HERMON LABORATORIES

ELECTRICAL TESTING
0839.01

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TEST REPORT

ACCORDING TO: FCC 47CFR part 15 subpart C §15.247 (FHSS)
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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1 Applicant information

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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. 293, Ben Gurion Airoport, Airoport 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:	06-Nov-18
Test specification(s):	FCC 47CFR part 15, subpart C, §15.247(FHSS); RSS-247 issue 2, RSS-Gen issue 5

5 Tests summary

Test	Status
Transmitter characteristics	
FCC section 15.247(a)1/ RSS-247 section 5.1(c), 20 dB bandwidth	Pass
FCC section 15.247(a)1/ RSS-247 section 5.1(b), Frequency separation	Pass
FCC section 15.247(a)1/ RSS-247 section 5.1(c), Number of hopping frequencies	Pass
FCC section 15.247(a)1/ RSS-247 section 5.1(c), Average time of occupancy	Pass
FCC section 15.247(b) / RSS-247 section 5.4(a), 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(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. A. Morozov, test engineer Mr. S. Samokha, test engineer	November 6, 2018	
Reviewed by:	Mrs. M. Cherniavsky, certification engineer	December 10, 2018	
Approved by:	Mr. K. Zushchyk, , Projects & Customer Manager, EMC & Radio	January 21, 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 902-928 MHz radio.

6.2 Ports and lines

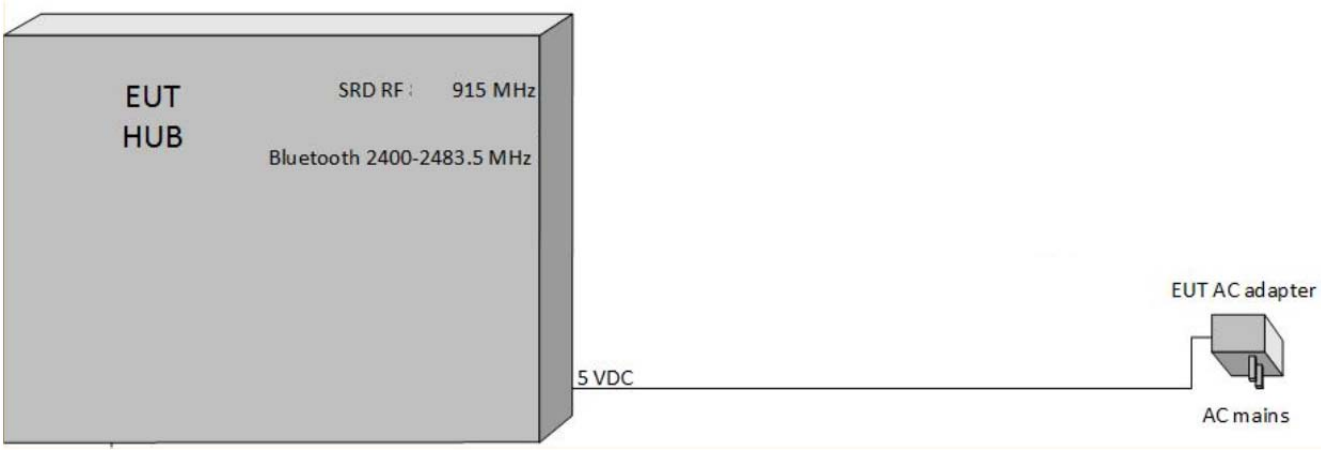
Port type	Port description	Connected from	Connected to	Qty.	Cable type	Cable length, m
Power	AC	AC adapter	AC mains	1	NA	NA
Power	DC	AC adapter	EUT HUB	1	Unshielded	1.5 m

6.3 Changes made in EUT

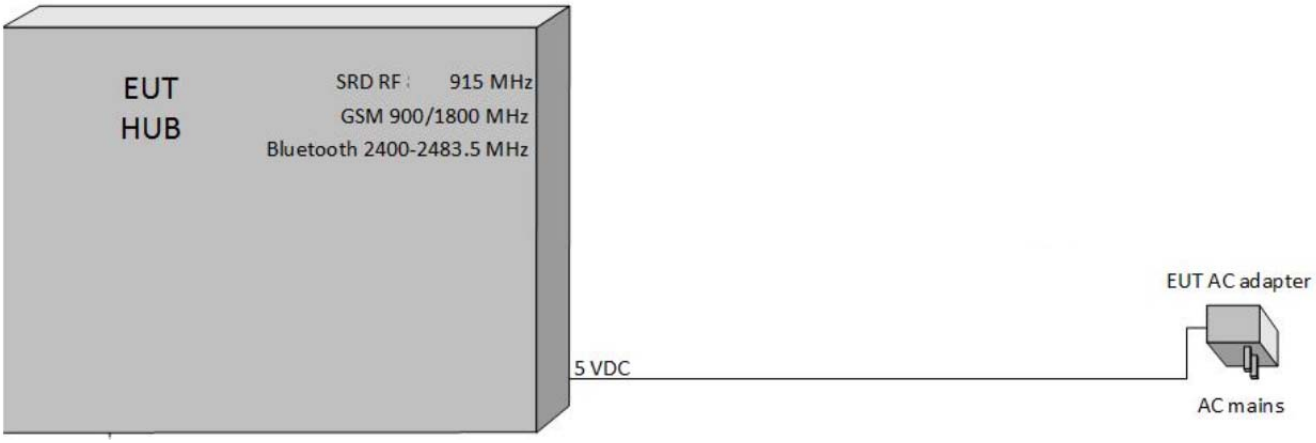
To withstand the standard requirements, the following changes were implemented in the EUT during testing:
a power transient voltage suppressor (TVS) of 100V manufactured by CYG WAYON CIRCUIT PROTECTION CO., LTD., model SMAJ100CA-TR was soldered on top of C86 capacitor of 1nF/2KV placed on main PCB.
It 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	902 – 928 MHz
Operating frequencies	905.6 – 926.0 MHz

Maximum rated output power	At transmitter 50 Ω RF output connector	dBm
	Peak output power	16.22 dBm (Hub 2820), 14.32 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	2.2 dBi

Transmitter aggregate data rate/s	50 kbps
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	X	Frequency hopping (FHSS)
		Digital transmission system (DTS)
		Hybrid

Spread spectrum parameters for transmitters tested per FCC 15.247 only		
FHSS	Total number of hops	52
	Bandwidth per hop	102.9 kHz
	Max. separation of hops	400 kHz

Test specification:	FCC section 15.247(a)1, RSS-247 section 5.1(c), 20 dB bandwidth		
Test procedure:	ANSI C63.10, section 7.8.7		
Test mode:	Compliance	Verdict:	PASS
Date(s):	11-Oct-18		
Temperature: 25 ºC	Relative Humidity: 44 %	Air Pressure: 1012 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 20 dB bandwidth

7.1.1 General

This test was performed to measure the 20 dB bandwidth of the transmitter hopping channel. Specification test limits are given in Table 7.1.1.

Table 7.1.1 The 20 dB bandwidth limits

Assigned frequency, MHz	Maximum bandwidth, kHz	Modulation envelope reference points*, dBc
902.0 – 928.0	250	20

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

7.1.2 Test procedure

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

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

7.1.2.3 The transmitter bandwidth was measured with spectrum analyzer as frequency delta between reference points on modulation envelope and provided in Table 7.1.2, Table 7.1.3 and associated plots.

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

Figure 7.1.1 The 20 dB bandwidth test setup

Test specification:	**FCC section 15.247(a)1, RSS-247 section 5.1(c), 20 dB bandwidth**		
Test procedure:	ANSI C63.10, section 7.8.7		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 44 %	**Air Pressure:** 1012 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Table 7.1.2 The 20 dB bandwidth test results

ASSIGNED FREQUENCY BAND: 902 – 928 MHz
DETECTOR USED: Peak
SWEEP TIME: Auto
VIDEO BANDWIDTH: ≥ RBW
MODULATION ENVELOPE REFERENCE POINTS: 20.0 dBc
MODULATING SIGNAL: PRBS
FREQUENCY HOPPING: Disabled

Carrier frequency, MHz	Type of modulation	Data rate, kbps	Symbol rate, Msymbols/s	20 dB bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
Low frequency							
905.60	GFSK	50	NA	102.90	250.00	-147.10	Pass
Mid frequency							
916.00	GFSK	50	NA	101.90	250.00	-148.10	Pass
High frequency							
926.00	GFSK	50	NA	102.70	250.00	-147.30	Pass

Table 7.1.3 The 99% bandwidth test results

ASSIGNED FREQUENCY BAND: 902 – 928 MHz
DETECTOR USED: Peak
SWEEP TIME: Auto
VIDEO BANDWIDTH: ≥ RBW
MODULATION ENVELOPE REFERENCE POINTS: 20.0 dBc
MODULATING SIGNAL: PRBS
FREQUENCY HOPPING: Disabled

Carrier frequency, MHz	Type of modulation	Data rate, kbps	Symbol rate, Msymbols/s	99% bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
Low frequency							
905.60	GFSK	50	NA	95.21	250.00	-154.79	Pass
Mid frequency							
916.00	GFSK	50	NA	92.18	250.00	-157.82	Pass
High frequency							
926.00	GFSK	50	NA	93.76	250.00	-156.24	Pass

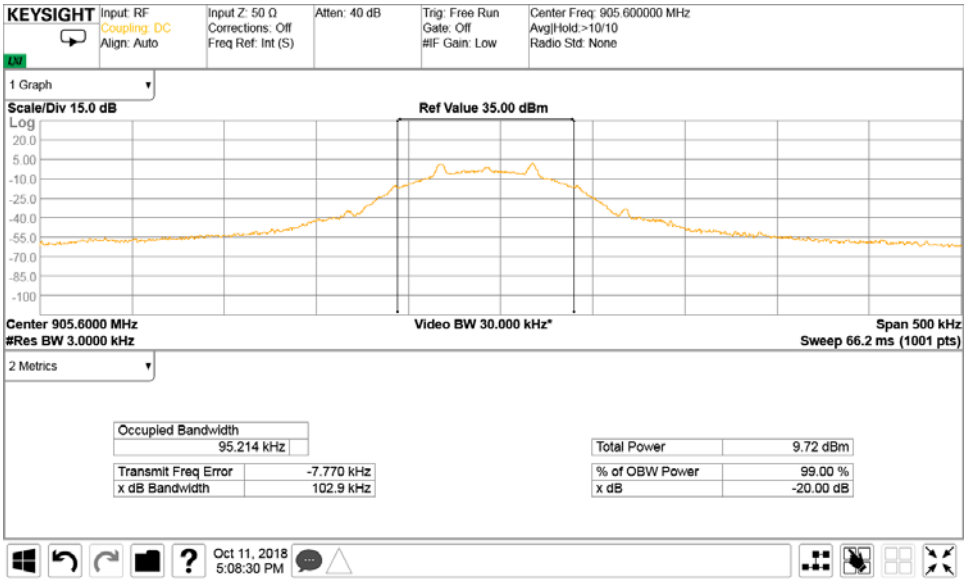
Reference numbers of test equipment used

HL 5376	HL 5409							

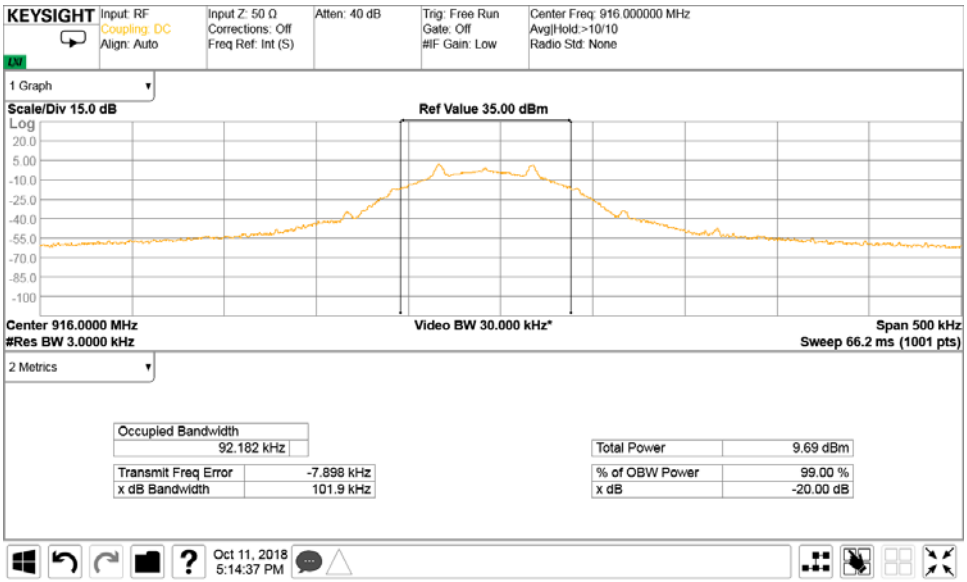
Full description is given in Appendix A.

Test specification:	**FCC section 15.247(a)1, RSS-247 section 5.1(c), 20 dB bandwidth**		
Test procedure:	ANSI C63.10, section 7.8.7		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 44 %	**Air Pressure:** 1012 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Plot 7.1.1 The 20 dB bandwidth test result at low frequency

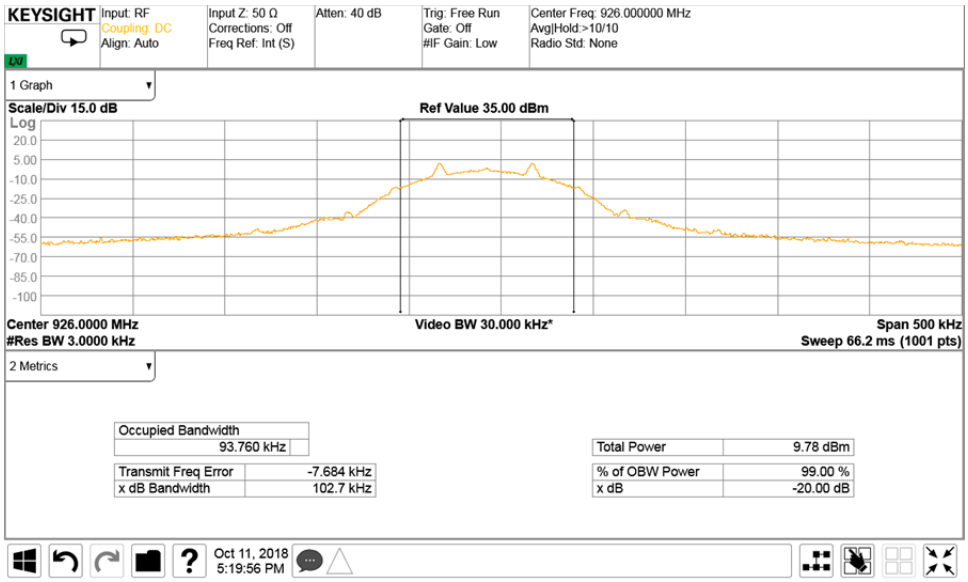


Plot 7.1.2 The 20 dB bandwidth test result at mid frequency



Test specification:	**FCC section 15.247(a)1, RSS-247 section 5.1(c), 20 dB bandwidth**		
Test procedure:	ANSI C63.10, section 7.8.7		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 44 %	**Air Pressure:** 1012 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Plot 7.1.3 The 20 dB bandwidth test result at high frequency



Test specification:	Section 15.247(a)1, RSS-247 section 5.1(b), Frequency separation		
Test procedure:	ANSI C63.10, section 7.8.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	11-Oct-18		
Temperature: 25 ºC	Relative Humidity: 44 %	Air Pressure: 1012 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

7.2 Carrier frequency separation

7.2.1 General

This test was performed to measure frequency separation between the peaks of adjacent channels. Specification test limits are given in Table 7.2.1.

Table 7.2.1 Carrier frequency separation limits

Assigned frequency range, MHz	Carrier frequency separation	
	Output power 30 dBm	Output power 21 dBm
902.0 – 928.0	25 kHz or 20 dB bandwidth of the hopping channel, whichever is greater	25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater

7.2.2 Test procedure

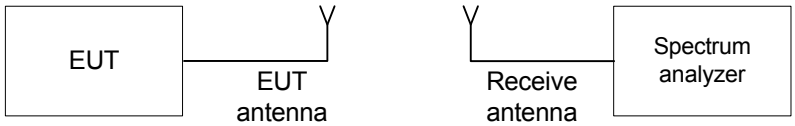
7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized with frequency hopping function enabled and its proper operation was checked.

7.2.2.2 The spectrum analyzer span was set to capture the carrier frequency and both of adjacent channels, the lower and the higher. The resolution bandwidth was set wider than 1 % of the frequency span.

7.2.2.3 The spectrum analyzer was set in max hold mode and allowed trace to stabilize.

7.2.2.4 The frequency separation between the peaks of adjacent channels was measured as provided in Table 7.2.2 and associated plot.

