

TEST REPORT

ACCORDING TO: FCC 47CFR part 15 subpart C §15.247 (DTS) and subpart B,
RSS-247 Issue 2:2017, RSS-Gen Issue 5:2018, ICES-003 Issue 6:2016

FOR:

TriplePlus

Shuttie

Model: ALF-000023-001

FCC ID: 2AFOILORA

IC: 20798-LORA

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1 Applicant information

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Telephone: +972-72-22-11-370
Fax: +972-4-959-3991
E-mail: yuval.abraham@tripleplus.io
Contact name: Mr. Yuval Abraham

2 Equipment under test attributes

Product name: Shuttie
Product type: LoRa based Ball valve Actuator
Model(s): ALF-000023-001
Serial number: Prototype
Hardware version: V2.0
Software release: 1.0.7.0
Receipt date 28-Jan-20

3 Manufacturer information

Manufacturer name: TriplePlus
Address: 5 Hamada street, Yokneam 2069200, Israel
Telephone: +972-72-22-11-370
Fax: +972-4-959-3991
E-Mail: yuval.abraham@tripleplus.io
Contact name: Mr. Yuval Abraham

4 Test details




Project ID: 36587
Location: Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started: 11-Feb-20
Test completed: 09-Mar-20
Test specification(s): FCC 47CFR part 15 subpart C §15.247 (DTS) and subpart B, RSS-247 Issue 2:2017, RSS-Gen Issue 5:2018, ICES-003 Issue 6:2016

5 Tests summary

Test	Status
Transmitter characteristics	
FCC section 15.247(a)2 / RSS-247 section 5.2(1), 6 dB bandwidth	Pass
FCC section 15.247(b)3/ RSS-247 section 5.4(4), Peak output power	Pass
FCC section 15.247(i) / RSS-102 section 2.5.2, RF exposure	Pass, the exhibit to the application of certification is provided
FCC section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions	Pass
FCC section 15.247(d)/ RSS-247 section 5.5, Emissions at band edges	Pass
FCC section 15.247(e) / RSS-247 section 5.2(2), Peak power density	Pass
FCC section 15.203 / RSS-Gen section 8.3, Antenna requirement	Pass
FCC section 15.207(a) / RSS-Gen section 8.8, Conducted emission	Not required
Unintentional emissions	
FCC section 15.107/ ICES-003, Section 6.1, Class B, Conducted emission	Not required
FCC section 15.109/ RSS-Gen section 7.1.2 /ICES-003, Section 6.2, Class B, Radiated 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 EMC & Radio	11-Feb-20 – 09-Mar-20	
Reviewed by:	Mrs. S Peysahov Sheynin, test engineer EMC & Radio	03-May-20	
Approved by:	Mr. S. Samokha, technical manager EMC & Radio	19-May-20	

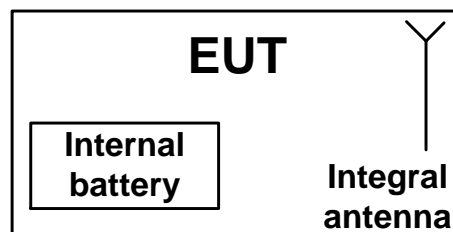
6 EUT description

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

6.1 General information

The EUT is an electro-mechanical water valve, powered by batteries and controlled by remote radio.

6.2 Test configuration



6.3 Changes made in EUT

No changes were implemented in the EUT during the testing.

6.4 Transmitter characteristics

Type of equipment					
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 range		902 - 928 MHz			
Operating frequency		902.8 - 927.2 MHz			
Maximum rated output power		Peak output power		18.24 dBm	
Is transmitter output power variable?		X	No		
		Yes		continuous variable	
				stepped variable with stepsize	
				minimum RF power	dBm
				maximum RF power	dBm
Antenna connection					
unique coupling		standard connector		X	integral
				X	with temporary RF connector
					without temporary RF connector
Antenna/s technical characteristics					
Type		Manufacturer		Model number	
Integral		Triple+		920	
				Gain	
				2 dBi	
Modulation		LoRa			
Transmitter aggregate data rate/s		12.5 kbps			
Modulating test signal (baseband)		PRBS			
Transmitter power source					
X	Battery	Nominal rated voltage	6 VDC	Battery type	CR123A
	DC	Nominal rated voltage	VDC		
	AC mains	Nominal rated voltage	VAC	Frequency	
Spread spectrum technique used			Frequency hopping (FHSS)		
		X	Digital transmission system (DTS)		
			Hybrid		



Test specification:		Section 15.247(a)2/ RSS-247 section 5.2(a), 6 dB bandwidth	
Test procedure:		ANSI C63.10 section 11.8.1	
Test mode:		Verdict: PASS	
Date(s):			
12-Feb-20			
Temperature: 22 °C	Relative Humidity: 46 %	Air Pressure: 1022 hPa	Power: 6 VDC
Remarks:			

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

7.1 Minimum 6 dB bandwidth

7.1.1 General

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

Table 7.1.1 6 dB bandwidth limits

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

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

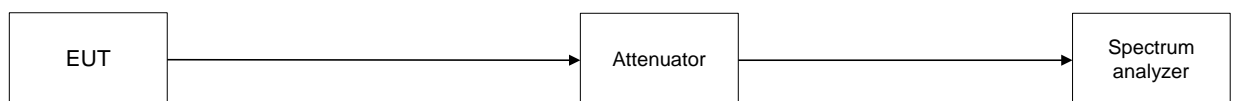
7.1.2 Test procedure

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

7.1.2.2 The EUT was set to transmit modulated carrier.

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

Figure 7.1.1 6 dB bandwidth test setup





Test specification: Section 15.247(a)2/ RSS-247 section 5.2(a), 6 dB bandwidth			
Test procedure: ANSI C63.10 section 11.8.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 12-Feb-20			
Temperature: 22 °C	Relative Humidity: 46 %	Air Pressure: 1022 hPa	Power: 6 VDC
Remarks:			

Table 7.1.2 6 dB bandwidth test results

ASSIGNED FREQUENCY BAND: 902.0 – 928.0 MHz
 DETECTOR USED: Peak
 RESOLUTION BANDWIDTH: 100 kHz
 VIDEO BANDWIDTH: 300 kHz
 MODULATION: LoRa
 BIT RATE: 12.5 kbps

Carrier frequency, MHz	6 dB bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
Low frequency				
902.4	763.0	500	263.0	Pass
Mid frequency				
915.0	768.4	500	268.4	Pass
High frequency				
927.6	778.0	500	278.0	Pass

Reference numbers of test equipment used

HL 5376	HL5608							
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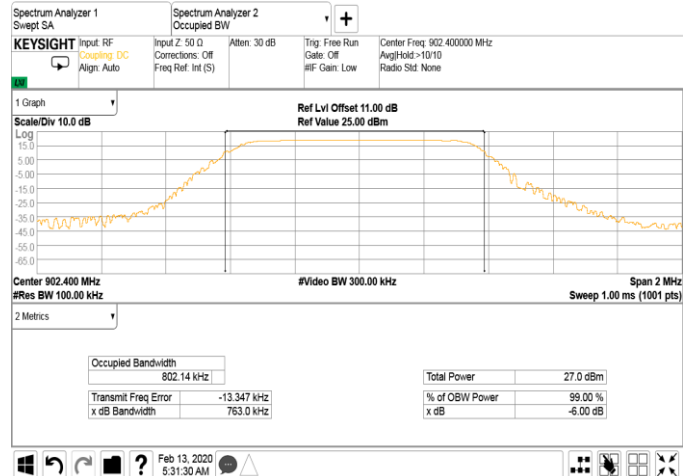
Full description is given in Appendix A.



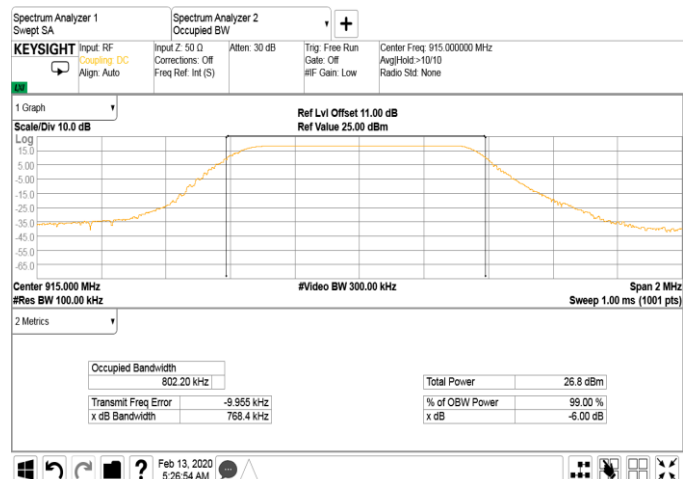
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Test specification: Section 15.247(a)2/ RSS-247 section 5.2(a), 6 dB bandwidth			
Test procedure: ANSI C63.10 section 11.8.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 12-Feb-20			
Temperature: 22 °C	Relative Humidity: 46 %	Air Pressure: 1022 hPa	Power: 6 VDC
Remarks:			

Plot 7.1.1 6 dB bandwidth test result at low frequency



Plot 7.1.2 6 dB bandwidth test result at mid frequency



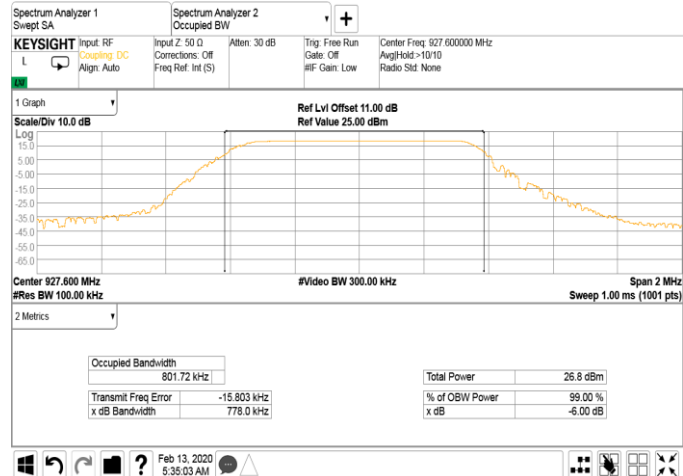


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Report ID: TRIRAD_FCC.36587
Date of Issue: 19-May-20

Test specification:		Section 15.247(a)2/ RSS-247 section 5.2(a), 6 dB bandwidth	
Test procedure:		ANSI C63.10 section 11.8.1	
Test mode:		Verdict: PASS	
Date(s):			
12-Feb-20			
Temperature: 22 °C	Relative Humidity: 46 %	Air Pressure: 1022 hPa	Power: 6 VDC
Remarks:			

Plot 7.1.3 6 dB bandwidth test result at high frequency





Test specification:		Section 15.247(b)3/ RSS-247 section 5.4(d), Peak output power	
Test procedure:		ANSI C63.10 sections 11.9.2.2.4	
Test mode:		Verdict: PASS	
Date(s):			
10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

7.2 Peak output power

7.2.1 General

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

Table 7.2.1 Peak output power limits

Assigned frequency range, MHz	Maximum antenna gain, dBi	Peak output power*	
		W	dBm
902.0 – 928.0	6.0	1.0	30.0
2400.0 – 2483.5			
5725.0 – 5850.0			

*- If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value as follows:

by 1 dB for every 3 dB that the directional gain of antenna exceeds 6 dBi for fixed point-to-point transmitters operate in 2400-2483.5 MHz band;

without any corresponding reduction for fixed point-to-point transmitters operate in 5725-5850 MHz band;

by the amount in dB that the directional gain of antenna exceeds 6 dBi for the rest of transmitters.

