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

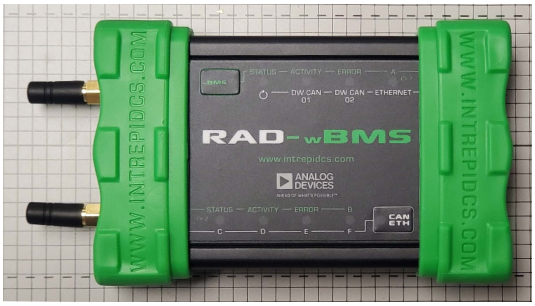
IwBMS-WR2237TX
Issued: **January 12, 2023**

EMC Test Report

regarding

USA: CFR Title 47, Part 15.247 (Emissions)
Canada: IC RSS-247v2/GENv5 (Emissions)

for



RAD-wBMS

Category: DTS Transceiver

Judgments:
Aligns with FCC Part 15.247, ISED RSS-247v2
Testing Completed: January 11, 2023

TESTING
NVLAP LAB CODE 200129-0

Prepared for:

Intrepid Control Systems, Inc.

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Rpt. Auth. by: Dr. Joseph Brunett, EMC-002790-NE
Date of Issue: January 12, 2023

Revision History

Rev. No.	Date	Details	Revised By
r0	January 12, 2023	Initial Release.	J. Brunett
r1	February 23, 2023	Updated tables for gain/distance.	J. Nantz
r2	May 10, 2023	Corrected Antenna Gain	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 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
Spectrum Analyzer	R & S / FSV30	101660	RSFSV30001	RS / Apr-2023
Spectrum Analyzer	R & S / FPC1000	101060	RSFPC1K01	RS / Jan-2023
Quad Ridge Horn	Singer / A6100	C35200	HQR1TO18S01	Keysight / Aug-2024
Biconical	EMCO / 93110B	9802-3039	BICEMCO01	Keysight / Aug-2023
Log Periodic Antenna	EMCO / 3146	9305-3614	LOGEMCO01	Keysight / Aug-2023
K-Band Horn	JEF / NRL Std.	001	HRNK01	AHD / Jul-2023
LISN	Solar / 8012-50-R-24-BNC	970917	LISNB	AHD / February-2024
BNC-BNC Coax	WRTL / RG58/U	001	CAB001-BLACK	AHD / Sept-2023
3.5-3.5MM Coax	PhaseFlex / PhaseFlex	001	CAB015-PURP	AHD / Jun-2023

2 Test Specifications and Procedures

2.1 Test Specification and General Procedures

The goal of Intrepid Control Systems, 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 Intrepid Control Systems, Inc. RAD-wBMS for compliance to:

Country/Region	**Rules or Directive**	**Referenced Section(s)**
United States	Code of Federal Regulations	CFR Title 47, Part 15.247
Canada	ISED Canada	IC RSS-247v2/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"
KDB 558074 D01 v05r02	"GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES "
KDB 662911 D01v02r01	"Emissions Testing of Transmitters with Multiple Outputs in the Same Band"
KDB 662911 D02 v01	"MIMO with Cross-Polarized Antenna"
TP0102RA	"AHD Internal Document TP0102 - Radiated Emissions Test Procedure"
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 EUT is an DTS transmitter used as a network manager to monitor the state of health of multiple battery cells. The EUT employs two identical radios with dedicated external antennas. The EUT is used for vehicle battery development, manufacturing and testing applications. The EUT is approximately 14 x 9 x 3.5 cm in dimension, and is depicted in Figure 1. It is powered by 6-40 VDC mains power adapter. This product is used as a wireless battery cell state of health network manager. Table 3 outlines provider declared EUT specifications.

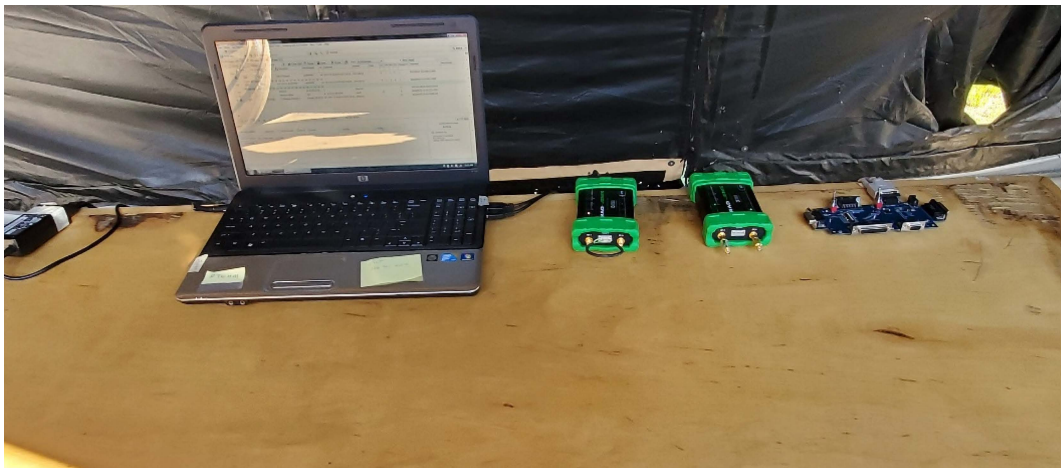


Figure 1: Photos of EUT.

Table 3: EUT Declarations.

General Declarations	
Equipment Type:	DTS Transceiver
Country of Origin:	Not Declared
Nominal Supply:	6-40 VDC
Oper. Temp Range:	Not Declared
Frequency Range:	2405 - 2475 MHz
Antenna Dimension:	2.5 x 0.75 cm
Antenna Type:	Short Whip
Antenna Gain:	0.56 dBi max.
Number of Channels:	15
Channel Spacing:	5 MHz
Alignment Range:	Not Declared
Type of Modulation:	GFSK
United States	
FCC ID Number:	2A923230117BMSE1
Classification:	DTS
Canada	
IC Number:	29961-230117BMSE1
Classification:	DTS

3.1.1 EUT Configuration

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

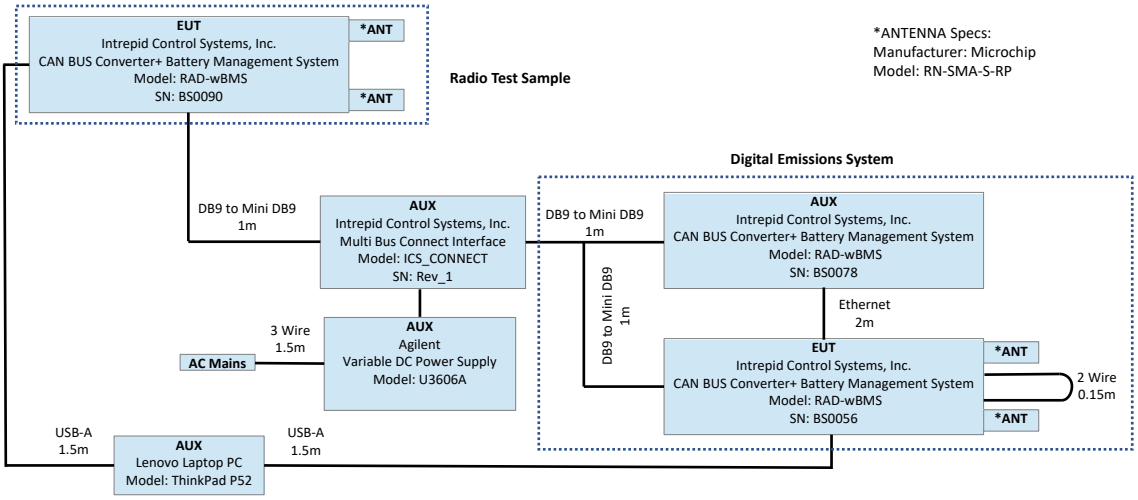


Figure 2: EUT Test Configuration Diagram.

3.1.2 Modes of Operation

The EUT employs both 1Mbps and 2Mbps modulations on each of its two radios, each employing 15 operating channels. In normal use the EUT routes or converts automotive bus traffic via ethernet / USB / CAN / and wireless battery cell monitoring. The manufacturer provided software for radio configuration and for monitoring the device performance during testing.

3.1.3 Variants

There is only a single variant of the EUT.

3.1.4 Test Samples

Two samples of the EUT were provided for DTS emissions testing. One which is programmed with a radio test firmware configurable by laptop for radio testing (SN: BS0090) and one normal operating sample (SN:BS0056), both of which were tested herein.

3.1.5 Functional Exerciser

The manufacturer provided a laptop with a special GUI to monitor each port during testing (green light good, red light bad)

3.1.6 Modifications Made

Pretesting indicated the radio power level had to be reduced to a setting of 6 to ensure near-band intermodulation products comply with the regulations when both radios are active. Final testing was performed on samples with this power level implemented by the manufacturer.

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 integrates two identical radios which can be operated simultaneously but never on the same channel. As such, radiated intermodulation testing was performed with both radios operating in combinations of low, mid and high channels to assess compliance of which results are contained herein. The EUT also employs external antennas with RP-SMA connectors.

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.

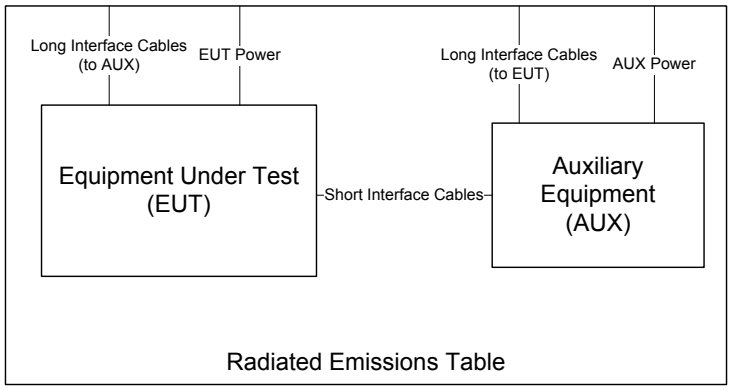


Figure 3: Radiated Emissions Diagram of the EUT.

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.

