EMC Technologies (NZ) Ltd

Test Report No **81104.3**
Report date: 24 December 2008

TEST REPORT

WheelTime Elite Cycle Timing System

tested to the

Code of Federal Regulations (CFR) 47

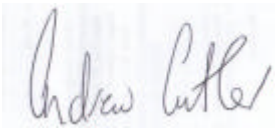
Part 15 – Radio Frequency Devices,

Subpart B – Unintentional Radiators

Subpart C – Intentional Radiators
Section 15.247 – Operation in the bands 902 – 928 MHz

for

Times-7



This Test Report is issued with the authority of:

Andrew Cutler - General Manager

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1. STATEMENT OF COMPLIANCE

The **WheelTime Elite Cycle Timing System** complies with FCC Part 15 subparts A, B and C as described below when tested in accordance with ANSI C63.4, 2003.

2. RESULTS SUMMARY

Testing was carried out in accordance with the test methods defined in 47 CFR Part 15 and in particular Subparts A, B and C as described below.

Subpart B

Clause	Description	Results
15.101	Equipment authorisations	Digital devices classed as Class A devices
15.103	Exempted devices	Device is not exempt
15.107	Conducted emissions	Complies – See 15.207
15.109	Radiated emissions	Complies
15.111	Antenna power conducted limits	Not applicable

Subpart C

Clause	Description	Results
15.203	Antenna requirement	Complies
15.207	Conducted emissions	Complies
15.209	Radiated emissions	See 15.247(d)
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. CLIENT INFORMATION

Company Name	Times-7
Address	69 Gracefield Road Seaview
City	Lower Hutt
Country	New Zealand
Contact	Dr Warren Young

4. DESCRIPTION OF TEST SAMPLE

Brand Name	WheelTime
Model Number	Elite
Product	Cycle Timing system
Manufacturer	Times-7
Country of Origin	New Zealand
Serial Number	081103003 + 080617002
FCC ID	WBF-70400
Ancillaries	Not applicable

Testing has been carried out on 920.1 MHz and 925.9 MHz and the digital devices within the device have been classed as Class A digital devices.

Testing has been carried out to confirm that the conducted power to each antenna is less than 1 watt and when summed the total conducted power is less than 1 watt.

Radiated emissions testing has been carried out to confirm that the total power does not exceed 4 watts.

The system consists of two transmitters which each supply 3 mat antennas with all 6 antennas being laid out on the ground in a line to form the start and finish line for sporting events.

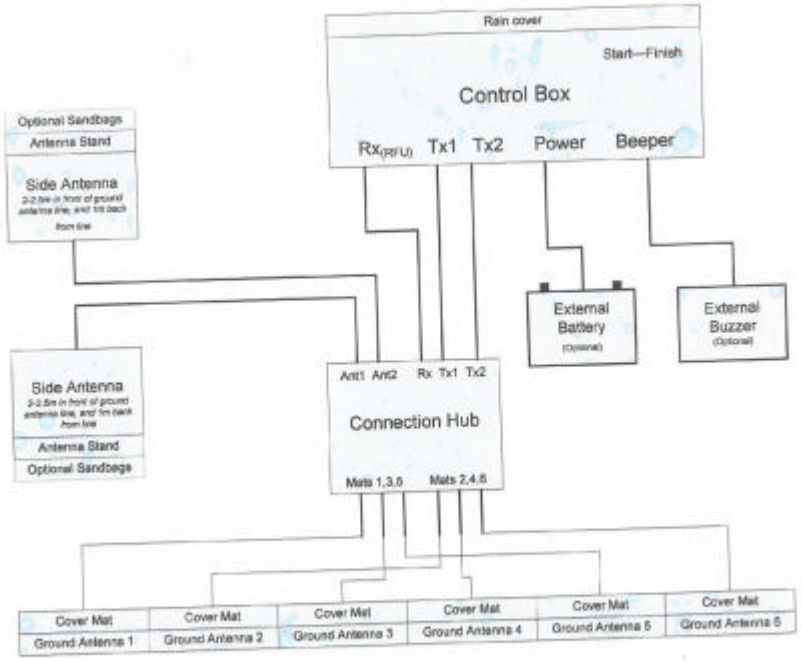
Each transmitter is operated with a 50% duty cycle. A start/finish toggle is available to change the time periods from 31ms to 9ms.

The system is primarily used for timing cycling events where by a tag is attached to the competitor's bicycle that is read by the timing system when they cross the start line of a race and when they cross the finish line.

The system consists of a control box that contains the timing electronics, receiver and two transmitters that feed into a permanently attached antenna connection hub that then supplies phased signals to 6 antenna mats that are placed across the finishing line.

The power level to each mat is trimmed in order that the power level at the input to each mat does not exceed 1 watt and is identical regardless of the different coax cable lengths.

Frequency hopping spread spectrum techniques have been used in the 920 – 926 MHz band.



Testing has also been carried out for conducted emissions when the device is charging and the transmitter not operating and when device is charging with the transmitter operating.

Testing was also carried out with the registration reader attached to the transmitter.

5. RESULTS

Section 15.101 – Equipment authorisation

This device contains a 920 – 926 MHz spread spectrum transmitter and a number of digital devices for control and data input and output purposes.

The digital devices include:

1. The digital electronics that drive the transmitter & receiver (including a decoder). This is the card labelled "UHF RFU"

2. An embedded computer running Linux (which talks to device (1)). This is the card labelled "Delta" (or "DIMI" in older versions).

3. Some digital electronics that control the switching of the 2 RF outputs. This is the card labelled "UHF Controller".

Section 15.107 – Conducted emissions

See section 15.207

Section 15.109 – Radiated emissions

Radiated emission testing was carried out over the frequency range of 30 to 2000 MHz.

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

This site conforms to the requirements of CISPR 16 and ANSI C63.4 - 2003.

Before testing was carried out, a receiver Self Test and Internal Calibration was undertaken along with a check of all connecting cables and programmed antenna factors.

The device was placed on the fibreglass test table that has a dielectric constant near 1 which is a total of 0.8 m above the test site ground plane.

Measurements of the radiated field were made with the antenna located at a 10 metre horizontal distance from the boundary of the digital devices under test.

Testing is carried out by manually scanning between 30 and 1000 MHz in 100 kHz steps while aurally and visually monitoring for emissions.

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.

The emission is measured in both vertical and horizontal antenna polarisations using a Quasi Peak detector with a bandwidth of 120 kHz.

During the test, a number of ambient emissions are identified (list of which can be provided upon request).

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

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

Measurements were made while the device was being powered at 110 Vac when transmitting with the mats attached and when the registration reader was attached.

Testing was carried out when the transmitter was transmitting continuously with cables with droops not exceeding 40 cm were attached to the following ports of a peripheral laptop computer that was located more not less than 10 cm from the digital device and the registration reader when attached:
- 2 x USB memory sticks in the USB ports
- RS-485 port connected to a laptop computer using a looped 1 m data cable
- LAN port connected to a laptop computer using a looped 1 metre loop back data cable
- USB comms port connected to a laptop computer
- Console USB port that was connected to a laptop computer
- Tx1, Tx2 and Rx cables to the connection hub
- External battery charger that was powered at 110 Vac

The limits as described in Section 15.109 have been applied as follows:

30.0 – 88.0 MHz	90 uV/m	39.0 dBuV/m
88.0 – 216.0 MHz	150 uV/m	43.5 dBuV/m
216.9 – 960.0 MHz	210 uV/m	46.4 dBuV/m
above 960.0 MHz	500 uV/m	54.0 dBuV/m

A number of emissions with a margin to the limit exceeding 20 dB were observed but have not been recorded in this report

Result: Complies with a 1.8 dB margin at 750 MHz (Horizontal) when the mat antennas were attached. Measurement falls within the window of uncertainty for this test method.

Measurement uncertainty with a confidence interval of 95% is:
- Free radiation tests (30 – 1000 MHz) ± 4.1 dB

30 – 2000 MHz test results when tested with the mats attached

Frequency MHz	Vertical dBuV/m	Hort dBuV/m	Limit dBuV/m	Margin dB	Antenna Polarisation	Detector
43.910	31.5		39.0	7.5	Vertical	QP
55.890	30.9	23.8	39.0	8.1	Vertical	QP
60.225	29.8	24.5	39.0	9.2	Vertical	QP
64.190	26.5	21	39.0	12.5	Vertical	QP
64.870	30.0	21.9	39.0	9.0	Vertical	QP
66.220	30.5	24.1	39.0	8.5	Vertical	QP
68.310	29.1		39.0	9.9	Vertical	QP
69.100	30.4	25.7	39.0	8.6	Vertical	QP
75.000	28.7	23.9	39.0	10.3	Vertical	QP
99.535	40.6	33.1	43.5	2.9	Vertical	QP
113.800	26.4	31.6	43.5	11.9	Horizontal	QP
125.000	29.1		43.5	14.4	Vertical	QP
142.640	25.9	27.6	43.5	15.9	Horizontal	QP
149.303	29.9		43.5	13.6	Vertical	QP
248.839	26.5	29.4	46.4	17.0	Horizontal	QP
250.000	32.2	30.2	46.4	14.2	Vertical	QP
275.000		28.4	46.4	18.0	Horizontal	QP
298.600	32.5	29.9	46.4	13.9	Vertical	QP
326.300	33.2	29.4	46.4	13.2	Vertical	QP
348.370	32.6	29.1	46.4	13.8	Vertical	QP
375.000	31.6		46.4	14.8	Vertical	QP
400.000		29.8	46.4	16.6	Horizontal	QP
450.000	32.0	34.2	46.4	12.2	Horizontal	QP
475.000		31.9	46.4	14.5	Horizontal	QP
497.678	31.6		46.4	14.8	Vertical	QP
500.000	32.6	37.1	46.4	9.3	Horizontal	QP
525.000		35.2	46.4	11.2	Horizontal	QP
597.218	28.3	38.1	46.4	8.3	Horizontal	QP
625.015		37.8	46.4	8.6	Horizontal	QP
650.000		39.4	46.4	7.0	Horizontal	QP
696.748	35.9	33.5	46.4	10.5	Vertical	QP
700.000		42.7	46.4	3.7	Horizontal	QP
750.005	36.3	44.6	46.4	1.8	Horizontal	QP
796.283	34.3		46.4	12.1	Vertical	QP
875.025		38.9	46.4	7.5	Horizontal	QP
895.818	35.1		46.4	11.3	Vertical	QP
1000.000	43.3	45.2	54.0	8.8	Horizontal	QP
1125.000	35.1	39.1	54.0	14.9	Horizontal	AVG
1250.000	40.4	39.7	54.0	13.6	Vertical	AVG

30 – 2000 MHz test results when tested with the registration reader attached

Frequency MHz	Vertical dBuV/m	Hort dBuV/m	Limit dBuV/m	Margin dB	Antenna Polarisation	Detector
55.890	30.9	23.8	39.0	8.1	Vertical	QP
60.225	29.8	24.5	39.0	9.2	Vertical	QP
64.190	26.5	21.0	39.0	12.5	Vertical	QP
64.870	30.0	21.9	39.0	9.0	Vertical	QP
66.220	30.5	24.1	39.0	8.5	Vertical	QP
68.310	29.1		39.0	9.9	Vertical	QP
69.100	30.4	25.7	39.0	8.6	Vertical	QP
75.000	28.7	23.9	39.0	10.3	Vertical	QP
99.535	39.6	33.1	43.5	3.9	Vertical	QP
113.800	33.7	26.6	43.5	9.8	Vertical	QP
121.058	31.6	28.3	43.5	11.9	Vertical	QP
123.468	31.5	28.2	43.5	12.0	Vertical	QP
125.000	35.3		43.5	8.2	Vertical	QP
130.638	28.9	19.6	43.5	14.6	Vertical	QP
142.640	28.5	27.6	43.5	15.0	Vertical	QP
250.000	32.2	31.6	46.4	14.2	Vertical	QP
275.000		33.0	46.4	13.4	Horizontal	QP
298.600	31.8	29.9	46.4	14.6	Vertical	QP
326.300	36.5	32.3	46.4	9.9	Vertical	QP
348.370	32.7	31.3	46.4	13.7	Vertical	QP
375.000	36.2	33.3	46.4	10.2	Vertical	QP
400.000	34.5	31.3	46.4	11.9	Vertical	QP
450.000	34.7	32.4	46.4	11.7	Vertical	QP
475.000		31.6	46.4	14.8	Horizontal	QP
497.678	31.6		46.4	14.8	Vertical	QP
500.000	35.6	38.4	46.4	8.0	Horizontal	QP
550.000	33.6	35.2	46.4	11.2	Horizontal	QP
600.000	28.3	36.1	46.4	10.3	Horizontal	QP
625.015		37.8	46.4	8.6	Horizontal	QP
650.000		39.4	46.4	7.0	Horizontal	QP
696.748	35.9	33.5	46.4	10.5	Vertical	QP
700.000	37.2	40.7	46.4	5.7	Horizontal	QP
750.005	37.0	41.6	46.4	4.8	Horizontal	QP
775.000	35.9		46.4	10.5	Vertical	QP
875.025		38.9	46.4	7.5	Horizontal	QP
895.818	35.1		46.4	11.3	Vertical	QP
1000.000	40.4	45.2	54.0	8.8	Horizontal	QP
1125.000	35.1	39.1	54.0	14.9	Horizontal	AVG
1250.000	40.4	40.8	54.0	13.2	Horizontal	AVG

Section 15.203 – Antenna requirement

6 external mat antennas are used. All antenna connectors are unique in that they are reverse TNC connectors.

Section 15.205 – Restricted bands of operation

Refer to measurements made with reference to Section 15.247 (d).

Section 15.107 and 15.207 – Conducted emissions

Conducted emission testing has been carried out when the device was being charged with the transmitter turned off and when the device was being charged with the transmitter operating.

This mode has been tested, even though there is a warning on the front of the device stating that charging should only occur when the transmitter is not operating, in order to address the worst case mode which can easily occur despite the warning on the device.

Testing has been carried out using a representative 110 Vac charger that was attached to the charger port on the transmitter.

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 15.107 and 15.207 using a measuring receiver and a 50 uH / 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.

