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FCC/ Canada Certification Test Report
For the
Frederick Energy Products LLC
Magnetic Field XL Generator with Collision Avoidance

FCC ID: QUI-HN-MFG-XL-C
IC: 11625A-HNMFGXLWCA

WLL JOB# **14012-01 Rev 0**
June 25, 2015

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

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

Testing Certificate AT-1448

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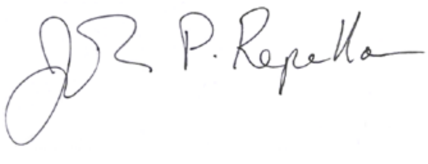
Prepared by:

James Ritter
EMC Engineer

Reviewed by:



John P. Repella
EMC & Wireless Lab Manager

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 XL Generator with Collision Avoidance.

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 XL Generator with Collision Avoidance complies with the limits for an Intentional Radiator device under FCC Part 15.231 and RSS210 annex 1.

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1 Introduction

1.1 Compliance Statement

The Frederick Energy Products LLC Magnetic Field XL Generator with Collision Avoidance 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, IC RSS 210, and ANSI C63.10:2013 (Site validated to ANSI C63.4: 2009). 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:	68839
PO Number	6137

1.4 Test Dates

Testing was performed on the following date(s):	6/16/2015-6/17/2015

1.5 Test and Support Personnel

Washington Laboratories, LTD	James Ritter
Customer Representative(s)	Ed Richardson

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 XL Generator with Collision Avoidance is a vehicle mounted that operates in conjunction with the Frederick Energy products PAD and other generator units. The Magnetic Field XL Generator with Collision Avoidance produces a 73 kHz proximity field (certified under a separate report). When a user wearing a PAD unit 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 (received on 916.49MHz) that causes the generator to visibly and audibly alarm. The Magnetic Field XL Generator with Collision Avoidance device also monitors for other field generators and when in the presents of their magnetic fields alarms and generates a 916.49MHz (tested in this report) signal that will cause the other generator to also alarm.

The PAD unit is a separate transmitter already certified.

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-XL-C
IC:	11625A-HNMFGXLWCA
Model:	HN-MFG-XL-C
FCC Rule Parts:	§15.231
IC Rule Parts:	RSS210 Annex 1
Emission Designator:	211KF1D
Maximum Field Strength	57719.3 uV/m Peak at 3m , 6551.2 uV/m average at 3m
Modulation:	FM
Occupied Bandwidth:	148.3 kHz (20dB), 211.33kHz (99%)
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:	24VDC Vehicle Battery
Receiver	73kHz (exempt from certification)

2.2 Test Configuration

The EUT is a standalone unit..

2.3 Testing Algorithm

The Magnetic Field XL Generator with Collision Avoidance 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 C63.4:2014 Methods of Measurement of Radio Noise from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz .
- ANSI C63.10:2013 Procedures for Compliance Testing of Unlicensed Wireless Devices

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 (R2012) 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

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

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 List

Test Name:	**Radiated Emissions**	Test Date:	**06/17/2015**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
823	AGILENT - N9010A	EXA SPECTRUM ANALYZER	07/06/2015
559	HP - 8447D	AMPLIFIER	2/20/2016
522	HP - 8449B	PRE-AMPLIFIER 1-26.5GHZ	12/24/2015
644	SUNOL SCIENCES CORPORATION - JB1 925-833-9936	BICONALOG ANTENNA	1/17/2016
626	ARA - DRG-118/A	ANTENNA HORN	1/6/2016

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 * LOG (on time/100 ms)

The measurement was performed in accordance with ANSI C63.10 section 7.5 “Procedure for determining the average value of pulsed emissions”

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. Mutliple sweeps were made to find the worst case 100ms. Calculations of the duty cycle correction factor were obtained from time data provided by the plots.

