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TEST REPORT

4RF SR+ SQ928M140 Point to Multi-point Digital Radio

tested to the

Code of Federal Regulations (CFR) 47

Part 101 –Fixed Microwave Services

for

4RF Limited

This Test Report is issued with the authority of:

Andrew Cutler - General Manager

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

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1. COMPLIANCE STATEMENT

The **4RF SR+ SQ928M140 Point to Multi-point Digital Radio** complies with the limits defined in 47 CFR Part 101 and 47 CFR Part 2 when tested in-accordance with the test methods described in 47 CFR Part 2 and ANSI C63.4, 2002.

2. RESULT SUMMARY

The results of testing, carried out between 31st March and 7th April 2014, are summarised below.

Clause	Description	Result
2.1055 101.107	Frequency stability Frequency tolerance	Noted Complies
2.1049 2.202 101.109 101.111	Occupied bandwidth Bandwidths Bandwidth Emission limitations	Noted Noted Complies Complies
2.1046 101.113 (a)	RF power output Power and antenna height limits	Noted Noted
2.1051	Spurious emissions at antenna terminals	Complies
2.1053	Field strength of spurious radiation	Complies

3. 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.

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

To the best of my knowledge, these tests were performed using measurement procedures that are consistent with industry or Commission 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

4. CLIENT INFORMATION

Company Name	4RF Limited
Address	26 Glover Street Ngauranga Wellington
Country	New Zealand
Contact	Mr Paul Young

5. TEST SAMPLE DESCRIPTION

Brand Name	Aprisa SR+
Model Number	SQ928M140
Product	Point to Multi Point Digital Radio
Manufacturer	4RF Limited
Manufactured in	New Zealand
Designed in	New Zealand
Serial Numbers	-
FCC ID	UIPSQ928M140

The sample tested has the following specifications:

Rated Transmitter Output Power

5.0 Watts (37.0 dBm)

Transmitter FCC frequency ranges

928.0 - 929.0 MHz
932.0 - 932.5 MHz
932.5 - 935.0 MHz
941.0 - 941.5 MHz
941.5 - 944.0 MHz
952.0 - 960.0 MHz

Test frequencies

Frequency (MHz)	Power (Watts)	Spacing (kHz)
928.525	5.0	12.5, 25.0, 50.0
942.525	5.0	12.5, 25.0, 50.0
952.525	5.0	12.5, 25.0, 50.0

Emission Designators / Modes of operation

G1D and D1D emissions designators have been applied when the transmitter uses 12.5, 25.0 and 50 kHz channel spacing.

G1D emission designator is applied when QPSK modulation is utilised

D1D emission designator is applied when 16QAM and 64QAM modulation is utilised

Power Supply

The equipment is powered using an external DC supply.

Standard Temperature and Humidity

Temperature: +15°C to + 30°C maintained.
Relative Humidity: 20% to 75% observed.

Standard Test Power Source

Nominal Voltage: 13.8 V dc.
Standard Test Voltage: 13.8 V dc.

Extreme Temperature

High Temperature: + 50°C maintained.
Low Temperature: - 30°C maintained.

Extreme Test Voltages

High Voltage: 30.0 Vdc
Low Voltage: 10.0 Vdc

6. TEST RESULTS

Frequency Stability

Frequency stability 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.

Nominal Frequency: 942.525 MHz

Temperature (°C)	Voltage (10.8 Vdc)	Voltage (13.8 Vdc)	Voltage (15.6 Vdc)
+50	-33.0 Hz	-36.0 Hz	-36.0 Hz
+40	-30.0 Hz	-31.0 Hz	-31.0 Hz
+30	+33.0 Hz	+32.0 Hz	+33.0 Hz
+20	+30.0 Hz	+28.0 Hz	+28.0 Hz
+10	+116.0 Hz	+116.0 Hz	+118.0 Hz
0	+101.0 Hz	+103.0 Hz	+105.0 Hz
-10	+95.0 Hz	+95.0 Hz	+96.0 Hz
-20	+209.0 Hz	+208.0 Hz	+208.0 Hz
-30	+228.0 Hz	+227.0 Hz	+229.0 Hz

Limit:
Part 101.107 states that transmitters operating in the following bands must meet the associate frequency tolerances,

Frequency (MHz)	Frequency Tolerance (%)
928.0 to 929.0	0.00050
932.0 to 932.5	0.00015
932.5 to 935.0	0.00025
941.0 to 941.5	0.00015
941.5 to 944.0	0.00025
952.0 to 960.0	0.00050

A worst case frequency tolerance of 1.5 ppm (0.00015%) has been applied to this transmitter.

The transmitter was tested on 942.525 MHz.

1.5 ppm = 1.5 x = 1414 Hz.

The worst case observed was +229 Hz = 0.24 ppm

Result: Complies.
Measurement Uncertainty: ± 30 Hz.

Modulation types:

The following emission types are used:

- G1D digital data when QPSK modulation is utilised

- D1D digital data when 16QAM or 64QAM modulation is utilised

Part 101.109 Bandwidth:

The authorised bandwidth is taken to be the necessary bandwidth.

Measurements have been made to verify the declared bandwidth.

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 a 30 dB attenuator.

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 23 dB (99%) absolute bandwidth points determined.

