Washington Laboratories, Ltd

FCC / Industry Canada Certification Test Report

JLG INDUSTRIES, INC

RFID KEYPAD

WLL REPORT# **15748-01 Rev 3**
October 22, 2018
Re-issued November 8, 2018

FCC ID: 2ADCD1001242423

IC ID: 244141001242423

Prepared for:
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FCC / Industry Canada Certification Test Report

For the

JLG INDUSTRIES INC.

RFID KEYPAD

FCC ID: 2ADCD1001242423

IC ID: 244141001242423

WLL REPORT# **15748-01 Rev 3**
October 18, 2018
Re-issued November 8, 2018

Prepared by:

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EMC Compliance Engineer

Reviewed by:

Mike Violette
CEO

Abstract

This report has been prepared on behalf of JLG Industries Inc to support the attached Application for Equipment Authorization. The test report and application are submitted for an Intentional Radiator under Part 15.225 of the FCC Rules and Regulations and Industry Canada RSS1210. This Certification Test Report documents the test configuration and test results for the RFID Keypad unit.

Testing was performed on an Open Area Test Site (OATS) of Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory.

These tests are accredited and meet the requirements of ISO/IEC 17025 as verified by the ANSI-ASQ National Accreditation Board/ANAB. Refer to certificate and scope of accreditation AT-1448.

The RFID Keypad complies with the limits for an Intentional Radiator device under FCC Part 15.225 and Industry Canada RSS 210.

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Revision History	Reason	Date
Rev 0	Initial Release	September 27, 2018
Rev 1	Updated to address reviewers' comments	October 22, 2018
Rev 2	Updated to address reviewers' comments	November 8, 2018

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1.1 Compliance Statement

The RFID Keypad complies with the limits for an Intentional Radiator device under FCC Part 15.225 (10/2010) and Industry Canada RSS 210 (Issue 9).

1.2 Test Scope Summary

Tests for radiated and conducted emissions were performed. All measurements were performed in accordance with the 2013 version of ANSI C63.10. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

Test Specification	Specific Description	Date Completed	Result	Modifications (Y/N)
CFR47 Part 15.209, RSS Gen section 7.2.5	Class B Radiated Emissions	8/29/2018	Complied	No
RSS Gen section 6	Receiver Spurious Emissions	8/29/2018	Complied	No
CFR47 Part 15.225, RSS 210 section A2.6	Field Strength	8/29/2018	Complied	No
CFR47 Part 15.225, RSS GEN section 4.7	Frequency Stability	9/13/2018	Complied	No
CFR47 Part 2.1049	Occupied Bandwidth	9/5/2018	Complied	No

1.3 Contract Information

Customer:	JLG Industries, Inc 1 JLG Dr McConnellsburg, PA 17233
Purchase Order Number:	P394788
Quotation Number:	70702B

1.4 Test Dates

Testing was performed on the following date(s):	8/27/2018 – 9/13/2018

1.5 Test and Support Personnel

Washington Laboratories, LTD	Nikolas Allen
Customer Representative	Patrick Booth

1.6 Abbreviations

A	**A**mpere
ac	**a**lternating **c**urrent
AM	Amplitude Modulation
Amps	**Amp**eres
b/s	**b**its per **s**econd
BW	**B**and**W**idth
CE	**C**onducted **E**mission
cm	**C**enti**m**eter
CW	**C**ontinuous **W**ave
dB	**d**eci**B**el
dc	**d**irect **c**urrent
EMI	**E**lectro**m**agnetic **I**nterference
EUT	**E**quipment **U**nder **T**est
FM	**F**requency **M**odulation
G	**g**iga - prefix for 10^9 multiplier
Hz	**H**ertz
IF	**I**ntermediate **F**requency
k	**k**ilo - prefix for 10^3 multiplier
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
M	**M**ega - prefix for 10^6 multiplier
m	**M**eter
µ	**m**icro - prefix for 10^{-6} multiplier
NB	**N**arrow**b**and
QP	**Q**uasi-**P**eak
RE	**R**adiated **E**missions
RF	**R**adio **F**requency
rms	**r**oot-**m**ean-**s**quare
SN	**S**erial **N**umber
S/A	**S**pectrum **A**nalyzer
V	**V**olt

