

PARTIAL TEST REPORT

ACCORDING TO: FCC 47CFR part 15 subpart C § 15.247 (FHSS) and subpart B

FOR:

Roseman Engineering Ltd.
Wireless Automated Fueling
Model: WAF FH 2.4GHz
FCC ID: JAKFG3E

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1 Applicant information

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E-mail: haim@roseman.co.il
Contact name: Mr. Haim Kashi

2 Equipment under test attributes

Product name: Wireless Automated Fueling
Product type: Transceiver
Model(s): WAF FH 2.4GHz
Serial number: 108121950016
Hardware version: ASS-22-84Kx-02
Software release: RFU_250F_Vxx
Receipt date 23-Jan-22

3 Manufacturer information

Manufacturer name: Roseman Engineering Ltd.
Address: Kiryat Atidim, Building 7, P.O.B 58181, Tel Aviv 6158101, Israel
Telephone: +972-3-573-1801
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E-Mail: haim@roseman.co.il
Contact name: Mr. Haim Kashi

4 Test details

Project ID: 45843
Location: Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started: 20-Jun-22
Test completed: 28-Jul-22
Test specification(s): FCC 47CFR part 15, subpart C, §15.247 (FHSS) and subpart B

5 Tests summary

Test	Status
Transmitter characteristics	
Section 15.247(a)1, 20 dB bandwidth	Pass*
Section 15.247(a)1, Frequency separation	Pass*
Section 15.247(a)1, Number of hopping frequencies	Pass*
Section 15.247(a)1, Average time of occupancy	Pass*
Section 15.247(b), Peak output power	Pass
Section 15.247(d), Radiated spurious emissions	Pass
Section 15.247(d), Emissions at band edges	Pass
Section 15.247(i)5, RF exposure	Pass, the exhibit to the application of certification is provided
Unintentional emissions	
Section 15.109, Radiated emission	Pass

The EUT were certified by FCC under FCC ID: JAKFG3E. The EUT was revised with the following changes:




1. Depopulation of J19 I/O connector and all the I/O interfaces
2. Depopulation of ACC connector and It's interfaces components
3. Depopulation of RTC and Coin cell Battery
4. Depopulation of the Accelerometer and External Memory (serial Flash)
5. Add 2.4 GHz Antenna sources with lower gain (2dBi max)

* The relevant tests were performed to support Application for Class II permissive changes certification, all other tests are referenced to the original certification.

This test report supersedes the previously issued test report identified by Doc ID: ROSRAD_FCC.45843_Rev3

Testing was completed against all relevant requirements of the test standard. The results obtained indicate that the product under test complies in full with the requirements tested.

The test results relate only to the items tested. Pass/ fail decision was based on nominal values.

	Name and Title	Date	Signature
Tested by:	Mr. H. N. Abayev, test engineer, EMC & Radio	20-Jun-22 – 28-Jul-22	
Reviewed by:	Mrs. S. Peysahov Sheynin, test engineer, EMC & Radio	21-Sep-22	
Approved by:	Mr. M. Nikishin, group leader, EMC & Radio	22-Sep-22	



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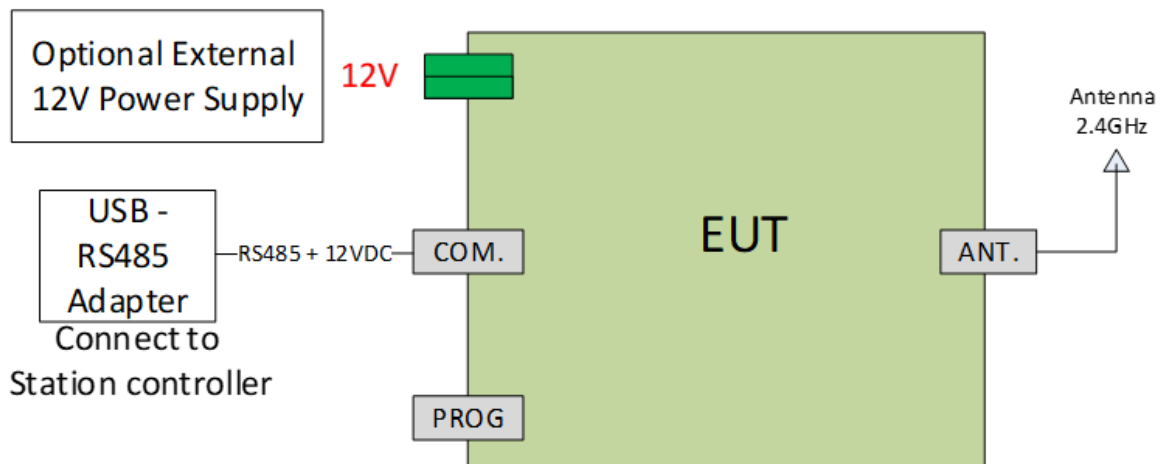
6 EUT description

Note: The following data in this clause is provided by the customer and represents his sole responsibility

6.1 General information

The 2.4 GHz WAF (Wireless Automated Fueling) is a transceiver that in conjunction with the Dual Mode Wireless Nozzle Reader (WNR) enables identifying a vehicle automatically and on what hose that it is fueling. When a nozzle is inserted into a vehicles tank inlet, it reads the vehicle identification device (FJ3 or SVID) and transmits a command to the WAF unit to start the fueling process and at the end of the fueling, it transmits command to stop the fueling.

6.2 Test configuration



6.3 Changes made in EUT

No changes were implemented in the EUT during testing.



6.4 Transmitter characteristics

Type of equipment			
X	Stand-alone (Equipment with or without its own control provisions)		
	Combined equipment (Equipment where the radio part is fully integrated within another type of equipment)		
	Plug-in card (Equipment intended for a variety of host systems)		
Intended use		Condition of use	
	fixed	Always at a distance more than 2 m from all people	
X	mobile	Always at a distance more than 20 cm from all people	
	portable	May operate at a distance closer than 20 cm to human body	
Assigned frequency ranges		2400-2483.5 MHz	
Operating frequencies		2401-2478.3 MHz	
Maximum rated output power		At transmitter 50 Ω RF output connector	
		Peak output power	12.2 dBm
Is transmitter output power variable?		X	No
			continuous variable
		Yes	stepped variable with stepsize
			dB
			minimum RF power
			dBm
			maximum RF power
			dBm
Antenna connection			
unique coupling	standard connector	X	integral
			with temporary RF connector
			without temporary RF connector
Antenna/s technical characteristics			
Type	Manufacturer	Model number	Gain
External	Nearson Inc	S131AH-2450S	2.0 dBi*
External	TE Connectivity	2195630-1	2.0 dBi
External	Cirocomm	03N15E03030020T	-0.6 dBi
Transmitter aggregate data rate/s		250 kbps	
Type of modulation		MSK	
Modulating test signal (baseband)		PRBS	
Transmitter power source			
	Battery	Nominal rated voltage	VDC
X	DC	Nominal rated voltage	12 VDC
	AC mains	Nominal rated voltage	VAC
		Frequency	
Common power source for transmitter and receiver		X	yes
			no
Spread spectrum technique used		X	Frequency hopping (FHSS)
			Digital transmission system (DTS)
			Hybrid
Spread spectrum parameters for transmitters tested per FCC 15.247 only			
FHSS	Total number of hops	16	
	Bandwidth per hop	2441.4 kHz	
	Max. separation of hops	5185.0 kHz	

* - The antennas are interchangeable. The EUT was tested with S131AH-2450S external antenna as worst case.



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 20-Jun-22			
Temperature: 20 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

7 Transmitter tests according to 47CFR part 15 subpart C requirements

7.1 Peak output power

7.1.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.1.1.

Table 7.1.1 Peak output power limits

Assigned frequency range, MHz	Peak output power*		Equivalent field strength limit @ 3m, dB(μV/m)*	Maximum antenna gain, dBi
	W	dBm		
902.0 – 928.0	0.25 (<50 hopping channels)	24.0(<50 hopping channels)	125.2 (<50 hopping channels)	6.0*
	1.0 (≥50 hopping channels)	30.0 (≥50 hopping channels)	131.2 (≥50 hopping channels)	
2400.0 – 2483.5	0.125 (<75 hopping channels)	21.0(<75 hopping channels)	122.2 (<75 hopping channels)	
	1.0 (≥75 hopping channels)	30.0 (≥75 hopping channels)	131.2 (≥75 hopping channels)	
5725.0 – 5850.0	1.0	30.0	131.2	

*- Equivalent field strength limit was calculated from the peak output power as follows: $E = \sqrt{30 \times P \times G} / r$, where P is peak output power in Watts, r is antenna to EUT distance in meters and G is transmitter antenna gain in dBi.

** - The limit is provided in terms of conducted RF power at the antenna connector. If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value as follows:

- by 1 dB for every 3 dB that the directional gain of antenna exceeds 6 dBi for fixed point-to-point transmitters operate in 2400-2483.5 MHz band;
- without any corresponding reduction for fixed point-to-point transmitters operate in 5725-5850 MHz band;
- by the amount in dB that the directional gain of antenna exceeds 6 dBi for the rest of transmitters.

7.1.2 Test procedure

7.1.2.1 The EUT was set up as shown in Figure 7.1.1, energized and its proper operation was checked.

7.1.2.2 The EUT was adjusted to produce maximum available to end user RF output power.

7.1.2.3 The frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. To find maximum radiation the turntable was rotated 3600 and the measuring antenna height was swept in both vertical and horizontal polarizations.

7.1.2.4 The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.1.2 and associated plots.

7.1.2.5 The maximum peak output power was calculated from the field strength of carrier as follows:

$$P = (E \times d)^2 / (30 \times G),$$

where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.

The above equation was converted in logarithmic units for 3 m test distance:

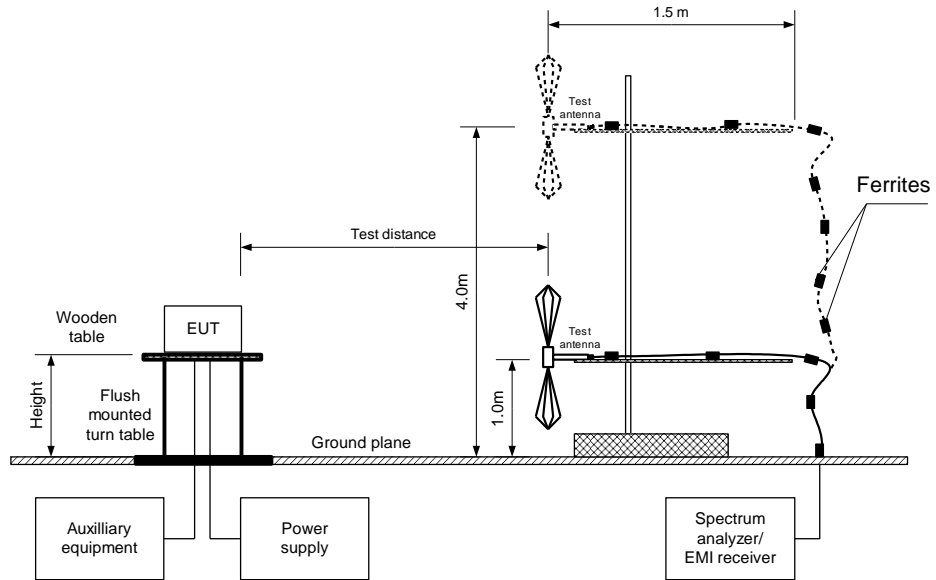
$$\text{Peak output power in dBm} = \text{Field strength in dB}(\mu\text{V/m}) - \text{Transmitter antenna gain in dBi} - 95.2 \text{ dB}$$

7.1.2.6 The worst test results (the lowest margins) were recorded in Table 7.1.2.



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 20-Jun-22			
Temperature: 20 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Figure 7.1.1 Setup for peak output power measurements





Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 20-Jun-22			
Temperature: 20 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Table 7.1.2 Peak output power test results

ASSIGNED FREQUENCY: 2400 – 2483.5 MHz
TEST DISTANCE: 3 m
TEST SITE: Semi anechoic chamber
DETECTOR USED: Peak
TEST ANTENNA TYPE: Double ridged guide
MODULATION: MSK
MODULATING SIGNAL: PRBS
BIT RATE: 250 kbps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Peak
FREQUENCY HOPPING: Disabled

Frequency, MHz	Field strength, dB(µV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
2401.0	109.4	Vertical	1.5	43	2	12.2	21	-8.8	Pass
2436.9	108.0	Vertical	1.5	45	2	10.8	21	-10.2	Pass
2478.0	106.8	Vertical	1.4	40	2	9.6	21	-11.4	Pass

*- EUT front panel refer to 0 degrees position of turntable.

** - Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$, where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance: *Peak output power in dBm = Field strength in dB(µV/m) - Transmitter antenna gain in dBi - 95.2 dB*

*** - Margin = Peak output power – specification limit.

Reference numbers of test equipment used

HL 3902	HL 4355	HL 4360	HL 4933	HL 5902			
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Full description is given in Appendix A.

