The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
Tel: (734) 647-1792

Measured Radio Frequency Emissions From

Johnson Controls, Inc. Homelink Transmitter Model 120N

Report No. 415031-026
January 31, 2000

For:
Johnson Controls, Inc.
Automotive Systems Group
915 E. 32nd Street
Holland, MI 49423

EXHIBIT 6
Page 1-19 of 19
U of Mich file 415031-26

Contact:
Mark Jacob
Tel: (616) 394-8517 Fax: (616) 394-8499
P.O. verbal

Measurements made by:
Valdis V. Liepa
Tony Kalacanic (JCI)

Tests supervised by:
Report approved by:
Valdis V. Liepa
Research Scientist

Summary
Tests for compliance with FCC Regulations, Part 15, Subpart C, and for compliance with Industry Canada RSS-210, were performed on Johnson Controls (Universal Garage Door Opener) Transmitter, Model 120N. In the tests the transmitter was trained to three duty factors (30%, 50%, and 80%) and to three frequencies (288 MHz, 310 MHz, and 418 MHz).

In testing performed during January 13-14, 24-26, 2000, in the worst case of the all combinations tested, the device tested in the worst case met the allowed limits for radiated emissions by 1.7 dB at the fundamental (p. 10) and by 4.0 dB at the harmonics (p. 9). Besides harmonics and presence of short "blips" when locking the VCO to the required frequency, there were no other significant spurious emissions found.

The conductive emission tests do not apply, since the device is powered from a 12V automobile source.

1. Introduction

Johnson Controls transmitter, Model 120N, 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	October 1999/UM
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E SN: 3107A01131	September 1999/HP
Spectrum Analyzer (0.1-1500 MHz)		Hewlett-Packard 182T/8558B SN: 1529A01114/543592	October 1999/U of M Rad Lab
Preamplifier (5-1000MHz)	X	Watkins-Johnson A11 -1 plus A25-1S	October 1999/U of M Rad Lab
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)		University of Michigan	June 1996/U of M Rad Lab
Dipole Antenna Set (25-1000 MHz)	X	University of Michigan	Dec. 1997/U of M Rad Lab
Dipole Antenna Set (30-1000 MHz)		EMCO 3121C SN: 992	June 1996/U of M Rad Lab
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)	X	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 7.5 x 3 x 1.5 inch OEM device that goes in automobile console and is powered by 12 VDC. The DUT contains a learning garage door opener transmitter, and convenience devices such as a compass, a trip computer, temperature display, etc. It differs from a standard Garage Door Opener (GDO) in that it does not have a fixed frequency or code, but rather learns and repeats the frequency and code from an another GDO, with capability to store up to three GDOs. The DUT uses a 20.0 MHz crystal frequency reference and operates over 288 to 418 MHz. The forbidden bands are "blocked out" in firmware. Depending on the frequency and the duty factor of the GDO that is being learned, the DUT attenuates the emissions in firmware using predetermined attenuation settings.

The DUT was designed and manufactured by Johnson Controls, Inc., Automotive Systems Group, 915 E. 32nd Street, Holland, MI 49423. It is identified as:

Johnson Controls Homelink Transmitter
Model: 120N
SN: FCC120N
FCC ID: CB2120NHL3
CANADA: to be provided by IC

The same unit was used in all the tests. It was programmed for repeated periodic pulse modulation for predetermined duty factors and carrier frequencies.

3.1 EMI Relevant Modifications

There were no modifications made to the DUT by this laboratory after submission for final testing. However, during the development of the product, JCI used the University of Michigan facilities to optimize the firmware of the device.

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). For Industry Canada it is subject to RSS-210, (Sections 6.1 and 6.3). 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: 15.231(b), 15.205(a); IC: RSS-210; 6.1, 6.3) Transmitter.

Frequency	Fundamental Ave. E_{lim} (3m)		Spurious** Ave. E_{lim} (3m)	
(MHz)	(μV/m)	dB (μV/m)	(μV/m)	dB (μV/m)
260.0-470.0	3750-12500*		375-1250	
322-335.4 399.9-410 608-614	Restricted Bands		200	46.0
960-1240 1300-1427 1435-1626.5 1660-1710 1718.9-1722.2 2200-2300	Restricted Bands		500	54.0

* Linear interpolation, formula: E = -7083 + 41.67*f (MHz)

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

Table 4.2. Radiated Emission Limits (FCC: 15.33, 15.35, 15.109; IC: RSS-210, 6.2.2(r)). (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)

4.2 Conductive Emission Limits

The conductive emission limits and tests do not apply here, since the DUT is powered from automotive 12 VDC source.

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 anechonic 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 modified for continuous emissions was used. It was placed in a styrofoam block to facilitate its orientation on any of its three major axis, i. e., flat down, 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 4.2 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 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

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

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 Sec. 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 Tables 5.1 through 5.3. There we see that the DUT meets the limit by 1.7 dB (p. 10).

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

As agreed previous between FCC and Prince (now JCI), the DUT was taught signals of 30, 50, and 80% duty factors at 310 MHz. The repeated wave shape were measured and from those the duty factors were obtained. Figures 6.1(a) through 6.1(c) show the measured wave shapes from which the duty factors were computed. They are:

30% duty factor The modulation consists of 0.5375 ms wide pulses of period 1.85 ms. Thus,

K_E = 0.5375/1.85 = 0.291 or -10.7 dB.

50% duty factor The modulation consists of 0.925 ms wide pulses of period 1.85 ms. Thus,

K_E = 0.925/1.85 = 0.500 or -6.0 dB.

