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FCC & Industry Canada
Class II Permissive Change Test Report
For the

MUELLER SYSTEMS

REPEATER RADIO MODULE

FCC ID: SM6-RMXR

IC ID: 9235A-RMXR

WLL Report# 12804-01 Rev. 0
January 16, 2013

Re-Issued

WLL Report# 12804-01 Rev. 2
February 8, 2013

Prepared for:

Mueller Systems
48 Leona Drive
Middleboro, MA 02346

Prepared By:

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

ACCREDITED TESTING

Testing Certificate AT-1448

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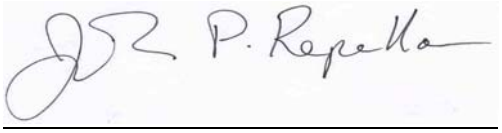

John P. Repella
EMC Compliance Engineer

Reviewed by:

James Ritter
EMC Laboratory Manager

Abstract

This report has been prepared on behalf of Mueller Systems to support Application for a Class II Permissive Change to existing certified equipment. The test report and application are submitted for a limited modular
Frequency Hopping Spread Spectrum Transmitter under Part 15.247 (10/2010) of the FCC Rules and Spectrum Management and Telecommunications Policy RSS-210 issue 8 of Industry Canada. This Certification Test Report documents the test configuration and test results for the Repeater 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. 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 Repeater Radio Module remains in compliance with the limits for a Frequency Hopping Spread Spectrum Transmitter under Part 15.247 (10/2010).

Revision History	Reason	Date
Rev 0	Initial Release	January 16, 2013
Rev 1	Update to reflect customer comments related to equipment list calibration dates	January 31, 2013
Rev 2	PCII updated to include co-location data for use with Bluetooth radio	February 8,2013

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1 Introduction

1.1 Reason for Class II Permissive Change

This Class II permissive change is to incorporate the following modifications or additions to the Repeater Radio Module:

Shield size has been reduced to approximately one half the height of the original shield and to remove the need for the RF absorber on the bottom side of the module.

The addition of the following antenna:

Laird Model B8965C 5dBi Closed Collinear antenna

The Repeater Radio Module was also tested in the Mueller maintenance host device to verify EMC compliance with the following co-located radio:

Bluetooth: Sena module ESD100V2-01 FCC ID # S7APARANIESD1XXV2

1.2 Compliance Statement

The Mueller Systems Repeater Radio Module remains in compliance with the limits for a Frequency Hopping System under Part 15.247 (10/2010) and Industry Canada RSS-210 issue 8.

1.3 Test Scope

Tests for radiated emissions and conducted Peak Power (at antenna terminal) were performed. All measurements were performed in accordance with FCC Public Notice DA 00-705 and the 2009 version of ANSI C63.4. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation unless a different measurement technique is specified by the FCC.

1.4 Contract Information

Customer:	Mueller Systems 48 Leona Drive Middleboro, MA 02346
Purchase Order Number:	853760
Quotation Number:	67160

1.5 Test Dates

Testing was performed on the following date(s):	1/08/2013 (co-location testing 1/11/2013)

1.6 Test and Support Personnel

Washington Laboratories, LTD	John P. Repella
Customer Representative	David Splitz

1.7 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 Mueller Systems device is a Repeater Radio Module.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Mueller Systems
FCC ID: IC ID:	SM6-RMXR 9235A-RMXR
Model:	Repeater Radio Module
FCC Rule Parts:	§15.247
Frequency Range:	902.5MHz – 927.35MHz
Maximum Output Power:	29.35dBm
Antenna Connector	RPSMA (for external antenna)
Antenna Type	Closed Collinear antenna
Antenna Gain	5.0dBi
Power Source & Voltage:	120VAC Power Supply providing 3.7VDC

2.2 Test Configuration

The Repeater Radio Module was operated from 3.7VDC power supply.. Commands were sent to the Repeater Radio Module using an RS232 port connected to a support laptop using Windows HyperTerminal program. Radiated Emissions test were performed with the replacement antenna and the module in the worst case orthogonal position.

