CERTIFICATION TEST REPORT

for the

70300R

FCC ID: 2ASFCRADAR

REPORT# 15933 -01 REV 1

Prepared for:

Lasso Technologies, LLC

8111 Lyndon Johnson Parkway, Suite 900

Dallas TX 75251

Prepared By:

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FCC & ISED Canada Certification Test Report

for the

Lasso Technologies, LLC

70300R

FCC ID: 2ASFCRADAR

AUGUST 6, 2020

WLL REPORT# 15933 REV 1

Prepared by:

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Revision History	Description of Change	Date
Rev 0	Initial Release	August 6, 2020
Rev 1	Added upper scan frequency to report	August 17, 2020

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1 INTRODUCTION

1.1 COMPLIANCE STATEMENT

The 70300R complies with the requirements of FCC Part 15.25.

1.2 CONTRACT INFORMATION

Customer:	Lasso Technologies
Address	8111 Lyndon Johnson Parkway, Suite 900
	Dallas TX 75251
Purchase Order Number:	VERBAL
Quotation Number:	70806

1.3 TEST DATES

Testing was performed on the following date(s): 27-28 July 2020.

1.4 TEST AND SUPPORT PERSONNEL

Washington Laboratories, LTD	Mike Violette
Customer Representative	Peter McCormick

EQUIPMENT UNDER TEST

1.5 EUT IDENTIFICATION & DESCRIPTION

The Lasso Technologies, LLC 70300R is a field disturbance sensor. It is intended to monitor the level of liquids in an enclosed tank.

Table 1: Device Summary

Model(s) Tested:	**70300R**
EUT Specifications	
Manufacturer:	Lasso Technologies, LLC
FCC ID:	2ASFCRADAR
EUT Name:	FMCW RADAR
FCC Rule Parts:	15.256
Frequency Range:	79-8l GHz
Maximum Output Power:	7.9 dBm EIRP peak in 3 MHz RBW 24.4 dBm EIRP peak in 50 MHz RBW -34.1 dBm EIRP average in 50 MHz RBW
Modulation:	FMCW
Occupied Bandwidth:	133 MHz (10 dB BW)
Keying:	Automatic
Type of Information:	Radar chirp
Number of Channels:	N/A
Antenna Connector:	None
Antenna Type Manufacturer, Model and Gain:	Luneburg Lens 3dB beamwidth: 6.5~7.1° Sidelobes over +/- 60° < -38 dBi Horn gain: 26.2 dBi
Interface Cables:	None
Highest TX Spurious Emission:	None detected to 200 GHz System noise floor = 70.1dBuV/m @ 3m
Power Source & Voltage:	DC 6V battery powered

1.6 TEST CONFIGURATION

The 70300R was configured for normal operation. The output of the device was set to boresight on the measurement antennas.

1.7 TEST LOCATION

All measurements herein were performed at Washington Laboratories, Ltd. test center in Frederick, 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 Testing Certificate AT-1448 as an independent FCC test laboratory.

1.8 MEASUREMENTS

1.8.1 References

1. ANSI C63.2 (Jan-2016) Specifications for Electromagnetic Noise and Field Strength Instrumentation
2. ANSI C63.4 (Jan 2014) American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
3. ANSI C63.10 (Jun 2013) American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
4. FCC §15.256 Operation of level probing radars within the bands 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz.
5. FCC Report: TR 14-1007 MEASUREMENT OF FUNDAMENTAL EMISSIONS OF FMCW LEVEL PROBING RADARS (LPR) UNDER PART 15, SECTION 15.256 June 13, 2014 Prepared by: Thomas W. Phillips Technical Research Branch Laboratory Division Office of Engineering and Technology
6. FCC KDB 412172 Guidelines for Determining the Effective Radiated Power (ERP) and Equivalent Isotropically-Radiated Power (EIRP) of a RF Transmitting System
7. FCC KDB 890966 D01 Measurement Procedure for Level Probing Radars. September 10, 2014
8. FCC §15.215(c)

