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Measured Radio Frequency Emissions From

Schrader Remote Tire Pressure Monitoring Transmitter PN: 70503020

Report No. 415031-950
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For:
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Summary

Tests for compliance with FCC Regulations, subject to Part 15, Subpart C, were performed on Schrader Remote Tire Pressure Monitoring Transmitter. This device is subject to Rules and Regulations as a low power (data) transmitter. As a Digital Device it is exempt, but such measurements we make as a matter of routine to assess the transmitters's overall emissions.

The Sensor was tested " in free space", i.e., without a tire and off a rim. In testing performed on July 20, 21, and 23, 1998, the device tested in the worst case met the 15.231(e) limits for radiated emissions by 3.0 dB (315 MHz) (see p. 6). Besides harmonics there were no other significant spurious emissions found.

No conductive emission tests were made, since the transmitter is powered by a 3 V internal lithium battery.

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1. Introduction

Schrader Remote Tire Pressure Monitoring Transmitter, PN: 70503020, was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989. 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 attenuation characteristics of the Open Site facility are on file with FCC Laboratory, Columbia, Maryland. (FCC file 31040/SIT)

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)		Hewlett-Packard 8593A SN: 3107A01358	June 1998/HP
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E SN: 3107A01131	June 1997/HP
Spectrum Analyzer (0.1-1500 MHz)	X	Hewlett-Packard 182T/8558B SN: 1529A01114/543592	August 1996/U of M Rad Lab
Preamplifier (5-1000MHz)	X	Watkins-Johnson A11 -1 plus A25-1S	May 1996/U of M Rad Lab
Preamplifier (5-4000 MHz)	X	Avantek	Nov. 1992/ U of M Rad Lab
Power Meter		Hewlett-Packard 432A	August 1989/U of M Rad Lab
w/ Thermistor		Hewlett-Packard 478A	August 1989/U of M Rad Lab
Broadband Bicone (20-200 MHz)	X	University of Michigan	July 1988/U of M Rad Lab
Broadband Bicone (200-1000 MHz)	X	University of Michigan	June 1996/U of M Rad Lab
Dipole Antenna Set (25-1000 MHz)	X	University of Michigan	June 1996/U of M Rad Lab
Dipole Antenna Set (30-1000 MHz)		EMCO 3121C SN: 992	June 1996/U of M Rad Lab
Active Loop Antenna (0.090-30MHz)		EMCO 6502 SN: 2855	December 1993/ EMCO
Active Rod (30Hz-50 MHz)		EMCO 3301B SN: 3223	December 1993/EMCO
Ridge-horn Antenna (0.5-5 GHz)	X	University of Michigan	February 1991/U of M Rad Lab
LISN Box		University of Michigan	May 1994/U of M Rad Lab
Signal Cables	X	Assorted	January 1993/U of M Rad Lab
X-Y Plotter		Hewlett-Packard 7046A	During Use/U of M Rad Lab
Signal Generator (0.1-990 MHz)		Hewlett-Packard 8656A	January 1990/U of M Rad Lab
Printer	X	Hewlett-Packard 2225A	August 1989/HP

3. Configuration and Identification of Device Under Test

The DUT is a 5.2 x 5.5 x 1.5 cm size potted tire pressure sensor/transmitter that mounts on a rim inside the tire and uses a wire or spring antenna that is 5.5 cm long. When the vehicle is in motion it transmits the tire pressure information to the receiver in the vehicle. The transmission consists of eight PWM words repeated typically every 60 seconds. The 315 MHz carrier is generated by a SAW stabilized oscillator. The coding is performed by an ASIC timed by a 32.768 kHz crystal 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 Transmitter
PN: 70503020
SN: FCC20
FCC ID: MRXTSR200
CANADA:

Three devices were provided. These were: (1) modified for CW emission that was used for radiated emission measurements, (2) modified for pulsed emissions for signal (pulse) and bandwidth characteristic measurements, and (3) unpotted for photographs.

