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TEST REPORT

Gallagher T20 (C305460) Multi Tech PIV Proximity Card Reader

tested to

47 Code of Federal Regulations

Part 15 - Radio Frequency Devices

Subpart C – Intentional Radiators

Section 15.209

and

Section 15.225
Operation within the band 13.110 -14.010 MHz

for

Gallagher Group Ltd

This Test Report is issued with the authority of:

Andrew Cutler- General Manager

IANZ ACCREDITED LABORATORY

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 **Gallagher T20 (C305460) Multi Tech PIV Proximity Card Reader** complies with FCC Part 15 Subpart C Section 15.225 as an Intentional Radiator when the methods as described in ANSI C63.4 - 2014 are applied.

2. RESULTS SUMMARY

The results from testing carried out in March 2016 are summarised in the following table:

Clause	Parameter	Result
15.201	Equipment authorisation requirement	Certification required.
15.203	Antenna requirement	Complies. Antennas internal to the device.
15.204	External PA and antenna modifications	Not applicable. No external devices.
15.205	Restricted bands of operation	Complies. Device transmits on 13.560 MHz with an occupied bandwidth of 447 kHz. It also transmits on 125 kHz with an occupied bandwidth of 1382.7 Hz
15.207	Conducted limits	Complies.
15.209	Radiated emission limits - Emissions < 30 MHz	Complies.
15.209	Radiated emission limits – Emissions > 30 MHz	Complies.
15.225	Radiated emission limits - Fundamental	Complies.
15.225	Frequency stability	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.

This report replaces report number 160108.1 to address issues raised during the FCC certification process.

4. CLIENT INFORMATION

Company Name	Gallagher Group Ltd
Address	Kahikatea Drive
City	Hamilton
Country	New Zealand
Contact	Mr Brian Rose

5. DESCRIPTION OF TEST SAMPLE

Brand Name	Gallagher
Model Number Tested	T20 (C305460)
Product	Proximity Card Reader
Manufacturer	Gallagher Group Ltd
Country of Origin	New Zealand
Serial Number	1606420002
FCC ID	M5VC30046XA

The model tested is a dual mode transmitter operating on 125 kHz and 13.560 MHz.

6. SETUPS AND PROCEDURES

Standard

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

Methods and Procedures

The measurement methods and procedures as described in ANSI C63.4 - 2014 were used.

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

This device has internal antennas for the 125 kHz and 13.560 MHz transmitters.

Result: Complies.

Section 15.204: External radio frequency power amplifiers and antenna modifications

It is not possible to attach an external power amplifier to this transmitter.

Result: Complies.

Section 15.205: Restricted bands of operation

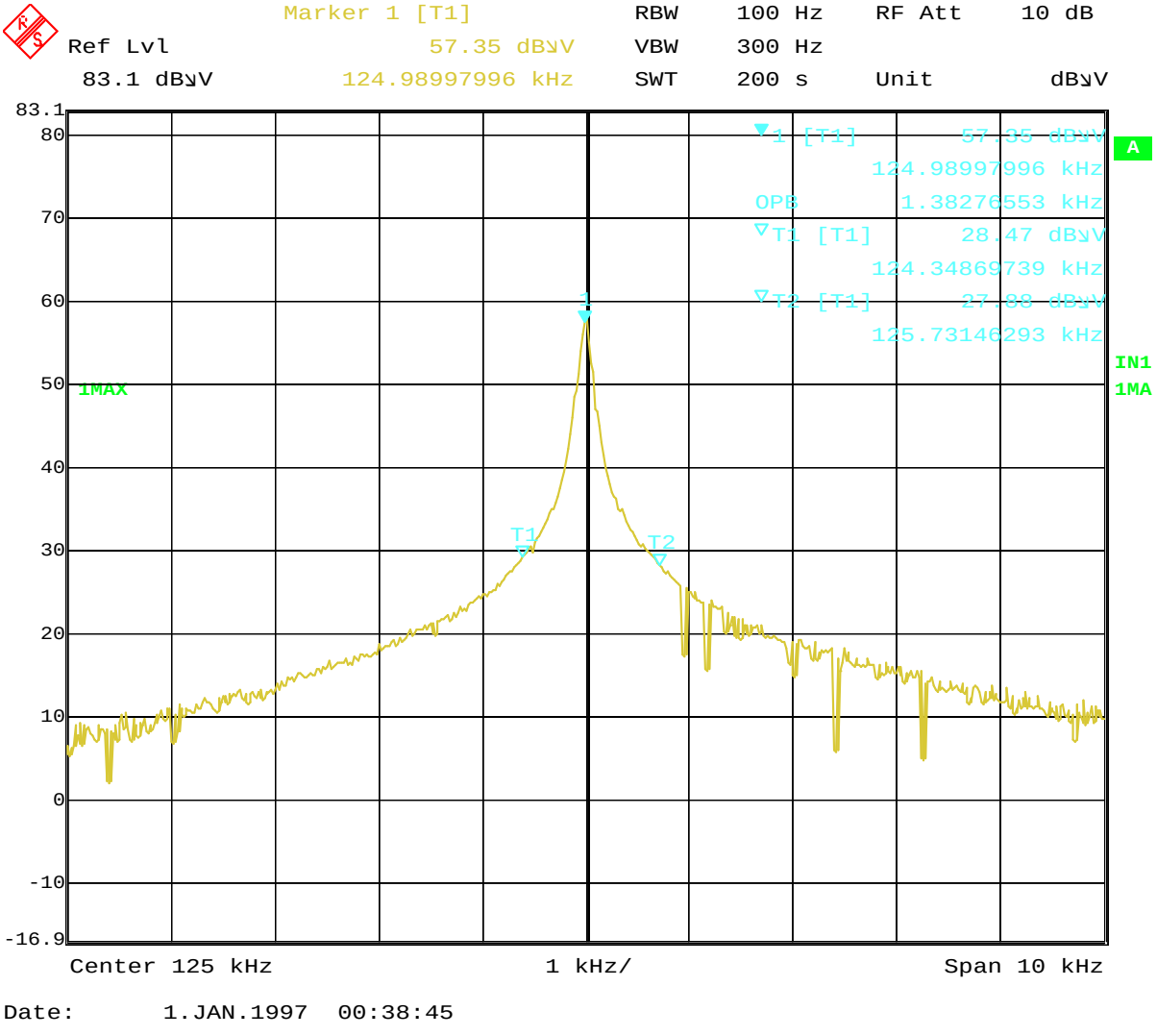
The transmitter transmits on 125.000 kHz.

