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Measured Radio Frequency Emissions
From

Siemens VDO EZ-key 315 MHz Transmitter: RKE Mode

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For:
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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 Siemens VDO EZ-key transmitter in RKE mode. This device is subject to the Rules and Regulations as a transmitter and as a digital device.

In testing performed between September 30 and November 10, 2003, the device tested in the worst case met the allowed specifications for radiated emissions by 0.8 dB at fundamental and by 13.6 dB at harmonics (see p. 6). Besides harmonics, there were no other significant spurious emissions found; emissions from digital circuitry were negligible. Since the device is powered by a 3-volt battery, line conducted emission tests do not apply.

1. Introduction

Siemens EZ-key Transmitter was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 5, dated November, 2001. 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 Procedure and Equipment Used

The pertinent test equipment commonly used in our facility for measurements is listed in Table 2.1 below. The middle column identifies the specific equipment used in these tests.

Table 2.1. Test equipment.

Test Instrument	Eqpt Used	Manufacturer/Model
Spectrum Analyzer (0.1-1500 MHz)		Hewlett-Packard, 182T/8558B
Spectrum Analyzer (9kHz-22GHz)	X	Hewlett-Packard 8593A SN: 3107A01358
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E, SN: 3412A01131
Spectrum Analyzer (9kHz-26GHz)		Hewlett-Packard 8563E, SN: 3310A01174
Spectrum Analyzer (9kHz-40GHz)		Hewlett-Packard 8564E, SN: 3745A01031
Power Meter		Hewlett-Packard, 432A
Power Meter		Anritsu, ML4803A/MP
Harmonic Mixer (26-40 GHz)		Hewlett-Packard 11970A, SN: 3003A08327
Harmonic Mixer (40-60 GHz)		Hewlett-Packard 11970U, SN: 2332A00500
Harmonic Mixer (75-110 GHz)		Hewlett-Packard 11970W, SN: 2521A00179
Harmonic Mixer (140-220 GHz)		Pacific Millimiter Prod., GMA, SN: 26
S-Band Std. Gain Horn		S/A, Model SGH-2.6
C-Band Std. Gain Horn		University of Michigan, NRL design
XN-Band Std. Gain Horn		University of Michigan, NRL design
X-Band Std. Gain Horn		S/A, Model 12-8.2
X-band horn (8.2- 12.4 GHz)		Narda 640
X-band horn (8.2- 12.4 GHz)		Scientific Atlanta , 12-8.2, SN: 730
K-band horn (18-26.5 GHz)		FXR, Inc., K638KF
Ka-band horn (26.5-40 GHz)		FXR, Inc., U638A
U-band horn (40-60 GHz)		Custom Microwave, HO19
W-band horn(75-110 GHz)		Custom Microwave, HO10
G-band horn (140-220 GHz)		Custom Microwave, HO5R
Bicone Antenna (30-250 MHz)	X	University of Michigan, RLBC-1
Bicone Antenna (200-1000 MHz)	X	University of Michigan, RLBC-2
Dipole Antenna Set (30-1000 MHz)	X	University of Michigan, RLDP-1,-2,-3
Dipole Antenna Set (30-1000 MHz)		EMCO 2131C, SN: 992
Active Rod Antenna (30 Hz-50 MHz)		EMCO 3301B, SN: 3223
Active Loop Antenna (30 Hz-50 MHz)		EMCO 6502, SN:2855
Ridge-horn Antenna (300-5000 MHz)	X	University of Michigan
Amplifier (5-1000 MHz)	X	Avantak, A11-1, A25-1S
Amplifier (5-4500 MHz)	X	Avantak
Amplifier (4.5-13 GHz)		Avantek, AFT-12665
Amplifier (6-16 GHz)		Trek
Amplifier (16-26 GHz)		Avantek
LISN (50 µH)		University of Michigan
Signal Generator (0.1-2060 MHz)		Hewlett-Packard, 8657B
Signal Generator (0.01-20 GHz)		Hewlett-Packard

3. Configuration and Identification of Device Under Test

The DUT is a hand held three-, four-, or five-button low power RKE transmitter designed to send identification and control signals to a companion receiver. Same PC part is used in all versions, only the plastics are different and there are small differences in IDs and control. It activated by pushing any of the buttons or is activated by 125 kHz LF signal that comes from the car when a door handle is raised. The DUT also has a remote car start button or function; this mode has higher peak emissions. In this document the emissions from the RKE operation are reported. The other document reports on remote start operation.

