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Measured Radio Frequency Emissions
From

Code Systems, Inc Transceiver
Transmitter Report
FCC ID: GOH-GMRFAB01
Model/PN(s): GM19131628, GM19131602

Report No. 415031-460a
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For:
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Summary

Tests for compliance with FCC Regulations Part 15, Subpart C, and Industry Canada RSS-210/GEN, were performed on Code Systems, Inc model/PN(s) GM19131628, GM19131602. This device is subject to the Rules and Regulations as a Transceiver.

In testing completed on September 7, 2008, the device tested in the worst case met the allowed FCC specifications for radiated emissions by 1.8 dB (see p. 6). Besides harmonics, there were no other significant spurious emissions found; emissions from digital circuitry were negligible. The conducted emission tests do not apply, since the device is powered from a 12 VDC battery.

1. Introduction

Code Systems, Inc model/PN(s) GM19131628, GM19131602 were 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/Gen, Issue 7, June 2007. 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 Area Test Site are on file with FCC Laboratory, Columbia, Maryland (FCC Reg. No: 91050) and with Industry Canada, Ottawa, ON (File Ref. No: IC 2057A-1).

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. The quality system employed at the University of Michigan Radiation Laboratory Willow Run Test Range has been established to ensure all equipment has a clearly identifiable classification, calibration expiry date, and that all calibrations are traceable to national standards.

Table 2.1 Test Equipment.

Test Instrument	Used	Manufacturer/Model	Q Number
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E, SN: 3412A01131	HP8593E1
Spectrum Analyzer (9kHz-6.5GHz)		Hewlett-Packard 8595E, SN: 3543A01546	JDB8595E
Power Meter		Hewlett-Packard, 432A	HP432A1
Harmonic Mixer (26-40 GHz)		Hewlett-Packard 11970A, SN: 3003A08327	HP11970A1
Harmonic Mixer (40-60 GHz)		Hewlett-Packard 11970U, SN: 2332A00500	HP11970U1
Harmonic Mixer (75-110 GHz)		Hewlett-Packard 11970W, SN: 2521A00179	HP11970W1
Harmonic Mixer (140-220 GHz)		Pacific Millimeter Prod., GMA, SN: 26	PMPGMA1
S-Band Std. Gain Horn		S/A, Model SGH-2.6	SBAND1
C-Band Std. Gain Horn		University of Michigan, NRL design	CBAND1
XN-Band Std. Gain Horn		University of Michigan, NRL design	XNBAND1
X-Band Std. Gain Horn		S/A, Model 12-8.2	XBAND1
X-band horn (8.2- 12.4 GHz)		Narda 640	XBAND2
X-band horn (8.2- 12.4 GHz)		Scientific Atlanta , 12-8.2, SN: 730	XBAND3
K-band horn (18-26.5 GHz)		FXR, Inc., K638KF	KBAND1
Ka-band horn (26.5-40 GHz)		FXR, Inc., U638A	KABAND1
U-band horn (40-60 GHz)		Custom Microwave, HO19	UBAND1
W-band horn(75-110 GHz)		Custom Microwave, HO10	WBAND1
G-band horn (140-220 GHz)		Custom Microwave, HO5R	GBAND1
Bicone Antenna (30-250 MHz)	X	University of Michigan, RLBC-1	LBBIC1
Bicone Antenna (200-1000 MHz)	X	University of Michigan, RLBC-2	HBBIC1
Dipole Antenna Set (30-1000 MHz)	X	University of Michigan, RLDP-1,-2,-3	UMDIP1
Dipole Antenna Set (30-1000 MHz)		EMCO 3121C, SN: 992 (Ref. Antennas)	EMDIP1
Active Rod Antenna (30 Hz-50 MHz)		EMCO 3301B, SN: 3223	EMROD1
Active Loop Antenna (30 Hz-50 MHz)		EMCO 6502, SN:2855	EMLOOP1
Ridge-horn Antenna (300-5000 MHz)	X	University of Michigan	UMRH1
Amplifier (5-1000 MHz)	X	Avantek, A11-1, A25-1S	AVAMP1
Amplifier (5-4500 MHz)	X	Avantek	AVAMP2
Amplifier (4.5-13 GHz)		Avantek, AFT-12665	AVAMP3
Amplifier (6-16 GHz)		Trek	TRAMP1
Amplifier (16-26 GHz)		Avantek	AVAMP4
LISN Box		University of Michigan	UMLISN1
Signal Generator		Hewlett-Packard 8657B	HPSG1

