HERMON LABORATORIES

ELECTRICAL TESTING
0839.01

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TEST REPORT

ACCORDING TO: FCC 47CFR part 15 subpart C § 15.247 (DTS)

FOR:

Valerann Ltd.
Road stud module of the Smart Road System
Model:AS2200
FCC ID:2AR64AS2200

Table of contents

1 Applicant information

Client name:	Valerann Ltd.
Address:	26 Elifelet street, Tel Aviv 6608026, Israel
Telephone:	+972 54-7414542
E-mail:	Daniel.Yakovich@valerann.com
Contact name:	Daniel Yakovich

2 Equipment under test attributes

Product name:	Road stud module of the Smart Road System
Product type:	Automotive
Model(s):	AS2200
Serial number:	ES3
Hardware version:	3.1
Software release:	2
Receipt date	25-Sep-18

3 Manufacturer information

Manufacturer name:	26 Elifelet street, Tel Aviv 6608026, Israel
Address:	+972 54-7414542
Telephone:	Daniel.Yakovich@valerann.com
E-Mail:	Daniel Yakovich
Contact name:	26 Elifelet street, Tel Aviv 6608026, Israel

4 Test details

Project ID:	31514
Location:	Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started:	08-Oct-18
Test completed:	28-Nov-18
Test specification(s):	FCC 47CFR part 15 subpart C § 15.247 (DTS)

5 Tests summary

Test	Status
Transmitter characteristics	
Section 15.247(a)2, 6 dB bandwidth	Pass
Section 15.247(b)3, Peak output power	Pass
Section 15.247(b)5, RF exposure	Pass *
Section 15.247(d), Radiated spurious emissions	Pass
Section 15.247(d), Band edge emissions	Pass
Section 15.247(d), Peak power density	Pass
Section 15.207(a), Conducted emission	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:	Mrs. E. Pitt, test engineer	08-Oct-18 – 25-Dec-18	
	Mr. S. Samokha, test engineer		
Reviewed by:	Mrs. Y. Rapin, technical writer	30-Dec-18	
Approved by:	Mr. K. Zushchyk, project and customer manager, EMC and radio group	22-Jan-19	

6 EUT description

6.1 General information

The EUT is a battery powered road stud module of the Smart Road System.

Valerann's smart road system enable effective traffic management and mitigation of congestion, road risks and accidents. The product has two devices: the sensor unit, refer as the road stud [P/N AS2200], and the gateway [P/N AS3100] which collects the data from the road studs and send it to Valerann's cloud-based server. The road stud is a wireless IoT road pavement marker that collects data from the road network. It contains several sensors that enable the capture of road traffic and environmental data.

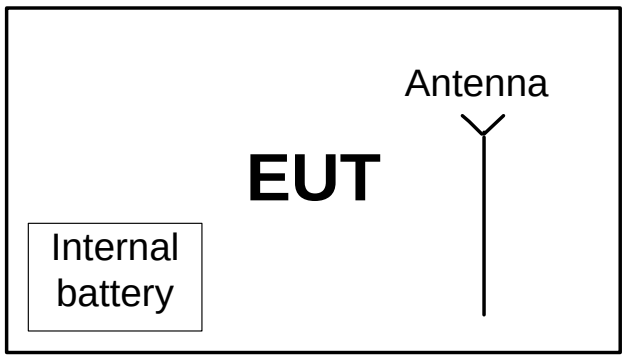
6.2 Changes made in EUT

No changes were implemented in the EUT during the testing.

6.3 Operating frequencies

Source	Frequency						
Clock	8 MHz	1 MHz	400 kHz	-	-	-	-
Tx	915 MHz	-	-	-	-	-	-
Rx	915 MHz	-	-	-	-	-	-

6.4 Test configuration



6.5 Transmitter characteristics

Type of equipment	
	Stand-alone (Equipment with or without its own control provisions)
X	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 range	902.0 – 928.0 MHz			
Operating frequency range	915 MHz			
Maximum rated output power	At transmitter 50 Ω RF output connector			NA
	Peak output power			21.11 dBm
Is transmitter output power variable?	X	No		
		Yes		continuous variable
				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
			X without temporary RF connector

Antenna/s technical characteristics			
Type	Manufacturer	Model number	Gain
Monopole	Valerann	EP2331	-5 dBi

Transmitter aggregate data rate/s	
Type of modulation	FSK
Modulating test signal (baseband)	

Transmitter power source					
X	Battery	**Nominal rated voltage**	3.65 VDC	Battery type	Lithium
	DC	**Nominal rated voltage**	VDC		
	AC mains	**Nominal rated voltage**	VAC	Frequency	Hz

Common power source for transmitter and receiver	X	yes		no

Test specification:	Section 15.247(a)2, 6 dB bandwidth		
Test procedure:	ANSI C63.10 section 11.8.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	08-Oct-18		
Temperature: 24.3 ºC	Relative Humidity: 46 %	Air Pressure: 1009 hPa	Power Supply: Battery
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 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.

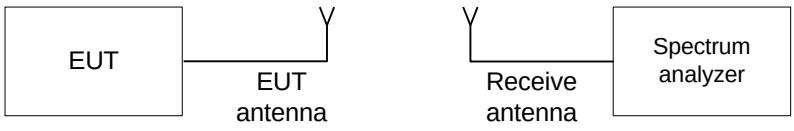
7.1.2 Test procedure

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 6 dB bandwidth test setup



Test specification:	Section 15.247(a)2, 6 dB bandwidth		
Test procedure:	ANSI C63.10 section 11.8.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	08-Oct-18		
Temperature: 24.3 ºC	Relative Humidity: 46 %	Air Pressure: 1009 hPa	Power Supply: Battery
Remarks:			

Table 7.1.2 6 dB bandwidth test results

ASSIGNED FREQUENCY BAND: 902 – 928 MHz
DETECTOR USED: Peak
SWEEP MODE: Max Hold
SWEEP TIME: Auto
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: 100 kHz
MODULATION ENVELOPE REFERENCE POINTS: 6.0 dBc
MODULATION: FSK
MODULATING SIGNAL: PRBS
BIT RATE: 20 kbps

Carrier frequency, MHz	6 dB bandwidth, kHz	Limit, kHz	Margin, kHz*	Verdict
Mid frequency				
914.985	765.0	500.0	-265.0	Pass

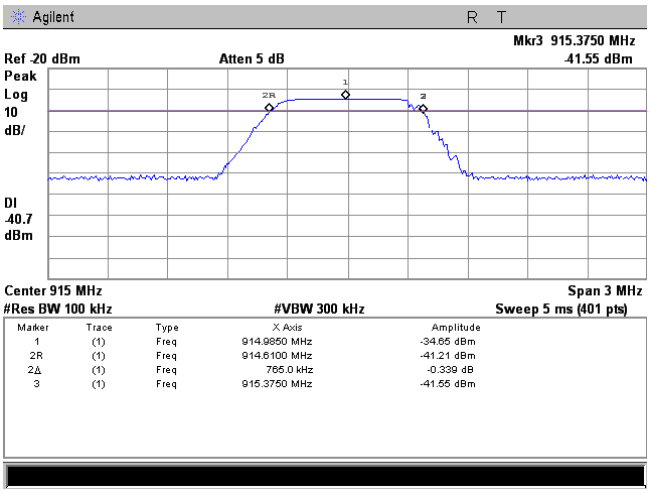
* - Margin = Specification limit – 6 dB bandwidth

Reference numbers of test equipment used

HL 0337	HL 3903	HL 5376						

Full description is given in Appendix A.

Plot 7.1.1 6 dB bandwidth test result at carrier frequency



Test specification:	**Section 15.247(b), Maximum output power**		
Test procedure:	ANSI C63.10 section 11.9.1.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1010 hPa	**Power Supply:** Battery
Remarks:			

7.2 Maximum 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×P×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 360^0 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:

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

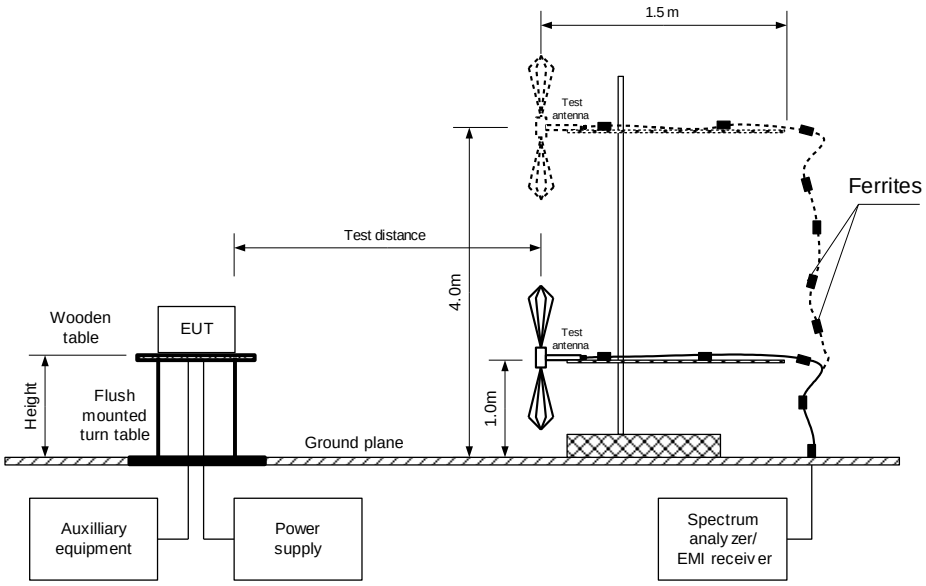
where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.
The above equation was converted in logarithmic units for 3 m test distance:

Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi – 95.2 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), Maximum output power**		
Test procedure:	ANSI C63.10 section 11.9.1.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1010 hPa	**Power Supply:** Battery
Remarks:			

Figure 7.2.1 Setup for carrier field strength measurements



Test specification:	**Section 15.247(b), Maximum output power**		
Test procedure:	ANSI C63.10 section 11.9.1.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1010 hPa	**Power Supply:** Battery
Remarks:			

Table 7.2.2 Peak output power test results

ASSIGNED FREQUENCY:	915 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)
MODULATION:	FSK
MODULATING SIGNAL:	PRBS
BIT RATE:	62 kbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Peak
EUT 6 dB BANDWIDTH:	527 kHz
RESOLUTION BANDWIDTH:	3 MHz
VIDEO BANDWIDTH:	50 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
914.97	111.34	Horizontal	1.52	-115	-5	21.11	30	-8.89	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 – 95.23 dB*
***- Margin = Peak output power – specification limit.

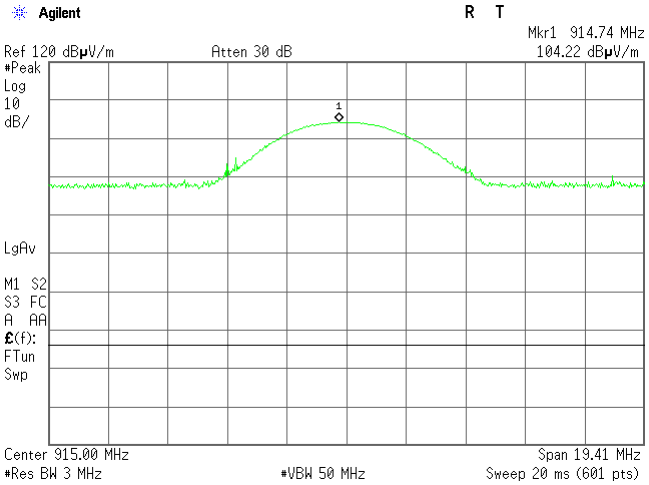
Reference numbers of test equipment used

HL 3901	HL 3818	HL 5288	HL 5112				

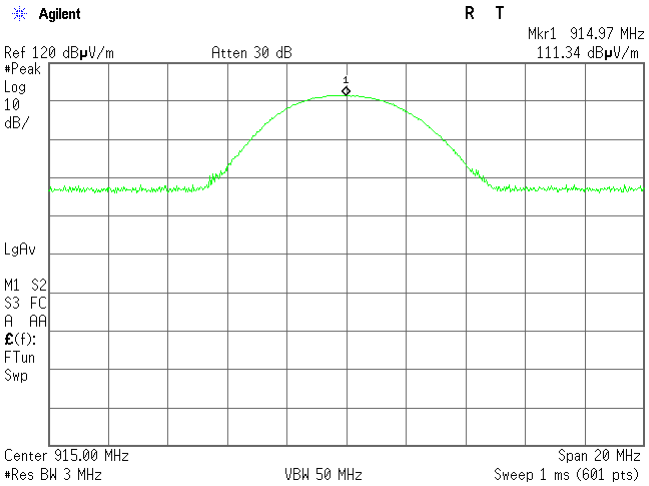
Full description is given in Appendix A.

Test specification:	Section 15.247(b), Maximum output power		
Test procedure:	ANSI C63.10 section 11.9.1.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Oct-18		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1010 hPa	Power Supply: Battery
Remarks:			

Plot 7.2.1 Field strength of carrier at 915 MHz frequency, vertical antenna polarization



Plot 7.2.2 Field strength of carrier at 915 MHz frequency, horizontal antenna polarization



Test specification:	**Section 15.247(d), Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1010 hPa	**Power Supply:** Battery
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 – 10thharmonic	74.0	NA	54.0	

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

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

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 360^0 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 1.1.3, 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 360^0, 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:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1010 hPa	Power Supply: Battery
Remarks:			

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

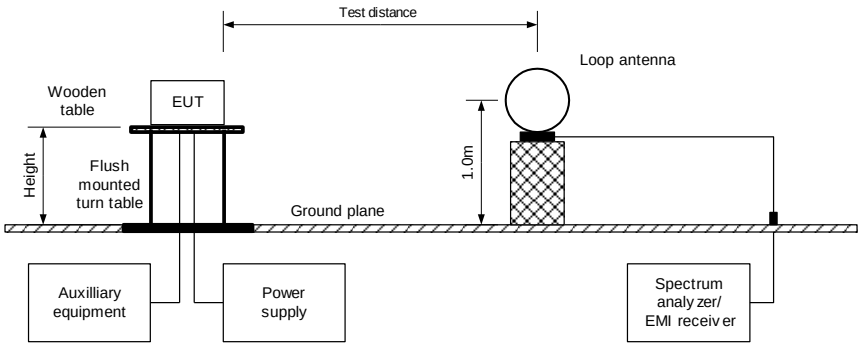


Figure 7.3.2 Setup for spurious emission field strength measurements in 30 – 1000 MHz

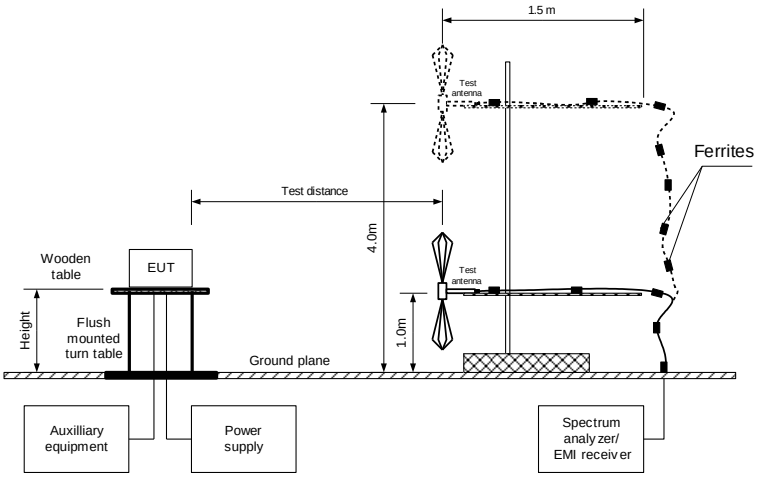
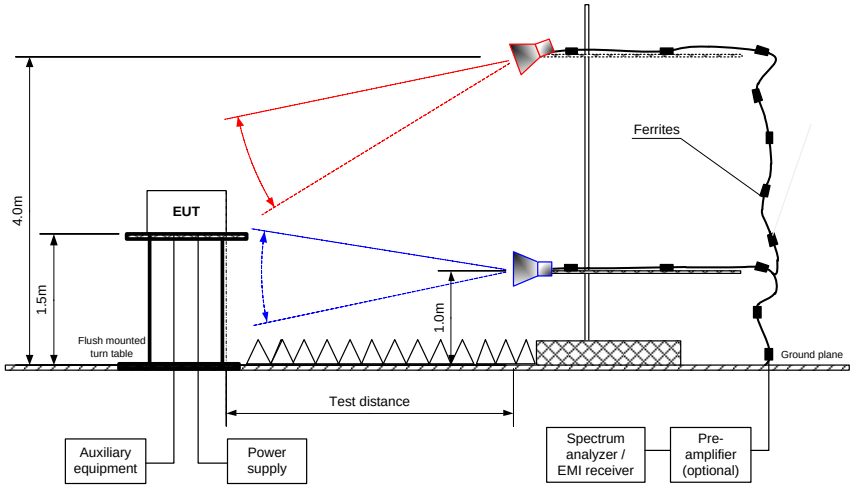


Figure 7.3.3 Setup for spurious emission field strength measurements above 1000 MHz



Test specification:	**Section 15.247(d), Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1010 hPa	**Power Supply:** Battery
Remarks:			

Table 7.3.2 Field strength of emissions outside restricted bands

ASSIGNED FREQUENCY: 915 MHz
INVESTIGATED FREQUENCY RANGE: 0.009 – 9500 MHz
TEST DISTANCE: 3 m
MODULATION: FSK
MODULATING SIGNAL: PRBS
BIT RATE: 62 kbps
DUTY CYCLE: 0.39 %
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)

