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Measured Radio Frequency Emissions
From

TRW Inc. Receiver
FCC ID: GQ4-46R

Test Report No. 417124-631
June 6, 2012

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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 TRW, FCC ID: GQ4-46R. This device under test (DUT) is subject to the rules and regulations as a Receiver.

In testing completed on February 27, 2012, the DUT tested met the allowed specifications for radiated emissions by 9.0 dB. Conducted emissions are not subject to regulation as the DUT is powered by a 12 VDC battery.

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1. Introduction

This TRW Receiver 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 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 10 x 11 x 2 cm in dimension. For testing, a generic harness was provided by the manufacturer. The DUT is designed and manufactured by TRW Automotive, 24175 Research Drive, Farmington Hills, MI 48335-2642.

Device	Make	P/N	EMC Consideration
DUT	TRW	231686-115	Fully populated with internal UHF receive antenna
DUT	TRW	231686-116	Fully populated with external UHF receive antenna connector
	TRW	231686-101, 231686-102, 231686-104, 231686-108, 231686-111,	Variants with digital or software components depopulated

3.2 Variants & Samples

There were two samples of the DUT provided for testing, one Part Number 231686-116 which was fully populated with external UHF receive antenna connector and one Part Number 231686-115 which was fully populated with an internal UHF receive antenna. An additional 5 variants (listed above) fall under this certification, where each variant has a either a digital component depopulated or a software variation not related to the RF portion of the product. The two worst-case variants are tested herein.

3.3 Modes of Operation

The DUT is capable of only a single mode of operation, as a 433.9 MHz UHF receiver.

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.

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 Table 4.2 below.

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, 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 : Radiated Emissions

6.1.1 Emission Spectrum

The only detectable RF emission occurs at the LO or 2 x LO = VCO. The relative DUT emission spectrum is recorded and is shown in Figures 6.1 through 6.3.

6.1.2 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 6.0 to 18.0 volts. The emission variation is shown in Figure 6.4.

Supply Voltage	V	=	13.0 V
Current	I	=	72 mA (always on)

6.1.3 Receive Antenna Conducted Emissions

These measurements are made by connecting the DUT antenna terminal (PN: 231686-116) directly to the spectrum analyzer 50 Ω input and recording all spurious signals. The VCO employed in the receiver circuit operates at 3386 MHz. The following worst case conducted emissions from the sample tested are:

Frequency	Power(dBm)	Power(nW)	Limit (nW)
433.8 MHz	-123.7	0.00000004	2

Receive chain radiated emissions have been evaluated to 5 times the VCO frequency.

