Excellence in Compliance Testing

Transceiver Certification Test Report

FCC ID: LV3RF24
IC: 3015A-RF24

FCC Rule Part: 15.249
IC Standards Specification: RSS-210

ACS Report Number: 07-0262-15C

Manufacturer: Digitrax Inc.
Model: RF24

Test Begin Date: 6/4/07
Test End Date: 8/6/07

Report Issue Date: 8/6/07

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.

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This report contains 16 pages

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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 Radio Standards Specification RSS-210.

1.2 Product Description

1.2.1 General
The RF24 is a 1.1"x 1.9"x 0.125" self-contained plug-in 16 Channel DSSS Modular-Certified 2.4GHz data transceiver for wireless data connectivity of proprietary Digitrax LocoNet ™ network devices. The RF24 transports data at the LocoNet ™ network burst data rate of 16,457 bits/sec by employing 802.15.4 format WPAN packets. Access devices such as a UR92 that connect to a wired LocoNet ™ network contain an RF24 module that may then exchange data with hand-held user controllers such as a DT402, UT42 and DT500, or other device that also hosts an RF24 module.

Applicant Information:
DIGITRAX INC.
450 S CEMETERY ST
SUITE 206
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(770) 441-7992 FAX (770) 441-0759

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

1.2.2 Intended Use
The RF24 is designed to connect to Digitrax Host devices and exchange data with hand-held user controllers such as a DT402, UT42 and DT500, or other device that also hosts an RF24 module.

1.3 Test Methodology and Considerations
The RF24 has a special selectable Test mode to allow the compliance testing of the module Transmitter and Receiver, stand-alone without the need for a Digitrax Host device. The only connection needed is a DC power pack and a SPST switch for Test mode selection.

The module was configured stand-alone for all radiated emissions tests. For the purpose of AC power line conducted emissions, the RF24 module was installed in a typical host device. See the section 6.0 for additional test setup information.

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: 89450
Industry Canada Lab Code: IC 4175
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:

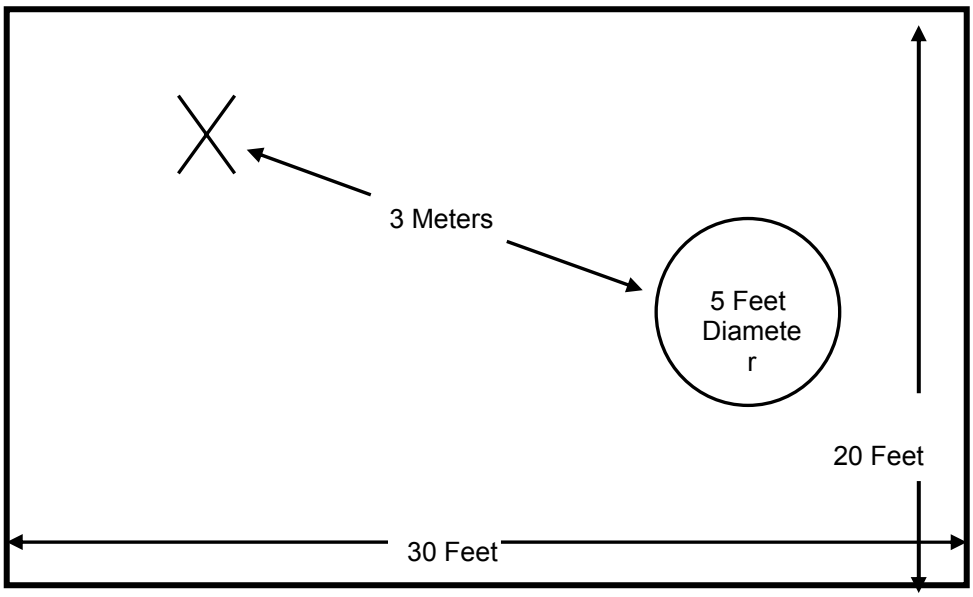

Figure 2.3-1: Semi-Anechoic Chamber Test Site

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:

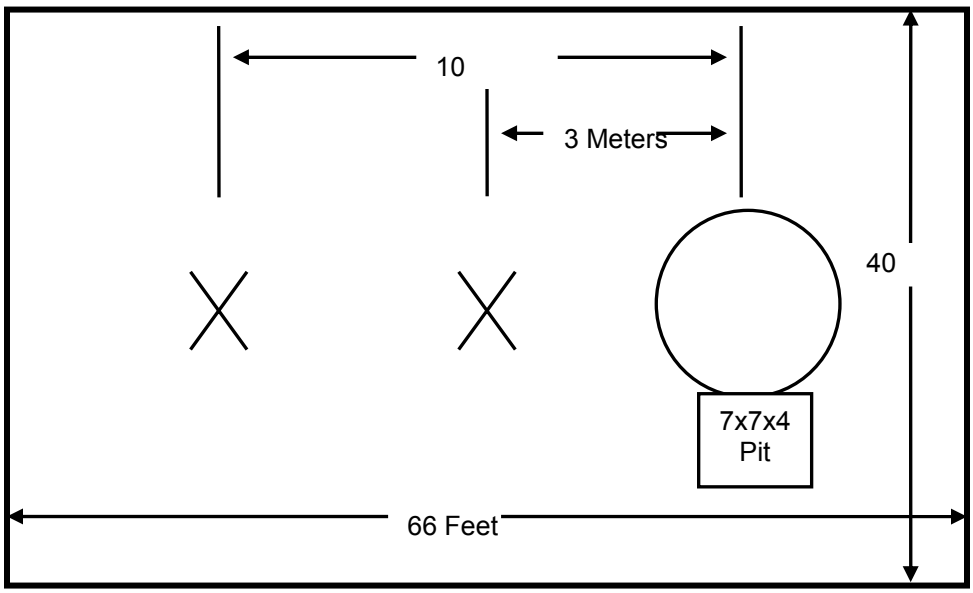

Figure 2.3-2: Open Area Test Site

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 2.4-1:

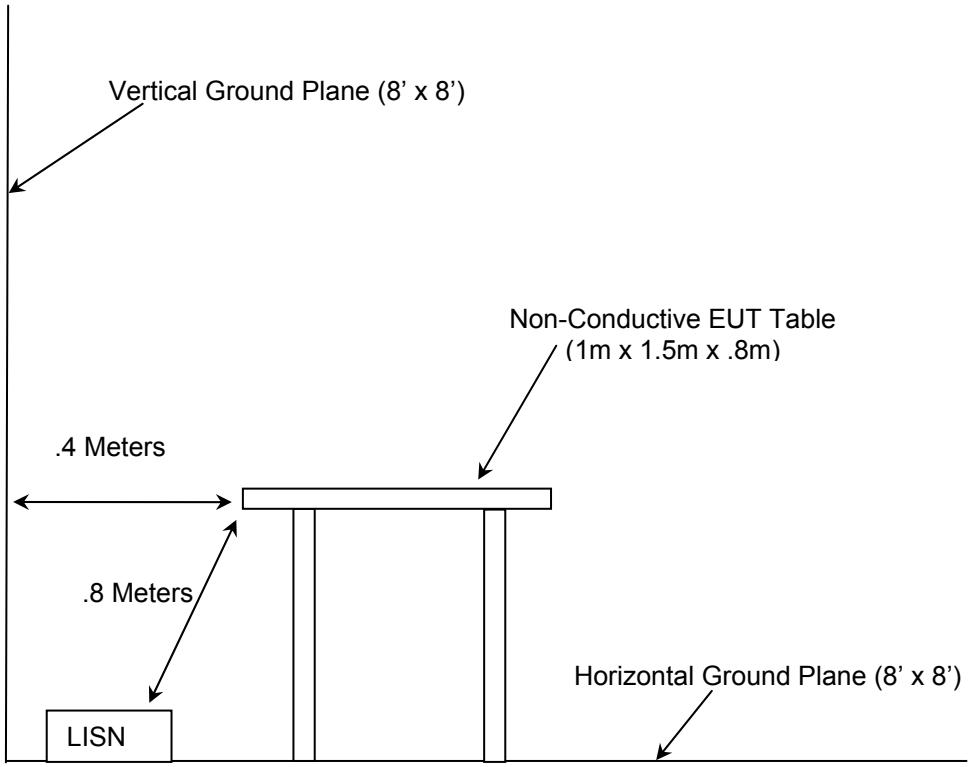

Figure 2.4-1: AC Mains Conducted EMI Site

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, 2006
- US Code of Federal Regulations (CFR): Title 47, Part 15: Radio Frequency Devices, 2006
- Industry Canada Radio Standards Specification: RSS-210: Low-power Licence-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment, Issue 7 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 4.0-1: Test Equipment

