TEST REPORT

Microair Avionics T2000UAV-L ATCRBS Transponder

tested for compliance with the

Code of Federal Regulations (CFR) 47

Part 87 –Aviation Services

for

Microair Avionics PTY Ltd

This Test Report is issued with the authority of:

Andrew Cutler - General Manager

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1. CLIENT INFORMATION

Company Name Microair Avionics PTY Ltd

Address PO Box 5532
Bundaberg West
Queensland 4670

Country AUSTRALIA

Contact Mr Ian Mugan

2. DESCRIPTION OF TEST SAMPLE

Brand Name Microair

Model Tested T2000UAV-L

Product ATCRBS Transponder

Manufacturer Microair Avionics PTY Ltd

Country of Origin Australia

Serial Number 001182

FCC ID PS3T2000UAV-L

The device that was tested is a single frequency aircraft transponder that has been specifically designed to operate on board UAV aircraft.

Therefore the device has no operator controls or indicators.

3. COMPLIANCE STATEMENT & RESULT SUMMARY

The **Microair Avionics T2000UAV-L ATCRBS Transponder** complies with 47 CFR Part 87 when tested in accordance with 47 CFR Part 2 and Part 87 and when the test methods as described in ANSI C63.4 – 2003 were applied.

A summary of the applicable clauses is detailed below

CLAUSE	TEST PERFORMED	RESULT
2.1041	Measurement procedures	Noted
2.1057	Frequency spectrum to be investigated	Noted
87.131 2.1046	Power and emissions RF power output	Complies Noted
87.133 2.1055	Frequency stability Frequency stability	Complies Noted
87.135 2.202 2.1049	Bandwidth of emission Bandwidths Occupied bandwidth	Complies Noted Noted
87.137	Types of emissions	Complies
87.139 2.1051 2.1053	Emission limitations Spurious emissions at antenna terminals Field strength of spurious radiation	Complies Noted Noted
87.141	Modulation requirements	Not applicable
87.143	Transmitter control requirements	Complies
87.145	Acceptability of transmitters for licensing	Noted
87.147	Authorisation of equipment	Noted
87.149	Special requirements for automatic link establishment (ALE)	Not applicable
87.151	Special requirements for differential GPS Receivers	Not applicable
1.1310	Radio frequency radiation exposure limits	Complies

4. TEST SAMPLE DESCRIPTION

The sample tested has the following specifications:

Rated Transmitter Output Power

200 watts peak (+53.0 dBm)

Duty Cycle

0.1 %

Mean power

0.2 watts

Transmitter operating frequency

1090.0 MHz

Receiver operating frequency

1030.0 MHz

FCC Bands

Part 87: Aircraft radio navigation band (transponder) 960 - 1215 MHz

Emission Designators / Modes of operation

14M5M1D

Power Supply

External supply between 12 – 28 Vdc supply.

Typical operating voltages would be 13.2 Vdc or 28 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:	13.2 Vdc and 28 Vdc.

Extreme Temperature

High Temperature:	+ 50°C maintained.
Low Temperature:	- 20 °C maintained.

Extreme Test Voltages

High Voltage:	33.0 Vdc
Low Voltage:	10.0 Vdc

Testing carried out at the extremes of voltages as stated by customer

6. ATTESTATION

The **Microair Avionics T2000UAV-L ATCRBS Transponder** complies with the Code of Federal Regulations (CFR) 47 Part 87 – Aviation 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

Power and emissions

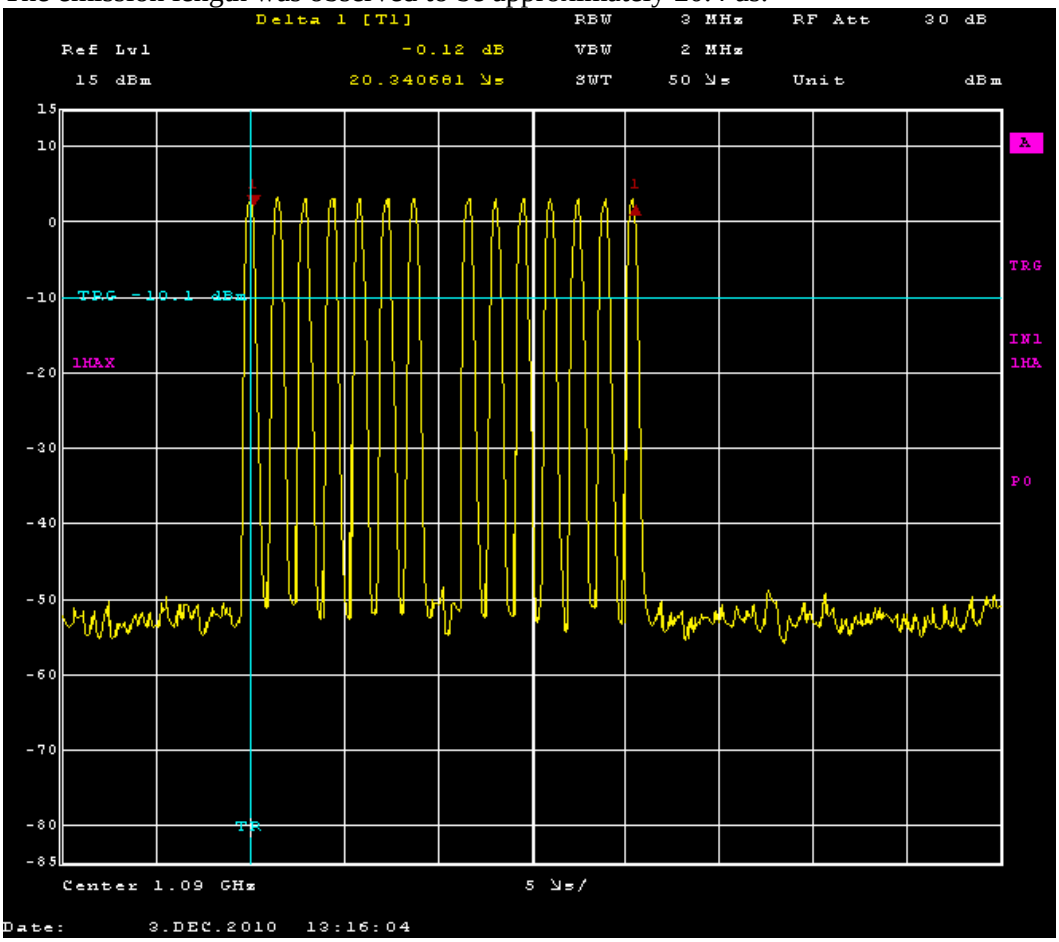
The transponder was directly connected, using a directional coupler, to the output of a Aeroflex IFR 6000 Ramp Test Set which was configured to operate in ATCRBS Mode A.

