HERMON LABORATORIES

ELECTRICAL TESTING
0839.01

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TEST REPORT

ACCORDING TO: FCC 47CFR part 15 subpart C §15.247 (DTS)
RSS-247 issue 2, RSS-Gen issue 5

FOR:

Airthings AS
1) HUB model 2810
2) HUB Cellular model 2820
FCC ID:2APPT-2820
IC:23900-2820

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Table of contents

1 Applicant information ... 3
2 Equipment under test attributes ... 3
3 Manufacturer information ... 3
4 Test details ... 3
5 Tests summary ... 4
6 EUT description ... 5
6.1 General information ... 5
6.2 Ports and lines ... 5
6.3 Changes made in EUT ... 5
6.4 Test configuration ... 6
6.5 Transmitter characteristics ... 7
7 Transmitter tests according to 47CFR part 15 subpart C and RSS-247 requirements ... 8
7.1 Minimum 6 dB bandwidth and 99% occupied bandwidth ... 8
7.2 Maximum peak output power ... 12
7.3 Maximum peak output power ... 15
7.4 Field strength of spurious emissions ... 18
7.5 Field strength of spurious emissions ... 34
7.6 Band edge radiated emissions ... 48
7.7 Band edge radiated emissions ... 51
7.8 Maximum power spectral density (PSD) ... 54
7.9 Antenna requirements ... 58
7.10 Conducted emissions ... 59
8 APPENDIX A Test equipment and ancillaries used for tests ... 62
9 APPENDIX B Measurement uncertainties ... 63
10 APPENDIX C Test laboratory description ... 64
11 APPENDIX D Specification references ... 64
12 APPENDIX E Test equipment correction factors ... 65
13 APPENDIX F Abbreviations and acronyms ... 72

1 Applicant information

Client name:	Airthings AS
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Telephone:	+47 909 686 23
E-mail:	eivind.fremstad@airthings.com
Contact name:	Mr. Eivind Fremstad

2 Equipment under test attributes

Product name:	HUB
Product type:	Transceiver
Model:	HUB 2810
Hardware version:	2
Software release:	1.0.0
Model:	HUB Cellular 2820
Hardware version:	2
Software release:	1.0.0
Receipt date	22-Aug-18

3 Manufacturer information

Manufacturer name:	Crow Electronic Engineering Ltd.
Address:	12 Kineret street, P.O.Box 293, Ben Gurion Airport, Airport City, 7010000, Israel
Telephone:	+972 3972 6049
Fax:	+972 3972 6001
E-Mail:	igal@crow.co.il
Contact name:	Mr. Igal Bromberg

4 Test details

Project ID:	31178
Location:	Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started:	22-Aug-18
Test completed:	17-Mar-19
Test specification(s):	FCC 47CFR part 15, subpart C, §15.247(DTS); RSS-247 issue 2, RSS-Gen issue 5

5 Tests summary

Test	Status
Transmitter characteristics	
FCC section 15.247(a)2/ RSS-247 section 5.2(a), 6 dB bandwidth and RSS-Gen section 6.7, 99% occupied bandwidth	Pass
FCC section 15.247(b)3/ RSS-247 section 5.4(d), Maximum peak output power	Pass
FCC section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions	Pass
FCC section 15.247(d) / RSS-247 section 5.5, Emissions at band edges	Pass
FCC section 15.247(e) / RSS-247 section 5.2(b), Maximum power spectral density	Pass
FCC section 15.247(i)5/ RSS-102 section 2.5, RF exposure	Pass, the exhibit to the application of certification is provided
FCC section 15.203/ RSS-Gen section 6.8, Antenna requirements	Pass
FCC section 15.207(a) / RSS-Gen section 8.8, Conducted emission	Pass

Testing was completed against all relevant requirements of the test standard. The results obtained indicate that the product under test complies in full with the requirements tested.
The test results relate only to the items tested. Pass/ fail decision was based on nominal values.

	Name and Title	Date	Signature
Tested by:	Mr. K. Zushchyk, test engineer Mr. A. Morozov, test engineer Mr. S. Samokha, test engineer	November 6, 2018	
Reviewed by:	Mrs. M. Cherniavsky, certification engineer	March 20, 2019	
Approved by:	Mr. M. Nikishin, EMC and radio group leader	March 25, 2019	

6 EUT description

6.1 General information

The Hub is the heart of the Airthings Ecosystem. It brings one or more supported devices online, providing on-demand access to Indoor Air Quality (IAQ) data at anytime, from anywhere. Continuous monitoring of your Indoor Air Quality levels is necessary to minimize potential health effects in all populated spaces.

The HUB is provided in two configurations: with and without Cellular module.

The HUB, model 2810, has CC2640R2F BLE 2.4 GHz chip on the board. The BLE 2.4GHz chip is actively used in RF operation. There is one additional radio in the HUB. That is CC1310F128 operating in 902-928 MHz.
The HUB Cellular, model 2820, has CC2640R2F BLE 2.4GHz chip radio on the board.There are two additional radios in HUB Cellular. That is CC1310F128 operating in 902-928 MHz and BG96 Cellular Module, FCC ID XMR201707BG96, that operates at many cellular frequency bands.
The HUB is powered from AC mains via AC/DC adapter manufactured by Dongguan Yingna Electronic Technology Co., model YNQX12H050200HL.

This test report represents test results for 2.4 MHz radio.

6.2 Ports and lines

Port type	Port description	Connected from	Connected to	Qty.	Cable type	Cable length, m
Power	AC	AC adapter	AC mains	1	NA	NA
Power	DC	AC adapter	EUT HUB	1	Unshielded	1.5 m

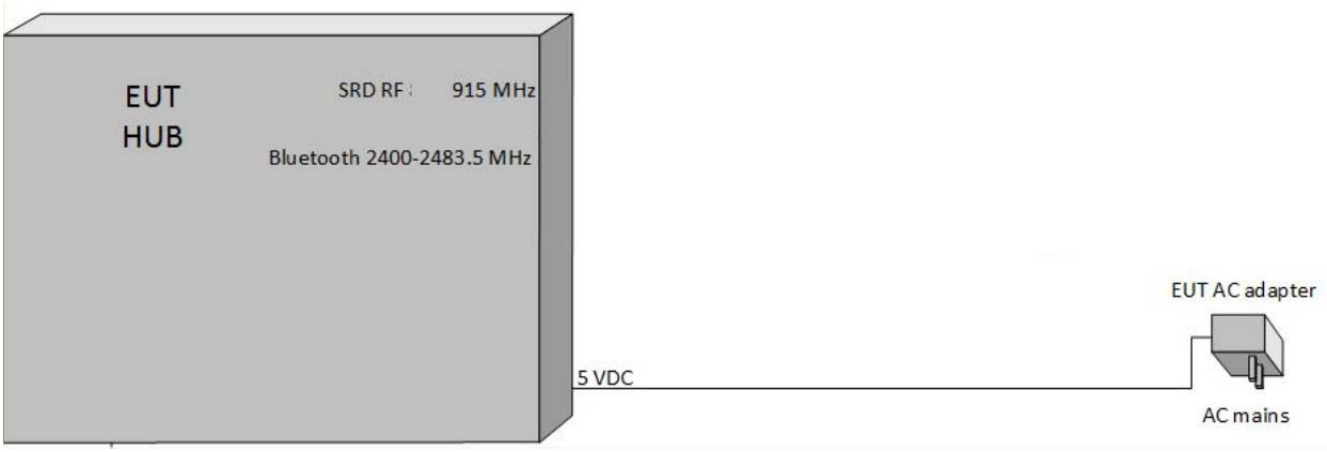
*may be up to 100 m

6.3 Changes made in EUT

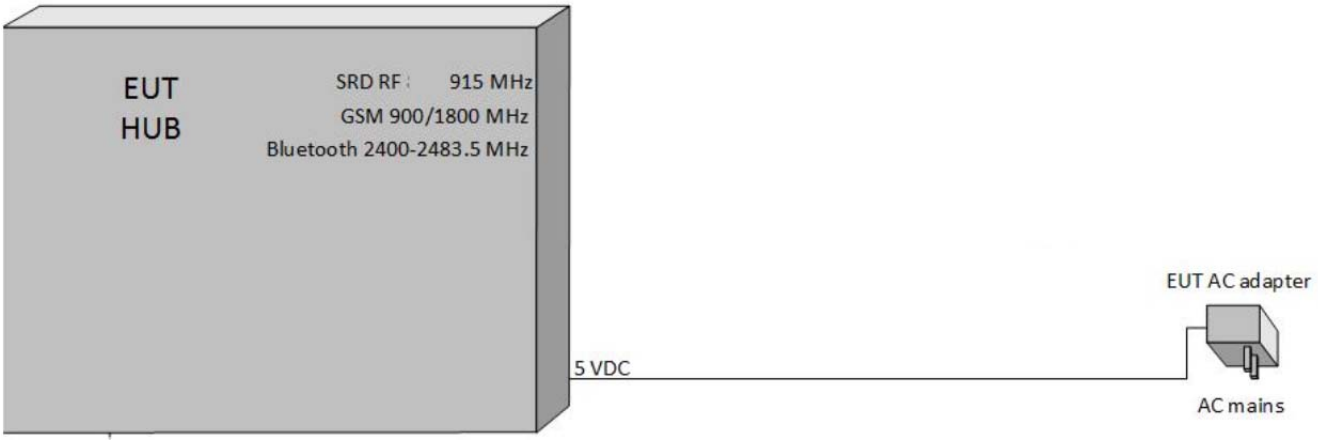
To withstand the standard requirements, the following changes were implemented in the EUT during testing:
a power transient voltage suppressor (TVS) of 100V manufactured by CYG WAYON CIRCUIT PROTECTION CO., LTD., model SMAJ100CA-TR was soldered on top of C86 capacitor of 1nF/2KV placed on main PCB.
It is manufacturer responsibility to implement the change in the production version of the EUT. In any case the test report applies to the tested item only.

6.4 Test configuration

6.4.1 HUB model 2810 configuration



6.4.2 HUB Cellular model 2820 configuration



6.5 Transmitter characteristics

Type of equipment	
X	Stand-alone (Equipment with or without its own control provisions)
	Combined equipment (Equipment where the radio part is fully integrated within another type of equipment)
	Plug-in card (Equipment intended for a variety of host systems)

Intended use		Condition of use
	fixed	Always at a distance more than 2 m from all people
X	mobile	Always at a distance more than 20 cm from all people
	portable	May operate at a distance closer than 20 cm to human body

Assigned frequency ranges	2400-2483.5 MHz
Operating frequencies	2402-2480 MHz

Maximum rated output power	At transmitter 50 Ω RF output connector	dBm
	Peak output power	-1.03 dBm (Hub 2820), -0.12 dBm (Hub 2810)

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
Integral	Crow	Printed	2.5 dBi

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

Transmitter power source					
	Battery	**Nominal rated voltage**		Battery type	
	DC	**Nominal rated voltage**	5		
X	AC mains	**Nominal rated voltage**	Via 120 VAC/5 VDC adapter	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 / RSS-247 section 5.2(a), 6 dB bandwidth and RSS-Gen section 6.7, 99% occupied bandwidth**		
Test procedure:	ANSI C63.10 section 11.8.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

7 Transmitter tests according to 47CFR part 15 subpart C and RSS-247 requirements

7.1 Minimum 6 dB bandwidth and 99% occupied bandwidth

7.1.1 General

This test was performed to measure the 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
2400.0 – 2483.5	**6.0**	500.0

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

Table 7.1.2 The 99% bandwidth limits

Assigned frequency, MHz	Modulation envelope reference points	Limit, kHz
2400.0 – 2483.5	99%	NA

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.

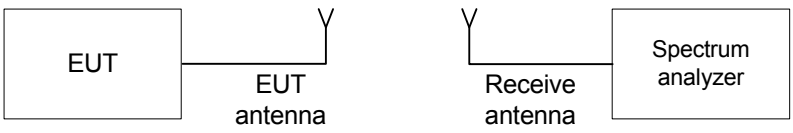
7.1.2.2 The EUT was set to transmit modulated carrier at maximum data rate (low channel).

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 7.1.3 and the associated plots.

7.1.2.4 The test was repeated for mid and high carrier frequencies.

7.1.2.5 The transmitter 99% occupied bandwidth was measured with spectrum analyzer as frequency delta between reference points on modulation envelope and provided in Table 7.1.4 and the associated plots.

Figure 7.1.1 The 6 dB bandwidth test setup



Test specification:	**Section 15.247(a)2 / RSS-247 section 5.2(a), 6 dB bandwidth and RSS-Gen section 6.7, 99% occupied bandwidth**		
Test procedure:	ANSI C63.10 section 11.8.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Table 7.1.3 The 6 dB bandwidth test results

ASSIGNED FREQUENCY BAND: 2400 – 2483.5 MHz
DETECTOR USED: Peak
SWEEP TIME: Auto
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: 300 kHz
MODULATION ENVELOPE REFERENCE POINTS: 6.0 dBc

Carrier frequency, MHz	6 dB bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
2402	744.0	500	244.0	Pass
2440	751.3	500	251.3	Pass
2480	762.9	500	262.9	Pass

Table 7.1.4 The 99% bandwidth test results

ASSIGNED FREQUENCY BAND: 2400 – 2483.5 MHz
DETECTOR USED: Peak
SWEEP TIME: Auto
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: 300 kHz
MODULATION ENVELOPE REFERENCE POINTS: 99% BW

Carrier frequency, MHz	99% bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
2402	1079.2	NA	NA	Pass
2440	1086.1	NA	NA	Pass
2480	1095.7	NA	NA	Pass

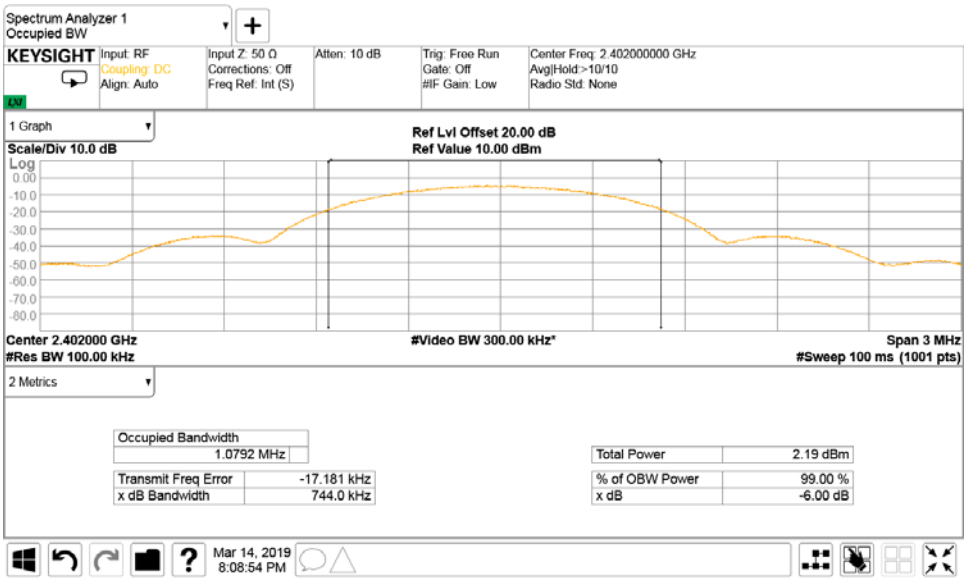
Reference numbers of test equipment used

HL 3440	HL 5376							

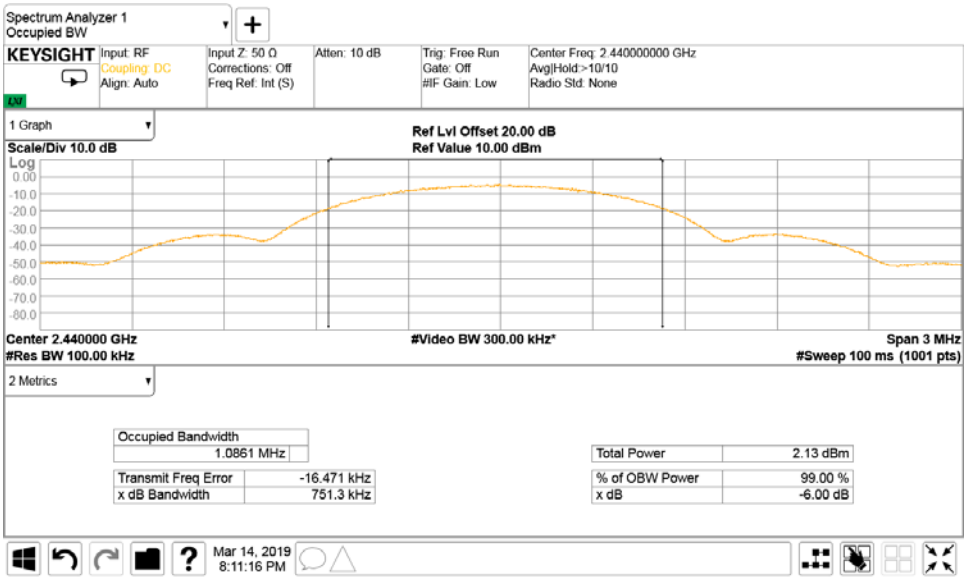
Full description is given in Appendix A.