The DUT was designed by Siemens VDO Automotive, 4685 Investment Drive, Troy, MI 48098. It is identified as:

Siemens EZ-key Transmitter
Series: GM EZ-key 215/245/295
SN: PV-99
PNs(three-button): 5WY7572, 5WY7573
PNs(four-button): 5WY7377, 5WY7380
PNs(five-button): 5WY7277, 5WY7278, 5WY7276
FCC ID: M3N65981403
IC: 267F-65981403

For the tests one board was provided and three-, four-, and five-button plastics. We performed complete measurements on five-button version and then checked emissions with other button plastics at the worst case previous measured. Measurements were done in a pulsed mode.

3.1 EMI Relevant Modifications

No modifications were made to the DUT by this laboratory. However, during the period of testing, software was modified by Siemens to reduce the duty factor by decreasing the ON/OFF ratio in ASK Manchester encoding of the signal.

4. Emission Limits

4.1 Radiated Emission Limits

The DUT tested falls under the category of an Intentional Radiators and the Digital Devices. For FCC, it is subject to Part 15, Subpart C, (Section 15.231), Subpart B, (Section 15.109), and Subpart A, (Section 15.33). For Industry Canada it is subject to RSS-210, (Sections 6.1 and 6.3). The applicable testing frequencies with corresponding emission limits are given in Tables 4.1 and 4.2 below. As a digital device, the DUT is considered as a Class B device.

Table 4.1. 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)

Table 4.2. Radiated Emission Limits (FCC: 15.231(b), 15.205(a); IC: RSS-210; 6.1, 6.3). (Transmitter)

Frequency (MHz)	Fundamental Ave. E_{lim} (3m)		Spurious** Ave. E_{lim} (3m)	
	(μV/m)	dB (μV/m)	(μV/m)	dB (μV/m)
260.0-470.0	3750-12500*		375-1250	
322-335.4 399.9-410 608-614	Restricted Bands		200	46.0
960-1240 1300-1427 1435-1626.5 1660-1710 1718.9-1722.2 2200-2300	Restricted Bands		500	54.0

* Linear interpolation, formula: E = -7083 + 41.67*f (MHz)
** Measure up to tenth harmonic; 120 kHz BW up to 1 GHz, 1 MHz BW above 1 GHz

4.2 Conductive Emission Limits

The conductive emission limits and tests do not apply here, since the DUT is powered by one internal 3-volt battery.

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 testing for radiated emissions, the transmitter was activated using the lock/unlock button with a special wooden clamp for repeated pulse emissions. It was placed on the test table flat, on its side, or on its end.

In the chamber we studied and recorded all the emissions using a bicone antenna up to 300 MHz and a ridged horn antenna above 200 MHz. The measurements made in the chamber below 1 GHz are used for pre-test evaluation only. The measurements made above 1 GHz are used in pre-test evaluation and in the final compliance assessment. We note that for the horn antenna, the antenna pattern is more directive and hence the measurement is essentially that of free space (no ground reflection). Consequently it is not essential to measure the DUT for both antenna polarizations, as long as the DUT is measured on all three of its major axis. 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 30 MHz to 3.15 GHz using bicone and the ridge horn antennas, there were no other significant spurious emissions observed.

5.2 Outdoor Measurements

After the chamber measurements, the emissions were re-measured on the outdoor 3-meter site at fundamental and harmonics up to 1 GHz using tuned dipoles and/or the high frequency bicone.

Photographs in Appendix (at end of this report) show the DUT on the open in site table (OATS).

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 limits by 0.8 dB at fundamental and by 13.6 dB at harmonics.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

When the transmitter is activated by momentary push of RKE funtion button, it transmits ASK encoded (repeated) words for about 0.5 seconds. When a button is kept depressed, it transmits repeated words for up to 30 seconds. At the start the words are wider (worst case senario), then reduce to narrower words. Manchester format coding is used: ones and zeros are encoded as low-high, high-low transitions. The ON/(ON+OFF) ratio is 0.5215. Fig. 6.1. The word is 46.875 ms long, and the period of repetition is 100 ms. Duty factor is thus

$$K_E = 46.875ms \times (54.45\mu s/104.4\mu s)/100ms = 0.244 \text{ or } -12.2 \text{ dB}.$$

6.2 Emission Spectrum

Using the ridge-horn antenna and DUT placed in its aperture, 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. The allowed (-20 dB) bandwidth is 0.25% of 315 MHz, or 787.25 KHz. From the plot we see that the -20 dB bandwidth is 145.0 kHz, and the center frequency is 315.00 MHz.