7.2.2 Test procedure

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

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

7.2.2.3 The duty cycle of the transmitter output signal was measured and recorded.

7.2.2.4 The frequency span of spectrum analyzer was set greater than the OBW of the transmitter at least 1.5 times. The maximum power spectral density was measured using a power average (RMS) detector with resolution bandwidth set to 1 MHz, VBW = 3 MHz. The trace average at least 100 traces was performed.

7.2.2.5 The maximum power level was determined within the fundamental OBW.

7.2.2.6 The duty cycle correction factor was added to the measured power to compute the average power during the actual transmission times and recorded in Table 7.2.2.



Test specification:		Section 15.247(b)3/ RSS-247 section 5.4(d), Peak output power	
Test procedure:		ANSI C63.10 sections 11.9.2.2.4	
Test mode:		Verdict: PASS	
Date(s):			
10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Figure 7.2.1 Setup for carrier field strength measurements

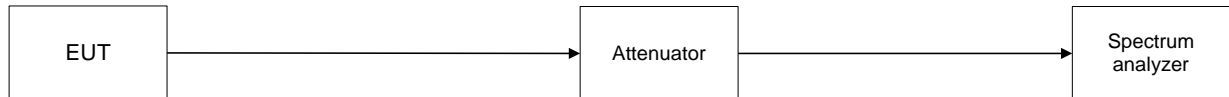


Table 7.2.2 Peak output power test results

ASSIGNED FREQUENCY RANGE:	902.0 – 928.0 MHz
MODULATION:	LoRa
BIT RATE:	12.5 kbps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Average
TRACE AVERAGING:	> 100 traces
EUT 6 dB BANDWIDTH:	778 kHz
RESOLUTION BANDWIDTH:	1 MHz
VIDEO BANDWIDTH:	3 MHz

Carrier frequency, MHz	Spectrum analyzer reading, dBm	External attenuation, dB	Cable loss, dB	Peak output power,** dBm	Limit, dBm	Margin*, dB	Verdict
902.4	16.78	Included	Included	18.01	30.0	-11.99	Pass
915.0	17.01	Included	Included	18.24	30.0	-11.76	Pass
927.6	16.88	Included	Included	18.11	30.0	-11.89	Pass

* - Margin = Peak output power – specification limit.

** - Peak power over OBW = SA reading + Duty cycle factor where

Duty cycle correction factor = $10 \cdot \log(1/D) = 1.23$

Reference numbers of test equipment used

HL 5376	HL5608						
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Full description is given in Appendix A.

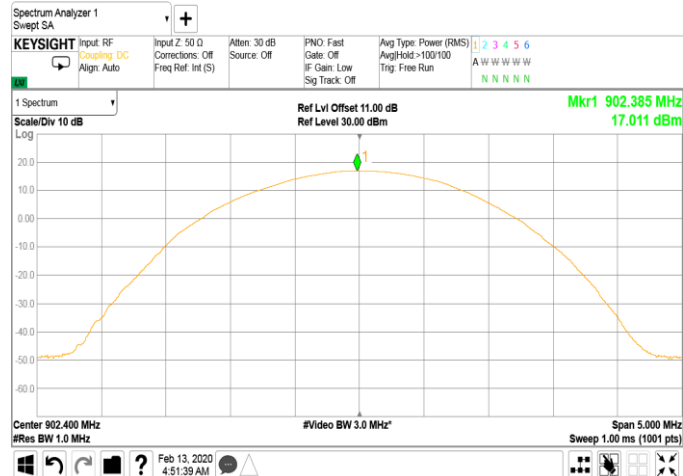


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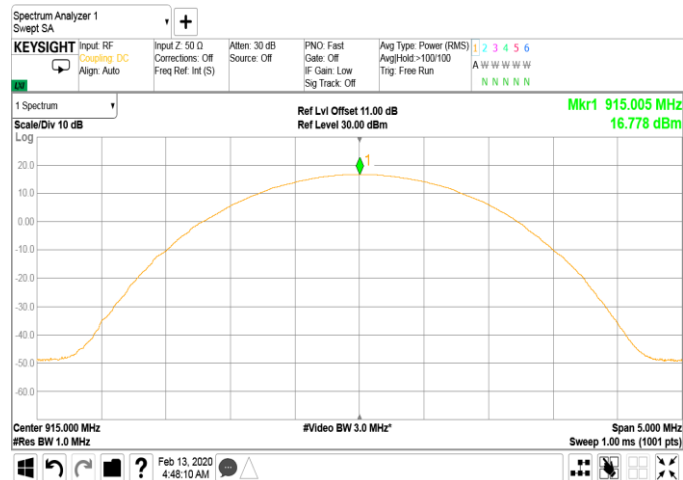
Report ID: TRIRAD_FCC.36587
Date of Issue: 19-May-20

Test specification: Section 15.247(b)3/ RSS-247 section 5.4(d), Peak output power			
Test procedure: ANSI C63.10 sections 11.9.2.2.4			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Plot 7.2.1 Peak output power at low frequency



Plot 7.2.2 Peak output power at mid frequency





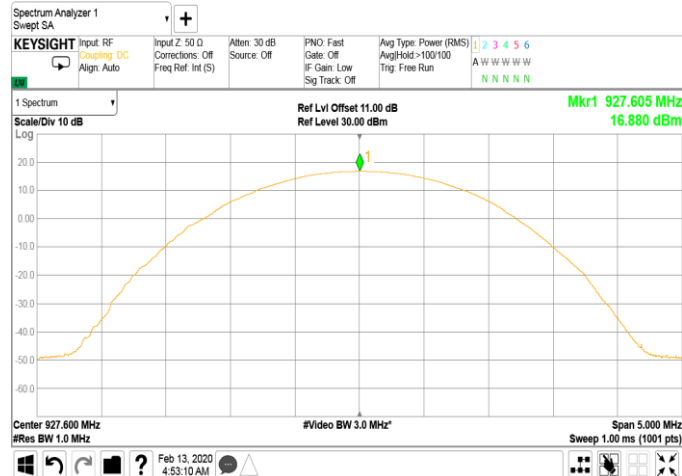
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Report ID: TRIRAD_FCC.36587

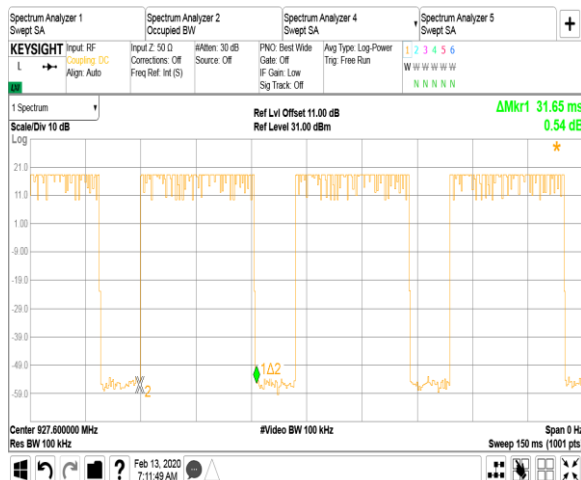
Date of Issue: 19-May-20

Test specification:		Section 15.247(b)3/ RSS-247 section 5.4(d), Peak output power	
Test procedure:		ANSI C63.10 sections 11.9.2.2.4	
Test mode:		Verdict: PASS	
Date(s):			
10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Plot 7.2.3 Peak output power at high frequency



Plot 7.2.4 Pulse duration and pulse period test result





Test specification: Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

7.3 Field strength of spurious emissions

7.3.1 General

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

Table 7.3.1 Radiated spurious emissions limits

Frequency, MHz	Field strength at 3 m within restricted bands, dB(μV/m)*			Attenuation of field strength of spurious versus carrier outside restricted bands, dBc***
	Peak	Quasi Peak	Average	
0.009 – 0.090	148.5 – 128.5	NA	128.5 – 108.5**	20.0
0.090 – 0.110	NA	108.5 – 106.8**	NA	
0.110 – 0.490	126.8 – 113.8	NA	106.8 – 93.8**	
0.490 – 1.705	NA	73.8 – 63.0**	NA	
1.705 – 30.0*		69.5		
30 – 88		40.0		
88 – 216		43.5		
216 – 960		46.0		
960 - 1000		54.0		
1000 – 10 th harmonic	74.0	NA	54.0	

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

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

where S_1 and S_2 – standard defined and test distance respectively in meters.

** - The limit decreases linearly with the logarithm of frequency.

*** - The field strength limits applied from the lowest radio frequency generated in the device, without going below 9 kHz up to the tenth harmonic of the highest fundamental frequency.

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

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

7.3.2.2 The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360° and the measuring antenna was rotated around its vertical axis.

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

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

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

7.3.3.2 The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360°, the measuring antenna height was changed from 1 to 4 m, its polarization was switched from vertical to horizontal.

