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Measured Radio Frequency Emissions
From

XM Satellite Radio
915 MHz Receiver

Report No. 415031-493
May 26, 2009

For:
XM Satellite Radio
1500 Eckington PL NE
Concourse Level Washington, DC 20002

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Summary

Tests for compliance with FCC Regulations Part 15, Subpart C, and Industry Canada RSS-210/GEN, were performed on XM Satellite Radio Receiver. This device is subject to the Rules and Regulations as a Receiver.

In testing completed on March 10, 2009, the device tested in the worst case met the allowed FCC specifications for radiated emissions by 15.0 dB (see p. 6). Besides harmonics, there were no other significant spurious emissions found; emissions from digital circuitry were negligible. AC power line conducted emission tests were performed using a linear power supply, as the unit in question is powered by 5VDC supplied from an XM radio module.

1. Introduction

This XM Satellite Radio receiver was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989 as subsequently amended, and with Industry Canada RSS-210/Gen, Issue 7, June 2007. The tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-2003 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". Test site description and attenuation characteristics are on file with the FCC Laboratory, Columbia, Maryland (FCC Reg. No: 91050) and with Industry Canada, Ottawa, ON (File Ref. No: IC 2057A-1).

2. Test Procedure and Equipment Used

The pertinent test equipment commonly used in our facility for measurements is listed in Table 2.1 below. The middle column identifies the specific equipment used in these tests. The quality system employed at the University of Michigan Radiation Laboratory Willow Run Test Range has been established to ensure all equipment has a clearly identifiable classification, calibration expiry date, and that all calibrations are traceable to national standards.

Table 2.1 Test Equipment.

Test Instrument	Used	Manufacturer/Model	Q Number
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E, SN: 3412A01131	HP8593E1
Spectrum Analyzer (9kHz-6.5GHz)	X	Hewlett-Packard 8595E, SN: 3543A01546	JDB8595E
Power Meter		Hewlett-Packard, 432A	HP432A1
Harmonic Mixer (26-40 GHz)		Hewlett-Packard 11970A, SN: 3003A08327	HP11970A1
Harmonic Mixer (40-60 GHz)		Hewlett-Packard 11970U, SN: 2332A00500	HP11970U1
Harmonic Mixer (75-110 GHz)		Hewlett-Packard 11970W, SN: 2521A00179	HP11970W1
Harmonic Mixer (140-220 GHz)		Pacific Millimeter Prod., GMA, SN: 26	PMPGMA1
S-Band Std. Gain Horn		S/A, Model SGH-2.6	SBAND1
C-Band Std. Gain Horn		University of Michigan, NRL design	CBAND1
XN-Band Std. Gain Horn		University of Michigan, NRL design	XNBAND1
X-Band Std. Gain Horn		S/A, Model 12-8.2	XBAND1
X-band horn (8.2- 12.4 GHz)		Narda 640	XBAND2
X-band horn (8.2- 12.4 GHz)		Scientific Atlanta , 12-8.2, SN: 730	XBAND3
K-band horn (18-26.5 GHz)		FXR, Inc., K638KF	KBAND1
Ka-band horn (26.5-40 GHz)		FXR, Inc., U638A	KABAND1
U-band horn (40-60 GHz)		Custom Microwave, HO19	UBAND1
W-band horn(75-110 GHz)		Custom Microwave, HO10	WBAND1
G-band horn (140-220 GHz)		Custom Microwave, HO5R	GBAND1
Bicone Antenna (30-250 MHz)	X	University of Michigan, RLBC-1	LBBIC1
Bicone Antenna (200-1000 MHz)	X	University of Michigan, RLBC-2	HBBIC1
Dipole Antenna Set (30-1000 MHz)	X	University of Michigan, RLDP-1,-2,-3	UMDIP1
Dipole Antenna Set (30-1000 MHz)		EMCO 3121C, SN: 992 (Ref. Antennas)	EMDIP1
Active Rod Antenna (30 Hz-50 MHz)		EMCO 3301B, SN: 3223	EMROD1
Active Loop Antenna (30 Hz-50 MHz)		EMCO 6502, SN:2855	EMLOOP1
Ridge-horn Antenna (300-5000 MHz)	X	University of Michigan	UMRH1
Amplifier (5-1000 MHz)	X	Avantek, A11-1, A25-1S	AVAMP1
Amplifier (5-4500 MHz)	X	Avantek	AVAMP2
Amplifier (4.5-13 GHz)		Avantek, AFT-12665	AVAMP3
Amplifier (6-16 GHz)		Trek	TRAMP1
Amplifier (16-26 GHz)		Avantek	AVAMP4
LISN Box		University of Michigan	UMLISN1
Signal Generator	X	Hewlett-Packard 8657B	HPSG1
Linear Unfiltered Power Supply	X	Hydro Products	PSHP217

