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Measured Radio Frequency Emissions
From

Lear Corporation Transceiver
FCC ID: KOBKRC11A
IC: 3521A-KRC11A

Test Report No. 417124-605
June 15, 2011

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 Lear, FCC ID: KOBKRC11A, IC: 3521A-KRC11A. This device under test (DUT) is subject to the rules and regulations as a Transceiver.

In testing completed on May 31, 2011, the DUT tested met the allowed specifications for radiated emissions by more than 13.4 dB. Conducted emissions are not subject to regulation as the DUT is powered by a 12 VDC vehicular system.

Table of Contents

1. Introduction

This Lear 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 & Block Diagram

The DUT contains a 125 kHz Immobilizer, 125 kHz Transmitter, and 433.9 MHz Receiver designed for automotive/vehicular applications, and as such it is powered by a 12 VDC source. The device is housed in a plastic case approximately 22 x 13 x 5 cm in dimension. For testing, a generic harness was provided by the manufacturer.

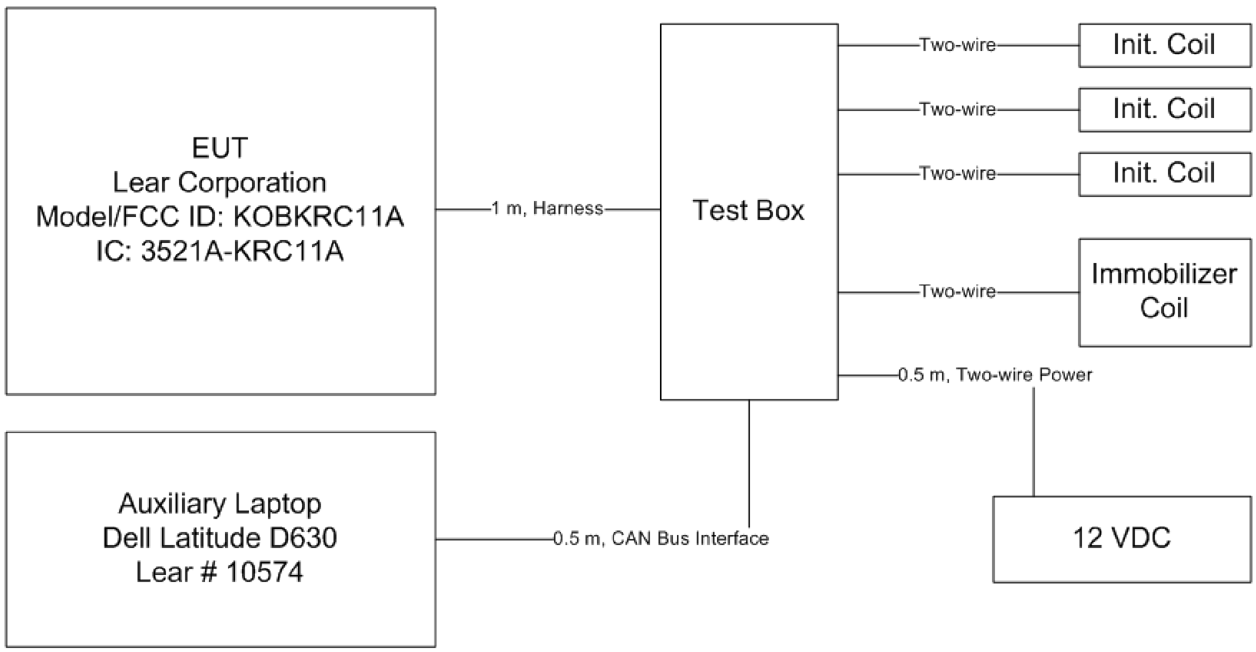

Figure 3.1 Block Diagram

3.2 Samples & Variants

Two samples were provided for testing. The first sample is a fully functional device controlled over it's CAN bus that activates the LF Immobilizer and LF Inititiators from external commands (e.g. as if the door handles or a butter were being pressed on the vehicle). The second sample supplied had the receiver circuitry forced into a continuous awake state to perform receiver emissions verification.

