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Measured Radio Frequency Emissions
From

Gentex Corporation Transceiver
FCC ID: NZLNI13HL4
IC: 4112A-NI13HL4

Test Report No. 417124-648
November 26, 2012

For:
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Summary

Tests for compliance with FCC Regulations, CFR 47, Part 15 and with Industry Canada RSS-210/Gen, were performed on a Gentex, FCC ID: NZLNI13HL4, IC: 4112A-NI13HL4. This device under test (DUT) is subject to the rules and regulations as a Universal Garage Door Opener Transceiver. As such, the DUT was trained to and fully tested for three duty factors (30%, 50%, and 80%) and at four frequencies (288 MHz, 310 MHz, 390 MHz, and 434 MHz).

In testing completed on November 21, 2012, the DUT met the allowed limits for radiated emissions by 0.7 dB at the fundamental and by 7.4 dB at the harmonics, in the worst case. Besides harmonics there were no other significant spurious emissions found. It was also verified that the device does not transmit in Restricted Bands. AC mains power conducted emissions limits do not apply as the device is powered from a 12VDC vehicular source.

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1. Introduction

This Gentex Transceiver 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/Gen, Issue 8. 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 2057A-1).

2. Equipment Used

The test equipment commonly used in our facility is listed in Table 2.1. Except where indicated as a pre-test, monitoring, or support device; all equipment listed below is a part of the University of Michigan Radiation Laboratory (UMRL) quality system. This quality system 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)	☒	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)	☒	University of Michigan, RLBC-1	LBBIC1
Bicone Antenna (200-1000 MHz)	☒	University of Michigan, RLBC-2	HBBIC1
Dipole Antenna Set (30-1000 MHz)	☒	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)	☒	University of Michigan	UMRH1
Amplifier (5-1000 MHz)	☒	Avantek, A11-1, A25-1S	AVAMP1
Amplifier (5-4500 MHz)	☒	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 Description & Block Diagram

The DUT is a Universal Garage Door Opener (UGDO) Transceiver that is trained to replicate a transmission from a standard Garage Door Opener (GDO). The DUT is designed for installation in a motor vehicle and is powered by its 12 VDC system. The device is housed in a plastic rear view mirror approximately 15 x 5 x 5 cm in dimension. For testing, a generic harness was provided by the manufacturer. The DUT is capable of transmissions from 288 to 450 MHz, however transmissions in restricted bands are "blocked out" in firmware. Depending on the frequency and the duty factor of the GDO that is learned, the DUT attenuates the emissions in firmware using predetermined attenuation settings. The transmitter is activated only when a button is depressed, and ceases operation upon button release.

Device	**[Make], Model**	**[S/N],P/N**	**EMC Consideration**
DUT Sample A	[Gentex], NI13HL4	-	Normal Operating
DUT Sample B	[Gentex], NI13HL4	-	Normal Operating, dismantled for photos.

3.2 Variants and Samples

There is only a single variant of the DUT as tested. Two normal operating samples were provided for testing, and one was dismantled to be photographed after testing.

3.3 Modes of Operation

The DUT is capable of only a single mode of operation, as a learning garage door opener. In performing this function, the DUT employ a TRAINING mode where it receives a UHF signal from the GDO it is learning, and a TRANSMISSION mode where the user presses a button on the DUT to transmit the learned code.

3.4 Exemptions

The DUT is permanently installed in a transportation vehicle. As such, digital emissions are exempt (per FCC 15.103(a) and IC correspondence on ICES-003) from regulation.

3.5 EMC Relevant Modifications

No EMI Relevant Modifications were performed by this test laboratory. Both samples were trained by laboratory personnel to the prescribed test signals necessary to demonstrate compliance.

4. Emissions Limits

4.1 Radiated Emissions Limits

The DUT tested falls under the category of an Intentional Radiator. The applicable testing frequencies and corresponding emission limits set by both the FCC and IC are given in Tables 4.1 and 4.2 below.

Table 4.1. TX Emission Limits (FCC: 15.231(b), .205(a); IC: RSS-210 2.7 T4).

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

Table 4.2. Spurious Emission Limits (FCC: 15.33, .35, .109/209; IC: RSS-210 2.7, T2)

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 RBW), PRF of intentional emissions > 20 Hz for QPK to apply.

Power Line Conducted Emissions Limits

Table 4.3 Emission Limits (FCC:15.107 (CISPR); IC: RSS-Gen, 7.2.2 T2).

Frequency (MHz)	Class A (dBμV) Quasi-peak	Class A (dBμV) Average	Class B (dBμV) Quasi-peak	Class B (dBμV) Average
.150 - 0.50	79	66	66 - 56*	56 - 46*
0.50 - 5	73	60	56	46
5 - 30	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

5. Measurement Procedures

5.1 Semi-Anechoic Chamber Radiated Emissions

To become familiar with the radiated emission behavior of the DUT, the device is first studied and measured in our shielded semi-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.

The DUT is laid on the test table as shown in the included block diagram and/or photographs. A shielded loop antenna is employed when studying emissions from 9 kHz to 30 MHz. Above 30 MHz and below 250 MHz a biconical antenna is employed. Above 250 MHz a ridge or and standard gain horn antennas are used. The spectrum analyzer resolution and video bandwidths are set so as to measure the DUT emission without decreasing the emission bandwidth (EBW) of the device. Emissions are studied for all orientations (3-axes) of the DUT and all test antenna polarizations. In the chamber, spectrum and modulation characteristics of intentional carriers are recorded. Receiver spurious emissions are measured with an appropriate carrier signal applied. Associated test data is presented in subsequent sections.

5.2 Outdoor Radiated Emissions

After measurements are performed indoors, emissions on our outdoor 3-meter Open Area Test Site (OATS) are made, when applicable. If the DUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.4 are employed. Alternatively, an on-table layout more representative of actual use may be employed if the resulting emissions appear to be worst-case in such a configuration. Any intentionally radiating elements are placed on the test table flat, on their side, and on their end (3-axes) and worst case emissions are recorded. For each configuration the DUT is rotated 360 degrees about its azimuth and the receive antenna is raised and lowered between 1 and 4 meters to maximize radiated emissions from the device. Receiver spurious emissions are measured with an appropriate carrier signal applied. For devices with intentional emissions below 30 MHz, our shielded loop antenna at a 1 meter receive height is used. Low frequency field extrapolation to the regulatory limit distance is employed as needed. Emissions between 30 MHz and 1 GHz are measured using tuned dipoles and/or biconical antennas. Care is taken to ensure that the RBW and VBW used meet the regulatory requirements, and that the EBW of the DUT is not reduced. The Photographs included in this report show the Test Setup.

5.3 Radiated Field Computations

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

$$E3(dB\mu V/m) = 107 + PR + KA - KG + KE - CF$$

where PR = power recorded on spectrum analyzer, dBm, measured at 3 m
KA = antenna factor, dB/m
KG = pre-amplifier gain, including cable loss, dB
KE = duty correction factor, dB
CF = distance conversion (employed only if limits are specified at alternate distance), dB

When presenting the data at each frequency, the highest measured emission under all of the possible DUT orientations (3-axes) is given.

5.4 Indoor Power Line Conducted Emissions

When applicable, power line conducted emissions are measured in our semi-anechoic chamber. If the DUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.4 are employed. Alternatively, an on-table layout more representative of actual use may be employed if the resulting emissions appear to be worst-case in such a configuration.

The conducted emissions measured with the spectrum analyzer and recorded (in dBμV) from 0-2 MHz and 2-30 MHz for both the ungrounded (Hi) and grounded (Lo) conductors. The spectrum analyzer is set to peak-hold mode in order to record the highest peak throughout the course of functional operation. Only when the emission exceeds or is near the limit are quasi-peak and average detection used.

5.5 Supply Voltage Variation

Measurements of the variation in the fundamental radiated emission were performed with the supply voltage varied by no less than 85% and 115% of the nominal rated value. For battery operated equipment, tests were performed using a new battery, and worst case emissions are re-checked employing a new battery.

6. Test Results

6.1 Radiated Emissions

6.1.1 Correction for Pulse Operation

As agreed previously with the FCC and IC, the DUT was taught signals of 30, 50, and 80% duty factors at low, middle, and high frequencies. The duty cycle is confirmed here at 310 MHz. The replicated wave shapes emanating from the DUT are measured, and from those the duty factors are obtained.