3. Configuration and Identification of Device Under Test

3.1 Identification of the DUT

The DUT was designed and manufactured by XM Satellite Radio, 1500 Eckington PL NE, Concourse Level, Washington, DC 20002.

Refer to separate Photo Exhibit file for this unit.

3.2 Variants
There is only one variant of this device. The DUT is a superheterodyne receiver / up-converter that translates received signal in the 902-928 MHz ISM band and outputs the up-converted spectrum at 2.3 GHz XM Radio SDARS band via a coaxial cable to a XM satellite receiver. It is housed in a plastic case approximately 0.5 by 5.25 by 1.25 inches in dimension. For testing, a bias-t was provided by the manufacturer to inject the 5 VDC supply onto the SDARS antenna jack. This module does not decode the received signal, and thus no other digital logic is used.

3.3 EMI/EMC Relevant Modifications
There were no modifications made to the DUT by this laboratory.

4. Emission Limits

The DUT tested falls under Part 15, Subpart B, "Unintentional Radiators". The pertinent test frequencies, with corresponding emission limits, are given in Tables 4.1 and 4.2 below.

4.1 Radiated Emission Limits

Table 4.1. Radiated Emission Limits (Ref: FCC 15.33, 15.35, and 15.109; IC RSS-210, 2.6 Table 2).

Freq. (MHz)	E_{lim} (3m) μV/m	E_{lim} (3m) dB(μV/m)
30-88	100	40.0
88-216	150 μV/m	43.5
216-960	200 μV/m	46.0
960-2000	500 μV/m	54.0

Note: Quasi-Peak readings apply to 1000 MHz (120 kHz BW)
Average readings apply above 1000 MHz (1 MHz BW)

4.2 Power Line Conducted Emission Limits

Table 4.3 Conducted Emission Limits (FCC:15.107 (CISPR); IC: RSS-Gen, 7.2.2 Table 2).

Frequency	Class A (dBμV)		Class B (dBμV)	
MHz	Quasi-peak	Average	Quasi-peak	Average
.150 - 0.50	79	66	66 - 56*	56 - 46*
0.50 – 5.0	73	60	56	46
5.0 – 30.0	73	60	60	50

Notes:
1. The lower limit shall apply at the transition frequency
2. The limit decreases linearly with the logarithm of the frequency in the range 0.15-0.50 MHz:

*Class B Quasi-peak: dBμV = 50.25 - 19.12*log(f)
*Class B Average: dBμV = 40.25 - 19.12*log(f)

3. 9 kHz RBW

4.3 Antenna Power Conduction Limits

Ref: FCC 15.111(a). Pmax = 2 nW; for frequency range see Table 4.1.

5. Emission Tests and Results

Even though the FCC and Industry Canada specify radiated and conductive emissions be measured using the Quasi-Peak and/or average detection schemes, we normally use peak detection since Quasi-Peak is cumbersome to use with our instrumentation. In case the measurement fails to meet the limits or the measurement is near the limit, it is re-measured using the appropriate detection scheme. Note, a peak detected signal is always greater than or equal to the Quasi-Peak or average detected signal. In this report the margin of compliance may be better, but not worse than that indicated. The type of detection used is indicated in the data table, Table 5.1.

5.1 Anechoic Chamber Radiated Emission Tests

To become familiar with the emission behavior of the DUT, the device was first studied and measured in a shielded semi-anechoic chamber. In the chamber is a set-up similar to that of an outdoor 3-meter site, with a turntable, antenna mast, and a ground plane. Instrumentation includes spectrum analyzers and other equipment as needed.

