The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
Tel: (734) 764-0500

Measured Radio Frequency Emissions
From

Schrader Remote Tire Pressure Monitoring Transmitter Model: MRXDCXAMRX1

Report No. 415031-086
June 6, 2001

For:
Schrader Electronics Ltd.
11 Technology Park
Belfast Road
Antrim
N. Ireland, BT411 1QS
PO: R7668

Contact:
Brendan McDonnell
Tel: 011-44 2894-482078
Fax: 011-44 2894-468440

Measurements made by: Joseph Brunett

Tests supervised by:
Report approved by: Valdis V. Liepa
Research Scientist

Summary
Tests for compliance with FCC Regulations subject to Part 15, Subpart B, and with Industry Canada Regulations subject to RSS-210, were performed on Schrader Remote Tire Pressure Monitoring Receiver. This device is subject to Rules and Regulations as a Receiver. As a Digital Device it is exempt, but such measurements were made to assess the receiver's overall emissions.

In testing performed on June 1, 2001, the device tested in the worst case met the specifications for radiated emissions by 9.3 dB (see p. 6). The line conductive emission tests do not apply, since the device is powered from an automotive 12 VDC source.

1. Introduction

Schrader Remote Tire Pressure Monitoring superheterodyne receiver, Model MRXDCXAMRX1, was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 5. The tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-1992 "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 2057).

2. Test Procedure and Equipment Used

The test equipment commonly used in our facility is listed in Table 2.1 below. The second column identifies the specific equipment used in these tests. The HP 8593E spectrum analyzer is used for primary amplitude and frequency reference.

Table 2.1. Test Equipment.

Test Instrument	Equipment Used	Manufacturer/Model	Cal. Date/By
Spectrum Analyzer (9kHz-22GHz)	X	Hewlett-Packard 8593A SN: 3107A01358	December 2000/UM
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E SN: 3107A01131	December 2000/HP
Spectrum Analyzer (0.1-1500 MHz)		Hewlett-Packard 182T/8558B SN: 1529A01114/543592	December 2000/UM
Preamplifier (5-1000MHz)	X	Watkins-Johnson A11 -1 plus A25-1S	December 2000/UM
Preamplifier (5-4000 MHz)	X	Avantek	Oct. 1999/ U of M Rad Lab
Broadband Bicone (20-200 MHz)	X	University of Michigan	June 1999/U of M Rad Lab
Broadband Bicone (200-1000 MHz)	X	University of Michigan	June 1999/U of M Rad Lab
Dipole Antenna Set (25-1000 MHz)	X	University of Michigan	June 2000/UM
Dipole Antenna Set (30-1000 MHz)		EMCO 3121C SN: 992	June 2000/UM
Active Loop Antenna (0.090-30MHz)		EMCO 6502 SN: 2855	December 1999/UM
Active Rod (30Hz-50 MHz)		EMCO 3301B SN: 3223	December 1999/UM
Ridge-horn Antenna (0.5-5 GHz)	X	University of Michigan	March 1999/U of M Rad Lab
LISN Box		University of Michigan	Dec. 2000/U of M Rad Lab
Signal Generator (0.1-2060 MHz)	X	Hewlett-Packard 8657B	January 2000/Uof M Rad Lab
Printer	X	Hewlett-Packard 2225A	August 1989/HP

3. Configuration and Identification of Device Under Test

The DUT is a 433.92 MHz superheterodyne receiver, designed for onboard automobile tire pressure monitoring applications and, as such, it is powered from an automobile 12 VDC source. It uses a SAW RF filter at antenna input and SAW stabilized LO, producing a 500 kHz IF. In the receiver, decoding, signal processing, etc., are performed by a micro, timed by a 4.00 MHz x-tal oscillator.

The DUT was designed and manufactured by Schrader Electronics Limited, 11 Technology Park, Belfast Road, Antrim BT41 1QS, Northern Ireland. It is identified as:

Schrader Remote Tire Pressure Monitoring Receiver
Model: MRXDCXAMRX1
SN: 467
FCC ID: MRXDCXAMRX1
CANADA:

One device was provided for testing.

3.1 Modifications Made

There were no modifications made to the DUT by this laboratory.

