Amber Helm Development L.C.
92723 Michigan Hwy-152
Sister Lakes, Michigan 49047 USA
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PBCRCM-WR2422TXC
Issued: **August 22, 2024**

LF Test Report

regarding

USA: CFR Title 47, Part 15.209 (Emissions)
Canada: RSS-210v11/GENv5 (Emissions)

for

CRCM1101B1

Category: Reader Control Module

Judgments:
Complies with FCC Part 15.209, ISED RSS-210v11
Testing Completed: July 1, 2024

TESTING
NVLAP LAB CODE 200129-0

Prepared for:

PassiveBolt, Inc.

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Rpt. Auth. by: Dr. Joseph Brunett, EMC-002790-NE
Rpt. Prep./Rev. by: John Nantz — John Nantz
Date of Issue: August 22, 2024

Revision History

Rev. No.	Date	Details	Revised By
r0	August 22, 2024	Initial Release.	J. Nantz
r1	September 10, 2024	Minor changes.	J. Brunett
r2	October 7, 2024	Minor changes.	J. Nantz

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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 September 2034.

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 1.8.0 lists all sites employed herein. Specific test sites utilized are also listed in the test results sections of this report where needed.

Table 1.8.0 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 1.9.0 . 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. All equipment is evaluated on a cycle no greater than 12 months following laboratory validation procedures and is calibrated following manufacturer recommended intervals.

Table 1.9.0 Equipment List.

Description	Manufacturer/Model	SN	Quality Num.	Cal/Ver By / Date Due
Spectrum Analyzer	R & S / FSV30	101660	RSFSV3001	RS / Apr-2025
Spectrum Analyzer	R & S / FPC1500	101692	RSFPC15001	RS / Feb-2025
Shielded Loop Antenna	EMCO / 6502	9502-2926	EMCOLOOP1	Keysight / Jul-2026
Biconical	EMCO / 93110B	9802-3039	BICEMCO01	Keysight / Aug-2025
Log Periodic Antenna	EMCO / 3146	9305-3614	LOGEMCO01	Keysight / Aug-2025

2 Test Specifications and Procedures

2.1 Test Specification and General Procedures

The goal of PassiveBolt, Inc. 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 PassiveBolt, Inc. CRCM1101B1 for compliance to:

Country/Region/Manu.	**Rules or Directive**	**Referenced Section(s)**
United States	Code of Federal Regulations	CFR Title 47, Part 15.209
Canada	ISED Canada	RSS-210v11/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"
WR-ITP0102RA	"AHD Internal Document - Radiated Emissions Test Method"
WR-ITP0101LC	"AHD Internal Document - Conducted Emissions Test Method"

3 Configuration and Identification of the Equipment Under Test

3.1 Description and Declarations

The EUT is wireless gateway module for use in electronic access systems. The EUT is approximately 4.5 x 4.5 x 1 cm in dimension, and is depicted in Figure 3.1.0 . It is powered by 5 Vdc host power system. This device is a modular radio intended to be installed into electronic access products. Table 3.1.0 outlines provider declared EUT specifications.

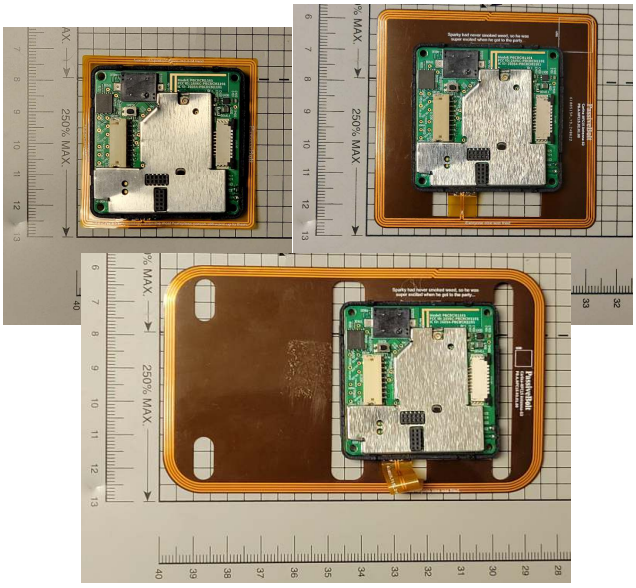

Figure 3.1.0 Photos of EUT.

Table 3.1.0 EUT Declarations.

