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

Measured Radio Frequency Emissions From

Visteon Immobilizer Module Models:

VP2W9F-15607-A (Jaguar) 98AP-15607-A (Ford 98AP) 98BP-15607-A (Ford 98BP) 98VP-15607-A (Ford 98VP)

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Summary

Tests for compliance with FCC Regulations, Part 15, Subpart C, and for compliance with Industry Canada RSS-210, were performed on Visteon Immobilizer Module. These devices are subject to Rules and Regulations as transmitters. As digital devices they are exempt, but such measurements were made to assess the device's overall emissions.

In testing performed June 25 through July 13, 2001, the devices tested in the worst case met the allowed specifications for transmitter radiated emissions by 42.0 dB (see p. 6); the digital emission, Class B, were met by at least 20 dB. The conductive emission tests do not apply, since the device is powered from an automotive 12 VDC battery.

1. Introduction

Visteon Immobilizer Module was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 2, dated February 14, 1998. 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 Procedures 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)		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)		University of Michigan	June 2000/UM
Dipole Antenna Set (30-1000 MHz)		EMCO 3121C SN: 992	June 2000/UM
Active Loop Antenn (0.090-30MHz)	a X	EMCO 6502 SN: 2855	December 2000/UM
Active Rod (30Hz-50 MHz)		EMCO 3301B SN: 3223	December 2000/UM
Ridge-horn Antenna (0.5-5 GHz)		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)		Hewlett-Packard 8657B	January 2000/Uof M Rad Lab

3. Configurations and Identification of Device Under Test

The DUT is a car security system that electronically identifies the "real" ignition key for the car. The system tested consisted of a T/R module (including coupling coil antenna) and a "passive" transponder imbedded in a special key. The transponder in the key is considered passive because it uses the energy supplied by the transmitter coil to operate its micro and, hence, is not subject to the regulations. A two-meter, multi-wire harness was used in testing. In the middle of the harness was a load/control box; the power was supplied from 13.8 VDC laboratory power supply.

The DUT was designed and manufactured by Visteon. It is identified as:

Visteon Immobilizer Module

Models: VP2W9F-15607-A, 98AP-15607-A, 98BP-15607-A, 98VP-15607-A

FCC ID: NT8-15607CPATXCVR CANADA: to be provided by IC

A control box was provided to operate the module in a standard operating mode or in a CW mode needed to perform emission field strength measurements. The difference between 98AP-15607-A, 98BP-15607-A and 98VP-15607-A is only in the shape of the molded plastic case. Because the coil location differs for each case, all three models were tested. The VP2W9F-15607-A uses a different lock cylinder than the 98XX models, requiring a different Antenna tunning circuit. See Description of Operation for more details.

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 (FCC: 15.205, 15.35; IC: RSS-210 (6.2.2(r), 6.3)). (Transmitter)

	Fundamental
Frequency	and Spurious*
(MHz)	(μV/m)
0.009-0.490	2400/F(kHz), 300m
0.490-1.705	24,000/F(kHz), 30m
0.090-0.110	Restricted
0.49-0.51	Bands

^{*} Harmonics must be below the fundamental.

For extrapolation to other distances, see Section 6.6.

Table 4.2. Radiated Emission Limits (FCC: 15.33, 15.35, 15.109; IC: RSS-210, 6.2.2(r)). (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 12VDC system.

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 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 ground.

The DUT was laid on the test table as seen in the Attachment-Test Setup Photos. Using the loop antenna we studied emissions up to 2 MHz. The spectrum analyzer resolution and video bandwidths were usually set to 1 kHz, and sometimes to 300 Hz. 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. In scanning from 0.0-2.0 MHz there were no spurious emissions observed other than harmonics. In some instances, it was difficult to separate the DUT emissions from AM band signals.