The incident output of the directional coupler was connected to the input of a spectrum analyser via a 30 dB attenuator.

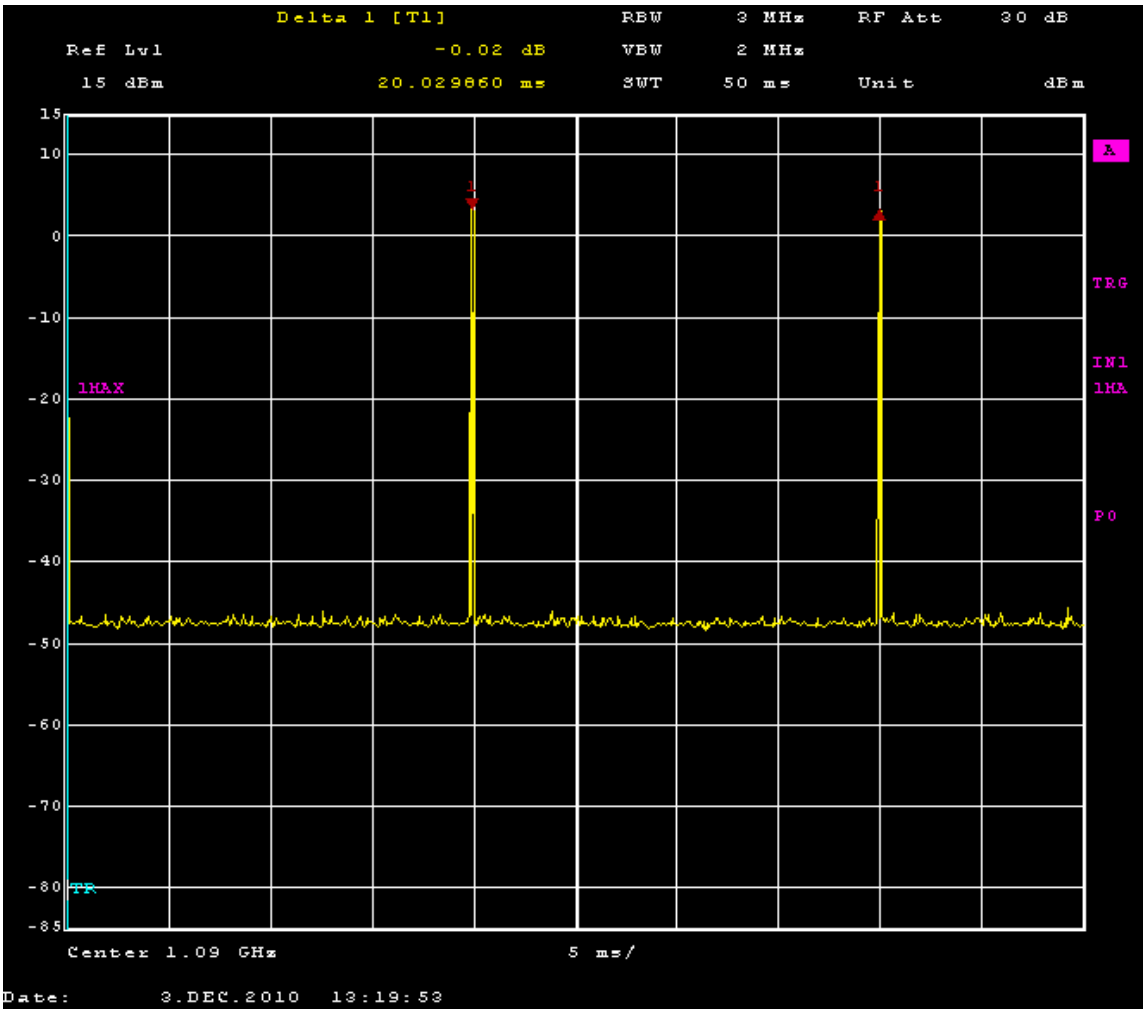
A total of 51 dB attenuation was provided between the output of the transponder and the input of the spectrum analyser.

With the transponder operating in Mode A sending an assigned code of 7777 the following measurements were made.

The emission length was observed to be approximately 20.4 us.