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
Mid carrier frequency 915 MHz									
1829.9127	57.19	V	2.35	-63.0	111.34	54.15	20.0	34.15	Pass
5489.7338	54.60	V	1.63	133.0		56.74		36.74	
6404.2452	53.21	H	1.54	119.0		58.13		38.13	

*****- 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:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1010 hPa	**Power Supply:** Battery
Remarks:			

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

ASSIGNED FREQUENCY:	915 MHz
INVESTIGATED FREQUENCY RANGE:	1000 - 9500 MHz
TEST DISTANCE:	3 m
MODULATION:	FSK
MODULATING SIGNAL:	PRBS
BIT RATE:	62 kbps
DUTY CYCLE:	0.39 %
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	1000 kHz
TEST ANTENNA TYPE:	Double ridged guide

Frequency, MHz	Antenna		Azimuth, degrees*	Peak field strength(VBW=3 MHz)			Average field strength(VBW=10 Hz)				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***	
Mid carrier frequency 915 MHz											
2745.1998	V	1.81	-31.0	48.68	74.00	-25.32	48.68	40.43	54.0	-13.57	Pass
3659.2111	H	1.28	-64.0	54.60	74.00	-19.40	54.60	46.35	54.0	-7.65	
4575.6176	H	2.62	34.0	62.04	74.00	-11.96	62.04	53.79	54.0	-0.21	
7295.1125	H	3.50	54.0	47.16	74.00	-26.84	47.16	38.91	54.0	-15.09	
8184.7840	V	2.62	80.0	48.68	74.00	-25.32	48.68	40.43	54.0	-13.57	

*****- 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		
38.67	9970	NA	NA	NA	-8.25

*- Average factor was calculated as follows

for pulse train shorter than 100 ms: $$Average\ factor = 20 \times \log_{10}\left(\frac{Pulse\ duration}{Pulse\ period} \times \frac{Burst\ duration}{Train\ duration} \times Number\ of\ bursts\ within\ pulse\ train\right)$$

for pulse train longer than 100 ms: $$Average\ factor = 20 \times \log_{10}\left(\frac{Pulse\ duration}{Pulse\ period} \times \frac{Burst\ duration}{100\,ms} \times Number\ of\ bursts\ within\ 100\,ms\right)$$

Test specification:	**Section 15.247(d), Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1010 hPa	**Power Supply:** Battery
Remarks:			

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

ASSIGNED FREQUENCY:	915 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 1000 MHz
TEST DISTANCE:	3 m
MODULATION:	FSK
MODULATING SIGNAL:	PRBS
BIT RATE:	62 kbps
DUTY CYCLE:	0.26 %
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, 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***				
Mid carrier frequency 915 MHz								
No emissions were found								Pass

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

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

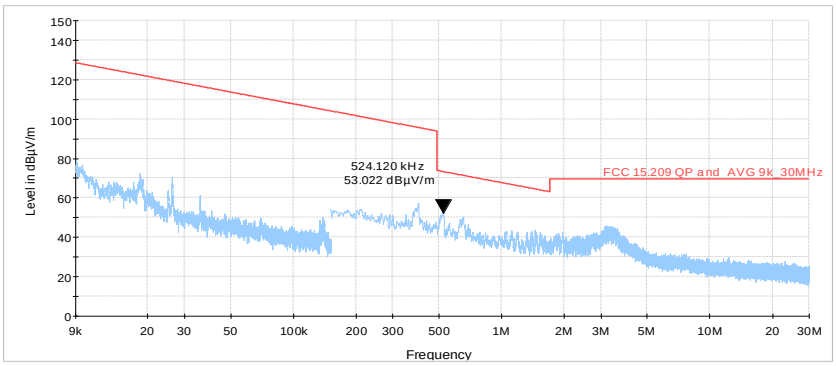
HL 0446	HL 3901	HL 4360	HL 4956	HL 5288	HL 5112		

Full description is given in Appendix A.

Test specification:	Section 15.247(d), Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1010 hPa	Power Supply: Battery
Remarks:			

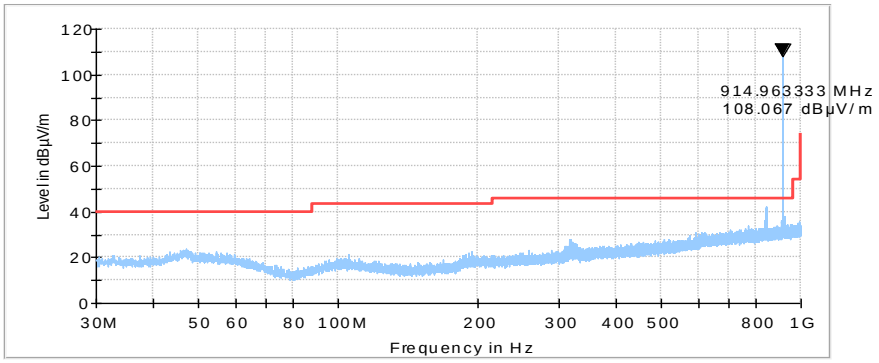
Plot 7.3.1 Radiated emission measurements from 9 kHz to 30 MHz at the 915 MHz carrier frequency

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



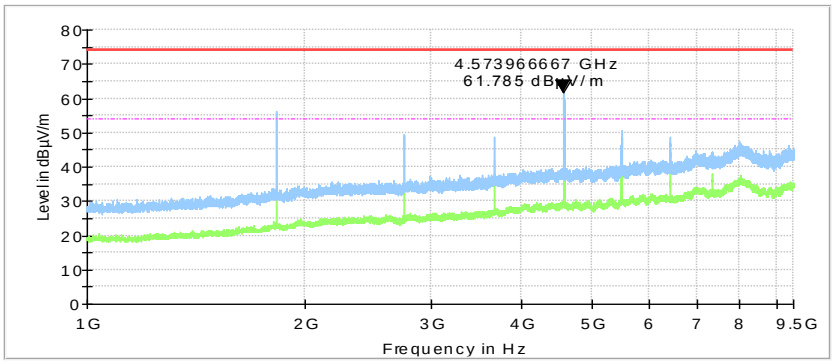
Plot 7.3.2 Radiated emission measurements from 30 to 1000 MHz at the 915 MHz carrier frequency

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



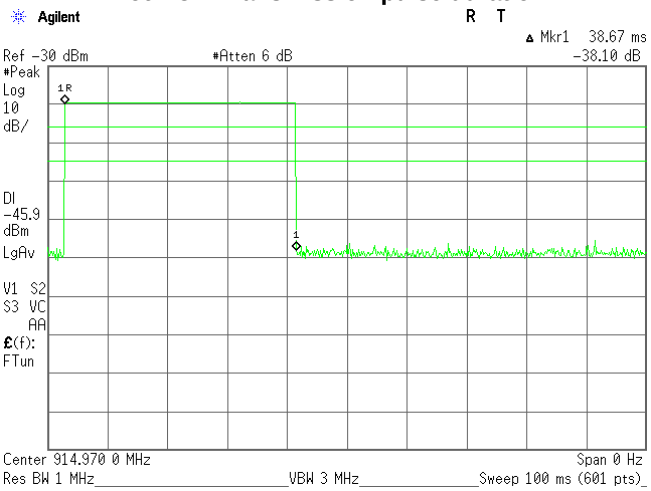
Plot 7.3.3 Radiated emission measurements from 1000 to 9500 MHz at the 915 MHz carrier frequency

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

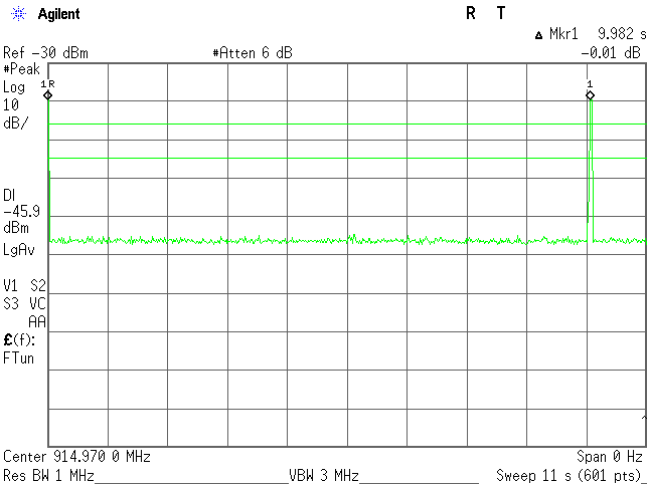


Test specification:	Section 15.247(d), Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1010 hPa	Power Supply: Battery
Remarks:			

Plot 7.3.4 Transmission pulse duration



Plot 7.3.5 Transmission pulse period



Test specification:	Section 15.247(d), Band edge emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	08-Oct-18 - 01-Nov-18		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1010 hPa	Power Supply: Battery
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			
Averaged over a time interval	902.0 – 928.0	30.0	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.