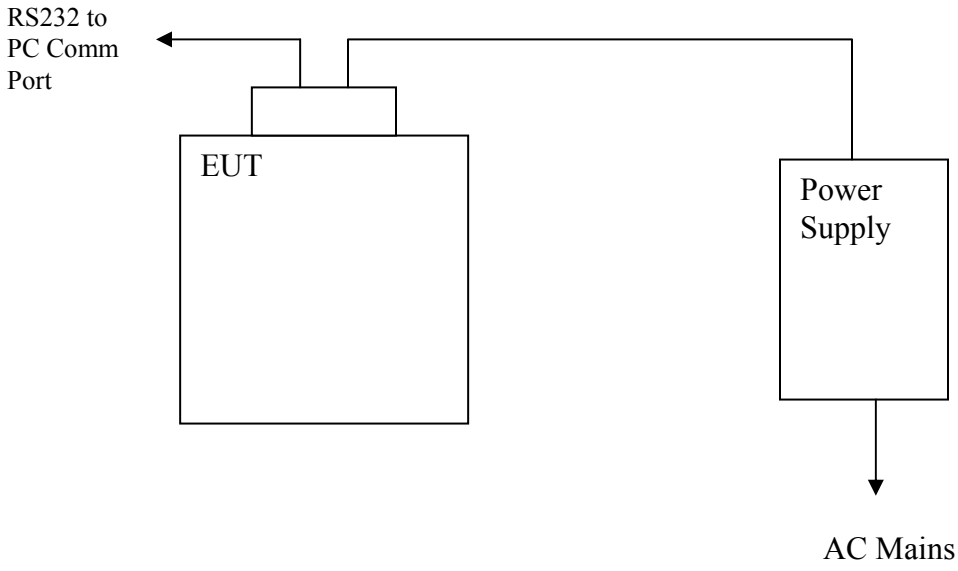

Figure 1: Test Configuration

2.3 Testing Algorithm

The Repeater Radio Module was programmed for operation via a serial cable connected to a laptop running HyperTerminal. Channel selection and modulation was accomplished using the laptop to set the EUT into a continuous transmit pseudo-random data stream at the Low, Center and High channels. Once the channel was set, the laptop was removed from the setup.

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

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

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

3 Test Equipment

Table 3 lists the test equipment used for measurements along with the calibration information.

Table 3: Test Equipment List

Test Name:	**Conducted Emissions at Antenna Terminal**	Test Date:	**01/08/2013**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
74	HP – 8593A	ANALYZER SPECTRUM	10/4/2013

Test Name:	**Radiated Emissions**	Test Date:	**01/08/2013**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
742	PENN ENGINEERING - WR284	2.2-4.15GHZ BANDPASS FILTER	5/29/2014
280	ITC - 21C-3A1	WAVEGUIDE 3.45-11.0GHZ	5/29/2014
337	WLL - 1.2-5GHZ	FILTER BAND PASS	4/19/2014
281	ITC - 21A-3A1	WAVEGUIDE 4.51-10.0GHZ	5/29/2014
627	AGILENT - 8449B	AMPLIFIER 1-26GHZ	5/24/2013
528	AGILENT - E4446A	ANALYZER SPECTRUM	8/30/2013
4	ARA - DRG-118/A	ANTENNA DRG 1-18GHZ	2/15/2013
644	SUNOL SCIENCES CORPORATION - JB1 925-833-9936	BICONALOG ANTENNA	1/12/2013
69	HP - 85650A	ADAPTER QP	6/27/2013
73	HP - 8568B	ANALYZER SPECTRUM	6/27/2013
71	HP - 85685A	PRESELECTOR RF	6/27/2013

4 Test Results

4.1 RF Power Output (FCC Part15.247 (b) & IC RSS-210 [A8.4 (1)])

To measure the output power the output from the transmitter was connected to the input of a spectrum analyzer. The original grant RF power levels and the original report filing levels are reported in the tables below along with the measured RF power levels.

This is applicable for the 902 – 928MHz band of this device.

