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TEST REPORT

Crescendo RFI-150
(HWHDD01 & HNMDD01)
VHF Digital Modem

tested to the

Code of Federal Regulations (CFR) 47

Part 90 –Private Land Mobile Services

Part 15 – Radio Frequency Devices

for

STI Engineering

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 **Crescendo RFI-150 (HWHDD01 & HNMDD01) VHF Digital Modem** complies with the limits defined in 47 CFR Part 15, 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 C63.4, 2002.

2. RESULT SUMMARY

The results of testing, carried out in 6th – 10th August 2012, 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)	Modulation Characteristics Low pass filter response Modulation limiting characteristics	Noted 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 22.355 90.213	Frequency stability Frequency stability Frequency stability	Noted Complies Complies
90.214	Transient frequency behaviour	Complies
15.109 15.111	Receiver radiated emissions Receiver local oscillator voltage	Complies 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.

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 STI Engineering

Address 22 Boulder Rd
Malaga, WA 6090

Country Australia

Contact Mr Lahiru Raffel

5. TEST SAMPLE DESCRIPTION

Brand Name Crescendo

Model Number RFI-150

Versions HWHDD01 (19.2 kbps)
HNMDD01 (9.6 kbps)

Product VHF digital modem

Manufacturer RF Innovations

Manufactured in Australia

Designed in Australia

Serial Number B03191202100

FCC ID P5MRFI150H

The Crescendo RFI-150 is a digital radio modem designed for telemetry and SCADA radio applications in point to point and point to multipoint industrial systems.

The test sample has sockets for a transmit antenna, dc power, Main RS232 and Aux RS232 ports.

The radio was tested for emissions using 4 –level FSK modulation with two different channel bandwidths, 25.0 kHz (19.2 kbps air rate) and 12.5 kHz 9.6 kbps air rate.

The sample tested has the following specifications:

Rated Transmitter Output Power

5.0 Watts (37.0 dBm)

Transmitter FCC frequency range

Part 90: 150.000 – 174.000 MHz

Test frequencies

Chl	Frequency MHz	Power Watts	Spacing kHz
1	161.025	5.0	12.5
2	161.025	5.0	25.0

Emission Designators / Modes of operation

F1D – 19.2 kbps baud digital data
F1D – 9.6 kbps baud digital data

Power Supply

Rechargeable Lead acid battery DC voltage supply typically 12.0 Vdc

Standard Temperature and Humidity

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

Standard Test Power Source

Standard Test Voltage: 13.8 Vdc

Extreme Temperature

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

Extreme Test Voltages

High Voltage: 15.6 Vdc
Low Voltage: 10.8 Vdc

6. TEST RESULTS

Certification required

Part 90.203(j)

4) Applications for part 90 certification of transmitters designed to operate on frequencies in the 150.8–162.0125 MHz, 173.2–173.4 MHz, and/or 421–512 MHz bands, received on or after January 1, 2011,

(ii) 12.5 kHz for multi-bandwidth mode equipment with a maximum channel bandwidth of 12.5 kHz if it is capable of operating on channels of 6.25 kHz or less;

(iii) 25 kHz for multi-bandwidth mode equipment with a maximum channel bandwidth of 25 kHz if it is capable of operating on channels of 6.25 kHz or less; and

(iv) Up to 25 kHz if the equipment meets the efficiency standard of paragraph (j)(5) of this section.

(5), Application for part 90 certification of transmitters designed to operate on frequencies in the 150.8–162.0125 MHz, 173.2–173.4 MHz, and/or 421–512 MHz bands, after January 1, 2011, must include a certification that the equipment meets a spectrum efficiency standard of one voice channel per 6.25 kHz of channel bandwidth.

Additionally, if the equipment is capable of transmitting data, has transmitter output power greater than 500 mW, and has a channel bandwidth of more than 6.25 kHz, the equipment must be capable of supporting a minimum data rate of 4800 bits per second per 6.25 kHz of channel bandwidth.

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).

Frequency (MHz)	Voltage (Vdc)	Rated (dBm)	Measured (dBm)
161.025	13.8Vdc	37.0	37.4
161.025	15.6 Vdc	37.0	37.8
161.025	10.8 Vdc	37.0	36.1

Limits:

90.205 Power and antenna height limits,

This section states that the output power shall not exceed the manufacturer rated output power by more than 20%

Result: Complies
Measurement Uncertainty: ±0.5 dB

Part 90.207 – Emission types:
The following emission types are used:

- F1D Frequency modulation with digital data.

Part 90.209 – Bandwidth limitations:

The authorised bandwidth is taken to be the necessary bandwidth.

Measurement has been used to determine as in cases not covered by paragraph (c) (1), (2), or (3) of section 90.209

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.

