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Measured Radio Frequency Emissions
From

Delphi-Delco Communiport MPC-PRO (FM-BandTransmitter) Model: 12205129

Report No. 415031-058
December 18, 2000

For:
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Summary

Tests for compliance with FCC Regulations, Part 15, Subpart C, were performed on Delphi-Delco Communiport MPC-PRO transmitter. This device is subject to the Rules and Regulations as a transmitter; since it is used in a car, as a digital device it is exempt.

In testing performed on December 15 through 19, 2000, the device tested in the worst case met the allowed specifications for radiated emissions by 0.6 dB at fundamental and by 2.8 dB at harmonics (see p. 6). Besides harmonics, there were no other significant spurious transmitter emissions found. At the DC power-up, there is VCO "lock on" chirp emission sweeping from 82 MHz to the frequency of operation; this emission was neglected when considering the device for compliance.

The line conducted emission tests do not apply, since the device is powered from 12V car cigarette lighter socket. The radiated digital emission are at about Class B limit; they were not formally measured since they are exempt for devices used in transportation vehicles.

1. Introduction

Delphi-Delco Communiport MPC-PRO transmitter was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 2, 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 file 31040/SIT) and with Industry Canada, Ottawa, ON (File Ref. No: IC2057).

2. Test Procedure and Equipment Used

The test equipment commonly used in our facility is listed in Table 2.1 below. The second column identifies the specific equipment used in these tests. The HP 8593E spectrum analyzer is used for primary amplitude and frequency reference.

Table 2.1. Test Equipment.

Test Instrument	Equipment Used	Manufacturer/Model	Cal. Date/By
Spectrum Analyzer (9kHz-22GHz)	X	Hewlett-Packard 8593A SN: 3107A01358	December 2000/UM
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E SN: 3107A01131	December 2000/HP
Spectrum Analyzer (0.1-1500 MHz)		Hewlett-Packard 182T/8558B SN: 1529A01114/543592	December 2000/UM
Preamplifier (5-1000MHz)	X	Watkins-Johnson A11 -1 plus A25-1S	December 2000/UM
Preamplifier (5-4000 MHz)	X	Avantek	Oct. 1999/ U of M Rad Lab
Broadband Bicone (20-200 MHz)	X	University of Michigan	June 1996/U of M Rad Lab
Broadband Bicone (200-1000 MHz)	X	University of Michigan	June 1996/U of M Rad Lab
Dipole Antenna Set (25-1000 MHz)	X	University of Michigan	June 2000/UM
Dipole Antenna Set (30-1000 MHz)		EMCO 3121C SN: 992	June 2000/UM
Active Loop Antenna (0.090-30MHz)		EMCO 6502 SN: 2855	December 1993/ EMCO
Active Rod (30Hz-50 MHz)		EMCO 3301B SN: 3223	December 1993/EMCO
Ridge-horn Antenna (0.5-5 GHz)	X	University of Michigan	March 1999/U of M Rad Lab
LISN Box		University of Michigan	Dec. 1997/U of M Rad Lab
Signal Cables	X	Assorted	January 1993/U of M Rad Lab
X-Y Plotter		Hewlett-Packard 7046A	During Use/U of M Rad Lab
Signal Generator (0.1-990 MHz)		Hewlett-Packard 8656A	January 1990/U of M Rad Lab
Printer	X	Hewlett-Packard 2225A	August 1989/HP

3. Configuration and Identification of Device Under Test

The DUT is a palm size device that interfaces with a personal organizer and a cellular telephone. It signal processes and executes voice commands and generates audio signals that are transmitted from the device to the car's FM radio. The DUT can be programmed to transmit from 88.1 to 107.9 MHz.

The DUT was designed by Delphi-Delco Electronics Systems, One Corporate Center, Kokomo, IN 46904-9005. It will be manufactured by Kodenshi/INT Corp., 570-300 832 Palbong-Dong, IKSAN, KOREA. It is identified as:

Delphi-Delco Communiport MPC-PRO
Model: 12205129
FCC ID: L2C0014T

Three DUTs were provided, programmed for 88.3 MHz, 97.5 MHz, and 107.9 MHz transmission.

