TEST REPORT

Trio DataCom
EB 450 Radio Data Modem Base/Repeater

tested for compliance with the

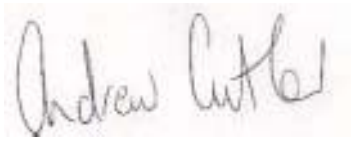
Code of Federal Regulations (CFR) 47

Part 90 –Private Land Mobile Services

for

Trio DataCom Pty Ltd

This Test Report is issued with the authority of:



Andrew Cutler - General Manager

Prepared By:

Karen Miller - Office Administrator

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1. CLIENT INFORMATION

Company Name	Trio DataCom Pty Ltd
Address	41 Aster Avenue Carrum Downs
State	Victoria 3201
Country	Australia
Contact	Mr Henk van Hoek

2. DESCRIPTION OF TEST SAMPLE

Brand Name	Trio DataCom
Approval Model	EB 450
Model Tested	EB450-51F01
Product	Radio Data Modem Base / Repeater
Manufacturer	Trio DataCom Pty Ltd
Country of Origin	Australia
Serial Number	050014
FCC ID	NI8

The model tested (EB450-51F01) is representative of a range of radios that this client is wishing to have certified.

The product model coding is EB450-xxF01 where:
xx = model type number
F = FCC approved model
01 = 12.5 kHz channeling

The range is known as the EB450 Series, which cover the range from 380 – 520 MHz.

This band is covered with the following model numbers.

- Type 47 380 to 396 MHz
- Type 48 395 to 406 MHz
- Type 50 403 to 417 MHz
- Type 56 418 to 435 MHz
- Type 55 436 to 450 MHz
- Type 51 450 to 465 MHz
- Type 52 465 to 480 MHz
- Type 53 480 to 494 MHz
- Type 60 490 to 505 MHz
- Type 54 505 to 518 MHz

3. SUMMARY OF TEST RESULTS

Testing was carried out in accordance with the test methods defined in 47 CFR Part 2. Listed below are the relevant Part 2 test methods and the limits defined in Part 90.

CLAUSE	TEST PERFORMED	RESULT
2.1041	Measurement procedures	Noted
2.1046	RF power output	Noted
90.205	Power and antenna height limits	Complies
2.1047	Modulation Characteristics	Noted
2.1047(a)	Low pass filter response	Complies
2.1047(b)	Modulation limiting characteristics	Complies
90.211(a)	Modulation characteristics	Complies
2.1049	Occupied bandwidth	Noted
2.202	Bandwidths	Noted
90.207	Types of emissions	Complies
90.209	Bandwidth limitations	Complies
90.210	Emission masks	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
2.1057	Frequency spectrum to be investigated	Noted
15.111	Antenna conducted power measurement	Complies
1.1310	Radio frequency radiation exposure limits	Complies

4. TEST SAMPLE DESCRIPTION

The sample tested has the following specifications:

Rated Transmitter Output Power

5.0 Watts (37.0 dBm)

Transmitter frequency range

450 – 465 MHz

Transmit frequency

The majority of tests were carried on 457.500 with a small number of tests also being carried out on 450.000 and 465.000 MHz

Channel Spacing

12.5 kHz

FCC Bands

Part 90: 421 – 512 MHz

Emission Designators / Modes of operation

11k2F1D – FM 9600 bps data (4 level GMSK)
11k2F1D – FM 9600 bps data (2 level GMSK)
11k2F1D – FM 19200 bps data (4 level GMSK)

Power Supply

External 10 – 16 Vdc supply. Typically 13.8 Vdc

5. TEST CONDITIONS

Standard Temperature and Humidity

Temperature: +25°C ± 4° maintained.
Relative Humidity: 60% ± 10% 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: 15.9 Vdc
Low Voltage: 11.7 Vdc

6. ATTESTATION

The **Trio DataCom EB450 Radio Data Modem Base/Repeater** complies with the Code of Federal Regulations (CFR) 47 Part 90 –Private Land Mobile Services.

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.

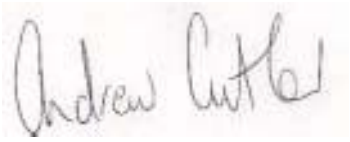
This report does not contain corrections or erasures.

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

7. 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.

Measurements were made with the input voltage set to 13.8 Vdc.

		RF power output (dBm)	
Frequency	**Channel Spacing**	**Rated**	**Measured**
450.000	12.5 kHz	37.0	37.5
457.500	12.5 kHz	37.0	36.9
465.000	12.5 kHz	37.0	36.9

Testing was carried out at maximum power output.

The output power of the transmitter is continuously variable from the value listed above (5 watts) to 2% of the value listed (100 mW).

Limits:
Clause 90.205(g) of Part 90 specifies that in the band 450 – 470 MHz the maximum allowable station effective radiated power (ERP) is dependent upon the station's antenna HAAT and the required service area.

Result: Complies

Measurement Uncertainty: *±0.5 dB*

Modulation Characteristics

The transmitter tested has been designed to transmit digital data on frequencies between 450.000 MHz and 465.000 MHz using a standard 12.5 kHz channel allocation.

(a) Frequency response of the audio frequency low pass filter between 100 Hz and 5000 Hz.

This clause is not applicable to this radio as the modulation is numerically generated.

Any base band filtering is implemented digitally by the DSP, the accuracy of which is determined by the tolerance of the system clock frequency that is typically 20 ppm.

(b) A family of curves showing the percentage of modulation versus the modulation input voltage.

Numerically Generated I-Q Modulation

1. Modulation is controlled by a DSP located on a separate processor board. The DSP receives input data via a microcontroller from the external data ports or from data generated by the microcontroller in response to received messages.

2. Data bits to be transmitted are converted to positive/negative impulses of an amplitude that will not cause the following filter to saturate.

3. The impulse stream is passed through a raised cosine FIR filter that produces a numeric representation of the desired modulating signal.

4. The numeric modulating signal is then scaled to determine the final modulated RF deviation.

5. Each sample of the modulating signal's amplitude is added to a phase accumulator to produce the phase angle of a frequency modulated signal.

6. This phase angle is then converted into I and Q signals using polar to rectangular conversion.

7. Finally, the I and Q signals are scaled and have a DC offset added to match the requirements of the external I-Q modulator before being output to a DAC. Selection of different modulation types is achieved by changing the impulse conversion, raised cosine FIR filter and transmit deviation scaling parameters. The parameters for each modulation type are stored in non-volatile memory and cannot be modified by users.

Analog RF Modulation

1. The numeric I and Q signals are converted by 2 channels of a 4 channel 10 bit DAC.

2. The analog I and Q signals then pass through reconstruction filters to remove sampling frequency products.

3. The filtered I and Q signals are then fed to a I-Q modulator along with a carrier frequency local oscillator to produce the modulated RF.

Attached is a block diagram showing how the modulation is generated.

Result: Noted

Occupied Bandwidth

The spectrum masks are defined in:

Section 90.210(d) – Mask D has been applied as the transmitter can operate in the band 421 – 512 MHz using an authorised bandwidth of 11.25 kHz as per Section 90.209(b)(5).

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.