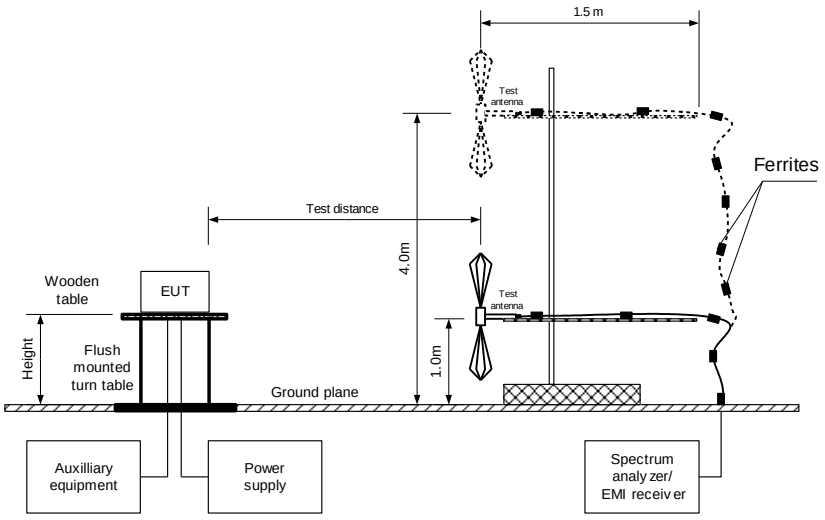
7.4.2.4 The spectrum analyzer was set in max hold mode and allowed trace to stabilize. The highest emission level within the authorized band was measured.

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.

7.4.2.7 The above procedure was repeated with the frequency hopping function enabled.

Figure 7.4.1 Band edge emission test setup



Test specification:	**Section 15.247(d), Band edge emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	08-Oct-18 - 01-Nov-18		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1010 hPa	**Power Supply:** Battery
Remarks:			

Table 7.4.2 Band edge emission test results

ASSIGNED FREQUENCY RANGE: 902-928 MHz
DETECTOR USED: Peak
MODULATION: FSK
MODULATING SIGNAL: PRBS
BIT RATE: 62 kbps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
RESOLUTION BANDWIDTH: 120 kHz
VIDEO BANDWIDTH: ≥ RBW

Frequency, MHz	Band edge emission, dBm	Emission at carrier, dBm	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
Peak power						
902.00	35.61	106.01	70.4	20.0	50.4	Pass
928.00	36.01		70		51	

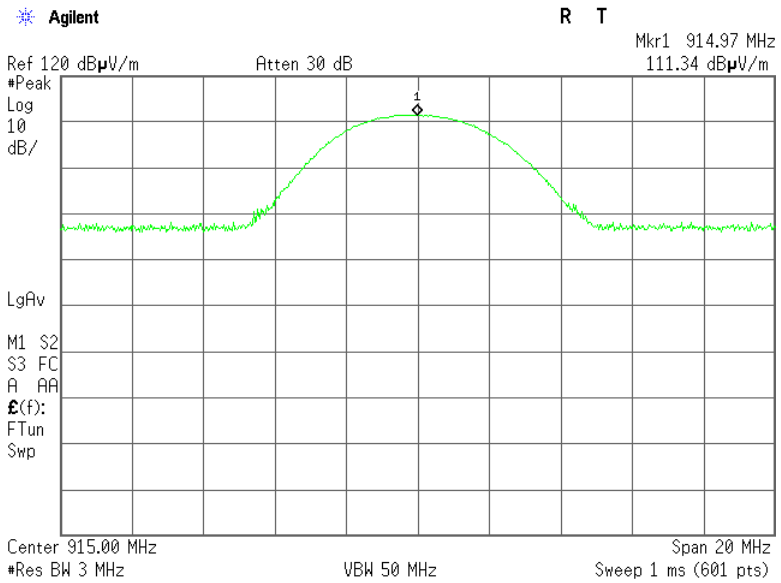
*- Margin = Attenuation below carrier – specification limit.

Reference numbers of test equipment used

HL 3818	HL 3901	HL 5112	HL 5288				

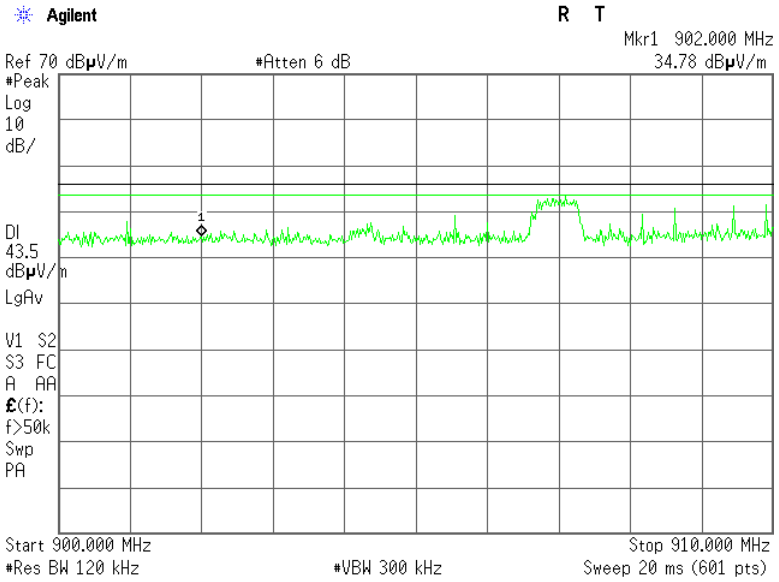
Full description is given in Appendix A.

Plot 7.4.1 The carrier frequency

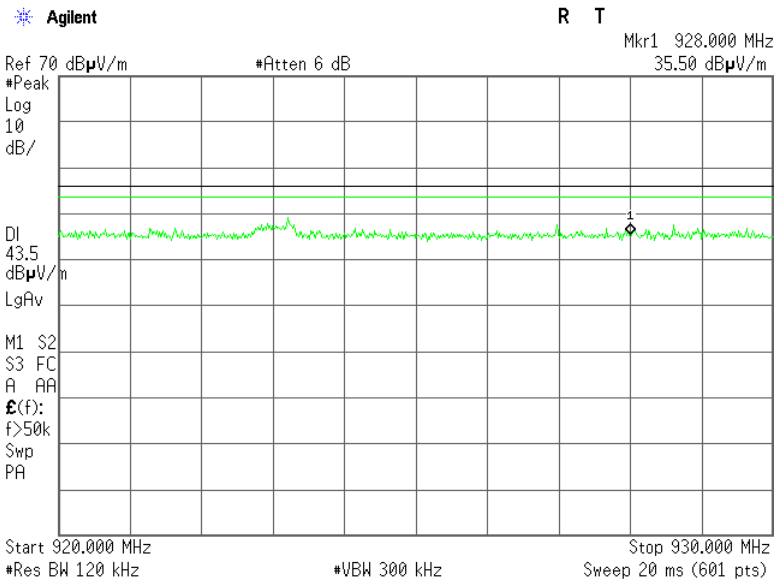


Test specification:	Section 15.247(d), Band edge emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	08-Oct-18 - 01-Nov-18		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1010 hPa	Power Supply: Battery
Remarks:			

Plot 7.4.2 The highest low band edge emission



Plot 7.4.3 The highest high band edge emission



Test specification:	**Section 15.247(e), Maximum power spectral density**		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Oct-18 - 01-Nov-18		
Temperature: 24 ºC	**Relative Humidity:** 42 %	**Air Pressure:** 1002 hPa	**Power Supply:** Battery
Remarks:			

7.5 Maximum power spectral density (PSD)

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×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.

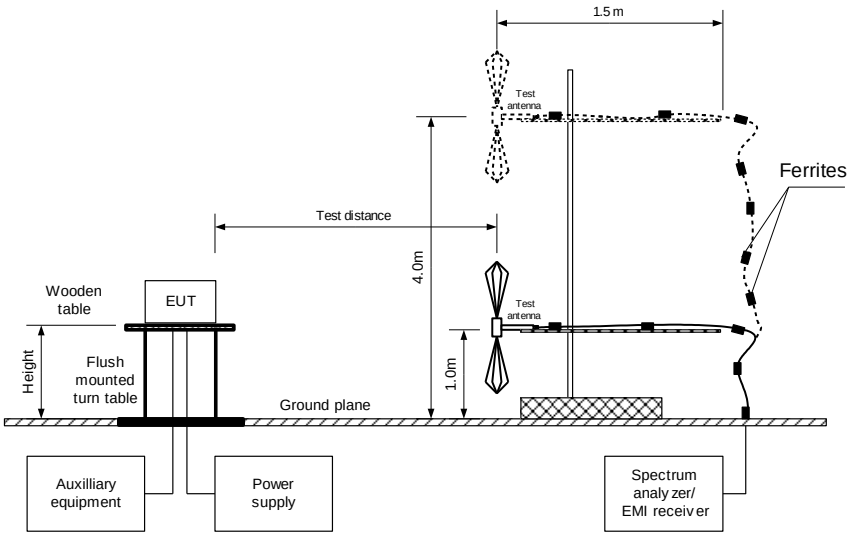
7.5.2.2 The EUT was adjusted to produce maximum available to end user RF output power.

