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Measured Radio Frequency Emissions
From

iKeyless, LLC Limited Modular Transmitter
FCC ID: X32A
IC: 8797A-A

Test Report No. 417124-548
May 30, 2010

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 iKeyless, FCC ID: X32A, IC: 8797A-A. This device under test (DUT) is subject to the rules and regulations as a Limited Modular Transmitter.

In testing completed on May 4, 2010, the DUT tested met the allowed specifications for radiated emissions by 0.5 dB. Conducted emissions are not subject to regulation as the DUT manufacturer states that the LMA transmitter will always be powered by a 3 VDC lithium battery and is internally voltage regulated.

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1. Introduction

This iKeyless Transmitter 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 7, June 2007. 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 limited modular use transmitter that operates on select frequencies (channels) between 300 and 320 MHz, and at 433.9 MHz. The DUT is powered by a 3 VDC battery and is 4.5 x 3 x 0.25 cm in dimension, including its permanently attached wire antenna. For testing, a programming board was provided by the manufacturer. The DUT is designed and manufactured by iKeyless, LLC, 1201 Story Ave., Suite 301, Louisville, KY 40206.

Device	[Make], Model	[S/N],P/N	EMC Consideration
DUT	[iKeyless], 661-0001	[20090922]	CW Tx
DUT	[iKeyless], 661-0001	[20090922], P92214	Modulated Tx w/ programmer
Programmer	[iKeyless], 661-0003	-	Used to set module modes

3.2 Variants and Samples

There is only a single variant of the DUT. Two samples were provided for testing. One stand-alone module was provided with a programming board used to set the module into CW transmit mode at select frequencies. The second sample provided allowed for modulated transmission in “normal use” modes via a second programmer board.

3.3 Modes of Operation

The DUT is capable of ASK modulation over a range of manufacturer selectable fixed frequencies between 301 MHz and 320 MHz, and at 433.9 MHz. Because the device is capable of operation over a range of frequencies (set by the manufacturer in software), the low, middle, and high frequencies at 301 MHz, 310 MHz, and 320 MHz are fully tested in addition to the single 433.9 MHz frequency to demonstrate compliance across the operating bands. According the manufacturer, the DUT will be placed only in products that are manually activated and the normal mode sample provided demonstrated that the DUT as such ceases transmission within 5 seconds of button release.

3.4 Exemptions

None.

3.5 EMC Relevant Modifications

No EMI Relevant Modifications were performed by this test laboratory. However, pretesting was performed on the unit and the unit was returned to the manufacturer for retuning prior to final measurement.

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.

4.2 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

Per the manufacturer's specifications, when manually activated the DUT is capable of ASK transmission with a range of duty cycles between 22.5 % and 61.5 %. The exact duty cycle will be software programmed by the manufacturer. Peak output power remains constant independent of duty cycle employed. The supplied sample was programmed to transmit ASK signals at the highest and lowest duty cycles possible. In the worst case, the lowest duty cycle consists of repeated 200 ms Machester words exhibiting a pulse width of 1.28 ms and a pulse period of 2.08 ms. The highest duty cycle consists of three packets of Manchester encoded data with 0.268 ms pulse width and 0.422 ms pulse period. See Figure 6.1. Computing the duty factor results in:

$$K_{E(\text{highest duty})} = (1.280 \text{ ms} / 2.080 \text{ ms}) = 0.615 \text{ or } \mathbf{-4.2\ dB}.$$

$$K_{E(\text{lowest duty})} = (0.268 \text{ ms} / 0.422 \text{ ms}) \times (4.875 + 17.750 + 12.875 \text{ ms}) / 100 \text{ ms} = 0.225 \text{ or } -12.9 \text{ dB}.$$

Since the DUT peak output power is not adjusted for duty cycle, the worst case (e.g. lowest duty cycle) value of -4.2 dB is employed when demonstrating compliance.

6.1.2 Emission Spectrum

The relative DUT emission spectrum is recorded and is shown in Figure 6.2 for all four frequencies tested.

6.1.3 Emission Bandwidth

The emission bandwidth at each frequency tested is shown in Figure 6.3. The worst case allowed 99% bandwidth is 0.25% of 300 MHz or 750 kHz. From the plot we see that the worst case EBW measured was 52.5 kHz at a frequency of 433.9 MHz.

6.1.4 Supply Voltage and Supply Voltage Variation

The DUT has been designed to be powered by a 3 VDC lithium battery. For this test, relative radiated power was measured at the fundamental as the voltage was varied from 2.5 to 3.5 volts. The emission variation is shown in Figure 6.4.

Batteries:	before testing	V_{oc} =	3.28 V
	after testing	V_{oc} =	2.98 V
Ave. current from batteries		I =	32 mA (pulsed)

6.2 Conducted Emissions

These tests do not apply, since the DUT is powered from a 3 VDC battery.

