18 December 2001

TEST REPORT

Exicom EX7100 Digital Transceiver

Tested for compliance with the

Code of Federal Regulations (CFR) 47

Part 90 –Private Land Mobile Services

This Test Report is issued with the authority of:

Andrew Cutler - General Manager

Prepared By:

Karen Miller - Office Administrator

Table of Contents

1. CLIENT INFORMATION

Company Name	Exicom Technologies (1996) Ltd
Address	Private Bag 50912 Porirua
City	Wellington
Country	New Zealand
Contact	Mr Peter Wilkinson

2. DESCRIPTION OF TEST SAMPLE

Brand Name	Exicom
Model Number	EX7100
Product	Digital Transceiver
Manufacturer	Exicom Technologies (1996) Ltd
Country of Origin	New Zealand
Serial Number	388342
FCC ID	H4UEX7100-3

Device tested communicating with a second EX7100 transceiver SN# 388339

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 and Part 15.

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	
2.1047(d)	Other types of equipment	Complies
90.211(a)	Modulation characteristics	Complies
2.1049	Occupied bandwidth	Noted
90.207	Types of emissions	Complies
90.209	Bandwidth limitations	Complies
90.210	Emission masks	Complies
2.1051	Spurious emissions at the transmitter antenna terminals	Complies
2.1053	Field strength of transmitter spurious radiation	Complies
15.109	Receiver radiated emissions	Complies
15.111	Antenna power conduction limits for receivers	Complies
2.1055	Frequency stability	Noted
90.213	Frequency stability	Complies
2.1057	Frequency spectrum to be investigated	Noted
15.33	Frequency range of unintentional radiators	Noted

4. TEST SAMPLE DESCRIPTION

The sample tested is a UHF digital transmitter capable of sending 6 telephone channels over a standard 25 kHz channel audio bandwidth with the following specifications:

Rated Transmitter Output Power

10 Watts Peak Envelope Power (40.0 dBm)

Test frequencies

461.0000 MHz Receive 456.0000 MHz Transmit

Channel spacing

25.0 kHz

Band of operation

421 – 512 MHz

Emission Types and Necessary Bandwidths

18k4D1WET

6 audio channel digital transceiver, using 16QAM modulation.

Authorised bandwidth

20.0 kHz

Power Supply

24.0 Vdc from an external DC power supply (eg lead acid battery).

5. TEST CONDITIONS

Standard Temperature and Humidity

Temperature: +25°C ± 4° maintained.
Relative Humidity: 60% ± 10% observed.

Extreme Temperature

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

Tests carried out in 10° intervals over this range.

6. ATTESTATION

This report describes the tests and measurements performed for the purpose of determining compliance with the specification with the following conditions:

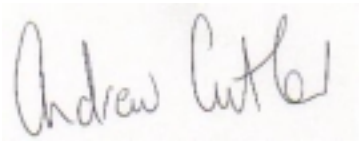
The client selected the test sample.

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

7. TRANSMITTER TEST RESULTS

RF power output

Measurements were carried out at the RF output terminals of the transmitter using a power attenuator, power splitter and a spectrum analyser using a resolution bandwidth wider than the occupied bandwidth of the transmitter operating in peak hold.

A resolution bandwidth of 30 kHz has been used.

Transmitter tested with a 64 kB/s data transfer established with a second EX7100 Digital Transceiver.

Measurements were made with the input voltage set to 24.0 Vdc.

RF power output (dBm)			
Frequency	**Channel Spacing**	**Rated**	**Measured**
456.000 MHz	25 kHz	40.0	39.5

Power control of the transmitter is determined using software.

A coupler at the power amplifier output feeds a sample of the output power to a power detector. This detector provides an output voltage, that is proportional to the input power, which is fed to an analogue to digital converter.

Any adjustment is calculated and feed as a control word to a digital to analogue converter which controls an attenuator in the transmitter driver.

In this way the output power is kept constant.

Limits:
Part 90 contains no transmitter base power limits.

Section 90.205(d) defines that maximum allowable station ERP which is dependent upon the station's antenna HAAT and required service area.

Result: Complies

Measurement Uncertainty: *±0.5 dB*

Modulation Characteristics

This transmitter uses Digital Modulation, 16QAM modulation with a 17 kilo symbols per second symbol rate, with the emission designation 18k4D1WET.

The emission type D1W is used because the modulation method is 16QAM.

This results in a carrier that can have a number of phase angles and amplitudes. This is defined in 2.201 as D "An emission in which the main carrier is amplitude and angle modulated either simultaneously or in a pre-established sequence".

The data being sent is a single 68 kbit/s stream of digital data. This is defined in 2.201 as 1 " A single channel containing quantised or digital information without the use of a modulating subcarrier".

The information being transmitted is six telephone circuits and a digital engineering control circuit. This is information type D and type E. Because it is a combination of both types the designator W is used which is defined in 2.201 as a combination of types.

If the fact that the information being transmitted is six telephone circuits makes the second symbol a 7 (Two or more channels containing quantised or digital information) then the designator D7W would be a suitable alternative.