1.9 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, CISPR32, CISPR14, FCC Part 15	±2.63 dB
Radiated Emissions	CISPR11, CISPR22, CISPR32, CISPR14, FCC Part 15	±4.55 dB

2 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:	**Conducted Emissions Voltage**	Test Date:	**7/27/2020 -7/30/2020**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00528	AGILENT	E4446A	1/21/2021
00906	OML INC.	M12HW	2/19/2021
00104	OLESON MICROWAVE LABS	M05HW	2/19/2021
00904	OML INC.	M19HW	2/20/2021
00210	NARDA	V638	CNR
00104	OLESON MICROWAVE LABS	M05HW	2/19/2021
00904	OML INC.	M19HW	2/20/2021
00905	OML INC.	M08HW	2/19/2021
00906	OML INC.	M12HW	2/19/2021
00382	SUNOL SCIENCES CORPORATION	JB1	8/1/2020
00209	NARDA	V637	CNR
00558	HP	8447D	5/18/2021
00928	Virginia Diodes	SAX	7/20/2023

3 TEST RESULTS

3.1 §15.256 OPERATION WITHIN THE BAND 75-85 GHZ: OUTPUT POWER

(a) Operation under this section is limited to level probing radar (LPR) devices.

This device is a Level Probing Radar.

(b) LPR devices operating under the provisions of this section shall utilize a dedicated or integrated transmit antenna, and the system shall be installed and maintained to ensure a vertically downward orientation of the transmit antenna's main beam.

This device uses an integrated transmit antenna and is mounted such that the beam is oriented in a vertically-downward direction.

(c) LPR devices operating under the provisions of this section shall be installed only at fixed locations. The LPR device shall not operate while being moved, or while inside a moving container.

This device is fixed-mount.

(d) Hand-held applications are prohibited.

This device is fixed-mount.

(e) Marketing to residential consumers is prohibited.

This device is not marketed to residential consumers.

(f) The fundamental bandwidth of an LPR emission is defined as the width of the signal between two points, one below and one above the center frequency, outside of which all emissions are attenuated by at least 10 dB relative to the maximum transmitter output power when measured in an equivalent resolution bandwidth.

(1) The minimum fundamental emission bandwidth shall be 50 MHz for LPR operation under the provisions of this section.

Fundamental bandwidth is shown in the following figure. The bandwidth is in shown to be 133 MHz.

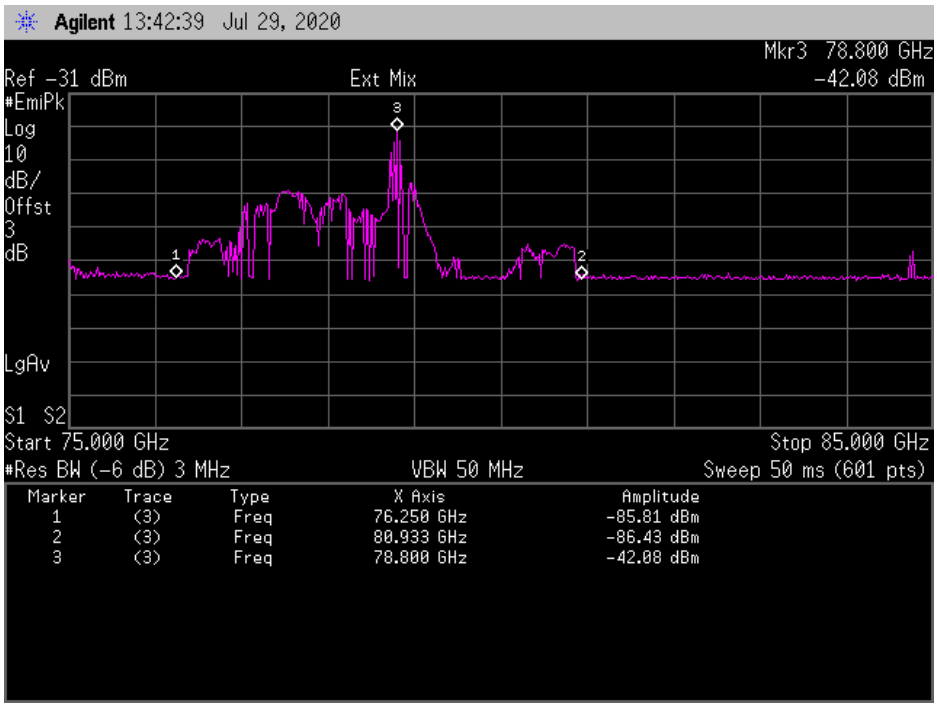
Figure 1. 10 dB Bandwidth (Marker 4)

The 10 dB bandwidth was measured to be 133 MHz.

