

TEST REPORT

ACCORDING TO:

FCC 47CFR part 15 2019 subpart C §15.247

FCC 47CFR part 15 2019 subpart B §15.107, §15.109

FOR:

Juganu Ltd.

RF module

Model: JNET1

FCC ID: 2ATPH-JNET1-915MHZ

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1 Applicant information

Client name: Juganu Ltd.
Address: 1 Yahadut Canada St., Or Yehuda 6037501, Israel
Telephone: +972-52-279-0969
E-mail: davidd@juganu.com
Contact name: Mr.David Davidov

2 Equipment under test attributes

Product name: RF module
Product type: Data transmit network unit
Model(s): JNET1
Part number: JL-AS000398
Serial number: A0:00:4E:2A
Hardware version: 50
Receipt date 28-Mar-19

3 Manufacturer information

Manufacturer name: Juganu Ltd.
Address: 1 Yahadut Canada St., Or Yehuda 6037501, Israel
Telephone: +972-52-279-0969
E-Mail: davidd@juganu.com
Contact name: Mr.David Davidov

4 Test details

Project ID: 32978
Location: Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started: 01-Apr-19
Test completed: 24-Apr-19
Test specification(s): FCC 47CFR part 15 2019 subpart C §15.247
FCC 47CFR part 15 2019 subpart B §15.107, §15.109

5 Tests summary

Test	Status
Transmitter characteristics	
Section 15.247(a)(2), 6 dB bandwidth	Pass
Section 15.247(d), Radiated spurious emissions	Pass
Section 15.247(b)(3), Peak output power	Pass
Section 15.247(i), RF exposure	Pass*
Section 15.247(d), Band edge emissions	Pass
Section 15.247(e), Peak power density	Pass
Section 15.207(a), Conducted emission	Pass
Section 15.203, Antenna requirement	Pass
Unintentional emissions	
Section 15.107, Conducted emission at AC power port	Pass
Section 15.109, Radiated emission	Pass

* Pass, the exhibit to the application of certification is provided.

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. K. Zushchuk, test engineer, EMC & Radio	April 24, 2019	
Reviewed by:	Mrs. S. Peysahov Sheynin, test engineer, EMC & Radio	April 1, 2020	
Approved by:	Mr. S. Samokha, Technical Manager, EMC & Radio	June 17, 2020	

6 EUT description

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

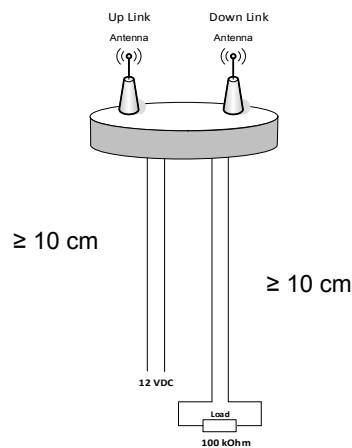
6.1 General information

The EUT is an end unit of wireless network spread on "smart lighting" street-lights or other consumers

6.2 Ports and lines

Port type	Port description	Connected from	Connected to	Qty.	Cable type	Cable length, m
Power	DC	EUT	DC Power supply	1	Unshielded	0.25
Signal	Signal	EUT	Resistor 100 kOhm	1	Unshielded	0.25

6.3 Test configuration



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		902 – 928 MHz		
Operating frequencies		903 – 927 MHz		
Maximum rated output power		At transmitter 50 Ω RF output connector		
		Peak output power		10.45 dBm
Is transmitter output power variable?		V	No	
			continuous variable	
			stepped variable with stepsize	
		Yes	minimum RF power	
			maximum RF power	
Antenna connection				
unique coupling	V	standard connector*	integral	with temporary RF connector without temporary RF connector
Antenna/s technical characteristics				
Type	Manufacturer	Model number	Gain	
Vertical	MAN - HANGYU-SZ	JL_PH000008 915MHz	2.5 dBi	
Transmitter aggregate data rate/s		500 kbps		
Type of modulation		2GFSK		
Modulating test signal (baseband)		PRBS		
Transmitter power source				
	Battery	Nominal rated voltage	Battery type	
X	DC	Nominal rated voltage	12 VDC	
	AC mains	Nominal rated voltage		
Common power source for transmitter and receiver				
X yes no				
Spread spectrum technique used		Frequency hopping (FHSS)		
		X Digital transmission system (DTS)		
		Hybrid		

*Antenna not available for the user.

Test specification: Section 15.247(a)(2), 6 dB bandwidth			
Test procedure: ANSI C63.10 section 11.8; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 23-Apr-19			
Temperature: 24 °C	Relative Humidity: 52 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

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

7.1 Minimum 6 dB bandwidth

7.1.1 General

This test was performed to measure 6 dB bandwidth of the EUT carrier frequency. Specification test limits are given in Table 7.1.1.

Table 7.1.1 The 6 dB bandwidth limits

Assigned frequency, MHz	Modulation envelope reference points*, dBc	Minimum bandwidth, kHz
902.0 – 928.0	6.0	500.0
2400.0 – 2483.5		
5725.0 – 5850.0		

* - Modulation envelope reference points provided in terms of attenuation below the peak of modulated carrier.

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 set to transmit modulated carrier.

7.1.2.3 The transmitter minimum 6 dB bandwidth was measured with spectrum analyzer as frequency delta between reference points on modulation envelope and provided in Table 7.1.2 and associated plot.

Figure 7.1.1 The 6 dB bandwidth test setup





Test specification: Section 15.247(a)(2), 6 dB bandwidth			
Test procedure: ANSI C63.10 section 11.8; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 23-Apr-19			
Temperature: 24 °C	Relative Humidity: 52 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Table 7.1.2 The 6 dB bandwidth test results

ASSIGNED FREQUENCY BAND: 902-928 MHz
 DETECTOR USED: Peak
 SWEEP MODE: Max Hold
 SWEEP TIME: 100 ms
 RESOLUTION BANDWIDTH: 100 kHz
 VIDEO BANDWIDTH: 300 kHz
 MODULATION ENVELOPE REFERENCE POINTS: 6.0 dBc
 MODULATION: 2GFSK
 BIT RATE: 500 kbps

Carrier frequency, MHz	6 dB bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
TX Antenna 1				
903.0	507.745	500	7.745	Pass
915.0	508.570	500	8.570	Pass
927.0	508.698	500	8.698	Pass
TX Antenna 2				
903.0	507.681	500	7.681	Pass
915.0	508.662	500	8.662	Pass
927.0	505.889	500	5.889	Pass

Reference numbers of test equipment used

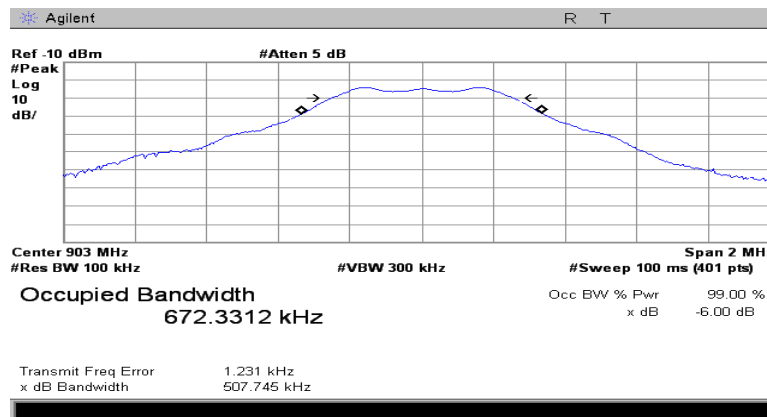
HL 2909	HL 4135	HL 4275	HL 5397					
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Full description is given in Appendix A.

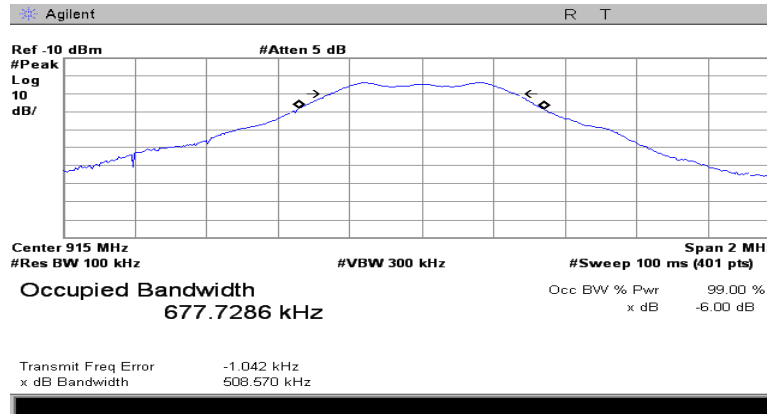
Test specification:		Section 15.247(a)(2), 6 dB bandwidth	
Test procedure:		ANSI C63.10 section 11.8; KDB 558074	
Test mode:		Verdict: PASS	
Date(s):			
23-Apr-19			
Temperature: 24 °C	Relative Humidity: 52 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

ANTENNA 1

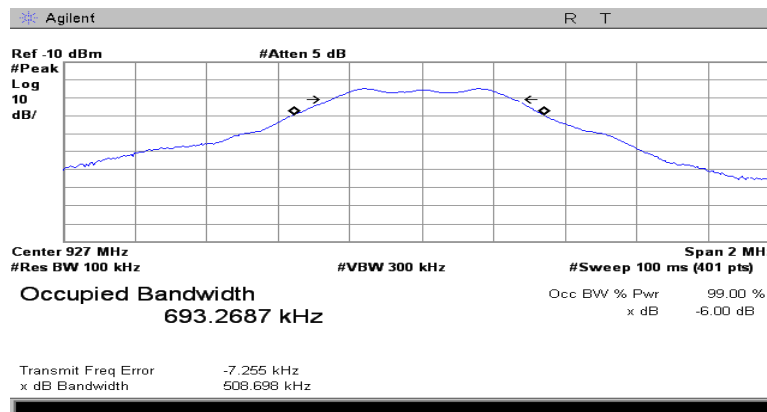
Plot 7.1.1 The 6 dB bandwidth test result at low frequency



Plot 7.1.2 The 6 dB bandwidth test result at mid frequency



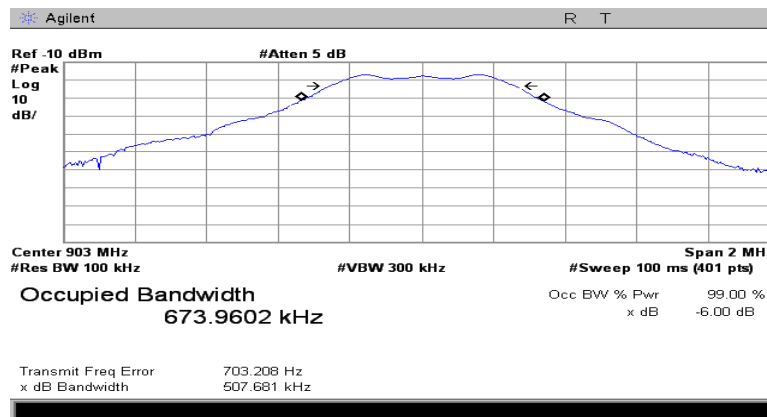
Plot 7.1.3 The 6 dB bandwidth test result at high frequency



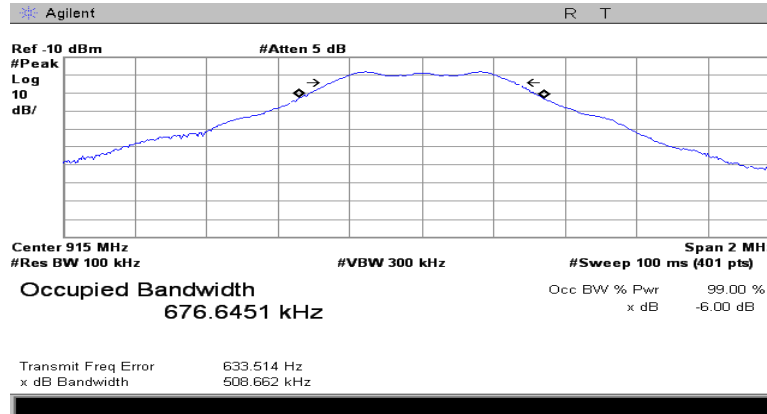
Test specification: Section 15.247(a)(2), 6 dB bandwidth			
Test procedure: ANSI C63.10 section 11.8; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 23-Apr-19			
Temperature: 24 °C	Relative Humidity: 52 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

ANTENNA 2

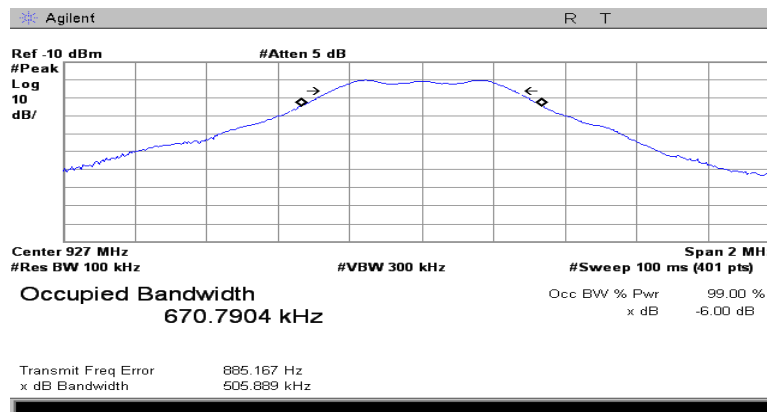
Plot 7.1.4 The 6 dB bandwidth test result at low frequency



Plot 7.1.5 The 6 dB bandwidth test result at mid frequency



Plot 7.1.6 The 6 dB bandwidth test result at high frequency



Test specification: Section 15.247(b)(3), Peak output power			
Test procedure: ANCI C63.10 section 11.9; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

7.2 Peak output power

7.2.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.2.1.

Table 7.2.1 Peak output power limits

Assigned frequency range, MHz	Maximum antenna gain, dBi	Peak output power*		Equivalent field strength limit @ 3m, dB(μV/m)**
		W	dBm	
902.0 – 928.0	6.0	1.0	30.0	131.2
2400.0 – 2483.5				
5725.0 – 5850.0				

*- 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.

** - 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.

7.2.2 Test procedure

7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

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

7.2.2.3 The resolution bandwidth of spectrum analyzer was set wider than 6 dB bandwidth of the EUT and the field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360° and the measuring antenna height was swept in both vertical and horizontal polarizations.

7.2.2.4 The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.2.2 and associated plots.

7.2.2.5 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.

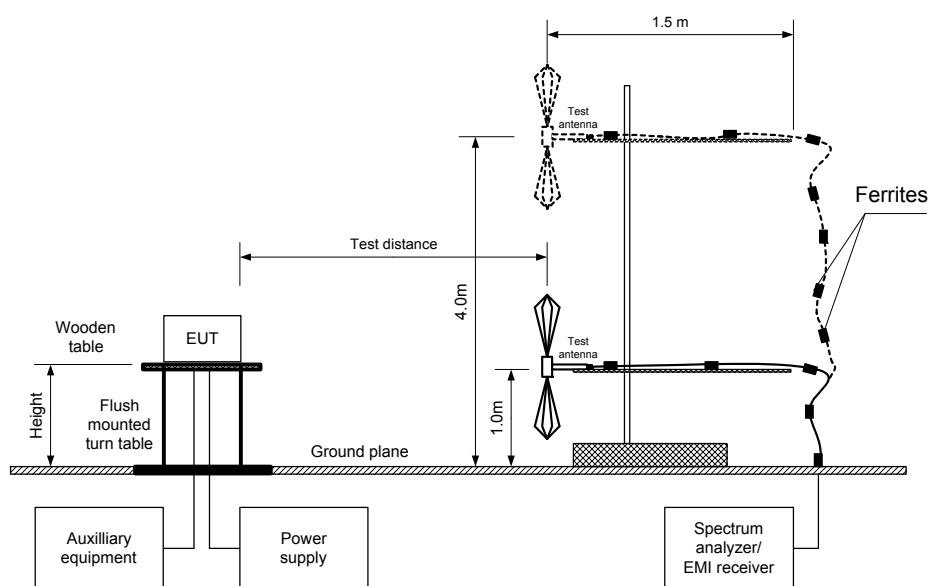
The above equation was converted in logarithmic units for 3 m test distance:

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

7.2.2.6 The worst test results (the lowest margins) were recorded in Table 7.2.2.

Test specification: Section 15.247(b)(3), Peak output power			
Test procedure: ANCI C63.10 section 11.9; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Figure 7.2.1 Setup for carrier field strength measurements





HERMON LABORATORIES

Test specification: Section 15.247(b)(3), Peak output power			
Test procedure: ANCI C63.10 section 11.9; KDB 558074			
Test mode: Compliance	Verdict: PASS		
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Table 7.2.2 Peak output power test results

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
 TEST DISTANCE: 3 m
 TEST SITE: Semi anechoic chamber
 EUT HEIGHT: 0.8 m
 DETECTOR USED: Peak
 TEST ANTENNA TYPE: Biconilog (30 MHz – 1000 MHz)
 Double ridged guide (above 1000 MHz)
 MODULATION: 2GFSK
 BIT RATE: 500 kbps
 DETECTOR USED: Peak
 EUT 6 dB BANDWIDTH: 508.7 kHz
 RESOLUTION BANDWIDTH: 1 MHz
 VIDEO BANDWIDTH: 3 MHz

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
TX Antenna 1									
903.00	108.15	Horizontal	1.00	120	2.50	10.45	30.00	-19.05	Pass
915.00	106.27	Vertical	1.15	-102	2.50	8.57	30.00	-20.93	Pass
927.00	104.09	Vertical	1.10	100	2.50	6.39	30.00	-23.11	Pass
TX Antenna 2									
903.00	106.21	Horizontal	1.67	45	2.50	8.51	30.00	-20.99	Pass
915.00	107.50	Horizontal	1.66	-95	2.50	9.80	30.00	-19.70	Pass
927.00	106.72	Horizontal	1.67	-95	2.50	9.02	30.00	-20.48	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

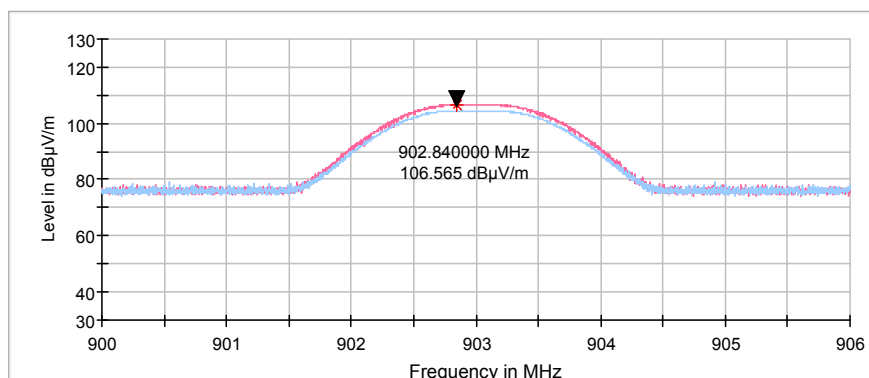
HL 3903	HL 4360	HL 5288	HL 5404				
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Full description is given in Appendix A.