3.3 Modes of Operation

The EUT operates as a 125 kHz Ignition Immobilizer and 125 kHz LF Initiator (to activate RF keyless entry fobs held by the user), and an RF receiver (to detect transmissions from the keyless entry fobs). All three modes were tested to demonstrate compliance.

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. Furthermore, the receiver employed in association with the transmitter is subject only to verification measurements.

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. Transmitter Radiated Emission Limits (FCC: 15.205, 15.35; IC: RSS-210, 2.6 Tab. 1,3)

Frequency (MHz)		Fundamental and Spurious* (μV/m)
0.009-0.490 0.490-1.705		2400/F(kHz), 300m 24,000/F(kHz), 30m
0.090-0.110 0.49-0.51 2.1735-2.190 3.020-3.026 (IC) 4.125-4.128 4.17725-4.17775 4.20725-4.20775 5.677-5.683 (IC) 6.215-6.218 6.26775-6.26825 6.31175-6.31225	8.291-8.294 8.37625 - 8.38675 8.41425 - 8.41475 12.29 - 12.293 12.51975 - 12.52025 12.57675 - 12.57725 13.36 - 13.41 16.42 - 16.423 16.69475 - 16.69525 16.80425 - 16.80475 25.5 - 25.67	Restricted Bands

* Harmonics must be below the fundamental. To translate measurements to the 300/30 m distance, we refer to the journal paper: "Extrapolating Near-Field Emissions of Low-Frequency Loop Transmitters," J. D. Brunett, V. V. Liepa, D. L. Sengupta, IEEE Trans. EMC, Vol. 47, No. 3, August 2005.

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)		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, 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
When the Ignition Immobilizer mode is activated by the user (press of vehicle start button, etc…), the device can, in the worst case, transmit one CW LF pulse no longer than 21.25 ms. When the Passive Start (LF Initiator) mode is activated by the user (e.g. the lift of door handle or press of a button), the tested device transmitted three frames from each LF coil, only one set of which could occur within any given 100 ms window. Each frame consisted of a minimum length CW pulse, 4.13 ms in duration. See Figure 6.1. However, the manufacturer wishes to retain the right to modify the length of the LF transmissions in these modes to meet their customers specifications, so no duty cycle is applied when demonstrating compliance.

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 signals in both modes is shown in Figure 6.3, and are the results of testing the worst-case (maximum frame rate) available in both modes. From the plot we see that the 99% bandwidth for the Immobilizer mode is 18.25 kHz, and for the Initiator mode it is 17.63 kHz. Both spectra are more than 31.0 dBc in the 110 kHz restricted band.

6.1.4 Supply Voltage and Supply Voltage Variation
The DUT has been designed to be powered by a 12 VDC battery. For this test, relative radiated power was measured at the fundamental as the voltage was varied from 8.0 to 18.0 volts. The emission variation is shown in Figure 6.4.

Supply Voltage	V	=	12.0 V
Current	I	=	325 mA (cw)

6.2 AC Mains Conducted Emissions
These tests do not apply, since the DUT is powered from a 12 VDC system.

6.3 Rx Antenna Port Conducted Emissions - Verification
Emissions measured directly from the receive antenna port on the EUT were all less than 1pW, meeting the 2 nW requirement. Rx radiated emission measured with 50 Ohm termination on Rx antenna port.

