Excellence in Compliance Testing

Certification Test Report

Frequency Hopping Spread Spectrum Transmitter

Test Report

FCC ID: V2A-TR2
IC: 7566A-TR2

FCC Rule Part: 15.247
IC Radio Standards Specification: RSS-210

ACS Report Number: 08-0053 - 15C

Manufacturer: Infinity Metering, Inc.
Model: TR2

Test Begin Date: February 28, 2008
Test End Date: March 12, 2008

Report Issue Date: May 2, 2008

FOR THE SCOPE OF ACCREDITATION UNDER LAB Code 200612-0

This report is not be used to claim certification, approval, or endorsement by NVLAP, NIST or any government agency.

Prepared by: Ken Rivers

Ken Rivers
Wireless Certifications Technician
ACS, Inc.

Reviewed by: _____

J. Kirby Munroe
Director, Wireless Certifications
ACS, Inc.

This report contains 16 pages

Table of Contents

Additional Exhibits Included In Filing

Internal Photographs
External Photographs
Test Setup Photographs
Product Labeling
RF Exposure – MPE Calculations
Installation/Users Guide
Theory of Operation
BOM (Parts List)
System Block Diagram
Schematics

1.0 GENERAL

1.1 Purpose
The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations and Industry Canada's Radio Standards Specification RSS-210.

1.2 Product Description

1.2.1 General
The Infinity Metering, Inc. Tesla TR2 is a transceiver to be used in the utility industry to transmit meter-reading data from a utility meter to a mobile data-collecting device.

Manufacturer Information:
Infinity Metering, Inc.
P.O. Box 948
Claremore, OK 74018

Test Sample Condition:
The test samples were provided in good working order with no visible defects.

Detailed photographs of the EUT are filed separately with this filing.

1.2.2 Intended Use
The unit is intended to be used to transmit meter-reading data from a utility meter to a mobile data-collecting device.

1.3 Test Methodology and Considerations
A sample with a temporary RF connector for RF conducted measurements could not be provided. All tests were performed radiated. The Tesla TR2 is a transceiver is battery powered. Intentional and unintentional radiated emissions measurements were performed.

2.0 TEST FACILITIES

2.1 Location
The radiated and conducted emissions test sites are located at the following address:

Advanced Compliance Solutions
5015 B.U. Bowman Drive
Buford, GA 30518
Phone: (770) 831-8048
Fax: (770) 831-8598

2.2 Laboratory Accreditations/Recognitions/Certifications
The Semi-Anechoic Chamber Test Site, Open Area Test Site (OATS) and Conducted Emissions Site have been fully described, submitted to, and accepted by the FCC, Industry Canada and the Japanese Voluntary Control Council for Interference by information technology equipment. In addition, ACS is compliant to ISO 17025 as certified by the National Institute of Standards and Technology under their National Voluntary Laboratory Accreditation Program. The following certification numbers have been issued in recognition of these accreditations and certifications:

FCC Registration Number: 894540
Industry Canada Lab Code: IC 4175A
VCCI Member Number: 1831
- VCCI OATS Registration Number R-1526
- VCCI Conducted Emissions Site Registration Number: C-1608

NVLAP Lab Code: 200612-0

2.3 Radiated Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site

The Semi-Anechoic Chamber Test Site consists of a 20' x 30' x 18' shielded enclosure. The chamber is lined with Toyo Ferrite Grid Absorber, model number FFG-1000. The ferrite tile grid is 101 x 101 x 19mm thick and weighs approximately 550 grams. These tiles are mounted on steel panels and installed directly on the inner walls of the chamber.

The turntable is 150cm in diameter and is located 160cm from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is all steel, flush mounted table installed in an all steel frame. The table is remotely operated from inside the control room located 25' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Behind the turntable is a 3' x 6' x 4' deep shielded pit used for support equipment if necessary. The pit is equipped with 1 - 4" PVC chases from the turntable to the pit that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit.

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3-1 below:

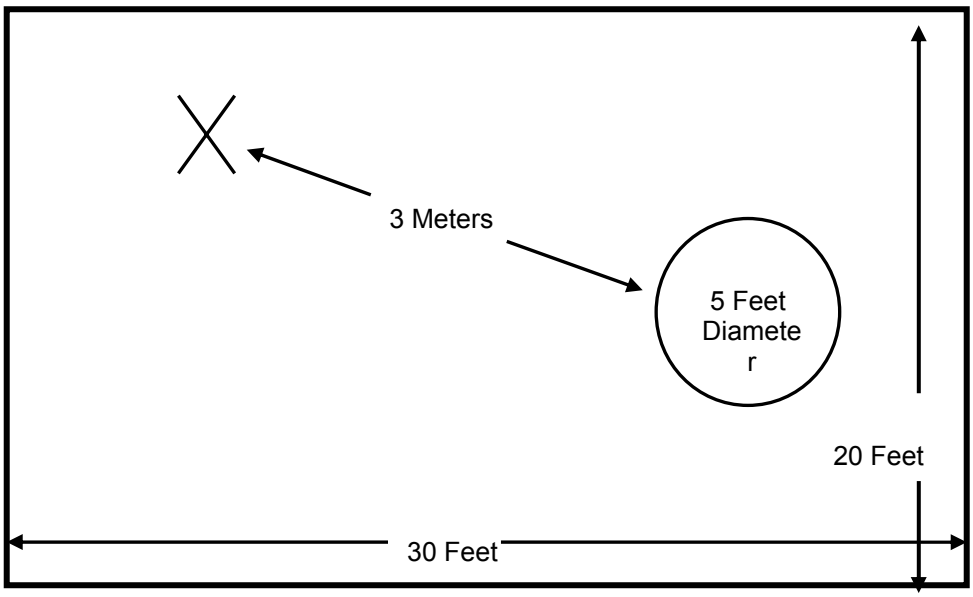

Figure 2.3-1: Semi-Anechoic Chamber Test Site

2.3.2 Open Area Tests Site (OATS)

The open area test site consists of a 40' x 66' concrete pad covered with a perforated electro-plated galvanized sheet metal. The perforations in the sheet metal are 1/8" holes that are staggered every 3/16". The individual sheets are placed to overlap each other by 1/4" and are riveted together to provide a continuous seam. Rivets are spaced every 3" in a 3 x 20 meter perimeter around the antenna mast and EUT area. Rivets in the remaining area are spaced as necessary to properly secure the ground plane and maintain the electrical continuity.

The entire ground plane extends 12' beyond the turntable edge and 16' beyond the antenna mast when set to a 10 meter measurement distance. The ground plane is grounded via 4 - 8' copper ground rods, each installed at a corner of the ground plane and bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is an all aluminum 10' flush mounted table installed in an all aluminum frame. The table is remotely operated from inside the control room located 40' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Adjacent to the turntable is a 7' x 7' square and 4' deep concrete pit used for support equipment if necessary. The pit is equipped with 5 - 4" PVC chases from the pit to the control room that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit. The pit is covered with 2 sheets of 1/4" diamond style re-enforced steel sheets. The sheets are painted to match the perforated steel ground plane; however the underside edges have been masked off to maintain the electrical continuity of the ground plane. All reflecting objects are located outside of the ellipse defined in ANSI C63.4.

A diagram of the Open Area Test Site is shown in Figure 2.3-2 below:

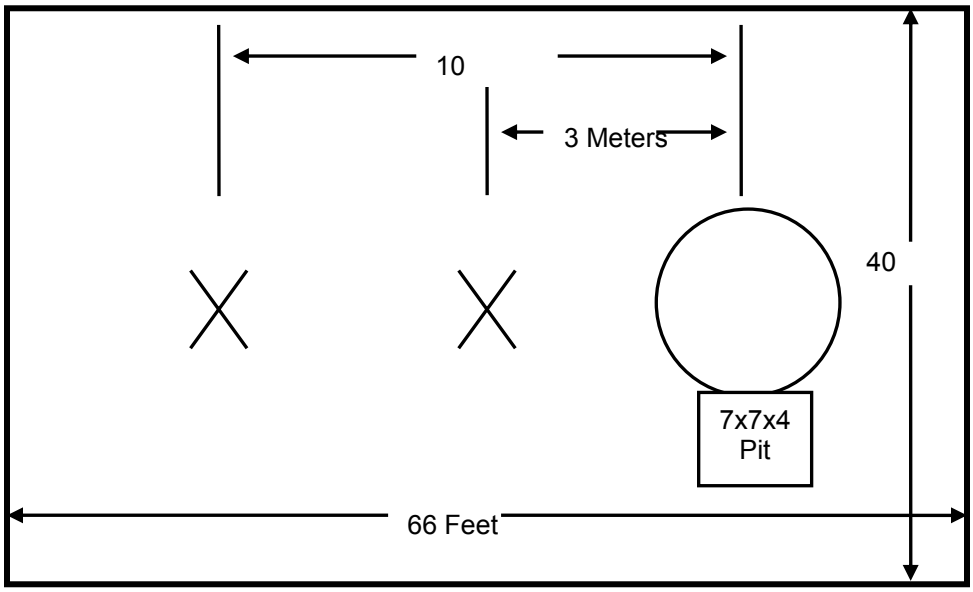

Figure 2.3-2: Open Area Test Site

2.4 Conducted Emissions Test Site Description

The AC mains conducted EMI site is located in the main EMC lab. It consists of an 8' x 8' solid aluminum horizontal group reference plane (GRP) bonded every 3" to an 8' X 8' vertical ground plane.

The site is of sufficient size to test table top and floor standing equipment in accordance with section 6.1.4 of ANSI C63.4.

