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TEST REPORT

MiMOMax MWL-TORNADO *E/F/G A/B/C* Fixed Digital Transceiver

tested to the

Code of Federal Regulations (CFR) 47

Part 101 –Fixed Microwave Services

for
**EMC
Technologies**

MiMOMax Wireless Ltd

Testing carried out by;

Douglas Poole - Radio Testing Officer

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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The logo for EMC Technologies. It features the letters 'EMC' in a large, bold, black font. Below 'EMC', the word 'Technologies' is written in a smaller, black, sans-serif font. The entire logo is set against a background of several concentric, semi-transparent blue and white arcs that resemble a stylized globe or a series of overlapping ellipses.

1. STATEMENT OF COMPLIANCE

The **MiMOMax MWL-TORNADO*E/F/G A/B/C* Fixed Digital Transceiver** complies with the Code of Federal Regulations (CFR) 47 Part 101 – Fixed Microwave Services.

2. RESULTS SUMMARY

The results of testing, carried out in July 2015 are summarised below.

Clause	Description	Result
101.107	Frequency tolerance	Complies
101.109	Bandwidth	Complies
101.111	Emission limitations Spurious emission at antenna port Spurious emissions field strength	Complies Complies Complies
101.113	Transmitter power limitations	Complies
1.1310	Radio frequency exposure limits	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 MiMOMax Wireless Ltd

Address 540 Wairakei Road
Christchurch

Country New Zealand

Contact Mr Paul Reid

5. DESCRIPTION OF TEST SAMPLE

Brand Name MiMOMax

Model Number MWL-TORNADO *E/F/G A/B/C*

Product Fixed Digital Transceiver

Manufacturer MiMOMAX Wireless Ltd

Manufactured in New Zealand

Designed in New Zealand

Serial Numbers 26901718

FCC ID XMK-MMXTRNB003

The sample tested has the following specifications:

Rated Transmitter Output Power

Two transmitters each outputting +24 dBm (0.25 Watt) average

Transmitter FC Frequency Bands

928.0 – 929.0 MHz
932.5 – 935.0 MHz
941.0 – 941.5 MHz
941.5 – 944.0 MHz
952.0 – 958.0 MHz
958.0 – 960.0 MHz

Testing was performed on a single frequency that is representative of the performance of the radio over the range 928.0 – 960.0 MHz

Test frequencies – Transmit

952.0250 MHz

Test frequencies – Receive

928.0250 MHz

Channel bandwidths

12.5 kHz, 25.0 kHz, 50.0 kHz

Declared Authorised Bandwidths

10.0 kHz, 20 kHz, 41 kHz

Modulation Types

QPSK, QAM16, QAM64, QAM256

Emission Designators / Modes of operation

10k0W1W – digital speech and data

20k0W1W – digital speech and data

41k0W1W – digital speech and data

Power Supply

DC voltage supply over the range of 10.5 Vdc to 60 Vdc

Typically 12.0 Vdc or 24.0 Vdc using lead acid batteries

Standard Temperature and Humidity

Temperature: +15°C to + 30° maintained.

Relative Humidity: 20% to 75% observed.

Standard Test Power Source

Standard Test Voltage: 24.0 Vdc

Extreme Test Voltages

High Voltage: 60.0 Vdc

Low Voltage: 10.5 Vdc

Extreme Temperature

High Temperature: + 50°C maintained.

Low Temperature: - 30 °C maintained.

6. ATTESTATION

This report describes the tests and measurements performed for the purpose of determining compliance with the specification with the following conditions:

The client selected the test sample.

The report relates only to the sample tested.

This report does not contain corrections or erasures.

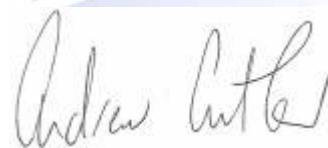
Measurement uncertainties with statistical confidence intervals of 95% are shown below test results. Both Class A and Class B uncertainties have been accounted for, as well as influence uncertainties where appropriate.

All compliance statements have been made with respect of the specification limit with no reference to the measurement uncertainty.

In addition this equipment has been tested in accordance with the requirements contained in the appropriate FCC regulations.

To the best of my knowledge, these tests were performed using measurement procedures that are consistent with industry or Industry Canada standards and demonstrate that the equipment complies with the appropriate standards.

I further certify that the necessary measurements were made by EMC Technologies NZ Ltd, 47 MacKelvie Street, Grey Lynn, Auckland, New Zealand.



Andrew Cutler
General Manager
EMC Technologies NZ Ltd

7. TEST RESULTS

Part 101.107 Frequency Tolerance

Frequency tolerance measurements were between - 30 °C and + 50°C in 10°C increments.

At each temperature the transmitter was given a period of 30 minutes to stabilise. The transmitter was then turned on and the frequency error measured after a period of 1 minute.

Frequency: 952.0250 MHz

Temperature	Voltage 10.5 Vdc	Voltage 24.0 Vdc	Voltage 60.0 Vdc
+50°C	+281.0 Hz	+294.0 Hz	+332.0 Hz
+40°C	+233.0 Hz	+212.0 Hz	+232.0 Hz
+30°C	+160.0 Hz	+189.0 Hz	+191.0 Hz
+20°C	-175.0 Hz	-180.0 Hz	-170.0 Hz
+10°C	-101.0 Hz	-98.0 Hz	-84.0 Hz
0°C	-218.0 Hz	-215.0 Hz	-222.0 Hz
-10°C	-267.0 Hz	-296.0 Hz	-301.0 Hz
-20°C	-346.0 Hz	-363.0 Hz	-384.0 Hz
-30°C	-335.0 Hz	-359.0 Hz	-389.0 Hz

Limit:

Part 101.107 (a) states that for multiple address master stations a frequency tolerance of +/- 0.00015 % will apply.

Transmitter was tested on 952.025 MHz: +/- 0.000150% = +/- 1428 Hz.

A worst case frequency error of -389 Hz or 0.41 ppm or 0.000041%

Result: Complies

Measurement Uncertainty: ±30 Hz

Part 101.109 Bandwidth limitations:

The transmitter tested has been designed to operate using four modulation types: QPSK, 16QAM, 64QAM and 256QAM.

An emission designator of W1W has been applied by the client with the transmitter being capable of operating with declared bandwidths of 10.0 kHz, 20.0 and 41.0 kHz.

The authorised bandwidth that would apply to this transmitter would be 12.5 kHz, 25 kHz and 50 kHz respectively.

Measurements were made when the transmitter was operating on 952.0250 MHz.

The occupied bandwidth has been measured and compared against the occupied bandwidth declared by the client.

Measurements have been made of each modulation type using a spectrum analyser operating in peak hold mode and an external 30 dB attenuator applied which has been accounted for in the spectrum plots below.

Initially power measurements are made using a resolution bandwidth of 120 kHz.

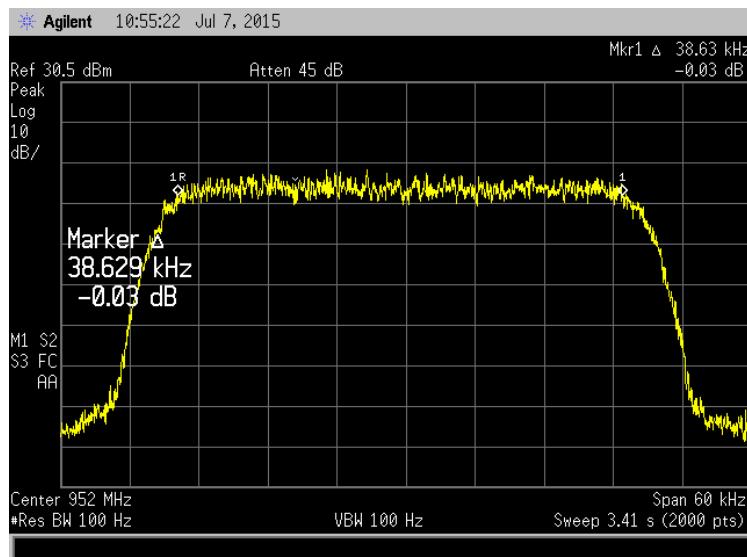
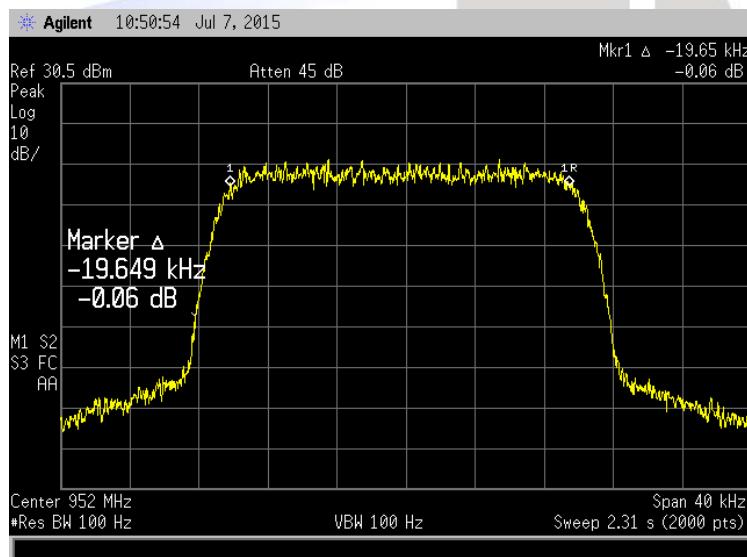
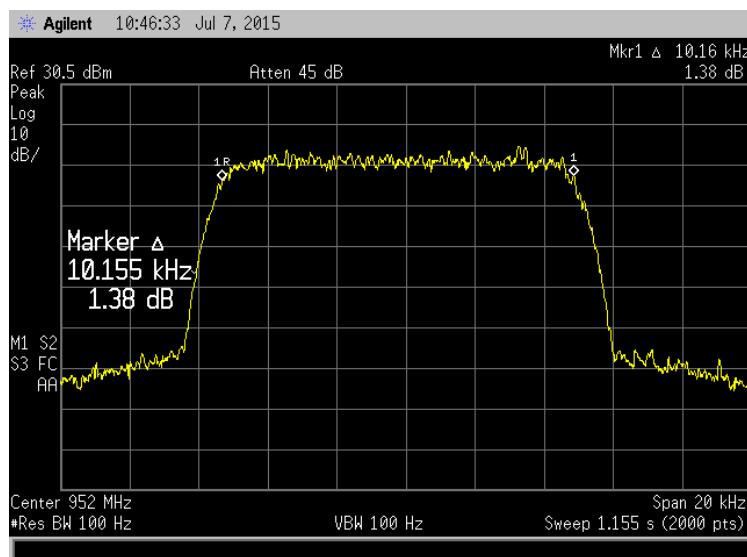
This level is used as a reference level on the spectrum analyser.

