Radio Test Report

LMK Thermosafe Ltd

PROX-ATEX TEMPERATURE CONTROLLER Z1C

47 CFR Part 15.225 Effective Date 1st October 2018
DXX: Part 15 Low Power communication device transmitter
Test Date: 22nd February 2019 to 25th February 2019
Report Number: 02-10990-1-19 Issue 01

R.N. Electronics Ltd.
Arnolds Court
Arnolds Farm Lane
Mountnessing
Essex
CM13 1UT
U.K.

www.RNelectronics.com

Telephone: +44 (0) 1277 352219
Email: sales@RNelectronics.com

Arnolds Court, Arnolds Farm Lane, Mountnessing, Brentwood Essex, CM13 1UT

Certificate of Test 10990-1

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:	PROX-ATEX TEMPERATURE CONTROLLER Z1C
Model Number:	25A / 15A
Unique Serial Number:	18Z1C/25/RED1 (All tests) 18Z1C/25/RED2 (AC Conducted Emissions only)
Applicant:	LMK Thermosafe Ltd 9/10 Moonhall Business Park Helions Bumpstead Road Haverhill, Suffolk CB9 7AA
Full measurement results are detailed in Report Number:	02-10990-1-19 Issue 01
Test Standards:	47 CFR Part 15.225 Effective Date 1st October 2018 DXX: Part 15 Low Power communication device transmitter

NOTE:
Certain tests were not performed based upon manufacturer's declarations. 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:	22nd February 2019 to 25th February 2019
Test Engineer:	Digitally signed by: Graham Blake DN: CN = Graham Blake C = GB O = RN Electronics Ltd Date: 2019.04.05 16:49:11 +01'00'
Approved By: Radio Approvals Manager	Digitally signed by: Daniel Sims DN: CN = Daniel Sims C = GB O = RN Electronics Ltd Date: 2019.04.04 11:00:53 Z
Customer Representative:	

2360

1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	LMK Thermosafe Ltd 9/10 Moonhall Business Park Helions Bumpstead Rd Haverhill Suffolk CB9 7AA	
Manufacturer of EUT	LMK Thermosafe Ltd	
Full Name of EUT	PROX-ATEX TEMPERATURE CONTROLLER Z1C	
Model Number of EUT	25A / 15A	
Serial Number of EUT	18Z1C/25/RED1 (All tests) 18Z1C/25/RED2 (AC Conducted Emissions only)	
Date Received	22nd February 2019	
Date of Test:	22nd February 2019 to 25th February 2019	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	8th March 2019	
Main Function	On/Off temperature indication and control.	
Information Specification	Height	345 mm
	Width	75 mm
	Depth	95 mm
	Weight	3.5 kg
	Voltage	100 - 240 VAC 50/60 Hz
	Current	15 or 25 Amp

Note: LMK Thermosafe declare that the PROX-ATEX Temperature Controller has got two versions. A 25A and a 15A. Both versions are identical in PCB layouts and firmware. The differences between them are three thermal fuses in the main board having different rated operational current and functioning temperature which has no effect on tests performed in this report.

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Wall mounted
Choice of model(s) for type tests	Sample
Antenna details	Integral loop antenna
Antenna port	No
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	27.12 MHz
Lowest Signal generated in EUT	16 MHz
Hardware Version	EUT comprising of: Main V3 NFC V2 Filter V2
Software Version	Not Applicable
Firmware Version	Test V1.1
Technology Type	RFID
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	13.56 MHz fixed frequency
EUT Declared Modulation Parameters	RFID ISO14443
EUT Declared Power level	Not declared
EUT Declared Signal Bandwidths	Not declared
EUT Declared Channel Spacing's	Single Channel
EUT Declared Duty Cycle	Not declared
Declared frequency stability	<100 ppm
FCC Class	
DXX: Part 15 Low Power communication device transmitter	

2.3 Functional description

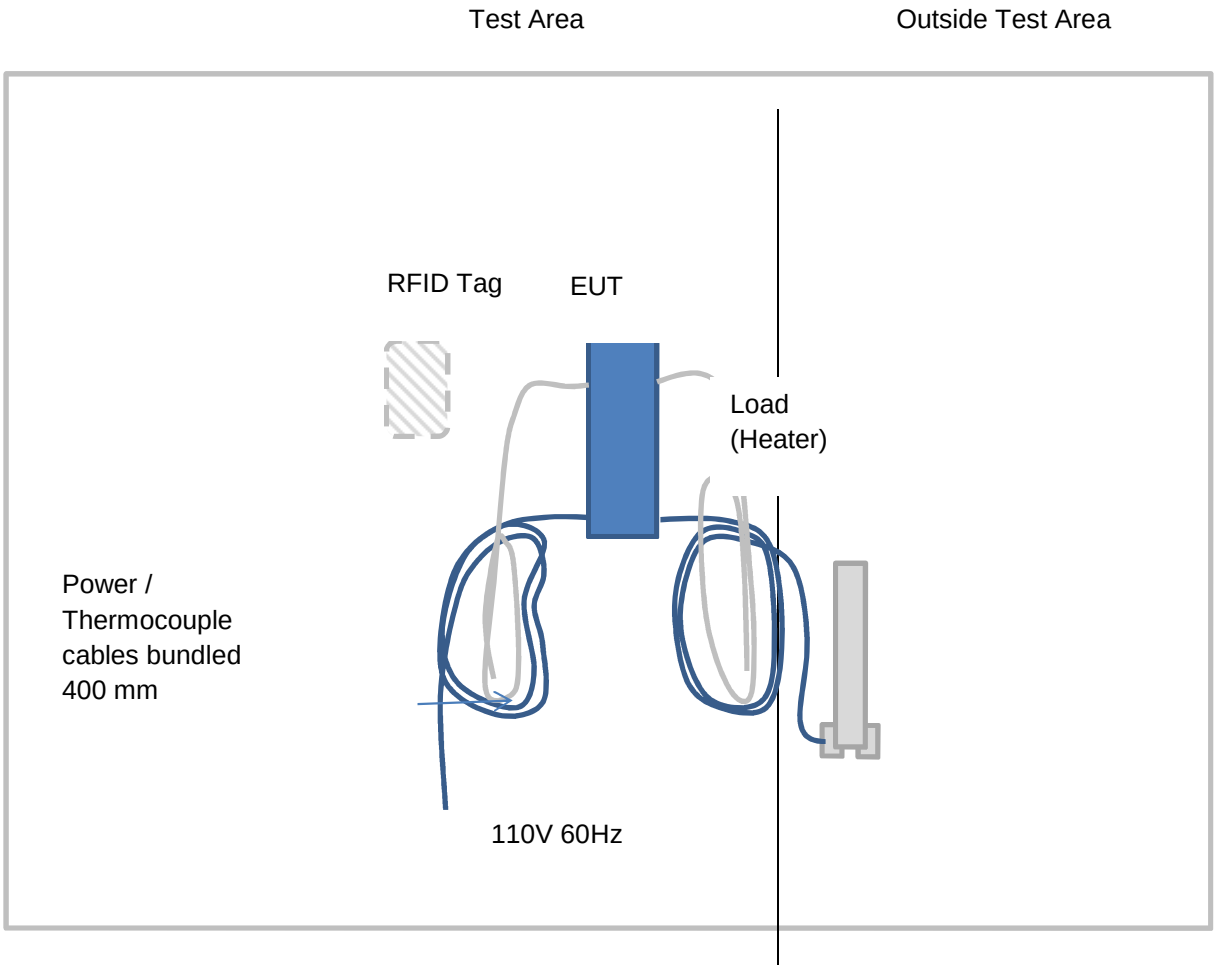
The PROX-ATEX Z1C is an on-off temperature controller with up to two temperature probes for heating equipment. It is housed in an enclosure with a glass window for viewing a four-digit display. A keypad can be used for device configuration. The Z1C also features a near field communication (NFC) transceiver operating at 13.56 MHz for communicating with pre-configured NFC cards.

2.4 Modes of operation

Mode Reference	Description	Used for testing
Tag read	The RFID tag is placed in close proximity to the EUT. The card is read continuously.	Yes
No tag	The EUT is active. No RFID tag is presented to the EUT.	Yes
No tag (Antenna disconnected)	The EUT is active. No RFID tag is presented to the EUT. The RFID loop antenna has been disconnected.	Yes

Note: Mode with antenna disconnected was only used to determine compliance with AC conducted emissions.

2.5 Emissions configuration



The equipment under test was powered by 110V 60 Hz AC mains. A heater was used as a load and this was connected to the mains output of the EUT. The EUT was configured so that the mains output was continuously energised and therefore the load was drawing current through the EUT.

The thermocouple and power cables were bundled and positioned above the ground plane.

For the purposes of test, the applicant provided an RFID tag which is used with the product. To determine worst case emissions, a pre-test was performed and the EUT was assessed with the tag presented to the EUT's tag reader and also without the RFID tag present.

For AC conducted emissions two separate test units were assessed. One unit was the standard production unit and the second unit had been modified for the purposes of test where the RFID loop antenna had been removed. The second test unit was used to confirm that the 13.56 MHz emission observed on the production unit was radiated on to the mains cable and not a conducted emission.

For measurement performed at extremes of temperature and voltage, a test fixture was used which was connected to the spectrum analyser. The EUT was powered via a Variac so that the supply voltage could be varied to the values stated in section 4.3.

2.5.1 Signal leads

Port Name	Cable Type	Connected
AC Power input	3-core (fitted with clip-on ferrite)	Yes
AC Power output	2-core	Yes
Thermocouple 1	Screened 2-core	Yes
Thermocouple 2	Screened 2-core	Yes

3 Summary of test results

The PROX-ATEX TEMPERATURE CONTROLLER Z1C, 25A/15A was tested for compliance to the following standard(s) :

47 CFR Part 15.225 Effective Date 1st October 2018

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
Transmitter Tests		
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	PASSED
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209	PASSED
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.225(d)	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.209	NOT APPLICABLE[1]
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

[1] Radiated emissions measurements above 1 GHz are not required. The highest frequency generated or used within the equipment is 27.12 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	110V DC
T minimum	-20 °C	V minimum	95.6V DC
T maximum	50 °C	V maximum	126.5V DC

Extremes of voltage are based on nominal +/-15%.

Extremes of temperature are as listed in the standard.

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 the EUT's mains cable which was reduced in length to 1 metre.

Details of the Peripheral and Ancillary Equipment connected for this test are listed in section 10.

The EUT was operated in No tag and No tag (Antenna disconnected) modes for this test.

5.1.3 Test procedure

Measurements were made via a LISN on the live and neutral conductors using both average and quasi-peak detectors.

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

Two separate units were used to perform this test. One unit was the standard production unit and the second unit had been modified for the purposes of test where the RFID loop antenna had been removed. The second test unit was used to confirm that the 13.56 MHz emission observed on the production unit was radiated on to the mains cable and not a conducted emission.

Tests were performed in Test Site F.

5.1.4 Test equipment

E150, E035, ZSW1, E624, E411, E465

See Section 9 for more details

5.1.5 Test results

Temperature of test environment 20°C
Humidity of test environment 40 - 50%
Pressure of test environment 100kPa

Band	13.553-13.567 MHz
Power Level	Maximum
Channel Spacing	Single Frequency
Mod Scheme	RFID
Single channel	13.56 MHz

Cond 1 AC (Standard production test unit)

Plot refs
10990-1 Cond 1 AC Live 150kHz-30MHz Average
10990-1 Cond 1 AC Live 150kHz-30MHz Quasi-Peak
10990-1 Cond 1 AC Neutral 150kHz-30MHz Average
10990-1 Cond 1 AC Neutral 150kHz-30MHz Quasi-Peak

Band	13.553-13.567 MHz
Power Level	Maximum
Channel Spacing	Single Frequency
Mod Scheme	RFID
Single channel	13.56 MHz

Cond 2 AC (Modified test unit – 13.56 MHz RFID antenna removed)

Plot refs
10990-1 Cond 2 AC Live 150kHz-30MHz Average
10990-1 Cond 2 AC Live 150kHz-30MHz Quasi-Peak
10990-1 Cond 2 AC Neutral 150kHz-30MHz Average
10990-1 Cond 2 AC Neutral 150kHz-30MHz Quasi-Peak

Table of signals measured for Cond 1 AC Live 150kHz-30MHz

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.363	42.0	37.7	-21.0	27.5	-21.2
2	0.545	40.1	35.0	-21.0	25.6	-20.4
3	0.757	39.8	35.4	-20.6	25.5	-20.5
4	1.574	41.1	34.0	-22.0	24.3	-21.7
5	2.009	41.8	37.7	-18.3	29.0	-17.0
6	2.352	48.7	42.9	-13.1	33.7	-12.3
7	2.632	41.2	35.8	-20.2	26.3	-19.7
8	2.664	41.7	34.8	-21.2	25.5	-20.5
9	13.558	65.0	64.2	4.2*	59.0	9.0*
10	27.12	36.2	35.2	-24.8	30.3	19.7

Table of signals measured for Cond 1 AC Neutral 150kHz-30MHz

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.374	42.9	38.4	-20.0	27.6	-20.8
2	0.410	45.8	39.3	-18.3	27.3	-20.3
3	0.528	43.4	36.3	-19.7	25.1	-20.9
4	0.771	44.0	36.9	-19.1	25.6	-20.4
5	0.795	43.9	37.5	-18.5	23.9	-22.1
6	0.911	42.1	36.3	-19.7	25.0	-21.0
7	0.960	44.0	37.1	-18.9	25.4	-20.6
8	1.163	43.4	37.7	-18.3	25.1	-20.9
9	1.804	43.9	38.0	-18.0	26.5	-19.5
10	2.122	42.8	40.0	-16.0	31.0	-15.0
11	2.243	51.5	44.0	-12.0	33.1	-12.9
12	2.306	47.4	44.8	-11.2	33.7	-12.3
13	2.388	52.1	44.6	-11.4	33.3	-12.7
14	13.558	66.3	65.5	5.5*	60.3	10.3*
15	27.116	35.2	34.1	-25.9	29.0	-21.0

*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 generated by the EUTs' radio, the test was repeated with a second test unit where the integral antenna was disconnected and the EUTs' RF output fitted with a 50 ohm load. Please refer to the plots and following result tables for the test with the antenna disconnected.