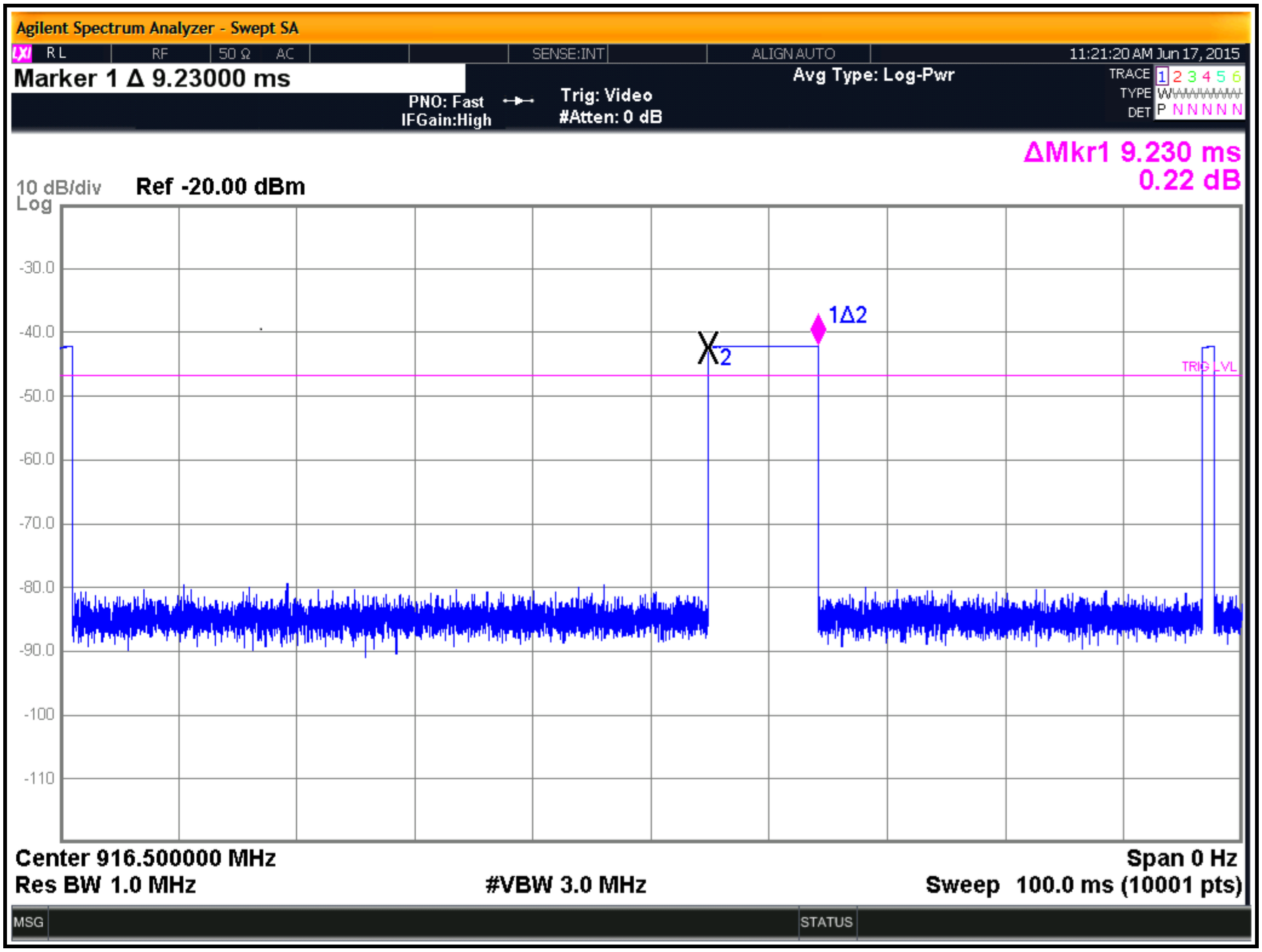

Figure 1: Duty Cycle Plot – Worst Case 100ms and Pulse Train

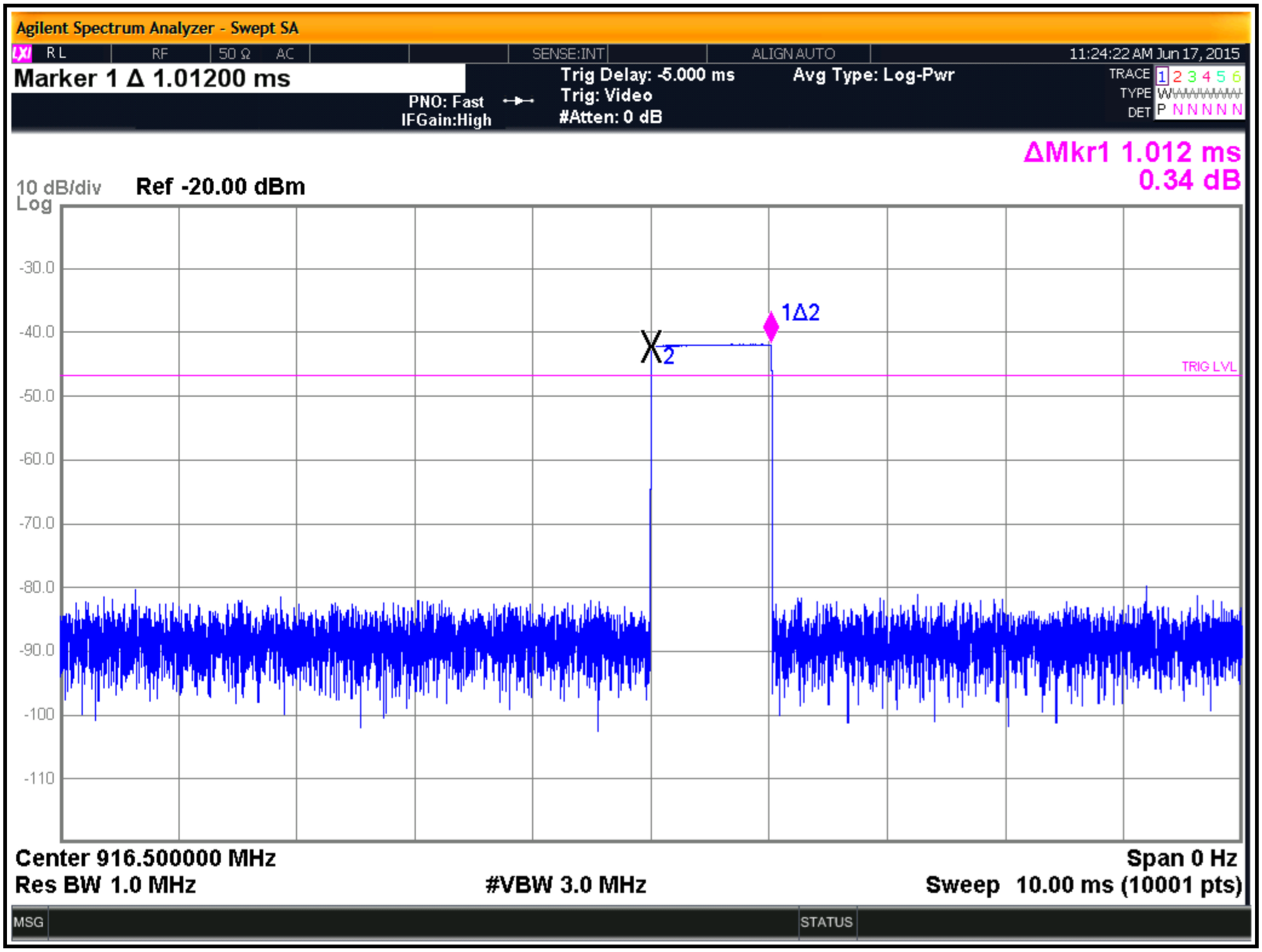

Figure 2: Duty Cycle Plot – Pulse Width

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

The worst case on time was comprised of two 1.012ms short pulses and one 9.23ms long pulse
On Time Per 100ms (worst case):

2 x 1.012ms = 2.024ms plus 9.23ms= 11.254ms

Duty cycle calculation:

20*LOG (11.254ms/100ms) = 20*LOG (0.11254) = -18.97dB 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). Time to turn-off was measured at 1.9 seconds.

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.

