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Measured Radio Frequency Emissions From

Code Alarm Transmitter Models M-49 and M-51

Report No. 415031-962
September 2, 1998

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Summary

Tests for compliance with FCC Regulations subject to Part 15, Subparts B and C, were performed on Code Alarm RKE Transmitter. There are two models; the difference being in the existance of a SMT 220Ω resistor and LED. This device is subject to the Rules and Regulations as a transmitter and as a digital device.

In testing performed on August 11, 1998, the devices tested in the worst case met the allowed specifications for radiated emissions by 11.0 dB at the fundamental and by 3.6 dB at the harmonics (see p. 6). Besides harmonics, there were no other significant spurious emissions found; emissions from digital circuitry were also negligible. The conductive emission tests do not apply, since the device is powered by a 12 VDC battery.

1. Introduction

Code Alarm RKE transmitters, Models M-49 and M-51, were 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	Equipment Used	Manufacturer/Model	Cal. Date/By
Spectrum Analyzer (9kHz-22GHz)		Hewlett-Packard 8593A SN: 3107A01358	June 1998/HP
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E SN: 3107A01131	July 1998/HP
Spectrum Analyzer (0.1-1500 MHz)	X	Hewlett-Packard 182T/8558B SN: 1529A01114/543592	August 1997/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 1988/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)	X	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 paper match box size four-button low power transmitter, with rolling code. There are two versions, differing only the existance of a SMT 220Ω resistor and LED. It is designed to send control commands and identification to a matching receiver. It is activated by depressing any of the four buttons, transmitting as long as the button is depressed, up to ten seconds. The waveform is a pulse-position code, amplitude modulating a 314.2 MHz carrier that is generated by a SAW stabilized oscillator. The coding is performed by a microprocessor plus an E-prom for rolling code, timed by a 3.2 MHz RC stabilized oscillator.

The DUT was designed and manufactured by Code Alarm Engineering, Inc., 950 East Whitcomb, Madison Heights, Michigan 48071. It is identified as:

Code Alarm Transmitter
Model: M-51; four-button w/ LED
Model: M-49; four button w/o LED (and 220Ω resistor)
FCC ID: GOH-4BL98
CANADA: to be provided by IC

3.1 EMI Relevent Modifications

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

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 15.231; and Subpart B, Section 15.109 (transmitter genereated 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, the DUT is considered as a Class B device.

Table 4.1. Radiated Emission Limits [Ref: 15.231(b), 15.205(a)] --Transmitter.

Frequency	Fundamental Ave. E_{lim} (3m)		Spurious** Ave. E_{lim} (3m)	
(MHz)	(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

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 by an internal 12 VDC 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 modified for continuous emissions was used. It was placed in a styrofoam block to faciliate its orientation on any of its three major axis, i. e., flat down, 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 characterisics of the carrier. These data are presented in subsequent sections. We also note that in scanning from 30 MHz to 3142 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 314.2, 628.4, and 942.6 MHz using tuned dipoles and/or the high frequency bicone.

Figure 5.1 shows the DUT placed flat on the open-site table. This is the placement and the orientation of the DUT with respect to the antenna for the worst case emission at fundamental.

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 3 m
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 3.6 dB.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

When the transmitter is activated by depressing a button, it transmits PPM coded (repeated) words for as long as button is depressed, up to 10.0 seconds. Transmission stops immediately when button is released. The word length about 17 ms, repeating every 98.9 ms. The "worst case" occurs when the whole word falls within a 98.9 ms window (period).

For the rolling code operation, a word consists of one 885 μs wide pulse , followed by 33 228.8 μs (pulse-positioned) pulses. These pulses encode data by "low-high" and "high-low" transitions. When "low-high" transition is followed by "high-low" transition, a double width pulse appears. Such then is counted as two pulses in the computation. See Figure 6.1b. For this device, the duty factor is

$$K_E = (0.885 + 33 \times 0.2288 \text{ ms}) / 98.9 \text{ ms} = 0.0853 \text{ or } -21.4 \text{ dB. Use } -20.0 \text{ dB.}$$

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 314.2 MHz, or 786 kHz. From the plot we see that the -20 dB bandwidth is 60 kHz, and the center frequency is 314.25 MHz.

