Intertek ETL SEMKO

11/29/2005

Bob White
LoJack Corporation
780 Dedham Street
Canton, MA 02021

Mr. White,

Enclosed you will find our Emissions Test Report covering testing on your VLU Utility Transceiver.

If there are any questions regarding this report, please contact the undersigned or your account representative.

Sincerely,

Nicholas Abbondante
Project Engineer

Jeff Goulet
Team Leader, EMC

Enclosure

Intertek ETL SEMKO

EMISSIONS TEST REPORT

Report Number: 3087070BOX.001
Project Number: 3087070

Testing performed on the
VLU Utility Transceiver
Model: VUT

to

FCC Part 90

For

LoJack Corporation

Test Performed by:
Intertek – ETL SEMKO
70 Codman Hill Road
Boxborough, MA 01719

Test Authorized by:
LoJack Corporation
780 Dedham Street
Canton, MA 02021

Prepared by: _____ Date: 11/23/05
Nicholas Abbondante

Reviewed by: _____ Date: 11-23-2005
Roland W. Gubisch

1.0 Job Description

1.1 Client Information

This EUT has been tested at the request of

Company:	LoJack Corporation 780 Dedham Street Canton, MA 02021
Contact:	Bob White
Telephone:	781-302-7128
Fax:	781-302-7299

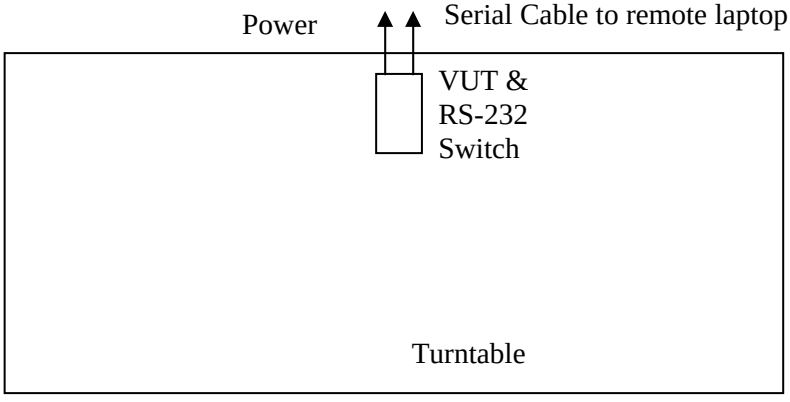
1.2 Equipment Under Test

Equipment Type:	VLU Utility Transceiver
Model Number(s):	VUT
Serial number(s):	1105006, 1105007
FCC ID Number:	IDIVUT
Manufacturer:	LoJack Corporation
EUT receive date:	11/14/2005
EUT received condition:	Prototype in Good Condition
Test report issue date:	11/23/2005
Test start date:	11/15/2005
Test end date:	11/22/2005

1.3 Test Plan Reference: Tested according to the standards listed.

1.4 Test Configuration

1.4.1 Block Diagram



1.4.2 Cable List:

Cable	Shielding	Connector	Length (m)	Qty.
Power	None	Wire	2	1
Serial	Braid	Metal/360	4	1

1.4.3 Support Equipment:

Name: Protek Triple DC Power Supply
Model No.: 3040T
Serial No.: AC3518

Name: Dell Precision M70 Laptop
Model No.: PP15L
Serial No.: 8XZGN81

Name: RS-232 Switch
Model No.: N/L
Serial No.: N/L

1.5 Mode of Operation:

The VUT was powered from an AC/DC power supply or a DC power supply at 5VDC. The VUT was connected to the laptop via a serial cable through the RS232 switch to allow software to send instructions to the radio. Software on the laptop instructed the VUT to transmit. During the frequency stability and the transient frequency behavior testing, the transmitter was unmodulated.

