



2360

## Radio Test Report

**Eccel Technology Ltd**

**ISO14443A RFID Reader**

**BioRad RFID Reader v2.0.16**

47 CFR Part 15.225 Effective Date 1st October 2015

DXX: Part 15 Low Power Communication Device Transmitter

Test Date: 20th February 2017 to 21st February 2017

Report Number: 02-9290-2-17 Issue 02

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### Certificate of Test 9290-2

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:	ISO14443A RFID Reader
Model Number:	BioRad RFID Reader v2.0.16
Unique Serial Number:	000176
Applicant:	Eccel Technology Ltd 198 Station Road, Glenfield, Leicester Leicestershire, LE3 8GT
Proposed FCC ID	2ALHYBIORADRDR0200
Full measurement results are detailed in Report Number:	02-9290-2-17 Issue 02
Test Standards:	47 CFR Part 15.225 Effective Date 1st October 2015 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: 20th February 2017 to 21st February 2017

Test Engineer:

Approved By:  
Radio Approvals Manager

Customer  
Representative:



2360

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## 2 Equipment under test (EUT)

### 2.1 Equipment specification

Applicant	Eccel Technology Ltd 198 Station Road Glenfield Leicester Leicestershire LE3 8GT	
Manufacturer of EUT	Eccel Technology Ltd	
Full Name of EUT	ISO14443A RFID Reader	
Model Number of EUT	BioRad RFID Reader v2.0.16	
Serial Number of EUT	000176	
Date Received	30th January 2017	
Date of Test:	20th February 2017 to 21st February 2017	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Created	8th March 2017	
Main Function	13.56MHz RFID Reader intended to be fitted into a host product.	
Information Specification	Height	9.5 mm
	Width	50 mm
	Depth	75 mm
	Weight	0.015 kg
	Voltage	3.2 - 3.4 VDC
	Current	200 mA

## 2.2 Configurations for testing

General Parameters	
EUT Normal use position	Module fitted inside host product
Choice of model(s) for type tests	Production Prototype
Antenna details	Integral
Antenna port	No
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	27.12 MHz
Lowest Signal generated in EUT	13.56 MHz
Technology Type	13.56 MHz RFID. ISO/IEC 14443 Type A MIFARE
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	13.56 MHz (single frequency)
EUT Declared Modulation Parameters	ISO/IEC 14443A, ASK Modulation
EUT Declared Power level	100 - 150 mW
EUT Declared Signal Bandwidths	500 kHz
EUT Declared Channel Spacing's	Single channel
EUT Declared Duty Cycle	100%
Unmodulated carrier available?	No
Declared frequency stability	+/- 7kHz
RX Parameters	
Alignment range – receiver	13.56 MHz (single frequency)
EUT Declared RX Signal Bandwidth	500 kHz
FCC equipment Class	
DXX: Part 15 Low Power Communication Device Transmitter	

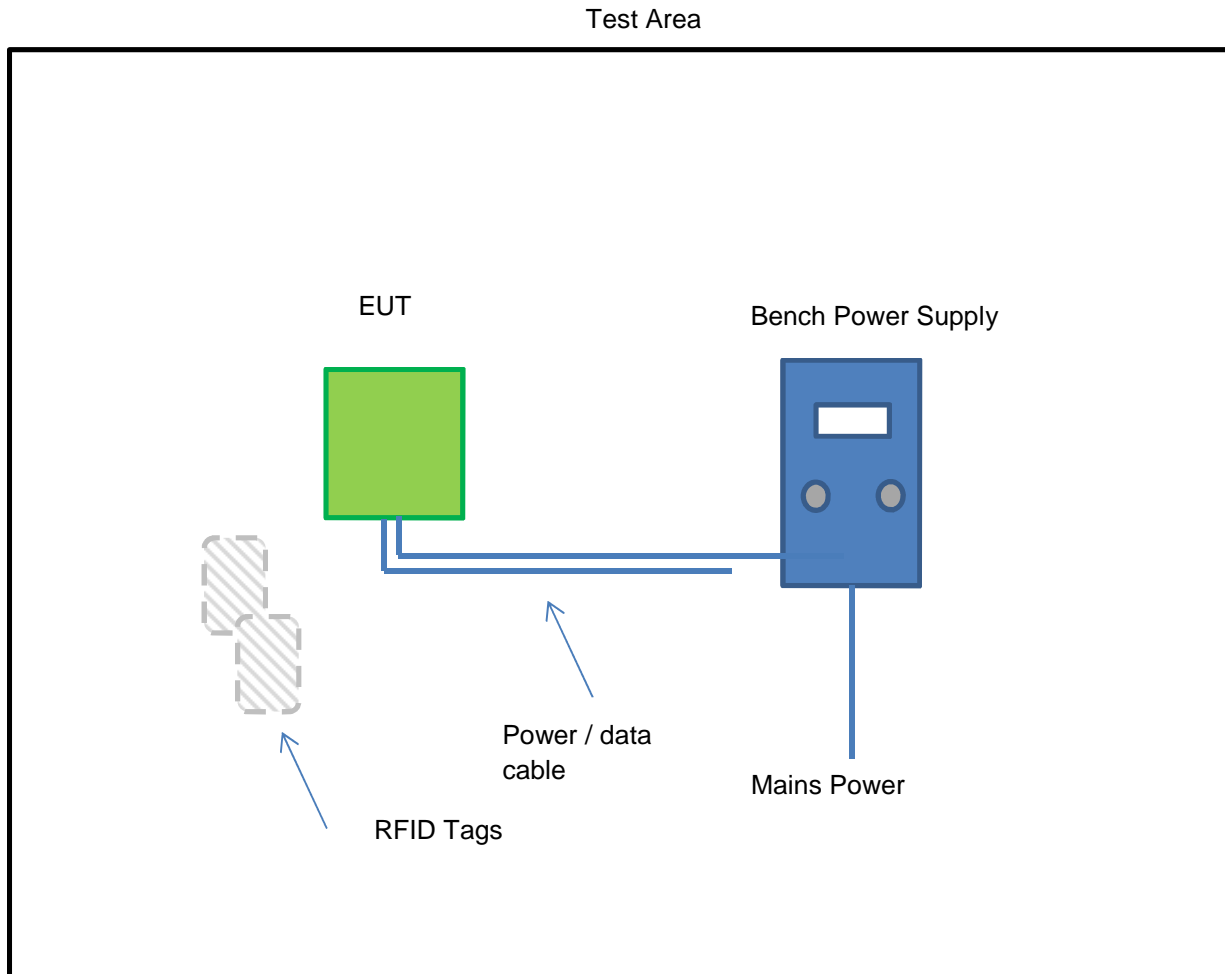
## 2.3 Functional description

The EUT is an RFID tag reader operating at a fixed frequency of 13.56 MHz. The EUT is a printed circuit board which is intended to be fitted inside a host product. In the final application, the host product would provide DC power to the EUT and a connection to the EUTs' data lines via the combined power / data socket (J1). The EUT uses the ISO/IEC 14443A transmission protocol and is compatible with NTag2XX transponders, such as those used in smart cards and other similar passive contactless products.

## 2.4 Modes of operation

Mode Reference	Description	Used for testing
TX (No tag)	The EUT is transmitting continuously and is awaiting presentation of an RFID tag	Yes
TX (Tag presented)	An RFID tag is presented to the EUT and the tags data is read continuously	Yes
Idle	The EUT is powered. The RFID transmitter and receiver are switched off.	No

## 2.5 Emissions configuration



The EUT is an RFID tag reader intended to be fitted inside a host product. In the final application, the host product provides power to the EUT and a connection is made to the data lines via the EUTs combined power / data socket (J1). The EUT was powered from a bench power supply which was set to the nominal supply voltage. For testing purposes the EUT was programmed by the manufacturer with engineering firmware. The manufacturer also supplied two compatible RFID tags of different physical sizes, a smaller self-adhesive tag and a larger credit-card sized tag. In a pre-test both RFID tags were assessed to establish worst-case emissions, however there was no discernible difference between the two tags and therefore the smaller self-adhesive tag was used for convenience. When the EUT was awaiting presentation of the RFID tag, the EUT would continuously transmit and receive at 20 ms intervals (TX No tag). When an RFID tag was presented, the EUT would read the tag repeatedly. The EUT operated at a fixed frequency and was supplied by the manufacturer set to the maximum power level which would be available in the final product.

### 2.5.1 Signal leads

Port Name	Cable Type	Connected
J1	4-core (DC power and data)	Yes

### 3 Summary of test results

The ISO14443A RFID Reader, BioRad RFID Reader v2.0.16 was tested for compliance to the following standards :

47 CFR Part 15.225 Effective Date 1st October 2015  
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	NOT APPLICABLE <sup>1</sup>
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(a)	PASSED
5. Intentional radiator field strength	47 CFR Part 15C Part 15.225(a)	PASSED
6. Occupied bandwidth	47 CFR Part 15C Part 15.215	PASSED
7. Spectrum mask	47 CFR Part 15C Part 15.225	PASSED
8. Frequency stability	47 CFR Part 15C Part 15.225(e)	PASSED

<sup>1</sup> EUT does not currently have provision to operate from the AC power lines. However, AC power line conducted emissions should be performed with the EUT in operation in its host product if that host product connects to the AC power lines.

Note: Spectrum investigated started at a frequency of 9 kHz up to a frequency of 1GHz based on 10 times the highest channel/ signal generated in equipment of 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	2015	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	3.3V DC
T minimum	-20 °C	V minimum	3.2V DC
T maximum	50 °C	V maximum	3.4V DC

Extremes of voltage are as declared by the applicant

Extremes of temperature are based the requirements of FCC 15.225

The ambient test conditions of humidity and pressure in the laboratory were as follows:  
50 %; 101 kPa.

### 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

NOT APPLICABLE: EUT does not currently have provision to operate from the AC power lines. However, AC power line conducted emissions should be performed with the EUT in operation in its host product if that host product connects to the AC power lines.

## 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. Radiated Emissions testing was performed with the EUT powered from a bench power supply. The EUT was operated in TX (No tag) and TX (Tag presented) modes.

### 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 final measurements 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 and OATS.

### 5.2.4 Test equipment

E533, E534, E535, TMS45, TMS81

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	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A (TX No tag)
Mid channel	13.56 MHz

Plot refs	
9290-2 Rad 1 9k-150kHz Para	
9290-2 Rad 1 9k-150kHz Perp	

Band	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A TX (Tag presented)
Mid channel	13.56 MHz

Plot refs	
9290-2 Rad 2 9k-150kHz Para	
9290-2 Rad 2 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  $\pm 3.9$ 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. Radiated Emissions testing was performed with the EUT powered from a bench power supply. The EUT was operated in TX (No tag) and TX (Tag presented) modes.