Equipment Calibration Information					
ACS#	**Mfg.**	**Model**	**S/N**	**Equipment Type**	**Cal. Due**
22	Agilent	8449B	3008A00526	Amplifiers	10-Apr-08
25	Chase	CBL6111	1043	Antennas	06-Jun-08
30	Spectrum Technologies	DRH-0118	970102	Antennas	10-May-08
290	Florida RF Cables	SMSE-200-72.0-SMRE	None	Cables	15-May-08
291	Florida RF Cables	SMRE-200W-12.0-SMRE	None	Cables	15-May-08
292	Florida RF Cables	SMR-290AW-480.0-SMR	None	Cables	24-May-08
282	Microwave Circuits	H2G020G4	74541	Filters	09-Mar-08
153	EMCO	3825/2	9411-2268	LISN	16-Nov-07
152	EMCO	3825/2	9111-1905	LISN	20-Feb-08
283	Rohde & Schwarz	FSP40	1000033	Spectrum Analyzers	09-Nov-08
4	Rohde & Schwarz	ESMI - Receiver	833827/003	Spectrum Analyzers	24-Oct-07
3	Rohde & Schwarz	ESMI - Display	839379/011	Spectrum Analyzers	24-Oct-07
73	Agilent	Pre-Amplifier	8447D	272A05624	09-May-08
25	Chase	CBL6111	1043	Antennas	06-Jun-08
30	Spectrum Technologies	DRH-0118	970102	Antennas	10-May-08
70	Rohde & Schwarz	ESH-3	879676/050	Spectrum Analyzers	09-Oct-07
168	Hewlett Packard	11947A	44829	Attenuator	13-Mar-08

5.0 SUPPORT EQUIPMENT

Table 5.0-1: Support Equipment

Equipment Type	Manufacturer	Model Number	Serial Number	FCC ID
EUT Host	Digitrax	UR92	NA	NA
EUT Host	Digitrax	UR92	NA	NA
Power Supply	Digitrax	PS2	48ST E198424 0704	NA

