Project 07022-10

Freescale Semiconductor
Model ZStar Triaxial Accelerometer

Electromagnetic Emission Test Report

Prepared for:

Freescale Semiconductor
6501 William Cannon Drive West
Austin, Texas 78735

By

Professional Testing (EMI), Inc.
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November 1, 2006

Rev 3

Reviewed by	Written by
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Revision History

Rev 1 – 2006-10-09 EL
Re-measured peak power with correct 3 MHz RBW/VBW, revised affected tables. Significant changes noted. Procedures revised accordingly.
Re-measured 3 kHz PSD, included plotted raw data. Affected tables revised. New PSD agreed with old measurement with error < 3 dB.

Rev 2 – 2006-10-19 EL
The description of the site locations was revised to specify test sites as were actually used.
Re-measured the 99% 20dB bandwidth using the Industry Canada method that references the entire bandwidth peak power.
Removed 26 dB bandwidth section.
Re-measured peak power with correct bandwidth of instrument, revised affected tables & forms.
Revised incorrect test measurement distances for tests above 1 GHz, incorrectly listed 3 meters.
Investigated adjacent restricted bands and reported measurements.
Re-measured transmit harmonics/spurious, including average detection measurements.
Further explained/justified no measurements of receive/standby mode spurious emissions.
More precisely named the applicant/client and EUT.
Further explained battery power method and that a charger is not used.
Specified that the EUT does not connect to a computer.

Rev 3 – 2006-11-01 EL
EUT harmonics exceeded limits, power reduced ~10 dB and new measurements taken.
Re-measured harmonic & spurious emissions above 1 GHz.
Re-measured adjacent restricted bands emissions with measurements at band edges included.
Peak power and power spectral density re-measured and affected tables revised.
Bandwidth 6 dB and 20 dB re-measured and affected tables revised.
Explained/justified no receiver spurious measurements, receiving mode not available though dominates transmit duty cycle.
Corrected model number to match silk screened product markings.
Revised test setup drawings to specify frequency range of measurements where the illustrations applied.

Applicant: Freescale Semiconductor

Applicant's Address: 6501 William Cannon Drive West
Austin, TX 78735

FCC ID: RUNZT

IC Number: 6744A-ZT

Project Number: 07022-10

Test Dates: 25 May 2006 to 31 October 2006

The **Freescale Semiconductor Model ZStar Triaxial Accelerometer** was tested to and found to be in compliance with FCC 47 CFR Part 15 and IC RSS-210.

The highest emissions generated by the above equipment are listed below:

Parameter	Frequency (MHz)	Level		Limit	Margin (dB)
Transmitter: Mains Conducted	Not applicable, battery powered.				
Transmitter: Radiated Spurious	7215	82.5 dBµV/m @ 1 m		83.5 dBµV/m	-1.0
Transmitter: Peak Power @ 1 m	2440	-17.37 dBm	0.018 mW	+30 dBm	-47.4
Transmitter: Power Spectral Density	2440	-34.57dBm / 3 kHz		8 dBm / 3 kHz	-42.6
Receiver: Mains Conducted	Not applicable, battery powered.				
Receiver: Radiated Spurious	Not applicable.				

Occupied Bandwidth		Emission Designator FCC (6 dB BW)	Emission Designator IC (20 dB BW)
6 dB	20 dB		
1.55 MHz	1.91 MHz	1M55G1D	1M91G1D

I, Jason Anderson, for Professional Testing (EMI), Inc., being familiar with the FCC rules and test procedures have reviewed the test setup, measured data and this report. I believe them to be true and accurate.

Jason Anderson
Regulatory Department Manager

This report has been reviewed and accepted by Freescale Semiconductor. The undersigned is responsible for ensuring that this device will continue to comply with the FCC and IC rules.

1.0 Introduction

1.1 Scope

This report describes the extent of the Equipment Under Test (EUT) conformance to the Electromagnetic Compatibility requirements of the USA and Canada.

1.2 EUT Description

The Freescale Semiconductor Model ZStar Triaxial Accelerometer, a ZigBee radio (EUT), is a high performance, low power, solely battery operated, 2.4 GHz ISM band transceiver. The EUT is 1 item in a kit of 2 radios that provide a demonstration of the integrated circuits for actual or potential customers of Freescale Semiconductor, the chip manufacturer. The EUT is tested in actual use with the companion ZStar USB Stick radio. This EUT is stand-alone does not connect to a computer.

The companion ZStar USB Stick ZigBee radio receives accelerometer data from the ZStar Triaxial Accelerometer. It is tested and submitted separately from the EUT herein.

1.3 EUT Operation

The EUT was tested while in a continuous transmit mode. The EUT was tuned to a low, middle, and high channel to perform power, occupied bandwidth, and spurious/harmonic tests. For conducted emissions the device was tuned to its center frequency. The EUT continuously transmitted at maximum power a pulsed, DSSS modulated packet with a 125 byte payload. The system tested consisted of the following:

Manufacturer	Model	FCC ID Number	IC Identifier
Freescale Semiconductor	ZStar Triaxial Accelerometer	RUNZT	6744A-ZT

The following rules apply to the operation of the EUT:

Guidelines	FCC Rules	IC Rules	
	Part 15	RSS-GEN Issue 1	RSS-210 Issue 6
Transmitter Characteristics	15.247	4.1-4.6, 7	2.2, 2.6-2.7, A2.9, A8, A9
Spurious Radiated Power	15.209	4.2, 4.7, 4.8, 6, 7	2.2, 2.6-2.7, A2.9, A8, A9
Power Line Conducted	15.207 (Not applicable.)	4.2, 4.7, 7.2 (Not applicable.)	
Antenna Requirement	15.203	7.1, 7.1.4	

1.4 Test Site

Measurements of EUT characteristics below 1 GHz were made at the Professional Testing "Open Field" Site 3, located in Round Rock, Texas, USA. This site was registered with the FCC under section 2.948 of CFR 47. The site is also listed with Industry Canada as IC-3036-3 and in this report used at 3 meters. Measurements above 1 GHz were performed indoors at a distance of 1 meter or less with directional antennas and care exercised to minimize unwanted effects of the surroundings.

1.5 Test Results

The data collected for this report are presented entirely in Appendix B.

2.0 Power Line Conducted Emissions

EUT is entirely battery operated. Battery is coin-style non-rechargeable lithium. This test does not apply.

3.0 Peak Output Power

Peak power measurements were made on selected fundamental transmit frequencies of the EUT for the lowest, most center, and highest transmit frequency.

Tests of the fundamental emissions of the EUT also determined the worse case polarization of the device. The emissions of the device were measured with the EUT in three orthogonal axes.

3.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a motorized turntable, which allows 360-degree rotation. For measurements of the fundamental signal, a measurement antenna was positioned at a distance of 1 meter as measured from the closest point of the EUT. Rotating the EUT maximized the emissions.

A spectrum analyzer with peak detection was used to find the maximum field strength during the variability testing. Resolution bandwidth (RBW) is chosen to encompass the entire 6 dB bandwidth of the fundamental signal, up to 3 times the bandwidth if possible. RBW used is recorded. A calculation was then made to determine the peak power at the antenna terminal. A drawing showing the test setup is given in Appendix A.

3.2 Test Criteria

The maximum peak output power is 30 dBm for DSSS devices operating in the frequency range 2400-2483.5 MHz according to FCC 15.247(b)(3) and RSS-210.

4.0 Occupied Bandwidth: 6 dB, 20 dB

Occupied bandwidth measurements were performed on the EUT to determine compliance with FCC 15.247(a)(2) and RSS-210.

4.1 Test Procedure

The occupied bandwidth was measured with a spectrum analyzer connected to a double-ridged guide horn while the EUT was operating in continuous transmit mode at the appropriate center frequency. The analyzer center frequency was set to the EUT carrier frequency. Display line and marker delta functions were used to measure the 6 dB occupied bandwidth of the EUT. However, the 20 dB bandwidth is referenced to a peak power measurement taken at the entire bandwidth or more for RBW, then using 1% RBW for 20 dB bandwidth. This is used to report the 99% power bandwidth for RSS-210.Measurements were made at three frequencies. A drawing showing the test setup is given in Appendix A.

4.2 Test Criteria

The minimum 6 dB occupied bandwidth for the EUT is 500 kHz as stated in 15.247(a)(2) and RSS-210.

5.0 Power Spectral Density

Power spectral density measurements were performed on the EUT to determine compliance with FCC 15.247(d) and RSS-210.

5.1 Test Procedure

The fundamental emission of the EUT is maximized and the spectrum analyzer is tuned to the highest point as measured in max-hold with peak detection. The analyzer is then centered on the maximum peak and set with the following parameters: RBW = 3 kHz, VBW > RBW, span = 300 kHz, and sweep time = 100s. The peak level is obtained after the sweep completes. The test setup is included in Appendix A.

5.2 Test Criteria

According to section FCC 15.247(d) and RSS-210 the maximum power spectral density is +8 dBm in any 3 kHz bandwidth.

