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Measured Radio Frequency Emissions
From

Wayne Dalton / Martec Transmitter
Model: 3966

Report No. 415031-240
March 15, 2005

For:
Wayne Dalton
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Pensacola, Florida 32514

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Summary

Tests for compliance with FCC Regulations Part 15, Subpart C, and Industry Canada RSS-210, were performed on Wayne Dalton Corporation model 3966. This device is subject to the Rules and Regulations as a Transmitter.

In testing completed on March 15, 2005, the device tested in the worst case met the allowed FCC specifications for radiated emissions by 4.3 dB (see p. 6). Besides harmonics, there were no other significant spurious emissions found; emissions from digital circuitry were negligible. The conducted emission tests do not apply, since the device is powered from a 6 VDC battery (2 x 3 VDC).

1. Introduction

Wayne Dalton Corporation model 3966 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, 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 Millimeter 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 Box		University of Michigan
Signal Generator		Hewlett-Packard 8657B

3. Configuration and Identification of Device Under Test

The DUT is a 372.5 MHz transmitter, 2 x 4 x 1 inches in size. Its carrier is pulse width modulated and LC stabilized, antenna is internal.

The DUT was designed and manufactured by Wayne Dalton, 3395 Addison Drive, Pensacola, Florida 32514. It is identified as:

Wayne Dalton / Martec Transmitter
Model: 3966
FCC ID: KJ8KYE5-3720
IC: 3540A-KYE53270

The transmitter provided was modified in software for continuous repeating transmission to make testing more convenient. Note: The commercial DUT is manually activated and ceases to transmit within 5 seconds of deactivation as defined within the microprocessor software.

3.1 Modifications Made

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

4. 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.

4.1 Radiated Emission Limits

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	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

4.3 Conducted Emissions Limits

The conductive emission limits and tests do not apply here, since the DUT is powered by a 6 VDC battery.

5. Radiated Emission Tests and Results

5.1 Anechoic 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 Open Site Radiated Emission Tests

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 included in this filing show the DUT on the Open Area Test Site (OATS).

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 4.3 dB.

5.4 Conducted Emission Tests

These tests do not apply, since the DUT is powered from a 6 VDC battery.

6. Other Measurements

6.1 Correction For Pulse Operation

When the transmitter is activated by push action, it transmits PWM 372.5 MHz carrier. Each transmitted word is repeated every 112.5 ms. One word transmission consists of and initial 12, 220 us pulses followed by a dataset of 67 pulses, each with a maximum possible width of 430 us. See Figure 6.1. Thus, the duty factor is

$$K_E = (12 \times 0.220 \text{ ms} + 67 \times 0.430 \text{ ms}) / 100 \text{ ms} = 0.3145 \text{ or } -10.0 \text{ dB}.$$

6.2 Bandwidth of the Emission Spectrum

The measured spectrum of the signal is shown in Figure 6.2. The allowed (-20 dB) bandwidth is 0.25% of 372.5 MHz, or 931.25 kHz. From the plot we see that the -20 dB bandwidth is 108.0 kHz, and the center frequency is 372.5 MHz.

6.3 Effect of Supply Voltage Variation

The DUT has been designed to be powered by 6 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 4 to 7 volts. The emission variation is shown in Figure 6.3.

6.4 Input Voltage at Battery Terminals

Batteries:	before testing	V_{oc} =	6.6 V
	after testing	V_{oc} =	6.1 V
Ave. current from batteries		I =	13.0 mA (pulsed)

Table 5.1 Highest Emissions Measured

Radiated Emission - RF											Wayne Dalton, 5B TX, 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	372.6	Dip	H	-24.3	Pk	20.4	18.9	74.2	78.5	**4.3**	flat
2	372.6	Dip	V	-28.0	Pk	20.4	18.9	70.5	78.5	8.0	end
3	745.2	Dip	H	-60.6	Pk	26.7	16.8	46.3	58.5	12.2	flat
4	745.2	Dip	V	-68.8	Pk	26.7	16.8	38.1	58.5	20.4	side
5	1117.7	Horn	H	-51.7	Pk	20.1	28.0	37.4	54.0	16.6	flat
6	1490.3	Horn	H	-65.5	Pk	21.3	28.0	24.8	54.0	29.2	side
7	1862.9	Horn	H	-65.7	Pk	22.2	28.0	25.5	58.5	33.1	side
8	2235.5	Horn	H	-63.4	Pk	23.1	26.9	29.8	54.0	24.2	flat
9	2608.1	Horn	H	-60.6	Pk	24.1	26.1	34.4	58.5	24.1	flat
10	2980.6	Horn	H	-64.8	Pk	25.3	25.3	32.2	58.5	26.3	end
11	3353.2	Horn	H	-72.5	Pk	26.5	24.5	26.5	54.0	27.5	side
12	3725.8	Horn	H	-72.1	Pk	27.6	23.7	28.8	54.0	25.2	end
13											
14											
15											
16											
17											
18	* Includes -10.0 dB duty factor										
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. 3/15/2005; U of Mich.

