The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
Tel: (734) 647-1792

Measured Radio Frequency Emissions From

Siemens Modular Receiver Model 5WK48203

Report No. 415031-025
January 12, 2000

For:
Siemens Automotive
2400 Executive Hills Drive
Auburn Hills, MI 48326-2980

Contact:
Dave Reimus
Tel: 248-209-4569
Fax: 248-253-6635
PO: 11457, 12162

EXHIBIT 6
Page 1-10 of 10
U of Mich file 415031- 025

Measurements made by: Valdis V. Liepa

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

Summary

Tests for compliance with FCC Regulations subject to Part 15, Subpart B, and with Industry Canada Regulations subject to RSS-210, were performed on Siemens Superregenerative Receiver Module. This device is subject to the 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 August 18 and 20, and November 30, 1999, the device tested in the worst case met the allowed specifications for radiated emissions by 18.3 dB (see p. 6), and met the allowed specifications for the antenna conducted emissions by 2.3 dB. The line conductive emission tests do not apply, since the device is powered from an automobile electric system.

1. Introduction

Siemens Modular Superregenerative Receiver, Model 5WK48203, 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 file 31040/SIT) and with Industry Canada, Ottawa, ON (File Ref. No: IC 2057).

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)	X	Hewlett-Packard 8593A SN: 3107A01358	October 1999/UM
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E SN: 3107A01131	September 1999/HP
Spectrum Analyzer (0.1-1500 MHz)		Hewlett-Packard 182T/8558B SN: 1529A01114/543592	October 1999/U of M Rad Lab
Preamplifier (5-1000MHz)	X	Watkins-Johnson A11 -1 plus A25-1S	Oct. 1999/U of M Rad Lab
Preamplifier (5-4000 MHz)	X	Avantek	Nov. 1996/ U of M Rad Lab
Broadband Bicone (20-200 MHz)	X	University of Michigan	June 1996/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)	X	University of Michigan	June 1997/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	March 1999/U of M Rad Lab
LISN Box		University of Michigan	Dec 1997/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 board designed for onboard automobile security/convenience applications, and plugs in (as daughter board) on Control Module board. The receiver board is 2.4 x 4.0 cm in size, and when plugged in a mother board, all the components are on the inside side and a ground plane (shield) is on the outer side. The control module is powered from automobile 12 VDC and the receiver from the module at 5 VDC. For testing, a brass fixture about twice the size of the receiver board was used. The board plugged into the fixture which, in turn, provided connections for antenna (SMA), signal out (BNC), and 5 VDC power (banana plugs). When testing, connecting cables were about 2.0 m; end of signal coax was left open. There are no digital circuitry on the board on the receiver board.

The DUT was designed and manufactured by Siemens Automotive; 2400 Executive Hills Drive; Auburn Hills, MI 48326-2980. It is identified as:

Siemens Modular Receiver
Model: 5WK48203
SN: E2
FCC ID: M3N-5WK48203
CANADA: to be provided by IC

3.1 Modifications Made

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

4. Emission Limits

For FCC the DUT falls under Part 15, Subpart B, "Unintentional Radiators". For Industry Canada the DUT falls under Receiver category and is subject to technical requirement of sections 7.1 to 7.4 in RSS-210. The pertinent test frequencies, with corresponding emission limits, are given in Tables 4.1 and 4.2 below.

4.1 Radiated Emission Limits

Table 4.1. Radiated Emission Limits (FCC: 15.33, 15.35, 15.109; IC: RSS-210, 7.3).

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 Conducted Emission Limits

Table 4.2. Conducted Emission Limits (FCC: 15.107; IC: RSS-210, 6.6).