Test specification:	**Section 15.247(a)2 / RSS-247 section 5.2(a), 6 dB bandwidth and RSS-Gen section 6.7, 99% occupied bandwidth**		
Test procedure:	ANSI C63.10 section 11.8.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Plot 7.1.1 The 6 dB bandwidth test result at low frequency

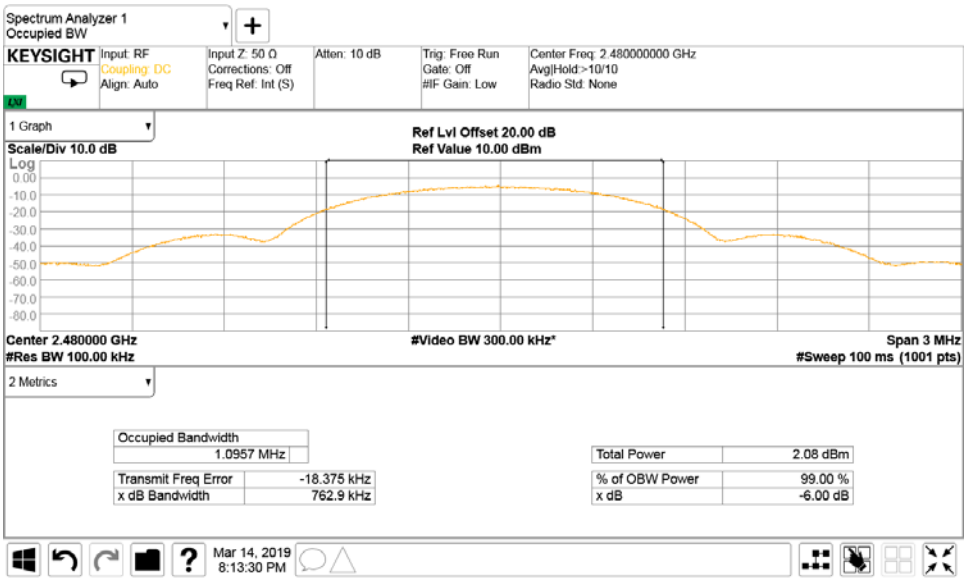


Plot 7.1.2 The 6 dB bandwidth test result at mid frequency



Test specification:	**Section 15.247(a)2 / RSS-247 section 5.2(a), 6 dB bandwidth and RSS-Gen section 6.7, 99% occupied bandwidth**		
Test procedure:	ANSI C63.10 section 11.8.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Plot 7.1.3 The 6 dB bandwidth test result at high frequency



Test specification:	Section 15.247(b)3/ RSS-247 section 5.4(d), Maximum peak output power		
Test procedure:	ANSI C63.10 section 11.9.1.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Oct-18 - 05-Nov-18		
Temperature: 22 ºC	Relative Humidity: 50 %	Air Pressure: 1013 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2810			

7.2 Maximum peak output power

7.2.1 General

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

Table 7.2.1 Peak output power limits

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

*- 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.
**- 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.

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 frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. To find maximum radiation the turntable was rotated 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:

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

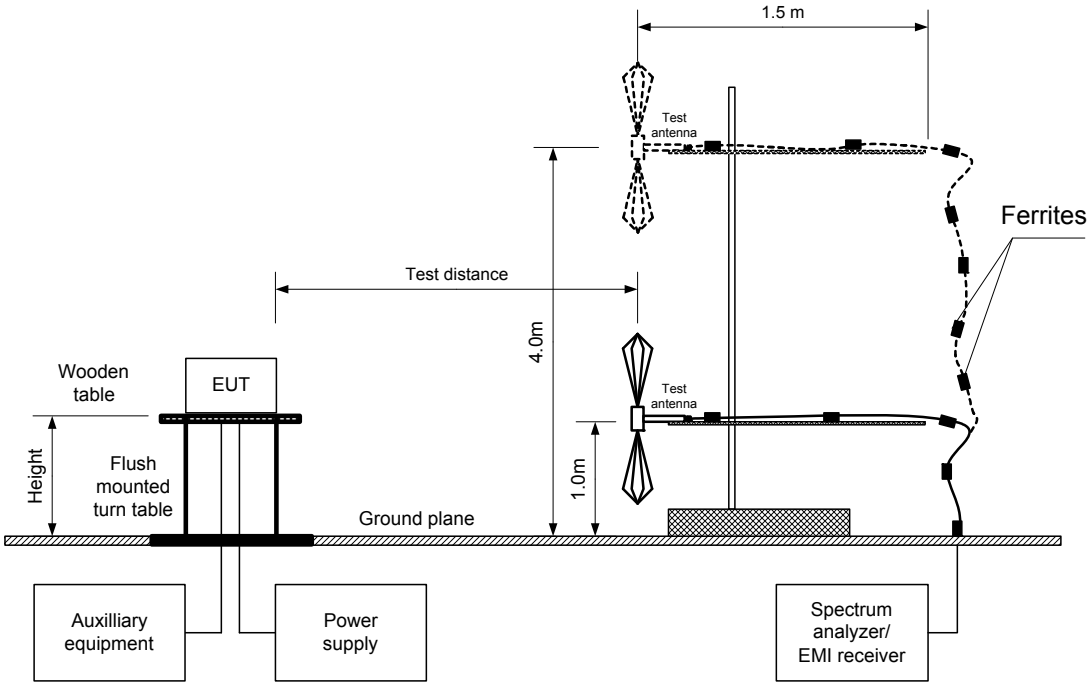
where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.
The above equation was converted in logarithmic units for 3 m test distance:

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)3/ RSS-247 section 5.4(d), Maximum peak output power**		
Test procedure:	ANSI C63.10 section 11.9.1.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Oct-18 - 05-Nov-18		
Temperature: 22 ºC	**Relative Humidity:** 50 %	**Air Pressure:** 1013 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Figure 7.2.1 Setup for carrier field strength measurements



Test specification:	**Section 15.247(b)3/ RSS-247 section 5.4(d), Maximum peak output power**		
Test procedure:	ANSI C63.10 section 11.9.1.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Oct-18 - 05-Nov-18		
Temperature: 22 ºC	**Relative Humidity:** 50 %	**Air Pressure:** 1013 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.2.2 Peak output power test results

ASSIGNED FREQUENCY:	2400-2483.5 MHz
TEST DISTANCE:	3 m
TEST SITE:	Semi anechoic chamber
DETECTOR USED:	Peak
TEST ANTENNA TYPE:	Double ridged guide (above 1000 MHz)
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
RESOLUTION BANDWIDTH:	3 MHz
VIDEO BANDWIDTH:	10 MHz
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Field strength, dB(µV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
2401.9806	97.54	V	1.03	-112.0	2.5	-0.16	30.0	-30.16	Pass
2439.7333	95.88	V	1.00	26.0	2.5	-1.82	30.0	-31.82	Pass
2479.6995	97.58	V	1.12	-36.0	2.5	-0.12	30.0	-30.12	Pass

*****- EUT front panel refer to 0 degrees position of turntable.
******- Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$,
where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance: *Peak output power in dBm = Field strength in dB(µV/m) - Transmitter antenna gain in dBi – 95.2 dB*
***- Margin = Peak output power – specification limit.

Reference numbers of test equipment used

HL 3903	HL4360	HL 4933	HL 5405				

Full description is given in Appendix A.

Test specification:	Section 15.247(b)3/ RSS-247 section 5.4(d), Maximum peak output power		
Test procedure:	ANSI C63.10 section 11.9.1.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	23-Aug-18		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1008 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2820			

7.3 Maximum peak output power

7.3.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.3.1.

Table 7.3.1 Peak output power limits

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

*- 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.
**- 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.

7.3.2 Test procedure

7.3.2.1 The EUT was set up as shown in Figure 7.3.1, energized and its proper operation was checked.

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

7.3.2.3 The frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. To find maximum radiation the turntable was rotated 360^0 and the measuring antenna height was swept in both vertical and horizontal polarizations.

7.3.2.4 The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.6.2 and associated plots.

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

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

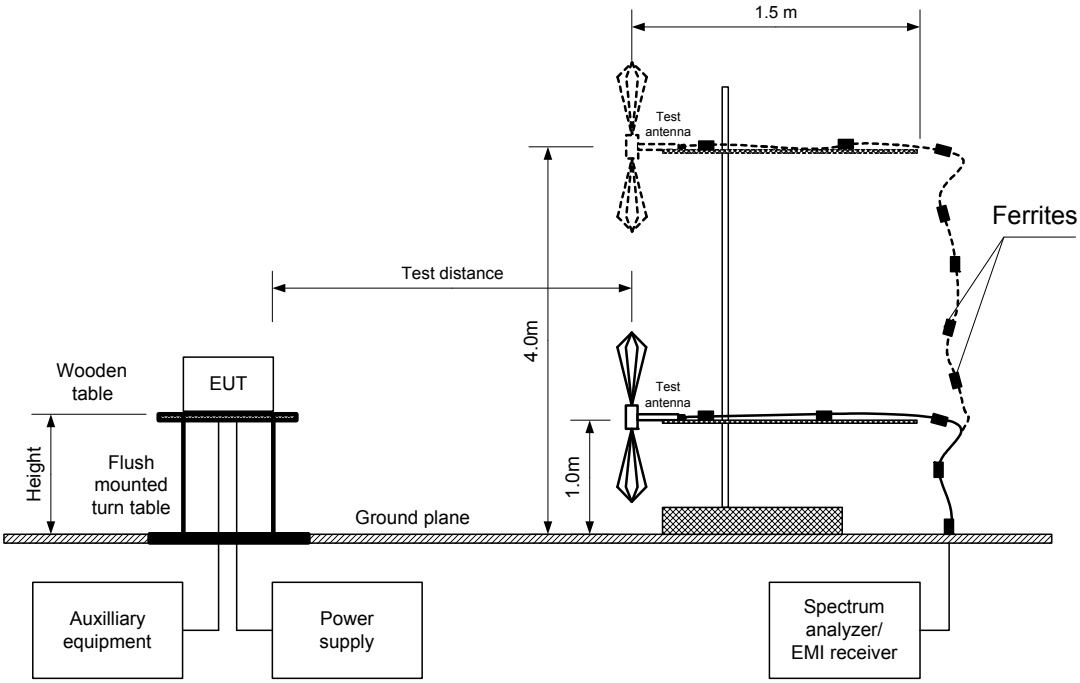
where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.
The above equation was converted in logarithmic units for 3 m test distance:

Peak output power in dBm = Field strength in dB(µV/m) - Transmitter antenna gain in dBi – 95.2 dB

7.3.2.6 The worst test results (the lowest margins) were recorded in Table 7.3.2.

Test specification:	**Section 15.247(b)3/ RSS-247 section 5.4(d), Maximum peak output power**		
Test procedure:	ANSI C63.10 section 11.9.1.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Figure 7.3.1 Setup for carrier field strength measurements



Test specification:	**Section 15.247(b)3/ RSS-247 section 5.4(d), Maximum peak output power**		
Test procedure:	ANSI C63.10 section 11.9.1.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.3.2 Peak output power test results

ASSIGNED FREQUENCY:	2400 – 2483.5 MHz
TEST DISTANCE:	3 m
TEST SITE:	Semi anechoic chamber
DETECTOR USED:	Peak
TEST ANTENNA TYPE:	Double ridged guide (above 1000 MHz)
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	3 MHz
VIDEO BANDWIDTH:	10 MHz
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Field strength, dB(µV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
2401.8915	96.67	Vertical	1.52	97.0	2.5	-1.03	30.00	-31.03	Pass
2440.1365	96.10	Vertical	1.78	112.0	2.5	-1.60	30.00	-31.60	Pass
2480.2370	95.44	Vertical	1.01	101.0	2.5	-2.06	30.00	-32.06	Pass

*****- EUT front panel refer to 0 degrees position of turntable.
******- Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$,
where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance: *Peak output power in dBm = Field strength in dB(µV/m) - Transmitter antenna gain in dBi – 95.2 dB*
***- Margin = Peak output power – specification limit.

Reference numbers of test equipment used

HL 3903	HL 4360	HL 4933	HL 5405				

Full description is given in Appendix A.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

7.4 Field strength of spurious emissions

7.4.1 General

This test was performed to measure field strength of spurious emissions from the EUT. Specification test limits are given in Table 7.4.1.

Table 7.4.1 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 – 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 tenth harmonic of the highest fundamental frequency.

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

7.4.2.1 The EUT was set up as shown in Figure 7.4.1, energized and the performance check was conducted.

7.4.2.2 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.

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

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

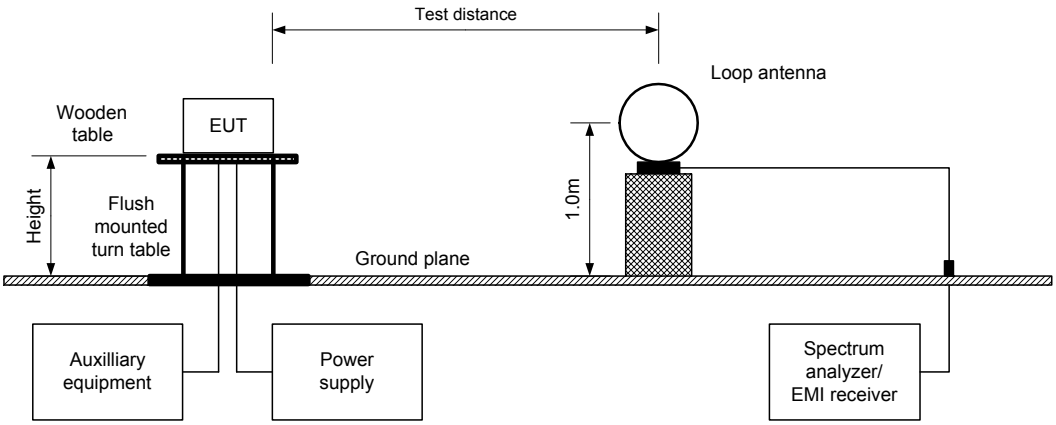
7.4.3.1 The EUT was set up as shown in Figure 7.4.2, Figure 7.4.3, energized and the performance check was conducted.

7.4.3.2 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.

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

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Figure 7.4.1 Setup for spurious emission field strength measurements below 30 MHz



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Figure 7.4.2 Setup for spurious emission field strength measurements from 30 to 1000 MHz

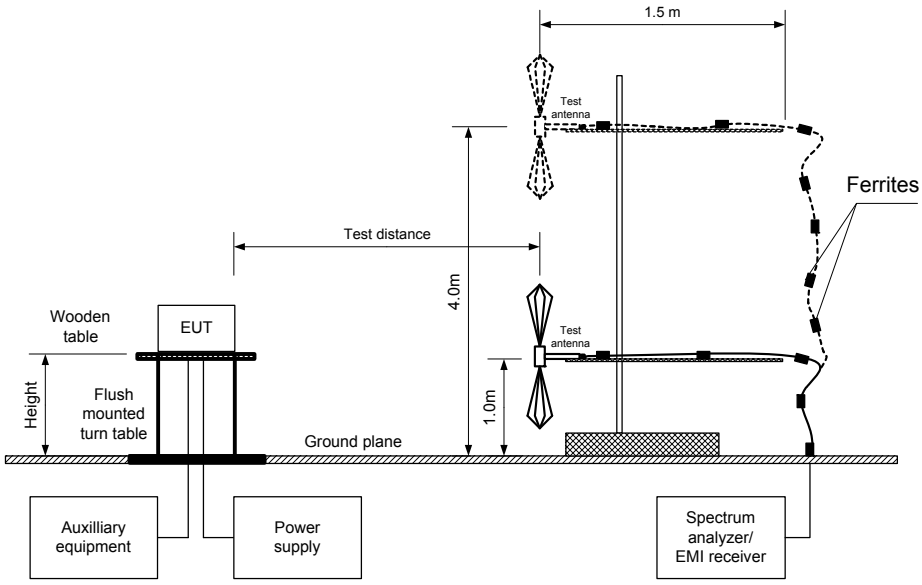
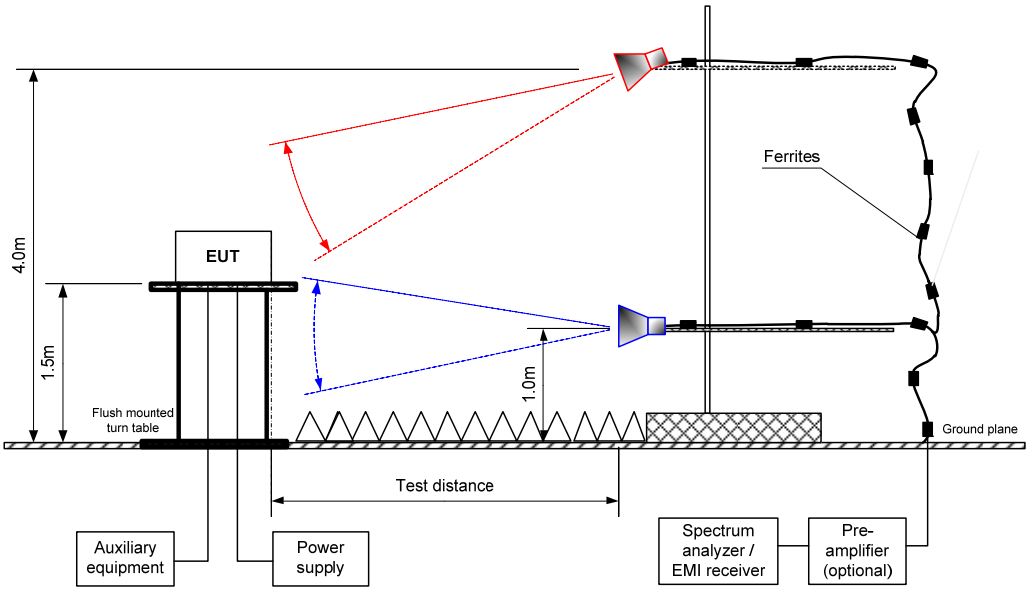


