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Measured Radio Frequency Emissions
From

Lear Corporation Receiver
Model(s): L0101456 (Int. Ant.), L0111925 (Ext. Ant.)

Report No. 415031-276
February 10, 2006

For:
Lear Corporation
5200 Auto Club Dr.
Dearborn, MI 48126-9982

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Summary

Tests for compliance with FCC Regulations Part 15, Subpart B, and Industry Canada RSS-210/GEN, were performed on Lear Corporation models L0101456 and L0111925. This device is subject to the Rules and Regulations as a Receiver. As a Digital Device it is exempt, but such measurements were made to assess the receiver's overall emissions.

In testing completed on February 8, 2005, the device tested in the worst case met the allowed Class B specifications for radiated emissions by 10.9 dB (see p. 6). RF power conducted emissions met the allowed specifications by 53.3 dB (see p. 5). The power line conducted emissions tests do not apply, since the device is powered from a 12 V dc system.

1. Introduction

Lear Corporation models L0101456 and L0111925 was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 6 and RSS-Gen, Issue 1, September, 2005. 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". The Site description and attenuation characteristics of the Open Site facility are on file with FCC Laboratory, Columbia, Maryland (FCC Reg. No: 91050) and with Industry Canada, Ottawa, ON (File Ref. No: IC 2057).

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.

Table 2.1 Test Equipment.

Test Instrument	Eqpt. Used	Manufacturer/Model
Spectrum Analyzer (0.1-1500 MHz)		Hewlett-Packard, 182T/8558B
Spectrum Analyzer (9kHz-22GHz)	X	Hewlett-Packard 8593A SN: 3107A01358
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E, SN: 3412A01131
Spectrum Analyzer (9kHz-26GHz)		Hewlett-Packard 8563E, SN: 3310A01174
Spectrum Analyzer (9kHz-40GHz)		Hewlett-Packard 8564E, SN: 3745A01031
Power Meter		Hewlett-Packard, 432A
Power Meter		Anritsu, ML4803A/MP
Harmonic Mixer (26-40 GHz)		Hewlett-Packard 11970A, SN: 3003A08327
Harmonic Mixer (40-60 GHz)		Hewlett-Packard 11970U, SN: 2332A00500
Harmonic Mixer (75-110 GHz)		Hewlett-Packard 11970W, SN: 2521A00179
Harmonic Mixer (140-220 GHz)		Pacific Millimeter Prod., GMA, SN: 26
S-Band Std. Gain Horn		S/A, Model SGH-2.6
C-Band Std. Gain Horn		University of Michigan, NRL design
XN-Band Std. Gain Horn		University of Michigan, NRL design
X-Band Std. Gain Horn		S/A, Model 12-8.2
X-band horn (8.2- 12.4 GHz)		Narda 640
X-band horn (8.2- 12.4 GHz)		Scientific Atlanta , 12-8.2, SN: 730
K-band horn (18-26.5 GHz)		FXR, Inc., K638KF
Ka-band horn (26.5-40 GHz)		FXR, Inc., U638A
U-band horn (40-60 GHz)		Custom Microwave, HO19
W-band horn(75-110 GHz)		Custom Microwave, HO10
G-band horn (140-220 GHz)		Custom Microwave, HO5R
Bicone Antenna (30-250 MHz)	X	University of Michigan, RLBC-1
Bicone Antenna (200-1000 MHz)	X	University of Michigan, RLBC-2
Dipole Antenna Set (30-1000 MHz)	X	University of Michigan, RLDP-1,-2,-3
Dipole Antenna Set (30-1000 MHz)		EMCO 2131C, SN: 992
Active Rod Antenna (30 Hz-50 MHz)		EMCO 3301B, SN: 3223
Active Loop Antenna (30 Hz-50 MHz)		EMCO 6502, SN:2855
Ridge-horn Antenna (300-5000 MHz)	X	University of Michigan
Amplifier (5-1000 MHz)	X	Avantak, A11-1, A25-1S
Amplifier (5-4500 MHz)	X	Avantak
Amplifier (4.5-13 GHz)		Avantek, AFT-12665
Amplifier (6-16 GHz)		Trek
Amplifier (16-26 GHz)		Avantek
LISN Box		University of Michigan
Signal Generator	X	Hewlett-Packard 8657B

3. Configuration and Identification of Device Under Test

The DUT is a superheterodyne receiver designed for onboard automobile security/convenience applications, and as such, it is powered from an automotive 12 VDC source. It is housed in a plastic case approximately 2.5 by 2 by 1 inches. For testing, a generic harness was provided by the manufacturer. In the receiver digital section, the decoding, signal processing, etc. are performed by a microprocessor timed by an 8.0 MHz oscillator. The RF LO at 304.3 MHz references a 9.509 MHz crystal oscillator, and is mixed down from 2 x LO at 608.6 MHz on chip.