This pulse was observed to occur every 20 ms



Therefore it can be seen that this device is operating with a duty cycle of

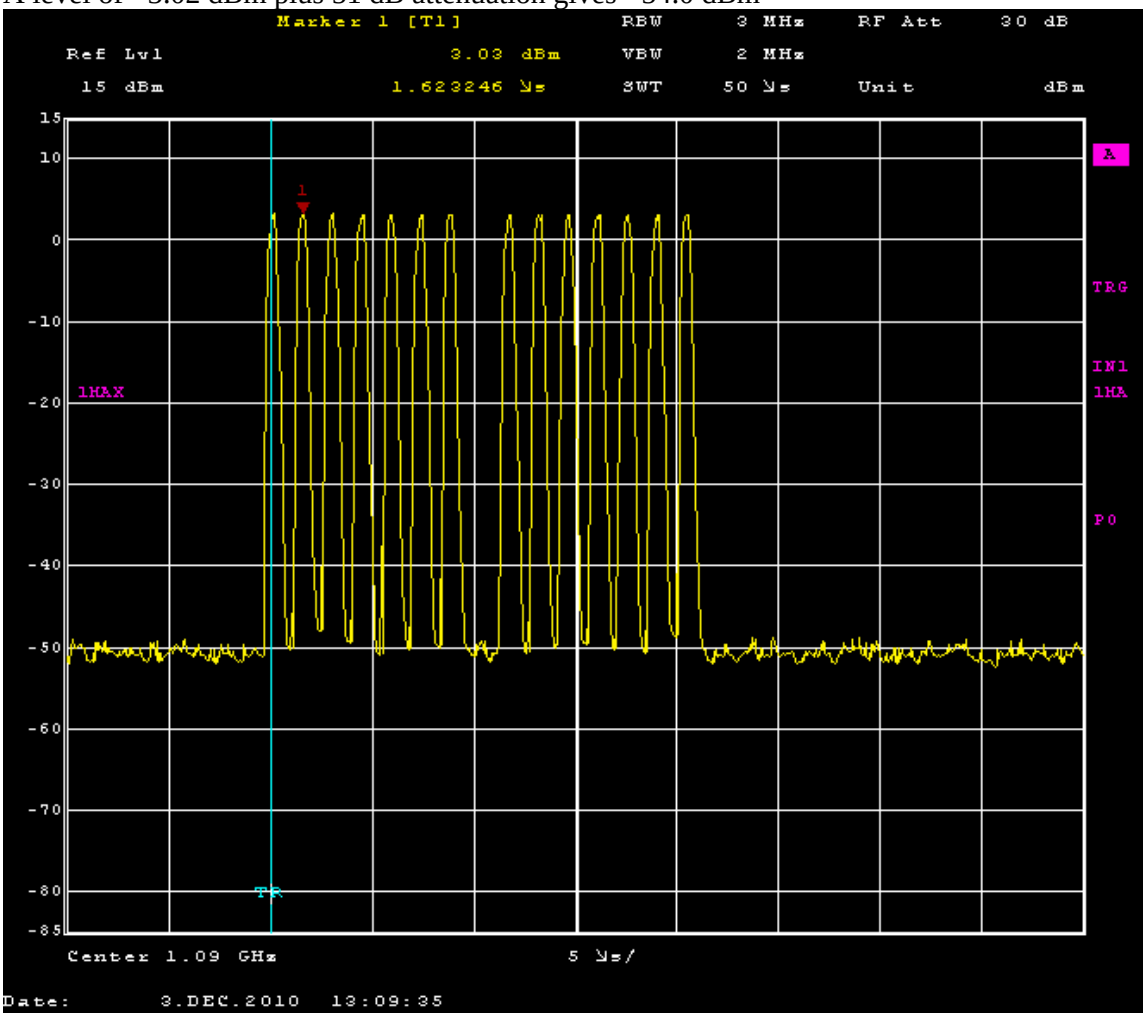
= 20 us / 20 ms + 20 us

= 9.99×10^{-4}

= 0.0999%

The following peak power measurements were made with the peak of the 20 us burst being measured using the spectrum analyser with a 3 MHz resolution bandwidth and a 0 Hz span when tuned to 1090.0 MHz

A level of +3.02 dBm plus 51 dB attenuation gives +54.0 dBm



The supply voltage was varied as follows

Frequency (MHz)	Voltage (Vdc)	Rated (dBm)	Measured (dBm)
1090.000	10.0	53.0	54.02
1090.000	13.2	53.0	54.04
1090.000	28.0	53.0	54.07
1090.000	33.0	53.0	54.05

The measured power and rated power level correlate very closely.

Testing was carried out at maximum power output as the device has no power control mechanisms.

The transmitter is used for aircraft radio navigation purposes in the 960 – 1215 MHz band with an emission designation of M1D.

Limit:

Section 87.131 does not specify a frequency band, authorised emission type of maximum power for this type of device.

Note 7 states that these parameters will be determined by appropriate standards during the certification process.

Result: Complies
Measurement Uncertainty: ±0.5 dB

Frequency Stability

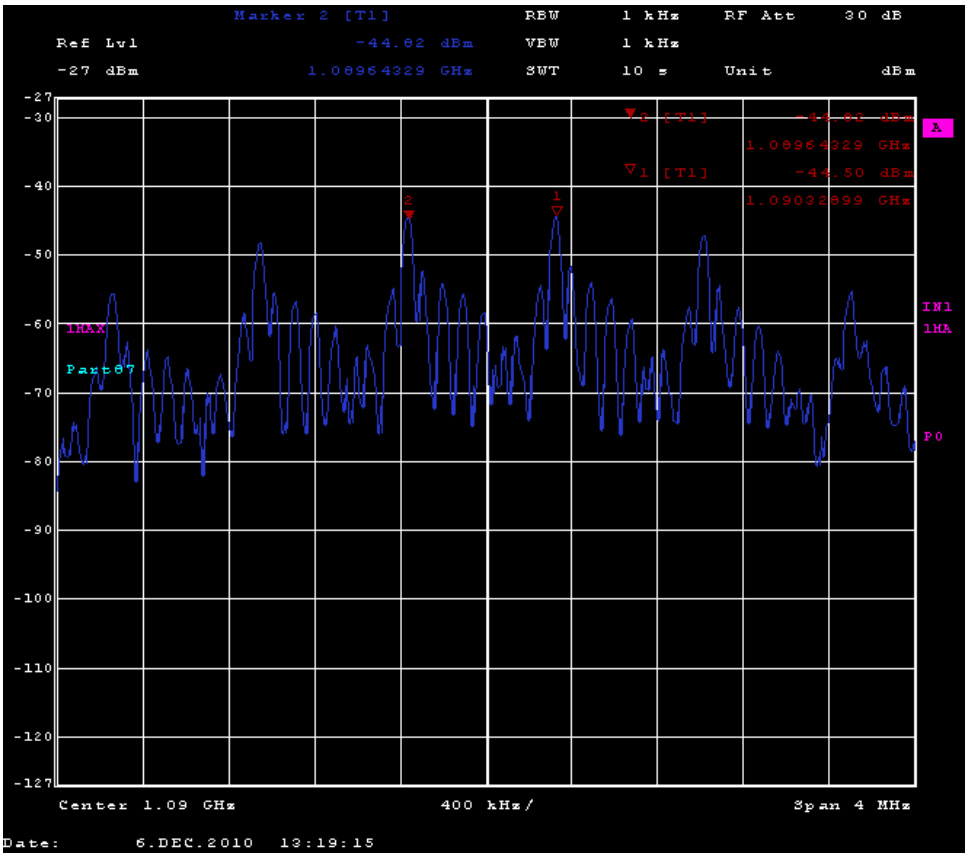
Frequency stability measurements were between - 20 °C and + 50°C in 10°C increments.

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 at 10 Vdc, 13.2 Vdc, 28.0 Vdc and 33.0 Vdc which are the stated voltage extremes.
Initial testing showed that emission spectrum for this device appeared to consisted of 4 similar high amplitude carriers equally spaced around a centre frequency of 1090 MHz.

Testing was carried out using a spectrum analyser operating in peak hold mode with a resolution bandwidth of 1 kHz and a span of 8 MHz which was then reduced to 500 kHz once the highest emission had been determined.

Therefore frequency stability measurements were made with reference to the nominal frequency of the highest level carrier at ambient temperature as can be seen below



Frequency error in MHz with reference to 1090.000 MHz

Temp.	10.0 Vdc	13.2 Vdc	28.0 Vdc	33.0 Vdc
+50°C		0.33	0.33	
+40°C		0.32	0.32	
+30°C		0.33	0.34	
+20°C	0.34	0.34	0.34	0.34
+10°C		-0.36	-0.36	
0°C		-1.04	-1.05	
-10°C		-1.04	-1.04	
-20°C		-1.03	-1.03	

Limit:

Part 87.133 states that in the (7) Band: 470 to 2450 MHz radio navigation stations operating between 960 – 1215 MHz after 1 January 1990 are required to have frequency tolerance of 20 ppm.

