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TEST REPORT

4RF SR+ SQ896M141 Point to Multi-point Digital Radio

tested to the

Code of Federal Regulations (CFR) 47

Part 90 –Private Land Mobile Services

for

4RF Limited

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

Table of Contents

1. COMPLIANCE STATEMENT

The **4RF SR+ SQ896M141 Point to Multi-point Digital Radio** complies with the limits defined in 47 CFR Part 90 and 47 CFR Part 2 when tested in-accordance with the test methods described in 47 CFR Part 2, ANSI C63.4, 2002 and ANSI / TIA-603-C, 2004.

2. RESULT SUMMARY

The results of testing, carried out in April, May and July 2014 are summarised below.

Clause	Description	Result
90.203	Certification required	Noted
2.1046 90.205	RF power output Power and antenna height limits	Noted Noted
2.1049 2.202 90.207 90.209 90.210	Occupied bandwidth Bandwidths Types of emissions Bandwidth limitations Emission masks	Noted Noted Complies Complies Complies
2.1051	Spurious emissions at antenna terminals	Complies
2.1053	Field strength of spurious radiation	Complies
2.1055 90.213	Frequency stability Frequency stability	Noted Complies
1.1310	Radio frequency exposure limits	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.

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 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 Tested	SQ928M141
Certification Model	SQ896M141
Product	Point to Multi Point Digital Radio
Manufacturer	4RF Limited
Manufactured in	New Zealand
Designed in	New Zealand
Serial Numbers	-
Tested FCC ID	UIPSQ928M141
Certification FCC ID	UIPSQ896M141

The client has declared that model numbers SQ928M141 and SQ896M141 are identical and therefore this report has been generated on that basis.

The samples tested have the following specifications:

Rated Transmitter Output Power
5.0 Watts (37.0 dBm)

Transmitter FCC Frequency Range and Channel Spacings

896 - 901 MHz:	12.5 kHz and 25.0 kHz
929 - 930 MHz	25.0 kHz
935 - 940 MHz	12.5 kHz and 25.0 kHz

Test Frequencies
899.00 MHz
929.525 MHz
937.000 MHz

Emission Designators / Modes of operation
G1D and D1D emissions designators have been applied when the transmitter uses 12.5 and 25.0 channel spacing as appropriate.

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

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: 899.000 MHz

Frequency (MHz)	Voltage (Vdc)	Rated (dBm)	Measured (dBm)
899.000	10.0	37.0	36.8
899.000	13.8	37.0	36.8
899.000	30.0	37.0	36.8

Nominal Frequency: 929.525 MHz

Frequency (MHz)	Voltage (Vdc)	Rated (dBm)	Measured (dBm)
929.525	10.0	37.0	36.8
929.525	13.8	37.0	36.9
929.525	30.0	37.0	36.9

Nominal Frequency: 937.000 MHz

Frequency (MHz)	Voltage (Vdc)	Rated (dBm)	Measured (dBm)
937.000	10.0	37.0	36.7
937.000	13.8	37.0	36.8
937.000	30.0	37.0	36.8

Result: Complies
Measurement Uncertainty: ± 0.5 dB

Part 90.207 – Emission 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 90.209 – Bandwidth limitations:

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: 899.000 MHz

Emission	Channel (kHz)	Measured (kHz)	Authorised Bandwidth (kHz)
QPSK	12.5	11.125	11.250
16QAM	12.5	10.750	11.250
64QAM	12.5	10.562	11.250
QPSK	25.0	19.250	20.000
16QAM	25.0	18.975	20.000
64QAM	25.0	18.750	20.000

Nominal Frequency: 929.525 MHz

Emission	Channel (kHz)	Measured (kHz)	Authorised Bandwidth (kHz)
QPSK	25.0	19.250	20.0
16QAM	25.0	17.850	20.0
64 QAM	25.0	17.550	20.0

Nominal Frequency: 937.000 MHz

Emission	Channel (kHz)	Measured (kHz)	Authorised Bandwidth (kHz)
QPSK	12.5	11.000	11.250
16QAM	12.5	10.750	11.250
64QAM	12.5	10.687	11.250
QPSK	25.0	19.175	20.000
16QAM	25.0	18.850	20.000
64QAM	25.0	18.675	20.000

Result: Complies.

Spectrum Masks: 929 - 930 MHz band

Part 90.210 states all equipment operating in other bands equipment designed to operate with a must meet the requirements of Emission Mask B or G, as applicable.

Mask B has been applied as the transmitter has an audio low pass filter.

The transmitter can operate in the band 929-930 MHz using an authorised bandwidth of 20 kHz and a channel spacing of 25 kHz.

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.

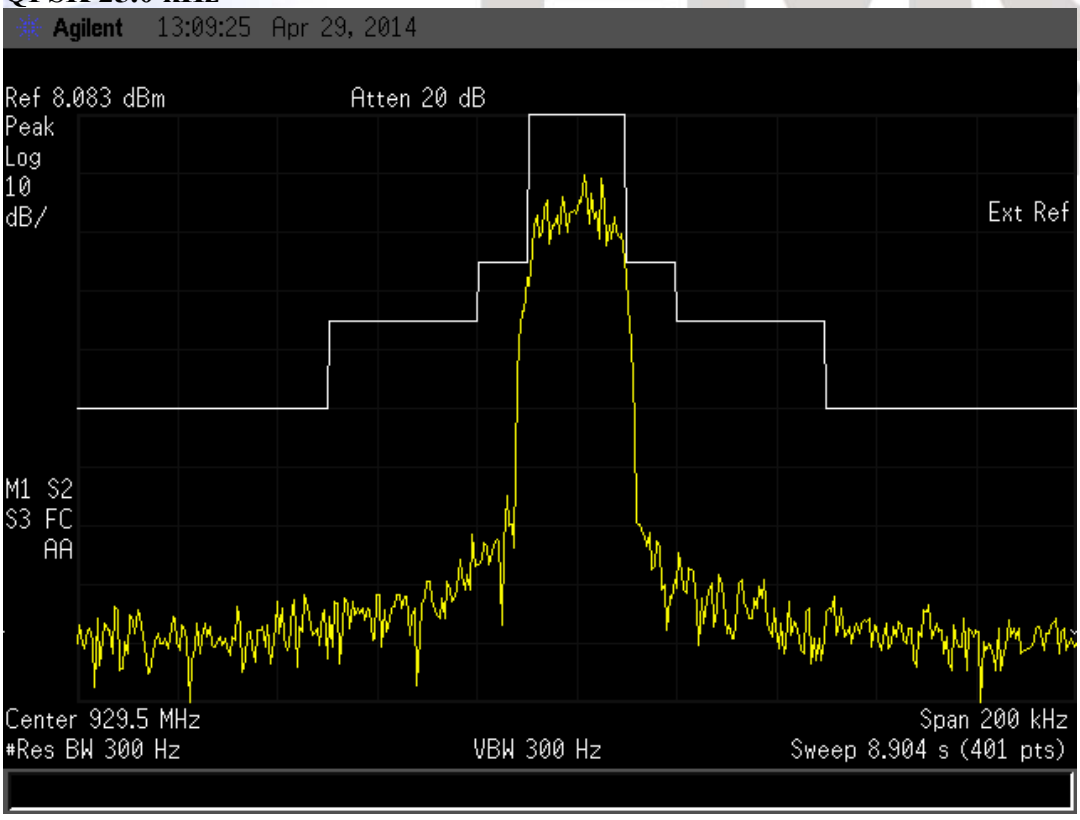
This level is used as a reference level on the spectrum analyser.