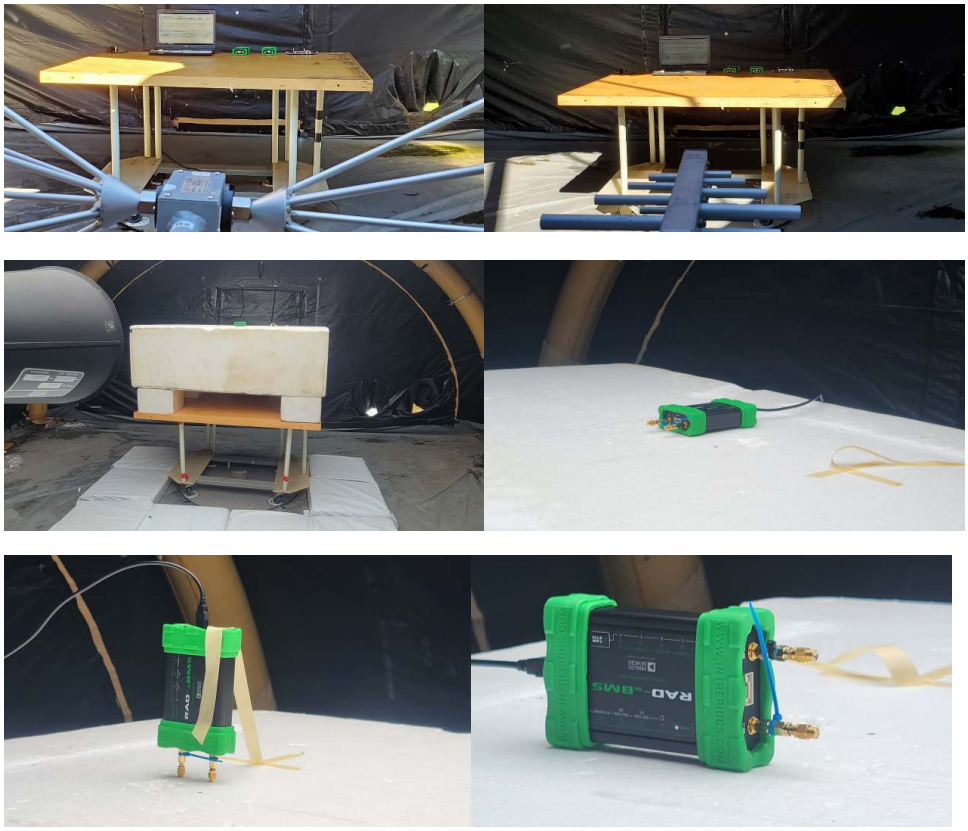


Figure 4: Radiated Emissions Test Setup Photograph(s).

4.1.2 Conducted Emissions Test Setup and Procedures

Transmit Antenna Port Conducted Emissions At least one sample EUT supplied for testing was provided with a 50Ω antenna port. Conducted transmit chain emissions measurements (where applicable) are made by connecting the EUT antenna port directly to the test receiver port. Photographs of the test setup employed are depicted in Figure 5.

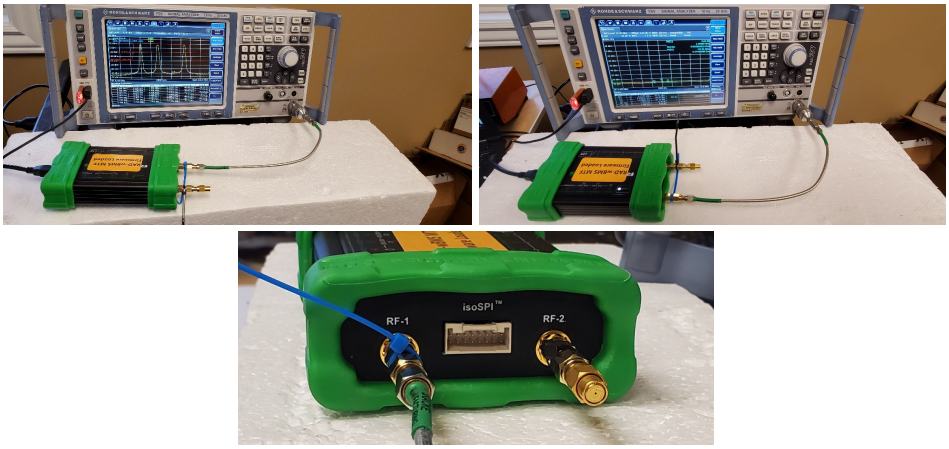


Figure 5: Conducted RF Test Setup Photograph(s).

AC Port Conducted Spurious For this device, AC power line conducted emissions are measured in our screen room. If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.4 / CISPR 22 are employed. Alternatively, an on-table layout more representative of actual use may be employed if the resulting emissions appear to be worst-case in such a configuration. See Figure 6.

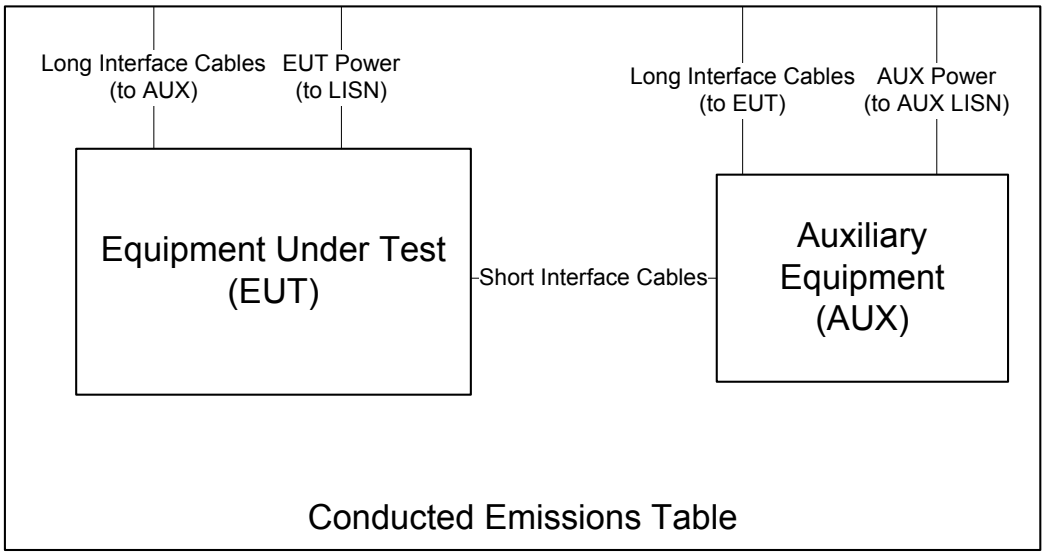


Figure 6: Conducted Emissions Setup Diagram of the EUT.

Conducted emissions are measured and recorded for each AC mains power source over the spectrum 0.15 MHz to 30 MHz for both the ungrounded (HI/PHASE) and grounded (LO/GND) conductors with the EUT placed in its highest current draw operating mode(s). The test receiver is set to peak-hold mode in order to record the peak emissions throughout the course of functional operation. Only if an emission exceeds or is near the limit are quasi-peak and average detection applied. Photographs of the test setup employed are depicted in Figure 7.

Figure 7: Conducted Emissions Test Setup Photograph(s).

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 of this EUT, measurements of the worst-case radiated emissions are performed with the supply voltage varied by no less than 85% and 115% of the nominal rated value for devices connecting to AC power mains.

4.2 Intentional Emissions

4.2.1 Duty and Transmission Cycle, Pulsed Operation

The details and results of testing the EUT for pulsed operation are summarized in Table 4. Plots showing the measurements made to obtain these values are provided in Figure 8.

Table 4: Pulsed Emission Characteristics (Duty Cycle).

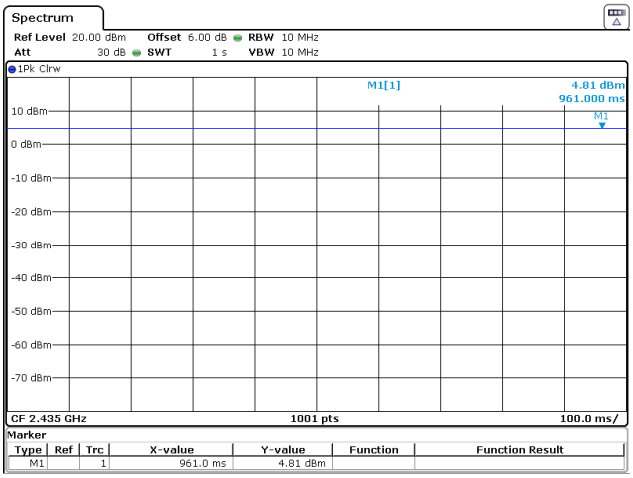
Test Date: 13-Dec-22
Test Engineer: John Nantz
EUT INTR1 RAD w/BMS
Meas. Distance: Conducted

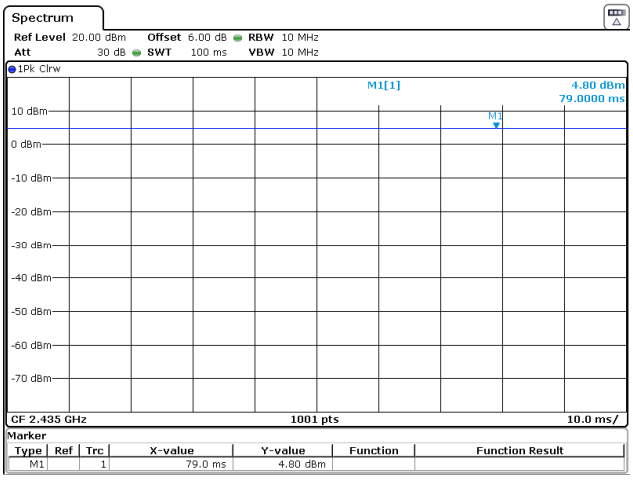
	Test Mode Pulsed Operation / Average Measurement Duty Cycle							
R0	Mode	Data Rate Mbps	Voltage V	Oper. Freq MHz	Pulse Length	Pulse Period	Duty Cycle %	Power Duty Correction dB
R1	RADIO 1 - CM	1.0	5.0	2435.0	1.0	1.0	100.0	0.0
R2	RADIO 1 - CM	2.0	5.0	2435.0	1.0	1.0	100.0	0.0
R3	RADIO 2 - CM	1.0	5.0	2435.0	1.0	1.0	100.0	0.0
R4	RADIO 2 - CM	2.0	5.0	2435.0	1.0	1.0	100.0	0.0
R5	NOTE: SUPPLY VOLTAGE TO THE EUT WAS VARIED FROM 5 V TO 31 V DC. THE DEVICE CEASED TO OPERATE BELOW 5 V. THERE WAS NO							
R6	MEASURABLE DIFFERENCE OBSERVED WITHIN THE VOLTAGE RANGE TESTED. WORST CASE EMISSIONS OBSERVED AT NOMINAL 5 VDC.							
#	C1	C3	C4	C5	C6	C7	C8	C9

* Duty Cycle is measured in line with DTS guidance 558074 D01 v5 r02 section 6(b) for averaging only over full-power transmission pulses.

