Washington Laboratories, Ltd.
www.wll.com
7560 Lindbergh Drive Gaithersburg, MD 20879
301.216.1500 info@wll.com

FCC/ Canada Certification Test Report

For the

Frederick Energy Products LLC

Magnetic Field Generator w/ CAM

FCC ID: QUI-HN-MFG-C
IC: 11625A-HNMFGWCA

WLL JOB# **13305-02 Rev 1**
February 07, 2014
Revised January 6, 2015

Prepared for:
Frederick Energy Products LLC
1769 Jeff Road
Huntsville, AL 35806

Prepared By:
Washington Laboratories, Ltd.
7560 Lindbergh Drive
Gaithersburg, Maryland 20879

ACLASS ACCREDITED TESTING

Testing Certificate AT-1448

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Prepared by:

John P. Repella
EMC Engineer

Reviewed by:

James Ritter
EMC Compliance Engineer

Abstract

This report has been prepared on behalf of Frederick Energy Products LLC to support the attached Application for Equipment Authorization. The test report and application are submitted for an Intentional Radiator under Part 15.231 (10/2013) of the FCC Rules and Regulations and Industry Canada RSS210 issue 8 Annex 1. This Certification Test Report documents the test configuration and test results for a Frederick Energy Products LLC Magnetic Field Generator w/ CAM.

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. The Industry Canada OATS numbers are 3035A-1 and 3035A-2 for Washington Laboratories, Ltd. Site 1 and Site 2, respectively. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ACLASS under Certificate AT-1448 as an independent FCC test laboratory.

The Frederick Energy Products LLC Magnetic Field Generator w/ CAM complies with the limits for an Intentional Radiator device under FCC Part 15.231 and RSS210 annex 1.

Revision History	Description of Change	Date
Rev 0	Initial Release	February 7, 2014
Rev 1	Revised model number to HN-MFG-C	January 6, 2015 JR

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1 Introduction

1.1 Compliance Statement

The Frederick Energy Products LLC Magnetic Field Generator w/ CAM complies with the limits for an Intentional Radiator device under FCC Part 15.231 (10/2013) and IC RSS210 issue 8.

1.2 Test Scope

Tests for radiated were performed. All measurements were performed in accordance with FCC part 15.231 and the 2003 version of ANSI C63.4. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Frederick Energy Products LLC 1769 Jeff Road Huntsville, AL 35806
Quotation Number:	67877

1.4 Test Dates

Testing was performed on the following date(s):	1/27/14, 2/6/2014

1.5 Test and Support Personnel

Washington Laboratories, LTD	John P. Repella
Customer Representative(s)	Ed Richardson, Ishmael Chigumira

1.6 Abbreviations

A	**A**mpere
ac	**a**lternating **c**urrent
AM	Amplitude Modulation
Amps	**Amp**ere**s**
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

The Frederick Energy Products LLC Magnetic Field Generator w/ CAM is a personnel worn proximity alarm that operates in conjunction with the Frederick Energy products, LLC Magnetic Field Generator which produces a 73kHz proximity field. When a Magnetic Field Generator w/ CAM enters this field it causes the PAD unit to visually and audibly alarm. In addition the PAD unit sends its serial number back to the Magnetic Field Generator that causes the generator to visibly and audibly alarm.

The generator device is typically mounted on a vehicle, the PAD units are worn by personnel to warn both the equipment operators and people in the proximity of this equipment of possibly dangerous conditions.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Frederick Energy Products LLC
FCC ID:	QUI-HN-MFG-C
IC:	11625A-HNMFGWCA
Model:	HN-MFG-C
FCC Rule Parts:	§15.231
IC Rule Parts:	RSS210 Annex 1
Emission Designator:	104KF1D
Maximum Field Strength	87360.3 uV/m at 3m
Modulation:	FM
Occupied Bandwidth:	103.62 kHz
Keying:	Automatic
Type of Information:	data
Number of Channels:	1 (916.49MHz)
Power Output Level	Fixed
Antenna Connector	integral
Antenna Type	Grounded Line Planar Antenna
Interface Cables:	None
Power Source & Voltage:	3.7Vdc Li-ion battery
Receiver	73kHz

2.2 Test Configuration

The EUT is a standalone unit. The EUT has a rechargeable battery, however the transceiver does not operate while charging.

2.3 Testing Algorithm

The Magnetic Field Generator w/ CAM was configured to transmit constantly at 916.49MHz for radiated measurements. A second identical unit had been programmed with the end user program; this unit was used for the timing measurements.

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

2.4 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 ACLASS under Certificate AT-1448 as an independent FCC test laboratory.

