

COMPLIANCE WORLDWIDE INC. TEST REPORT 388-13

In Accordance with the Requirements of
Industry Canada RSS 220, Issue 1, March 2009
Federal Communications Commission 47 CFR Part 15, Part F
Technical Requirements for Vehicular Radar Systems

Issued to

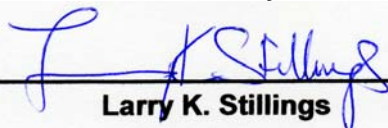
**Autoliv Active Safety
1001 Pawtucket Blvd
Lowell, MA 01854
978-674-6500**

For the
**24 GHz SQ Sensor
Model Number: 24 GHz SQ**

**FCC ID: WU8SQ24
IC: 8436B-SQ24**


Report Issued on August 2, 2013

Tested By



Larry K. Stillings

Reviewed By



Brian F. Breault

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1. Scope

This test report certifies that the Autoliv Active Safety 24 GHz SQ Sensor, as tested, meets the FCC Part 15, Subpart F and Industry Canada RSS 220 requirements. The scope of this test report is limited to the test sample provided by the client, only in as much as that sample represents other production units. If any significant changes are made to the unit, the changes shall be evaluated and a retest may be required.

2. Product Details

2.1. Manufacturer:	Autoliv Electronics
2.2. Model Number:	24 GHz SQ Sensor, 623444806A
2.3. Serial Number:	0063
2.4. Description:	Vehicular Radar Sensor
2.5. Power Source:	DC 13.5 volts nominal – Automotive power system.
2.6. Hardware Revision:	06/13/00
2.7. Software Revision:	07/13/03
2.8. Modulation Type:	Pulse Modulation, Frequency Hopping
2.9. Operating Frequency:	24.95 GHz Nominal
2.10. EMC Modifications:	None

3. Product Configuration

3.1 Operational Characteristics & Software

Hardware Setup:

Connect the 24 GHz SQ Sensor lead set to the CANcard/DHSC dongle and the 13.5 VDC power supply (automotive battery).

3. Product Configuration (continued)

3.2. EUT Hardware

Manufacturer	Model/Part # / Options	Serial Number	Input Volts	Freq (Hz)	Description/Function
Autoliv	623444806A	0063	13.5	DC	24 GHz SQ Sensor

3.3. EUT Cables/Transducers

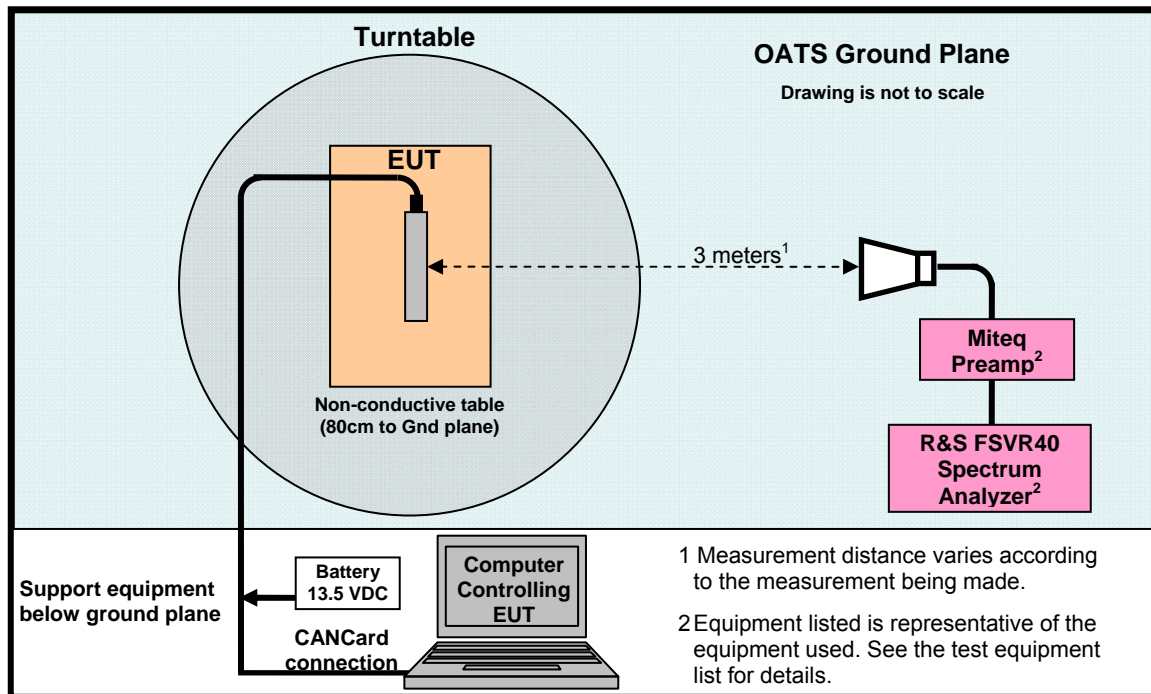
Manufacturer	Model/Part #	Length (m)	Shield Y/N	Description/Function
Custom	NA	10	N	Power and signal cable from Softing CANCard 2 DHSC to the DUT
Softing	CANCard 2 DHSC	0.5	N	Softing CANCard 2 DHSC dongle/cable

3.4. Support Equipment

Manufacturer	Model/Part #	Serial Number	Input Voltage	Input Freq.	Description/Function
Dell	Latitude D830	CN-OHN338-48643-7AF-2781	120/240	50/60	Laptop computer
Softing	CANCard 2 DHSC	003700748	N/A	N/A	Dual CAN PC Card