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
(FCC: 15.111(a); IC: RSS-210, 7.2). Pmax = 2 nW; for requency 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 13.5 VDC. A 315 MHz CW signal was injected (radiated) from a nearby signal generator using a short wire antenna. The DUT was taped to a syrofoan block and placed on the test table on each of the three axis. At each orientation, 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 and injection signal (315 MHz), 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 small bicone, or dipoles when the measurement is near the limit. The DUT was excersised 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). The test set-up photographs are in the Appendix (i.e., end of this report).

The emissions from digital circuitry were measured using a standard bicone. These results are also presented 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

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

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 18.3 dB.

5.4 Conducted Emission Tests
These tests do not apply, since the DUT is powered from an automotive 12 VDC 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 5 VDC power. Using a spectrum analyzer, relative radiated emissions were recorded at the "fundamental" (317 MHz) as voltage was varied from 4.0 to 5.5 VDC. Figure 6.2 shows the emission variation.

6.3 Operating Voltage and Current

V = 5.0 VDC
I = 1.2 mADC

6.4 Antenna RF Power Conducted Measurements

These measurements are made by connecting a spectrum analyzer directly to the DUT antenna terminal and recording, in this case, the typical regenerative receiver "finger" pattern shown in Figure 6.3. Power readings of individual lines, plus other emissions if present, are summed up. In this case, the sum is 0.951 nW, which is 3.2 dB below the 2 nW limit. The peak line in Figure 6.3 is the locking signal and not counted as part of conducted emission. It injected into the receiver via radiation from a nearby antenna which, in turn, is connected to a signal generator.

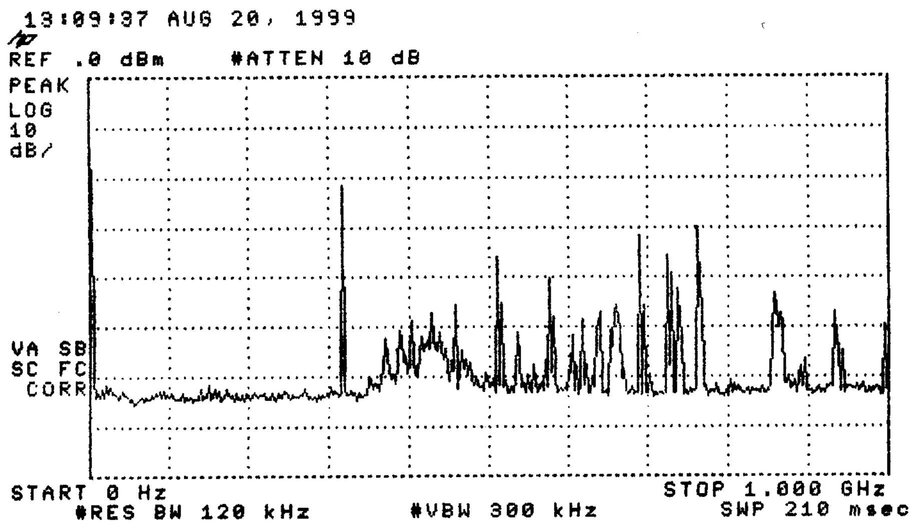
The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, Michigan 48109-2122
(734) 647-1792