6.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAMS

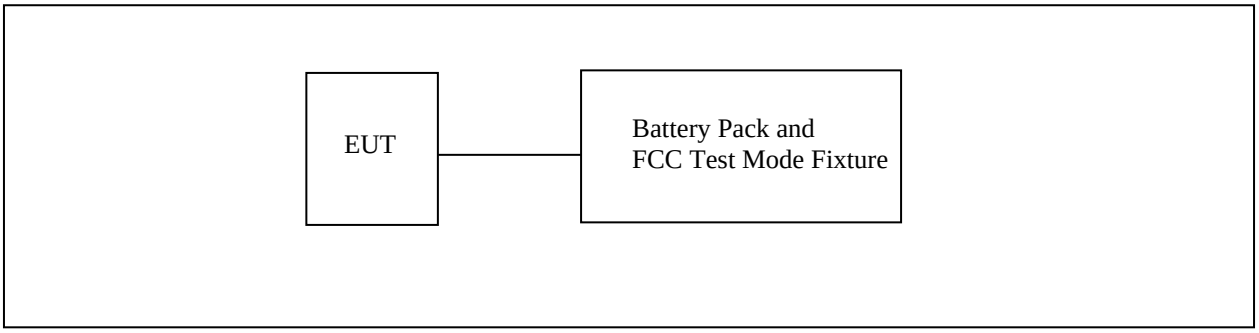

Figure 6.0-1: EUT Test Setup – Radiated Emissions

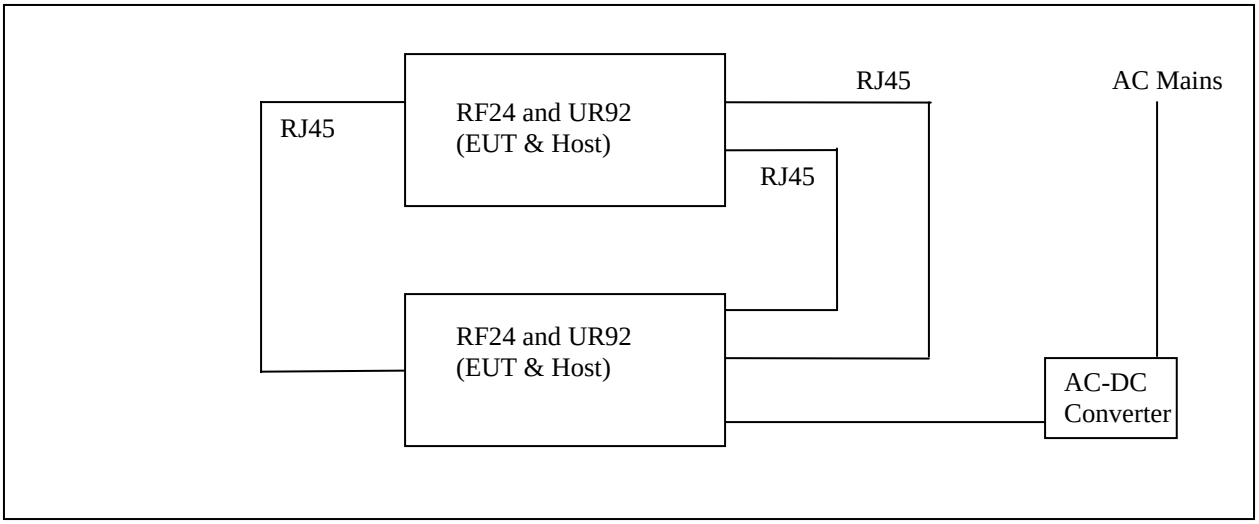

Figure 6.0-2: EUT Test Setup – AC Power Line Conducted Emissions

*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 RF24 antenna is an integral PCB design with +1dBi gain.

7.2 Power Line Conducted Emissions

7.2.1 Test Methodology

Conducted emissions were performed with an EMI receiver. The calculation for the conducted emissions is as follows:

Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss
Margin = Applicable Limit - Corrected Reading

Results of the test are shown below in and Table 7.2.2-1.

7.2.2 Test Results

Table 7.2.2-1: Conducted EMI Results

Frequency (MHz)	Uncorrected Reading (dBuV)		Total Correction Factor (dB)	Corrected Level (dBuV)		Limit (dBuV)		Margin (dB)	
	Quasi-	Average		Quasi-Peak	Average	Quasi-Peak	Average	Quasi-Peak	Average
Line 1									
0.18	29.5	8.7	9.80	39.30	18.50	64.49	54.49	25.2	36.0
0.26	28.4	4.4	9.80	38.20	14.20	61.43	51.43	23.2	37.2
0.47	27.1	3.7	9.80	36.90	13.50	56.51	46.51	19.6	33.0
0.78	23.3	2.1	9.80	33.10	11.90	56.00	46.00	22.9	34.1
5.51	5.1	-2.1	9.81	14.91	7.71	60.00	50.00	45.1	42.3
29.92	12.7	3.8	10.30	23.00	14.10	60.00	50.00	37.0	35.9
Line 2									
0.18	28	7	9.80	37.80	16.80	64.49	54.49	26.7	37.7
0.21	26.3	3.5	9.80	36.10	13.30	63.21	53.21	27.1	39.9
0.47	20.2	1.2	9.80	30.00	11.00	56.51	46.51	26.5	35.5
5.58	3	-1.9	9.81	12.81	7.91	60.00	50.00	47.2	42.1
23.88	3.9	-1.6	10.21	14.11	8.61	60.00	50.00	45.9	41.4
29.56	11.4	2.9	10.30	21.70	13.20	60.00	50.00	38.3	36.8

