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Measured Radio Frequency Emissions From

Visteon
Ford Passive Anti-Theft System (PATS)

Report No. 415031-877
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For:
Visteon Automotive Systems
17000 Rotunda Drive
Dearborn, Michigan 48121

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Summary

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

In testing performed on December 2 and 4, 1997, the device tested in the worst case met the allowed specifications for transmitter radiated emissions by 50.7 dB (see p. 6).

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

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 (16.104 and 32.768 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 load box, digital control module, ignition key assembly, and the key.

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

Ford PATS system
Model PATS3
PN: XL3T-15607-AB
SN: 62597
FCC ID: NT8-15607-PATS3
CANADA: to be provided by IC

With load box that was provided, either a pulsed (normal operation) or a CW emission could be selected.

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	2400/F(kHz), 300m
0.490-1.705	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 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 3 kHz. 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

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

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 50.7 dB.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

When the transmitter is activated by push action, it transmits a single 134 kHz pulse 46.5 ms long. Thus, the averaging factor or pulse operation correction factor is

$$K_E = 46.5\text{ms} / 100\text{ ms} = 0.465 \text{ or } -6.7\text{ dB}$$

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 367 Hz, and the center frequency is 133.4 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 5.5 to 18.0 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage and Current

V = 13.8 V

I = 57 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:

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

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

Table 5.1 Highest Emissions Measured

Radiated Emissions Ford Immobilizer; 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	133.5	Loop	V	-45.2	Pk	9.9	0.0	-25.1	25.6	50.7	loop normal (axis in dir. of prop.)
2	133.5	Loop	V	-48.5	Pk	9.9	0.0	-50.7	25.6	76.3	loop planar (loop in dir. of prop.)
3	267.0	Loop	V	-75.0	Pk	9.8	0.0	-55.0	25.6	80.6	loop normal, noise
4	267.0	Loop	V	-76.2	Pk	9.8	0.0	-78.5	25.6	104.1	loop planar, noise
5	400.5	Loop	V	-73.2	Pk	9.8	0.0	-53.2	25.6	78.8	loop normal, noise
6	400.5	Loop	V	-75.7	Pk	9.8	0.0	-78.0	25.6	103.6	loop planar, noise
7	534.0	Loop	V	-76.3	Pk	9.8	0.0	-56.3	25.6	81.9	loop normal, noise
8	543.0	Loop	V	-77.6	Pk	9.8	0.0	-79.9	25.6	105.5	loop planar, noise
9	667.5	Loop	V	-75.3	Pk	9.8	0.0	-55.3	25.6	80.9	loop normal, noise
10	667.5	Loop	V	-74.7	Pk	9.8	0.0	-77.0	25.6	102.6	loop planar, noise

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

* The averaging factor is -6.7 dB; data is extrapolated to 300m distance

1 kHz 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											
2											
3		More than 20 dB below the Class B limits									
4											

Conducted Emissions

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

Meas. 12/2/97; U of Mich.

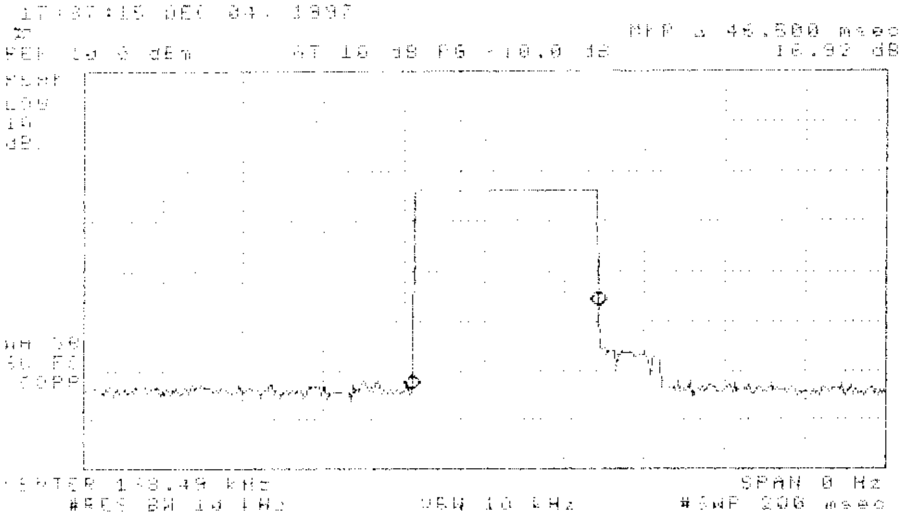

Figure 6.1. Transmissions modulation characteristics. Complete transmission is a single pulse.

