



W66 N220 Commerce Court • Cedarburg, WI 53012 • USA

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www.lsr.com

TEST REPORT #: 313082

LSR Job #: C-1669

Compliance Testing of:

Bolus

Test Date(s):

April 26, 2013, December 18 & 19, 2013

Prepared For:

Bella AG

27096 CR 388

Kersey, CO 80644

In accordance with:
Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.249
Industry Canada (IC) RSS 210 Annex 2
Transmitters Operating in the
Frequency Band 902 MHz – 928 MHz

This Test Report is issued under the Authority of:

Peter Feilen, EMC Engineer

Signature: Peter Feilen

Date: 8/28/14

Test Report Reviewed by:

Adam Alger, EMC Engineer

Signature:

Date: 5/27/14

Tested by:

Peter Feilen, EMC Engineer

Signature:

Date: 8/28/14

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EXHIBIT 1. INTRODUCTION

1.1 Scope

References:	FCC Part 15, Subpart C, Section 15.249 and 15.209 FCC Part 2, Section 2.1043 paragraph (b)1. RSS GEN and RSS 210 Annex 2
Title:	FCC : Telecommunication – Code of Federal Regulations, CFR 47, Part 15. IC : Low-power License-exempt Radio-communication Devices (All Frequency Bands): Category I Equipment
Purpose of Test:	To gain FCC and IC Certification Authorization for Low-Power License-Exempt Transmitters.
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 – 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.

1.2 Normative References

Publication	Title
47 CFR, Parts 0-15 (FCC)	Code of Federal Regulations - Telecommunications
RSS 210	Low-power License-exempt Radio-communication Devices (All Frequency Bands): Category I Equipment
ANSI C63.4	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.

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1.3 LS Research, LLC Test Facility

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) to conform to ISO/IEC 17025, 2005 "General Requirements for the Competence of Calibration and Testing Laboratories".

LS Research, LLC's scope of accreditation includes all test methods listed herein, unless otherwise noted. Accreditation status can be verified at A2LA's web site: www.a2la.org.

1.4 Location of Testing

All testing was performed at LS Research, LLC, W66 N220 Commerce Court, Cedarburg, Wisconsin, 53012 USA, utilizing the facilities listed below, unless otherwise noted.

List of Facilities Located at LS Research, LLC:

- Semi-Anechoic Chamber

1.5 Test Equipment Utilitized

A complete list of equipment utilized in testing is provided in Appendix A of this test report. Calibration dates are indicated in Appendix A. All test equipment is calibrated in accordance with A2LA standards.

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EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 Client Information

Manufacturer Name:	Bella AG
Address:	27906 CR 388 Kersey, CO 80644 United States
Contact Name:	Nick Rettedal

2.2 Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	Bolus
Model Number:	Bolus
Serial Number:	Engineering Sample

2.3 Associated Antenna Description

PCB trace antenna on board

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2.4 EUT'S Technical Specifications

EUT Frequency Range (in MHz)	915.15-920.85 MHz
Maximum Field Strength at 3 meters	93.0 dBuV/m @ 3m
Occupied Bandwidth	97 kHz
Type of Modulation	GFSK
Emission Designator	97KF1D
Transmitter Spurious (worst case) at 3 meters	49.9 dBuV/m @ 3m
Antenna Information	
Detachable/non-detachable	Non-detachable
Type	Trace
Gain (in dBi)	0 dBi
EUT will be operated under FCC Rule Part(s)	15.249
EUT will be operated under RSS Rule Part(s)	RSS 210
Modular Filing	☐ Yes ☒ No
Portable or Mobile?	Mobile