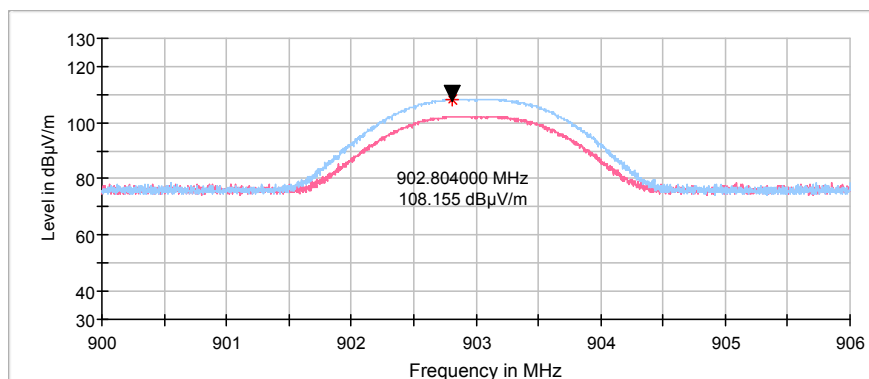
Test specification: Section 15.247(b)(3), Peak output power			
Test procedure: ANCI C63.10 section 11.9; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

ANTENNA 1

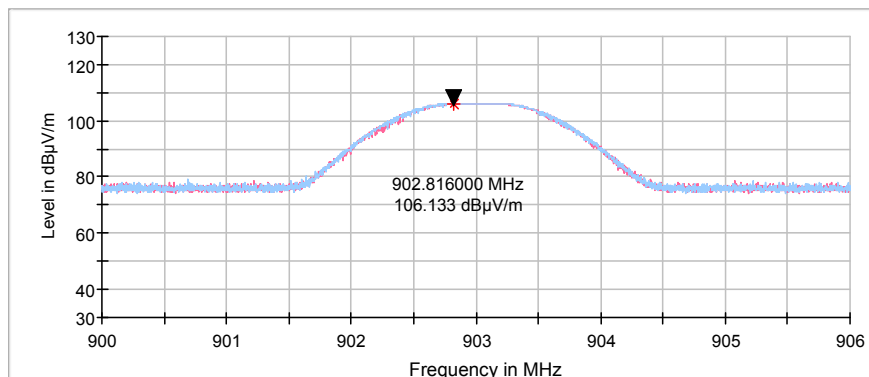
Plot 7.2.1 Field strength of carrier at low frequency, X position



Plot 7.2.2 Field strength of carrier at low frequency, Y position



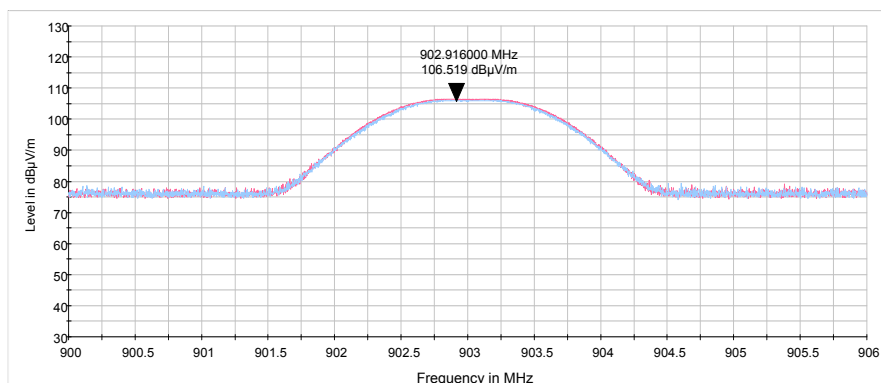
Plot 7.2.3 Field strength of carrier at low frequency, Z position



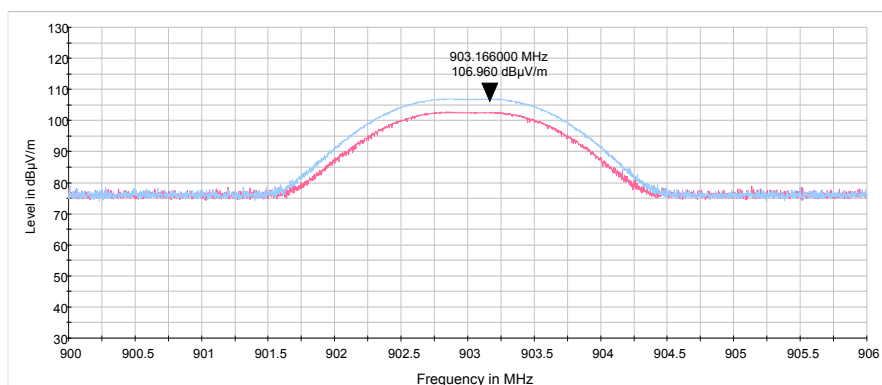
Test specification: Section 15.247(b)(3), Peak output power			
Test procedure: ANCI C63.10 section 11.9; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

ANTENNA 2

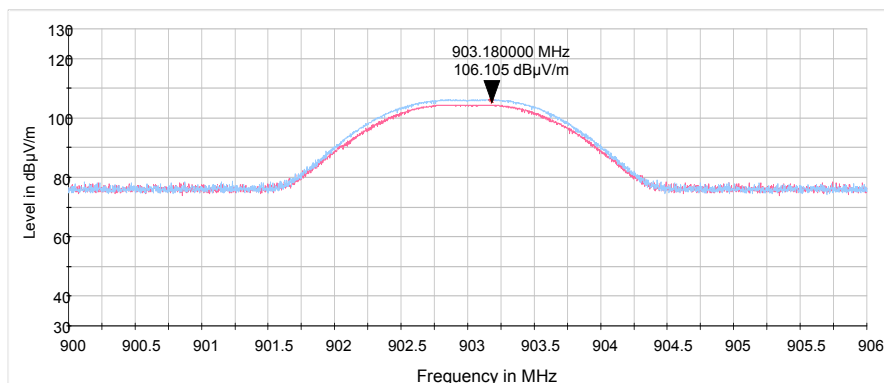
Plot 7.2.4 Field strength of carrier at low frequency, X position



Plot 7.2.5 Field strength of carrier at low frequency, Y position



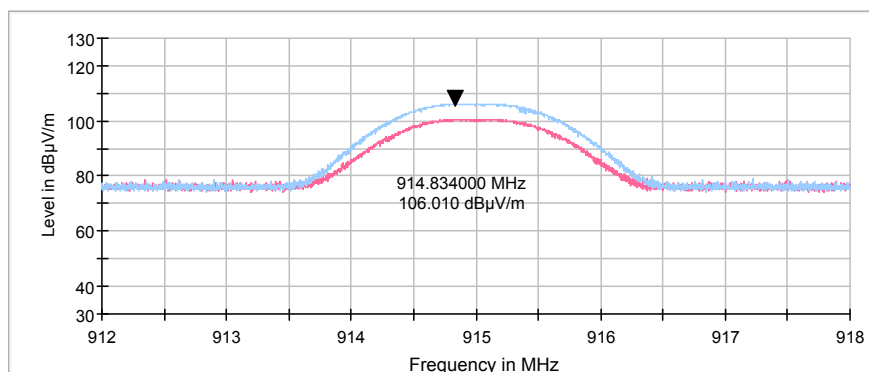
Plot 7.2.6 Field strength of carrier at low frequency, Z position



Test specification: Section 15.247(b)(3), Peak output power			
Test procedure: ANCI C63.10 section 11.9; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

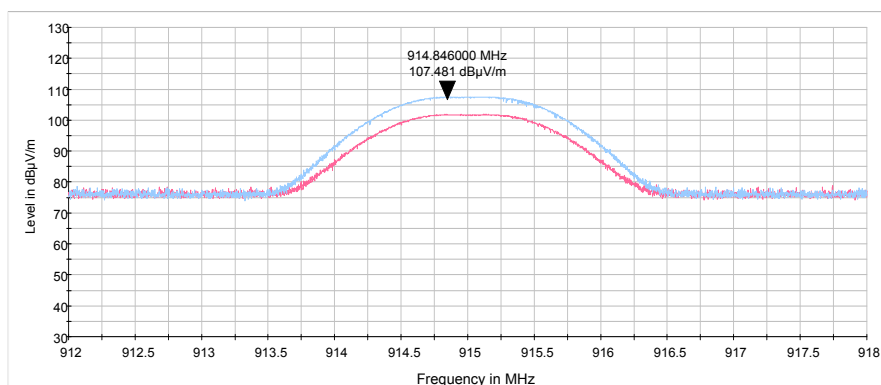
ANTENNA 1

Plot 7.2.7 Field strength of carrier at mid frequency



ANTENNA 2

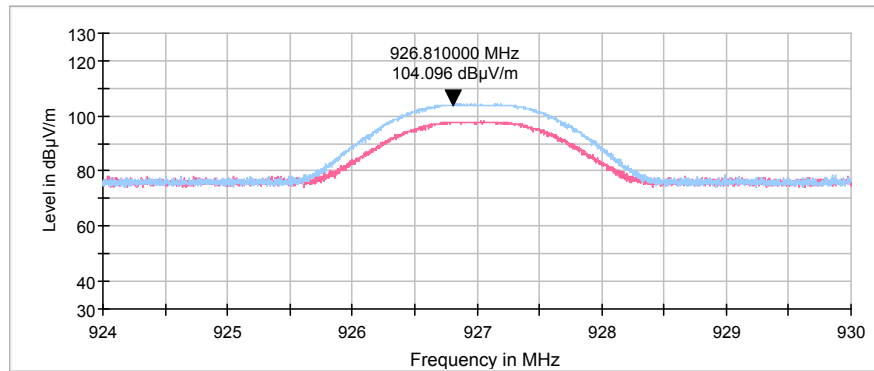
Plot 7.2.8 Field strength of carrier at mid frequency



Test specification:		Section 15.247(b)(3), Peak output power	
Test procedure:		ANCI C63.10 section 11.9; KDB 558074	
Test mode:		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

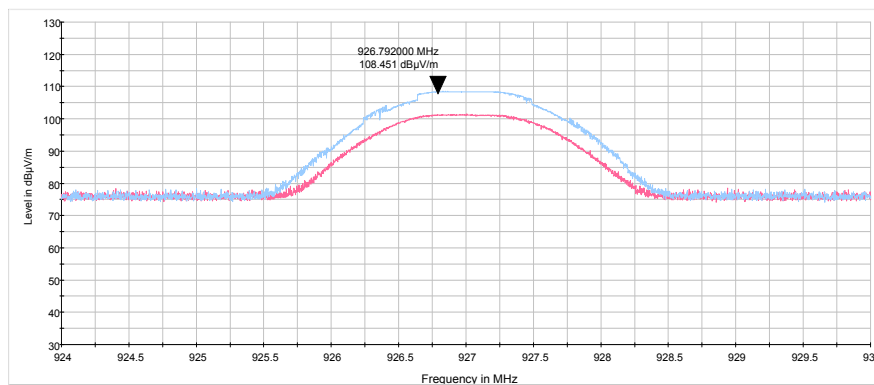
ANTENNA 1

Plot 7.2.9 Field strength of carrier at high frequency



ANTENNA 2

Plot 7.2.10 Field strength of carrier at high frequency





Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

7.3 Field strength of spurious emissions

7.3.1 General

This test was performed to measure field strength of spurious emissions from the EUT. Specification test limits are given in Table 7.3.1.

Table 7.3.1 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:

$$\text{Lim}_{S2} = \text{Lim}_{S1} + 40 \log (S_1/S_2),$$

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.

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

7.3.2.1 The EUT was set up as shown in Figure 7.3.1, energized and the performance check was conducted.

7.3.2.2 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.

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

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

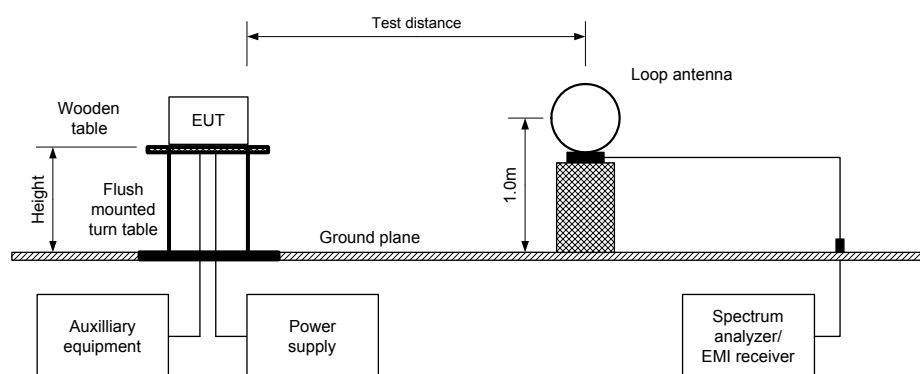
7.3.3.1 The EUT was set up as shown in Figure 7.3.2, Figure 7.3.3, energized and the performance check was conducted.

7.3.3.2 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.