Table 6.1(a) Highest Emissions Measured

Radiated Emission - RF											iKeyless 661-0001; 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	301.0	Dip	H	-35.1	Pk	18.1	20.0	65.8	74.7	8.9	flat
2	301.0	Dip	V	-37.4	Pk	18.1	20.0	63.5	74.7	11.2	end
3	602.0	Dip	H	-72.0	Pk	24.0	17.0	37.8	54.7	16.9	flat
4	602.0	Dip	V	-73.3	Pk	24.0	17.0	36.5	54.7	18.2	end
5	903.0	Dip	H	-72.3	Pk	28.3	14.9	43.9	54.7	10.9	flat, noise
6	945.0	Dip	V	-73.5	Pk	28.8	14.7	43.4	54.7	11.4	end, noise
7	1204.0	Horn	H	-64.0	Pk	20.4	28.1	31.1	54.0	22.9	max all, noise
8	1505.0	Horn	H	-65.0	Pk	21.3	28.1	31.0	54.0	23.0	max all, noise
9	1806.0	Horn	H	-44.5	Pk	22.0	28.1	52.2	54.7	**2.5**	side
10	2107.0	Horn	H	-63.4	Pk	22.8	26.5	35.7	54.7	19.1	side
11	2408.0	Horn	H	-59.1	Pk	23.5	26.3	41.0	54.7	13.8	end
12	2709.0	Horn	H	-69.0	Pk	24.4	25.3	32.9	54.0	21.1	max all, noise
13	3010.0	Horn	H	-72.0	Pk	25.4	24.0	32.2	54.7	22.6	max all, noise
14											
15	* includes 4.2 dB duty cycle.										
16											
17	310.0	Dip	H	-27.7	Pk	18.4	19.9	73.6	75.3	1.7	flat
18	310.0	Dip	V	-29.7	Pk	18.4	19.9	71.6	75.3	3.7	end
19	620.0	Dip	H	-67.6	Pk	24.2	16.8	42.6	55.3	12.7	flat
20	620.0	Dip	V	-70.7	Pk	24.2	16.8	39.5	55.3	15.8	end
21	930.0	Dip	H	-91.2	Pk	28.7	14.8	25.4	55.3	29.9	flat, noise
22	930.0	Dip	V	-93.5	Pk	28.7	14.8	23.1	55.3	32.2	end, noise
23	1240.0	Horn	H	-62.2	Pk	20.5	28.1	33.0	54.0	21.0	end
24	1550.0	Horn	H	-68.5	Pk	21.4	28.1	27.6	54.0	26.4	flat
25	1860.0	Horn	H	-42.5	Pk	22.2	28.1	54.3	55.3	**1.0**	side
26	2170.0	Horn	H	-55.7	Pk	22.9	26.5	43.5	55.3	11.8	side
27	2480.0	Horn	H	-51.0	Pk	23.8	26.1	49.4	55.3	5.9	end
28	2790.0	Horn	H	-68.0	Pk	24.7	24.9	34.5	54.0	19.5	side
29	3100.0	Horn	H	-73.4	Pk	25.7	23.7	31.3	55.3	24.0	max all, noise
30											
31	* includes 4.2 dB duty cycle.										
32											
33											
34	Digital emissions more than 20 dB below FCC/IC Class B Limit.										
35											
36											
37											
38											
39											

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Table 6.1(b) Highest Emissions Measured

Radiated Emission - RF											iKeyless 661-0001; 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	320.0	Dip	H	-26.4	Pk	18.7	19.8	75.4	75.9	**0.5**	flat
2	320.0	Dip	V	-29.0	Pk	18.7	19.8	72.8	75.9	3.1	end
3	640.0	Dip	H	-73.0	Pk	24.5	16.7	37.6	55.9	18.3	flat
4	640.0	Dip	V	-78.7	Pk	24.5	16.7	31.9	55.9	24.0	end
5	960.0	Dip	H	-90.5	Pk	29.0	14.7	26.6	55.9	29.3	flat, noise
6	945.0	Dip	V	-91.7	Pk	28.8	14.7	25.2	55.9	30.7	end, noise
7	1280.0	Horn	H	-71.4	Pk	20.7	28.1	24.0	54.0	30.0	flat
8	1600.0	Horn	H	-67.9	Pk	21.5	28.1	28.4	54.0	25.6	flat
9	1920.0	Horn	H	-46.9	Pk	22.3	28.2	50.0	55.9	5.9	side
10	2240.0	Horn	H	-58.2	Pk	23.1	26.4	41.2	54.0	12.8	side
11	2560.0	Horn	H	-59.0	Pk	24.0	25.9	41.9	55.9	14.0	flat
12	2880.0	Horn	H	-60.2	Pk	25.0	24.5	43.0	54.0	11.0	side
13	3200.0	Horn	H	-72.2	Pk	26.0	23.5	33.1	55.9	22.8	max all, noise
14											
15	* includes 4.2 dB duty cycle.										
16											
17	433.9	Dip	H	-35.6	Pk	21.5	18.5	70.2	80.8	**10.6**	flat
18	433.9	Dip	V	-35.7	Pk	21.5	18.5	70.1	80.8	10.7	end
19	867.8	Dip	H	-68.7	Pk	27.8	15.1	46.8	60.8	14.0	flat
20	867.8	Dip	V	-69.5	Pk	27.8	15.1	46.0	60.8	14.8	end
21	1301.7	Horn	H	-62.6	Pk	20.7	28.1	32.8	54.0	21.2	side
22	1735.6	Horn	H	-51.6	Pk	21.9	28.1	45.0	60.8	15.8	flat
23	2169.5	Horn	H	-61.2	Pk	22.9	26.5	38.0	60.8	22.8	side
24	2603.4	Horn	H	-57.6	Pk	24.1	25.7	43.6	60.8	17.2	end
25	3037.3	Horn	H	-72.0	Pk	25.5	23.9	32.3	60.8	28.5	max all, noise
26	3471.2	Horn	H	-71.5	Pk	26.8	23.2	34.9	60.8	25.9	max all, noise
27	3905.1	Horn	H	-73.5	Pk	28.1	22.4	35.1	54.0	18.9	max all, noise
28	4339.0	Horn	H	-72.2	Pk	29.5	16.2	43.8	54.0	10.2	max all, noise
29											
30	* includes 4.2 dB duty cycle.										
31											
32											
33											
34	Digital emissions more than 20 dB below FCC/IC Class B Limit.										
35											
36											
37											
38											
39											