Measurements were made with the spectrum analyser operating in peak hold centred on the allocated frequency.

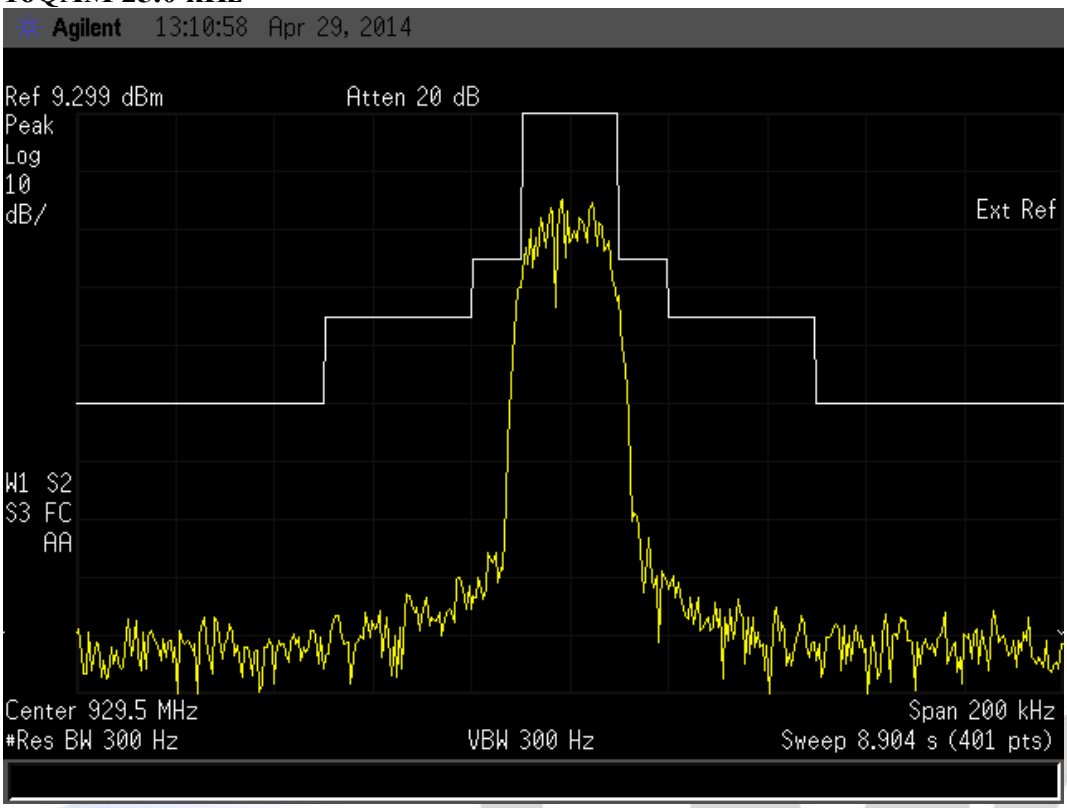
Result: Complies

Nominal Frequency: 929.525 MHz

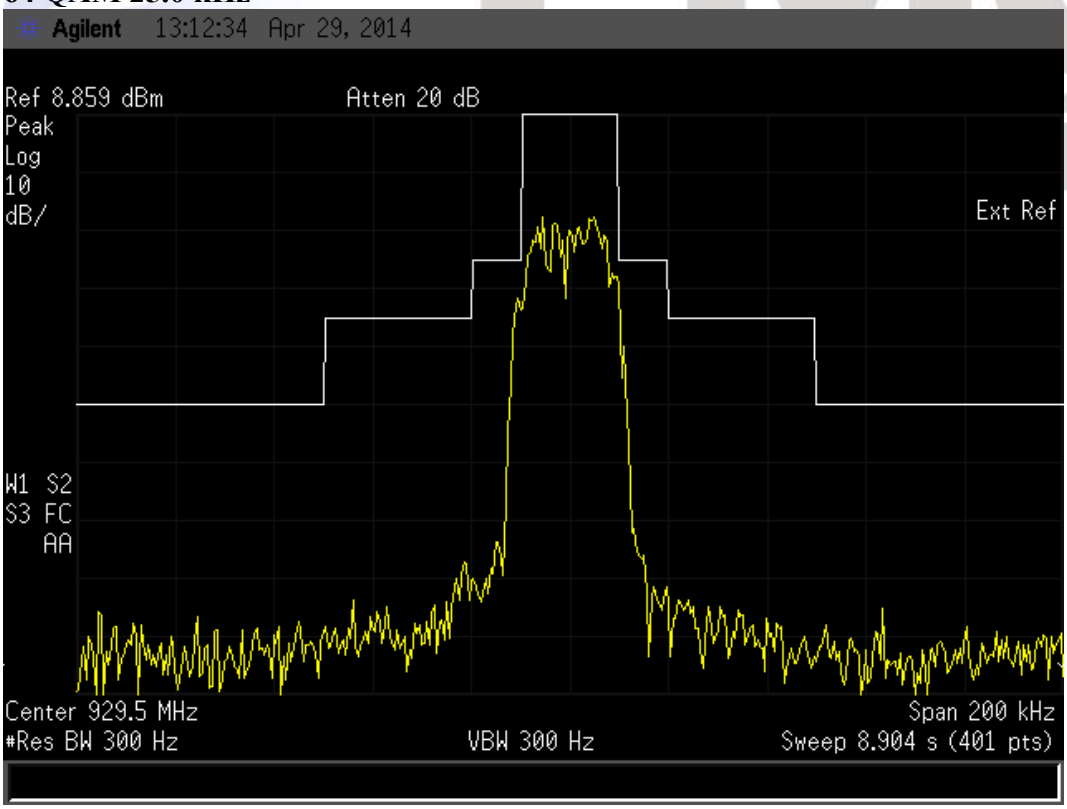
QPSK 25.0 kHz



16QAM 25.0 kHz



64 QAM 25.0 kHz



Result: Complies

Spectrum Masks: 896 - 901 MHz and 935 - 940 MHz bands

Part 90.210 states all equipment operating in other bands equipment designed to operate with a must meet the requirements of Emission Mask I or Mask J.

Mask I has been applied as the transmitter has an audio low pass filter.