The transmitter has 6 audio inputs with each path containing a low pass filter.

Testing of the transmitter has been carried out in accordance with section 90.210 which shows that the emission from this digital transmitter meet the requirements for Mask B.

The radio continually transmits a digital data stream and only the data in the stream changes according to its use. The data stream is scrambled so that it presents the same characteristics to the radio under all operating conditions.

The digital signal is first scrambled using a V.35 scrambler as detailed below.

(Extract from the V.35 standard)

The binary value of the next transmitted bit shall be such as to produce odd parity when considered together with the twentieth and third earlier transmitted bits and the applied data bit unless an adverse state is apparent, in which case the binary value of the next transmitted bit shall be such as to produce even instead of odd parity.
An adverse state shall be apparent only if the binary values of the p^{th} and $(p + 8)^{th}$ earlier transmitted bits have not differed from one another when p represents all the integers from 1 to q inclusive. The value of q shall be such that, for p = (q + 1), the p^{th} and $(p + 8)^{th}$ earlier transmitted bits had opposite binary values and q = (31 + 32 r), r being 0 or any positive integer.
At the time of commencement, i.e. when no earlier bits have been transmitted, an arbitrary 20-bit pattern may be assumed to represent the earlier transmitted bits. At this time also it may be assumed that the p^{th} and $(p + 8)^{th}$ earlier transmitted bits have had the same binary value when p represents all the integers up to any arbitrary value. Similar assumptions may be made for the descrambling process at commencement.

The scrambler ensures that the data presented to the modulator has no repetitive patterns or spectral components that could affect the modulated spectrum.

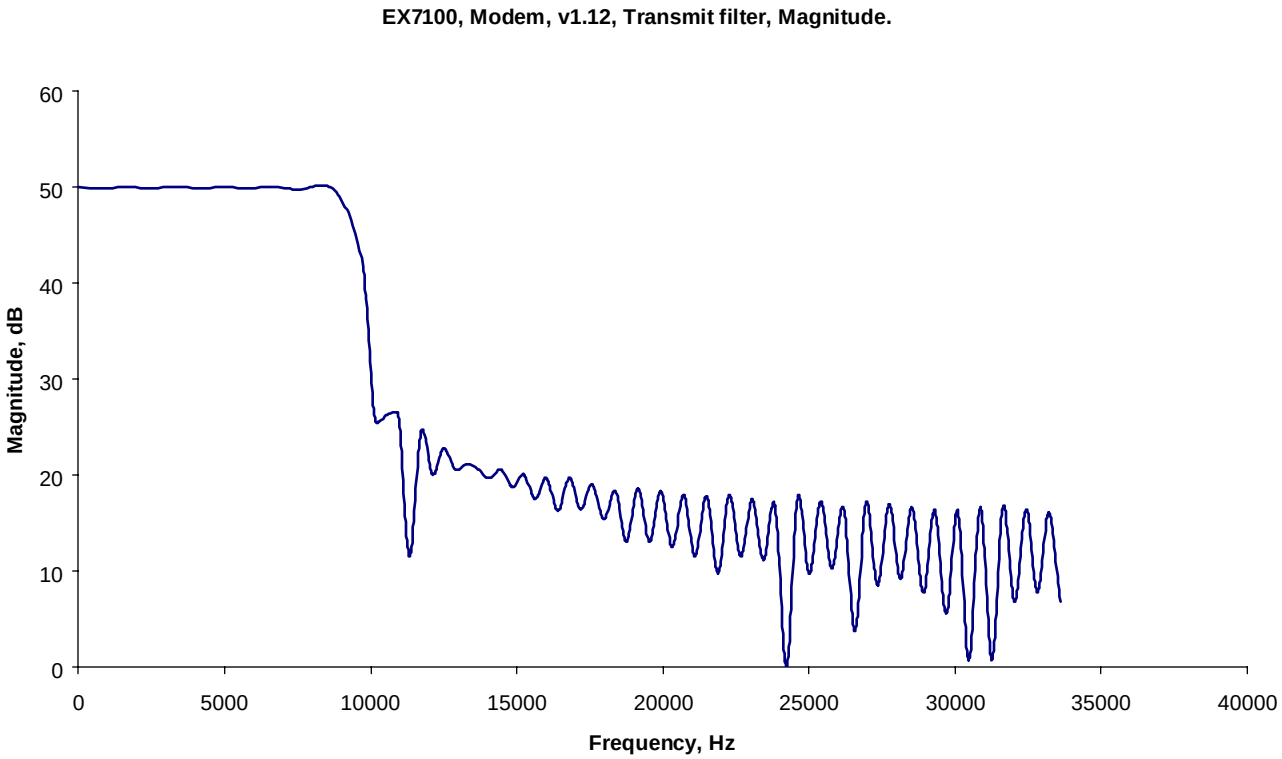
This data stream is then split into I and Q channels and filtered so that the final spectrum will be within the channel limitations.

