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Technical Report No. 07-051

For FCC FRN: 0016495871

"EMI Evaluation of the Home Automation Inc.'s Z-Wave Thermostat to FCC Part 15, Class B, Conducted and Radiated Emission Requirements."

Performed: 24 April 2007

Customer: Boca Devices, LLC
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1. **INTRODUCTION**

A Home Automation, Inc.'s (HAI) Z-Wave Thermostat was evaluated for compliance to the FCC CFR-47, Part 15, Class B requirements as well as for operation in the frequency range of 902 to 928 MHz. The HAI Z-Wave Thermostat is device that allows remote control of thermostat settings. The device is able to listen to remote control commands and to send information about the thermostat status. For this evaluation, the device was programmed to transmit a frequency shift keying (FSK) modulated signal centered at 908.4 MHz. The results apply only to the specific items of equipment, configurations and procedures supplied to the Florida Atlantic University EMI R&D Laboratory as reported in this document.

2. OBJECTIVE

This evaluation was performed to verify conformance of the Home Automation, Inc.'s Z-Wave Thermostat to the U.S. Federal Communications Commission (FCC), Code of Federal Regulations (CFR), Title 47 - Telecommunication, FCC Part 15 Subpart B- Unintentional Radiators, Sections 15.107(b) and 15.109 (b), FCC Class B conducted and radiated emission requirements, and Subpart C- Intentional Radiators, Section 15.249 (a), Operation within the bands 902-928 MHz.

3. CONCLUSION

The Home Automation, Inc. Z-Wave Thermostat met the FCC, Part 15, Class B conducted and radiated emission requirements, as well as the requirements for operation within the band of 902-928 MHz, as described in the following pages.

4. TEST PROCEDURES AND RESULTS

4.1 TEST PROCEDURES

The measurement techniques identified in the measurement procedure of ANSI C63.4-2003 *"American National Standard of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"* were followed as close as practical during this evaluation. Complete details and specific procedures used are discussed in the respective test result sections.

4.2 CONDUCTED EMISSIONS TEST RESULTS

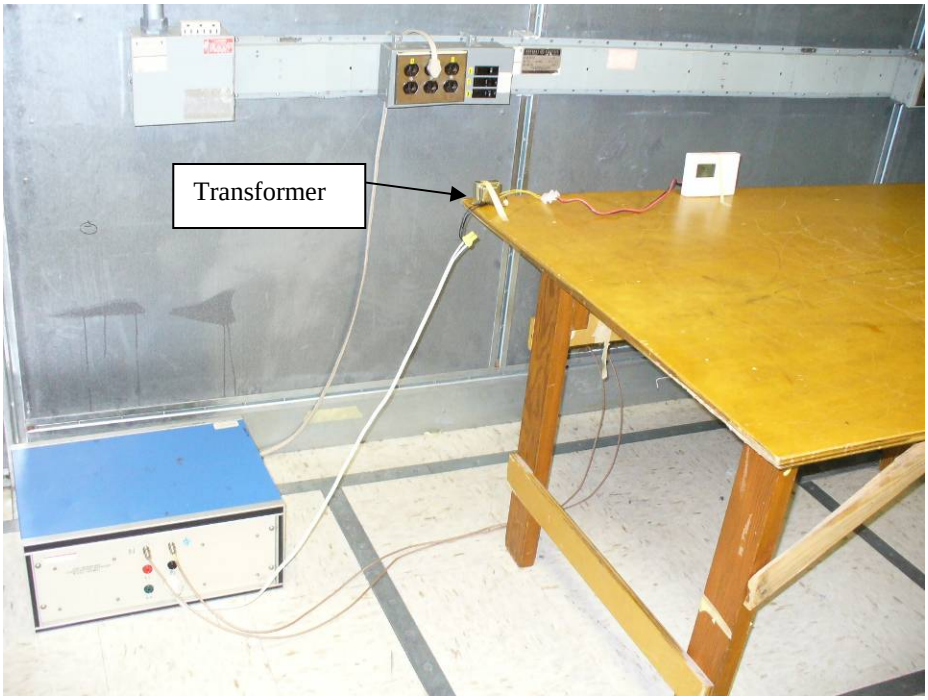
4.2.1 CONDUCTED POWERLINE EMISSIONS

The Home Automation, Inc.'s Z-Wave Thermostat was evaluated for conducted emission requirements. The unit was powered through an AC transformer. For the evaluation, the unit was set to transmit periodically an FSK modulated signal centered at 908.4 MHz at a rate of 9600 bits per second. The data was transmitted and received correctly as confirmed by the Boca Devices Engineer. Photographs 1 and 2 show the setup used during the evaluations.