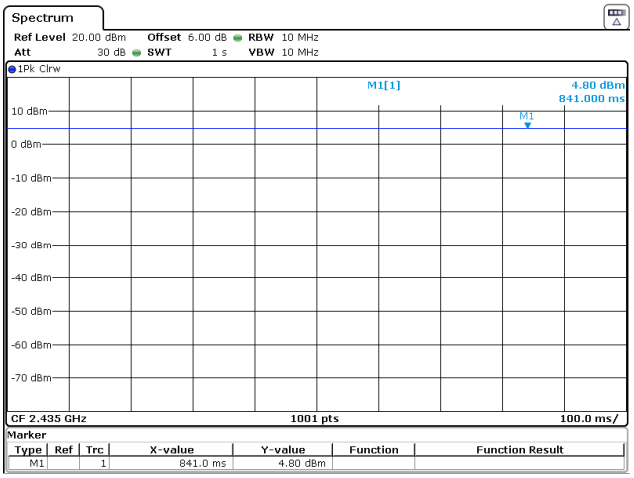
RADIO 1

1 Mbps





2 Mbps



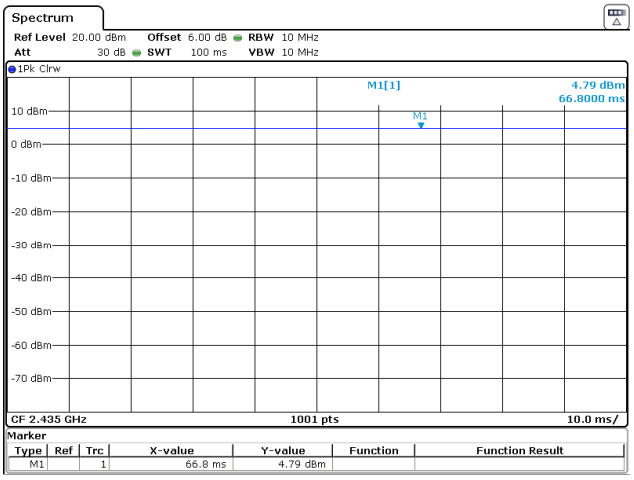
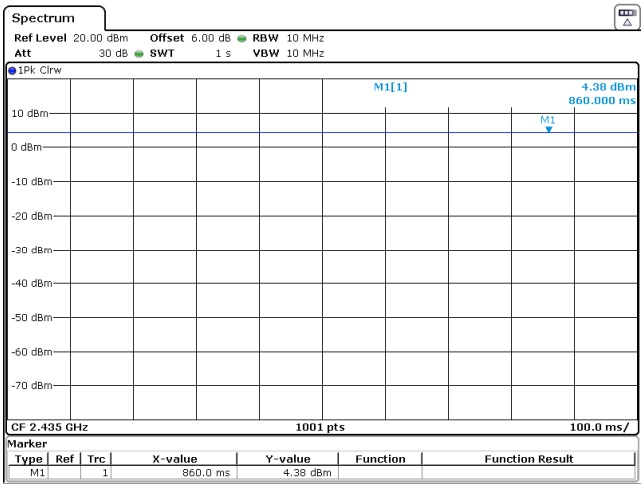
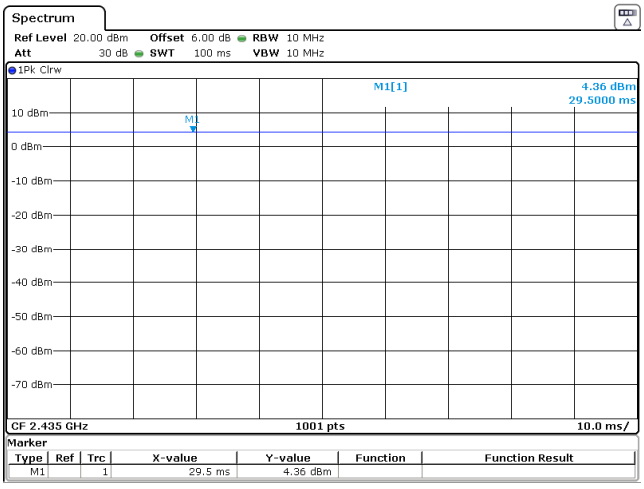


Figure 8(a): Example Pulsed Emission Characteristics (Duty Cycle).

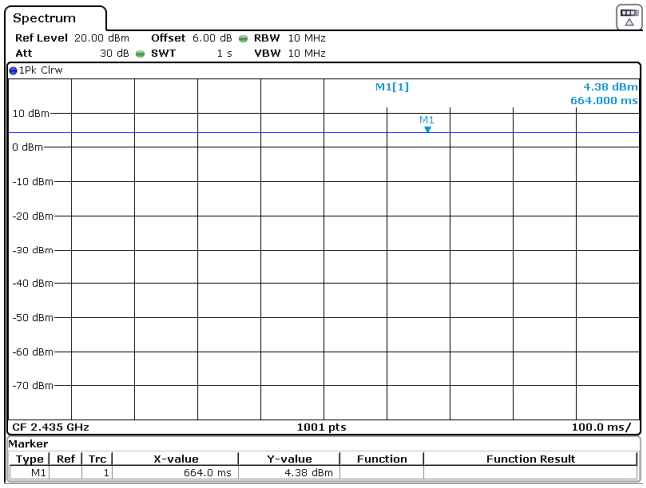
RADIO 2

1 Mbps





2 Mbps



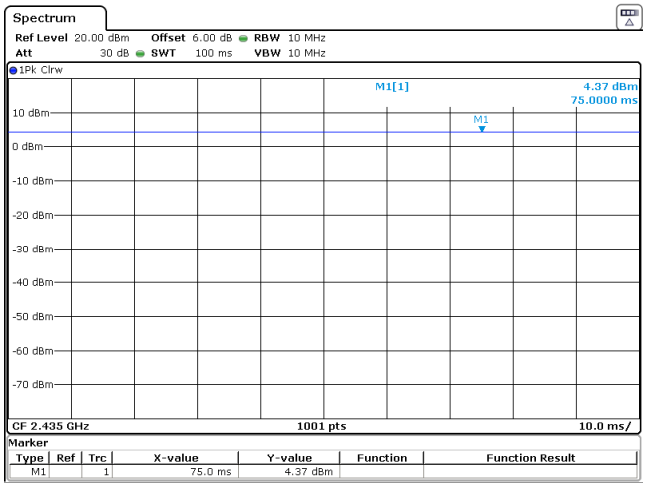


Figure 8(b): Example Pulsed Emission Characteristics (Duty Cycle).

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 packet length and minimum packet spacing. Radiated emissions are recorded following the test procedures listed in Section 2.1. The 6 dB bandwidth is measured for the lowest, middle, and highest channels available. The 99% emission bandwidth per IC test procedures is also reported. The results of this testing are summarized in Table 5. Plots showing measurements employed obtain the emission bandwidths reported are provided in Figure 9.

Table 5: Intentional Emission Bandwidth.

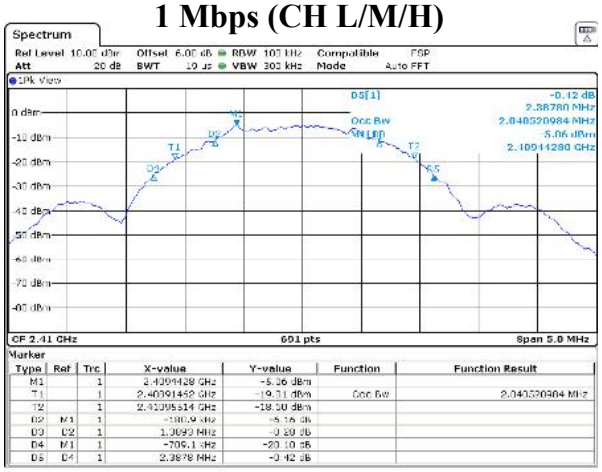
Test Date: 13-Dec-22
Test Engineer: John Nantz
EUT INTR1 RAD w/BMS
Meas. Distance: Conducted

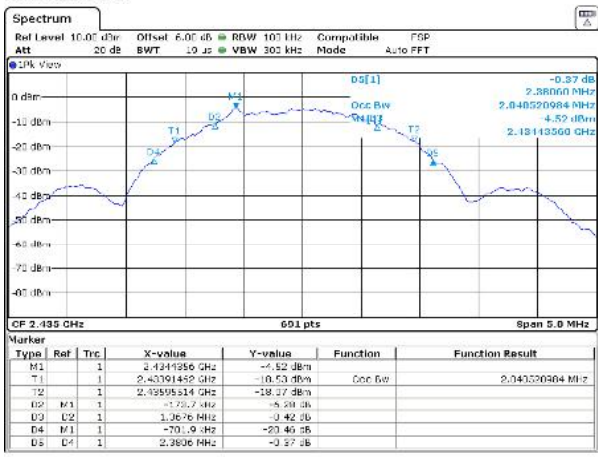
				Occupied Bandwidth					
R0	Transmit Mode	Data Rate (Mbps)	Voltage (V)	Oper. Freq (MHz)	6 dB BW (MHz)	6 dB BW Limit (MHz)	99% OBW (MHz)	20 dB BW (MHz)	Pass/Fail
R1	RADIO 1 - CM	1.0	5.0	2405.0	1.389	0.50	2.041	2.388	Pass
R2				2435.0	1.368	0.50	2.041	2.381	Pass
R3				2475.0	1.404	0.50	2.041	2.388	Pass
R4	RADIO 1 - CM	2.0	5.0	2405.0	1.375	0.50	2.041	2.381	Pass
R5				2435.0	1.382	0.50	2.041	2.381	Pass
R6				2475.0	1.375	0.50	2.041	2.388	Pass
R7	RADIO 2 - CM	1.0	5.0	2405.0	1.433	0.50	2.048	2.388	Pass
R8				2435.0	2.366	0.50	2.033	2.366	Pass
R9				2475.0	1.411	0.50	2.048	2.395	Pass
R10	RADIO 2 - CM	2.0	5.0	2405.0	1.346	0.50	2.048	2.373	Pass
R11				2435.0	1.382	0.50	2.033	2.359	Pass
R12				2475.0	1.418	0.50	2.041	2.381	Pass
#	C1	C2	C3	C4	C5	C6	C7	C8	C9

