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

Measured Radio Frequency Emissions From

Martec/Allstar 288 MHz Transmitter Model 111025

Report No. 415031-156
January 30, 2003

For:
Martec Access Products Inc.
240 Sheffield Street
Mountainside, NJ 07092

Contact:
Cathy Moran
cam@grtmars.com
Tel: 908-233-5766
Fax: 908-233-0691
PO: 2901-00

Measurements made by: Valdis V. Liepa

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 IC Regulations RSS-210, were performed on Martec/Allstar Transmitter. This device is subject to the Rules and Regulations as a transmitter and as a digital device.

In testing performed on October 13 -November 11, 2002, and January 30, 2003, the device tested in the worst case met the allowed specifications for radiated emissions by 1.5 dB at the fundamental and by 2.4 dB at the harmonics (see p. 6). Besides harmonics, there were no other significant spurious emissions found; emissions from digital circuitry were negligible. The line conducted emission tests do not apply, since the device is powered by a pair of 3-volt batteries.

1. Introduction

Martec/Allstar Transmitter, Model 111025, 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)	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 (50 μH)		University of Michigan
Signal Generator (0.1-2060 MHz)		Hewlett-Packard, 8657B
Signal Generator (0.01-20 GHz)		Hewlett-Packard

3. Configuration and Identification of Device Under Test

The DUT is a battery powered three-button door-control transmitter, 1.75 x 3.0 x 0.5 inches in size. It is push button activated and operates at 288 MHz, ASK modulated. The carrier is LC stabilized; the code is micro genetated based on a 1.2 MHz reference clock. Antenna is a trace on the PCB. The transmitter can be used with or without a metal belt-clip, hence was tested for both configurations. The DUT was designed and manufactured by Martec Access Products Inc., 240 Sheffield Street, Mountainside, NJ 07092.

It is identified as:

Martec/Allstar 288 MHz Transmitter
Model: 111025
SN: M0902-288
FCC ID: NM483AQCT03
IC: 4369A-83AQCT03

One transmitter was provided with two pre-programmed micros. One is for normal operation (max. about 10 second transmission) and the other for continuous pulsed operation as long as a button is depressed.

3.1 EMI Relevant Modifications

None.

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: 15.33, 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)

Table 4.2. Radiated Emission Limits (FCC: 15.231(b), 15.205(a); IC: RSS-210; 6.1, 6.3). (Transmitter)

Frequency (MHz)	Fundamental Ave. E_{lim} (3m)		Spurious** Ave. E_{lim} (3m)	
	(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

4.2 Conductive Emission Limits

The conductive emission limits and tests do not apply here, since the DUT is powered by internal 6-volt battery.

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 by depressing button with a special wooden clamp for repeated pulse emissions. It was placed on the test table flat, on its side, and on its end.

In the chamber we studied and recorded all the emissions using a ridged horn antenna up to 4.4 GHz. The measurements made in the chamber below 1 GHz are used for pre-test evaluation only. The measurements made above 1 GHz are also used in pre-test evaluation and in 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). 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 4.4 GHz, 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

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

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 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 limits by 1.5 dB at fundamental and by 2.4 dB at harmonics.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

When the transmitter is activated by push action, it transmits ASK 288 MHz carrier, as long as the button is depressed, up to 12 seconds. It transmits about 80 ms long words, repeating every 111 ms and the worst case is when the whole word falls within a 100 ms window. In the word there are 18 PWM pulses, the wide being 4.025 ms long. See Figure 6.1. Thus, the duty factor is

$$K_E = (4.025\text{ms} \times 18)/100\text{ms} = 0.7245 \text{ or } -2.8 \text{ dB}.$$

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 allowed (-20 dB) bandwidth is 0.25% of 288 MHz, or 720.0 kHz. From the plot we see that the -20 dB bandwidth is 65.0 kHz, and the center frequency is 288.05 MHz.

6.4 Effect of Supply Voltage Variation

The DUT has been designed to be powered by 6-volt battery. For this test, the battery was replaced by a laboratory variable power supply. Relative power radiated was measured at the fundamental as the voltage was varied from 4 to 7 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage at Battery Terminals

Batteries:	before testing	V_{oc}	=	6.28 V
	after testing	V_{oc}	=	6.06 V
	current at 6 V	I	=	3.9 mA (pulsed)

6.6 Verification for Deactivation Within 5 Seconds

When a button is depressed, the DUT transmits up to 12 seconds. When the button is released, the transmission essentially ceases at that time. Figure 6.5 shows emission when the DUT button is depressed and released; the emission is less than five seconds.