2.0 Test Summary

TEST STANDARD	RESULTS	
FCC Part 90		
SUB-TEST	**TEST PARAMETER**	**COMMENT**
RF Output Power and Spurious Emissions FCC 2.1046, 2.1053, 90.20(e)(6), 90.210(c)	RF Output Power must not exceed 2.5 Watts. Spurious emissions must not exceed –13 dBm.	Pass
Occupied Bandwidth FCC 2.1049, 90.20(e)(6)	Occupied bandwidth must not exceed 20 kHz.	Pass
Emissions Mask FCC 90.210(c)	The transmit waveform must meet the requirements of Emissions Mask C.	Pass
On-Time FCC 90.20(e)(6)	On time must not exceed 200 ms over the period of 1 second when the transmitter is in active mode. On time must not exceed 200 ms over the period of 10 seconds when the transmitter is not in active mode.	Pass
Transient Frequency Behavior FCC 90.214	The transmit frequency must stay within 12.5 kHz of the nominal frequency for the 20 ms after the first 5 ms that follow the transmitter being keyed on.	Pass
Frequency Stability FCC 2.1055, 90.213	Frequency drift must not exceed 50 PPM	Pass

3.0 Sample Calculations

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF - AG
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

Level in μV/m = [10(32 dBμV/m)/20] = 39.8 μV/m

The following is how net line-conducted readings were determined:

NF = RF + LF + CF + AF
Where NF = Net Reading in dBμV
RF = Reading from receiver in dBμV
LF = LISN Correction Factor in dB
CF = Cable Correction Factor in dB
AF = Attenuator Loss Factor in dB

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV

Example:

NF = RF + LF + CF + AF = 28.5 + 0.2 + 0.4 + 20.0 = 49.1 dBμV
$UF = 10^{(48.1\ dB\mu V / 20)}$ = 254 μV/m

3.1 Measurement Uncertainty

Compliance of the product is based on the measured value. However, the measurement uncertainty is included for informational purposes.
The expanded uncertainty (k = 2) for radiated emissions from 30 to 1000 MHz has been determined to be:

±3.5 dB at 10m, ±3.8 dB at 3m

The expanded uncertainty (k = 2) for mains conducted emissions from 150 kHz to 30 MHz has been determined to be:

±2.6 dB

The expanded uncertainty (k = 2) for telecom port conducted emissions from 150 kHz to 30 MHz has been determined to be:

±3.2 for ISN and voltage probe measurements
±3.1 for current probe measurements

3.2 Site Description

Test Site(s): 2

Our OATS are 3m and 10m sheltered emissions measurement ranges located in a light commercial environment in Boxborough, Massachusetts. They meet 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 a 2 inch wide metal strips to provide low RF impedance contact throughout. The sheets 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 (12,000 lb. in Site 3) 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. The 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 and 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.

The EMC Lab has two Semi-anechoic Chambers and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference groundplanes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

Test Results: Pass

Test Standard: FCC 2.1046, 2.1053, 90.20(e)(6), 90.210(c)

Test: RF Output Power and Spurious Emissions

Performance Criterion: RF output power must not exceed 2.5 Watts. Spurious emissions must not exceed –13 dBm.

Test Environment:
See Data Tables

Software:

Name	Manufacturer	Version
EXCEL 2000	Microsoft Corporation	9.0.6926 SP-3
EMI BOXBOROUGH	Intertek	11/16/05 Revision

Test Date: 11/16/2005 **Engineer Initials:** NA **Date:** 11/23/05
Test Engineer: Nicholas Abbondante **Reviewer Initials:** RWA **Date:** 11-23-05

Test Equipment Used:

Intertek ID	Manufacturer	Model	Serial Number	Cal. Due
BAR2	Mannix	0ABA116	BAR2	08/02/2006
REC2	Hewlett Packard	8542E	3520A00125	02/08/2006
RECFL2	Hewlett Packard	85420E	3427A00126	02/08/2006
LOG2	EMCO	3142	9711-1223	12/13/2005
S2 10M FLR	ITS	RG214B/U	S2 10M FLR	09/02/2006
CBL028	Megaphase	TM40 K1K1 197	CBL028	12/01/2005
CBL029	Megaphase	TM40 K1K1 80	CBL029	12/01/2005
CBL030	Megaphase	TM40 K1K1 80	CBL030	12/01/2005
HORN2	EMCO	3115	9602-4675	09/13/2006
HORN3	EMCO	3115	9610-4980	09/13/2006
ANT2A	Compliance Design	B100	1852	08/29/2006
ANT2B	Compliance Design	B200	1850	08/29/2006
ANT2C	Compliance Design	B300	00674	08/29/2006
HEW62	Hewlett Packard	83620A	3213A01244	01/25/2006