Figure 7.2.1 Carrier frequency separation test setup



Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(b), Frequency separation**		
Test procedure:	ANSI C63.10, section 7.8.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 44 %	**Air Pressure:** 1012 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Table 7.2.2 Carrier frequency separation test results

ASSIGNED FREQUENCY BAND:	902 – 928 MHz
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	50 kbps
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	30% of the channel spacing
VIDEO BANDWIDTH:	≥ RBW
FREQUENCY HOPPING:	Enabled
20 dB BANDWIDTH:	102.9 kHz

Carrier frequency separation, kHz	Limit, kHz	Margin*, kHz	Verdict
400.00	102.9	298.1	Pass

* - Margin = Carrier frequency separation – specification limit.

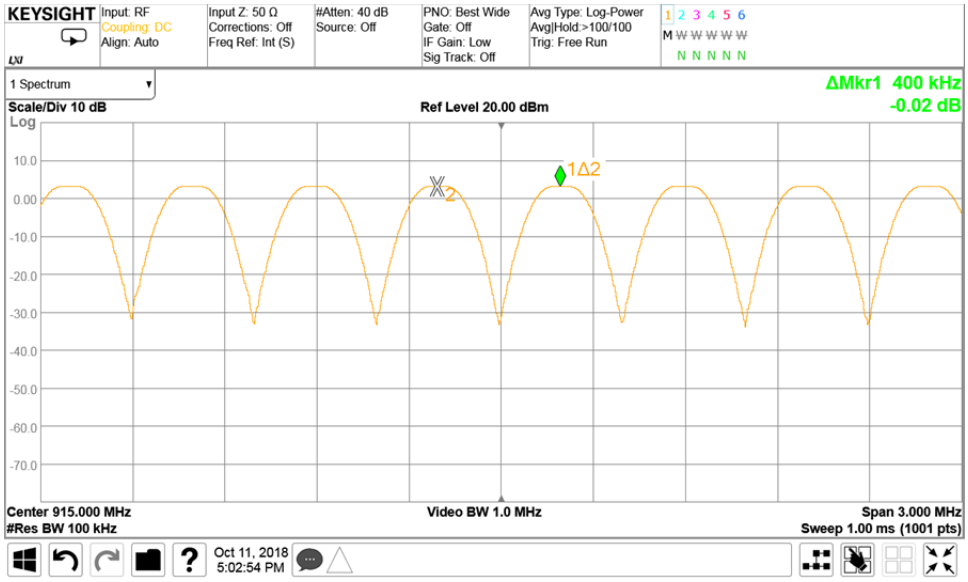
Reference numbers of test equipment used

HL 5409	HL 5376	HL					

Full description is given in Appendix A.

Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(b), Frequency separation**		
Test procedure:	ANSI C63.10, section 7.8.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 44 %	**Air Pressure:** 1012 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Plot 7.2.1 Carrier frequency separation



Test specification:	Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	Verdict:	PASS
Date(s):	11-Oct-18		
Temperature: 23 ºC	Relative Humidity: 45 %	Air Pressure: 1012 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

7.3 Number of hopping frequencies

7.3.1 General

This test was performed to calculate the number of hopping frequencies used by the EUT. Specification test limits are given in Table 7.3.1.

Table 7.3.1 Minimum number of hopping frequencies

Assigned frequency range, MHz	Number of hopping frequencies
902.0 – 928.0	**50 (if the 20 dB bandwidth is less than 250 kHz)** 25 (if the 20 dB bandwidth is 250 kHz or greater)

7.3.2 Test procedure

7.3.2.1 The EUT was set up as shown in Figure 7.3.1, energized with frequency hopping function enabled and its proper operation was checked.

7.3.2.2 Initially the spectrum analyzer span was set equal to frequency band of operation and the resolution bandwidth was set wider than 1 % of the frequency span. If the separate hopping channels were not clearly resolved the frequency band of operation was broken to sections and the resolution bandwidth was set wider than 1 % of the frequency span of each section.

7.3.2.3 The spectrum analyzer was set in max hold mode and allowed trace to stabilize.

7.3.2.4 The number of frequency hopping channels was calculated as provided in Table 7.3.2 and the associated plots.

Figure 7.3.1 Hopping frequencies test setup

Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies**		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	11-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 45 %	**Air Pressure:** 1012 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Table 7.3.2 Hopping frequencies test results

ASSIGNED FREQUENCY:	902 – 928 MHz
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	50 kbps
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	< 30% of the channel spacing or 20dB bandwidth, whichever is smaller
VIDEO BANDWIDTH:	≥ RBW
FREQUENCY HOPPING:	Enabled

Number of hopping frequencies	Minimum number of hopping frequencies	Margin*	Verdict
52	50	2	Pass

* - Margin = Number of hopping frequencies – Minimum number of hopping frequencies.

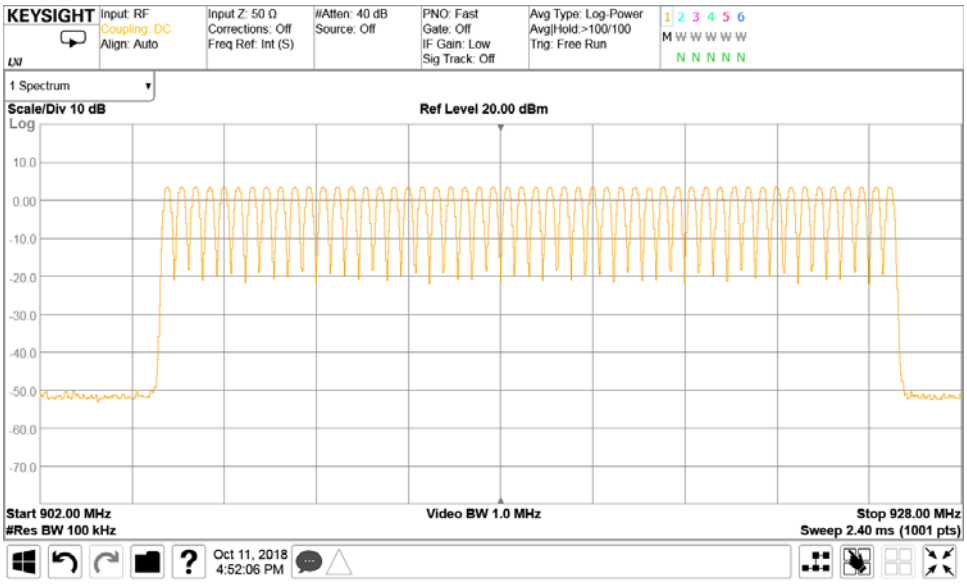
Reference numbers of test equipment used

HL 5376	HL 5409						

Full description is given in Appendix A.

Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies**		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	11-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 45 %	**Air Pressure:** 1012 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Plot 7.3.1 Number of hopping frequencies



Test specification:	Section 15.247(a)1, RSS-247 section 5.1(c), Average time of occupancy		
Test procedure:	ANSI C63.10, section 7.8.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	05-Nov-18		
Temperature: 25 ºC	Relative Humidity: 48 %	Air Pressure: 1012 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

7.4 Average time of occupancy

7.4.1 General

This test was performed to calculate the average time of occupancy (dwell time) on any frequency channel of the EUT. Specification test limits are given in Table 7.4.1.

Table 7.4.1 Average time of occupancy limits

Assigned frequency range, MHz	Maximum average time of occupancy, s	Investigated period, s	Number of hopping frequencies
902.0 – 928.0	**0.4**	**20.0**	**≥ 50**
902.0 – 928.0	0.4	10.0	< 50

7.4.2 Test procedure

7.4.2.1 The EUT was set up as shown in Figure 7.4.1, energized with frequency hopping function enabled and its proper operation was checked.

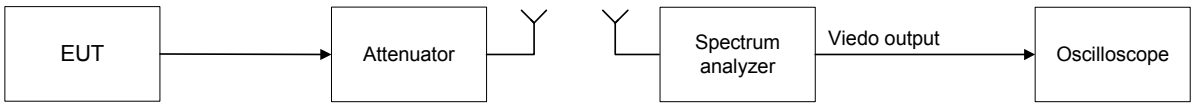
7.4.2.2 The spectrum analyzer span was set to zero centered on a hopping channel.

7.4.2.3 The single transmission duration and period were measured with oscilloscope.

7.4.2.4 The average time of occupancy was calculated as the single transmission time multiplied by the investigated period and divided by the single transmission period.

7.4.2.5 The test was repeated at each data rate and modulation type as provided in Table 7.4.2 and the associated plots.

Figure 7.4.1 Average time of occupancy test setup



Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Average time of occupancy**		
Test procedure:	ANSI C63.10, section 7.8.4		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	05-Nov-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Table 7.4.2 Average time of occupancy test results

ASSIGNED FREQUENCY: 902 – 928 MHz
MODULATION: GFSK
MODULATING SIGNAL: PRBS
BIT RATE: 50 kBps
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: 300 kHz
NUMBER OF HOPPING FREQUENCIES: 52
INVESTIGATED PERIOD: 20 s
FREQUENCY HOPPING: Enabled

Carrier frequency, MHz	Single transmission duration, s	Number of hops	Average time of occupancy*, s	Limit, s	Margin, s**	Verdict
916.00	0.01627	4	0.065	0.4	-0.335	Pass

* - Average time of occupancy = Single transmission duration × Number of hops)
** - Margin = Average time of occupancy – specification limit.

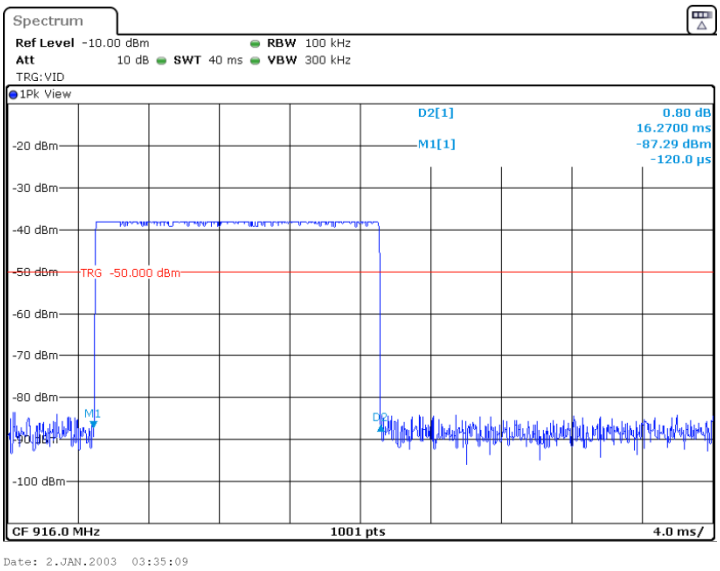
Reference numbers of test equipment used

HL 4355							

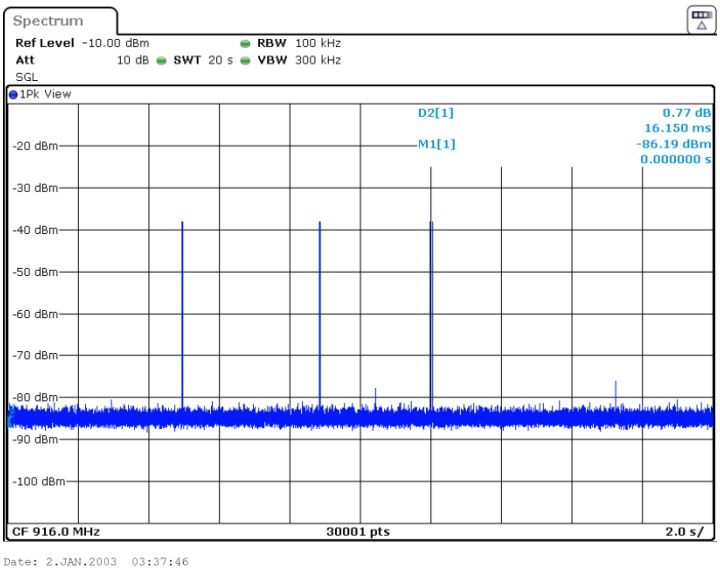
Full description is given in Appendix A.

Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Average time of occupancy**		
Test procedure:	ANSI C63.10, section 7.8.4		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	05-Nov-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Plot 7.4.1 Single transmission duration

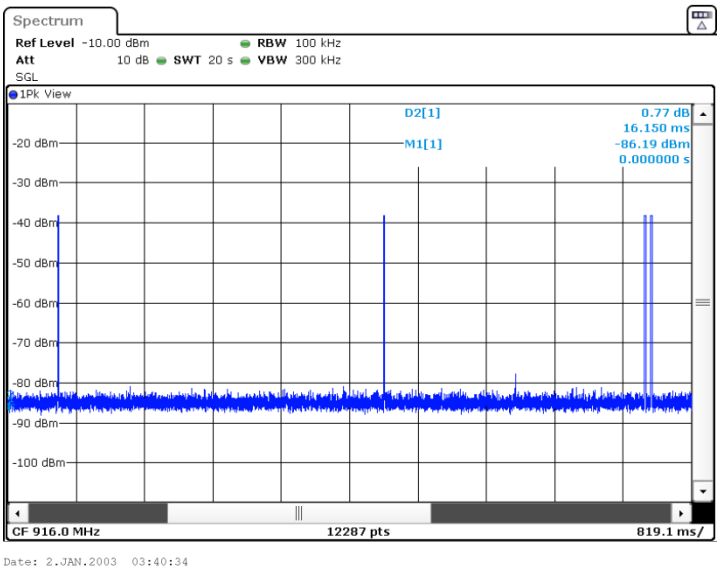


Plot 7.4.2 Number of hops



Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Average time of occupancy**		
Test procedure:	ANSI C63.10, section 7.8.4		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	05-Nov-18		
Temperature: 25 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810, HUB 2820			

Plot 7.4.3 Number of hops (zoom)



Test specification:	Section 15.247(b), RSS-247 section 5.4(a), Peak output power		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	26-Aug-18 - 05-Sep-18		
Temperature: 25 ºC	Relative Humidity: 52 %	Air Pressure: 1013 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2820			

7.5 Peak output power

7.5.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.5.1.

Table 7.5.1 Peak output power limits

Assigned frequency range, MHz	Peak output power*		Equivalent field strength limit @ 3m, dB(μV/m)*	Maximum antenna gain, dBi
	W	dBm		
902.0 – 928.0	0.25 (<50 hopping channels) 1.0 (≥50 hopping channels)	24.0(<50 hopping channels) 30.0 (≥50 hopping channels)	125.2 (<50 hopping channels) 131.2 (≥50 hopping channels)	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 the amount in dB that the directional gain of antenna exceeds 6 dBi.

7.5.2 Test procedure

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

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

7.5.2.3 The 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.

7.5.2.4 The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.5.2 and associated plots.

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

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

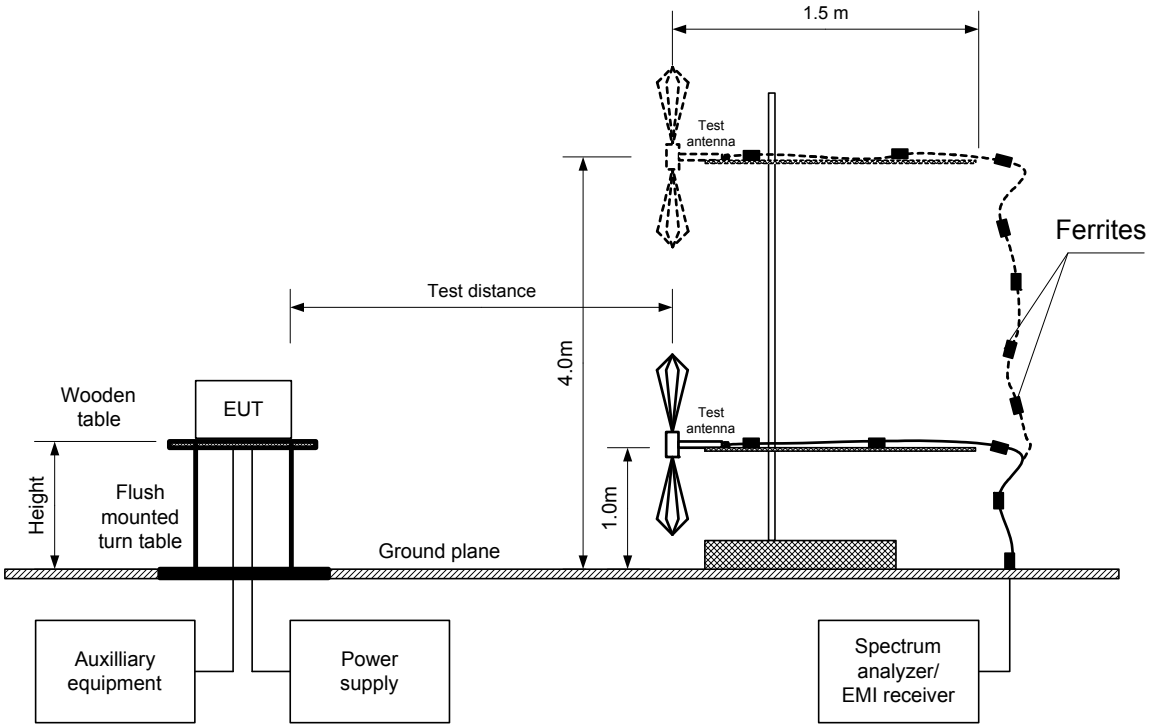
where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.
The above equation was converted in logarithmic units for 3 m test distance:

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

7.5.2.6 The worst test results (the lowest margins) were recorded in Table 7.5.2.

Test specification:	Section 15.247(b), RSS-247 section 5.4(a), Peak output power		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	26-Aug-18 - 05-Sep-18		
Temperature: 25 ºC	Relative Humidity: 52 %	Air Pressure: 1013 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2820			

Figure 7.5.1 Setup for carrier field strength measurements



Test specification:	**Section 15.247(b), RSS-247 section 5.4(a), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	26-Aug-18 - 05-Sep-18		
Temperature: 25 ºC	**Relative Humidity:** 52 %	**Air Pressure:** 1013 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.5.2 Peak output power test results

ASSIGNED FREQUENCY BAND:	902 – 928 MHz
TEST DISTANCE:	3 m
TEST SITE:	Semi anechoic chamber
EUT HEIGHT:	0.8 m
DETECTOR USED:	Peak
TEST ANTENNA TYPE:	Biconilog (30 MHz – 1000 MHz)
MODULATION:	GFSK
BIT RATE:	50 kbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
EUT 20 dB BANDWIDTH:	102.9 kHz
RESOLUTION BANDWIDTH:	1 MHz
VIDEO BANDWIDTH:	3 MHz
FREQUENCY HOPPING:	Disabled
NUMBER OF FREQUENCY HOPPING CHANNELS:	52

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
905.5914	112.84	V	1.02	180.0	2.20	15.44	30.0	-14.56	Pass
916.0063	113.62	V	1.04	177.0	2.20	16.22	30.0	-13.78	Pass
926.0023	113.17	V	1.02	40.0	2.20	15.77	30.0	-14.23	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.
Note: Maximum peak output power was obtained at U_{nom} (115%U_{nom}, 85%U_{nom}) input power voltage.