The resolution bandwidth is then changed to 100 Hz and the reference level minus 26 dB (99%) absolute bandwidth points determined

Result: Complies

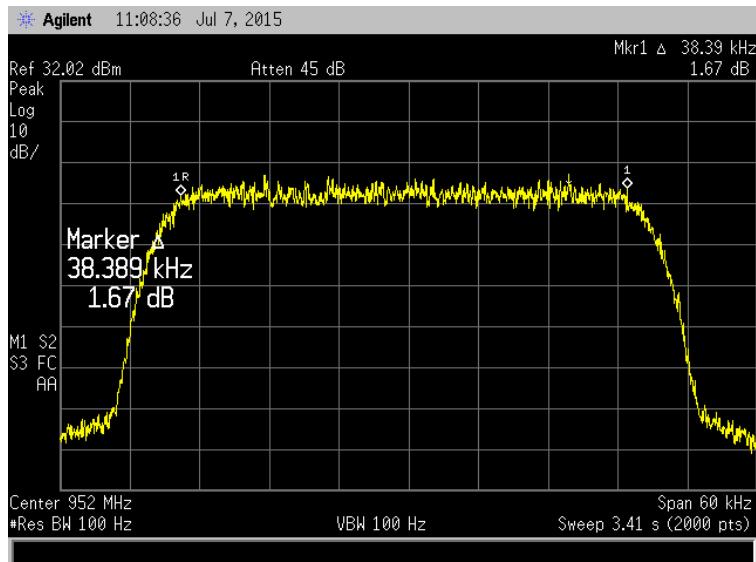
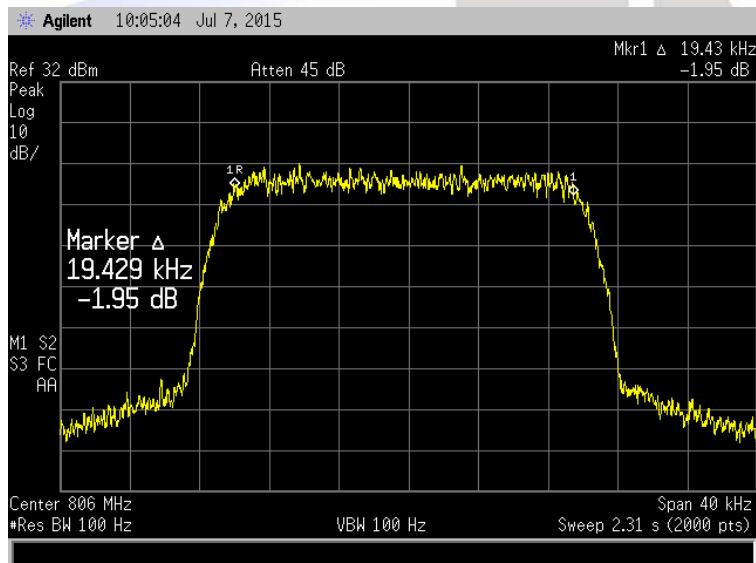
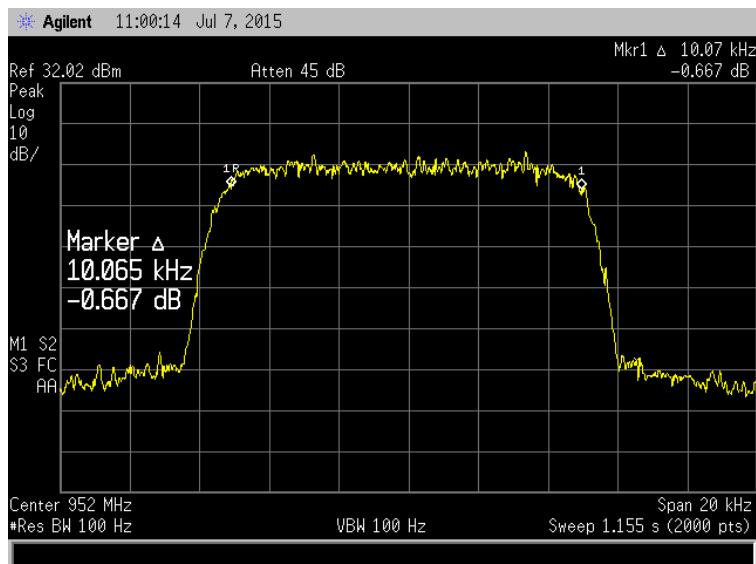
QPSK

Emission	Measured	Designated	Authorised
W1W	10.155 kHz	10.0 kHz	12.5 kHz
W1W	19.649 kHz	20.0 kHz	25.0 kHz
W1W	38.629 kHz	41.0 kHz	50.0 kHz



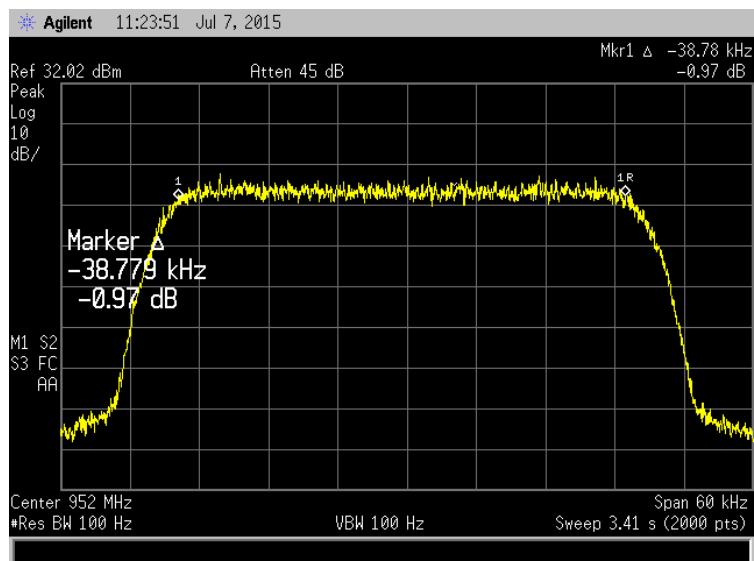
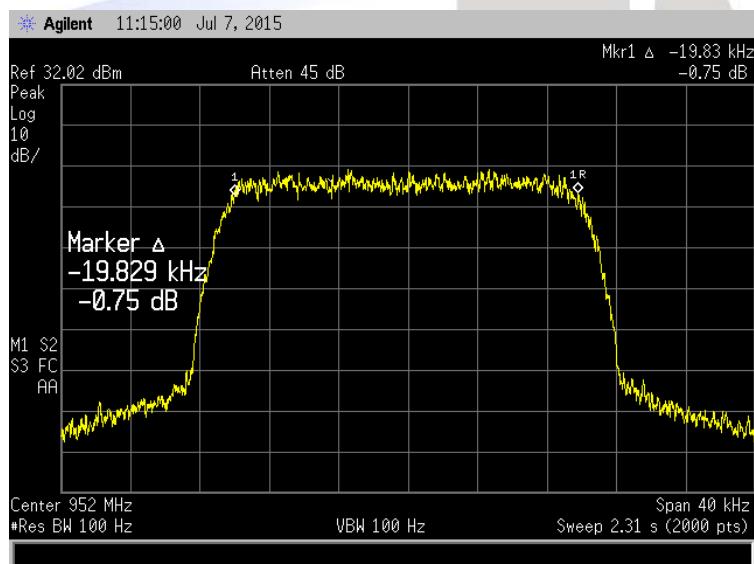
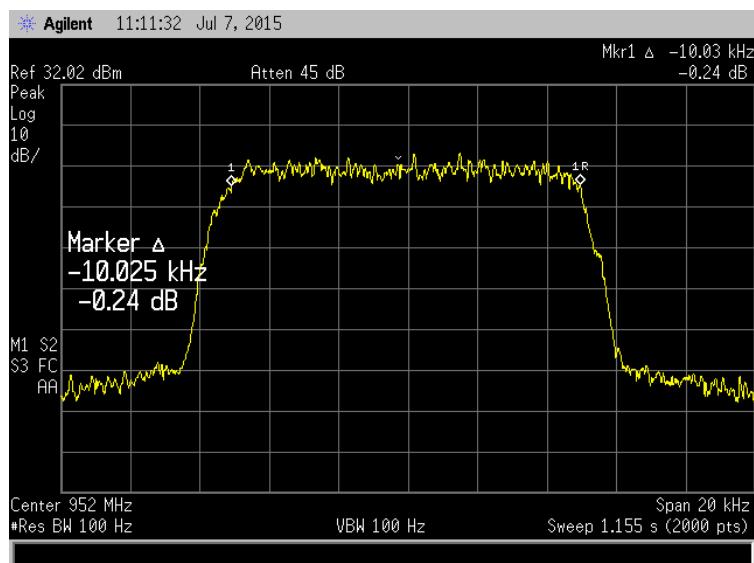
16 QAM

