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TEST REPORT

Salcom 15-85-0450 UHF Transceiver

tested to the

Code of Federal Regulations (CFR) 47

Part 90 –Private Land Mobile Services

for

Salcom Technologies Ltd

Testing carried out by;

A handwritten signature in black ink, appearing to read "D Poole".

Douglas Poole - Radio Testing Officer

This Test Report is issued with the authority of:

A handwritten signature in black ink, appearing to read "Andrew Cutler".

Andrew Cutler - General Manager



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

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EMC
Technologies

1. COMPLIANCE STATEMENT

The **Salcom 15-85-0450 UHF Transceiver** 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 and ANSI/TIA-603-C.

2. RESULT SUMMARY

The results of testing carried out in October and November 2015 are summarised below.

Clause	Description	Result
90.203	Certification required	Noted
2.1046 90.205	RF power output Power and antenna height limits	Noted Complies
2.1047 2.1047(a) 2.1047(b) 90.211(a)	Modulation Characteristics Low pass filter response Modulation limiting characteristics Modulation characteristics	Noted Noted Noted Complies
2.1049 2.202	Occupied bandwidth Bandwidths	Noted Noted
90.207 90.209 90.210	Types of emissions Bandwidth limitations Emission masks	Complies Complies Complies
2.1051	Spurious emissions at antenna terminals	Complies
2.1053	Field strength of spurious radiation	Complies
2.1055	Frequency stability	Noted
90.213	Frequency stability	Complies
90.214	Transient frequency behaviour	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.

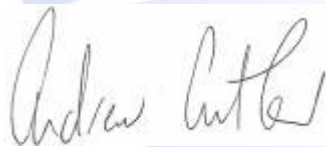
Measurement uncertainties with statistical confidence intervals of 95% are shown below test results. Both Class A and Class B uncertainties have been accounted for, as well as influence uncertainties where appropriate.

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

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

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 Salcom Technologies Ltd

Address 10 Magdala Place
Middleton
Christchurch, 8024

Country New Zealand

Contact Mr Kevin Milner

5. TEST SAMPLE DESCRIPTION

Brand Name Salcom

Model Number 15-85-0450

Product UHF Transceiver

Manufacturer Sea Air Land Communications Ltd

Manufactured in New Zealand

Serial Numbers 0239

FCC ID O87158555

The transmitter that was tested can operate in the FCC UHF band of 450-470 MHz.

The radio that was tested is an analogue transceiver that is being used to send 1200 Hz and 1800 Hz tones audio tones using frequency shift keying.

This can operating using channel bandwidths of 6.25, 12.5 and 25.0 kHz.

The client has declared that this transmitter will operate using a regulated power supply at 13 Vdc +/- 0.5 Vdc.

The client has also declared that the audio input levels to this transmitter will not exceed 100 mV rms.

The sample tested has the following specifications:

Rated Transmitter Output Power

5.0 Watts (37.0 dBm)

Transmitter FCC Frequency Bands

Part 90: 421 - 512 MHz

Test frequencies

Frequency (MHz)	Power (Watts)	Channel Bandwidth (kHz)	Modulation Type	Emission Designator
459.075	5.0	6.25	FSK FM	6K00F2D
459.075	5.0	12.5	FSK FM	11K0F2D
459.075	5.0	25.0	FSK FM	16K0F2D

Power Supply

DC voltage supply at 13.0 Vdc +/- 0.5 Vdc as specified by the client

Standard Temperature and Humidity

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

Standard Test Power Source

Standard Test Voltage: 13.0 Vdc

Extreme Temperature

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

Extreme Test Voltages

High Voltage: 13.5 Vdc
Low Voltage: 12.5 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 power output.

Frequency (MHz)	Voltage (Vdc)	Rated (dBm)	Measured (dBm)
459.075	12.5	37.0	37.4
459.075	13.0	37.0	37.4
459.075	13.5	37.0	37.4

Limits:

Part 90 does not specify the transmitter output power.

Result: Complies

Measurement Uncertainty: ± 0.5 dB

Modulation Characteristics

This transmitter is capable of producing analogue speech and data modulations.

Frequency response of the audio frequency low pass filter between 100 Hz and 10 kHz.

This measurement was carried out using an audio signal generator and an audio modulation analyser.

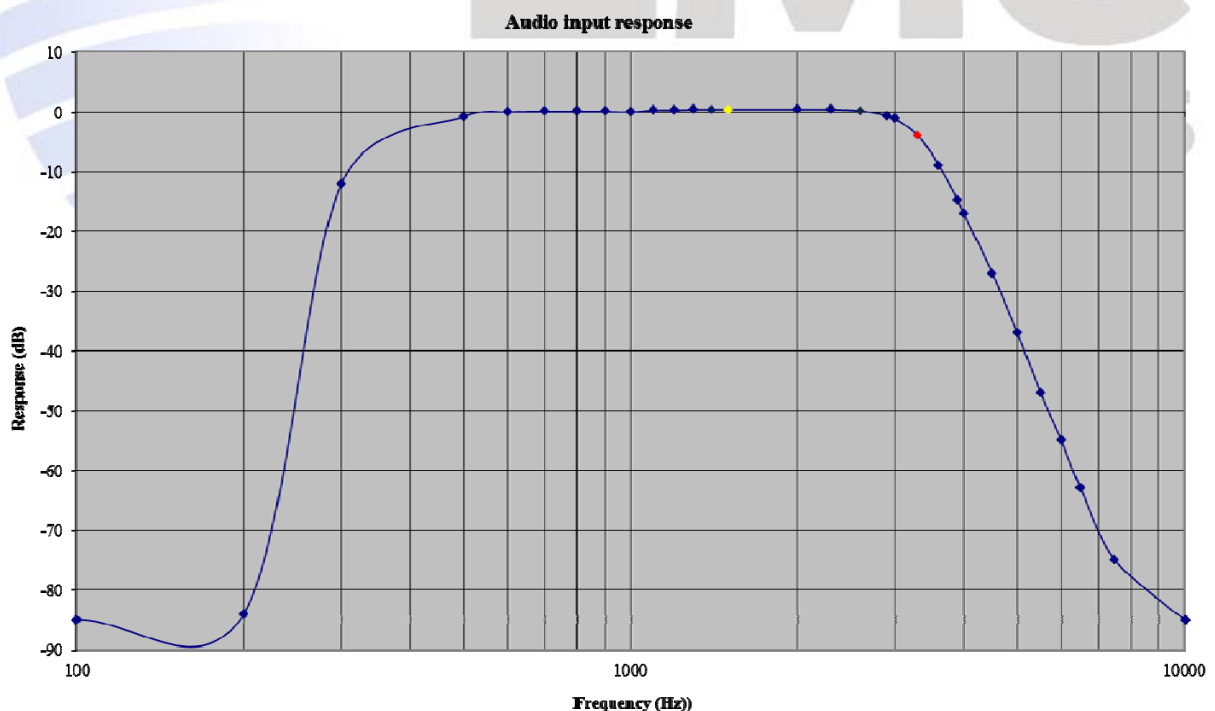
At 1 kHz an audio signal, at a level that did not exceed 100 mV rms (-18 dBm), was applied which was used as a 0 dB response reference.

The frequency of the input signal was then varied and the output response noted.

This measurement was carried out from 100 Hz to 5000 Hz as required by Part 2 with further measurements carried out in order to show the full range of this filter which is used for the 12.5 kHz and 25 kHz channel bandwidth emissions.

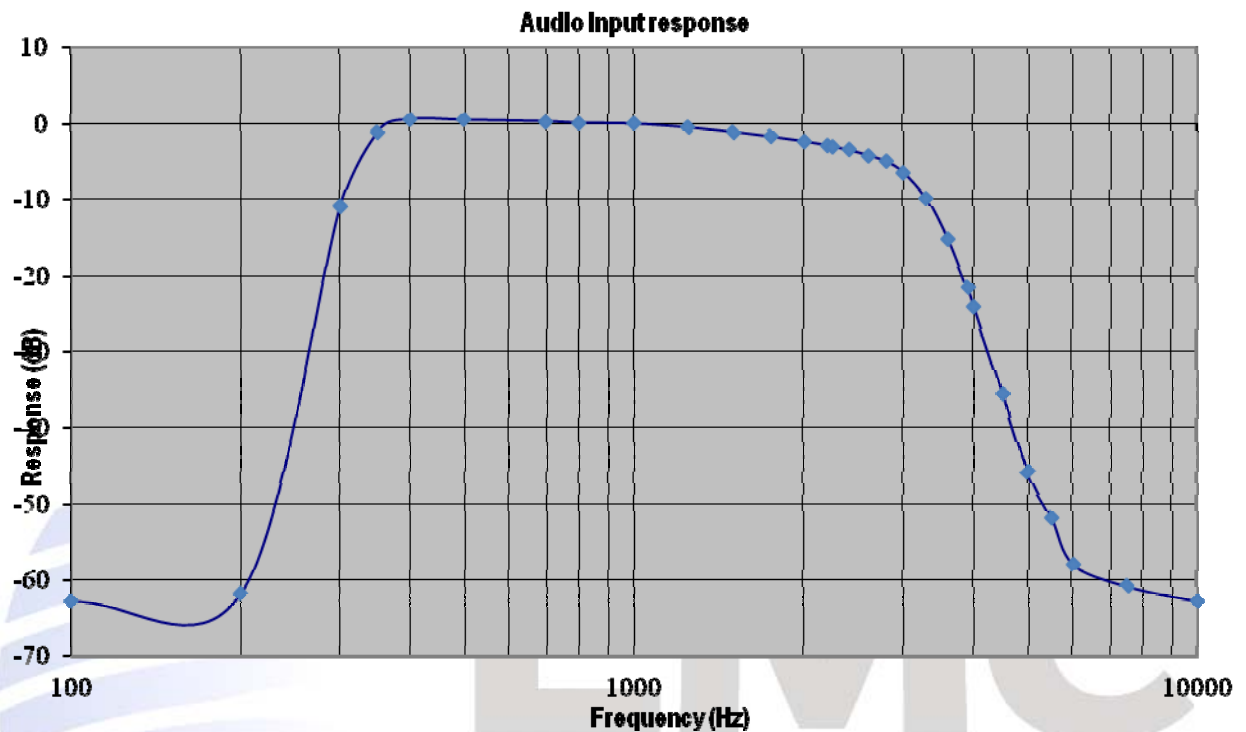
The peak deviation response was found to be at 2300 Hz and is denoted as the yellow data series point on the following graph.

