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Measured Radio Frequency Emissions
From

SPX Corporation Composite Device 315/433 MHz Receiver Test Report Model: TPM

Report No. 415031-279-C
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For:
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Summary

Tests for compliance with FCC Regulations Part 15, Subpart B, and Industry Canada RSS-210/GEN, were performed on SPX Corporation model TPM. 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 completed on February 11, 2006, the device tested in the worst case met the allowed Class B specifications for radiated emissions by 4.6 dB (see p. 6). The conducted emissions tests do not apply, since the device is powered from three 1.5 V dc batteries.

1. Introduction

SPX Corporation model TPM was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 6 and RSS-Gen, Issue 1, September, 2005. The tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-2003 "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	X	Hewlett-Packard 8657B

3. Configuration and Identification of Device Under Test

The DUT is a composite device consisting of a 315 MHz transmitter, a 433 MHz transmitter, a 125 kHz transmitter, a 315 MHz receiver, and a 433 MHz receiver. This report details the emissions relating to the 315 MHz and 433 MHz receiver portion of the device. The 315MHz superheterodyne receiver uses a 10.78 MHz reference, with LO at 325.7 MHz mixed down from 2xLO at 651.4 MHz on chip. The 433.92 MHz superheterodyne receiver uses a 13.225 MHz reference, with LO at 423.4 MHz mixed down from 2xLO at 846.7 MHz on chip. The antennas are integral, spiral traces on the PCB. The device is 4.5 x 10 x 2 inches in size.

The DUT was designed and manufactured by Nu-Di Corporation, 12730 Triskett Rd, Cleveland, OH 44111 on behalf of SPX Corporation, 8001 Angling Rd., Portage, MI 49024. It is identified as:

SPX Corporation Composite Device
Model: TPM
P/N(s): J-46079 (black), J-46915 (grey)
FCC ID: RP3-J46079
IC: 4811A-J46079

Note 1: One of each part number was provided for testing. Both parts have identical electronics, the only difference is in the color of the plastic housing.

3.1 Modifications Made

There were no modifications made to the DUT by this laboratory. However, during testing software revisions were made by SPX to bring the device into compliance with the FCC/IC rules and regulations.

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.

4.1 Radiated Emission Limits

Table 4.1. Radiated Emission Limits (Ref: FCC 15.33, 15.35, and 15.109; IC RSS-210, 2.6 Table 2).

Freq. (MHz)	E_{lim} (3m) μV/m	E_{lim} (3m) dB(μV/m)
30-88	100	40.0
88-216	150 μV/m	43.5
216-960	200 μV/m	46.0
960-2000	500 μV/m	54.0

Note: Quasi-Peak readings apply to 1000 MHz (120 kHz BW)
Average readings apply above 1000 MHz (1 MHz BW)

4.2 Power Line Conducted Emission Limits

Table 4.3 Conducted Emission Limits (FCC:15.107 (CISPR); IC: RSS-Gen, 7.2.2 Table 2).

Frequency MHz	Class A (dBμV)		Class B (dBμV)	
	Quasi-peak	Average	Quasi-peak	Average
.150 - 0.50	79	66	66 - 56*	56 - 46*
0.50 – 5.0	73	60	56	46
5.0 – 30.0	73	60	60	50

Notes:
1. The lower limit shall apply at the transition frequency
2. The limit decreases linearly with the logarithm of the frequency in the range 0.15-0.50 MHz:

*Class B Quasi-peak: dBμV = 50.25 - 19.12*log(f)

*Class B Average: dBμV = 40.25 - 19.12*log(f)

3. 9 kHz RBW

4.3 Antenna Power Conduction Limits
Ref: FCC 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 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 re-measured 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 4.5 V dc. A MHz CW signal was injected (radiated) from a nearby signal generator using a short wire antenna. The DUT was taped to a Styrofoam 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 (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 (Fig. 5.1) are used for initial evaluation only, while those above 1000 MHz (Fig. 5.2) are used in final assessment for compliance.

5.2 Open Area Test Site Radiated Emission Tests

The DUT was then moved to the 3 meter Open Area 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 exercised 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). Sometimes lower IF bandwidth is used to help bring signals out of noise and this is noted in the data table. Photographs included in this filing show the DUT on the Open Area Test Site (OATS).