My client advises that as this equipment is not a radio navigation station and clause (e), The Commission may authorise tolerances other than those specified upon satisfactory showing of need, should apply.

This transponder device is also covered by FCC Technical Standard Order (TSO) C74d which relates to the minimum operation performance of such devices.

This TSO in turn references Standard RTCA/DO-144A which relates to the operational requirements for transponder equipment.

RTCA/DO-144A section 2.4.3.1 defines a transmitter centre frequency of 1090 MHz +/- 3 MHz.

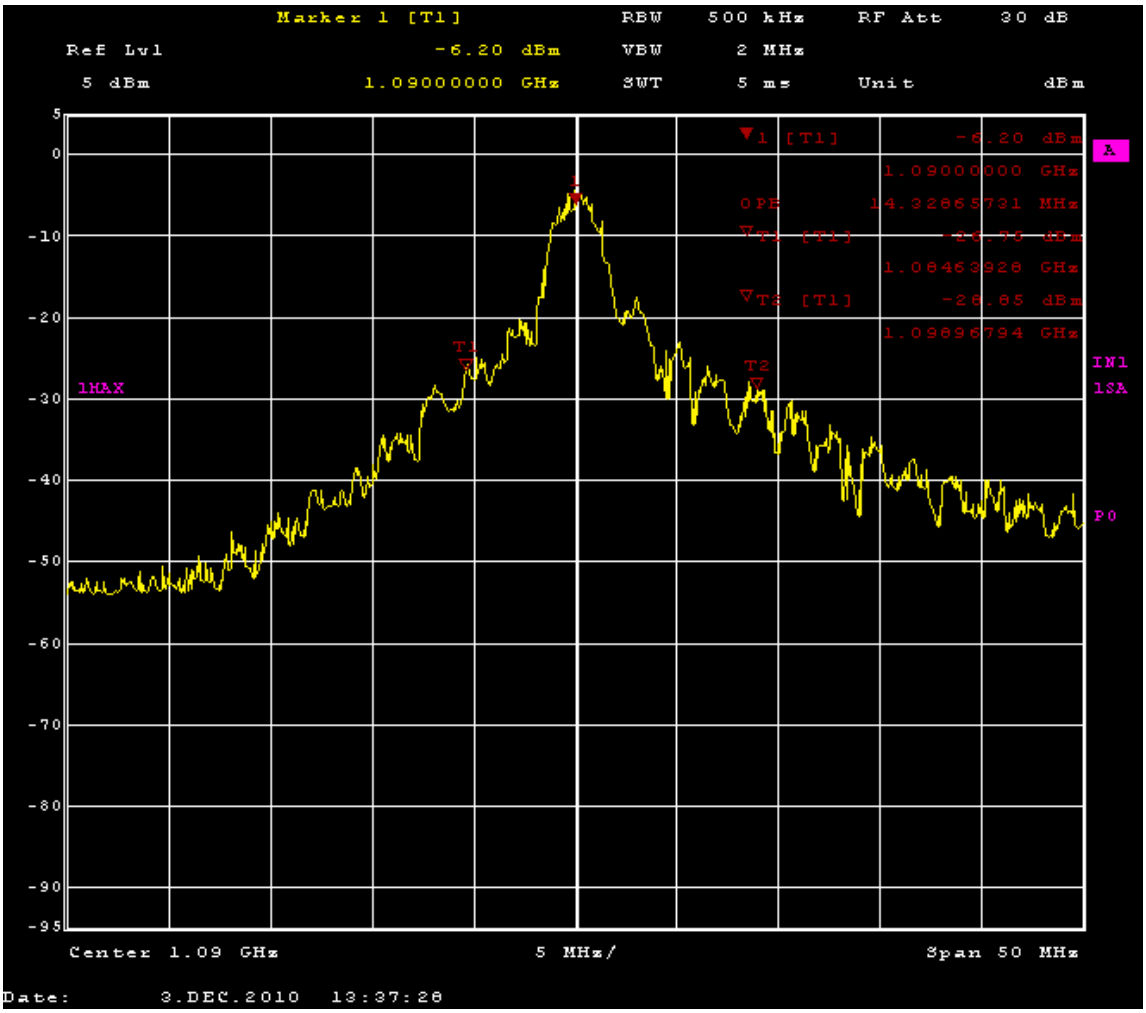
Therefore a frequency stability of +/- 3 MHz (+/- 3,000,000 Hz) has been applied to this device.

Result: Complies
Measurement Uncertainty: ±30 Hz

Bandwidth of emission

Using the ESIB spectrum analyser operating in occupied bandwidth mode with a resolution bandwidth of 500 kHz and video bandwidth of 2 MHz the following was observed when operating in peak hold mode.

The occupied bandwidth at the 99% power points will be 14.328 MHz which approximates to 14.5 MHz



No authorised bandwidth is specified for this emission type so therefore the necessary bandwidth will be the authorised bandwidth.

Result: Complies

Types of emission

The emission type as declared by the client is not listed in the table in 87.137 (a)

As per 87.137 (b) the emission type has been determined to be M1D as per FCC part 2.

The emission consists of a periodic short pulse that contains information.

Therefore the following would apply:

M The type of modulation is pulse modulation that is modulated in position / phase

1 The signals modulating the carrier are a single channel containing information without the use of a modulating sub carrier

D The information transmitted is data

The necessary 99% bandwidth has been measured to be approximately 14 MHz

Further to these measurements calculations were made to determine the theoretical occupied bandwidth.