3. Device Under Test

3.1 Identification

The DUT is a 315 MHz transceiver, 3 x 2 x 1 inches in size. The device is the in-vehicle unit used in a two way remote vehicle start/keyless entry system. The DUT contains both a 315 MHz transmitter and a 315 MHz receiver. Emissions relating only to the transmitter portion of the device are reported herein. The DUT transmits Manchester encoded data at 2.1 kbs. The antenna is external to the DUT. The DUT was designed and manufactured by Code Systems, Inc, 525 Minnesota Ave., Troy, Michigan 48083. It is identified as:

Code Systems, IncTransceiver
Model/PN(s): GM19131628, GM19131602
FCC ID: GOH-GMRFAB01
IC: 3954A-RFA1

3.2 Variants

There are two models of the DUT (GM19131628 and GM19131602). Both units contain identical RF circuitry, but in the digital section the input power connector and the CAN bus message structure are different. The device with the green connector (GM19131628) utilizes 29 bit CAN messages while the device with the black connector (GM19131602) utilizes 11 bit CAN messages. This reassessment employs two new external antennas that are tuned specifically for use in particular mounting configurations within the automobile, PNs GM19213158 and GM19213160. The originally certified transmitters are unchanged (output power of the units has not changed) only a change in external antenna is evaluated.

3.3 Modes of Operation

The DUT utilizes only a single mode of operation. The device is remotely activated after interrogation from an associated hand-held unit via an encoded protocol. After interrogation, the DUT ceases to transmit within 5 seconds (see Figure 6.1).

3.4 EMI/EMC Relevant Modifications

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

4. 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(a-c), 15.209), and Subpart A, (Section 15.33). For Industry Canada it is subject to RSS-210 (Section 2.6 and 2.7). The applicable testing 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, 15.209; IC: RSS-210, 2.7 Table 2).
(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; 2.7 Table 4). (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	
315	6042	75.6	604.2	55.6
433.9	10966	80.8	1096.6	60.8
322-335.4 399.9-410 608-614	Restricted Bands		200	46.0
960-1240/1427(IC) 1300-1427 1435-1626.5 1645.5-1646.5 (IC) 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

4.3 Exemptions
None.

4.4 Power Line Conducted Emission Limits
The power line conducted emission limits and tests do not apply here, as the DUT is powered by a 12 VDC battery.

4.5 Supply Voltage Variation
Measurements of the variation in the fundamental radiated emission shall be performed with the supply voltage varied between 85% and 115% of the nominal rated value. For battery operated equipment, the equipment tests shall be performed using a new battery.

5. Test Procedures

5.1 Semi-Anechoic Chamber Radiated Emission Testing
To become familiar with the emission behavior of the DUT, the DUT was first studied and measured in a shielded semi-anechoic chamber. In the chamber is 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.

In testing for radiated emissions, a transmitter was provided by the manufacturer that is capable of repeated 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 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 final compliance assessment. We note that for the horn antenna, the antenna pattern is directive and 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.

5.2 Open Area Test Site (OATS) Radiated Emission Testing

After the chamber measurements are complete, emissions are re-measured on the outdoor 3-meter open area test site at the fundamental and harmonics up to 1 GHz using tuned dipoles and/or a high frequency biconical antenna. 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 DUT is tested on all three major axes.

5.3 Field Calculation for Radiated Emission Measurements

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 1.8 dB.

5.4 Power Line Conducted Emission Testing

These tests do not apply, since the DUT is powered from a 12 VDC battery.

6. Test Results

6.1 Correction For Pulse Operation

When the transmitter is activated by remote interrogation it can, in the worst case, repeatedly transmit Manchester encoded ASK data with a period of 100 ms, an on time of 19.05 ms until the interrogation stops. For a single interrogation, 11 datasets were observed. See Figure 6.1. Computing the duty factor results in:

$$K_E = (19.05 \text{ ms x } 0.201 \text{ ms} / 0.386 \text{ ms}) / 100 \text{ ms} = 0.099 < -20 \text{ dB}.$$

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. We note that in scanning from 30 MHz to 4.5 GHz using Bicone and the ridge horn antennas, there were no other significant spurious emissions observed.

