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PBCRCM-WR2422TXB
Issued: **August 22, 2024**

NFC Test Report

regarding

USA: CFR Title 47, Part 15.225 (Emissions)
Canada: RSS-210v10/GENv5 (Emissions)

for



CRCM1101B1

Category: Reader Control Module

Judgments:

Complies with FCC Part 15.225, and ISED RSS-210v11

Testing Completed: July 1, 2024



Prepared for:

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r0	August 22, 2024	Initial Release.	J. Nantz
r1	September 10, 2024	Minor changes.	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 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

This report shall not be reproduced, except in full, without the written approval of Amber Helm Development L.C.

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 15.225
Canada	ISED Canada	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”	
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 12 x 7.5 x 1 cm max. 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.

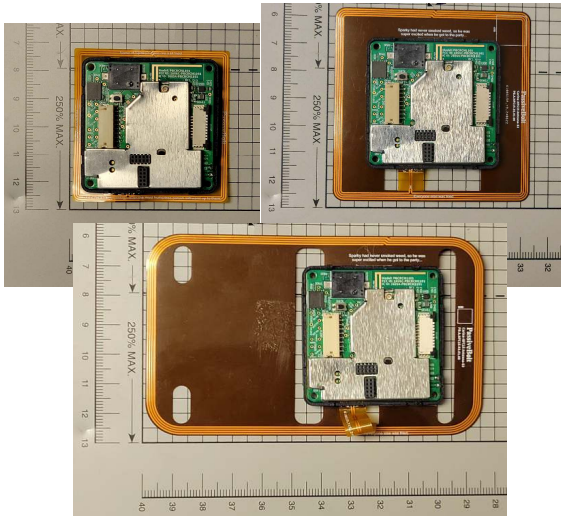


Figure 3.1.0 Photos of EUT.

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:	13.56 MHz
Antenna Dimension:	Integral
Antenna Type:	Integral Flexible Printed Circuit (FPC)
Antenna Gain:	Integral
Number of Channels:	1
Channel Spacing:	None
Alignment Range:	Not Declared
Type of Modulation:	ASK
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 .

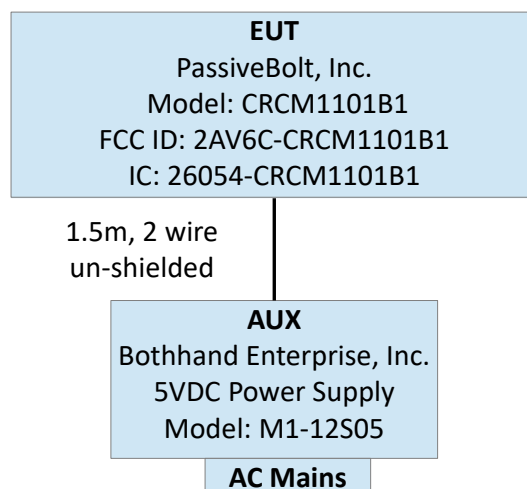


Figure 3.1.1 EUT Test Configuration Diagram.

3.1.2 Modes of Operation

The EUT is capable of two modes of operation, POLLING to detect a 13.56 MHz tag and TAG READ interrogation if detected. Both modes are tested herein. In addition to its NFC radio functionality, the EUT is also co-located with an onboard BLE radio (addressed in AHD Report No.PBCRCM-WR2422TXA) and a 125 kHz LF radio (addressed in AHD Report No.PBCRCM-WR2422TXC). Spurious emissions from the EUT's digital electronics as well as AC conducted emissions when employing a representative AC power adapter are reported herein with all radios active. The integral BLE + NFC or BLE + LF radios are all capable of simultaneous transmission, however the NFC and LF radios are not capable of simultaneous operation. Digital spurious and AC mains spurious emissions are reported 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 NFC radio via a mobile application (PDQ Dev, version 2.1.2). Three NFC antenna samples were provided for testing demonstrating min, mid and max performance options for the antennas.

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.