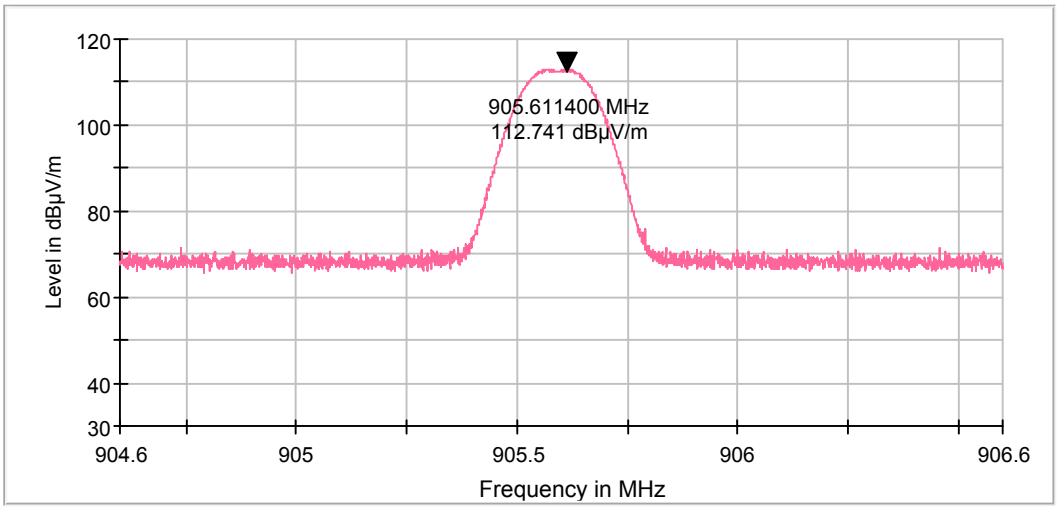
Reference numbers of test equipment used

HL 3903	HL 4360	HL 5288	HL 5405				

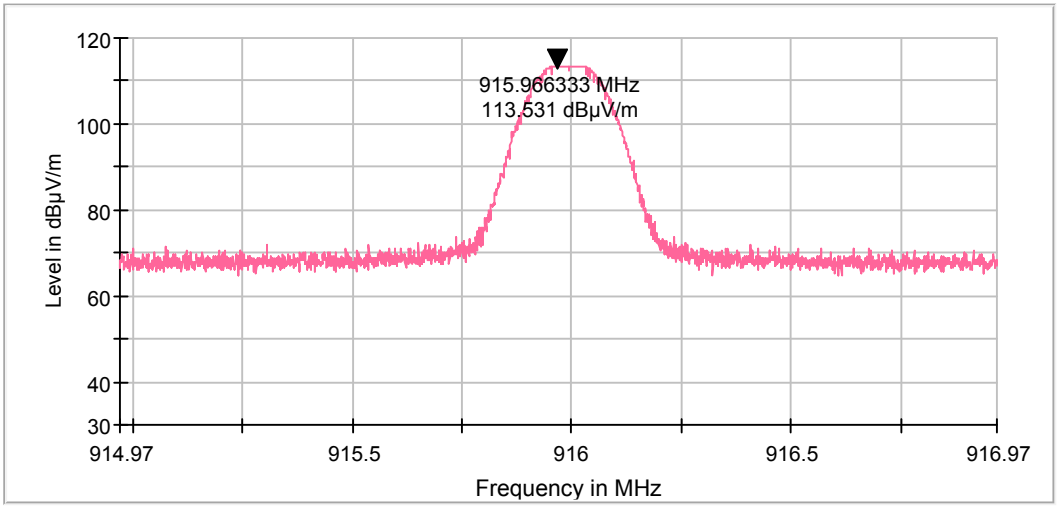
Full description is given in Appendix A.

Test specification:	Section 15.247(b), RSS-247 section 5.4(a), Peak output power		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	26-Aug-18 - 05-Sep-18		
Temperature: 25 ºC	Relative Humidity: 52 %	Air Pressure: 1013 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2820			

Plot 7.5.1 Field strength of carrier at low frequency

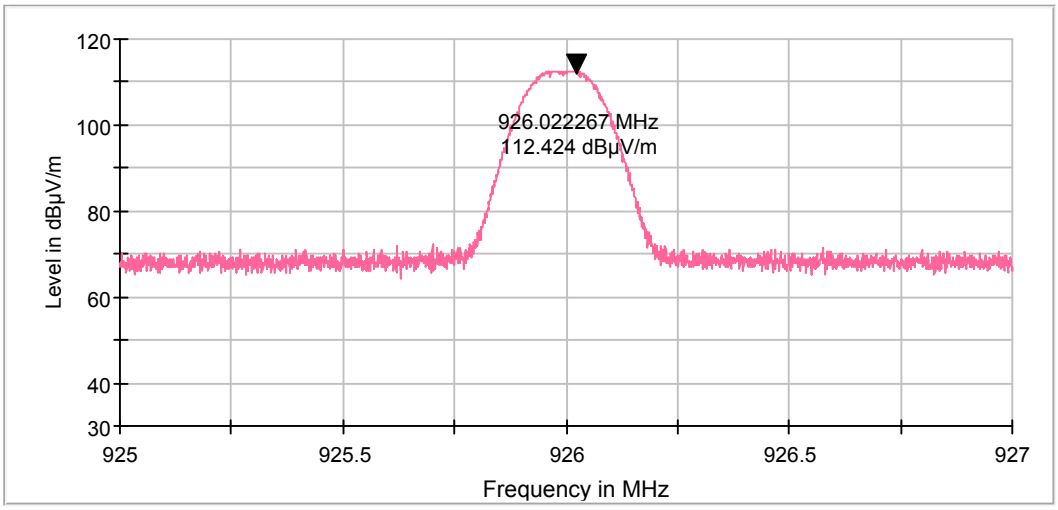


Plot 7.5.2 Field strength of carrier at mid frequency



Test specification:	**Section 15.247(b), RSS-247 section 5.4(a), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	26-Aug-18 - 05-Sep-18		
Temperature: 25 ºC	**Relative Humidity:** 52 %	**Air Pressure:** 1013 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Plot 7.5.3 Field strength of carrier at high frequency



Test specification:	Section 15.247(b), RSS-247 section 5.4(a), Peak output power		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	Relative Humidity: 54 %	Air Pressure: 1011 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2810			

7.6 Peak output power

7.6.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.6.1.

Table 7.6.1 Peak output power limits

Assigned frequency range, MHz	Peak output power*		Equivalent field strength limit @ 3m, dB(μV/m)*	Maximum antenna gain, dBi
	W	dBm		
902.0 – 928.0	0.25 (<50 hopping channels) 1.0 (≥50 hopping channels)	24.0(<50 hopping channels) 30.0 (≥50 hopping channels)	125.2 (<50 hopping channels) 131.2 (≥50 hopping channels)	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 the amount in dB that the directional gain of antenna exceeds 6 dBi.

7.6.2 Test procedure

7.6.2.1 The EUT was set up as shown in Figure 7.6.1, energized and its proper operation was checked.

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

7.6.2.3 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.

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

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

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

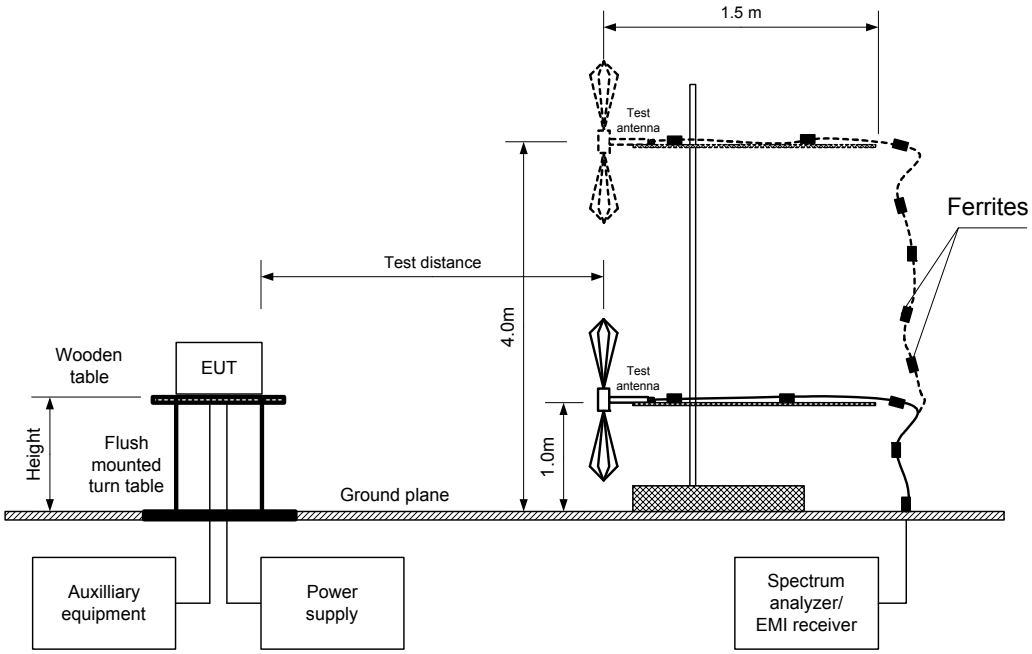
where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.
The above equation was converted in logarithmic units for 3 m test distance:

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

7.6.2.6 The worst test results (the lowest margins) were recorded in Table 7.6.2.

Test specification:	**Section 15.247(b), RSS-247 section 5.4(a), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 54 %	**Air Pressure:** 1011 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Figure 7.6.1 Setup for carrier field strength measurements



Test specification:	**Section 15.247(b), RSS-247 section 5.4(a), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 54 %	**Air Pressure:** 1011 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.6.2 Peak output power test results

ASSIGNED FREQUENCY BAND: 902 – 928 MHz
TEST DISTANCE: 3 m
TEST SITE: Semi anechoic chamber
EUT HEIGHT: 0.8 m
DETECTOR USED: Peak
EUT 20 dB BANDWIDTH: 102.9 kHz
TEST ANTENNA TYPE: Biconilog (30 MHz – 1000 MHz)
MODULATION: GFSK
BIT RATE: 50 kbps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
RESOLUTION BANDWIDTH: 1 MHz
VIDEO BANDWIDTH: 3 MHz
FREQUENCY HOPPING: Disabled
NUMBER OF FREQUENCY HOPPING CHANNELS: 52

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
905.617	111.72	Horizontal	1.87	-23	2.20	14.32	30	-15.68	Pass
916.012	111.72	Horizontal	1.00	7	2.20	14.32	30	-15.68	Pass
925.963	110.34	Horizontal	1.00	-2	2.20	12.94	30	-17.06	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.
Note: Maximum peak output power was obtained at Unom (115%Unom, 85%Unom) input power voltage.

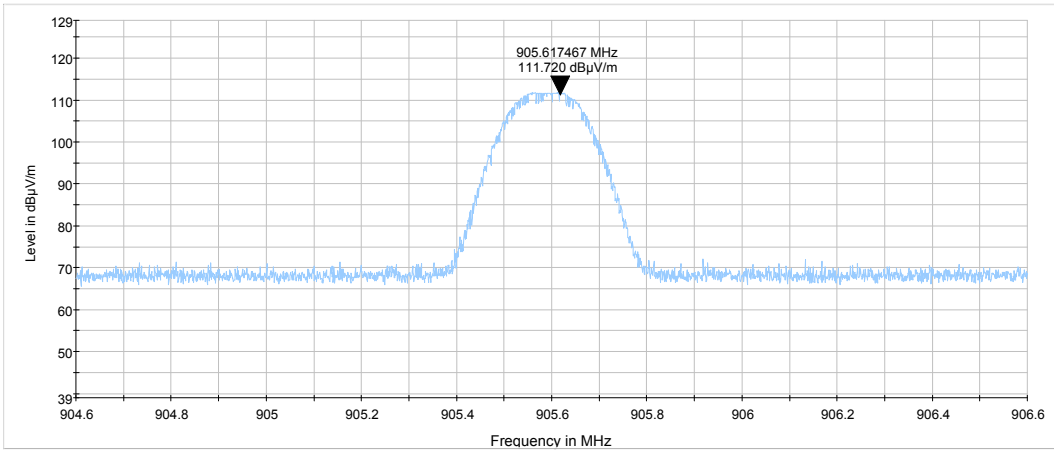
Reference numbers of test equipment used

HL 3903	HL 4360	HL 5288	HL 5405				

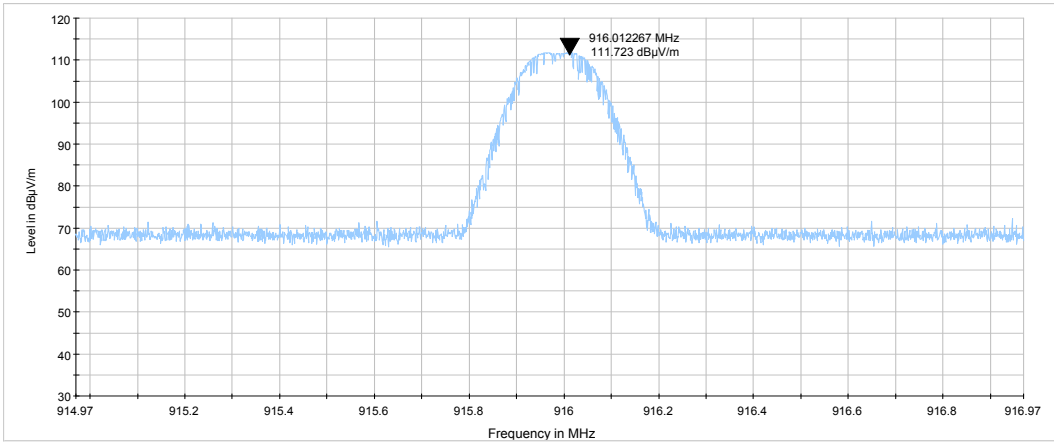
Full description is given in Appendix A.