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

Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Figure 7.3.1 Setup for spurious emission field strength measurements below 30 MHz



Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Figure 7.3.2 Setup for spurious emission field strength measurements in 30 – 1000 MHz

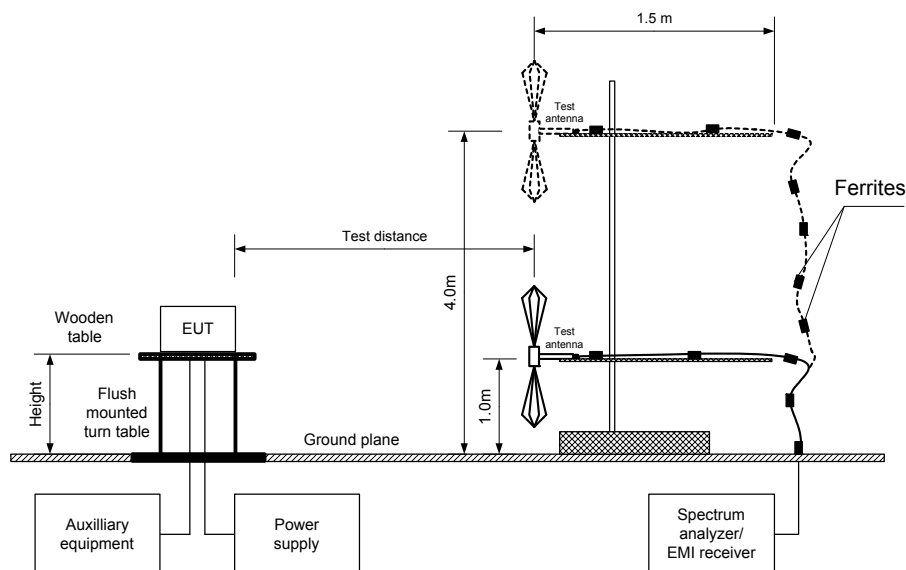
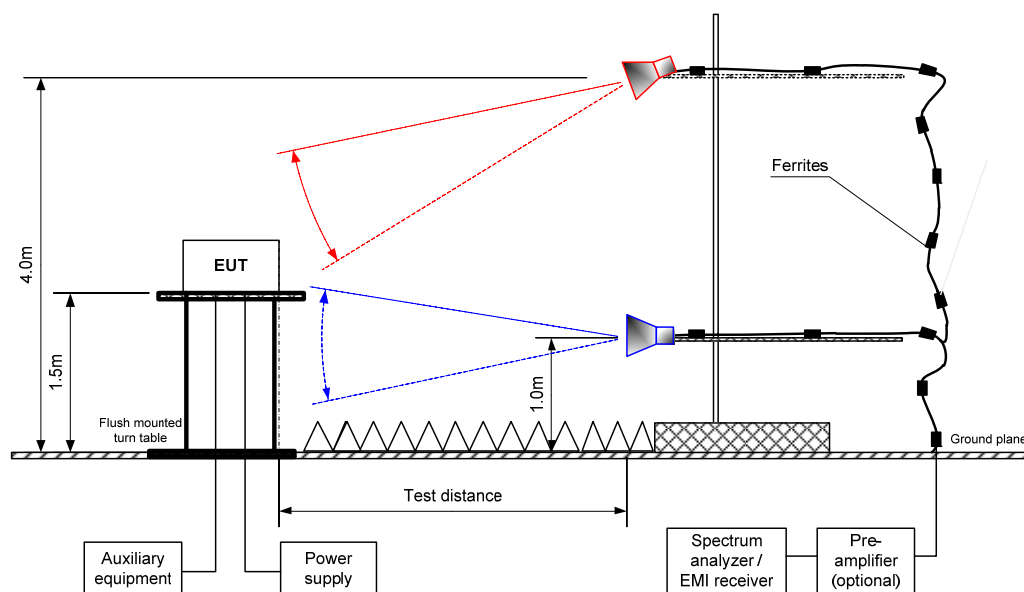


Figure 7.3.3 Setup for spurious emission field strength measurements above 1000 MHz





HERMON LABORATORIES

Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance	Verdict: PASS		
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Table 7.3.2 Field strength of emissions outside restricted bands

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
 INVESTIGATED FREQUENCY RANGE: 0.009 - 10000 MHz
 TEST DISTANCE: 3 m
 MODULATION: 2GFSK
 BIT RATE: 500 kbps
 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)

CONFIGURATION: Tx Antenna 1

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									
36.460000	39.06	Vertical	1.01	-16	111.55	72.49	20.0	52.49	Pass
239.975000	45.70	Vertical	1.01	-180		65.85		45.85	
956.276500	53.00	Vertical	1.01	38		58.55		38.55	
Mid carrier frequency									
36.333000	38.58	Vertical	3.10	-123	108.83	70.25	20.0	50.25	Pass
41.417000	39.91	Vertical	2.65	-100		68.92		48.92	
65.386500	39.63	Vertical	1.31	160		69.20		49.20	
239.975000	45.87	Vertical	1.02	-180		62.96		42.96	
High carrier frequency									
34.918000	46.78	Vertical	1.00	-100	109.66	62.88	20.0	42.88	Pass
37.071500	38.24	Vertical	4.00	-121		71.42		51.42	
41.427500	39.82	Vertical	4.00	-78		69.84		49.84	
53.392000	41.23	Horizontal	1.75	-41		68.43		48.43	
338.041500	42.34	Vertical	4.00	-41		67.32		47.32	
480.007500	47.52	Horizontal	1.02	137		62.14		42.14	
680.000000	50.67	Horizontal	2.22	104		53.33		33.33	
903.683000	52.50	Horizontal	4.00	-123		57.16		37.16	

CONFIGURATION: Tx Antenna 2

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									
34.545810	27.25	Horizontal	1.00	180	110.71	83.46	20	63.46	Pass
926.493794	70.42	Vertical	2.66	-180		40.29		20.29	
Mid carrier frequency									
35.159323	36.23	Vertical	1.0	-91	107.21	70.98	20	50.98	Pass
High carrier frequency									
35.695457	36.74	Vertical	1.00	-89	109.69	72.95	20	52.95	Pass
75.243560	34.70	Vertical	1.02	0		74.99		54.99	

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

**-. Margin = Attenuation below carrier – specification limit.



Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Table 7.3.3 Field strength of spurious emissions above 1 GHz within restricted bands

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
 INVESTIGATED FREQUENCY RANGE: 1000 - 10000 MHz
 TEST DISTANCE: 3 m
 MODULATION: 2GFSK
 BIT RATE: 500 kbps
 DETECTOR USED: Peak
 RESOLUTION BANDWIDTH: 1000 kHz
 TEST ANTENNA TYPE: Double ridged guide
 CONFIGURATION: Tx Antenna 1

Antenna			Azimuth, degrees*	Peak field strength			Average field strength				Verdict
Frequency, MHz	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											
1120.000000	Vertical	1.79	93	48.40	74.0	-25.60	48.40	45.11	54.0	-8.89	Pass
2709.165000	Horizontal	1.27	-30	47.54	74.0	-26.46	47.54	44.25	54.0	-9.75	
Mid carrier frequency											
2745.387500	Horizontal	2.05	-163	45.53	74.0	-28.47	45.53	42.24	54.0	-11.76	Pass
High carrier frequency											
2780.365000	Horizontal	1.00	-144	42.73	74.0	-31.27	42.73	39.44	54.0	-14.56	Pass

CONFIGURATION: Tx Antenna 2

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											
1120.000000	Vertical	1.79	95	44.39	74.0	-29.61	44.39	41.10	54.0	-12.9	Pass
2708.665000	Horizontal	1.54	-51	47.89	74.0	-26.11	47.89	44.60	54.0	-9.4	
Mid carrier frequency											
2745.387500	Horizontal	2.06	-63	47.63	74.0	-26.37	47.63	44.34	54.0	-9.66	Pass
High carrier frequency											
2781.487500	Horizontal	1.54	105	49.84	74.0	-24.16	49.84	46.55	54.0	-7.45	Pass

*- 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.

Table 7.3.4 Average factor calculation

Transmission pulse		Transmission burst		Transmission train duration, ms	Average factor, dB
Duration, ms	Period, ms	Duration, ms	Period, ms		
1.802	8.025	NA	NA	NA	-12.9738

*- Average factor was calculated as follows

for pulse train shorter than 100 ms:

$$\text{Average factor} = 20 \times \log_{10} \left(\frac{\text{Pulse duration}}{\text{Pulse period}} \times \frac{\text{Burst duration}}{\text{Train duration}} \times \text{Number of bursts within pulse train} \right)$$

Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance	Verdict: PASS		
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Table 7.3.5 Field strength of spurious emissions below 1 GHz within restricted bands

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
 INVESTIGATED FREQUENCY RANGE: 0.009 – 1000 MHz
 TEST DISTANCE: 3 m
 MODULATION: 2GFSK
 BIT RATE: 500 kbps
 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)
 CONFIGURATION: Tx Antenna 1

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								
75.201500	38.47	29.91	40.0	-10.09	Vertical	2.25	-140	Pass
112.798500	39.08	32.25	43.5	-11.25	Vertical	1.67	55	
Mid carrier frequency								
75.169500	37.90	29.94	40.0	-10.06	Vertical	1.76	179	Pass
113.935500	39.27	31.95	43.5	-11.55	Vertical	4.00	-156	
990.793500	53.93	47.24	54.0	-6.76	Horizontal	1.75	-180	
High carrier frequency								
113.158500	39.75	32.19	43.5	-11.31	Vertical	1.75	-89	Pass
240.017500	45.89	42.77	46.0	-3.23	Vertical	1.00	-180	

CONFIGURATION: Tx Antenna 2

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								
239.993000	39.90	39.10	46.0	-6.90	Horizontal	1.32	-120	Pass
Mid carrier frequency								
239.994565	40.670	40.12	46.0	-5.88	Horizontal	1.32	-120	Pass
High carrier frequency								
112.430724	34.88	29.39	46.0	-10.61	Vertical	1.02	-141	Pass
239.997065	41.52	40.73	46.0	-5.27	Vertical	1.04	-172	

*- Margin = Measured emission - specification limit.

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



Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Table 7.3.6 Restricted bands

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

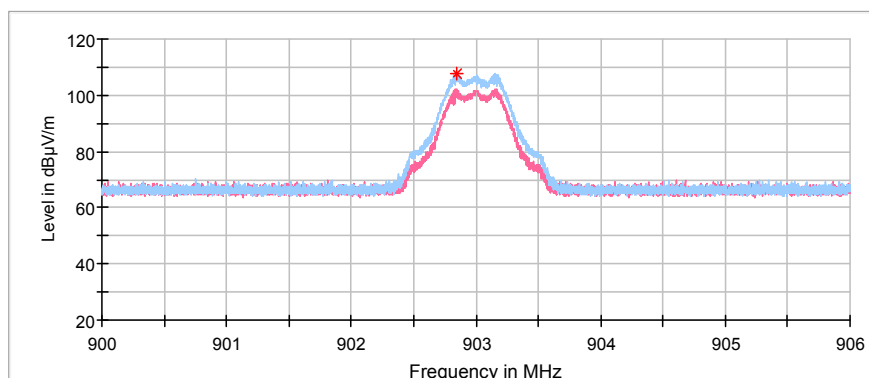
HL3903	HL4339	HL4360	HL4933	HL5288	HL5404		
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Full description is given in Appendix A.

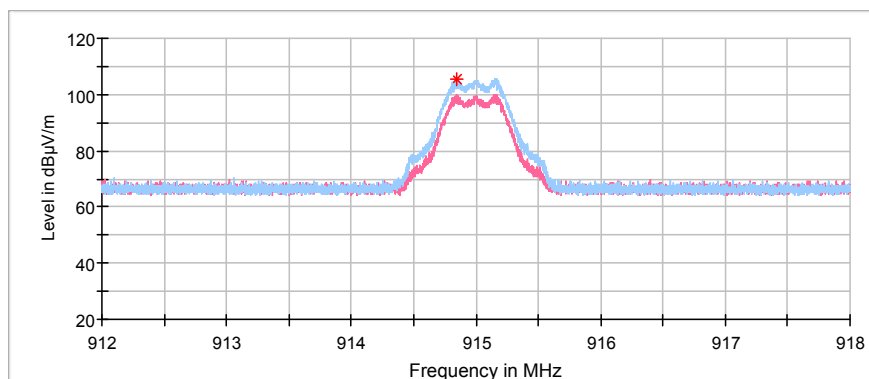
Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

ANTENNA 1

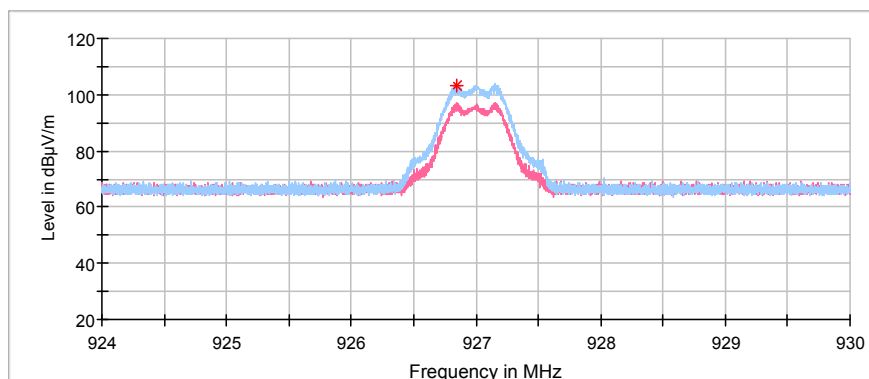
Plot 7.3.1 Field strength of carrier at low frequency



Plot 7.3.2 Field strength of carrier at mid frequency



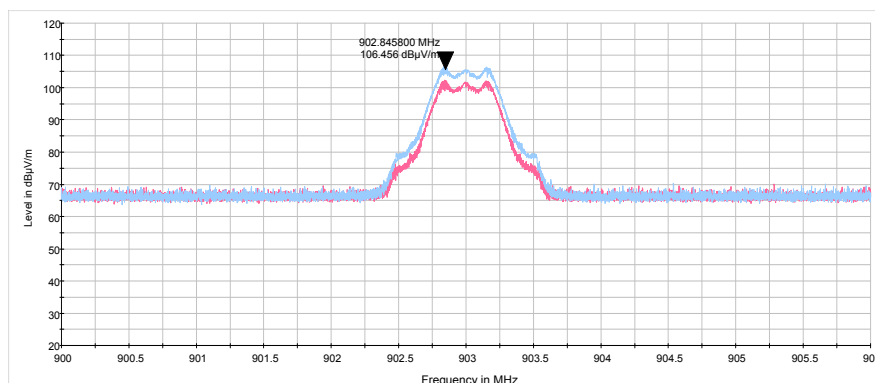
Plot 7.3.3 Field strength of carrier at high frequency



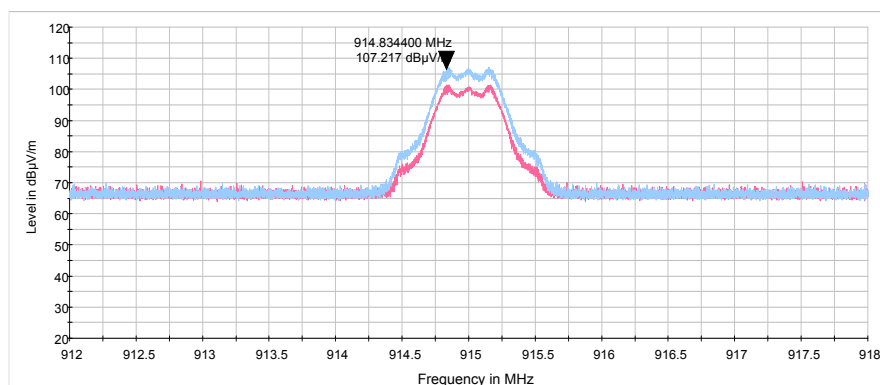
Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

ANTENNA 2

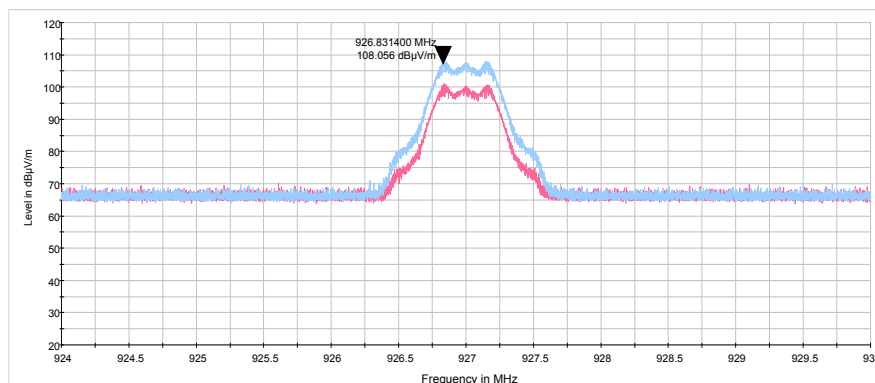
Plot 7.3.4 Field strength of carrier at low frequency



Plot 7.3.5 Field strength of carrier at mid frequency



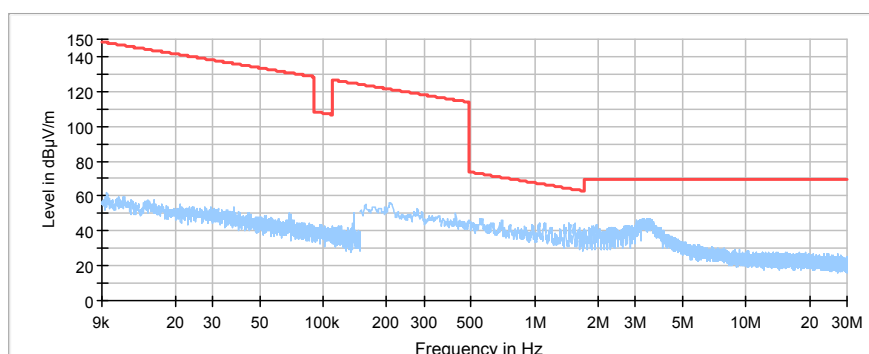
Plot 7.3.6 Field strength of carrier at high frequency



Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

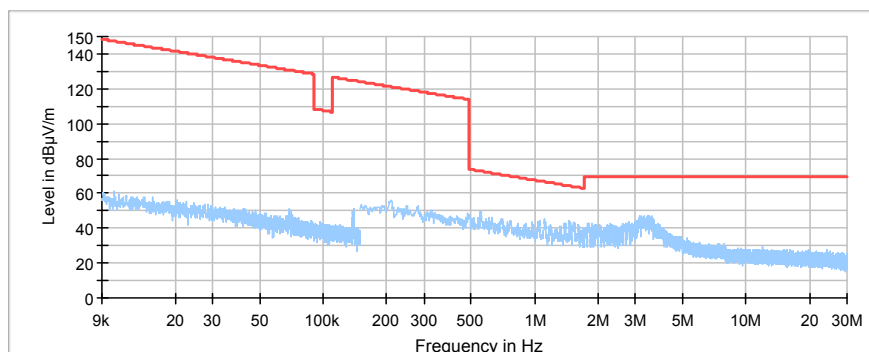
Plot 7.3.7 Radiated emission measurements from 9 kHz to 30 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 1



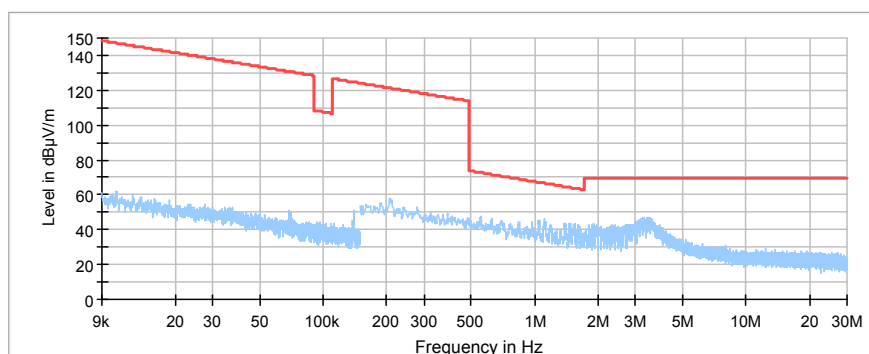
Plot 7.3.8 Radiated emission measurements from 9 kHz to 30 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 1



Plot 7.3.9 Radiated emission measurements from 9 kHz to 30 MHz at the high carrier frequency

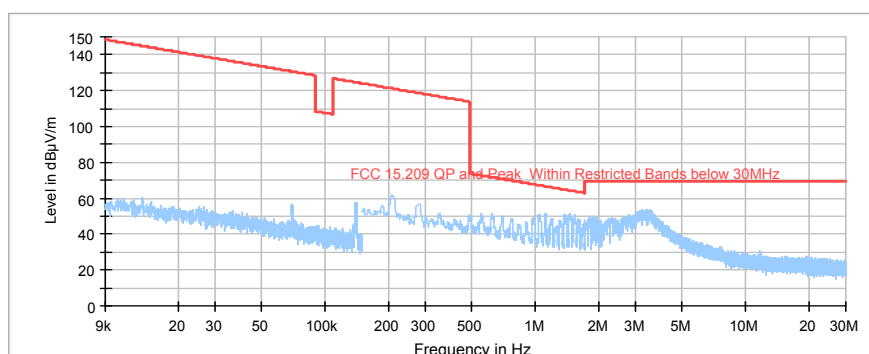
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 1



Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

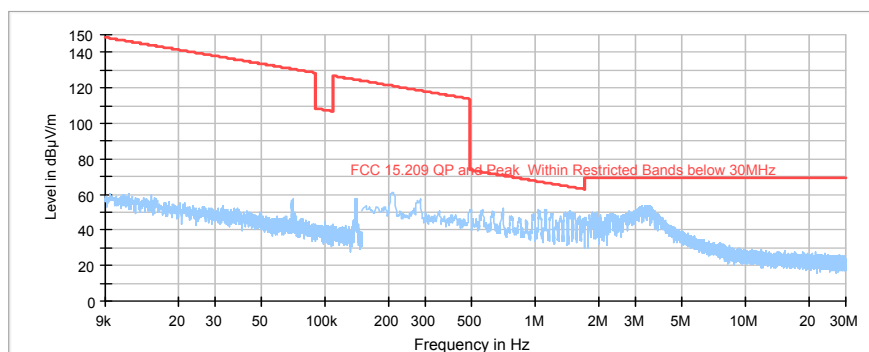
Plot 7.3.10 Radiated emission measurements from 9 kHz to 30 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 2



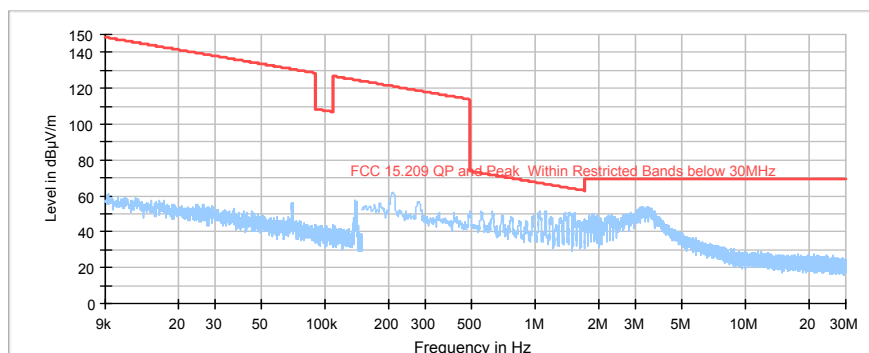
Plot 7.3.11 Radiated emission measurements from 9 kHz to 30 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 2



Plot 7.3.11 Radiated emission measurements from 9 kHz to 30 MHz at the high carrier frequency

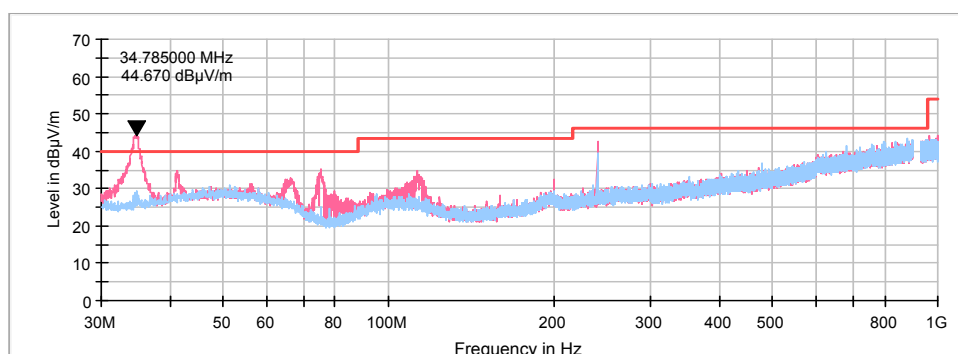
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 2



Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

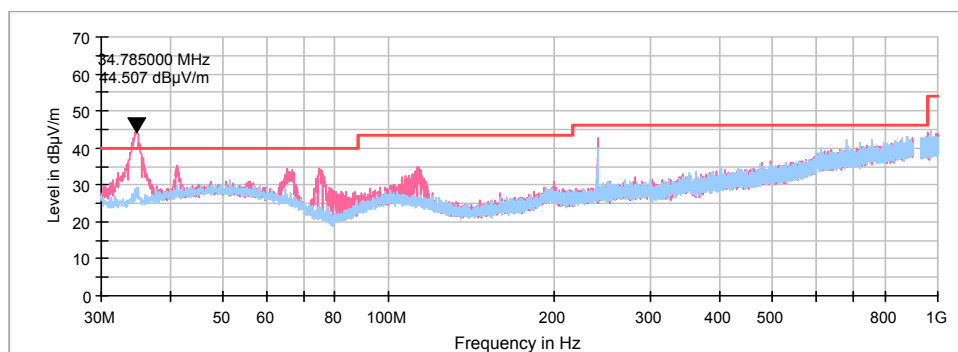
Plot 7.3.12 Radiated emission measurements from 30 to 1000 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 1



Plot 7.3.13 Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

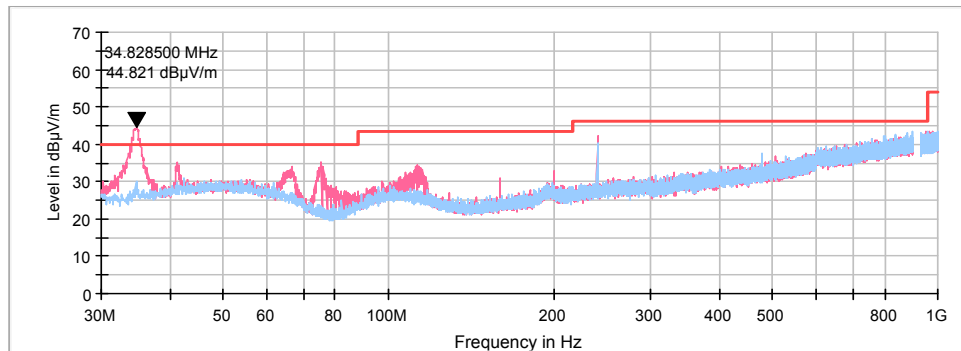
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 1



Test specification:		Section 15.247(d), Radiated spurious emissions	
Test procedure:		ANCI C63.10 section 11.11 & 11.12; KDB 558074	
Test mode:		Verdict: PASS	
Date(s):			
01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Plot 7.3.14 Radiated emission measurements from 30 to 1000 MHz at the high carrier frequency

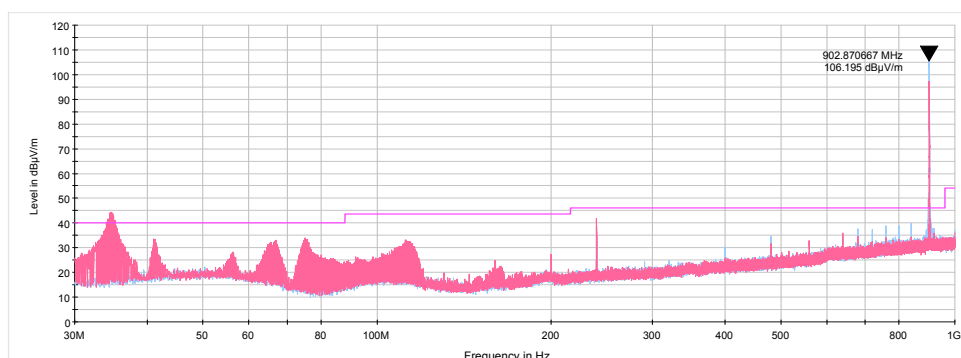
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 1



Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

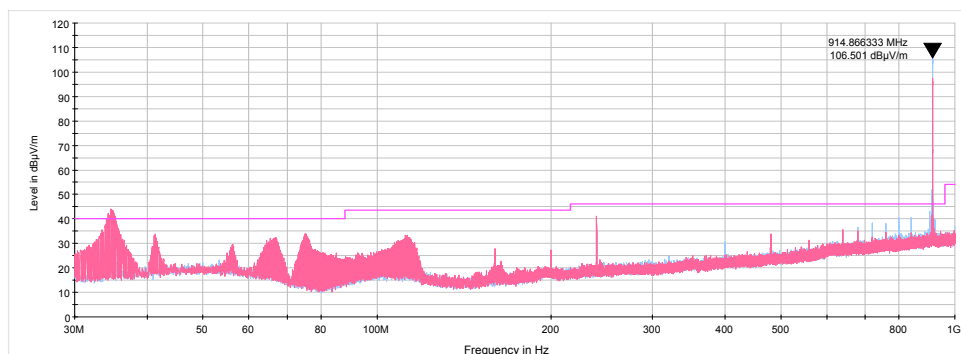
Plot 7.3.15 Radiated emission measurements from 30 to 1000 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 2



Plot 7.3.16 Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

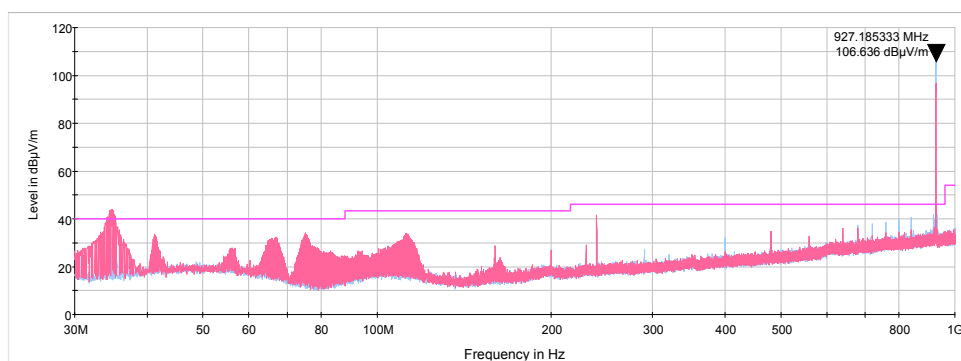
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 2



Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Plot 7.3.17 Radiated emission measurements from 30 to 1000 MHz at the high carrier frequency

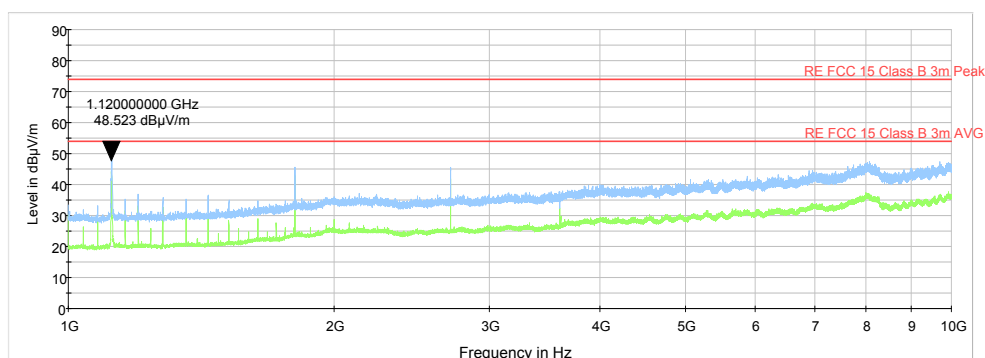
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 2



Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

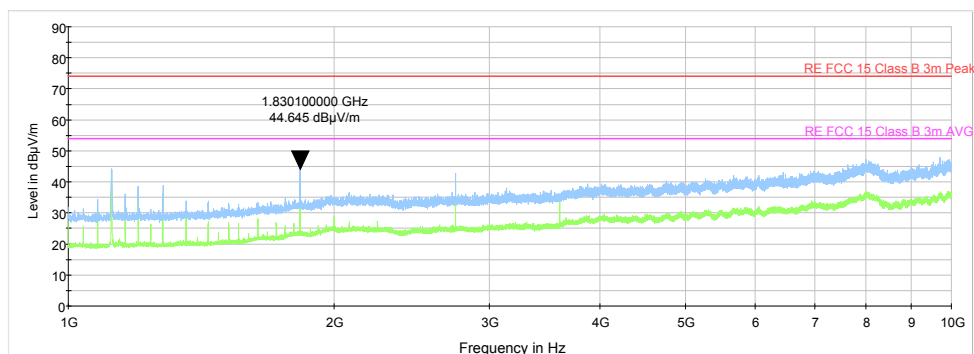
Plot 7.3.18 Radiated emission measurements from 1000 to 10000 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 1



Plot 7.3.19 Radiated emission measurements from 1000 to 10000 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 1



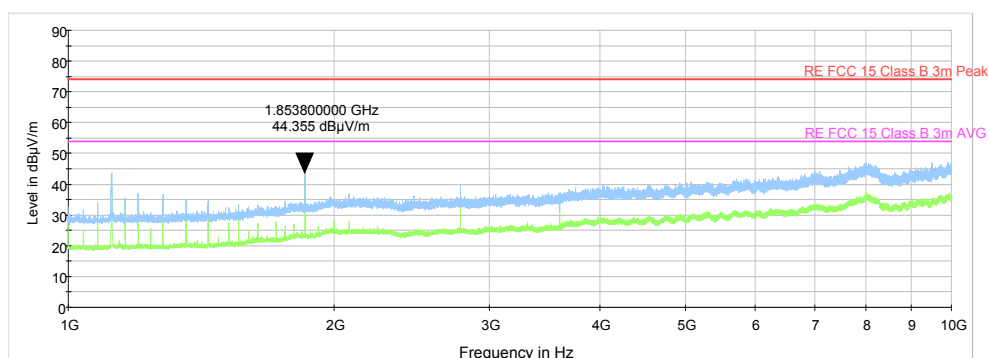


HERMON LABORATORIES

Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Plot 7.3.20 Radiated emission measurements from 1000 to 10000 MHz at the high carrier frequency

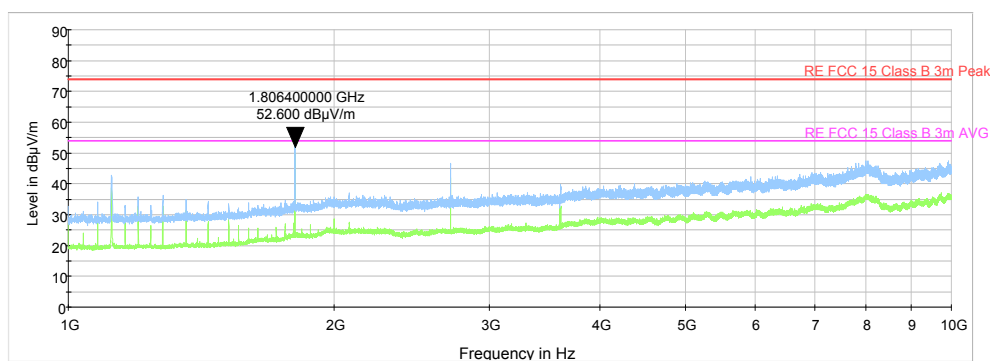
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 1



Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

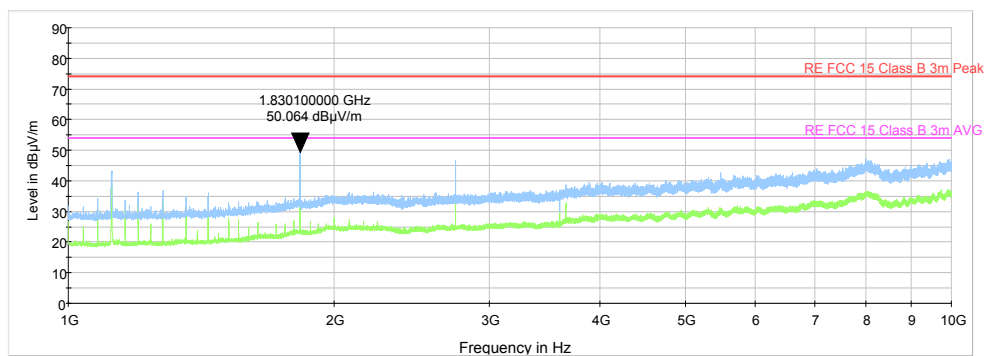
Plot 7.3.21 Radiated emission measurements from 1000 to 10000 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 2



Plot 7.3.22 Radiated emission measurements from 1000 to 10000 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 2





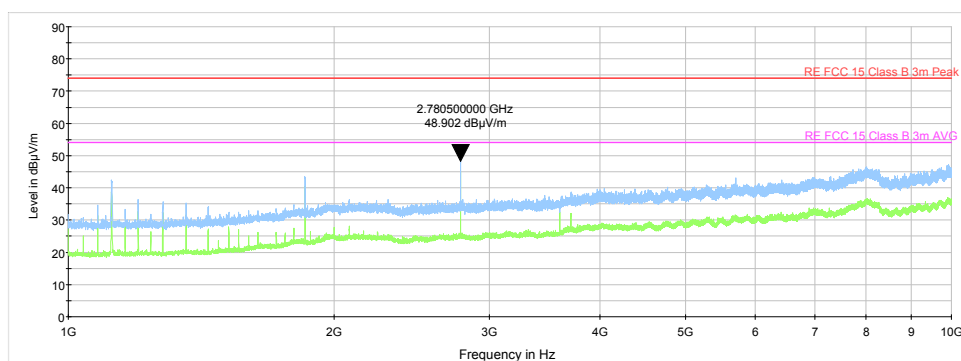
HERMON LABORATORIES

Report ID: JUGRAD_FCC.32978.docx
Date of Issue: 17-Jun-20

Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Plot 7.3.23 Radiated emission measurements from 1000 to 10000 MHz at the high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA OUTPUT: 2

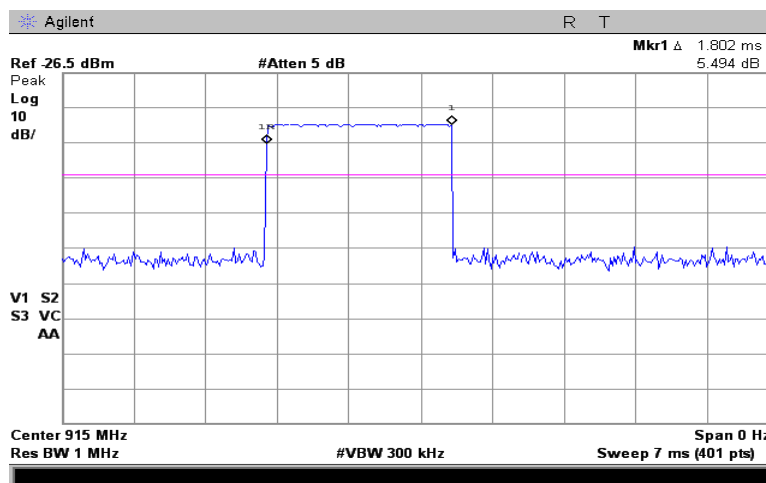




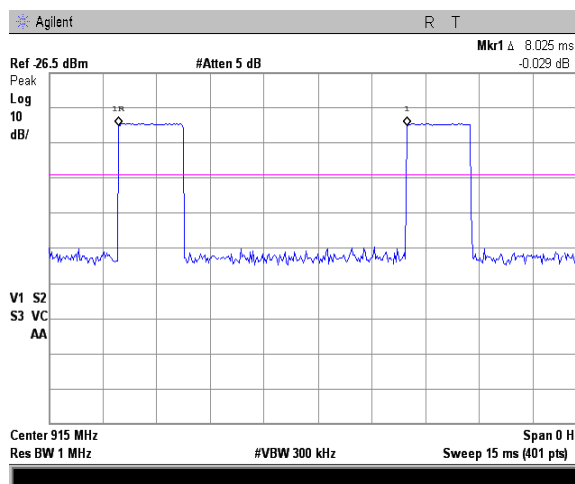
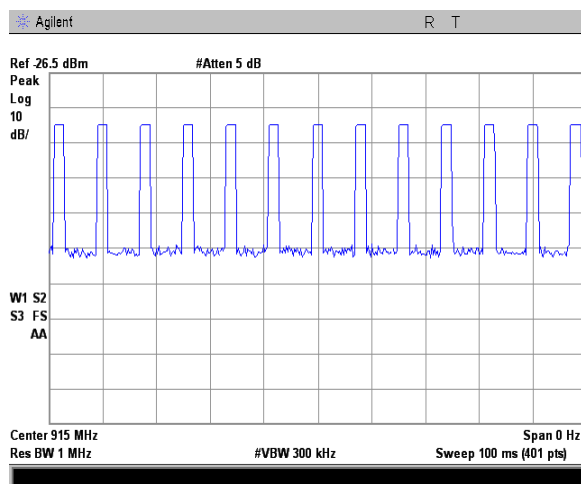
HERMON LABORATORIES

Test specification: Section 15.247(d), Radiated spurious emissions			
Test procedure: ANCI C63.10 section 11.11 & 11.12; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 18-Apr-19			
Temperature: 25 °C	Relative Humidity: 46 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Plot 7.3.24 Transmission pulse duration



Plot 7.3.25 Transmission pulse period



Test specification: Section 15.247(d), Band edge emissions			
Test procedure: ANSI C63.10, section 7.8.6; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 24 °C	Relative Humidity: 48 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

7.4 Band edge radiated emissions

7.4.1 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 7.4.1.

Table 7.4.1 Band edge emission limits

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

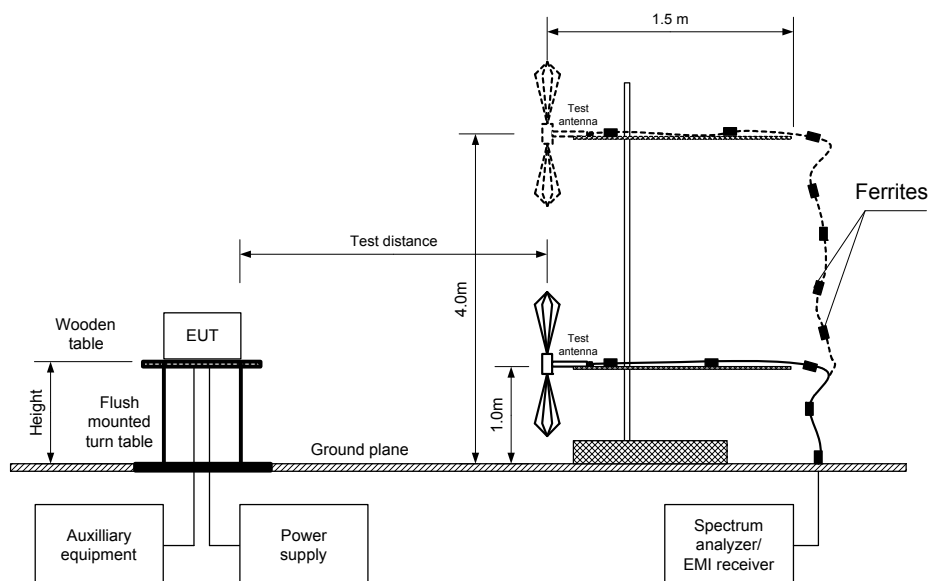
* - Band edge emission limit is provided in terms of attenuation below the peak of modulated carrier measured with the same resolution bandwidth.

7.4.2 Test procedure

- 7.4.2.1 The EUT was set up as shown in Figure 7.4.1 energized normally modulated at the maximum data rate and its proper operation was checked.
- 7.4.2.2 The EUT was adjusted to produce maximum available to end user RF output power at the lowest carrier frequency.
- 7.4.2.3 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.
- 7.4.2.4 The spectrum analyzer was set in max hold mode and allowed trace to stabilize. The highest emission level within the authorized band was measured.
- 7.4.2.5 The maximum band edge emission and modulation product outside of the band were measured as provided in Table 7.4.2 and associated plots and referenced to the highest emission level measured within the authorized band.
- 7.4.2.6 The above procedure was repeated with the EUT adjusted to produce maximum RF output power at the highest carrier frequency.

Test specification: Section 15.247(d), Band edge emissions			
Test procedure: ANSI C63.10, section 7.8.6; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 24 °C	Relative Humidity: 48 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Figure 7.4.1 Band edge emission test setup





Test specification: Section 15.247(d), Band edge emissions			
Test procedure: ANSI C63.10, section 7.8.6; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 24 °C	Relative Humidity: 48 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

Table 7.4.2 Band edge emission test results

ASSIGNED FREQUENCY RANGE: 902.0 – 928.0 MHz
 DETECTOR USED: Peak
 MODULATION: 2GFSK
 BIT RATE: 500 kbps
 VIDEO BANDWIDTH: ≥ RBW

Frequency, MHz	Band edge emission, dB(μV/m)	Emission at carrier, dB(μV/m)	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
TX Antenna 1						
901.82	69.86	107.61	37.75	20.0	17.75	Pass
928.05	70.56	103.22	32.66		12.66	
TX Antenna 2						
901.76	69.34	106.45	37.11	20.0	17.11	Pass
929.44	69.77	108.05	38.28		18.28	

*- Margin = Attenuation below carrier – specification limit.

Reference numbers of test equipment used

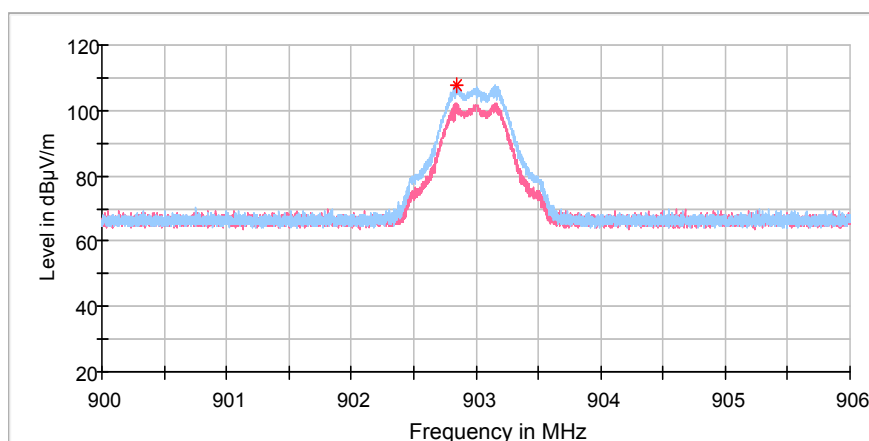
HL 3903	HL 4360	HL 5288	HL 5404				
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Full description is given in Appendix A.

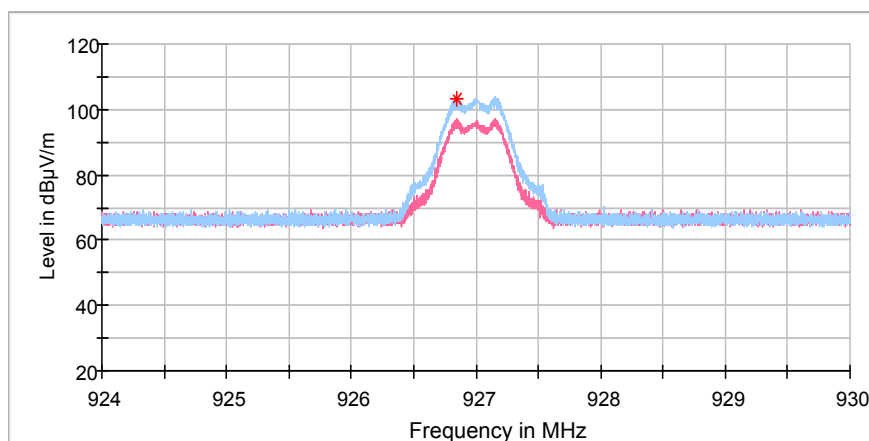
Test specification: Section 15.247(d), Band edge emissions			
Test procedure: ANSI C63.10, section 7.8.6; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 24 °C	Relative Humidity: 48 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

ANTENNA 1

Plot 7.4.1 The highest band edge emission at low carrier frequency



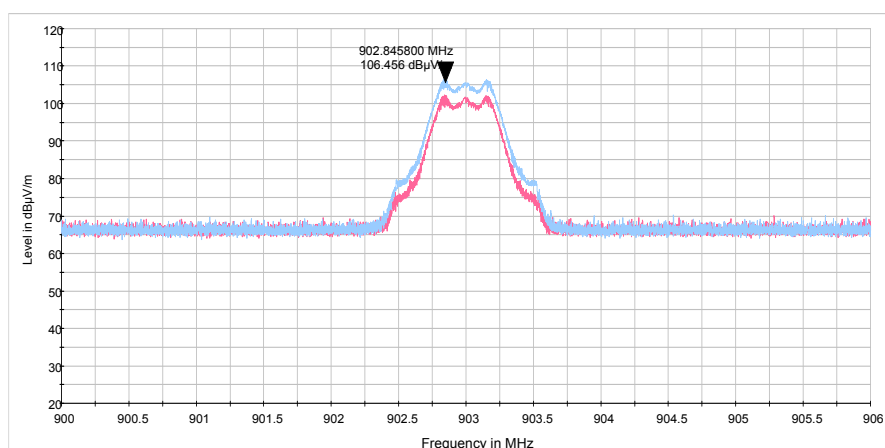
Plot 7.4.2 The highest band edge emission at high carrier frequency



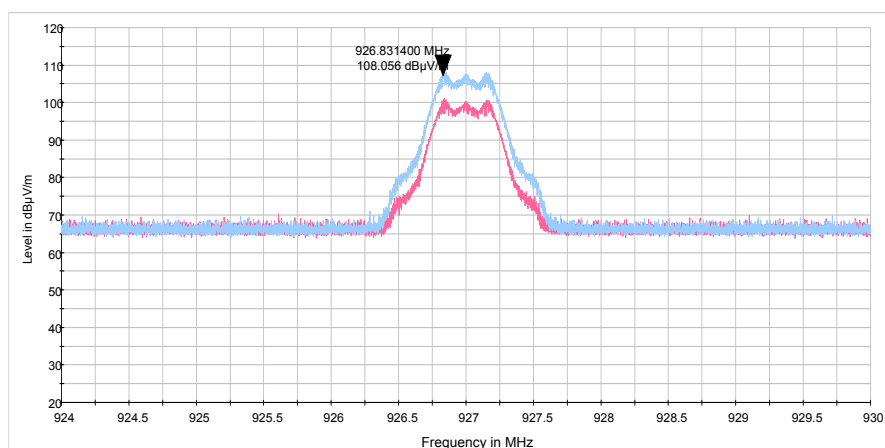
Test specification: Section 15.247(d), Band edge emissions			
Test procedure: ANSI C63.10, section 7.8.6; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 24 °C	Relative Humidity: 48 %	Air Pressure: 1010 hPa	Power: 12 VDC
Remarks:			

ANTENNA 2

Plot 7.4.3 The highest band edge emission at low carrier frequency



Plot 7.4.4 The highest band edge emission at high carrier frequency



Test specification: Section 15.247(e), Peak power density			
Test procedure: ANSI C63.10 section 11.10; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 15-Apr-19			
Temperature: 24 °C	Relative Humidity: 48 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

7.5 Peak spectral power density

7.5.1 General

This test was performed to measure the peak spectral power density radiated by the transmitter RF antenna. Specification test limits are given in Table 7.5.1.

