The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
Tel: (313) 747-1792

Measured Radio Frequency Emissions
From

Visteon
Passive Antitheft System
(PATS 900T)

Report No. 415031-983
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For:
Visteon Automotive Systems
17000 Rotunda Drive
Dearborn, MI 48121

Contact:
Frank Thompson
Tel: (313) 390-8951
Fax: (313) 323-8438
PO: 47-J-QI2158

Measurements made by:
Sheila Pung
Valdis V. Liepa

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

Summary

Tests for compliance with FCC Regulations subject to Part 15, Subpart C, were performed on Visteon PATS Immobilizer Module. This device is subject to Rules and Regulations as a transmitter. As a digital device it is exempt, but we made such measurements to assess the device's overall emissions.

In testing performed on January 18, 21, and 22, 1999, the device tested in the worst case met the allowed specifications for transmitter radiated emissions by 59.0 dB (see p. 6). The digital emissions met Class B limit by 19.8 dB at 51.7 MHz (see p. 6).

The conductive emission tests do not apply, since the device is powered from an automobile 12V system.

EXHIBIT E

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1. Introduction

Visteon Passive Anti-Theft System (PATS), Model 900T, 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	July 1998/HP
Spectrum Analyzer (0.1-1500 MHz)	X	Hewlett-Packard 182T/8558B SN: 1529A01114/543592	August 1997/U of M Rad Lab
Preamplifier (5-1000MHz)	X	Watkins-Johnson A11 -1 plus A25-1S	May 1997/U of M Rad Lab
Preamplifier (5-4000 MHz)		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)		University of Michigan	June 1996/U of M Rad Lab
Dipole Antenna Set (25-1000 MHz)		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)	X	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)		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 car security system that electronically identifies the "true" ignition key for the car. The system consists of a coupling coil (transmitter), a passive transponder in the key, and a control module. The operating frequency is 134 kHz and the frequency is crystal stabilized (17.18 MHz). The transponder is considered passive (it uses energy supplied by the transmitter coil to operate its micro that changes the resonant frequency of the transponder), and is not subject to the rules. The system tested consisted of a test box, control module (TX), ignition key assembly, a part of housing, and a key.

The DUT was designed and manufactured by Visteon Automotive Sysytems, Dearborn, Michigan 48121. It is identified as:

Visteon PATS system
Model: 900T
FCC ID: NT8-15607YU3FXCVR
CANADA: to be provided by IC

For testing the entire metal housing was not used, but we did use a metal section from the housings to support the coil (antenna) on the lock cylinder. (We found that the metal ring does have affect on the resonant frequency of the coil and, hence, should be used in the tests.)

3.1 EMI Relevant Modifications

None.

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 15.209; 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, it is exempt.

Table 4.1. Radiated Emission Limits (Ref: 15.209, 15.205) --Transmitter.

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	Restricted Bands

* For extrapolating to other distances, see Section 6.6.

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

4.2 Conductive Emission Limits
The conductive emission limits and tests do not apply here, since the DUT is powered from an automobile 12V system.

5. Radiated Emission Tests and Results

5.1 Anechonic Chamber Measurements
To familiarize with the radiated emission behavior of the DUT, the DUT was first studied and measured in a 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 this case, the receiving antenna was an active loop, placed on a tripod, approximately 1.5 meters above the ground.

The DUT was laid on the test table as seen in Figure 5.1. Using the loop antenna we studied emissions up to 2 MHz. The resolution and video bandwidths were 300 Hz. The emissions were studied with the plane of the loop perpendicular and parallel to the direction of propagation from the DUT. Larger emissions were observed when the loop was perpendicular. 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 0.0-2.0 MHz there were no spurious emissions observed other than harmonics. Sometimes it was difficult to separate the DUT emissions from the AM band signals.

5.2 Outdoor Measurements
After the chamber measurements, the emissions were measured on our outdoor 3-meter site. The DUT was laid on the turntable and the loop antenna was set at a 3 meter distance. Only the first (fundamental) harmonic could be seen. The resolution bandwidth used outdoors was 300 Hz.

