Amber Helm Development L.C.
92723 Michigan Hwy-152
Sister Lakes, Michigan 49047 USA
Tel: 888-847-8027

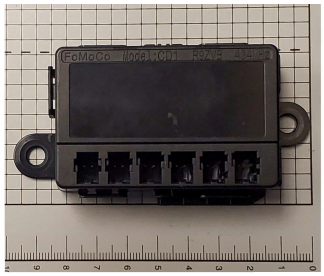
MQCD1-WR2233US
Issued: **December 10, 2022**

EMC Test Report

regarding

USA: CFR Title 47, Part 15.231 (Emissions)
Canada: ISED RSS-210v10/GENv5 (Emissions)

for



CD1

Category: Wireless Beltminder

Judgments:
Compliant 15.231/RSS-210v10 Transmitter
Testing Completed: November 28, 2022

TESTING
NVLAP LAB CODE 200129-0

Prepared for:

Marquardt GmbH

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Rpt. Prep./Rev. by: John Nantz — John Nantz

Date of Issue: December 10, 2022

Revision History

Rev. No.	Date	Details	Revised By
r0	December 10, 2022	Initial Release.	J. Brunett

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1 Test Report Scope and Limitations

1.1 Laboratory Authorization

Test Facility description and attenuation characteristics are on file with the FCC Laboratory, Columbia, Maryland (FCC Reg. No: US5348 and US5356) and with ISED Canada, Ottawa, ON (File Ref. No: 3161A and 24249). Amber Helm Development L.C. holds accreditation under NVLAP Lab Code 200129-0.

1.2 Report Retention

For equipment verified to comply with the regulations herein, the manufacturer is obliged to retain this report with the product records for the life of the product, and no less than ten years. A copy of this Report will remain on file with this laboratory until January 2033.

1.3 Subcontracted Testing

This report does not contain data produced under subcontract.

1.4 Test Data

This test report contains data included within the laboratory's scope of accreditation. Any data in this report that is not covered under the laboratory's scope is clearly identified.

1.5 Limitation of Results

The test results contained in this report relate only to the item(s) tested. Any electrical or mechanical modification made to the test item subsequent to the test date shall invalidate the data presented in this report. Any electrical or mechanical modification made to the test item subsequent to this test date shall require reevaluation.

1.6 Copyright

1.7 Endorsements

This report shall not be used to claim product endorsement by any accrediting, regulatory, or governmental agency.

1.8 Test Location

The EUT was fully tested by **Amber Helm Development L.C.**, headquartered at 92723 Michigan Hwy-152, Sister Lakes, Michigan 49047 USA. Table 1 lists all sites employed herein. Specific test sites utilized are also listed in the test results sections of this report where needed.

Table 1: Test Site List.

Description	Location	Quality Num.
OATS (3 meter)	3615 E Grand River Rd., Williamston, Michigan 48895	OATSC

1.9 Traceability and Equipment Used

Pertinent test equipment used for measurements at this facility is listed in Table 2. The quality system employed at Amber Helm Development L.C. has been established to ensure all equipment has a clearly identifiable classification, calibration expiry date, and that all calibrations are traceable to the SI through NIST, other recognized national laboratories, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards.

Table 2: Equipment List.

Description	Manufacturer/Model	SN	Quality Num.	Cal/Ver By / Date Due
Biconical	EMCO / 93110B	9802-3039	BICEMCO01	Keysight / Aug-2023
Log Periodic Antenna	EMCO / 3146	9305-3614	LOGEMCO01	Keysight / Aug-2023
BNC-BNC Coax	WRTL / RG58/U	001	CAB001-BLACK	AHD / March-2023
3.5-3.5MM Coax	PhaseFlex / PhaseFlex	001	CAB015-PURP	AHD / Dec-2022
Spectrum Analyzer	R & S / FSV30	101660	RSFSV30001	RS / Apr-2023
Quad Ridge Horn	Singer / A6100	C35200	HQR1TO18S01	Keysight / Aug-2024

2 Test Specifications and Procedures

2.1 Test Specification and General Procedures

The goal of Marquardt GmbH is to demonstrate that the Equipment Under Test (EUT) complies with the Rules and/or Directives below. Detailed in this report are the results of testing the Marquardt GmbH CD1 for compliance to:

Country/Region	**Rules or Directive**	**Referenced Section(s)**
United States	Code of Federal Regulations	CFR Title 47, Part 15.231
Canada	ISED Canada	ISED RSS-210v10/GENv5

It has been determined that the equipment under test is subject to the rules and directives above at the date of this testing. In conjunction with these rules and directives, the following specifications and procedures are followed herein to demonstrate compliance (in whole or in part) with these regulations.