6.3 Bandwidth of the Emission Spectrum

The measured spectrum of the signal is shown in Figure 6.3. The allowed (-20 dB, 99%) bandwidth is 0.25% of 315 MHz, or 787.25 kHz. From the plot we see that the -20 dB bandwidth is 373 kHz, and the center frequency is 315 MHz.

6.4 Effect of Supply Voltage Variation and Test Battery Voltages

The DUT has been designed to be powered by a 12 VDC 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 6 to 18 volts. The emission variation is shown in Figure 6.4.

V = 12.3 VDC
I = 24.0 mADC

Table 5.1 Highest Emissions Measured

Radiated Emission - RF RKE											Code In-Car Tx, Antennas; 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	**Ant: GM19213158**										
2	315.0	Dip	H	-18.8	Pk	18.6	21.3	65.4	75.6	10.2	antenna H; 11-bit model
3	315.0	Dip	V	-23.4	Pk	18.6	21.3	60.8	75.6	14.8	antenna V;
4	630.0	Dip	H	-59.4	Pk	24.4	18.3	33.7	55.6	21.9	antenna H
5	630.0	Dip	V	-61.4	Pk	24.4	18.3	31.7	55.6	23.9	antenna V
6	945.0	Dip	H	-74.5	Pk	28.8	16.3	25.1	55.6	30.6	antenna H
7	945.0	Dip	V	-77.3	Pk	28.8	16.3	22.3	55.6	33.4	antenna V
8	1260.0	Horn	H	-43.1	Pk	20.6	28.1	36.4	54.0	17.6	flat
9	1575.0	Horn	H	-42.7	Pk	21.5	28.1	37.7	54.0	16.3	flat
10	1890.0	Horn	H	-32.6	Pk	22.2	28.1	48.5	55.6	7.1	flat
11	2205.0	Horn	H	-42.1	Pk	23.0	26.5	41.4	54.0	12.6	flat
12	2520.0	Horn	H	-46.7	Pk	23.9	26.0	38.2	55.6	17.5	flat
13	2835.0	Horn	H	-51.5	Pk	24.8	24.7	35.6	54.0	18.4	flat
14	3150.0	Horn	H	-55.2	Pk	25.8	23.6	34.0	55.6	21.6	flat
15											
16	315.0	Dip	H	-17.0	Pk	18.6	21.3	67.2	75.6	8.4	antenna H; 29-bit model
17											
18	**Ant: GM19213160**										
19	315.0	Dip	H	-10.8	Pk	18.6	21.3	73.4	75.6	**2.2**	antenna H; 11-bit model
20	315.0	Dip	V	-18.4	Pk	18.6	21.3	65.8	75.6	9.8	antenna V;
21	630.0	Dip	H	-58.7	Pk	24.4	18.3	34.4	55.6	21.2	antenna H
22	630.0	Dip	V	-60.0	Pk	24.4	18.3	33.1	55.6	22.5	antenna V
23	945.0	Dip	H	-70.6	Pk	28.8	16.3	29.0	55.6	26.7	antenna H
24	945.0	Dip	V	-67.6	Pk	28.8	16.3	32.0	55.6	23.7	antenna V
25	1260.0	Horn	H	-44.3	Pk	20.6	28.1	35.2	54.0	18.8	flat
26	1575.0	Horn	H	-42.1	Pk	21.5	28.1	38.3	54.0	15.7	flat
27	1890.0	Horn	H	-31.4	Pk	22.2	28.1	49.7	55.6	5.9	flat
28	2205.0	Horn	H	-44.5	Pk	23.0	26.5	39.0	54.0	15.0	flat
29	2520.0	Horn	H	-46.7	Pk	23.9	26.0	38.2	55.6	17.5	flat
30	2835.0	Horn	H	-50.2	Pk	24.8	24.7	36.9	54.0	17.1	flat
31	3150.0	Horn	H	-57.4	Pk	25.8	23.6	31.8	55.6	23.8	flat
32											
33	315.0	Dip	H	-10.4	Pk	18.6	21.3	73.8	75.6	**1.8**	antenna H; 29-bit model
34											
35											
36											
37	* includes 20 dB duty cycle.										
38											
39	* For devices used in transportation vehicles, digital emissions are exempt from FCC regulations per FCC 15										
40											
41											

Meas09/04/2008; U of Mich.