Table 7.5.1 Peak spectral power density limits

Assigned frequency range, MHz	Measurement bandwidth, kHz	Peak spectral power density, dBm	Equivalent field strength limit @ 3m, dB(μV/m)*
902.0 – 928.0	3.0	8.0	103.2
2400.0 – 2483.5			
5725.0 – 5850.0			

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

7.5.2 Test procedure for field strength measurements

7.5.2.1 The EUT was set up as shown in Figure 7.5.1, energized and its proper operation was checked.

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

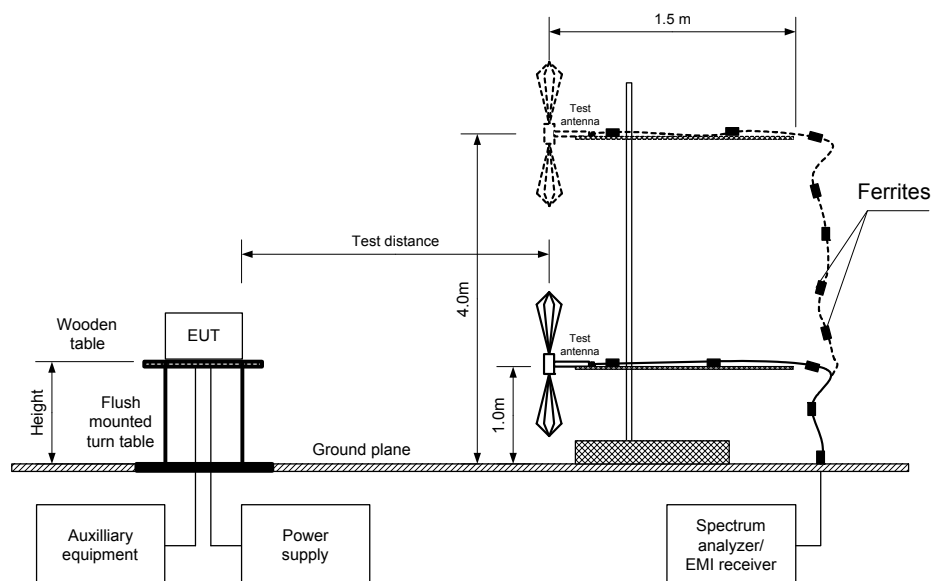
7.5.2.3 The field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360° and the measuring antenna height was swept in both vertical and horizontal polarizations.

7.5.2.4 The frequency span of spectrum analyzer was set to capture the entire 6 dB band of the transmitter, in peak hold mode with resolution bandwidth set to 3.0 kHz, video bandwidth wider than resolution bandwidth, auto sweep time and sufficient number of sweeps was allowed for trace stabilization. The spectrum lines spacing was verified to be wider than 3 kHz. Otherwise the resolution bandwidth was reduced until individual spectrum lines were resolved and the power of individual spectrum lines was integrated over 3 kHz band.

7.5.2.5 The peak of emission was zoomed with span set just wide enough to capture the emission peak area and sweep time was set equal to span width divided by resolution bandwidth. Spectrum analyzer was set in peak hold mode, sufficient number of sweeps was allowed for trace stabilization and peak spectral power density was measured as provided in Table 7.5.2 and associated plots.

Test specification: Section 15.247(e), Peak power density			
Test procedure: ANSI C63.10 section 11.10; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 15-Apr-19			
Temperature: 24 °C	Relative Humidity: 48 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Figure 7.5.1 Setup for carrier field strength measurements





HERMON LABORATORIES

Test specification: Section 15.247(e), Peak power density			
Test procedure: ANSI C63.10 section 11.10; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 15-Apr-19			
Temperature: 24 °C	Relative Humidity: 48 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Table 7.5.2 Field strength measurement of peak spectral power density

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
 TEST DISTANCE: 3 m
 TEST SITE: Semi anechoic chamber
 EUT HEIGHT: 0.8 m
 DETECTOR USED: Peak
 RESOLUTION BANDWIDTH: 3 kHz
 VIDEO BANDWIDTH: 10 kHz
 TEST ANTENNA TYPE: Biconilog
 MODULATION: 2GFSK
 BIT RATE: 500 kbps

CONFIGURATION

TX Antenna 1

Frequency, MHz	Field strength, dB(μV/m)	EUT antenna gain, dBi	PSD* dBm	Limit dBm	Margin, dB**	Verdict
903.00	95.81	2.00	-1.42	8.0	-9.42	Pass
915.00	94.06	2.00	-3.17	8.0	-11.17	Pass
927.00	92.59	2.00	-4.64	8.0	-12.64	Pass

CONFIGURATION

TX Antenna 2

Frequency, MHz	Field strength, dB(μV/m)	EUT antenna gain, dBi	PSD* dBm	Limit dBm	Margin, dB**	Verdict
903.00	98.23	2.00	1.00	8.0	-7.00	Pass
915.00	95.14	2.00	-2.09	8.0	-10.09	Pass
927.00	94.84	2.00	-2.39	8.0	-10.39	Pass

*- PSD was calculated from the field strength of carrier as follows: $PSD = (E \times d)^2 / (30 \times G)$,

where PSD 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: $PSD \text{ in dBm} = \text{Field strength in dB}(\mu\text{V/m}) - \text{Transmitter antenna gain in dBi} - 95.23 \text{ dB}$

** - Margin = PSD in dBm – Limit in dBm.

Reference numbers of test equipment used

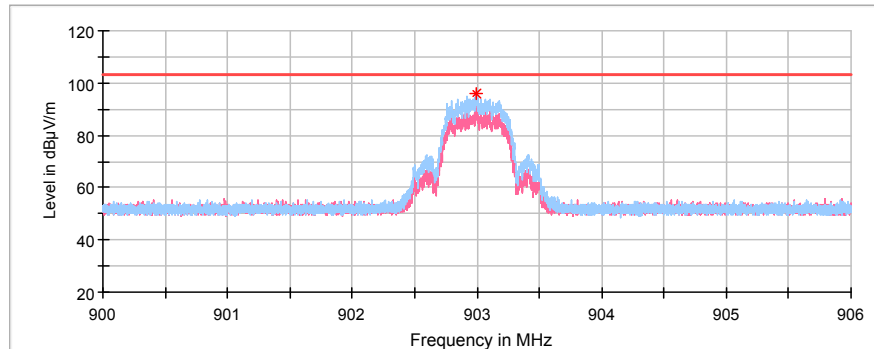
HL 3903	HL 4360	HL 5288	HL 5404				
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Full description is given in Appendix A.

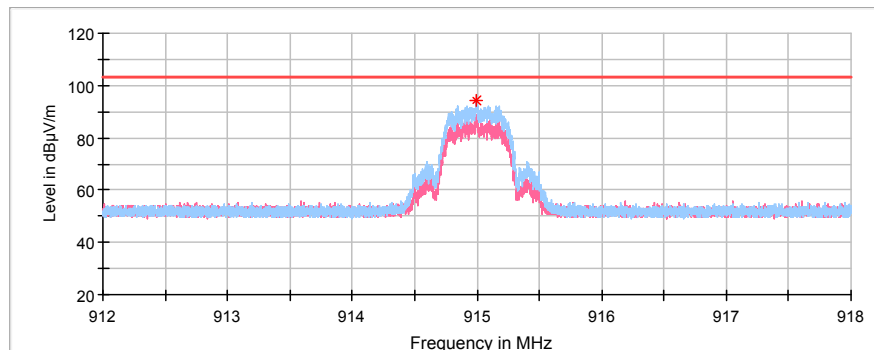
Test specification: Section 15.247(e), Peak power density			
Test procedure: ANSI C63.10 section 11.10; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 15-Apr-19			
Temperature: 24 °C	Relative Humidity: 48 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

ANTENNA 1

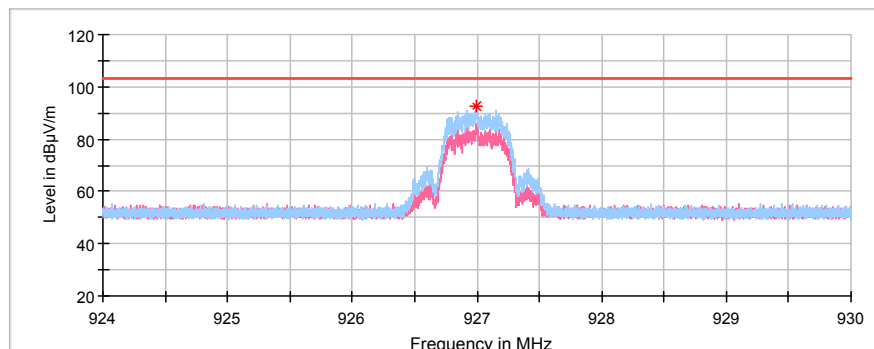
Plot 7.5.1 Peak spectral power density at low frequency zoomed at the peak



Plot 7.5.2 Peak spectral power density at mid frequency zoomed at the peak



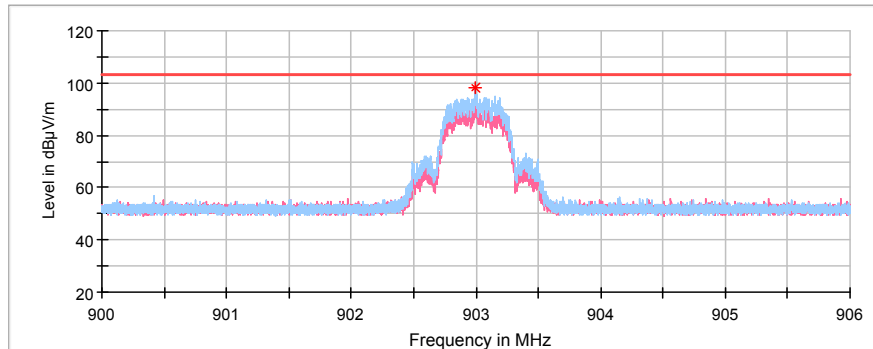
Plot 7.5.3 Peak spectral power density at high frequency zoomed at the peak



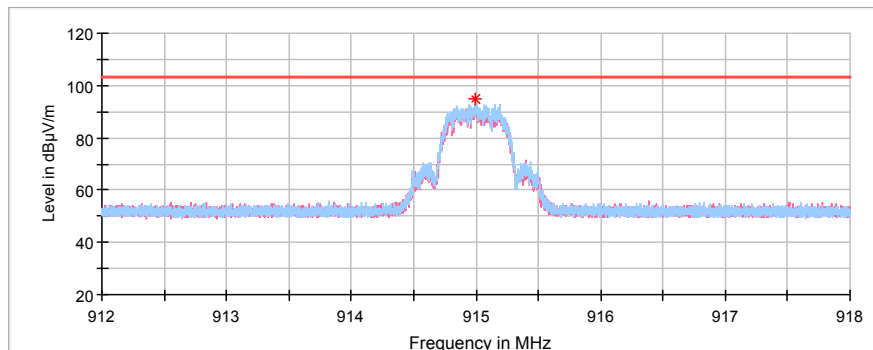
Test specification: Section 15.247(e), Peak power density			
Test procedure: ANSI C63.10 section 11.10; KDB 558074			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19 - 15-Apr-19			
Temperature: 24 °C	Relative Humidity: 48 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

ANTENNA 2

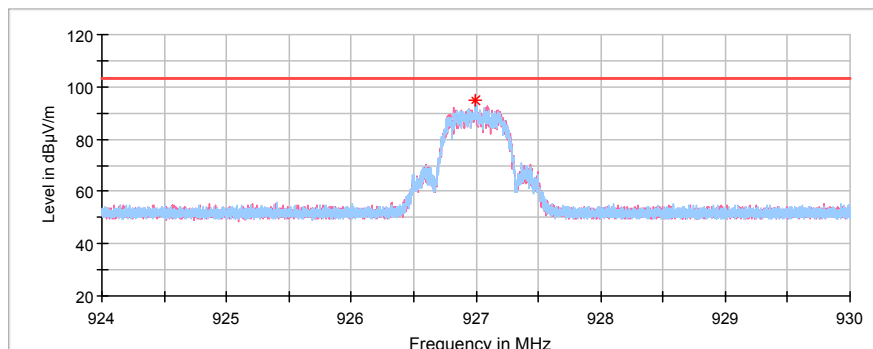
Plot 7.5.4 Peak spectral power density at low frequency zoomed at the peak



Plot 7.5.5 Peak spectral power density at mid frequency zoomed at the peak



Plot 7.5.6 Peak spectral power density at high frequency zoomed at the peak



Test specification: Section 15.207(a), Conducted emission			
Test procedure: ANSI C63.10, Section 6.2			
Test mode: Compliance		Verdict: PASS	
Date(s): 19-Apr-19 - 24-Apr-19			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 12 VDC
Remarks:			

7.6 Conducted emissions

7.6.1 General

This test was performed to measure common mode conducted emissions at the mains power port. Specification test limits are given in Table 7.6.1. The worst test results (the lowest margins) were recorded in Table 7.6.2 and shown in the associated plots.

Table 7.6.1 Limits for conducted emissions

Frequency, MHz	Class B limit, dB(μV)	
	QP	AVRG
0.15 - 0.5	66 - 56*	56 - 46*
0.5 - 5.0	56	46
5.0 - 30	60	50

* The limit decreases linearly with the logarithm of frequency.

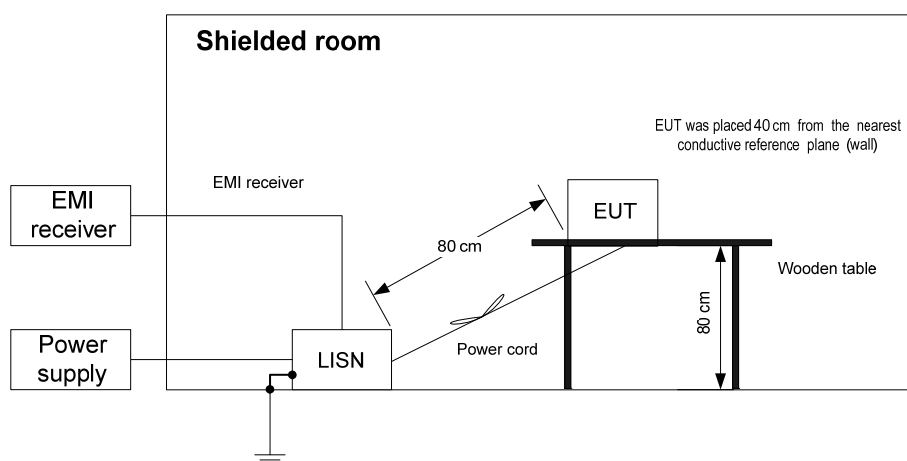
7.6.2 Test procedure

7.6.2.1 The EUT was set up as shown in Figure 7.6.1 and associated photographs, energized and the performance check was conducted.

7.6.2.2 The measurements were performed at power terminals with the LISN, connected to a spectrum analyzer in the frequency range referred to in Table 7.6.2. Unused coaxial connector of the LISN was terminated with 50 Ohm. Quasi-peak and average detectors were used throughout the testing.

7.6.2.3 The position of the device cables was varied to determine maximum emission level.

Figure 7.6.1 Setup for conducted emission measurements, table-top equipment





HERMON LABORATORIES

Test specification: Section 15.207(a), Conducted emission			
Test procedure: ANSI C63.10, Section 6.2			
Test mode: Compliance		Verdict: PASS	
Date(s): 19-Apr-19 - 24-Apr-19			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 12 VDC
Remarks:			

Table 7.6.2 Conducted emission test results

LINE: AC mains
 LIMIT: Class B
 EUT OPERATING MODE: Transmit
 EUT SET UP: TABLE-TOP
 TEST SITE: SHIELDED ROOM
 DETECTORS USED: PEAK / QUASI-PEAK / AVERAGE
 FREQUENCY RANGE: 150 kHz - 30 MHz
 RESOLUTION BANDWIDTH: 9 kHz

Frequency, MHz	Peak emission, dB(μV)	Quasi-peak			Average			Line ID	Verdict
		Measured emission, dB(μV)	Limit, dB(μV)	Margin, dB*	Measured emission, dB(μV)	Limit, dB(μV)	Margin, dB*		
0.160945	45.32	45.28	65.42	-20.14	45.19	55.42	-10.14	L1	Pass
0.200745	44.36	44.25	63.58	-19.33	44.12	53.58	-9.33		
0.363925	41.85	41.67	58.64	-16.97	41.48	48.64	-6.97		
0.401735	40.32	40.11	57.82	-17.71	39.58	47.82	-7.71		
0.429595	40.64	40.53	57.26	-16.73	40.34	47.26	-6.73		
0.447505	39.58	39.33	56.92	-17.59	38.94	46.92	-7.59		
0.153980	46.17	46.03	65.78	-19.75	45.86	55.78	-9.75	L2	Pass
0.175870	45.26	45.21	64.68	-19.47	45.16	54.68	-9.47		
0.238555	41.42	41.26	62.15	-20.89	41.08	52.15	-10.89		
0.506210	37.05	36.88	56.00	-19.12	36.62	46.00	-9.12		
0.534070	38.13	38.11	56.00	-17.89	37.94	46.00	-7.89		
0.569890	37.28	37.24	56.00	-18.76	37.04	46.00	-8.76		
0.604715	35.51	35.48	56.00	-20.52	35.09	46.00	-10.52		

*- Margin = Measured emission - specification limit.