2.5 Product Description

After assembly and production testing the bolus is potted and turned on. After this, the bolus is put into a sleep mode. While in sleep mode, the bolus will sample the ambient temperature every 15 minutes. The bolus is designed to be swallowed by a cow and measure the temperature of a cow's stomach. Once inserted into the cow by a qualified individual; the animal's internal temperature (the average is 102.7F) will bring the bolus up beyond a threshold that will activate the normal operation mode. The Bolus will require 6 temperature samples above the threshold before switching to normal operation. The Bolus will not be passed through the cow digestive system and remains in the stomach permanently. The bolus will collect temperature samples while inside the Cow's stomach, periodically waking up and sampling the temperature. The radio does not turn on during temperature samples. After a certain threshold of samples is gathered, the radio will periodically turn on and transmit a beacon signal. If the bolus receives an acknowledgement from a Collector unit, the bolus replies by sending all stored temperature data. After this, the bolus returns to sleep and periodically samples and stores the stomach temperature again and the process repeats. The sample threshold as well as the temperature sample rate can both be set by the farmer. Changes to the sample rate and threshold are push back to the bolus when it receives an acknowledgement from the Collector unit. Operation will only cease when the battery dies.

The Bolus uses a SiLabs 4461 transceiver with GFSK modulation and a 50kbps datarate. The host processor is TI MSP430. The system operates between 915MHz and 921 MHz. Channels spacing is 300 kHz, with 20 channels available for use. Radio crystal frequency is 32 MHz, processor crystal is 32.768 kHz. It uses a loop antenna.

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EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 Climate Test Conditions

Temperature:	20-25° C
Humidity:	30-60 %
Pressure:	645-795 mmHg

3.2 Applicability & Summary of EMC Emission Test Results

FCC and IC Paragraph	Test Requirements	Compliance (yes/no)
FCC : 15.207 IC : RSS GEN sect. 7.2.2	Power Line Conducted Emissions Measurements	Not Applicable
IC : RSS GEN section 4.6.1	20 dB Bandwidth	Yes
FCC : 15.249(A) & 1.1310 IC : RSS 210 A2.9 (a)	Maximum Output Power	Yes
FCC : 1.1307, 1.1310, 2.1091 & 2.1093 IC : RSS 102	RF Exposure Limit	Yes
FCC : 15.249(a) IC : RSS 210 A2.9(a)	Transmitter harmonics	Yes
FCC : 15.249(d), 15.209 & 15.205 IC : RSS 210 A2.9(b),	Transmitter Radiated Emissions	Yes

3.3 Modifications Incorporated in the EUT for Compliance Purposes

☒ None ☐ Yes (explain below)

3.4 Deviations & Exclusions From Test Specifications

☒ None ☐ Yes (explain below)

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EXHIBIT 4. DECLARATION OF CONFORMITY

The EUT was found to MEET the requirements as described within the specification of FCC Title 47, CFR Part 15.249, Part 15.109, and Industry Canada RSS-210, RSS-GEN.

If some emissions are seen to be within 3 dB of their respective limits:

As these levels are within the tolerances of the test equipment and site employed, there is a possibility that this unit, or a similar unit selected out of production may not meet the required limit specification if tested by another agency.

LS Research, LLC certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results in this Test Report apply only to the item(s) tested on the above-specified dates. Any modifications made to the EUT subsequent to the indicated test date(s) will invalidate the data herein, and void this certification.

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EXHIBIT 5. RADIATED EMISSIONS TEST

5.1 Test Setup

The test setup was assembled in accordance with Title 47, CFR FCC Part 15, RSS GEN and ANSI C63.4. The EUT was placed on an 80cm high non-conductive pedestal, centered on a flush mounted 2-meter diameter turntable inside a 3 meter Semi-Anechoic, FCC listed Chamber. The EUT was operated in continuously transmitting modulated mode using power as provided by a battery. The unit has the capability to operate on 19 channels. The EUT was controlled via PC programming. The test sample was operated on one of two (2) standard channels: **915 MHz and 920.8 MHz** to comply with FCC Part 15.31(m).

The applicable limits apply at a 3 meter distance.

5.2 Test Procedure

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 10000 MHz was scanned and investigated. The radiated RF emission levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive pedestal in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. The EUT was positioned in three orthogonal positions for the test.

A Biconical Antenna was used to measure emissions from 30 MHz to 300 MHz, and a Log Periodic Antenna was used to measure emissions from 300 MHz to 1000 MHz. A Double-Ridged Waveguide Horn Antenna was used from 1 GHz to 10 GHz.

In the frequency range of 30 MHz to 10 GHz, the maximum radiated RF emissions were found by raising and lowering the antenna between 1 and 4 meters in height, and the polarity of the antenna was switched between horizontal and vertical polarity.