5.2 Outdoor Measurements

After the chamber measurements, the emissions on our outdoor 3-meter site were measured. For transmitter emissions a loop antenna was used; the resolution bandwidth was usually 1 kHz. See Appendix for measurement set-up. For digital emissions bicone and dipole antennas were used.

See Section 6.6 for field extrapolation of transmitter data from 3 m to 300 m.

5.3 Computations and Results

To convert the dBm measured on the spectrum analyzer to $dB(\mu V/m)$, 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 3 m

 K_A = antenna factor, dB/m

KG = pre-amplifier gain, including cable loss, dB KE = 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 Tables 5.1 though 5.4. There we see that as a transmitter, the DUT meets the limit by 42.0 dB. The digital emissions, Class B, were met by at least 20 dB.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

In normal a operation the transmitter is activated when a key is placed into the ignition. When the ignition key is turned on, an interrogation pulse is sent out and if the key is responds with proper code, the immobilizer goes in sleep mode. The interrogation pulse is 51.0 ms long. The frequency is 134.4 kHz. See Figure 6.1. The averaging factor for such operation is

$$K_E = 51.0 \text{ ms} / 100 \text{ ms} = 0.51 \text{ or} -5.8 \text{ dB}$$

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 1.9 kHz.

6.4 Effect of Supply Voltage Variation

The DUT is designed to operate from an automobile 12VDC system. For this test, the relative power radiated was measured at the fundamental as the voltage was varied from 5.0 to 18.0 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage and Current

V = 12.0 V

I = 110 mA (Data Transmission)

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 (August 17, 1994) 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:

<u>Coplanar case</u>: 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

	Transmitter Radiated Emissions										VР2W9F-15607-А; F€С/IС
	Freq.	Ant.	Ant.	Pr, 3m	Det.	Ka	Kg	E300*	E300lim	Pass	
#	kHz	Used	Orien.	dBm	Used	dB/m	dB	dΒμV/m	$dB\mu V/m$	dB	Comments
1	134.2	Loop	V	-37.4	Pk	9.9	0.0	-16.4	25.6	42.0	loop normal (axis in dir. of prop.)
2	134.2	Loop	V	-43.6	Pk	9.9	0.0		25.6		loop planar (loop in dir. of prop.)
3	268.4	Loop	V	-82.2	Pk	9.8	0.0	-61.3	25.6	86.9	loop normal, noise
4	268.4	Loop	V	-78.4	Pk	9.8	0.0	-57.5	25.6	83.1	loop planar
5	402.6	Loop	V	-75.0	Pk	9.8	0.0	-54.1	25.6	79.7	loop normal
6	402.6	Loop	V	-79.6	Pk	9.8	0.0	-58.7	25.6	84.3	loop planar
7	536.8	Loop	V	-82.5	Pk	9.8	0.0	-61.6	25.6		loop normal, noise
8	536.8	Loop	V	-87.8	Pk	9.8	0.0	-66.9	25.6	92.5	loop planar, noise
9	671.0	Loop	V	-89.4	Pk	9.8	0.0	-68.5	25.6	94.1	loop normal, noise
10	671.0	Loop	V	-86.2	Pk	9.8	0.0	-65.3	25.6	90.9	loop planar, noise
				·							
	All other	harmon	ics/orie	ntations	are in	the noi:	se (Pr	< -70 dE	3m)		
	* The av	eraging f	factor is	-5.8 dE	3; data i	s extra	polate	ed to 300	m distance	•	
	1 kHz Rl	BW used	in the r	neasure	ments						
										_	
			Digital	Radiat	ted Em	issions	, Cla	ss B			
	Freq.	Ant.	Ant.	Pr	Det.	Ka	Kg	E3	E3lim	Pass	
#	MHz	Used	Pol.	dBm	Used	dB/m	dB	dΒμV/m	dBμV/m	dB	Comments
			Meets	class E	limit b	y more	than	20dB			

				(Conduc		nissio	ns			
	Freq.	Line	Det.	Vtest	Vlim	Pass					
#	MHz	Side	Used	dΒμV	dΒμV	dB	_		Comment	S	
1											
2		1	Not app	licable							
3											1 06/20/01 06/20/01: U of Mich

Meas. 06/28/01, 06/29/01, 06/30/01; U of Mich.