80% duty factor The modulation consists of 1.5625 ms wide pulses of period 1.85 ms. Thus,

K_E = 1.5125/1.85 = 0.845 or -1.5 dB.

6.2 Emission Spectrum

Using the ridge-horn antenna and DUT placed in its aperture, emission spectrum was recorded and is shown in Figure 6.2.

6.3 Bandwidth of the Emission Spectrum

The measured spectrum of the signal is shown in Figure 6.3. The measurements were made at 310 MHz for 30, 50, and 80% duty factor modulations. At 310 MHz the allowed (-20 dB, 0.25%) bandwidth is 775 kHz. From the plots we see that, in the worst case, the -20 dB bandwidth is 110.0 kHz for 30% duty factor (Fig. 6.3(a)).

6.4 Effect of Supply Voltage Variation

The DUT has been designed to be powered from automotive 12 V battery. For this test, a laboratory variable power supply was used and relative radiated field was measured at the fundamental, as the voltage was varied from 6 to 18 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage and Current (310 MHz, CW)

Supply Voltage	=	13.0 VDC
Current	=	197.0 mADC

6.6 Verification of Non-operation in Restricted Bands

The DUT has been designed to learn and operate over 288 to 418 MHz frequency range. It also has been programmed to stay out of the Restricted Bands. In the operating range of the DUT, these bands are 240.0 - 285.0 MHz, 322.0 - 335.4 MHz, and 399.9 - 410.0 MHz.

Using a 500 Hz 50% duty factor modulated carrier from a signal generator, the DUT was "taught" frequencies from 240.0 to 440.0 MHz. It repeated frequencies from 288.0 MHz to 320.5 MHz , from 337.5 MHz to 398.5 MHz, and from 411.0 MHz to 420.0 MHz . In any case, no frequency was learned in the Restricted Bands. (Also there were no spurious emissions in the Restricted Bands.)

The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, Michigan 48109-2122
(734) 647-1792

Table 5.1. Highest Emissions Measured

Radiated Emissions											JCI, 120N; 288 MHz
#	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	288	Dip	H	-20.6	Pk	18.1	22.7	71.3	73.9	2.6	side 30% duty factor (meas. -10.5 dB)
2	288	Dip	V	-24.1	Pk	18.1	22.7	67.8	73.9	6.1	end
3	576	Dip	H	-57.5	Pk	24.4	19.1	44.3	53.9	9.6	end
4	576	Dip	V	-57.1	Pk	24.4	19.1	44.7	53.9	9.2	side
5	864	Dip	H	-75.2	Pk	28.1	16.9	32.5	53.9	21.4	flat
6	864	Dip	V	-76.0	Pk	28.1	16.9	31.7	53.9	22.2	side
7	1152	Horn	H	-57.9	Pk	20.2	28.1	30.7	53.9	23.2	end
8	1440	Horn	H	-51.1	Pk	21.2	28.3	38.4	53.9	15.6	end
9	1728	Horn	H	-64.5	Pk	21.9	27.8	26.1	53.9	27.9	side
10	2016	Horn	H	-63.4	Pk	22.5	26.6	29.0	53.9	24.9	side
11	2304	Horn	H	-69.0	Pk	23.2	26.9	23.9	53.9	30.1	max all, noise
12	2592	Horn	H	-69.0	Pk	24.0	26.6	24.9	53.9	29.0	max all, noise
13	2880	Horn	H	-69.0	Pk	24.8	25.5	26.8	53.9	27.2	max all, noise
14											
15	288	Dip	H	-24.8	Pk	18.1	22.7	71.6	73.9	2.3	side 50% duty factor (meas. -6.0 dB)
16	288	Dip	V	-29.7	Pk	18.1	22.7	66.7	73.9	7.2	end
17	576	Dip	H	-62.6	Pk	24.4	19.1	43.7	53.9	10.2	end
18	576	Dip	V	-61.6	Pk	24.4	19.1	44.7	53.9	9.2	side
19	864	Dip	H	-78.9	Pk	28.1	16.9	33.3	53.9	20.6	flat
20	864	Dip	V	-77.0	Pk	28.1	16.9	35.2	53.9	18.7	side
21	1152	Horn	H	-63.2	Pk	20.2	28.1	29.9	53.9	24.0	end
22	1440	Horn	H	-56.9	Pk	21.2	28.3	37.1	53.9	16.9	end
23	1728	Horn	H	-63.0	Pk	21.9	27.8	32.1	53.9	21.9	flat, noise
24	2016	Horn	H	-66.1	Pk	22.5	26.6	30.8	53.9	23.1	flat
25	2304	Horn	H	-69.0	Pk	23.2	26.9	28.4	53.9	25.6	max all, noise
26	2592	Horn	H	-68.0	Pk	24.0	26.6	30.4	53.9	23.5	flat, noise
27	2880	Horn	H	-69.0	Pk	24.8	25.5	31.3	53.9	22.7	max all, noise
28											
29											
30											