Table of signals measured for Cond 2 AC Live 150kHz-30MHz

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.358	32.6	29.6	-29.2	17.6	-31.2
2	0.424	35.6	32.8	-24.6	19.9	-27.5
3	1.750	34.4	32.1	-23.9	22.1	-23.9
4	2.646	41.5	39.6	-16.4	29.4	-16.6

Table of signals measured for Cond 2 AC Neutral 150kHz-30MHz

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.343	32.5	29.8	-29.3	18.9	-30.2
2	0.421	35.1	32.5	-24.9	20.1	-27.3
3	1.584	34.1	31.7	-24.3	21.6	-24.4
4	1.653	34.4	32.3	-23.7	22.2	-23.8
5	2.519	39.7	37.7	-18.3	27.4	-18.6
6	2.667	41.6	39.7	-16.3	29.2	-16.8
7	2.800	39.6	37.8	-18.2	27.4	-18.6

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

LIMITS:
15.207: 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 ±3.6dB

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 Tag read mode which was found to be worst case.

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 and the antenna were rotated 360 degrees to record the worst case emissions. Tests were performed in Test Site H.

5.2.4 Test equipment

E534, E535, TMS81

See Section 9 for more details

5.2.5 Test results

Temperature of test environment	20°C
Humidity of test environment	40%
Pressure of test environment	102kPa

Band	13.553-13.567 MHz
Power Level	Maximum
Channel Spacing	Single Frequency
Mod Scheme	RFID
Single channel	13.56 MHz

Plot refs
10990-1 Rad 1 9-150kHz Para
10990-1 Rad 1 9-150kHz 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 ±3.9dB

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 Tag read mode which was found to be worst case.

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 and the antenna were rotated 360 degrees to record the worst case emissions. Tests were performed in Test Site H

5.3.4 Test equipment

E534, E535, TMS81

See Section 9 for more details

5.3.5 Test results

Temperature of test environment	20°C
Humidity of test environment	40%
Pressure of test environment	102kPa

Band	13.553-13.567 MHz
Power Level	Maximum
Channel Spacing	Single Frequency
Mod Scheme	RFID
Single channel	13.56 MHz

Plot refs
10990-1 Rad 2 150kHz-30MHzHz Para
10990-1 Rad 2 150kHz-30MHzHz 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 ±3.9dB

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 Tag read mode which was found to be worst case.

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 H

5.4.4 Test equipment

E660, E744, NSA-H, ZSW1, E534, E535, E748, N460

See Section 9 for more details

5.4.5 Test results

Temperature of test environment	20°C
Humidity of test environment	40%
Pressure of test environment	102kPa

Band	13.553-13.567 MHz
Power Level	Maximum
Channel Spacing	Single Frequency
Mod Scheme	RFID
Single channel	13.56 MHz

Plot refs
10990-1 Rad 1 VHF Horiz
10990-1 Rad 1 VHF Vert
10990-1 Rad 1 UHF Horiz
10990-1 Rad 1 UHF Vert

Table of signals measured for Rad 1 Horizontal Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	189.823	25.4	22.0	-21.5
2	216.932	24.3	19.7	-26.3

Table of signals measured for Rad 1 Vertical Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	82.527	18.8	12.0	-28.0
2	189.814	26.6	23.8	-19.7
3	189.938	20.8	13.8	-29.7
4	216.933	23.9	19.1	-26.9
5	254.536	27.4	20.6	-25.4
6	271.159	30.5	26.6	-19.4

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit lines 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 ±6.1dB

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 27.12 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)/(b)/(c)/(d) [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 Tag read mode which was found to be worst case.

5.6.3 Test procedure

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

Pre-scan measurements were made in a semi-anechoic chamber and final measurements on an OATS. These sites are listed with the FCC. Both the equipment and the antenna were rotated 360 degrees to record the maximised emission.

Measurements were made at Site H and OATS.

5.6.4 Test equipment

E534, E535, TMS81

See Section 9 for more details

5.6.5 Test results

Temperature of test environment 20°C
Humidity of test environment 40%
Pressure of test environment 102kPa

Band	13.553-13.567 MHz
Power Level	Maximum
Channel Spacing	Single Frequency
Mod Scheme	RFID
Single channel	13.56 MHz

	Single channel 13.56 MHz
Peak Level (dBµV/m) @ 3m	46.7
Plot reference	10990-1 H Field
Antenna Polarisation	Perpendicular
EUT Polarisation	Upright

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) @ 30m	6.7

LIMITS:

15.225(a) QP/Peak = the field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 µV/m @ 30m = 84 dBµV/m @ 30m.
15.225(b) QP/Peak = within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 µV/m @ 30m = 50.5 dBµV/m @ 30m.
15.225(c) QP/Peak = within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 µV/m @ 30m = 40.5 dBµV/m @ 30m.
15.225(d) QP/Peak = outside of the 13.110-14.010 MHz band shall not exceed the general radiated emissions limits of 15.209.

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 in a chamber and was positioned for maximised emissions. The EUT was measured at a distance of 3 metres. The EUT was operated in Tag read mode.

5.7.3 Test procedure

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

5.7.4 Test equipment

E534, E535, TMS81

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	20°C
Humidity of test environment	40%
Pressure of test environment	102kPa

Band	13.553-13.567 MHz
Power Level	Maximum
Channel Spacing	Single Frequency
Mod Scheme	RFID
Single channel	13.56 MHz

	Single channel 13.56 MHz
20 dB Bandwidth (MHz)	1.736
Plot for 20 dB Bandwidth	10990-1 OBW

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)/(b)/(c)/(d) [Reference 4.1.1 of this report]

5.8.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The EUT was measured at a distance of 3 metres. The EUT and antenna were positioned for maximum field strength and referenced to the field strength measured on the OATS. The EUT was operated in Tag read mode.

5.8.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.
Measurements were made at Site H. This site is listed with the FCC.
Max-held 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

5.8.4 Test equipment

E412, E434, E555, L264, P266, S032, TMS38

See Section 9 for more details

5.8.5 Test results

Temperature of test environment	20°C
Humidity of test environment	50%
Pressure of test environment	102kPa

Band	13.553-13.567 MHz
Power Level	Maximum
Channel Spacing	Single Frequency
Mod Scheme	RFID
Single channel	13.56 MHz

	Single channel 13.56 MHz
Nominal Temperature, Nominal Voltage, Maximised RF field strength	6.7
Nominal plot reference	10990-1 Spectrum mask at 30metres - RFID Tag Read - Tnom Vnom

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 13.553-13.567 MHz shall not exceed 15,848 µV/m @ 30m = 84 dBµV/m @ 30m.
15.225(b) QP/Peak = within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 µV/m @ 30m = 50.5 dBµV/m @ 30m.
15.225(c) QP/Peak = within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 µV/m @ 30m = 40.5 dBµV/m @ 30m.
15.225(d) QP/Peak = outside of the 13.110-14.010 MHz band shall not exceed the general radiated emissions limits of 15.209.

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: <± 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

The EUT's power port was connected to a variable power supply. This allowed the voltage to be set as required by the specification.

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 Tag read mode.

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 the RF signal using a spectrum analyser counter function. At nominal temperature the EUT supply was varied by +/-15%. 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 A.

5.9.4 Test equipment

E412, E434, E555, L264, P266, S032, TMS38

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 102kPa

Band	13.553-13.567 MHz
Power Level	Maximum
Channel Spacing	Single Frequency
Mod Scheme	RFID
Single channel	13.56 MHz

Test conditions		Frequency Error (MHz) Single channel
-30°C	Volts Nominal (110)	13.558686
-20°C	Volts Nominal (110)	13.558732
-10°C	Volts Nominal (110)	13.558772
0°C	Volts Nominal (110)	13.558650
10°C	Volts Nominal (110)	13.558780
20°C	Volts Minimum (95.6)	13.558780
	Volts Nominal (110)	13.559052
	Volts Maximum (126.5)	13.559122
30°C	Volts Nominal (110)	13.558776
40°C	Volts Nominal (110)	13.558765
50°C	Volts Nominal (110)	13.558735
Max Frequency Error per chan (Hz)		-1350
Max Frequency Error observed (MHz)		-0.001350

Note: Error shown is referenced to nominal Channel frequency value.

Maximum variation observed was -1350Hz

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

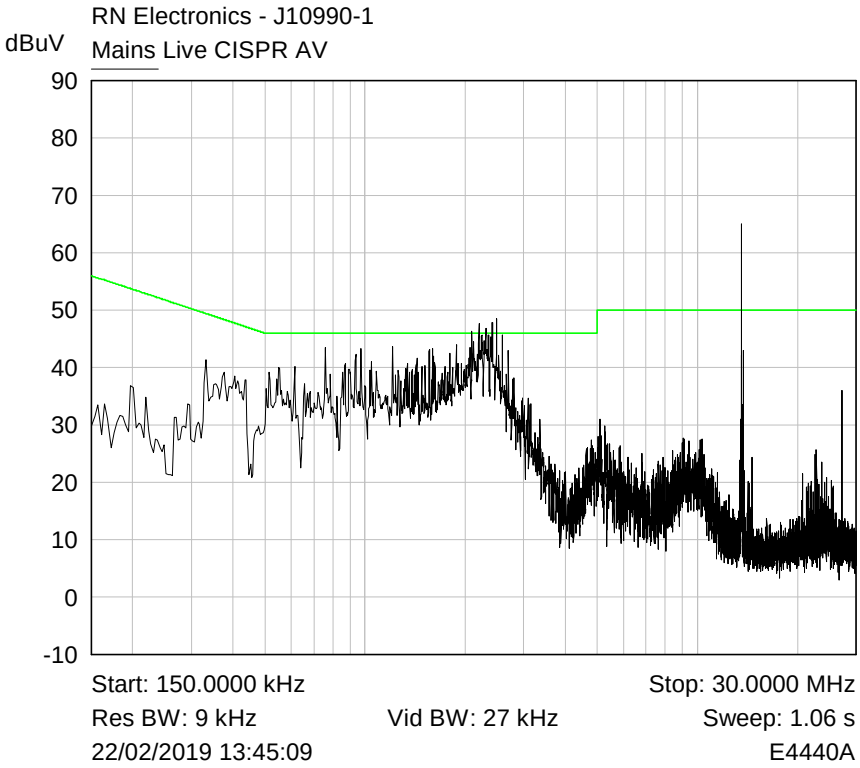
These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
<± 0.7 ppm