Table 6.1(a) Highest Emissions Measured

Radiated Emission - LF — Lear KOBKRC11A; FCC/IC

#	Freq. kHz	Ant. Used	Ant. Orien.	Pr, 3m dBm	Det. Used	Ka dB/m	Kg dB	Conv.** 3/30/300 m	E* dBµV/m	Elim dBµV/m	Pass dB	Comments
1	**Immobilizer**											
2	125.0	Loop	V/perp	-36.4	Pk	9.9	0.0	114.8	-34.3	25.7	60.0	loop perp. (axis in dir. of prop.)
3	125.0	Loop	V/par	-39.1	Pk	9.9	0.0	114.8	-37.0	25.7	62.7	loop paral. (loop in dir. of prop.)
4	125.0	Loop	H	-42.0	Pk	9.9	0.0	114.8	-39.9	25.7	65.6	loop horiz. (loop in horiz. plane)
5	250.0	Loop	V/perp	-79.4	Pk	9.8	0.0	110.4	-73.0	19.6	92.6	loop perp. (noise)
6	250.0	Loop	V/par	-83.0	Pk	9.8	0.0	110.4	-76.6	19.6	96.2	loop paral. (noise)
7	250.0	Loop	H	-93.6	Pk	9.8	0.0	110.4	-87.2	19.6	106.8	loop horiz. (noise)
8	375.0	Loop	V/perp	-70.1	Pk	9.8	0.0	104.5	-57.8	16.1	73.9	loop perp.
9	375.0	Loop	V/par	-75.5	Pk	9.8	0.0	104.5	-63.2	16.1	79.3	loop paral.
10	375.0	Loop	H	-77.1	Pk	9.8	0.0	104.5	-64.8	16.1	80.9	loop horiz.
11	500.0	Loop	V/perp	-85.0	Pk	9.8	0.0	56.3	-24.5	33.6	58.1	max all, noise
12	625.0	Loop	V/perp	-81.4	Pk	9.8	0.0	56.1	-20.7	31.7	52.4	max all, background
13	750.0	Loop	All	-88.9	Pk	9.8	0.0	55.9	-28.0	30.1	58.1	max all, noise
14	875.0	Loop	All	-87.0	Pk	9.8	0.0	55.6	-25.8	28.8	54.6	max all, noise
15	1000.0	Loop	All	-87.0	Pk	9.8	0.0	55.4	-25.6	27.6	53.2	max all, noise
16	1125.0	Loop	All	-83.2	Pk	9.8	0.0	55.1	-21.5	26.6	**48.1**	max all, background
17	1250.0	Loop	All	-89.3	Pk	9.8	0.0	54.8	-27.3	25.7	52.9	max all, noise
18												
22	* Averaging applies up to 490 kHz, 0.0 dB employed in this case											
23	Limit at 300m for f<0.490MHz; 30m for f>0.490MHz											
24	Measurements made at 3 m, see Test Report for extrapolation reference.											
25	9 kHz RBW for f >= 150 kHz, 200 Hz for f < 150 kHz											
26	** Represents the worst case conversion factor for all possible orientations and ground materials.											

Receive Chain Radiated Emissions Verification

#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBµV/m	E3lim dBµV/m	Pass dB	Comments
27	423.3	Sbic	H	-84.4	Pk	21.6	20.5	23.7	46.0	22.3	max. of all, noise
28	423.3	Sbic	V	-79.3	Pk	21.6	20.5	28.8	46.0	17.2	max. of all, noise
29	846.5	Sbic	H	-85.4	Pk	27.9	17.1	32.4	46.0	13.6	max. of all, noise
30	846.5	Sbic	V	-85.2	Pk	27.9	17.1	32.6	46.0	**13.4**	max. of all, noise
31	1020.0	Horn	H	-71.5	Pk	19.7	28.0	27.2	54.0	26.8	max. of all, noise
32	1100.0	Horn	H	-74.0	Pk	20.0	28.1	25.0	54.0	29.0	max. of all, noise
33	1200.0	Horn	H	-72.0	Pk	20.4	28.1	27.3	54.0	26.7	max. of all, noise
34	1300.0	Horn	H	-71.8	Pk	20.7	28.1	27.8	54.0	26.2	max. of all, noise
35	1400.0	Horn	H	-73.0	Pk	21.0	28.1	26.9	54.0	27.1	max. of all, noise
36	1500.0	Horn	H	-73.0	Pk	21.3	28.1	27.2	54.0	26.8	max. of all, noise
37	1600.0	Horn	H	-71.6	Pk	21.5	28.1	28.9	54.0	25.1	max. of all, noise
38											
39											