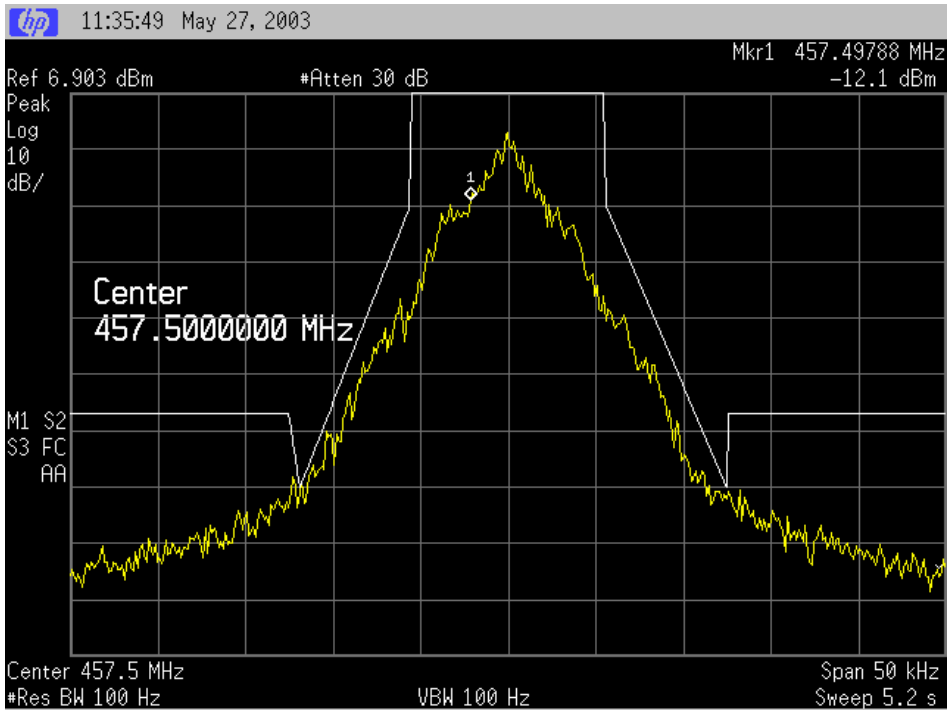
The transmitter was modulated using the following forms of modulation that was generated using software supplied by the client.

– FM 9600 bps data (2 level GMSK)
– FM 9600 bps data (4 level GMSK)
– FM 19200 bps data (4 level GMSK)

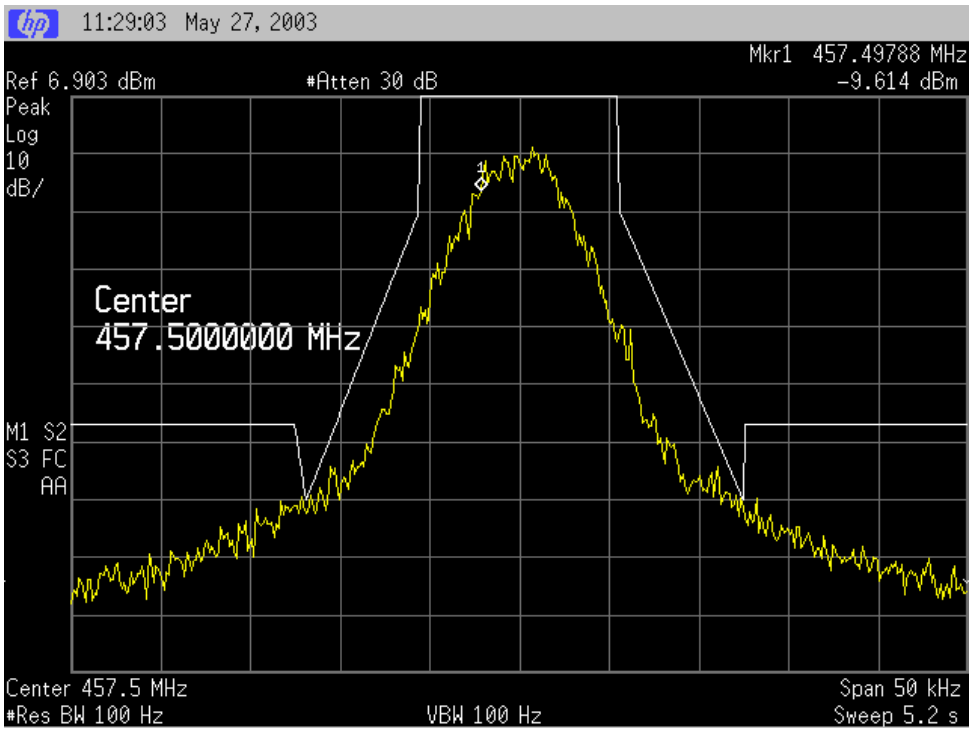
All measurements were made at 457.500 MHz with check measurements carried out at 450.000 MHz and 465.000 MHz using the modulation that produced the closest margin at 457.500 MHz.

Result: Complies

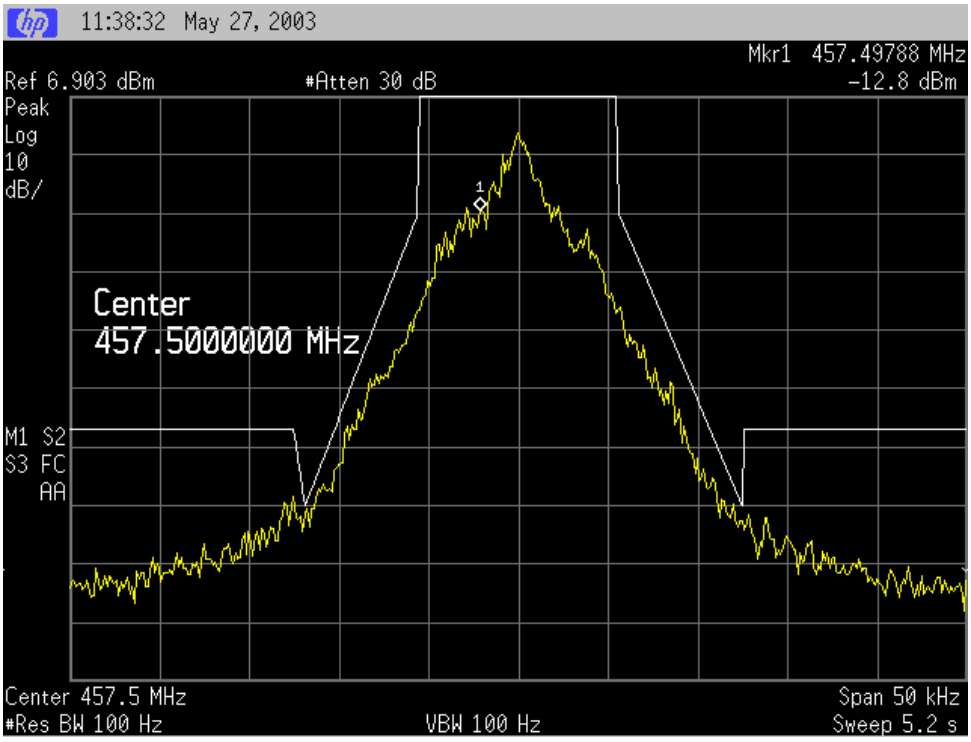
FM 9600 bps data (2 level GMSK)