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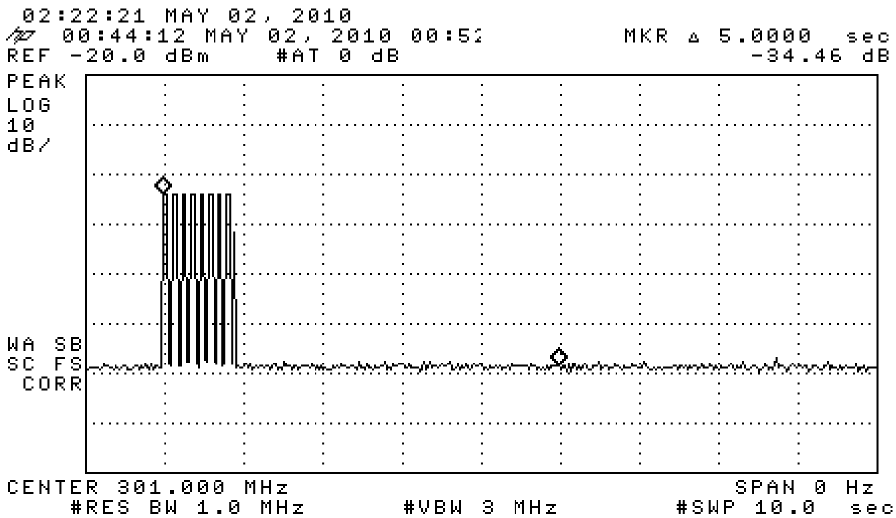


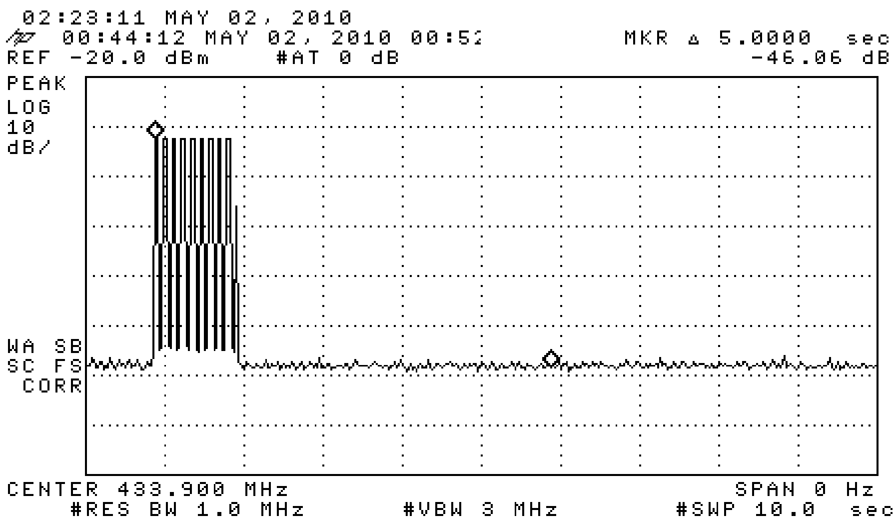


Figure 6.1. Manually Activated Transmission Turn Off.
(top) 301 MHz example, (bottom) 433.9 MHz example.