The 80% on-time modulation consists of 1.6375 ms wide pulses of period 2.0000 ms. The 50% on-time modulation consists of 1.0250 ms wide pulses of period 1.9625 ms. The modulation consists of 0.6250 ms wide pulses of period 2.0000 ms. Figures 6.1(a) through 6.1(d) show the measured wave shapes from which the duty factors are computed.

$$K_{E80\%} = 1.6375 / 2.0000 = 0.819 \text{ or } -1.7 \text{ dB.}$$
$$K_{E50\%} = 1.0250 / 1.9625 = 0.522 \text{ or } -5.6 \text{ dB.}$$
$$K_{E30\%} = 0.6250 / 2.0000 = 0.313 \text{ or } -10.1 \text{ dB.}$$

6.1.2 Emission Spectrum

The relative DUT emission spectrum is recorded and is shown in Figure 6.2.

6.1.3 Emission Bandwidth

The emission bandwidth of the signal is shown in Figures 6.3(a),(b),(c), and (d) for each of the duty cycles employed at low, middle, and high channels. The allowed 99% bandwidth is 0.25% of the operating frequency.

Freq.	Duty	99% EBW
288	30%	100 kHz
288	50%	100 kHz
288	80%	97 kHz

Freq.	Duty	99% EBW
310	30%	118 kHz
310	50%	108 kHz
310	80%	125 kHz

Freq.	Duty	99% EBW
390	30%	115 kHz
390	50%	123 kHz
390	80%	133 kHz

Freq.	Duty	99% EBW
434	30%	170 kHz
434	50%	118 kHz
434	80%	123 kHz

6.1.4 Verification of Non-operation in Restricted Bands

The DUT has been designed to learn and operate over 288 to 450 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. In addition, since the second harmonic of 304 - 307 MHz range falls in the restricted band (608-614 MHz), these frequencies are also excluded as a precaution.

Using a 500 Hz 50% duty factor modulated carrier from a signal generator, the DUT was "taught" frequencies from 240.0 to 450.0 MHz. It repeated frequencies from 286.00 to 303.70 MHz, from 307.50 to 321.10 MHz, from 336.50 to 398.50 MHz, and from 411.30 to 449.40 MHz. In all cases, no frequencies were repeated in the Restricted Bands and there were no spurious emissions observed in the Restricted Bands.

6.1.5 Learning receiver emissions

When the DUT is put in learn mode, a detector sweeps typically from 285 to 450 MHz looking for a signal. Once found, it locks onto the signal and learns its frequency and AM modulation. The detector is based on a superheterodyne design, with 10.7 MHz IF. The emissions are anticipated from the LO circuit.

All spurious emissions were measured with the DUT in TRAINING mode from 30 MHz to 2.0 GHz. Measurements were made on OATS (up to 1 GHz) and in the chamber above 1 GHz. The emissions are presented in Table 6.1(d). There it shows that the receiver spurious emissions observed meet Class B limits by no less than 6.3 dB.

6.1.6 Supply Voltage and Supply Voltage Variation

The DUT has been designed to be powered by a 12 VDC vehicular system. For this test, relative radiated power was measured at the fundamental as the voltage was varied from 6.0 to 18.0 volts for the DUT programmed to 310 MHz and 50% duty cycle. The emission variation is shown in Figure 6.4.

V = 12 VDC
I = 190 mA (pulsed)

6.2 AC Mains Conducted Emissions

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

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Table 6.1(a) Highest Emissions Measured

#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3* dBμV/m	E3lim dBμV/m	Pass dB	Comments
	Radiated Emission - RF										Gentex UGDO Tx, L53H; FCC/IC
	30 % Duty Factor (meas. 10.1 dB)										
1	288.0	Sbic	H	-20.6	Pk	18.1	22.5	71.9	73.8	**2.0**	end
2	288.0	Sbic	V	-24.1	Pk	18.1	22.5	68.4	73.8	5.5	flat
3	576.0	Sbic	H	-56.6	Pk	24.4	20.9	43.8	53.8	10.0	flat
4	576.0	Sbic	V	-54.9	Pk	24.4	20.9	45.5	53.8	**8.3**	end
5	864.0	Sbic	H	-77.7	Pk	28.1	18.7	28.5	53.8	25.3	max all, noise
6	864.0	Sbic	V	-77.1	Pk	28.1	18.7	29.1	53.8	24.7	max all, noise
7	1152.0	Horn	H	-64.6	Pk	20.2	28.1	24.4	54.0	29.6	max all
8	1440.0	Horn	H	-54.7	Pk	21.1	28.3	35.0	54.0	19.0	max all
9	1728.0	Horn	H	-65.6	Pk	21.8	27.8	25.3	53.8	28.5	max all
10	2016.0	Horn	H	-70.3	Pk	22.5	26.6	22.5	53.8	31.3	max all
11	2304.0	Horn	H	-71.8	Pk	23.3	26.9	21.5	53.8	32.4	max all
12	2592.0	Horn	H	-71.9	Pk	24.1	26.6	22.5	53.8	31.4	max all, noise
13	2880.0	Horn	H	-70.5	Pk	25.0	25.5	25.9	54.0	28.1	max all
	50 % Duty Factor (meas. 5.6 dB)										
14	288.0	Sbic	H	-25.4	Pk	18.1	22.5	71.5	73.8	**2.3**	end
15	288.0	Sbic	V	-28.7	Pk	18.1	22.5	68.2	73.8	5.6	flat
16	576.0	Sbic	H	-63.3	Pk	24.4	20.9	41.6	53.8	12.3	flat
17	576.0	Sbic	V	-67.8	Pk	24.4	20.9	37.1	53.8	16.8	end
18	864.0	Sbic	H	-77.4	Pk	28.1	18.7	33.3	53.8	20.5	max all, noise
19	864.0	Sbic	V	-77.2	Pk	28.1	18.7	33.5	53.8	20.3	max all, noise
20	1152.0	Horn	H	-71.1	Pk	20.2	28.1	17.9	54.0	36.1	max all
21	1440.0	Horn	H	-56.0	Pk	21.1	28.3	33.7	54.0	20.3	max all
22	1728.0	Horn	H	-67.6	Pk	21.8	27.8	23.3	53.8	30.5	max all
23	2016.0	Horn	H	-71.0	Pk	22.5	26.6	21.8	53.8	32.0	max all, noise
24	2304.0	Horn	H	-70.8	Pk	23.3	26.9	22.5	53.8	31.4	max all, noise
25	2592.0	Horn	H	-70.3	Pk	24.1	26.6	24.1	53.8	29.8	max all, noise
26	2880.0	Horn	H	-71.8	Pk	25.0	25.5	24.6	54.0	29.4	max all, noise
	80 % Duty Factor (meas. 1.7 dB)										
27	288	Sbic	H	-29	Pk	18.1	22.5	71.8	73.8	**2.0**	end
28	288	Sbic	V	-32.9	Pk	18.1	22.5	67.9	73.8	5.9	flat
29	576	Sbic	H	-68.5	Pk	24.4	20.9	40.3	53.8	13.6	flat
30	576	Sbic	V	-72.1	Pk	24.4	20.9	36.7	53.8	17.2	end
31	864	Sbic	H	-77.5	Pk	28.1	18.7	37.1	53.8	16.7	max all, noise
32	864	Sbic	V	-78.7	Pk	28.1	18.7	35.9	53.8	17.9	max all, noise
33	1152	Horn	H	-69.7	Pk	20.2	28.1	27.7	54.0	26.3	max all
34	1440	Horn	H	-57.1	Pk	21.1	28.3	41.0	54.0	13.0	max all
35	1728	Horn	H	-67.6	Pk	21.8	27.8	31.7	53.8	22.1	max all
36	2016	Horn	H	-73.6	Pk	22.5	26.6	27.6	53.8	26.2	max all, noise
37	2304	Horn	H	-72.2	Pk	23.3	26.9	29.4	53.8	24.4	max all, noise
38	2592	Horn	H	-72.3	Pk	24.1	26.6	30.4	53.8	23.4	max all, noise
39	2880	Horn	H	-74.1	Pk	25.0	25.5	30.6	54.0	23.4	max all, noise

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Table 6.1(b) Highest Emissions Measured