General Declarations	
Equipment Type:	Reader Control Module
Country of Origin:	USA
Nominal Supply:	5 Vdc
Oper. Temp Range:	Not Declared
Frequency Range:	125 kHz
Antenna Dimension:	Integral
Antenna Type:	Wire Coil
Antenna Gain:	Integral
Number of Channels:	1
Channel Spacing:	None
Alignment Range:	Not Declared
Type of Modulation:	ASK+FSK
United States	
FCC ID Number:	2AV6C-CRCM1101B1
Classification:	DXX
Canada	
IC Number:	26054-CRCM1101B1
Classification:	Remote Control Device

3.1.1 EUT Configuration

The EUT is configured for testing as depicted in Figure 3.1.1 .

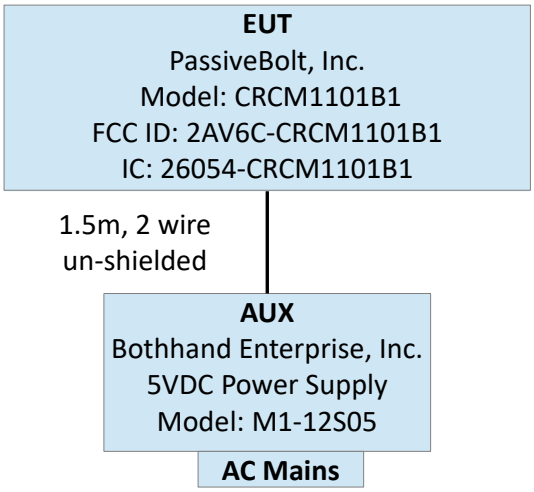

Figure 3.1.1 EUT Test Configuration Diagram.

3.1.2 Modes of Operation

The EUT is capable of two LF modes of operation, POLLING continuously to detect a 125 kHz tag and TAG READ interrogation if detected. Both modes are tested herein. This product is also populated with a 13.56 MHz tag reader circuitry with test data reported in AHD Report No. PBCRCM-WR2422TXB and a BLE transceiver circitry with test data reported in AHD Report No. PBCRCM-WR2422TXA. Digital spurious and AC mains spurious emissions are reported with all radio components active in AHD Report No. PBCRCM-WR2422TXA.

3.1.3 Variants

There is only a single version of the EUT, but the NFC tag reader may be populated by 3 different NFC antennas. All three were evaluated and the worst case emissions including all antenna variants are reported herein.

3.1.4 Test Samples

Two samples of the EUT were provided for testing (SN: 2CA7742EE299, 7446B3EB8FE8), both capable of CW and modulated transmission of the LF radio via a mobile application (PDQ Dev, version 2.1.2). This product is also populated with a 13.56 MHz tag reader circuitry which can employ three different NFC film antennas. Emissions with all three NFC antennas are reported herein.

3.1.5 Functional Exerciser

Normal functionality was confirmed by measurement of transmitted signals.

3.1.6 Modifications Made

There were no modifications made to the EUT by this laboratory.

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 a module, subject to further compliance evaluation in every host access product into which it may be employed. The manufacturer provides host integration instructions in compliance with FCC KDB 996369 D04 Module Integration Guide v02.

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 4.1.1 . 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.

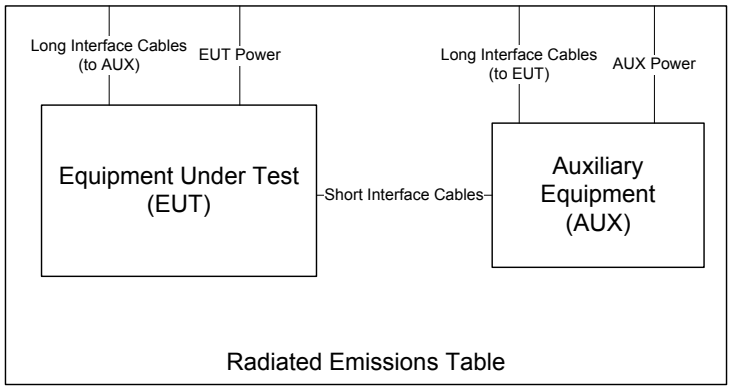

Figure 4.1.1 Radiated Emissions Diagram of the EUT.

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 4.1.1 .

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.