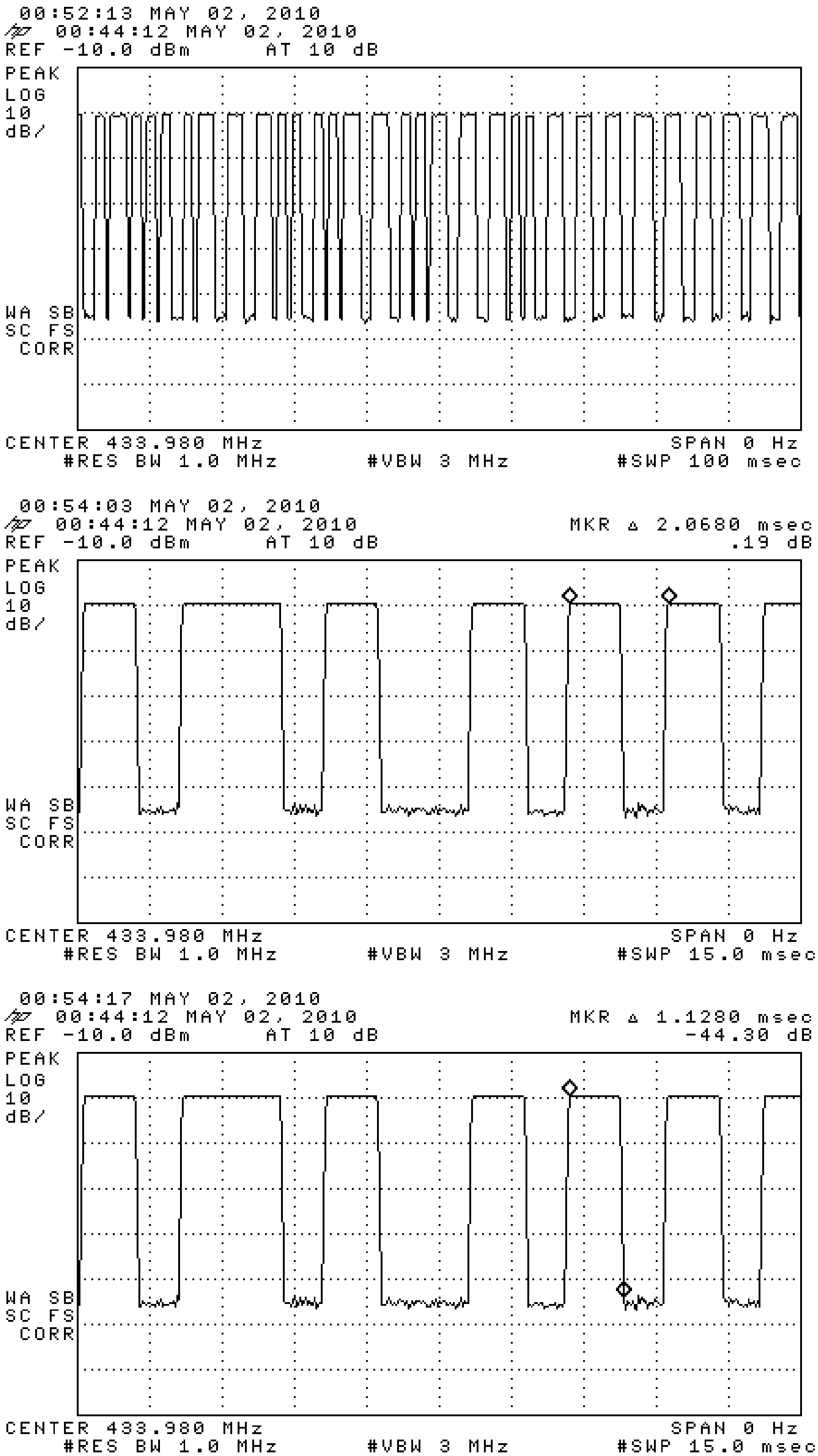


Figure 6.1. Highest duty cycle transmission characteristics. (top) Manchester Encoded transmission, (center) pulse period, (bottom) pulse width.

