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

Measured Radio Frequency Emissions
From

Visteon SNOOK Receiver
PN: PWB-9447
Tested in Three Installations

Report No. 415031-133
August 29, 2002

For:
Visteon Deutschland Gmbh
D-50818 Koeln
PO: 222355

Contact:
Werner Loebach
D-V/PV-E1
Tel: +49-(0)221-5406-274
Fax: +49-(0)221-5406-261

Measurements made by:
Valdis V. Liepa
Joseph Brunett

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 Visteon Receiver. This device was tested when installed in three representative installations and is subject to the Rules and Regulations as a Receiver. As a Digital Device it is exempt, since it will be used only in transportation vehicles.

In testing performed on July 10 and 11 and August 28 and 29, 2002, the devices tested in the worst case met the specifications for antenna conducted emissions by 45.0 dB (see p. 5) and for radiated emissions by 21.1 dB (see p. 6). Since the device is powered from an automobile 12-volt system, the line conductive emission tests do not apply.

1. Introduction

Visteon 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 February 14, 1998. 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 superheterodyne receiver, designed for onboard automobile security/convenience applications. It is on a PC board, 1.5 x 5.5 cm in size. Connecting pins are for power, ground, enable, antenna, and data out. The receiver was installed in three typical installations that are representative of its application and these were tested for the receiver emissions. To characterize the receiver emissions more precisely, we selected to use the antenna rf conducted technique. In testing the devices were powered by 12VDC.

The DUTs were designed and manufactured by Visteon Automotive Systems, Dearborn, Michigan 48121. They are identified as:

Visteon SNOOK Receiver
Receiver PN: PWB-9447
Installation PNs : 2W9F-14B115-PA, VP2W9F-13C791-AC, VP2W9F-13C791-AA
Receiver SNs: XQ0KXB79, XQ0KXNRH, XQ0KXNSX (respectively)
Installation SNs: XQ0KXB79, XPHB0001W, B000008 (respectively)
FCC ID: NT8-14B115RXSNOOK
IC: 3043A-RXSNOOK

3.1 Modifications Made

There were no modifications made to the DUTs by this laboratory. However, standard connectors were added to access the antenna terminals for antenna conducted emission measurements.

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 Tables 4.1 and 4.2 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

Table 4.2. Conducted Emission Limits (FCC: 15.107; IC: RSS-210, 6.6).

Freq. (MHz)	μV	dB(μV)
0.450 - 1.705	250	48.0
1.705 - 30.0	250	48.0

Note: Quasi-Peak readings apply here

4.3 Antenna Power Conduction Limits
Pmax = 2 nW; for requency range see Table 4.1. (FCC: 15.111(a); IC: RSS-210, 7.2).

5. Emission Tests and Results

For these tests the antenna was deactivated and the receiver antenna terminal terminated in 50 ohms.

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 compliance.

The plots (Figures 5.1 through 6.2) presented in the report are for PN: 2W9F-14B115-PA. For the other two devices they were very similar, since the emissions from all three are extremely low (practically unmeasurable).

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 reduced RBW to help discriminate emissions from the ambient signals and noise. The test set-up photographs are in the Appendix (i.e., 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(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 limits by more than 21.1 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. In this case we could only detect an LO, and that is some -133 dBm. The plot is shown in Figure 6.1. This was measured with with an LNA and 300 Hz RBW!

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 LO frequency (325.7 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 = 12.8 VDC
I = 10.0 mADC

6.4 Antenna RF Power Conducted Measurements

These measurements are made by connecting a spectrum analyzer directly to the DUT antenna terminal and recording, in this case, the LO signal, its harmonics, and any other spurious signals. Using an LNA before the spectrum analyzer, we were able barely to see the LOs at 325.7 MHz. These are:

PN: 2W9F-14B115-PA	-107.5 dBm (noise floor)
PN: VP2W9F-13C791-AC	-102.0 dBm (signal)
PN: VP2W9F-13C791-AA	-103.6 dBm (signal)

The RBW was 120 kHz, peak detection.

Since the 2nW limit corresponds to -57.0 dBm, the antenna conducted emissions pass by 45.0 dB.

