ITS Intertek Testing Services
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Test Report
for
LoJack Corporation
on the
Remote Locator Unit
Model: RLU3
to
FCC Part 90 Emissions for Mobile Radios

Test Report #: 3049174A
Date of Report: November 17, 2003
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Project #s: 3049174
Dates of Test: October 13-15, November 14, December 9, 2003

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LoJack Remote Locator Unit
Serial No.: 04316C6
Model No.: RLU3

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This report replaces report #3049174. Section 4.1 has been revised to incorporate retest data.

2.0 General Description

2.1 Product Description

The EUT is a transmitter operating at 173.075 MHz, that is used to locate stolen vehicles. Once activated, it sends repeated transmissions of an ID code that can be used for radiolocation of and identification of the stolen vehicle. The sample received was configured to test in the worst-case transmission mode, corresponding to the mode where the transmitter has been activated as if it were in a stolen vehicle.

The EUT has been tested at the request of

Company:	LoJack Corporation 780 Dedham Street Canton, MA, 02021
Name of contact:	Mr. Jesse Rhodes
Telephone:	(781) 302-7107
Fax:	(781) 302-7299

2.2 Related Submittal(s) Grants

None.

2.3 Test Facility

Site 2C (Middle Site) is a 3m and 10m sheltered EMI measurement range located in a light commercial environment in Boxborough, Massachusetts. It meets the technical requirements of ANSI C63.4-1992 and CISPR 22:1993/EN 55022:1994 for radiated and conducted emission measurements. The shelter structure is entirely fiberglass and plastic, with outside dimensions of 33 ft x 57 ft. The structure resembles a quonset hut with a center ceiling height of 16.5 ft.

The testing floor is covered by a galvanized sheet metal groundplane that is earth-grounded via copper rods around the perimeter of the site. The joints between individual metal sheets are bridged with 2 inch wide metal strips to provide low RF impedance contact throughout. The sheets of metal are screwed in place with stainless steel, round-head screws every three inches. Site illumination and HVAC are provided from beneath the ground reference plane through flush entry ports, the port covers are electrically bonded to the ground plane.

A flush metal turntable with 12 ft. diameter and 5000 lb. load capacity is provided for floor-standing equipment. A wooden table 80 cm high is used for table-top equipment. The turntable is electrically connected to the ground plane with three copper straps. The straps are connected to the turntable at the center of it with ground braid. A copper strap is directly connected to the groundplane at the edges of the turntable. The turntable is located on the south end of the structure and the antennas are mounted 3 and 10 meters away to the north. The antenna mast is a non-conductive with remote control of antenna height and polarization. The antenna height is adjustable from 1 to 4 meters.

All final radiated emission measurements are performed with the testing personnel and measurement equipment located below the ground reference plane. The site has a full basement underneath the turntable where support equipment may be remotely located. Operation of the antenna, turntable and equipment under test is controlled by remote controls that manipulate the antenna height and polarization with a turntable control. Test personnel are

located below the ellipse when measurements are performed, however the site maintains the ability of having personnel manipulate cables while monitoring test equipment. Ambient radiated emissions are 6 dB or more below the relevant FCC emission limits.

AC mains power is brought to the equipment under test through a power line filter, to remove ambient conducted noise. 50 Hz (240 VAC single phase), 60 Hz power (120 VAC single phase, 208 VAC three phase), and 60 Hz (480 VAC three phase) are available. Conducted emission measurements are performed with a Line Impedance Stabilization Network (LISN) or Artificial Mains Network (AMN) bonded to the ground reference plane. A removable vertical groundplane (2 meter X 2 meter area) is used for line-conducted measurements for table top equipment. The vertical groundplane is electrically connected to the reference groundplane.

