



EMC Technologies (NZ) Ltd
PO Box 68-307
Newton, Auckland
Phone 09 360 0862
Fax 09 360 0861
E-Mail Address: aucklab@ihug.co.nz
Web Site: www.emctech.com.au

TEST REPORT

Heyrex Rexnet v3 Animal Biometrics Monitoring Device

tested to

47 Code of Federal Regulations

Part 15 - Radio Frequency Devices

Subpart C – Intentional Radiators

including

Section 15.247 - Operation in the band 2400 – 2483.5 MHz

for

Say Systems

A handwritten signature in blue ink, reading "Andrew Cutler".

This Test Report is issued with the authority of:

Andrew Cutler - General Manager



All tests reported
herein have been
performed in accordance
with the laboratory's
scope of accreditation

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1. STATEMENT OF COMPLIANCE

The **Heyrex Rexnet v3 Animal Biometrics Monitoring Device** complies with FCC Part 15 Subpart C including Section 15.247 as an Intentional Radiator when the methods as described in ANSI C63.4 - 2003 and those defined in FCC Public Notice DA 00-705 are applied.

2. RESULTS SUMMARY

The results of testing carried out between September 2012 and December 2012 are detailed below:

Clause	Parameter	Result
15.201	Equipment authorisation requirement	Certification required.
15.203	Antenna requirement	Complies. External antenna has a unique antenna connector
15.204	External PA and antenna modifications	Noted.
15.205	Restricted bands of operation	Complies.
15.207	Conducted limits	Not applicable
15.209	Radiated emission limits	Complies.
15.247		
(a)(1)	Hopping channel separation	Complies
(a)(1)(i)(iii)	Channel occupancy / Bandwidth	Complies
(b)(1)(2)	Peak output power	Complies
(b)(4)	Antenna gain less than 6 dBi	Complies
(d)	Out of band emissions	Complies
(g)	Use of all channels	Not applicable
(h)	Intelligent frequency hopping	Not applicable
(i)	Radio frequency hazards	Complies

3. INTRODUCTION

This report describes the tests and measurements performed for the purpose of determining compliance with the specification.

The client selected the test sample.

This report relates only to the sample tested.

This report contains no corrections or erasures.

Measurement uncertainties with statistical confidence intervals of 95% are shown below test results. Both Class A and Class B uncertainties have been accounted for, as well as influence uncertainties where appropriate.

4. CLIENT INFORMATION

Company Name	Say Systems Ltd
Address	Level 1, 236-256 Karori Rd, Karori
City	Wellington
Country	New Zealand
Contact	Mr Mark Solly

5. DESCRIPTION OF TEST SYSTEM

Brand Name	Heyrex
Model Number	Rexnet v3
Product	Animal Biometrics Monitoring Device
Manufacturer	Say Systems Ltd
Country of Origin	New Zealand
Serial Number	Sample not serialized
FCC ID	RGZ-R3

Product Description

The Heyrex animal biometrics and telemetry system consists of a base station (Rexnet v3) that communicates with a battery powered sensor module (Collar Biosensor Capsule v6) which is attached to the animal that is to be monitored.

The base station is powered with using an ac adapter and is connected to an Ethernet network (Internet etc) using the RJ45 Ethernet port.

The base station stores and relays data from the collar sensor to an external location.

Band of Operation: 2400-2483.5 MHz

Number of channels: 21

Operating frequencies: 2402 – 2462 MHz

Channel spacing: 3 MHz

Rated Conducted Power: +20 dBm

Modulation Type: Proprietary 2 Mbps GFSK Frequency Hopping using Nordic Enhanced Shock Burst Protocol

Antenna Type: Omni-directional with unique RP-SMA connector

Power Supply: 5 Vdc via external AC transformer / switch mode power supply

Ports: RJ45 (Ethernet 10/100mbps)

6. RESULTS

Standard

The sample was tested in accordance with 47 CFR Part 15 Subpart C.

Methods and Procedures

The following measurement methods and procedures have been applied:

- ANSI C63.4 – 2003
- FCC Public Notice DA 00-0705

Section 15.201: Equipment authorisation requirement

Certification as detailed in Subpart J of Part 2 is required for this device.

Section 15.203: Antenna requirement

The base station uses a detachable dipole with a reverse SMA connector which meets the definition of a unique connector.

Result: Complies.

Section 15.204: External radio frequency power amplifiers and antenna modifications

An external power amplifier is provided for use with this transmitter.

Suitable warning will be placed in the user manual regarding the modification of the device.

Result: Complies.

Section 15.205: Restricted bands of operation

The device tested transmits on 21 channels between 2402 MHz and 2462 MHz using frequency hopping spread spectrum techniques.

Section 15.247 allows this between 2400 – 2483.5 MHz

Result: Complies.

Section 15.107: Conducted limits

Conducted emission testing has been carried out when the device was powered at 120 Vac 60 Hz using the supplied AC power supply.

Conducted emission testing was carried out over the frequency range of 150 kHz to 30 MHz at the Laboratory's MacKelvie Street premises in a 2.4 m x 2.4 m x 2.4 m screened room.

Testing was carried out in accordance with section 15.207(a) using a measuring receiver and a 50 μ H / 50 ohm artificial mains network which is also known as a line impedance stabilisation network (LISN).

Measurements on both the phase and neutral lines were made using either a Quasi Peak or an Average detector with a 9 kHz bandwidth.

The supplied conducted emission plot is a combined plot showing the worst case of the Peak, Quasi Peak and Average levels for both phase and neutral.

The Class B conducted limits have been applied

Result: Complies

Measurement uncertainty with a confidence interval of 95% is:

Conducted emissions tests (0.15 - 30 MHz) $\pm$ 2.2 dB

Conducted Emissions – AC Input Power Port

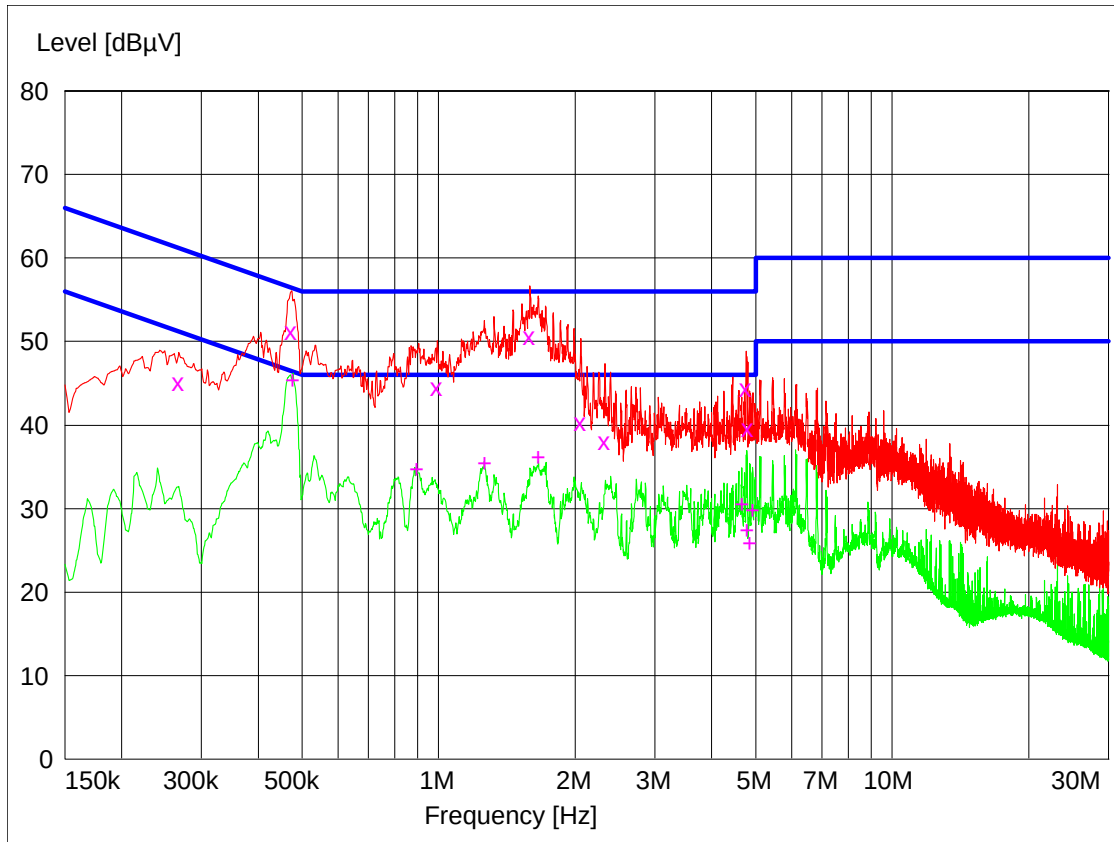
Setup: Device tested when powered at 120 Vac 60 Hz when frequency hopping continuously.

Peak ---

Average --

Quasi Peak X

Average +



Final Quasi-Peak Measurements

Frequency MHz	Level dBμV	Limit dBμV	Margin dB	Phase	Rechecks dBμV
0.267000	45.10	61.3	16.2	N	
0.474000	51.20	56.0	5.3	N	
0.993000	44.50	56.0	11.5	N	
1.590000	50.70	56.0	5.3	N	
2.058500	40.40	56.0	15.7	N	
2.324000	38.10	56.0	17.9	N	
4.767500	44.40	56.0	11.6	L1	
4.803500	39.60	56.0	16.4	N	

Final Average Measurements

Frequency MHz	Level dBμV	Limit dBμV	Margin dB	Phase	Rechecks dBμV
0.477000	45.40	46.0	1.0	L1	45.4
0.894000	34.80	46.0	11.2	L1	
1.260000	35.50	46.0	10.5	L1	
1.659000	36.20	46.0	9.8	L1	
4.659500	30.50	46.0	15.5	L1	
4.785500	27.50	46.0	18.6	N	
4.848500	25.90	46.0	20.1	N	
4.925000	29.80	46.0	16.2	L1	

Section 15.209 – Radiated emissions

As this device contains digital devices that operate using frequencies below 30 MHz, low frequency measurements were attempted between 9 kHz – 30 MHz at the open area test site over a distance of 10 metres using a loop antenna the centre of which was 1 metre above the ground.

Details of the general test set up are provided in the photograph section of this report.

The general limits described in 15.209 have been applied with the 300 metre and 30 metre limits being extrapolated by a factor of 40 dB per decade as allowed for in section 15.31(d)(2).

Between 9 – 90 kHz and between 110 – 490 kHz an Average detector and a Peak detector were used.

Where a peak detector was used the limit was increased by +20 dB

Between 90 kHz and 110 kHz band between 490 kHz and 30 MHz a Quasi Peak detector was used.

No emissions were detected on these frequencies of interest and no other emissions were detected from this device over the range of 9 kHz – 30 MHz

Result: Complies

Measurement uncertainty with a confidence interval of 95% is:

- Free radiation tests (9 kHz – 30 MHz) $\pm$ 4.8 dB

Section 15.247(a)(1) - Channel occupancy / bandwidth

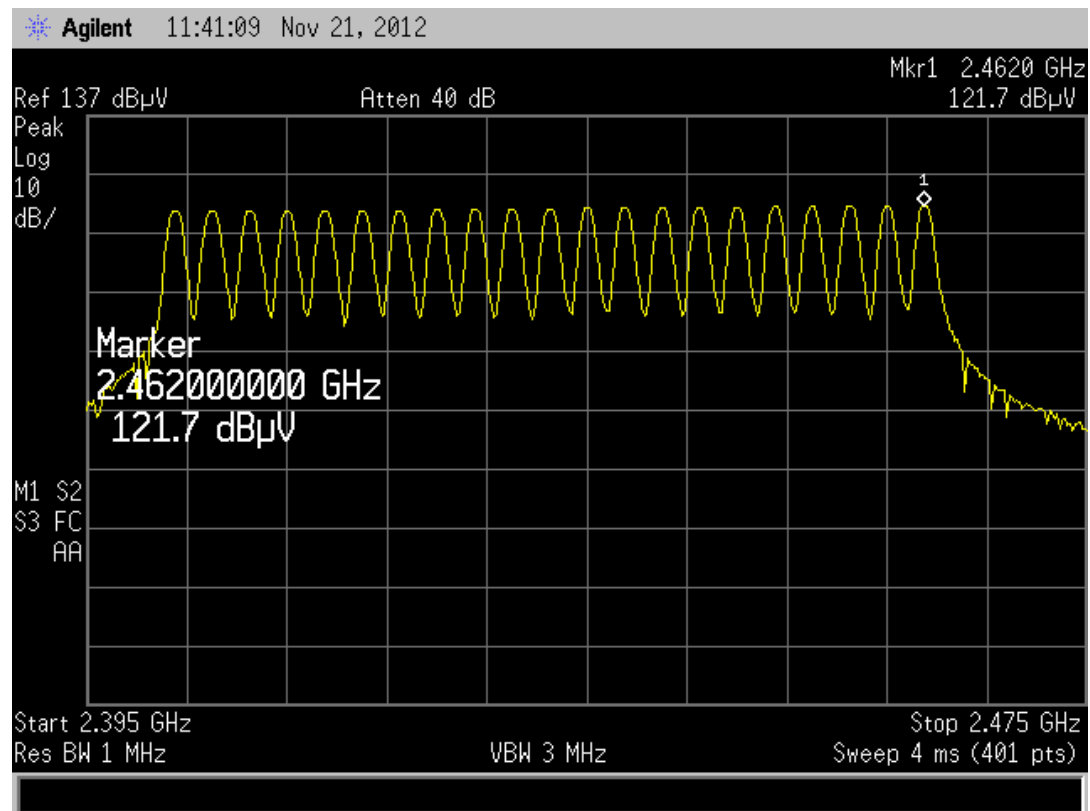
The results are summarised as follows:

Parameter	Limit	Observation	Result
Number of channels	Minimum of 15 channels	21 channels with 3 MHz spacing	Pass
20 dB bandwidth	Less than the channel spacing	A worst case bandwidth of 1.075 MHz was measured	Pass
Hop interval	Greater than 20 dB bandwidth	3 MHz	Pass
Dwell time	Not to exceed 400 ms in any 8.4 second period	394.875 ms	Pass

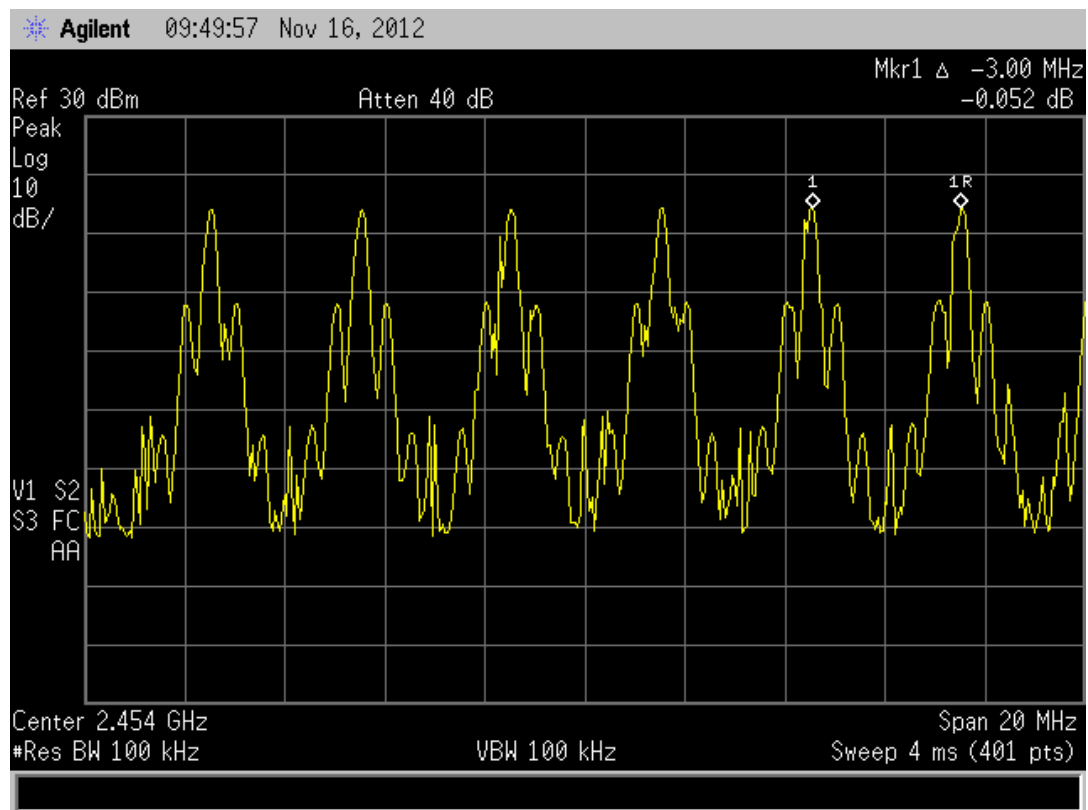
Result: Complies

This device operates using Frequency Hopping Spread Spectrum techniques.

21 channels were observed between 2402 – 2480 MHz

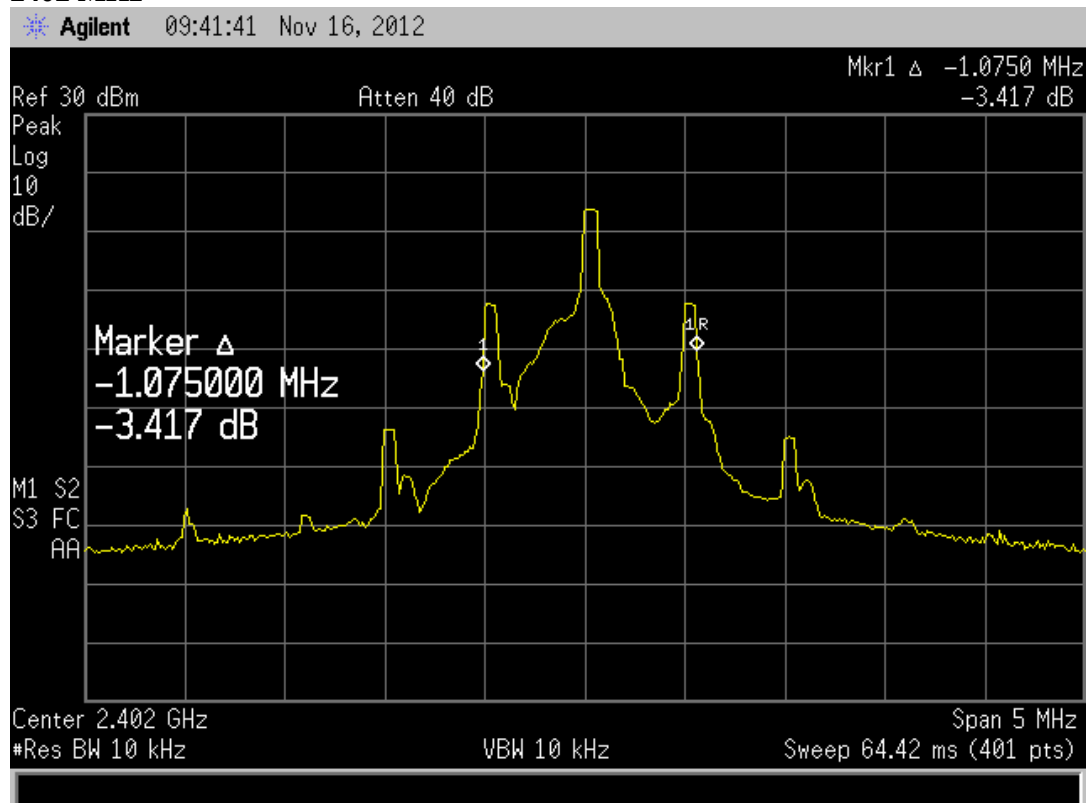


The channels were observed between 2402 MHz and 2462 MHz with 3 MHz channel spacing