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											Martec/Allstar 288; 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	288	Dip	H	-30.0	Pk	18.1	19.9	72.4	73.9	1.5	flat, w/o metal clip
2	288	Dip	V	-33.9	Pk	18.1	19.9	68.5	73.9	5.4	end
3	576	Dip	H	-60.5	Pk	24.4	16.6	51.5	53.9	2.4	flat
4	576	Dip	V	-67.6	Pk	24.4	16.6	44.4	53.9	9.5	end
5	864	Dip	H	-71.6	Pk	28.1	14.5	46.2	53.9	7.7	flat
6	864	Dip	V	-73.5	Pk	28.1	14.5	44.3	53.9	9.6	end
7	1152	Horn	H	-63.7	Pk	20.2	28.1	32.6	54.0	21.4	side
8	1440	Horn	H	-61.9	Pk	21.2	28.3	35.3	54.0	18.8	flat
9	1728	Horn	H	-64.3	Pk	21.9	27.8	34.0	54.0	20.0	flat
10	2016	Horn	H	-66.2	Pk	22.5	26.6	33.9	54.0	20.1	flat
11	2304	Horn	H	-70.5	Pk	23.2	26.9	30.1	54.0	24.0	end
12	2592	Horn	H	-71.5	Pk	24.0	26.6	30.1	54.0	23.9	side
13	2880	Horn	H	-70.9	Pk	24.8	25.5	32.6	54.0	21.5	side
14											
15	288	Dip	H	-30.0	Pk	18.1	19.9	72.4	73.9	1.5	flat, with metal clip
16		* Includes -2.8 dB duty factor									
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	Emissions in the noise floor; meets Class B limit by at least 20 dB						
3							

Meas. 10/13,11/01/02; U of Mich.

