HERMON LABORATORIES

ELECTRICAL TESTING
0839.01

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TEST REPORT

ACCORDING TO: FCC 47CFR part 15 subpart C §15.247 (DTS),
RSS-247 Issue 2:2017, RSS-Gen Issue 5:2019

FOR:

ST Engineering Telematics Wireless Ltd

Meter Interface Unit

Model: MIU1USLA

FCC ID: NTAMIU1USLA

IC: 4732A-MIU1USLA

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1 Applicant information

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

2 Equipment under test attributes

Product name:	Meter Interface Unit
Product type:	Transceiver
Model(s):	MIU1USLA
Serial number:	1700042
Hardware version:	Rev. B
Software release:	Fc01
Receipt date	02-Jan-20

3 Manufacturer information

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

4 Test details

Project ID:	35688
Location:	Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started:	12-Jan-20
Test completed:	19-Mar-20
Test specification(s):	FCC 47CFR part 15 subpart C §15.247 (DTS)
	RSS-247 Issue 2:2017, RSS-Gen Issue 5:2019

5 Tests summary

Test	Status
Transmitter characteristics	
FCC section 15.247(a)2 / RSS-247 section 5.2(a), 6 dB bandwidth	Pass
FCC section 15.247(b)3/ RSS-247 section 5.4(d), 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(e) / RSS-247 section 5.2(b), Peak power density	Pass
FCC section 15.247(d)/ RSS-247 section 5.5, Emissions at band edges	Pass
FCC section 15.203 / RSS-Gen section 6.8, Antenna requirement	Pass
FCC section 15.207(a) / RSS-Gen section 8.8, Conducted emission	Not required

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	12-Jan-20 – 19-Mar-20	
Reviewed by:	Mrs. S. Peysahov Sheynin, test engineer, EMC & Radio	24-May-20	
Approved by:	Mr. S. Samokha, technical manager, EMC & Radio	23-Jun-20	

6 EUT description

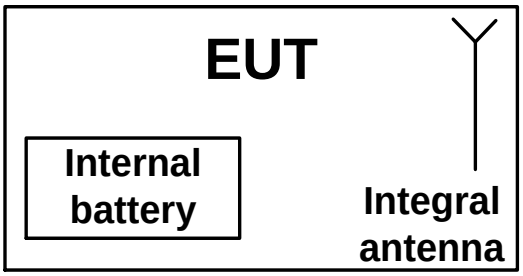
Note: The following data in this clause is provided by the customer and represents his sole responsibility

6.1 General information

The EUT is an interface unit connected to a water meter.

This interface unit is used to control and collect data from the water meter and send the data via RF link to the system control center.

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 range	903 – 927 MHz

Maximum rated output power	At transmitter 50 Ω RF output connector	NA
	Peak output power	20.29 dBm

Is transmitter output power variable?	X	No			
		Yes		continuous variable	
				stepped variable with stepsize	dB
			minimum RF power		dBm
			maximum RF power		dBm

Antenna connection					
unique coupling	standard connector	X	integral	X	with temporary RF connector
					without temporary RF connector

Antenna/s technical characteristics			
Type	Manufacturer	Model number	Gain
Printed	NA	NA	+1.5 dBi

Type of modulation	LoRa
Modulating test signal (baseband)	PRBS

Transmitter power source					
X	Battery	**Nominal rated voltage**	3.6 VDC	Battery type	Lithium size D
	DC	**Nominal rated voltage**			
	AC mains	**Nominal rated voltage**		Frequency	

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-Jan-20		
Temperature: 24.8 ºC	Relative Humidity: 40 %	Air Pressure: 1024 hPa	Power: 3.6 VDC
Remarks:			

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

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

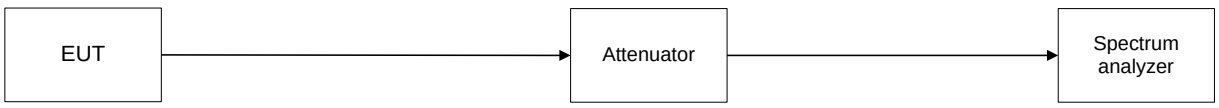
7.1.2 Test procedure

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

7.1.2.2 The EUT was set to transmit modulated carrier.

7.1.2.3 The transmitter minimum 6 dB bandwidth was measured with spectrum analyzer RBW=100 kHz as frequency delta between reference points on modulation envelope and provided in Table 7.1.2 and associated plot.

Figure 7.1.1 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-Jan-20		
Temperature: 24.8 ºC	**Relative Humidity:** 40 %	**Air Pressure:** 1024 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.1.2 6 dB bandwidth test results

ASSIGNED FREQUENCY BAND:	902.0 – 928.0MHz
DETECTOR USED:	Peak
SWEEP MODE:	Maxhold
SWEEP TIME:	Auto
RESOLUTION BANDWIDTH:	100 kHz
VIDEO BANDWIDTH:	300 kHz
MODULATION ENVELOPE REFERENCE POINTS:	6.0 dBc
MODULATION:	LoRa
BIT RATE:	1500 bps

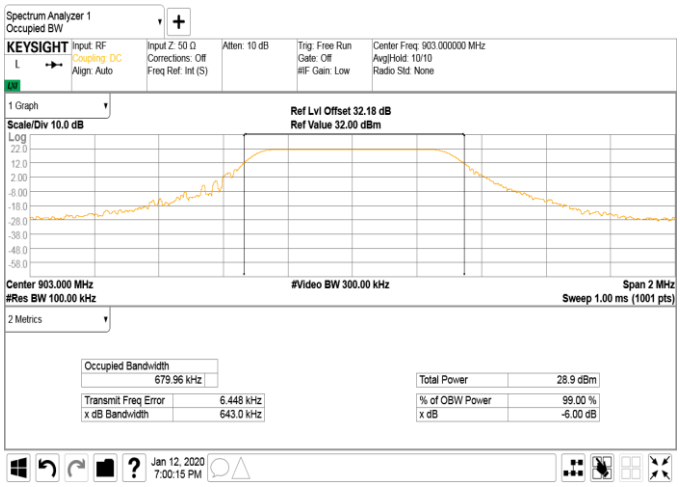
Carrier frequency, MHz	6 dB bandwidth, kHz	Min limit, kHz	Margin, kHz	Verdict
Low frequency				
903.00	643.0	500.00	143.0	Pass
Mid frequency				
915.00	643.2	500.00	143.2	Pass
High frequency				
927.00	643.4	500.00	143.4	Pass

Reference numbers of test equipment used

HL 5376	HL 4071	HL 5410	HL 4136	HL 1809				

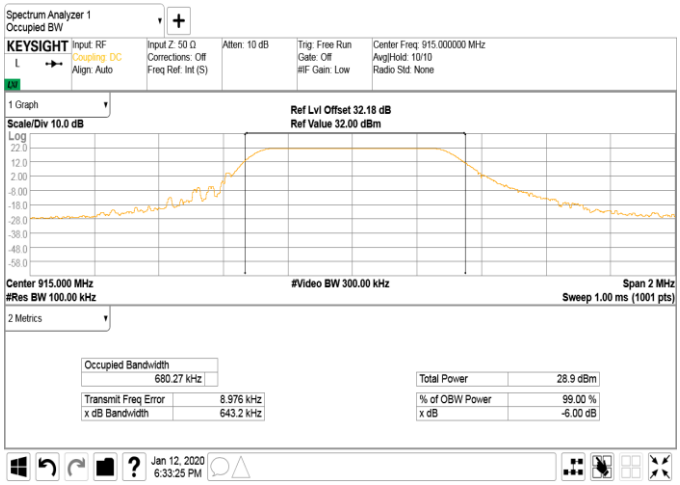
Full description is given in Appendix A.

Plot 7.1.1 6 dB bandwidth test result at low frequency

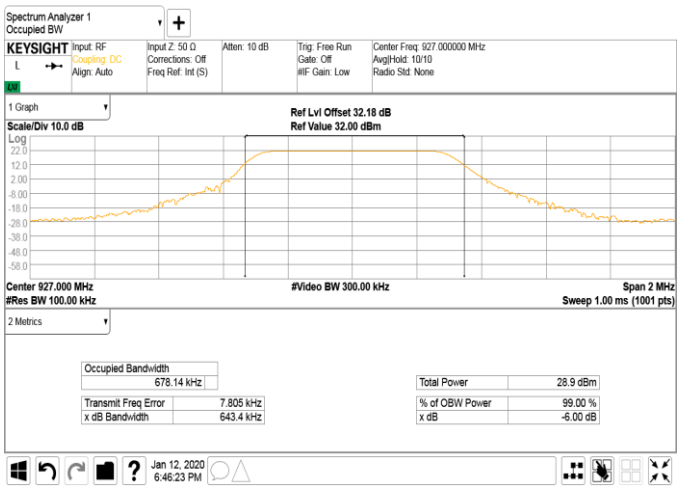


Test specification:	Section 15.247(a)2/ RSS-247 section 5.2(a), 6 dB bandwidth		
Test procedure:	ANSI C63.10 section 11.8.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	12-Jan-20		
Temperature: 24.8 ºC	Relative Humidity: 40 %	Air Pressure: 1024 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.1.2 6 dB bandwidth test result at mid frequency



Plot 7.1.3 6 dB bandwidth test result at high frequency



Test specification:	Section 15.247(b)3/ 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):	06-Feb-20		
Temperature: 22.5 ºC	Relative Humidity: 40 %	Air Pressure: 1015 hPa	Power: 3.6 VDC
Remarks:			

7.2 Peak output power

7.2.1 General

This test was performed to measure the maximum peak output power at the transmitter RF antenna connector. Specification test limits are given in Table 7.2.1.