(2) LPR devices operating under this section must confine their fundamental emission bandwidth within the 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz bands under all conditions of operation.

The emissions from the device are shown in the following figure, well within the 75-85 GHz band.

Figure 2. FMCW Emissions



(g) *Fundamental emissions limits.* (1) All emission limits provided in this section are expressed in terms of Equivalent Isotropic Radiated Power (EIRP).

(2) The EIRP level is to be determined from the maximum measured power within a specified bandwidth.

(i) The EIRP in 1 MHz is computed from the maximum power level measured within any 1-MHz bandwidth using a power averaging detector;

The emissions were computed using Reference 5 above.

(ii) The EIRP in 50 MHz is computed from the maximum power level measured with a peak detector in a 50-MHz bandwidth centered on the frequency at which the maximum average power level is realized and this 50 MHz bandwidth must be contained within the authorized operating bandwidth. For a RBW less than 50 MHz, the peak EIRP limit (in dBm) is reduced by 20 log(RBW/50) dB where RBW is the resolution bandwidth in megahertz. The RBW shall not be lower than 1 MHz or greater than 50 MHz. The video bandwidth of the measurement instrument shall not be less than the RBW. If the RBW is greater than 3 MHz, the application for certification filed shall contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

(3) The EIRP limits for LPR operations in the bands authorized by this rule section are provided in Table 1. The emission limits in Table 1 are based on boresight measurements (*i.e.*, measurements performed within the main beam of an LPR antenna).

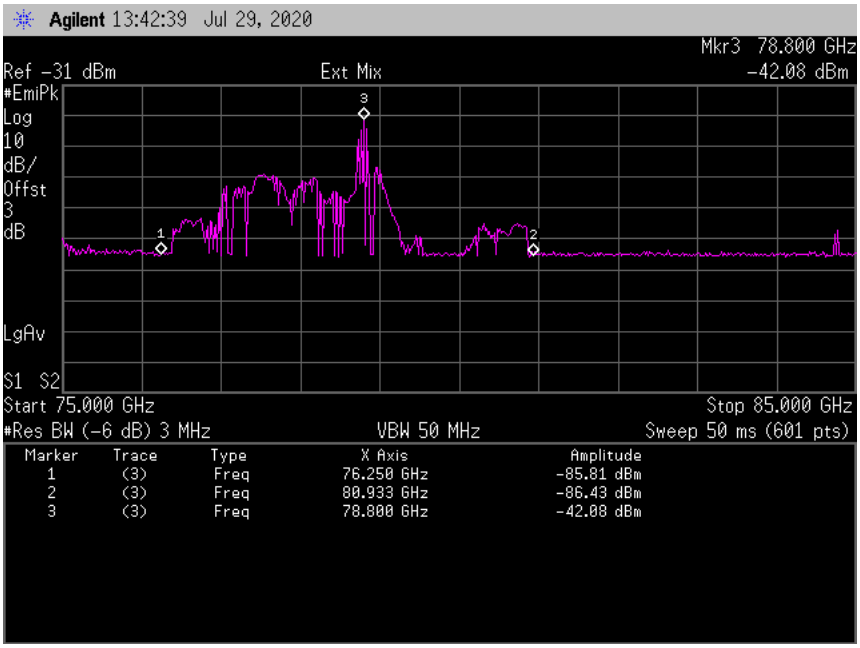
Table 4. LPR EIRP Emission Limits

Frequency band of operation (GHz)	Average emission limit (EIRP in dBm measured in 1 MHz)	Peak emission limit (EIRP in dBm measured in 50 MHz)
5.925-7.250	−33	7
24.05-29.00	−14	26
75-85	−3	34

Radiated measurements were performed at 0.5m distance on a test bench boresight to the antenna array and as PEAK power measurements. The measurements were collected using a down-converter to convert the mmWave signal to the in-band operation of the spectrum analyzer.