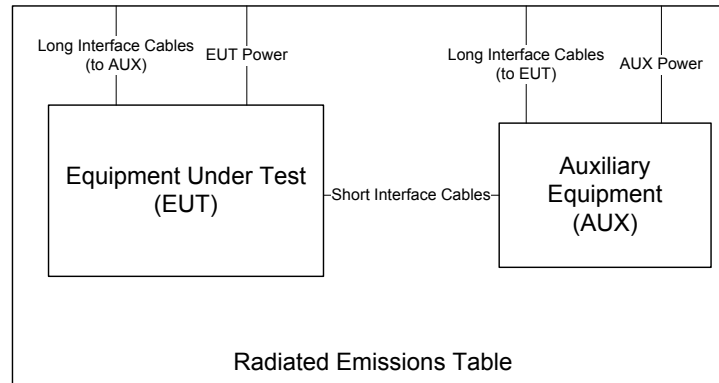


Figure 4.1.1 Radiated Emissions Diagram of the EUT.

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 ISSED 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° 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.

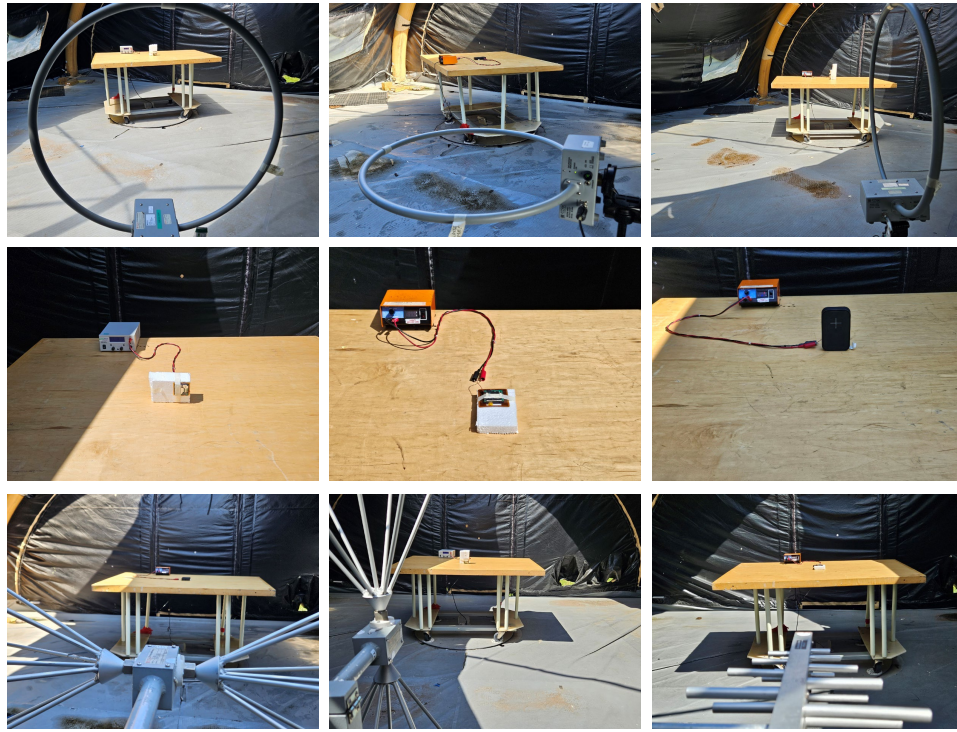


Figure 4.1.1 Radiated Emissions Test Setup Photograph(s).

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).

Frequency Range		Det	IF Bandwidth	Video Bandwidth	Test Date:	
9 kHz ≤ f ≤ 150 kHz		Pk/QPk	200 Hz	300 Hz	18-Jul-24	
150 kHz ≤ f ≤ 30 MHz		Pk/QPk	9 kHz/10 kHz	30 kHz	Test Engineer:	
25 MHz ≤ f ≤ 1 000 MHz		Pk/QPk	120 kHz	300 kHz	J. Nantz	
f > 1 000 MHz		Pk	3 MHz	3MHz	EUT Mode:	
f > 1 000 MHz		Avg	3 MHz	10kHz	Normal Operating	
					Meas. Distance:	
					3 meters	
					EUT Tested:	
					PassiveBolt CRCM1101B1	