The system was installed in the FAU EMI Research facilities conducted emissions shielded enclosure, on a wooden test table 80 centimeters above the ground plane floor and 40 centimeters from the rear wall. The transformer was then plugged into a Line Impedance Stabilization Network (LISN) EMCO Model No.3825/2R Serial No. 1095.

Conducted power line emissions were measured on both the phase and neutral lines with reference to earth ground, over the specified 150 kHz to 30 MHz range on a Hewlett Packard HP 8566B Spectrum Analyzer operated in the peak detection mode, in conjunction with HP 85685A Preselector, with a bandwidth of 9 kHz obtained through the HP 85650A Quasi Peak Adapter.

Figure 1 shows the conducted emissions on both the phase and neutral lines measured in the receiver peak detection mode. It can be seen that on both the phase and neutral lines, the emissions did not exceed the limits. Hence, the system is in compliance.



Photographs 1 & 2: Conducted Emission Setup

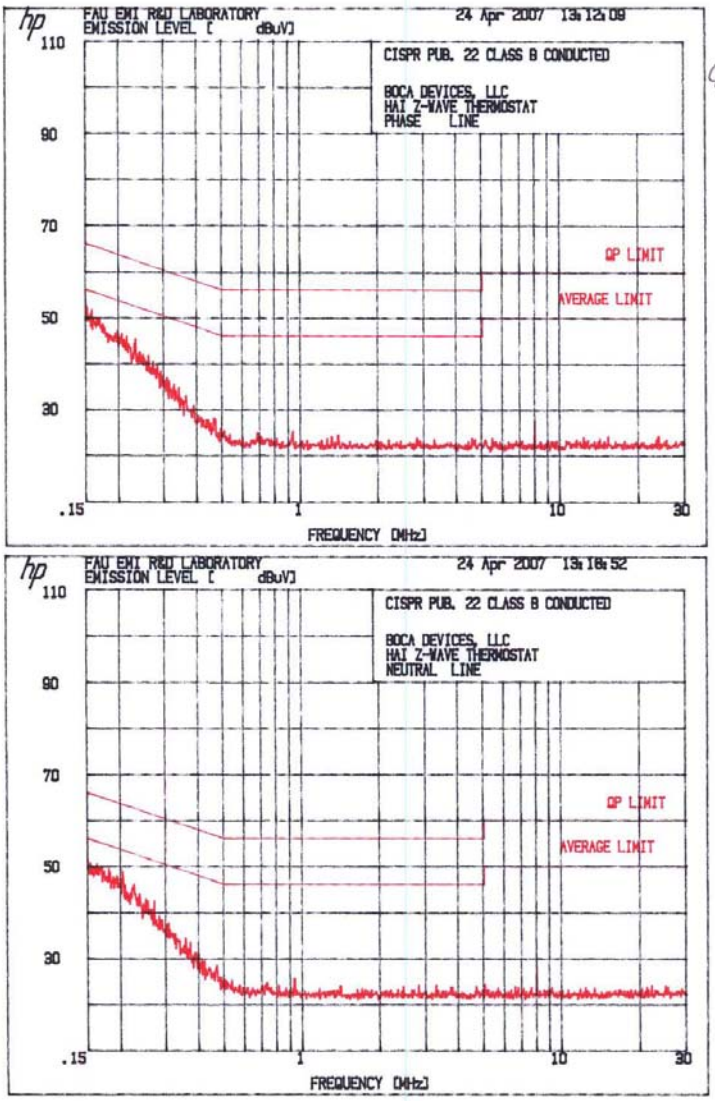


Figure 1: Phase and Neutral Conducted Emissions

From the above Figure, the emissions that exceeded or were within 5 dB of the limit are reported in Table 1.