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

Meas. 2/13-14, 24-25/00

Table 5.1(Cont.). Highest Emissions Measured

Radiated Emissions											JCI, 120N; 288 MHz
#	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	288	Dip	H	-28.8	Pk	18.1	22.7	72.1	73.9	1.8	side 80% duty factor (meas. -1.5 dB)
2	288	Dip	V	-32.8	Pk	18.1	22.7	68.1	73.9	5.8	end
3	576	Dip	H	-70.9	Pk	24.4	19.4	39.6	53.9	14.4	end
4	576	Dip	V	-76.5	Pk	24.4	19.4	34.0	53.9	20.0	end
5	864	Dip	H	-79.0	Pk	28.1	17.3	37.3	53.9	16.6	side
6	864	Dip	V	-78.0	Pk	28.1	17.3	38.3	53.9	15.6	flat
7	1152	Horn	H	-78.0	Pk	20.2	28.1	19.6	53.9	34.3	end
8	1440	Horn	H	-60.1	Pk	21.2	28.3	38.4	53.9	15.6	flat
9	1728	Horn	H	-65.0	Pk	21.9	27.8	34.6	53.9	19.4	flat, noise
10	2016	Horn	H	-67.0	Pk	22.5	26.6	34.4	53.9	19.5	flat, noise
11	2304	Horn	H	-69.0	Pk	23.2	26.9	32.9	53.9	21.1	max all, noise
12	2592	Horn	H	-67.7	Pk	24.0	26.6	35.2	53.9	18.7	flat
13	2880	Horn	H	-69.0	Pk	24.8	25.5	35.8	53.9	18.2	max all, noise
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29		Digital emissions are more than 20 dB below FCC Class B limit.									
30											

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

Meas. 2/13-14, 24-25/00

Table 5.2. Highest Emissions Measured

Radiated Emissions											JCI, 120N; 310 MHz
#	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	310	Dip	H	-19.5	Pk	18.8	22.3	73.5	75.3	1.8	side 30% duty factor (meas. -10.5 dB)
2	310	Dip	V	-21.6	Pk	18.8	22.3	71.4	75.3	3.9	end
3	620	Dip	H	-51.3	Pk	25.1	19.0	51.3	55.3	4.0	flat
4	620	Dip	V	-53.8	Pk	25.1	19.0	48.8	55.3	6.5	side
5	927	Dip	H	-77.0	Pk	26.1	16.7	28.9	55.3	26.4	max all
6	927	Dip	V	-76.0	Pk	26.1	16.7	29.9	55.3	25.4	max all
7	1240	Horn	H	-55.5	Pk	20.4	28.0	33.4	54.0	20.6	end
8	1550	Horn	H	-51.1	Pk	21.5	28.2	38.7	54.0	15.4	end
9	1860	Horn	H	-62.4	Pk	22.1	28.3	27.9	55.3	27.4	flat
10	2170	Horn	H	-66.9	Pk	22.8	27.1	25.3	55.3	30.0	max all, noise
11	2480	Horn	H	-68.0	Pk	23.8	26.5	25.8	55.3	29.5	max all, noise
12	2790	Horn	H	-68.0	Pk	24.5	25.6	27.4	54.0	26.6	max all, noise
13	3100	Horn	H	-70.0	Pk	25.8	25.1	27.3	55.3	28.1	max all, noise
14											
15	310	Dip	H	-24.1	Pk	18.8	22.3	73.4	75.3	1.9	side 50% duty factor (meas. -6.0 dB)
16	310	Dip	V	-26.4	Pk	18.8	22.3	71.1	75.3	4.2	end
17	620	Dip	H	-59.0	Pk	25.1	19.0	48.1	55.3	7.2	flat
18	620	Dip	V	-59.9	Pk	25.1	19.0	47.2	55.3	8.1	side
19	930	Dip	H	-74.0	Pk	26.1	16.6	36.5	55.3	18.9	max all
20	930	Dip	V	-78.0	Pk	26.1	16.6	32.5	55.3	22.9	max all
21	1240	Horn	H	-61.0	Pk	20.4	28.0	32.4	54.0	21.6	end
22	1550	Horn	H	-55.7	Pk	21.5	28.2	38.6	54.0	15.5	end
23	1860	Horn	H	-66.5	Pk	22.1	28.3	28.3	55.3	27.1	end
24	2170	Horn	H	-67.0	Pk	22.8	27.1	29.7	55.3	25.6	max all, noise
25	2480	Horn	H	-69.0	Pk	23.8	26.5	29.3	55.3	26.0	max all, noise
26	2790	Horn	H	-69.0	Pk	24.5	25.6	30.9	54.0	23.1	max all, noise
27	3100	Horn	H	-70.0	Pk	25.8	25.1	31.8	55.3	23.6	max all, noise
28											
29											
30											

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

Meas. 2/13-14, 24-25/00

Table 5.2(Cont.). Highest Emissions Measured

Radiated Emissions										JCI, 120N; 310 MHz
#	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	310	Dip	H	-28.4	Pk	18.8	22.3	73.6	75.3	1.7	side 80% duty factor (meas. -1.5 dB)
2	310	Dip	V	-31.6	Pk	18.8	22.3	70.4	75.3	4.9	end
3	620	Dip	H	-66.2	Pk	25.1	19.0	45.4	55.3	9.9	flat
4	620	Dip	V	-66.8	Pk	25.1	19.0	44.8	55.3	10.5	side
5	927	Dip	H	-79.0	Pk	26.1	16.7	35.9	55.3	19.4	max all
6	927	Dip	V	-73.7	Pk	26.1	16.7	41.2	55.3	14.1	max all
7	1240	Horn	H	-63.3	Pk	20.4	28.0	34.6	54.0	19.4	end
8	1550	Horn	H	-58.9	Pk	21.5	28.2	39.9	54.0	14.2	flat
9	1860	Horn	H	-67.0	Pk	22.1	28.3	32.3	55.3	23.1	side, noise
10	2170	Horn	H	-69.0	Pk	22.8	27.1	32.2	55.3	23.1	max all, noise
11	2480	Horn	H	-69.0	Pk	23.8	26.5	33.8	55.3	21.5	max all, noise
12	2790	Horn	H	-69.0	Pk	24.5	25.6	35.4	54.0	18.6	max all, noise
13	3100	Horn	H	-70.0	Pk	25.8	25.1	36.3	55.3	19.1	max all, noise
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29		Digital emissions are more than 20 dB below FCC Class B limit.									
30											