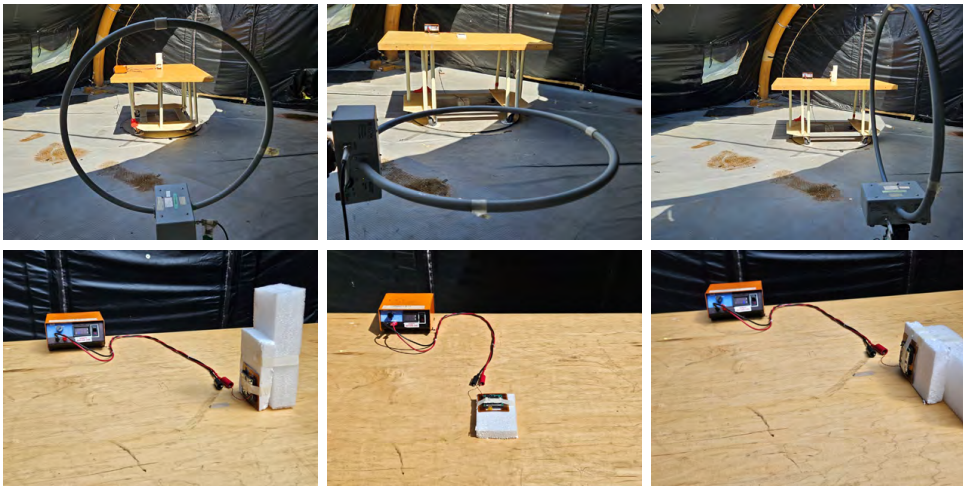

Figure 4.1.1 Radiated Emissions Test Setup Photograph(s).

4.1.2 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.

4.2 Intentional Emissions

4.2.1 Fundamental Emission Pulsed Operation

The details and results of testing the EUT for pulsed operation are summarized in Table 4.2.1 .

Table 4.2.1 Pulsed Emission Characteristics (Duty Cycle).

Test Date: 23-Jul-24
Test Engineer: John Nantz
EUT Mode: See Below
Meas. Distance: 10cm
EUT Tested: PassiveBolt CRCM1101B1

		Overall Transmission			Internal Frame Characteristics			Computed Duty Cycle*	
#	EUT Mode	Min. Repetition Rate (sec)	Max. No. of Frames	Total Transmission Length (sec)	Max. Frame Length (ms)	Min. Frame Period (s)	Frame Encoding	(%)	Duty (dB)
1	Polling 125kHz	2.39	2	1.839	1488.0	0.9	When first powered, the EUT performs a single poll for the presense of an access tag via a 351.4ms frame followed by a 1.488s frame all within 2.39s.	100.000	*
2	Tag Read 125kHz	N/A	1	0.52748	527.5	-	When a tag is presented to the EUT, it is interrogated via a 527.5ms long transmission.	100.000	*

* No Duty Cycle is employed when demonstrating compliance.