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Table 6.1(b) Highest Emissions Measured

					Radiated Emission - LF							Lear KOBKRC11A; FCC/IC
#	Freq. kHz	Ant. Used	Ant. Orien.	Pr, 3m dBm	Det. Used	Ka dB/m	Kg dB	Conv.** 3/30/300 m	E* dBµV/m	Elim dBµV/m	Pass dB	Comments
1	**Passive Start (LF Initiator Coils)**											
2	125.0	Loop	V/perp	-24.4	Pk	9.9	0.0	114.8	-22.3	25.7	**48.0**	loop perp. (axis in dir. of prop.)
3	125.0	Loop	V/par	-28.2	Pk	9.9	0.0	114.8	-26.1	25.7	51.8	loop paral. (loop in dir. of prop.)
4	125.0	Loop	H	-41.4	Pk	9.9	0.0	114.8	-39.3	25.7	65.0	loop horiz. (loop in horiz. plane)
5	250.0	Loop	V/perp	-79.7	Pk	9.8	0.0	110.4	-73.3	19.6	92.9	loop perp. (noise)
6	250.0	Loop	V/par	-83.2	Pk	9.8	0.0	110.4	-76.8	19.6	96.4	loop paral. (noise)
7	250.0	Loop	H	-82.0	Pk	9.8	0.0	110.4	-75.6	19.6	95.2	loop horiz. (noise)
8	375.0	Loop	V/perp	-61.5	Pk	9.8	0.0	104.5	-49.2	16.1	65.3	loop perp.
9	375.0	Loop	V/par	-67.0	Pk	9.8	0.0	104.5	-54.7	16.1	70.8	loop paral.
10	375.0	Loop	H	-68.5	Pk	9.8	0.0	104.5	-56.2	16.1	72.3	loop horiz.
11	500.0	Loop	V/perp	-84.2	Pk	9.8	0.0	56.3	-23.7	33.6	57.3	max all, noise
12	625.0	Loop	V/perp	-65.1	Pk	9.8	0.0	56.1	- 4.4	31.7	**36.1**	max all, background
13	750.0	Loop	All	-85.9	Pk	9.8	0.0	55.9	-25.0	30.1	55.1	max all, noise
14	875.0	Loop	All	-80.6	Pk	9.8	0.0	55.6	-19.4	28.8	48.2	max all, noise
15	1000.0	Loop	All	-87.4	Pk	9.8	0.0	55.4	-26.0	27.6	53.6	max all, noise
16	1125.0	Loop	All	-77.4	Pk	9.8	0.0	55.1	-15.7	26.6	42.3	max all, background
17	1250.0	Loop	All	-84.9	Pk	9.8	0.0	54.8	-22.9	25.7	48.5	max all, noise
18												
19												
20												
21												
22												
23	* Averaging applies up to 490 kHz, 0.0 dB employed in this case											
24	Limit at 300m for f<0.490MHz; 30m for f>0.490MHz											
25	Measurements made at 3 m, see Test Report for extrapolation reference.											
26	9 kHz RBW for f >= 150 kHz, 200 Hz for f < 150 kHz											
27	** Represents the worst case conversion factor for all possible orientations and ground materials.											
28												
29												
30												
31												

					Digital Spurious Emissions*							
#	Freq. kHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB		E3 dBµV/m	E3lim dBµV/m	Pass dB	Comments
32												
33												
34												
35												
36	*For devices used in transportation vehicles, digital emissions are exempt per FCC 15.103(a) and ICES-003e correspondence.											
37												

Meas. 05/20/2011; U of Mich.