To study and test for radiated emissions, the DUT was powered by a laboratory power supply at 5 VDC. The receiver was activated, attached to a Styrofoam block, and placed on the test table on each of the three axis. A cw signal at the center of the operating band was radiated into the room. At each orientation, the table was rotated to obtain maximum signal for vertical and horizontal emission polarizations. This sequence was repeated throughout the required frequency range. In the chamber we studied and recorded all the emissions using a ridge-horn antenna, which covers 200 MHz to 5000 MHz, up to 2 GHz. In scanning from 30 MHz to 2.0 GHz, there were no spurious emissions observed. Detection of the LO required the addition of an LNA. Figures 5.1 and 5.2 show emissions measured 0-1000 MHz and 1000-2000 MHz, respectively. These measurements are made with a ridge-horn antenna at less than 3m distance, with spectrum analyzer in peak hold mode and the receiver rotated in all orientations (3 axes). The measurements up to 1000 MHz (Fig. 5.1) are used for initial evaluation only, while those above 1000 MHz (Fig. 5.2) are used in final assessment for compliance.

5.2 Open Area Test Site Radiated Emission Tests

After the chamber measurements are complete, emissions are re-measured on the outdoor 3-meter open area test site up to 1 GHz using tuned dipoles and/or a high frequency biconical antenna. The measurements were made with a spectrum analyzer using 120 kHz IF bandwidth and peak detection mode, and, when appropriate, using Quasi-Peak or average detection (see Section 5.0). Sometimes lower IF bandwidth is used to help bring signals out of noise and this is noted in the data table. The DUT is placed on the test table flat, on its side, and on its end (3 axes), and worst case emissions are recorded. Photographs included in this filing show the DUT on the OATS.

The emissions from digital circuitry were measured using a standard Bicone. These results are also presented in Table 5.1.

5.3 Computations and Results for Radiated Emissions
To convert the dBm's measured on the spectrum analyzer to dB(μV/m), we use expression

$$E_3(dB\mu V/m) = 107 + P_R + K_A - K_G$$

where P_R = power recorded on spectrum analyzer, dB, measured at 3m
K_A = antenna factor, dB/m
K_G = pre-amplifier gain, including cable loss, dB

When presenting the data, at each frequency the highest measured emission under all of the possible orientations is given. Computations and results are given in Table 5.1. There we see that the DUT meets the limit by 15.0 dB.

5.4 Conducted Emission Tests
The DUT is powered from 5 VDC injected into the output SDARS jack. For the purposes of our testing the device was powered by a laboratory power supply using a bias-t. AC power line conducted emissions are reported for this configuration in Table 5.2, demonstrating DUT compliance.

6. Other Measurements

6.1 Emission Spectrum
The only detectable RF emission occurs at the LO and its harmonics. The plot is shown in Figure 6.1.

6.2 Effect of Supply Voltage Variation
The DUT has been designed to operate from 5 VDC power. Using a spectrum analyzer, relative radiated emissions were recorded at the LO as voltage was varied from 3.0 to 7.0 VDC. Figure 6.2 shows the emission variation.

6.3 Operating Voltage and Current

V = 5 VDC
I = 42.0 mADC

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Table 5.1 Highest Radiated Emissions Measured