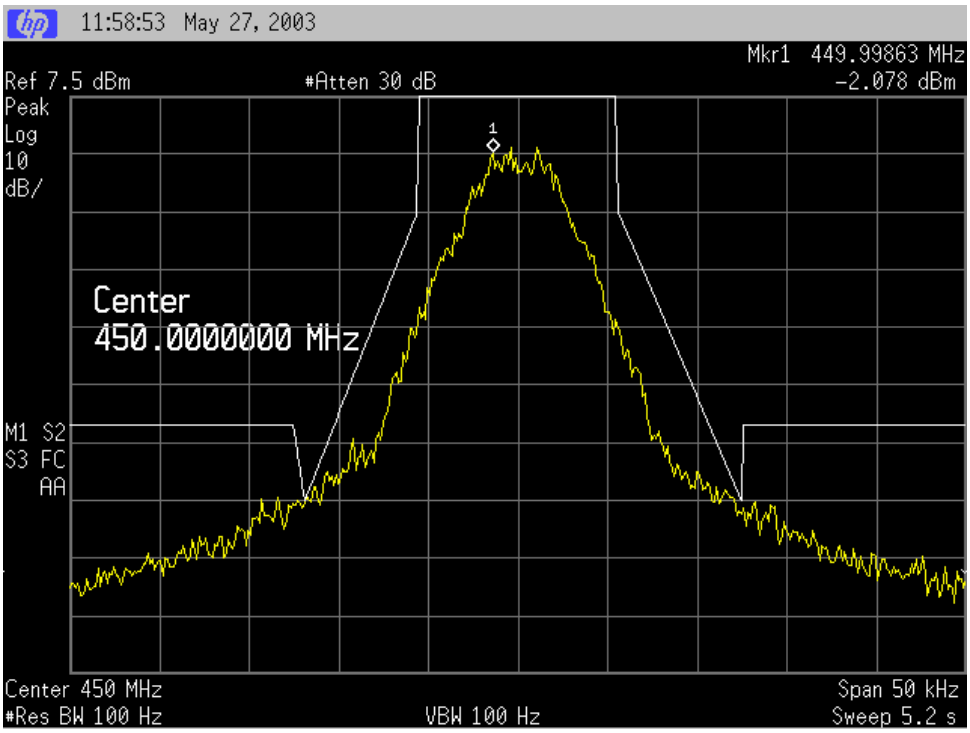
FM 9600 bps data (4 level GMSK)



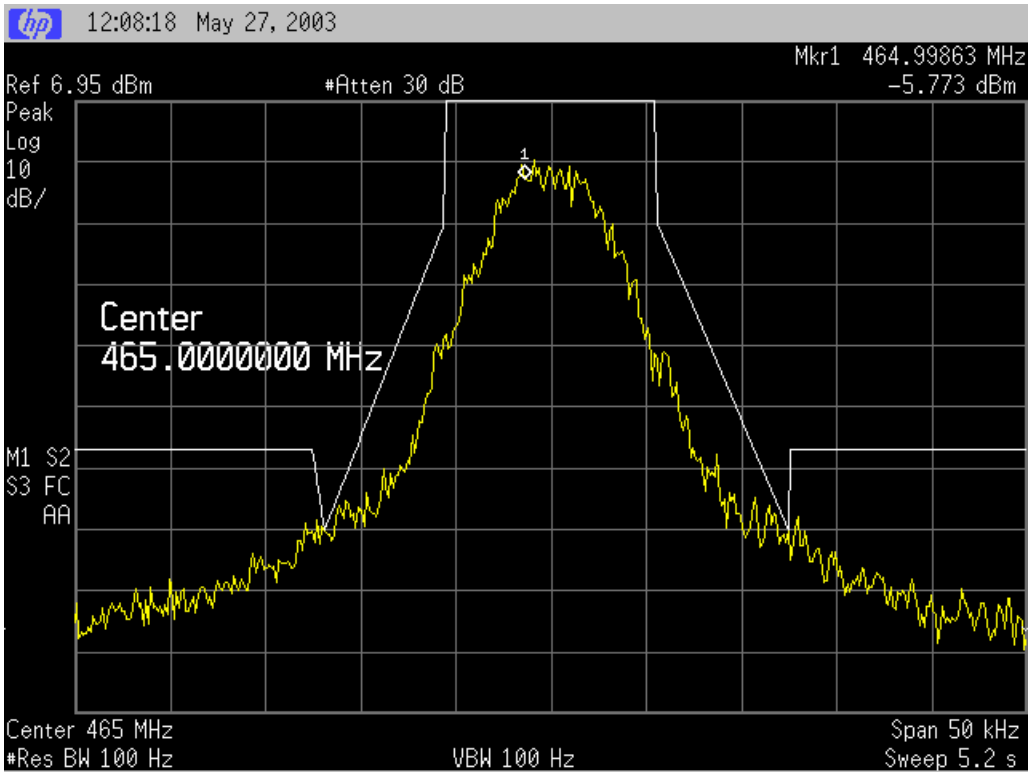
FM 19200 bps data (4 level GMSK)



FM 9600 bps data (4 level GMSK) additional measurement at 450.0 MHz



FM 9600 bps data (4 level GMSK) additional measurement at 465.0 MHz



Part 90.207 – Emission types:

The following emission type has been used:

- F1D: Frequency modulation with a single channel containing digital information, without a subcarrier, used for the transmission of data.

Part 90.209 – Bandwidth limitations:

The client has declared an authorised bandwidth of 11.25 kHz for this transmitter, which is used, where a 12.5 kHz channel plan is used.

In this instance the authorised bandwidth is taken to be the necessary bandwidth.

A bandwidth for the F1D emissions could not be determined easily using the tables in Part 2.202 – Bandwidth.

Measurements of the authorised / occupied bandwidth at the 99% power level have been carried out.

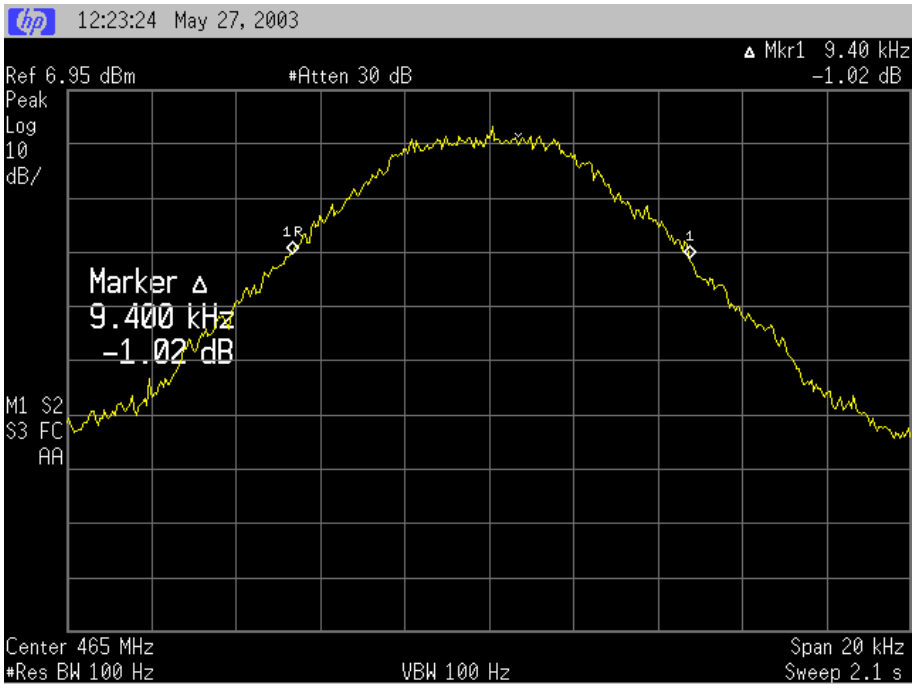
This was carried out at the –23 dB points with the spectrum analyser in peak hold mode.