3. Product Configuration (continued)

3.5. Test Setup Diagram



4. Measurements Parameters

4.1. Measurement Equipment Used to Perform Test

Device	Manufacturer	Model No.	Serial No.	Cal Due
EMI Receiver 9 kHz to 6.5 GHz	Hewlett Packard	8546A	3330A00115	6/8/2014
Spectrum Analyzer 20 Hz to 40 GHz	Rohde & Schwarz	FSV40	100899	6/5/2015
Spectrum Analyzer 10 Hz to 40 GHz	Rohde & Schwarz	FSVR40	100909	5/15/2015
Spectrum Analyzer 20 Hz to 67 GHz	Rohde & Schwarz	FSU67	101388	5/1/2014
Microwave Preamp 1 to 26.5 GHz	Hewlett Packard	8449B	3008A01323	6/5/2015
Microwave Preamp 2 to 50 GHz	Hewlett Packard	83050A	3331A00404	6/28/2015
Notch Filter 24.0 – 24.25 GHz	K&L Microwave	5NSP-00002	001	CBU
Bilog Antenna 30 MHz – 2 GHz	Com-Power	AC-220	25509	8/31/2013
Horn Antenna 1 to 18 GHz	ETS Lindgren	3117	00143292	1/14/2015
Horn Antenna 1 to 18 GHz	Com-Power	AH-118	10078	8/28/2014
Horn Antenna 18 to 26.5 GHz	Com-Power	AH-826	081051	8/28/2014
Horn Antenna 18 to 40 GHz	Com-Power	AH-840	03075	8/27/2014
Horn Antenna 18 to 40 GHz	Com-Power	AH-840	101032	4/6/2014
Horn Antenna 18 to 26.5 GHz WR42 to 3.5mm Adapter	Hughes Hewlett Packard	45820H-2020 K281C	037 3032A10738	Not Req'd
External Mixer WR28 Horn Antenna 26.5 to 40 GHz WR28 to 3.5mm Adapter	Hewlett Packard Alpha Industries Hewlett Packard	11970A 861A/599 R281A	3003A08210 324 03197	Not Req'd
External Mixer WR22 Horn Antenna 33 to 50 GHz WR22 to 3.5mm Adapter	Hewlett Packard Alpha Industries Hewlett Packard	11970Q 861B/383 Q281B	3003A01273 133 00116	Not Req'd
External Mixer WR19 External Mixer WR19 Horn Antenna 40 to 60 GHz WR19 to 1.85mm Adapter	Hewlett Packard Rohde & Schwarz M/A Com Baytron Hewlett Packard	11970U FS-Z60 3-19-720 U281A	2332A00425 100128 N/A 00209	Not Req'd
External Mixer WR12 Horn Antenna 50 to 75 GHz WR12 to 1.85mm Adapter	Hewlett Packard Aerowave Hewlett Packard	11970V 15-7025 V281B	2521A00357 N/A 00369	Not Req'd
External Mixer WR10 Horn Antenna 75 to 110 GHz	Hewlett Packard Alpha Industries	11970W 861A/387	2521A00230 359	Not Req'd
Anechoic Chamber 3 Meter – Free Space	Keene Ray Proof	S-81	R-2338	Not Req'd
DMM / Temperature	Fluke	187	79690058	2/21/2014
RF Signal Generator 100 kHz to 40 GHz	Rohde & Schwarz	SMB 100A	175352	5/14/2014
RF Signal Generator 40 to 60 GHz	Wiltron	6672A	604001	CBU
RF Power Meter	Boonton	4220A	203603AA	6/13/2014
Power Sensor 1 MHz to 40 GHz	Boonton	51081	29412	6/13/2014
Power Sensor 40 to 50 GHz	Boonton	51082	29425	6/13/2014
DC Variable Source 60 Volt, 3 Amp	Hewlett Packard	6296A	7M0599	1/5/2014
Thermal Chamber	Associated Testing Labs	SLHU-1-CRLC	N/A	N/A
3 dB & 10 dB Attenuators DC to 40 GHz	Narda	4768-3 4768-10	9610 9806	Not Req'd
Barometric Pressure / Humidity / Temperature Data Logger	Extech Instruments	SD700	Q590483	5/1/2014

4. Measurements Parameters (continued)

4.2. Measurement & Equipment Setup

Test Dates:	5/22/2013, 6/27/2013, 7/19/2013, 7/26/2013, 8/2/2013
Test Engineers:	Brian Breault, Larry Stillings
Normal Site Temperature (15 - 35°C):	21.6
Relative Humidity (20 -75%RH):	35
Frequency Range:	32 kHz to 100 GHz
Measurement Distance:	3 Meters
EMI Receiver IF Bandwidth:	200 Hz – 32 kHz to 150 kHz 9 kHz – 150 kHz to 30 MHz 120 kHz - 30 MHz to 1 GHz 1 MHz - Above 1 GHz
EMI Receiver Avg Bandwidth:	300 Hz – 32 kHz 50 150 kHz 30 kHz – 150 kHz to 30 MHz 300 kHz - 30 MHz to 1 GHz 3 MHz - Above 1 GHz
Detector Function:	Peak, Quasi-Peak & Average

4.3. Measurement Procedure

Test measurements were made in accordance FCC Parts 15.209, 15.515 Subpart F, and IC RSS-220 Issue I.

The test methods used to generate the data is this test report is in accordance with ANSI C63.10:2009, American National Standard for Testing Unlicensed Wireless Devices.

4.4. Measurement Uncertainty

The following uncertainties are expressed for an expansion/coverage factor of K=2.

RF Frequency (out of band)	$\pm 1 \times 10^{-8}$
Radiated Emission of Transmitter to 100 GHz	± 4.55 dB
Radiated Emission of Receiver	± 4.55 dB
Temperature	$\pm 0.91^{\circ}$ C
Humidity	$\pm 5\%$

5. Measurements Summary

Test Requirement	FCC Rule Requirement	IC Rule Requirement	Test Report Section	Result	Comment
Antenna Requirement	15.203	RSS-GEN 7.1.4	6.1	Compliant	The antenna is housed within a sealed enclosure with the intentional radiator.
Operational Requirements	15.515 (a)	RSS-220 4	6.2	Compliant	
UWB Bandwidth	15.515 (b) 15.503 (d)	RSS-220 4.1	6.3	Compliant	
Occupied Bandwidth	N/A	RSS-GEN	6.3	Compliant	
Emissions Attenuation Above the Horizontal Plane	15.515 (c)	RSS-220 4.1(g)	6.4	Compliant	
Spurious Radiated Emissions	15.515 (d) 15.209	RSS-220 3.4 RSS-220 4.1(d)	6.5	Compliant	No measurable spurious emissions.
Radiated Emissions in GPS Bands	15. 515 (e) 15.209	RSS-220 4.1(e)			No measurable spurious emissions.
Peak Emissions in a 50 MHz Bandwidth	15.515 (f)	RSS-220 4.1(h)	6.6	Compliant	
Conducted Emissions	15.207	RSS-GEN	N/A	N/A	Automotive Battery Powered Device
Effect of Supply Voltage Variations	2, 15.215	RSS-GEN	6.8	Compliant	
Transmitter Frequency Stability	N/A	RSS-GEN 4.7	6.9	Compliant	
Radio Frequency Exposure	FCC OET Bulletin 65	RSS-GEN	6.10	Compliant	

6. Measurement Data**6.1. Antenna Requirement (15.203), RSS-GEN Section 7.1.4**

Requirement: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply

Result: The antenna utilized by the device under test is an internal, non user replaceable unit.

6.2. Operational Requirements of the Device under Test (15.515 (a)), RSS-220 Sec 4

Requirement: Operation under the provisions of this section is limited to UWB field disturbance sensors mounted in terrestrial transportation vehicles. These devices shall operate only when the vehicle is operating, e.g., the engine is running. Operation shall occur only upon specific activation, such as upon starting the vehicle, changing gears, or engaging a turn signal.

Result: The manufacturer states that the device under test complies with the requirements outlined in section 6.1 (FCC Part 15.515 (a)).

