.5  | Occupied bandwidth.....                                                | 46 |
| 6.6  | Spectrum mask.....                                                     | 48 |
| 7    | Explanatory Notes .....                                                | 50 |
| 7.1  | Explanation of Table of Signals Measured.....                          | 50 |
| 7.2  | Explanation of limit line calculations for radiated measurements ..... | 51 |
| 8    | Photographs .....                                                      | 53 |
| 8.1  | EUT Front View.....                                                    | 53 |
| 8.2  | EUT Reverse Angle .....                                                | 55 |
| 8.3  | EUT Left side View.....                                                | 56 |
| 8.4  | EUT Right side View .....                                              | 57 |
| 8.5  | EUT Antenna .....                                                      | 58 |
| 8.6  | EUT Display .....                                                      | 59 |
| 8.7  | EUT Internal photos .....                                              | 60 |
| 8.8  | EUT ID Label .....                                                     | 64 |
| 8.9  | EUT Chassis .....                                                      | 64 |
| 8.10 | AC power line conducted emissions.....                                 | 65 |
| 8.11 | Radiated emissions 150 kHz - 30 MHz .....                              | 66 |
| 8.12 | Radiated emissions 30 MHz -1 GHz.....                                  | 68 |
| 8.13 | Radiated emission diagrams .....                                       | 69 |
| 8.14 | AC powerline conducted emission diagram .....                          | 70 |
| 9    | Test equipment calibration list .....                                  | 71 |
| 10   | Auxiliary and peripheral equipment.....                                | 72 |
| 10.1 | Customer supplied equipment.....                                       | 72 |
| 10.2 | RN Electronics supplied equipment .....                                | 72 |
| 11   | Condition of the equipment tested .....                                | 73 |
| 11.1 | Modifications before test.....                                         | 73 |
| 11.2 | Modifications during test.....                                         | 74 |
| 12   | Description of test sites.....                                         | 75 |
| 13   | Abbreviations and units .....                                          | 76 |

## 2 Equipment under test (EUT)

### 2.1 Equipment specification

|                           |                                                                                                          |                   |
|---------------------------|----------------------------------------------------------------------------------------------------------|-------------------|
| Applicant                 | Eccel Technology Ltd<br>198 Station Road<br>Glenfield<br>Leicester<br>Leicestershire<br>LE3 8GT          |                   |
| Manufacturer of EUT       | Eccel Technology Ltd                                                                                     |                   |
| Full Name of EUT          | Action Cam User Interface RFID Unit                                                                      |                   |
| Model Number of EUT       | 000443                                                                                                   |                   |
| Serial Number of EUT      | 000001                                                                                                   |                   |
| Date Received             | 29th May 2020                                                                                            |                   |
| Date of Test:             | 5th June 2020 to 30th June 2020                                                                          |                   |
| Purpose of Test           | To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations. |                   |
| Date Report Issued        | 1 <sup>st</sup> October 2020                                                                             |                   |
| Main Function             | RFID Waypoint Recorder and user instruction display.                                                     |                   |
| Information Specification | Height                                                                                                   | 142 mm            |
|                           | Width                                                                                                    | 216 mm            |
|                           | Depth                                                                                                    | 31 mm             |
|                           | Weight                                                                                                   | 0.5 kg            |
|                           | Voltage                                                                                                  | 44 - 57 VDC (PoE) |
|                           | Current                                                                                                  | Not declared      |

## 2.2 Configurations for testing

| General Parameters                 |                                                             |
|------------------------------------|-------------------------------------------------------------|
| EUT Normal use position            | Wall mounted                                                |
| Choice of model(s) for type tests  | Sample                                                      |
| Antenna details                    | Integral PCB track antenna                                  |
| Antenna port                       | No                                                          |
| Baseband Data port (yes/no)?       | No                                                          |
| Highest Signal generated in EUT    | 50 MHz                                                      |
| Lowest Signal generated in EUT     | 12 MHz                                                      |
| Hardware Version                   | 1.3                                                         |
| Software Version                   | Not applicable                                              |
| Firmware Version                   | 1.3                                                         |
| Type of Equipment                  | User interface                                              |
| Technology Type                    | RFID                                                        |
| Geo-location (yes/no)              | No                                                          |
| TX Parameters                      |                                                             |
| Alignment range – transmitter      | 13.56 MHz                                                   |
| EUT Declared Modulation Parameters | ISO15693                                                    |
| EUT Declared Power level           | Not declared                                                |
| EUT Declared Signal Bandwidths     | Not declared                                                |
| EUT Declared Channel Spacing's     | Single channel                                              |
| EUT Declared Duty Cycle            | 100%                                                        |
| Unmodulated carrier available?     | No                                                          |
| Declared frequency stability       | 20 ppm                                                      |
| RX Parameters                      |                                                             |
| Alignment range – receiver         | 13.56 MHz                                                   |
| EUT Declared RX Signal Bandwidth   | Not declared                                                |
| Receiver Signal Level (RSL)        | Not applicable                                              |
| Method of Monitoring Receiver BER  | Not applicable                                              |
| FCC Parameters                     |                                                             |
| FCC Transmitter Class              | FCC DXX: Part 15 Low Power Communication Device Transmitter |

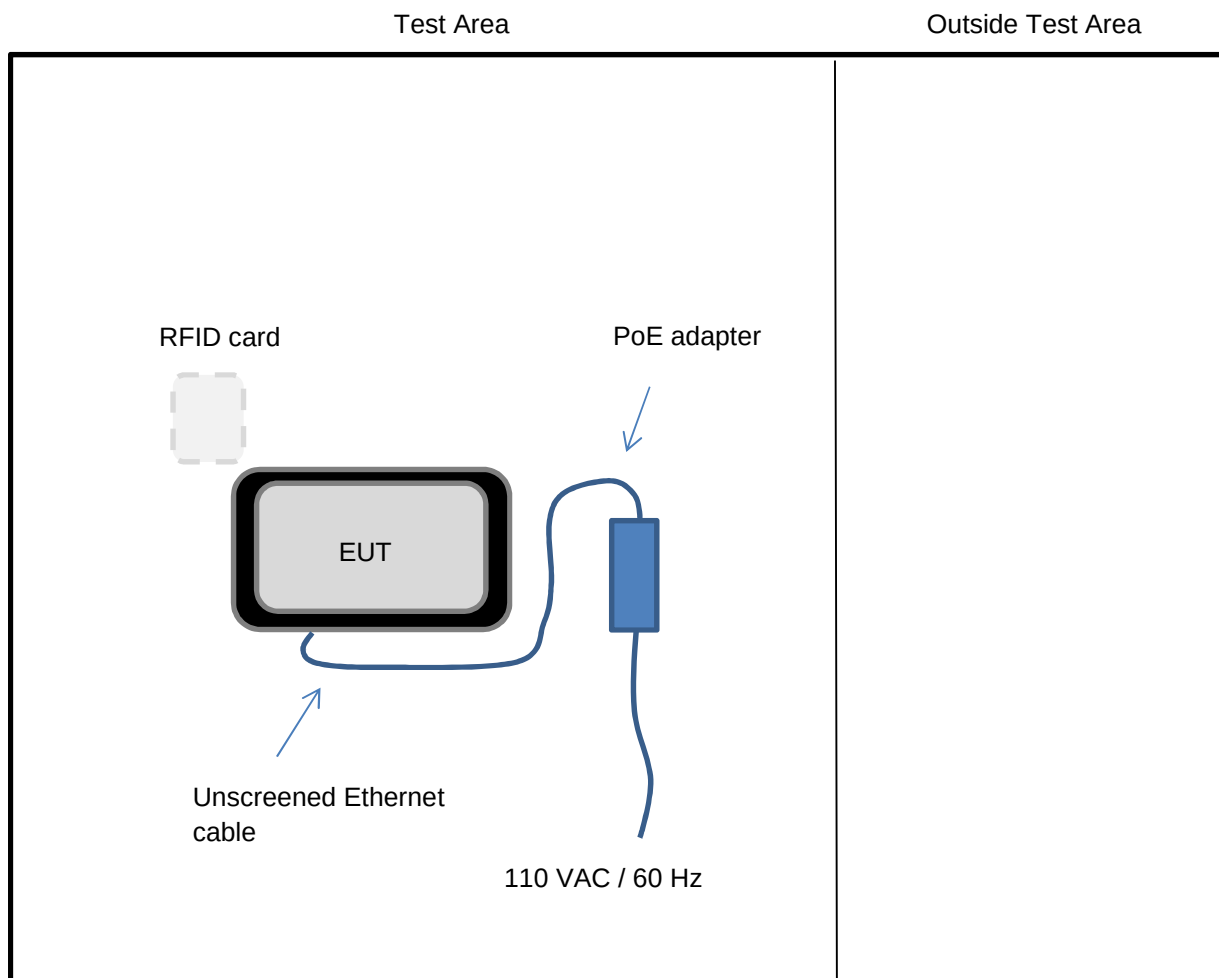
## 2.3 Functional description

The EUT is an LCD display with RFID reader. The EUT is powered using an off-the-shelf Power over Ethernet (PoE) adapter via the EUT's Ethernet port.

## 2.4 Modes of operation

| Mode Reference     | Description                                                                                                 | Used for testing |
|--------------------|-------------------------------------------------------------------------------------------------------------|------------------|
| TX (No tag)        | The RFID reader is active and transmitting at 13.56 MHz. The reader is awaiting presentation of an RFID tag | Yes              |
| TX (Tag presented) | The RFID reader is active and transmitting at 13.56 MHz. An RFID tag is presented to the reader.            | Yes              |

## 2.5 Emissions configuration



The EUT was powered using an off the shelf Power over Ethernet adapter (PoE). The PoE adapter was powered using 110 VAC 60 Hz power source. The EUT's RFID radio was continuously transmitting upon power-up. For the purposes of test, the applicant provided a typical RFID card used with the EUT. To determine 'worst-case' emissions, a pre-test was performed where the EUT was tested with and without the RFID card in close proximity. It was found that there was no discernible difference between these modes and therefore for full test the EUT was tested without presentation of the RFID card.

For tests performed at extremes of temperature and voltage, a modified Ethernet cable was used so that a bench power supply could be connected so that the supply voltage could be set to the levels as stated in section 4.3.

The frequency of the RFID reader was 13.56 MHz (single frequency) and the power was set by the applicant to the maximum setting available to the end-user.

### 2.5.1 Signal leads

| Port Name | Cable Type | Connected |
|-----------|------------|-----------|
| Debug     | 6-way      | No*       |
| Power     | RJ45       | Yes       |

\*The applicant states that debug port is used for firmware upgrade and debug purposes only and not used by the end-user.

### 3 Summary of test results

The Action Cam User Interface RFID Unit, 000443 was tested for compliance to the following standard :

47 CFR Part 15.225 Effective Date 1st October 2018  
DXX: Part 15 Low Power Communication Device Transmitter

Any compliance statements are made reliant on (a) the application of the product and use of the assigned band being acceptable to the FCC and (b) the modes of operation as instructed to us by the Customer based on their specific knowledge of the application and functionality of the EUT. Whilst every effort is made to assure quality of testing, type tests are not exhaustive and although no non-conformances may be found, this doesn't exclude the possibility of equipment not meeting the intentions of the standard or the essential requirements of the directive, particularly under different conditions to those during testing. Statements of compliance, where measurements were made, do not include the measurement uncertainty. The measurement uncertainty, where stated, is the expanded uncertainty based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

| Title                                  | References                                     | Results                     |
|----------------------------------------|------------------------------------------------|-----------------------------|
| <b>Transmitter Tests</b>               |                                                |                             |
| 1. AC power line conducted emissions   | 47 CFR Part 15C Part 15.207                    | PASSED                      |
| 2. Radiated emissions 9 - 150 kHz      | 47 CFR Part 15C Part 15.209, 15.205            | PASSED                      |
| 3. Radiated emissions 150 kHz - 30 MHz | 47 CFR Part 15C Part 15.209, 15.205            | PASSED                      |
| 4. Radiated emissions 30 MHz -1 GHz    | 47 CFR Part 15C Part 15.225(d), 15.209, 15.205 | PASSED                      |
| 5. Radiated emissions above 1 GHz      | 47 CFR Part 15C Part 15.209, 15.205            | NOT APPLICABLE <sup>1</sup> |
| 6. Intentional radiator field strength | 47 CFR Part 15C Part 15.225(a)                 | PASSED                      |
| 7. Occupied bandwidth                  | 47 CFR Part 15C Part 15.215                    | PASSED                      |
| 8. Spectrum mask                       | 47 CFR Part 15C Part 15.225                    | PASSED                      |
| 9. Frequency stability                 | 47 CFR Part 15C Part 15.225(e)                 | PASSED                      |

<sup>1</sup> Radiated emissions measurements above 1 GHz are not required. The highest frequency generated or used within the equipment is 50 MHz.

## 4 Specifications

The tests were performed and operated in accordance with R.N. Electronics Ltd procedures and the relevant standards listed below.

### 4.1 Relevant standards

| Ref.  | Standard Number | Version | Description                                                                                                                                                         |
|-------|-----------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4.1.1 | 47 CFR Part 15C | 2018    | Federal Communications Commission PART 15 – RADIO FREQUENCY DEVICES                                                                                                 |
| 4.1.2 | ANSI C63.10     | 2013    | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices                                                                      |
| 4.1.3 | ANSI C63.4      | 2014    | American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz |

### 4.2 Deviations

No deviations were applied

### 4.3 Tests at extremes of temperature & voltage

The following test conditions were used to simulate testing at nominal or extremes.

| Temperature Test Conditions |        | Voltage Test Conditions |        |
|-----------------------------|--------|-------------------------|--------|
| T nominal                   | 20 °C  | V nominal               | 48V DC |
| T minimum                   | -20 °C | V minimum               | 44V DC |
| T maximum                   | 50 °C  | V maximum               | 57V DC |

Extremes of voltage are based on the standard maximum and minimum voltages required for PoE devices.

Extremes of temperature are based upon the requirements of 47 CFR Part 15C

The ambient test conditions of humidity and pressure in the laboratory were as specified in each specific test section within this report

### 4.4 Test fixtures

In order to measure RF parameters at temperature extremes, the EUT was tested in a temperature controlled chamber as follows:

A test fixture was used for testing.

## 5 Tests, methods and results

### 5.1 AC power line conducted emissions

#### 5.1.1 Test methods

|                    |                                                              |
|--------------------|--------------------------------------------------------------|
| Test Requirements: | 47 CFR Part 15C Part 15.207 [Reference 4.1.1 of this report] |
| Test Method:       | ANSI C63.10 Clause 6.2 [Reference 4.1.2 of this report]      |
| Limits:            | 47 CFR Part 15C Part 15.207 [Reference 4.1.1 of this report] |

#### 5.1.2 Configuration of EUT

The EUT was placed on a wooden table 0.8m above the ground plane and connected to a LISN via a 1m mains cable. Details of the Peripheral and Ancillary Equipment connected for this test are listed in section 10.

During the initial scan, there was no discernible difference between test modes so for full-test the EUT was tested in TX (No tag) mode.

#### 5.1.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted in the 'Test Equipment' Section. Measurements were made on the live and neutral conductors using both average and quasi-peak detection.

At least 6 signals within 20dB and/or all signals within 10dB of the limit were investigated.

Tests were performed in Test Site F.