4. Emission Limits

For FCC the DUT falls under Part 15, Subpart B, "Unintentional Radiators". For Industry Canada the DUT falls under Receiver category and is subject to technical requirement of sections 7.1 to 7.4 in RSS-210. The pertinent test frequencies, with corresponding emission limits, are given in Tables 4.1 and 4.2 below.

4.1 Radiated Emission Limits

Table 4.1. Radiated Emission Limits (FCC: 15.33, 15.35, 15.109; IC: RSS-210, 7.3).

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: Quasi-Peak readings apply to 1000 MHz (120 kHz BW)
Average readings apply above 1000 MHz (1 MHz BW)

4.2 Conducted Emission Limits

Table 4.2. Conducted Emission Limits (FCC: 15.107; IC: RSS-210, 6.6).

Freq. (MHz)	μV	dB(μV)
0.450 - 1.705	250	48.0
1.705 - 30.0	250	48.0

Note: Quasi-Peak readings apply here

4.3 Antenna Power Conduction Limits
Ref: 15.111(a). Pmax = 2 nW; for frequency range see Table 4.1.

5. Emission Tests and Results

NOTE: Even though the FCC and/or Industry Canada specify that both the radiated and conductive emissions be measured using the Quasi-Peak and/or average detection schemes, we normally use peak detection since especially the Quasi-Peak is cumbersome to use with our instrumentation. In case the measurement fails to meet the limits, or the measurement is near the limit, it is remeasured using appropriate detection. We note, that since the peak detected signal is always higher or equal to the Quasi-Peak or average detected signal, the margin of compliance may be better, but not worse, than indicated in this report. The type of detection used is indicated in the data table, Table 5.1.

5.1 Anechoic Chamber Radiated Emission Tests
To familiarize with the radiated emission behavior of the DUT, it was studied and measured in the shielded anechoic chamber. In the chamber there is a set-up similar to that of an outdoor 3-meter site, with turntable, antenna mast, and a ground plane. Instrumentation includes spectrum analyzers and other equipment as needed.

To study and test for radiated emissions, the DUT was powered by a laboratory power supply at 13.6 VDC. A 433.92 MHz CW signal was injected (radiated) from a nearby signal generator using a short wire antenna. The DUT was taped to a syrofoam block and placed on the test table on each of the three axis. At each orientation, the table was rotated to obtain maximum signal for vertical and horizontal emission polarizations. This sequence was repeated throughout the required frequency range.

In the chamber we studied and recorded all the emissions using a ridge-horn antenna, which covers 200 MHz to 5000 MHz, up to 2 GHz. In scanning from 30 MHz to 2.0 GHz, there were no spurious emissions observed other than the LO, the injection signal, and the LO harmonics. Figures 5.1 and 5.2 show emissions measured 0-1000 MHz and 1000-2000 MHz, respectively. These measurements are made with a ridge-horn antenna at 3m, with spectrum analyzer in peak hold mode and the receiver rotated in all orientations. The measurements up to 1000 MHz (Fi.g. 5.1) are used for initial evaluation only, but those above 1000 MHz (Fig. 5.2) are used in final assessment for compliance.

5.2 Open Site Radiated Emission Tests
The DUT was then moved to the 3 meter Open Field Test Site where measurements were repeated up to 1000 MHz usually using a bicones, or dipoles when the measurement is near the limit. The DUT was excersised as described in Sec. 5.1 above. The measurements were made with a spectrum analyzer typically using 120 kHz IF bandwidth and peak detection mode, and, when appropriate, using Quasi-Peak or average detection (see 5.0). The test set-up photographs are in Appendix (i.e., at end of this report).

The emissions from digital circuitry were measured using a standard bicone. These results are also presented in Table 5.1.

5.3 Computations and Results for Radiated Emissions
To convert the dBm's measured on the spectrum analyzer to dB(μV/m), we use expression

$$E_3(dB\mu V/m) = 107 + P_R + K_A - K_G$$

where P_R = power recorded on spectrum analyzer, dB, measured at 3m
K_A = antenna factor, dB/m
K_G = pre-amplifier gain, including cable loss, dB

When presenting the data, at each frequency the highest measured emission under all of the possible orientations is given. Computations and results are given in Table 5.1. There we see that the DUT meets the limit by 9.3 dB.

5.4 Conducted Emission Tests
These tests do not apply, since the DUT is powered from an automotive 12 VDC source.

6. Other Measurements

6.1 Emission Spectrum Near Fundamental
Near operating frequency the emission spectrum is measured typically over 50 MHz span with and without injection signal. These data are taken with the DUT close to antenna and, hence, amplitudes are relative. The plots are shown in Figure 6.1.