ANSI C63.4:2014	"Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"
ANSI C63.10:2013	"American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices"
TP0102RA	"AHD Internal Document TP0102 - Radiated Emissions Test Procedure"
ISED Canada	"The Measurement of Occupied Bandwidth"
ICES-003; Issue 7 (2020)	"Information Technology Equipment (ITE) - Limits and methods of measurement"

3 Configuration and Identification of the Equipment Under Test

3.1 Description and Declarations

The equipment under test is part of an automotive Wireless Beltminder System (seat belt and occupant detection status monitor) consisting of an RF transmitter with an LF receiver. The EUT is approximately 10 x 5.2 x 2.8 cm in dimension, and is depicted in Figure 1. It is powered by 3 VDC Lithium battery. In use, this device is mounted inside an automotive vehicle. Table 3 outlines provider declared EUT specifications.

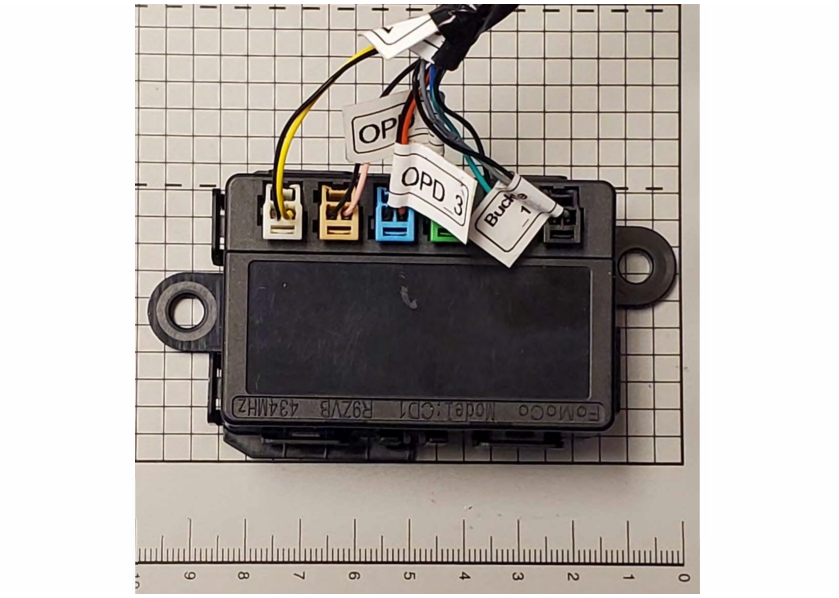

Figure 1: Photos of EUT.

Table 3: EUT Declarations.

General Declarations	
Equipment Type:	Wireless Beltminder
Country of Origin:	Not Declared
Nominal Supply:	3 VDC
Oper. Temp Range:	$-40°$C to +85C
Frequency Range:	433.92 MHz
Antenna Dimension:	Not Declared
Antenna Type:	integral
Antenna Gain:	Not Declared
Number of Channels:	1
Channel Spacing:	Not Applicable
Alignment Range:	Not Declared
Type of Modulation:	FSK
United States	
FCC ID Number:	IYZCD1
Classification:	DSC
Canada	
IC Number:	2701A-CD1
Classification:	Remote Control Device

3.1.1 EUT Configuration

The EUT is configured for testing as depicted in Figure 2.

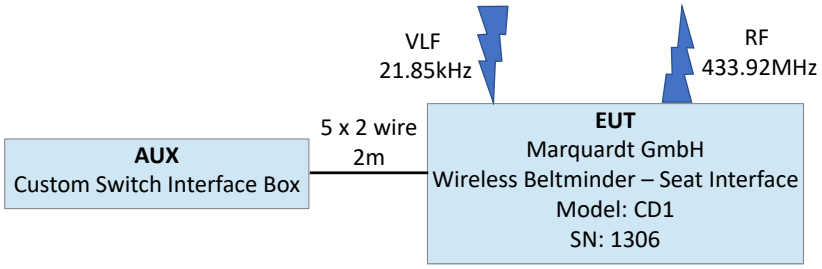

Figure 2: EUT Test Configuration Diagram.

3.1.2 Modes of Operation

There are two modes of operation for this device. The EUT may be manual operated via a seat belt / or occupant detection switch status change or it may be automatically interrogated vis LF at 21.85kHz (The EUT contains an LF receiver which is evaluated separately as an SDOC). In both instances the EUT will transmit a seat belt and occupant detection status signal at 433.92 MHz.