Test specification:	**Section 15.247(b), RSS-247 section 5.4(a), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 54 %	**Air Pressure:** 1011 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Plot 7.6.1 Field strength of carrier at low frequency

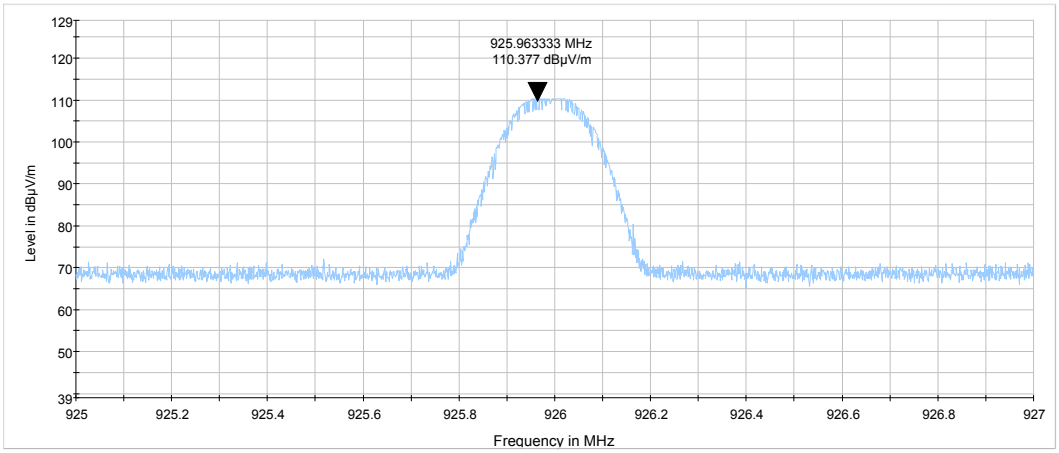


Plot 7.6.2 Field strength of carrier at mid frequency



Test specification:	**Section 15.247(b), RSS-247 section 5.4(a), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 54 %	**Air Pressure:** 1011 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Plot 7.6.3 Field strength of carrier at high frequency



Test specification:	Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	Verdict:	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	Relative Humidity: 48 %	Air Pressure: 1010 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2810			

7.7 Field strength of spurious emissions

7.7.1 General

This test was performed to measure field strength of spurious emissions from the EUT. Specification test limits are given in Table 7.7.1.

Table 7.7.1 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.

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

7.7.2.1 The EUT was set up as shown in Figure 7.7.1, energized and the performance check was conducted.

7.7.2.2 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.

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

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

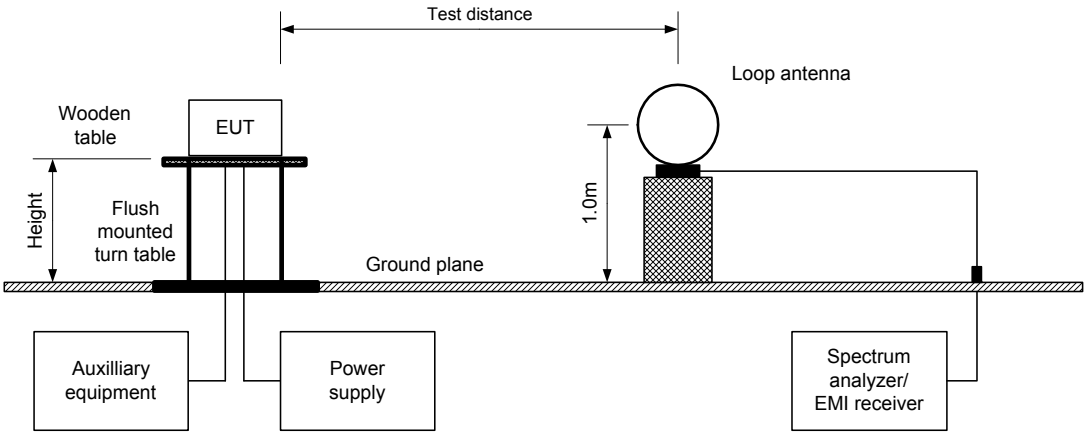
7.7.3.1 The EUT was set up as shown in Figure 7.7.2, Figure 7.7.3, energized and the performance check was conducted.

7.7.3.2 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.

7.7.3.3 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, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Figure 7.7.1 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, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Figure 7.7.2 Setup for spurious emission field strength measurements from 30 to 1000 MHz

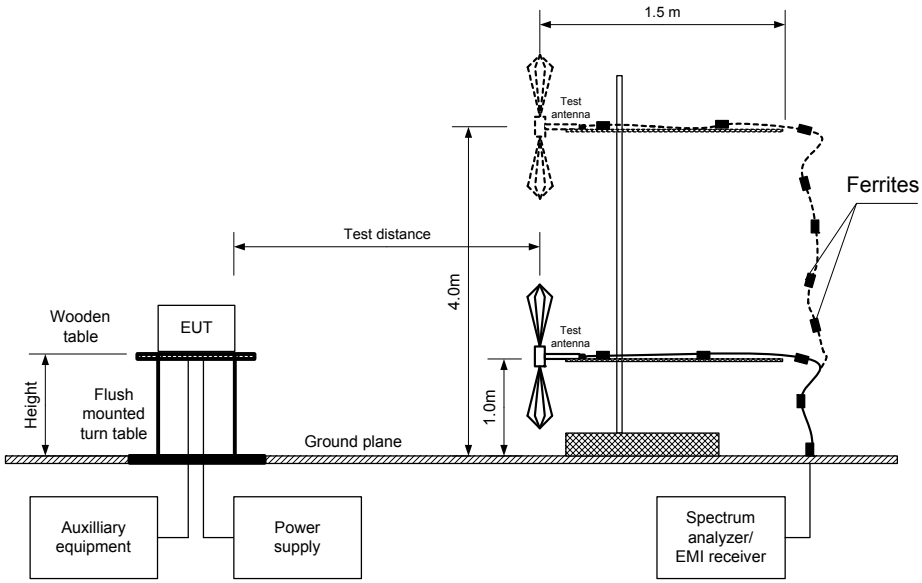
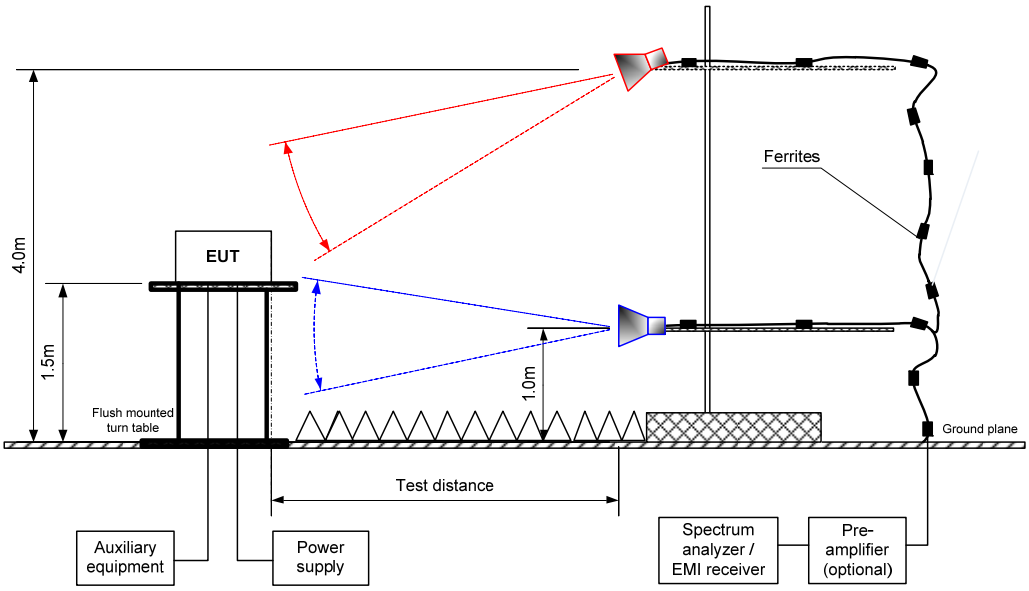


Figure 7.7.3 Setup for spurious emission field strength measurements above1000 MHz



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.7.2 Field strength of emissions outside restricted bands

ASSIGNED FREQUENCY BAND:	902 - 928 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 9500 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
BIT RATE:	50 kbps
DUTY CYCLE:	100 %
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
TRANSMITTER OUTPUT POWER:	14.32 dBm at low carrier frequency 14.32 dBm at mid carrier frequency 12.94 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									
1811.1275	56.27	Vertical	1.27	-65	111.72	55.45	20.0	35.45	Pass
Mid carrier frequency									
1832.07017	56.59	Vertical	1	-68	111.72	55.13	20.0	35.13	Pass
High carrier frequency									
1851.9075	57.06	Vertical	2.05	-87	110.34	53.28	20.0	33.28	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, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.7.3 Field strength of spurious emissions above 1 GHz within restricted bands

ASSIGNED FREQUENCY BAND:	905-928 MHz
INVESTIGATED FREQUENCY RANGE:	1000 - 9500 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
BIT RATE:	50 kbps
DUTY CYCLE:	100 %
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	1000 kHz
TEST ANTENNA TYPE:	Double ridged guide
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Antenna		Azimuth, degrees*	Peak field strength(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											
2717.02233	Vertical	1.54	-87	58.86	74.0	-15.14	58.86	35.51	54.0	-18.49	Pass
3622.41767	Horizontal	2.06	-68	62.63	74.0	-11.37	62.63	39.28	54.0	-14.72	
4527.8125	Vertical	1.53	-162	58.03	74.0	-15.97	58.03	34.68	54.0	-19.32	
Mid carrier frequency											
2747.9100	Vertical	1.28	-65	56.86	74.0	-17.14	56.86	33.51	54.0	-20.49	Pass
3663.8025	Horizontal	2.06	-64	63.00	74.0	-11.00	63.00	39.65	54.0	-14.35	
4580.14233	Vertical	1.53	-161	59.02	74.0	-14.98	59.02	35.67	54.0	-18.33	
High carrier frequency											
2778.19233	Vertical	2.05	134	56.97	74.0	-17.03	56.97	33.62	54.0	-20.38	Pass
3703.97767	Horizontal	1.79	-98	61.60	74.0	-12.40	61.60	38.25	54.0	-15.75	
4629.7625	Vertical	2.32	31	56.05	74.0	-17.95	56.05	32.70	54.0	-21.30	

*- EUT front panel refers to 0 degrees position of turntable.
**- Margin = Measured field strength - specification limit.
***- Margin = Calculated field strength - specification limit,
where Calculated field strength = Measured field strength + average factor.

Table 7.7.4 Average factor calculation

Transmission pulse		Transmission burst		Transmission train duration, ms	Average factor, dB
Duration, ms	Period, ms	Duration, ms	Period, ms		
6.8	220	NA	NA	NA	-23.35

*- Average factor was calculated as follows

for pulse train shorter than 100 ms:

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

for pulse train longer than 100 ms:

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

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.7.5 Field strength of spurious emissions below 1 GHz within restricted bands

ASSIGNED FREQUENCY BAND:	905-928 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 1000 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	50 kbps
DUTY CYCLE:	100 %
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
RESOLUTION BANDWIDTH:	0.2 kHz (9 kHz – 150 kHz) 9.0 kHz (150 kHz – 30 MHz) 120 kHz (30 MHz – 1000 MHz)
VIDEO BANDWIDTH:	> Resolution bandwidth
TEST ANTENNA TYPE:	Active loop (9 kHz – 30 MHz) Biconilog (30 MHz – 1000 MHz)
FREQUENCY HOPPING:	Disabled

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

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

Reference numbers of test equipment used

HL 0446	HL 3903	HL 4360	HL 4933	HL 5288	HL 5405	HL 5376	HL 5409

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, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.7.6 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	

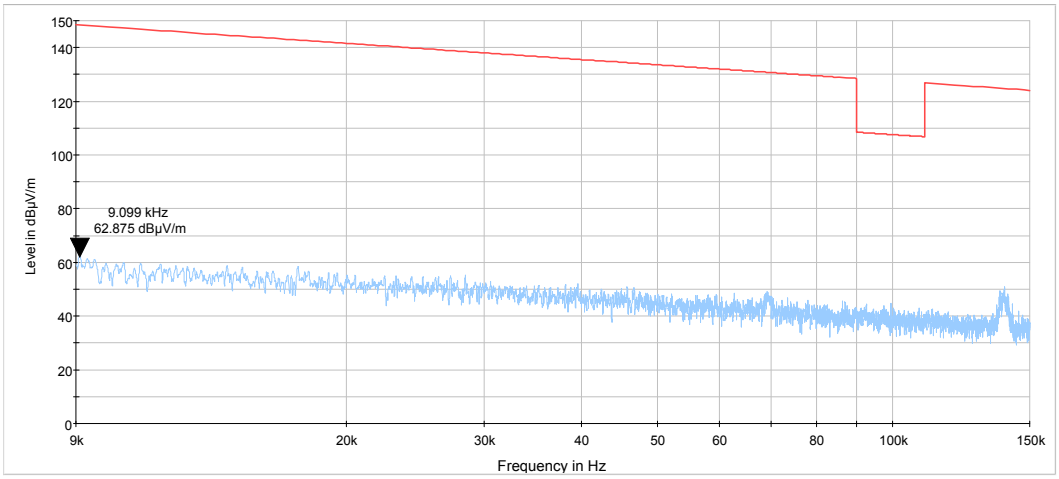
Table 7.7.7 Restricted bands according to RSS-Gen

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, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

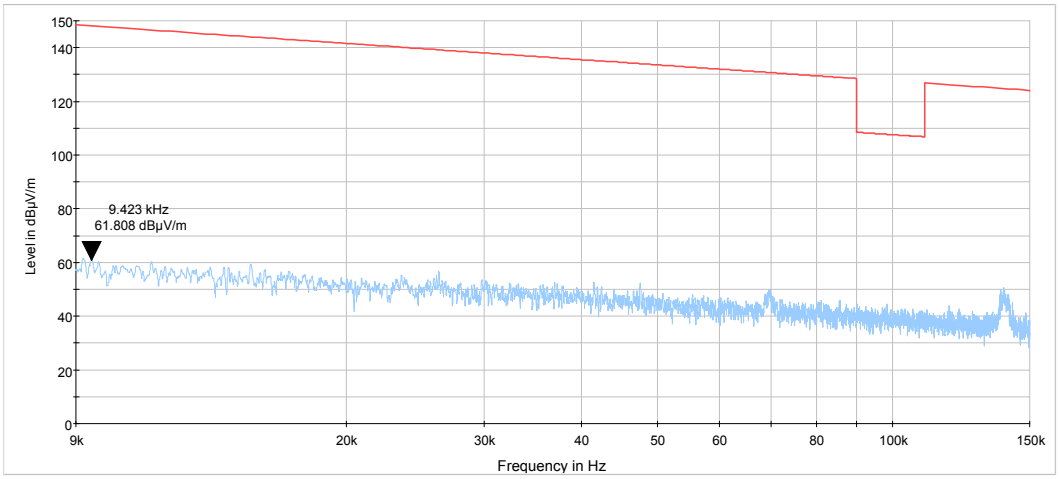
Plot 7.7.1 Radiated emission measurements from 9 to 150 kHz at the low carrier frequency

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



Plot 7.7.2 Radiated emission measurements from 9 to 150 kHz at the mid carrier frequency

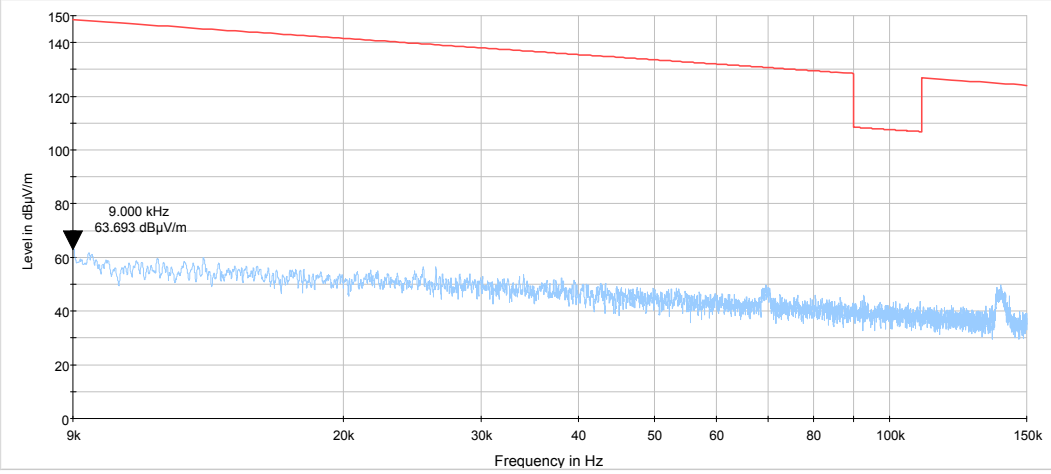
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

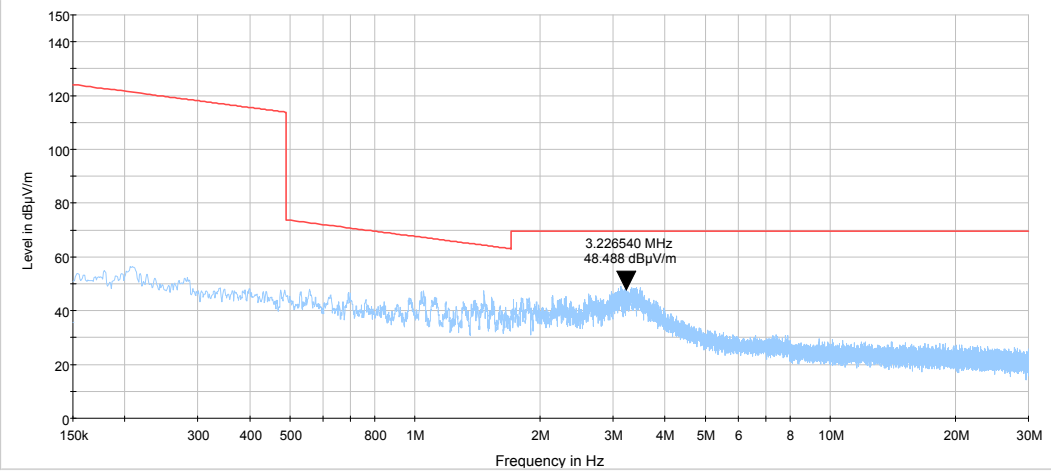
Plot 7.7.3 Radiated emission measurements from 9 to 150 kHz at the high carrier frequency