6.2 Effect of Supply Voltage Variation
The DUT has been designed to operate from 12 VDC power. Using a spectrum analyzer, relative radiated emissions were recorded at the "fundamental" (433.42 MHz) as voltage was varied from 6.0 to 18.0 VDC. Figure 6.2 shows the emission variation.

6.3 Operating Voltage and Current

V = 12.5 VDC
I = 13.0 mADC

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Table 5.1 Highest Emissions Measured

Radiated Emission - RF Schrader 434 MHz 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	433.5	Dip	H	-73.8	Pk	21.8	19.1	35.9	46.0	10.1	flat
2	433.5	Dip	H	-73.0	Pk	21.8	19.1	36.7	46.0	9.3	side
3	433.5	Dip	H	-74.7	Pk	21.8	19.1	35.0	46.0	11.0	end
4	433.5	Dip	V	-77.0	Pk	21.8	19.1	32.7	46.0	13.3	flat
5	433.5	Dip	V	-76.6	Pk	21.8	19.1	33.1	46.0	12.9	side
6	433.5	Dip	V	-73.1	Pk	21.8	19.1	36.6	46.0	9.4	end
7	867.0	Dip	H	-85.5	Pk	28.1	15.4	34.2	46.0	11.8	flat, 30 kHz RBW
8	867.0	Dip	H	-86.4	Pk	28.1	15.4	33.3	46.0	12.7	side, 30 kHz RBW
9	867.0	Dip	H	-89.0	Pk	28.1	15.4	30.7	46.0	15.3	end, 30 kHz RBW
10	867.0	Dip	V	-89.2	Pk	28.1	15.4	30.5	46.0	15.5	flat, 30 kHz RBW
11	867.0	Dip	V	-87.8	Pk	28.1	15.4	31.9	46.0	14.1	side, 30 kHz RBW
12	867.0	Dip	V	-87.9	Pk	28.1	15.4	31.8	46.0	14.2	end, 30 kHz RBW
13	1300.5	Horn	H	-66.0	Pk	20.5	20.3	41.2	54.0	12.8	max of all, noise floor
14	1734.0	Horn	H	-69.0	Pk	21.4	21.8	37.6	54.0	16.4	max of all, noise floor
15											
16											
17											
18											

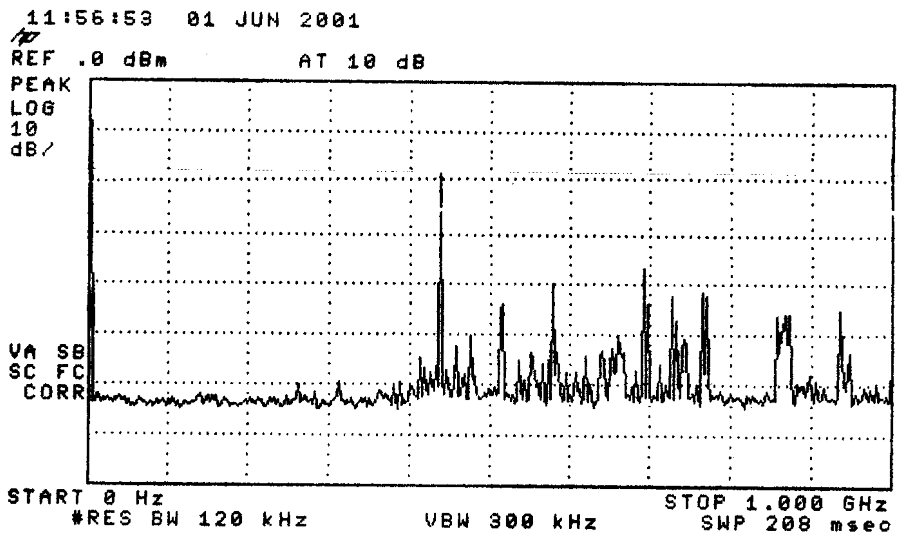
Radiated Emission - Digital (Class B)

1											
2											
3	Digital Emissions more than 20 dB below FCC Class B limits										
4											
5											
6											
7											
8											
9											
10											
11											
12											

Conducted Emissions

#	Freq. MHz	Line Side	Det. Used	Vtest dBµV	Vlim dBµV	Pass dB	Comments
1							
2	Not applicable						
3							

Meas. 06/01/01; U of Mich.