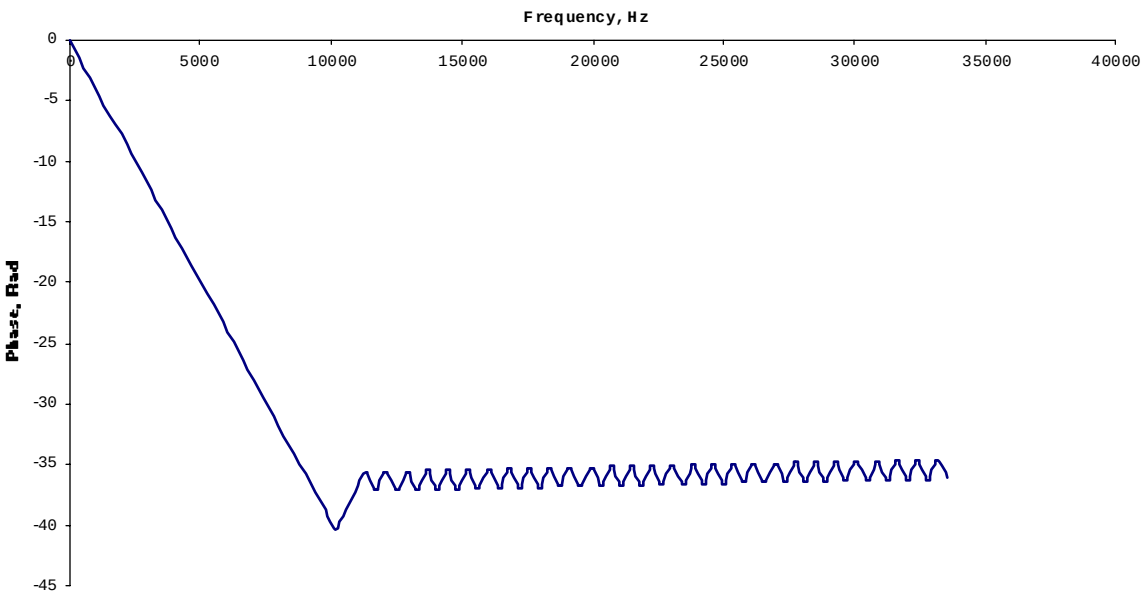
These filters operate in the time domain but equivalent frequency responses are shown on the attached graphs.

The filtered signals are fed to an IQ modulator to produce the final modulated spectrum.

Audio processing is carried out using an AMD Am79C02 Dual Subscriber Line Audio Processing Circuit (DSLAC) Device that contains the low pass filters.

The manufacturer's specification for these filters is also attached.

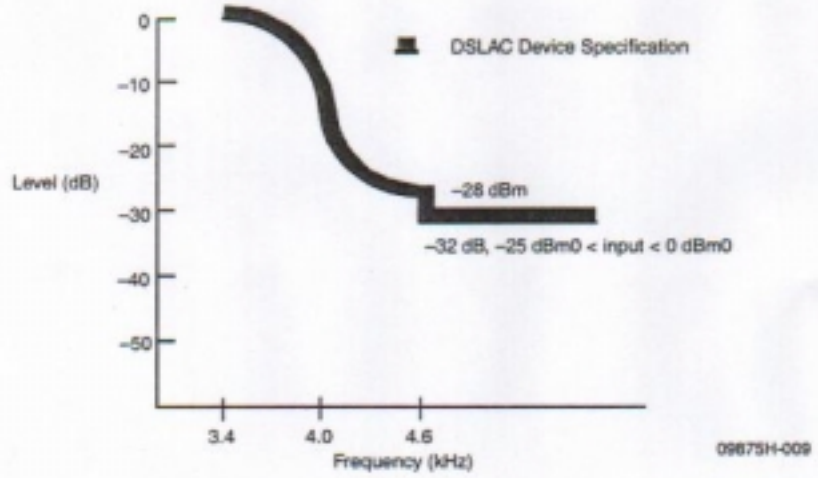




Discrimination against Out-of-Band Input Signals

When an out-of-band sine wave signal with frequency f and level A is applied to the analog input, there may be frequency components below 4 kHz at the digital output, caused by the out-of-band signal. These components are at least the specified dB level below the level of a signal at the same output originating from a 1014 Hz sine wave signal with a level of A dBm0 also applied to the analog input. The minimum specifications are shown in Figure 5.

