Certification Test Report

FCC ID: 2AHPO-HWMS1

FCC Rule Part: 15.231

Report Number: BO72130552.100

Manufacturer: Enco Electronic Systems, LLC
Model(s): HWMS1

Test Begin Date: August 18, 2017
Test End Date: August 24, 2017

Report Issue Date: November 13, 2017

FOR THE SCOPE OF ACCREDITATION UNDER CERTIFICATE NUMBER AT-1533

This report must not be used by the client to claim product certification, approval, or endorsement by ANAB, ANSI, or any agency of the Federal Government.

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This report contains 21 pages

TABLE OF CONTENTS

1 GENERAL

1.1 Purpose

The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations.

1.2 Manufacturer Information

ENCO Electronic Systems, LLC
165 Hostdale Road
Dothan, AL 36303

1.3 Product description

The Enco Electronic Systems, LLC Halo Wireless Moisture Sensor model HWMS1 consists of a 319.5 MHz transceiver used for moisture detection.

Technical Details
Frequency of Operation: 319.5 MHz
Number of Channels: 1
Modulation: OOK
Antenna / Gain: PCB Loop Antenna, 0 dBi
Input Voltage: 6 VDC

Test Sample Serial Number(s): N/A

Test Sample Condition: The test sample was in good operating condition with no physical damage.

1.4 Test Methodology and Considerations

The EUT was evaluated for radiated emissions in three orthogonal orientations. The TX output power is not configurable. The EUT was operating at the maximum output power during the evaluation.

The EUT bandwidth and timing parameters were measured using a near field probe. The timing was investigated for multiple states of the sensor. The sensor was triggered by a test fixture simulating different states such as dry, damp and wet. The wet condition is defined as an alarm condition per the customer. The worst cases are provided in this test report.

The EUT is battery operated only and therefore is exempted from the power line conducted emissions test requirements.

The EUT was also evaluated for unintentional emissions. The results are documented in a verfication test report.

2 TEST FACILITIES

2.1 Location

The radiated and conducted emissions test sites are located at the following address:

TÜV SÜD America, Inc.
3998 FAU Blvd, Suite 310
Boca Raton, Florida 33431
Phone: (561) 961-5585
Fax: (561) 961-5587
http://www.tuv-sud-america.com

2.2 Laboratory Accreditations/Recognitions/Certifications

TÜV SÜD America, Inc. is accredited to ISO/IEC 17025 by ANSI-ASQ National Accreditation Board under their ANAB program and has been issued certificate number AT-1533 in recognition of this accreditation. Unless otherwise specified, all test methods described within this report are covered under the ISO/IEC 17025 scope of accreditation.

FCC Test Firm Registration #: 475089
ISED Canada Lab Code: 4175C

2.3 Radiated & Conducted Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site

The EMC radiated test facility consists of an RF-shielded enclosure. The interior dimensions of the indoor semi-anechoic chamber are approximately 48 feet (14.6 m) long by 36 feet (10.8 m) wide by 24 feet (7.3 m) high and consist of rigid, 1/8 inch (0.32 cm) steel-clad, wood core modular panels with steel framing. In the shielded enclosure, the faces of the panels are galvanized and the chamber is self-supporting. 8-foot RF absorbing cones are installed on 4 walls and the ceiling. The steel-clad ground plane is covered with vinyl flooring.

The turntable is driven by pneumatic motor, which can support a 2000 lb. load. The turntable is flush with the chamber floor which it is connected to, around its circumference, with a continuous metallic loaded spring. An EMCO Model 1060 Multi-device Controller controls the turntable position.

A pneumatic motor is used to control antenna polarizations and height relative to the ground. The height information is displayed on the control unit EMCO Model 1050.

The control room is an RF shielded enclosure attached to the semi-anechoic chamber with two bulkhead panels for connecting RF, and control cables. The dimension of the room is 7.3 m x 4.9 m x 3 m high and the entrance doors of both control and conducted rooms are 3 feet (0.91 m) by 7 feet (2.13 m).