Plots of these measurements are attached.

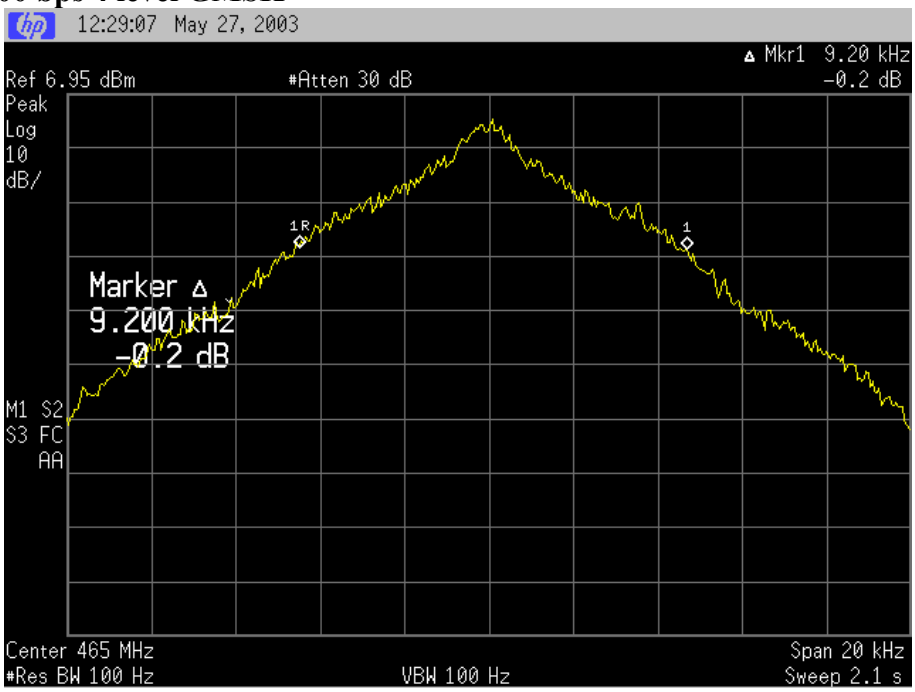
A worst case bandwidth of 9.4 kHz has been recorded when 4 level GMSK at 9600 bps is used.

This is confirmed in the emission designation, 11k2F1D, as declared by the client.

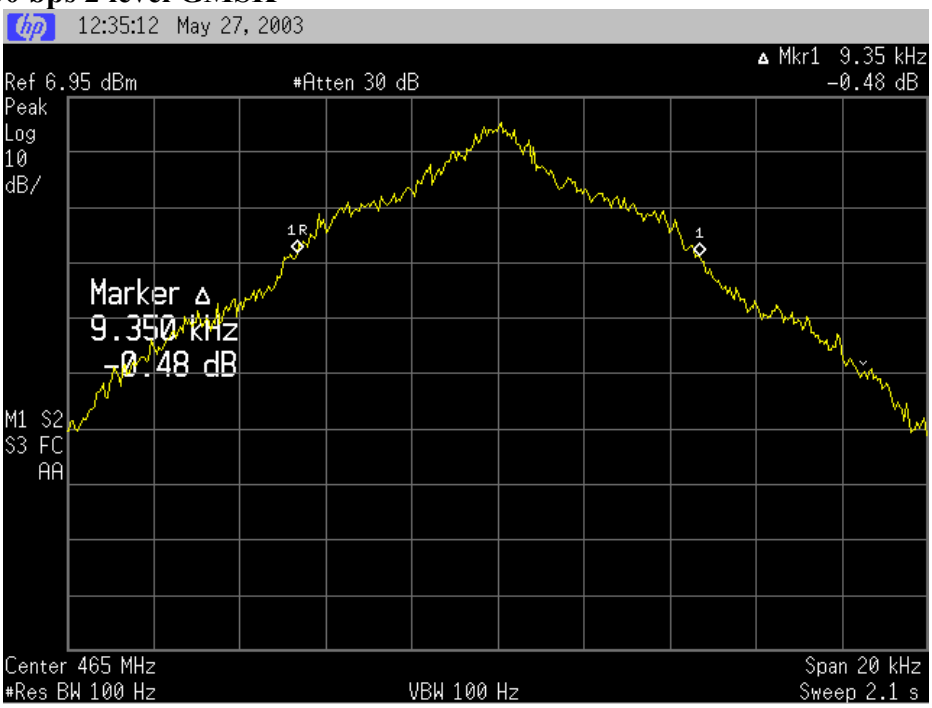
9600 bps 4 level GMSK



19200 bps 4 level GMSK



9600 bps 2 level GMSK



Result: Complies

Transmitter spurious emissions at the antenna terminals

Frequency: 450.000 MHz

Measured Spurious Emission		
Spurious emission (MHz)	**Emission level (dBm)**	**Limit (dBm)**
900.000	-42.0	-20.0
1350.000	-49.5	-20.0
1800.000	Less than-55.0	-20.0
2250.000	Less than-55.0	-20.0
2700.000	Less than-55.0	-20.0
3150.000	Less than-55.0	-20.0
3600.000	Less than-55.0	-20.0
4050.000	Less than-55.0	-20.0
4500.000	Less than-55.0	-20.0

Frequency: 457.500 MHz

Measured Spurious Emission		
Spurious emission (MHz)	**Emission level (dBm)**	**Limit (dBm)**
915.000	-42.5	-20.0
1372.500	-51.6	-20.0
1830.000	Less than-55.0	-20.0
2287.500	Less than-55.0	-20.0
2745.000	Less than-55.0	-20.0
3202.500	Less than-55.0	-20.0
3660.000	Less than-55.0	-20.0
4117.500	Less than-55.0	-20.0
4575.000	Less than-55.0	-20.0

Frequency: 465.000 MHz

Measured Spurious Emission		
Spurious emission (MHz)	**Emission level (dBm)**	**Limit (dBm)**
930.000	-47.4	-20.0
1395.000	-52.5	-20.0
1860.000	Less than-55.0	-20.0
2325.000	Less than-55.0	-20.0
2790.000	Less than-55.0	-20.0
3255.000	Less than-55.0	-20.0
3720.000	Less than-55.0	-20.0
4185.000	Less than-55.0	-20.0
4650.000	Less than-55.0	-20.0

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 spacings 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 10^{th} harmonic if the transmitter operates below 10 GHz.

A rated powers of 5 watts gives a limit of –20 dBm.

Emissions less that –40 dBm have been reported for completeness.

No measurements were made above the 10^{th} harmonic.

Measurements have been made with the transmitter transmitting continuously when modulated using 4 layer GMSK at 9600 bps, which was found to cause the worst case spurious emission levels.

Result: Complies

Measurement Uncertainty: *±3.3 dB*

Receiver Spurious emissions at antenna terminals

Receive frequency: 450.0 MHz

Intermediate frequency: 83.1625 MHz

Measured Spurious Emission		
Spurious emission (MHz)	**Emission level (dBm)**	**Limit (dBm)**
533.1635	-115.6	-57.0
1599.4905	-96.0	-57.0

All other emissions observed less than –100.0 dBm.

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.

This gives a limit of –57.0 dBm.