Frequency of Out-of-Band Signal	Amplitude of Out-of-Band Signal	Level below A
16.6 Hz < f < 45 Hz	–25 dBm0 < A ≤ 0 dBm0	18 dB
45 Hz < f < 65 Hz	–25 dBm0 < A ≤ 0 dBm0	25 dB
65 Hz < f < 100 Hz	–25 dBm0 < A ≤ 0 dBm0	10 dB
3400 Hz < f < 4600 Hz	–25 dBm0 < A ≤ 0 dBm0	see Figure 5
4600 Hz < f < 100 kHz	–25 dBm0 < A ≤ 0 dBm0	32 dB



Note:
The attenuation of the waveform below amplitude A between 3400 Hz and 4600 Hz is given by the formula:

$$\text{Attenuation (dB)} = 14 - 14 \sin \frac{\pi(4000 - f)}{1200}$$

Figure 5. Discrimination against Out-of-Band Signals

Occupied Bandwidth

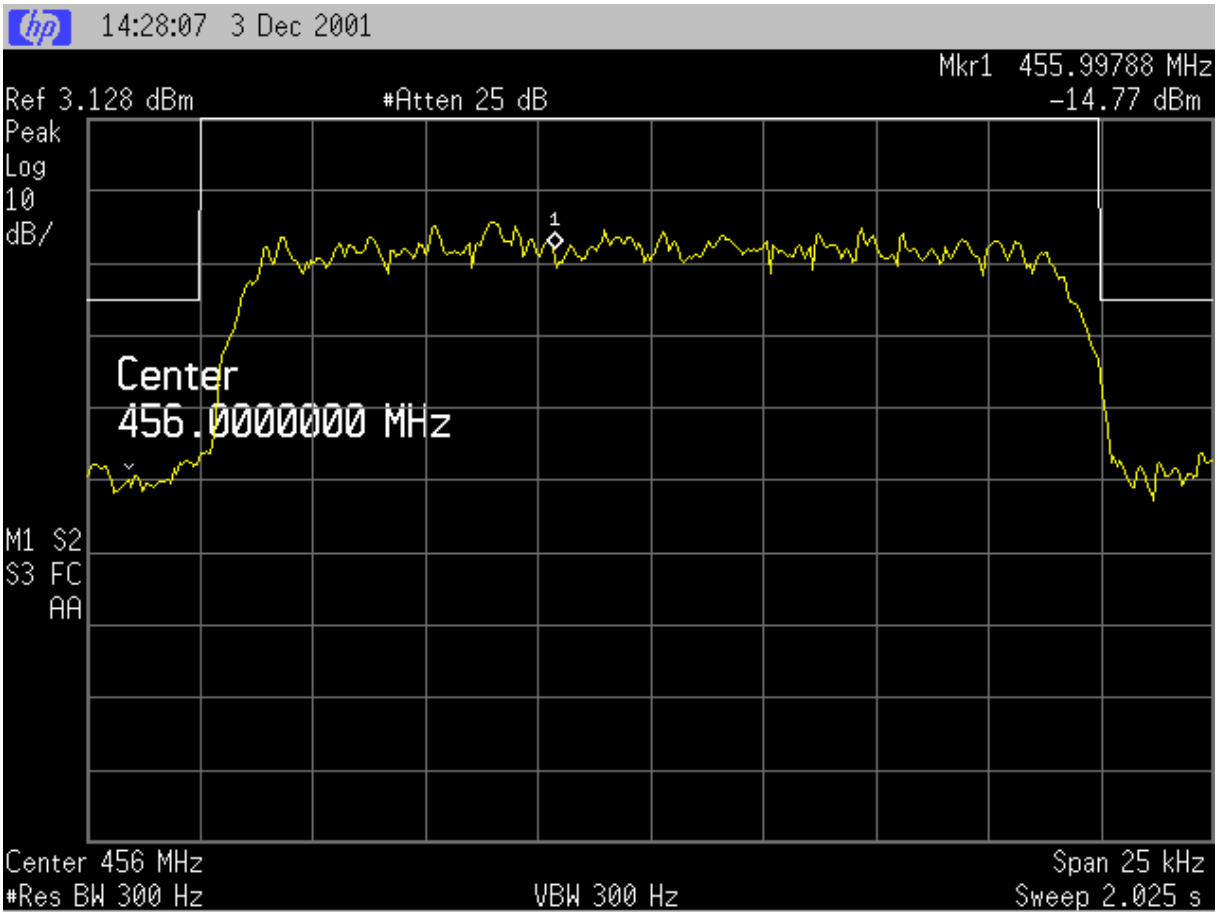
Section 90.210(b) – Mask B has been applied as the transmitter can operate in the band 421 - 512 MHz.

Section 90.209(b)(5) defines the authorised bandwidth as 20 kHz where 25 kHz channeling is used in the band 421 – 521 MHz.