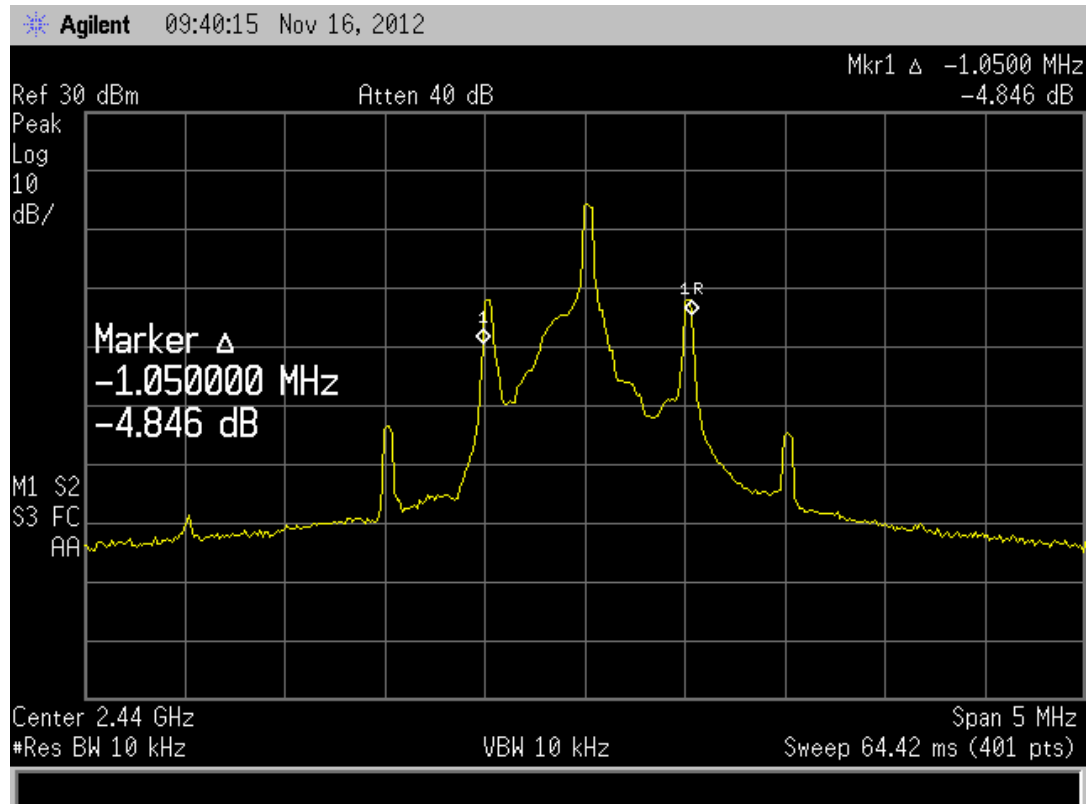


The -20 dB bandwidth for each device has been determined below

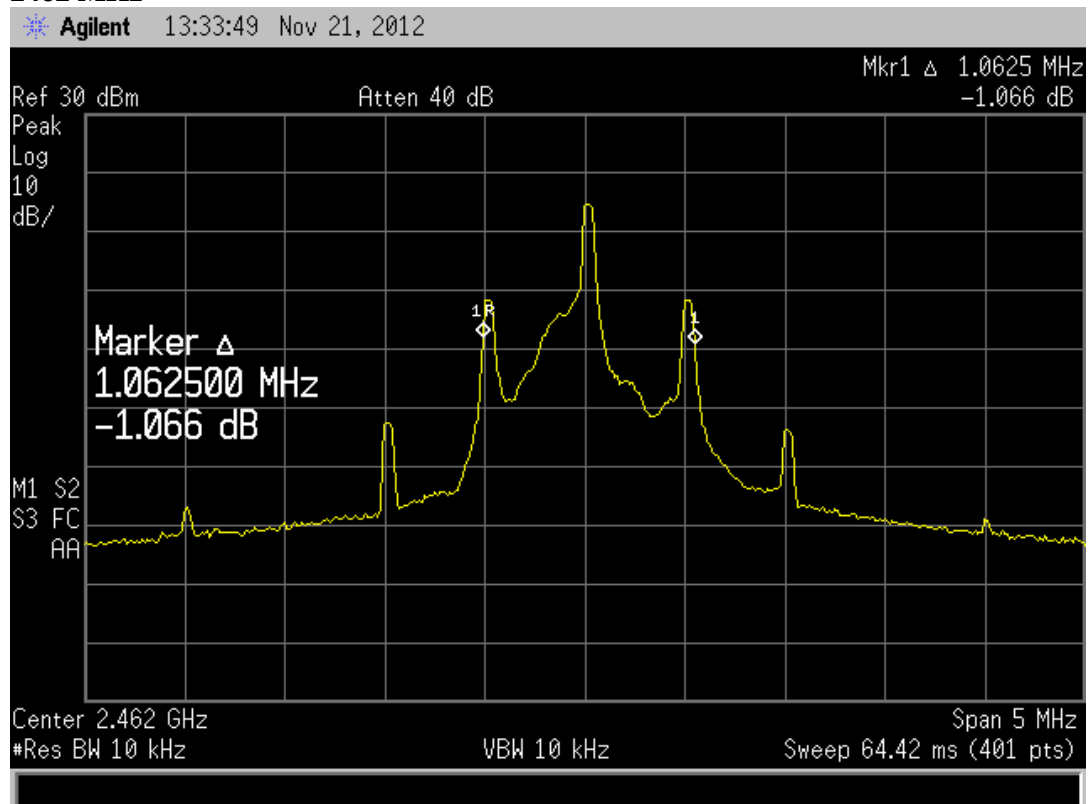
2402 MHz



2440 MHz

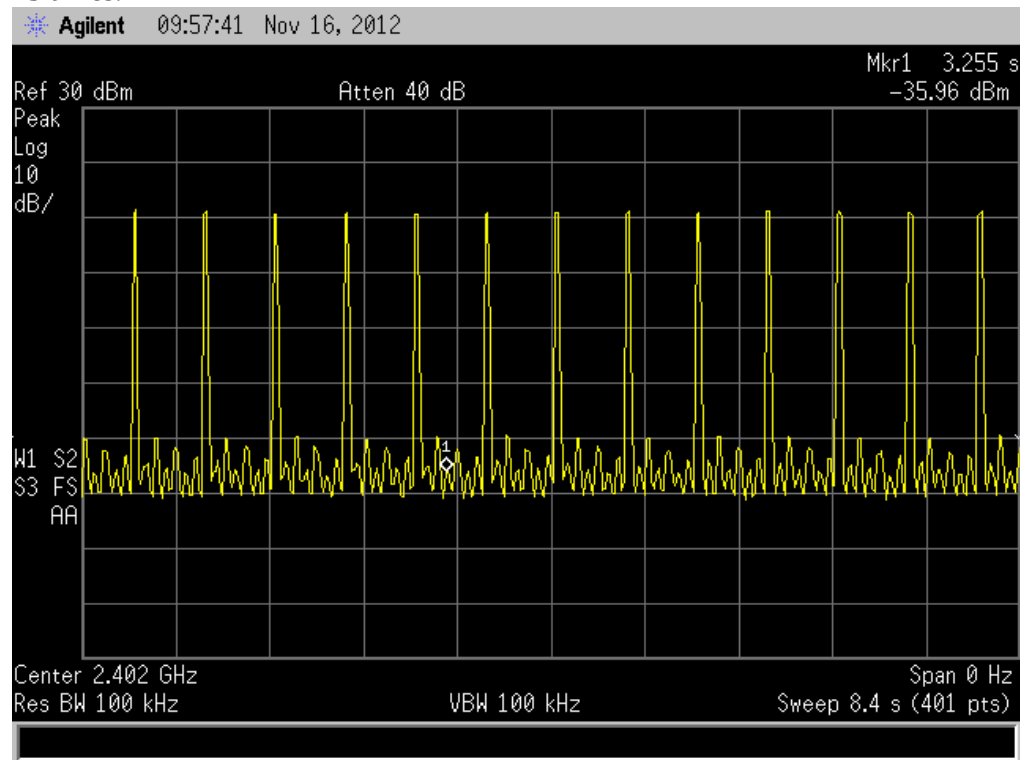


2462 MHz

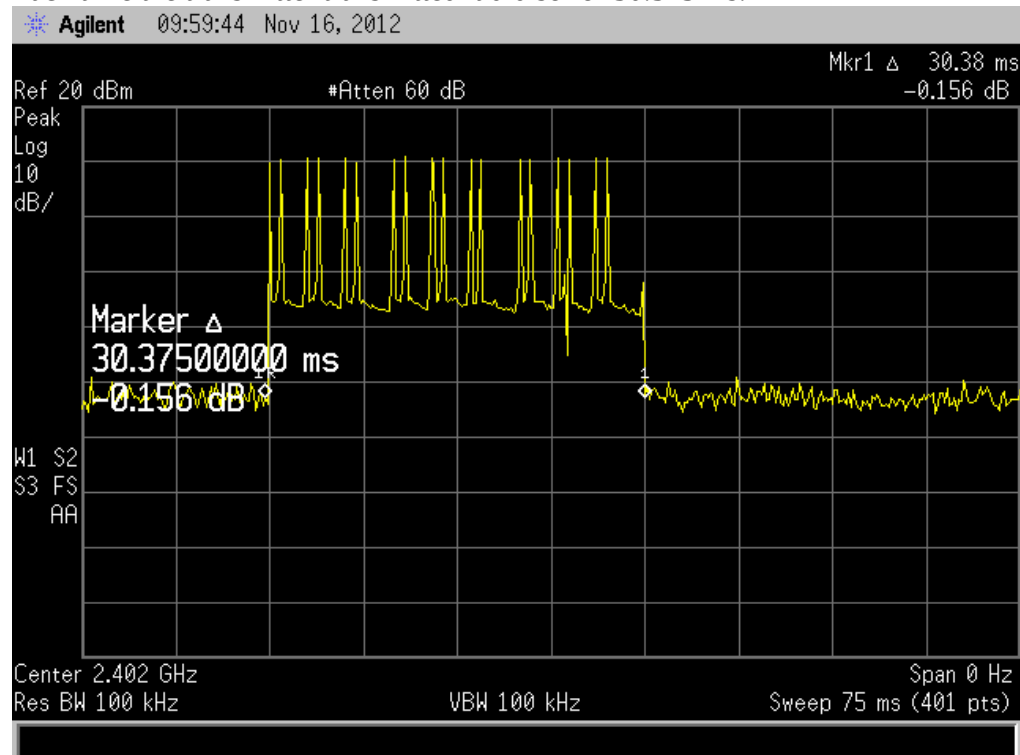


A worst case 20 dB bandwidth of 1.075 MHz was measured.

In a period of 8.4 seconds (0.4 seconds x 21 channels) the transmitter was observed to transmit 13 times.



Each time the transmitter transmitted it did so for 30.375 ms.



The dwell time will therefore be 13 transmissions x 30.375 ms = 394.875 ms.

Result: Complies

Section 15.247(b)(1)+(2)– Peak output power

Measurements were made at the antenna port using a measuring receiver with a peak detector and a resolution bandwidth of 3 MHz.

Testing was carried out when the carrier was modulated with power set to level 8

Frequency (MHz)	Level (dBm)	Power (Watts)	Limit (Watts)
2402.0000	13.7	0.023	0.125
2440.0000	14.1	0.026	0.125
2462.0000	14.5	0.028	0.125

A conducted limit of 0.125 watt (+20 dBm) has been applied as less than 75 channels are in use.

Radiated power measurements were also made using the supplied whip antenna on the highest low, mid and high frequency channel using both vertical and horizontal polarisations.

Only vertical emissions have been recorded as this polarisation gave the worst case result.

Frequency (MHz)	Field Strength (dB μ V/m)	Radiated Power (dBm)	Conducted Power (dBm)	Antenna Gain (dB)
2402	105.5	10.3	13.7	-3.4
2440	107.4	12.2	14.1	-1.9
2462	112.6	17.4	14.5	+2.9

The radiated power level in dBm was determined by formula from the field strength using the formula Field strength (V/m) = (square root of (30 x transmitter power (watts))) / distance (metres)

These calculations have been included to determine the gain / loss due to the antenna and cabling.

Testing was carried out at EMC Technologies NZ Ltd Open Area Test Site, which is located at Orere Point, Auckland with the device being placed in the centre of the test table at a height of 80 cm above the ground plane.

