



EMISSIONS TEST REPORT

Report Number: 3161283BOX-011

Project Number: 3161283

Testing performed on the

Vehicle Location Unit

Models: VLU7-SP, VLU7-VP

To

CFR47 "Telecommunications" FCC Part 90 "Private Land Mobile Radio Services"

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: 
Nicholas Abbondante

Date: 11/12/2008

Reviewed by: 
Jeff Goulet

Date: 11/14/08

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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: Mr. Bob White
Telephone: 781-302-7128
Fax: 781-302-7299
Email: rwhite@lojack.com

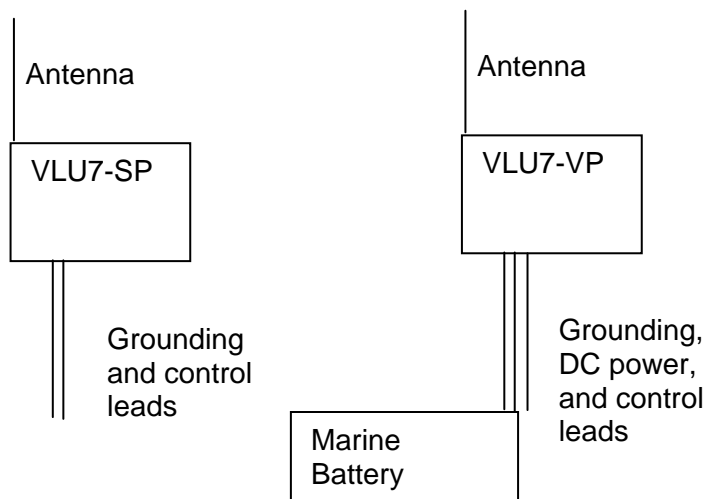
1.2 Equipment Under Test

Equipment Type: Vehicle Location Unit
Model Number(s): VLU7-SP, VLU7-VP
Serial number(s): 7, 9 (VLU7-SP); 8, 10 (VLU7-VP)
Manufacturer: LoJack Corporation
EUT receive date: 11-03-2008
EUT received condition: Prototype in Good Condition
Test start date: 11-03-2008
Test end date: 11-05-2008

1.3 Test Plan Reference: Tested according to the standards listed and with the guidance of ANSI/TIA-603-C-2004

1.4 Test Configuration

1.4.1 Block Diagram





1.4.2. Cables:

| Cable | Shielding | Connector | Length (m) | Qty. |
|-----------|-----------|-----------|------------|------|
| Antenna | None | Wire | 1.067 | 1 |
| DC Ground | None | Wire | 0.4 | 1 |
| Control | None | Wire | 0.4 | 1 |
| DC Power | None | Wire | 0.61 | 1 |

1.4.3. Support Equipment:

Name: GW DC Power Supply
Model No.: GPS-1830D
Serial No.: E00233

Name: Marine Battery
Model No.: N/L
Serial No.: N/L

1.5 Mode(s) of Operation:

The EUT was activated from a fresh battery throughout testing, except for frequency stability testing where a DC power supply was used to supply 13.8 VDC to the VLU7-VP and 6.1 and 3.3 VDC to the VLU7-SP. During frequency stability testing, samples were configured to transmit continuously in unmodulated (CW) mode. All other testing was performed using both the FSK and MSK modulation schemes, set to normal burst lengths but configured to transmit the burst repetitively to aid in testing. Conducted emissions and output power testing was performed through a Mini Circuits 50 Ohm transformer used as a temporary 50 Ohm antenna port.

1.6 Floor Standing Equipment: Applicable:____ Not Applicable: X

2.0 Test Summary

| TEST STANDARD | RESULTS | |
|---|---|---------|
| CFR47 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 (34 dBm). | Pass |
| Conducted Spurious Emissions | Spurious emissions must not exceed –13 dBm. | Pass |
| Radiated Spurious Emissions | 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 |

REVISION SUMMARY – The following changes have been made to this Report:

| | | | | | |
|-------------|----------------|----------------|----------------|-------------|------------------------------|
| <u>Date</u> | <u>Project</u> | <u>Project</u> | <u>Page(s)</u> | <u>Item</u> | <u>Description of Change</u> |
| | <u>No.</u> | <u>Handler</u> | | | |

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 dB μ V/m
- RA = Receiver Amplitude (including preamplifier) in dB μ V
- 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 dB μ V 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 dB μ V/m. This value in dB μ V/m was converted to its corresponding level in μ V/m.

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

$$\text{Level in } \mu\text{V/m} = [10(32 \text{ dB}\mu\text{V/m})/20] = 39.8 \mu\text{V/m}$$

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

$$NF = RF + LF + CF + AF$$

Where NF = Net Reading in dB μ V

- RF = Reading from receiver in dB μ V
- LF = LISN Correction Factor in dB
- CF = Cable Correction Factor in dB
- AF = Attenuator Loss Factor in dB

To convert from dB μ V to μ V or mV the following was used:

$$UF = 10^{(NF / 20)} \text{ where UF = Net Reading in } \mu\text{V}$$

Example:

$$NF = RF + LF + CF + AF = 28.5 + 0.2 + 0.4 + 20.0 = 49.1 \text{ dB}\mu\text{V}$$

$$UF = 10^{(49.1 \text{ dB}\mu\text{V} / 20)} = 254 \mu\text{V/m}$$



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 C63.4-2003 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 Part 90

Test: RF Output Power

Performance Criterion: RF Output Power must not exceed 2.5 Watts (34 dBm).

Test Environment:

| | | | | | | |
|--|---------------------|-----------------------|--------------------------|----------------------|-----------------|-------------------------|
| Environmental Conditions During Testing: | Ambient (°C): | 20 | Humidity (%): | 34 | Pressure (hPa): | 1026 |
| Pretest Verification Performed | Yes | Equipment under Test: | | VLU7-SP, VLU7-VP | | |
| Test Engineer(s): | Nicholas Abbondante | | EUT Serial Number: | | 7, 9 | |
| Engineer's Initials: | NNA | Date Test Performed: | 11-03-2008 11-05-2008 | Reviewer's Initials: | JG | Date Reviewed: 11/14/08 |

Test Equipment Used:

| TEST EQUIPMENT LIST | | | | | |
|---------------------|--------------------------|----------------|-----------|------------|---------------|
| Item | Equipment Type | Make | Model No. | Serial No. | Next Cal. Due |
| 1 | Digital 4 Line Barometer | Mannix | 0ABA116 | BAR1 | 06/01/2009 |
| 2 | Universal Power meter | Gigatronics | 8651A | 8651298 | 01/23/2009 |
| 3 | Power Sensor | Gigatronics | 80334A | 1835789 | 01/23/2009 |
| 4 | 10W, 30dB Attenuator | Weinschel Corp | 47-30-34 | BD43291 | 10/15/2009 |

Test Details:

Notes: Output power of the VLU7-SP was measured to be 31.07 dBm for FSK modulation and 31.07 dBm for MSK modulation at the temporary 50 Ohm antenna port.

Output power of the VLU7-VP was measured to be 30.84 dBm for FSK modulation and 30.81 dBm for MSK modulation at the temporary 50 Ohm antenna port.



Test Results: Pass

Test Standard: FCC Part 90

Test: Conducted Spurious Emissions

Performance Criterion: Spurious emissions must not exceed -13 dBm.

Test Environment:

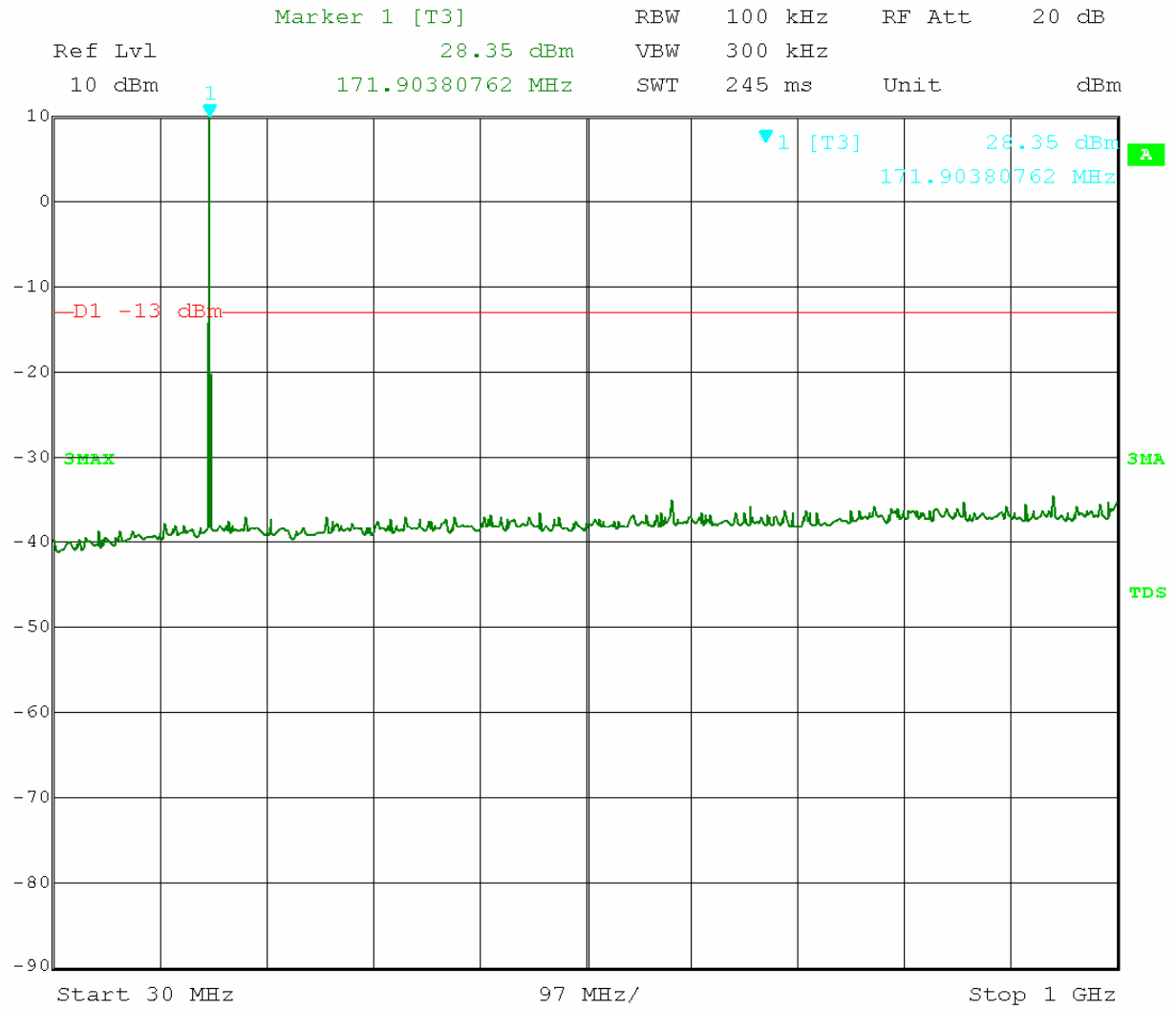
| | | | | | | |
|--|---------------------|-----------------------|--------------------|----------------------|-----------------|-------------------------|
| Environmental Conditions During Testing: | Ambient (°C): | 20 | Humidity (%): | 34 | Pressure (hPa): | 1026 |
| Pretest Verification Performed | Yes | Equipment under Test: | | VLU7-SP | | |
| Test Engineer(s): | Nicholas Abbondante | | EUT Serial Number: | | 7 | |
| Engineer's Initials: | NNA | Date Test Performed: | 11-03-2008 | Reviewer's Initials: | JG | Date Reviewed: 11/14/08 |