The -3dB roll off from peak deviation occurs at 3300 Hz, and is denoted as a red data series point on the following graph.



Below is the filter response for when the transmitter is operating in 6.25 kHz channel bandwidth mode.

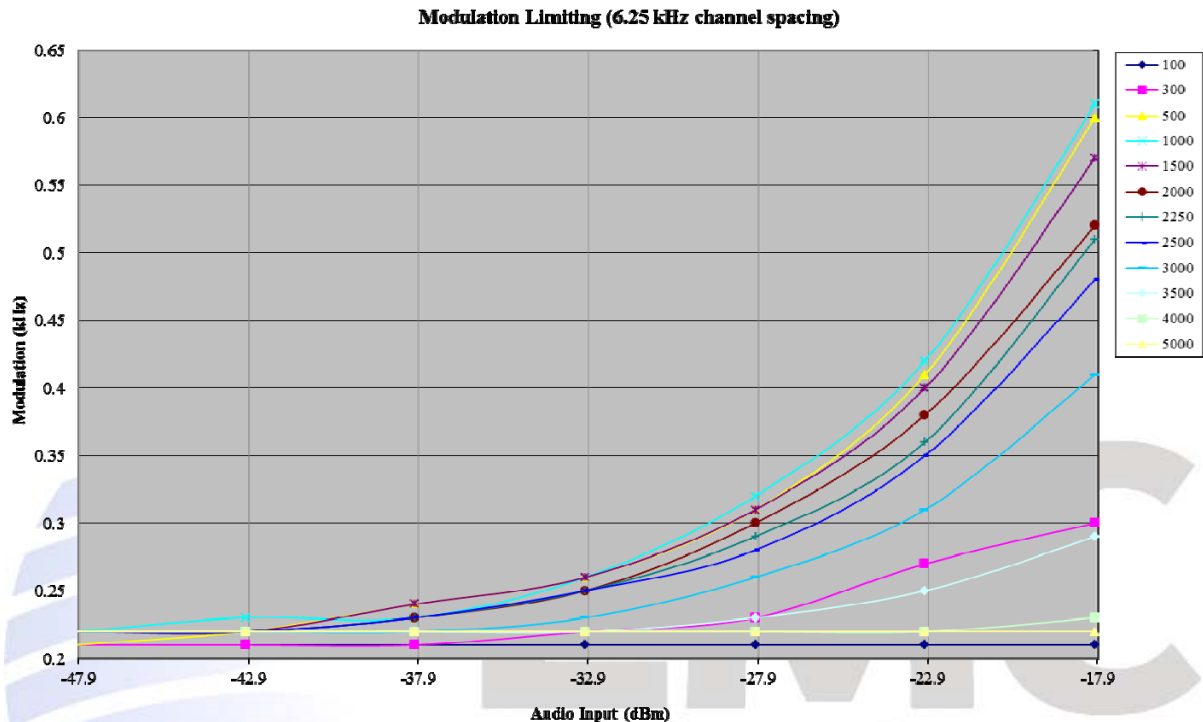
The -3dB roll off from peak deviation was measured to occur at 2250 Hz.



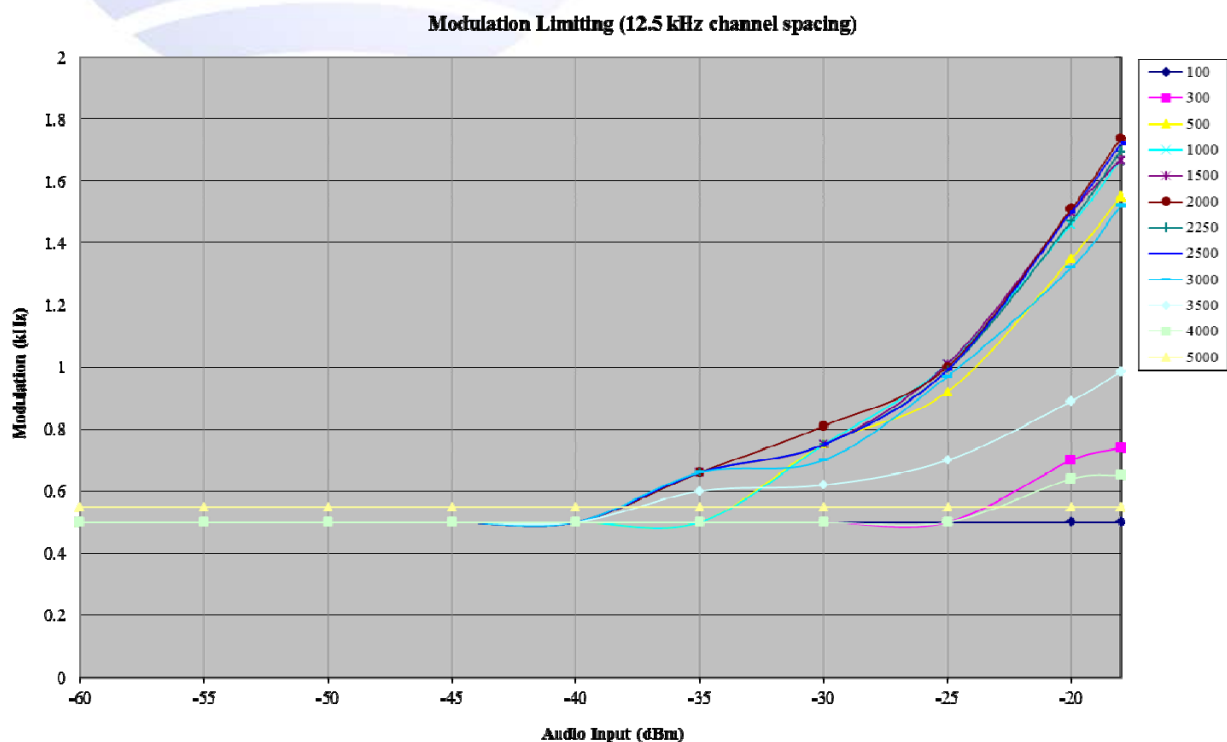
(a) A family of curves showing the percentage of modulation versus the modulation input voltage. Measurements were made between 100 Hz to 5 kHz.

At each frequency the input voltage was slowly increased, up to 100 mV (-17.9 dBm) with the resulting frequency deviation of the transmitter being recorded.