2 Equipment Under Test

2.1 EUT Identification & Description

This keypad provides numeric buttons to enter an access code, and LED indicators to show access statuses. Additional functionality includes an RFID antenna to allow for a card to be read rather than typing in a code. The keypad is simply an I/O device in the system, where a separate controller receives the user input data and determines whether access should be granted. A return message to the keypad will provide lighting outputs to the user as feedback. The messaging between keypad and controller is done via 250k J1939 CAN. The RFID emission is based on ISO 14443 standard with a carrier center frequency of 13.56MHz.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	JLG Industries INC.
FCC ID:	2ADCD1001242423
IC ID:	24414-1001242423
Model:	RFID Keypad
FCC Rule Parts:	§15.225
IC Rule Part	§RSS 210 A2.6 & RSS Gen
Frequency Range:	13.56MHz
Maximum Output Power:	96.6 uV/m at 30 meters
Modulation:	NFC
Occupied Bandwidth:	63.79 kHz
Emissions Designator:	63K8K1D
Type of Information:	Data
Number of Channels:	1
Power Output Level	Fixed
Antenna Type	Internal PCB trace
Frequency Tolerance:	<±0.01% (±100 ppm)
Interface Cables:	Fixed mounting on construction equipment
Highest TX Spurious Emission	257.64 MHz: 114.8 µV/m @ 3m
Highest RX Spurious Emission	162.72 MHz: 80.6 µV/m @ 3m
Power Source & Voltage:	12 Vdc from AC/DC Supply

2.2 Test Configuration

The device can provide input to the access control system by (1) sending typed in values to the controller or (2) sending RFID card scanned information to the controller.

2.3 Testing Algorithm

The EUT operates continuously when power is applied set to transmit at 13.56MHz. An RFID card is placed in close proximity to provide a constant TX signal.

Worst case emission levels are provided in the test results data.

2.4 Measurements

2.4.1 References

ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.10:2013 American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

2.5 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Gaithersburg, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent laboratory.

2.6 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 (R2002) with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

Equation 1: Standard Uncertainty

$$u_c = \pm\sqrt{\frac{a^2}{div_a{}^2} + \frac{b^2}{div_b{}^2} + \frac{c^2}{div_c{}^2} + ...}$$

Where u_c = standard uncertainty

a, b, c,.. = individual uncertainty elements

$div_{a, b, c}$ = the individual uncertainty element divisor based on the probability distribution

Divisor = 1.732 for rectangular distribution

Divisor = 2 for normal distribution

Divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = ku_c$$

Where U = expanded uncertainty

k = coverage factor

$k \leq 2$ for 95% coverage (ANSI/NCSL Z540-2 Annex G)

u_c = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 2 below.

Table 2: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	CISPR11, CISPR22, CISPR14, FCC Part 15	±2.63 dB
Radiated Emissions	CISPR11, CISPR22, CISPR14, FCC Part 15	±4.55 dB

3 Test Equipment

Table 3 shows a list of the test equipment used for measurements along with the calibration information.

Table 3: Test Equipment

Test Name:	**Radiated Emissions**	Test Date:	**08/27/2018**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
66	B&Z (HP) - BZ-01002650-401545-282525	HF PRE-AMPLIFIER 1-26.5GHZ (MODIFIED)	2/12/2019
4	ARA - DRG-118/A	ANTENNA DRG 1-18GHZ	12/14/2018
695	WLL - RG-223	BNC CABLE	10/4/2018
528	AGILENT - E4446A	3HZ - 44GHZ ANALYZER SPECTRUM	12/19/2018
644	SUNOL SCIENCES CORPORATION - JB1 925-833-9936	BICONALOG ANTENNA	1/16/2020
276	ELECTRO-METRICS - BPA-1000	RF PRE-AMPLIFIER	2/7/2019