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

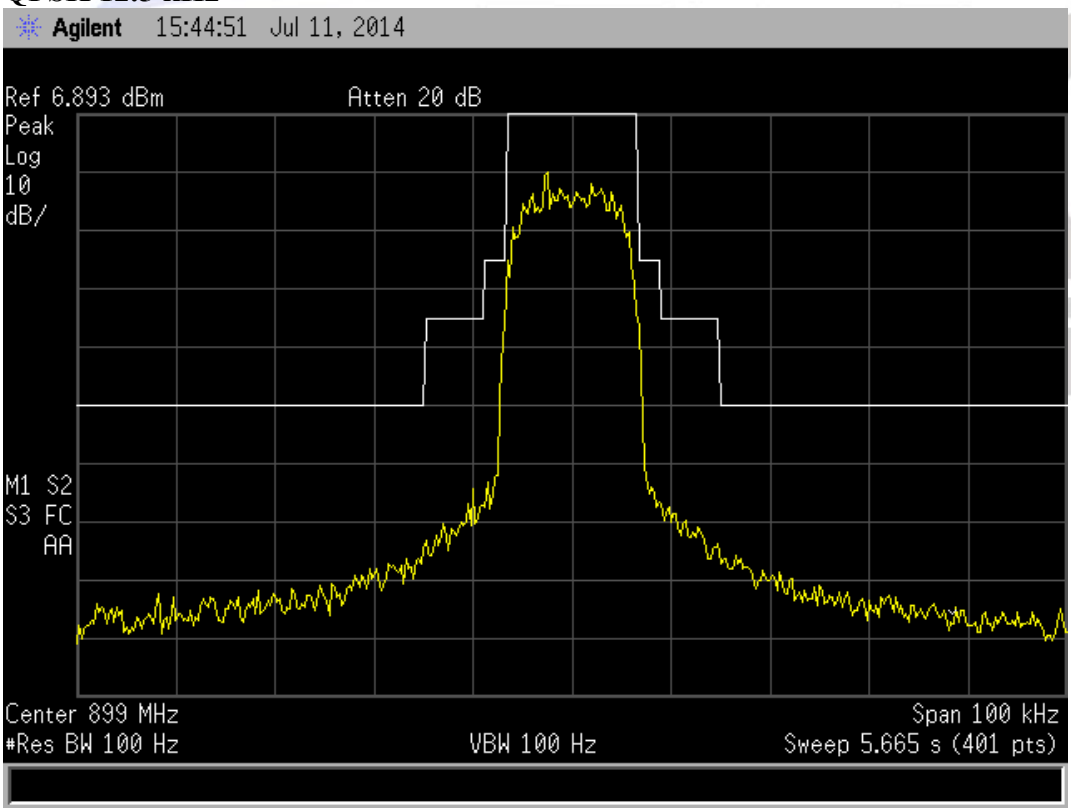
Initially power measurements are made using a resolution bandwidth of 120 kHz.

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

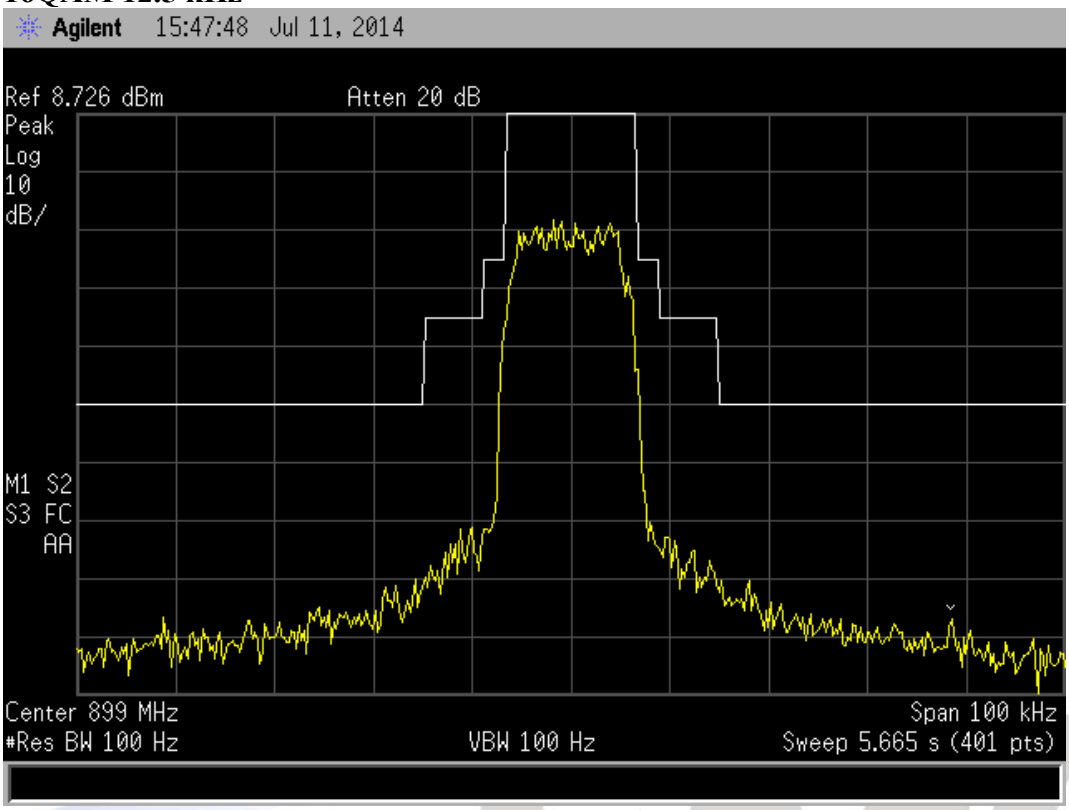
Measurements were made with the spectrum analyser operating in peak hold centred on the allocated frequency.