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 360^0 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.

Figure 7.5.1 Setup for carrier field strength measurements



Test specification:	**Section 15.247(e), Maximum power spectral density**		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	10-Oct-18 - 01-Nov-18		
Temperature: 24 ºC	**Relative Humidity:** 42 %	**Air Pressure:** 1002 hPa	**Power Supply:** Battery
Remarks:			

Table 7.5.2 Field strength measurement of peak spectral power density

ASSIGNED FREQUENCY: 902-928 MHz
TEST DISTANCE: 3 m
TEST SITE: Semi anechoic chamber
EUT HEIGHT: 0.8 m
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 5.1 kHz
VIDEO BANDWIDTH: 15 kHz
TEST ANTENNA TYPE: Biconilog (30 MHz – 1000 MHz)
MODULATION: FSK
MODULATING SIGNAL: PRBS
BIT RATE: 62 kbps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum

Frequency, MHz	Field strength, dB(μV/m)	EUT antenna gain, dBi	Limit, dB(μV/m)	Margin, dB*	Antenna polarization	Antenna height, m	Turn-table position**, degrees
915	101.77	0	103.2	-1.43	Horizontal	1.03	340

*****- Margin = Field strength - EUT antenna gain - calculated field strength limit.
******- EUT front panel refer to 0 degrees position of turntable.

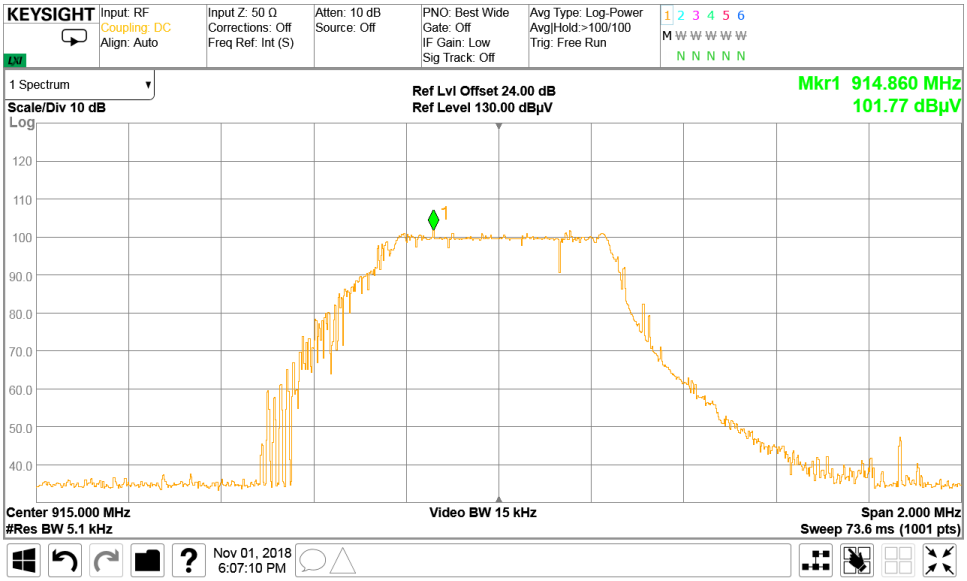
Reference numbers of test equipment used

HL 2909	HL 3615	HL 4276	HL 5288	HL 5376			

Full description is given in Appendix A.

Test specification:	Section 15.247(e), Maximum power spectral density		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Oct-18 - 01-Nov-18		
Temperature: 24 ºC	Relative Humidity: 42 %	Air Pressure: 1002 hPa	Power Supply: Battery
Remarks:			

Plot 7.5.1 Peak spectral power density at carrier frequency within 6 dB band



Test specification:	**FCC Part 15, Section 203, Antenna requirements**		
Test procedure:	Visual inspection		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	08-Oct-18		
Temperature: 26 ºC	**Relative Humidity:** 40 %	**Air Pressure:** 1005 hPa	**Power Supply:** Battery
Remarks:			

7.6 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 employ 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 7.6.1.

Table 7.6.1 Antenna requirements

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

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):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power Supply:** Battery
Remarks:			

8 Emission tests 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: $Lim_{S2} = Lim_{S1} + 20 \log (S_1/S_2)$,
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

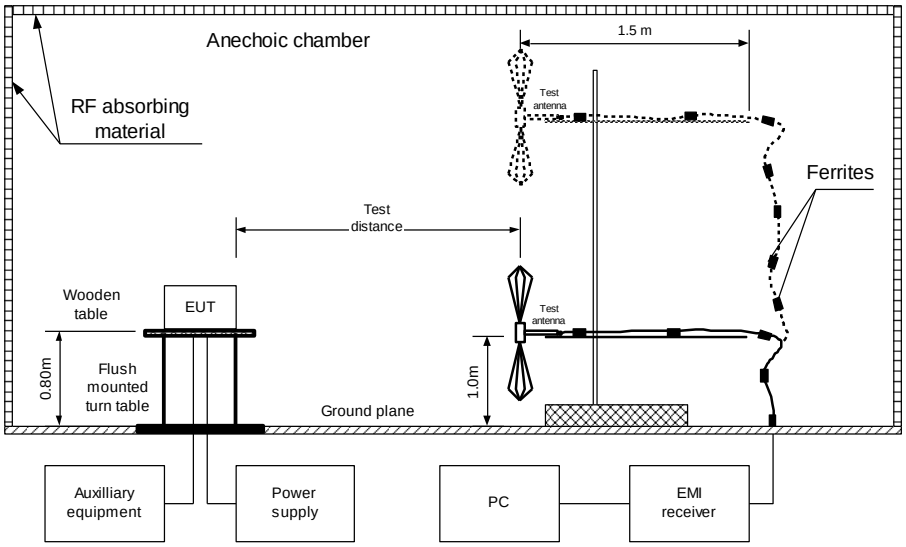
8.1.2.1 The EUT was set up as shown in Figure 8.1.1 and associated photographs, energized and the performance check was conducted.

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 360^0, 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.

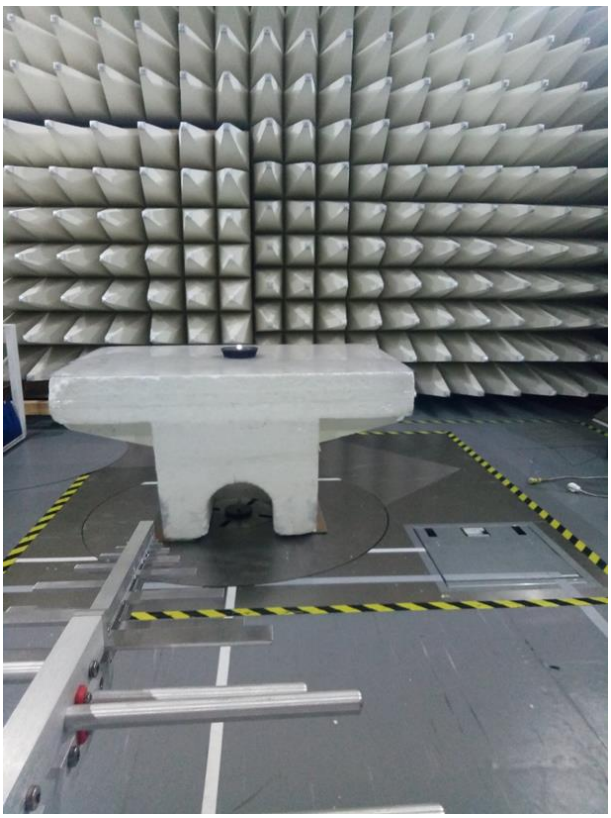
8.1.2.3 The worst test results (the lowest margins) were recorded in Table 8.1.2 and shown in the associated plots.