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

Meas. 2/13-14, 24-25/00

Table 5.3. Highest Emissions Measured

Radiated Emissions										JCI, 120N; 418 MHz
#	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	418	Dip	H	-24.3	Pk	21.1	20.7	72.6	80.3	7.7	side 30% duty factor (meas. -10.5 dB)
2	418	Dip	V	-22.2	Pk	21.1	20.7	74.7	80.3	5.6	end
3	836	Dip	H	-55.5	Pk	27.7	17.1	51.6	60.3	8.7	end
4	836	Dip	V	-58.2	Pk	27.7	17.1	48.9	60.3	11.4	side
5	1254	Horn	H	-48.0	Pk	20.5	28.1	40.9	60.3	19.4	end
6	1672	Horn	H	-51.8	Pk	21.5	28.1	38.1	54.0	15.9	end
7	2090	Horn	H	-62.2	Pk	22.7	26.8	30.2	60.3	30.1	flat
8	2508	Horn	H	-64.6	Pk	24.0	26.5	29.4	60.3	30.9	flat
9	2926	Horn	H	-69.0	Pk	25.1	25.2	27.4	60.3	32.9	max all, noise
10	3344	Horn	H	-70.0	Pk	26.5	24.7	28.3	54.0	25.7	max all, noise
11	3762	Horn	H	-70.0	Pk	27.7	24.3	29.9	54.0	24.1	max all, noise
12	4180	Horn	H	-71.0	Pk	28.9	20.7	33.7	54.0	20.3	max. all, noise
13											
14	418	Dip	H	-28.4	Pk	21.1	20.7	73.3	80.3	7.0	side 50% duty factor (meas. -6.0 dB)
15	418	Dip	V	-26.3	Pk	21.1	20.7	75.4	80.3	4.9	end
16	836	Dip	H	-60.5	Pk	27.7	17.1	51.4	60.3	8.9	flat
17	836	Dip	V	-71.1	Pk	27.7	17.1	40.8	60.3	19.5	flat
18	1254	Horn	H	-52.8	Pk	20.5	28.1	40.9	60.3	19.4	end
19	1672	Horn	H	-56.4	Pk	21.5	28.1	38.3	54.0	15.7	end
20	2090	Horn	H	-64.6	Pk	22.7	26.8	32.6	60.3	27.7	flat
21	2508	Horn	H	-68.0	Pk	24.0	26.5	30.8	60.3	29.5	max all, noise
22	2926	Horn	H	-69.0	Pk	25.1	25.2	32.2	60.3	28.1	max all, noise
23	3344	Horn	H	-70.0	Pk	26.5	24.7	33.1	54.0	20.9	max all, noise
24	3762	Horn	H	-70.0	Pk	27.7	24.3	34.7	54.0	19.3	max all, noise
25	4180	Horn	H	-72.0	Pk	28.9	20.7	37.5	54.0	16.5	max. all, noise
26											
27											
28											
29											
30											

Conducted Emissions						
#	Line Side	Line Side	Det. Used	Vtest dBμV	Vlim dBμV	Pass dB	Comments
1							
2							
3							
4				Not Applicable			
5							