Emission	Measured	Designated	Authorised
W1W	10.065 kHz	10.0 kHz	12.5 kHz
W1W	19.429 kHz	20.0 kHz	25.0 kHz
W1W	38.389 kHz	41.0 kHz	50.0 kHz



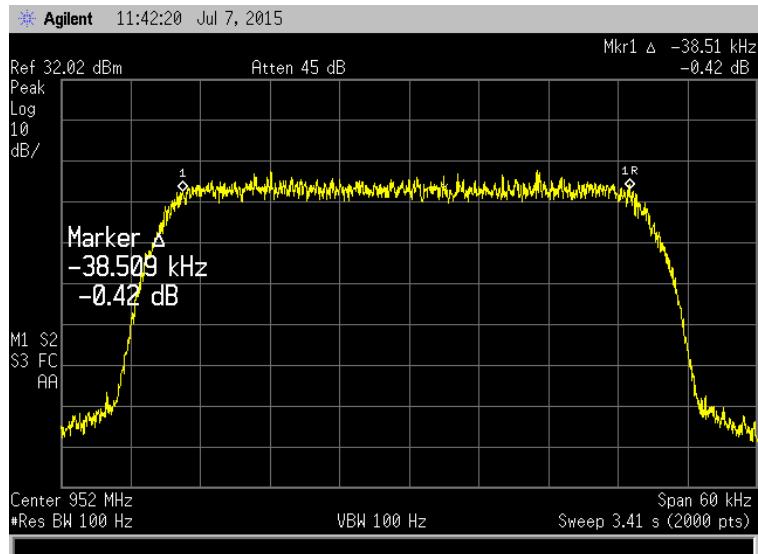
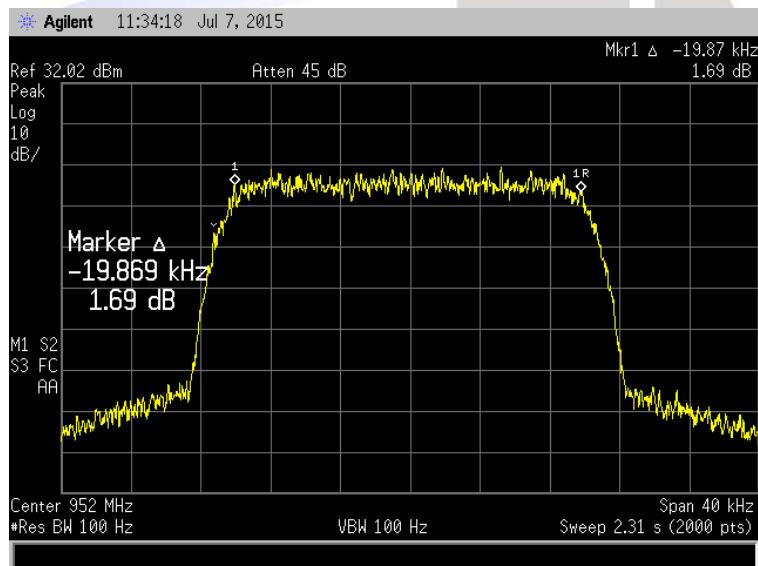
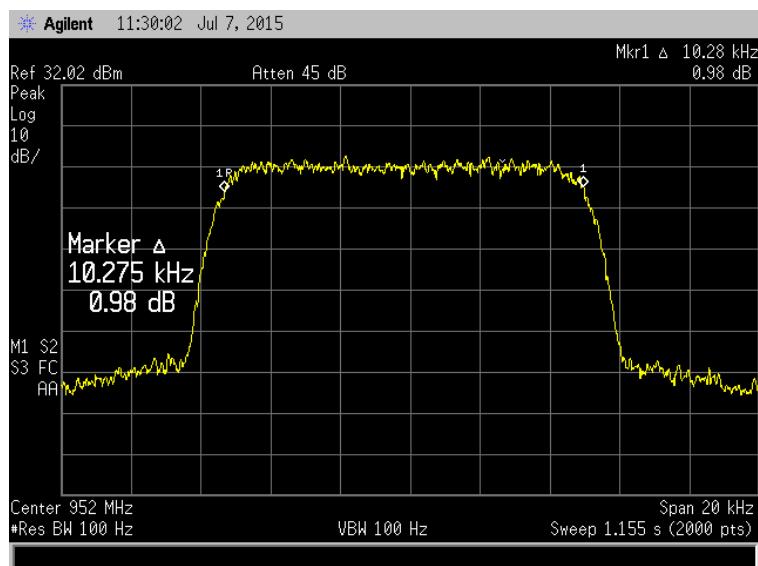
64 QAM

Emission	Measured	Designated	Authorised
W1W	10.025 kHz	10.0 kHz	12.5 kHz
W1W	19.829 kHz	20.0 kHz	25.0 kHz
W1W	38.779 kHz	41.0 kHz	50.0 kHz



256 QAM

Emission	Measured	Designated	Authorised
W1W	10.275 kHz	10.0 kHz	12.5 kHz
W1W	19.869 kHz	20.0 kHz	25.0 kHz
W1W	38.509 kHz	41.0 kHz	50.0 kHz



101.111 Emission limitations

As this transmitter uses digital modulation in the 900 MHz multiple address frequencies with 10 kHz, 20.0 kHz and 41.0 kHz authorised bandwidths the emission masks as per section 101.111 (a) (5) and (6) have been applied.

The reference level for the following emission mask measurements has been determined when the transmitter was transmitting an un-modulated carrier using a spectrum analyser using the appropriate spectrum mask resolution bandwidth that is described below.

All spectrum mask measurements have been made using spectrum analyser operating in average mode with the transmitter operating on 952.025 MHz.

When spectrum mask measurements were made the transmitter was modulated using modulation sources internal to the transmitter as supplied by the client.

In the absence of prescribed measurements resolution bandwidths, spectrum mask measurements have been made using a resolution bandwidth of 1% of the declared authorised bandwidths.

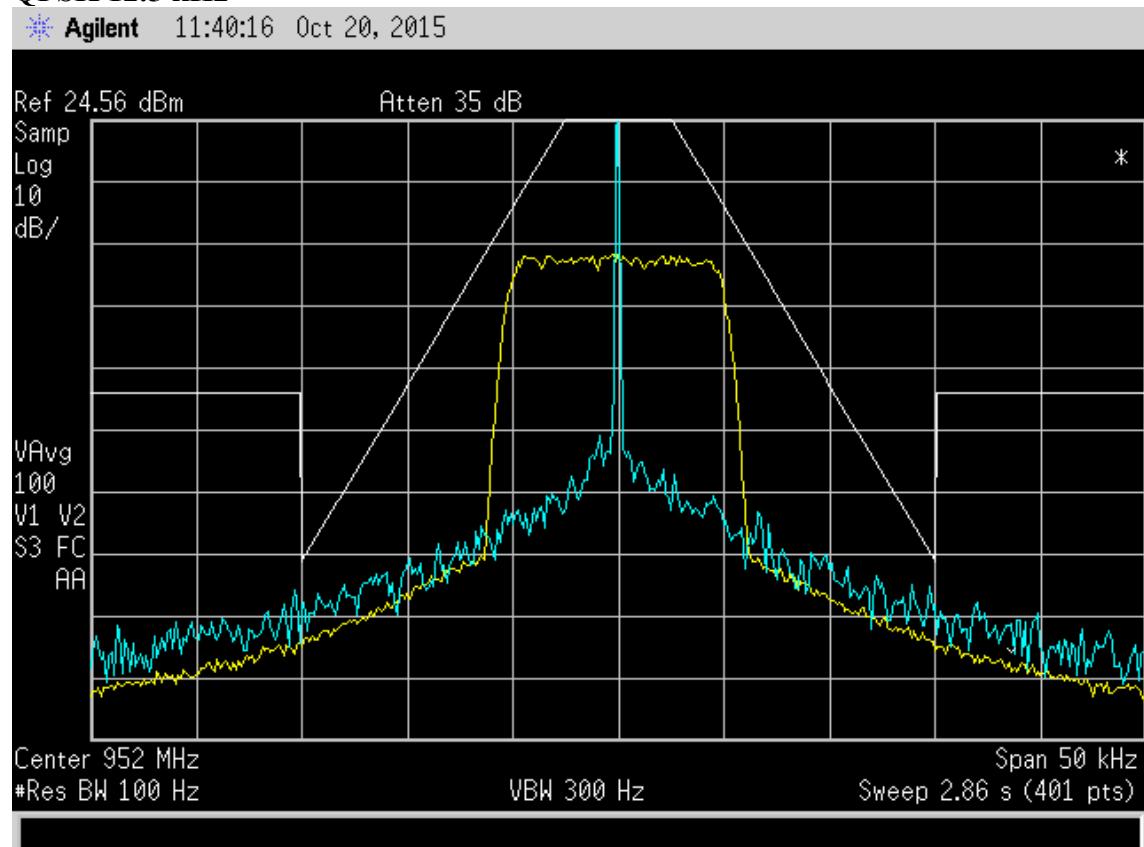
When the 12.5 kHz channel bandwidth mask (a)(5) was applied a 100 Hz resolution bandwidth was used (1% of 10 kHz = 100 Hz).