Result: Complies

***Measurement Uncertainty*:** *±3.3 dB*

Field strength of the transmitter spurious emissions

Frequency: 457.500 MHz

Frequency (MHz)	Level (dBuV/m)	Power (dBm)	Limit (dBm)	Margin (dB)	Polarity
915.0000	31.9	-63.3	-20.0	43.3	Horizontal
915.0000	32.2	-63.0	-20.0	43.0	Vertical
1372.5000	-	-	-20.0	-	Horizontal
1372.5000	-	-	-20.0	-	Vertical
1830.0000	-	-	-20.0	-	Horizontal
1830.0000	-	-	-20.0	-	Vertical
2287.5000	43.9	-51.3	-20.0	31.3	Horizontal
2287.5000	44.0	-51.2	-20.0	31.2	Vertical
2745.0000	-	-	-20.0	-	Horizontal
2745.0000	-	-	-20.0	-	Vertical
3202.5000	-	-	-20.0	-	Horizontal
3202.5000	-	-	-20.0	-	Vertical
3660.0000	-	-	-20.0	-	Horizontal
3660.0000	-	-	-20.0	-	Vertical
4117.5000	-	-	-20.0	-	Horizontal
4117.5000	-	-	-20.0	-	Vertical
4575.0000	-	-	-20.0	-	Horizontal
4575.0000	-	-	-20.0	-	Vertical

Other emissions detected when the transmitter was transmitting

Frequency (MHz)	Level (dBuV/m)	Power (dBm)	Limit (dBm)	Margin (dB)	Polarity
533.1625	41.0	-54.2	-20.0	34.2	Horizontal
533.1625	43.2	-52.0	-20.0	32.0	Vertical
1599.4875	38.0	-57.2	-20.0	37.2	Horizontal
1599.4875	40.1	-55.1	-20.0	35.1	Vertical

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 on May 12th, 2003.

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.

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*

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.

Measurements were made with the supply varied between 115% and 85% of the nominal supply voltage (13.8 Vdc).

Nominal Frequency: 457.5000 MHz

Voltage / Temp.	Frequency Error (Hz) 11.7 Vdc	13.8 Vdc	15.9 Vdc
+50°C	-177.0	-177.0	-176.0
+40°C	-252.0	-253.0	-252.0
+30°C	-209.0	-209.0	-201.0
+20°C	-199.0	-199.0	-199.0
+10°C	-55.0	-54.0	-54.0
0°C	+3.0	+1.0	+2.0
-10°C	-95.0	-96.0	-97.0
-20°C	-202.0	-201.0	-203.0
-30°C	-301.0	-301.0	-301.0

Limit:
Part 90.213 states that base station transmitters operating between 421 – 512 MHz are required to have frequency tolerance of 2.5 ppm.

This transmitter operates on 450.0 MHz. 2.5 ppm = 2.5 x 450 = 1125 Hz.

Result: Complies

Measurement Uncertainty: ±30 Hz

Transient frequency behaviour

Transient frequency behaviour measurements are applicable to wide band and narrow band transmitters operating in the frequency band 421 – 512 MHz.

Measurements were carried out at 457.500 MHz 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 457.500 MHz 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.

Measured Transient Deviation		
Period t_1 (ms)	period t_2 (ms)	period t_3 (ms)
10.0	25.0	10.0
Frequency Difference from the Nominal Frequency (kHz)		
Less than 3 kHz	Nil	nil

Limits:
The maximum frequency difference:

Channel Spacing (kHz)	Transmitter Period t_1 (kHz)	Transmitter Period t_2 (kHz)	Transmitter Period t_3 (kHz)
12.5	± 12.5	± 6.25	± 12.5

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

12.5 kHz transmitter turn on

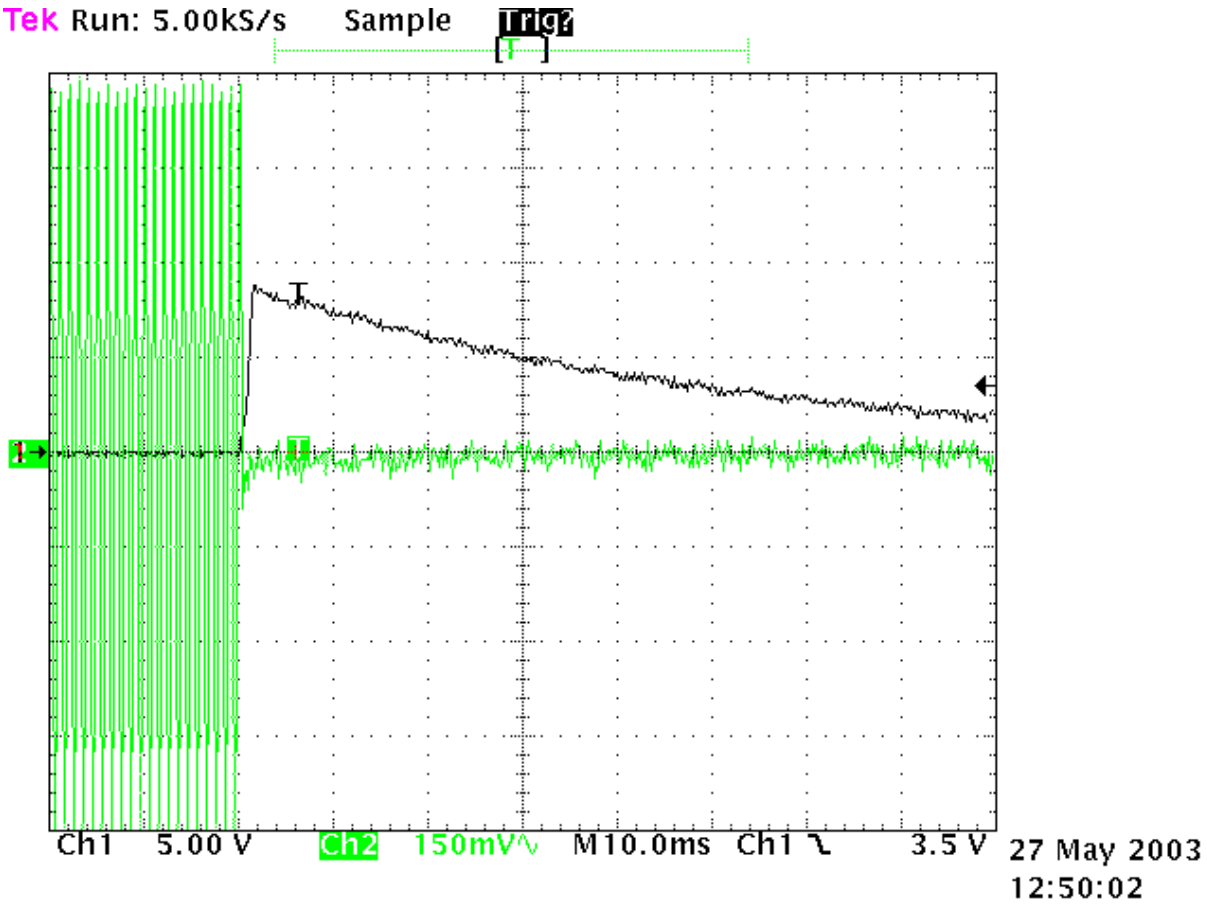
Green Trace = 1 kHz tone with FM deviation of 12.5 kHz.
Black trace = transmitter amplitude response (AC coupled).

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 3.0 divisions from the left-hand edge.
t2 occurs between 3.0 and 5.5 divisions from the left-hand edge.

A very small transient responses 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.
Black trace = transmitter amplitude response (AC coupled).