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



Test specification: Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

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

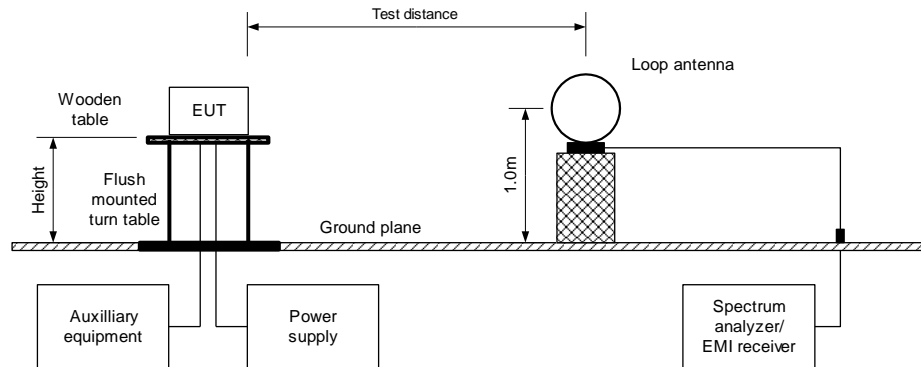
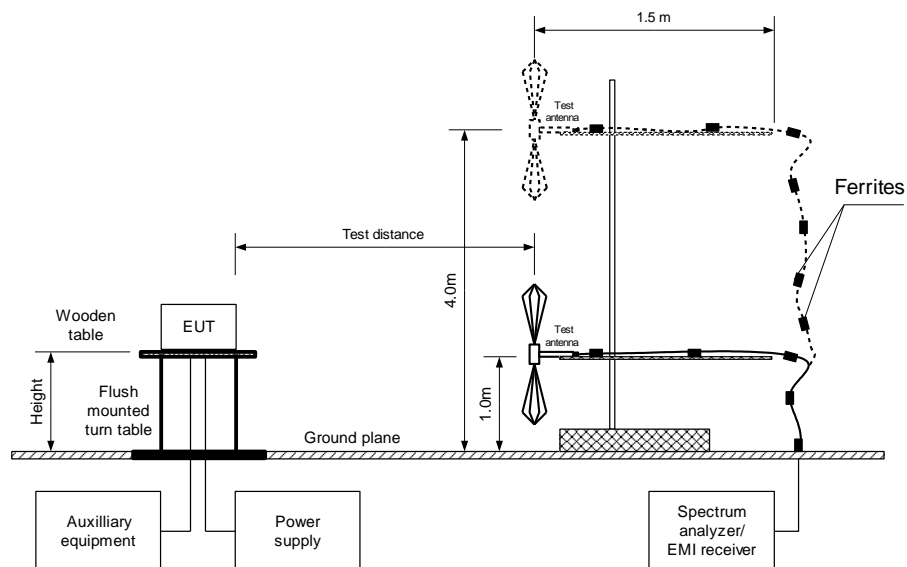
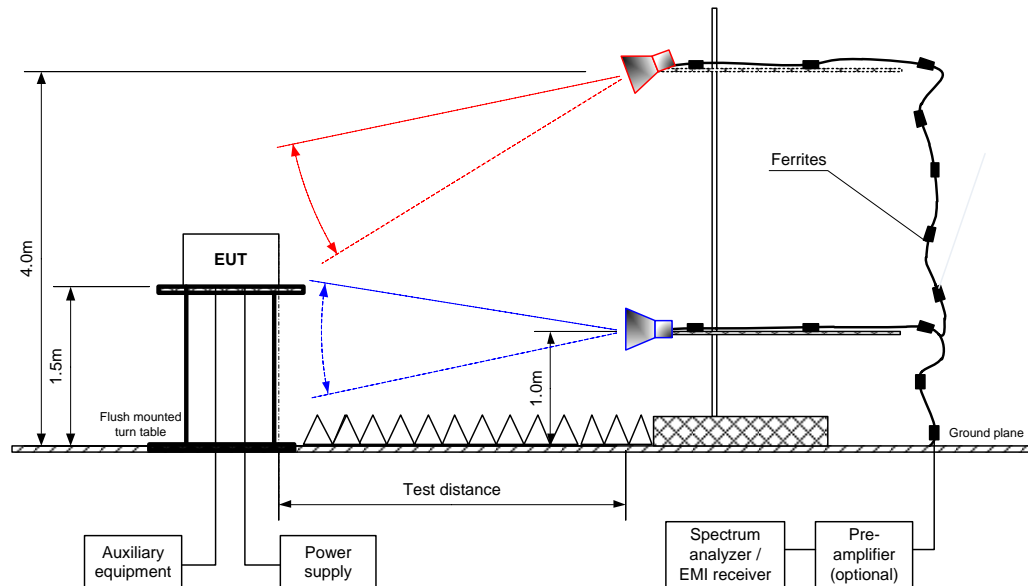


Figure 7.3.2 Setup for spurious emission field strength measurements in 30 – 1000 MHz



Test specification:		Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions	
Test procedure:		ANSI C63.10 section 11.12.1	
Test mode:		Verdict: PASS	
Date(s):			
10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

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





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Test specification: Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Table 7.3.2 Field strength of emissions outside restricted bands

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
 INVESTIGATED FREQUENCY RANGE: 0.009 – 9500 MHz
 TEST DISTANCE: 3 m
 MODULATION: LoRa
 MODULATING SIGNAL: PRBS
 BIT RATE: 12.5 kbps
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 DETECTOR USED: Peak
 RESOLUTION BANDWIDTH: 100 kHz
 VIDEO BANDWIDTH: 300 kHz
 TEST ANTENNA TYPE: Active loop (9 kHz – 30 MHz)
 Biconilog (30 MHz – 1000 MHz)
 Double ridged guide (above 1000 MHz)

Scatter signal table (above 1000 MHz)									
Frequency, MHz	Field strength of spurious, dB(μV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	Field strength of carrier, dB(μV/m)	Attenuation below carrier, dBc	Limit, dBc	Margin, dB**	Verdict
Low carrier frequency 902.4 MHz									
1803.950	50.18	Horizontal	2.31	77	110.36	60.18	20.0	40.18	Pass
6315.533	52.38	Vertical	1.79	217		57.98		37.98	
7216.583	67.59	Horizontal	1.02	240		42.77		22.77	
Mid carrier frequency 915.0 MHz									
1829.600	53.33	Horizontal	2.58	83	111.88	58.55	20.0	38.55	Pass
5490.050	45.80	Vertical	2.65	227		66.08		46.08	
6405.000	50.14	Horizontal	1.00	221		61.74		41.74	
High carrier frequency 927.6 MHz									
1854.533	57.43	Vertical	1.00	202	112.47	55.04	20.0	35.04	Pass
5565.417	46.23	Vertical	1.79	232		66.24		46.24	
6491.767	54.09	Horizontal	1.79	311		58.38		38.38	
9274.033	52.47	Horizontal	1.00	257		60.00		40.00	

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

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



Test specification: Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

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

ASSIGNED FREQUENCY: 902.0 -928.0 MHz
 INVESTIGATED FREQUENCY RANGE: 1000 – 9500 MHz
 TEST DISTANCE: 3 m
 MODULATION: LoRa
 MODULATING SIGNAL: PRBS
 BIT RATE: 12.5 kbps
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 DETECTOR USED: Peak
 RESOLUTION BANDWIDTH: 1000 kHz
 TEST ANTENNA TYPE: Double ridged guide

Antenna			Azimuth, degrees*	Peak field strength(VBW=3 MHz)			Average field strength(VBW=10 Hz)				Verdict
Frequency, MHz	Polarization	Height, m		Measured, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	Measured, dB(μV/m)	Calculated, dB(μV/m)	Limit, dB(μV/m)	Margin, dB***	
Low carrier frequency 902.4 MHz											
2706.017	Horizontal	2.58	148	46.09	74.0	-27.91	46.09	28.32	54.0	-25.68	Pass
3608.650	Horizontal	2.06	23	43.11	74.0	-30.89	43.11	25.34	54.0	-28.66	
5414.967	Vertical	4.00	82	44.41	74.0	-29.59	44.41	26.64	54.0	-27.36	
8118.667	Horizontal	1.53	230	60.14	74.0	-13.86	60.14	42.37	54.0	-11.63	
9025.583	Horizontal	1.02	342	54.00	74.0	-20.00	54.00	36.23	54.0	-17.77	
Mid carrier frequency 915.0 MHz											
2744.200	Horizontal	3.36	192	45.22	74.0	-28.78	45.22	27.45	54.0	-26.55	Pass
3660.067	Horizontal	1.78	23	43.31	74.0	-30.69	43.31	25.54	54.0	-28.46	
7318.467	Horizontal	1.00	231	66.76	74.0	-7.24	66.76	48.99	54.0	-5.01	
8232.700	Horizontal	2.32	230	59.63	74.0	-14.37	59.63	41.86	54.0	-12.14	
9150.650	Horizontal	2.31	230	54.53	74.0	-19.47	54.53	36.76	54.0	-17.24	
High carrier frequency 927.6 MHz											
2783.167	Horizontal	2.06	78	49.31	74.0	-24.69	49.31	31.54	54.0	-22.46	Pass
3709.367	Vertical	1.89	308	45.32	74.0	-28.68	45.32	27.55	54.0	-26.45	
4638.133	Horizontal	2.06	106	42.60	74.0	-31.40	42.60	24.83	54.0	-29.17	
7418.917	Horizontal	2.32	237	64.97	74.0	-9.03	64.97	47.20	54.0	-6.80	
8346.733	Horizontal	1.27	203	58.12	74.0	-15.88	58.12	40.35	54.0	-13.65	

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

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

*** - Margin = Calculated field strength - specification limit, where Calculated field strength = Measured field strength + average factor.

Table 7.3.4 Average factor calculation

Transmission pulse		Transmission burst		Transmission train duration, ms	Average factor, dB
Duration, ms	Period, ms	Duration, ms	Period, ms		
NA	NA	12.93	1037	NA	-17.77

*- Average factor was calculated as follows

for pulse train shorter than 100 ms:

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

for pulse train longer than 100 ms:

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



Test specification: Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

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

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
 INVESTIGATED FREQUENCY RANGE: 0.009 – 1000 MHz
 TEST DISTANCE: 3 m
 MODULATION: LoRa
 MODULATING SIGNAL: PRBS
 BIT RATE: 12.5 kbps
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 RESOLUTION BANDWIDTH: 0.2 kHz (9 kHz – 150 kHz)
 9.0 kHz (150 kHz – 30 MHz)
 120 kHz (30 MHz – 1000 MHz)
 VIDEO BANDWIDTH: > Resolution bandwidth
 TEST ANTENNA TYPE: Active loop (9 kHz – 30 MHz)
 Biconilog (30 MHz – 1000 MHz)

Frequency, 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 902.4 MHz								
No emissions were found								Pass
Mid carrier frequency 915.0 MHz								
No emissions were found								Pass
High carrier frequency 927.6 MHz								
No emissions were found								Pass

*- Margin = Measured emission - specification limit.