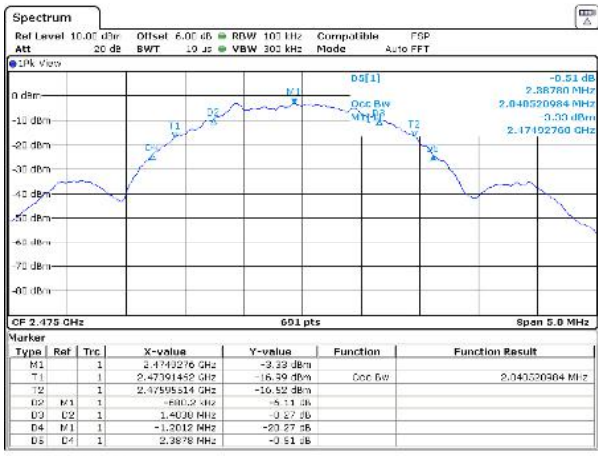
ROW	COLUMN	NOTE
R0	C5	DTS Bandwidth measured with RBW = 100 kHz per ANSI C63.10 11.8.1

RADIO 1

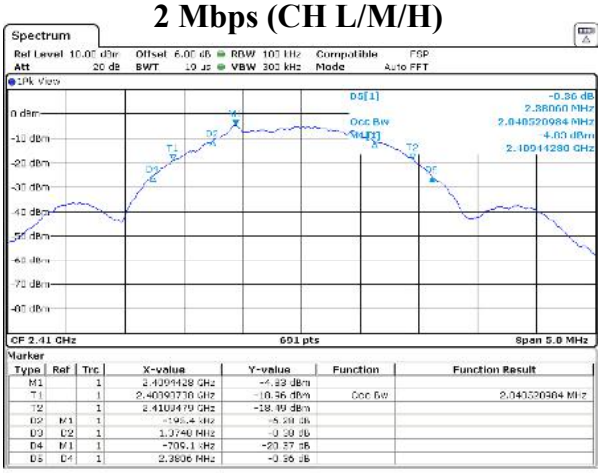
1 Mbps (CH L/M/H)

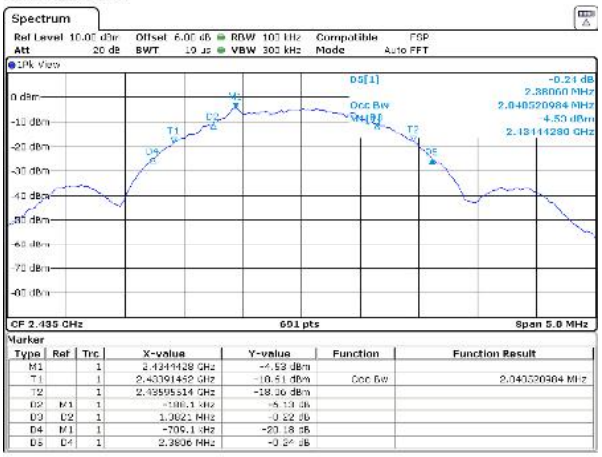






2 Mbps (CH L/M/H)





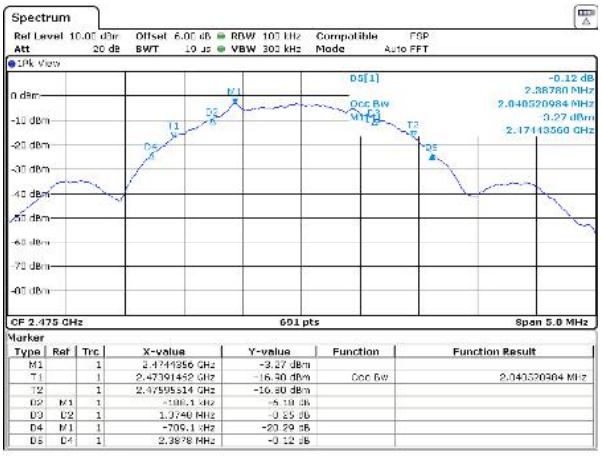
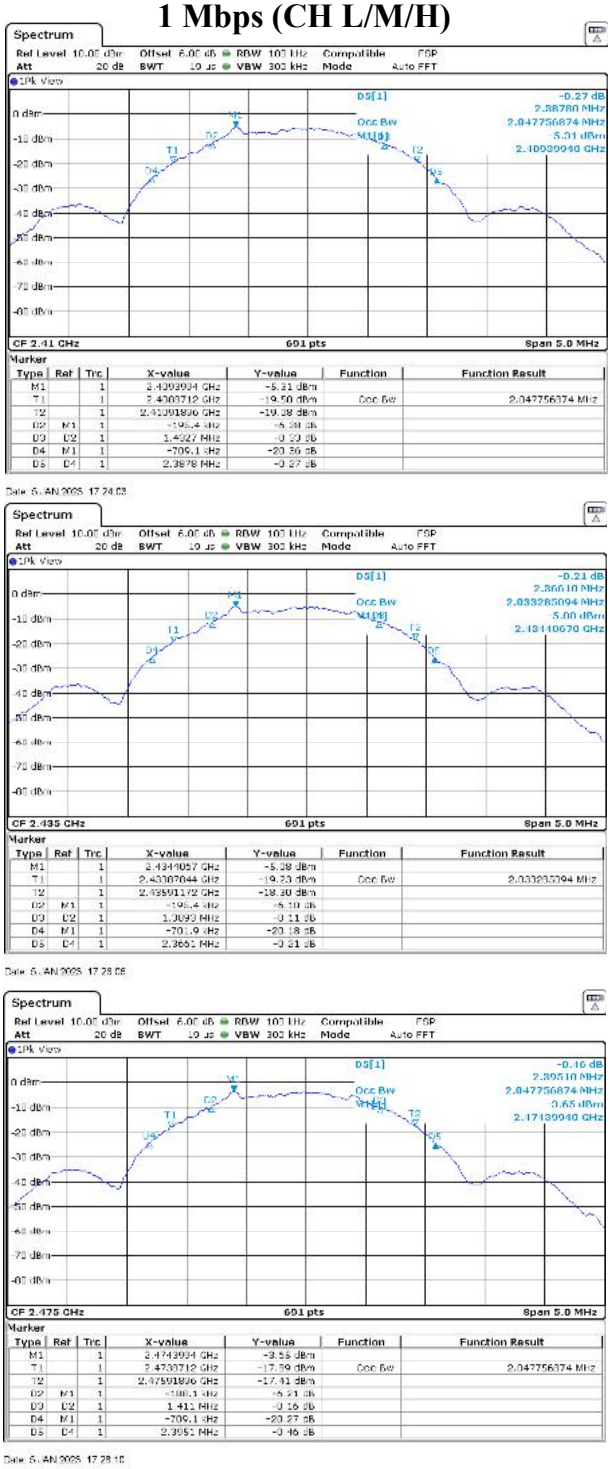


Figure 9(a): Example Intentional Emission Bandwidth Plots.

RADIO 2

1 Mbps (CH L/M/H)



2 Mbps (CH L/M/H)

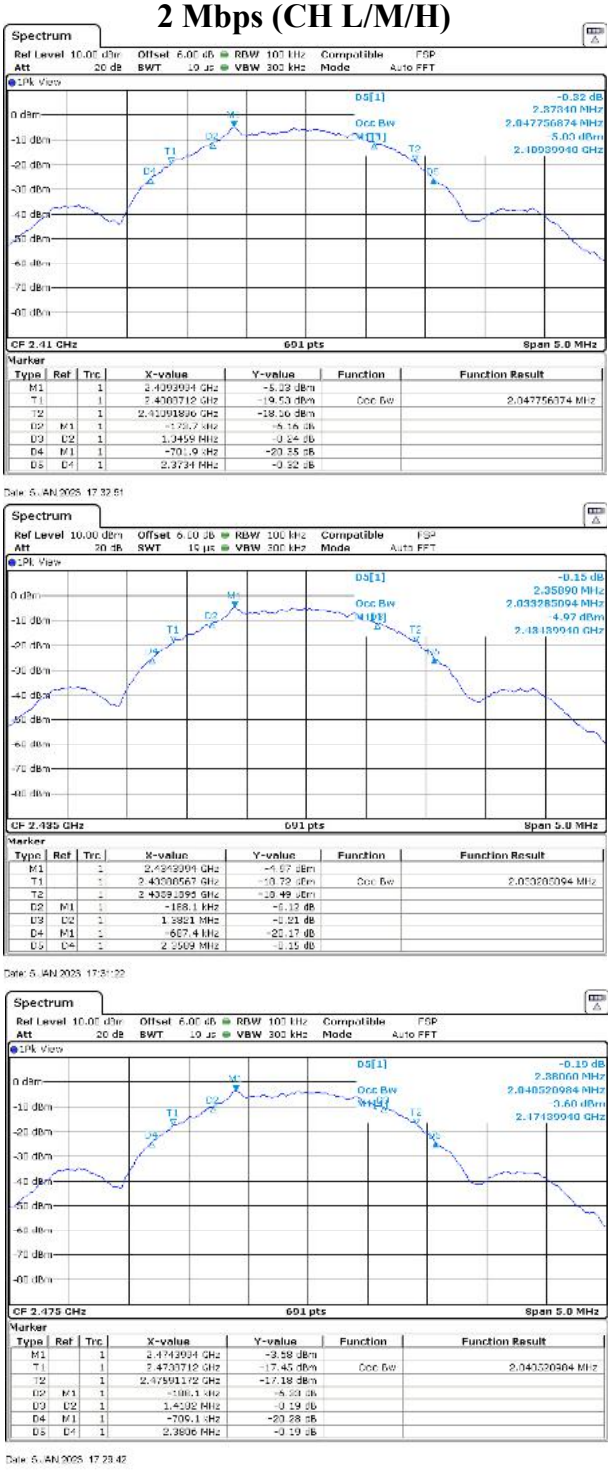


Figure 9(b): Example Intentional Emission Bandwidth Plots.

4.2.3 Effective Isotropic Radiated Power

The EUT's radiated power is computed from antenna port conducted power measurements and the gain of the EUT antenna(s). Where the EUT is not sold with an antenna connector, a modified product has been provided including such. The results of this testing are summarized in Table 6.

Table 6: Radiated Power Results.