#### 5.1.4 Test equipment

E150, E035, ZSW1, E624, E411

See Section 9 for more details

#### 5.1.5 Test results

|                                 |         |
|---------------------------------|---------|
| Temperature of test environment | 20°C    |
| Humidity of test environment    | 50%     |
| Pressure of test environment    | 101 kPa |

|                 |                   |
|-----------------|-------------------|
| Band            | 13.110-14.010 MHz |
| Power Level     | Maximum           |
| Channel Spacing | Single Channel    |
| Mod Scheme      | ASK               |
| Single channel  | 13.56 MHz         |

|                                               |
|-----------------------------------------------|
| Plot refs                                     |
| 12244-1 Cond 1 AC Live 150k-30M Average       |
| 12244-1 Cond 1 AC Live 150k-30M Quasi-Peak    |
| 12244-1 Cond 1 AC Neutral 150k-30M Average    |
| 12244-1 Cond 1 AC Neutral 150k-30M Quasi-Peak |

**Table of signals measured for Cond 1 AC Live 150k-30M**

| Signal No. | Freq (MHz)    | Peak Amp (dBuV) | QP Amp (dBuV) | QP -Lim (dB) | AV Amp (dBuV) | AV -Lim (dB) |
|------------|---------------|-----------------|---------------|--------------|---------------|--------------|
| 1          | 0.173         | 56.2            | 50.2          | -14.6        | 30.4          | -24.4        |
| 2          | 0.220         | 50.4            | 44.1          | -18.7        | 24.9          | -27.9        |
| 3          | 0.309         | 42.6            | 35.1          | -24.9        | 19.4          | -30.6        |
| 4          | 0.336         | 38.0            | 32.5          | -26.8        | 11.0          | -38.3        |
| 5          | 0.416         | 41.2            | 37.5          | -20.0        | 35.3          | -12.2        |
| 6          | 8.436         | 38.1            | 35.0          | -25.0        | 28.7          | -21.3        |
| 7          | <b>13.561</b> | <b>70.2</b>     | <b>70.1</b>   | <b>10.1</b>  | <b>69.4</b>   | <b>19.4*</b> |

**Table of signals measured for Cond 1 AC Neutral 150k-30M**

| Signal No. | Freq (MHz)    | Peak Amp (dBuV) | QP Amp (dBuV) | QP -Lim (dB) | AV Amp (dBuV) | AV -Lim (dB) |
|------------|---------------|-----------------|---------------|--------------|---------------|--------------|
| 1          | 0.166         | 57.0            | 50.8          | -14.4        | 30.8          | -24.4        |
| 2          | 0.169         | 56.2            | 49.7          | -15.3        | 30.6          | -24.4        |
| 3          | 0.211         | 52.0            | 45.1          | -18.1        | 26.5          | -26.7        |
| 4          | 0.223         | 50.4            | 43.3          | -19.4        | 23.7          | -29.0        |
| 5          | 0.312         | 41.3            | 34.9          | -25.0        | 15.2          | -34.7        |
| 6          | 0.393         | 41.7            | 39.3          | -18.7        | 37.6          | -10.4        |
| 7          | 8.307         | 39.0            | 34.9          | -25.1        | 28.7          | -21.3        |
| 8          | <b>13.561</b> | <b>70.4</b>     | <b>70.3</b>   | <b>10.3</b>  | <b>69.5</b>   | <b>19.5*</b> |

\*The results tables above show the fundamental frequency of the EUT at 13.56 MHz exceeding the limit. This was due to the EUTs integral antenna radiating the fundamental carrier on to the 1 metre mains lead used as part of the test setup. To confirm that the emission was radiated by the EUTs' radio and not conducted, the test was repeated with the EUTs' integral antenna terminated in a suitable load per FCC requirements.

Please refer to the following result tables for the test with the antenna disconnected.

|                 |                            |
|-----------------|----------------------------|
| Band            | 13.110-14.010 MHz          |
| Power Level     | Maximum                    |
| Channel Spacing | Single Channel             |
| Mod Scheme      | ASK (antenna disconnected) |
| Single channel  | 13.56 MHz                  |

|                                               |
|-----------------------------------------------|
| Plot refs                                     |
| 12244-1 Cond 2 AC Live 150k-30M Average       |
| 12244-1 Cond 2 AC Live 150k-30M Quasi-Peak    |
| 12244-1 Cond 2 AC Neutral 150k-30M Average    |
| 12244-1 Cond 2 AC Neutral 150k-30M Quasi-Peak |

**Table of signals measured for Cond 2 AC Live 150k-30M**

| Signal No. | Freq (MHz) | Peak Amp (dBuV) | QP Amp (dBuV) | QP -Lim (dB) | AV Amp (dBuV) | AV -Lim (dB) |
|------------|------------|-----------------|---------------|--------------|---------------|--------------|
| 1          | 0.152      | 57.9            | 53.8          | -12.1        | 34.1          | -21.8        |
| 2          | 0.165      | 55.6            | 50.4          | -14.8        | 31.2          | -24.0        |
| 3          | 0.220      | 49.1            | 42.2          | -20.6        | 23.3          | -29.5        |
| 4          | 0.234      | 47.5            | 41.1          | -21.2        | 24.0          | -28.3        |
| 5          | 0.248      | 46.4            | 39.2          | -22.6        | 20.9          | -30.9        |
| 6          | 0.263      | 44.7            | 37.8          | -23.5        | 18.5          | -32.8        |
| 7          | 0.411      | 41.0            | 39.2          | -18.4        | 36.6          | -11.0        |
| 8          | 7.806      | 40.2            | 37.5          | -22.5        | 31.6          | -18.4        |
| 9          | 13.560     | 24.6            | 20.9          | -39.1        | 15.5          | -34.5        |

**Table of signals measured for Cond 2 AC Neutral 150k-30M**

| Signal No. | Freq (MHz) | Peak Amp (dBuV) | QP Amp (dBuV) | QP -Lim (dB) | AV Amp (dBuV) | AV -Lim (dB) |
|------------|------------|-----------------|---------------|--------------|---------------|--------------|
| 1          | 0.153      | 58.2            | 53.3          | -12.5        | 34.9          | -20.9        |
| 2          | 0.163      | 56.6            | 51.7          | -13.6        | 31.9          | -23.4        |
| 3          | 0.197      | 52.2            | 46.0          | -17.7        | 27.8          | -25.9        |
| 4          | 0.198      | 51.3            | 46.0          | -17.7        | 27.7          | -26.0        |
| 5          | 0.202      | 51.6            | 44.9          | -18.6        | 27.2          | -26.3        |
| 6          | 0.249      | 45.9            | 39.7          | -22.1        | 21.9          | -29.9        |
| 7          | 0.287      | 42.1            | 36.0          | -24.6        | 17.1          | -33.5        |
| 8          | 8.403      | 38.0            | 35.4          | -24.6        | 29.4          | -20.6        |
| 9          | 13.560     | 24.5            | 22.0          | -38.0        | 16.5          | -33.5        |

Peak detector "Max held" Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report.

**LIMITS:**

15.207: as given in the above tables / drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:

150kHz to 30MHz  $\pm 3.6$ dB

## 5.2 Radiated emissions 9 - 150 kHz

### 5.2.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]  
Test Method: ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]  
Limits: 47 CFR Part 15C Part 15.225(d) [Reference 4.1.1 of this report]

### 5.2.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The antenna was orientated in both Parallel and Perpendicular polarisations. The EUT was rotated in all three orthogonal planes. The EUT was operated in TX (No tag) mode.

### 5.2.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.

Measurements were made in a semi-anechoic chamber (pre-scan) with any final measurements required performed on an OATS without a ground plane. The antenna was placed 1m above the ground. The equipment was rotated 360 degrees to record the worst case emissions.

At least 6 signals within 20dB and all signals within 10dB of the limit were investigated.

Tests were performed using Test Site M.

### 5.2.4 Test equipment

TMS81, ZSW1, E624, E411

See Section 9 for more details

### 5.2.5 Test results

Temperature of test environment 20°C  
Humidity of test environment 50%  
Pressure of test environment 101kPa

|                 |                   |
|-----------------|-------------------|
| Band            | 13.110-14.010 MHz |
| Power Level     | Maximum           |
| Channel Spacing | Single Channel    |
| Mod Scheme      | ASK               |
| Single channel  | 13.56 MHz         |

|                              |
|------------------------------|
| Plot refs                    |
| 12244-1 Rad 1 9k-150kHz Para |
| 12244-1 Rad 1 9k-150kHz Perp |

Peak detector "Max held" Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report.

**LIMITS:**

15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.

n.b. the general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:  
9kHz - 30MHz  $\pm 3.9\text{dB}$

## 5.3 Radiated emissions 150 kHz - 30 MHz

### 5.3.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]  
Test Method: ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]  
Limits: 47 CFR Part 15C Part 15.225(d) [Reference 4.1.1 of this report]

### 5.3.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The antenna was orientated in both Parallel and Perpendicular polarisations. The EUT was rotated in all three orthogonal planes. The EUT was operated in TX (No tag) mode.

### 5.3.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.

Measurements were made in a semi-anechoic chamber (pre-scan) with any final measurements required performed on an OATS without a ground plane. The antenna was placed 1m above the ground. The equipment was rotated 360 degrees to record the worst case emissions.

At least 6 signals within 20dB and all signals within 10dB of the limit were investigated.

Tests were performed using Test Site M.

### 5.3.4 Test equipment

TMS81, ZSW1, E624, E411

See Section 9 for more details

### 5.3.5 Test results

Temperature of test environment 20°C  
Humidity of test environment 50%  
Pressure of test environment 101kPa

|                 |                   |
|-----------------|-------------------|
| Band            | 13.110-14.010 MHz |
| Power Level     | Maximum           |
| Channel Spacing | Single Channel    |
| Mod Scheme      | ASK               |
| Single channel  | 13.56 MHz         |

|                               |
|-------------------------------|
| Plot refs                     |
| 12244-1 Rad 1 150k-30MHz Para |
| 12244-1 Rad 1 150k-30MHz Perp |

Peak detector "Max held" Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report.



**LIMITS:**

15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.

n.b. the general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:  
9kHz - 30MHz  $\pm 3.9$ dB

## 5.4 Radiated emissions 30 MHz -1 GHz

### 5.4.1 Test methods

|                    |                                                                 |
|--------------------|-----------------------------------------------------------------|
| Test Requirements: | 47 CFR Part 15C Part 15.225(d) [Reference 4.1.1 of this report] |
| Test Method:       | ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]         |
| Limits:            | 47 CFR Part 15C Part 15.225(d) [Reference 4.1.1 of this report] |

### 5.4.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. The EUT was operated in TX (No tag) mode.

### 5.4.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements were made in a semi-anechoic chamber. The antenna was height scanned between 1 and 4metres and the equipment was rotated 360 degrees to record the worst case emissions. Both Horizontal and vertical polarisations of measuring antenna were tested. Tests were performed in Test Site M.

### 5.4.4 Test equipment

LPE364, E743, NSA-M, ZSW1, E624, E411

See Section 9 for more details

### 5.4.5 Test results

|                                 |        |
|---------------------------------|--------|
| Temperature of test environment | 20°C   |
| Humidity of test environment    | 50%    |
| Pressure of test environment    | 101kPa |

|                 |                   |
|-----------------|-------------------|
| Band            | 13.110-14.010 MHz |
| Power Level     | Maximum           |
| Channel Spacing | Single Channel    |
| Mod Scheme      | ASK               |
| Single channel  | 13.56 MHz         |

|                         |
|-------------------------|
| Plot refs               |
| 12244-1 Rad 1 VHF Horiz |
| 12244-1 Rad 1 VHF Vert  |
| 12244-1 Rad 1 UHF Horiz |
| 12244-1 Rad 1 UHF Vert  |

**Table of signals measured for Rad 2 Horizontal Sig List**

| Signal No. | Freq (MHz) | Peak Amp (dBuV/m) | QP Amp (dBuV/m) | QP -Lim (dB) |
|------------|------------|-------------------|-----------------|--------------|
| 1          | 201.904    | 33.7              | 30.6            | -12.9        |
| 2          | 203.187    | 33.3              | 29.9            | -13.6        |
| 3          | 205.839    | 34.0              | 31.5            | -12.0        |
| 4          | 207.139    | 33.8              | 31.5            | -12.0        |
| 5          | 211.092    | 33.2              | 30.5            | -13.0        |
| 6          | 250.000    | 35.4              | 33.4            | -12.6        |
| 7          | 449.999    | 36.5              | 34.2            | -11.8        |
| 8          | 511.873    | 38.1              | 33.6            | -12.4        |
| 9          | 549.999    | 38.9              | 36.8            | -9.2         |
| 10         | 607.244    | 38.9              | 33.5            | -12.5        |
| 11         | 631.367    | 41.2              | 35.6            | -10.4        |

**Table of signals measured for Rad 2 Vertical Sig List**

| Signal No. | Freq (MHz) | Peak Amp (dBuV/m) | QP Amp (dBuV/m) | QP -Lim (dB) |
|------------|------------|-------------------|-----------------|--------------|
| 1          | 40.682     | 35.4              | 33.9            | -6.1         |
| 2          | 52.620     | 36.7              | 33.1            | -6.9         |
| 3          | 62.154     | 35.3              | 32.7            | -7.3         |
| 4          | 129.720    | 39.2              | 36.1            | -7.4         |
| 5          | 250.000    | 28.6              | 23.7            | -22.3        |
| 6          | 449.999    | 37.4              | 35.0            | -11.0        |
| 7          | 549.999    | 37.8              | 35.1            | -10.9        |
| 8          | 583.151    | 39.2              | 34.6            | -11.4        |
| 9          | 607.390    | 40.2              | 35.4            | -10.6        |
| 10         | 630.790    | 40.6              | 36.4            | -9.6         |
| 11         | 654.835    | 37.7              | 32.4            | -13.6        |

Peak detector "Max held" Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report.

**LIMITS:**

15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.

n.b. the general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:

30MHz - 1000MHz  $\pm 6.1$ dB



## 5.5 Radiated emissions above 1 GHz

NOT APPLICABLE: Radiated emissions measurements above 1 GHz are not required. The highest frequency generated or used within the equipment is 50 MHz.

## 5.6 Intentional radiator field strength

### 5.6.1 Test methods

|                    |                                                                 |
|--------------------|-----------------------------------------------------------------|
| Test Requirements: | 47 CFR Part 15C Part 15.225(a) [Reference 4.1.1 of this report] |
| Test Method:       | ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]         |
| Limits:            | 47 CFR Part 15C Part 15.225(a) [Reference 4.1.1 of this report] |

### 5.6.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The antenna was orientated in both Parallel and Perpendicular polarisations. The EUT was rotated in all three orthogonal planes. The EUT was operated in TX (No tag) mode.

### 5.6.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.

Measurements were made in a semi-anechoic chamber and/ or on an OATS. This site is listed with the FCC.

Both the equipment and the antenna were rotated 360 degrees to record the maximised emission.

Measurements were made at Site OATS.

### 5.6.4 Test equipment

E410, E642, E856, TMS81

See Section 9 for more details

### 5.6.5 Test results

|                                 |        |
|---------------------------------|--------|
| Temperature of test environment | 16°C   |
| Humidity of test environment    | 60%    |
| Pressure of test environment    | 101kPa |

|                 |                   |
|-----------------|-------------------|
| Band            | 13.110-14.010 MHz |
| Power Level     | Maximum           |
| Channel Spacing | Single Channel    |
| Mod Scheme      | ASK               |
| Single channel  | 13.56 MHz         |

|                                |                 |
|--------------------------------|-----------------|
|                                | Single channel  |
| Peak Level (dBµV/m @ 3 metres) | 88.6            |
| Plot reference                 | 12244-1 FS OATS |
| Antenna Polarisation           | Parallel        |
| EUT Polarisation               | Upright         |

|                                 |      |
|---------------------------------|------|
| Peak Level (dBµV/m @ 30 metres) | 48.6 |
|---------------------------------|------|

Analyser plots can be found in Section 6 of this report.

An extrapolation factor of 40dB/decade per ANSI C63.10:2013 clause 6.4 is applied to the 3m results to give the following field strengths at 30m for comparison to the limits:

Peak level (dBμV/m @ 3m) – 40 dB = Peak level (dBμV/m @ 30m)

88.6 dBμV/m – 40 dB = 48.6 (dBμV/m @ 30m)

**LIMITS:**

15.225(a) QP/Peak = the field strength of any emissions within the band 13.110-14.010 MHz shall not exceed 15,848 μV/m @ 30m = 84 dBμV/m @ 30m.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:  
<± 3.9 dB

## 5.7 Occupied bandwidth

### 5.7.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.215 [Reference 4.1.1 of this report]  
Test Method: ANSI C63.10 Clause 6.9 [Reference 4.1.2 of this report]  
Limits: 47 CFR Part 15C Part 15.215 [Reference 4.1.1 of this report]

### 5.7.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres.  
The EUT was operated in TX (No tag) and TX (Tag presented) modes.

### 5.7.3 Test procedure

Tests were performed using Test Site R.  
Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. A 10kHz RBW, 3x VBW, auto sweep time and max hold settings were used for the 20 dB bandwidth.

