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

WSKPT1-WR2319EM
Issued: **October 9, 2023**

EMC Test Report

regarding

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

for

Pet Tag

Category: BLE Transceiver

Judgments:
FCC 15.247, ISED RSS-247v2 Compliant
Testing Completed: October 6, 2023

TESTING
NVLAP LAB CODE 200129-0

Prepared for:

Whisker

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Data Rec./Rev. by: _____
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Rpt. Auth. by: _____
Dr. Joseph Brunett, EMC-002790-NE

Rpt. Prep./Rev. by: _____
Mr. John Nantz

Date of Issue: October 9, 2023

Revision History

Rev. No.	Date	Details	Revised By
r0	October 9, 2023	Initial Release.	J. Nantz
r1	October 30, 2023	Added Digital Emissions	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 October 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	RSFSV3001	RS / Apr-2024
Biconical	EMCO / 93110B	9802-3039	BICEMCO01	Keysight / Aug-2025
Log Periodic Antenna	EMCO / 3146	9305-3614	LOGEMCO01	Keysight / Aug-2025
Quad Ridge Horn	Singer / A6100	C35200	HQR1TO18S01	Keysight / Aug-2024
K-Band Horn	JEF / NRL Std.	001	HRNK01	AHD / Jul-2024
BNC-BNC Coax	WRTL / RG58/U	001	CAB001-BLACK	AHD / Dec-2023
3.5-3.5MM Coax	PhaseFlex / PhaseFlex	001	CAB015-PURP	AHD / Dec-2023

2 Test Specifications and Procedures

2.1 Test Specification and General Procedures

The goal of Whisker 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 Whisker Pet Tag 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-247/GENe

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 a BLE transceiver. The EUT is approximately 3 x 3.5 x 0.5 cm in dimension, and is depicted in Figure 1. It is powered by 3 VDC Lithium cell. This device is used as a BLE beacon pet identifier. Table 3 outlines provider declared EUT specifications.

Figure 1: Photos of EUT.

Table 3: EUT Declarations.

General Declarations	
Equipment Type:	BLE Transceiver
Country of Origin:	not declared
Nominal Supply:	3 VDC
Oper. Temp Range:	not declared
Frequency Range:	2402 – 2480 MHz
Antenna Dimension:	Integral
Antenna Type:	Ceramic chip
Antenna Gain:	1.5 dBi
Number of Channels:	40
Channel Spacing:	2 MHz
Alignment Range:	Not Declared
Type of Modulation:	GFSK
United States	
FCC ID Number:	2BCHY-WSKR-PETTAG
Classification:	DTS
Canada	
IC Number:	31068-WSKRPETTAG
Classification:	Other

3.1.1 EUT Configuration

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

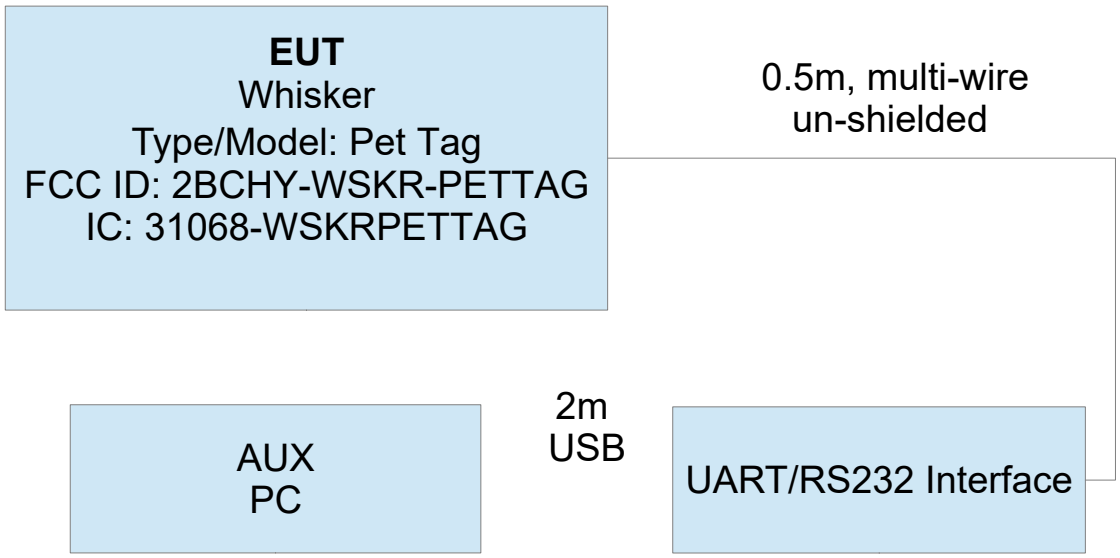


Figure 2: EUT Test Configuration Diagram.

3.1.2 Modes of Operation

The EUT is capable of 1MBps, 2MBps, 500kbps (LR), and 125kbps (LR) data rates, all of which are tested herein.

3.1.3 Variants

There is only a single variant of the EUT, as tested.

3.1.4 Test Samples

Two samples in total were provided. One normal operating sample (SN: 001) and one sample with the antenna replaced by an RF connector for conducted RF emissions testing (SN:002).

3.1.5 Functional Exerciser

Normal functionality was confirmed by measurement of transmitted signals.

3.1.6 Modifications Made

The manufacturer has firmware fixed the power setting of the product at -9 dBm. Full testing of the EUT was completed at this power setting.

3.1.7 Production Intent

The EUT appears to be a production ready sample.

3.1.8 Declared Exemptions and Additional Product Notes

None

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.

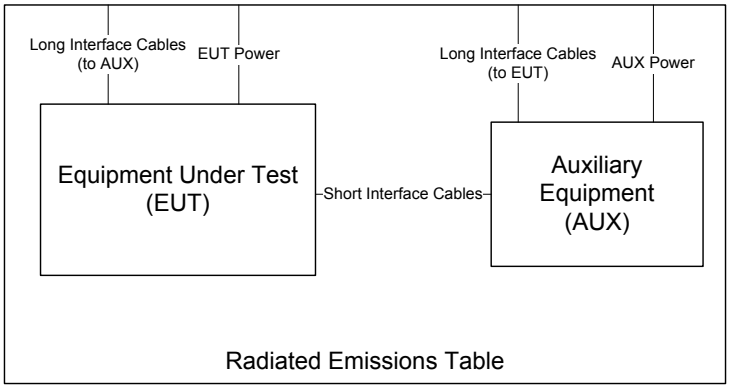


Figure 3: Radiated Emissions Diagram of the EUT.

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.

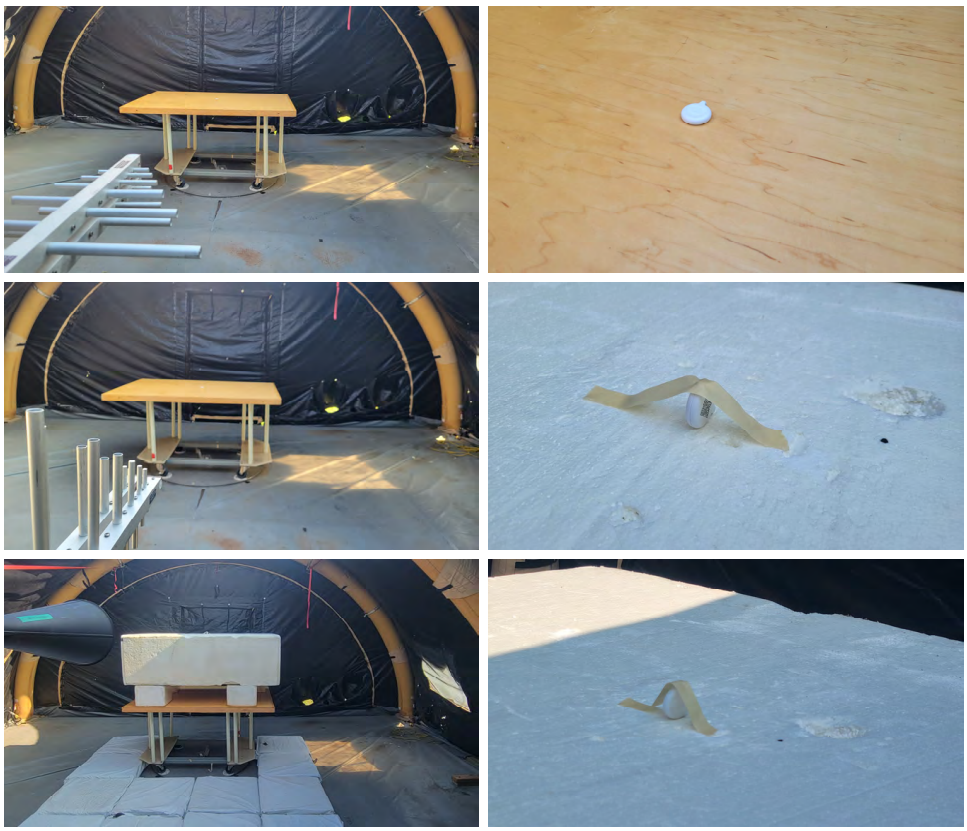


Figure 4: Radiated Emissions Test Setup Photograph(s).