Line Tested	Frequency (kHz)	Peak Value (dBµV)	QP Value (dBµV)	Average Value (dBµV)	Avg. Limit (dBµV)	Margin to Avg. Limit (dB)*
Phase	150	52.8			56.00	3.20
Neutral	150	51.7			56.00	4.30
Phase	208	45.3			54.96	9.66
Neutral	208	49.1			54.96	5.86

Table 1: Conducted Emission Peak Measurements

*****Margin to Avg. Limit (dB) = Avg. Limit (dBµV) – the measured value (either Peak, Quasi-Peak or Average Value) in dBµV

4.3 RADIATED EMISSIONS TEST RESULTS

The Boca Devices, HAI Z-Wave Thermostat was powered an AC transformer. The device was set to transmit periodically an FSK modulated signal centered at 908.4 MHz at a rate of 9600 bits per second. The thermostat was then set up on a wooden table 80 centimeters above the ground plane turntable of the Semi-Anechoic test site, as shown in Photographs 3 & 4. For this test the power used was 110V/ 60 Hz. The data was transmitted and received correctly as confirmed by the Boca Devices' Engineer.

An EMCO, Model 3104, S/N 299988A, the Broadband Biconical antenna was installed on an EMCO pneumatically controlled antenna mast at a distance of 3 meters from the system. The 30 MHz to 200 MHz frequency range was automatically scanned on the HP 8566B Spectrum analyzer (SA) that was operated in the peak detector mode with a bandwidth of 120 kHz obtained through the HP 85650A Quasi Peak Adapter. It should be noted that the RES BW and VBW of the spectrum analyzer must be set to 1 MHz for the Quasi Peak Adaptor to provide a 120 kHz bandwidth correctly. Hence, in the figures, RES BW and VBW are still indicated as 1 MHz.

After setting the SA to operate between 30-200 MHz, the max hold switch on the SA was pressed. The Biconical antenna was set to horizontal polarization at 1-m above the floor. The turntable was then rotated 360 degrees. After a full revolution, the turntable was rotated back to the previously noted azimuth angles where the higher E-fields occurred, and the antenna was then scanned from 1 to 4 meters high at those angles in order to determine the height that will provide to highest amplitude. The antenna was moved back to the location where the highest amplitude was observed and the turn table was rotated again 360º. The maximum value was plotted and presented herein. The antenna was then rotated to measure the vertical polarized E-field and the above procedure was repeated.

For the 200-1000 MHz band, a Log Periodic antenna (EMCO 3146) was installed and the SA was set to operate between 200-1000 MHz. To collect data, the above procedure was then repeated.

Figures 2-5 show the worse case radiated emissions of both configurations, for this evaluation, independent of azimuth or antenna height. The E-field is calculated using antenna factor, cable loss, and amplifier gain based on the following equation:

E (dBμV/m) = SA reading (dBμV) + Antenna Factor (dB/m) + Cable Loss (dB) - Amplifier Gain (dB)