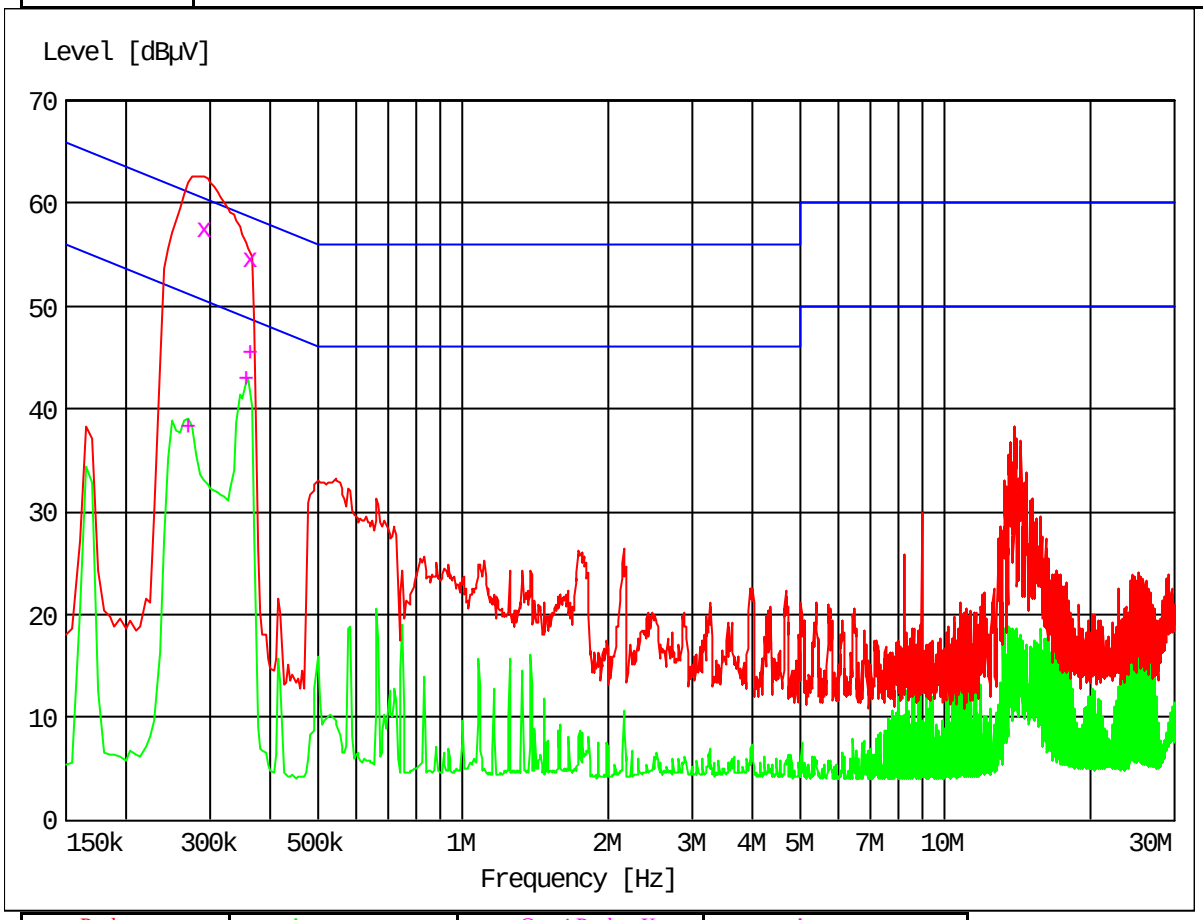
The supplied conducted emission plot is a combined plot showing the worst case of the Peak, Quasi Peak and Average levels for both phase and neutral.

The class B limits have been applied as a worst case option even though the digital devices have been classed as class A devices

Result: Complies.
Measurement uncertainty with a confidence interval of 95% is:
- Mains terminal tests (0.15 - 30 MHz) ± 2.2 dB

Conducted emissions

Comments:	Device tested when being charged at 110 Vac with the transmitter turned off



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

Quasi-Peak Measurements

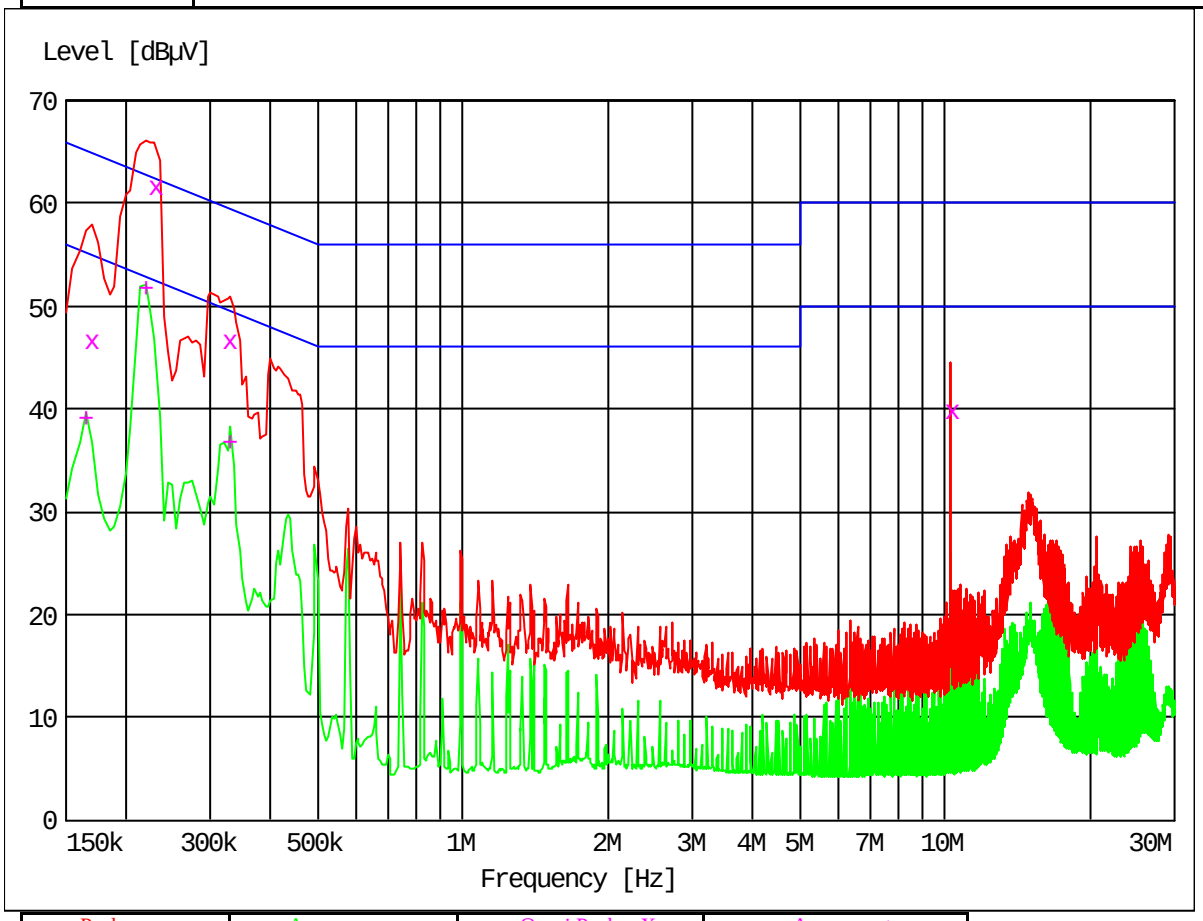
Frequency MHz	Level dBmV	Limit dBmV	Margin dB	Phase	Rechecks dBmV
0.290000	57.70	60.5	2.8	N	56.9
0.360000	54.80	58.7	3.9	N	55.0

Average Measurements

Frequency MHz	Level dBmV	Limit dBmV	Margin dB	Phase	Rechecks dBmV
0.270000	38.50	51.1	12.6	L1	
0.355000	43.10	48.8	5.7	L1	
0.360000	45.60	48.7	3.1	L1	44.8

Conducted emissions

Comments:	Device tested when powered at 110 Vac when charging with the transmitter operating continuously.



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

Quasi-Peak Measurements

Frequency MHz	Level dBmV	Limit dBmV	Margin dB	Phase	Rechecks dBmV
0.155000	52.80	64.9	12.1	L1	
0.230000	62.40	62.4	0.0	L1	62.4
0.330000	49.40	59.4	10.0	N	
10.330000	43.70	60.0	16.3	L1	

Average Measurements

Frequency MHz	Level dBmV	Limit dBmV	Margin dB	Phase	Rechecks dBmV
0.165000	39.20	55.2	15.9	N	39.7
0.220000	51.80	52.8	0.9	N	51.7
0.330000	36.90	49.4	12.5	L1	

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

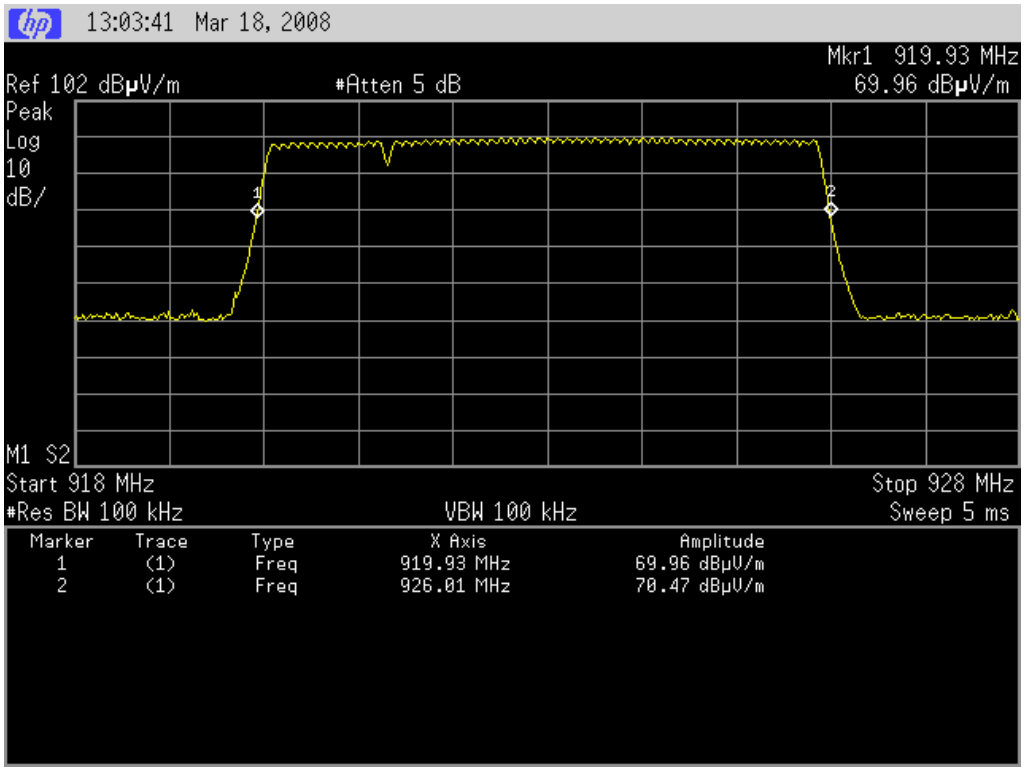
This device operates using Frequency Hopping Spread Spectrum techniques between 920.000 MHz and 926.000 MHz

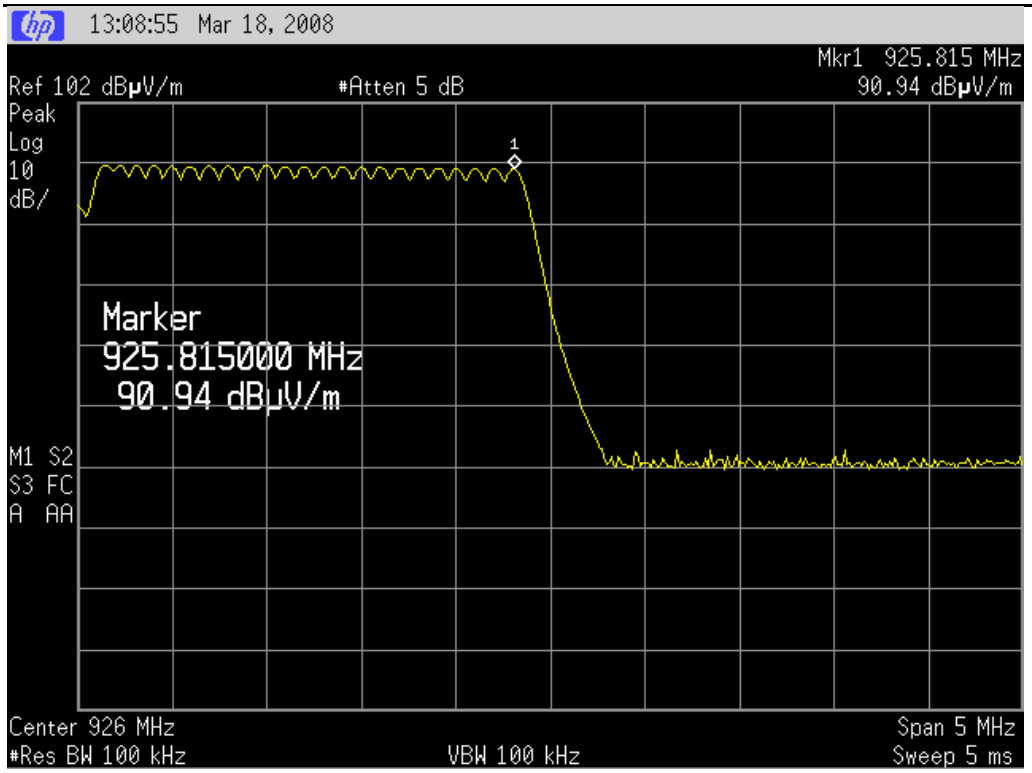
The results are summarised as follows:

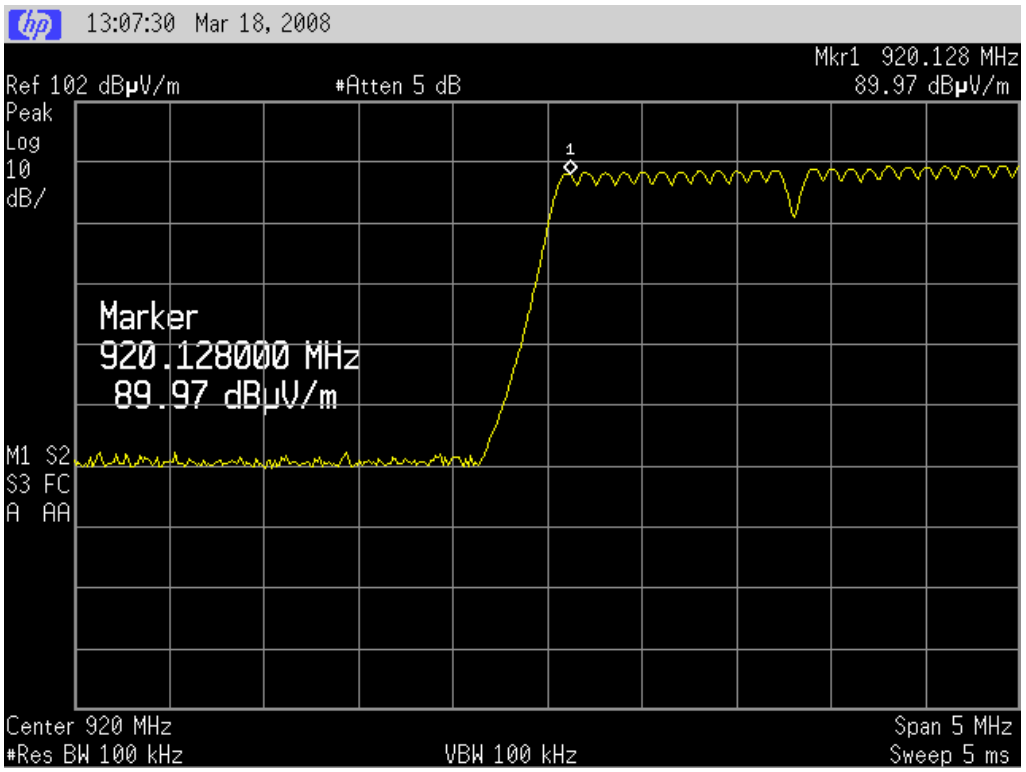
Parameter	Limit	Observation	Result
Number of channels	Minimum of 50 channels	58 channels	Pass
20 dB bandwidth	Not greater than 250 kHz	41 kHz	Pass
Hop interval	Greater than 20 dB bandwidth	100 kHz	Pass
Dwell time	Not exceed 400 ms in any 20 second period	387 ms	Pass

Result: Complies

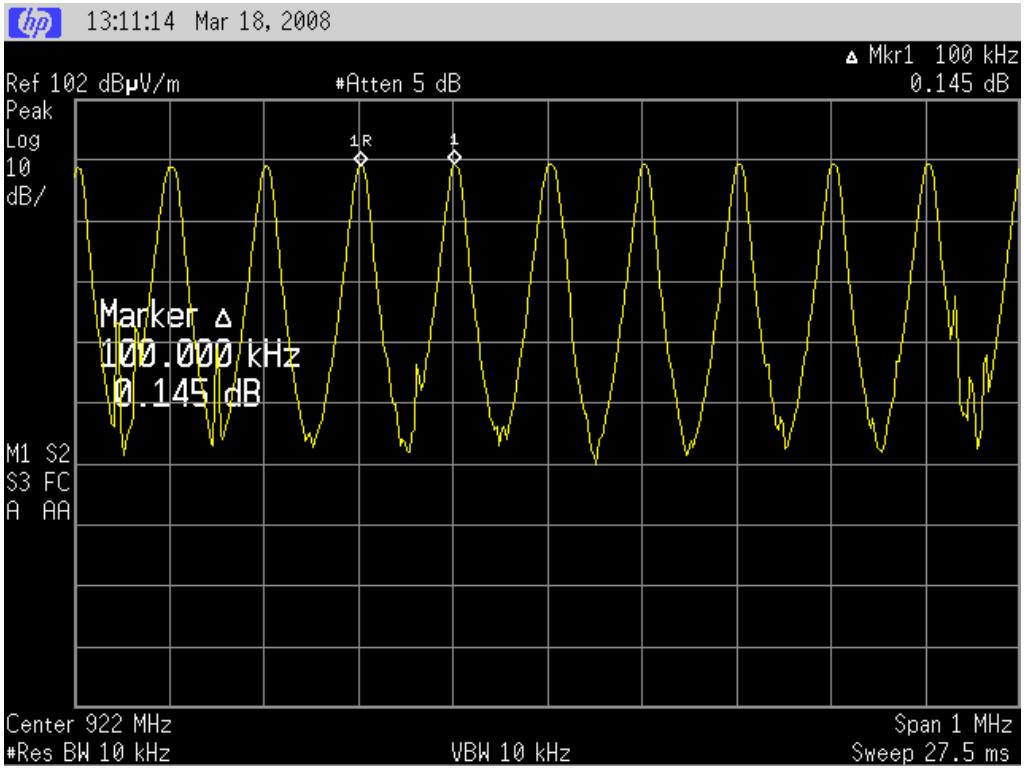
The device was observed to operate between 920.100 MHz and 925.800 MHz using 58 channels separated by 100 kHz.



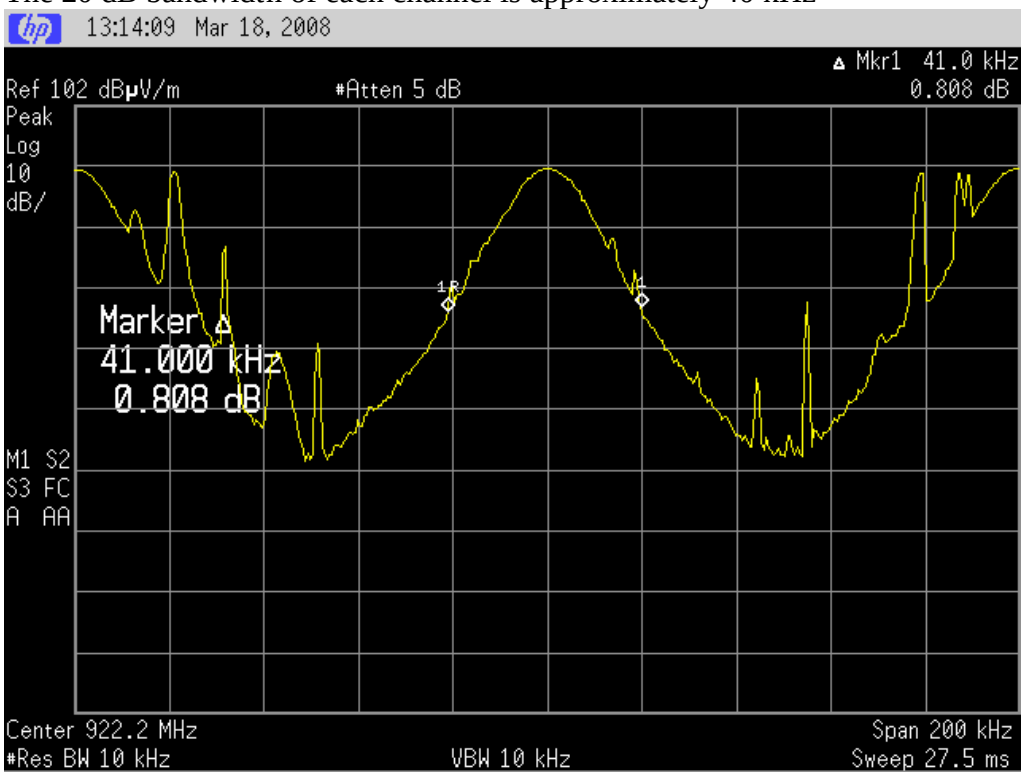




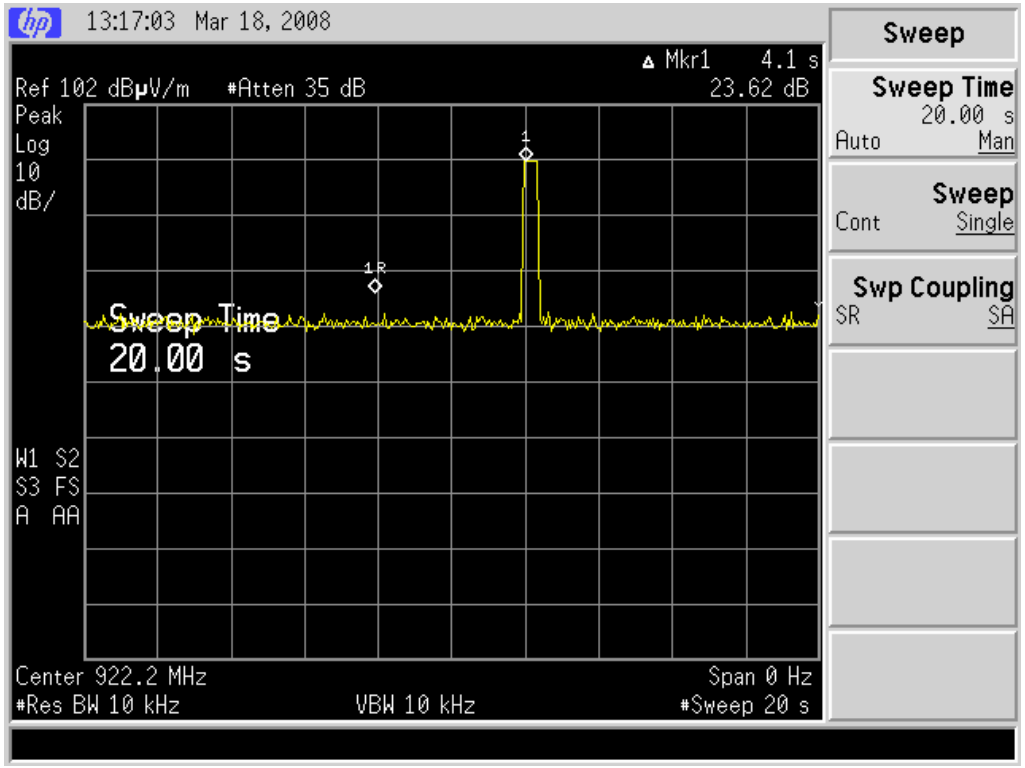
The channels were observed to 100 kHz spaced



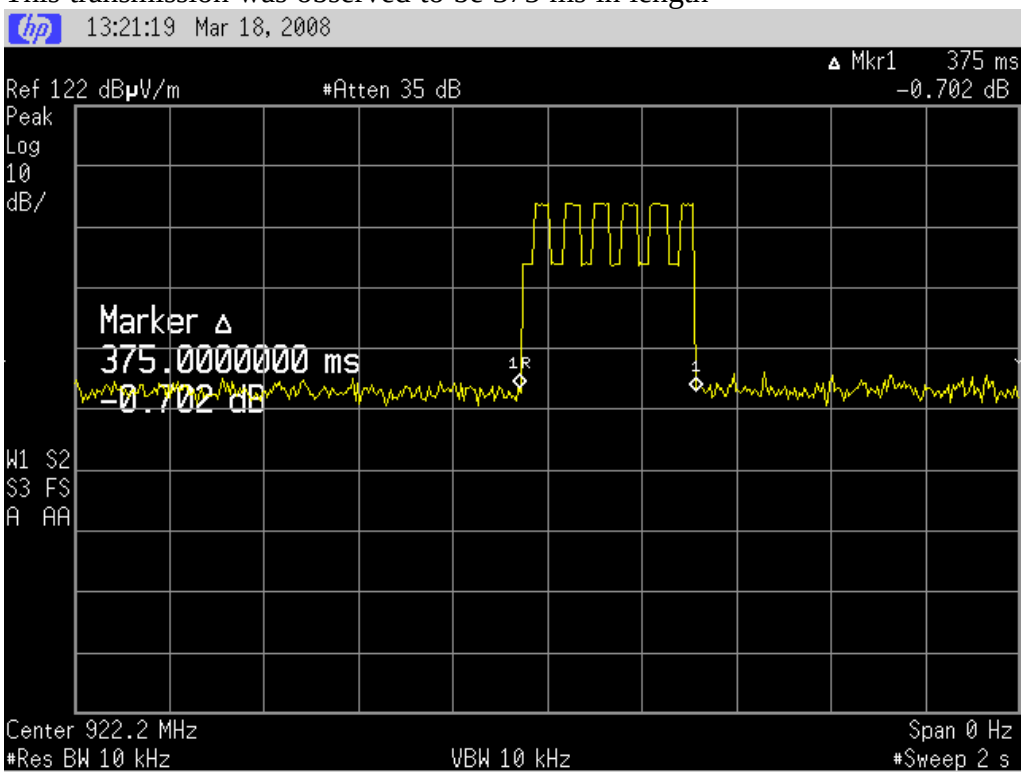
The 20 dB bandwidth of each channel is approximately 40 kHz



In any 20 second period the transmitter was observed to transmit once



This transmission was observed to be 375 ms in length



Section 15.247(b)(1)+(2)– Peak output power with the mat antennas connected

This device uses 2 transmitters which are permanently attached to an antenna connection hub that divides the power from each transmitter to two sets of three plate antennas.

Each transmitter operates with a 50% duty cycle being ON for approximately 31 ms and then OFF for 31 ms and vice versa.

Transmitter 1 supplies mat antennas 1, 3 and 5 and transmitter 2 supplies mat antennas 2, 4 and 6.

The conducted power to each antenna is trimmed by the manufacturer in order that the power at the input to each antenna is identical regardless of the varying lengths of coax cable that are used between the connection hub and each antenna.

The power output at the coax connectors on the connection hub will never exceed 1 watt (+30 dBm) which has been confirmed below.

Conducted power output: 920.1 MHz

Mat	Power (dBm)	Power (watts)	Total power (watts)	Limit (watts)
1	16.2	0.042	0.478	1.0
2	19.8	0.095		
3	18.5	0.071		
4	19.5	0.089		
5	18.8	0.076		
6	20.2	0.105		

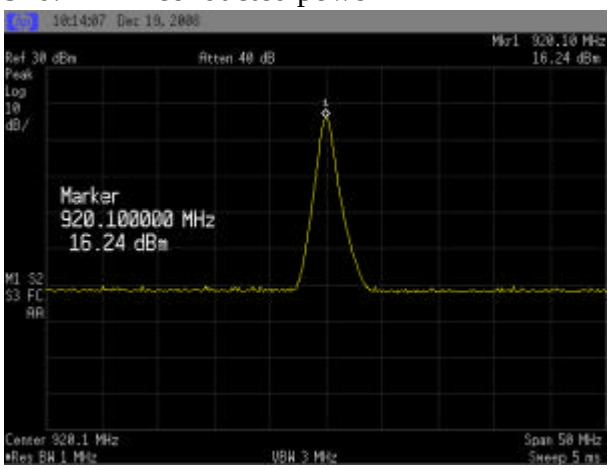
Conducted power output: 925.9 MHz

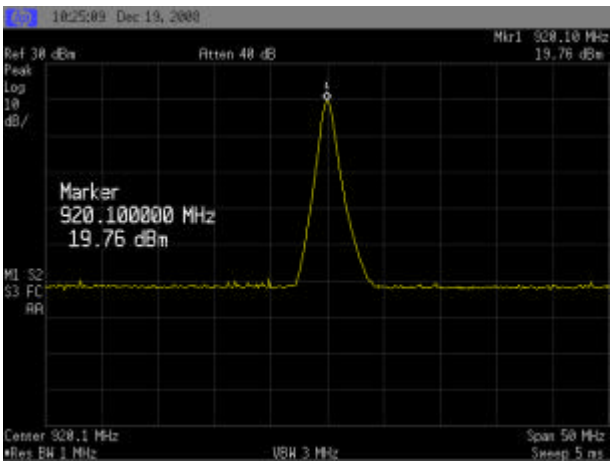
Mat	Power (dBm)	Power (watts)	Total power (watts)	Limit (watts)
1	14.4	0.028	0.326	1.0
2	16.9	0.049		
3	14.4	0.028		
4	18.6	0.072		
5	16.5	0.045		
6	20.2	0.105		

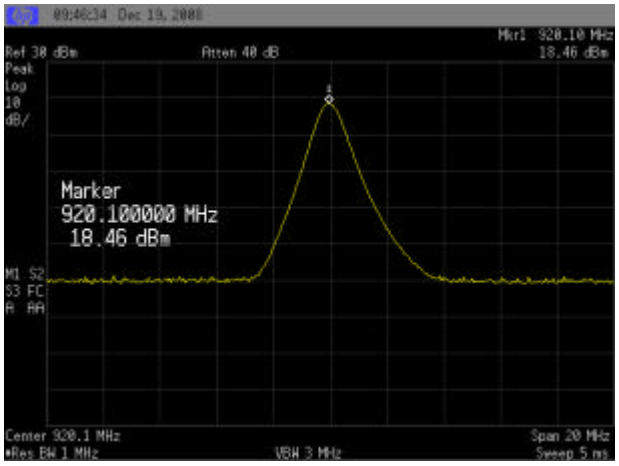
Testing was carried out using a spectrum analyser that was attached to each antenna port individually when the system was operating.