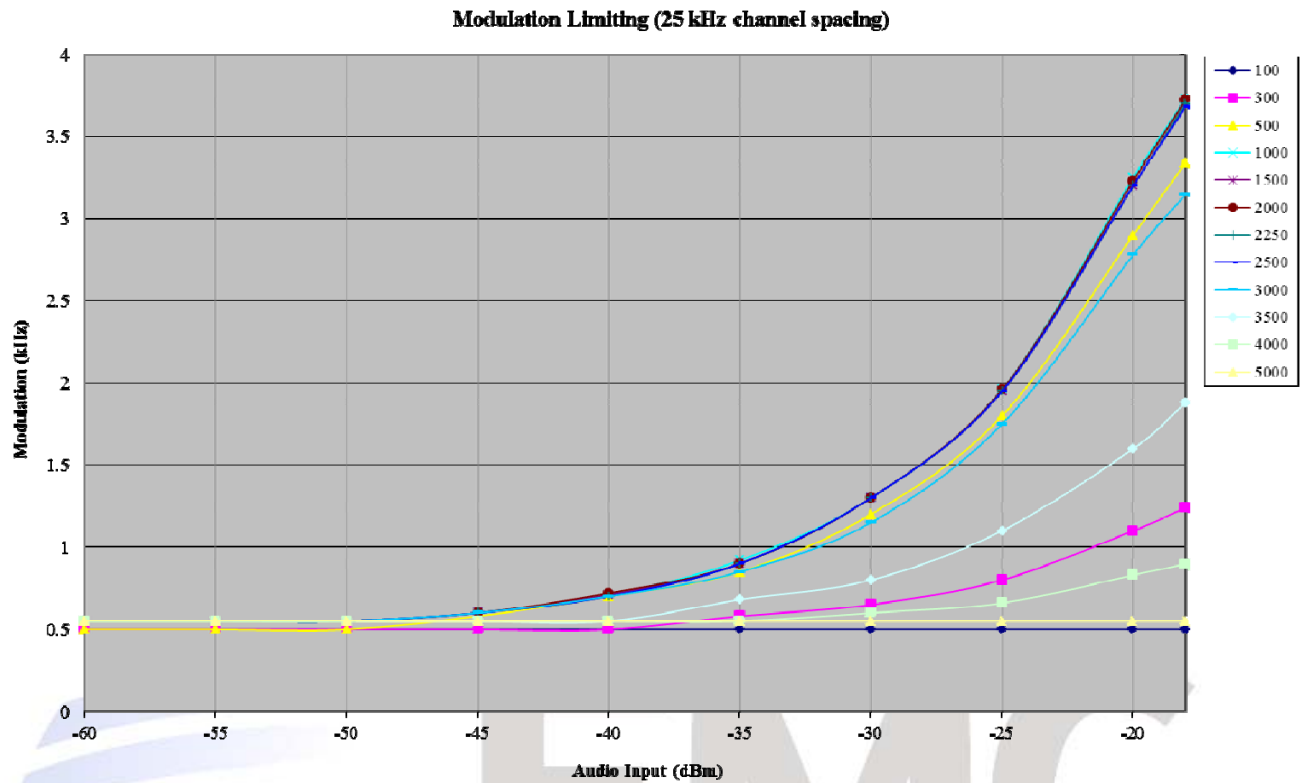
For 6.25 kHz channel bandwidth a maximum deviation of 0.61 kHz was measured.



For 12.5 kHz channel bandwidth a maximum deviation of 1.74 kHz was measured.



For 25 kHz channel bandwidth a maximum deviation of 3.72 kHz was measured.



Result: Complies

Measurement Uncertainty: $\pm 1\%$.

Bandwidth limitations:

The authorised bandwidth is taken to be the necessary bandwidth.

Using the formulas contained in Part 2.202 the necessary bandwidth calculation for the 6.25 kHz channel bandwidth emission is:

$$B_n = 2 \times D + 2 \times M$$

Where D = maximum deviation: 1.0 kHz

Where M = maximum modulation frequency: 2.0 kHz

$$B_n = 6 \text{ kHz}$$

Measurements show the following

$$B_n = 2 \times D + 2 \times M$$

Where D = maximum deviation: 0.61 kHz

Where M = maximum modulation frequency: 2.25 kHz

$$B_n = 5.7 \text{ kHz}$$

Using the formulas contained in Part 2.202 the necessary bandwidth calculation for the 12.5 kHz channel bandwidth emission is:

$$B_n = 2 \times D + 2 \times M$$

Where D = maximum deviation: 2.5 kHz

Where M = maximum modulation frequency: 3 kHz

$$B_n = 11 \text{ kHz}$$

Measurements show the following

$$B_n = 2 \times D + 2 \times M$$

Where D = maximum deviation: 1.74 kHz

Where M = maximum modulation frequency: 3.3 kHz

$$B_n = 10.08 \text{ kHz}$$

Using the formulas contained in Part 2.202 the necessary bandwidth calculation for the 25 kHz channel bandwidth emission is:

$$B_n = 2 \times D + 2 \times M$$

Where D = maximum deviation: 5.0 kHz

Where M = maximum modulation frequency: 3 kHz

$$B_n = 16 \text{ kHz}$$

Measurements show the following

$$B_n = 2 \times D + 2 \times M$$

Where D = maximum deviation: 3.72 kHz

Where M = maximum modulation frequency: 3.3 kHz

$$B_n = 14.04 \text{ kHz}$$

Result: Complies.

Spectrum Masks

The spectrum masks are defined in:

Section 90.210(e) – Mask E has been applied as the transmitter can operate in the band 421 - 512 MHz using a channel bandwidth of 6.25 kHz as per Section 90.209(b)(5).

Section 90.210(d) – Mask D has been applied as the transmitter can operate in the band 421 - 512 MHz using a channel bandwidth of 12.5 kHz as per Section 90.209(b)(5).

Section 90.210(b) – Mask B has been applied as the transmitter can operate in the band 421 - 512 MHz using a channel bandwidth of 25.0 kHz as per Section 90.209(b)(5).

The reference level for the following emission mask measurements has been determined using an un-modulated carrier which is the aqua trace in the Mask E measurements.

All measurements have been made using a 30 dB attenuator that is placed between the transmitter and the spectrum analyser.

All spectrum mask plots need to have 30 dB added to all amplitudes.

The rated power of the transmitter is 5 watts (+37 dBm)

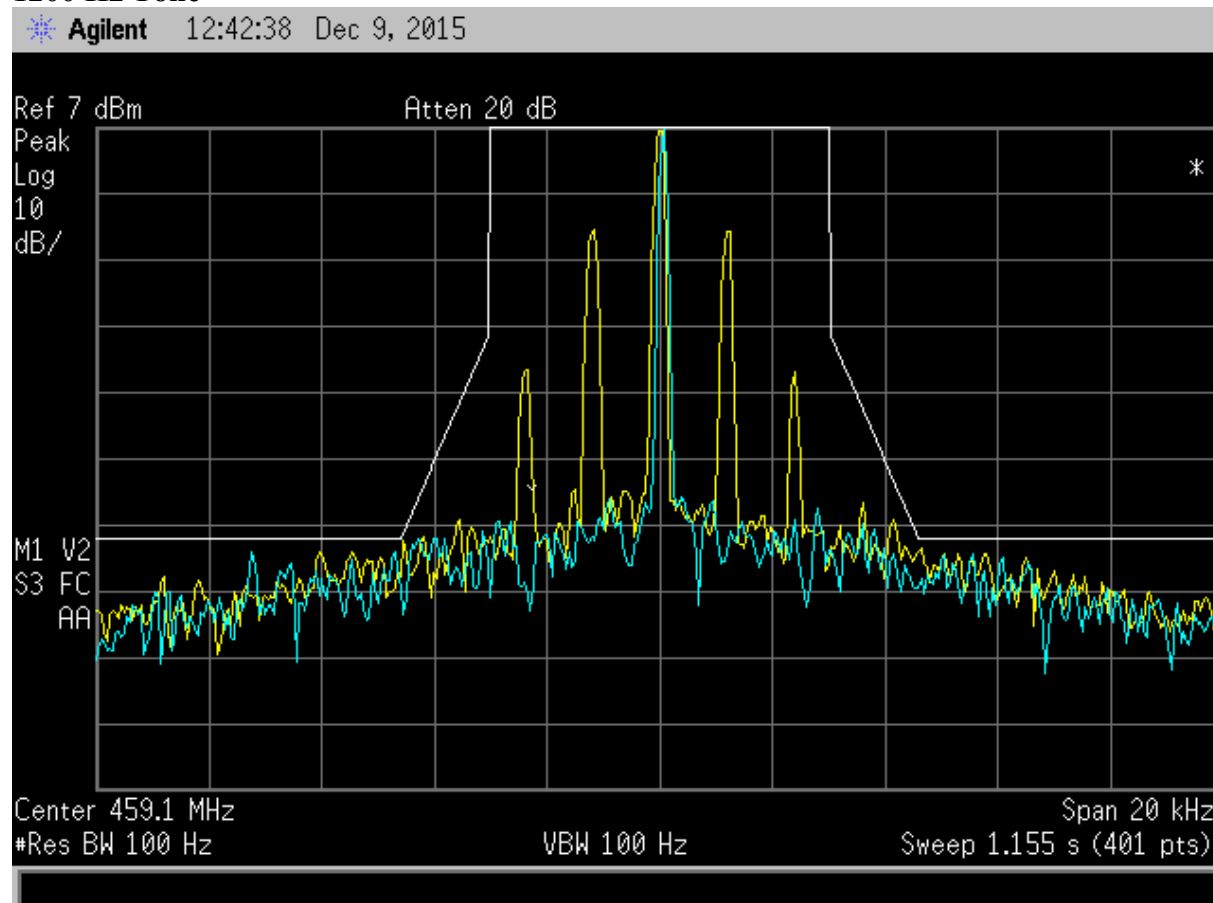
All masks can be observed to have reference levels of approximately $+7.1 \text{ dB} + 30 \text{ dBm} = +37.1 \text{ dBm}$ which approximates the rated power of 5 watts (+37 dBm).

Measurements were made in peak hold.

