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Measured Radio Frequency Emissions
From

Evigia Systems, Inc. Transponder Reader
FCC ID: XND-EMR-1
IC: 8519A-EMR1

Test Report No. 417124-534
October 29, 2009

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 Evigia, FCC ID: XND-EMR-1, IC: 8519A-EMR1. This device under test (DUT) is subject to the rules and regulations as a Transceiver.

In testing completed on October 15, 2009, the DUT tested meets the allowed specifications for intentional radiated emissions by 1.0 dB. Harmonic radiated emissions meet the regulations by more than 3.1 dB. The FCC Class A digital emissions limit is met by more than 20 dB. Power line conducted emissions are not subject as the device only operates when connected to a battery powered scanner device.

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1. Introduction

This Evigia 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 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

The DUT is a 433.9 MHz FSK, active RFID interrogator designed for cargo tracking applications. This device is housed in a plastic case approximately 9 x 17 x 5 cm in dimension and is powered from a handheld barcode scanner. Tested with this unit was a commercial barcode scanner. The DUT is designed and manufactured by Evigia Systems, Inc., 3810 Varsity Drive, Ann Arbor, MI 48108-2224.

Device Under Test	[Make], Model	[S/N],P/N	EMC Consideration
Hand Held Interrogator	[Evigia], EV3-HHI	[Proto1]	FCC 15.231, 15.240 IC RSS-210 2.7, A5
Barcode Scanner	[Symbol], MC9090	MC9090-GJOHJEFA6WR	

3.2 Variants and Samples

There is only a single variant of the DUT. One sample was provided for testing. An Evigia engineer programmed the devices into CW, normal operating, and Rx only modes for testing.

3.3 Modes of Operation

This interrogator is capable of two principle modes of operation, and qualifies for certification under two rule parts (FCC 15.231/RSS-210 2.7 and FCC 15.240/RSS-210 A5).

When manually activated (via button press on scanner unit), the device will send a transponder wake-up command followed by request mode transmission. Communication ceases if no transponders reply. Alternatively, a transponder tag in the operating range of this device would reply with a single request mode packet that may then automatically activate a single request-mode response from the DUT.

The DUT verifies the integrity of the request mode packet sent back before requesting any new packet. Both the interrogator and any associated transponder tag employ the ISO 18000-7:2008 RFID protocol.

3.4 Exemptions & Notes

The DUT is not subject to AC power line conducted emissions testing as it draws power from the scanner unit. The DUT must be removed from the scanner to charge the battery in the scanner unit.

The DUT employs a SMA_RP (reverse-polarized) removable antenna, and is professionally installed.

3.5 EMC Relevant Modifications

No EMI Relevant Modifications were performed by this test laboratory.

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 4.1(b). TX Emission Limits (FCC: 15.240; IC: RSS-210 A5).

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)
433.5-434.5	11000	80.8	200 < 1 GHz 500 > 1 GHz	46.0 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)		Class B (dBμV)	
	Quasi-peak	Average	Quasi-peak	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. 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 received 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 DUT on the OATS.

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

When manually activated, the device begins by sending a wake mode transmission consisting of a 2.5 second continuous burst of FSK with a 0.0 dB duty cycle, see Figure 6.1.

$$K_{EWAKE} = 0.0 \text{ dB.}$$

This wake-up is then followed by request mode transmissions with transmitted packet length of 27.75 ms and a fixed packet period of 100.05 ms, see Figure 6.1. This mode has a duty cycle of

$$K_{EREQ} = 27.75 \text{ ms} / 100 \text{ ms} = 0.27.75 \text{ or } -11.1 \text{ dB.}$$

If no transponder tag is present, only four request packets follow the wake-up, and transmission will cease in less than 5 seconds. This is considered the only manually activated mode. If a transponder tag is present, the tag will respond with its own request mode packet, and can automatically activate the DUT to send a new request mode packet depending on the amount of information being transferred. This response consists of only a single request mode packet, and meets the requirements of FCC 15.231 that the response to an automatic activation ceases within 5 seconds. Further, if at any time the transponder tag is removed from the DUT operating area, automatic activation via request-mode transmission on behalf of both the DUT and the transponder tag immediately cease.