6. Measurement Data (continued)

6.3. UWB Bandwidth (15.515 (b)), RSS-220 Section 4.1

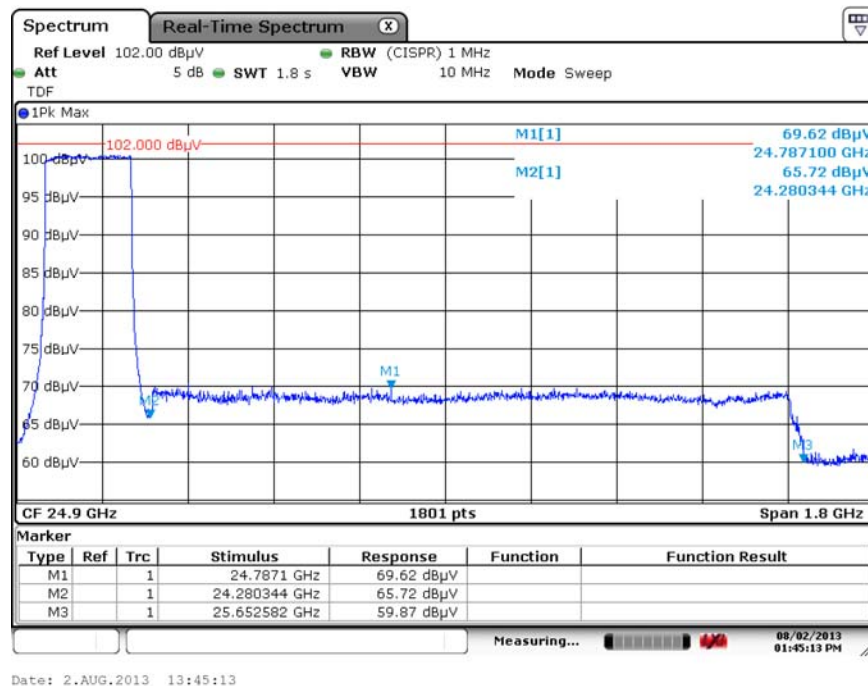
Requirement: The UWB bandwidth of a vehicular radar system operating under the provisions of this section shall be contained between 22 GHz and 29 GHz. In addition, the center frequency, f_C , and the frequency at which the highest level emission occurs, f_M , must be greater than 24.075 GHz. Operation under the provisions of this section is limited to UWB field disturbance sensors mounted in terrestrial transportation vehicles.

6.3.1. Measurement Data – Long Pulse Mode (Values in GHz)

f_M	The highest emission peak	24.7871
f_L	10 dB below the highest peak	24.2803
f_H	10 dB above the highest peak	25.6526
f_C	Calculated: $(f_H + f_L) / 2$	24.9665
Bandwidth	Calculated: $(f_H - f_L)$	1.3722
Fractional BW	Calculated: $2 * (f_H - f_L) / (f_H + f_L)$	0.0550

Note: The Bandwidth is greater than 500 MHz and therefore the fractional bandwidth requirement does not need to be met.

6.3.2. Measurement Plot of 10 dB frequencies



Note: ISM Signal on the left hand side of the plot is covered under a different rule part.

6. Measurement Data (continued)

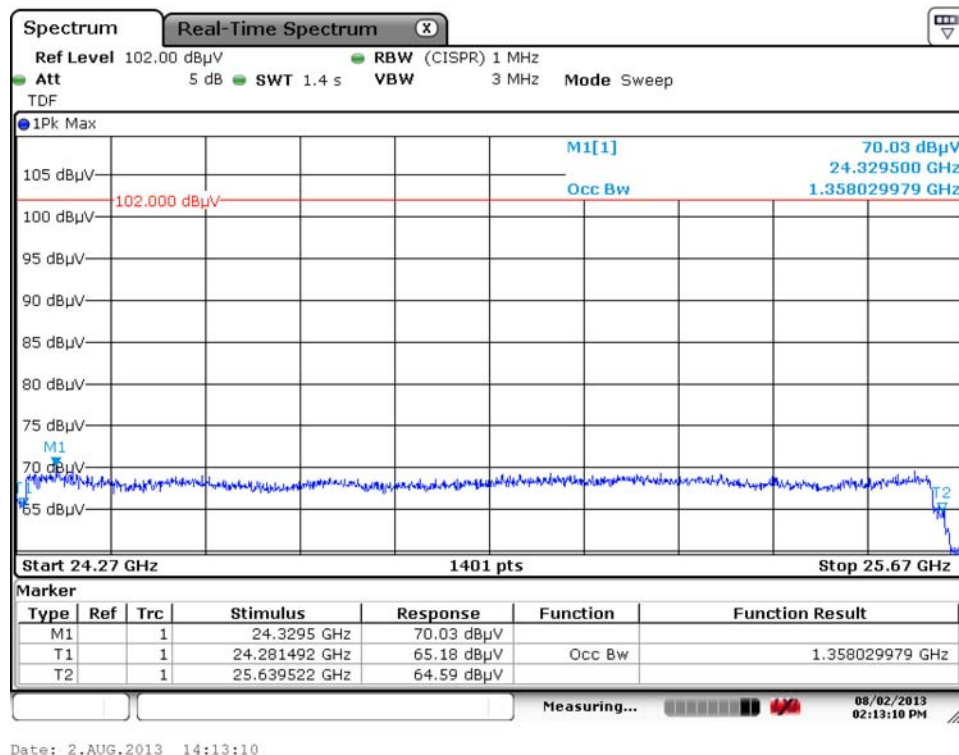
6.3. Occupied Bandwidth RSS-GEN Section 4.6.1

Requirement: When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99% emission bandwidth, as calculated or measured.

Result: Compliant

Center Frequency	99% Power Bandwidth	Result
GHz	GHz	
24.970	1.3580	Compliant

6.3.3. Measurement Plot of 99% Power Bandwidth



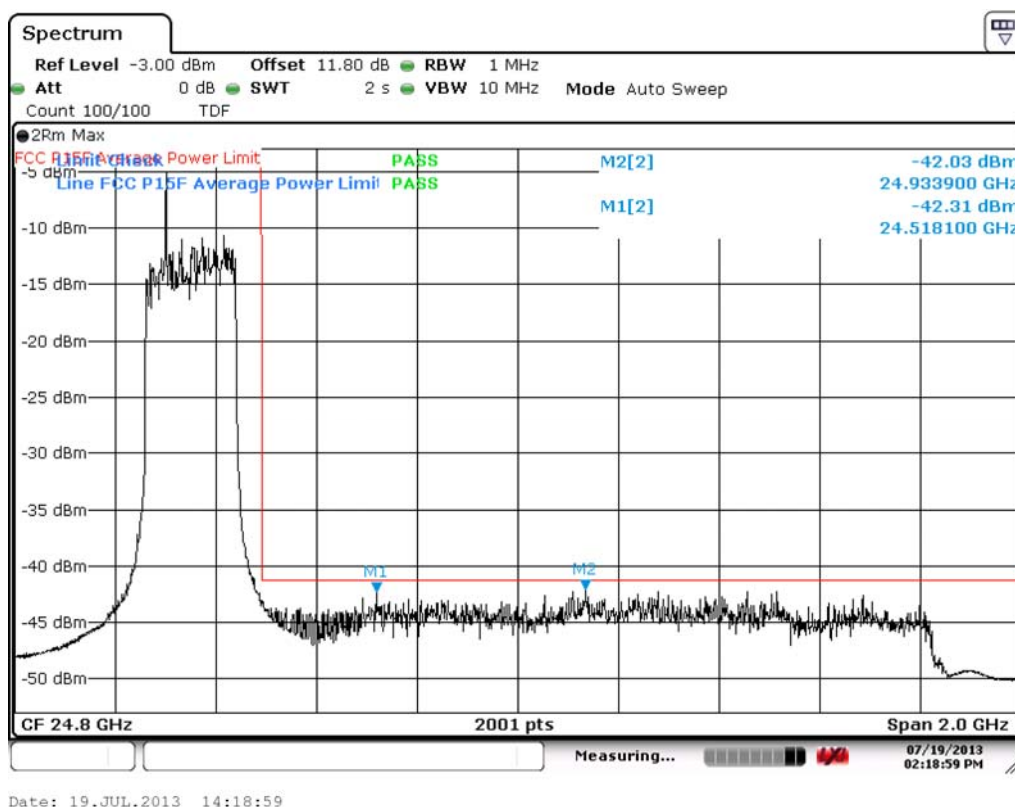
6. Measurement Data (continued)

6.3. UWB Radiated Emissions 22 to 26.5 GHz (15.515 (d), RSS-220 Section 3.4)

Frequency (GHz)	EIRP ¹ (dBm)	Limit (dBm)	Margin (dB)	Result
24.51810	-42.31	-41.30	1.01	Compliant
24.93390	-42.03	-41.30	0.73	Compliant

¹ Derived from the field strength measurements and adjusted for 3M distance.