Test Details:

Radiated Emissions, Substitution

Company: LoJack Corporation
Model #: VUT
Serial #: 1105006
Engineer(s): Nicholas Abbondante
Project #: 3087070
Standard: FCC Part 90
Barometer: BAR2 Temp/Humidity/Pressure: 20c 54% 1002 mB
Test Distance (m): 10 Voltage/Frequency: 120V/60Hz
Location: Site 2 Date(s): 11/16/05

Rx Antenna: LOG2
Rx Cable(s): S2 10M FLR
Rx Preamp: NONE Receiver: REC2/RECFL2
Tx Antenna: ANT2A ANT2B ANT2C
Tx Cable(s): CBL029
Tx Signal Generator: HEW62
ERP or EIRP?: ERP
Frequency Range: 30-1000 MHz

Net = Generator Level (0.00 dBm) + (EUT reading - Generator reading) - Cable Loss + Antenna Gain (dBi or dBd)
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor RB = Restricted Band; Bandwidth denoted as RBW/VBW

Detector Type	Ant. Pol. (V/H)	Frequency MHz	EUT Reading dB(uV)	Generator Reading dB(uV)	Transmit Cable Loss dB	Transmit Antenna dBi	Generator Level dBm	ERP Net dBm	ERP Limit dBm	Margin dB	Bandwidth	
PK	V	171.488	21.2	74.9	0.3	-1.4	0.0	-57.5	-13.0	-44.5	120/300 kHz	
PK	V	173.075	65.5	74.1	0.3	-1.7	0.0	-12.7	34.0	-46.7	120/300 kHz	
PK	V	346.150	16.6	69.2	0.4	-1.2	0.0	-56.4	-13.0	-43.4	120/300 kHz	NF
PK	V	519.225	16.9	57.3	0.5	2.2	0.0	-40.9	-13.0	-27.9	120/300 kHz	NF
PK	V	692.300	16.8	44.8	0.6	1.2	0.0	-29.6	-13.0	-16.6	120/300 kHz	NF
PK	V	865.375	18.7	56.0	0.7	1.2	0.0	-38.9	-13.0	-25.9	120/300 kHz	NF

Radiated Emissions, Substitution

Company: LoJack Corporation
Model #: VUT
Serial #: 1105006
Engineer(s): Nicholas Abbondante
Project #: 3087070
Standard: FCC Part 90
Barometer: BAR2 Temp/Humidity/Pressure: 20c 54% 1002 mB
Test Distance (m): 10 Voltage/Frequency: 120V/60Hz
Location: Site 2 Date(s): 11/16/05

Rx Antenna: HORN2
Rx Cable(s): CBL028 CBL030
Rx Preamp: NONE Receiver: REC2/RECFL2
Tx Antenna: HORN3
Tx Cable(s): CBL029
Tx Signal Generator: HEW62
ERP or EIRP?: EIRP
Frequency Range: 1 - 2 GHz

Net = Generator Level (0.00 dBm) + (EUT reading - Generator reading) - Cable Loss + Antenna Gain (dBi or dBd)
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor RB = Restricted Band; Bandwidth denoted as RBW/VBW

Detector Type	Ant. Pol. (V/H)	Frequency MHz	EUT Reading dB(uV)	Generator Reading dB(uV)	Transmit Cable Loss dB	Transmit Antenna dBi	Generator Level dBm	EIRP Net dBm	EIRP Limit dBm	Margin dB	Bandwidth	
PK	V	1038.450	20.7	77.2	0.7	6.0	0.0	-51.3	-13.0	-38.3	1/3 MHz	NF
PK	V	1211.525	20.8	72.2	0.8	6.7	0.0	-45.6	-13.0	-32.6	1/3 MHz	NF
PK	V	1384.600	23.3	73.4	0.9	7.5	0.0	-43.6	-13.0	-30.6	1/3 MHz	NF
PK	V	1557.675	22.0	77.8	0.9	8.0	0.0	-48.7	-13.0	-35.7	1/3 MHz	NF
PK	V	1730.750	22.0	72.5	1.0	8.0	0.0	-43.5	-13.0	-30.5	1/3 MHz	NF

NF – This measurement is a measurement of the instrumentation noise floor.