Table 5.1 Highest Emissions Measured

Radiated Emission - RF											Siemens RX; 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	317.0	Dip	H	-80.0	Pk	18.9	22.2	23.7	46.0	22.3	flat
2	317.0	Dip	H	-79.0	Pk	18.9	22.2	24.7	46.0	21.3	side
3	317.0	Dip	H	-76.0	Pk	18.9	22.2	27.7	46.0	**18.3**	end
4	317.0	Dip	V	-84.0	Pk	18.9	22.2	19.7	46.0	26.3	flat
5	317.0	Dip	V	-86.0	Pk	18.9	22.2	17.7	46.0	28.3	side
6	317.0	Dip	V	-78.0	Pk	18.9	22.2	25.7	46.0	20.3	end
7	630.0	Dip	H/V	-94.0	Pk	26.1	18.9	20.2	46.0	25.8	max. of all, noise; 10 kHz BW
8	945.0	Dip	H/V	-94.0	Pk	29.5	16.5	26.1	46.0	19.9	max. of all, noise; 10 kHz BW
9	1280.0	Horn	H	-68.0	Pk	20.6	28.0	31.6	54.0	22.4	max. of all, noise
10	1320.0	Horn	H	-73.0	Pk	21.0	28.1	26.9	54.0	27.1	max. of all, noise
11	1520.0	Horn	H	-66.0	Pk	21.3	28.3	34.0	54.0	20.0	max. of all, noise
12	1610.0	Horn	H	-70.0	Pk	21.4	28.2	30.2	54.0	23.8	max. of all, noise
13	1780.0	Horn	H	-71.0	Pk	21.8	27.9	29.9	54.0	24.1	max. of all, noise
14	1850.0	Horn	H	-70.0	Pk	22.2	28.2	31.0	54.0	23.0	max. of all, noise
15	1950.0	Horn	H	-70.0	Pk	22.4	28.3	31.1	54.0	22.9	max. of all, noise
16											
17											
18											
19											
20											
21											
22		Digital emissions more than 20 dB below FCC/IC Class B Limit.									
23											
24											
25											
26											
27											

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

Meas. 8/18 and 20,11/30/99; U of Mich.



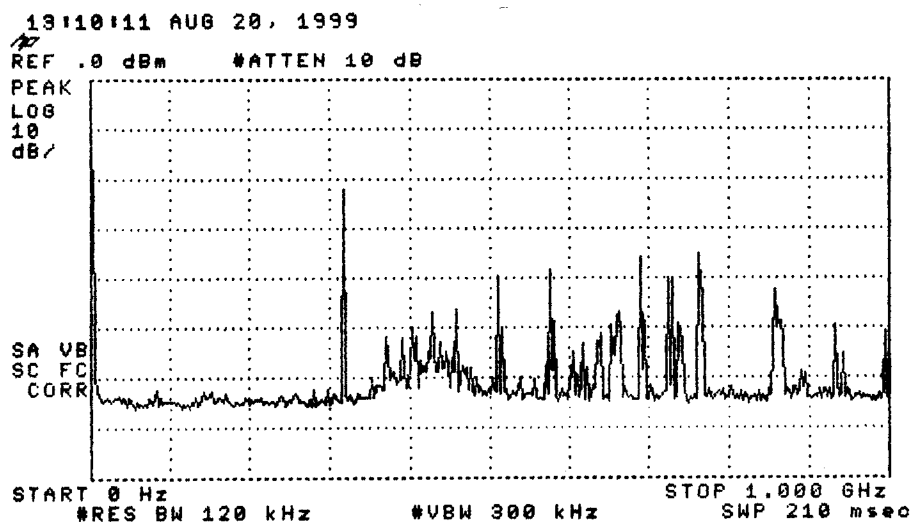
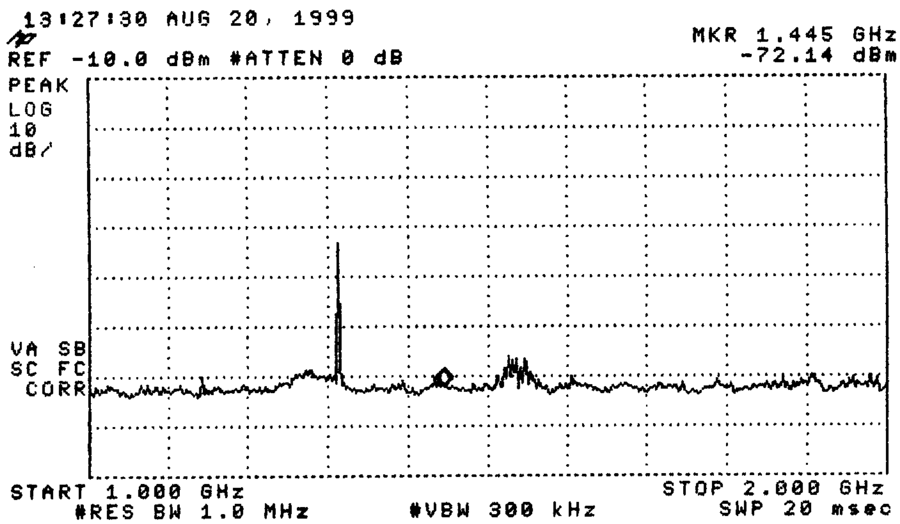


