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Measured Radio Frequency Emissions From

Delphi Automotive Systems Receiver Model: GMT 355

Report No. 415031-183
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For:
Delphi Automotive Systems
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Kokomo, IN 46904-9005

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Summary
Tests for compliance with FCC Regulations Part 15, Subpart B, and with Industry Canada Regulations, RSS-210, were performed on Delphi-Delco RKE Receiver. This device is subject to FCC 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 on September 3, 2003, the device tested in the worst case met the allowed FCC (Class B) specifications for radiated emissions by 10.3 dB (see p. 6). Since the device is powered from an automotive 12 VDC system, the line conductive emission tests do not apply.

1. Introduction

Delphi-Delco RKE Receiver 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 C63.4-1992 "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 Millimiter 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	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 (50 µH)		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 automotive 12 VDC source. It is housed in a plastic case approximately 6.0 by 4.5 by 1.5 inches. Antenna is internal. For testing, a 3 meter long section of generic harness was used, with power wires separated from the control/signal wires. In the digital section of the receiver, decoding, signal processing, etc. are performed by a micro timed by a 4.2 MHz ceramic resonator.

The DUT was designed and manufactured by Delphi Automotive Systems, One Corporate Center, Kokomo, IN 46904-9005. It is identified as:

Delphi-Delco RKE Receiver
Model: GMT 355
S/N: 15126385
FCC ID: L2C0018R
IC: 3432A-0018R

One receiver was provided and tested for compliance.

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 Table 4.1 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) µV/m	E_{lim} dB(µV/m)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
960-2000	500	54.0

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

4.2 Conducted Emission Limits (not applicable for automotive receivers)

4.3 Antenna Power Conduction Limits

(FCC: 15.111(a); IC: RSS-210, 7.2). Pmax = 2 nW; for requency 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 especially the 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 remeasured 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 13.5 VDC. A 315 MHz CW signal was injected (radiated) from a nearby signal generator using a short wire antenna. When powered up, the receiver pulses on-off at a second rate to reduce current draw. Measurements were made in a pulsed mode. The DUT was taped to a syrofoam 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 (315 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, but those above 1000 MHz (Fig. 5.2) are used in final assessment for compliance. Above 1GHz the RBW is 1 MHz.

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 excersised 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 (see 5.0). In some instances, where ambient signals are dominant, the RBW is decreased to lower the interference. When such measurement is critical, a care is taken to assure that the emission signal is indeed narrow band and is correctly measured with decreased bandwitdh. The test set-up photographs are in Appendix (i.e., at end of this report).

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

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

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 10.3 dB.

5.4 Conducted Emission Tests

These tests do not apply, since the DUT is powered from an automotive 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 emissions were recorded at the "fundamental" (311.2MHz) as voltage was varied from 9VDC minimum operating voltage to 18.0 VDC. Figure 6.2 shows the emission variation.

6.3 Operating Voltage and Current

V = 12.3 VDC
I = 42.0 mADC (pulsing mode)

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Table 5.1 Highest Emissions Measured

Radiated Emission - RF — Delphi-Delco GTM 355 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	316.2	SBic	H	-75.0	Pk	18.9	17.7	33.2	46.0	12.8	flat
2	316.2	SBic	H	-76.4	Pk	18.9	17.7	31.8	46.0	14.2	side
3	316.2	SBic	H	-75.2	Pk	18.9	17.7	33.0	46.0	13.0	end
4	316.2	SBic	V	-79.7	Pk	18.9	17.7	28.5	46.0	17.5	flat
5	316.2	SBic	V	-78.3	Pk	18.9	17.7	29.9	46.0	16.1	side
6	316.2	SBic	V	-78.0	Pk	18.9	17.7	30.2	46.0	15.8	end
7	630.0	SBic	H	-88.8	Pk	25.2	14.4	29.1	46.0	16.9	max. of all, noise; 10 kHz BW
8	630.0	SBic	V	-89.3	Pk	25.2	14.4	28.6	46.0	17.4	max. of all, noise; 10 kHz BW
9	945.0	SBic	H	-88.2	Pk	28.9	12.0	35.7	46.0	**10.3**	max. of all, noise; 10 kHz BW
10	945.0	SBic	V	-88.3	Pk	28.9	12.0	35.6	46.0	10.4	max. of all, noise; 10 kHz BW
11	1260.0	Horn	H	-69.5	Ave	20.4	28.0	29.9	54.0	24.1	max. of all, noise floor
12	1525.0	Horn	H	-70.0	Ave	20.6	28.0	29.6	54.0	24.4	max. of all, noise floor
13	1890.0	Horn	H	-69.0	Ave	20.8	28.2	30.6	54.0	23.4	max. of all, noise floor
14											
15											
16											
17											
18											

