Report on the FCC Testing of the

Enco Electronic Systems, LLC
HWMS2

In accordance with FCC Rule Part 15.231

Prepared for: Enco Electronic Systems, LLC
165 Hostdale Road
Dothan, AL 36303

FCC ID: 2AHPO-HWMS1

COMMERCIAL-IN-CONFIDENCE

Document Number: BO72138735.100 | Issue: 01

America

Add value.
Inspire trust.

SIGNATURE			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Pete Walsh	**Service Line Manager**	**Authorized Signatory**	2018-November-26

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD America, Inc. document control rules.

FCC Accreditation
Designation Number US1063 Tampa, FL Test Laboratory

Innovation, Science, and Economic Development Canada Accreditation
Main Site Number 2087A-2 Tampa, FL Test Laboratory
Satellite Site Number: 4175C Boca Raton, FL Test Laboratory

EXECUTIVE SUMMARY
A sample of this product was tested and found to be compliant with FCC Rule Part 15.231

A2LA Cert. No. 2955.15

ACCREDITATION
Our A2LA Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our A2LA Accreditation.

TÜV SÜD America
5610 West Sligh Ave., Suite 100
Tampa, FL 33634

Phone: 813-284-2715
www.tuv-sud-america.com

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 for a Class 2 Permissive Change.

The purpose of the Class 2 Permissive Change is to add the model variant HSMW2 to the FCC ID: 2AHPO-HWMS1. The model variant HWMS2 differs to the model HSMW1 by the moisture sensing circuits. There are no changes to the power or timing parameters. Additional information about the change is described in the devices' updated Theory of Operations.

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 HWMS2 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 (2x Coin Batteries)

Test Sample Serial Number(s): 2 (radiated emissions)

Test Sample Condition: The samples were in good operating condition without any physical damage.

1.4 Test Methodology and Considerations

To account to the layout changes to the digital circuits, the evaluation was limited to radiated emissions. The EUT is battery operated only and therefore is exempted from the power line conducted emissions test requirements.

The TX output power is not configurable. The EUT was operating at the maximum output power during the evaluation.

Preliminary radiated emissions measurements were performed for the EUT in three orthogonal orientations. Final measurements were performed using the orientation leading to the highest emissions.

Compliance to the unintentional emissions test requirements are documented in a supplier's declaration of conformity 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

Innovation, Science and Economic Development Canada Lab Code: 4175C

2.2 Laboratory Accreditations/Recognitions/Certifications

TÜV SÜD America, Inc. is accredited to ISO/IEC 17025 by American Association for Laboratory Accreditation (A2LA) and has been issued certificate number 2955.15 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.

Main Site Information:

TÜV SÜD America, Inc.
5610 West Sligh Ave., Suite 100
Tampa, FL 33634
Phone: 813-284-2715
www.tuv-sud-america.com

FCC Designation Number US1063
FCC Test Firm Registration #: 160606
Innovation, Science, and Economic Development Canada Lab Code: 2087A-2

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:

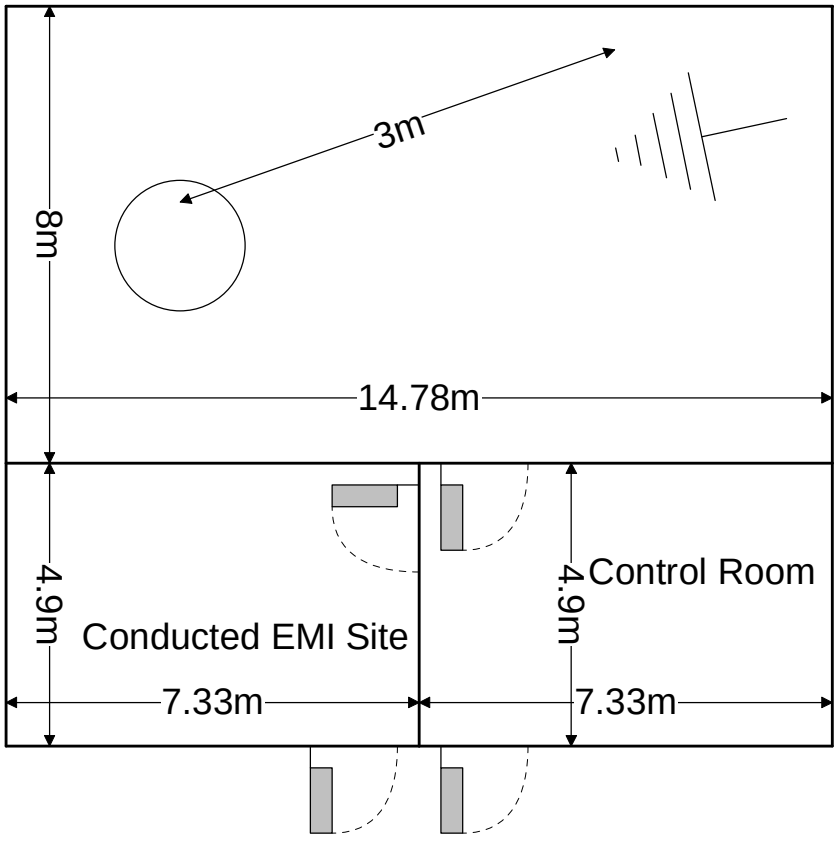

Figure 2.3.1-1: Semi-Anechoic Chamber Test Site

2.3.2 Conducted Emissions Test Site Description

The dimensions of the shielded conducted room are 7.3 x 4.9 x 3 m^3. 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:

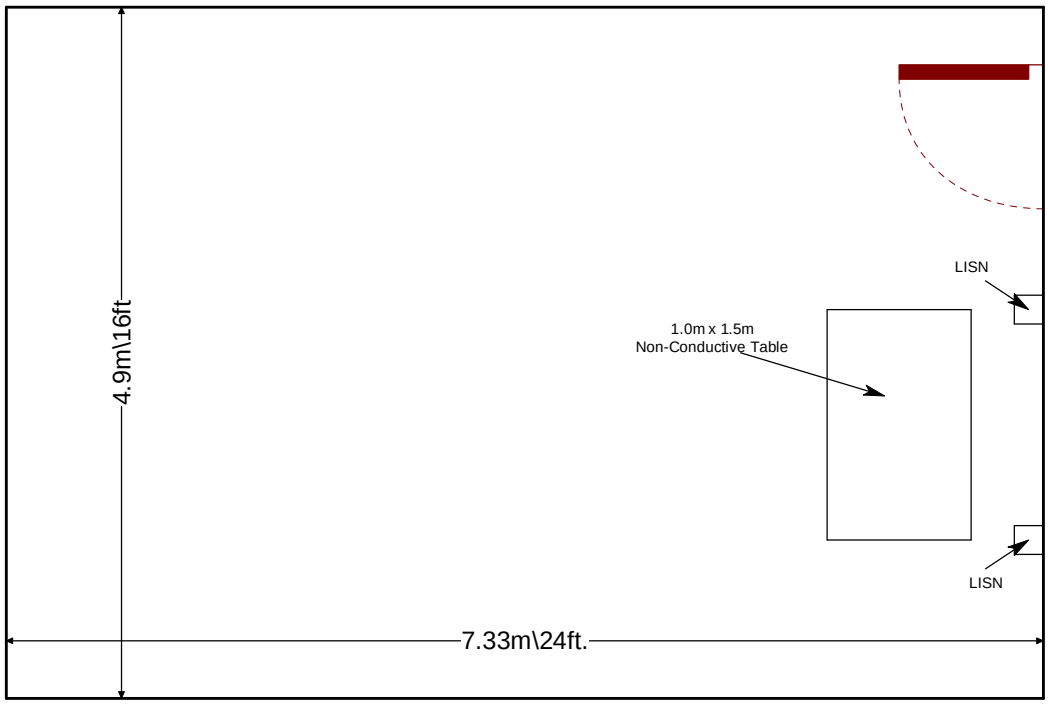

Figure 2.3.2-1: AC Mains Conducted EMI Site

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
BEMC00078	EMCO	6502	Active Loop Antenna	9104-2608	5/9/2018	5/9/2020
BEMC00523	Agilent	E7405	9kHz-26.5GHz EMC analyzer/HYZ	MY45103293	12/9/2016	12/9/2018
BEMC02002	EMCO	3108	30 MHz to 200 MHz Biconical Antenna	2147	11/28/2017	11/30/2019
BEMC02004	EMCO	3146	200 MHz to 1 GHz Log Periodic Antenna	1385	12/27/2017	12/27/2019
BEMC02006	EMCO	3115	Linear Polarized Horn antenna, 1-18 GHz	2573	4/7/2017	4/7/2019
BEMC02011	Hewlett-Packard	HP 8447D	100 kHz to 1.3 GHz low-noise, high gain amplifier	2443A03952	10/18/2018	10/18/2019
BEMC02083	Mini-Circuits	NHP-600	600 MHz High Pass Filter	2083	5/17/2018	5/17/2019
BEMC02086	Merrimac	FAN-6-10K	10dB Attenuator	23148-83-1	10/17/2018	10/17/2019
BEMC02094	Mini Circuits	SHP-1000+	High Pass Filter, 1000-3000 MHz, 50 OHM	R UU27401137	2/28/2018	2/28/2019
BEMC02095	ETS Lindgren	TILE4! - Version 4.2.A	Tile Automation Software	85242	NCR	NCR
BEMC02121	Teledyne Storm Products	A81-0303	Radiated Cable Set	2121	7/26/2018	7/26/2019
BEMC02138	Hewlett Packard	8449B	Pre-Amplifier	3008A00320	12/1/2017	12/1/2018

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 – Radiated Emissions

Item #	Type Device	Manufacturer	Model/Part #	Serial #
1	EUT	Enco Electronic Systems, LLC	HWMS2	2

Table 5-2: Cable Description – Radiated Emissions

Cable #	Cable Type	Length	Shield	Termination
A	The EUT is a stand-alone device without any provision for wired connection to accessory equipment.			

6 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

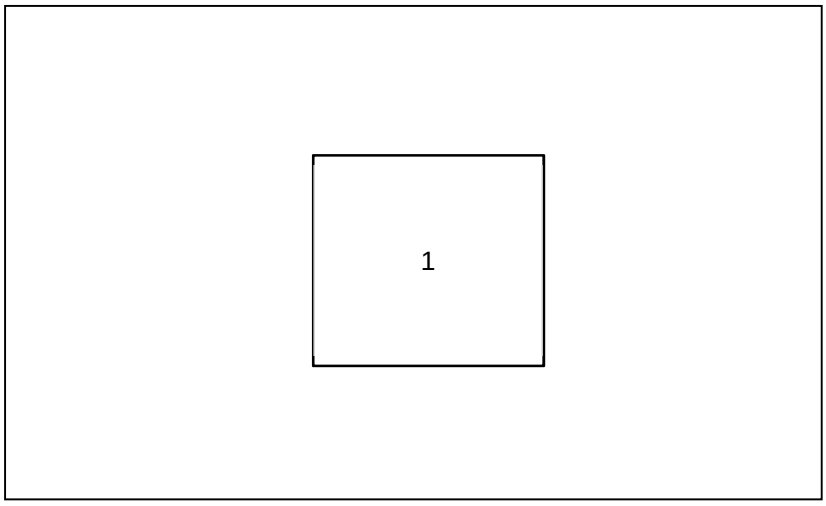

Figure 6-1: EUT Test Setup Block Diagram

7 SUMMARY OF TESTS

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

Test Begin Date: August 16, 2018
Test End Date: November 8, 2018

Table 7-1: Summary of Tests

Test Description	FCC 47 CFR Rule Part	Test Results
Antenna Requirements	FCC: Section 15.203	Compliant
20dB Bandwidth	FCC: Section 15.231(c)	Compliant
Field Strength of Fundamental and Spurious Emissions	FCC: Sections 15.231(b)	Compliant

7.1 Antenna Requirement – FCC: Section 15.203

The EUT uses an integral 0 dBi 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 spectrum analyzer span was set to 2 to 5 times the estimated bandwidth of the emission. 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 Marker function of the analyzer set at 20 dB below the maximum level of the fundamental emission 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 0.8 MHz. Therefore the 20 dB bandwidth of the emission is less than 0.25% of the center frequency.