Table 5.2 Highest Emissions Measured

			Trans		98AP-15607-A; F&C/IC						
	Freq.	Ant.	Ant.	Pr, 3m	Det.	Ka	Kg	E300*	E300lim	Pass	
#	kHz	Used	Orien.	dBm	Used	dB/m	dB	dΒμV/m	dBμV/m	dB	Comments
1	134.2	Loop	V	-42.9	Pk	9.9	0.0	-21.9	25.6	47.5	loop normal (axis in dir. of prop.)
2	134.2	Loop	V	-47.8	Pk	9.9	0.0	-26.8	25.6	52.4	loop planar (loop in dir. of prop.)
3	268.4	Loop	V	-77.4	Pk	9.8	0.0	-56.5	25.6	82.1	loop normal
4	268.4	Loop	V	-74.8	Pk	9.8	0.0	-53.9	25.6	79.5	loop planar
5	402.6	Loop	V	-74.7	Pk	9.8	0.0	-53.8	25.6	79.4	loop normal
6	402.6	Loop	V	-77.8	Pk	9.8	0.0	-56.9	25.6	82.5	loop planar
7	536.8	Loop	V	-82.6	Pk	9.8	0.0	-61.7	25.6	87.3	loop normal, noise
8	536.8	Loop	V	-80.9	Pk	9.8	0.0	-60.0	25.6	85.6	loop planar, noise
9	671.0	Loop	V	-82.5	Pk	9.8	0.0	-61.6	25.6	87.2	loop normal, noise
10	671.0	Loop	V	-82.4	Pk	9.8	0.0	-61.5	25.6	87.1	loop planar, noise
										·	
	All other	r harmor	nics/orie	ntation	s are in	the no	ise (P	r < -70 d	Bm)		
	* The av	eraging	factor i	s -5.8 d	B; data	is extra	apola	ted to 300	Om distanc	e	
	1 kHz R	BW use	d in the	measur	ements						
		·									
			Digital	Radiat	ed Em	issions	, Cla	ss B			
	Freq.	Ant.	Ant.	Pr	Det.	Ka	Kg	E3	E3lim	Pass	
#	MHz	Used	Pol.	dBm	Used	dB/m	dB	dΒμV/m	dBµV/m	dB	Comments
			·								
			Meets	s class I	3 limit	by mor	e thai	1 20dB			
						- 11					
											·
				(Conduc	ted En	nissio	ns			
	Freq.	Line	Det.	Vtest	Vlim	Pass					
#	MHz	Side	Used	dΒμV	dΒμV	dB			Comment	S	
1											
2			Not app	licable							
3											

Meas. 06/28/01,06/29/0, 06/30/01; U of Mich.