6.3.4. Measurement Plot (RMS Power)



Note: ISM Signal on the left hand side of the plot is covered under a different rule part.

6. Measurement Data (continued)

6.4. Emissions Attenuation above the Horizontal Plane

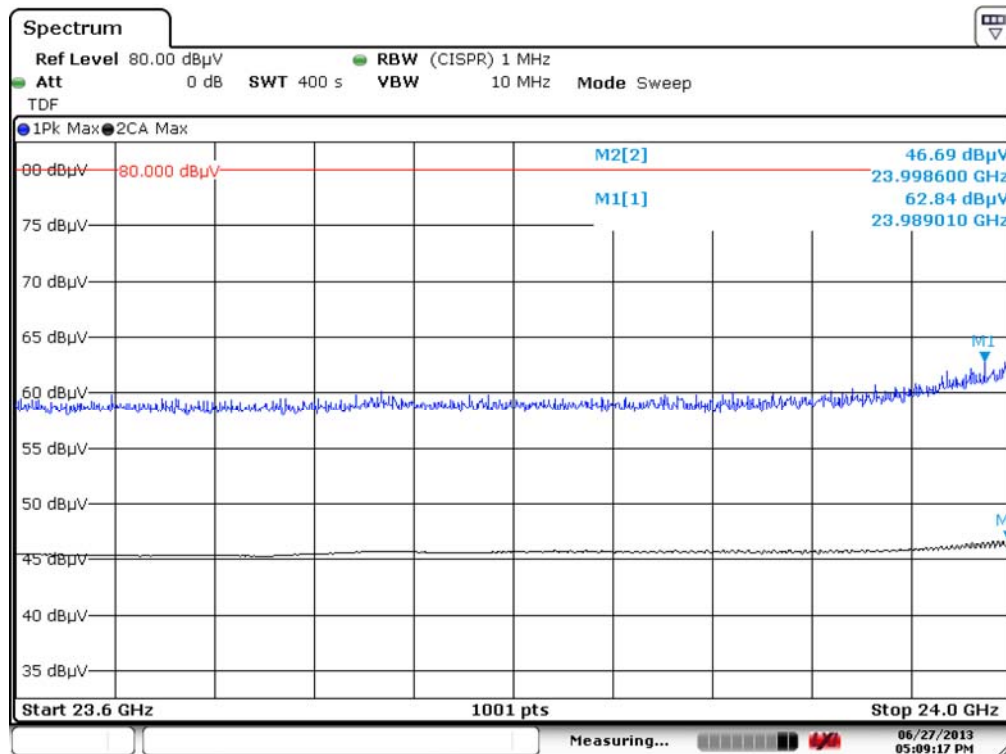
(15.515 (c), RSS-220 Section 4.1(g))

Requirement: Following proper installation, vehicular radar systems shall attenuate any emissions within the 23.6-24.0 GHz band that appear 30 degrees or greater above the horizontal plane by 25 dB below the limit specified in paragraph section 6.5 of this report. [January 1, 2005 requirement] 30 dB by January 1, 2010 and 35 dB by January 1, 2014

Test Note: The 0 value on the plots in this section refer to the absolute limit outlined in section 6.5 of this report.

Result: Compliant, the EUT does not emit any signals in the 23.6 to 24 GHz Range.

6.4.1 Plot of no signals in the satellite band 23.6 to 24.0 GHz, made at 3 Meters



Date: 27.JUN.2013 17:09:17

Note: EUT meets the requirements of 15.209 for peak (74 dBμV/m) and average (54 dBμV/m) emissions.

6. Measurement Data (continued)

6.5. Spurious Radiated Emissions (15.515 (d), 15.209, RSS-220 Section 4.1(d))

Requirement: The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in Section 15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency (MHz)	EIRP (dBm)
960 - 1610	-75.3
1610 - 22000	-61.3
22000 - 29000	-41.3
29000 - 31000	-51.3
Above 31000	-61.3

Spurious Radiated Emissions in GPS Bands

(15.515 (e), 15.209, RSS-220 Section 4.1(e))

Requirement: In addition to the radiated emission limits specified in the table in paragraph (d) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency (MHz)	EIRP (dBm)
1164 - 1240	-85.3
1559 - 1610	-85.3

Radiated Emissions Field Strength Limits at 3 Meters

(Section 15.209, RSS-GEN)

Frequency (MHz)	Field Strength (dBμV/m)
20 - 30	69.5
30 - 88	40
88 - 216	43.5
216 - 960	46
960 - 100,000	54

Test Notes: Refer to Section 4.1 for the test equipment used and Section 4.2 for the test equipment setups.

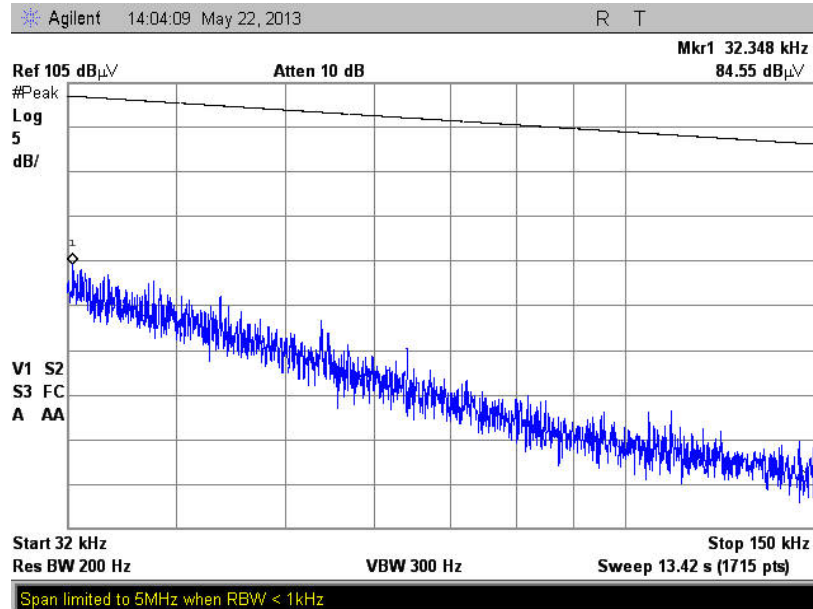
6. Measurement Data (continued)

6.5. Spurious Radiated Emissions (15.515 (d), 15.209, RSS-220 Section 4.1(d))

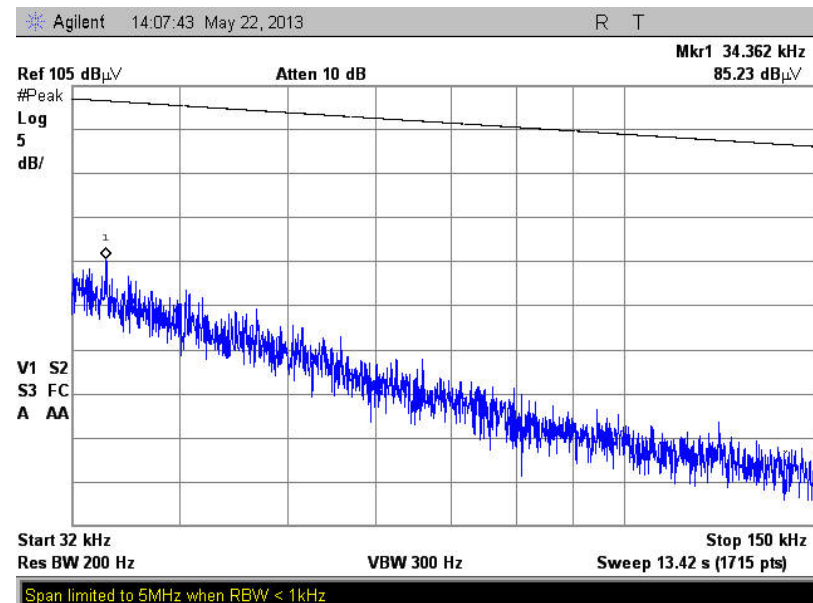
6.5.1. 32 kHz to 960 MHz, measured at 3 Meters

The device was prescreened in our 3 Meter Semi-Anechoic Chamber. There were no measurable emissions below 960 MHz on our 3 Meter OATS.