Table 7.2.1 Peak output power limits

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

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

7.2.2 Test procedure

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

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

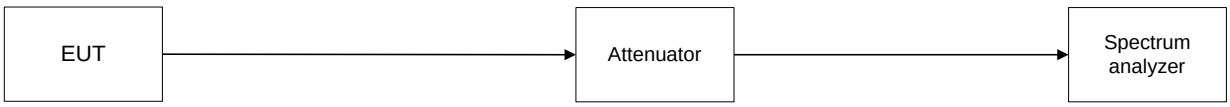
7.2.2.3 The duty cycle of the transmitter output signal was measured and recorded.

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 output power 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.

Figure 7.2.1 Peak output power test setup



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):	06-Feb-20		
Temperature: 22.5 ºC	Relative Humidity: 40 %	Air Pressure: 1015 hPa	Power: 3.6 VDC
Remarks:			

Table 7.2.2 Peak output power test results

ASSIGNED FREQUENCY:	902.0 – 928.0 MHz
MODULATION:	LoRa
BIT RATE:	1500 bps
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Average
EUT 6 dB BANDWIDTH:	0.644 MHz
RESOLUTION BANDWIDTH:	1MHz
VIDEO BANDWIDTH:	3MHz

Carrier frequency, MHz	SA reading, dBm	External attenuation, dB	Cable loss, dB	DC factor, dB	Peak output power,** dBm	Limit, dBm	Margin*, dB	Verdict
903.00	19.21	included	included	1.03	20.24	30.0	-9.76	Pass
915.00	19.26	included	included	1.03	20.29	30.0	-9.71	Pass
927.00	19.24	included	included	1.03	20.27	30.0	-9.73	Pass

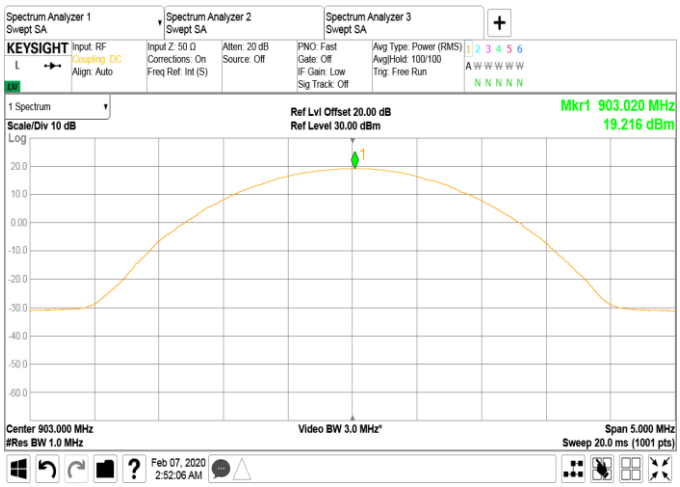
* - Margin = Peak output power – specification limit.
** - Peak output power = SA reading + DC factor, where
DC Factor = 10*log (1/(Txon / Txon+Txoff)) = 1.03dB

Reference numbers of test equipment used

HL 5376	HL 5616	HL 5609	HL 4135	HL 1809			

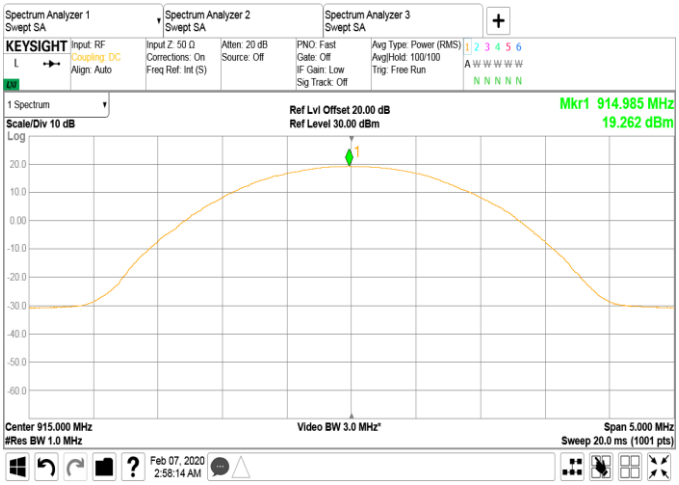
Full description is given in Appendix A.

Plot 7.2.1 Peak output power at low frequency and Unom

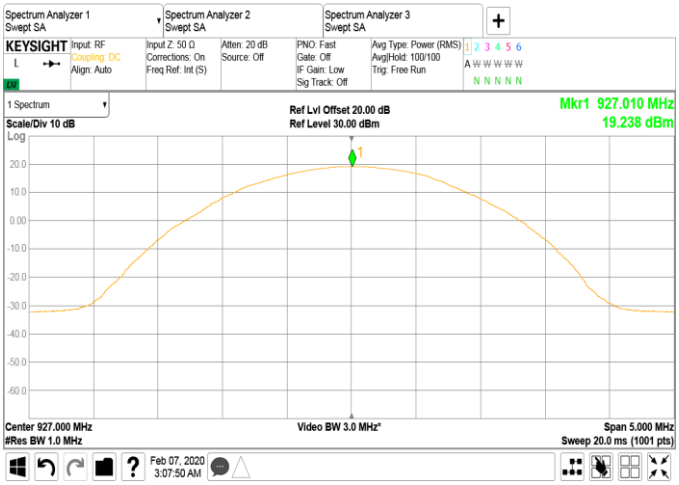


Test specification:	Section 15.247(b)3/ RSS-247 section 5.4(d), Peak output power		
Test procedure:	ANSI C63.10 sections 11.9.2.2.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	06-Feb-20		
Temperature: 22.5 ºC	Relative Humidity: 40 %	Air Pressure: 1015 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.2.2 Peak output power at mid frequency and Unom

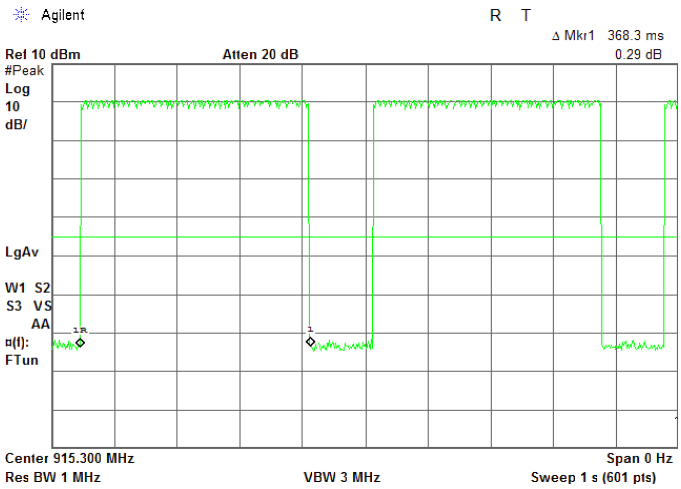


Plot 7.2.3 Peak output power at high frequency and Unom

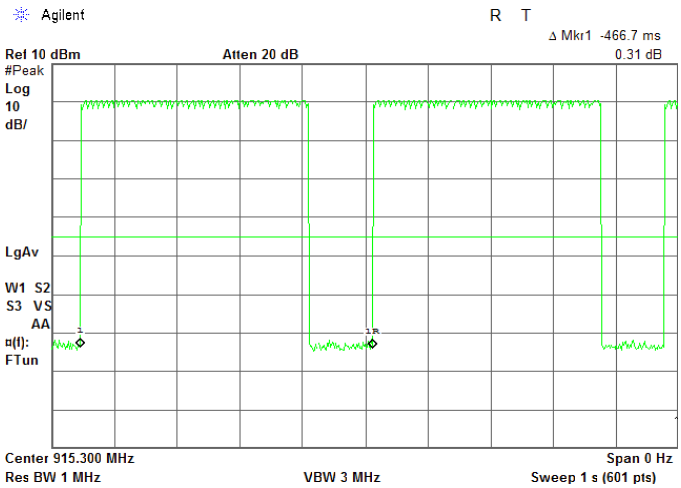


Test specification:	Section 15.247(b)3/ RSS-247 section 5.4(d), Peak output power		
Test procedure:	ANSI C63.10 sections 11.9.2.2.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	06-Feb-20		
Temperature: 22.5 ºC	Relative Humidity: 40 %	Air Pressure: 1015 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.2.4 Transmission pulse duration



Plot 7.2.5 Transmission pulse period



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):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	**Relative Humidity:** 39 %	**Air Pressure:** 1014 hPa	**Power:** 3.6 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**	30.0
0.090 – 0.110	NA	108.5 – 106.8**	NA	
0.110 – 0.490	126.8 – 113.8	NA	106.8 – 93.8**	
0.490 – 1.705	NA	73.8 – 63.0**	NA	
1.705 – 30.0*		69.5		
30 – 88		40.0		
88 – 216		43.5		
216 – 960		46.0		
960 - 1000		54.0		
1000 – 10thharmonic	74.0	NA	54.0	

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

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

where S_1 and S_2 – standard defined and test distance respectively in meters.
**- The limit decreases linearly with the logarithm of frequency.
*** - The field strength limits applied from the lowest radio frequency generated in the device, without going below 9 kHz up to the tenth harmonic of the highest fundamental frequency.

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

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

7.3.2.2 The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360^0 and the measuring antenna was rotated around its vertical axis.

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

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

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

7.3.3.2 The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360^0, the measuring antenna height was changed from 1 to 4 m, its polarization was switched from vertical to horizontal.