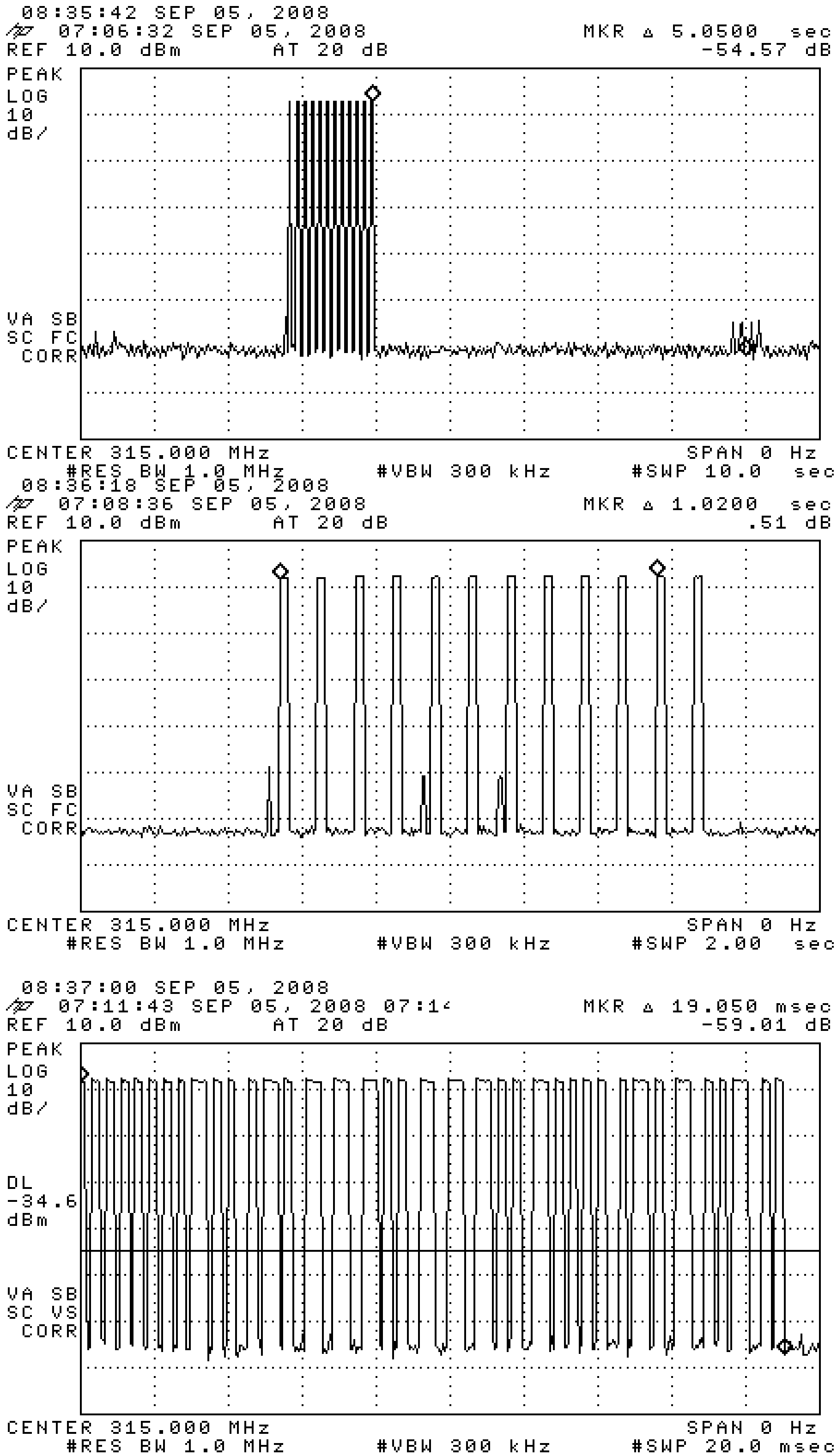
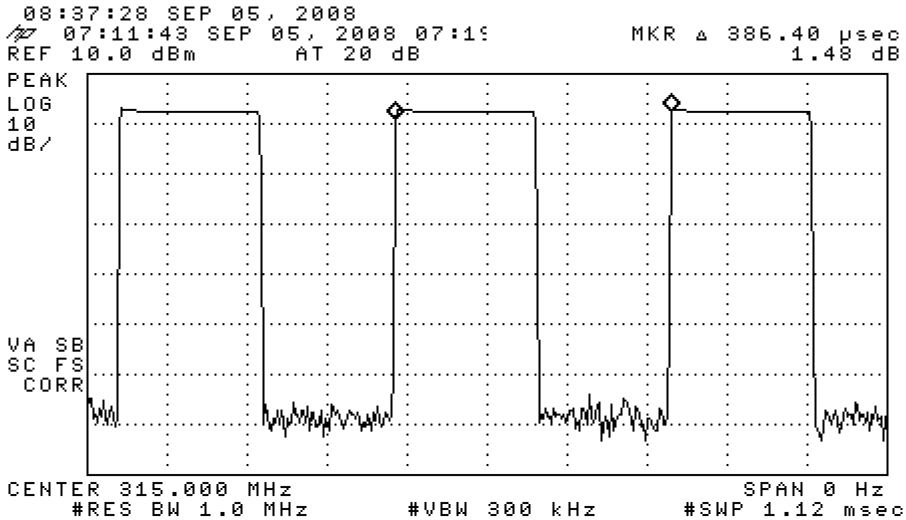