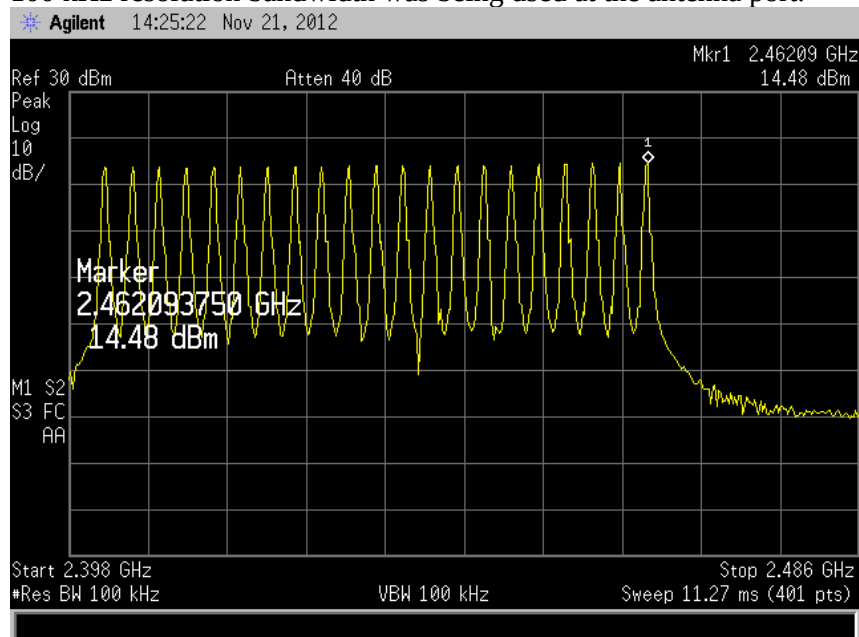
Result: Complies

Measurement Uncertainty: ± 4.1 dB

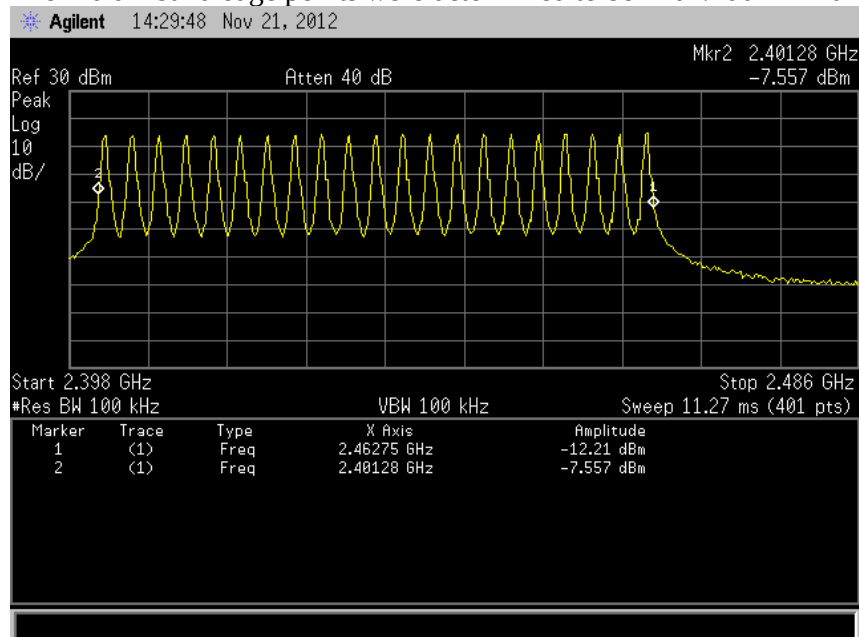
Section 15.247 (d) – Out of band emissions

Band edge measurements:

Testing shows a worst case emission level of 14.4 dBm being observed at 2462 MHz when a 100 kHz resolution bandwidth was being used at the antenna port.



The -20 dB band edge points were determined to be 2401.200 MHz and 2462.750 MHz



The device is required to remain within the band of 2400 – 2483.5 MHz.

In addition radiated measurements were made in the restricted bands of 2310 – 2390 MHz and between 2483.5 – 2500 MHz where the limits as defined in section 15.209 were applied.

The following emissions were detected at the band edges when measured at a distance of three metres

The highest emission observed was on 2462 MHz using vertical polarisation with a level of 111.0 dBuV/m recorded being recorded when a 100 kHz bandwidth peak detector was used

Transmitting on 2402 MHz

Observations made in the 2200 – 2300 MHz and 2310 – 2390 MHz restricted bands.

Frequency MHz	Vertical dBuV/m	Horizontal dBuV/m	Limit dBuV/m	Margin dB	Result	Antenna	Detector
2400.000	73.1		91.0	17.9	Pass	Vertical	Peak
2386.000	72.4		74.0	1.6	Pass	Vertical	Peak
2386.000	53.1		54.0	0.9	Pass	Vertical	Average
2204.000	55.1		74.0	18.9	Pass	Vertical	Peak
2204.000	40.4		54.0	13.6	Pass	Vertical	Average
2223.000	54.0		74.0	20.0	Pass	Vertical	Peak
2223.000	41.0		54.0	13.0	Pass	Vertical	Average
2400.000	73.1		93.1	20.0	Pass	Vertical	Peak

Transmitting on 2462 MHz

Observations made in the 2483.5 – 2500 MHz restricted band.

Frequency MHz	Vertical dBuV/m	Horizontal dBuV/m	Limit dBuV/m	Margin dB	Result	Antenna	Detector
2483.500	68.5	64.4	74.0	5.5	Pass	Vertical	Peak
	44.0	43.8	54.0	10.0	Pass	Vertical	Average
2486.000	68.6	65.3	74.0	5.4	Pass	Vertical	Peak
	49.4	47.1	54.0	4.6	Pass	Vertical	Average
2494.000	67.5	62.5	74.0	6.5	Pass	Vertical	Peak
	48.9	45.1	54.0	5.1	Pass	Vertical	Average

Observations were made in horizontal however not recorded as vertical gave significantly higher levels.

Testing was carried out at EMC Technologies NZ Ltd Open Area Test Site, which is located at 670 Kawakawa Orere Road, Orere Point, Auckland.

Result: Complies

Measurement Uncertainty: ± 4.1 dB

Spurious emissions and restricted band radiated emission measurements

Testing was carried out at EMC Technologies NZ Ltd Open Area Test Site, which is located at Driving Creek, Orere Point, Auckland.

Radiated emission measurements were carried out with the limits as per section 15.209 applied when these emissions fell within the restricted bands.