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



Plot 7.7.4 Radiated emission measurements from 0.15 to 30 MHz at the low carrier frequency

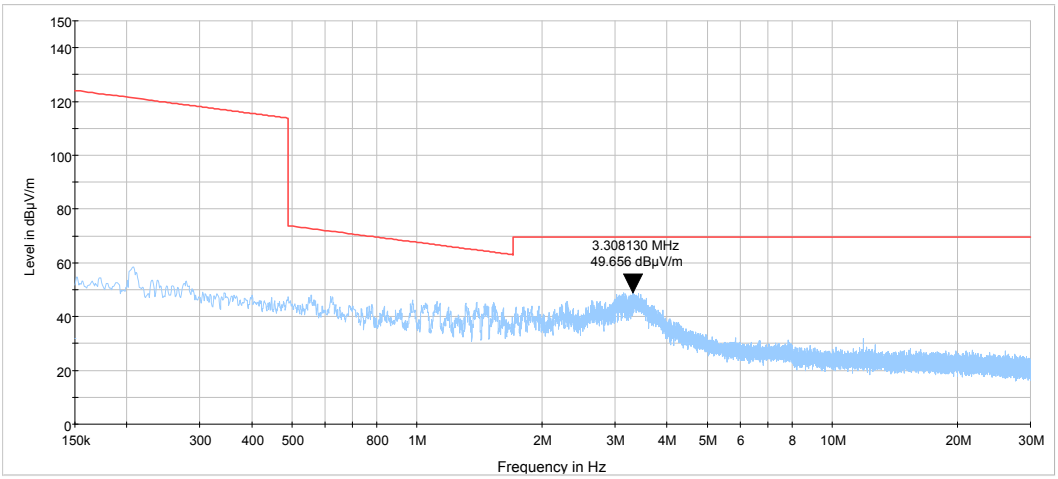
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

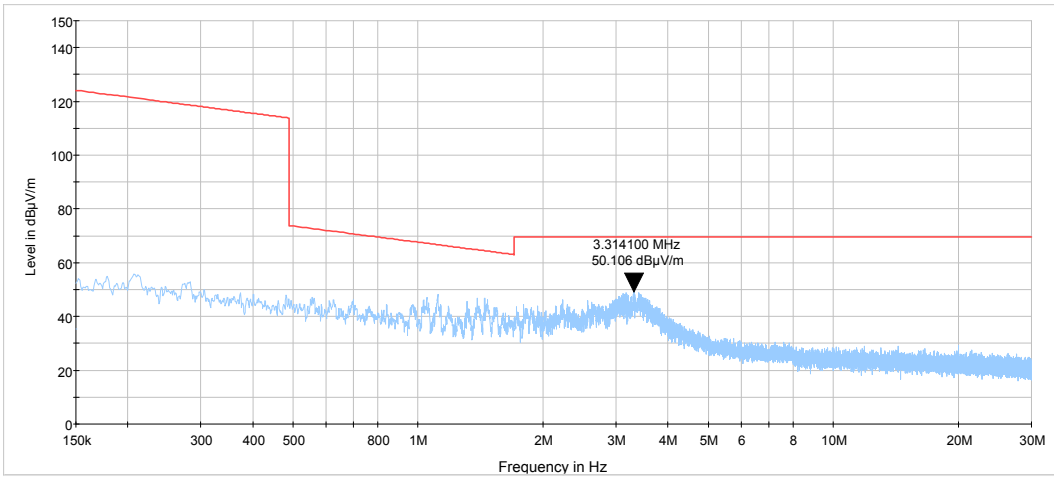
Plot 7.7.5 Radiated emission measurements from 0.15 to 30 MHz at the mid carrier frequency

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



Plot 7.7.6 Radiated emission measurements from 0.15 to 30 MHz at the high carrier frequency

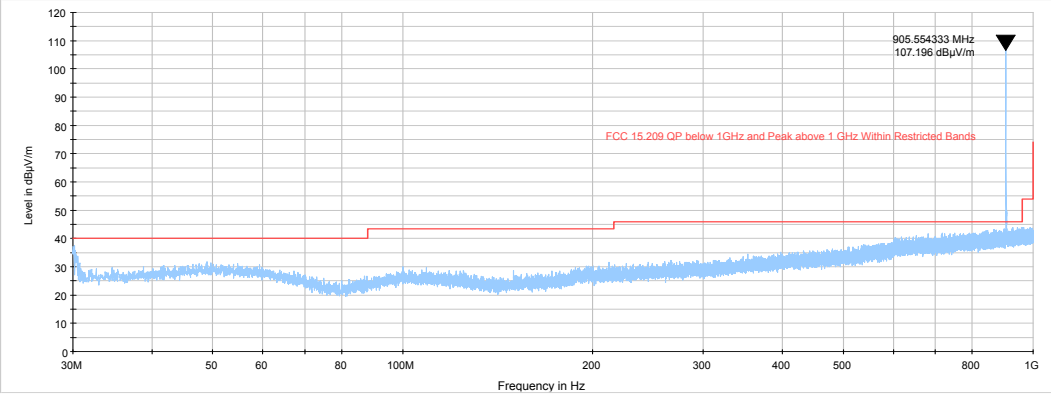
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

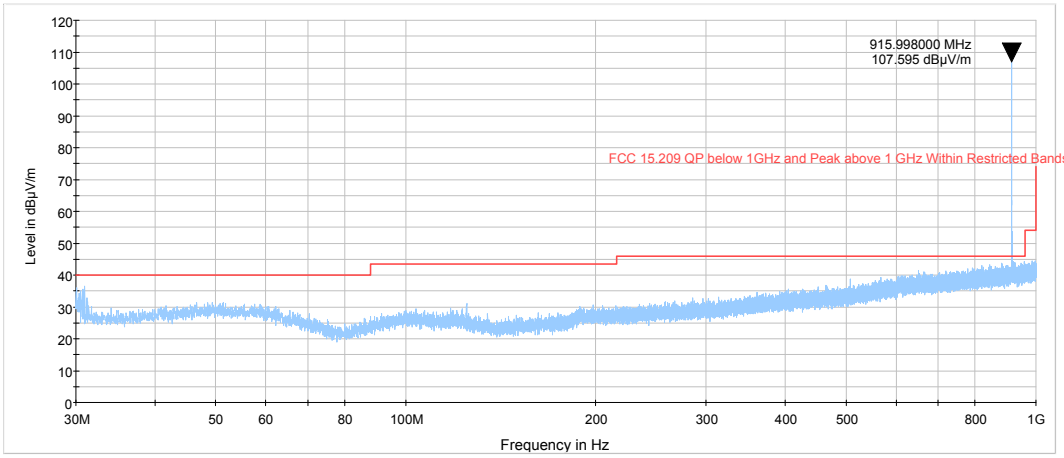
Plot 7.7.7 Radiated emission measurements from 30 to 1000 MHz at the low carrier frequency

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



Plot 7.7.8 Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

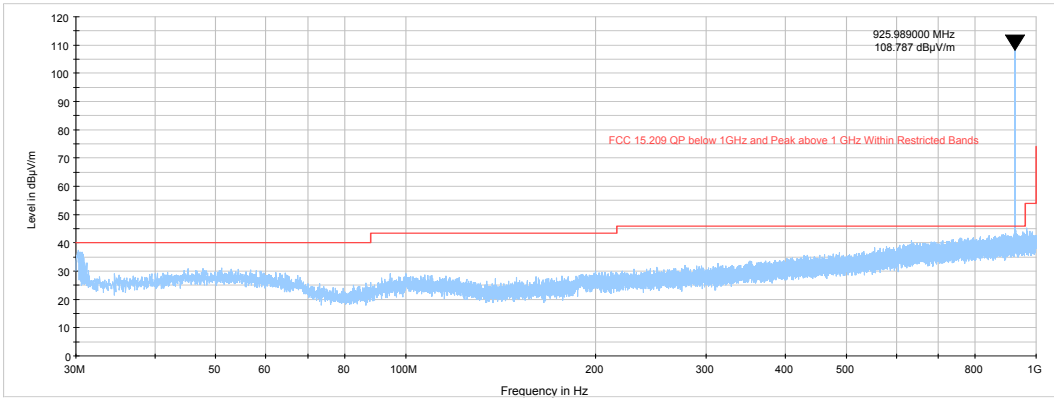
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

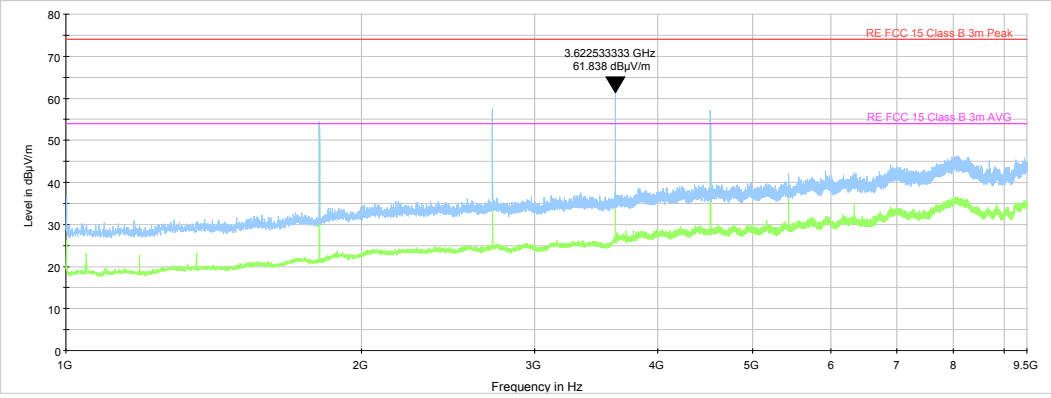
Plot 7.7.9 Radiated emission measurements from 30 to 1000 MHz at the high carrier frequency

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



Plot 7.7.10 Radiated emission measurements from 1000 to 9500 MHz at the low carrier frequency

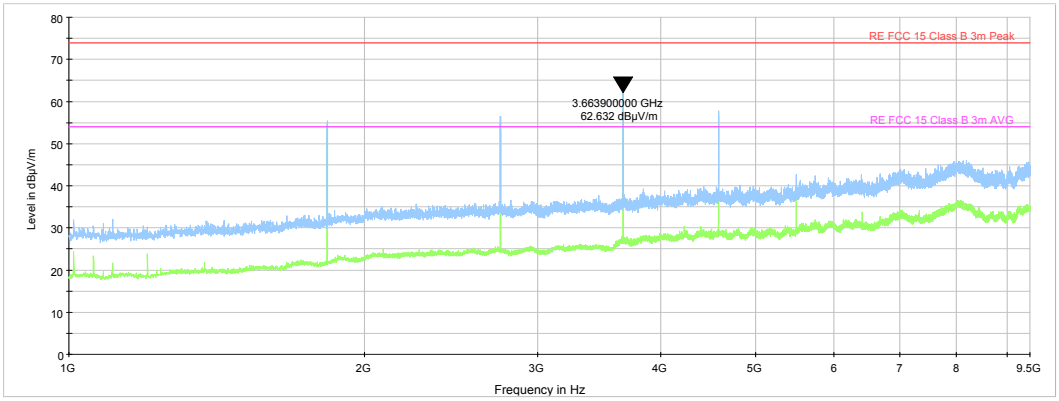
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

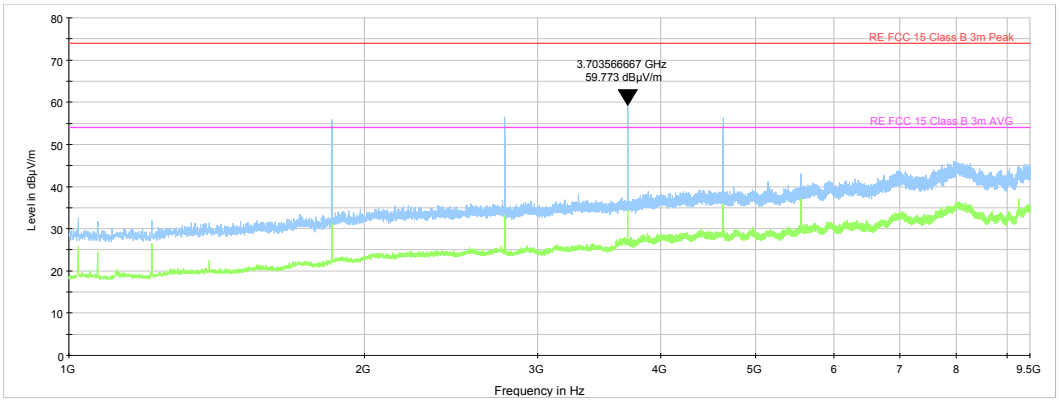
Plot 7.7.11 Radiated emission measurements from 1000 to 9500 MHz at the mid carrier frequency

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



Plot 7.7.12 Radiated emission measurements from 1000 to 9500 MHz at the high carrier frequency

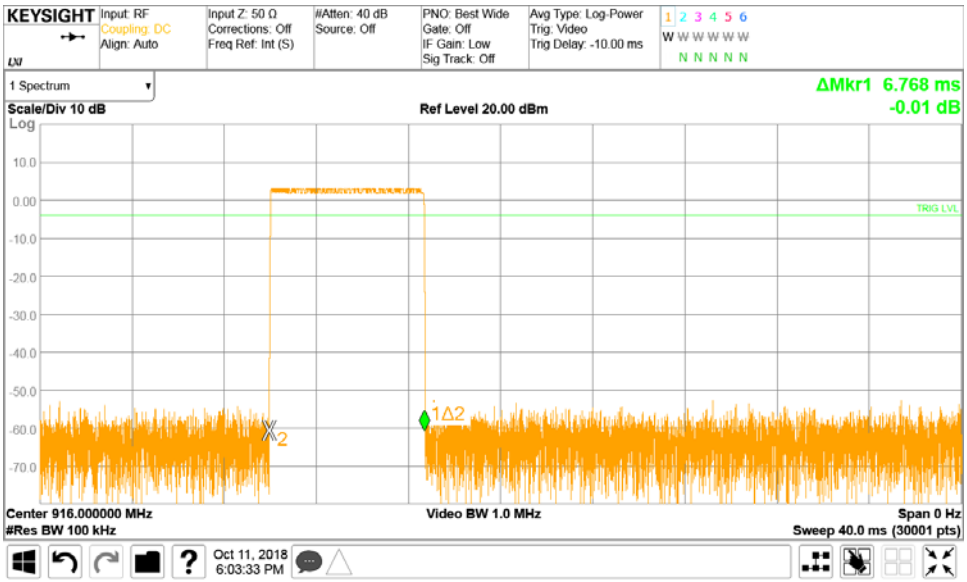
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-18		
Temperature: 24 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Plot 7.7.13 Transmission period

Plot 7.7.14 Transmission duration



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

7.8 Field strength of spurious emissions

7.8.1 General

This test was performed to measure field strength of spurious emissions from the EUT. Specification test limits are given in Table 7.8.1.

Table 7.8.1 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.

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

7.8.2.1 The EUT was set up as shown in Figure 7.8.1, energized and the performance check was conducted.

7.8.2.2 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.

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

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

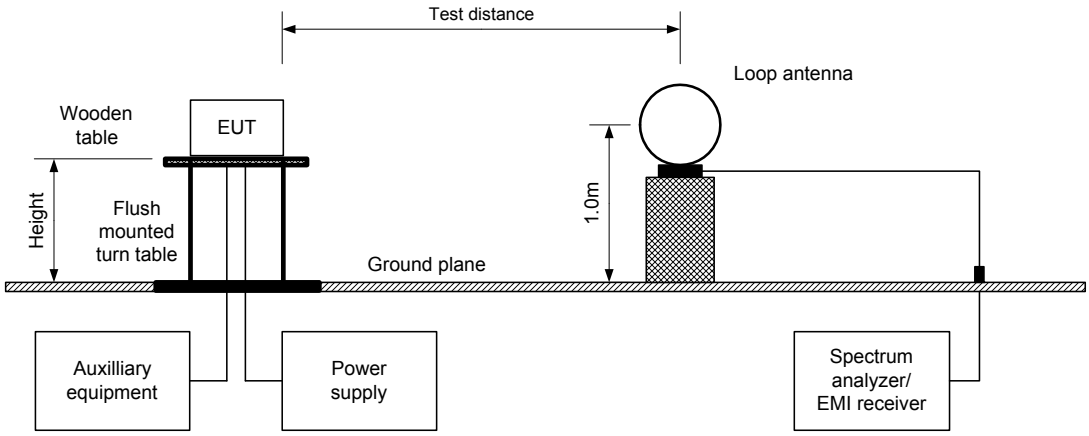
7.8.3.1 The EUT was set up as shown in Figure 7.8.2, Figure 7.8.3, energized and the performance check was conducted.