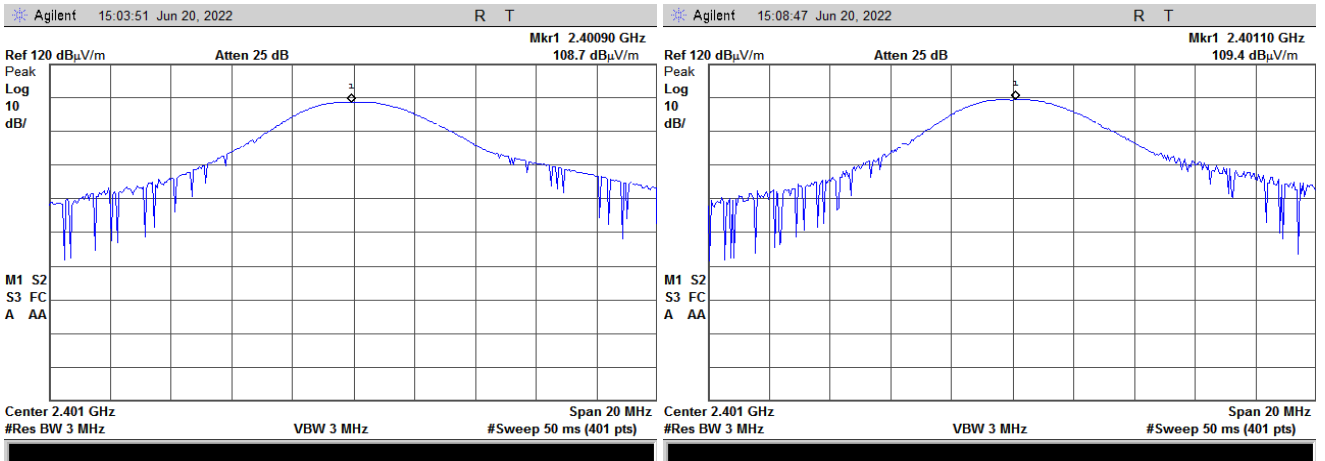


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Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 20-Jun-22			
Temperature: 20 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

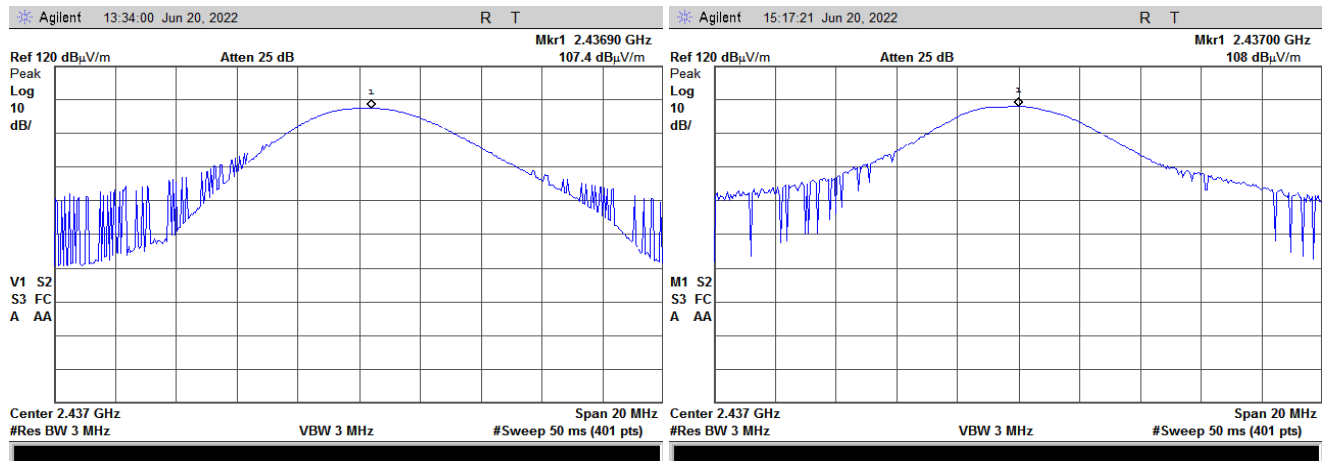
Plot 7.1.1 Field strength of carrier at low frequency

EUT POSITION: Typical Installation
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.1.2 Field strength of carrier at mid frequency

EUT POSITION: Typical Installation
ANTENNA POLARIZATION: Vertical and Horizontal



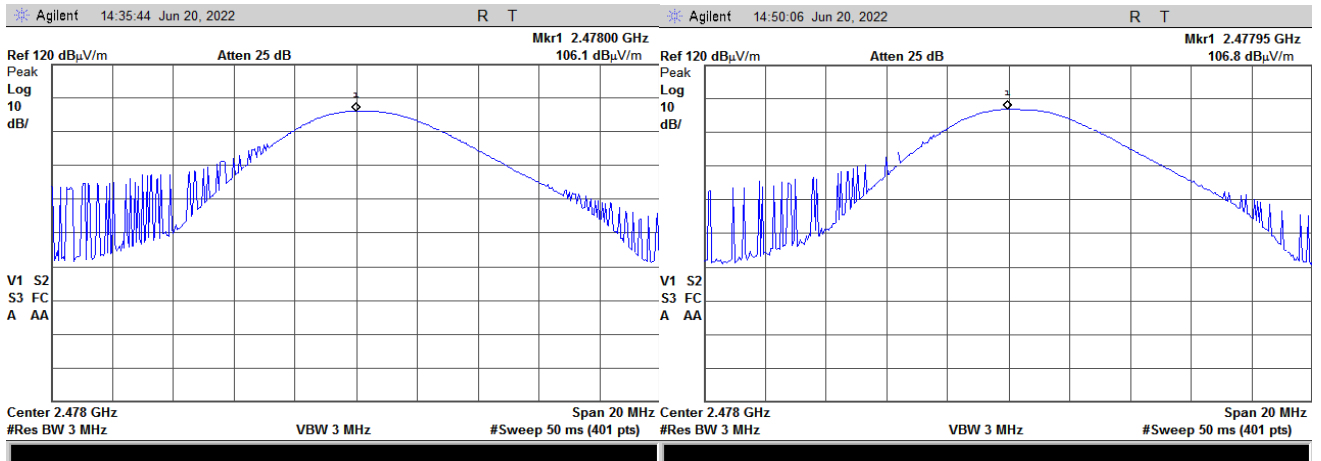


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Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 20-Jun-22			
Temperature: 20 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Plot 7.1.3 Field strength of carrier at high frequency

EUT POSITION: Typical Installation
ANTENNA POLARIZATION: Vertical and Horizontal





Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

7.2 Field strength of spurious emissions

7.2.1 General

This test was performed to measure field strength of spurious emissions from the EUT. Specification test limits are given in Table 7.2.1.

Table 7.2.1 Radiated spurious emissions limits

Frequency, MHz	Field strength at 3 m within restricted bands, dB(μV/m)***			Attenuation of field strength of spurious versus carrier outside restricted bands, dBc***
	Peak	Quasi Peak	Average	
0.009 – 0.090	148.5 – 128.5	NA	128.5 – 108.5**	20.0
0.090 – 0.110	NA	108.5 – 106.8**	NA	
0.110 – 0.490	126.8 – 113.8	NA	106.8 – 93.8**	
0.490 – 1.705	NA	73.8 – 63.0**	NA	
1.705 – 30.0*		69.5		
30 – 88		40.0		
88 – 216		43.5		
216 – 960		46.0		
960 - 1000		54.0		
1000 – 10 th harmonic	74.0	NA	54.0	

*- The limit for 3 m test distance was calculated using the inverse square distance extrapolation factor as follows:

$$\text{Lim}_{S_2} = \text{Lim}_{S_1} + 40 \log (S_1/S_2),$$

where S_1 and S_2 – standard defined and test distance respectively in meters.

** - The limit decreases linearly with the logarithm of frequency.

*** - The field strength limits applied from the lowest radio frequency generated in the device, without going below 9 kHz up to the tenth harmonic of the highest fundamental frequency.

7.2.2 Test procedure for spurious emission field strength measurements in 9 kHz to 30 MHz band

7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized and the performance check was conducted.

7.2.2.2 The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360° and the measuring antenna was rotated around its vertical axis.

7.2.2.3 The worst test results (the lowest margins) were recorded and shown in the associated plots.

7.2.3 Test procedure for spurious emission field strength measurements above 30 MHz

7.2.3.1 The EUT was set up as shown in Figure 7.2.2, Figure 7.2.3, energized and the performance check was conducted.

7.2.3.2 The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360°, the measuring antenna height was changed from 1 to 4 m, its polarization was switched from vertical to horizontal.

7.2.3.3 The worst test results (the lowest margins) were recorded and shown in the associated plots.



Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Figure 7.2.1 Setup for spurious emission field strength measurements below 30 MHz

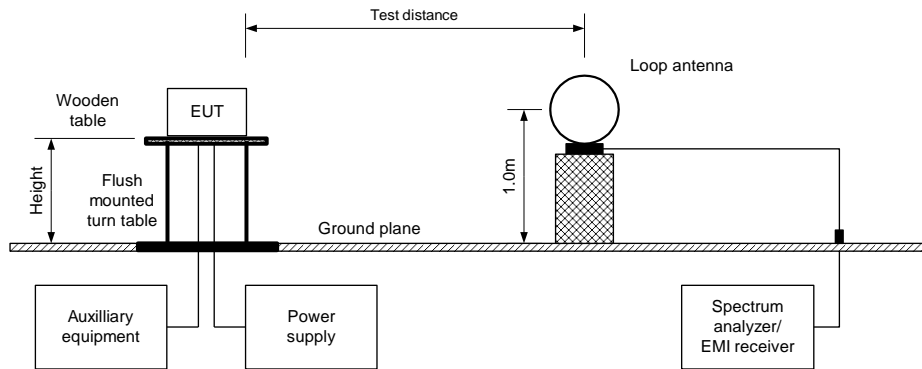
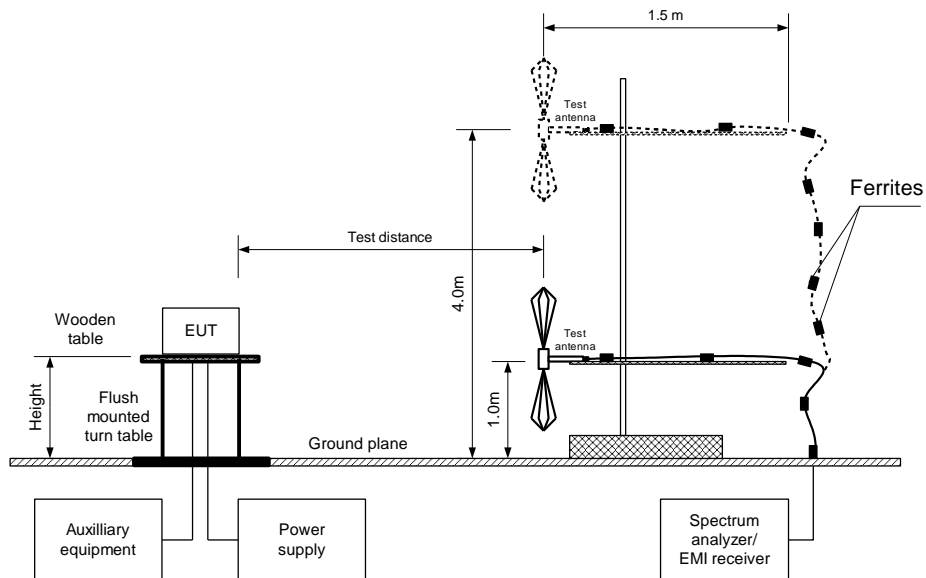


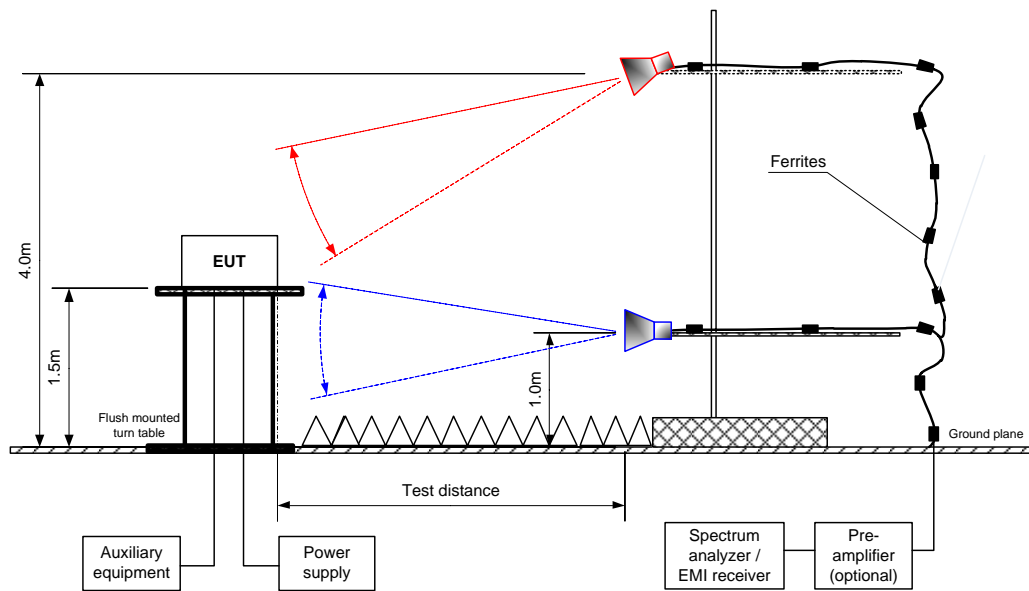
Figure 7.2.2 Setup for spurious emission field strength measurements from 30 to 1000 MHz





Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Figure 7.2.3 Setup for spurious emission field strength measurements above 1000 MHz





Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Table 7.2.2 Field strength of emissions outside restricted bands

ASSIGNED FREQUENCY: 2400.0 – 2483.5 MHz
 INVESTIGATED FREQUENCY RANGE: 0.009 – 25000 MHz
 TEST DISTANCE: 3 m
 MODULATION: MSK
 MODULATING SIGNAL: PRBS
 BIT RATE: 250 kbps
 DUTY CYCLE: 100 %
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 DETECTOR USED: Peak
 RESOLUTION BANDWIDTH: 100 kHz
 VIDEO BANDWIDTH: 300 kHz
 TEST ANTENNA TYPE: Active loop (9 kHz – 30 MHz)
 Biconilog (30 MHz – 1000 MHz)
 Double ridged guide (above 1000 MHz)
 Disabled

FREQUENCY HOPPING:

Frequency, MHz	Field strength of spurious, dB(µV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	Field strength of carrier, dB(µV/m)	Attenuation below carrier, dBc	Limit, dBc	Margin, dB**	Verdict
Low carrier frequency									
7202	56.1	Vertical	1.5	45	109.4	53.3	20	33.3	Pass
Mid carrier frequency									
No emissions were found									Pass
High carrier frequency									
No emissions were found									Pass

*- EUT front panel refers to 0 degrees position of turntable.

**- Margin = Specification limit- attenuation below carrier.



Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Table 7.2.3 Field strength of spurious emissions above 1 GHz within restricted bands

ASSIGNED FREQUENCY: 2400.0 – 2483.5 MHz
 INVESTIGATED FREQUENCY RANGE: 1000 – 25000 MHz
 TEST DISTANCE: 3 m
 MODULATION: MSK
 MODULATING SIGNAL: PRBS
 BIT RATE: 250 kbps
 DUTY CYCLE: 100 %
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 DETECTOR USED: Peak
 RESOLUTION BANDWIDTH: 1000 kHz
 TEST ANTENNA TYPE: Double ridged guide
 FREQUENCY HOPPING: Disabled

Frequency, MHz	Antenna		Azimuth, degrees*	Peak field strength			Average field strength				Verdict
	Polarization	Height, m		Measured, dB(µV/m)	Limit, dB(µV/m)	Margin, dB**	Measured, dB(µV/m)	Calculated, dB(µV/m)	Limit, dB(µV/m)	Margin, dB***	
Low carrier frequency											
4802	Vertical	1.5	25	56.58	74	-17.42	56.58	24.02	54	-29.98	Pass
Mid carrier frequency											
4874	Vertical	1.5	25	49.22	74	-24.78	49.22	17.62	54	-36.38	Pass
High carrier frequency											
4956	Vertical	1.5	23	53.77	74	-20.23	53.77	22.17	54	-31.83	Pass
7434	Vertical	1.5	151	53.83	74	-20.17	53.83	22.23	54	-31.77	

*- EUT front panel refers to 0 degrees position of turntable.

** - Margin = Measured field strength - specification limit.

*** - Margin = Calculated field strength - specification limit, where Calculated field strength = Measured field strength + average factor.



Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Table 7.2.4 Field strength of spurious emissions below 1 GHz within restricted bands

ASSIGNED FREQUENCY: 2400.0 – 2483.5 MHz
 INVESTIGATED FREQUENCY RANGE: 0.009 – 1000 MHz
 TEST DISTANCE: 3 m
 MODULATION: MSK
 MODULATING SIGNAL: PRBS
 BIT RATE: 250 kbps
 DUTY CYCLE: 100 %
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 RESOLUTION BANDWIDTH: 0.2 kHz (9 kHz – 150 kHz)
 9.0 kHz (150 kHz – 30 MHz)
 120 kHz (30 MHz – 1000 MHz)
 VIDEO BANDWIDTH: > Resolution bandwidth
 TEST ANTENNA TYPE: Active loop (9 kHz – 30 MHz)
 Biconilog (30 MHz – 1000 MHz)
 FREQUENCY HOPPING: Disabled

Frequency, MHz	Peak emission, dB(µV/m)	Quasi-peak			Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
		Measured emission, dB(µV/m)	Limit, dB(µV/m)	Margin, dB*				
Low carrier frequency								
131.6	29.3	27.2	43.5	-16.3	Vertical	1.2	-170	Pass
165.6	31.4	29.3	43.5	-14.2	Vertical	1.0	14	
403.6	39.3	37.0	46.0	-9.0	Horizontal	1.3	-36	
Mid carrier frequency								
131.6	30.1	28.2	43.5	-15.3	Vertical	1.2	-169	Pass
165.6	31.4	29.3	43.5	-14.2	Vertical	1.0	14	
403.6	39.1	36.7	46.0	-9.3	Horizontal	1.2	-33	
High carrier frequency								
134.3	27.8	25.6	43.5	-17.9	Vertical	1.2	-159	Pass
165.6	29.3	27.4	43.5	-16.1	Vertical	1.0	20	
403.6	37.4	35.2	46.0	-10.8	Horizontal	1.3	-20	

*- Margin = Measured emission - specification limit.
 **- EUT front panel refer to 0 degrees position of turntable.



Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Table 7.2.5 Restricted bands according to FCC section 15.205

MHz	MHz	MHz	MHz	MHz	GHz
0.09 - 0.11	8.37625 - 8.38675	73 - 74.6	399.9 - 410	2690 - 2900	10.6 - 12.7
0.495 - 0.505	8.41425 - 8.41475	74.8 - 75.2	608 - 614	3260 - 3267	13.25 - 13.4
2.1735 - 2.1905	12.29 - 12.293	108 - 121.94	960 - 1240	3332 - 3339	14.47 - 14.5
4.125 - 4.128	12.51975 - 12.52025	123 - 138	1300 - 1427	3345.8 - 3358	15.35 - 16.2
4.17725 - 4.17775	12.57675 - 12.57725	149.9 - 150.05	1435 - 1626.5	3600 - 4400	17.7 - 21.4
4.20725 - 4.20775	13.36 - 13.41	156.52475 - 156.52525	1645.5 - 1646.5	4500 - 5150	22.01 - 23.12
6.215 - 6.218	16.42 - 16.423	156.7 - 156.9	1660 - 1710	5350 - 5460	23.6 - 24
6.26775 - 6.26825	16.69475 - 16.69525	162.0125 - 167.17	1718.8 - 1722.2	7250 - 7750	31.2 - 31.8
6.31175 - 6.31225	16.80425 - 16.80475	167.72 - 173.2	2200 - 2300	8025 - 8500	36.43 - 36.5
8.291 - 8.294	25.5 - 25.67	240 - 285	2310 - 2390	9000 - 9200	Above 38.6
8.362 - 8.366	37.5 - 38.25	322 - 335.4	2483.5 - 2500	9300 - 9500	

Reference numbers of test equipment used

HL 0446	HL 0604	HL 3902	HL 4355	HL 4360	HL 4933	HL 4956	HL 5112
HL 5902							

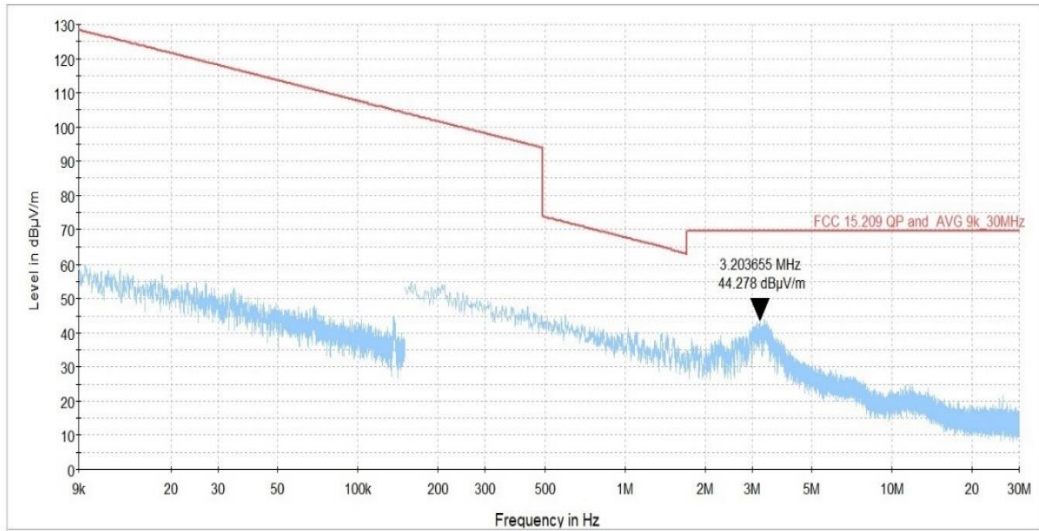
Full description is given in Appendix A.



Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

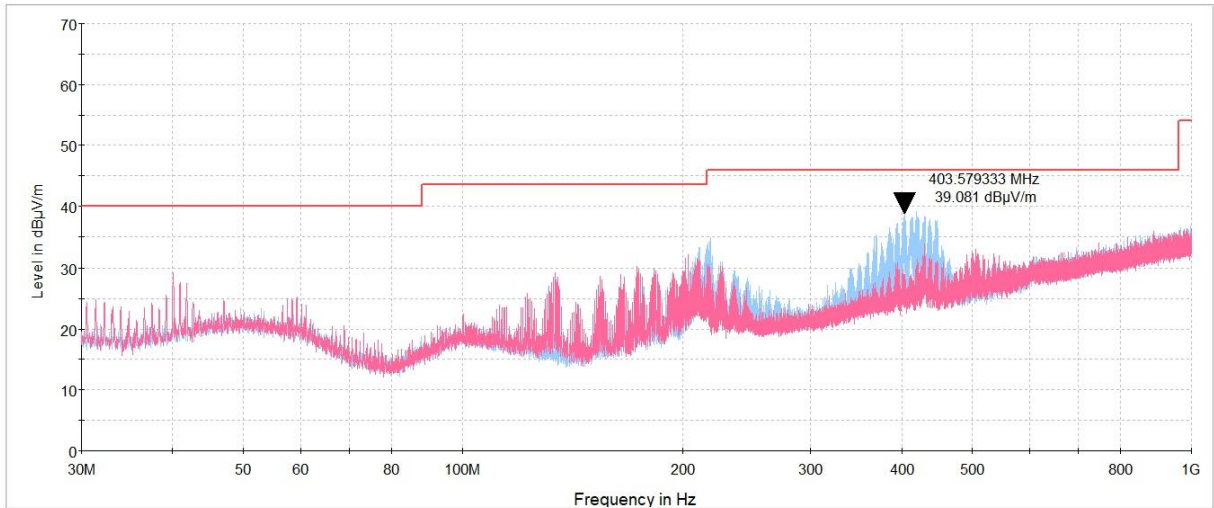
Plot 7.2.1 Radiated emission measurements from 9 kHz to 30 MHz at the low, mid, high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m



Plot 7.2.2 Radiated emission measurements from 30 to 1000 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