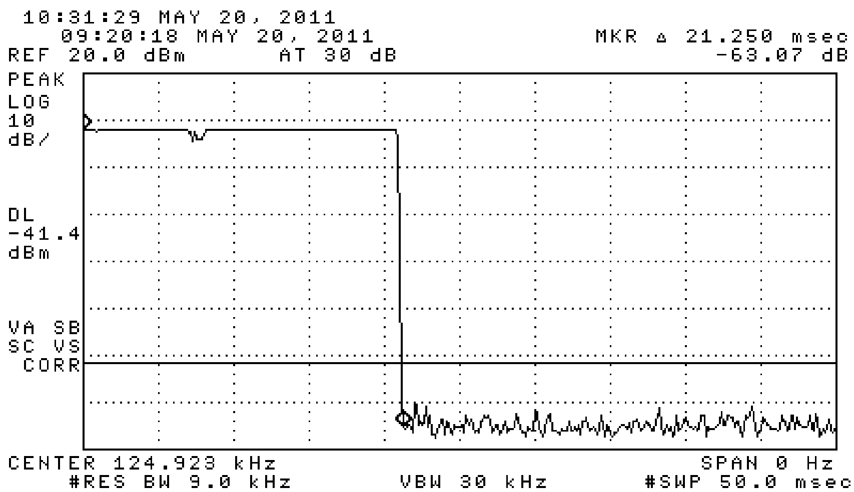


Figure 6.1(a). Immobilizer Mode Transmission modulation characteristics (as tested). Single LF frame.