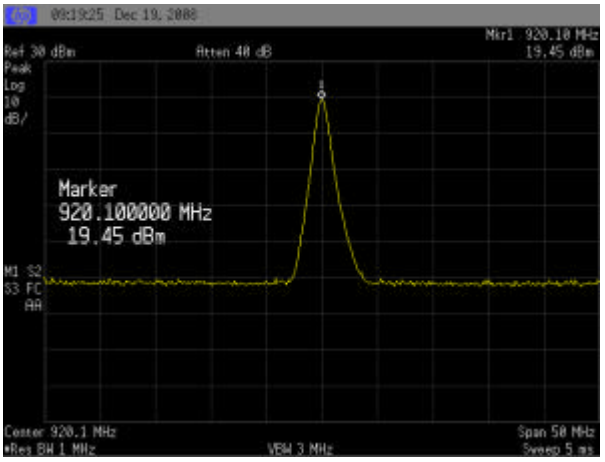
A resolution bandwidth of 1 MHz was used with the plots attached below:

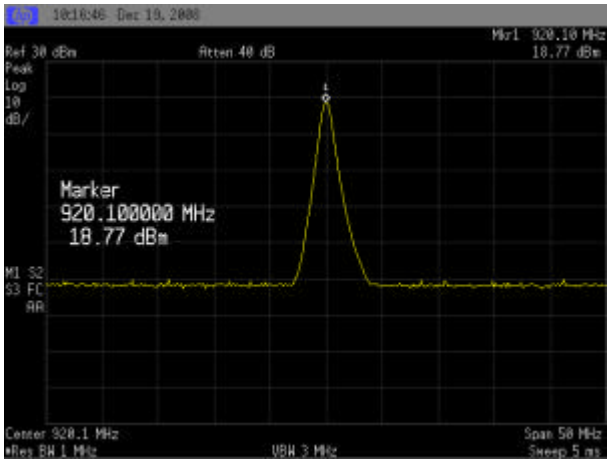
920.1 MHz conducted power

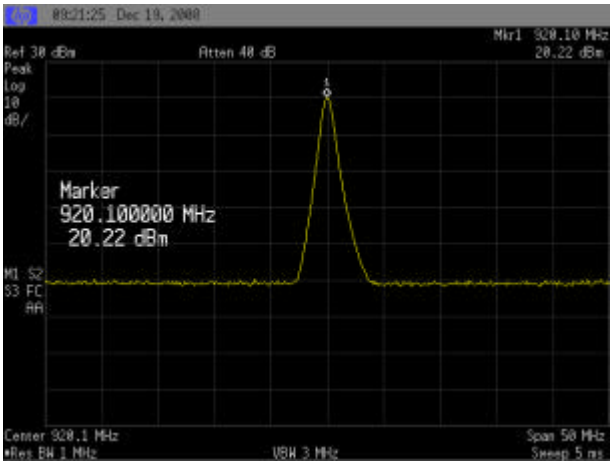




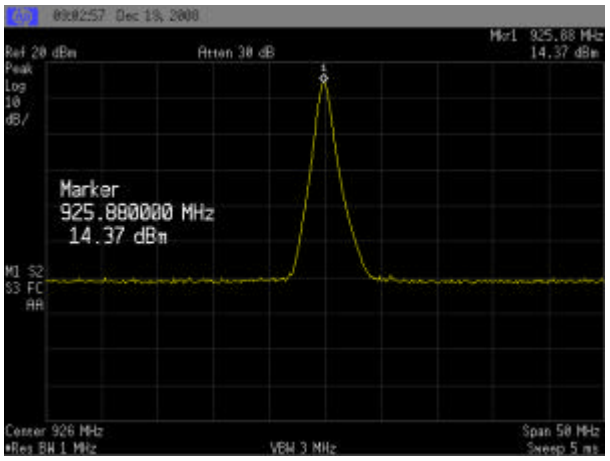


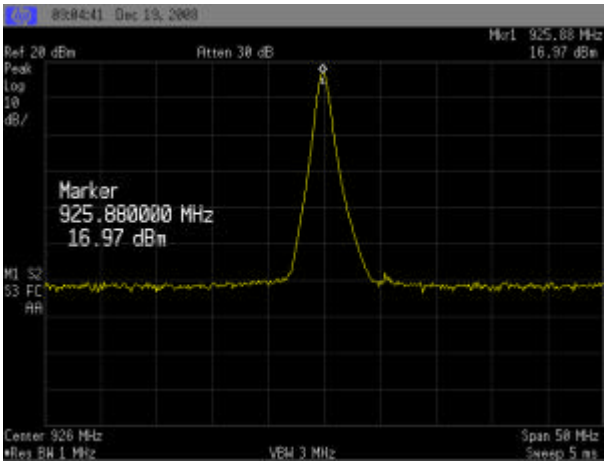


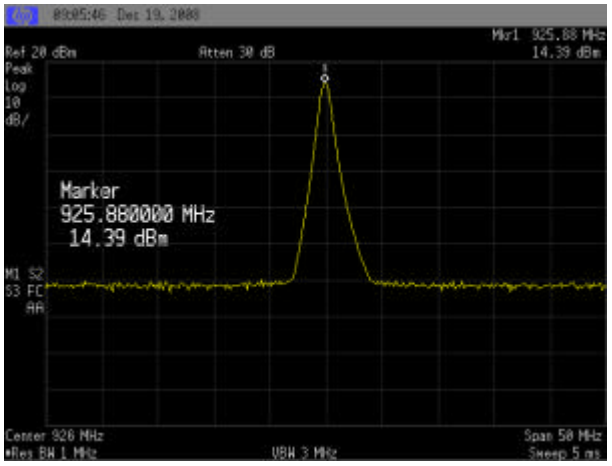


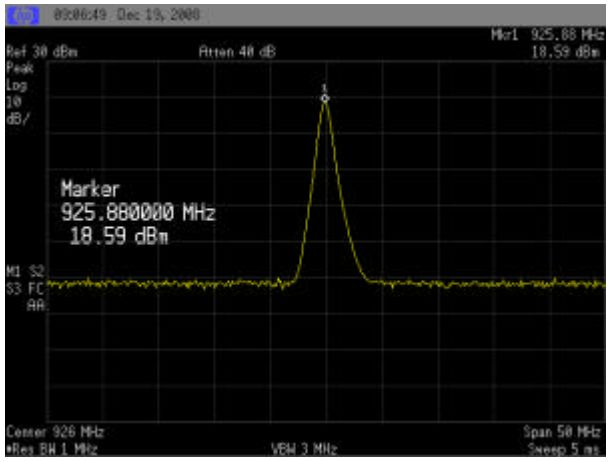


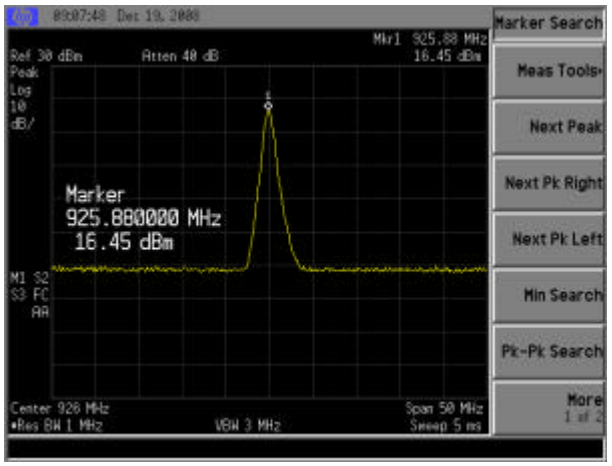
925.9 MHz conducted power

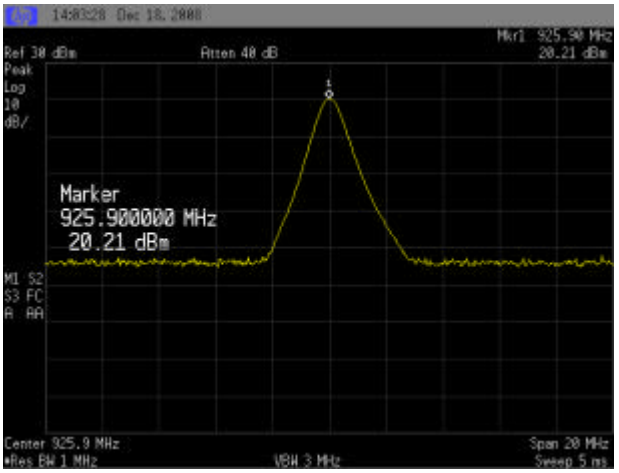












Radiated power measurements were made to confirm that the +36 dBm limit was not exceeded.

To confirm this, measurements were made when the transmitter was transmitting continuously on 920.1 MHz and 925.9 MHz.

Testing was carried out at a distance of 3 metres from the edge of each transmitting mat.

Pre-testing was carried out to determine the worst was antenna orientation which included rotating single mat and antennas and combinations of mat antennas to determine the worst case orientation.

This was determined to be when the line of antennas was placed on the test site ground plane, as would be used in real life, facing directly the test antenna with the worst case location being the centre of each mat antenna when vertical polarisation was used.

Transmitting on 920.1 MHz. Vertical polarisation (worst case polarisation).

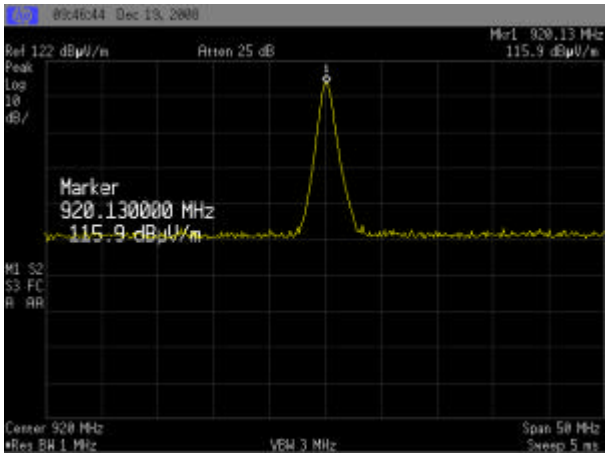
Mat	Level (dBµV/m)	Power (dBm)	Power (watts)	Summed (watts)	Summed (dBm)	Limit (dBm)
1	115.9	20.7	0.117	0.894	29.5	36.0
2	119.5	24.3	0.267			
3	115.9	20.7	0.117			
4	117.3	22.1	0.161			
5	114.7	19.5	0.089			
6	116.8	21.6	0.144			

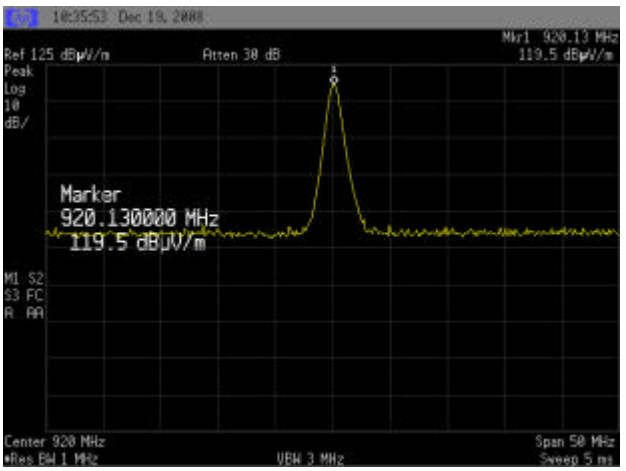
Transmitting on 925.9 MHz. Vertical polarisation (worst case polarisation).

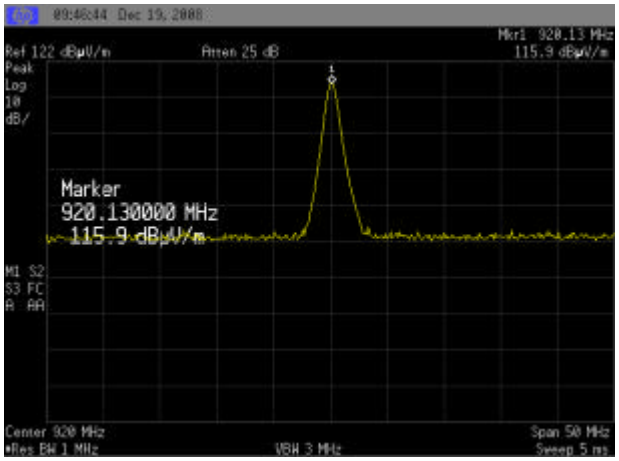
Mat	Level (dBµV/m)	Power (dBm)	Power (watts)	Summed (watts)	Summed (dBm)	Limit (dBm)
1	114.5	19.3	0.085	0.562	27.5	36.0
2	116.3	21.1	0.128			
3	109.0	13.8	0.024			
4	116.9	21.7	0.147			
5	112.0	16.8	0.048			
6	116.4	21.2	0.131			

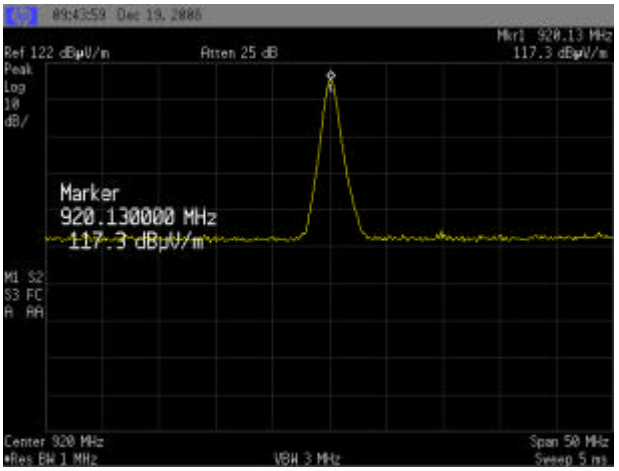
Plots showing these levels are attached below.