3.1 EMI Relevant Modifications

As received, the device had a 24 cm antenna length and with that (fundamental) emissions were above the limit. By cutting the length to 22 cm (measured from the outside of the case to the end of the wire), the emission was brought below the limit.

4. Emission Limits

4.1 Radiated Emission Limits

The DUT tested falls under the category of an Intentional Radiators and the Digital Devices. For FCC, it is subject to Part 15, Subpart C, (Section 15.231), Subpart B, (Section 15.109), and Subpart A, (Section 15.33). The applicable testing frequencies with corresponding emission limits are given in Tables 4.1 and 4.2 below. As a digital device, the DUT is considered as a Class B device.

Table 4.1. Radiated Emission Limits (FCC: 15.33, 15.35, 15.109).
(Digital Class B)

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

Table 4.2. Radiated Emission Limits (FCC: 15.239, 15.209)
(Transmitter)

Frequency	Fundamental Ave. E_{lim} (3m)		Spurious** Ave. E_{lim} (3m)	
(MHz)	(μV/m)	dB (μV/m)	(μV/m)	dB (μV/m)
88 - 108	250	48.0		
30 - 88			100	40.0
88 - 216			150	43.5
216 - 960			200	46.0
above 960			500	54.0

** Measure up to tenth harmonic; 120 kHz BW up to 1 GHz, 1 MHz BW above 1 GHz

4.2 Conductive Emission Limits

The conductive emission limits and tests do not apply here, since the DUT is powered by automobile 12V system.

5. Radiated Emission Tests and Results

5.1 Anechonic Chamber Measurements

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

In testing for radiated emissions, the transmitter was activated using the lock/unlock button with a special wooden clamp for repeated pulse emissions. It was placed on the test table flat, on its side, or on its end.

In the chamber we studied and recorded all the emissions using a bicone antenna up to 300 MHz and a ridged horn antenna above 200 MHz. The measurements made in the chamber below 1 GHz are used for pre-test evaluation only. The measurements made above 1 GHz are used in pre-test evaluation and in the final compliance assessment. We note that for the horn antenna, the antenna pattern is more directive and hence the measurement is essentially that of free space (no ground reflection). Consequently it is not essential to measure the DUT for both antenna polarizations, as long as the DUT is measured on all three of its major axis. In the chamber we also recorded the spectrum and modulation characteristics of the carrier. These data are presented in subsequent sections. We also note that in scanning from 30 MHz to 2.0 GHz using bicone and the ridge horn antennas, there were no other significant spurious emissions observed.

5.2 Outdoor Measurements

After the chamber measurements, the emissions were re-measured on the outdoor 3-meter site at fundamental and harmonics up to 1 GHz using tuned dipoles and/or the high frequency bicone.

Photographs in Appendix (at end of this report) show the DUT on the open in site table (OATS).

5.3 Computations and Results

To convert the dBm measured on the spectrum analyzer to dB(μV/m), we use expression

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

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
- K_E = pulse operation correction factor, dB (see 6.1)

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 0.6 dB.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

When the transmitter is operating, it transmits continuous FM signal. See Figure 6.1. The duty factor for such is

$$K_E = 100/\ 100\ ms = 1.00 \text{ or } 0.0\ dB.$$

6.2 Emission Spectrum

Using bicone antenna , emission spectrum was recorded and is shown in Figure 6.2. Note, there are substantial digital emissions present which are not subject to FCC regulations.

We also wish to point out that there is a turn-on "chirp" emission when the device is powered up. The VCO starts from 82 MHz and steps up to the programmed operating frequency. This emission is at the same level (peak measurement) as the operating emission level. For compliance with FCC regulations, this turn-on emission was not considered.