To ensure compliance with the rules outlined in FCC 15.240, the exchange of request mode transmissions never exceeds 60 seconds. The API driver maintains two timers: 1) a 10 second timer that times the period between transmissions and is reset after each transmission, and 2) a 60 second timer that times the active transmission period and is reset when the 10 second timer elapses. This algorithm guarantees a 10 second pause in transmission after 60 seconds of continuous transactions regardless of message destination and application requests.

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 Figure 6.3. The allowed 99% bandwidth is 0.25% of 433.9 MHz, or 1.085 MHz. From the plot we see that the worst case EBW occurs in the wake mode at 245.0 kHz, and the center frequency is 433.92 MHz.

6.1.4 Supply Voltage and Supply Voltage Variation
The DUT has been designed to be powered by from the 5 VDC supply of a battery powered barcode scanner. Because of the scanner's construction, it was not possible to vary the supply voltage to the radio module. A fully charged scanner was employed during testing.

6.1.5 Conducted Emissions
AC Power line conducted emissions tests are not applicable as the device is battery powered. Note that the DUT must be removed from the scanner to charge the battery in the scanner unit.

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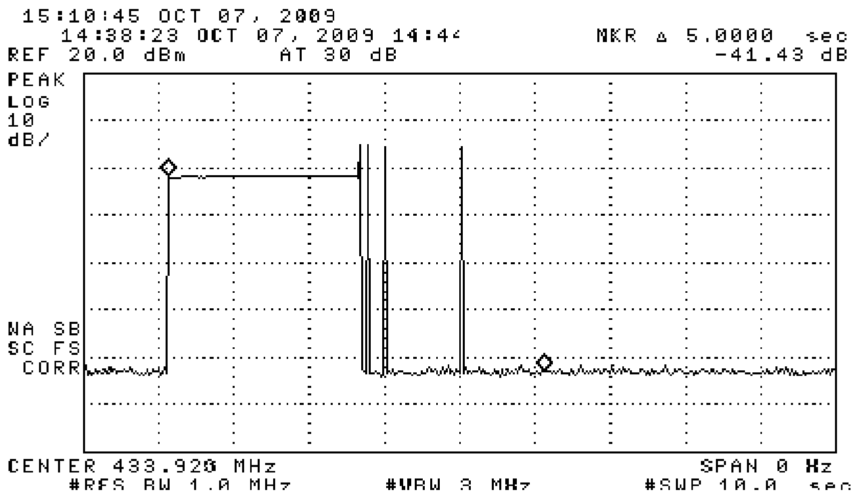
Table 6.1 Fundamental & Harmonic Emissions