2.5 Measurements

2.5.1 References

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

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

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 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 ≤ 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 List

Test Name:	**Radiated Emissions**	Test Date:	**1/28/2014**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
69	HP - 85650A	ADAPTER QP	1/9/2015
71	HP - 85685A	PRESELECTOR RF W/OPT 8ZE	1/9/2015
802	HP - 8568B	ANALYZER SPECTRUM	1/9/2015
382	SUNOL SCIENCES CORPORATION - JB1	ANTENNA BICONLOG	12/26/2014
4	ARA - DRG-118/A	ANTENNA HORN	2/20/2015
528	AGILENT - E4446A	ANALYZER SPECTRUM	2/28/2014
522	HP - 8449B	PRE-AMPLIFIER 1-26.5GHZ	10/4/2014

4 Test Results

4.1 Duty Cycle Correction

Measurements may be adjusted where pulsed RF is utilized to find the average level associated with a quantity. This calculation is applied to limits for unlicensed devices.

- For Unlicensed Intentional Radiators under 47CFR Part 15, all duty cycle measurements are compared to a 100 millisecond period

The duty cycle correction factor is calculated by:

20 x LOG (on time/100 ms)

The following Figures show the plots of the modulated carrier. The spectrum analyzer was set to Zero Span and the video triggered to collect the pulse train of the modulation. Calculations of the duty cycle correction factor were obtained from time data provided by the plots.