6.3 Bandwidth of the Emission Spectrum

The measured spectrum of the signal is shown in Figure 6.3. The allowed bandwidth is 200 kHz. From the plot we see that inthe worst case, the bandwidth is 81.5 kHz at 97.5 MHz.

6.4 Effect of Supply Voltage Variation

The DUT has been designed to be powered by 12 VDC battery. For this test, the battery was replaced by a laboratory variable power supply. Relative power radiated was measured at the fundamental (97.5 MHZ) as the voltage was varied from 6 to 18 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage at Battery Terminals

Voltage = 14 VDC

Current = 157 mADC

Table 5.1 Highest Radiated Emissions Measured

Delphi/Delco FM Tx; 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	107.9	Dip	H	-45.9	Pk	9.2	24.5	45.7	48.0	2.3	flat
2	107.9	Dip	V	-44.2	Pk	9.2	24.5	47.4	48.0	0.6	flat
3	215.8	SBic	H,V	-71.0	Pk	15.5	23.0	28.4	43.5	15.1	max. all
4	323.7	SBic	H,V	-82.0	Pk	19.2	21.7	22.5	46.0	23.5	max. all, noise
5	431.6	SBic	H,V	-83.0	Pk	21.8	20.4	25.4	46.0	20.6	max. all, noise
6	539.5	SBic	H,V	-81.0	Pk	23.8	19.2	30.6	46.0	15.4	max. all, noise
7	647.4	SBic	H,V	-71.0	Pk	25.5	18.3	43.2	46.0	2.8	max. all, noise
8	755.3	SBic	H,V	-83.0	Pk	26.9	17.5	33.4	46.0	12.6	max. all, noise
9	863.2	SBic	H,V	-78.0	Pk	28.1	16.7	40.3	46.0	5.7	max. all, noise
10	971.1	SBic	H,V	-81.0	Pk	29.1	15.7	39.4	54.0	14.6	max. all, noise
11	1079.0	Horn	H	-81.0	Pk	30.1	13.9	42.2	54.0	11.8	max. all, noise
12											
13	97.5	Dip	H	-53.7	Pk	8.3	24.7	36.9	48.0	11.1	side
14	97.5	Dip	V	-47.1	Pk	8.3	24.7	43.5	48.0	4.5	flat
15	195.0	SBic	H,V	-75.0	Pk	14.6	23.3	23.2	43.5	20.3	max. all
16	292.5	SBic	H,V	-79.0	Pk	18.2	22.1	24.2	46.0	21.8	max. all, noise
17	390.0	SBic	H,V	-81.0	Pk	20.9	20.9	26.0	46.0	20.0	max. all, noise
18	487.5	SBic	H,V	-82.0	Pk	22.9	19.8	28.1	46.0	17.9	max. all, noise
19	585.0	SBic	H,V	-81.0	Pk	24.5	18.8	31.7	46.0	14.3	max. all, noise
20	682.5	SBic	H,V	-81.0	Pk	25.9	18.0	34.0	46.0	12.0	max. all, noise
21	780.0	SBic	H,V	-80.0	Pk	27.1	17.3	36.8	46.0	9.2	max. all, noise
22	877.5	SBic	H,V	-77.0	Pk	28.2	16.6	41.6	46.0	4.4	max. all, noise
23	975.0	SBic	H,V	-80.0	Pk	29.2	15.7	40.5	54.0	13.5	max. all, noise
24											
25	88.3	Dip	H	-46.3	Pk	7.4	24.8	43.2	48.0	4.8	end
26	88.3	Dip	V	-42.1	QP	7.4	24.8	47.4	48.0	0.6	end
27	176.6	SBic	H,V	-72.0	Pk	15.2	23.6	26.6	43.5	16.9	max. all
28	264.9	SBic	H,V	-81.0	Pk	18.6	22.4	22.2	46.0	23.8	max. all, noise
29	353.2	SBic	H,V	-82.0	Pk	21.1	21.3	24.8	46.0	21.2	max. all, noise
30	441.5	SBic	H,V	-73.0	Pk	23.0	20.3	36.7	46.0	9.3	max. all
31	529.8	SBic	H,V	-81.0	Pk	24.6	19.3	31.2	46.0	14.8	max. all, noise
32	618.1	SBic	H,V	-81.0	Pk	25.9	18.5	33.4	46.0	12.6	max. all, noise
33	706.4	SBic	H,V	-80.0	Pk	27.0	17.8	36.2	46.0	9.8	max. all, noise
34	794.7	SBic	H,V	-81.0	Pk	28.0	17.2	36.8	46.0	9.2	max. all, noise
35	883.0	SBic	H,V	-78.0	Pk	28.9	16.6	41.4	46.0	4.6	max. all, noise
36											
37											
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Meas. 12/16/00; U of Mich.