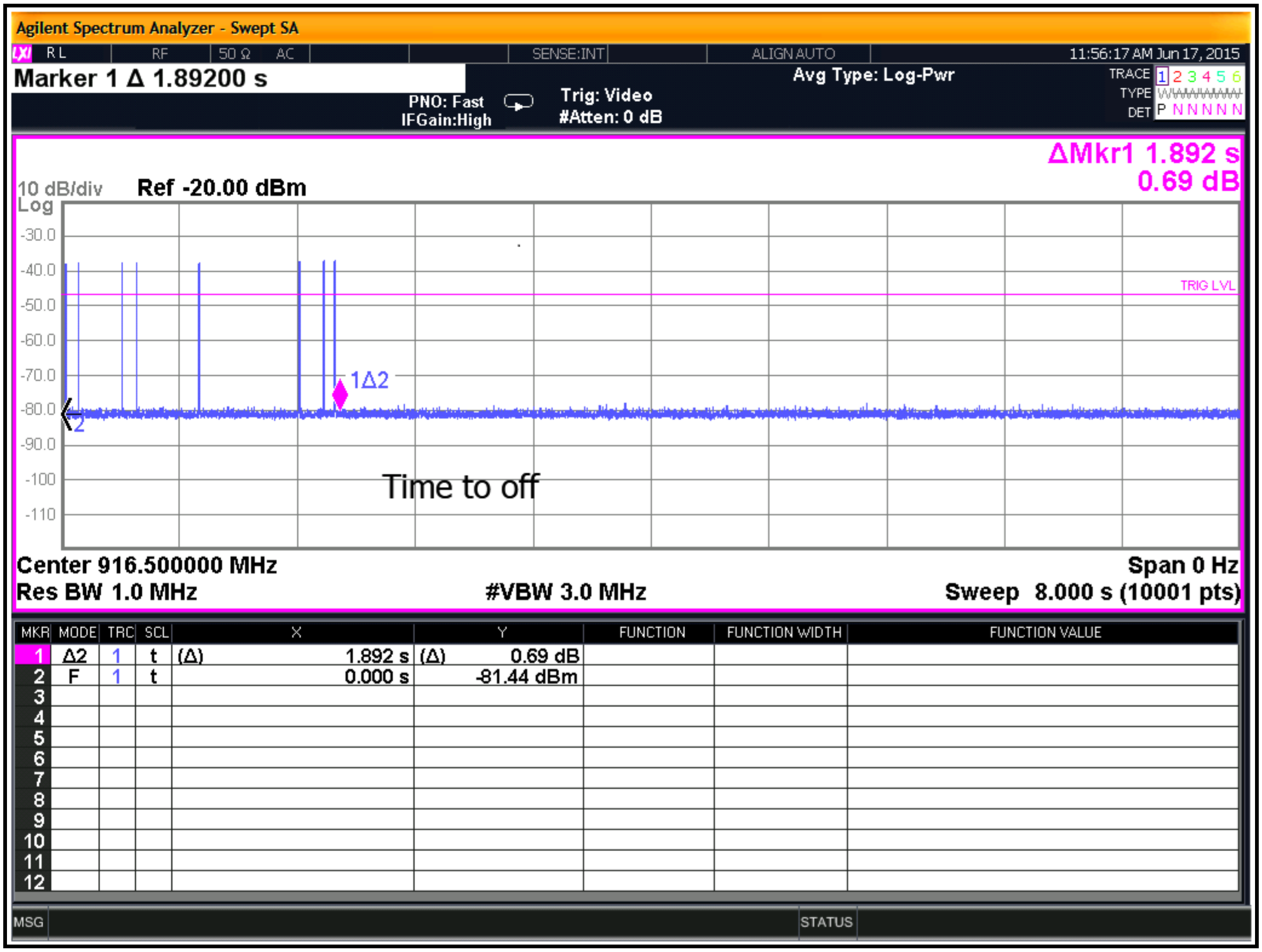

Figure 3: EUT Turnoff Time

4.3 Periodic Transmissions 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 8.74ms per 40.20 seconds or 0.783 seconds per hour. As this is used in a personnel safety application this complies with this section.