Test Date: 13-Dec-22
Test Engineer: John Nantz
EUT: INTR1 RAD w/BMS
Meas. Distance: Conducted

	Fundamental Power										
R0	Mode	Channel	Freq. MHz	Pout (Pk) dBm	Duty dB	Pout + Duty dBm	Ant Gain dBi	EIRP (Avg) dBm	EIRP (Avg) Limit dBm	Pass dB	Comments
R1	RADIO 1 - CM (1MBPS)	L	2405.0	4.3		4.3	0.56	4.87	36.0	31.1	
R2		M	2435.0	4.4		4.4	0.56	4.93	36.0	31.1	
R3		H	2475.0	4.3		4.3	0.56	4.84	36.0	31.2	
R4	RADIO 1 - CM (2MBPS)	L	2412.0	4.3		4.3	0.56	4.85	36.0	31.2	
R5		M	2437.0	4.4		4.4	0.56	4.91	36.0	31.1	
R6		H	2462.0	4.3		4.3	0.56	4.83	36.0	31.2	
R7	RADIO 2 - CM (1MBPS)	L	2412.0	4.2		4.2	0.56	4.79	36.0	31.2	
R8		M	2437.0	4.4		4.4	0.56	4.95	36.0	31.1	
R9		H	2462.0	4.4		4.4	0.56	4.96	36.0	**31.0**	
R10	RADIO 2 - CM (2MBPS)	L	2412.0	4.2		4.2	0.56	4.79	36.0	31.2	
R11		M	2437.0	4.4		4.4	0.56	4.94	36.0	31.1	
R12		H	2462.0	4.4		4.4	0.56	4.95	36.0	31.1	
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11

(ROW)	(COLUMN)	NOTE:
R0	C5	Measured maximum peak conducted power from the radio using conducted test sample following DTS Guidance 558074 D01 v5 r02 Section 8.3.1.1
R0	C7	Worst Case Antenna Gain as declared by Manufacturer is 0.56 dBi.

4.2.4 Power Spectral Density

For this test, the EUT was attached directly to the test receiver. Following FCC DTS measurement procedures, the emission spectrum is first scanned for maximum spectral peaks, the span and receiver bandwidth are then reduced until the power spectral density is measured in the prescribed receiver bandwidth. The results of this testing are summarized in Table 7. Plots showing how these measurements were made are depicted in Figure 10.

Table 7: Power Spectral Density Results.

Frequency Range	Detector	IF Bandwidth	Video Bandwidth		
2400-2483.5	Pk	3 kHz	10 kHz	**Test Date:**	13-Dec-22
				Test Engineer:	John Nantz
				EUT:	INTR1 RAD w/BMS
				Meas. Distance:	Conducted

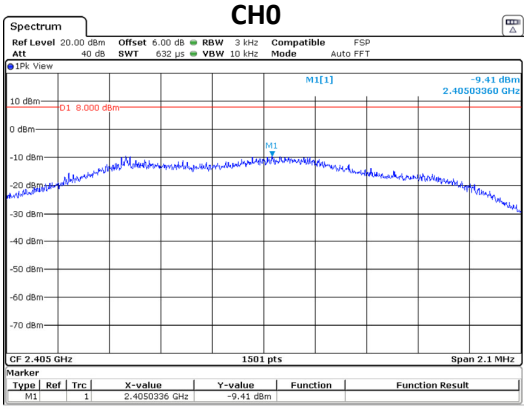
Power Spectral Density							
R0	Mode	Channel	Frequency (MHz)	Ant. Used	PSDcond (meas) (dBm/3kHz)	PSD Limit (dBm/3kHz)	Pass By (dB)
R1	RADIO 1 - CM (1MBPS)	L	2405.0	Cond.	-9.4	8.00	17.4
R2		M	2435.0	Cond.	-9.1	8.00	**17.1**
R3		H	2475.0	Cond.	-9.3	8.00	17.3
R4	RADIO 1 - CM (2MBPS)	L	2412.0	Cond.	-9.2	8.00	17.2
R5		M	2437.0	Cond.	-9.3	8.00	17.3
R6		H	2462.0	Cond.	-9.2	8.00	17.2
R7	RADIO 2 - CM (1MBPS)	L	2412.0	Cond.	-9.6	8.00	17.6
R8		M	2437.0	Cond.	-9.6	8.00	17.6
R9		H	2462.0	Cond.	-9.6	8.00	17.6
R10	RADIO 2 - CM (2MBPS)	L	2412.0	Cond.	-9.6	8.00	17.6
R11		M	2437.0	Cond.	-9.6	8.00	17.6
R12		H	2462.0	Cond.	-9.9	8.00	17.9
#	C1	C2	C3	C4	C5	C6	C7

(ROW) (COLUMN) NOTE:
R0 C5 PSD measured conducted out the EUT antenna port following ANSI C63.10, section: 11.10.2

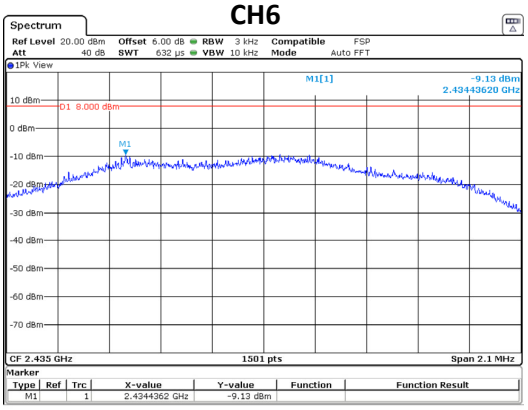
RADIO 1

1 Mbps

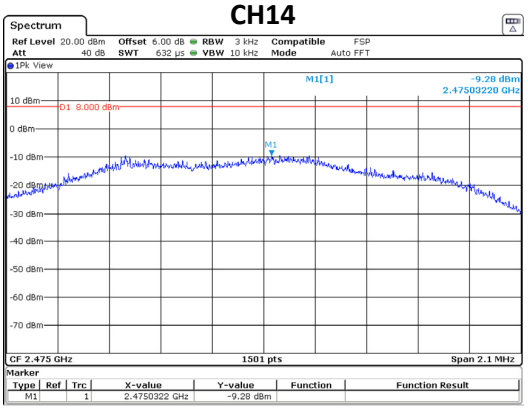
CH0



CH6

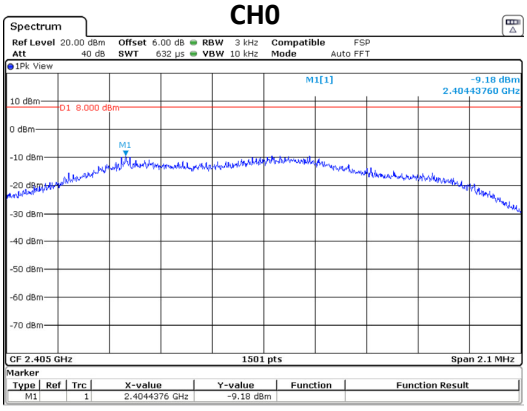


CH14

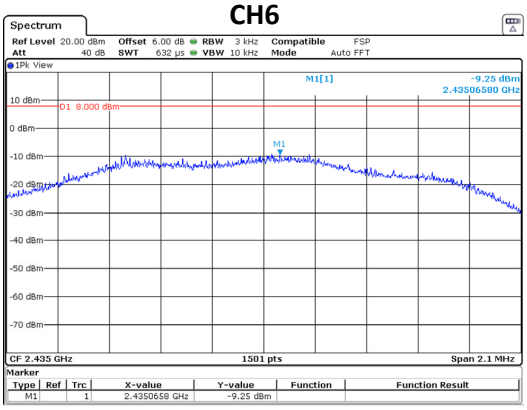


2 Mbps

CH0



CH6



CH14

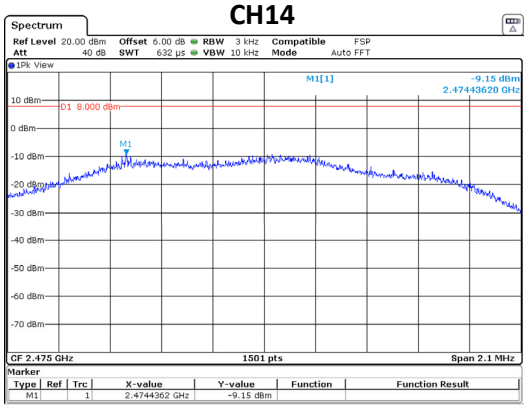
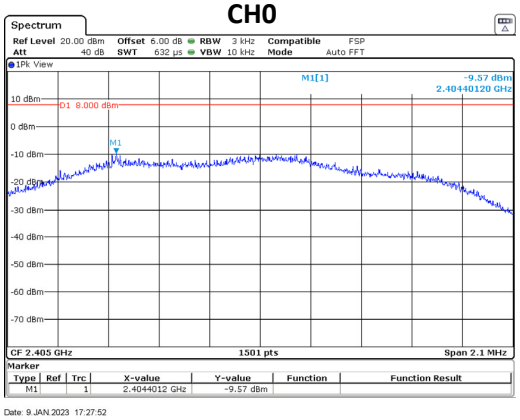


Figure 10(a): Power Spectral Density Plots.