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.

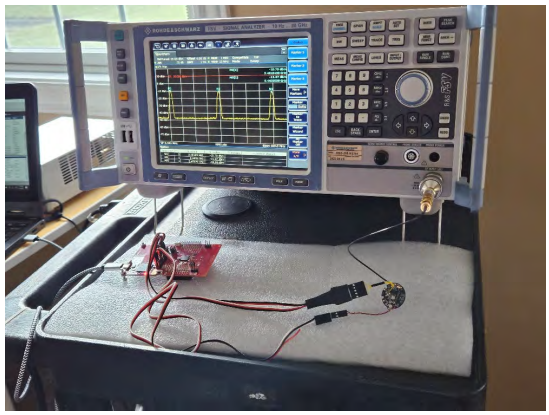


Figure 5: Conducted RF Test Setup Photograph(s).

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 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 6.

Table 4: Pulsed Emission Characteristics (Duty Cycle).

Test Date:	31-Jul-23
Test Engineer:	Joseph Brunett
EUT	WSKR PT1
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	BLE	0.125	3.0	2440.0	1.0	1.0	100.0	0.0
R2		0.500	3.0	2440.0	1.0	1.0	100.0	0.0
R3		1.000	3.0	2440.0	1.0	1.0	100.0	0.0
R4		2.000	3.0	2440.0	1.0	1.0	100.0	0.0
#	C1	C3	C4	C5	C6	C7	C8	C9

(ROW)	(COLUMN)	NOTE
R0	C8	Duty Cycle is measured in line with DTS guidance 558074 D01 v5 r02 section 6(b) for averaging only over full-power transmission pulses.

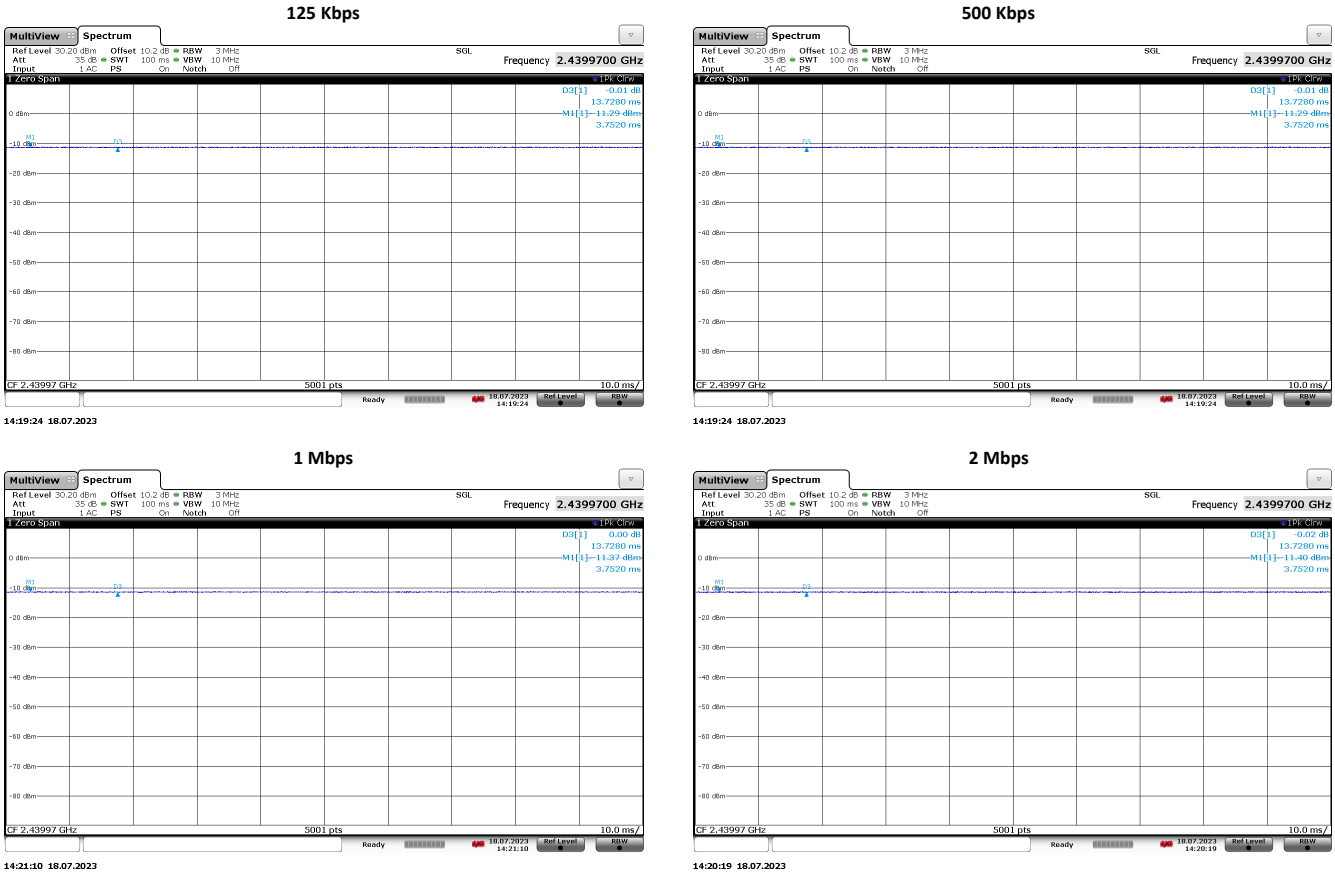


Figure 6: Example Pulsed Emission Characteristics (Duty Cycle).

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 7.

Table 5: Intentional Emission Bandwidth.

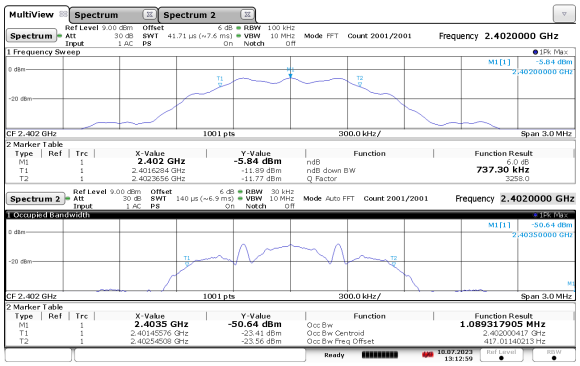
Test Date: 31-Jul-23
Test Engineer: Joseph Brunett
EUT: WSKR PT1
Meas. Distance: Conducted

	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)	Pass/Fail
R1	BLE-LR	0.125	3.0	2402.0	0.737	0.500	1.089	Pass
R2				2440.0	0.767	0.500	1.102	Pass
R3				2480.0	0.764	0.500	1.100	Pass
R4	BLE-LR	0.500	3.0	2402.0	0.767	0.500	1.049	Pass
R5				2440.0	0.788	0.500	1.057	Pass
R6				2480.0	0.806	0.500	1.066	Pass
R7	BLE	1.000	3.0	2402.0	0.788	0.500	1.061	Pass
R8				2440.0	0.803	0.500	1.065	Pass
R9				2480.0	0.818	0.500	1.069	Pass
R10	BLE	2.000	3.0	2402.0	1.440	0.500	2.077	Pass
R11				2440.0	1.550	0.500	2.110	Pass
R12				2480.0	1.540	0.500	2.113	Pass
#	C1	C2	C3	C4	C5	C6	C7	C9