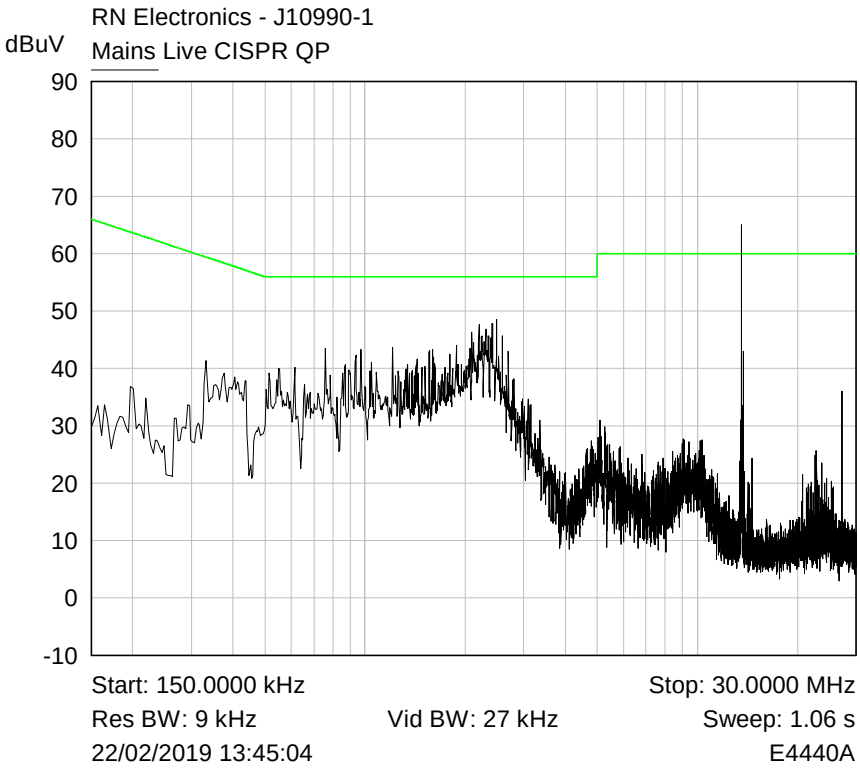
6 Plots/Graphical results

6.1 AC power line conducted emissions

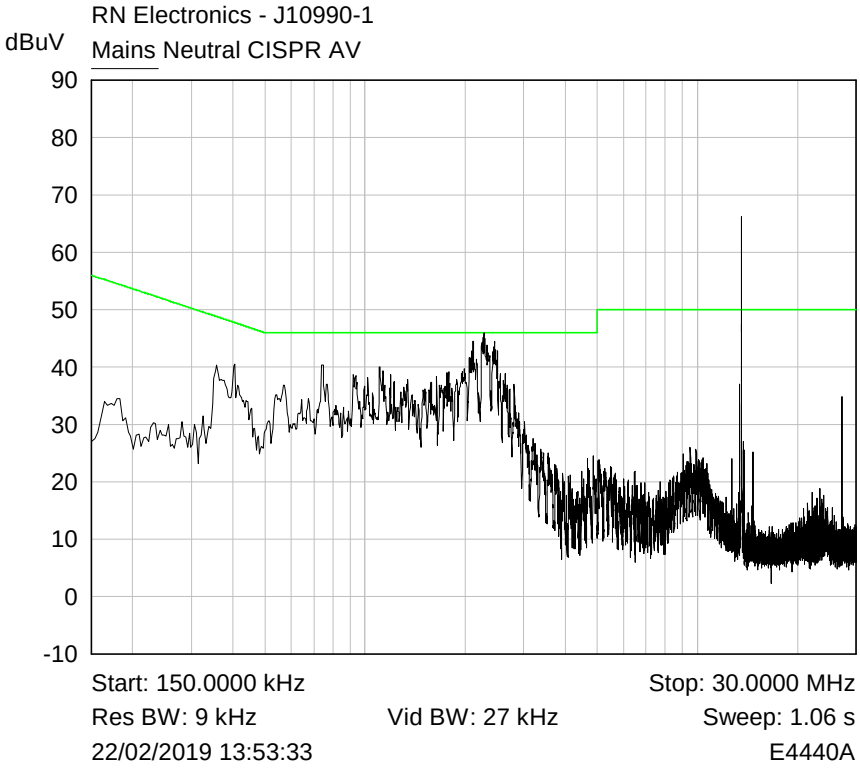
RF Parameters: Band 13.553-13.567 MHz, Power Maximum, Channel Spacing Single Frequency, Modulation RFID, Channel 13.56 MHz



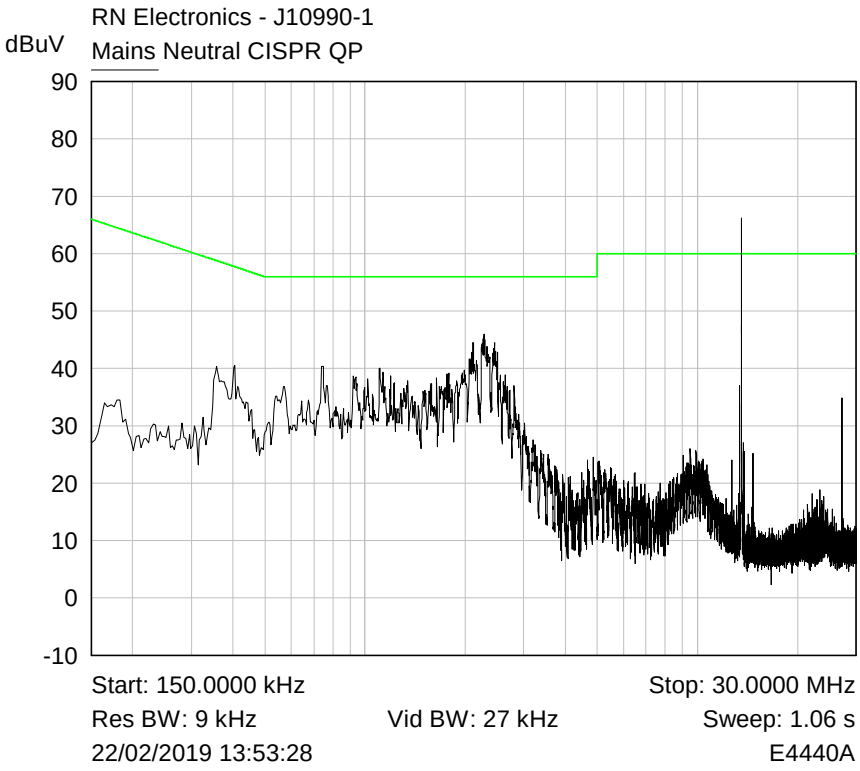
Plot of Live150kHz-30MHz Average (EUT is a standard production unit)
Note: The emission that exceeds the limit line is the fundamental carrier of the 13.56 MHz transmitter radiating on to the mains lead.



Plot of Live150kHz-30MHz Quasi-Peak (EUT is a standard production unit)
Note: The emission that exceeds the limit line is the fundamental carrier of the 13.56 MHz transmitter radiating on to the mains lead.

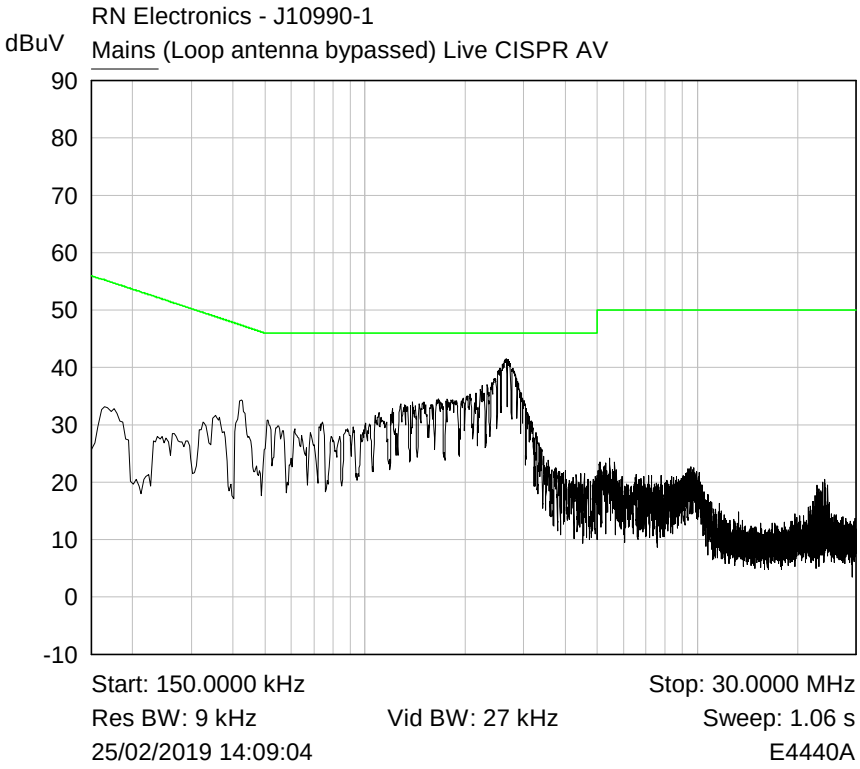


Plot of Neutral150kHz-30MHz Average (EUT is a standard production unit)
Note: The emission that exceeds the limit line is the fundamental carrier of the 13.56 MHz transmitter radiating on to the mains lead.

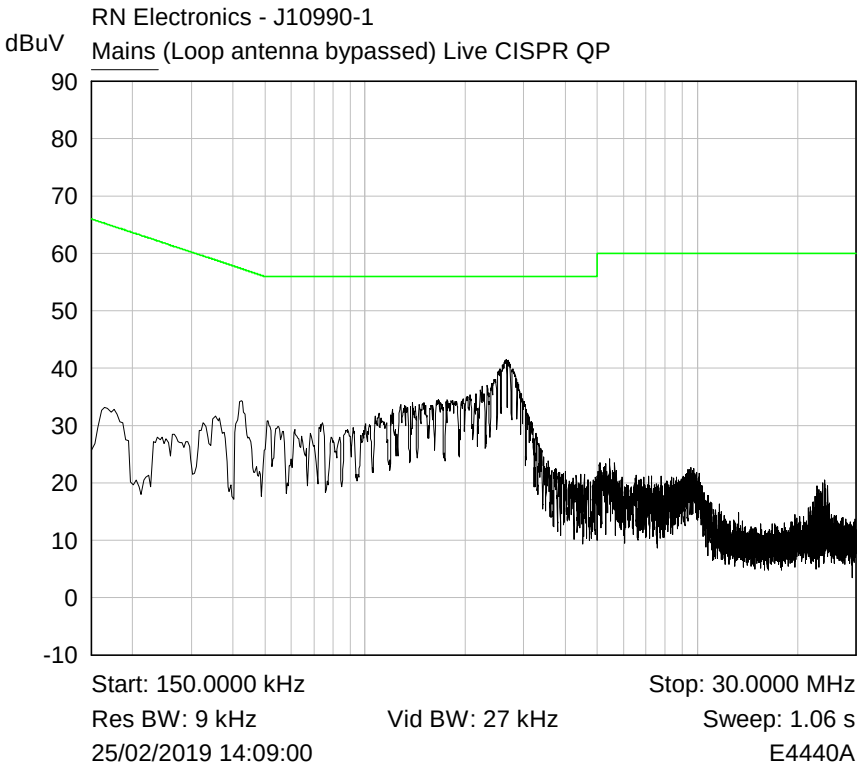


Plot of Neutral150kHz-30MHz Quasi-Peak (EUT is a standard production unit)
Note: The emission that exceeds the limit line is the fundamental carrier of the 13.56 MHz transmitter radiating on to the mains lead.

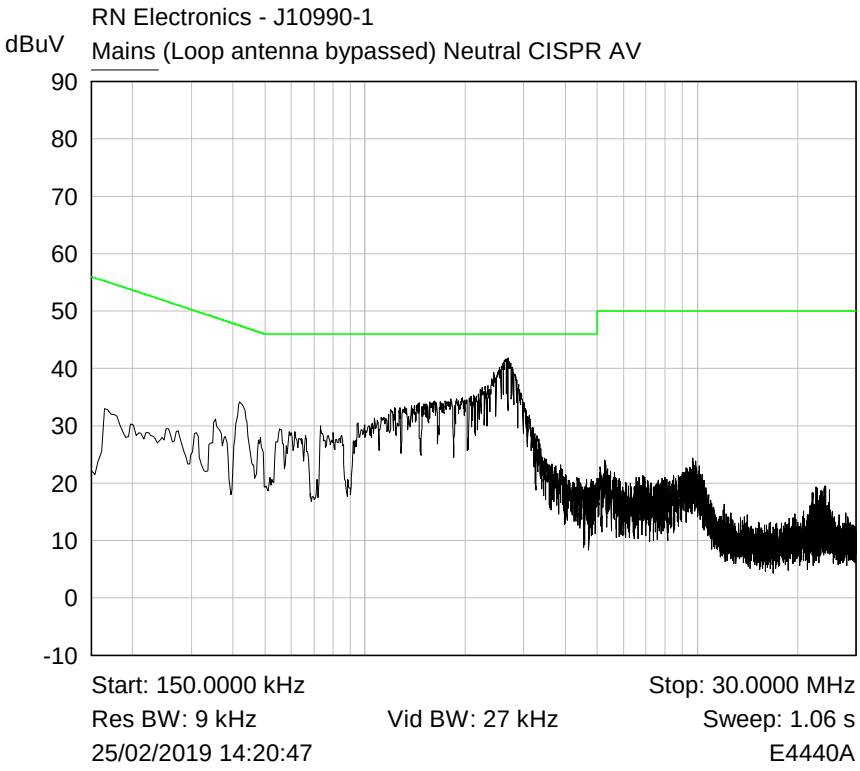
RF Parameters: Band 13.553-13.567 MHz, Power Maximum, Channel Spacing Single Frequency, Modulation RFID, Channel 13.56 MHz



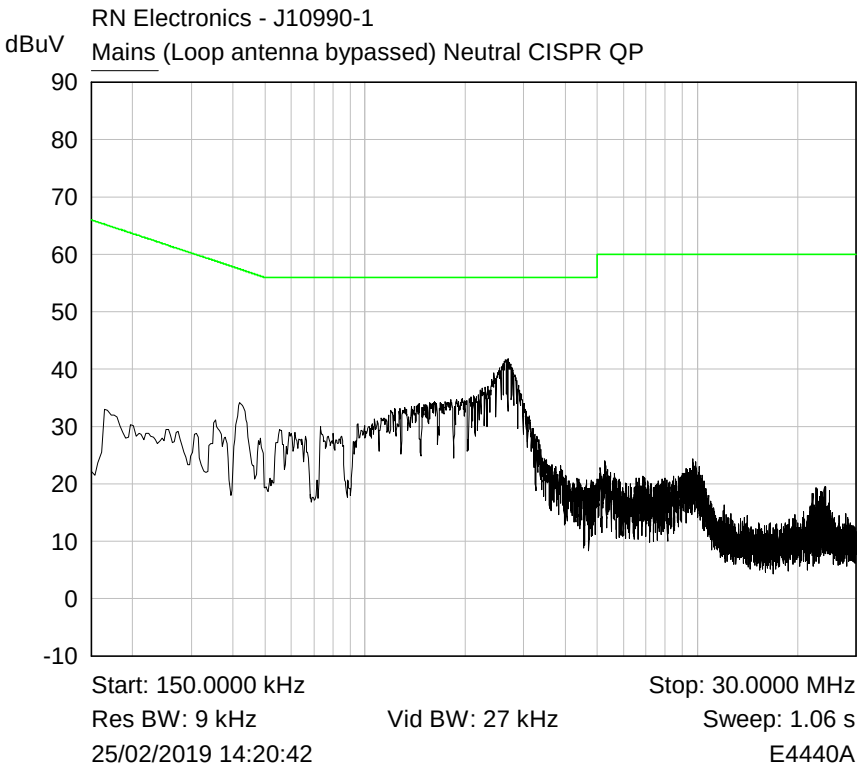
Plot of Live150kHz-30MHz Average (EUT is a modified test unit with antenna terminated)