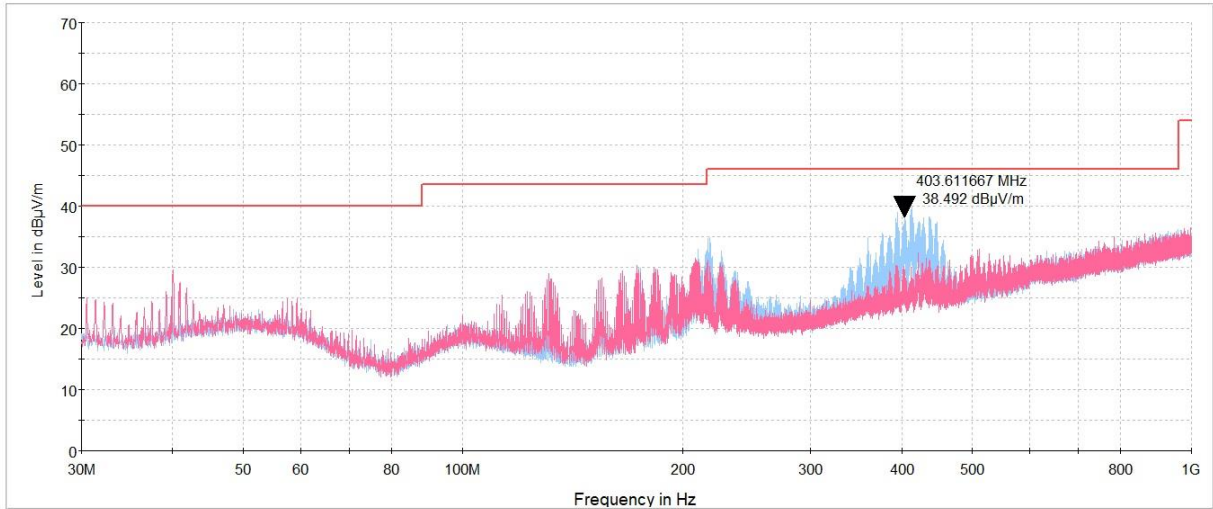


HERMON LABORATORIES

Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

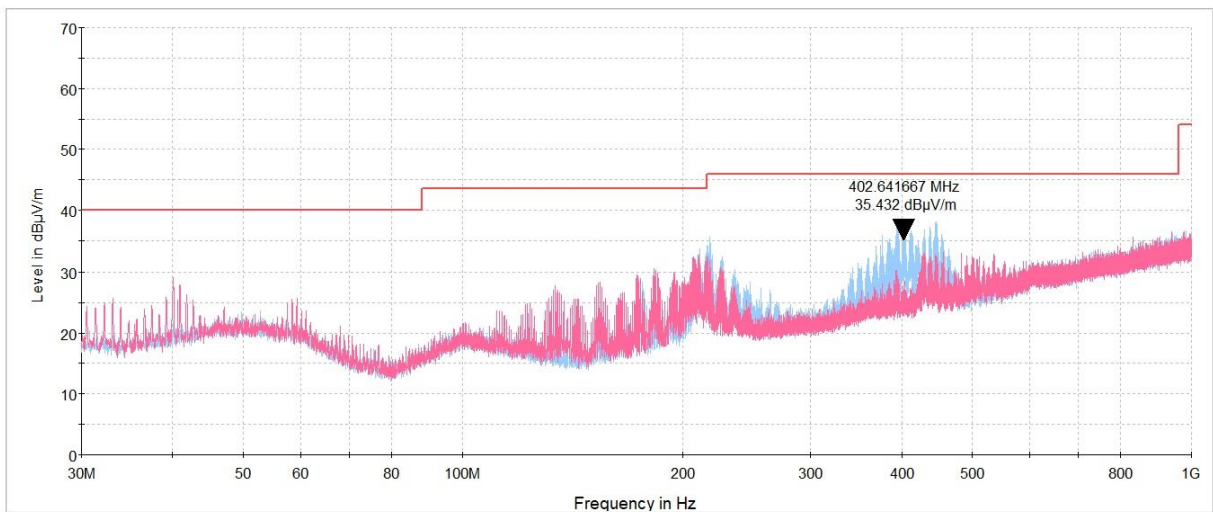
Plot 7.2.3 Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.2.4 Radiated emission measurements from 30 to 1000 MHz at the high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

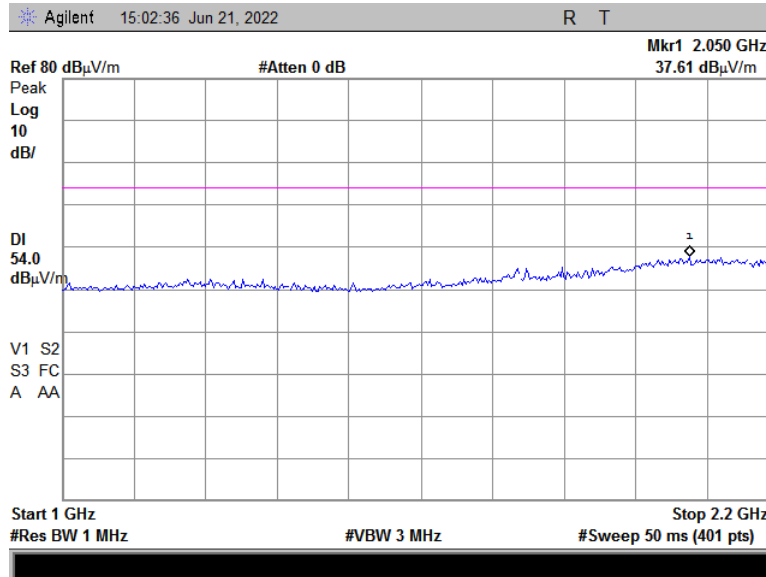




Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

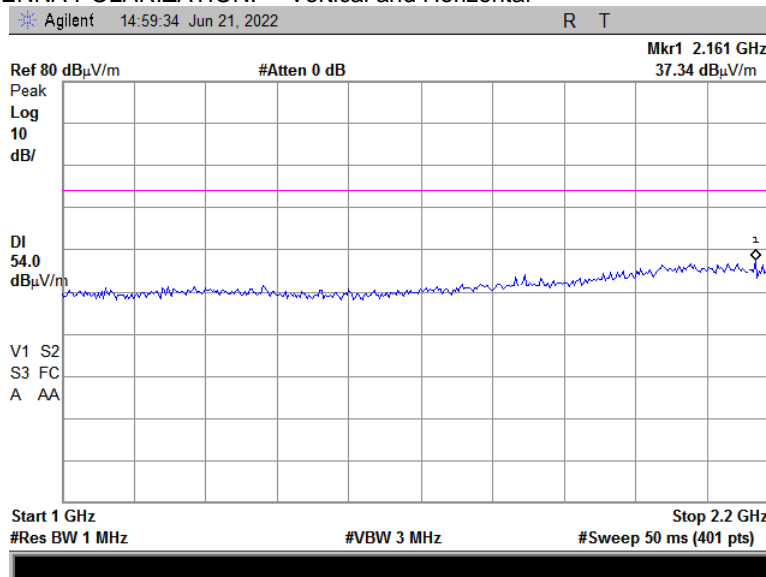
Plot 7.2.5 Radiated emission measurements from 1000 to 2200 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.2.6 Radiated emission measurements from 1000 to 2200 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

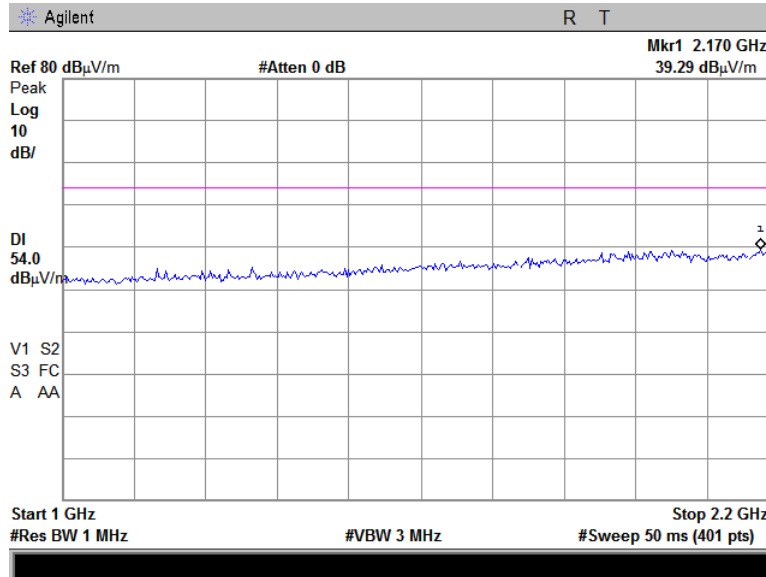




Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Plot 7.2.7 Radiated emission measurements from 1000 to 2200 MHz at the high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



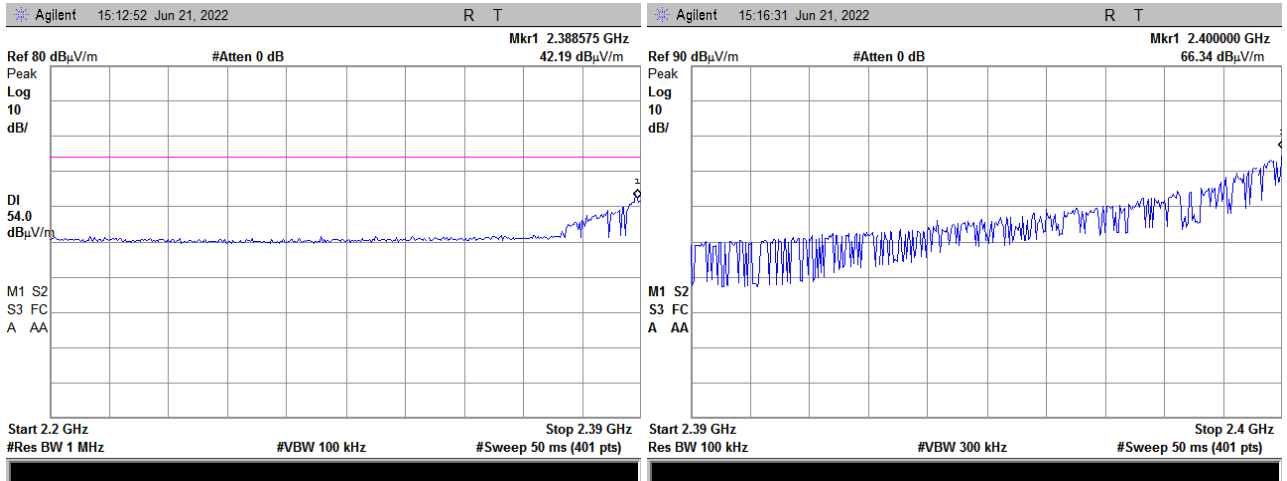


HERMON LABORATORIES

Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Plot 7.2.8 Radiated emission measurements from 2200 to 2400 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

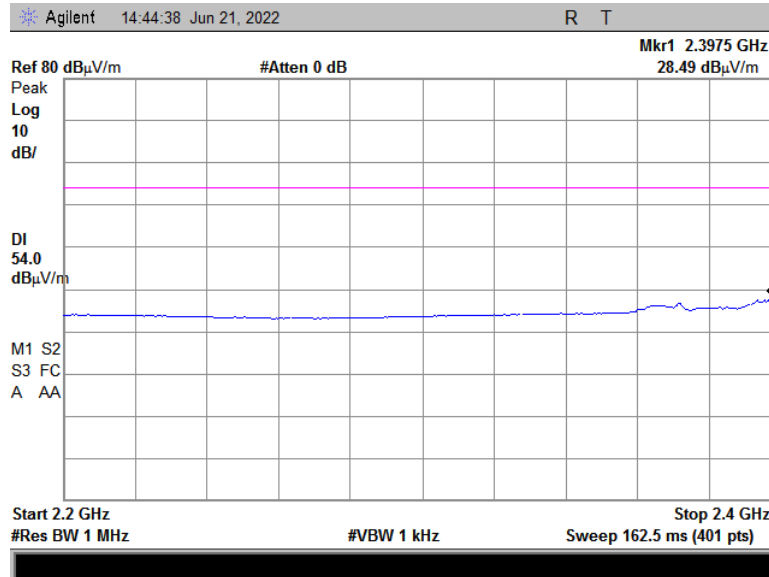




Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

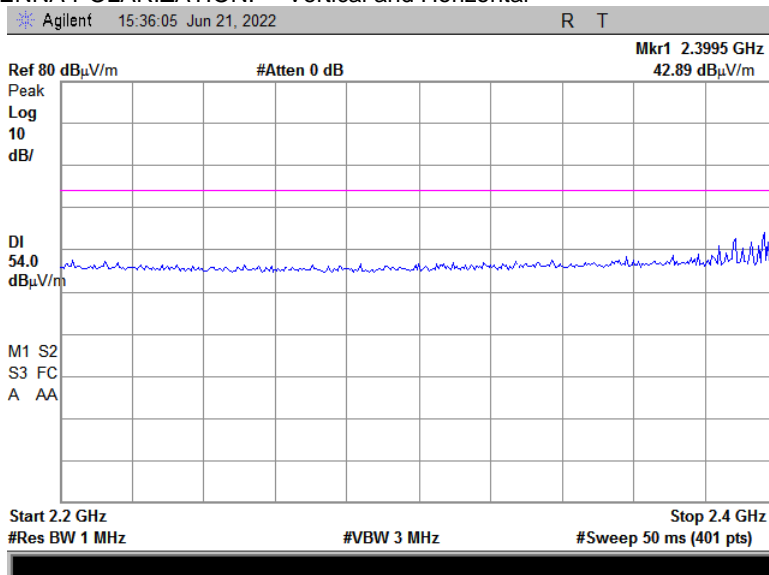
Plot 7.2.9 Radiated emission measurements from 2200 to 2400 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.2.10 Radiated emission measurements from 2200 to 2400 MHz at the high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