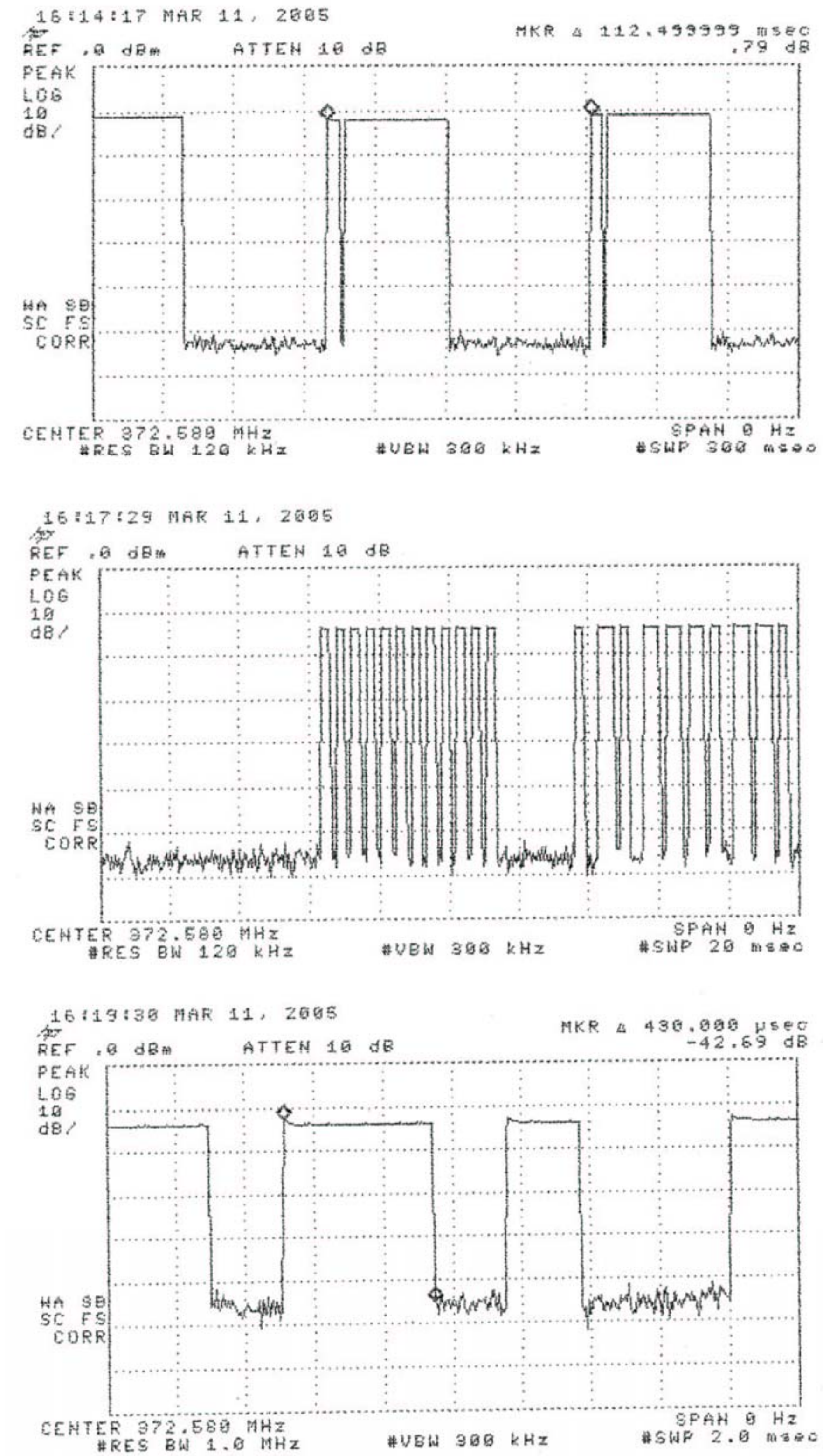

Figure 6.1. Transmissions modulation characteristics: (top) complete transmission, (center) preamble, (bottom) expanded PWM word.