Table 6.1 Highest Receive Chain Radiated Emissions Measured

Radiated Emission - RF											TRW RFHM Rx.; 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	**DUT with External Antenna + 50 Ohm Load**										
2	325.0	Sbic	H	-77.2	Pk	19.2	22.2	26.8	46.0	19.2	max. of all, noise
3	325.0	Sbic	V	-77.0	Pk	19.2	22.2	27.0	46.0	19.0	max. of all, noise
4	640.0	Sbic	H	-76.9	Pk	25.3	19.1	36.3	46.0	9.7	max. of all, noise
5	640.0	Sbic	V	-76.2	Pk	25.3	19.1	37.0	46.0	**9.0**	max. of all, noise
6	975.0	Sbic	H	-77.8	Pk	29.2	17.1	41.3	54.0	12.7	max. of all, noise
7	975.0	Sbic	V	-77.5	Pk	29.2	17.1	41.6	54.0	12.4	max. of all, noise
8	1001.0	R-Horn	H/V	-74.5	Pk	19.6	28.0	24.1	54.0	29.9	max. of all, noise
9	1200.0	R-Horn	H/V	-66.6	Pk	20.4	28.0	32.8	54.0	21.2	max. of all, noise
10	1400.0	R-Horn	H/V	-74.6	Pk	21.0	28.0	25.4	54.0	28.6	max. of all, noise
11	1600.0	R-Horn	H/V	-74.5	Pk	21.5	28.0	26.0	54.0	28.0	max. of all, noise
12	1800.0	R-Horn	H/V	-72.4	Pk	22.0	28.0	28.6	54.0	25.4	max. of all, noise
13	2000.0	R-Horn	H/V	-73.0	Pk	22.5	27.4	29.1	54.0	24.9	max. of all, noise
14	3750.0	R-Horn	H/V	-76.0	Pk	27.7	23.6	35.0	54.0	19.0	max. of all, noise
15	7450.0	XN-Horn	H/V	-64.6	Pk	25.3	36.8	30.9	54.0	23.1	max. of all, noise
16	11500.0	X-Horn	H/V	-63.8	Pk	28.9	36.8	35.3	54.0	18.7	max. of all, noise
17	14900.0	Ku-Horn	H/V	-86.4	Pk	33.4	16.8	37.2	54.0	16.8	max. of all, noise
18	17000.0	Ku-Horn	H/V	-85.3	Pk	34.7	15.5	40.9	54.0	13.1	max. of all, noise
19											
20	**DUT with Internal Antenna**										
21	325.0	Sbic	H	-77.7	Pk	19.2	22.2	26.3	46.0	19.7	max. of all, noise
22	325.0	Sbic	V	-77.6	Pk	19.2	22.2	26.4	46.0	19.6	max. of all, noise
23	640.0	Sbic	H	-77.6	Pk	25.3	19.1	35.6	46.0	10.4	max. of all, noise
24	640.0	Sbic	V	-77.2	Pk	25.3	19.1	36.0	46.0	**10.0**	max. of all, noise
25	975.0	Sbic	H	-77.3	Pk	29.2	17.1	41.8	54.0	12.2	max. of all, noise
26	975.0	Sbic	V	-76.7	Pk	29.2	17.1	42.4	54.0	11.6	max. of all, noise
27	1001.0	R-Horn	H/V	-74.5	Pk	19.6	28.0	24.1	54.0	29.9	max. of all, noise
28	1200.0	R-Horn	H/V	-66.6	Pk	20.4	28.0	32.8	54.0	21.2	max. of all, noise
29	1400.0	R-Horn	H/V	-74.6	Pk	21.0	28.0	25.4	54.0	28.6	max. of all, noise
30	1600.0	R-Horn	H/V	-74.5	Pk	21.5	28.0	26.0	54.0	28.0	max. of all, noise
31	1800.0	R-Horn	H/V	-72.4	Pk	22.0	28.0	28.6	54.0	25.4	max. of all, noise
32	2000.0	R-Horn	H/V	-73.0	Pk	22.5	27.4	29.1	54.0	24.9	max. of all, noise
3	3750.0	R-Horn	H/V	-74.7	Pk	27.7	23.6	36.3	54.0	17.7	max. of all, noise
4	7450.0	XN-Horn	H/V	-65.2	Pk	25.3	36.8	30.3	54.0	23.7	max. of all, noise
5	11500.0	X-Horn	H/V	-64.0	Pk	28.9	36.8	35.1	54.0	18.9	max. of all, noise
6	14900.0	Ku-Horn	H/V	-86.2	Pk	33.4	16.8	37.4	54.0	16.6	max. of all, noise
7	17000.0	Ku-Horn	H/V	-85.9	Pk	34.7	15.5	40.3	54.0	13.7	max. of all, noise
8											
9											

Meas. 02/23/2012; U of Mich.