Plot of Live150kHz-30MHz Quasi-Peak (EUT is a modified test unit with antenna terminated)



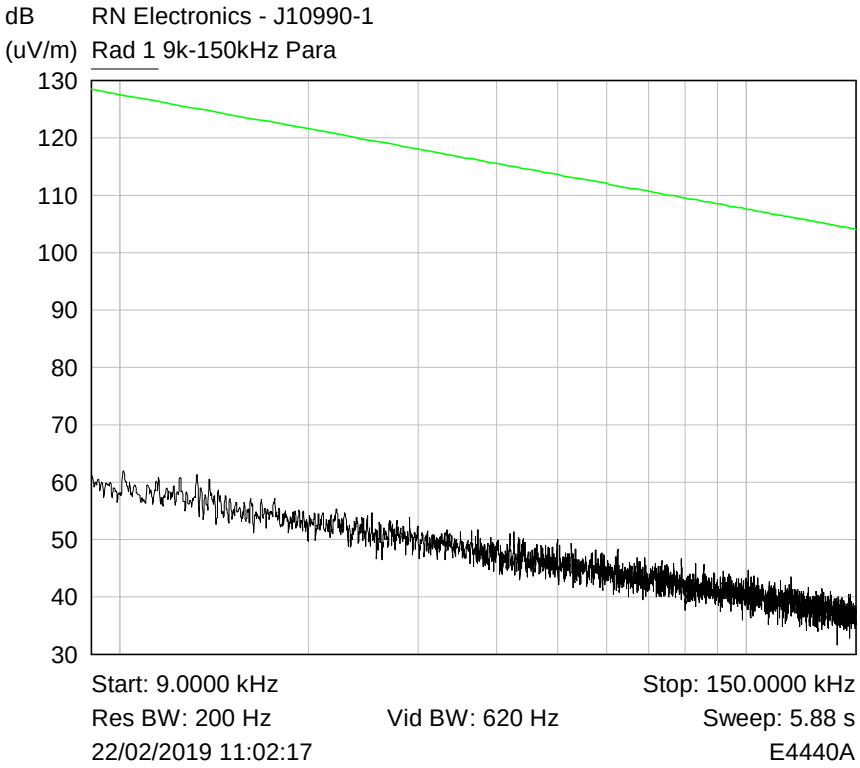
Plot of Neutral150kHz-30MHz Average (EUT is a modified test unit with antenna terminated)



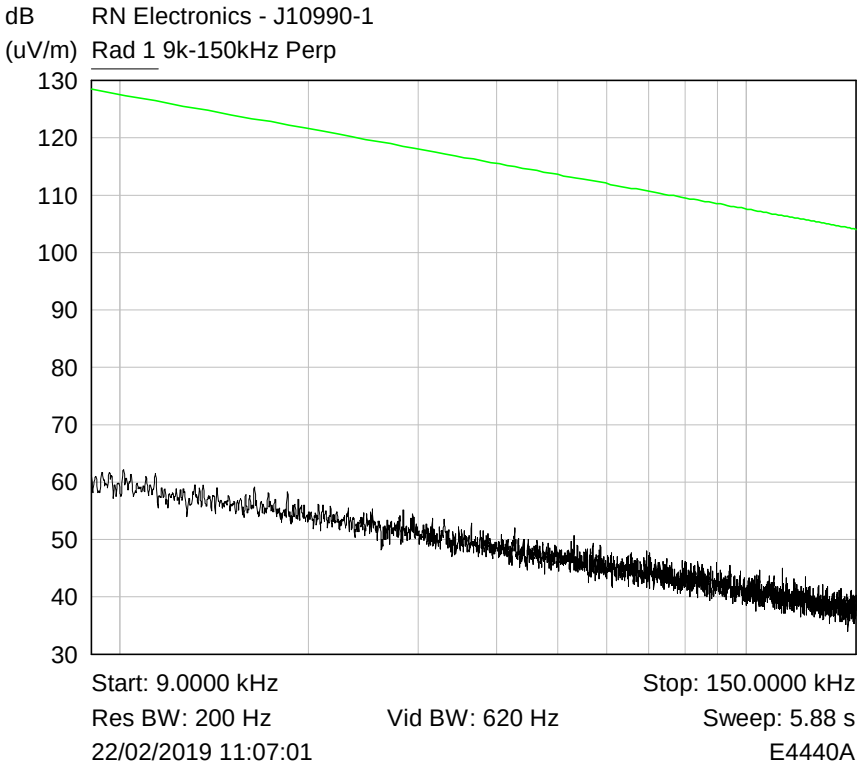
Plot of Neutral150kHz-30MHz Quasi-Peak (EUT is a modified test unit with antenna terminated)

6.2 Radiated emissions 9 - 150 kHz

RF Parameters: Band 13.553-13.567 MHz, Power Maximum, Channel Spacing Single Frequency, Modulation RFID, Channel 13.56 MHz



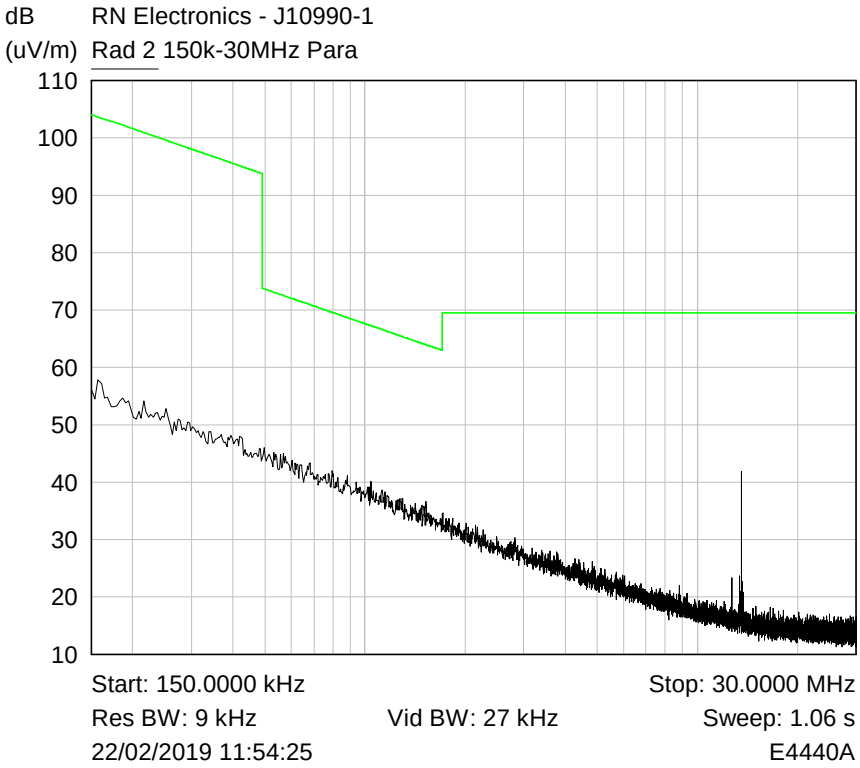
Plot of 9-150kHz Parallel



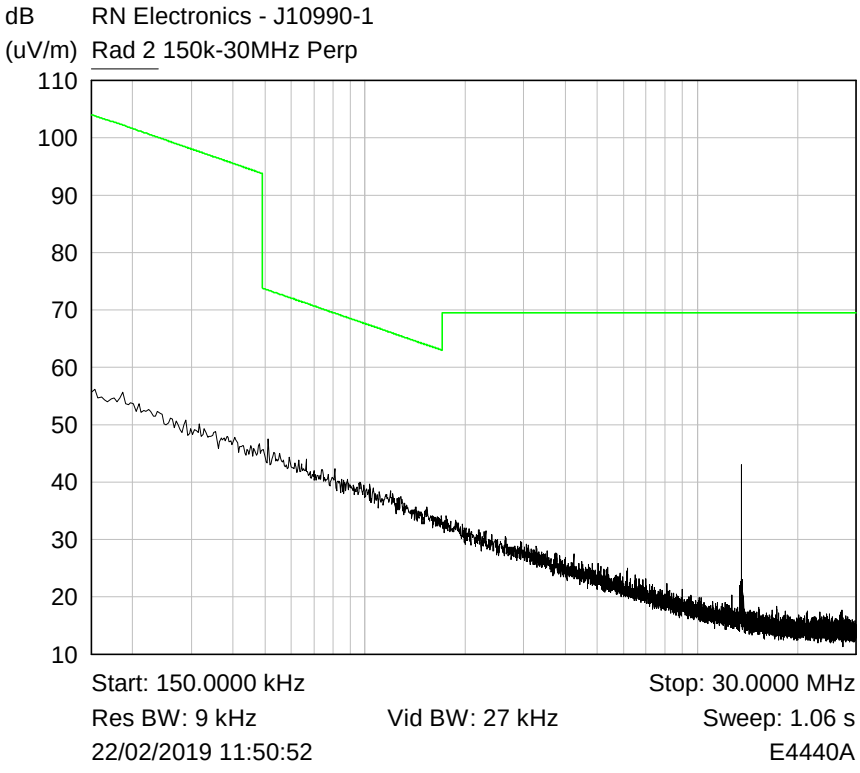
Plot of 9-150kHz Perpendicular

6.3 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 13.553-13.567 MHz, Power Maximum, Channel Spacing Single Frequency, Modulation RFID, Channel 13.56 MHz



