HERMON LABORATORIES

ELECTRICAL TESTING
0839.01

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TEST REPORT

ACCORDING TO:

FCC 47CFR part 15 subpart C § 15.247 (DTS) and subpart B, Class B

FOR:

Telematics Wireless Ltd.

Light Control Unit

Model: LCUN2LUS

FCC ID:NTALCUN2L

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1 Applicant information

Client name:	Telematics Wireless Ltd.
Address:	26 Hamelacha street, POB 1911, Holon, 5811801, Israel
Telephone:	+972 3557 5700
Fax:	+972 3557 5703
E-mail:	Emzari.Roketlishvili@telematics-wireless.com
Contact name:	Mr. Emzari Roketlishvili

2 Equipment under test attributes

Product name:	Light Control Unit
Product type:	Transceiver
Model(s):	LCUN2LUS
Serial number:	98300
Hardware version:	Rev. D
Software release:	1.0.2-9
Receipt date	01-Feb-19

3 Manufacturer information

Manufacturer name:	Telematics Wireless Ltd.
Address:	26 Hamelacha street, POB 1911, Holon, 5811801, Israel
Telephone:	+972 3557 5700
Fax:	+972 3557 5703
E-Mail:	Emzari.Roketlishvili@telematics-wireless.com
Contact name:	Mr. Emzari Roketlishvili

4 Test details

Project ID:	32272
Location:	Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started:	21-Mar-19
Test completed:	11-Apr-19
Test specification(s):	FCC 47CFR part 15 subpart C § 15.247 (DTS) and subpart B, Class B

5 Tests summary

Test	Status
Transmitter characteristics	
FCC section 15.247(a)2, 6 dB bandwidth	Pass
FCC section 15.247(b)3, Maximum peak output power	Pass
FCC section 15.247(i), RF exposure	Pass *
FCC section 15.247(d), Radiated spurious emissions	Pass
FCC section 15.247(d), Emissions at band edges	Pass
FCC section 15.247(e), Maximum power spectral density	Pass
FCC section 15.203, Antenna requirement	Pass
FCC section 15.207(a), Conducted emission	Pass
Unintentional emissions	
FCC section 15.107, ICES-003, section 6.1, Class B, Conducted emission at AC power port	Pass
FCC section 15.109, ICES-003, section 6.2, Class B, 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	29-Mar-19 – 11-Apr-19	
Reviewed by:	Mrs. Y. Rapin, technical writer	06-May-19	
Approved by:	Mr. S. Samokha, technical manager, EMC and Radio	04-Aug-19	

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 a wireless controlling unit installed outside at the top of the light fixture (twist-lock connector) which handles the data collection from the Luminaire and command transfer between the light unit and the street light management system.

The EUT operates in 902-928 MHz frequency range using LoRa modulation with 1kbps bit rate.

6.2 Test configuration

6.3 Changes made in EUT

No changes were implemented in the EUT during the testing.

6.4 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	902-928 MHz
Operating frequency range	903-927 MHz

Maximum rated output power	At transmitter 50 Ω RF output connector	NA
	Peak output power	17.54 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	X	with temporary RF connector
					without temporary RF connector

Antenna/s technical characteristics			
Type	Manufacturer	Model number	Gain
Printed	Telematics Wireless	NA	0 dBi

Transmitter aggregate data rate/s	1 kbps
Type of modulation	LoRa
Modulating test signal (baseband)	PRBS

Transmitter power source						
	Battery	**Nominal rated voltage**	VDC	Battery type		
	DC	**Nominal rated voltage**	VDC			
X	AC mains	**Nominal rated voltage**	110 VAC	Frequency	60 Hz	

Common power source for transmitter and receiver	X	yes		no

Spread spectrum technique used		Frequency hopping (FHSS)
	X	Digital transmission system (DTS)
		Hybrid

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):	05-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

7 Transmitter tests according to 47CFR part 15 subpart C

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

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

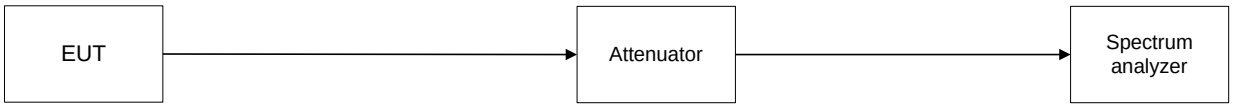
7.1.2 Test procedure

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 RBW=100 kHz 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 11.8.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	05-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

Table 7.1.2 The 6 dB bandwidth test results

ASSIGNED FREQUENCY BAND: 902-928 MHz
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: 300 kHz
MODULATION ENVELOPE REFERENCE POINTS: 6.0 dBc
MODULATION: LoRa
BIT RATE: 1 kbps

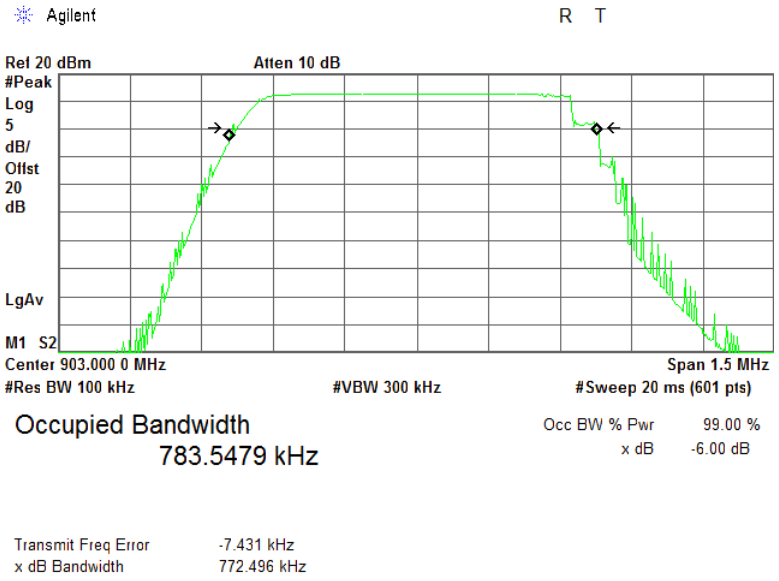
Carrier frequency, MHz	6 dB bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
903	772.496	500	272.496	Pass
915	755.414	500	255.414	Pass
927	761.401	500	261.401	Pass

Reference numbers of test equipment used

HL 3818	HL 3440	HL 3433						

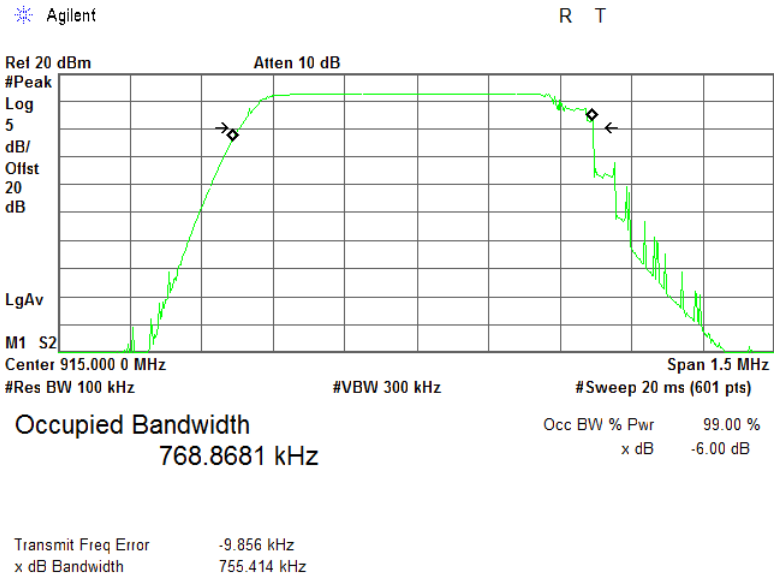
Full description is given in Appendix A.

Plot 7.1.1 6 dB bandwidth test result at low frequency

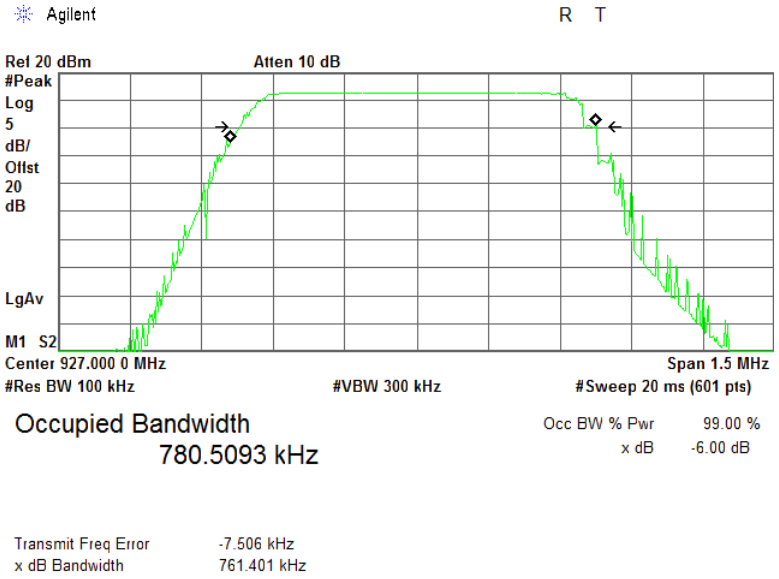


Test specification:	Section 15.247(a)(2), 6 dB bandwidth		
Test procedure:	ANSI C63.10 section 11.8.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	05-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

Plot 7.1.2 6 dB bandwidth test result at mid frequency



Plot 7.1.3 6 dB bandwidth test result at high frequency



Test specification:	**Section 15.247(b)(3), Peak output power**		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	11-Apr-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

7.2 Peak output power

7.2.1 General

This test was performed to measure the maximum peak output power at the transmitter RF antenna connector. 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*	
		W	dBm
902.0 – 928.0	6.0	1.0	30.0

*- If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value by the amount in dB that the directional gain of antenna exceeds 6 dBi.

7.2.2 Test procedure

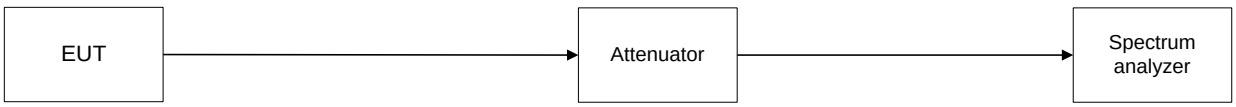
7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

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

7.2.2.3 The resolution bandwidth of spectrum analyzer was set to 1-5% of the OBW but not exceeding 1 MHz, and video bandwidth was ≥ 3xRBW. The selected frequency was traced in the power averaging mode. The number of traces was sufficient to accurately represent the true average over the ON and OFF periods of the transmitter, but not less than 100 traces.