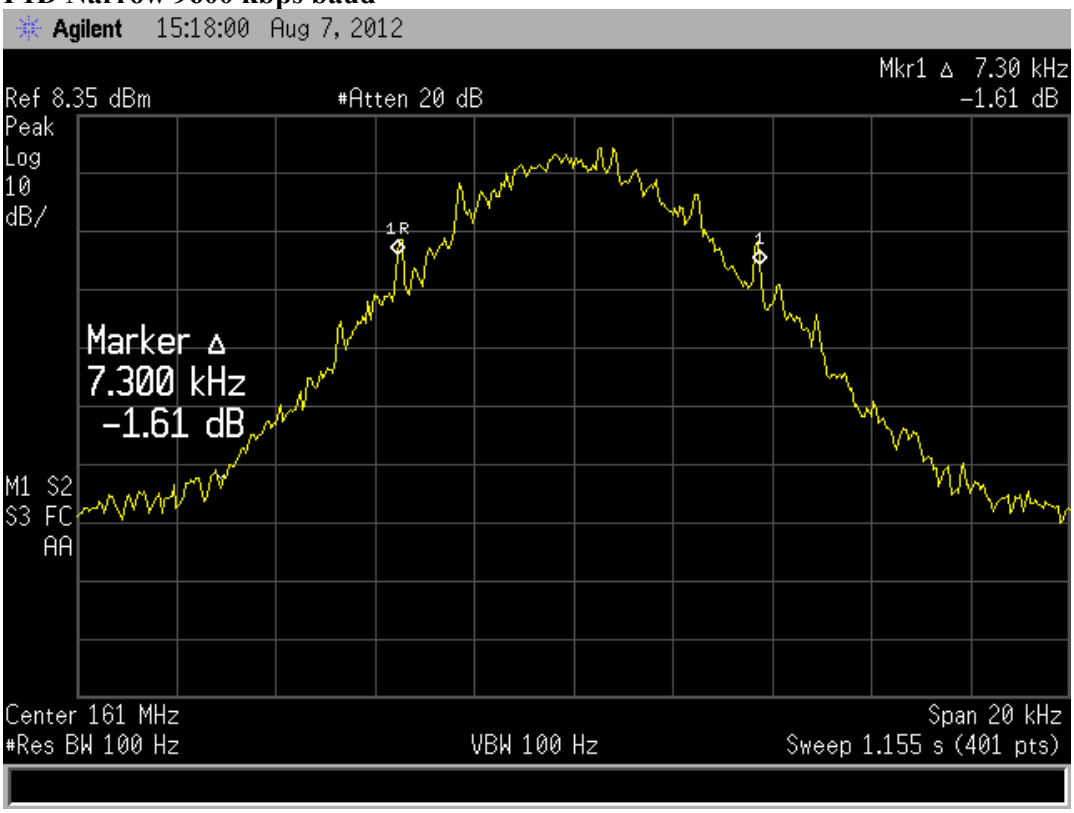
Initially power measurements are made using a resolution bandwidth of 120 kHz.

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

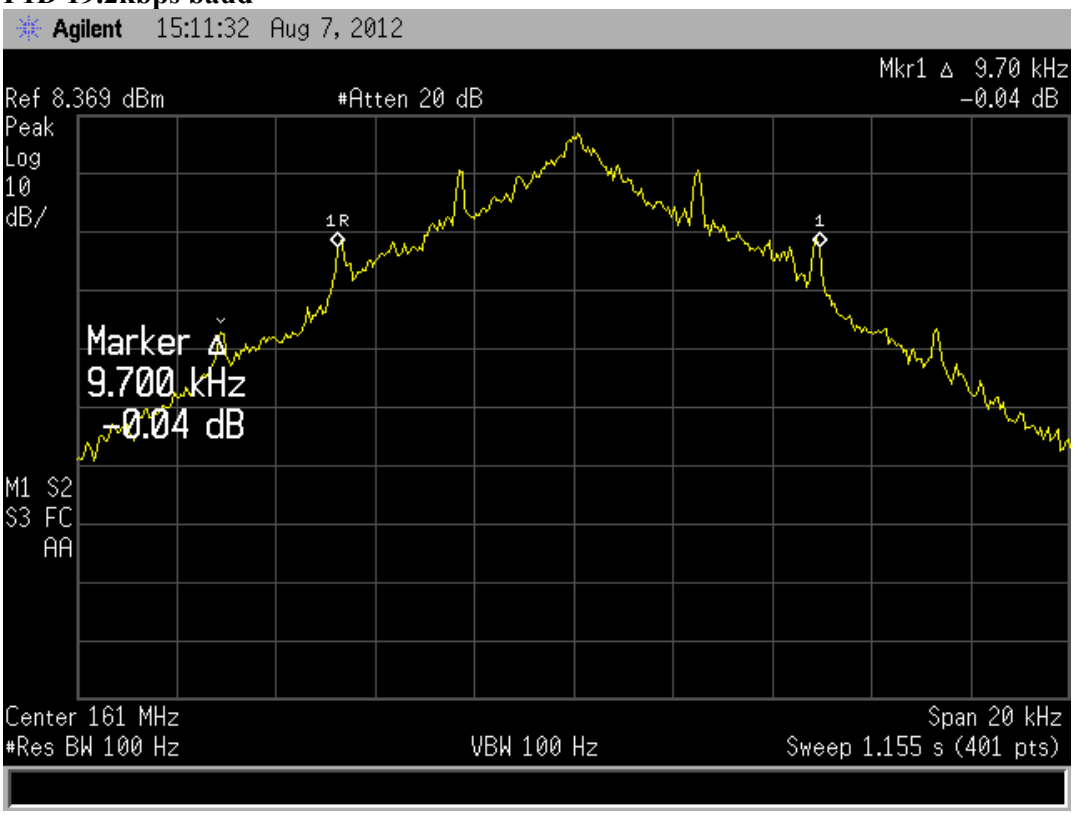
The resolution bandwidth is then changed to 100 Hz and the reference level minus 23 dB (99%) absolute bandwidth points determined

Emission	Channel	Measured	Authorised Bandwidth
F1D	12.5 kHz	7.3 kHz	11.25 kHz
F1D	25.0 kHz	9.7 kHz	20.0 kHz

F1D Narrow 9600 kbps baud



F1D 19.2kbps baud



Result: Complies

Spectrum Masks

Part 90.210 (2) states equipment designed to operate with a 25 kHz channel bandwidth must meet the requirements of Emission Mask B or C, as applicable. Equipment designed to operate with a 12.5 kHz channel bandwidth must meet the requirements of Emission Mask D.

Masks C and D have been applied as the transmitter has no audio low pass filter.