The peak power measured is shown in the following figure.

Figure 3. Peak Power Measurement



Peak measured power was found at 78.8 GHz. To determine the EIRP to compare with the limit, it is first necessary to solve for the field strength.

The maximum peak power was measured as:

Pr = -42.08 dBm

Convert to conducted voltage:

VdBuV = Pr + 107 dB = 64.92 dBuV

Correct for downconverter losses.

VdBuV/m corrected = VdBuV + CLdB

Where CL is the down converter losses at 78.8 GHz (9.6dB).

To compute field strength, the gain of the receive antenna is converted to Antenna Factor.

The gain of the receive antenna is 24 dBi or 251 numeric. (= invLog(GdBi/10)).

The antenna factor (dB/m) is found from the following equation:

AF = 20*log(9.73/(λ*SQRT(Gnum))

Where λ = 3E8/f = 0.00381 meters.

Solving for AF,

AF = 20*log(9.73/(15.8))

AF = 44.1 dB/m

The field strength is found from the following formula:

E-field dBuV/m = VdBuV/m + AF

E-field = 118.7 dBuV/m

The Peak EIRP limit is 34dBm in a 50 MHz bandwidth.

Converting the electric field to EIRP at 0.5 m:

E-field uV/m = invLog^(E-fieldd BuV/m)/20) = 0.9 V/m

Thus,

E-field = 0.9 V/m

From FCC KDB 412172:

EIRP W= ((E*d)^2)/30 Watts

The test distance is 0.5 m, thus

EIRP W = [(0.9 * 0.5)^2/30]

EIRP = 0.0061 W

EIRP = 6.1 mW

EIRP = 7.9 dBm

Per FCC 15.256, the power in a 50 MHz band must be provided. The measurement used a 3 MHz RBW, so a correction of 20*log(50/3) = 24.4 dB is applied to the measurement.

This yields a corrected power density of

EIRP (corrected) = 7.9 + 24.4

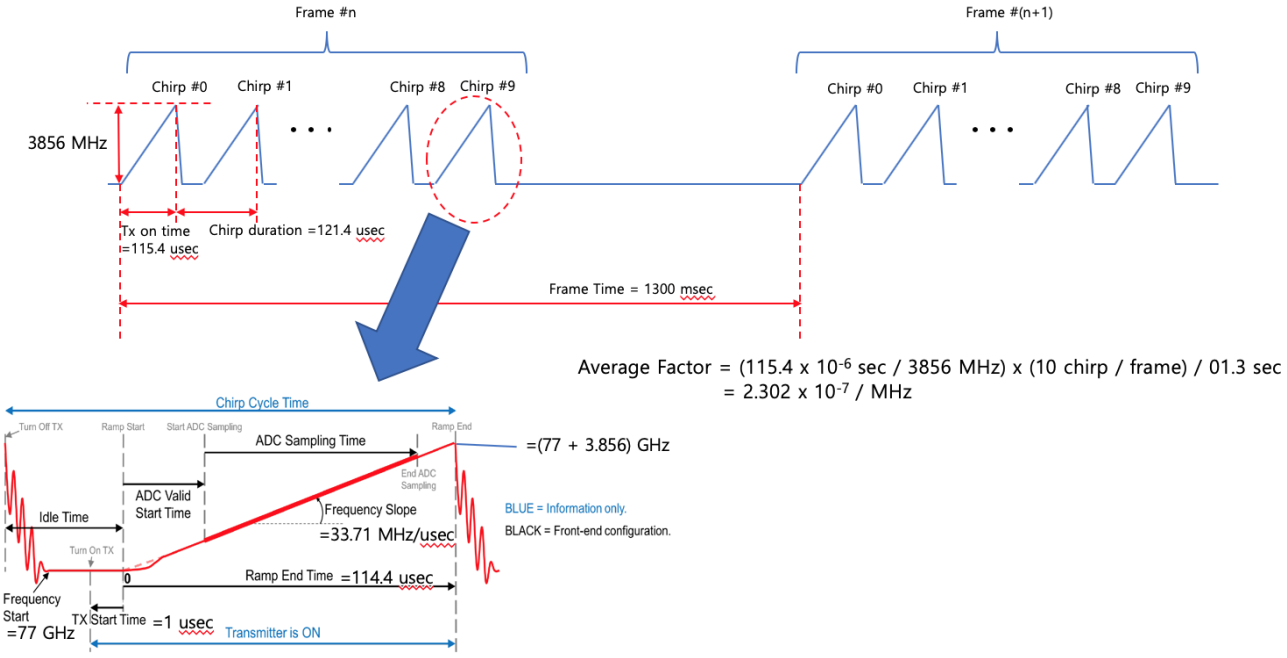
EIRP (corrected) = 32.3 dBm in 50 MHz RBW