6.0 Band Edge Spurious Emissions

Band edge spurious emissions measurements were performed on the EUT to determine compliance to FCC 15.247(c) and RSS-210.

6.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a motorized turntable, which allows 360-degree rotation. For measurements of the fundamental signal, a measurement antenna was positioned at a distance of 1 meter as measured from the closest point of the EUT. Rotating the EUT maximized the emissions.

The spectrum analyzer was set for peak detection using a 100 kHz resolution bandwidth. The span is set to 10 MHz with the center of the display at the frequency of the band edge. Measurement is made at the band edge using the marker delta method while transmitting on the channels nearest the band edge to determine if the EUT meets the test criteria. The test setup is included in Appendix A.

6.2 Test Criteria

According to FCC 15.247(c) and RSS-210 the band edge spurious emissions must be 20 dB below the highest peak in the operating band in any 100 kHz bandwidth. If the frequency falls in the restricted bands of 15.205 the maximum permitted average must be below the field strength listed in 15.209.

Alternatively, the band edge spurious emissions will meet criteria if they are attenuated below the limits specified in FCC 15.209 or RSS-210 Table 3. For this test the adjacent restricted band measurement included measurements of the band edge emissions and compared to 15.209.

7.0 Out of Band Spurious Emissions

Out of band spurious/harmonic emissions measurements were performed on the EUT to determine compliance to FCC sections 15.247(c), 15.209 and RSS-210.

7.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a rotating turntable. For measurements of the fundamental signal, the measurement antenna was positioned at a distance of 1 meter as measured from the closest point of the EUT. Rotating the EUT maximized the emissions.

For spurious emissions below 1 GHz quasi-peak detection is used with a resolution bandwidth of 120 kHz and measured at a distance of 3 meters.

Spurious/harmonic emissions above 1 GHz peak are measured with average and peak detection with a resolution bandwidth of 1 MHz. Average detection is used to determine compliance of the EUT if the peak does not meet the average limit. A resolution bandwidth of 1 MHz and video bandwidth of (1/transmitter “on-time”) Hz is used for average detection of pulsed emissions. A peak to average calculation is also employed for averaging pulsed harmonic emissions. Non-harmonic emissions must satisfy the average limit and the peak limit (20 dB above average). The test setup is included in Appendix A.

Above 1 GHz testing was completed at 3 transmit frequencies to determine compliance.

7.2 Test Criteria

The radiated limits of FCC 15.209 and RSS-210 are shown below. The limits specified are at 3 meters. The limits are quasi-peak for emissions below 1 GHz and average for emissions above 1 GHz. Also above 1 GHz the peak limit is 20 dB above the average limit.

Frequency MHz	Test Distance (Meters)	Field Strength (µV/m)	Field Strength (dBµV/m)
30 to 88	3	100	40.0
88 to 216	3	150	43.5
216 to 960	3	200	46.0
Above 960	3	500	54.0

Note: Emissions above 1 GHz were measured at a distance of 1 meter. The limit was increased by 9.5 dB. Emissions above 18 GHz were measured at a distance of 10 cm and the limit increased by 29.5 dB.

8.0 Antenna Requirements

An antenna evaluation was performed on the EUT determine compliance with FCC sections 15.203, 15.247(b) and RSS-210.

8.1 Evaluation Procedure

The design of the EUT antenna is evaluated for conformance to engineering requirements for gain and to prevent substitution of unapproved antennae. Gain of the antenna is assessed by reviewing the antenna manufacturer’s data sheet.

8.2 Evaluation Criteria

The antenna design must meet at least one of the following criteria:

a) Antenna is permanently attached to the unit.
b) Antenna must use a unique type of connector to attach to the EUT.
c) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

Section 15.247(b)(4)(i) states that if the transmitting antenna has a directional gain greater than 6 dBi the power shall be reduced the amount in dB that the directional gain is greater than 6 dBi.

9.0 Timing Assessment

The timing between transmissions and duration of each transmission on the EUT was assessed to determine an appropriate peak to average correction factor for typical operation.

9.1 Test Procedure

Using a spectrum analyzer set in zero span two pulses are captured on the screen. The ratio of on-time to off-time is calculated and converted to the dB scale. The test setup is included in Appendix A.

9.2 Test Criteria

There are no criteria. This correction factor is used to determine the averaged peak value of a harmonic emission if the measured peak emission exceeds the peak limit.

10.0 Receiver Requirements

Emissions measurements were not possible for either a receive or standby mode. The EUT initiated transmissions to seek out the companion Sensor unit (submitted separately) as soon as it received power.

The transmitter duty cycle is low such that the peak averaging factor exceeded the maximum of 20 dB. Consequently, the receiving mode was active most of the time during the transmit mode spurious and harmonic measurements.

11.0 Modifications

To satisfy the peak harmonic emission limits at the 3rd harmonic, transmitter power was reduced by ~10 dB in firmware. New measurements of transmit spurious/harmonics > 1 GHz, adjacent restricted band emissions, peak power, power spectral density, and bandwidth were performed and reported herein.

12.0 Test Equipment

< 1 GHz

Asset #	Manufacturer	Model #	Description	Calibration Due
C005	None	None	Underground Coaxial Cable	8 Dec 2006
1494	EMCO	3110B	Biconical Dipole Antenna	20 Apr 2007
0290	EMCO	3146	Log Periodic Antenna	22 May 2007
0483	HP	8447D	Preamplifier, < 1 GHz	12 Jan 2007
0043	HP	8567A	Spectrum Analyzer	28 Mar 2007
0044	HP	85662A	Spectrum Analyzer Display	28 Mar 2007
0085	HP	85650A	Spectrum Analyzer QP Adapter	26 Sep 2006
0483	Tektronix	2706	RF Preselector	27 Oct 2007

> 1 GHz

Asset #	Manufacturer	Model #	Description	Calibration Due
C025	Belden	RG223	Coaxial Cable	Calibrate Before Use
0081	Elgar	1751SL	Variable AC Power Source	Calibrate Before Use
1525	HP	8566B	Spectrum Analyzer	10 Jul 2007
1526	HP	8566B	Spectrum Analyzer Display	28 Jun 2007
0950	HP	8566B	Spectrum Analyzer	30 May 2007
0949	HP	8566B	Spectrum Analyzer Display	30 May 2007
0897	Miteq	-	Preamplifier, > 1 GHz	16 May 2007
0582	EMCO	3115	Horn 1 – 18 GHz	21 Jul 2007
0910	HP	11971T	Harmonic Mixer Set	CBU
None	Waveline	850-1	Standard Gain Horn 18-26 GHz	CBU
1057	HP	11517A	Mixer, 12.4 – 40 GHz	CBU
0989	MicroTronics	HPM50111	2.5 GHz High Pass Filter	CBU

Note that no mains conducted emission equipment appears above because those tests were not required.

Appendix A Test Setup Diagrams

FIGURE 1: Radiated Emissions Test Setup > 1 GHz
Peak Power, Occupied Bandwidth, Power Spectral Density, Timing Assessment, Band Edge Spurious, Adjacent Restricted Band Emissions