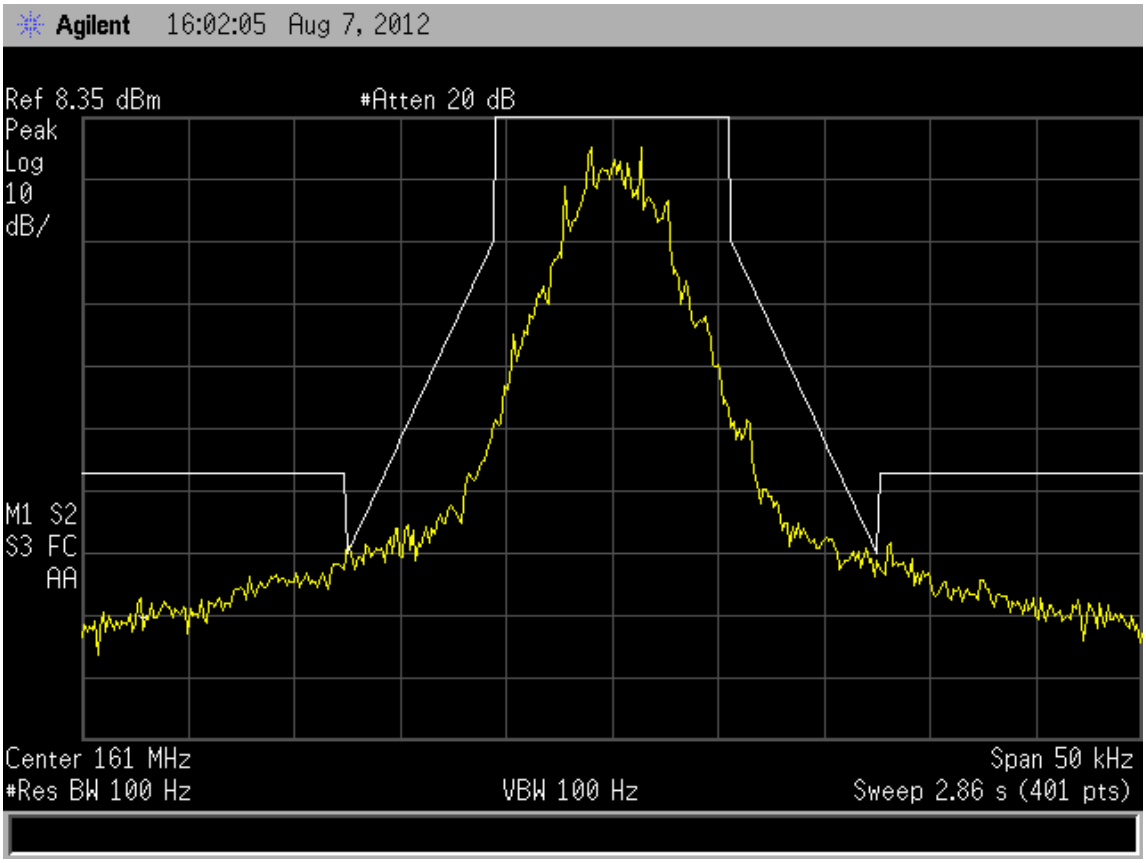
The transmitter can operate in the band 150-174 MHz using an authorised bandwidth of 11.25 kHz and channel spacing of 12.5 kHz and an authorised bandwidth of 20 kHz and a channel spacing of 25 kHz.

The reference level for the following emission mask measurements has been determined using a resolution bandwidth of 30 kHz with the transmitter not being modulated.

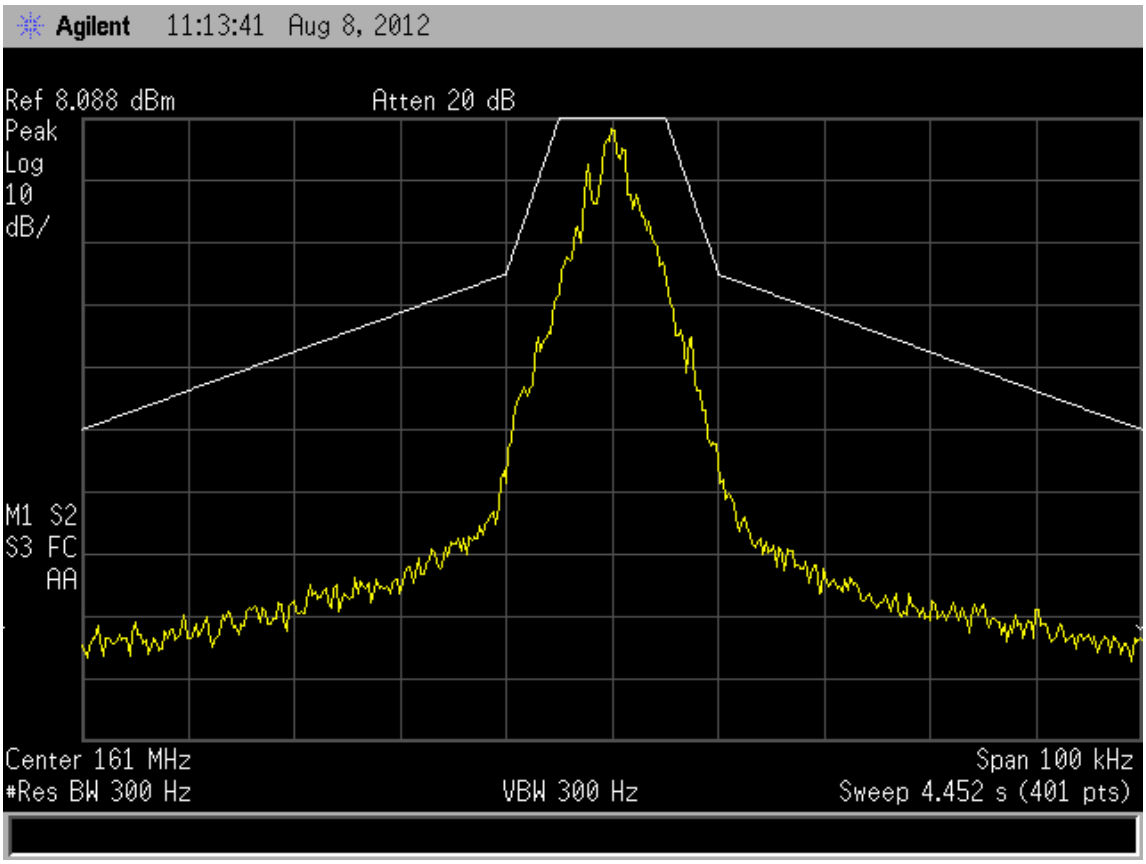
Measurements were made with the spectrum analyser operating in peak hold centred on the allocated frequency.

Result: Complies

F1D 12.5 kHz Mask D



F1D 25.0 kHz Mask C



Transmitter spurious emissions at the antenna terminals

Frequency: 161.025 MHz

Spurious emission (MHz)	Emission level (dBm)	Limit (dBm)
322.050	-42.1	-20.0
483.075	-56.0	-20.0
644.100	-56.4	-20.0
805.125	-56.0	-20.0
966.150	<-60.0	-20.0
1127.175	<-60.0	-20.0
1288.200	<-60.0	-20.0
1449.225	<-60.0	-20.0
1610.250	<-60.0	-20.0

No other emissions observed.