7.3.3.3 The worst test results (the lowest margins) were recorded 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):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

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

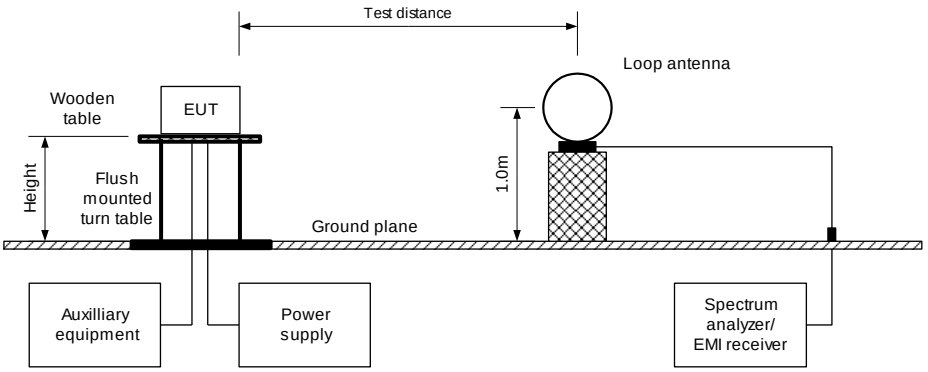
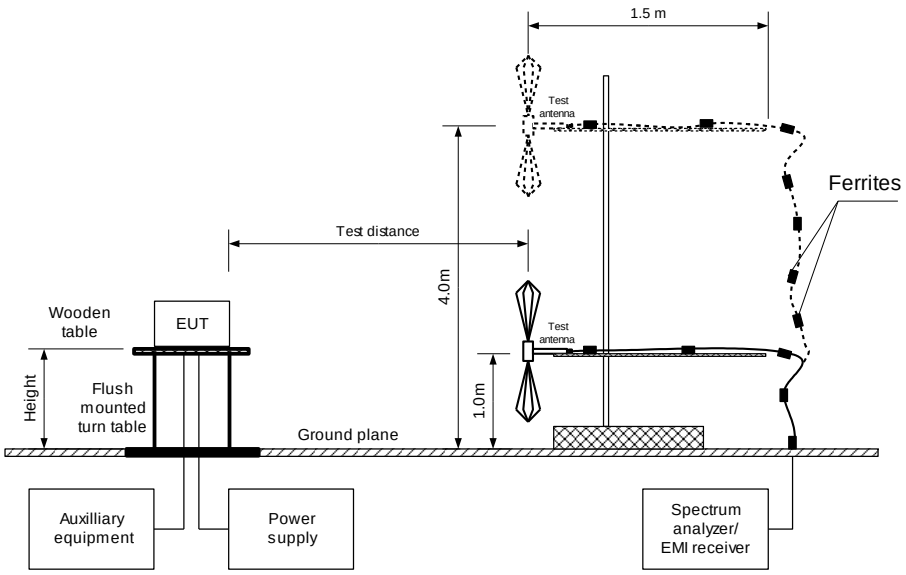
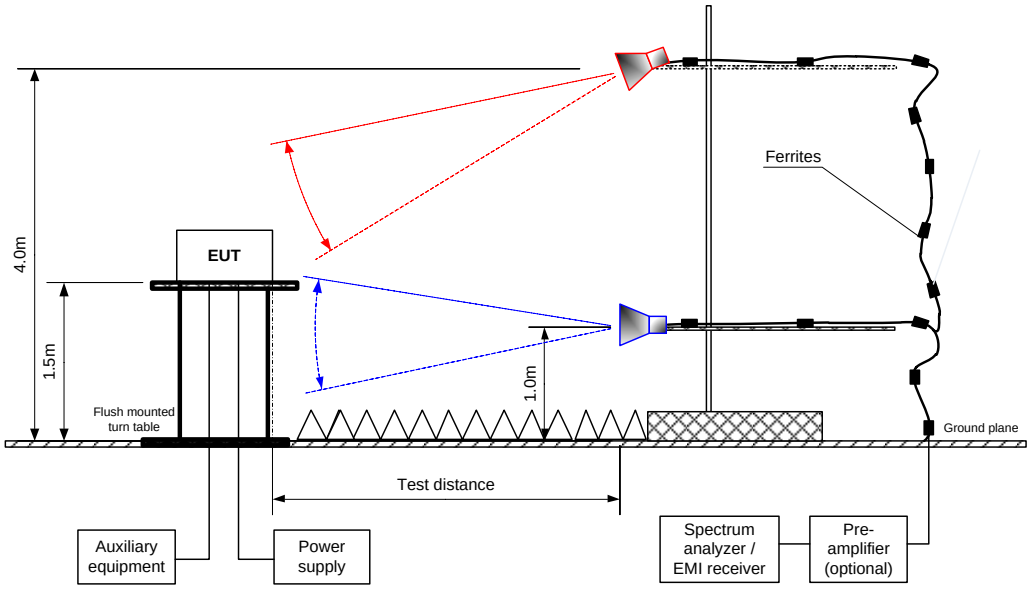


Figure 7.3.2 Setup for spurious emission field strength measurements in 30 – 1000 MHz



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:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Figure 7.3.3 Setup for spurious emission field strength measurements above1000 MHz



Test specification:	**Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	**Relative Humidity:** 39 %	**Air Pressure:** 1014 hPa	**Power:** 3.6 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 - 10000 MHz
TEST DISTANCE: 3 m
MODULATION: LoRa
BIT RATE: 1500 bps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: 300 kHz
TEST ANTENNA TYPE: Active loop (9 kHz – 30 MHz)
Biconilog (30 MHz – 1000 MHz)
Double ridged guide (above 1000 MHz)

Frequency, MHz	Field strength of spurious, dB(µV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	Field strength of carrier, dB(µV/m)	Attenuation below carrier, dBc	Limit, dBc	Margin, dB**	Verdict
Low carrier frequency									
6319.740	60.10	H	1.50	-47.0	120.43	60.33	30.0	30.33	Pass
7225.620	57.18	V	1.50	-17.0		63.25		33.25	
Mid carrier frequency									
883.1153	46.29	V	1.04	-68.0	119.62	73.33	30.0	43.33	Pass
5489.050	60.73	V	1.54	19.0		58.89		28.89	
6406.700	58.56	V	2.05	-72.0		61.06		31.06	
High carrier frequency									
787.0059	45.31	V	1.02	-52.0	121.317	76.007	30.0	46.007	Pass
5563.370	61.59	V	1.50	-38.0		59.727		29.727	
6489.325	58.91	V	1.50	-60.0		62.407		32.407	

*****- 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):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 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 – 10000 MHz
TEST DISTANCE: 3 m
MODULATION: LoRa
MODULATING SIGNAL: PRBS
BIT RATE: 1500 bps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 1000 kHz
TEST ANTENNA TYPE: Double ridged guide

Frequency, MHz	Antenna		Azimuth, degrees*	Peak field strength(VBW=3 MHz)			Average field strength(VBW=10 Hz)				Verdict
	Polarization	Height, m		Measured, dB(µV/m)	Limit, dB(µV/m)	Margin, dB**	Measured, dB(µV/m)	Calculated, dB(µV/m)	Limit, dB(µV/m)	Margin, dB***	
Low carrier frequency											
2708.355	V	1.50	-17	48.49	74.0	-25.51	44.41	NA	54.0	-9.59	Pass
5419.220	H	1.50	-98	56.06	74.0	-17.94	47.78	NA	54.0	-6.22	
Mid carrier frequency											
2744.755	V	1.54	19	46.10	74.0	-27.90	41.24	NA	54.0	-12.76	Pass
7318.585	V	1.54	-7	55.61	74.0	-18.39	44.61	NA	54.0	-9.39	
High carrier frequency											
2781.725	V	1.50	-59	43.95	74.0	-30.05	38.03	NA	54.0	-15.97	Pass
4635.650	H	1.50	14	51.49	74.0	-22.51	44.68	NA	54.0	-9.32	
7417.460	V	1.50	-18	54.06	74.0	-19.94	43.07	NA	54.0	-10.93	

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

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		
368.3	466.7	NA	NA	NA	0

*- 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 section 11.12.1		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	**Relative Humidity:** 39 %	**Air Pressure:** 1014 hPa	**Power:** 3.6 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:	9 kHz – 1000 MHz
TEST DISTANCE:	3 m
MODULATION:	LoRa
BIT RATE:	1500 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								
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.

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):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	**Relative Humidity:** 39 %	**Air Pressure:** 1014 hPa	**Power:** 3.6 VDC
Remarks:			

Table 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

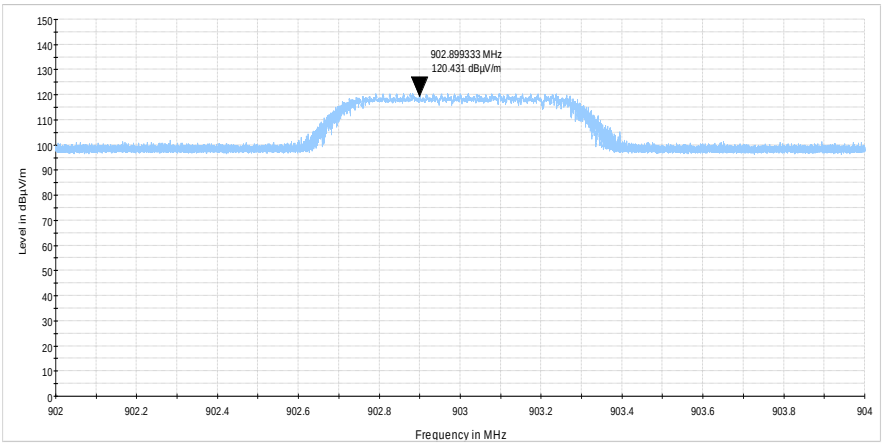
HL 0446	HL 3346	HL 3903	HL 4011	HL 4360	HL 4917	HL 4933	HL 5085
HL 5284	HL 5288	HL 5309	HL 5311	HL 5372	HL 5376	HL 5405	

Full description is given in Appendix A.

Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

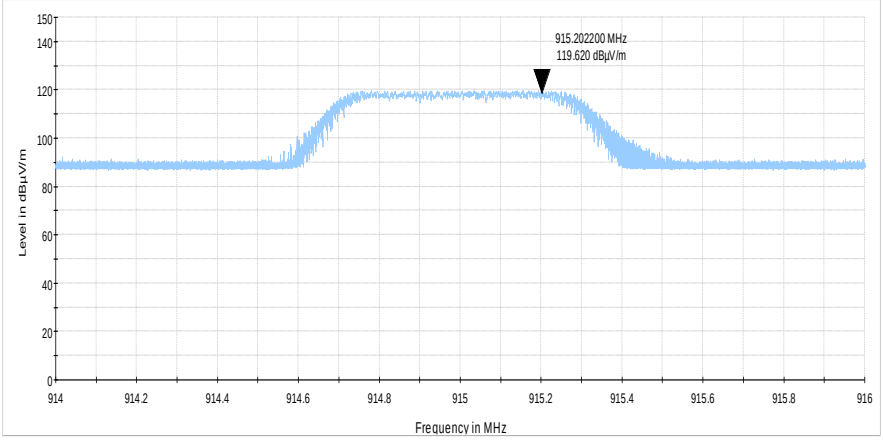
Plot 7.3.1 Radiated emission measurements at the low carrier frequency

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

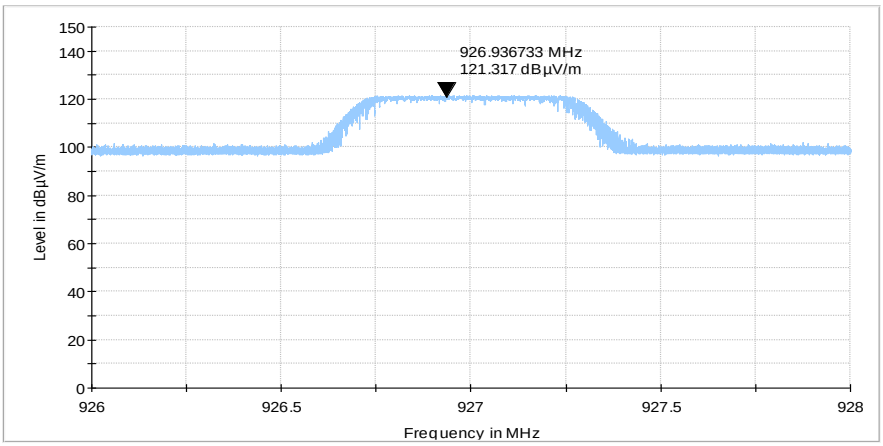
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and horizontal



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:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

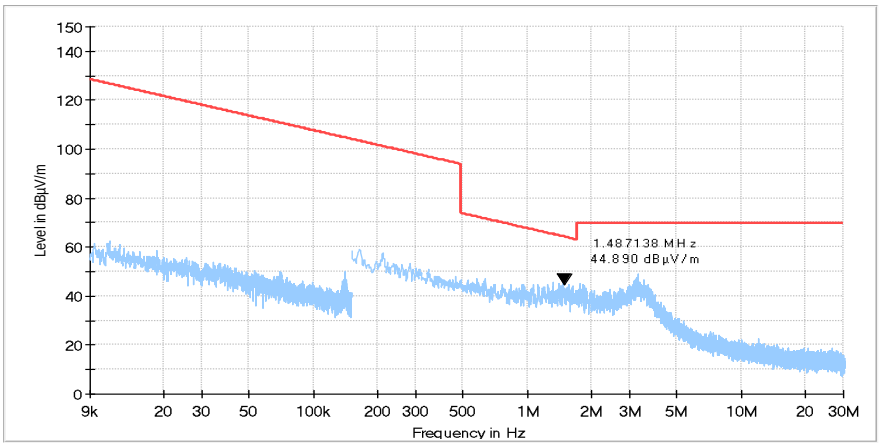
Plot 7.3.3 Radiated emission measurements at the high carrier frequency

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



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

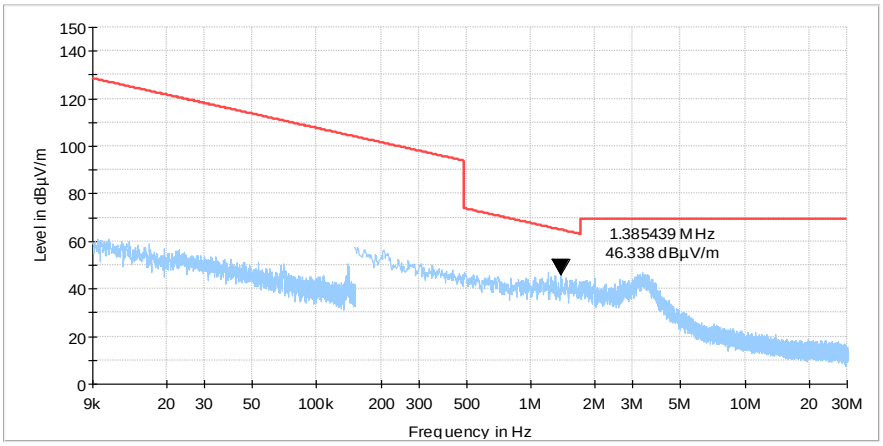
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and horizontal



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):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

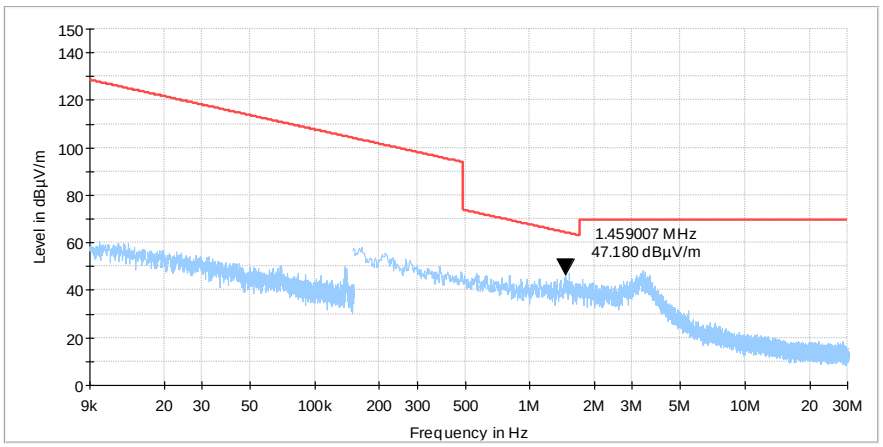
Plot 7.3.5 Radiated emission measurements from 9 kHz to 30 MHz at the mid carrier frequency

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



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

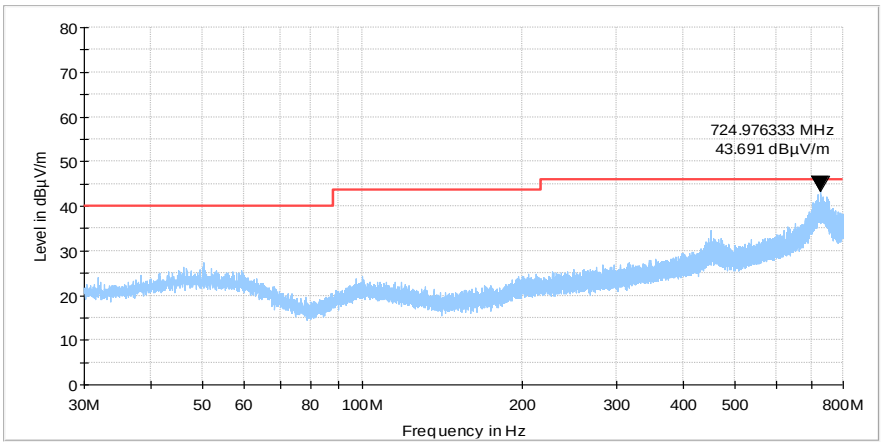
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and horizontal



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):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

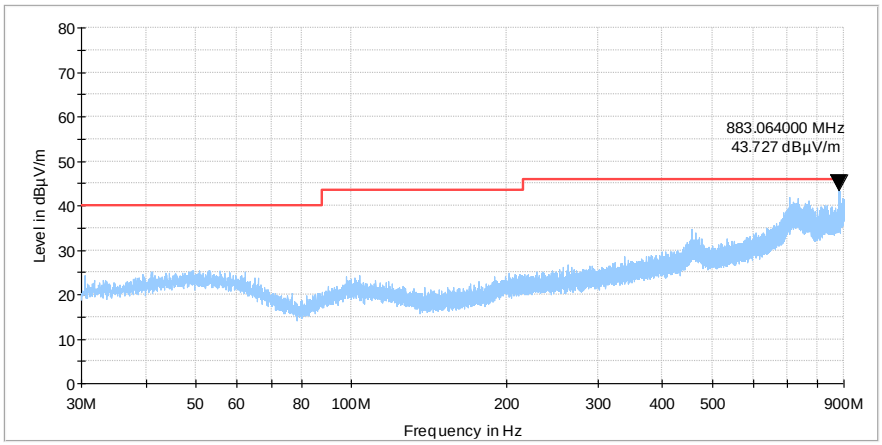
Plot 7.3.7 Radiated emission measurements from 30 to 800 MHz at the low carrier frequency

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



Plot 7.3.8 Radiated emission measurements from 30 to 900 MHz at the mid carrier frequency

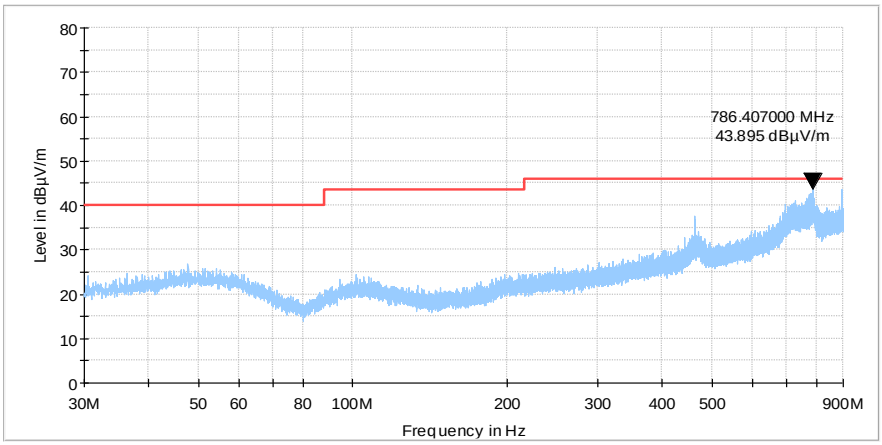
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



