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Measured Radio Frequency Emissions
From

Visteon Ford WIN126 Receiver
PN: XF2F-15K602-AA

Report No. 415031-905
April 11, 1998

For:
Visteon Automotive Systems
17000 Rotunda Drive
Dearborn, Michigan 48121

EXHIBIT E
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U of Mich file 415031-905

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Summary

Tests for compliance with FCC Regulations subject to Part 15, Subpart B, were performed on Visteon WIN126 superregenerative 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 December 18, 1997 and April 10, 1998, the device tested in the worst case met the specifications for radiated emissions by 6.1 dB (see p. 6). The line conductive emission tests do not apply, since the device is powered from an automobile 12 VDC system.

1. Introduction

Visteon Ford WIN126 receiver, PN: XF2F-15K602-AA, 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	Eq'nt Used	Manufacturer/Model	Cal. Date/By
Spectrum Analyzer (9kHz-22GHz)		Hewlett-Packard 8593A SN: 3107A01358	July 1997/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 1997/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 1996/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)		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)	X	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 315.0 MHz superregenerative receiver, designed for onboard automobile security/convenience applications, and as such, it is powered from an automotive 12 VDC source. It is housed in a plastic case approximately 6.5 by 3.5 by 1.0 inches. Antenna is internal. For testing, a 3 meter long section of generic harness was used, with power wires separated from the control/signal wires. In the receiver digital section, the decoding, signal processing, etc. are performed by a microprocessor timed by a 12 MHz resonator.

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

Visteon Ford Receiver
Model WIN126
PN: XF2F-15K602-AA
SN: 006
FCC ID: NT8-13C791-DDM
CANADA: to be provided by IC

3.1 Modifications Made

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

4. Emission Limits

The DUT tested falls under Part 15, Subpart B, "Unintentional Radiators". The pertinent test frequencies, with corresponding emission limits, are given in Tables 4.1 and 4.2 below and Section 4.3.

4.1 Radiated Emission Limits

Table 4.1. Radiated Emission Limits (Ref: 15.33, 15.35, 15.109).

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 Line Conducted Emission Limits

Table 4.2. Conducted Emission Limits (Ref: 15.107).

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 315 MHz CW signal was injected (radiated) from a nearby signal generator using a short wire antenna. The DUT was placed on the test table on each of its three axis. For each placement, 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 using a dipole. The DUT was excersized as described in Sec. 5.1 above. The measurements were made with a spectrum analyzer using 120 kHz IF bandwidth and peak detection mode, and, when appropriate, using Quasi-Peak or average detection (see 5.0). Figure 5.3 shows the DUT on the test table, and figure 5.4 shows the table oriented with respect to antenna for the worst case emissions for measurement at "fundamental".

The emissions from digital circuitry were measured on the Open Site using a standard dipole. These results are also given 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

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

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 6.1 dB.

5.4 Conducted Emission Tests

These tests do not apply, since the DUT is powered from a 12 V automobile system.

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" (316MHz) as voltage was varied from 5.0 to 18.0 VDC. Figure 6.2 shows the emission variation.

6.3 Operating Voltage and Current

V = 12.5 V
I = 24.2 mADC

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Table 5.1 Highest Emissions Measured

#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBμV/m	E3lim dBμV/m	Pass dB	Comments
Radiated Emission - RF											Visteon Win126 RX; FCC
1	316.7	SBic	H	-64.3	Pk	19.0	21.8	39.9	46.0	**6.1**	flat
2	316.7	SBic	H	-65.2	Pk	19.0	21.8	39.0	46.0	7.0	side
3	316.7	SBic	H	-64.5	Pk	19.0	21.8	39.7	46.0	6.3	end
4	316.7	SBic	V	-70.1	Pk	19.0	21.8	34.1	46.0	11.9	flat
5	316.7	SBic	V	-70.5	Pk	19.0	21.8	33.7	46.0	12.3	side
6	316.7	SBic	V	-71.4	Pk	19.0	21.8	32.8	46.0	13.2	end
7	630.0	SBic	V/H	-83.5	Pk	25.2	18.5	30.3	46.0	15.7	max. of all, noise; 10 kHz BW
8	945.0	SBic	V/H	-86.3	Pk	28.9	16.1	33.5	46.0	12.5	max. of all, noise; 10 kHz BW
9	1260.0	Horn	H	-64.0	Pk	20.4	28.0	35.4	54.0	18.6	max. of all, noise
10	1575.0	Horn	H	-63.5	Pk	20.6	28.0	36.1	54.0	17.9	max. of all, noise
11	1890.0	Horn	H	-63.5	Pk	20.8	28.2	36.1	54.0	17.9	max. of all, noise
12											
13											
14											
15											
16											
17											
18											