Radiated Emission - RF											Gentex UGDO Tx, L53H; 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
	30 % Duty Factor (meas. 10.1 dB)										
1	310.0	Dip	H	-17.6	Pk	18.4	23.2	74.5	75.3	**0.8**	end
2	310.0	Sbic	V	-20.9	Pk	18.8	22.8	71.9	75.3	3.4	flat
3	620.0	Sbic	H	-55.2	Pk	25.1	21.1	45.7	55.3	9.6	flat
4	620.0	Sbic	V	-60.4	Pk	25.1	21.1	40.5	55.3	14.8	end
5	930.0	Sbic	H	-82.5	Pk	28.7	18.9	24.3	55.3	31.1	max all, noise
6	930.0	Sbic	V	-83.6	Pk	28.7	18.9	23.2	55.3	32.2	max all, noise
7	1240.0	Horn	H	-64.1	Pk	20.5	28.0	25.3	54.0	28.7	side
8	1550.0	Horn	H	-56.6	Pk	21.4	28.2	33.5	54.0	20.5	side
9	1860.0	Horn	H	-68.0	Pk	22.2	28.3	22.8	55.3	32.6	flat
10	2170.0	Horn	H	-66.6	Pk	22.9	27.1	26.1	55.3	29.2	end
11	2480.0	Horn	H	-69.8	Pk	23.8	26.5	24.4	55.3	31.0	end
12	2790.0	Horn	H	-71.5	Pk	24.7	25.6	24.5	54.0	29.5	flat
13	3100.0	Horn	H	-70.4	Pk	25.7	25.1	27.1	55.3	28.3	end
	50 % Duty Factor (meas. 5.6 dB)										
14	310.0	Dip	H	-22.0	Pk	18.4	23.2	74.6	75.3	**0.7**	end
15	310.0	Sbic	V	-25.3	Pk	18.8	22.8	72.0	75.3	3.3	flat
16	620.0	Sbic	H	-59.6	Pk	25.1	21.1	45.8	55.3	9.6	flat
17	620.0	Sbic	V	-65.6	Pk	25.1	21.1	39.8	55.3	15.6	end
18	930.0	Sbic	H	-82.4	Pk	28.7	18.9	28.8	55.3	26.5	max all, noise
19	930.0	Sbic	V	-82.8	Pk	28.7	18.9	28.4	55.3	26.9	max all, noise
20	1240.0	Horn	H	-67.6	Pk	20.5	28.0	21.8	54.0	32.2	end
21	1550.0	Horn	H	-51.1	Pk	21.4	28.2	39.0	54.0	15.0	flat
22	1860.0	Horn	H	-66.6	Pk	22.2	28.3	24.2	55.3	31.2	flat
23	2170.0	Horn	H	-67.2	Pk	22.9	27.1	25.5	55.3	29.8	end
24	2480.0	Horn	H	-69.3	Pk	23.8	26.5	24.9	55.3	30.5	side
25	2790.0	Horn	H	-70.2	Pk	24.7	25.6	25.8	54.0	28.2	end
26	3100.0	Horn	H	-70.6	Pk	25.7	25.1	26.9	55.3	28.5	side
	80 % Duty Factor (meas. 1.7 dB)										
27	310.0	Sbic	H	-27.5	Pk	18.8	22.8	73.7	75.3	**1.6**	end
28	310.0	Sbic	V	-30.2	Pk	18.8	22.8	71.0	75.3	4.3	flat
29	620.0	Sbic	H	-66.8	Pk	25.1	21.1	42.5	55.3	**12.9**	flat
30	620.0	Sbic	V	-72.8	Pk	25.1	21.1	36.5	55.3	18.9	end
31	930.0	Sbic	H	-83.1	Pk	28.7	18.9	32.0	55.3	23.3	max all, noise
32	930.0	Sbic	V	-83.4	Pk	28.7	18.9	31.7	55.3	23.6	max all, noise
33	1240.0	Horn	H	-66.3	Pk	20.5	28.0	31.5	54.0	22.5	max all
34	1550.0	Horn	H	-59.5	Pk	21.4	28.2	39.0	54.0	15.0	max all
35	1860.0	Horn	H	-67.8	Pk	22.2	28.3	31.3	55.3	24.0	max all
36	2170.0	Horn	H	-70.5	Pk	22.9	27.1	30.6	55.3	24.7	max all
37	2480.0	Horn	H	-62.3	Pk	23.8	26.5	40.2	55.3	15.1	max all
38	2790.0	Horn	H	-72.1	Pk	24.7	25.6	32.2	54.0	21.8	max all
39	3100.0	Horn	H	-70.7	Pk	25.7	25.1	35.1	55.3	20.2	max all

 Meas.9/24/2012 -10/25/2012; U of Mich.

Table 6.1(c) Highest Emissions Measured

Radiated Emission - RF											Gentex UGDO Tx, L53H; 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
	30 % Duty Factor (meas. 10.1 dB)										
1	390.0	Sbic	H	-18.0	Pk	20.9	22.2	77.6	79.2	**1.7**	end
2	390.0	Sbic	V	-19.1	Pk	20.9	22.2	76.5	79.2	2.8	flat
3	780.0	Sbic	H	-62.0	Pk	27.1	20.1	42.0	59.2	17.3	side
4	780.0	Sbic	V	-59.7	Pk	27.1	20.1	44.3	59.2	**15.0**	end
5	1170.0	Horn	H	-59.2	Pk	20.3	28.1	29.9	54.0	24.1	max all
6	1560.0	Horn	H	-60.7	Pk	21.4	28.1	29.5	54.0	24.5	max all
7	1950.0	Horn	H	-58.4	Pk	22.4	26.8	34.1	59.2	25.2	max all
8	2340.0	Horn	H	-70.3	Pk	23.4	26.5	23.5	54.0	30.5	max all, noise
9	2730.0	Horn	H	-71.1	Pk	24.5	25.2	25.1	54.0	28.9	max all, noise
10	3120.0	Horn	H	-69.8	Pk	25.7	24.7	28.1	59.2	31.1	max all, noise
11	3510.0	Horn	H	-70.5	Pk	27.0	24.3	29.1	59.2	30.2	max all, noise
12	3900.0	Horn	H	-70.7	Pk	28.1	20.7	33.6	54.0	20.4	max all, noise
13											
	50 % Duty Factor (meas. 5.6 dB)										
14	390.0	Sbic	H	-22.4	Pk	20.9	22.2	77.6	79.2	**1.6**	end
15	390.0	Sbic	V	-23.1	Pk	20.9	22.2	76.9	79.2	2.3	flat
16	780.0	Sbic	H	-76.0	Pk	27.1	20.1	32.4	59.2	26.8	side, noise
17	780.0	Sbic	V	-65.9	Pk	27.1	20.1	42.5	59.2	16.7	end
18	1170.0	Horn	H	-64.7	Pk	20.3	28.1	28.9	54.0	25.1	max all
19	1560.0	Horn	H	-62.9	Pk	21.4	28.1	31.8	54.0	22.2	max all
20	1950.0	Horn	H	-64.0	Pk	22.4	26.8	32.9	59.2	26.3	max all
21	2340.0	Horn	H	-70.6	Pk	23.4	26.5	27.6	54.0	26.4	max all, noise
22	2730.0	Horn	H	-71.6	Pk	24.5	25.2	29.1	54.0	24.9	max all, noise
23	3120.0	Horn	H	-71.3	Pk	25.7	24.7	31.1	59.2	28.2	max all, noise
24	3510.0	Horn	H	-70.2	Pk	27.0	24.3	33.8	59.2	25.4	max all, noise
25	3900.0	Horn	H	-72.1	Pk	28.1	20.7	36.7	54.0	17.3	max all, noise
26											
	80 % Duty Factor (meas. 1.7 dB)										
27	390.0	Sbic	H	-26.5	Pk	20.9	22.2	77.5	79.2	**1.8**	end
28	390.0	Sbic	V	-28.1	Pk	20.9	22.2	75.9	79.2	3.4	flat
29	780.0	Sbic	H	-71.0	Pk	27.1	20.1	41.4	59.2	17.9	side
30	780.0	Sbic	V	-70.2	Pk	27.1	20.1	42.2	59.2	17.1	end
31	1170.0	Horn	H	-68.8	Pk	20.3	28.1	28.7	54.0	25.3	max all
32	1560.0	Horn	H	-65.1	Pk	21.4	28.1	33.5	54.0	20.5	max all
33	1950.0	Horn	H	-65.8	Pk	22.4	26.8	35.1	59.2	24.2	max all
34	2340.0	Horn	H	-70.7	Pk	23.4	26.5	31.5	54.0	22.5	max all, noise
35	2730.0	Horn	H	-71.0	Pk	24.5	25.2	33.6	54.0	20.4	max all, noise
36	3120.0	Horn	H	-70.5	Pk	25.7	24.7	35.8	59.2	23.4	max all, noise
37	3510.0	Horn	H	-71.3	Pk	27.0	24.3	36.7	59.2	22.6	max all, noise
38	3900.0	Horn	H	-70.9	Pk	28.1	20.7	41.8	54.0	12.2	max all, noise
39											

Meas.11/20/2012; U of Mich.