5.3 Test Equipment Utilized

Please refer to Appendix A for a complete list of test equipment.

5.4 Test Results

The EUT was found to **MEET** the Radiated Emissions requirements of Title 47 CFR, FCC Part 15.249 and Canada RSS-210, Annex 2.9. The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

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5.5 Calculation of Radiated Emissions Limits

Field Strength of Fundamental Frequencies:

The fundamental emissions for an intentional radiator in the 902-928 MHz band, operating under FCC part 15.249 and RSS 210 A2.9 limits must have electric field strength of no greater than 50 mV/m, for the fundamental frequency, when measured at 3 meters, and harmonic field strength of no greater than 500 $\mu\text{V/m}$, when measured at 3 meters. Spurious emissions outside the 902-928 MHz band shall be attenuated by at least 50 dB below the level of the fundamental, or meet the limits expressed in FCC part 15.209 under general emission limits.

Field Strength of Fundamental Frequencies is Limited to 50,000 $\mu\text{V/m}$, or 94 dB $\mu\text{V/m}$.

Field Strength of Harmonic and Spurious Frequencies is Limited by FCC 15.249 a and d

The harmonic limit of -50 dBc with respect to the fundamental limit would be:

$$94 \text{ dB}\mu\text{V/m} - 50 \text{ dB} = 44 \text{ dB}\mu\text{V/m},$$

with the exception of where FCC 15.209 allows for a higher limit to be used.

Frequency (MHz)	3 m Limit ($\mu\text{V/m}$)	3 m Limit (dB $\mu\text{V/m}$)
902-928	50,000	94.0
30-88 ; 88-216	159	44.0
216-902 ; 928-960	500	46.0*
960-40,000	500	54.0*

The following table depicts the general radiated emission limits obtained from Title 47 CFR, part 15.209a, for radiated emissions measurements, including restricted band limits as expressed in 47 CFR, part 15.205.

Frequency (MHz)	3 m Limit ($\mu\text{V/m}$)	3 m Limit (dB $\mu\text{V/m}$)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
960-40,000	500	54.0

Sample conversion from field strength $\mu\text{V/m}$ to dB $\mu\text{V/m}$:

$$\text{dB}\mu\text{V/m} = 20 \log_{10} (3\text{m limit})$$

from 30 - 88 MHz for example: $\text{dB}\mu\text{V/m} = 20 \log_{10} (100)$

$$40.0 \text{ dB}\mu\text{V/m} = 20 \log_{10} (100)$$

Note: Limits are conservatively rounded to the nearest tenth of a whole number.

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5.6 Radiated Emissions Test Data Chart

Measurements of Electromagnetic Radiated Emissions
Frequency Range Inspected: 30 MHz to 10000 MHz

Manufacturer:	Bella AG					
Date(s) of Test:	December 18-19, 2013					
Project Engineer:	Peter Feilen					
Voltage:	3.6 VDC					
Operation Mode:	Continuous TX, Continuous RX					
EUT Power:		Single Phase 120 VAC			3 Phase ____ VAC	
	X	Battery: 3.6 VDC			Other:	
EUT Placement:	X	80cm non-conductive table			10cm Spacers	
EUT Test Location:	X	3 Meter Semi-Anechoic FCC Listed Chamber			3/10m OATS	
Measurements:		Pre-Compliance			Preliminary	X Final
Detectors Used:	X	Peak		X	Quasi-Peak	X Average

The following table depicts the level of radiated transmit fundamental:

Frequency (MHz)	Receive Antenna	EUT ANTENNA	Height (m)	Azimuth (0° - 360°)	Peak (dBuV/m)	Q. Peak (dBuV/m)	Limit (dBuV/m)	Margin (dB)
915.15	H	F	1.64	0	92.7	92.5	94.0	1.5
920.85	H	F	1.58	0	93.2	93.0	94.0	1.0