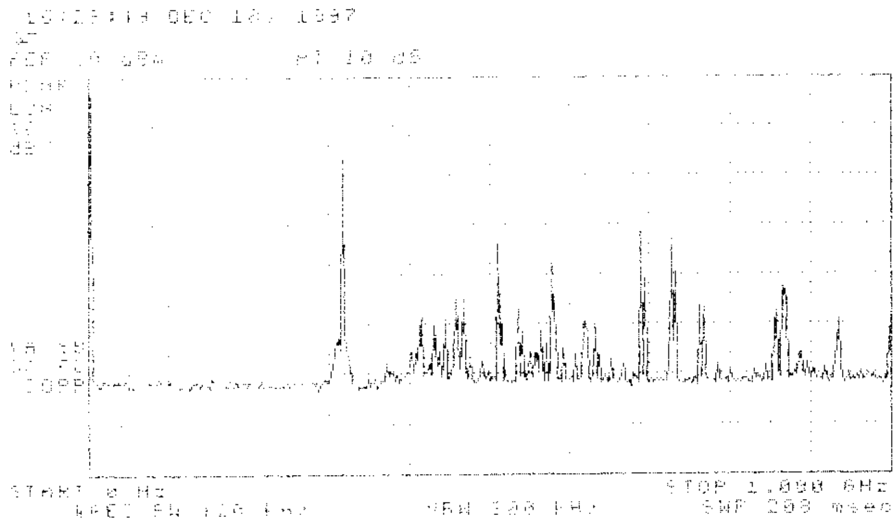
Radiated Emission - Digital (Class B)

#											
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. 12/18/97,4/10/98; U of Mich.



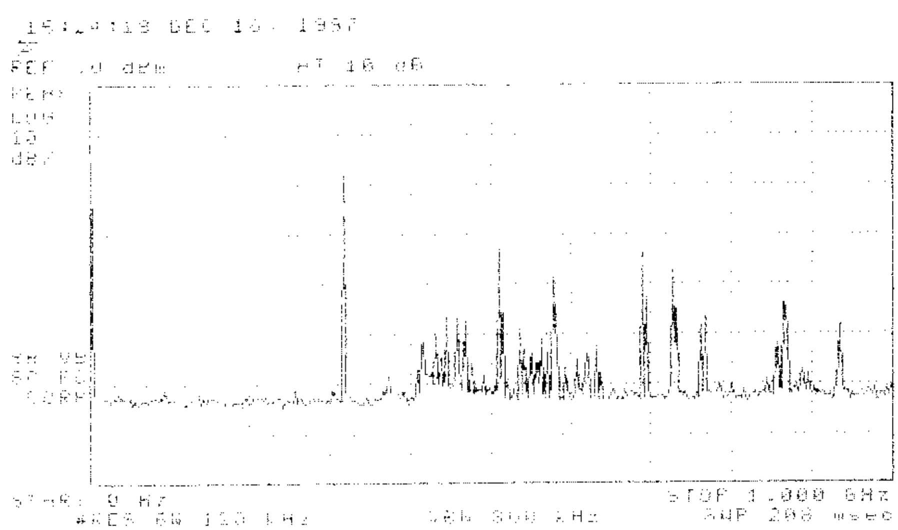


Figure 5.1. Emissions measured at 3 meters in anechoic chamber, 0-1000 MHz.
(top) Receiver plus ambient
(bottom) Ambient