This device would therefore fall between the restricted bands of 90 – 110 kHz and 495 – 505 kHz.

Measurements were made using a span of 10 kHz with a resolution bandwidth of 100 Hz and a video bandwidth of 300 Hz.

Measurements were made using a spectrum analyser with an occupied bandwidth measurement function.

At 125 kHz the modulation bandwidth was measured to be 1382.7 Hz.



The transmitter transmits on 13.560 MHz.

This device would therefore fall into the band of 13.110 – 14.010 MHz that is covered by Section 15.225.

Representative measurements were made based upon the field strength measured at the test side

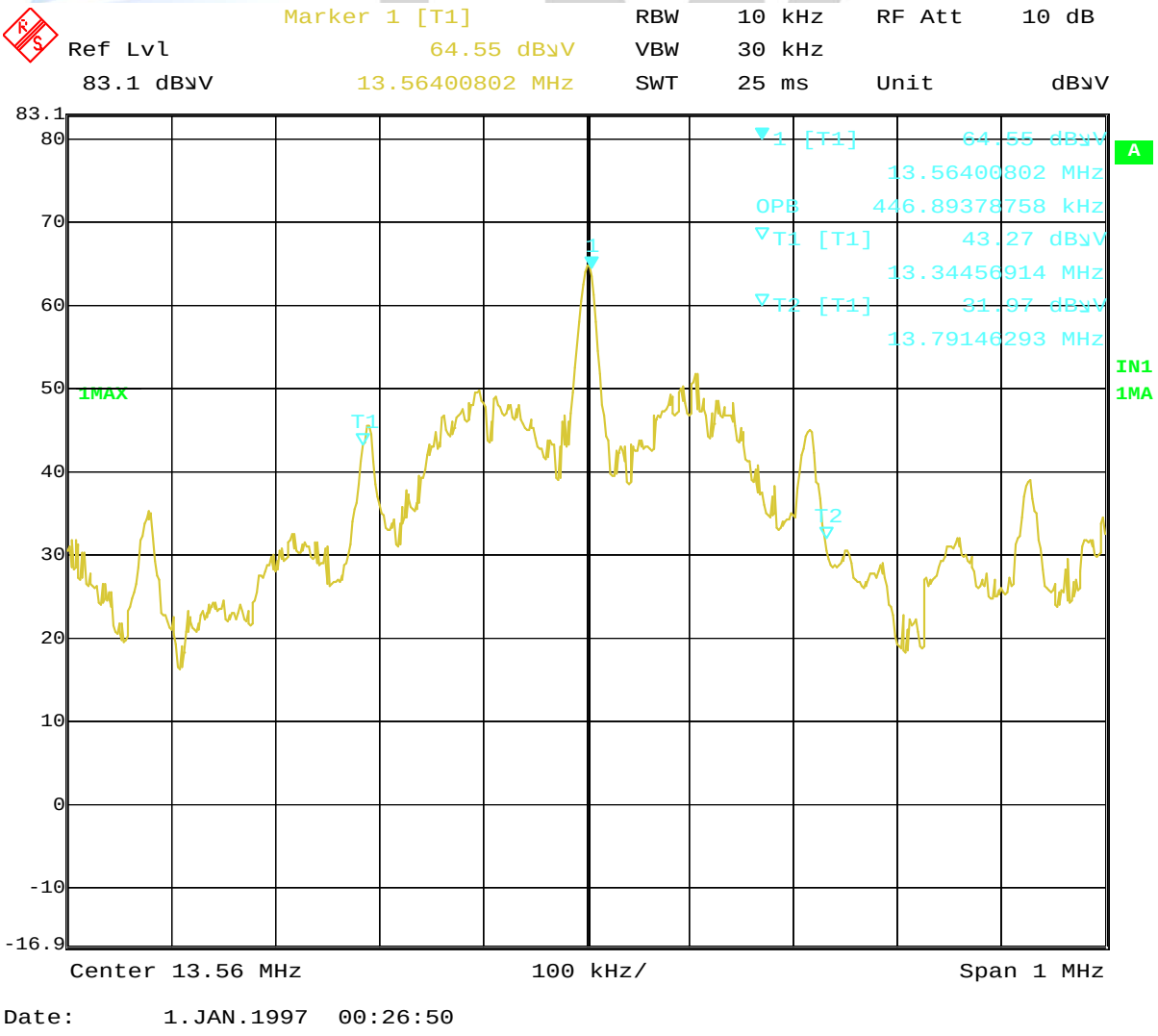
Measurements were made when the device was waiting of a card and when it was reading a card.

Measurements were made using a spectrum analyser with an occupied bandwidth measurement function.