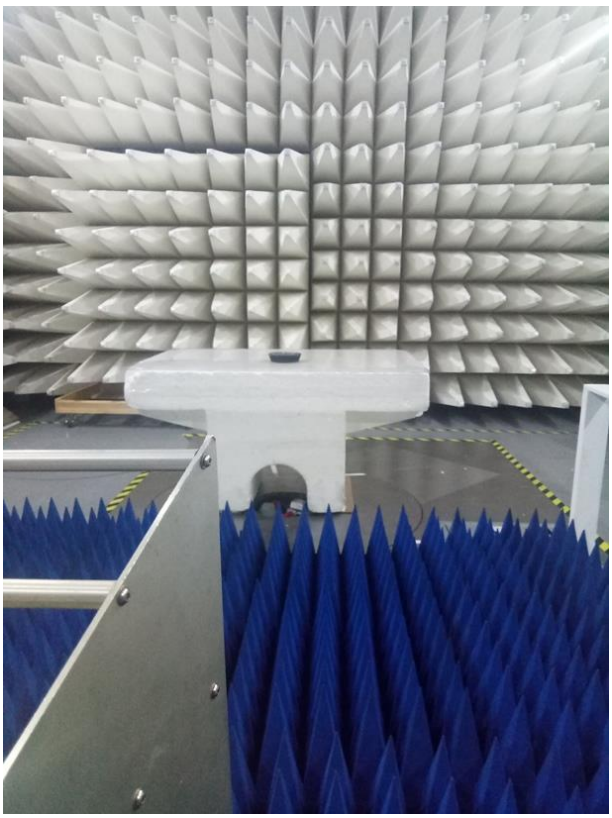
Test specification:	Section 15.109, Radiated emission		
Test procedure:	ANSI C63.4, Sections 11.6 and 12.1.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	Relative Humidity: 48 %	Air Pressure: 1010 hPa	Power Supply: Battery
Remarks:			

Figure 8.1.1 Setup for radiated emission measurements



Photograph 8.1.1 Setup for final radiated emission measurements





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):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power Supply:** Battery
Remarks:			

Table 8.1.2 Radiated emission test results

EUT SET UP: TABLE-TOP
LIMIT: Class B
EUT OPERATING MODE: Receive / Standby
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***				
No emissions were found								Pass

DETECTORS USED: PEAK / AVERAGE
FREQUENCY RANGE: 1000 MHz – 9200 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										Pass

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

Reference numbers of test equipment used

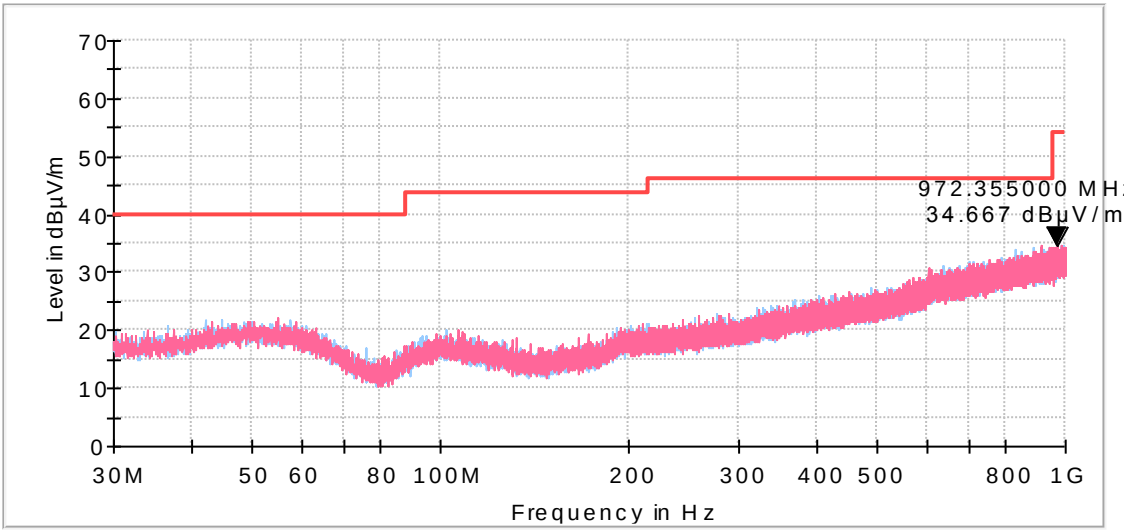
HL 3901	HL 4360	HL 4956	HL 5112	HL 5288			

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):	10-Oct-18 - 11-Oct-18		
Temperature: 23 ºC	Relative Humidity: 48 %	Air Pressure: 1010 hPa	Power Supply: Battery
Remarks:			

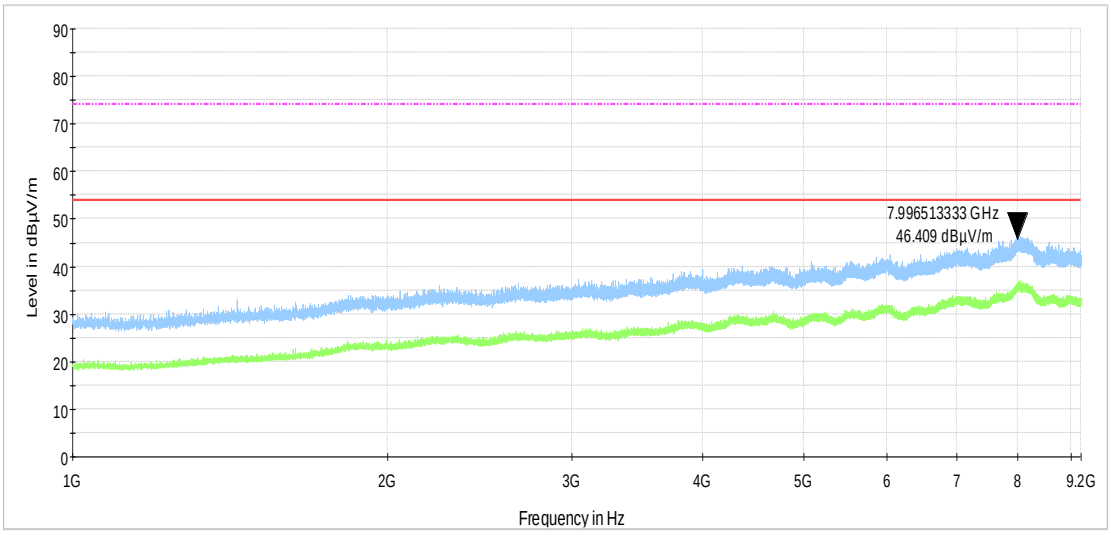
Plot 8.1.1 Radiated emission measurements in 30 - 1000 MHz range, vertical & horizontal antenna polarization

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



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 / Standby



9 APPENDIX A 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 1, 2, 15, 18 parts of Code of Federal Regulations 47 (CFR 47), Test Firm Registration Number is 927748, Designation Number is IL1001; registered by Industry Canada for electromagnetic emissions, file number IC 2186A-1 for OATS, certified by VCCI, Japan (the registration numbers are R-808 for OATS, R-1082 for anechoic chamber, G-869 for RE measurements above 1 GHz, C-845 for conducted emissions site and T-1606 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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10 APPENDIX B Test equipment and ancillaries used for tests

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
0337	Probe Set, Hand held, 5 probes	Electro-Metrics	EHFP-30	238	03-Jun-18	03-Jun-19
0446	Antenna, Loop, Active, 10 kHz - 30 MHz	EMCO	6502	2857	11-Feb-18	11-Feb-19
0495	Autotransformer 0-255V, 10A	Variac	EMPL01	495	03-Jun-18	03-Jun-19
0787	Transient Limiter 9 kHz-200 MHz	Hewlett Packard	11947A	3107A01877	08-Oct-18	08-Oct-19
2909	Spectrum analyzer, ESA-E, 100 Hz to 26.5 GHz	Agilent Technologies	E4407B	MY41444762	27-Mar-18	27-Mar-19
3016	LISN, Two-line V-network, 9 kHz to 30 MHz, (50 uH+5 Ohm), CISPR16-1, MIL-461E	Rohde & Schwarz	ESH 3-Z5	892239/002	11-Jan-18	11-Jan-19
3615	Cable RF, 6.5 m, N type-N type, DC-6 GHz	Suhner Switzerland	RG 214/U	NA	10-Jun-18	10-Jun-19
3818	PSA Series Spectrum Analyzer, 3 Hz- 44 GHz	Agilent Technologies	E4446A	MY48250288	28-May-18	28-May-19
3901	Microwave Cable Assembly, 40.0 GHz, 3.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1225/2A	07-Feb-18	07-Feb-19
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1226/2A	07-Feb-18	07-Feb-19
4276	Test Cable , DC-18 GHz, 3.05 m, N/M - N/M	Mini-Circuits	APC-10FT-NMNM+	0747A	01-Aug-18	01-Aug-19
4278	Test Cable , DC-18 GHz, 4.6 m, N/M - N/M	Mini-Circuits	APC-15FT-NMNM+	0755A	01-Aug-18	01-Aug-19
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	26-Dec-17	26-Dec-18
4778	EMI Receiver, 9 kHz - 2.9 GHz, System: HL1431, HL4777	Hewlett Packard	8542E	30807A00262 , 3427A00123	28-Oct-18	28-Oct-19
4956	Active horn antenna, 18 to 40 GHz	COM-POWER CORPORATION	AHA-840	105004	11-Jan-18	11-Jan-19
5112	RF cable, 40 GHz, 5.5 m, K-type	Huber-Suhner	SF102EA/11SK/11SK/5500MM	502494/2EA	02-Aug-18	02-Aug-19
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	809	21-Jan-18	21-Jan-19
5376	EXA Signal Analyzer, 10 Hz - 32 GHz	Keysight Technologies	N9010B	MY57470404	16-Mar-18	16-Mar-19

11 APPENDIX C Test equipment correction factors

HL 0446: Active Loop Antenna
EMCO, model: 6502, s/n 2857

Frequency,	Measured antenna factor, dBS/m	Measurement uncertainty, dB
10	-33.4	±1.0
20	-37.8	±1.0
50	-40.5	±1.0
75	-41.0	±1.0
100	-41.2	±1.0
150	-41.2	±1.0
250	-41.1	±1.0
500	-41.2	±1.0
750	-41.3	±1.0
1000	-41.3	±1.0

Frequency,	Measured antenna factor, dBS/m	Measurement uncertainty, dB
2000	-41.4	±1.0
3000	-41.4	±1.0
4000	-41.5	±1.0
5000	-41.5	±1.0
10000	-41.7	±1.0
15000	-42.1	±1.0
20000	-42.7	±1.0
25000	-44.2	±1.0
30000	-45.8	±1.0

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμA/m.