Figure 7.4.3 Setup for spurious emission field strength measurements above1000 MHz



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.4.2 Field strength of emissions outside restricted bands

ASSIGNED FREQUENCY:	2400.0 – 2483.5 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 25 000 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	1 Mbps
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 HOPPING:	Disabled

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									
33.8043	35.17	Vertical	1.01	180.0	96.77	61.60	20.0	41.60	Pass
55.8976	37.29	Vertical	1.00	99.0		59.48		39.48	
69.1060	30.68	Vertical	1.54	-46.0		66.09		46.09	
175.0240	39.89	Vertical	1.00	-46.0		56.88		36.88	
629.4770	37.92	Vertical	1.00	-46.0		58.85		38.85	
Mid carrier frequency									
33.7516	36.91	Vertical	1.00	180.0	94.84	57.93	20.0	37.93	Pass
57.0510	39.55	Vertical	1.00	99.0		55.29		35.29	
70.8091	28.63	Vertical	3.14	-98.0		66.21		36.21	
174.9936	39.69	Vertical	1.00	-46.0		55.15		35.15	
629.9506	36.91	Horizontal	1.23	-46.0		57.93		37.93	
High carrier frequency									
34.0796	34.72	Vertical	1.01	180.0	96.63	61.91	20.0	41.91	Pass
56.9830	38.31	Vertical	1.02	129.0		58.32		38.32	
64.6728	34.13	Vertical	1.54	-17.0		62.50		42.50	
174.9937	36.82	Vertical	1.00	-27.0		59.81		39.81	
623.9453	45.38	Horizontal	1.01	-134.0		51.25		31.25	

*****- EUT front panel refers to 0 degrees position of turntable.
******- Margin = Attenuation below carrier – specification limit.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.4.3 Field strength of spurious emissions above 1 GHz within restricted bands

ASSIGNED FREQUENCY:	2400.0 – 2483.5 MHz
INVESTIGATED FREQUENCY RANGE:	1000 – 25000 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	1000 kHz
TEST ANTENNA TYPE:	Double ridged guide
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Antenna		Azimuth, degrees*	Peak field strength(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**	
Low carrier frequency											
4804.4125	H	1.86	4.0	50.82	74.00	-23.18	43.66	NA	54.00	-10.34	Pass
Mid carrier frequency											
4879.5000	H	1.60	4.0	52.11	74.00	-21.89	45.80	NA	54.00	-8.2	Pass
High carrier frequency											
4959.4875	H	1.78	3.0	49.60	74.00	-24.40	41.19	NA	54.00	-12.81	Pass

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

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.4.4 Field strength of spurious emissions below 1 GHz within restricted bands

ASSIGNED FREQUENCY:	2400.0 – 2483.5 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 1000 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
RESOLUTION BANDWIDTH:	0.2 kHz (9 kHz – 150 kHz) 9.0 kHz (150 kHz – 30 MHz) 120 kHz (30 MHz – 1000 MHz)
VIDEO BANDWIDTH:	> Resolution bandwidth
TEST ANTENNA TYPE:	Active loop (9 kHz – 30 MHz) Biconilog (30 MHz – 1000 MHz)
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Peak emission, dB(μV/m)	Quasi-peak			Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
		Measured emission, dB(μV/m)	Limit, dB(μV/m)	Margin, dB*				
Low carrier frequency								
37.6748	36.14	32.88	40.00	-7.12	Vertical	1.01	180.0	Pass
124.9740	39.57	34.75	43.50	-8.75	Vertical	1.01	-46.0	
130.9221	35.82	30.05	43.50	-13.45	Vertical	1.23	-39.0	
Mid carrier frequency								
37.6736	36.79	32.96	40.00	-7.04	Vertical	1.01	180.0	Pass
123.9840	32.82	27.67	43.50	-15.83	Vertical	2.45	176.0	
127.3801	38.11	32.40	43.50	-11.10	Vertical	1.22	-17.0	
High carrier frequency								
37.5240	35.67	30.61	40.00	-9.39	Vertical	1.02	-180.0	Pass
123.4335	39.83	33.90	43.50	-9.60	Vertical	1.01	180.0	
134.3763	32.14	24.96	43.50	-18.54	Vertical	1.54	-46.0	

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

Reference numbers of test equipment used

HL 0446	HL 3903	HL 4360	HL 4933	HL 5288	HL 5405		

Full description is given in Appendix A.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.4.5 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	

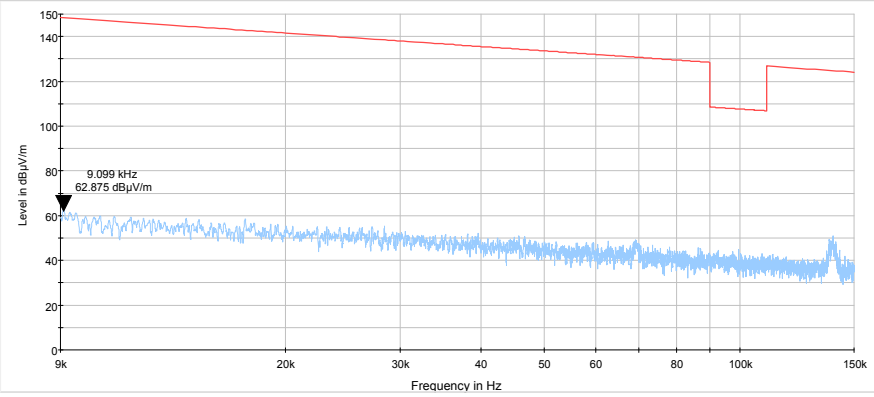
Table 7.4.6 Restricted bands according to RSS-Gen

MHz	MHz	MHz	MHz	MHz	GHz
0.09 - 0.11	8.291 - 8.294	16.80425 - 16.80475	399.9 - 410	3260 - 3267	10.6 - 12.7
2.1735 - 2.1905	8.362 - 8.366	25.5 - 25.67	608 - 614	3332 – 3339	13.25 - 13.4
3.020 – 3.026	8.37625 - 8.38675	37.5 - 38.25	960 – 1427	3345.8 – 3358	14.47 – 14.5
4.125 – 4.128	8.41425 - 8.41475	73 - 74.6	1435 – 1626.5	3500 – 4400	15.35 – 16.2
4.17725 – 4.17775	12.29 – 12.293	74.8 - 75.2	1645.5 – 1646.5	4500 – 5150	17.7 – 21.4
4.20725 – 4.20775	12.51975 – 12.52025	108 – 138	1660 - 1710	5350 – 5460	22.01 – 23.12
5.677 – 5.683	12.57675 – 12.57725	156.52475 – 156.52525	1718.8 - 1722.2	7250 - 7750	23.6 - 24
6.215 - 6.218	13.36 – 13.41	156.7 - 156.9	2200 - 2300	8025 – 8500	31.2 - 31.8
6.26775 - 6.26825	16.42 - 16.423	240 - 285	2310 - 2390	9000 - 9200	36.43 - 36.5
6.31175 - 6.31225	16.69475 - 16.69525	322 - 335.4	2655 - 2900	9300 - 9500	Above 38.6

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

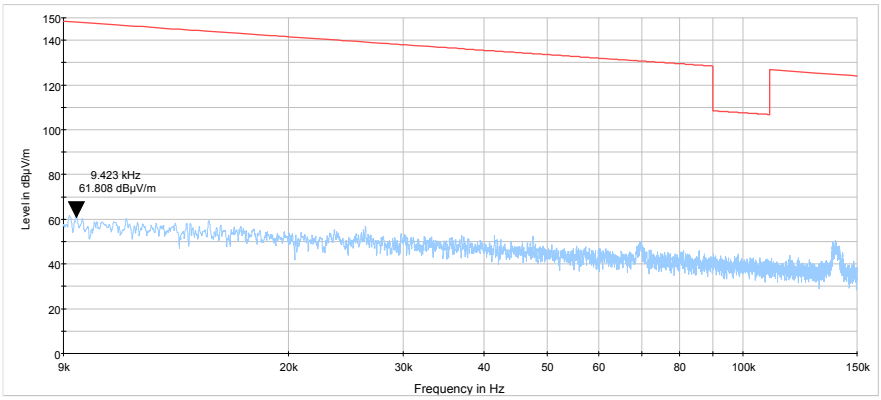
Plot 7.4.1 Radiated emission measurements from 9 to 150 kHz at the low carrier frequency

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



Plot 7.4.2 Radiated emission measurements from 9 to 150 kHz at the mid carrier frequency

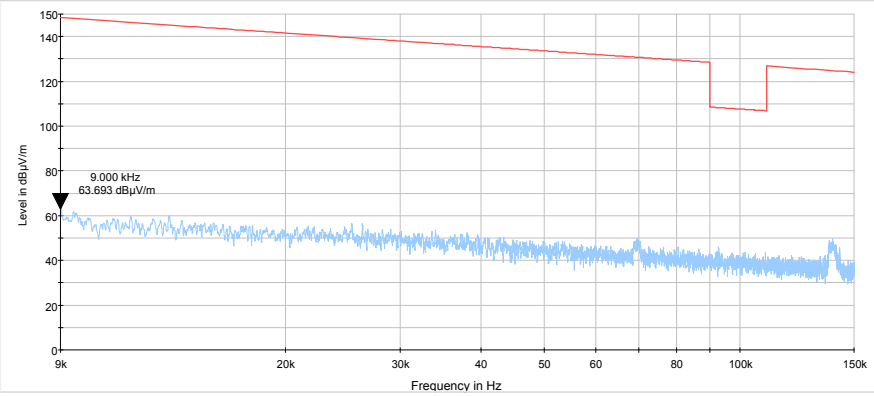
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical & horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

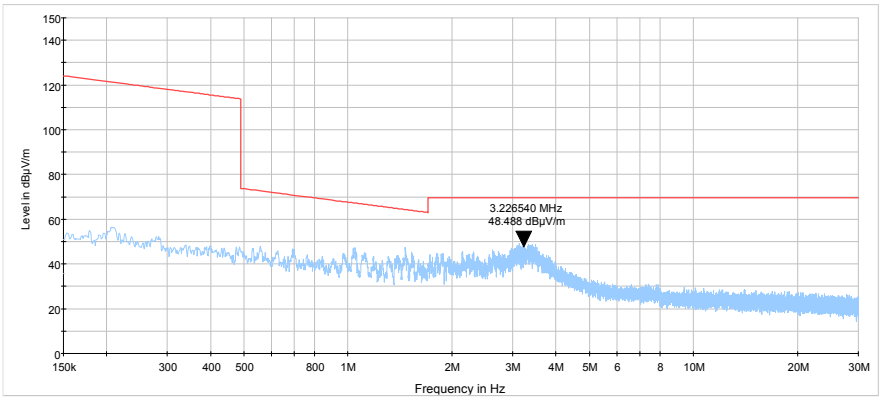
Plot 7.4.3 Radiated emission measurements from 9 to 150 kHz at the high carrier frequency

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



Plot 7.4.4 Radiated emission measurements from 0.15 to 30 MHz at the low carrier frequency

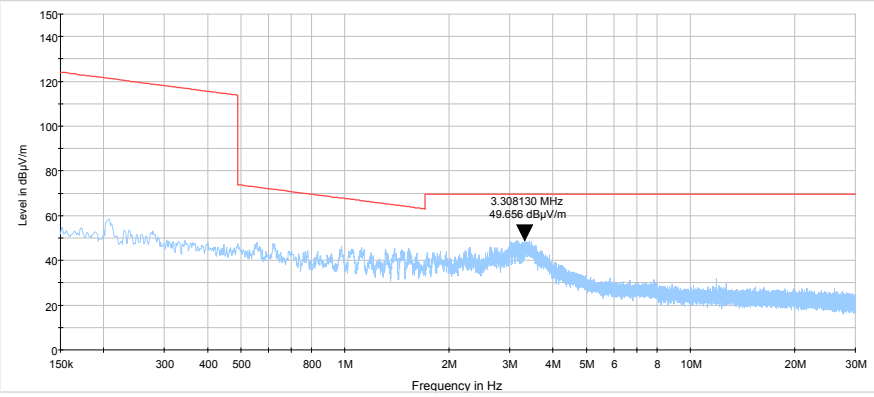
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical & horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

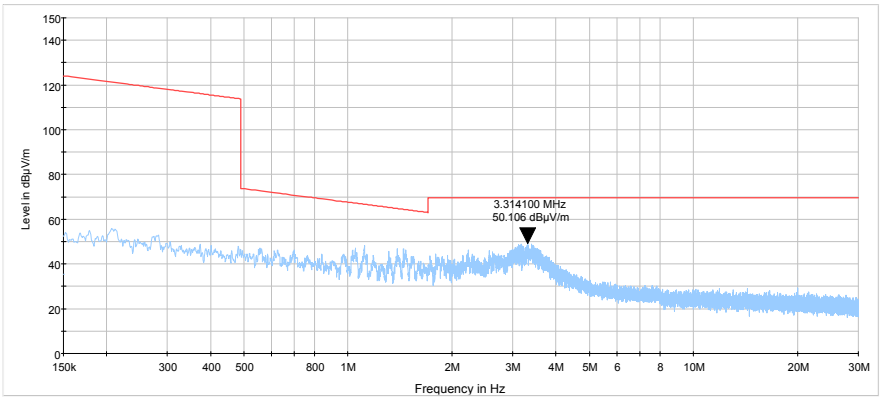
Plot 7.4.5 Radiated emission measurements from 0.15 to 30 MHz at the mid carrier frequency

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



Plot 7.4.6 Radiated emission measurements from 0.15 to 30 MHz at the high carrier frequency

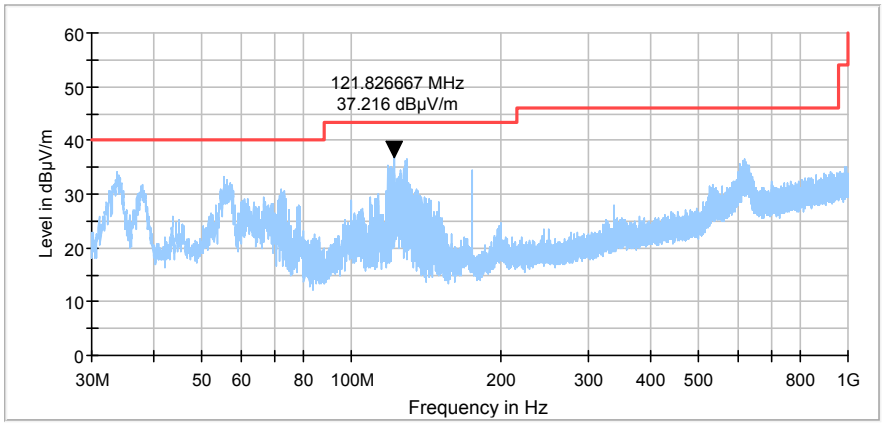
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical & horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

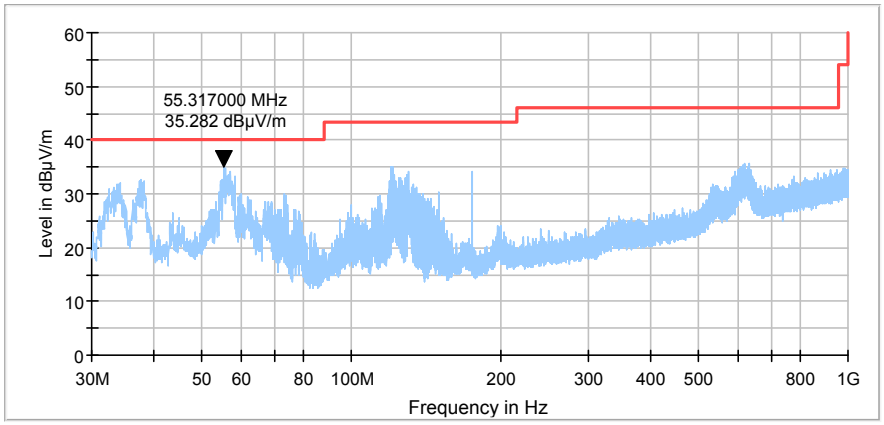
Plot 7.4.7 Radiated emission measurements from 30 to 1000 MHz at the low carrier frequency