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3.1-1 below:

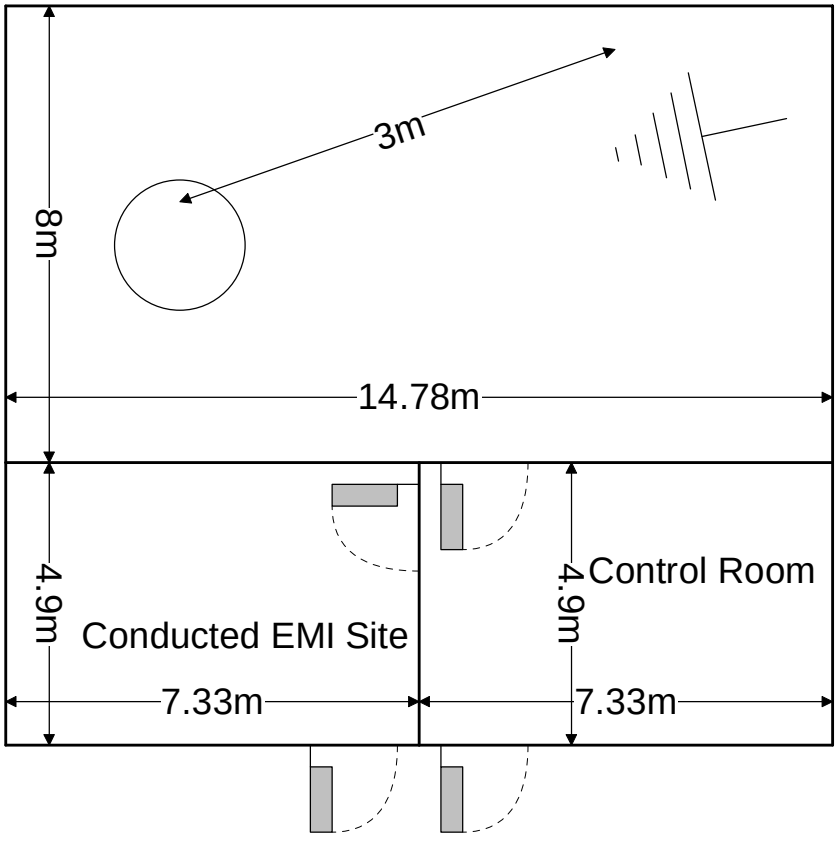

Figure 2.3.1-1: Semi-Anechoic Chamber Test Site

2.3.2 Conducted Emissions Test Site Description

The dimensions of the shielded conducted room are 7.3 x 4.9 x 3 m3. The power line conducted emission site includes two LISNs: a Solar Model 8028-50 50 Ω/50 µH and an EMCO Model 3825/2R, which are installed as shown in the figure below. For evaluations requiring 230 V, 50 Hz AC input, a Polarad LISN (S/N 879341/048) is used in conjunction with a California Instruments signal generator Model 2001RP-OP1.

A diagram of the room is shown below in figure 2.3.2-1:

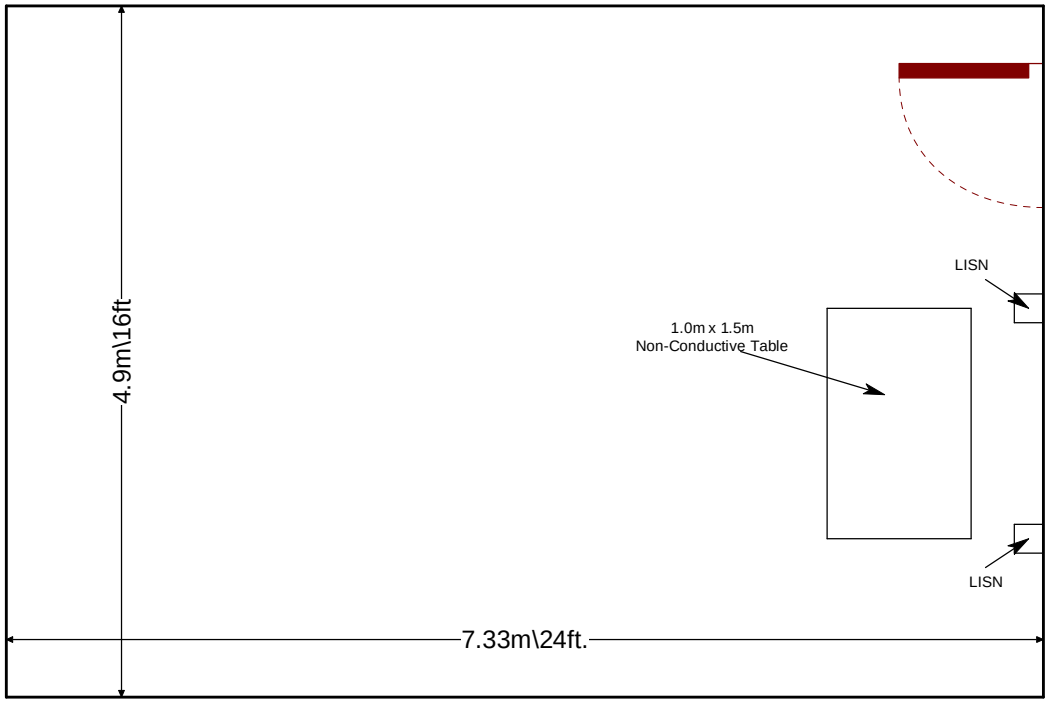

Figure 2.3.2-1: AC Mains Conducted EMI Site

3 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2017.
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2017.