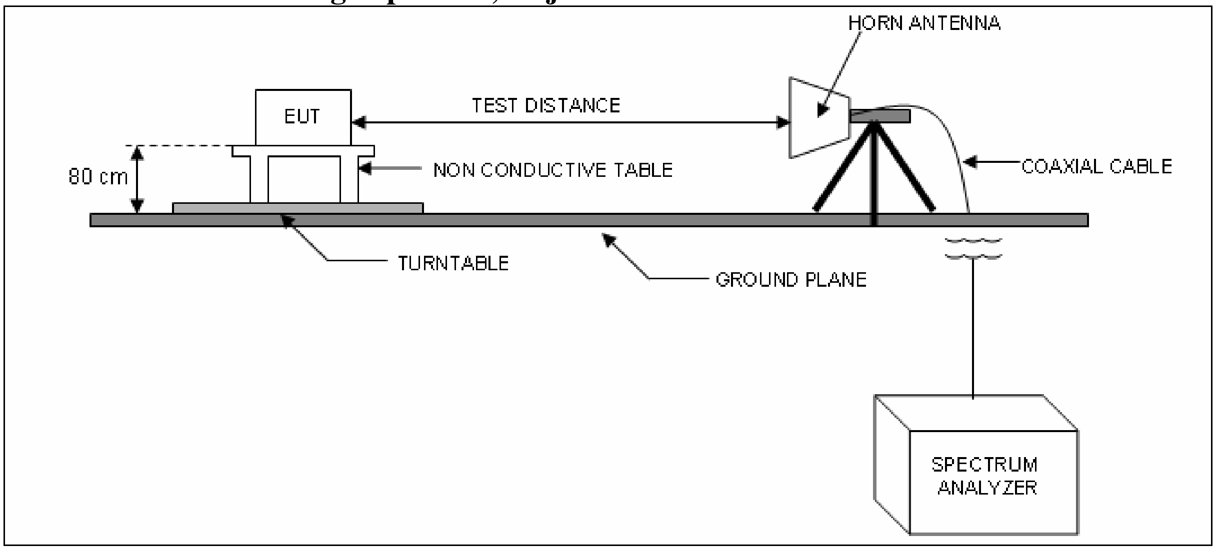


FIGURE 2: Radiated Emissions Test Setup – Spurious < 1 GHz

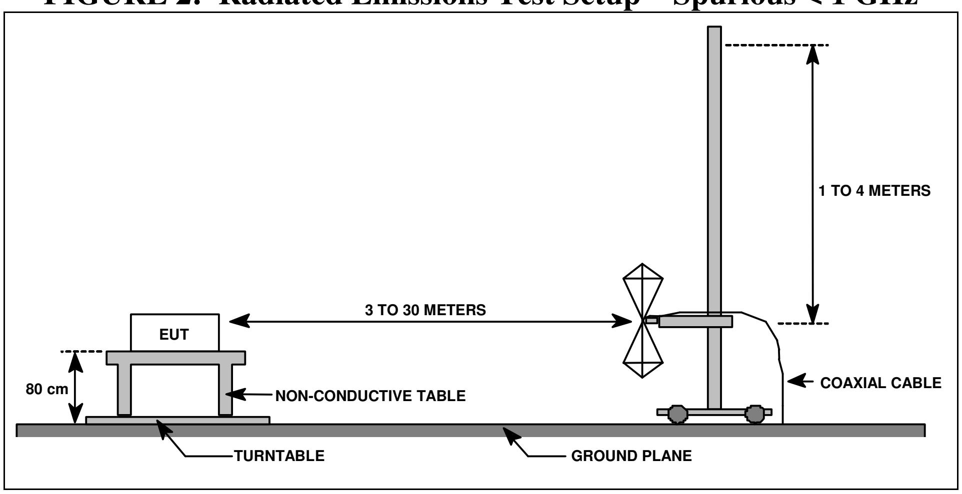
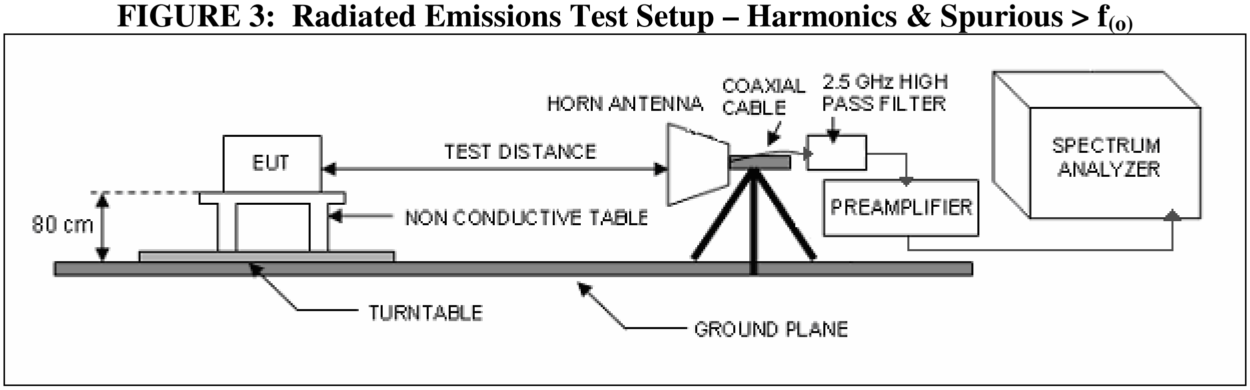


FIGURE 3: Radiated Emissions Test Setup – Harmonics & Spurious > $f_{(o)}$



For the tests in this report, the transmitter power was sufficiently low as to not require a high pass filter.

Peak Power
Freescale Semiconductor Model ZStar Triaxial Accelerometer
Peak Detection, RBW = 3 MHz, VBW = 3 MHz

Test Date: October 31, 2006
Test Distance 1 meters

All Orientations

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Corrected Level (dBµV /m)
2405	180	1	58.6	0.0	28.2	0.6	87.4
2440	180	1	57.5	0.0	28.2	0.6	86.3
2480	180	1	57.3	0.0	28.3	0.6	86.2

Note – 2405 & 2440 peak power measurements are as shown, the same level.

Calculations

$$P = \frac{(E * d)^2}{30 * G}$$

P=Power in watts, E=measured maximum field strength in V/m, d=distance in meters, G=numeric gain of transmitting antenna

Distance=1 meters
Gain=0 dBi

Calculated Result

Frequency (MHz)	Field Strength (dBµV)	E.I.R.P.		Limit (dBm)
		dBm	mW	
2405	87.4	-17.37	0.018	30
2440	86.3	-18.47	0.014	30
2480	86.2	-18.57	0.014	30

Result: PASS

Test Engineer: Eric Lifsey

Power Spectral Density
Freescale Semiconductor Model ZStar Triaxial Accelerometer
Peak Detection, RBW = 3 kHz, VBW = 3 MHz
Test Distance 1 meter

Test Date: October 31, 2006
All Orientations

Frequency (MHz)	**EUT Direction (degrees)**	**Antenna Elevation (Meters)**	**Recorded Level** (dBµV)	**Amplifier Gain (dB)**	**Antenna Factor (dB/m)**	**Cable Loss (dB)**	**Corrected Level** (dBµV **/m)**
2405	180	1	41.4	0.0	28.2	0.6	70.2
2440	90	1	39.4	0.0	28.2	0.6	68.2
2480	180	1	40.1	0.0	28.3	0.6	69.0

Calculations

$$P = \frac{(E * d)^2}{30 * G}$$

P=Power in watts, E=measured maximum field strength in V/m, d=distance in meters, G=numeric gain of transmitting antenna

Distance=1 meters
Gain=0 dBi

Calculated Result

Frequency (MHz)	Field Strength (dBµV / 3 kHz)	E.I.R.P (dBm / 3 kHz)	Limit (dBm / 3 kHz)
2405	70.2	-34.57	8
2440	68.2	-36.57	8
2480	69.0	-35.77	8

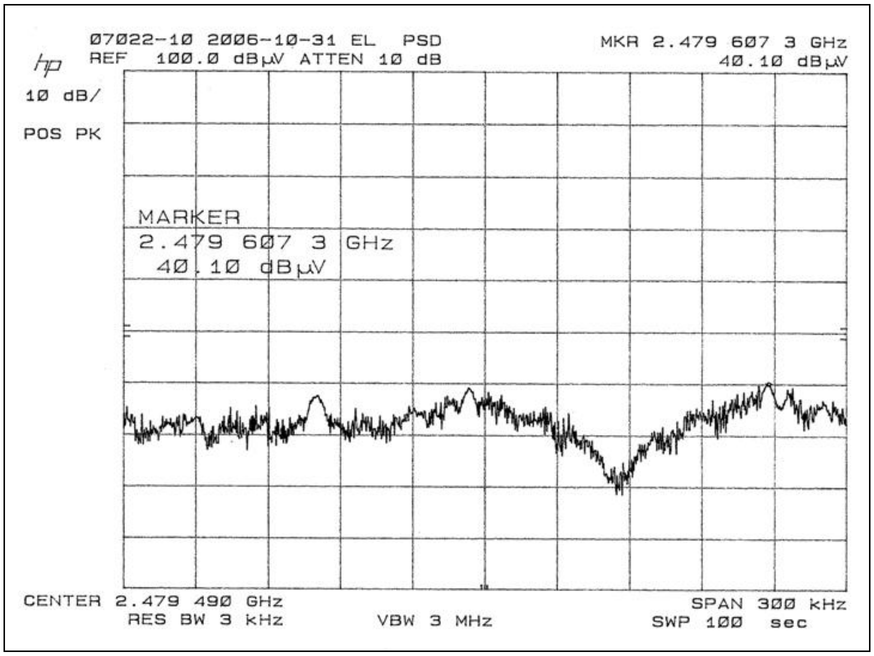
Plots of PSD measurements are presented on the following pages.