A diagram of the room is shown below in figure 4.1.3-1:

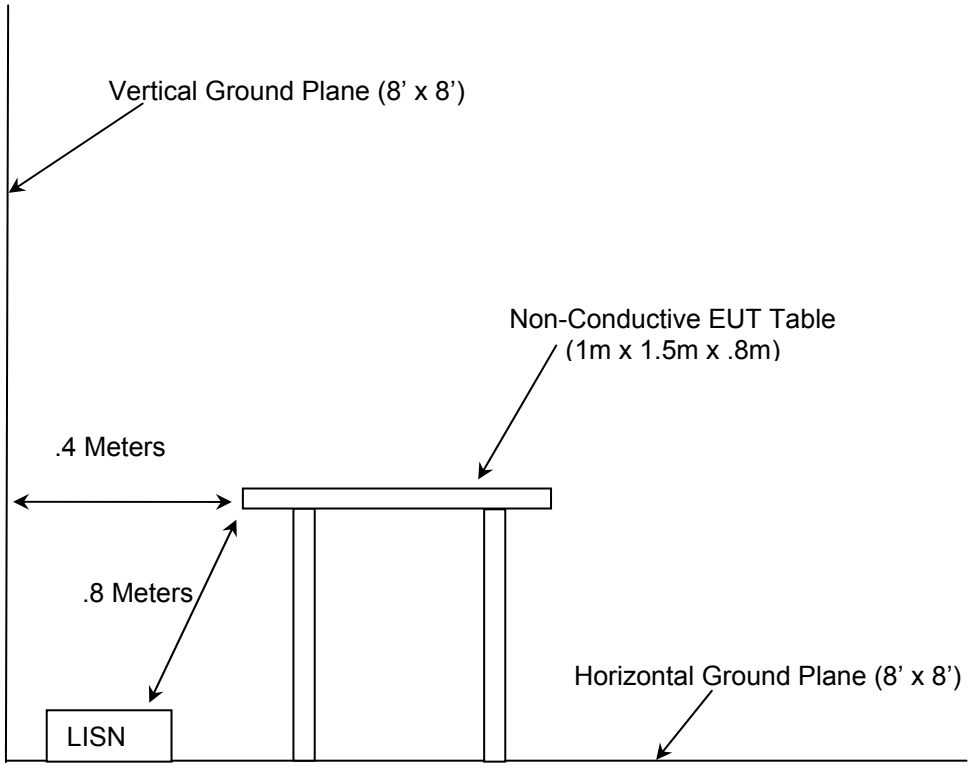

Figure 2.4-1: AC Mains Conducted EMI Site

3.0 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ANSI C63.4-2003: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the 9KHz to 40GHz
- US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2007
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2007
- FCC OET Bulletin 65 Appendix C - Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, 2001
- FCC Public Notice DA 00-705 - Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems, March 30, 2000
- Industry Canada Radio Standards Specification: RSS-210 - Low-power License-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment, Issue 7 June 2007
- Industry Canada Radio Standards Specification: RSS-GEN: General Requirements and Information for the Certification of Radiocommunication Equipment, Issue 2 June 2007

4.0 LIST OF TEST EQUIPMENT

All test equipment used for regulatory testing is calibrated yearly or according to manufacturer's specifications.

Table 4-1: Test Equipment

Equipment Calibration Information					
ACS#	**Mfg.**	**Eq. type**	**Model**	**S/N**	**Cal. Due**
1	Rohde & Schwarz	Spectrum Analyzers	ESMI - Display	833771/007	10-26-2008
2	Rohde & Schwarz	Spectrum Analyzers	ESMI-Receiver	839587/003	10-26-2008
22	Agilent	Amplifiers	8449B	3008A00526	10-25-2008
25	Chase	Antennas	CBL6111	1043	06-06-2008
30	Spectrum Technologies	Antennas	DRH-0118	970102	05-10-2008
167	ACS	Cables	Chamber EMI Cable Set	167	01-04-2009
193	ACS	Cable Set	OATS cable Set	193	01-04-2009
283	Rohde & Schwarz	Spectrum Analyzers	FSP40	1000033	11-09-2008
321	Hewlett Packard	Amplifiers	HPC 8447D	1937A02809	07-17-2008
331	Microwave Circuits	Filters	H1G513G1	31417	08-27-2008
332	Rohde & Schwarz	Amplifiers	TS-PR40	100021	10-26-2008
337	Microwave Circuits	Filters	H1G513G1	282706	08-28-2008
338	Hewlett Packard	Amplifiers	8449B	3008A01111	10-24-2008
343	Florida RF Cables	Cables	SMRE-200W-12.0-SMRE	N/A	11-21-2008
344	Florida RF Cables	Cables	SMS-290AW-480.0-SMR	N/A	01-16-2009

5.0 SUPPORT EQUIPMENT

Table 5-3: Support Equipment

Item	Equipment Type	Manufacturer	Model Number	Serial Number	FCC ID
The EUT was tested as a stand alone device and no support equipment was utilized.					

