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FCC Permissive Class 2 Test Report
For the
Mueller Systems
MINODE (DCOM3) Radio Module

FCC ID: SM6-MINODE-WATER3

WLL JOB# **11964-0**
April 29, 2011

Prepared for:

Mueller Systems
48 Leona Drive
Middleboro, MA, 02346 USA

Prepared By:

Washington Laboratories, Ltd.
7560 Lindbergh Drive
Gaithersburg, Maryland 20879

ACCREDITED TESTING

Testing Certificate AT-1448

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Prepared by:

Steven Dovell
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Reviewed by:

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Abstract

This report has been prepared on behalf of Mueller Systems to support the attached Class 2 permissive change. The Permissive Class 2 Test Report for a modular Frequency Hopping Spread Spectrum Transmitter operating under Part 15.247 (10/2009) of the FCC Rules. This Certification Permissive Class 2 Test Report documents the test configuration and test results for a Mueller Systems MINODE (DCOM3) Radio Module.

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 Mueller Systems MINODE (DCOM3) Radio Module remains in compliance with the limits for a Frequency Hopping Spread Spectrum Transmitter device under FCC Part 15.247.

Revision History	Description of Change	Date
Rev 0	Initial Release	March 29, 2011

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1 Introduction

1.1 Reason for Class 2 Permissive Change

This class 2 permissive change is being generated to add a -1dBi gain helically wound ¼ wave whip antenna. The original antenna was a 0dBi fixed monopole antenna.

1.2 Compliance Statement

The Mueller Systems MINODE (DCOM3) Radio Module remains in compliance with the limits for a modular Frequency Hopping Spread Spectrum Transmitter device under FCC Part 15.247 (10/2009).

1.3 Test Scope

Tests for radiated and conducted (at antenna terminal) emissions were performed in the host device. All measurements were performed in accordance with FCC Public Notice DA 00-705, "Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems". The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.4 Contract Information

Customer:	Mueller Systems 48 Leona Drive Middleboro, MA, 02346 USA
Purchase Order Number:	750671
Quotation Number:	66199