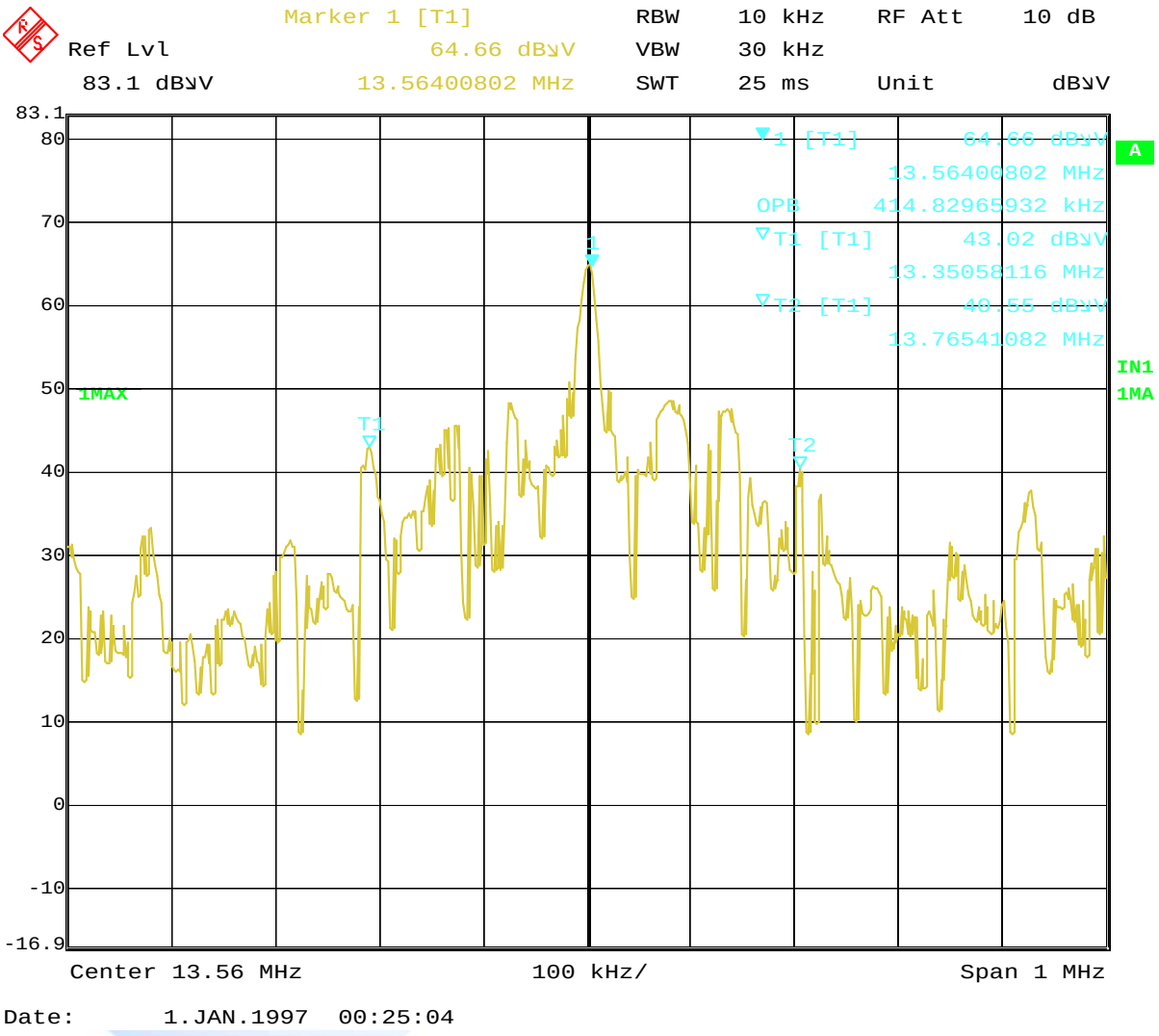
Measurements were made using a span of 1.0 MHz with a resolution bandwidth of 10 kHz and a video bandwidth of 30 kHz.

A worst case modulation bandwidth of 446.894 kHz was measured

13.560 MHz when reading a card



13.560 MHz when awaiting a card



Result: Complies.

Section 15.207: Conducted emissions testing

Conducted Emissions testing was carried out over the frequency range of 150 kHz to 30 MHz which was carried out 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 using a representative AC power supply system that was powered at 120 Vac 60 Hz which supplied 12 Vdc to a Gallagher Controller 6000 device which in turn powered the Card Reader at 12 Vdc.

The device operates on 125 kHz and 13.560 MHz.

Testing was carried out with both transmitters operating with their standard antennas attached and when the 13.560 MHz antenna was removed and replaced with a dummy load.

The device is deemed to comply providing it complies when the test is carried out with the dummy load attached and the overall emission signature for the product remains similar with no additional emissions being detected.

This is the case with this device.

The device was placed on top of the emissions table, which is 1 m x 1.5 m, 80 cm above the screened room floor which acts as the horizontal ground plane.

In addition the device was positioned 40 cm away from the screened room wall which acts as the vertical ground plane.

The artificial mains network was bonded to the screened room floor.

At all times the device was kept more than 80 cm from the artificial mains network.

The Class B limits have been applied.

The supplied plot is combined plot showing the worst case quasi peak and average results of both the phase and neutral lines to the representative AC power supply.

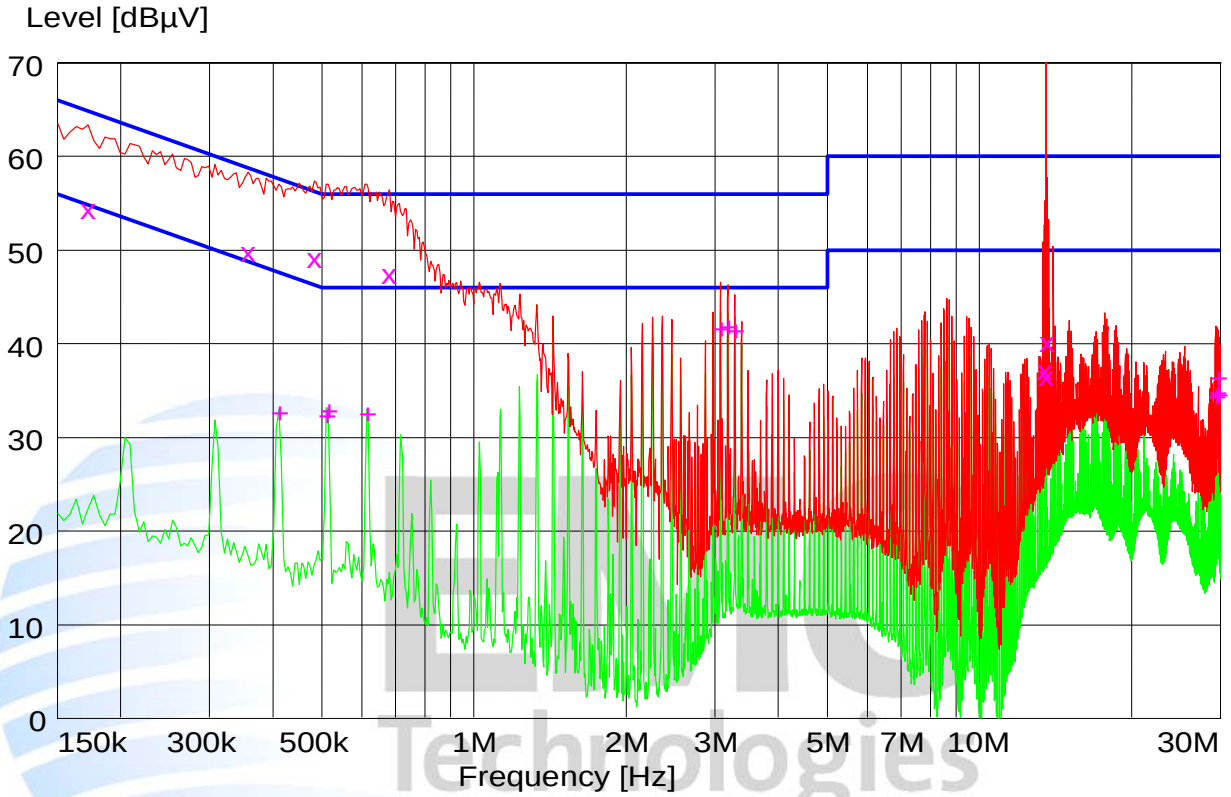
Quasi peak and average detectors have been used with resolution bandwidths of 9 kHz.