3.1 EMI Relevant Modifications

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

4. Emission Limits

4.1 Radiated Emission Limits

The DUT tested falls under the category of an Intentional Radiators and the Digital Devices, subject to Subpart C, Section 15.231; and Subpart B, Section 15.109 (transmitter generated signals excluded); and Subpart A, Section 15.33. The applicable testing frequencies with corresponding emission limits are given in Tables 4.1 and 4.2 below. As a digital device, the DUT is considered as a Class B device.

Table 4.1 Radiated Emission Limits (15.231(e)) — Transmitter (Data).

Frequency	Fundamental Ave. E_{lim} (3m)		Spurious** Ave. E_{lim} (3m)	
(MHz)	(μV/m)	dB (μV/m)	(μV/m)	dB (μV/m)
260-470	1500-5000*		150-500	
315	2418	67.7	241.8	47.7

* Linear interpolation, formula: E = -2833.2 + 16.67*f (MHz)
** Measure up to tenth harmonic; 120 kHz BW up to 1 GHz, 1 MHz BW above 1 GHz

Table 4.2. Radiated Emission Limits (Ref: 15.33, 15.35, 15.109) -- Digital (Class B).

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 Conductive Emission Limits

The conductive emission limits and tests do not apply here, since the DUT is powered by a 3 V internal lithium battery.

5. Radiated Emission Tests and Results

5.1 Anechoic Chamber Measurements

To familiarize with the radiated emission behavior of the DUT, the DUT was first studied and measured in a semi-shielded 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.

In the chamber we studied and recorded all the emissions using a ridged horn antenna up to 3.15 GHz. The measurements made in the chamber below 1 GHz are used for pre-test evaluation only. The measurements made above 1 GHz are also used in pre-test evaluation and in final compliance assessment. We note that for the horn antenna, the antenna pattern is more directive and hence the measurement is essentially that of free space (no ground reflection). In the chamber we also recorded the spectrum and modulation characteristics of the carrier. These data are presented in subsequent sections. We also note that in scanning from 30 MHz to 3.15 GHz, there were no other significant spurious emissions observed.

5.2 Outdoor Measurements

After the chamber measurements, the emissions were re-measured on the outdoor 3-meter site at 315.0, 630.0, and 945.0 MHz using tuned dipoles and/or the high frequency bicone.

Figure 5.1 shows the DUT placed on the open-site table.

5.3 Computations and Results

To convert the dBm measured on the spectrum analyzer to dB(μV/m), we use expression

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

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
K_E = pulse operation correction factor, dB (see 6.1)

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 3.0 dB at fundamental and by 17.6 dB at harmonics.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

The transmitter is activated by rotation of the wheel and transmitsits once every one minute. The transmission consists of 8 words of 91.18 period. In a word there is a 2.19 lead-in pulse, followed by five 0.3625 ms wide sync pulses, and then followed by 34 data pulses (assume all wide). See Figure 6.1. In such, case the averaging factor is

$$K_E = (1 \times 2.19 + (5 + 34) \times 0.3625) \text{ ms} / 91.18 \text{ ms} = 0.179 \text{ or } -14.9 \text{ dB}$$

6.2 Emission Spectrum

Using the ridge-horn antenna and DUT placed in its aperture, emission spectrum was recorded and is shown in Figure 6.2.

6.3 Bandwidth of the Emission Spectrum

The measured spectrum of the signal is shown in Figure 6.3. The allowed (-20 dB) bandwidth is 0.25% of 315.0 MHz, or 786 kHz, and from the plot we see that the -20 dB bandwidth is 48.8 kHz, and the center frequency is 315.03 MHz.