1.5 Test Dates

Testing was performed on the following date(s):	4/25/11

1.6 Test and Support Personnel

Washington Laboratories, LTD	Steven Dovell
Client Representative	David Splitz

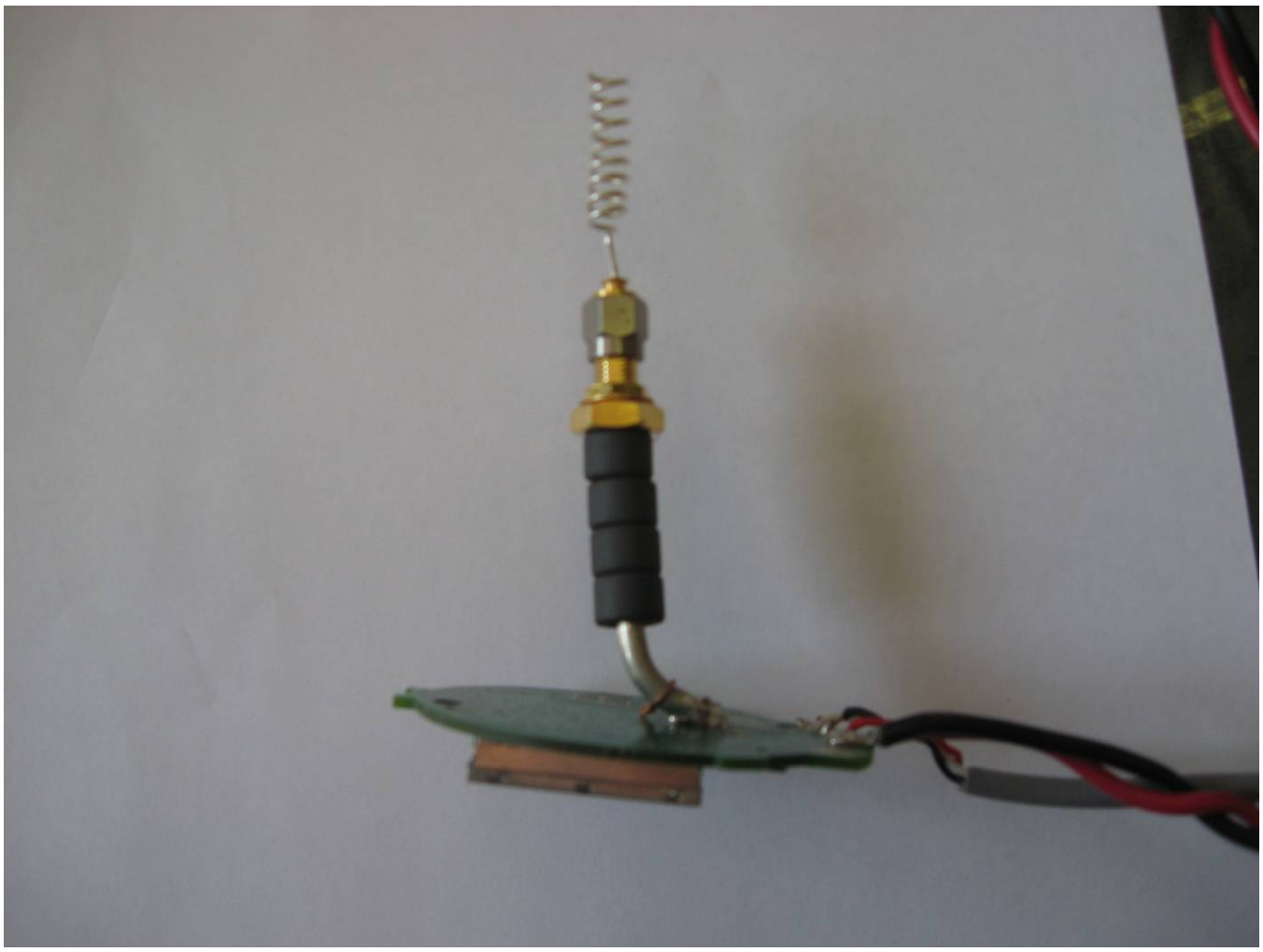
1.7 Abbreviations

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

The Mueller Systems MINODE (DCOM3) radio module is a battery powered transceiver using 902.5-927.35MHz FHSS technology. The system uses 2 modes of operation data mode which uses 50 channels from 902.5 to 927MHz. The system also has a hailing mode to awaken units that are sleeping (these units go into a sleep mode when inactive). The hailing frequencies consist of 50 hailing channels from 902.65 to 927.35MHz. Both of these modes use FHSS technology. The characteristics (power & bandwidth) of the hailing channels are identical to the data channels and are produced from the same RF circuitry. For more detailed information refer to the theory of operation.



Photograph 1: DCOM3 with New Antenna

2.2 Test Configuration

The MINODE (DCOM3) Radio Module was operated from AC/DC power supply set to 3.6VDC output. Commands were sent to the MINODE (DCOM3) Radio Module using a programming to a support laptop using Windows HyperTerminal program. This connection was disconnected after the test mode was set (radiated tests).

2.3 Testing Algorithm

The MINODE (DCOM3) Radio Module was programmed via an internal 3 pin programming port on the EUT to a Serial port on the support laptop. The support laptop used HyperTerminal to command the EUT to transmit on the lowest, center, and highest channels. Commands were also sent to allow the unit to transmit in a hopping fashion. The unit was preloaded with a typical data payload to transmit.

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. 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.

2.5 Measurements

2.5.1 References

FCC Public Notice DA 00-705, Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems

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

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

$k \leq 2$ 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 1 below.

Table 1: 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 2 shows a list of the test equipment used for measurements along with the calibration information.

Table 2. Test Equipment List

Test Name: **Conducted Antenna Port**		Test Date: **7/29/2010**	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
618	HP, 8563A	ANALYZER, SPECTRUM	06/04/2011
528	AGILENT, E4446A	ANALYZER, SPECTRUM	0 9/04/2010

Test Name: **Radiated Emissions**		Test Date: **04/25/2011**	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
522	HP - 8449B	PRE-AMPLIFIER 1-26.5GHZ	7/27/2011
528	AGILENT - E4446A	ANALYZER SPECTRUM	9/27/2011
280	ITC - 21C-3A1	WAVEGUIDE 3.45-11.0GHZ	3/24/2012
337	WLL - 1.2-5GHZ	FILTER BAND PASS	3/24/2012
4	ARA - DRG-118/A	ANTENNA DRG 1-18GHZ	2/15/2013
68	HP - 85650A	ADAPTER QP	6/22/2011
72	HP - 8568B	ANALYZER SPECTRUM	6/22/2011
70	HP - 85685A	PRESELECTOR RF W/OPT 8ZE	6/22/2011
644	SUNOL SCIENCES CORPORATION - JB1 925-833-9936	BICONALOG ANTENNA	12/20/2011

4 Test Summary

The Table Below shows the results of testing for compliance with a Frequency Hopping System in accordance with FCC Part 15.247 10:2009, RSS210 issue 8, and RSS-Gen issue 3. Full results are shown in section 5.

Table 3. Test Summary Table

FCC Rule Part	Description	Result
15.247 (a)(1)(i)	20dB Bandwidth	Pass
15.247 (b)(2)	Transmit Output Power	Pass
15.205 15.209	General Field Strength Limits (Restricted Bands & RE Limits)	Pass

5 Test Results

5.1 RF Power Output: (FCC Part §2.1046)

To measure the output power the hopping sequence was stopped while the frequency dwelled on the lowest, Center, and highest channel. The output from the transmitter was connected to an attenuator and then to the input of the RF Spectrum Analyzer. The analyzer offset was adjusted to compensate for the attenuator, cable, and other losses in the system.