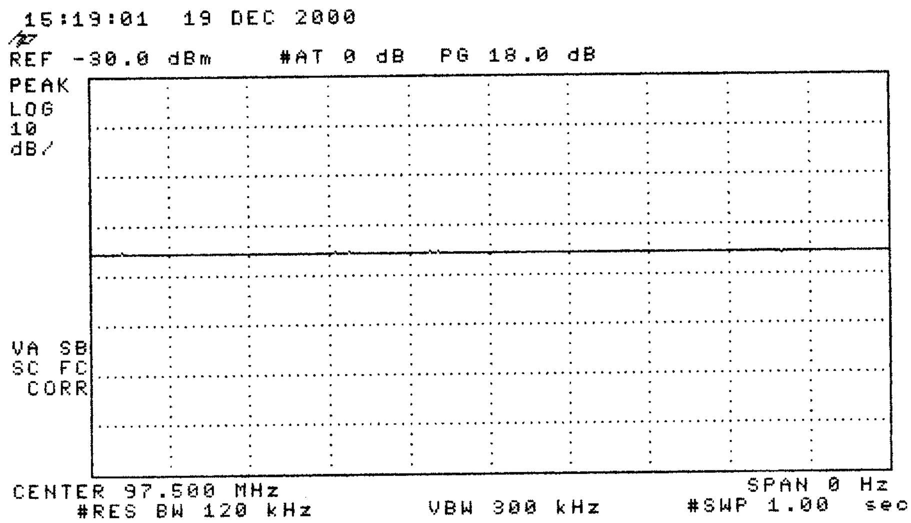

Figure 6.1. Transmissions modulation characteristics; CW-FM emission.