Nominal Frequency: 942.525 MHz

Emission	Channel (kHz)	Measured (kHz)	Authorised Bandwidth (kHz)
QPSK	12.5	10.950	12.5
16QAM	12.5	10.750	12.5
64QAM	12.5	10.650	12.5
QPSK	25.0	19.350	20.0
16QAM	25.0	18.375	20.0
64QAM	25.0	18.075	20.0
QPSK	50.0	40.750	45.0
16QAM	50.0	37.750	45.0
64QAM	50.0	36.500	45.0

Result: Complies.

101.111 Emission Limitations

When using transmissions employing digital modulation techniques on the 900 MHz multiple address frequencies with a 12.5 KHz bandwidth, the power of any emission must be attenuated below the unmodulated carrier power of the transmitter (P) in accordance with the following schedule:

(i) On any frequency removed from the centre of the authorized bandwidth by a displacement frequency (fd in KHz) of more than 2.5 KHz up to and including 6.25 KHz: At least 53 $\log_{10}$ (fd/2.5) decibels;

(ii) On any frequency removed from the centre of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 6.25 KHz up to and including 9.5 KHz: At least 103 $\log_{10}$ (fd/3.9) decibels;

(iii) On any frequency removed from the centre of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 9.5 kHz up to and including 15 kHz: At least 157 $\log_{10}$ (fd/5.3) decibels; and

(iv) On any frequency removed from the centre of the authorized bandwidth by a displacement frequency greater than 15 kHz: At least 50 plus 10 $\log_{10}$(P) or 70 decibels, whichever is the lesser attenuation.

When using transmissions employing digital modulation techniques on the 900 MHz multiple address frequencies with a bandwidth greater than 12.5 kHz, the power of any emission must be attenuated below the unmodulated carrier power of the transmitter (P) in accordance with the following schedule:

(i) On any frequency removed from the centre of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5 kHz up to and including 10 kHz: At least 83 $\log_{10}$ (fd/5) decibels;

(ii) On any frequency removed from the centre of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 10 kHz up to and including 250 percent of the authorized bandwidth: At least 116 $\log_{10}$ (fd/6.1) decibels or 50 plus 10 $\log_{10}$ (P) or 70 decibels, whichever is the lesser attenuation; and

(iii) On any frequency removed from the centre of the authorized bandwidth by more that 250 percent of the authorized bandwidth: At least 43 plus 10 $\log_{10}$ (output power in watts) decibels or 80 decibels, whichever is the lesser attenuation.

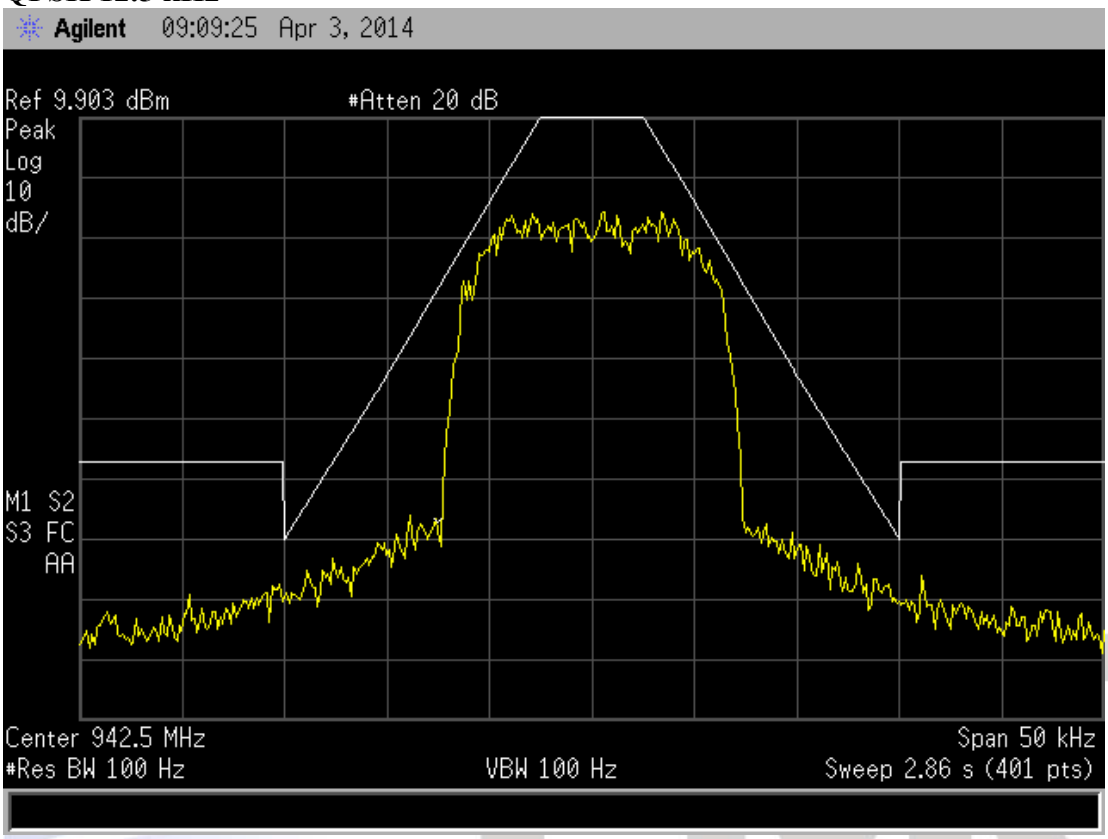
Measurements have been made of each modulation type using a spectrum analyser operating in peak hold mode and a 30 dB attenuator.