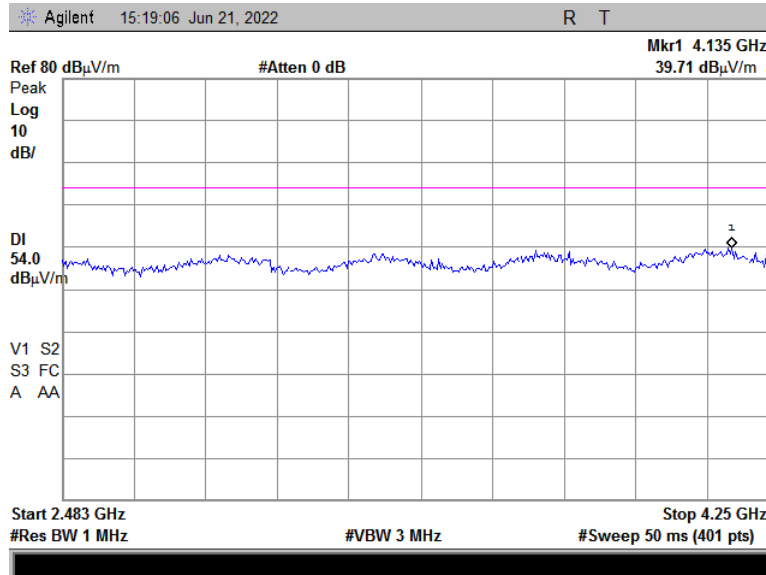




Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

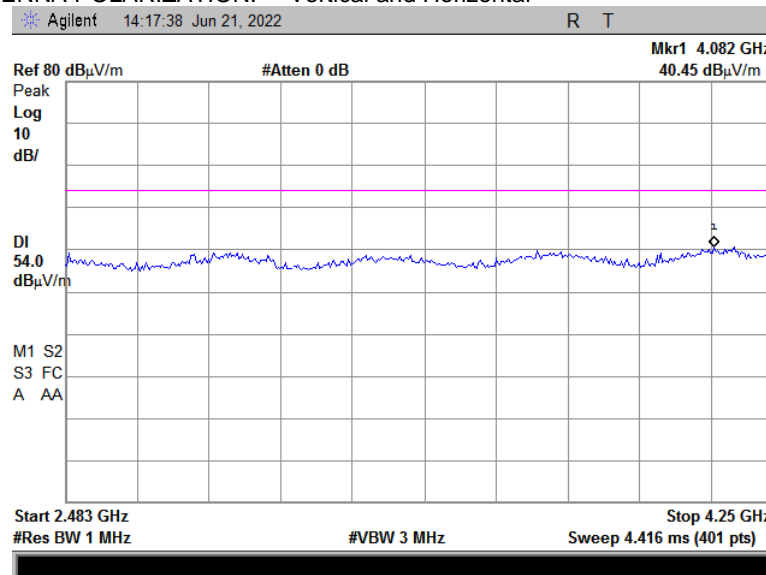
Plot 7.2.11 Radiated emission measurements from 2483.5 to 4250 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.2.12 Radiated emission measurements from 2483.5 to 4250 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



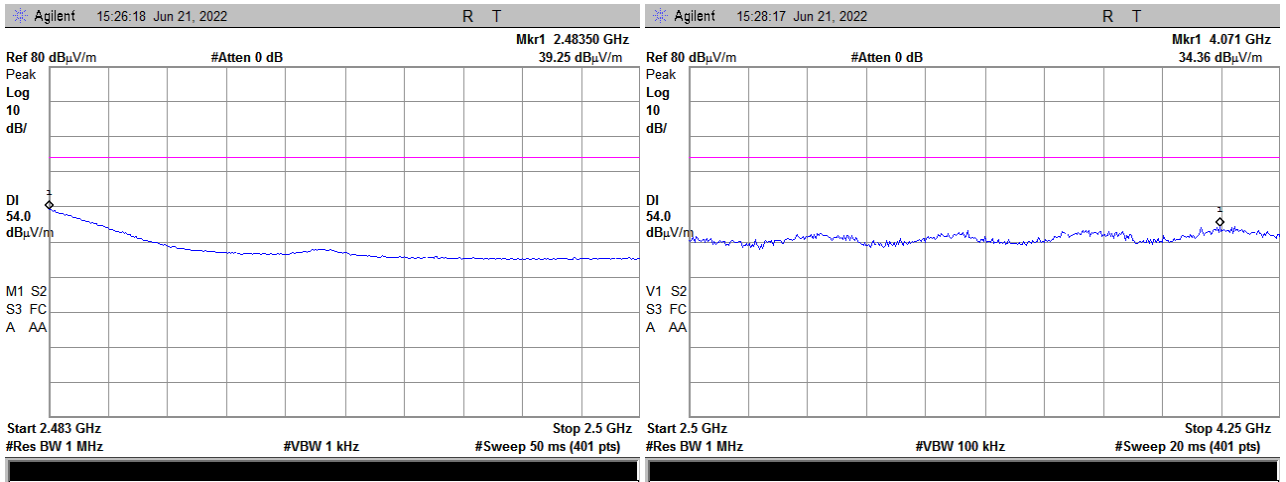


HERMON LABORATORIES

Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Plot 7.2.13 Radiated emission measurements from 2483.5 to 4250 MHz at the high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

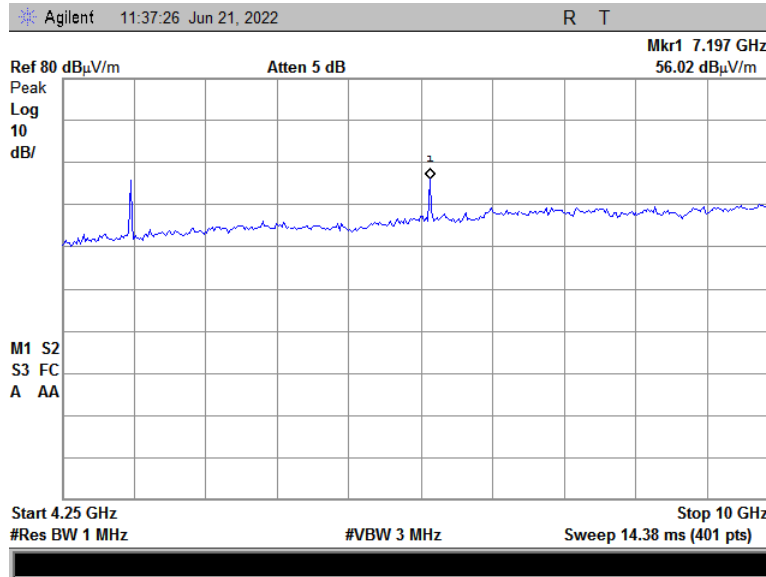




Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

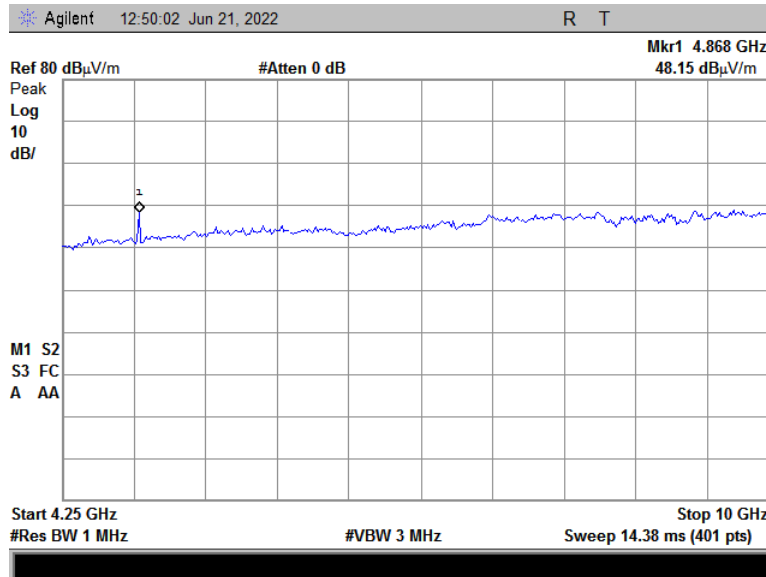
Plot 7.2.14 Radiated emission measurements from 4250 to 10000 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.2.15 Radiated emission measurements from 4250 to 10000 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

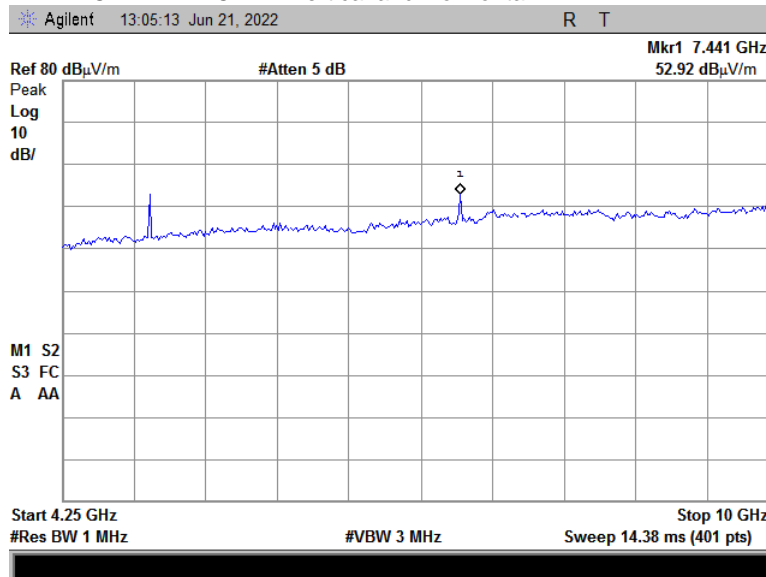




Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

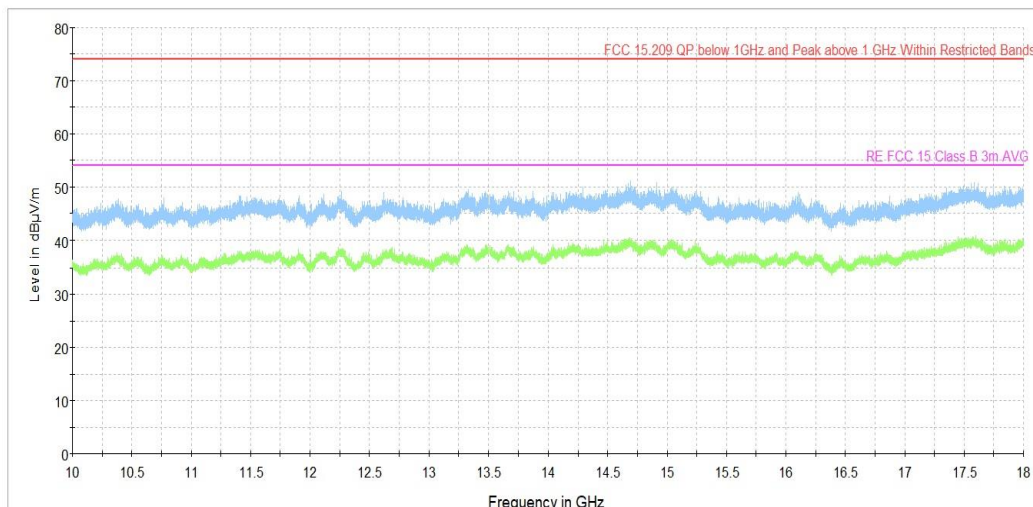
Plot 7.2.16 Radiated emission measurements from 4250 to 10000 MHz at the high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.2.17 Radiated emission measurements from 10000 to 18000 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