6.4 Effect of Supply Voltage Variation

The DUT has been designed to be powered by 3 VDC battery. For this test, the battery was replaced by a laboratory variable power supply. Relative power radiated was measured at the fundamental as the voltage was varied from 2.5 to 4.0 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage at Battery Terminals

Batteries:	before testing	V_{oc}	=	3.28 V
	after testing	V_{oc}	=	2.85 V
Ave. current from batteries		I	=	3.8 mA (pulsed)

6.6 Verification for Deactivation Within 5 Seconds

When a button is kept depressed, the DUT transmits up to about 30 seconds. When the button is released, the transmission essentially ceases at that time. We observed 0.5 sec. transmission for short button press. Figure 6.5 shows emission when the DUT is activated by LF, producing about 50 ms emission. In all cases, the deactivation is less than five seconds.

Table 5.1 Highest Emissions Measured

Radiated Emission - RF											Siemens 295 Tx RKE; PV-99; 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	315.0	Dip	H	-19.7	Pk	18.9	19.3	74.6	75.6	1.0	flat Five-button
2	315.0	Dip	V	-22.6	Pk	18.9	19.3	71.7	75.6	3.9	end
3	630.0	Dip	H	-70.1	Pk	25.2	16.0	33.9	55.6	21.7	flat
4	630.0	Dip	V	-70.8	Pk	25.2	16.0	33.2	55.6	22.4	side
5	945.0	Dip	H	-69.3	Pk	28.9	13.6	40.8	55.6	14.8	falt
6	945.0	Dip	V	-70.6	Pk	28.9	13.6	39.5	55.6	16.1	side
7	1260.0	Horn	H	-57.2	Pk	20.4	28.1	29.9	55.6	25.7	flat
8	1575.0	Horn	H	-50.9	Pk	21.4	28.2	37.1	54.0	16.9	side
9	1890.0	Horn	H	-59.3	Pk	22.1	28.1	29.5	55.6	26.1	side
10	2205.0	Horn	H	-55.7	Pk	22.9	27.0	35.0	54.0	19.0	flat
11	2520.0	Horn	H	-54.8	Pk	24.0	26.6	37.4	55.6	18.2	flat
12	2835.0	Horn	H	-53.9	Pk	24.9	25.4	40.4	54.0	13.6	flat
13	3150.0	Horn	H	-53.7	Pk	25.2	24.8	41.5	55.6	14.1	flat
14											
15	Other plastic cases:										
16	315.0	Dip	H	-19.6	Pk	18.9	19.3	74.7	75.6	0.9	flat Four-button
17	315.0	Dip	H	-19.5	Pk	18.9	19.3	74.8	75.6	**0.8**	flat Three-button
18											
19											
20		* Includes 12.23 dB duty factor									
21											

Digital Emissions											
#	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											
2											
3			Digital emissions are more than 20 dB below FCC Class B limit								
4											

Conducted Emissions							
#	Freq. MHz	Line Side	Det. Used	Vtest dBµV	Vlim dBµV	Pass dB	Comments
1							
2			Not applicable				
3							
4							

Meas. 9/30,11/10/03; U of Mich.