Measurement uncertainty with a confidence interval of 95% is:
- AC Mains port (0.15-30 MHz) ± 2.8 dB

Conducted Emissions – AC Input Power Port - Normal Operating Mode

Setup:	Device tested when powered at 12 Vdc when using a controller that is powered by an 120 Vac 60 Hz power supply. The 13.560 MHz card reader was operating continuously.

Peak ---	Average --	Quasi Peak X	Average +



Final Quasi-Peak Measurements

Frequency (MHz)	Level (dBµV)	Limit (dBµV)	Margin (dB)	Phase	Rechecks (dBµV)
0.172500	54.60	64.8	10.2	L1	
0.357000	50.10	58.8	8.7	L1	
0.483000	49.40	56.3	6.9	N	49.5
0.681000	47.70	56.0	8.3	L1	47.7
13.485000	37.50	60.0	22.5	N	
13.560000	75.80	60.0	-15.8	L1	Transmit Frequency
13.575000	36.90	60.0	23.1	L1	
13.635000	40.40	60.0	19.6	L1	

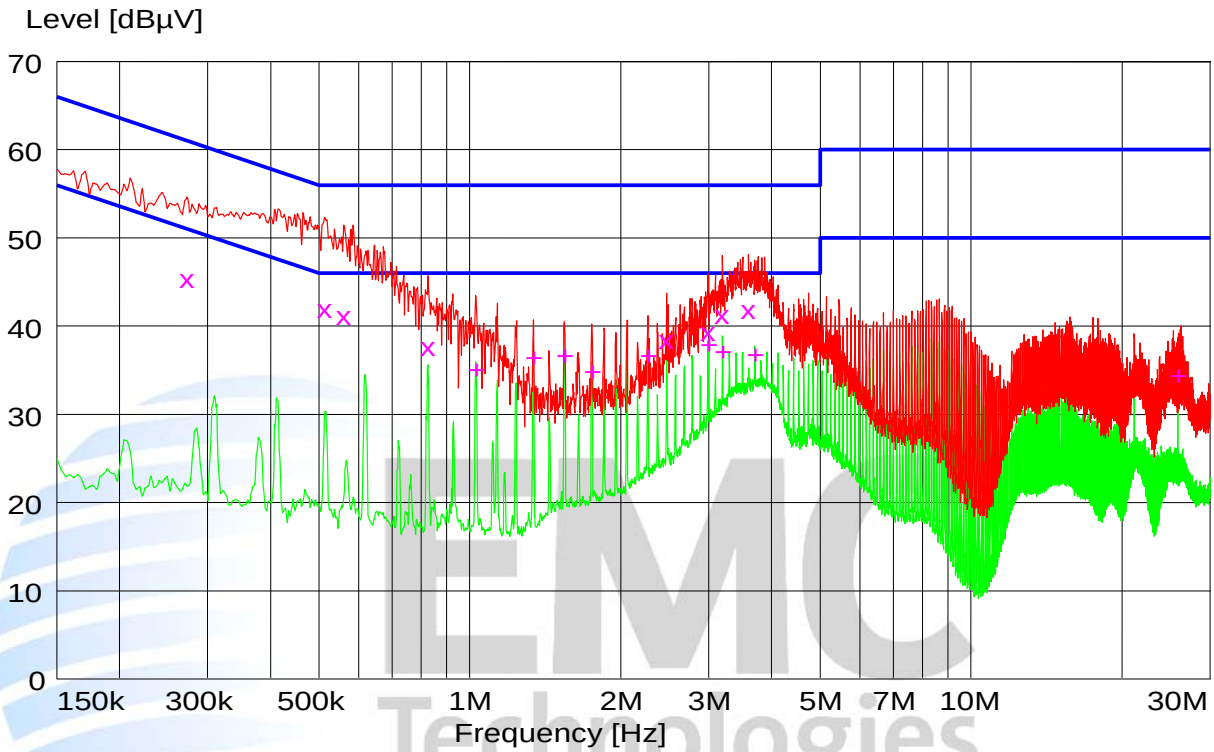
Final Average Measurements

Frequency (MHz)	Level (dBµV)	Limit (dBµV)	Margin (dB)	Phase	Rechecks (dBµV)
0.411000	32.90	47.6	14.7	N	
0.510000	32.60	46.0	13.4	N	
0.514500	33.10	46.0	12.9	L1	
0.613500	32.80	46.0	13.2	N	
3.075000	41.90	46.0	4.1	N	41.8
3.180000	42.00	46.0	4.0	N	41.5
3.280000	41.70	46.0	4.3	N	41.4
13.560000	71.20	50.0	-21.2	L1	Transmit Frequency
29.430000	34.70	50.0	15.3	L1	
29.535000	35.10	50.0	14.9	N	
29.635000	36.60	50.0	13.4	N	
29.740000	34.80	50.0	15.2	N	

Conducted Emissions – AC Input Power Port - Dummy Load Attached

Setup:	Device tested when powered at 12 Vdc when using a controller that is powered by an 120 Vac 60 Hz power supply. Dummy load attached to the 13.560 MHz card reader that was operating continuously.