HL 4956: Active horn antenna
COM-POWER Corp., model: AHA-840, s/n 105004

Frequency, MHz	Measured antenna factor, dB/m
18000	5.1
18500	3.6
19000	2.2
19500	0.7
20000	0.7
20500	0.8
21000	0.5
21500	-1.3
22000	-2.1
22500	-2.0
23000	-1.6
23500	-2.9
24000	-2.3
24500	-2.6
25000	-1.8
25500	-1.2
26000	-0.5
26500	-1.2
27000	-0.1
27500	-1.0
28000	-0.7
28500	0.5

Frequency, MHz	Measured antenna factor, dB/m
29500	1.4
30000	2.9
30500	2.9
31000	2.9
31500	1.2
32000	0.7
32500	0.2
33000	-1.7
33500	-2.2
34000	2.3
34500	-1.1
35000	0.7
35500	-1.1
36000	0.1
36500	1.4
37000	3.7
37500	5.8
38000	6.6
38500	7.3
39000	6.5
39500	7.3
40000	7.1

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

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

Frequency, MHz	Antenna factor, dB/m	Frequency, MHz	Antenna factor, dB/m
30	14.96	160	12.67
35	15.33	180	13.34
40	16.37	200	15.40
45	17.56	250	16.42
50	17.95	300	17.28
60	16.87	400	19.98
70	13.22	500	21.11
80	10.56	600	22.90
90	13.61	700	24.13
100	15.46	800	25.25
120	14.03	900	26.35
140	12.23	1000	27.18

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

HL 3615: Cable RF
Suhner Switzerland, model: RG 214/U, s/n: NA, HL 3615

Set / Applied, MHz	Measured, dB	Uncertainty, dB	Set / Applied, MHz	Measured, dB	Uncertainty, dB
50	0.31	+0.08 / -0.08 dB	3300	3.78	+0.17 / -0.17 dB
100	0.45	+0.08 / -0.08 dB	3400	3.88	+0.17 / -0.17 dB
200	0.66	+0.08 / -0.08 dB	3500	3.96	+0.17 / -0.17 dB
300	0.83	+0.09 / -0.09 dB	3600	4.06	+0.17 / -0.17 dB
400	0.98	+0.09 / -0.09 dB	3700	4.15	+0.17 / -0.17 dB
500	1.12	+0.09 / -0.09 dB	3800	4.26	+0.17 / -0.17 dB
600	1.26	+0.09 / -0.09 dB	3900	4.36	+0.17 / -0.17 dB
700	1.38	+0.09 / -0.09 dB	4000	4.48	+0.17 / -0.17 dB
800	1.50	+0.09 / -0.09 dB	4100	4.58	+0.22 / -0.23 dB
900	1.63	+0.09 / -0.09 dB	4200	4.72	+0.22 / -0.23 dB
1000	1.74	+0.09 / -0.09 dB	4300	4.80	+0.22 / -0.23 dB
1100	1.85	+0.09 / -0.09 dB	4400	4.93	+0.22 / -0.23 dB
1200	1.97	+0.09 / -0.09 dB	4500	5.00	+0.22 / -0.23 dB
1300	2.08	+0.09 / -0.09 dB	4600	5.10	+0.22 / -0.23 dB
1400	2.19	+0.09 / -0.09 dB	4700	5.20	+0.22 / -0.23 dB
1500	2.30	+0.09 / -0.09 dB	4800	5.30	+0.22 / -0.23 dB
1600	2.41	+0.09 / -0.09 dB	4900	5.43	+0.22 / -0.23 dB
1700	2.53	+0.09 / -0.09 dB	5000	5.54	+0.22 / -0.23 dB
1800	2.63	+0.09 / -0.09 dB	5100	5.65	+0.22 / -0.23 dB
1900	2.74	+0.09 / -0.09 dB	5200	5.73	+0.22 / -0.23 dB
2000	2.83	+0.09 / -0.09 dB	5300	5.86	+0.22 / -0.23 dB
2100	2.93	+0.11 / -0.11 dB	5400	5.95	+0.22 / -0.23 dB
2200	3.00	+0.11 / -0.11 dB	5500	6.05	+0.22 / -0.23 dB
2300	3.07	+0.11 / -0.11 dB	5600	6.16	+0.22 / -0.23 dB
2400	3.13	+0.11 / -0.11 dB	5700	6.28	+0.22 / -0.23 dB
2500	3.19	+0.15 / -0.15 dB	5800	6.38	+0.22 / -0.23 dB
2600	3.25	+0.15 / -0.15 dB	5900	6.53	+0.22 / -0.23 dB
2700	3.33	+0.15 / -0.15 dB	6000	6.63	+0.22 / -0.23 dB
2800	3.40	+0.15 / -0.15 dB	6100	6.75	+0.22 / -0.23 dB
2900	3.48	+0.15 / -0.15 dB	6200	6.82	+0.22 / -0.23 dB
3000	3.57	+0.15 / -0.15 dB	6300	6.93	+0.22 / -0.23 dB
3100	3.63	+0.17 / -0.17 dB	6400	7.00	+0.22 / -0.23 dB
3200	3.71	+0.17 / -0.17 dB	6500	7.05	+0.22 / -0.23 dB

HL 4277:Test Cable
Mini-Circuits, model: APC-10FT-NMNM+, s/n 0748A

Set / Applied, MHz	Measured, dB	Uncertainty, dB
0.1	0.26	+0.07 / -0.07 dB
50	0.27	+0.07 / -0.07 dB
100	0.38	+0.07 / -0.07 dB
200	0.55	+0.07 / -0.07 dB
300	0.69	+0.08 / -0.09 dB
400	0.80	+0.08 / -0.09 dB
500	0.91	+0.08 / -0.09 dB
600	1.00	+0.08 / -0.09 dB
700	1.08	+0.08 / -0.09 dB
800	1.17	+0.08 / -0.09 dB
900	1.24	+0.08 / -0.09 dB
1000	1.32	+0.08 / -0.09 dB
1100	1.39	+0.12 / -0.13 dB
1200	1.45	+0.12 / -0.13 dB
1300	1.52	+0.12 / -0.13 dB
1400	1.58	+0.12 / -0.13 dB
1500	1.65	+0.12 / -0.13 dB
1600	1.71	+0.12 / -0.13 dB
1700	1.77	+0.12 / -0.13 dB
1800	1.82	+0.12 / -0.13 dB
1900	1.88	+0.12 / -0.13 dB
2000	1.93	+0.12 / -0.13 dB
2100	1.99	+0.12 / -0.13 dB
2200	2.05	+0.12 / -0.13 dB
2300	2.10	+0.12 / -0.13 dB
2400	2.15	+0.12 / -0.13 dB
2500	2.20	+0.17 / -0.18 dB
2600	2.25	+0.17 / -0.18 dB
2700	2.30	+0.17 / -0.18 dB
2800	2.35	+0.17 / -0.18 dB
2900	2.40	+0.17 / -0.18 dB
3000	2.44	+0.17 / -0.18 dB
3100	2.49	+0.19 / -0.2 dB
3200	2.54	+0.19 / -0.2 dB
3300	2.58	+0.19 / -0.2 dB
3400	2.62	+0.19 / -0.2 dB
3500	2.66	+0.19 / -0.2 dB
3600	2.71	+0.19 / -0.2 dB
3700	2.75	+0.19 / -0.2 dB
3800	2.79	+0.19 / -0.2 dB
3900	2.84	+0.19 / -0.2 dB
4000	2.88	+0.19 / -0.2 dB