Setup Photos

Test Results: Pass

Test Standard: FCC 2.1049, 90.20(e)(6)

Test: Occupied Bandwidth

Performance Criterion: The 20 dB bandwidth of the emission must not exceed 20 kHz.

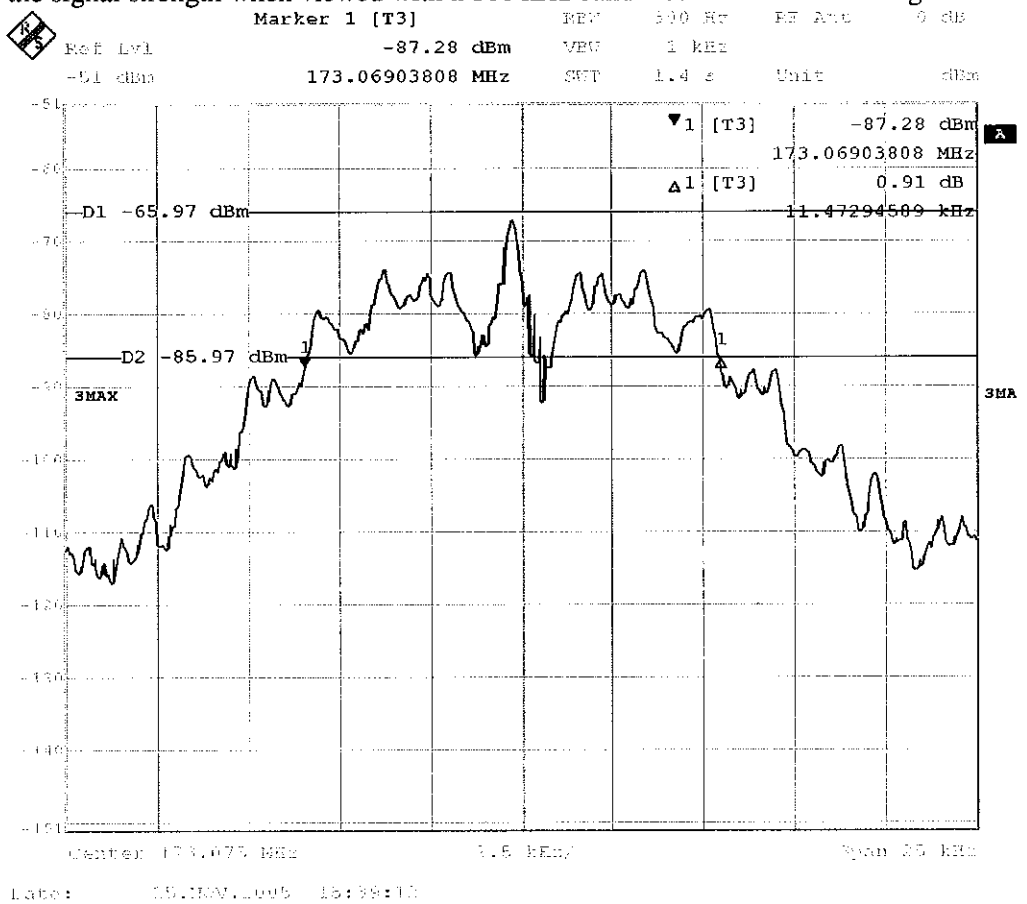
Test Date: 11/15/2005 **Engineer Initials:** NNA **Date:** 11/23/05
Test Engineer: Nicholas Abbondante **Reviewer Initials:** RWR **Date:** 11-23-05

Test Equipment Used:

Intertek ID	Manufacturer	Model	Serial Number	Cal. Due
ROS001	Rohde & Schwarz	FSEK-30	100225	07/26/2006

Test Details:

Notes: The 20 dB bandwidth is 11.47 kHz. The measurement is a relative measurement and is referenced to the signal strength when viewed with a 100 kHz bandwidth in the same configuration.



Test Results: Pass

Test Standard: FCC 90.210(c)

Test: Emissions Mask

Performance Criterion: The transmit waveform must meet the requirements of Emissions Mask C. 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(f2/11), whichever is the lesser attenuation.