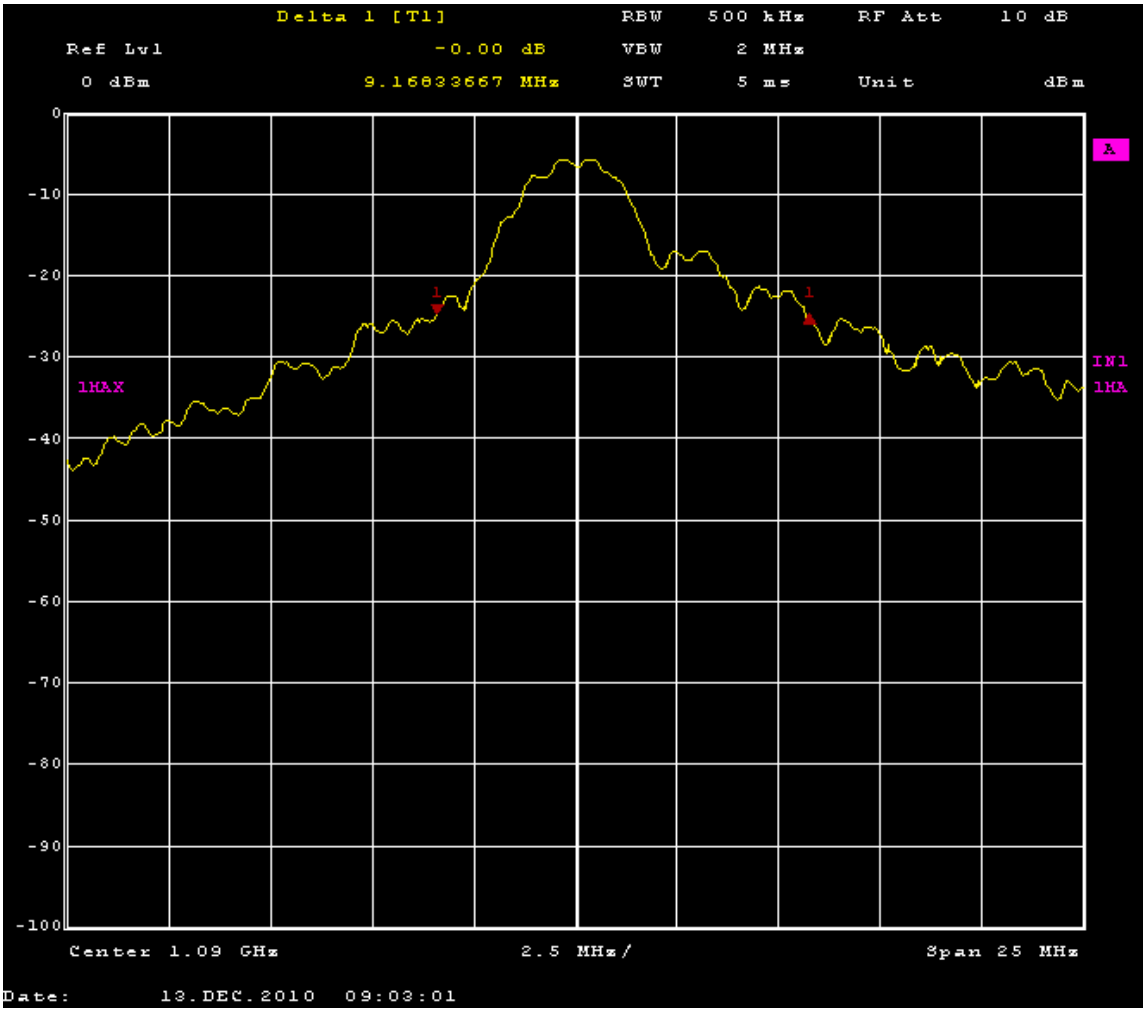
The only formula that could be determined states that the necessary bandwidth Bn will be the 20 dB bandwidth.

RTCA/DO-144A section 2,4,4,4 states that the transponder pulse shall have a duration (t) of 350 – 550 ns, rise time (tr) of 50 – 100 ns and a decay time (tf) of 50 – 200 ns.

The client advises that the factory settings for this device are
Tr 84 ns
Tf 104 ns
T 476 ns

$Bn = 1.79 / (t * tr)^{0.5}$
$Bn = 1.79 / (476\ ns * 84\ ns)^{0.5}$
$Bn = 8.95\ MHz$

A necessary bandwidth measurement at the -20 dB points has been made as detailed below.



A measured value of 9.2 MHz compares favourably with the -20 dB calculated value of 9.0 MHz

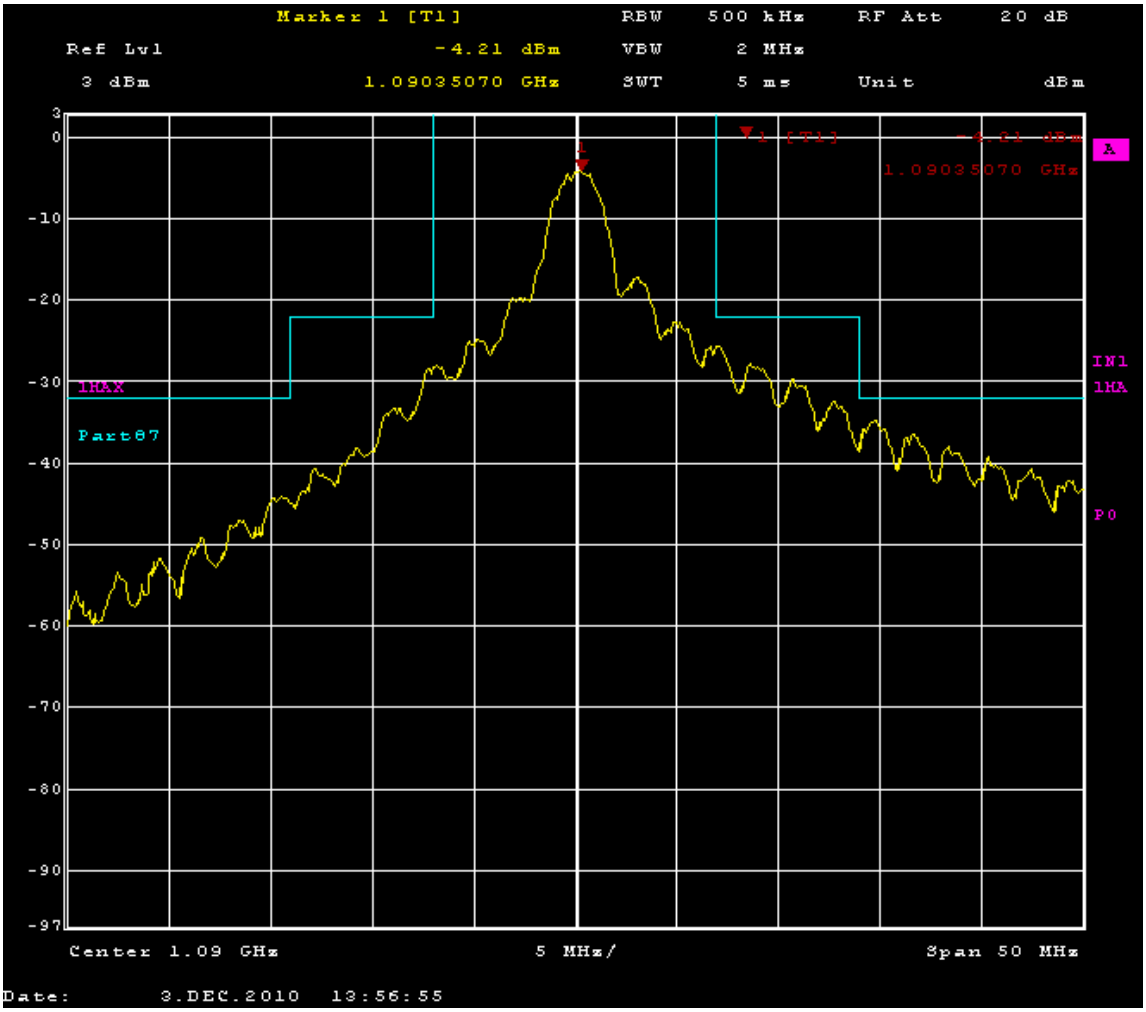
Result: Complies

Emission limitations

The mask defined in Section 87.139 (a)(1)(2)(3) has been applied to this transmitter.