Result: PASS

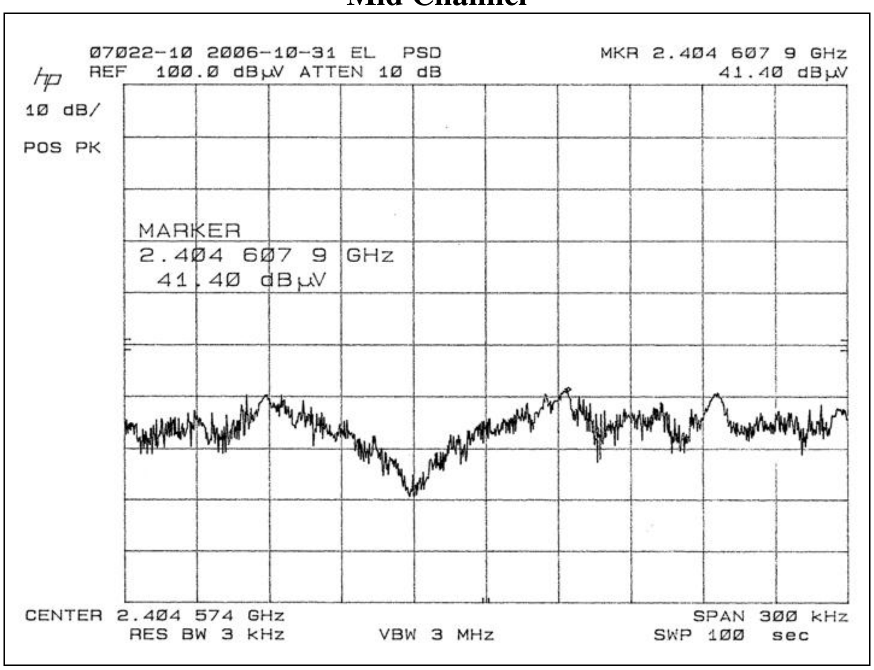
Test Engineer: Eric Lifsey

Power Spectral Density
Freescale Semiconductor Model ZStar Triaxial Accelerometer
Peak Detection, RBW = 3 kHz, VBW = 3 MHz
Span 300 kHz, 100 second sweep
Test Distance 1 meter

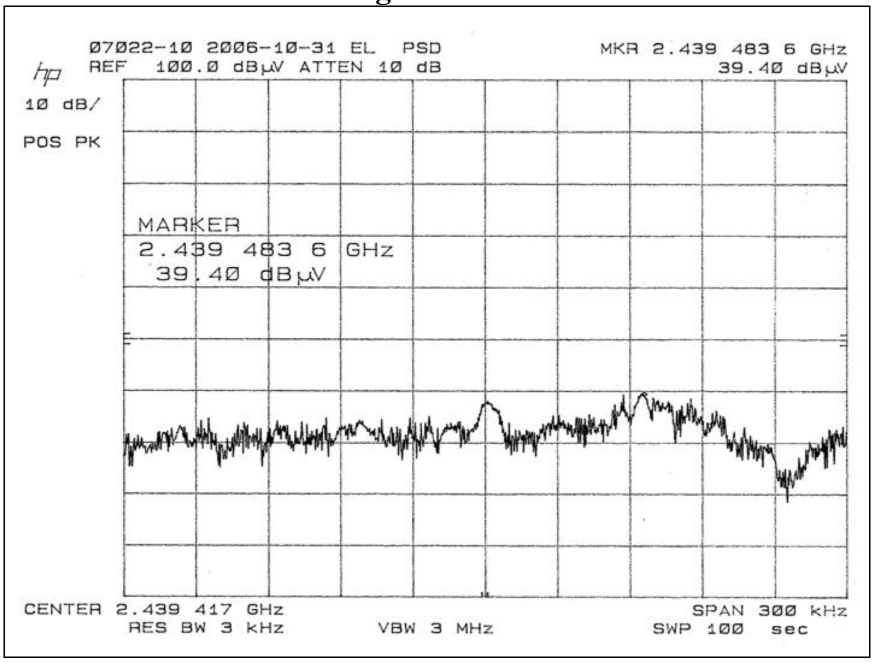
Low Channel



Mid Channel



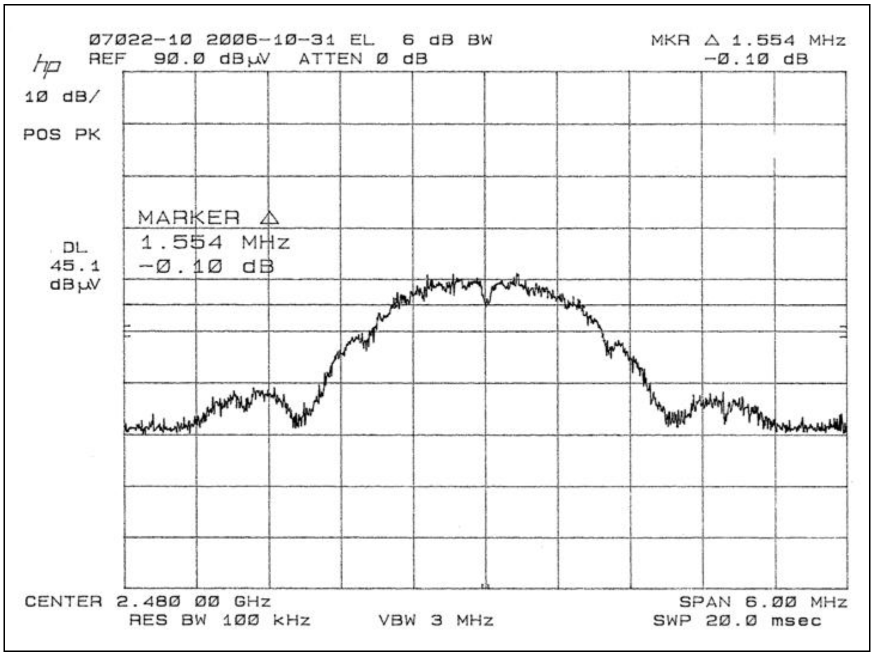
High Channel



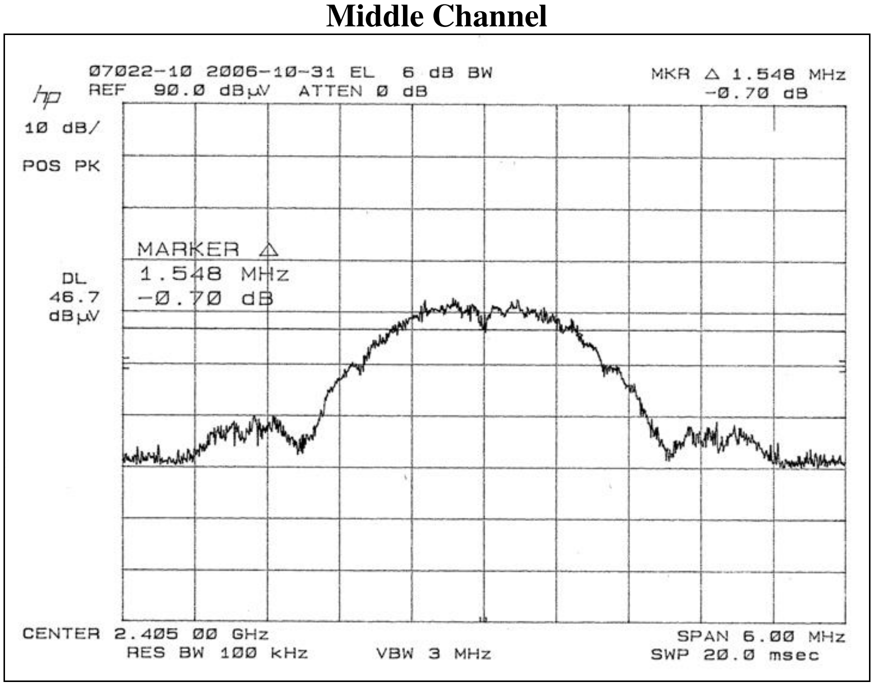
Occupied Bandwidth 6 dB
Freescale Semiconductor Model ZStar Triaxial Accelerometer
Peak Detection, RBW = 100 kHz

