



The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
Tel: (734) 764-0500

Measured Radio Frequency Emissions
From

**Lear Receiver
Model RFA-X**

Report No. 415031-234
March 25, 2005

Copyright © 2005

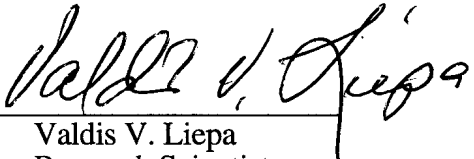
For:
Lear Corporation
5200 Auto Club Drive
Dearborn, Michigan 48126-9982

Contact:
John Nantz
e-mail: jnantz@lear.com
Tel: 313-240-3068
Fax: 313-240-3062
PO: 100833 (UPG)

Measurements made by:

Valdis V. Liepa

Tests supervised by:
Report approved by:


Valdis V. Liepa
Research Scientist

Summary

Tests for compliance with FCC Regulations Part 15, Subpart B, and with Industry Canada Regulations, RSS-210, were performed on Lear 315 MHz Receiver. The 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 performed March 16 through 18, 2005, the device tested in the worst case met specifications for radiated emissions by 14.5 dB (see p. 6). Since the device is powered from an automotive 12-volt system, the line conductive regulation tests do not apply.

1. Introduction

Lear RKE receiver, Model RFA-X, was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 5, dated November 1, 2001. The tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-2002 "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.

<u>Test Instrument</u>	<u>Eqpt Used</u>	<u>Manufacturer/Model</u>
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)		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)		University of Michigan
Amplifier (5-1000 MHz)	X	Avantek, A11-1, A25-1S
Amplifier (5-4500 MHz)	X	Avantek
Amplifier (4.5-13 GHz)		Avantek, AFT-12665
Amplifier (6-16 GHz)		Trek
Amplifier (16-26 GHz)		Avantek
LISN (50 μ H)		University of Michigan
Signal Generator (0.1-2060 MHz)	X	Hewlett-Packard, 8657B
Signal Generator (0.01-20 GHz)		Hewlett-Packard

3. Configuration and Identification of Device Under Test

The DUT is a 315.0 MHz superregenerative receiver, designed for onboard automobile security/convenience applications and, as such, it is powered from an automobile 12 VDC source. The receiver is housed in a small plastic case approximately 3 x 2 x 0.75 inches, having one multi-pin connector for power input and digital signal output. The antenna is internal. For testing, a "generic" harness was made up, one bundle containing a pair of power-up wires and another wire for digital (serial) output. The length of the harness was about 2.0 m and the ends of signal wires were left open. In the receiver, decoding, signal processing, etc., are performed by a micro, timed by a 4.19 MHz oscillator.

The DUT was designed and manufactured by Lear Corporation, 5200 Auto Club Drive, Dearborn, MI 48126. It is identified as:

Lear RKE Receiver
Model: RFA-X
SN: R1428 4093A
FCC ID: KOBUT1XR
IC: 1983 102 283A

3.1 Modifications Made

There were no modifications made to the DUT by this laboratory.

4. Emission Limits

For FCC the DUT falls under Part 15, Subpart B, "Unintentional Radiators". For Industry Canada the DUT falls under Receiver category and is subject to technical requirement of sections 7.1 to 7.4 in RSS-210. The pertinent test frequencies, with corresponding emission limits, are given in below.

4.1 Radiated Emission Limits

Table 4.1. Radiated Emission Limits (FCC: 15.33, 15.35, 15.109; IC: RSS-210, 7.3).

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

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

4.2 Antenna Power Conduction Limits

P_{max} = 2 nW; for frequency range see Table 4.1. (FCC: 15.111(a); IC: RSS-210, 7.2).

4.3 Conducted Emission Limits

Table 4.2. Conducted Emission Limits (FCC:15.107 (CISPR)).

Frequency MHz	Class A (dBμV)		Class B (dBμV)	
	Quasi-peak	Average	Quasi-peak	Average
.150 - 0.50	79	66	66 - 56*	56 - 46*
0.50 - 5	73	60	56	46
5 - 30	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 QP: $\text{dB}\mu\text{V} = 50.25 - 19.12 \cdot \log(f)$ *Class B Ave: $\text{dB}\mu\text{V} = 40.25 - 19.12 \cdot \log(f)$
3. 9 kHz RBW

5. Emission Tests and Results

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. A 315 MHz CW signal was injected (radiated) from a nearby signal generator using a short wire antenna. The DUT was placed on the test table on each of its three axis. For each placement, 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, the injection signal, 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, but those above 1000 MHz (Fig. 5.2) are used in final assessment for the compliance.