7.2.2.4 The measured power was recalculated for the duty cycle factor by adding 10log(1/DC). The results are shown in Table 7.2.2 and associated plots.

Figure 7.2.1 Peak output power test setup



Test specification:	Section 15.247(b)(3), Peak output power		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	11-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

Table 7.2.2 Peak output power test results

ASSIGNED FREQUENCY: 902-928 MHz
MODULATION: LoRa
BIT RATE: 1 kbps

Carrier frequency, MHz	Spectrum analyzer reading, dBm	6 dB BW kHz	DC factor, dB	Peak output power,** dBm	Limit, dBm	Margin*, dB	Verdict
903	10.66	772.496	6.88	17.54	30	-12.46	Pass
915	10.44	755.414	6.88	17.32	30	-12.68	Pass
927	10.21	761.401	6.88	17.09	30	-12.91	Pass

* - Margin = Peak output power – specification limit.
** - Peak output power = SA Reading + Duty cycle Factor

Table 7.2.3 Duty cycle factor calculation

Transmission pulse		Transmission burst		Transmission train duration, ms	Duty cycle factor, dB
Duration, ms	Period, ms	Duration, ms	Period, ms		
420	2050	NA	NA	NA	6.88

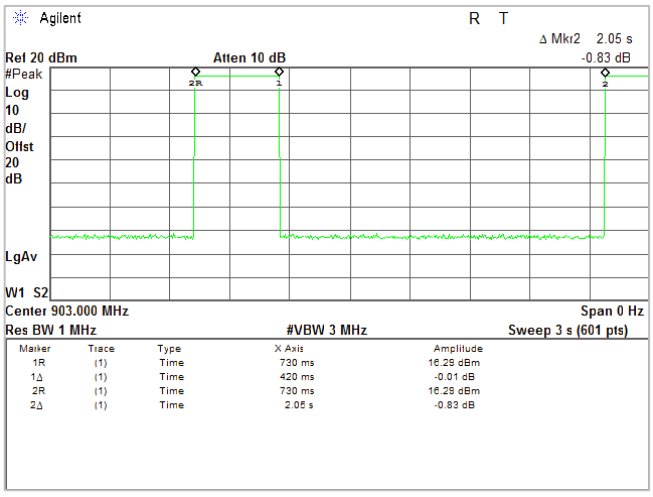
* - Duty cycle factor was calculated as follows:
Duty cycle factor = 10*log(1/D),
Where D is duty cycle = Tx_{on} / Tx_{on} + Tx_{off}

Reference numbers of test equipment used

HL 2909	HL 3434	HL 3440	HL 3818				

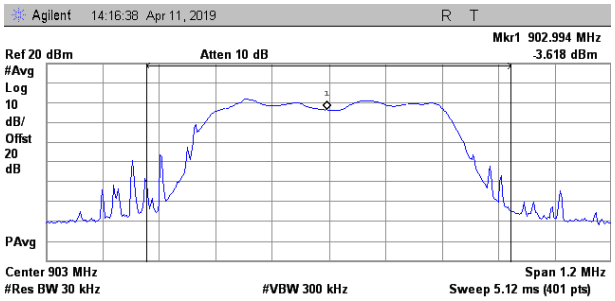
Full description is given in Appendix A.

Plot 7.2.1 Duty cycle measurements

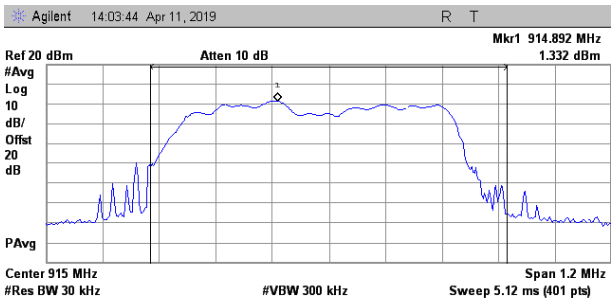


Test specification:	Section 15.247(b)(3), Peak output power		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	11-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

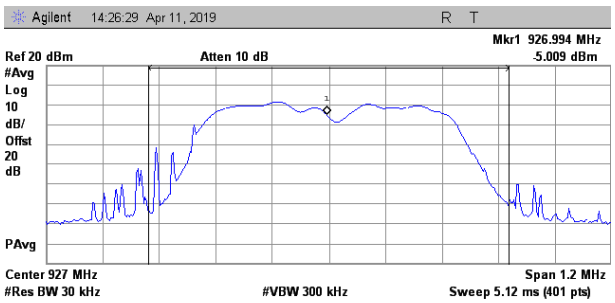
Plot 7.2.2 Peak output power at low frequency



Plot 7.2.3 Peak output power at mid frequency



Plot 7.2.4 Peak output power at high frequency



Test specification:	**Section 15.247(d), Radiated spurious emissions**		
Test procedure:	ANSI C63.10, Section 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
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**	30.0
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 – 10th harmonic	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 10th 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 Table 7.3.2, Table 7.3.3 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 360^0, 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 Table 7.3.2, Table 7.3.3 and shown in the associated plots.

Test specification:	Section 15.247(d), Radiated spurious emissions		
Test procedure:	ANSI C63.10, Section 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

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

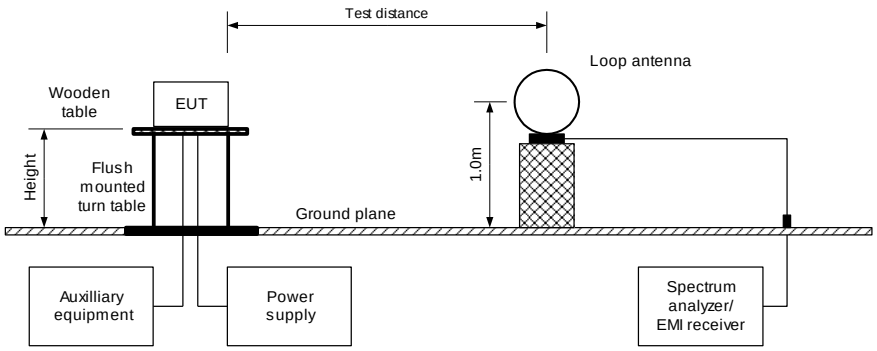


Figure 7.3.2 Setup for spurious emission field strength measurements from 30 to 1000 MHz

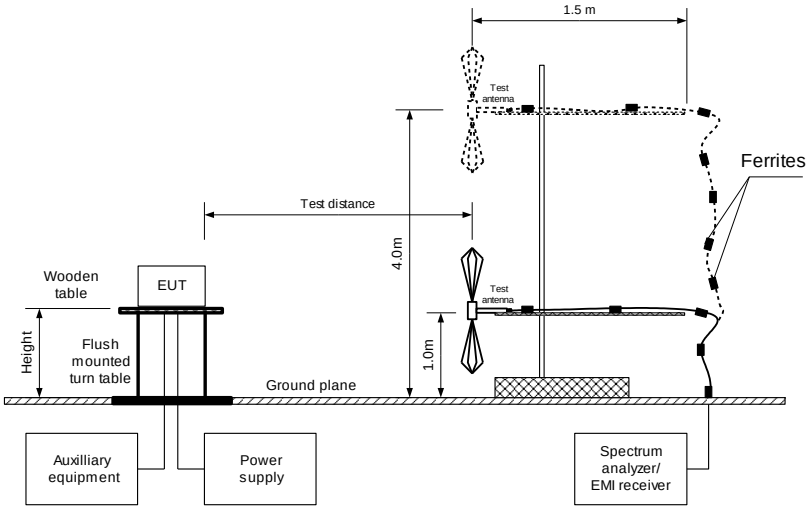
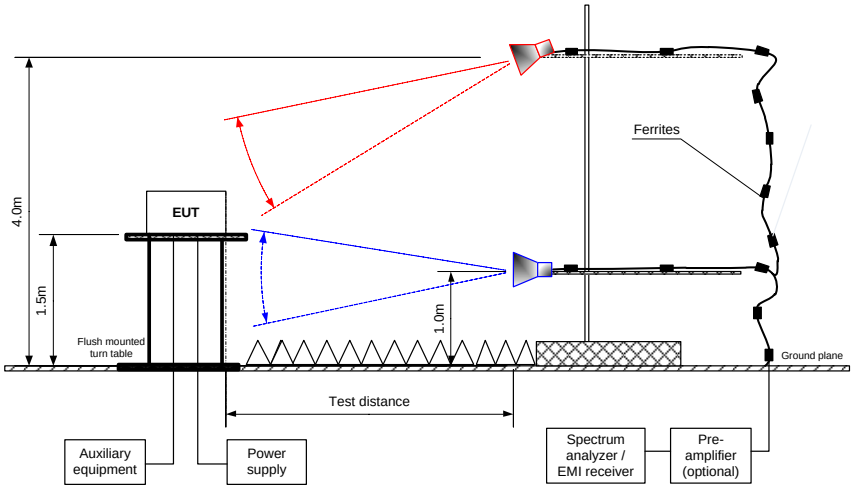


Figure 7.3.3 Setup for spurious emission field strength measurements above1000 MHz



Test specification:	**Section 15.247(d), Radiated spurious emissions**		
Test procedure:	ANSI C63.10, Section 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

Table 7.3.2 Field strength of emissions outside restricted bands

ASSIGNED FREQUENCY: 902-928 MHz
INVESTIGATED FREQUENCY RANGE: 0.009 -10000MHz
TEST DISTANCE: 3 m
MODULATION: LoRa
FREQUENCY HOPPING: Disabled
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Peak
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
Low carrier frequency									
1806.0	38.93	Vertical	1.3	-10	113.1	74.17	30.0	44.17	Pass
6320.0	46.05	Vertical	1.5	-89		67.05		37.05	
7222.0	52.12	Vertical	1.8	33		60.98		30.98	
Mid carrier frequency									
1830.0	39.83	Vertical	1.4	-65	112.6	72.77	30.0	42.77	Pass
5490.0	43.60	Vertical	2.0	-80		69.00		39.00	
6405.0	47.85	Vertical	1.5	-89		64.75		34.75	
High carrier frequency									
1854.0	46.33	Vertical	1.9	-100	112.2	65.87	30.0	35.87	Pass
6489.0	48.32	Vertical	2.3	-80		63.88		33.88	
9270.0	56.00	Vertical	2.4	-89		56.20		26.20	

*****- 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 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

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

ASSIGNED FREQUENCY: 902-928 MHz
INVESTIGATED FREQUENCY RANGE: 1000 - 9500MHz
TEST DISTANCE: 3 m
MODULATION: LoRa
FREQUENCY HOPPING: Disabled
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 1 MHz
TEST ANTENNA TYPE: Double ridged guide

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)	Limit, dB(μV/m)	Margin, dB**	
Low carrier frequency										
2709	Vertical	2.2	83	44.27	74.00	-29.73	38.75	54.00	-15.25	Pass
8126	Vertical	1.9	-120	53.43	74.00	-20.57	46.33	54.00	-7.67	
Mid carrier frequency										
2745	Vertical	2.6	83	44.32	74.00	-29.68	38.13	54.00	-15.87	Pass
7320	Vertical	2.6	-120	54.83	74.00	-19.17	48.32	54.00	-5.68	
8235	Vertical	2.1	-70	53.38	74.00	-20.62	47.18	54.00	-6.82	
9150	Vertical	2.3	40	48.43	74.00	-25.57	41.83	54.00	-12.17	
High carrier frequency										
2781	Vertical	2.0	85	45.73	74.00	-28.27	39.11	54.00	-14.89	Pass
7416	Vertical	2.8	132	55.95	74.00	-18.05	49.33	54.00	-4.67	
8343	Vertical	2.7	-65	45.12	74.00	-28.88	38.74	54.00	-15.26	

*****- EUT front panel refers to 0 degrees position of turntable.
******- Margin = Measured field strength - specification limit.