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

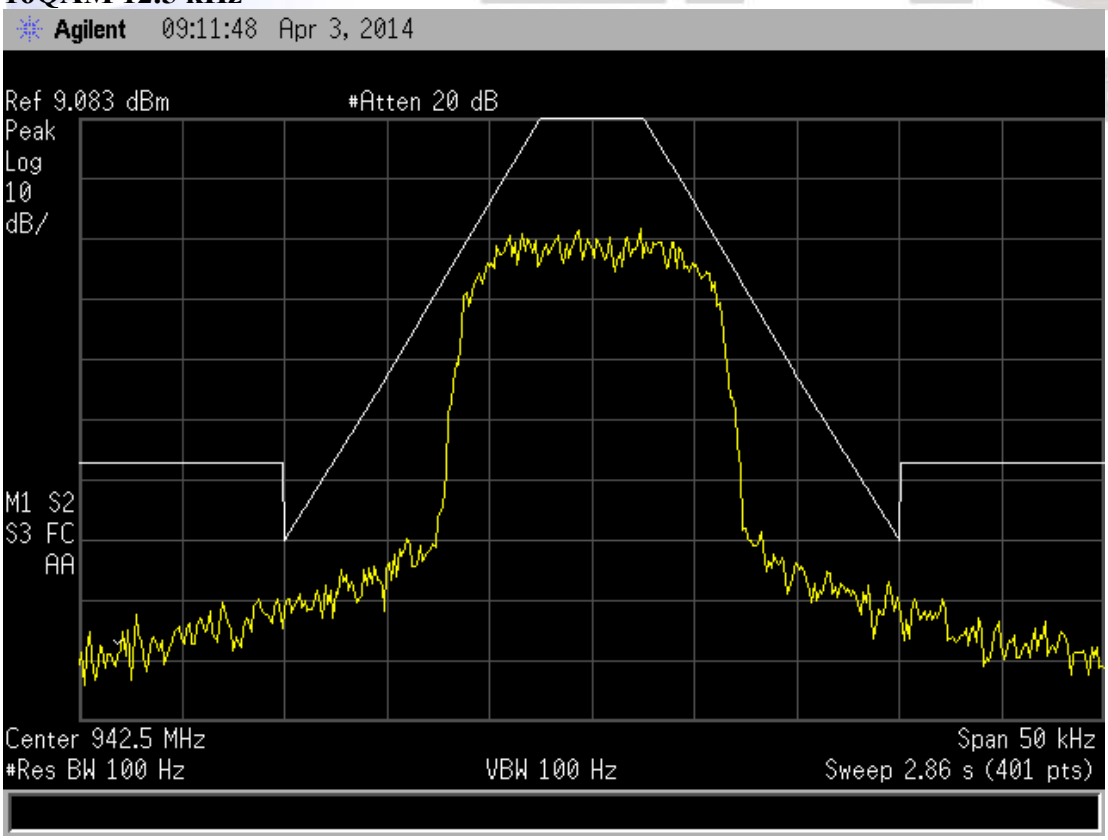
This level is used as a reference level on the spectrum analyser.