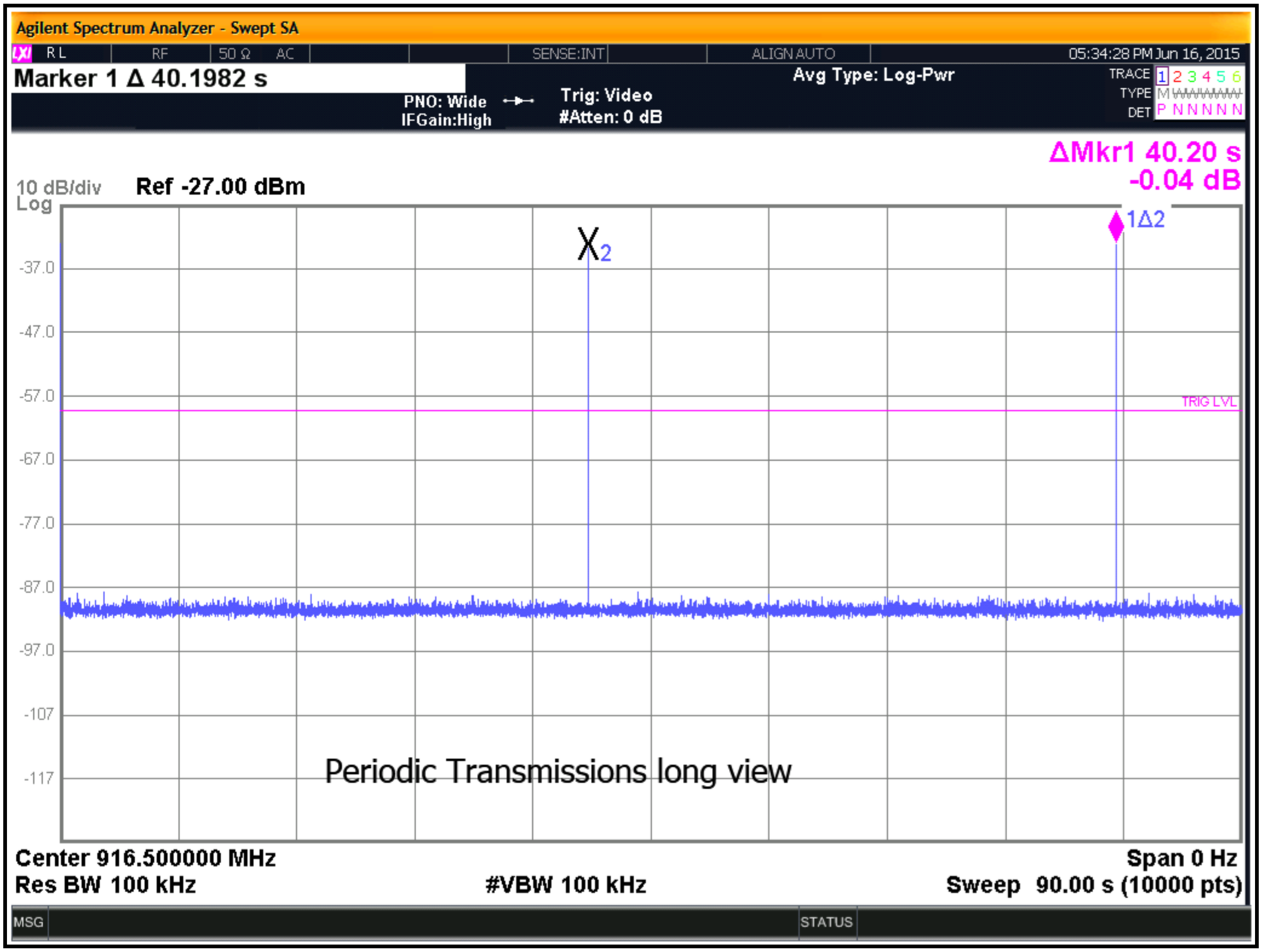

Figure 4: Periodic Transmission Timing

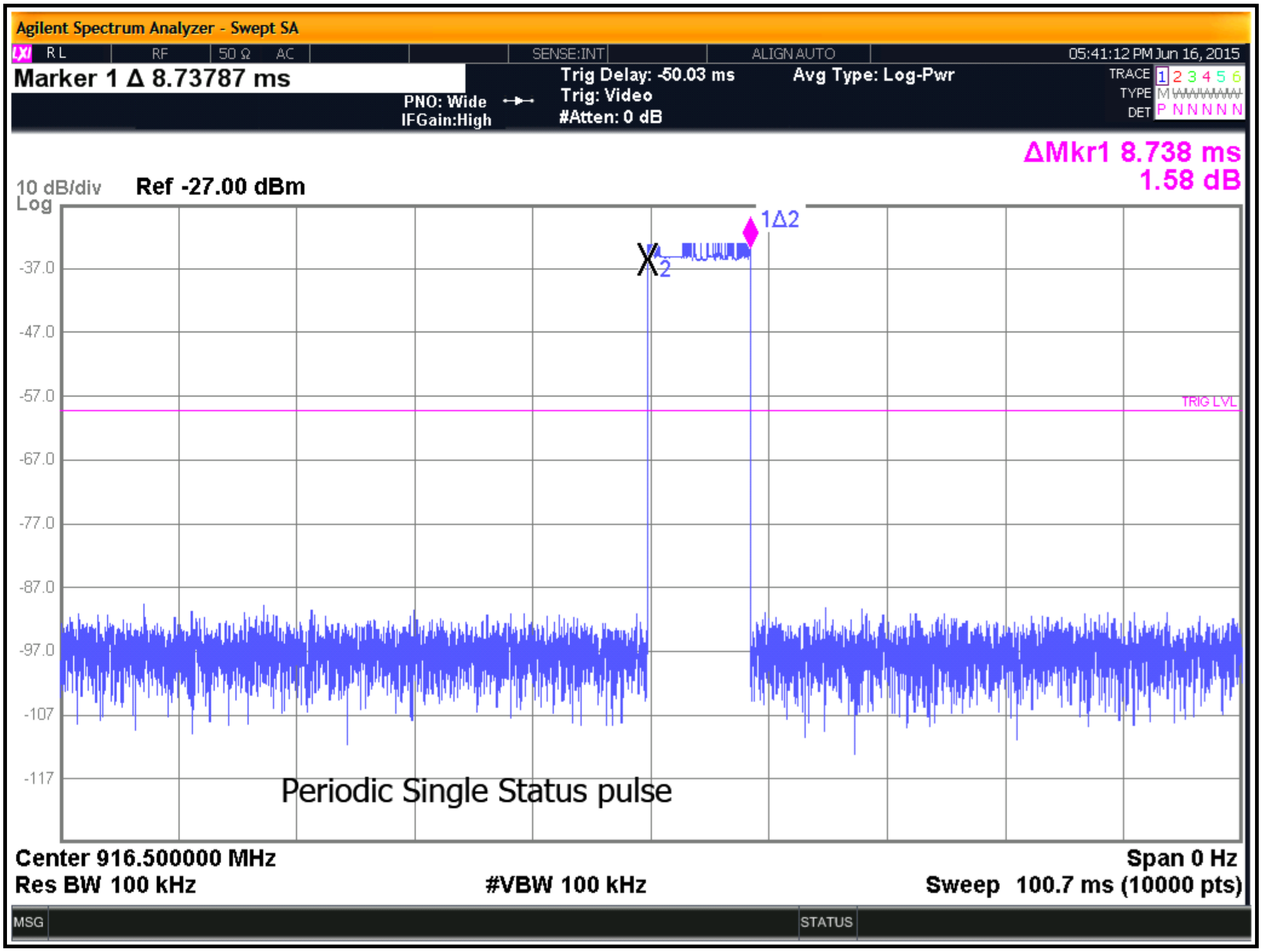

Figure 5: Single Pulse Time

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 via an antenna.