Test Date: October 31, 2006

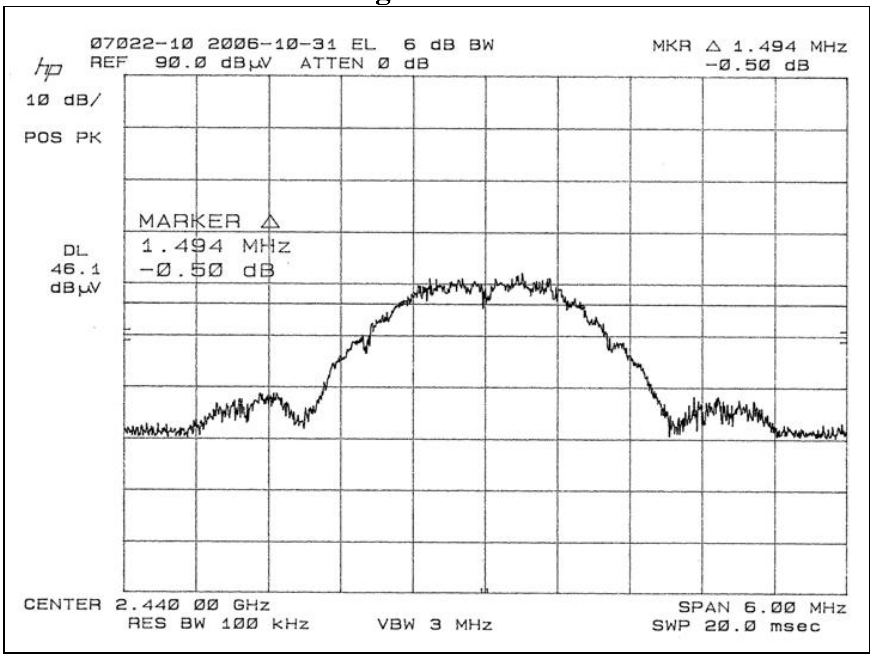
Low Channel



Middle Channel



High Channel

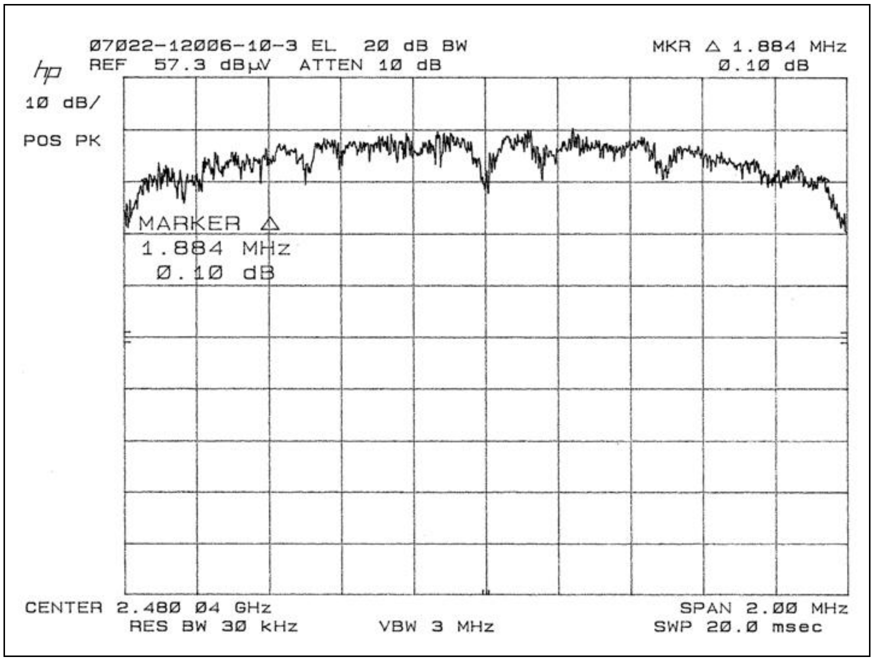


Test Engineer: Eric Lifsey

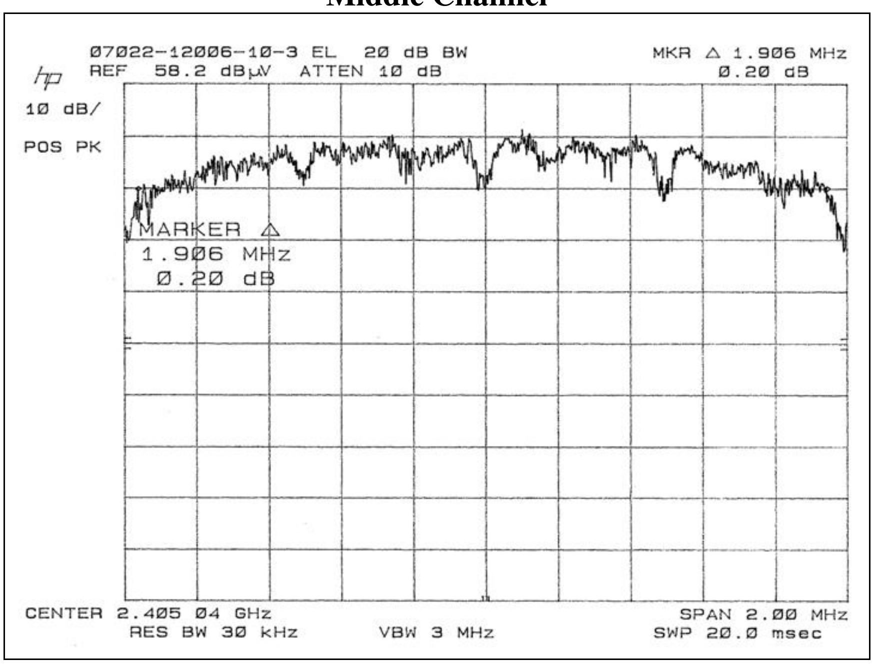
Occupied Bandwidth 20 dB
Freescale Semiconductor Model ZStar Triaxial Accelerometer
Peak Detection, RBW = 30 kHz
Reference Levels Based on 3 MHz RBW Peak Measurement

Test Date: October 31, 2006

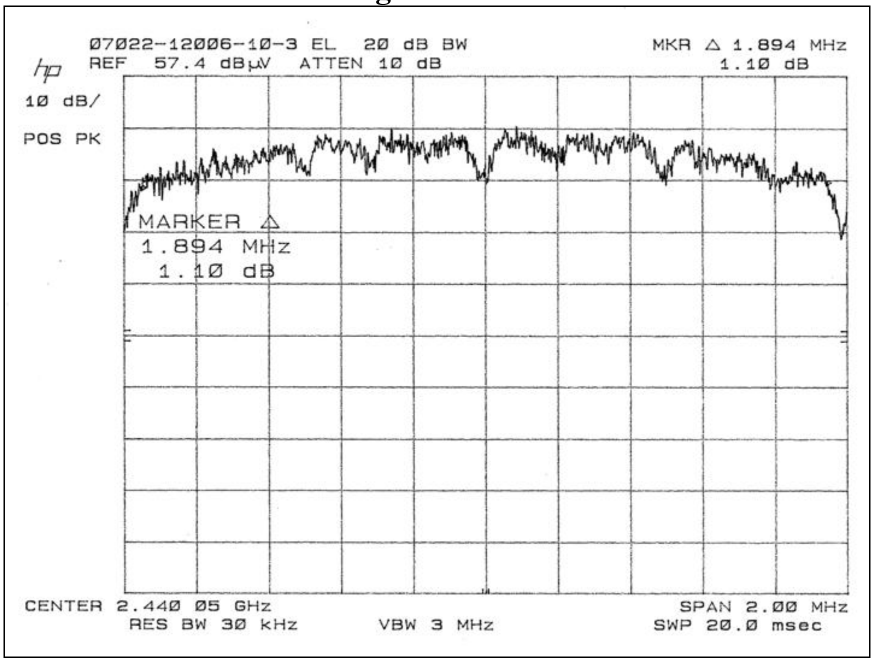
Low Channel



Middle Channel



High Channel

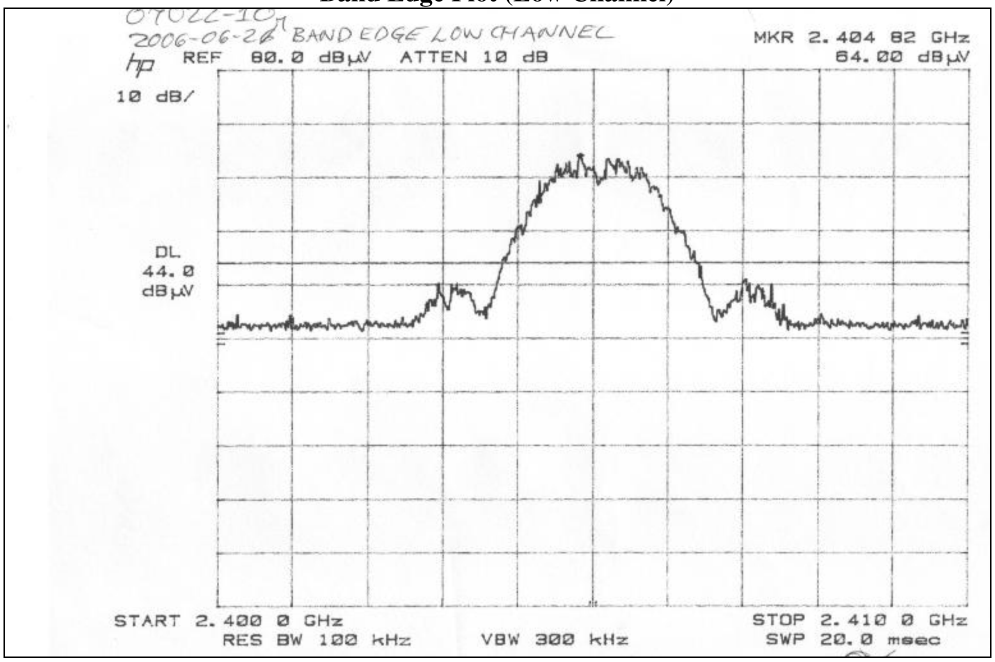


Band Edge Spurious Emissions
Freescale Semiconductor Model ZStar Triaxial Accelerometer
Peak Detection, RBW = 100 kHz

