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

Measured Radio Frequency Emissions
From

Think Wireless Receiver
Model(s): SIRWRR1

Report No. 415031-356
March 15, 2007

For:
Think Wireless, Inc.
6188 NW 62nd Ter
Parkland, FL 33067

Contact:
Argy Petros
argy.petros@thinkwireless.com
Tel: 561-434-3777
Fax: 954-317-5659
PO: Verbal

Measurements made by: Joseph D. Brunett

Test Report Prepared by: Joseph D. Brunett

Tests supervised by:
Report approved by:

Valdis V. Liepa
Research Scientist

Summary

Tests for compliance with FCC Regulations Part 15, Subpart B, and Industry Canada RSS-210/GEN, were performed on Think model SIRWRR1. This device is subject to the Rules and Regulations as a Receiver and a digital device.

In testing completed on March 14, 2007, the device tested in the worst case met the allowed Class B specifications for radiated emissions by 11.0 dB (see p. 6). The device demonstrates compliance with power line conducted emissions limits by more than 4.0 dB.

1. Introduction

Think model SIRWRR1 was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989 as subsequently amended, and with Industry Canada RSS-210, Issue 6 and RSS-Gen, Issue 1, September, 2005. The tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-2003 "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 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)	X	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)	X	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 Box		University of Michigan
Signal Generator	X	Hewlett-Packard 8657B

3. Configuration and Identification of Device Under Test

3.1 Design and Identification of the Device

The DUT was designed by Think Wireless, Inc., 6188 NW 62nd Ter, Parkland, FL 33067. It is identified as:

Think Wireless Receiver
Model(s): SIRWRR1
FCC ID: UX3TWISIRWRR1

3.2 Models

There is only one model of the device. The DUT is a superheterodyne receiver / up-converter that translates received signal in the 902-928 MHz ISM band and outputs the up-converted spectrum at 2.3 GHz SIRIUS Radio SDARS band via a coaxial cable to a SIRIUS satellite receiver. It is housed in a plastic case approximately 3.5 by 3.5 by 0.5 inches. Antenna is attached to case. For testing, a bias-t was provided by the manufacturer to inject the 5 VDC supply onto the coaxial cable. This modules does not decode the received signal, and thus no other digital logic is used.

3.1 Modifications Made

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

4. Emission Limits

The DUT tested falls under Part 15, Subpart B, "Unintentional Radiators". 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 (Ref: FCC 15.33, 15.35, and 15.109; IC RSS-210, 2.6 Table 2).

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

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

4.2 Power Line Conducted Emission Limits

Table 4.3 Conducted Emission Limits (FCC:15.107 (CISPR); IC: RSS-Gen, 7.2.2 Table 2).

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 – 5.0	73	60	56	46
5.0 – 30.0	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 Quasi-peak: dBμV = 50.25 - 19.12*log(f)

*Class B Average: dBμV = 40.25 - 19.12*log(f)

3. 9 kHz RBW

4.3 Antenna Power Conduction Limits

Ref: FCC 15.111(a). Pmax = 2 nW; for frequency range see Table 4.1.

5. Emission Tests and Results

Even though the FCC and Industry Canada specify radiated and conductive emissions be measured using the Quasi-Peak and/or average detection schemes, we normally use peak detection since 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 re-measured using the appropriate detection scheme. Note, a peak detected signal is always greater than or equal to the Quasi-Peak or average detected signal. In this report the margin of compliance may be better, but not worse than that indicated. The type of detection used is indicated in the data table, Table 5.1.

5.1 Anechoic Chamber Radiated Emission Tests

To become familiar with the emission behavior of the DUT, the device was first studied and measured in a shielded semi-anechoic chamber. In the chamber is a set-up similar to that of an outdoor 3-meter site, with a 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 22 VDC. The receiver was activated, attached to a Styrofoam 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. Detection of the LO required the addition of an LNA. 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 less than 3m distance, 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, while those above 1000 MHz (Fig. 5.2) are used in final assessment for compliance.