The following table depicts the level of spurious emissions in transmit mode

Frequency (MHz)	Antenna Height (m)	Azimuth (deg)	Peak Field Strength Reading (dBuV/m)	Average Field Strength Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Antenna Polarity	EUT Position
3660	1.07	158	54.7	49.8	54.0	4.2	H	FLAT
3685	1.11	181	53.6	49.9	54.0	4.1	H	FLAT

The following table depicts the level of spurious emissions in receive mode

Frequency (MHz)	Antenna Height (m)	Azimuth (deg)	Peak Field Strength Reading (dBuV/m)	Average Field Strength Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Antenna Polarity	EUT Position
3681.5	1.11	184	51.7	46.7	54.0	7.3	H	FLAT
3658	1.08	178	53.14	47.6	54.0	6.4	H	FLAT

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5.7 Screen Captures - Radiated Emissions Test

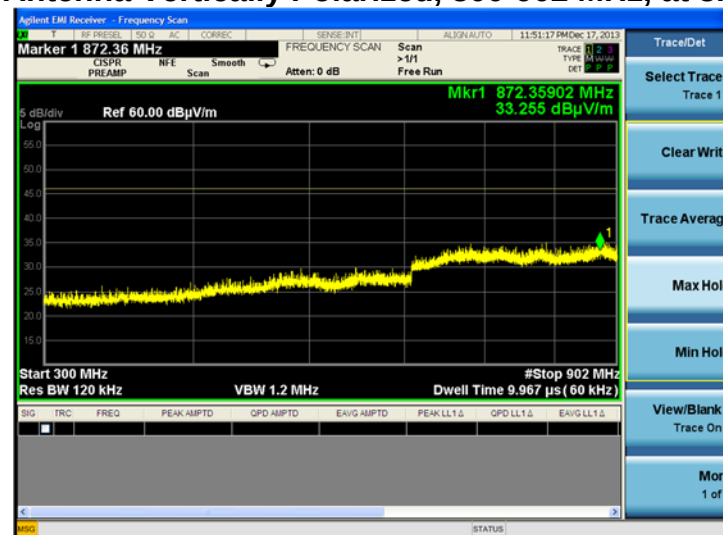
These screen captures represent Peak Emissions. For radiated emission measurements, a Quasi-Peak detector function is utilized when measuring frequencies below 1 GHz, and a peak detector with video averaging is utilized when measuring frequencies above 1 GHz.

The signature scans shown here are from worst-case emissions, as measured on channels low and high, with the sense antenna both in vertical and horizontal polarity for worst case presentations.

Antenna Vertically Polarized, 30-300 MHz, at 3m



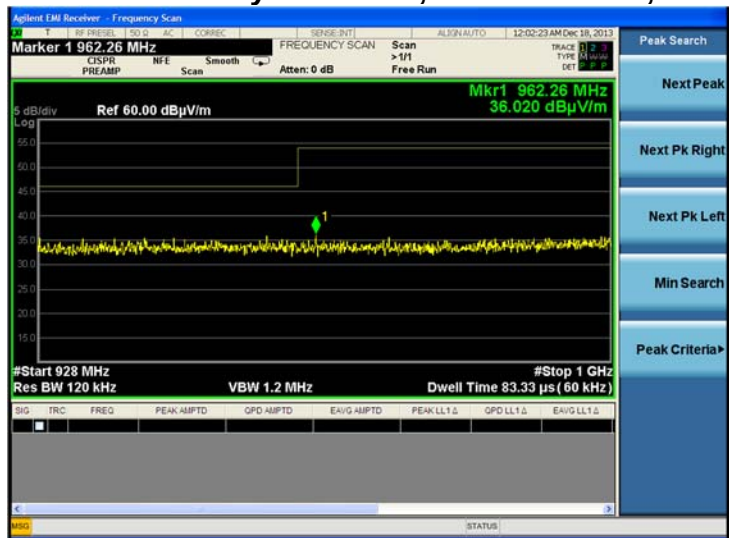
Antenna Vertically Polarized, 300-902 MHz, at 3m