Software:

Name	Manufacturer	Version
EXCEL 2000	Microsoft Corporation	9.0.6926 SP-3

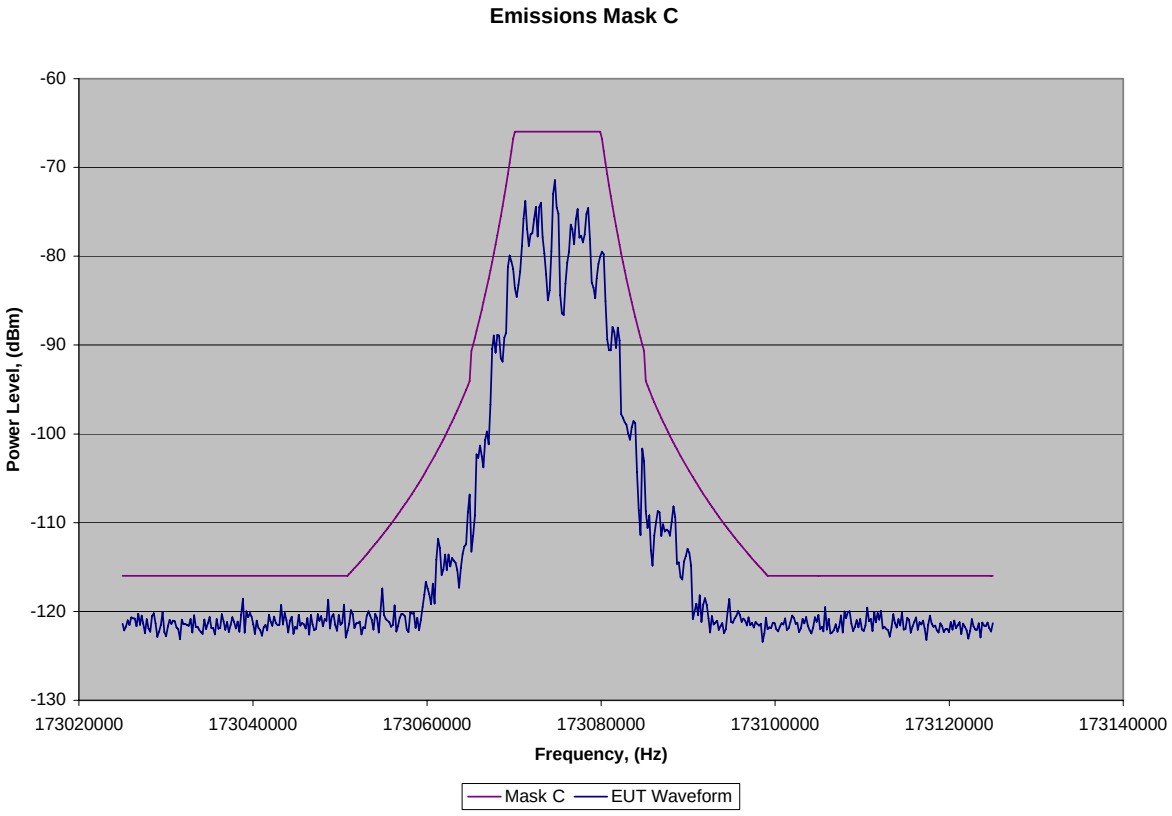
Test Date: 11/15/2005 **Engineer Initials:** NNA **Date:** 11/23/05
Test Engineer: Nicholas Abbondante **Reviewer Initials:** RWH **Date:** 11-23-05

Test Equipment Used:

Intertek ID	Manufacturer	Model	Serial Number	Cal. Due
ROS001	Rohde & Schwarz	FSEK-30	100225	07/26/2006

Test Details:

Notes: The measurement is a relative measurement and is referenced to the signal strength when viewed with a 100 kHz bandwidth in the same configuration, which was –65.97 dBm.



Test Results: Pass

Test Standard: FCC 90.20(e)(6)

Test: On Time

Performance Criterion: On time must not exceed 200 ms over the period of 1 second when the transmitter is in active mode. On time must not exceed 200 ms over the period of 10 seconds when the transmitter is not in active mode.