To compute the average power, the peak EIRP is corrected by an the Average Factor which i is defined according FCC Report TR 14-1007 as:

Average factor = (sweep freq. time/sweep span in MHz)/cycle time

To calculate the Average Factor, the following description of the chirp structure is provided.

Figure 4. Radar Chirp Structure



For this signal,

Average Factor = (115.4 x 10^{-6} sec / 3856 MHz) x (10 chirp / frame) / 01.3 sec
= 2.302 x 10^{-7} / MHz

Average Factor = 10*log(2.302E-7) dB

Average Factor = 66.4 dB

Thus, the average emissions from the device is:

EIRP Average = EIRP Peak dBm – Average Factor

32.3 – 66.4 = -34 dBm

(h) *Unwanted emissions limits.* Unwanted emissions from LPR devices shall not exceed the general emission limit in §15.209 of this chapter.

Unwanted emissions comply with the emissions limits of §15.209 and were scanned to 200 GHz. See Table 5**.**

(i) *Antenna beamwidth.* (A) LPR devices operating under the provisions of this section within the 5.925-7.250 GHz and 24.05-29.00 GHz bands must use an antenna with a −3 dB beamwidth no greater than 12 degrees.

(B) LPR devices operating under the provisions of this section within the 75-85 GHz band must use an antenna with a −3 dB beamwidth no greater than 8 degrees.

(j) *Antenna side lobe gain.* LPR devices operating under the provisions of this section must limit the side lobe antenna gain relative to the main beam gain for off-axis angles from the main beam of greater than 60 degrees to the levels provided in Table 2.

The antenna is a Luneberg lens with the following characteristics.

Type: Luneburg Lens
3dB beamwidth : 6.5~7.1°
Sidelobes over +/- 60° < -38 dBi
Horn gain : 26.2 dBi