The DUT was designed by Lear Corporation, 5200 Auto Club Dr., Dearborn, MI 48126-9982. It is identified as:

Lear Corporation Receiver
Model(s): L0101456, L0111925
FCC ID: KOBGR07A
IC: 3521A-R07A

Two models were provided, one with internal antenna and one with external antenna connector. They differ only in minor matching circuitry, depopulation of the internal antenna, and population of an external antenna connector. Data for both devices is provided herein.

3.1 Modifications Made

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

NOTE: Even though the FCC and/or Industry Canada specify that both the 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 appropriate detection. We note that since the peak detected signal is always higher or equal to the Quasi-Peak or average detected signal, the margin of compliance may be better, but not worse, than indicated in this report. The type of detection used is indicated in the data table, Table 5.1.

5.1 Anechoic Chamber Radiated Emission Tests
To familiarize with the radiated emission behavior of the DUT, it was studied and measured in the shielded anechoic chamber. In the chamber there is a set-up similar to that of an outdoor 3-meter site, with 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 12 VDC. A MHz CW signal was injected (radiated) from a nearby signal generator using a short wire antenna. The DUT was taped to a Styrofoam block and placed on the test table on each of the three axis. 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 other than the LO and injection signal (MHz), and the LO harmonics. 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 3m, with spectrum analyzer in peak hold mode and the receiver rotated in all orientations. 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
The DUT was then moved to the 3 meter Open Area Test Site where measurements were repeated up to 1000 MHz using a small Bicone, or dipoles when the measurement is near the limit. The DUT was exercised as described in Sec. 5.1 above. 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 5.0). Sometimes lower IF bandwidth is used to help bring signals out of noise and this is noted in the data table. Photographs included in this filing show the DUT on the Open Area Test Site (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 10.9 dB.

5.4 Power Line Conducted Emission Tests
These tests do not apply, since the DUT is powered from an 12 VDC system.

6. Other Measurements

6.1 Emission Spectrum Near Fundamental
Near operating frequency the emission spectrum is measured typically over 50 MHz span with and without injection signal. These data are taken with the DUT close to antenna and hence amplitudes are relative. The plots are shown in Figure 6.1.

6.2 Effect of Supply Voltage Variation
The DUT has been designed to operate from 12 VDC power. Using a spectrum analyzer, relative radiated and conducted emissions were recorded at the 2xLO (608.6 MHz) as voltage was varied from 5.0 to 18.0 VDC. Figure 6.2 shows the emission variation.

6.3 Operating Voltage and Current

V = 12 V dc
I = 29 mA dc

6.4 Antenna RF Power Conducted Measurements
These measurements are made by connecting a spectrum analyzer directly to the DUT antenna connector and recording the LO, its harmonics, and any other spurious emissions. The following antenna conducted emissions were observed.

LO	304.29 MHz	-131.1 dBm	0.00000008 nW
2xLO	608.58 MHz	-119.7 dBm	0.00000125 nW
3xLO	912.87 MHz	-126.7 dBm	0.00000021 nW
4xLO	1217.16 MHz	-118.4 dBm	0.00000145 nW
5xLO	1521.45 MHz	-117.9 dBm	0.00000162 nW (noise)
6xLO	1825.74 MHz	-117.9 dBm	0.00000479 nW (noise)
		Total:	0.00000940 nW

This meets the 2 nW limit by 53.3 dB. See figure 6.1 for sample measurement.