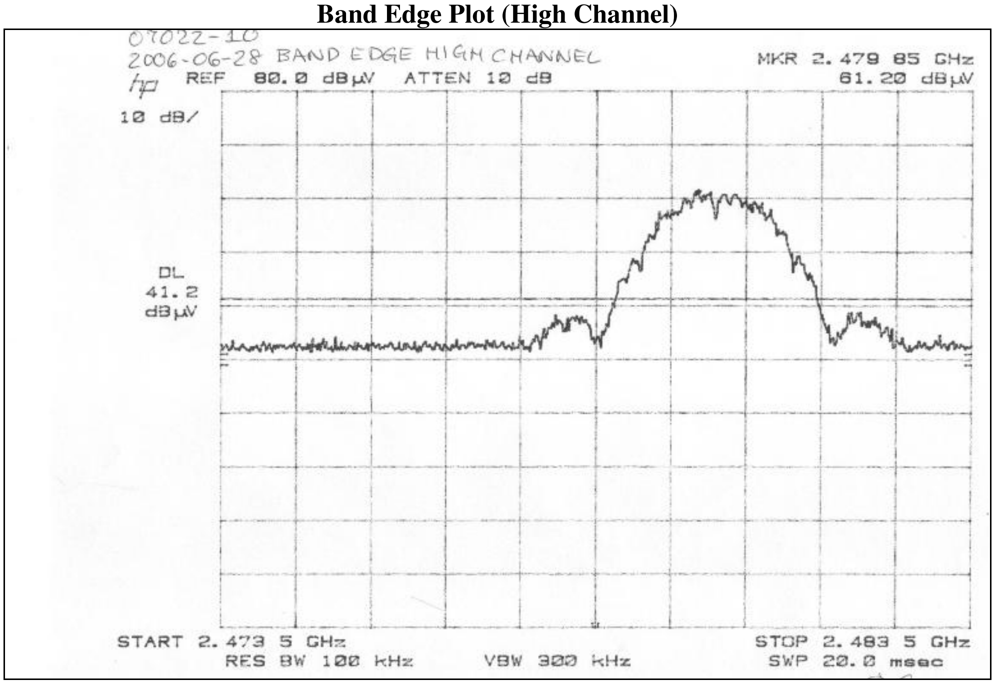
Test Date: June 27, 2006
Test Distance 1 meters

Please see Adjacent Restricted Bands tables for actual measurement of band edge levels.

Band Edge Plot (Low Channel)



Band Edge Plot (High Channel)



Spurious Radiated Emissions Data Sheet
Emissions 30 MHz … 1 GHz

PROJECT #	DATE	CLASS	DISTANCE	ANTENNA	RBW	VBW	DETECTOR
07022-10	14 Jul 2006	FCC B	3 m	Bicon | Log	CISPR 120 kHz	1 MHz	As Noted

COMMENT	Transmitting

Horizontal

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector
30	noise	floor	31.5	26.7	10.8	2.2	17.8	40	-22.2	pk
40	noise	floor	30.5	26.5	11.3	2.2	17.5	43.5	-26.0	pk
80	noise	floor	31	26.7	6.9	2.9	14.2	43.5	-29.3	pk
110	noise	floor	30.1	26.7	12.3	3.5	19.2	43.5	-24.3	pk
200	noise	floor	30.7	26.9	11.6	4.7	20.0	46	-26.0	pk
300	noise	floor	31.2	27.1	15.4	5.8	25.3	46	-20.7	pk

Vertical

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector
38	noise	floor	31	26.6	11.2	2.2	17.9	40	-22.1	pk
60	noise	floor	30.9	26.7	8.7	2.6	15.5	43.5	-28.0	pk
80	noise	floor	33.3	26.7	6.9	2.9	16.5	43.5	-27.0	pk
120	noise	floor	32.9	26.7	12.0	3.7	21.9	43.5	-21.6	pk
220	noise	floor	30.4	26.8	11.4	5.1	20.1	46	-25.9	pk
330	noise	floor	31	27.1	15.0	6.4	25.3	46	-20.7	pk

Test Engineer: Eric Lifsey

Spurious/Harmonic Emissions
1 GHz … 25 GHz

PROJECT #	DATE	CLASS	DISTANCE	ANTENNA	RBW	VBW	DETECTOR
07022-10	31 Oct 2006	FCC B	1 m	Horn	1 MHz	1 MHz	As Noted

COMMENT	Transmitting Low Channel Peak averaging factor -20 dB. Harmonics and spurious investigated up to 24050 MHz.

Horizontal

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Applied Duty Cycle Average	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector Function
4810	270	1	71.8	31.3	34.0	3.8	0.0	78.4	83.5	-5.1	pk
4810	270	1	71.8	31.3	34.0	3.8	20.0	58.4	63.5	-5.1	avg*
7215	180	1	72.3	31.0	36.7	4.4	0.0	82.5	83.5	-1.0	pk
7215	180	1	72.3	31.0	36.7	4.4	20.0	62.5	63.5	-1.0	avg*
9620	225	1	52.8	30.9	37.8	4.5	0.0	64.2	83.5	-19.3	pk
9620	225	1	52.8	30.9	37.8	4.5	20.0	44.2	63.5	-19.3	avg*
12025	noise	floor	47.5	30.4	39.1	5.0	0.0	61.2	83.5	-22.3	pk
12025	noise	floor	33.4	30.4	39.1	5.0	0.0	47.1	63.5	-16.4	avg
14430	noise	floor	51.9	29.6	41.2	4.8	0.0	68.3	83.5	-15.2	pk
14430	noise	floor	37.8	29.6	41.2	4.8	0.0	54.2	63.5	-9.3	avg
16835	noise	floor	51.2	31.5	41.4	5.1	0.0	66.3	83.5	-17.2	pk
16385	noise	floor	37.6	31.5	39.6	5.0	0.0	50.7	63.5	-12.8	avg

Vertical

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Applied Duty Cycle Average	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector Function
4810	270	1	67.1	31.3	34.0	3.8	0.0	73.7	83.5	-9.8	pk
4810	270	1	67.1	31.3	34.0	3.8	20.0	53.7	63.5	-9.8	avg*
7215	350	1	63.3	31.0	36.7	4.4	0.0	73.5	83.5	-10.0	pk
7215	350	1	63.3	31.0	36.7	4.4	20.0	53.5	63.5	-10.0	avg*
9620	270	1	49.7	30.9	37.8	4.5	0.0	61.1	83.5	-22.4	pk
9620	270	1	49.7	30.9	37.8	4.5	20.0	41.1	63.5	-22.4	avg*
12025	noise	floor	47.2	30.4	39.1	5.0	0.0	60.9	83.5	-22.6	pk
12025	noise	floor	33.4	30.4	39.1	5.0	0.0	47.1	63.5	-16.4	avg
14430	noise	floor	51.8	29.6	41.2	4.8	0.0	68.2	83.5	-15.3	pk
14430	noise	floor	38	29.6	41.2	4.8	0.0	54.4	63.5	-9.1	avg
16835	noise	floor	51.5	31.5	41.4	5.1	0.0	66.6	83.5	-16.9	pk
16835	noise	floor	38.4	31.5	41.4	5.1	0.0	53.5	63.5	-10.0	avg

Note: When applied (*), peak average was calculated using a peak to average correction factor based on transmitter duty cycle. This is calculated in the timing assessment.

Test Engineer: Eric Lifsey

Spurious/Harmonic Emissions
1 GHz … 25 GHz

PROJECT #	DATE	CLASS	DISTANCE	ANTENNA	RBW	VBW	DETECTOR
07022-10	31 Oct 2006	FCC B	1 m	Horn	1 MHz	1 MHz	As Noted

COMMENT	Transmitting Middle Channel Peak averaging factor -20 dB. Harmonics & spurious investigated up to 24400 MHz.

Horizontal

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Applied Duty Cycle Average	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector Function
4880	270	1	66.9	31.1	34.2	3.8	0.0	73.8	83.5	-9.7	pk
4880	270	1	66.9	31.1	34.2	3.8	20.0	53.8	63.5	-9.7	avg*
7320	270	1	70.7	30.9	36.9	4.4	0.0	81.1	83.5	-2.4	pk
7320	270	1	70.7	30.9	36.9	4.4	20.0	61.1	63.5	-2.4	avg*
9760	45	1	50.4	30.8	37.9	4.5	0.0	62.0	83.5	-21.5	pk
9760	45	1	50.4	30.8	37.9	4.5	20.0	42.0	63.5	-21.5	avg*
12200	noise	floor	47.3	30.4	39.4	5.0	0.0	61.2	83.5	-22.3	pk
12200	noise	floor	33.1	30.4	39.4	5.0	0.0	47.0	63.5	-16.5	avg
14640	noise	floor	51.6	29.3	40.5	4.8	0.0	67.6	83.5	-15.9	pk
14640	noise	floor	37.7	29.3	40.5	4.8	0.0	53.7	63.5	-9.8	avg
17080	noise	floor	50.6	31.3	42.7	5.2	0.0	67.2	83.5	-16.3	pk
17080	noise	floor	36.9	31.3	42.7	5.2	0.0	53.5	63.5	-10.0	avg

Vertical

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Applied Duty Cycle Average	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector Function
4880	270	1	59.3	31.1	34.2	3.8	0.0	66.2	83.5	-17.3	pk
4880	270	1	59.3	31.1	34.2	3.8	20.0	46.2	63.5	-17.3	avg*
7320	225	1	62.4	30.9	36.9	4.4	0.0	72.8	83.5	-10.7	pk
7320	225	1	62.4	30.9	36.9	4.4	20.0	52.8	63.5	-10.7	avg*
9760	90	1	48.9	30.8	37.9	4.5	0.0	60.5	83.5	-23.0	pk
9760	90	1	48.9	30.8	37.9	4.5	20.0	40.5	63.5	-23.0	avg*
12200	noise	floor	47.3	30.4	39.4	5.0	0.0	61.2	83.5	-22.3	pk
12200	noise	floor	33.1	30.4	39.4	5.0	0.0	47.0	63.5	-16.5	avg
14640	noise	floor	51.6	29.3	40.5	4.8	0.0	67.6	83.5	-15.9	pk
14640	noise	floor	37.7	29.3	40.5	4.8	0.0	53.7	63.5	-9.8	avg
17080	noise	floor	49.9	31.3	42.7	5.2	0.0	66.5	83.5	-17.0	pk
17080	noise	floor	37	31.3	42.7	5.2	0.0	53.6	63.5	-9.9	avg

Note: When applied (*), peak average was calculated using a peak to average correction factor based on transmitter duty cycle. This is calculated in the timing assessment.