Photographs 3 & 4: Radiated Emission Setup

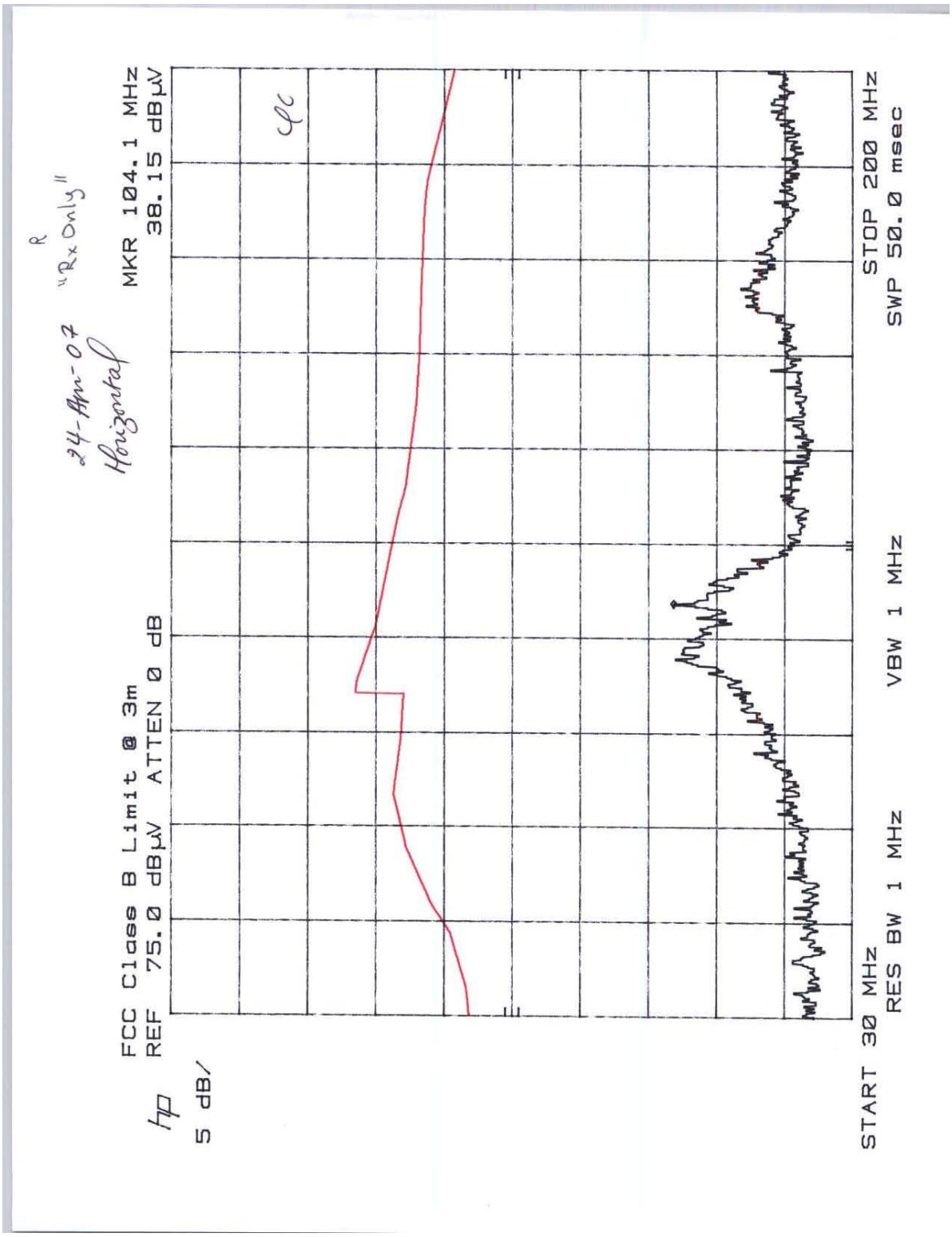


FIGURE 2: Radiated Emission 30 – 200 MHz Horizontal Polarization

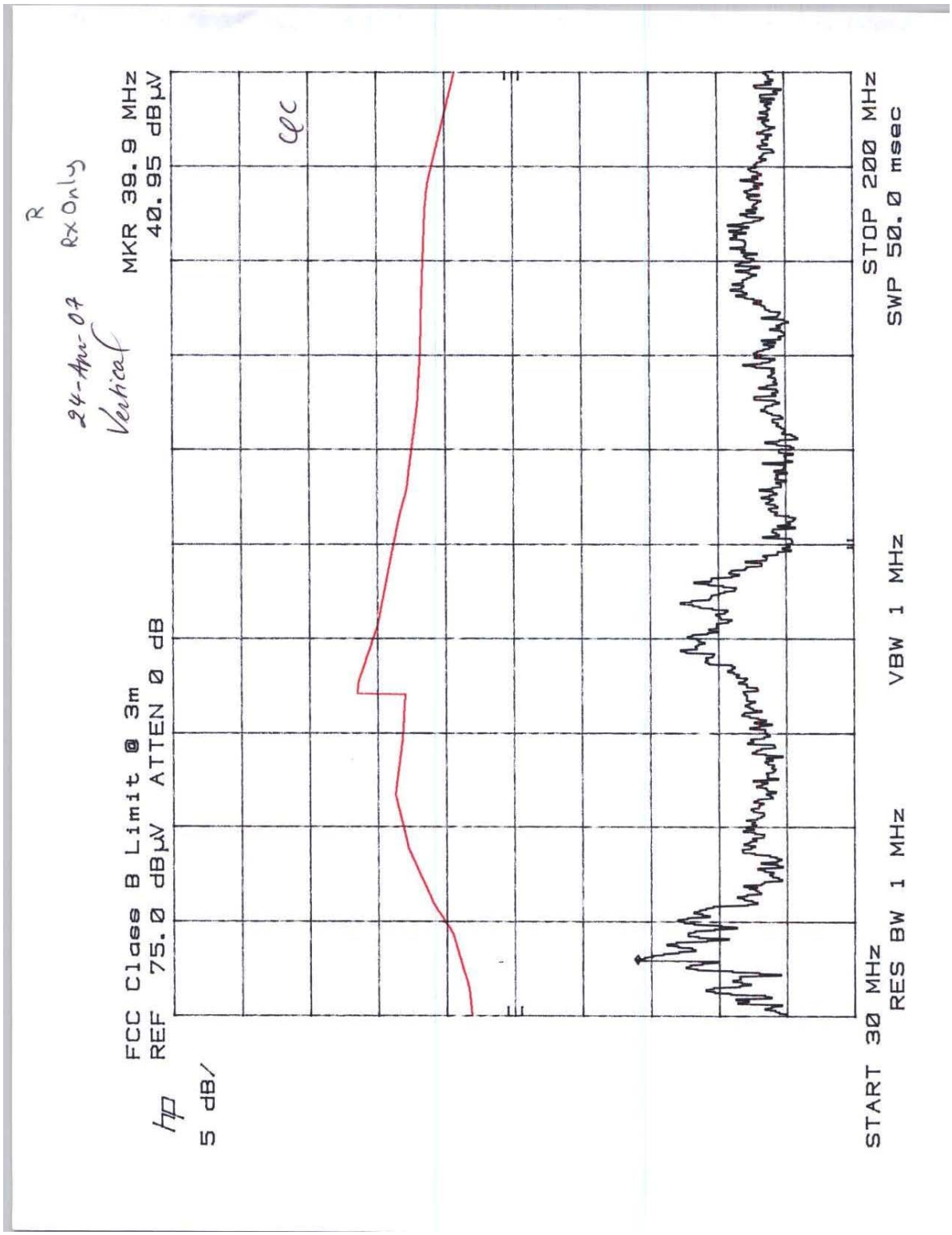


FIGURE 3: Radiated Emission 30 – 200 MHz Vertical Polarization

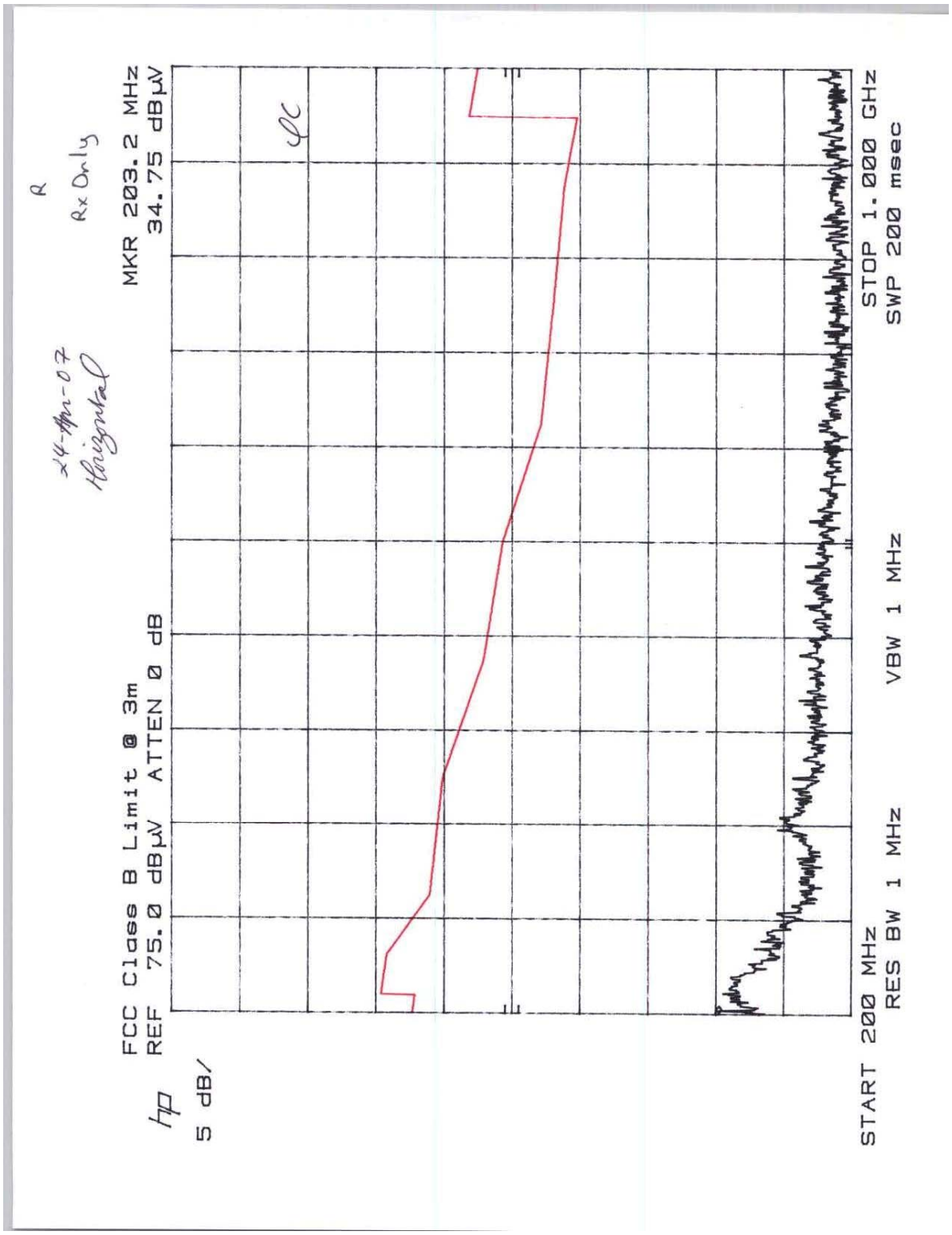


FIGURE 4: Radiated Emission 200 MHz – 1 GHz Horizontal Polarization

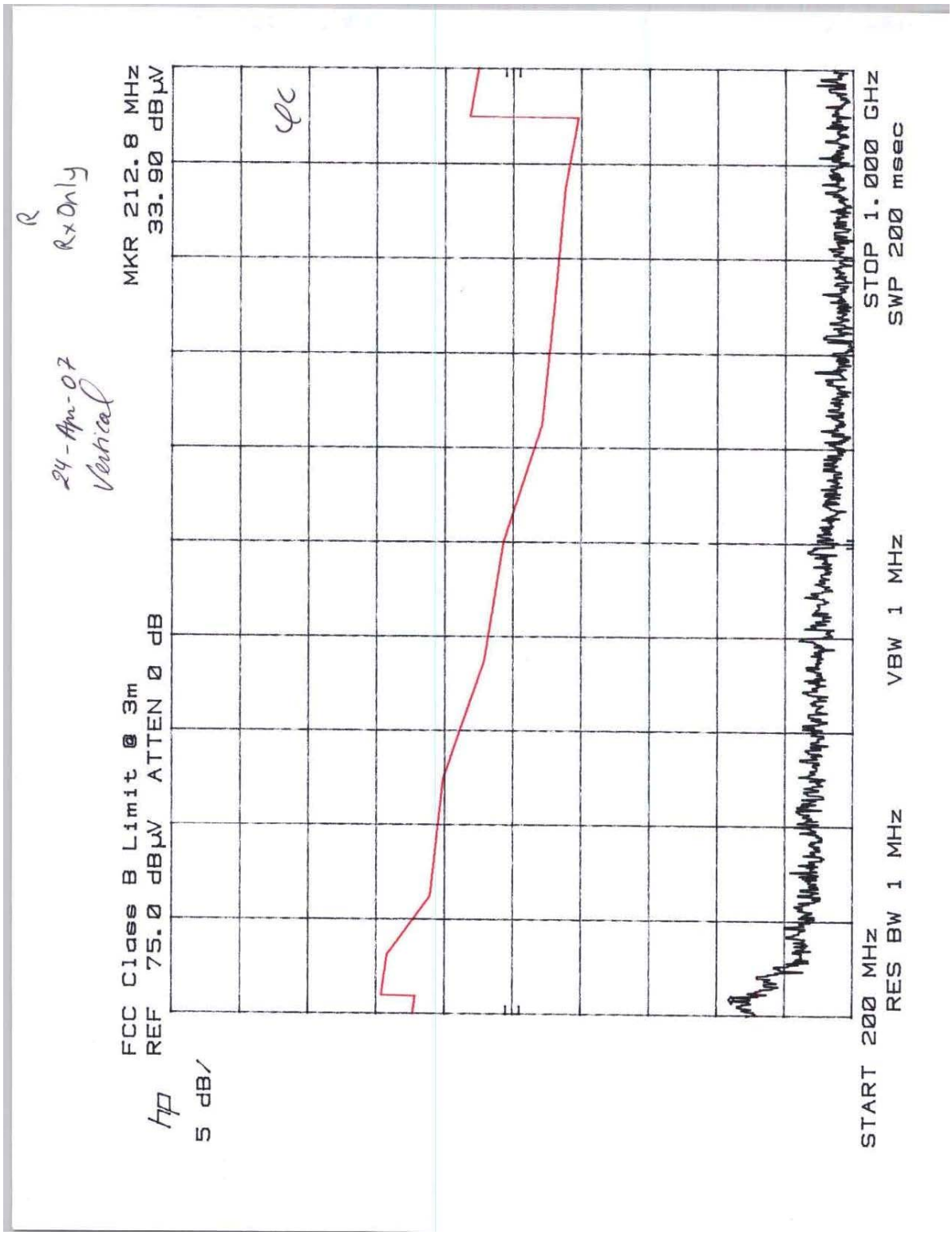


FIGURE 5: Radiated Emission 200 MHz – 1 GHz Vertical Polarization

From Figures 2-5, the peak emissions that exceeded or were within 5 dB of the limit are reported in Table 2. Since all the emissions are more than 5 dB below the limit, there are no values to be reported in Table 2.