5.2 Open Area Test Site Radiated Emission Tests

After the chamber measurements are complete, emissions are re-measured on the outdoor 3-meter open area test site up to 1 GHz using tuned dipoles and/or a high frequency biconical antenna. 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 (see Section 5.0). Sometimes lower IF bandwidth is used to help bring signals out of noise and this is noted in the data table. The DUT is placed on the test table flat, on its side, and on its end, and worst case emissions are recorded. Photographs included in this filing show the DUT on the OATS.

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 11.0 dB.

5.4 Conducted Emission Tests
The DUT is powered from 5 VDC injected into the output coaxial cable. For the purposes of our testing the device was powered by a laboratory power supply using a bias-t. AC power line conducted emissions are reported for this configuration in Table 5.2, demonstrating DUT compliance.

6. Other Measurements

6.1 Emission Spectrum
The only detectable RF emission occurs at the LO or 2 x LO. The emission spectrum is measured typically over 1 MHz span. This data is taken with the DUT close to antenna and hence amplitudes are relative. The plot is shown in Figure 6.1.

6.2 Effect of Supply Voltage Variation
The DUT has been designed to operate from 5 VDC power. Using a spectrum analyzer, relative radiated emissions were recorded at the LO (or 2 x LO) as voltage was varied from 3 to 7.0 VDC. Figure 6.2 shows the emission variation.

6.3 Operating Voltage and Current

V = 5 VDC
I = 60 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											Think SIRWRR; 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	1411.0	Horn	H	-65.8	Pk	20.6	28.0	33.9	54.0	20.2	LO, max all
2	2822.0	Horn	H	-63.9	Pk	21.0	25.6	38.5	54.0	15.5	noise
3											
4											
5											
Digital Radiated Emissions											
#	Freq. kHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBμV/m	E3lim dBμV/m	Pass dB	Comments
6	41.8	Bic	H	-80.4	Pk	10.4	25.9	11.2	40.0	28.8	noise
7	41.8	Bic	V	-78.0	Pk	10.4	25.9	13.6	40.0	26.4	noise
8	64.8	Bic	H	-77.3	Pk	7.8	25.5	12.0	40.0	28.0	background
9	64.8	Bic	V	-73.8	Pk	7.8	25.5	15.5	40.0	24.5	background
10	79.8	Bic	H	-72.9	Pk	7.6	25.3	16.4	40.0	23.6	background
11	79.8	Bic	V	-75.9	Pk	7.6	25.3	13.4	40.0	26.6	background
12	138.6	Bic	H	-82.9	Pk	11.6	24.4	11.3	43.5	32.2	noise
13	138.6	Bic	V	-84.4	Pk	11.6	24.4	9.8	43.5	33.7	noise
14	208.3	Bic	H	-81.3	Pk	14.8	23.4	17.1	43.5	26.4	noise
15	208.3	Bic	V	-77.7	Pk	14.8	23.4	20.7	43.5	22.8	background
16	258.6	SBic	H	-79.2	Pk	16.0	22.9	20.9	46.0	25.1	background
17	258.6	SBic	V	-78.5	Pk	16.0	22.9	21.6	46.0	24.4	background
18	291.4	SBic	H	-82.9	Pk	17.5	22.5	19.1	46.0	26.9	noise
19	291.4	SBic	V	-82.4	Pk	17.5	22.5	19.6	46.0	26.4	noise
20	318.9	SBic	H	-81.4	Pk	18.6	22.2	22.0	46.0	24.0	noise
21	318.9	SBic	V	-78.7	Pk	18.6	22.2	24.7	46.0	21.3	background
22	400.1	SBic	H	-81.4	Pk	21.1	21.3	25.4	46.0	20.6	noise
23	400.1	SBic	V	-80.7	Pk	21.1	21.3	26.1	46.0	19.9	noise
24	428.0	SBic	H	-82.2	Pk	21.8	21.0	25.6	46.0	20.4	noise
25	428.0	SBic	V	-81.7	Pk	21.8	21.0	26.1	46.0	19.9	noise
26	547.8	SBic	H	-82.3	Pk	23.9	19.9	28.7	46.0	17.3	noise
27	547.8	SBic	V	-77.8	Pk	23.9	19.9	33.2	46.0	12.8	background
28	751.5	SBic	H	-81.9	Pk	26.7	18.4	33.4	46.0	12.6	noise
29	751.5	SBic	V	-83.3	Pk	26.7	18.4	32.0	46.0	14.0	noise
30	1198.0	Horn	H/V	-63.0	Pk	20.4	28.0	36.4	54.0	17.6	background
31	1500.0	Horn	H/V	-67.2	Pk	21.3	28.0	33.1	54.0	20.9	noise
32	2000.0	Horn	H/V	-66.3	Pk	22.5	27.4	35.8	54.0	18.2	noise
33	2500.0	Horn	H/V	-62.9	Pk	23.8	26.3	41.6	54.0	12.4	noise
34	3000.0	Horn	H/V	-64.1	Pk	25.3	25.3	43.0	54.0	**11.0**	noise
35											
36											