Peak ---	Average --	Quasi Peak X	Average +



Final Quasi-Peak Measurements

Frequency (MHz)	Level (dBµV)	Limit (dBµV)	Margin (dB)	Phase	Rechecks (dBµV)
0.273000	45.70	61.0	15.3	L1	
0.513000	42.20	56.0	13.8	L1	
0.561000	41.40	56.0	14.6	L1	
0.825000	37.90	56.0	18.1	L1	
2.472500	38.70	56.0	17.3	N	
2.990000	39.60	56.0	16.4	N	
3.192500	41.50	56.0	14.5	N	
3.602000	42.10	56.0	13.9	L1	

Final Average Measurements

Frequency (MHz)	Level (dBµV)	Limit (dBµV)	Margin (dB)	Phase	Rechecks (dBµV)
1.029000	35.30	46.0	10.7	L1	
1.338000	36.70	46.0	9.3	L1	
1.545000	36.90	46.0	9.1	N	
1.752000	35.10	46.0	10.9	N	
2.265500	36.90	46.0	9.1	L1	
2.985500	38.10	46.0	7.9	L1	
3.192500	37.40	46.0	8.6	N	
3.705500	37.10	46.0	8.9	N	
25.872500	34.70	50.1	15.4	L1	

Section 15.209: Radiated emission limits, general requirements

Radiated emissions testing was carried out over the frequency range of 100 kHz to 2000 MHz as the highest frequency in use has been stated to be 133 MHz which is greater than 108 MHz but less than 500 MHz.

Testing was carried out at the laboratory's open area test site - located at Driving Creek, Orere Point, Auckland, New Zealand.

An enclosure containing absorber material, Panashield HYB-NF-12, has been placed between the turntable and the measurement antenna for when measurements are made above 1 GHz.

This material has no absorbing affect below 1 GHz with site verification measurements confirming this.

Testing was carried out using a representative AC power supply system that was powered at 120 Vac 60 Hz which supplied 12 Vdc to a Controller 6000 device which in turn powered the Card Reader also at 12 Vdc.

The Controller 6000 and representative AC power supply were placed 5 metres directly behind the device under test (in the coffin).

Testing was carried out with the device being placed in the centre of the test table standing vertically upright using a test jig.

The device was transmitting continuously on 125 kHz and 13.560 MHz.

Correct operation was confirmed periodically by placing a suitable card in front of the device which would give an audible beep.

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, where appropriate, with an automated antenna tower.

Below 30 MHz a magnetic loop is used with the centre of the loop being 1 metre above the ground with measurements being made using a quasi peak detector.

Above 30 MHz the emission is measured in both vertical and horizontal antenna polarisations, where appropriate, using a quasi peak detector.

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

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

Result: Complies

Measurement uncertainty with a confidence interval of 95% is:

- Free radiation tests (30 – 1000 MHz) ± 4.1 dB
- Free radiation tests (100 kHz – 30 MHz) ± 4.8 dB

Section 15.209: 125 kHz Fundamental emission:

Measurements were made using a magnetic loop antenna and a receiver with an average detector and a peak detector both using a 9 kHz bandwidth

Frequency (kHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Distance (metres)
125.000	55.0	84.7	29.7	Average	10
125.000	68.1	104.7	36.6	Peak	10

Measurements were made at a distance of 10 metres with the limit being determined by using the extrapolation factor of 40 dB per decade limit as detailed in section 15.31 f (2).

The 300 metre limit between 125 – 490 kHz has been scaled by a factor of 40 dB per decade, as per section 15.31 (f) (2).

The average limit at 300 m at 125.0 kHz is 19.2 uV/m or 25.7 dBuV/m and 45 dBuV/m in peak.

= 25.7 dBuV/m + -40 dB/decade * (log (10) - log (300))
= 25.7 dBuV/m + -40 dB/decade * (1.000 - 2.477)
= 25.7 dBuV/m + -40 dB/decade * - 1.477
= 25.7 dBuV/m + 59.08
= 84.7 dBuV/m

This gives a limit at 10 m at 134.2 kHz of 84.7 dBuV/m and 104.7 dBuV/m in peak

Testing was also carried out to determine whether a variation in the supply voltage would cause a significant change in field strength.

As a worst case indication the 12 Vdc supply to the card reader was varied by +/- 15% between 10.2 Vdc and 13.8 Vdc.

Voltage (Vdc)	Field Strength (dBuV/m)
10.2	55.0
12.0	55.0
13.8	55.0

Result: Complies.
Measurement uncertainty with a confidence interval of 95% is:
- Free radiation tests (100 kHz – 30 MHz) ± 4.8 dB

Section 15.209: 125 kHz Spurious Emissions (below 30 MHz)

A receiver with an average detector and a peak detector using a 9 kHz bandwidth was used between 110 – 490 kHz and a quasi peak detector with a 9 kHz bandwidth was used between 490 kHz – 30.0 MHz.

Frequency (kHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Comment
250.000	44.0	78.7	-	Average	Noise Floor
250.000	54.0	98.7	-	Peak	Noise Floor
375.000	46.0	75.2	-	Average	Noise Floor
375.000	56.0	95.2	-	Peak	Noise Floor
500.000	43.0	52.7	-	Quasi Peak	Noise Floor
625.000	40.0	50.8	-	Quasi Peak	Ambient
750.000	34.0	49.2	-	Quasi Peak	Noise Floor
875.000	33.0	47.8	-	Quasi Peak	Ambient
1000.000	30.0	46.7	-	Quasi Peak	Noise Floor
1125.000	32.0	45.7	-	Quasi Peak	Noise Floor
1250.000	35.0	44.7	-	Quasi Peak	Ambient
1375.000	26.0	43.9	-	Quasi Peak	Noise Floor
1500.000	28.0	43.2	-	Quasi Peak	Noise Floor
1625.000	24.0	42.5	-	Quasi Peak	Noise Floor
1750.000	24.0	48.6	-	Quasi Peak	Noise Floor
1875.000	22.0	48.6	-	Quasi Peak	Noise Floor

Magnetic loop measurements were made a distance of 10 metres with the measurement antenna being further adjusted to give the highest field strength.

The 300 metre limit between 125 – 490 kHz has been scaled by a factor of 40 dB per decade, as per section 15.31 (f) (2).

= Limit (dBuV/m) + -40 dB/decade * (log (10) - log (300))
= Limit (dBuV/m) + -40 dB/decade * (1.000 - 2.477)
= Limit (dBuV/m) + -40 dB/decade * - 1.477
= Limit (dBuV/m) + 59.08

The limit between 110 – 490 kHz was increased by 20 dB when the peak detector was used.

The 30 metre limit between 490 – 1705 kHz has been scaled by a factor of 40 dB per decade, as per section 15.31 (f) (2).

= Limit (dBuV/m) + -40 dB/decade * (log (10) - log (30))
= Limit (dBuV/m) + -40 dB/decade * (1.000 - 1.477)
= Limit (dBuV/m) + -40 dB/decade * - 0.477
= Limit (dBuV/m) + 19.08

The spurious emissions observed do not exceed the level of the fundament emission.