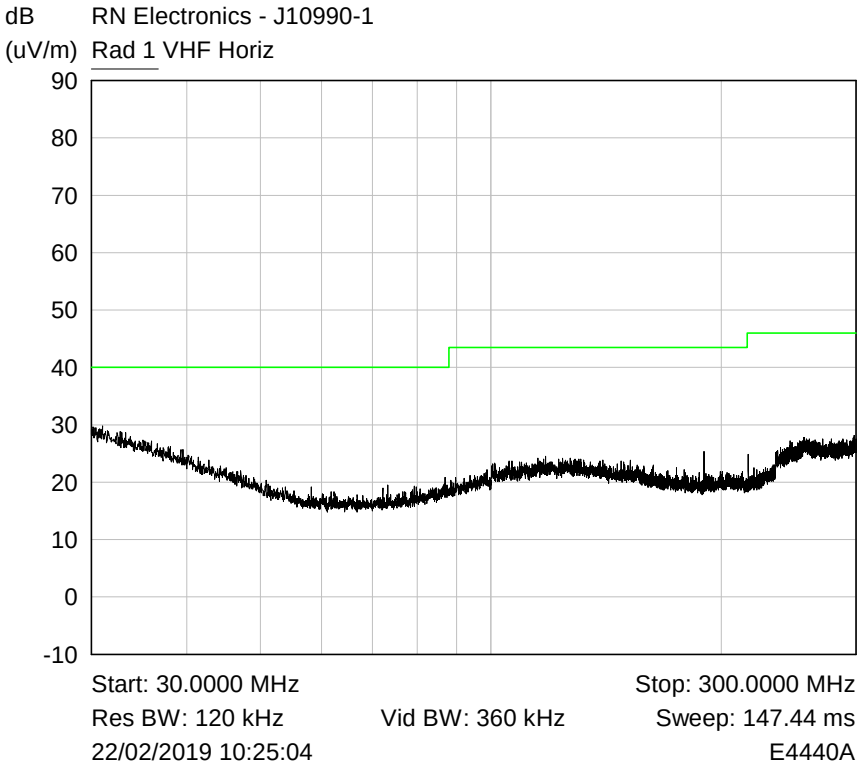
Plot of 150kHz-30MHz Parallel



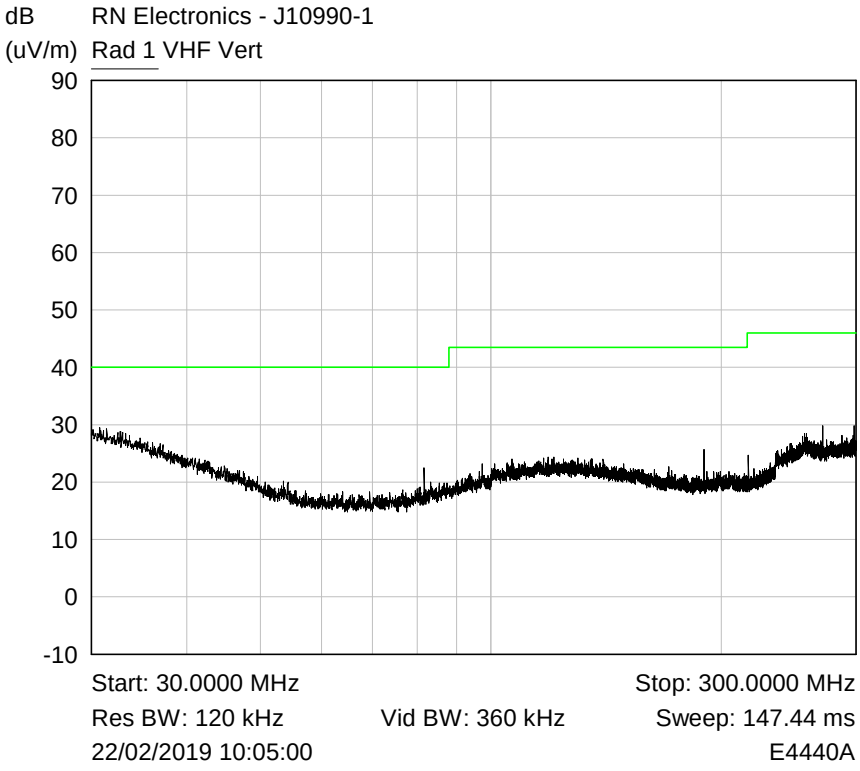
Plot of 150kHz-30MHz Perpendicular

6.4 Radiated emissions 30 MHz -1 GHz

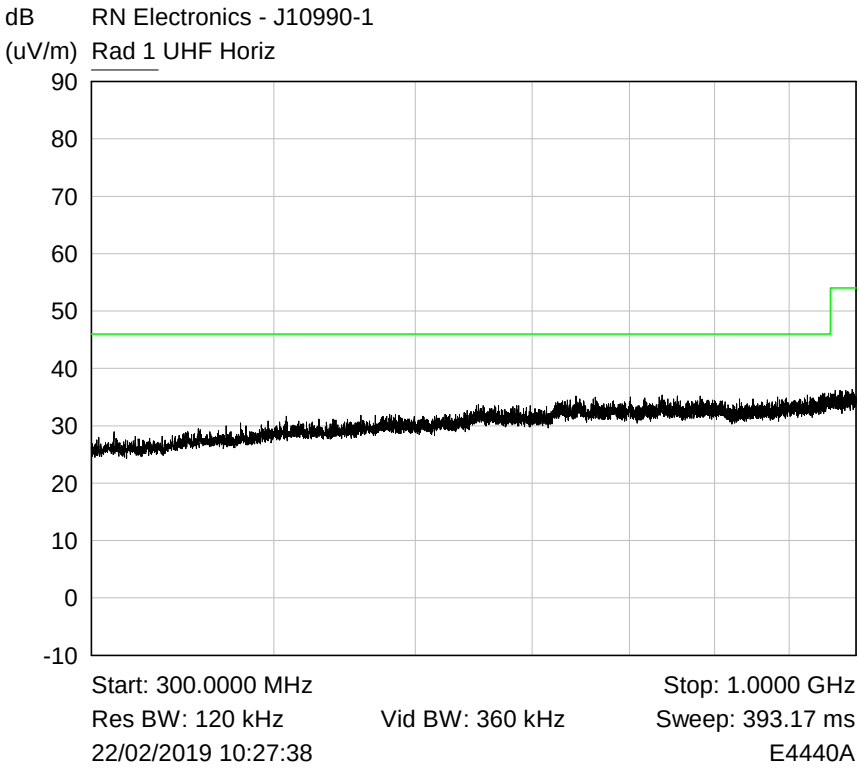
RF Parameters: Band 13.553-13.567 MHz, Power Maximum, Channel Spacing Single Frequency, Modulation RFID, Channel 13.56 MHz



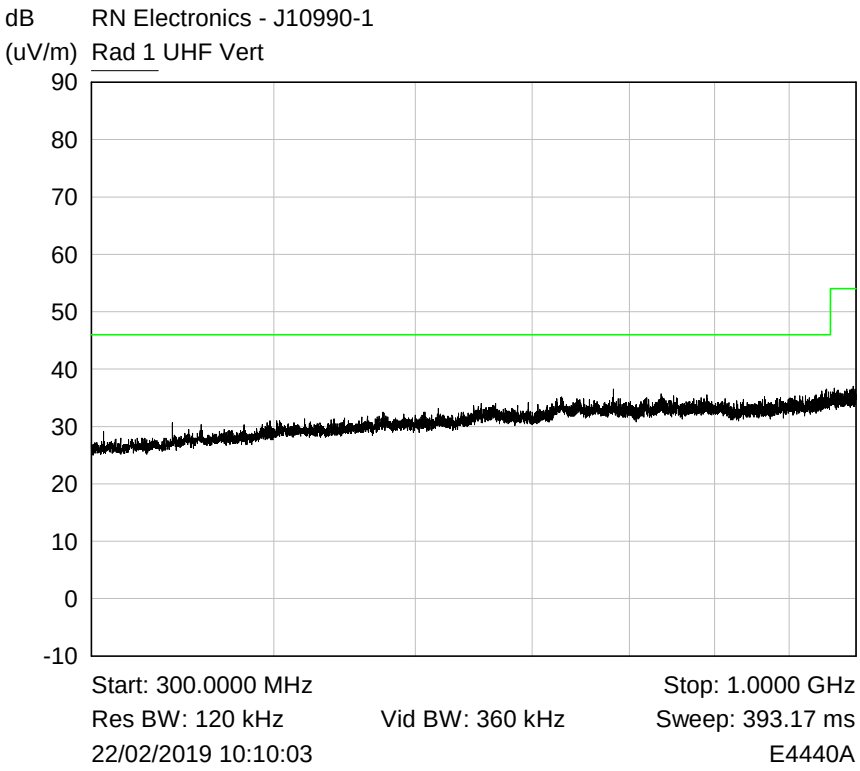
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

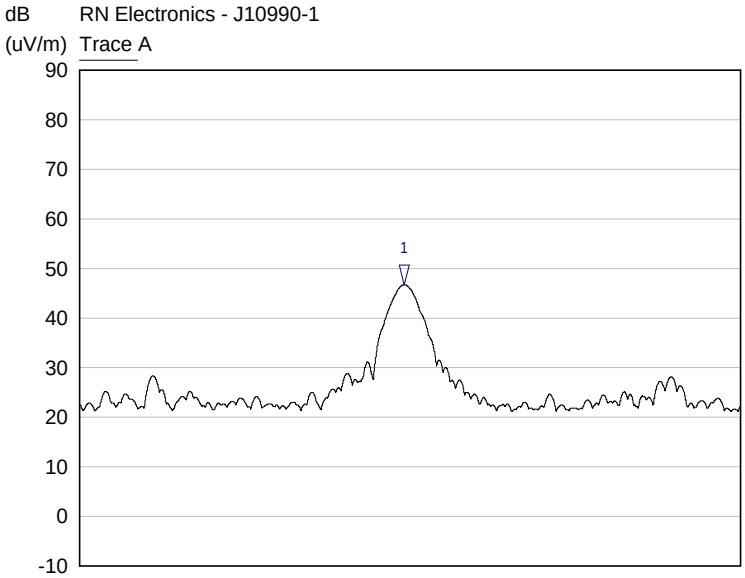


Plot of Peak emissions for UHF Horizontal against the QP limit line.



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

6.5 Intentional radiator field strength

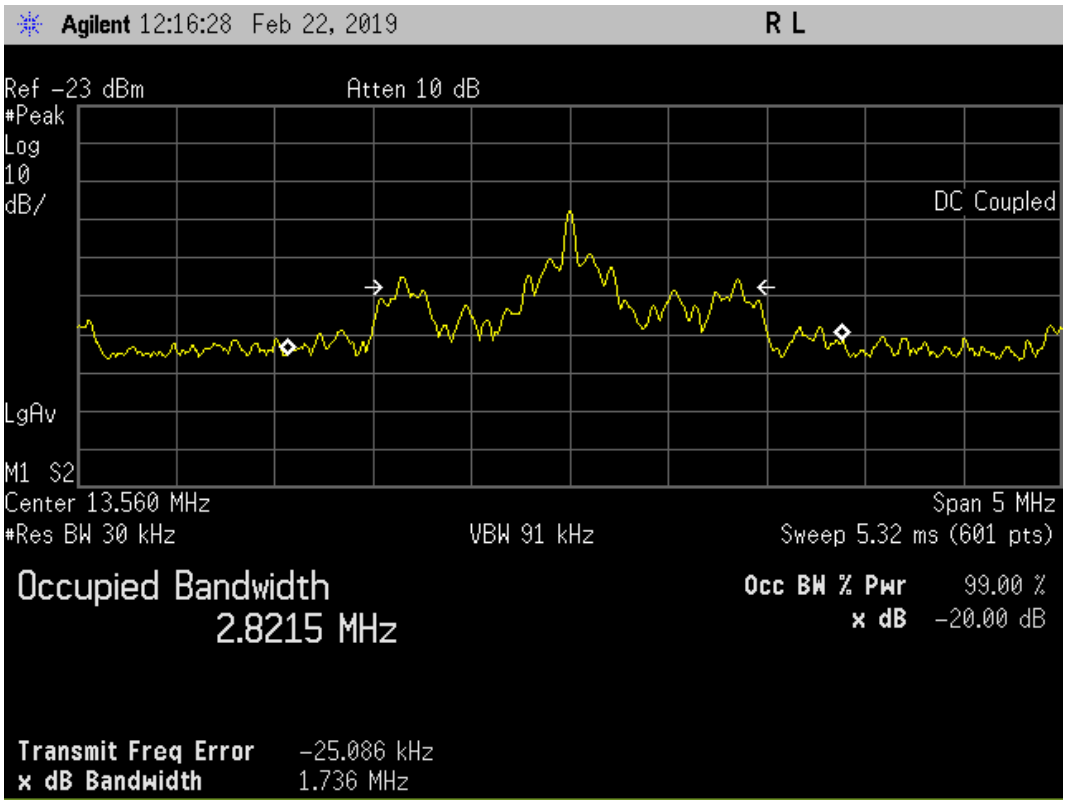


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	13.5578 MHz	46.71 dB(uV/m)	

Intentional radiator field strength H-Field measurement at 3 metres

6.6 Occupied bandwidth

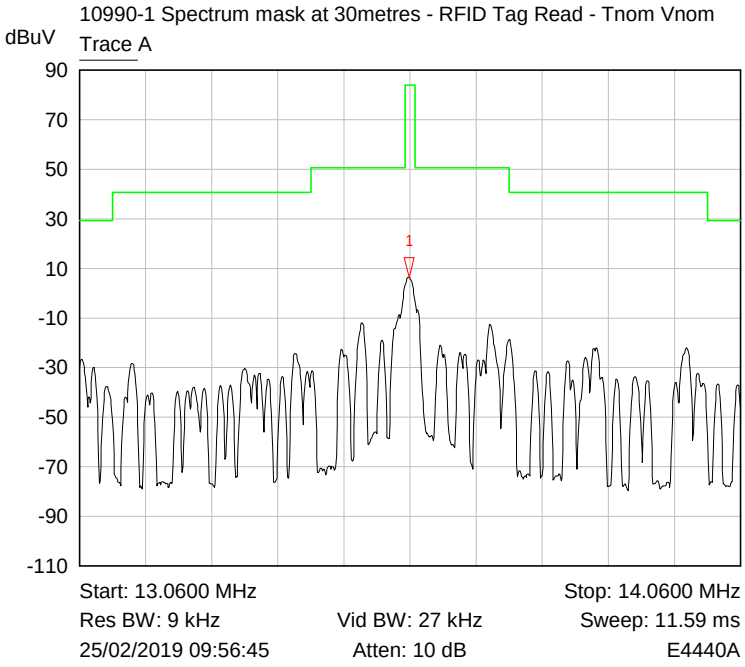
RF Parameters: Band 13.553-13.567 MHz, Power Maximum, Channel Spacing Single Frequency, Modulation RFID, Channel 13.56 MHz



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

6.7 Spectrum mask

RF Parameters: Band 13.553-13.567 MHz, Power Maximum, Channel Spacing Single Frequency, Modulation RFID, Channel 13.56 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	13.5585 MHz	6.47 dBuV	

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 (dBuV)	Pk – Lim 1 (dB)	QP Amp (dBuV)	QP - Lim1 (dB)	Av Amp (dBuV)	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 µV/m at a specified distance), whereas the measured values are expressed as peak, quasi peak or average values in dBµV/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 µV/m equates to 20.log (500) = 54 dB µV/m.

(b) limit of 300 µV/m at 10m equates to 20.log (300 . 10/3) = 60 dB µV/m at 3m

(c) limit of 30 µV/m at 30m, but below 30MHz, equates to 20.log(30) + 40.log(30/3) = 69.5 dBµV/m at 3m, as extrapolation factor below 30MHz is 40dB/decade per 15.31(f)(2).