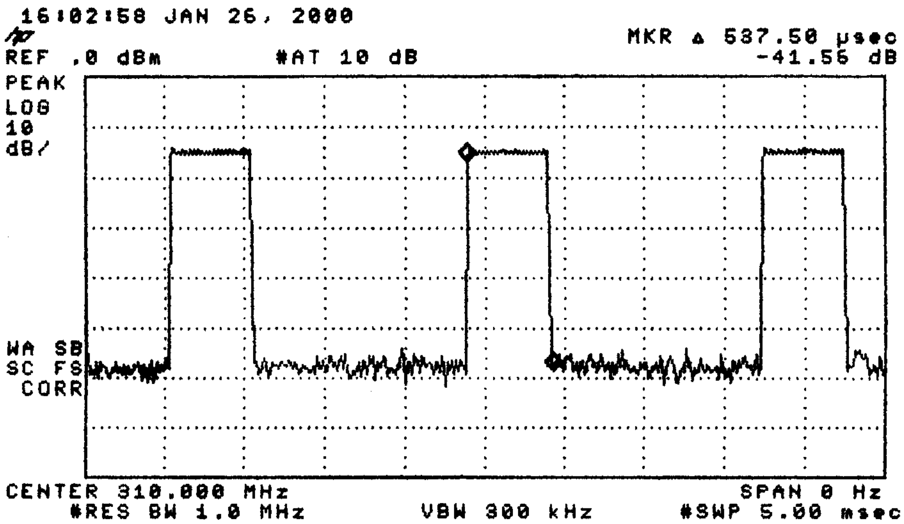
Meas. 2/13-14, 24-25/00

Table 5.3(Cont.). Highest Emissions Measured

Radiated Emissions											JCI, 120N; 418 MHz
#	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	418	Dip	H	-33.0	Pk	21.1	20.7	72.9	80.3	7.4	side 80% duty factor (meas. -1.5 dB)
2	418	Dip	V	-30.8	Pk	21.1	20.7	75.1	80.3	5.2	end
3	836	Dip	H	-68.6	Pk	27.7	17.1	47.5	60.3	12.8	flat
4	836	Dip	V	-72.3	Pk	27.7	17.1	43.8	60.3	16.5	side
5	1254	Horn	H	-57.5	Pk	20.5	28.1	40.4	60.3	19.9	flat
6	1672	Horn	H	-60.4	Pk	21.5	28.1	38.5	54.0	15.5	flat
7	2090	Horn	H	-65.7	Pk	22.7	26.8	35.7	60.3	24.6	flat
8	2508	Horn	H	-69.0	Pk	24.0	26.5	34.0	60.3	26.3	max all, noise
9	2926	Horn	H	-69.0	Pk	25.1	25.2	36.4	60.3	23.9	max all, noise
10	3344	Horn	H	-70.0	Pk	26.5	24.7	37.3	54.0	16.7	max all, noise
11	3762	Horn	H	-70.0	Pk	27.7	24.3	38.9	54.0	15.1	max all, noise
12	4180	Horn	H	-72.0	Pk	28.9	20.7	41.7	54.0	12.3	max. all, noise
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29		Digital emissions are more than 20 dB below FCC Class B limit.									
30											

Conducted Emissions							
#	Line Side	Line Side	Det. Used	Vtest dBµV	Vlim dBµV	Pass dB	Comments
1							
2							
3							
4				Not Applicable			
5							

Meas. 2/13-14, 24-25/00



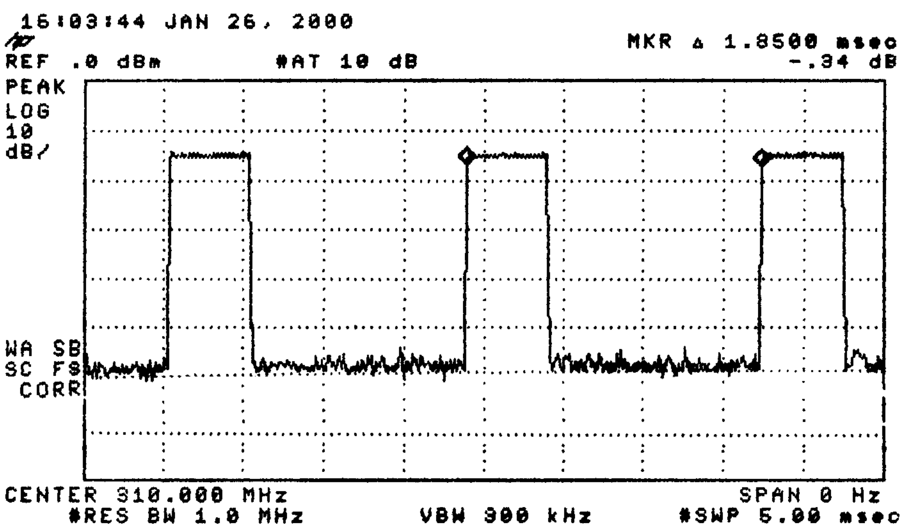
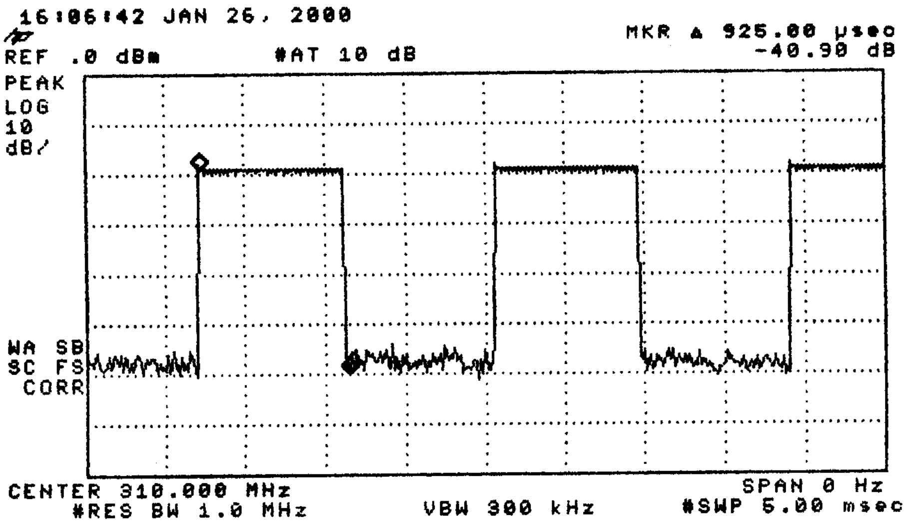


Figure 6.1(a). Transmissions modulation characteristics: (top) pulse width, (bottom) pulse period. (310 MHz, 30% duty factor)