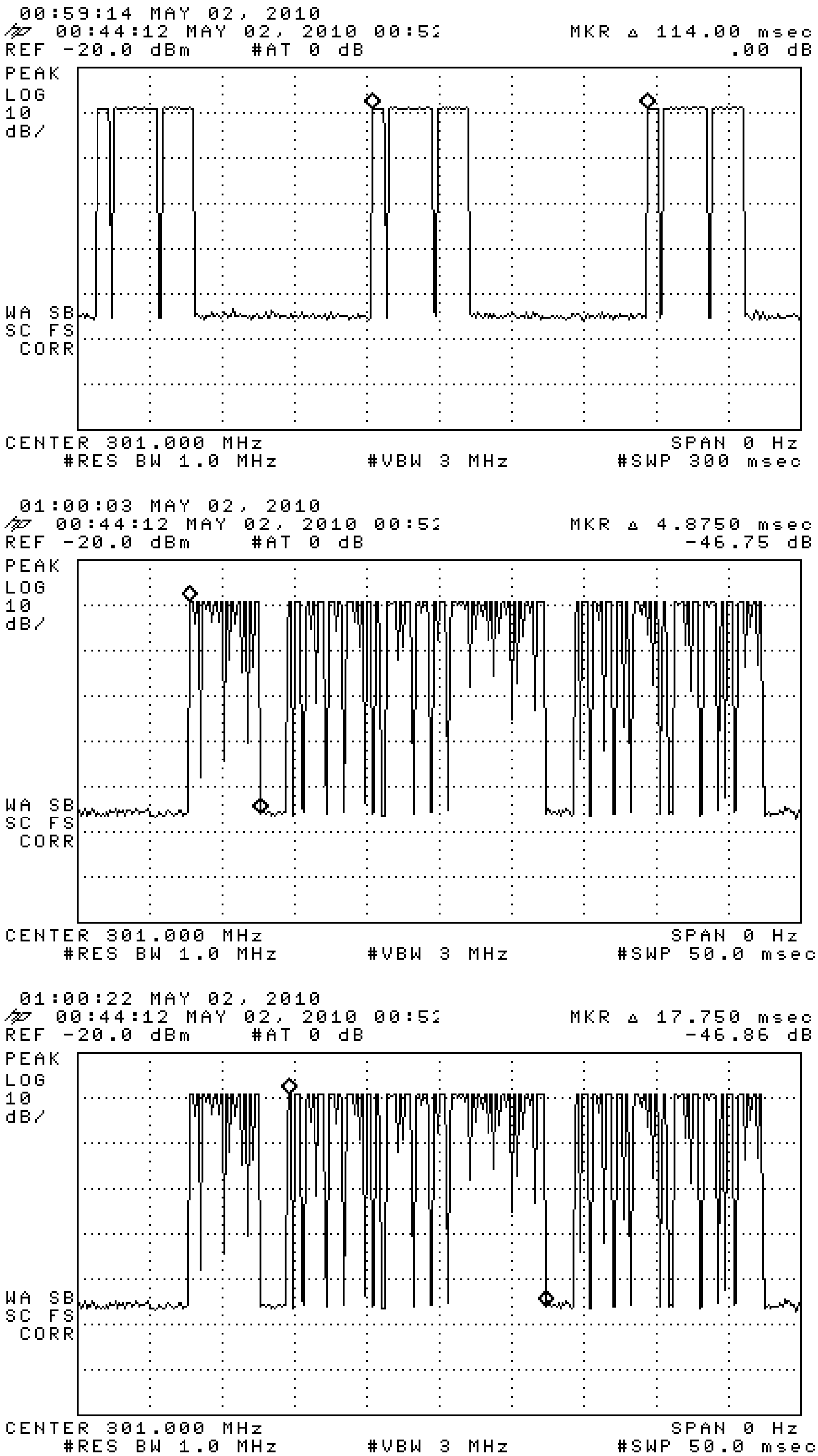


Figure 6.1. Lowest duty cycle transmission characteristics. (top) transmission period, (center) first packet length, (bottom) second packet length.