Table 4: Data Channel RF Power Output

Frequency	Level	Limit	Pass/Fail
Low Channel: 902.5MHz	29.51dBm	30dBm	Pass
Center Channel: 915.0MHz	29.76dBm	30dBm	Pass
High Channel: 927.35MHz	28.83dBm	30dBm	Pass

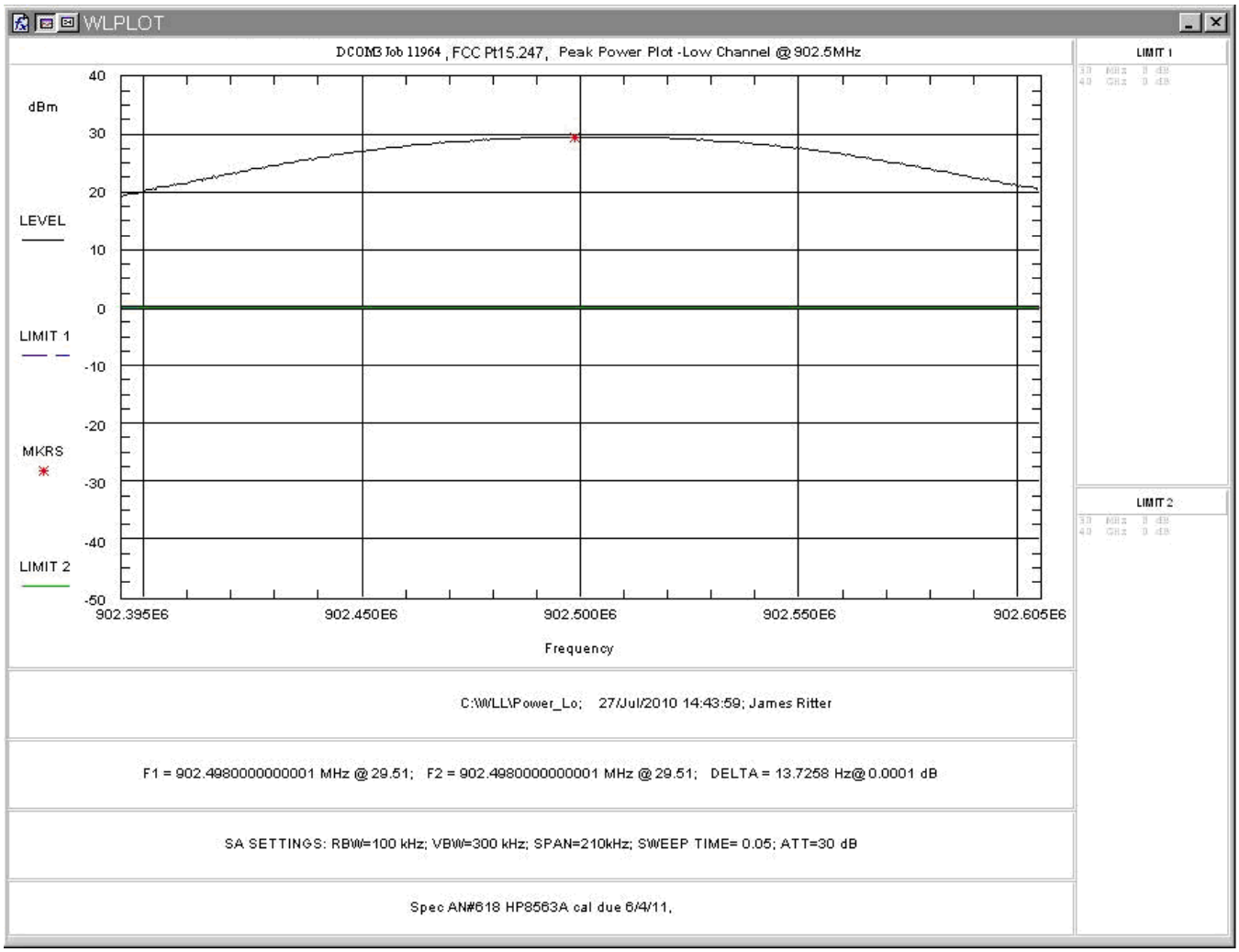


Figure 1. Channel RF Peak Power, Low Channel

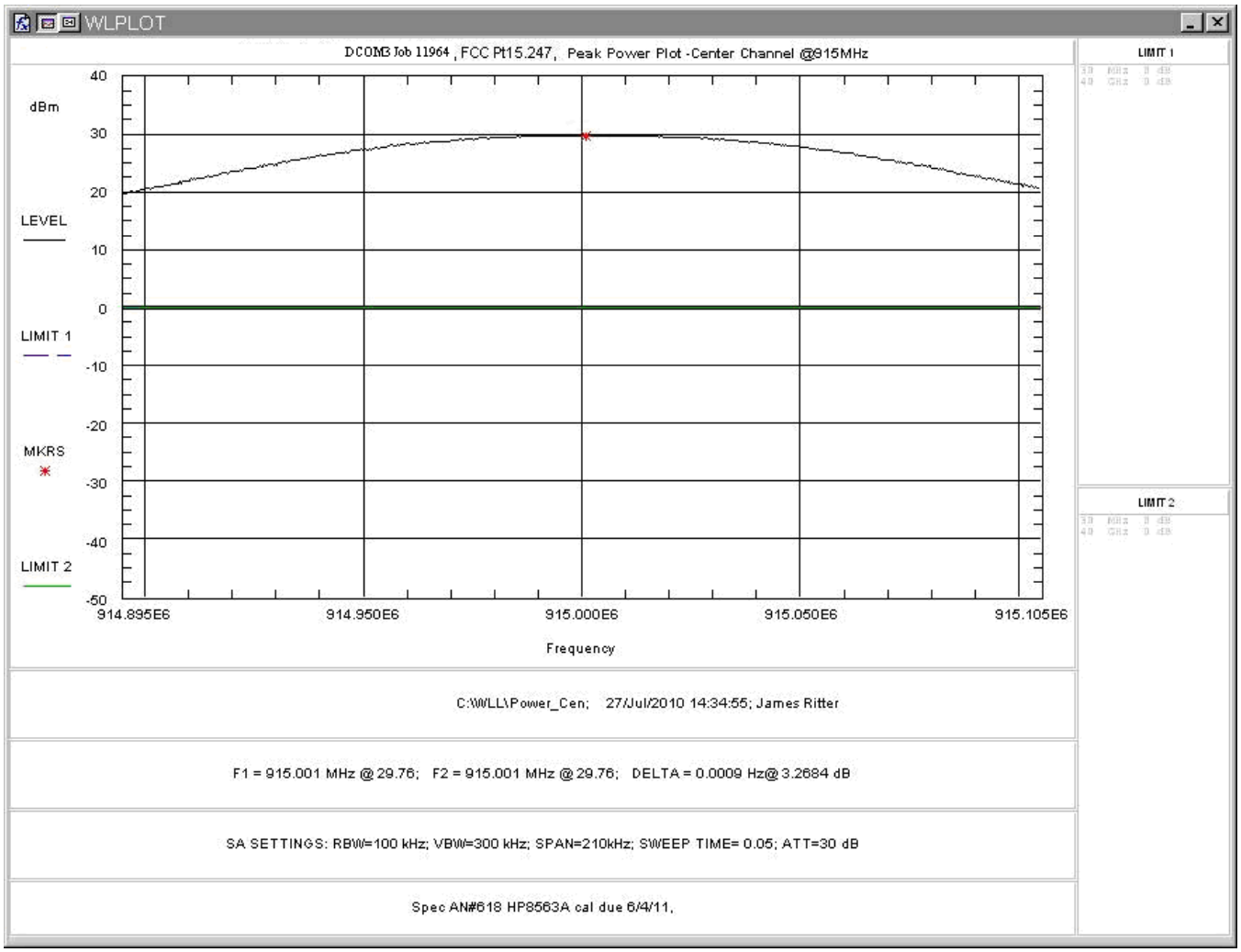


Figure 2. Channel RF Peak Power, Center Channel

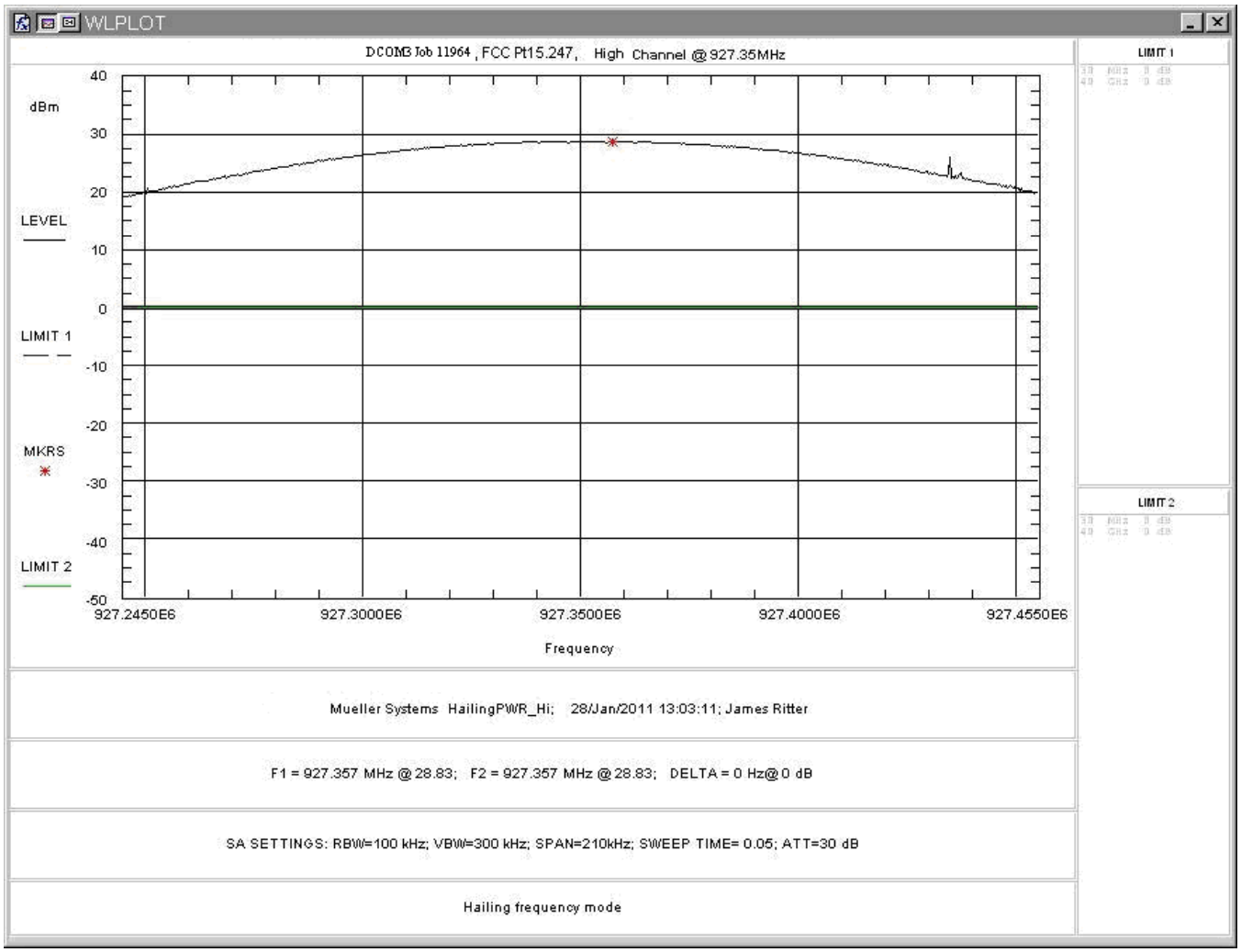


Figure 3. Channel RF Peak Power, High Channel

5.2 Radiated Spurious Emissions: (FCC Part §2.1053)

The EUT must comply with the requirements for radiated spurious emissions that fall within the restricted bands. These emissions must meet the limits specified in §15.209 and §15.35(b) for peak measurements.

5.2.1 Test Procedure