5.2 Open Site Radiated Emission Tests

The DUT was then moved to the 3-meter Open Field 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. When emissions are narrow band, as in a case of an LO, measurements may be made with a reduced RBW to help discriminate the emissions from ambient signals and noise. Test set-up photographs are in the Appendix (i.e., at end of this report).

The emissions from digital circuitry were measured using a standard bicone. These results are noted in Table 5.1.

5.3 Computations and Results for Radiated Emissions

To convert the dBm's measured on the spectrum analyzer to dB(μ V/m), we use the expression

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

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 more than 14.5 dB.

5.4 Conducted Emission Tests

These tests do not apply, since the DUT is powered from a 12-volt automotive 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 emissions were recorded at the "fundamental" (316 MHz) as voltage was varied from 5.5 to 18.0 VDC. Figure 6.2 shows the emission variation.

6.3 Operating Voltage and Current

V = 12.3 VDC
I = 2.0 mADC

The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, Michigan 48109-2122
(734) 764-0500

Table 5.1 Highest Emissions Measured

Radiated Emission - RF											Lear Regen 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	315.7	Sbic	H	-81.7	Pk	18.9	20.0	24.2	46.0	21.8	flat
2	315.7	Sbic	H	-81.5	Pk	18.9	21.9	22.5	46.0	23.5	end
3	315.7	Sbic	V	-88.5	Pk	18.9	21.9	15.5	46.0	30.5	side
4	315.7	Sbic	V	-88.1	Pk	18.9	21.9	15.9	46.0	30.1	end
5	630.0	Sbic	H	-88.7	Pk	18.9	20.1	17.1	46.0	28.9	side
6	630.0	Sbic	V	-87.8	Pk	18.9	20.1	18.0	46.0	28.0	end
7	945.0	Sbic	H	-87.1	Pk	29.5	17.9	31.5	46.0	14.5	flat
8	945.0	Sbic	V	-87.8	Pk	29.5	17.9	30.8	46.0	15.2	side
9	1280.0	Horn	H	-71.0	Pk	20.6	28.0	36.6	54.0	17.4	max. of all, noise
10	1320.0	Horn	H	-69.0	Pk	21.0	28.1	37.4	54.0	16.6	max. of all, noise
11	1520.0	Horn	H	-70.0	Pk	21.3	28.3	37.0	54.0	17.0	max. of all, noise
12	1610.0	Horn	H	-69.0	Pk	21.4	28.2	37.2	54.0	16.8	max. of all, noise
13	1780.0	Horn	H	-71.0	Pk	21.8	27.9	38.9	54.0	15.1	max. of all, noise
14	1850.0	Horn	H	-71.0	Pk	22.2	28.2	39.0	54.0	15.0	max. of all, noise
15	1950.0	Horn	H	-70.0	Pk	22.4	28.3	38.1	54.0	15.9	max. of all, noise
16											
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