7.8.3.2 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.

7.8.3.3 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, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Figure 7.8.1 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, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Figure 7.8.2 Setup for spurious emission field strength measurements from 30 to 1000 MHz

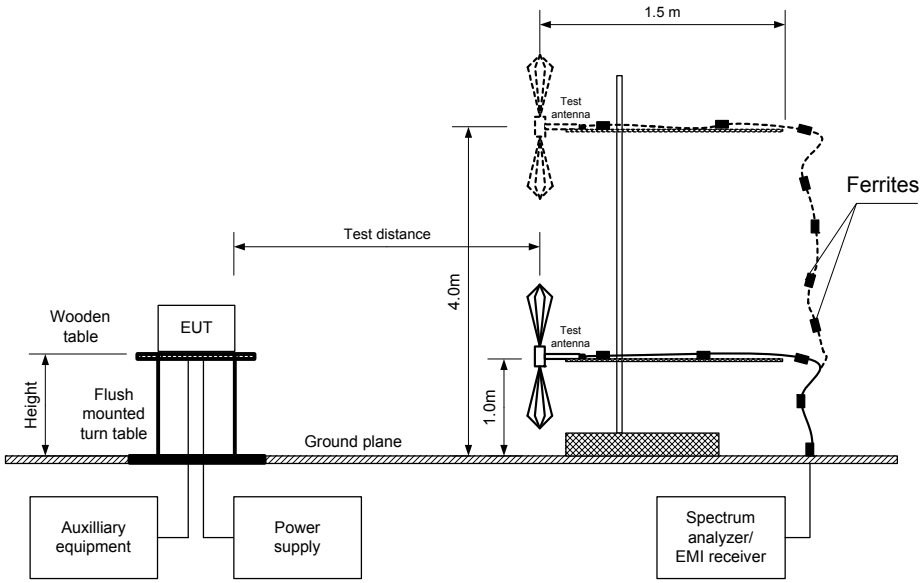
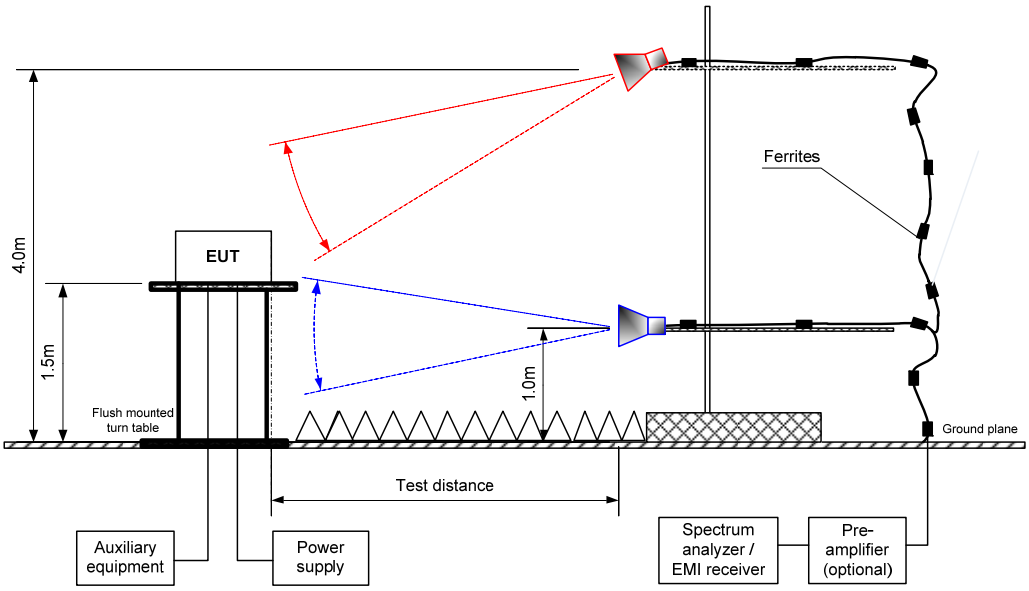


Figure 7.8.3 Setup for spurious emission field strength measurements above1000 MHz



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.8.2 Field strength of emissions outside restricted bands

ASSIGNED FREQUENCY BAND:	902 - 928 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 9500 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
BIT RATE:	50 kbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
TRANSMITTER OUTPUT POWER:	15.44 dBm at low carrier frequency 15.92 dBm at mid carrier frequency 15.77 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									
62.4130	39.11	V	1.02	180.0	112.84	73.73	20.0	53.73	Pass
1811.4038	39.88	V	2.08	105.0		72.96		52.96	
Mid carrier frequency									
1832.0702	40.49	V	1.29	80.0	113.62	73.13	20.0	53.13	Pass
High carrier frequency									
1852.1838	40.26	V	1.00	105.0	113.17	72.91	20.0	52.91	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, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.8.3 Field strength of spurious emissions above 1 GHz within restricted bands

ASSIGNED FREQUENCY BAND:	902-928 MHz
INVESTIGATED FREQUENCY RANGE:	1000 - 9500 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
BIT RATE:	50 kbps
DUTY CYCLE:	100 %
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	1000 kHz
TEST ANTENNA TYPE:	Double ridged guide
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Antenna		Azimuth, degrees*	Peak field strength(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											
2716.7986	Horizontal	2.43	171.0	48.71	74.00	-25.29	48.71	25.36	54.00	-28.64	Pass
3622.1940	Vertical	1.89	81.0	50.64	74.00	-23.36	50.64	27.29	54.00	-26.71	
4528.0888	Vertical	2.62	96.0	52.53	74.00	-21.47	52.53	29.18	54.00	-24.82	
Mid carrier frequency											
2748.1863	Vertical	1.29	55.0	48.10	74.00	-25.90	48.10	24.75	54.00	-29.25	Pass
3663.8025	Vertical	1.63	81.0	51.09	74.00	-22.91	51.09	27.74	54.00	-26.26	
4579.9186	Vertical	2.08	98.0	52.11	74.00	-21.89	52.11	28.76	54.00	-25.24	
High carrier frequency											
2777.7450	Horizontal	2.44	-173.0	49.39	74.00	-24.61	49.39	26.04	54.00	-27.96	Pass
3703.7540	Vertical	1.54	72.0	52.14	74.00	-21.86	52.14	28.79	54.00	-25.21	
4629.8151	Vertical	1.81	-155.0	50.98	74.00	-23.02	50.98	27.63	54.00	-26.37	

*- EUT front panel refers to 0 degrees position of turntable.
**- Margin = Measured field strength - specification limit.
***- Margin = Calculated field strength - specification limit,
where Calculated field strength = Measured field strength + average factor.

Table 7.8.4 Average factor calculation

Transmission pulse		Transmission burst		Transmission train duration, ms	Average factor, dB
Duration, ms	Period, ms	Duration, ms	Period, ms		
6.8	220	NA	NA	NA	-23.35

*- Average factor was calculated as follows

for pulse train shorter than 100 ms:

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

for pulse train longer than 100 ms:

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

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.8.5 Field strength of spurious emissions below 1 GHz within restricted bands

ASSIGNED FREQUENCY BAND:	902-928 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 1000 MHz
TEST DISTANCE:	3 m
MODULATION:	GFSK
MODULATING SIGNAL:	PRBS
BIT RATE:	50 kbps
DUTY CYCLE:	100 %
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
RESOLUTION BANDWIDTH:	0.2 kHz (9 kHz – 150 kHz) 9.0 kHz (150 kHz – 30 MHz) 120 kHz (30 MHz – 1000 MHz)
VIDEO BANDWIDTH:	> Resolution bandwidth
TEST ANTENNA TYPE:	Active loop (9 kHz – 30 MHz) Biconilog (30 MHz – 1000 MHz)
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Peak emission, dB(μV/m)	Quasi-peak			Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
		Measured emission, dB(μV/m)	Limit, dB(μV/m)	Margin, dB*				
Low carrier frequency								
129.8215	39.62	30.45	43.5	-13.05	V	1.55	-162.0	Pass
Mid carrier frequency								
No emissions were found								Pass
High carrier frequency								
No emissions were found								Pass

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

Reference numbers of test equipment used

HL 0446	HL 3903	HL 4360	HL 4933	HL 5288	HL 5405	HL 5376	HL 5409

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, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.8.6 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	

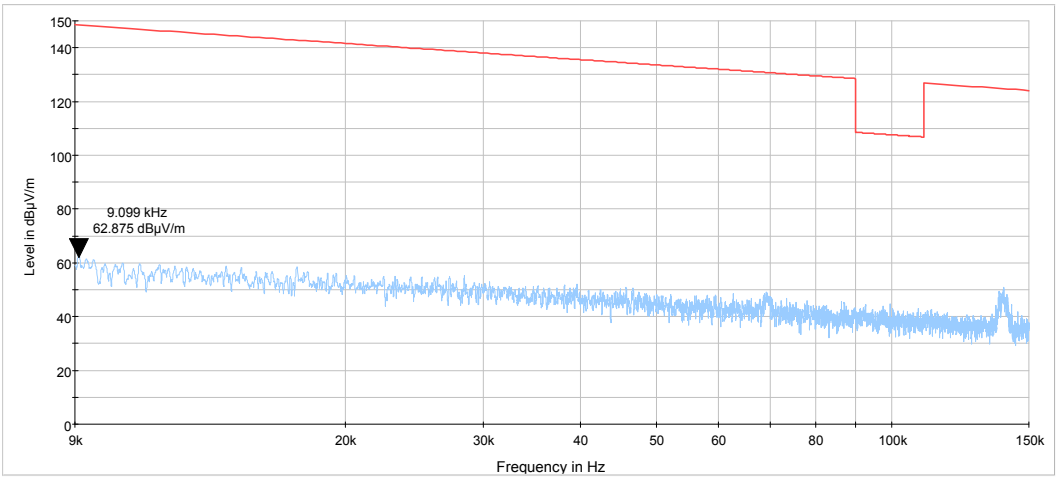
Table 7.8.7 Restricted bands according to RSS-Gen

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, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

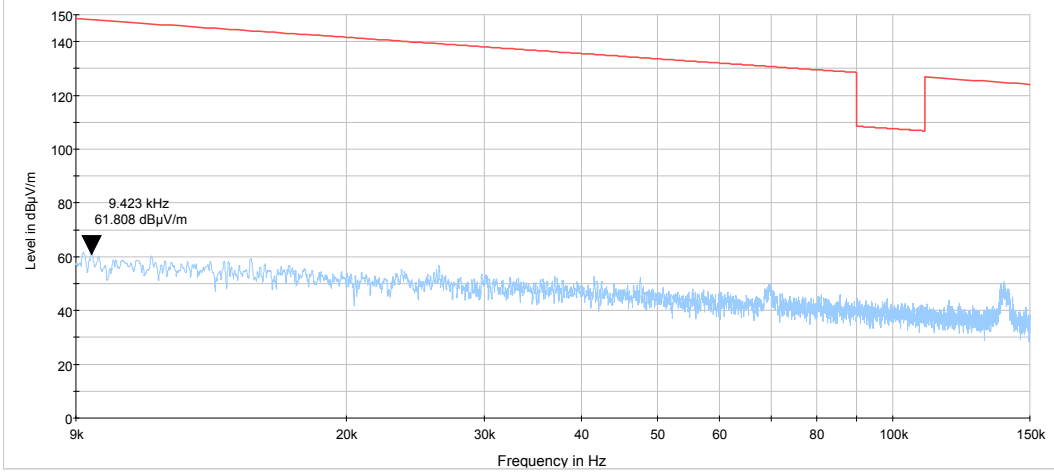
Plot 7.8.1 Radiated emission measurements from 9 to 150 kHz at the low carrier frequency

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



Plot 7.8.2 Radiated emission measurements from 9 to 150 kHz at the mid carrier frequency

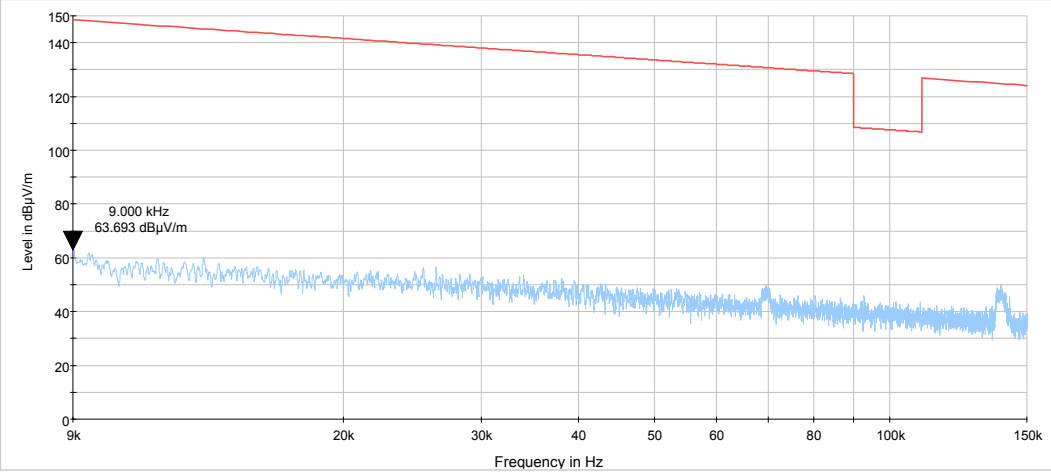
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

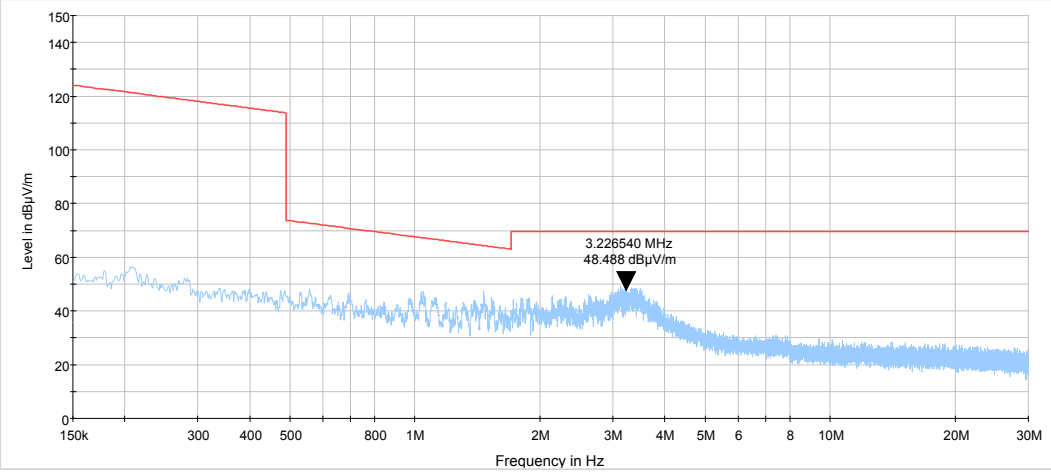
Plot 7.8.3 Radiated emission measurements from 9 to 150 kHz at the high carrier frequency

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



Plot 7.8.4 Radiated emission measurements from 0.15 to 30 MHz at the low carrier frequency

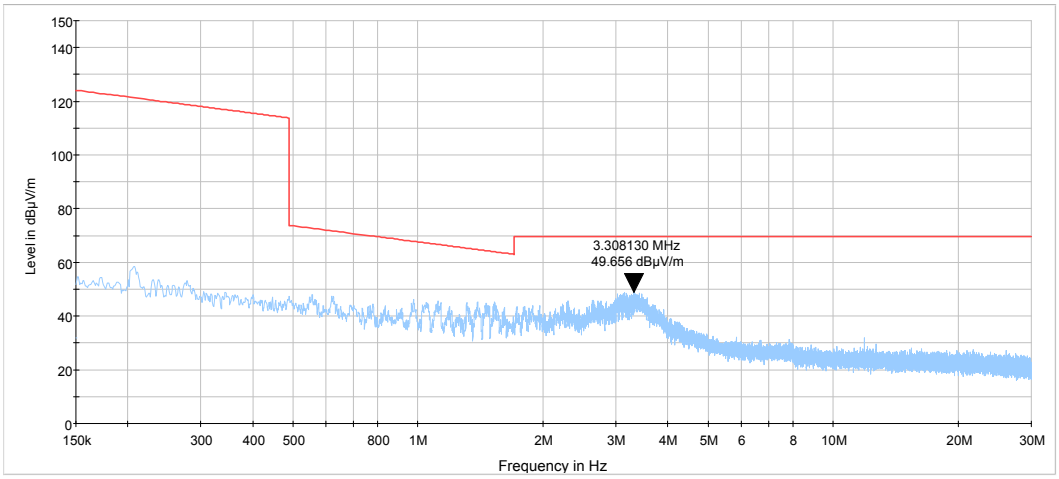
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