Reference numbers of test equipment used

HL 0787	HL 2888	HL 5278	HL 5372				
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Full description is given in Appendix A.

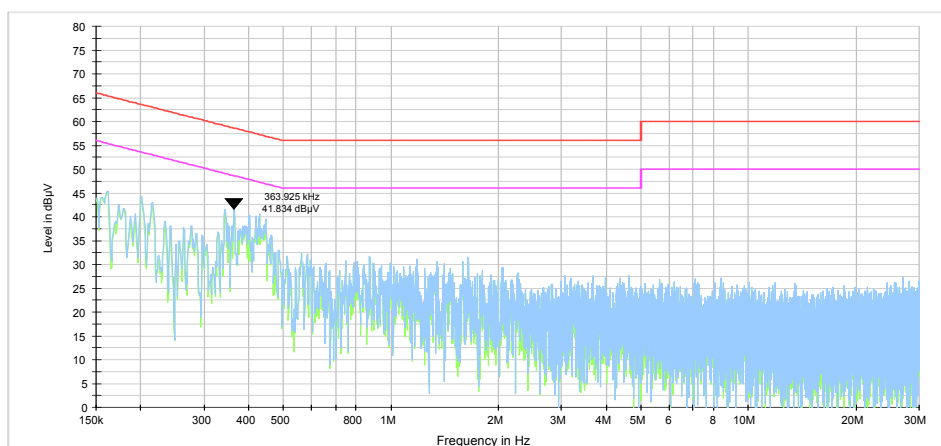


HERMON LABORATORIES

Test specification: Section 15.207(a), Conducted emission			
Test procedure: ANSI C63.10, Section 6.2			
Test mode: Compliance		Verdict: PASS	
Date(s): 19-Apr-19 - 24-Apr-19			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 12 VDC
Remarks:			

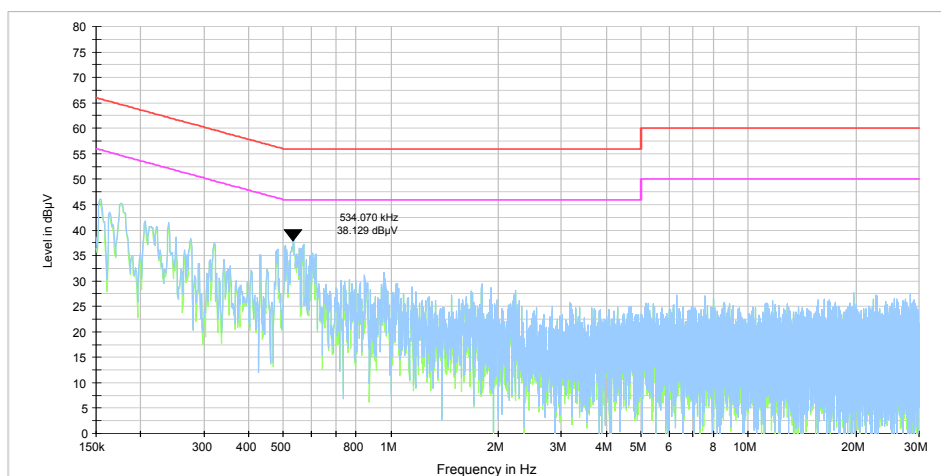
Plot 7.6.1 Conducted emission measurements

LINE: L1
LIMIT: Class B
EUT OPERATING MODE: Tx
LIMIT: QUASI-PEAK, AVERAGE
DETECTOR: PEAK



Plot 7.6.2 Conducted emission measurements

LINE: L2
LIMIT: Class B
EUT OPERATING MODE: Tx
LIMIT: QUASI-PEAK, AVERAGE
DETECTOR: PEAK





Test specification: FCC section 15.203, Antenna requirement			
Test procedure: Visual inspection			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 25 °C	Relative Humidity: 49 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

7.7 Antenna requirements

The EUT was verified for compliance with antenna requirements. A transmitter shall be designed to ensure that no antenna other than that furnished by the responsible party will be used with the device. It may be either permanently attached or employs a unique antenna connector for every antenna proposed for use with the EUT. This requirement does not apply to professionally installed transmitters.

The rationale for compliance with the above requirements was either visual inspection results or supplier declaration. The summary of results is provided in Table 7.7.1.

Table 7.7.1 Antenna requirements

Requirement	Rationale	Verdict
The transmitter antenna is permanently attached	Visual inspection*	Comply
The transmitter employs a unique antenna connector	NA	
The transmitter requires professional installation	NA	

* Not available for the user.

Test specification: Section 15.107, Conducted emission at AC power port			
Test procedure: ANSI C63.4, Section 7			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 25 °C	Relative Humidity: 49 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

8 Emission tests according to 47CFR part 15 subpart B requirements

8.1 Conducted emissions

8.1.1 General

This test was performed to measure common mode conducted emissions at the power port. Specification test limits are given in Table 8.1.1.

Table 8.1.1 Limits for conducted emissions

Frequency, MHz	Class B limit, dB(μ V)	
	QP	AVRG
0.15 - 0.5	66 - 56*	56 - 46*
0.5 - 5.0	56	46
5.0 - 30	60	50

* The limit decreases linearly with the logarithm of frequency.

8.1.2 Test procedure

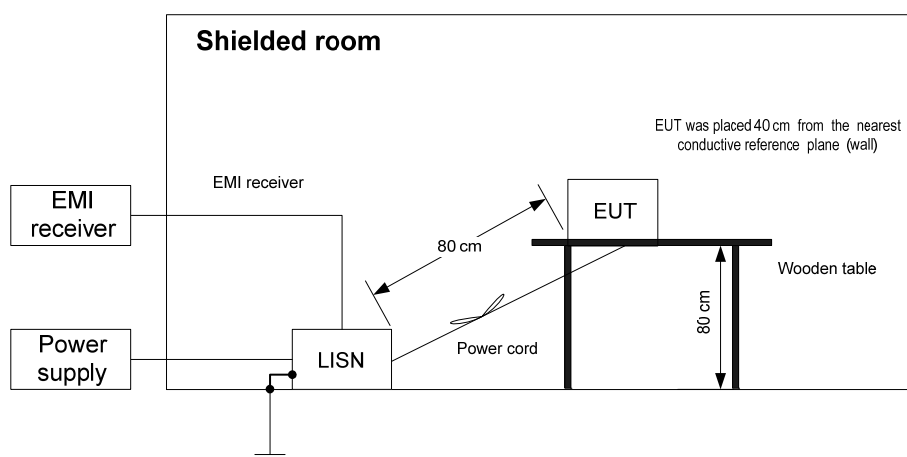
8.1.2.1 The EUT was set up as shown in Figure 8.1.1 and associated photographs, energized and the performance check was conducted.

8.1.2.2 The measurements were performed at power terminals with the LISN, connected to a spectrum analyzer in the frequency range referred to in Table 8.1.2. Unused coaxial connector of the LISN was terminated with 50 Ohm. Quasi-peak and average detectors were used throughout the testing.

8.1.2.3 The position of the device cables was varied to determine maximum emission level.

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

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





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Test specification: Section 15.107, Conducted emission at AC power port			
Test procedure: ANSI C63.4, Section 7			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 25 °C	Relative Humidity: 49 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Table 8.1.2 Conducted emission test results

LINE: AC mains
 LIMIT: Class B
 EUT OPERATING MODE: Receive / Stand-by
 EUT SET UP: TABLE-TOP
 TEST SITE: SHIELDED ROOM
 DETECTORS USED: PEAK / QUASI-PEAK / AVERAGE
 FREQUENCY RANGE: 150 kHz - 30 MHz
 RESOLUTION BANDWIDTH: 9 kHz

Frequency, MHz	Peak emission, dB(μV)	Quasi-peak			Average			Line ID	Verdict
		Measured emission, dB(μV)	Limit, dB(μV)	Margin, dB*	Measured emission, dB(μV)	Limit, dB(μV)	Margin, dB*		
0.160945	45.32	45.28	65.42	-20.14	45.19	55.42	-10.14	L1	Pass
0.200745	44.36	44.25	63.58	-19.33	44.12	53.58	-9.33		
0.363925	41.85	41.67	58.64	-16.97	41.48	48.64	-6.97		
0.401735	40.32	40.11	57.82	-17.71	39.58	47.82	-7.71		
0.429595	40.64	40.53	57.26	-16.73	40.34	47.26	-6.73		
0.447505	39.58	39.33	56.92	-17.59	38.94	46.92	-7.59		
0.153980	46.17	46.03	65.78	-19.75	45.86	55.78	-9.75	L2	Pass
0.175870	45.26	45.21	64.68	-19.47	45.16	54.68	-9.47		
0.238555	41.42	41.26	62.15	-20.89	41.08	52.15	-10.89		
0.506210	37.05	36.88	56.00	-19.12	36.62	46.00	-9.12		
0.534070	38.13	38.11	56.00	-17.89	37.94	46.00	-7.89		
0.569890	37.28	37.24	56.00	-18.76	37.04	46.00	-8.76		
0.604715	35.51	35.48	56.00	-20.52	35.09	46.00	-10.52		

*- Margin = Measured emission - specification limit.

Reference numbers of test equipment used

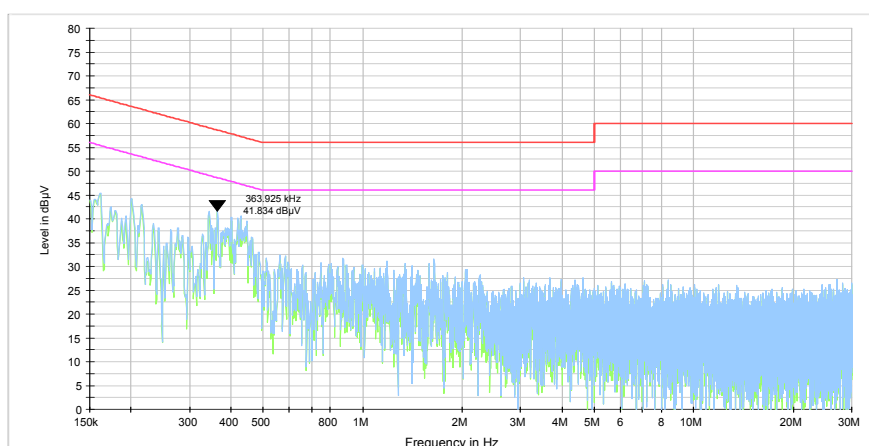
HL 0787	HL 2888	HL 5278	HL 5372	HL			
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Full description is given in Appendix A.

Test specification: Section 15.107, Conducted emission at AC power port			
Test procedure: ANSI C63.4, Section 7			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 25 °C	Relative Humidity: 49 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

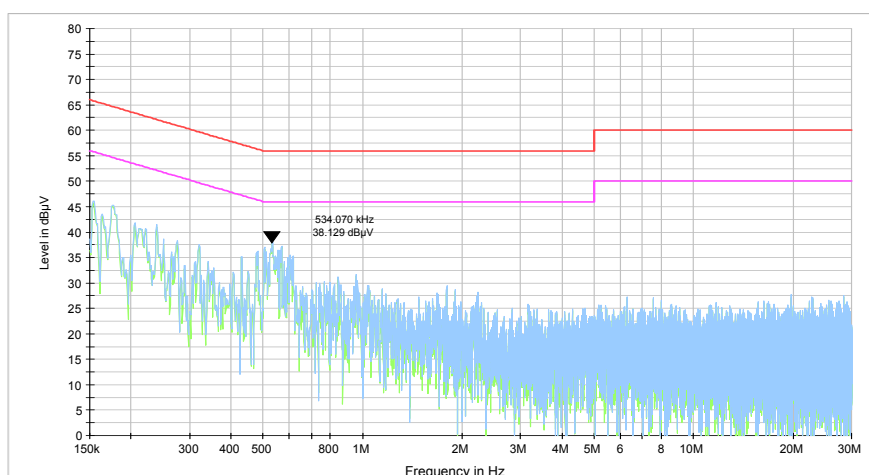
Plot 8.1.1 Conducted emission measurements

LINE: L1
LIMIT: Class B
EUT OPERATING MODE: Rx
LIMIT: QUASI-PEAK, AVERAGE
DETECTOR: PEAK



Plot 8.1.2 Conducted emission measurements

LINE: L2
LIMIT: Class B
EUT OPERATING MODE: Rx
LIMIT: QUASI-PEAK, AVERAGE
DETECTOR: PEAK



Test specification: Section 15.109, Radiated emission			
Test procedure: ANSI C63.4, Section 8			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 25 °C	Relative Humidity: 49 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

8.2 Radiated emission measurements

8.2.1 General

This test was performed to measure radiated emissions from the EUT enclosure. Specification test limits are given in Table 8.2.1.

Table 8.2.1 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: $\text{Lim}_{S_2} = \text{Lim}_{S_1} + 20 \log(S_1/S_2)$, where S_1 and S_2 – standard defined and test distance respectively in meters.

8.2.2 Test procedure

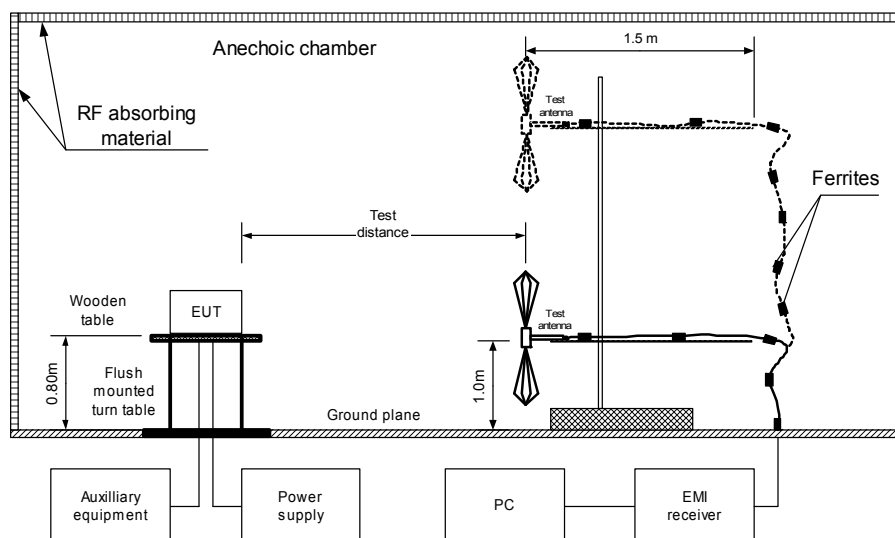
8.2.2.1 The EUT was set up as shown in Figure 8.2.1, energized and the performance check was conducted.

8.2.2.2 The specified frequency range was investigated with biconilog antenna connected to 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 and the EUT cables position was varied.

8.2.2.3 The worst test results (the lowest margins) were recorded in Table 8.2.2 and shown in the associated plots.

Test specification: Section 15.109, Radiated emission			
Test procedure: ANSI C63.4, Section 8			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 25 °C	Relative Humidity: 49 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Figure 8.2.1 Setup for radiated emission measurements in anechoic chamber, table-top equipment





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Test specification: Section 15.109, Radiated emission			
Test procedure: ANSI C63.4, Section 8			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 25 °C	Relative Humidity: 49 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

Table 8.2.2 Radiated emission test results

EUT SET UP: TABLE-TOP
LIMIT: Class B
EUT OPERATING MODE: Receive / Stand-by
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*				
40.011000	28.38	25.91	40.0	-14.09	Vertical	1.02	8	Pass
160.000500	30.03	28.45	43.5	-15.05	Vertical	1.02	8	
359.994000	35.71	34.12	46.0	-11.88	Horizontal	1.00	17	
480.014833	36.59	33.41	46.0	-12.59	Horizontal	1.75	179	
800.001000	45.67	42.40	46.0	-3.60	Horizontal	1.00	158	

TEST SITE: SEMI ANECHOIC CHAMBER
TEST DISTANCE: 3 m
DETECTORS USED: PEAK / AVERAGE
FREQUENCY RANGE: 1 GHz – 10 GHz
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*				
Not emission were found										Pass

*- Margin = Measured emission - specification limit.