Table 6.1(d) Highest Emissions Measured

	Radiated Emission - RF									Gentex UGDO Tx, L53H; 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
	30 % Duty Factor (meas. 10.1 dB)										
1	433.9	Sbic	H	-22.0	Pk	21.8	20.5	76.2	80.8	**4.6**	end
2	433.9	Sbic	V	-20.4	Pk	21.8	20.5	77.8	80.8	3.0	flat
3	867.8	Sbic	H	-65.6	Pk	28.1	18.3	41.1	60.8	19.7	side
4	867.8	Sbic	V	-70.6	Pk	28.1	18.3	36.1	60.8	24.7	end
5	1301.8	Sbic	H	-54.0	Pk	31.8	28.1	46.6	54.0	**7.4**	max all
6	1735.7	Sbic	H	-53.2	Pk	21.9	28.1	37.5	60.8	23.4	max all
7	2169.6	Horn	H	-63.6	Pk	22.9	26.8	29.4	60.8	31.4	max all
8	2603.5	Horn	H	-71.4	Pk	24.1	26.5	23.1	60.8	37.7	max all
9	3037.4	Horn	H	-70.3	Pk	25.5	25.2	26.9	60.8	34.0	max all, noise
10	3471.4	Horn	H	-70.4	Pk	26.8	24.7	28.6	60.8	32.2	max all, noise
11	3905.3	Horn	H	-72.7	Pk	28.1	24.3	28.0	54.0	26.0	max all, noise
12	4339.2	Horn	H	-72.3	Pk	29.5	20.7	33.4	54.0	20.6	max all, noise
13											
	50 % Duty Factor (meas. 5.6 dB)										
14	433.9	Dip	H	-25.9	Pk	21.8	20.5	76.8	80.8	**4.1**	end
15	433.9	Dip	V	-24.9	Pk	21.8	20.5	77.8	80.8	3.1	flat
16	867.8	Dip	H	-68.2	Pk	28.1	18.3	43.0	60.8	17.8	side
17	867.8	Dip	V	-72.2	Pk	28.1	18.3	39.0	60.8	21.8	end
18	1301.8	Horn	H	-64.4	Pk	31.8	28.1	36.2	54.0	17.8	max all
19	1735.7	Horn	H	-61.3	Pk	21.9	28.1	29.4	60.8	31.5	max all
20	2169.6	Horn	H	-65.9	Pk	22.9	26.8	27.1	60.8	33.7	max all
21	2603.5	Horn	H	-72.0	Pk	24.1	26.5	22.5	60.8	38.3	max all, noise
22	3037.4	Horn	H	-70.6	Pk	25.5	25.2	26.6	60.8	34.3	max all, noise
23	3471.4	Horn	H	-72.3	Pk	26.8	24.7	26.7	60.8	34.1	max all, noise
24	3905.3	Horn	H	-70.5	Pk	28.1	24.3	30.2	54.0	23.8	max all, noise
25	4339.2	Horn	H	-73.2	Pk	29.5	20.7	32.5	54.0	21.5	max all, noise
26											
	80 % Duty Factor (meas. 1.7 dB)										
27	433.9	Bic	H	-30.0	Pk	21.8	20.5	76.6	80.8	**4.3**	end
28	433.9	Bic	V	-29.2	Pk	21.8	20.5	77.4	80.8	3.5	flat
29	867.8	Bic	H	-74.2	Pk	28.1	18.3	40.9	60.8	19.9	flat
30	867.8	Bic	V	-76.4	Pk	28.1	18.3	38.7	60.8	22.1	end
31	1301.8	Bic	H	-66.8	Pk	31.8	28.1	42.2	54.0	11.8	max all
32	1735.7	Bic	H	-66.1	Pk	21.9	28.1	32.9	60.8	27.9	max all
33	2169.6	Horn	H	-71.6	Pk	22.9	26.8	29.8	60.8	31.1	max all
34	2603.5	Horn	H	-70.2	Pk	24.1	26.5	32.7	60.8	28.2	max all, noise
35	3037.4	Horn	H	-70.9	Pk	25.5	25.2	34.6	60.8	26.2	max all, noise
36	3471.4	Horn	H	-71.9	Pk	26.8	24.7	35.5	60.8	25.3	max all, noise
37	3905.3	Horn	H	-70.2	Pk	28.1	24.3	38.9	54.0	15.1	max all, noise
38	4339.2	Horn	H	-73.8	Pk	29.5	20.7	40.2	54.0	13.8	max all, noise
39											

 Meas.9/24/2012 -10/25/2012; U of Mich.

Table 6.1(e) Receiver Spurious Emissions Measured

Receive Chain Spurious											Gentex UGDO Rx, L53H; 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	120.0	SBic	H,V	-57.7	Pk	10.2	36.5	23.0	43.5	20.5	max. of all
2	213.0	SBic	H,V	-53.9	Pk	15.4	36.5	32.0	43.5	11.5	max. of all
3	260.0	SBic	H,V	-55.2	Pk	17.2	36.5	32.5	46.0	13.5	max. of all
4	293.0	SBic	H,V	-54.8	Pk	18.3	36.5	34.0	46.0	12.0	max. of all
5	365.0	SBic	H,V	-55.3	Pk	20.3	36.5	35.5	46.0	10.5	max. of all
6	413.0	SBic	H,V	-53.2	Pk	21.4	36.5	38.7	46.0	7.3	max. of all
7	660.0	SBic	H,V	-61.9	Pk	25.6	36.5	34.2	46.0	11.8	max. of all
8	1073.0	Horn	H,V	-67.4	Pk	19.9	28.0	31.5	54.0	22.5	max. of all
9	1090.0	Horn	H,V	-51.3	Pk	20.0	28.0	47.7	54.0	**6.3**	max. of all
10	1305.0	Horn	H,V	-63.0	Pk	20.6	28.0	36.6	54.0	17.4	max. of all
11	1325.0	Horn	H,V	-62.6	Pk	20.7	28.0	37.1	54.0	16.9	max. of all
12	1450.0	Horn	H,V	-60.6	Pk	21.0	28.0	39.4	54.0	14.6	max. of all
13	1595.0	Horn	H,V	-63.3	Pk	21.4	28.0	37.1	54.0	16.9	max. of all
14	1713.0	Horn	H,V	-67.3	Pk	21.8	28.2	33.3	54.0	20.7	max. of all
15	1788.0	Horn	H,V	-58.1	Pk	22.0	28.2	42.7	54.0	11.3	max. of all
16	1833.0	Horn	H,V	-63.1	Pk	22.1	28.2	37.8	54.0	16.2	max. of all
17	1898.0	Horn	H,V	-62.1	Pk	22.3	28.2	39.0	54.0	15.0	max. of all
18											
19											
20											
Digital Spurious Emissions*											
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3* dBµV/m	E3lim dBµV/m	Pass dB	Comments
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											
31	emissions are exempt from FCC regulations per FCC 15.103(a)										

Meas. 11/05/2012; U of Mich.

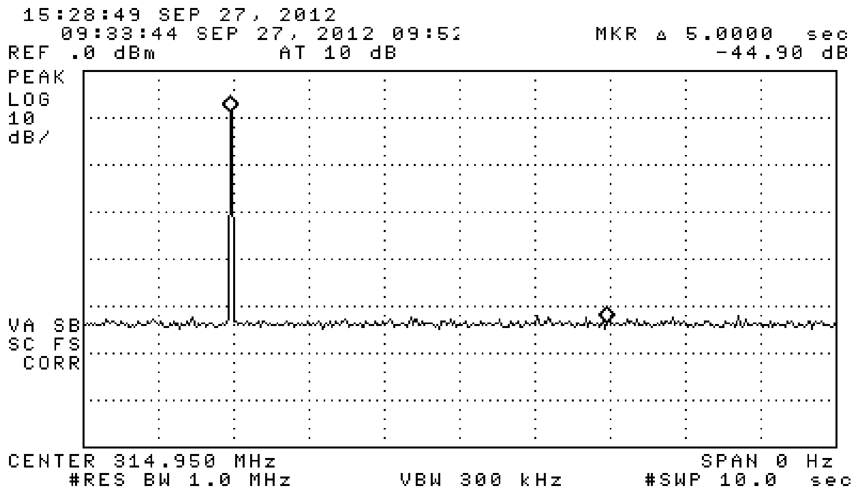
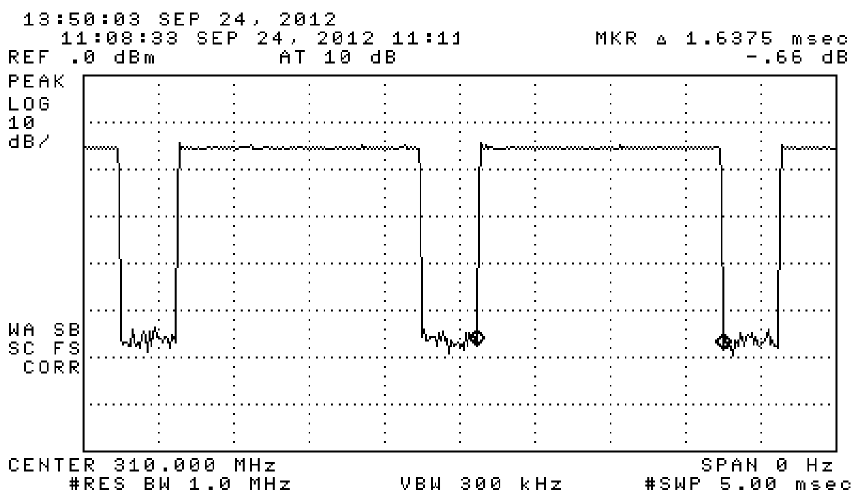