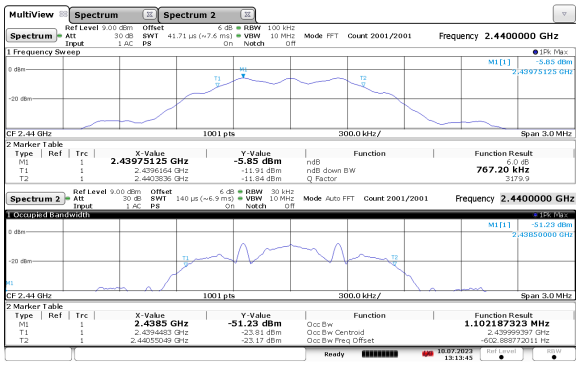
ROW	COLUMN	NOTE
R1-R12	C5	DTS Bandwidth measured with RBW = 100 kHz per ANSI C63.10, section 11.8.1

LR 125kbps

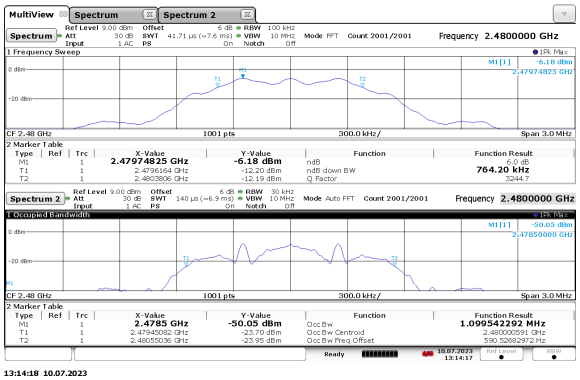
CH0



CH19

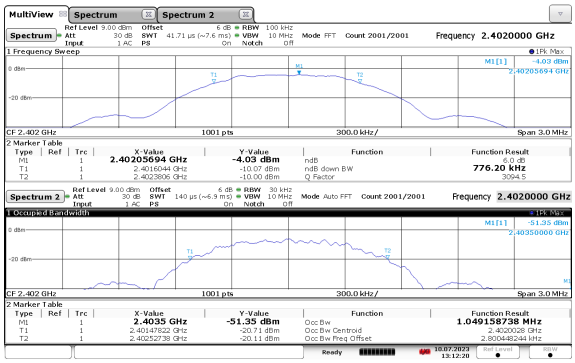


CH39



LR 500kbps

CH0



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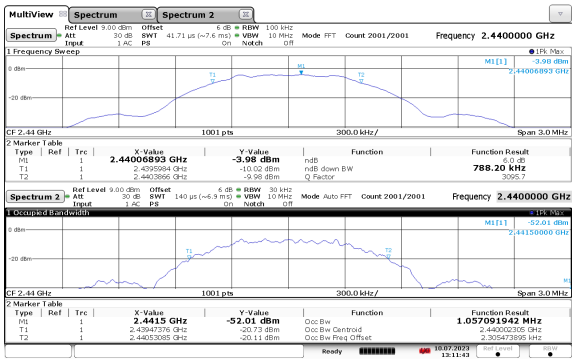

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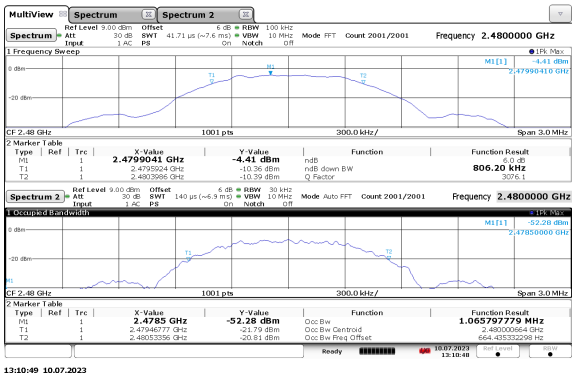
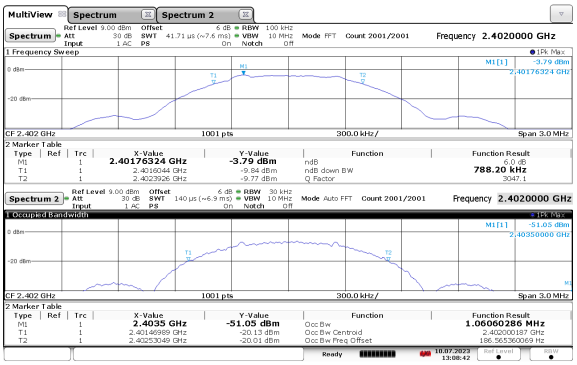


Figure 7(a): Example Intentional Emission Bandwidth Plots.

1 Mbps

CH0



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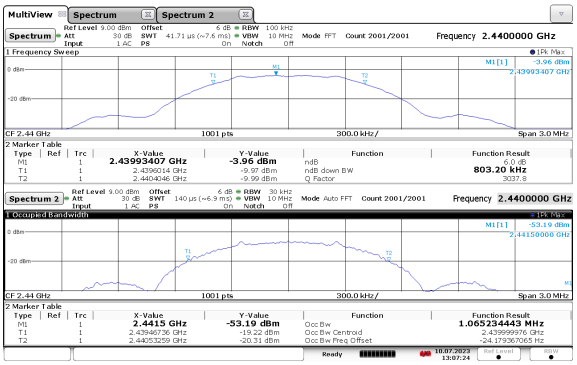

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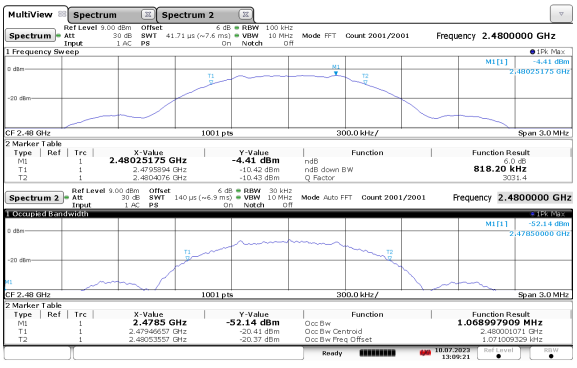
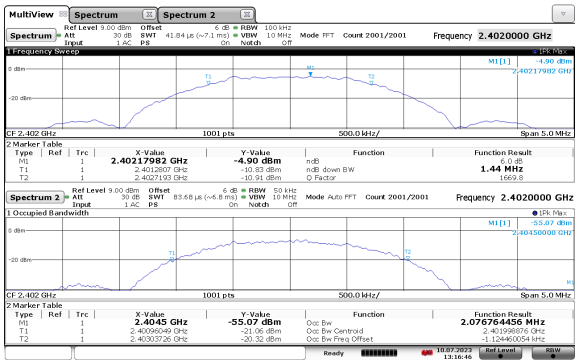


2 Mbps

CH0



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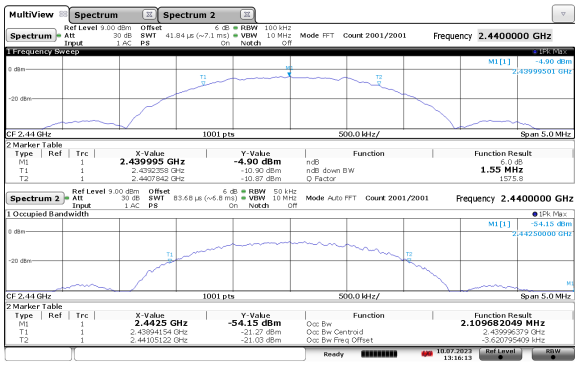

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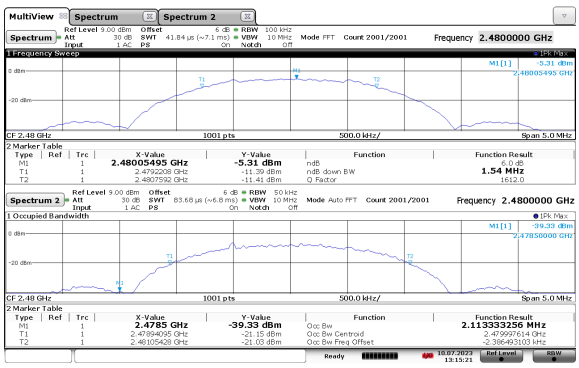


Figure 7(b): Example Intentional Emission Bandwidth Plots.