The EUT was placed on a 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. The EUT was tested in 3 orthogonals with the worst case readings provided. Both the horizontal and vertical field components were measured. 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	10 Hz (Avg.) 1MHz (Peak)

5.2.2 Areas of concern

None

Table 5: Radiated Emission Test Data, Low Frequency Data (<1GHz)

(emissions were common to all tested channels,
the frequencies listed are the highest emitted restricted bands)

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)
36.21	V	313.00	1.00	7.30	16.1	14.8	100.0	-16.6
45.52	V	217.00	1.00	12.30	10.1	13.2	100.0	-17.6
49.02	V	15.00	1.00	18.90	8.7	24.0	100.0	-12.4
77.71	V	119.00	1.00	13.50	10.1	15.1	100.0	-16.4
156.00	V	176.00	1.00	3.80	14.1	7.8	150.0	-25.7
217.57	V	292.00	1.44	10.90	13.2	16.0	200.0	-21.9
450.35	V	185.00	1.00	5.00	20.1	17.9	200.0	-20.9
537.29	V	350.00	1.00	8.20	21.6	31.0	200.0	-16.2
708.58	V	45.00	1.00	4.60	23.9	26.7	200.0	-17.5
900.28	V	125.00	1.00	11.60	27.1	86.2	200.0	-7.3
990.29	V	125.00	1.00	5.70	28.4	50.7	500.0	-19.9
49.57	H	270.00	4.00	4.80	8.6	4.7	100.0	-26.6
72.92	H	45.00	4.00	3.10	9.2	4.1	100.0	-27.7
80.03	H	90.00	4.00	6.70	9.7	6.6	100.0	-23.6
117.93	H	125.00	4.00	5.70	14.2	9.9	150.0	-23.6
168.84	H	180.00	4.00	3.50	13.6	7.1	150.0	-26.4
217.57	H	180.00	4.00	4.50	13.2	7.7	200.0	-28.3
450.05	H	125.00	4.00	5.20	20.1	18.3	200.0	-20.8
537.27	H	270.00	4.00	12.40	21.6	50.3	200.0	-12.0
900.00	H	180.00	1.73	5.30	27.1	41.7	200.0	-13.6

Table 6: Radiated Emission Test Data, High Frequency Data (>1GHz)

(Restricted Bands)

(Worst case readings are with EUT Flat)