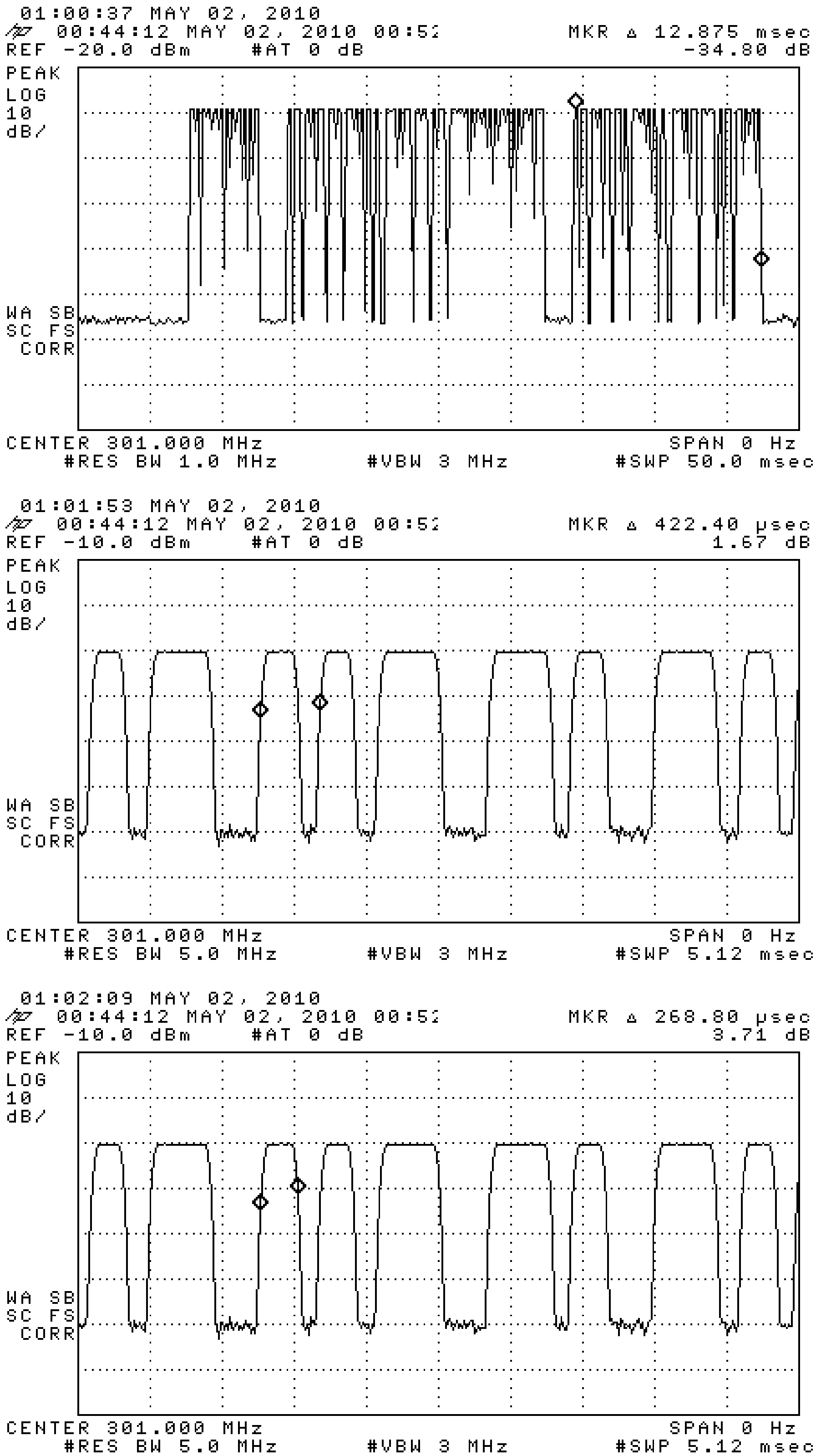


Figure 6.1. Lowest duty cycle transmission characteristics. (top) third packet length, (center) expanded transmission, (bottom) expanded word.

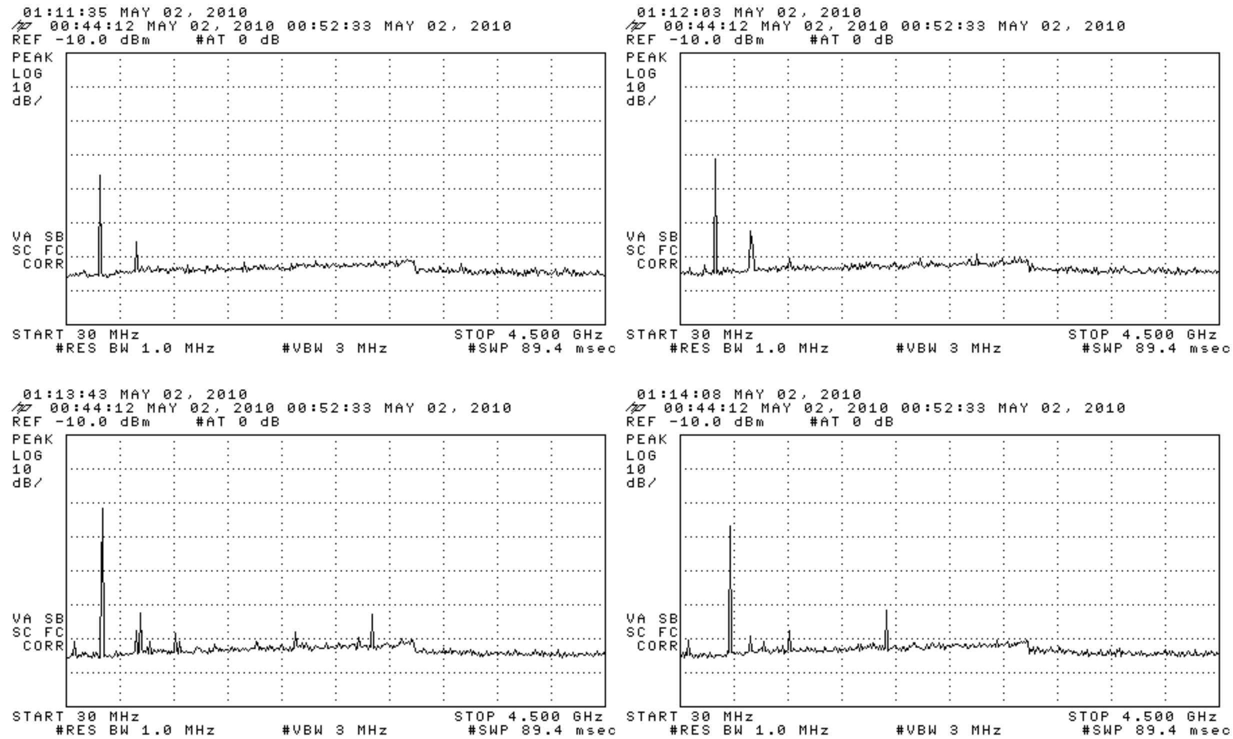


Figure 6.2. Emission spectrum of the DUT (pulsed emission). Amplitudes are only indicative (not calibrated).
(top, left) 301 MHz, (top, right) 310 MHz,
(bottom, left) 320 MHz, (bottom, right) 310 MHz.