Table 5.1 Highest Emissions Measured

Radiated Emission - RF											Lear RX; FCC/IC
#	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	304.3	Sbic	H	-81.7	Pk	18.6	22.8	21.1	46.0	24.9	max. of all, noise
2	304.3	Sbic	V	-82.3	Pk	18.6	22.8	20.5	46.0	25.5	max. of all, noise
3	608.6	Sbic	H	-83.0	Pk	24.9	19.9	29.0	46.0	17.0	max. of all, noise
4	608.6	Sbic	V	-83.5	Pk	24.9	19.9	28.5	46.0	17.5	max. of all, noise
5	912.9	Sbic	H	-83.1	Pk	28.6	17.9	34.6	46.0	11.4	max. of all, noise
6	912.9	Sbic	V	-82.6	Pk	28.6	17.9	35.1	46.0	**10.9**	max. of all, noise
7	1000.0	Horn	H	-71.5	Pk	20.6	28.0	28.1	54.0	25.9	max. of all, noise
8	1100.0	Horn	H	-72.3	Pk	21.0	28.1	27.6	54.0	26.4	max. of all, noise
9	1200.0	Horn	H	-72.0	Pk	21.3	28.3	28.0	54.0	26.0	max. of all, noise
10	1300.0	Horn	H	-70.1	Pk	21.4	28.2	30.1	54.0	23.9	max. of all, noise
11	1400.0	Horn	H	-68.7	Pk	21.8	27.9	32.2	54.0	21.8	max. of all, noise
12	1500.0	Horn	H	-68.9	Pk	22.2	28.2	32.1	54.0	21.9	max. of all, noise
13	1600.0	Horn	H	-68.7	Pk	22.4	28.3	32.4	54.0	21.6	max. of all, noise
14											
15											
16	* Both internal antenna and external antenna models tested										
17											
18											
19											
20											
21											
22	Digital emissions more than 20 dB below FCC/IC Class B Limit.										
23											
24											
25											
26											
27											

Conducted Emissions							
#	Freq. MHz	Line Side	Det. Used	Vtest dBµV	Vlim dBµV	Pass dB	Comments
	Not applicable						

Meas. 01/23/2006; U of Mich.

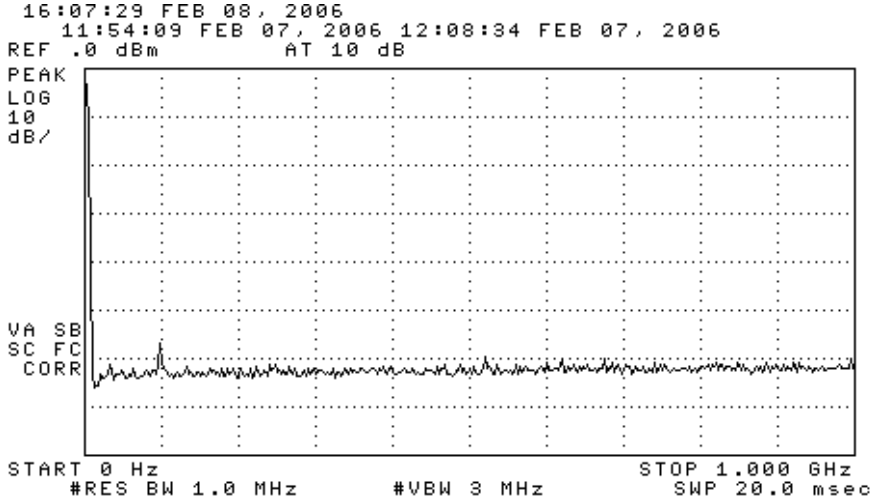


Figure 5.1. Emissions measured at 3 meters in chamber, 0-1000 MHz.

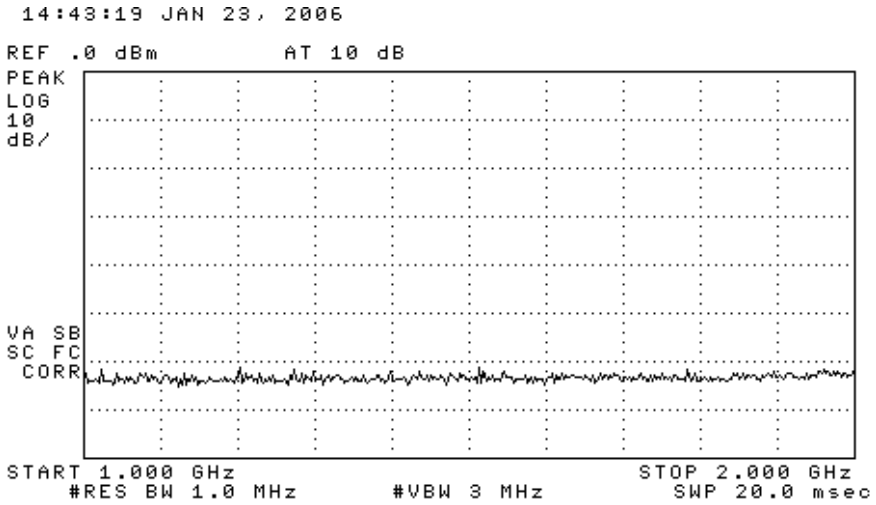


Figure 5.2. Emissions measured at 3 meters in chamber, 1000-2000 MHz.