XM Receiver; FCC/IC B

#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBμV/m	E3lim dBμV/m	Pass dB	Comments
1	35.8	Bic	H	-73.6	Pk	11.7	24.9	20.2	40.0	19.8	background
2	35.8	Bic	V	-74.8	Pk	11.7	24.9	19.0	40.0	21.0	noise
3	52.8	Bic	H	-77.8	Pk	8.7	24.7	13.2	40.0	26.8	noise
4	52.8	Bic	V	-76.8	Pk	8.7	24.7	14.2	40.0	25.8	noise
5	65.3	Bic	H	-75.9	Pk	7.8	24.5	14.3	40.0	25.7	noise
6	65.3	Bic	V	-73.8	Pk	7.8	24.5	16.4	40.0	23.6	noise
7	74.0	Bic	H	-78.1	Pk	7.6	24.4	12.1	40.0	27.9	noise
8	74.0	Bic	V	-78.1	Pk	7.6	24.4	12.1	40.0	27.9	noise
9	86.1	Bic	H	-77.9	Pk	7.7	24.2	12.6	40.0	27.4	noise
10	86.1	Bic	V	-78.2	Pk	7.7	24.2	12.3	40.0	27.7	noise
11	123.2	Bic	H	-79.2	Pk	10.3	23.7	14.3	43.5	29.2	noise
12	123.2	Bic	V	-80.2	Pk	10.3	23.7	13.3	43.5	30.2	noise
13	168.7	Bic	H	-80.8	Pk	13.7	23.1	16.7	43.5	26.8	noise
14	168.7	Bic	V	-76.8	Pk	13.7	23.1	20.7	43.5	22.8	background
15	238.2	SBic	H	-77.6	Pk	15.0	22.2	22.1	46.0	23.9	background
16	238.2	SBic	V	-79.1	Pk	15.0	22.2	20.6	46.0	25.4	noise
17	265.5	SBic	H	-78.5	Pk	16.4	21.9	23.0	46.0	23.0	background
18	265.5	SBic	V	-79.8	Pk	16.4	21.9	21.7	46.0	24.3	noise
19	347.5	SBic	H	-80.7	Pk	19.6	21.0	25.0	46.0	21.0	noise
20	347.5	SBic	V	-77.9	Pk	19.6	21.0	27.8	46.0	18.2	background
21	501.5	SBic	H	-76.2	Pk	23.2	19.4	34.7	46.0	11.3	background
22	501.5	SBic	V	-80.3	Pk	23.2	19.4	30.6	46.0	15.4	noise
23											
24											
25											
26	1423.8	R-Horn	H/V	-69.0	Avg	21.1	28.0	31.1	54.0	22.9	LO
27	2847.5	R-Horn	H/V	-67.5	Avg	24.9	25.6	38.8	54.0	15.2	2 x LO
28	4271.3	R-Horn	H/V	-81.8	Avg	29.2	22.5	31.9	54.0	22.1	3 xLO
29	5695.0	C-Horn	H/V	-57.8	Avg	24.8	38.0	36.0	54.0	18.0	4 x LO
30	7118.8	Xn-Horn	H/V	-56.2	Avg	25.0	36.8	39.0	54.0	**15.0**	5 x LO
31											
32											
33	Note: Avg measured with 1 MHz RBW, 10 kHz VBW										
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Meas. 03/10/2009; U of Mich.

Table 5.2 Highest Conducted Emissions Measured

XM 915 MHz Receiver; FCC/CISPR B												
	Freq.	Line	Peak Det., dBµV		Pass	QP Det., dBµV		Pass	Ave. Det., dBµV		Pass	
#	MHz	Side	Vtest	Vlim*	dB*	Vtest	Vlim	dB	Vtest	Vlim	dB	Comments
1	0.16	Hi	47.2	55.5	8.3		65.6			55.5		
2	0.19	Hi	45.4	53.9	8.5		63.9			53.9		
3	0.18	Hi	44.7	54.3	9.6		64.4			54.3		
4	0.25	Hi	42.8	51.8	9.0		61.8			51.8		
5	0.28	Hi	42.0	50.7	8.7		60.7			50.7		
6	0.48	Hi	38.8	46.3	7.5		56.4			46.3		
7	0.31	Hi	42.1	49.9	7.8		60.0			49.9		
8	0.76	Hi	31.4	46.0	14.6		56.0			46.0		
9	1.58	Hi	30.6	46.0	15.4		56.0			46.0		
10	7.28	Hi	30.6	50.0	19.4		60.0			50.0		
11	3.68	Hi	30.5	46.0	15.5		56.0			46.0		
12	20.63	Hi	25.9	50.0	24.1		60.0			50.0		
13	27.08	Hi	25.5	50.0	24.5		60.0			50.0		
14												
15												
16	0.17	Lo	46.3	55.0	8.7		65.1			55.0		
17	0.18	Lo	44.7	54.5	9.8		64.6			54.5		
18	0.21	Lo	43.9	53.2	9.3		63.3			53.2		
19	0.25	Lo	42.5	51.8	9.3		61.8			51.8		
20	0.28	Lo	43.0	50.7	7.7		60.7			50.7		
21	0.33	Lo	39.6	49.5	9.9		59.5			49.5		
22	0.36	Lo	42.1	48.8	6.7		58.8			48.8		
23	0.38	Lo	42.8	48.2	5.4		58.3			48.2		
24	0.61	Lo	38.0	46.0	8.0		56.0			46.0		
25	0.83	Lo	32.9	46.0	13.1		56.0			46.0		
26	7.28	Lo	28.4	50.0	21.6		60.0			50.0		
27	3.68	Lo	28.1	46.0	17.9		56.0			46.0		
28	17.93	Lo	25.5	50.0	24.5		60.0			50.0		
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**Average limit*