6.4 Effect of Supply Voltage Variation

The DUT has been designed to be powered by a 3 V battery. For this test, the battery was replaced by a laboratory variable power supply and relative power radiated was measured at the fundamental as the voltage was varied from 2.25 to 3.6 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage and Current at Battery Terminals

Batteries:	before testing	V_{oc}	=	2.83 V
	after testing	V_{oc}	=	2.70 V
		I	=	1.57 mA (CW)

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Table 5.1 Highest Emissions Measured

Radiated Emission - RF											Schrader Model: TSR300 TX; 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	315.0	Dip	H	-24.9	Pk	18.9	21.4	64.7✓	67.7	**3.0**	side
2	315.0	Dip	V	-31.9	Pk	18.9	21.4	57.7	67.7	10.0	flat
3	630.0	Dip	H	-76.8	Pk	25.2	18.1	22.5	47.7	25.2	flat
4	630.0	Dip	V	-73.8	Pk	25.2	18.1	25.5	47.7	22.2	flat
5	945.0	Dip	H	-78.0	Pk	28.9	15.7	27.3	47.7	20.4	flat
6	945.0	Dip	V	-83.8	Pk	28.9	15.7	21.5	47.7	26.2	side
7	1260.0	Horn	H	-54.3	Pk	20.4	28.1	30.1	47.7	17.6	flat
8	1575.0	Horn	H	-61.4	Pk	21.4	28.2	23.9	47.7	23.8	flat
9	1890.0	Horn	H	-71.4	Pk	22.1	28.1	14.7	47.7	33.0	end
10	2205.0	Horn	H	-73.1	Pk	22.9	27.0	14.9	47.7	32.8	flat
11	2520.0	Horn	H	-63.7	Pk	24.0	26.6	25.8	47.7	21.9	flat
12	2835.0	Horn	H	-68.2	Pk	24.9	25.4	23.4	47.7	24.3	flat
13	3150.0	Horn	H	-69.7	Pk	25.2	24.8	22.8	47.7	24.9	side
14											
15											
16											
17											
18			*includes -14.9 dB duty factor								
19											
20			Digital emissions are more than 20 dB below FCC Class B limit								
21											
22											
23											
24											
25											
26											
27											

Conducted Emissions							
#	Freq. MHz	Line Side	Det. Used	Vtest dBµV	Vlim dBµV	Pass dB	Comments
1							
2	Not applicable						
3							
4							
5							
6							
7							

Meas. 7/20, 21/1998; UMich.