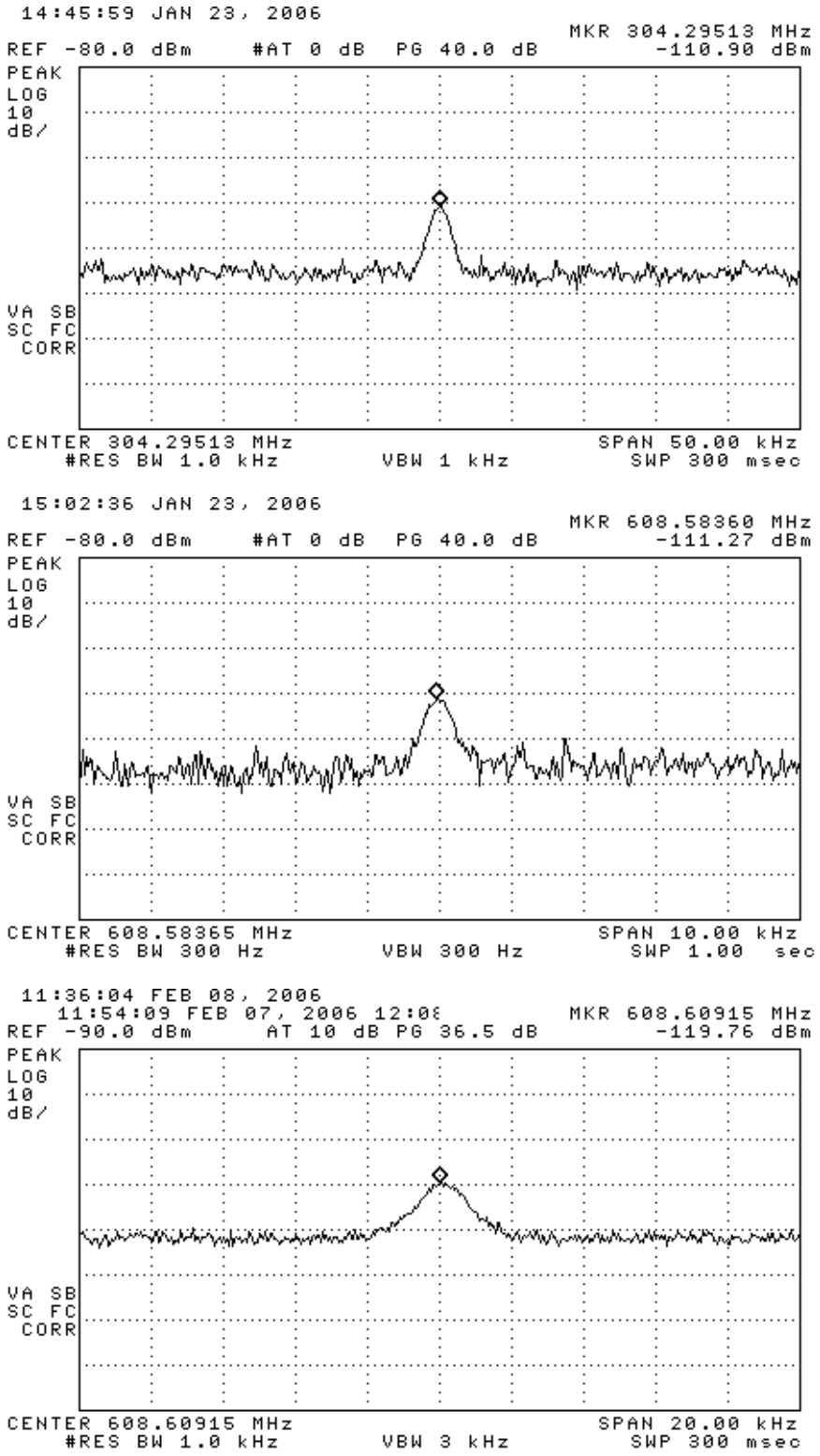


Figure 6.1. Relative receiver emissions, Radiated and Conducted.
(top) radiated, (middle) radiated, (bottom) conducted