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



Test specification: Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

7.3.6 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 7.3.7 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

Reference numbers of test equipment used

HL 0446	HL 3903	HL 4360	HL 4933	HL 5288	HL 5665		
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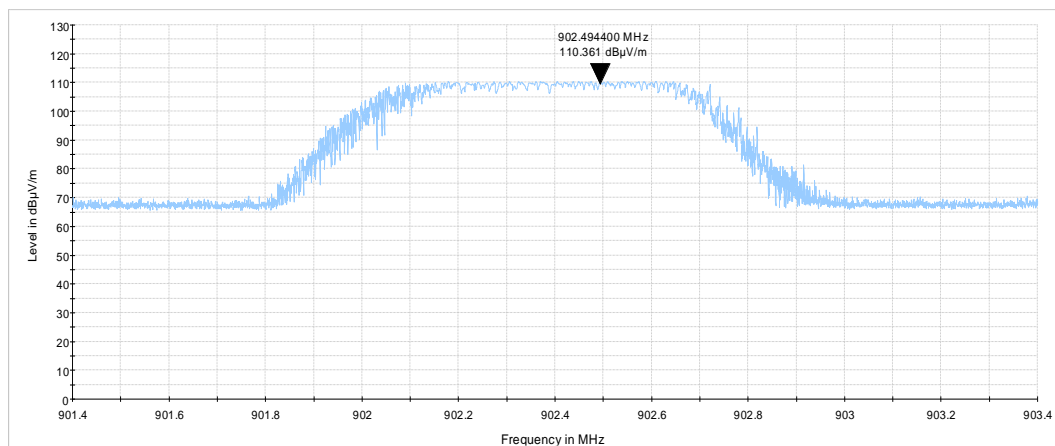
Full description is given in Appendix A.



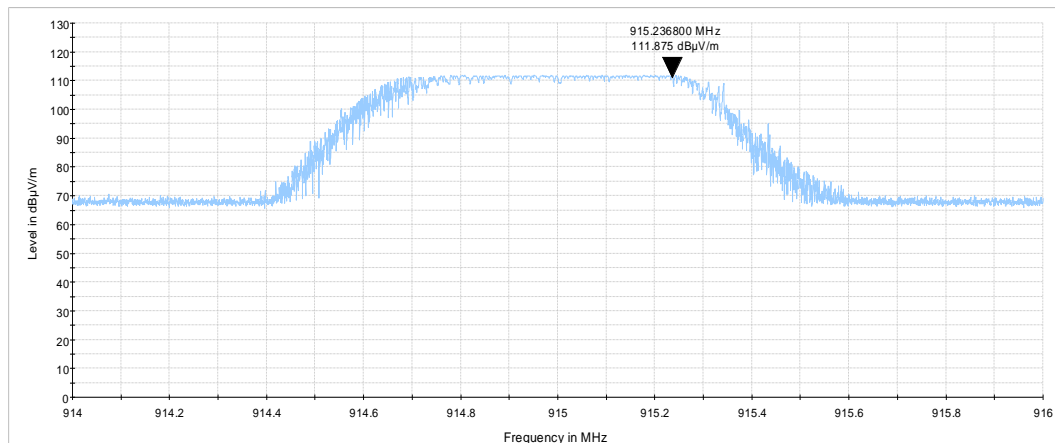
Test specification: Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Plot 7.3.1 Radiated emission measurements at the low carrier frequency

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

**Plot 7.3.2 Radiated emission measurements at the mid carrier frequency**

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

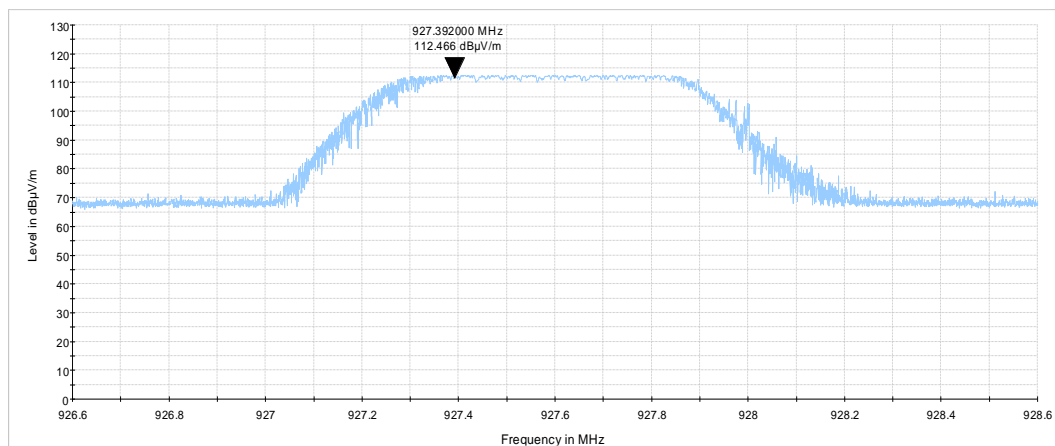




Test specification:		Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions	
Test procedure:		ANSI C63.10 section 11.12.1	
Test mode:		Verdict: PASS	
Date(s):			
10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Plot 7.3.3 Radiated emission measurements at the high carrier frequency

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





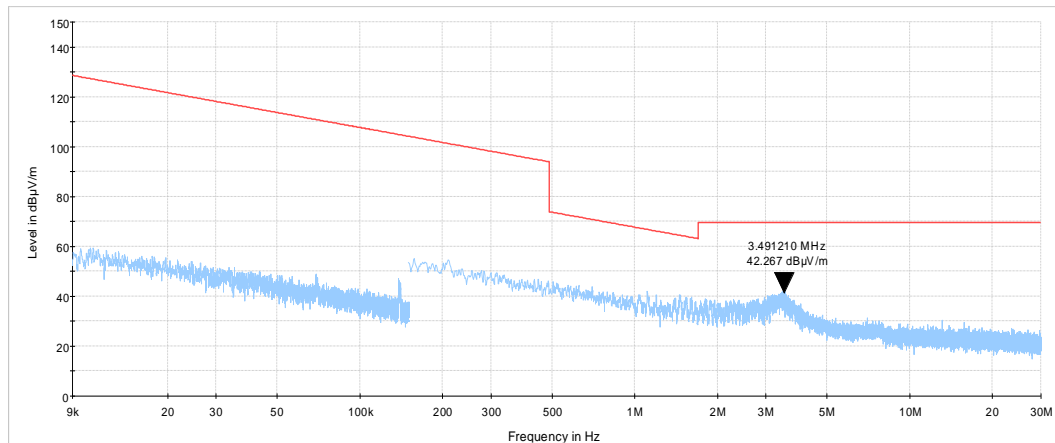
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Report ID: TRIRAD_FCC.36587
Date of Issue: 19-May-20

Test specification:		Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions	
Test procedure:		ANSI C63.10 section 11.12.1	
Test mode:		Verdict: PASS	
Date(s):			
10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

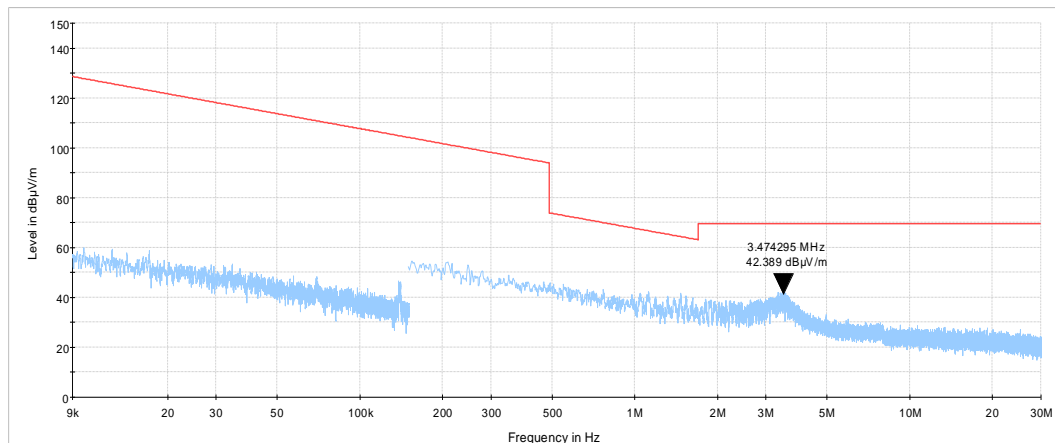
Plot 7.3.4 Radiated emission measurements from 9 kHz to 30 MHz at the low carrier frequency

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



Plot 7.3.5 Radiated emission measurements from 9 kHz to 30 MHz at the mid carrier frequency

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

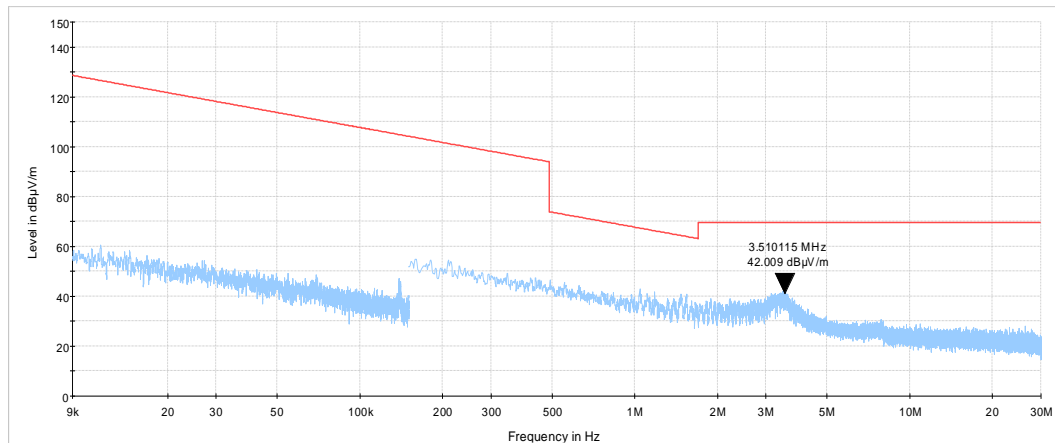




Test specification: Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Plot 7.3.6 Radiated emission measurements from 9 kHz to 30 MHz at the high carrier frequency

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





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Report ID: TRIRAD_FCC.36587

Date of Issue: 19-May-20

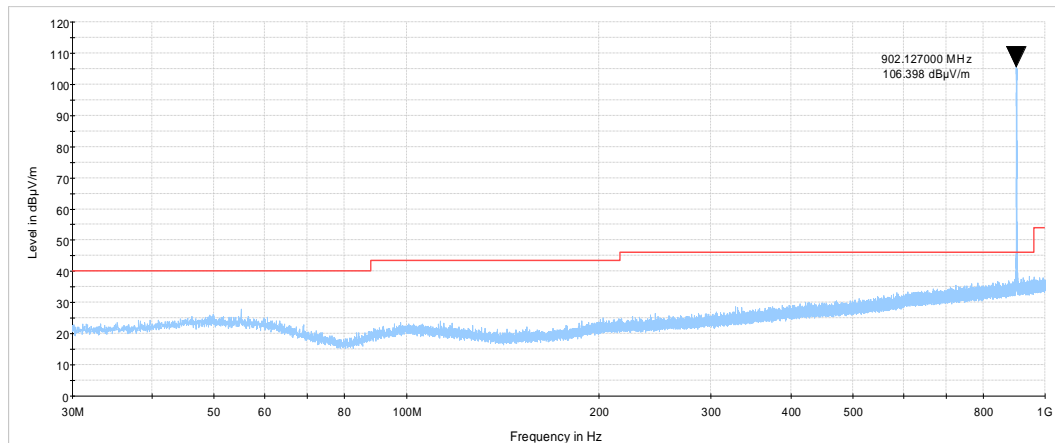
Test specification: Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Plot 7.3.7 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