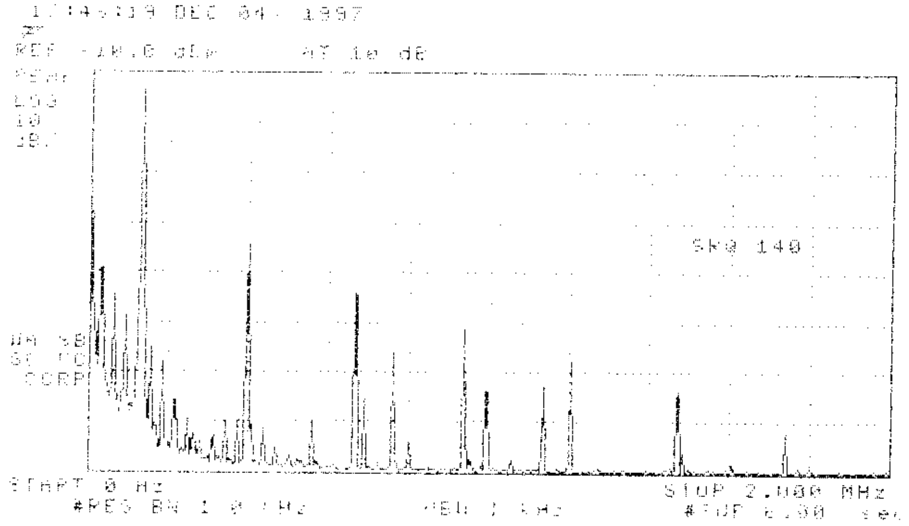

Figure 6.2. Emission spectrum of the DUT (CW emission). The amplitudes are only indicative (not calibrated).

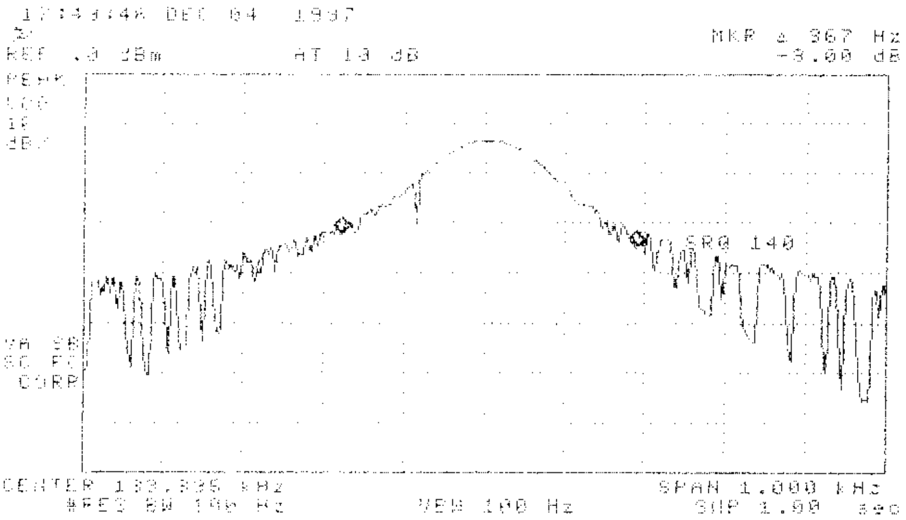

Figure 6.3. Measured bandwidth of the DUT (pulsed emission).