Radiated Emission - RF											Evigia EV3-HHI; 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	**Wake Interrogation** - includes 0.0 dB duty cycle (continuous FSK)										
2	433.9	Dip	H	-30.9	Pk	21.2	18.8	78.5	80.8	2.4	flat
3	433.9	Dip	V	-29.5	Pk	21.2	18.8	79.9	80.8	**1.0**	side
4	867.8	Dip	H	-76.1	Pk	27.4	15.4	42.9	46.0	3.1	background
5	867.8	Dip	V	-76.8	Pk	27.4	15.4	42.2	46.0	3.8	background
6	1301.8	Horn	H	-65.2	Pk	20.7	28.1	34.4	54.0	19.6	end
7	1735.7	Horn	H	-69.2	Pk	21.9	28.1	31.6	54.0	22.4	side
8	2169.6	Horn	H	-62.2	Pk	22.9	26.5	41.2	54.0	12.8	side
9	2603.5	Horn	H	-58.9	Pk	24.1	25.7	46.5	54.0	7.5	side
10	3037.4	Horn	H	-71.0	Pk	25.5	23.9	37.5	54.0	16.5	max all, noise
11	3471.4	Horn	H	-72.2	Pk	26.8	23.2	38.4	54.0	15.6	max all, noise
12	3905.3	Horn	H	-71.6	Pk	28.1	22.4	41.2	54.0	12.8	max all, noise
13	4339.2	Horn	H	-72.1	Pk	29.5	16.2	48.1	54.0	5.9	max all, noise
14											
15	**Reqest Mode** - includes 11.1 dB duty cycle										
16	433.9	Dip	H	-19.8	Pk	21.2	18.8	78.5	80.8	2.4	flat
17	433.9	Dip	V	-18.7	Pk	21.2	18.8	79.6	80.8	**1.3**	side
18	867.8	Dip	H	-72.9	Pk	27.4	15.4	35.0	46.0	11.0	background
19	867.8	Dip	V	-74.0	Pk	27.4	15.4	33.9	46.0	12.1	background
20	1301.8	Horn	H	-53.1	Pk	20.7	28.1	35.4	54.0	18.6	end
21	1735.7	Horn	H	-61.1	Pk	21.9	28.1	28.6	54.0	25.4	side
22	2169.6	Horn	H	-49.8	Pk	22.9	26.5	42.5	54.0	11.5	flat
23	2603.5	Horn	H	-58.6	Pk	24.1	25.7	35.7	54.0	18.3	side
24	3037.4	Horn	H	-62.7	Pk	25.5	23.9	34.7	54.0	19.3	max all, noise
25	3471.4	Horn	H	-63.8	Pk	26.8	23.2	35.7	54.0	18.3	max all, noise
26	3905.3	Horn	H	-63.3	Pk	28.1	22.4	38.4	54.0	15.6	max all, noise
27	4339.2	Horn	H	-63.7	Pk	29.5	16.2	45.4	54.0	8.6	max all, noise
28											
29	** Harmonic Emissions Limit is 60.8 dBuV/m under 15.231, 46 dBuV/m - 54 dBuV/m under 15.240.										
30	*** Peak Emissions Limit under 15.240 is 94.8 dBuV/m										

Spurious Digital & Receiver Emissions (Class B)											
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBµV/m	E3lim dBµV/m	Pass dB	Comments
31	433.89	SBic	H	-83.1	Pk	21.9	18.8	27.0	46.0	19.0	LO, noise
32	433.95	SBic	H	-82.9	Pk	21.9	18.8	27.2	46.0	18.8	LO, noise
33	867.77	SBic	H	-84.0	Pk	28.6	15.4	36.2	46.0	9.8	2 x LO, noise
34	867.91	SBic	V	-83.1	Pk	28.6	15.4	37.1	46.0	8.9	2 x LO, noise
35											
36	No digital emissions were observed within 20 dB of the Class B limit										

Meas. 09/01/2009; U of Mich.



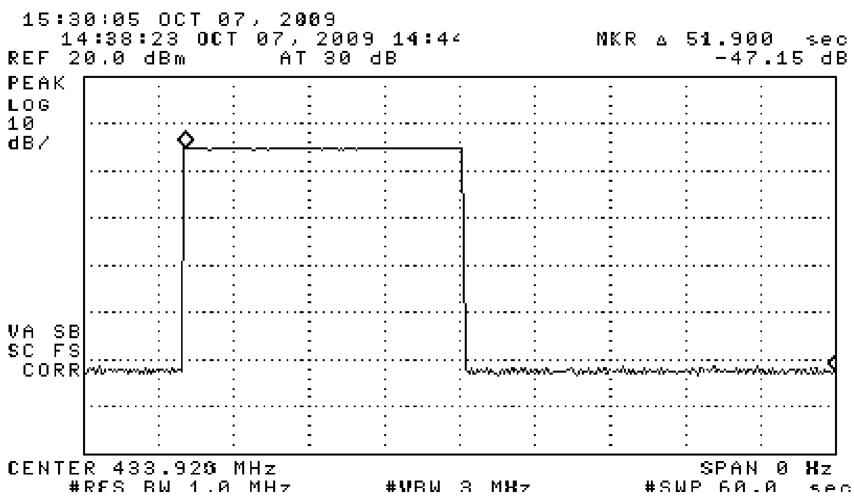
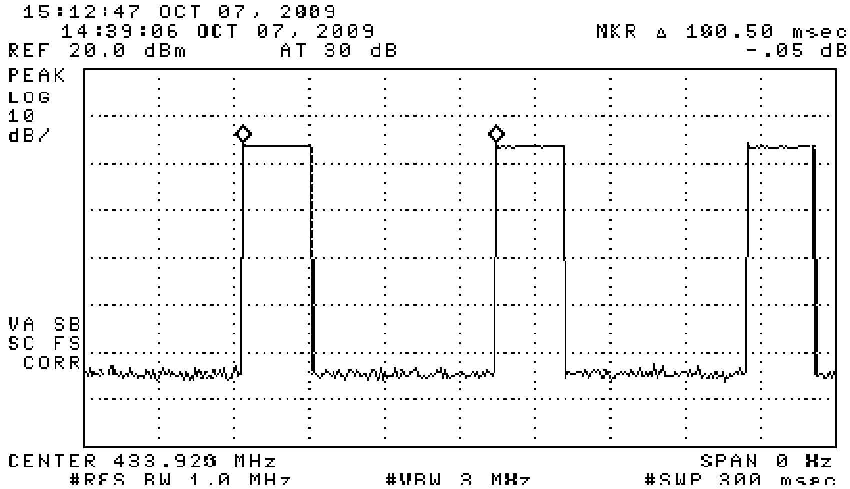