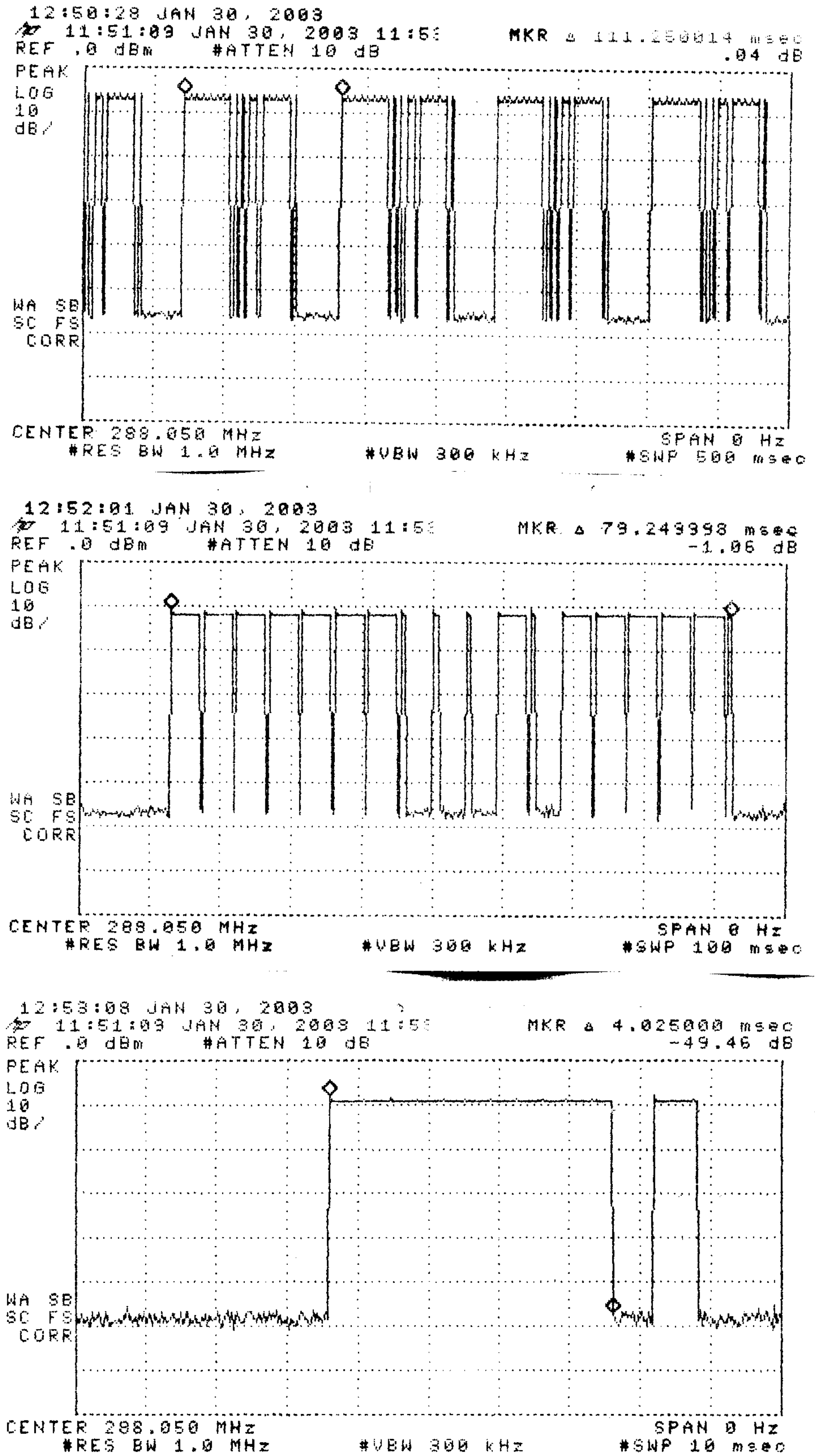


Figure 6.1. Transmissions modulation characteristics: (top) complete transmission, (center) single word, (bottom) expanded bits.

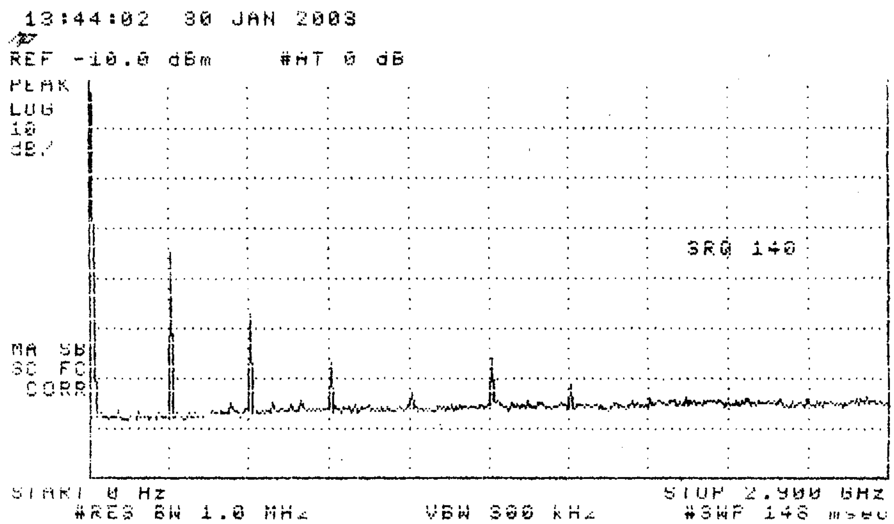


Figure 6.2. Emission spectrum of the DUT (pulsed emission).
The amplitudes are only indicative (not calibrated).