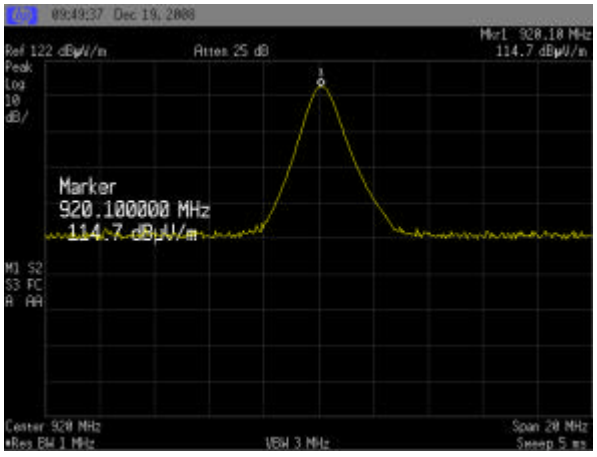
920.1 MHz radiated – vertical polarisation

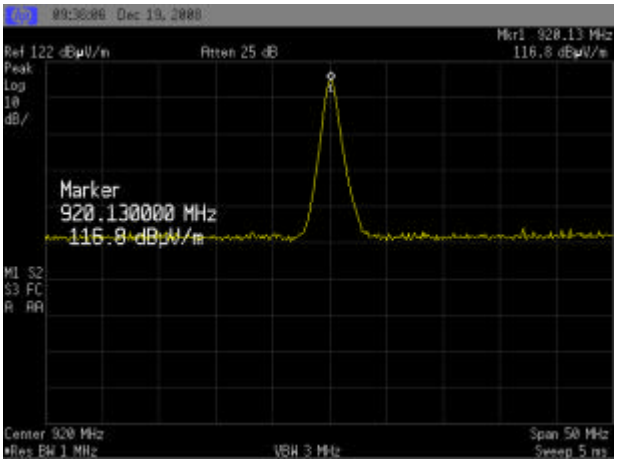




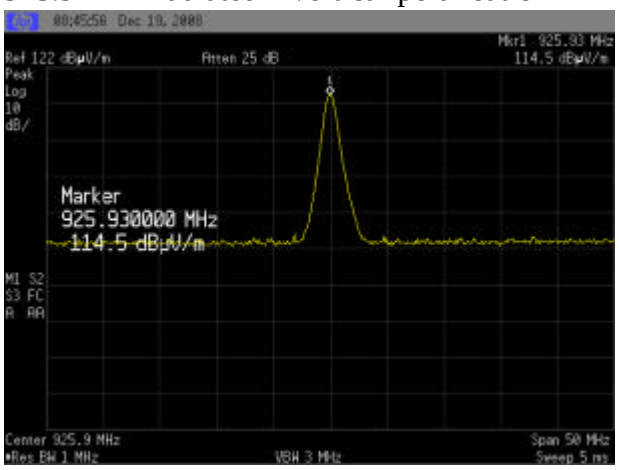


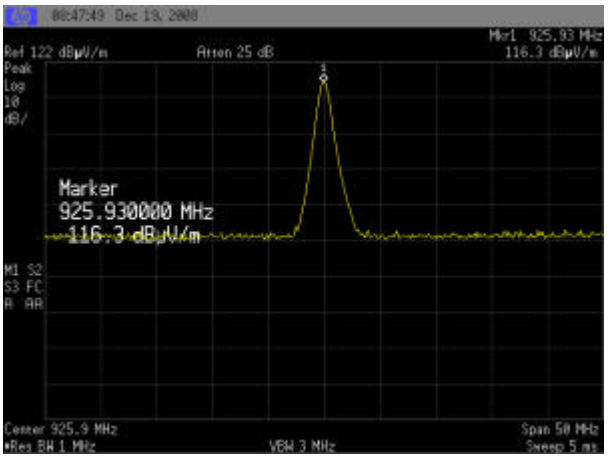


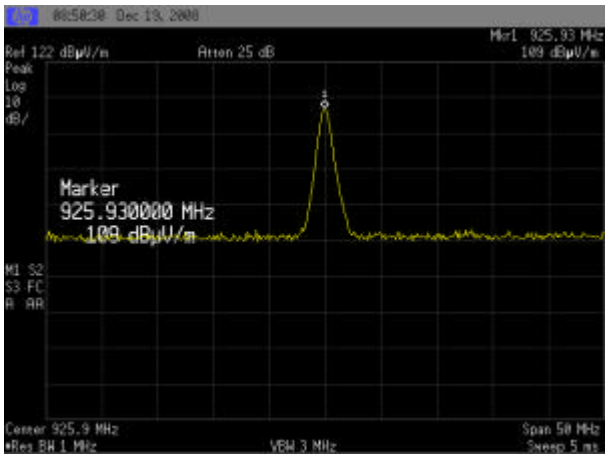


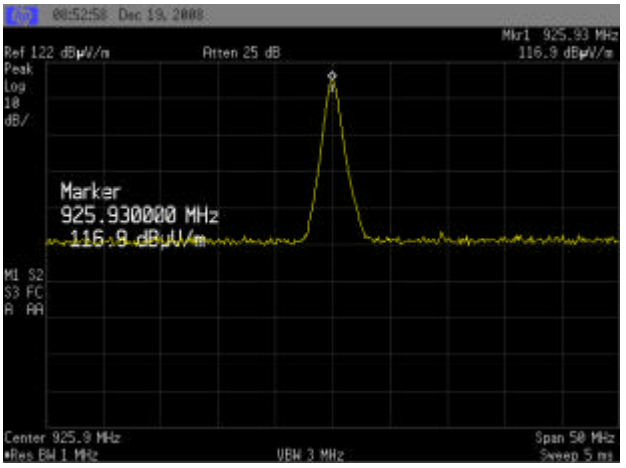


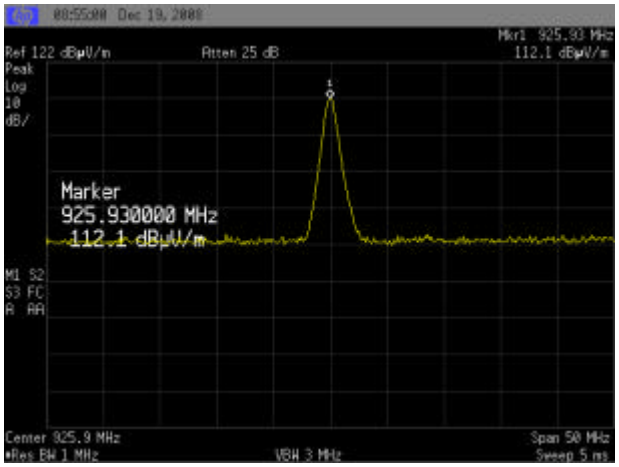
925.9 MHz radiated – vertical polarisation

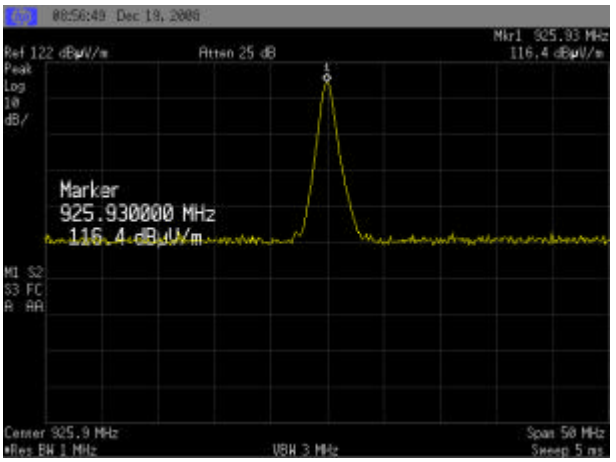












Measurements were made of the antenna gain to determine the antenna and to ensure that it was less than 6 dBi

920.1 MHz				925.9 MHz			
Mat	Conducted dBm	Radiated dBm	Gain dBi	Mat	Conducted dBm	Radiated dBm	Gain dBi
1	16.2	20.7	4.5	1	14.4	19.3	4.9
2	19.8	24.3	4.5	2	16.9	21.1	4.2
3	18.5	20.7	2.2	3	14.4	13.8	-0.6
4	19.5	22.1	2.6	4	18.6	21.7	3.1
5	18.8	19.5	0.7	5	16.5	16.8	0.3
6	20.2	21.6	1.4	6	20.2	21.2	1.0

The results confirm that the antenna gain does not exceed 6 dBi

The 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)

Measurements were made in peak using a measuring receiver with the measurement antenna being raised in height between 1 and 4 metres in both vertical and horizontal antenna polarisations.

The transmitter itself was placed in the centre of the test table at a height of 80 cm above the ground plane.

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

The emission was measured in both vertical and horizontal antenna polarisations.

A conducted limit of 1 watt (+30 dBm) has been applied as more than 50 channels are in use.

The antenna system has a gain of less than 6 dBi so a radiated limit of 36 dBm has been applied.

Result: Complies
Measurement Uncertainty: ±4.1 dB

Section 15.247(b)(1)+(2)– Peak output power with the registration reader attached

The registration reader is small antenna that consists of a 20 dB attenuator that attaches to the output of the 2 transmitters and the receiver port in order to the test the devices that are attached to the cyclists.

Each transmitter operates with a 50% duty cycle being ON for approximately 31 ms and then OFF for 31 ms and vice versa.

Testing was carried out using a spectrum analyser that was attached to each antenna port individually when the system was operating.

A resolution bandwidth of 1 MHz was used with the plots attached below:

The conducted output power shall not exceed 1 watt (+30 dBm) and the radiated power output shall not exceed +36 dBm as the antenna gain has been stated to be less than 6 dBi which is confirmed below.

Conducted power output

Freq (MHz)	Transmitter	Power (dBm)	Limit (dB)
925.900	1	24.2	30.0
	2	28.3	30.0
920.100	1	20.7	30.0
	2	26.6	30.0

Radiated power out: 925.9 MHz

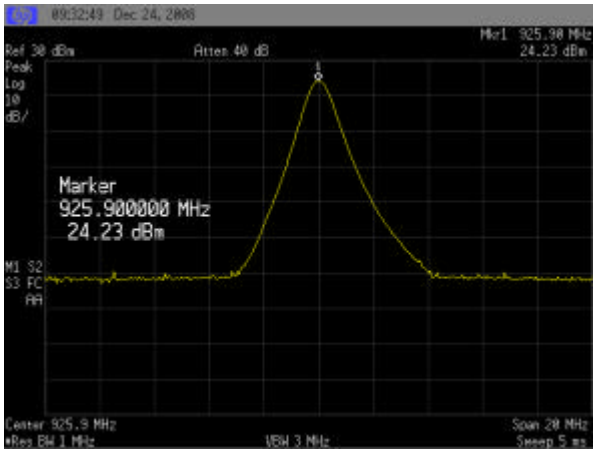
Transmitter	Conducted dBm	Radiated dBuV/m	Radiated dBm	Gain dBi	PolarisatIon
1	24.2	108.1	12.9	-11.3	Horizontal
	24.2	100.1	4.9	-19.3	Vertical
2	28.3	108.1	12.9	-15.4	Horizontal
	28.3	100.1	4.9	-23.4	Vertical

Radiated power output: 920.1 MHz

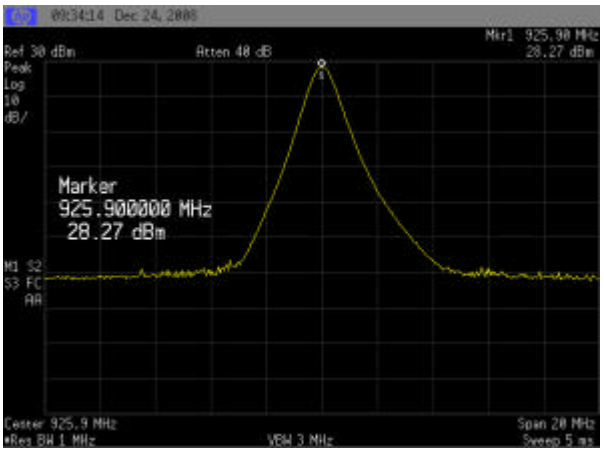
Transmitter	Conducted dBm	Radiated dBuV/m	Radiated dBm	Gain dBi	PolarisatIon
1	20.7	106.4	11.2	-9.5	Horizontal
	20.7	98.4	3.2	-17.5	Vertical
2	26.6	106.4	11.2	-15.4	Horizontal
	26.6	98.4	3.2	23.4	Vertical