Nominal Frequency: 899.000 MHz

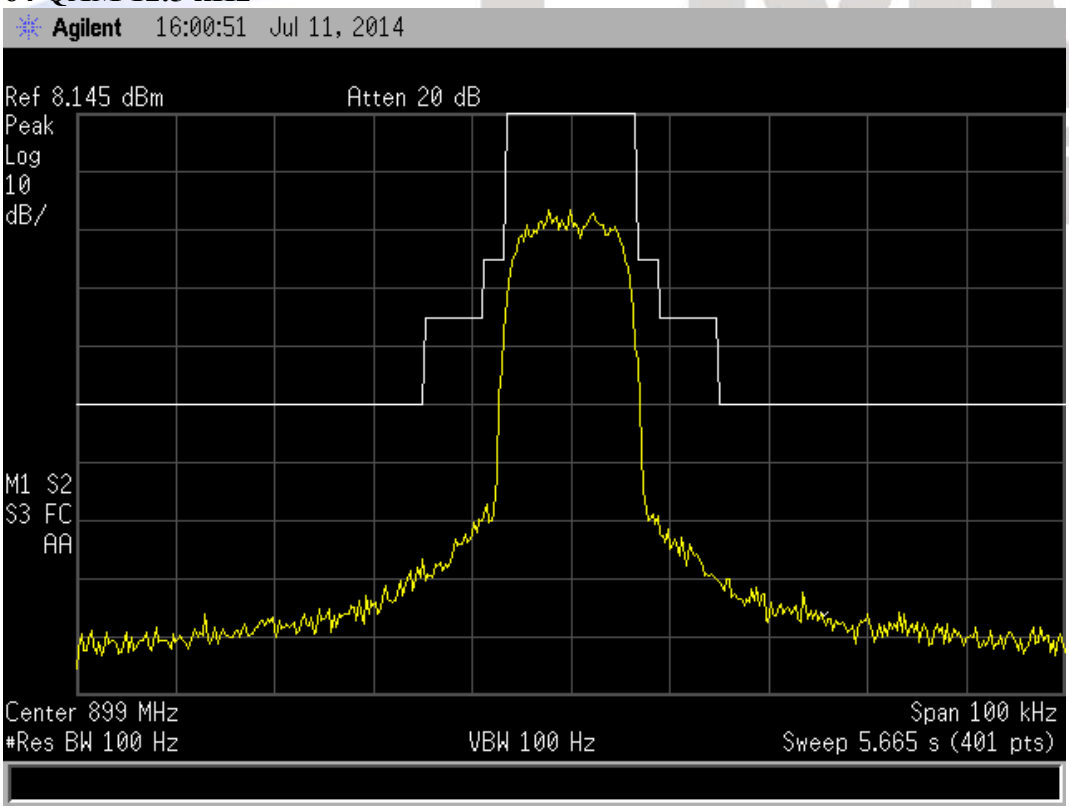
QPSK 12.5 kHz



16QAM 12.5 kHz

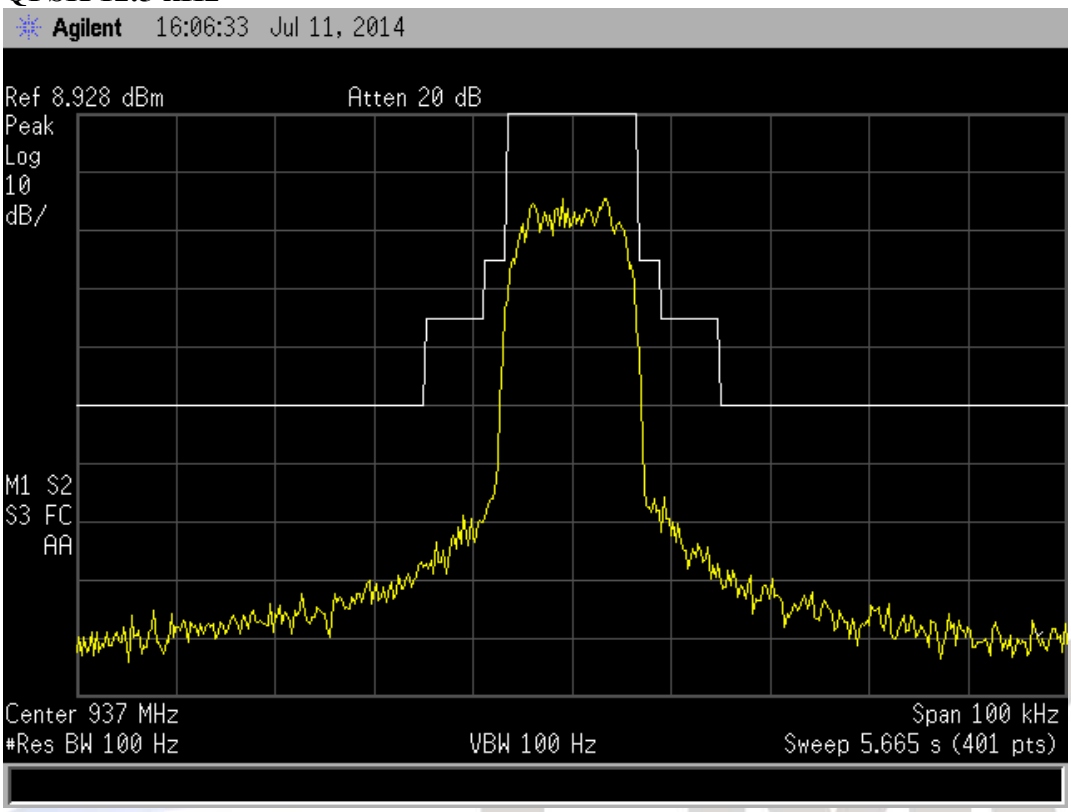


64 QAM 12.5 kHz

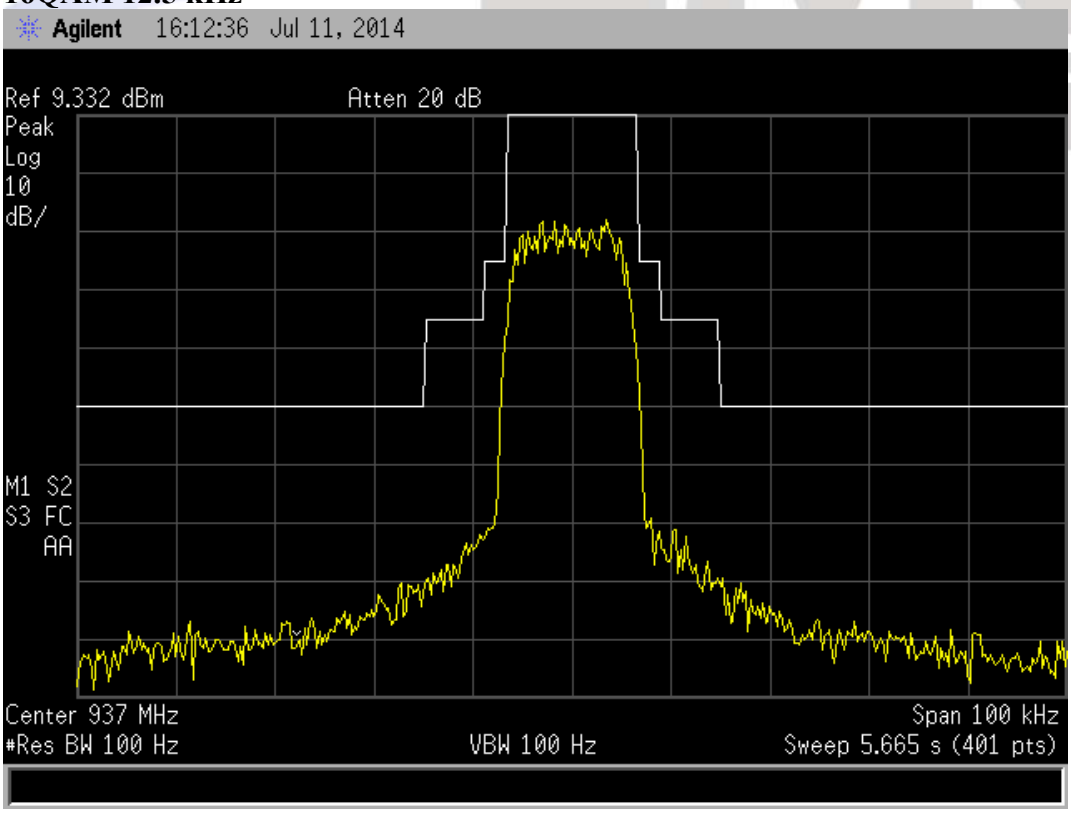


Nominal Frequency: 937.000 MHz

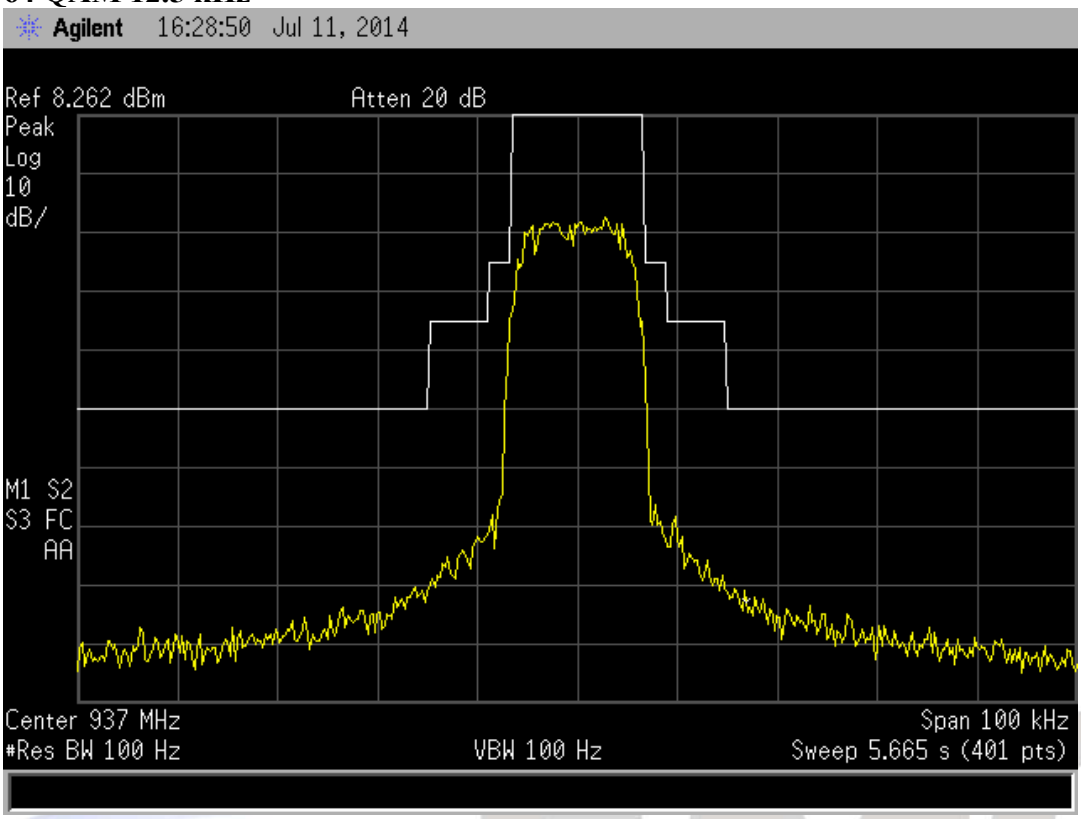