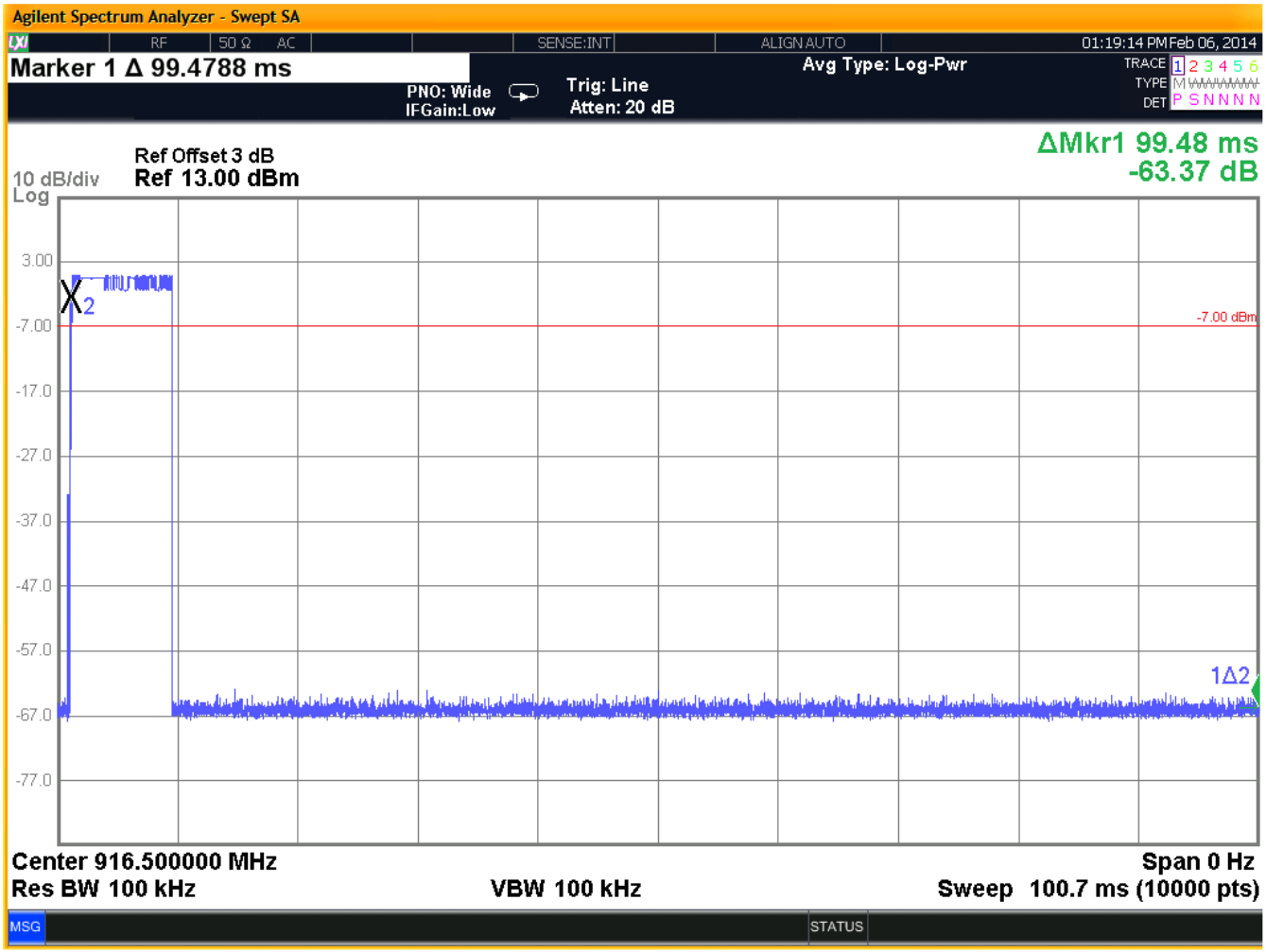

Figure 1: Duty Cycle Plot – Worst Case 100ms and Pulse Train

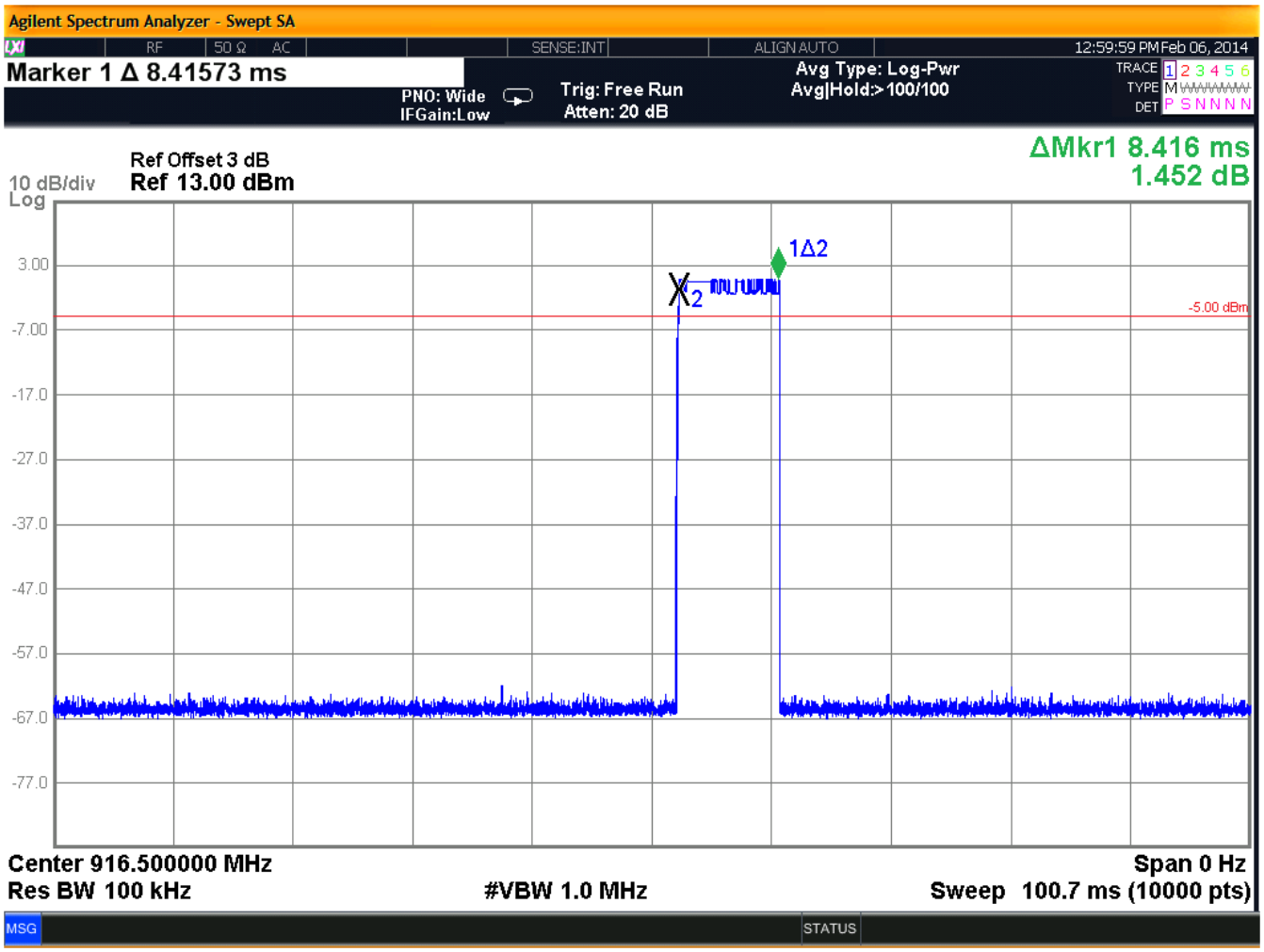

Figure 2: Duty Cycle Plot – Pulse Width

From the data in figures 2 and 3 the following calculations are made.

On Time Per 100ms (worst case):

1 x 8.42ms = 8.42ms

Duty cycle calculation:

8.42ms/100ms = 20LOG (8.42ms/100ms) = 20LOG (0.0842) = -21.49dB duty cycle correction

4.2 Transmit Turnoff Time (FCC Part §15.231(a) (2))

Per FCC part 15.231 Paragraph (a)(2) and RSS210 Annex1 *'A transmitter activated automatically shall cease transmission within 5 seconds after activation.'*

The below figure shows that the turnoff time after activation is less than 5 seconds (see marker delta on plot) complying with the requirements of part 15.231(a)(2).

The EUT was measured by a spectrum analyzer through a near field antenna. The sweep was activated at the start of the EUT transmit signal.