#### 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 final measurements 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 and OATS.

#### 5.3.4 Test equipment

E533, E534, E535, TMS45, TMS81

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	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A (TX No tag)
Mid channel	13.56 MHz

Plot refs	
9290-2 Rad 1 150k-30MHz Para	
9290-2 Rad 1 150k-30MHz Perp	

Band	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A TX (Tag presented)
Mid channel	13.56 MHz

Plot refs	
9290-2 Rad 2 150k-30MHz Para	
9290-2 Rad 2 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(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]

### 5.4.2 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. Radiated Emissions testing was performed with the EUT powered from a bench power supply. The EUT was operated in TX (No tag) and TX (Tag presented) modes.

### 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 (pre-scan) with final measurements 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 and OATS.

### 5.4.4 Test equipment

E533, E534, E535, LPE364, TMS45

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	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A (TX No tag)
Single channel	13.56 MHz

Plot refs	
9290-2 Rad 1 VHF Horiz	
9290-2 Rad 1 VHF Vert	
9290-2 Rad 1 UHF Horiz	
9290-2 Rad 1 UHF Vert	

Band	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A TX (Tag presented)
Single channel	13.56 MHz

Plot refs	
9290-2 Rad 2 VHF Horiz	
9290-2 Rad 2 VHF Vert	
9290-2 Rad 2 UHF Horiz	
9290-2 Rad 2 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	149.161	24.0	18.9	-24.6
2	176.290	27.2	24.4	-19.1
3	203.417	24.9	21.9	-21.6
4	339.045	33.0	29.5	-16.5

**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	126.519	21.1	15.0	-28.5
2	176.281	24.2	20.1	-23.4
3	203.403	24.3	20.2	-23.3
4	749.599	35.5	28.5	-17.5

**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	94.933	22.2	18.1	-25.4
2	149.164	24.6	20.3	-23.2
3	176.307	23.4	19.3	-24.2
4	203.416	26.6	24.0	-19.5

**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	40.681	30.3	26.7	-13.3
2	94.933	23.6	19.7	-23.8
3	149.164	26.7	23.6	-19.9
4	176.297	25.4	22.0	-21.5
5	203.416	26.8	24.1	-19.4

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 ±6.1dB



## 5.5 Intentional radiator field strength

### 5.5.1 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]

### 5.5.2 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) and TX (Tag presented) modes.

### 5.5.3 Test procedure

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

Measurements were made at Site H. Measurements were made in a semi-anechoic chamber and 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.

### 5.5.4 Test equipment

E533, E534, E535, TMS45, TMS81

See Section 9 for more details

### 5.5.5 Test results

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

Band	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A (TX No tag)
Single channel	13.56 MHz

	Single channel
Peak Level (dBµV/m @ 3 metres)	64.0
Plot reference	9290-2 Field strength - TX (No tag) mode
Antenna Polarisation	Parallel
EUT Polarisation	Side

Highest field strength was measured with EUT in its side position and the loop antenna in the parallel position. 3 metre distance was used. A 40 dB extrapolation factor as per FCC was used to convert the field strength to 30 metres. This gave a field strength result of 24 dBuV/m at 30 metres. Any analyser plots can be found in Section 6 of this report.

Band	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A TX (Tag presented)
Single channel	13.56 MHz

	Single channel
Peak Level (dB $\mu$ V/m @ 3 metres)	63.1
Plot reference	9290-2 Field strength - TX (Tag presented) mode
Antenna Polarisation	Parallel
EUT Polarisation	Side

Highest field strength was measured with EUT in its side position and the loop antenna in the parallel position. 3 metre distance was used. A 40 dB extrapolation factor as per FCC was used to convert the field strength to 30 metres. This gave a field strength result of 23.1 dB $\mu$ V/m at 30 metres. Any 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  $\mu$ V/m @ 30m = 84 dB $\mu$ 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:  
 $\leq \pm 3.9$  dB

## 5.6 Occupied bandwidth

### 5.6.1 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]

### 5.6.2 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 EUT was tested whilst powered from a bench power supply. The EUT was operated in TX (No tag) and TX (Tag presented) modes.

### 5.6.3 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 10kHz RBW, 3x VBW, auto sweep time and max hold settings were used for the 20 dB bandwidth measurement.

### 5.6.4 Test equipment

E533, E534, E535, TMS45, TMS81

See Section 9 for more details

### 5.6.5 Test results

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

Band	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A (TX No tag)
Mid channel	13.56 MHz

20dB Bandwidth (MHz) Plot reference	Single channel
	0.278
	9290-2 OBW - TX (No tag) mode

Band	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A TX (Tag presented)
Mid channel	13.56 MHz

20dB Bandwidth (MHz) Plot reference	Single channel
	0.431
	9290-2 OBW - TX (Tag presented) mode

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 %

## 5.7 Spectrum mask

### 5.7.1 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]

### 5.7.2 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 TX (No tag) and TX (Tag presented) modes.

### 5.7.3 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 H. This site is listed with the FCC.

### 5.7.4 Test equipment

E533, E534, E535, TMS45, TMS81

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	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A (TX No tag)
#Channel# channel	13.56 MHz

	Single
Nominal, Maximised RF Output / field strength dBuV/m @ 30m	24.0
Nominal plot reference	9290-2 Spectrum mask at 30metres - TX (No tag) mode

Band	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A TX (Tag presented)
#Channel# channel	13.56 MHz

	Single
Nominal, Maximised RF Output / field strength dBuV/m @ 30m	23.1
Nominal plot reference	9290-2 Spectrum mask at 30metres with tag

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  $\mu\text{V/m}$  @ 30m = 84 dB $\mu\text{V/m}$  @ 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  $\mu\text{V/m}$  @ 30m = 50.5 dB $\mu\text{V/m}$  @ 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  $\mu\text{V/m}$  @ 30m = 40.5 dB $\mu\text{V/m}$  @ 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:

< $\pm$  4.1 dB

## 5.8 Frequency stability

### 5.8.1 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]

### 5.8.2 Configuration of EUT

The EUT's power port was connected 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.

### 5.8.3 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 peak of the measured signal. At nominal temperature the EUT supply was varied to the manufacturers' 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 A.

### 5.8.4 Test equipment

E434, E541, E642, P266, TMS38, TMS57, TMS80

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	101kPa

Band	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A (TX No tag)
Single channel	13.56 MHz

Test conditions		Frequency Error (MHz) Single
-20°C	Volts Nominal (3.3)	13.560747
-10°C	Volts Nominal (3.3)	13.560797
0°C	Volts Nominal (3.3)	13.560815
10°C	Volts Nominal (3.3)	13.560813
20°C	Volts Minimum (3.2)	13.560801
	Volts Nominal (3.3)	13.560807
	Volts Maximum (3.4)	13.560803
30°C	Volts Nominal (3.3)	13.560781
40°C	Volts Nominal (3.3)	13.560774
50°C	Volts Nominal (3.3)	13.560761
Max Frequency Error per chan (Hz)		+8 / -60
Max Frequency Error observed (Hz)		-60

Band	13.11-14.01 MHz
Power Level	Maximum
Channel Spacing	Single Channel
Mod Scheme	ISO14443A TX (Tag presented)
Single channel	13.56 MHz

Test conditions		Frequency Error (MHz) Single
-20°C	Volts Nominal (3.3)	13.560749
-10°C	Volts Nominal (3.3)	13.560799
0°C	Volts Nominal (3.3)	13.560819
10°C	Volts Nominal (3.3)	13.560819
20°C	Volts Minimum (3.2)	13.560805
	Volts Nominal (3.3)	13.560805
	Volts Maximum (3.4)	13.560802
30°C	Volts Nominal (3.3)	13.560781
40°C	Volts Nominal (3.3)	13.560757
50°C	Volts Nominal (3.3)	13.560761
Max Frequency Error per chan (Hz)		+14 / -56
Max Frequency Error observed (MHz)		-56

Maximum variation observed was -60 Hz.

**LIMITS:**

+/- 0.01%. (+/- 1356 Hz)

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:

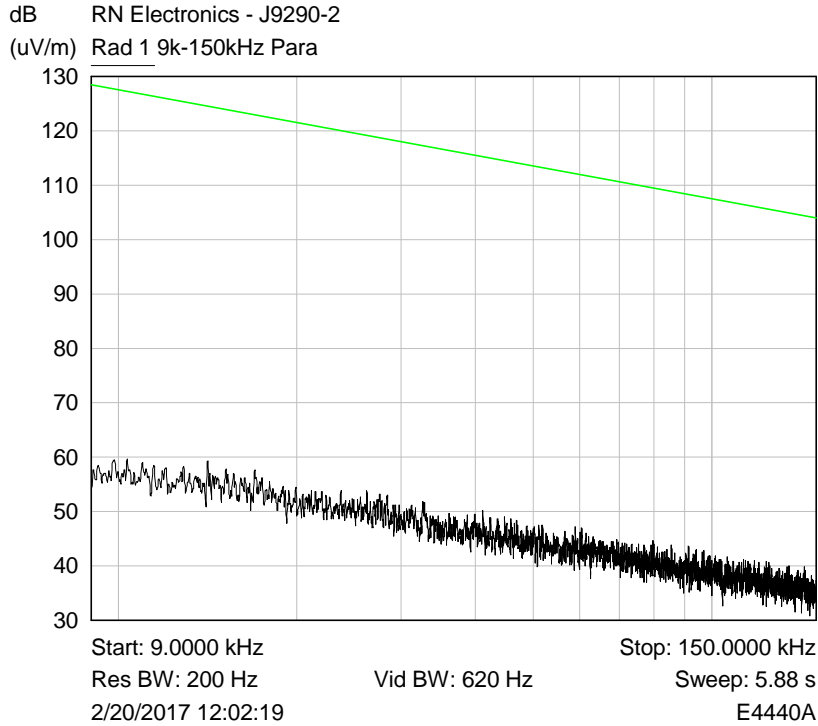
<± 0.7 ppm



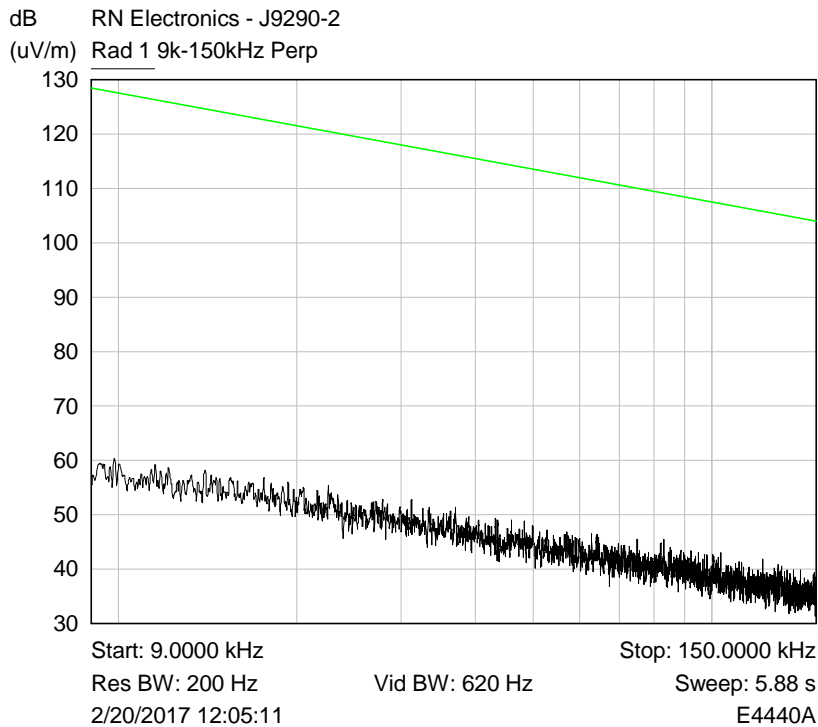
## 6 Plots/Graphical results

### 6.1 Radiated emissions 9 - 150 kHz

RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO14443A (TX No tag), Channel 13.56 MHz

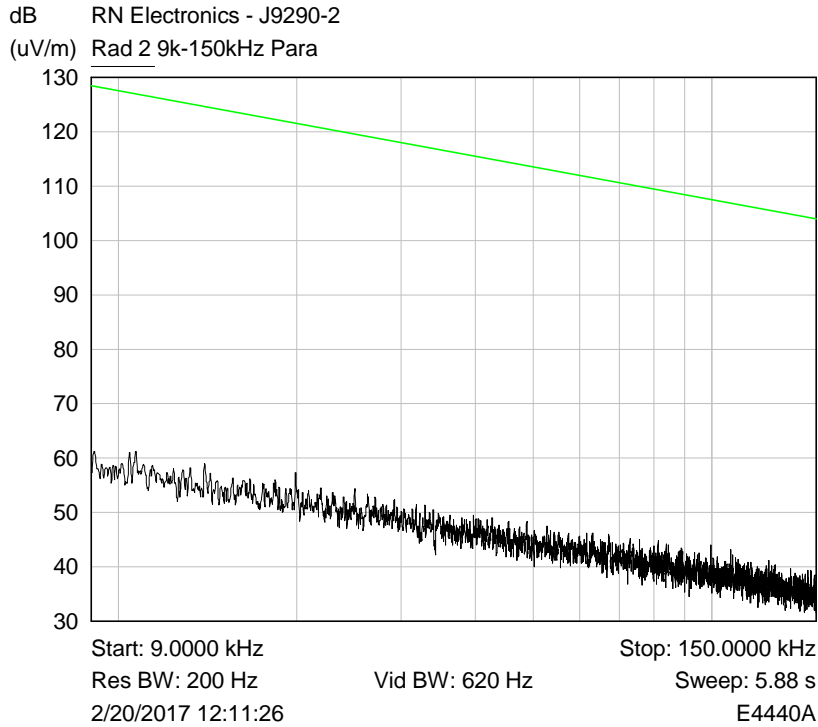


Plot of 9-150kHz Parallel

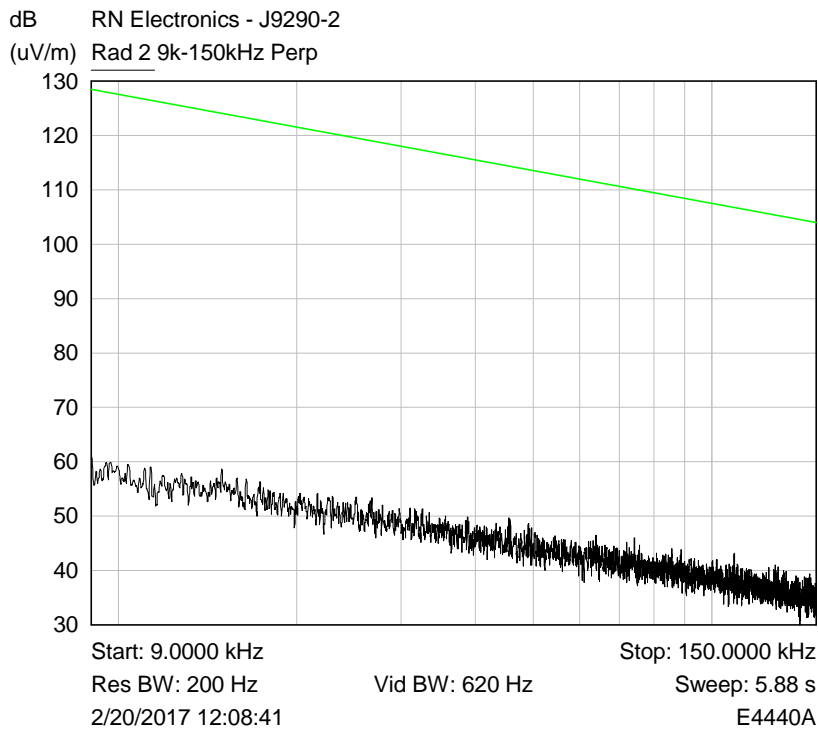


Plot of 9-150kHz Perpendicular

RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel,  
Modulation ISO14443A TX (Tag presented), Channel 13.56 MHz