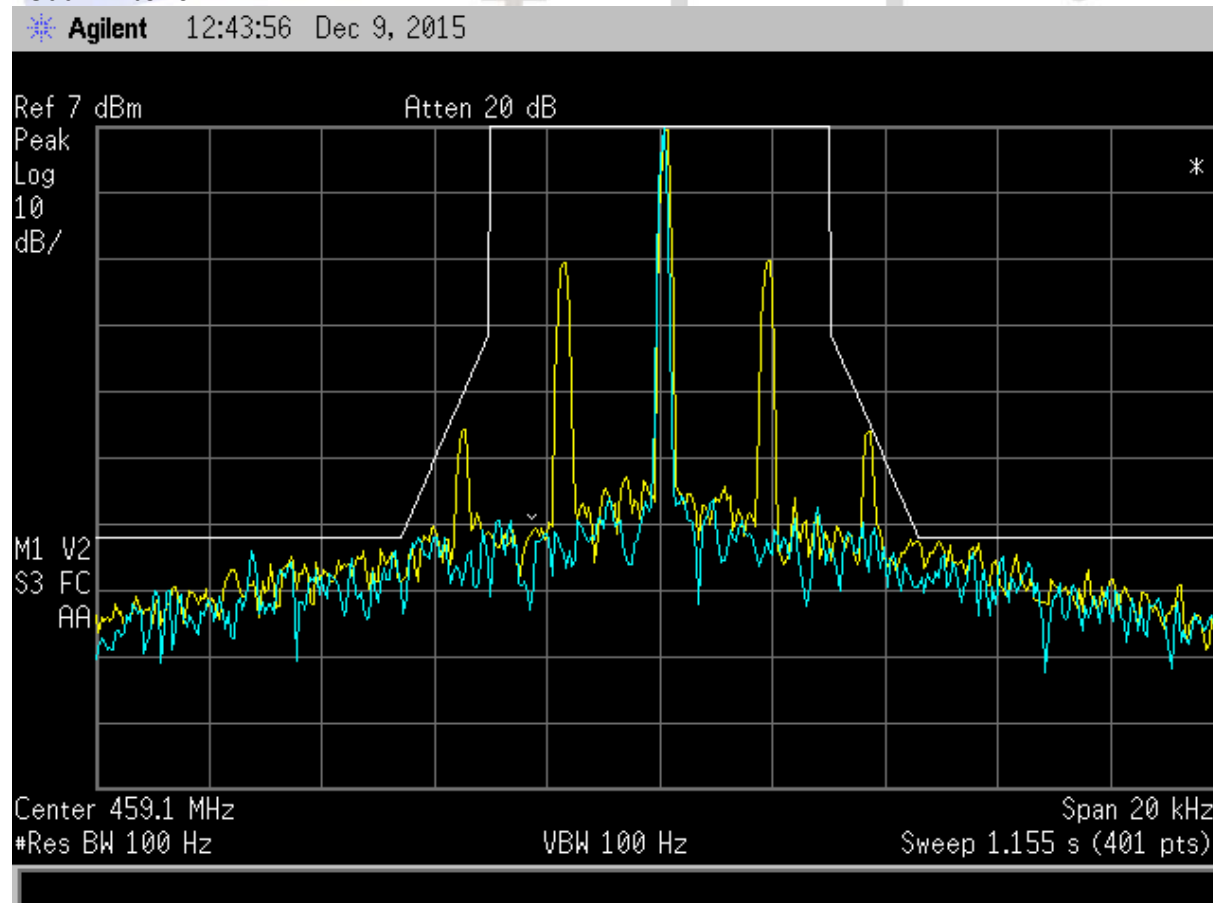
Result: Complies.

Mask E. 6.25 kHz channel bandwidth. F2D.

1200 Hz Tone

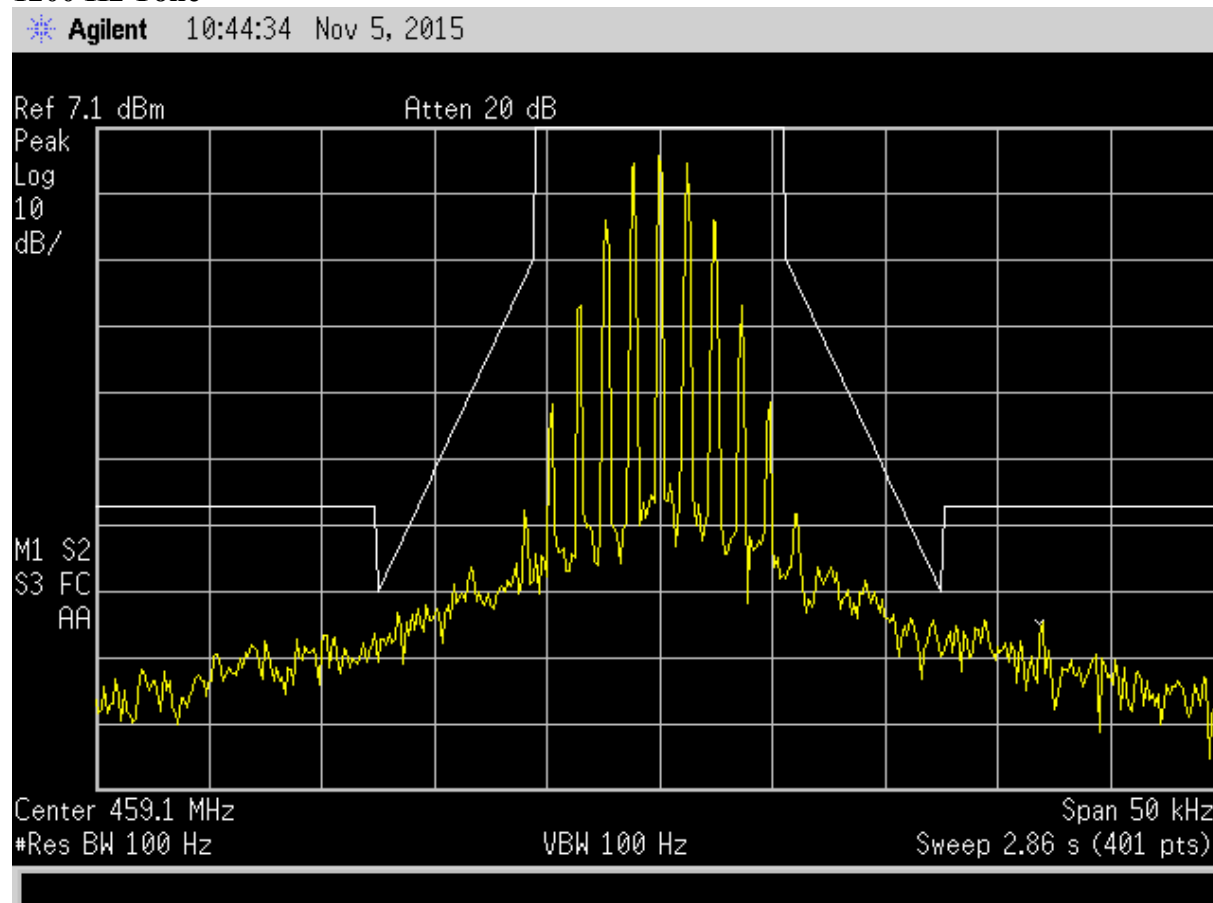


1800 Hz tone

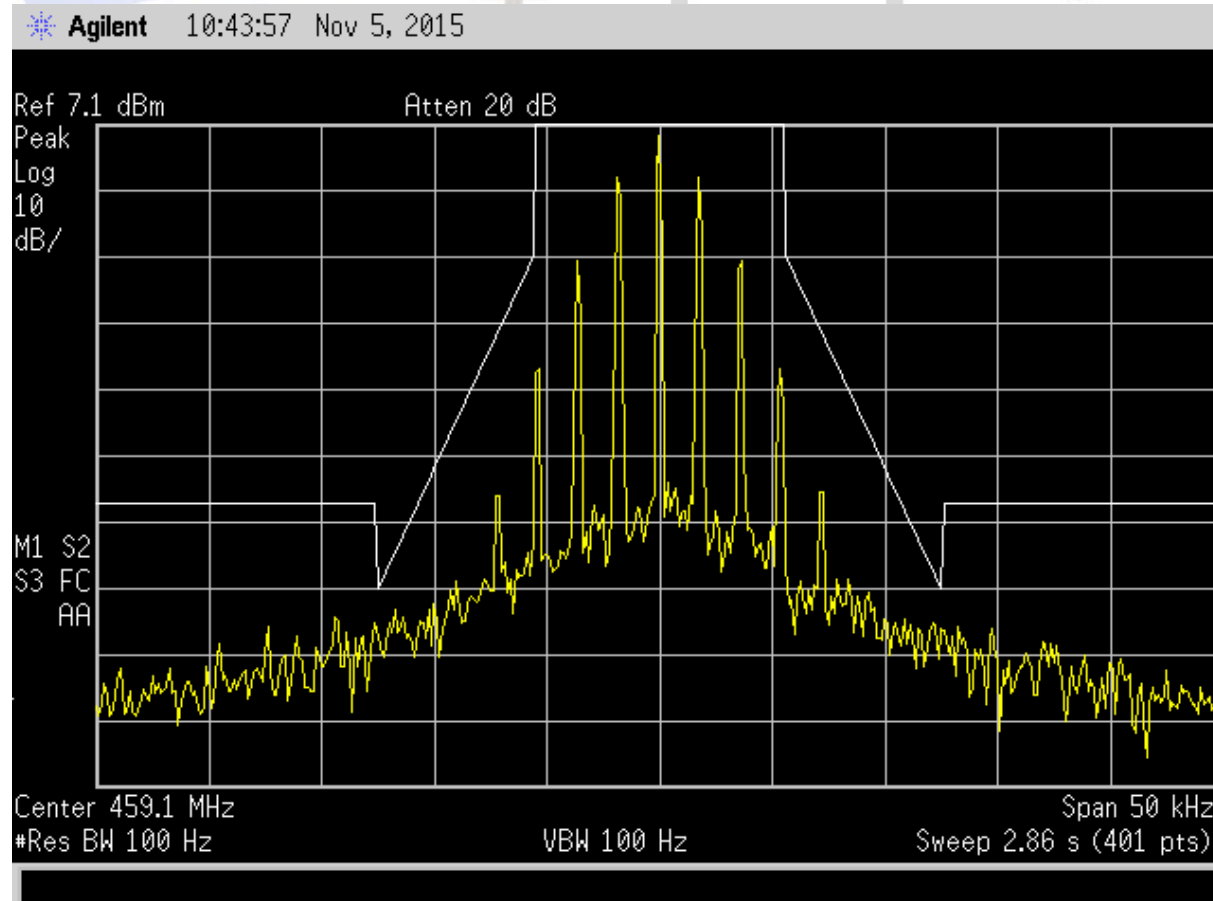


Mask D. 12.5 kHz channel bandwidth. F2D.