QPSK 12.5 kHz



16QAM 12.5 kHz

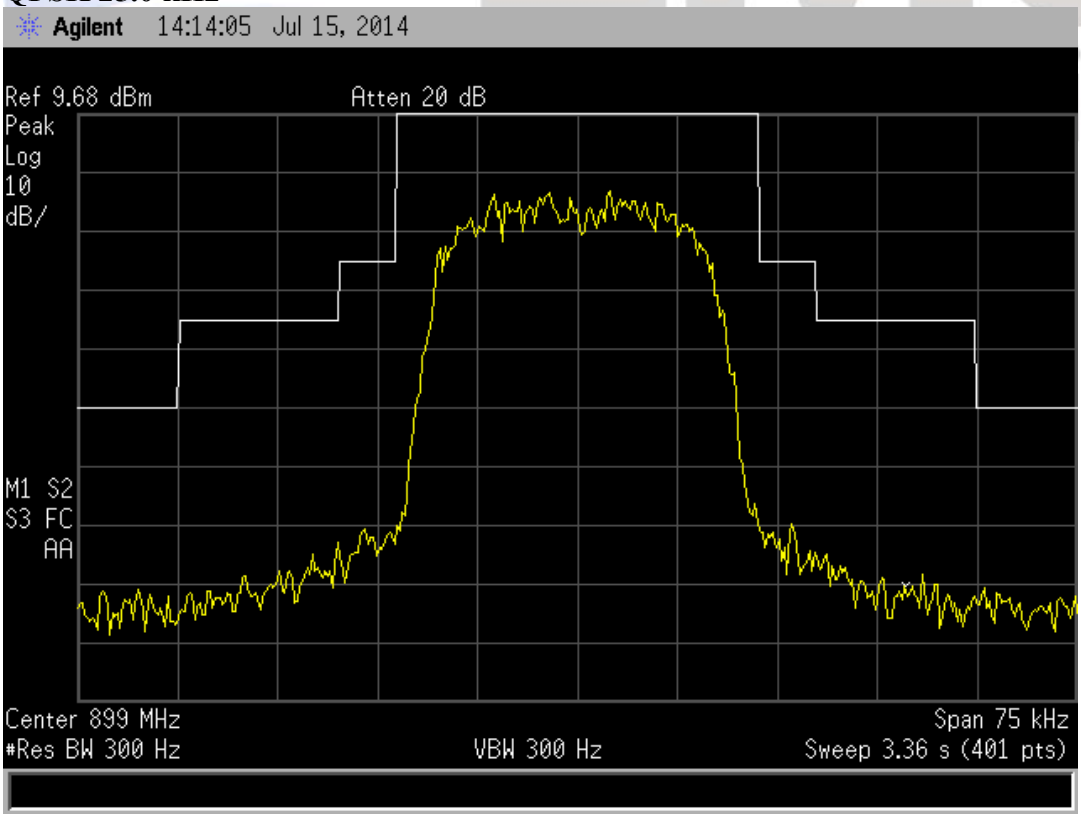


64 QAM 12.5 kHz

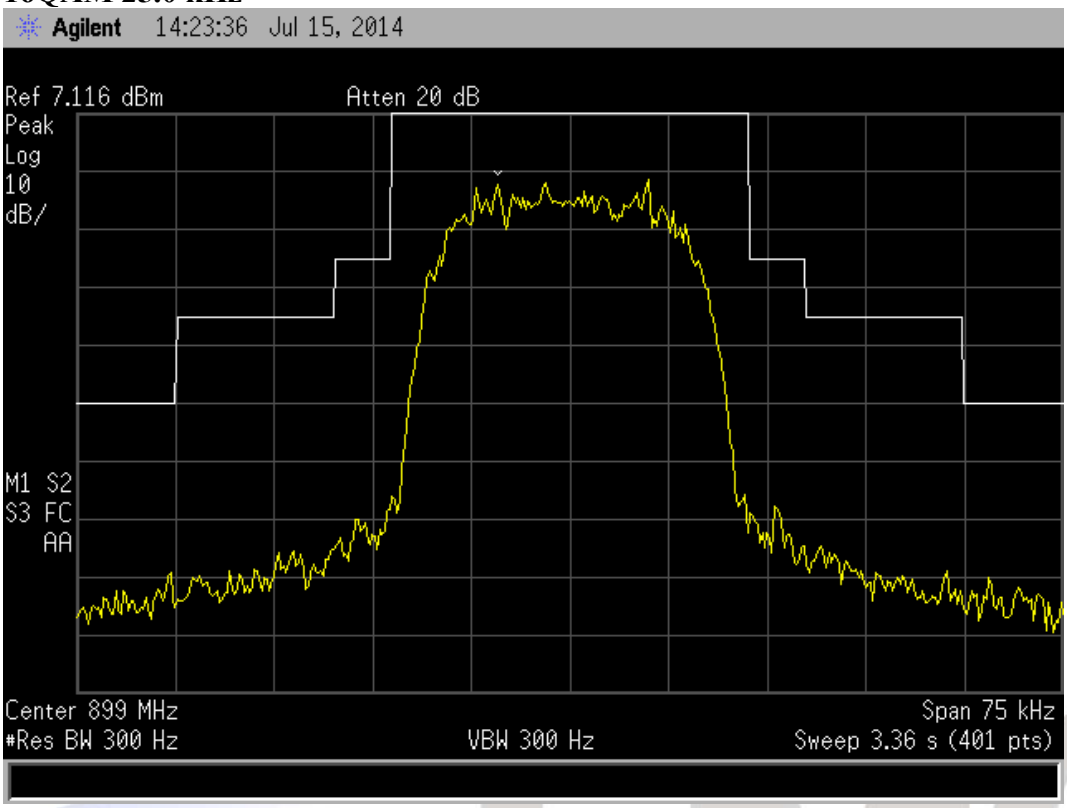


Nominal Frequency: 899.000 MHz

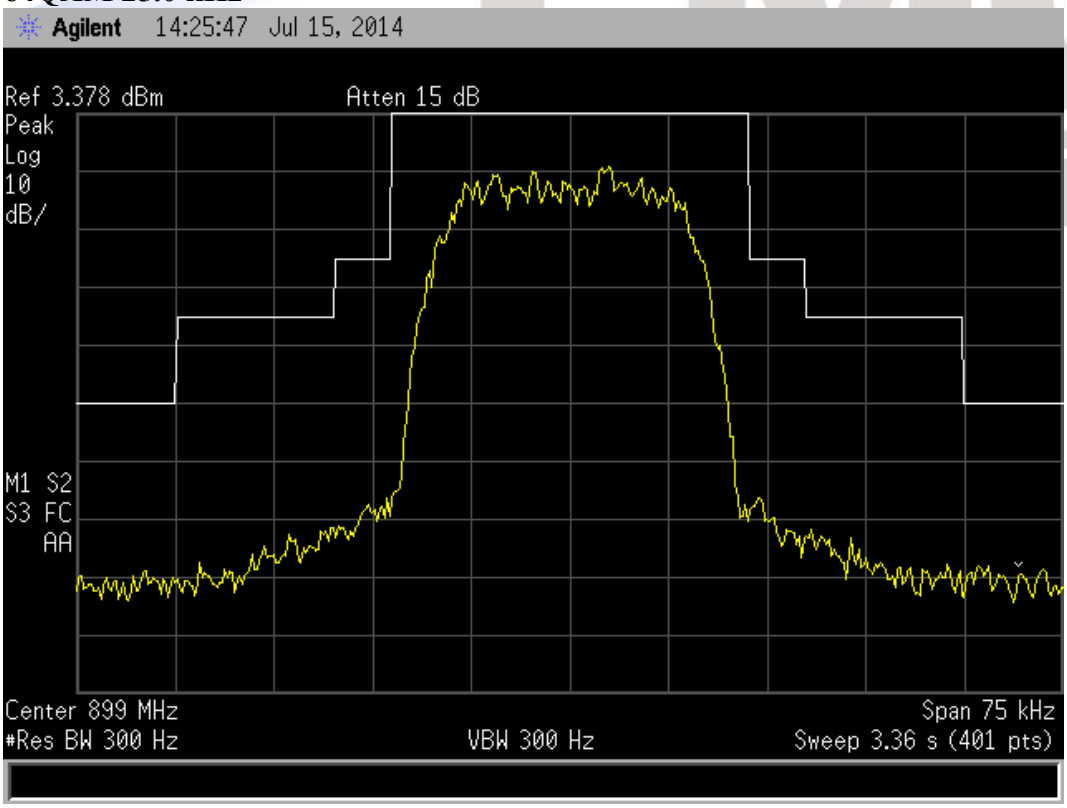
QPSK 25.0 kHz



16QAM 25.0 kHz

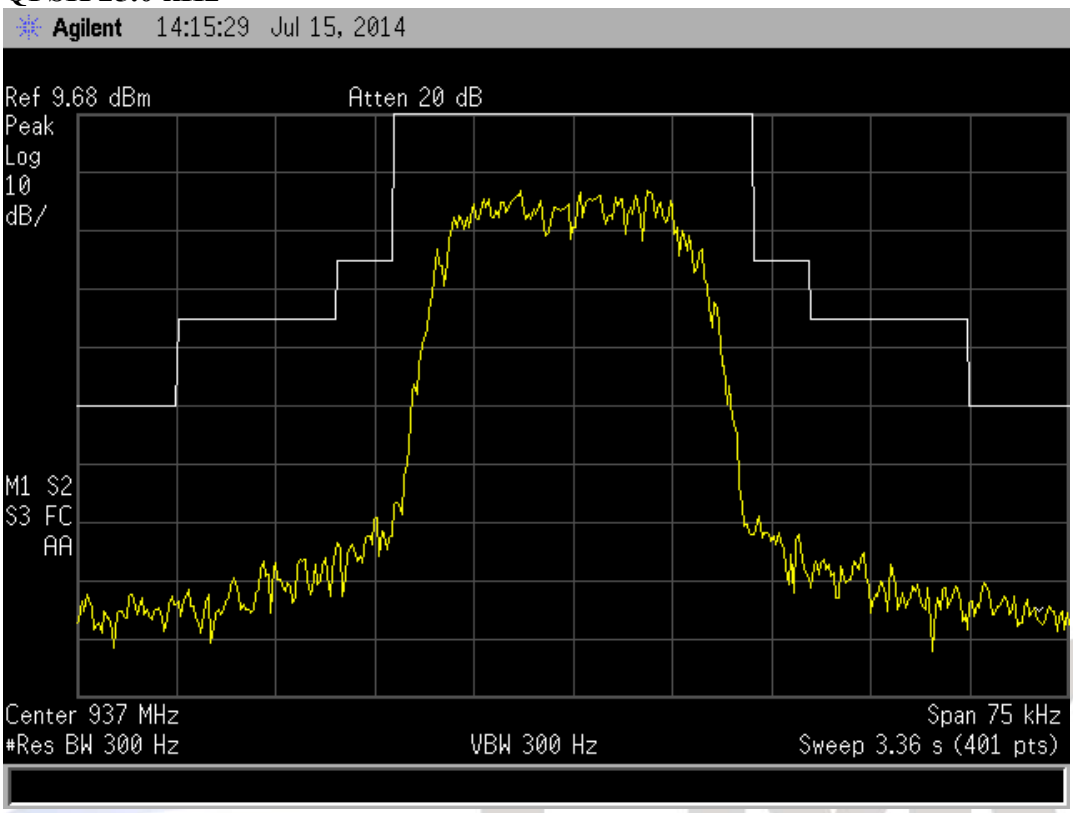