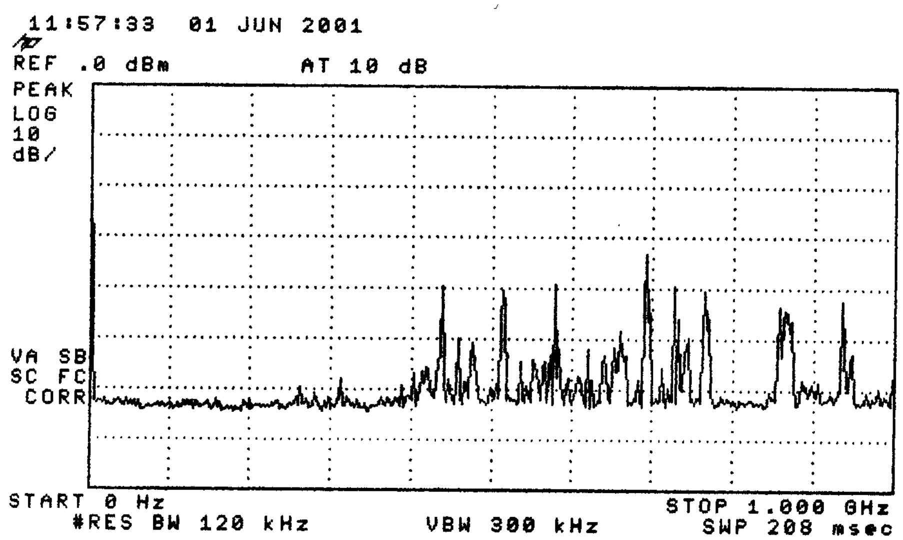
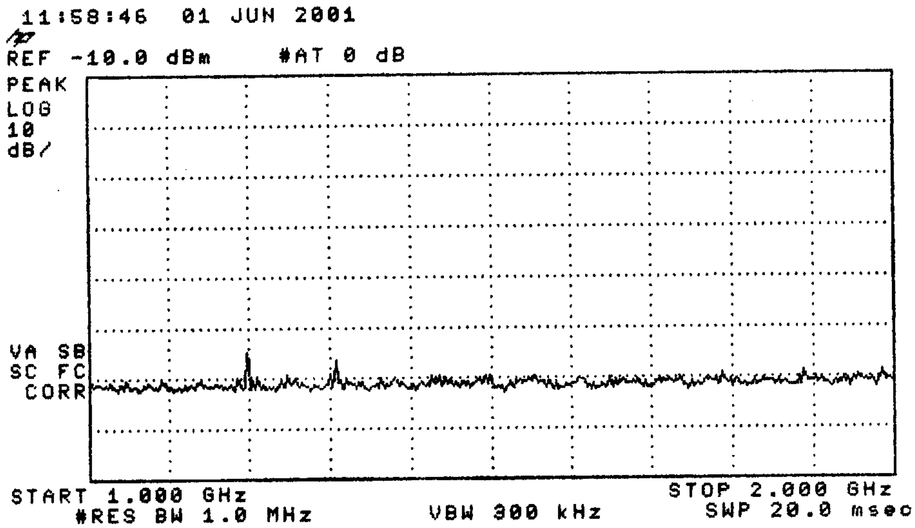


Figure 5.1. Emissions measured at 3 meters in anechoic chamber, 0-1000 MHz.
(top) Receiver plus ambient
(bottom) Ambient