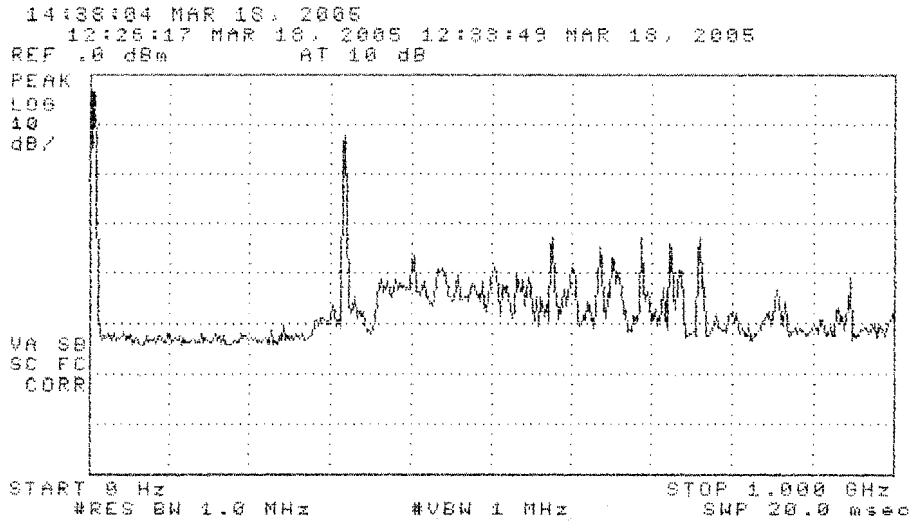
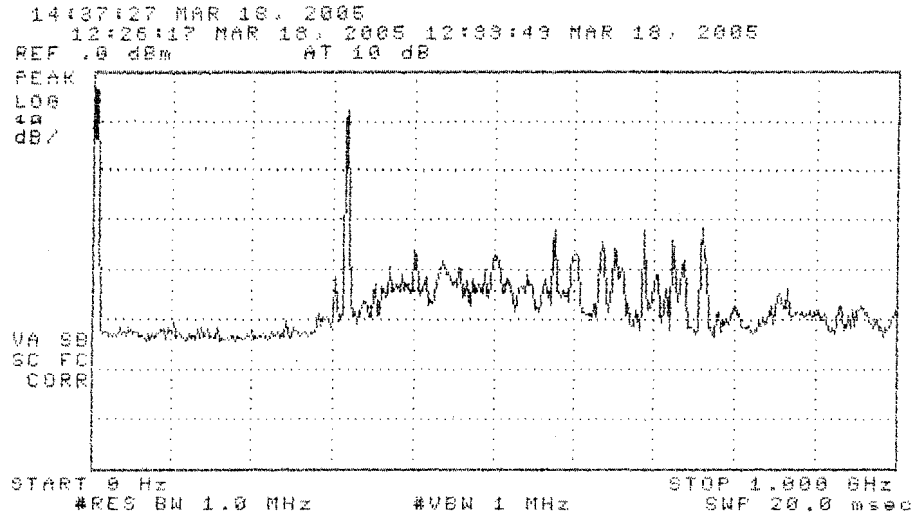


Figure 5.1. Emissions measured at 3 meters in anechoic chamber, 0-1000 MHz.
 (top) Receiver plus ambient
 (bottom) Ambient

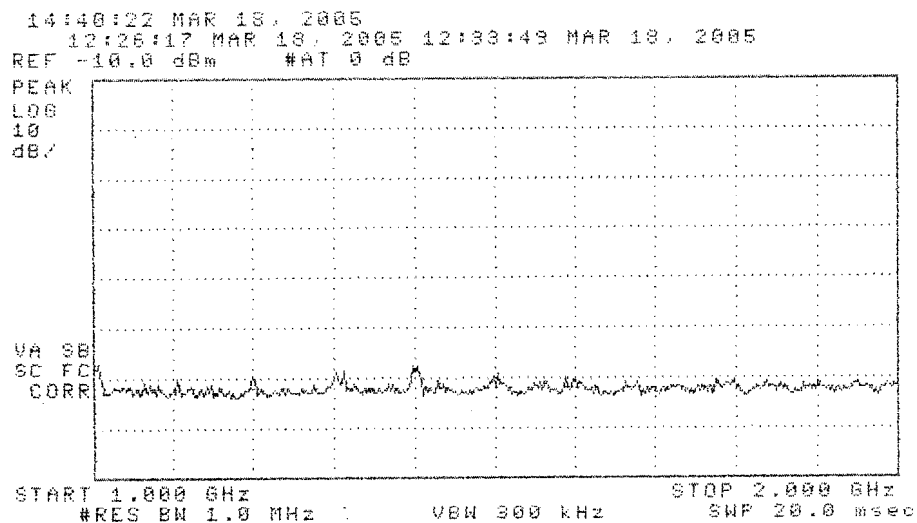
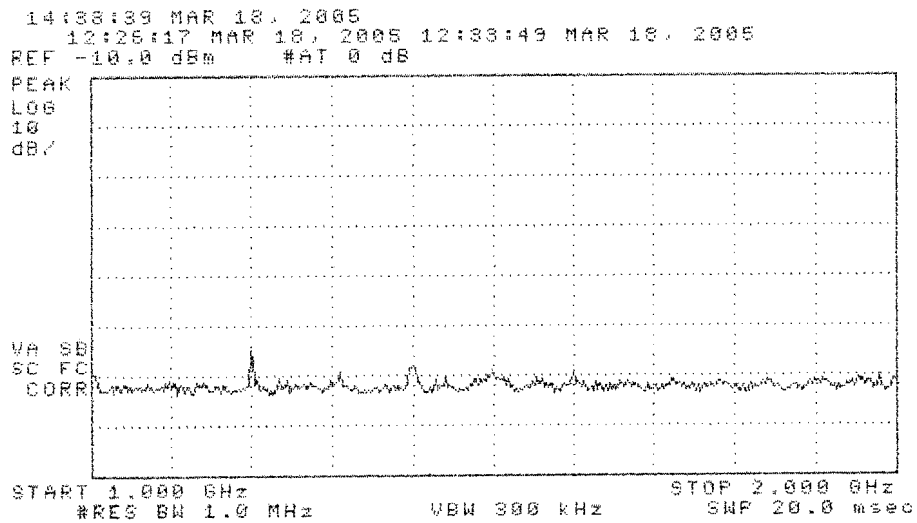