Meas. 3/14/2007; U of Mich.

Table 5.2 Highest Conducted Emissions Measured

Think SIRWRR1; FCC/CISPR B												
	Freq.	Line	Peak Det., dBμV		Pass	QP Det., dBμV		Pass	Ave. Det., dBμV		Pass	
#	MHz	Side	Vtest	Vlim*	dB*	Vtest	Vlim	dB	Vtest	Vlim	dB	Comments
1	0.18	Lo	47.3	54.3	7.0		64.4			54.3		
2	0.23	Lo	44.7	52.5	7.8		62.5			52.5		
3	0.27	Lo	44.2	51.1	6.9		61.1			51.1		
4	0.31	Lo	43.0	49.9	6.9		59.9			49.9		
5	0.35	Lo	42.1	48.8	6.7		58.9			48.8		
6	0.41	Lo	40.8	47.7	6.9		57.8			47.7		
7	0.47	Lo	40.6	46.5	6.0		56.6			46.5		
8	0.49	Lo	39.4	46.1	6.6		56.1			46.1		
9	0.51	Lo	40.0	46.0	6.0		56.0			46.0		
10	0.77	Lo	40.2	46.0	**5.8**		56.0			46.0		
11	3.54	Lo	28.7	46.0	17.3		56.0			46.0		
12	5.43	Lo	25.6	50.0	24.4		60.0			50.0		
13	5.99	Lo	26.3	50.0	23.7		60.0			50.0		
14	6.97	Lo	28.4	50.0	21.6		60.0			50.0		
15												
16	0.15	Hi	48.4	55.7	7.3		65.8			55.7		
17	0.18	Hi	49.2	54.3	5.2		64.4			54.3		
18	0.23	Hi	46.9	52.5	5.6		62.5			52.5		
19	0.26	Hi	46.2	51.5	5.3		61.6			51.5		
20	0.28	Hi	44.5	50.9	6.4		61.0			50.9		
21	0.31	Hi	44.3	49.9	5.5		59.9			49.9		
22	0.32	Hi	44.5	49.6	5.2		59.7			49.6		
23	0.33	Hi	44.6	49.4	4.8		59.4			49.4		
24	0.38	Hi	43.5	48.3	4.8		58.4			48.3		
25	0.42	Hi	43.3	47.3	**4.0**		57.4			47.3		
26	2.70	Hi	28.6	46.0	17.4		56.0			46.0		
27	3.05	Hi	28.0	46.0	18.0		56.0			46.0		
28	4.52	Hi	27.9	46.0	18.1		56.0			46.0		
29	5.22	Hi	27.2	50.0	22.9		60.0			50.0		
30	7.04	Hi	28.9	50.0	21.1		60.0			50.0		
31												
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42												
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**Average limit* Meas. 01/31/2007; U of Mich.