4 LIST OF TEST EQUIPMENT

The calibration interval of test equipment is annually or the manufacturer's recommendations. Where the calibration interval deviates from the annual cycle based on the instrument manufacturer's recommendations, it shall be stated below.

Table 4-1: Test Equipment

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
78	EMCO	6502	Antennas	9104-2608	5/11/2016	5/11/2018
283	Rohde & Schwarz	FSP40	Spectrum Analyzers	1000033	7/21/2016	7/21/2018
523	Agilent	E7405	Spectrum Analyzers	MY45103293	12/9/2016	12/9/2018
2002	EMCO	3108	Antennas	2147	11/19/2015	11/19/2017
2004	EMCO	3146	Antennas	1385	11/19/2015	11/19/2017
2006	EMCO	3115	Antennas	2573	4/7/2017	4/7/2019
2011	Hewlett-Packard	HP 8447D	Amplifiers	2443A03952	11/2/2016	11/2/2017
2073	Mini Circuits	NHP-800	Filter	10247	12/1/2016	12/1/2017
2086	Merrimac	FAN-6-10K	Attenuators	23148-83-1	11/2/2016	11/2/2017
2089	Agilent Technologies, Inc.	83017A	Amplifiers	3123A00214	12/2/2016	12/2/2017
2094	Mini Circuits	SHP-1000+	Filter	R UU27401137	2/27/2017	2/27/2018
2095	ETS Lindgren	TILE4! - Version 4.2.A	Software	85242	NCR	NCR
2111	Aeroflex Inmet	40AH2W-20	Attenuator	2111	7/20/2017	7/20/2018
2112	Teledyne Storm Products	921-0101-036	Cables	12-06-698	11/2/2016	11/2/2017
2121	ACS Boca	Radiated Cable Set	Cable Set	2121	7/31/2017	7/31/2018

Notes:

- **NCR=No Calibration Required**
- **The assets calibration cycle information is provided to cover the entire test period. The assets were only used during the active period of the calibration cycle.**

5 SUPPORT EQUIPMENT

Table 5-1: EUT and Support Equipment

Item #	Type Device	Manufacturer	Model/Part #	Serial #
1	EUT	Enco Electronic Systems, LLC	HWMS1	N/A

Table 5-2: Cable Description

Cable #	Cable Type	Length	Shield	Termination
	The EUT is a standalone device with no provision for additional connection to accessory equipment.			

6 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

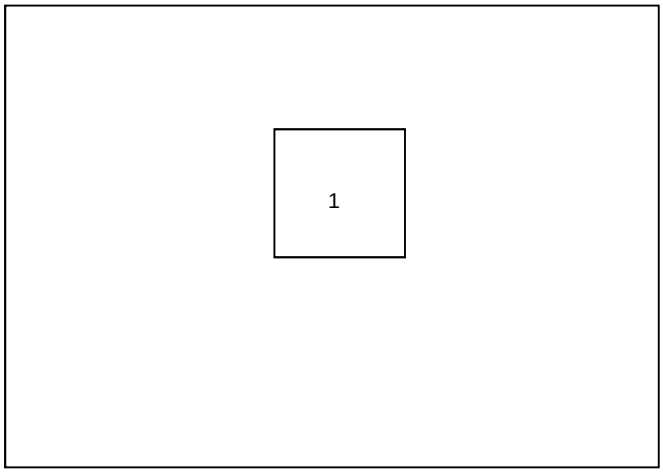

Figure 6-1: EUT Test Setup

7 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

7.1 Antenna Requirement – FCC: Section 15.203

The EUT uses an integral PCB loop antenna that is etched to the PCB. The antenna is not removable and therefore meets the requirements of FCC Section 15.203.

7.2 20dB Bandwidth: FCC: Section 15.231(c)

7.2.1 Measurement Procedure

The RBW was set from 1% to 5% of the estimated emission bandwidth. The trace was set to max hold with a peak detector active. The Delta function of the analyzer was utilized to determine the 20-dB bandwidth of the emission.

7.2.2 Measurement Results

0.25% of the 319.5 MHz center frequency is equivalent to 0.80 MHz. Therefore the 20 dB bandwidths of the emission are less than 0.25% of the center frequency.

Results are shown below in Table 7.2.2-1 and Figure 7.2.2-1.