6.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

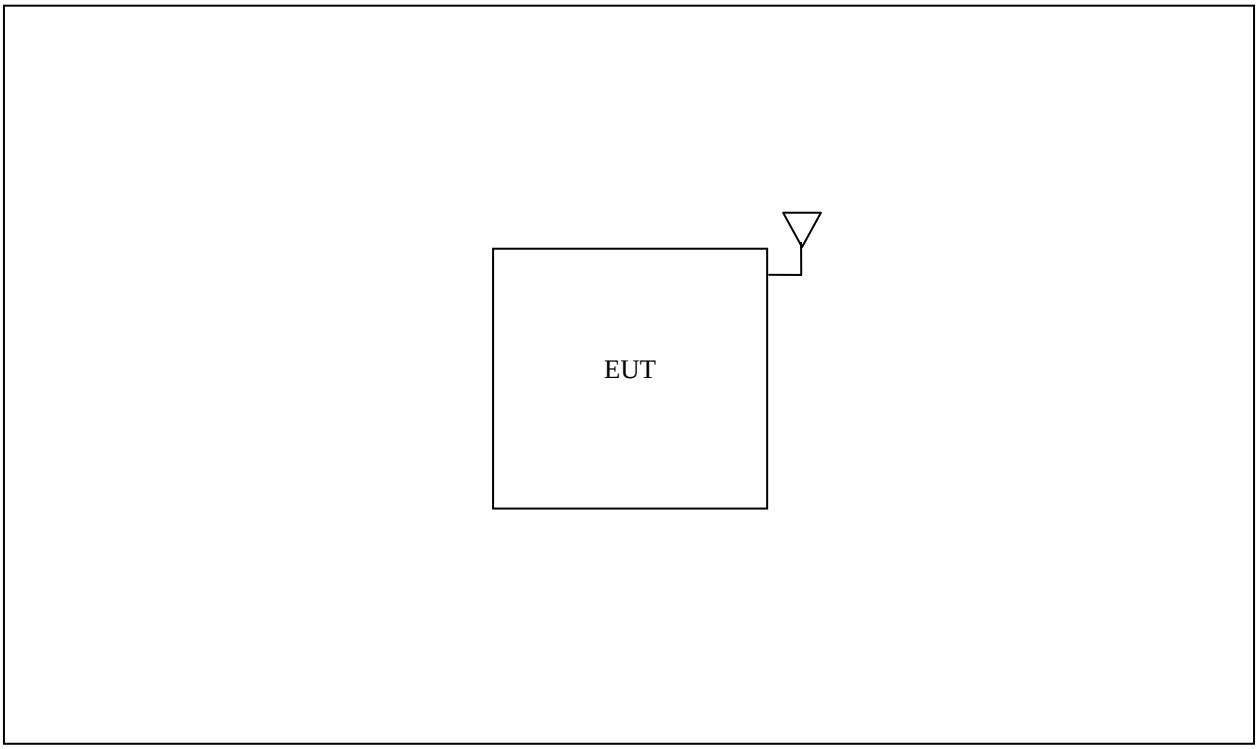

Figure 6-1: EUT Test Setup

*See Test Setup photographs for additional detail.

7.0 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

7.1 Antenna Requirement

The EUT employs a permanently attached internal integral helical monopole 0dBi gain antenna which can not be modified.

7.2 Power Line Conducted Emissions

The Tesla TR2 is battery powered and therefore power line conducted emissions are not required.

7.3 Radiated Emissions - Unintentional Radiation

7.3.1 Test Methodology

Radiated emissions tests were performed over the frequency range of 30MHz to 5GHz. Measurements of the radiated field strength were made at a distance of 3m from the boundary of the equipment under test (EUT) and the receiving antenna. The antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. Radiated measurements were made with the Spectrum Analyzer's resolution bandwidth set to 120 KHz for measurements above 30MHz. Average measurements are taken with the RBW and VBW were set to 1MHz and 10 Hz respectively for measurements above 1000MHz.

7.3.2 Test Results

Results of the test are given in Table 7.3-1 below:

Table 7.3-1: Radiated Emissions Tabulated Data

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
30.188	---------	18.60	H	-13.67	---------	4.93	--------	40.0	---------	35.07
39.066	---------	18.45	H	-16.07	---------	2.38	--------	40.0	---------	37.62
157.877	---------	18.15	V	-11.14	---------	7.01	--------	43.5	---------	36.49
97.244	---------	18.68	V	-15.03	---------	3.65	--------	43.5	---------	39.85
129.166	---------	18.93	V	-14.25	---------	4.68	--------	43.5	---------	38.82
595.732	---------	26.30	V	-5.81	---------	20.49	--------	46.0	---------	25.51
927	---------	20.13	H	0.57	---------	20.70	--------	46.0	---------	25.30
718.22	---------	22.06	H	-2.70	---------	19.36	--------	46.0	---------	26.64
848.88	---------	20.66	V	-1.13	---------	19.53	--------	46.0	---------	26.47
591.239	---------	31.98	H	-5.10	---------	26.88	--------	46.0	---------	19.12

* Note: All emissions above 591.239 MHz were attenuated below the permissible limit.

7.4 Peak Output Power

7.4.1 Test Methodology

Antenna conducted measurements could not be performed on this device, therefore radiated tests were performed to show compliance with the peak output power limit according to the alternative test methods in the FCC publication DA 00-705.

The procedures set forth in ANSI C63.4 were followed with respect to maximizing the peak emission. The resolution bandwidth of the spectrum analyzer was set to 3 MHz which was greater the 20 dB bandwidth measured in section 7.5.4. The video bandwidth was set to 10 MHz and a peak detector using the Max Hold function was utilized.