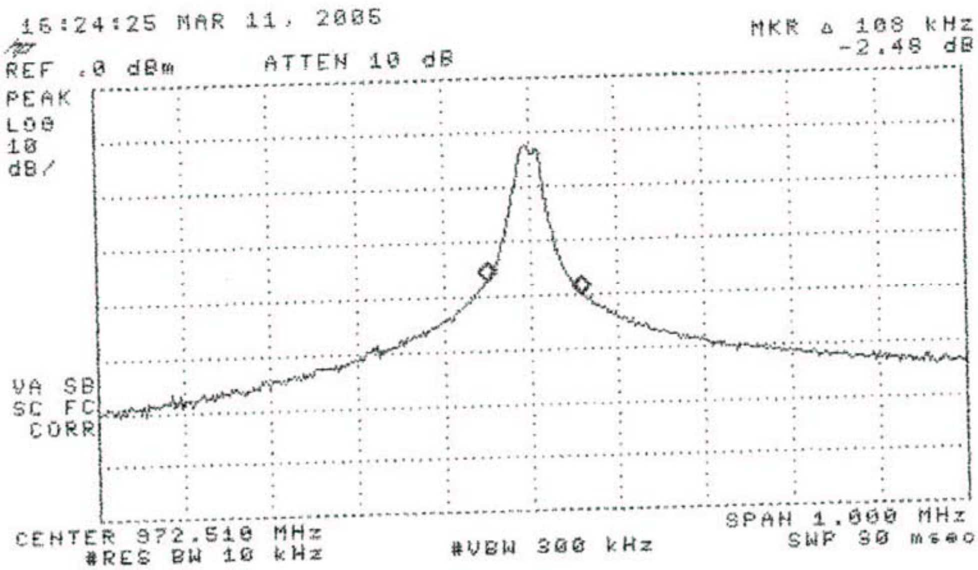

Figure 6.2. Measured bandwidth of the DUT (pulsed emission). "locked-in" mode.

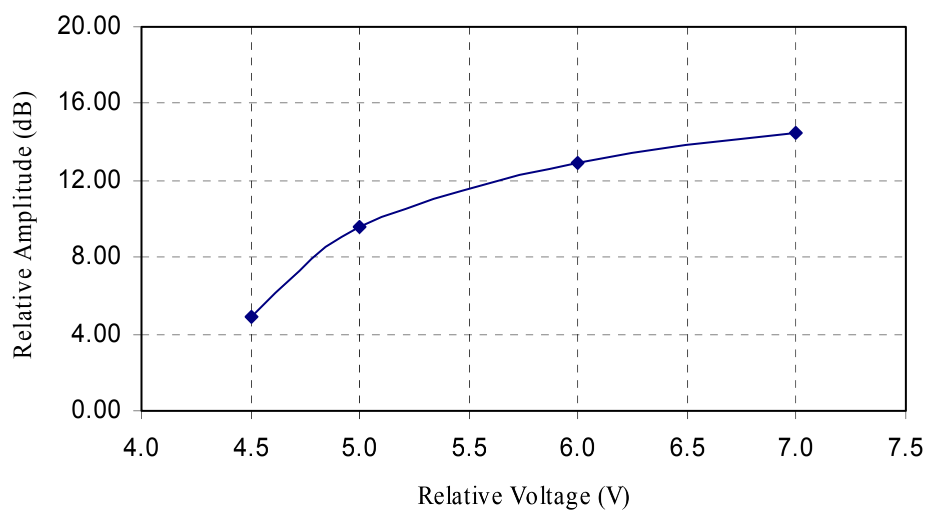

Figure 6.3. Relative emission at 315.0 MHz vs. supply voltage (pulsed emission).

DUT on OATS

DUT on OATS (close-up)