Performed by Thierry Jean-Charles

Table 7.2.2-1: 20dB Bandwidth

Frequency [MHz]	20dB Bandwidth [kHz]
319.5	42.10

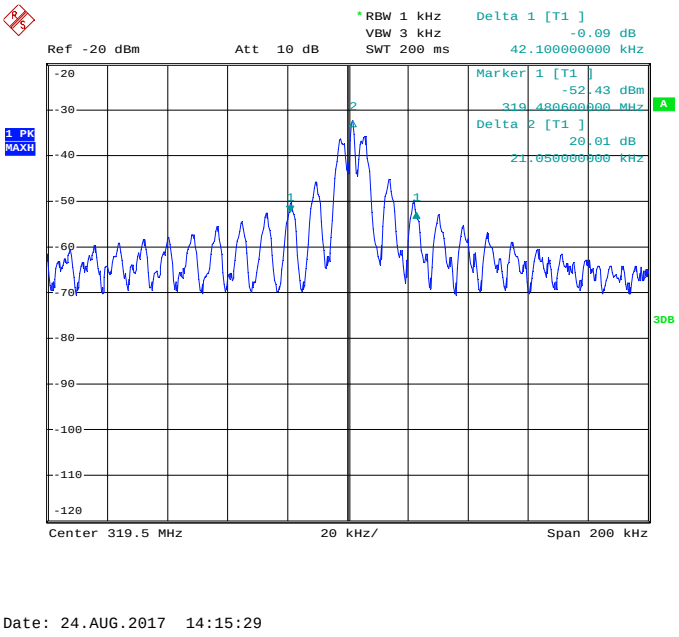

Figure 7.2.2-1: 20dB BW

7.3 Radiated Spurious Emissions – FCC: Section 15.231(b)

7.3.1 Measurement Procedure

Radiated emissions tests were made over the frequency range of 9 kHz to 3.2 GHz, 10 times the highest fundamental frequency.

Measurements below 30 MHz were performed in a semi-anechoic chamber with a 3-meter separation distance between the EUT and measurement antenna. The EUT was rotated 360° to maximize each emission. The magnetic loop receiving antenna was positioned with its lowest point 1 meter above the ground. The loop antenna was aligned along the site axis, orthogonal to the site axis, and ground-parallel to the site axis.

The spectrum analyzer's resolution and video bandwidths were set to 200 Hz and 1000 Hz respectively for frequencies below 150 kHz and 9 kHz and 30 kHz respectively for frequencies above 150 kHz and below 30 MHz.

For measurements above 30 MHz, the EUT was rotated through 360° and the receive antenna height was varied from 1 meter to 4 meters so that the maximum radiated emissions level would be detected. For frequencies below 1000 MHz, measurements were made using a resolution bandwidth (RBW) of 120 kHz and a video bandwidth (VBW) of 300 kHz. For frequencies above 1000 MHz, measurements were made with RBW of 1 MHz and a VBW of 3 MHz.

An average detector was used for all measurement. The peak emissions were also compared to a limit corresponding to 20 dB above the maximum permitted average limit according to Part 15.35. The final measurements were then corrected by antenna correction factors and cable loss for comparison to the limits. Further, compliance with the provisions of 15.205 was demonstrated using the measurement instrumentation specified in that section where applicable.

7.3.2 Duty Cycle Correction

A Duty Cycle Correction of 7.92% corresponding to 20*log(7.92/100) = -22.03 dB was applied to the average measurements for the corrected average results. The justification of the duty cycle is provided in the equipment's theory of operation document.

7.3.3 Measurement Results

Radiated spurious emissions found in the band of 9 kHz to 3.2 GHz are reported below.