Figure 6.1(a). Transmissions modulation characteristics: (top) single actuation, (center) expanded transmission, (bottom) expanded word.



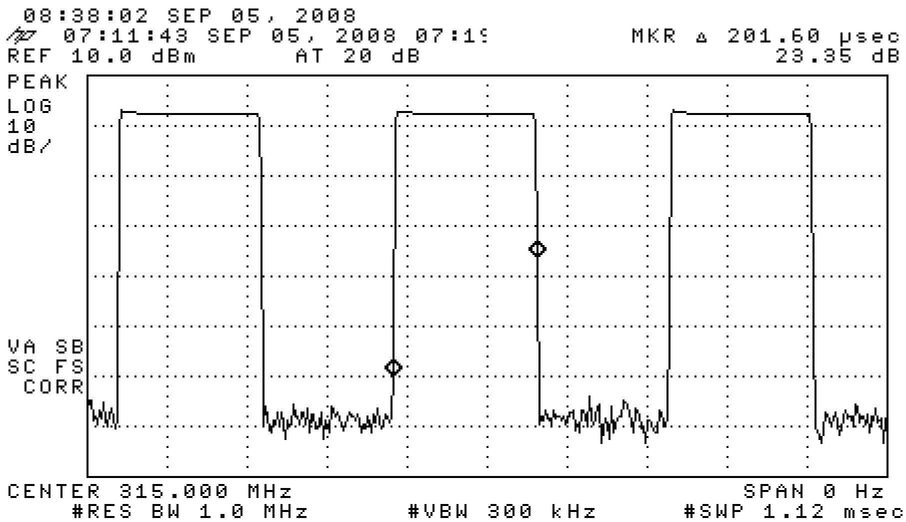


Figure 6.1(b). Transmissions modulation characteristics: (top) period, (bottom) on-time.

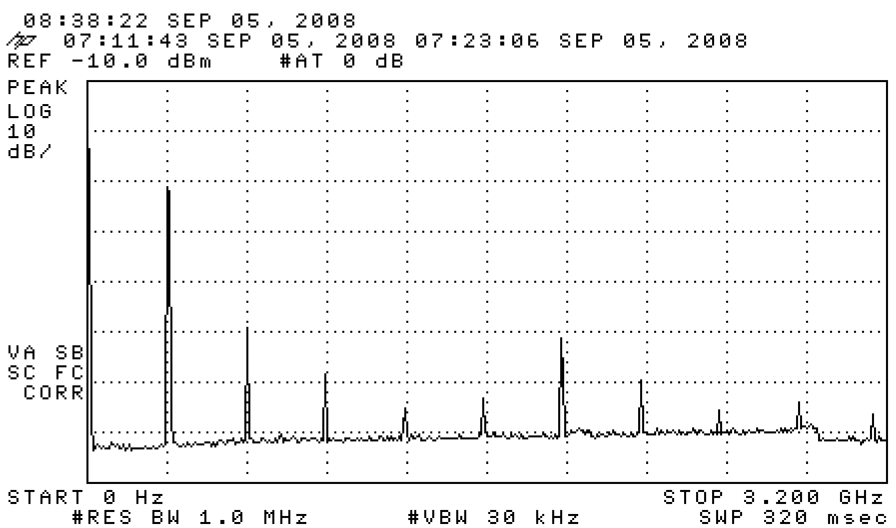


Figure 6.2. Emission spectrum of the DUT (pulsed emission).
The amplitudes are only indicative (not calibrated).