The test was performed per ANSI C63.10 6.9.2 Occupied bandwidth—relative measurement procedure for the 20dB bandwidth and ANSI C63.10 6.9.3 Occupied bandwidth—power bandwidth (99%) measurement procedure (using power bandwidth function of the instrument).

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.

For a system operating at 916.49MHz the maximum 20dB (99%) bandwidth is 4.58MHz.

At full modulation, the occupied bandwidth was measured at 148kHz for the 20dB BW and 211.33kHz for the 99% Bandwidth (as shown below):

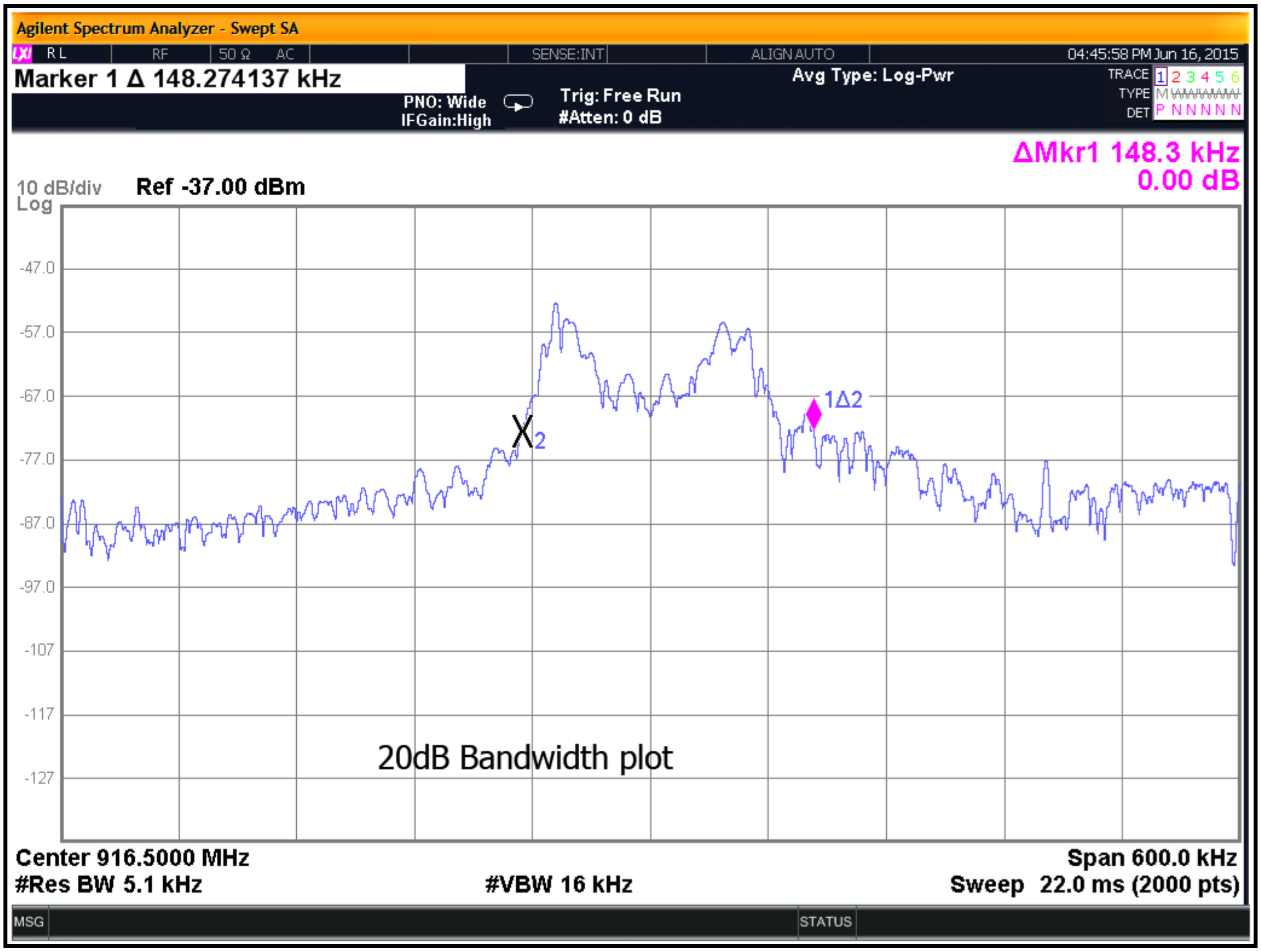