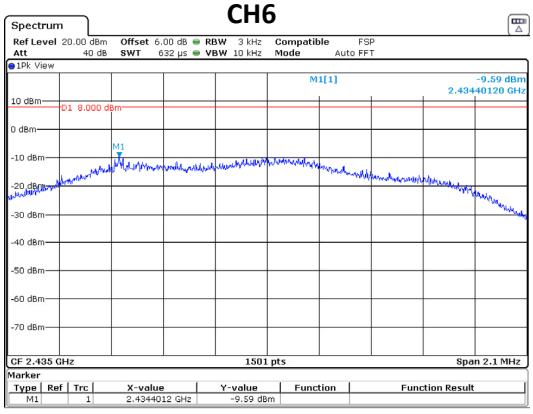
RADIO 2

1 Mbps

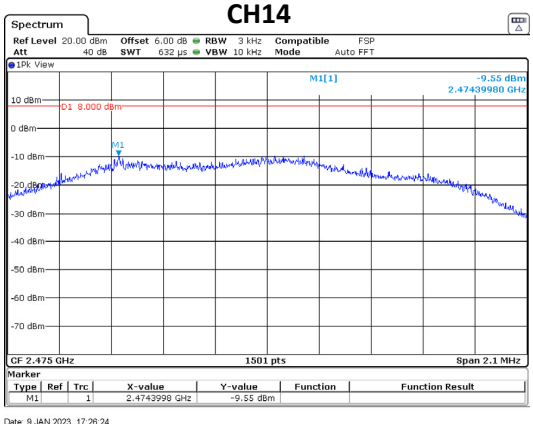
CH0



CH6

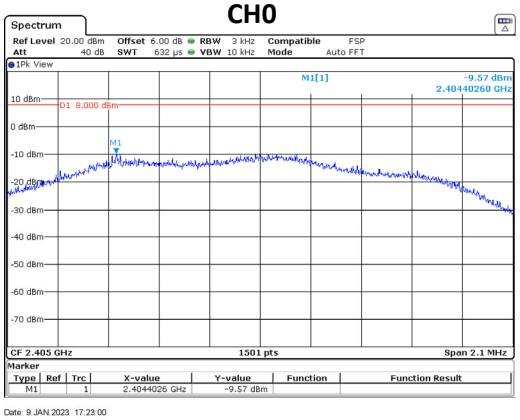


CH14

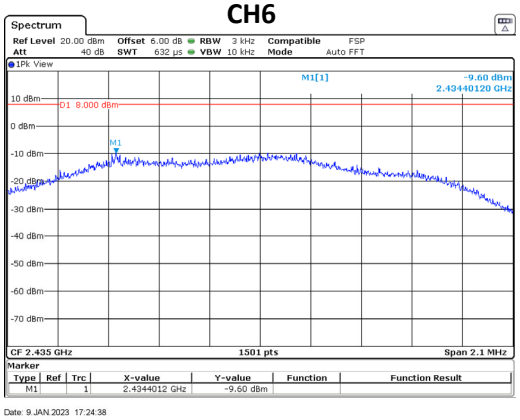


2 Mbps

CH0



CH6



CH14

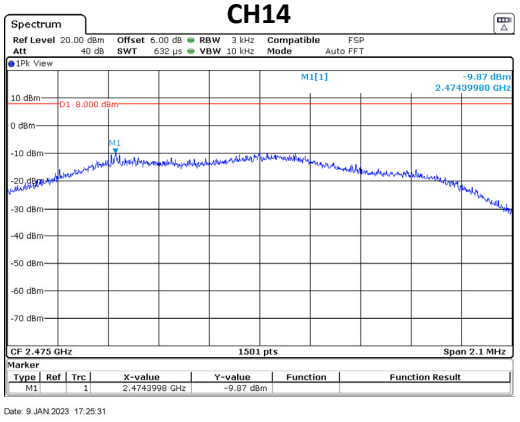


Figure 10(b): Power Spectral Density Plots.

4.3 Unintentional Emissions

4.3.1 Restricted Band Transmit Chain Spurious Emissions

The results for the measurement of transmit chain spurious emissions at the nominal voltage and temperature are provided in Table 8. Measurements are performed to 10 times the highest fundamental operating frequency.

Table 8(a): Transmit Chain Spurious Emissions.

Frequency Range	Det	IF Bandwidth	Video Bandwidth		
30 MHz < f < 1 000 MHz	Pk/Qpk	100 kHz	300 kHz	**Test Date:**	13-Dec-22
f > 1 000 MHz	Pk/Avg	1 MHz	3 MHz	**Test Engineer:**	John Nantz
				EUT:	INTR1 RAD w/BMS
				Meas. Distance:	Conducted

Transmitter Spurious - RADIO 1														FCC/IC
		Frequency		Output Power		Ant	GR Factor	Avg Duty	Electric Field @ 3m				Pass	
	Mode	Start	Stop	Pk	Avg	Gain		Factor	Meas. Pk	Limit Pk	Meas. Avg	Limit Avg		
R0		MHz	MHz	dBm	dBm	dBi	dB	dB	dBuV/m	dBuV/m	dBuV/m	dBuV/m	dB	Comments
R1	Fundamental Restricted Band Edge (Low Side)													
R2	CM	2390.0	2390.0	-62.4	-76.0	2.0	0.0	0.0	34.8	74.0	21.2	54.0	32.8	max all - baud rates/L,M,H channels/noise
R3	Fundamental Restricted Band Edge (High Side)													
R4	CM	2483.5	2483.5	-59.9	-71.5	2.0	0.0	0.0	37.3	74.0	25.7	54.0	28.3	max all - baud rates/L,M,H channels/noise
R5	Restricted Bands Emissions													
R6	CM	30	88	-76.1		2.0	4.7	0.0	25.8			40	14.2	max all - baud rates/L,M,H channels/noise
R7	CM	88	216	-79.2		2.0	4.7	0.0	22.7			43	20.3	max all - baud rates/L,M,H channels/noise
R8	CM	216	1000	-73.3		2.0	4.7	0.0	28.7			46	17.4	max all - baud rates/L,M,H channels/noise
R9	CM	1000.0	2400.0	-65.1	-70.9	2.0	0.0	0.0	32.1	74.0	26.3	54.0	27.7	max all - baud rates/L,M,H channels/noise
R10	CM	2483.5	4000.0	-60.5	-66.8	2.0	0.0	0.0	36.7	74.0	30.5	54.0	23.5	max all - baud rates/L,M,H channels/noise
R11	CM	4810.0	4810.0	-57.7	-64.8	2.0	0.0	0.0	39.5	74.0	32.5	54.0	21.5	max all - baud rates/L,M,H channels/noise
R12	CM	4870.0	4870.0	-56.0	-62.4	2.0	0.0	0.0	41.2	74.0	34.9	54.0	19.1	max all - baud rates/L,M,H channels/noise
R13	CM	4950.0	4950.0	-49.6	-55.7	2.0	0.0	0.0	47.6	74.0	41.6	54.0	**12.4**	max all - baud rates/L,M,H channels/noise
R14	CM	4000.0	6000.0	-49.6	-55.7	2.0	0.0	0.0	47.6	74.0	41.6	54.0	**12.4**	max all - baud rates/L,M,H channels/noise
R15	CM	6000.0	8400.0	-55.8	-62.8	2.0	0.0	0.0	41.4	74.0	34.5	54.0	19.5	max all - baud rates/L,M,H channels/noise
R16	CM	8400.0	12500.0	-58.3	-64.8	2.0	0.0	0.0	38.9	74.0	32.5	54.0	21.5	max all - baud rates/L,M,H channels/noise
R17	CM	12500.0	25000.0	-64.9	-70.8	2.0	0.0	0.0	32.3	74.0	26.5	54.0	27.5	max all - baud rates/L,M,H channels/noise
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14

(ROW)	(COLUMN)	NOTE:
R0	C4/C5	Conducted measurements were made in line with DTS guidance 558074 D01 v5 r02 sections 8.5, 8.6 and 8.7 respectively.
R2/R4	C4/C5	Measured using the mode with widest bandwidth and max. output power/PSD according to ANSI C63-10-2013 sections 5.6.2.2 and 6.10.5.2 respectively
R0	C6	Worst Case Antenna Gain as declared by Manufacturer is 0.56 dBi therefore 2 dBi is used for calculation in alignment with ANSI C63.10, section 11.12.2.6
R0	C7	Ground Reflection Factor as described in ANSI C63.10-2013 section 11.12.2.2 c
R0	C9	Computed according to ANSI C63.10-2013 section 11.12.2.2 e

Table 8(b): Transmit Chain Spurious Emissions.

Frequency Range	Det	IF Bandwidth	Video Bandwidth		
30 MHz < f < 1 000 MHz	Pk/Qpk	100 kHz	300 kHz	**Test Date:**	13-Dec-22
f > 1 000 MHz	Pk/Avg	1 MHz	3 MHz	**Test Engineer:**	John Nantz
				EUT:	INTR1 RAD w/BMS
				Meas. Distance:	Conducted

Transmitter Spurious - RADIO 2 FCC/IC

	Mode	Frequency		Output Power		Ant	GR Factor	Avg Duty	Electric Field @ 3m				Pass	
		Start	Stop	Pk	Avg	Gain		Factor	Meas. Pk	Limit Pk	Meas. Avg	Limit Avg		
R0		MHz	MHz	dBm	dBm	dBi	dB	dB	dBuV/m	dBuV/m	dBuV/m	dBuV/m	dB	Comments
R1	Fundamental Restricted Band Edge (Low Side)													
R2	CM	2390.0	2390.0	-63.6	-74.2	2.0	0.0	0.0	33.6	74.0	23.0	54.0	31.0	max all - baud rates/L,M,H channels/noise
R3	Fundamental Restricted Band Edge (High Side)													
R4	CM	2483.5	2483.5	-59.6	-75.5	2.0	0.0	0.0	37.6	74.0	21.7	54.0	32.3	max all - baud rates/L,M,H channels/noise
R5	Restricted Bands Emissions													
R6	CM	30	88	-74.9		2.0	4.7	0.0	27.0			40	13.0	max all - baud rates/L,M,H channels/noise
R7	CM	88	216	-79.8		2.0	4.7	0.0	22.1			43	20.9	max all - baud rates/L,M,H channels/noise
R8	CM	216	1000	-67		2.0	4.7	0.0	34.9			46	11.1	max all - baud rates/L,M,H channels/noise
R9	CM	1000.0	2400.0	-64.3	-70.5	2.0	0.0	0.0	32.9	74.0	26.7	54.0	27.3	max all - baud rates/L,M,H channels/noise
R10	CM	2483.5	4000.0	-61.3	-68.2	2.0	0.0	0.0	35.9	74.0	29.1	54.0	24.9	max all - baud rates/L,M,H channels/noise
R11	CM	4810.0	4810.0	-55.1	-61.3	2.0	0.0	0.0	42.1	74.0	36.0	54.0	18.0	max all - baud rates/L,M,H channels/noise
R12	CM	4870.0	4870.0	-54.4	-60.1	2.0	0.0	0.0	42.8	74.0	37.2	54.0	16.8	max all - baud rates/L,M,H channels/noise
R13	CM	4950.0	4950.0	-49.2	-55.9	2.0	0.0	0.0	48.0	74.0	41.3	54.0	**12.7**	max all - baud rates/L,M,H channels/noise
R14	CM	4000.0	6000.0	-49.2	-55.9	2.0	0.0	0.0	48.0	74.0	41.3	54.0	**12.7**	max all - baud rates/L,M,H channels/noise
R15	CM	6000.0	8400.0	-57.1	-64.4	2.0	0.0	0.0	40.1	74.0	32.9	54.0	21.1	max all - baud rates/L,M,H channels/noise
R16	CM	8400.0	12500.0	-58.2	-64.7	2.0	0.0	0.0	39.0	74.0	32.6	54.0	21.4	max all - baud rates/L,M,H channels/noise
R17	CM	12500.0	25000.0	-65.4	-72.2	2.0	0.0	0.0	31.8	74.0	25.1	54.0	28.9	max all - baud rates/L,M,H channels/noise
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14

(ROW)	(COLUMN)	NOTE:
R0	C4/C5	Conducted measurements were made in line with DTS guidance 558074 D01 v5 r02 sections 8.5, 8.6 and 8.7 respectively.
R2/R4	C4/C5	Measured using the mode with widest bandwidth and max. output power/PSD according to ANSI C63-10-2013 sections 5.6.2.2 and 6.10.5.2 respectively
R0	C6	Worst Case Antenna Gain as declared by Manufacturer is 0.56 dBi therefore 2 dBi is used for calculation in alignment with ANSI C63.10, section 11.12.2.6
R0	C7	Ground Reflection Factor as described in ANSI C63.10-2013 section 11.12.2.2 c
R0	C9	Computed according to ANSI C63.10-2013 section 11.12.2.2 e

Table 8(c): Transmit Chain Spurious Emissions.