2.4 Test Equipment and Support Equipment

Test Equipment

Description	Manufacturer	Model Number	ITS ID	Serial Number	Cal Due Date
Antenna	EMCO	3142	LOG4	9711-1225	02/18/2004
EMI Receiver Set	Hewlett Packard	8542E	REC2	3520A00125	12/05/2003
RF Filter	Hewlett Packard	85420E	RECFL2	3427A00126	12/05/2003
High Frequency Cable+	Megaphase	TM40 K1K1 80	CBL030	CBL030	11/13/2003
Signal Generator	Hewlett Packard	8648C	HEW59	3426A01040	07/14/2004
Horn Antenna	EMCO	3115	HORN2	9602-4675	09/03/2004
Horn Antenna+	EMCO	3115	HORN1	9512-4632	10/31/2003
Attenuator, 20 dB	Mini Circuits	20 dB, 50 Ohm	DS24	DS24	01/07/2004
Temperature/Humidity Chamber	Bryant Manufacturing	TH-5S	SAF187	1207	07/16/2004
Spectrum Analyzer	Hewlett Packard	8591E	SA0003	3346A02319	07/14/2004
Storage Oscilloscope	LeCroy	9304AM	TEL160	93041831	05/20/2004
Universal Power Meter	Gigatronics	8651A	GIG1	8651298	10/24/2004
Peak Power Sensor	Gigatronics	80354A	GIG2	1821196	10/24/2004
Measuring Receiver	Hewlett Packard	8902A	HEW65	3749A04397	10/17/2004
Signal Generator	Hewlett Packard	8648B	SIG1	3537A01040	05/19/2004
Spectrum Analyzer	Hewlett Packard	8593A	HP3	3009A00659	04/09/2004
Digital Multimeter	BK Precision	391	SAF013	099050522	05/19/2004
Antenna	Compliance Design	B100	ANT4A	3317	09/19/2004
Antenna	Compliance Design	B200	ANT4B	3245	09/19/2004
Antenna	Compliance Design	B300	ANT4C	3352	09/19/2004

+ - Items marked with a plus (+) sign were only used during the October 13-15 portion of testing
Testing on December 9, 2003 used only devices HP3 and LOG4

Support Equipment			
Description	**Manufacturer**	**Model Number**	**Serial Number**
DC Power Supply*	N/L	N/L	N/L

* - DC Power Voltage was verified using a digital multimeter, listed in the test equipment section

Cables					
Quantity	**Type**	**Length (m)**	**Shielding**	**Ferrite**	**Connector Type**
1	Power Supply AC Mains	1	None	None	US 120V Plug
2	DC Leads	1	None	None	Lead

3.0 RF Power Output
FCC § 90.20(e)(6)

3.1 Test Procedure

The transmitter was placed on a wooden turntable. The measurement antenna was placed at a distance of 10 meters from the EUT. During the tests, the antenna height and polarization were varied, and the EUT was rotated through 360 degrees and manipulated on three orthogonal axes in order to identify the maximum level of emissions from the EUT. A max hold function was used to determine maximum field strength levels.

The Radiated Power was measured by the substitution method using a horn antenna or a biconical antenna connected to a signal generator. Power P (in dBm) was calculated as follows:

$$P = P_{sg} + dB_{adj} - L + G_H - G_d$$

Where G_H is the gain of the transmit horn/biconical antenna attached to the signal generator
L is the loss in the cable between the signal generator and the transmit antenna
P_{sg} is the generator output power
G_d is 2.14 dBi – the gain of the half-wave dipole.
dB_{adj} is the adjustment in dB used to correct for the difference between the observed field strengths of the EUT and of the signal generator signal, respectively.

Requirement: The RF Power Output must be below 2.5 Watts (4 dBW).

3.2 Test Results

Results: Passed

Performed 10/14/2003
Equipment: REC2, RECFL2, CBL030, HORN1, HORN2, HEW59, ANT4, LOG4

Frequency (MHz)	Description	Value (dBm)	Value (dBW)	Limit (dBW)
173.075	LoJack Remote Locator Unit	27.76	-2.24	4

4.0 Transmitter Characteristics
FCC § 90.20(e)(6), § 90.214

4.1 Occupied Bandwidth
FCC § 90.20(e)(6)

The EUT was set to transmit in worst-case mode, and the bandwidth was measured using the receiver 99% bandwidth function. Resolution and Video bandwidth were set to 300 Hz.