Test Equipment Used:

| TEST EQUIPMENT LIST | | | | | |
|---------------------|---------------------------------|------------------|---------------|-------------|---------------|
| Item | Equipment Type | Make | Model No. | Serial No. | Next Cal. Due |
| 1 | Digital 4 Line Barometer | Mannix | 0ABA116 | BAR1 | 06/01/2009 |
| 2 | 40 GHz Cable | Megaphase | TM40-K1K1-197 | 7030801 002 | 06/05/2009 |
| 3 | 10W, 30dB Attenuator | Weinschel Corp | 47-30-34 | BD43291 | 10/15/2009 |
| 4 | Spectrum Analyzer 20Hz - 40 GHz | Rohde & Schwartz | FSEK-30 | 100225 | 11/26/2008 |

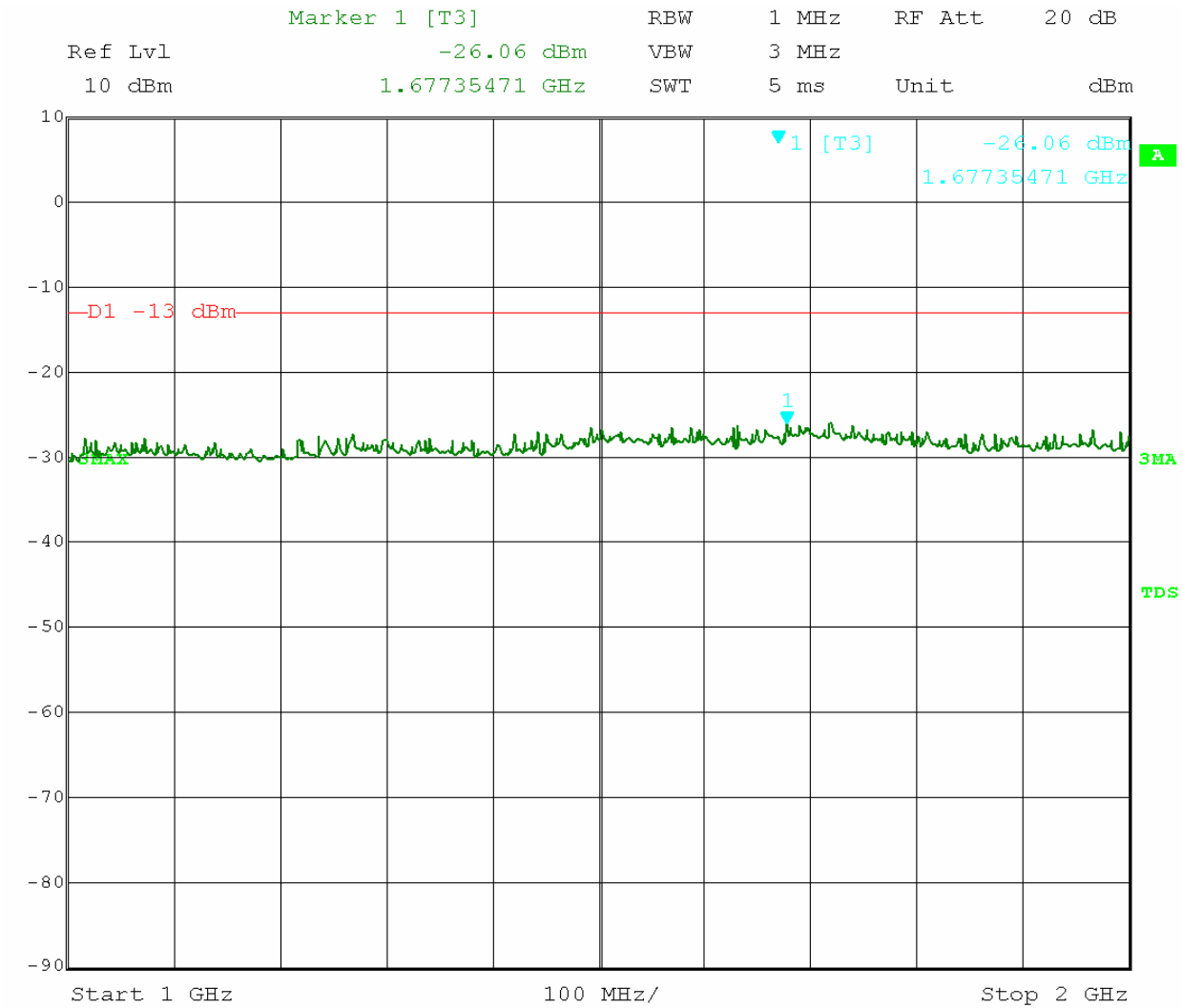


Test Details:

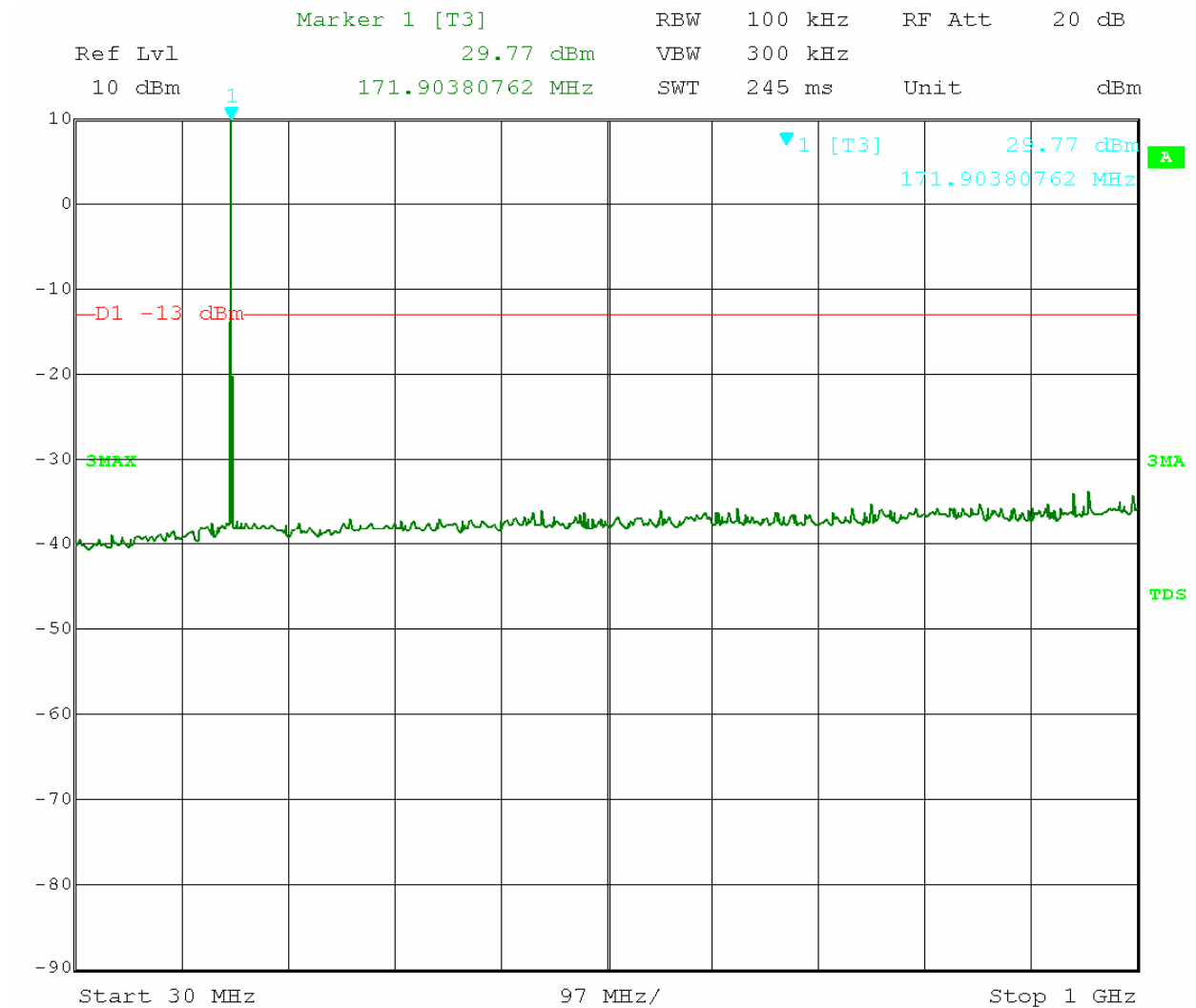


Date: 3.NOV.2008 15:12:14

Spurious Emissions, 30-1000 MHz, FSK Modulation, VLU7-SP

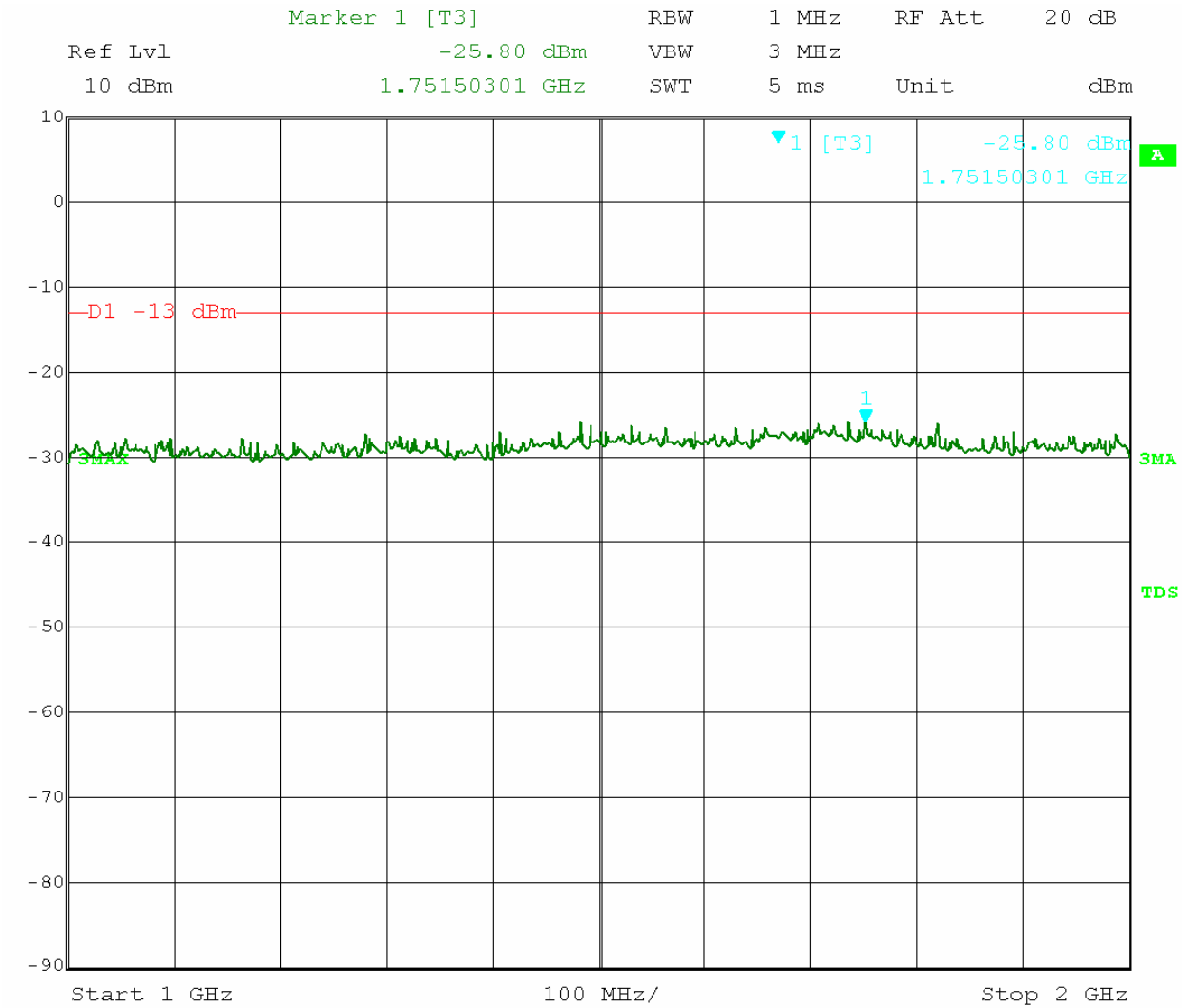


Date: 3.NOV.2008 15:14:28
Spurious Emissions, 1-2 GHz, FSK Modulation, VLU7-SP



Date: 3.NOV.2008 17:42:45

Spurious Emissions, 30-1000 MHz, MSK Modulation, VLU7-SP



Date: 3.NOV.2008 17:43:30
Spurious Emissions, 1-2 GHz, MSK Modulation, VLU7-SP



Test Results: Pass

Test Standard: FCC Part 90

Test: Occupied Bandwidth

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

Test Environment:

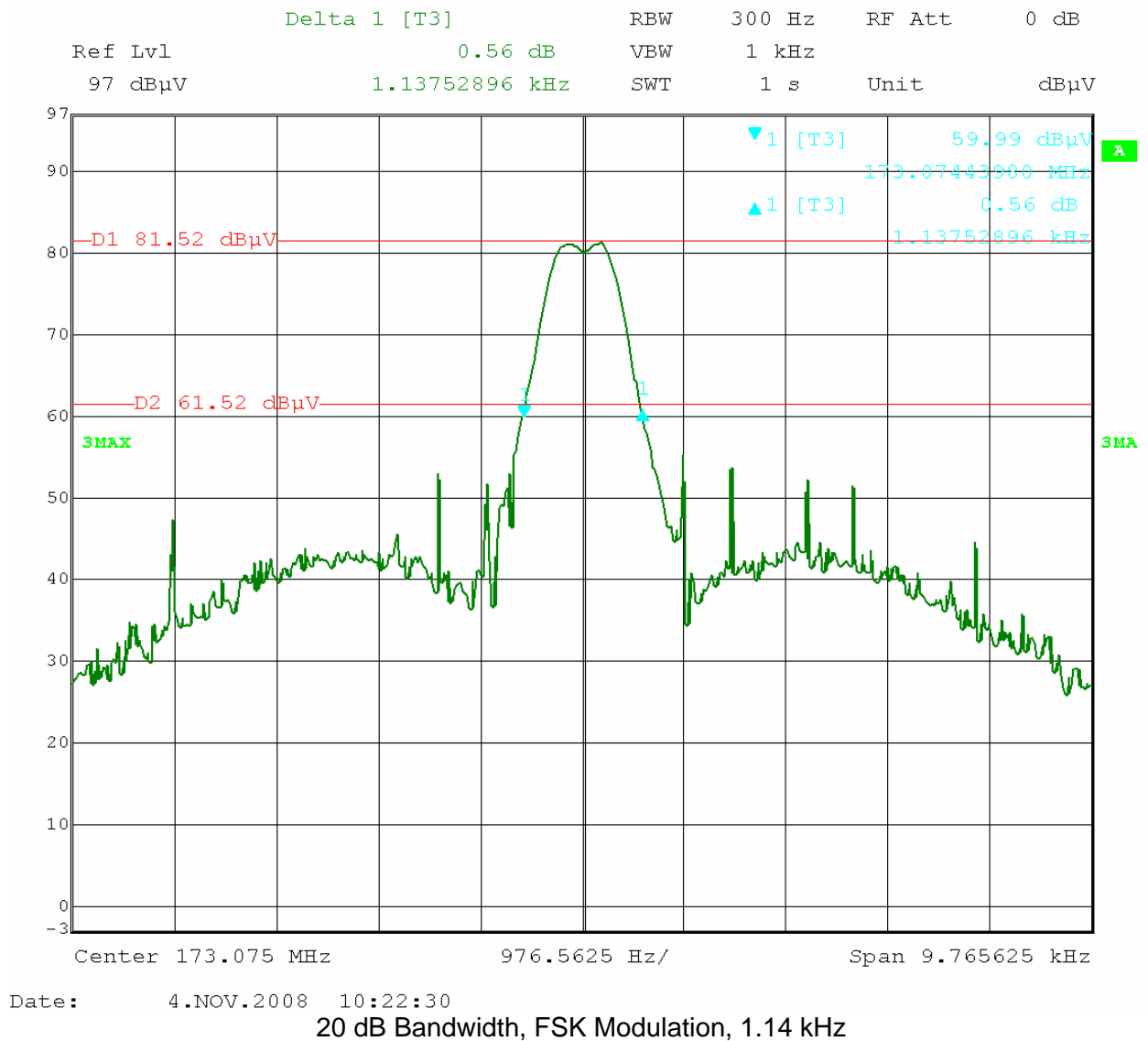
| | | | | | | |
|--|---------------------|-----------------------|--------------------|----------------------|-----------------|-------------------------|
| Environmental Conditions During Testing: | Ambient (°C): | N/A | Humidity (%): | N/A | Pressure (hPa): | N/A |
| Pretest Verification Performed | Yes | Equipment under Test: | | VLU7-SP | | |
| Test Engineer(s): | Nicholas Abbondante | | EUT Serial Number: | | 7 | |
| Engineer's Initials: | NNA | Date Test Performed: | 11-04-2008 | Reviewer's Initials: | JG | Date Reviewed: 11/14/08 |

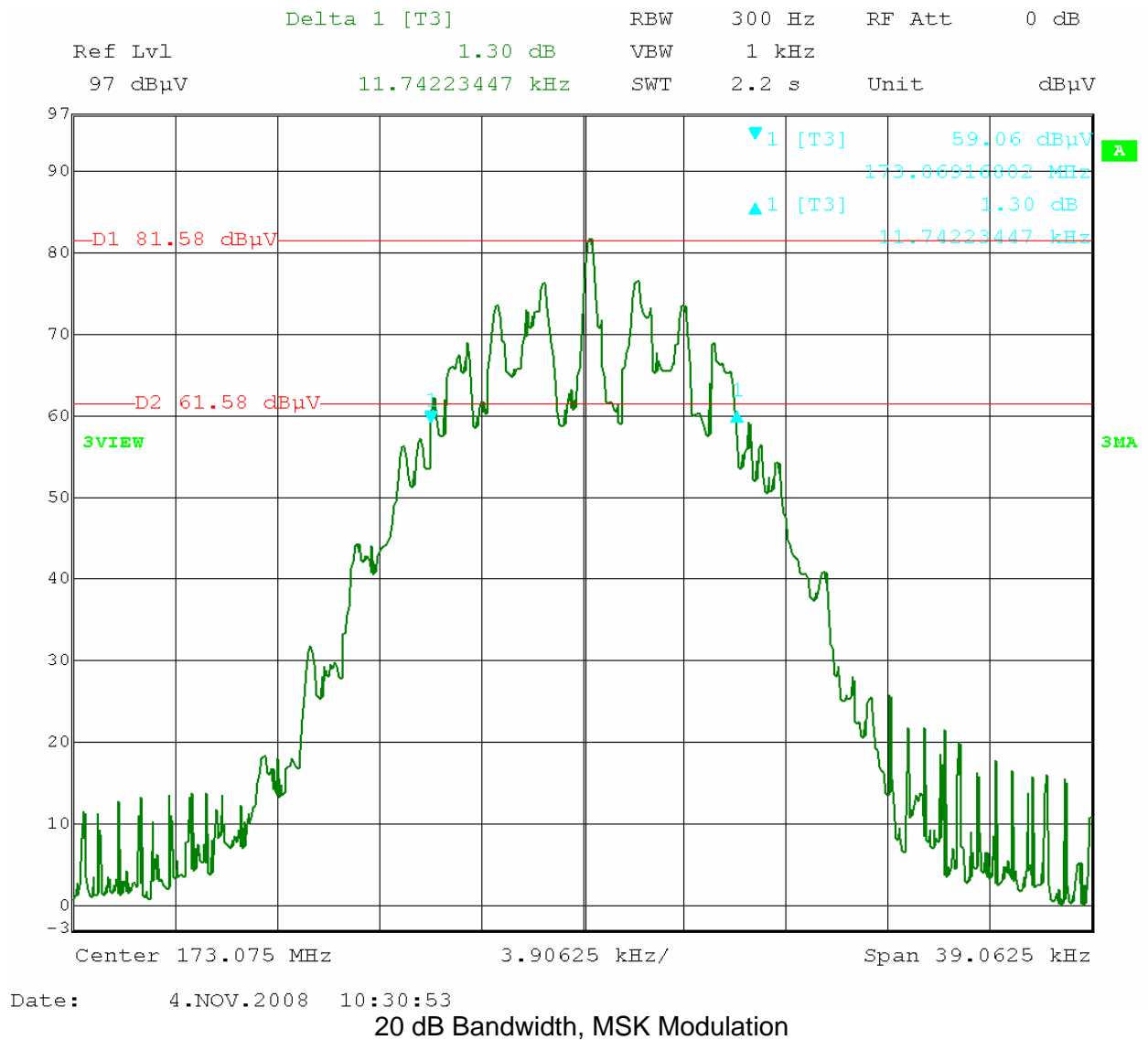
Test Equipment Used:

| TEST EQUIPMENT LIST | | | | | |
|---------------------|------------------------------------|------------------|-----------|------------|---------------|
| Item | Equipment Type | Make | Model No. | Serial No. | Next Cal. Due |
| 1 | Spectrum Analyzer 20Hz - 40 GHz | Rohde & Schwartz | FSEK-30 | 100225 | 11/26/2008 |

Test Details:

Notes: The 20 dB bandwidth is 1.14 kHz for FSK modulation and 11.74 kHz for MSK modulation. 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 Part 90

Test: Emissions Masks

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 $83 \cdot \log(f/5)$ 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 $29 \cdot \log(f^2/11)$, whichever is the lesser attenuation.

Test Environment:

| | | | | | | |
|--|---------------------|----------------------|-----------------------|----------------------|-----------------|-------------------------|
| Environmental Conditions During Testing: | Ambient (°C): | 19 | Humidity (%): | 39 | Pressure (hPa): | 1018 |
| Pretest Verification Performed | Yes | | Equipment under Test: | VLU7-SP | | |
| Test Engineer(s): | Nicholas Abbondante | | EUT Serial Number: | 7 | | |
| Engineer's Initials: | NNA | Date Test Performed: | 11-04-2008 | Reviewer's Initials: | Jo | Date Reviewed: 11/14/08 |

Test Equipment Used:

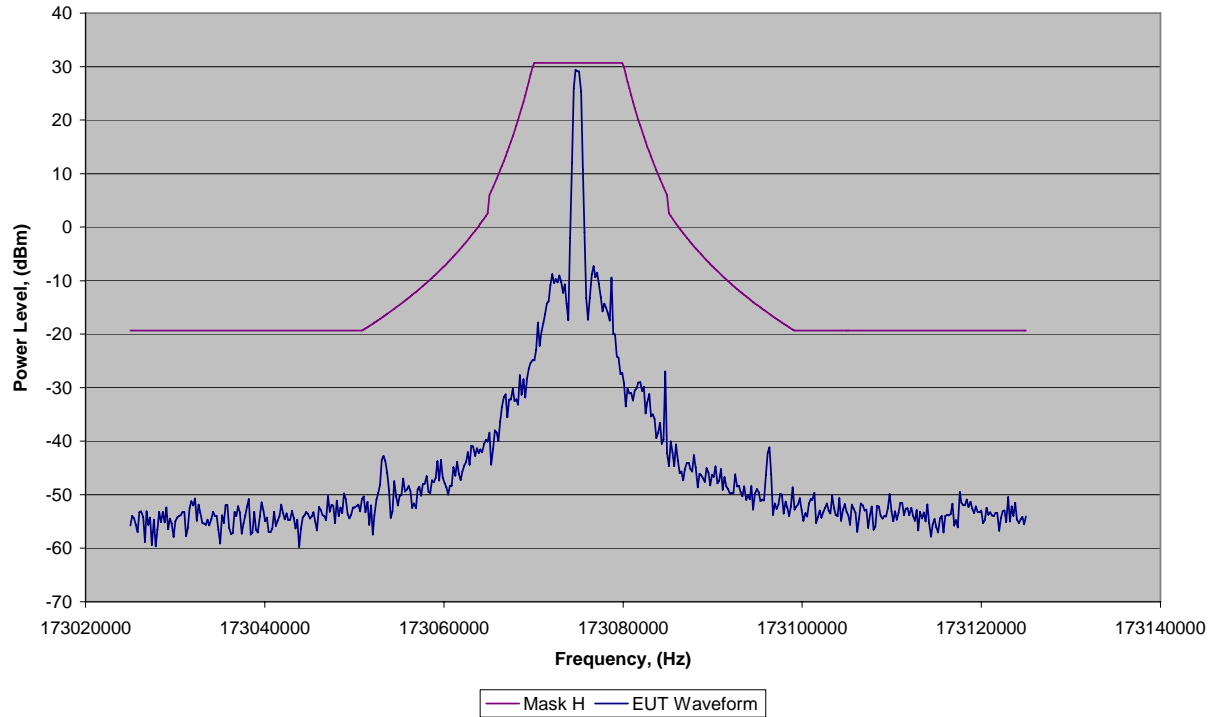
| TEST EQUIPMENT LIST | | | | | |
|---------------------|---------------------------------|------------------|---------------|-------------|---------------|
| Item | Equipment Type | Make | Model No. | Serial No. | Next Cal. Due |
| 1 | 4 Line Digital Barometer * | Mannix | 0ABA116 | SAF291 | 01/30/2009 |
| 2 | Spectrum Analyzer 20Hz - 40 GHz | Rohde & Schwartz | FSEK-30 | 100225 | 11/26/2008 |
| 3 | 10W, 30dB Attenuator | Weinschel Corp | 47-30-34 | BD43291 | 10/15/2009 |
| 4 | 40 GHz Cable | Megaphase | TM40-K1K1-197 | 7030801 002 | 06/05/2009 |

Software Utilized:

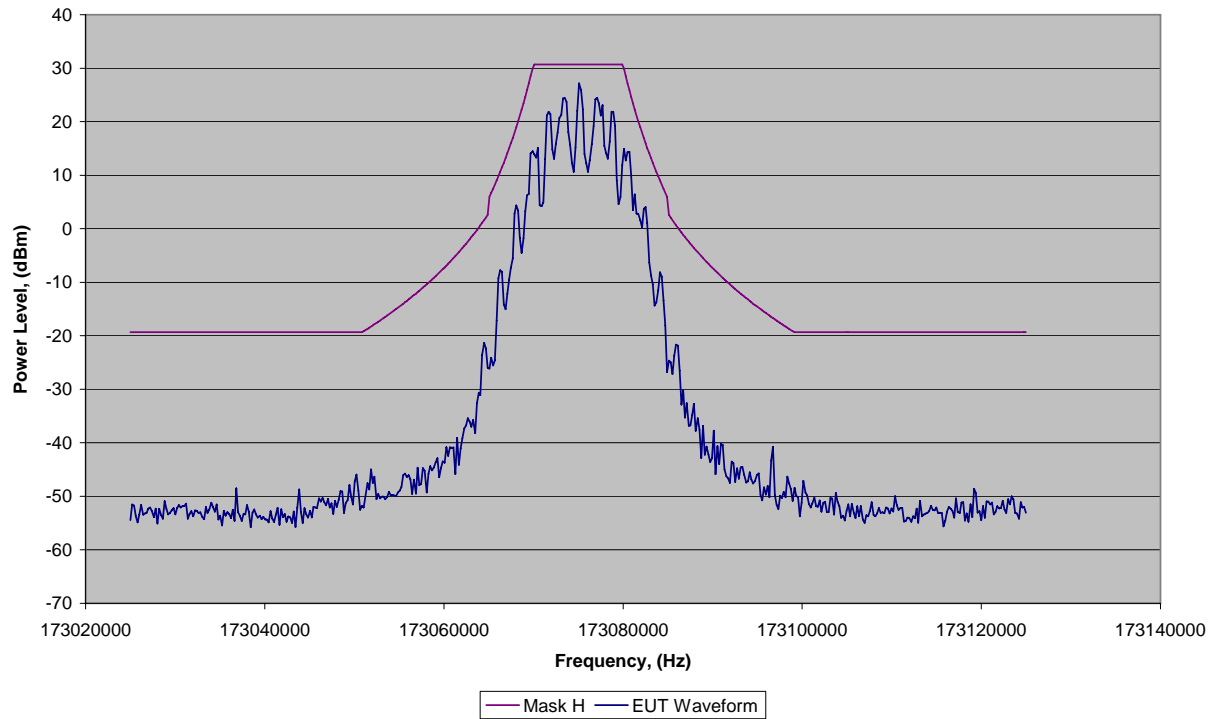
| Name | Manufacturer | Version |
|------------|-----------------------|---------------|
| EXCEL 2000 | Microsoft Corporation | 9.0.6926 SP-3 |

Test Details:

Emissions Mask C FSK Modulation



Emissions Mask C MSK Modulation



Test Results: Pass

Test Standard: FCC Part 90

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.
t₁ is the time period immediately following t_{on}.
t₂ is the time period immediately following t₁.
t₃ 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 t₁ and t₃ may exceed the maximum frequency difference limit for those periods.