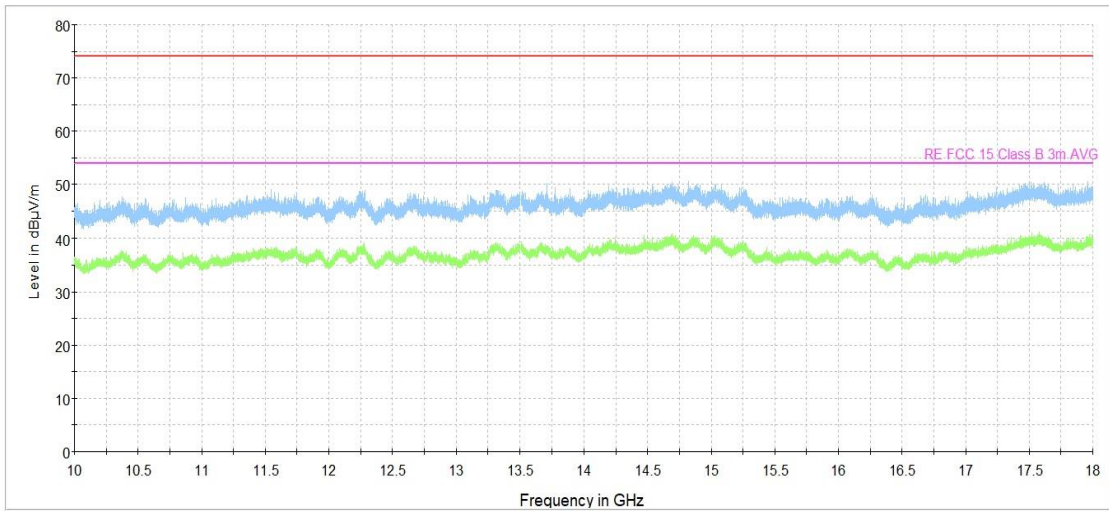




Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

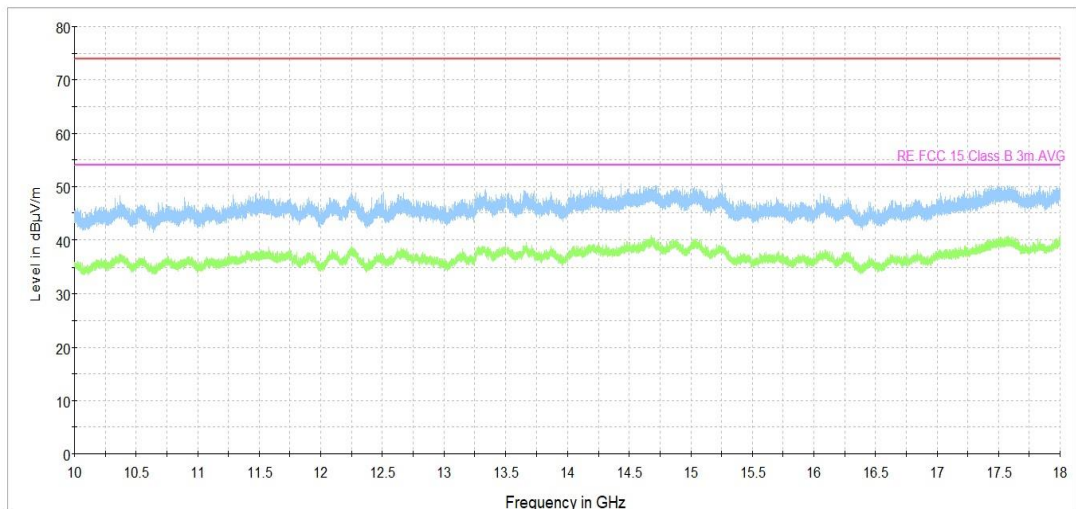
Plot 7.2.18 Radiated emission measurements from 10000 to 18000 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.2.19 Radiated emission measurements from 10000 to 18000 MHz the high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

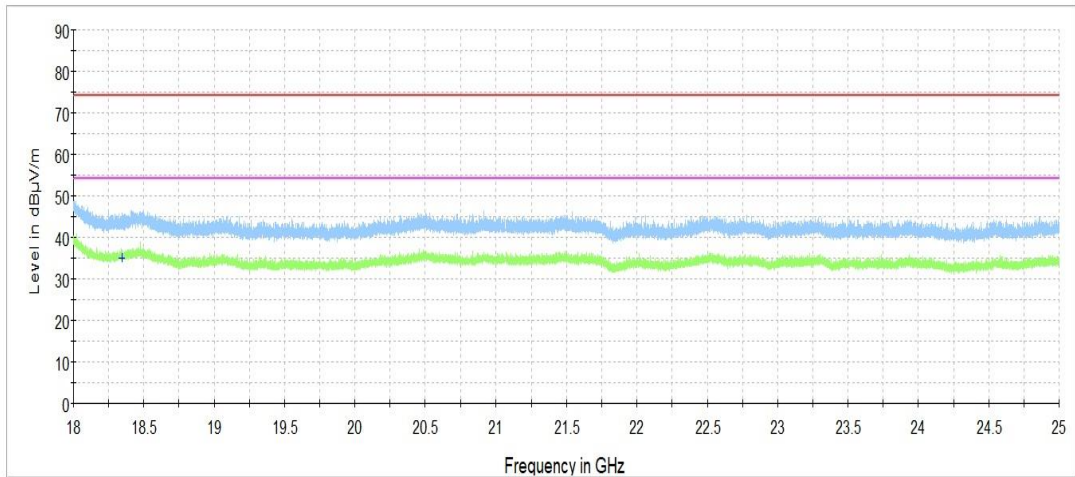




Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Plot 7.2.20 Radiated emission measurements from 18000 to 25000 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
 TEST DISTANCE: 3 m
 ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.2.21 Radiated emission measurements from 18000 to 25000 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
 TEST DISTANCE: 3 m
 ANTENNA POLARIZATION: Vertical and Horizontal

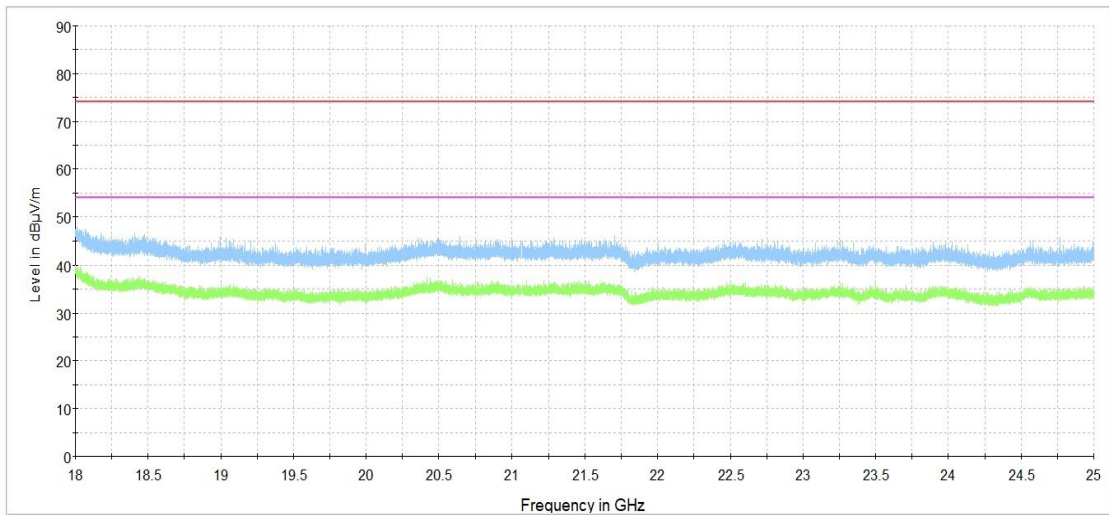




Test specification: Section 15.247(c), Radiated spurious emissions			
Test procedure: ANSI C63.10, sections 6.5, 6.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 22-Jul-22 - 28-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Plot 7.2.22 Radiated emission measurements from 18000 to 25000 MHz at the high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal





Test specification: Section 15.247(d), Emissions at band edges			
Test procedure: ANSI C63.10, section 7.8.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 26-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

7.3 Band edge radiated emissions

7.3.1 General

This test was performed to measure emissions, radiated from the EUT at the assigned frequency band edges. Specification test limits are given in Table 7.3.1.

Table 7.3.1 Band edge emission limits

Assigned frequency, MHz	Attenuation below carrier*, dBc	Field strength at 3 m within restricted bands, dB(µV/m)	
		Peak	Average
902.0 – 928.0	20.0	74.0	54.0
2400.0 – 2483.5			
5725.0 – 5850.0			

* - Band edge emission limit is provided in terms of attenuation below the peak of modulated carrier measured with the same resolution bandwidth.

7.3.2 Test procedure

- 7.3.2.1 The EUT was set up as shown in Figure 7.3.1, energized normally modulated at the maximum data rate with its hopping function disabled and its proper operation was checked.
- 7.3.2.2 The EUT was adjusted to produce maximum available to end user RF output power at the lowest carrier frequency.
- 7.3.2.3 The spectrum analyzer span was set to capture the carrier frequency and associated modulation products. The resolution bandwidth was set wider than 1 % of the frequency span.
- 7.3.2.4 The spectrum analyzer was set in max hold mode and allowed trace to stabilize. The highest emission level within the authorized band was measured.
- 7.3.2.5 The maximum band edge emission and modulation product outside of the band were measured as provided in Table 7.3.2 and associated plots and referenced to the highest emission level measured within the authorized band.
- 7.3.2.6 The above procedure was repeated with the EUT adjusted to produce maximum RF output power at the highest carrier frequency.
- 7.3.2.7 The above procedure was repeated with the frequency hopping function enabled.

Figure 7.3.1 Band edge emission test setup





Test specification: Section 15.247(d), Emissions at band edges			
Test procedure: ANSI C63.10, section 7.8.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 26-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Table 7.3.2 Band edge emission outside restricted band test results

ASSIGNED FREQUENCY RANGE: 2400.0 – 2483.5 MHz
 DETECTOR USED: Peak
 MODULATION: MSK
 BIT RATE: 250 kbps
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 RESOLUTION BANDWIDTH: 100 kHz
 VIDEO BANDWIDTH: 300 kHz

Frequency, MHz	Band edge emission, dBm	Emission at carrier, dBm	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
Frequency hopping disabled						
2399.42	75.29	109.1	33.81	20.0	13.81	Pass
Frequency hopping enabled						
2399.52	76.73	108.7	31.97	20.0	11.97	Pass

*- Margin = Attenuation below carrier – specification limit.

Table 7.3.3 Band edge emission within restricted band test results

ASSIGNED FREQUENCY RANGE: 2400.0 – 2483.5 MHz
 DETECTOR USED: Peak
 MODULATION: MSK
 MODULATING SIGNAL: PRBS
 BIT RATE: 250 kbps

Frequency, MHz	Peak field strength			Average field strength			Verdict
	Measured, dB(μV/m)	Limit, dB(μV/m)	Margin, dB*	Calculated, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	
Frequency hopping disabled							
2483.5	62.09	74.0	-11.91	30.49	54.0	-23.51	Pass
Frequency hopping enabled							
2483.5	62.51	74.0	-11.49	30.91	54.0	-23.09	Pass
2485.37	66.24	74.0	-7.76	34.64	54.0	-19.36	Pass

*- Margin = Measured field strength - specification limit.

**- Margin = Calculated field strength - specification limit,
 where Calculated field strength = Measured field strength + average factor.

Reference numbers of test equipment used

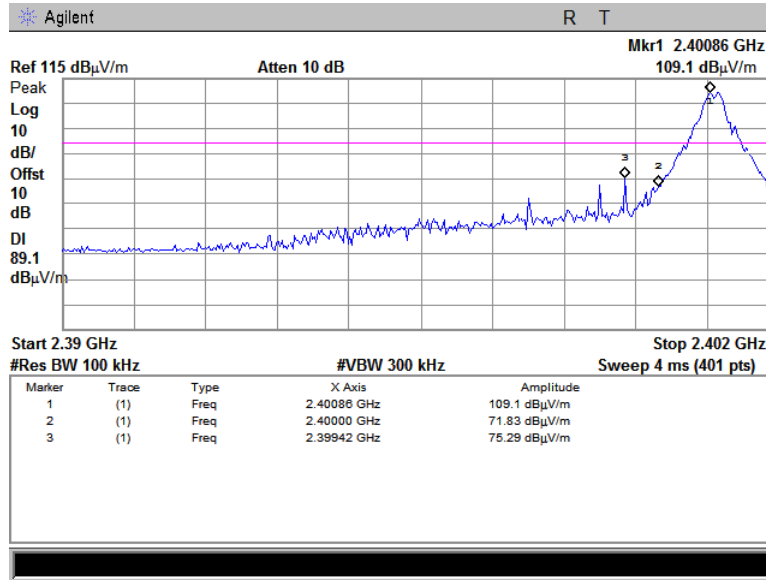
HL 2909	HL 4933	HL 3903	HL 5597	HL 5902		
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Full description is given in Appendix A.