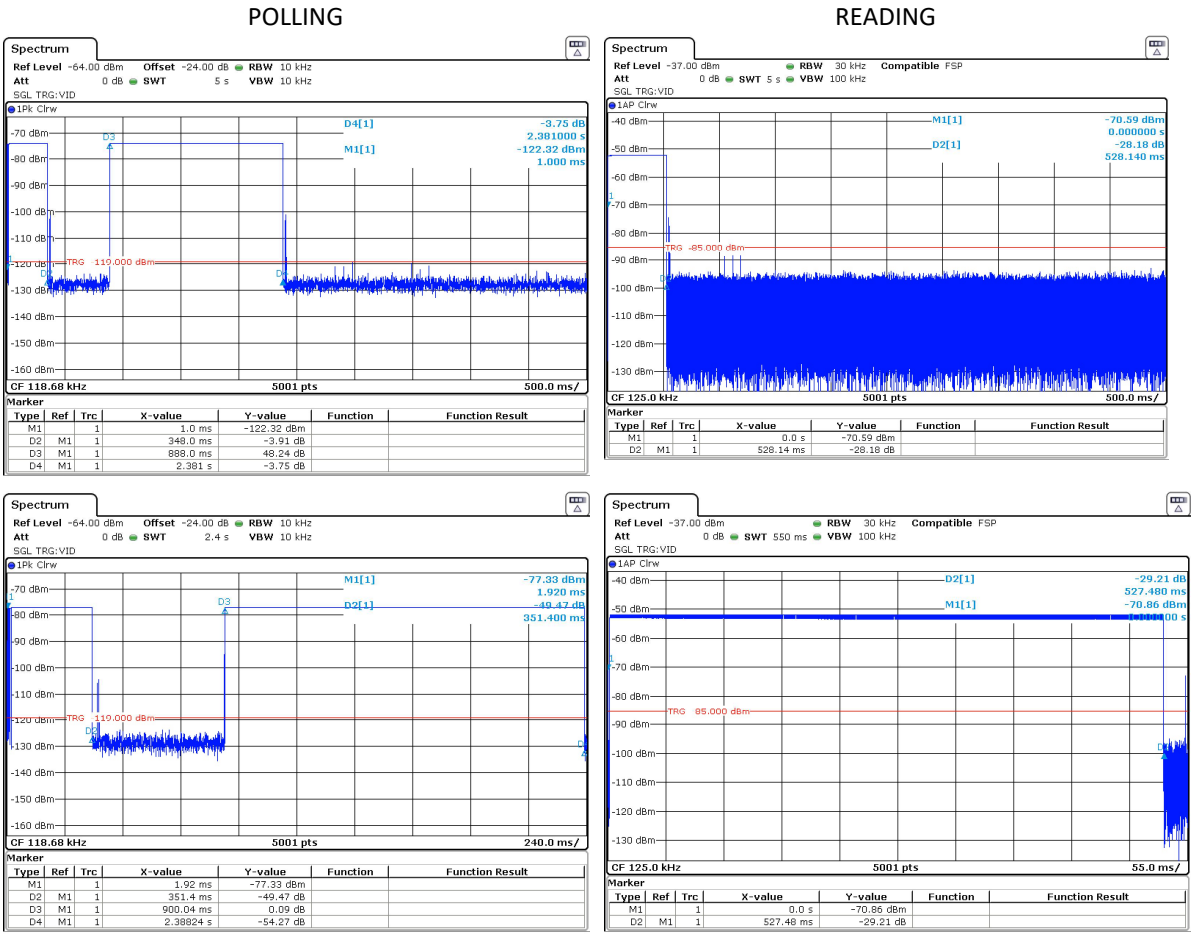

Figure 4.2.1 Example Pulsed Emission Characteristics (Duty Cycle).

4.2.2 Fundamental Emission Bandwidth

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. Radiated emissions are recorded following the test procedures listed in Section 2.1. 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 separately reported.The results of EBW testing are summarized in Table 4.2.2 . Plots showing measurements employed to obtain the emission bandwidth reported are provided in Figure 4.2.2 .

Table 4.2.2 Intentional Emission Bandwidth.

Frequency Range	Det	IF Bandwidth	Video Bandwidth		
9 kHz ≤ f ≤ 150 kHz	Pk	> 1% Span	>= 3 * IFBW	**Test Date:**	23-Jul-24
150 kHz ≤ f ≤ 30 MHz	Pk	> 1% Span	>= 3 * IFBW	**Test Engineer:**	John Nantz
				EUT Mode:	See Below
				Meas. Distance:	10cm
				EUT Tested:	PassiveBolt CRCM1101B1

#	Mode	Frequency (MHz)	Temp (C)	Supply (VDC)	20 dB EBW (kHz)	99% EBW (kHz)	110 kHz Restricted Band* (dBc)		
1	Polling	0.1186803	23	5	0.8035	0.72086	50.44		
2	Tag Read	0.11869	23	5	0.7825	2.63847	45.85		

* Note: The EUT emissions in the 90-110 kHz restricted band are within 20 dB of the fundamental. However, the FCC permits emissions in that band so long as they are beyond the first null of the modulated spectrum, as those are not considered part of the fundamental intentional emission.