Performed by Thierry Jean-Charles, Jean Rene

Table 7.3.3-1: Radiated Spurious Emissions Tabulated Data – EUT Flat

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	avg	(H/V)	(dB)	pk	avg	pk	avg	pk	avg
Flat										
Fundamental Frequency										
319.5	107.30	106.40	H	-11.92	95.38	72.46	95.9	75.9	0.5	3.4
319.5	89.71	88.89	V	-11.92	77.79	54.95	95.9	75.9	18.1	21.0
Spurious Emissions										
639	64.02	63.96	H	-4.91	59.11	37.02	75.9	55.9	16.8	18.9
639	55.39	55.17	V	-4.91	50.48	28.23	75.9	55.9	25.4	27.7
958.5	57.22	56.96	H	-0.88	56.34	34.05	75.9	55.9	19.6	21.8
958.5	53.04	52.83	V	-0.88	52.16	29.92	75.9	55.9	23.7	26.0
1278	62.94	60.98	H	-11.15	51.79	27.81	75.9	55.9	24.1	28.1
1278	55.62	51.83	V	-11.15	44.47	18.66	75.9	55.9	31.4	37.2
1597.5	62.30	60.73	H	-8.97	53.33	29.73	74	54	20.7	24.3
1597.5	57.52	55.00	V	-8.97	48.55	24.00	74	54	25.5	30.0
1917	51.49	45.92	H	-6.71	44.78	17.18	75.9	55.9	31.1	38.7
1917	49.28	41.50	V	-6.71	42.57	12.76	75.9	55.9	33.3	43.1
2236.5	53.44	50.08	H	-5.11	48.33	22.94	74	54	25.7	31.1
2236.5	49.42	43.92	V	-5.11	44.31	16.78	74	54	29.7	37.2
2556	65.87	64.49	H	-3.71	62.16	38.76	75.9	55.9	13.7	17.1
2556	54.10	51.06	V	-3.71	50.39	25.33	75.9	55.9	25.5	30.6
2875.5	62.67	61.21	H	-2.12	60.55	37.06	74	54	13.5	16.9
2875.5	54.50	51.51	V	-2.12	52.38	27.36	74	54	21.6	26.6
3195	58.73	56.56	H	-0.83	57.90	33.71	75.9	55.9	18.0	22.2
3195	53.28	49.87	V	-0.83	52.45	27.02	75.9	55.9	23.4	28.9

Notes:

- **The fundamental emissions were measured using RBW = 1 MHz which is greater than the measured occupied bandwidth.**
- **A duty cycle correction factor of -22.03 dB was applied to the average measurements for the spurious emissions.**

Table 7.3.3-2: Radiated Spurious Emissions Tabulated Data – EUT Vertical

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	avg	(H/V)	(dB)	pk	avg	pk	avg	pk	avg
Standing										
Fundamental Frequency										
319.5	99.41	98.66	H	-11.92	87.49	64.72	95.9	75.9	8.4	11.2
319.5	103.30	102.60	V	-11.92	91.38	68.66	95.9	75.9	4.5	7.2
Spurious Emissions										
639	61.93	61.84	H	-4.91	57.02	34.90	75.9	55.9	18.9	21.0
639	63.50	63.03	V	-4.91	58.59	36.09	75.9	55.9	17.3	19.8
958.5	56.06	55.85	H	-0.88	55.18	32.94	75.9	55.9	20.7	23.0
958.5	55.99	55.79	V	-0.88	55.11	32.88	75.9	55.9	20.8	23.0
1278	59.09	56.59	H	-11.15	47.94	23.42	75.9	55.9	28.0	32.5
1278	61.82	59.48	V	-11.15	50.67	26.31	75.9	55.9	25.2	29.6
1597.5	57.01	54.38	H	-8.97	48.04	23.38	74	54	26.0	30.6
1597.5	61.08	59.37	V	-8.97	52.11	28.37	74	54	21.9	25.6
1917	49.38	42.61	H	-6.71	42.67	13.87	75.9	55.9	33.2	42.0
1917	50.67	46.02	V	-6.71	43.96	17.28	75.9	55.9	31.9	38.6
2236.5	51.21	46.78	H	-5.11	46.10	19.64	74	54	27.9	34.4
2236.5	53.93	50.45	V	-5.11	48.82	23.31	74	54	25.2	30.7
2556	56.25	53.45	H	-3.71	52.54	27.72	75.9	55.9	23.4	28.2
2556	65.92	64.68	V	-3.71	62.21	38.95	75.9	55.9	13.7	17.0
2875.5	59.34	57.38	H	-2.12	57.22	33.23	74	54	16.8	20.8
2875.5	61.14	59.48	V	-2.12	59.02	35.33	74	54	15.0	18.7
3195	57.49	55.00	H	-0.83	56.66	32.15	75.9	55.9	19.2	23.8
3195	61.36	59.07	V	-0.83	60.53	36.22	75.9	55.9	15.4	19.7

Notes:

- **The fundamental emissions were measured using RBW = 1 MHz which is greater than the measured occupied bandwidth.**
- **A duty cycle correction factor of -22.03 dB was applied to the average measurements for the spurious emissions.**