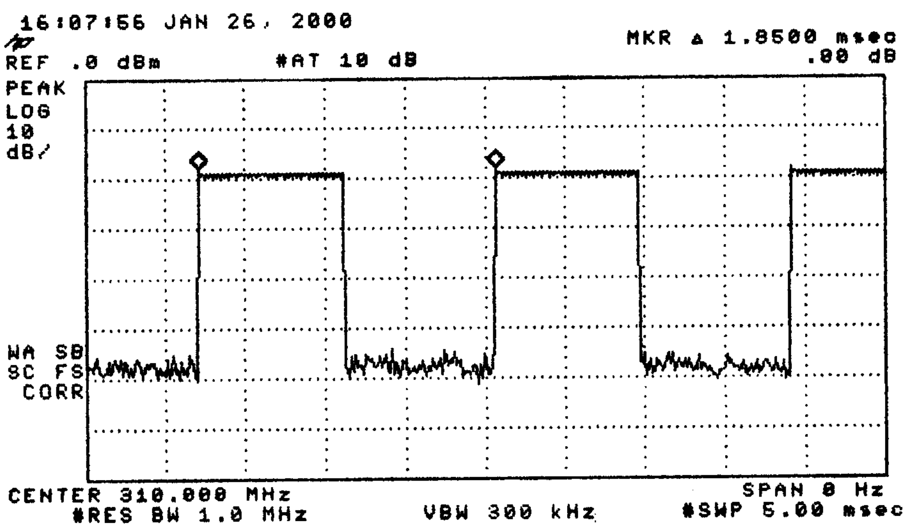
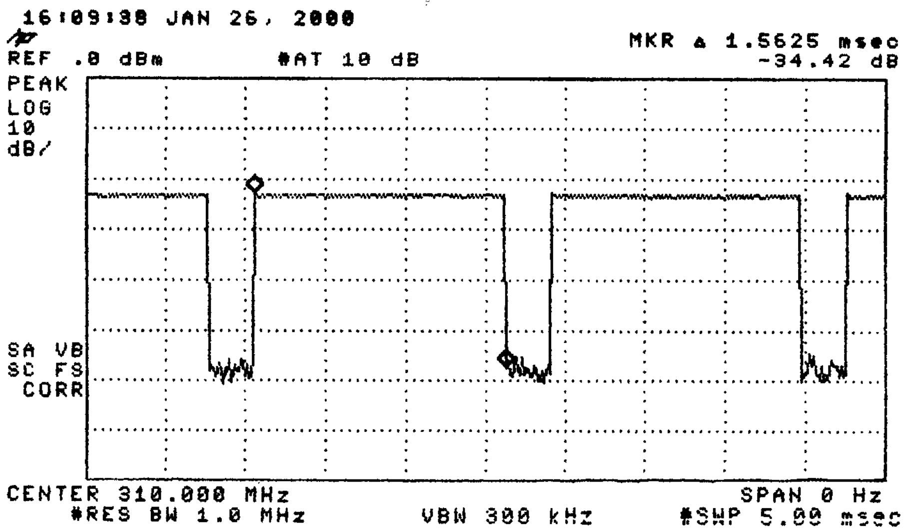


Figure 6.1(b). Transmissions modulation characteristics: (top) pulse width, (bottom) pulse period. (310 MHz, 50% duty factor)



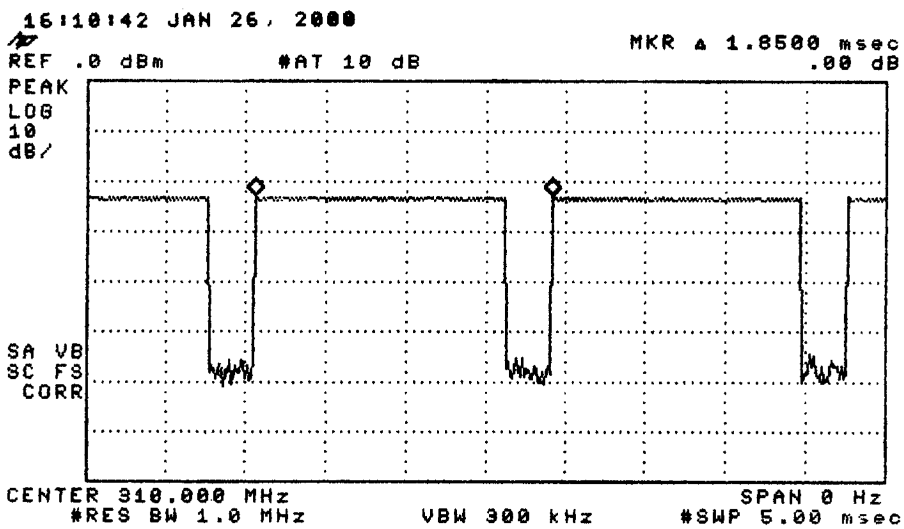


Figure 6.1(c). Transmissions modulation characteristics: (top) pule width, (bottom) pulse period. (310 MHz, 80% duty factor)

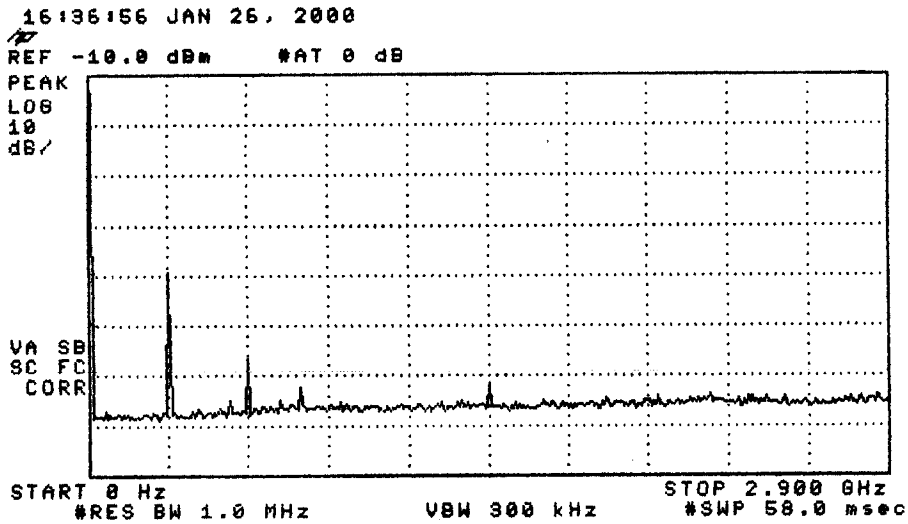


Figure 6.2(a). Emission spectrum of the DUT (288 MHz, 50% duty factor) The amplitudes are only indicative (not calibrated).