Test Environment:

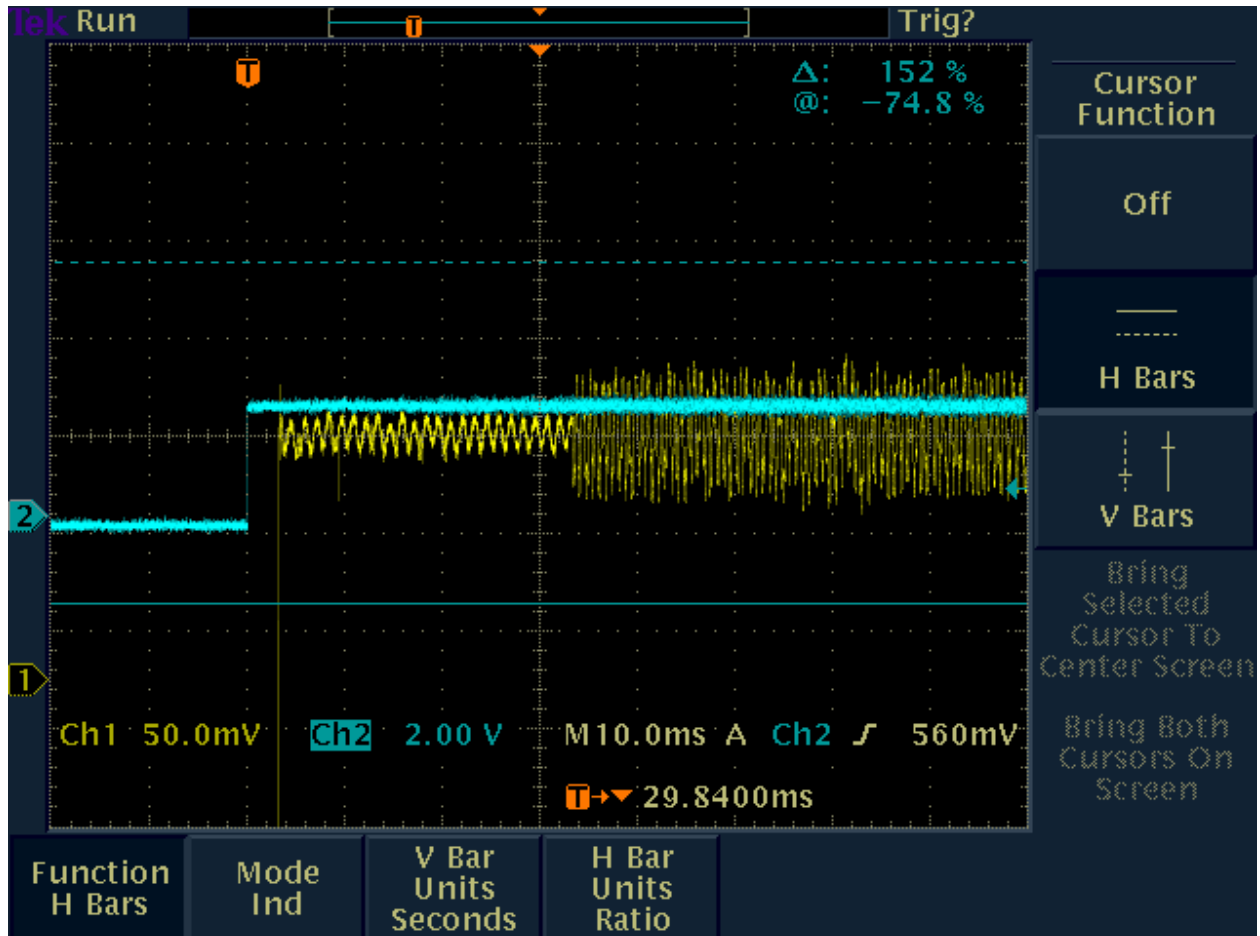
| | | | | | | |
|--|---------------------|-----------------------|--------------------|----------------------|-----------------|-------------------------|
| Environmental Conditions During Testing: | Ambient (°C): | 19 | Humidity (%): | 39 | Pressure (hPa): | 1018 |
| Pretest Verification Performed | Yes | Equipment under Test: | | VLU7-SP | | |
| Test Engineer(s): | Nicholas Abbondante | | EUT Serial Number: | 7 | | |
| Engineer's Initials: | NNA | Date Test Performed: | 11-04-2008 | Reviewer's Initials: | JG | Date Reviewed: 11/14/08 |

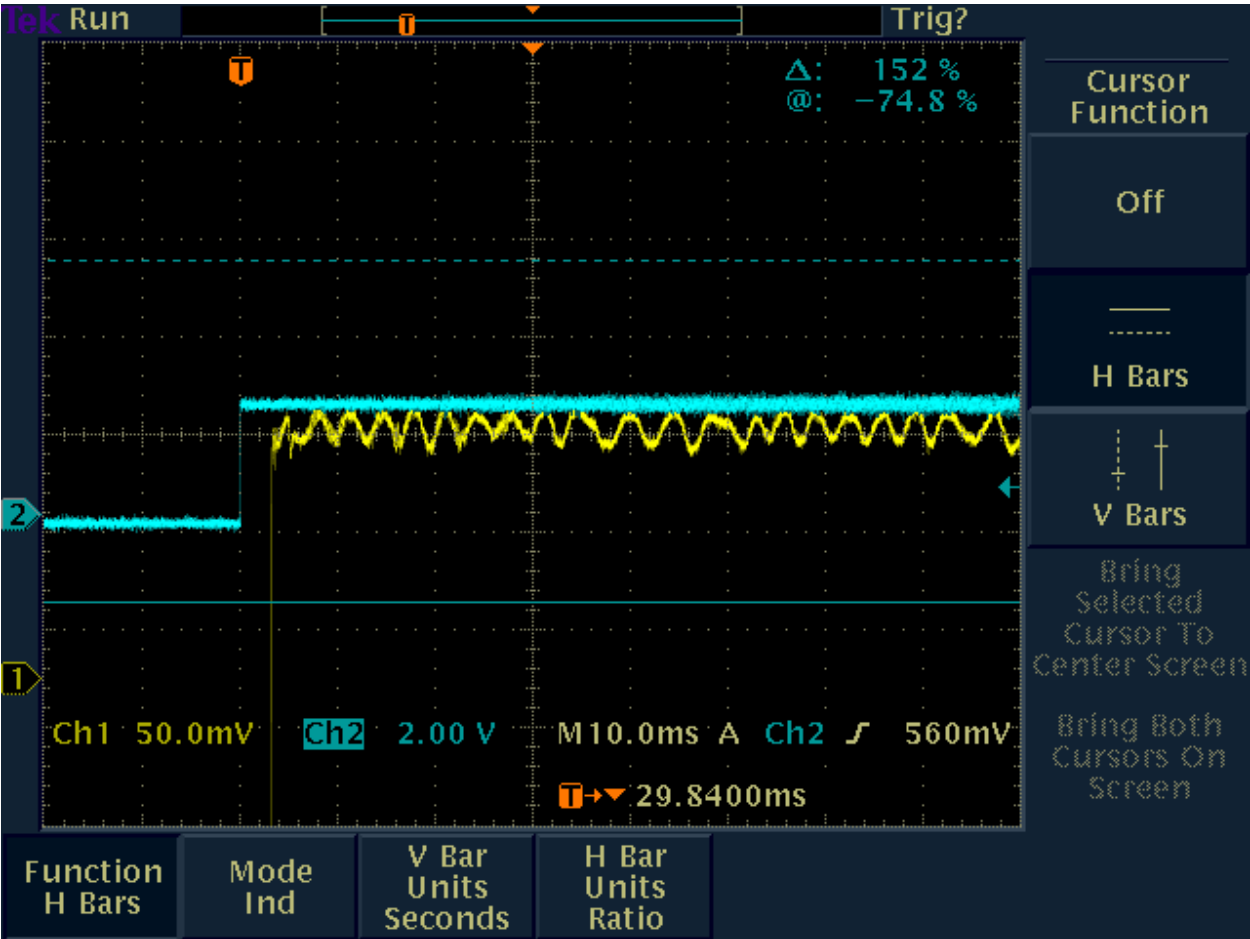
Test Equipment Used:

| TEST EQUIPMENT LIST | | | | | |
|---------------------|-------------------------------|-----------------|-----------|------------|---------------|
| Item | Equipment Type | Make | Model No. | Serial No. | Next Cal. Due |
| 1 | 4 Line Digital Barometer * | Mannix | 0ABA116 | SAF291 | 01/30/2009 |
| 2 | Oscilloscope, Digital Storage | Tektronix | TDS3052 | B014809 | 03/21/2009 |
| 3 | Measuring Receiver | Hewlett Packard | 8902A | 3749A04397 | 04/04/2009 |
| 4 | Generator, Signal | Hewlett Packard | 8648B | 3537A01040 | 06/30/2009 |

Test Details:

Notes: The upper and lower bounds were set using a signal generator. The blue trace is the trigger, at which point the transmitter will irrevocably turn on. The horizontal cursors correspond to ± 12.5 kHz from the nominal frequency, 173.075 MHz.





FSK Modulation



Test Results: Pass

Test Standard: FCC Part 90

Test: On Time

Performance Criterion: On time must not exceed 400 ms over the period of 1 second when the transmitter is in active mode. On time must not exceed 400 ms over the period of 10 seconds when the transmitter is not in active mode. In uplink mode, on time must not exceed 7200 ms over the period of 300 seconds.

Test Environment:

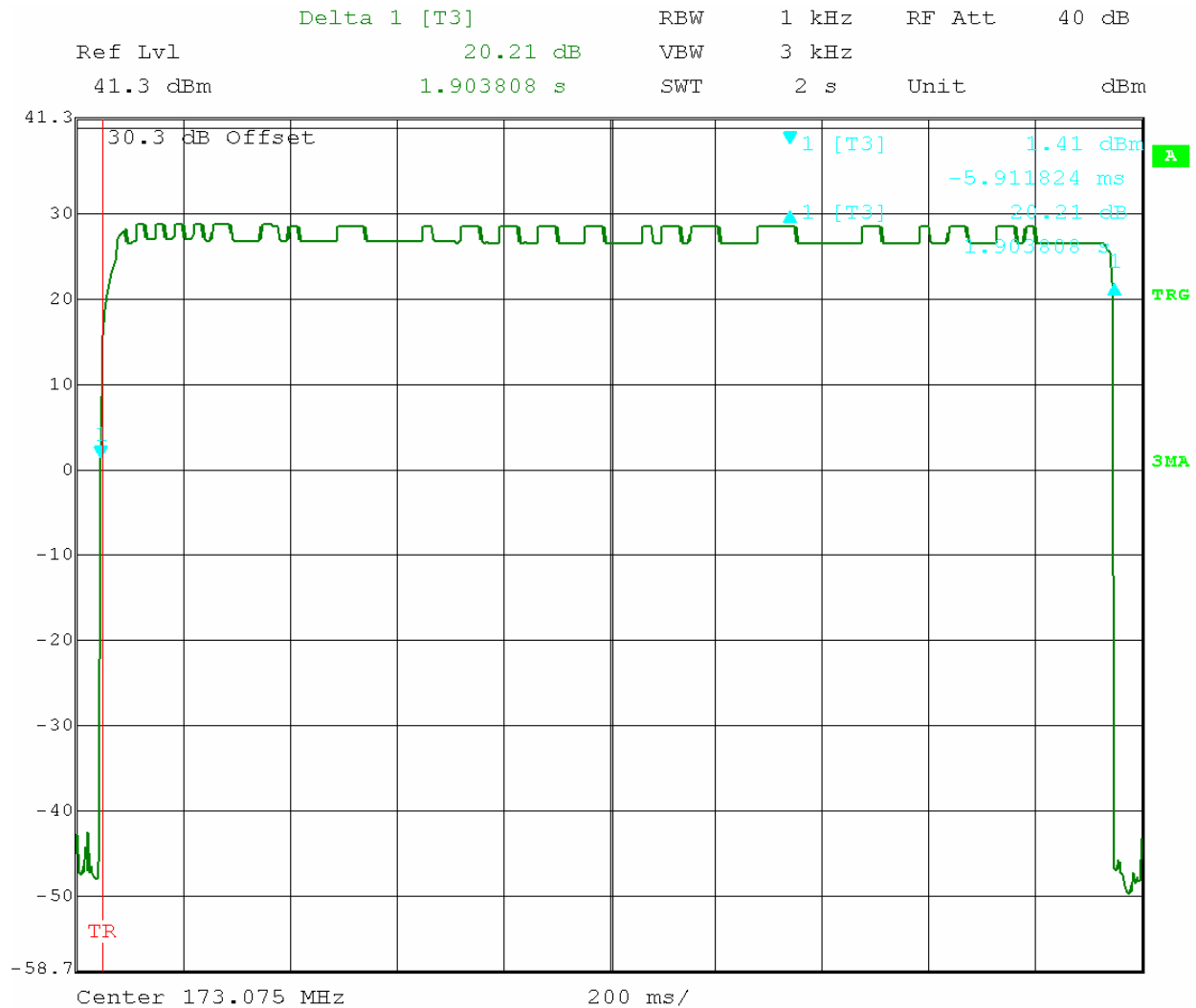
| | | | | | | | |
|--|---------------------|----------------------|------------|-----------------------|----|-----------------|----------|
| Environmental Conditions During Testing: | | Ambient (°C): | 19 | Humidity (%): | 39 | Pressure (hPa): | 1018 |
| Pretest Verification Performed | | Yes | | Equipment under Test: | | VLU7-SP | |
| Test Engineer(s): | Nicholas Abbondante | | | EUT Serial Number: | | 7 | |
| Engineer's Initials: | NNA | Date Test Performed: | 11-04-2008 | Reviewer's Initials: | JO | Date Reviewed: | 11/14/08 |

Test Equipment Used:

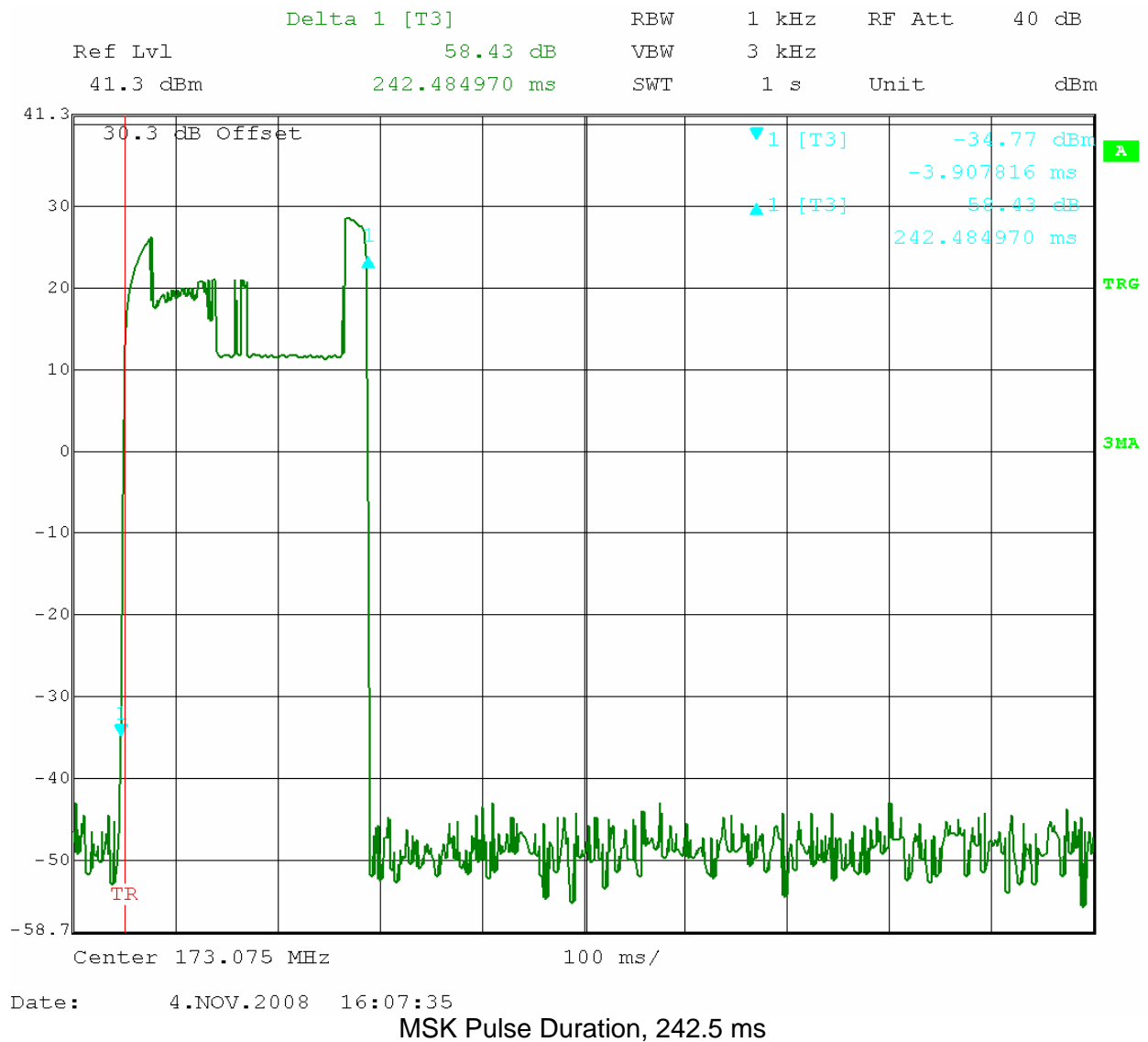
| TEST EQUIPMENT LIST | | | | | |
|---------------------|---------------------------------|------------------|---------------|-------------|---------------|
| Item | Equipment Type | Make | Model No. | Serial No. | Next Cal. Due |
| 1 | 4 Line Digital Barometer | Mannix | 0ABA116 | SAF291 | 01/30/2009 |
| 2 | Spectrum Analyzer 20Hz - 40 GHz | Rohde & Schwartz | FSEK-30 | 100225 | 11/26/2008 |
| 3 | 10W, 30dB Attenuator | Weinschel Corp | 47-30-34 | BD43291 | 10/15/2009 |
| 4 | 40 GHz Cable | Megaphase | TM40-K1K1-197 | 7030801 002 | 06/05/2009 |

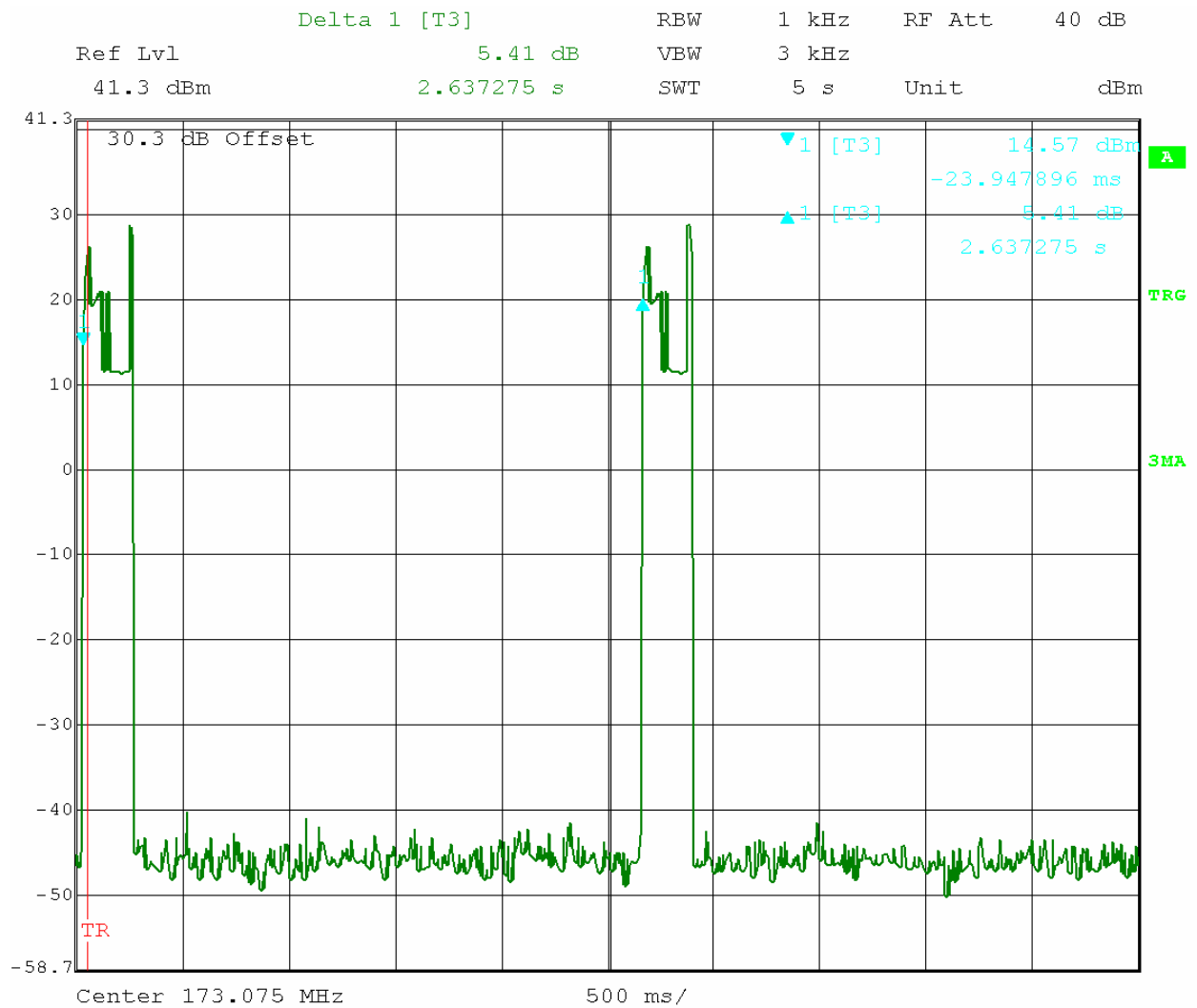
Test Details:

Notes: MSK modulation pulse duration is 242.5 ms. MSK modulation pulse intervals in active mode are 2.637 seconds long. This meets the requirement of not more than 400 ms of on time in any 1 second period in active mode. The transmitter only transmits when instructed to go into active mode or in tower uplink mode. In tower uplink mode (FSK modulation), pulse duration is 1904 ms, and LoJack attests that uplink transmissions do not occur more than once in a 300 second time frame.