See Section 6.6 for field extrapolation measurements from 3 m to 300 m.

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

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

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 59.0 dB.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

When the transmitter is activated to transmit, it transmits a single 134 kHz pulse 50.5 ms long. Thus, the averaging factor or pulse operation correction factor is

K_E = 50.5 ms / 100 ms = 0.505 or -5.9 dB

6.2 Emission Spectrum

Using the loop antenna, the 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. From the plot we see that the -20 dB bandwidth is 321 Hz, and the center frequency is 134.59 kHz.

6.4 Effect of Supply Voltage Variation

The DUT has been designed to be operated from an automobile 12V system. For this test, the relative power radiated was measured at the fundamental as the voltage was varied from 2.5 to 18.0 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage and Current

V = 13.8 V

I = 170.0 mA (CW emission)

6.6 Field Behavior at 134 kHz

Because at the specified 300 m measurement distance the signal is too small to measure, measurements were made at 3 m. To relate the 300 m distance to the 3 m , field attenuation experiments were performed using two loops, one transmitting, the other receiving. Even then we could only go up to 50 m before noise became a factor. Measurements were made with the loops coplanar (planes of the loops in the same plane) and with loops axial (same axis for both loops). Figures 6.5 and 6.6 show results. From these we then deduce the difference in dB between the 300 m and 3 m distances is:

Coplanar case: 0.0 - (-112.4) = 112.4 dB (56 dB/decade)

Axial case: - 6.0 - (- 96.1) = 90.1 dB (45 dB/decade)

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Table 5.1 Highest Emissions Measured

Radiated Emissions — Ford-Visteon, Germany; FCC, IC

#	Freq. kHz	Ant. Used	Ant. Orien.	Pr, 3m dBm	Det. Used	Ka dB/m	Kg dB	E300* dBµV/m	E300lim dBµV/m	Pass dB	Comments
1	134.6	Loop	V	-54.3	Pk	9.9	0.0	-33.4	25.6	**59.0**	loop normal (axis in dir. of prop.)
2	134.6	Loop	V	-59.5	Pk	9.9	0.0	-60.9	25.6	86.5	loop planar (axis in dir. of prop.)
3	269.2	Loop	V	-72.3	Pk	9.8	0.0	-51.5	25.6	77.1	loop normal, noise
4	269.2	Loop	V	-71.8	Pk	9.8	0.0	-73.3	25.6	98.9	loop planar, noise
5	403.7	Loop	V	-66.1	Pk	9.8	0.0	-45.3	25.6	70.9	loop normal
6	403.7	Loop	V	-72.8	Pk	9.8	0.0	-74.3	25.6	99.9	loop planar, noise
7	538.6	Loop	V	-74.3	Pk	9.8	0.0	-53.5	25.6	79.1	loop normal, noise
8	538.6	Loop	V	-73.3	Pk	9.8	0.0	-74.8	25.6	100.4	loop planar, noise
9	672.6	Loop	V	-64.9	Pk	9.8	0.0	-44.1	25.6	69.7	loop normal
10	672.6	Loop	V	-71.9	Pk	9.8	0.0	-73.4	25.6	99.0	loop planar, noise

All other harmonics/orientations are in the noise (Pr < -68 dBm)

* The averaging factor is -5.9 dB; data is extrapolated to 300m distance

300 Hz RBW used in measurements

DIGITAL EMISSIONS Class B Limits

#	Freq. MHz	Ant. Used	Ant. Pol.	Pr, 3m dBm	Det. Used	Ka dB/m	Kg dB	E3 dBµV/m	E3lim dBµV/m	Pass dB	Comments
1	51.7	Bic	V	-72.8	Pk	11.4	25.5	20.2	40.0	19.8	Max. digital emission

All other digital Emissions are also more than 20 dB below FCC Class B limits

Conducted Emissions

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

Meas. 1/22/99; U of Mich.