Figure 5.2. Emissions measured at 3 meters in anechoic chamber, 1000-2000 MHz.
 (top) Receiver plus ambient
 (bottom) Ambient

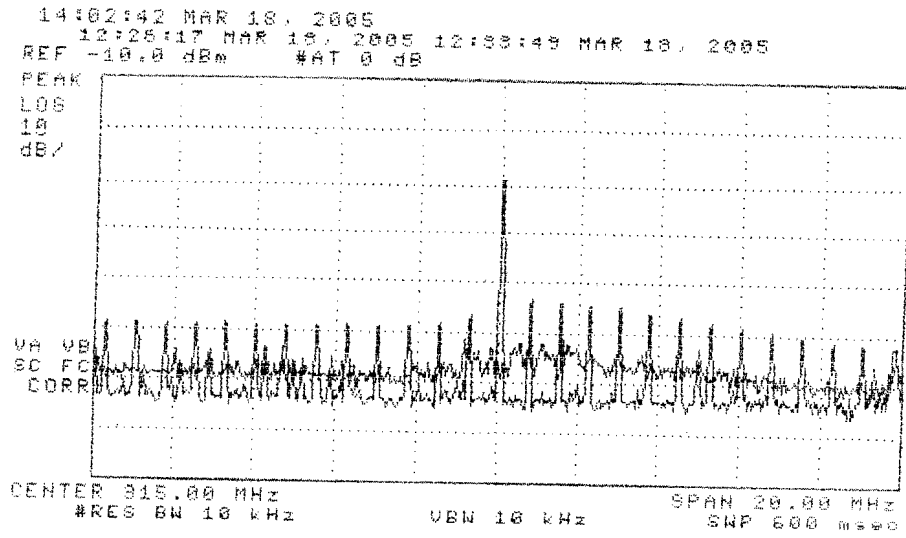


Figure 6.1. Relative receiver emissions in stand-by and "locked-in" modes. The final emission measurements were made with the receiver in "locked-in" mode.