Figure 6.1(a). Transmission modulation characteristics. Single Button Press



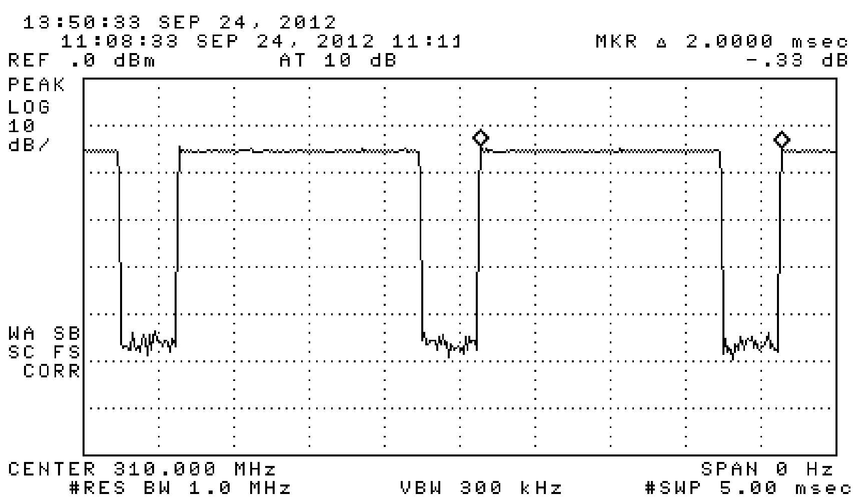
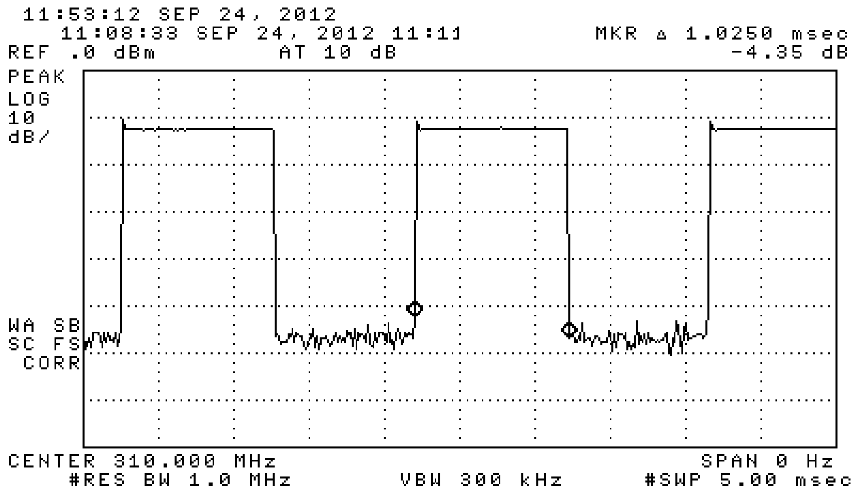


Figure 6.1(b). 80% transmission modulation characteristics. (top) pulse width, (bottom) pulse period.



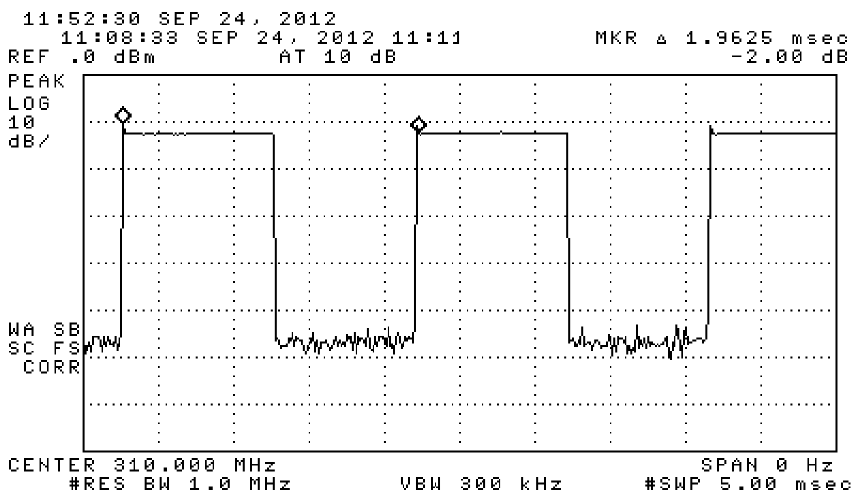
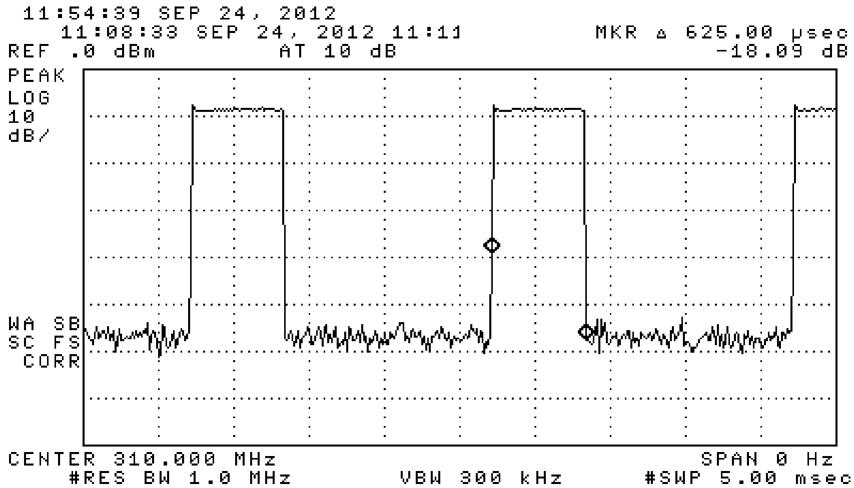


Figure 6.1(c). 50% transmission modulation characteristics. (top) pulse width, (bottom) pulse period.



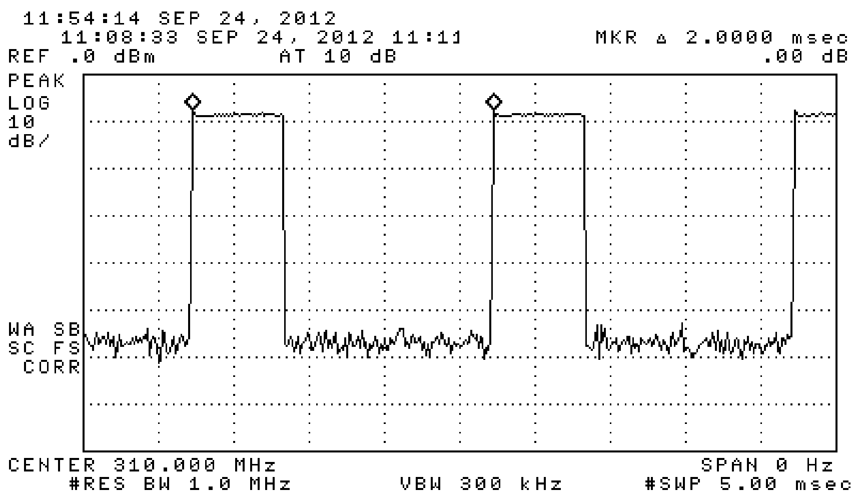


Figure 6.1(c). 30% transmission modulation characteristics. (top) pulse width, (bottom) pulse period.