Test specification:	**Section 15.247(d), Radiated spurious emissions**		
Test procedure:	ANSI C63.10, Section 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

Table 7.3.4 Field strength of spurious emissions below 1 GHz within restricted bands

ASSIGNED FREQUENCY: 902-928 MHz
INVESTIGATED FREQUENCY RANGE: 0.009 – 1000 MHz
TEST DISTANCE: 3 m
MODULATION: LoRa
MODULATING SIGNAL: PRBS
BIT RATE: 1 kbps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
RESOLUTION BANDWIDTH: 0.2 kHz (9 kHz – 150 kHz)
9.0 kHz (150 kHz – 30 MHz)
120 kHz (30 MHz – 1000 MHz)
VIDEO BANDWIDTH: > Resolution bandwidth
TEST ANTENNA TYPE: Active loop (9 kHz – 30 MHz)
Biconilog (30 MHz – 1000 MHz)
FREQUENCY HOPPING: Disabled

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

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

Table 7.3.5 Restricted bands according to FCC section 15.205

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

Reference numbers of test equipment used

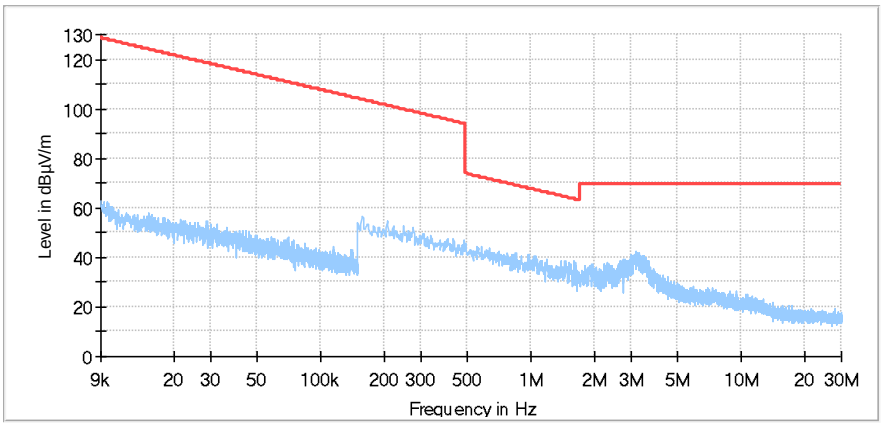
HL 1915	HL 3615	HL 4277	HL 4339	HL 4360	HL 4933	HL 5111	HL 5288
HL 2909	HL 0446						

Full description is given in Appendix A.

Test specification:	Section 15.247(d), Radiated spurious emissions		
Test procedure:	ANSI C63.10, Section 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

Plot 7.3.1 Radiated emission measurements from 9 kHz to 30 MHz at the low; mid; high carrier frequency

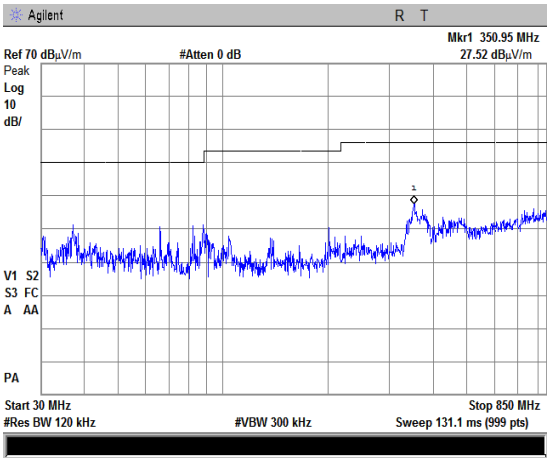
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
CS=200 kHz

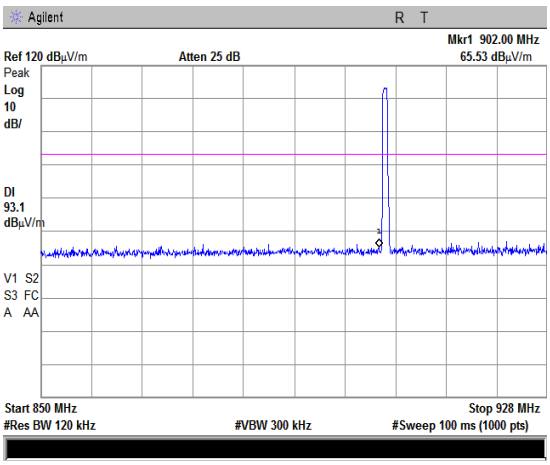


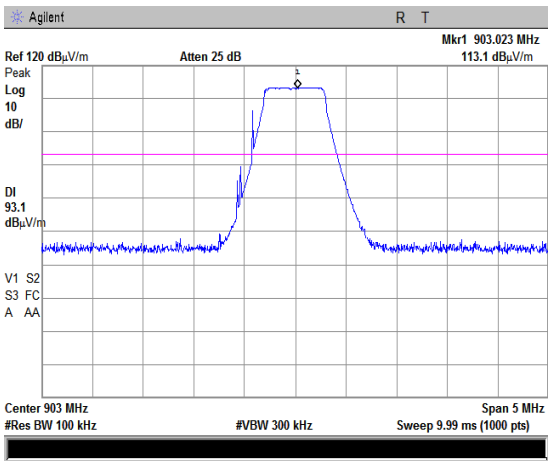
Test specification:	Section 15.247(d), Radiated spurious emissions		
Test procedure:	ANSI C63.10, Section 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

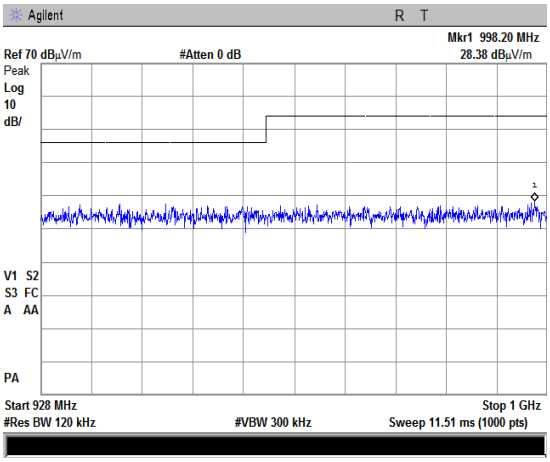
Plot 7.3.2 Radiated emission measurements from 30 to 1000 MHz at the low carrier frequency

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





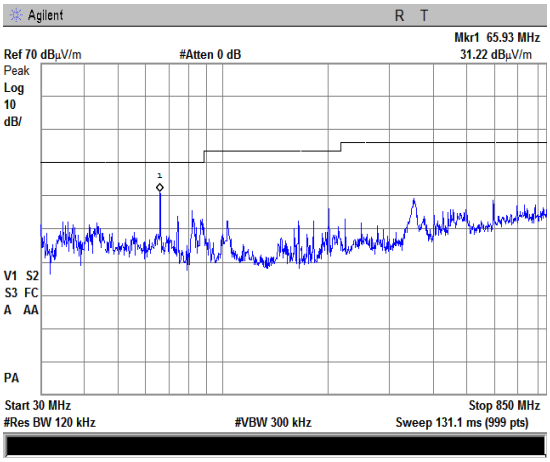


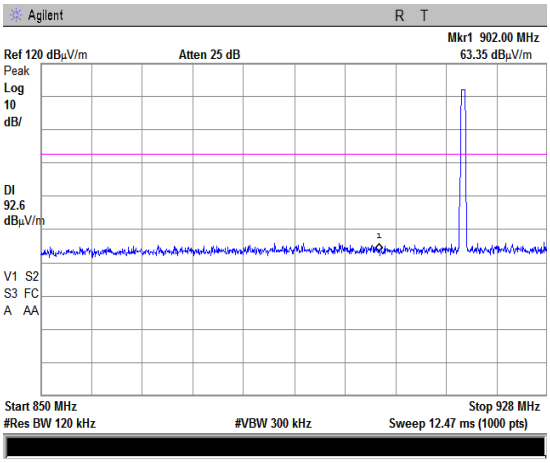


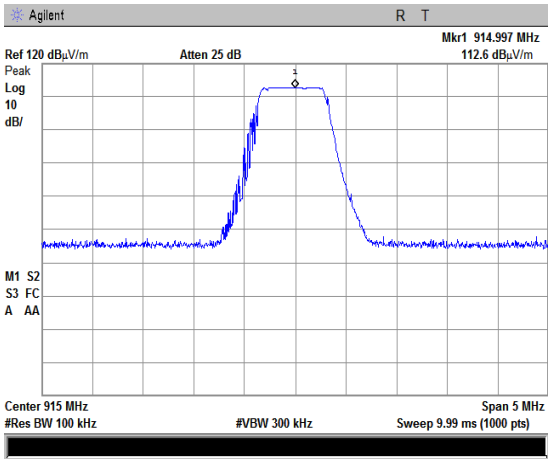
Test specification:	Section 15.247(d), Radiated spurious emissions		
Test procedure:	ANSI C63.10, Section 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

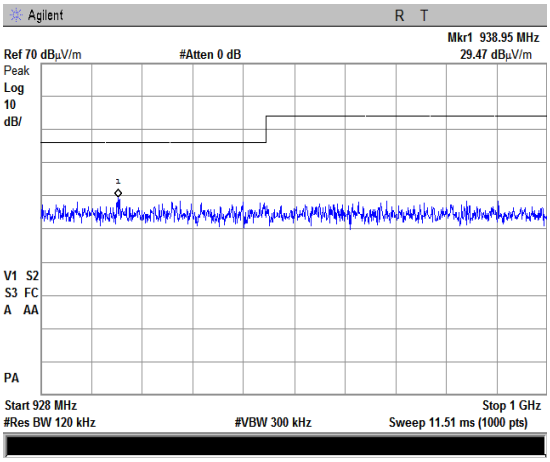
Plot 7.3.3 Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