Table 4: Part 15.247 RF Power Output Results

Grant listed as 0.955 Watts for 902 - 928MHz

Channel and/or Frequency	Peak Measured Level (dBm)	Peak Measured Level (Watts)	Original Grant Report Level (dBm)	Original Grant Report Level (Watts)	Limit (dBm)
Low Channel (902.5MHz)	28.70dBm	0.741	29.07dBm	0.807	30
Mid Channel (915.35MHz)	28.97dBm	0.789	29.07dBm	0.807	30
High Channel (927.35MHz)	29.35dBm	0.861	29.70dBm	0.933	30

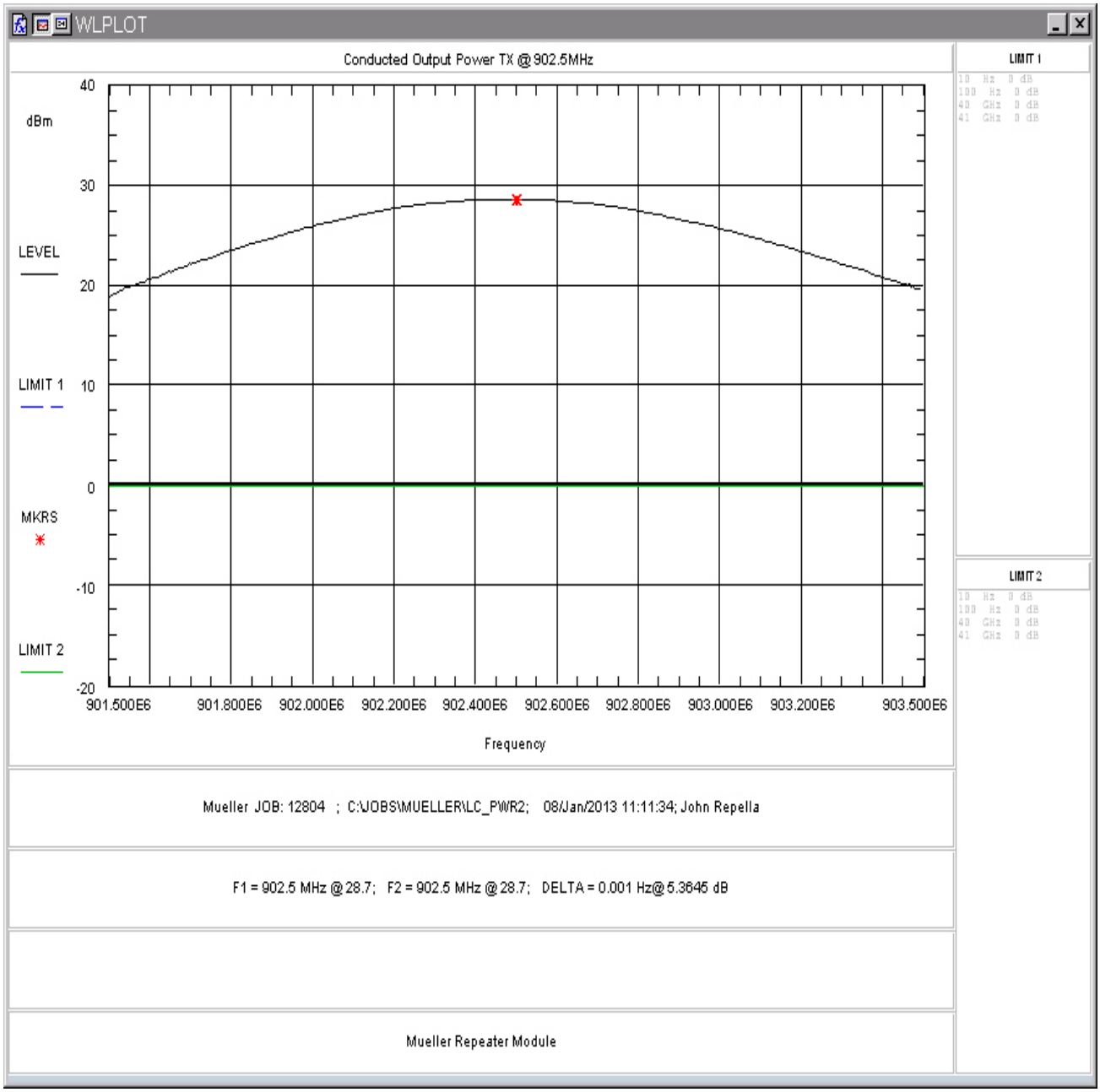

Figure 2: Conducted Peak Power, 902.5MHz

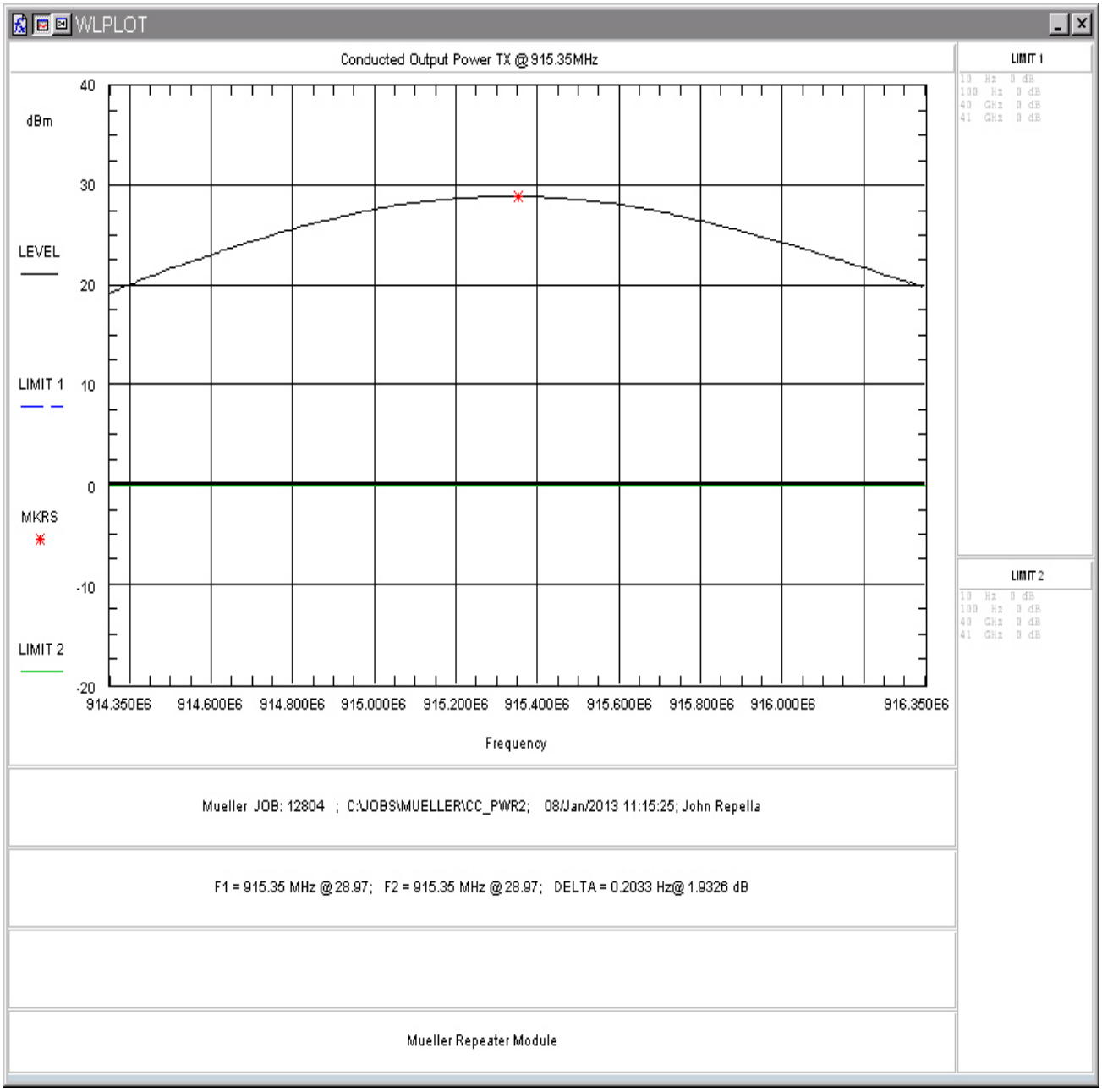

Figure 3: Conducted Peak Power, 915.35MHz

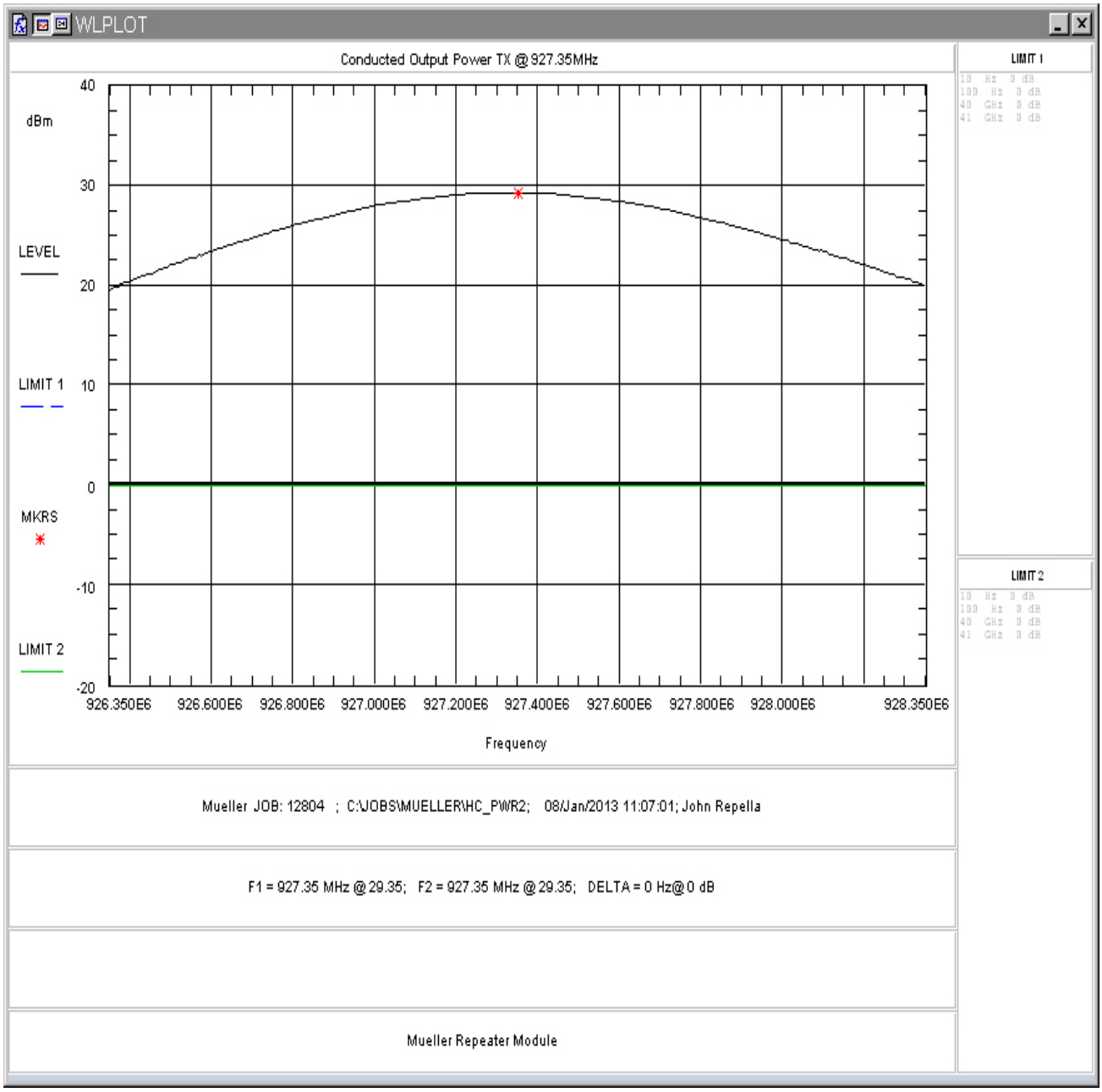

Figure 4: Conducted Peak Power, 927.35MHz

4.2 Radiated Spurious Emissions: (FCC Part §15.247 & IC RSS-210 Sect.2.2)

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.

4.2.1 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. The peripherals were placed on the table in accordance with ANSI C63.4-2003. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

3 Orthogonals of the EUT were scanned in the restricted bands up to the 10^{th} harmonic with the worst case readings shown.