The power was calculated using the following equation:

$$P = \frac{(E * d)^2}{30 * G}$$

Where: G = Numeric Gain of the transmitting antenna with reference to an isotropic radiator
d = The distance in meters from which the field strength was measured
E = The measured maximum fundamental field strength in V/m

7.4.2 Test Results

Results are shown below in tables 7.4.2-1 and 7.4.2-2:

Table 7.4.2-1: Fundamental Field Strength

Frequency (MHz)	Uncorrected Level (dBuV)	Antenna Polarity (H/V)	Correction Factors (dB)	Corrected Level (dBuV/m)
902.971	106.42	V	2.59	109.01
915.00	109.13	V	2.85	111.98
926.26	107.74	V	3.03	110.77

Table 7.4.2-2: Peak Output Power

Frequency (MHz)	Measurement Distance (m)	Antenna Gain (dBi)	Field Strength (V/m)	Antenna Gain (Num)	Power (mW)	Power (dBm)
902.971	3	0	0.28	1.00	23.88	13.78
915.00	3	0	0.40	1.00	47.33	16.75
926.26	3	0	0.35	1.00	35.78	15.54

7.5 Channel Usage Requirements

7.5.1 Carrier Frequency Separation

7.5.1.1 Test Methodology

The span of the spectrum analyzer was set wide enough to capture two adjacent peaks and the RBW and VBW were set to ≥ 1% of the span.

7.5.1.2 Test Results

The maximum 20dB bandwidth of the hopping channel was measured to be 498kHz (See figure 7.5.4-1 to 7.5.4-3 below). The adjacent channel separation was measured to be 750kHz. Results are shown in figure 7.5.1-1 below:

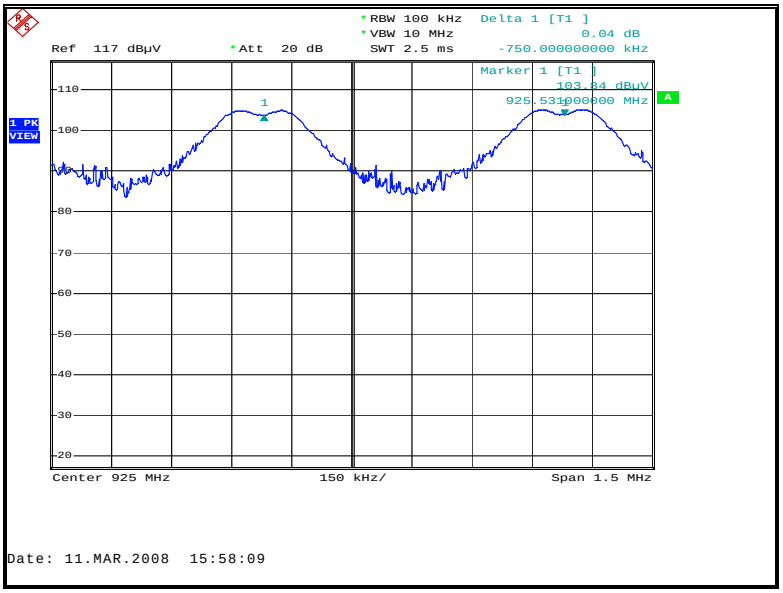

Figure 7.5.1-1: Carrier Frequency Separation

7.5.2 Number of Hopping Channels

The 20dB bandwidth of the device is less than 250 kHz. The device employs 26 hopping channels as required. Results are shown in Figure 7.5.2-1 below:

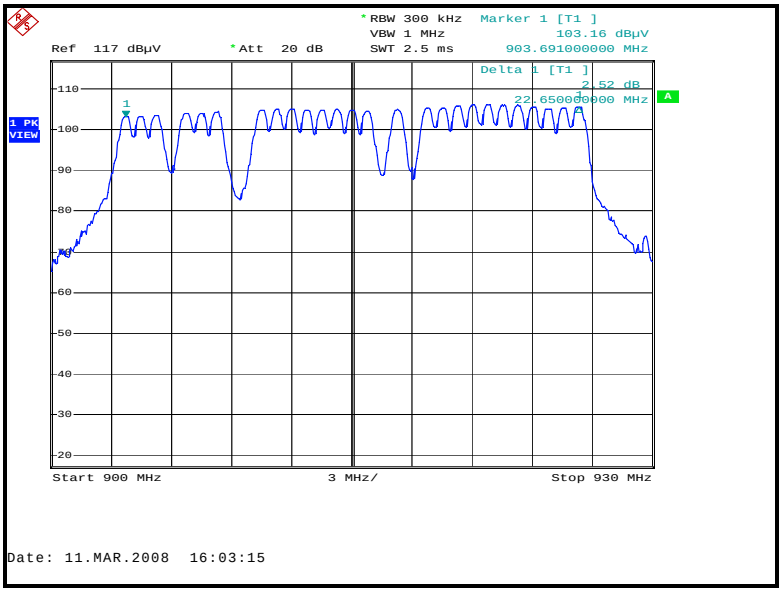

Figure 7.5.2-1: Number of Hopping Channels

7.5.3 Channel Dwell Time

7.5.3.1 Test Methodology

The emission measured centered on the analyzer and the span set to 0 Hz. The RBW was set to 1 MHz and the VBW to 3 MHz. Sweep time was set to 500 ms to capture the burst duration of the emission. The marker –delta function of the analyzer was employed to measure the burst duration.