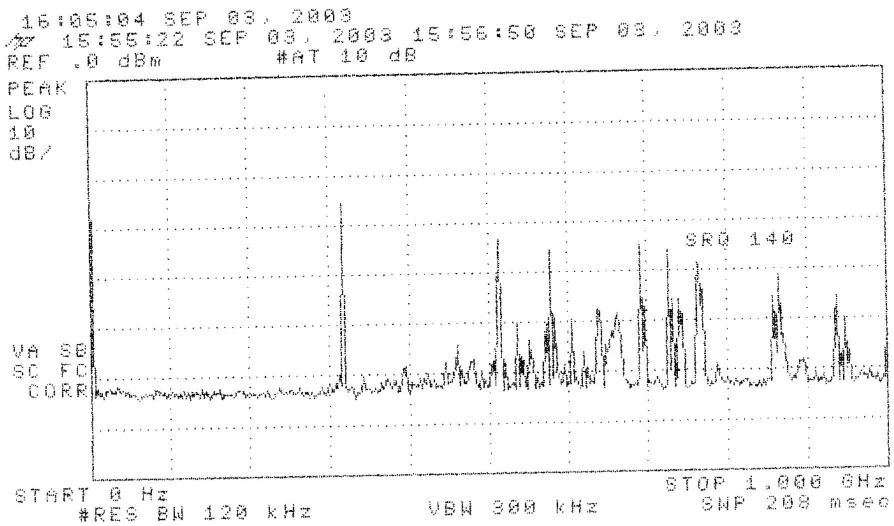
Radiated Emission - Digital (Class B)

#											
1											
2											
3	Digital Emissions more than 20 dB below FCC Class B limits										
4											
5											
6											
7											
8											
9											
10											
11											
12											

Conducted Emissions

#	Freq. MHz	Line Side	Det. Used	Vtest dBμV	Vlim dBμV	Pass dB	Comments
1							
2	Not applicable						
3							

Meas. 09/03/03; U of Mich.



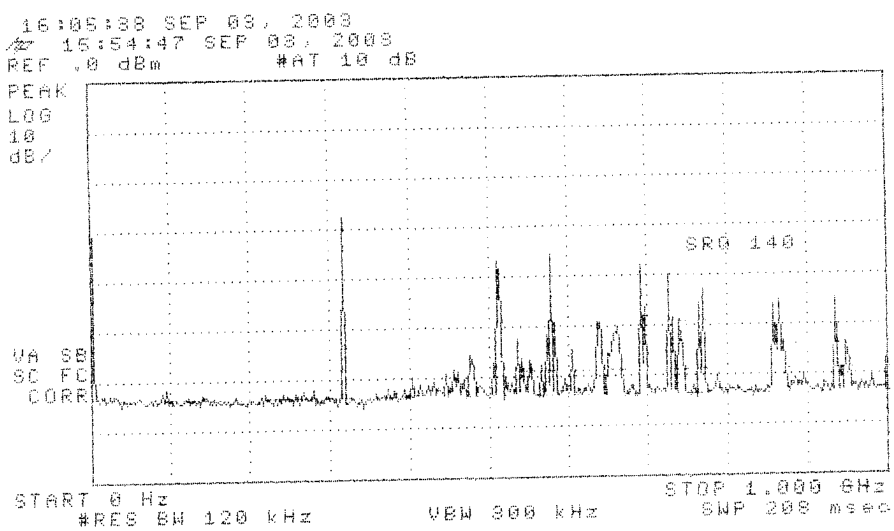
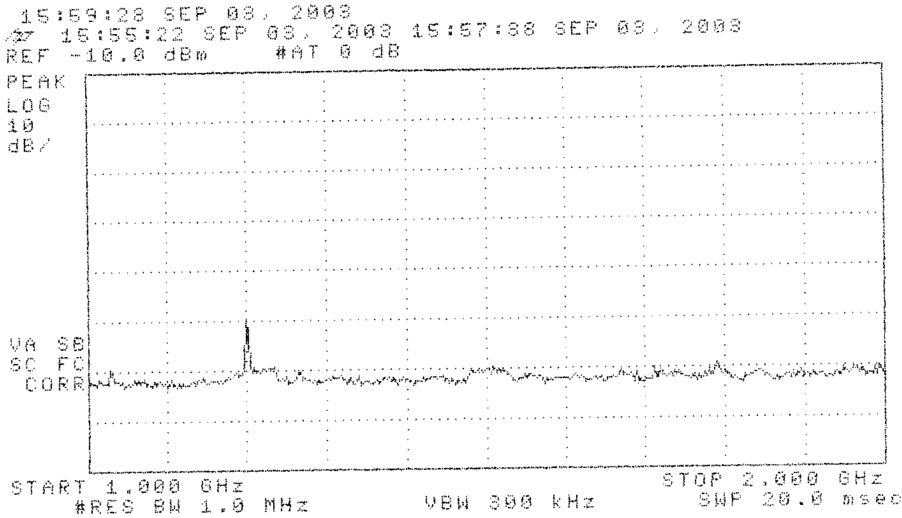