Figure 5.1. Emissions measured at 3 meters in anechoic chamber, 0-1000 MHz.
(top) Receiver plus ambient
(bottom) Ambient



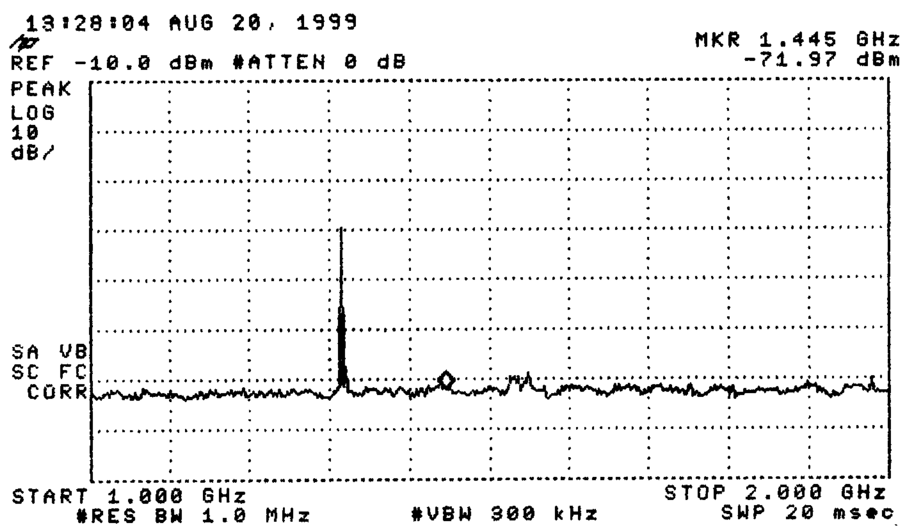


Figure 5.2. Emissions measured at 3 meters in anechoic chamber, 1000-2000 MHz.
(top) Receiver plus ambient
(bottom) Ambient

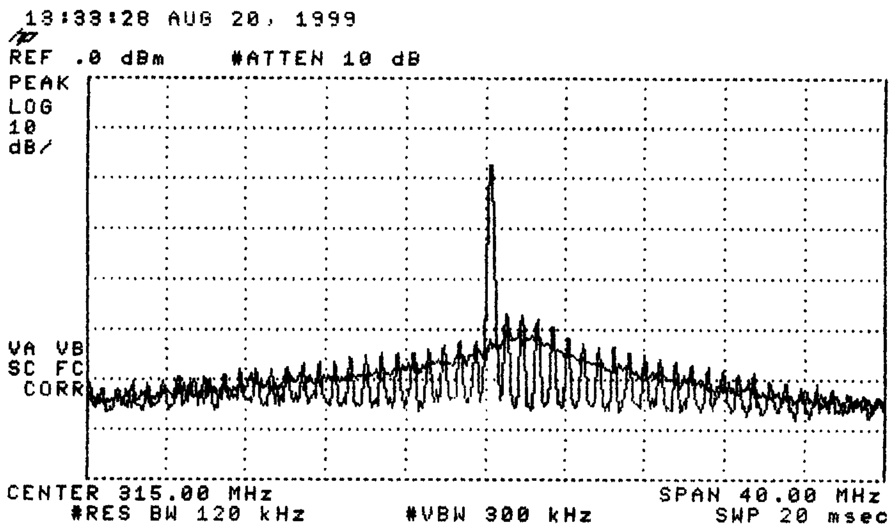


Figure 6.1. Relative receiver emissions in stand-by and "locked-in" modes. The final radiated emission measurements were made with the receiver in "locked-in" mode.