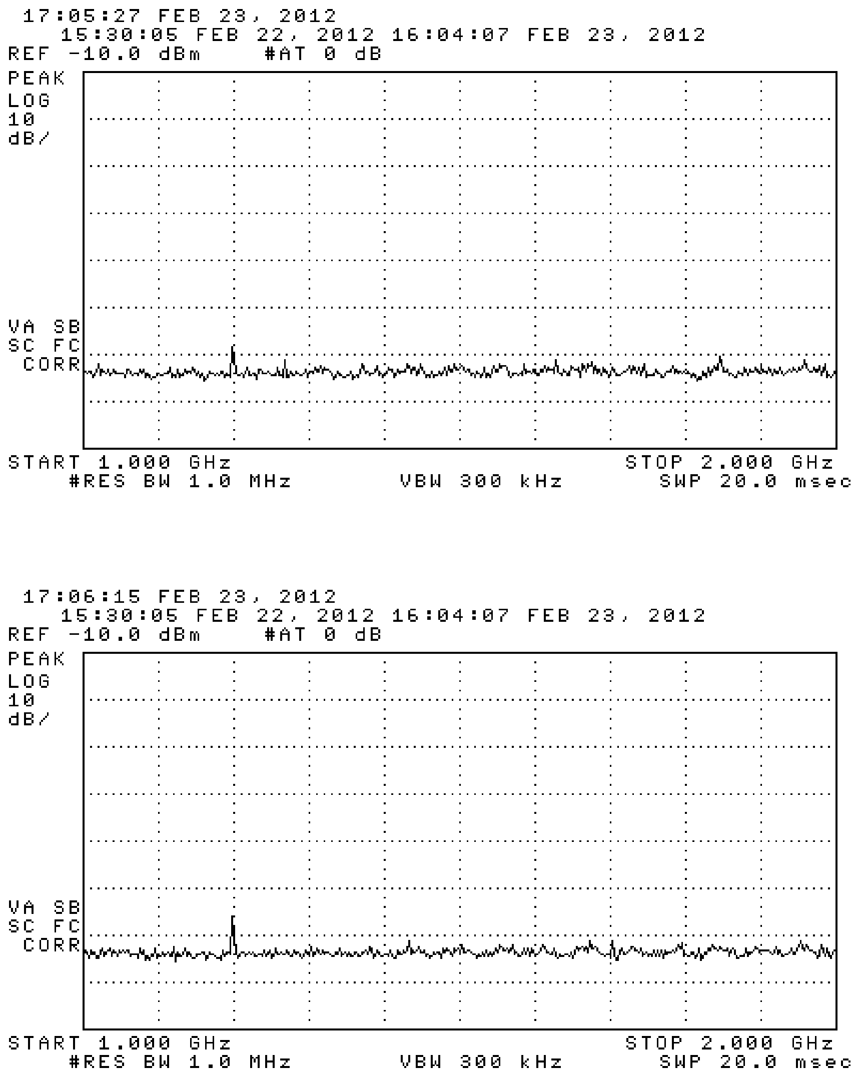
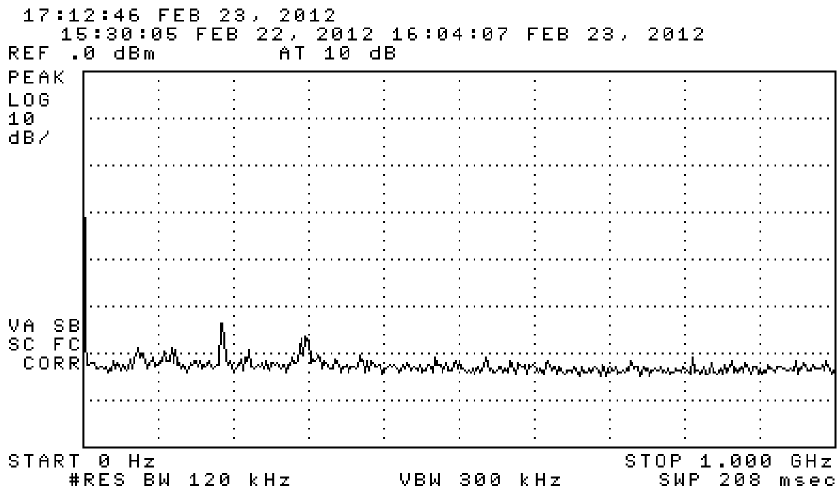


Figure 6.1. Emissions measured at 3 meters in chamber, 0-1000 MHz.

(top) DUT + background, (bottom) background



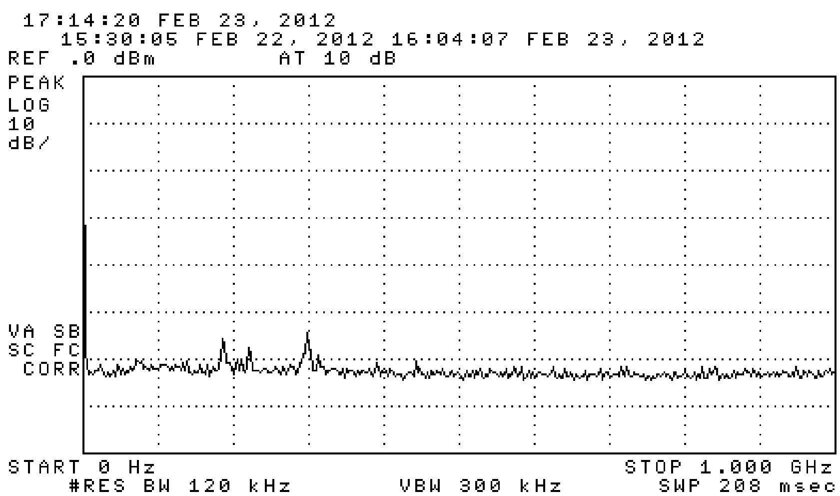


Figure 6.2. Emissions measured at 3 meters in chamber, 1000-2000 MHz.