Limit:
Applied mask D, 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 70.0 dB whichever is the lesser attenuation.

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

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

The spurious emission limit defined by Mask D has been applied as this transmitter can operate using channel spacing 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.

Result: Complies
Measurement Uncertainty: ±3.3 dB

Receiver spurious emissions at antenna terminals

Frequency: 150.050 MHz

Frequency (MHz)	Level (dBm)	Limit (dBm)
139.350	-97.0	-57.0
278.700	< -100.0	-57.0
418.050	< -100.0	-57.0
557.400	< -100.0	-57.0
696.750	< -100.0	-57.0
836.100	-98.0	-57.0
975.450	< -100.0	-57.0
1114.800	-97.8	-57.0
1254.150	-92.3	-57.0
1393.500	-85.1	-57.0

Frequency: 161.025 MHz

Frequency (MHz)	Level (dBm)	Limit (dBm)
150.325	-90.6	-57.0
300.650	< -100.0	-57.0
450.975	< -100.0	-57.0
601.300	< -100.0	-57.0
751.625	< -100.0	-57.0
901.950	< -100.0	-57.0
1052.278	< -100.0	-57.0
1202.600	-94.5	-57.0
1352.925	-89.0	-57.0
1503.250	-92.0	-57.0

Frequency: 174.000 MHz

Frequency (MHz)	Level (dBm)	Limit (dBm)
163.300	-89.0	-57.0
323.600	< -100.0	-57.0
489.900	< -100.0	-57.0
656.200	< -100.0	-57.0
816.500	< -100.0	-57.0
979.800	< -100.0	-57.0
1143.100	-98.2	-57.0
1306.400	-89.0	-57.0
1469.700	-94.0	-57.0
1633.000	-93.0	-57.0

The receiver has an intermediate frequency of 10.7 MHz

Limit: In accordance with CFR 47 Part 15, section 15.111 the power of any emission at the antenna terminal should not exceed 2 nW (–57.0 dBm).

Result: Complies
Measurement Uncertainty: ±3.3 dB

Field strength of the transmitter spurious emissions

Frequency: 161.025 MHz

Frequency (MHz)	Level (dBµV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)
322.0500	58.3	-39.1	-20.0	Vertical	19.1
322.0500	61.1	-36.3	-20.0	Horizontal	16.3
483.0750	44.6	-52.8	-20.0	Vertical	32.8
483.0750	50.8	-46.6	-20.0	Horizontal	26.6
644.1000	49.0	-48.4	-20.0	Vertical	28.4
644.1000	59.5	-37.9	-20.0	Horizontal	17.9
805.1250	55.5	-41.9	-20.0	Vertical	21.9
805.1250	62.0	-35.4	-20.0	Horizontal	15.4
966.1500	46.0	-51.4	-20.0	Vertical	31.4
966.1500	49.7	-47.7	-20.0	Horizontal	27.7
1127.175	47.2	-50.2	-20.0	Vertical	30.2
1127.175	52.3	-45.1	-20.0	Horizontal	25.1
1288.200	58.9	-38.5	-20.0	Vertical	18.5
1288.200	62.6	-34.8	-20.0	Horizontal	14.8
1449.225	46.5	-50.9	-20.0	Vertical	30.9
1449.225	57.5	-39.9	-20.0	Horizontal	19.9
1610.750	57.8	-39.6	-20.0	Vertical	19.6
1610.750	63.3	-34.1	-20.0	Horizontal	14.1

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. Details of this site have been filed with the Commission, Registration Number: 90838, which was last updated in January 2011

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 10^{th} harmonic.

Result: Complies
Measurement Uncertainty: ±4.1 dB

Field strength of the receiver spurious emissions

As this device has an antenna terminal testing to Section 15.109 is not strictly required as receiver testing was carried out at the antenna terminal to Section 15.111.

However for completeness receiver radiated emissions testing to Section 15.109 on a single representative channel has been carried out.

Frequency: 161.025 MHz

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Polarity	Margin (dB)
72.075	26.2	40.0	Vertical	13.8
72.075	23.0	40.0	Horizontal	17.0
168.000	36.5	43.5	Vertical	7.0
192.000	36.1	43.5	Vertical	7.4
192.000	29.5	43.5	Horizontal	14.0
240.000	32.0	46.5	Vertical	14.5
288.000	35.6	46.5	Vertical	10.9
288.000	30.0	46.5	Horizontal	16.5
336.000	27.5	46.5	Vertical	19.0
336.000	31.8	46.5	Horizontal	14.7

The receiver has an intermediate frequency of 10.7 MHz

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

Below 1000 MHz a quasi peak detector was used with a bandwidth of 120 kHz and 1000 MHz an average detector was used with a bandwidth of 1 MHz.

The receiver was tested while receiving continuously while attached to a dummy load.

Limit:
The field strength limits as per CFR 47 Part 15, section 15.109 have been applied.

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.

Frequency: 161.025 MHz

Temperature	Voltage 10.8 Vdc	Voltage 13.8 Vdc	Voltage 15.6 Vdc
+50°C	-57.0	-55.0	-55.0
+40°C	-30.0	-26.0	-27.0
+30°C	+3.0	+6.0	+5.0
+20°C	+2.0	+4.0	+4.0
+10°C	+62.0	+62.0	+60.0
0°C	+119.0	+122.0	+122.0
-10°C	+141.0	+142.0	+140.0
-20°C	+144.0	+145.0	+145.0
-30°C	+150.0	+151.0	+151.0

Limit:
Part 90.213 (5) In the 150–174 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 2.5 ppm.

This transmitter was tested on 161.025 MHz.

2.5 ppm = 2.5 x 161.025 = 402 Hz.

Result: Complies
Measurement Uncertainty: ±30 Hz

Transient frequency behaviour

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 with a 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.