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)

Table 5: Radiated Emission Test Data below 1GHz (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)	Comments
117.86	V	90.00	1.00	12.70	16.0	27.1	150.0	-14.9	
266.96	V	0.00	1.20	7.40	16.3	15.2	200.0	-22.4	
117.92	H	135.00	4.00	10.80	16.0	21.8	150.0	-16.8	
168.14	H	135.00	4.00	7.40	14.2	12.1	150.0	-21.9	
266.96	H	0.00	4.00	7.00	16.3	14.6	200.0	-22.8	

Frequencies Common to all TX channels

Table 6: Radiated Emission Test Data, Laird 5dBi Antenna TX@ 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
2707.50	V	270.0	2.3	48.7	-3.1	190.2	5000.0	-28.4	
2707.50	V	270.0	2.3	41.2	-3.1	79.9	500.0	-15.9	
3610.00	V	270.0	2.3	43.7	-1.3	132.3	5000.0	-31.6	
3610.00	V	270.0	2.3	36.8	-1.3	59.8	500.0	-18.5	
4512.50	V	270.0	2.3	41.5	0.8	130.4	5000.0	-31.7	
4512.50	V	270.0	2.3	32.3	0.8	45.2	500.0	-20.9	
2707.50	H	225.0	2.3	49.0	-3.1	197.1	5000.0	-28.1	
2707.50	H	225.0	2.3	40.5	-3.1	73.8	500.0	-16.6	
3610.00	H	225.0	2.3	45.8	-1.3	168.4	5000.0	-29.5	
3610.00	H	225.0	2.3	37.2	-1.3	62.6	500.0	-18.1	
4512.50	H	225.0	2.3	42.2	0.8	141.3	5000.0	-31.0	
4512.50	H	225.0	2.3	31.3	0.8	40.3	500.0	-21.9	

Table 7: Radiated Emission Test Data, Laird 5dBi Antenna, TX@ 915.35MHz

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
2746.05	V	270.0	2.3	50.6	-3.2	234.0	5000.0	-26.6	
2746.05	V	270.0	2.3	41.6	-3.2	82.7	500.0	-15.6	
3661.40	V	270.0	2.3	45.4	-0.9	167.2	5000.0	-29.5	
3661.40	V	270.0	2.3	35.6	-0.9	54.1	500.0	-19.3	
4576.75	V	270.0	2.3	41.6	0.9	133.0	5000.0	-31.5	
4576.75	V	270.0	2.3	34.5	0.9	58.7	500.0	-18.6	
2746.05	H	225.0	2.3	47.5	-3.2	164.7	5000.0	-29.6	
2746.05	H	225.0	2.3	41.8	-3.2	85.1	500.0	-15.4	
3661.40	H	225.0	2.3	44.9	-0.9	157.9	5000.0	-30.0	
3661.40	H	225.0	2.3	39.4	-0.9	83.8	500.0	-15.5	
4576.75	H	225.0	2.3	44.1	0.9	177.3	5000.0	-29.0	
4576.75	H	225.0	2.3	36.2	0.9	71.4	500.0	-16.9	

Table 8: Radiated Emission Test Data, Laird 5dBi Antenna, TX@ 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
2782.50	V	180.0	2.3	48.9	-3.2	190.6	5000.0	-28.4	
2782.05	V	180.0	2.3	43.2	-3.2	99.5	500.0	-14.0	
3709.40	V	270.0	2.3	45.2	-0.6	169.2	5000.0	-29.4	
3709.40	V	270.0	2.3	36.7	-0.6	63.6	500.0	-17.9	
4636.75	V	270.0	2.3	42.8	1.2	158.5	5000.0	-30.0	
4636.75	V	270.0	2.3	36.1	1.2	73.3	500.0	-16.7	
2782.50	H	225.0	2.3	48.6	-3.2	184.1	5000.0	-28.7	
2782.05	H	225.0	2.3	42.8	-3.2	94.7	500.0	-14.5	
3709.40	H	225.0	2.3	45.3	-0.6	171.2	5000.0	-29.3	
3709.40	H	225.0	2.3	38.2	-0.6	75.6	500.0	-16.4	
4636.75	H	225.0	2.3	42.0	1.2	144.6	5000.0	-30.8	
4636.75	H	225.0	2.3	34.1	1.2	58.2	500.0	-18.7	

4.3 Receiver Radiated Emissions (FCC 15.209 & IC RSS-210 sect 2.5)

Requirements

Test Arrangement: Table Top

RSS210 Compliance Limits for Receivers	
Frequency	**Limits**
30-88 MHz	100 µV/m
88-216 MHz	150 µV/m
216-960 MHz	200 µV/m
>960MHz	500 µV/m

Test Procedure

The requirements of call for the EUT to be placed on an 80 cm high 1 X 1.5 meters non-conductive 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. Biconical and log periodic broadband 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 output of the antenna was connected to the input of the spectrum analyzer and the emissions in the frequency range of 30 MHz to 3 GHz were measured. The peripherals were placed on the table in accordance with ANSI C63.4-2003. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

The output from the antenna was connected, via a preamplifier, to the input of the spectrum analyzer. The detector function was set to quasi-peak, peak, or average as appropriate. The measurement bandwidth of the spectrum analyzer system was set to at least 120 kHz, with all post-detector filtering no less than 10 times the measurement bandwidth.