When the 25.0 kHz channel bandwidth mask (a)(6) was applied a 200 Hz resolution bandwidth was used (1% of 20 kHz = 200 Hz)

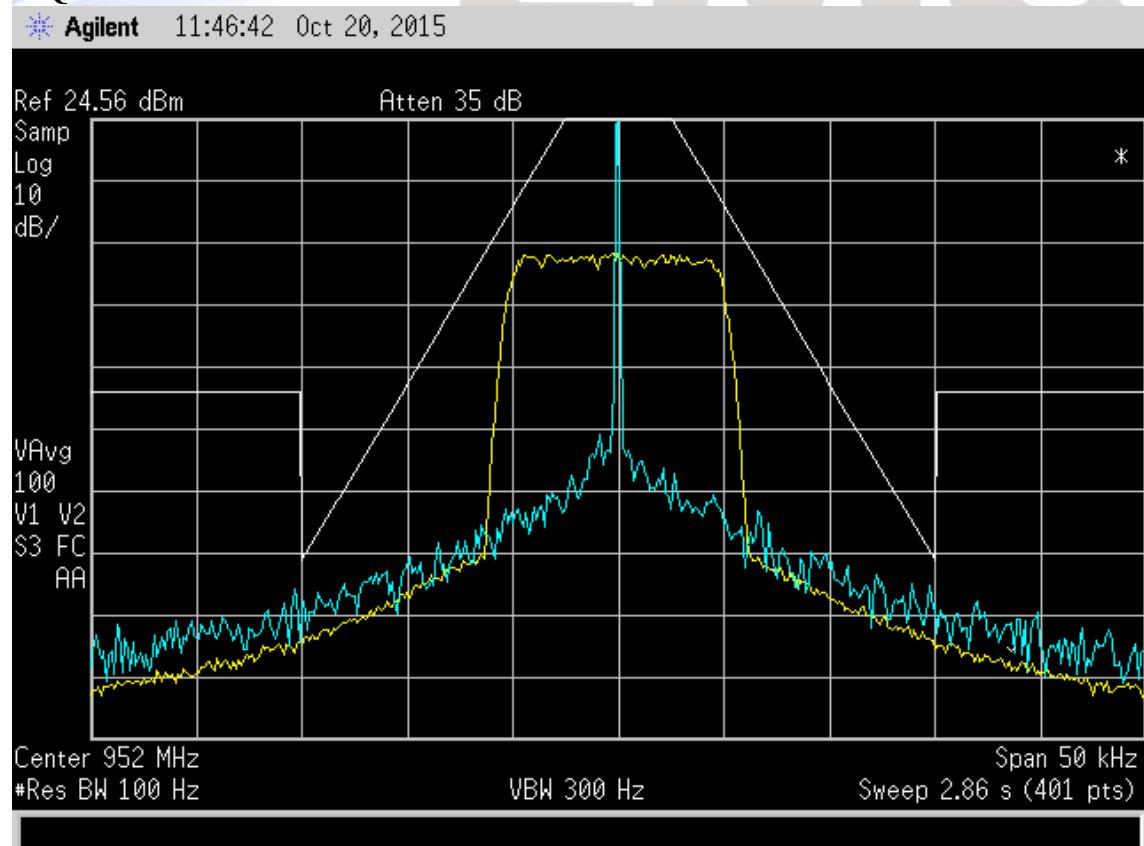
When the 50.0 kHz aggregated channel bandwidth mask (a)(6) was applied a 300 Hz resolution bandwidth was applied (1% of 41 kHz = 410 Hz. Spectrum analyser has 300 Hz or 1 kHz settings so 300 Hz was used as it was closer).

Result: Complies.