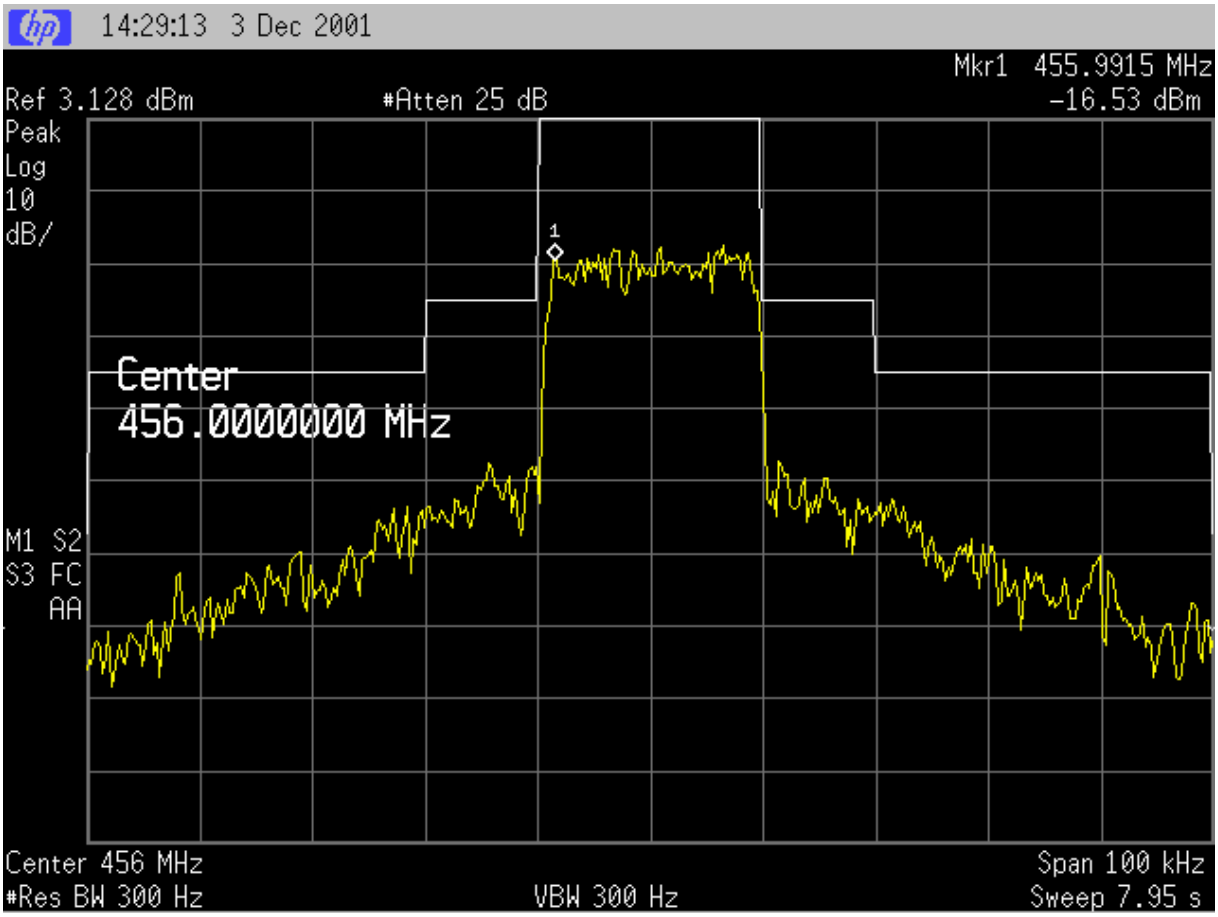
The reference level for all emission mask measurements has been determined using a resolution bandwidth of 30 kHz.

Emission mask plots have been made using a resolution bandwidth of 300 Hz.

Mask B with a 64 kB/s data transfer established with a second EX7100 Digital Transceiver with a span of 25 kHz.



Mask B with a 64 kB/s data transfer established with a second EX7100 Digital Transceiver with a span of 150 kHz.



Result: Complies

Spurious Emission Measurements:

The following spurious emission measurements have been made

1. Spurious emissions at the transmitter antenna terminals
2. Field strength of transmitter spurious emissions at the antenna terminals
3. Field strength of receiver spurious emissions
4. Antenna power conduction limits for receivers.

Spurious emissions are controlled by the following means:

1. A band pass filter between the transmitter and the power amplifier.
2. Matching networks in each stage of the power amplifier that roll off above and below the signal pass band.
3. High and low pass filter element contained with in the duplexer which is attached to the output of the power amplifier.

Spurious emissions at the transmitter antenna terminals

Frequency: 456.000 MHz

Measured Spurious Emission	
Spurious emission (MHz)	**Emission level (dBm)**
912.000	–39.0
1368.000	–40.0
1824.000	–46.0
2280.000	less than –55.0
2736.000	less than –55.0
3192.000	less than –55.0
3648.000	less than –55.0
4104.000	less than –55.0
4560.000	less than –55.0

Limit
Part 90.210(b) Mask B, (3) on any frequency removed by more than 250% all emissions are to be attenuated by at least 43 + 10 log (P).

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.

Rated power is 10 watts. 43 + 10 log (P) gives a limit of –13 dBm.

No measurements less that –35 dBm have been reported except those reported.

No measurements were made above the 10th harmonic.

Result: Complies.