3.1.3 Variants

There is only one variant of the EUT, as tested.

3.1.4 Test Samples

Three samples of the EUT were provided including the following: one normal operating, one continuous RF transmitting, and one paired with a complete Wireless Beltminder system with continuous cyclical operation.

3.1.5 Functional Exerciser

Normal operating EUT functionality was verified by observation of transmitted signal.

3.1.6 Modifications Made

There were no modifications made to the EUT by this laboratory. However, during pretesting it was determined that the EUT harness (that leads to a set of switches) had a strong influence on the RF emissions. To decrease this uncertainty the harness provided was modified by the manufacturer from a straight to a twisted wire bundle.

3.1.7 Production Intent

The EUT appears to be a production ready sample.

3.1.8 Declared Exemptions and Additional Product Notes

The EUT is permanently installed in a transportation vehicle. As such, digital emissions are exempt from US and Canadian digital emissions regulations (per FCC 15.103(a) and IC correspondence on ICES-003).

4 Emissions

4.1 General Test Procedures

4.1.1 Radiated Test Setup and Procedures

Radiated electromagnetic emissions from the EUT are first pre-scanned in our screen room. Spectrum and modulation characteristics of all emissions are recorded. Instrumentation, including spectrum analyzers and other test equipment as detailed in Section 1.8 are employed. After pre-scan, emission measurements are made on the test site of record. If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in relevant test standards are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed if the resulting emissions appear to be worst-case in such a configuration. See Figure 3. All intentionally radiating elements that are not fixed-mounted in use are placed on the test table lying flat, on their side, and on their end (3-axes) and the resulting worst case emissions are recorded. If the EUT is fixed-mounted in use, measurements are made with the device oriented in the manner consistent with installation and then emissions are recorded. If the EUT exhibits spurious emissions due to internal receiver circuitry, such emissions are measured with an appropriate carrier signal applied.

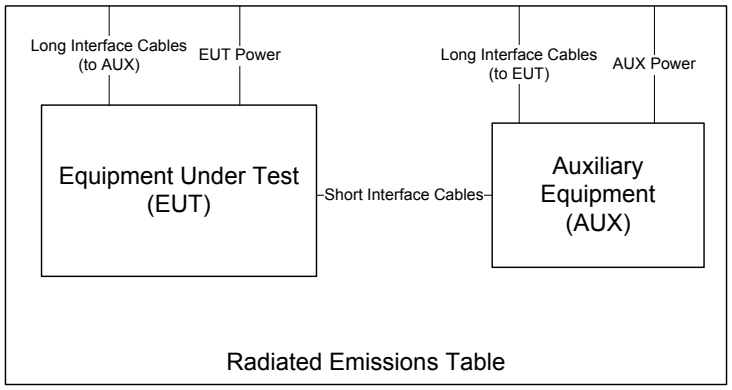

Figure 3: Radiated Emissions Diagram of the EUT.

For devices with intentional emissions below 30 MHz, a shielded loop antenna and/or E-field and H-Field broadband probes are used depending on the regulation. Shielded loops are placed at a 1 meter receive height at the desired measurement distance. For exposure in this band, 10cm diameter single-axis broadband probes meeting the requirements of ISED SPR-002 section 5.2 are employed. Measurements are repeated and summed over three axes, and the entire frequency range is measured with and without the EUT transmitting.

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. For both horizontal and vertical polarizations, the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected. The EUT is then rotated through 360^o in azimuth until the highest emission is detected. The test antenna is then raised and lowered one last time from 1 to 4 m and the worst case value is recorded. Emissions above 1 GHz are characterized using standard gain or broadband ridge-horn antennas on our OATS with a 4×5 m rectangle of ECCOSORB absorber covering the OATS ground screen and a 1.5m table height. Care is taken to ensure that test receiver resolution and video bandwidths meet the regulatory requirements, and that the emission bandwidth of the EUT is not reduced. Photographs of the test setup employed are depicted in Figure 4.

Where regulations allow for direct measurement of field strength, power values (dBm) measured on the test receiver / analyzer are converted to dBμV/m at the regulatory distance, using

$$E_{dist} = 107 + P_R + K_A - K_G + K_E - C_F$$

where P_R is the power recorded on spectrum analyzer, in dBm, K_A is the test antenna factor in dB/m, K_G is the combined pre-amplifier gain and cable loss in dB, K_E is duty correction factor (when applicable) in dB, and C_F is a distance conversion (employed only if limits are specified at alternate distance) in dB. This field strength value is then compared with the regulatory limit. If effective isotropic radiated power (EIRP) is computed, it is computed as

$$EIRP(dBm) = E_{3m}(dB\mu V/m) - 95.2.$$

When presenting data at each frequency, the highest measured emission under all possible EUT orientations (3-axes) is reported.