6.5.1.1 Parallel Measurement Antenna – 32 kHz to 150 kHz



6.5.1.2 Perpendicular Measurement Antenna – 32 kHz to 150 kHz



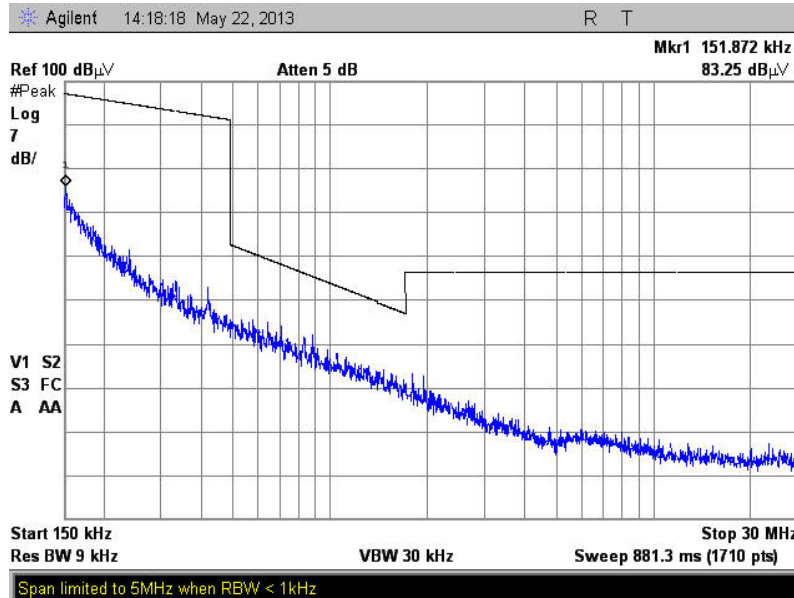
6. Measurement Data (continued)

6.5. Spurious Radiated Emissions (15.515 (d), 15.209, RSS-220 Section 4.1(d))

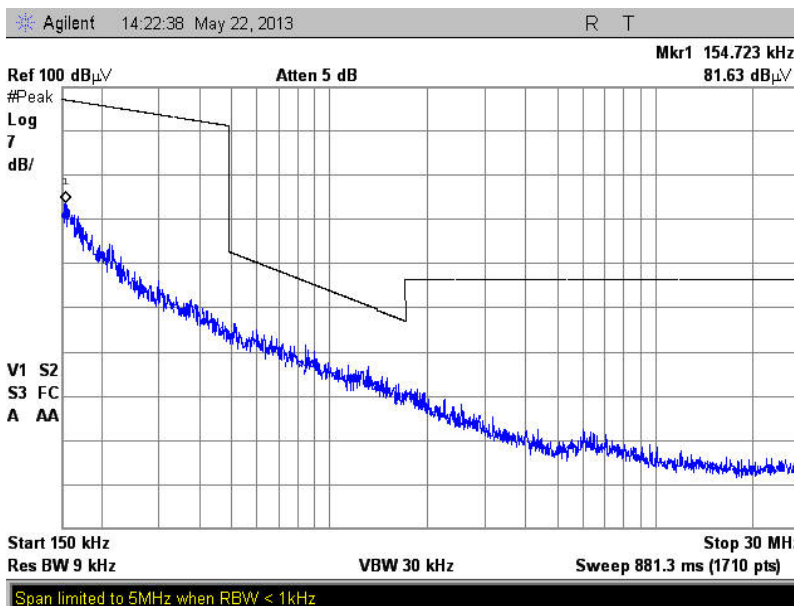
6.5.1. 32 kHz to 960 MHz, measured at 3 Meters

The device was prescreened in our 3 Meter Semi-Anechoic Chamber. There were no measurable emissions below 960 MHz on our 3 Meter OATS.

6.5.1.3 Parallel Measurement Antenna – 150 kHz to 30 MHz



6.5.1.4 Perpendicular Measurement Antenna – 150 kHz to 30 MHz



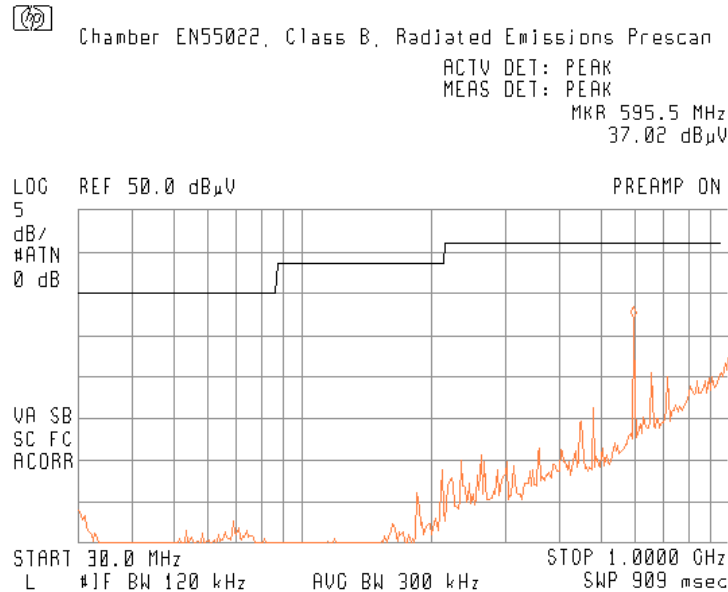
6. Measurement Data (continued)

6.5. Spurious Radiated Emissions (15.515 (d), 15.209, RSS-220 Section 4.1(d))

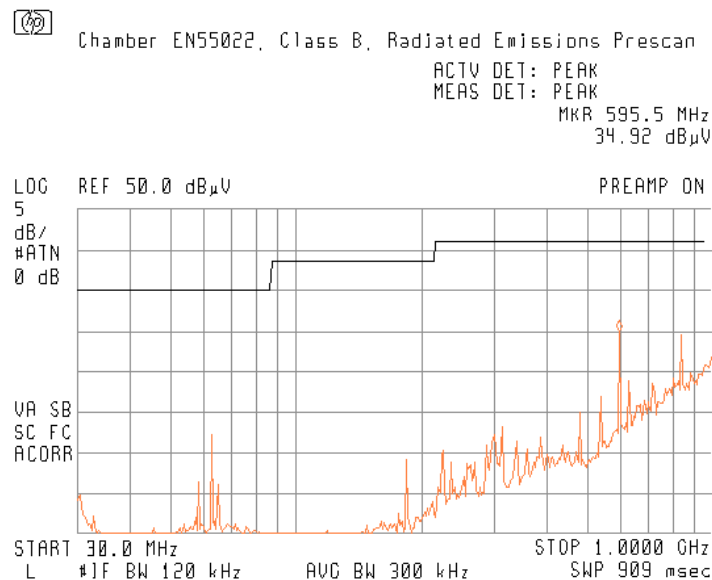
6.5.1. 32 kHz to 960 MHz, measured at 3 Meters

The device was prescreened in our 3 Meter Semi-Anechoic Chamber. There were no measurable emissions below 960 MHz on our 3 Meter OATS.