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



Plot 7.4.8 Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

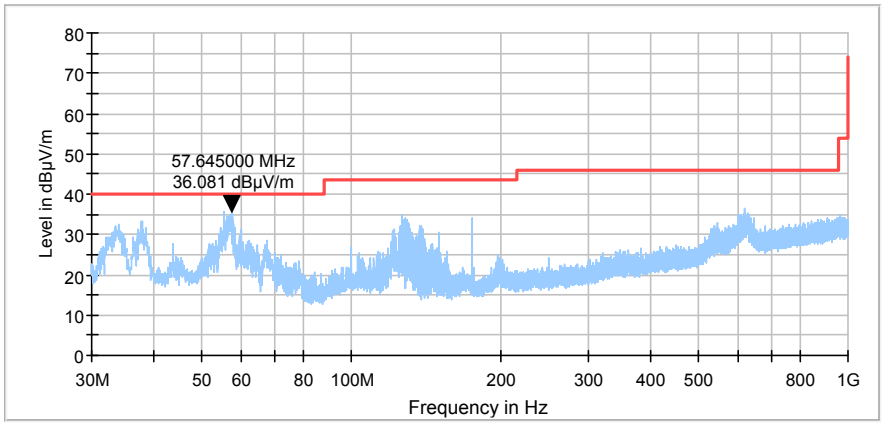
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

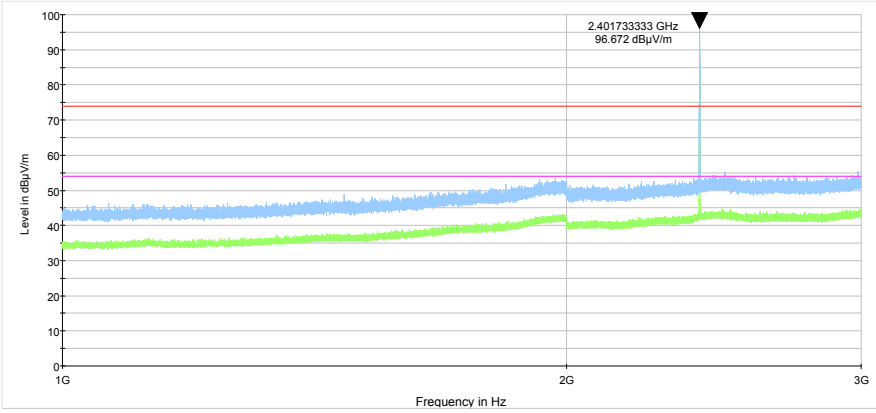
Plot 7.4.9 Radiated emission measurements from 30 to 1000 MHz at the high carrier frequency

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



Plot 7.4.10 Radiated emission measurements from 1000 to 3000 MHz at the low carrier frequency

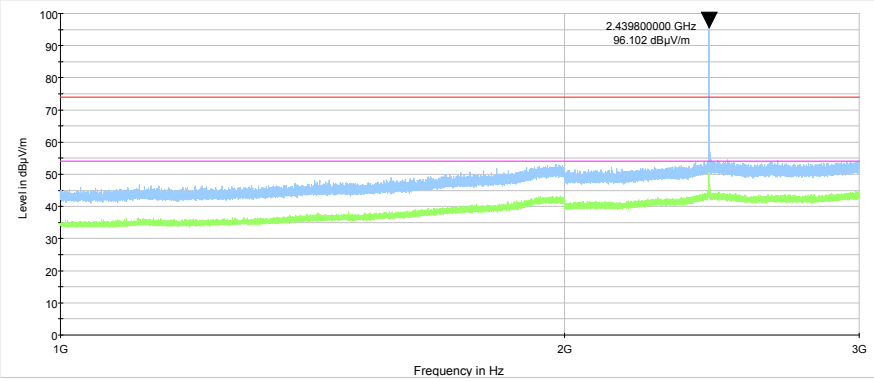
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

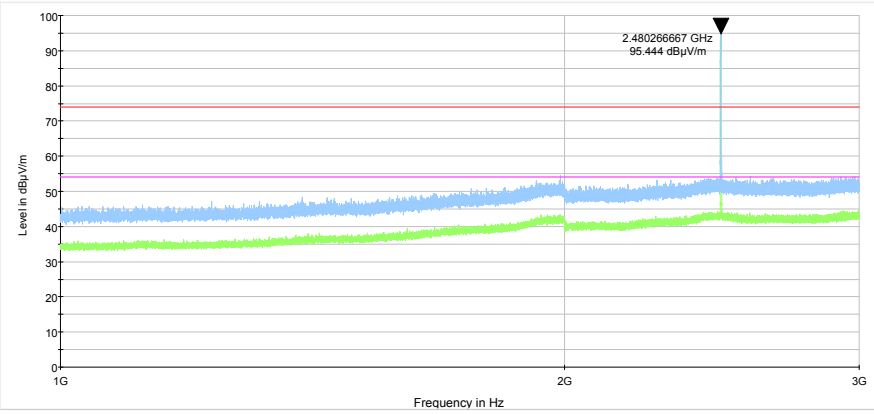
Plot 7.4.11 Radiated emission measurements from 1000 to 3000 MHz at the mid carrier frequency

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



Plot 7.4.12 Radiated emission measurements from 1000 to 3000 MHz at the high carrier frequency

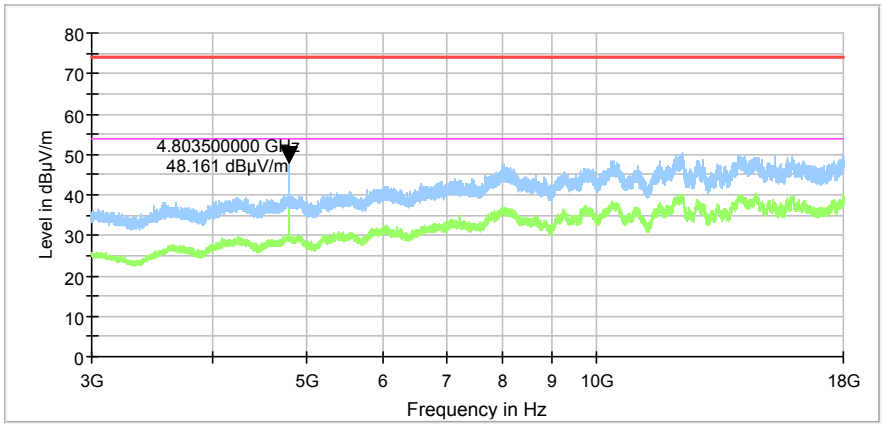
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

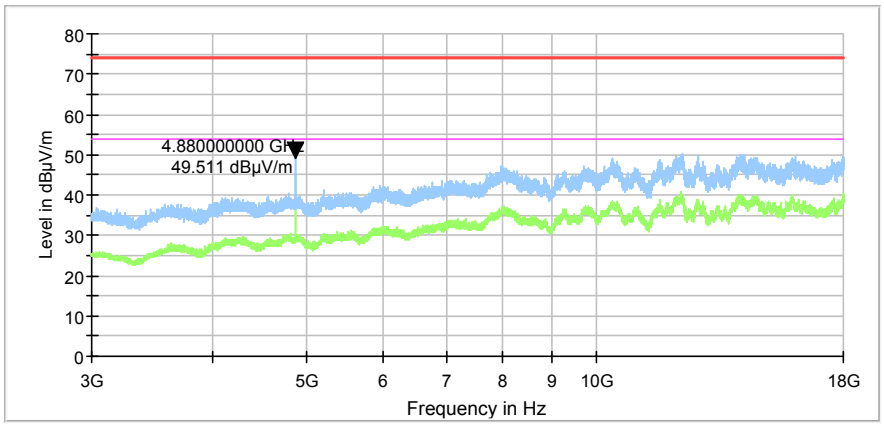
Plot 7.4.13 Radiated emission measurements from 3000 to 18000 MHz at the low carrier frequency

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



Plot 7.4.14 Radiated emission measurements from 3000 to 18000 MHz at the mid carrier frequency

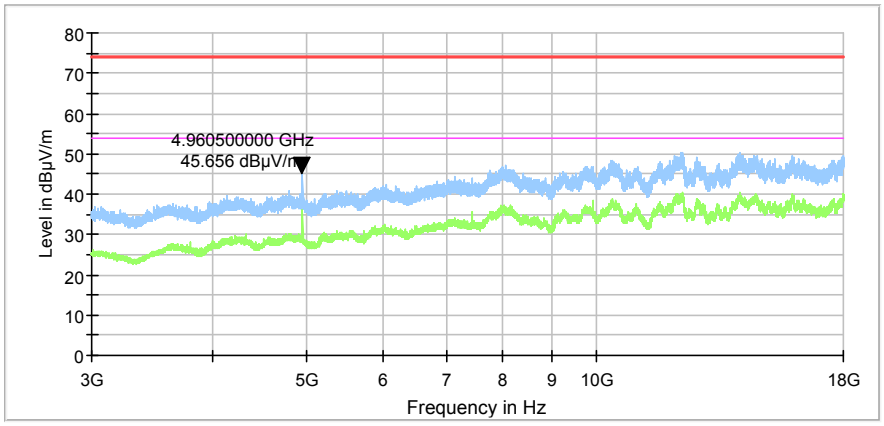
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

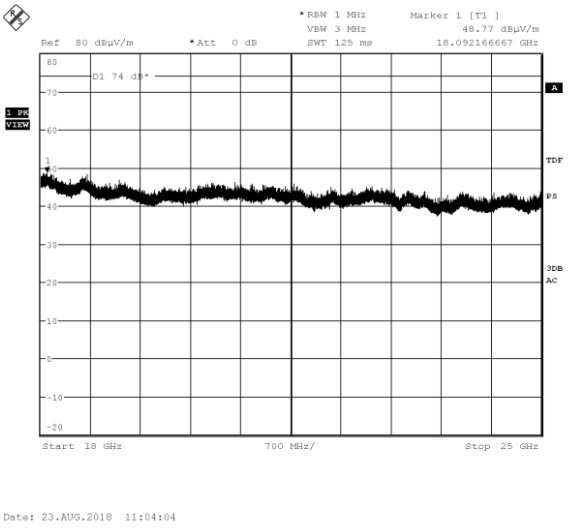
Plot 7.4.15 Radiated emission measurements from 3000 to 18000 MHz at the high carrier frequency

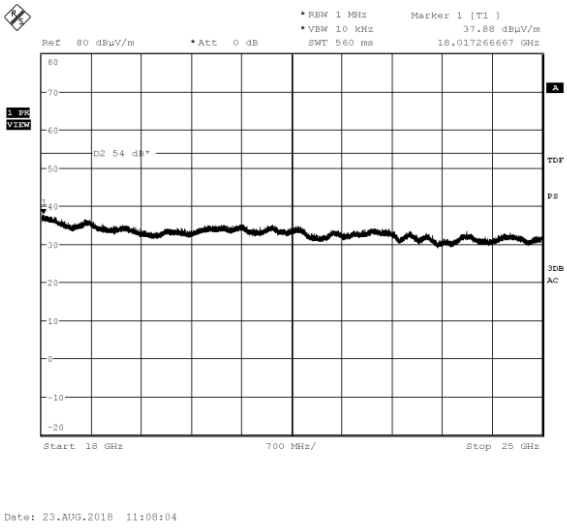
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.4.16 Radiated emission measurements from 18000 to 25000 MHz at the low carrier frequency

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

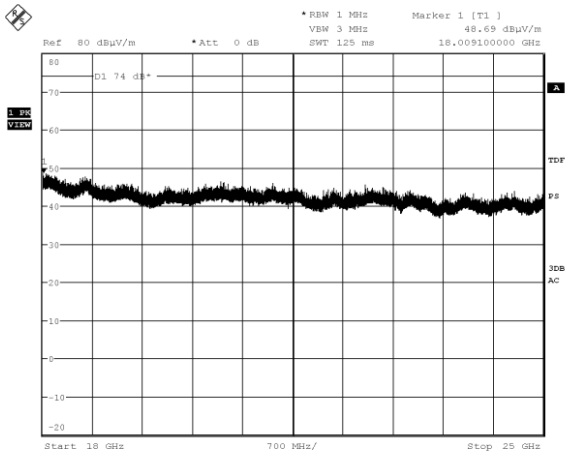


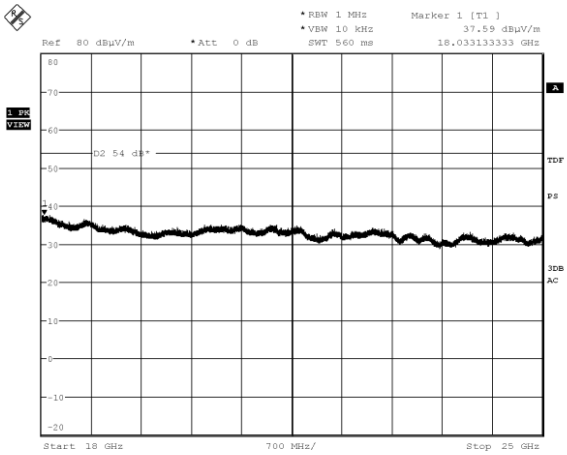


Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Plot 7.4.17 Radiated emission measurements from 18000 to 25000 MHz at the mid carrier frequency

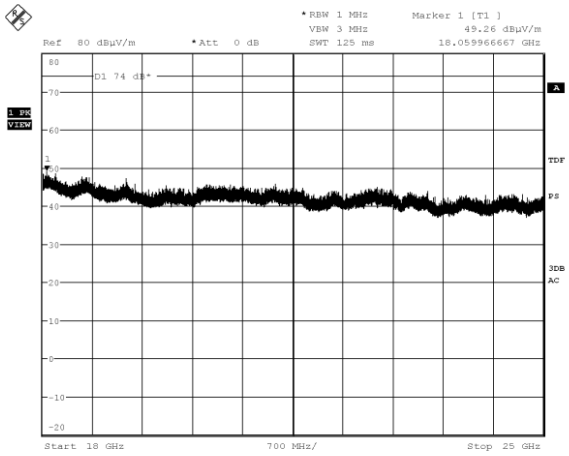
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

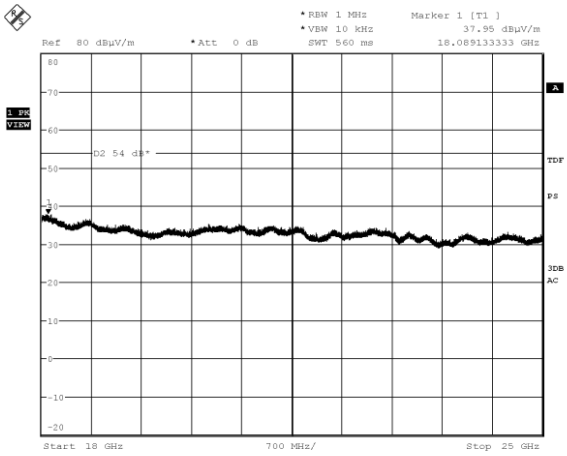




Plot 7.4.18 Radiated emission measurements from 18000 to 25000 MHz at the high carrier frequency

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





Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

7.5 Field strength of spurious emissions

7.5.1 General

This test was performed to measure field strength of spurious emissions from the EUT. Specification test limits are given in Table 7.5.1.

Table 7.5.1 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 – 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 tenth harmonic of the highest fundamental frequency.

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

7.5.2.1 The EUT was set up as shown in Figure 7.5.1, energized and the performance check was conducted.

7.5.2.2 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.

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

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

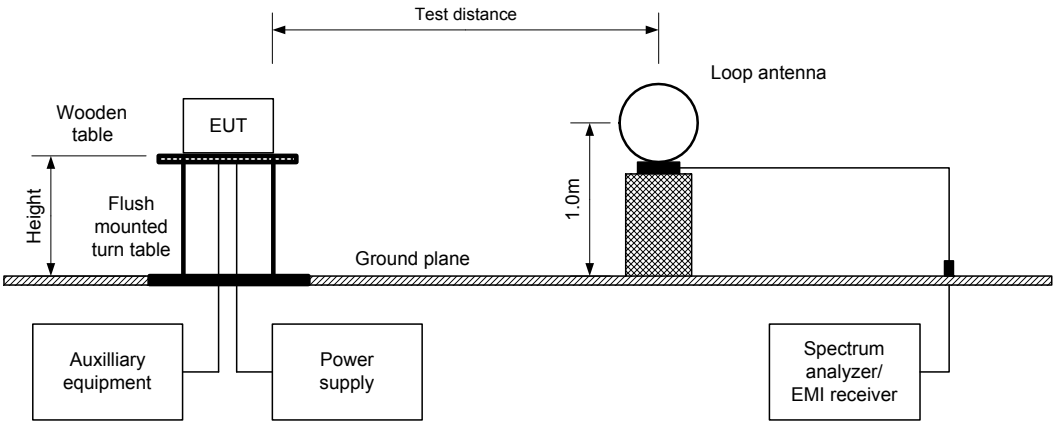
7.5.3.1 The EUT was set up as shown in Figure 7.5.2, Figure 7.5.3, energized and the performance check was conducted.

7.5.3.2 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.