### 5.7.4 Test equipment

E412, E843 E807

See Section 9 for more details

### 5.7.5 Test results

Temperature of test environment 20°C  
Humidity of test environment 50%  
Pressure of test environment 101kPa

|                 |                   |
|-----------------|-------------------|
| Band            | 13.110-14.010 MHz |
| Power Level     | Maximum           |
| Channel Spacing | Single Channel    |
| Mod Scheme      | ASK (with tag)    |
| Single channel  | 13.56 MHz         |

|                                                     | Single channel   |
|-----------------------------------------------------|------------------|
| 20 dB Bandwidth (MHz) Nominal Temp & Volts          | 0.109            |
| Plot for 20 dB Bandwidth (MHz) Nominal Temp & Volts | 12244-1 With tag |

|                 |                   |
|-----------------|-------------------|
| Band            | 13.110-14.010 MHz |
| Power Level     | Maximum           |
| Channel Spacing | Single Channel    |
| Mod Scheme      | ASK (without tag) |
| Single channel  | 13.56 MHz         |

|                                                     | Single channel |
|-----------------------------------------------------|----------------|
| 20 dB Bandwidth (MHz) Nominal Temp & Volts          | 0.275          |
| Plot for 20 dB Bandwidth (MHz) Nominal Temp & Volts | 12244-1 No tag |

Analyser plots can be found in Section 6 of this report.



**LIMITS:**

No limits apply however, per 15.215, the 20dB bandwidth of the emission is to remain within the band over expected variations in temperature and supply voltage. It is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimise the possibility of out-of-band operation.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:  
<± 1.9 %

## 5.8 Spectrum mask

### 5.8.1 Test methods

|                    |                                                                 |
|--------------------|-----------------------------------------------------------------|
| Test Requirements: | 47 CFR Part 15C Part 15.225 [Reference 4.1.1 of this report]    |
| Test Method:       | ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]         |
| Limits:            | 47 CFR Part 15C Part 15.225(a) [Reference 4.1.1 of this report] |

### 5.8.2 Configuration of EUT

The EUT was placed on a bench and measurements were made via a test fixture and referenced to the field strength measured on the OATS. The EUT was operated in TX (No tag) and TX (Tag presented) modes.

### 5.8.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Plots were taken and results were referenced to limits at 30m by using the extrapolation factor of 40dB/decade, per ANSI C63.10 clause 6.4. Measurements were made at Site R.

### 5.8.4 Test equipment

E412, E422

See Section 9 for more details

### 5.8.5 Test results

|                                 |        |
|---------------------------------|--------|
| Temperature of test environment | 20°C   |
| Humidity of test environment    | 60%    |
| Pressure of test environment    | 101kPa |

|                 |                   |
|-----------------|-------------------|
| Band            | 13.110-14.010 MHz |
| Power Level     | Maximum           |
| Channel Spacing | Single Channel    |
| Mod Scheme      | ASK (With tag)    |
| Single channel  | 13.56 MHz         |

|                                               |                                                    |
|-----------------------------------------------|----------------------------------------------------|
|                                               | Single channel                                     |
| Nominal, Maximised RF Output / field strength | 48.6                                               |
| Nominal plot reference                        | 12241-1 Spectrum mask at 30metres - Card presented |

|                 |                   |
|-----------------|-------------------|
| Band            | 13.110-14.010 MHz |
| Power Level     | Maximum           |
| Channel Spacing | Single Channel    |
| Mod Scheme      | ASK (without tag) |
| Single channel  | 13.56 MHz         |

|                                               |                                             |
|-----------------------------------------------|---------------------------------------------|
|                                               | Single channel                              |
| Nominal, Maximised RF Output / field strength | 48.6                                        |
| Nominal plot reference                        | 12241-1 Spectrum mask at 30metres - No Card |

Analyser plots can be found in Section 6 of this report.

**LIMITS:**

15.225(a) QP/Peak = the field strength of any emissions within the band 13.110-14.010 MHz shall not exceed 15,848  $\mu\text{V/m}$  @ 30m = 84 dB $\mu\text{V/m}$  @ 30m.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:  
< $\pm$  4.1 dB

## 5.9 Frequency stability

### 5.9.1 Test methods

|                    |                                                                 |
|--------------------|-----------------------------------------------------------------|
| Test Requirements: | 47 CFR Part 15C Part 15.225(e) [Reference 4.1.1 of this report] |
| Test Method:       | ANSI C63.10 Clause 6.8 [Reference 4.1.2 of this report]         |
| Limits:            | 47 CFR Part 15C Part 15.225(e) [Reference 4.1.1 of this report] |

### 5.9.2 Configuration of EUT

A modified Ethernet cable was used to connect the EUT to a variable power supply. This allowed the voltage end points to be set as declared by the manufacturer.

The EUT was placed in a temperature controlled chamber. The EUT emissions were observed by means of a test fixture. The EUT was operated in TX (No tag) and TX (Tag presented) modes.

### 5.9.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.

Temperature stability was achieved at each test level before taking measurements. A frequency count was made on a CW signal. At nominal temperature the EUT supply was varied to the applicant declared end points.

A max-held spectrum analyser was used to monitor the frequency of the carrier. The analyser was set with a suitable span, RBW and VBW to allow for a measurement resolution of 1Hz.

Tests were performed using Test Site R.

### 5.9.4 Test equipment

E412, E422, E807, E843, L264, S036

See Section 9 for more details

### 5.9.5 Test results

|                                 |        |
|---------------------------------|--------|
| Temperature of test environment | 20°C   |
| Humidity of test environment    | 50%    |
| Pressure of test environment    | 101kPa |

|                 |                   |
|-----------------|-------------------|
| Band            | 13.110-14.010 MHz |
| Power Level     | Maximum           |
| Channel Spacing | Single Channel    |
| Mod Scheme      | ASK (with card)   |
| Single channel  | 13.56 MHz         |

| Test conditions |                    | Frequency Error (MHz)<br>Single channel |
|-----------------|--------------------|-----------------------------------------|
| -20°C           | Volts Nominal (48) | 13.560749                               |
| -10°C           | Volts Nominal (48) | 13.560745                               |
| 0°C             | Volts Nominal (48) | 13.560757                               |
| 10°C            | Volts Nominal (48) | 13.560737                               |
| 20°C            | Volts Minimum (44) | 13.560692                               |
|                 | Volts Nominal (48) | 13.560694                               |
|                 | Volts Maximum (57) | 13.560682                               |
| 30°C            | Volts Nominal (48) | 13.560683                               |
| 40°C            | Volts Nominal (48) | 13.560673                               |
| 50°C            | Volts Nominal (48) | 13.560670                               |

|                                   |      |
|-----------------------------------|------|
| Max Frequency Error per chan (Hz) | +757 |
|-----------------------------------|------|

|                 |                    |
|-----------------|--------------------|
| Band            | 13.110-14.010 MHz  |
| Power Level     | Maximum            |
| Channel Spacing | Single Channel     |
| Mod Scheme      | ASK (without card) |
| Single channel  | 13.56 MHz          |

| Test conditions                   |                    | Frequency Error (MHz)<br>Single channel |
|-----------------------------------|--------------------|-----------------------------------------|
| -20°C                             | Volts Nominal (48) | 13.560736                               |
| -10°C                             | Volts Nominal (48) | 13.560749                               |
| 0°C                               | Volts Nominal (48) | 13.560743                               |
| 10°C                              | Volts Nominal (48) | 13.560742                               |
| 20°C                              | Volts Minimum (44) | 13.560692                               |
|                                   | Volts Nominal (48) | 13.560692                               |
|                                   | Volts Maximum (57) | 13.560683                               |
| 30°C                              | Volts Nominal (48) | 13.560678                               |
| 40°C                              | Volts Nominal (48) | 13.560673                               |
| 50°C                              | Volts Nominal (48) | 13.560682                               |
| Max Frequency Error per chan (Hz) |                    | +749                                    |

Maximum variation observed was +757 Hz

**LIMITS:**

+/- 0.01%. (+/- 1.356kHz)

These results show that the EUT has PASSED this test.

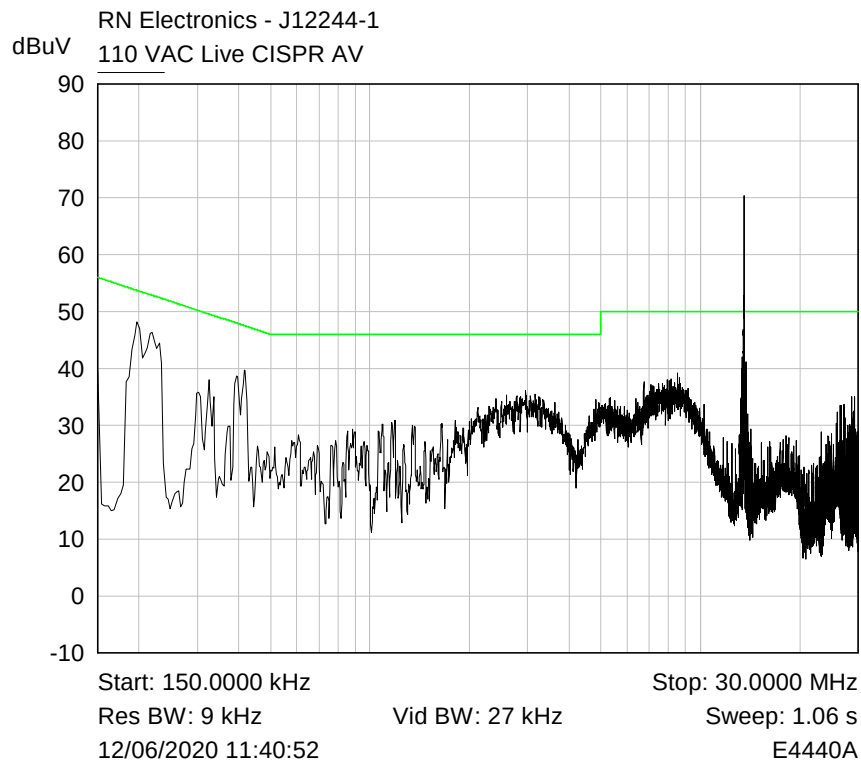
The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:

<± 0.7 ppm

## 6 Plots/Graphical results

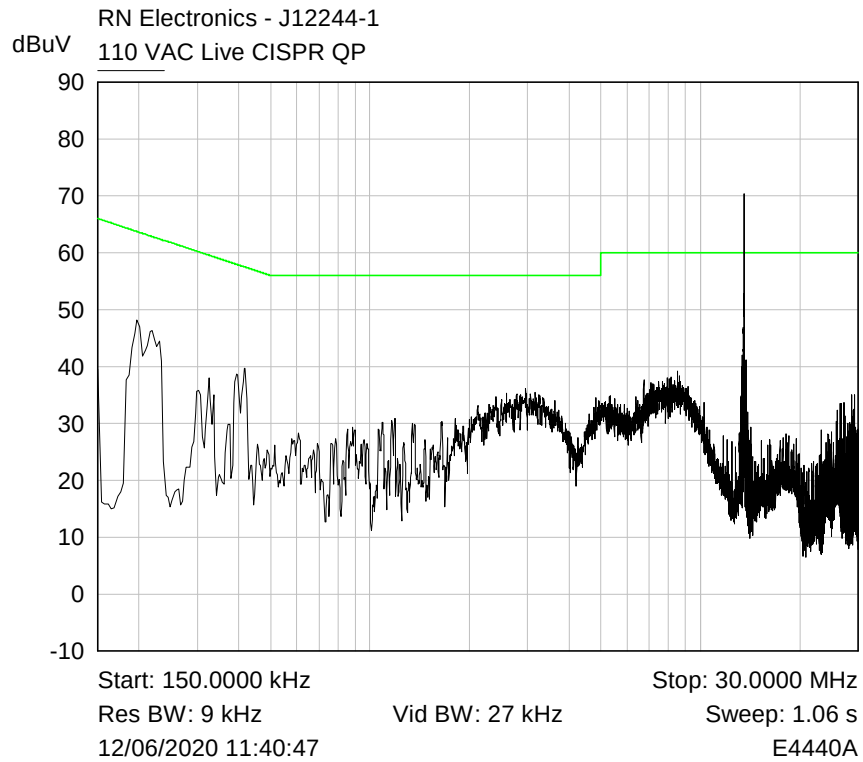
### 6.1 AC power line conducted emissions

RF Parameters: Band 13.110-14.010 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO15693, Channel 13.56 MHz



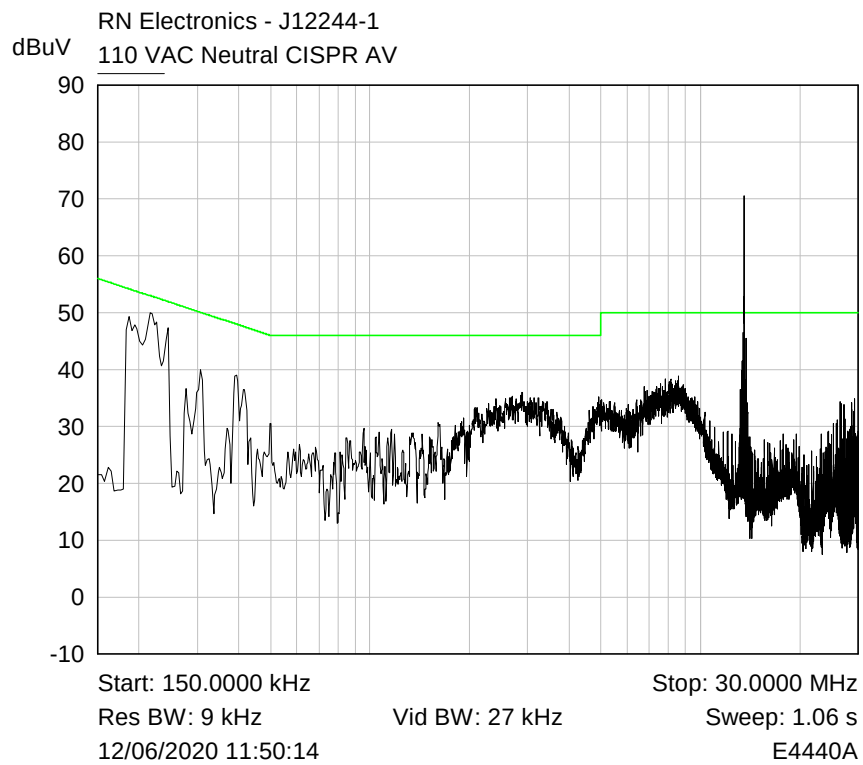
Plot of Live150k-30M Average

Note: The emission that exceeds the limit line is the fundamental carrier of the 13.56 MHz transmitter radiating on to the mains lead



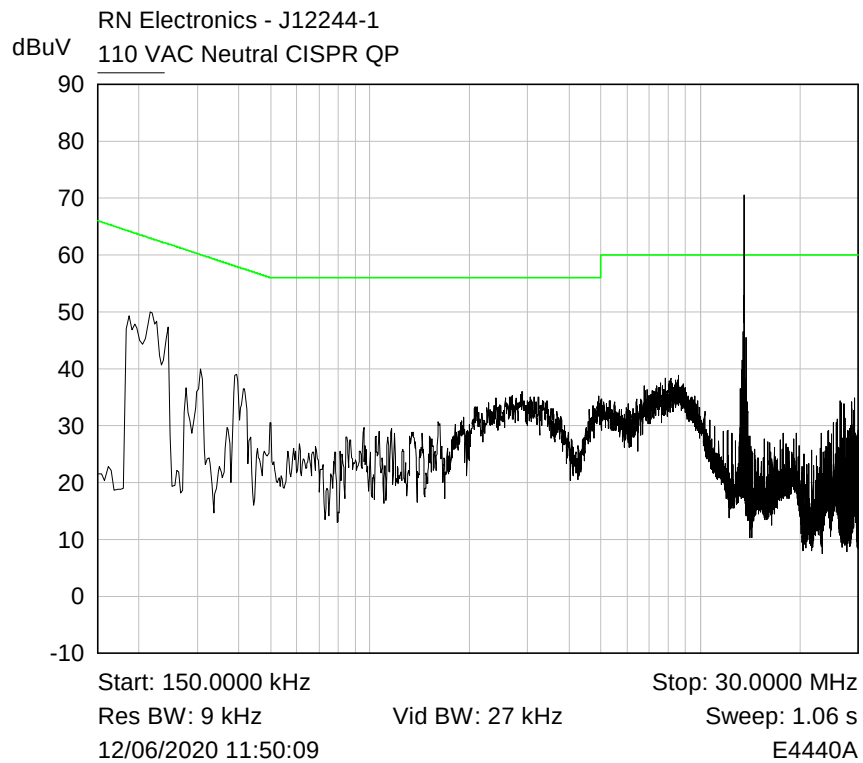
Plot of Live150k-30M Quasi-Peak

Note: The emission that exceeds the limit line is the fundamental carrier of the 13.56 MHz transmitter radiating on to the mains lead