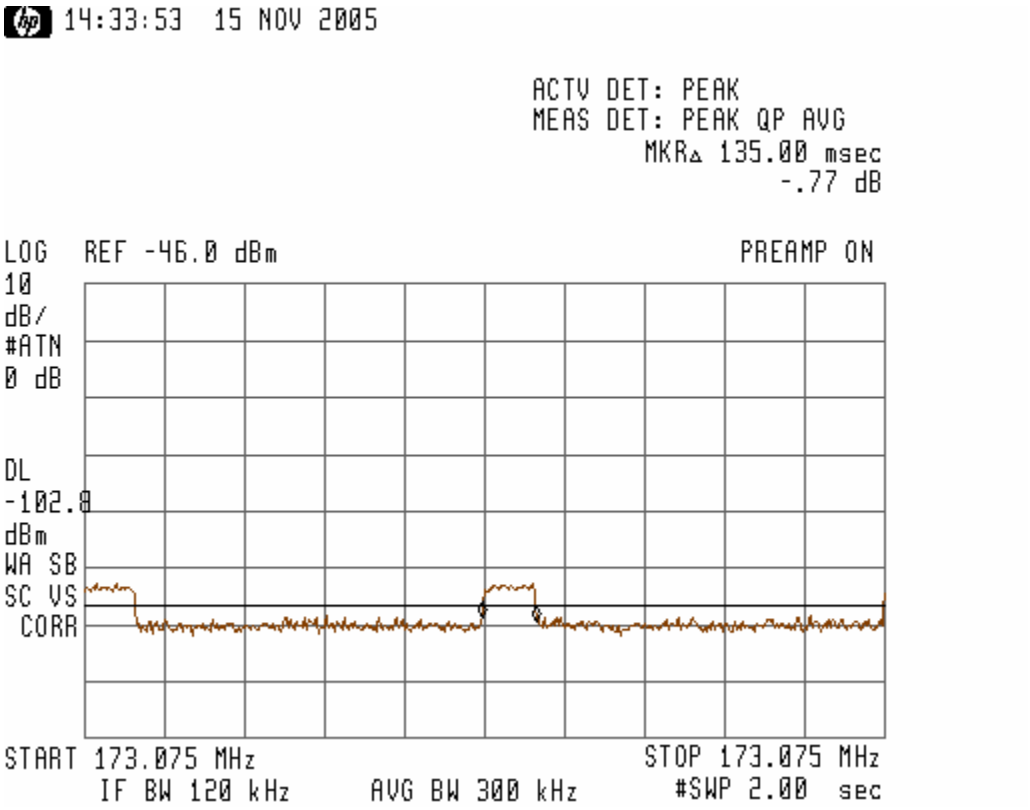
Test Date: 11/15/2005 **Engineer Initials:** NNA **Date:** 11/27/05
Test Engineer: Nicholas Abbondante **Reviewer Initials:** RWH. **Date:** 11-23-05

Test Equipment Used:

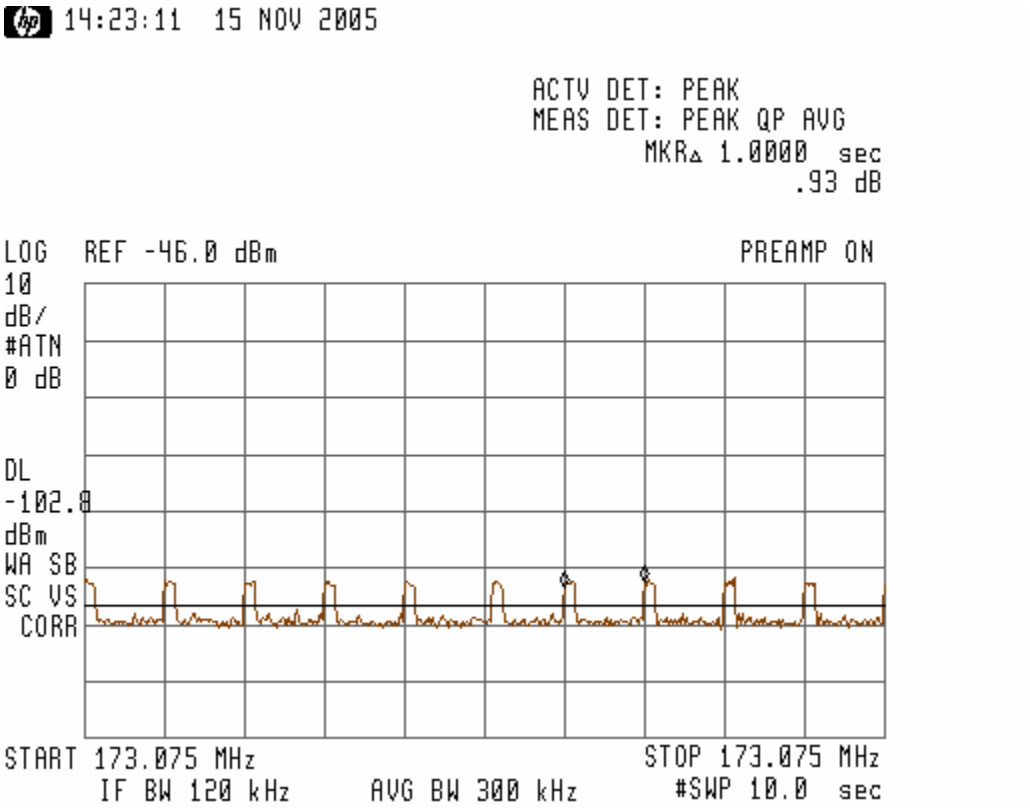
Intertek ID	Manufacturer	Model	Serial Number	Cal. Due
REC2	Hewlett Packard	8542E	3520A00125	02/08/2006
RECFL2	Hewlett Packard	85420E	3427A00126	02/08/2006

Test Details:

Notes: Pulse duration is 135 ms. Pulses occurred every 1 second. This meets the requirement of not more than 200 ms of on time in any 1 second period in active mode. The transmitter only transmits when instructed to do so.



Pulse Duration



Active mode pulse intervals

Test Results: Pass

Test Standard: FCC 90.214

Test: Transient Frequency Behavior

Performance Criterion: The EUT operates at 173.075 MHz at not more than 2.5 Watts of output power, therefore only the time interval t2 (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.

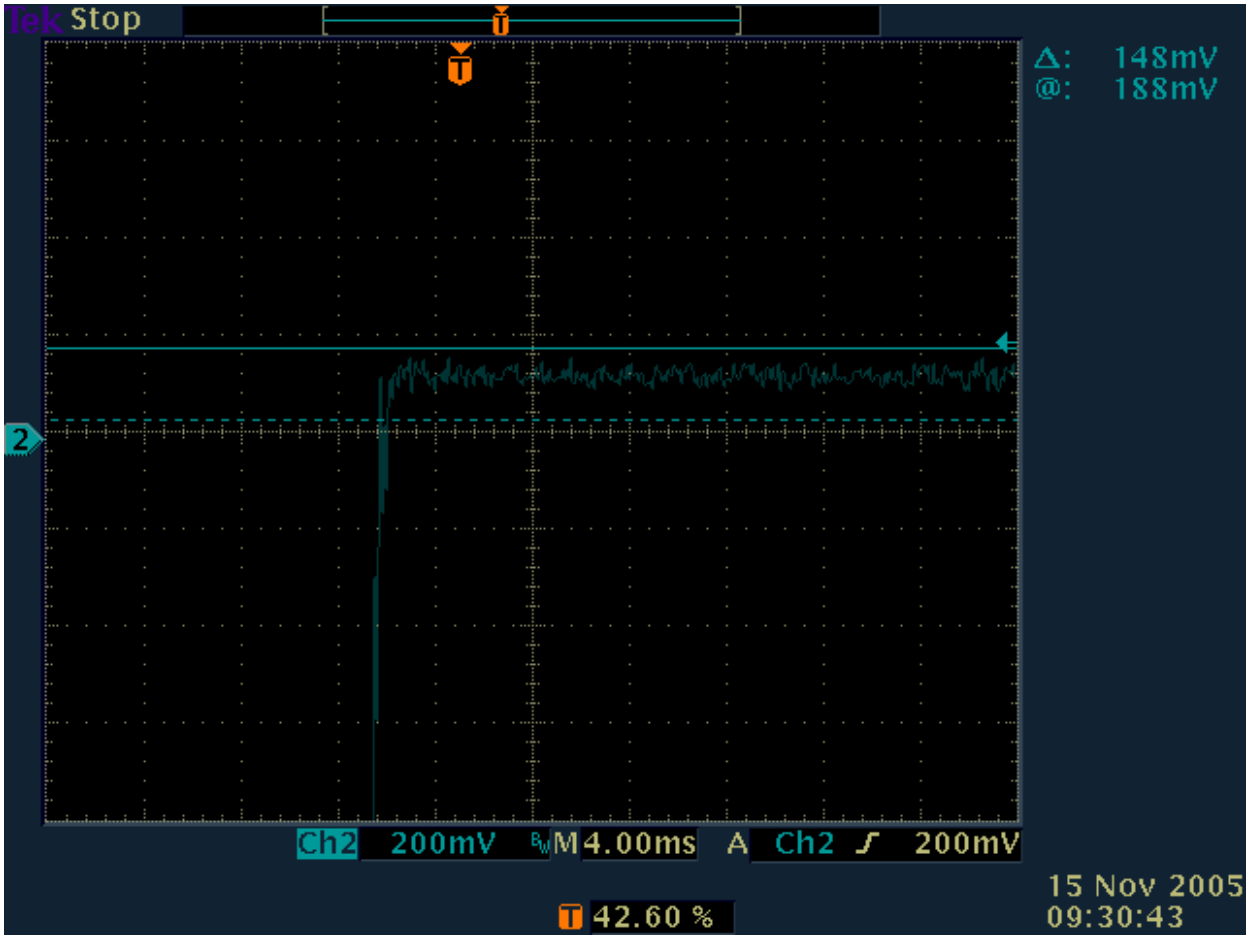
Test Date: 11/15/2005 **Engineer Initials:** NNA **Date:** 11/23/05
Test Engineer: Nicholas Abbondante **Reviewer Initials:** RWH **Date:** 11-23-05