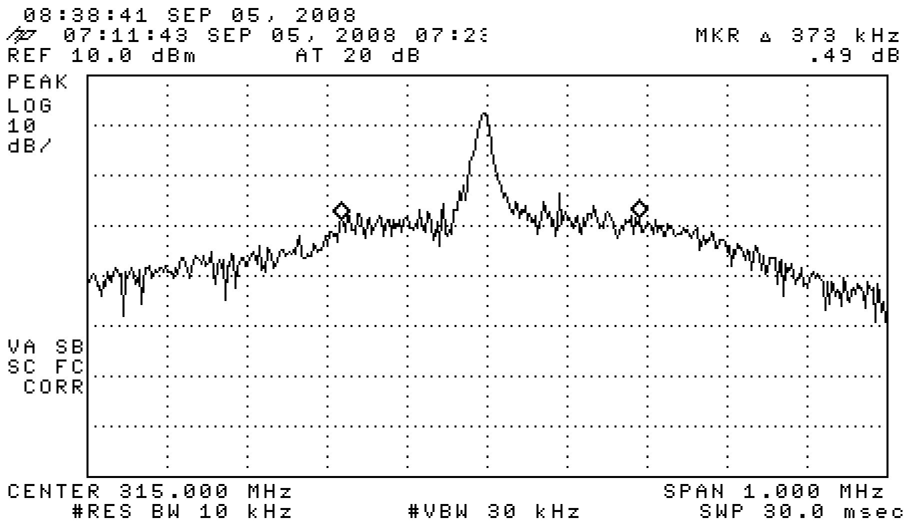


Figure 6.3. Measured bandwidth of the DUT (pulsed emission).