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





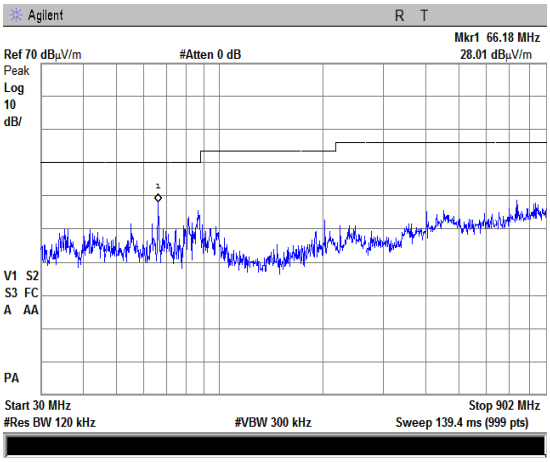


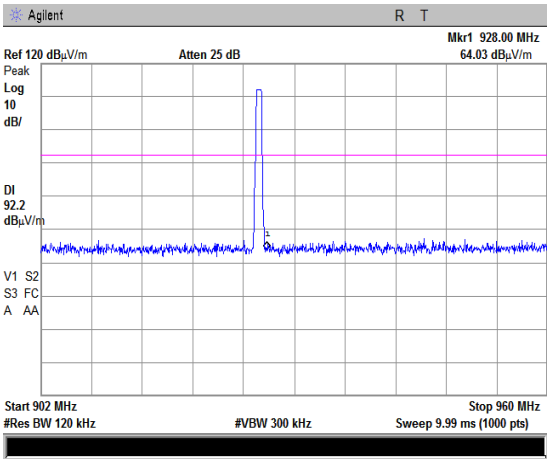


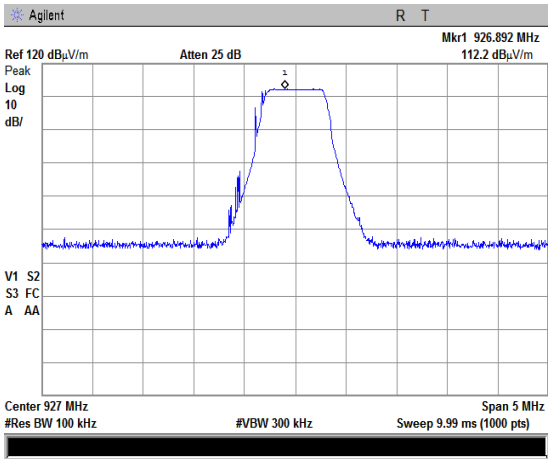
Test specification:	Section 15.247(d), Radiated spurious emissions		
Test procedure:	ANSI C63.10, Section 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

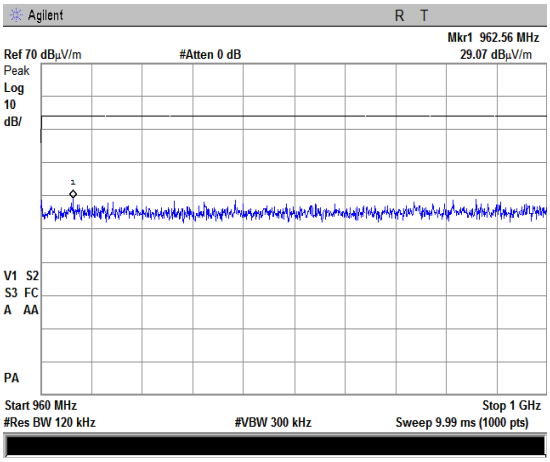
Plot 7.3.4 Radiated emission measurements from 30 to 1000 MHz at the high carrier frequency

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





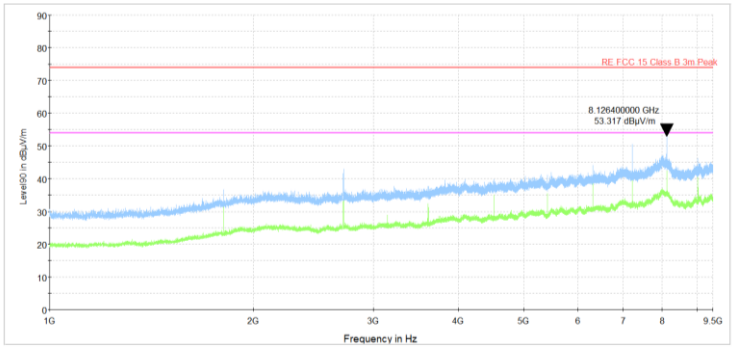




Test specification:	Section 15.247(d), Radiated spurious emissions		
Test procedure:	ANSI C63.10, Section 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

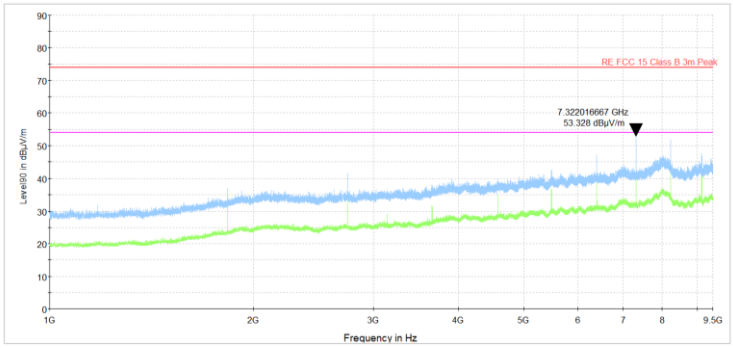
Plot 7.3.5 Radiated emission measurements from 1000 to 9500 MHz at the low carrier frequency

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



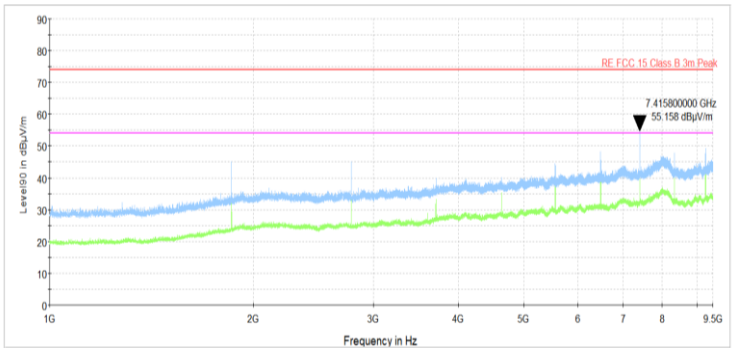
Plot 7.3.6 Radiated emission measurements from 1000 to 9500 MHz at the mid carrier frequency

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



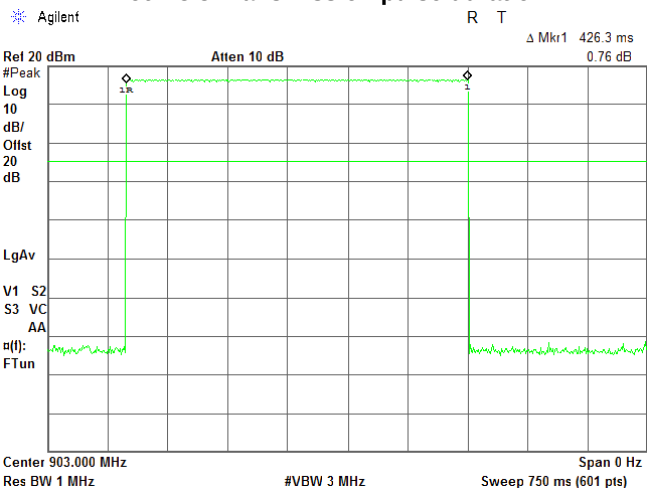
Plot 7.3.7 Radiated emission measurements from 1000 to 9500 MHz at the high carrier frequency

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



Test specification:	Section 15.247(d), Radiated spurious emissions		
Test procedure:	ANSI C63.10, Section 6.3, 6.5, 6.6, 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

Plot 7.3.8 Transmission pulse duration



Test specification:	**Section 15.247(d), Band edge emissions**		
Test procedure:	ANSI C63.10 section 11.13.3.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

7.4 Band edge emissions

7.4.1 General

This test was performed to measure band edge emissions at RF antenna connector. 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
Averaged over a time interval	902.0 – 928.0	30.0

* - 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.

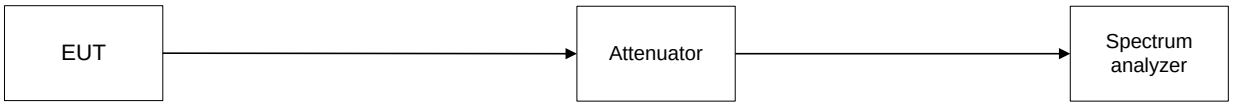
7.4.2.3 The spectrum analyzer span was set to capture the carrier frequency and associated modulation products. The resolution bandwidth was set wider than 1 % of the frequency span.

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.