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

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Figure 7.5.1 Setup for spurious emission field strength measurements below 30 MHz



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Figure 7.5.2 Setup for spurious emission field strength measurements from 30 to 1000 MHz

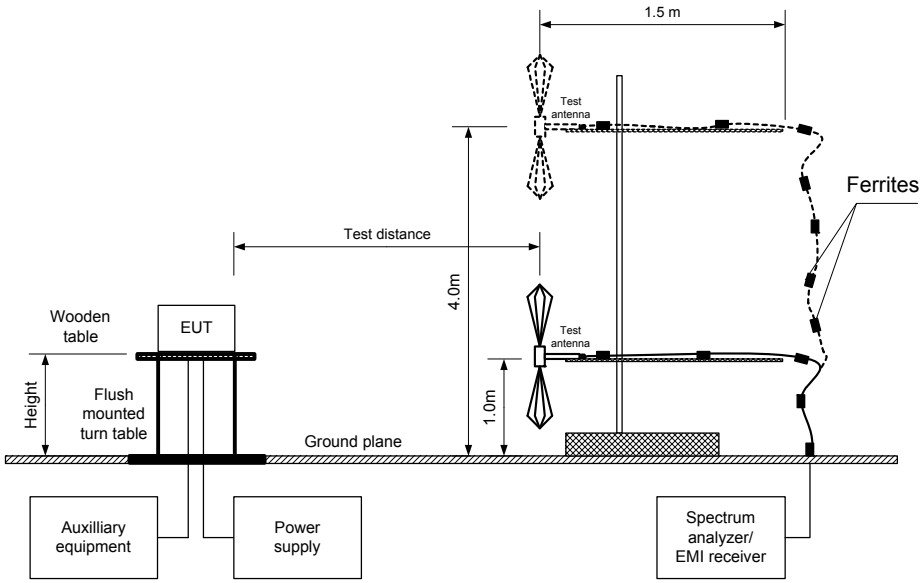
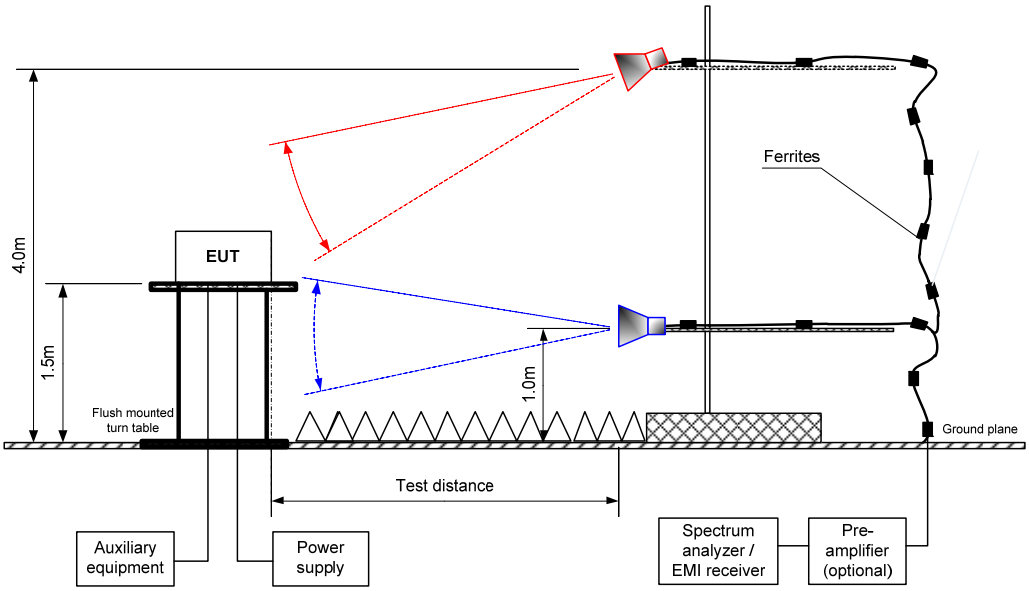


Figure 7.5.3 Setup for spurious emission field strength measurements above1000 MHz



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.5.2 Field strength of emissions outside restricted bands

ASSIGNED FREQUENCY:	2400-2483.5 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 25000 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
BIT RATE:	1 Mbps
DUTY CYCLE:	100 %
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
TRANSMITTER OUTPUT POWER:	-0.92 dBm at low carrier frequency -1.45 dBm at mid carrier frequency -5.33 dBm at high carrier frequency
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 HOPPING:	Disabled

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									
7205.3750	59.89	V	1.79	-80.0	96.78	36.89	20.0	16.89	Pass
14389.4125	52.34	H	2.32	59.0		44.44		24.44	
Mid carrier frequency									
14430.6375	52.58	V	1.00	96.0	96.25	43.67	20.0	23.67	Pass
High carrier frequency									
14411.2625	52.40	V	1.00	130.0	92.37	39.97	20.0	19.97	Pass

*****- EUT front panel refers to 0 degrees position of turntable.
******- Margin = Attenuation below carrier – specification limit.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.5.3 Field strength of spurious emissions above 1 GHz within restricted bands

ASSIGNED FREQUENCY:	2400.0 – 2483.5 MHz
INVESTIGATED FREQUENCY RANGE:	1000 – 25000 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	1000 kHz
TEST ANTENNA TYPE:	Double ridged guide
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Antenna		Azimuth, degrees*	Peak field strength(VBW=3 MHz)			Average field strength				Verdict
	Polarization	Height, m		Measured, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	Measured, dB(μV/m)	Calculated, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	
Low carrier frequency											
4804.4000	V	1.50	-80.0	58.94	74.00	-15.06	53.17	N/A	54.00	-0.83	Pass
12257.8375	H	1.50	-92.0	52.10	74.00	-21.90	38.32	N/A	54.00	-15.68	
15943.1000	V	3.91	80.0	52.86	74.00	-21.14	38.39	N/A	54.00	-15.61	
Mid carrier frequency											
4880.4875	V	1.53	-81.0	63.80	74.00	-10.20	52.24	N/A	54.00	-1.76	Pass
7319.0250	V	1.00	-80.0	55.81	74.00	-18.19	47.00	N/A	54.00	-7.00	
12237.7375	V	1.00	98.0	52.19	74.00	-21.81	38.12	N/A	54.00	-15.88	
15948.0000	H	1.00	-105.0	52.71	74.00	-21.29	38.53	N/A	54.00	-15.47	
High carrier frequency											
4960.5000	V	1.53	-93.0	63.64	74.00	-10.36	53.18	N/A	54.00	-0.82	Pass
7438.9875	V	1.00	-93.0	56.79	74.00	-17.21	48.22	N/A	54.00	-5.78	
12277.7125	V	1.00	-32.0	52.21	74.00	-21.79	38.21	N/A	54.00	-15.79	
15936.3500	V	1.00	43.0	52.10	74.00	-21.90	38.16	N/A	54.00	-15.84	

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

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.5.4 Field strength of spurious emissions below 1 GHz within restricted bands

ASSIGNED FREQUENCY:	2400.0 – 2483.5 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 1000 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
RESOLUTION BANDWIDTH:	0.2 kHz (9 kHz – 150 kHz) 9.0 kHz (150 kHz – 30 MHz) 120 kHz (30 MHz – 1000 MHz)
VIDEO BANDWIDTH:	> Resolution bandwidth
TEST ANTENNA TYPE:	Active loop (9 kHz – 30 MHz) Biconilog (30 MHz – 1000 MHz)
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Peak emission, dB(μV/m)	Quasi-peak			Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
		Measured emission, dB(μV/m)	Limit, dB(μV/m)	Margin, dB*				
Low carrier frequency								
37.5187	35.09	33.18	40.00	-6.82	Vertical	1.11	-180.0	Pass
123.1965	38.98	35.91	43.50	-7.59	Vertical	1.06	-65.0	
131.3674	35.56	31.14	43.50	-12.36	Vertical	1.15	-95.0	
Mid carrier frequency								
37.5487	36.25	33.87	40.00	-6.13	Vertical	1.51	-180.0	Pass
123.9652	32.87	28.65	43.50	-14.85	Vertical	1.16	65.0	
127.1298	38.65	33.47	43.50	-10.03	Vertical	1.12	171.0	
High carrier frequency								
37.5847	35.49	32.61	40.00	-7.39	Vertical	1.12	180.0	Pass
123.6835	39.61	35.95	43.50	-7.55	Vertical	1.01	51.0	
134.5763	32.85	29.14	43.50	-14.36	Vertical	1.04	-1.0	

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

Reference numbers of test equipment used

HL 0446	HL 3903	HL 4360	HL 4933	HL 5288	HL 5405		

Full description is given in Appendix A.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.5.5 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	

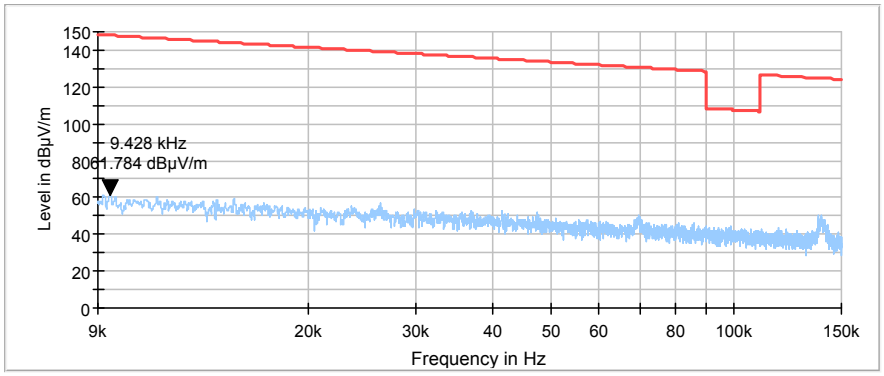
Table 7.5.6 Restricted bands according to RSS-Gen

MHz	MHz	MHz	MHz	MHz	GHz
0.09 - 0.11	8.291 - 8.294	16.80425 - 16.80475	399.9 - 410	3260 - 3267	10.6 - 12.7
2.1735 - 2.1905	8.362 - 8.366	25.5 - 25.67	608 - 614	3332 – 3339	13.25 - 13.4
3.020 – 3.026	8.37625 - 8.38675	37.5 - 38.25	960 – 1427	3345.8 – 3358	14.47 – 14.5
4.125 – 4.128	8.41425 - 8.41475	73 - 74.6	1435 – 1626.5	3500 – 4400	15.35 – 16.2
4.17725 – 4.17775	12.29 – 12.293	74.8 - 75.2	1645.5 – 1646.5	4500 – 5150	17.7 – 21.4
4.20725 – 4.20775	12.51975 – 12.52025	108 – 138	1660 - 1710	5350 – 5460	22.01 – 23.12
5.677 – 5.683	12.57675 – 12.57725	156.52475 – 156.52525	1718.8 - 1722.2	7250 - 7750	23.6 - 24
6.215 - 6.218	13.36 – 13.41	156.7 - 156.9	2200 - 2300	8025 – 8500	31.2 - 31.8
6.26775 - 6.26825	16.42 - 16.423	240 - 285	2310 - 2390	9000 - 9200	36.43 - 36.5
6.31175 - 6.31225	16.69475 - 16.69525	322 - 335.4	2655 - 2900	9300 - 9500	Above 38.6

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

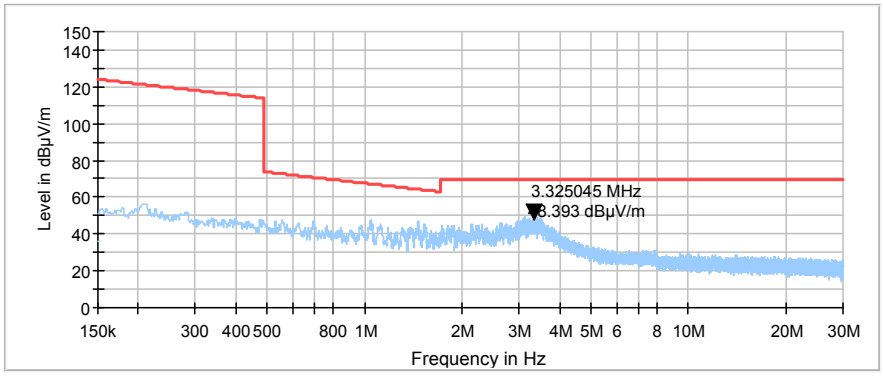
Plot 7.5.1 Radiated emission measurements from 9 to 150 kHz at the low; mid; high carrier frequency

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



Plot 7.5.2 Radiated emission measurements from 0.150 to 30 MHz at the low; mid; high carrier frequency

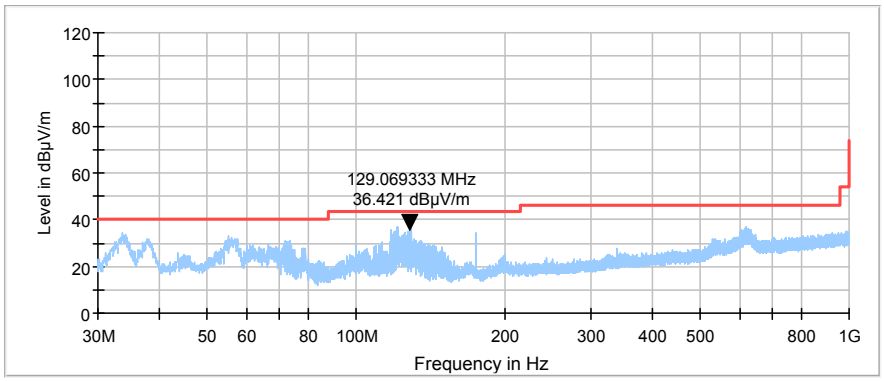
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

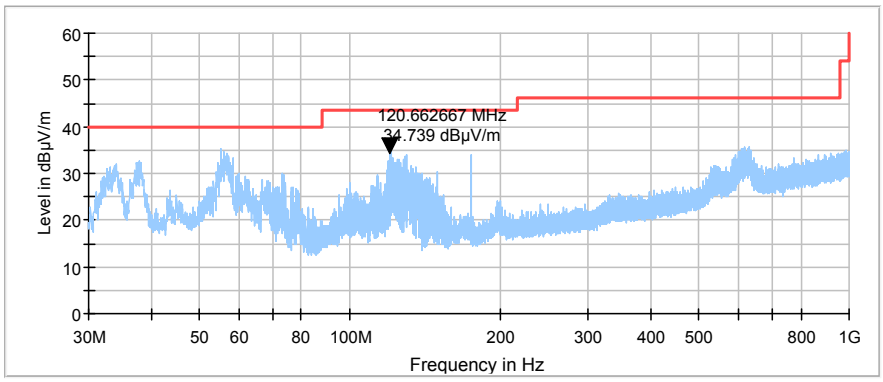
Plot 7.5.3 Radiated emission measurements from 30 to 1000 MHz at the low carrier frequency

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



Plot 7.5.4 Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

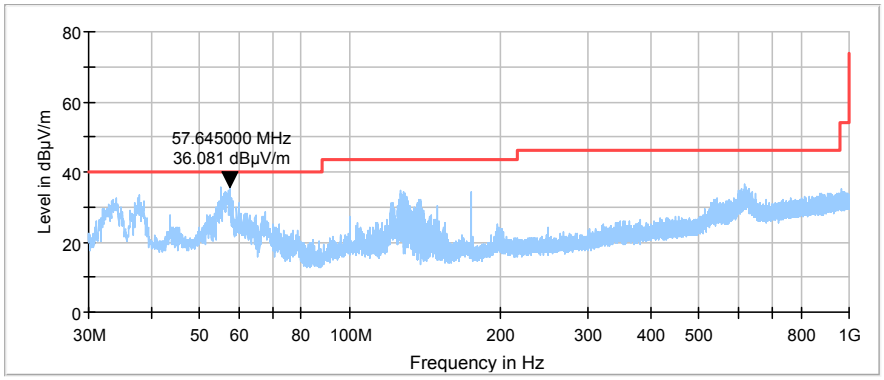
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

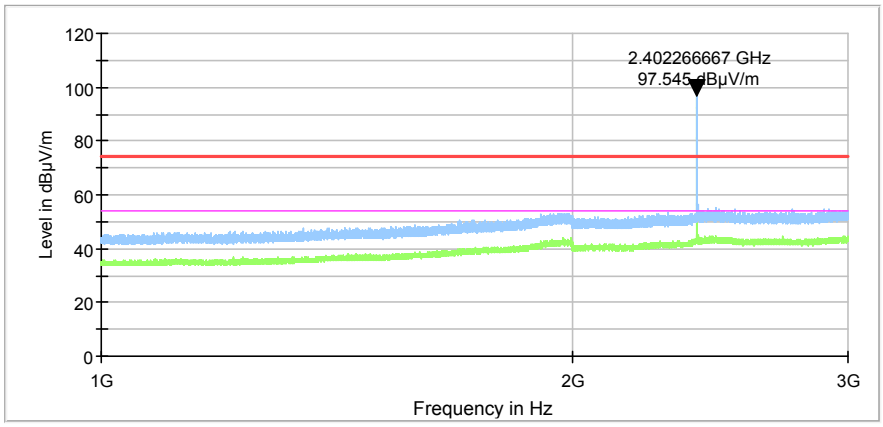
Plot 7.5.5 Radiated emission measurements from 30 to 1000 MHz at the high carrier frequency