Figure 6: Occupied Bandwidth 20dB

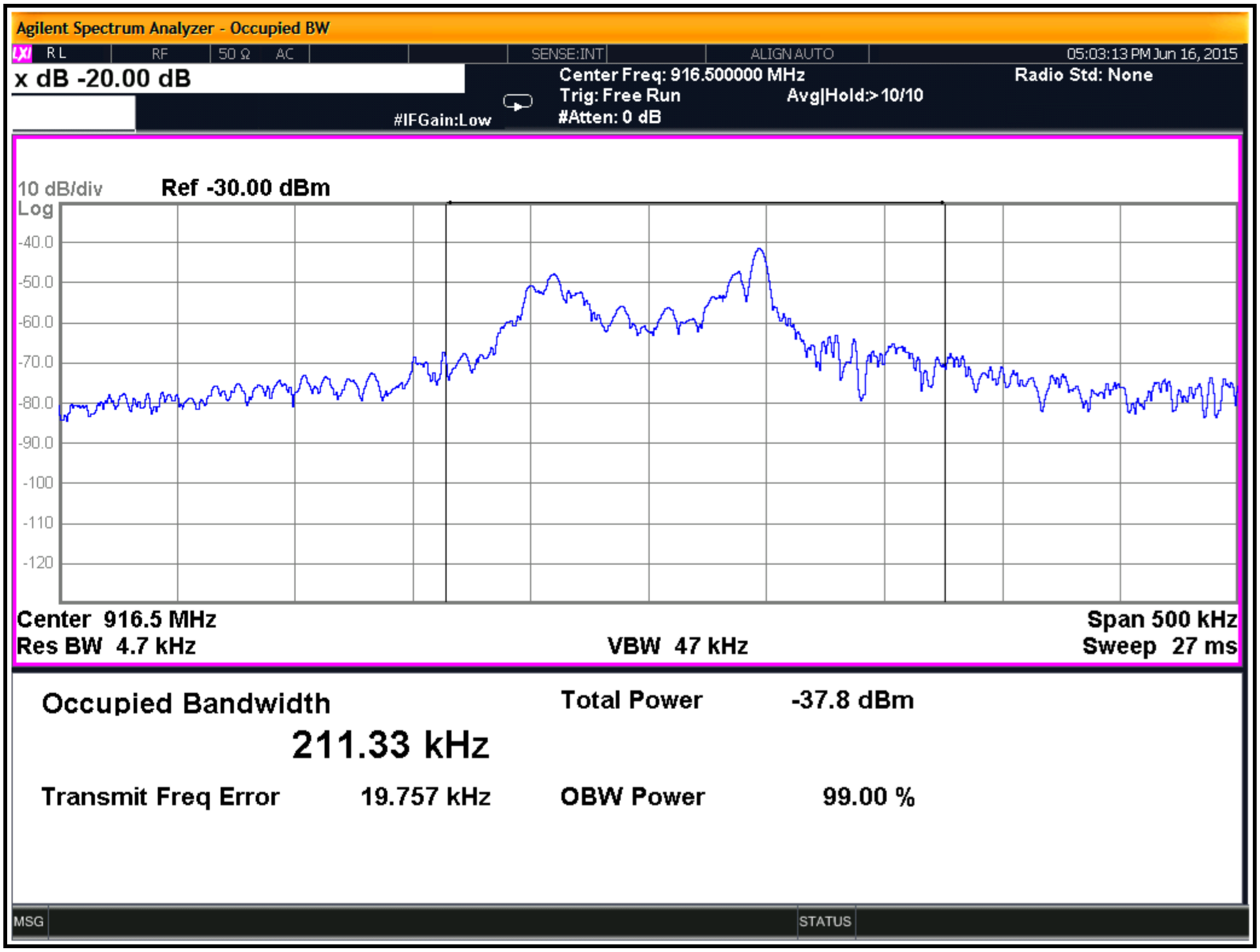

Figure 7: Occupied Bandwidth 99%

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 measurement was performed in accordance with ANSI C63.10 section 6.5 “Radiated emissions from unlicensed wireless devices in the frequency range of 30 MHz to1000 MHz” and section 6.6 “Radiated emissions from unlicensed wireless devices above 1 GHz”. Above 1 GHz RF absorber was placed between the EUT and Receive antenna in accordance with ANSI C63.4:2009 (deviation from C63.10:2013 allowed until December 2015).