Requirement: Occupied bandwidth must not exceed 20 kHz.

Results: Pass

Frequency (MHz)	Bandwidth (kHz)	Limit (kHz)
173.075	13.3	20

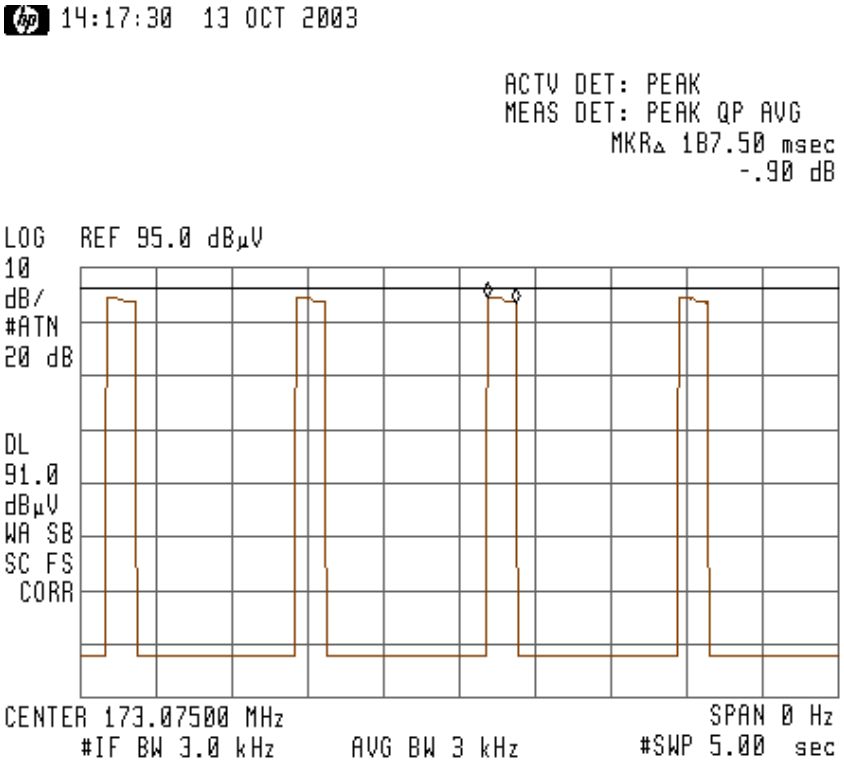
4.2 On Time
FCC § 90.20(e)(6)

The EUT was set to transmit in its worst case duty cycle mode, and a plot was made of the fundamental frequency using zero span to observe the time domain.

Requirement: Vehicle locating units actively being used for tracking are limited to not more an average of 200 ms of on time per second.

Results: Passed

The sweep time in the plot below is 5 seconds, with 4 peaks shown of 187.5 ms duration each, which meets the requirement of not more than 200 ms of on time per second.



4.3 Transient Frequency Behavior
FCC § 90.214

Transient frequency behavior is a measure of the difference, as a function in time, of the actual transmitter frequency to the assigned transmitter frequency when the transmitted RF output power is switched on or off.

A storage oscilloscope was set to 5 ms per division, and was configured to trigger alternately on increasing or decreasing power from the output of the power meter power sensor, depending on whether the on or the off condition was being investigated. The measuring receiver reference frequency was set to the EUT rated transmit frequency. The EUT was coupled to the measuring receiver and the power meter using wire coiled around the EUT, as the EUT does not have an antenna port. The DC output of the measuring receiver, which outputs a DC voltage with magnitude based on the amount of error from the reference frequency, was used as input to the channel being plotted on the storage oscilloscope. In order to define the limits in terms of this DC output voltage, a signal generator was set to the frequencies which coincided with the reference frequency plus or minus the maximum allowed frequency difference for the time interval and bandwidth being investigated. The two dotted display lines were positioned at the location of the oscilloscope trace that corresponded with the upper and lower maximum frequency difference. Next, the signal generator was removed and the EUT was activated. The oscilloscope trace corresponding to the EUT activation is expected to lay between the two display lines that were set to the upper and lower frequency deviation limits.