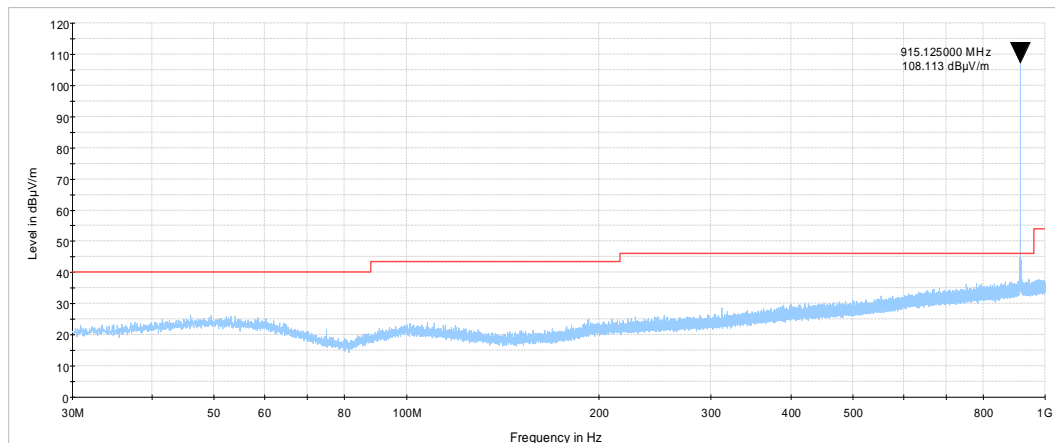


Plot 7.3.8 Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber

TEST DISTANCE: 3 m

ANTENNA POLARIZATION: Vertical and Horizontal





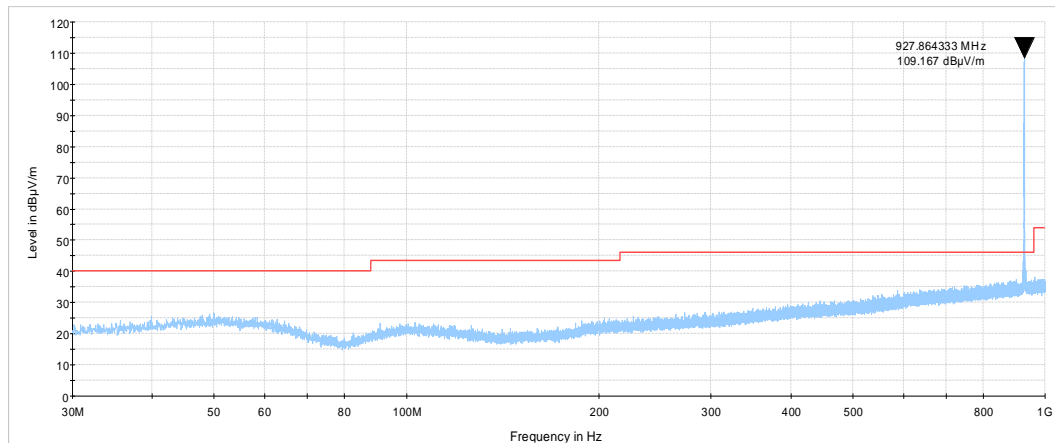
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Report ID: TRIRAD_FCC.36587
Date of Issue: 19-May-20

Test specification:		Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions	
Test procedure:		ANSI C63.10 section 11.12.1	
Test mode:		Verdict: PASS	
Date(s):			
10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Plot 7.3.9 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





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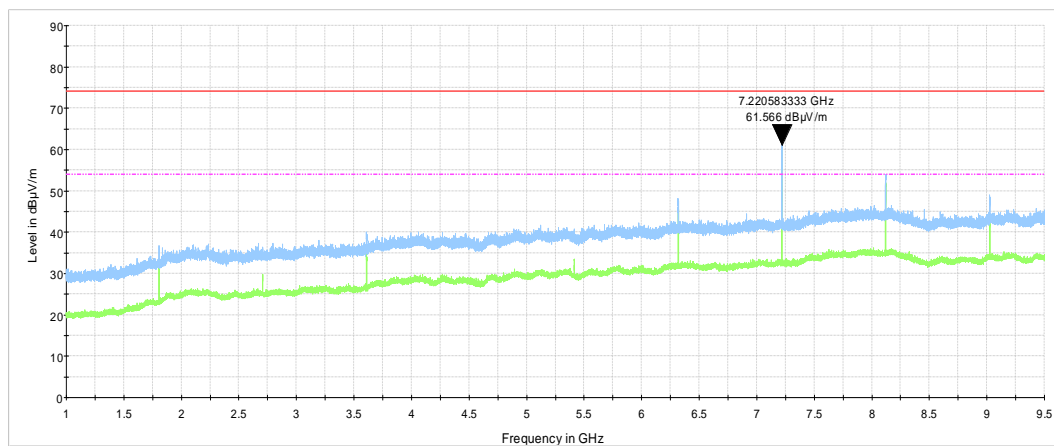
Report ID: TRIRAD_FCC.36587

Date of Issue: 19-May-20

Test specification: Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

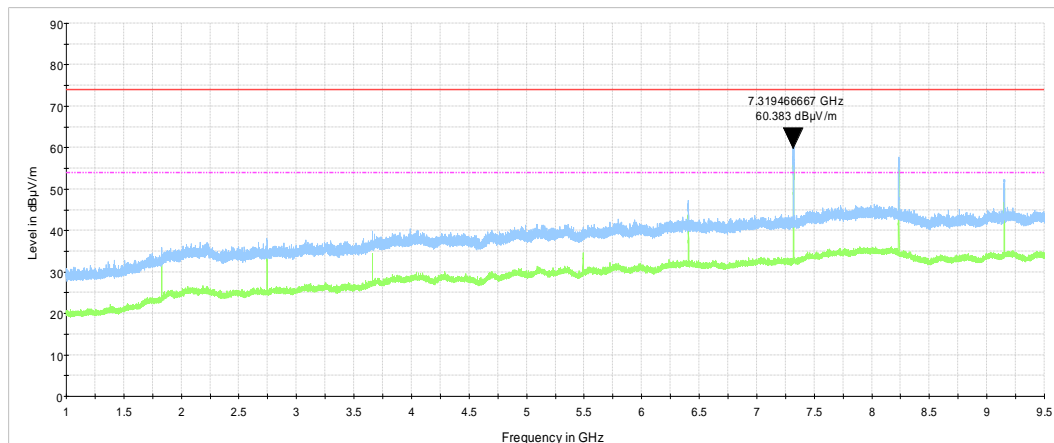
Plot 7.3.10 Radiated emission measurements from 1000 to 9500 MHz at the low carrier frequency

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



Plot 7.3.11 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

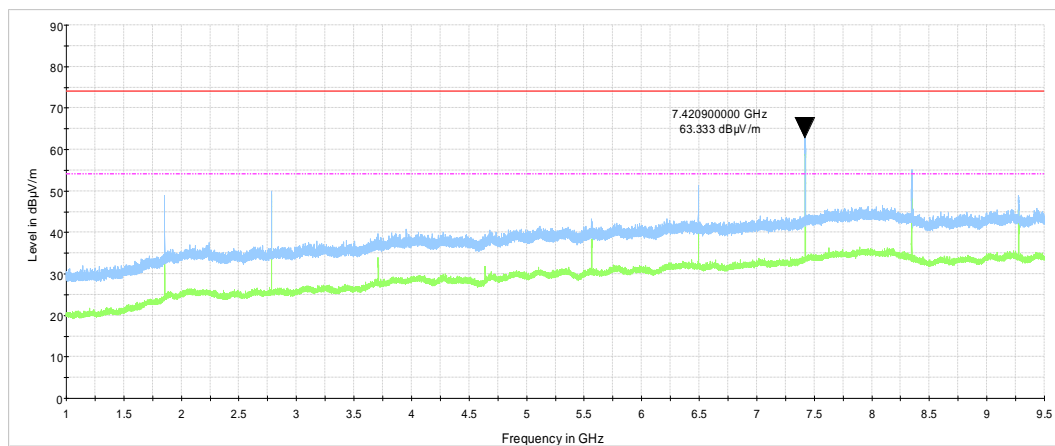




Test specification:		Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions	
Test procedure:		ANSI C63.10 section 11.12.1	
Test mode:		Verdict: PASS	
Date(s):			
10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Plot 7.3.12 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



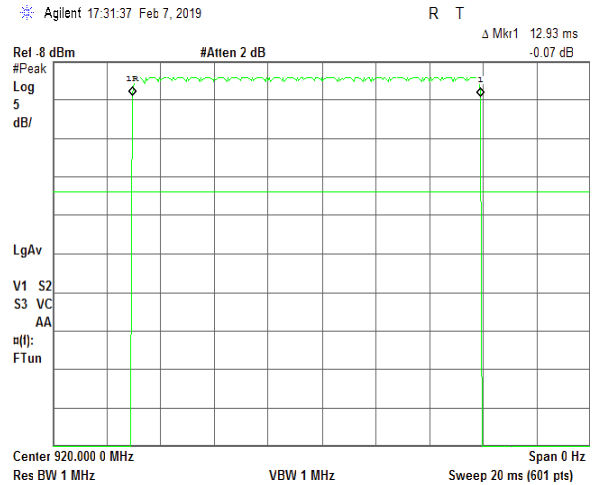
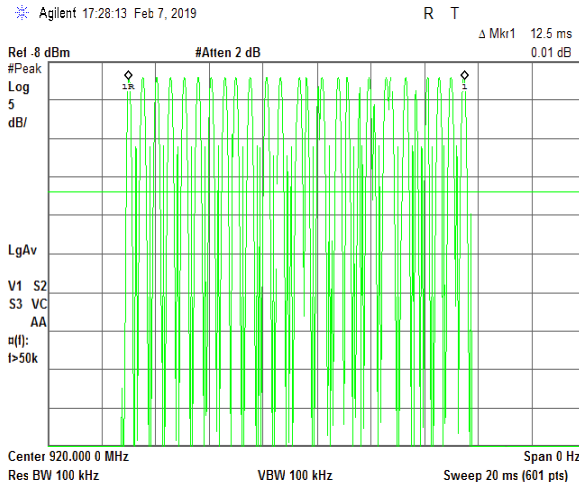