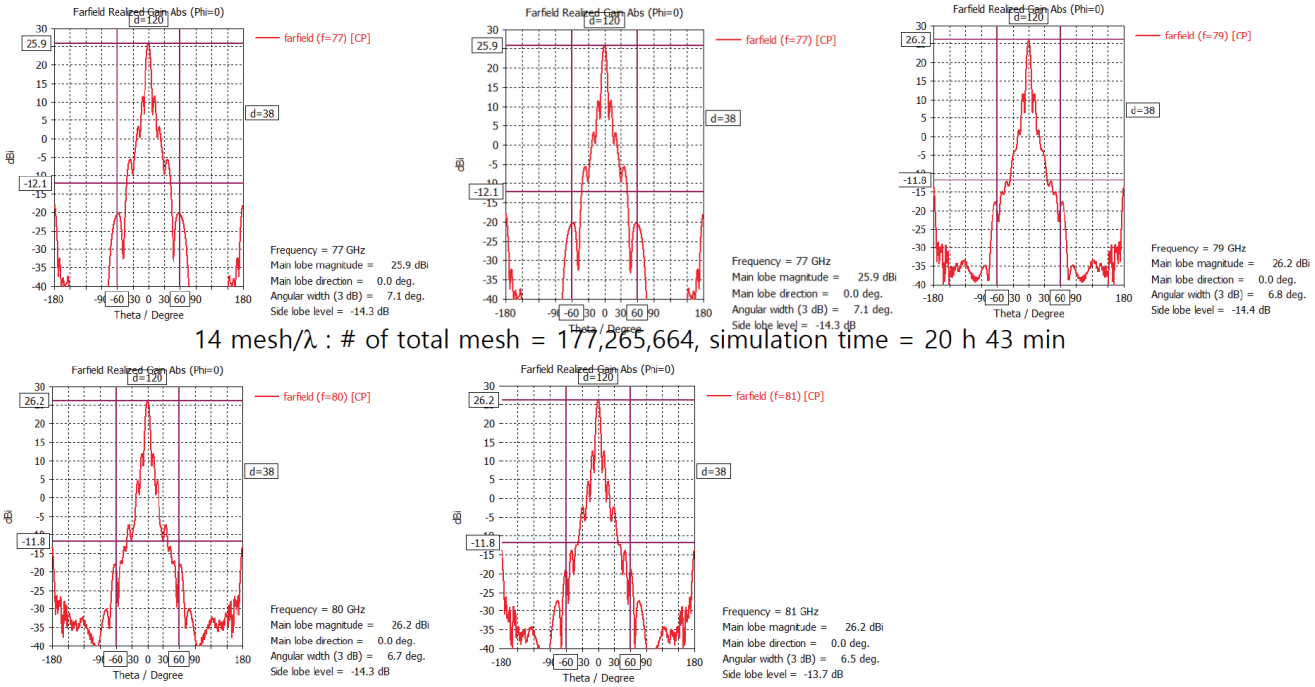
Table 2—Antenna Side Lobe Gain Limits

Frequency range (GHz)	Antenna side lobe gain limit relative to main beam gain (dB)
5.925-7.250	−22
24.05-29.00	−27
75-85	−38

As shown in the following figure the antenna side lobes are > 38dB below the main lobe.

Figure 5. Antenna Pattern @ 77, 79 and 81 GHz

Luneburg Lens COMPUTER SIMULATION



14 mesh/λ : # of total mesh = 177,265,664, simulation time = 20 h 43 min

Table 5: Radiated Emissions < 1 GHz

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)
54.0	V	45	1	38.67	-18.14	10.62	100	-19.47
64.0	V	90	1	30.85	-17.51	4.64	100	-26.66
80.0	V	0	1	32.85	-17.30	5.98	100	-24.45
212.0	V	180	1	40.31	-13.55	21.7	150	-16.78
275.0	V	135	1	29.51	-10.33	9.07	200	-26.85
600.0	V	180	1	25.37	-6.406	8.87	200	-27.05
54.0	H	45	1	27.94	-18.14	3.08	100	-30.20
64.0	H	180	1	25.87	-17.51	2.61	100	-31.64
80.0	H	0	1	29.53	-17.30	4.08	100	-27.77
212.0	H	90	1	34.29	-13.55	10.87	150	-22.79
275.0	H	180	1	30.23	-10.33	9.87	200	-26.19
600.0	H	180	1	21.68	-6.406	5.80	200	-30.74

3.2 FREQUENCY STABILITY §15.215(C)

The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Per KDB 890966 D01, the bandwidth of the fundamental emission must be contained in the frequency band over the temperature range -20 to 50C with an input voltage of 85% to 115%.

As this is a battery-powered device, the battery end-point was measured. As state by the manufacturer the nominal battery end-point is 5.5VDC.

The device was set to normal transmit and the frequency spectrum monitored under the following temperature conditions:

-20 to +50C in 10C increments. Markers were placed at the nominal operating frequency lower and upper frequencies (76.3 GHz and 81GHz, respectively.

The following figure shows the nominal signal output at 25C. The signal did not go outside the 75-85 GHz operating range over the test conditions stated above.

Figure 6. Monitoring Temperature and Voltage Stability