Plot of Neutral150k-30M Average

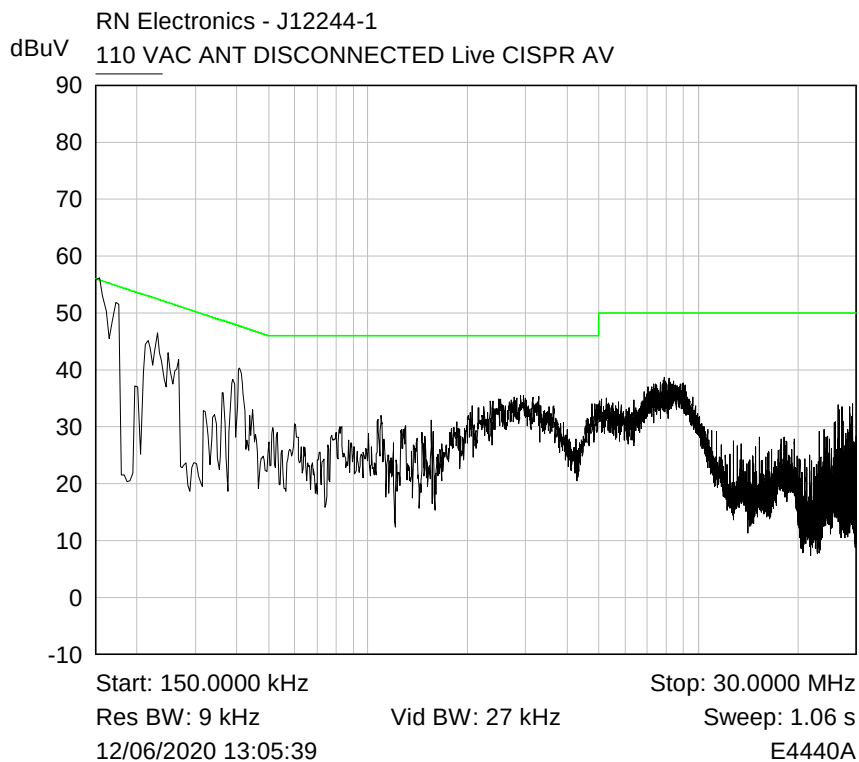
Note: The emission that exceeds the limit line is the fundamental carrier of the 13.56 MHz transmitter radiating on to the mains lead



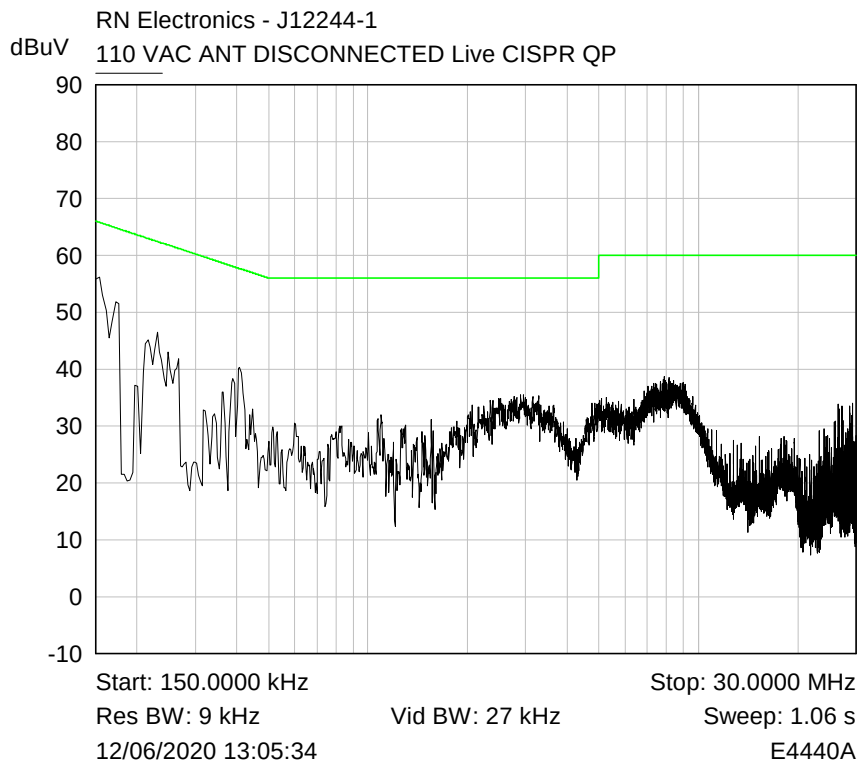
Plot of Neutral150k-30M Quasi-Peak

Note: The emission that exceeds the limit line is the fundamental carrier of the 13.56 MHz transmitter radiating on to the mains lead

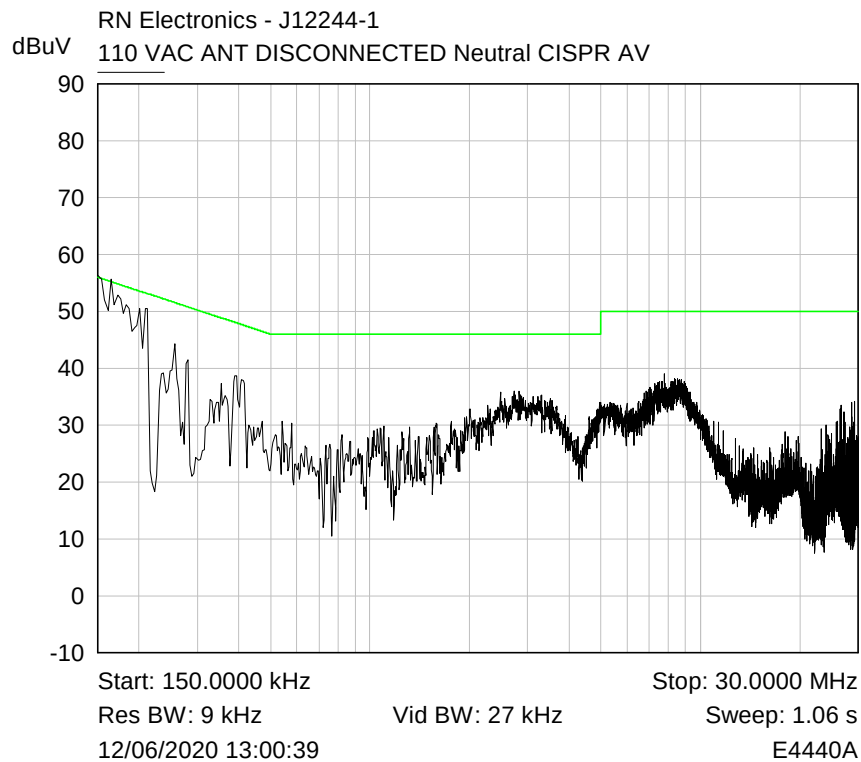
RF Parameters: Band 13.110-14.010 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO15693 (antenna disconnected), Channel 13.56 MHz



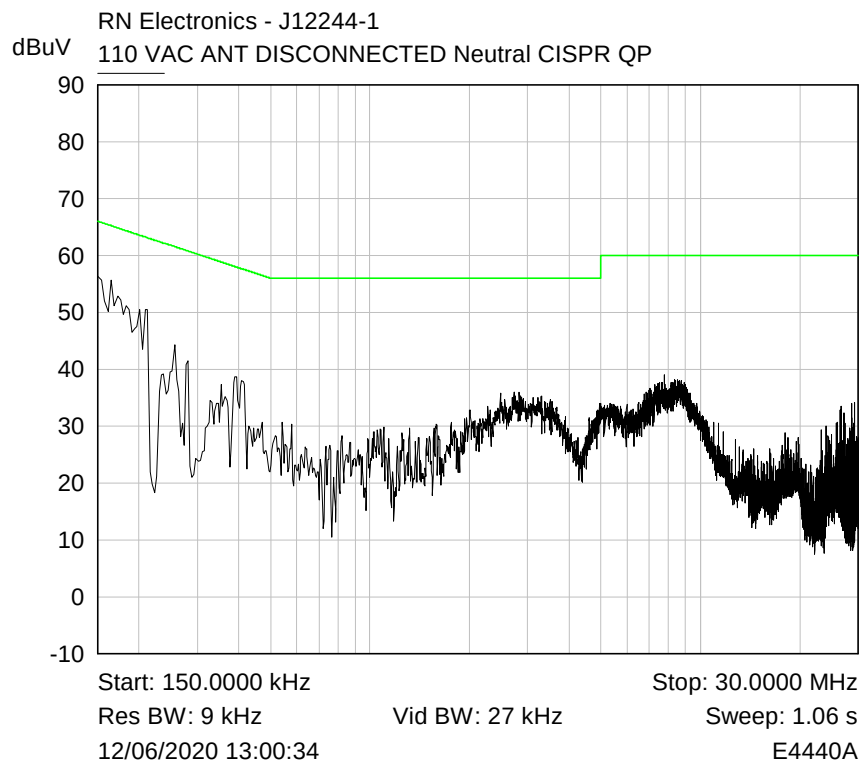
Plot of Live150k-30M Average



Plot of Live150k-30M Quasi-Peak



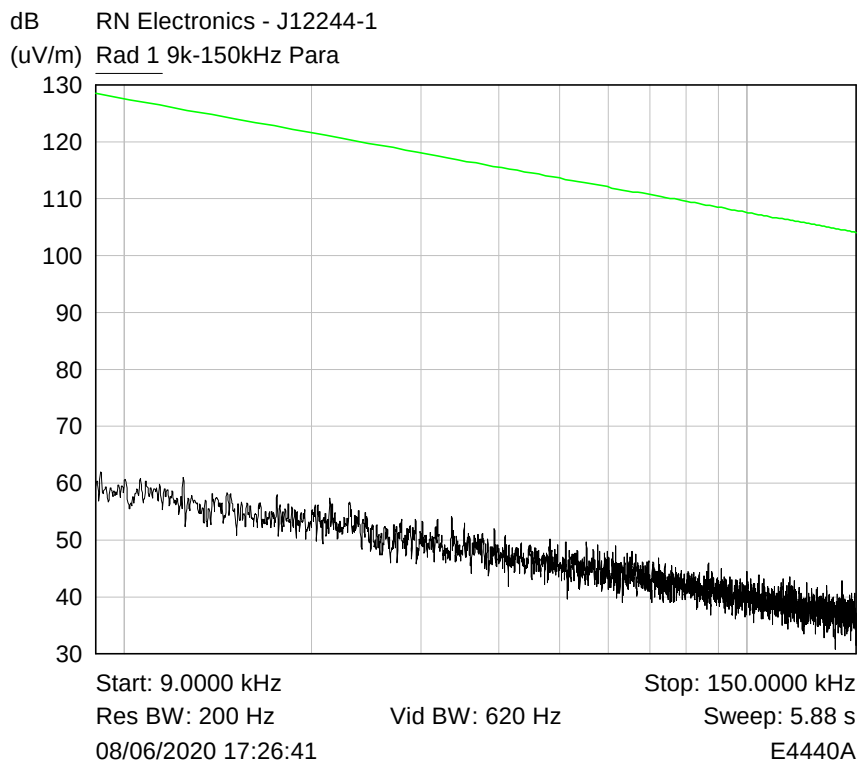
Plot of Neutral150k-30M Average



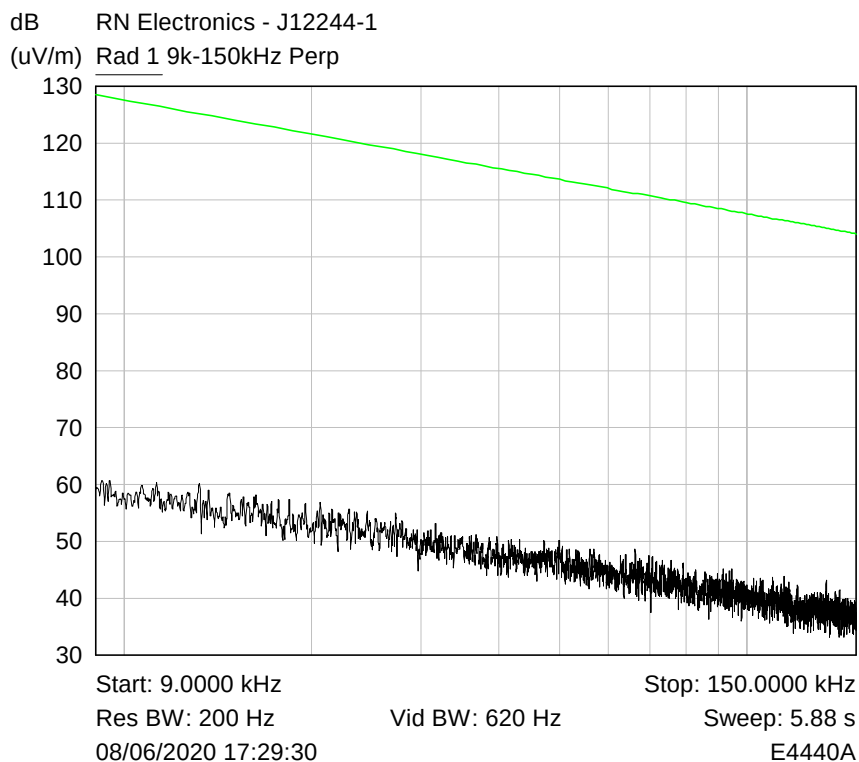
Plot of Neutral150k-30M Quasi-Peak

## 6.2 Radiated emissions 9 - 150 kHz

RF Parameters: Band 13.110-14.010 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO15693, Channel 13.56 MHz