Performed by: Thierry Jean-Charles

Table 7.2.2-1: 20dB / 99% Bandwidth

Frequency [MHz]	20dB Bandwidth [kHz]
319.5	49.81

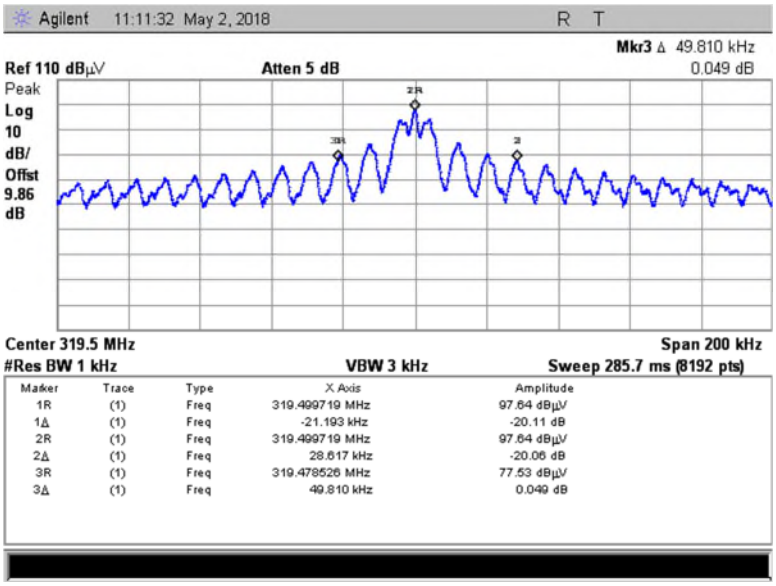

Figure 7.2.2-1: 20dB Bandwidth

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

Performed by: Thierry Jean-Charles, Jean Rene

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

Table 7.3.3-1: Radiated Spurious Emissions Tabulated Data

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	104.80	104.80	H	-11.44	93.36	71.33	95.9	75.9	2.5	4.6
319.5	88.75	88.75	V	-11.44	77.31	55.28	95.9	75.9	18.6	20.6
Spurious Emissions										
639	67.09	67.09	H	-4.85	62.24	40.21	75.9	55.9	13.7	15.7
639	54.86	54.86	V	-4.85	50.01	27.98	75.9	55.9	25.9	27.9
958.5	66.56	66.56	H	-0.17	66.39	44.37	75.9	55.9	9.5	11.5
958.5	60.86	60.86	V	-0.17	60.69	38.67	75.9	55.9	15.2	17.2
1278	48.40	48.40	H	-4.47	43.93	21.91	75.9	55.9	32.0	34.0
1278	46.98	46.98	V	-4.47	42.51	20.49	75.9	55.9	33.4	35.4
1597.5	52.12	52.12	H	-2.72	49.40	27.38	74	54	24.6	26.6
1597.5	48.08	48.08	V	-2.72	45.36	23.34	74	54	28.6	30.7
1917	44.04	44.04	H	-0.68	43.36	21.33	75.9	55.9	32.5	34.6
1917	44.04	44.04	V	-0.68	43.36	21.33	75.9	55.9	32.5	34.6
2236.5	43.48	43.48	H	0.68	44.16	22.13	74	54	29.8	31.9
2236.5	44.26	44.26	V	0.68	44.94	22.91	74	54	29.1	31.1
2556	46.98	46.98	H	1.87	48.85	26.82	75.9	55.9	27.1	29.1
2556	45.83	45.83	V	1.87	47.70	25.67	75.9	55.9	28.2	30.2
2875.5	51.97	51.97	H	3.38	55.35	33.32	74	54	18.7	20.7
2875.5	48.85	48.85	V	3.38	52.23	30.20	74	54	21.8	23.8
3195	55.58	55.58	H	4.71	60.29	38.27	75.9	55.9	15.6	17.6
3195	50.04	50.04	V	4.71	54.75	32.73	75.9	55.9	21.1	23.2

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: 52.12 + (-2.72) = 49.40 dBµV/m
Margin: 74.00 dBµV/m – 49.40 dBµV/m = 24.60 dB

Example Calculation: Average
Corrected Level: 52.12 + (-2.72) -22.03= 27.37 dBµV/m
Margin: 54.00 dBµV – 27.37 dBµV/m = 26.63 dB

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 HWMS2, manufactured by Enco Electronic Systems, LLC meets the requirements of FCC Part 15 subpart C.

END REPORT