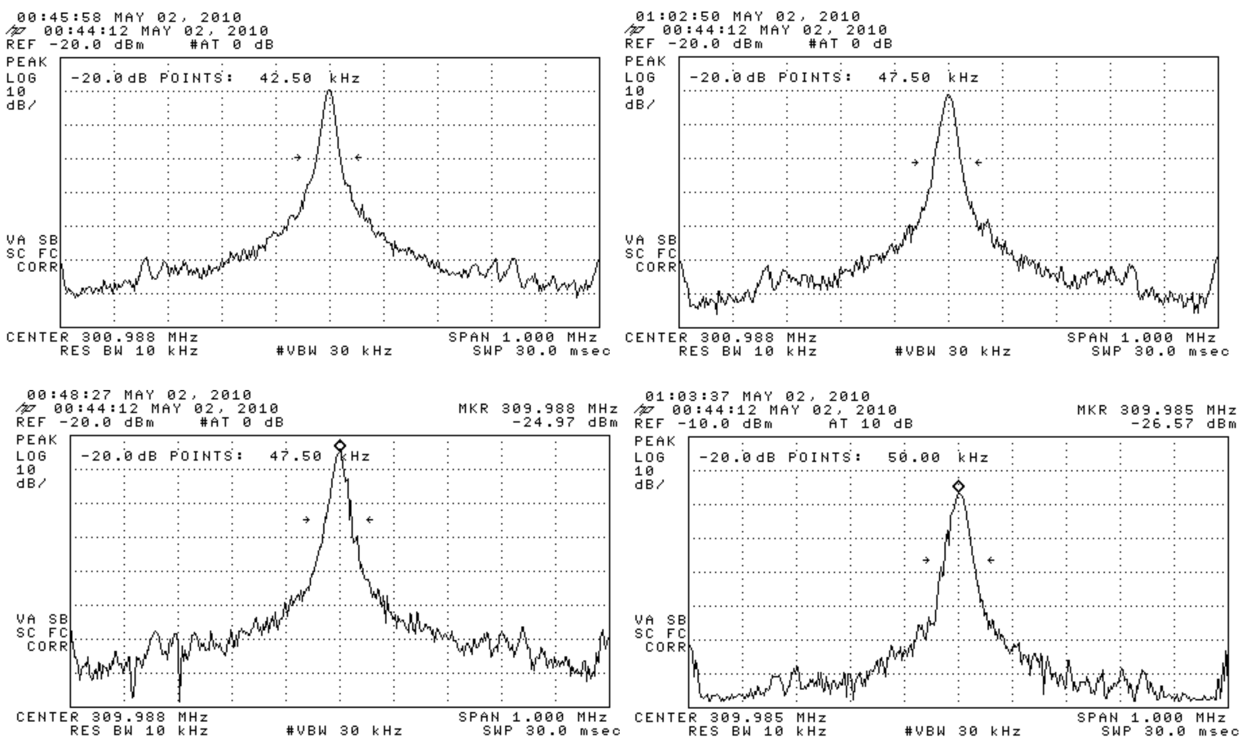


Figure 6.3(a). Measured emission bandwidth of the DUT (pulsed).
(top, left) 301 MHz ASK lowest duty, (top, right) 301 MHz ASK highest duty,
(bottom, left) 310 MHz ASK lowest duty, (bottom, right) 310 MHz ASK highest duty