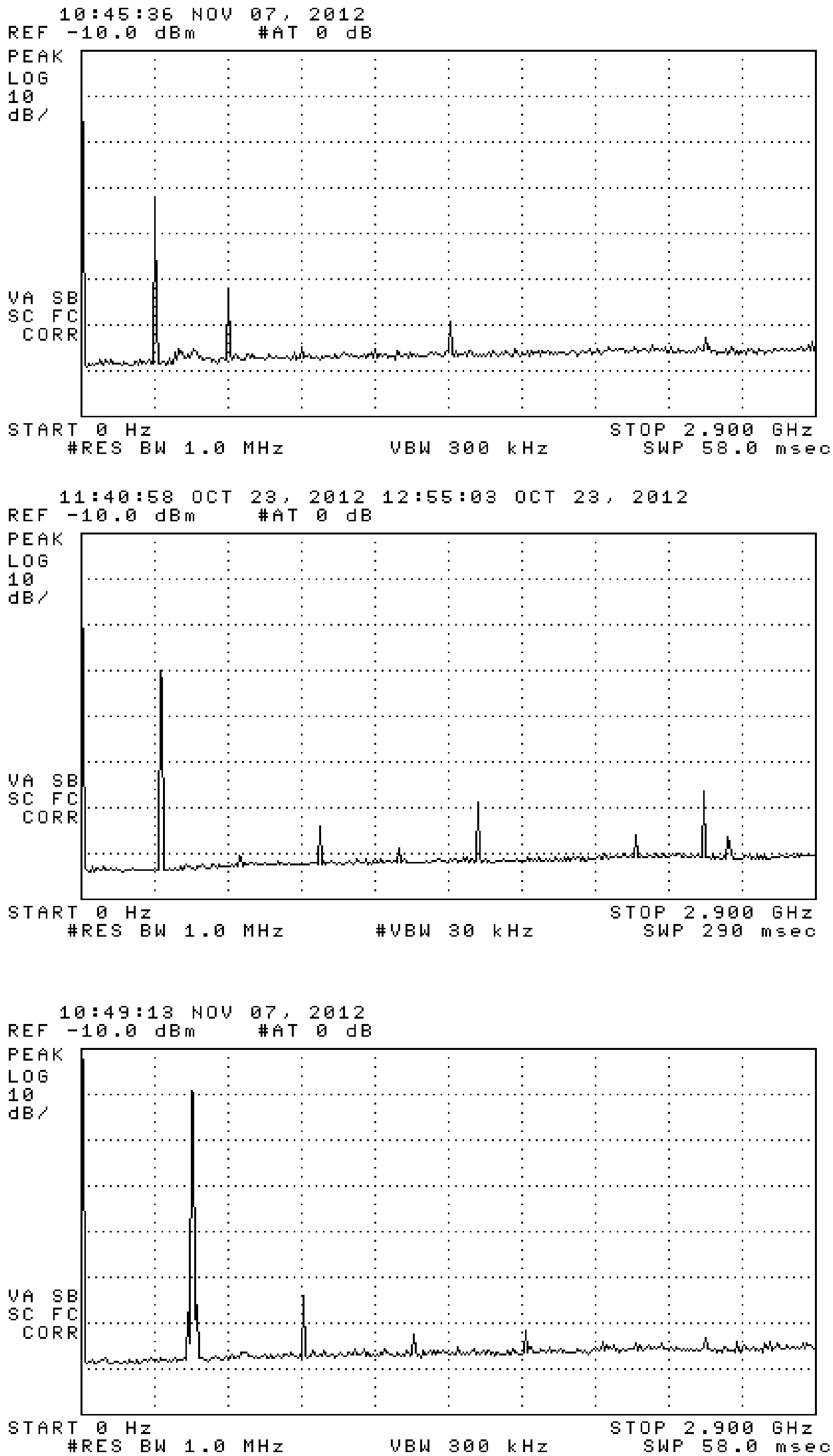


Figure 6.2. Emission spectrum of the DUT (pulsed emission). (top) 288 MHz, (middle) 310 MHz, (bottom) 434 MHz. Amplitudes are only indicative (not calibrated).

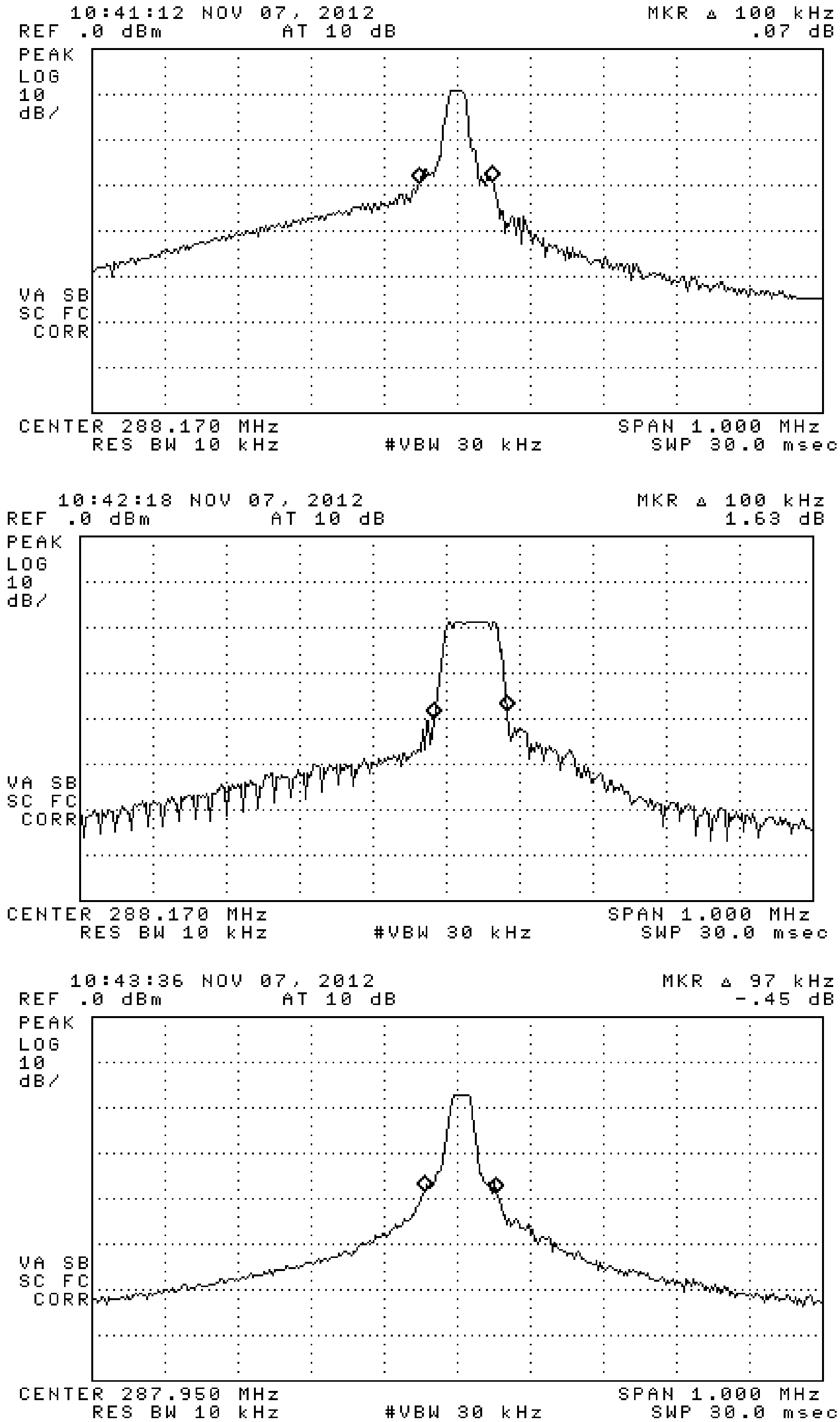


Figure 6.3(a). 288 MHz Measured emission bandwidth of the DUT (pulsed). (top) 30%, (middle) 50%, (bottom) 80%