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

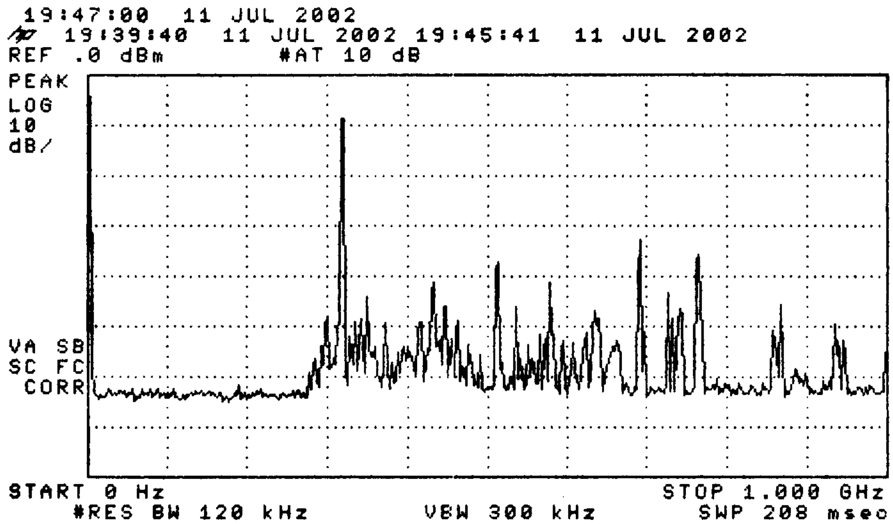
Table 5.1 Highest Emissions Measured

Radiated Emission - RF											Visteon SIP Het 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											
2	325.7	SBic	H,V	-80.0	QP	19.2	21.3	24.9	46.0	21.1	max all orient., noise floor
3	651.4	SBic	H,V	-98.9	QP	25.5	17.9	15.7	46.0	30.3	max. of all, noise; 9 kHz BW
4	977.1	SBic	H,V	-96.6	QP	29.2	15.3	24.3	54.0	29.7	max. of all, noise; 9 kHz BW
5	1300.0	Horn	H	-71.0	Pk	20.4	28.0	28.4	54.0	25.6	max. of all, noise floor
6	1626.0	Horn	H	-70.0	Pk	20.6	28.0	29.6	54.0	24.4	max. of all, noise floor
7	1952.0	Horn	H	-70.0	Pk	20.8	28.2	29.6	54.0	24.4	max. of all, noise floor
8											
9											
10	325.7	SBic	H,V	-81.8	QP	19.2	21.3	23.1	46.0	22.9	max all orient., noise floor
11	651.4	SBic	H,V	-90.1	QP	25.5	17.9	24.5	46.0	21.5	max. of all, noise; 9 kHz BW
12	977.1	SBic	H,V	-97.2	QP	29.2	15.3	23.7	54.0	30.3	max. of all, noise; 9 kHz BW
13	1300.0	Horn	H	-71.5	Pk	20.4	28.0	27.9	54.0	26.1	max. of all, noise floor
14	1626.0	Horn	H	-71.5	Pk	20.6	28.0	28.1	54.0	25.9	max. of all, noise floor
15	1952.0	Horn	H	-71.0	Pk	20.8	28.2	28.6	54.0	25.4	max. of all, noise floor
16											
17											
18	325.7	SBic	H,V	-80.7	QP	19.2	21.3	24.2	46.0	21.8	max all orient., noise floor
19	651.4	SBic	H,V	-89.5	QP	25.5	17.9	25.1	46.0	20.9	max. of all, noise; 9 kHz BW
20	977.1	SBic	H,V	-97.2	QP	29.2	15.3	23.7	54.0	30.3	max. of all, noise; 9 kHz BW
21	1300.0	Horn	H	-71.0	Pk	20.4	28.0	28.4	54.0	25.6	max. of all, noise floor
22	1626.0	Horn	H	-70.5	Pk	20.6	28.0	29.1	54.0	24.9	max. of all, noise floor
23	1952.0	Horn	H	-71.0	Pk	20.8	28.2	28.6	54.0	25.4	max. of all, noise floor
24											
25											

Radiated Emission - Digital (Class B)											
1											
2											
3	Not applicable										
4											
12											

Conducted Emissions							
1	Freq.	Line	Det.	Vtest	Vlim	Pass	
2	MHz	Side	Used	dBμV	dBμV	dB	Comments
3							
4	Not applicable						
5							

Meas. 07/10,8/29/2002; U of Mich.