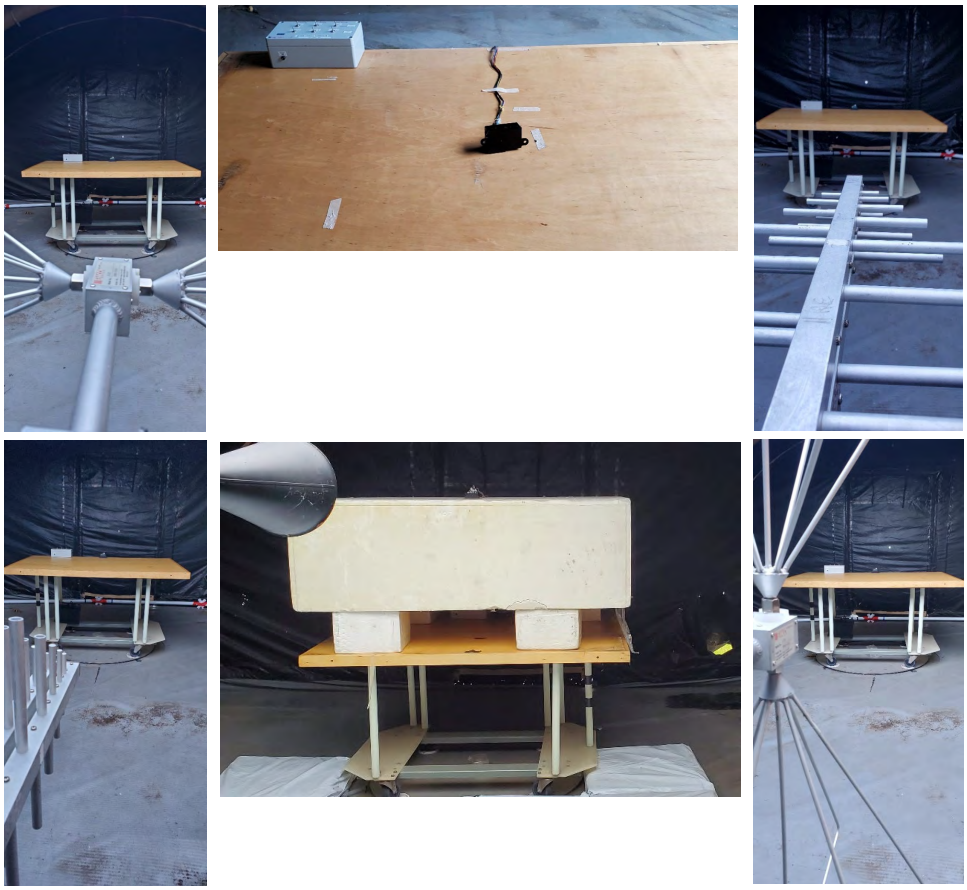

Figure 4: Radiated Emissions Test Setup Photograph(s).

4.1.2 Conducted Emissions Test Setup and Procedures

The EUT is not subject to measurement of power line conducted emissions as it is powered solely by its internal battery.

4.1.3 Power Supply Variation

Tests at extreme supply voltages are made if required by the procedures specified in the test standard, and results of this testing are detailed in this report.

In the case the EUT is designed for operation from a battery power source, the extreme test voltages are evaluated over the range specified in the test standard; no less than ±10% of the nominal battery voltage declared by the manufacturer. For all battery operated equipment, worst case intentional and spurious emissions are re-checked employing a new (fully charged) battery.

4.2 Intentional Emissions

4.2.1 Fundamental Emission Pulsed Operation

Test Setup & Procedure The test equipment and facilities were setup in accordance with the standards and procedures listed in Section 2.1. Environmental conditions were set at the appropriate temperature and thermal balance was checked with a thermocouple based probe. Duty cycle is reported for all relevant modes of operation. The test equipment employed includes RSFSV30001, LOGEMCO01.

Measurement Results The details and results of testing the EUT are summarized in Table 4. Plots showing the measurements made to obtain these values are provided in Figure 5.

Table 4: Fundamental Emission Pulsed Operation.