Requirement: The EUT operates at 173.075 MHz at not more than 2.5 Watts of output power, therefore only the time interval t_2 (5-25 ms after turning the EUT on) is subject to the limits below.

equipment designed to operate on 25 kHz channels			
time intervals [1]	maximum frequency difference, kHz	**frequency range, MHz**	
		IC: 138-174 FCC: 150-174	IC: 406.1-470 FCC: 421-512
t_1	± 25	5 ms	10 ms
t_2	± 12.5	20 ms	25 ms
t_3	± 25	5 ms	10 ms

NOTES: 1. t_{on} is the instant when the EUT starts transmitting.
t_1 is the time period immediately following t_{on}.
t_2 is the time period immediately following t_1.
t_3 is the time period from the instant when the transmitter is turned off until t_{off}.
t_{off} is the instant when the transmitter stops transmitting.

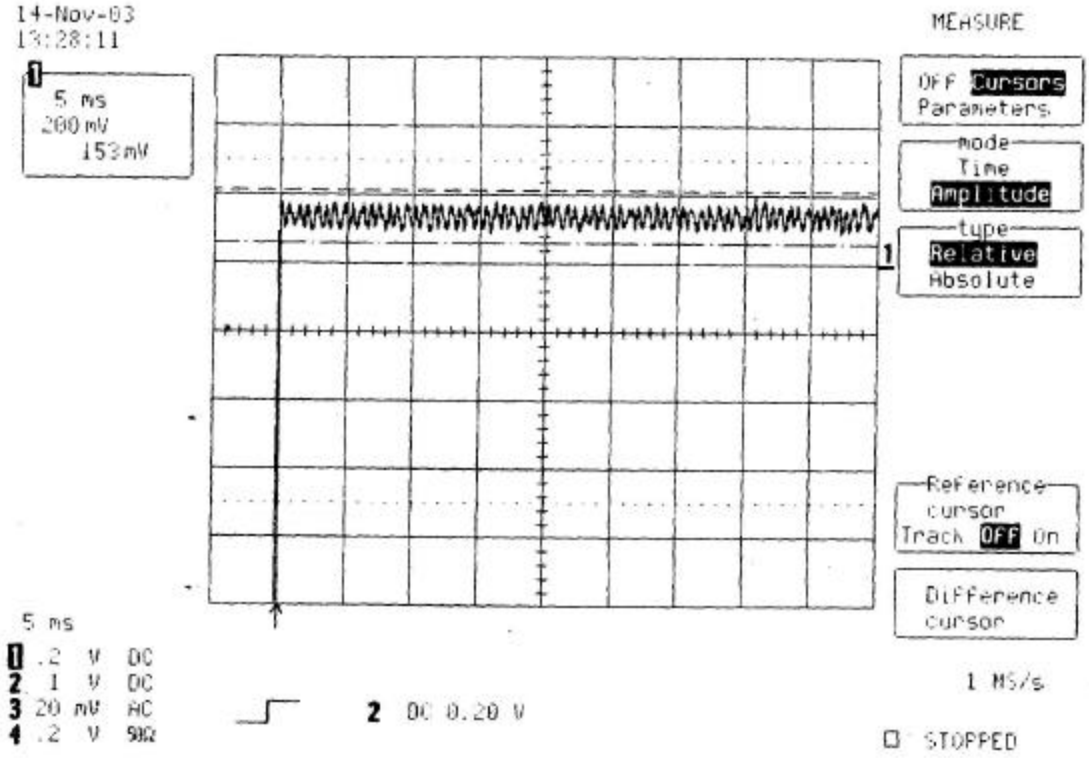
2. If the transmitter carrier output power is 6 W or less, the frequency difference during the time periods t_1 and t_3 may exceed the maximum frequency difference limit for those periods.