Date: 4.NOV.2008 16:00:46
FSK Modulation Pulse Duration, 1904 ms





Date: 4.NOV.2008 16:10:55
 MSK Pulse Interval, 2.637 seconds



Test Results: Pass

Test Standard: FCC Part 90

Test: Frequency Stability

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

Test Environment:

| | | | | | | |
|--|---------------------|----------------------|-----------------------|----------------------|-----------------|-------------------------|
| Environmental Conditions During Testing: | Ambient (°C): | N/A | Humidity (%): | N/A | Pressure (hPa): | N/A |
| Pretest Verification Performed | Yes | | Equipment under Test: | VLU7-SP, VLU7-VP | | |
| Test Engineer(s): | Nicholas Abbondante | | EUT Serial Number: | 8, 10 | | |
| Engineer's Initials: | NNA | Date Test Performed: | 11-05-2008 | Reviewer's Initials: | JG | Date Reviewed: 11/14/08 |

Test Equipment Used:

| TEST EQUIPMENT LIST | | | | | |
|---------------------|-----------------------|-----------------|--------------|----------------|---------------|
| Item | Equipment Type | Make | Model No. | Serial No. | Next Cal. Due |
| 1 | Temp/Humidity Chamber | Envirotronics | SH27C | 08015563S11263 | 03/18/2009 |
| 2 | 40 GHz Cable | Megaphase | TM40-K1K1-80 | 7030802 002 | 06/05/2009 |
| 3 | Spectrum Analyzer | Hewlett Packard | 8591E | 3308A01445 | 02/15/2009 |
| 4 | 10W, 30dB Attenuator | Weinschel Corp | 47-30-34 | BD43291 | 10/15/2009 |

Software Utilized:

| Name | Manufacturer | Version |
|----------------|-----------------------|------------------|
| EXCEL 2000 | Microsoft Corporation | 9.0.6926 SP-3 |
| EMI BOXBOROUGH | Intertek | 3/07/07 Revision |

Test Details:

Notes: The VLU7-VP is powered directly from the car battery through one regulator and therefore 13.8 VDC was used as a nominal voltage for frequency stability over voltage variations. The VLU7-SP is powered internally by an ~7 Volt battery and a 3.3 Volt battery. When transmissions are occurring, the 7 Volt line drops consistently to 6.1V. Therefore frequency stability over voltage variations was performed on the two different regulators at the appropriate voltage for each, using 6.1 and 3.3 VDC as a nominal voltage for voltage variations.



Frequency Stability

Company: LoJack Corporation

Model #: VLU7-SP

Serial #: 8

Engineer(s): Nicholas Abbondante

Project #: 3161283

Standard: FCC Part 90

Test Equipment Used:

148012 WEI13

SA0001

MEG004

147239

Location: Littleton

Date(s): 11/05/08

Limit: 50 PPM

Nominal f: 173.075 MHz

Voltage: 6.1 VDC

| % | Voltage Volts | Frequency MHz | Deviation kHz | Limit kHz |
|------|------------------|------------------|------------------|-----------|
| -15% | 5.185 | 173.075537 | 0.011 | 8.65 |
| -10% | 5.49 | 173.075685 | 0.159 | 8.65 |
| -5% | 5.795 | 173.075709 | 0.183 | 8.65 |
| +0% | 6.1 | 173.075526 | 0 | 8.65 |
| +5% | 6.405 | 173.075487 | -0.039 | 8.65 |
| +10% | 6.71 | 173.075454 | -0.072 | 8.65 |
| +15% | 7.015 | 173.075410 | -0.116 | 8.65 |

| Temp Celsius | Frequency MHz | Deviation kHz | Limit kHz |
|-----------------|------------------|------------------|-----------|
| -30 | 173.075171 | -0.791 | 8.65 |
| -20 | 173.076026 | 0.064 | 8.65 |
| -10 | 173.076460 | 0.498 | 8.65 |
| 0 | 173.076536 | 0.574 | 8.65 |
| 10 | 173.076334 | 0.372 | 8.65 |
| 20 | 173.075962 | 0 | 8.65 |
| 30 | 173.075460 | -0.502 | 8.65 |
| 40 | 173.074976 | -0.986 | 8.65 |
| 50 | 173.075016 | -0.946 | 8.65 |

Voltage: 3.3 VDC

| % | Voltage Volts | Frequency MHz | Deviation kHz | Limit kHz |
|------|------------------|------------------|------------------|-----------|
| -15% | 2.805 | 173.075450 | -0.065 | 8.65 |
| -10% | 2.97 | 173.075496 | -0.019 | 8.65 |
| -5% | 3.135 | 173.075519 | 0.004 | 8.65 |
| +0% | 3.3 | 173.075515 | 0 | 8.65 |
| +5% | 3.465 | 173.075432 | -0.083 | 8.65 |
| +10% | 3.63 | 173.075390 | -0.125 | 8.65 |
| +15% | 3.795 | 173.075349 | -0.166 | 8.65 |



Frequency Stability

Company: LoJack Corporation

Model #: VLU7-VP

Serial #: 10

Engineer(s): Nicholas Abbondante

Project #: 3161283

Standard: FCC Part 90

Test Equipment Used:

148012 WEI13

SA0001

MEG004

147239

Location: Littleton

Date(s): 11/05/08

Limit:

50 PPM

Nominal f:

173.075 MHz

Voltage:

13.8 VDC

| % | Voltage Volts | Frequency MHz | Deviation kHz | Limit kHz |
|------|------------------|------------------|------------------|-----------|
| -15% | 11.73 | 173.074490 | 0.042 | 8.65 |
| -10% | 12.42 | 173.074563 | 0.115 | 8.65 |
| -5% | 13.11 | 173.074732 | 0.284 | 8.65 |
| +0% | 13.8 | 173.074448 | 0 | 8.65 |
| +5% | 14.49 | 173.074426 | -0.022 | 8.65 |
| +10% | 15.18 | 173.074409 | -0.039 | 8.65 |
| +15% | 15.87 | 173.074364 | -0.084 | 8.65 |




Test Results: Pass

Test Standard: FCC Part 90

Test: Radiated Emissions

Performance Criterion: Spurious emissions must not exceed -13 dBm.

Test Environment:

| | | | | | | | |
|--|-----|----------------------------------|------------|-----------------------|---|------------------|----------|
| Environmental Conditions During Testing: | | Ambient (°C): | 20 | Humidity (%): | 34 | Pressure (hPa): | 1026 |
| Pretest Verification Performed | | Yes | | Equipment under Test: | | VLU7-SP, VLU7-VP | |
| Test Engineer(s): | | Vathana Ven, Nicholas Abbondante | | EUT Serial Number: | | 7, 9 | |
| Engineer's Initials: | VFV | Date Test Performed: | 11-03-2008 | Reviewer's Initials: |  | Date Reviewed: | 11/14/08 |

Test Equipment Used:

| TEST EQUIPMENT LIST | | | | | |
|---------------------|------------------------------------|-------------------|---------------|-------------|---------------|
| Item | Equipment Type | Make | Model No. | Serial No. | Next Cal. Due |
| 1 | Digital 4 Line Barometer | Mannix | 0ABA116 | BAR1 | 06/01/2009 |
| 2 | Synthesized Sweep Generator | Hewlett Packard | 83620A | 3213A01244 | 02/06/2009 |
| 3 | 40 GHz Cable | Megaphase | TM40-K1K1-80 | 7030802 002 | 06/05/2009 |
| 4 | BROADBAND ANTENNA | Compliance Design | B100 | 1649 | 10/14/2009 |
| 5 | BROADBAND ANTENNA | Compliance Design | B200 | 1650 | 10/02/2009 |
| 6 | BROADBAND ANTENNA | Compliance Design | B300 | 00668 | 10/02/2009 |
| 7 | HORN ANTENNA | EMCO | 3115 | 9602-4675 | 10/13/2009 |
| 8 | Spectrum Analyzer 20Hz - 40 GHz | Rohde & Schwartz | FSEK-30 | 100225 | 11/26/2008 |
| 9 | 40GHz Cable | Megaphase | TM40-K1K1-197 | 7030801 001 | 06/05/2009 |
| 10 | 40 GHz Cable | Megaphase | TM40-K1K1-197 | 7030801 002 | 06/05/2009 |
| 11 | 10 Meter in floor cable for site 2 | ITS | RG214B/U | S2 10M FLR | 09/23/2009 |
| 12 | ANTENNA | EMCO | 3142 | 9711-1223 | 02/22/2009 |
| 13 | HORN ANTENNA | EMCO | 3115 | 22023 | 04/02/2009 |

Software Utilized:

| Name | Manufacturer | Version |
|----------------|-----------------------|------------------|
| EXCEL 2000 | Microsoft Corporation | 9.0.6926 SP-3 |
| EMI BOXBOROUGH | Intertek | 3/07/07 Revision |