Since Vpeak >= Vqp >= Vave and if Vtestpeak < Vavelim, then Vqplim and Vavelim are met.

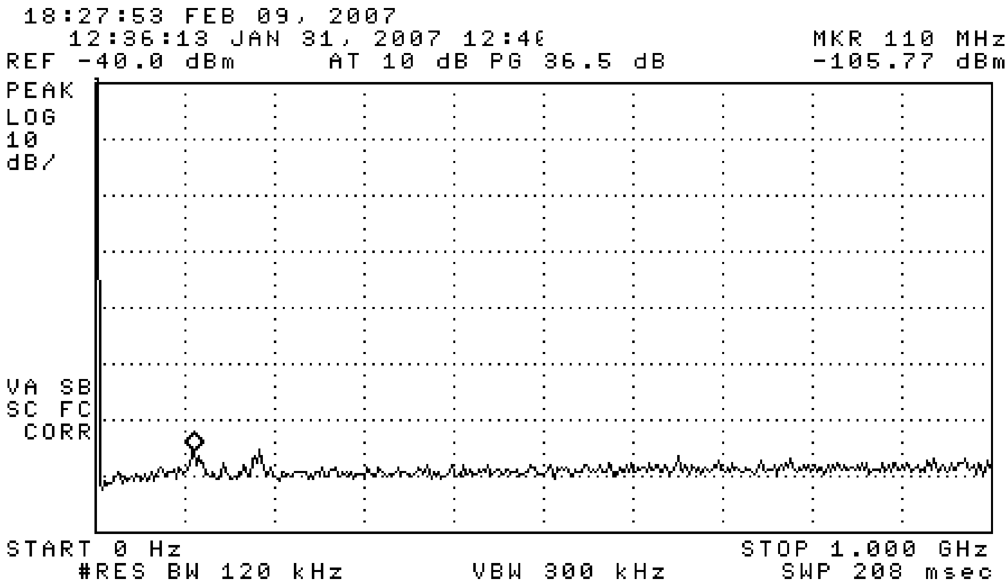

Figure 5.1. Emissions measured at 3 meters in chamber, 0-1000 MHz.

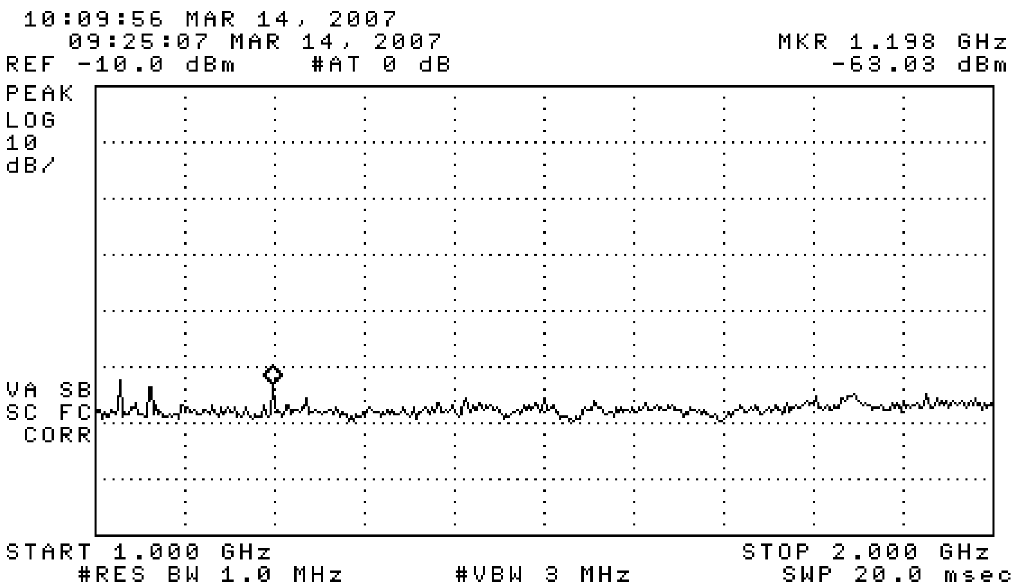

Figure 5.2. Emissions measured at 3 meters in chamber, 1000-2000 MHz.
(emission at marker is background)