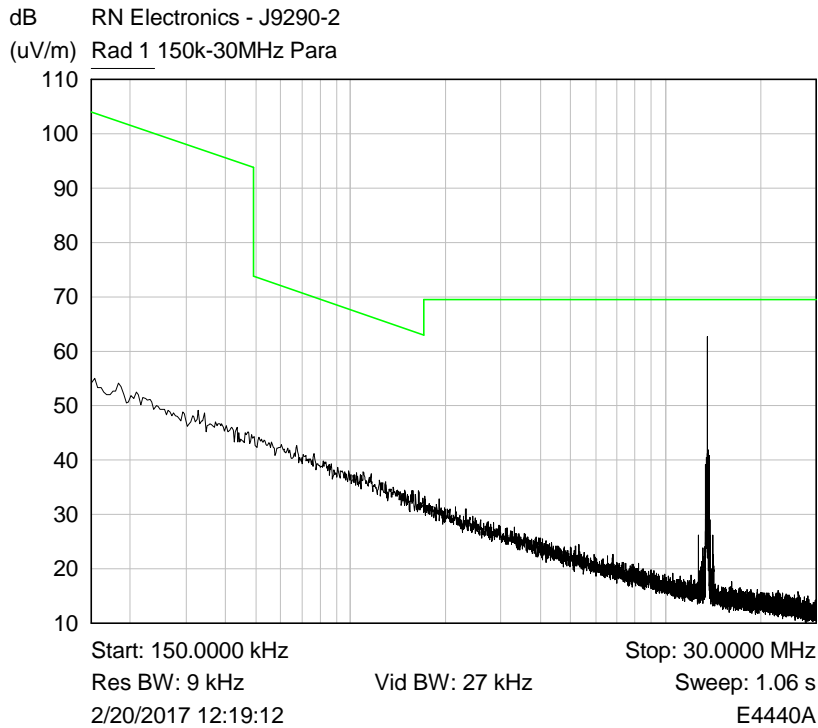
Plot of 9-150kHz Parallel



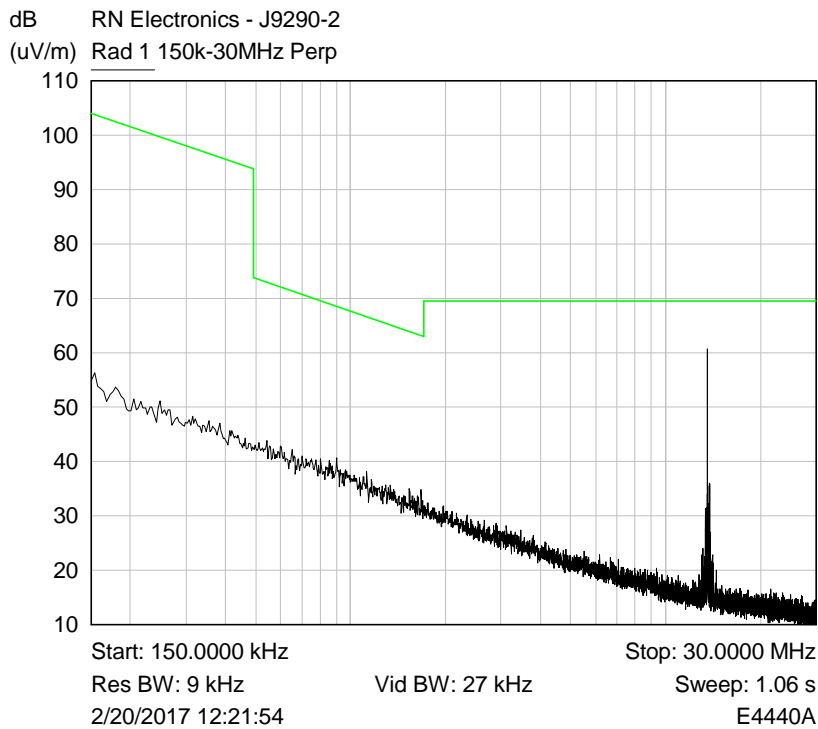
Plot of 9-150kHz Perpendicular

## 6.2 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO14443A (TX No tag), Channel 13.56 MHz

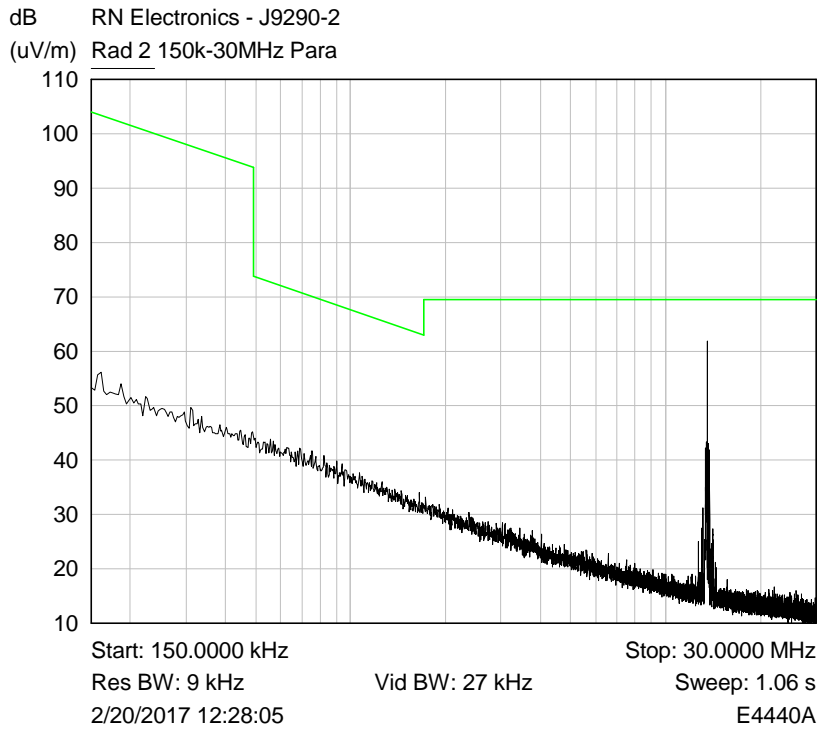


Plot of 150kHz-30MHz Parallel

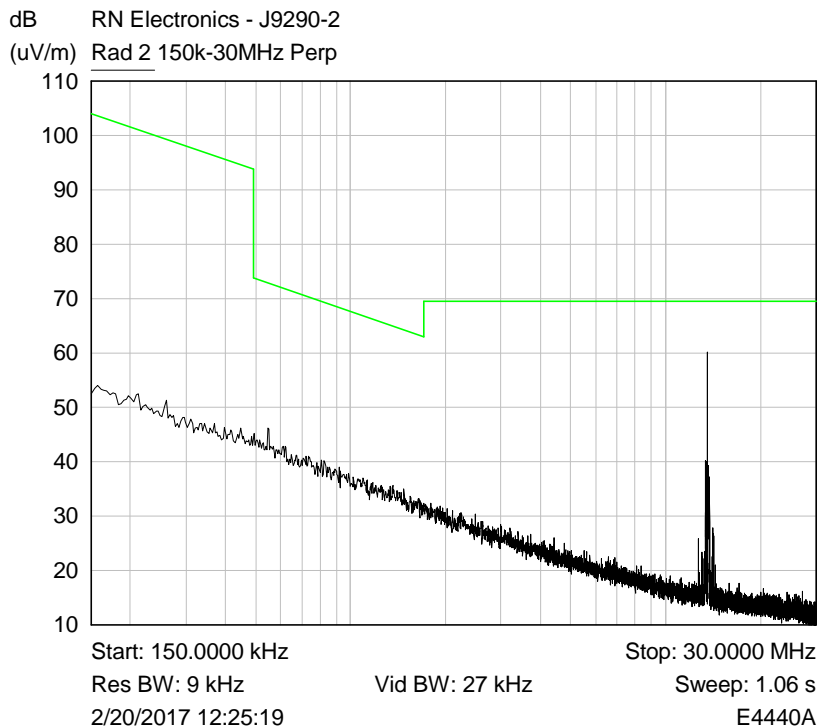


Plot of 150kHz-30MHz Perpendicular

RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel,  
Modulation ISO14443A TX (Tag presented), Channel 13.56 MHz



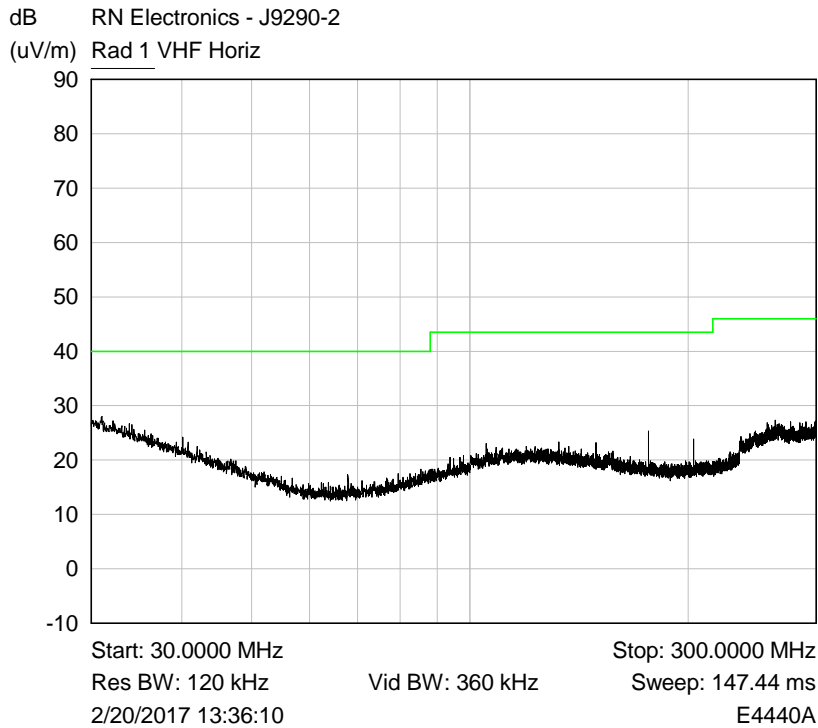
Plot of 150kHz-30MHz Parallel



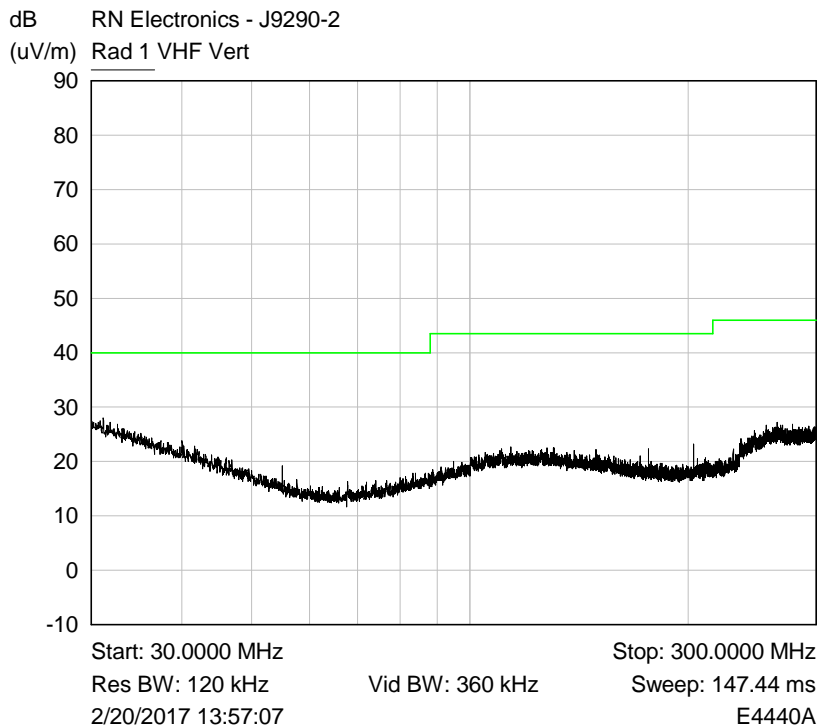
Plot of 150kHz-30MHz Perpendicular

### 6.3 Radiated emissions 30 MHz -1 GHz

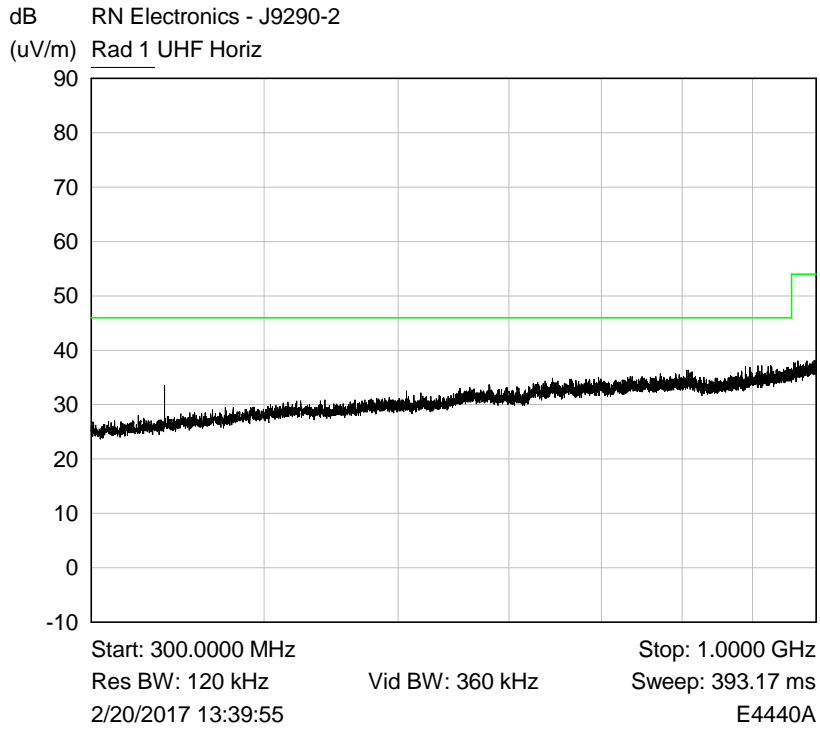
RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO14443A (TX No tag), Channel 13.56 MHz