Figure 5.1. Emissions measured at 3 meters in anechoic chamber, 0-1000 MHz.
(top) Receiver plus ambient
(bottom) Ambient



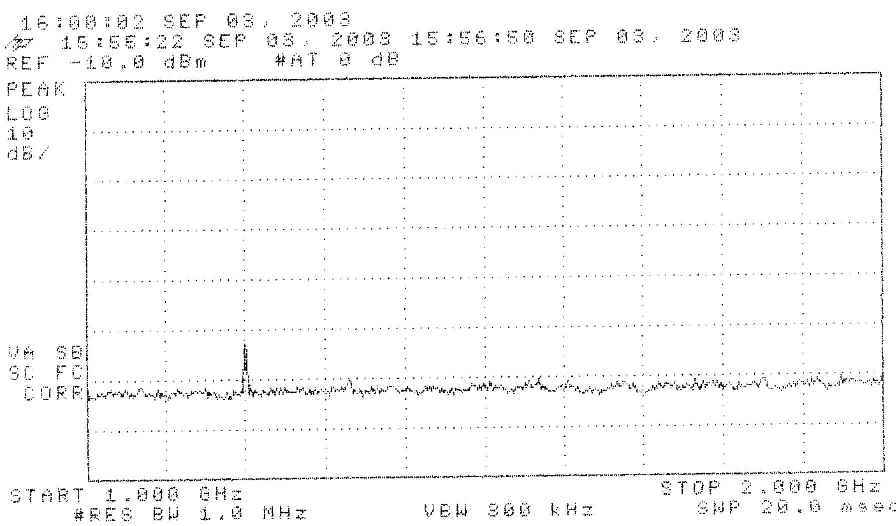


Figure 5.2. Emissions measured at 3 meters in anechoic chamber, 1000-2000 MHz.
(top) Receiver plus ambient
(bottom) Ambient

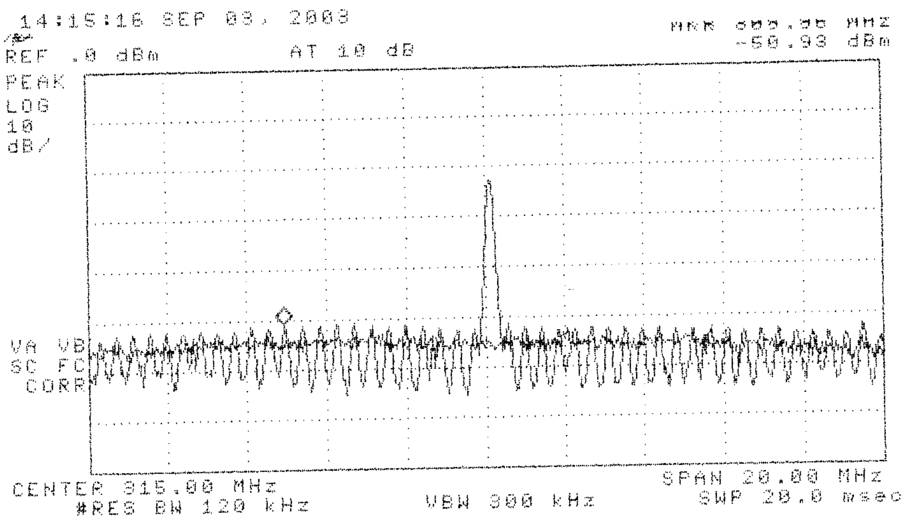


Figure 6.1. Relative receiver emissions in stand-by and "locked-in" modes. The final emission measurements were made with the receiver in "locked-in" mode.