QPSK 12.5 kHz

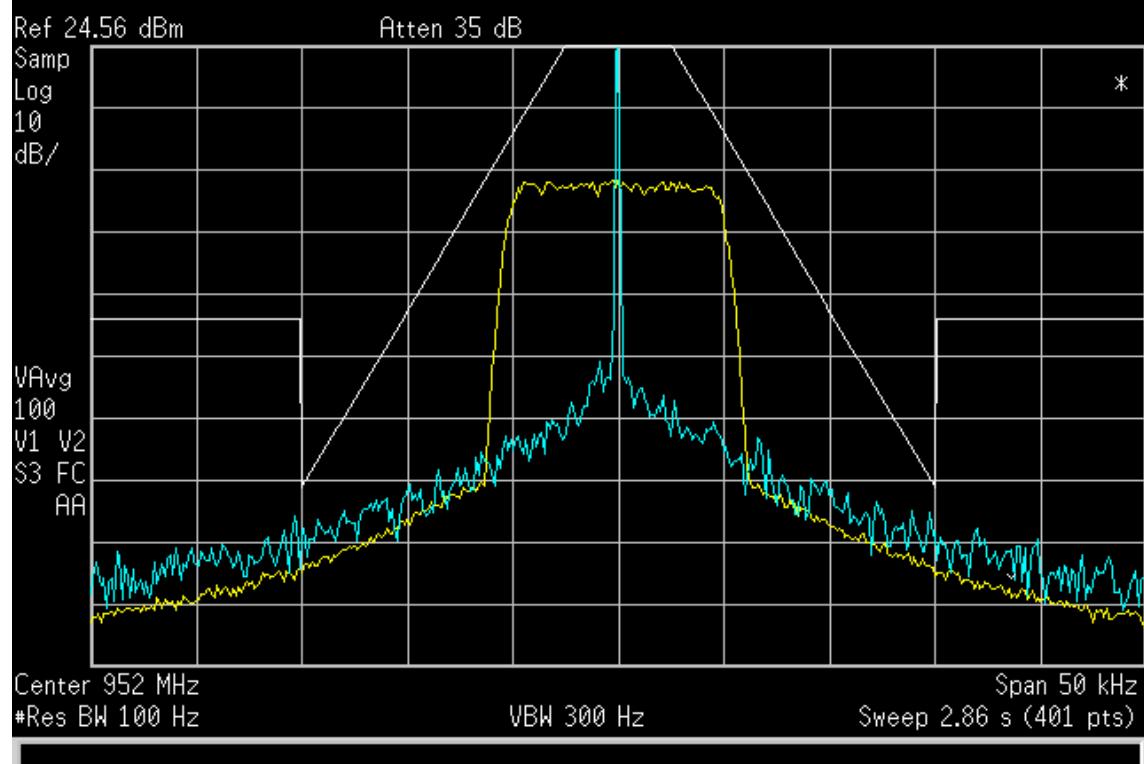


16QAM 12.5 kHz



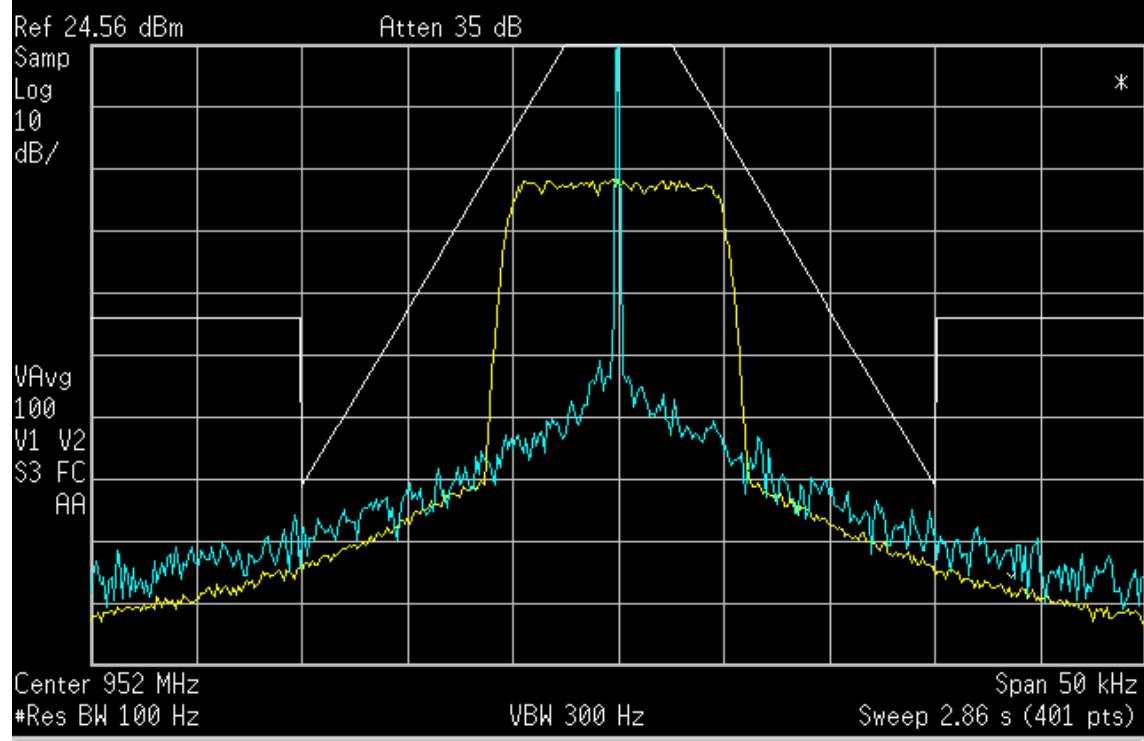
64QAM 12.5 kHz

* Agilent 11:56:37 Oct 20, 2015

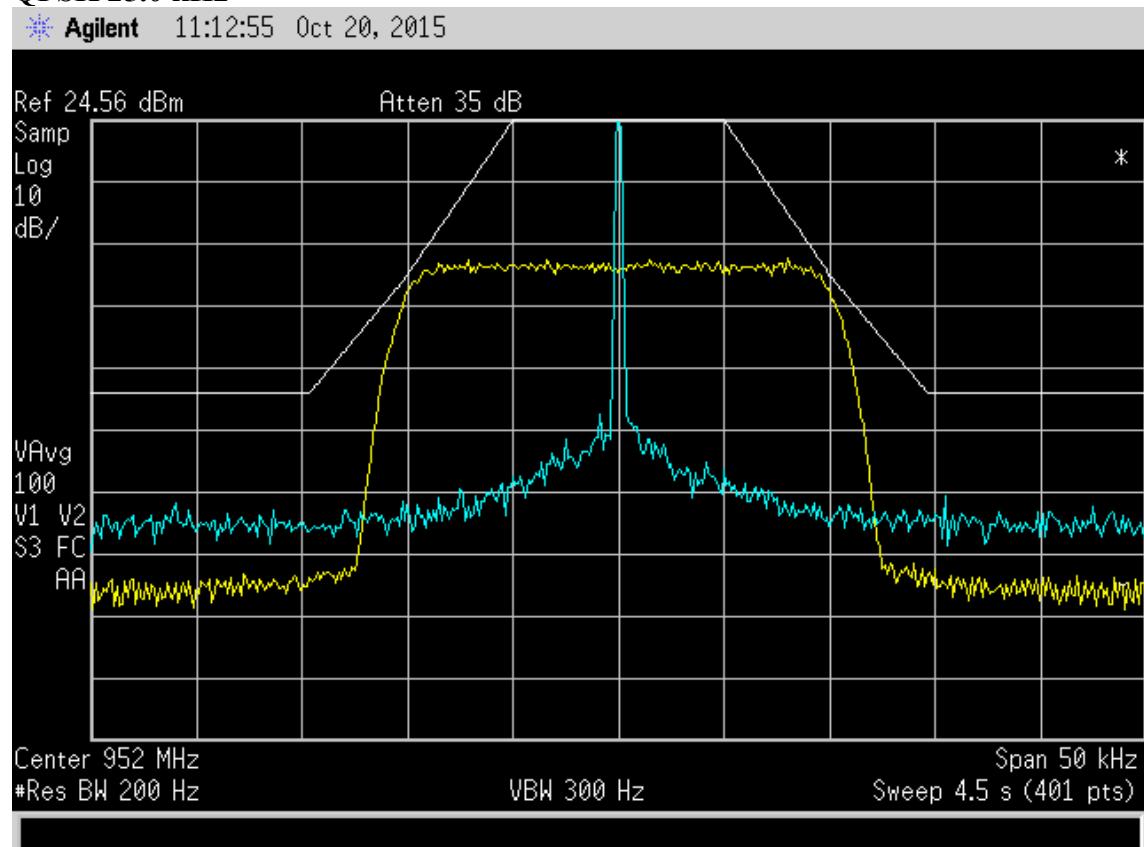


256QAM 12.5 kHz

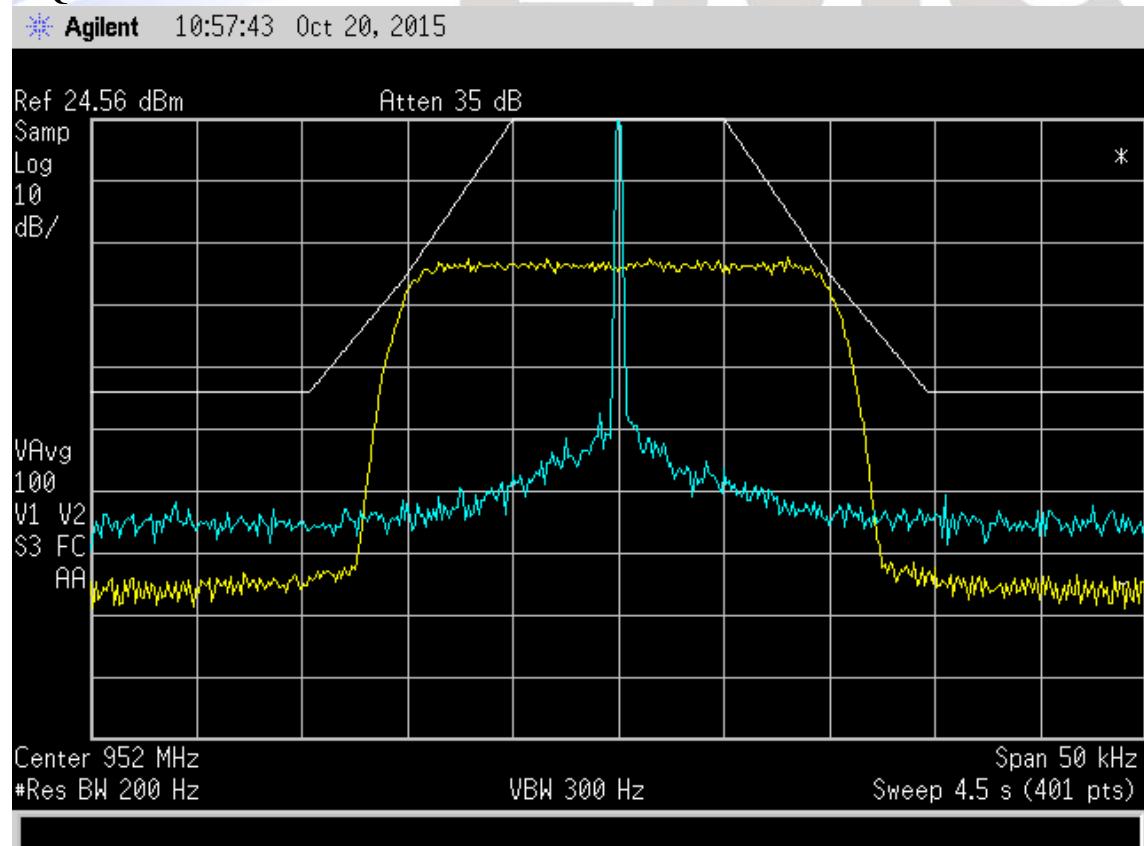
* Agilent 12:05:29 Oct 20, 2015



QPSK 25.0 kHz

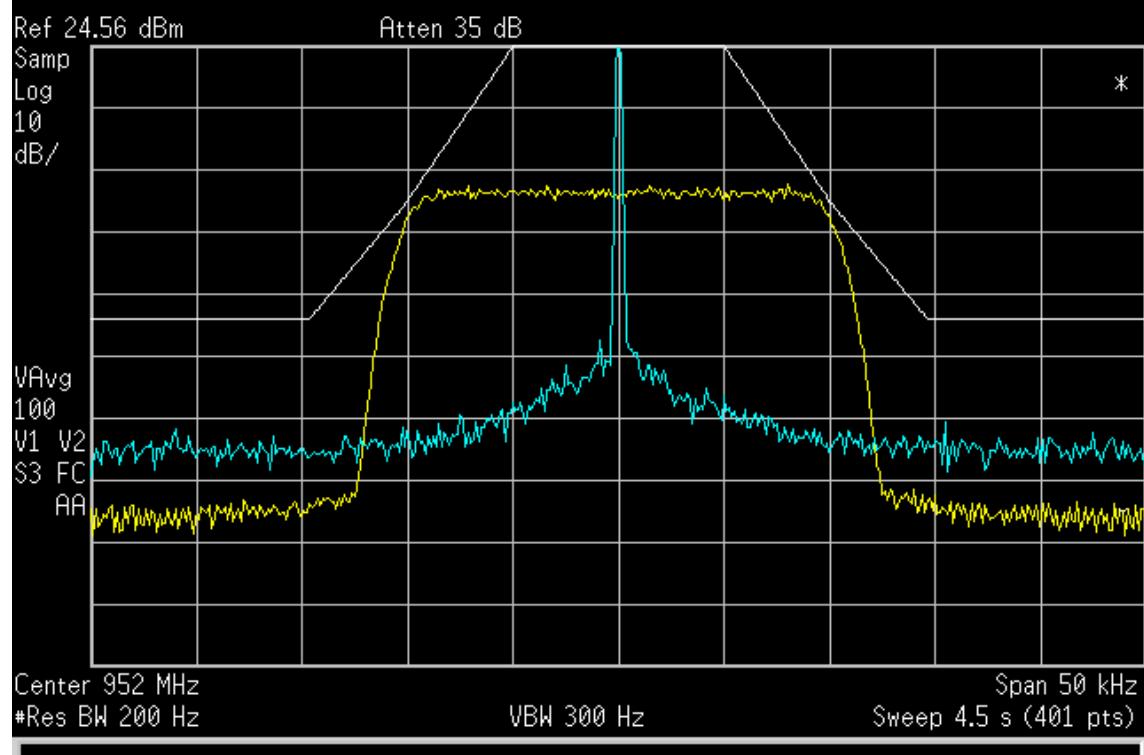


16QAM 25.0 kHz



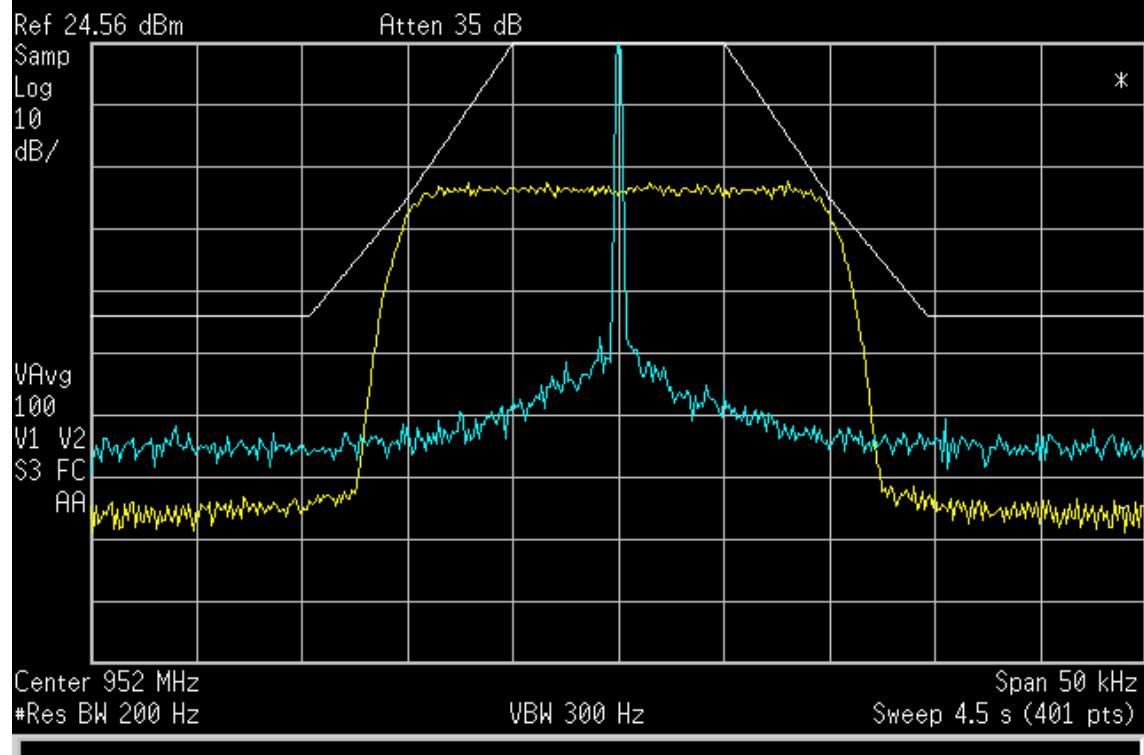
64QAM 25.0 kHz

* Agilent 10:50:06 Oct 20, 2015

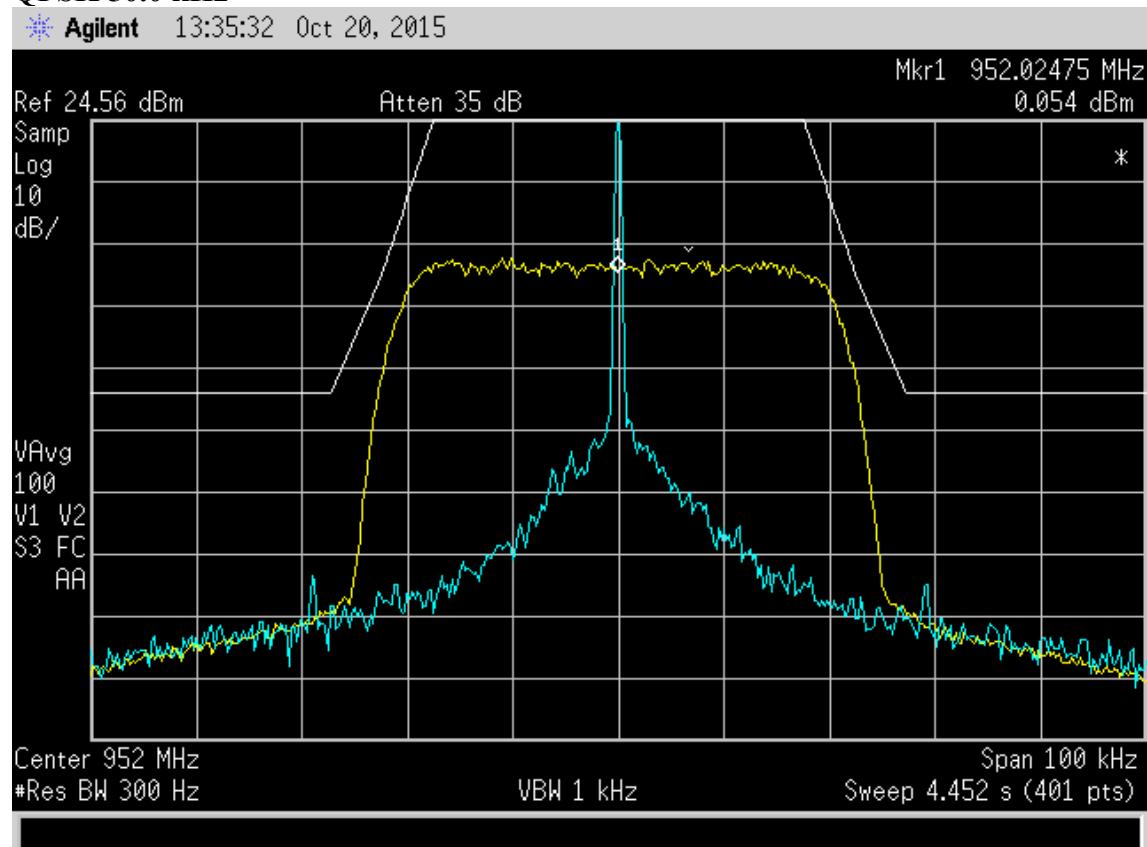