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):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

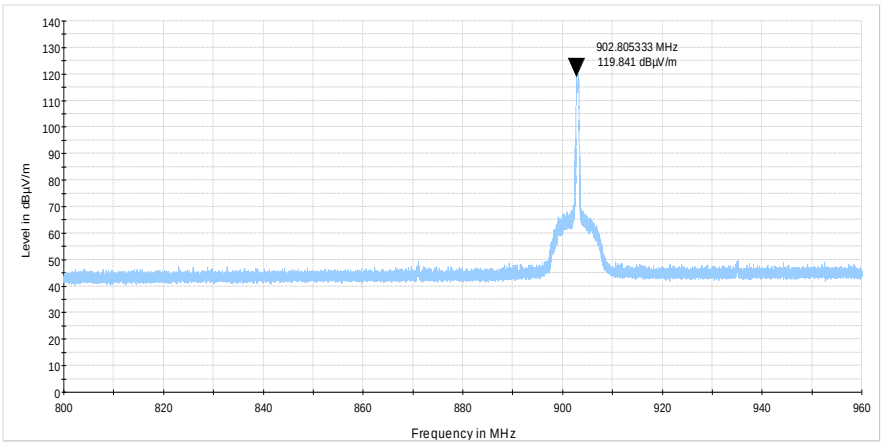
Plot 7.3.9 Radiated emission measurements from 30 to 900 MHz at the high carrier frequency

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



Plot 7.3.10 Radiated emission measurements from 800 to 960 MHz at the low carrier frequency

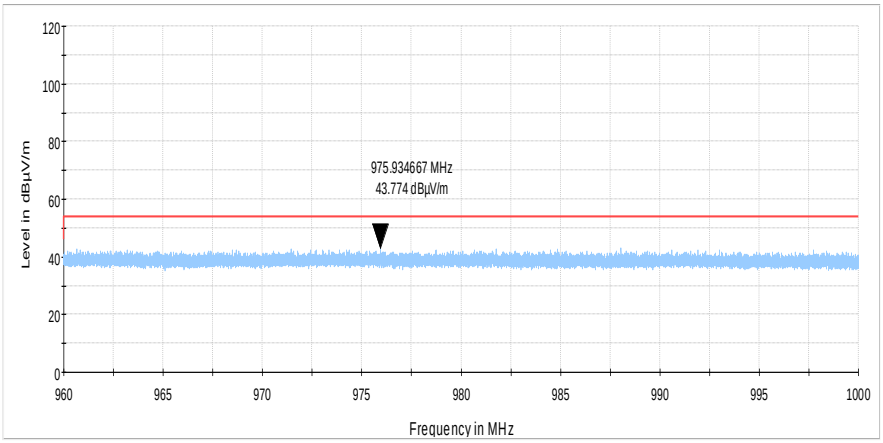
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

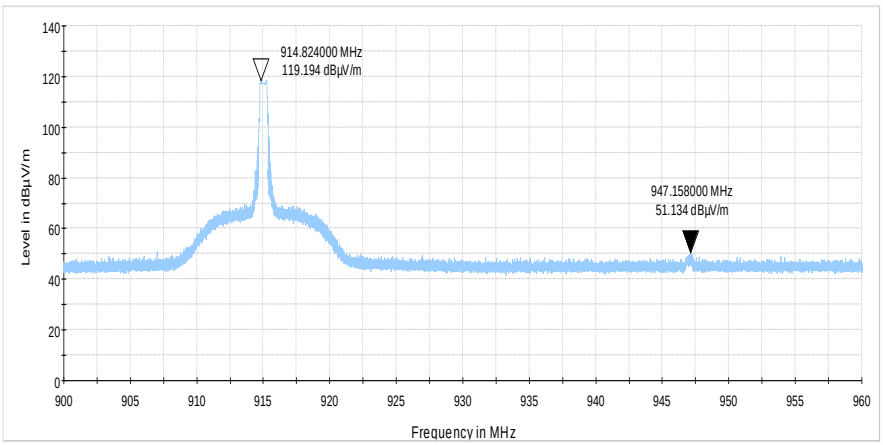
Plot 7.3.11 Radiated emission measurements from 960 to 1000 MHz at the low carrier frequency

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



Plot 7.3.12 Radiated emission measurements from 900 to 960 MHz at the mid carrier frequency

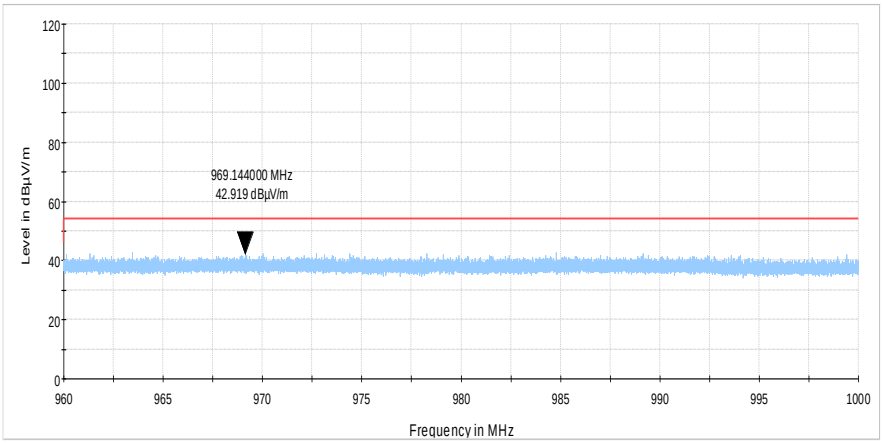
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



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):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

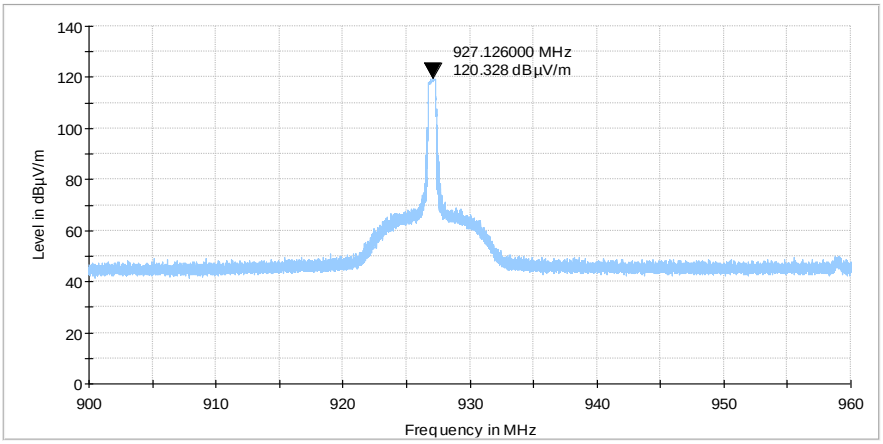
Plot 7.3.13 Radiated emission measurements from 960 to 1000 MHz at the mid carrier frequency

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



Plot 7.3.14 Radiated emission measurements from 900 to 960 MHz at the high carrier frequency

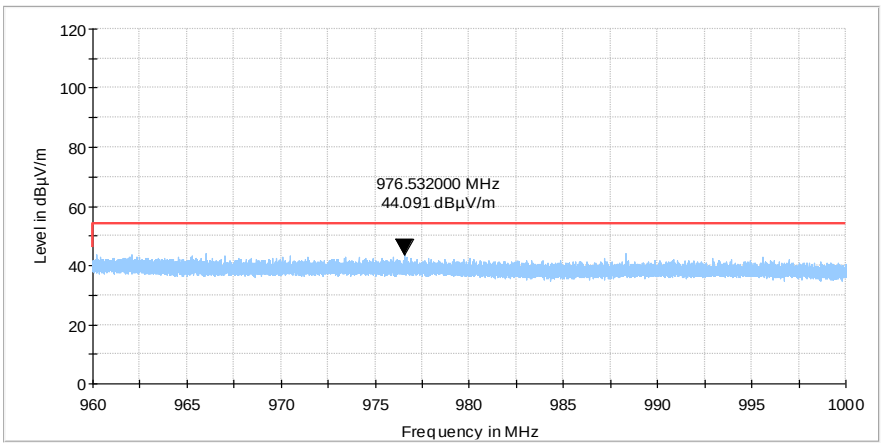
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

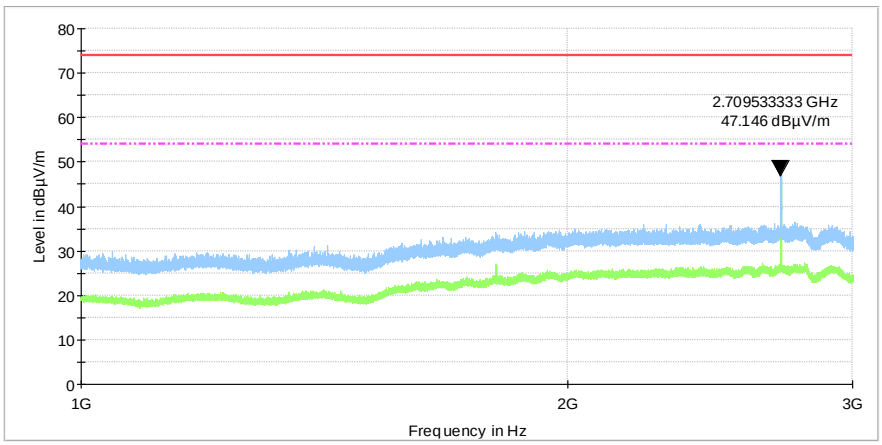
Plot 7.3.15 Radiated emission measurements from 960 to 1000 MHz at the high carrier frequency

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



Plot 7.3.16 Radiated emission measurements from 1000 to 3000 MHz at the low carrier frequency