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. Peak conducted output power was measured

Table 6: Radiated Power Results.

Test Date: 31-Jul-23
Test Engineer: Joseph Brunett
EUT: WSKR PT1
Meas. Distance: Conducted

	Fundamental Power										
R0	Mode	Channel	Freq. MHz	Pout (Pk/Avg) dBm	Duty dB	Pout + Duty (Pk) dBm	Ant Gain (declared) dBi	EIRP (Avg) dBm	EIRP (Avg) Limit dBm	Pass dB	Comments
R1	LR 125 Kbps	0	2402.0	-10.7	0.0	-10.7	1.5	-9.2	36.0	**45.2**	
R2		19	2440.0	-11.4	0.0	-11.4	1.5	-9.9	36.0	45.9	
R3		39	2480.0	-12.1	0.0	-12.1	1.5	-10.6	36.0	46.6	
R4	LR 500 Kbps	0	2402.0	-10.7	0.0	-10.7	1.5	-9.2	36.0	**45.2**	
R5		19	2440.0	-11.4	0.0	-11.4	1.5	-9.9	36.0	45.9	
R6		39	2480.0	-12.1	0.0	-12.1	1.5	-10.6	36.0	46.6	
R7	1Mbps	0	2402.0	-10.7	0.0	-10.7	1.5	-9.2	36.0	**45.2**	
R8		19	2440.0	-11.4	0.0	-11.4	1.5	-9.9	36.0	45.9	
R9		39	2480.0	-12.0	0.0	-12.0	1.5	-10.5	36.0	46.5	
R10	2Mbps	0	2402.0	-10.7	0.0	-10.7	1.5	-9.2	36.0	**45.2**	
R11		19	2440.0	-11.4	0.0	-11.4	1.5	-9.9	36.0	45.9	
R12		39	2480.0	-12.1	0.0	-12.1	1.5	-10.6	36.0	46.6	
	Measured Antenna Gain										
R13	Mode	Channel	Freq. MHz	Pout (Pk) dBm	E3meas (Pk) dBuV/m	EIRP (Pk) dBm	Ant Gain (meas) dBi	Comments			
R14	CW	0	2402.0	-11.0	85.4	-9.8	1.2	Measured gain inline with manuf. Declaration inc. meas uncert.			
R15		19	2440.0	-11.2	85.2	-10	1.2	Measured gain inline with manuf. Declaration inc. meas uncert.			
R16		39	2480.0	-11.7	84.7	-10.5	1.2	Measured gain inline with manuf. Declaration inc. meas uncert.			
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11

(ROW)	(COLUMN)	NOTE
R0	C4	Maximum peak conducted output power measured following DTS Guidance 558074 D01 v5 r02 Section 8.3.1.1
R0	C7	Worst case measured antenna gain is 1.2dBi but using 1.5dBi as declared by manuf data.
R13	C5	Peak measured field strength at 3 meters on OATS
R13	C6	EIRP (Pk) computed from measured field strength.

directly from the EUT at the port where the antenna attaches. The test receiver bandwidth was set to be greater than the measured emission bandwidth of the EUT to capture the true peak. Antenna gain is either provided directly by the manufacturer or measured by comparison between calculated EIRP and conducted output power. Plots showing conducted measurements made are depicted in Figure 8.

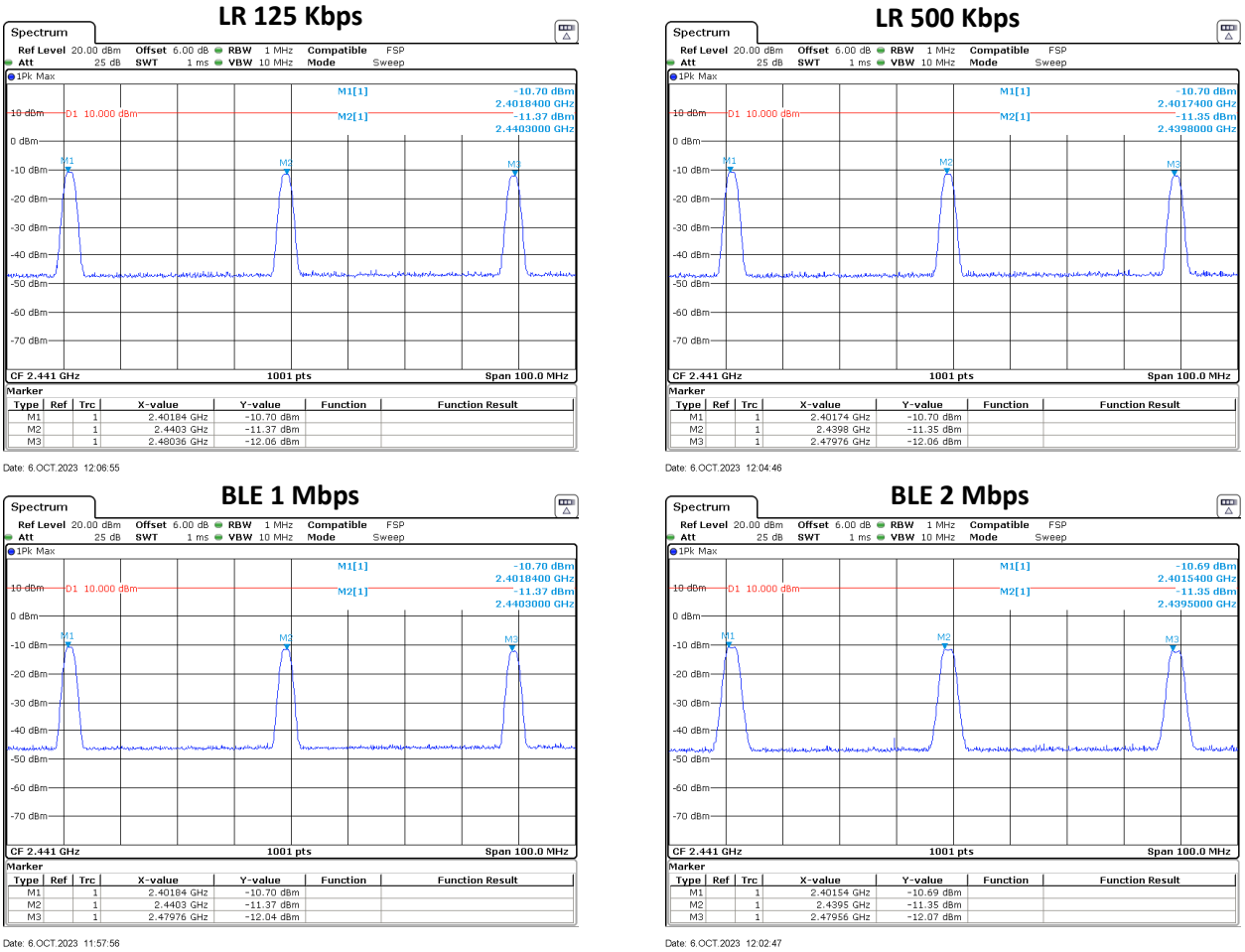


Figure 8: Conducted RF Power Plots

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 9.

Table 7: Power Spectral Density Results.