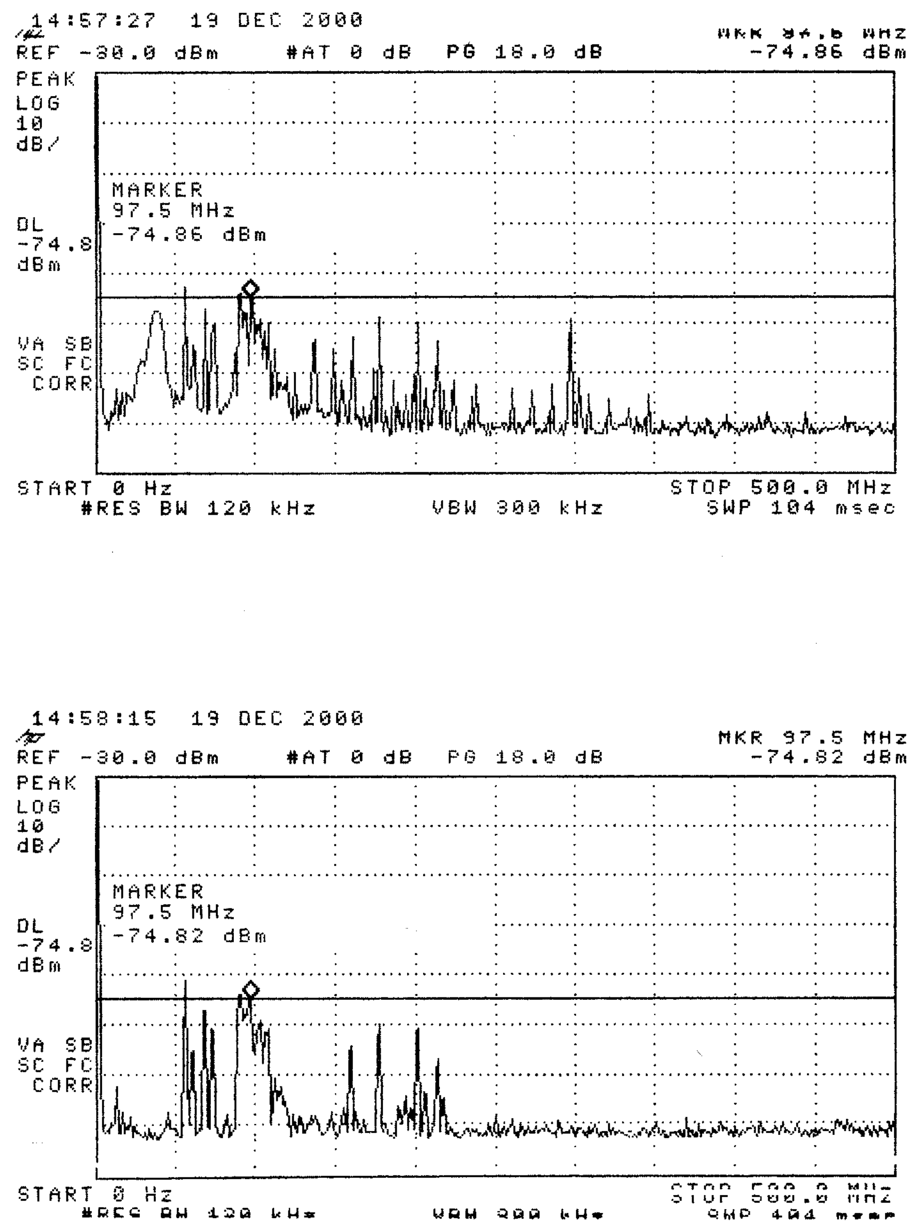

Figure 6.2. Emission spectrum of the DUT at 97.5 MHz.
Top - composite, bottom - background.