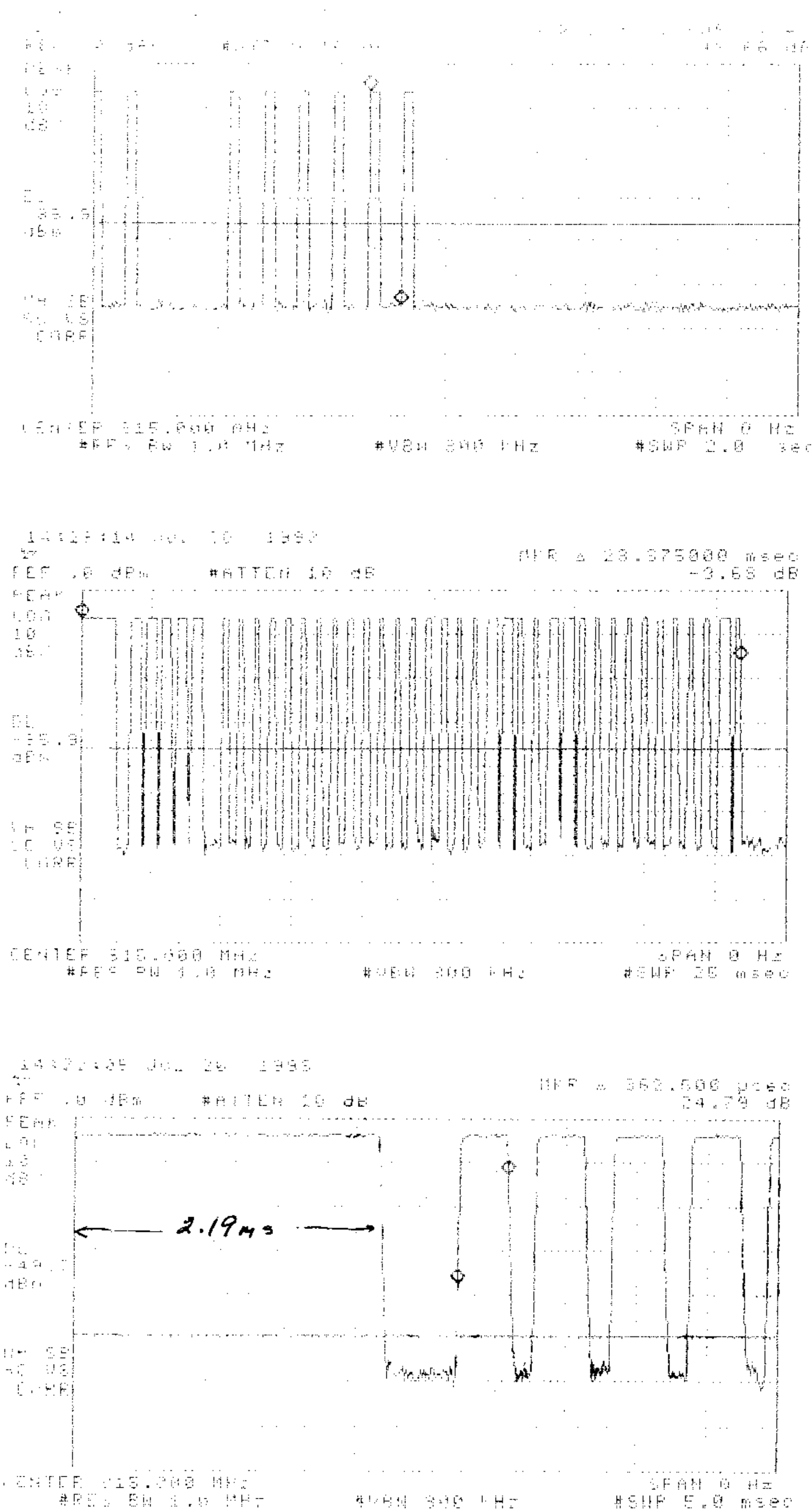

Figure 6.1. Transmissions modulation characteristics: (top) complete transmission, (center) expanded word, (bottom) expanded bits.

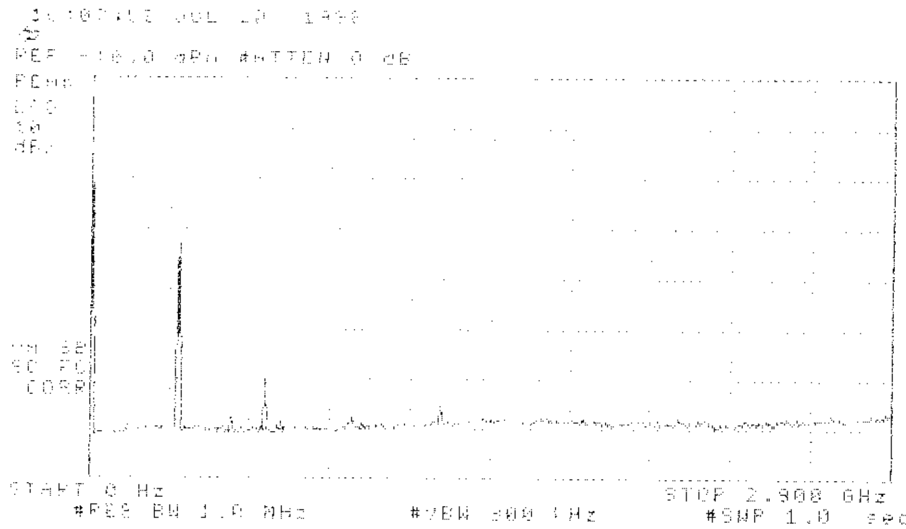

Figure 6.2. Emission spectrum of the DUT in free space (repeated pulsed emission). The amplitudes are only indicative (not calibrated).