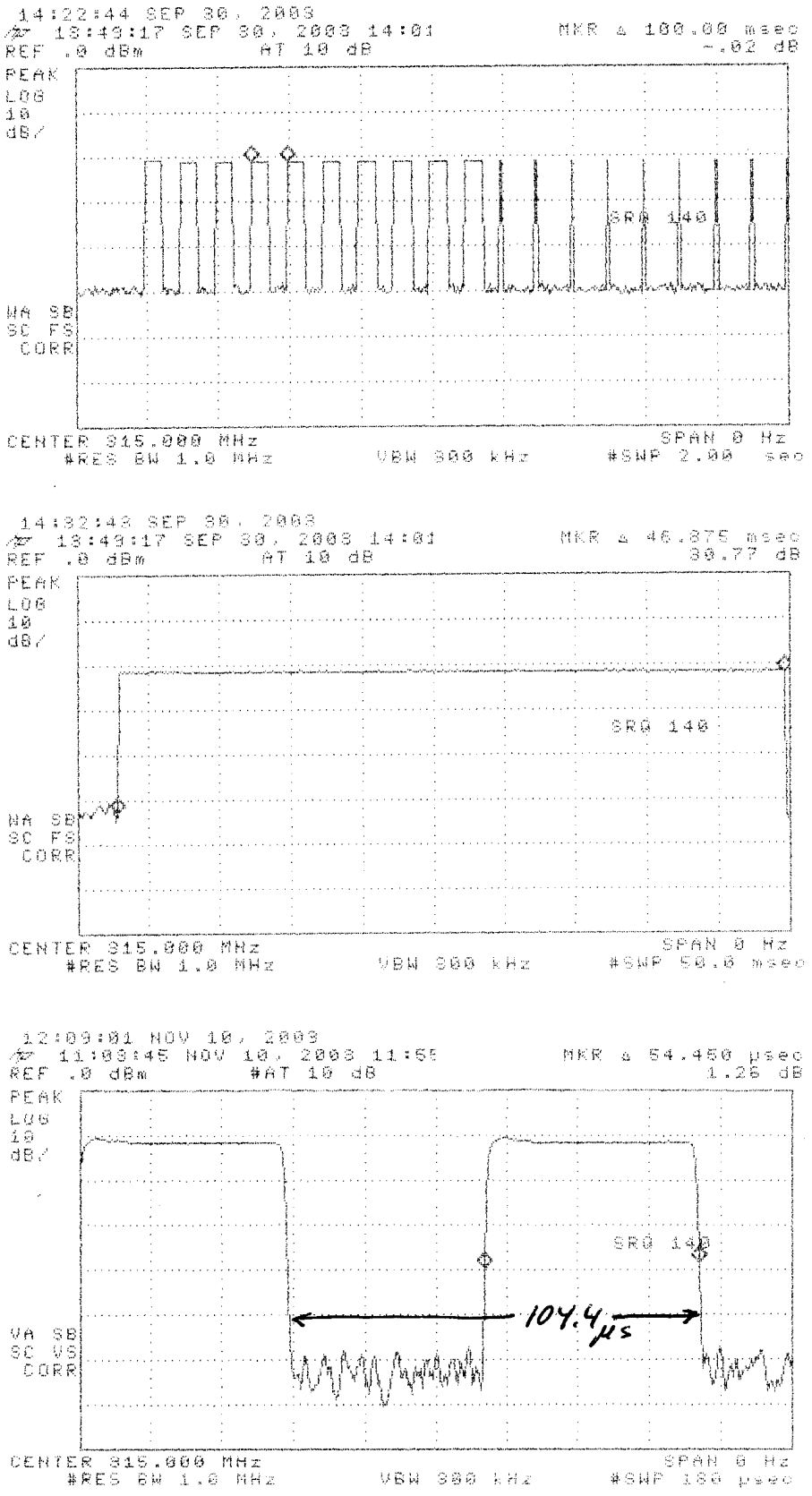

Figure 6.1. Transmissions modulation characteristics: (top) complete transmission, (center) expanded word, (bottom) expanded bits.

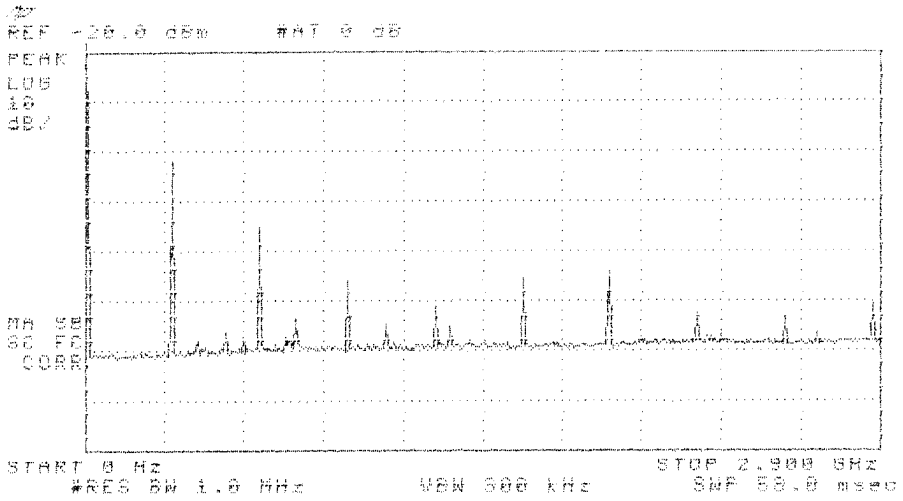

Figure 6.2. Emission spectrum of the DUT (pulsed emission).
The amplitudes are only indicative (not calibrated).