256QAM 25.0 kHz

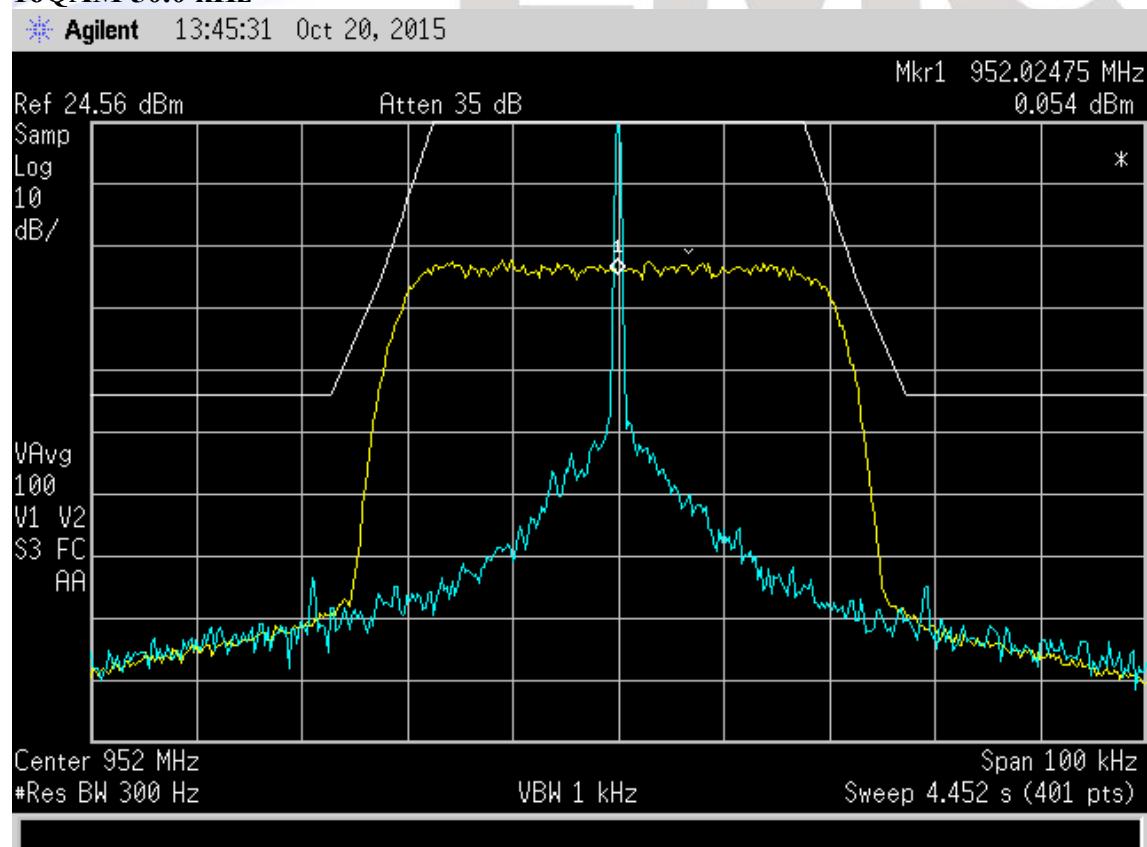
* Agilent 11:26:31 Oct 20, 2015



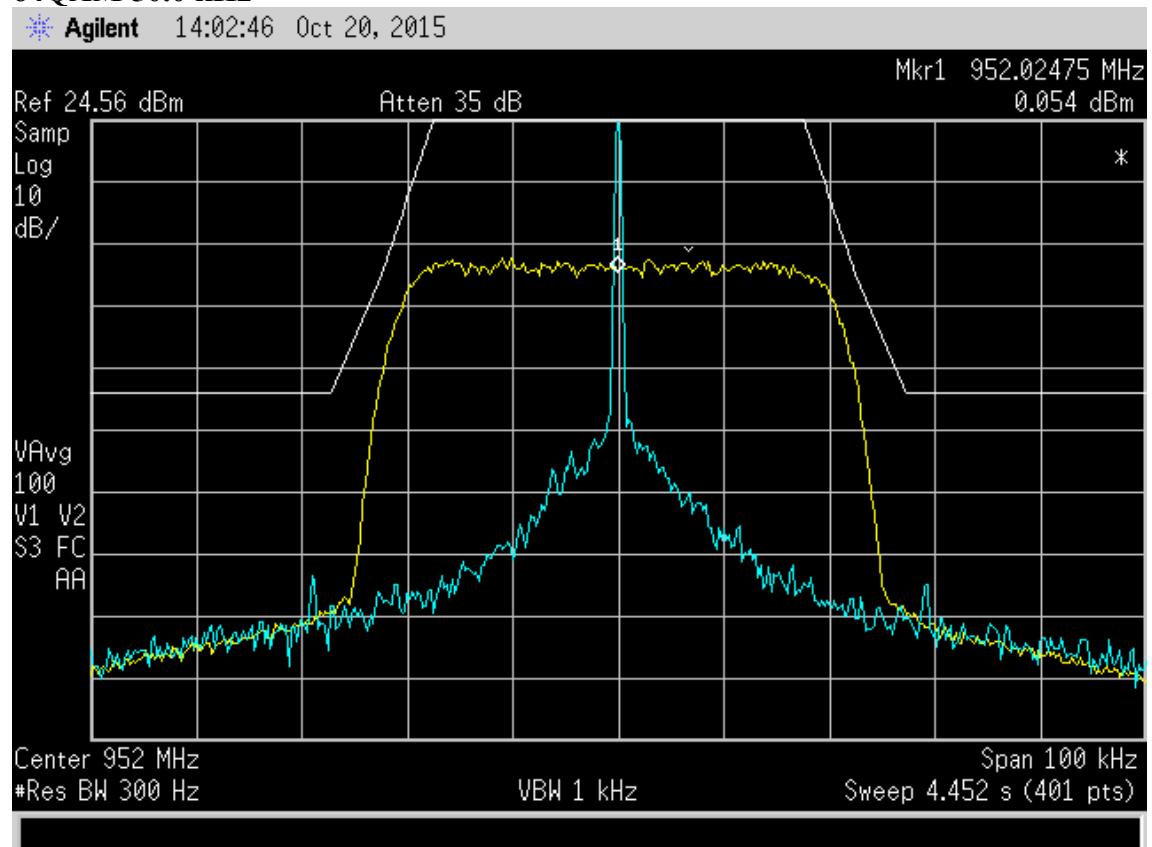
QPSK 50.0 kHz



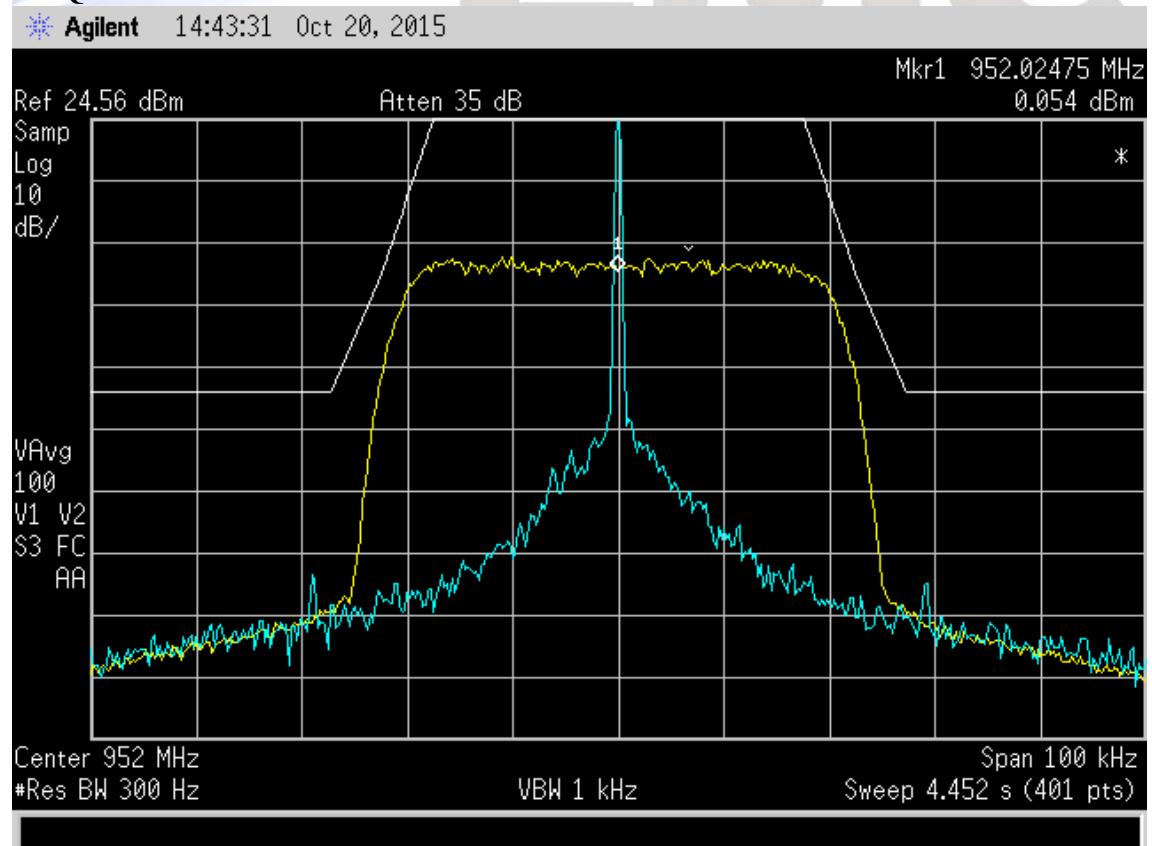
16QAM 50.0 kHz



64QAM 50.0 kHz



256QAM 50.0 kHz



Transmitter unwanted emissions – antenna terminal

As per section 2.1051 spurious emission measurements were made at the antenna port of the transmitter.

The spectrum analyser bandwidth was set to 100 kHz for measurements below 1 GHz and 1 MHz for measurements above 1 GHz.

Frequency: 952.025 MHz

Spurious emission (MHz)	Emission level (dBm)	Limit (dBm)
1904.050	-60.0 *	-20.0
2856.075	-60.0 *	-20.0
3808.100	-60.0 *	-20.0
4760.125	-60.0 *	-20.0
5712.150	-60.0 *	-20.0
6664.175	-60.0 *	-20.0
7616.200	-60.0 *	-20.0
8568.225	-60.0 *	-20.0
9520.250	-60.0 *	-20.0

* no emission present – noise floor measurement

Testing was carried out using 12.5 kHz, 25.0 kHz and 50 kHz channel bandwidths with identical results being obtained.