3. Transmitters with output power not exceeding 120 mW are exempt from transient frequency constraints, but must comply with alternative spectrum masks. See FCC 90.217 and RSS-119 (6.7).

Results: Passed

Performed 11/14/2003

Equipment: TEL160, SIG1, HP3, GIG1, GIG2, HEW65
Transmitter Turning On (t_{on}, t_1, and t_2)



5.0 Emissions Mask Requirements at the Fundamental

FCC § 90.210(c)

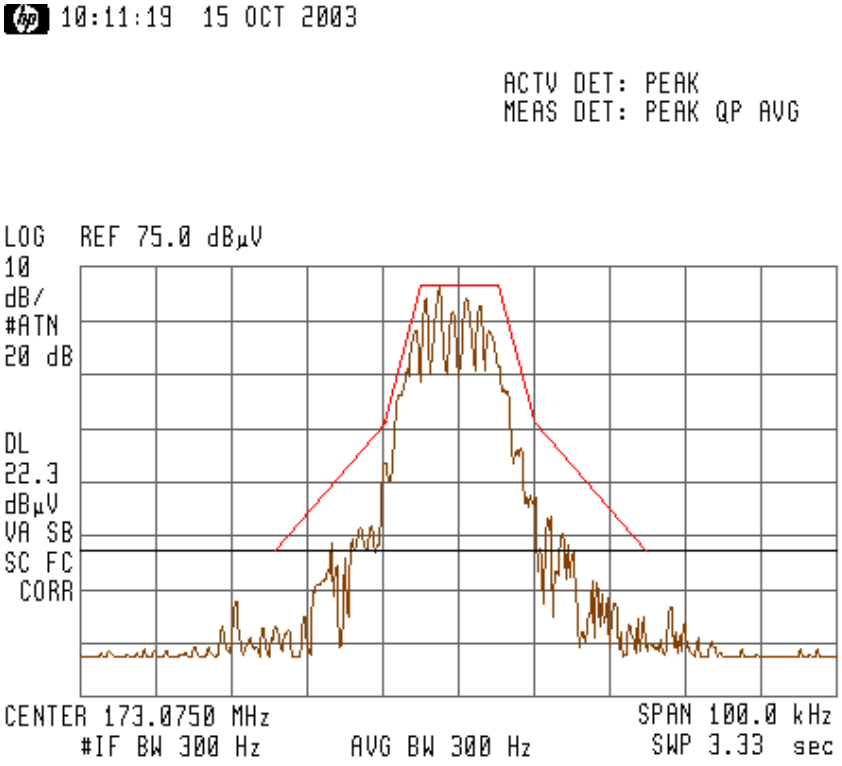
5.1 Test Procedure

The EUT activated and the fundamental was observed on a spectrum analyzer through sufficient attenuation to prevent overloading the analyzer. The resolution and video bandwidths of the spectrum analyzer were set at 300 Hz. A plot of a 100 kHz span around the fundamental was made for comparison to emissions mask C of FCC §90.210(c).

Requirement: The fundamental emission waveform must be attenuated below the measured fundamental power P in watts by zero dB for frequencies within 5 kHz of the fundamental center frequency and by 83*log (f/5) dB (f in kHz) in the bands between 5 and 10 kHz offset from the fundamental center frequency. Emissions offset by 10 kHz to 50 kHz must be attenuated below the measured fundamental power by at either 50 dB or 29*log(f^2/11), whichever is the lesser attenuation.