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 the peak reading. For this EUT a duty cycle correction of -18.9dB 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)	Corr Factor (dB)	Duty Cycle correction (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Notes
Unit flat	916.49	V	10.00	1.20	86.77	1.1	0.0	24849.7	125000.0	-14.0	peak
	916.49	V	10.00	1.20	86.77	1.1	-18.9	2820.5	12500.0	-12.9	ave
	916.49	H	270.00	1.00	91.34	1.1	0.0	42055.3	125000.0	-9.5	peak
	916.49	H	270.00	1.00	91.34	1.1	-18.9	4773.3	12500.0	-8.4	ave
Unit on side	916.49	V	350.00	1.20	85.80	1.1	0.0	22223.9	125000.0	-15.0	peak
	916.49	V	350.00	1.20	85.80	1.1	-18.9	2522.4	12500.0	-13.9	ave
	916.49	H	270.00	1.00	94.09	1.1	0.0	57719.3	125000.0	-6.7	peak
	916.49	H	270.00	1.00	94.09	1.1	-18.9	6551.2	12500.0	-5.6	ave
Unit upright	916.49	V	0.00	1.10	91.30	1.1	0.0	41862.1	125000.0	-9.5	peak
	916.49	V	0.00	1.10	91.30	1.1	-18.9	4751.4	12500.0	-8.4	ave
	916.49	H	45.00	1.00	87.39	1.1	0.0	26688.3	125000.0	-13.4	peak
	916.49	H	45.00	1.00	87.39	1.1	-18.9	3029.2	12500.0	-12.3	ave

Table 6: Radiated Emission Data, Spurious Emissions <1GHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Duty Cycle correction (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
33.83	V	90.00	1.00	41.39	-5.3	0.0	63.8	1250.0	-25.8	peak
60.00	V	0.00	1.10	37.50	-16.5	0.0	11.2	1250.0	-41.0	peak
79.30	V	90.00	1.10	43.90	-15.8	0.0	25.5	1250.0	-33.8	peak
145.68	V	0.00	1.30	35.02	-10.6	0.0	16.6	1250.0	-37.6	peak
212.89	V	90.00	1.58	46.01	-12.4	0.0	47.8	1250.0	-28.4	peak
226.96	V	180.00	1.60	45.70	-12.0	0.0	48.5	1250.0	-28.2	peak
251.90	V	180.00	1.90	40.81	-11.3	0.0	30.0	200.0	-16.5	res band
260.16	V	90.00	2.04	45.50	-10.8	0.0	54.1	200.0	-11.4	res band
276.78	V	180.00	2.00	43.90	-9.6	0.0	52.1	200.0	-11.7	res band
	V									
38.02	H	45.00	1.00	33.12	-8.4	0.0	17.2	100.0	-15.3	res band
60.00	H	180.00	4.00	37.80	-16.5	0.0	11.6	1250.0	-40.7	peak
195.81	H	90.00	3.10	45.70	-11.4	0.0	51.9	1250.0	-27.6	peak
114.44	H	90.00	3.60	37.04	-9.8	0.0	22.9	150.0	-16.3	res band
212.89	H	180.00	2.80	52.10	-12.4	0.0	96.3	1250.0	-22.3	peak
224.55	H	90.00	2.55	51.37	-12.1	0.0	91.7	1250.0	-22.7	peak
256.13	H	10.00	2.10	45.90	-11.2	0.0	54.1	200.0	-11.4	res band
272.30	H	0.00	0.00	41.27	-9.8	0.0	37.6	200.0	-14.5	res band

Table 7: Radiated Emissions Data >1GHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Duty Cycle correction (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
1832.98	V	270.00	2.50	55.66	-7.5	0.0	255.1	12500.0	-33.8	peak
1832.98	V	270.00	2.50	55.66	-7.5	-18.9	29.0	1250.0	-32.7	ave
2749.47	V	90.00	2.60	44.63	-2.8	0.0	123.8	5000.0	-32.1	peak
2749.47	V	90.00	2.60	44.63	-2.8	-18.9	14.1	500.0	-31.0	ave
3665.96	V	45.00	2.89	43.13	-0.3	0.0	138.4	5000.0	-31.2	peak
3665.96	V	45.00	2.89	43.13	-0.3	-18.9	15.7	500.0	-30.1	ave
1832.98	H	10.00	1.60	55.66	-7.5	0.0	255.1	12500.0	-33.8	peak
1832.98	H	10.00	1.60	55.66	-7.5	-18.9	29.0	1250.0	-32.7	ave
2749.47	H	90.00	2.12	45.88	-2.8	0.0	142.9	5000.0	-30.9	peak
2749.47	H	90.00	2.12	45.88	-2.8	-18.9	16.2	500.0	-29.8	ave
3665.96	H	45.00	2.34	47.90	-0.3	0.0	239.7	500.0	-6.4	peak
3665.96	H	45.00	2.34	47.90	-0.3	-18.9	27.2	500.0	-25.3	ave

No Harmonics seen above 3665.96MHz

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.