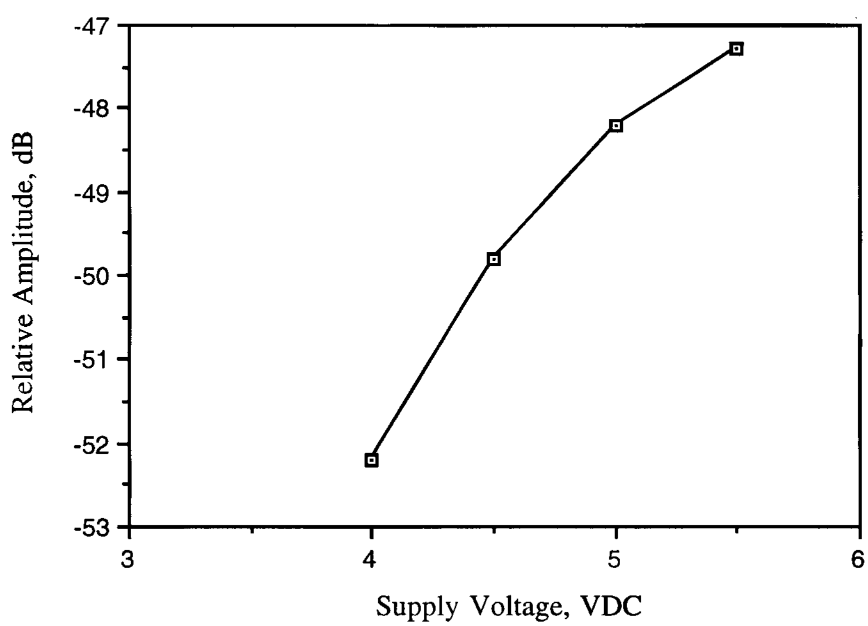


Figure 6.2. Relative emission at "fundamental" vs. supply voltage.

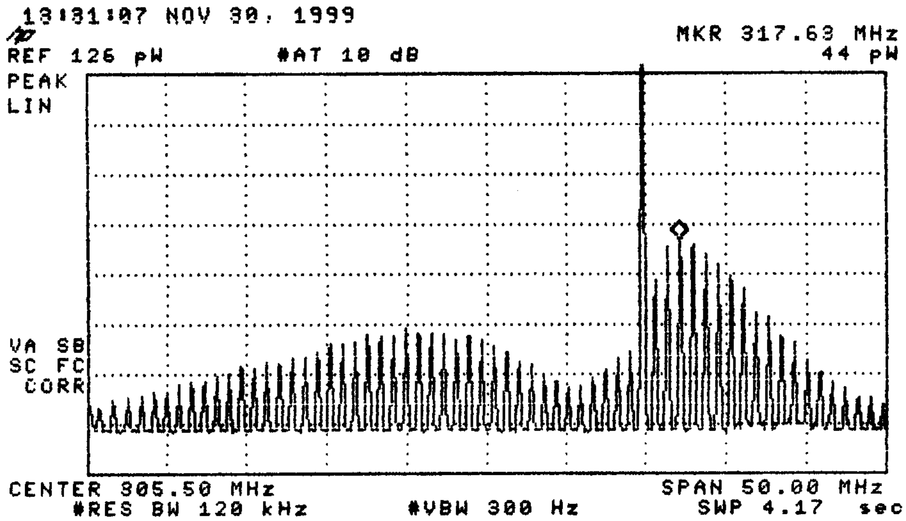


Figure 6.3. Antenna conducted emissions. The max peak is the injected signal.