Table 5.3 Highest Emissions Measured

			Tran		98BP-15607-A; F C C/IC						
	Freq.	Ant.	Ant.	Pr, 3m	Det.	Ka	Kg	E300*	E300lim	Pass	
#	kHz	Used	Orien.	dBm	Used	dB/m	dB	dΒμV/m	dBµV/m	dB	Comments
1	134.2	Loop	V	-40.7	Pk	9.9	0.0	-19.7	25.6	45.3	loop normal (axis in dir. of prop.)
2	134.2	Loop	V	-46.9	Pk	9.9	0.0	-25.9	25.6	51.5	loop planar (loop in dir. of prop.)
3	268.4	Loop	V	-78.4	Pk	9.8	0.0	-57.5	25.6	83.1	loop normal, noise
4	268.4	Loop	V	-78.2	Pk	9.8	0.0	-57.3	25.6	82.9	loop planar, noise
5	402.6	Loop	V	-75.4	Pk	9.8	0.0	-54.5	25.6	80.1	loop normal
6	402.6	Loop	V	-77.8	Pk	9.8	0.0	-56.9	25.6	82.5	loop planar, noise
7	536.8	Loop	V	-79.3	Pk	9.8	0.0	-58.4	25.6	84.0	loop normal, noise
8	536.8	Loop	V	-76.7	Pk	9.8	0.0	-55.8	25.6	81.4	loop planar, noise
9	671.0	Loop	V	-85.1	Pk	9.8	0.0	-64.2	25.6	89.8	loop normal, noise
10	671.0	Loop	V	-80.3	Pk	9.8	0.0	-59.4	25.6	85.0	loop planar, noise
	- 1										
	All other	harmon	ics/orie	ntations	s are in	the noi	ise (P	r < -70 d	Bm)		
	* The av	eraging	factor is	s -5.8 dl	B; data	is extra	apolat	ed to 300	m distanc	e	
	1 kHz R	BW used	1 in the	measur	ements						
			Digital	Radia	ted Em	issions	s, Cla	ss B			
	Freq.	Ant.	Ant.	Pr	Det.	Ka	Kg	E3	E3lim	Pass	
#	MHz	Used	Pol.	dBm	Used	dB/m	dB	dΒμV/m	dBμV/m	dB	Comments
		·									
			Meets	class I	3 limit l	y mor	e thar	1 20dB	··		
\Box											
				1							
	_										
	_										
					Condu	cted Ex	missio	ons			
	Freq.	Line	Det.	Vtest	Conduc	cted En	missi	ons			
#	Freq. MHz	Line			Vlim		missic	ons	Comments	S	
# 1	- 1			Vtest	Vlim	Pass	missi	ons	Comments	S	
$\vdash \!$	- 1	Side		Vtest dBµV	Vlim	Pass	missio	ons	Comments	5	

Table 5.4 Highest Emissions Measured

1 134.1 Loop V -45.1 Pk 9.9 0.0 -24.1 25.6 49.7 loop normal (a. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2.	mments
1 134.1 Loop V -45.1 Pk 9.9 0.0 -24.1 25.6 49.7 loop normal (a. 2 134.1 Loop V -40.3 Pk 9.9 0.0 -19.3 25.6 44.9 loop planar (loop	
2 134.1 Loop V -40.3 Pk 9.9 0.0 -19.3 25.6 44.9 loop planar (lo	1
	xis in dir. of prop.)
	oop in dir. of prop.)
3 268.2 Loop V -78.6 Pk 9.8 0.0 -57.7 25.6 83.3 loop normal, n	noise
4 268.2 Loop V -82.8 Pk 9.8 0.0 -61.9 25.6 87.5 loop planar	
5 402.3 Loop V -80.1 Pk 9.8 0.0 -59.2 25.6 84.8 loop normal	
6 402.3 Loop V -77.0 Pk 9.8 0.0 -56.1 25.6 81.7 loop planar	
7 536.4 Loop V -84.7 Pk 9.8 0.0 -63.8 25.6 89.4 loop normal, no	oise
8 536.4 Loop V -86.2 Pk 9.8 0.0 -65.3 25.6 90.9 loop planar, no	oise
9 670.5 Loop V -84.7 Pk 9.8 0.0 -63.8 25.6 89.4 loop normal, no	oise
10 670.5 Loop V -86.8 Pk 9.8 0.0 -65.9 25.6 91.5 loop planar, no	oise
All other harmonics/orientations are in the noise (Pr < -70 dBm)	
* The averaging factor is -5.8 dB; data is extrapolated to 300m distance	
1 kHz RBW used in the measurements	
Digital Radiated Emissions, Class B	
Freq. Ant. Ant. Pr Det. Ka Kg E3 E3lim Pass	
# MHz Used Pol. dBm Used dB/m dB dB\u03b2V/m dB\u03b2V/m dB Cor	mments
Meets class B limit by more than 20dB	
Conducted Emissions	
Freq. Line Det. Vtest Vlim Pass	100 100 100 100 100 100 100 100 100 100
# MHz Side Used dBµV dBµV dB Comments	
2 Not applicable	
3	