All other emissions are required to meet a limit of -20 dBc with relation to the highest in band emission.

The highest emission observed was on 2462 MHz using vertical polarisation with a level of 111.0 dBuV/m recorded being recorded when a 100 kHz bandwidth peak detector was used

The transmitter was placed on the test table top which was a total of 0.8 m above the test site ground plane.

Measurements of the radiated field were attempted at 3 metres from the device with no emission being detected.

Measurements below 1000 MHz were made using a Quasi Peak Detector with a bandwidth of 120 kHz.

Measurements above 1000 MHz were made using an average detector with a bandwidth of 1.0 MHz and also a peak detector with a bandwidth of 1.0 MHz.

When an emission is located, it is positively identified and its maximum level is found by rotating the automated turntable, and by varying the antenna height with an automated antenna tower.

All emissions were measured in both vertical and horizontal antenna polarisations.

The emission level is determined in field strength by taking the following into consideration:

Level (dBμV/m) = Receiver Reading (dBμV) + Antenna Factor (dB) + Coax Loss (dB) – Amplifier Gain (dB)

Result: Complies

Measurement uncertainty: ± 4.1 dB

Transmitting continuously on 2402 MHz

Frequency MHz	Vertical dBuV/m	Horizontal dBuV/m	Limit dBuV/m	Margin dB	Result	Antenna	Detector
4804.000	56.8	< 59.0	74.0	17.2	Pass	Horizontal	Peak
	45.6	< 46.0	54.0	8.4	Pass	Horizontal	Average
7206.000	< 59.0	< 59.0	93.0	> 34.0	Pass	Vert/Hort	Peak
9608.000	< 59.0	< 59.0	93.0	> 34.0	Pass	Vert/Hort	Peak
12010.000	< 59.0	< 59.0	74.0	> 15.0	Pass	Vert/Hort	Peak
	< 46.0	< 46.0	54.0	> 8.0	Pass	Vert/Hort	Average
14412.000	< 59.0	< 59.0	91.0	> 32.0	Pass	Vert/Hort	Peak
16814.000	< 59.0	< 59.0	93.0	> 32.0	Pass	Vert/Hort	Peak
19216.000	< 59.0	< 59.0	74.0	> 15.0	Pass	Vert/Hort	Peak
	< 46.0	< 46.0	54.0	> 8.0	Pass	Vert/Hort	Average
21618.000	< 59.0	< 59.0	74.0	> 15.0	Pass	Vert/Hort	Peak
	< 46.0	< 46.0	54.0	> 8.0	Pass	Vert/Hort	Average
24020.000	< 59.0	< 59.0	74.0	> 15.0	Pass	Vert/Hort	Peak
	< 46.0	< 46.0	54.0	> 8.0	Pass	Vert/Hort	Average

The device was then observed when hopping continuously with all average emissions levels observed to drop with continue to comply.

Transmitting continuously on 2440 MHz

Frequency MHz	Vertical dBuV/m	Horizontal dBuV/m	Limit dBuV/m	Margin dB	Result	Antenna	Detector
4880.000	58.7	56.0	74.0	15.3	Pass	Vertical	Peak
	49.7	43.0	54.0	4.3	Pass	Vertical	Average
7320.000	58.4	55.0	74.0	15.6	Pass	Vertical	Peak
	52.5	42.0	54.0	1.5	Pass	Vertical	Average
9760.000	< 59.0	< 59.0	91.0	> 32.0	Pass	Vert/Hort	Peak
12200.000	< 59.0	< 59.0	74.0	> 15.0	Pass	Vert/Hort	Peak
	< 46.0	< 46.0	54.0	> 8.0	Pass	Vert/Hort	Average
14640.000	< 59.0	< 59.0	91.0	> 32.0	Pass	Vert/Hort	Peak
17080.000	< 59.0	< 59.0	91.0	> 32.0	Pass	Vert/Hort	Peak
19520.000	< 59.0	< 59.0	74.0	> 15.0	Pass	Vert/Hort	Peak
	< 46.0	< 46.0	54.0	> 8.0	Pass	Vert/Hort	Average
21960.000	< 59.0	< 59.0	74.0	> 15.0	Pass	Vert/Hort	Peak
	< 46.0	< 46.0	54.0	> 8.0	Pass	Vert/Hort	Average
24400.000	< 59.0	< 59.0	74.0	> 15.0	Pass	Vert/Hort	Peak
	< 46.0	< 46.0	54.0	> 8.0	Pass	Vert/Hort	Average

The device was then observed when hopping continuously with all average emissions levels observed to drop with continue to comply.

Transmitting continuously on 2462 MHz

Frequency MHz	Vertical dBuV/m	Horizontal dBuV/m	Limit dBuV/m	Margin dB	Result	Antenna	Detector
4924.000	61.4	< 59.0	74.0	12.6	Pass	Vertical	Peak
	53.3	< 46.0	54.0	0.7	Pass	Vertical	Average
7386.000	68.3	56.8	74.0	5.7	Pass	Vertical	Peak
	53.8	45.5	54.0	0.2	Pass	Vertical	Average
9848.000	61.8	< 59.0	91.0	29.2	Pass	Vertical	Peak
12310.000	63.1	< 59.0	74.0	10.9	Pass	Vertical	Peak
	51.8	< 46.0	54.0	2.2	Pass	Vertical	Average
14772.000	< 59.0	< 59.0	91.0	> 32.0	Pass	Vert/Hort	Peak
17234.000	< 59.0	< 59.0	91.0	> 32.0	Pass	Vert/Hort	Peak
19696.000	< 59.0	< 59.0	74.0	> 15.0	Pass	Vert/Hort	Peak
	< 46.0	< 46.0	54.0	> 8.0	Pass	Vert/Hort	Average
22158.000	< 59.0	< 59.0	74.0	> 15.0	Pass	Vert/Hort	Peak
	< 46.0	< 46.0	54.0	> 8.0	Pass	Vert/Hort	Average
24620.000	< 59.0	< 59.0	91.0	> 32.0	Pass	Vert/Hort	Peak

The device was then observed when hopping continuously with all average emissions levels observed to drop with continue to comply.

Section 15.247(i) – Radio Frequency Hazard Information

As per Section 15.247 (i) spread spectrum transmitters operating in the 2400 – 2483.5 MHz band are required to be operated in a manner that ensures that the public is not exposed to RF energy levels in accordance with CFR 47, Section 1.1307(b)(1).

The device when in operation is fixed and a safe distance could be maintained when events are undertaken.