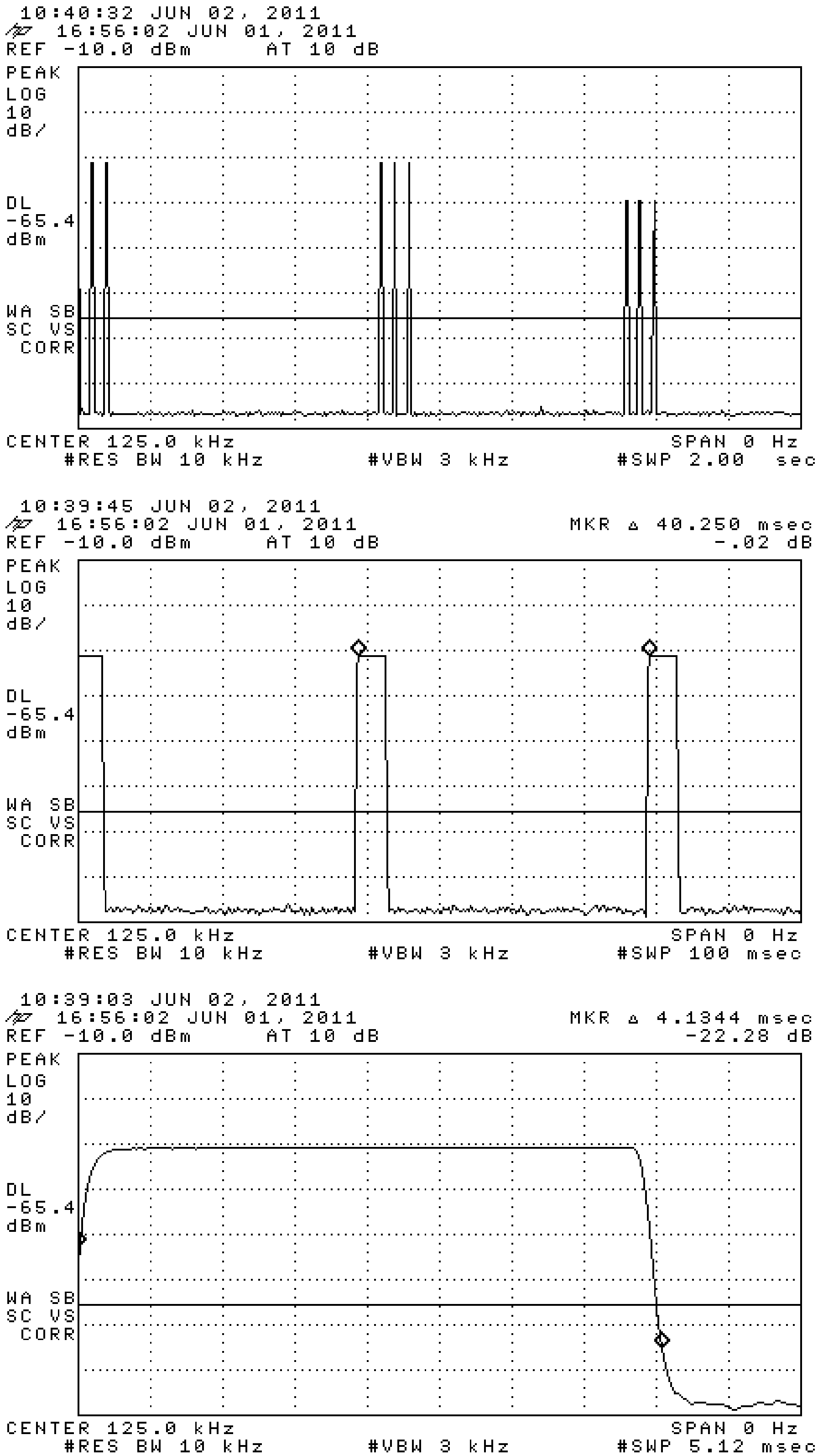
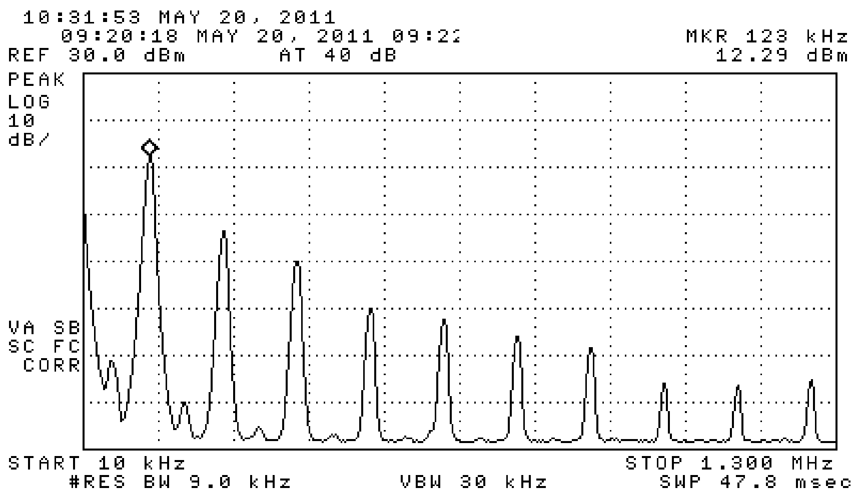


Figure 6.1(b). LF Initiator Transmission modulation characteristics. (top) complete transmission, (center) expanded transmission, (bottom) expanded word.