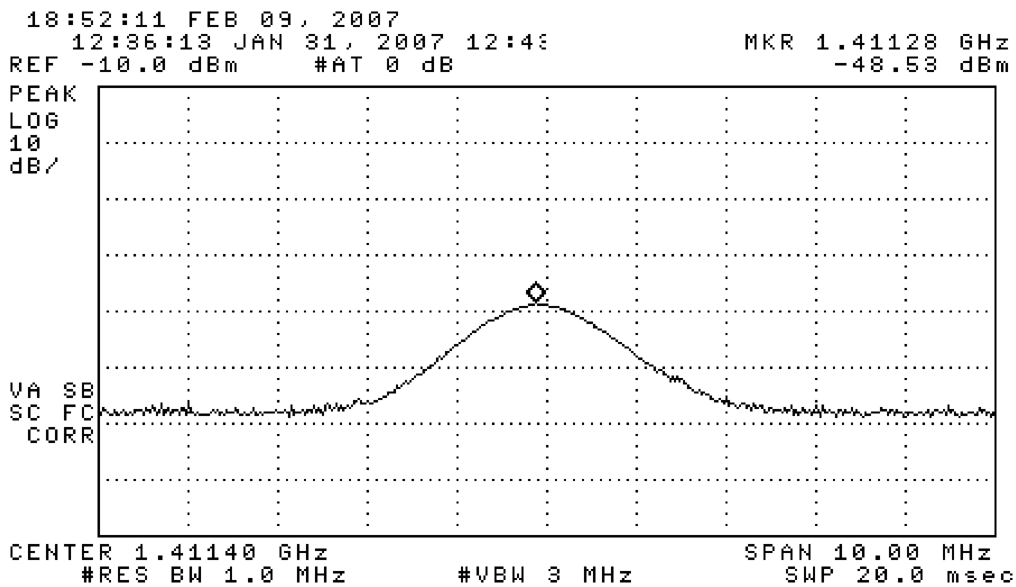

Figure 6.1. Relative receiver emissions.

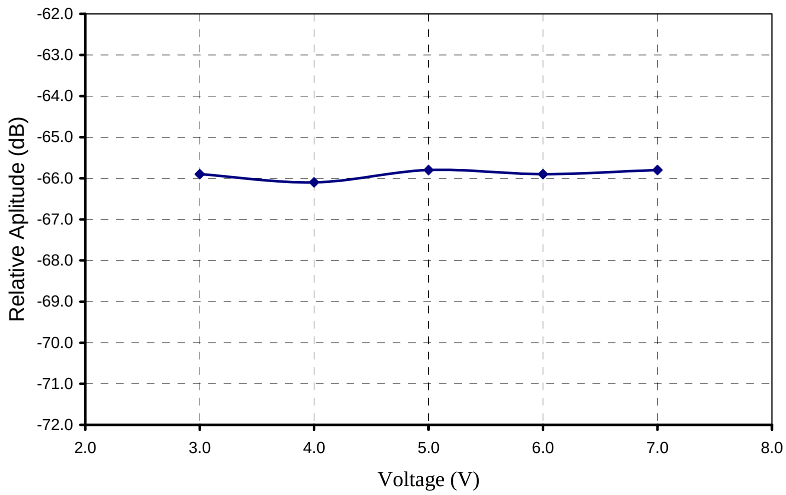

Figure 6.2. Relative emission at vs. supply voltage.

DUT on OATS

DUT on OATS (close-up)