Measurement Uncertainty: *±3.3 dB*

Field strength of transmitter spurious emissions at the antenna terminals

Frequency: 456.000 MHz

Transmit Frequency (MHz)	Level (dBuV/m)	Power (dBm)	Limit (dBm)	Margin (dB)	Polarity
Tx harmonics					
912.000	-	-	-20.0	-	Vert/Hort
1368.000	36.6	-62.5	-20.0	-42.5	Horizontal
1824.000	51.0	-44.3	-20.0	-24.3	Vertical
2280.000	47.1	-53.5	-20.0	-33.5	Horizontal
2736.000	46.4	-55.3	-20.0	-35.3	Horizontal
3192.000	-	-	-20.0	-	Vert/Hort
3648.000	-	-	-20.0	-	Vert/Hort
4104.000	-	-	-20.0	-	Vert/Hort
4560.000	-	-	-20.0	-	Vert/Hort
Other emissions					
83.300	46.6	-52.0	-20.0	-32.0	Vertical
139.260	45.9	-45.0	-20.0	-25.0	Horizontal
140.000	42.4	-48.0	-20.0	-28.0	Horizontal
191.490	44.5	-53.0	-20.0	-33.0	Vertical
200.000	54.6	-42.0	-20.0	-22.0	Vertical
208.890	45.4	-47.0	-20.0	-27.0	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 Dakota Lane, Ardmore Aerodrome, Auckland. Details of this site have been filed with the Commission, Registration Number: 90838, which were last updated on February 11, 2000.

The transmitter tested while transferring data at a rate of 64 kb/s from a 2nd EX7100 which, was located 30 metres away.

Attached to the output of the transmitter was a 30 dB power attenuator.

The transmitter was tested transmitting and receiving continuously (100% duty cycle).

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 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 is 10 watts, which gives a limit of –20 dBm.

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

All transmitter harmonic emissions observed have been reported.

All other emissions are more than 20 dB below the above specification limit and have therefore not been reported in accordance with Section 2.1057(c).

Result: Complies

Field strength of receiver spurious emissions

Receive frequency: 461.000 MHz

IF Frequency: 21.4 MHz

Tests carried out in accordance with Part 15, Section 15.109.

Transmit frequency (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Polarity
477.400	-	46.0	-	Vert/Hort
954.800	-	54.0	-	Vert/Hort
1132.225	-	54.0	-	Vert/Hort
1309.650	-	54.0	-	Vert/Hort
1487.075	-	54.0	-	Vert/Hort
1664.500	-	54.0	-	Vert/Hort
1841.925	-	54.0	-	Vert/Hort
2019.350	-	54.0	-	Vert/Hort
2196.775	-	54.0	-	Vert/Hort
2374.200	-	54.0	-	Vert/Hort

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 si located at Dakota Lane, Ardmore Aerodrome, Auckland. Details of this site have been filed with the Commission, Registration Number: 90838, which were last updated on February 11, 2000.

The receiver was tested while the systems were transferring data at a rate of 64 kb/s from a 2nd EX7100 which was located 30 metres away.

This transceiver operates with a 100% duty cycle meaning that the receiver operates continuously along with the transmitter.

Limit
Part 15 section 15.109(a). The following limits have been applied:

216 – 960 MHz: 200 uV/m = 46.0 dBuV/m
above 960 MHz: 500 uV/m = 54.0 dBuV/m

Result: Complies

Measurement Uncertainty: *±4.1 dB*

Antenna power conduction limits for receivers.

Receive frequency: 461.000 MHz

IF Frequency: 21.4 MHz

Tests carried out in accordance with Part 15, Section 15.111.

As the transceiver has no dedicated antenna, spurious emission measurements were made at the antenna terminals using a spectrum analyser.

Measured Spurious Signals		
Spurious signal (MHz)	**Level at the receiver input (dBm)**	**Description**
482.410	-91.1	LO
964.805	-90.0	2LO
1929.610	-90.0	4LO

All other emissions detected were less than –92.0 dBm.

Limit
The spurious emission power should not exceed 2 nW (-57 dBm).

Result: Complies

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

Frequency Stability

Frequency stability measurements were made over the range - 30 °C to + 50°C in + 10°C increments.

At each temperature the transmitter was given a period of 30 minutes to stabilise.

Measurements were made with the supply varied between 115% and 85% of the nominal supply voltage (24 Vdc).

Nominal Frequency: 456.000 MHz

Frequency Error (Hz)			
Voltage Temp.	**20.4 Vdc**	**24.0 Vdc**	**27.6 Vdc**
+50°C	-792.0	-786.0	-789.0
+40°C	-373.0	-369.0	-373.0
+30°C	-25.0	-25.0	-25.0
+20°C	-32.0	-33.0	-35.0
+10°C	-24.0	-25.0	-25.0
0°C	-137.0	-137.0	-137.0
-10°C	-177.0	-179.0	-180.0
-20°C	-503.0	-501.0	-505.0
-30°C	-909.0	-910.0	-912.0

The frequency determining circuit of the radio is a phase locked loop oscillator in the transmitter unit. The LC oscillator is phase locked to a temperature compensated crystal oscillator.

Limit
Part 90.213 states a number of frequency stability requirements for fixed and base transmitters operating between 421 – 512 is 2.5 ppm.

This transmitter operates on 456.000 MHz.
2.5 ppm = 2.5 x 456.000 = 1140 Hz.

Result: Complies.