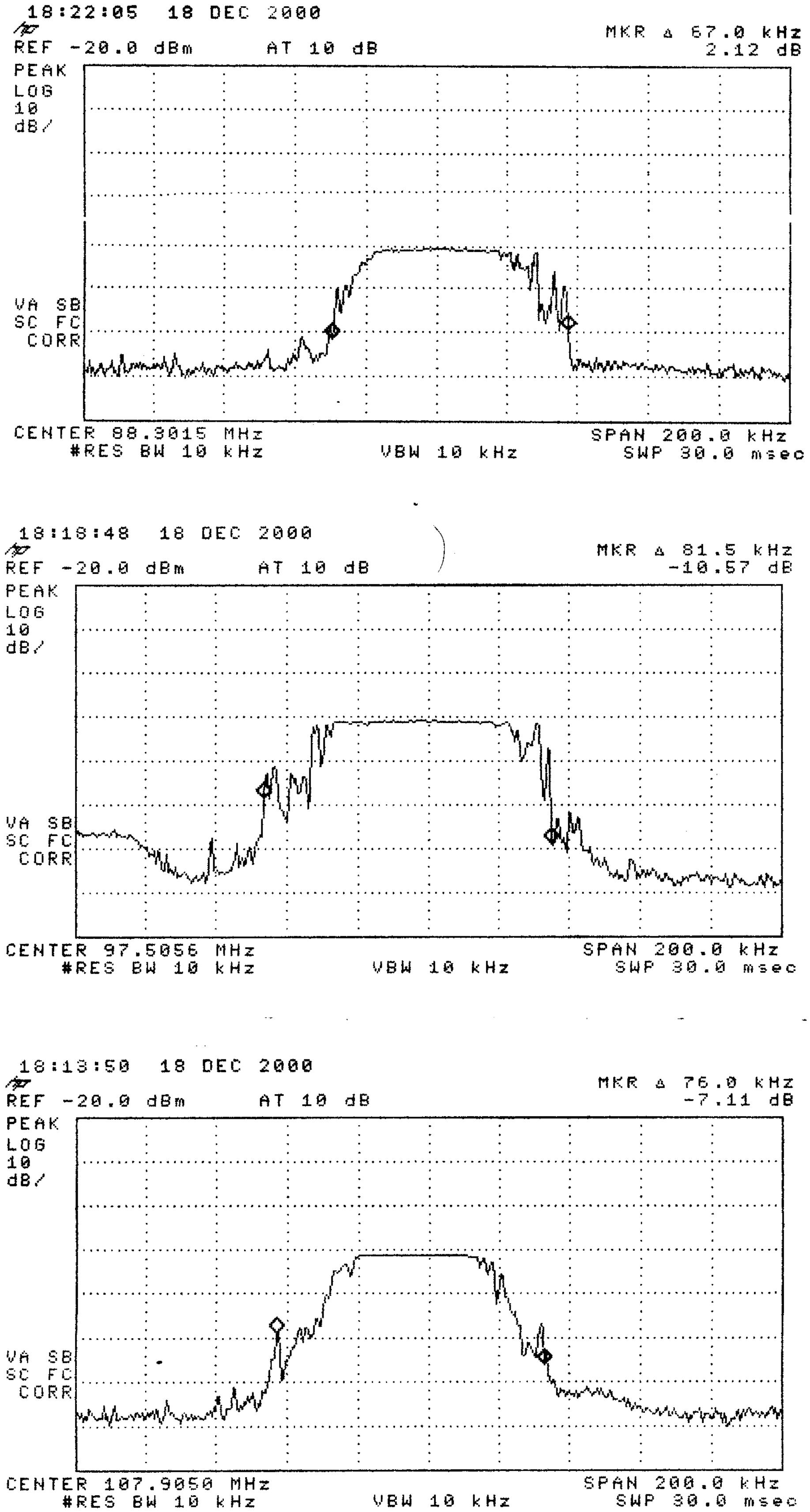

Figure 6.3. Measured bandwidth of the DUT. Top - 88.3 MHz, middle - 97.5 MHz, bottom - 107.9 MHz.

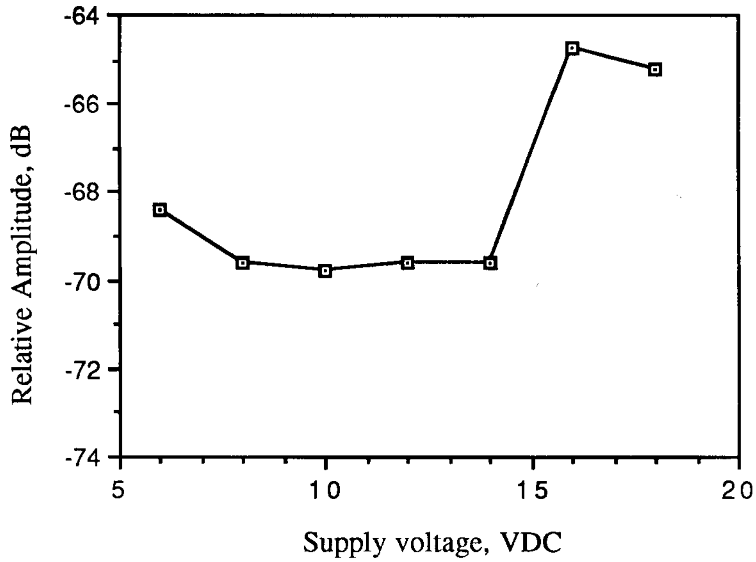

Figure 6.4. Relative emission at 97.5 MHz vs. supply voltage .