6.5.1.3 Horizontal Polarity – 30 to 960 MHz



6.5.1.4 Vertical Polarity – 30 to 960 MHz



6. Measurement Data (continued)

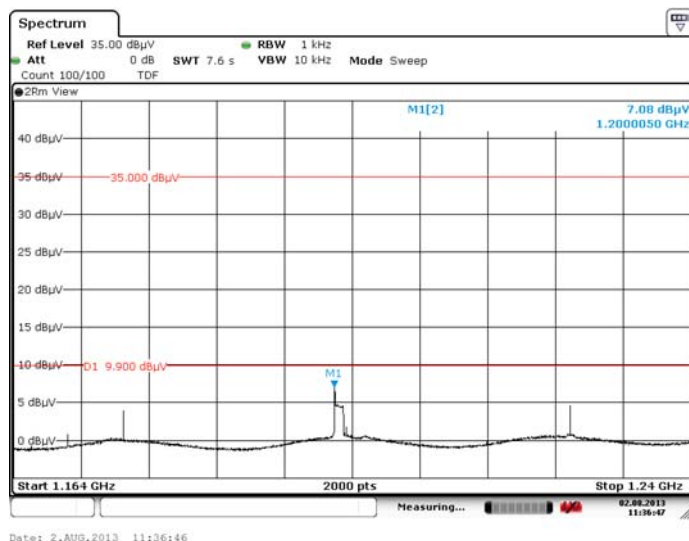
6.5. Spurious Radiated Emissions (15.515 (d), 15.209, RSS-220 Section 4.1(d))

Spurious Radiated Emissions in GPS Bands (15.515 (e), 15.209, RSS-GEN)

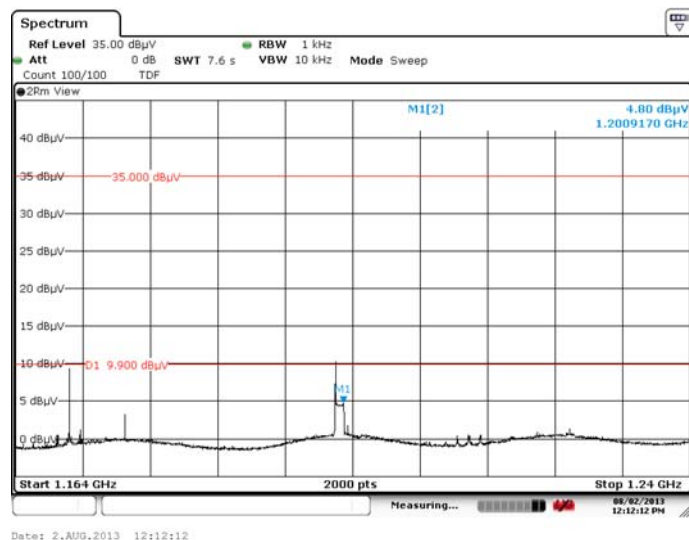
6.5.2 1164 to 1240 MHz & 1559 to 1610 MHz

There were no broadband emissions related to the UWB transmitter. Measured signals were narrowband and related to the microprocessor / clocks and do not fall under the requirements of this section. Measurements were made at 3 Meters and the -85.3 dBm limit was converted to a field strength limit of 9.9 dBuV/m.

6.5.2.1 Horizontal Measurement Polarity 1164 to 1240 MHz



6.5.2.2 Vertical Measurement Polarity 1164 to 1240 MHz

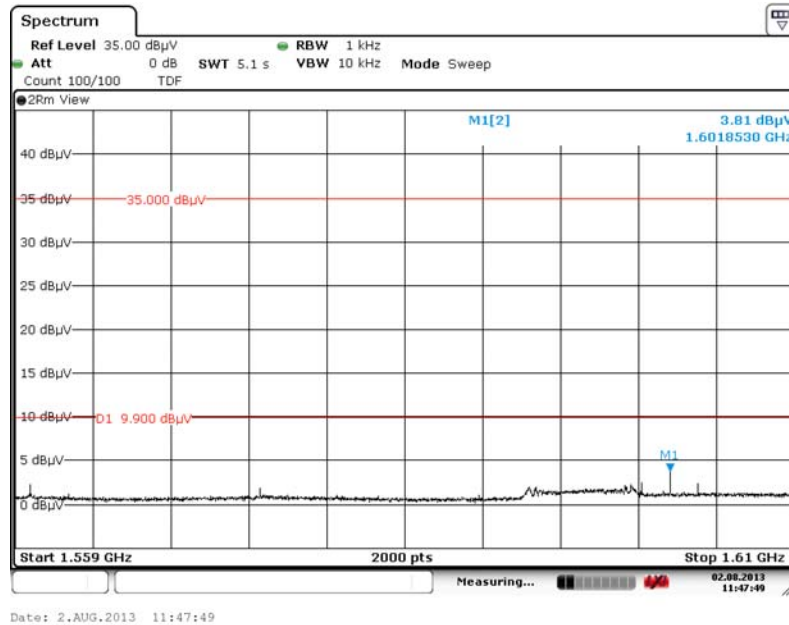


Note: Only UWB Signals are applicable, narrowband signals fall under a different rule part.

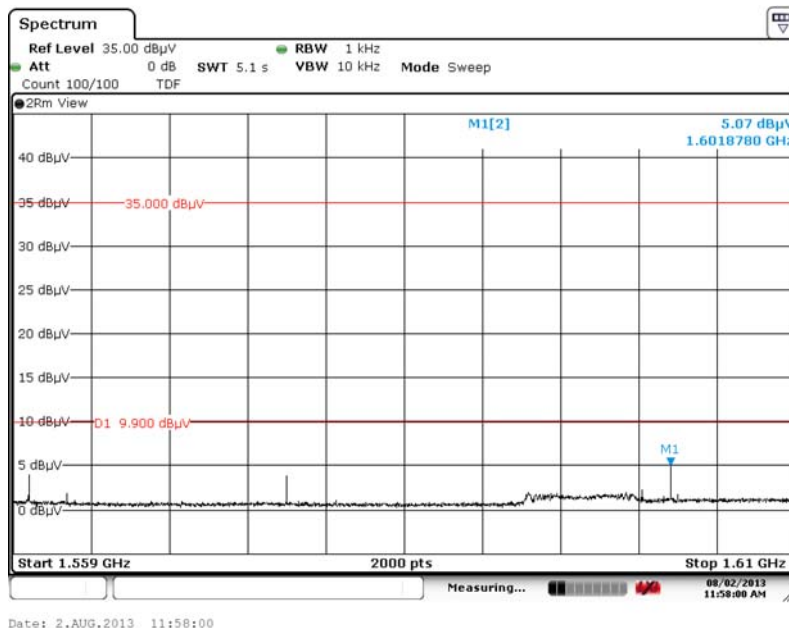
6. Measurement Data (continued)