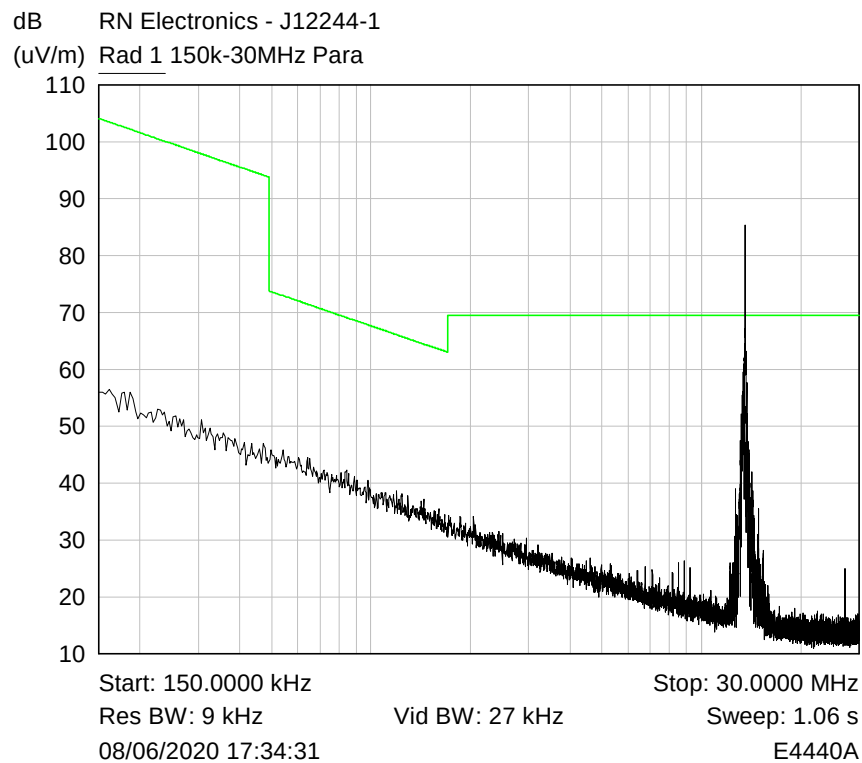
Plot of 9k-150kHz Parallel



Plot of 9k-150kHz Perpendicular

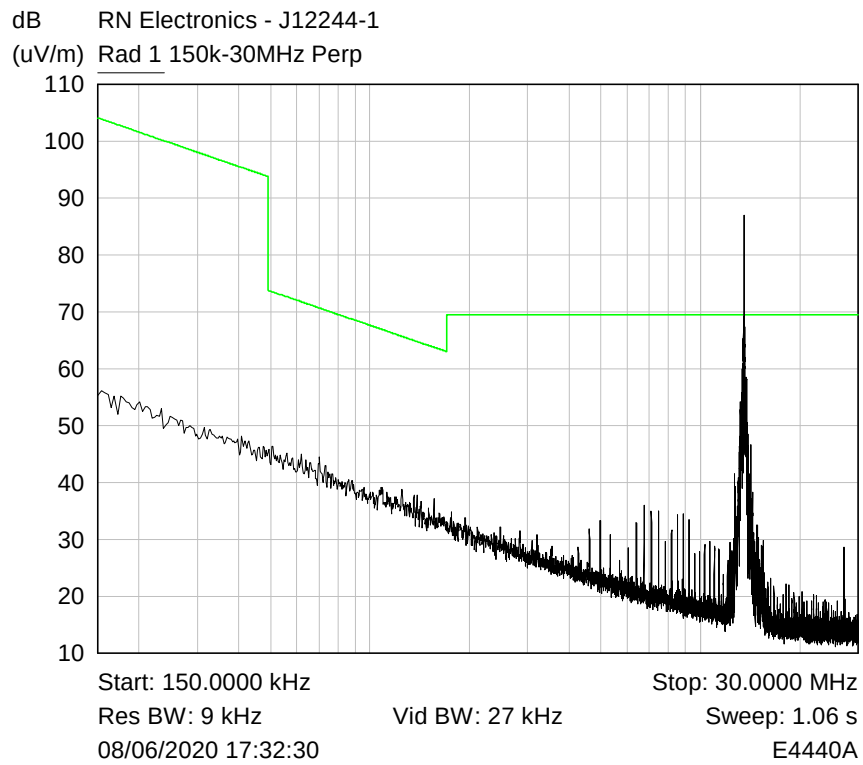
### 6.3 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 13.110-14.010 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO15693, Channel 13.56 MHz



Plot of 150kHz-30MHz Parallel

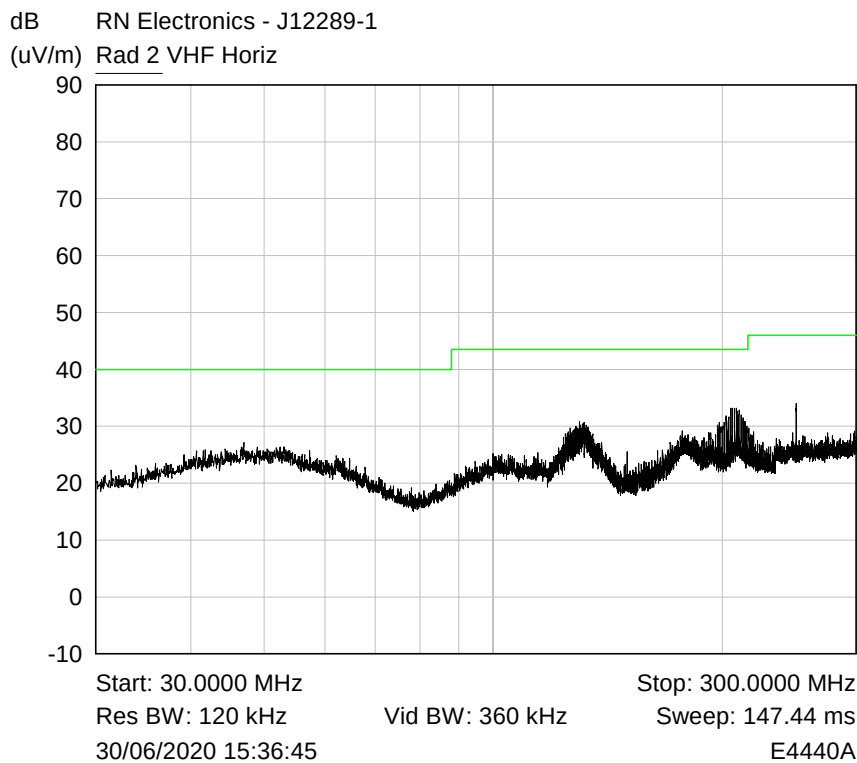
Note: Plot shows the fundamental carrier at 13.56 MHz



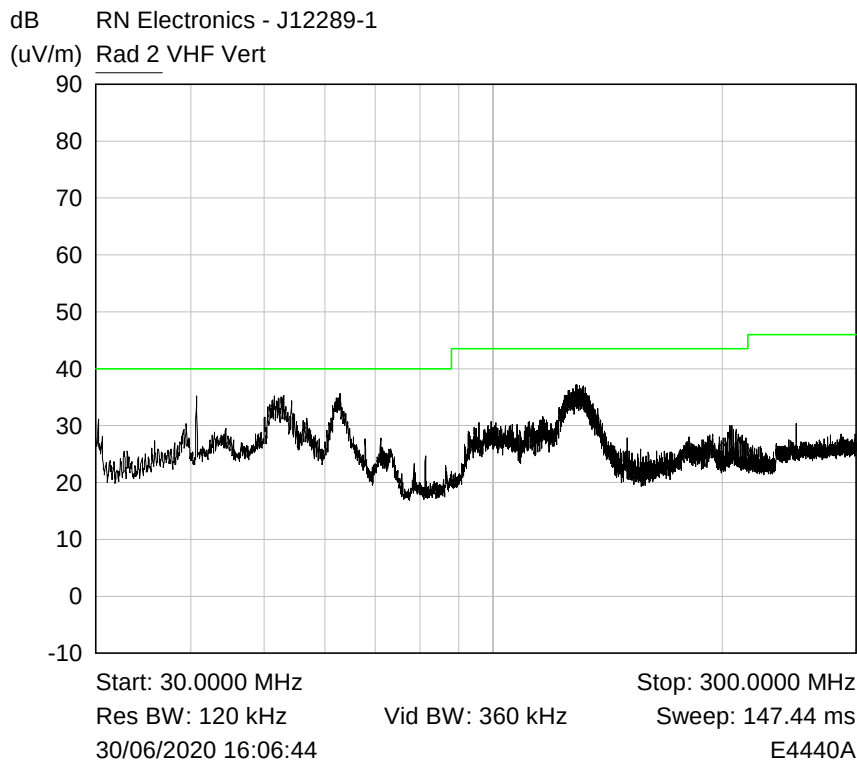
Plot of 150kHz-30MHz Perpendicular  
Note: Plot shows the fundamental carrier at 13.56 MHz

## 6.4 Radiated emissions 30 MHz -1 GHz

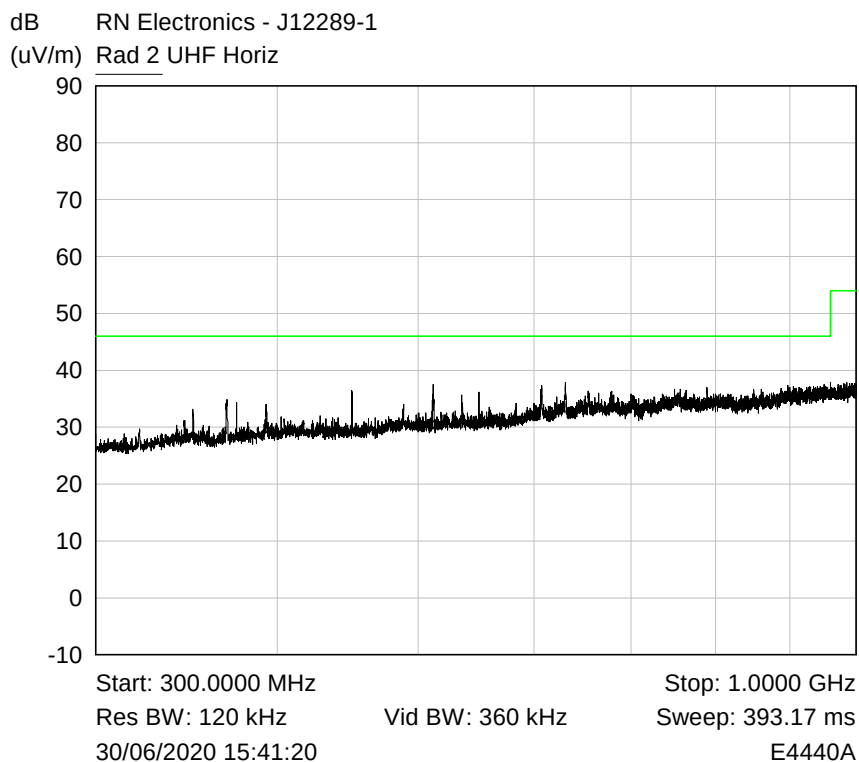
RF Parameters: Band 13.110-14.010 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO15693, Channel 13.56 MHz



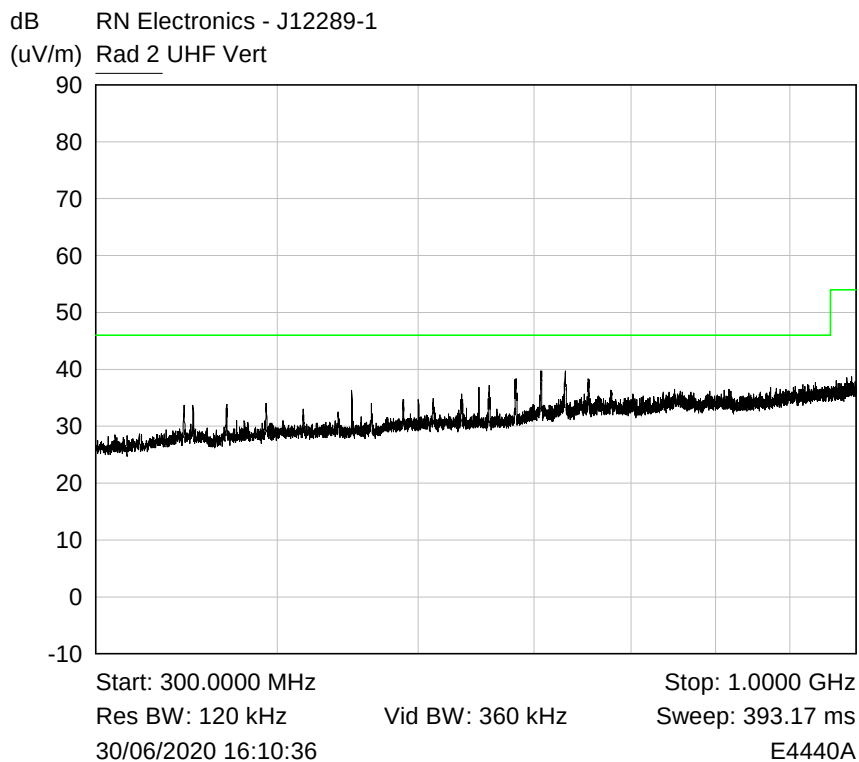
Plot of Peak emissions for VHF Horizontal against the QP limit line.



Plot of Peak emissions for VHF Vertical against the QP limit line.



Plot of Peak emissions for UHF Horizontal against the QP limit line.



Plot of Peak emissions for UHF Vertical against the QP limit line.

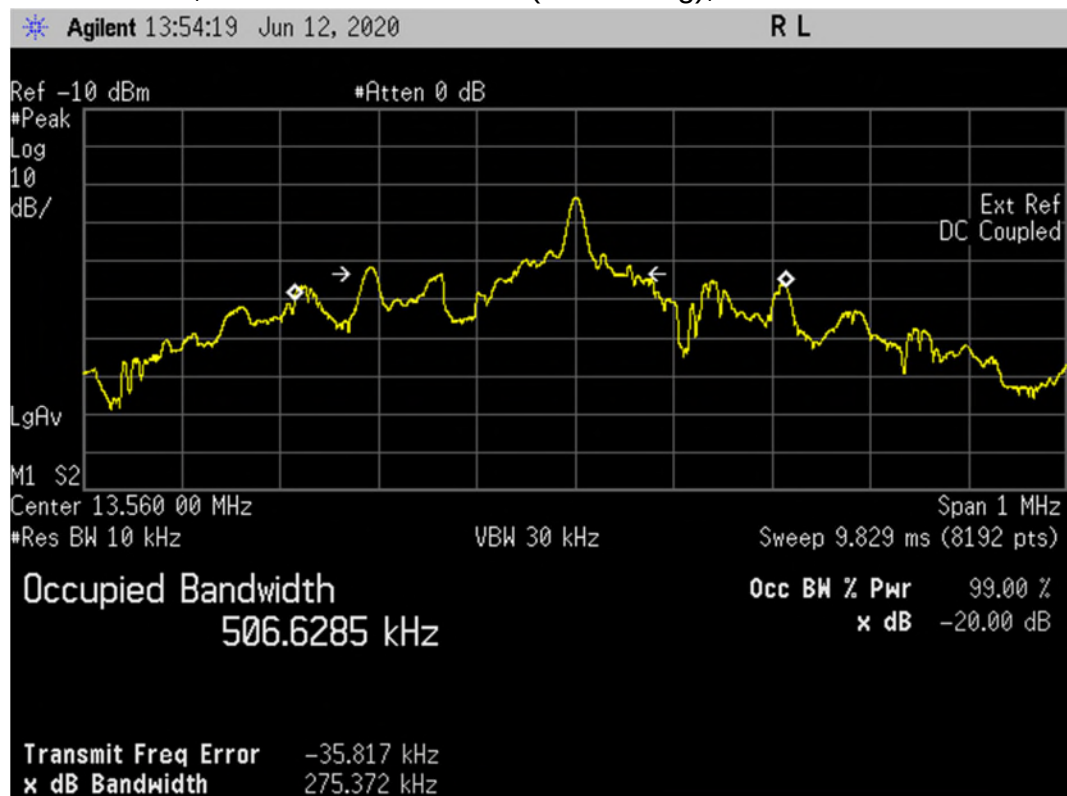
## 6.5 Occupied bandwidth

RF Parameters: Band 13.110-14.010 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO15693 (With tag), Channel 13.56 MHz



Plot for 20 dB Bandwidth (MHz) Nominal Temp & Volts

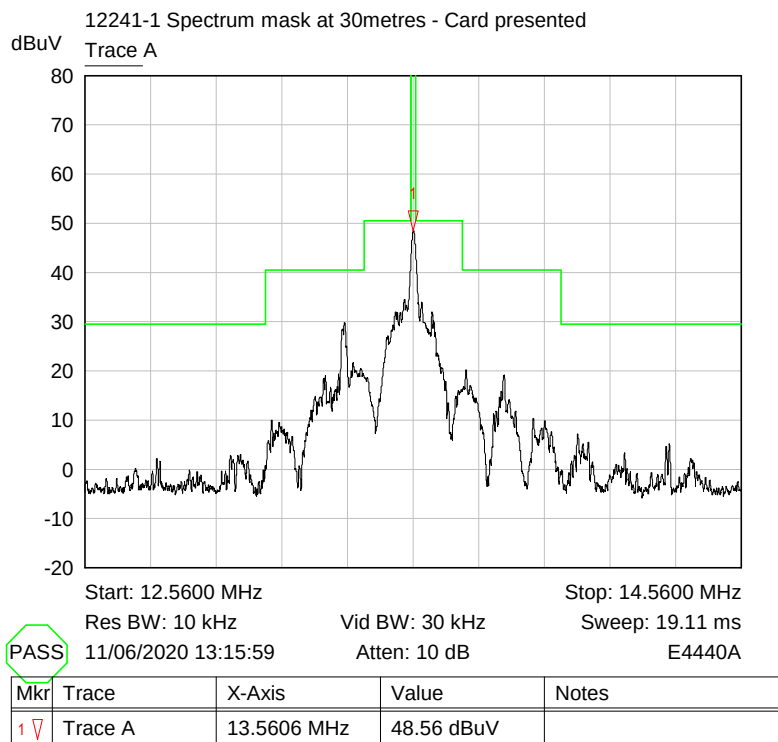
RF Parameters: Band 13.110-14.010 MHz, Power Maximum, Channel Spacing Single  
Channel, Modulation ISO15693 (without tag), Channel 13.56 MHz