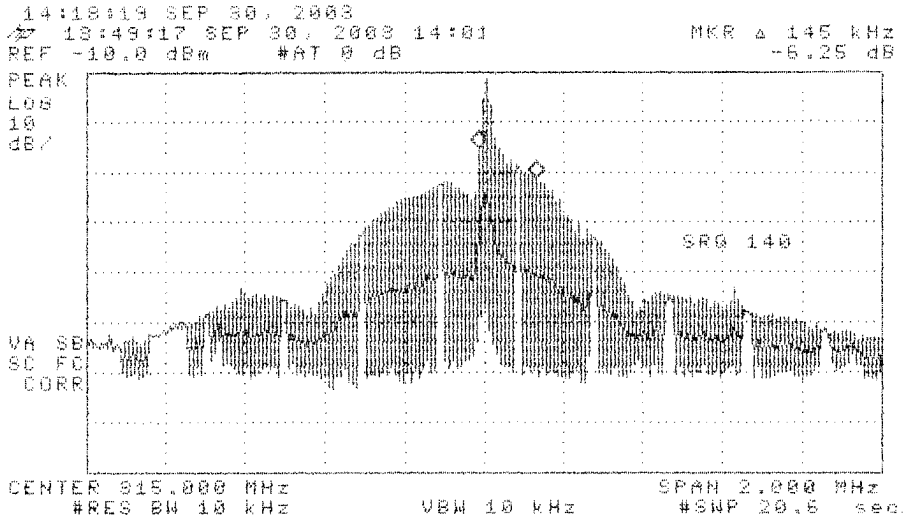

Figure 6.3. Measured bandwidth of the DUT (pulsed emission).

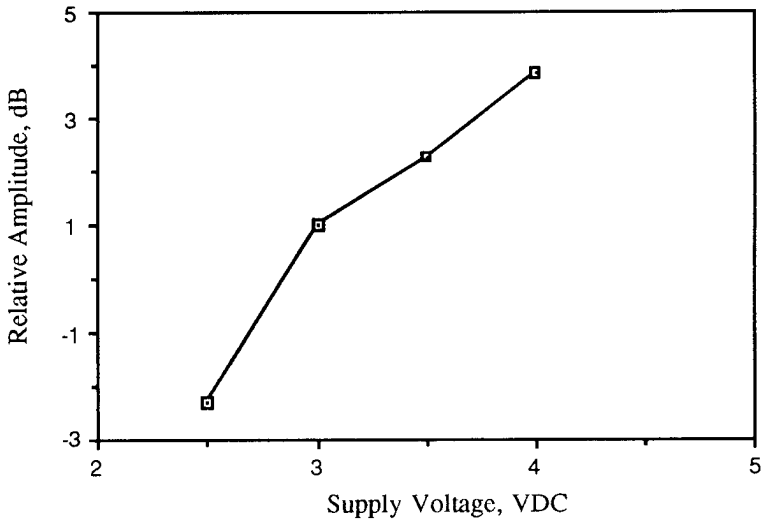

Figure 6.4. Relative emission at 315.0 MHz vs. supply voltage (pused emission).

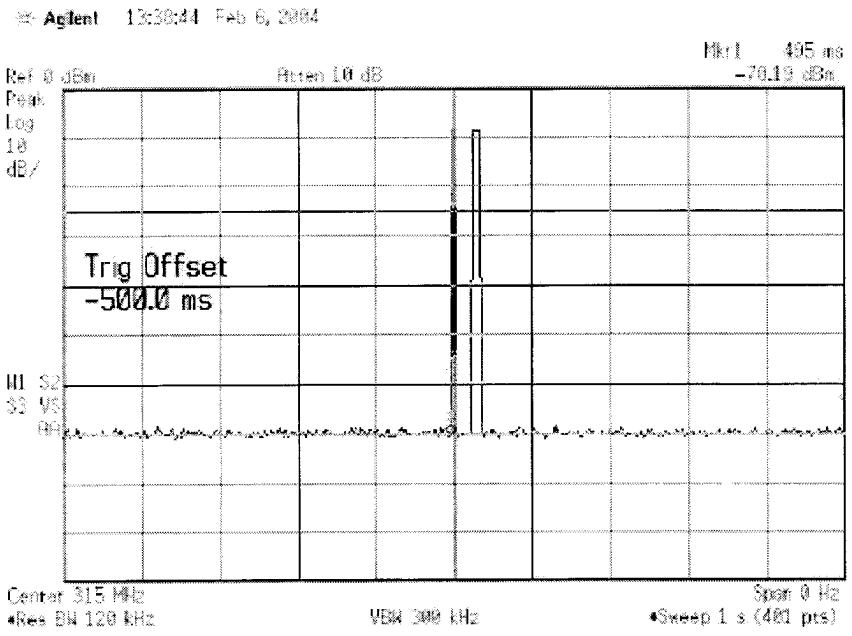

Figure 6.5. Emission for LF (remote) activation.


DUT on OATS (RKE Mode)

DUT on OATS close-up (RKE Mode)