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

Reference numbers of test equipment used

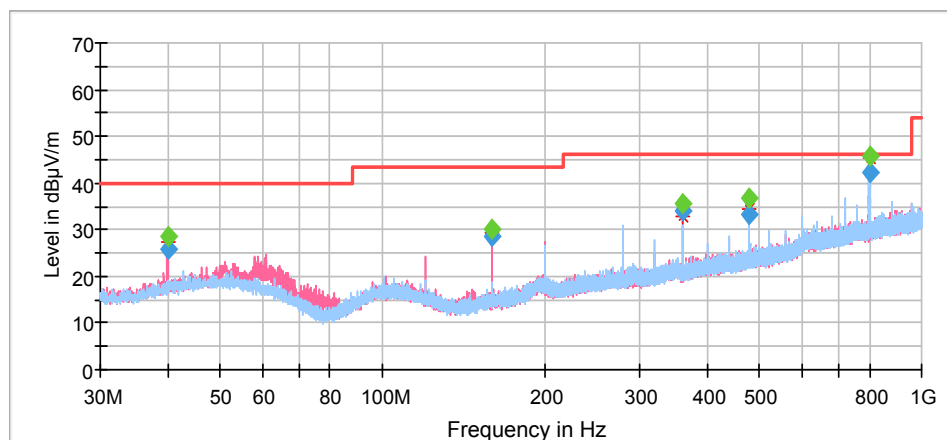
HL 3903	HL 4360	HL 4933	HL 5085	HL 5288	HL 5405		
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Full description is given in Appendix A.

Test specification: Section 15.109, Radiated emission			
Test procedure: ANSI C63.4, Section 8			
Test mode: Compliance		Verdict: PASS	
Date(s): 01-Apr-19			
Temperature: 25 °C	Relative Humidity: 49 %	Air Pressure: 1014 hPa	Power: 12 VDC
Remarks:			

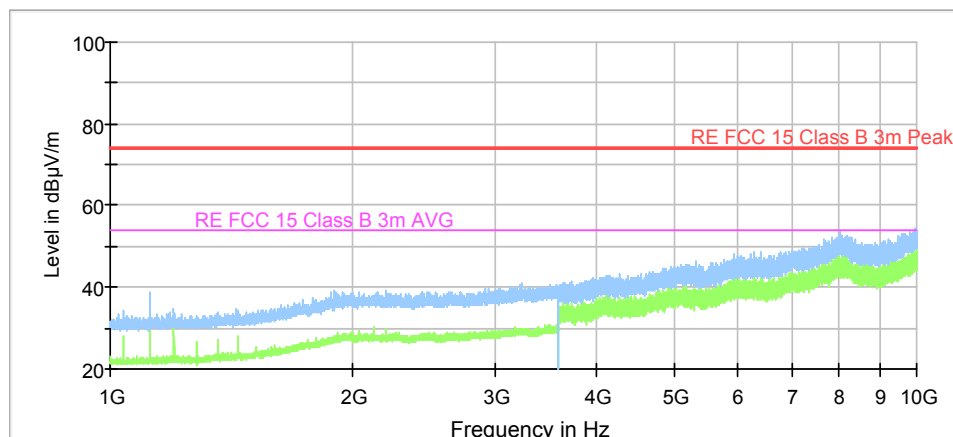
Plot 8.2.1 Radiated emission measurements in 30 - 1000 MHz range, vertical and horizontal antenna polarization

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



Plot 8.2.2 Radiated emission measurements above 1000 MHz, vertical and horizontal antenna polarization

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



9 APPENDIX A Test equipment and ancillaries used for tests

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
0787	Transient Limiter 9 kHz-200 MHz	Hewlett Packard	11947A	3107A01877	08-Oct-18	08-Oct-19
2888	LISN Two-line V-Network 50 Ohm / 50 uH + 5 Ohm, 16A, MIL STD 461E, CISPR 16-1	Rolf Heine	NNB-2/16Z	02/10018	19-Mar-19	19-Mar-20
2909	Spectrum analyzer, ESA-E, 100 Hz to 26.5 GHz	Agilent Technologies	E4407B	MY41444762	04-Apr-19	04-Apr-20
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1226/2A	07-Apr-19	07-Apr-20
4135	Shield Box	TESCOM CO., LTD	TC-5916A	5916A000136	24-Apr-19	24-Apr-20
4275	Test Cable , DC-18 GHz, 1.8 m, SMA/M - N/M	Mini-Circuits	CBL-6FT-SMNM+	70050	21-Apr-19	21-Apr-20
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	31-Dec-18	31-Dec-19
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	06-Jan-19	06-Jan-20
5085	Attenuator, 4 dB, DC - 6 GHz, 1 W	Mini-Circuits	UNAT-4+	NA	08-Feb-19	08-Feb-20
5278	Cable RF, 4.2 m, BNC/BNC	Hermon Laboratories	M17/167 MIL-C-17	NA	02-Sep-18	02-Sep-19
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	08-Feb-19	08-Feb-22
5372	MXE EMI receiver, 3 Hz to 44 GHz	Keysight Technologies	N9038A	MY57290155	21-May-18	21-Jun-19
5397	H-field near field probe, 3 cm	ETS Lindgren	7405-902	NA	31-Jul-18	31-Jul-19
5404	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11 N(x2)	500024/18	01-Aug-18	01-Aug-19
5405	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11 N(x2)	500023/118	01-Aug-18	01-Aug-19

10 APPENDIX B Test equipment correction factors

HL 3903

Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA
Huber-Suhner SUCOFLEX 102A, s/n 1226/2A HL 3903

Set / Applied, MHz	Measured, dB	Uncertainty, dB	Set / Applied, MHz	Measured, dB	Uncertainty, dB
50	0.14	±0.06	4400	1.31	±0.13
100	0.19	±0.06	4500	1.33	±0.13
150	0.24	±0.07	4600	1.34	±0.13
200	0.28	±0.07	4700	1.36	±0.13
300	0.34	±0.07	4800	1.37	±0.13
400	0.39	±0.07	4900	1.39	±0.13
500	0.44	±0.07	5000	1.40	±0.13
600	0.49	±0.07	5100	1.41	±0.13
700	0.52	±0.07	5200	1.43	±0.13
800	0.56	±0.07	5300	1.45	±0.13
900	0.59	±0.07	5400	1.46	±0.13
1000	0.62	±0.07	5500	1.47	±0.13
1100	0.65	±0.07	5600	1.48	±0.13
1200	0.68	±0.07	5700	1.50	±0.13
1300	0.71	±0.07	5800	1.51	±0.13
1400	0.74	±0.07	5900	1.52	±0.13
1500	0.76	±0.07	6000	1.54	±0.13
1600	0.78	±0.07	6100	1.55	±0.13
1700	0.81	±0.07	6200	1.56	±0.13
1800	0.83	±0.07	6300	1.58	±0.13
1900	0.86	±0.07	6400	1.59	±0.13
2000	0.88	±0.07	6500	1.60	±0.13
2100	0.90	±0.07	6600	1.61	±0.13
2200	0.92	±0.07	6700	1.63	±0.13
2300	0.94	±0.07	6800	1.64	±0.13
2400	0.96	±0.07	6900	1.65	±0.13
2500	0.98	±0.09	7000	1.66	±0.13
2600	1.00	±0.09	7100	1.68	±0.13
2700	1.02	±0.09	7200	1.69	±0.13
2800	1.04	±0.09	7300	1.70	±0.13
2900	1.06	±0.09	7400	1.71	±0.13
3000	1.08	±0.09	7500	1.73	±0.13
3100	1.10	±0.09	7600	1.74	±0.13
3200	1.11	±0.09	7700	1.76	±0.13
3300	1.14	±0.09	7800	1.76	±0.13
3400	1.15	±0.09	7900	1.78	±0.13
3500	1.17	±0.09	8000	1.78	±0.13
3600	1.19	±0.09	8100	1.80	±0.13
3700	1.20	±0.09	8200	1.81	±0.13
3800	1.21	±0.09	8300	1.82	±0.13
3900	1.23	±0.09	8400	1.82	±0.13
4000	1.25	±0.09	8500	1.85	±0.13
4100	1.27	±0.13	8600	1.86	±0.13
4200	1.28	±0.13	8700	1.87	±0.13
4300	1.30	±0.13			

Set / Applied, MHz	Measured, dB	Uncertainty, dB
8800	1.87	±0.13
8900	1.89	±0.13
9000	1.90	±0.13
9100	1.91	±0.13
9200	1.92	±0.13
9300	1.93	±0.13
9400	1.95	±0.13
9500	1.95	±0.13
9600	1.97	±0.13
9700	1.98	±0.13
9800	1.99	±0.13
9900	2.00	±0.13
10000	2.01	±0.13
10100	2.02	±0.13
10200	2.02	±0.13
10300	2.04	±0.13
10400	2.05	±0.13
10500	2.06	±0.13
10600	2.07	±0.13
10700	2.08	±0.13
10800	2.09	±0.13
10900	2.10	±0.13
11000	2.11	±0.13
11100	2.12	±0.13
11200	2.13	±0.13
11300	2.14	±0.13
11400	2.15	±0.13
11500	2.15	±0.13
11600	2.17	±0.13
11700	2.17	±0.13
11800	2.19	±0.13
11900	2.19	±0.13
12000	2.20	±0.13
12100	2.21	±0.16
12200	2.22	±0.16
12300	2.23	±0.16
12400	2.25	±0.16
12500	2.26	±0.22
12600	2.26	±0.22
12700	2.27	±0.22
12800	2.29	±0.22
12900	2.30	±0.22
13000	2.30	±0.22
13100	2.31	±0.22
13200	2.32	±0.22
13400	2.34	±0.22

Set / Applied, MHz	Measured, dB	Uncertainty, dB
13500	2.35	±0.22
13600	2.36	±0.22
13700	2.36	±0.22
13800	2.38	±0.22
13900	2.38	±0.22
14000	2.40	±0.22
14100	2.40	±0.22
14200	2.41	±0.22
14300	2.42	±0.22
14400	2.43	±0.22
14500	2.44	±0.22
14600	2.45	±0.22
14700	2.46	±0.22
14800	2.47	±0.22
14900	2.48	±0.22
15000	2.49	±0.22
15100	2.49	±0.22
15200	2.51	±0.22
15300	2.51	±0.22
15400	2.52	±0.22
15500	2.53	±0.22
15600	2.54	±0.22
15700	2.54	±0.22
15800	2.55	±0.22
15900	2.56	±0.22
16000	2.57	±0.22
16100	2.58	±0.22
16200	2.59	±0.22
16300	2.60	±0.22
16400	2.61	±0.22
16500	2.62	±0.22
16600	2.63	±0.22
16700	2.63	±0.22
16800	2.63	±0.22
16900	2.65	±0.22
17000	2.66	±0.22
17100	2.66	±0.22
17200	2.67	±0.22
17300	2.68	±0.22
17400	2.69	±0.22
17500	2.70	±0.22
17600	2.71	±0.22
17700	2.71	±0.22
17800	2.72	±0.22
17900	2.74	±0.22

HL 5288:

Trilog Antenna Frankonia, model: ALX-8000E, s/n: 00809

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.

HL 4933

Active Horn Antenna, 1 GHz to 18 GHz
COM-POWER CORPORATION AHA-118 , s/n 701046 HL 4933

Frequency, MHz	Measured antenna factor, dB/m	Frequency, MHz	Measured antenna factor, dB/m
1000	-16.1	3200	-11.2
1050	-16.0	3250	-10.8
1100	-15.1	3300	-10.8
1150	-16.4	3350	-10.7
1200	-16.0	3400	-10.3
1250	-15.6	3450	-10.2
1300	-15.1	3500	-10.1
1350	-14.8	3550	-10.4
1400	-15.1	3600	-10.5
1450	-15.1	3650	-10.4
1500	-15.5	3700	-10.4
1550	-15.2	3750	-10.3
1600	-14.7	3800	-10.1
1650	-14.4	3850	-10.0
1700	-14.4	3900	-9.9
1750	-14.0	3950	-9.8
1800	-13.6	4000	-9.7
1850	-12.7	4050	-9.3
1900	-11.9	4100	-8.6
1950	-11.9	4150	-8.2
2000	-11.8	4200	-8.3
2050	-11.3	4250	-8.5
2100	-11.3	4300	-8.5
2150	-11.7	4350	-8.3
2200	-12.3	4400	-8.0
2250	-12.3	4450	-7.7
2300	-12.4	4500	-7.6
2350	-12.2	4550	-7.4
2400	-11.7	4600	-7.5
2450	-11.5	4650	-7.8
2500	-11.5	4700	-7.6
2550	-11.5	4750	-6.8
2600	-11.5	4800	-6.1
2650	-11.3	4850	-5.7
2700	-11.3	4900	-5.8
2750	-11.1	4950	-5.8
2800	-11.1	5000	-6.0
2850	-11.3	5050	-5.7
2900	-11.1	5100	-5.4
2950	-11.0	5150	-5.1
3000	-11.1	5200	-4.6
3050	-10.9	5250	-4.6
3100	-10.7	5300	-4.8
3150	-10.6	5350	-5.1

Frequency, MHz	Measured antenna factor, dB/m	Frequency, MHz	Measured antenna factor, dB/m
5400	-5.1	8300	0.8
5450	-4.6	8350	0.5
5500	-4.0	8400	0.3
5550	-3.5	8450	0.5
5600	-3.1	8500	0.8
5650	-3.3	8550	0.9
5700	-3.8	8600	0.9
5750	-4.3	8650	0.6
5800	-4.3	8700	0.0
5850	-4.0	8750	-0.3
5900	-3.5	8800	0.0
5950	-3.2	8850	0.5
6000	-3.2	8900	0.6
6050	-3.2	8950	0.4
6100	-3.3	9000	-0.3
6150	-3.3	9050	-1.0
6200	-3.1	9100	-1.2
6250	-2.9	9150	-0.6
6300	-2.8	9200	-0.1
6350	-3.0	9250	0.0
6400	-3.2	9300	-0.1
6450	-3.4	9350	-0.5
6500	-3.7	9400	-0.7
6550	-3.6	9450	-0.4
6600	-3.4	9500	0.2
6650	-2.9	9550	0.5
6700	-2.6	9600	0.5
6750	-2.5	9650	0.3
6800	-2.6	9700	0.0
6850	-2.8	9750	0.0
6900	-2.7	9800	0.6
6950	-2.3	9850	1.4
7000	-2.0	9900	1.8
7050	-1.9	9950	1.7
7100	-1.8	10000	1.4
7150	-1.8	10100	0.8
7200	-1.7	10200	1.2
7250	-1.7	10300	1.5
7300	-1.6	10400	1.1
7350	-1.5	10500	1.6
7400	-1.5	10600	3.0
7450	-1.3	10700	2.9
7500	-1.4	10800	1.3
7550	-1.3	10900	1.0
7600	-1.0	11000	1.1
7650	-0.7	11100	0.7
7700	-0.3	11200	1.1
7750	0.1	11300	1.5
7800	0.3	11400	1.4
7850	0.4	11500	0.6
7900	0.2	11600	1.0
7950	0.1	11700	1.4
8000	0.2	11800	0.7
8050	0.3	11900	0.9
8100	0.8	12000	2.1
8150	1.1	12100	2.1
8200	1.1	12200	0.9
8250	1.0	12300	1.6
12400	2.1		
12500	1.2		
12600	1.3		
12700	2.4		
12800	1.8		



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12900	0.6
13000	0.9
13100	1.1
13200	0.7
13300	0.9
13400	1.8
13500	2.1
13600	1.2
13700	0.8
13800	1.2
13900	1.5
14000	1.7
14100	2.2
14200	2.8
14300	3.0
14400	3.0
14500	3.3
14600	4.0
14700	5.4
14800	5.4
14900	4.7
15000	3.1
15100	2.0
15200	1.5
15300	1.4
15400	1.7
15500	1.9
15600	1.2
15700	0.2
15800	0.6
15900	1.2
16000	0.6
16100	0.6
16200	1.9
16300	2.2
16400	0.9
16500	0.7
16600	1.7
16700	1.3
16800	1.0
16900	2.0
17000	2.4
17100	1.8
17200	1.8
17300	2.5
17400	2.7
17500	3.1
17600	3.7
17700	4.3
17800	4.8
17900	5.7
18000	5.1

11 APPENDIX C 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.

12 APPENDIX D Test facility 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 are R-10808 for OATS, R-11082 for anechoic chamber, 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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13 APPENDIX E Specification references

FCC 47CFR part 15: 2019	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 9KHz to 40 GHz
KDB 558074:2019	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

14 APPENDIX F Abbreviations and acronyms

A	ampere
AC	alternating current
AM	amplitude modulation
AVRG	average (detector)
cm	centimeter
dB	decibel
dBm	decibel referred to one milliwatt
dB(μ V)	decibel referred to one microvolt
dB(μ V/m)	decibel referred to one microvolt per meter
dB(μ A)	decibel referred to one microampere
DC	direct current
EIRP	equivalent isotropically radiated power
ERP	effective radiated power
EUT	equipment under test
F	frequency
GHz	gigahertz
GND	ground
H	height
HL	Hermon laboratories
Hz	hertz
k	kilo
kHz	kilohertz
LO	local oscillator
m	meter
MHz	megahertz
min	minute
mm	millimeter
ms	millisecond
μ s	microsecond
NA	not applicable
NB	narrow band
OATS	open area test site
Ω	Ohm
PM	pulse modulation
PS	power supply
ppm	part per million (10^{-6})
QP	quasi-peak
RE	radiated emission
RF	radio frequency
rms	root mean square
Rx	receive
s	second
T	temperature
Tx	transmit
V	volt

END OF DOCUMENT