Detector	Span	IF Bandwidth	Video Bandwidth
Pk	0	1 MHz	3 MHz

Test Date:	9-Nov-22
Test Engineer:	J. Nantz
EUT:	MARQ1 CD1
EUT Mode:	Normal Operating
Meas. Distance:	10 cm

FCC/IC

R0	Test Freq.		Overall Transmission			Internal Frame Characteristics			Computed Duty Cycle	
	(MHz)	EUT Test Mode*	Min. Repetition Rate (sec)	Max. No. of Frames	Total Transmission Length (sec)	Max. Frame Length (ms)	Min. Frame Period (ms)	Frame Encoding	(%)	(dB)
R1	433.92	SWITCH ACTIVATED	single	3	0.42	9.45	NA	In the worse case, the EUT may transmit one 9.45 ms FSK data frame in any given 100ms window.	9.450	-20.0
R2	434.92	LF ACTIVATED	single	1	1.00	14.80	2025.0	In the worse case, the EUT may transmit one 14.8 ms FSK data frame in any given 100ms window.	14.800	**-16.6**
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10

Example Calculation: 14.8 ms / 100 ms = 14.8 % on-time.

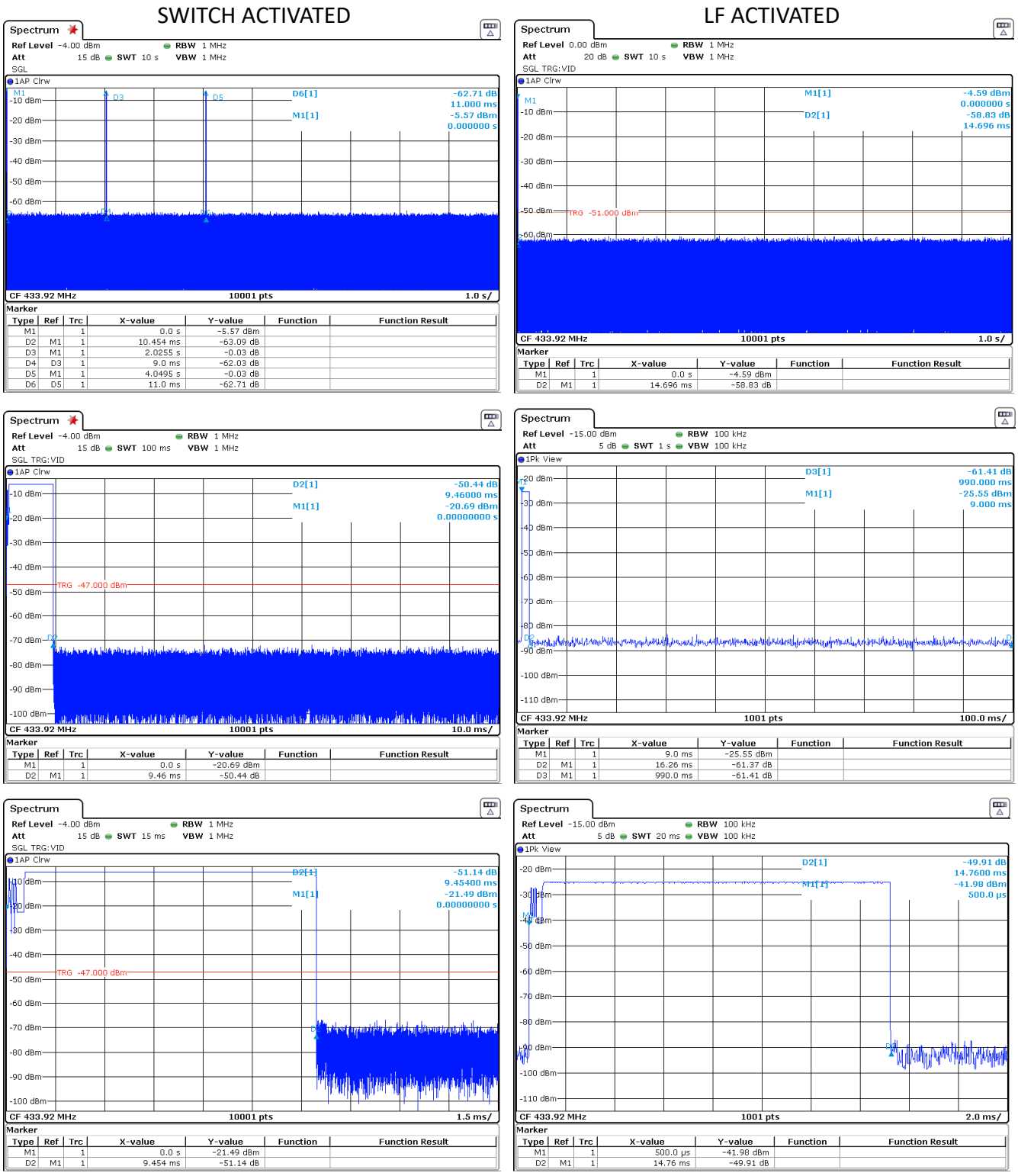

Figure 5: Fundamental Emission Pulsed Operation.