6.5. Spurious Radiated Emissions (15.515 (d), 15.209, RSS-220 Section 4.1(d)) Spurious Radiated Emissions in GPS Bands (15.515 (e), 15.209, RSS-GEN)

6.5.2.3 Horizontal Measurement Polarity 1559 to 1610 MHz



6.5.2.4 Vertical Measurement Polarity 1559 to 1610 MHz



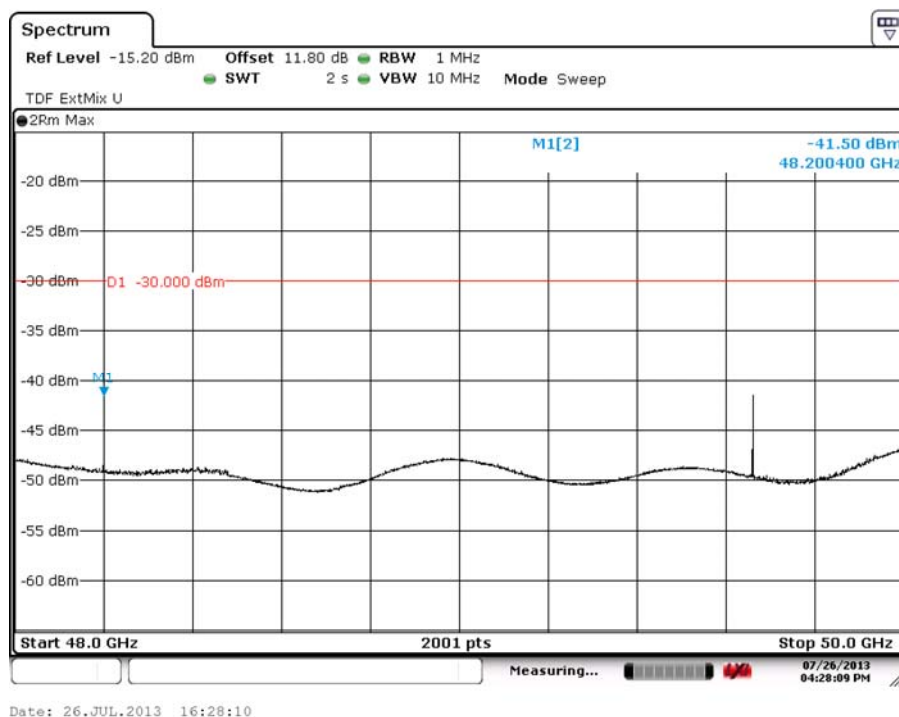
6. Measurement Data (continued)

6.5. Spurious Radiated Emissions (15.515 (d), 15.209, RSS-220 Section 4.1(d))

6.5.3. 960 MHz to 40 GHz

There were no other measurable emissions between 960 MHz and 40 GHz.

6.5.4. Plot of RMS Power 48.5 to 50 GHz measured at 3 Meters



Note: Narrow band signals fall under a different rule part.

6.5.5. Table of Harmonics

Frequency (GHz)	Amplitude (dBμV/m) ²		Average Limit	Margin (dB)	Ant Pol	Ant Ht	TT Pos	Result
	Peak	Avg	Avg		H/V	cm	Deg	
48.5 -50	There were no measurable emissions							Compliant
72 - 77	There were no measurable emissions							Compliant
96 - 100	There were no measurable emissions							Compliant

¹ Individual points representing the low, middle and high points of the device under test were taken across the span of the measured signal in non-sweeping mode. Refer to Section 3.1 for information regarding sweeping vs. non-sweeping modes.

² Measurement taken at 75 centimeters and corrected for a 3-meter distance. Distance and measurement equipment correction factors are included in the columns 2 and 3 test data.

6. Measurement Data (continued)

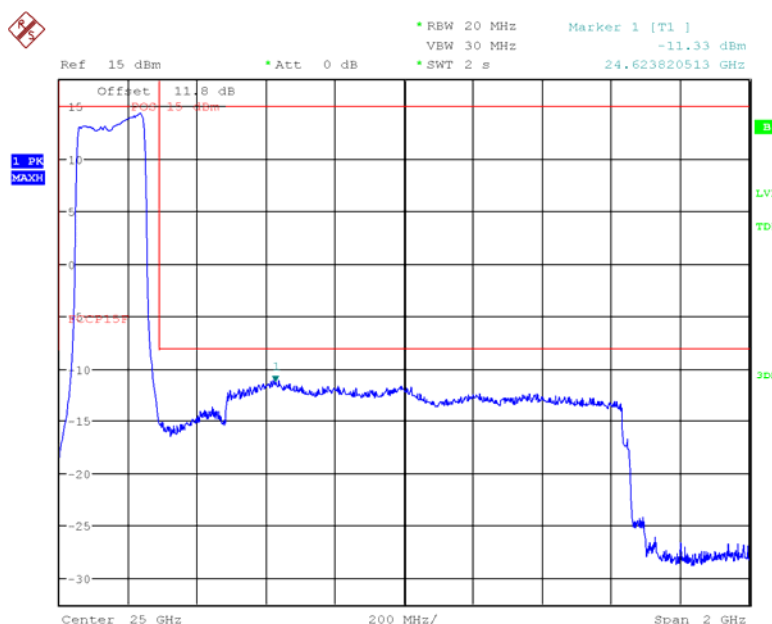
6.6. Peak Emissions in a 50 MHz Bandwidth (15.515 (f), RSS-220 Section 4.1 (h))

Requirement: There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, f_M . That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in Section 15.521.

Refer to the measurement data in Section 6.3. The resolution bandwidth used to perform the measurements was 20 MHz and the limit was adjusted to -7.96 dBm at 3 meters.

Highest emission peak (f_M) GHz:	24.62382
Adjusted limit based on a 20 MHz bandwidth:	-7.96
Measured value adjusted for 3 Meter distance in 20 MHz	-11.33
Margin:	3.37

6.6.1 Plot of Peak Power at 3 Meters



Date: 19.JUL.2013 23:28:33

Note: ISM Signal on the left hand side of the plot is covered under a different rule part.