Result: Complies.
Measurement uncertainty with a confidence interval of 95% is:
- Free radiation tests (100 kHz – 30 MHz) ± 4.8 dB

Section 15.209: 13.560 MHz transmitter below 30 MHz spurious emission measurements

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
27.120	16.5	48.6	35.4

Testing was carried out when the device was transmitting continuously.

Magnetic loop measurements were attempted at a distance of 10 metres.

A receiver with a quasi peak detector with a 9 kHz bandwidth was used between 490 kHz – 30.0 MHz.

The 30 metre limit between 1.705 MHz – 30 MHz has been scaled by a factor of 40 dB per decade, as per section 15.31 (f) (2).

The limit at 27.122 MHz when measured at 30 metres is 30 uV/m or 29.54 dBuV/m.

Therefore when scaled the limit at 10 metres will be 48.6 dBuV/m as detailed below.

= 29.54 dBuV/m + -40 dB/decade * (log (10) - log (30))
= 29.54 dBuV/m + -40 dB/decade * (1.000 - 1.477)
= 29.54 dBuV/m + -40 dB/decade * - 0.477
= 29.54 dBuV/m + 19.08
= 48.6 dBuV/m

The spurious emission observed does not exceed the level of the fundament emission

Result: Complies.
Measurement uncertainty with a confidence interval of 95% is:
- Free radiation tests (100 kHz – 30 MHz) ± 4.8 dB

Section 15.209: Spurious Emissions (above 30 MHz)

Measurements between 30 –2000 MHz have been made at a distance of 3 metres.

A receiver with a quasi peak detector with a 120 kHz bandwidth was used between 30 – 1000 MHz and with a peak and average detector with a 1 MHz bandwidth was used between 1000 – 2000 MHz.

The limits as described in Section 15.209 have been applied.

Harmonics

Frequency (MHz)	Vertical (dBµV/m)	Horizontal (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Antenna Pol.	Detector	BW (kHz)
40.680	39.1	25.7	40.0	0.9	Vertical	QP	120
54.240	30.4		40.0	9.6	Vertical	QP	120
67.800	30.1		40.0	9.9	Vertical	QP	120
81.360	27.3	25.2	40.0	12.7	Vertical	QP	120
108.480	24.5		43.5	19.0	Vertical	QP	120
135.600	29.2		43.5	14.3	Vertical	QP	120

Other emissions

Frequency (MHz)	Vertical (dBµV/m)	Horizontal (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Antenna Pol.	Detector	BW (kHz)
58.941	24.8	19.0	40.0	15.2	Vertical	QP	120
62.770	30.1	21.6	40.0	9.9	Vertical	QP	120
65.334	30.5	21.4	40.0	9.5	Vertical	QP	120
69.170	32.3	22.4	40.0	7.7	Vertical	QP	120
71.727	30.6	23.0	40.0	9.4	Vertical	QP	120
84.629	28.1	26.0	40.0	11.9	Vertical	QP	120
88.000	28.6	31.4	40.0	8.6	Horizontal	QP	120
94.000	29.5		43.5	14.0	Vertical	QP	120
104.000	26.8		43.5	16.7	Vertical	QP	120
107.600	29.3	26.8	43.5	14.2	Vertical	QP	120
110.144	28.5	25.7	43.5	15.0	Vertical	QP	120
114.000	30.9	26.5	43.5	12.6	Vertical	QP	120
116.600	31.2	27.3	43.5	12.3	Vertical	QP	120
120.430	31.1	26.0	43.5	12.4	Vertical	QP	120
122.954	30.2	23.0	43.5	13.3	Vertical	QP	120
126.841	28.9	24.8	43.5	14.6	Vertical	QP	120
145.792		27.7	43.5	15.8	Horizontal	QP	120
148.492		27.3	43.5	16.2	Horizontal	QP	120
168.517		28.5	43.5	15.0	Horizontal	QP	120
171.222		27.5	43.5	16.0	Horizontal	QP	120
175.000		26.7	43.5	16.8	Horizontal	QP	120
257.800		25.3	46.0	20.7	Horizontal	QP	120
261.829	26.3	41.3	46.0	4.7	Horizontal	QP	120
290.800		23.9	46.0	22.1	Horizontal	QP	120
343.486	35.9	33.5	46.0	10.1	Vertical	QP	120
392.726	42.8	31.9	46.0	3.2	Vertical	QP	120
523.611	32.1	34.1	46.0	11.9	Horizontal	QP	120

All other emissions observed had a margin to the limit that exceeded 15 dB when measurements were attempted over the range of 30 – 2000 MHz using both vertical and horizontal polarisations.

Result: Complies.
Measurement uncertainty with a confidence interval of 95% is:
- Free radiation tests (30 MHz – 2000 MHz) ± 4.1 dB

Section 15.225: Fundamental emission:

Measurements were made using a magnetic loop antenna and a receiver with a quasi peak detector using a 9 kHz bandwidth

Measurements were made at a distance of 10 metres with the limit being determined by using the extrapolation factor of 40 dB per decade limit, as detailed in section 15.31 f (2).

The limit at 30 m at 13.560 MHz is 15,848 uV/m or 84.0 dBuV/m.

Applying the extrapolation factor of 40 dB/ per decade, the limit is 103.1 dBuV/m.