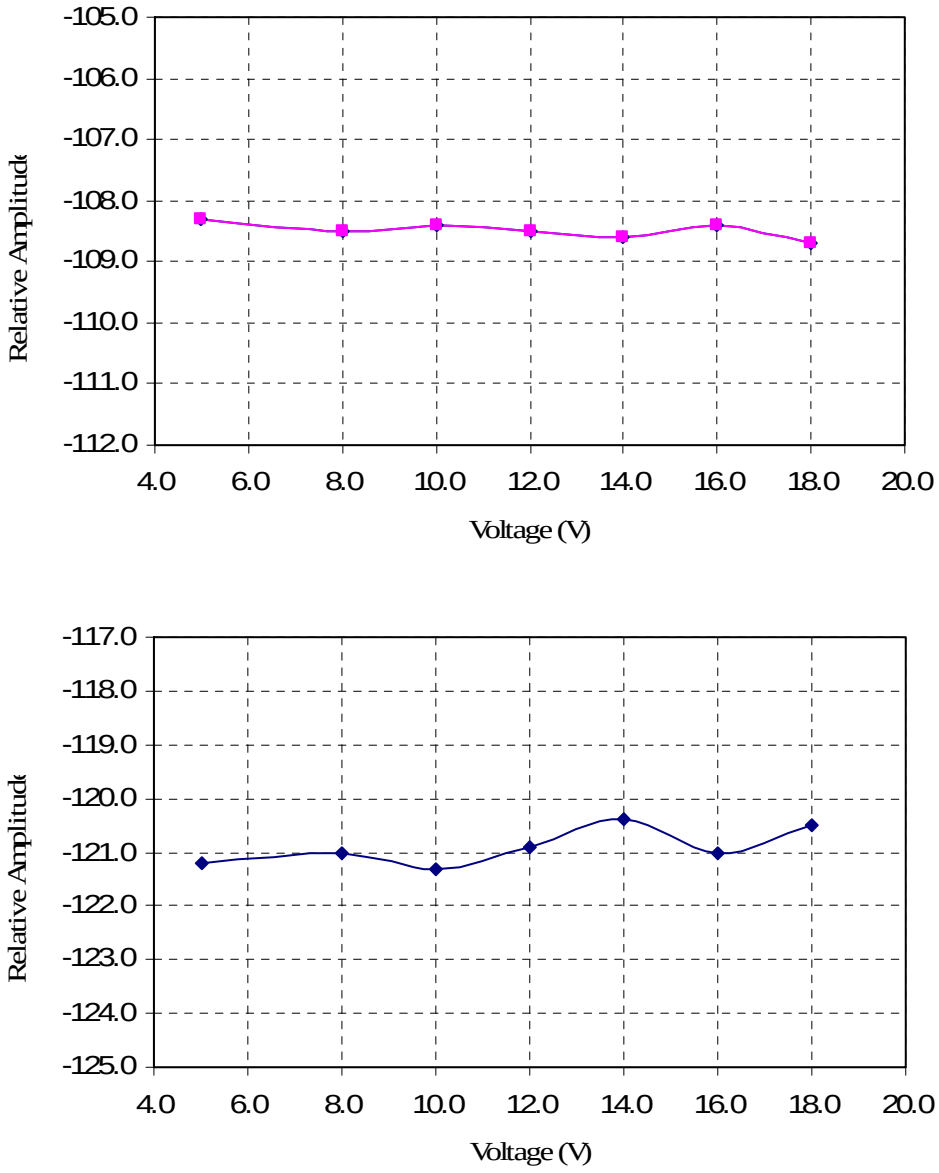
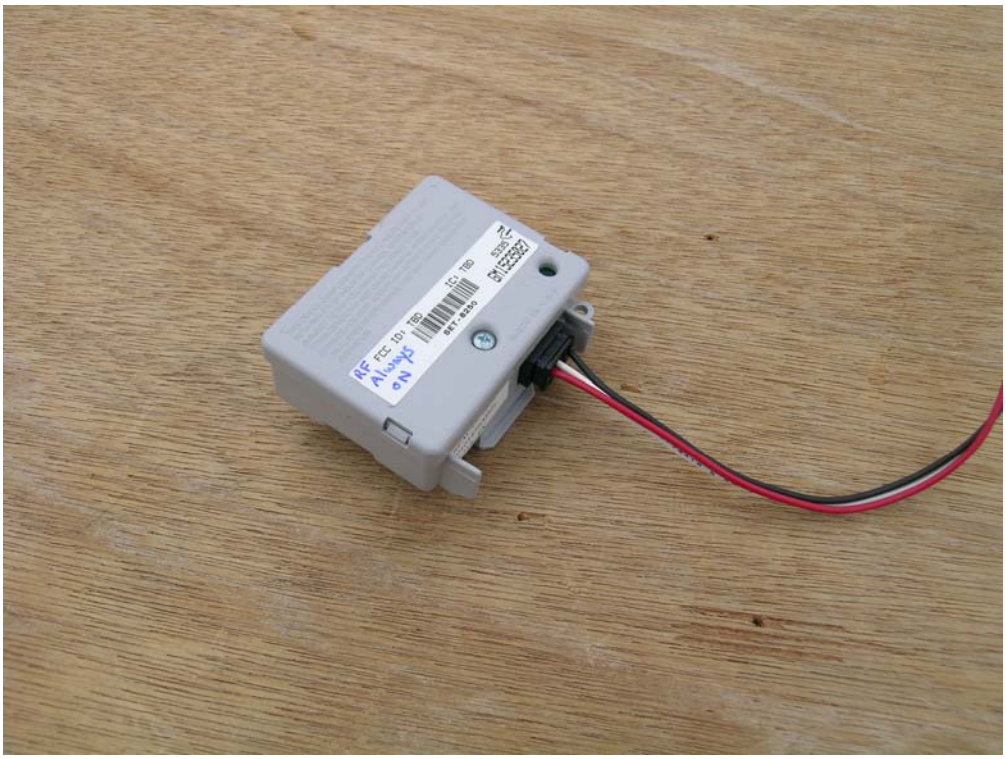