R0	EUT Mode	Overall Transmission			Internal Frame Characteristics		Computed Duty Cycle	
		Min. Repetition Rate (sec)	Max. No. of Frames	Total Transmission Length (sec)	Max. Frame Length (ms)	Min. Frame Period (ms)	Frame Encoding	Computed Duty Cycle
R1	13.56 MHz Polling	0.979	14	-	6.72	13.46	In normal operation the EUT NFC device transmits 14 short pulses at 13.56 MHz every 979 ms looking for a tag (coil loading change).	N/A
R2	13.56 MHz Tag Read	Single	1	-	128.52	-	When a tag is detected the EUT NFC device will transmit a longer (128.52 ms) frame to read the tag. This frame occurs on every tag read.	N/A
#	C1	C2	C3	C4	C5	C6	C7	C8
(ROW)	R0	(COLUMN)	C8/C9	NOTE: No Duty Cycle is employed when demonstrating compliance.				

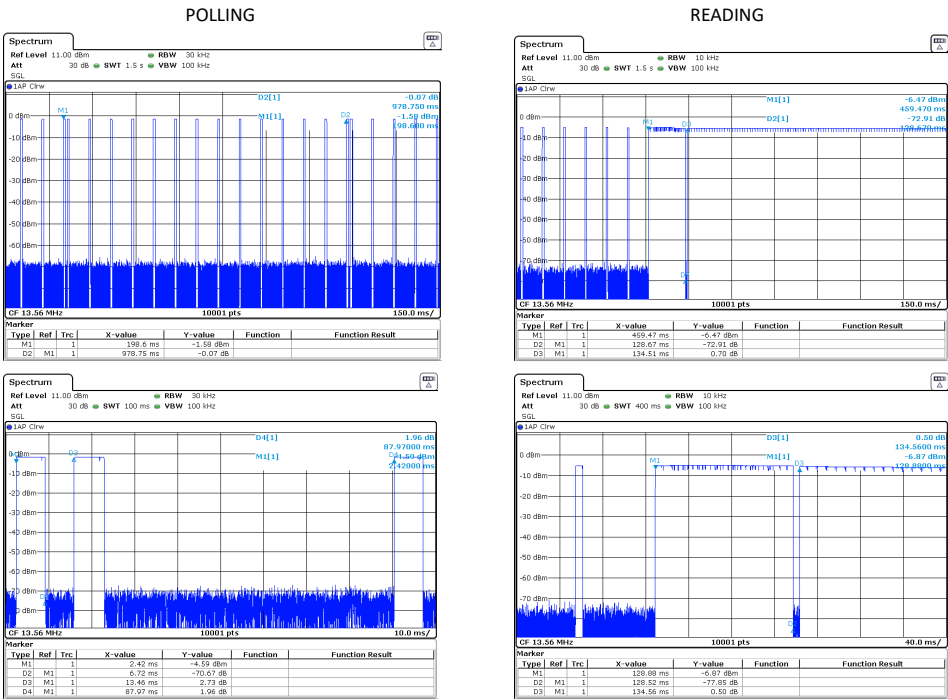


Figure 4.2.1 Example Pulsed Emission Characteristics (Duty Cycle).

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.