Nominal Frequency: 942.525 MHz

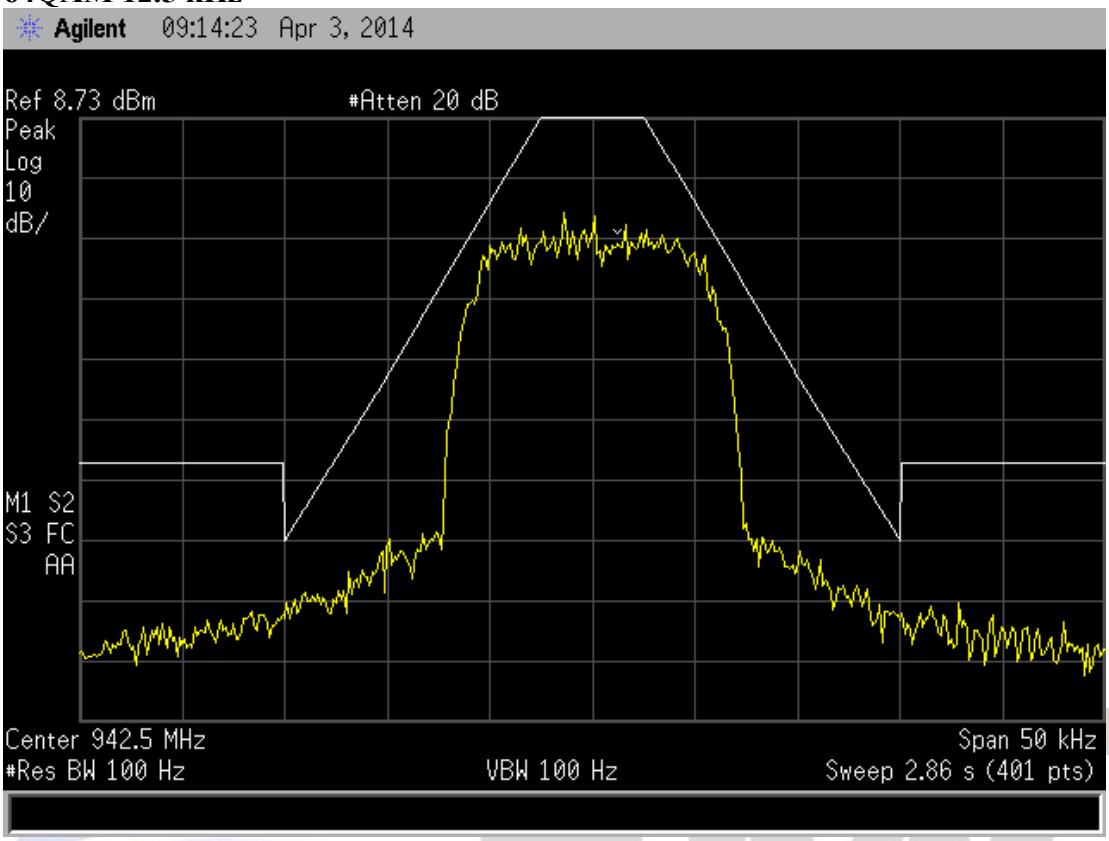
QPSK 12.5 kHz



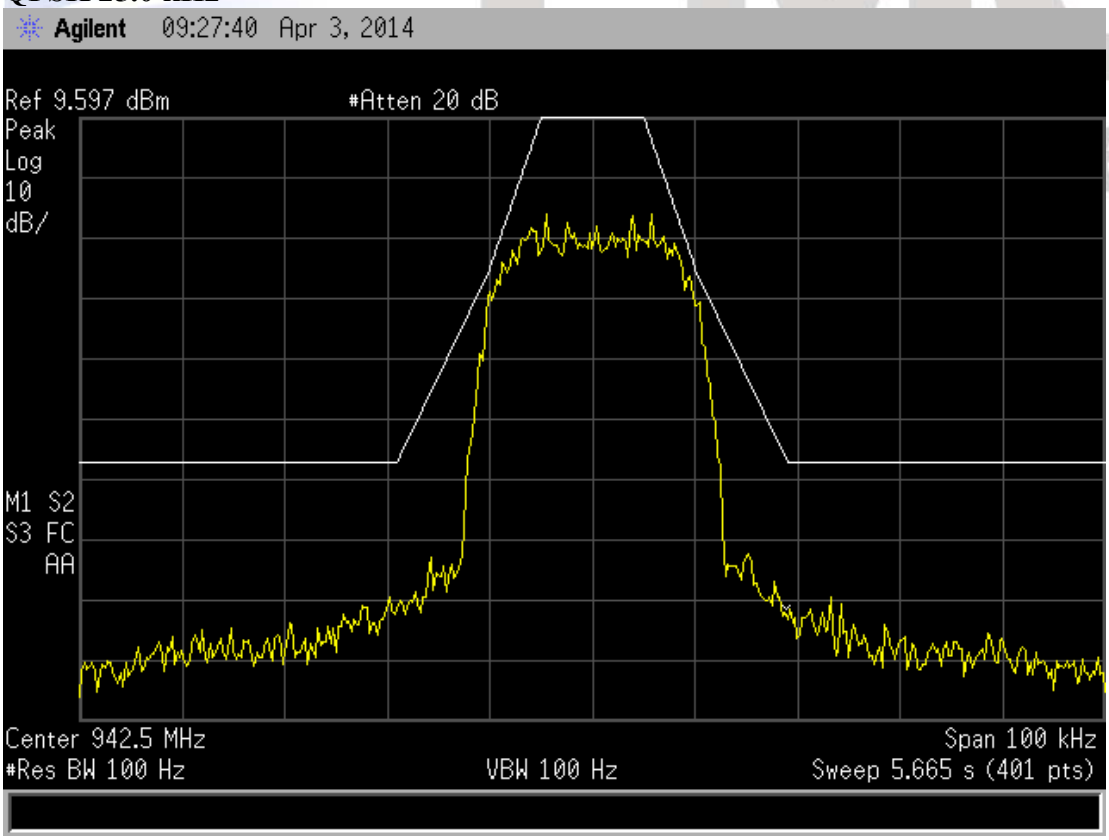
16QAM 12.5 kHz



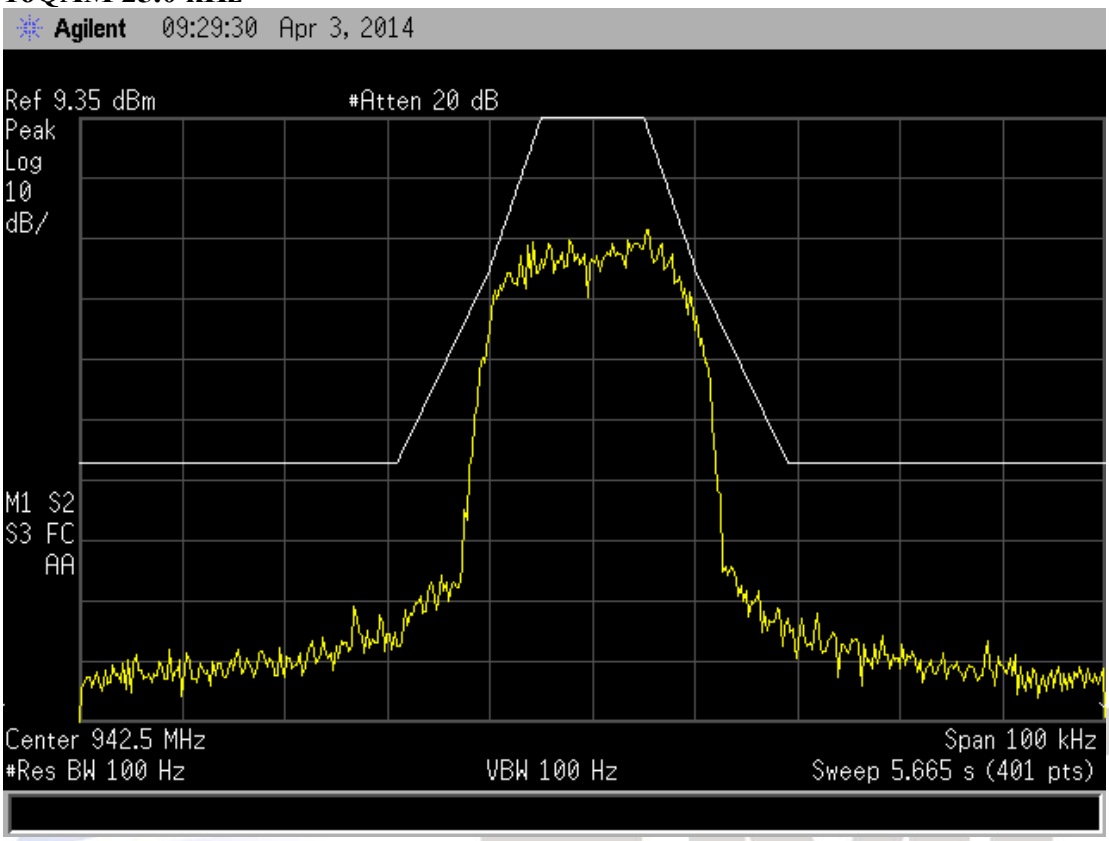
64QAM 12.5 kHz



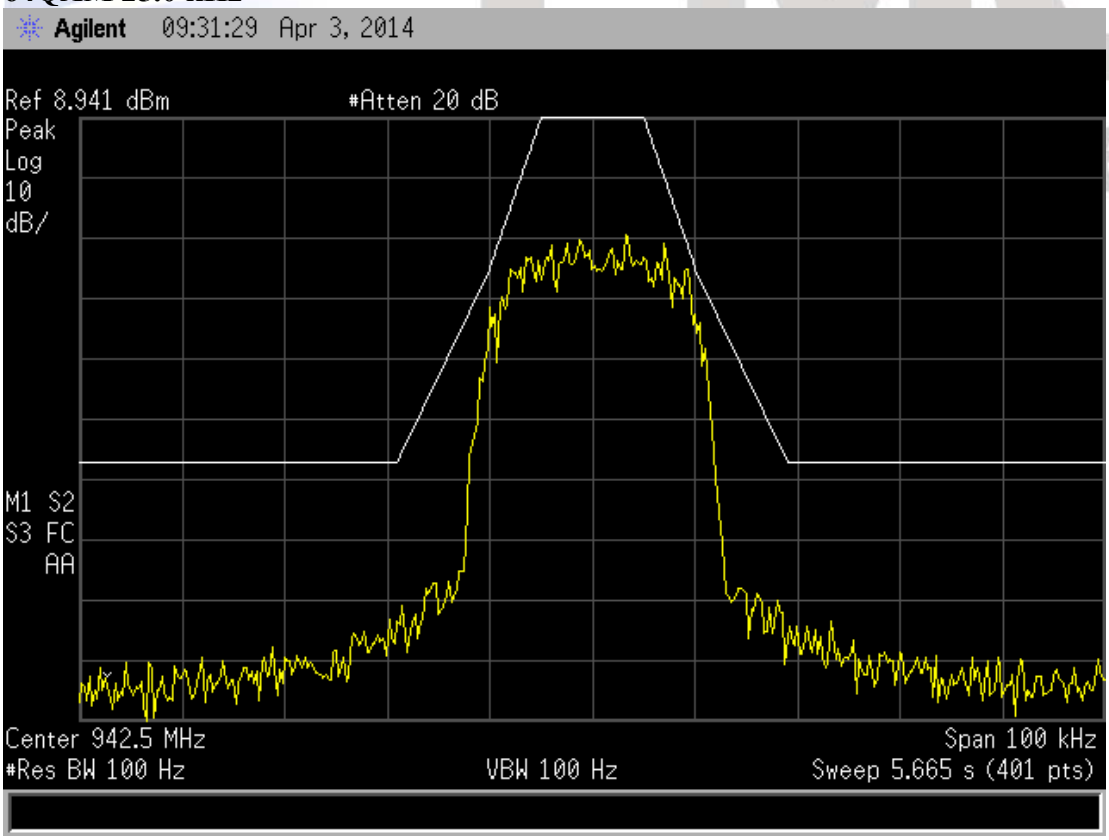
QPSK 25.0 kHz



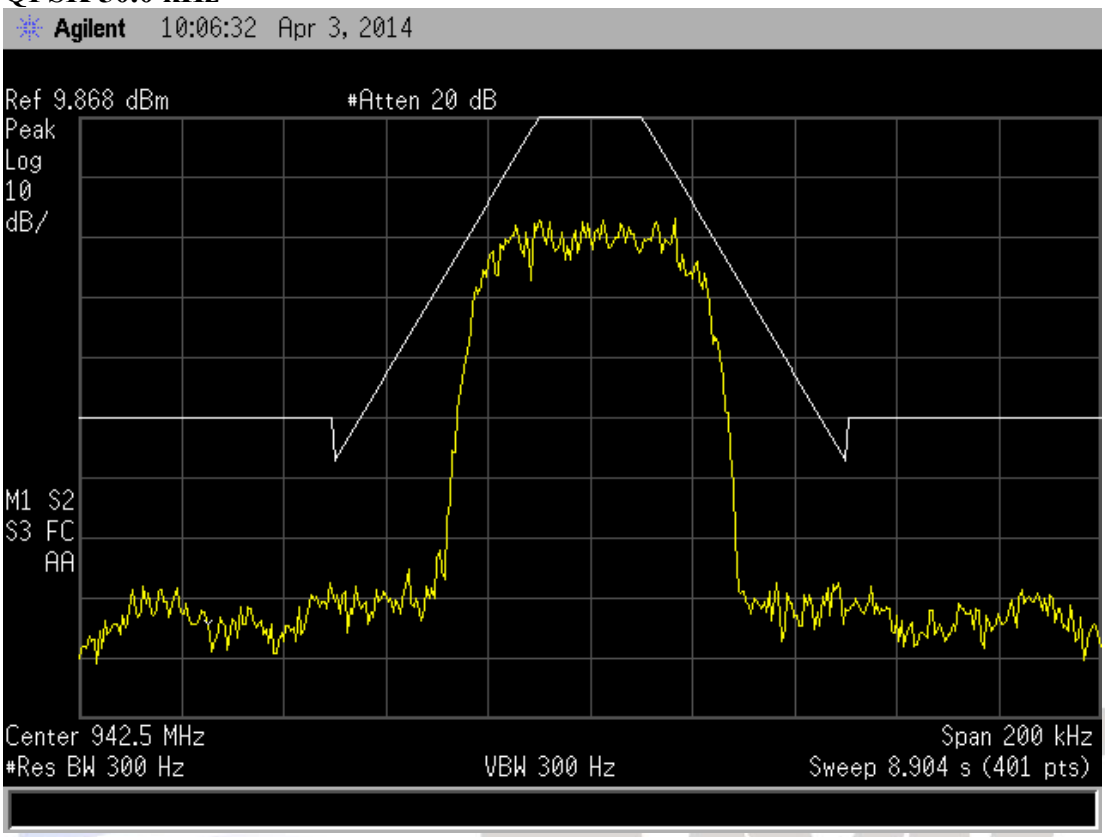
16QAM 25.0 kHz



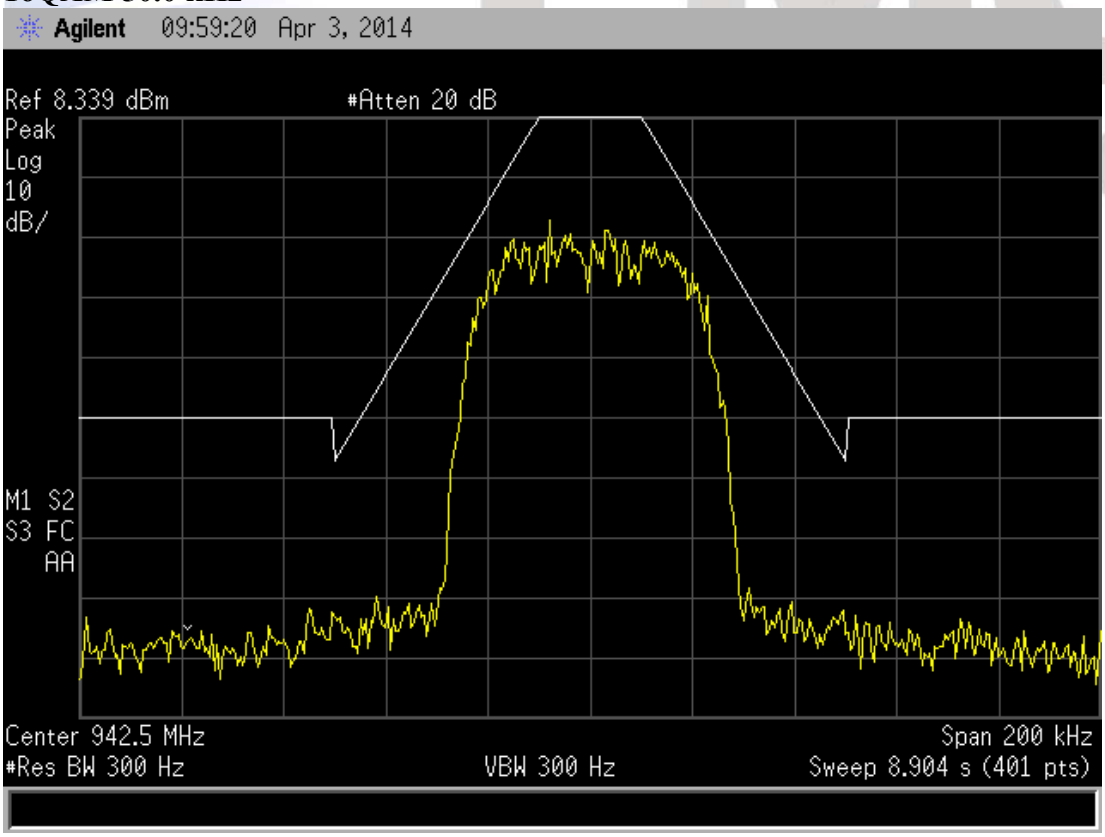
64QAM 25.0 kHz



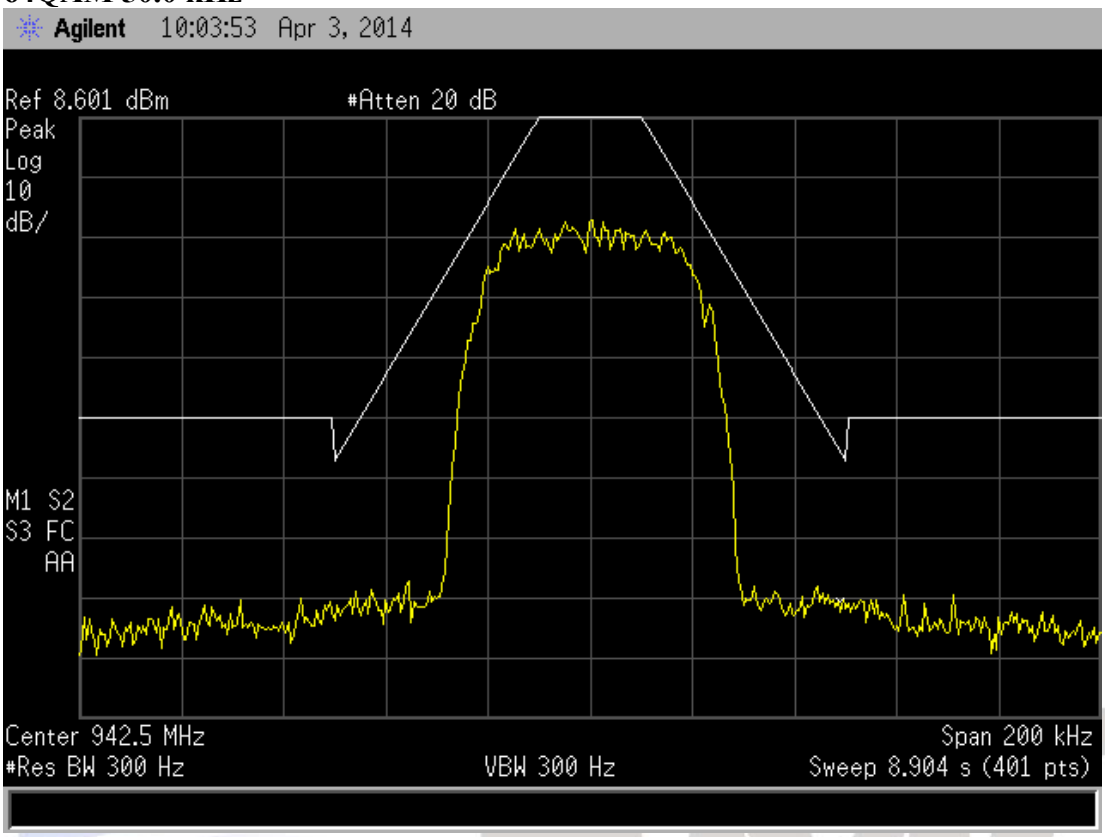
QPSK 50.0 kHz