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



Plot 7.5.6 Radiated emission measurements from 1000 to 3000 MHz at the low carrier frequency

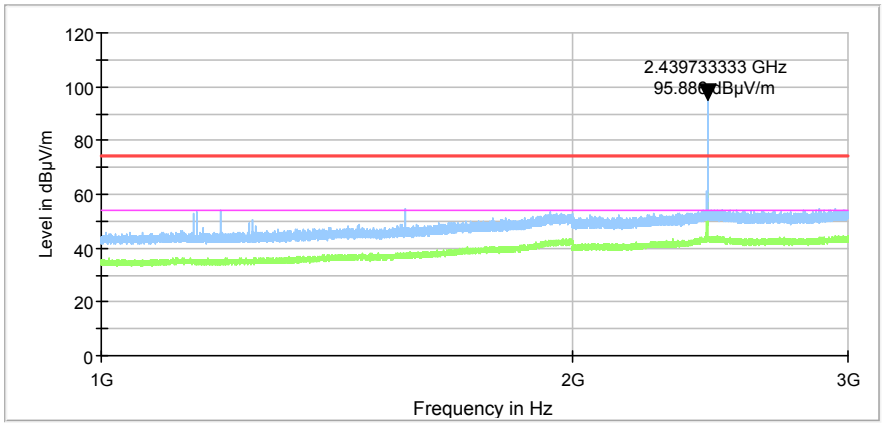
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

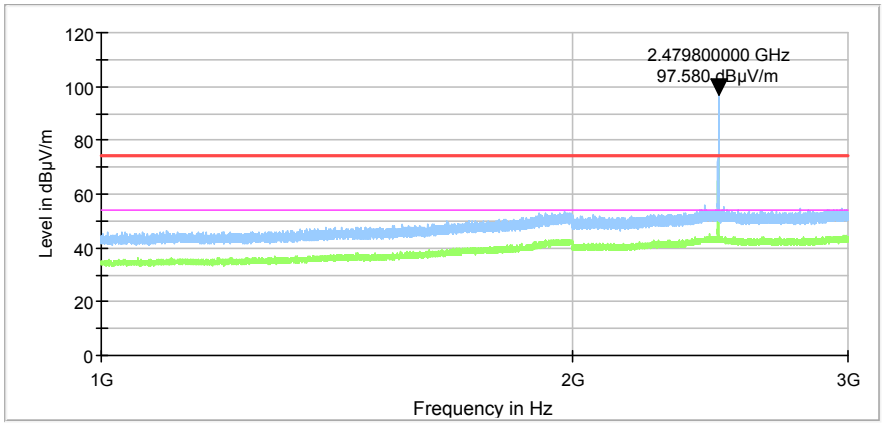
Plot 7.5.7 Radiated emission measurements from 1000 to 3000 MHz at the mid carrier frequency

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



Plot 7.5.8 Radiated emission measurements from 1000 to 3000 MHz at the high carrier frequency

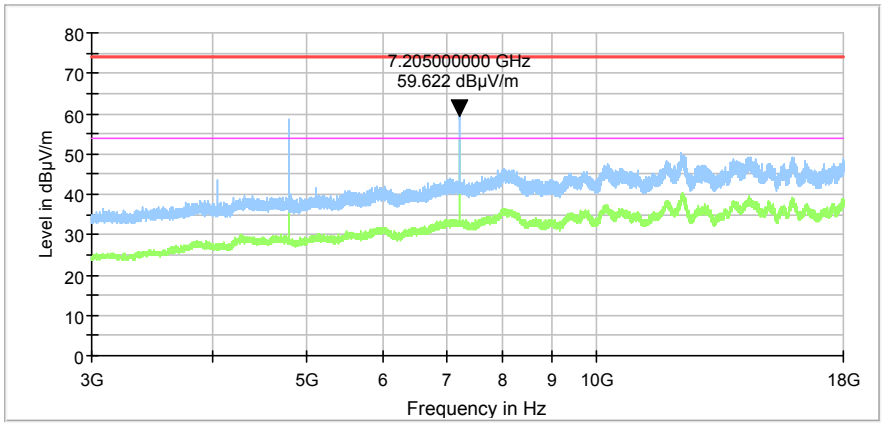
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

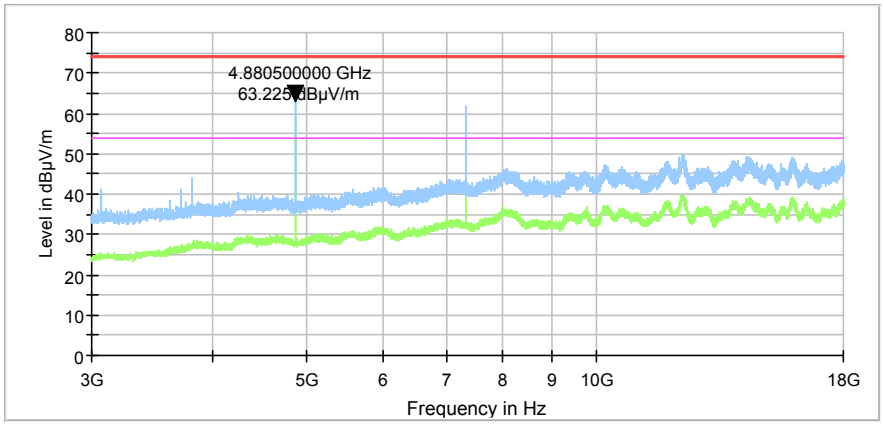
Plot 7.5.9 Radiated emission measurements from 3000 to 18000 MHz at the low carrier frequency

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



Plot 7.5.10 Radiated emission measurements from 3000 to 18000 MHz at the mid carrier frequency

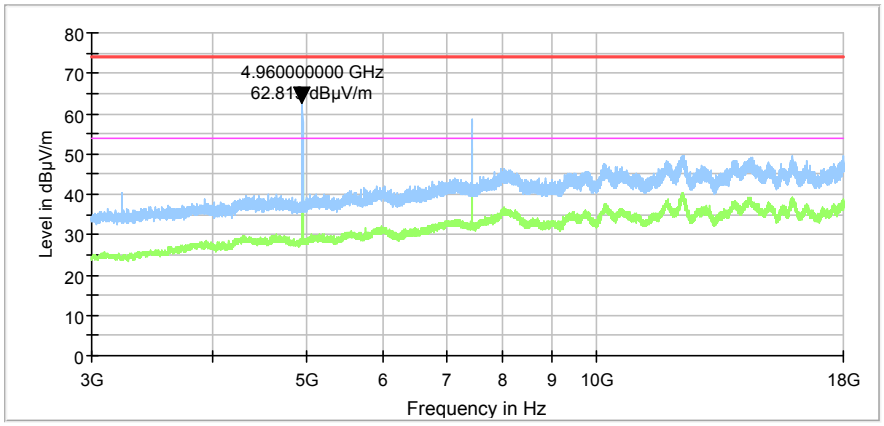
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

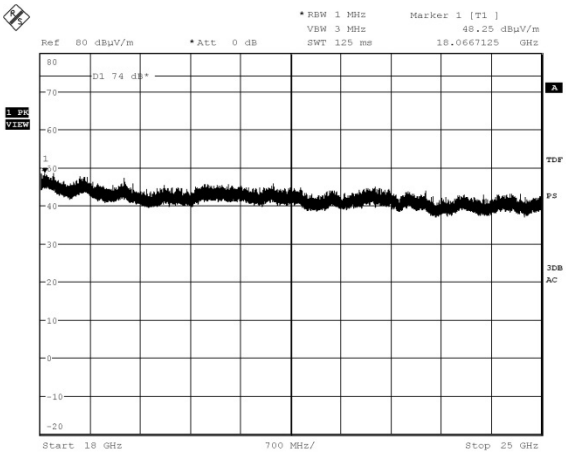
Plot 7.5.11 Radiated emission measurements from 3000 to 18000 MHz at the high carrier frequency

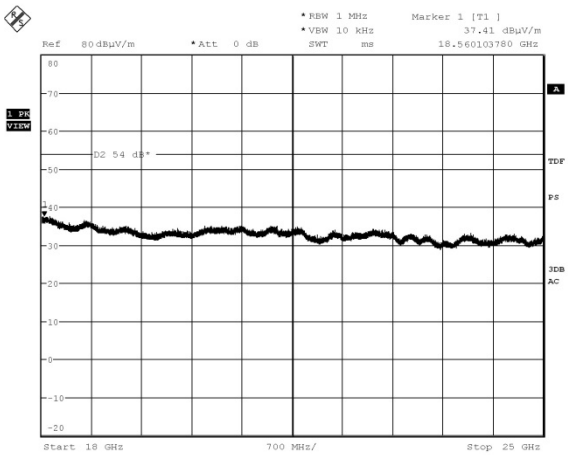
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.5.12 Radiated emission measurements from 18000 to 25000 MHz at the low carrier frequency

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



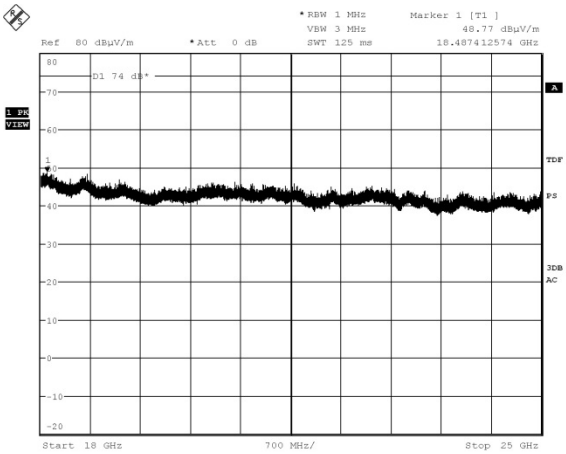


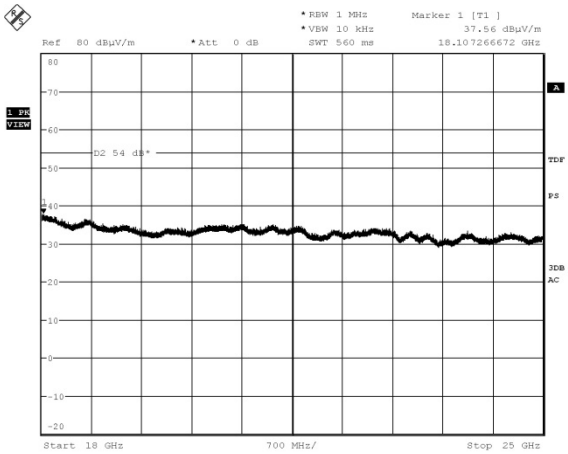
Date: 23.AUG.2018 18:23:25

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1008 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Plot 7.5.13 Radiated emission measurements from 18000 to 25000 MHz at the mid carrier frequency

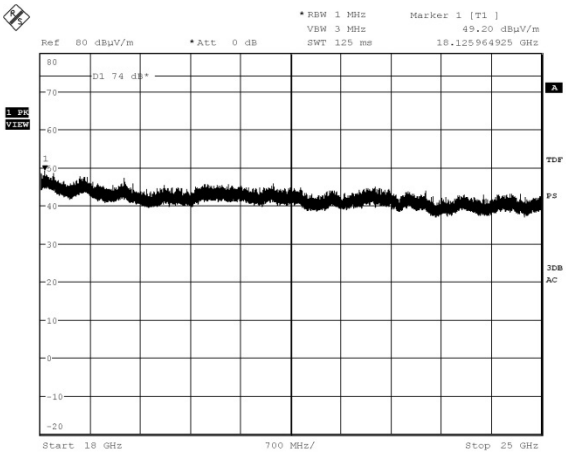
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

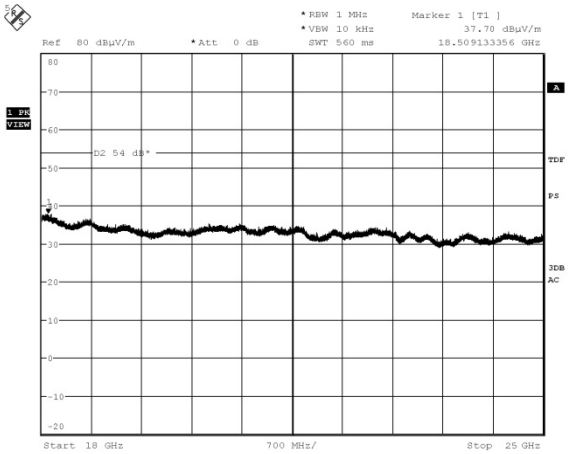




Plot 7.5.14 Radiated emission measurements from 18000 to 25000 MHz at the high carrier frequency

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





Test specification:	**Section 15.247(d) / RSS-247 section 5.5, Band edge emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Oct-18 - 06-Nov-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1013 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

7.6 Band edge radiated emissions

7.6.1 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 7.6.1.

Table 7.6.1 Band edge emission limits

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

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

7.6.2 Test procedure

7.6.2.1 The EUT was set up as shown in Figure 7.6.1, energized normally modulated at the maximum data rate with its hopping function disabled and its proper operation was checked.

7.6.2.2 The EUT was adjusted to produce maximum available to end user RF output power at the lowest carrier frequency.

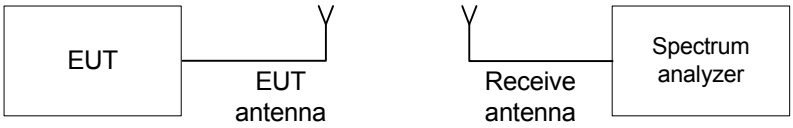
7.6.2.3 The spectrum analyzer span was set to capture the carrier frequency and associated modulation products. The resolution bandwidth was set wider than 1 % of the frequency span.

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

7.6.2.5 The maximum band edge emission and modulation product outside of the band were measured as provided in Table 7.6.2 and associated plots and referenced to the highest emission level measured within the authorized band.

7.6.2.6 The above procedure was repeated with the EUT adjusted to produce maximum RF output power at the highest carrier frequency.

Figure 7.6.1 Band edge emission test setup



Test specification:	**Section 15.247(d) / RSS-247 section 5.5, Band edge emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Oct-18 - 06-Nov-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1013 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.6.2 Band edge emission test results

ASSIGNED FREQUENCY RANGE:	2400 – 2483.5 MHz
DETECTOR USED:	Peak
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
TRANSMITTER OUTPUT POWER:	-0.92 dBm at low carrier frequency -5.33 dBm at high carrier frequency
RESOLUTION BANDWIDTH:	≥ 1% of the span
VIDEO BANDWIDTH:	≥ RBW

Frequency, MHz	Band edge emission, dBuV/m	Emission at carrier, dBuV/m	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
Low carrier frequency 2402 MHz						
2400.0	55.44	96.78	41.34	20.0	21.34	Pass

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

Frequency, MHz	Peak field strength(VBW=3 MHz)			Average field strength			Verdict
	Measured, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	Measured, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	
Low carrier frequency 2402 MHz							
2390.0	55.44	74.0	-18.56	45.63	54.0	-8.37	Pass
High carrier frequency 2480 MHz							
2483.5	51.04	74.0	-22.96	42.97	54.0	-11.03	Pass

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

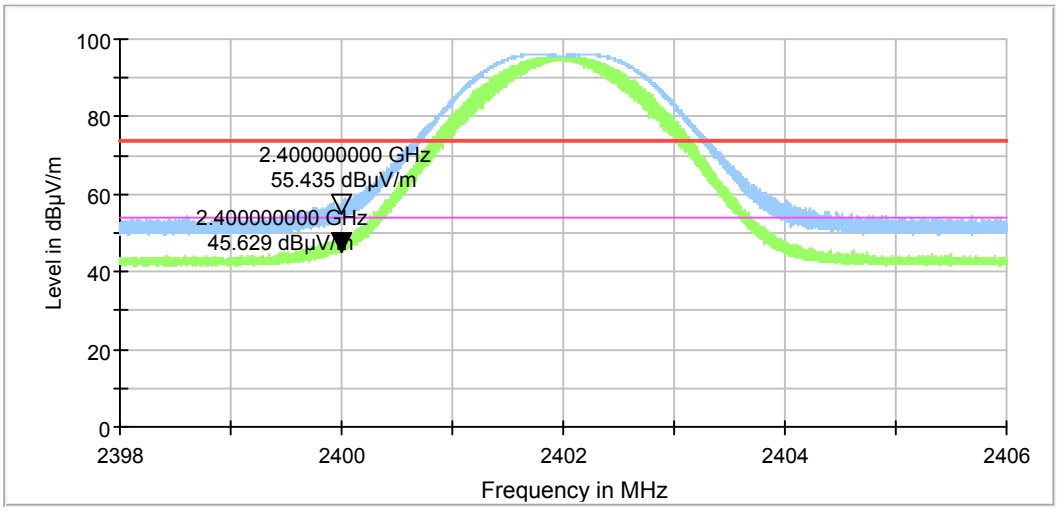
Reference numbers of test equipment used

HL 3903	HL 4360	HL 4933	HL 5405				

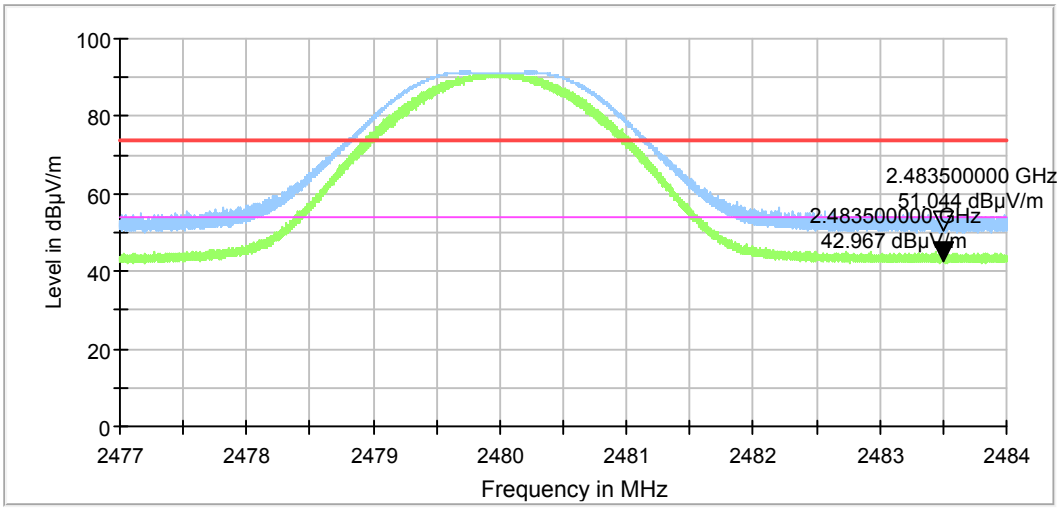
Full description is given in Appendix A.