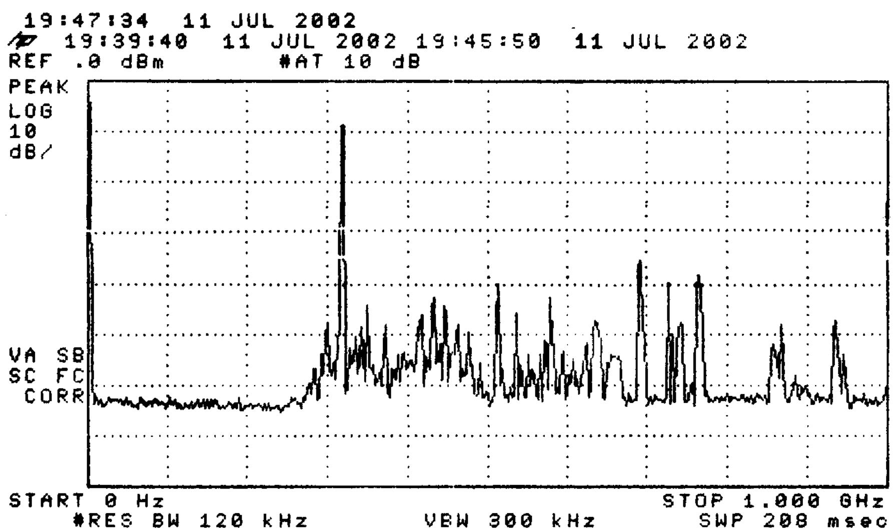
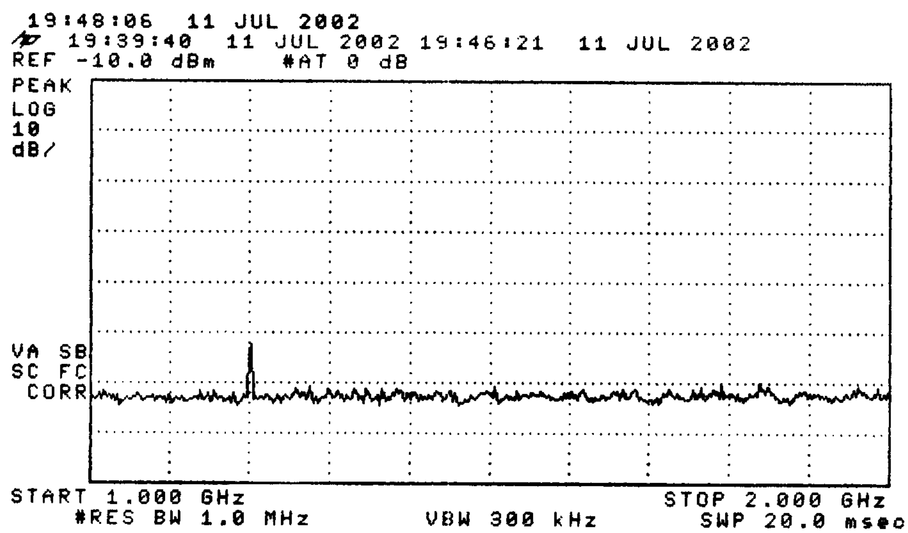


Figure 5.1. Emissions measured at 3 meters in anechoic chamber, 0-1000 MHz.
(top) Receiver plus ambient
(bottom) Ambient