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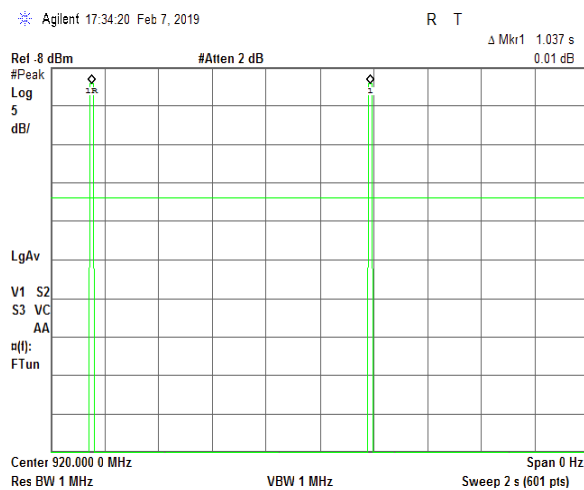
Report ID: TRIRAD_FCC.36587
Date of Issue: 19-May-20

Test specification:		Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions	
Test procedure:		ANSI C63.10 section 11.12.1	
Test mode:		Verdict: PASS	
Date(s):			
10-Feb-20			
Temperature: 22 °C	Relative Humidity: 48 %	Air Pressure: 1026 hPa	Power: 6 VDC
Remarks:			

Plot 7.3.13 Transmission burst duration



Plot 7.3.14 Transmission burst period





Test specification: Section 15.247(d) / RSS-247 section 5.5, Band edge emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 09-Mar-20			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 6 VDC
Remarks:			

7.4 Band edge conducted emissions

7.4.1 General

This test was performed to measure emissions, radiated from the EUT at the assigned frequency band edges. Specification test limits are given in Table 7.4.1.

Table 7.4.1 Band edge emission limits

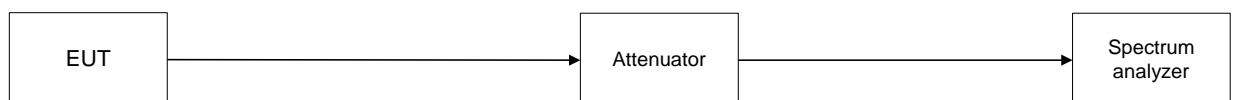
Output power	Assigned frequency, MHz	Attenuation below carrier*, dBc	Field strength at 3 m within restricted bands, dB(μV/m)	
			Peak	Average
Peak	902.0 – 928.0	20.0	74.0	54.0
	2400.0 – 2483.5			
	5725.0 – 5850.0			
Averaged over a time interval	902.0 – 928.0	30.0	74.0	54.0
	2400.0 – 2483.5			
	5725.0 – 5850.0			

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

7.4.2 Test procedure

- 7.4.2.1 The EUT was set up as shown in Figure 7.4.1, energized normally modulated at the maximum data rate and its proper operation was checked.
- 7.4.2.2 The EUT was adjusted to produce maximum available to end user RF output power at the lowest carrier frequency.
- 7.4.2.3 The spectrum analyzer span was set to capture the carrier frequency and associated modulation products. The resolution bandwidth was set wider than 1 % of the frequency span.
- 7.4.2.4 The spectrum analyzer was set in max hold mode and allowed trace to stabilize. The highest emission level within the authorized band was measured.
- 7.4.2.5 The maximum band edge emission and modulation product outside of the band were measured as provided in Table 7.4.2 and associated plots and referenced to the highest emission level measured within the authorized band.
- 7.4.2.6 The above procedure was repeated with the EUT adjusted to produce maximum RF output power at the highest carrier frequency.
- 7.4.2.7 The above procedure was repeated with the frequency hopping function enabled.

Figure 7.4.1 Band edge emission test setup





Test specification: Section 15.247(d) / RSS-247 section 5.5, Band edge emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 09-Mar-20			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 6 VDC
Remarks:			

Table 7.4.2 Band edge emission test results

ASSIGNED FREQUENCY RANGE: 902.0 – 928.0 MHz
 MODULATION: LoRa
 BIT RATE: 12.5 kbps
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 DETECTOR USED: Average
 TRACE AVERAGING: > 100 traces
 EUT 6 dB BANDWIDTH: 778 kHz
 RESOLUTION BANDWIDTH: 100 kHz
 VIDEO BANDWIDTH: 300 kHz

Frequency, MHz	Band edge emission, dBm	Emission at carrier, dBm	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
Averaged over a time interval power						
902.0	-55.88	9.48	65.36	30.0	35.36	Pass
928.0	-51.78	11.02	62.80		32.80	

*- Margin = Attenuation below carrier – specification limit.

Reference numbers of test equipment used

HL 3818							
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Full description is given in Appendix A.



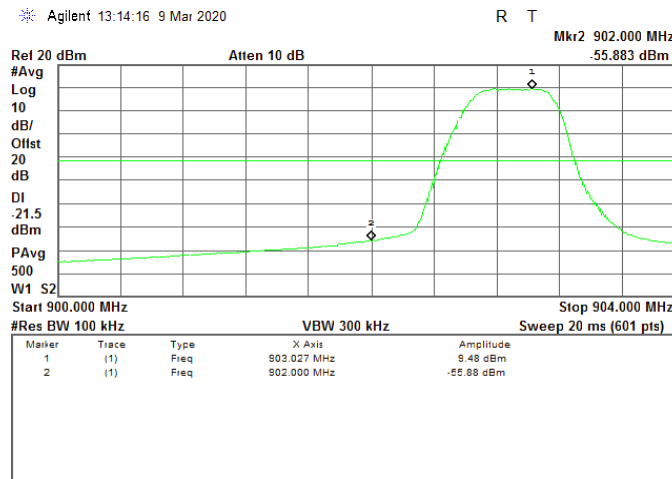
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Report ID: TRIRAD_FCC.36587

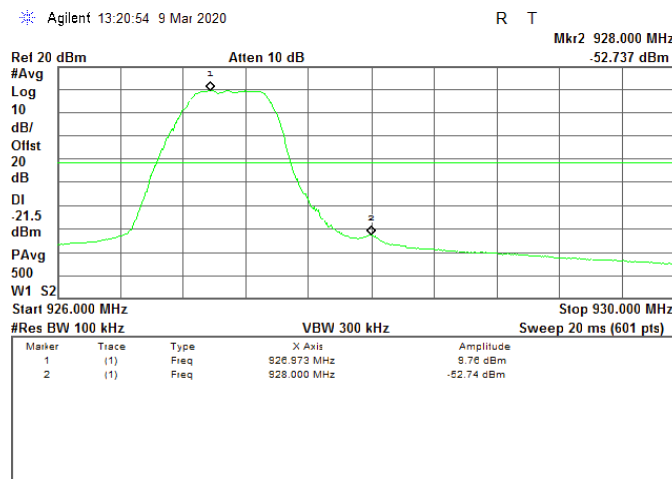
Date of Issue: 19-May-20

Test specification: Section 15.247(d) / RSS-247 section 5.5, Band edge emissions			
Test procedure: ANSI C63.10 section 11.12.1			
Test mode: Compliance		Verdict: PASS	
Date(s): 09-Mar-20			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 6 VDC
Remarks:			

Plot 7.4.1 The highest band edge emission at low carrier frequency



Plot 7.4.2 The highest band edge emission at high carrier frequency





Test specification:		Section 15.247(e), / RSS-247 section 5.2(b), Peak power density	
Test procedure:		ANSI C63.10 section 11.9.2.2.4	
Test mode:		Verdict: PASS	
Date(s):			
12-Feb-20			
Temperature: 22 °C	Relative Humidity: 46 %	Air Pressure: 1022 hPa	Power: 6 VDC
Remarks:			

7.5 Peak spectral power density

7.5.1 General

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

Table 7.5.1 Peak spectral power density limits

Assigned frequency range, MHz	Measurement bandwidth, kHz	Peak spectral power density, dBm
902.0 – 928.0	3.0	8.0

7.5.2 Test procedure

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

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

7.5.2.3 The duty cycle of the transmitter output signal was measured and recorded.

7.5.2.4 The frequency span of spectrum analyzer was set greater than the OBW of the transmitter at least 1.5 times. The maximum power spectral density was measured using a power average (RMS) detector with resolution bandwidth set to 3 kHz, VBW ≥9 kHz. The trace average at least 100 traces was performed.

7.5.2.5 The maximum power level was determined in any 3 kHz band within the fundamental OBW.

7.5.2.6 The duty cycle correction factor was added to the measured power to compute the average power during the actual transmission times.



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Report ID: TRIRAD_FCC.36587

Date of Issue: 19-May-20

Test specification: Section 15.247(e), / RSS-247 section 5.2(b), Peak power density			
Test procedure: ANSI C63.10 section 11.9.2.2.4			
Test mode: Compliance		Verdict: PASS	
Date(s): 12-Feb-20			
Temperature: 22 °C	Relative Humidity: 46 %	Air Pressure: 1022 hPa	Power: 6 VDC
Remarks:			

Figure 7.5.1 Setup for carrier field strength measurements



Table 7.5.2 Field strength measurement of peak spectral power density

ASSIGNED FREQUENCY: 902 - 928 MHz
 MODULATION: LoRa
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 DETECTOR USED: Average
 TRACE AVERAGING: > 100 traces
 RESOLUTION BANDWIDTH: 10 kHz
 VIDEO BANDWIDTH: ≥ 30 kHz

Modulation, Bit rate, kbps	Spectrum analyzer reading, dBm	External attenuation, dB	Cable loss, dB	Duty cycle factor	Peak spectral power density*, dBm/10kHz	Limit, dBm/3kHz	Margin**, dB	Verdict
902.4 MHz BW, low channel								
12.5	2.09	Included	Included	1.23	3.32	8.0	-4.68	Pass
915.0 MHz BW, mid channel								
12.5	2.37	Included	Included	1.23	3.60	8.0	-4.40	Pass
927.6 MHz BW, high channel								
12.5	0.89	Included	Included	1.23	2.12	8.0	-5.88	Pass

* - Peak spectral power density (dBm/3kHz) = Measured power density (dBm/10kHz) + Duty cycle correction factor, where
 Duty cycle correction factor = $10 \cdot \log(1/D) = 1.23$

** - Margin = Peak spectral power density – specification limit.

Reference numbers of test equipment used

HL 5376	HL 5608						
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Full description is given in Appendix A.