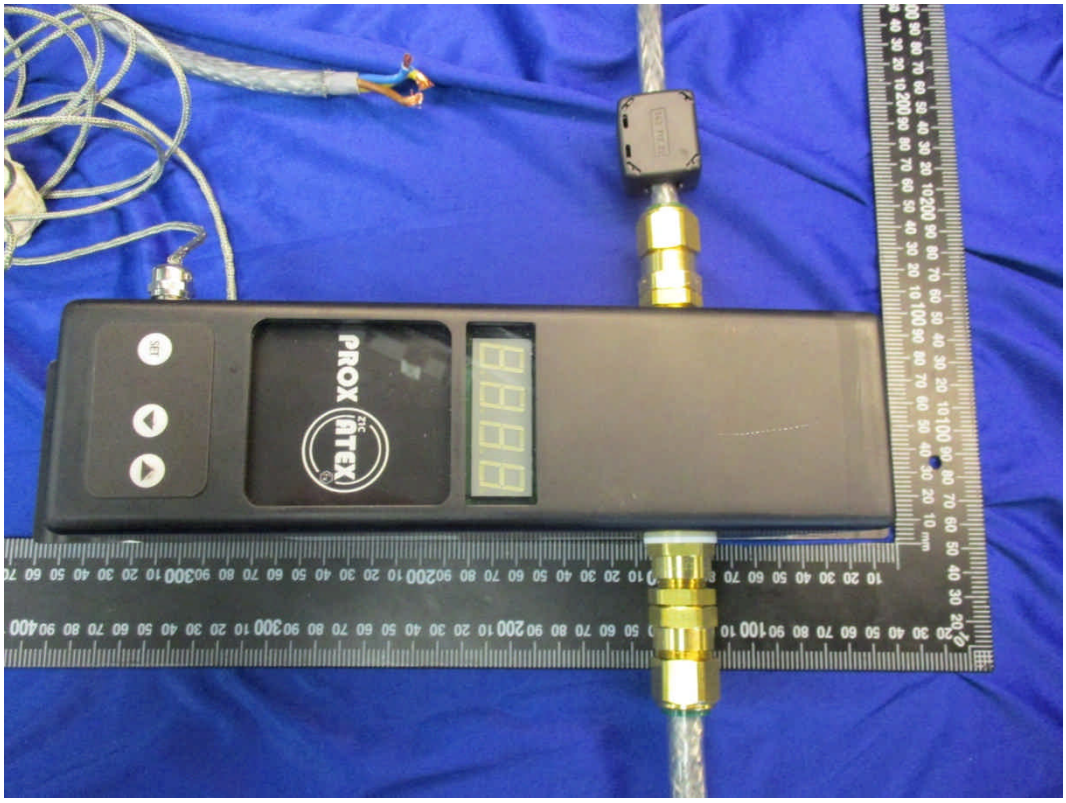
The measurement receiver used for emissions testing, performs the field strength (FS) calculations automatically. The receiver combines the signal amplitude (RA), Antenna Factor (AF) and Cable Loss (CL) factors for the frequency to be measured.

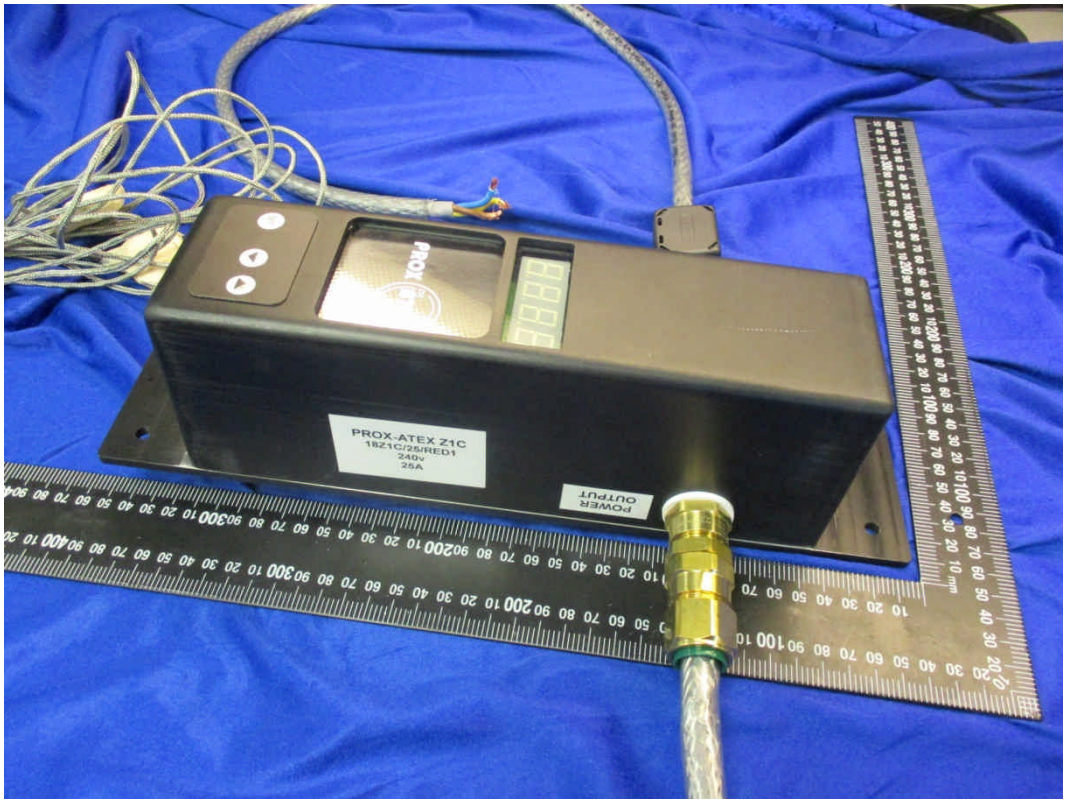
Example calculation: - FS = RA + AF + CL.

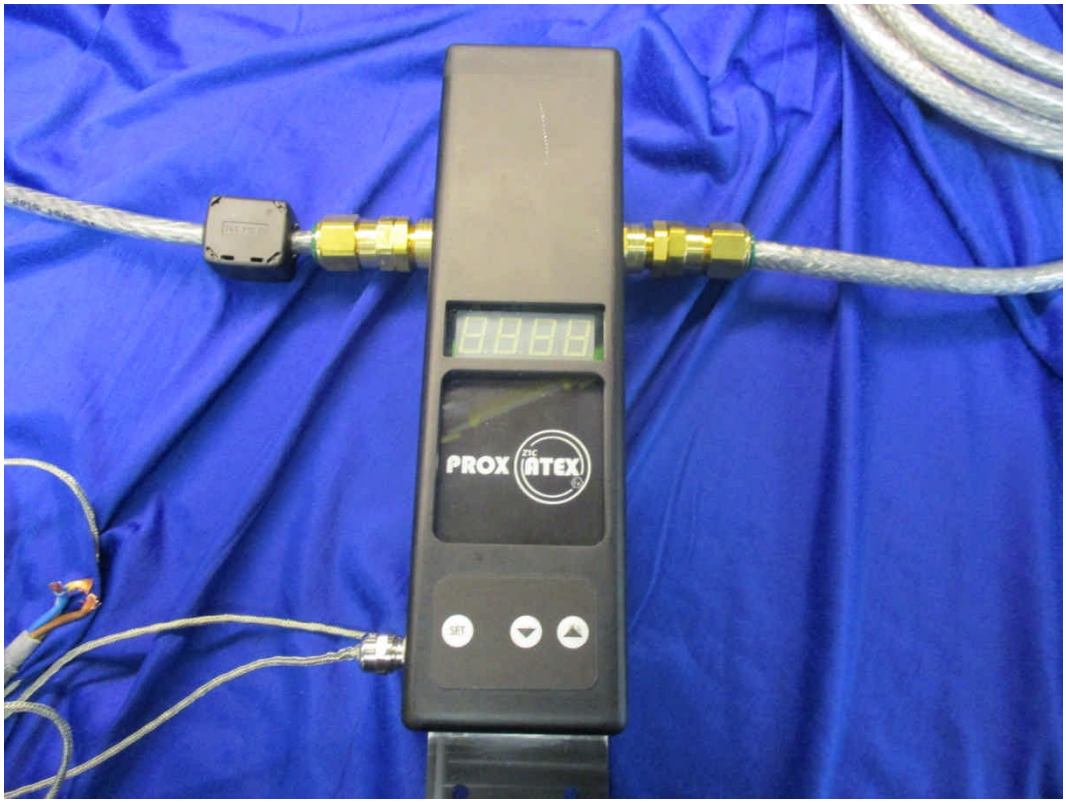
Receiver amplitude (RA)	Antenna factor (3m) (AF)	Cable loss (CL)	Field strength result (3m) (FS)
20dBuV	25 dB	3 dB	48dBuV/m