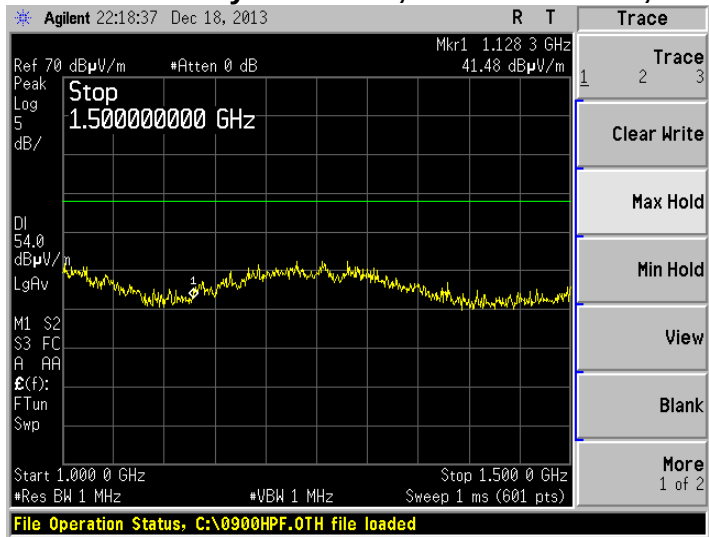
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Screen Captures - Radiated Emissions Testing (continued)

Antenna Vertically Polarized, 928-1000 MHz, at 3m



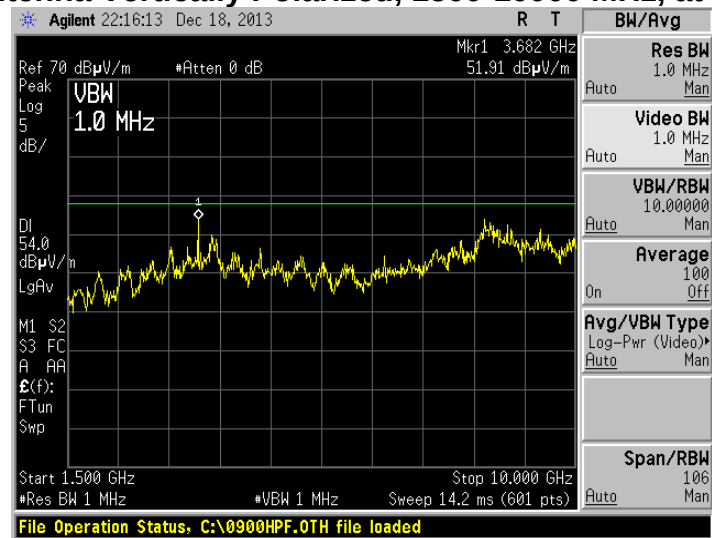
Antenna Vertically Polarized, 1000-1500 MHz, at 3m



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Screen Captures - Radiated Emissions Testing (continued)

Antenna Vertically Polarized, 1500-10000 MHz, at 3m



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EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE:

Not Applicable for this EUT. Exclusively battery powered EUT.

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EXHIBIT 7. OCCUPIED BANDWIDTH:

7.1 Limits

There are no limits specified. The occupied bandwidth need only be reported.