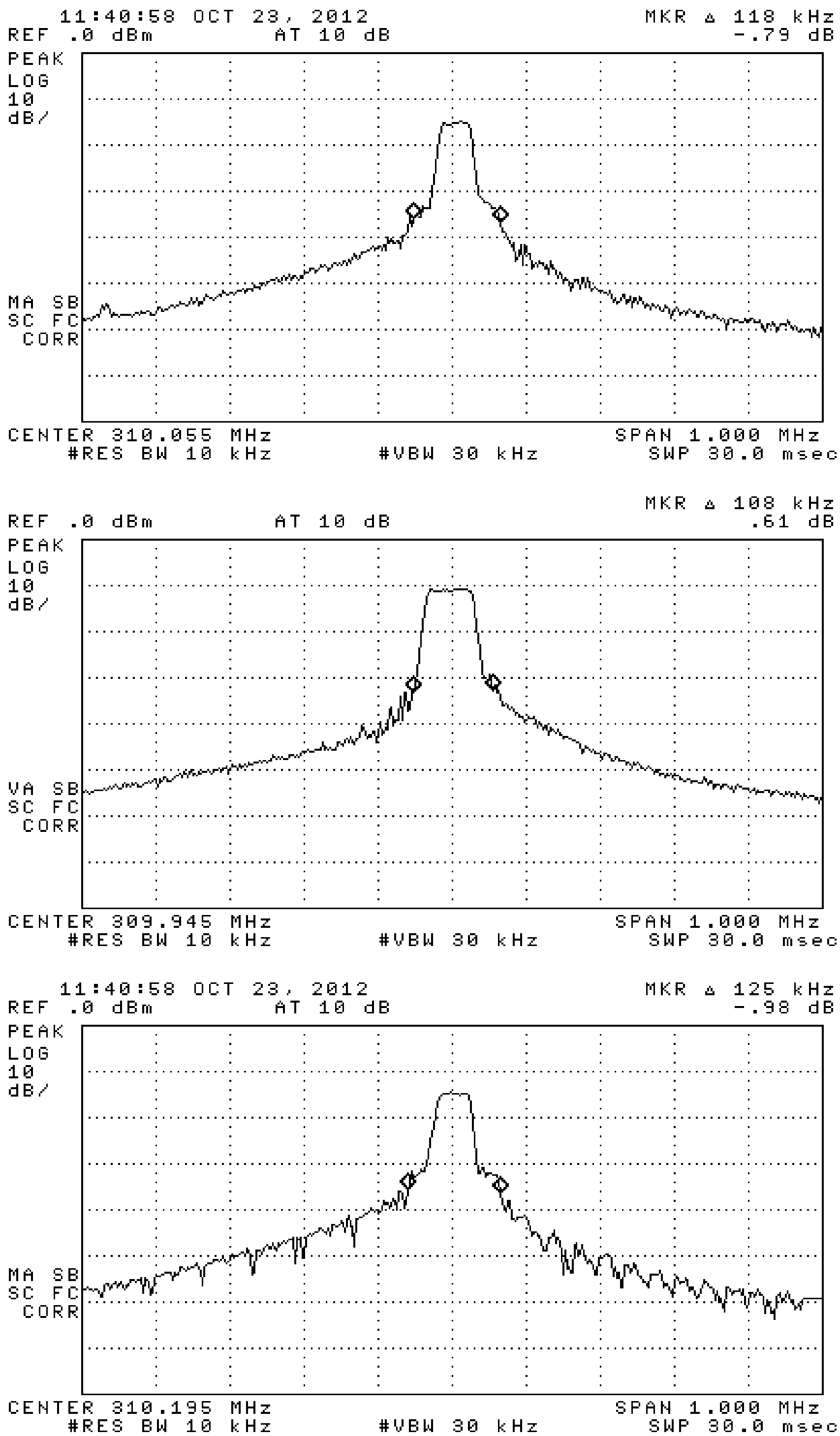


Figure 6.3(b). 310 MHz Measured emission bandwidth of the DUT (pulsed). (top) 30%, (middle) 50%, (bottom) 80%

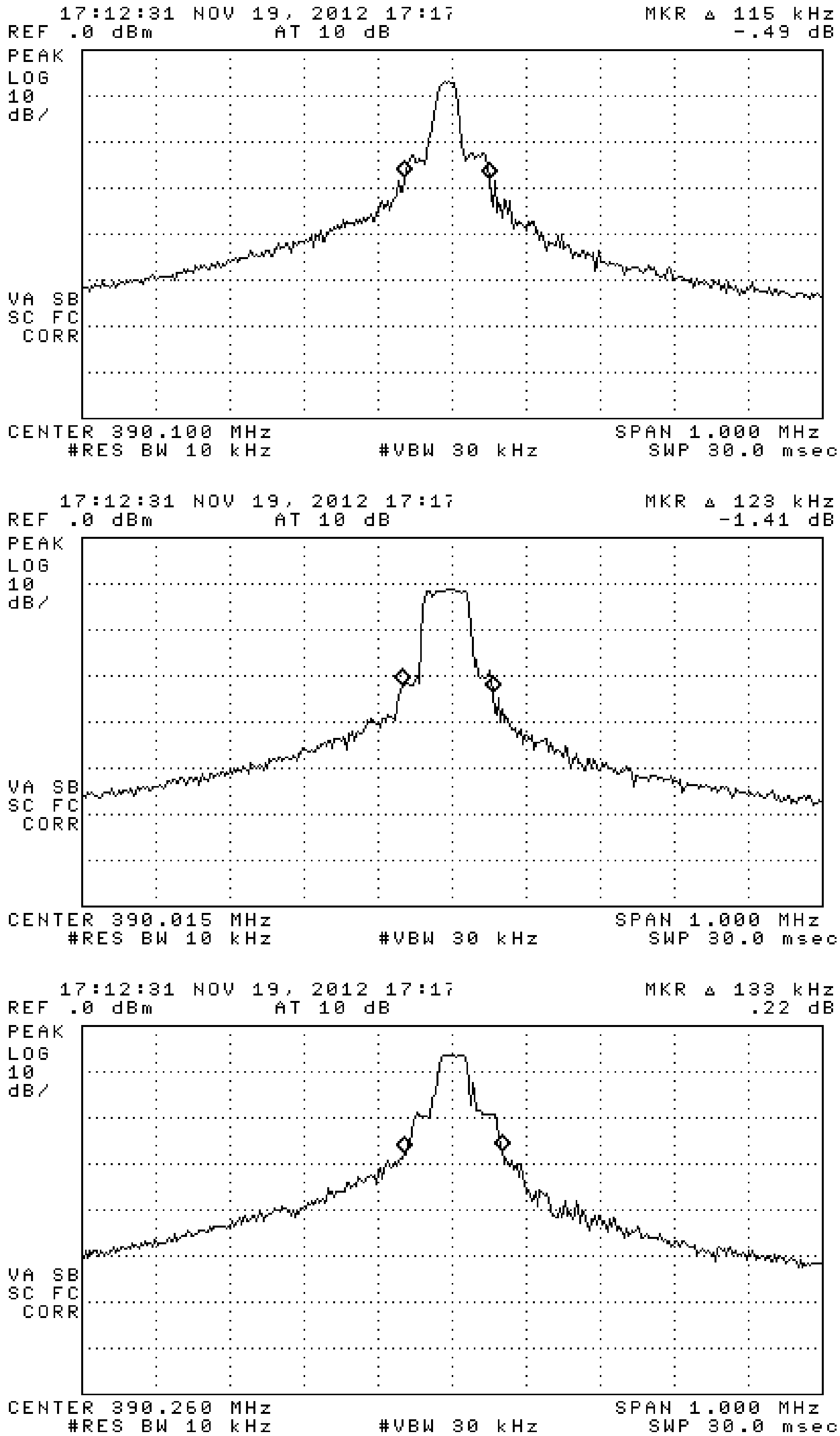


Figure 6.3(b). 390 MHz Measured emission bandwidth of the DUT (pulsed). (top) 30%, (middle) 50%, (bottom) 80%