Frequency Range	**Detector**	**IF Bandwidth**	**Video Bandwidth**	**Test Date:**	31-Jul-23
2400-2483.5	Pk	3 kHz	10 kHz	**Test Engineer:**	Joseph Brunett
				EUT:	WSKR PT1
				Meas. Distance:	Conducted

3kHz Power Spectral Density							
R0	Mode	Channel	Frequency (MHz)	Ant. Used	PSDcond (meas) (dBm/3kHz)	PSD Limit (dBm/3kHz)	Pass By (dB)
R1	LR 125 Kbps	0	2402.0	Cond.	-17.6	8.00	**25.6**
R2		19	2440.0	Cond.	-17.8	8.00	25.8
R3		39	2480.0	Cond.	-18.4	8.00	26.4
R4	LR 500 Kbps	0	2402.0	Cond.	-22.9	8.00	**30.9**
R5		19	2440.0	Cond.	-23.3	8.00	31.3
R6		39	2480.0	Cond.	-24.7	8.00	32.7
R7	1Mbps	0	2402.0	Cond.	-24.3	8.00	32.3
R8		19	2440.0	Cond.	-23.3	8.00	31.3
R9		39	2480.0	Cond.	-25.6	8.00	33.6
R10	2Mbps	0	2402.0	Cond.	-26.3	8.00	34.3
R11		19	2440.0	Cond.	-26.8	8.00	34.8
R12		39	2480.0	Cond.	-26.5	8.00	34.5
#	C1	C2	C3	C4	C5	C6	C7

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

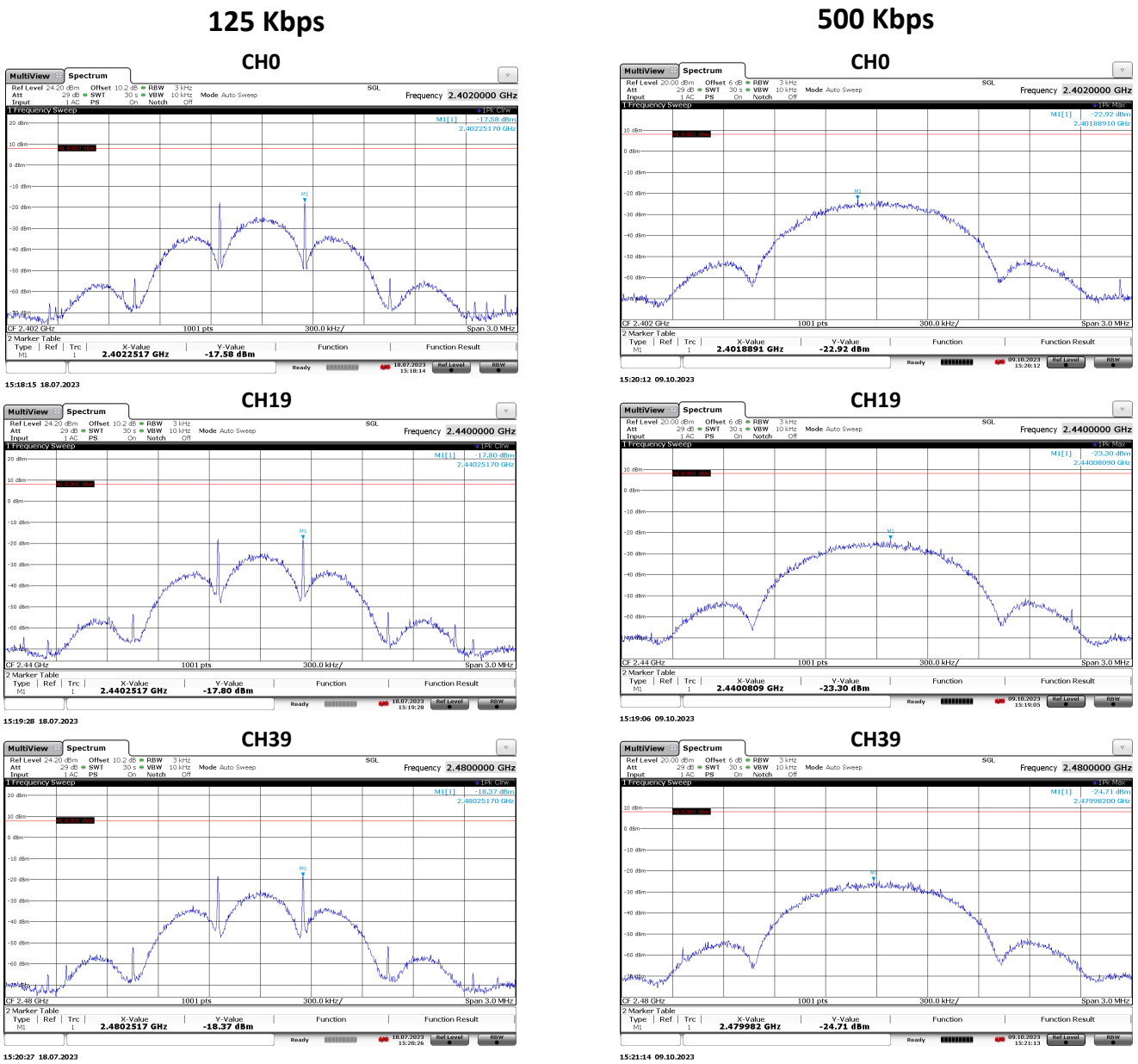
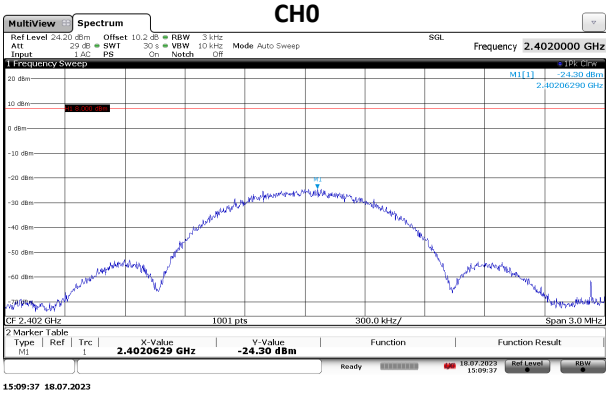


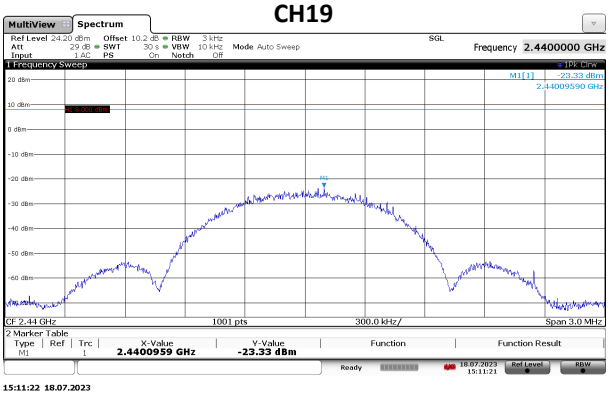
Figure 9(a): Power Spectral Density Plots.

1 Mbps

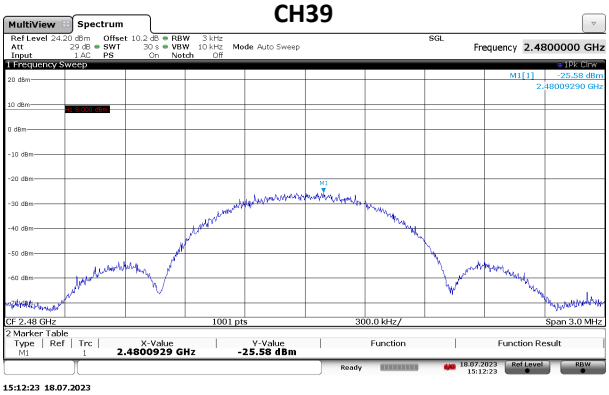
CH0



CH19

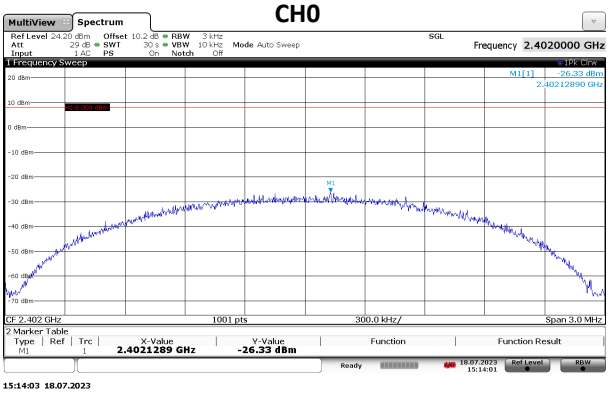


CH39

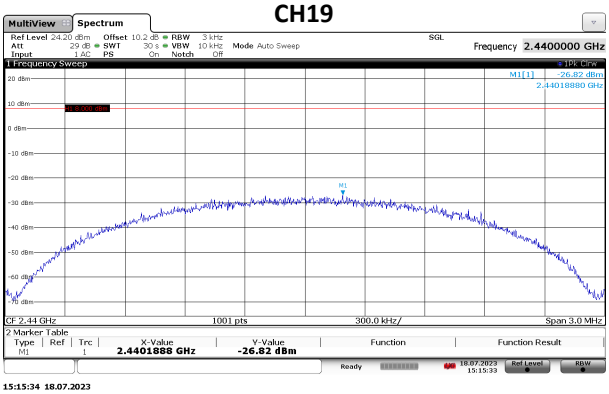


2 Mbps

CH0



CH19



CH39

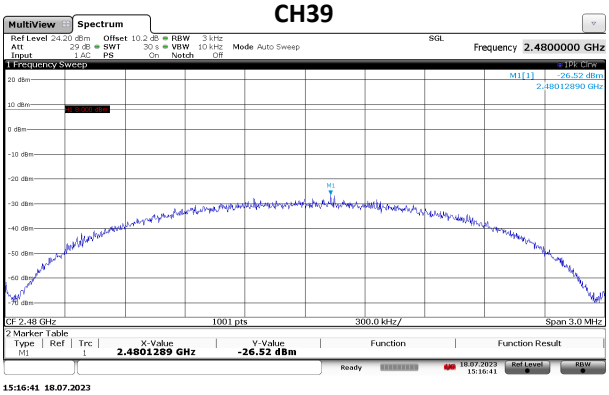


Figure 9(b): Power Spectral Density Plots.