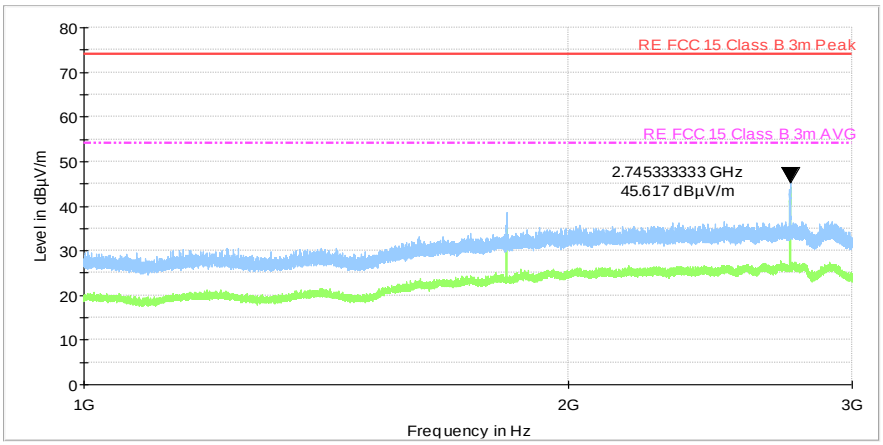
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

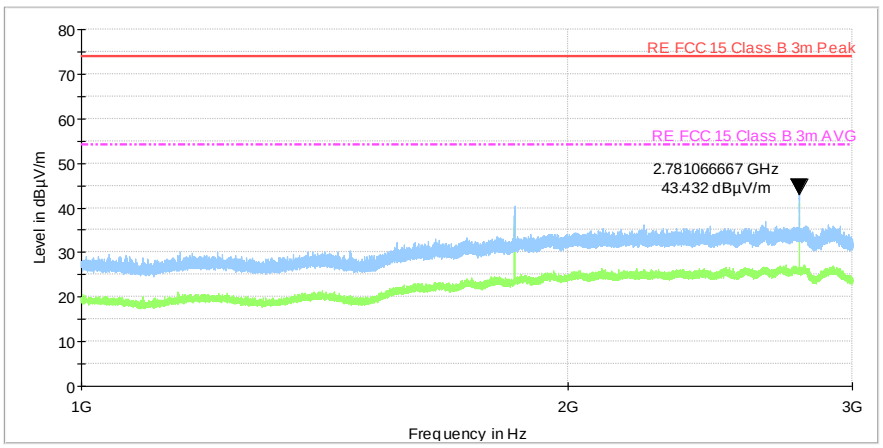
Plot 7.3.17 Radiated emission measurements from 1000 to 3000 MHz at the mid carrier frequency

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



Plot 7.3.18 Radiated emission measurements from 1000 to 3000 MHz at the high carrier frequency

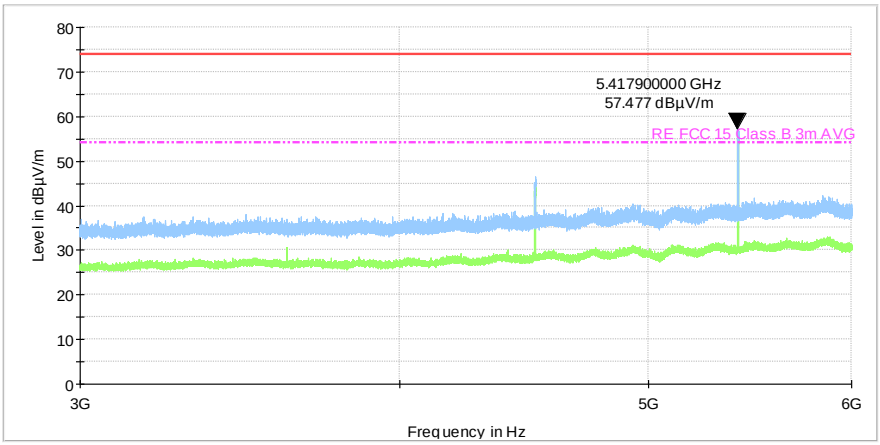
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

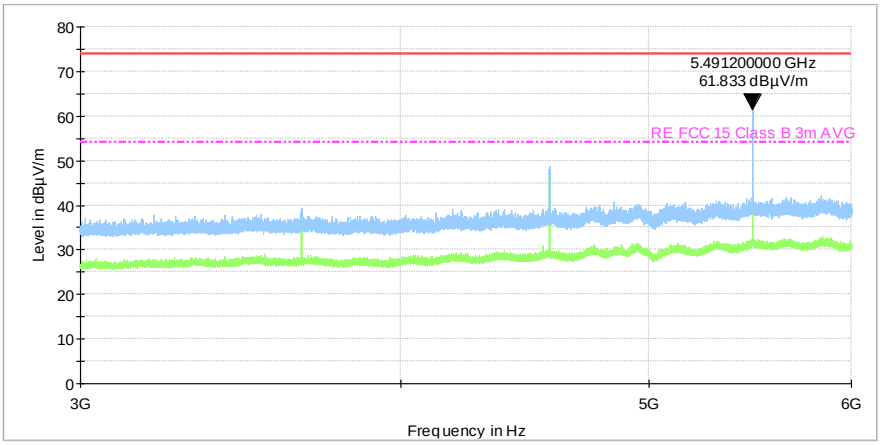
Plot 7.3.19 Radiated emission measurements from 3000 to 6000 MHz at the low carrier frequency

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



Plot 7.3.20 Radiated emission measurements from 3000 to 6000 MHz at the mid carrier frequency

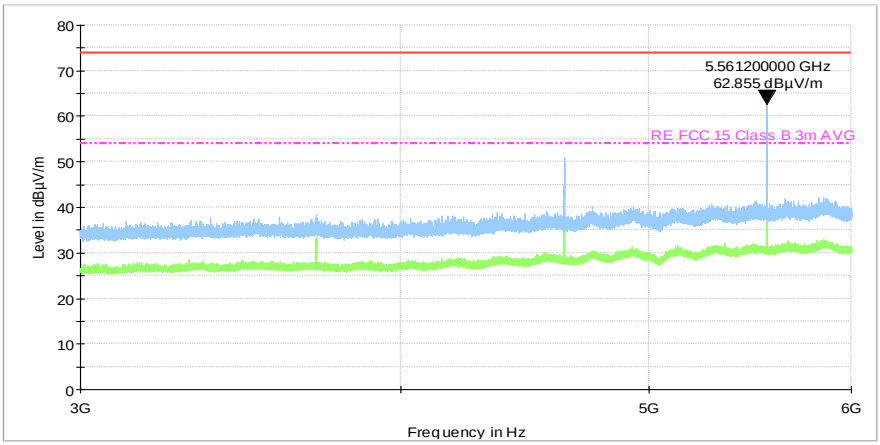
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



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):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

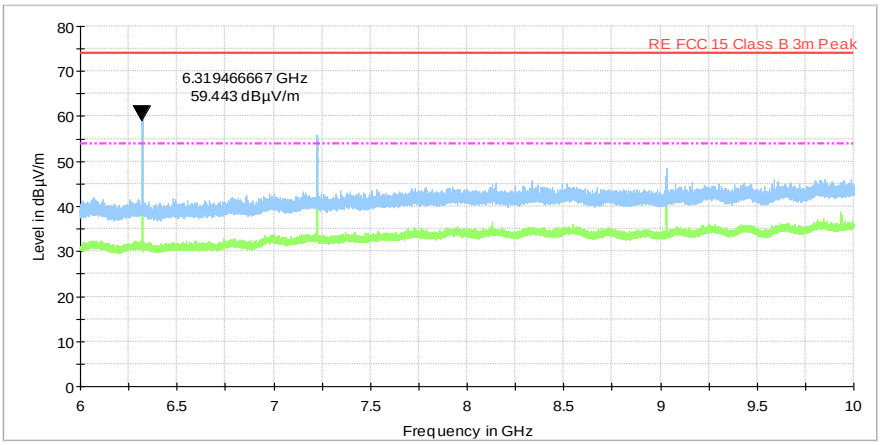
Plot 7.3.21 Radiated emission measurements from 3000 to 6000 MHz at the high carrier frequency

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



Plot 7.3.22 Radiated emission measurements from 6000 to 10000 MHz at the low carrier frequency

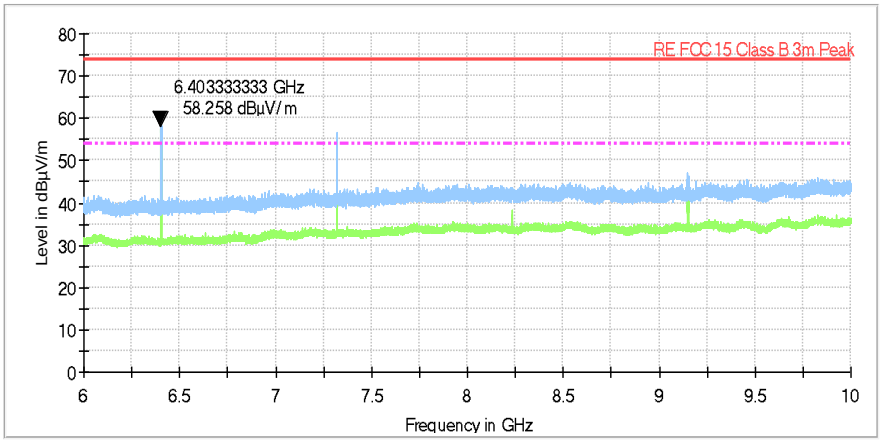
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