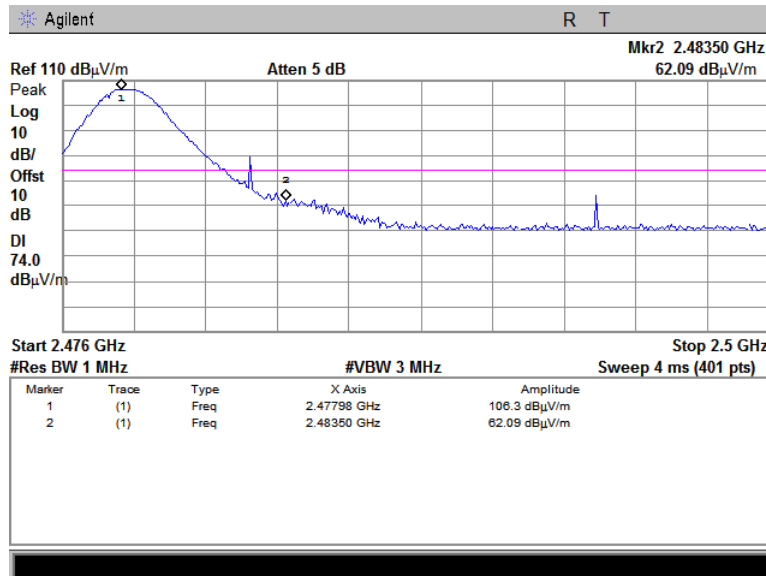


Test specification: Section 15.247(d), Emissions at band edges			
Test procedure: ANSI C63.10, section 7.8.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 26-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Plot 7.3.1 The highest band edge emission at low carrier frequency with hopping function disabled



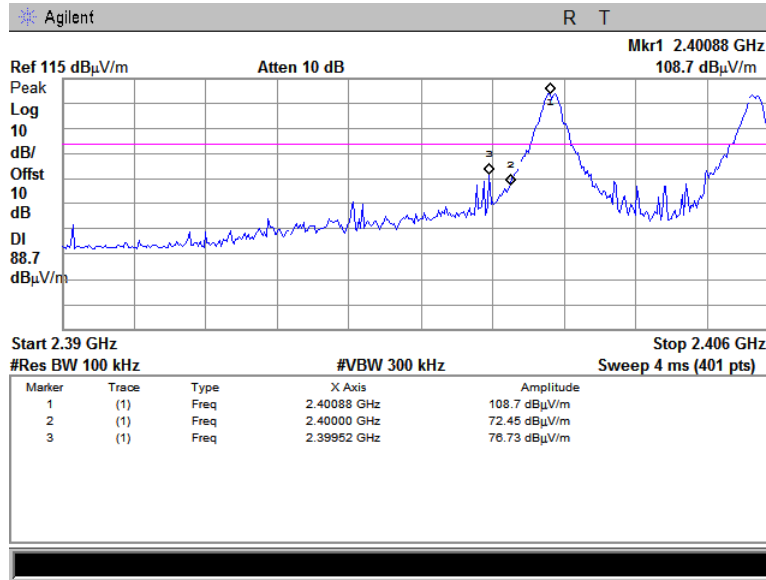
Plot 7.3.2 The highest band edge emission at high carrier frequency with hopping function disabled



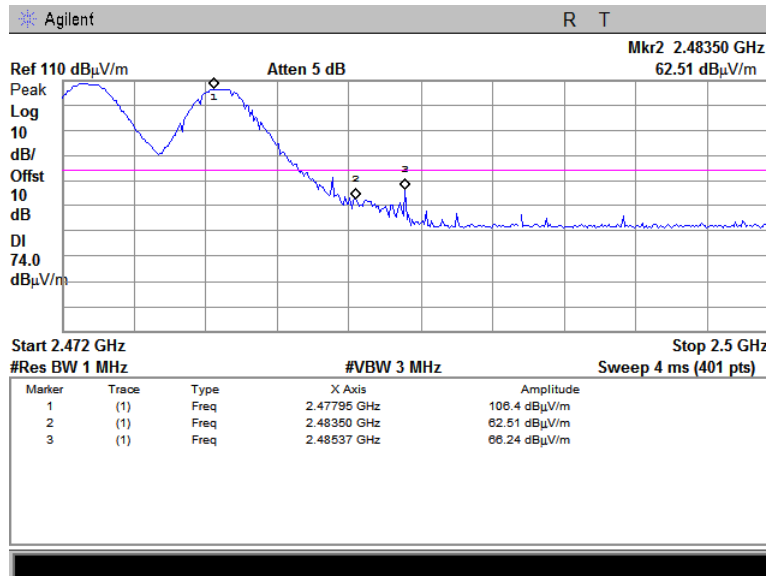


Test specification: Section 15.247(d), Emissions at band edges			
Test procedure: ANSI C63.10, section 7.8.6			
Test mode: Compliance		Verdict: PASS	
Date(s): 26-Jul-22			
Temperature: 50 °C	Relative Humidity: 45 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Plot 7.3.3 The highest band edge emission at low carrier frequency with hopping function enabled



Plot 7.3.4 The highest band edge emission at high carrier frequency with hopping function enabled





Test specification: Section 15.109, Radiated emission			
Test procedure: ANSI C63.4, Sections 11.6 and 12.1.4			
Test mode: Compliance		Verdict: PASS	
Date(s): 26-Jul-22			
Temperature: 20 °C	Relative Humidity: 50 %	Air Pressure: 1007 hPa	Power: 12 VDC
Remarks:			

8 Unintentional emissions according to 47CFR part 15 subpart B requirements

8.1 Radiated emission measurements

8.1.1 General

This test was performed to measure radiated emissions from the EUT enclosure. Specification test limits are given in Table 8.1.1.

Table 8.1.1 Radiated emission test limits

Frequency, MHz	Class B limit, dB(μV/m)		Class A limit, dB(μV/m)	
	10 m distance	3 m distance	10 m distance	3 m distance
30 - 88	29.5*	40.0	39.0	49.5*
88 - 216	33.0*	43.5	43.5	54.0*
216 - 960	35.5*	46.0	46.4	56.9*
Above 960	43.5*	54.0	49.5	60.0*

* The limit for test distance other than specified was calculated using the inverse linear distance extrapolation factor as follows: $Lims_2 = Lims_1 + 20 \log(S_1/S_2)$, where S_1 and S_2 – standard defined and test distance respectively in meters.

8.1.2 Test procedure for measurements in semi-anechoic chamber

8.1.2.1 The EUT was set up as shown in Figure 8.1.1 and associated photograph/s, energized and the performance check was conducted.

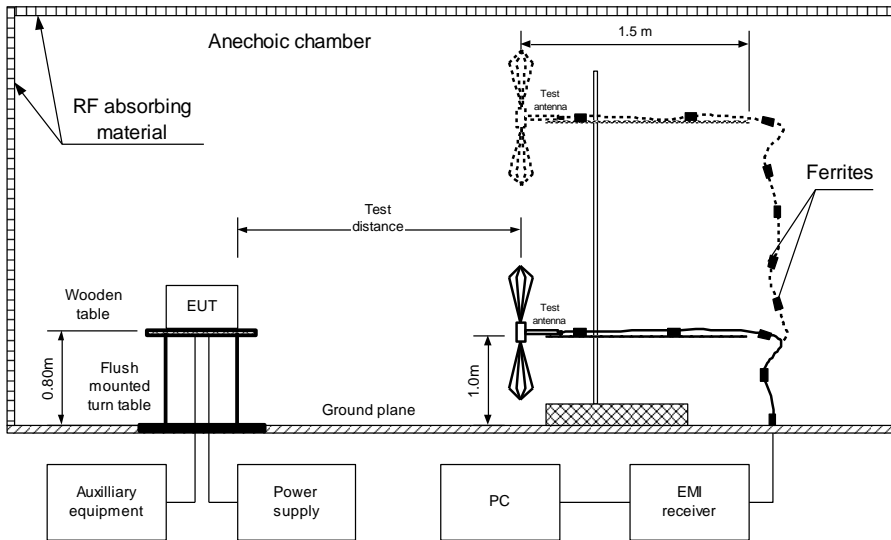
8.1.2.2 The specified frequency range was investigated with biconilog antenna connected to EMI receiver. To find maximum radiation the turntable was rotated 3600, the measuring antenna height was changed from 1 to 4 m, its polarization was switched from vertical to horizontal and the EUT cables position was varied.

8.1.2.3 The worst test results (the lowest margins) were recorded in Table 8.1.2 and shown in the associated plots.



Test specification: Section 15.109, Radiated emission			
Test procedure: ANSI C63.4, Sections 11.6 and 12.1.4			
Test mode: Compliance		Verdict: PASS	
Date(s): 26-Jul-22			
Temperature: 20 °C	Relative Humidity: 50 %	Air Pressure: 1007 hPa	Power: 12 VDC
Remarks:			

Figure 8.1.1 Setup for radiated emission measurements, table-top equipment





Test specification: Section 15.109, Radiated emission			
Test procedure: ANSI C63.4, Sections 11.6 and 12.1.4			
Test mode: Compliance		Verdict: PASS	
Date(s): 26-Jul-22			
Temperature: 20 °C	Relative Humidity: 50 %	Air Pressure: 1007 hPa	Power: 12 VDC
Remarks:			

Table 8.1.2 Radiated emission test results

EUT SET UP: TABLE-TOP
LIMIT: Class B
EUT OPERATING MODE: Receive
TEST SITE: SEMI ANECHOIC CHAMBER
TEST DISTANCE: 3 m
DETECTORS USED: PEAK / QUASI-PEAK
FREQUENCY RANGE: 30 MHz – 1000 MHz
RESOLUTION BANDWIDTH: 120 kHz

Frequency, MHz	Peak emission, dB(µV/m)	Quasi-peak			Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
		Measured emission, dB(µV/m)	Limit, dB(µV/m)	Margin, dB*				
46.0	32.2	28.3	40.0	-11.7	Vertical	1.0	129	Pass
61.0	37.4	32.6	40.0	-7.4	Vertical	1.0	153	
177.3	37.5	35.9	43.5	-7.6	Vertical	1.0	-43	
187.0	37.1	35.2	43.5	-8.3	Vertical	1.0	-46	
211.3	43.8	38.3	43.5	-5.2	Vertical	1.0	180	
214.7	42.7	37.4	43.5	-6.1	Vertical	1.0	-172	

TEST SITE: SEMI ANECHOIC CHAMBER
TEST DISTANCE: 3 m
DETECTORS USED: PEAK / AVERAGE
FREQUENCY RANGE: 1000 MHz – 13000 MHz
RESOLUTION BANDWIDTH: 1000 kHz

Frequency, MHz	Peak			Average			Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
	Measured emission, dB(µV/m)	Limit, dB(µV/m)	Margin, dB*	Measured emission, dB(µV/m)	Limit, dB(µV/m)	Margin, dB*				
No emissions were found										

*- Margin = Measured emission - specification limit.
**- EUT front panel refer to 0 degrees position of turntable.

Reference numbers of test equipment used

HL 5288	HL 4933	HL 4360	HL 3903	HL 5902			
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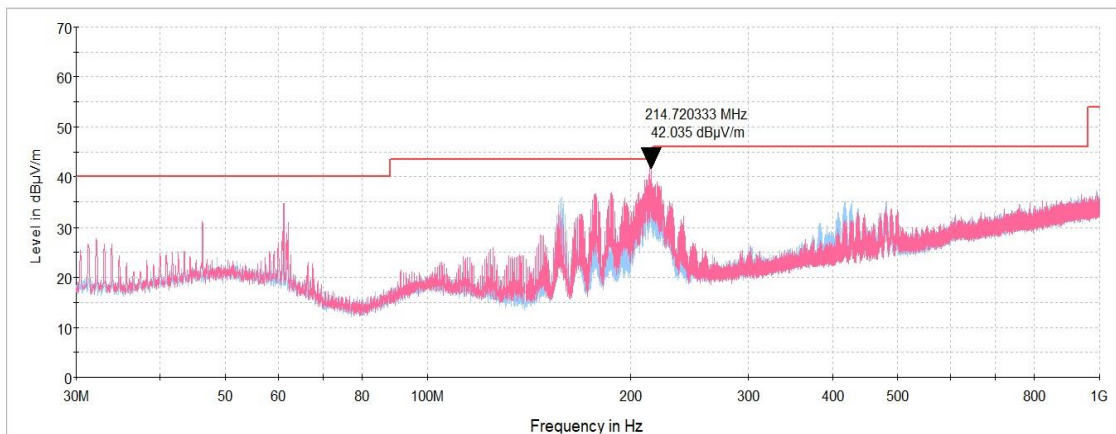
Full description is given in Appendix A.



Test specification: Section 15.109, Radiated emission			
Test procedure: ANSI C63.4, Sections 11.6 and 12.1.4			
Test mode: Compliance		Verdict: PASS	
Date(s): 26-Jul-22			
Temperature: 20 °C	Relative Humidity: 50 %	Air Pressure: 1007 hPa	Power: 12 VDC
Remarks:			

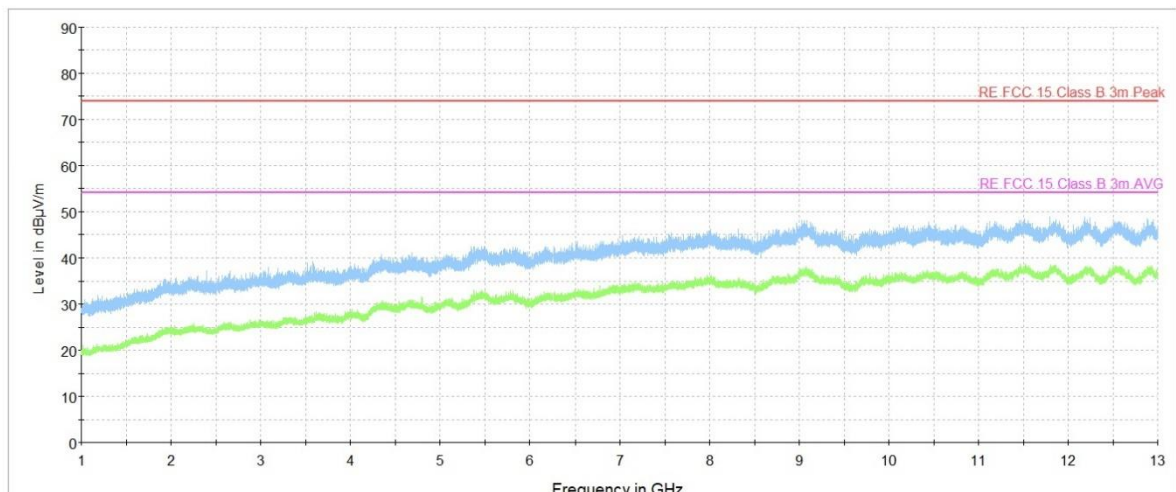
Plot 8.1.1 Radiated emission measurements in 30 - 1000 MHz range, vertical antenna polarization