5.2 Test Results

Results: Passed



6.0 Field Strength of Spurious Radiation

FCC §2.1053, § 90.210(c)

6.1 Test Procedure

The transmitter was placed on a wooden turntable. The measurement antenna was placed at a distance of 10 meters from the EUT. During the tests, the antenna height and polarization were varied, and the EUT was rotated through 360 degrees and manipulated on three orthogonal axes in order to identify the maximum level of emissions from the EUT. A max hold function was used to determine maximum field strength levels.

The Radiated Power was measured by the substitution method using a horn antenna or a biconical antenna connected to a signal generator. Power P (in dBm) was calculated as follows:

$$P = P_{sg} + dB_{adj} - L + G_H - G_d$$

Where G_H is the gain of the transmit horn/biconical antenna attached to the signal generator
L is the loss in the cable between the signal generator and the transmit antenna
P_{sg} is the generator output power
G_d is 2.14 dBi – the gain of the half-wave dipole.
dB_{adj} is the adjustment in dB used to correct for the difference between the observed field strengths of the EUT and of the signal generator signal, respectively.

Requirement: The power into a dipole necessary to duplicate spurious emissions and harmonics must be attenuated below the power of the unmodulated carrier (P) on any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth at least (43 + 10 log P) dB. P is the measured RF output power in Watts. This corresponds to an ERP limit of –13 dBm. A table showing ERP values for the harmonics and spurious is shown.