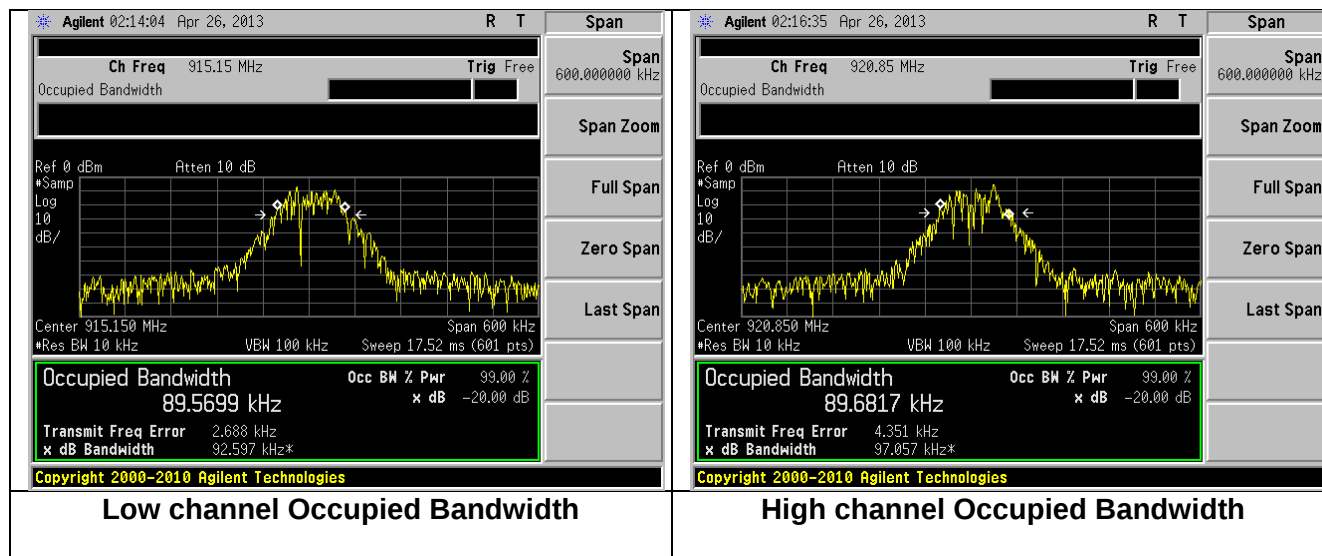
7.2 Method of Measurements

This test is performed in accordance with ANSI C63.4. This test was performed in a conducted radio fashion. The resolution bandwidth was set to a value that was greater than or equal to 1% of the measured bandwidth. Using the 20dBc marker, the bandwidth was measured.

7.3 Test Data

Center Frequency (MHz)	Measured -20 dBc Occ. BW (kHz)
915.15	92.6
920.85	97.0

7.4 Screen Captures - Occupied Bandwidth



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APPENDIX A - Instrumentation Sheet



Date : 19-Dec-2013

Type Test : Radio

Job # : C-1656

Prepared By: Peter

Customer : Bella

Quote #: 313063

No	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	5/9/2013	5/9/2014	Active Calibration
2	AA 960004	Log Periodic Antenna	EMCO	93146	9512-4276	9/21/2013	9/21/2014	Active Calibration
3	AA 960005	Biconical Antenna	EMCO	93110B	9601-2280	9/21/2013	9/21/2014	Active Calibration
4	EE 960088	8GHz MXE Spectrum Analyzer	Agilent	N9038A	MY51210138	11/19/2013	11/19/2014	Active Calibration
5	AA 960007	Double Ridge Horn Antenna	EMCO	3115	9311-4138	6/10/2013	6/10/2014	Active Calibration
6	EE 960146	Std. Gain Horn Ant. w/preamp	Adv. Micro / EMCO WLA622-4 / 3160-09	123001		9/24/2013	9/24/2014	Active Calibration

Project Engineer:

Peter Fidler

Quality Assurance:

LHJ

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APPENDIX B - Test Standards

STANDARD #	DATE	Am. 1	Am. 2
ANSI C63.4	2003		
CISPR 11	2009-05	2009-12 P	
CISPR 16-1-1 Note 1	2010-01		
CISPR 16-1-2 Note 1	2003	2004-04	2006-07
FCC 47 CFR, Parts 0-15, 18, 90, 95	2009		
FCC Public Notice DA 00-1407	2000		2002-10
FCC ET Docket # 99-231	2002		
FCC Procedures	2007		
RSS GEN	2007-06		
RSS 210	2007-06		

APPENDIX C - Uncertainty Statement

This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k=2.

Table of Expanded Uncertainty Values, (K=2) for Specified Measurements

Measurement Type	Particular Configuration	Uncertainty Values
Radiated Emissions	3 – Meter chamber, Biconical Antenna	4.24 dB
Radiated Emissions	3-Meter Chamber, Log Periodic Antenna	4.8 dB
Radiated Emissions	10-Meter OATS, Biconical Antenna	4.18 dB
Radiated Emissions	10-Meter OATS, Log Periodic Antenna	3.92 dB
Conducted Emissions	Shielded Room/EMCO LISN	1.60 dB
Radiated Immunity	3 Volts/Meter in 3-Meter Chamber	1.128 Volts/Meter
Conducted Immunity	3 Volts level	1.0 V