Test Equipment Used:

Intertek ID	Manufacturer	Model	Serial Number	Cal. Due
TEK4	Tektronix	TDS3052	B014809	02/24/2006
HEW63	Hewlett Packard	8648C	3847A05291	01/04/2006
HEW65	Hewlett Packard	8902A	3749A04397	01/20/2006

Test Details:

Notes: The upper and lower bounds were set using a signal generator.



Test Results: Pass

Test Standard: FCC 2.1055, 90.213

Test: Frequency Stability

Performance Criterion: The frequency drift must not exceed 50 PPM.

Test Date: 11/22/2005 **Engineer Initials:** NNA **Date:** 11/23/05
Test Engineer: Nicholas Abbondante **Reviewer Initials:** RWB **Date:** 11-23-05

Test Equipment Used:

Intertek ID	Manufacturer	Model	Serial Number	Cal. Due
SA0003	Hewlett Packard	8591E	3346A02319	08/09/2006
SAF187	Bryant Manufacturing	TH-5S	1207	04/06/2006
CBL029	Megaphase	TM40 K1K1 80	CBL029	12/01/2005

Test Details:

Frequency Stability

Company: LoJack Corporation
Model #: VUT
Serial #: 1105007
Engineer(s): Nicholas Abbondante
Project #: 3087070
Standard: FCC Part 90

Test Equipment Used:
SA0003 SAF187 CBL029

Location: Safety

Date(s): 11/22/05

Limit: 50 PPM

Nominal f: 173.075 MHz

Voltage: 5 VDC

%	Voltage Volts	Frequency MHz	Deviation kHz	Limit kHz
-15%	4.25	173.07440	-0.6	8.65
-10%	4.5	173.07495	-0.05	8.65
-5%	4.75	173.07495	-0.05	8.65
+0%	5	173.07500	0	8.65
+5%	5.25	173.07495	-0.05	8.65
+10%	5.5	173.07495	-0.05	8.65
+15%	5.75	173.07505	0.05	8.65

Temp Celsius	Frequency MHz	Deviation kHz	Limit kHz
-30	173.07415	-0.85	8.65
-20	173.07440	-0.6	8.65
-10	173.07445	-0.55	8.65
0	173.07465	-0.35	8.65
10	173.07480	-0.2	8.65
20	173.07500	0	8.65
30	173.07500	0	8.65
40	173.07540	0.4	8.65
50	173.07535	0.35	8.65