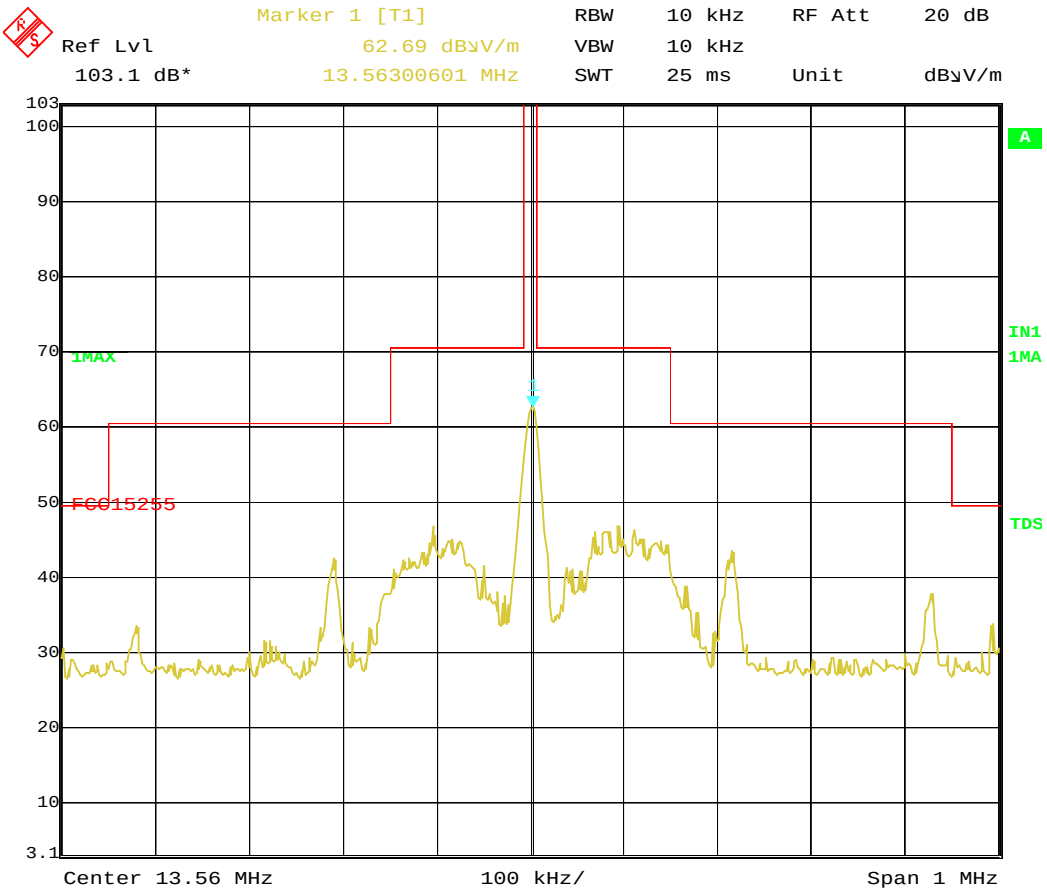
= 84.0 dBuV/m + -40 dB/decade * (log (10) - log (30))
= 84.0 dBuV/m + 19.08
= 103.1 dBuV/m

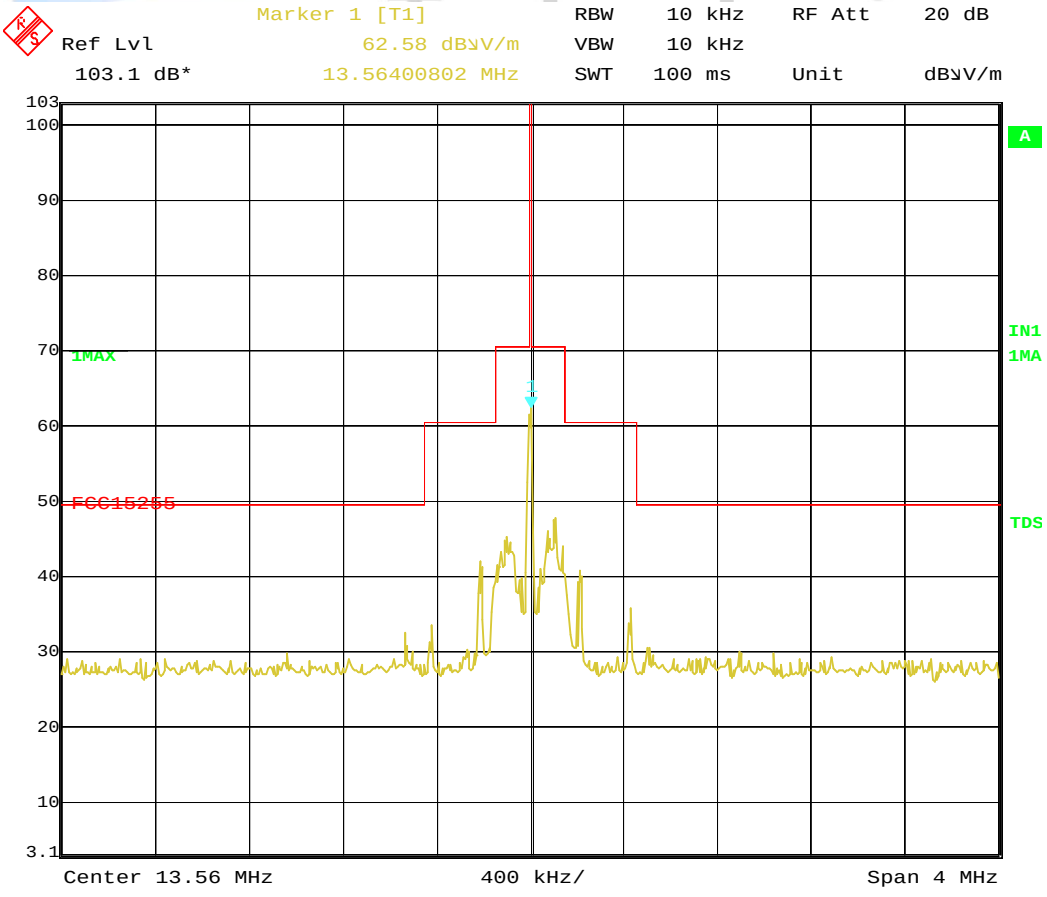
As a worst case testing was also carried out when the device was transmitting continuously when the 12.0 Vdc supply to the device was varied by +/- 15%.

Frequency (MHz)	Level (dBuV/m)	Distance (metres)	Limit (dBuV/m)	Voltage (Vdc)	Margin (dB)
13.560	62.9	10.0	103.1	10.2	51.0
13.560	62.9	10.0	103.1	12.0	51.0
13.560	62.9	10.0	103.1	13.8	51.0

A representative spectrum analyser plot shows that the carrier and modulation peaks within, +/- 1 MHz and +/- 4 MHz of the carrier.

Result: Complies.
Measurement uncertainty with a confidence interval of 95% is:
- Free radiation tests (100 kHz – 30 MHz) ± 4.8 dB





Section 15.225: Frequency tolerance:

The frequency tolerance of the carrier is required to be +/- 0.01% of operating frequency when the temperature is varied between -20 degrees and +50 degrees.

The device operates nominally on 13.560 MHz which gives a frequency tolerance of +/- 1,356 Hz.