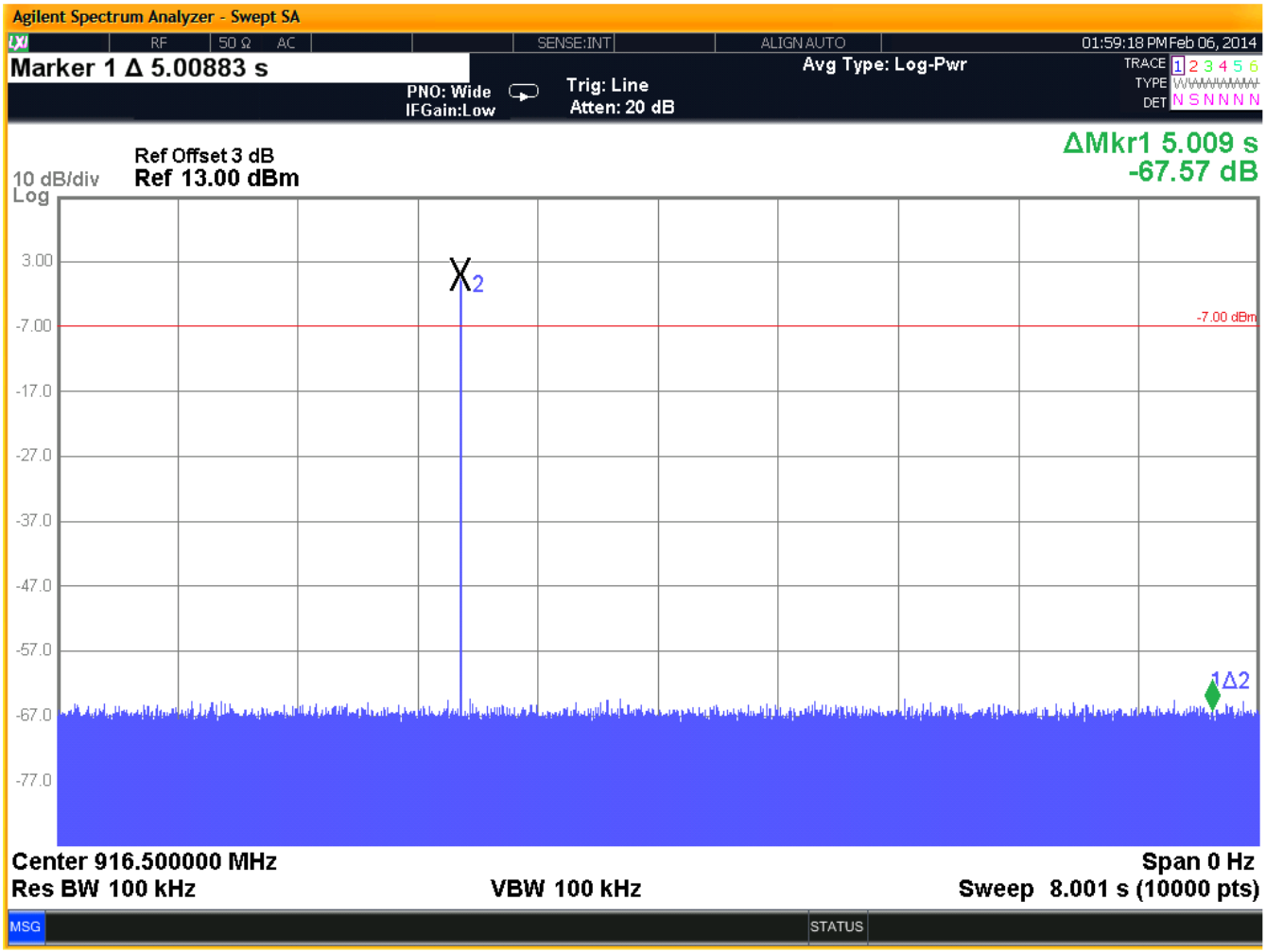

Figure 3: EUT Turnoff Time

4.3 FCC Part §15.231(a) (3) Compliance

Per FCC part 15.231 Paragraph (a)(3) and RSS210 Annex1 *'Periodic transmissions at regular predetermined intervals are not permitted. However, polling or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed if the total duration of transmissions does not exceed more than two seconds per hour for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed two seconds per hour'*

The EUT transmits periodic data consisting of its serial number and battery. The below figures show that the periodic signal on time equals 8.42ms per 40.27 seconds or 0.761 seconds per hour. As this is used in a personnel safety application this complies with this section.