The peak power of this transmitter has been measured to be 200 watts (+53 dB).

The authorised bandwidth that equates to the necessary bandwidth is 14.5 MHz



The reference level for this mask has been set to the peak power level that was previously measured in this report using a resolution bandwidth of 3 MHz.

Measurements were then made using the spectrum analyser settings that were used to make the occupied bandwidth measurements.

Result: Complies

Transmitter spurious emissions at the antenna terminals

Frequency: 1090.000 MHz

Spurious emission (MHz)	Emission mean power (dBm)	Limit (dBm)
2180.00	-32.8	-17.0
3270.00	-39.3	-17.0
4360.00	-46.5	-17.0
5450.00	-38.6	-17.0
6540.00	-47.6	-17.0
7630.00	-50.3	-17.0
8720.00	-52.4	-17.0
9810.00	-51.8	-17.0
10900.00	-58.2	-17.0

Measurements have been made with the transmitter transmitting continuously when powered at 13.2 Vdc and 28 Vdc.

Limit:

Part 87.139(a) states that when the frequency is removed from the assigned frequency by more that 250% of the authorised bandwidth the attenuation for aircraft stations must be at least 40 dB.

With a measured peak power of 200 watts (+53 dBm) and the mean power has been calculated to be 0.2 watts (+23 dBm) which gives a mean power limit of -17 dBm.

Measurements were made in peak using a spectrum analyser with a resolution bandwidth of 1 MHz and span of 0 Hz with the mean power being calculated using a duty cycle of 0.001 (-30 dB).

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.

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

Result: Complies
Measurement Uncertainty: ±3.3 dB

Field strength of the transmitter spurious emissions

Frequency: 1090.000 MHz

Frequency (MHz)	Level (dBuV/m)	Power (dBm)	Limit (dBm)	Polarity	Margin (dB)
2180.0000	54.5	-72.9	-17.0	Vertical	55.9
2180.0000	53.9	-73.5	-17.0	Horizontal	56.5
3270.0000	75.3	-52.1	-17.0	Vertical	35.1
3270.0000	64.5	-62.9	-17.0	Horizontal	45.9
4360.0000	56.4	-71.0	-17.0	Vertical	54.0
4360.0000	56.1	-71.3	-17.0	Horizontal	54.3
5450.0000	63.0	-64.4	-17.0	Vertical	47.4
5450.0000	63.8	-63.6	-17.0	Horizontal	46.6
6540.0000	62.1	-65.3	-17.0	Vertical	48.3
6540.0000	61.4	-66.0	-17.0	Horizontal	49.0
7630.0000	57.0	-70.4	-17.0	Vertical	53.4
7630.0000	57.0	-70.4	-17.0	Horizontal	53.4
8720.0000	58.0	-69.4	-17.0	Vertical	52.4
8720.0000	58.0	-69.4	-17.0	Horizontal	52.4
9810.0000	59.0	-68.4	-17.0	Vertical	51.4
9810.0000	59.0	-68.4	-17.0	Horizontal	51.4
10900.0000	61.0	-66.4	-17.0	Vertical	49.4
10900.0000	61.0	-66.4	-17.0	Horizontal	49.4

The transmitter was tested when powered at 13.2 Vdc and also 28 Vdc

No other emissions were detected between 30 – 10900 MHz when measurements were attempted using either horizontal or vertical polarisations.

When operating in standby mode no emissions were detected from this device.

Testing was carried out when the device was communication continuously with an Aeroflex IFR6000 Ramp Test Set with the device operating in Mode A sending the code 7777 using a 10 metre length of coax cable.

Also attached to the device was a laptop computer that was used to control the transmitter.

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, 2010.

All initial measurements were made using a spectrum analyser / measuring receiver operating in peak with a resolution bandwidth of 1 MHz.

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

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

These peak levels were then converted to mean power levels using a factor of 0.001 (-30 dB)

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:

Part 87.139(a) states that when the frequency is removed from the assigned frequency by more that 250% of the authorised bandwidth the attenuation for aircraft stations must be at least 40 dB.

With a measured peak power of 200 watts (+53 dBm) and the mean power has been calculated to be 0.2 watts (+23 dBm) which gives a mean power limit of -17 dBm.

Measurements were made using a spectrum analyser and measuring receiver using a peak detector with a resolution bandwidth of 1 MHz and span of 0 Hz with the mean power being calculated using a duty cycle of 0.001.

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.

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

Result: Complies
Measurement Uncertainty: ±4.1 dB

Modulation Requirements

The requirements of Section 87.141 will not apply to this type of transmitter.

Transmitter control requirements

The requirements of Section 87.143 will apply to this transmitter.

This transmitter has no operator controls and when in use the device will be operated in an aircraft that does not have an operator (UAV).

An interface port is provided however this port is for set up and diagnostic purposes only and would not normally be accessible.

Result: Complies

Radio Frequency Hazard Information

As per Section 1.1310 mobile 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 0.73 mW/m^2 (1090/1500) has been applied.

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

E for MPE: $(1090/1500) = E^2/3770$
$E = \sqrt{(1090/1500)*3770}$
$E = \underline{52.5\ V/m}$

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 and separation distance in metres:

The rated maximum power of this transmitter is 200 watts with a duty cycle of 0.1% which gives a mean power of 0.2 watts

In a typically mobile installation this transceiver would be used with a whip ¼ wave dipole type of antenna with a gain of 1.64.