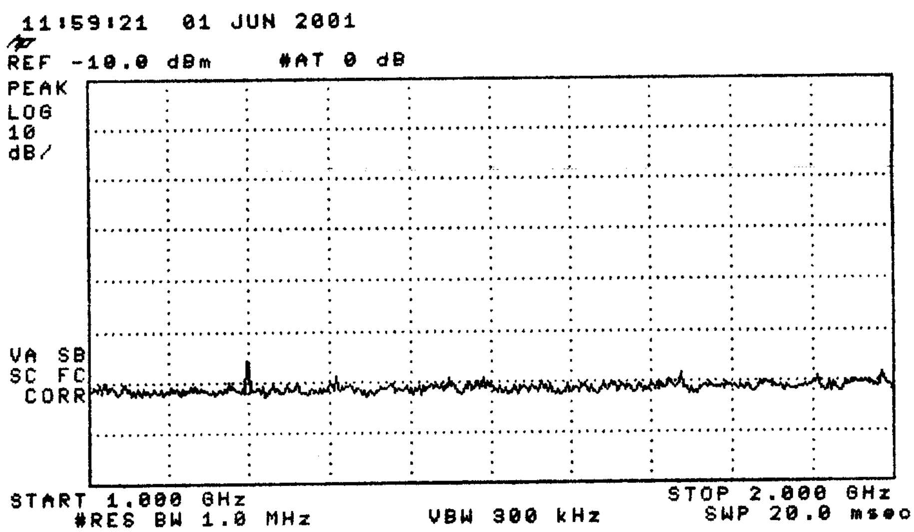


Figure 5.2. Emissions measured at 3 meters in anechoic chamber, 1000-2000 MHz.
(top) Receiver plus ambient
(bottom) Ambient

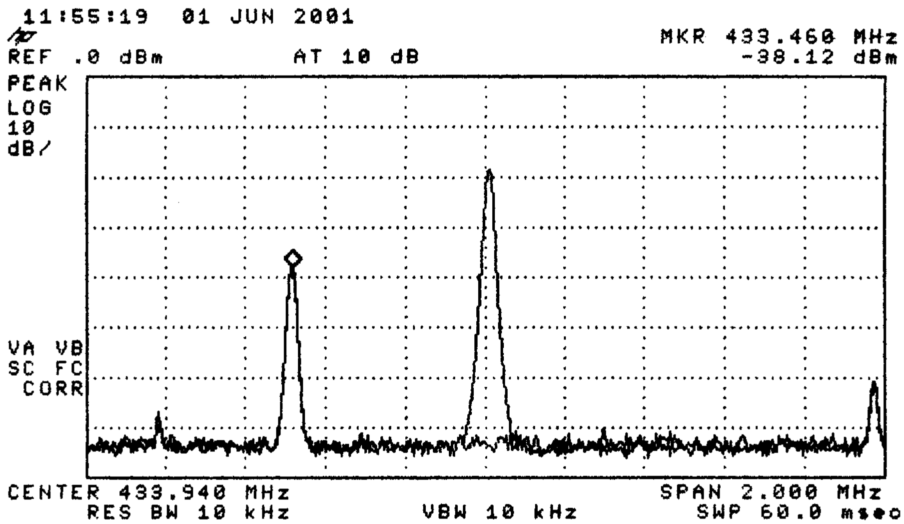


Figure 6.1. Relative receiver emissions in stand-by and "locked-in" modes. The final emission measurements were made with the receiver in "locked-in" mode.

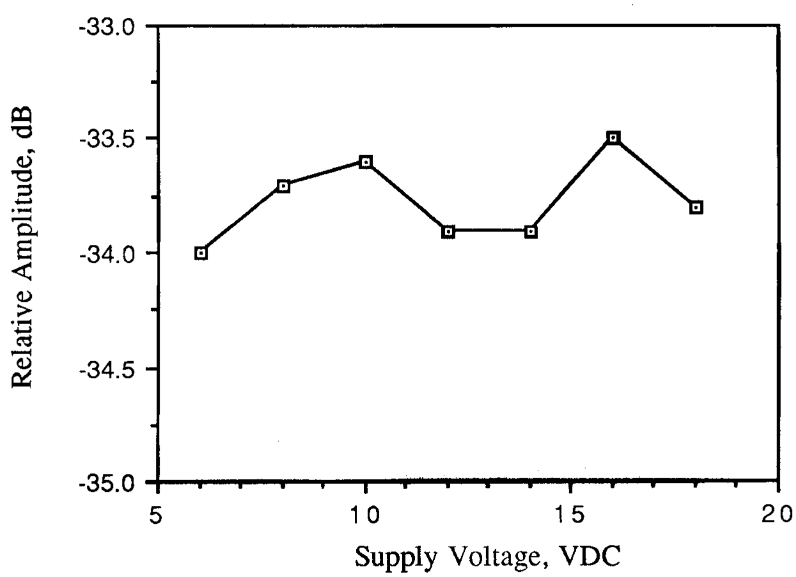


Figure 6.2. Relative emission at "fundamental" vs. supply voltage.