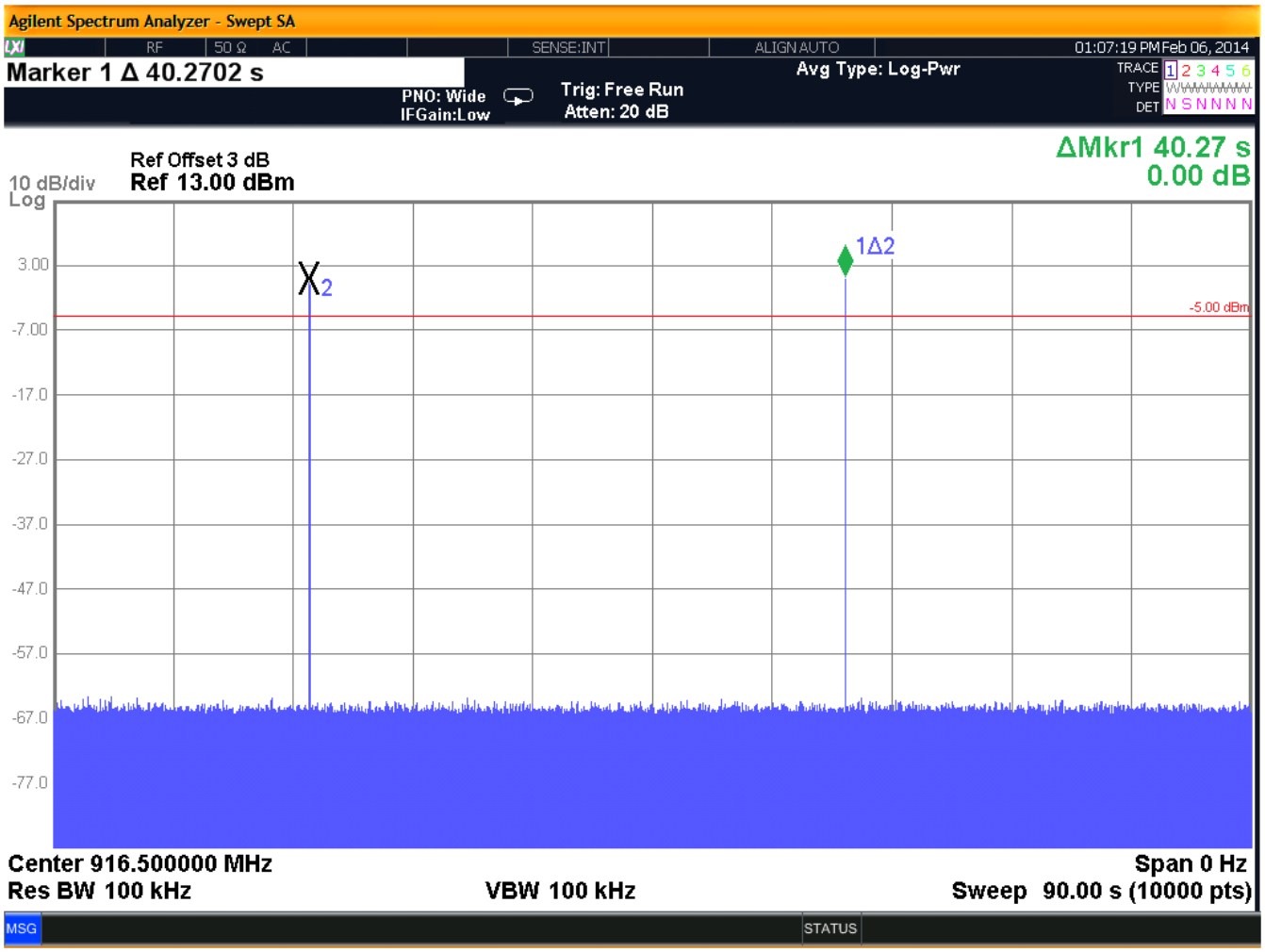

Figure 4: Periodic Transmission Timing

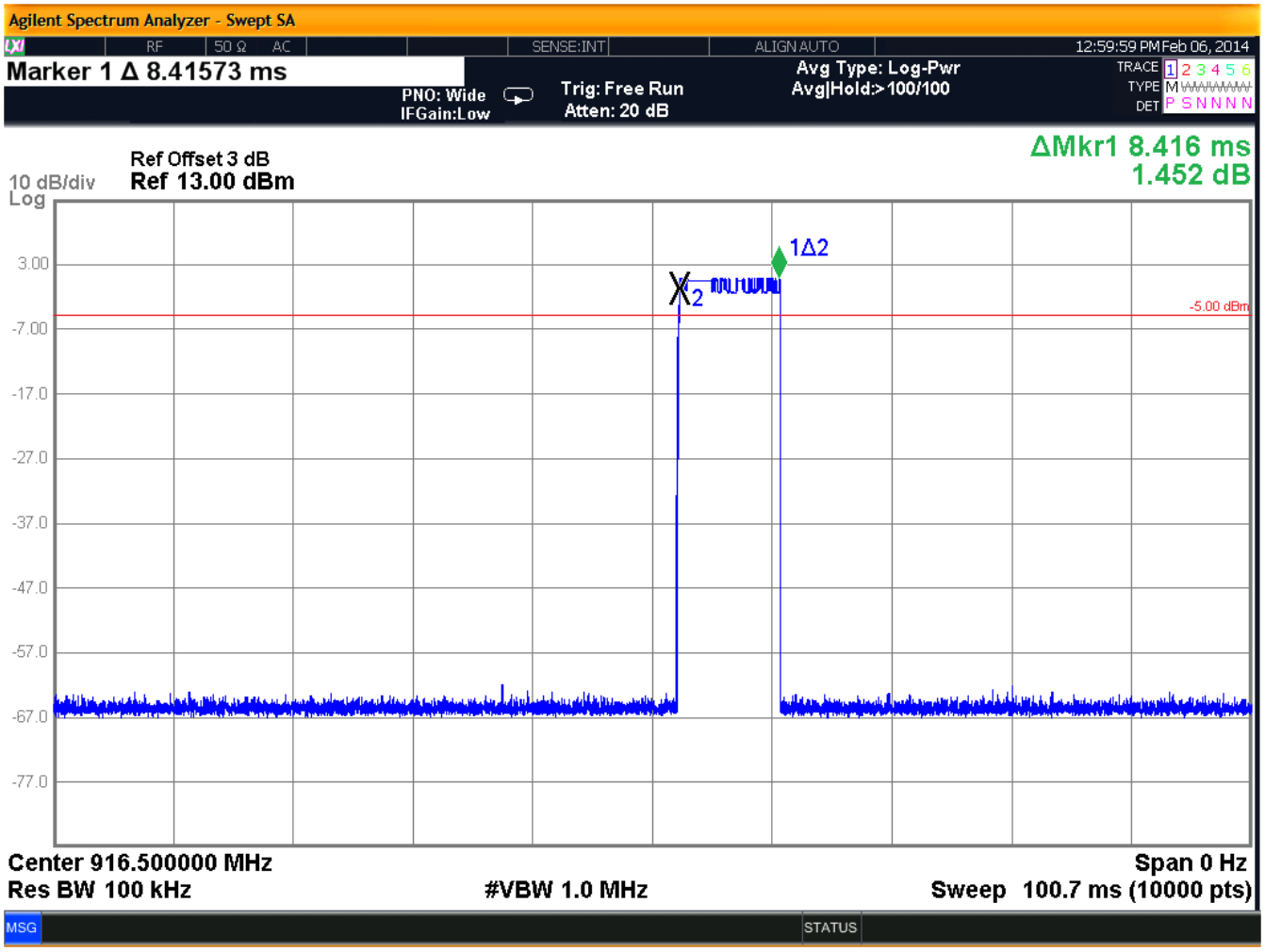

Figure 5: Single Pulse Time

4.4 Occupied Bandwidth: (FCC Part §2.1049)

Occupied bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer.

According to FCC Part 15.231 & RSS210 Annex1 the Occupied bandwidth (20dB) shall be:

> *(c) The bandwidth of the emission shall be no wider than 0.25% of the center frequency for devices operating above 70 MHz and below 900 MHz. For devices operating above 900 MHz, the emission shall be no wider than 0.5% of the center frequency. Bandwidth is determined at the points 20 dB down from the modulated carrier.*

Note: Industry Canada accepts the FCC 20dB Measurements technique in lieu of a 99% bandwidth plot.

For a system operating at 916.49MHz the maximum 20dB bandwidth is 4.58MHz.

At full modulation, the occupied bandwidth was measured at 103.62kHz (as shown below):