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 4.6 dB.

5.4 Conducted Emission Tests

These tests do not apply, since the DUT is powered from three 1.5 V dc batteries.

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 4.5 V dc power. Using a spectrum analyzer, relative radiated emissions were recorded at the LO (or 2xLO) as voltage was varied from 3.75 to 5.25 volts. Figure 6.2 shows the emission variation.

6.3 Operating Voltage and Current

V = 4.5 V dc
I = 42 mA dc

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Table 5.1 Highest Emissions Measured

Radiated Emission - RF SPX TPM Tool; 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	325.7	Sbic	H	-79.4	Pk	19.2	18.2	28.6	46.0	17.4	max. of all, noise
2	325.7	Sbic	V	-79.1	Pk	19.2	18.2	28.9	46.0	17.1	max. of all, noise
3	651.4	Sbic	H	-83.7	Pk	25.5	15.1	33.7	46.0	12.3	max. of all, noise
4	651.4	Sbic	V	-77.5	Pk	25.5	15.1	39.9	46.0	6.1	background
5	977.1	Sbic	H	-86.8	Pk	29.2	13.2	36.2	54.0	17.8	max. of all, noise
6	977.1	Sbic	V	-87.2	Pk	29.2	13.2	35.8	54.0	18.2	max. of all, noise
7	1000.0	Horn	H	-63.0	Pk	20.6	28.0	36.6	54.0	17.4	max. of all, noise
8	1100.0	Horn	H	-64.0	Pk	21.0	28.1	35.9	54.0	18.1	max. of all, noise
9	1200.0	Horn	H	-62.9	Pk	21.3	28.3	37.1	54.0	16.9	max. of all, noise
10	1300.0	Horn	H	-63.1	Pk	21.4	28.2	37.1	54.0	16.9	max. of all, noise
11	1400.0	Horn	H	-64.2	Pk	21.8	27.9	36.7	54.0	17.3	max. of all, noise
12	1500.0	Horn	H	-63.8	Pk	22.2	28.2	37.2	54.0	16.8	max. of all, noise
13	1600.0	Horn	H	-62.9	Pk	22.4	28.0	38.5	54.0	15.5	max. of all, noise
14											
15											
16											
17	423.3	Sbic	H	-81.4	Pk	21.6	17.2	30.0	46.0	16.0	max. of all, noise
18	423.3	Sbic	V	-79.9	Pk	21.6	17.2	31.5	46.0	14.5	max. of all, noise
19	846.6	Sbic	H	-79.6	Pk	27.9	13.9	41.4	46.0	**4.6**	background
20	846.6	Sbic	V	-86.6	Pk	27.9	13.9	34.4	46.0	11.6	max. of all, noise
21	1269.9	Horn	H	-63.1	Pk	20.6	28.0	36.5	54.0	17.5	max. of all, noise
22	1269.9	Horn	H	-63.5	Pk	20.6	28.0	36.1	54.0	17.9	max. of all, noise
23	1300.0	Horn	H	-62.1	Pk	20.6	28.2	37.3	54.0	16.7	max. of all, noise
24	1400.0	Horn	H	-63.1	Pk	21.0	27.9	37.0	54.0	17.0	max. of all, noise
25	1500.0	Horn	H	-63.6	Pk	21.3	28.2	36.5	54.0	17.5	max. of all, noise
26	1600.0	Horn	H	-63.8	Pk	21.4	28.0	36.6	54.0	17.4	max. of all, noise
27	1700.0	Horn	H	-62.8	Pk	21.8	28.1	37.9	54.0	16.1	max. of all, noise
28	1800.0	Horn	H	-69.3	Pk	22.2	28.0	31.9	54.0	22.1	max. of all, noise
29	1900.0	Horn	H	-68.9	Pk	22.4	27.9	32.6	54.0	21.4	max. of all, noise
30											
31											
32											
33											

Conducted Emissions

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

Meas. 02/08/2006; U of Mich.