Low Hailing Channel-902.5MHz

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
902.50									
2707.50	V	327.00	2.47	50.08	-3.9	204.1	5000.0	-27.8	Peak
3610.00	V	266.00	2.43	46.10	-1.4	172.7	5000.0	-29.2	Peak
4512.50	V	54.00	3.00	45.34	0.7	200.8	5000.0	-27.9	Peak
5415.00	V	90.00	1.87	43.30	3.1	209.3	5000.0	-27.6	Peak
8122.50	V	251.00	1.87	44.10	7.3	373.0	5000.0	-22.5	Peak
2707.50	V	327.00	2.47	41.80	-3.9	78.7	500.0	-16.1	Avg
3610.00	V	266.00	2.43	36.85	-1.4	59.5	500.0	-18.5	Avg
4512.50	V	54.00	3.00	35.80	0.7	66.9	500.0	-17.5	Avg
5415.00	V	90.00	1.87	33.72	3.1	69.5	500.0	-17.1	Avg
8122.50	V	251.00	1.87	34.76	7.3	127.3	500.0	-11.9	Avg
2707.50	H	209.00	2.44	47.02	-3.9	143.5	5000.0	-30.8	Peak
3610.00	H	0.00	2.67	43.60	-1.4	129.5	5000.0	-31.7	Peak
4512.50	H	90.00	2.50	43.80	0.7	168.2	5000.0	-29.5	Peak
5415.00	H	0.00	2.50	42.80	3.1	197.6	5000.0	-28.1	Peak
8122.50	H	0.00	2.50	43.76	7.3	358.7	5000.0	-22.9	Peak
2707.50	H	209.00	2.44	35.20	-3.9	36.8	500.0	-22.7	Avg
3610.00	H	0.00	2.67	33.05	-1.4	38.4	500.0	-22.3	Avg
4512.50	H	90.00	2.50	32.24	0.7	44.4	500.0	-21.0	Avg
5415.00	H	0.00	2.50	32.20	3.1	58.3	500.0	-18.7	Avg
8122.50	H	0.00	2.50	32.20	7.3	94.8	500.0	-14.4	Avg

Center Data Channel – 915MHz

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
915.00									
2745.00	V	204.00	1.94	47.86	-4.0	156.3	5000.0	-30.1	Peak
3660.00	V	201.00	2.00	45.48	-1.3	161.8	5000.0	-29.8	Peak
4575.00	V	102.00	2.10	45.10	0.5	190.1	5000.0	-28.4	Peak
7320.00	V	82.00	2.32	42.91	7.2	318.9	5000.0	-23.9	Peak
8235.00	V	286.00	2.30	44.38	7.4	389.1	5000.0	-22.2	Peak
2745.00	V	204.00	1.94	40.70	-4.0	68.5	500.0	-17.3	Avg
3660.00	V	201.00	2.00	34.05	-1.3	43.4	500.0	-21.2	Avg
4575.00	V	102.00	2.10	36.82	0.5	73.3	500.0	-16.7	Avg
7320.00	V	82.00	2.32	32.53	7.2	96.5	500.0	-14.3	Avg
8235.00	V	286.00	2.30	37.62	7.4	178.7	500.0	-8.9	Avg
2745.00	H	259.00	2.31	47.15	-4.0	144.0	5000.0	-30.8	Peak
3660.00	H	263.00	2.30	43.94	-1.3	135.5	5000.0	-31.3	Peak
4575.00	H	330.00	2.39	43.20	0.5	152.8	5000.0	-30.3	Peak
7320.00	H	201.00	2.40	42.23	7.2	294.9	5000.0	-24.6	Peak
8235.00	H	180.00	2.32	42.91	7.4	328.6	5000.0	-23.6	Peak
	H								
2745.00	H	259.00	2.31	39.82	-4.0	61.9	500.0	-18.1	Avg
3660.00	H	263.00	2.30	32.85	-1.3	37.8	500.0	-22.4	Avg
4575.00	H	330.00	2.39	34.00	0.5	53.0	500.0	-19.5	Avg
7320.00	H	201.00	2.40	31.42	7.2	84.9	500.0	-15.4	Avg
8235.00	H	180.00	2.32	32.20	7.4	95.7	500.0	-14.4	Avg