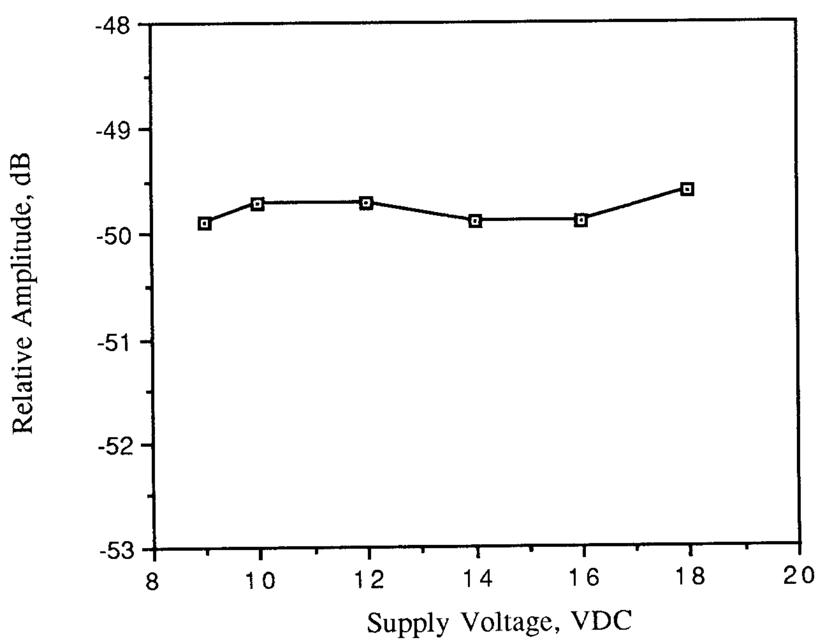
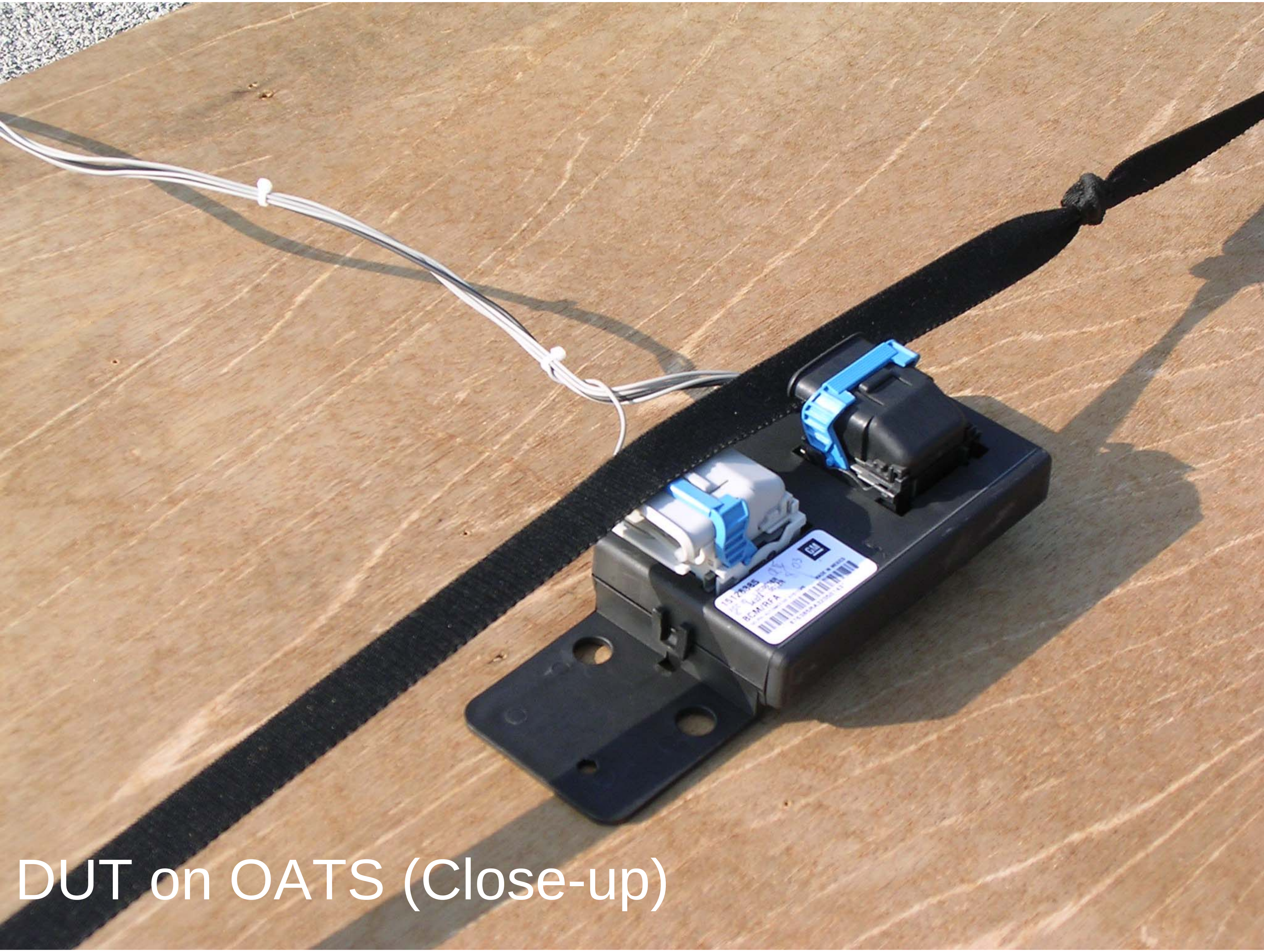


Figure 6.2. Relative emission at "fundamental" vs. supply voltage.

DUT on OATS



DUT on OATS (Close-up)