Measurement Uncertainty: ±30 Hz

Transient frequency behaviour

Transient frequency behaviour measurements are applicable to wide band transmitters operating in the frequency band 412 – 512 MHz as required by section 90.214.

Measurements were carried out at 456.000 MHz using the method described in ETS 300-086.

While this transmitter usually operates with a 100% duty cycle, measurements have been made to show the affect of the transmitter being powered on and off.

In summary this method calls for the use of an external signal generator tuned to 456.0 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 25.0 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 and a picture on the oscilloscope.

The result of the change in the ration 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 5 kHz	Nil	Nil

Result: Complies

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

Transmitter turn on:

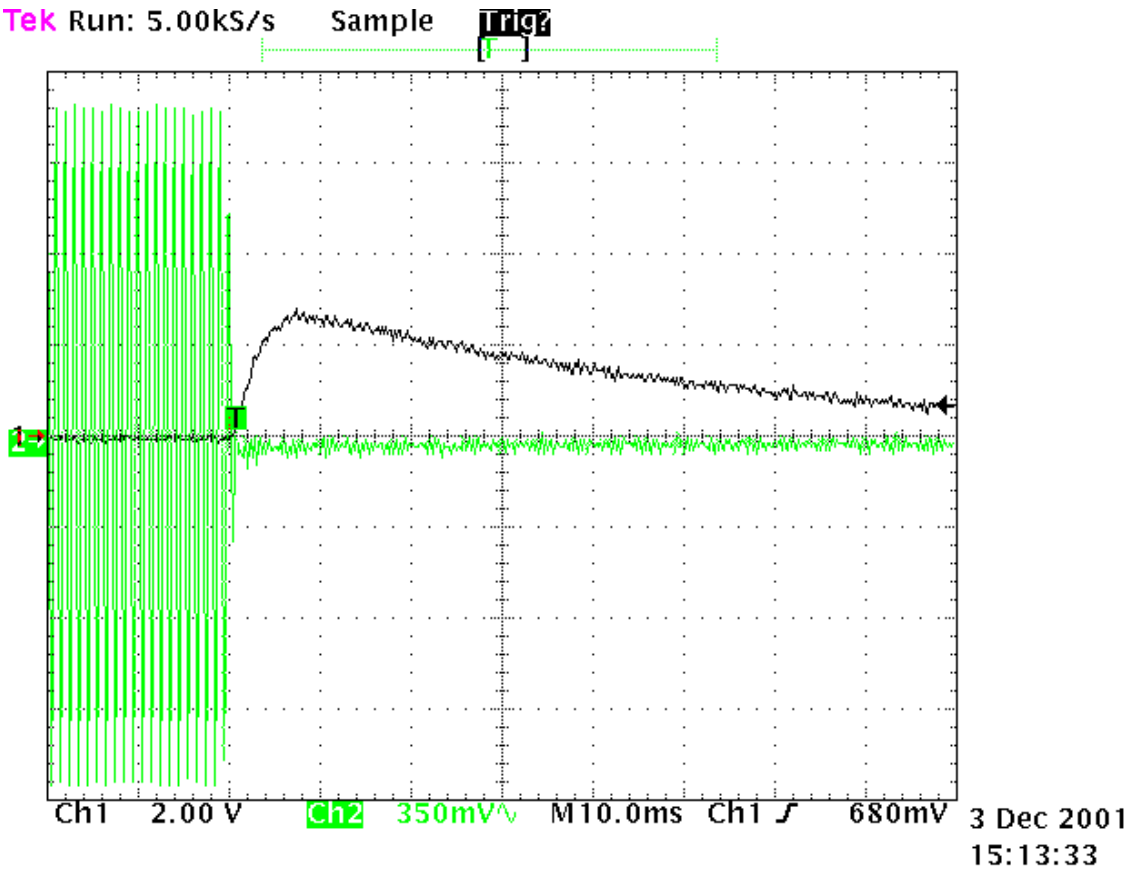
Green Trace = 1 kHz tone with FM deviation of 25 kHz.
Black trace = transmitter amplitude response.

Green trace has been maximised to give full screen indication of a +/- 25 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).
This is position *t*on.

*t*1 occurs between 2 and 3 divisions from the left-hand edge.
t2 occurs between 3 and 5.5 divisions from the left-hand edge.

A very small transient response can be observed after *t*on.



Transmitter turn off:

Green Trace = 1 kHz tone with FM deviation of 25 kHz.
Black trace = transmitter amplitude response.