(top) DUT + background, (bottom) background

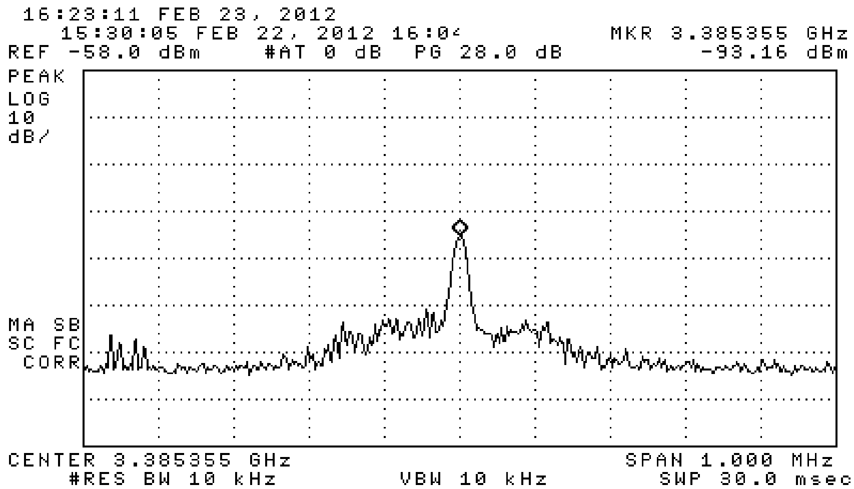


Figure 6.3. Relative receiver emission(s).

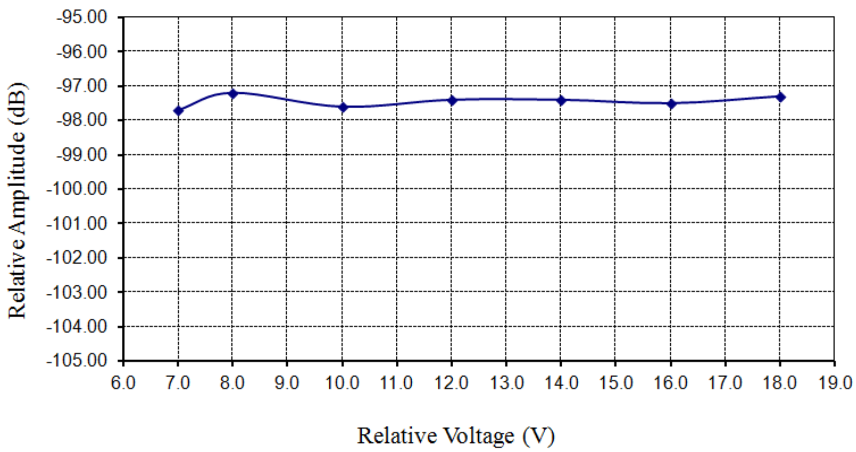
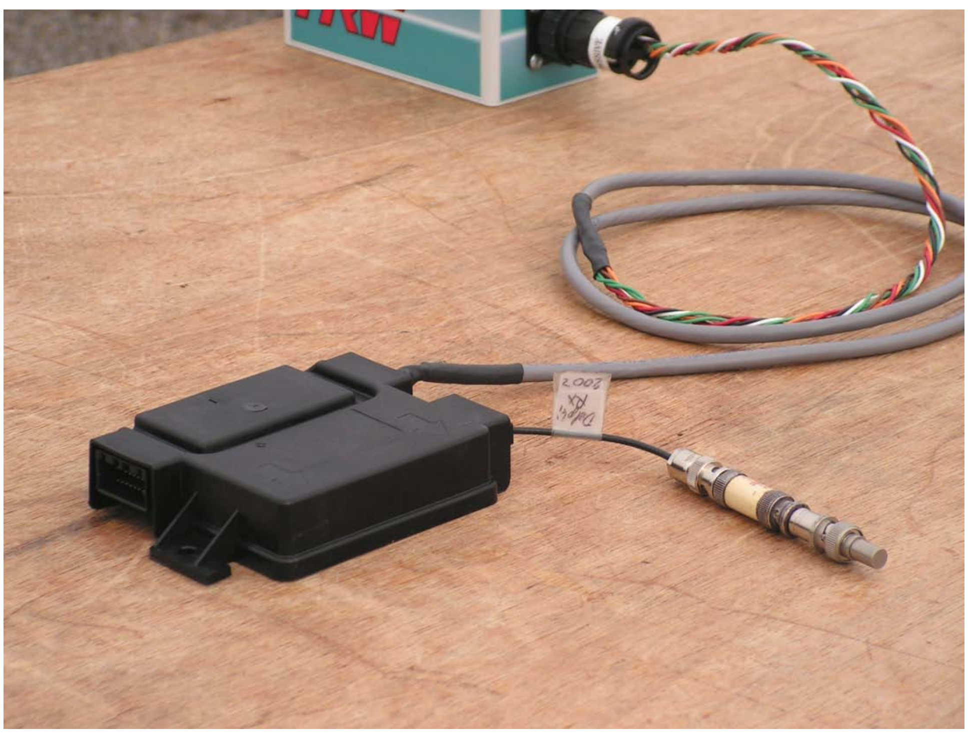


Figure 6.4. Relative emission vs. supply voltage.

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)