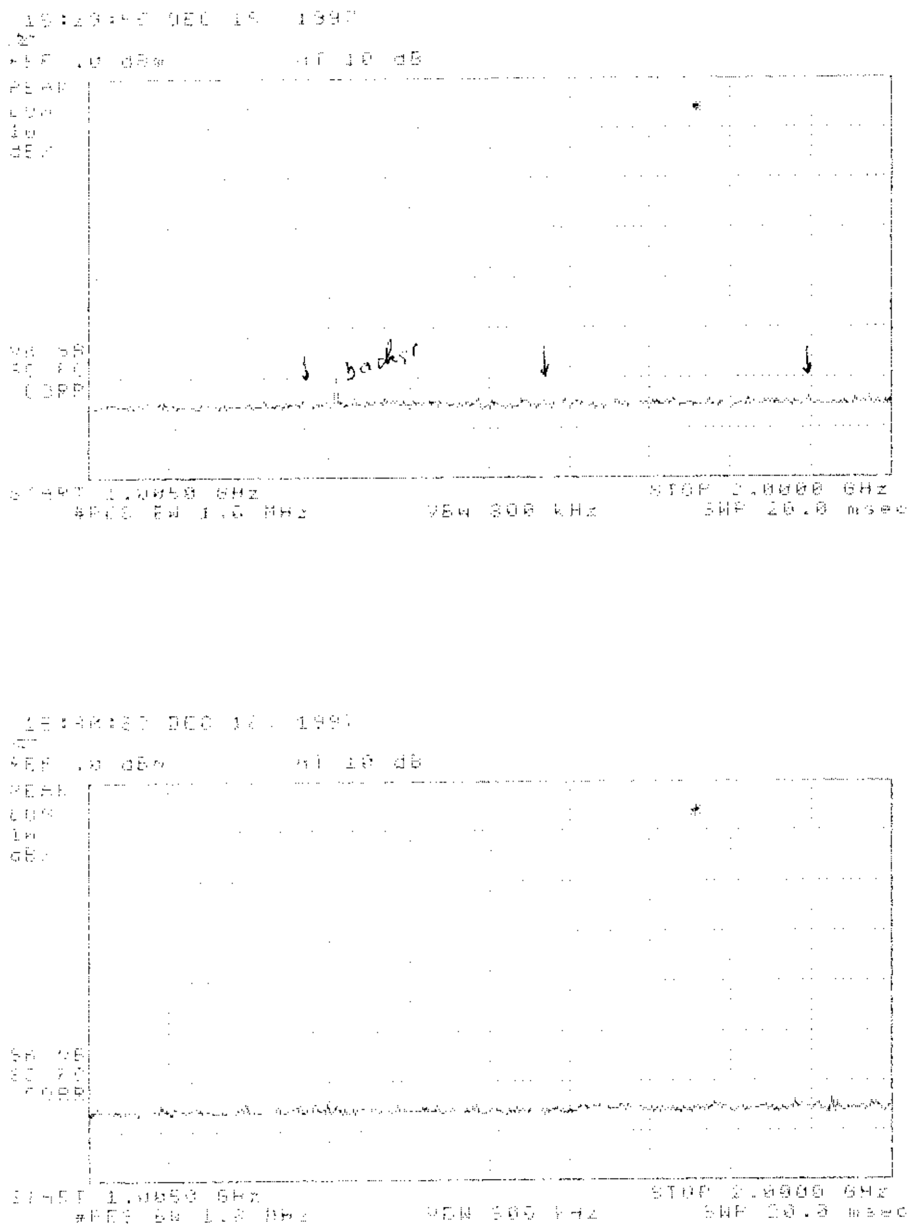


Figure 5.2. Emissions measured at 3 meters in anechoic chamber, 1000-2000 MHz.
(top) Receiver plus ambient
(bottom) Ambient

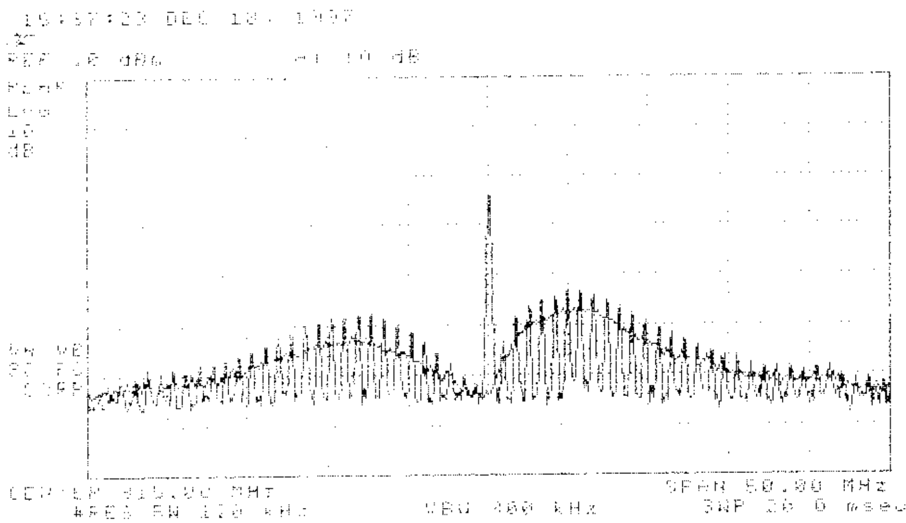


Figure 6.1. Relative receiver emissions in stand-by and "locked-in" modes. The final emission measurements were made with the receiver in "locked-in" mode.

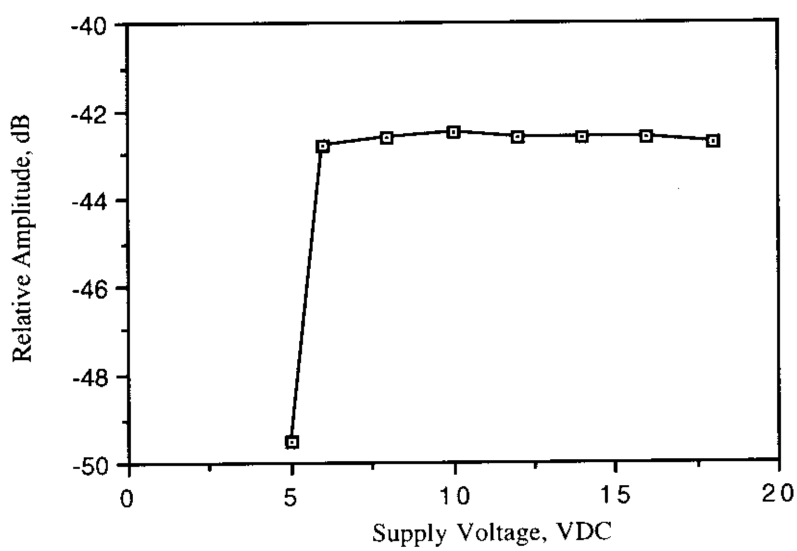


Figure 6.2. Relative emission at "fundamental" vs. supply voltage.