Channel Spacing	Period t_1 (kHz)	Period t_2 (kHz)	Period t_3 (kHz)
12.5 kHz	nil	nil	nil
25.0 kHz	nil	nil	nil

Limits:

Time Interval	Period	12.5 kHz Deviation (kHz)	25 kHz Deviation (kHz)
t_1	5 mS	± 12.5	± 25.0
t_2	20 mS	± 6.25	± 12.5
t_3	5 mS	± 12.5	± 25.0

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

12.5 kHz transmitter turn on

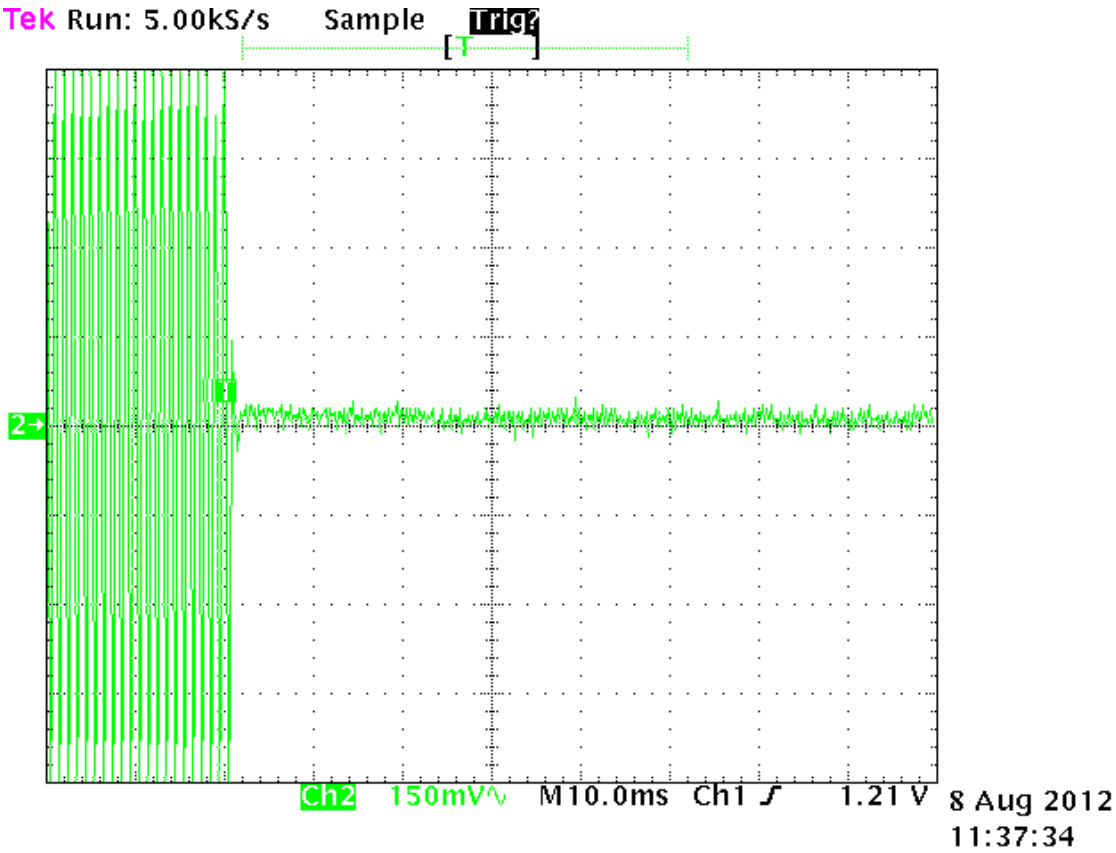
Green Trace = 1 kHz tone with FM deviation of 12.5 kHz and any transient.

Green trace has been maximised to give full screen indication of a ±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). This is position *t*on.

*t*1 occurs between 2.0 and 2.5 divisions from the left-hand edge.
t2 occurs between 2.5 and 4.5 divisions from the left-hand edge.

No transient can be observed just after *t*on.



12.5 kHz transmitter turn off

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

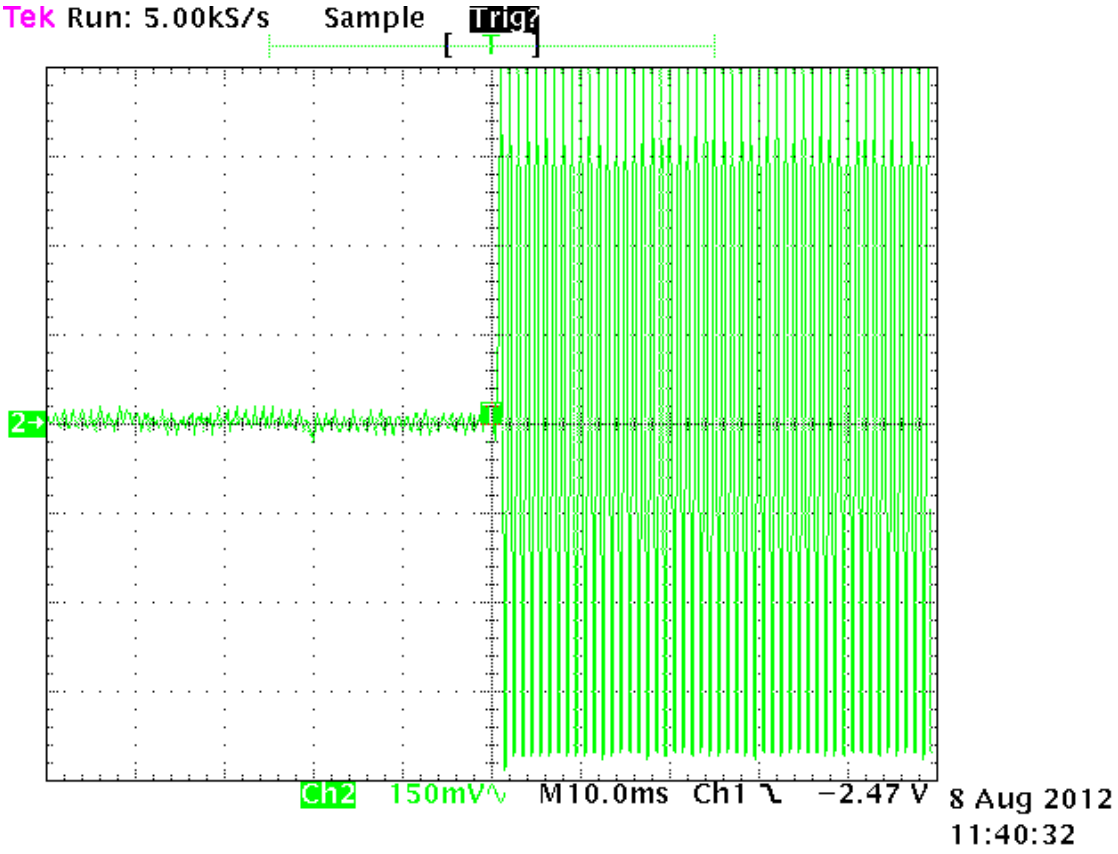
Green trace has been maximised to give full screen indication of a ± 12.5 kHz.
Therefore each Y axis division = 3.125 kHz per division.
The X axis has been set to a sweep rate of 10 mS/division.