Limit:

Section 101.111 (a)(5) states that on any frequency removed from the centre of the authorised bandwidth by a displacement frequency of more than 12.5 kHz shall be attenuated by at least $50 + 10 \log (P)$ or 70 dB whichever is the lesser attenuation.

All spurious emissions are to be attenuated by at least $50 + 10 \log (P)$. The rated power of 24 dBm gives a limit of -20 dBm.

The spectrum has been investigated up to the 10th harmonic of the transmitter.

Result: Complies

Measurement Uncertainty: ± 3.3 dB

Field strength of the transmitter spurious emissions

Testing was carried out then the transmitter was transmitting continuously with a dummy load attached to each of the transmitter output ports.

When operating in transmit mode no significant emissions were detected between the harmonic emissions that were detected.

Testing was carried out at EMC Technologies NZ Ltd Open Area Test Site over a distance of 3 metres which has been filed with the Commission, Registration Number: 90838.

The level recorded is the signal generator output level in dBm less any gains / losses due to the coax cable and the dipole antenna.

Frequency: 952.025 MHz

Frequency (MHz)	Level (dB μ V/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)
1904.0500	49.1	-48.3	-20.0	Vertical	28.3
	44.5	-52.9	-20.0	Horizontal	32.9
2856.0750	48.5	-48.9	-20.0	Vertical	28.9
	48.1	-49.3	-20.0	Horizontal	29.3
3808.1000	52.0 *	-45.4	-20.0	Vertical	25.4
	52.0 *	-45.4	-20.0	Horizontal	25.4
4760.1250	54.0 *	-43.4	-20.0	Vertical	23.4
	54.0 *	-43.4	-20.0	Horizontal	23.4
5712.1500	58.0 *	-39.4	-20.0	Vertical	19.4
	58.0 *	-39.4	-20.0	Horizontal	19.4
6664.1750	60.0 *	-37.4	-20.0	Vertical	17.4
	60.0 *	-37.4	-20.0	Horizontal	17.4
7616.2000	54.5 *	-42.9	-20.0	Vertical	22.9
	54.5 *	-42.9	-20.0	Horizontal	22.9
8568.2250	56.5 *	-40.9	-20.0	Vertical	20.9
	56.5 *	-40.9	-20.0	Horizontal	20.9
952.0250	58.0 *	-39.4	-20.0	Vertical	19.4
	58.0 *	-39.4	-20.0	Horizontal	19.4

* no emission present – noise floor measurement

Testing was carried out using 12.5 kHz, 25.0 kHz and 50 kHz channel bandwidths with identical results being obtained.

Limit:

All spurious emissions are to be attenuated by at least $50 + 10 \log (P)$. The rated power of +24 dBm gives a limit of -20 dBm.

The spectrum has been investigated up to the 10th harmonic of the transmitter.

Result: Complies

Measurement Uncertainty: ± 4.1 dB

101.113 Transmitter power limitations

Output power test

Measurements were carried out at the RF output terminals of the transmitter using a spectrum analyser with a 120 kHz resolution bandwidth with measurements made using an average when the transmitter was modulated using the various modulation modes.

The rated output power is 0.5 Watt (+24 dBm) average to each of the transmitter output ports.

Testing was carried out on both output ports with the supply voltage being varied when the device was operating on 952.025 MHz with the levels being recorded directly in dBm.

Test Frequency: 952.0250 MHz

Vertical output port: QPSK in Average

Channel bandwidth	Voltage 10.5 (Vdc)	Voltage 24.0 (Vdc)	Voltage 60.0 (Vdc)
12.5 kHz	24.6	24.6	24.6
25.0 kHz	24.6	24.6	24.6
50.0 kHz	24.6	24.6	24.6

Horizontal output port: QPSK in Average

Channel bandwidth	Voltage 10.5 (Vdc)	Voltage 24.0 (Vdc)	Voltage 60.0 (Vdc)
12.5 kHz	24.6	24.6	24.6
25.0 kHz	24.6	24.6	24.6
50.0 kHz	24.6	24.6	24.6

The above results show that a variation in supply voltage does not vary the output power and the output power on each port is identical.

Measurements were then made on just the Horizontal port.

Horizontal output port: QAM16 in Average

Channel bandwidth	Voltage 10.5 (Vdc)	Voltage 24.0 (Vdc)	Voltage 60.0 (Vdc)
12.5 kHz	24.5	24.5	24.5
25.0 kHz	24.5	24.5	24.5
50.0 kHz	24.5	24.5	24.5

Horizontal output port: QAM64 in Average

Channel bandwidth	Voltage 10.5 (Vdc)	Voltage 24.0 (Vdc)	Voltage 60.0 (Vdc)
12.5 kHz	24.5	24.5	24.5
25.0 kHz	24.5	24.5	24.5
50.0 kHz	24.5	24.5	24.5

Horizontal output port: QAM256 in Average

Channel bandwidth	Voltage 10.5 (Vdc)	Voltage 24.0 (Vdc)	Voltage 60.0 (Vdc)
12.5 kHz	24.5	24.5	24.5
25.0 kHz	24.5	24.5	24.5
50.0 kHz	24.5	24.5	24.5

Measurements were made to show that the declared power output of the transmitter measured power was within +/- 1 dB of the measured output power (+24.0 dBm).

A power limit of +40.0 dBW EIRP per polarisation applies to Fixed Equipment operating in the 952.0 - 960.0 MHz band.

Result: Complies

Measurement Uncertainty: ±0.5 dB



Radio Frequency Hazard Information

As per FCC KDB 447498 D01 and Section 2.1091 radio frequency transmitters are required to be operated in a manner that ensures the public is not exposed to RF energy levels.

Calculations have been made using the General Public/Uncontrolled Exposure limits that are defined in Section 1.1310.

Minimum safe distances have been calculated below.

As this radio can operate over the range of 928 – 960 MHz the lowest frequency of operation in the USA, which will give the worst case result, would be 928 MHz.

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

- General Population / Uncontrolled exposure limit will be 0.619 mW/cm²
(f/1500 = 928 MHz/1500)

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

$$\text{Power Density} = 0.63 \text{ mW/cm}^2 = E^2/3770$$

$$E = \sqrt{0.619 * 3770}$$

$$E = 48.3 \text{ V/m}$$

The rated maximum transmitter power = 0.25 watts (+24 dBm).

A duty cycle of 100% as the transmitter is a base station could possibly be operated for long periods of time.

The client has declared that this transmitter can be operated using a range of antennas with various gains, as detailed in the table below.

Antenna Type	Gain (dBi)	Max Gain (G)	Safe Distance (Metres)	Safe Distance (cm)
Panel Antenna	16.0	39.8	0.359	35.8
	12.5	17.8	0.239	23.9
	10.0	10.0	0.179	17.9
Omni Directional	8.0	6.3	0.142	14.2
	5.0	3.2	0.101	10.1

A sample calculation for the safe distance would be:

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

$$d = \sqrt{(30 * 0.25 * 39.8 * 1.0) / 48.3}$$

$$d = 0.358 \text{ metres or } 35.8 \text{ cm}$$

Result: Complies if the safe distances defined above are applied.

8. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial #	Asset	Cal Due	Period
Aerial Controller	EMCO	1090	9112-1062	RFS 3710	N/a	N/a
Aerial Mast	EMCO	1070-1	9203-1661	RFS 3708	N/a	N/a
Biconical Antenna	Schwarzbeck	BBA 9106	9594	RFS 3696	03/02/18	3 years
Log Periodic	Schwarzbeck	VUSLP9111	9111-228	RFS 3785	01/12/17	3 years
Horn Antenna	EMCO	3115	9511-4629	E1526	04/07/17	3 years
Power Attenuator	Weinschel	49-20-43	GC104	E1308	N/a	N/a
Power Supply	Hewlett Packard	6032A	2743A-02859	E1069	N/a	N/a
RF Power Meter	Hewlett Packard	HP 436A	2512A22439	E1198	12/08/16	1 year
Spectrum Analyser	Hewlett Packard	E7405A	US39150142	RFS 3776	07/10/15	1 year
Measuring Receiver	Rhode & Schwarz	ESIB-40	100171	EMC4003	16/04/16	1 year
Thermal chamber	Contherm	M180F	86025	E1129	N/a	N/a
Thermometer	DSIR	RT200	035	E1049	N/a	N/a
Turntable	EMCO	1080-1-2.1	9109-1578	RFS 3709	N/a	N/a

9. ACCREDITATIONS

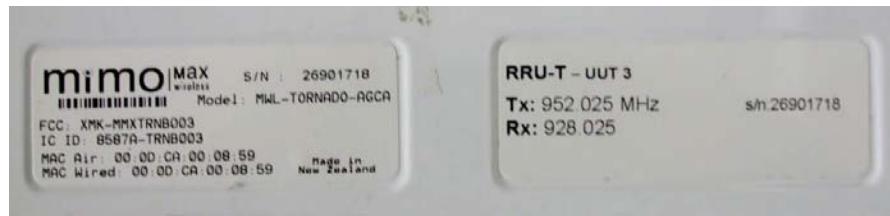
Testing was carried out in accordance with EMC Technologies Ltd registration with the Federal Communications Commission as a listed facility, registration number: 90838, which was updated in June 2014.

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.

10. PHOTOGRAPHS



Radiated emissions setup photos