Test specification:	**Section 15.247(d) / RSS-247 section 5.5, Band edge emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Oct-18 - 06-Nov-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1013 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Plot 7.6.1 The highest emission level within the assigned band at low carrier frequency



Plot 7.6.2 The highest emission level within the assigned band at high carrier frequency



Test specification:	**Section 15.247(d) / RSS-247 section 5.5, Band edge emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18 - 17-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 42 %	**Air Pressure:** 1009 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

7.7 Band edge radiated emissions

7.7.1 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 7.7.1.

Table 7.7.1 Band edge emission limits

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

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

7.7.2 Test procedure

7.7.2.1 The EUT was set up as shown in Figure 7.7.1, energized normally modulated at the maximum data rate with its hopping function disabled and its proper operation was checked.

7.7.2.2 The EUT was adjusted to produce maximum available to end user RF output power at the lowest carrier frequency.

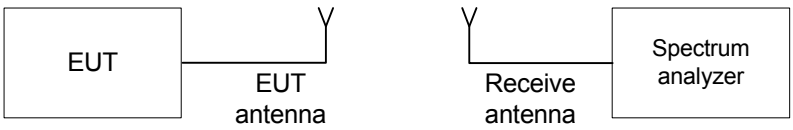
7.7.2.3 The spectrum analyzer span was set to capture the carrier frequency and associated modulation products. The resolution bandwidth was set wider than 1 % of the frequency span.

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

7.7.2.5 The maximum band edge emission and modulation product outside of the band were measured as provided in Table 7.7.2 and associated plots and referenced to the highest emission level measured within the authorized band.

7.7.2.6 The above procedure was repeated with the EUT adjusted to produce maximum RF output power at the highest carrier frequency.

Figure 7.7.1 Band edge emission test setup



Test specification:	**Section 15.247(d) / RSS-247 section 5.5, Band edge emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18 - 17-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 42 %	**Air Pressure:** 1009 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.7.2 Band edge emission test results

ASSIGNED FREQUENCY RANGE:	2400-2483.5 MHz
DETECTOR USED:	Peak
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
TRANSMITTER OUTPUT POWER:	-0.93 dBm at low carrier frequency -1.07 dBm at high carrier frequency
RESOLUTION BANDWIDTH:	≥ 1% of the span
VIDEO BANDWIDTH:	≥ RBW

Frequency, MHz	Band edge emission, dBuV/m	Emission at carrier, dBuV/m	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
Low carrier frequency 2402 MHz						
2400.0	54.96	96.77	41.81	20.0	21.81	Pass

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

Frequency, MHz	Peak field strength(VBW=3 MHz)			Average field strength			Verdict
	Measured, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	Measured, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	
Low carrier frequency 2402 MHz							
2390.0	54.94	74.0	-19.06	44.94	54.0	-9.06	Pass
High carrier frequency 2480 MHz							
2483.5	51.84	74.0	-22.16	43.67	54.0	-10.33	Pass

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

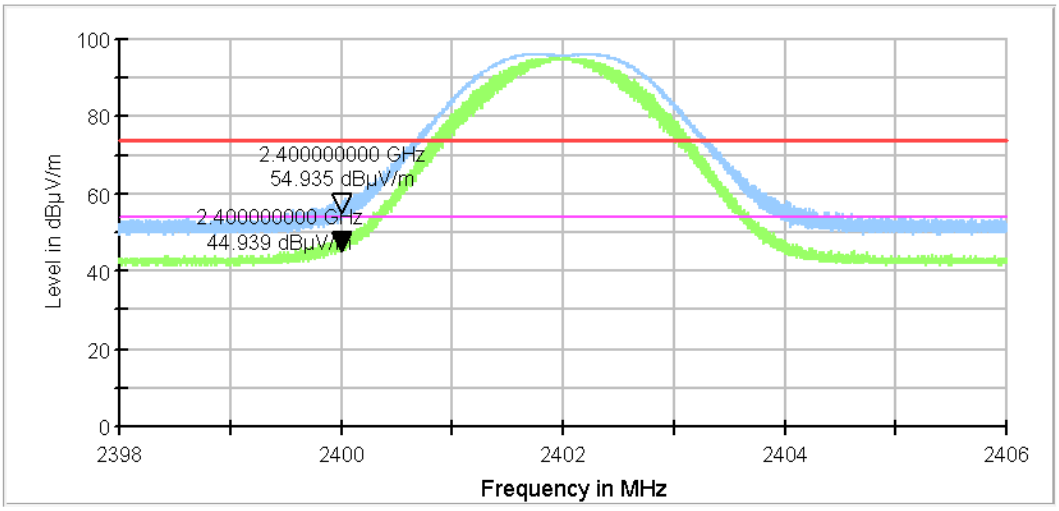
Reference numbers of test equipment used

HL 3903	HL 4360	HL 4933	HL 5405				

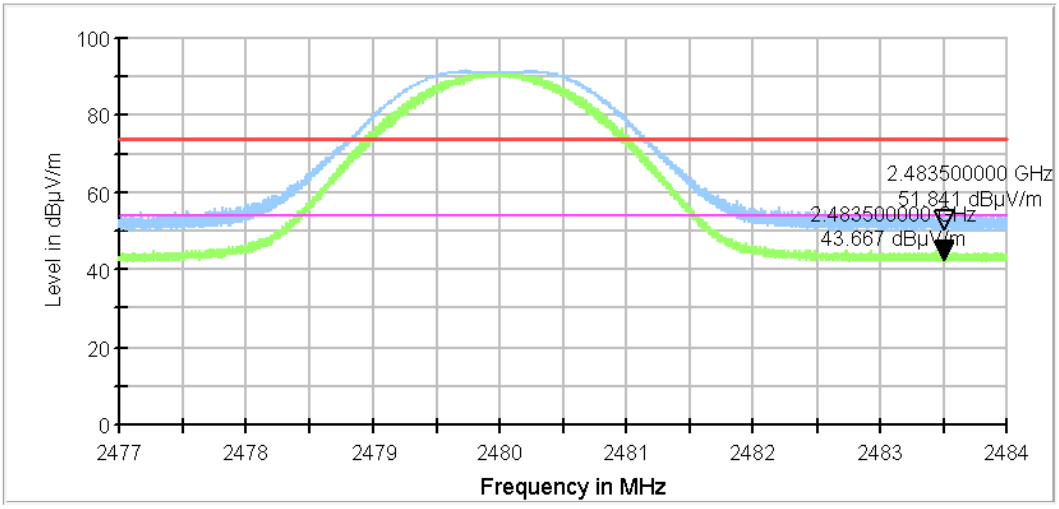
Full description is given in Appendix A.

Test specification:	**Section 15.247(d) / RSS-247 section 5.5, Band edge emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	23-Aug-18 - 17-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 42 %	**Air Pressure:** 1009 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Plot 7.7.1 The highest emission level within the assigned band at low carrier frequency



Plot 7.7.2 The highest emission level within the assigned band at high carrier frequency



Test specification:	Section 15.247(e) / RSS-247 section 5.2(b), Maximum power density		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Mar-19		
Temperature: 23 ºC	Relative Humidity: 55 %	Air Pressure: 1009 hPa	Power: 120 VAC, 60 Hz
Remarks:			

7.8 Maximum power spectral density (PSD)

7.8.1 General

This test was performed to measure the peak power spectral density radiated by the transmitter RF antenna. Specification test limits are given in Table 7.8.1.

Table 7.8.1 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)*
2400.0 – 2483.5	3.0	8.0	103.2

* - Equivalent field strength limit was calculated from the peak spectral power density as follows: E=sqrt(30×PxG)/r, where P is peak spectral power density and r is antenna to EUT distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator.

7.8.2 Test procedure

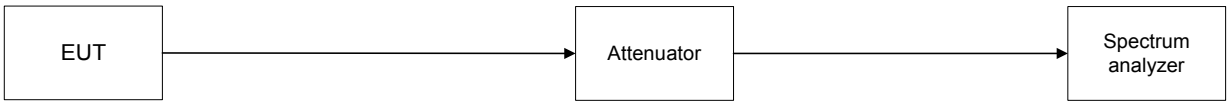
7.8.2.1 The EUT was set up as shown in Figure 7.8.1, energized and its proper operation was checked.

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

7.8.2.3 The peak power spectral density was measured in peak hold mode with resolution bandwidth set to 100 kHz, video bandwidth ≥ 300 kHz, auto sweep time and sufficient number of sweeps was allowed for trace stabilization. The maximum power level was determined in any 100 kHz band within the fundamental EBW.

7.8.2.4 The peak spectral power density was measured as provided in Table 7.8.2 and the associated plots.

Figure 7.8.1 Peak spectral power density test setup



Test specification:	**Section 15.247(e) / RSS-247 section 5.2(b), Maximum power density**		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1009 hPa	**Power:** 120 VAC, 60 Hz
Remarks:			

Table 7.8.2 Peak spectral power density test results

ASSIGNED FREQUENCY:	2400-2483.5 MHz
TEST DISTANCE:	3 m
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	100 kHz
VIDEO BANDWIDTH:	300 kHz
MODULATION:	GFSK
BIT RATE:	1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum

Frequency, MHz	PSD at antenna connector, dBm	EUT antenna gain, dBi	PSD, dBm	Limit, dBm	Margin, dB*	Verdict
2402	1.78	2.5	4.28	8	-3.72	Pass
2440	2.00	2.5	4.50	8	-3.50	Pass
2480	2.14	2.5	4.64	8	-3.36	Pass

*****- Margin, dB = PSD, dBm – Limit, dBm.

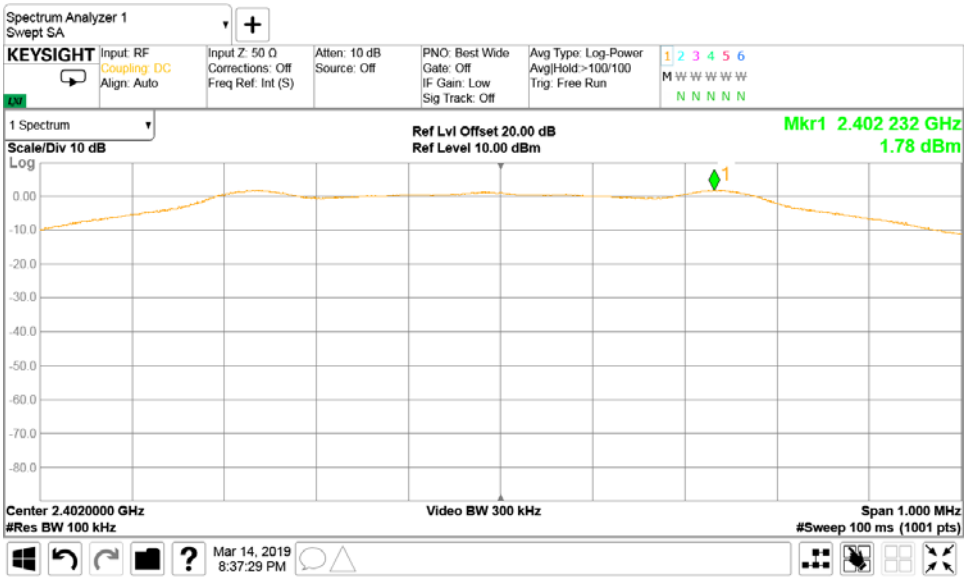
Reference numbers of test equipment used

HL 3440	HL 3903	HL 5376					

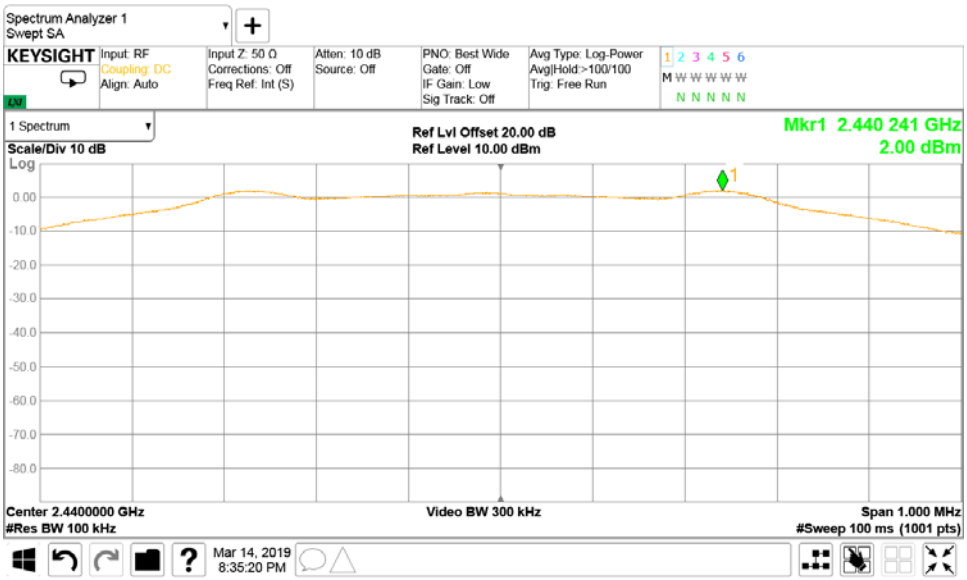
Full description is given in Appendix A.

Test specification:	**Section 15.247(e) / RSS-247 section 5.2(b), Maximum power density**		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1009 hPa	**Power:** 120 VAC, 60 Hz
Remarks:			

Plot 7.8.1 Peak spectral power density at low frequency

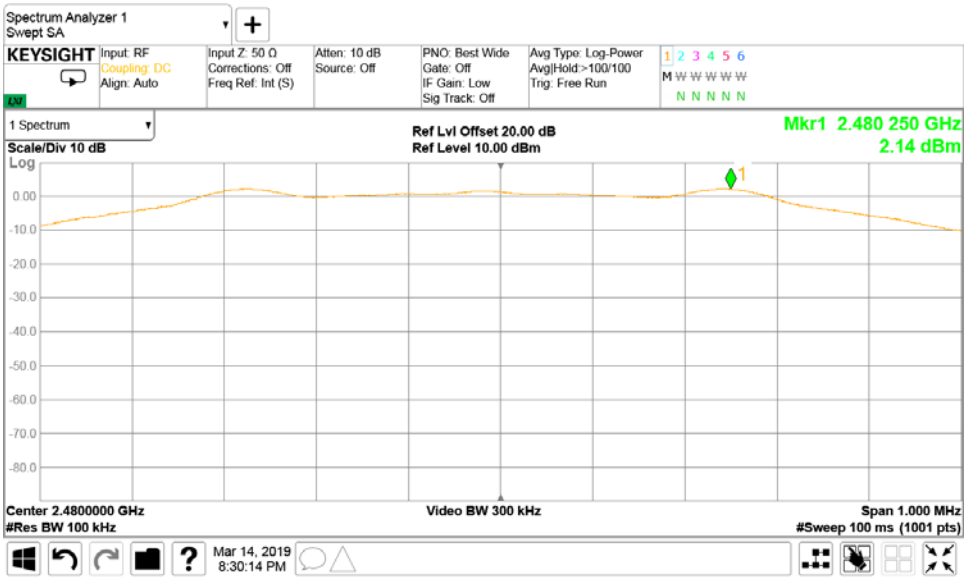


Plot 7.8.2 Peak spectral power density at mid frequency



Test specification:	**Section 15.247(e) / RSS-247 section 5.2(b), Maximum power density**		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Mar-19		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1009 hPa	**Power:** 120 VAC, 60 Hz
Remarks:			

Plot 7.8.3 Peak spectral power density at high frequency



Test specification:	**FCC Part 15, Section 15.203, RSS-Gen section 6.8, Antenna requirements**		
Test procedure:	Visual inspection		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	15-Oct-18		
Temperature: 24.3 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1009 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

7.9 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 7.9.1.