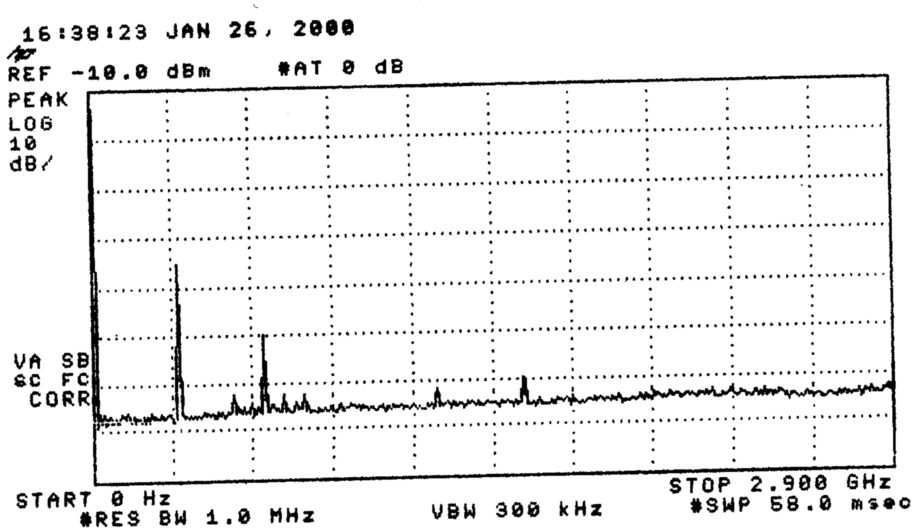


Figure 6.2(b). Emission spectrum of the DUT (310 MHz, 50% duty factor). The amplitudes are only indicative (not calibrated).

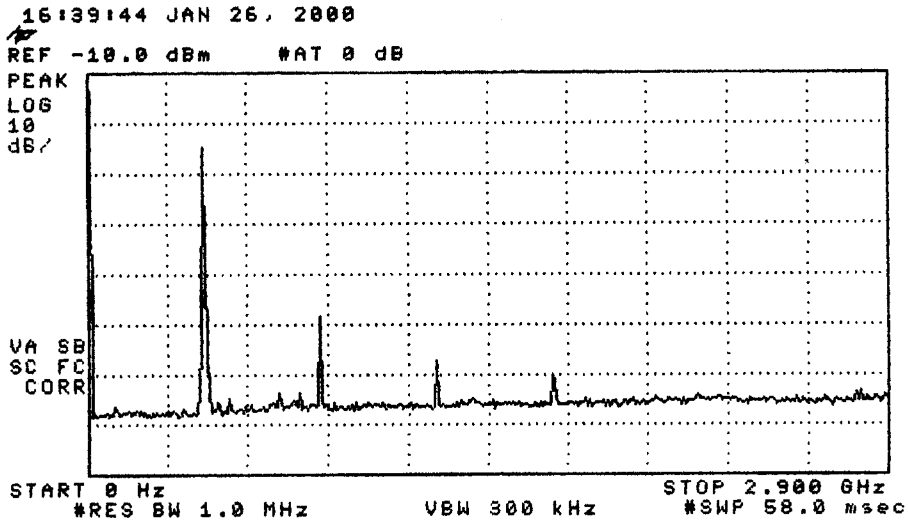


Figure 6.2(c). Emission spectrum of the DUT (418 MHz, 50% duty factor).
The amplitudes are only indicative (not calibrated).

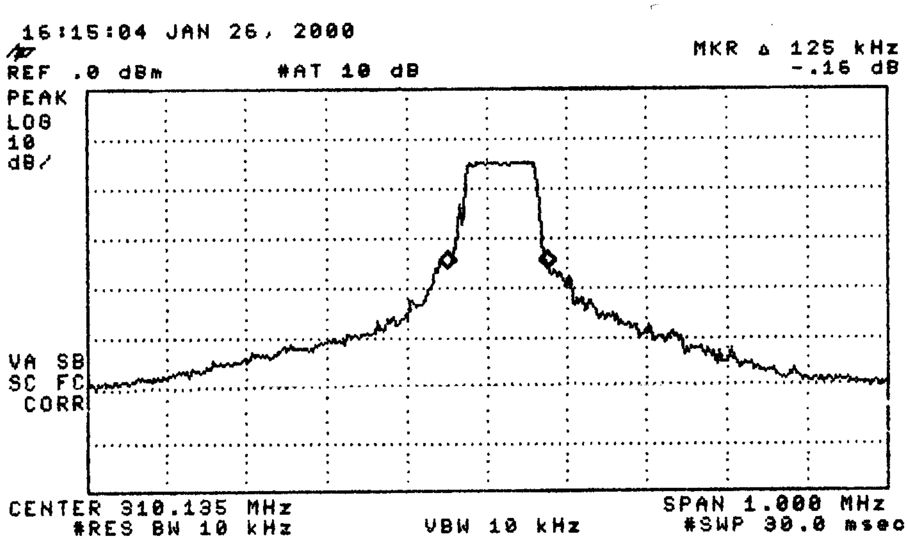


Figure 6.3(a). Measured bandwidth of the DUT.
(Pulsed mode, 310 MHz, 30% duty factor).