High Data Channel-927.35MHz

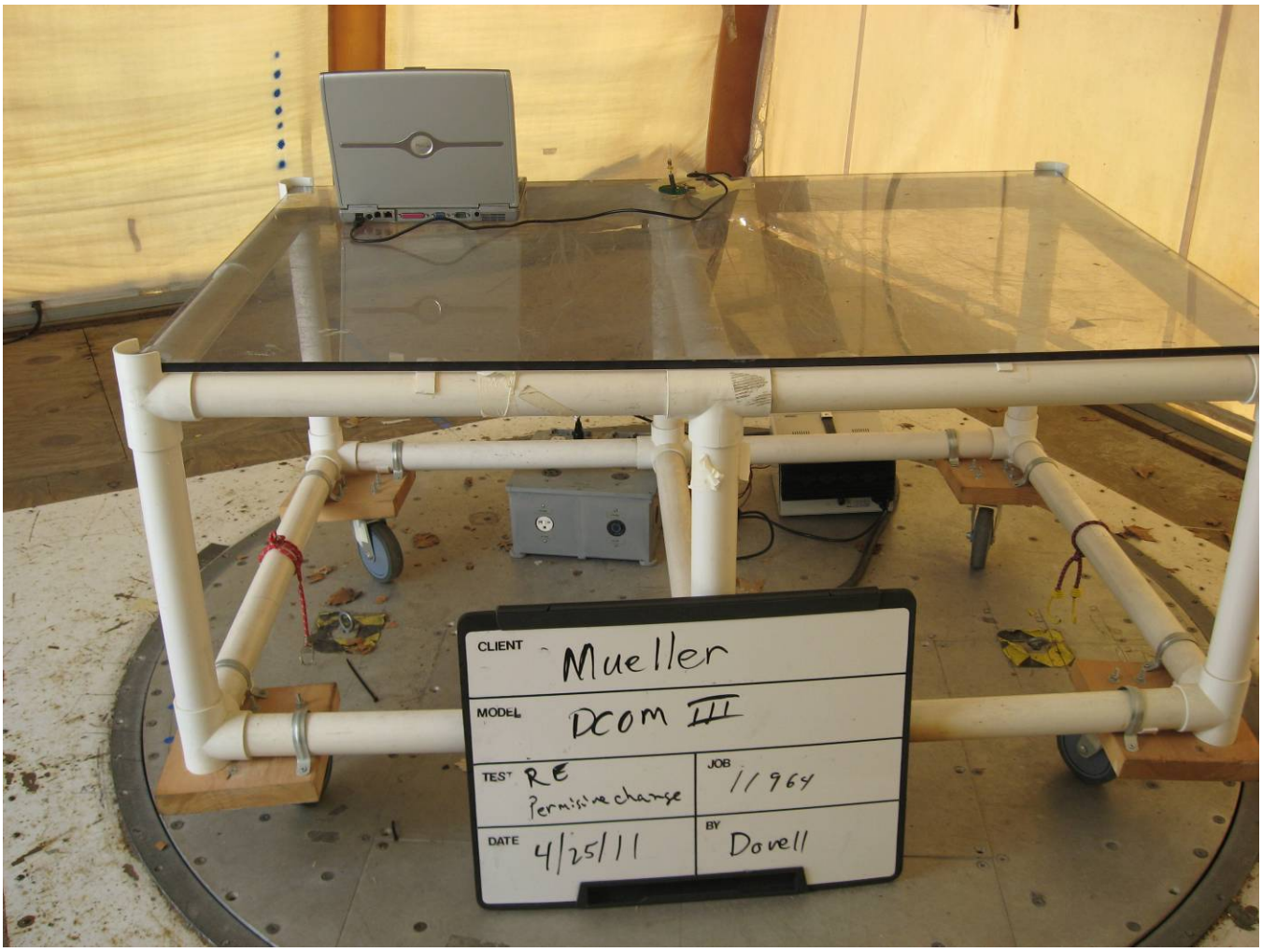
Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Comments
927.35									
2782.05	V	180.00	2.12	47.55	-3.8	153.6	5000.0	-30.3	Peak
3709.40	V	131.00	2.00	44.90	-1.2	153.7	5000.0	-30.2	Peak
4636.80	V	92.00	2.00	44.32	0.9	182.1	5000.0	-28.8	Peak
7418.85	V	250.00	2.00	44.10	7.0	359.1	5000.0	-22.9	Peak
8346.20	V	249.00	1.90	44.40	7.0	371.6	5000.0	-22.6	Peak
2782.05	V	180.00	2.12	41.06	-3.8	72.7	500.0	-16.7	Avg
3709.40	V	131.00	2.00	35.61	-1.2	52.7	500.0	-19.5	Avg
4636.80	V	92.00	2.00	36.14	0.9	71.0	500.0	-17.0	Avg
7418.85	V	250.00	2.00	32.51	7.0	94.6	500.0	-14.5	Avg
8346.20	V	249.00	1.90	34.76	7.0	122.5	500.0	-12.2	Avg
2782.05	H	350.00	2.15	48.40	-3.8	169.3	5000.0	-29.4	Peak
3709.40	H	58.00	2.15	44.89	-1.2	153.5	5000.0	-30.3	Peak
4636.80	H	299.00	2.15	43.02	0.9	156.8	5000.0	-30.1	Peak
7418.85	H	90.00	2.10	42.05	7.0	283.6	5000.0	-24.9	Peak
8346.20	H	270.00	2.23	42.84	7.0	310.5	5000.0	-24.1	Peak
	H								
2782.05	H	350.00	2.15	40.52	-3.8	68.4	500.0	-17.3	Avg
3709.40	H	58.00	2.15	35.84	-1.2	54.2	500.0	-19.3	Avg
4636.80	H	299.00	2.15	33.48	0.9	52.3	500.0	-19.6	Avg
7418.85	H	90.00	2.10	32.23	7.0	91.6	500.0	-14.7	Avg
8346.20	H	270.00	2.23	32.87	7.0	98.5	500.0	-14.1	Avg