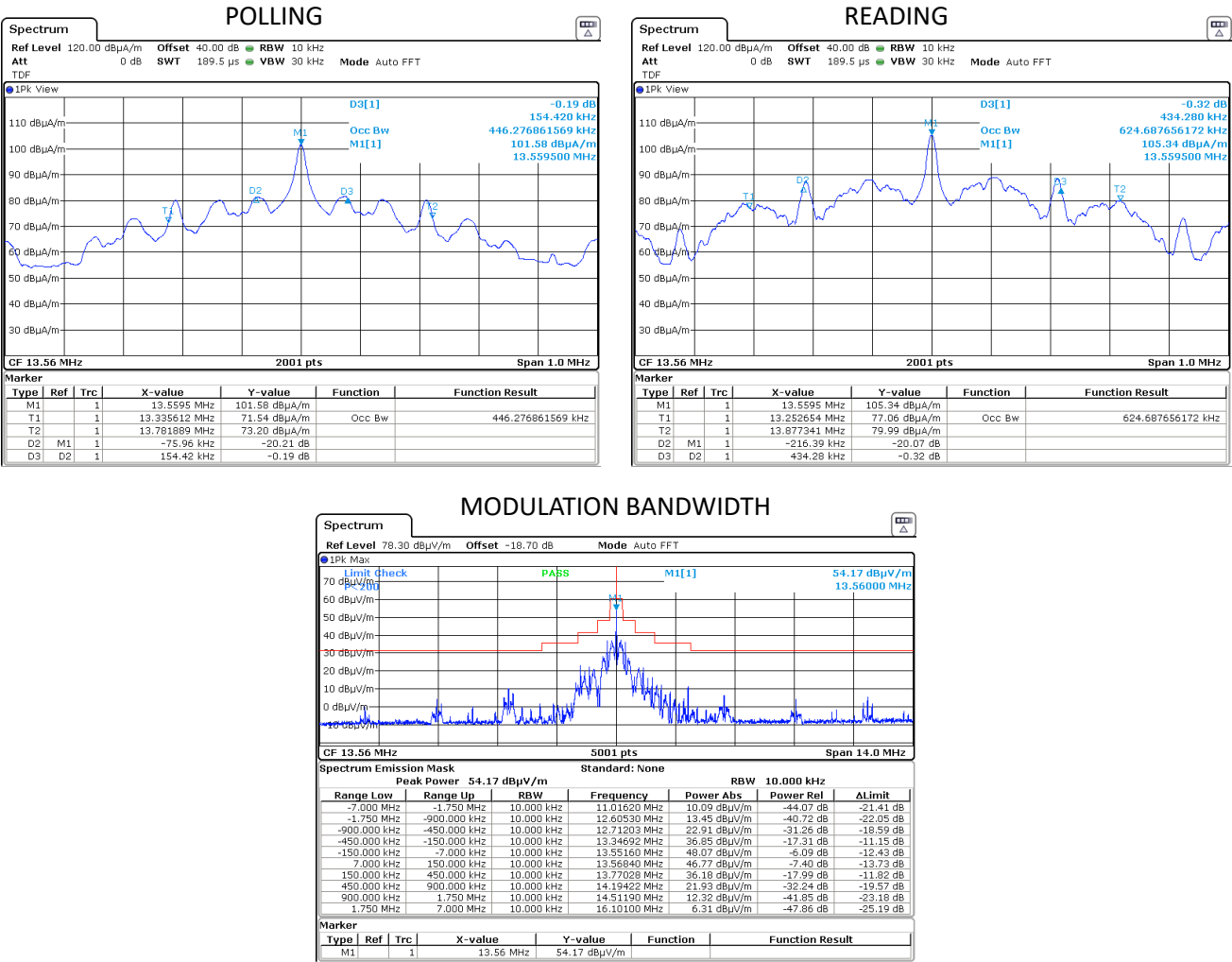
Frequency Range	Det	IF Bandwidth	Video Bandwidth	Test Date:	18-Jul-24
9 kHz $\leq f \leq$ 150 kHz	Pk	> 1% Span	$\geq 3 * \text{IFBW}$	Test Engineer:	J. Nantz
150 kHz $\leq f \leq$ 30 MHz	Pk	> 1% Span	$\geq 3 * \text{IFBW}$	EUT Mode:	See Below
				Meas. Distance:	0.1 meters
				EUT Tested:	PassiveBolt CRCM1101B1

R0	Mode	Frequency Range (MHz)	Temp (C)	Supply (V)	99% PWR BW (kHz)	20 dB EBW (kHz)	fL (20 dBc) (MHz)	fH (20 dBc) (MHz)
R1	13.56 MHz Polling	13.56	20	5	446.28	154.40	13.484	13.638
R2	13.56 MHz Tag Read	13.56	20	5	624.69	434.28	13.343	13.777
#	C1	C2	C3	C4	C5	C6	C7	C9

(ROW)

(COLUMN)

NOTE:



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		Test Date:		18-Jul-24	
9 kHz ≤ f ≤ 150 kHz														Pk/QPk		200 Hz		300 Hz		Test Engineer:		J. Nantz	
150 kHz ≤ f ≤ 30 MHz														Pk/QPk		9 kHz		30 kHz		Meas. Distance:		3 meters	
30 MHz ≤ f ≤ 1 000 MHz														Pk/QPk		120 kHz		300 kHz		EUT Tested:		PassiveBolt CRCM1101B1	
																				EUT Mode:		CM	