Meas. 03/10/2009; U of Mich.

Since Vpeak >= Vqp >= Vave and if Vtestpeak < Vavelim, then Vqplim and Vavelim are met.

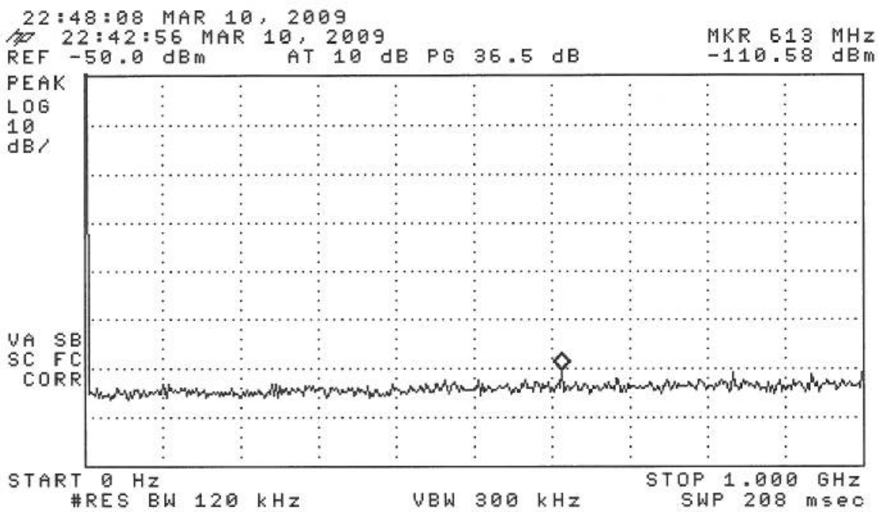

Figure 5.1. Emissions measured at 3 meters in chamber, 0-1000 MHz.

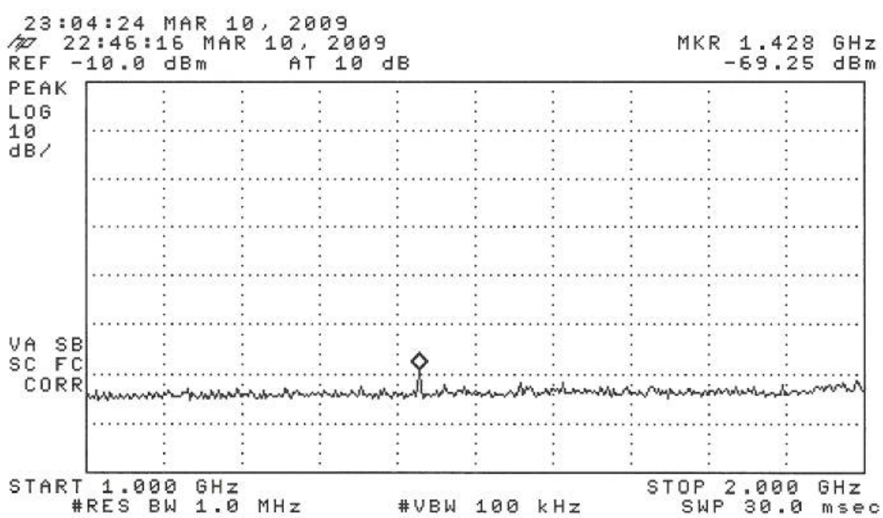

Figure 5.2. Emissions measured at 3 meters in chamber, 1000-2000 MHz.