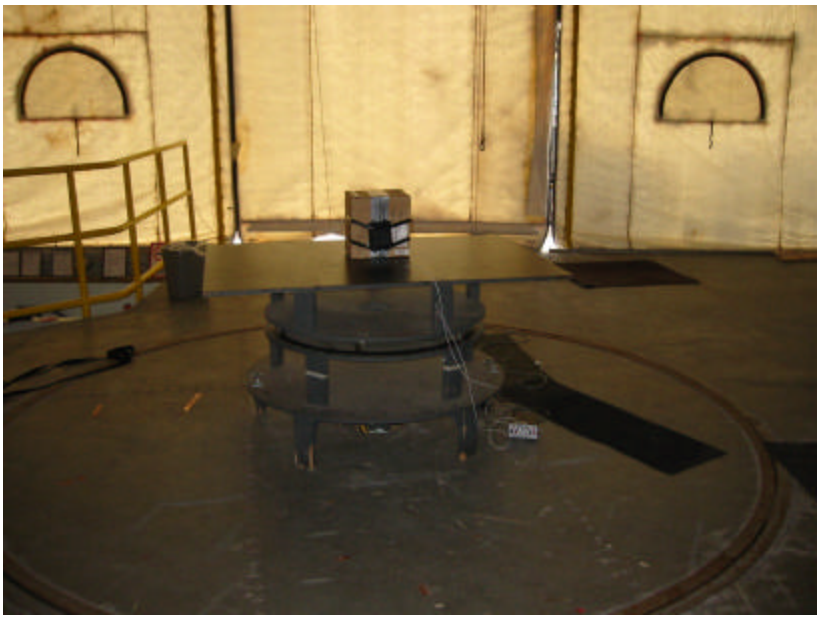
6.2 Test Results

Results: Pass

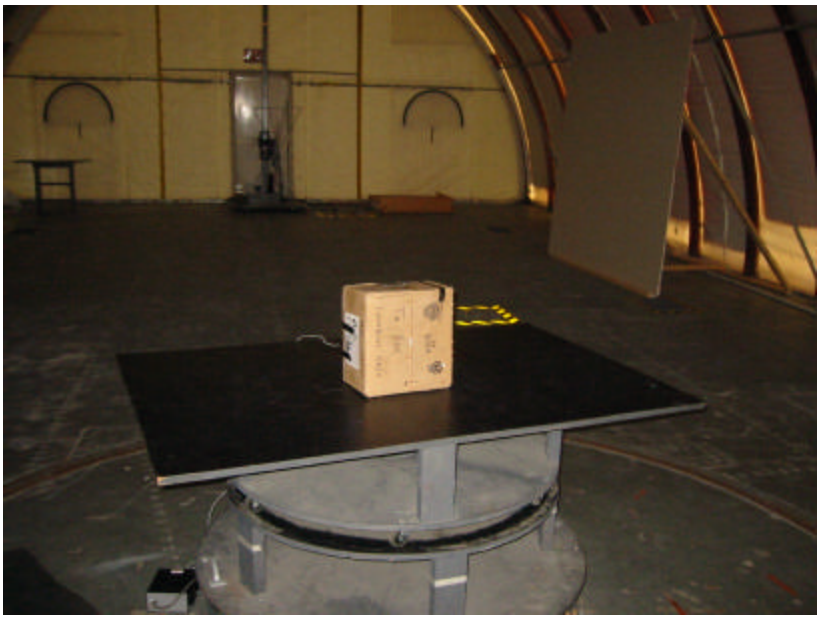
Performed 10/14/2003
Equipment: REC2, RECFL2, CBL030, HORN1, HORN2, HEW59, ANT4, LOG4

Frequency (MHz)	Description	Value (dBm)	Limit (dBm)
346.2	Harmonic	-34.74	-13
519.2	Harmonic	-42.14	-13
692.3	Harmonic	-42.84	-13
865.4	Harmonic	-32.44	-13
1038.5	Harmonic	-30.89	-13
1211.5	Harmonic	-38.36	-13
1384.6	Harmonic	-36.64	-13
1557.7	Harmonic	-39.12	-13
1730.8	Harmonic	-43.44	-13

6.3 Configuration Photographs – Radiated Emissions



Spurious Test Setup, Front View



Spurious Test Setup, Back View

7.0 Frequency Stability vs Temperature

FCC § 2.1055, § 90.213

7.1 Test Procedure

The equipment under test was connected to an external DC power supply and set to transmit at worst case duty cycle. The EUT was placed inside a temperature chamber. A cable for measuring the fundamental frequency was fed into the chamber through an opening insulated to minimize heat flow. After the temperature stabilized, the frequency of the fundamental was recorded from the analyzer.

Requirement: The frequency must not deviate by more than 50 parts-per-million (ppm) in the frequency band 150-174 MHz. For a fundamental of 173.075 MHz, this corresponds to an allowed deviation of up to 8650 Hz.

7.2 Test Results

Performed 10/15/2003
Equipment: SA0003, SAF187

Temperature, C	Reading (MHz)	Difference (Hz)	Limit (Hz)
+50	173.07435	600	8650
+40	173.07450	700	8650
+30	173.07390	150	8650
+20	173.07375	0 (Nominal Value)	8650
+10	173.07385	100	8650
0	173.07435	600	8650
-10	173.07505	1300	8650
-20	173.07525	1500	8650
-30	173.07555	1800	8650

Results: Passed

8.0 Frequency Stability vs Voltage
FCC § 2.995(d)(2), § 90.213

8.1 Test Procedure

An external variable DC power supply was connected to the EUT. The frequency of the transmitter was measured for 115% and for 85% of the DC nominal value of 13.8V and at voltages between the two.

Requirement: The frequency must not deviate by more than 50 parts-per-million (ppm) in the frequency band 150-174 MHz. For a fundamental of 173.075 MHz, this corresponds to an allowed deviation of up to 8650 Hz.

8.2 Test Results

Results: Passed

Performed 10/15/2003
Equipment: REC2, RECFL2, LOG4, SAF013

Voltage, VDC	Reading (MHz)	Difference (Hz)	Limit (Hz)
11.73 (85%)	173.07635	450	8650
12.42 (90%)	173.07645	550	8650
13.11 (95%)	173.07585	50	8650
13.8 (100%)	173.07590	0 (Nominal Voltage)	8650
14.49 (105%)	173.07575	150	8650
15.18 (110%)	173.07540	500	8650
15.87 (115%)	173.07560	300	8650