7.5.3.2 Test Results

The duration of the RF transmission is 375 ms. There is a minimum 15 second rest period in which the device hops to another channel according to the pseudorandom frequency table before transmitting another 375ms transmission. Therefore the average time of occupancy on any channel in a 10 second period is 375ms. A single transmission is shown in figure 7.5.3-1 below:

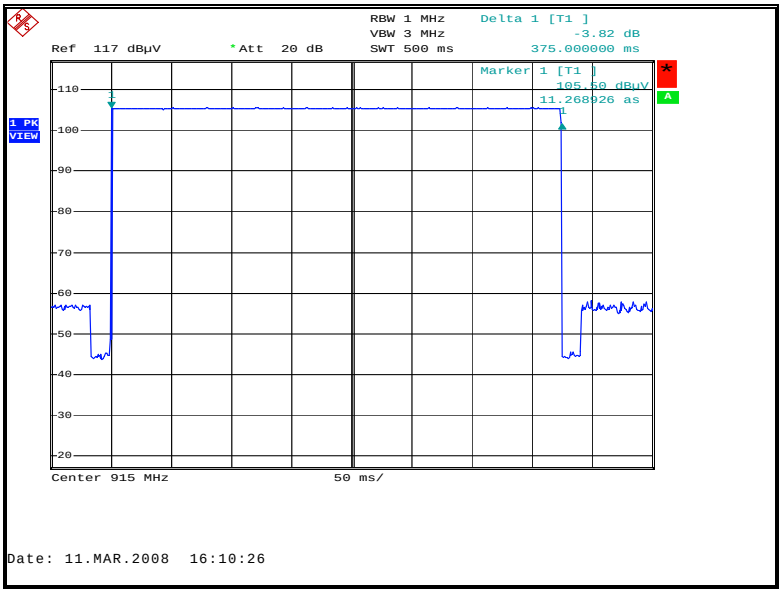

Figure 7.5.3-1: Channel Dwell Time

7.5.4 20dB Bandwidth

7.5.4.1 Test Methodology

The spectrum analyzer span was set to 2 to 3 times the estimated 20 dB bandwidth of the emission. The RBW was to ≥ 1% of the estimated 20 dB bandwidth. The trace was set to max hold with a peak detector active. The Delta function of the analyzer was utilized to determine the 20 dB bandwidth of the emission. The span and RBW were examined and re-adjusted if necessary to meet the requirements of 2 to 3 times the 20 bandwidth for the span and ≥ 1% of the 20 dB bandwidth for the RBW.

7.5.4.2 Test Results

The maximum 20dB bandwidth was found to be approximately 498kHz. Results are shown below in Table 7.5.4-1 and Figures 7.5.4-1 through 7.5.4-3.

Table 7.5.4-1

Channel	Frequency (MHz)	20dB Bandwidth (kHz)
Low	902.971	498
Mid	915.000	396
High	926.260	354

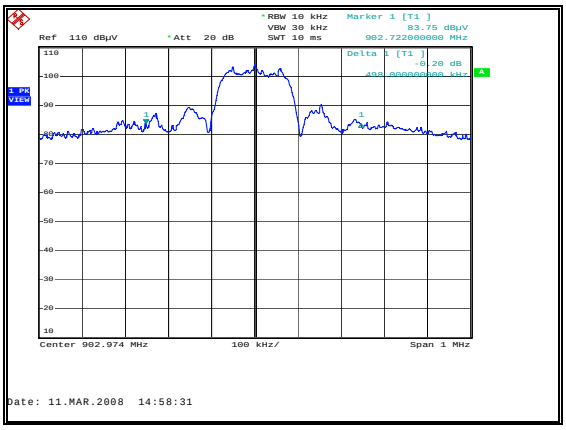

Figure 7.5.4-1: 20dB Bandwidth Low Channel

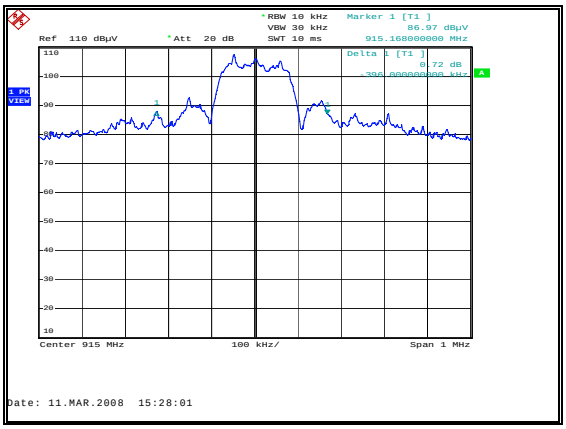

Figure 7.5.4-2: 20dB Bandwidth Mid Channel

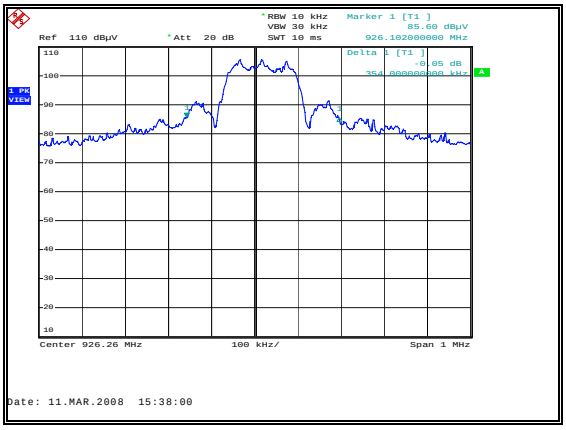

Figure 7.5.4-3: 20dB Bandwidth High Channel

7.6 Band-Edge Compliance and Spurious Emissions

7.6.1 Band-Edge Compliance of RF Emissions

7.6.1.1 Test Methodology

The EUT was investigated at the lowest and highest channel available to determine band-edge compliance. For each measurement the spectrum analyzer's RBW was set to 100 kHz, which is ≥ 1% of the span, and the VBW was set to 10MHz.