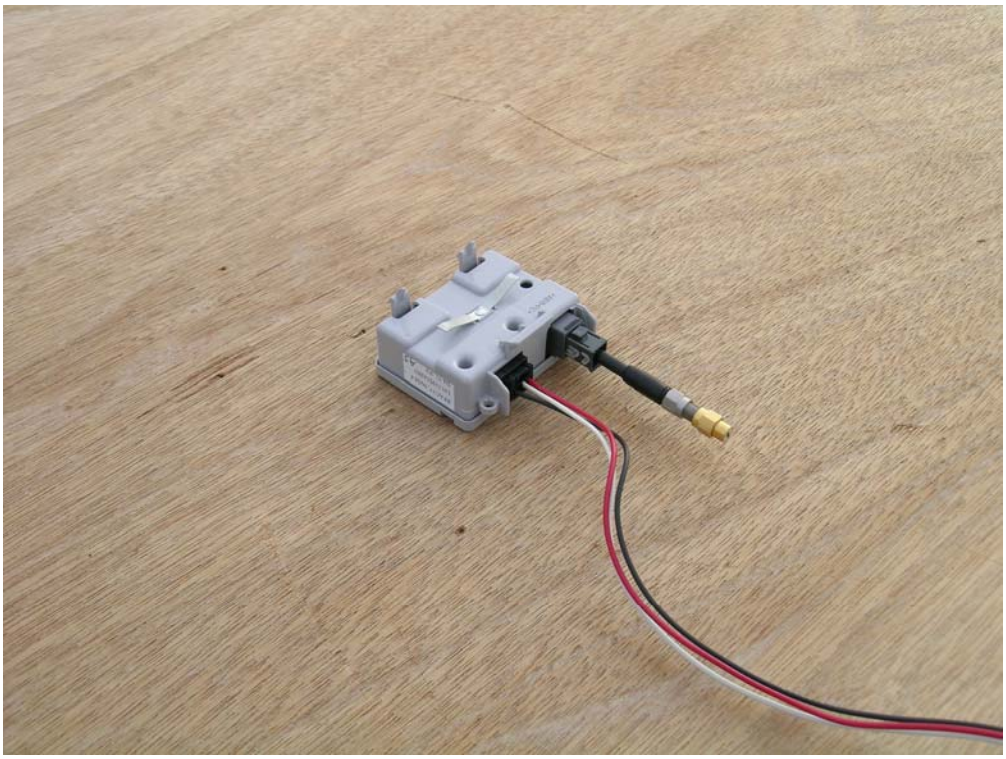
Figure 6.2. Relative emission at vs. supply voltage.
(top) Radiated, (bottom) Conducted

DUT on OATS



DUT on OATS (close-up)

DUT on OATS



DUT on OATS (close-up) – 50 Ohm Load on Ext. Antenna Connector.