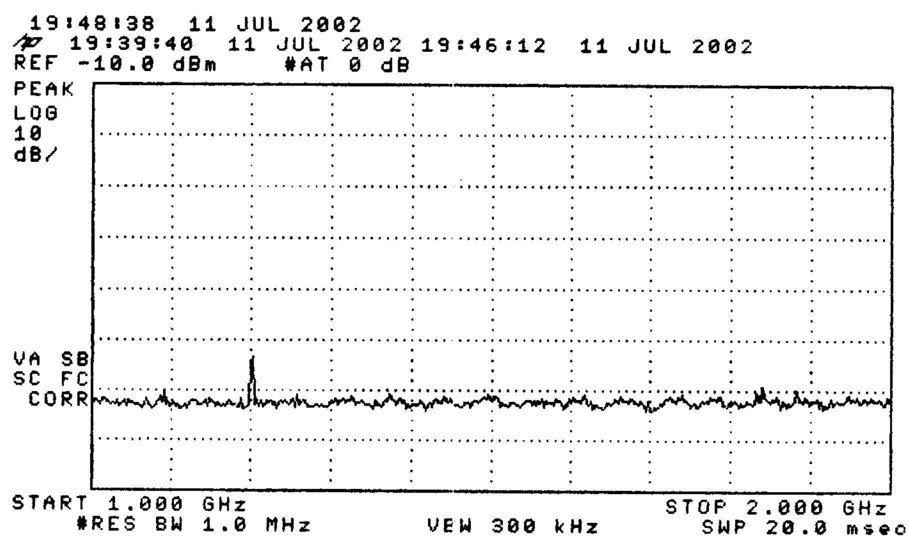


Figure 5.2. Emissions measured at 3 meters in anechoic chamber, 1000-2000 MHz.
(top) Receiver plus ambient
(bottom) Ambient

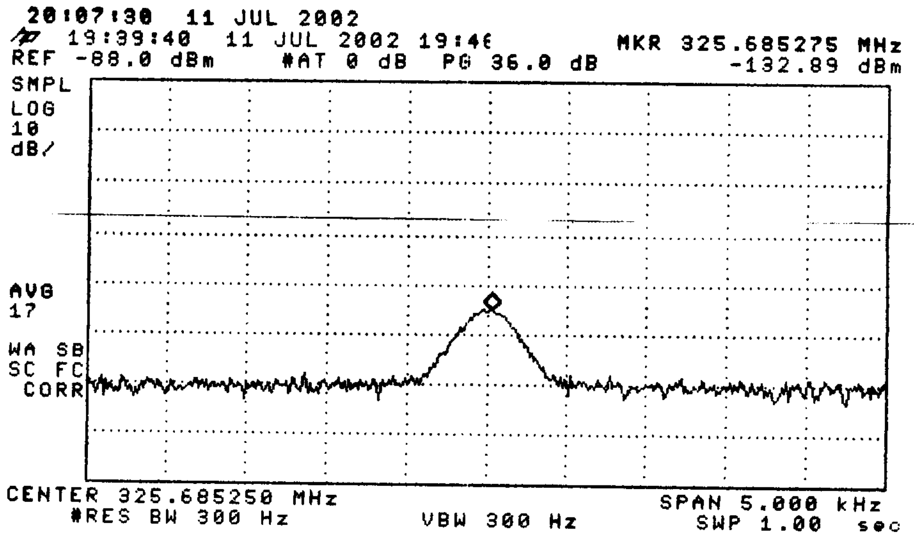


Figure 6.1. Emissions at LO.

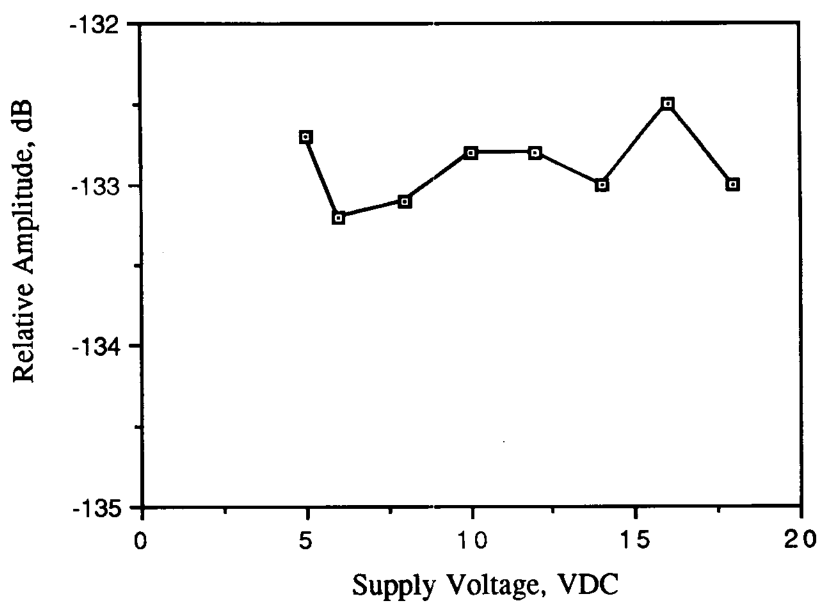


Figure 6.2. Relative emission at "fundamental" vs. supply voltage.