In accordance with Section 1.1310 the Maximum Permissible Exposure (MPE) limits for the General Population / Uncontrolled Exposure of 1 mW/cm^2 has been applied.

The maximum distance from the antenna at which the MPE is met or exceeded is calculated from the equation relating field strength in V/m, transmit power in watts, transmit antenna gain and separation distance in metres:

$$E, \text{ V/m} = (\sqrt{30 * P * G}) / d$$

$$\text{Power density, mW/cm}^2 = E^2 / 3770$$

$$E \text{ for MPE: } 1 = E^2 / 3770$$

$$E = \sqrt{1 * 3770}$$

$$E = 61.4 \text{ V/m}$$

The highest radiated power that has been measured is +17.4 dBm or 0.055 watts.

Therefore:

$$E = \sqrt{30 * P * G} / d$$

$$d = \sqrt{30 * P * G} / E$$

$$d = \sqrt{30 * 0.055} / 61.4$$

$$d = 0.0209 \text{ m or } 2.1 \text{ cm}$$

Result: Complies if a minimum safe distance of 20 cm is specified in the set up instructions for this system.

7. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial No	Asset Ref	Cal Due
Aerial Controller	EMCO	1090	9112-1062	RFS 3710	Not applic
Aerial Mast	EMCO	1070-1	9203-1661	RFS 3708	Not applic
Turntable	EMCO	1080-1-2.1	9109-1578	RFS 3709	Not applic
Receiver	R & S	ESIB 40	100171	R-27-1	10 Oct 2013
Receiver	R & S	ESHS 10	828404/005	RFS 3728	2 Dec 2012
Mains Network	R & S	ESH2-Z5	881362/034	3628	29 Jul 2013
VHF Balun	Schwarzbeck	VHA 9103	-	RFS 3603	30 Jan 2013
Biconical Antenna	Schwarzbeck	BBA 9106	-	RFS 3612	30 Jan 2013
Log Periodic	Schwarzbeck	VUSLP 9111	9111-228	3785	30 Jan 2013
Horn Antenna	EMCO	3115	9511-4629	E1526	3 May 2013
Horn Antenna	EMCO	3116	92035	-	16 Jun 2013
Loop Antenna	EMCO	6502	9003-2485	3798	9 May 2014

8. ACCREDITATIONS

Testing was carried out in accordance with EMC Technologies Ltd registration with the Federal Communications Commission as a listed facility, registration number: 90838, which was updated on 15 February, 2011.

All testing was carried out in accordance with the terms of EMC Technologies (NZ) Ltd International Accreditation New Zealand (IANZ) Accreditation to NZS/ISO/IEC 17025, 2005.

All measurement equipment has been calibrated in accordance with the terms of the EMC Technologies (NZ) Ltd International Accreditation New Zealand (IANZ) Accreditation to NZS/ISO/IEC 17025, 2005.

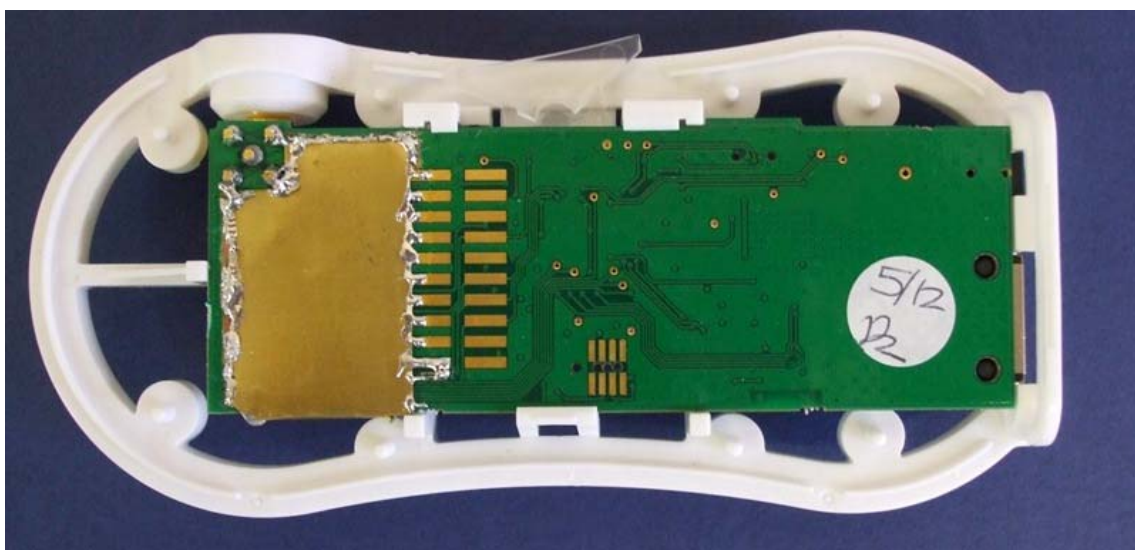
International Accreditation New Zealand has Mutual Recognition Arrangements for testing and calibration with various accreditation bodies in a number of economies. This includes NATA (Australia), UKAS (UK), SANAS (South Africa), NVLAP (USA), A2LA (USA), SWEDAC (Sweden). Further details can be supplied on request.

9. PHOTOGRAPHS





Internal Photos



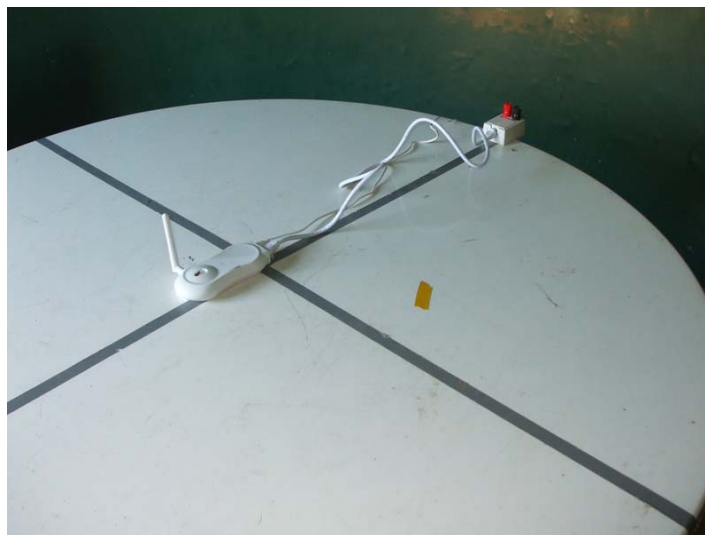


Radiated emissions test set up photos – Below 30 MHz



Radiated emissions test set up photos – Above 30 MHz





Conducted Emissions Test Set Up