Plot for 20 dB Bandwidth (MHz) Nominal Temp & Volts

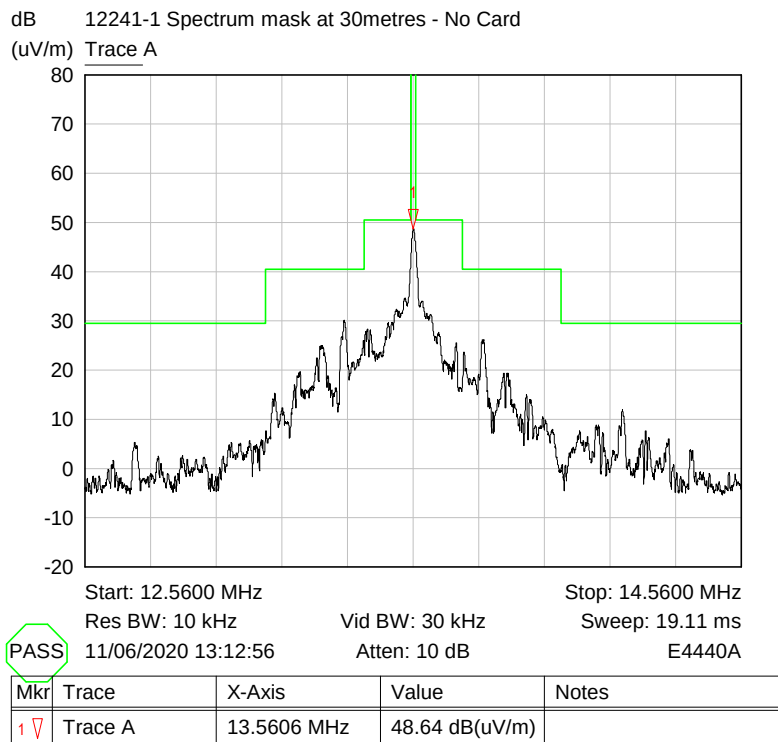
## 6.6 Spectrum mask

RF Parameters: Band 13.110-14.010 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO15693 (With tag), Channel 13.56 MHz



Nominal Temperature, Nominal Voltage

RF Parameters: Band 13.110-14.010 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO15693 (without tag), Channel 13.56 MHz



Nominal Temperature, Nominal Voltage

## 7 Explanatory Notes

### 7.1 Explanation of Table of Signals Measured

Measurements are made as required by the standard. These measurements are made and recorded using detectors, either peak, quasi peak or average dependant on the test. A table of results has been given following the relevant plots. This table looks similar to the one illustrated below dependant on the measurements required by the test: -

| Signal No. | Freq (MHz) | Peak Amp (dBμV) | Pk – Lim 1 (dB) | QP Amp (dBμV) | QP - Lim1 (dB) | Av Amp (dBμV) | Av - Lim1 (dB) |
|------------|------------|-----------------|-----------------|---------------|----------------|---------------|----------------|
| 1          | 12345      | 54.9            | -10.5           | 48            | -12.6          | 37.6          | -14.4          |

Column One - Labelled Signal No. is an incremental number that the receiver has given to each signal that has been measured.

Column Two - Labelled Freq (MHz) is the approximate frequency of the signal received.

Column Three - Labelled Peak Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the peak detector.

Column Four - Labelled Pk - Lim1 (dB) is the difference in level from the peak signal given to the active limit line. If this column appears in the table the peak detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Column Five - Labelled QP Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the quasi-peak detector.

Column Six - Labelled QP - Lim1 (dB) is the difference in level from the quasi-peak signal given to the active limit line. If this column appears in the table the quasi-peak detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Column Seven - Labelled Av Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the average detector.

Column Eight - Labelled Av - Lim1 (dB) is the difference in level from the average signal given to the active limit line. If this column appears in the table the average detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Only signals highlighted in red are deemed to exceed the limit of the detector required.

## 7.2 Explanation of limit line calculations for radiated measurements

The limits given in the test standard are normally expressed as absolute values (e.g. in  $\mu\text{V/m}$  at a specified distance), whereas the measured values are expressed as peak, quasi peak or average values in  $\text{dB}\mu\text{V/m}$  referenced to the measuring instrument inputs. RN Electronics calibrate the test set-up to account for any path losses, antenna gains, etc. so that the value read at the receiver relates directly to the absolute value required, except that it is expressed in dB relative to one microVolt and may need to take account of any alternative measuring distance used. Examples:

- (a) limit of  $500 \mu\text{V/m}$  equates to  $20.\log(500) = 54 \text{ dB } \mu\text{V/m}$ .
- (b) limit of  $300 \mu\text{V/m}$  at 10m equates to  $20.\log(300 \cdot 10/3) = 60 \text{ dB } \mu\text{V/m}$  at 3m
- (c) limit of  $30 \mu\text{V/m}$  at 30m, but below 30MHz, equates to  $20.\log(30) + 40.\log(30/3) = 69.5 \text{ dB}\mu\text{V/m}$  at 3m, as extrapolation factor below 30MHz is 40dB/decade per  $15.31(f)(2)$ .

The measurement receiver used for emissions testing, performs the field strength (FS) calculations automatically. The receiver combines the signal amplitude (RA), Antenna Factor (AF) and Cable Loss (CL) factors for the frequency to be measured.

Example calculation: - FS = RA + AF + CL.

| Receiver amplitude (RA) | Antenna factor (3m) (AF) | Cable loss (CL) | Field strength result (3m) (FS) |
|-------------------------|--------------------------|-----------------|---------------------------------|
| 20dBuV                  | 25 dB                    | 3 dB            | 48dBuV/m                        |

### Additional calculation examples per ANSI C63.10 clause 9.4 – 9.6 equations 21, 22, 25 & 26:

**Equation 21:**  $E_{\text{Linear}} = 10^{((E_{\text{Log}} - 120)/20)}$

And therefore equation 21 transposed is:  $E_{\text{Log}} = 20 \times \log(E_{\text{Linear}}) + 120$

Where:

$E_{\text{Linear}}$  is the field strength of the emission in V/m

$E_{\text{Log}}$  is the field strength of the emissions in  $\text{dB}\mu\text{V/m}$

**Equation 22:**  $\text{EIRP} = E_{\text{Meas}} + 20\log(d_{\text{Meas}}) - 104.7$

Where:

EIRP is equivalent isotropically radiated power in dBm

$E_{\text{Meas}}$  is the field strength of the emission at the measurement distance in  $\text{dB}\mu\text{V/m}$

$d_{\text{Meas}}$  is the measurement distance in metres

**Equation 25:**  $\text{PD} = \text{EIRP}_{\text{Linear}} / 4\pi d^2$

And therefore equation 25 transposed is:  $\text{EIRP}_{\text{Linear}} = \text{PD} \times 4\pi d^2$

Where:

PD is the power density at distance specified by the limit, in  $\text{W/m}^2$

$\text{EIRP}_{\text{Linear}}$  is the equivalent isotropically radiated power in Watts

d is the distance at which the power density limit is specified in metres

**Equation 26:**  $\text{PD} = E_{\text{SpecLimit}}^2 / 377$

And therefore equation 26 transposed is:  $E_{\text{Spec limit}} = \sqrt{(PD \times 377)}$

Where:

PD is the power density at distance specified by the limit, in  $\text{W/m}^2$

$E_{\text{Spec limit}}$  is the field strength at the distance specified by the limit in  $\text{V/m}$

**Example:**

Radiated spurious emissions limit at 3metres of  $90\text{pW/cm}^2$ .

$$90\text{pW/cm}^2 \times 100^2 = 0.9 \mu\text{W/m}^2 = (\text{EIRP Linear})$$

$$\text{Equation 25 transposed: } 0.9 \times 10^{-6} \times 4 \times \pi \times 3^2 = 0.0001017876 \text{ W}$$

And

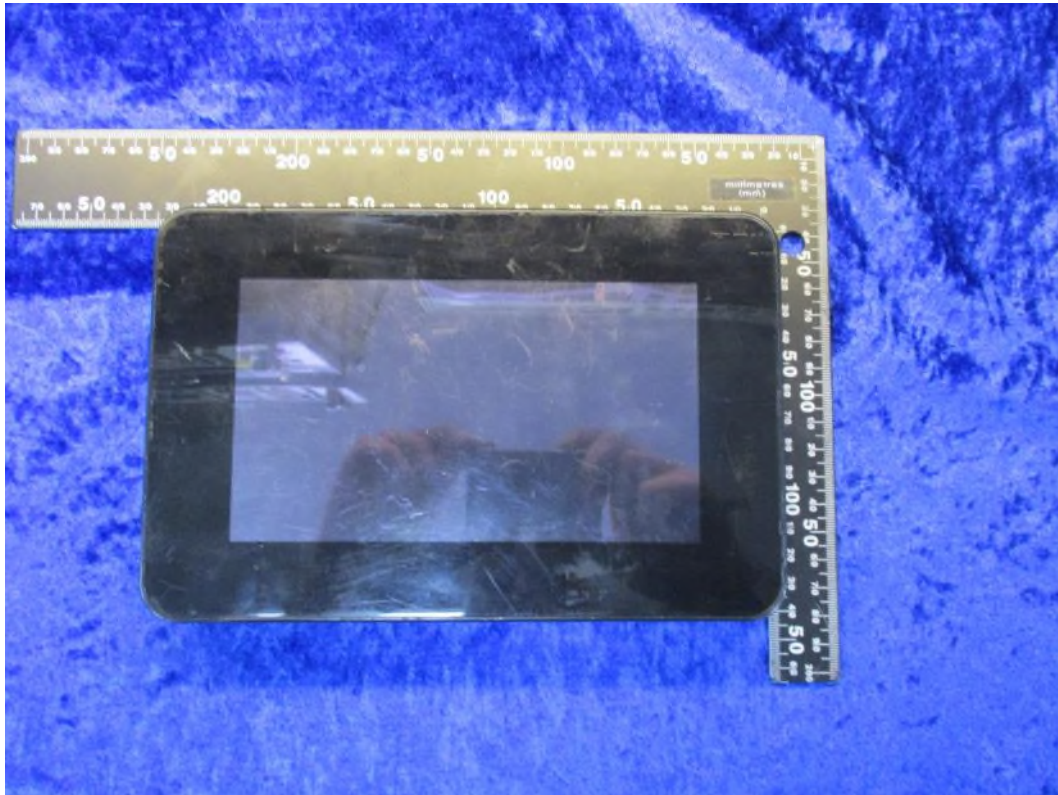
$$\text{Equation 26 transposed: } E_{\text{Spec limit}} = \sqrt{(0.9 \times 10^{-6} \times 377)} = 0.01842 \text{ V/m.}$$

And

$$\text{Equation 21 transposed: } E_{\text{Log}} = 20\text{Log}(0.01842) + 120 = 85.3\text{dB}\mu\text{V/m @ 3m.}$$

## 8 Photographs

### 8.1 EUT Front View



Photograph shows the RFID card used for tests.



## 8.2 EUT Reverse Angle



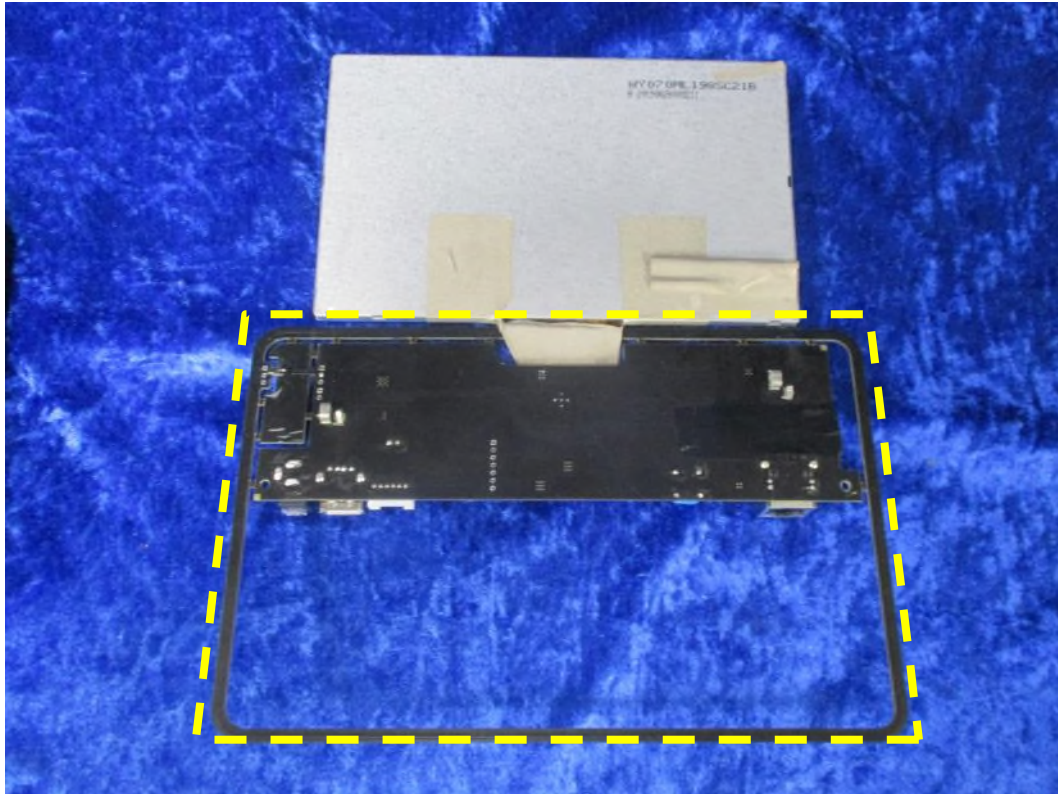
### 8.3 EUT Left side View



## 8.4 EUT Right side View



## 8.5 EUT Antenna

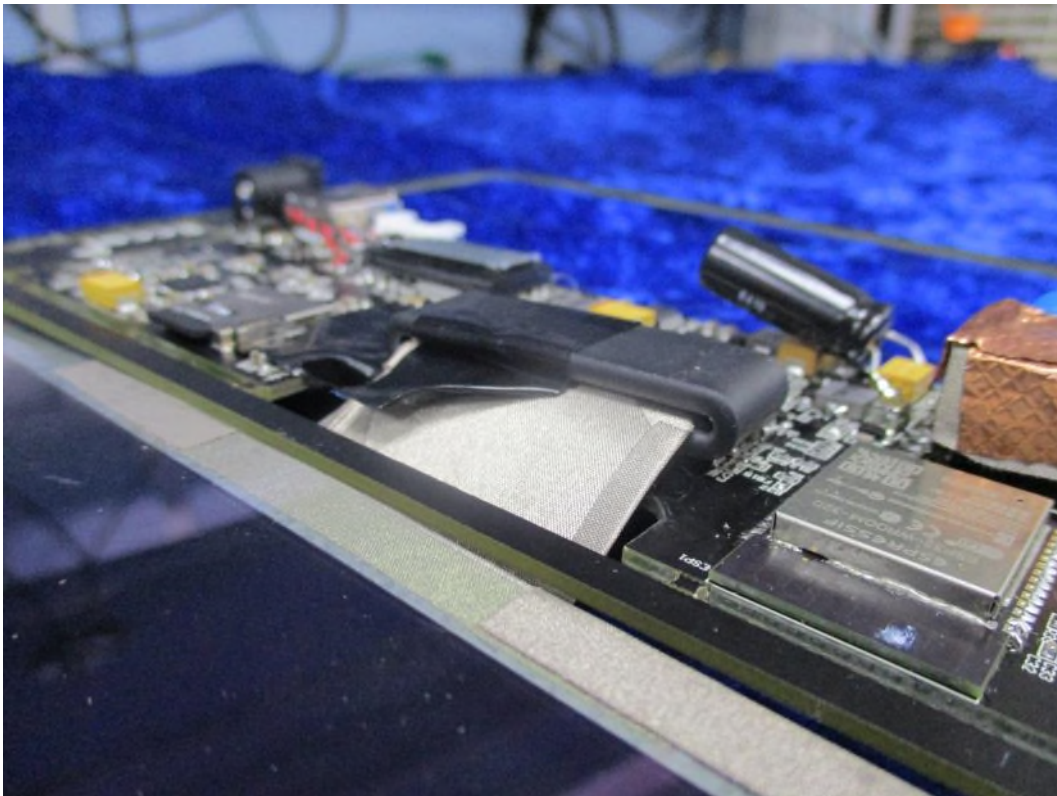


Photograph shows the EUT's PCB etched coil antenna (highlighted)