Temperature (°C)	Frequency (MHz)	Difference (Hz)
-20.0	13.559 437	-563
-10.0	13.559 453	-547
0.0	13.559 449	-551
10.0	13.559 439	-561
20.0	13.559 410	-590
30.0	13.559 419	-581
40.0	13.559 407	-593
50.0	13.559 417	-583

Variation of the 120 Vac 60 Hz supply to the AC power supply did not vary the 12 Vdc supply to the Controller 6000 or the device under test.

As a worst case scenario the 12 Vdc supply to the device was varied between 85% and 115% of the supply voltage at +20 degrees.

Voltage (Vdc)	Frequency (MHz)	Difference (Hz)
10.2	13.559 410	-590
12.0	13.559 410	-590
13.8	13.559 410	-590

Result: Complies
Measurement uncertainty with a confidence interval of 95% is:
- Frequency tolerance ± 50 Hz

7. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial No	Asset Ref	Period	Cal Due
AC Supply	APT	7008	4170003	-	-	Not applicable
Aerial Controller	EMCO	1090	9112-1062	RFS 3710	-	Not applicable
Aerial Mast	EMCO	1070-1	9203-1661	RFS 3708	-	Not applicable
Biconical	Schwarzbeck	BBA 9106	-	RFS 3612	3 years	5 Feb 2017
Log Periodic	Schwarzbeck	VUSLP 9111	9111-228	3785	3 years	5 Feb 2017
Loop Antenna	EMCO	6502	9003-2485	3798	3 years	7 Jul 2017
Mains Network	R & S	ESH2-Z5	881362/032	3628	2 years	2 Oct 2016
Receiver	R & S	ESHS 10	828404/005	3728	1 year	27 June 2016
Receiver	R & S	ESIB-40	100171	R-27-1	1 year	15 Feb 2017
Turntable	EMCO	1080-1-2.1	9109-1578	RFS 3709	-	Not applicable
VHF Balun	Schwarzbeck	VHA 9103	-	RFS 3603	3 years	5 Feb 2017

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 in June 2014.

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.

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.

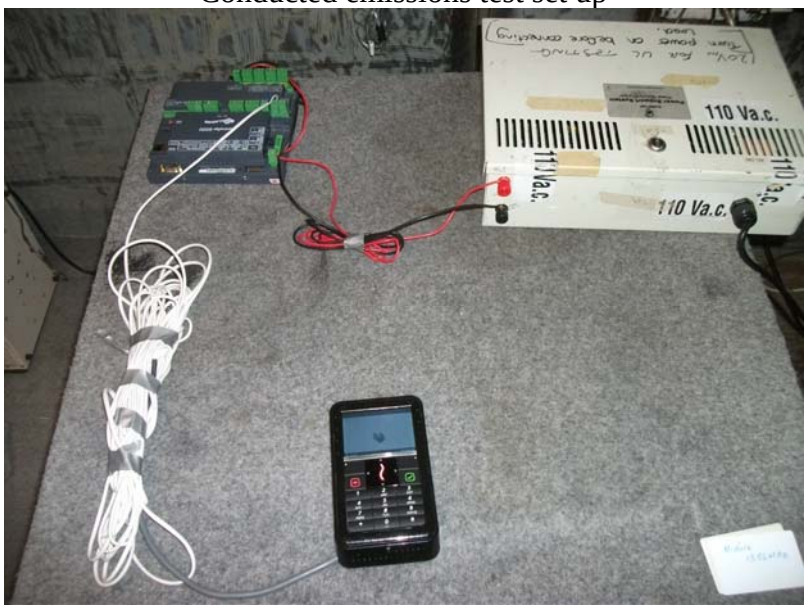
International Accreditation New Zealand has Mutual Recognition Arrangements for testing and calibration with various accreditation bodies in a number of economies. This includes NATA (Australia), UKAS (UK), SANAS (South Africa), NVLAP (USA), A2LA (USA), SWEDAC (Sweden). Further details can be supplied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

9. PHOTOGRAPHS

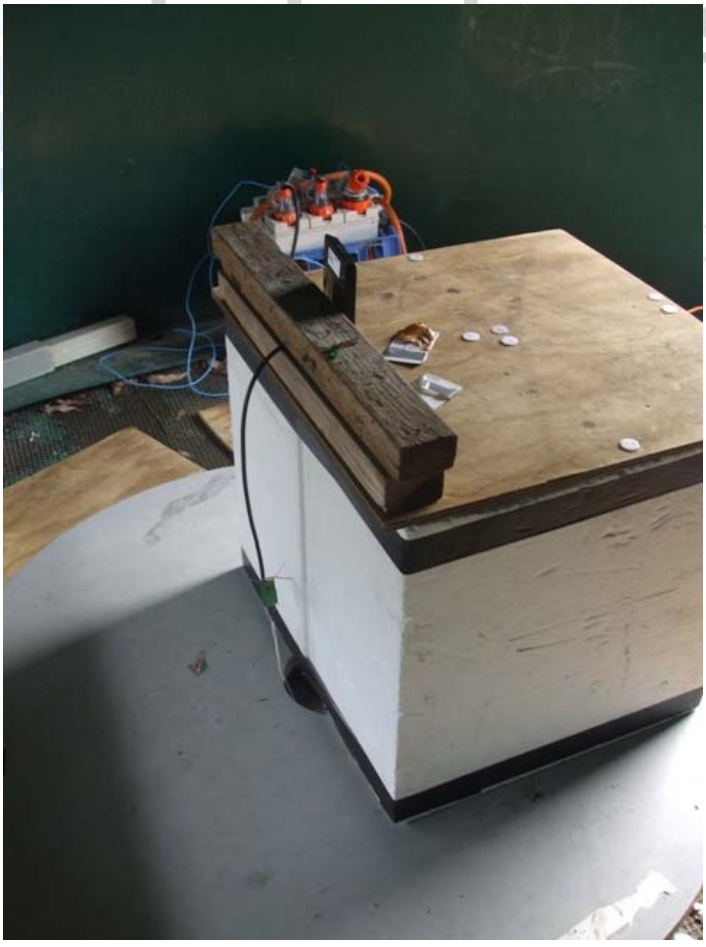
Identification Label

External photographs

Conducted emissions test set up



Radiated emissions test set up



Ancillary equipment test set up

EMCO Loop antenna (9 kHz - 30 MHz)

Biconnical Antenna (30 - 300 MHz)

Schwarzbeck Log Periodic Antenna (300 - 2000 MHz)