Fundamental Emissions Measurements																				
R0	Mode / Antenna	Test Antenna	Freq.	Ant.	Ant	Table	Meas. Dist.	Pr	Ka	Kg	NF/FF boundary m	Cf	E3m (Pk)	E30m			H30m			Pass By
		Polarization	MHz	Used	Ht.	Angle	m	dBm	dB/m	dB		3 m / 30 m dB	Pk dBuV/m	Pk	QPk/Avg	Limit	Pk	QPk/Avg	Limit	
R1	CM (Min Antenna)	Coaxial	13.56	EMCOLOOP1	1.0	90.0	3.0		16.9	0.8	3.5	20.0	65.0	45.0		84.0	-6.5			39.0
R2		Coplanar – Horz	13.56	EMCOLOOP1	1.0	90.0	3.0		16.9	0.8	3.5	20.0	55.1	35.1		84.0	-16.4			48.9
R3		Coplanar – Vert	13.56	EMCOLOOP1	1.0	90.0	3.0		16.9	0.8	3.5	20.0	59.2	39.2		84.0	-12.3			44.8
R4		Coaxial	13.56	EMCOLOOP1	1.0	90.0	3.0		16.9	0.8	3.5	20.0	74.3	54.3		84.0	2.8			29.7
R5	CM (Mid Antenna)	Coplanar – Horz	13.56	EMCOLOOP1	1.0	90.0	3.0		16.9	0.8	3.5	20.0	64.7	44.7		84.0	-6.8			39.3
R6		Coplanar – Vert	13.56	EMCOLOOP1	1.0	90.0	3.0		16.9	0.8	3.5	20.0	71.6	51.6		84.0	.1			32.4
R7	CM (Max Antenna)	Coaxial	13.56	EMCOLOOP1	1.0	90.0	3.0		16.9	0.8	3.5	20.0	75.1	55.1		84.0	3.6			28.9
R8		Coplanar – Horz	13.56	EMCOLOOP1	1.0	90.0	3.0		16.9	0.8	3.5	20.0	64.6	44.6		84.0	-6.9			39.4
R9		Coplanar – Vert	13.56	EMCOLOOP1	1.0	90.0	3.0		16.9	0.8	3.5	20.0	71.8	51.8		84.0	.3			32.2

Frequency Stability over Temperature/Voltage																				
R10	Mode	Temp (°C)	Freq. (MHz)	Voltage (VDC)	Freq. Variation (+/- ppm)				Freq. Variation Limit (+/- ppm)				Pass							
R11	CM	20	13.559765	5.0					BASELINE				TRUE							
R12	CM	-20	13.559767	5.0	0				100											
R13	CM	55	13.559690	5.0	-6				100											
R14	CM	20	13.559765	6.0	0				100											
R15	CM	20	13.559765	4.0	0				100											
R16	CM	20	13.559765	3.0	0				100											
R17	CM	20		2.0	off				100											
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20

(ROW)	(COLUMN)	NOTE:
R0	C1	EUT was tested in CM mode. No averaging applied, Peak data reported to demonstrate compliance.
R0	C11	NF/FF Boundary at lambda/2pi distance for small radiator.
R0	C12	40 dB/dec near field conversion factor, 20 dB/dec far-field conversion factors are permitted. 20dB is chosen to show compliance under worst case conversion.
R0	C13	When E-field is reported directly from Spectrum Analyzer, Antenna Factors and Cable losses are included directly in SA settings.
R0	C17	H-field is computed by subtracting dBΩ in freespace from E-Field measurements = 20*log(120π) = 51.5dB

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	±1.9 dB
Radiated Emm. Amplitude ($f < 30 \text{ MHz}$)	±3.1 dB
Radiated Emm. Amplitude (30 – 200 MHz)	±4.0 dB
Radiated Emm. Amplitude (200 – 1000 MHz)	±5.2 dB
Radiated Emm. Amplitude ($f > 1000 \text{ MHz}$)	±3.7 dB

[†]Ref: CISPR 16-4-2:2011+A1:2014



Figure 5.0.0 Accreditation Documents