## 8.6 EUT Display



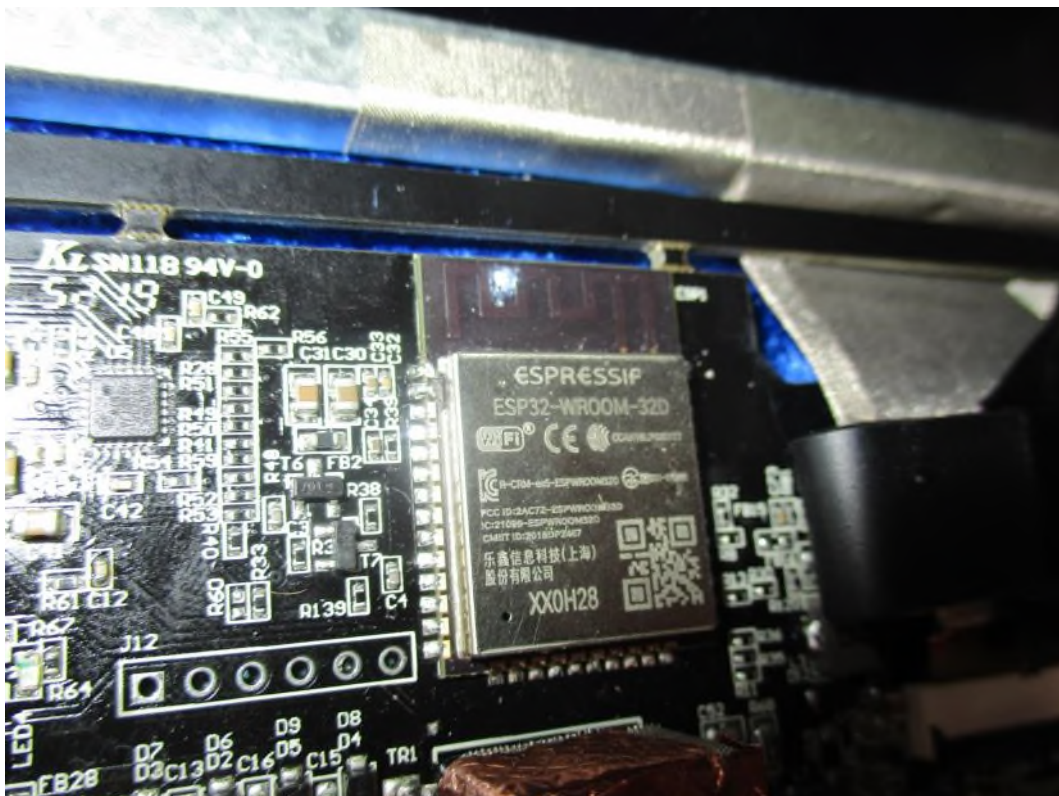
## 8.7 EUT Internal photos



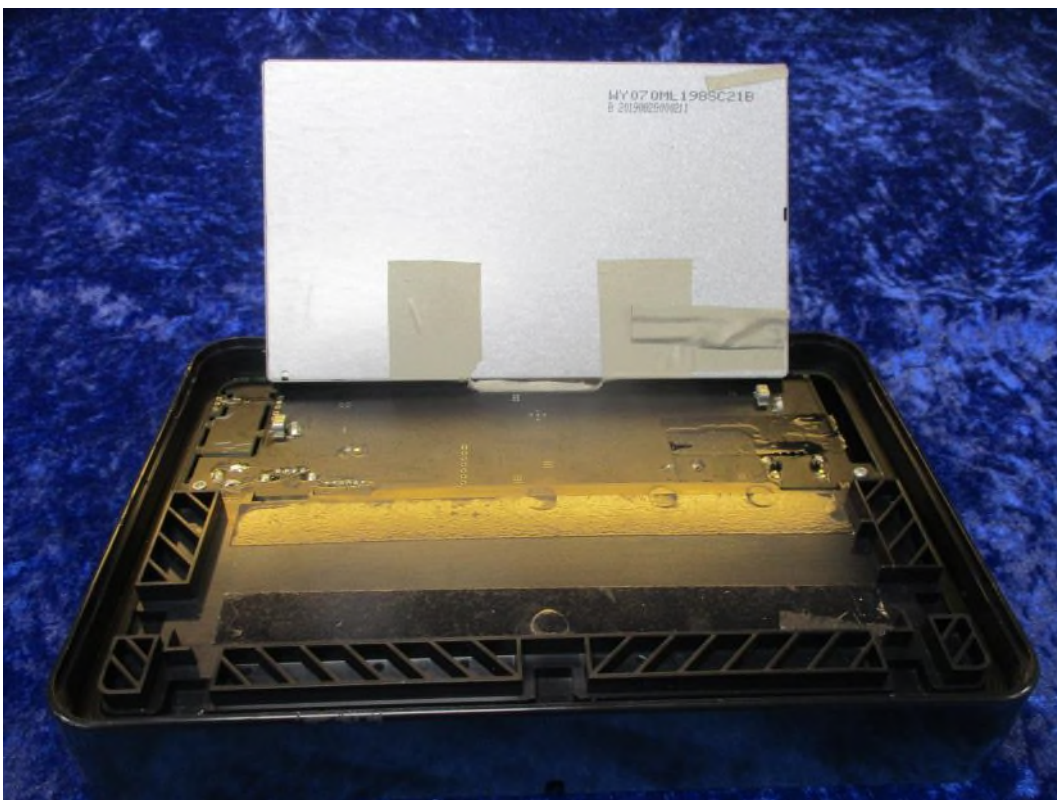
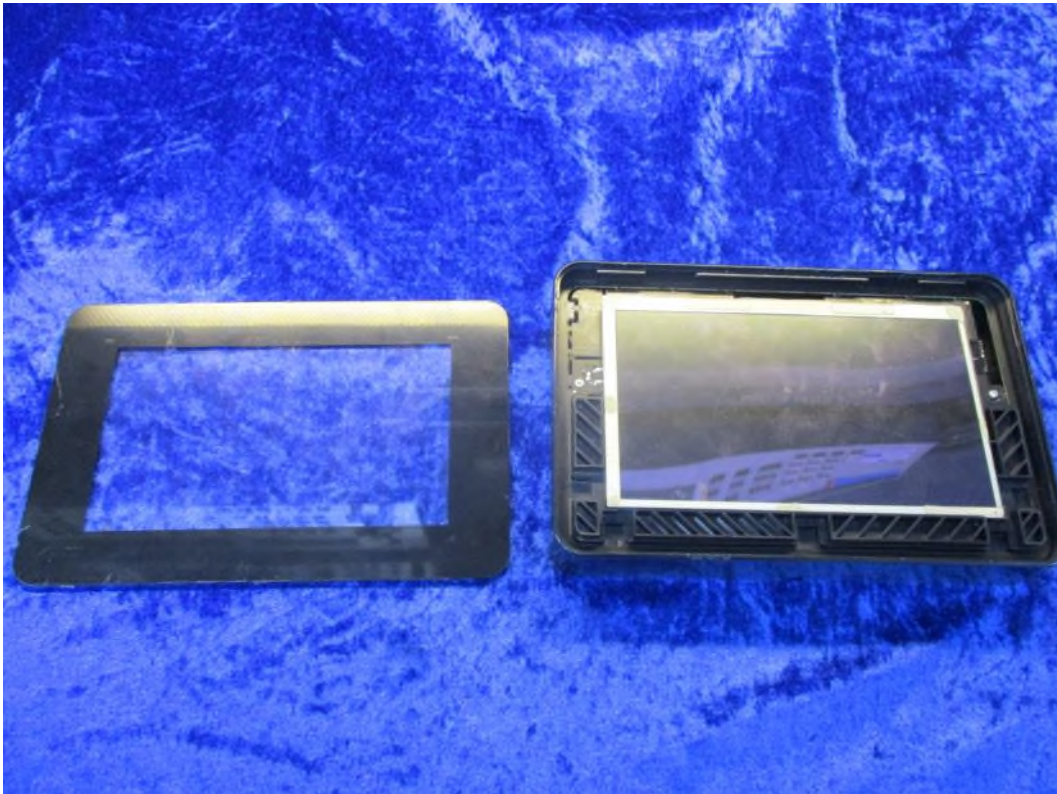
Photograph shows ferrite fitted to the LCD flexi-cable.



Photograph shows the debug port, and internal USB and DC sockets. The USB and DC ports are not accessible to the end-user. The applicant declares that the debug port is used for firmware / debug purposes only.



Photograph shows the EUT Wi-Fi / Bluetooth module. The applicant declares this is not operational on the current product.



Photograph shows conductive tape on the rear of the LCD screen.