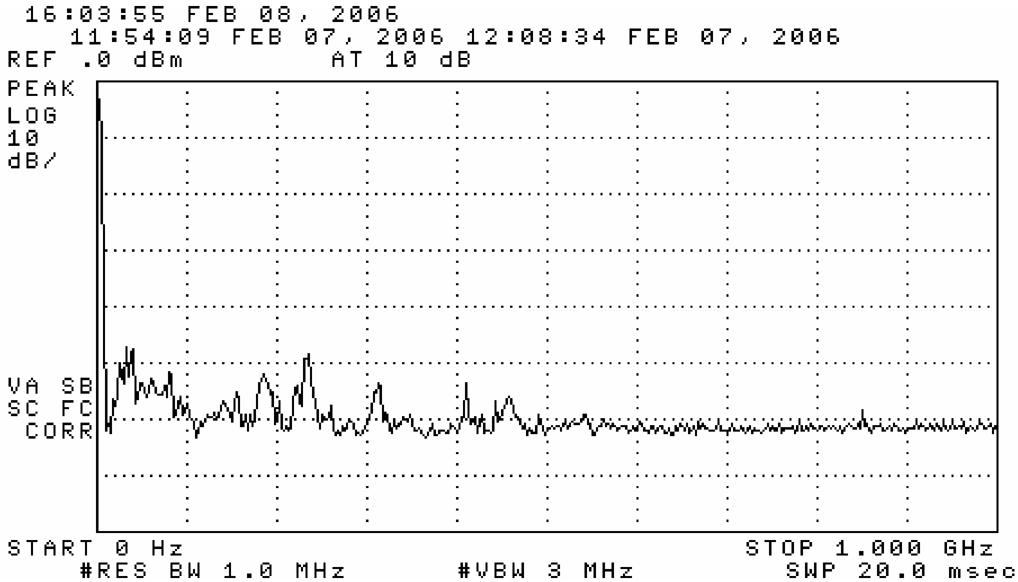


Figure 5.1. Emissions measured at 3 meters in chamber, 0-1000 MHz.

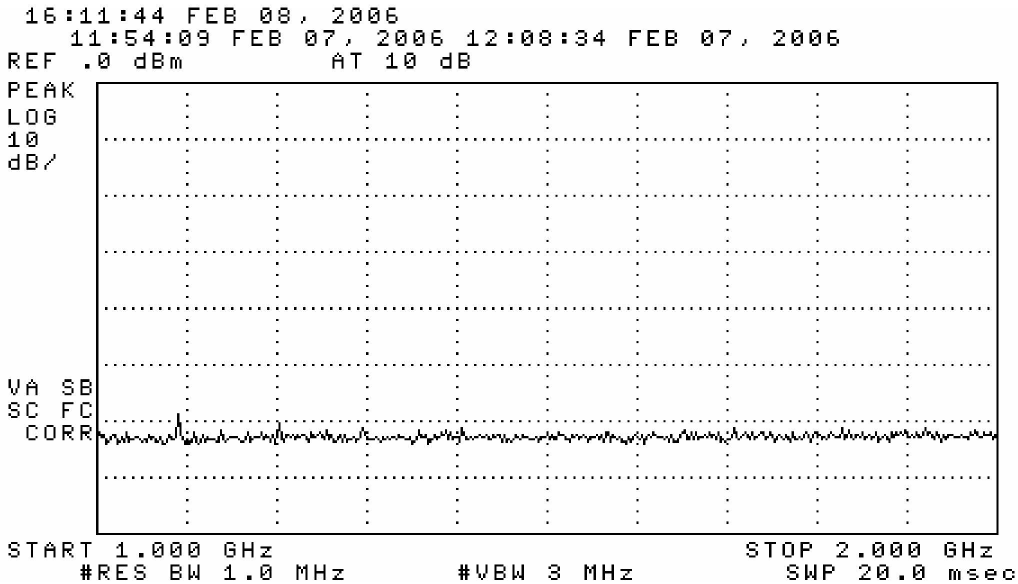
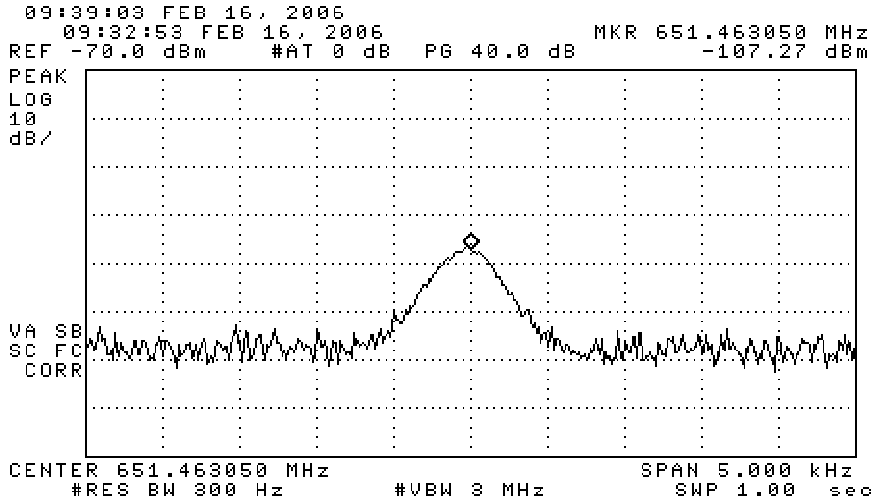