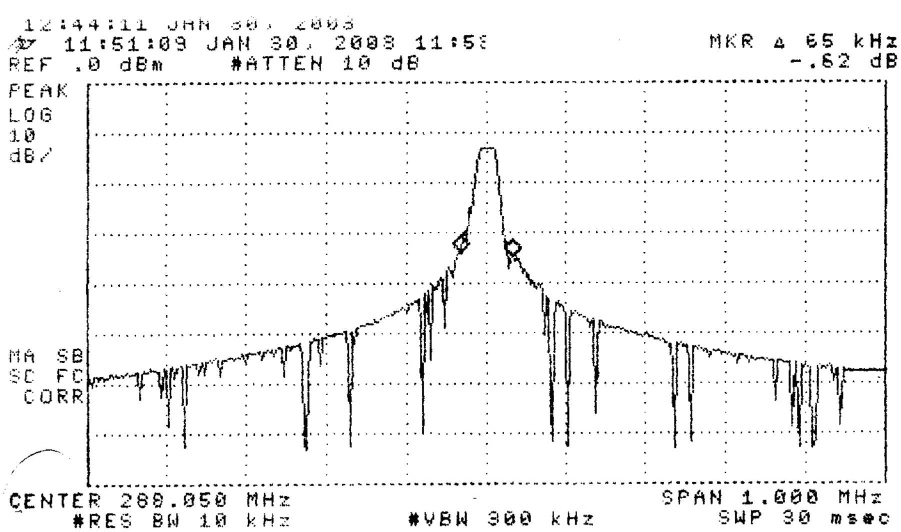


Figure 6.3. Measured bandwidth of the DUT (pulsed emission).

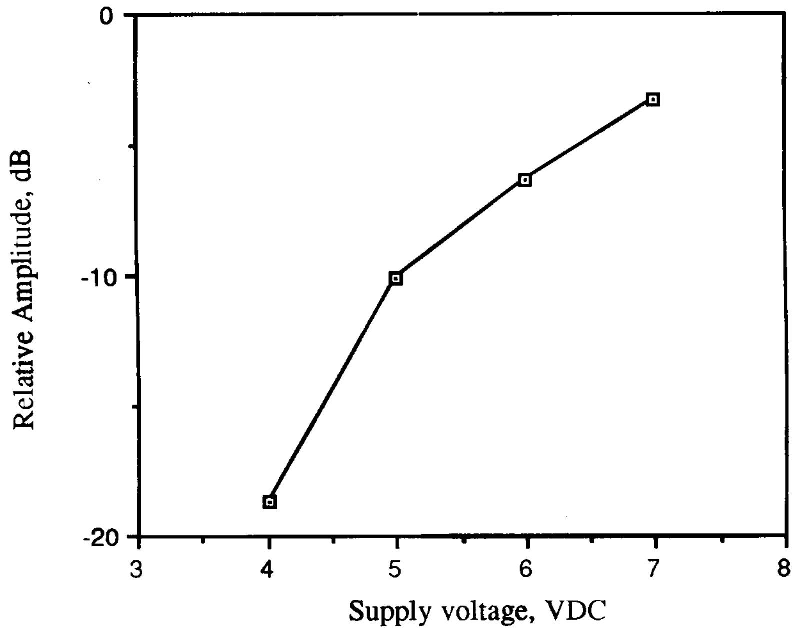


Figure 6.4. Relative fundamental emission vs. supply voltage (pulsed emission).