7.3 Unintentional Radiated Emissions – (Receiver)

7.3.1 Test Methodology

Radiated emissions tests were performed over the frequency range of 30MHz to 12500 MHz. 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. For frequencies below 1000 MHz a Quasi-peak detector was enabled and measurements were taken with the Spectrum Analyzer's resolution bandwidth set to 120 KHz. For frequencies above 1000MHz, average measurements were made using an RBW of 1 MHz and a VBW of 10 Hz and peak measurements were made with RBW of 1 MHz and a VBW of 1 MHz.

7.3.2 Test Results

Results of the test are given in Table 7.3.2-1 below:

Table 7.3.2-1 – Radiated Emissions (Unintentional)

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
284.96	---------	37.70	H	-10.30	---------	27.40	--------	46.0	---------	18.60
704	---------	23.23	H	-2.66	---------	20.57	--------	46.0	---------	25.43
919.11	---------	22.32	H	0.98	---------	23.30	--------	46.0	---------	22.70
198.33	---------	23.77	H	-8.40	---------	15.37	--------	43.5	---------	28.13
165.22	---------	24.00	V	-9.38	---------	14.62	--------	43.5	---------	28.88
125.28	---------	20.69	V	-13.05	---------	7.64	--------	43.5	---------	35.86

* Note: All emissions above 919.11MHz were not detected above the noise floor of the measurement equipment and therefore attenuated below the permissible limit.

7.4 20dB Bandwidth

7.4.1 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.

7.4.2 Test Results

The 20dB bandwidth was determined to be 2.62 MHz. The frequency band designated under FCC Part 15.249 and IC RSS-210 is 2400-2483.5MHz, therefore the 20dB bandwidth is contained within the frequency band designated under this rule part. Results are shown below in Table 7.4.2-1 and Figures 7.4.2-1 through 7.4.2-3.