The display of the 1 kHz signal rising has been positioned 5 divisions from the left hand edge (50 mS).

This is position *t*off.

*t*3 occurs between 4.5 and 5.0 divisions from the left hand edge.

No transient response can be observed just before toff.



25.0 kHz transmitter turn on

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

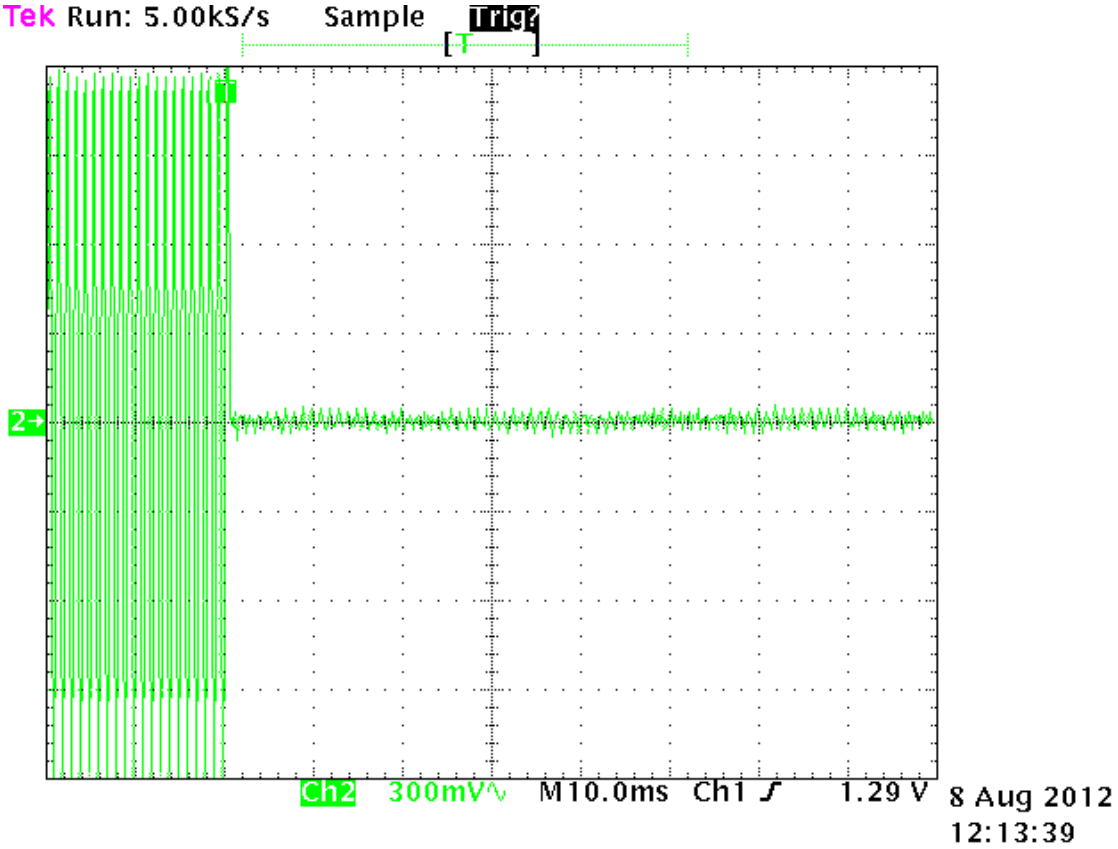
Green trace has been maximised to give full screen indication of +/- 25.0 kHz.
Therefore each Y axis division = 6.25 kHz per division.
The X axis has been set to a sweep rate of 10 mS/division.

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 2.5 divisions from the left hand edge.
*t*2 occurs between 2.5 and 4.5 divisions from the left hand edge.

No transient response can be observed during *t*1 and *t*2.