Figure 7.4.1 Band edge emission test setup



Test specification:	**Section 15.247(d), Band edge emissions**		
Test procedure:	ANSI C63.10 section 11.13.3.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

Table 7.4.2 Band edge emission test results

ASSIGNED FREQUENCY RANGE: 902-928 MHz
DETECTOR USED: Average
MODULATION: LoRa
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
RESOLUTION BANDWIDTH: ≥ 1% of the span
VIDEO BANDWIDTH: ≥ RBW

Frequency, MHz	Band edge emission, dBm	Emission at carrier, dBm	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
Averaged over a time interval power						
902	-58.30	6.24	64.54	30.0	34.54	Pass
928	-58.30	4.42	62.72		32.72	

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

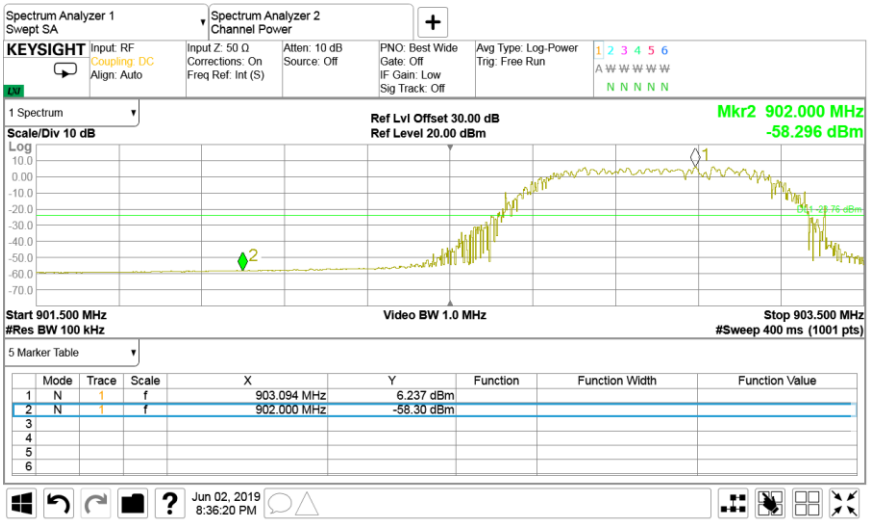
Reference numbers of test equipment used

HL 4068	HL 5112	HL 5376					

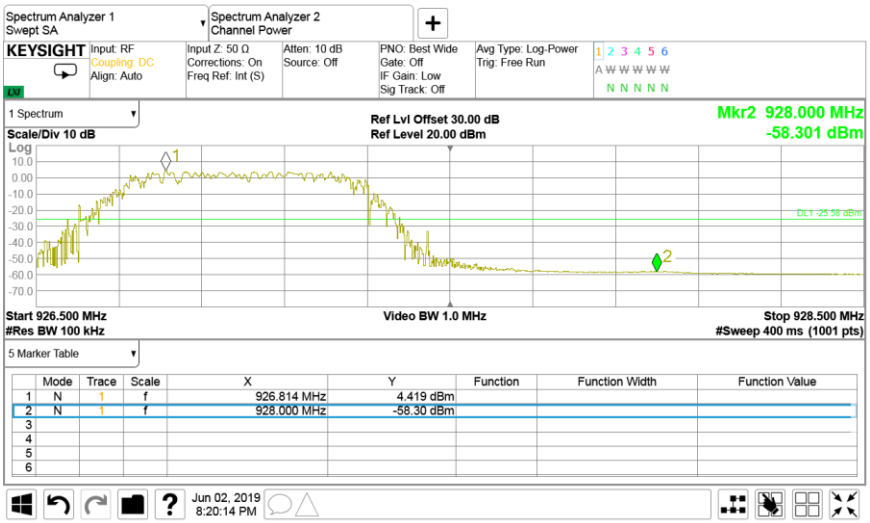
Full description is given in Appendix A.

Test specification:	Section 15.247(d), Band edge emissions		
Test procedure:	ANSI C63.10 section 11.13.3.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

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(e), Peak power density		
Test procedure:	ANSI C63.10, Section 11.10.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	05-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

7.5 Peak spectral power density

7.5.1 General

This test was performed to measure the peak spectral power density at the transmitter RF antenna connector. 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
902-928	3.0	8.0

7.5.2 Test procedure

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 resolution bandwidth of spectrum analyzer was set to be 3 kHz ≤ RBW ≤ 100 kHz, and video bandwidth was ≥ 3xRBW, sufficient number of sweeps (>100) was allowed for trace stabilization. The selected frequency was swept in the power averaging mode.

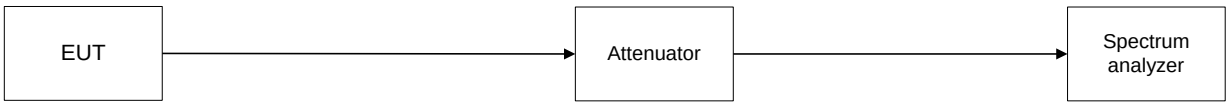
7.5.2.4 The peak marker function was used to determine the maximum amplitude level.

7.5.2.5 The measured PSD was recalculated for the duty cycle factor by adding 10log(1/DC).

7.5.2.6 If measured value exceeded the limit, then the RBW was reduced (but no less than 3 kHz) and the frequency was swept once again with zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced.

7.5.2.7 The measurement results are provided in Table 7.5.2 and associated plots.

Figure 7.5.1 Peak spectral power density test setup



Test specification:	Section 15.247(e), Peak power density		
Test procedure:	ANSI C63.10, Section 11.10.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	05-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

Table 7.5.2 Peak spectral power density test results

ASSIGNED FREQUENCY: 902-928 MHz
MODULATION: LoRa
BIT RATE: 1 kbps
DETECTOR USED: Power averaging
RESOLUTION BANDWIDTH: 3 kHz
VIDEO BANDWIDTH: 10 kHz

Carrier frequency, MHz	Spectrum analyzer reading, dBm	External attenuation, dB	Cable loss, dB	DC factor, dB	Peak power density, dB(mW/3 kHz)**	Limit, dBm	Margin*, dB	Verdict
903	-6.20	including	including	6.88	0.679	8	-7.321	Pass
915	-4.39	including	including	6.88	2.481	8	-5.519	Pass
927	-6.50	including	including	6.88	0.376	8	-7.624	Pass

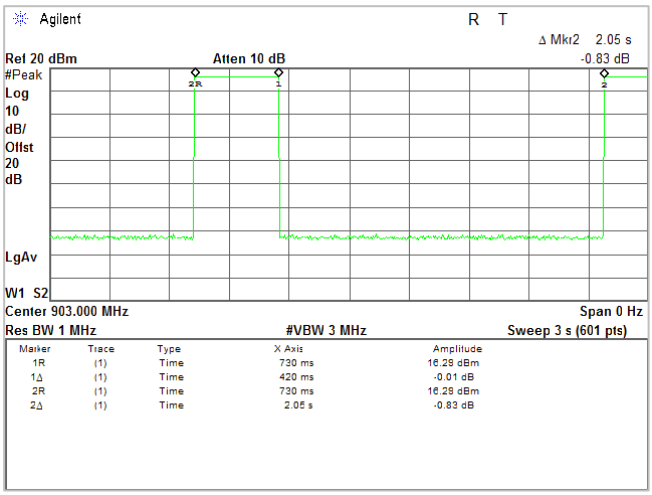
* - Margin = Peak power density – specification limit.
** - Peak power spectral density = SA reading + DC factor
Note: DC factor = 10*Log(1/ (T_{on} / T_{period})) = 6.88 dB

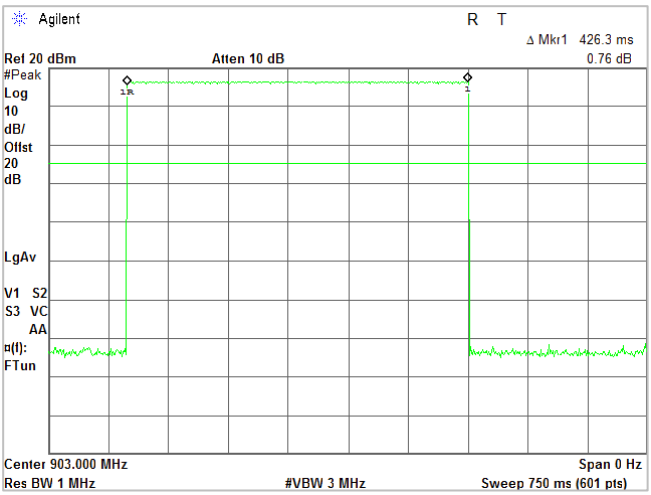
Reference numbers of test equipment used

HL 3818	HL 3440	HL 3433					

Full description is given in Appendix A.

Plot 7.5.1 Duty cycle measurements

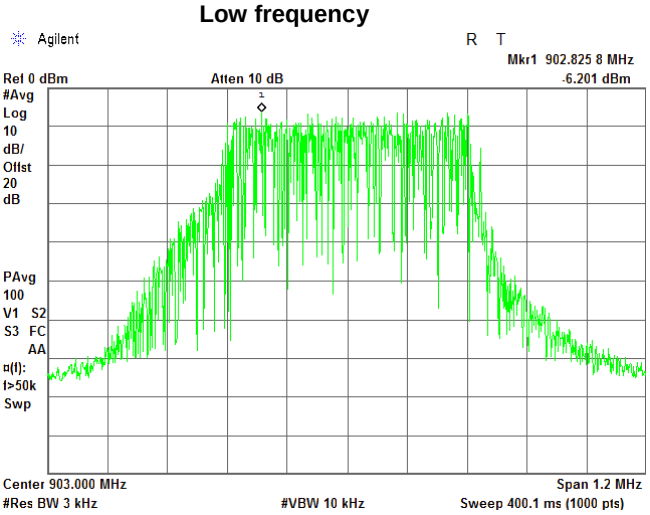




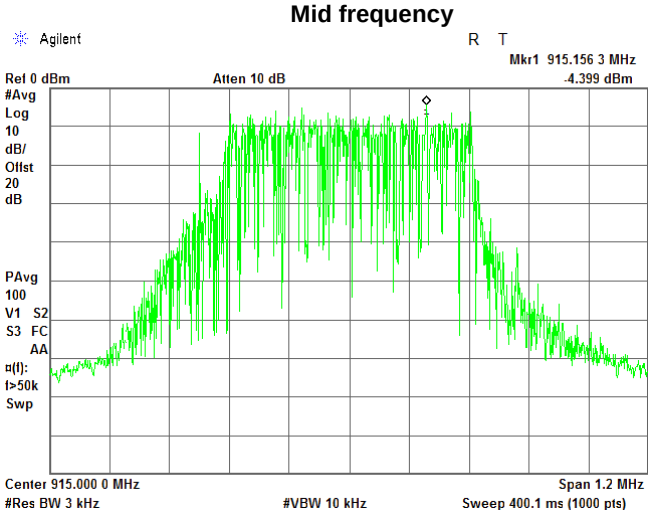
Test specification:	Section 15.247(e), Peak power density		
Test procedure:	ANSI C63.10, Section 11.10.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	05-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

Plot 7.5.2 Peak spectral power density

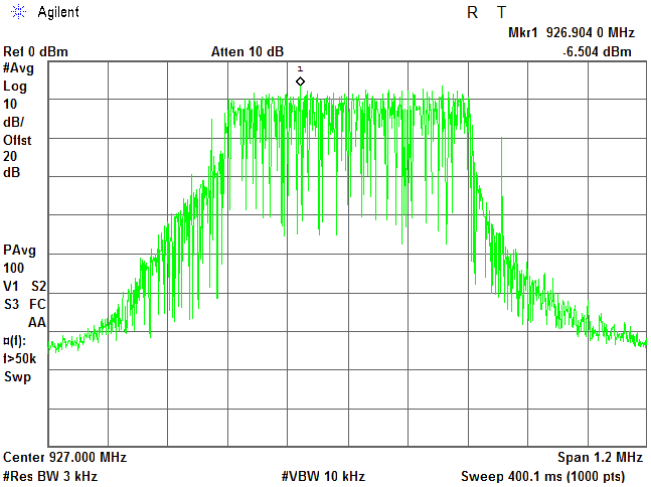
Low frequency



Mid frequency



High frequency



Test specification:	**Section 15.207, Conducted emission at AC power port**		
Test procedure:	ANSI C63.10, Section 6.7		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	04-Apr-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

7.6 Conducted emissions at AC power port

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)		Class A limit, dB(μV)	
	QP	AVRG	QP	AVRG
0.15 - 0.5	66 - 56*	56 - 46*	79	66
0.5 - 5.0	56	46	73	60
5.0 - 30	60	50	73	60

* The limit decreases linearly with the logarithm of frequency.