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		
Restricted Band Emissions	30 MHz< f < 1 000 MHz	Pk/Qpk	100 KHz	300 KHz	**Test Date:**	31-Jul-23
Restricted Band Emissions	f > 1 000 MHz	Pk/Avg	1 MHz	3 MHz	**Test Engineer:**	Joseph Brunett
Restricted Band Edge	f > 1 000 MHz	Pk/Avg	100 Khz	300 KHz	**EUT:**	WSKR PT1
					Meas. Distance:	Conducted

Transmitter Spurious														FCC/IC
		Frequency		Output Power Meas.		Ant	GR Factor	Avg Duty	Electric Field @ 3m				Pass	
	Mode	Start	Stop	Pk	Qpk/Avg	Gain		Factor	Calc. Pk	Limit Pk	Calc. 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	LR 125 Kbps	2390.0	2390.0	-65.1	-73.0	2.0			32.1	74.0	24.2	54.0	29.8	max L,M,H channels or noise
R3	Fundamental Restricted Band Edge (High Side)													
R4	LR 125 Kbps	2483.5	2483.5	-62.8	-73.6	2.0			34.4	74.0	23.7	54.0	30.3	max L,M,H channels or noise
R5	Restricted Bands Emissions													
R6	LR 125 Kbps	30.0	88.0	-74.7	-76.1	2.0	4.7		27.2		25.8	40	14.2	max L,M,H channels or noise
R7	LR 125 Kbps	88.0	216.0	-67.9	-68.1	2.0	4.7		34.0		33.8	43.5	9.5	max L,M,H channels or noise
R8	LR 125 Kbps	216.0	960.0	-63.3	-63.7	2.0	4.7		38.6		38.2	46	7.4	max L,M,H channels or noise
R9	LR 125 Kbps	960.0	4000.0	-69.3	-69.6	2.0			27.9	74.0	27.7	54.0	26.3	max L,M,H channels or noise
R10	LR 125 Kbps	4804.0	4804.0	-46.0	-50.8	2.0			51.2	74.0	46.5	54.0	7.5	CH Low
R11	LR 125 Kbps	4880.0	4880.0	-46.6	-51.1	2.0			50.6	74.0	46.2	54.0	7.8	CH Mid
R12	LR 125 Kbps	4960.0	4960.0	-45.6	-50.3	2.0			51.6	74.0	47.0	54.0	**7.0**	CH High
R13	LR 125 Kbps	4000.0	6000.0	-75.7	-78.3	2.0			21.5	74.0	19.0	54.0	35.0	max L,M,H channels or noise
R14	LR 125 Kbps	6000.0	8400.0	-77.4	-80.5	2.0			19.8	74.0	16.8	54.0	37.2	max L,M,H channels or noise
R15	LR 125 Kbps	7320.0	7320.0	-71.3	-74.4	2.0			25.9	74.0	22.9	54.0	31.1	CH Mid
R16	LR 125 Kbps	7440.0	7440.0	-76.8	-79.3	2.0			20.4	74.0	18.0	54.0	36.0	CH High
R17	LR 125 Kbps	8400.0	12500.0	-54.9	-58.6	2.0			42.3	74.0	38.7	54.0	15.3	max L,M,H channels or noise
R18	LR 125 Kbps	12500.0	26000.0	-55.3	-57.2	2.0			41.9	74.0	40.1	54.0	13.9	max L,M,H channels or noise
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14

(ROW)	(COLUMN)	NOTES
R0	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	C5	Measured according to ANSI C63-10 section 11.13.3.3
R6-R8	C4	Measured according to ANSI C63-10 section 11.12.2.4
R9-R16	C5	Measured according to ANSI C63-10 section 11.12.2.5.1
R0	C6	Antenna Gain greater of actual gain or 2 dBi, per ANSI C63-10 11.12.2.6
R0	C7	Ground Reflection Factor as described in ANSI C63.10 section 11.12.2.2c
R0	C9/C11	Computed according to ANSI C63.10-2013 section 11.12.2.2e

Table 8(b): Transmit Chain Spurious Emissions.

	Frequency Range	Det	IF Bandwidth	Video Bandwidth		
Restricted Band Emissions	30 MHz< f < 1 000 MHz	Pk/Qpk	100 KHz	300 KHz	**Test Date:**	31-Jul-23
Restricted Band Emissions	f > 1 000 MHz	Pk/Avg	1 MHz	3 MHz	**Test Engineer:**	Joseph Brunett
Restricted Band Edge	f > 1 000 MHz	Pk/Avg	100 KHz	300 KHz	**EUT:**	WSKR PT1
					Meas. Distance:	Conducted

Transmitter Spurious FCC/IC

	Mode	Frequency		Output Power Meas.		Ant	GR Factor	Avg Duty	Electric Field @ 3m				Pass	
		Start	Stop	Pk	Qpk/Avg	Gain		Factor	Calc. Pk	Limit Pk	Calc. 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	BLE (500Kbps)	2390.0	2390.0	-64.8	-72.8	2.0			32.4	74.0	24.5	54.0	29.5	max L,M,H channels or noise
R3	Fundamental Restricted Band Edge (High Side)													
R4	BLE (500Kbps)	2483.5	2483.5	-63.1	-73.7	2.0			34.1	74.0	23.5	54.0	30.5	max L,M,H channels or noise
R5	Restricted Bands Emissions													
R6	BLE (500Kbps)	30.0	88.0	-72.5	-75.8	2.0	4.7		29.4		26.1	40	13.9	max L,M,H channels or noise
R7	BLE (500Kbps)	88.0	216.0	-65.2	-68.3	2.0	4.7		36.7		33.6	43.5	9.9	max L,M,H channels or noise
R8	BLE (500Kbps)	216.0	960.0	-60.3	-63.8	2.0	4.7		41.6		38.1	46	7.9	max L,M,H channels or noise
R9	BLE (500Kbps)	960.0	4000.0	-66.8	-69.5	2.0			30.4	74.0	27.8	54.0	26.2	max L,M,H channels or noise
R10	BLE (500Kbps)	4804.0	4804.0	-46.4	-50.4	2.0			50.8	74.0	46.9	54.0	7.1	CH Low
R11	BLE (500Kbps)	4880.0	4880.0	-46.6	-50.6	2.0			50.6	74.0	46.7	54.0	7.3	CH Mid
R12	BLE (500Kbps)	4960.0	4960.0	-45.2	-49.5	2.0			52.0	74.0	47.8	54.0	**6.2**	CH High
R13	BLE (500Kbps)	4000.0	6000.0	-72.9	-76.8	2.0			24.3	74.0	20.5	54.0	33.5	max L,M,H channels or noise
R14	BLE (500Kbps)	6000.0	8400.0	-80.4	-83.8	2.0			16.8	74.0	13.5	54.0	40.5	max L,M,H channels or noise
R15	BLE (500Kbps)	7320.0	7320.0	-72.1	-74.6	2.0			25.1	74.0	22.7	54.0	31.3	CH Mid
R16	BLE (500Kbps)	7440.0	7440.0	-77.3	-79.5	2.0			19.9	74.0	17.8	54.0	36.2	CH High
R17	BLE (500Kbps)	8400.0	12500.0	-58.3	-67.8	2.0			38.9	74.0	29.5	54.0	24.5	max L,M,H channels or noise
R18	BLE (500Kbps)	12500.0	26000.0	-58.8	-71.6	2.0			38.4	74.0	25.7	54.0	28.3	max L,M,H channels or noise
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14

(ROW)	(COLUMN)	NOTES
R0	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	C5	Measured according to ANSI C63-10 section 11.13.3.3
R6-R8	C4	Measured according to ANSI C63-10 section 11.12.2.4
R9-R16	C5	Measured according to ANSI C63-10 section 11.12.2.5.1
R0	C6	Antenna Gain greater of actual gain or 2 dBi, per ANSI C63-10 11.12.2.6
R0	C7	Ground Reflection Factor as described in ANSI C63.10 section 11.12.2.2c
R0	C9/C11	Computed according to ANSI C63.10-2013 section 11.12.2.2e

Table 8(c): Transmit Chain Spurious Emissions.