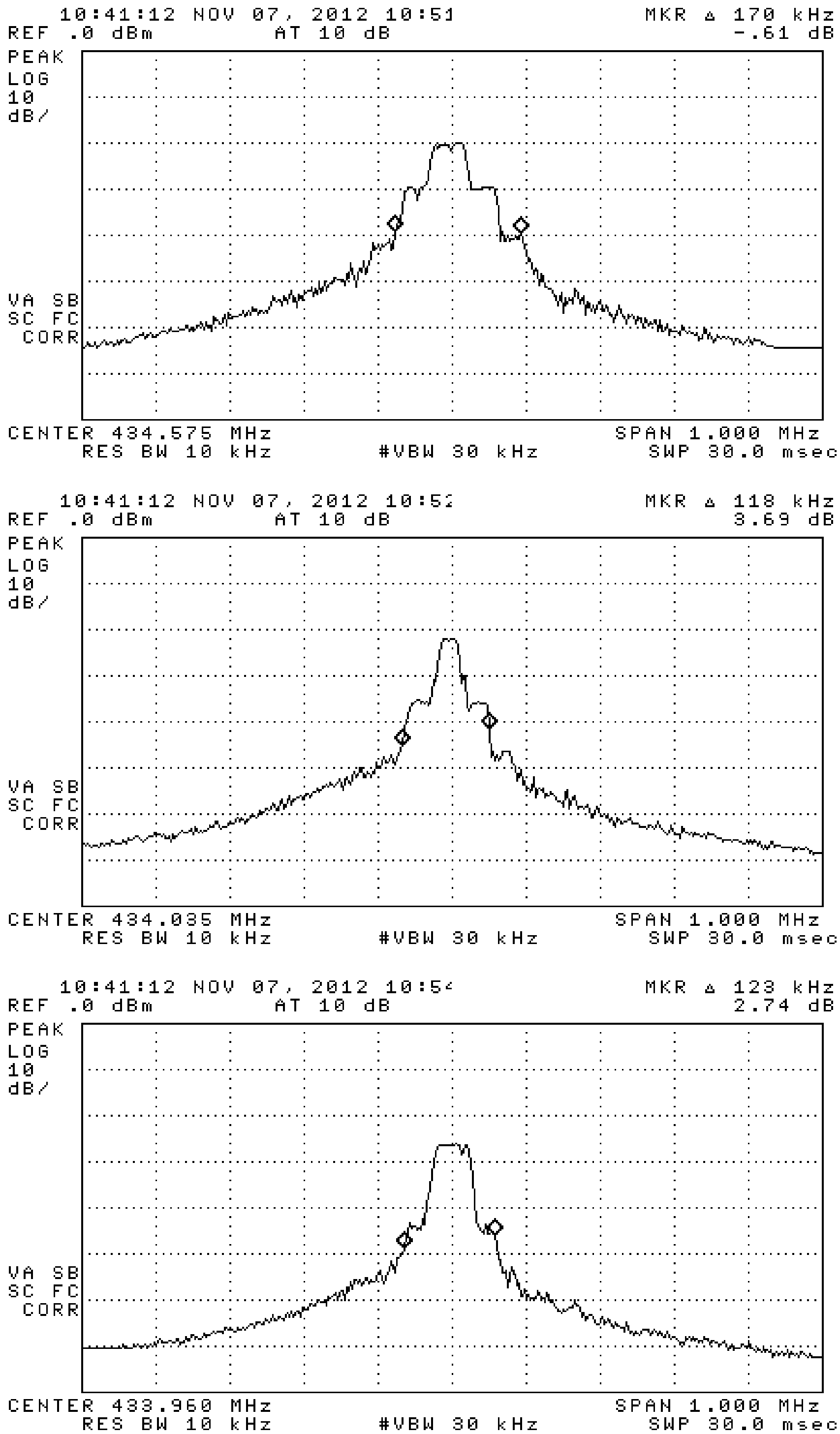


Figure 6.3(c). 434 MHz Measured emission bandwidth of the DUT (pulsed). (top) 30%, (middle) 50%, (bottom) 80%

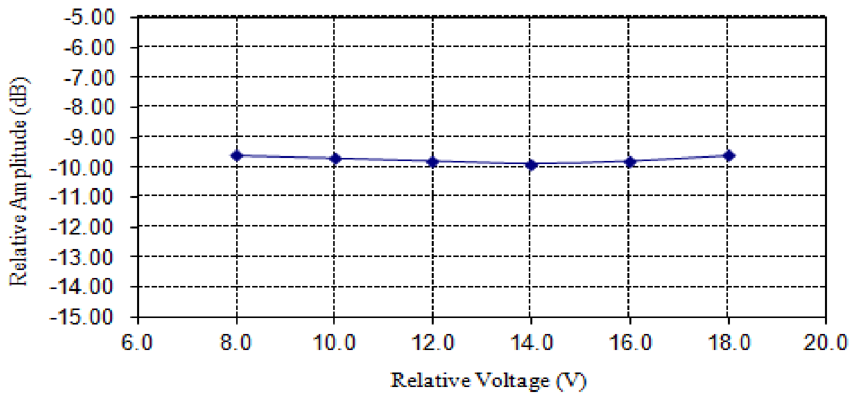
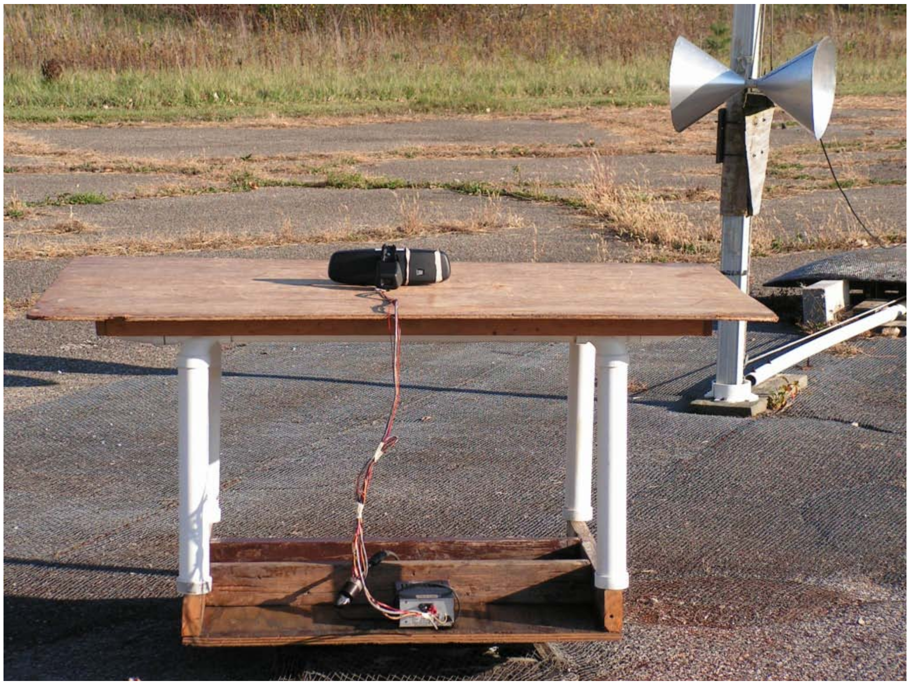
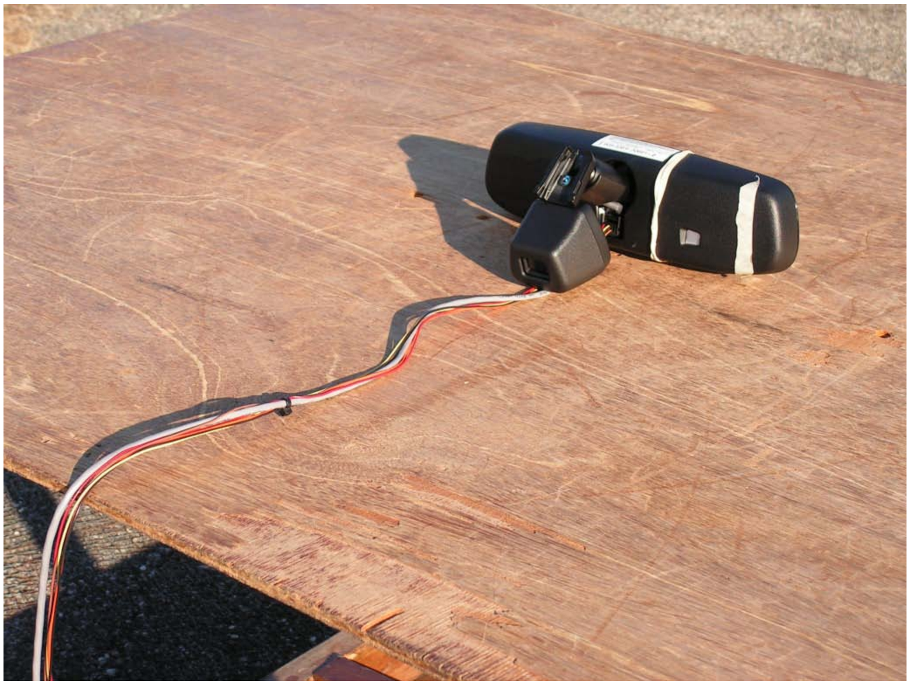


Figure 6.4. Relative emission at fundamental vs. supply voltage (pulsed).

Measured at 310 MHz with 50% Duty.



Photograph 6.5. DUT on OATS (one of three axes tested)



Photograph 6.6. Close-up of DUT on OATS (one of three axes tested)