Test Name:	**Temperature Stability**	Test Date:	**09/05/2018**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
776	TENNY - TJR-A-WS4	1.22 CUFT	6/1/2019
823	AGILENT – N9010A	EXA SPECTRUM ANALYZER	4/21/2019
528	AGILENT - E4446A	3HZ - 44GHZ ANALYZER SPECTRUM	12/19/2018

4 Test Results

4.1 Occupied Bandwidth

Occupied bandwidth measurement was performed by coupling the output of the EUT to the input of a spectrum analyzer using a near field probe. Table 4 provides a summary of the Occupied Bandwidth Results.

The occupied bandwidth was measured as shown:

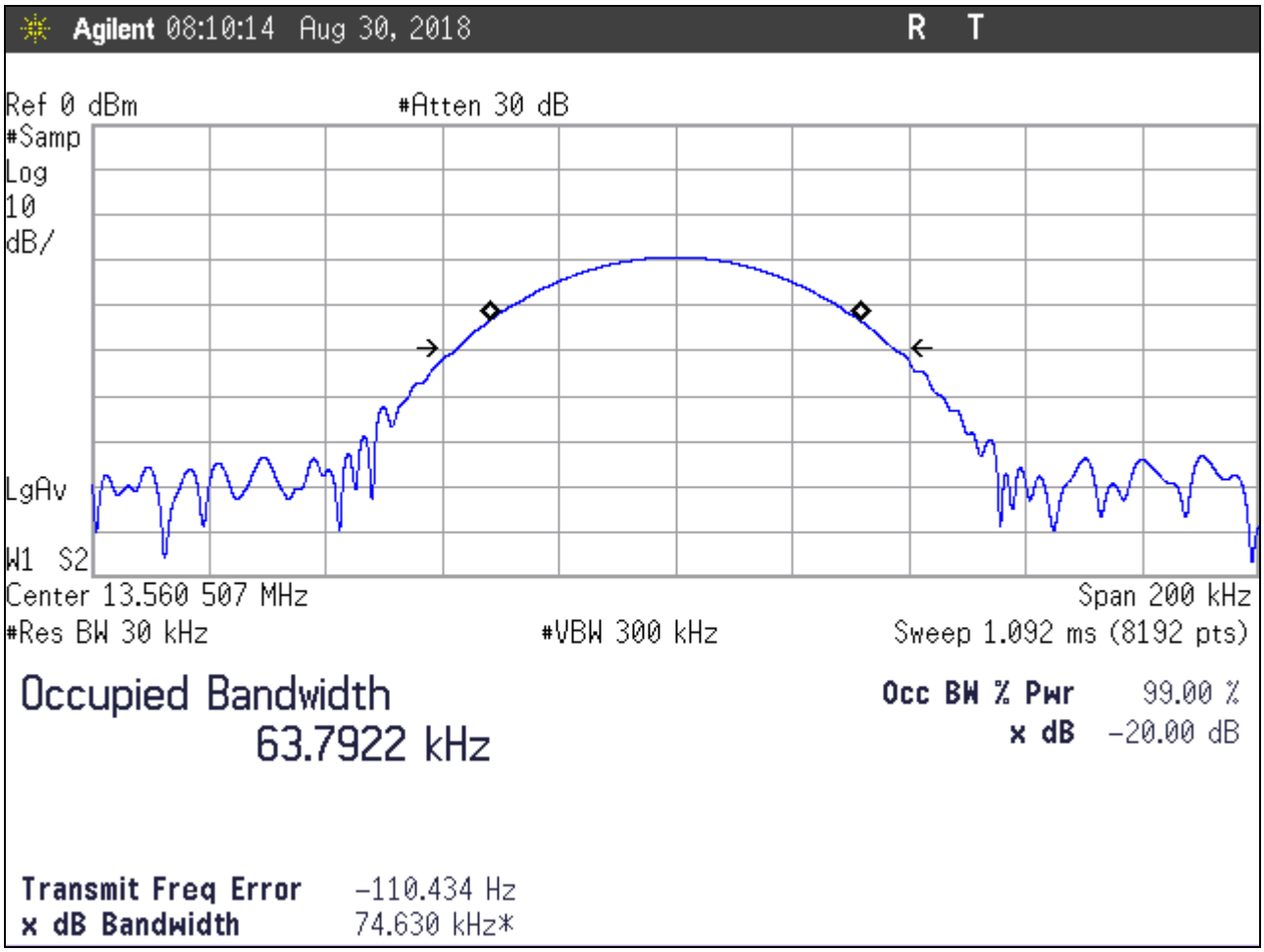

Figure 1: Occupied Bandwidth

Table 4: Occupied Bandwidth Results

Frequency	Bandwidth	Limit	Pass/Fail
13.560MHz	63.792 kHz	N/A	Pass

4.2 Radiated Spurious Emissions: FCC §15.225, §15.209, RSS 210 §A2.6, RSS GEN §7.2.5

Radiated emissions from the EUT must comply with the field strength limits as specified in FCC Part 15.225 and 15.209 and IC RSS 210 and RSS GEN. The limits for the radiated emissions are as shown in the following table.

Table 5: Radiated Spurious Emissions Limits

Frequency (MHz)	Limit (µV/m)	Rule Part Reference
13.553 - 13.567	15,848 (@ 30m) / 5282.62 (@ 10m)	§15.225(a), §RSS 210 A2.6(a)
13.410 – 13.553	334 (@ 30m)	§15.225(b), §RSS 210 A2.6(b)
13.567 – 13.710	334 (@ 30m)	§15.225(b), §RSS 210 A2.6(b)
13.110 – 13.410	106 (@ 30m)	§15.225(c), §RSS 210 A2.6(c)
13.710 – 14.010	106 (@ 30m)	§15.225(c), §RSS 210 A2.6(c)
1.705 – 13.110 14.010 – 30.0	30 (@ 30m)	§15.225(d), §RSS 210 A2.6(c) §15.209, RSS GEN 7.2.5
30.00 – 88.00	100 (@ 3m)	§15.225(d), §RSS 210 A2.6(d) §15.209, RSS GEN 7.2.5
88.00 – 216.00	150 (@ 3m)	§15.225(d), §RSS 210 A2.6(d) §15.209, RSS GEN 7.2.5
216.00 – 960.00	200 (@ 3m)	§15.225(d), §RSS 210 A2.6(d) §15.209, RSS GEN 7.2.5