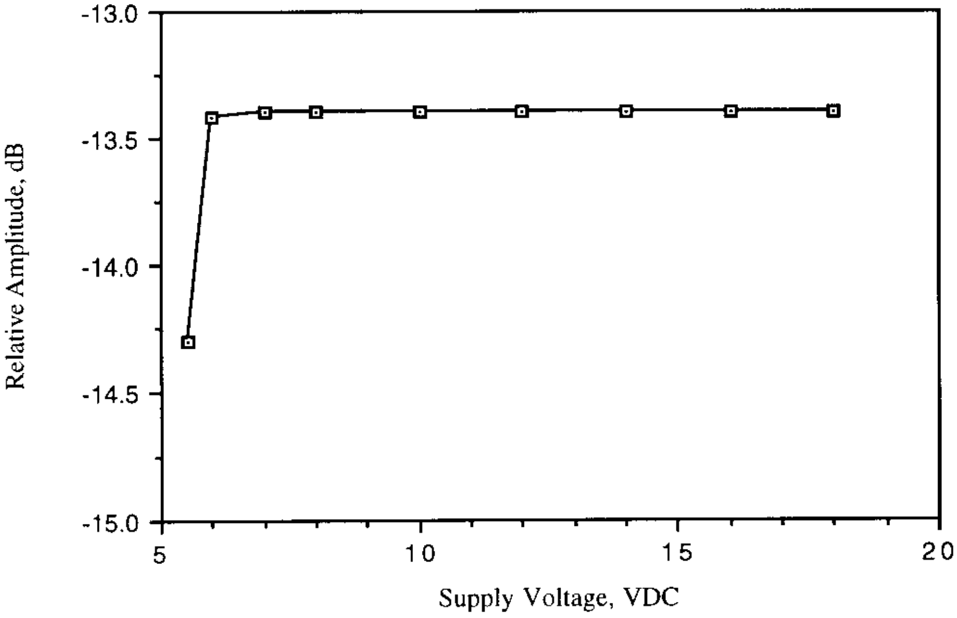

Figure 6.4. Relative emission at 133.5 MHz vs. supply voltage (CW emission).

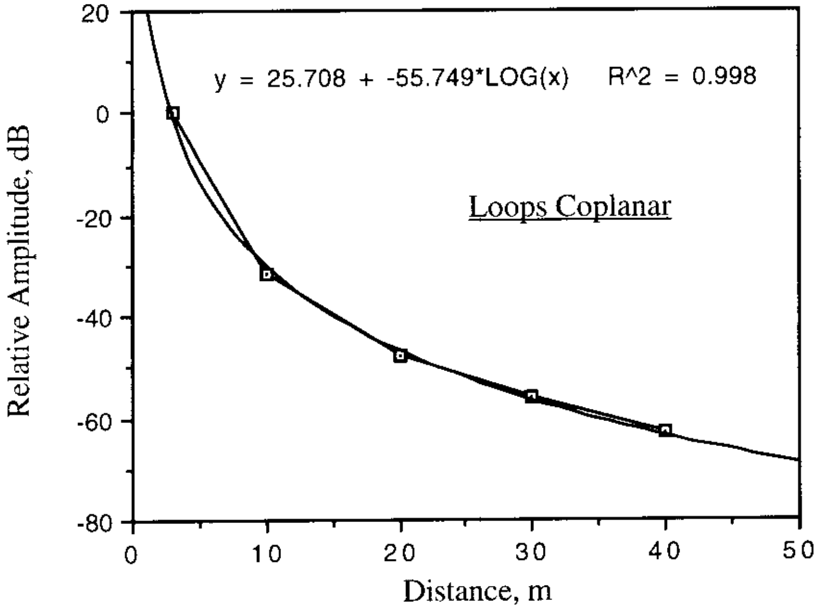

Figure 6.5. Field attenuation for case of coplanar loops.