Test Engineer: Eric Lifsey

Spurious/Harmonic Emissions
1 GHz … 25 GHz

PROJECT #	DATE	CLASS	DISTANCE	ANTENNA	RBW	VBW	DETECTOR
07022-10	31 Oct 2006	FCC B	1 m	Horn	1 MHz	1 MHz	As Noted

COMMENT	Transmitting High Channel Peak averaging factor -20 dB. Harmonics & spurious investigated up to 24800 MHz.

Horizontal

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Applied Duty Cycle Average	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector Function
4960	270	1	62.4	31.0	34.4	3.8	0.0	69.6	83.5	-13.9	pk
4960	270	1	62.4	31.0	34.4	3.8	20.0	49.6	63.5	-13.9	avg*
7440	270	1	67.2	30.9	37.1	4.4	0.0	77.8	83.5	-5.7	pk
7440	270	1	67.2	30.9	37.1	4.4	20.0	57.8	63.5	-5.7	avg*
9920	45	1	48.3	30.8	38.0	4.5	0.0	60.0	83.5	-23.5	pk
9920	45	1	48.3	30.8	38.0	4.5	20.0	40.0	63.5	-23.5	avg*
12400	noise	floor	45.9	30.5	39.7	4.9	0.0	60.0	83.5	-23.5	pk
12400	noise	floor	31.9	30.5	39.7	4.9	0.0	46.0	63.5	-17.5	avg
14880	noise	floor	49.9	29.4	39.4	4.9	0.0	64.8	83.5	-18.7	pk
14880	noise	floor	37.2	29.4	39.4	4.9	0.0	52.1	63.5	-11.4	avg
17360	noise	floor	50.4	31.5	44.6	5.0	0.0	68.5	83.5	-15.0	pk
17360	noise	floor	36.7	31.5	44.6	5.0	0.0	54.8	63.5	-8.7	avg

Vertical

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Applied Duty Cycle Average	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector Function
4960	135	1	56.7	31.0	34.4	3.8	0.0	63.9	83.5	-19.6	pk
4960	135	1	56.7	31.0	34.4	3.8	20.0	43.9	63.5	-19.6	avg*
7440	90	1	61.5	30.9	37.1	4.4	0.0	72.1	83.5	-11.4	pk
7440	90	1	61.5	30.9	37.1	4.4	20.0	52.1	63.5	-11.4	avg*
9920	350	1	49.3	30.8	38.0	4.5	0.0	61.0	83.5	-22.5	pk
9920	350	1	49.3	30.8	38.0	4.5	20.0	41.0	63.5	-22.5	avg*
12400	noise	floor	45.7	30.5	39.7	4.9	0.0	59.8	83.5	-23.7	pk
12400	noise	floor	31.8	30.5	39.7	4.9	0.0	45.9	63.5	-17.6	avg
14880	noise	floor	51	29.4	39.4	4.9	0.0	65.9	83.5	-17.6	pk
14880	noise	floor	37.3	29.4	39.4	4.9	0.0	52.2	63.5	-11.3	avg
17360	noise	floor	50.6	31.5	44.6	5.0	0.0	68.7	83.5	-14.8	pk
17360	noise	floor	36.7	31.5	44.6	5.0	0.0	54.8	63.5	-8.7	avg

Note: When applied (*), peak average was calculated using a peak to average correction factor based on transmitter duty cycle. This is calculated in the timing assessment.

Test Engineer: Eric Lifsey

Spurious/Harmonic Emissions
Adjacent Restricted Band (Lower)
2310 - 2390 MHz & 2390 - 2400 MHz

PROJECT #	DATE	CLASS	DISTANCE	ANTENNA	RBW	VBW	DETECTOR
07022-10	31 Oct 2006	FCC B	1 m	Horn	1 MHz	1 MHz	As Noted

COMMENT	Transmitting Low Channel

Horizontal

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector Function
2390	0	1	52.5	33.9	28.1	0.6	47.4	83.5	-36.1	pk
2390	0	1	33.4	33.9	28.1	0.6	28.3	63.5	-35.2	avg
2395	0	1	53.6	33.9	28.2	0.6	48.5	83.5	-35.0	pk
2395	0	1	33.5	33.9	28.2	0.6	28.4	63.5	-35.1	avg
2400	0	1	61.1	33.9	28.2	0.6	56.0	83.5	-27.5	pk
2400	0	1	34.2	33.9	28.2	0.6	29.1	63.5	-34.4	avg

Vertical

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector Function
2390	0	1	47.2	33.9	28.1	0.6	42.1	83.5	-41.4	pk
2390	0	1	33.5	33.9	28.1	0.6	28.4	63.5	-35.1	avg
2395	0	1	46.9	33.9	28.2	0.6	41.8	83.5	-41.7	pk
2395	0	1	33.3	33.9	28.2	0.6	28.2	63.5	-35.3	avg
2400	0	1	52.4	33.9	28.2	0.6	47.3	83.5	-36.2	pk
2400	0	1	33.4	33.9	28.2	0.6	28.3	63.5	-35.2	avg

Test Engineer: Eric Lifsey

Spurious/Harmonic Emissions
Adjacent Restricted Band (Upper)
2483.5 - 2500 MHz

PROJECT #	DATE	CLASS	DISTANCE	ANTENNA	RBW	VBW	DETECTOR
07022-10	31 Oct 2006	FCC B	1 m	Horn	1 MHz	1 MHz	As Noted

COMMENT	Transmitting High Channel

Horizontal

Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector Function
2483.5	0	1	63.9	33.8	28.3	0.6	59.0	83.5	-24.5	pk
2483.5	0	1	35.3	33.8	28.3	0.6	30.4	63.5	-33.1	avg
2485	225	1	60.1	33.8	28.3	0.6	55.2	83.5	-28.3	pk
2485	225	1	34.1	33.8	28.3	0.6	29.2	63.5	-34.3	avg
2491	225	1	56.3	33.8	28.3	0.6	51.4	83.5	-32.1	pk
2491	225	1	33.7	33.8	28.3	0.6	28.8	63.5	-34.7	avg
2498	0	1	50.7	33.8	28.3	0.6	45.8	83.5	-37.7	pk
2498	0	1	33.6	33.8	28.3	0.6	28.7	63.5	-34.8	avg