Table 7.3.3-3: Radiated Spurious Emissions Tabulated Data – EUT Sideways

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	avg	(H/V)	(dB)	pk	avg	pk	avg	pk	avg
Sideways										
Fundamental Frequency										
319.5	99.14	98.42	H	-11.92	87.22	64.48	95.9	75.9	8.7	11.4
319.5	103.89	103.00	V	-11.92	91.97	69.06	95.9	75.9	3.9	6.8
Spurious Emissions										
639	55.69	55.51	H	-4.91	50.78	28.57	75.9	55.9	25.1	27.3
639	63.79	63.69	V	-4.91	58.88	36.75	75.9	55.9	17.0	19.1
958.5	55.46	55.24	H	-0.88	54.58	32.33	75.9	55.9	21.3	23.6
958.5	57.00	56.97	V	-0.88	56.12	34.06	75.9	55.9	19.8	21.8
1278	61.43	59.38	H	-11.15	50.28	26.21	75.9	55.9	25.6	29.7
1278	58.90	56.73	V	-11.15	47.75	23.56	75.9	55.9	28.1	32.3
1597.5	61.13	59.68	H	-8.97	52.16	28.68	74	54	21.8	25.3
1597.5	57.54	55.45	V	-8.97	48.57	24.45	74	54	25.4	29.5
1917	49.00	42.98	H	-6.71	42.29	14.24	75.9	55.9	33.6	41.7
1917	49.96	44.62	V	-6.71	43.25	15.88	75.9	55.9	32.7	40.0
2236.5	53.97	50.95	H	-5.11	48.86	23.81	74	54	25.1	30.2
2236.5	50.48	45.56	V	-5.11	45.37	18.42	74	54	28.6	35.6
2556	65.28	64.11	H	-3.71	61.57	38.38	75.9	55.9	14.3	17.5
2556	57.85	55.68	V	-3.71	54.14	29.95	75.9	55.9	21.8	26.0
2875.5	61.32	59.52	H	-2.12	59.20	35.37	74	54	14.8	18.6
2875.5	58.67	56.43	V	-2.12	56.55	32.28	74	54	17.5	21.7
3195	60.03	57.99	H	-0.83	59.20	35.14	75.9	55.9	16.7	20.8
3195	57.18	54.57	V	-0.83	56.35	31.72	75.9	55.9	19.5	24.2

Notes:

- **The fundamental emissions were measured using RBW = 1 MHz which is greater than the measured occupied bandwidth.**
- **A duty cycle correction factor of -22.03 dB was applied to the average measurements for the spurious emissions.**

7.3.4 Sample Calculation

$R_C = R_U + CF_T$

Where:

CF_T	=	Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only)
R_U	=	Uncorrected Reading
R_C	=	Corrected Level
AF	=	Antenna Factor
CA	=	Cable Attenuation
AG	=	Amplifier Gain
DC	=	Duty Cycle Correction Factor

Example Calculation: Peak
Corrected Level: 62.3 + (-8.97) = 53.33 dBµV/m
Margin: 74 dBµV/m – 53.33 dBµV/m = 20.7 dB

Example Calculation: Average
Corrected Level: 60.73 + (-8.97) – 22.03 = 29.73 dBµV/m
Margin: 54 dBµV – 29.73 dBµV/m = 24.3 dB

7.4 Periodic Operation – FCC: CFR 47 15.231(a)

7.4.1 Test Methodology

A manually operated transmitter shall employ a switch that will automatically deactivate the transmitter within not more than 5 seconds of being released. A transmitter activated automatically shall cease transmission within 5 seconds after activation. The transmitter was activated automatically by simulating different moisture conditions and was evaluated using a spectrum analyzer at zero span.