Figure No.	Frequency (MHz)	Measured Peak (dBµV)	Quasi Peak (dBµV)	Correction Factor (dB/m)	Peak Field* (dBµV/m)	FCC Limit (dBµV/m)	Margin to limit (dB)

Table 2: Peak Measurement Results

* Peak field (dBµV/m) = the measured value (either Peak or Quasi Peak) in dBµV - Correction Factor (dB/m).

It can be seen from the previous figures and Table 2 that the emissions are below limit. Hence the unit is in compliance.

4.4 Operation in the 902 to 928 MHz Frequency Range

The Home Automation, Inc's Z-Wave Thermostat generates sporadically a 908.4 MHz FSK modulated signal at a rate of 9600 bits per second. EUT was set up on the wooden table 80 centimeters above the ground plane turntable of the Semi-Anechoic test site. The 6 dB bandwidth of the digitally modulated signal was measured to be 85 kHz on the HP 8566B Spectrum analyzer (SA) using a Log Periodic antenna (EMCO 3146) at a distance of 3 meters from the system. Hence, the device was tested for compliance to the FCC part 15, Subpart C, Section 15.249 (a), operation within the frequency band of 902 to 928 MHz.

The peak spurious emissions from the carrier frequency of the device were recorded on the HP 8566B Spectrum analyzer with the max hold button on. The spectrum analyzer was centered at the carrier frequency and the span was set to 1 MHz.

The Log Periodic antenna was initially set to horizontal polarization, at 1-m above the floor. The turntable was then rotated 360 degrees. After the completion, the turntable was rotated back to the previously noted azimuth angles where the higher E-fields occurred, and the antenna was then scanned from 1 to 4 meters high at those angles, in order to determine the height that will provide to highest amplitude. The antenna was moved back to the location where the highest amplitude was observed and the turn table was rotated again 360º. The maximum value was plotted and presented herein. The antenna was then rotated to measure the vertical polarized E-field and the above procedure was repeated.