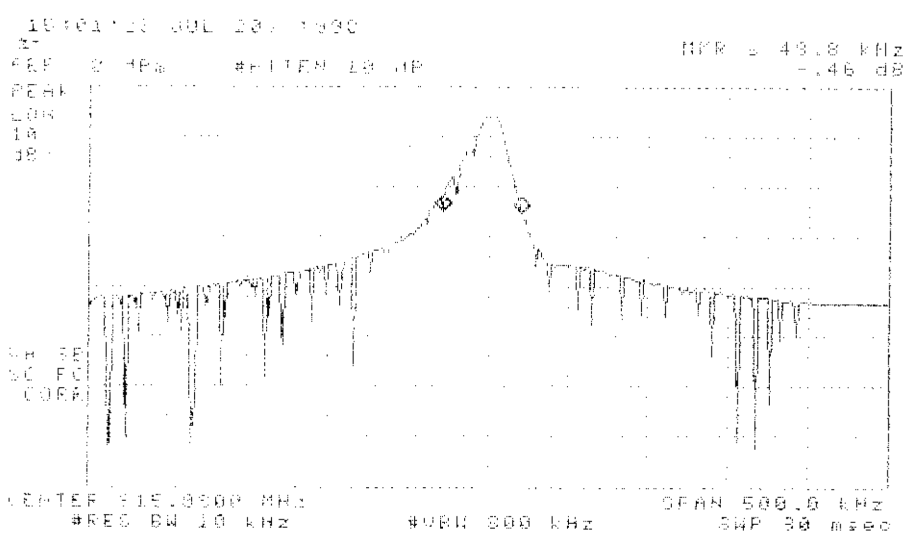

Figure 6.3. Measured bandwidth of the DUT (repated pulsed emission).

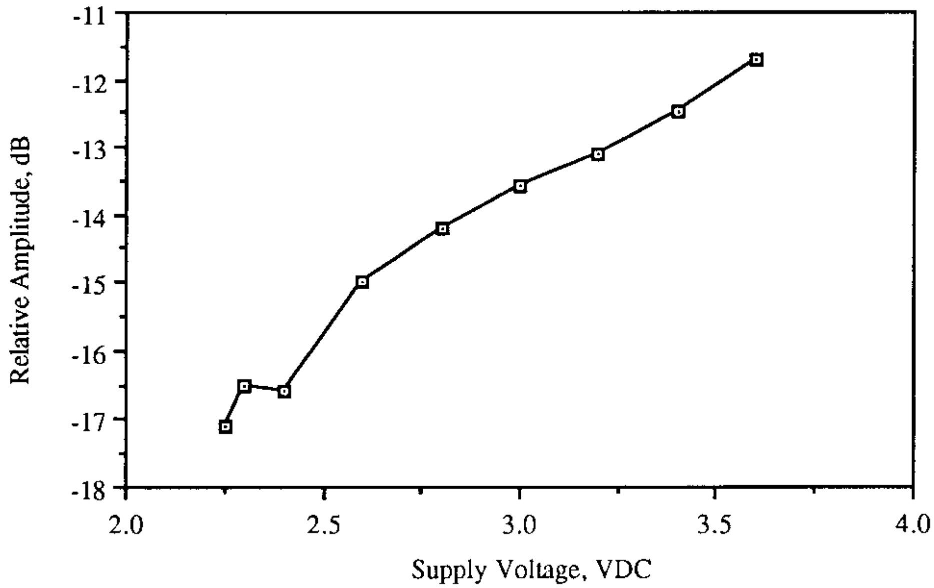

Figure 6.4. Relative emission at 315.0 MHz vs. supply voltage. (CW emission)