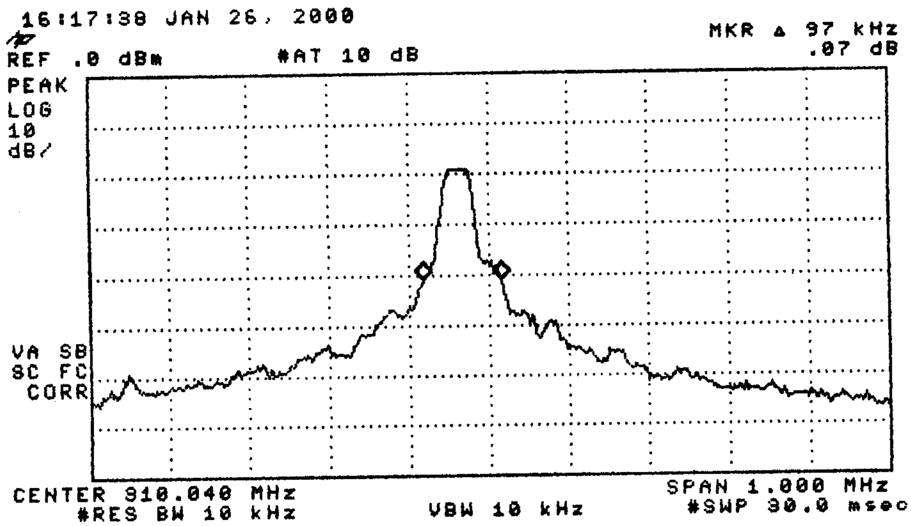


Figure 6.3(b). Measured bandwidth of the DUT.
(Pulsed mode, 310 MHz, 50% duty factor).

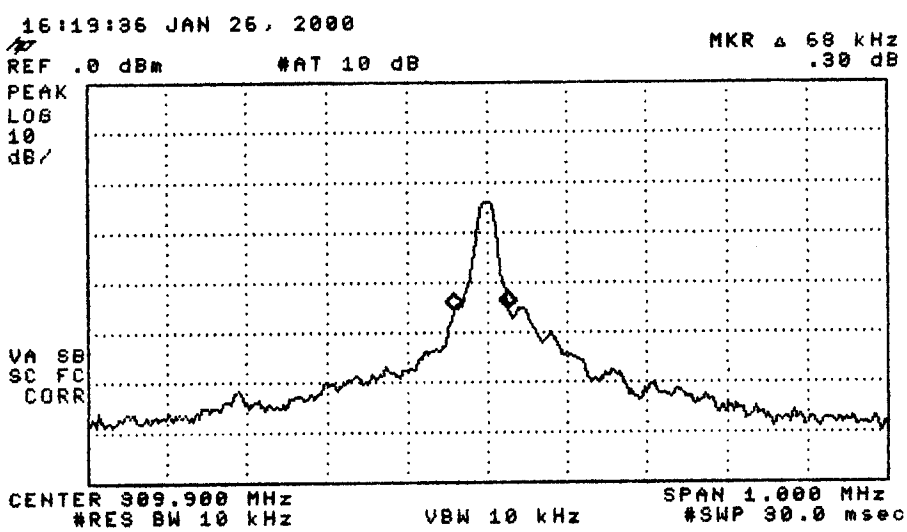


Figure 6.3(c). Measured bandwidth of the DUT.
(Pulsed mode, 310 MHz, 80% duty factor).

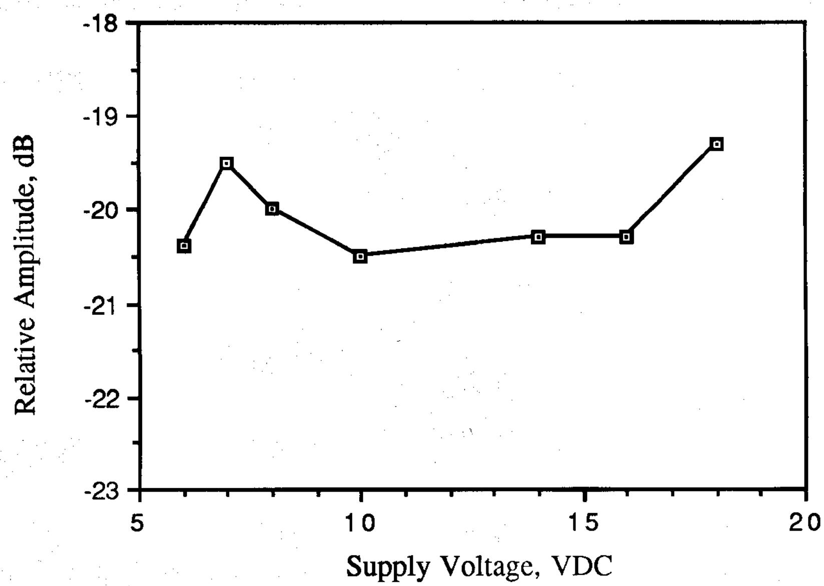


Figure 6.4. Relative emission vs. supply voltage. (310 MHz, continuous pulsed)