Registration reader operating on 925.9 MHz

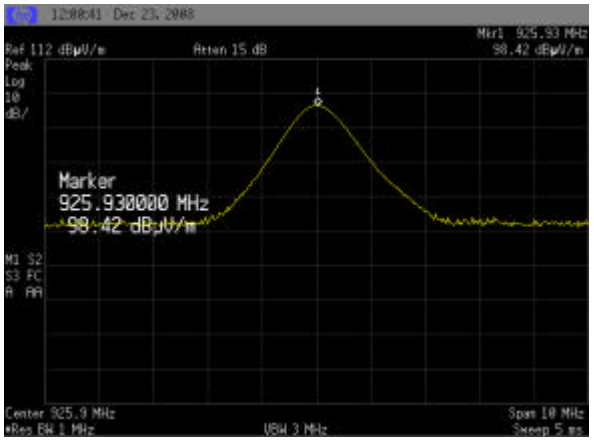
Transmitter 1 conducted



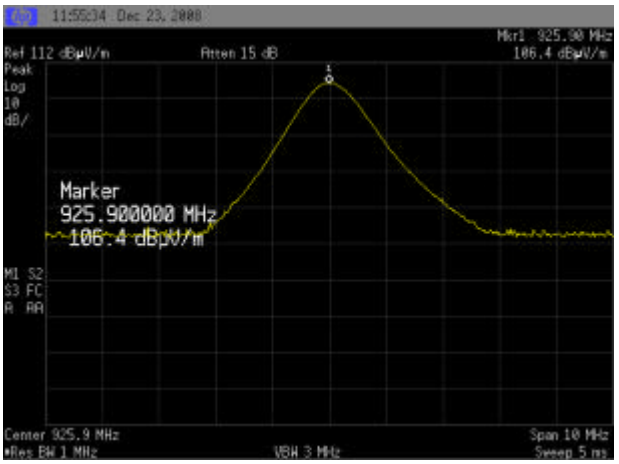
Transmitter 2 conducted



Radiated – Vertical

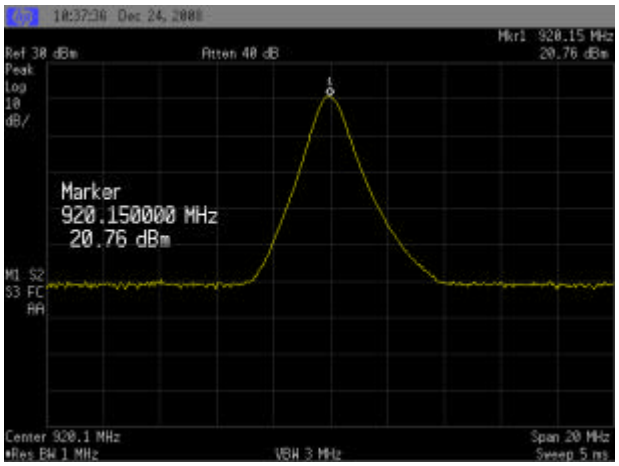


Radiated – Horizontal

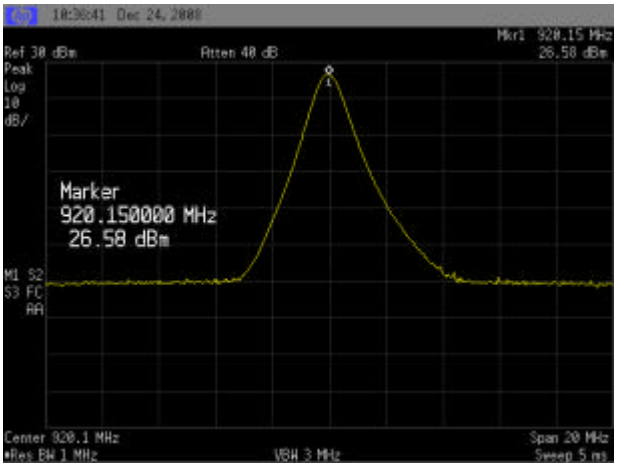


Registration reader operating on 920.1 MHz

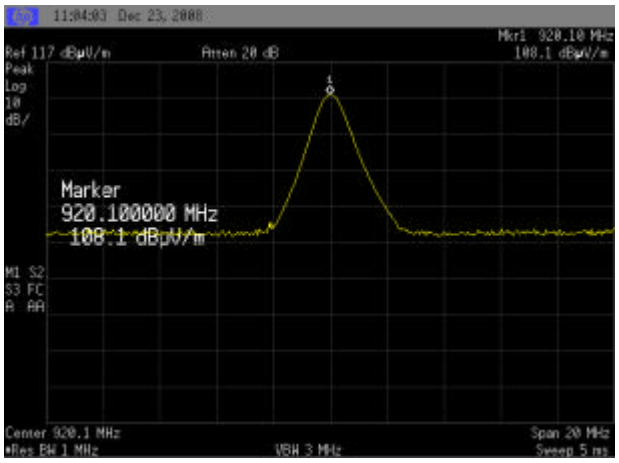
Transmitter 1 Conducted



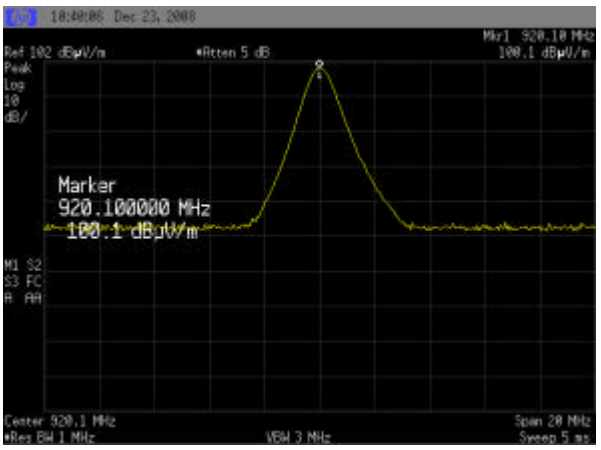
Transmitter 2 conducted



Radiated - Horizontal



Radiated – Vertical



The 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)

Measurements were made in peak using a measuring receiver with the measurement antenna being raised in height between 1 and 4 metres in both vertical and horizontal antenna polarisations.

The transmitter itself was placed in the centre of the test table at a height of 80 cm above the ground plane.

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

The emission was measured in both vertical and horizontal antenna polarisations.

A conducted limit of 1 watt (+30 dBm) has been applied as more than 50 channels are in use.

The antenna system has a gain of less than 6 dBi so a radiated limit of 36 dBm has been applied.

Result: Complies
Measurement Uncertainty: ±4.1 dB

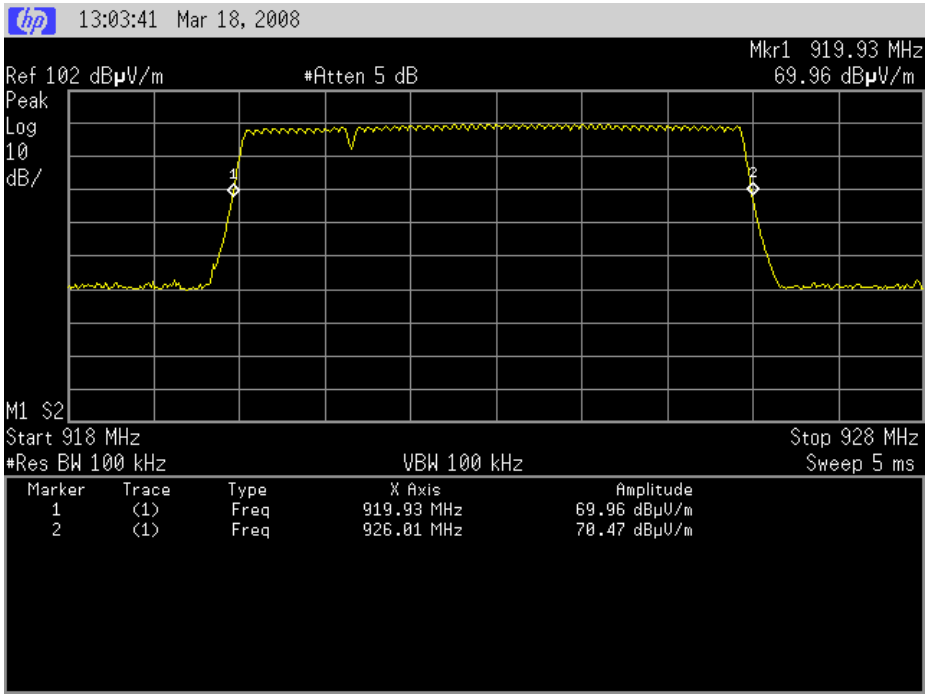
Section 15.247 (d) – Out of band emissions with the mat antenna attached

Band edge measurements:

At the band edges of 902 MHz and 928 MHz all emissions are required to be attenuated by more than 20 dB relative to the highest 100 kHz resolution bandwidth emission level observed in the band of operation.

Measurements were made at the edge of the band of operation (920 – 926 MHz) using a 100 kHz RBW.

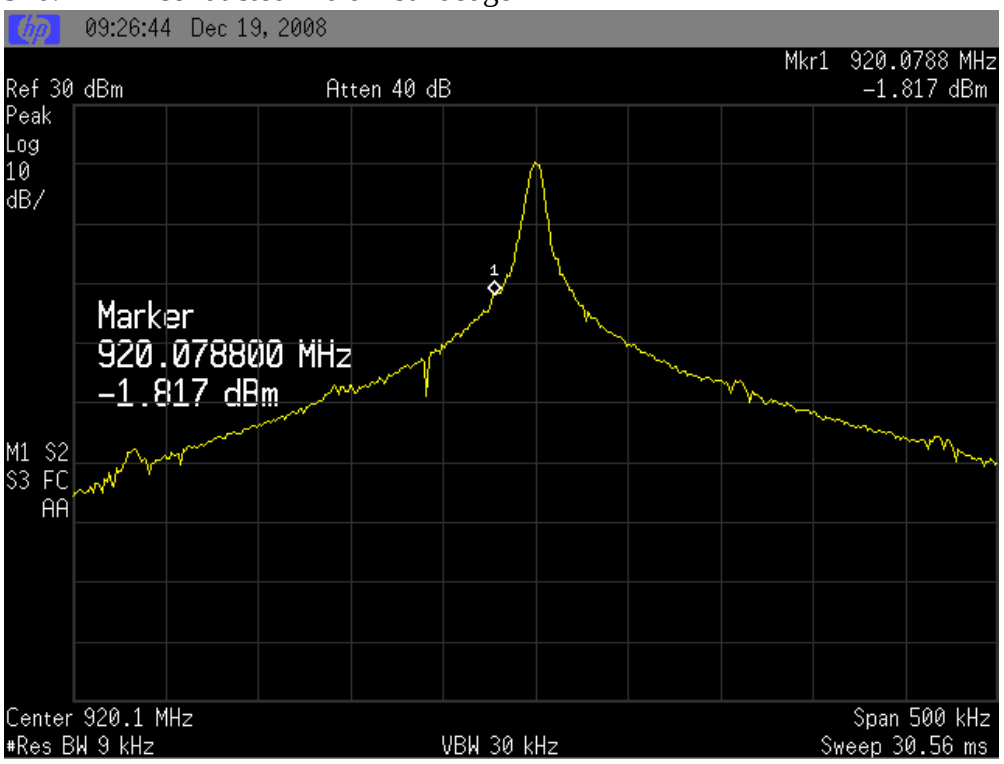
Measurements were then made in hop mode of the whole band.



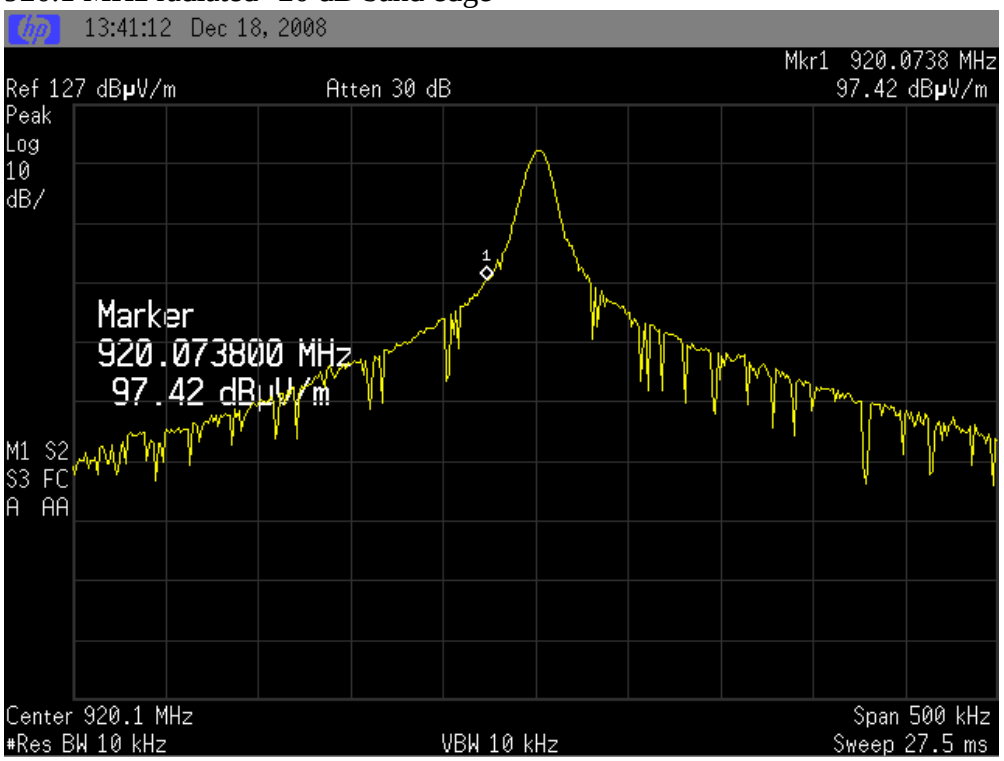
No emissions were observed at the band edges of 902 MHz or 928 MHz.

-20 dB radiated and conducted measurements have been made at 920.1 MHz and 925.9 MHz which show that the device would comply if the band edges were 920.0 MHz and 926.0 MHz

920.1 MHz conducted -20 dB bandedge

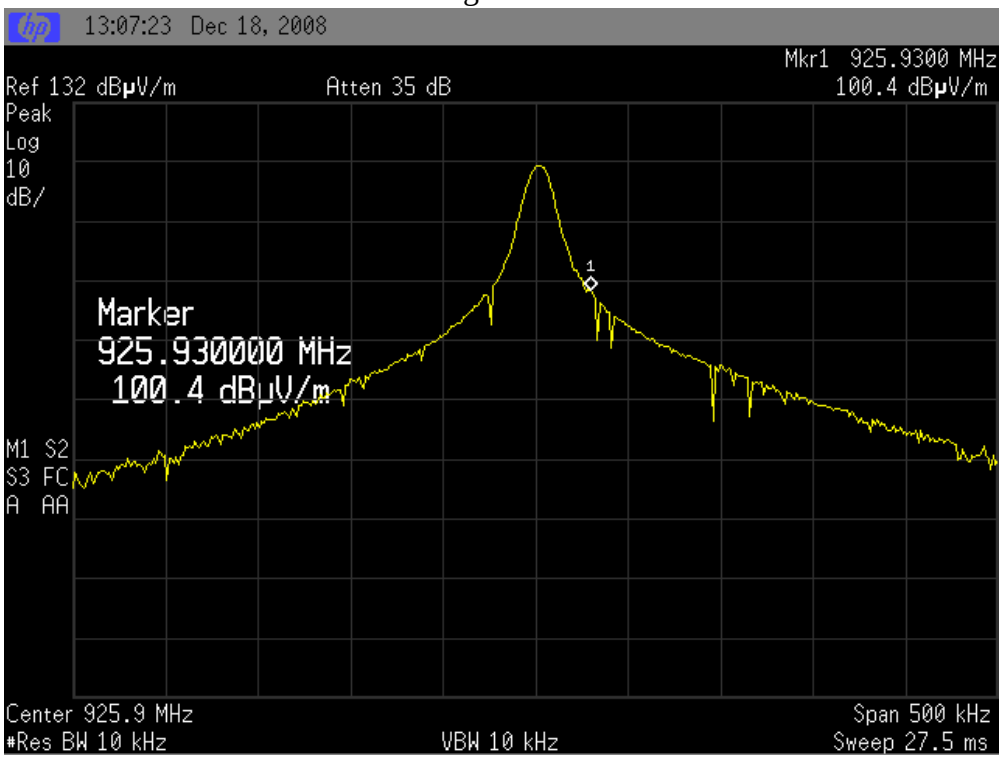


920.1 MHz radiated -20 dB band edge



925.9 MHz conducted -20 dB band edge

925.9 MHz radiated -20 dB band edge



Spurious emissions and restricted band radiated emission measurements

A number of out of band emissions have been shown to fall within the restricted bands of operation as defined in section 15.205(a).