Table 7.9.1 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	

Test specification:	**Section 15.207(a), RSS-Gen section 8.8, Conducted emission**		
Test procedure:	ANSI C63.10, section 6.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	15-Oct-18		
Temperature: 24.3 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1009 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

7.10 Conducted emissions

7.10.1 General

This test was performed to measure common mode conducted emissions at the mains power port. Specification test limits are given in Table 7.10.1.

Table 7.10.1 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.

7.10.2 Test procedure

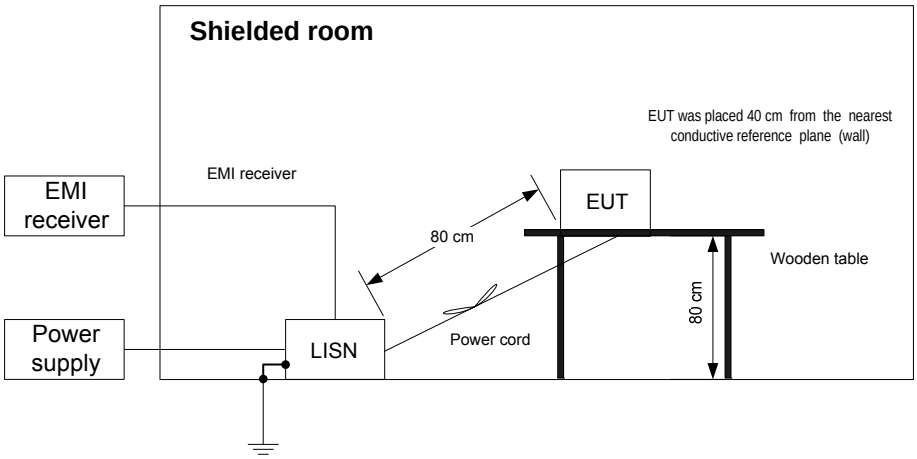
7.10.2.1 The EUT was set up as shown in Figure 7.10.1 and associated photographs, energized and the performance check was conducted.

7.10.2.2 The measurements were performed at power terminals with the LISN, connected to a spectrum analyzer in the frequency range referred to in Table 7.10.2. Unused coaxial connector of the LISN was terminated with 50 Ohm. Quasi-peak and average detectors were used throughout the testing.

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

7.10.2.4 The worst test results (the lowest margins) were recorded in Table 7.10.2 and shown in the associated plots.

Figure 7.10.1 Setup for conducted emission measurements, table-top equipment



Test specification:	**Section 15.207(a), RSS-Gen section 8.8, Conducted emission**		
Test procedure:	ANSI C63.10, section 6.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	15-Oct-18		
Temperature: 24.3 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1009 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Table 7.10.2 Conducted emission test results

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

Frequency, MHz	Peak emission, dB(μV)	Quasi-peak			Average			Line ID	Verdict
		Measured emission, dB(μV)	Limit, dB(μV)	Margin, dB*	Measured emission, dB(μV)	Limit, dB(μV)	Margin, dB*		
0.556475	51.9	50.8	56.0	-5.20	35.8	46.0	-10.20	L1	Pass
2.782638	40.5	38.6	56.0	-17.40	23.4	46.0	-22.60		
10.065250	39.8	35.9	60.0	-24.10	27.0	50.0	-23.00		
15.199400	43.0	36.5	60.0	-23.50	27.5	50.0	-22.50		
0.278661	35.2	31.2	60.9	-29.66	15.4	50.86	-35.46	L2	Pass
0.486590	37.1	27.2	56.2	-29.03	14.9	46.23	-31.33		
0.556260	52.2	50.5	56.0	-5.50	34.0	46.0	-12.00		
2.780588	41.0	38.7	56.0	-17.30	21.2	46.0	-24.80		
10.066280	39.0	33.0	60.0	-27.00	21.0	50.0	-29.00		
15.194888	41.2	34.9	60.0	-25.10	26.5	50.0	-23.50		

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

Reference numbers of test equipment used

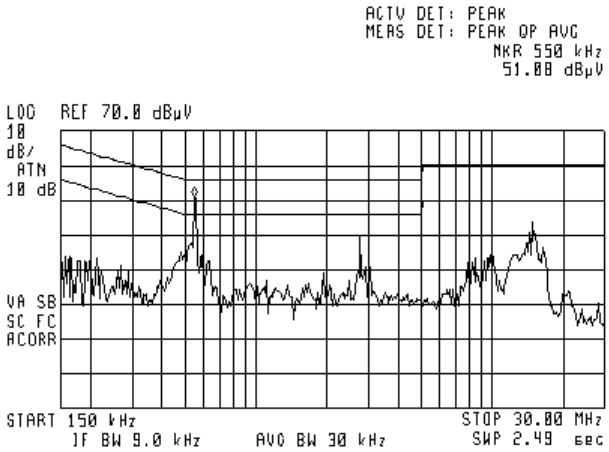
HL 0787	HL 3016	HL 4280	HL 4778				

Full description is given in Appendix A.

Test specification:	**Section 15.207(a), RSS-Gen section 8.8, Conducted emission**		
Test procedure:	ANSI C63.10, section 6.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	15-Oct-18		
Temperature: 24.3 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1009 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

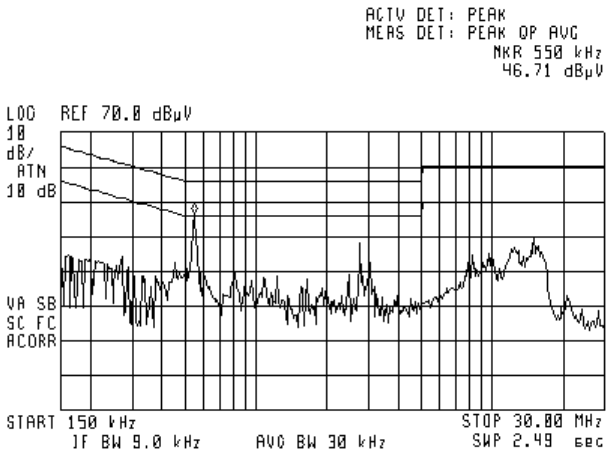
Plot 7.10.1 Conducted emission measurements

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



Plot 7.10.2 Conducted emission measurements

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



8 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 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
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	27-Jan-19	27-Jan-20
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
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1226/2A	07-Feb-18	07-Mar-19
4280	Test Cable , DC-18 GHz, 4.6 m, N/M - N/M	Mini-Circuits	APC-15FT-NMNM+	0763A	01-Aug-18	01-Aug-19
4355	Signal and Spectrum Analyzer, 9 kHz to 7 GHz	Rohde & Schwarz	FSV 7	101630	01-Jan-19	01-Jan-20
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
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	08-Feb-19	08-Feb-22
5376	EXA Signal Analyzer, 10 Hz - 32 GHz	Keysight Technologies	N9010B	MY57470404	18-Mar-19	18-Mar-20
5405	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11N(x2)	500023/118	01-Aug-18	01-Aug-19
5409	RF cable, 40 GHz, SMA-SMA, 2 m	Huber-Suhner	SF102EA/11SK/11SK/2000MM	503973/2EA	19-Aug-18	19-Aug-19

9 APPENDIX B 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.

10 APPENDIX C Test laboratory description

Tests were performed at Hermon Laboratories Ltd., which is a fully independent, private, EMC, Radio, Safety, Environmental and Telecommunication testing facility.
Hermon Laboratories is recognized and accredited by the Federal Communications Commission (USA) for 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-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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11 APPENDIX D Specification references

FCC 47CFR part 15: 2017	Radio Frequency Devices
ANSI C63.10: 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
KDB 558074 D01 15.247 Meas Guidance v05:2018	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
ANSI C63.2: 1996	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
RSS-247 Issue 2: 2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence- Exempt Local Area Network (LE-LAN) Devices
RSS-Gen Issue 5: 2018	General Requirements for Compliance of Radio Apparatus

12 APPENDIX E Test equipment correction factors

Antenna factor
Active loop antenna
Model 6502, S/N 2857, HL 0446

Frequency, MHz	Magnetic antenna factor, dB	Electric antenna factor, dB
0.009	-32.8	18.7
0.010	-33.8	17.7
0.020	-38.3	13.2
0.050	-41.1	10.4
0.075	-41.3	10.2
0.100	-41.6	9.9
0.150	-41.7	9.8
0.250	-41.6	9.9
0.500	-41.8	9.8
0.750	-41.9	9.7
1.000	-41.4	10.1
2.000	-41.5	10.0
3.000	-41.4	10.2
4.000	-41.4	10.1
5.000	-41.5	10.1
10.000	-41.9	9.6
15.000	-41.9	9.6
20.000	-42.2	9.3
25.000	-42.8	8.7
30.000	-44.0	7.5

Antenna factor in dB(1/m) is to be added to receiver meter reading in dB(μV) to convert it into field strength in dB(μV/m).

Antenna factor
Trilog antenna
Model ALX-8000E, Frankonia, S/N 00809, HL 5288, 30-1000 MHz

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

Antenna factor
Active Horn Antenna,
Com-Power Corporation, model: AHA-118, s/n 701046, HL 4933

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.

Cable loss
Microwave Cable Assembly, Huber-Suhner, 40 GHz, 1.5 m, SMA-SMA, S/N 1226/2A
HL 3903

Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB
10	-0.02	9500	1.84	21000	2.98
100	0.15	10000	1.86	22000	3.07
500	0.38	10500	1.93	23000	3.13
1000	0.56	11000	1.99	24000	3.21
1500	0.69	11500	2.04	25000	3.26
2000	0.82	12000	2.10	26000	3.48
2500	0.90	12500	2.15	27000	3.44
3000	0.98	13000	2.21	28000	3.53
3500	1.06	13500	2.25	29000	3.59
4000	1.11	14000	2.29	30000	3.66
4500	1.17	14500	2.34	31000	3.70
5000	1.24	15000	2.36	32000	3.79
5500	1.32	15500	2.40	33000	3.88
6000	1.40	16000	2.45	34000	3.94
6500	1.50	16500	2.48	35000	3.91
7000	1.56	17000	2.56	36000	4.05
7500	1.62	17500	2.58	37000	4.22
8000	1.68	18000	2.60	38000	4.25
8500	1.74	19000	2.84	39000	4.27
9000	1.78	20000	2.88	40000	4.33

Cable loss
Test cable, Mini-Circuits, S/N 0763A, 18 GHz, 4.6 m, N/M - N/M
APC-15FT-NMNM+, HL 4280

Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB
10	0.21	5000	4.27	10200	6.50	15400	8.49
30	0.26	5100	4.32	10300	6.55	15500	8.50
50	0.34	5200	4.35	10400	6.59	15600	8.55
100	0.51	5300	4.41	10500	6.62	15700	8.58
200	0.63	5400	4.43	10600	6.65	15800	8.61
300	0.73	5500	4.49	10700	6.66	15900	8.64
400	0.91	5600	4.54	10800	6.68	16000	8.68
500	1.07	5700	4.58	10900	6.70	16100	8.72
600	1.21	5800	4.63	11000	6.71	16200	8.73
700	1.33	5900	4.67	11100	6.72	16300	8.75
800	1.45	6000	4.73	11200	6.74	16400	8.77
900	1.55	6100	4.76	11300	6.77	16500	8.80
1000	1.65	6200	4.81	11400	6.81	16600	8.80
1100	1.75	6300	4.86	11500	6.84	16700	8.82
1200	1.85	6400	4.89	11600	6.87	16800	8.83
1300	1.94	6500	4.94	11700	6.89	16900	8.87
1400	2.03	6600	4.95	11800	6.94	17000	8.92
1500	2.11	6700	4.99	11900	7.00	17100	8.96
1600	2.19	6800	5.04	12000	7.05	17200	9.01
1700	2.27	6900	5.04	12100	7.10	17300	9.07
1800	2.34	7000	5.09	12200	7.17	17400	9.09
1900	2.42	7100	5.15	12300	7.23	17500	9.14
2000	2.49	7200	5.19	12400	7.29	17600	9.17
2100	2.56	7300	5.25	12500	7.34	17700	9.21
2200	2.63	7400	5.33	12600	7.38	17800	9.24
2300	2.69	7500	5.39	12700	7.44	17900	9.28
2400	2.76	7600	5.42	12800	7.48	18000	9.31
2500	2.83	7700	5.51	12900	7.55		
2600	2.89	7800	5.58	13000	7.58		
2700	2.95	7900	5.62	13100	7.63		
2800	3.02	8000	5.68	13200	7.67		
2900	3.08	8100	5.73	13300	7.72		
3000	3.15	8200	5.78	13400	7.76		
3100	3.21	8300	5.83	13500	7.81		
3200	3.27	8400	5.87	13600	7.85		
3300	3.33	8500	5.92	13700	7.88		
3400	3.38	8600	5.96	13800	7.93		
3500	3.44	8700	6.00	13900	7.97		
3600	3.49	8800	6.04	14000	8.01		
3700	3.55	8900	6.10	14100	8.05		
3800	3.60	9000	6.13	14200	8.09		
3900	3.65	9100	6.17	14300	8.12		
4000	3.71	9200	6.22	14400	8.15		
4100	3.75	9300	6.25	14500	8.19		
4200	3.81	9400	6.28	14600	8.22		
4300	3.86	9500	6.32	14700	8.26		
4400	3.93	9600	6.36	14800	8.29		
4500	3.98	9700	6.37	14900	8.32		
4600	4.03	9800	6.41	15000	8.36		
4700	4.08	9900	6.42	15100	8.40		
4800	4.13	10000	6.45	15200	8.43		
4900	4.18	10100	6.48	15300	8.44		

Cable loss
RF Cable, Huber-Suhner, 18 GHz, 6 m,
SF118/11N(x2), S/N 500023/118
HL 5405

5405

Specific Test Report

Frequency Range [GHz]	IL min S21 [dB]	IL min S12 [dB]	RL max S11 [dB]	RL max S22 [dB]
0.040 - 1.836	-1.431	-1.431	-37.037	-37.704
1.836 - 3.632	-2.062	-2.066	-33.573	-32.848
3.632 - 5.428	-2.576	-2.576	-28.548	-29.602
5.428 - 7.224	-3.013	-3.014	-30.738	-32.523
7.224 - 9.020	-3.415	-3.416	-33.728	-32.257
9.020 - 10.816	-3.772	-3.772	-29.302	-30.735
10.816 - 12.612	-4.138	-4.138	-28.768	-26.255
12.612 - 14.408	-4.456	-4.462	-27.109	-26.151
14.408 - 16.204	-4.786	-4.786	-26.056	-27.116
16.204 - 18.000	-5.113	-5.111	-27.762	-28.508

Type:	SF118/11N/11N/6000MM
Sales no.:	10497130
Serial no.:	500023 /118
PA no.:	1956306
Ring no.:	
Cable length:	6 m
Test length:	
Connector 1:	SF_11_N-656
Connector 2:	SF_11_N-656
Cable:	SUCOFLEX_118
Meas. System:	N5230C,MY49001834,A.09.42.22
Time:	7:04:21 AM
Date:	6/6/2018
Inspected by:	AZ /111
Start Freq.:	0.04000 GHz
Stop Freq.:	18.00000 GHz
Meas Points:	801
Source Power:	-5 dBm

Cable loss
RF Cable, Huber-Suhner, 40 GHz, 2 m, ,
SF102EA/11SK/11SK/2000MM, S/N 503973/2EA
HL 5409

Frequency, MHz	Cable loss, dB	Frequency, MHz	Cable loss, dB
100	0.26	20500	3.75
200	0.36	21000	3.80
300	0.45	21500	3.85
500	0.58	22000	3.90
1000	0.82	22500	3.95
1500	0.99	23000	4.00
2000	1.15	23500	4.04
2500	1.28	24000	4.09
3000	1.40	24500	4.13
3500	1.51	25000	4.19
4000	1.61	25500	4.25
4500	1.71	26000	4.30
5000	1.80	26500	4.37
5500	1.89	27000	4.45
6000	1.98	27500	4.47
6500	2.06	28000	4.45
7000	2.14	28500	4.49
7500	2.22	29000	4.57
8000	2.29	29500	4.60
8500	2.36	30000	4.59
9000	2.43	30500	4.63
9500	2.50	31000	4.68
10000	2.58	31500	4.74
10500	2.63	32000	4.81
11000	2.70	32500	4.89
11500	2.76	33000	4.89
12000	2.82	33500	4.92
12500	2.87	34000	4.94
13000	2.94	34500	4.99
13500	3.00	35000	5.07
14000	3.06	35500	5.12
14500	3.11	36000	5.14
15000	3.17	36500	5.22
15500	3.23	37000	5.28
16000	3.29	37500	5.30
16500	3.35	38000	5.39
17000	3.41	38500	5.48
17500	3.47	39000	5.44
18000	3.51	39500	5.45
18500	3.56	40000	5.51
19000	3.60		
19500	3.66		
20000	3.71		

13 APPENDIX F Abbreviations and acronyms

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

END OF DOCUMENT