1200 Hz Tone

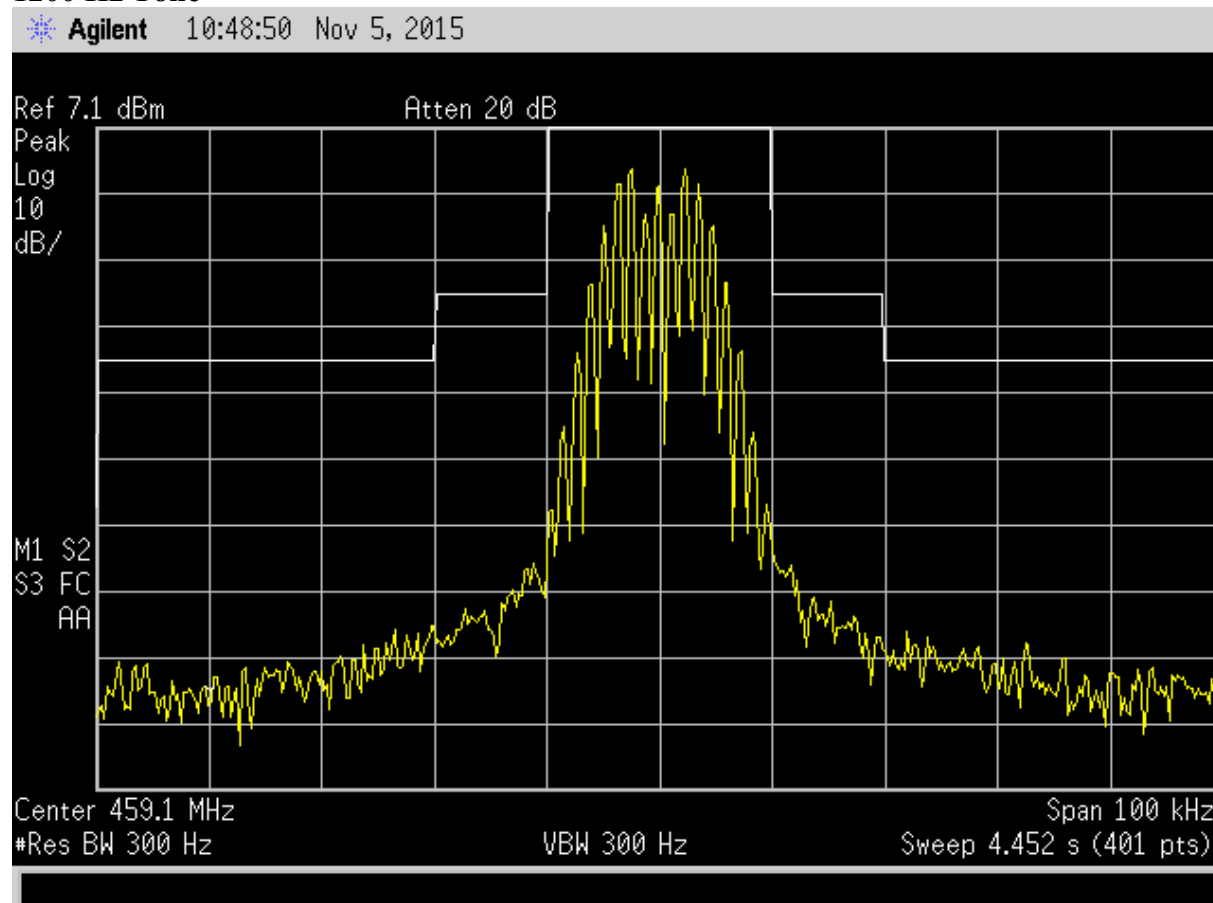


1800 Hz tone

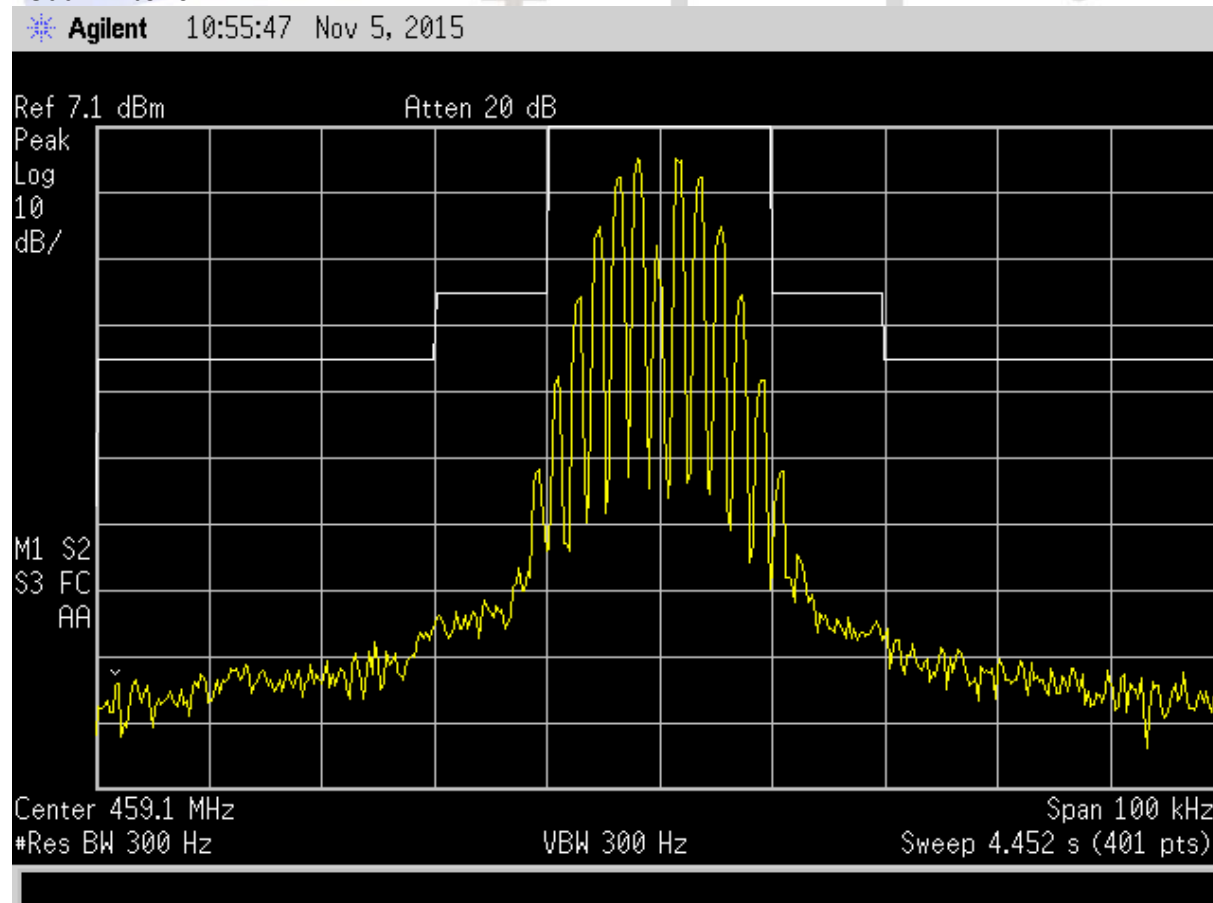


Mask B. 25.0 kHz channel bandwidth. F2D.

1200 Hz Tone



1800 Hz tone



Transmitter spurious emissions at the antenna terminals

Frequency: 459.075 MHz

Spurious emission (MHz)	Emission level (dBm)	Limit (dBm)
918.150	-40.8	-20.0
1377.225	-70.0*	-20.0
1836.300	-60.7	-20.0
2295.375	-65.0	-20.0
2754.450	-70.0*	-20.0
3213.525	-61.0	-20.0
3672.600	-70.0*	-20.0
4131.675	-70.0*	-20.0
4590.750	-65.4	-20.0

* Noise floor measurement. No emission observed

Limit:

Part 90.210(d) Mask D, (3) 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.