Vertical

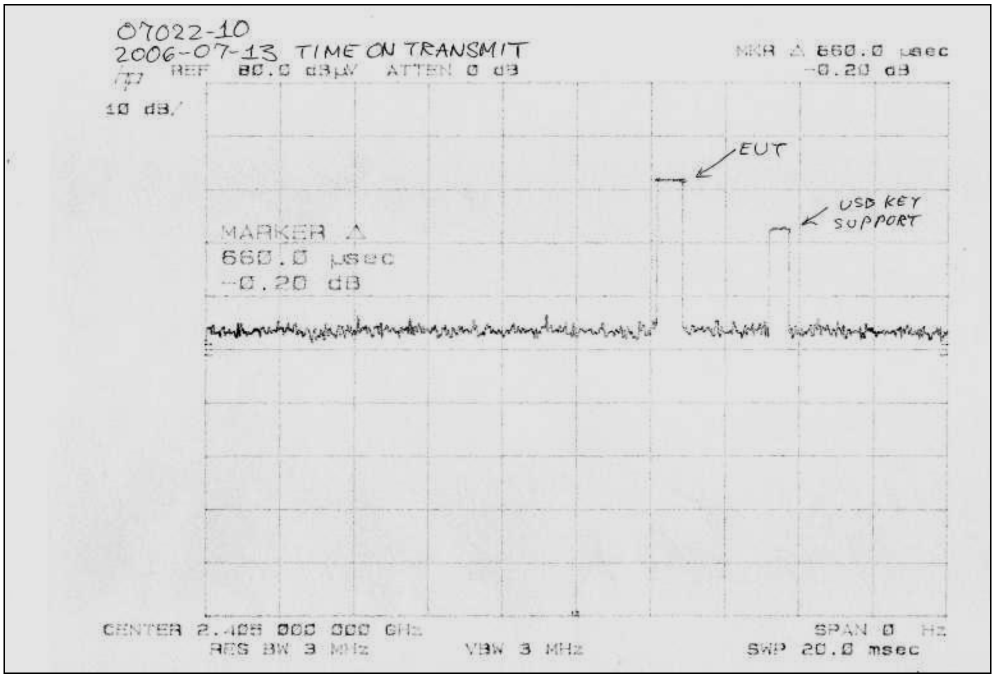
Frequency (MHz)	EUT Direction (degrees)	Antenna Elevation (Meters)	Recorded Level (dBµV)	Amplifier Gain (dB)	Antenna Factor (dB/m)	Cable Loss (dB)	Corrected Level (dBµV /m)	Limit (dBµV /m)	Margin (dB)	Detector Function
2483.5	0	1	48	33.8	28.3	0.6	43.1	83.5	-40.4	pk
2483.5	0	1	33.4	33.8	28.3	0.6	28.5	63.5	-35.0	avg
2485	135	1	46.9	33.8	28.3	0.6	42.0	83.5	-41.5	pk
2485	135	1	33.1	33.8	28.3	0.6	28.2	63.5	-35.3	avg
2493	270	1	47.2	33.8	28.3	0.6	42.3	83.5	-41.2	pk
2493	270	1	33.5	33.8	28.3	0.6	28.6	63.5	-34.9	avg
2499	0	1	47.8	33.8	28.3	0.6	42.9	83.5	-40.6	pk
2499	0	1	33.5	33.8	28.3	0.6	28.6	63.5	-34.9	avg

Test Engineer: Eric Lifsey

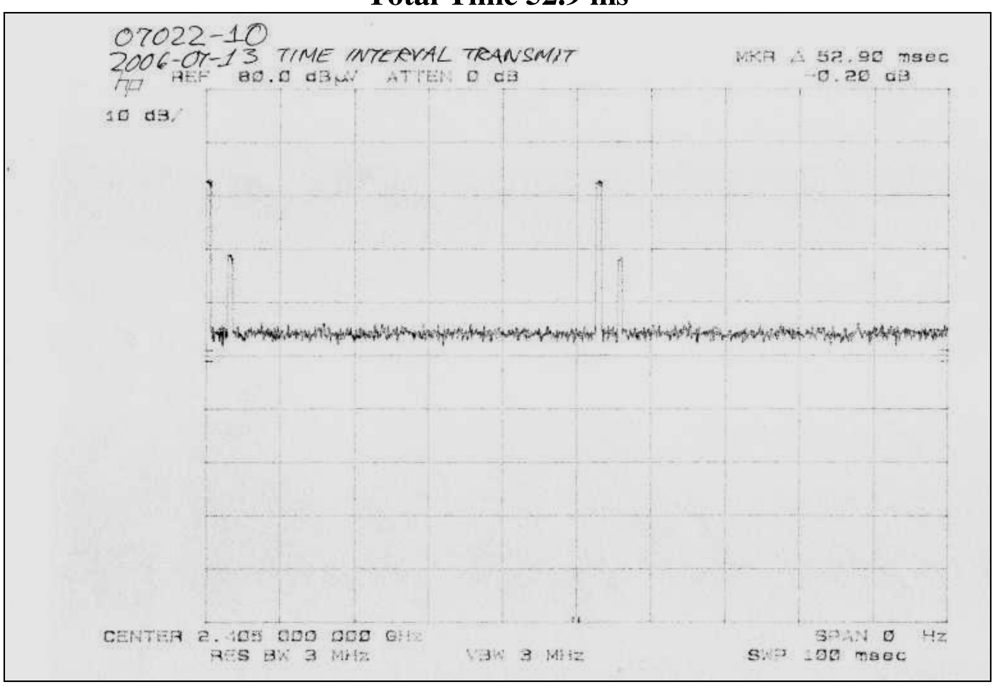
Timing Assessment
Freescale Semiconductor Model ZStar Triaxial Accelerometer
Peak Detection, RBW = 1 MHz

Test Date: July 13, 2006

Pulse Duration 0.860 ms



Total Time 52.9 ms



Test Engineer: Eric Lifsey

Timing Assessment
Freescale Semiconductor Model ZStar Triaxial Accelerometer
Calculations

Duty Cycle

$$DutyCycle = \frac{PulseDuration}{TotalTime}$$

$$DutyCycle = \frac{0.86mS}{52.9.9mS} = 1.6\%$$

Peak Averaging Correction Factor

$$CorrFact = 20 * \log(DutyCycle)$$

$$CorrFact = 20 * \log(0.016) = -35.9dB$$

(Maximum allowed is -20 dB.)

Allowed Duty Cycle Factor
-20 dB

Test Engineer: Eric Lifsey

Antenna Assessment

1. **The antenna is embedded permanently into the circuit board.**
2. **No connector is provided for an external antenna.**

Modification of the antenna is prevented by this design and it therefore satisfies the criteria.

Appendix C Policy, Rationale and Evaluation of EMC Measurement Uncertainty

All uncertainty calculations, estimates and expressions thereof shall be in accordance with NIST policy stated in Appendix E to NIST Technical Communications Program, Subchapter 4.09 of the Administrative Manual, as reproduced in Appendix C of NIST Technical Note (TN) 1297, 1994 Edition [1]1. The NIST policy is based on ISO Guide to the Expression of Uncertainty in Measurement [2] (herein after called the Guide), which shall take precedence in the event of disputes. The Guide is explained in TN 1297. Other notable explanations for the Guide are NAMAS Publications NIS 80 [3] and NIS 81 [4]; the latter being specifically for EMC measurements, and the easiest to understand. Since PTI operates in accordance with NIST (NVLAP) Handbook 150-11 [5], all instrumentation having an effect on the accuracy or validity of tests shall be periodically calibrated or verified traceable to national standards by a competent calibration laboratory. The certificates of calibration or verification on this instrumentation shall include estimates of uncertainty as required by NIST Handbook 150-11.

Rationale and Summary of Expanded Uncertainty

Each piece of instrumentation at PTI that is used in making measurements for determining conformance to a standard (or limit), shall be assessed to evaluate its contribution to the overall uncertainty of the measurement in which it is used. The assessment of each item will be based on either a type A evaluation or a type B evaluation. Most of the evaluations will be type B, since they will be based on the manufacture's statements or specifications of the calibration tolerances or uncertainty will be stated along with a brief rationale for the type of evaluation and the resulting state uncertainties.

The individual uncertainties included in the combined standard uncertainty for a specific test result will depend on the configuration in which the item of instrumentation is used. The combination will always be based on the law of propagation of uncertainty discussed in TN 1297, NIS 81, and the Guide. Any systematic effects will be accommodated by including their uncertainties, in the calculation of the combined standard uncertainty; except that if the direction and amount of the systematic effect cannot be determined and separated from its uncertainty, the whole effect will be treated as uncertainty and combined along with the other elements of the test setup.

Type A evaluations of standard uncertainty will usually be based on calculating the standard deviation of the mean of a series of independent observations, but may be based on a least-squares curve fit or the analysis of variance for unusual situations. Type B evaluations of standard uncertainty will usually be based on manufacturer's specifications, data provided in calibration reports, and experience. The type of probability distribution used (normal, rectangular, a-priori, or u-shaped) will be stated for each Type B evaluation.

[1] Numbers in square brackets identify documents listed in the reference section.

In the evaluation of the uncertainty of each type of measurement, the uncertainty caused by the operator will be estimated. One notable operator contribution to measurement uncertainty is the manipulation of cables to maximize the measured values of radiated emissions. The operator contribution to measurement uncertainty is evaluated by having several operators independently repeat the same test. This results in a Type A evaluation of operator-contributed measurement uncertainty.

A summary of the expanded uncertainties of PTI measurements if shown is Table 1. These are the worst-case uncertainties considering all operative influence factors.

Table 1-1
Summary of Measurement Uncertainties

Type of Measurement	Frequency Range	Meas. Dist.	Expanded Uncertainty U, dB (k=2)
Conducted Emissions	150 kHz to 30 MHz	N/A	2.9
Radiated Emissions, Site #1	30 to 200 MHz	3 m	4.7
		10 m	4.4
	200 to 1000 MHz	3 m	4.6
		10 m	4.0
	1 to 2.5 GHz	1 m	2.5
	2.5 to 12.5 GHz	1 m	3.6
	12.5 to 18 GHz	1 m	4.0
Radiated Emissions, Site #2	30 to 200 MHz	3 m	3.5
		10 m	3.7
	200 to 500 MHz	3 m	3.5
		10 m	3.1
	500 to 1000 MHz	3 m	4.0
		10 m	3.9
Radiated Emissions, Site #3	30 to 200 MHz	3 m	3.9
	200 to 500 MHz	3 m	4.0
	500 to 1000 MHz	3 m	4.3