$d = \sqrt{(30 * P * G) / E}$
$= \sqrt{(30 * 0.2 * 1.64) / 52.5}$
$= \underline{0.06 \text{ metres or } 6 \text{ cm}}$

The above calculations that this device will meet the MPE requirement for mobile devices providing a safe distance of at least 6 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 No	Asset Ref	Cal Due
Aerial Controller	EMCO	1090	9112-1062	RFS 3710	Not applic
Aerial Mast	EMCO	1070-1	9203-1661	RFS 3708	Not applic
Turntable	EMCO	1080-1-2.1	9109-1578	RFS 3709	Not applic
Power Supply	Hewlett Packard	6032A	2743A-02859	E1069	Not applic
Thermal chamber	Contherm	M180F	86025	E1129	Not applic
Thermometer	DSIR	RT200	035	E1049	27 Sept 2011
Receiver	R & S	ESIB-40	100171	R-27-1	10 June 2011
VHF Balun	Schwarzbeck	VHA 9103	-	RFS 3603	7 Feb 2011
Biconical Antenna	Schwarzbeck	BBA 9106	-	RFS 3612	7 Feb 2011
Log Periodic	Schwarzbeck	VUSLP 9111	9111-228	3785	7 Feb 2011
Horn Antenna	EMCO	3115	9511-4629	E1526	20 May 2011

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 in January 2010.

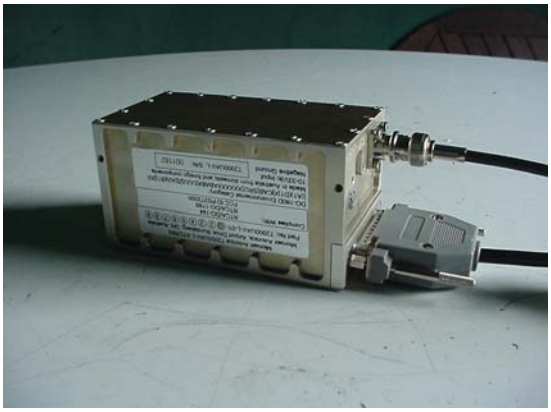
All testing has been carried out in accordance with the terms of EMC Technologies (NZ) Ltd's International Accreditation New Zealand (IANZ) Accreditation to ISO/IEC 17025.

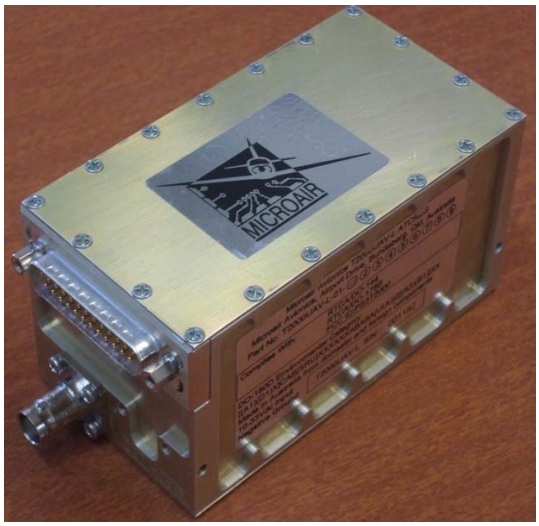
All measurement equipment has been calibrated in accordance with the terms of EMC Technologies (NZ) Ltd's International Accreditation New Zealand (IANZ) Accreditation to ISO/IEC 17025.

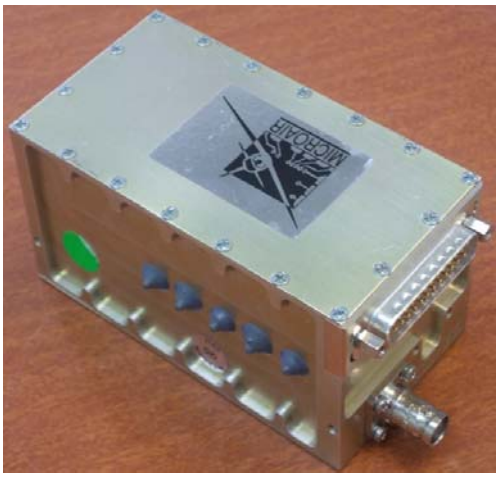
International Accreditation New Zealand has Mutual Recognition Arrangements for testing and calibration with a number of accreditation bodies in various economies. This includes NATA (Australia), UKAS (UK), SANAS (South Africa), NVLAP (USA), A2LA (USA), SWEDAC (Sweden). Further details can be supplied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