64QAM 25.0 kHz

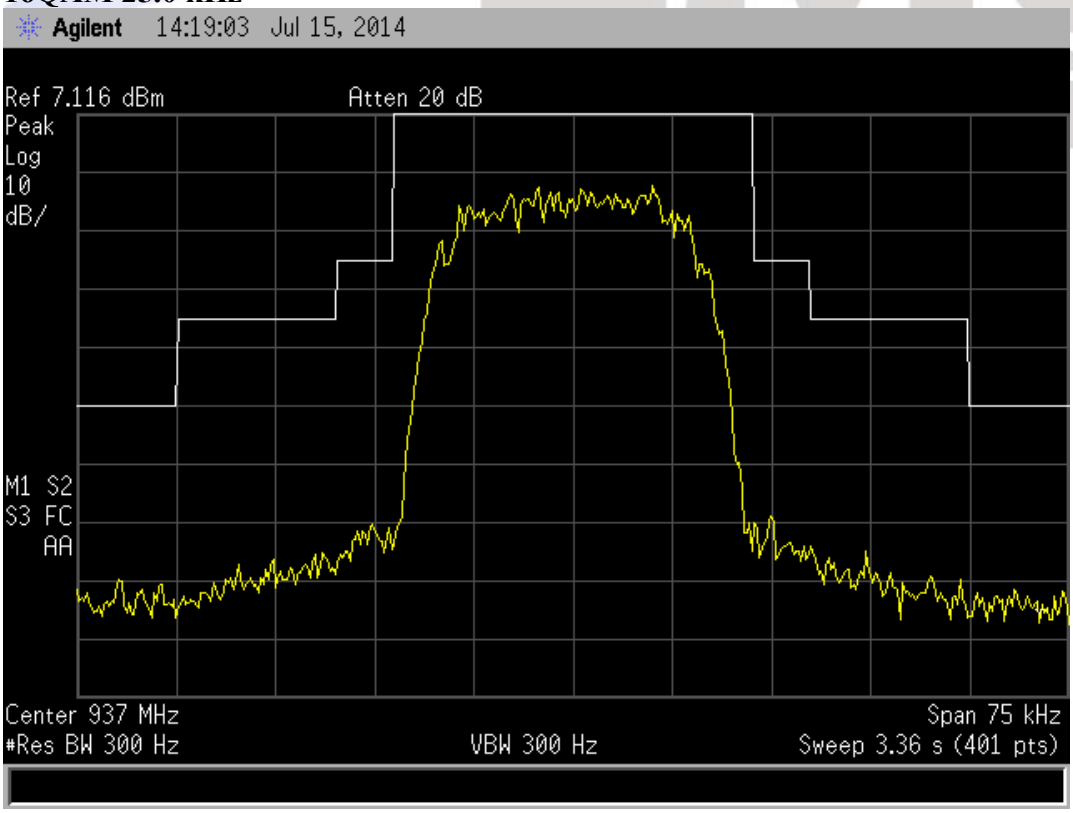


Nominal Frequency: 937.000 MHz

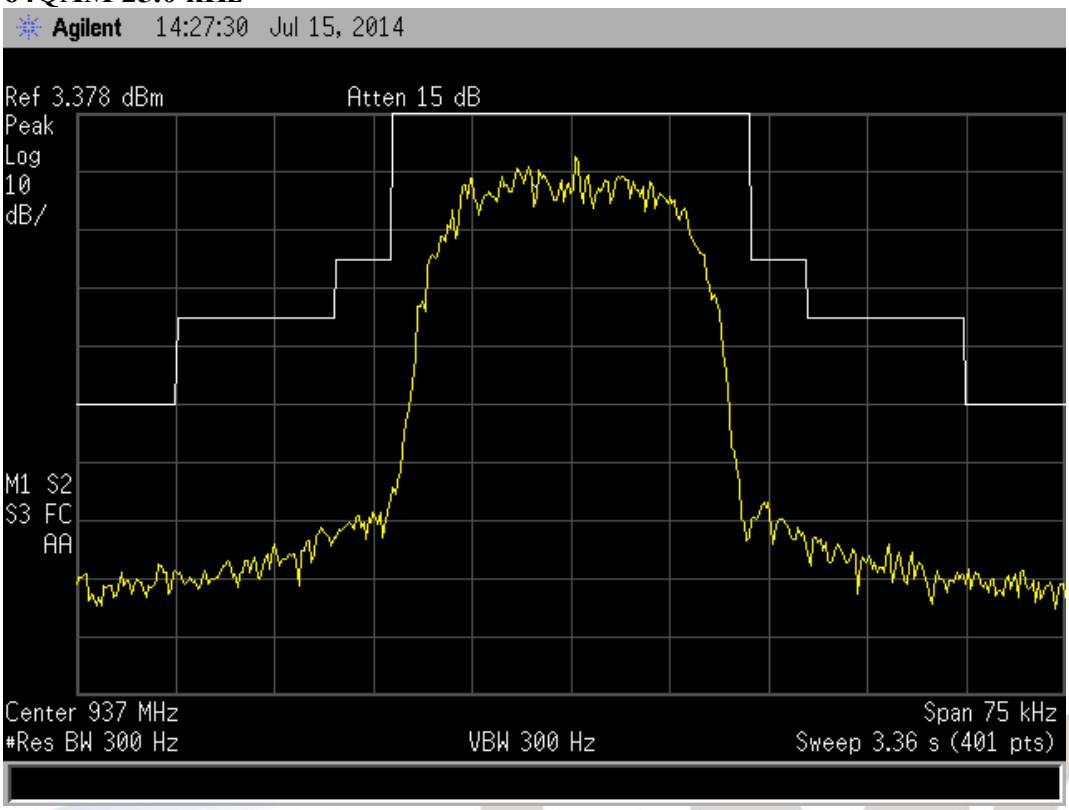
QPSK 25.0 kHz



16QAM 25.0 kHz



64QAM 25.0 kHz



Transmitter spurious emissions at the antenna terminals

Nominal Frequency: 899.000 MHz

Spurious emission (MHz)	Emission level (dBm)	Limit (dBm)
1798.000	-66.9	-13.0
2697.000	<-70.0	-13.0
3596.000	<-70.0	-13.0
4495.000	<-70.0	-13.0
5394.000	<-70.0	-13.0
6293.000	<-70.0	-13.0
7192.000	<-70.0	-13.0
8091.000	<-70.0	-13.0
8990.000	<-70.0	-13.0