25.0 kHz transmitter turn off

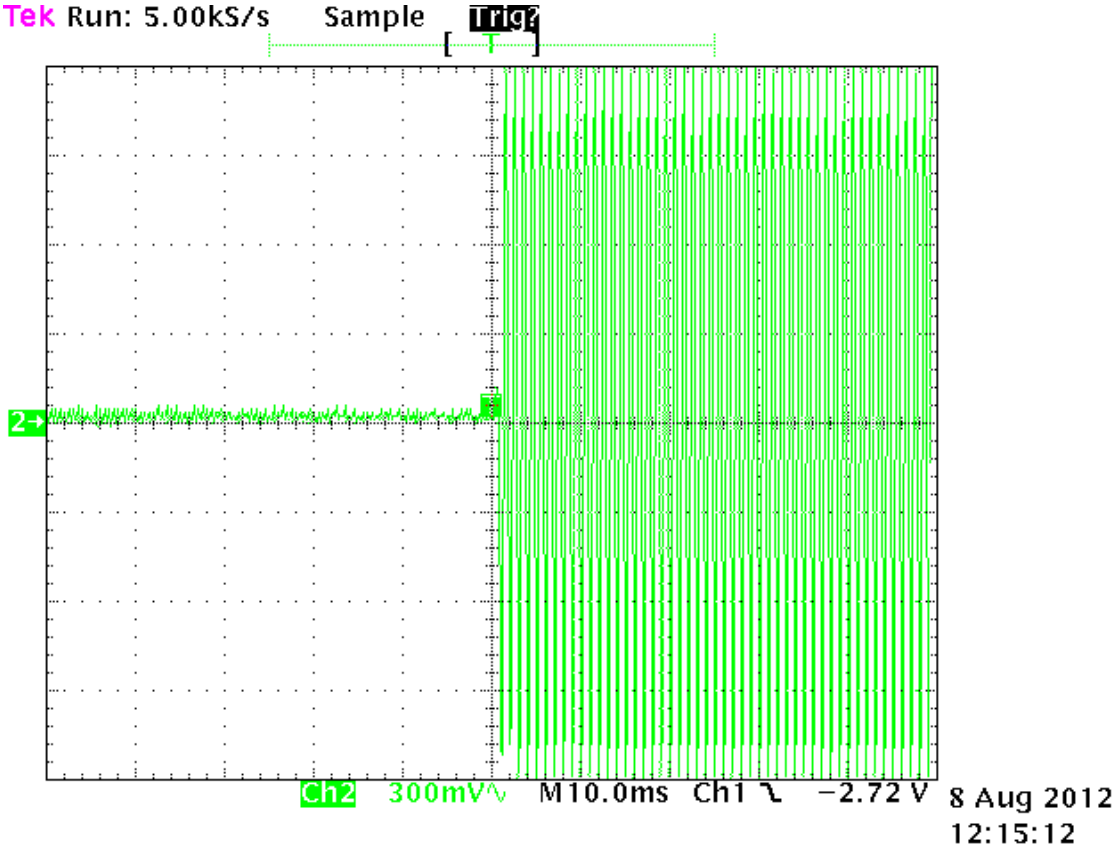
Green Trace = 1 kHz tone with FM deviation of 25.0 kHz.

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 *t*off.

*t*3 occurs between 4.5 and 5.0 divisions from the left hand edge..

No transient response can be observed before *t*off.



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.

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

- Occupational / Controlled Exposure limit will be 10 mW/m^2 or 60 V/m

- General Population / Uncontrolled exposure limit will be 2 mW/m^2 or 28 V/m

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 * DC)) / d

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

Transmitter is operated using an antenna with a gain (G) of up to 20 (13 dBi).

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

Controlled	**Uncontrolled**
d = √ (30 * P * G*DC) / E	
d = √ (30 * 5 * 20 * 1) / 60	d = √ (30 * 5 * 20 * 1) / 28
d = 0.91 metres or 91 cm	d = 1.95 metres or 195 cm

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

7. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial #	Asset	Cal Due
Aerial Controller	EMCO	1090	9112-1062	RFS 3710	N/a
Aerial Mast	EMCO	1070-1	9203-1661	RFS 3708	N/a
Audio Analyzer	Hewlett Packard	8903A	2216A01713	E1146	09/07/2014
Biconical Antenna	Schwarzbeck	BBA 9106	9594	RFS 3680	12/01/2015
Frequency Counter	Hewlett Packard	HP 5342A	1916A01713	E1224	17/12/2012
Level generator	Anritsu	MG443B	M61689	E1143	10/02/2013
Log Periodic	Schwarzbeck	VUSLP9111	9111-228	RFS 3785	12/01/2015
Receiver	Rohde & Schwarz	ESIB 40	100171	EMC4003	20/10/12
Modulation Analyzer	Rohde & Schwarz	FMA	837807/020	E1552	07/12/2012
Modulation Analyzer	Hewlett Packard	8901B	2608A00782	E1090	10/07/2014
Oscilloscope	Tektronics	745A	B010643	E1569	07/12/2012
Power Attenuator	Weinschel	49-20-43	GC104	E1308	N/a
Power Supply	Hewlett Packard	6032A	2743A-02859	E1069	N/a
RF Power Meter	Hewlett Packard	HP 436A	2512A22439	E1198	09/07/2014
Selective Level Meter	Anritsu	ML422C	M35386	E1140	21/10/2013
Signal Generator	Rohde & Schwarz	SMHU.58	838923/028	E1493	07/12/2012
Spectrum Analyzer	Hewlett Packard	E7405A	US39150142	RFS 3776	14/12/2012
Thermal chamber	Contherm	M180F	86025	E1129	N/a
Thermometer	DSIR	RT200	035	E1409	27/09/2012
Turntable	EMCO	1080-1-2.1	9109-1578	RFS 3709	N/a

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 January 2011.

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 46 accreditation bodies in 34 economies. This includes NATA (Australia), UKAS (UK), SANAS (South Africa), NVLAP (USA), A2LA (USA), SWEDAC (Sweden). Further details can be supplied on request.