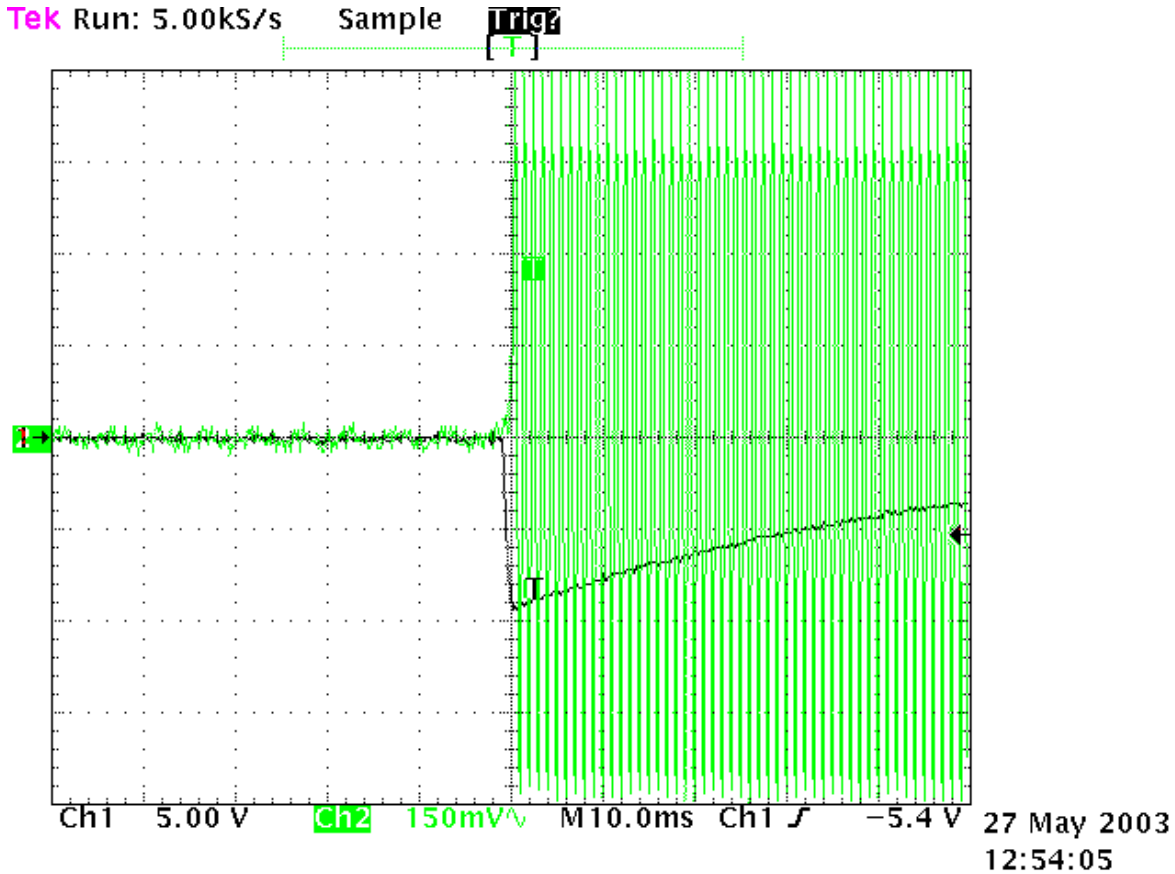
Green trace has been maximised to give full screen indication of a ± 12.5 kHz.
Therefore each Y axis division = 3.125 kHz per division.
The X axis has been set to a sweep rate of 10 mS/division.

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 4.0 and 5.0 divisions from the left hand edge.

No transient responses can be observed before toff.



Radio Frequency Hazard Information

As per Section 1.1310 and Section 2.1091 transmitters are required to be operated in a manner that ensures that the public is not exposed to RF energy levels in accordance with OST/OET Bulletin Number 65.

A minimum safe distance between the user / general public and the device has been calculated below.

In accordance with Section 1.1310 the Maximum Permissible Exposure (MPE) power density limit for the General Population / Uncontrolled Exposure of 0.3 mW/m^2 (f/1500 = 450 MHz/1500) has been applied.

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 and separation distance in metres:

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

Power density = 0.3 $mW/m^2 = E^2/3770$

$E = \sqrt{}0.3*3770$

$E = 33.6$ V/m

The maximum transmitter power = 5 watts.

As this transmitter can be used as a repeater / base the type of antenna that could be used is unknown however for the purposes of this calculation it has been assumed that a whip type of antenna with omni directional coverage and a gain of 1.5 has been used.

$d = \sqrt{} (30 * P * G) / E$
$= \sqrt{} (30 * 5 * 1.5) / 33.6$
= 0.446 metres or 44.6 cm

The above calculations therefore show that this device meets the MPE requirements providing a safe distance of at least 45 cm is provided.

A warning to this affect will need to be inserted in the equipment manual.

Result: Complies

8. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial #	Asset
Aerial Controller	EMCO	1090	9112-1062	RFS 3710
Aerial Mast	EMCO	1070-1	9203-1661	RFS 3708
Attenuator 10 dB	Hewlett Packard	HP8491A	24838	E1329
Attenuator 20 dB	Weinschel	49-20-43	GC-104	E1308
Audio Analyzer	Hewlett Packard	8903A	2216A01713	E1146
Biconical Antenna	Schwarzbeck	BBA 9106		RFS 3612
Frequency Counter	Hewlett Packard	HP 5342A	1916A01713	E1224
Level generator	Anritsu	MG443B	M61689	E1143
Log Periodic Antenna	Schwarzbeck	UHALP 9107		RFS 3702
Measurement Receiver	Rohde & Schwarz	ESCS 30	839873/1	
Modulation Analyzer	Rohde & Schwarz	FMA	837807/020	E1552
Modulation Analyzer	Hewlett Packard	8901B	2608A00782	E1090
Oscilloscope	Tektronics	745A	B010643	1569
Power Attenuator	Weinschel	49-20-43	GC104	E1308
Power Supply	Hewlett Packard	6032A	2743A-02859	E1069
RF Power Meter	Hewlett Packard	HP 436A	2512A22439	E1198
Rubidium Oscillator	Ball Efratom	FRS – C	4287	E1053
Selective Level Meter	Anritsu	ML422C	M35386	E1140
Signal Generator	Rohde & Schwarz	SMHU.58	838923/028	E1493
Spectrum Analyzer	Hewlett Packard	E7405A	US39150142	3776
Thermal chamber	Contherm	M180F	86025	E1129
Thermometer	DSIR	RT200	035	E1049
Turntable	EMCO	1080-1-2.1	9109-1578	RFS 3709
Variac	General Radio	1592	-	3690

9. 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 on May 12th, 2003.

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.