7.6.2 Test procedure

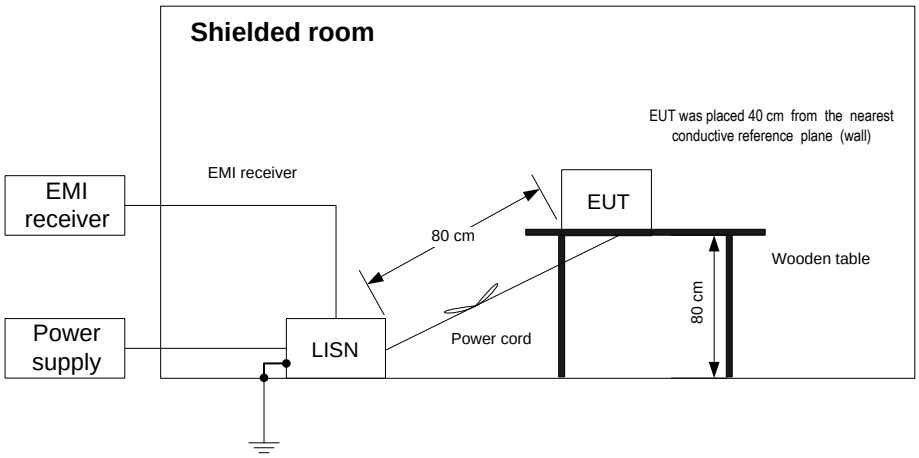
7.6.2.1 The EUT was set up as shown in Figure 7.6.1 and associated photographs, energized and the performance check was conducted.

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.

Test specification:	Section 15.207, Conducted emission at AC power port		
Test procedure:	ANSI C63.10, Section 6.7		
Test mode:	Compliance	Verdict:	PASS
Date(s):	04-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

Figure 7.6.1 Setup for conducted emission measurements



Photograph 7.6.1 Setup for conducted emission measurements

Test specification:	**Section 15.207, Conducted emission at AC power port**		
Test procedure:	ANSI C63.10, Section 6.7		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	04-Apr-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

Table 7.6.2 Conducted emission test results

LINE: AC mains
LIMIT: Class B
EUT OPERATING MODE: Tx / Rx
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*		
0.184	49.8	47.6	64.3	-16.7	34.7	54.3	-19.6	L1	Pass
0.220	49.7	47.6	62.9	-15.3	33	52.9	-19.9		
0.367	46.8	44.5	58.6	-14.1	37.2	48.6	-11.4		
0.489	41.9	39.9	56.1	-16.2	32.8	46.2	-13.4		
0.981	44.4	42.3	56	-13.7	40.1	46	-5.9		
1.958	43.2	40.7	56	-15.3	39.4	46	-6.6		
0.185	47.6	41.9	64.3	-22.4	33.2	54.3	-21.1	L2	Pass
0.220	47.8	44.4	62.9	-18.5	35.7	52.9	-17.2		
0.360	48.6	46.4	58.8	-12.4	41.3	48.8	-7.5		
0.400	46.2	44.4	57.9	-13.5	38.2	47.9	-9.7		
0.979	46.5	43.9	56	-12.1	41.9	46	-4.1		
1.958	43.7	40.8	56	-15.2	39.2	46	-6.8		

*****- Margin = Measured emission - specification limit.

Reference numbers of test equipment used

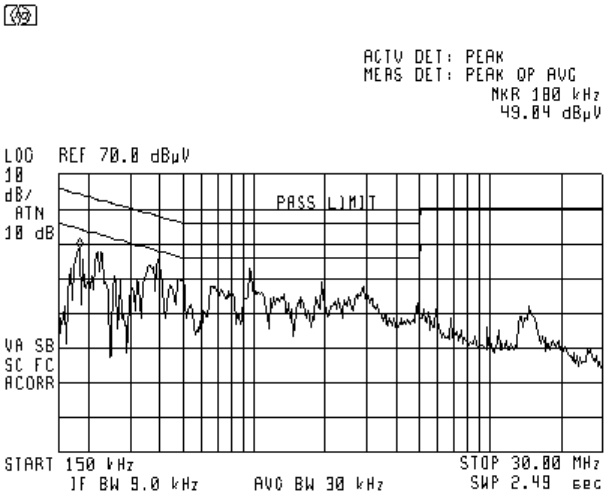
HL 0787	HL 3016	HL 4778					

Full description is given in Appendix A.

Test specification:	**Section 15.207, Conducted emission at AC power port**		
Test procedure:	ANSI C63.10, Section 6.7		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	04-Apr-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

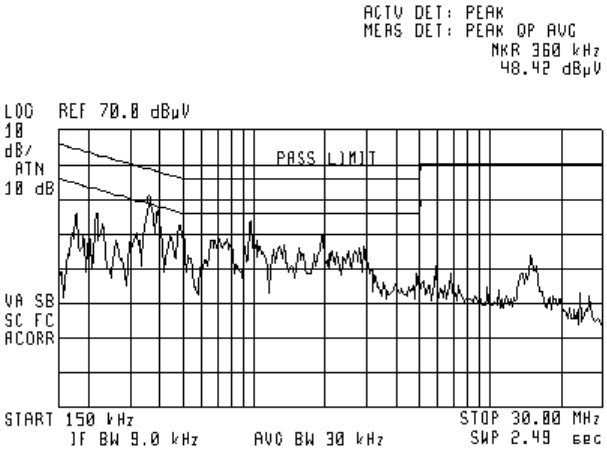
Plot 7.6.1 Conducted emission measurements

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



Plot 7.6.2 Conducted emission measurements

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



Test specification:	FCC Part 15, Section 203, Antenna requirements		
Test procedure:	Visual inspection		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: NA
Remarks:			

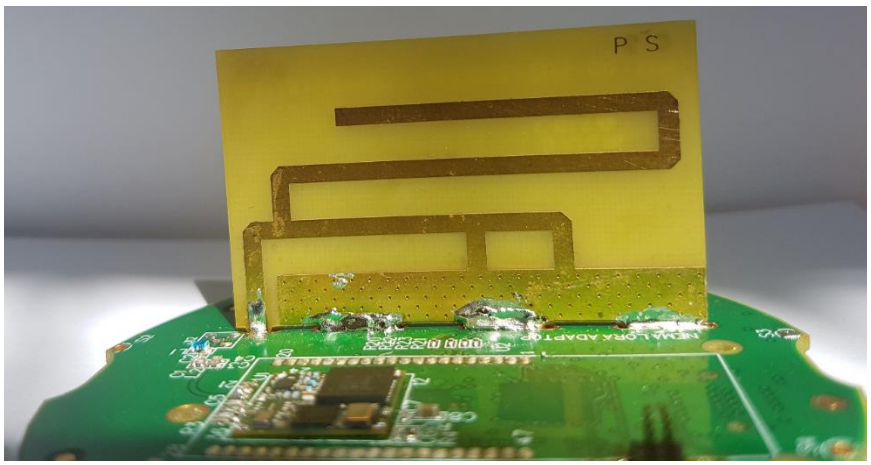
7.7 Antenna requirements

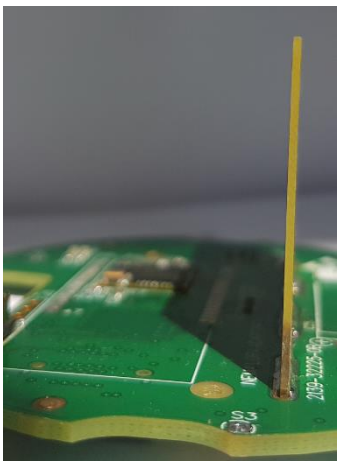
The EUT was verified for compliance with antenna requirements. A transmitter shall be designed to ensure that no antenna other than that furnished by the responsible party will be used with the device. It may be either permanently attached or employs a unique antenna connector for every antenna proposed 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.

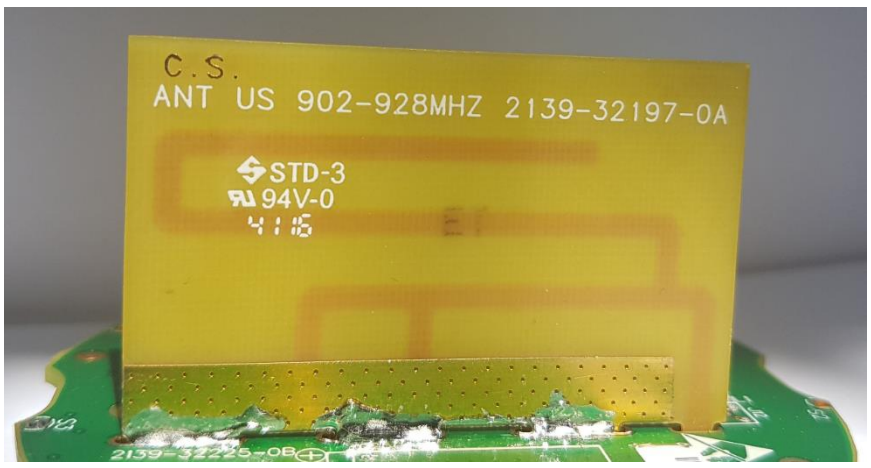
Table 7.7.1 Antenna requirements

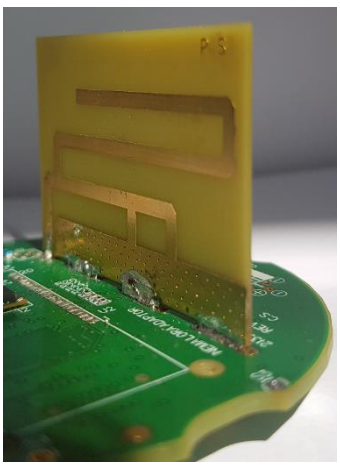
Requirement	Rationale	Verdict
The transmitter antenna is permanently attached	Visual inspection	Comply
The transmitter employs a unique antenna connector	NA	
The transmitter requires professional installation	NA	

Photograph 7.7.1 Antenna assembly









Test specification:	Section 15.107, Conducted emission at AC power port		
Test procedure:	ANSI C63.4, Sections 11.5 and 12.1.3		
Test mode:	Compliance	Verdict:	PASS
Date(s):	04-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

8 Unintentional emissions according to 47CFR part 15 subpart B

8.1 Conducted emissions

8.1.1 General

This test was performed to measure common mode conducted emissions at the mains power port.
Specification test limits are given in Table 8.1.1. The worst test results (the lowest margins) were recorded in Table 8.1.2 and shown in the associated plots.