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.

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

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 made 3 metres from the transmitting antenna.

Pre-testing of this device, which included various combinations of mat antennas being rotated on the turntable, has shown that the worst case emission levels from the transmitter are when the mat antennas are placed directly in line with the test antenna as shown in the photographs at the rear of this report.

The registration reader was tested when placed on top of the test table next to the transmitter.

No other spurious emissions other than harmonics were observed.

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)

Transmitting on 920.1 MHz when the mat antennas were attached.

The maximum vertical emission observed was 119.5 dBuV/m which gives a -20 dBc limit of 99.5 dBuV/m

When an emission falls into a restricted band the general limits as described in 15.209 have been applied.

Mats 1 to 6 when measurements were made at a distance of 3 metres

Frequency (MHz)	Vertical (dBµV/m)	Horizontal (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Polarity	Detector
Mat 1						
1840.2000	52.5	44.8	99.5	47.0	Vertical	Peak
2760.3000	48.9	33.1	54.0	5.1	Vertical	Average
2760.3000	59.6	49.0	74.0	14.4	Vertical	Peak
Mat 2						
1840.2000	49.1	41.8	99.5	50.4	Vertical	Peak
2760.3000	52.8	35.1	54.0	1.2	Vertical	Average
2760.3000	61.6	43.0	74.0	12.4	Vertical	Peak
Mat 3						
1840.2000	53.1	43.8	99.5	46.4	Vertical	Peak
2760.3000	48.7	32.1	54.0	5.3	Vertical	Average
2760.3000	56.9	44.0	74.0	17.1	Vertical	Peak
Mat 4						
1840.2000	49.2	45.8	99.5	50.3	Vertical	Peak
2760.3000	53.4	38.1	54.0	0.6	Vertical	Average
2760.3000	62.4	47.0	74.0	11.6	Vertical	Peak
Mat 5						
1840.2000	51.3	44.8	99.5	48.2	Vertical	Peak
2760.3000	49.3	37.1	54.0	4.7	Vertical	Average
2760.3000	57.4	46.0	74.0	16.6	Vertical	Peak
Mat 6						
1840.2000	48.5	42.8	99.5	5.1	Vertical	Peak
2760.3000	52.7	38.1	54.0	1.3	Vertical	Average
2760.3000	62.1	43.0	74.0	11.9	Vertical	Peak

Mats 1 to 6 all gave the same results when measurements were attempted up to 9201 MHz using vertical and horizontal polarisations.

Frequency (MHz)	Vertical (dBµV/m)	Horizontal (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Polarity	Detector
3680.400	< 42	< 42	54.0	-	Hort / Vert	Average
3680.400	< 42	< 42	74.0	-	Hort / Vert	Peak
4600.500	< 42	< 42	54.0	-	Hort / Vert	Average
4600.500	< 42	< 42	74.0	-	Hort / Vert	Peak
5520.600	< 44	< 44	54.0	-	Hort / Vert	Average
5520.600	< 44	< 44	74.0	-	Hort / Vert	Peak
6440.700	< 47	< 47	54.0	-	Hort / Vert	Average
6440.700	< 47	< 47	74.0	-	Hort / Vert	Peak
7360.800	< 49	< 49	54.0	-	Hort / Vert	Average
7360.800	< 49	< 49	74.0	-	Hort / Vert	Peak
8280.900	< 52	< 52	54.0	-	Hort / Vert	Average
8280.900	< 52	< 52	74.0	-	Hort / Vert	Peak
9201.000	< 52	< 52	54.0	-	Hort / Vert	Average
9201.000	< 52	< 52	74.0	-	Hort / Vert	Peak

Result: Complies with a 0.6 dB margin at 2760.300 MHz (Vertical) when measured with an average detector in front of mat 3.

Measurement uncertainty: ± 4.1 dB

Transmitting on 925.9 MHz when the mat antennas were attached.

The maximum emission observed was 116.9 dBuV/m which gives a -20 dBc limit of 96.9 dBuV/m

When an emission falls into a restricted band the general limits as described in 15.209 have been applied.

Mats 1 to 6 when measurements were made at a distance of 3 metres

Frequency (MHz)	Vertical (dBµV/m)	Horizontal (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Polarity	Detector
Mat 1						
1851.800	53.3	44.8	86.4	33.1	Vertical	Peak
2777.700	48.1	33.1	54.0	5.9	Vertical	Average
2777.700	59.8	49.0	74.0	14.2	Vertical	Peak
Mat 2						
1851.800	51.2	41.8	86.4	35.2	Vertical	Peak
2777.700	53.2	35.1	54.0	0.8	Vertical	Average
2777.700	60.9	43.0	74.0	13.1	Vertical	Peak
Mat 3						
1851.800	49.4	43.8	86.4	37.0	Vertical	Peak
2777.700	49.1	32.1	54.0	4.9	Vertical	Average
2777.700	57.8	44.0	74.0	16.2	Vertical	Peak
Mat 4						
1851.800	50.2	45.8	86.4	36.2	Vertical	Peak
2777.700	51.3	38.1	54.0	2.7	Vertical	Average
2777.700	59.3	47.0	74.0	14.7	Vertical	Peak
Mat 5						
1851.800	52.9	44.8	86.4	33.5	Vertical	Peak
2777.700	48.3	37.1	54.0	5.7	Vertical	Average
2777.700	58.1	46.0	74.0	15.9	Vertical	Peak
Mat 6						
1851.800	50.5	42.8	86.4	35.9	Vertical	Peak
2777.700	53.9	38.1	54.0	0.1	Vertical	Average
2777.700	61.6	43.0	74.0	12.4	Vertical	Peak

Mats 1 to 6 all gave the same results when measurements were attempted up to 9259 MHz using vertical and horizontal polarisations.

Frequency (MHz)	Vertical (dBµV/m)	Horizontal (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Polarity	Detector
3703.600	< 42	< 42	54.0	-	Hort / Vert	Average
3703.600	< 42	< 42	74.0	-	Hort / Vert	Peak
4629.500	< 42	< 42	54.0	-	Hort / Vert	Average
4629.500	< 42	< 42	74.0	-	Hort / Vert	Peak
5555.400	< 44	< 44	54.0	-	Hort / Vert	Average
5555.400	< 44	< 44	74.0	-	Hort / Vert	Peak
6481.300	< 47	< 47	54.0	-	Hort / Vert	Average
6481.300	< 47	< 47	74.0	-	Hort / Vert	Peak
7407.200	< 49	< 49	54.0	-	Hort / Vert	Average
7407.200	< 49	< 49	74.0	-	Hort / Vert	Peak
8333.100	< 52	< 52	54.0	-	Hort / Vert	Average
8333.100	< 52	< 52	74.0	-	Hort / Vert	Peak
9259.000	< 52	< 52	54.0	-	Hort / Vert	Average
9259.000	< 52	< 52	74.0	-	Hort / Vert	Peak

Result: Complies with an 0.1 dB margin at 2777.700 MHz (Vertical) when measured with an average detector in front of mat 6.

Measurement uncertainty: ± 4.1 dB

Transmitting on 920.1 MHz when the registration reader was attached

The maximum emission observed was 108.1 dBuV/m which gives a -20 dBc limit of 88.1 dBuV/m

When an emission falls into a restricted band the general limits as described in 15.209 have been applied.

Frequency (MHz)	Vertical (dBµV/m)	Horizontal (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Polarity	Detector
1840.2000	52.3	56.1	88.1	32.0	Horizontal	Peak
2760.3000	51.3	47.5	54.0	2.7	Vertical	Average
2760.3000	57.4	53.1	74.0	16.6	Vertical	Peak
3680.400	39.8	35.1	54.0	14.2	Vertical	Average
3680.400	45.8	<42	74.0	28.2	Vertical	Peak
4600.500	< 42	< 42	54.0	-	Hort / Vert	Average
4600.500	< 42	< 42	74.0	-	Hort / Vert	Peak
5520.600	< 44	< 44	54.0	-	Hort / Vert	Average
5520.600	< 44	< 44	74.0	-	Hort / Vert	Peak
6440.700	< 47	< 47	54.0	-	Hort / Vert	Average
6440.700	< 47	< 47	74.0	-	Hort / Vert	Peak
7360.800	< 49	< 49	54.0	-	Hort / Vert	Average
7360.800	< 49	< 49	74.0	-	Hort / Vert	Peak
8280.900	< 52	< 52	54.0	-	Hort / Vert	Average
8280.900	< 52	< 52	74.0	-	Hort / Vert	Peak
9201.000	< 52	< 52	54.0	-	Hort / Vert	Average
9201.000	< 52	< 52	74.0	-	Hort / Vert	Peak

Result: Complies with a 2.7 dB margin at 2760.300 MHz (Vertical) when measured with an average detector.

Measurement uncertainty: ± 4.1 dB

Transmitting on 925.9 MHz when the registration reader was attached

The maximum emission observed was 106.4 dBuV/m which gives a -20 dBc limit of 86.4 dBuV/m

When an emission falls into a restricted band the general limits as described in 15.209 have been applied.

Frequency (MHz)	Vertical (dBµV/m)	Horizontal (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Polarity	Detector
1851.800	58.1	58.5	86.4	27.9	Horizontal	Peak
2777.700	53.1	52.1	54.0	0.9	Vertical	Average
2777.700	59.1	56.8	74.0	14.9	Vertical	Peak
3703.600	38.7	34.2	54.0	15.3	Vertical	Average
3703.600	45.4	42.0	74.0	28.6	Vertical	Peak
4629.500	< 42	< 42	54.0	-	Hort / Vert	Average
4629.500	< 42	< 42	74.0	-	Hort / Vert	Peak
5555.400	< 44	< 44	54.0	-	Hort / Vert	Average
5555.400	< 44	< 44	74.0	-	Hort / Vert	Peak
6481.300	< 47	< 47	54.0	-	Hort / Vert	Average
6481.300	< 47	< 47	74.0	-	Hort / Vert	Peak
7407.200	< 49	< 49	54.0	-	Hort / Vert	Average
7407.200	< 49	< 49	74.0	-	Hort / Vert	Peak
8333.100	< 52	< 52	54.0	-	Hort / Vert	Average
8333.100	< 52	< 52	74.0	-	Hort / Vert	Peak
9259.000	< 52	< 52	54.0	-	Hort / Vert	Average
9259.000	< 52	< 52	74.0	-	Hort / Vert	Peak

Result: Complies with an 0.9 dB margin at 2777.700 MHz (Vertical) when measured with an average detector.

Measurement uncertainty: ± 4.1 dB

Section 15.247(i) – Radio Frequency Hazard Information

As per Section 15.247 (b) (4) spread spectrum transmitters operating in the 902 – 928 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 f/1500 have 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, V/m = (√ (30 * P * G)) / d
Power density, mW/m2 = E2/3770
E for MPE: (920/1500) = E2/3770
E = √(920/1500)*3770
E = 48.1 V/m

The highest summed radiated power has been measured to be 0.894 watts EiRP when operating on 920.1 MHz using the mat antenna.

Therefore:
E = √ (30 * P * G) / d
d = √ (30 * P * G) / E
d = √ (30 * 0.894) / 48.1
d = 0.107 m or 10.7 cm

When using the registration reader the maximum power observed was 0.0195 watts when operating on 925.9 MHz.

Therefore:
d = √ (30 * 0.0195) / 48.1
d = 0.016 m or 1.6 cm

Result: Complies if a minimum safe distance of 20 cm is specified in the set up instructions for this system when using the mat antennas or the registration reader.

6. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial No	Asset Ref	Cal Due
Aerial Controller	EMCO	1090	9112-1062	RFS 3710	Not applicable
Aerial Mast	EMCO	1070-1	9203-1661	RFS 3708	Not applicable
Biconical Antenna	Schwarzbeck	BBA 9106	-	RFS 3612	7 Feb 2009
Receiver	R & S	ESCS 30	847124/020	E1595	21 Dec 2008
Log Periodic	Schwarzbeck	VUSLP 9111	9111-228	3785	7 Feb 2009
Turntable	EMCO	1080-1-2.1	9109-1578	RFS 3709	Not applicable
VHF Balun	Schwarzbeck	VHA 9103	-	RFS 3603	7 Feb 2009
Pre Amplifier	Hewlett Packard	8349B	2644A01659	-	14 May 2009
Horn Antenna	Electrometrics	RGA-60	6234	E1494	14 May 2009
Spectrum Analyser	Hewlett Packard	E7405A	US39150142	3776	26 April 2009

7. ACCREDITATIONS

Testing was carried out at EMC Technologies NZ Ltd Open Area Test Site, which is located at Driving Creek, Orere Point, Auckland. Details of this site have been filed with the Commission, Registration Number: 90838, which was last updated on January 25th, 2007.