Figure 6.1(a). Transmission characteristics, (top) manual activation – 2.5 second wake followed by four data request commands, (bottom) manual activation followed by request mode communications between the DUT and transponder tag (longest possible operation time is shown here).



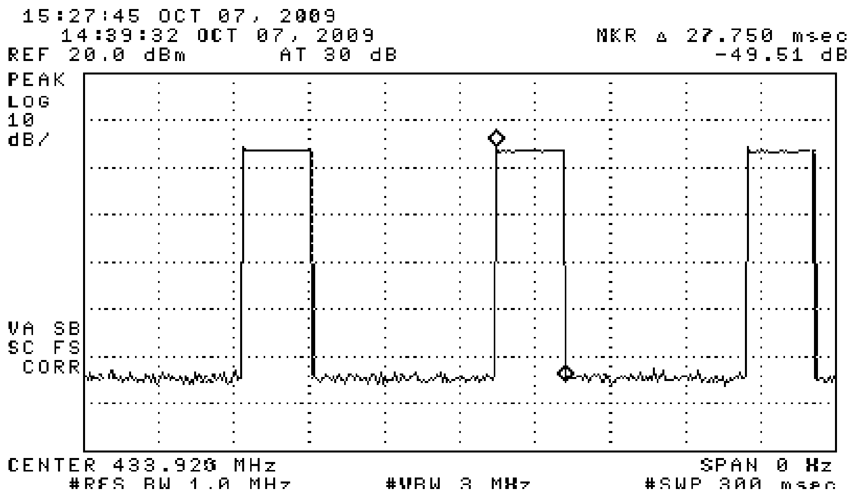


Figure 6.1(b). Transmission characteristics, (top) request mode packet period, (bottom) request mode FSK packet length.