Frequency Range	Det	IF Bandwidth	deo Bandwidth		
30 MHz < f < 1 000 MHz	Pk/Qpk	100 kHz	300 kHz	**Test Date:**	13-Dec-22
f > 1 000 MHz	Pk/Avg	1 MHz	3 MHz	**Test Engineer:**	John Nantz
				EUT:	INTR1 RAD w/BMS
				Meas. Distance:	3m

Radiated Transmitter Spurious Intermodulation Products – RADIO1 + RADIO2 FCC/IC

	Mode	Frequency		Antenna				Electric Field @ 3m				Pass	
		Start	Stop	QN	Test	Ka	Kg	Meas. Pk	Limit Pk	Meas. Avg	Limit Avg		
R0		MHz	MHz	Used	Pol.	dB/m	dB	dBuV/m	dBuV/m	dBuV/m	dBuV/m	dB	Comments
R1	CM, 1Mbps	2338.6	2338.6	HQR1TO18S01	H/V	31.7	-0.3	59.3	74.0	49.8	54.0	4.2	Radio 1, CH-H, Radio 2, CH-L
R2	CM, 1Mbps	2505.5	2505.5	HQR1TO18S01	H/V	33.0	-0.3	59.5	74.0	49.6	54.0	4.4	Radio 1, CH-H, Radio 2, CH-M
R3	CM, 1Mbps	2504.2	2504.2	HQR1TO18S01	H/V	33.0	-0.3	58.8	74.0	49.2	54.0	4.8	Radio 1, CH-H, Radio 2, CH-L
R4	CM, 1Mbps	2340.8	2340.8	HQR1TO18S01	H/V	31.8	-0.3	59.4	74.0	51.4	54.0	2.6	Radio 1, CH-H, Radio 2, CH-L
R5	CM, 1Mbps	2375.0	2375.0	HQR1TO18S01	H/V	32.0	-0.3	59.7	74.0	50.9	54.0	3.1	Radio 1, CH-L, Radio 2, CH-M
R6	CM, 1Mbps	2374.6	2374.6	HQR1TO18S01	H/V	32.0	-0.3	60.0	74.0	51.3	54.0	2.7	Radio 1, CH-M, Radio 2, CH-L
R13													
R14													
R15													
R16													
R17													
#	C1	C2	C3	C4	C5	C6	C7	C9	C10	C11	C12	C13	C14

(ROW) (COLUMN) NOTE:

4.3.2 OOB Transmit Chain Spurious Emissions

The results for the measurement of transmit chain spurious emissions relative to the fundamental in a 100 kHz receiver bandwidth (at the nominal voltage and temperature) in the worst cases are provided in Figure 11 below.

RADIO 1 – All Bauds/Channels

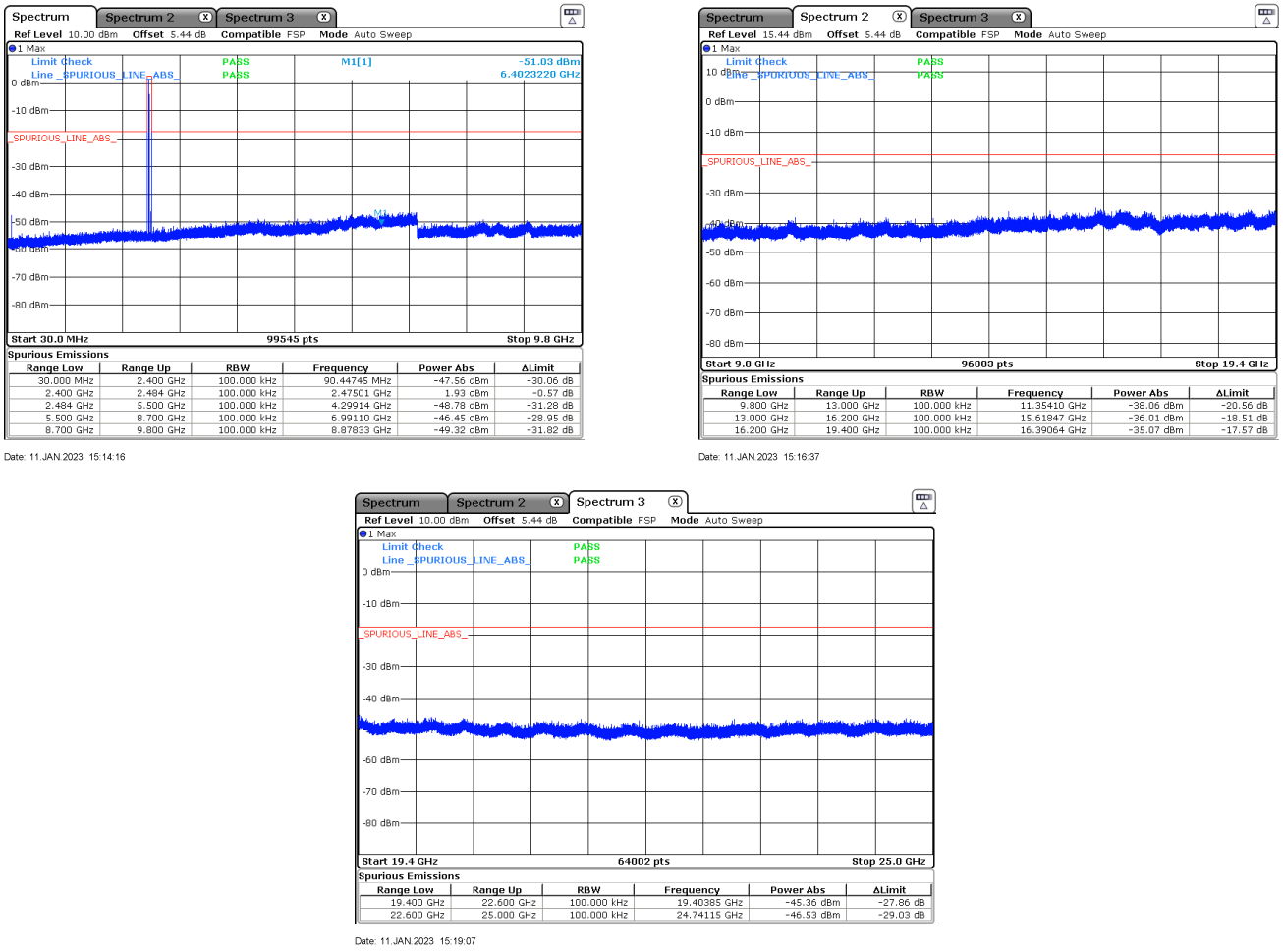
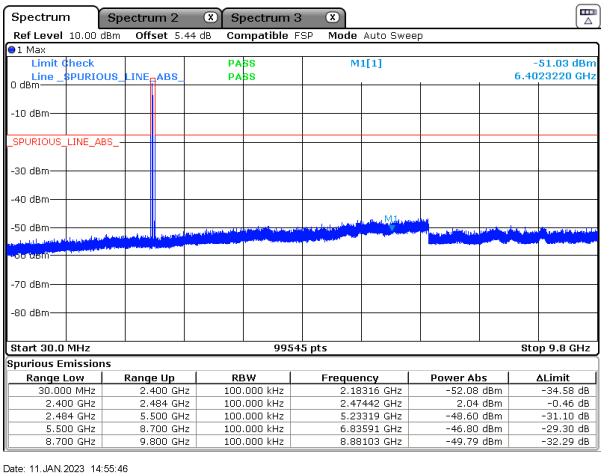
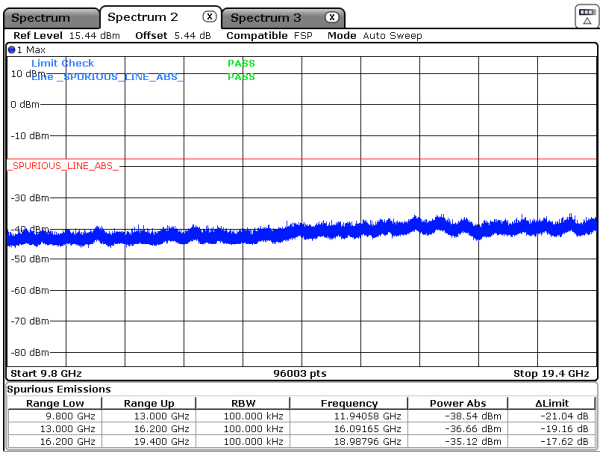


Figure 11(a): Worst Case Transmitter OOB Emissions Measured.

RADIO 2 – All Bauds/Channels





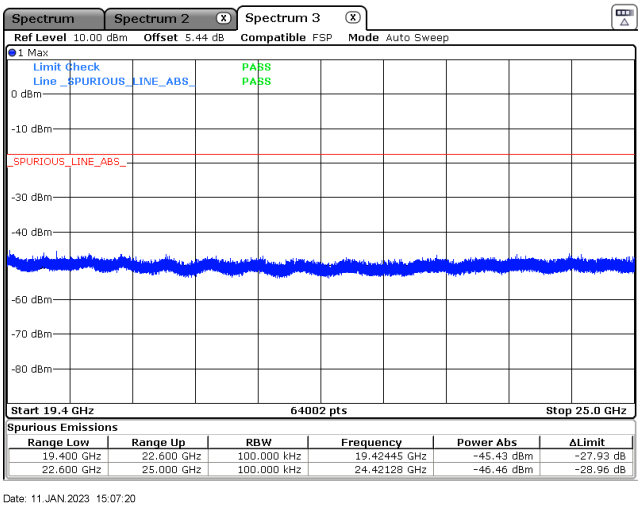


Figure 11(b): Worst Case Transmitter OOB Emissions Measured.

4.3.3 General Radiated Spurious

The results for the measurement of general spurious emissions (emissions arising from digital circuitry) at the nominal voltage and temperature are provided in Table 9. Radiation from digital components are measured up to 1000 MHz or to the highest frequency required by the applied standards, whichever is greater.

Table 9: Radiated Digital Spurious Emissions.