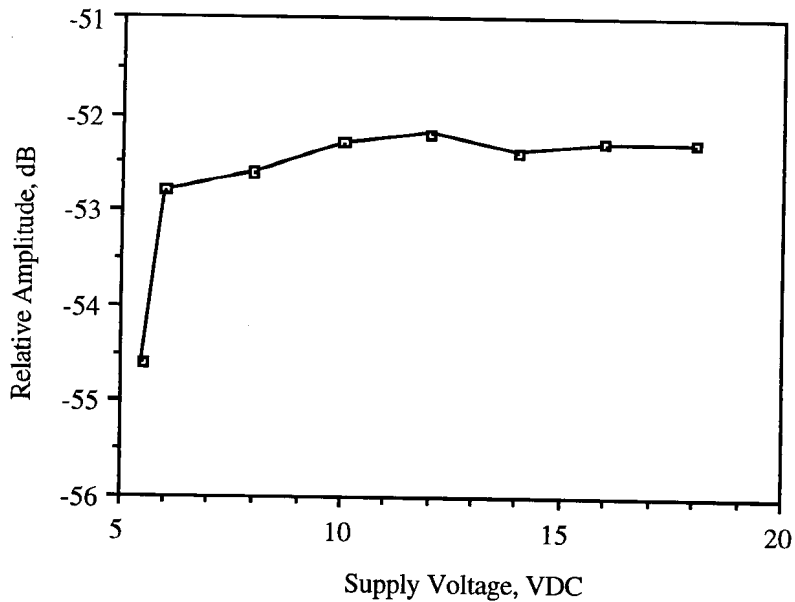
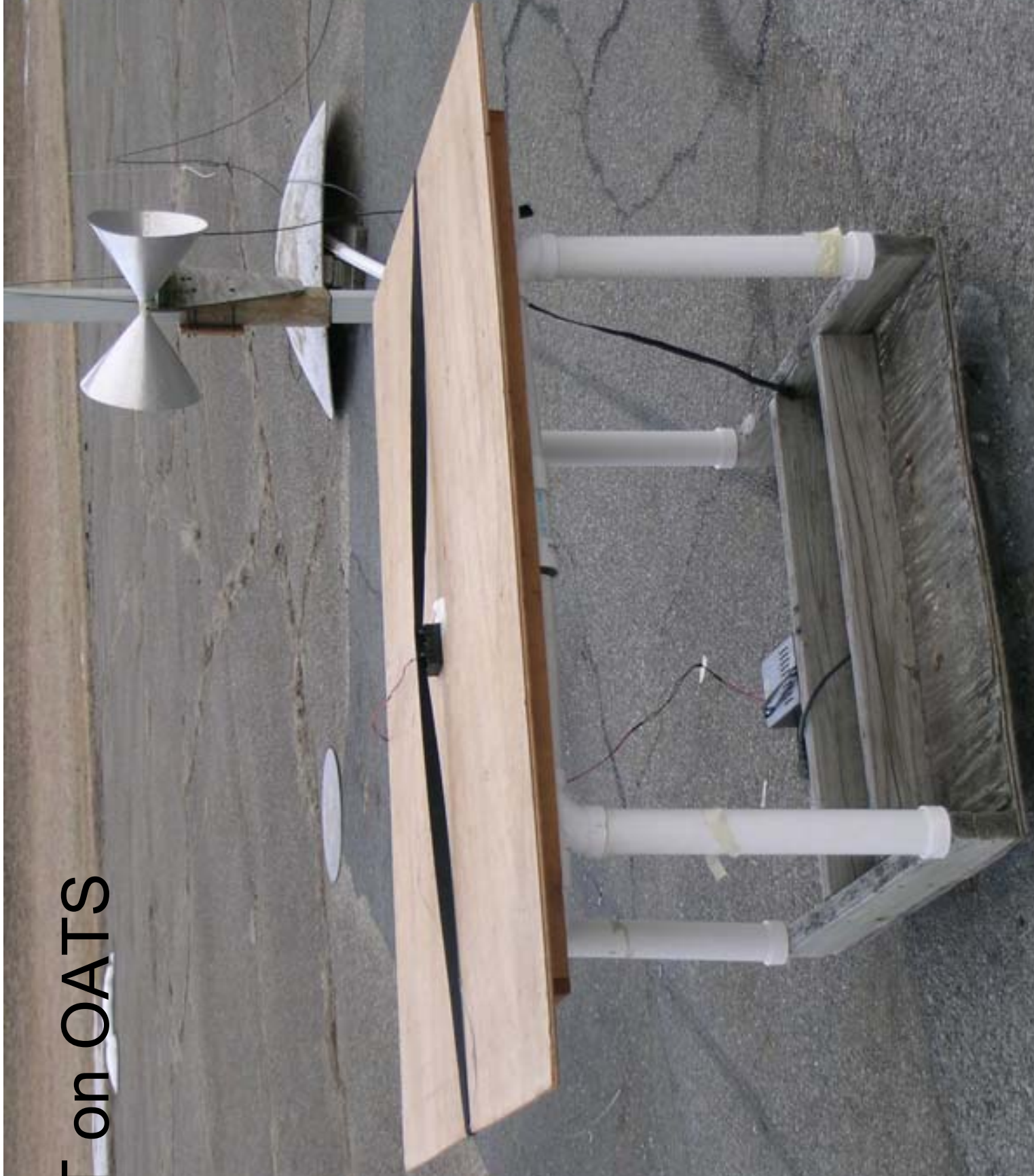
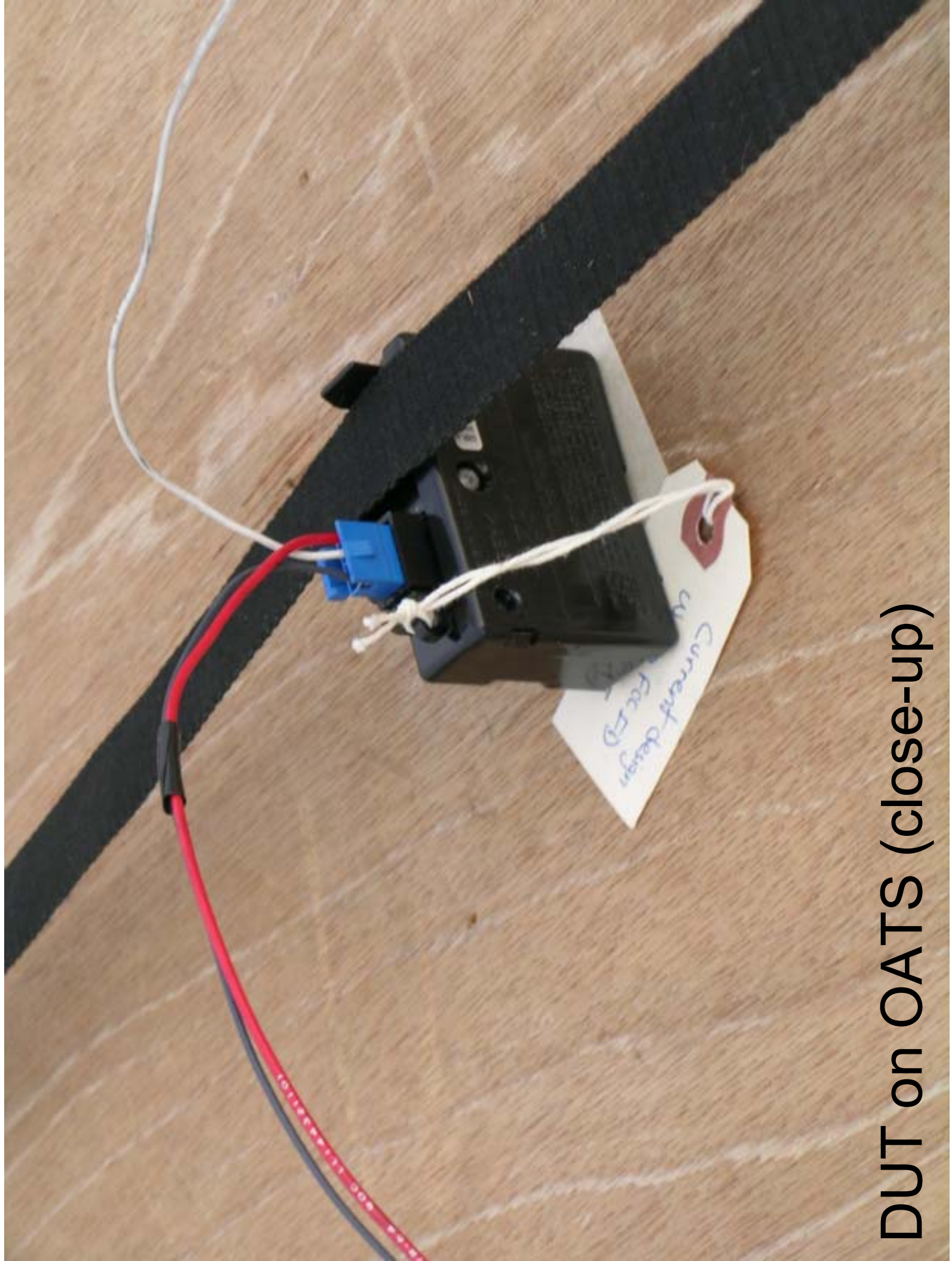


Figure 6.2. Relative emission at "fundamental" vs. supply voltage.

DUT on OATS





DUT on OATS (close-up)