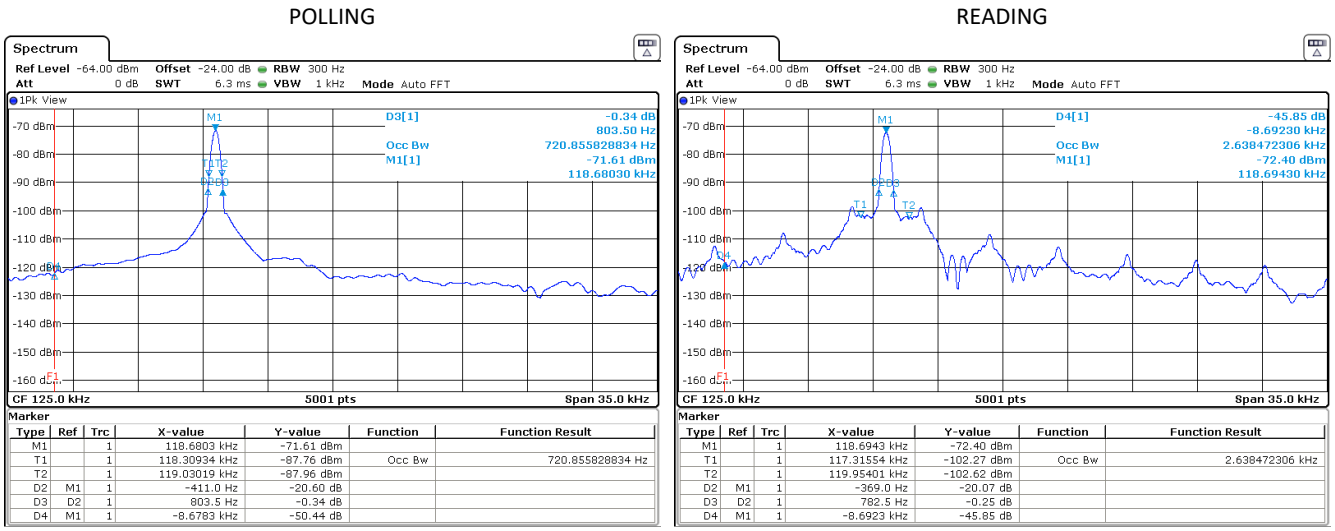

Figure 4.2.2 Example Intentional Emission Bandwidth.

4.2.3 Fundamental Emission

Following the test procedures listed in Section 2.1, field emissions measurements are made on the EUT for both Horizontal and Vertically polarized coupling fields. The EUT's loop antenna(s) are measured along all three axes, including when the EUT loop axes are aligned in the same axis as the test loop and aligned coplanar (in the same plane) with the test loop antenna. Table 4.2.3 details the results of these measurements.

Table 4.2.3 Fundamental Radiated Emissions.

Frequency Range	Det	IF Bandwidth	Video Bandwidth
9 kHz ≤ f ≤ 150 kHz	Pk/QPk	200 Hz	300 Hz
150 kHz ≤ f ≤ 30 MHz	Pk/QPk	9 kHz	30 kHz
25 MHz ≤ f ≤ 1 000 MHz	Pk/QPk	120 kHz	300 kHz
f > 1 000 MHz	Pk	1 MHz	3MHz
f > 1 000 MHz	Avg	1 MHz	3MHz

Test Date:	23-Jul-24
Test Engineer:	John Nantz
EUT Mode:	CM
Meas. Distance:	3 meters
EUT Tested:	PassiveBolt CRCM1101B1

Fundamental Emissions Measurements

#	Mode	EUT Orientation	Freq. kHz	Ant. Used QN	Ant.** Height m	Table Azim deg	Ka dB/m	Kg dB	Cf*** 3m / 300m dB	E-field @ 3m Pk dBuV/m	E-field @ 3m Qpk	E-field @ 300m Pk dBuV/m	E-field @ 300m Qpk dBuV/m	E-field @ 300m Limit Qpk	H-field @ 300m (ISED) Pk dBuA/m	H-field @ 300m (ISED) Qpk dBuA/m	H-field @ 300m (ISED) Limit Qpk	Pass By***
1	CM	Flat	118.7	EMCOLOOP1	1.0	0	10.1	0.0	80.0	81.5		1.5		26.1	-50.0		-25.4	**24.6**
2		Side	118.7	EMCOLOOP1	1.0	0	10.1	0.0	80.0	76.2		-3.8		26.1	-55.3		-25.4	29.9
3		End	118.7	EMCOLOOP1	1.0	0	10.1	0.0	80.0	77.6		-2.4		26.1	-53.9		-25.4	28.5

#	Mode	Test Antenna Polarization	Freq. kHz	DC Supply Voltage	E-field dBuV/m
4	CM	Flat	118.7	6.5	81.5
5			118.7	5.0	81.5
6			118.7	4.0	81.5
7			118.7	3.0	81.5
8			118.7	2.0	OFF

Measured DUT's Field Decay Rate Applied for Cf

Freq MHz	Dist from EUT m	E-field dBuV/m	Extrapolate Cf (Dist vs Distance)
#REF!	.5	133.8	-20.845 ln(x) + 129.55
#REF!	1.0	130.0	Base10 Rate of Decay***
#REF!	1.5	126.9	(dB/dec)
#REF!	2.0	123.7	**40.0**
#REF!	3.0	90.7	

* EUT is tested in CM (CONTINOUSLY MODULATED). No averaging applies and Quasi-Peak data was not needed to demonstrate compliance.