Above 960	500 (@ 3m)	§15.225(d), §RSS 210 A2.6(d) §15.209, RSS GEN 7.2.5

4.2.1 Test Procedure

The EUT was placed on motorized turntable for radiated testing on an Open Area Test Site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. For frequencies below 30MHz, the loop antenna was mounted on a tripod at a height of 1 meter and a distance of 10m from the EUT. Above 30MHz, Biconical and log periodic broadband receiving antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters at a distance of 3 meters from the EUT. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured

Below 150 kHz, bandwidths used were 300Hz RBW and 10 kHz VBW. Between 150 kHz and 30MHz, bandwidths used were 10kHz RBW and 30kHz VBW. The reading was taken at 10m. A correction factor was used to adjust the 10 meter results to the equivalent at 30 meters using the 40dB/decade roll-off. Three orientations of the loop antenna were tested. Above 30MHz, bandwidths used were 100 kHz RBW and 30kHz VBW.

Emissions were scanned from 9 kHz to 1GHz. Emissions from were measured using a Quasi-peak detector. Worst case emissions are reported in the data table.

The following is a sample calculation used in the data tables for calculating the final field strength of spurious emissions and comparing these levels to the specified limits.

Sample Calculation:

Spectrum Analyzer Voltage (SA Level):	VdBµV
Antenna Factor (Ant Corr):	AFdB/m
Cable Loss Correction (Cable Corr):	CCdB
Amplifier Gain:	GdB (if applicable)
Electric Field (Corr Level):	EdBµV/m = VdBµV + AFdB/m + CCdB - GdB
To convert to linear units:	EµV/m = antilog (EdBµV/m/20)

4.2.2 Test Results

The EUT complies with the radiated emission requirements of §15.225 and RSS-210. The following tables provide the test data.