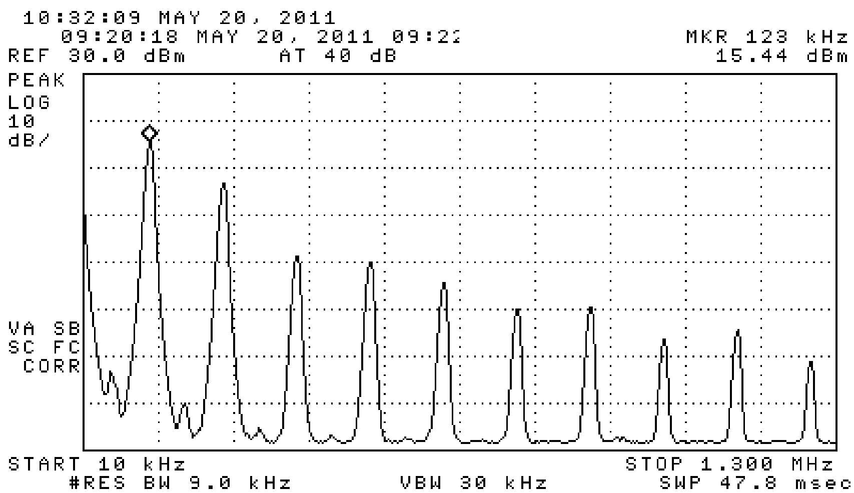


Figure 6.2. Emission spectrum of the DUT (pulsed emission). Amplitudes are only indicative (not calibrated).

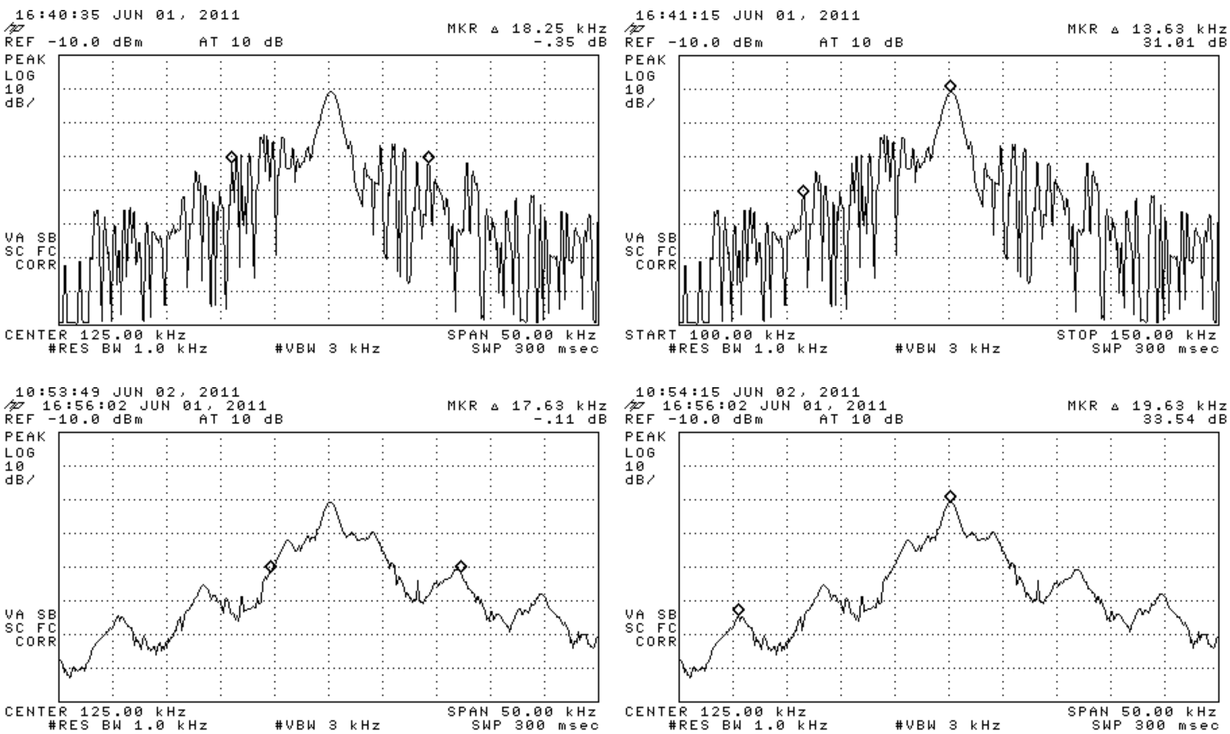


Figure 6.3. Measured emission bandwidth of the DUT (pulsed).