7.4.2 Test Results

Performed by Thierry Jean-Charles

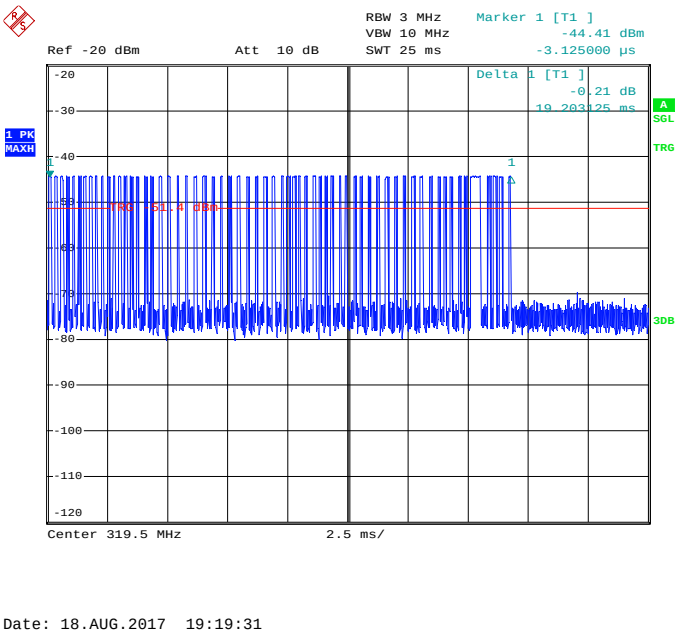

Figure 7.4.2-1: Typical Packets

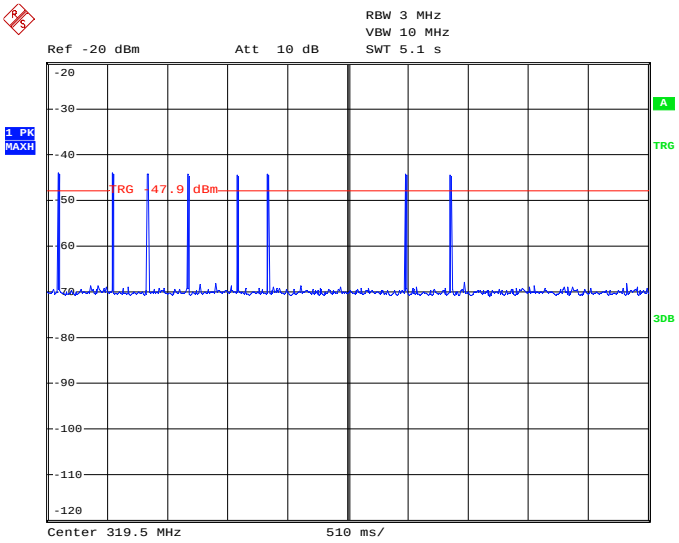

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Figure 7.4.2-2: Periodic Operation – Wet – 5 seconds

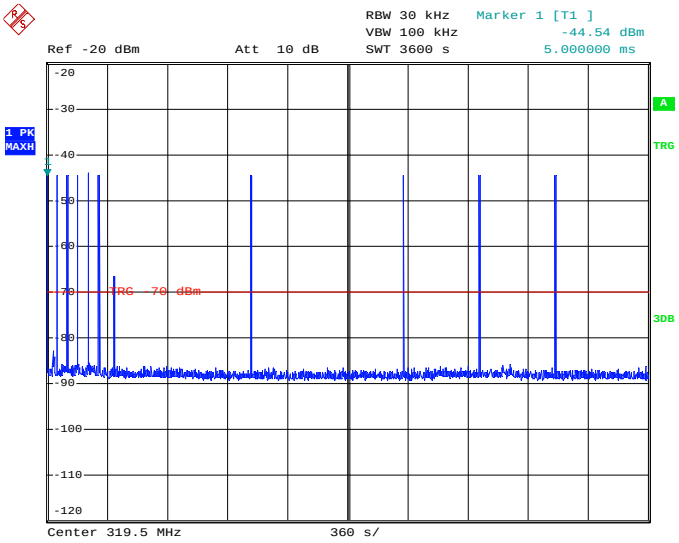

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Figure 7.4.2-3: Periodic Operation – Wet – 1 hour

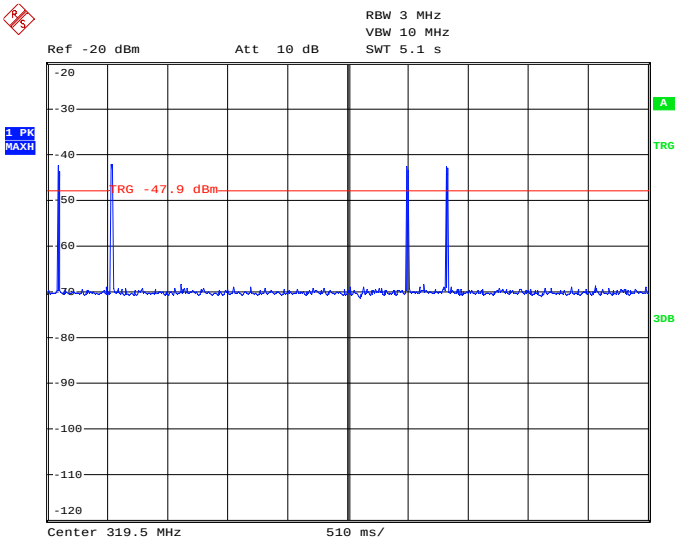

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Figure 7.4.2-4: Periodic Operation – Tampered – 5 seconds