Nominal Frequency: 929.525 MHz

Spurious emission (MHz)	Emission level (dBm)	Limit (dBm)
1859.050	-60.0	-13.0
2788.575	<-65.0	-13.0
3718.100	<-70.0	-13.0
4647.625	<-70.0	-13.0
5577.150	<-70.0	-13.0
6506.675	<-70.0	-13.0
7436.200	<-70.0	-13.0
8365.725	<-70.0	-13.0
9295.250	<-70.0	-13.0

Nominal Frequency: 937.000 MHz

Spurious emission (MHz)	Emission level (dBm)	Limit (dBm)
1874.000	-72.5	-13.0
2811.000	<-70.0	-13.0
3748.000	<-70.0	-13.0
4685.000	<-70.0	-13.0
5622.000	<-70.0	-13.0
6559.000	<-70.0	-13.0
7496.000	<-70.0	-13.0
8433.000	<-70.0	-13.0
9370.000	<-70.0	-13.0

Limit:

Applied mask B, 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 43 + 10 log (P).

A rated power of 5.0 watts (37.0 dBm) gives a limit of –13 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: 929.525 MHz

Frequency (MHz)	Level (dBµV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)
1859.0500	52.2	-45.2	-20.0	Vertical	25.2
1859.0500	49.5	-47.9	-20.0	Horizontal	27.9
2788.5750	<41.0	-56.4	-20.0	Vertical	36.4
2788.5750	<41.0	-56.4	-20.0	Horizontal	36.4
3718.1000	<44.0	-53.4	-20.0	Vertical	33.4
3718.1000	<44.0	-53.4	-20.0	Horizontal	33.4
4647.6250	<46.0	-51.4	-20.0	Vertical	31.4
4647.6250	<46.0	-51.4	-20.0	Horizontal	31.4
5577.1500	<48.0	-49.4	-20.0	Vertical	29.4
5577.1500	<48.0	-49.4	-20.0	Horizontal	29.4
6506.6750	<51.0	-46.4	-20.0	Vertical	26.4
6506.6750	<51.0	-46.4	-20.0	Horizontal	26.4
7436.2000	<47.0	-50.4	-20.0	Vertical	30.4
7436.2000	<47.0	-50.4	-20.0	Horizontal	30.4
8365.7250	<48.0	-49.4	-20.0	Vertical	29.4
8365.7250	<48.0	-49.4	-20.0	Horizontal	29.4
9295.2500	<51.0	-46.4	-20.0	Vertical	26.4
9295.2500	<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.

The power level of each emission was determined by replacing the transmitter with a dipole antenna that was connected to a signal generator.

The signal generator output level was increased until the same field strength level was observed at each emission frequency.

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

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

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 10^{th} harmonic.

Result: Complies.
Measurement Uncertainty: ± 4.1 dB

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.

The frequency error in Hz is listed below.

Nominal Frequency: 929.525 MHz

Temperature (°C)	Voltage (10.8 Vdc)	Voltage (13.8 Vdc)	Voltage (15.6 Vdc)
+50	+125.0	+125.0	+126.0
+40	+121.0	+121.0	+123.0
+30	+114.0	+115.0	+115.0
+20	+112.0	+113.0	+113.0
+10	+92.0	+92.0	+94.0
0	+100.0	+103.0	+103.0
-10	+86.0	+86.0	+87.0
-20	+53.0	+56.0	+56.0
-30	+3.0	+4.0	+4.0

Limit:

Part 90.213 states that fixed base station transmitters operating between 929-930 MHz are required to have a frequency tolerance of 1.5 ppm.

A frequency stability tolerance of 1.5 ppm has been applied to this transmitter.

This transmitter was tested on 929.525 MHz.

1.5 ppm = 1.5 x = 1394 Hz.

A worst case frequency error of 126 Hz or 0.136 ppm was observed

Part 90.213 also states that fixed base station transmitters operating between 896 - 901 MHz and 935 - 940 MHz are required to have a frequency tolerance of 0.1 ppm.

As per Section 90.213(a) this transmitter is to be operated in accordance with Section 90.645(f) and therefore no frequency stability requirements have been applied to these bands.

Result: Complies.
Measurement Uncertainty: ± 30 Hz.

Exposure of humans to RF fields

Transmit Frequency: 896.000 MHz

Minimum safe distances have been calculated below.

Power density, $W/m^2 = E^2/3770$

- Occupational / Controlled Exposure limit will be 2.98 W/m^2
(f/300 = 896.000 MHz/300)

- General Population / Uncontrolled exposure limit will be 0.59 W/m^2
(f/1500 = 896.000 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**
$E = 2.98\ W/m^2 = E^2/3770$	$E = 0.59\ W/m^2 = E^2/3770$
E= √2.98*3770	E= √0.59*3770
E = 106.0 V/m	E = 47.1 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) / 106.0	d = √ (30 * 5 * 631 * 1) / 47.1
d = 2.90 metres or 290.0 cm	d = 6.53 metres or 653.0 cm

Transmit Frequency: 929.525 MHz

Minimum safe distances have been calculated below.

Power density, $W/m^2 = E^2/3770$

- Occupational / Controlled Exposure limit will be 3.10 W/m^2
(f/300 = 929.525 MHz/300)

- General Population / Uncontrolled exposure limit will be 0.62 W/m^2
(f/1500 = 929.525 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**
$E = 3.10\ W/m^2 = E^2/3770$	$E = 0.62\ W/m^2 = E^2/3770$
$E = \sqrt{3.10*3770}$	$E = \sqrt{0.62*3770}$
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 = 2.84 metres or 284.0 cm	d = 6.37 metres or 637.0 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	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	04/07/2015	1 year
Receiver	R & S	ESIB-40	100171	EMC4003	29/01/2015	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	R & S	SMHU	838923/028	E1493	22/01/2015	1 year
Spectrum Analyzer	Hewlett Packard	E7405A	US39150142	RFS 3776	26/05/2015	1 year
Thermal chamber	Contherm	M180F	86025	E1129	01/06/2015	1 year
Thermometer	DSIR	RT200	035	E1049	01/06/2015	1 year

At the time of testing all test equipment was within calibration

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 June 2014.

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

Radiated emissions test set up photos