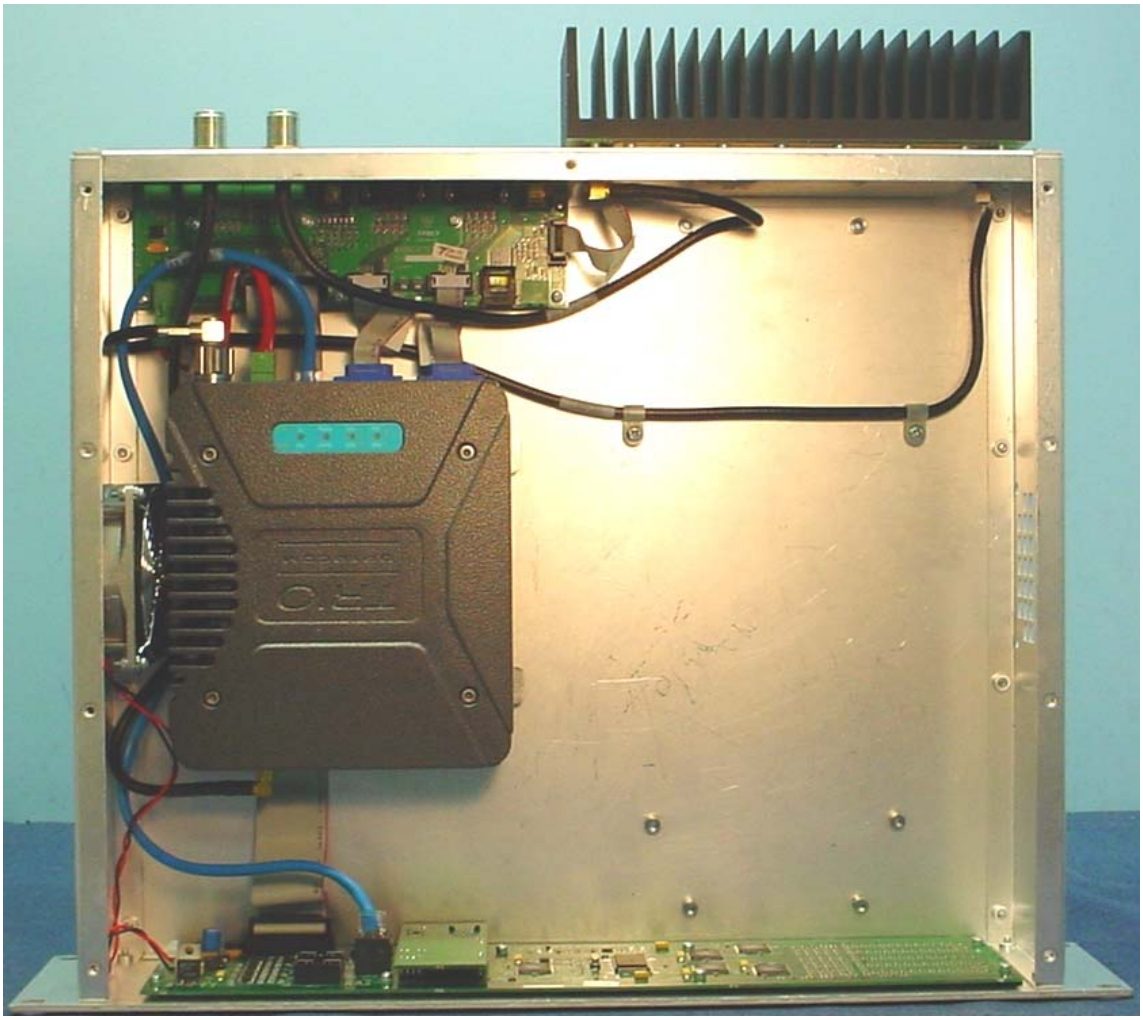
All measurement equipment has been calibrated in accordance with the terms of EMC Technologies (NZ) Ltd's International Accreditation New Zealand (IANZ) Accreditation to ISO/IEC 17025.

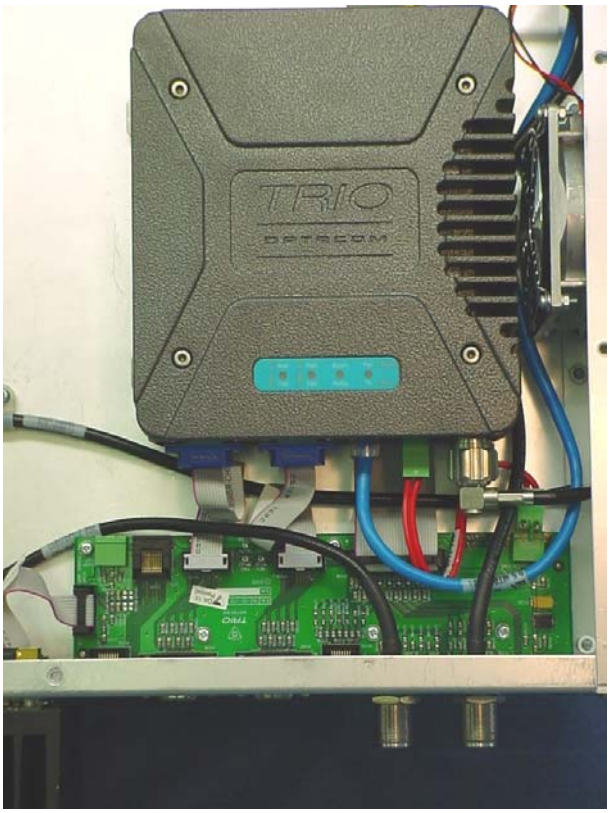
International Accreditation New Zealand has Mutual Recognition Arrangements for testing and calibration with 46 accreditation bodies in 34 economies. This includes NATA (Australia), UKAS (UK), SANAS (South Africa), NVLAP (USA), A2LA (USA), SWEDAC (Sweden). Further details can be supplied on request.

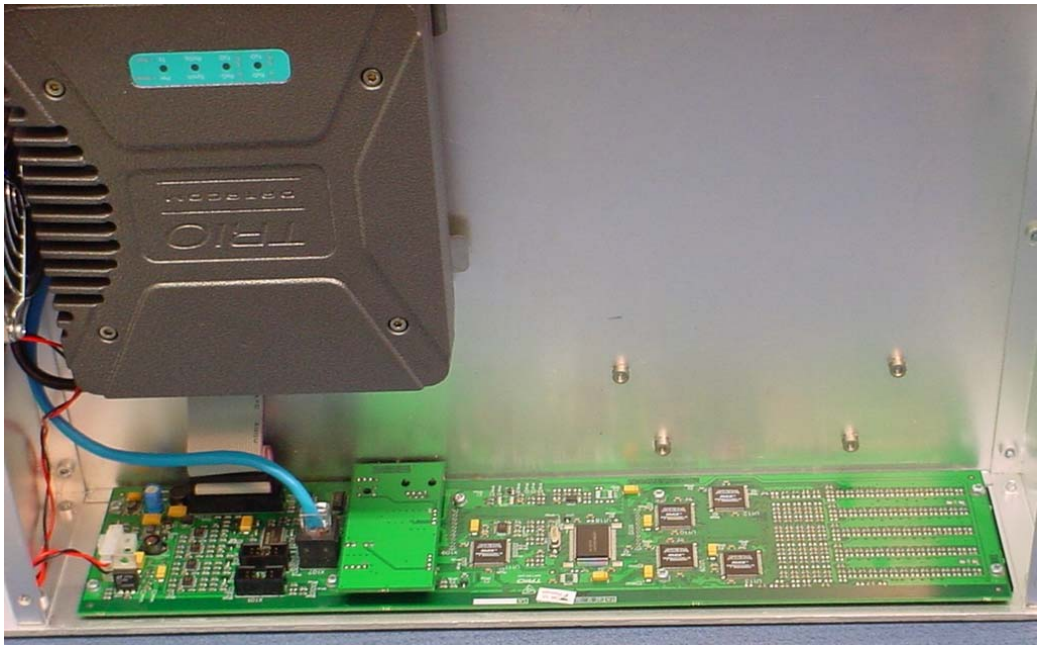
10. PHOTOGRAPH (S)