7.6.1.2 Test Results

In a 100 kHz bandwidth at the lower and upper band-edge, the radio frequency power that was produced by the EUT is at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power. Band-edge compliance is displayed in Figures 7.6.1-1 to 7.6.1-4

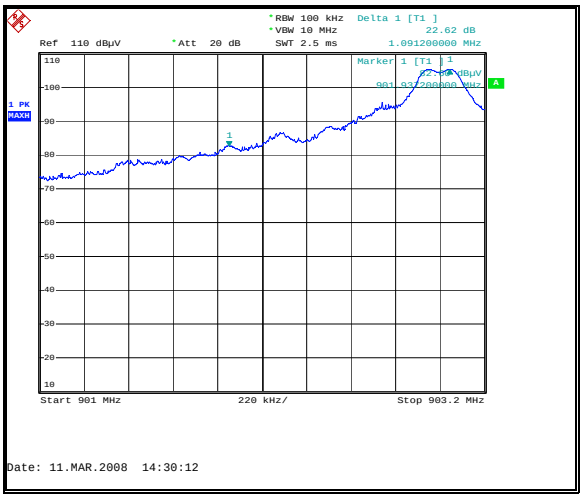

Figure 7.6.1-1: Lower Band-edge

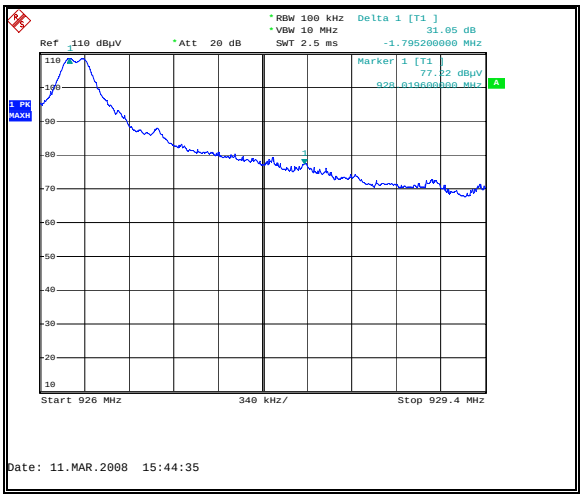

Figure 7.6.1-2: Upper Band-edge

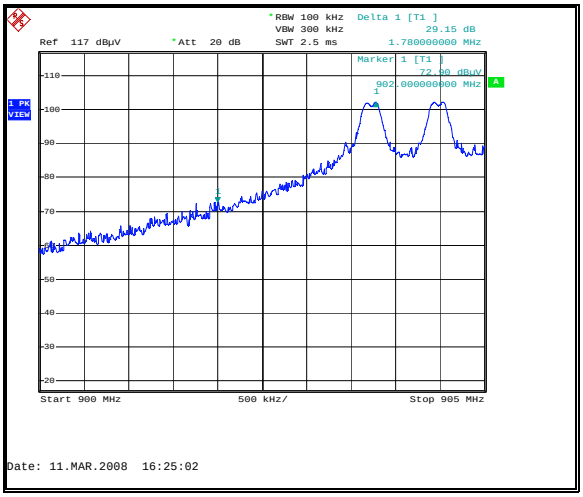

Figure 7.6.1-3: Lower Band-edge

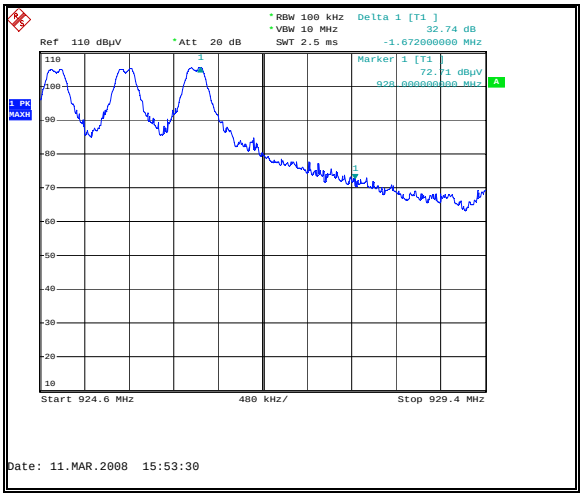

Figure 7.6.1-4: Upper Band-edge

7.6.2 RF Conducted Spurious Emissions

7.6.2.1 Test Methodology
Antenna conducted measurements could not be performed on this device, therefore radiated tests were performed to show compliance with the spurious RF conducted limit according to FCC publication DA 00-705.