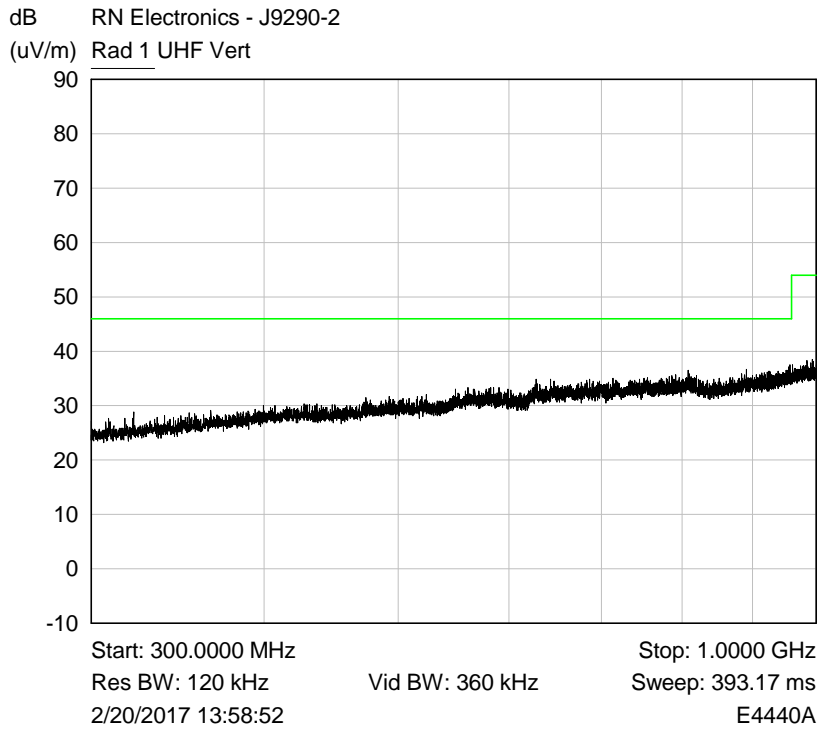
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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

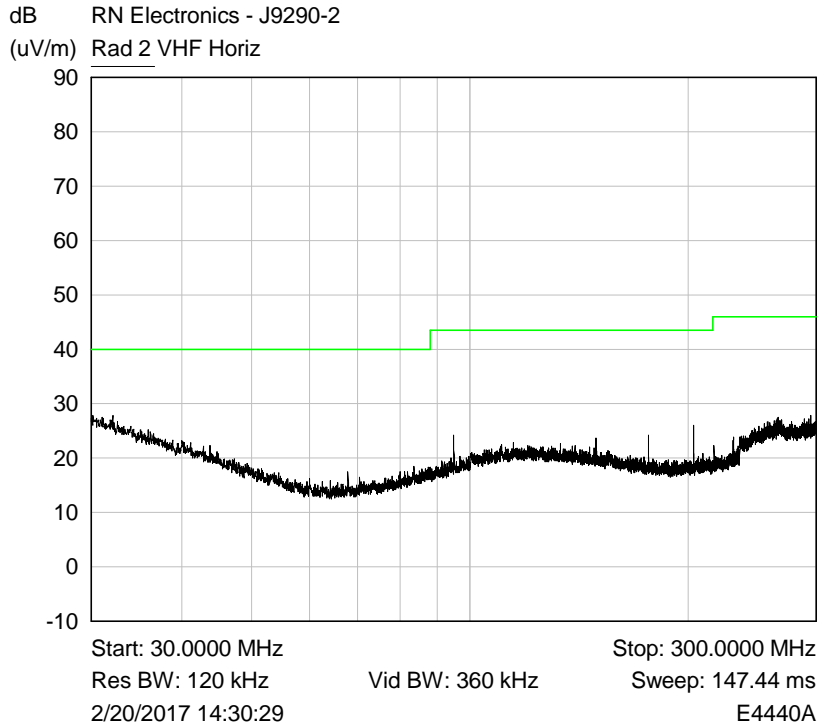


Plot of Peak emissions for UHF Horizontal against the QP limit line.

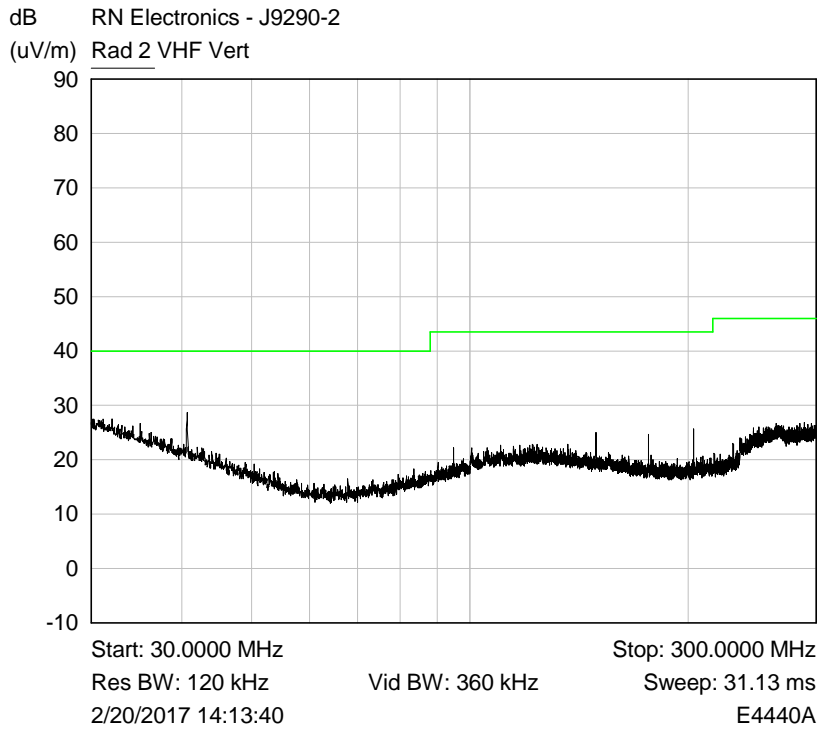


Plot of Peak emissions for UHF Vertical against the QP limit line.

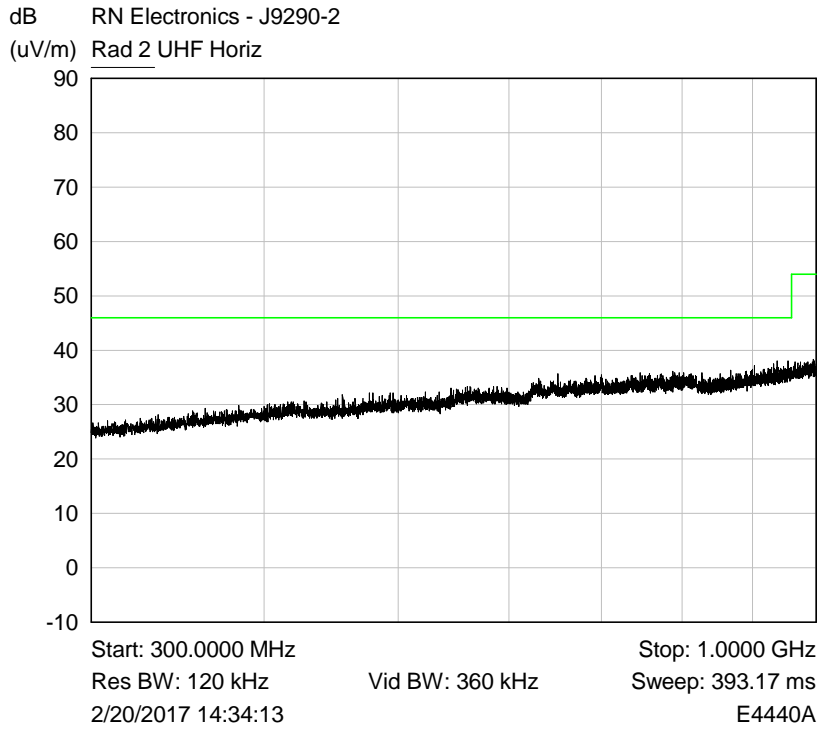
RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel,  
Modulation ISO14443A TX (Tag presented), Channel 13.56 MHz



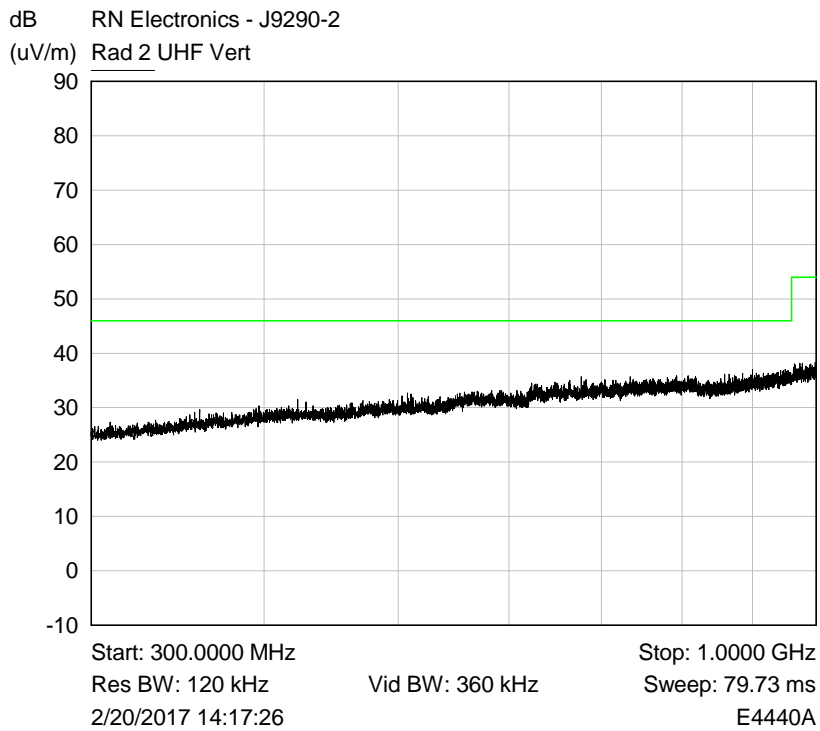
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



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

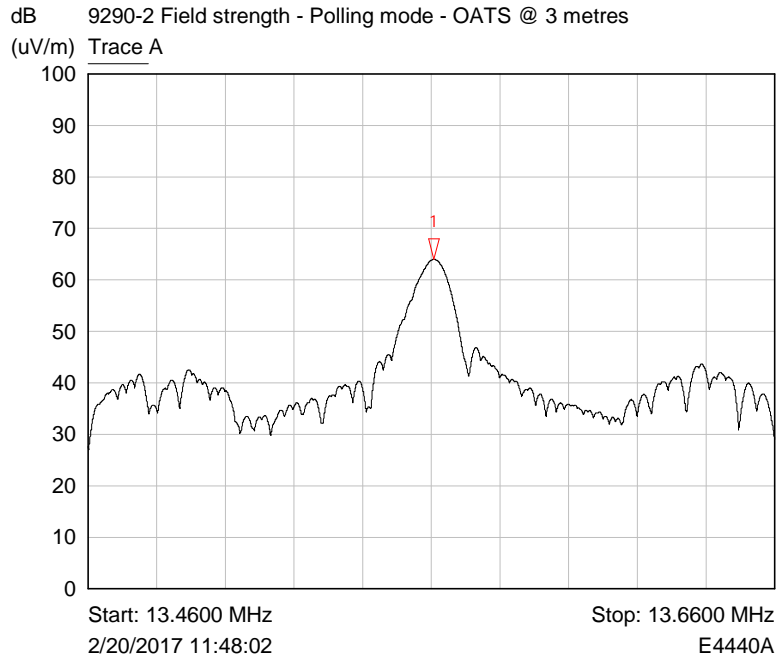


Plot of Peak emissions for UHF Vertical against the QP limit line.