All measurements above 1GHz were made at a distance of 3m with a Resolution Bandwidth of 1MHz and a Video bandwidth of 10Hz.

Test Data

The EUT complied with the Receiver Radiated Emissions requirements. Table 9 provides the test results for radiated emissions.

Radiated Data Reduction and Reporting

To convert the raw spectrum analyzer radiated data into a form that can be compared with the FCC limits, it is necessary to account for various calibration factors that are supplied with the antennas and other measurement accessories. These factors are included into the antenna factor (AF) column of the table and in the cable factor (CF) column of the table. The AF (in dB/m) and the CF (in dB) is algebraically added to the raw Spectrum Analyzer Voltage in dBµV to obtain the Radiated Electric Field in dBµV/m. This logarithm amplitude is converted to a linear amplitude, then compared to the Industry Canada limit.

Example:

Spectrum Analyzer Voltage: VdBµV

Antenna Correction Factor: AFdB/m

Cable Correction Factor: CFdB

Electric Field: EdBV/m = V dBµV + AFdB/m + CFdB

To convert to linear units of measure: EdBV/m/20 Inv log

Table 9: Receiver Radiated Emission Test Data

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
45.17	V	180.00	1.00	26.35	11.5	77.7	100.0	-2.2	
51.33	V	180.00	1.00	24.35	9.3	48.3	100.0	-6.3	
74.92	V	180.00	1.00	10.00	8.9	8.8	100.0	-21.1	
117.86	V	90.00	1.00	12.70	16.0	27.1	150.0	-14.9	
266.96	V	0.00	1.20	7.40	16.3	15.2	200.0	-22.4	
449.43	V	180.00	1.60	6.00	21.7	24.1	200.0	-18.4	
457.69	V	180.00	1.60	5.40	22.0	23.4	200.0	-18.6	
810.22	V	180.00	2.70	4.60	28.5	45.3	200.0	-12.9	
898.38	V	270.00	2.70	12.70	30.1	138.4	200.0	-3.2	
45.17	H	180.00	4.00	15.30	11.5	21.8	100.0	-13.2	
51.33	H	180.00	4.00	13.70	9.3	14.2	100.0	-17.0	
117.92	H	135.00	4.00	10.80	16.0	21.8	150.0	-16.8	
168.14	H	135.00	4.00	7.40	14.2	12.1	150.0	-21.9	
266.96	H	0.00	4.00	7.00	16.3	14.6	200.0	-22.8	
460.40	H	180.00	3.50	10.00	22.1	40.1	200.0	-14.0	
810.22	H	180.00	2.60	3.50	28.5	39.9	200.0	-14.0	
898.69	H	270.00	2.60	10.50	30.1	107.6	200.0	-5.4	

No Signals noted above 1GHz

5 Transceiver Co-location Attestation

The Mueller Systems Maintenance Module contains two transmit radios.

Bluetooth: Sena module ESD100V2-01 FCC# S7APARANIESD1XXV2

900 MHz Radio: Mueller repeater module FCC# SM6-RMXR

The 902-928 Mueller transceiver has two possible antenna configurations, the 6dBi Omni whip and PCB Trace antenna. Either one may be located within 20cm of the Bluetooth transceiver antenna, which is located in the same enclosure. Testing was performed to measure any potential spurious interactions between these 2 devices. The 902-928 MHz radio was tested with both of the antennas that could be used within 20cm of the Bluetooth antenna. This testing was performed in a radiated fashion with both transceivers continuously transmitting on a stationary frequency. The Bluetooth Radio was set to transmit at 2441MHz and the Repeater Module was set to 915.35MHz.

Testing was performed with both radios in the Mueller Maintenance Radio host unit (plastic enclosure).

The module was then scanned from up to 25GHz verifying that intermodulation products that fall within the restricted bands remain under class B limits. This device complied with this requirement.

Data for the above testing is held at Washington laboratories under WLL Job # 12803