Table 6: Radiated Emissions Fundamental

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	10 mtr. Corr. Level (dBuV/m)	Distance Correction (dB)	30m Level w/ Distance Correction (uV/m)	Limit (uV/m)	Margin (dB)
13.56	F	0.0	1.0	33.5	17.8	51.3	19.1	40.74	15848	-51.80
13.56	S	270.0	1.0	39.1	17.8	56.9	19.1	77.62	15848	-46.20
13.56	T	90.0	1.0	38.6	17.8	56.4	19.1	73.28	15848	-46.70
13.56	F	180.0	1.0	25.2	17.8	43.1	19.1	15.85	15848	-60.00
13.56	S	90.0	1.0	32.0	17.8	49.8	19.1	34.28	15848	-53.30
13.56	T	135.0	1.0	30.4	17.8	48.3	19.1	28.84	15848	-54.80
13.56	F	135.0	1.0	34.0	17.8	51.8	19.1	43.15	15848	-51.30
13.56	S	225.0	1.0	41.0	17.8	58.8	19.1	96.61	15848	-44.30
13.56	T	270.0	1.0	40.9	17.8	58.7	19.1	95.50	15848	-44.40

Table 7: Radiated Emissions below 30MHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV) @10m	Corr Factor (dB)	Corr. Level @30m (uV/m)	Limit @30m (uV/m)	Margin (dB)
13.348	X	180.00	1.00	18.90	-1.3	7.6	106.0	-22.9
13.348	Y	270.00	1.00	27.90	-1.3	21.4	106.0	-13.9
13.348	Z	90.00	1.00	22.70	-1.3	11.8	106.0	-19.1
13.553	X	180.00	1.00	20.22	-1.3	8.8	334.0	-31.5
13.553	Y	90.00	1.00	24.05	-1.3	13.7	334.0	-27.7
13.553	Z	0.00	1.00	17.80	-1.3	6.7	334.0	-34.0
13.567	X	180.00	1.00	26.58	-1.3	18.4	334.0	-25.2
13.567	Y	0.00	1.00	30.90	-1.3	30.2	334.0	-20.9
13.567	Z	0.00	1.00	26.70	-1.3	18.7	334.0	-25.1
13.773	X	180.00	1.00	17.90	-1.3	6.8	106.0	-23.9
13.773	Y	0.00	1.00	19.30	-1.3	8.0	106.0	-22.5
13.773	Z	0.00	1.00	15.23	-1.3	5.0	106.0	-26.6

Table 8: Radiated Emissions above 30MHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
40.68	V	135.0	1.00	35.6	-9.1	21.0	100.0	-13.5	W/Card
366.1170	V	180.00	1.00	45.61	-7.9	77.1	200.0	-8.3	W/ Card
108.4817	V	180.00	1.00	47.52	-12.8	54.2	150.0	-8.8	W/Card
149.1617	V	270.00	1.00	34.06	-9.6	16.7	150.0	-19.1	W/Card
162.7210	V	270.00	1.00	53.03	-12.7	104.2	150.0	-3.2	W/Card
244.0817	V	270.00	1.00	47.15	-12.1	56.5	200.0	-11.0	W/Card
257.6417	V	292.50	1.00	53.33	-12.1	114.8	200.0	-4.8	W/Card
40.6740	H	180.00	4.00	45.94	-11.6	52.3	100.0	-5.6	W/Card
67.7966	H	0.00	0.00	38.55	-14.5	15.9	100.0	-16.0	W/Card
149.1650	H	0.00	0.00	50.86	-12.4	83.6	150.0	-5.1	W/Card