Frequency Range	Det	IF Bandwidth	Video Bandwidth
25 MHz ≤ f ≤ 1 000 MHz	Pk/QPk	120 kHz	300 kHz
f > 1 000 MHz	Pk	1 MHz	3 MHz
f > 1 000 MHz	Avg/RMS	1 MHz	3 MHz

Test Date:	30-Nov-22
Test Engineer:	J. Nantz
EUT:	RAD w/BMS System
EUT Mode:	Both Radios Active, Antenna Ports Terminated
Meas. Distance:	3 m
Temperature:	18.3C
Rel. Humidty:	74%

Digital Spurious Emissions — CISPR 32 / FCC / IC

	Test	Antenna				E-Field @ 3m**		FCC CLB (QPk/Avg)		CE CLB (QPk/Avg)		FCC CLA (QPk/Avg)		CE CLA (QPk/Avg)		
	Freq.	QN	Test	Ka	Kg	Pk	Qpk/Avg	E3lim	Pass	E3lim	Pass	E3lim	Pass	E3lim	Pass	
R0	MHz		Pol.	dB/m	dB	dBµV/m	dBµV/m	dBµV/m	dB	dBµV/m	dB	dBµV/m	dB	dBµV/m	dB	Comments
R1	69.0	BICEMCO01	H	7.6	-.4	32.3	29.5	40.0	10.5	40.5	11.0	49.5	20.0	50.5	21.0	
R2	83.5	BICEMCO01	V	7.7	-.5	32.2	30.4	40.0	9.6	40.5	10.1	49.5	19.1	50.5	20.1	
R3	133.7	BICEMCO01	V	11.2	-.6	30.0	26.1	43.5	17.4	40.5	14.4	54.0	27.9	50.5	24.4	
R4	144.0	BICEMCO01	H	12.0	-.7	39.0	36.5	43.5	**7.0**	40.5	**4.0**	54.0	17.5	50.5	14.0	
R5	150.0	BICEMCO01	H	12.5	-.7	34.8	29.7	43.5	13.8	40.5	10.8	54.0	24.3	50.5	20.8	
R6	162.4	BICEMCO01	H	13.3	-.7	34.6	30.1	43.5	13.4	40.5	10.4	54.0	23.9	50.5	20.4	
R7	162.8	BICEMCO01	V	13.3	-.7	24.0	19.8	43.5	23.7	40.5	20.7	54.0	34.2	50.5	30.7	
R8	185.0	BICEMCO01	H	14.3	-.8	32.8	30.3	43.5	13.2	40.5	10.2	54.0	23.7	50.5	20.2	
R9	185.0	BICEMCO01	V	14.3	-.8	30.9	26.7	43.5	16.8	40.5	13.8	54.0	27.3	50.5	23.8	
R10	195.0	BICEMCO01	H	14.6	-.8	33.5	29.2	43.5	14.3	40.5	11.3	54.0	24.8	50.5	21.3	
R11	195.0	BICEMCO01	V	14.6	-.8	31.5	28.2	43.5	15.3	40.5	12.3	54.0	25.8	50.5	22.3	
R12	215.0	LOGEMCO01	H	11.2	-.9	40.1	36.2	43.5	7.3	40.5	4.3	54.0	17.8	50.0	13.8	
R13	215.0	LOGEMCO01	V	11.2	-.9	33.1	28.5	43.5	15.0	40.5	12.0	54.0	25.5	50.0	21.5	
R14	216.0	LOGEMCO01	H	11.3	-.9	40.5	35.8	43.5	7.7	40.5	4.7	54.0	18.2	50.0	14.2	
R15	216.0	LOGEMCO01	V	11.3	-.9	33	28.7	43.5	14.8	40.5	11.8	54.0	25.3	50.0	21.3	
R16	230.5	LOGEMCO01	V	11.8	-.9	33.1	30.4	46.0	15.6	47.5	17.1	56.9	26.5	57.0	26.6	
R17	240.8	LOGEMCO01	H	12.1	-1.0	36.3	32.5	46.0	13.5	47.5	15.0	56.9	24.4	57.0	24.5	
R18	252.0	LOGEMCO01	H	12.5	-1.0	37.6	34.6	46.0	11.4	47.5	12.9	56.9	22.3	57.0	22.4	
R19	252.0	LOGEMCO01	V	12.5	-1.0	28.2	24.6	46.0	21.4	47.5	22.9	56.9	32.3	57.0	32.4	
R20	288.0	LOGEMCO01	H	13.5	-1.1	37.4	33.1	46.0	12.9	47.5	14.4	56.9	23.8	57.0	23.9	
R21	288.0	LOGEMCO01	V	13.5	-1.1	35.2	30.4	46.0	15.6	47.5	17.1	56.9	26.5	57.0	26.6	
R22	308.0	LOGEMCO01	H	13.9	-1.2	31.5	27.3	46.0	18.7	47.5	20.2	56.9	29.6	57.0	29.7	
R23	324.0	LOGEMCO01	H	14.3	-1.2	35.2	30.1	46.0	15.9	47.5	17.4	56.9	26.8	57.0	26.9	
R24	324.0	LOGEMCO01	V	14.3	-1.2	30.5	27.1	46.0	18.9	47.5	20.4	56.9	29.8	57.0	29.9	
R25	336.0	LOGEMCO01	H	14.5	-1.2	39.7	36.8	46.0	9.2	47.5	10.7	56.9	20.1	57.0	20.2	
R26	360.0	LOGEMCO01	H	15.0	-1.3	36.1	33.2	46.0	12.8	47.5	14.3	56.9	23.7	57.0	23.8	
R27	360.0	LOGEMCO01	V	15.0	-1.3	29.9	24.5	46.0	21.5	47.5	23.0	56.9	32.4	57.0	32.5	
R28	366.0	LOGEMCO01	H	15.1	-1.3	32.3	28.8	46.0	17.2	47.5	18.7	56.9	28.1	57.0	28.2	
R29	366.0	LOGEMCO01	V	15.1	-1.3	30	26.3	46.0	19.7	47.5	21.2	56.9	30.6	57.0	30.7	
R30	381.0	LOGEMCO01	V	15.4	-1.4	27.8	23.9	46.0	22.1	47.5	23.6	56.9	33.0	57.0	33.1	
R31	399.8	LOGEMCO01	H	15.7	-1.4	33.6	29.4	46.0	16.6	47.5	18.1	56.9	27.5	57.0	27.6	
R32	432.0	LOGEMCO01	H	16.3	-1.5	34.3	30.9	46.0	15.1	47.5	16.6	56.9	26.0	57.0	26.1	
R33	432.0	LOGEMCO01	V	16.3	-1.5	33.7	29.7	46.0	16.3	47.5	17.8	56.9	27.2	57.0	27.3	
R34	456.0	LOGEMCO01	H	16.7	-1.6	33.4	28.7	46.0	17.3	47.5	18.8	56.9	28.2	57.0	28.3	
R35	456.0	LOGEMCO01	V	16.7	-1.6	36	33.5	46.0	12.5	47.5	14.0	56.9	23.4	57.0	23.5	
R36	476.3	LOGEMCO01	H	17.0	-1.7	38.9	35.8	46.0	10.2	47.5	11.7	56.9	21.1	57.0	21.2	
R37	541.1	LOGEMCO01	H	18.1	-1.8	36.1	32.7	46.0	13.3	47.5	14.8	56.9	24.2	57.0	24.3	
R38	562.9	LOGEMCO01	H	18.5	-1.9	40.3	36.4	46.0	9.6	47.5	11.1	56.9	20.5	57.0	20.6	
R43																
R44	NOTE 1: No other spruious emissions observed within 20 dB of the Class B limit for f > 1 GHz															
R45																
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16

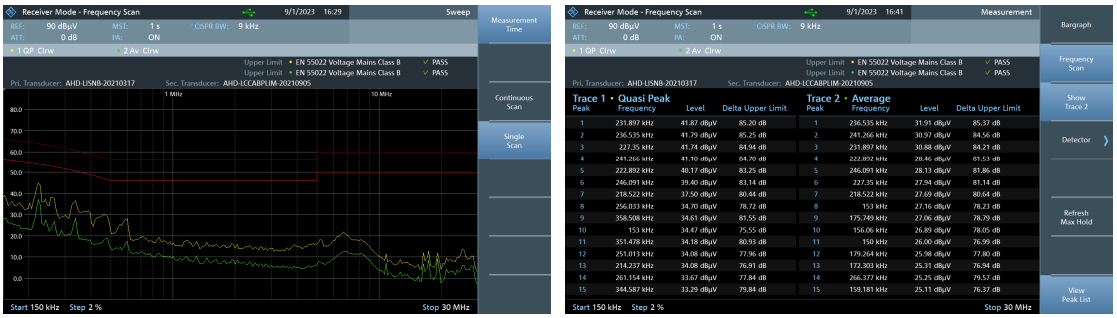
(ROW)	(COLUMN)	(NOTE)
R0	C7	Pk+Avg detection (narrowband), Pk + QPk detection (wideband) emissions
R0	C7	When E-field is reported directly from Spectrum Analyzer, Antenna Factors and Cable losses are included directly in SA settings.

4.3.4 Conducted Emissions Test Results - AC Power Port(s)

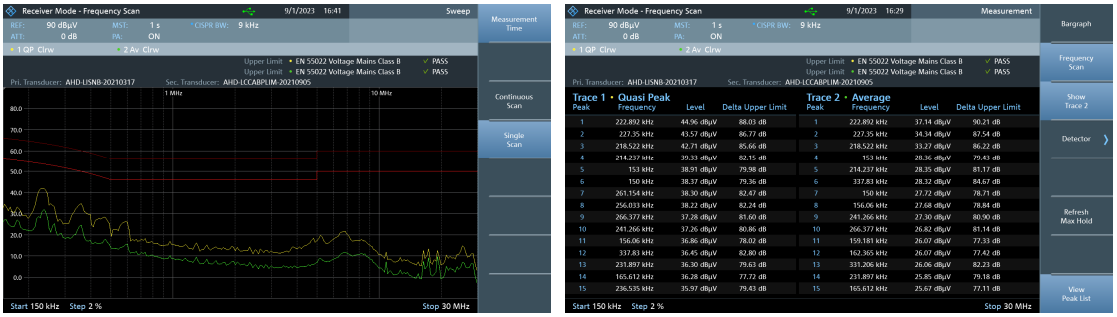
The results of emissions from the EUT's AC mains power port(s) are reported in Table 10.

Table 10: AC Mains Power Conducted Emissions Results.

AC Line Conducted Emissions – L1



AC Line Conducted Emissions – L2



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 11: 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 12: Accreditation Documents