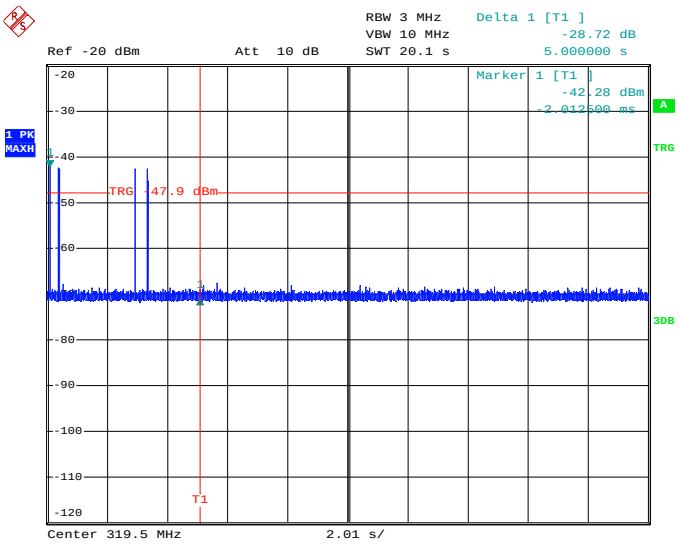

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Figure 7.4.2-5: Periodic Operation – Tampered – 20 seconds

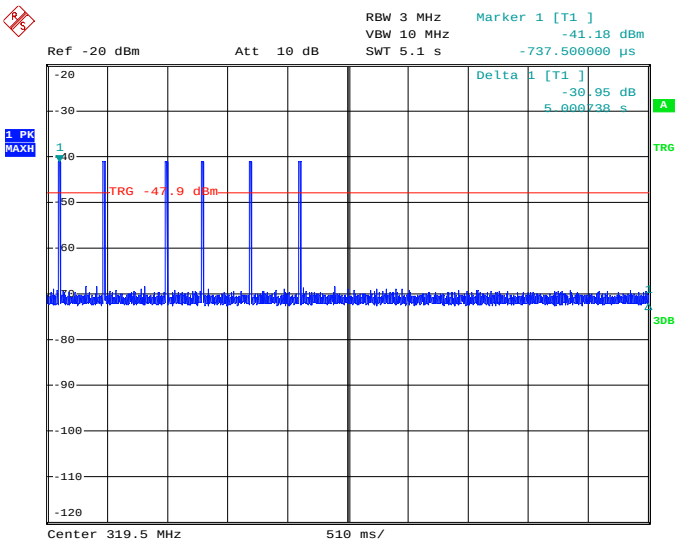

Figure 7.4.2-6: Periodic Operation – Tampered Clear – 5 seconds

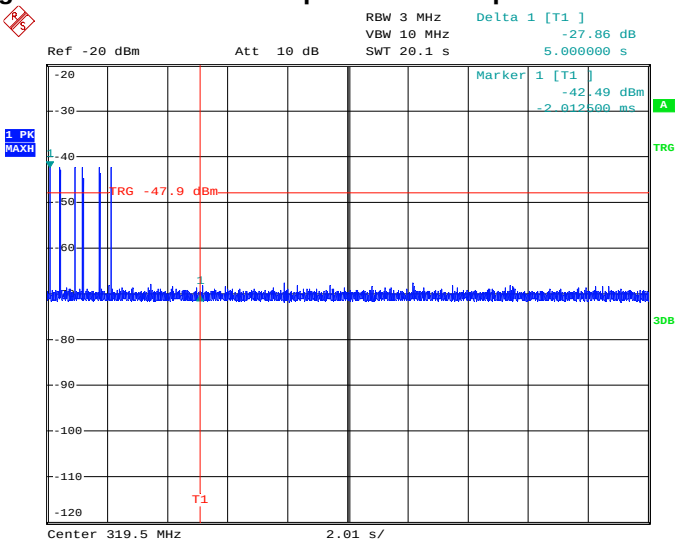

Figure 7.4.2-7: Periodic Operation – Tampered Clear – 20 seconds

8 MEASUREMENT UNCERTAINTIES

The expanded laboratory measurement uncertainty figures (U_{Lab}) provided below correspond to an expansion factor (coverage factor) k = 1.96 which provide confidence levels of 95%.

Table 8-1: Measurement Uncertainties

Parameter	U_{lab}
Occupied Channel Bandwidth	± 0.009 %
RF Conducted Output Power	± 1.15 dB
Power Spectral Density	± 1.15 dB
Antenna Port Conducted Emissions	± 1.15 dB
Radiated Emissions ≤ 1GHz	± 5.86 dB
Radiated Emissions > 1GHz	± 4.65 dB
Temperature	± 0.860 °C
Radio Frequency	$\pm 2.832 \times 10^{-8}$
AC Power Line Conducted Emissions	±3.72 dB

9 CONCLUSION

In the opinion of TÜV SÜD America, Inc. the model HWMS1, manufactured by Enco Electronic Systems, LLC meets the requirements of FCC Part 15 subpart C for the tests documented herein.

END REPORT