6.4 Effect of Supply Voltage Variation

The DUT has been designed to be powered by a 12 VDC alkaline battery. For this test, the battery was replaced by a laboratory variable power supply and relative radiated field was measured at the fundamental, as the voltage was varied from 4 to 14 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage at Battery Terminals

Battery:	before testing	V_{oc} =	12.55 V
	after testing	V_{oc} =	12.10 V
Ave. current from battery		I =	5.2 mA

Table 5.1 Highest Emissions Measured

	Radiated Emission - RF										Code-Alarm TX; 4-but. LED
#	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	314.2	Dip	H	-20.9	Pk	18.9	20.4	64.6	75.6	11.0	flat; 0202A-M-51 (with LED)
2	314.2	Dip	V	-23.4	Pk	18.9	20.4	62.1	75.6	13.6	side
3	628.4	Dip	H	-47.5	Pk	25.2	17.1	47.6	55.6	8.0	flat
4	628.4	Dip	V	-46.8	Pk	25.2	17.1	48.3	55.6	7.3	end
5	942.6	Dip	H	-60.6	Pk	28.9	14.7	40.6	55.6	15.0	flat
6	942.6	Dip	V	-60.6	Pk	28.9	14.7	40.6	55.6	15.0	end
7	1256.8	Horn	H	-36.3	Pk	20.4	28.1	43.0	55.6	12.6	flat
8	1571.0	Horn	H	-41.2	Pk	21.4	28.2	39.0	54.0	15.0	flat
9	1885.2	Horn	H	-33.9	Pk	22.1	28.1	47.1	55.6	8.5	flat
10	2199.4	Horn	H	-33.6	Pk	22.9	27.0	49.3	54.0	4.7	side
11	2513.6	Horn	H	-38.3	Pk	24.0	26.6	46.1	55.6	9.5	flat
12	2827.8	Horn	H	-34.5	Pk	24.9	25.4	52.0	55.6	**3.6**	side *worst case
13	3142.0	Horn	H	-52.5	Pk	25.2	24.8	34.9	55.6	20.7	end
14											
15	Other Model at the Worst Case (CW measurement)										
16	2827.8	Horn	H	-39.7	Pk	24.9	25.4	46.8	55.6	**8.8**	side; 0202A-M-49 (w/o LED)
17											
18			*includes -20.0 dB duty factor								
19											
20											

	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											
4			Digital emissions are more than 20 dB below FCC Class B limit								
5											