## 6.4 Intentional radiator field strength

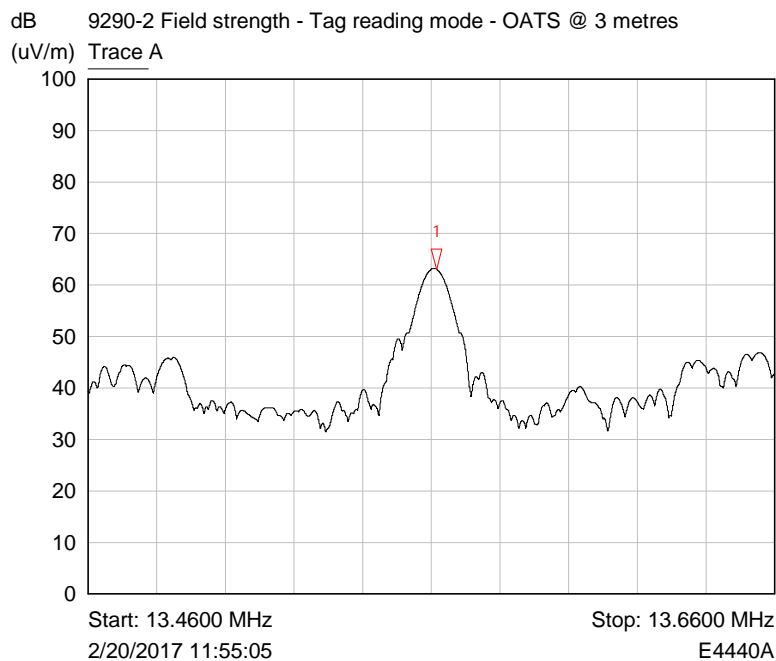
RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO14443A (TX No tag), Channel 13.56 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	13.5607 MHz	63.97 dB(uV/m)	

Plot of Parallel polarisation and EUT in Side position

RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO14443A TX (Tag presented), Channel 13.56 MHz

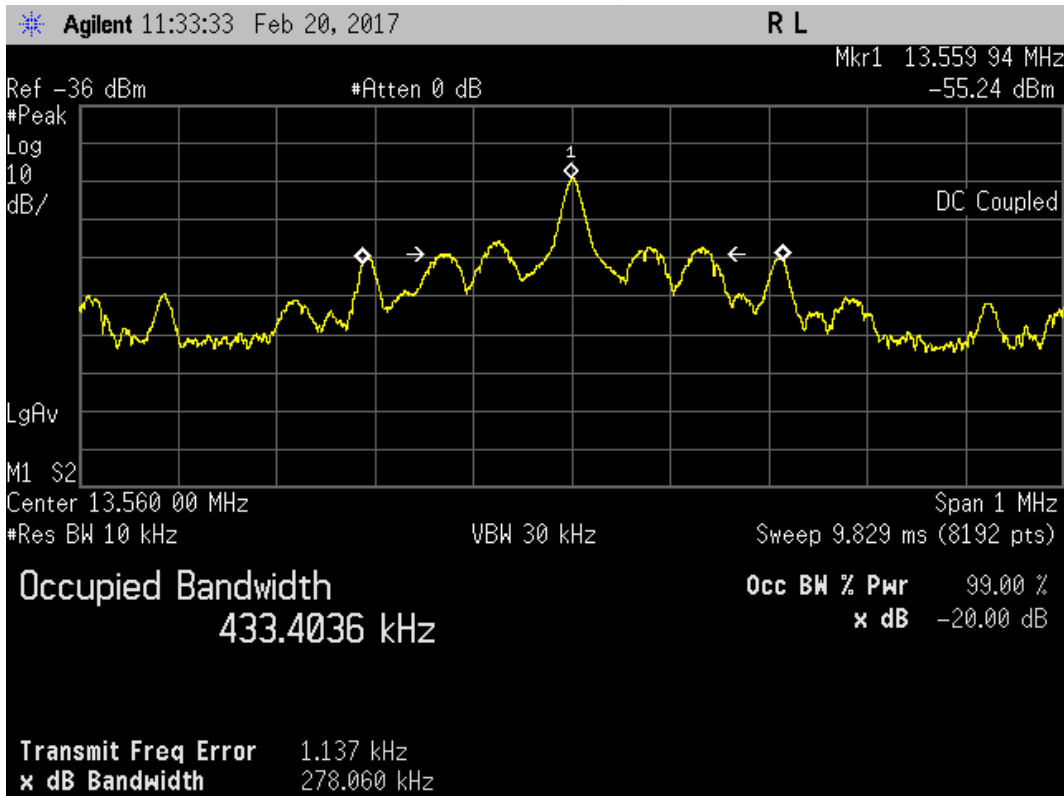


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	13.5615 MHz	63.08 dB(uV/m)	

Plot of Parallel polarisation and EUT in Side position

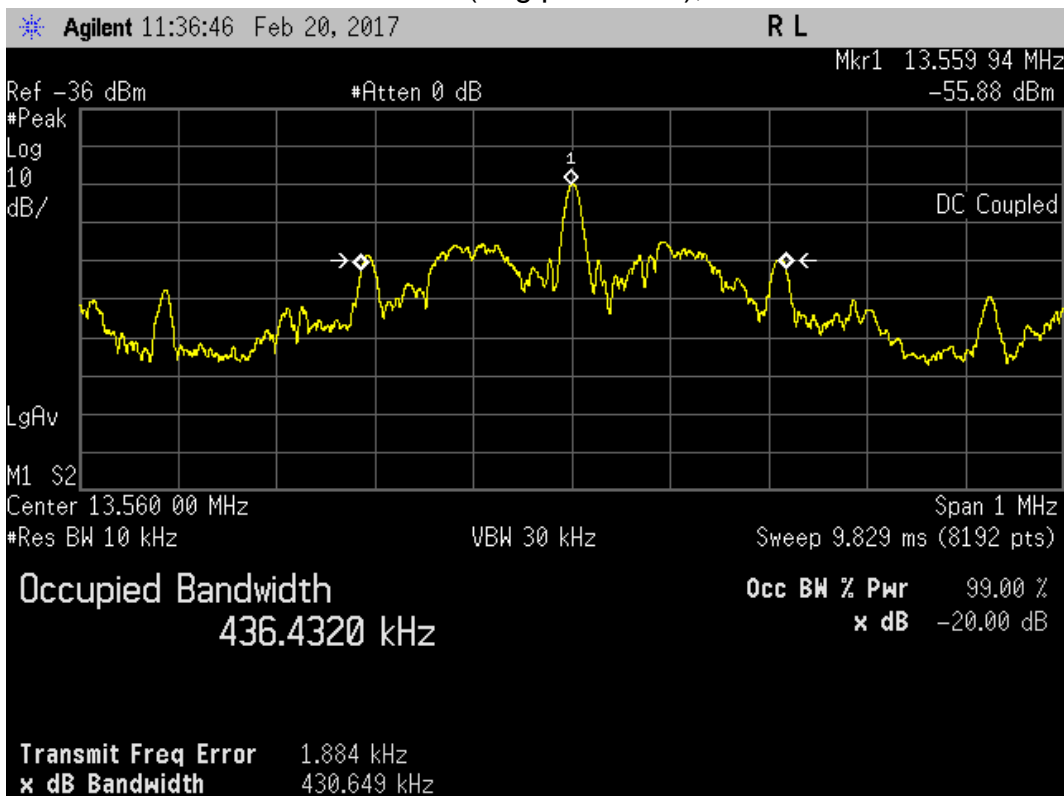
## 6.5 Occupied bandwidth

RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO14443A (TX No tag), Channel 13.56 MHz



Plot for 20dB Bandwidth (kHz)

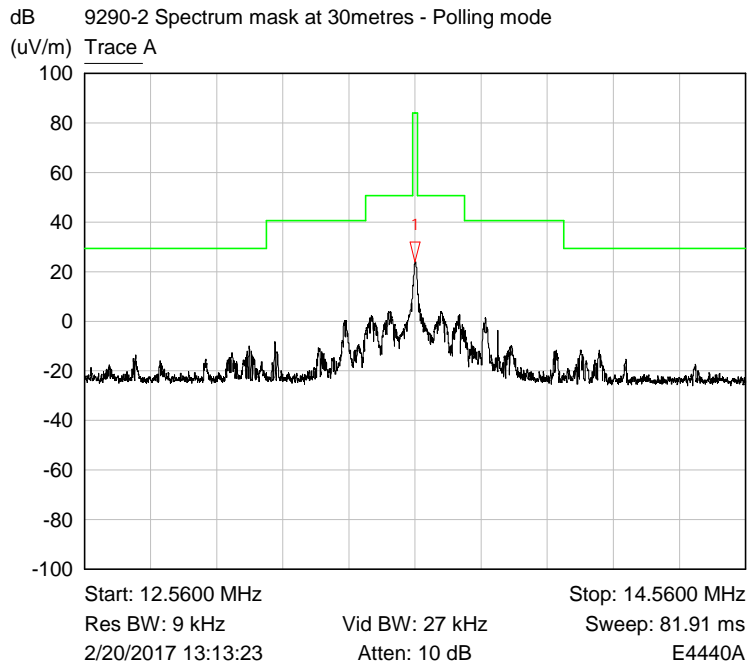
RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO14443A TX (Tag presented), Channel 13.56 MHz



Plot for 20dB Bandwidth (kHz)