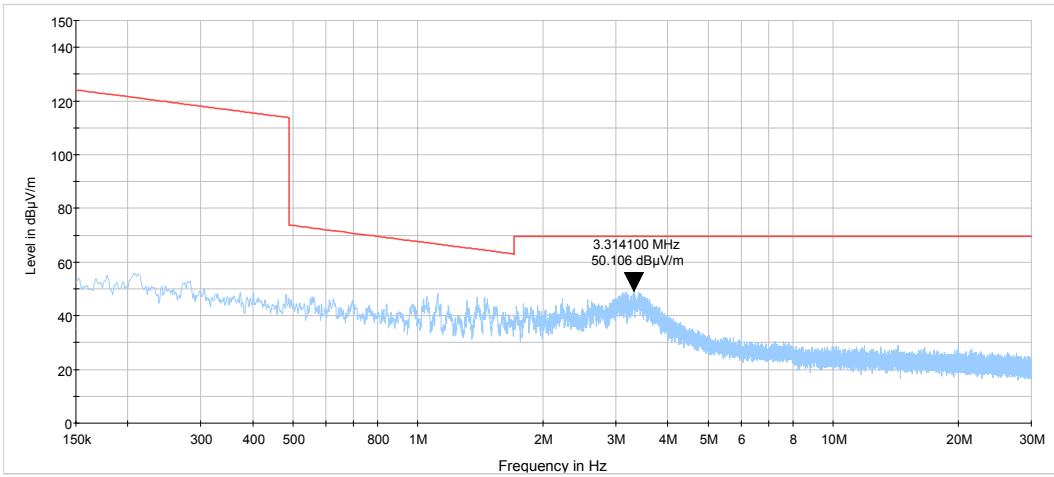
Plot 7.8.5 Radiated emission measurements from 0.15 to 30 MHz at the mid carrier frequency

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



Plot 7.8.6 Radiated emission measurements from 0.15 to 30 MHz at the high carrier frequency

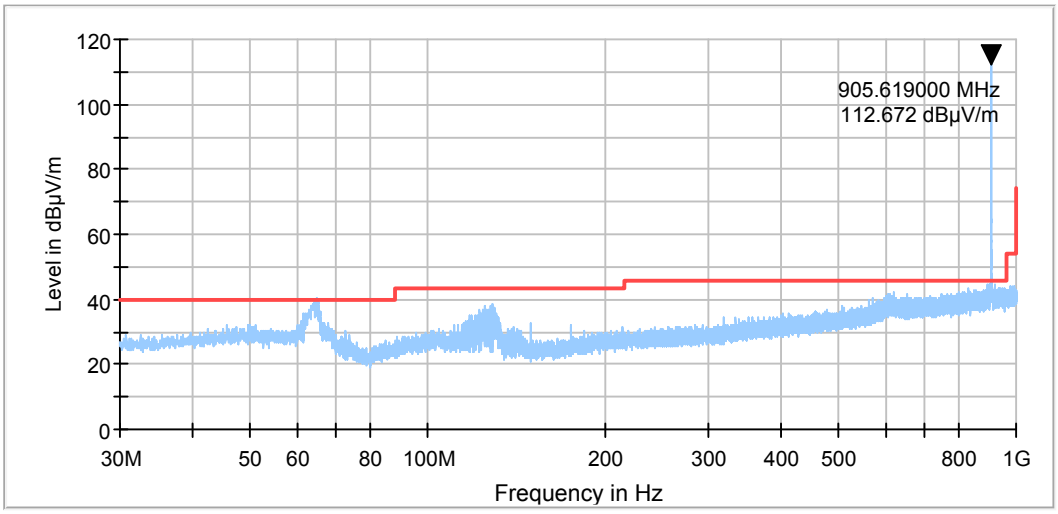
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

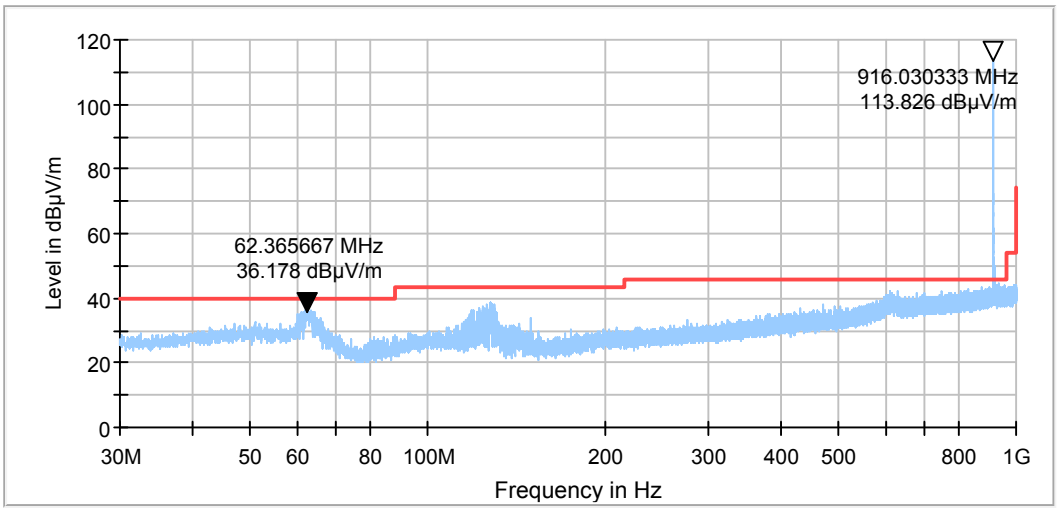
Plot 7.8.7 Radiated emission measurements from 30 to 1000 MHz at the low carrier frequency

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



Plot 7.8.8 Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

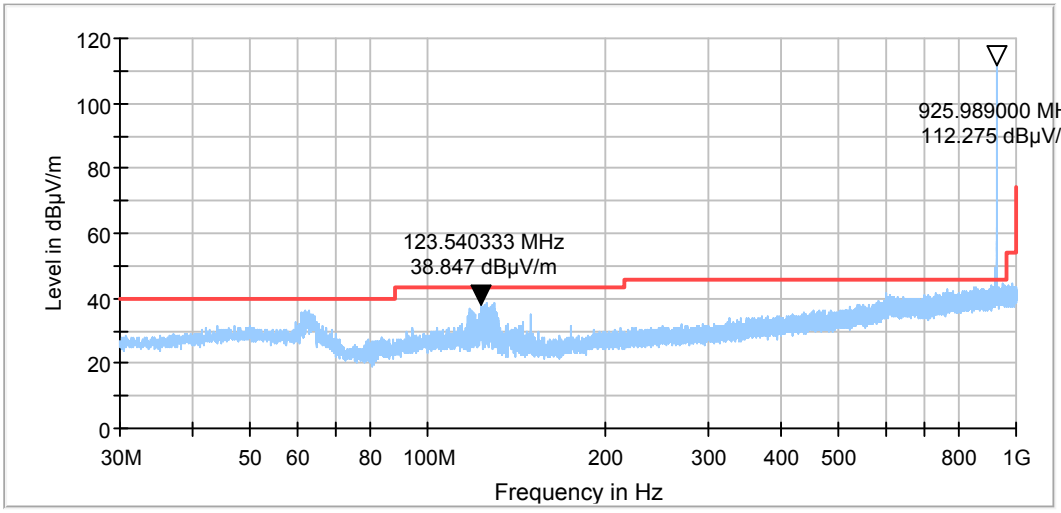
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	Verdict:	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	Relative Humidity: 51 %	Air Pressure: 1010 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2820			

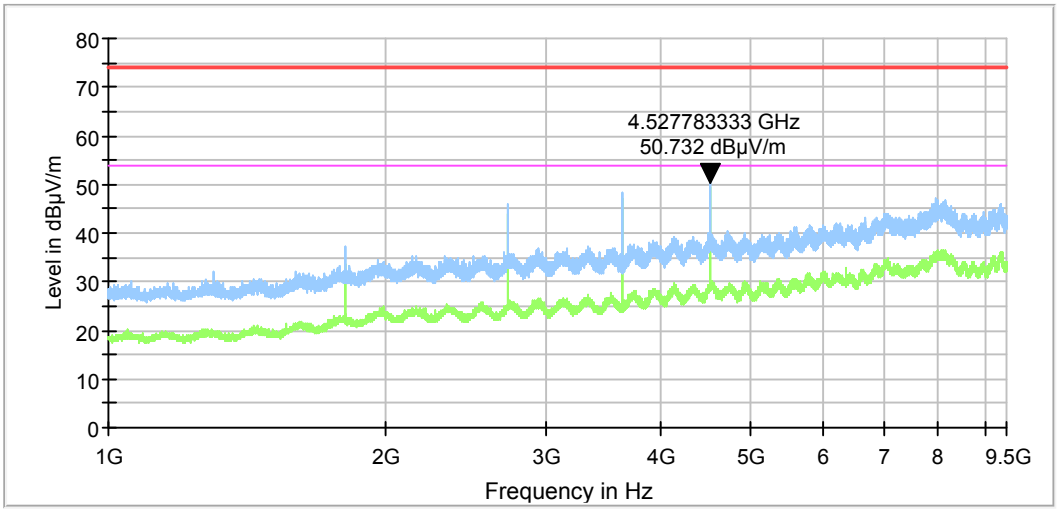
Plot 7.8.9 Radiated emission measurements from 30 to 1000 MHz at the high carrier frequency

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



Plot 7.8.10 Radiated emission measurements from 1000 to 9500 MHz at the low carrier frequency

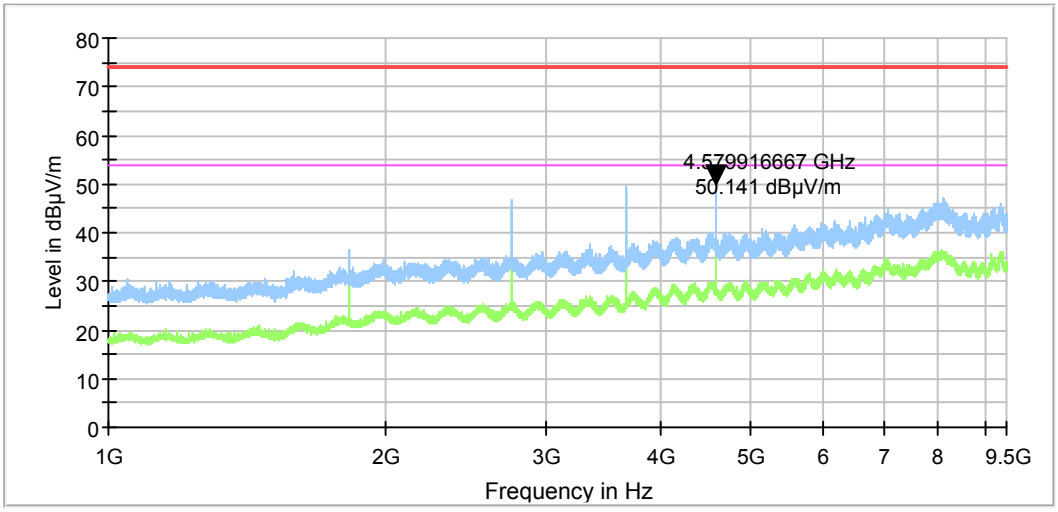
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

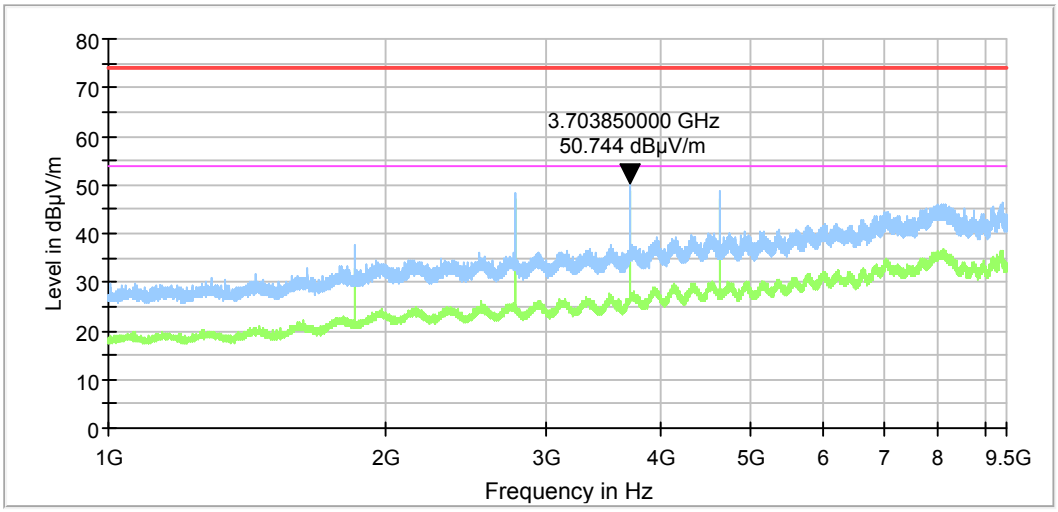
Plot 7.8.11 Radiated emission measurements from 1000 to 9500 MHz at the mid carrier frequency

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



Plot 7.8.12 Radiated emission measurements from 1000 to 9500 MHz at the high carrier frequency

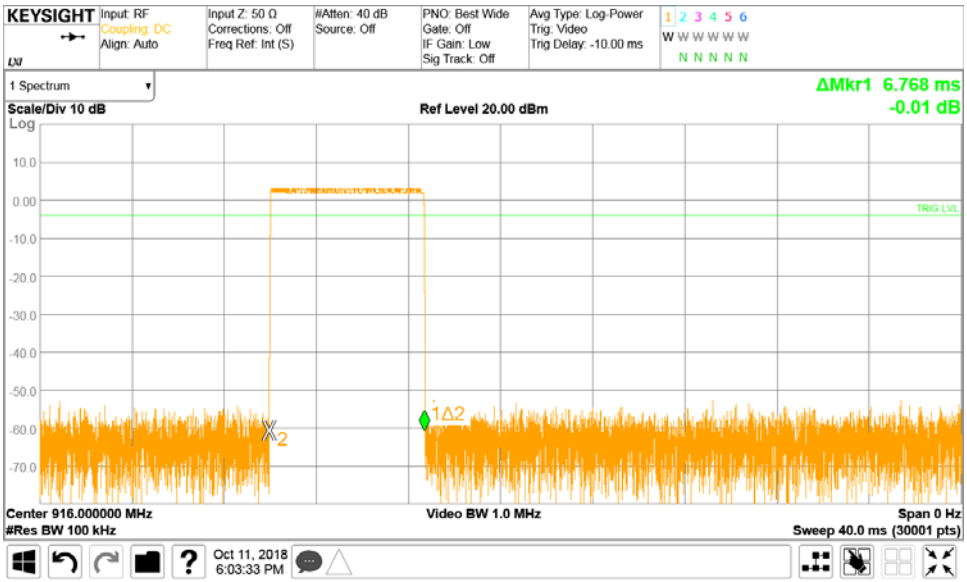
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	22-Aug-18 - 11-Oct-18		
Temperature: 25 ºC	**Relative Humidity:** 51 %	**Air Pressure:** 1010 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Plot 7.8.13 Transmission period

Plot 7.8.14 Transmission duration



Test specification:	Section 15.247(d), RSS-247 section 5.5, Emissions at band edges		
Test procedure:	ANSI C63.10, section 7.8.6		
Test mode:	Compliance	Verdict:	PASS
Date(s):	17-Oct-18		
Temperature: 23 ºC	Relative Humidity: 43 %	Air Pressure: 1016 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2810			

7.9 Band edge radiated emissions

7.9.1 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 7.9.1.

Table 7.9.1 Band edge emission limits

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

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

7.9.2 Test procedure

7.9.2.1 The EUT was set up as shown in Figure 7.9.1, energized normally modulated at the maximum data rate with its hopping function disabled and its proper operation was checked.

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

7.9.2.3 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.

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

7.9.2.5 The maximum band edge emission and modulation product outside of the band were measured as provided in Table 7.9.2 and associated plots and referenced to the highest emission level measured within the authorized band.

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

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

Figure 7.9.1 Band edge emission test setup

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Emissions at band edges**		
Test procedure:	ANSI C63.10, section 7.8.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 43 %	**Air Pressure:** 1016 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Table 7.9.2 Band edge emission test results

ASSIGNED FREQUENCY RANGE: 902-928 MHz
DETECTOR USED: Peak
MODULATION: GFSK
MODULATING SIGNAL: PRBS
BIT RATE: 1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
TRANSMITTER OUTPUT POWER: 14.32 dBm at low carrier frequency
12.94 dBm at high carrier frequency
RESOLUTION BANDWIDTH: ≥ 1% of the span
VIDEO BANDWIDTH: ≥ RBW
TX FREQUENCY: 905 MHZ

Frequency, MHz	Band edge emission, dBuv/m	Emission at carrier, dBuv/m	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
902	69.0	111.72	42.72	20.0	22.72	Pass
928	69.2		42.52		22.52	

TX FREQUENCY: 926 MHZ

Frequency, MHz	Band edge emission, dBuv/m	Emission at carrier, dBuv/m	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
902	69.0	110.34	41.34	20.0	21.34	Pass
928	69.2		41.14		21.14	

*- Margin = Attenuation below carrier – specification limit.