16QAM 50.0 kHz



64QAM 50.0 kHz



Result: Complies

RF power output

Measurements were carried out at the RF output terminals of the transmitter using a 30 dB power attenuator and a 50 Ω dummy load.

Measurements were carried out when the transmitter was not being modulated.

Testing was carried out at maximum rated power output of 5 watts (37 dBm).

Nominal Frequency: 928.525 MHz

Frequency (MHz)	Voltage (Vdc)	Rated (dBm)	Measured (dBm)
928.525	10.0	37.0	36.3
928.525	13.8	37.0	36.3
928.525	30.0	37.0	36.3

Nominal Frequency: 952.525 MHz

Frequency (MHz)	Voltage (Vdc)	Rated (dBm)	Measured (dBm)
952.525	10.0	37.0	36.4
952.525	13.8	37.0	36.4
952.525	30.0	37.0	36.4

Limits:

The output power shall be within +/- 1 dB of the manufacturers rated power.

Result: Complies.

Measurement Uncertainty: ± 0.5 dB.

Transmitter spurious emissions at the antenna terminals

Nominal Frequency: 928.525 MHz

Spurious emission (MHz)	Emission level (dBm)	Limit (dBm)
1857.050	-65.0	–20.0
2785.575	<-65.0	–20.0
3714.100	<-70.0	–20.0
4642.625	<-70.0	–20.0
5571.150	<-70.0	–20.0
6499.675	<-70.0	–20.0
7428.200	<-70.0	–20.0
8356.725	<-70.0	–20.0
9285.250	<-70.0	–20.0

Limit:

Applied mask, 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).

A rated power of 5.0 watts (37.0 dBm) gives a limit of –20 dBm.