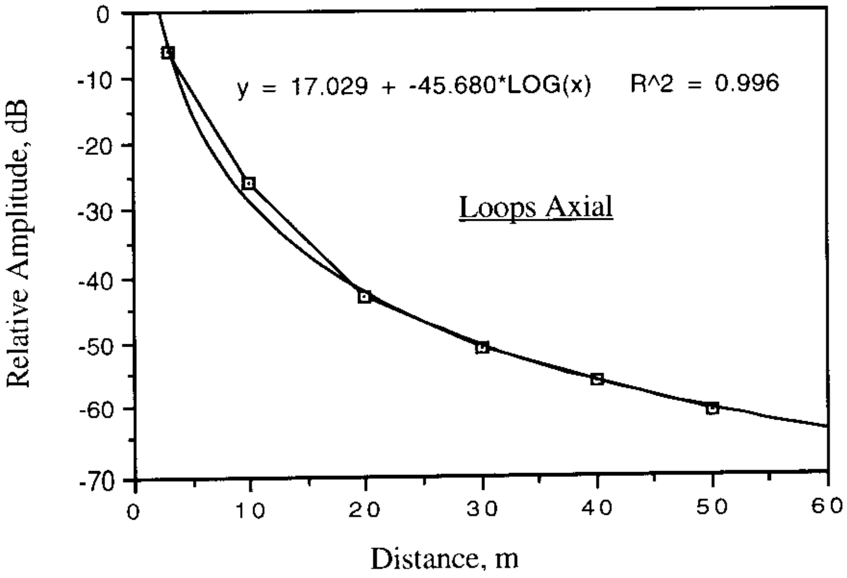

Figure 6.6. Field attenuation for case of axial loops.

Automotive Components Division
Security Products Engineering

FORD CONFIDENTIAL

Passive Anti-Theft System (PATS) Theory of Operation

Overview

The Passive Anti-Theft System (PATS) is a vehicle anti-theft system that uses Half-Duplex Radio Frequency Identification (RFID) technology to provide driveaway theft protection. During each vehicle start sequence, the electronically encoded ignition key is interrogated by the PATS system. If the keys electronic ID code matches one programmed into the PATS E^2 memory, the vehicle is enabled to start. If no match is found for the key, the vehicle's electronics do not allow the vehicle to start.
The PATS system contains an electronically encoded ignition key, a radio frequency transmitter/receiver (transceiver) module and a control module (system controller). Each of the system components will be briefly described below:

Transponder

PATS utilizes a passive RFID half-duplex transponder. The device is packaged in a small, hermetically sealed glass capsule (23mm X 3.85mm). The transponder is imbedded in the plastic head of the ignition key. The transponder has no internal battery and thus must receive its power from the transceiver (via. induction). The transponder charge-up frequency is 134.2Khz. The transponder transmits its data packet (15mS duration) in Frequency Shift Keyed (FSK) format. The two FSK frequencies used during data transmission are 134.2Khz and 123.2Khz.

Transceiver

The PATS transceiver performs two basic functions. The transceiver charges-up the transponder power source at 134.2Khz upon receiving a charge command pulse from the PATS controller (via. induction). After a 50ms charge, the transceiver receives the transponder FSK signal, demodulates it, and packs the demodulated data into bytes. These bytes are sent to the controller via. a 15.625KBaud serial communications interface (SCI). The transceiver performs these functions via. a CMOS ASIC which operates at a 16.104Mhz clock rate. Approx. 250mS after completion of the charge sequence, the 16.104Mhz oscillator will go to sleep to minimize EMI emissions. It will not reactivate until the next charge command is issued. The transceiver communicates with the transponder via. a parallel RLC tank circuit.

Controller

The PATS control module (controller) contains circuitry to interface to the vehicle electrical system, the transceiver module, the vehicle multiplex communications network and the vehicle theft indicator located in the instrument cluster. The PATS controller uses a microcontroller to control the system functions. The external microcontroller clock frequency is 32.768Khz. Internal to the microcontroller, the 32.768Khz is multiplied to 8Mhz then divided by 2 to 4Mhz for system timing. The Controller receives serial bytes of data from the Transceiver at 15.625KBaud.

System Operation

The PATS system is off until the ignition key is rotated to the RUN/START position. At RUN/START, ignition power is applied to the Controller and Transceiver. The controller sends a 50ms charge command pulse to the transceiver. The transceiver in turn begins producing a 134.2Khz time-varying electromagnetic field to charge the transponder. After 50ms, the charge command is terminated and the transceiver stops producing the electromagnetic field. The transceiver then becomes a receiver. The FSK signal from the transponder is received on the transceiver RLC tank circuit and the ASIC amplifies/demodulates and byte packs the transponder data. The transceiver transmits a diagnostic byte and the transponder code data bytes to the controller via. the SCI interface. The controller then compares the bytes received authorized codes stored in its EEPROM memory. If the transponder code is recognized by the controller as a valid code, the vehicle engine is permitted to operate. If the transponder code is recognized as a missing or invalid code, the vehicle engine is immobilized. PATS does not operate again until the ignition key is rotated to the OFF position, then to RUN/START.

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