The spurious emission limit defined by Mask D has been applied as this transmitter can operate using channel bandwidth of 12.5 kHz.

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.

A rated power of 5.0 watts gives a limit of -20.0 dBm.

No measurements were made above the 10th harmonic.

Result: Complies

Measurement Uncertainty: ± 3.3 dB

Field strength of the transmitter spurious emissions

Frequency: 459.075 MHz

Frequency (MHz)	Level (dBμV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
918.1500	45.1	-52.3	-20.0	Vertical	32.3	Pass
918.1500	47.0	-50.4	-20.0	Horizontal	30.4	Pass
1377.2250	48.3	-49.1	-20.0	Vertical	29.1	Pass
1377.2250	50.2	-47.2	-20.0	Horizontal	27.2	Pass
1836.3000	56.3	-41.1	-20.0	Vertical	21.1	Pass
1836.3000	54.0	-43.4	-20.0	Horizontal	23.4	Pass
2295.3750	62.0	-35.4	-20.0	Vertical	15.4	Pass
2295.3750	59.3	-38.1	-20.0	Horizontal	18.1	Pass
2754.4500	59.3	-38.1	-20.0	Vertical	18.1	Pass
2754.4500	59.3	-38.1	-20.0	Horizontal	18.1	Pass
3213.5250	49.6	-47.8	-20.0	Vertical	27.8	Pass
3213.5250	49.6	-47.8	-20.0	Horizontal	27.8	Pass
3672.6000	51.0	-46.4	-20.0	Vertical	26.4	Pass
3672.6000	51.0	-46.4	-20.0	Horizontal	26.4	Pass
4131.6750	53.5	-43.9	-20.0	Vertical	23.9	Pass
4131.6750	53.5	-43.9	-20.0	Horizontal	23.9	Pass
4590.7500	55.0	-42.4	-20.0	Vertical	22.4	Pass
4590.7500	55.0	-42.4	-20.0	Horizontal	22.4	Pass

The transmitter was tested while transmitting continuously while attached to a dummy load.

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

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.

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

Limit:

All spurious emissions are to be attenuated by at least $50 + 10 \log (P)$. The rated power of 5 watts gives a limit of -20 dBm.

No measurements were made above the 10th 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 client has declared that this transmitter can only operate over a very narrow range of voltages being +/- 0.5 volts with reference to 13 Vdc.

Testing has therefore be carried out over this voltage range only.

Frequency: 459.075 MHz

Temperature (°C)	Voltage (12.5 Vdc) Frequency Error (Hz)	Voltage (13.0 Vdc) Frequency Error (Hz)	Voltage (13.5 Vdc) Frequency Error (Hz)
+50	+192.0	+183.0	+195.0
+40	+85.0	+78.0	+95.0
+30	+26.0	+23.0	+25.0
+20	+38.0	+47.0	+50.0
+10	+35.0	+36.0	+41.0
0	+66.0	+72.0	+77.0
-10	+88.0	+85.0	+52.0
-20	+59.0	+55.0	+48.0
-30	+46.0	+32.0	+27.0

Limit:

In the 421-512 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 1.5 ppm.

Fixed and base stations with a 6.25 kHz channel bandwidth must have a frequency stability of 0.5 ppm.

A worst case frequency stability ($195 / 459.075$) of 0.425 ppm was observed

Result: Complies

Measurement Uncertainty: ± 30 Hz

Transient frequency behaviour

Transient frequency behaviour measurements are applicable to wide band and narrow band transmitters

Measurements were carried out using the method described in TIA-603 and EN 300-086.

In summary this method calls for the use of an external signal generator tuned to transmitter transmit frequency of 469.300 MHz with an output level 0.1 % (-30 dB) of the level from the transmitter with a 1 kHz tone with a frequency deviation of 12.5 kHz being applied to the input of a modulation analyser along with the output from the transmitter.

The modulation analyser produces an amplitude difference signal and a frequency difference signal, which are applied to the input of a storage oscilloscope.

The unmodulated transmitter is then keyed which produces a trigger pulse that is AC coupled to the oscilloscope that produces a display on the screen.

The result of the change in the ratio of power between the test signal from the signal generator and the transmitter output will produce 2 separate sides on the oscilloscope picture. One will show the 1000 Hz test modulation and the other will be the frequency difference of the transmitter versus time.

Results:

Channel Bandwidth	Period t_1 (kHz)	Period t_2 (kHz)	Period t_3 (kHz)
12.5 kHz	Less than 3.125	Less than 3.125	Less than 3.125
25.0 kHz	Less than 6.25	Less than 6.25	Less than 6.25

Limits:

Time Interval	Period	12.5 kHz	25 kHz
		Deviation (kHz)	Deviation (kHz)
t_1	10 ms	± 12.5	± 25.0
t_2	25 ms	± 6.25	± 12.5
t_3	10 ms	± 12.5	± 25.0

Result: Complies

Measurement Uncertainty: Frequency difference ± 1.6 kHz, Time period ± 1 ms

12.5 kHz transmitter turn on (459.075 MHz)

Green Trace = 1 kHz tone with FM deviation of 12.5 kHz.

Green trace has been maximised to give full screen indication of +/- 12.5 kHz.

Therefore each Y axis division = 3.125 kHz per division.

The X axis has been set to a sweep rate of 10 ms/division.

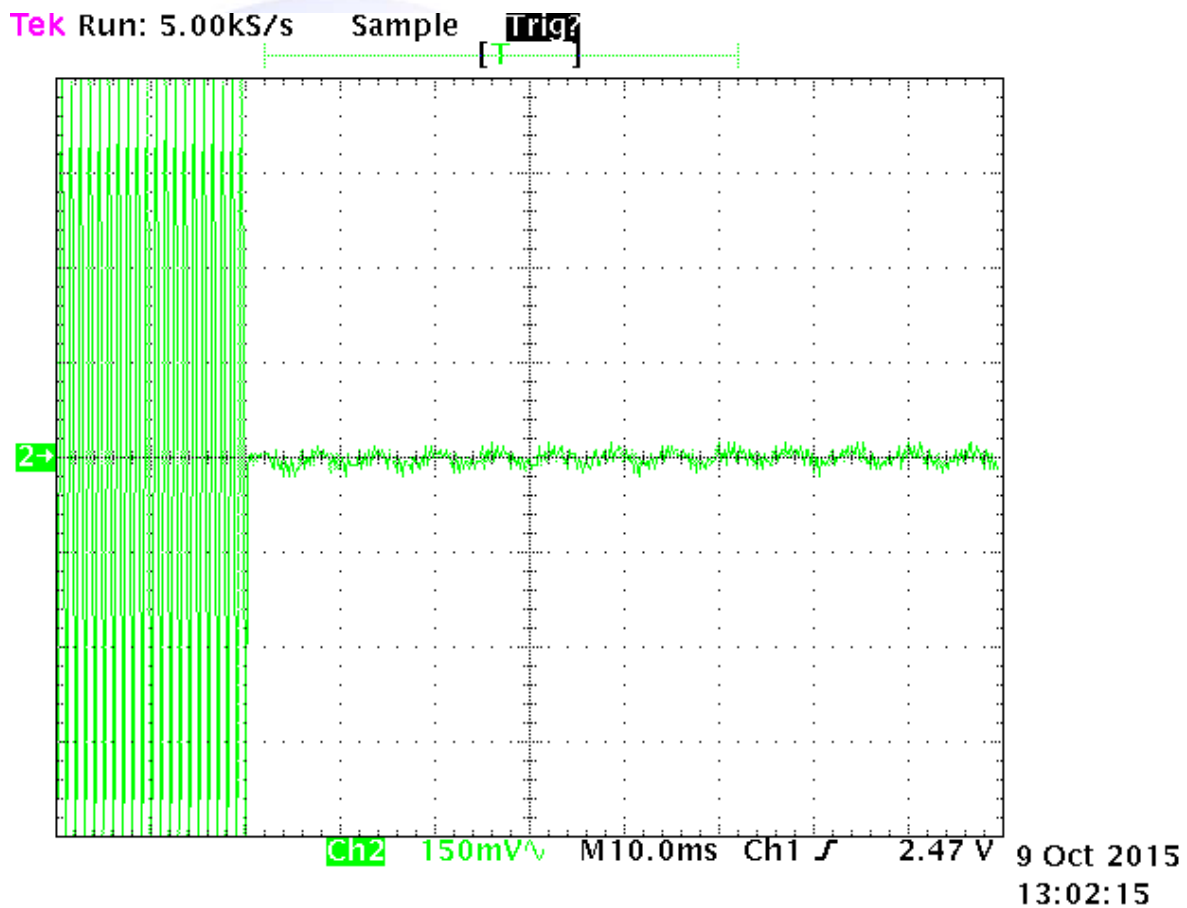
Triggering has been set to occur 2 divisions from the left hand edge (20 ms).

t_{on} occurs at 20 ms.

t_1 occurs between 2.0 and 3.0 divisions from the left hand edge.

t_2 occurs between 3.0 and 5.5 divisions from the left hand edge.

No transient response can be observed during t_1 and t_2 .



12.5 kHz transmitter turn off (459.075 MHz)

Green Trace = 1 kHz tone with FM deviation of 12.5 kHz.