Table 9: Radiated Emissions Receive Only

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
62.9300	V	180.00	1.00	49.48	-17.6	39.2	100.0	-8.1	W/O Card
108.4817	V	180.00	1.00	46.80	-12.8	49.9	150.0	-9.6	W/O Card
149.1617	V	270.00	1.00	34.41	-12.4	12.6	150.0	-21.5	W/O Card
162.7210	V	270.00	1.00	50.80	-12.7	80.6	150.0	-5.4	W/O Card
244.0800	V	270.00	1.00	44.94	-12.1	43.8	200.0	-13.2	W/O Card
257.6417	V	0.00	0.00	33.58	-12.1	11.8	200.0	-24.6	W/O Card
366.1170	V	180.00	1.00	36.96	-7.9	28.5	200.0	-16.9	W/O Card
40.6740	H	180.00	4.00	30.51	-11.6	8.8	100.0	-21.1	W/O Card
67.7942	H	180.00	4.00	39.57	-17.1	13.3	100.0	-17.5	W/O Card
149.1650	H	0.00	4.00	34.69	-12.4	13.0	150.0	-21.2	W/O Card

4.3 Frequency Stability: FCC Part §2.1055, §15.225, RSS GEN §4.7, RSS 210 §A2.6

Frequency as a function of temperature and voltage variation shall be maintained within the FCC-prescribed tolerances. Per §15.225(e) and RSS 210 A2.6, the frequency tolerance shall be maintained within ±0.01% of the reference frequency.

4.3.1 Test Procedure

The temperature stability was measured with the unit in an environmental chamber used to vary the temperature of the sample. The sample was held at each temperature step to allow the temperature of the sample to stabilize.

The frequency stability of the transmitter was examined at the voltage extremes and for the temperature range of -40°C to +65°C. The carrier frequency was measured while the EUT was in the temperature chamber. The reference frequency of the EUT was measured at the ambient room temperature with the frequency counter.

The frequency stabilities can be maintained to a lesser temperature range provided that the transmitter is automatically inhibited from operating outside the lesser temperature range.

The RF carrier frequency shall not depart from the reference frequency (reference frequency is the frequency at 25ºC and rated supply voltage) in excess of +/-1356 Hz.

The EUT was powered by 12 Vdc Voltage

The EUT was tested at the extreme points at the turn on point, 2-minute point, 5-minute point, and 10-minute point.

4.3.2 Test Results

The EUT complies with the temperature stability requirements of the specified standards. Test results are given in Table 10.

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Table 10: Frequency Stability Test Data

Temperature (Centigrade)	Frequency (MHz)	Deviation (Hz)	Limit (+/- Hz)	Pass/Fail
25(ambient)	13.562630	0	1356	**NA**
-40	13.56098	553	1356	Pass
-30	13.560768	341	1356	Pass
-20	13.563210	580	1356	Pass
-10	13.562830	200	1356	Pass
0	13.563000	370	1356	Pass
10	13.563170	540	1356	Pass
20	13.562580	-50	1356	Pass
30	13.562330	-300	1356	Pass
40	13.562170	-460	1356	Pass
50	13.562500	-130	1356	Pass

2 minutes after turning on

Temperature (Centigrade)	Frequency (MHz)	Deviation (Hz)	Limit (+/- Hz)	Pass/Fail
-40	13.56004	387	1356	Pass
65	13.56028	147	1356	Pass

5 minutes after turning on

Temperature (Centigrade)	Frequency (MHz)	Deviation (Hz)	Limit (+/- Hz)	Pass/Fail
-40	13.560718	291	1356	Pass
65	13.560912	488	1356	Pass

10 minutes after turning on

Temperature (Centigrade)	Frequency (MHz)	Deviation (Hz)	Limit (+/- Hz)	Pass/Fail
-40	13.56098	553	1356	Pass
65	13.561312	885	1356	Pass

Voltage Variation

Voltage	Frequency (MHz)	Deviation (Hz)	Limit (+/- Hz)	Pass/Fail
Nominal Voltage	13.560333	0	1356	**NA**
115% of Nom Volt (13.8VDC)	13.560320	-13	1356	Pass
85% of Nom Volt (10.2VDC)	13.560334	1	1356	Pass