Table 7.4.2-1

Frequency (MHz)	20dB Bandwidth (MHz)
2405	2.62
2440	2.62
2480	2.58

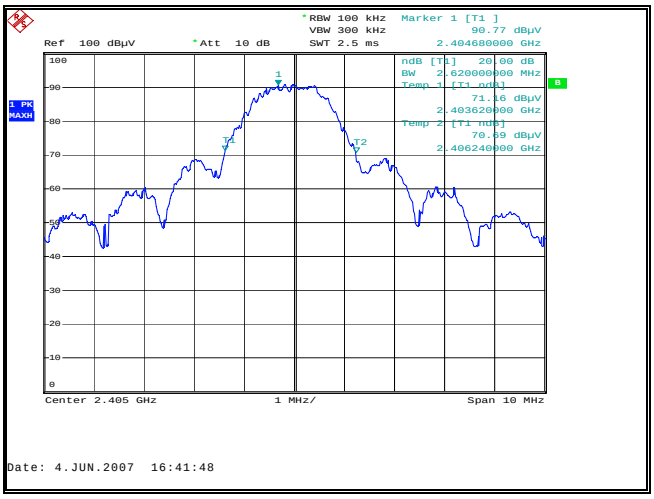

Figure 7.4.2-1: 20dB Bandwidth Low Channel

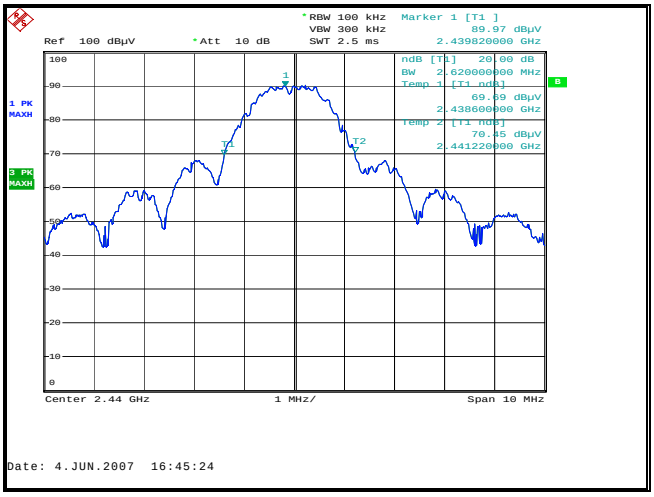

Figure 7.4.2-2: 20dB Bandwidth Mid Channel

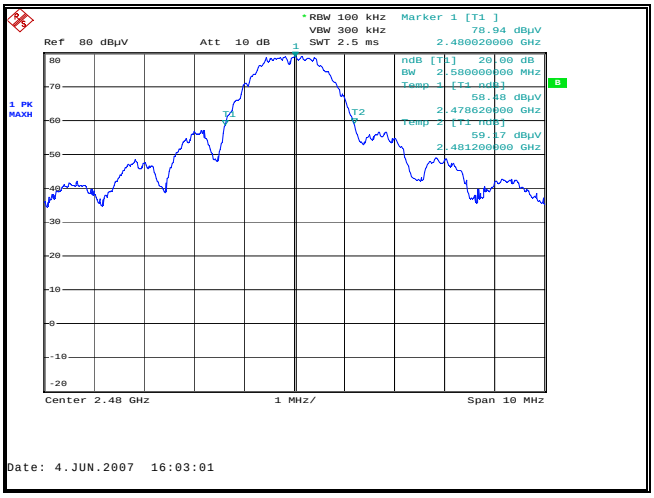

Figure 7.4.2-3: 20dB Bandwidth High Channel

7.5 Fundamental Field Strength

7.5.1 Test Methodology

Radiated emissions tests were made on the 3 channels in the 2400Hz to 2483.5MHz frequency range, the low channel being 2405 MHz, the middle channel being 2440 MHz, and the high channel being 2480 MHz. The worst case data is presented in this report.

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. Average measurements were made using an RBW of 1 MHz and a VBW of 10 Hz and peak measurements were made with RBW of 1 MHz and a VBW of 3 MHz.

7.5.2 Test Results

Results are shown below in table 7.5.2-1 below:

Table 7.5.2-1: Fundamental Field Strength

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
2405	94.56	94.56	H	-1.24	93.32	70.82	114.0	94.0	20.66	23.16
2405	98.77	98.77	V	-1.50	97.27	74.77	114.0	94.0	16.71	19.21
2440	88.06	88.06	H	-1.09	86.97	64.47	114.0	94.0	27.01	29.51
2440	97.22	97.22	V	-1.37	95.85	73.35	114.0	94.0	18.13	20.63
2480	94.99	94.99	H	-0.92	94.07	71.57	114.0	94.0	19.91	22.41
2480	96.16	96.16	V	-1.21	94.95	72.45	114.0	94.0	19.03	21.53

7.6 Band-Edge Compliance and Spurious Emissions

7.6.1 Band-Edge Compliance

7.6.1.1 Test Methodology

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in 15.209 and RSS-210, whichever is the lesser attenuation.

The EUT was investigated at the low and high channels of operation to determine band-edge compliance. Band-edge compliance for the lower and upper band-edge was determined using the radiated mark-delta method as outlined in FCC DA 00-705. The radiated field strength of the fundamental emission was first determined and then the mark-delta method was used to determine the field strength of the band-edge emissions as compared to the emission limit.

The duty cycle correction for average measurements is described in section 7.6.2.2.

7.6.1.2 Test Results

Band-edge compliance is displayed in Tables 7.6.1.2-1 to 7.6.1.2-2 and Figures 7.6.1.2-1 – 7.6.1.2-2.