7.6.2.2 Test Results
The magnitude of all emissions are reported in section 7.6.3 with the appropriate limit as referenced to 20 dB below the fundamental frequency field strength. Emissions that fell within the restricted bands were referenced to the radiated emissions limit set forth in FCC Section 15.209 and IC RSS-210 Section 2.6.

7.6.3 Radiated Spurious Emissions – Intentional Radiation

7.6.3.1 Test Methodology
Radiated emissions tests were made over the frequency range of 30MHz to 10GHz, 10 times the highest fundamental frequency.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000MHz, quasi-peak measurements were made using a resolution bandwidth (RBW) of 120 kHz and a video bandwidth (VBW) of 300 kHz. For frequencies above 1000MHz, peak measurements were made using an RBW of 1 MHz and a VBW of 3 MHz and for the average emissions a VBW of 10Hz. For those frequencies that fell outside the restricted bands as defined in 15.205, the alternative test methods in the FCC publication DA 00-705 was followed using a RBW of 100kHz and VBW of 300kHz and peak detector. The EUT was caused to generate a continuous carrier signal on the hopping channel.

7.6.3.2 Test Results
Radiated spurious emissions found in the band of 30MHz to 10GHz are reported in Table 7.6.3-1.

Table 7.6.3-1: Radiated Spurious Emissions

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
Low Channel										
1805.942	77.34	---------	H	-3.23	74.11	---------	88.6	---------	14.52	---------
1805.942	78.27	---------	V	-3.21	75.06	---------	88.6	---------	13.57	---------
2708.913	61.45	52.38	H	0.40	61.85	52.78	74.0	54.0	12.15	1.22
2708.913	60.21	51.56	V	0.14	60.35	51.70	74.0	54.0	13.65	2.30
3611.884	52.91	44.35	H	3.56	56.47	47.91	74.0	54.0	17.53	6.09
3611.884	40.74	37.96	V	3.58	44.32	41.54	74.0	54.0	29.68	12.46
4514.855	50.42	40.29	H	5.66	56.08	45.95	74.0	54.0	17.92	8.05
4514.855	50.59	40.07	V	5.57	56.16	45.64	74.0	54.0	17.84	8.36
5417.826	50.25	40.18	H	8.00	58.25	48.18	74.0	54.0	15.75	5.82
5417.826	49.78	39.13	V	8.18	57.96	47.31	74.0	54.0	16.04	6.69
Mid Channel										
1830	77.03	---------	H	-3.16	73.87	---------	91.5	---------	17.63	---------
1830	79.88	---------	V	-3.16	76.72	---------	91.5	---------	14.78	---------
2745	62.45	53.09	H	0.53	62.98	53.62	74.0	54.0	11.02	0.38
2745	60.50	51.62	V	0.28	60.78	51.90	74.0	54.0	13.22	2.10
3660	54.47	43.62	H	3.74	58.21	47.36	74.0	54.0	15.79	6.64
3660	48.84	34.89	V	3.77	52.61	38.66	74.0	54.0	21.39	15.34
4575	52.14	43.20	H	5.78	57.92	48.98	74.0	54.0	16.08	5.02
4575	48.36	38.06	V	5.71	54.07	43.77	74.0	54.0	19.93	10.23
5490	43.61	---------	H	8.24	51.85	---------	91.5	---------	39.65	---------
5490	42.88	---------	V	8.44	51.32	---------	91.5	---------	40.18	---------
High Channel										
1852.52	80.30	---------	H	-3.10	77.20	---------	91.0	---------	13.83	---------
1852.52	79.55	---------	V	-3.11	76.44	---------	91.0	---------	14.59	---------
2778.78	63.37	53.10	H	0.65	64.02	53.75	74.0	54.0	9.98	0.25
2778.78	59.35	49.90	V	0.41	59.76	50.31	74.0	54.0	14.24	3.69
3705.04	55.94	48.11	H	3.91	59.85	52.02	74.0	54.0	14.15	1.98
3705.04	49.86	40.07	V	3.95	53.81	44.02	74.0	54.0	20.19	9.98
4631.3	51.26	43.07	H	5.89	57.15	48.96	74.0	54.0	16.85	5.04
4631.3	50.05	40.63	V	5.84	55.89	46.47	74.0	54.0	18.11	7.53
5557.56	49.65	---------	V	8.50	58.15	---------	91.0	---------	32.87	---------

***** The magnitude of all emissions not reported were below the noise floor of the measurement system.

7.6.3.3 Sample Calculation:

$R_C = R_U + CF_T$

Where:

CF_T	=	Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only)
R_U	=	Uncorrected Reading
R_C	=	Corrected Level
AF	=	Antenna Factor
CA	=	Cable Attenuation
AG	=	Amplifier Gain
DC	=	Duty Cycle Correction Factor

Example Calculation

PEAK:
Corrected Level: 61.45+ 0.4= 61.85dBuV
Margin: 74dBuV – 61.85dBuV = 12.15dB

AVERAGE:
Corrected Level: 52.38+ 0.4= 52.78dBuV
Margin: 54dBuV – 52.78dBuV = 1.22dB

8.0 CONCLUSION
In the opinion of ACS, Inc. the TR2, manufactured by Infinity Metering, Inc. meets the requirements of FCC Part 15 subpart C and Industry Canada's Radio Standards Specification RSS-210.

END REPORT