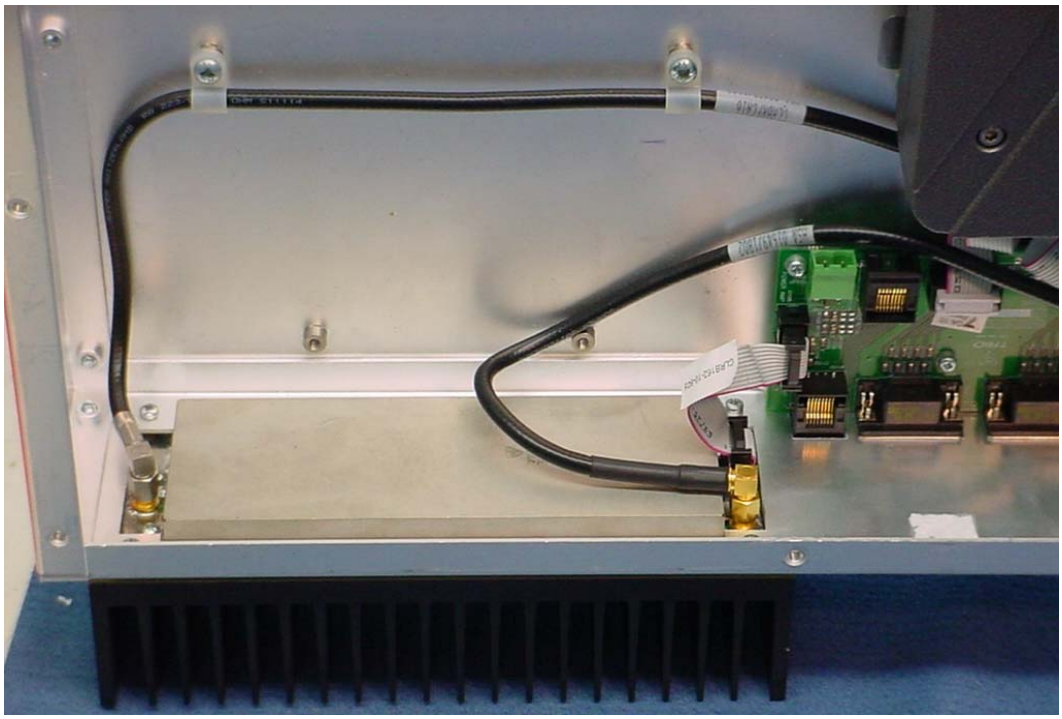
External view

Internal Views



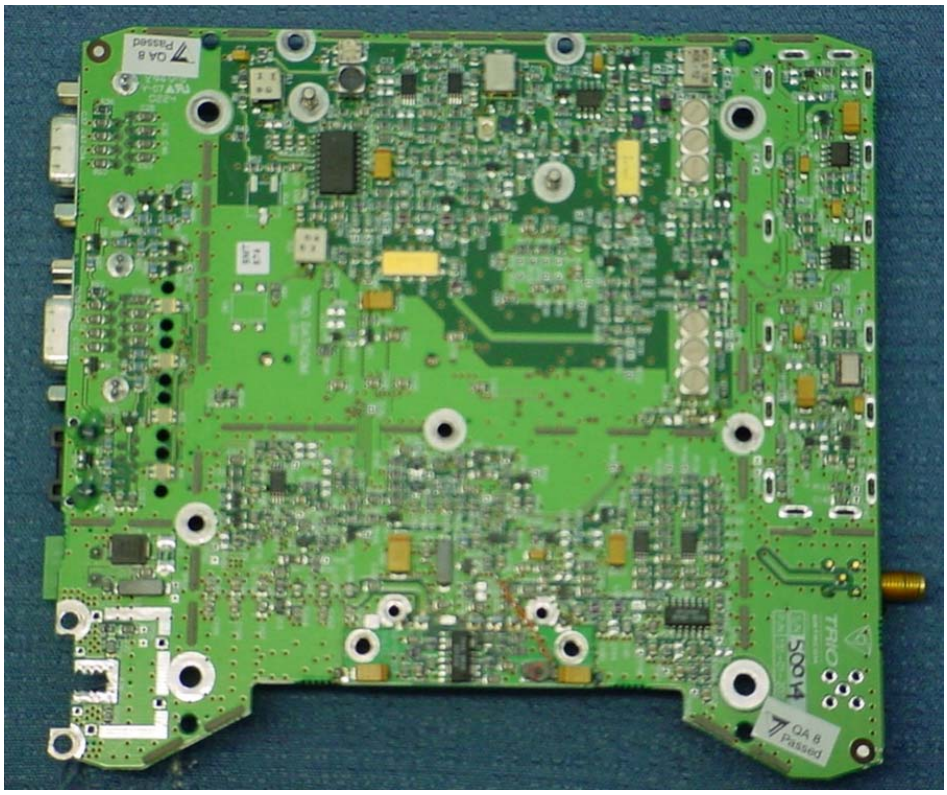


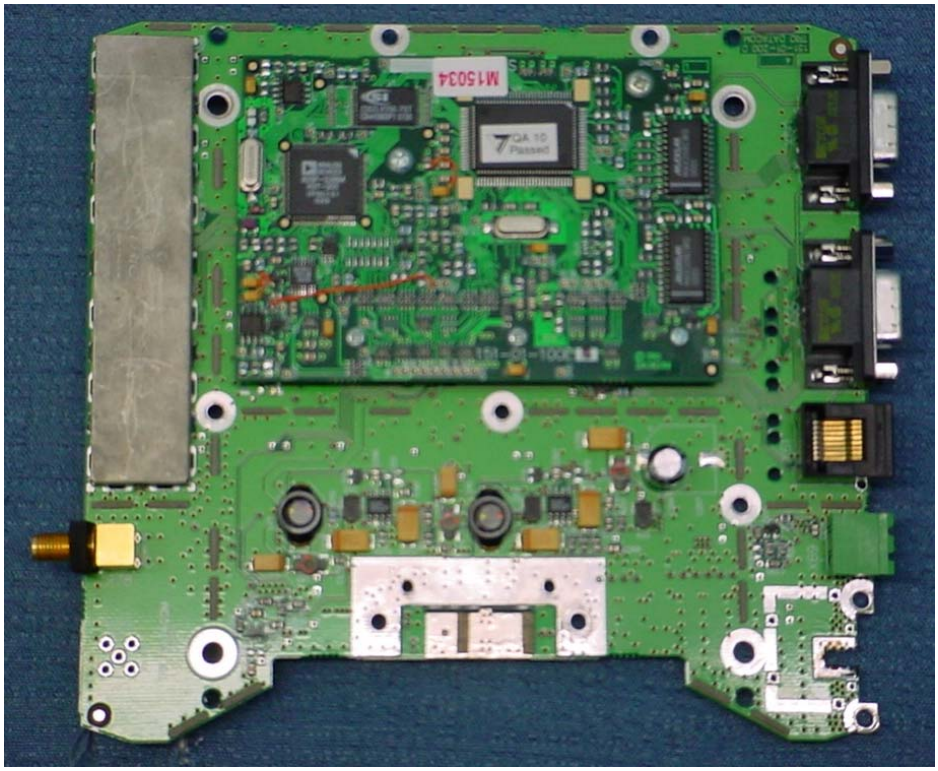




External views of the exciter

Internal views of the circuit boards





Radiated emissions test setup photos