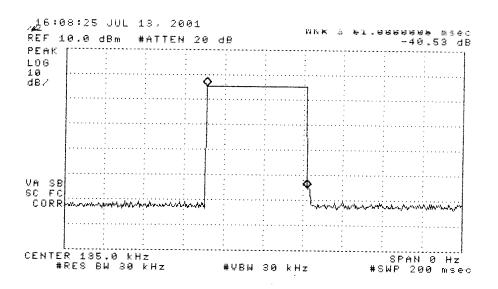


Figure 6.1. Transmission modulation characteristics.

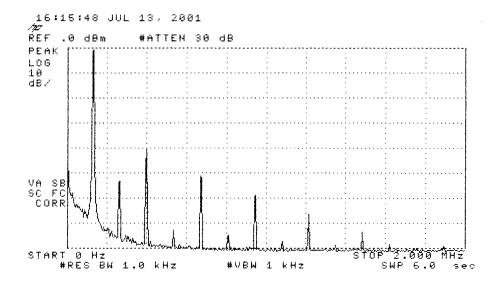


Figure 6.2. Emission spectrum of the DUT. The amplitudes are only indicative (not calibrated).

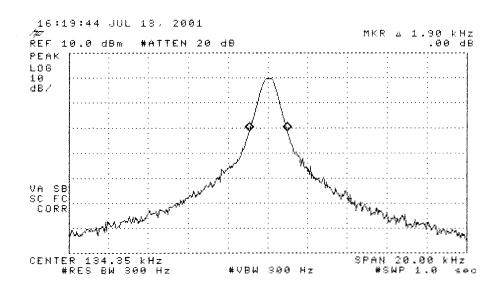


Figure 6.3. Measured bandwidth of the DUT. (pulsed)

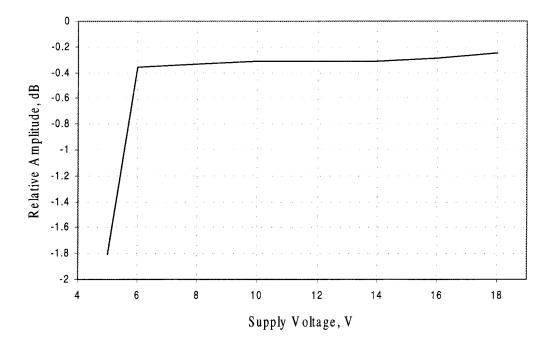


Figure 6.4. Relative emission at 134 kHz vs. supply voltage.

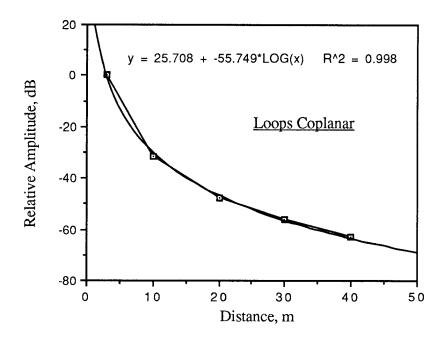


Figure 6.5. Field attenuation for case of coplanar loops.

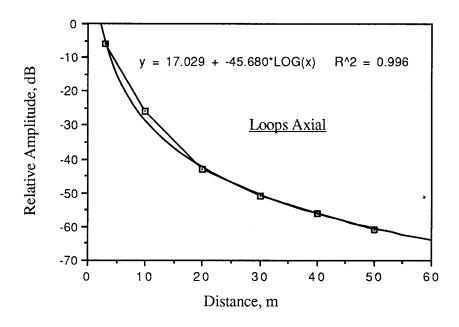


Figure 6.6. Field attenuation for case of axial loops.