** Emissions were evaluated at 1m test antenna height.

*** EUT field decay rate is assumed to be 40 dB/dec in line with regulatory allowance.

*** A Ln (x) = 2.303*A Log(x).

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 4.3.1 . Following the test procedures listed in Section 2.1, field emissions measurements are made on the EUT for both Horizontal and Vertically polarized coupling fields. The EUT's loop antenna(s) are measured when the EUT loop axes placed in all three axes, including when they are aligned along the same axis as the test loop antenna and are aligned coplanar with the test loop antenna. For all arrangements, test loop is rotated for maximum field. The results for the measurement of transmit chain spurious emissions at the nominal voltage and temperature are provided in Table 4.3.1 . Measurements are performed to 10 times the highest fundamental operating frequency.

Table 4.3.1 Transmit Chain Spurious Emissions.

Frequency Range	Det	IF Bandwidth	Video Bandwidth		
9 kHz ≤ f ≤ 150 kHz	Pk/QPk	200 Hz	300 Hz	**Test Date:**	9-Jul-24
150 kHz ≤ f ≤ 30 MHz	Pk/QPk	9 kHz	30 kHz	**Test Engineer:**	John Nantz
25 MHz ≤ f ≤ 1 000 MHz	Pk/QPk	120 kHz	300 kHz	**EUT Mode:**	CW
f > 1 000 MHz	Pk/Avg	1 MHz	3MHz	**Meas. Distance:**	3 meters
				EUT Tested:	PassiveBolt CRCM1101B1

Transmit Chain Spurious Emissions

#	Mode	EUT Orientation	Freq. kHz	Ant. Used	Ant.** Height m	Table Azim deg	Ka dB/m	Kg dB	Cf*** (3 to 30/300m) dB	E-field @ 3m Pk dBuV/m	E-field @ 3m Qpk dBuV/m	E-field @ 30/300m ****Pk dBuV/m	E-field @ 30/300m Qpk dBuV/m	E-field @ 30/300m Limit Qpk dBuV/m	H-field @ 30/300m (ISED) Pk dBuA/m	H-field @ 30/300m (ISED) Qpk dBuA/m	H-field @ 30/300m (ISED) Limit Qpk dBuA/m	Pass By	Comments
1	CW	Max All, Worst	237.4	EMCOLOOP1	1.0	90	10.0	0.0	80.0	57.0		-23.0		20.1	-74.5		-31.4	43.1	background
2		Max All, Worst	356.1	EMCOLOOP1	1.0	90	10.0	0.0	80.0	57.0		-23.0		16.6	-74.5		-34.9	39.6	background
3		Max All, Worst	474.8	EMCOLOOP1	1.0	90	10.2	0.0	40.0	46.2		6.2		14.1	-45.3		-17.4	**7.9**	background
4		Max All, Worst	593.5	EMCOLOOP1	1.0	90	10.2	0.0	40.0	43.9		3.9		32.1	-47.6		-19.4	28.2	background
5		Max All, Worst	712.2	EMCOLOOP1	1.0	90	10.1	0.0	40.0	47.7		7.7		30.6	-43.8		-21.0	22.9	background
6		Max All, Worst	830.9	EMCOLOOP1	1.0	90	10.3	0.0	40.0	46.2		6.2		29.2	-45.3		-22.3	23.0	background
7		Max All, Worst	949.6	EMCOLOOP1	1.0	90	11.5	0.0	40.0	45.5		5.5		28.1	-46.0		-23.5	22.6	background
8		Max All, Worst	1068.3	EMCOLOOP1	1.0	90	11.3	0.0	40.0	44.8		4.8		27.0	-46.7		-24.5	22.2	background
9		Max All, Worst	1187.0	EMCOLOOP1	1.0	90	12.3	0.0	40.0	47.4		7.4		26.1	-44.1		-25.4	18.7	background

* EUT was tested in CW mode. No averaging applied and Quasi-Peak data was not needed to demonstrate compliance.

** Emissions were evaluated at 1m test antenna height from 9 kHz to 30 MHz. No significant spurious were observed past the 10th harmonic.

*** FCC E-field 40 dB/dec decay assumed. EUT field decay rate was not measured over a range of distances to determine CF between measurement and limit distance.

**** Maximum of all coupling orientations

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 5.0.0 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).

2023-06-20 through 2024-06-30
Effective Dates

For the National Voluntary Laboratory Accreditation Program

Figure 5.0.0 Accreditation Documents