Table 7.6.1.2-1: Lower Band-edge Marker Delta Method

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Fundamental Field Strength (dBuV/m)		Delta-Marker (dB)	Band-edge Field Strength (dBuV/m)		Margin to Limit (dBuV/m) 74	54
	pk	avg	(H/V)	(dB)	pk	avg		pk	avg	pk	avg
Fundamental Frequency											
2405	98.77	98.77	V	-1.50	97.27	74.77	45.26	52.01	29.51	21.99	24.49

Table 7.6.1.2-2: Upper Band-edge Marker Delta Method

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Fundamental Field Strength (dBuV/m)		Delta-Marker (dB)	Band-edge Field Strength (dBuV/m)		Margin to Limit (dBuV/m) 74	54
	pk	avg	(H/V)	(dB)	pk	avg		pk	avg	pk	avg
Fundamental Frequency											
2480	96.16	96.16	V	-0.92	94.95	72.45	37.58	57.37	34.87	16.63	19.13

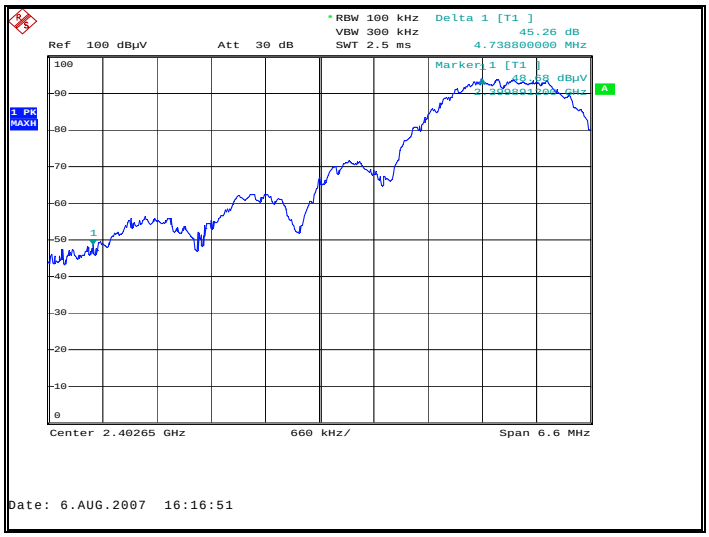

Figure 7.6.1.2-1 Lower Band-edge

Figure 7.6.1.2-2 Upper Band-edge

7.6.2 Radiated Spurious Emissions (Transmitter)

7.6.2.1 Test Methodology

Radiated emissions tests were made over the frequency range of 30MHz to 24.8 GHz, 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, average measurements were made using an RBW of 1 MHz and a VBW of 10 Hz and peak measurements were made with RBW of 1 MHz and a VBW of 1 MHz.

7.6.2.2 Duty Cycle Correction

For average radiated measurements, the measured level was reduced by a factor 22.50dB to account for the duty cycle of the EUT. The duty cycle was determined to be 7.5% or 7.5ms within a 100ms period. The duty cycle correction factor is determined using the formula: 20log (.075) = -22.50dB. Additional justification of the duty cycle can be found in the Theory of Operation supplied with this filing.

7.6.2.3 Test Results

Results are shown below in Table 7.6.2.3-1.

Table 7.6.2.3-1 - Radiated Spurious Emissions

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Antenna Height	Turntable Position	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(cm)	(o)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
					Spurious Emissions Low Channel							
4810	45.49	45.49	H	187	336	6.64	52.13	29.63	74.0	54.0	21.87	24.37
4810	44.37	44.37	V	196	102	6.66	51.03	28.53	74.0	54.0	22.97	25.47
					Spurious Emissions Mid Channel							
4880	45.85	45.85	H	155	300	6.84	52.69	30.19	74.0	54.0	21.31	23.81
4880	45.62	45.62	V	193	308	6.89	52.51	30.01	74.0	54.0	21.49	23.99
					Spurious Emissions High Channel							
4960	50.91	50.91	H	152	259	7.07	57.98	35.48	74.0	54.0	16.02	18.52
4960	48.83	48.83	V	159	231	7.15	55.98	33.49	74.0	54.0	18.02	20.51

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

7.6.2.4 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: 45.49 + 6.64 = 52.13dBuV
Margin: 74dBuV – 52.13dBuV = 21.87dB

AVERAGE:
Corrected Level: 45.49 + 6.64 -22.50= 29.63dBuV
Margin: 54dBuV – 29.63dBuV = 24.37dB

8.0 CONCLUSION

In the opinion of ACS, Inc. the RF24 manufactured by Digitrax meet the requirements of FCC Part 15 subpart C and IC RSS-210.

END REPORT