8 Photographs

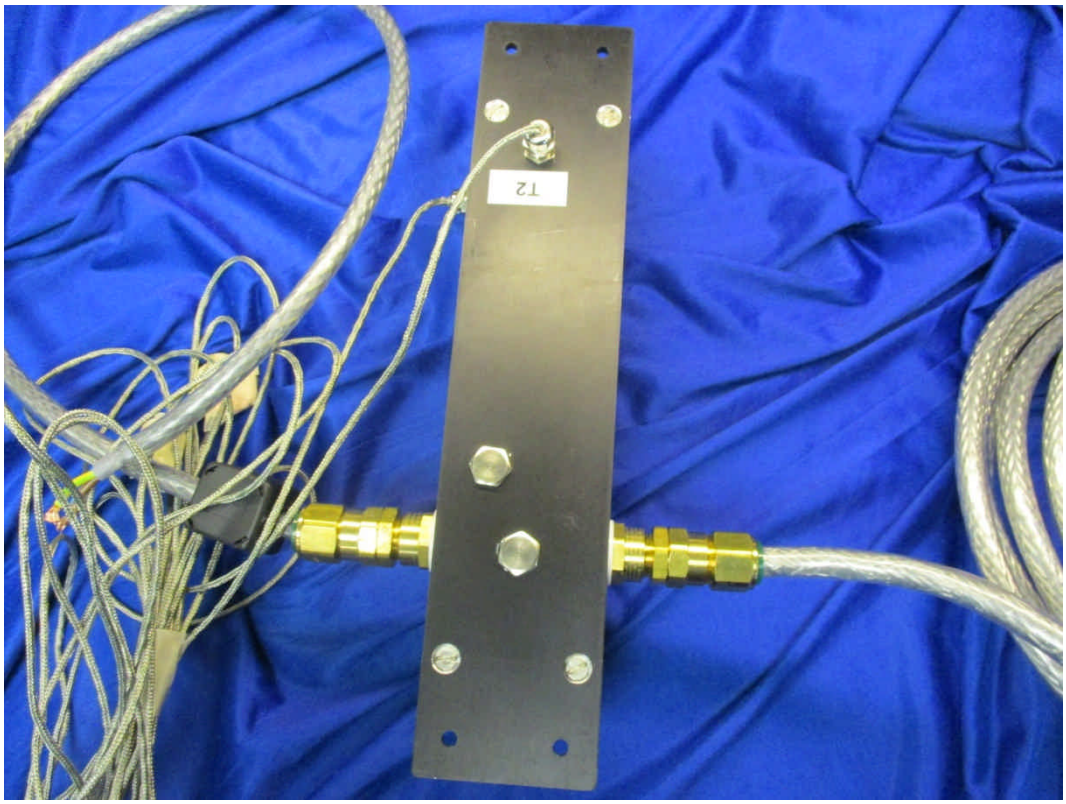
8.1 EUT Front View



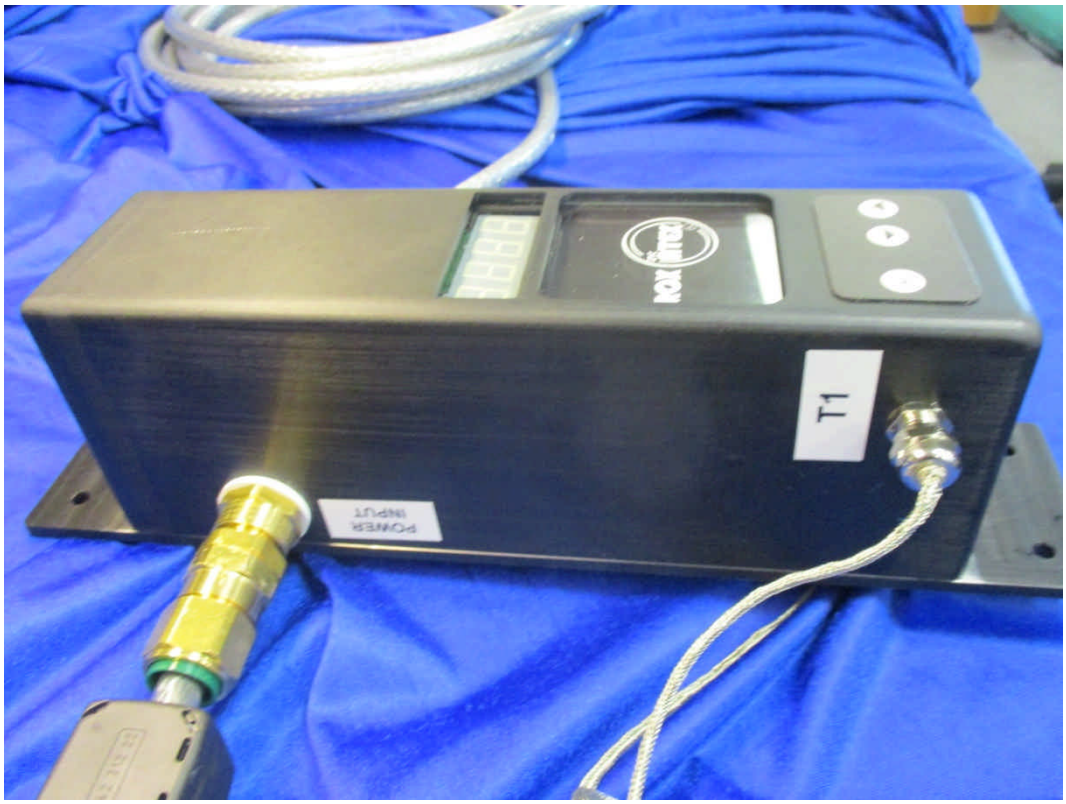



PROX
ATEX
SET

8.2 EUT Reverse Angle



8.3 EUT Left side View

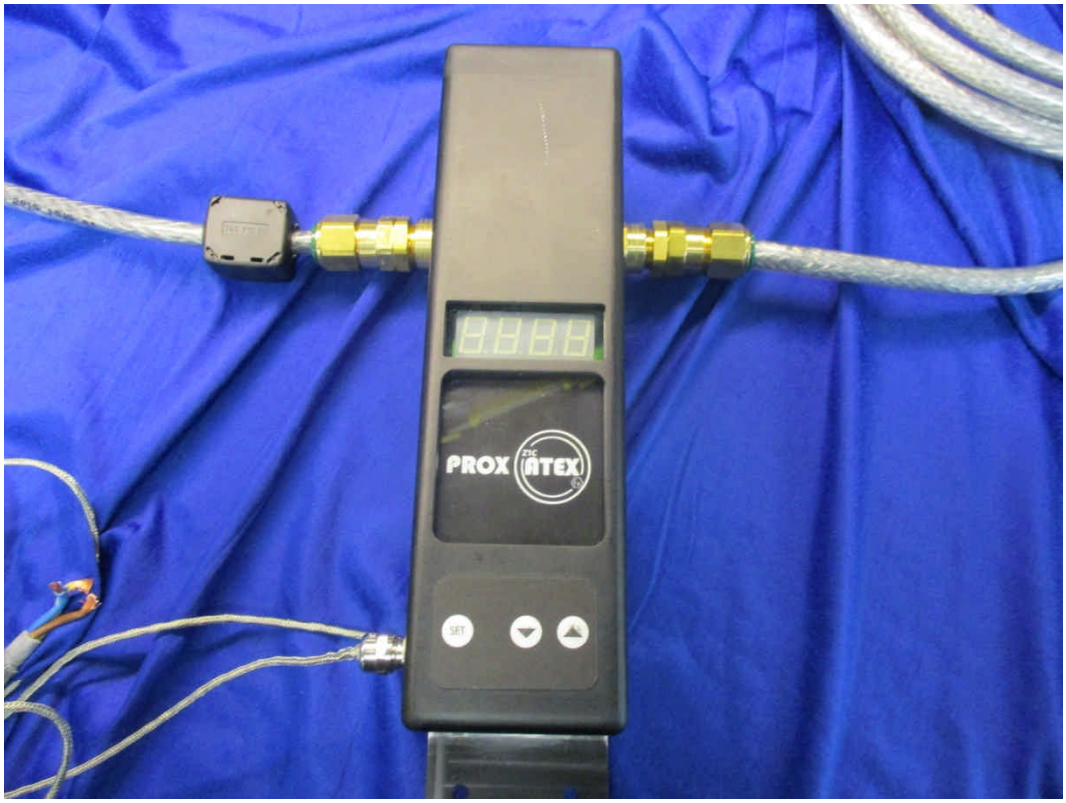


8.4 EUT Right side View

8.5 EUT Antenna Port

Internal photographs not taken or included in this test report at the request of the applicant.

8.6 EUT Display & Controls



8.7 EUT Internal photos

Internal photographs not taken or included in this test report at the request of the applicant.

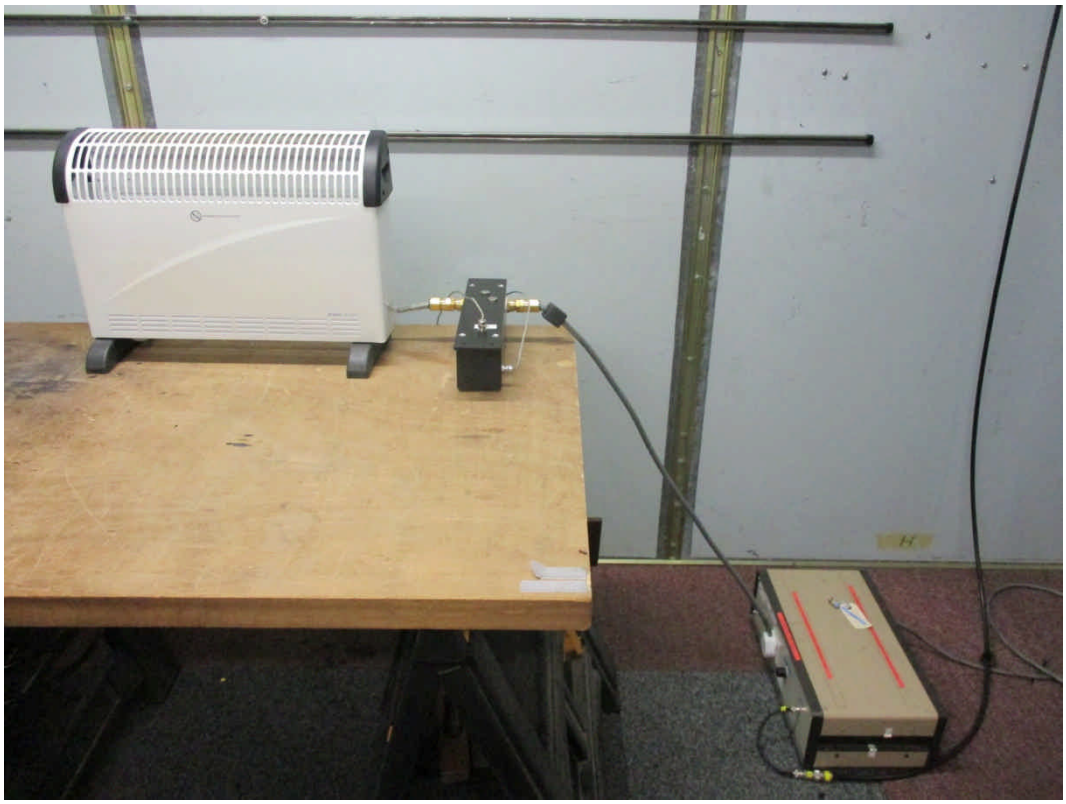
8.8 EUT ID Label

No label was available at the time of test

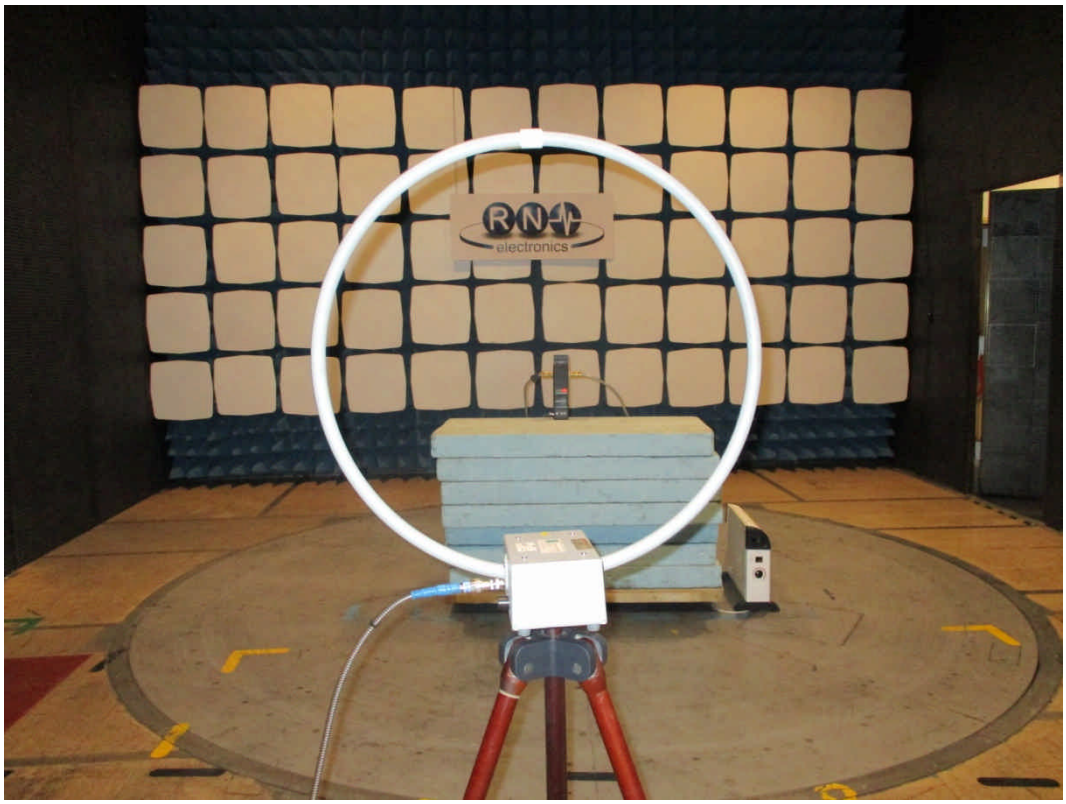
8.9 EUT Chassis

The EUT has no chassis

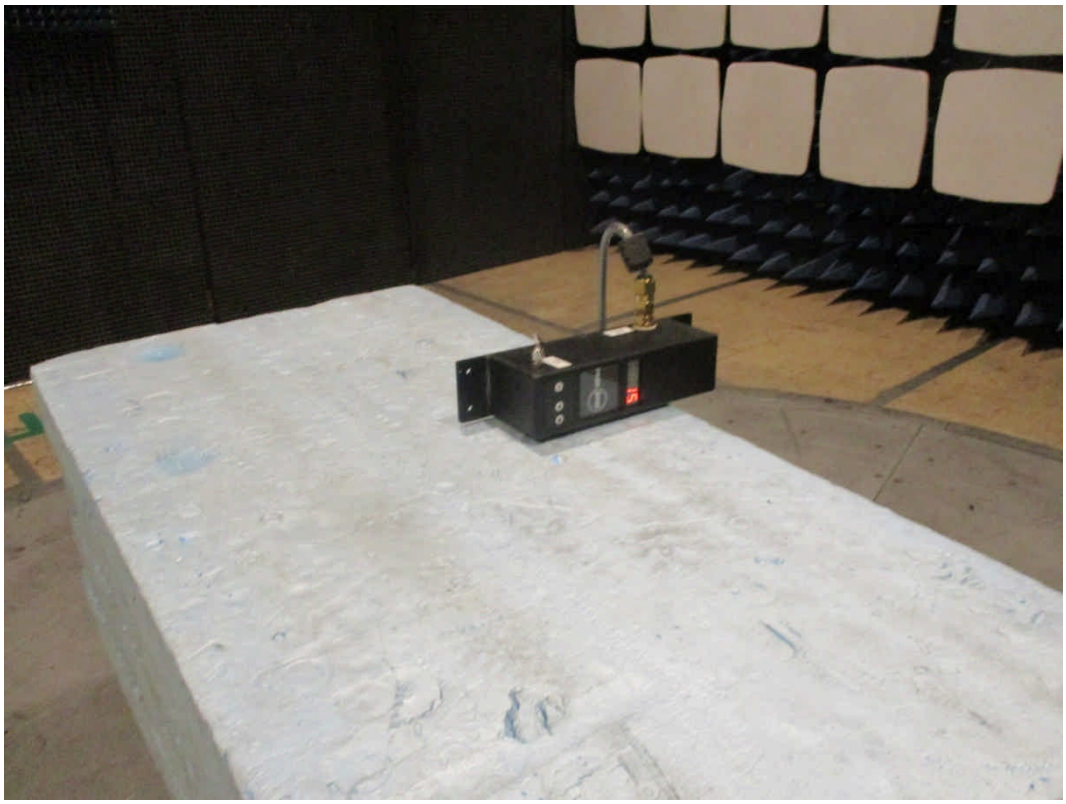
8.10 AC power line conducted emissions



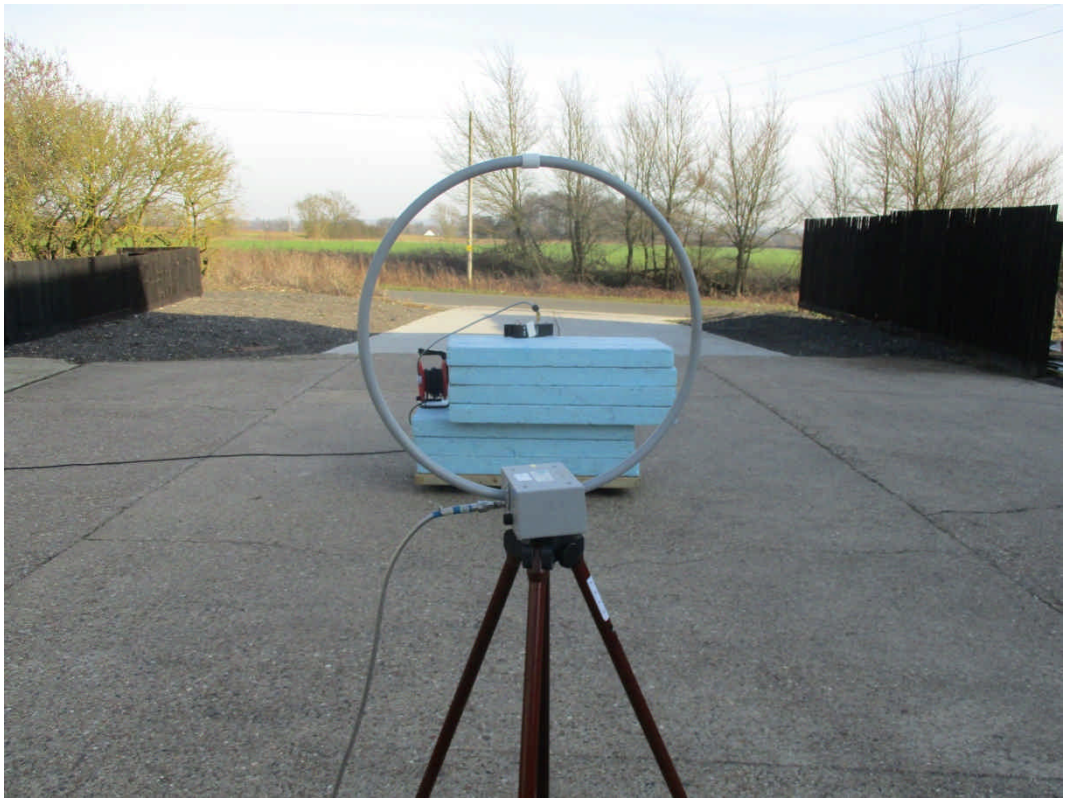
8.11 Radiated emissions 150 kHz - 30 MHz