4.2.2 Fundamental Emission Bandwidth

Test Setup & Procedure The test equipment and facilities were setup in accordance with the standards and procedures listed in Section 2.1. Environmental conditions were set at the appropriate temperature and thermal balance was checked with a thermocouple based probe. Emission bandwidth (EBW) of the EUT is measured with the device placed in the test mode(s) with the shortest available frame length and minimum frame spacing. The 20 dB EBW is measured as the max-held peak-detected signal when the IF bandwidth is greater than or equal to 1% of the receiver span. For complex modulations other than ASK and FSK, the 99% emission bandwidth per IC test procedures has a different result, and is also reported. The test equipment employed includes RSFSV30001, LOGEMCO01.

Measurement Results The details and results of testing the EUT are summarized in Table 5. Plots showing the measurements made to obtain these values are provided in Figure 6.

Table 5: Fundamental Emission Bandwidth.

Detector	IF Bandwidth	Video Bandwidth		
Pk	20 kHz	100 kHz		

Test Date:	10-Nov-22
Test Engineer:	J. Nantz
EUT:	MO FOB
EUT Mode:	Normal Operating
Meas. Distance:	10 cm

							FCC/IC
R0	Mode	Center Frequency (MHz)	20 dB EBW (MHz)	EBW Limit (MHz)	99% OBW (MHz)		
R1	FSK	433.92	0.127	1.085	0.164		
#	C1	C2	C3	C4	C5	C7	C8

(ROW) (COLUMN) NOTE:

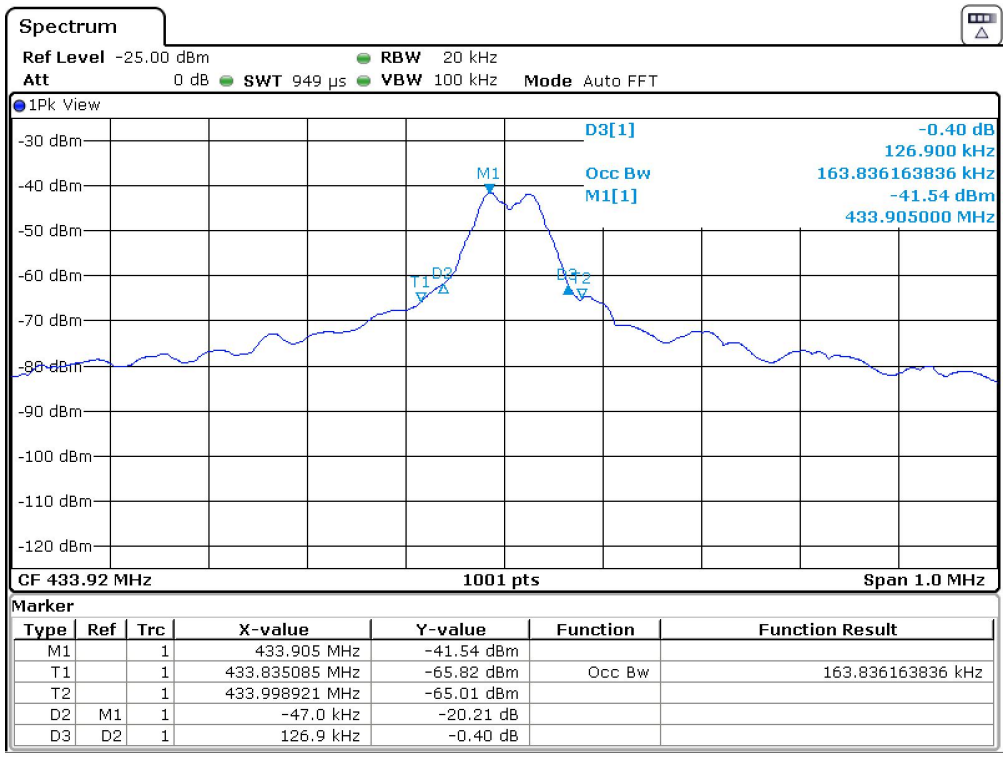

Figure 6: Fundamental Emission Bandwidth.