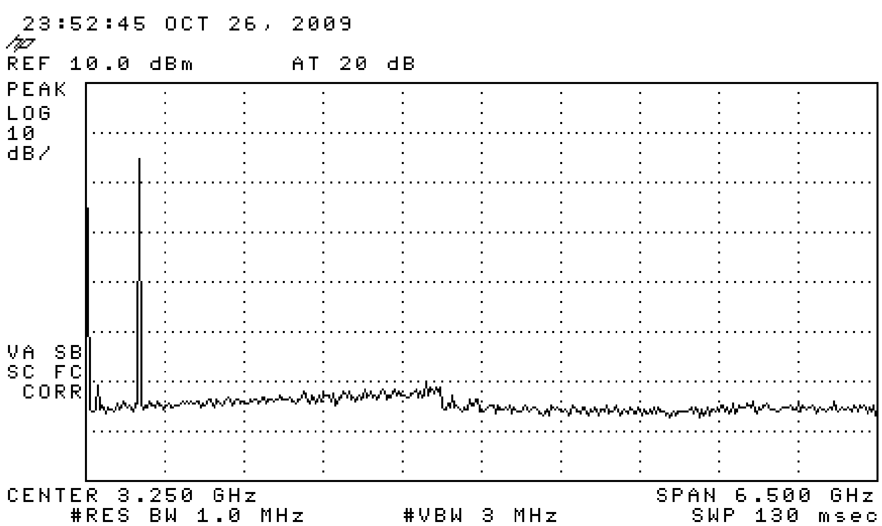
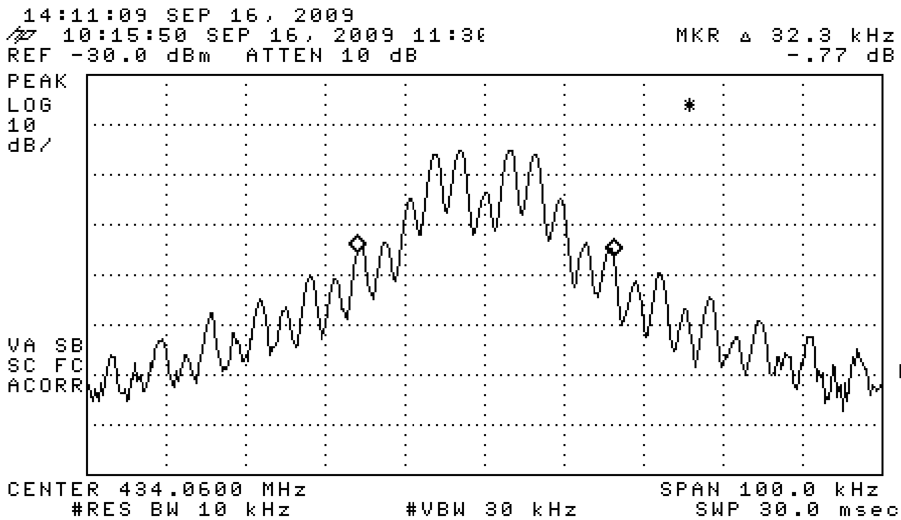


Figure 6.2. Emission spectrum of the DUT (pulsed). Amplitudes are only indicative (not corrected).



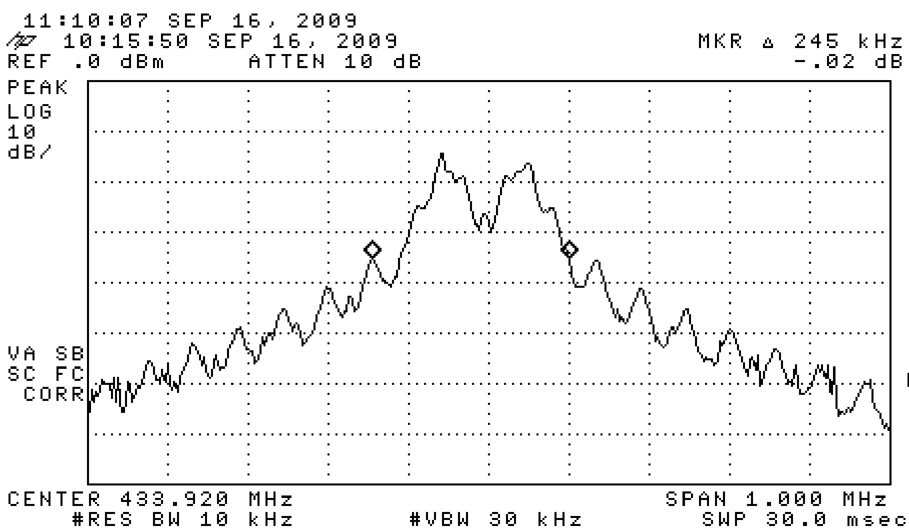


Figure 6.3. Measured emission bandwidth of the DUT. (top) wake transmissions (continuous FSK), (bottom) read data mode transmission (pulsed FSK).

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)