Site H

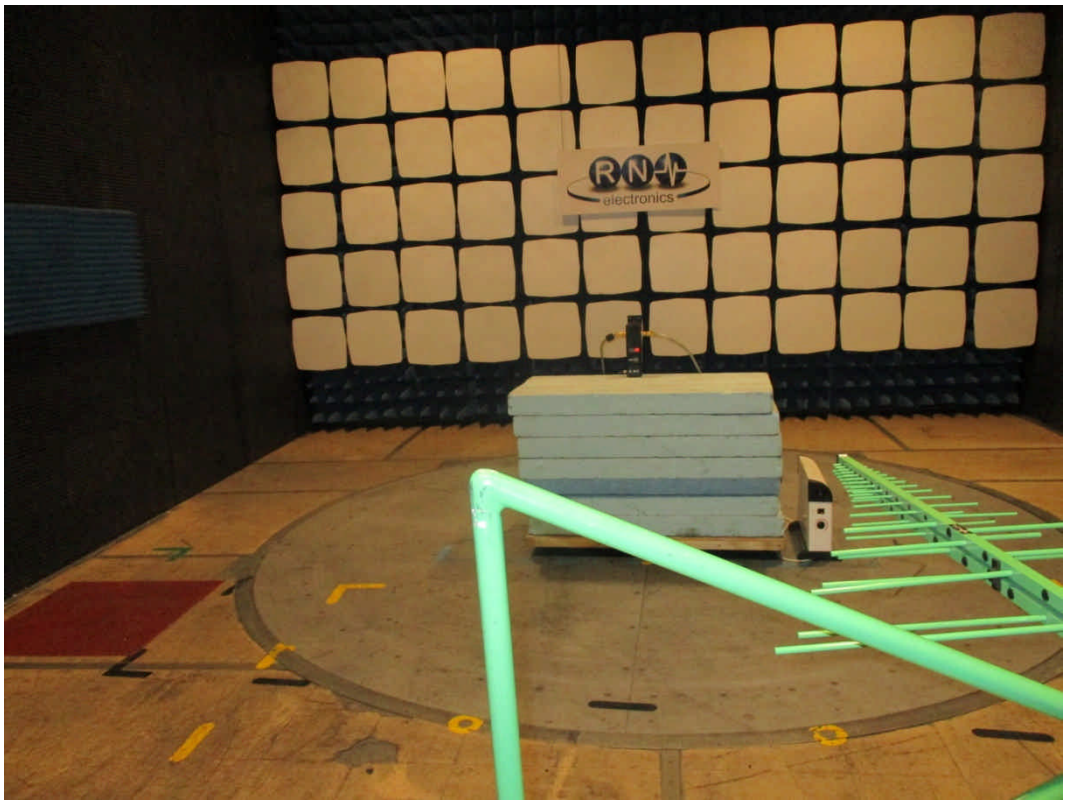


Site H

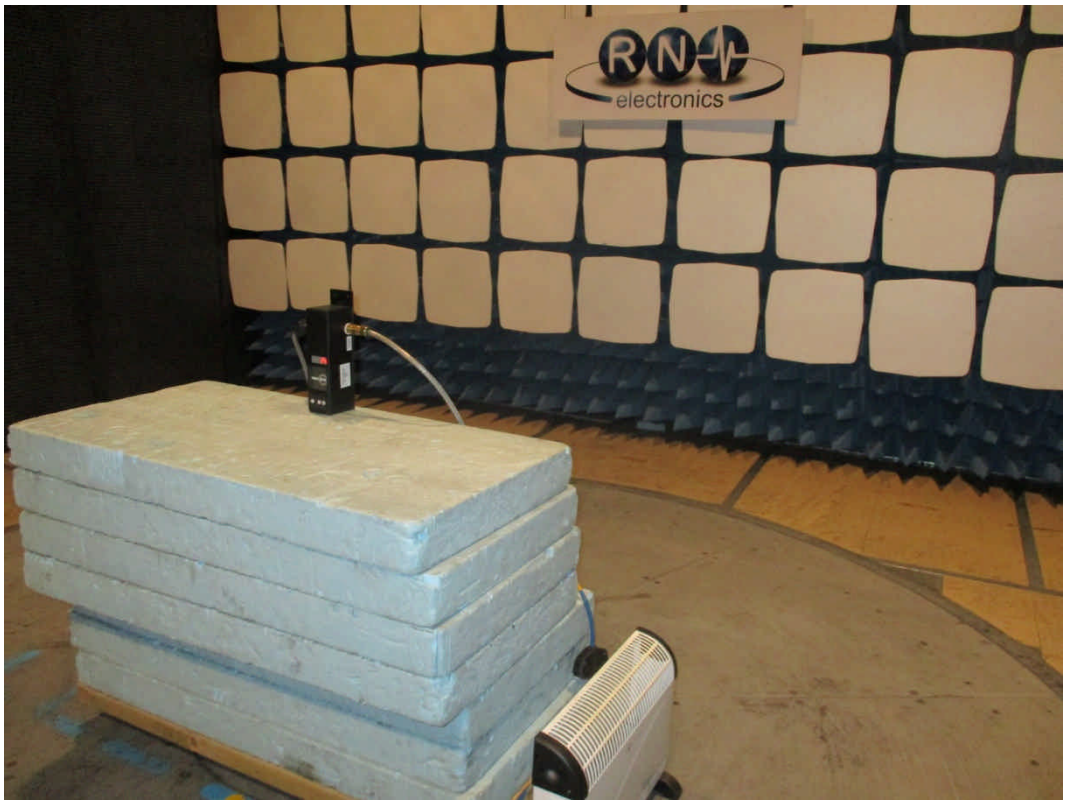


Site OATS

8.12 Radiated emissions 30 MHz -1 GHz



Site H



Site H

8.13 Radiated emission diagrams

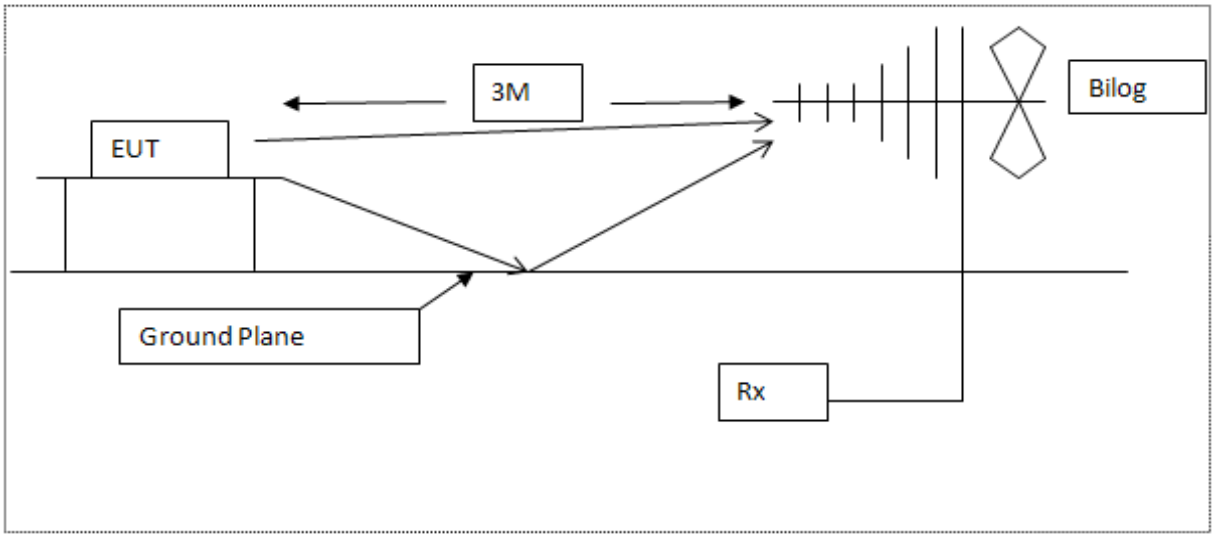


Diagram of the radiated emissions test setup 30 - 1000 MHz

8.14 AC powerline conducted emission diagram

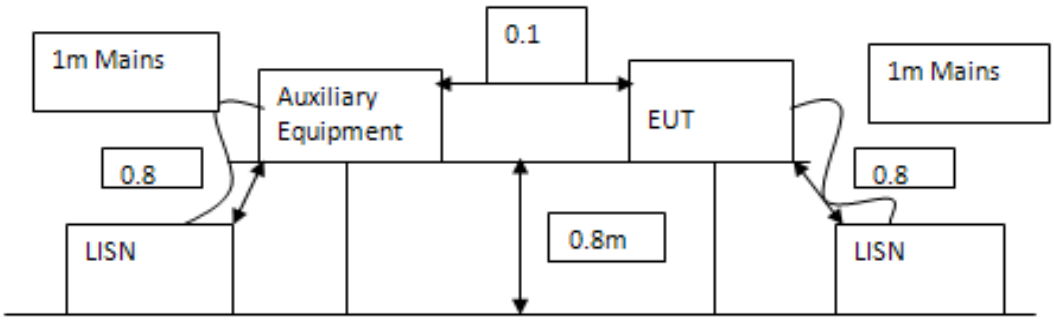


Diagram of the AC conducted emissions test setup

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	17-Dec-2018	6 months
E150	MN2050	LISN 13A	Chase	19-Apr-2018	12 months
E411	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	10-Jul-2018	12 months
E412	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	17-Jul-2018	24 months
E434	G3RUH	10MHz GPS Disciplined Oscillator	G3RUH - James Miller	#07-Mar-2019	3 months
E465	PCR2000LA	AC Power Source 2kVA	Kikusui	18-Jul-2018	12 months
E534	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	09-Jan-2019	24 months
E535	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	09-Jan-2019	12 months
E555	CMV 5E-1	Variac 5A	Carroll & Meynell Ltd	Not Applicable	
E624	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	09-Jan-2018	24 months
E660	CBL6112	Antenna Bilog 30MHz - 2GHz	Chase	21-Feb-2019	24 months
E744	RR2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	11-Feb-2019	12 months
E748	3001iM	AC Power Source 3kVA	California Instruments	08-Jan-2019	12 months
L264	DT75	Digital Thermometer	Instrotech Ltd	06-Dec-2017	24 months
N460	23468	5kVA Transformer	Max Holzinger & Co.	Not Applicable	
NSA-H	NSA - H	NSA - Site H	RN Electronics	12-Nov-2017	36 months
P266	9480	Distribution System	Racal Instruments Ltd	Not Applicable	
S032	177	True RMS Multimeter	Fluke	26-Mar-2018	12 months
TMS38	VMT04/140	Environmental Oven	Heraeus Votsch	Not Applicable	
TMS81	6502	Antenna Active Loop	EMCO	08-Jun-2017	24 months
ZSW1	V2.2	Measurement Software Suite	RN Electronics	Not Applicable	

Equipment was within calibration dates for tests and has been re-calibrated since/during date of tests.

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	Not stated	RFID Tag	Not stated	Not stated

10.2 RN Electronics supplied equipment

Item No	Model No.	Description	Manufacturer	Serial No
1	HG00916	Heater	PRO_ELEC	2016009160499

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

No modifications were made before test by RN Electronics Ltd.

11.2 Modifications during test

No modifications were made during test by RN Electronics Ltd.

12 Description of test sites

Site A Radio / Calibration Laboratory and anechoic chamber

Site B Semi-anechoic chamber
FCC Registration No. 293246
IC Registration No. 5612A-4

Site B1 Control Room for Site B

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)
FCC Registration No. 293246
IC Registration No. 5612A-2

Site J Screened Room

Site K Screened Room (Control Room for Site M)

Site M 3m Semi-anechoic chamber (indoor OATS)
FCC Registration No. 293246
IC Registration No. 5612A-3

Site Q Fully-anechoic chamber

Site OATS 3m and 10m Open Area Test Site
FCC Registration No. 293246
IC Registration No. 5612A-1

Site R Screened Room (Conducted Immunity)

Site S Safety Laboratory

Site T Transient Laboratory

13 Abbreviations and units

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