Test Results:

| Radiated Emissions, Substitution | | | | | | | | | | | |
|--|------|-----------------------------|-------------------|---|------------------|----------|----------------------------|------------------------------|------------------|--------|------------|
| Company: LoJack Corporation | | | | | | | Rx Antenna: LOG2 | | EMC-54 | | |
| Model #: VLU7-SP | | | | | | | Rx Cable(s): S2 10M FLR | | MEG001 | | MEG002 |
| Serial #: 7 | | | | | | | Rx Preamp: NONE | | Receiver: ROS001 | | |
| Engineer(s): Nicholas Abbondante | | | Vathana Ven | | Location: Site 2 | | Tx Antenna: ANT1A,B,C | | HORN2 | | |
| Project #: 3161283 | | | Date(s): 11/03/08 | | | | Tx Cable(s): MEG004 | | | | |
| Standard: FCC Part 90 | | | | | | | Tx Signal Generator: HEW62 | | | | |
| Barometer: BAR1 | | Temp/Humidity/Pressure: 20c | | 34% | | 1026mB | | ERP or EIRP?: ERP | | | |
| Test Distance (m): 10 & 3 | | | | Voltage/Frequency: Fresh 3.3 and 6V batteries | | | | Frequency Range: 30-1800 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 | Ant. | Frequency | EUT | Generator | Transmit | Transmit | Generator | Net | Limit | Margin | Bandwidth |
| Type | Pol. | (V/H) | Reading | Reading | Cable | Antenna | Level | dBm | dBm | dB | |
| | | MHz | dB(uV) | dB(uV) | Loss dB | dBi | dBm | | | | |
| Note: FSK Modulation | | | | | | | | | | | |
| PK | V | 173.075 | 104.6 | 73.3 | 0.3 | -2.3 | 0.0 | 26.5 | 34.0 | -7.5 | 100/300kHz |
| Note: MSK Modulation | | | | | | | | | | | |
| PK | V | 173.075 | 103.8 | 73.3 | 0.3 | -2.3 | 0.0 | 25.8 | 34.0 | -8.2 | 100/300kHz |
| PK | V | 346.159 | 53.3 | 65.7 | 0.4 | -0.8 | 0.0 | -15.8 | -13.0 | -2.8 | 100/300kHz |
| PK | V | 435.872 | 23.6 | 67.2 | 0.5 | 1.4 | 0.0 | -44.9 | -13.0 | -31.9 | 100/300kHz |
| PK | V | 519.228 | 53.0 | 66.5 | 0.5 | 1.0 | 0.0 | -15.2 | -13.0 | -2.2 | 100/300kHz |
| PK | V | 692.315 | 25.0 | 50.5 | 0.6 | 2.0 | 0.0 | -26.3 | -13.0 | -13.3 | 100/300kHz |
| PK | V | 865.375 | 23.0 | 61.2 | 0.7 | 0.9 | 0.0 | -40.2 | -13.0 | -27.2 | 100/300kHz |
| PK | V | 1006.713 | 38.6 | 93.5 | 0.8 | 4.9 | 0.0 | -53.0 | -13.0 | -40.0 | 1/3MHz |
| PK | H | 1038.570 | 60.0 | 101.8 | 0.8 | 4.9 | 0.0 | -39.9 | -13.0 | -26.9 | 1/3MHz |
| PK | H | 1211.552 | 59.9 | 96.2 | 0.8 | 4.9 | 0.0 | -34.4 | -13.0 | -21.4 | 1/3MHz |
| PK | H | 1384.720 | 59.0 | 101.4 | 0.9 | 8.6 | 0.0 | -36.9 | -13.0 | -23.9 | 1/3MHz |
| PK | H | 1557.723 | 50.2 | 101.1 | 0.9 | 8.6 | 0.0 | -45.4 | -13.0 | -32.4 | 1/3MHz |
| PK | H | 1730.810 | 47.0 | 93.1 | 1.0 | 8.6 | 0.0 | -40.7 | -13.0 | -27.7 | 1/3MHz |
| Note: FSK Modulation | | | | | | | | | | | |
| PK | V | 346.152 | 52.0 | 65.0 | 0.4 | -0.8 | 0.0 | -16.4 | -13.0 | -3.4 | 100/300kHz |
| PK | V | 435.872 | 23.0 | 67.2 | 0.5 | 1.4 | 0.0 | -45.5 | -13.0 | -32.5 | 100/300kHz |
| PK | V | 519.233 | 52.5 | 66.8 | 0.5 | 1.0 | 0.0 | -16.0 | -13.0 | -3.0 | 100/300kHz |
| PK | V | 692.332 | 24.4 | 50.5 | 0.6 | 2.0 | 0.0 | -26.9 | -13.0 | -13.9 | 100/300kHz |
| PK | V | 865.375 | 23.7 | 61.2 | 0.7 | 0.9 | 0.0 | -39.5 | -13.0 | -26.5 | 100/300kHz |
| PK | H | 1006.713 | 35.0 | 93.5 | 0.8 | 4.9 | 0.0 | -56.6 | -13.0 | -43.6 | 1/3MHz |
| PK | H | 1038.534 | 60.0 | 101.8 | 0.8 | 4.9 | 0.0 | -39.9 | -13.0 | -26.9 | 1/3MHz |
| PK | H | 1211.512 | 62.8 | 96.2 | 0.8 | 4.9 | 0.0 | -31.5 | -13.0 | -18.5 | 1/3MHz |
| PK | H | 1384.604 | 60.9 | 101.4 | 0.9 | 8.6 | 0.0 | -35.0 | -13.0 | -22.0 | 1/3MHz |
| PK | H | 1557.696 | 54.3 | 101.2 | 0.9 | 8.6 | 0.0 | -41.4 | -13.0 | -28.4 | 1/3MHz |
| PK | H | 1730.810 | 45.5 | 93.1 | 1.0 | 8.6 | 0.0 | -42.2 | -13.0 | -29.2 | 1/3MHz |



Radiated Emissions, Substitution

Company: LoJack Corporation
Model #: VLU7-VP
Serial #: 9

Engineer(s): Nicholas Abbondante Vathana Ven Location: Site 2
Project #: 3161283 Date(s): 11/04/08
Standard: FCC Part 90

Barometer: BAR1 Temp/Humidity/Pressure: 20c 34% 1026mB

Test Distance (m): 10 & 3 Voltage/Frequency: Fresh 3.3 and 6V batteries Frequency Range: 30-1800 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

Rx Antenna: LOG2 EMC-54
Rx Cable(s): S2 10M FLR MEG001 MEG002
Rx Preamp: NONE Receiver: ROS001
Tx Antenna: ANT1A,B,C HORN2
Tx Cable(s): MEG004
Tx Signal Generator: HEW62
ERP or EIRP?: ERP

| 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 | Net dBm | Limit dBm | Margin dB | Bandwidth |
|----------------------|-----------------|---------------|--------------------|--------------------------|------------------------|----------------------|---------------------|---------|-----------|-----------|------------|
| Note: MSK Modulation | | | | | | | | | | | |
| PK | V | 173.075 | 104.3 | 72.2 | 0.3 | -2.3 | 0.0 | 27.3 | 34.0 | -6.7 | 100/300kHz |
| PK | V | 346.159 | 51.0 | 67.4 | 0.4 | -0.8 | 0.0 | -19.8 | -13.0 | -6.8 | 100/300kHz |
| PK | V | 435.833 | 21.5 | 65.8 | 0.5 | 1.4 | 0.0 | -45.6 | -13.0 | -32.6 | 100/300kHz |
| PK | V | 519.224 | 51.5 | 66.8 | 0.5 | 1.0 | 0.0 | -17.0 | -13.0 | -4.0 | 100/300kHz |
| PK | H | 692.307 | 25.5 | 64.5 | 0.6 | 2.0 | 0.0 | -39.8 | -13.0 | -26.8 | 100/300kHz |
| PK | V | 865.375 | 23.7 | 53.0 | 0.7 | 0.9 | 0.0 | -31.3 | -13.0 | -18.3 | 100/300kHz |
| PK | V | 1006.691 | 39.0 | 95.0 | 0.8 | 4.9 | 0.0 | -54.1 | -13.0 | -41.1 | 1/3MHz |
| PK | H | 1038.456 | 58.8 | 99.4 | 0.8 | 4.9 | 0.0 | -38.7 | -13.0 | -25.7 | 1/3MHz |
| PK | H | 1211.552 | 59.0 | 95.1 | 0.8 | 4.9 | 0.0 | -34.2 | -13.0 | -21.2 | 1/3MHz |
| PK | H | 1384.600 | 58.5 | 101.9 | 0.9 | 8.6 | 0.0 | -37.9 | -13.0 | -24.9 | 1/3MHz |
| PK | H | 1557.690 | 52.4 | 101.2 | 0.9 | 8.6 | 0.0 | -43.3 | -13.0 | -30.3 | 1/3MHz |
| PK | H | 1730.810 | 47.0 | 93.6 | 1.0 | 8.6 | 0.0 | -41.2 | -13.0 | -28.2 | 1/3MHz |
| Note: FSK Modulation | | | | | | | | | | | |
| PK | V | 173.098 | 102.9 | 72.2 | 0.3 | -2.3 | 0.0 | 25.9 | 34.0 | -8.1 | 100/300kHz |
| PK | V | 346.152 | 49.5 | 67.4 | 0.4 | -0.8 | 0.0 | -21.3 | -13.0 | -8.3 | 100/300kHz |
| PK | V | 435.872 | 20.6 | 65.8 | 0.5 | 1.4 | 0.0 | -46.5 | -13.0 | -33.5 | 100/300kHz |
| PK | V | 519.234 | 49.8 | 66.8 | 0.5 | 1.0 | 0.0 | -18.7 | -13.0 | -5.7 | 100/300kHz |
| PK | V | 692.313 | 24.2 | 57.9 | 0.6 | 2.0 | 0.0 | -34.5 | -13.0 | -21.5 | 100/300kHz |
| PK | V | 865.375 | 23.7 | 53.0 | 0.7 | 0.9 | 0.0 | -31.3 | -13.0 | -18.3 | 100/300kHz |
| PK | V | 1006.713 | 37.0 | 94.5 | 0.8 | 4.9 | 0.0 | -55.6 | -13.0 | -42.6 | 1/3MHz |
| PK | H | 1038.458 | 55.8 | 99.4 | 0.8 | 4.9 | 0.0 | -41.7 | -13.0 | -28.7 | 1/3MHz |
| PK | H | 1211.546 | 60.5 | 95.1 | 0.8 | 4.9 | 0.0 | -32.7 | -13.0 | -19.7 | 1/3MHz |
| PK | H | 1384.640 | 60.0 | 101.9 | 0.9 | 8.6 | 0.0 | -36.4 | -13.0 | -23.4 | 1/3MHz |
| PK | H | 1557.696 | 58.0 | 101.2 | 0.9 | 8.6 | 0.0 | -37.7 | -13.0 | -24.7 | 1/3MHz |
| PK | H | 1730.810 | 44.5 | 93.6 | 1.0 | 8.6 | 0.0 | -43.7 | -13.0 | -30.7 | 1/3MHz |

Noise Floor

Noise Floor