4.2.3 Fundamental Emission Field Strength

Test Setup & Procedure The test equipment and facilities were setup in accordance with the standards and procedures listed in Section 2.1. Environmental conditions were set at the appropriate temperature and thermal balance was checked with a thermocouple based probe. Fundamental emissions are measured at the regulatory distance on our OATS. The test equipment employed includes RSFSV30001, LOGEMCO01.

Measurement Results The details and results of testing the EUT are summarized in Table 6.

Table 6: Fundamental Emission Field Strength.

EUT Modes: a1 CW a5
a2 a6
Test Date(s): 11/09/22 a3 a7
Test Engineer: J. Nantz a4 a8

	Frequency		Site						EUT			Test Antenna				Cable	Receiver				Field Strength @ DR						EIRP		Details
	Start	Stop	Temp.	Table	MR	DR	N/F	CF									Rx Power		Bandwidth		Pk			Qpk / Avg			Pk		
R0			(C)	Angle					Mode	Volt.	Dim	Pol.	Ant.	Dim.	Ka	Kg	Pk	Avg	RBW	VBW	Meas.	Limit		Calc.	Limit		Calc.		Pass
			Hum.						sec				Height									USA	CAN		USA	CAN			Fail
	MHz	MHz	%	deg	m			dB	table	(V)	cm	H/V	m	cm	dB/m	dB	dBm		MHz		dBuV/m						dBm		dB
R1	SETUP		OATSC						MARQ1 CD1			EMCOLOG				CAB001	RSFSV30001				NOTES: H-POL - FLAT, V-POL END Worst Case Orient								
R2	433.9	433.9	21.5 / 31	90.0	3.0	3.0		0.0	a1	3.0	10.0	H	1.0	100.0	16.3	-0.1			0.12	0.30	87.0	100.8	100.8	70.4	80.8	80.8	-8.1		**10.4**
R3	433.9	433.9	21.5 / 31	180.0	3.0	3.0		0.0	a1	3.0	10.0	V	1.3	100.0	16.3	-0.1			0.12	0.30	86.1	100.8	100.8	69.5	80.8	80.8	-9.0		11.3
R4																													
R5																													
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29

(ROW)	(COLUMN)	NOTE:
R0	C5	MR is Measurement Range, which is reduced from DR to achieve necessary SNR.
R0	C6	DR is the regulatory Desired Range measurement distance.
R0	C7	N/F is Near-Field / Far-Field distance computed for max of EUT Antenna Dimension (C10) computed above 1 GHz.
R0	C8	CF is computed using a 20 dB/decade Decay Rate.
R0	C17/18	When E-field or EIRP is reported directly from Spectrum Analyzer, Antenna Factors and Cable losses are included directly in SA settings and Pr is not reported.

4.3 Unintentional Emissions

4.3.1 Transmit Chain Spurious Emissions

The results for the measurement of transmit chain spurious emissions at the nominal voltage and temperature are provided in Table 7.

Table 7: Transmit Chain Spurious Emissions.

EUT Modes: a1 CW a5
a2 a6
Test Date(s): 11/09/22 a3 a7
Test Engineer: J. Nantz a4 a8