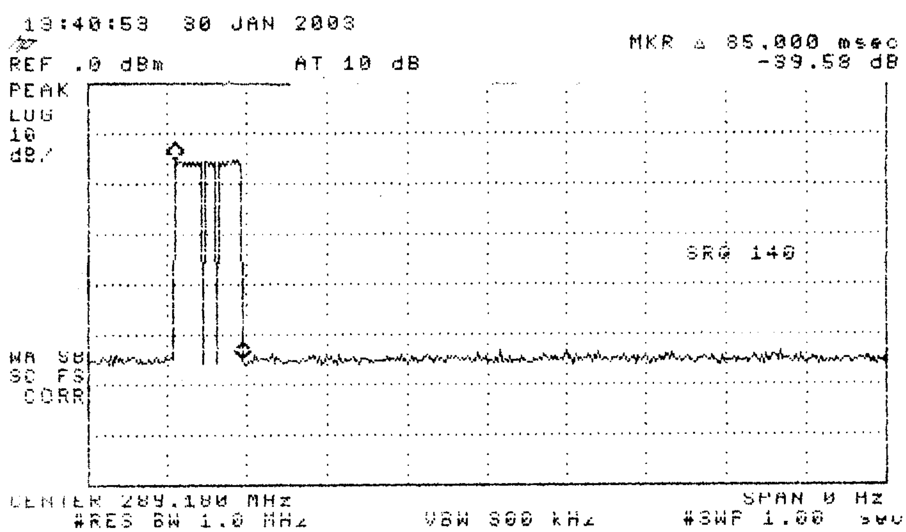
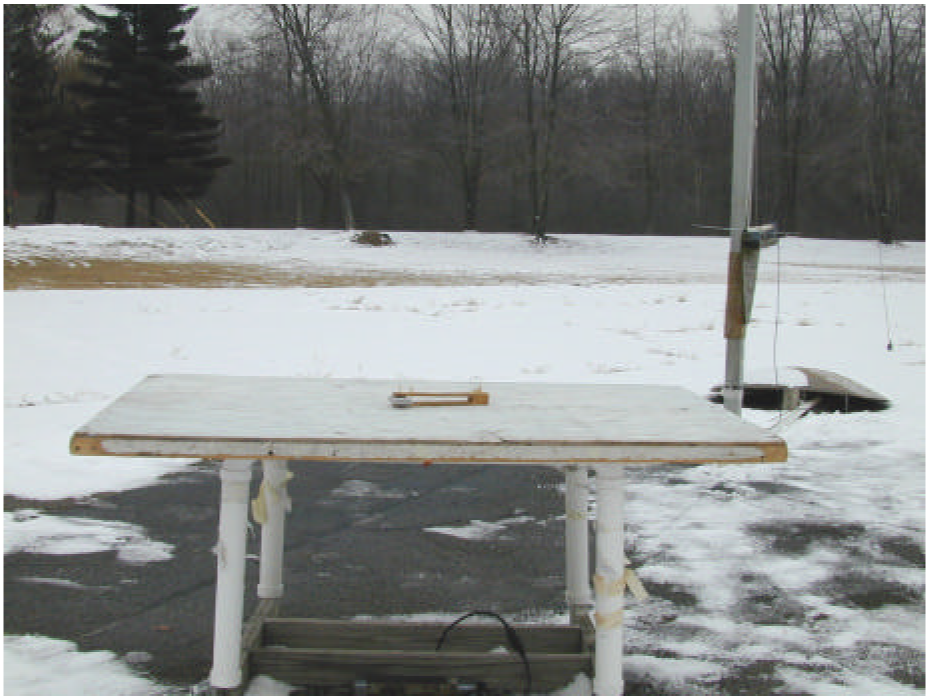
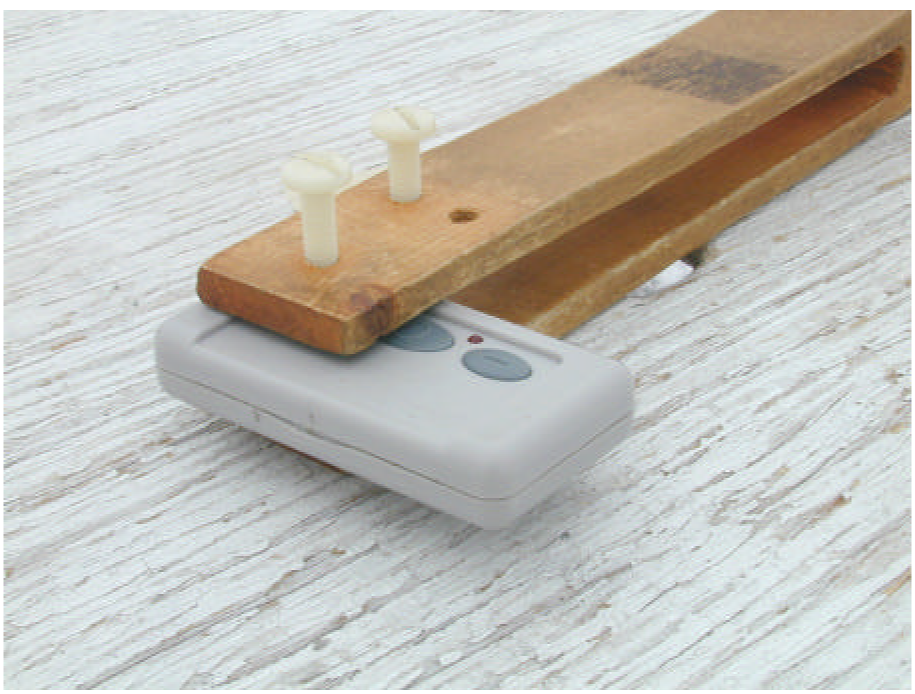


Figure 6.5. Emission after the DUT button is pressed and released.



DUT on OATS



Close-up on the DUT on OATS