## 6.6 Spectrum mask

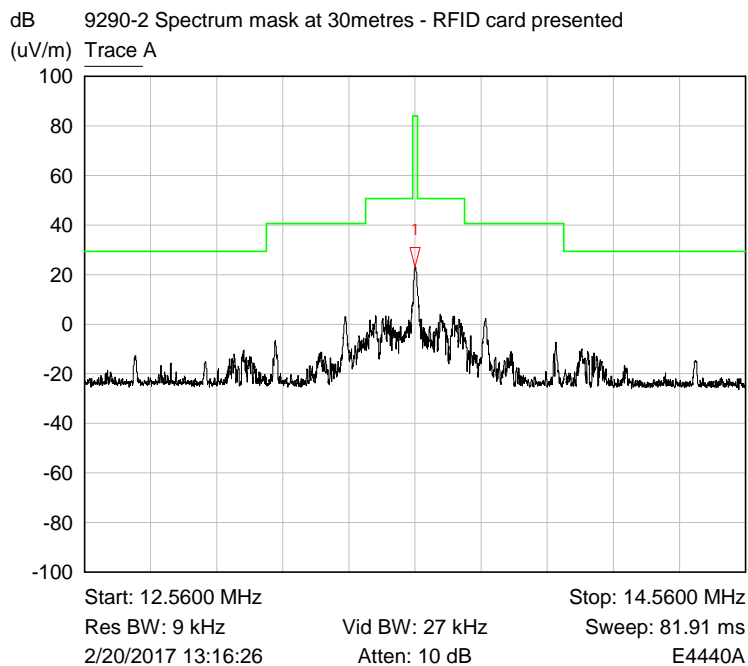
RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO14443A (TX No tag), Channel 13.56 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▾	Trace A	13.5606 MHz	24.01 dB(uV/m)	

Nominal Temperature, Nominal Voltage

RF Parameters: Band 13.11-14.01 MHz, Power Maximum, Channel Spacing Single Channel, Modulation ISO14443A TX (Tag presented), Channel 13.56 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▾	Trace A	13.5606 MHz	23.11 dB(uV/m)	

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 (dB $\mu$ V) is the level of received signal that was measured in dB above 1 $\mu$ V 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 (dB $\mu$ V) is the level of received signal that was measured in dB above 1 $\mu$ V 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 (dB $\mu$ V) is the level of received signal that was measured in dB above 1 $\mu$ V 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  $\mu$ V/m at a specified distance), whereas the measured values are expressed as peak, quasi peak or average values in dB $\mu$ 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  $\mu$ V/m equates to  $20.\log(500) = 54$  dB  $\mu$ V/m.

(b) limit of 300  $\mu$ V/m at 10m equates to  $20.\log(300 \cdot 10/3) = 60$  dB  $\mu$ V/m at 3m

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

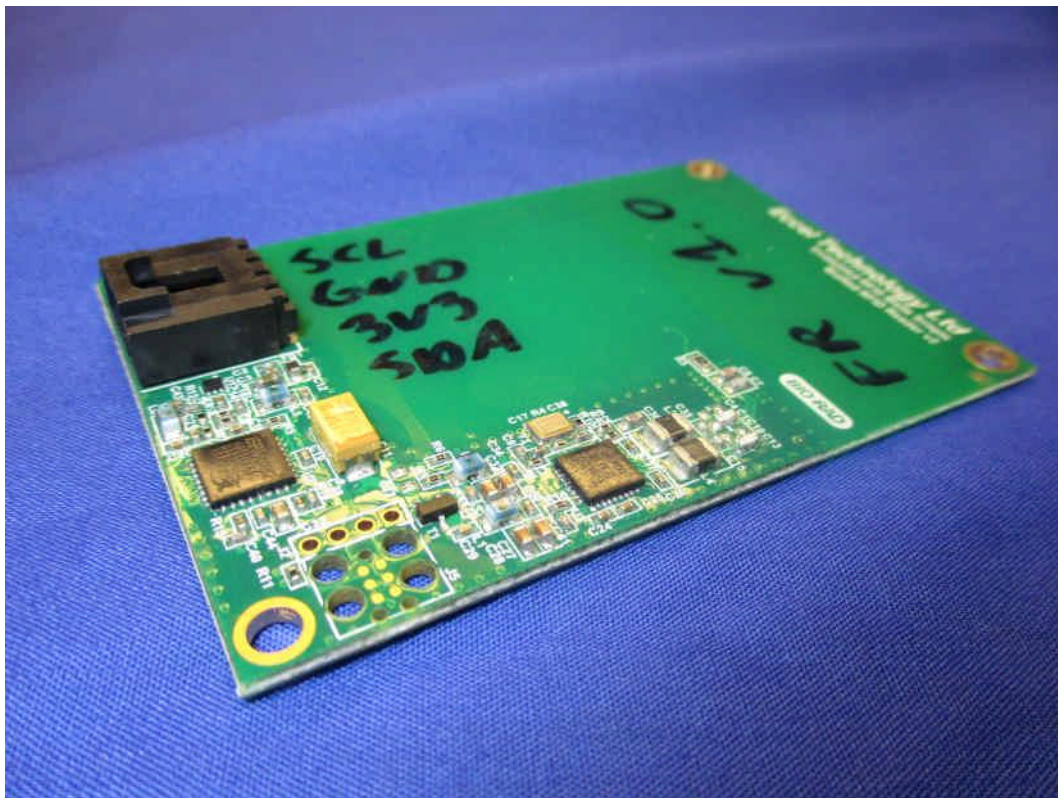
The measurement receiver used for emissions testing, performs the field strength (FS) calculations automatically. The receiver combines the signal amplitude (RA), Antenna Factor (AF) and Cable Loss (CL) factors for the frequency to be measured.

Example calculation: -  $\text{FS} = \text{RA} + \text{AF} + \text{CL}$ .

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





Photographs shows the EUT and the two RFID tags



## 8.2 EUT Reverse Angle





### 8.3 EUT Antenna



Photograph shows the EUT integral antenna (outlined in yellow)

### 8.4 EUT Display & Controls

The EUT has no display or controls

### 8.5 EUT Internal photos

The EUT is a PCB designed to be fitted inside a host product. Please refer to the identity photographs.

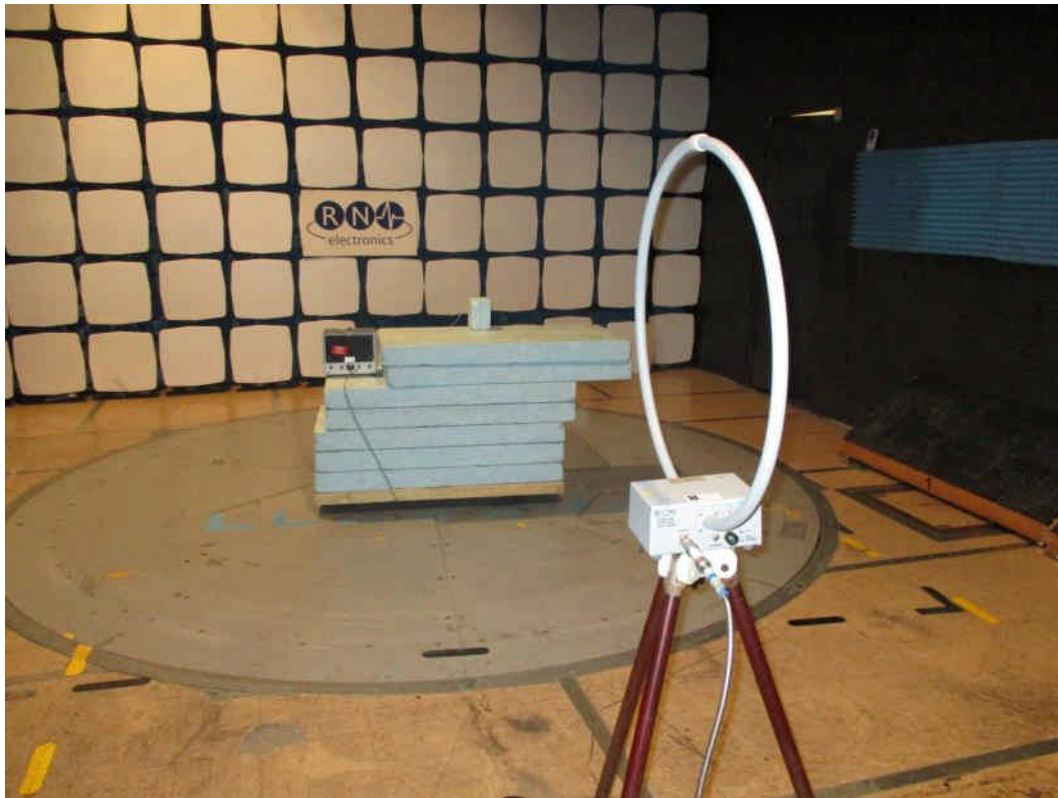
### 8.6 EUT ID Label

No label was available at the time of test.