	Frequency		Site						EUT			Test Antenna				Cable	Receiver				Field Strength @ DR							EIRP		Details
	Start	Stop	Temp.	Table	MR	DR	N/F	CF				Pol.	Ant.	Dim.	Ka	Kg	Rx Power		Bandwidth		Pk			Qpk / Avg						
R0			(C)	Angle					Mode	Volt.	Dim		Height				Pk	Avg	RBW	VBW	Meas.	Limit		Calc.	Limit			Calc.		Pass
			Hum.						see													USA	CAN		USA	CAN				Fail
	MHz	MHz	%	deg	m			dB	table	(V)	cm	H/V	m	cm	dB/m	dB	dBm		MHz		dBuV/m							dBm		dB
R1	SETUP		OATSC						MARQ1 CD1			EMCOLOG				CAB001	RSFSV30001				NOTES: H-POL - FLAT, V-POL END Worst Case Orient									
R2	867.8	867.8	15.6/ 36	220.0	3.0	3.0		0.0	a1	3.0	8.0	H	1.0	100.0	15.3	-0.2			0.12	0.30	61.1	80.8	80.8	44.5	60.8	60.8	-34.1		**16.3**
R3	867.8	867.8	15.6/ 36	0.0	3.0	3.0		0.0	a1	3.0	8.0	V	1.0	100.0	15.3	-0.2			0.12	0.30	58.7	80.8	80.8	42.1	60.8	60.8	-36.5		18.7
R4	SETUP		OATSC						MARQ1 CD1			HRNSINGQR				CAB015	RSFSV30001				NOTES: max all orientations of EUT									
R5	1301.8	1301.8	15.6/ 36	all	3.0	3.0	0.2	0.0	a1	3.0	8.0	H/V	all	15.0	22.0	-2.9			1.00	3.00	47.2	74.0	74.0	30.6	54.0	54.0	-48.0		23.4
R6	1735.7	1735.7	15.6/ 36	all	3.0	3.0	0.3	0.0	a1	3.0	8.0	H/V	all	15.0	26.7	-3.4			1.00	3.00	37.2	80.8	80.8	20.6	60.8	60.8	-58.0		40.2
R7	2169.6	2169.6	15.6/ 36	all	3.0	3.0	0.3	0.0	a1	3.0	8.0	H/V	all	15.0	29.6	-3.9			1.00	3.00	41.7	80.8	80.8	25.1	60.8	60.8	-53.5		35.7
R8	2603.5	2603.5	15.6/ 36	all	3.0	3.0	0.4	0.0	a1	3.0	8.0	H/V	all	15.0	31.1	-4.4			1.00	3.00	51.4	80.8	80.8	34.8	60.8	60.8	-43.8		26.0
R9	3037.4	3037.4	15.6/ 36	all	3.0	3.0	0.5	0.0	a1	3.0	8.0	H/V	all	15.0	31.8	-4.9			1.00	3.00	38.0	80.8	80.8	21.4	60.8	60.8	-57.2		39.4
R10	3471.4	3471.4	15.6/ 36	all	3.0	3.0	0.5	0.0	a1	3.0	8.0	H/V	all	15.0	31.9	-5.4			1.00	3.00	39.4	80.8	80.8	22.8	60.8	60.8	-55.8		38.0
R11	3905.3	3905.3	15.6/ 36	all	3.0	3.0	0.6	0.0	a1	3.0	8.0	H/V	all	15.0	32.0	-5.9			1.00	3.00	41.5	74.0	74.0	24.9	54.0	54.0	-53.7		29.1
R12	4339.2	4339.2	15.6/ 36	all	3.0	3.0	0.7	0.0	a1	4.0	8.0	H/V	all	15.0	32.3	-6.3			1.00	3.00	43.9	74.0	74.0	27.3	54.0	54.0	-51.3		26.7
R13																													
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29

(ROW)	(COLUMN)	NOTE:
R0	C5	MR is Measurement Range, which is reduced from DR to achieve necessary SNR.
R0	C6	DR is the regulatory Desired Range measurement distance.
R0	C7	N/F is Near-Field / Far-Field distance computed for max of EUT Antenna Dimension (C10) computed above 1 GHz.
R0	C8	CF is computed using a 20 dB/decade Decay Rate.
R0	C17/18	When E-field or EIRP is reported directly from Spectrum Analyzer, Antenna Factors and Cable losses are included directly in SA settings and Pr is not reported.
R3/R16	C21	Measured signal was background noise.

5 Measurement Uncertainty and Accreditation Documents

The maximum values of measurement uncertainty for the laboratory test equipment and facilities associated with each test are given in the table below. This uncertainty is computed for a 95.45% confidence level based on a coverage factor of $k = 2$.

Table 8: Measurement Uncertainty.

Measured Parameter	Measurement Uncertainty†
Radio Frequency	$\pm(f_{Mkr}/10^7 + RBW/10 + (SPN/(PTS-1))/2 + 1\,\text{Hz})$
Conducted Emm. Amplitude	$\pm 1.9\,\text{dB}$
Radiated Emm. Amplitude ($f < 30\,\text{MHz}$)	$\pm 3.1\,\text{dB}$
Radiated Emm. Amplitude ($30 - 200\,\text{MHz}$)	$\pm 4.0\,\text{dB}$
Radiated Emm. Amplitude ($200 - 1000\,\text{MHz}$)	$\pm 5.2\,\text{dB}$
Radiated Emm. Amplitude ($f > 1000\,\text{MHz}$)	$\pm 3.7\,\text{dB}$

†Ref: CISPR 16-4-2:2011+A1:2014


United States Department of Commerce
National Institute of Standards and Technology

NVLAP® ilac-MRA

Certificate of Accreditation to ISO/IEC 17025:2017

NVLAP LAB CODE: 200129-0

AHD (Amber Helm Development, L.C.)
Sister Lakes, MI

is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:

Electromagnetic Compatibility & Telecommunications

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).

2022-06-28 through 2023-06-30
Effective Dates

For the National Voluntary Laboratory Accreditation Program

Figure 7: Accreditation Documents