	Frequency Range	Det	IF Bandwidth	Video Bandwidth		
Restricted Band Emissions	30 MHz< f < 1 000 MHz	Pk/Qpk	100 KHz	300 KHz	**Test Date:**	31-Jul-23
Restricted Band Emissions	f > 1 000 MHz	Pk/Avg	1 MHz	3 MHz	**Test Engineer:**	Joseph Brunett
Restricted Band Edge	f > 1 000 MHz	Pk/Avg	100 KHz	300 KHz	**EUT:**	WSKR PT1
					Meas. Distance:	Conducted

Transmitter Spurious FCC/IC

	Mode	Frequency		Output Power Meas.		Ant	GR Factor	Avg Duty	Electric Field @ 3m				Pass	
		Start	Stop	Pk	Qpk/Avg	Gain		Factor	Calc. Pk	Limit Pk	Calc. 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	BLE (1Mbps)	2390.0	2390.0	-64.6	-72.7	2.0			32.6	74.0	24.6	54.0	29.4	max L,M,H channels or noise
R3	Fundamental Restricted Band Edge (High Side)													
R4	BLE (1Mbps)	2483.5	2483.5	-63.4	-73.7	2.0			33.9	74.0	23.6	54.0	30.4	max L,M,H channels or noise
R5	Restricted Bands Emissions													
R6	BLE (1Mbps)	30.0	88.0	-72.4	-76.2	2.0	4.7		29.5		25.7	40	14.3	max L,M,H channels or noise
R7	BLE (1Mbps)	88.0	216.0	-65.2	-68.4	2.0	4.7		36.7		33.5	43.5	10.0	max L,M,H channels or noise
R8	BLE (1Mbps)	216.0	960.0	-59.7	-63.8	2.0	4.7		42.2		38.1	46	7.9	max L,M,H channels or noise
R9	BLE (1Mbps)	960.0	4000.0	-65.9	-69.5	2.0			31.3	74.0	27.7	54.0	26.3	max L,M,H channels or noise
R10	BLE (1Mbps)	4804.0	4804.0	-46.5	-50.5	2.0			50.7	74.0	46.7	54.0	7.3	CH Low
R11	BLE (1Mbps)	4880.0	4880.0	-46.5	-51.0	2.0			50.7	74.0	46.2	54.0	7.8	CH Mid
R12	BLE (1Mbps)	4960.0	4960.0	-45.3	-49.8	2.0			51.9	74.0	47.4	54.0	**6.6**	CH High
R13	BLE (1Mbps)	4000.0	6000.0	-78.2	-81.3	2.0			19.0	74.0	15.9	54.0	38.1	max L,M,H channels or noise
R14	BLE (1Mbps)	6000.0	8400.0	-79.3	-82.7	2.0			17.9	74.0	14.5	54.0	39.5	max L,M,H channels or noise
R15	BLE (1Mbps)	7320.0	7320.0	-70.5	-74.3	2.0			26.7	74.0	22.9	54.0	31.1	CH Mid
R16	BLE (1Mbps)	7440.0	7440.0	-75.6	-79.4	2.0			21.6	74.0	17.8	54.0	36.2	CH High
R17	BLE (1Mbps)	8400.0	12500.0	-58.4	-67.7	2.0			38.8	74.0	29.5	54.0	24.5	max L,M,H channels or noise
R18	BLE (1Mbps)	12500.0	26000.0	-58.7	-71.3	2.0			38.5	74.0	25.9	54.0	28.1	max L,M,H channels or noise
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14

(ROW)	(COLUMN)	NOTES
R0	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	C5	Measured according to ANSI C63-10 section 11.13.3.3
R6-R8	C4	Measured according to ANSI C63-10 section 11.12.2.4
R9-R16	C5	Measured according to ANSI C63-10 section 11.12.2.5.1
R0	C6	Antenna Gain greater of actual gain or 2 dBi, per ANSI C63-10 11.12.2.6
R0	C7	Ground Reflection Factor as described in ANSI C63.10 section 11.12.2.2c
R0	C9/C11	Computed according to ANSI C63.10-2013 section 11.12.2.2e

Table 8(d): Transmit Chain Spurious Emissions.

	Frequency Range	Det	IF Bandwidth	Video Bandwidth		
Restricted Band Emissions	30 MHz< f < 1 000 MHz	Pk/Qpk	100 KHz	300 KHz	**Test Date:**	31-Jul-23
Restricted Band Emissions	f > 1 000 MHz	Pk/Avg	1 MHz	3 MHz	**Test Engineer:**	Joseph Brunett
Restricted Band Edge	f > 1 000 MHz	Pk/Avg	100 KHz	300 KHz	**EUT:**	WSKR PT1
					Meas. Distance:	Conducted

Transmitter Spurious FCC/IC

	Mode	Frequency		Output Power Meas.		Ant	GR Factor	Avg Duty	Electric Field @ 3m				Pass	
		Start	Stop	Pk	Qpk/Avg	Gain		Factor	Calc. Pk	Limit Pk	Calc. 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	BLE (2Mbps)	2390.0	2390.0	-65.0	-73.6	2.0			32.2	74.0	23.6	54.0	30.4	max L,M,H channels or noise
R3	Fundamental Restricted Band Edge (High Side)													
R4	BLE (2Mbps)	2483.5	2483.5	-59.3	-69.8	2.0			37.9	74.0	27.4	54.0	26.6	max L,M,H channels or noise
R5	Restricted Bands Emissions													
R6	BLE (2Mbps)	30.0	88.0	-71.3	-75.7	2.0	4.7		30.6		26.2	40	13.8	max L,M,H channels or noise
R7	BLE (2Mbps)	88.0	216.0	-63.9	-67.5	2.0	4.7		38.0		34.4	43.5	9.1	max L,M,H channels or noise
R8	BLE (2Mbps)	216.0	960.0	-60.3	-63.6	2.0	4.7		41.6		38.3	46	**7.7**	max L,M,H channels or noise
R9	BLE (2Mbps)	960.0	4000.0	-58.7	-70.1	2.0			38.5	74.0	27.1	54.0	26.9	max L,M,H channels or noise
R10	BLE (2Mbps)	4804.0	4804.0	-46.2	-53.0	2.0			51.0	74.0	44.2	54.0	9.8	CH Low
R11	BLE (2Mbps)	4880.0	4880.0	-46.6	-53.3	2.0			50.6	74.0	43.9	54.0	10.1	CH Mid
R12	BLE (2Mbps)	4960.0	4960.0	-45.3	-52.0	2.0			51.9	74.0	45.2	54.0	8.8	CH High
R13	BLE (2Mbps)	4000.0	6000.0	-76.3	-79.7	2.0			20.9	74.0	17.5	54.0	36.5	max L,M,H channels or noise
R14	BLE (2Mbps)	6000.0	8400.0	-79.1	-83.5	2.0			18.1	74.0	13.7	54.0	40.3	max L,M,H channels or noise
R15	BLE (2Mbps)	7320.0	7320.0	-71.6	-75.3	2.0			25.6	74.0	21.9	54.0	32.1	CH Mid
R16	BLE (2Mbps)	7440.0	7440.0	-74.8	-79.1	2.0			22.4	74.0	18.1	54.0	35.9	CH High
R17	BLE (2Mbps)	8400.0	12500.0	-58.2	-68.6	2.0			39.0	74.0	28.6	54.0	25.4	max L,M,H channels or noise
R18	BLE (2Mbps)	12500.0	26000.0	-59.2	-71.3	2.0			38.0	74.0	25.9	54.0	28.1	max L,M,H channels or noise
#	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14

(ROW)	(COLUMN)	NOTES
R0	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	C5	Measured according to ANSI C63-10 section 11.13.3.3
R6-R8	C4	Measured according to ANSI C63-10 section 11.12.2.4
R9-R16	C5	Measured according to ANSI C63-10 section 11.12.2.5.1
R0	C6	Antenna Gain greater of actual gain or 2 dBi, per ANSI C63-10 11.12.2.6
R0	C7	Ground Reflection Factor as described in ANSI C63.10 section 11.12.2.2c
R0	C9/C11	Computed according to ANSI C63.10-2013 section 11.12.2.2e

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 10 below.