### 8.7 EUT Chassis

The EUT has no chassis

### 8.8 Radiated emissions 9 - 150 kHz

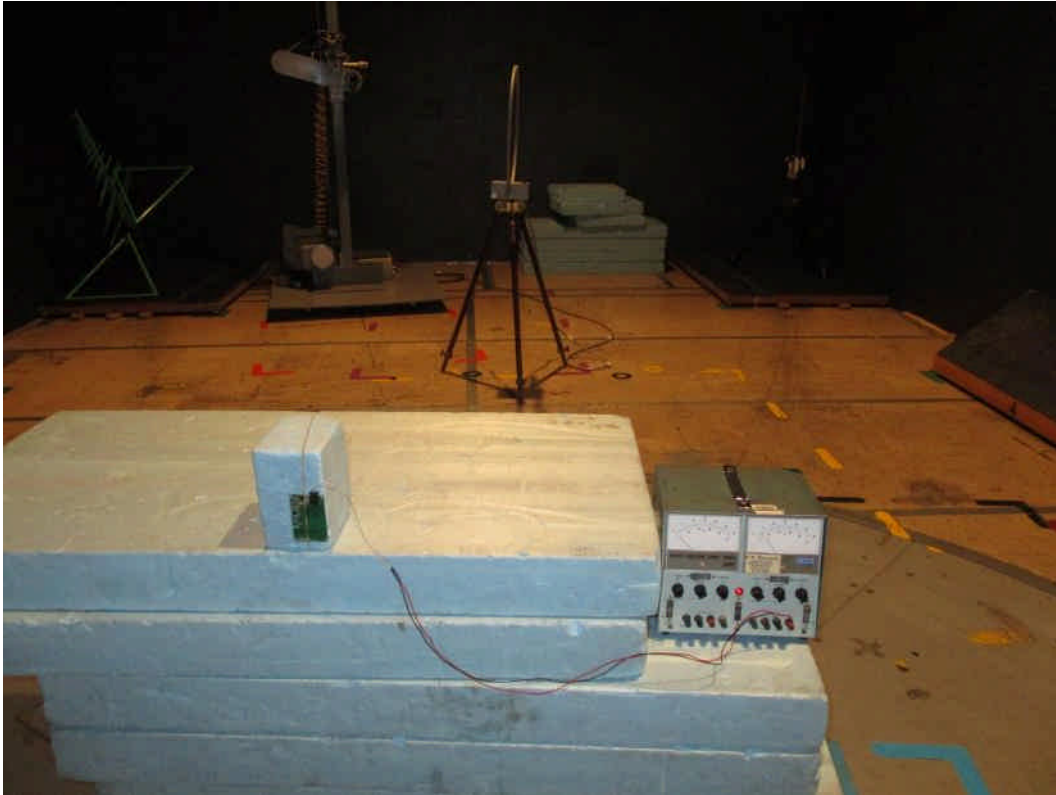


Test Site H

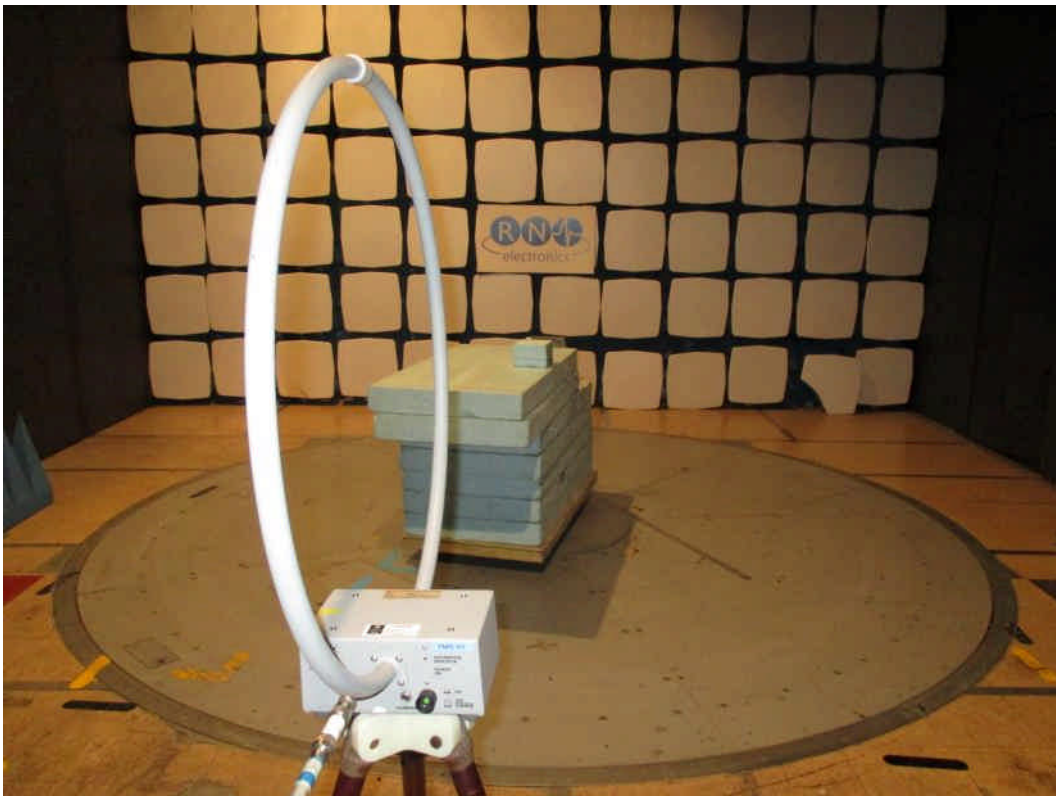


Test site OATS

### 8.9 Radiated emissions 150 kHz - 30 MHz



Test Site H



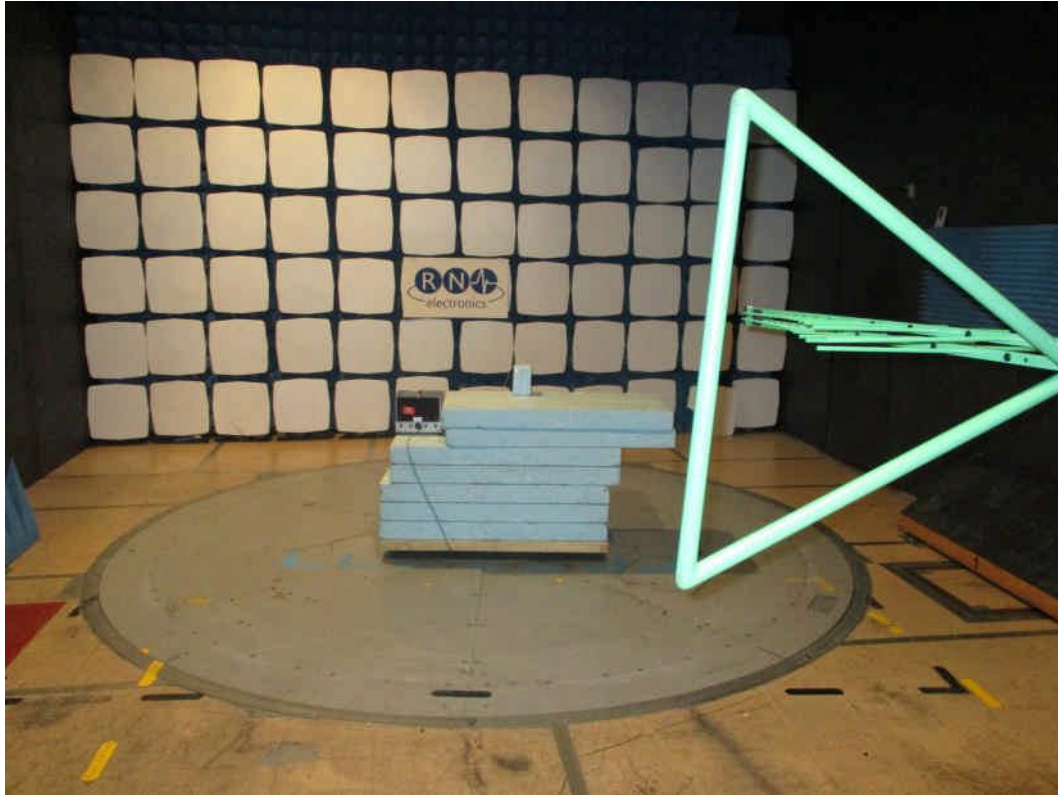
Test Site H





Test Site OATS (3 metre test distance)

## 8.10 Radiated emissions 30 MHz -1 GHz



### 8.11 Radiated emission diagram

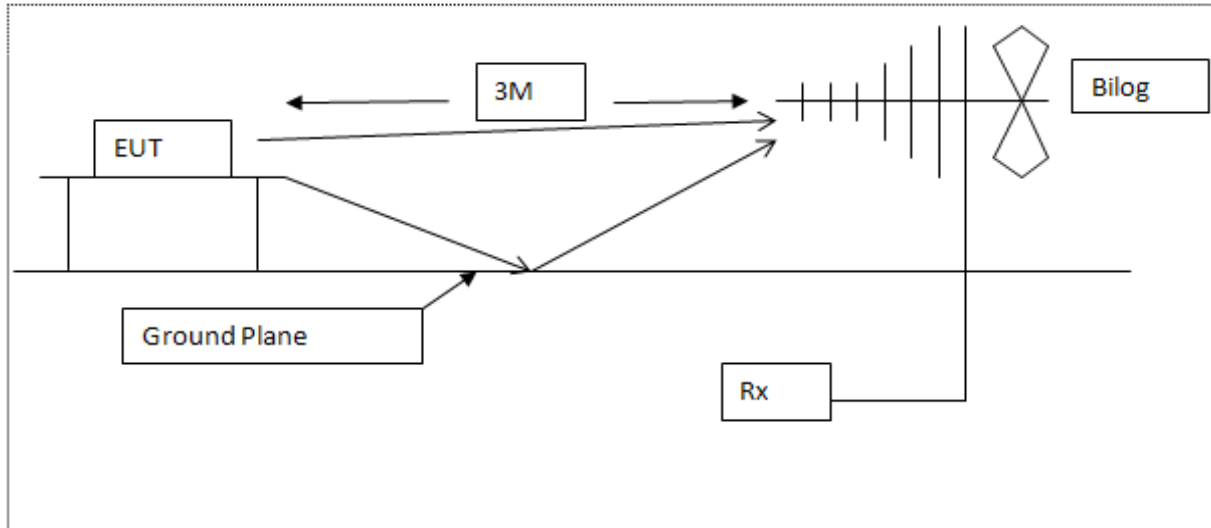


Diagram of the radiated emissions test setup 30 - 1000 MHz

## 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
E434	G3RUH	10MHz GPS Disciplined Oscillator	James Miller	Not applicable	
E533	N5182A	Signal Generator 6 GHz MXG	Agilent Technologies	18-Jan-2017	36 months
E534	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	18-Jan-2017	24 months
E535	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	18-Jan-2017	12 months
E642	E4440A	PSA 3 Hz - 26.5 GHz	Keysight	27-Nov-2015	24 months
LPE364	CBL6112A	30MHz - 2GHz Bilog Antenna	Chase Electronics Ltd	22-Jan-2016	24 months
P266	9480	Distribution System	Racal Instruments Ltd	Not applicable	
TMS38	VMT04/140	Environmental Oven	Heraeus Votsch	Not applicable	
TMS45	Model1	Attenuator 3dB 12.4GHz	Weinschel	02-Sep-2016	12 months
TMS57	2534	Digital Multimeter	Philips	06-Mar-2015	24 months
TMS80	206-3722	Digital Thermometer & K Probe	RS Components Ltd	17-Nov-2016	12 months
TMS81	6502	Active Loop Antenna	EMCO	27-Apr-2015	24 months

## 10 Auxiliary and peripheral equipment

### 10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	Not stated	Mifare contactless smart tag	Not stated	Not stated
2	D-100	RFID tag	BIO_RAD	290-1007

### 10.2 RN Electronics supplied equipment

RN No.	Model No.	Description	Manufacturer	Serial No
E541	None	Magnetic Loop	RN Electronics Ltd	E541
L285	PL320	Power Supply	Thurlby Thandar	-



## 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
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
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	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		