Green trace has been maximised to give full screen indication of +/- 12.5 kHz.

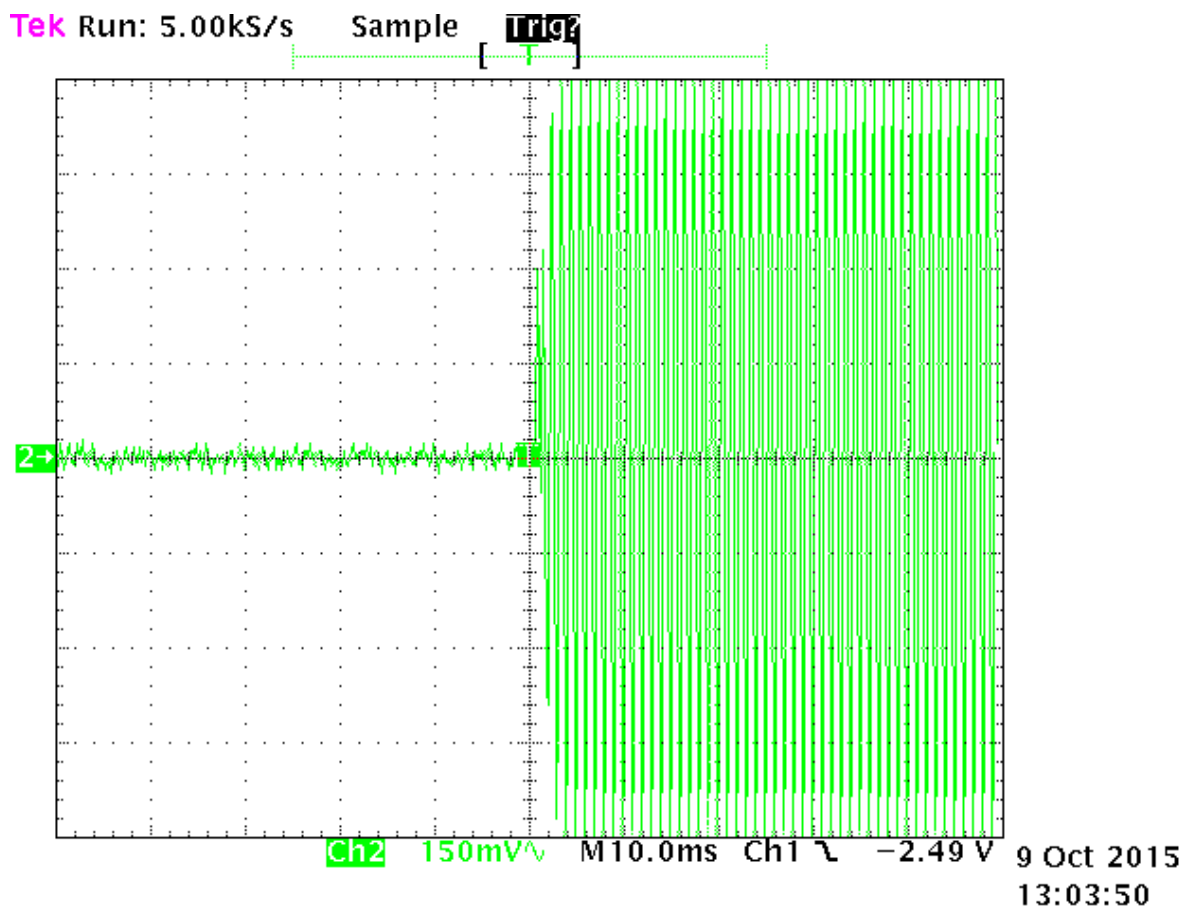
Therefore each Y axis division = 3.125 kHz per division.

The X axis has been set to a sweep rate of 10 ms/division

The display of the 1 kHz signal rising has been positioned 5 divisions from the left hand edge (50 ms). This is position toff.

t_3 occurs between 4.0 and 5.0 divisions from the left hand edge..

A small transient response can be observed before toff.



25.0 kHz transmitter turn on (459.075 MHz)

Green Trace = 1 kHz tone with FM deviation of 25.0 kHz.

Green trace has been maximised to give full screen indication of +/- 25.0 kHz.

Therefore each Y axis division = 6.25 kHz per division.

The X axis has been set to a sweep rate of 10 ms/division.

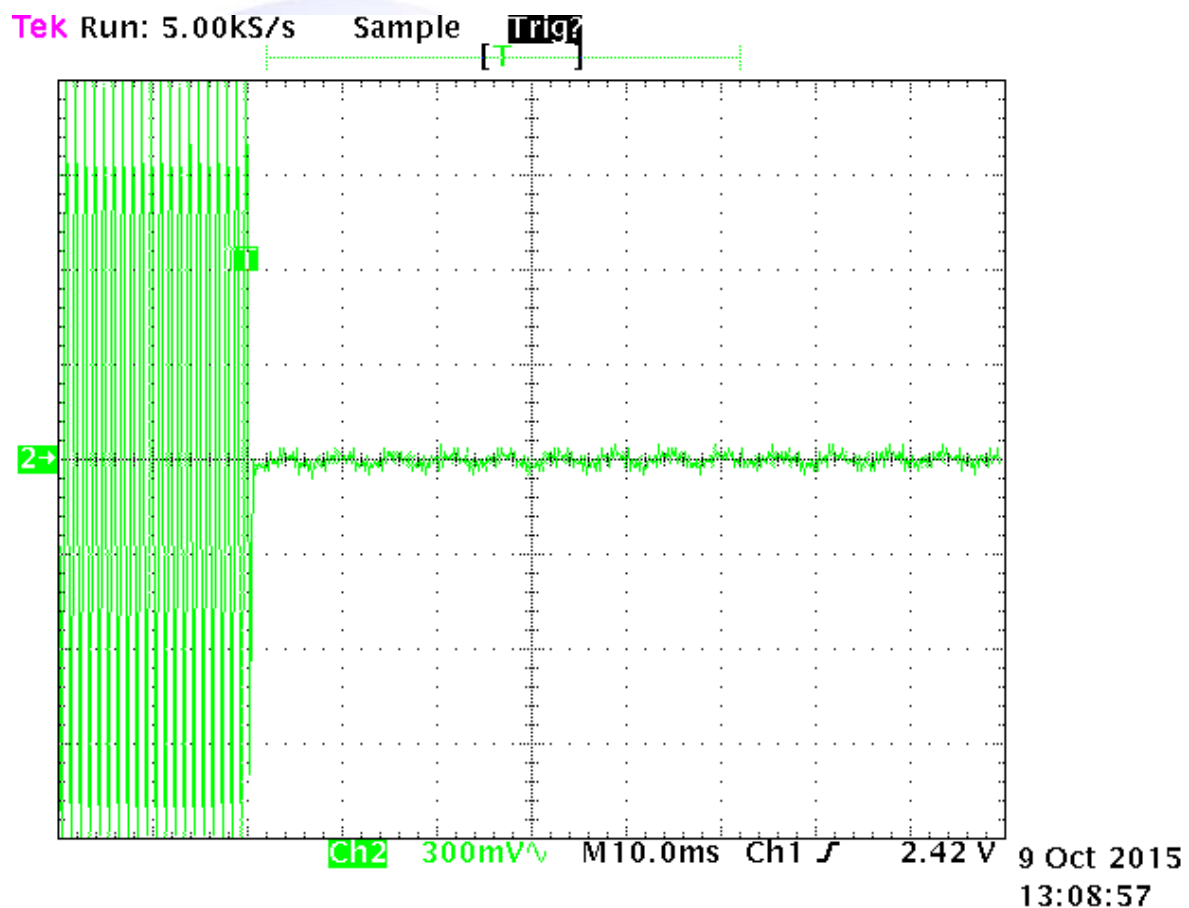
Triggering has been set to occur 2 divisions from the left hand edge (20 ms).

t_{on} occurs at 20 ms.

t_1 occurs between 2.0 and 3.0 divisions from the left hand edge.

t_2 occurs between 3.0 and 5.5 divisions from the left hand edge.

No transient response can be observed during t_1 and t_2 .



25.0 kHz transmitter turn off (459.075 MHz)

Green Trace = 1 kHz tone with FM deviation of 25.0 kHz.

Green trace has been maximised to give full screen indication of +/- 25.0 kHz.