6. Measurement Data (continued)

6.7. Devices that Employ Gated Transmissions

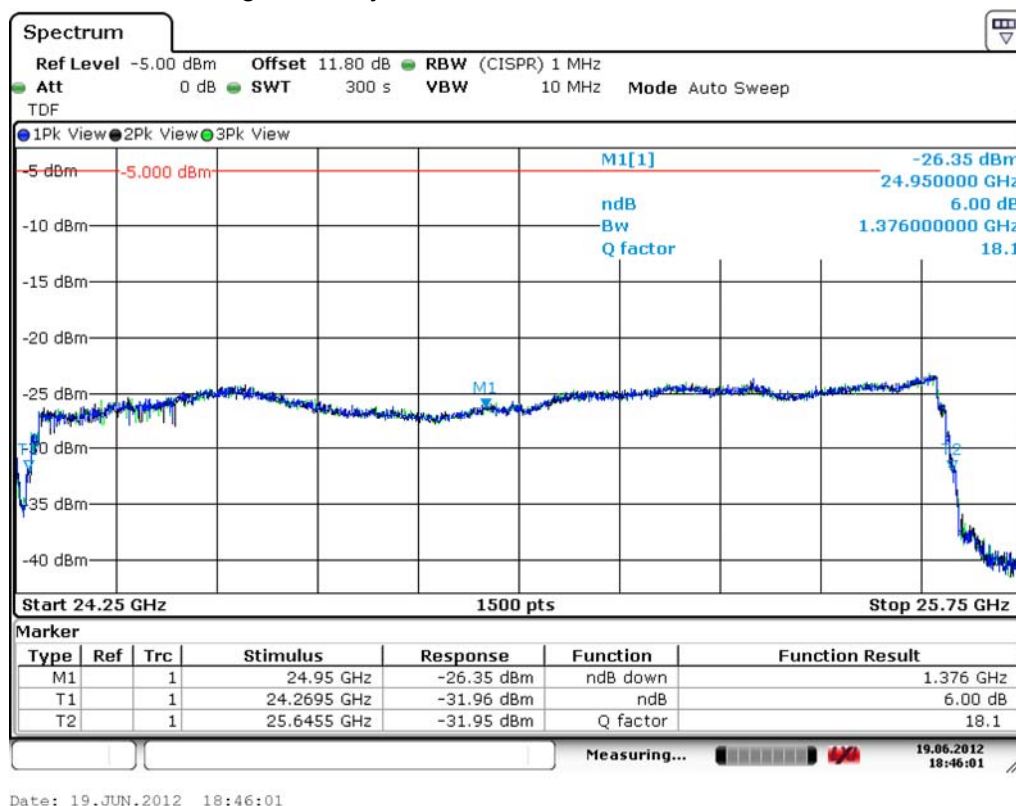
Requirement: The emission levels from devices operating under the provisions of this section that employ gated transmissions may be measured with the gating active. Measurements made in this manner shall be repeated over multiple sweeps with the analyzer set for maximum hold until the amplitude stabilizes.

6.8. Effect of Voltage Variations on Peak Emissions (15.215, RSS-GEN)

Requirement: Devices operating under this provision shall not increase in amplitude or change in bandwidth of the emission whereas it would fall out of the requirements of these rules.

Result: Compliant

6.8.1 Plot of Voltage Stability



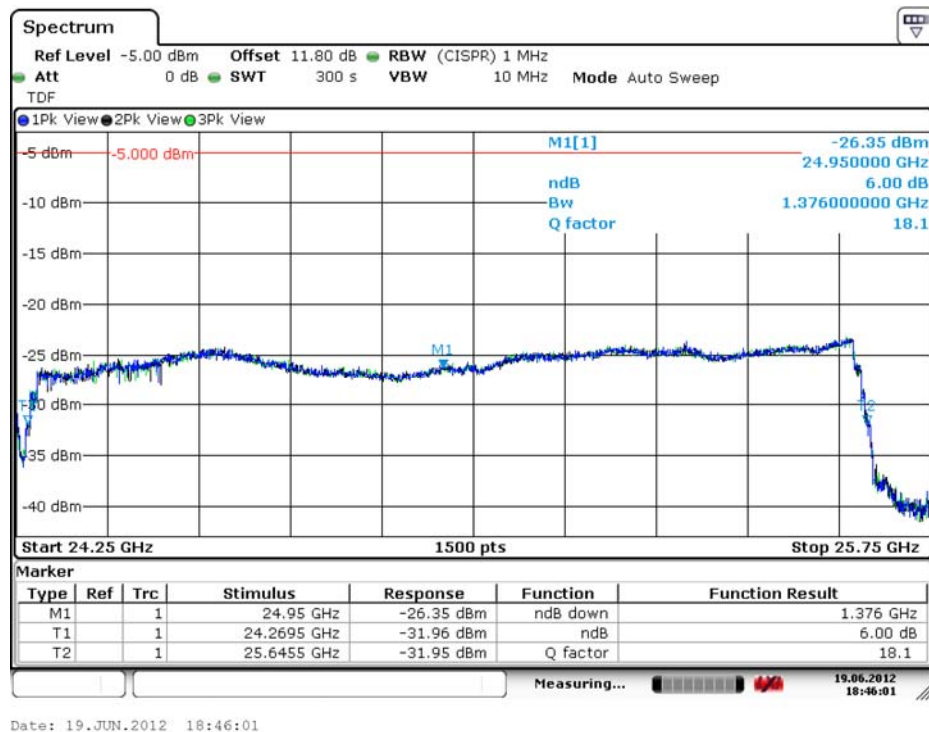
6. Measurement Data (continued)

6.9. Transmitter Frequency Stability of Unmodulated Carrier (RSS-GEN 4.7)

Requirement: Frequency stability is a measure of frequency drift due to temperature and supply voltage variations with reference to the frequency measured at an appropriate reference temperature and the rated supply voltage. Measure the device at temperatures of -30, +20 and +50 degrees C at the rated supply voltage and at a temperature of +20 degrees C at +/- 15 percent of the rated supply voltage. Measurement should be made on an unmodulated carrier frequency.

Test Conditions				Occupied Frequency Range	
				f _L (GHz)	f _H (GHz)
T _{nom}	25.9 °C	V _{nom}	13.5 VDC	24.2695	25.6455
T _{min}	-30 °C	V _{min}	11.5 VDC	24.2695	25.6455
		V _{max}	15.5 VDC	24.2695	25.6455
T _{max}	+50 °C	V _{min}	11.5 VDC	24.2695	25.6455
		V _{max}	15.5 VDC	24.2695	25.6455
Worst Case				24.2695	25.6455

6.9.1 Plot of Frequency Stability



6. Measurement Data (continued)

6.10. Public Exposure to Radio Frequency Energy Levels (15.247(i) (1.1307 (b)(1)) RSS-GEN 5.5, RSS 102

6.10.1. MPE Power Density Table.

MPE Distance (cm)	DUT Output Power (dBm)	DUT Antenna Gain (dBi)	Power Density		Limit (mW/cm ²)	Result
			(mW/cm ²)	(W/m ²)		
(1)	(2)	(3)	(4)		(5)	
20	-11.33	12.2	0.0002431	0.0024307	1	

$$PD = \frac{OP + AG}{(4 \times \pi \times d^2)}$$

PD = Power Density

OP = DUT Output Power (dBm)

AG = Antenna Gain (dBi)

D = MPE Distance

1. Reference CFR 2.1093(b): For purposes of this section, a portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user.
2. Section 6.1 of this test report.
3. Power density is calculated from conducted power output measurement and antenna gain.
4. Reference CFR 1.1310, Table 1: Limits for Maximum Permissible Exposure (MPE), Section (B): Limits for General Population/Uncontrolled Exposure.

7. Test Images

7.1. Spurious and Harmonic Emissions – 1 to 18 GHz



7. Test Images

7.2. Spurious and Harmonic Emissions – 18 to 40 GHz



8. Test Site Description

Compliance Worldwide is located at 357 Main Street in Sandown, New Hampshire. The test sites at Compliance Worldwide are used for conducted and radiated emissions testing in accordance with Federal Communications Commission (FCC) and Industry Canada standards. A description of the test sites is on file with the FCC (registration number **96392**) and Industry Canada (file number **IC 3023A-1**).

The radiated emissions test site is a 3 and 10 meter enclosed open area test site (OATS). Personnel, support equipment and test equipment are located in the basement beneath the OATS ground plane.

The conducted emissions site is part of a 16' x 20' x 12' ferrite tile chamber and uses one of the walls for the vertical ground plane required by EN 55022.

Both sites are designed to test products or systems 1.5 meter W x 1.5 meter L x 2.0 meter H, floor standing or table top.