Set / Applied, MHz	Measured, dB	Uncertainty, dB
4100	2.84	+0.19 / -0.2 dB
4200	2.88	+0.19 / -0.2 dB
4300	2.92	+0.3 / -0.33 dB
4400	2.96	+0.3 / -0.33 dB
4500	3.01	+0.3 / -0.33 dB
4600	3.05	+0.3 / -0.33 dB
4700	3.09	+0.3 / -0.33 dB
4800	3.13	+0.3 / -0.33 dB
4900	3.18	+0.3 / -0.33 dB
5000	3.21	+0.3 / -0.33 dB
5100	3.25	+0.3 / -0.33 dB
5200	3.30	+0.3 / -0.33 dB
5300	3.34	+0.3 / -0.33 dB
5400	3.39	+0.3 / -0.33 dB
5500	3.44	+0.3 / -0.33 dB
5600	3.48	+0.3 / -0.33 dB
5700	3.53	+0.3 / -0.33 dB
5800	3.57	+0.3 / -0.33 dB
5900	3.60	+0.3 / -0.33 dB
6000	3.65	+0.3 / -0.33 dB
6100	3.68	+0.3 / -0.33 dB
6200	3.72	+0.3 / -0.33 dB
6300	3.77	+0.3 / -0.33 dB
6400	3.83	+0.3 / -0.33 dB
6500	3.86	+0.3 / -0.33 dB
6600	3.92	+0.3 / -0.33 dB
6700	3.96	+0.3 / -0.33 dB
6800	4.00	+0.3 / -0.33 dB
6900	4.04	+0.3 / -0.33 dB
7000	4.08	+0.3 / -0.33 dB
7100	4.11	+0.3 / -0.33 dB
7200	4.16	+0.3 / -0.33 dB
7300	4.20	+0.3 / -0.33 dB
7400	4.24	+0.3 / -0.33 dB
7500	4.29	+0.3 / -0.33 dB
7600	4.33	+0.3 / -0.33 dB
7700	4.38	+0.3 / -0.33 dB
7800	4.42	+0.3 / -0.33 dB
7900	4.51	+0.3 / -0.33 dB
8000	4.52	+0.3 / -0.33 dB
8100	4.55	+0.34 / -0.36 dB
8200	4.55	+0.34 / -0.36 dB

HL 4277*:* Insertion loss

Set / Applied, MHz	Measured, dB	Uncertainty, dB
8300	4.57	+0.34 / -0.36 dB
8400	4.60	+0.34 / -0.36 dB
8500	4.60	+0.34 / -0.36 dB
8600	4.63	+0.34 / -0.36 dB
8700	4.63	+0.34 / -0.36 dB
8800	4.64	+0.34 / -0.36 dB
8900	4.65	+0.34 / -0.36 dB
9000	4.67	+0.34 / -0.36 dB
9100	4.69	+0.34 / -0.36 dB
9200	4.71	+0.34 / -0.36 dB
9300	4.73	+0.34 / -0.36 dB
9400	4.76	+0.34 / -0.36 dB
9500	4.78	+0.34 / -0.36 dB
9600	4.81	+0.34 / -0.36 dB
9700	4.85	+0.34 / -0.36 dB
9800	4.87	+0.34 / -0.36 dB
9900	4.89	+0.34 / -0.36 dB
10000	4.93	+0.34 / -0.36 dB
10100	4.96	+0.4 / -0.44 dB
10200	4.99	+0.4 / -0.44 dB
10300	5.02	+0.4 / -0.44 dB
10400	5.05	+0.4 / -0.44 dB
10500	5.08	+0.4 / -0.44 dB
10600	5.11	+0.4 / -0.44 dB
10700	5.14	+0.4 / -0.44 dB
10800	5.17	+0.4 / -0.44 dB
10900	5.19	+0.4 / -0.44 dB
11000	5.22	+0.4 / -0.44 dB
11100	5.25	+0.4 / -0.44 dB
11200	5.28	+0.4 / -0.44 dB
11300	5.31	+0.4 / -0.44 dB
11400	5.34	+0.4 / -0.44 dB
11500	5.38	+0.4 / -0.44 dB
11600	5.41	+0.4 / -0.44 dB
11700	5.45	+0.4 / -0.44 dB
11800	5.49	+0.4 / -0.44 dB
11900	5.53	+0.4 / -0.44 dB
12000	5.56	+0.4 / -0.44 dB
12100	5.60	+0.4 / -0.44 dB
12200	5.63	+0.4 / -0.44 dB
12300	5.68	+0.4 / -0.44 dB
12400	5.72	+0.4 / -0.44 dB
12500	5.75	+0.47 / -0.52 dB
12600	5.80	+0.47 / -0.52 dB
12700	5.84	+0.47 / -0.52 dB
12800	5.93	+0.47 / -0.52 dB
12900	5.94	+0.47 / -0.52 dB
13000	5.98	+0.47 / -0.52 dB
13100	6.03	+0.47 / -0.52 dB

Set / Applied, MHz	Measured, dB	Uncertainty, dB
13200	6.09	+0.47 / -0.52 dB
13300	6.17	+0.47 / -0.52 dB
13400	6.27	+0.47 / -0.52 dB
13500	6.37	+0.47 / -0.52 dB
13600	6.49	+0.47 / -0.52 dB
13700	6.57	+0.47 / -0.52 dB
13800	6.60	+0.47 / -0.52 dB
13900	6.61	+0.47 / -0.52 dB
14000	6.59	+0.47 / -0.52 dB
14100	6.57	+0.47 / -0.52 dB
14200	6.54	+0.47 / -0.52 dB
14300	6.53	+0.47 / -0.52 dB
14400	6.49	+0.47 / -0.52 dB
14500	6.48	+0.47 / -0.52 dB
14600	6.46	+0.47 / -0.52 dB
14700	6.46	+0.47 / -0.52 dB
14800	6.49	+0.47 / -0.52 dB
14900	6.51	+0.47 / -0.52 dB
15000	6.54	+0.47 / -0.52 dB
15100	6.57	+0.47 / -0.52 dB
15200	6.62	+0.47 / -0.52 dB
15300	6.64	+0.47 / -0.52 dB
15400	6.68	+0.47 / -0.52 dB
15500	6.71	+0.47 / -0.52 dB
15600	6.78	+0.47 / -0.52 dB
15700	6.79	+0.47 / -0.52 dB
15800	6.82	+0.47 / -0.52 dB
15900	6.88	+0.47 / -0.52 dB
16000	6.89	+0.47 / -0.52 dB
16100	6.96	+0.47 / -0.52 dB
16200	6.97	+0.47 / -0.52 dB
16300	7.02	+0.47 / -0.52 dB
16400	7.07	+0.47 / -0.52 dB
16500	7.12	+0.47 / -0.52 dB
16600	7.17	+0.47 / -0.52 dB
16700	7.20	+0.47 / -0.52 dB
16800	7.22	+0.47 / -0.52 dB
16900	7.23	+0.47 / -0.52 dB
17000	7.24	+0.47 / -0.52 dB
17100	7.27	+0.47 / -0.52 dB
17200	7.28	+0.47 / -0.52 dB
17300	7.28	+0.47 / -0.52 dB
17400	7.30	+0.47 / -0.52 dB
17500	7.34	+0.47 / -0.52 dB
17600	7.35	+0.47 / -0.52 dB
17700	7.39	+0.47 / -0.52 dB
17800	7.41	+0.47 / -0.52 dB
17900	7.41	+0.47 / -0.52 dB
18000	7.44	+0.47 / -0.52 dB

12 APPENDIX D Measurement uncertainties

Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements

Test description	Expanded uncertainty
Occupied bandwidth	± 8.0 %
Duty cycle, timing (Tx ON / OFF) and average factor measurements	± 1.0 %
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: 2017	Radio Frequency Devices.
ANSI C63.2:2016	American National Standard for Instrumentation-Electromagnetic Noise and Field Strength, 10 kHz to 40 GHz-Specifications.
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.
ANSI C63.10:2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
558074 D01 DTS Meas_Guidance v05	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
A/m	ampere per meter
AM	amplitude modulation
AVRG	average (detector)
cm	centimeter
CDN	coupling/ decoupling network
dB	decibel
dB(μV)	decibel referred to one microvolt
dB(μV/m)	decibel referred to one microvolt per meter
dB(μA)	decibel referred to one microampere
DC	direct current
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EN	European Norm
EUT	equipment under test
GHz	gigahertz
GND	ground
H	height
HCP	horizontal coupling plane
HL	Hermon laboratories
Hz	hertz
ITE	information technology equipment
k	kilo
kHz	kilohertz
kV	kilovolt
L	length
LISN	line impedance stabilization network
m	meter
MHz	megahertz
min	minute
mm	millimeter
ms	millisecond
μs	microsecond
NA	not applicable
NP	normal performance
OATS	open area test site
Ω	Ohm
QP	quasi-peak
PS	power supply
RE	radiated emission
RF	radio frequency
rms	root mean square
s	second
V	volt
VCP	vertical coupling plane

END OF DOCUMENT