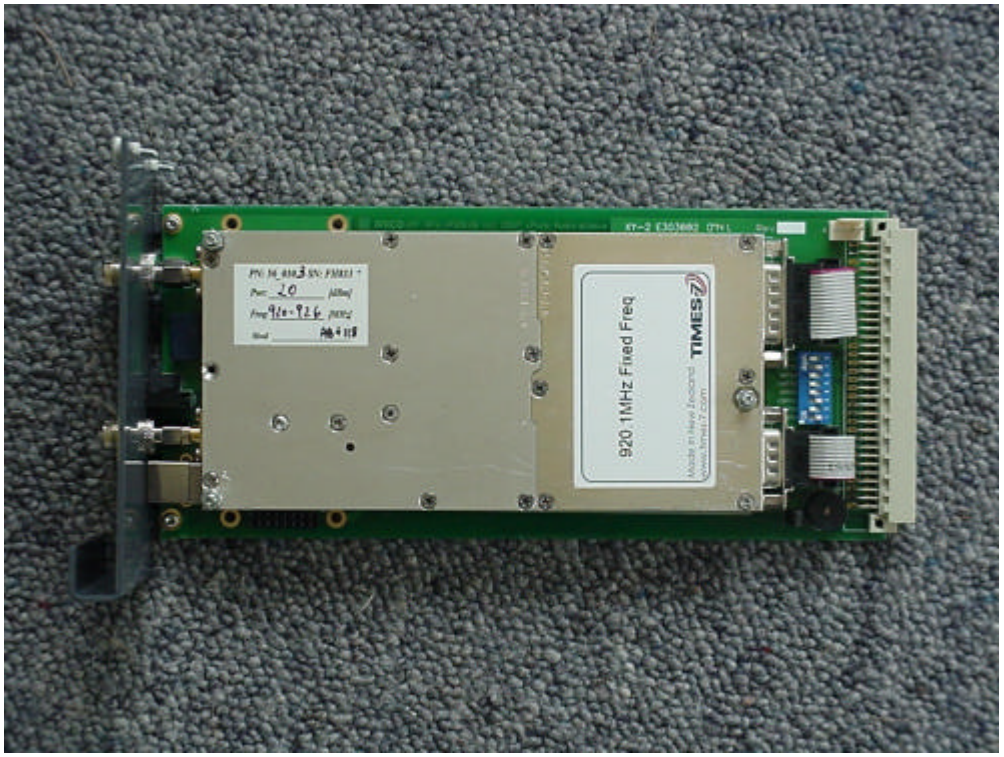
All testing was carried out in accordance with the terms of EMC Technologies (NZ) Ltd's International Accreditation New Zealand (IANZ) Accreditation to NZS/IEC/ISO 17025.

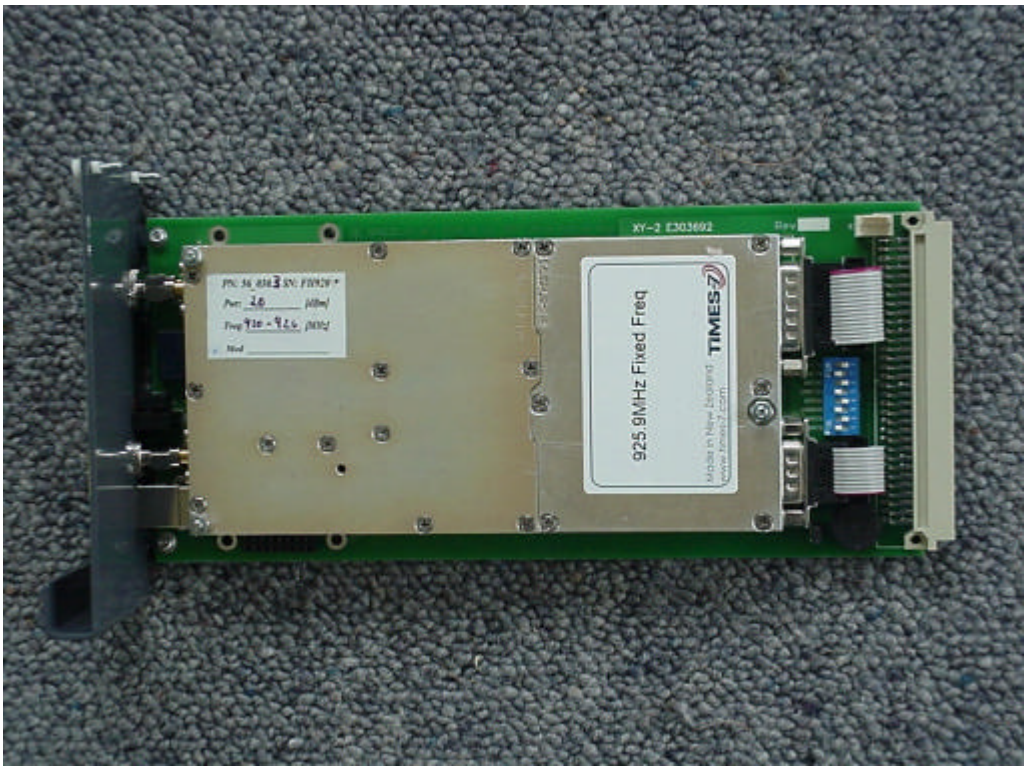
All measurement equipment has been calibrated in accordance with the terms of EMC Technologies (NZ) Ltd's International Accreditation New Zealand (IANZ) Accreditation to NZS/IEC/ISO 17025.

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

8. PHOTOGRAPHS Registration Reader

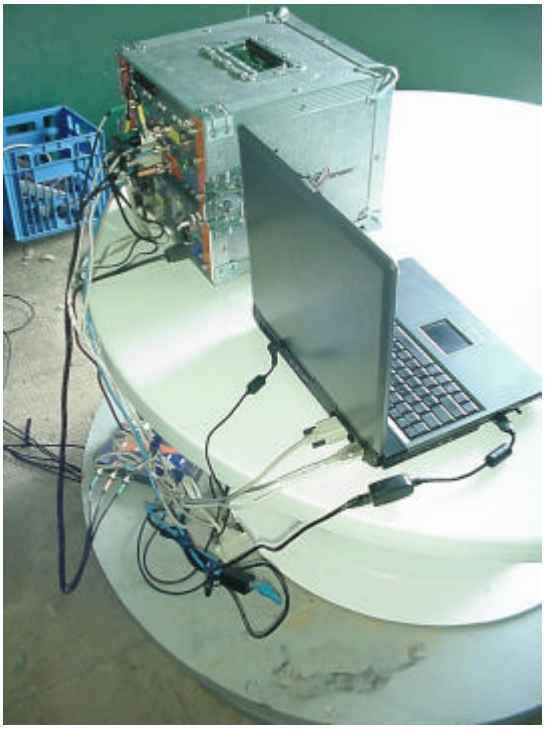
Transmitter modules

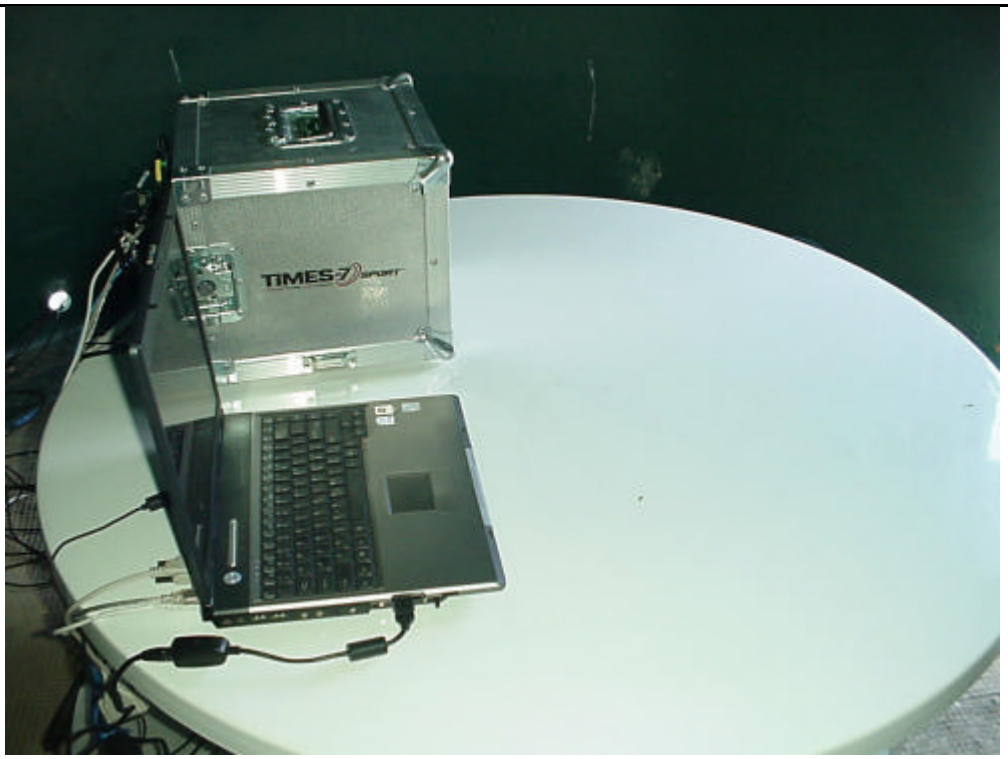




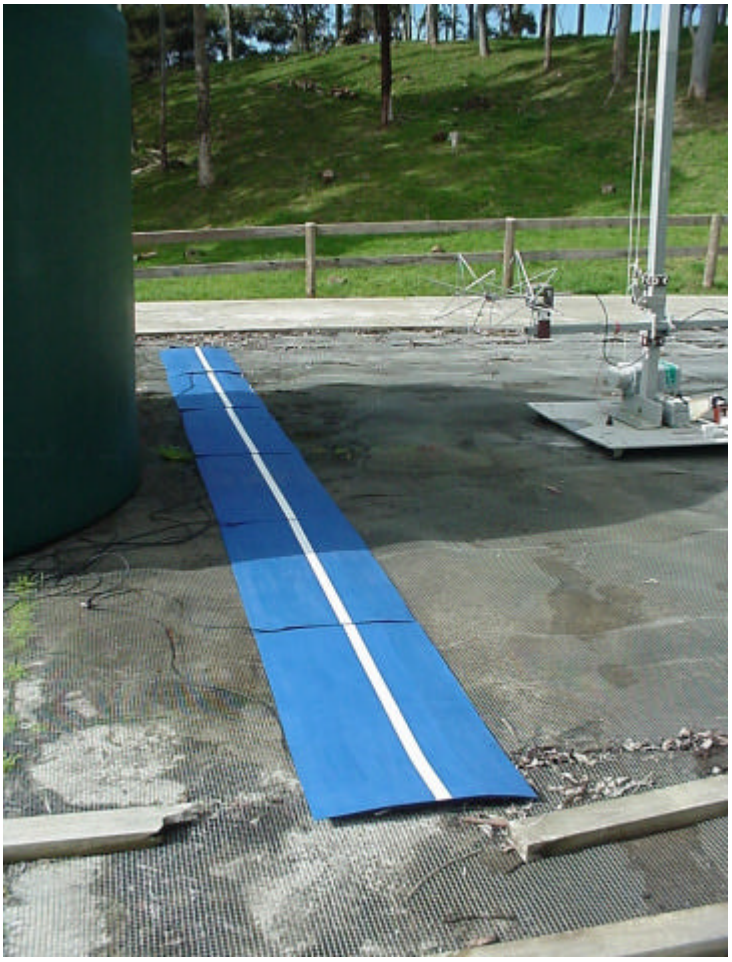
Registration reader radiated emissions test set up

Mat antenna radiated emissions test set up

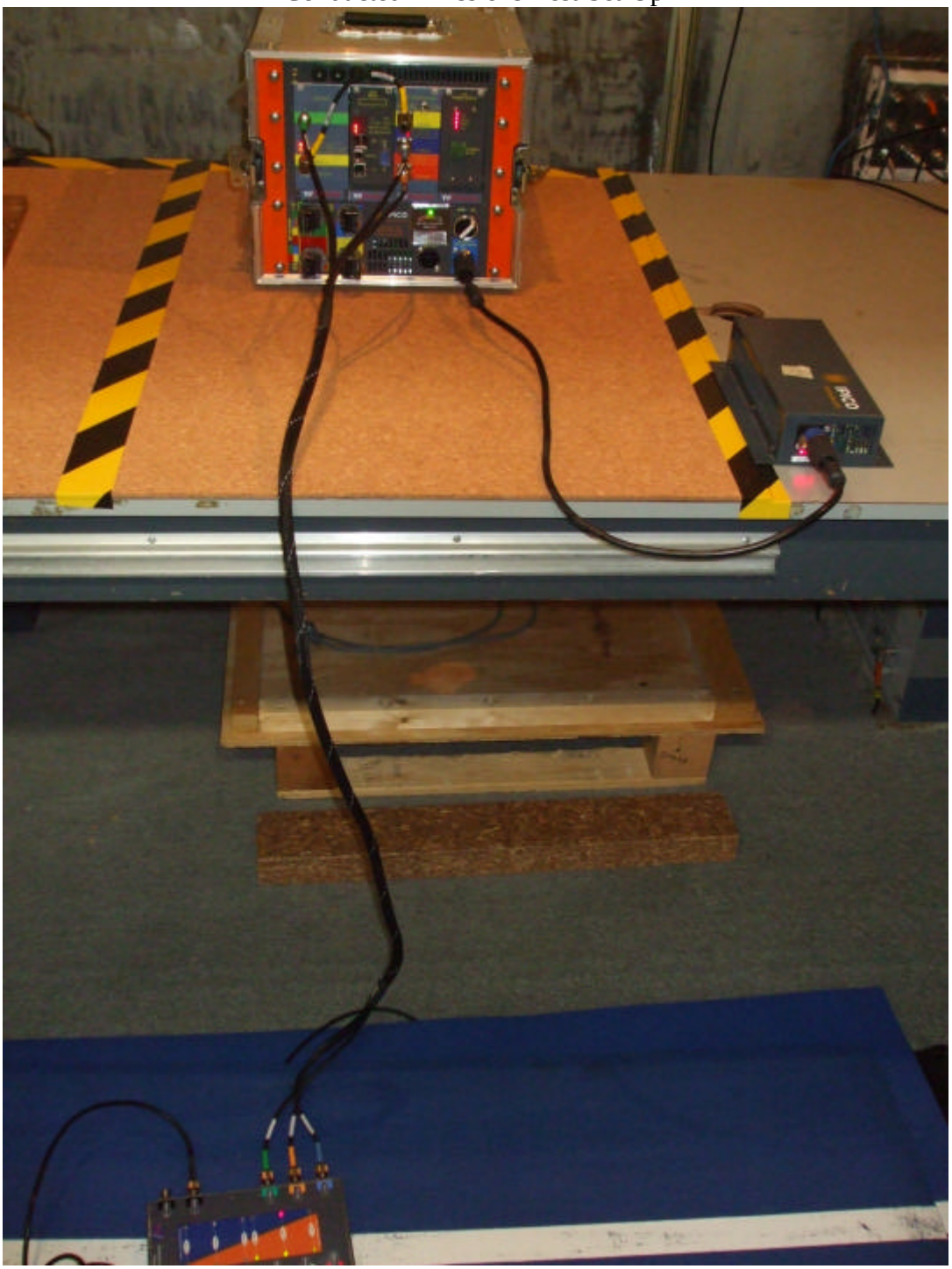




Matt antenna configuration test set up showing the worst case antenna position relative to the test antenna



Conducted Emissions Test Set Up



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