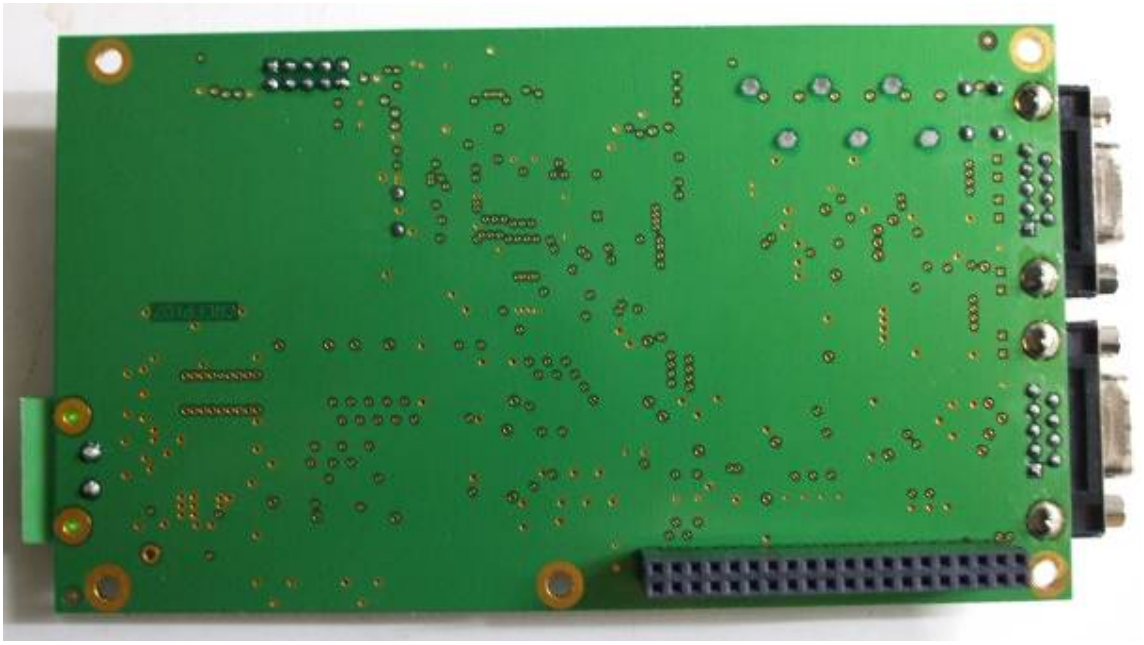
9. PHOTOGRAPHS

External views –

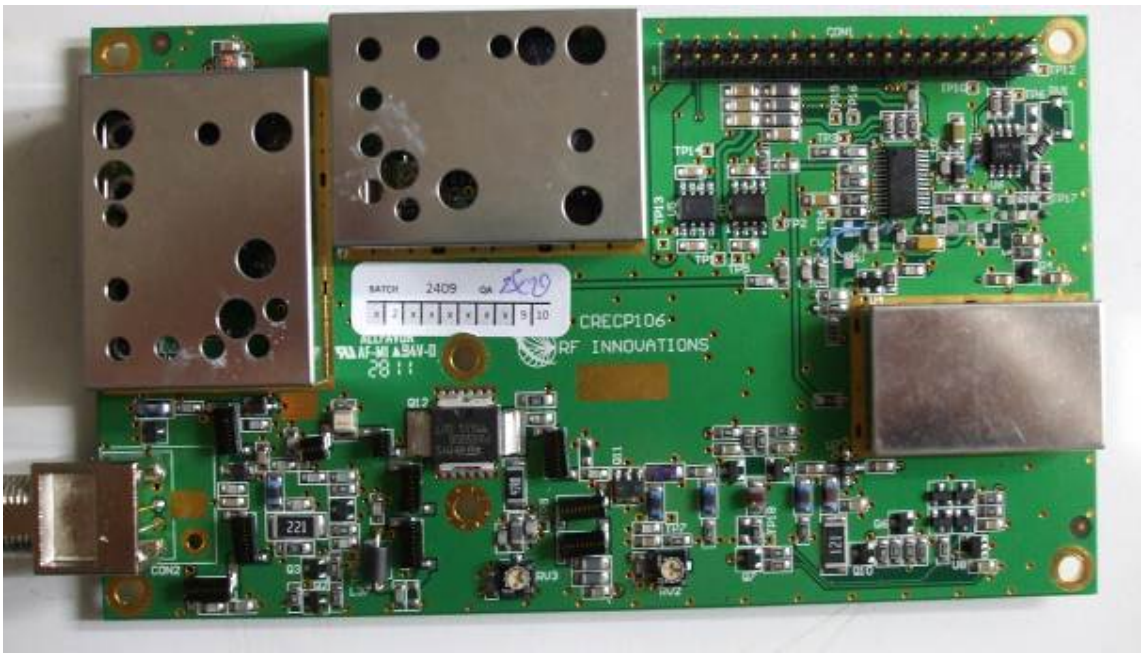
Labels

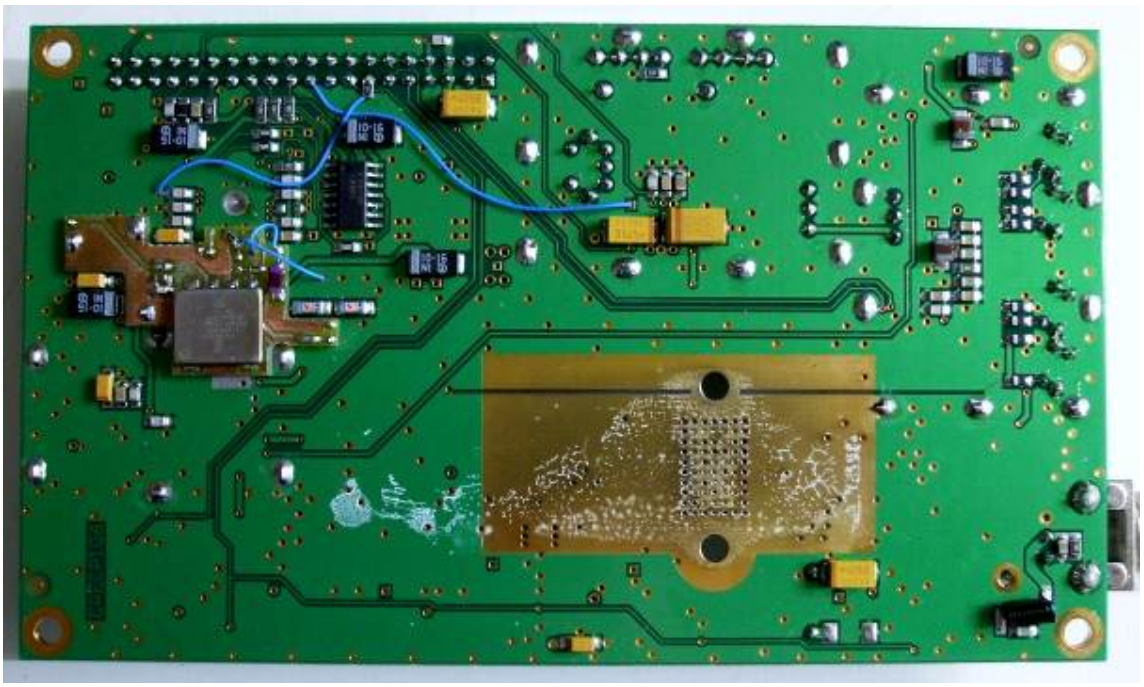
Internal Views

Top PCB –



Bottom PCB





Open Air Test Site Setup