TEST SITE: Semi anechoic chamber
LIMIT: Class B
TEST DISTANCE: 3 m
EUT OPERATING MODE: Receive



Plot 8.1.2 Radiated emission measurements above 1000 MHz, vertical & horizontal antenna polarization

TEST SITE: Semi anechoic chamber
LIMIT: Class B
TEST DISTANCE: 3 m
EUT OPERATING MODE: Receive



**9 APPENDIX A Test equipment and ancillaries used for tests**

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal/ Check	Due Cal/ Check
2780	EMC analyzer, 100 Hz to 26.5 GHz	Agilent Technologies	E7405A	MY45102462	03-Mar-22	03-Mar-23
2909	Spectrum analyzer, ESA-E, 100 Hz to 26.5 GHz	Agilent Technologies	E4407B	MY41444762	12-Jun-22	12-Jul-23
3434	Test Cable , DC-18 GHz, 1.5 m, SMA - SMA	Mini-Circuits	CBL-5FT-SMSM+	25683	25-Apr-22	25-Apr-23
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFL EX 102A	1226/2A	07-Apr-22	07-Apr-23
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	13-Jan-22	13-Jan-23
4372	High Pass Filter, 50 Ohm, 8.0 to 18.0 GHz,SMA-FM / SMA-FM	Tiger Micro-Electronics Institute	TGF-A2118-001	r-JSFG308-001	15-Jun-21	15-Jun-23
4529	High Pass Filter, 50 Ohm, 4250 to 10000 MHz., SMA-FM / SMA-M	Mini-Circuits	VHF-3800+	NA	15-Jun-21	15-Jun-23
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	13-Jan-22	13-Jan-23
4956	Active horn antenna, 18 to 40 GHz	COM-POWER CORPORATION	AHA-840	105004	07-Mar-22	07-Mar-23
5112	RF cable, 40 GHz, 5.5 m, K-type	Huber-Suhner	SF102EA/11SK/11SK/5500MM	502494/2EA	25-Apr-22	25-Apr-23
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	24-Mar-22	24-Apr-25
5597	Precision Fixed Attenuator, 50 Ohm, 5 W, 10 dB, DC to 18000 MHz	Mini Circuits	BW-N10W5+	NA	01-Mar-22	01-Mar-23
5902	RF cable, 18 GHz, 6.0m, N-type	Huber-Suhner	SF126EA/11N/11N/6000	NA	16-Jan-22	16-Jan-23



10 APPENDIX B Test equipment correction factors

HL 4933: Active Horn Antenna
COM-POWER CORPORATION, model: AHA-118, s/n 701046

Frequency, MHz	Measured antenna factor (with preamplifier), dB/m
1000	-16.1
1500	-15.1
2000	-10.9
2500	-11.9
3000	-11.1
3500	-10.6
4000	-8.6
4500	-8.3
5000	-5.9
5500	-5.7
6000	-3.3
6500	-4.0
7000	-2.2
7500	-1.7
8000	1.1
8500	-0.8
9000	-1.5
9500	-0.2

Frequency, MHz	Measured antenna factor (with preamplifier), dB/m
10000	1.8
10500	1.0
11000	0.3
11500	-0.5
12000	3.1
12500	1.4
13000	-0.3
13500	-0.4
14000	2.5
14500	2.2
15000	1.9
15500	0.5
16000	2.1
16500	1.2
17000	0.6
17500	3.1
18000	4.2

The antenna factor shall be added to receiver reading in dB μ V to obtain field strength in dB μ V/m.



HL 5288: Trilog Antenna
Frankonia, model: ALX-8000E, s/n: 00809
30-1000 MHz

Frequency, MHz	Antenna factor, dB/m
30	14.96
35	15.33
40	16.37
45	17.56
50	17.95
60	16.87
70	13.22
80	10.56
90	13.61
100	15.46
120	14.03
140	12.23

Frequency, MHz	Antenna factor, dB/m
160	12.67
180	13.34
200	15.40
250	16.42
300	17.28
400	19.98
500	21.11
600	22.90
700	24.13
800	25.25
900	26.35
1000	27.18

The antenna factor shall be added to receiver reading in dB μ V to obtain field strength in dB μ V/m.

above 1000 MHz

Frequency, MHz	Antenna factor, dB/m
1000	26.9
1100	28.1
1200	28.4
1300	29.6
1400	29.1
1500	30.4
1600	30.7
1700	31.5
1800	32.3
1900	32.6
2000	32.5
2100	32.9
2200	33.5
2300	33.2
2400	33.7
2500	34.6
2600	34.7
2700	34.6
2800	35.0
2900	35.5
3000	36.2
3100	36.8
3200	36.8
3300	37.0
3400	37.5
3500	38.2

Frequency, MHz	Antenna factor, dB/m
3600	38.9
3700	39.4
3800	39.4
3900	39.6
4000	39.7
4100	39.8
4200	40.5
4300	40.9
4400	41.1
4500	41.4
4600	41.3
4700	41.6
4800	41.9
4900	42.3
5000	42.7
5100	43.0
5200	42.9
5300	43.5
5400	43.6
5500	44.3
5600	44.7
5700	45.0
5800	45.0
5900	45.3
6000	45.9

The antenna factor shall be added to receiver reading in dB μ V to obtain field strength in dB μ V/m.



HL 5112, RF cable, 40 GHz, 5.5 m, K-type,
Huber-Suhner, SF102EA/11SK/11SK/5500MM, s/n 502494/2EA, HL 5112

Insertion loss

Set / Applied, MHz	Measured, dB	Uncertainty, dB
100	0.70	±0.07
200	0.99	±0.08
300	1.21	±0.08
500	1.55	±0.08
1000	2.18	±0.08
1500	2.67	±0.08
2000	3.09	±0.08
2500	3.46	±0.10
3000	3.80	±0.10
3500	4.12	±0.10
4000	4.41	±0.10
4500	4.69	±0.10
5000	4.95	±0.10
5500	5.20	±0.10
6000	5.45	±0.10
6500	5.68	±0.10
7000	5.91	±0.10
7500	6.13	±0.10
8000	6.34	±0.10
8500	6.56	±0.10
9000	6.76	±0.10
9500	6.95	±0.10
10000	7.16	±0.10
10500	7.33	±0.10
11000	7.51	±0.10
11500	7.68	±0.10
12000	7.85	±0.10
12500	8.02	±0.13
13000	8.17	±0.13
13500	8.31	±0.13
14000	8.46	±0.13
14500	8.61	±0.18
15000	8.76	±0.18
15500	8.91	±0.18
16000	9.07	±0.18
16500	9.22	±0.18
17000	9.36	±0.18
17500	9.51	±0.18
18000	9.66	±0.18
18500	9.81	±0.23
19000	9.95	±0.23
19500	10.10	±0.23

Set / Applied, MHz	Measured, dB	Uncertainty, dB
20000	10.25	±0.23
20500	10.38	±0.23
21000	10.52	±0.23
21500	10.67	±0.23
22000	10.84	±0.23
22500	11.00	±0.29
23000	11.10	±0.29
23500	11.20	±0.29
24000	11.32	±0.29
24500	11.42	±0.29
25000	11.59	±0.23
25500	11.70	±0.23
26000	11.85	±0.23
26500	11.97	±0.23
27000	12.07	±0.33
27500	12.17	±0.33
28000	12.26	±0.40
28500	12.38	±0.40
29000	12.50	±0.40
29500	12.63	±0.40
30000	12.75	±0.40
30500	12.82	±0.33
31000	12.93	±0.33
31500	13.09	±0.33
32000	13.22	±0.33
32500	13.35	±0.33
33000	13.48	±0.33
33500	13.60	±0.33
34000	13.72	±0.33
34500	13.80	±0.40
35000	13.92	±0.40
35500	14.01	±0.40
36000	14.12	±0.40
36500	14.23	±0.40
37000	14.34	±0.33
37500	14.44	±0.33
38000	14.57	±0.33
38500	14.72	±0.33
39000	14.82	±0.33
39500	14.94	±0.33
40000	15.08	±0.47



HERMON LABORATORIES

11 APPENDIX C Test laboratory description

Tests were performed at Hermon Laboratories Ltd., which is a fully independent, private, EMC, Radio, Safety, Environmental and Telecommunication testing facility.

Hermon Laboratories is recognized and accredited by the Federal Communications Commission (USA) for relevant parts of Code of Federal Regulations 47 (CFR 47), Test Firm Registration Number is 927748, Designation Number is IL1001; Recognized by Innovation, Science and Economic Development Canada for wireless and terminal testing (ISED), ISED #2186A, CAB identifier is IL1001; Certified by VCCI, Japan (the registration numbers for OATS are R-10808 for RE measurements below 1 GHz, G-20112 for RE measurements above 1 GHz, R-11082 for anechoic chamber for RE measurements below 1 GHz, G-10869 for RE measurements above 1 GHz, C-10845 for conducted emissions site and T-11606 for conducted emissions at telecommunication ports).

The laboratory is accredited by American Association for Laboratory Accreditation (USA) according to ISO/IEC 17025 for electromagnetic compatibility, product safety, telecommunications testing, environmental simulation and calibration (for exact scope please refer to Certificate No. 839.01, 839.03 and 839.04).

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Person for contact: Mr. Michael Nikishin, EMC&Radio group manager

**12 APPENDIX D Measurement uncertainties****Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements**

Test description	Expanded uncertainty
Conducted carrier power at RF antenna connector	Below 12.4 GHz: ± 1.7 dB 12.4 GHz to 40 GHz: ± 2.3 dB
Conducted emissions at RF antenna connector	9 kHz to 2.9 GHz: ± 2.6 dB 2.9 GHz to 6.46 GHz: ± 3.5 dB 6.46 GHz to 13.2 GHz: ± 4.3 dB 13.2 GHz to 22.0 GHz: ± 5.0 dB 22.0 GHz to 26.8 GHz: ± 5.5 dB 26.8 GHz to 40.0 GHz: ± 4.8 dB
Occupied bandwidth	± 8.0 %
Duty cycle, timing (Tx ON / OFF) and average factor measurements	± 1.0 %
Conducted emissions with LISN	9 kHz to 150 kHz: ± 3.9 dB 150 kHz to 30 MHz: ± 3.8 dB
Radiated emissions at 3 m measuring distance Horizontal polarization Vertical polarization	Biconilog antenna: ± 5.3 dB Biconical antenna: ± 5.0 dB Log periodic antenna: ± 5.3 dB Double ridged horn antenna: ± 5.3 dB Biconilog antenna: ± 6.0 dB Biconical antenna: ± 5.7 dB Log periodic antenna: ± 6.0 dB Double ridged horn antenna: ± 6.0 dB

Hermon Laboratories is accredited by A2LA for calibration according to present requirements of ISO/IEC 17025 and NCSL Z540-1. The accreditation is granted to perform calibration of parameters that are listed in the Scope of Hermon Laboratories Accreditation.

Hermon Laboratories calibrates its reference and transfer standards by calibration laboratories accredited to ISO/IEC 17025 by a mutually recognized Accreditation Body or by a recognized national metrology institute. All reference and transfer standards used in the calibration system are traceable to national or international standards.

In-house calibration of all test and measurement equipment is performed on a regular basis according to Hermon Laboratories calibration procedures, manufacturer calibration/verification procedures or procedures defined in the relevant standards. The Hermon Laboratories test and measurement equipment is calibrated within the tolerances specified by the manufacturers and/or by the relevant standards.



13 APPENDIX E Specification references

FCC 47CFR part 15: 2020	Radio Frequency Devices
ANSI C63.10: 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
ANSI C63.4: 2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

14 APPENDIX F Abbreviations and acronyms

A	ampere	LISN	line impedance stabilization network
AC	alternating current	m	meter
A/m	ampere per meter	MHz	megahertz
AM	amplitude modulation	MIL	military
ASSL	abnormal steady state limits	mm	millimeter
ATP	acceptance test procedure	ms	millisecond
AVRG	average (detector)	μF	microfarad
BB	broad band	μs	microsecond
cm	centimeter	NA	not applicable
dB	decibel	NB	narrow band
dBm	decibel referred to one milliwatt	NP	normal performance
dB(μA)	decibel referred to one microampere	NSSL	normal steady state limits
dBμV	decibel referred to one microvolt	NT	not tested
dBμV/m	decibel referred to one microvolt per meter	OATS	open area test site
DC	direct current	Ω	Ohm
EMI	electromagnetic interference	QP	quasi-peak
ESS	environmental stress screening	PBIT	periodic built in test
ESSL	emergency steady state limits	PM	pulse modulation
EUT	equipment under test	PS	power supply
FTE	functional test equipment	RE	radiated emission
GHz	gigahertz	RF	radio frequency
GND	ground	rms	root mean square
H	height	s	second
HL	Hermon laboratories	STD	standard
Hz	hertz	TBD	to be defined
k	kilo	V	volt
kHz	kilohertz	VA	volt-ampere
kV	kilovolt	W	width
L	length	W	watt

END OF DOCUMENT