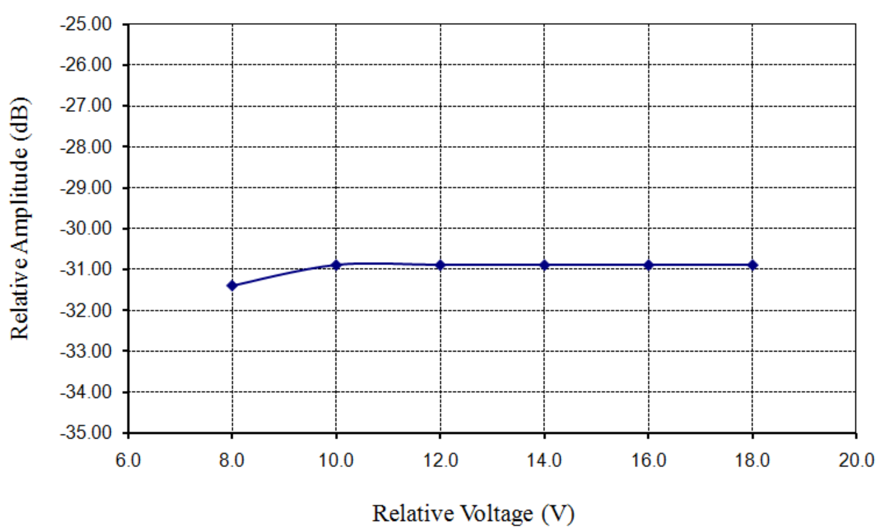
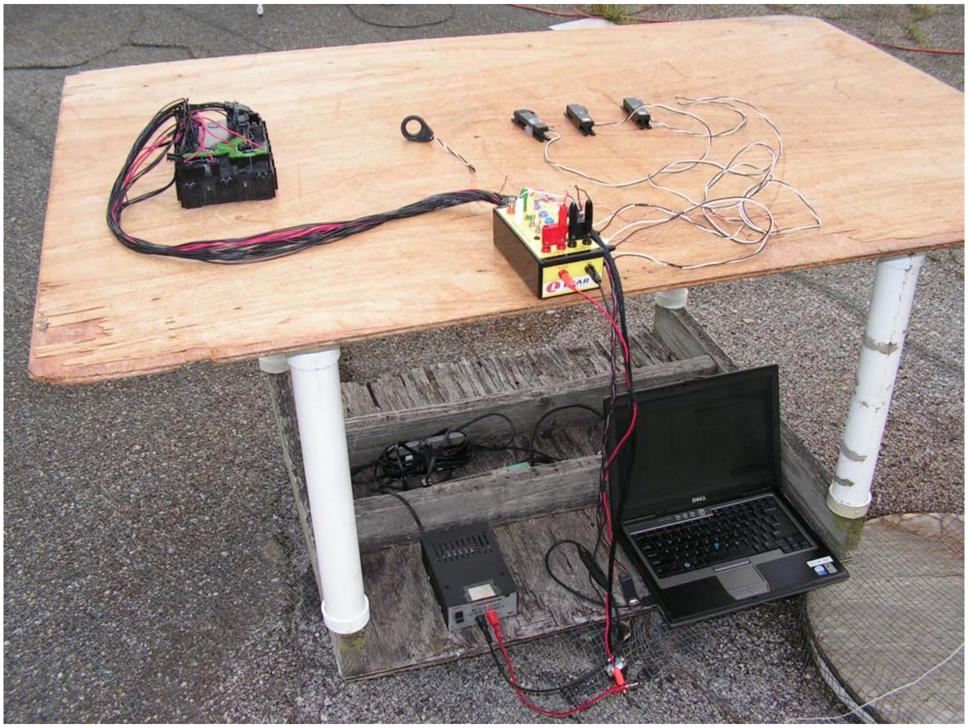


Figure 6.4. Relative emission at fundamental vs. supply voltage (CW).

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)