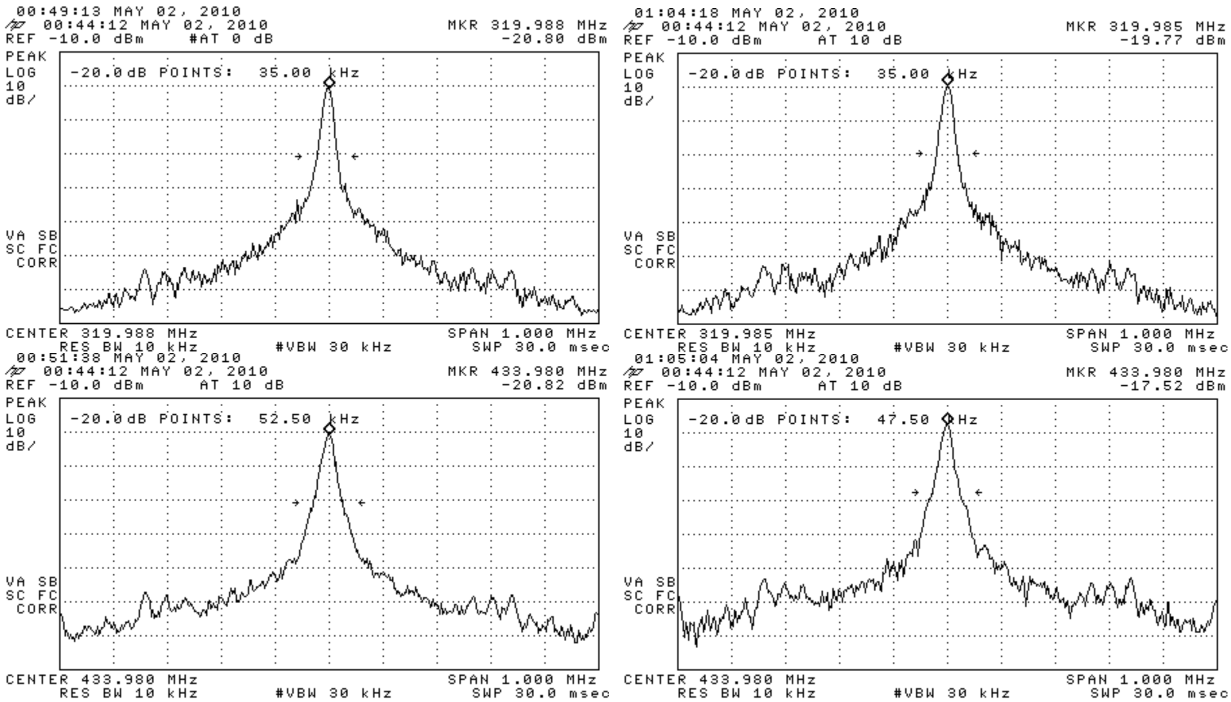


Figure 6.3(a). Measured emission bandwidth of the DUT (pulsed).
(top, left) 320 MHz ASK lowest duty, (top, right) 320 MHz ASK highest duty,
(bottom, left) 433.9 MHz ASK lowest duty, (bottom, right) 433.9 MHz ASK highest duty

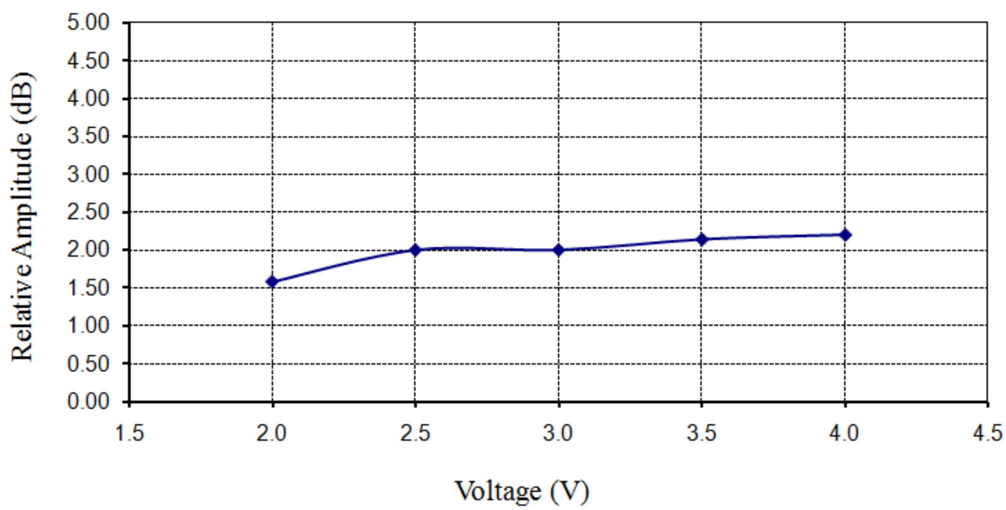
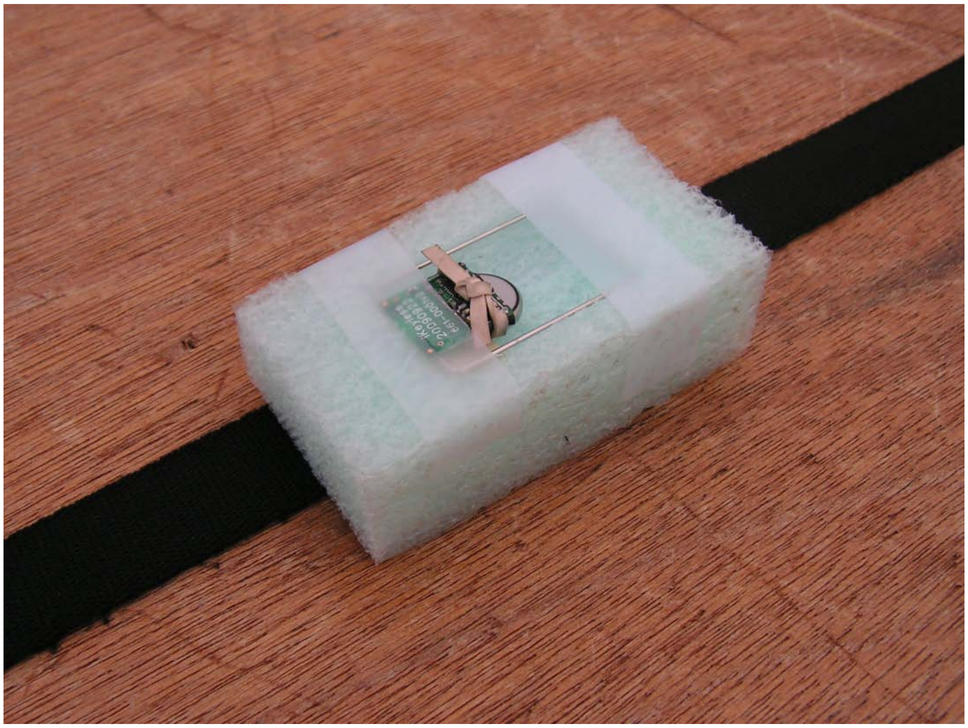


Figure 6.4. Relative emission at fundamental vs. supply voltage (pulsed).

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)