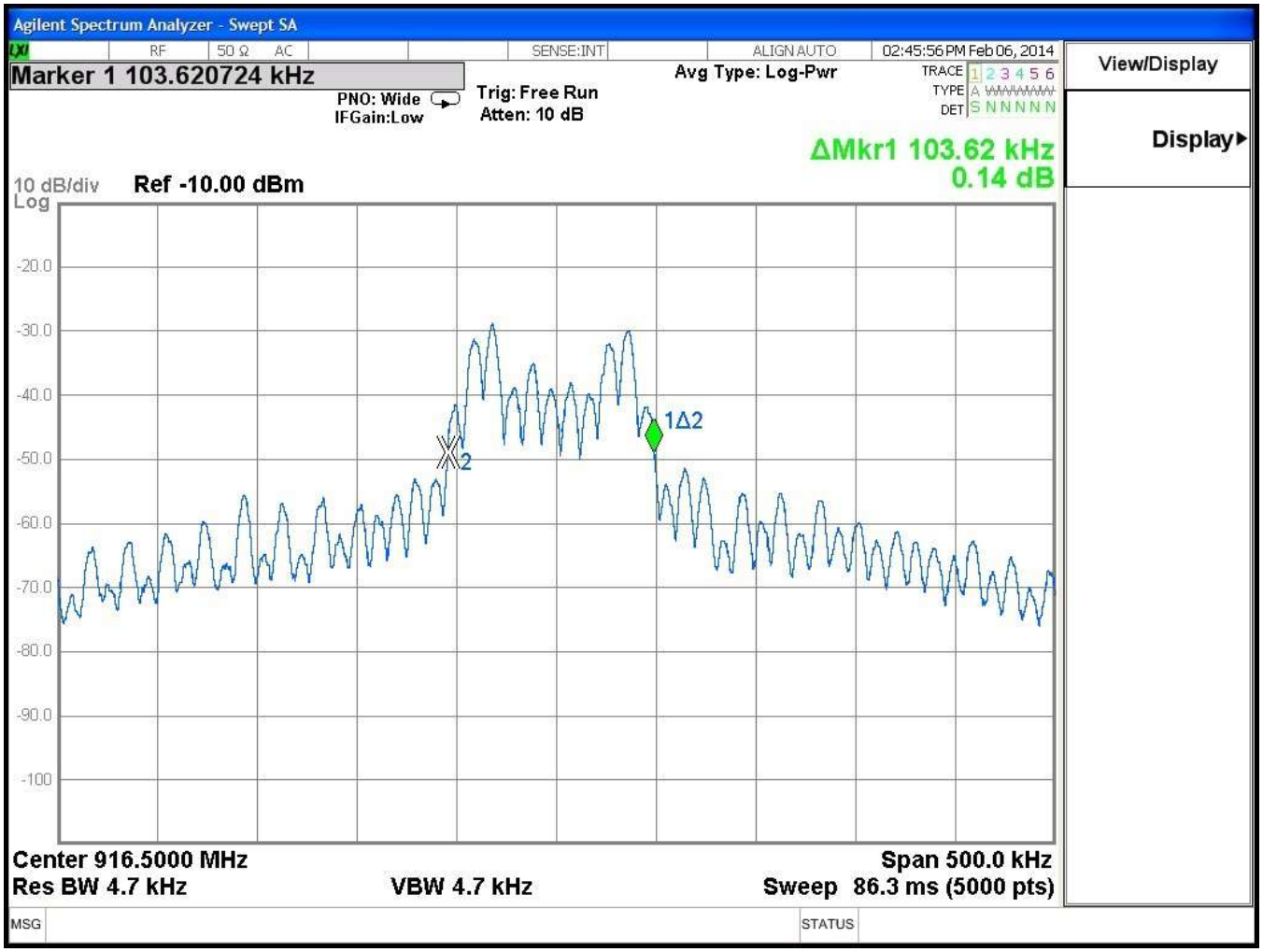

Figure 6: Occupied Bandwidth

4.5 Radiated Emissions: (FCC Part §2.1053)

The EUT must comply with the radiated emission limits of 15.231(a). The limits are as shown in the following table.

Table 4: Radiated Emissions Limits

Fundamental Frequency (MHz)	Field Strength of Fundamental (µV/m)	Field Strength of Field strength of spurious emission (µV/m)
40.66-40.70	2250	225
70-130	1250	125
130-174	1250 to 3750	125 to 375
174-260	3750	375
260-470	3750 to 12500	375 to 1250
Above 470	12500	1250

Frequencies that fall in FCC part 15.205 restricted bands must be below part 15.209 limits within these bands.

In accordance with FCC part 15.35 when averaging is used the peak limit shall be 20 dB above the average limits.

4.5.1 Test Procedure

The EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. 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.

In accordance with FCC part 15.35 averaging was performed by using a duty cycle correction subtracted from from the peak reading. For this EUT a duty cycle correction of -21.4dB was calculated.

The EUT was tested in 3 orthogonals with the worst case reported (fundamental frequency is reported in all orthogonals).

Non harmonic spurious emissions peaks were tested against the average limits for compliance (no duty cycle correction was used).

The emissions were measured using the following resolution bandwidths:

Frequency Range	Resolution Bandwidth	Video Bandwidth
30MHz-1000 MHz	120kHz	>100 kHz
>1000 MHz	1 MHz	1MHz (Peak)

Emissions were measured to the 10th harmonic of the transmit frequency. Worst case emission levels are reported.

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): V dBµV

Antenna Factor (Ant Corr): AFdB/m

Cable Loss Correction (Cable Corr): CCdB

Duty Cycle Correction (Average) DCCdB

Amplifier Gain: GdB

Electric Field (Corr Level): EdBµV/m = VdBµV + AFdB/m + CCdB + DCCdB - GdB

Table 5: Radiated Emission Test Data, 916.49MHz (Fundamental)

	Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Duty cycle correction (dB)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Notes
unit upright	916.49	V	0.00	1.00	69.22	0.00	28.5	77146.2	125000.0	-4.2	peak
	916.49	V	0.00	1.00	69.22	21.40	28.5	6566.2	12500.0	-5.6	ave
unit on side	916.49	V	10.00	1.30	63.70	0.00	28.5	40861.5	125000.0	-9.7	peak
	916.49	V	10.00	1.30	63.70	21.40	28.5	3477.9	12500.0	-11.1	ave
unit flat	916.49	V	90.00	3.49	59.30	0.00	28.5	24621.5	125000.0	-14.1	peak
	916.49	V	90.00	3.49	59.30	21.40	28.5	2095.6	12500.0	-15.5	ave
unit upright	916.49	H	10.00	1.81	60.10	0.00	28.5	26996.9	125000.0	-13.3	peak
	916.49	H	10.00	1.81	60.10	21.40	28.5	2297.8	12500.0	-14.7	ave
unit on side	916.49	H	45.00	0.00	68.90	0.00	28.5	74355.7	125000.0	-4.5	peak
	916.49	H	45.00	0.00	68.90	21.40	28.5	6328.7	12500.0	-5.9	ave
unit flat	916.49	H	180.00	1.00	70.30	0.00	28.5	87360.3	125000.0	-3.1	peak
	916.49	H	180.00	1.00	70.30	21.40	28.5	7435.6	12500.0	-4.5	ave

Table 6: Radiated Emission Test Data, Spurious Emissions

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Duty cycle correction (dB)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
1833.00	V	350.00	2.85	50.82	0.00	-8.3	134.3	12500.0	-39.4	peak
1833.00	V	350.00	2.85	50.85	21.40	-8.3	11.5	1250.0	-40.7	ave
2749.50	V	90.00	3.22	47.98	0.00	-3.5	166.7	5000.0	-29.5	peak
2749.50	V	90.00	3.22	47.98	21.40	-3.5	14.2	500.0	-30.9	ave
3666.00	V	90.00	3.49	53.92	0.00	-1.1	439.8	5000.0	-21.1	peak
3666.00	V	90.00	3.49	53.92	21.40	-1.1	37.4	500.0	-22.5	ave
4582.40	V	135.00	2.86	48.20	0.00	1.5	304.2	5000.0	-24.3	peak
4582.40	V	135.00	2.86	48.20	21.40	1.5	25.9	500.0	-25.7	ave
5499.00	V	270.00	2.98	43.73	0.00	5.4	286.1	12500.0	-32.8	peak
5499.00	V	270.00	2.98	43.73	21.40	5.4	24.3	1250.0	-34.2	ave
Non-Harmonics										
41.98	V	90.00	1.00	0.00	0.00	13.0	4.5	1250.0	-48.9	peak
60.02	V	180.00	1.00	13.33	0.00	8.1	11.8	1250.0	-40.5	peak
80.00	V	0.00	1.20	9.60	0.00	9.0	8.5	1250.0	-43.4	peak
250.00	V	10.00	1.46	5.90	0.00	14.1	10.0	200.0	-26.0	peak
344.40	V	270.00	2.00	6.20	0.00	17.4	15.1	1250.0	-38.4	peak
930.86	V	45.00	2.33	5.80	0.00	28.3	51.0	1250.0	-27.8	peak
1833.00	H	45.00	3.10	53.65	0.00	-8.3	186.0	12500.0	-36.5	peak
1833.00	H	45.00	3.10	53.65	21.40	-8.3	15.8	1250.0	-37.9	ave
2749.50	H	270.00	2.35	51.34	0.00	-3.5	245.4	5000.0	-26.2	peak
2749.50	H	270.00	2.35	51.34	21.40	-3.5	20.9	500.0	-27.6	ave
3666.00	H	45.00	1.00	52.85	0.00	-1.1	388.8	5000.0	-22.2	peak
3666.00	H	45.00	1.00	52.85	21.40	-1.1	33.1	500.0	-23.6	ave
4582.40	H	180.00	3.09	47.20	0.00	1.5	271.1	5000.0	-25.3	peak
4582.40	H	180.00	3.09	47.20	21.40	1.5	23.1	500.0	-26.7	ave
5499.00	H	0.00	0.00	43.24	0.00	5.4	270.4	12500.0	-33.3	peak
5499.00	H	0.00	0.00	43.24	21.40	5.4	23.0	1250.0	-34.7	ave
Non-Harmonics										
42.02	H	190.00	1.58	9.30	0.00	13.0	13.0	1250.0	-39.7	peak
60.02	H	0.00	3.02	5.50	0.00	8.1	4.8	1250.0	-48.3	peak
80.00	H	170.00	2.74	4.50	0.00	9.0	4.7	1250.0	-48.5	peak

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Duty cycle correction (dB)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
250.00	H	45.00	2.50	6.40	0.00	14.1	10.6	200.0	-25.5	peak
300.00	H	180.00	1.68	4.70	0.00	16.3	11.2	1250.0	-40.9	peak
930.86	H	180.00	1.60	10.80	0.00	28.3	90.6	1250.0	-22.8	peak

4.6 Conducted Emissions (AC Power Line)

As this unit is only powered from in internal battery no Power mains testing is required.

4.7 Receiver Emissions

As the receiver associated with this transmitter operates below 30MHz it is exempt from DOC or certification.