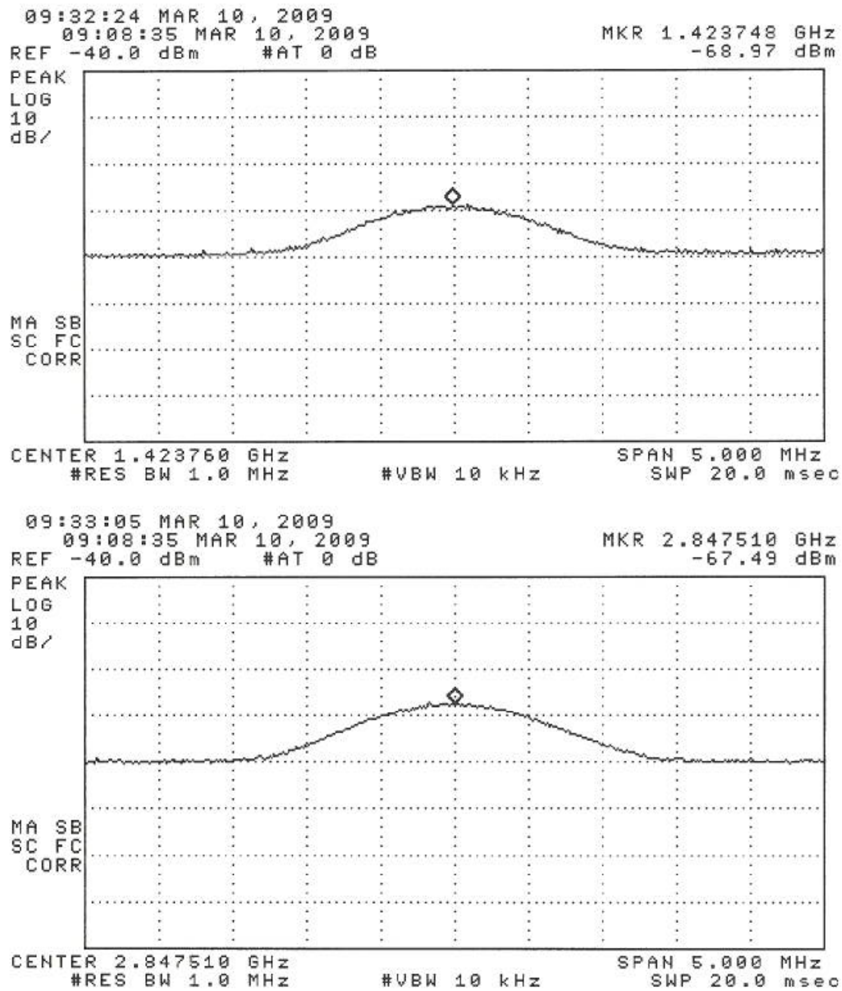

Figure 6.1. Relative receiver emissions. (top) LO, (bottom) 2 x LO.

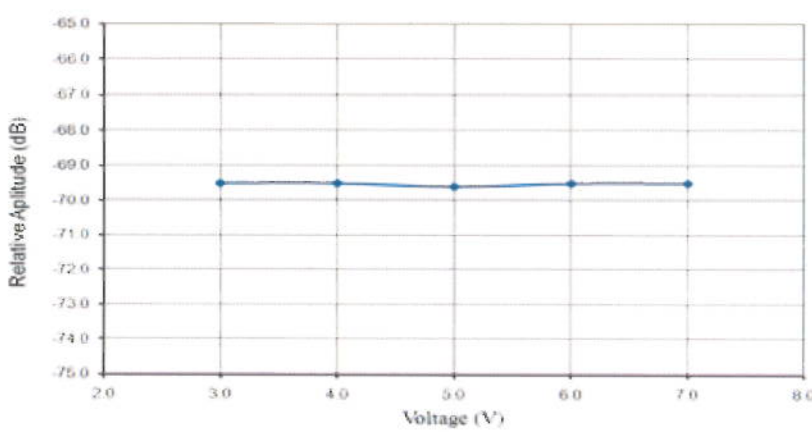

Figure 6.2. Relative LO emission vs. supply voltage.

Refer to separate Photo Exhibit file for this unit.