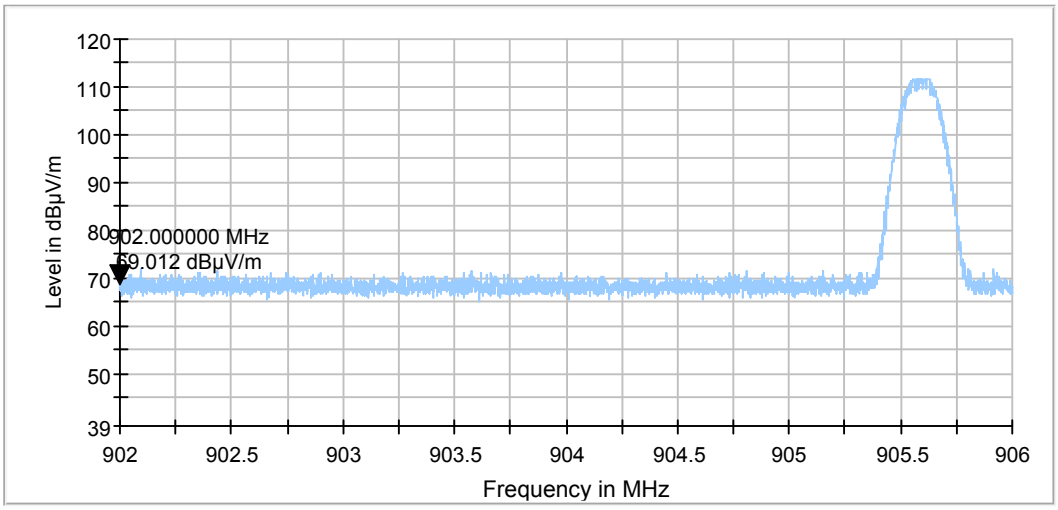
Reference numbers of test equipment used

HL 3903	HL 4360	HL 5288	HL 5405				

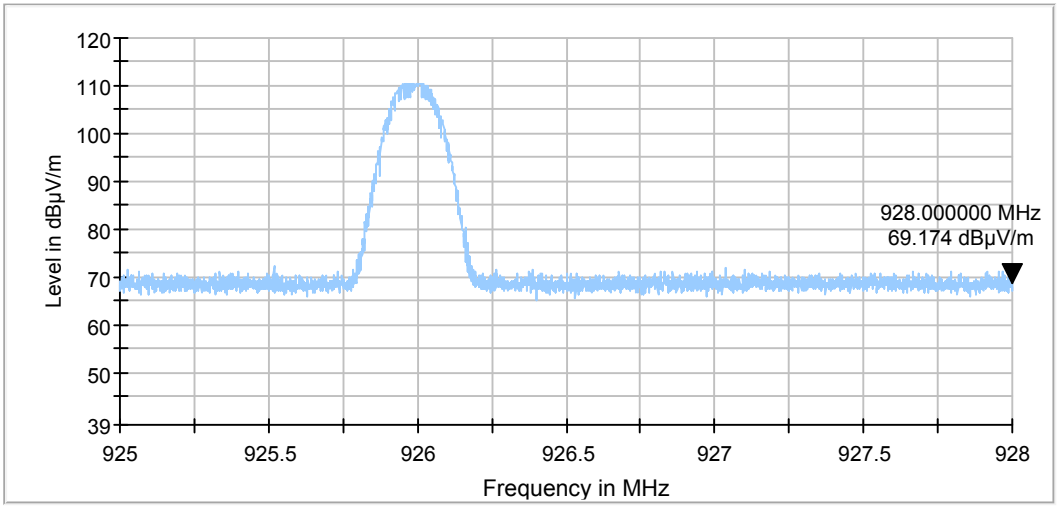
Full description is given in Appendix A.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Emissions at band edges**		
Test procedure:	ANSI C63.10, section 7.8.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	17-Oct-18		
Temperature: 23 ºC	**Relative Humidity:** 43 %	**Air Pressure:** 1016 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2810			

Plot 7.9.1 The highest emission level within the assigned band at low carrier frequency



Plot 7.9.2 The highest emission level within the assigned band at high carrier frequency



Test specification:	Section 15.247(d), RSS-247 section 5.5, Emissions at band edges		
Test procedure:	ANSI C63.10, section 7.8.6		
Test mode:	Compliance	Verdict:	PASS
Date(s):	05-Sep-18		
Temperature: 23 ºC	Relative Humidity: 42 %	Air Pressure: 1013 hPa	Power: 120 VAC, 60 Hz
Remarks: HUB 2820			

7.10 Band edge radiated emissions

7.10.1 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 7.10.1.

Table 7.10.1 Band edge emission limits

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

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

7.10.2 Test procedure

7.10.2.1 The EUT was set up as shown in Figure 7.10.1, energized normally modulated at the maximum data rate with its hopping function disabled and its proper operation was checked.

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

7.10.2.3 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.

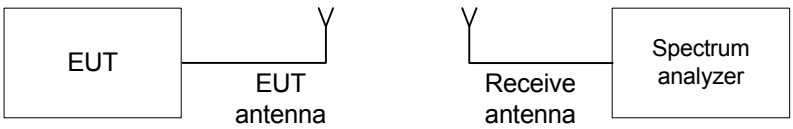
7.10.2.4 The spectrum analyzer was set in max hold mode and allowed trace to stabilize. The highest emission level within the authorized band was measured.

7.10.2.5 The maximum band edge emission and modulation product outside of the band were measured as provided in Table 7.10.2 and associated plots and referenced to the highest emission level measured within the authorized band.

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

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

Figure 7.10.1 Band edge emission test setup



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Emissions at band edges**		
Test procedure:	ANSI C63.10, section 7.8.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	05-Sep-18		
Temperature: 23 ºC	**Relative Humidity:** 42 %	**Air Pressure:** 1013 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Table 7.10.2 Band edge emission test results

ASSIGNED FREQUENCY RANGE: 902-928 MHz
DETECTOR USED: Peak
MODULATION: GFSK
MODULATING SIGNAL: PRBS
BIT RATE: 1 Mbps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
TRANSMITTER OUTPUT POWER: 15.44 dBm at low carrier frequency
15.77 dBm at high carrier frequency
RESOLUTION BANDWIDTH: ≥ 1% of the span
VIDEO BANDWIDTH: ≥ RBW
Tx FREQUENCY 905.6 MHz

Frequency, MHz	Band edge emission, dBuV/m	Emission at carrier, dBuV/m	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
902.0	67.5	112.84	45.34	20.0	25.34	Pass
928.0	67.5		45.34		35.34	

Tx FREQUENCY 926 MHz

Frequency, MHz	Band edge emission, dBuV/m	Emission at carrier, dBuV/m	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
902.0	67.5	113.17	45.67	20.0	25.67	Pass
928.0	67.5		45.67		25.67	

*- Margin = Attenuation below carrier – specification limit.

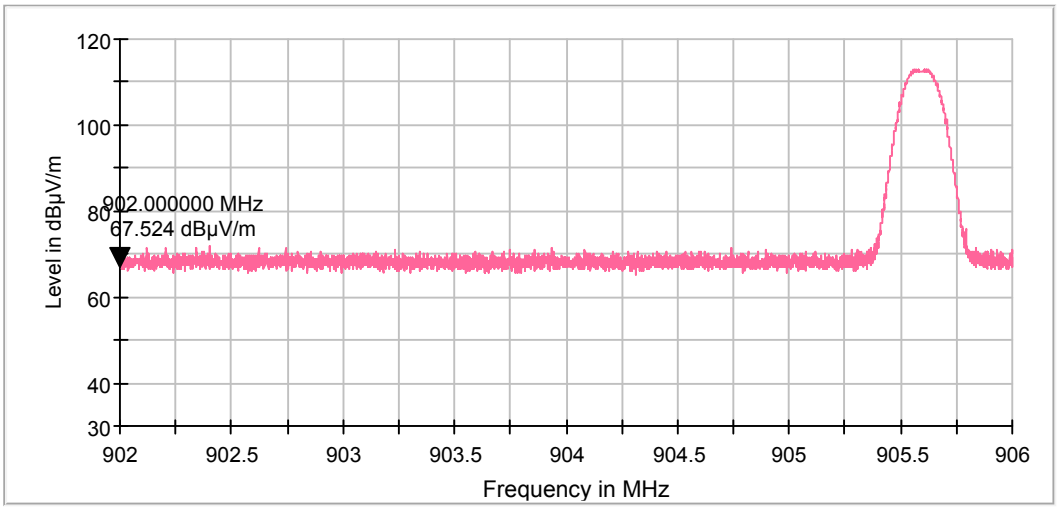
Reference numbers of test equipment used

HL 3903	HL 4360	HL 5288	HL 5405				

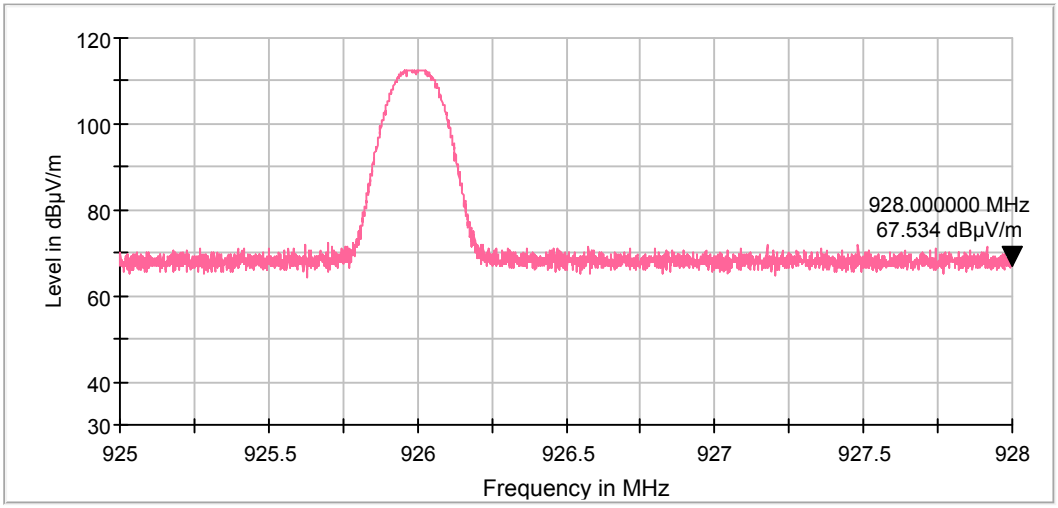
Full description is given in Appendix A.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Emissions at band edges**		
Test procedure:	ANSI C63.10, section 7.8.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	05-Sep-18		
Temperature: 23 ºC	**Relative Humidity:** 42 %	**Air Pressure:** 1013 hPa	**Power:** 120 VAC, 60 Hz
Remarks: HUB 2820			

Plot 7.10.1 The highest emission level within the assigned band at low carrier frequency



Plot 7.10.2 The highest emission level within the assigned band at high carrier frequency



Test specification:	**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			

7.11 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 7.11.1.

Table 7.11.1 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			

7.12 Conducted emissions

7.12.1 General

This test was performed to measure common mode conducted emissions at the mains power port. Specification test limits are given in Table 7.12.1.

Table 7.12.1 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.

7.12.2 Test procedure

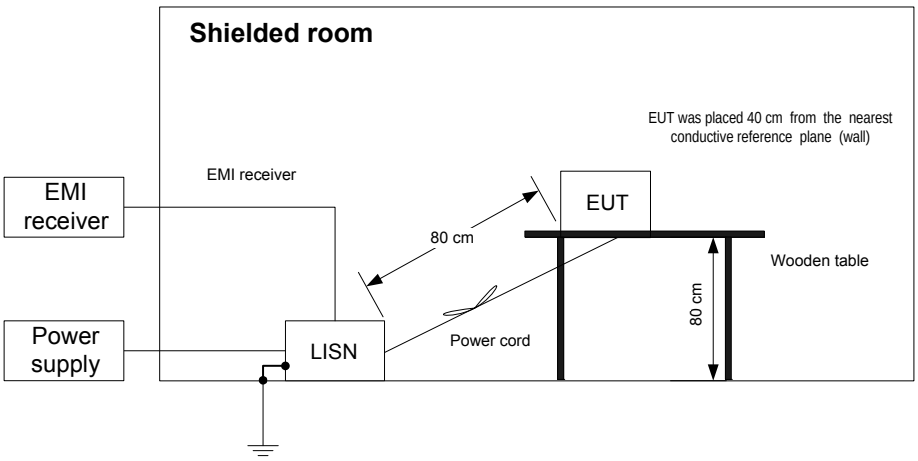
7.12.2.1 The EUT was set up as shown in Figure 7.12.1, energized and the performance check was conducted.

7.12.2.2 The measurements were performed at power terminals with the LISN, connected to a spectrum analyzer in the frequency range referred to in Table 7.12.2. Unused coaxial connector of the LISN was terminated with 50 Ohm. Quasi-peak and average detectors were used throughout the testing.

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

7.12.2.4 The worst test results (the lowest margins) were recorded in Table 7.12.2 and shown in the associated plots.

Figure 7.12.1 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 7.12.2 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*		
0.555935	52.6	51.3	56.0	-4.70	36.70	46.0	-9.30	L1	Pass
0.604333	39.1	33.5	56.0	-22.50	22.90	46.0	-23.10		
2.784850	44.8	42.2	56.0	-13.80	26.90	46.0	-19.10		
3.064438	35.1	31.7	56.0	-24.30	18.10	46.0	-27.90		
0.277865	36.6	32.3	60.9	-28.58	16.50	50.88	-34.38	L2	Pass
0.556330	52.8	51.0	56.0	-5.00	34.20	46.0	-11.80		
0.831655	34.2	29.3	56.0	-26.70	15.10	46.0	-30.90		
2.780405	45.1	41.7	56.0	-14.30	23.70	46.0	-22.30		
3.057405	35.8	30.5	56.0	-25.50	14.00	46.0	-32.00		

*- Margin = Measured emission - specification limit.

Reference numbers of test equipment used

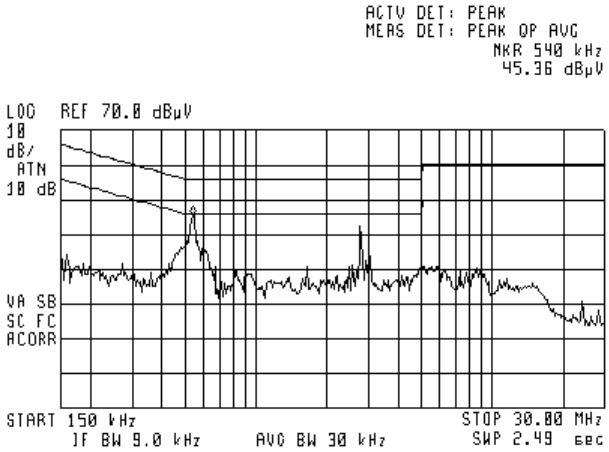
HL 0787	HL 3016	HL 4280	HL 4778		

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			

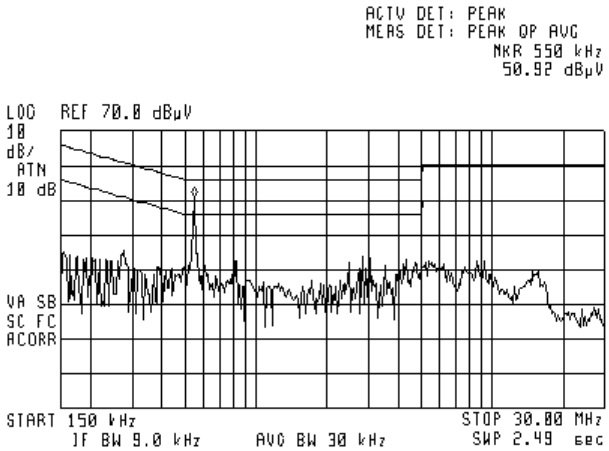
Plot 7.12.1 Conducted emission measurements

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



Plot 7.12.2 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	11-Feb-18	11-Feb-19
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	11-Jan-18	11-Jan-19
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1226/2A	07-Feb-18	07-Feb-19
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	28-Jun-18	28-Sep-19
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	26-Dec-17	26-Dec-18
4778	EMI Receiver, 9 kHz - 2.9 GHz, System: HL1431, HL4777	Hewlett Packard	8542E	30807A00262, 3427A00123	28-Oct-18	28-Oct-19
4933	Active Horn Antenna, 1 GHz to 18 GHz	Com-Power Corporation	AHA-118	701046	04-Jan-18	04-Jan-19
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	21-Jan-18	21-Jan-19
5376	EXA Signal Analyzer, 10 Hz - 32 GHz	Keysight Technologies	N9010B	MY57470404	16-Mar-18	16-Mar-19
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