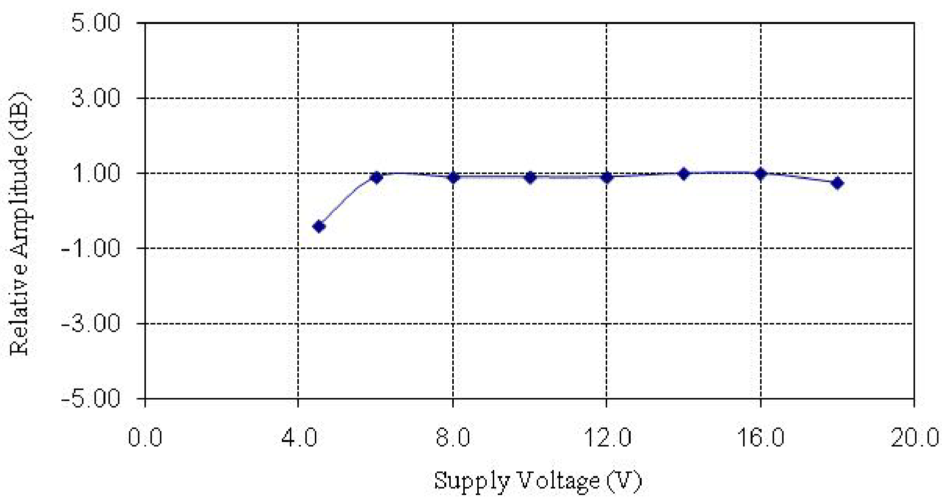
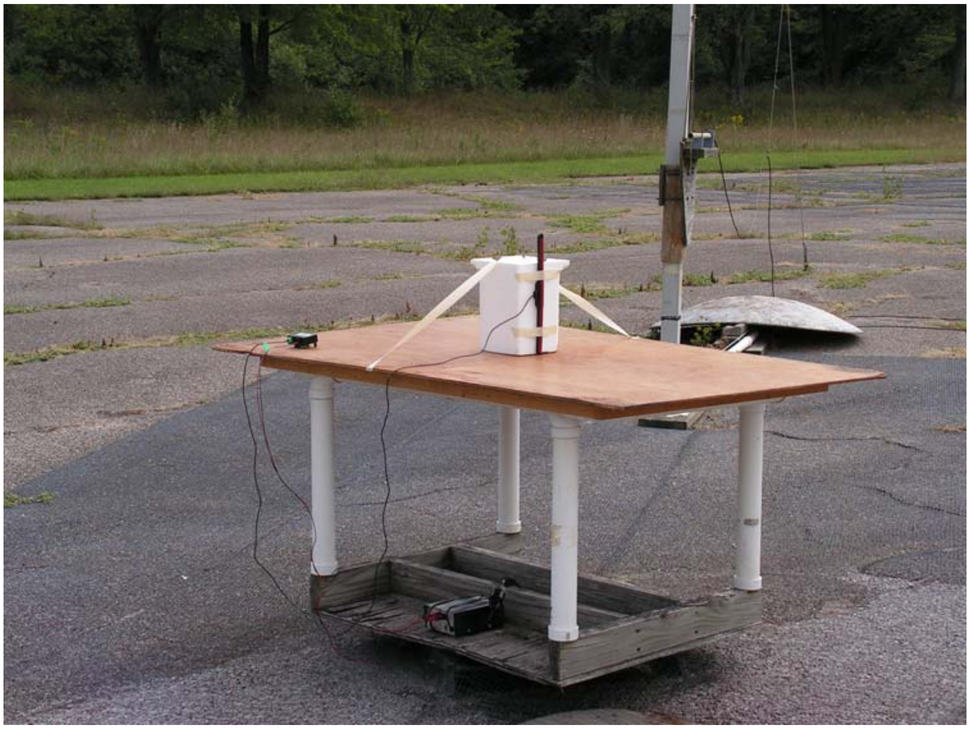
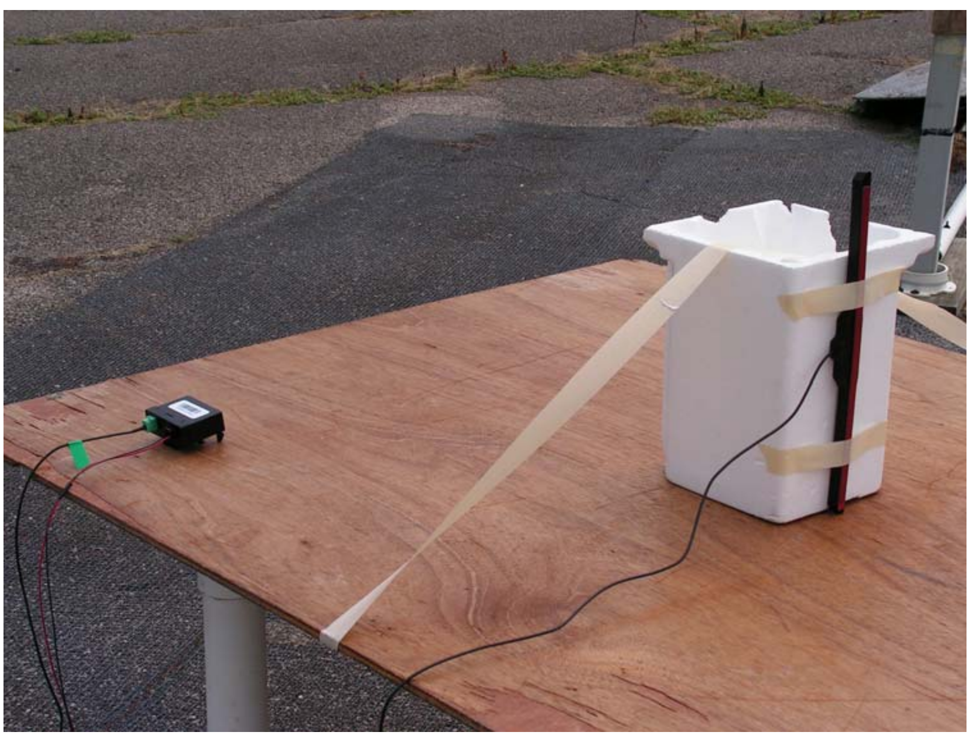


Figure 6.4. Relative emission at 315 MHz vs. supply voltage (pulsed emission).



DUT on OATS – one of three axes tested



DUT on OATS (close-up) – one of three axes tested