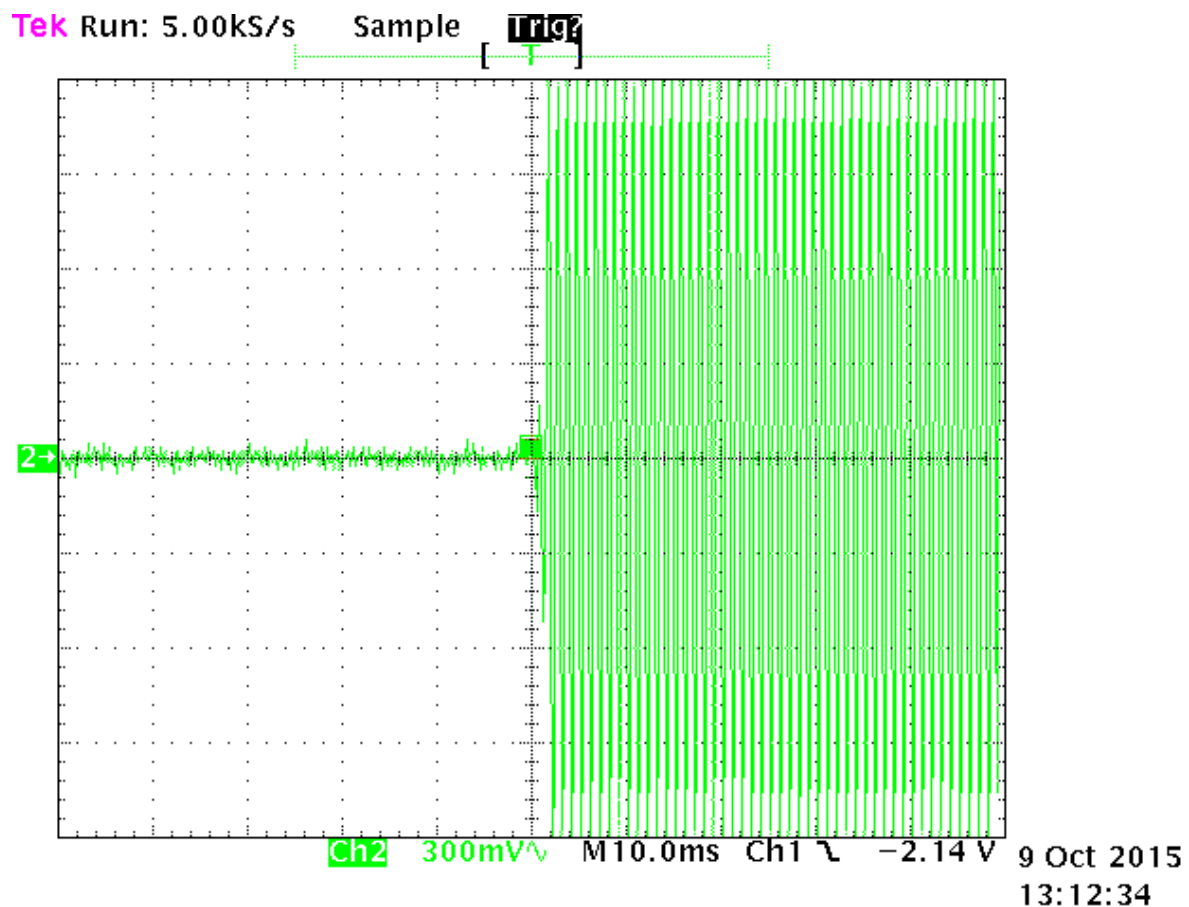
Therefore each Y axis division = 6.25 kHz per division.

The X axis has been set to a sweep rate of 10 ms/division

The display of the 1 kHz signal rising has been positioned 5 divisions from the left hand edge (50 ms). This is position toff.

t_3 occurs between 4.0 and 5.0 divisions from the left hand edge..

A small transient response can be observed before toff.



Exposure of humans to RF fields

As per Section 1.1310 mobile transmitters are required to be operated in a manner that ensures the public is not exposed to RF energy levels in accordance with OST/OET Bulletin Number 65.

Calculations have been made using the General Public/Uncontrolled Exposure limits.

Minimum safe distances have been calculated below.

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

- General Population / Uncontrolled exposure limit will be 0.30 mW/m²
(f/1500 = 450 MHz/1500)

As this radio can operate over the range of 450 - 470 MHz calculations have been made at 450 MHz which will give the worst case result for operations in the USA.

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:

$$E, \text{ V/m} = (\sqrt{30 * P * G}) / d$$

Uncontrolled

$$E = 0.30 \text{ mW/m}^2 = E^2/3770$$

$$E = \sqrt{0.30 * 3770}$$

$$E = 33.6 \text{ V/m}$$

The rated maximum transmitter power = 5.0 watts.

The transmitter is typically operated using a quarter wave whip antenna with a gain of 2.14 dBi (1.64).

A duty cycle of 100% has been applied as the transmitter could be used as a base station and it could possibly be operated for long periods of time.

Typically it would only be operated for relatively short periods of time

Uncontrolled

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

$$d = \sqrt{30 * 5 * 1.64 * 1.0} / 33.6$$

$$d = 0.466 \text{ metres or } 46.6 \text{ cm}$$

This number rounds up to 47 cm.

Result: Complies if the safe distances defined for this environment is applied.

7. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial #	Asset	Cal Due	Interval
Aerial Controller	EMCO	1090	9112-1062	3710	N/a	N/a
Aerial Mast	EMCO	1070-1	9203-1661	3708	N/a	N/a
Biconical Antenna	Schwarzbeck	BBA 9106	-	3612	03/02/2018	3 years
Horn Antenna	EMCO	3115	9511-4629	E1526	04/06/2017	3 years
Level generator	Anritsu	MG443B	M61689	E1143	21/05/2016	2 years
Log Periodic Antenna	Schwarzbeck	VUSLP 91111	9111-228	3785	17/12/2017	3 years
Modulation Analyzer	Rohde & Schwarz	FMA	837807/020	E1552	19/06/2017	2 years
Modulation Analyzer	Hewlett Packard	8901B	2608A00782	E1090	15/11/2016	2 years
Oscilloscope	Tektronics	745A	B010643	E1569	19/06/2017	2 years
Power Attenuator	JFW	50FH-030-100	-	-	N/a	N/a
Power Supply	Hewlett Packard	6032A	2743A-02859	E1069	N/a	N/a
Receiver	Rohde & Schwarz	ESIB-40	100171	4003	16/04/2016	1 year
Selective Level Meter	Anritsu	ML422C	M35386	E1140	07/11/2015	2 years
Signal Generator	Rohde & Schwarz	SMHU	838923/028	E1493	19/06/2017	2 years
Spectrum Analyzer	Hewlett Packard	E7405A	US39150142	3776	07/11/2015	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	3709	N/a	N/a
VHF Balun	Schwarzbeck	VHA9103	-	3603	03/02/2018	3 years

At the time of testing all test equipment was within calibration.

8. ACCREDITATIONS

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

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

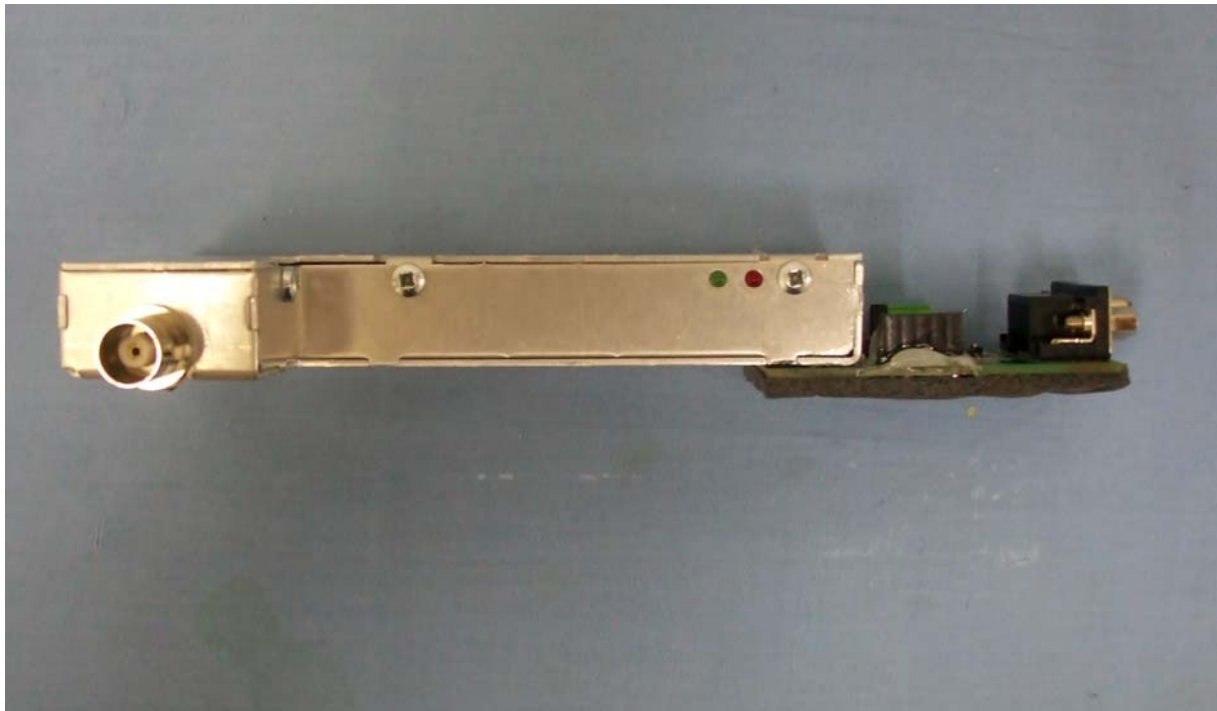
All measurement equipment has been calibrated in accordance with the terms of the EMC Technologies (NZ) Ltd International Accreditation New Zealand (IANZ) Accreditation to NZS/ISO/IEC 17025.

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

9. PHOTOGRAPHS

External Photos





Radiated emissions test setup photos