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

Part 2.1051 states that emissions greater than 20 dB below the limit need not be specified.

Part 2.1057 states that the spectrum should be investigated up to the 10th harmonic if the transmitter operates below 10 GHz.

Result: Complies.
Measurement Uncertainty: ± 3.3 dB

Field strength of the transmitter spurious emissions

Nominal Frequency: 928.525 MHz

Frequency (MHz)	Level (dBµV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)
1857.050	47.8	-49.6	-20.0	Vertical	29.6
1857.050	46.9	-50.5	-20.0	Horizontal	30.5
2785.575	<41.0	-56.4	-20.0	Vertical	36.4
2785.575	<41.0	-56.4	-20.0	Horizontal	36.4
3714.100	<44.0	-53.4	-20.0	Vertical	33.4
3714.100	<44.0	-53.4	-20.0	Horizontal	33.4
4642.625	<46.0	-51.4	-20.0	Vertical	31.4
4642.625	<46.0	-51.4	-20.0	Horizontal	31.4
5571.150	<48.0	-49.4	-20.0	Vertical	29.4
5571.150	<48.0	-49.4	-20.0	Horizontal	29.4
6499.675	<51.0	-46.4	-20.0	Vertical	26.4
6499.675	<51.0	-46.4	-20.0	Horizontal	26.4
7428.200	<47.0	-50.4	-20.0	Vertical	30.4
7428.200	<47.0	-50.4	-20.0	Horizontal	30.4
8356.725	<48.0	-49.4	-20.0	Vertical	29.4
8356.725	<48.0	-49.4	-20.0	Horizontal	29.4
9285.250	<51.0	-46.4	-20.0	Vertical	26.4
9285.250	<51.0	-46.4	-20.0	Horizontal	26.4

In transmit mode the transmitter was tested while transmitting continuously while attached to a dummy load.

Device was tested on an open area test site at a distance of 3 metres.

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 in July 2013

Limit:

All spurious emissions are to be attenuated by at least 50 + 10 log (P).

The rated power of 5.0 watts (37.0 dBm) gives a limit of –20 dBm.

No measurements were made above the 10th harmonic.

Result: Complies.
Measurement Uncertainty: ± 4.1 dB

Exposure of humans to RF fields

Transmit Frequency 928.525 MHz

Minimum safe distances have been calculated below.

Power density, $mW/cm^2 = E^2/3770$

- Occupational / Controlled Exposure limit will be 3.10 mW/cm^2
(f/300 = 930.5 MHz/300)

- General Population / Uncontrolled exposure limit will be 0.62 mW/cm^2
(f/1500 = 930.5 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:

E, V/m = (√ (30 * P * G)) / d

Controlled	**Uncontrolled**
$E = 3.10\ mW/cm^2 = E^2/3770$	$E = 0.62\ mW/cm^2 = E^2/3770$
E= √3.1*3770	E= √0.62*3770
E = 108.1 V/m	E = 48.3 V/m

The rated maximum transmitter power (P) = 5 watts.

Transmitter is operated using an antenna with a gain (G) of up to 631 (+28 dBi).

The client has declared a duty cycle (DC) of 100% (1)

Controlled	**Uncontrolled**
d = √ (30 * P * G*DC) / E	
d = √ (30 * 5 * 631 *1) / 108.1	d = √ (30 * 5 * 631 *1) / 48.3
d = 2.85 metres or 285 cm	d = 6.37 metres or 637 cm

Result: Complies if the safe distances defined for each environment are applied.

7. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial #	Asset	Cal Due	Internval
Aerial Controller	EMCO	1090	9112-1062	3710	N/a	N/a
Aerial Mast	EMCO	1070-1	9203-1661	3708	N/a	N/a
Turntable	EMCO	1080-1-2.1	9109-1578	3709	N/a	N/a
VHF Balun	Schwarzbeck	VHA9103	-	3603	12/01/2015	1 year
Biconical Antenna	Schwarzbeck	BBA 9106	-	3612	12/01/2015	1 year
Log Periodic	Schwarzbeck	VUSLP 91111	9111-228	3785	12/01/2015	1 year
Horn Antenna	Electrometrics	RGA-60	6234	E1494	04/07/2014	1 year
Measuring receiver	Rohde & Schwarz	ESIB-40	100171	EMC4003	29/01/2015	1 year
Modulation Analyzer	Rohde & Schwarz	FMA	837807/020	E1552	15/01/2015	1 year
Oscilloscope	Tektronics	745A	B010643	E1569	15/01/2015	1 year
Power Attenuator	Weinschel	49-20-43	GC104	E1308	N/a	N/a
Power Supply	Hewlett Packard	6032A	2743A-02859	E1069	N/a	N/a
Signal Generator	Rohde & Schwarz	SMHU	838923/028	E1493	22/01/2015	1 year
Spectrum Analyzer	Hewlett Packard	E7405A	US39150142	RFS 3776	26/05/2014	1 year
Thermal chamber	Contherm	M180F	86025	E1129	01/06/2014	1 year
Thermometer	DSIR	RT200	035	E1049	01/06/2014	1 year

8. ACCREDITATIONS

Testing was carried out in accordance with EMC Technologies NZ Ltd registration with the Federal Communications Commission as a listed facility, Registration Number: 90838, which was last updated in July 2013.

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

External photos of the device tested

Label

Radiated emissions test set up photos