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

Meas. 8/11/98

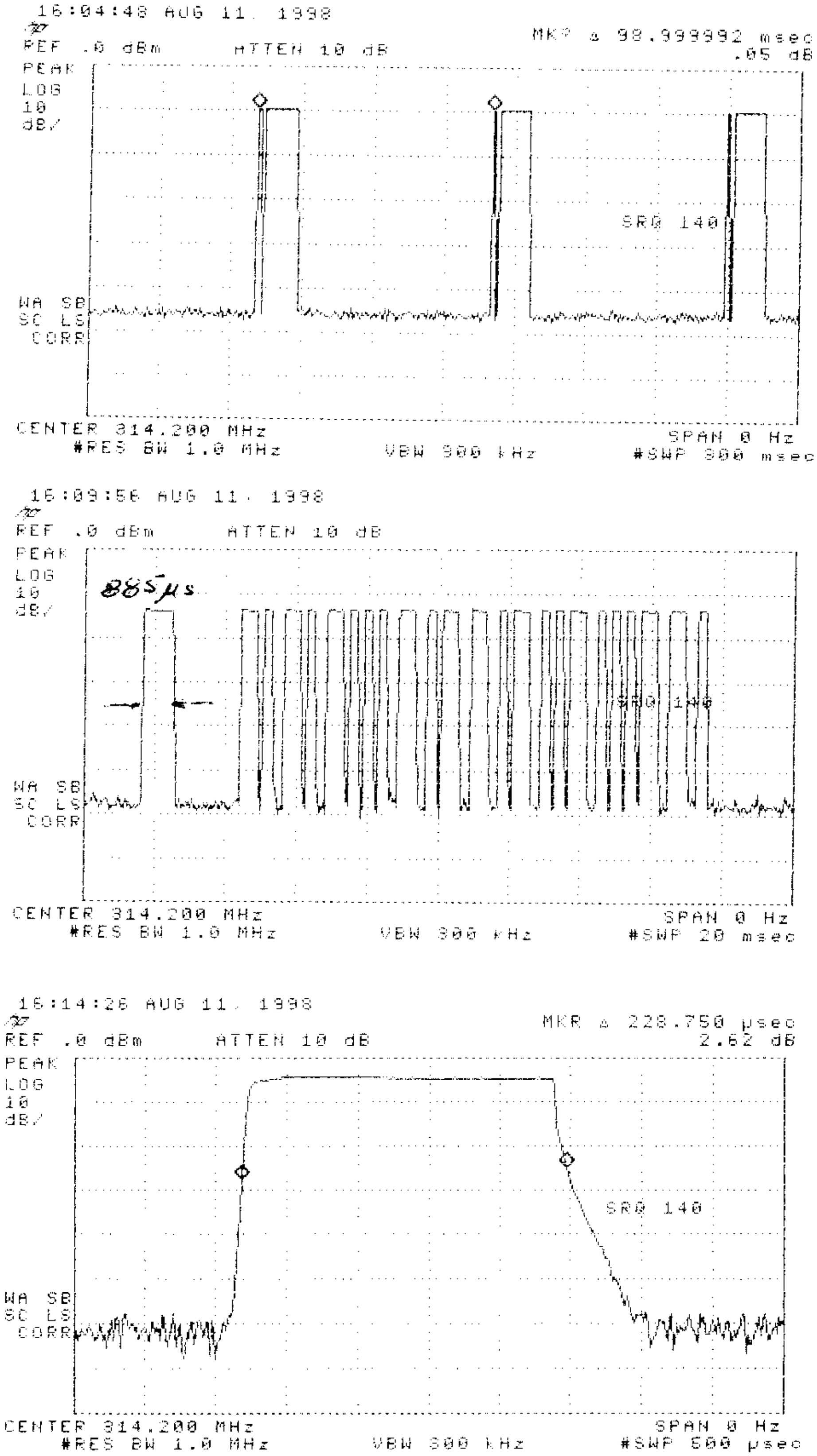

Figure 6.1 Transmissions modulation characteristics: (top) complete transmission, (center) expanded word, (bottom) expanded bits. (rolling code; M-51, M-49)

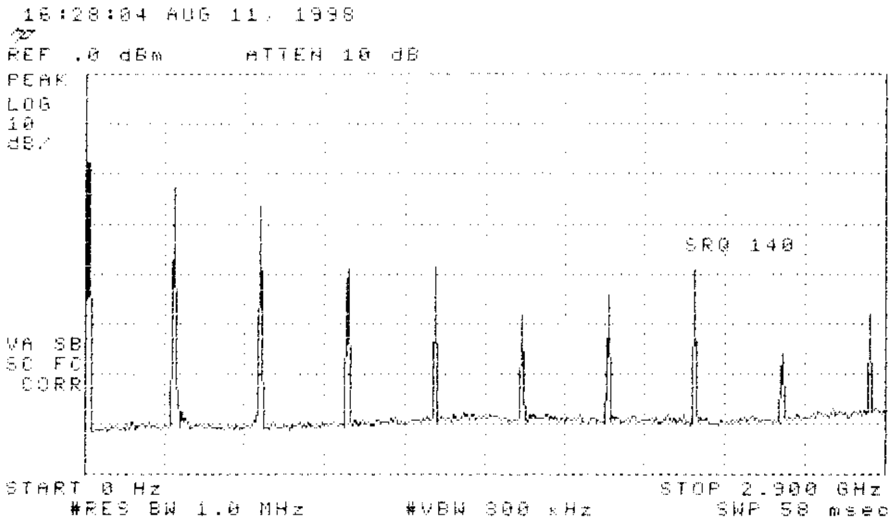

Figure 6.2. Emission spectrum of the DUT (repeated pulses).
The amplitudes are only indicative (not calibrated). (M-51)