Figure 5.2. Emissions measured at 3 meters in chamber, 1000-2000 MHz.



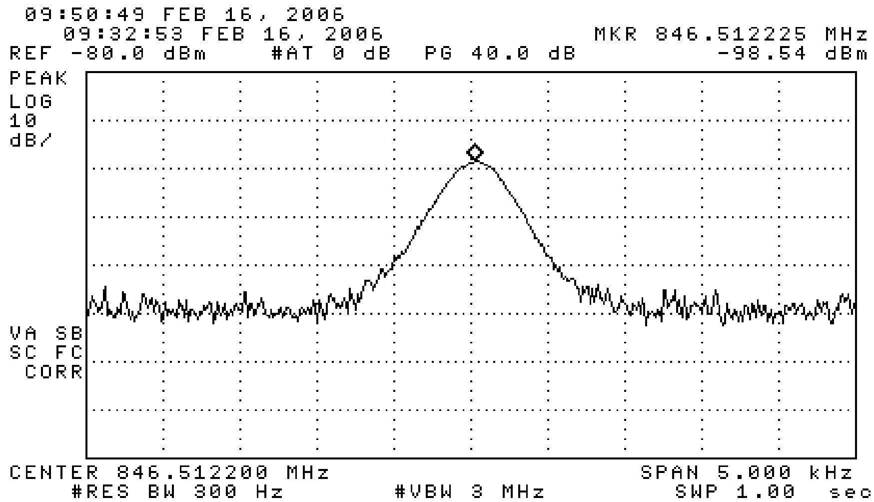


Figure 6.1. Relative receiver emissions.

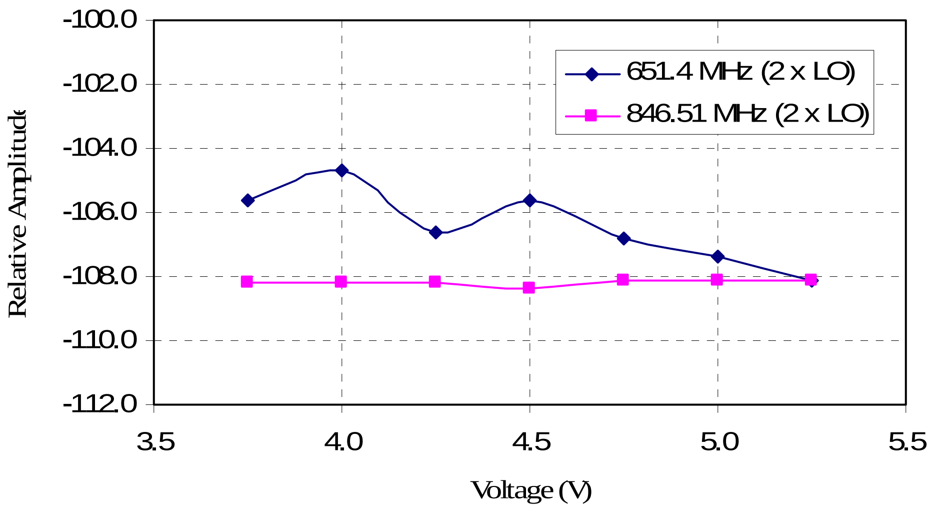


Figure 6.2. Relative emission at vs. supply voltage.

DUT on OATS

DUT on OATS (close-up)