## 8.8 EUT ID Label



## 8.9 EUT Chassis

The EUT has no chassis

## 8.10 AC power line conducted emissions



## 8.11 Radiated emissions 150 kHz - 30 MHz



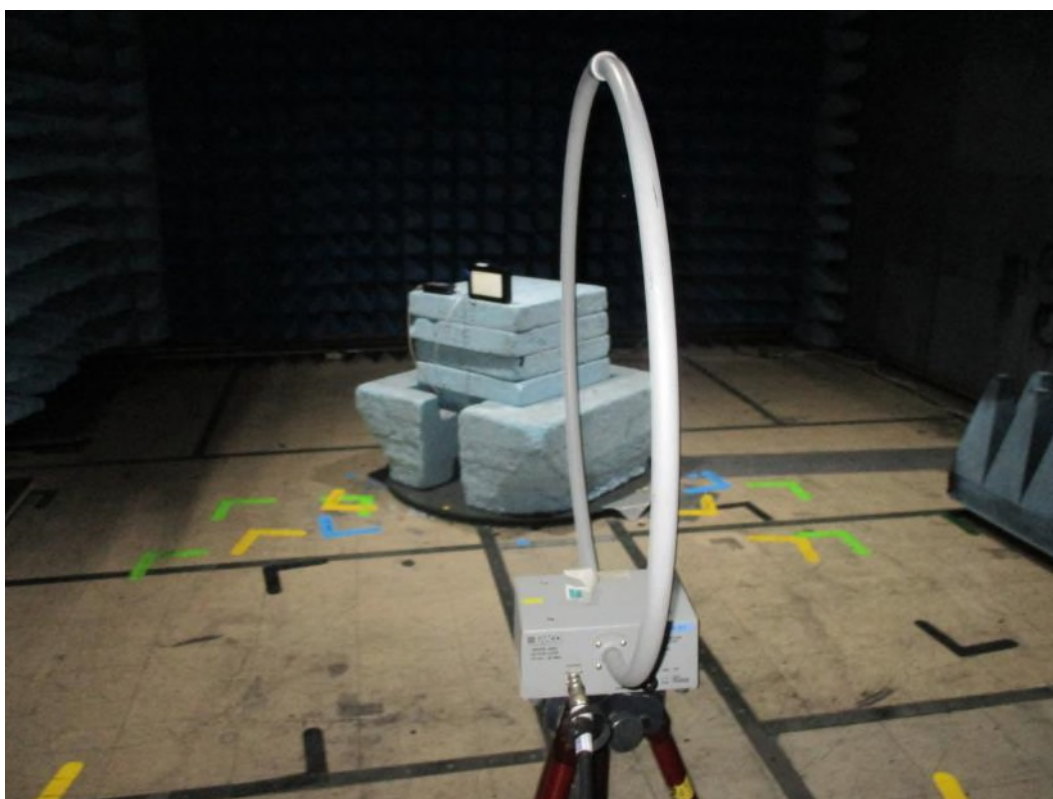
Site OATS



Site OATS

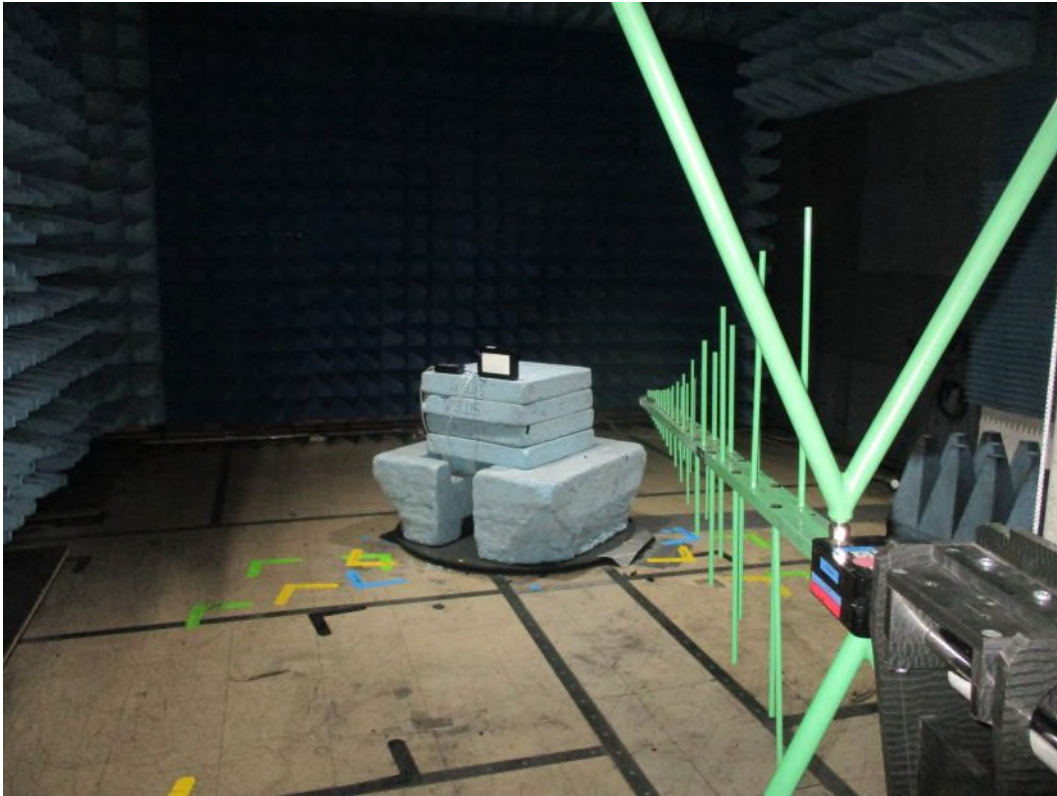


Site OATS



Site M

## 8.12 Radiated emissions 30 MHz -1 GHz



Site M



### 8.13 Radiated emission diagrams

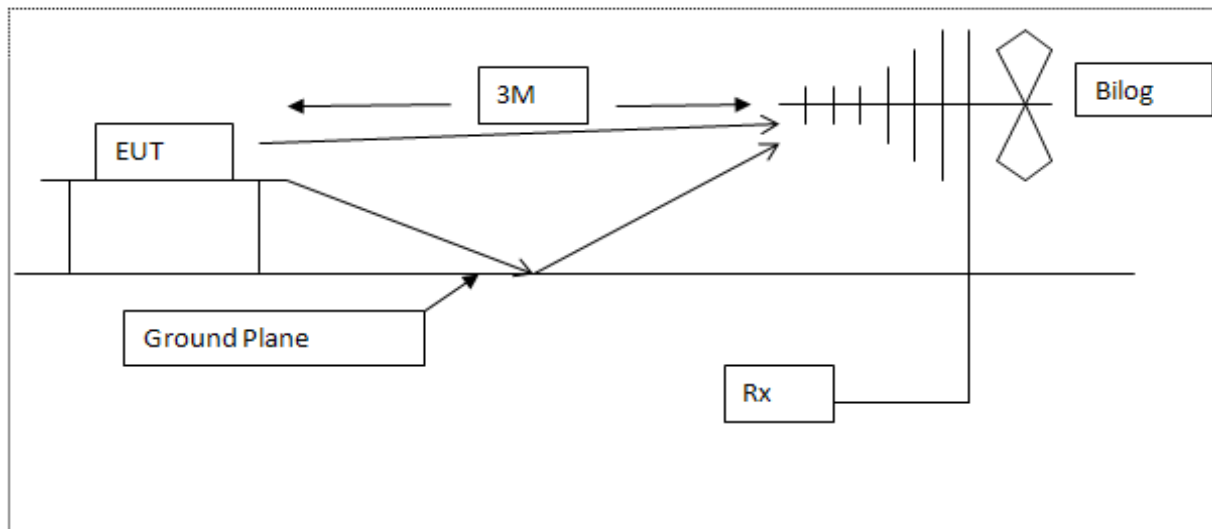


Diagram of the radiated emissions test setup 30 - 1000 MHz

## 8.14 AC powerline conducted emission diagram

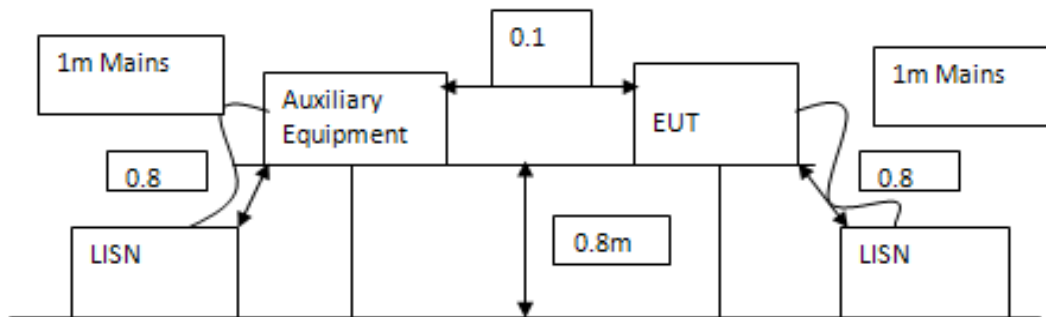


Diagram of the AC conducted emissions test setup

## 9 Test equipment calibration list

The following is a list of the test equipment used by R.N. Electronics Ltd to test the unit detailed within this report. In line with our procedures, the equipment was within calibration for the period during which testing was carried out.

| RN No. | Model No.  | Description                         | Manufacturer          | Calibration date | Cal period |
|--------|------------|-------------------------------------|-----------------------|------------------|------------|
| E035   | 11947A     | Transient Limiter 9kHz - 200MHz     | Hewlett Packard       | 16-Dec-2019      | 12 months  |
| E150   | MN2050     | LISN 13A                            | Chase                 | 22-Apr-2020      | 12 months  |
| E410   | N5181A     | Signal Generator 3 GHz MXG          | Agilent Technologies  | 13-Jul-2018      | 36 months  |
| E411   | N9039A     | 9 kHz - 1 GHz RF Filter Section     | Agilent Technologies  | 11-Jul-2019      | 12 months  |
| E412   | E4440A     | PSA 3 Hz - 26.5 GHz                 | Agilent Technologies  | 17-Jul-2018      | 24 months  |
| E422   | 34401A     | Digital Multimeter 6.5 digit        | Agilent Technologies  | 03-Apr-2020      | 12 months  |
| E624   | E4440A     | PSA 3 Hz - 26.5 GHz                 | Agilent Technologies  | 07-Mar-2020      | 24 months  |
| E642   | E4440A     | PSA 3 Hz - 26.5 GHz                 | Agilent Technologies  | 11-Dec-2019      | 24 months  |
| E743   | 2017 4/2dB | Attenuator 4/2dB 30-1000MHz         | RN Electronics        | 07-Feb-2020      | 12 months  |
| E807   | 10MHz OCXO | Frequency Standard 10MHz OCXO       | BG7TBL                | 11-Dec-2019      | 12 months  |
| E843   | G3RUH      | 10MHz GPS Disciplined Oscillator    | G3RUH - James Miller  | 03-Mar-2020      | 6 months   |
| E856   | N9039A     | 9 kHz - 1 GHz RF Filter Section     | Agilent Technologies  | 11-Dec-2019      | 12 months  |
| L264   | DT75       | Digital Thermometer                 | Instrotech Ltd        | 16-Dec-2019      | 24 months  |
| LPE364 | CBL6112A   | Antenna BiLog 30MHz - 2GHz          | Chase Electronics Ltd | 07-Mar-2020      | 24 months  |
| NSA-M  | NSA - M    | NSA - Site M                        | RN Electronics        | 09-Jan-2019      | 36 months  |
| S036   | FMH1 420   | Temperature & Humidity Test Chamber | JTS Ltd               | Not applicable   |            |
| TMS81  | 6502       | Antenna Active Loop                 | EMCO                  | 24-Jun-2019      | 24 months  |
| ZSW1   | V2.4       | Measurement Software Suite          | RN Electronics        | Not applicable   |            |

## 10 Auxiliary and peripheral equipment

### 10.1 Customer supplied equipment

| Item No. | Model No. | Description                 | Manufacturer | Serial No. |
|----------|-----------|-----------------------------|--------------|------------|
| 1        | ICODE SLI | RFID contactless smart card | Not stated   | Not stated |

### 10.2 RN Electronics supplied equipment

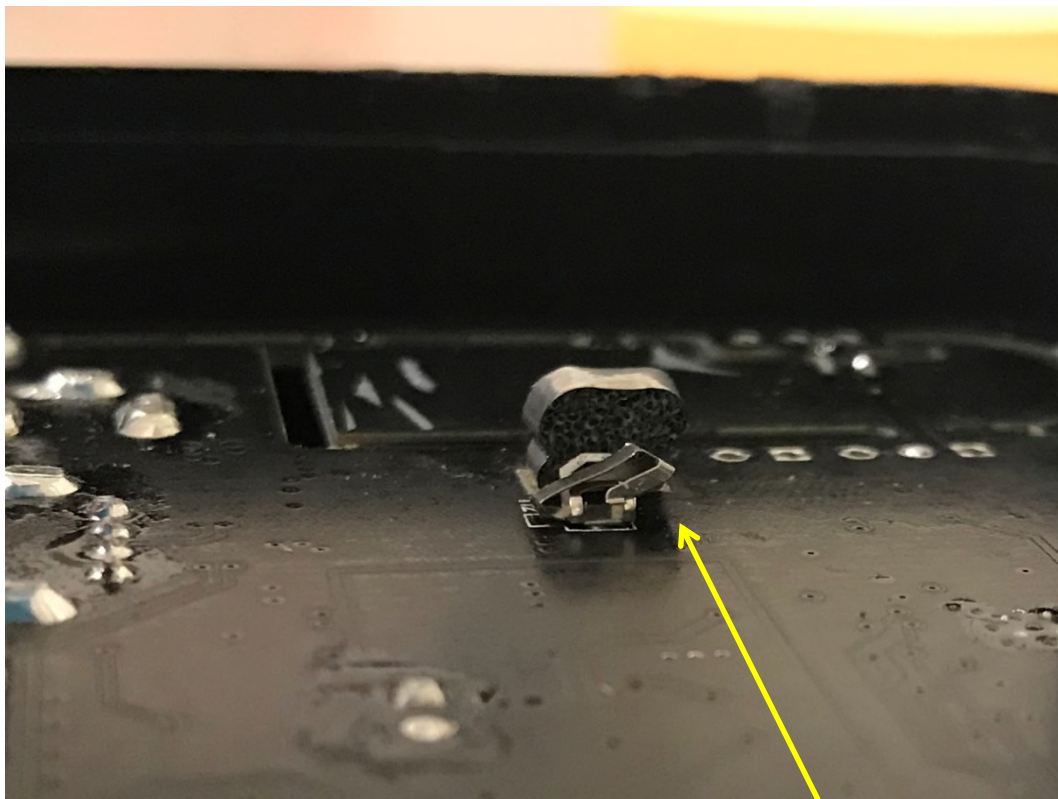
| RN No. | Model No. | Description          | Manufacturer | Serial No |
|--------|-----------|----------------------|--------------|-----------|
| E465   | PCR2000LA | AC Power Source 2kVA | Kikusui      | HJ000995  |

## 11 Condition of the equipment tested

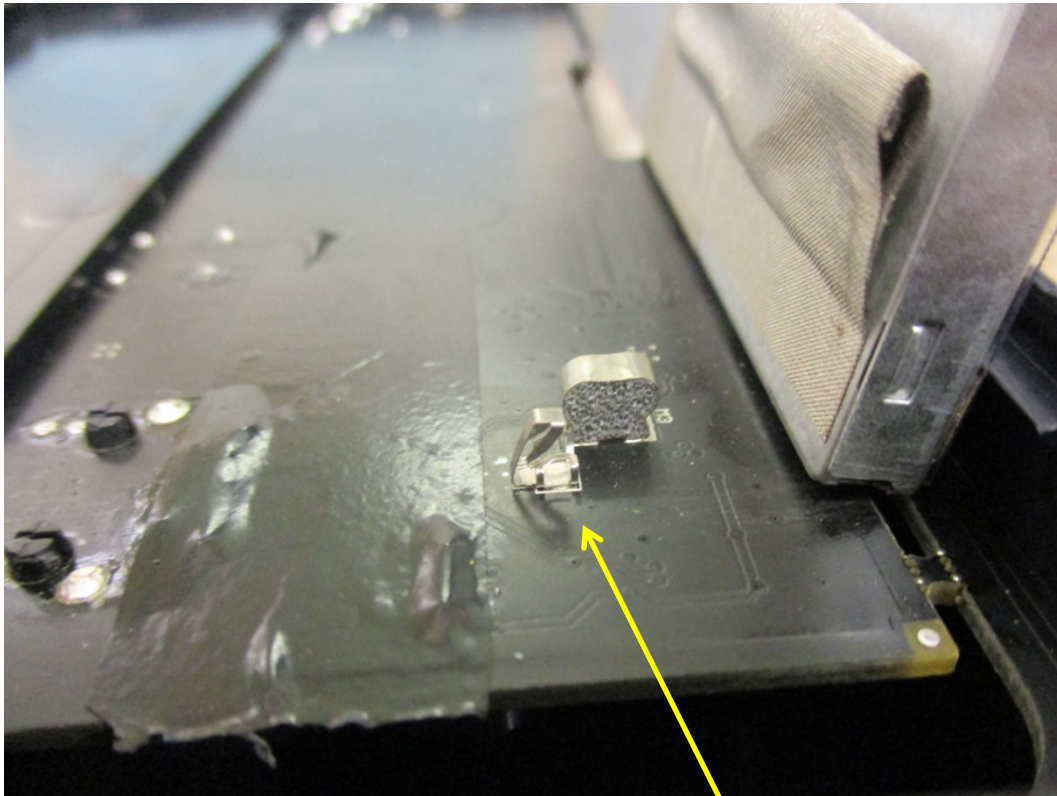
In order for the EUT to produce the results shown within this report the following modifications, if any, were implemented.

### 11.1 Modifications before test

| Test                            | Modification                                                                                                                                        | Time of modification | Photo Reference |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------------|
| TX Rad Em Field strength 30M-1G | Bending the grounding spring finger away from the PCB to increase the height so that a connection is made between the PCB and the LCD screen bezel. | Before testing       | MOD1.jpg        |



Before: Spring finger 'squashed-down'



After: Spring finger bent up.

## 11.2 Modifications during test

No modifications were made during test by RN Electronics Ltd.

## 12 Description of test sites

|           |                                                                                                      |
|-----------|------------------------------------------------------------------------------------------------------|
| Site A    | Radio Laboratory and Anechoic Chamber                                                                |
| Site B    | Semi-Anechoic Chamber and Control Room<br>FCC Registration No. 293246<br>IC Registration No. 5612A-4 |
| Site C    | Transient Laboratory                                                                                 |
| Site D    | Screened Room (Conducted Immunity)                                                                   |
| Site E    | Screened Room (Control Room for Site D)                                                              |
| Site F    | Screened Room (Conducted Emissions)                                                                  |
| Site G    | Screened Room (Control Room for Site H)                                                              |
| Site H    | 3m Semi-Anechoic Chamber (indoor OATS)<br>FCC Registration No. 293246<br>IC Registration No. 5612A-2 |
| Site J    | Transient Laboratory                                                                                 |
| Site K    | Screened Room (Control Room for Site M)                                                              |
| Site M    | 3m Semi-Anechoic Chamber (indoor OATS)<br>FCC Registration No. 293246<br>IC Registration No. 5612A-3 |
| Site N    | Radio Laboratory                                                                                     |
| Site Q    | Fully-Anechoic Chamber                                                                               |
| Site OATS | 3m and 10m Open Area Test Site<br>FCC Registration No. 293246<br>IC Registration No. 5612A-1         |
| Site R    | Screened Room (Conducted Immunity)                                                                   |
| Site S    | Safety Laboratory                                                                                    |
| Site T    | Transient Laboratory                                                                                 |

RN Electronics CAB identifier as issued by FCC is UK0015

## 13 Abbreviations and units

|        |                                                                      |        |                                                |
|--------|----------------------------------------------------------------------|--------|------------------------------------------------|
| %      | Percent                                                              | LBT    | Listen Before Talk                             |
| µA/m   | microAmps per metre                                                  | LO     | Local Oscillator                               |
| µV     | microVolts                                                           | mA     | milliAmps                                      |
| µW     | microWatts                                                           | max    | maximum                                        |
| AC     | Alternating Current                                                  | kPa    | Kilopascal                                     |
| ALSE   | Absorber Lined Screened Enclosure                                    | Mbit/s | MegaBits per second                            |
| AM     | Amplitude Modulation                                                 | MHz    | MegaHertz                                      |
| Amb    | Ambient                                                              | mic    | Microphone                                     |
| ATPC   | Automatic Transmit Power Control                                     | min    | minimum                                        |
| BER    | Bit Error Rate                                                       | mm     | milliMetres                                    |
| °C     | Degrees Celsius                                                      | ms     | milliSeconds                                   |
| C/I    | Carrier / Interferer                                                 | mW     | milliWatts                                     |
| CEPT   | European Conference of Postal and Telecommunications Administrations | NA     | Not Applicable                                 |
| COFDM  | Coherent OFDM                                                        | nom    | Nominal                                        |
| CS     | Channel Spacing                                                      | nW     | nanoWatt                                       |
| CW     | Continuous Wave                                                      | OATS   | Open Area Test Site                            |
| dB     | decibels                                                             | OFDM   | Orthogonal Frequency Division Multiplexing     |
| dBµA/m | decibels relative to 1µA/m                                           | ppm    | Parts per million                              |
| dBµV   | decibels relative to 1µV                                             | PRBS   | Pseudo Random Bit Sequence                     |
| dBc    | decibels relative to Carrier                                         | QAM    | Quadrature Amplitude Modulation                |
| dBm    | decibels relative to 1mW                                             | QPSK   | Quadrature Phase Shift Keying                  |
| DC     | Direct Current                                                       | R&TTE  | Radio and Telecommunication Terminal Equipment |
| DTA    | Digital Transmission Analyser                                        | Ref    | Reference                                      |
| EIRP   | Equivalent Isotropic Radiated Power                                  | RF     | Radio Frequency                                |
| ERP    | Effective Radiated Power                                             | RFC    | Remote Frequency Control                       |
| EU     | European Union                                                       | RSL    | Received Signal Level                          |
| EUT    | Equipment Under Test                                                 | RTP    | Room Temperature and Pressure                  |
| FM     | Frequency Modulation                                                 | RTPC   | Remote Transmit Power Control                  |
| FSK    | Frequency Shift Keying                                               | Rx     | Receiver                                       |
| g      | Grams                                                                | s      | Seconds                                        |
| GHz    | GigaHertz                                                            | SINAD  | Signal to Noise And Distortion                 |
| Hz     | Hertz                                                                | Tx     | Transmitter                                    |
| IF     | Intermediate Frequency                                               | V      | Volts                                          |
| kHz    | kiloHertz                                                            |        |                                                |