Table 8.1.1 Limits for conducted emissions

Frequency, MHz	Class B limit, dB(μV)		Class A limit, dB(μV)	
	QP	AVRG	QP	AVRG
0.15 - 0.5	66 - 56*	56 - 46*	79	66
0.5 - 5.0	56	46	73	60
5.0 - 30	60	50	73	60

* The limit decreases linearly with the logarithm of frequency.

8.1.2 Test procedure

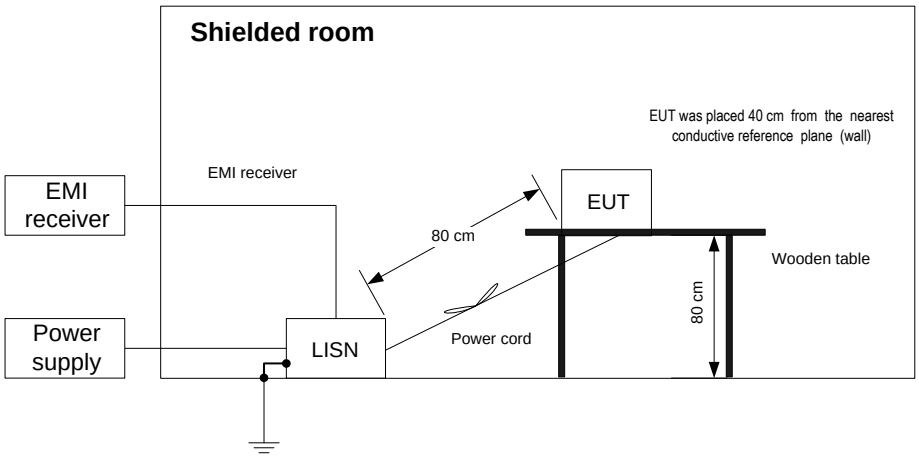
8.1.2.1 The EUT was set up as shown in Figure 8.1.1 and associated photographs, energized and the performance check was conducted.

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.

Test specification:	Section 15.107, Conducted emission at AC power port		
Test procedure:	ANSI C63.4, Sections 11.5 and 12.1.3		
Test mode:	Compliance	Verdict:	PASS
Date(s):	04-Apr-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

Figure 8.1.1 Setup for conducted emission measurements



Photograph 8.1.1 Setup for conducted emission measurements

Test specification:	**Section 15.107, Conducted emission at AC power port**		
Test procedure:	ANSI C63.4, Sections 11.5 and 12.1.3		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	04-Apr-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

Table 8.1.2 Conducted emission test results

LINE: AC mains
LIMIT: Class B
EUT OPERATING MODE: Tx / Rx
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*		
0.184	49.7	47.5	64.3	-16.8	34.6	54.3	-19.7	L1	Pass
0.220	49.7	47.6	62.9	-15.3	33.0	52.9	-19.9		
0.367	46.8	44.5	58.6	-14.1	37.2	48.6	-11.4		
0.489	41.8	39.8	56.2	-16.4	32.2	46.2	-14.0		
0.981	44.5	42.2	56.0	-13.8	40.0	46.0	-6.0		
1.958	43.1	40.6	56.0	-15.4	39.3	46.0	-6.7		
0.185	47.6	41.9	64.3	-22.4	33.2	54.3	-21.1	L2	Pass
0.220	47.7	44.3	62.9	-18.6	35.6	52.9	-17.3		
0.360	48.5	46.2	58.8	-12.6	41.3	48.8	-7.5		
0.400	46.1	44.4	57.9	-13.5	38.0	47.9	-9.9		
0.979	46.4	43.9	56.0	-12.1	41.8	46.0	-4.2		
1.958	43.6	40.7	56.0	-15.3	39.1	46.0	-6.9		

*****- Margin = Measured emission - specification limit.

Reference numbers of test equipment used

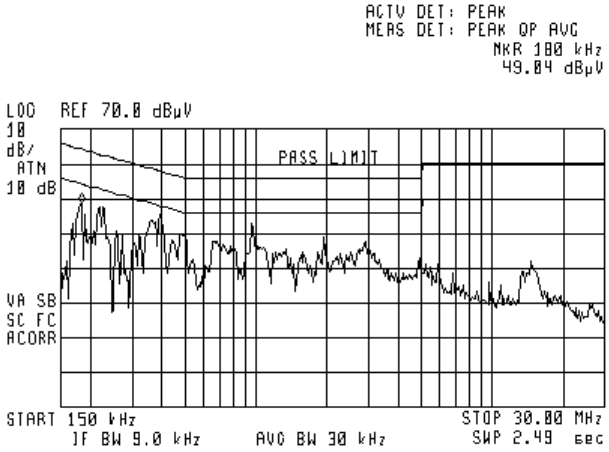
HL 3016	HL 4778	HL 787					

Full description is given in Appendix A.

Test specification:	**Section 15.107, Conducted emission at AC power port**		
Test procedure:	ANSI C63.4, Sections 11.5 and 12.1.3		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	04-Apr-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

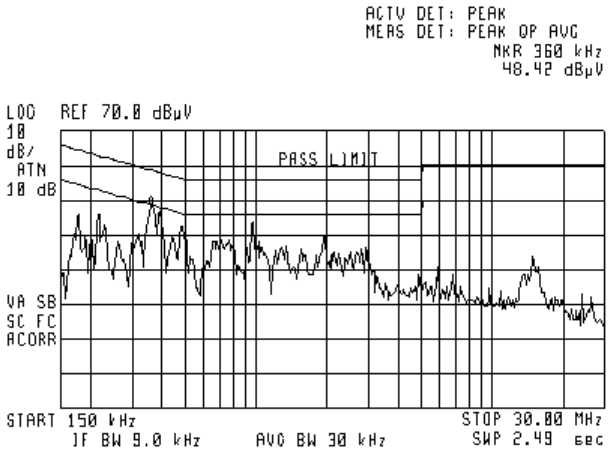
Plot 8.1.1 Conducted emission measurements

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



Plot 8.1.2 Conducted emission measurements

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



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):	29-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
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: $Lim_{S2} = Lim_{S1} + 20 \log (S_1/S_2)$,
where S_1 and S_2 – standard defined and test distance respectively in meters.

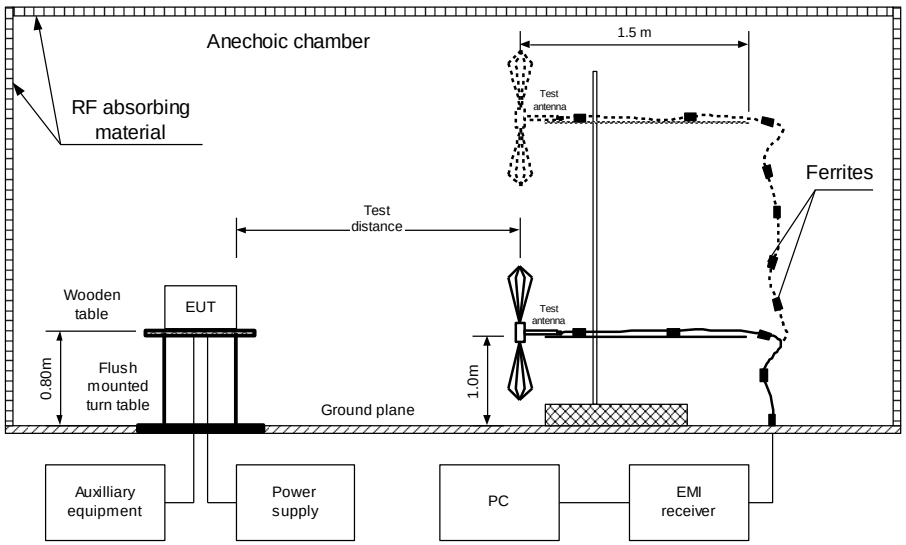
8.2.2 Test procedure for measurements in semi-anechoic chamber

8.2.2.1 The EUT was set up as shown in Figure 8.2.1 and associated photographs, 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 360^0, 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.

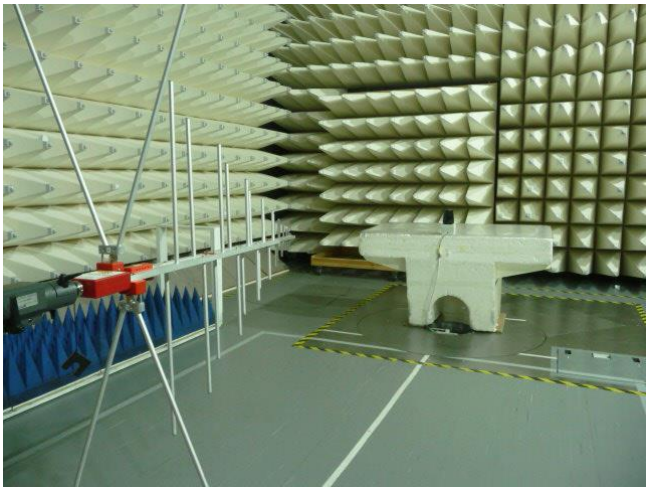
8.2.2.3 The worst test results (the lowest margins) were recorded in Table 8.2.2 and shown in the associated plots.