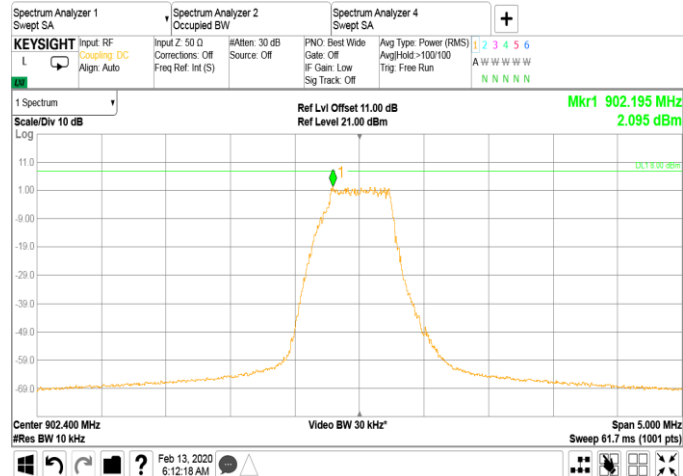


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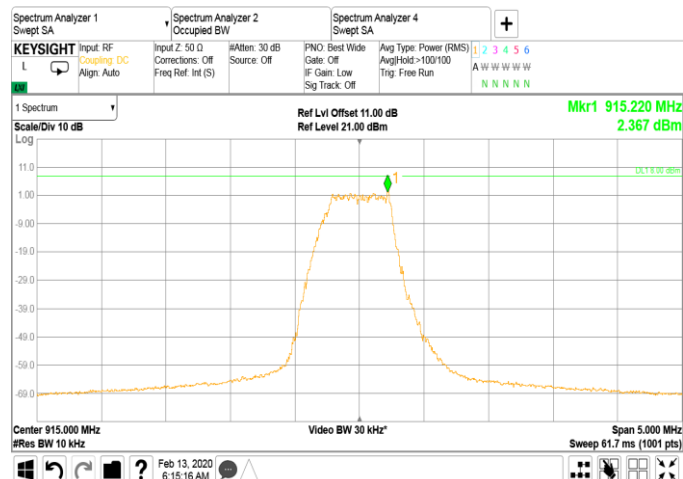
Report ID: TRIRAD_FCC.36587
Date of Issue: 19-May-20

Test specification: Section 15.247(e), / RSS-247 section 5.2(b), Peak power density			
Test procedure: ANSI C63.10 section 11.9.2.2.4			
Test mode: Compliance		Verdict: PASS	
Date(s): 12-Feb-20			
Temperature: 22 °C	Relative Humidity: 46 %	Air Pressure: 1022 hPa	Power: 6 VDC
Remarks:			

Plot 7.5.1 Peak spectral power density at low frequency



Plot 7.5.2 Peak spectral power density at mid frequency





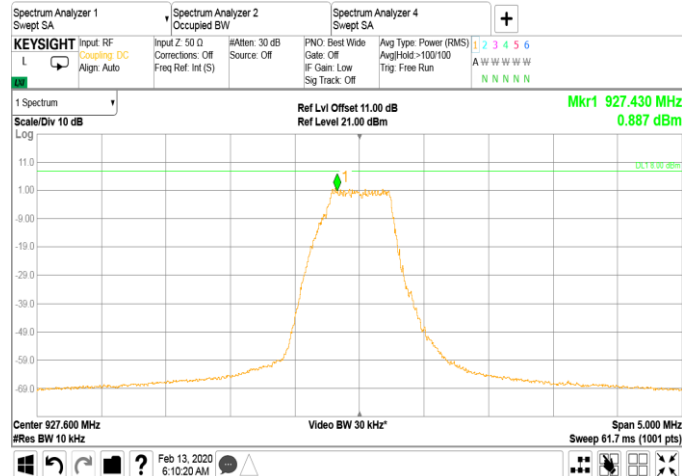
HERMON LABORATORIES

Report ID: TRIRAD_FCC.36587

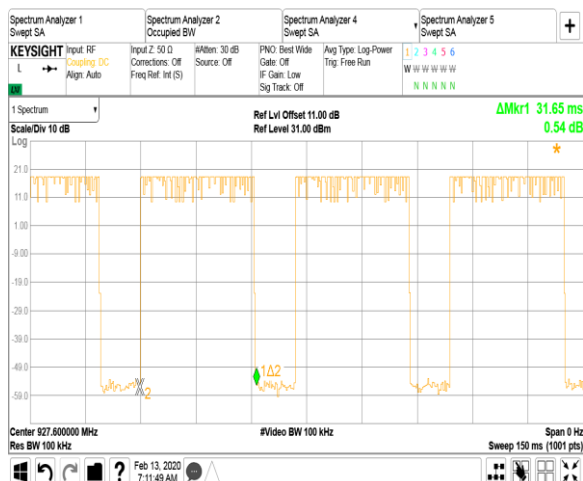
Date of Issue: 19-May-20

Test specification:		Section 15.247(e), / RSS-247 section 5.2(b), Peak power density	
Test procedure:		ANSI C63.10 section 11.9.2.2.4	
Test mode:		Compliance	Verdict: PASS
Date(s):		12-Feb-20	
Temperature: 22 °C	Relative Humidity: 46 %	Air Pressure: 1022 hPa	Power: 6 VDC
Remarks:			

Plot 7.5.3 Peak spectral power density at high frequency



Plot 7.5.4 Pulse duration and pulse period test result





Test specification: Section 15.203, RSS-Gen section 8.3, Antenna requirements			
Test procedure: Visual inspection			
Test mode: Compliance		Verdict: PASS	
Date(s): 13-Feb-20			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 6 VDC
Remarks:			

7.6 Antenna requirements

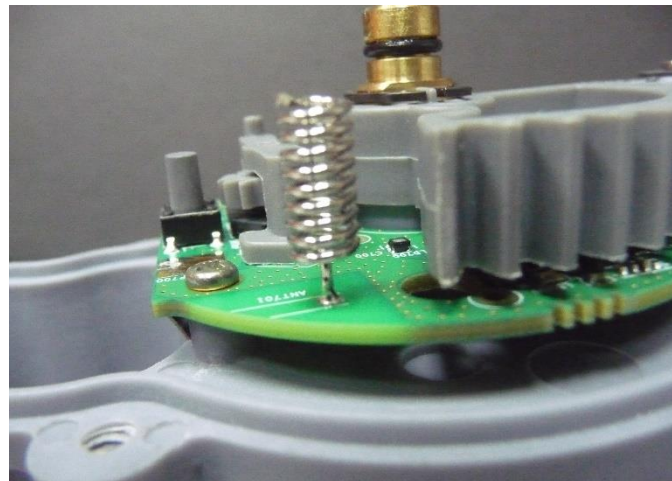
The EUT was verified for compliance with antenna requirements. A transmitter shall be designed to ensure that no antenna other than that furnished by the responsible party will be used with the device. It may be either permanently attached or employs a unique antenna connector for every antenna proposed 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 7.6.1.

Table 7.6.1 Antenna requirements

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

Photograph 7.6.1 Antenna assembly





Test specification:		FCC 47 CFR, Section 15.109, RSS-Gen, Section 7.1.2, ICES-003, Section 6.2, Class B, Radiated emissions	
Test procedure:		ANSI C63.4, Sections 8.3 and 12.2.5	
Test mode:		Verdict: PASS	
Date(s):			
13-Feb-20			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 6 VDC
Remarks:			

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

8.1 Radiated emission measurements

8.1.1 General

This test was performed to measure radiated emissions from the EUT enclosure. Specification test limits are given in Table 8.1.1.

Table 8.1.1 Radiated emission test limits

Frequency, MHz	Class B limit, dB(μV/m)		Class A limit, dB(μV/m)	
	10 m distance	3 m distance	10 m distance	3 m distance
30 - 88	29.5*	40.0	39.0	49.5*
88 - 216	33.0*	43.5	43.5	54.0*
216 - 960	35.5*	46.0	46.4	56.9*
Above 960	43.5*	54.0	49.5	60.0*

* The limit for test distance other than specified was calculated using the inverse linear distance extrapolation factor as follows: $\text{Lim}_{S2} = \text{Lim}_{S1} + 20 \log(S1/S2)$, where $S1$ and $S2$ – standard defined and test distance respectively in meters.

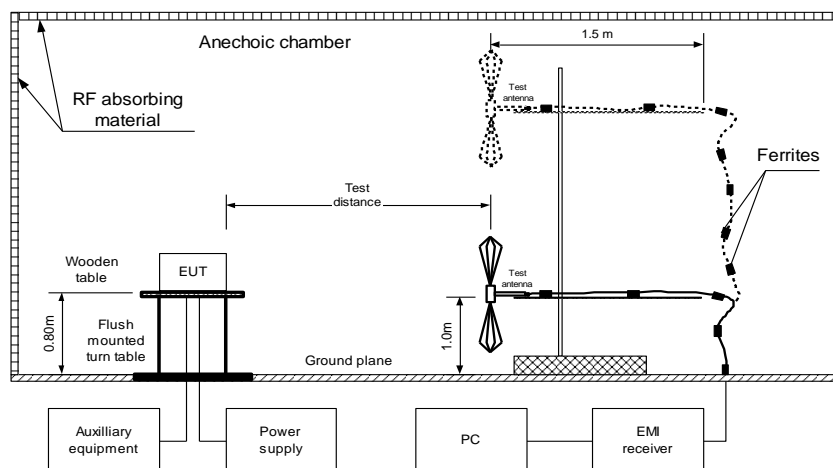
8.1.2 Test procedure for measurements in semi-anechoic chamber

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

8.1.2.2 The specified frequency range was investigated with biconilog antenna connected to EMI receiver. To find maximum radiation the turntable was rotated 360°, the measuring antenna height was changed from 1 to 4 m, its polarization was switched from vertical to horizontal and the EUT cables position was varied.

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

Figure 8.1.1 Setup for radiated emission measurements in anechoic chamber, table-top equipment





HERMON LABORATORIES

Report ID: TRIRAD_FCC.36587
Date of Issue: 19-May-20

Test specification: FCC 47 CFR, Section 15.109, RSS-Gen, Section 7.1.2, ICES-003, Section 6.2, Class B, Radiated emissions			
Test procedure: ANSI C63.4, Sections 8.3 and 12.2.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 13-Feb-20			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 6 VDC
Remarks:			

Table 8.1.2 Radiated emission test results

EUT SET UP: TABLE-TOP
LIMIT: Class B
EUT OPERATING MODE: Receive
TEST SITE: SEMI ANECHOIC CHAMBER
TEST DISTANCE: 3 m
DETECTORS USED: PEAK / QUASI-PEAK
FREQUENCY RANGE: 30 MHz – 1000 MHz
RESOLUTION BANDWIDTH: 120 kHz

RECESSION BANDWIDTH:					120 KHz			
Frequency, MHz	Peak emission, dB(μV/m)	Quasi-peak			Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
		Measured emission, dB(μV/m)	Limit, dB(μV/m)	Margin, dB*				
No emission were found								Pass

TEST SITE: SEMI ANECHOIC CHAMBER
TEST DISTANCE: 3 m
DETECTORS USED: PEAK / AVERAGE
FREQUENCY RANGE: 1000 MHz – 5000 MHz
RESOLUTION BANDWIDTH: 1000 kHz

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

*- Margin = Measured emission - specification limit.