5.3 AC Conducted Emissions (FCC Pt.15.207)

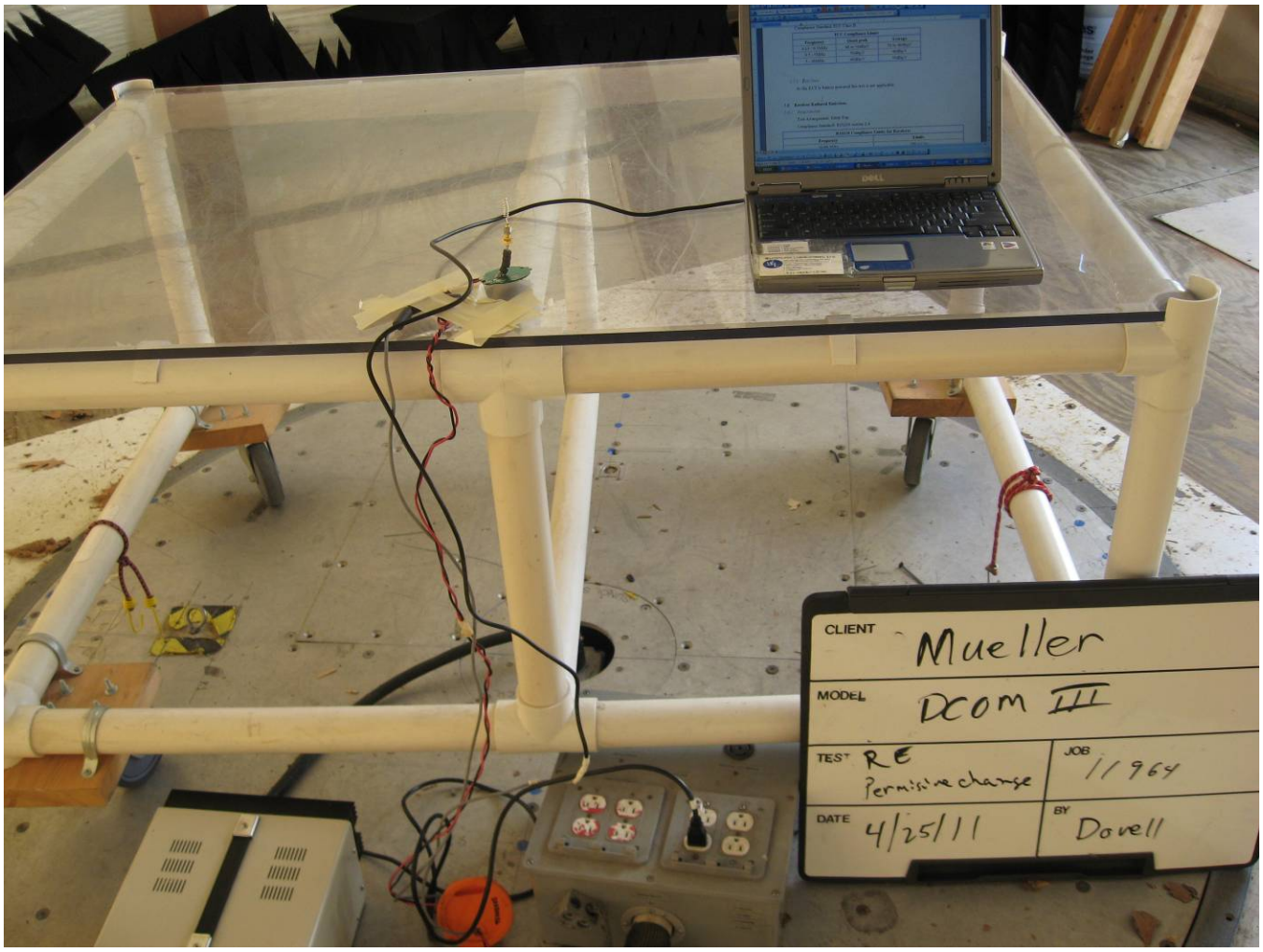
As the EUT is battery powered this test is not applicable.

5.4 Receiver Radiated Emissions

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)
36.21	V	313.00	1.00	7.30	16.1	14.8	100.0	-16.6
45.52	V	217.00	1.00	12.30	10.1	13.2	100.0	-17.6
49.02	V	15.00	1.00	18.90	8.7	24.0	100.0	-12.4
77.71	V	119.00	1.00	13.50	10.1	15.1	100.0	-16.4
156.00	V	176.00	1.00	3.80	14.1	7.8	150.0	-25.7
217.57	V	292.00	1.44	10.90	13.2	16.0	200.0	-21.9
450.35	V	185.00	1.00	5.00	20.1	17.9	200.0	-20.9
537.29	V	350.00	1.00	8.20	21.6	31.0	200.0	-16.2
708.58	V	45.00	1.00	4.60	23.9	26.7	200.0	-17.5
900.28	V	125.00	1.00	11.60	27.1	86.2	200.0	-7.3
990.29	V	125.00	1.00	5.70	28.4	50.7	500.0	-19.9
49.57	H	270.00	4.00	4.80	8.6	4.7	100.0	-26.6
72.92	H	45.00	4.00	3.10	9.2	4.1	100.0	-27.7
80.03	H	90.00	4.00	6.70	9.7	6.6	100.0	-23.6
117.93	H	125.00	4.00	5.70	14.2	9.9	150.0	-23.6
168.84	H	180.00	4.00	3.50	13.6	7.1	150.0	-26.4
217.57	H	180.00	4.00	4.50	13.2	7.7	200.0	-28.3
450.05	H	125.00	4.00	5.20	20.1	18.3	200.0	-20.8
537.27	H	270.00	4.00	12.40	21.6	50.3	200.0	-12.0
900.00	H	180.00	1.73	5.30	27.1	41.7	200.0	-13.6



Photograph 2: Radiated Emissions Test Setup – Front



Photograph 3: Radiated Emissions Test Setup - Rear