For the measurement of the spurious emissions from the harmonic frequencies of 908.4 MHz, the Log Periodic antenna was replaced by a double-rigged horn antenna. The spectrum analyzer was then centered to the respective harmonic frequencies with a frequency span of 5 MHz. The bypass switch of the quasi peak adapter was activated and the peak emissions were maximized using the procedure previously described.

The spurious peak emissions for the fundamental and harmonic frequencies for the HAI Z-Wave Thermostat are recorded in Tables 3 and 4 for respectively horizontal and vertical polarizations.

Frequency (MHz)	SA Reading (dBµV)	Correction Factor (dB/m)	Peak Field * (dBµV/m)	FCC Limit (dBµV/m)	Margin to limit (dB)
908.4	82.9	-0.04	82.94	98.93	15.99
1816.8	44.45	-0.67	45.12	54	8.88
2725.2	43.95	-5.48	49.43	54	4.57
3633.6	30.05	-10.11	40.16	54	13.84
4542	29.55	-12.41	41.96	54	12.04
5450.4	27.95	-15.72	43.67	54	10.33
6358.8	29.85	-18.59	48.44	54	5.56
7267.2	26.9	-20.88	47.78	54	6.22
8175.6	27.4	-22.05	49.45	54	4.55
9084	27.4	-23.68	51.08	54	2.92

Table 3: Spurious Peak Emissions (Horizontal Polarization)

Frequency (MHz)	SA Reading (dBµV)	Correction Factor (dB/m)	Peak Field * (dBµV/m)	FCC Limit (dBµV/m)	Margin to limit (dB)
908.4	78.5	-0.04	78.54	98.93	20.39
1816.8	48.45	-0.67	49.12	54	4.88
2725.2	44.5	-5.48	49.98	54	4.02
3633.6	31.65	-10.11	41.76	54	12.24
4542	29.65	-12.41	42.06	54	11.94
5450.4	28.2	-15.72	43.92	54	10.08
6358.8	29.9	-18.59	48.49	54	5.51
7267.2	26.9	-20.88	47.78	54	6.22
8175.6	27.45	-22.05	49.50	54	4.50
9084	27.45	-23.68	51.13	54	2.87

Table 4: Spurious Peak Emissions (Vertical Polarization)

* Peak field (dBµV/m) = SA Reading (dBµV) - Correction Factor (dB/m).

Tables 3 and 4 show the spurious peak emissions did not exceed the limit. Hence, the unit is in compliance.

MAJOR TEST EQUIPMENT

FAU EMI R&D LABORATORY TEST EQUIPMENT						
Equipment Type	**Manufacturer**	**Description**	**Model**	**Serial No.**	**Calibration Date**	**Calibration Interval (Years)**
Spectrum Analyzer	Hewlett Packard	RF Section	8566B	2403A06381	Aug-22-06	2
Spectrum Analyzer	Hewlett Packard	Display	85662A	2407A06381	Aug-22-06	2
Spectrum Analyzer	Hewlett Packard	Quasi Peak Adapter	85650A	2430A00559	Aug-22-06	2
RF Preselector	Hewlett Packard	Preselector	85685A	2510A00151	Feb-8-06	2
LISN	EMCO	LISN	3825/2R	1095	March-10-06	2
Antenna	EMCO	Biconical	3108	2147	Feb-24-06	2
Antenna	EMCO	Log Periodic	3146	1385	Feb-24-06	2
Amplifier	Hewlett Packard	Amplifier	8447D	2443A03952	Dec-01-06	2
Amplifier	Hewlett Packard	Microwave Amplifier	83017A	3123A00324	Nov-27-06	2

TEST FACILITY

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A2LA Certification No. 2129.01
FCC Registration: 90599
Industry of Canada: IC46405-4076

Description	The 3m semi-anechoic chamber and Power Line Conducted Spurious Voltage test setup are constructed and calibrated to meet the FCC requirements of Section 2.948, as well as Industry Canada RSS 212 Issue 1.
Site Filing	A site description is on file with the Federal Communications Commission, 7435 Oakland Mills Road, Columbia, MD 21046, and with the Industry Canada, Certification and Engineering Bureau, 3701 Carling Ave., Building 94, P.O. Box 11490, Station "H", Ottawa Ontario, K2H 8S2.
Instrument	All measuring equipment is in accord with ANSI C63.4 and CISPR 22 requirements.

End of Report