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

Reference numbers of test equipment used

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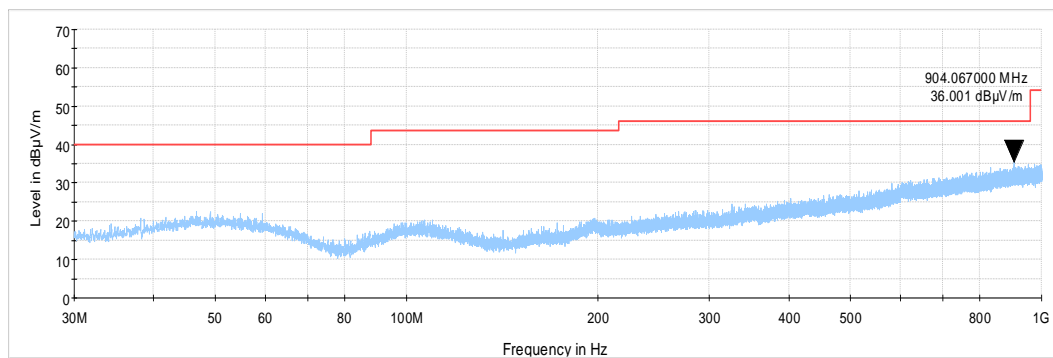
Full description is given in Appendix A.



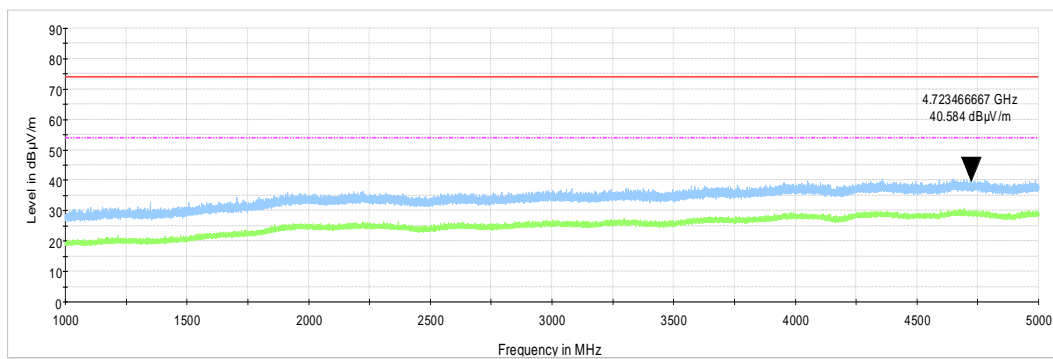
Test specification:		FCC 47 CFR, Section 15.109, RSS-Gen, Section 7.1.2, ICES-003, Section 6.2, Class B, Radiated emissions	
Test procedure:		ANSI C63.4, Sections 8.3 and 12.2.5	
Test mode:		Verdict: PASS	
Date(s):			
13-Feb-20			
Temperature: 24.2 °C	Relative Humidity: 48 %	Air Pressure: 1009 hPa	Power: 6 VDC
Remarks:			

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

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

**Plot 8.1.2 Radiated emission measurements in 1 - 5 GHz range, vertical and horizontal antenna polarization**

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



9 APPENDIX A Test equipment and ancillaries used for tests

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
0446	Antenna, Loop, Active, 10 (9) kHz - 30 MHz	EMCO	6502	2857	24-Feb-20	24-Feb-21
3818	PSA Series Spectrum Analyzer, 3 Hz- 44 GHz	Agilent Technologies	E4446A	MY48250288	24-Apr-19	24-Apr-20
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFL EX 102A	1226/2A	07-Apr-19	07-Apr-20
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	20-Jan-20	20-Jan-21
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	06-Jan-20	06-Jan-21
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	08-Feb-19	08-Feb-22
5376	EXA Signal Analyzer, 10 Hz - 32 GHz	Keysight Technologies	N9010B	MY57470404	18-Mar-19	18-Mar-20
5405	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11N(x2)	500023/118	11-Aug-19	11-Aug-20
5608	Precision Fixed Attenuator, 50 Ohm, 5 W, 10 dB, DC to 18 GHz	Mini Circuits	BW-S10W5+	NA	24-Sep-19	24-Sep-20
5665	Cable SF118/11N(x2)/6M, 18 GHz, 11N/11N	Huber-Suhner	SF118	501644/118	23-Oct-19	23-Oct-20

10 APPENDIX B Test equipment correction factors

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

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

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

The antenna factor shall be added to receiver reading in dB μ V to obtain field strength in dB μ A/m.

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

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

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

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

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

Frequency, MHz	Antenna factor, dB/m
160	12.67
180	13.34
200	15.40
250	16.42
300	17.28
400	19.98
500	21.11
600	22.90
700	24.13
800	25.25
900	26.35
1000	27.18

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

above 1000 MHz

Frequency, MHz	Antenna factor, dB/m
1000	26.9
1100	28.1
1200	28.4
1300	29.6
1400	29.1
1500	30.4
1600	30.7
1700	31.5
1800	32.3
1900	32.6
2000	32.5
2100	32.9
2200	33.5
2300	33.2
2400	33.7
2500	34.6
2600	34.7
2700	34.6
2800	35.0
2900	35.5
3000	36.2
3100	36.8
3200	36.8
3300	37.0
3400	37.5
3500	38.2

Frequency, MHz	Antenna factor, dB/m
3600	38.9
3700	39.4
3800	39.4
3900	39.6
4000	39.7
4100	39.8
4200	40.5
4300	40.9
4400	41.1
4500	41.4
4600	41.3
4700	41.6
4800	41.9
4900	42.3
5000	42.7
5100	43.0
5200	42.9
5300	43.5
5400	43.6
5500	44.3
5600	44.7
5700	45.0
5800	45.0
5900	45.3
6000	45.9

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

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

Frequency, MHz	Antenna factor, dB/m
160	12.67
180	13.34
200	15.40
250	16.42
300	17.28
400	19.98
500	21.11
600	22.90
700	24.13
800	25.25
900	26.35
1000	27.18

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

above 1000 MHz

Frequency, MHz	Antenna factor, dB/m
1000	26.9
1100	28.1
1200	28.4
1300	29.6
1400	29.1
1500	30.4
1600	30.7
1700	31.5
1800	32.3
1900	32.6
2000	32.5
2100	32.9
2200	33.5
2300	33.2
2400	33.7
2500	34.6
2600	34.7
2700	34.6
2800	35.0
2900	35.5
3000	36.2
3100	36.8
3200	36.8
3300	37.0
3400	37.5
3500	38.2

Frequency, MHz	Antenna factor, dB/m
3600	38.9
3700	39.4
3800	39.4
3900	39.6
4000	39.7
4100	39.8
4200	40.5
4300	40.9
4400	41.1
4500	41.4
4600	41.3
4700	41.6
4800	41.9
4900	42.3
5000	42.7
5100	43.0
5200	42.9
5300	43.5
5400	43.6
5500	44.3
5600	44.7
5700	45.0
5800	45.0
5900	45.3
6000	45.9

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



HL 5405: RF Cable
Huber-Suhner, model: SF118/11N(x2), s/n: 500023/118
Calibration date: 01-Aug-2018

Set / Applied, MHz	Measured, dB	Uncertainty, dB
0.1	0.01	±0.07
50	0.23	±0.07
100	0.32	±0.07
200	0.45	±0.08
300	0.55	±0.08
400	0.64	±0.08
500	0.71	±0.08
600	0.78	±0.08
700	0.85	±0.08
800	0.91	±0.08
900	0.97	±0.08
1000	1.02	±0.08
1100	1.07	±0.08
1200	1.12	±0.08
1300	1.16	±0.08
1400	1.21	±0.08
1500	1.25	±0.08
1600	1.30	±0.08
1700	1.34	±0.08
1800	1.38	±0.08
1900	1.42	±0.08
2000	1.47	±0.08
2500	1.64	±0.10
3000	1.81	±0.10
3500	1.97	±0.10
4000	2.11	±0.10
4500	2.25	±0.10
5000	2.38	±0.10
5500	2.48	±0.10
6000	2.59	±0.10
6500	2.72	±0.10
7000	2.84	±0.13
7500	2.97	±0.13
8000	3.08	±0.13
8500	3.21	±0.13
9000	3.31	±0.13
9500	3.42	±0.13
10000	3.52	±0.13

11 APPENDIX C Measurement uncertainties

Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements

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

Hermon Laboratories is accredited by A2LA for calibration according to present requirements of ISO/IEC 17025 and NCSL Z540-1. The accreditation is granted to perform calibration of parameters that are listed in the Scope of Hermon Laboratories Accreditation.

Hermon Laboratories calibrates its reference and transfer standards by calibration laboratories accredited to ISO/IEC 17025 by a mutually recognized Accreditation Body or by a recognized national metrology institute. All reference and transfer standards used in the calibration system are traceable to national or international standards.

In-house calibration of all test and measurement equipment is performed on a regular basis according to Hermon Laboratories calibration procedures, manufacturer calibration/verification procedures or procedures defined in the relevant standards. The Hermon Laboratories test and measurement equipment is calibrated within the tolerances specified by the manufacturers and/or by the relevant standards.

12 APPENDIX D Test laboratory description

Tests were performed at Hermon Laboratories Ltd., which is a fully independent, private, EMC, Radio, Safety, Environmental and Telecommunication testing facility.

Hermon Laboratories is recognized and accredited by the Federal Communications Commission (USA) for relevant parts of Code of Federal Regulations 47 (CFR 47), Test Firm Registration Number is 927748, Designation Number is IL1001; Recognized by Innovation, Science and Economic Development Canada for wireless and terminal testing (ISED), ISED #2186A, CAB identifier is IL1001; 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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website: www.hermonlabs.com

Person for contact: Mr. Michael Nikishin, EMC&Radio group manager

13 APPENDIX E

Specification references

FCC 47CFR part 15:2019

ANSI C63.4:2014

ANSI C63.10:2013

RSS-247:2017, Issue 2

RSS-Gen:2018, Issue 5

ICES-003:2016, Issue 6

558074 D01 DTS

Meas_Guidance v05

Radio Frequency Devices.

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.

American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License Exempt Local Area Network (LE-LAN) Devices

General Requirements for Compliance of Radio Apparatus

Information Technology Equipment (Including Digital Apparatus) – Limits and methods of measurement

Guidance for compliance measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices operating under section 15.247 of the FCC rules

14 APPENDIX F Abbreviations and acronyms

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

END OF DOCUMENT