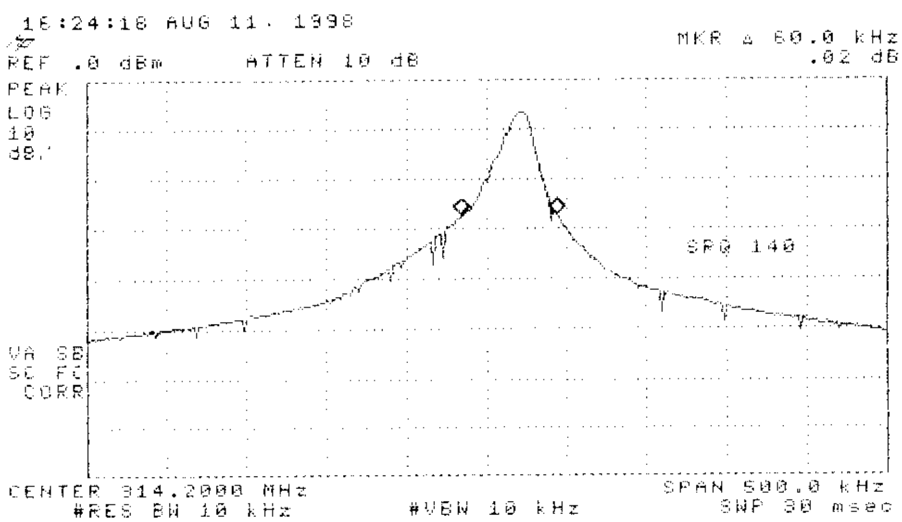

Figure 6.3. Measured bandwidth of the DUT (pulsed mode). (M-51)

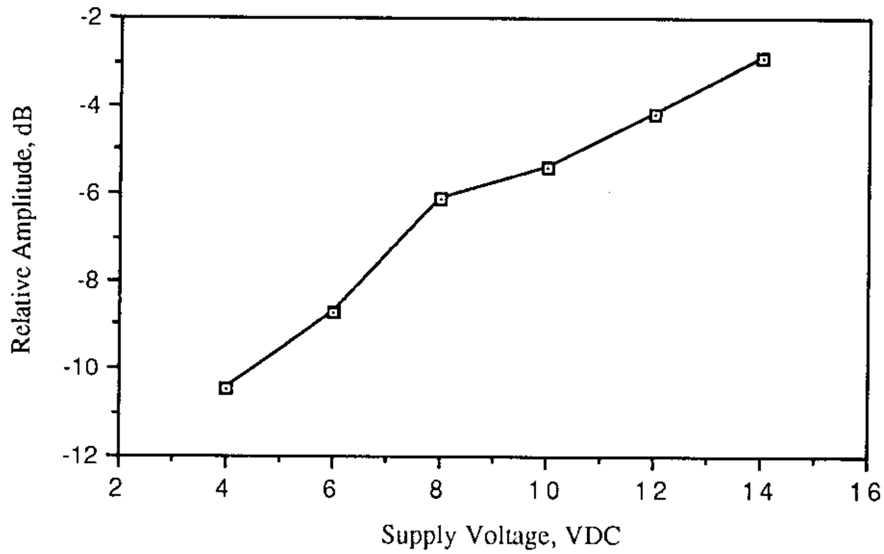

Figure 6.4. Relative emission at fundamental vs. supply voltage. (M-51)