Figure 8.2.1 Setup for radiated emission measurements

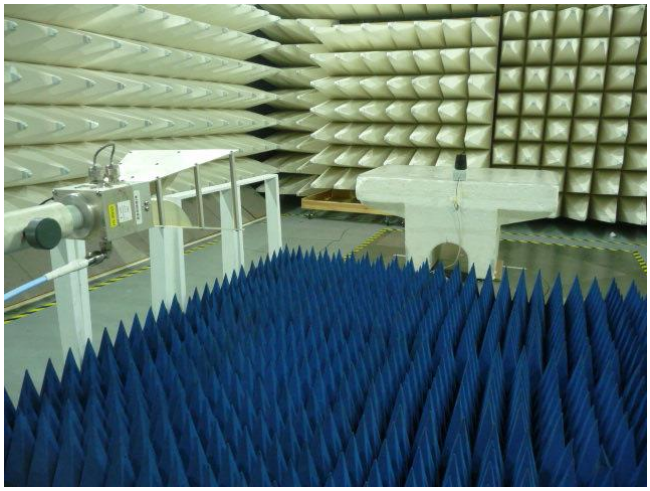


Test specification:	Section 15.109, Radiated emission		
Test procedure:	ANSI C63.4, Sections 11.6 and 12.1.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

Photograph 8.2.1 Setup for radiated emission measurements, general view

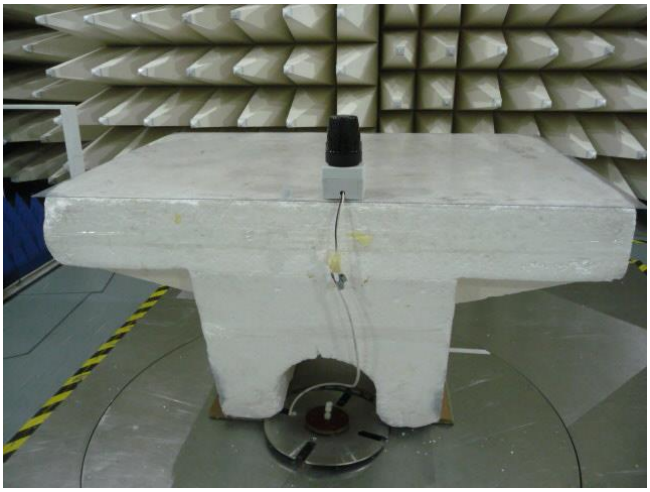


Below 1 GHz



Above 1 GHz

Photograph 8.2.2 Setup for radiated emission measurements, EUT cabling



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):	29-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 110 VAC, 60 Hz
Remarks:			

Table 8.2.2 Radiated emission test results

EUT SET UP: TABLE-TOP
LIMIT: Class B
EUT OPERATING MODE: Rx / 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***				
All emissions were at least 20 dB bellow limit								Pass

TEST SITE: SEMI ANECHOIC CHAMBER
TEST DISTANCE: 3 m
DETECTORS USED: PEAK / AVERAGE
FREQUENCY RANGE: 1000 MHz – 5000 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***				
All emissions were at least 20 dB bellow limit										Pass

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

Reference numbers of test equipment used

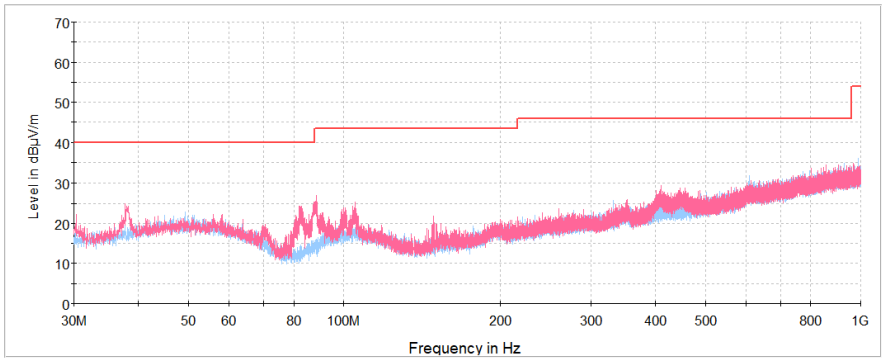
HL 5288	HL 4360	HL 3903	HL 5404	HL 4933			

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):	29-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1008 hPa	Power: 110 VAC, 60 Hz
Remarks:			

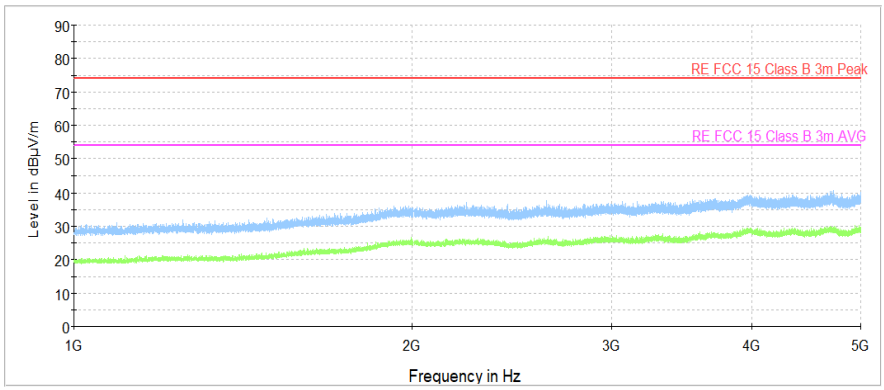
Plot 8.2.1 Radiated emission measurements in 30 - 1000 MHz range

TEST SITE: Semi anechoic chamber
LIMIT: Class B
TEST DISTANCE: 3 m
EUT OPERATING MODE: Rx / Standby
ANTENNA POLARIZATION: Vertical & Horizontal



Plot 8.2.2 Radiated emission measurements above 1000 MHz

TEST SITE: Semi anechoic chamber
LIMIT: Class B
TEST DISTANCE: 3 m
EUT OPERATING MODE: Rx / Standby
ANTENNA POLARIZATION: Vertical & Horizontal



9 APPENDIX A Test equipment and ancillaries used for tests

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
0446	Antenna, Loop, Active, 10 (9) kHz - 30 MHz	EMCO	6502	2857	24-Feb-19	24-Feb-20
0787	Transient Limiter 9 kHz-200 MHz	Hewlett Packard	11947A	3107A01877	08-Oct-18	08-Oct-19
1915	Antenna, Loop, Active Receiving, 1 kHz - 30 MHz	EMC Test Systems	6507	1457	24-Feb-19	24-Feb-20
2909	Spectrum analyzer, ESA-E, 100 Hz to 26.5 GHz	Agilent Technologies	E4407B	MY41444762	04-Apr-19	04-Apr-20
3016	LISN, Two-line V-network, 9 kHz to 30 MHz, (50 uH+5 Ohm)	Rohde & Schwarz	ESH 3-Z5	892239/002	27-Jan-19	27-Jan-20
3433	Test Cable , DC-18 GHz, 1.5 m, SMA - SMA	Mini-Circuits	CBL-5FT-SMSM+	25679	28-Mar-18	28-Mar-19
3434	Test Cable , DC-18 GHz, 1.5 m, SMA - SMA	Mini-Circuits	CBL-5FT-SMSM+	25683	28-Mar-18	28-Mar-19
3440	Precision Fixed Attenuator, 50 Ohm, 5 W, 20 dB, DC to 18 GHz	Mini-Circuits	BW-S20W5+	NA	10-Dec-18	10-Dec-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
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1226/2A	07-Apr-19	07-Apr-20
4277	Test Cable , DC-18 GHz, 3.05 m, N/M - N/M	Mini-Circuits	APC-10FT-NMNM+	0748A	01-Aug-18	01-Aug-19
4339	High pass Filter, 50 Ohm, 1-18 GHz, SMA-FM / SMA-M	Micro-Tronics	HPM50115-02	1	14-May-17	14-Mar-19
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	31-Dec-18	31-Dec-19
4778	EMI Receiver, 9 kHz - 2.9 GHz, System: HL1431, HL4777	Hewlett Packard	8542E	30807A00262 3427A00123	28-Oct-18	28-Oct-19
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	06-Jan-19	06-Jan-20
5111	RF cable, 40 GHz, 5.5 m, K-type	Huber-Suhner	SF102EA/11SK/11SK/5500MM	502493/2EA	09-Apr-18	09-Apr-19
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	809	08-Feb-19	08-Feb-22
5404	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11N(x2)	500024/18	01-Aug-18	01-Aug-19

10 APPENDIX B Test laboratory description

Tests were performed at Hermon Laboratories Ltd., which is a fully independent, private, EMC, Radio, Safety, Environmental and Telecommunication testing facility.
Hermon Laboratories is recognized and accredited by the Federal Communications Commission (USA) for relevant parts of Code of Federal Regulations 47 (CFR 47), Test Firm Registration Number is 927748, Designation Number is IL1001; Recognized by Innovation, Science and Economic Development Canada for wireless and terminal testing (ISED), CAB identifier is IL1001, ISED# number 2186A; Certified by VCCI, Japan (the registration numbers are R-10808 for OATS, R-1082 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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Person for contact: Mr. M. Nikishin, EMC and radio group leader

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 1915: Loop Antenna
EMC Test Systems, model: 6507, s/n 1457

Frequency,	Antenna factor, dB/m
9	-21.8
10	-23.0
20	-27.3
50	-31.3
75	-32.0
100	-32.2
150	-32.5
250	-32.8
500	-33.1
750	-33.2

Frequency, MHz	Antenna factor, dB/m
1000	-33.3
2000	-33.7
3000	-34.0
4000	-34.3
5000	-34.6
10000	-35.4
15000	-36.0
20000	-36.3
25000	-37.3
30000	-37.8

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

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

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

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

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

12 APPENDIX D Measurement uncertainties

Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements

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

Hermon Laboratories is accredited by A2LA for calibration according to present requirements of ISO/IEC 17025 and NCSL Z540-1. The accreditation is granted to perform calibration of parameters that are listed in the Scope of Hermon Laboratories Accreditation.
Hermon Laboratories calibrates its reference and transfer standards by calibration laboratories accredited to ISO/IEC 17025 by a mutually recognized Accreditation Body or by a recognized national metrology institute. All reference and transfer standards used in the calibration system are traceable to national or international standards.
In-house calibration of all test and measurement equipment is performed on a regular basis according to Hermon Laboratories calibration procedures, manufacturer calibration/verification procedures or procedures defined in the relevant standards. The Hermon Laboratories test and measurement equipment is calibrated within the tolerances specified by the manufacturers and/or by the relevant standards.

13 APPENDIX E Specification references

FCC 47CFR part 15:2018	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	LISN	line impedance stabilization network
AC	alternating current	m	meter
A/m	ampere per meter	MHz	megahertz
AM	amplitude modulation	MIL	military
ASSL	abnormal steady state limits	mm	millimeter
ATP	acceptance test procedure	ms	millisecond
AVRG	average (detector)	μF	microfarad
BB	broad band	μs	microsecond
cm	centimeter	NA	not applicable
dB	decibel	NB	narrow band
dBm	decibel referred to one milliwatt	NP	normal performance
dB(μA)	decibel referred to one microampere	NSSL	normal steady state limits
dBμV	decibel referred to one microvolt	NT	not tested
dBμV/m	decibel referred to one microvolt per meter	OATS	open area test site
DC	direct current	Ω	Ohm
EMI	electromagnetic interference	QP	quasi-peak
ESS	environmental stress screening	PBIT	periodic built in test
ESSL	emergency steady state limits	PM	pulse modulation
EUT	equipment under test	PS	power supply
FTE	functional test equipment	RE	radiated emission
GHz	gigahertz	RF	radio frequency
GND	ground	rms	root mean square
H	height	s	second
HL	Hermon laboratories	STD	standard
Hz	hertz	TBD	to be defined
k	kilo	V	volt
kHz	kilohertz	VA	volt-ampere
kV	kilovolt	W	width
L	length	W	watt

END OF DOCUMENT