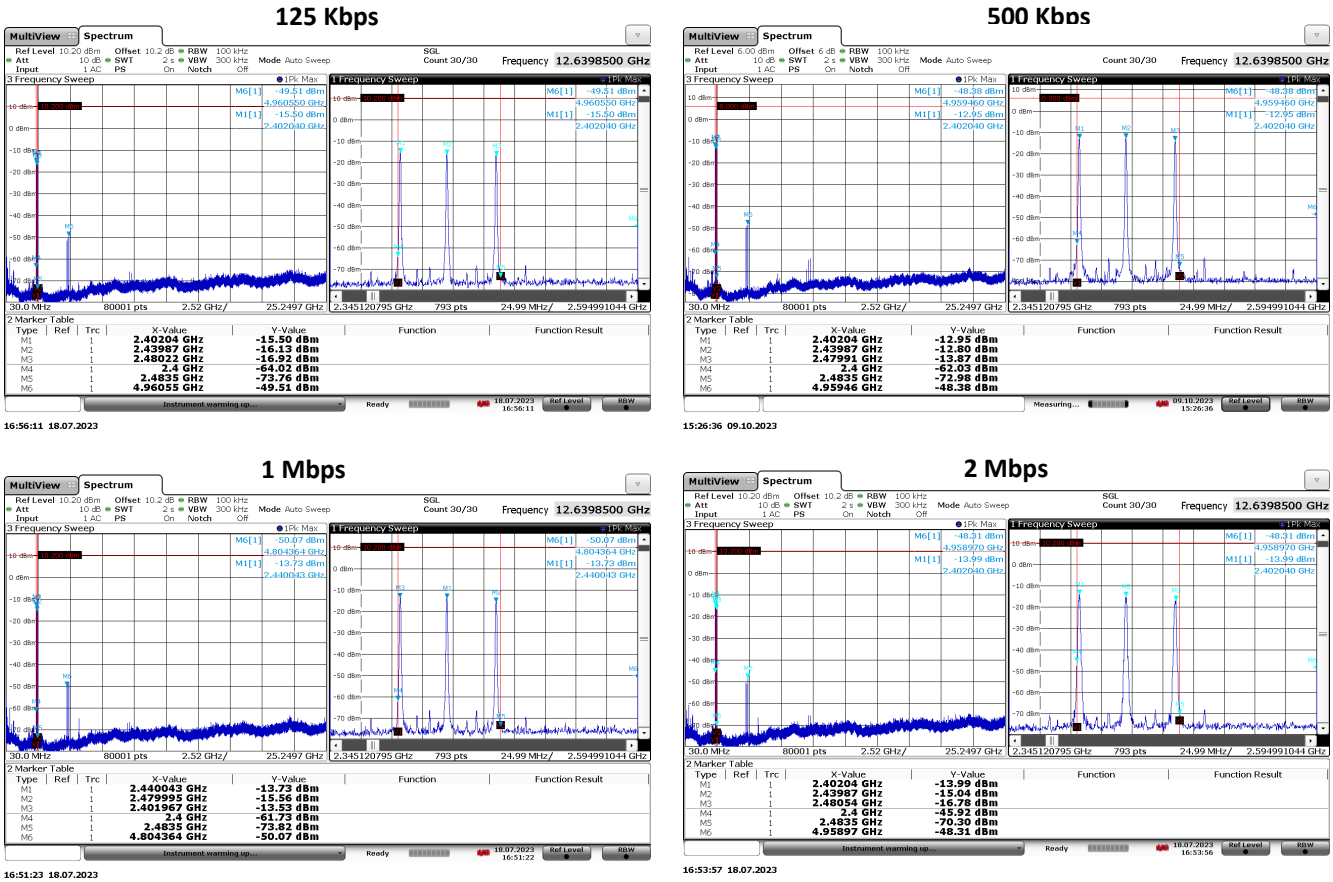


Figure 10: Worst Case Transmitter OOB Emissions Measured.

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 Spurious Emissions.

Frequency Range	Det	IF Bandwidth	Video Bandwidth		
25 MHz ≤ f ≤ 1 000 MHz	Pk/QPk	120 kHz	300 kHz	**Test Date:**	31-Jul-23
f > 1 000 MHz	Avg/RMS	1 MHz	3 MHz	**Test Engineer:**	Joseph Brunett
				EUT:	WSKR PT1
				EUT Mode:	**Active with BLE Radio off**
				Meas. Distance:	3 m
				Temperature:	27C
				Rel. Humidty:	58%

Transmitter Unwanted Spurious Emissions																FCC/IC + EU(CISPR)
	Test	Antenna				E-Field @ 3m**		FCC/IC Class B		EU 55032 Class B		FCC/IC Class A		EU 55032 Class A		
	Freq.	QN	Test	Ka	Kg	Pk	QPk/Avg	E3lim	Pass	E3lim	Pass	E3lim	Pass	E3lim	Pass	
#	MHz	Used	Pol.	dB/m	dB	dBµV/m	dBµV/m	dBµV/m	dB	dBµV/m	dB	dBµV/m	dB	dBµV/m	dB	Comments
1	33.7	BICEMCO01	H	12.2	-.3	38.4	35.9	40.0	4.1	40.5	4.6	49.5	13.6	50.5	14.6	background
2	33.7	BICEMCO01	V	12.2	-.3	31.1	26.9	40.0	13.1	40.5	13.6	49.5	22.6	50.5	23.6	background
3	71.6	BICEMCO01	H	7.6	-.4	23.9	19.5	40.0	20.5	40.5	21.0	49.5	30.0	50.5	31.0	
4	71.6	BICEMCO01	V	7.6	-.4	27.0	21.7	40.0	18.3	40.5	18.8	49.5	27.8	50.5	28.8	
5	112.3	BICEMCO01	H	9.3	-.6	25.0	19.8	43.5	23.7	40.5	20.7	54.0	34.2	50.5	30.7	
6	112.3	BICEMCO01	V	9.3	-.6	29.3	23.9	43.5	19.6	40.5	16.6	54.0	30.1	50.5	26.6	
7	470.0	LOGEMCO01	H	16.9	-1.6	33.5	31.3	46.0	14.7	47.5	16.2	56.9	25.6	57.5	26.2	
8	470.0	LOGEMCO01	V	16.9	-1.6	29.8	26.1	46.0	19.9	47.5	21.4	56.9	30.8	57.5	31.4	
9	868.0	LOGEMCO01	H	22.2	-2.8	39.5	35.0	46.0	11.0	47.5	12.5	56.9	21.9	57.5	22.5	background
10	868.0	LOGEMCO01	V	22.2	-2.8	31.0	26.1	46.0	19.9	47.5	21.4	56.9	30.8	57.5	31.4	
11	945.0	LOGEMCO01	H	23.2	-3.0	37.9	33.3	46.0	12.7	47.5	14.2	56.9	23.6	57.5	24.2	background
12	945.0	LOGEMCO01	V	23.2	-3.0	38.1	33.3	46.0	12.7	47.5	14.2	56.9	23.6	57.5	24.2	background
13																
14	No other spurious emissions observed within 20 dB of the regulatory limit up to 26.5 GHz.															
15																

*QPk detection below 1 GHz, Avg detection at or above 1 GHz with receiver bandwidth as specified at top of table.

** When E-field is reported directly from Spectrum Analyzer, Antenna Factors and Cable losses are included directly in SA settings.

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 10: 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 11: Accreditation Documents