10. PHOTOGRAPH (S)

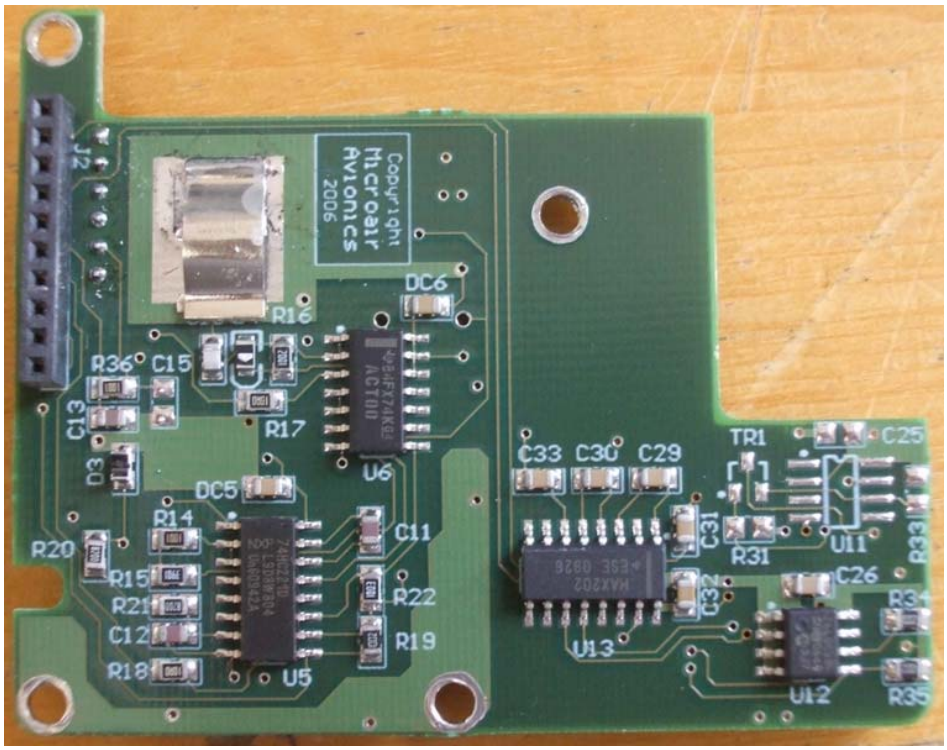
External view

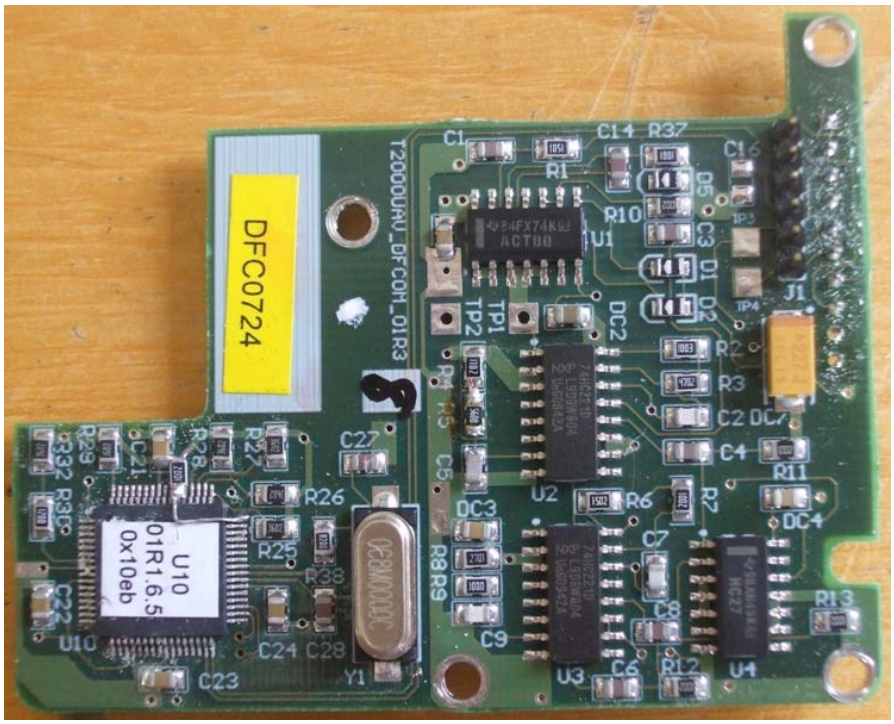


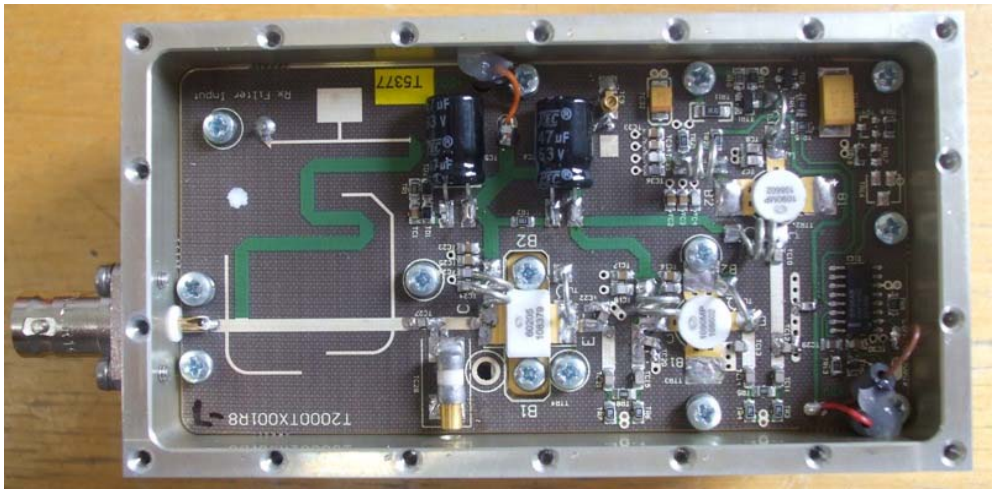




Internal Photos

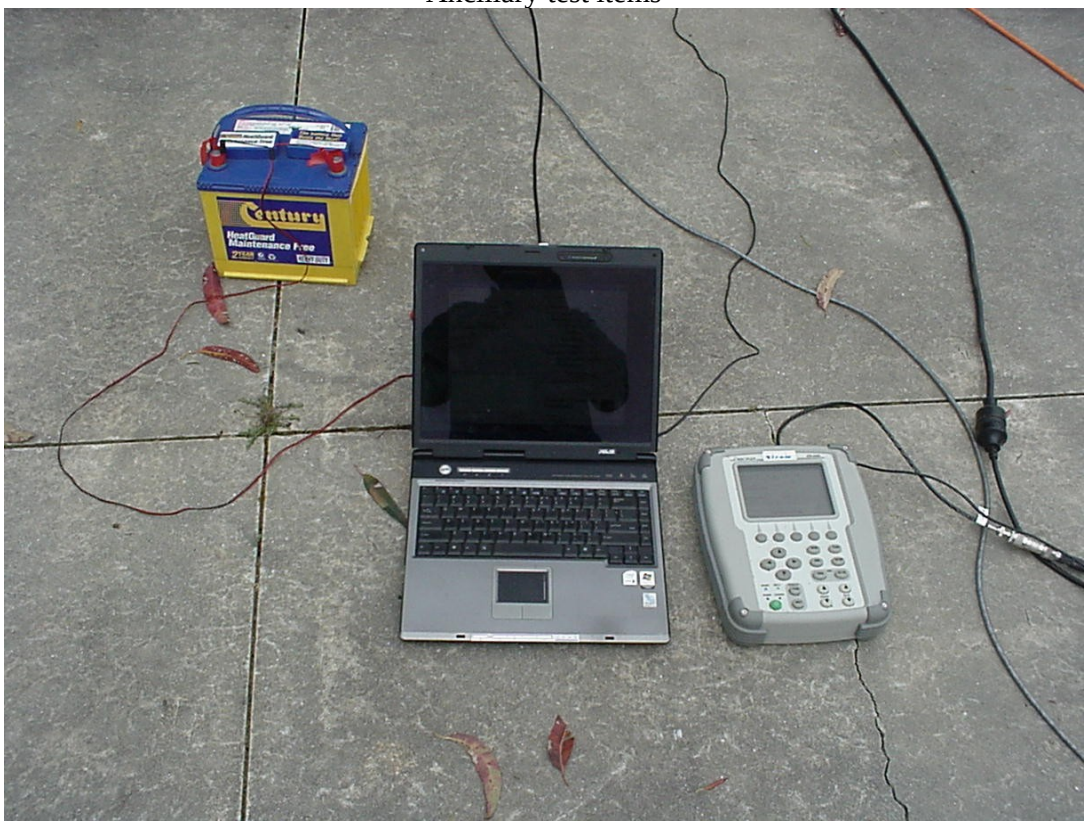






Label

Ancillary test items



Radiated emissions test set ups