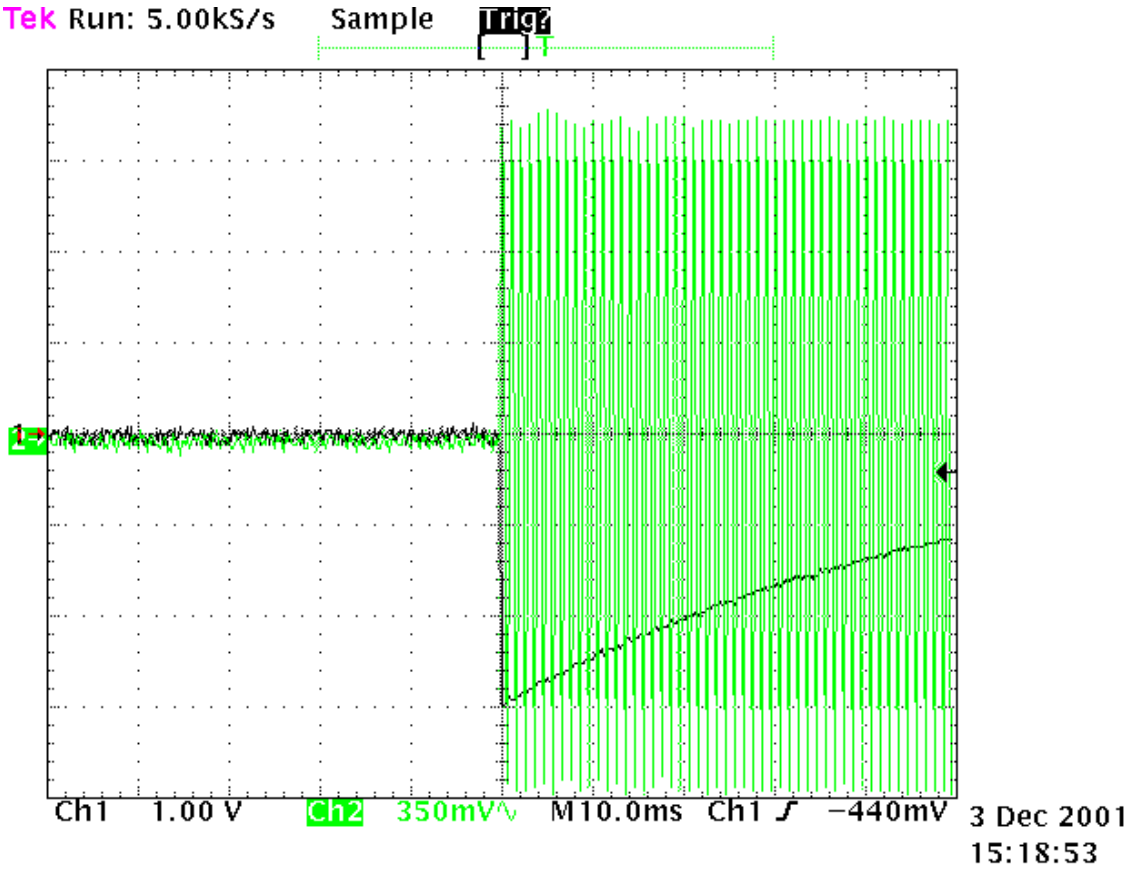
Green trace has been maximised to give full screen indication of a +/- 25 kHz.
Therefore each Y axis division = 6.25 kHz per division.
The X axis has been set to a sweep rate of 10 mS/division.

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 4.0 and 5.0 divisions from the left-hand edge.

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



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	Hewlett Packard	8491A	24838	E1329
Attenuator	Wienschel	49-20-43	GC104	E1308
Audio Analyzer	Hewlett Packard	HP 8903B	2216A01713	E1146
Biconical Antenna	Schwarzbeck	BBA 9106		RFS 3612
Biconical Antenna	Schwarzbeck	BBA 9106		RFS 3697
Coax Cable	Sucoflex	104PA	2736/4PA	
DC Power Supply	Hewlett Packard	HP6032A	2743A-02859	E1069
Frequency Counter	Hewlett Packard	HP 5342A	1916A01835	E1224
Horn Antenna	Electrometrics	RGA-60	6234	E1494
Horn Antenna	EMCO	3115	9511-4629	E1526
Level generator	Anritsu	MG443B	M61689	E1143
Log Periodic Antenna	Schwarzbeck	UHALP 9107	-	RFS 3696
Log Periodic Antenna	Schwarzbeck	UHALP 9107		RFS 3702
Measurement Receiver	Rohde & Schwarz	ESCS 30	839873/1	E1595
Modulation Analyzer	Hewlett Packard	HP 8901B	2608A00782	E1090
Resistance Thermometer Meter	DSIR	RT200	35	E1409
RF Power Meter	Hewlett Packard	HP 436A	2512A22439	E1198
Rubidium Oscillator	Ball Efratom	FRS – C	4287	E1053
Signal Generator	Rohde and Schwarz	SMP-04	1035 5005.04	E1560
Spectrum Analyser	Hewlett Packard	E7405A	US 39150142	RFS 3776
Thermal chamber	Contherm	M180F	86025	E1129
Turntable	EMCO	1080-1-2.1	9109-1578	RFS 3709

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 were updated on February 11th, 2000.

All measurement equipment has been calibrated in accordance with the terms of EMC Technologies (NZ) Ltd's International Accreditation New Zealand (IANZ) Accreditation to the New Zealand Code of Laboratory Management Practice incorporating ISO Guide 25: 1990 and ISO 9002: 1994.