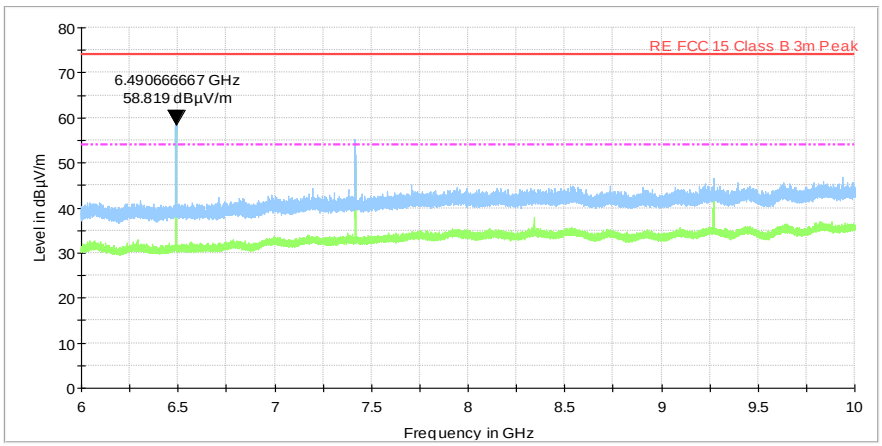
Plot 7.3.23 Radiated emission measurements from 6000 to 10000 MHz at the mid carrier frequency

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



Plot 7.3.24 Radiated emission measurements from 6000 to 10000 MHz at the high carrier frequency

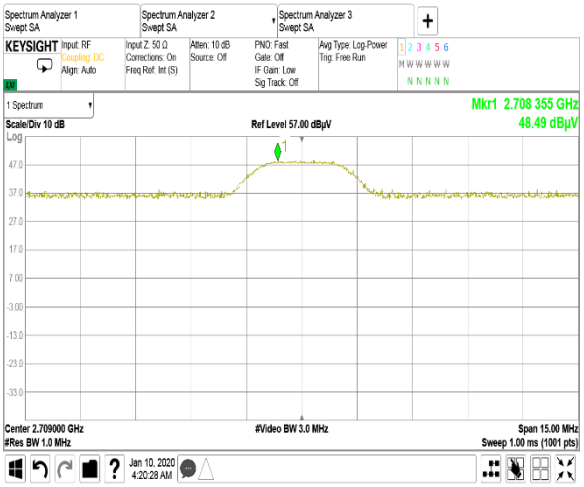
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal

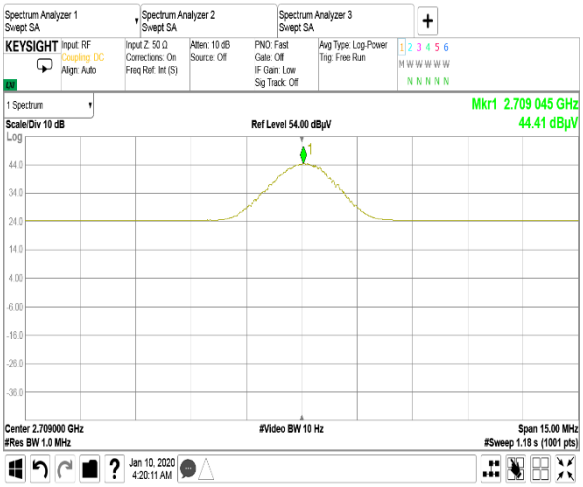


Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.25 Radiated emission measurements at the third harmonic of low carrier frequency

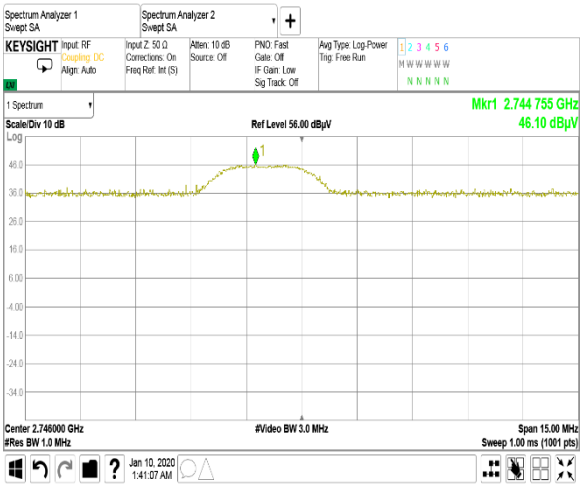
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: VBW = 3 MHz DETECTOR PEAK: VBW = 10 Hz

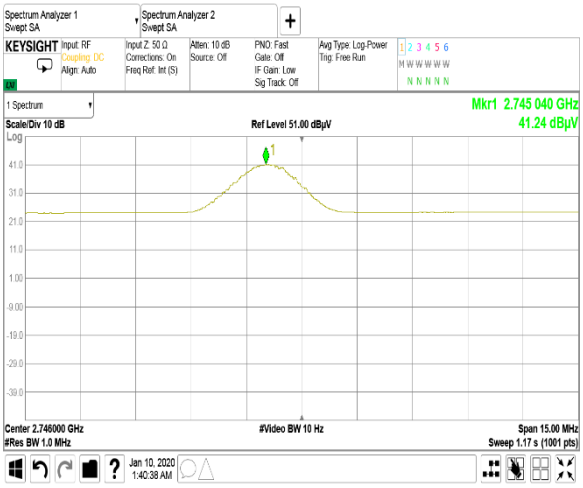




Plot 7.3.26 Radiated emission measurements at the third harmonic of mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: VBW = 3 MHz DETECTOR PEAK: VBW = 10 Hz

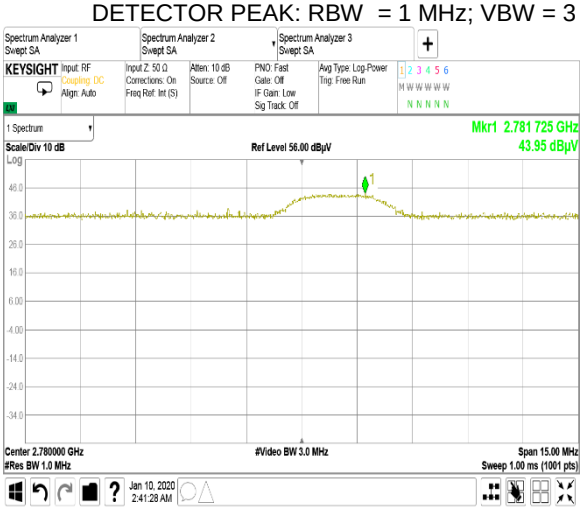




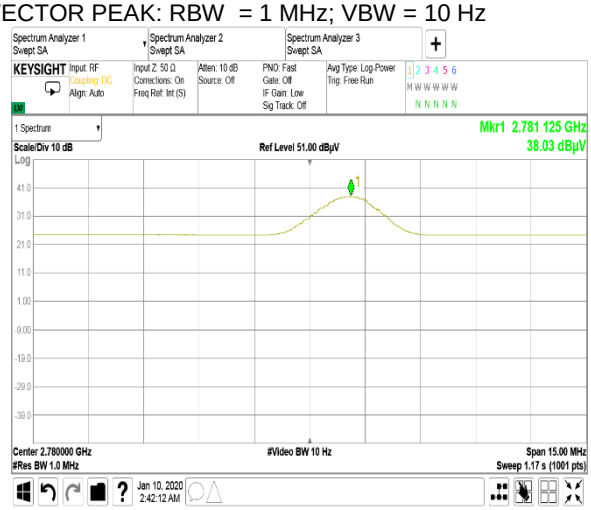
Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.27 Radiated emission measurements at the third harmonic of high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz

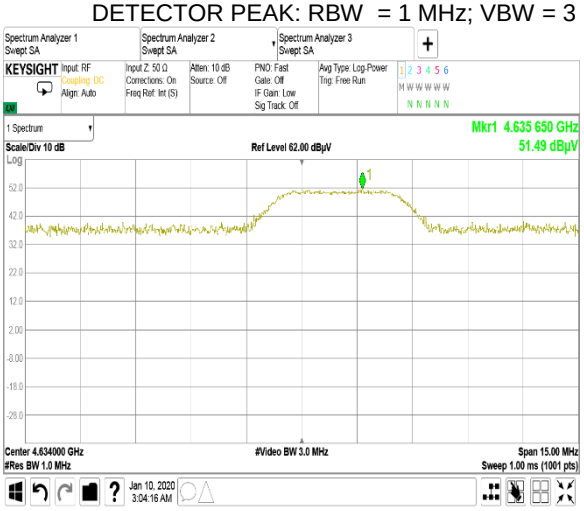


DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz

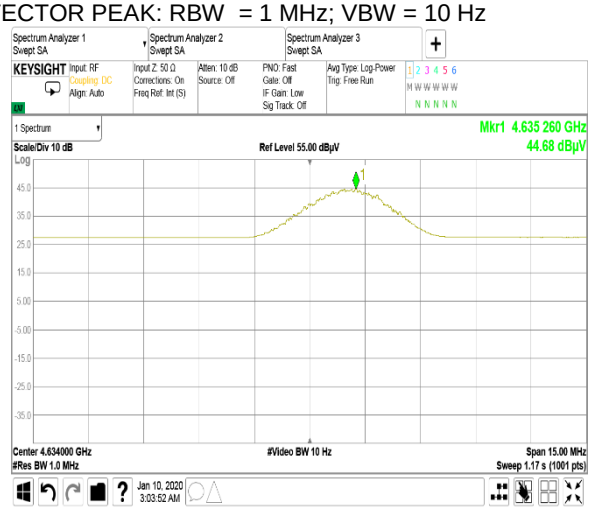


Plot 7.3.28 Radiated emission measurements at the fifth harmonic of high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz



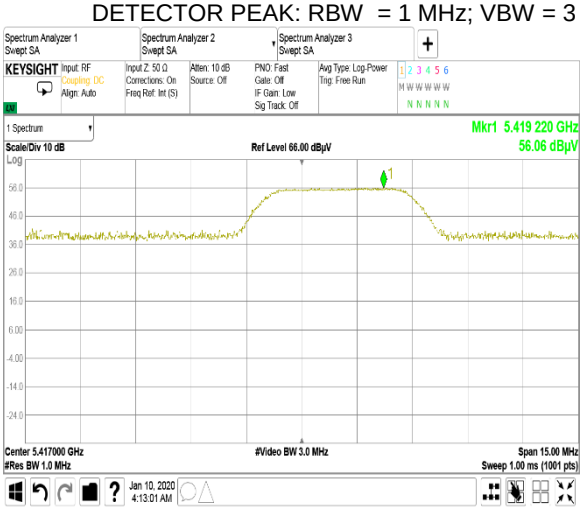
DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz



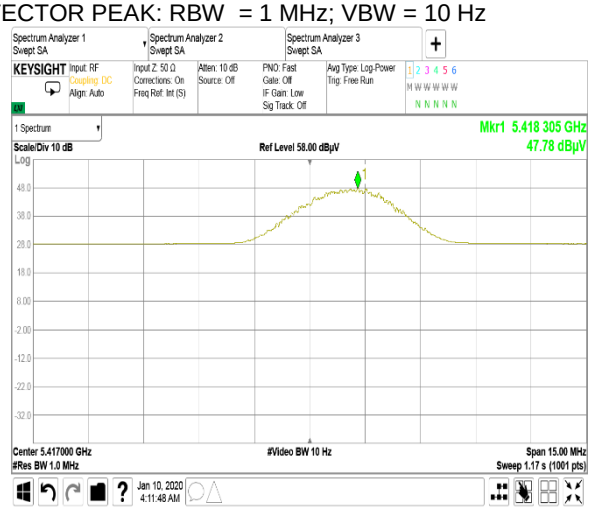
Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.29 Radiated emission measurements at the sixth harmonic of low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz

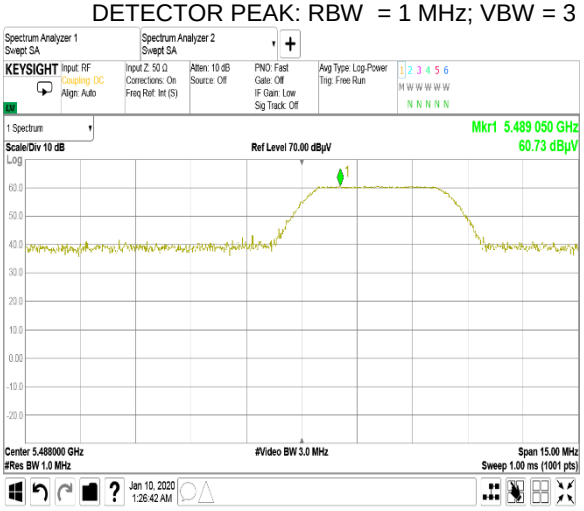


DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz



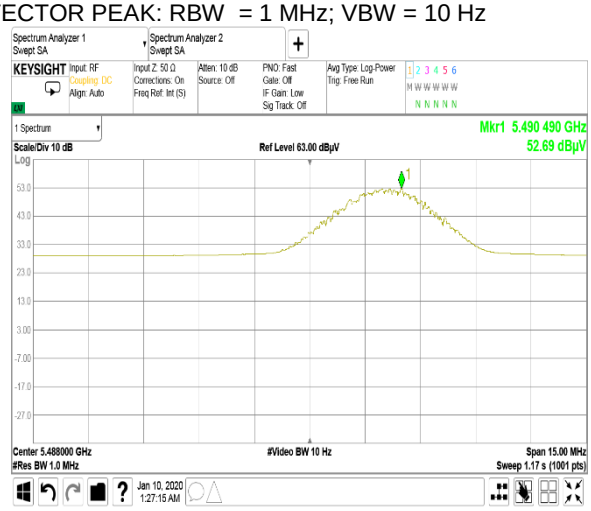
Plot 7.3.30 Radiated emission measurements at the sixth harmonic of mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz



b

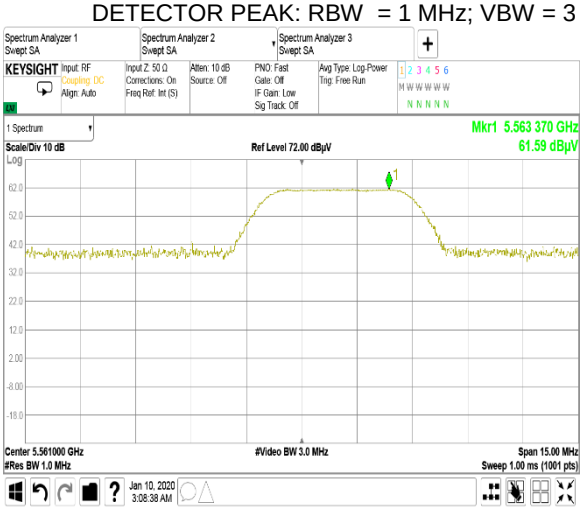
DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz

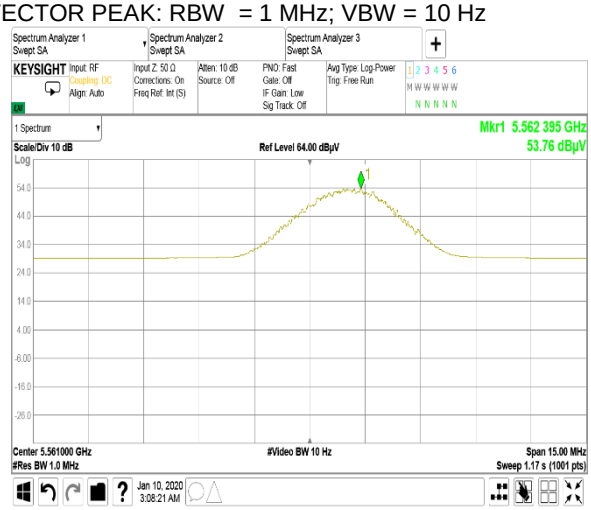


Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.31 Radiated emission measurements at the sixth harmonic of high carrier frequency

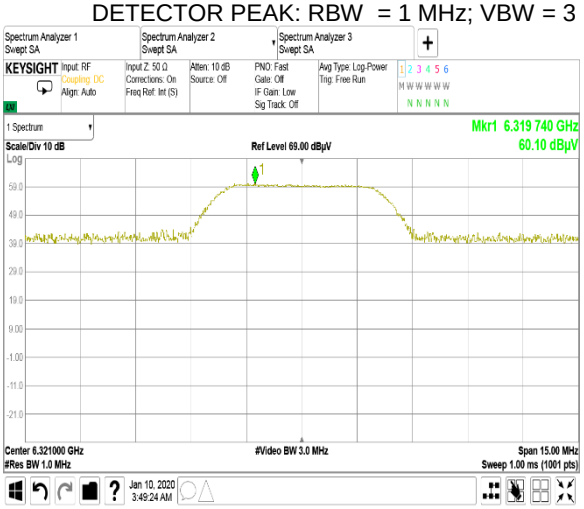
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz

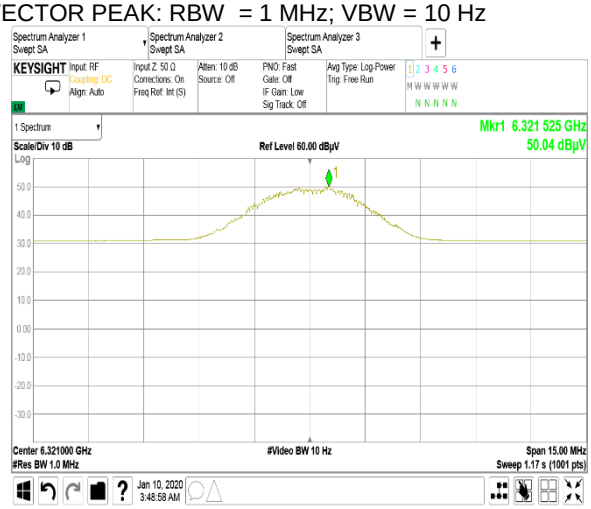




Plot 7.3.32 Radiated emission measurements at the seventh harmonic of low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz

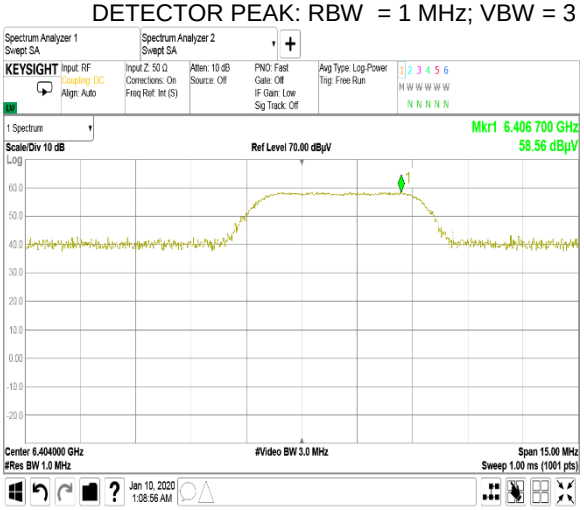




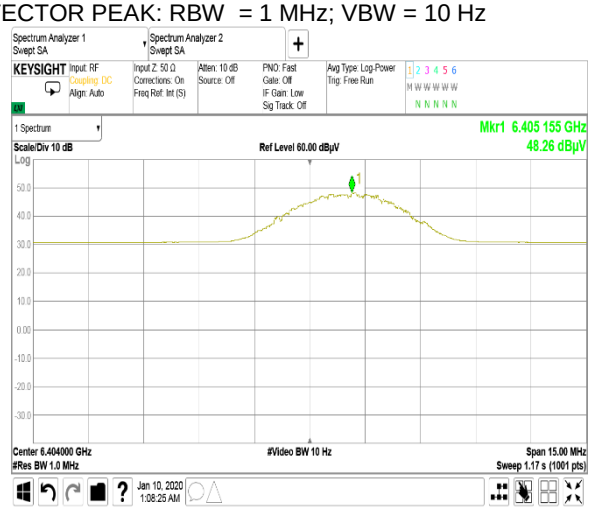
Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.33 Radiated emission measurements at the seventh harmonic of mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz

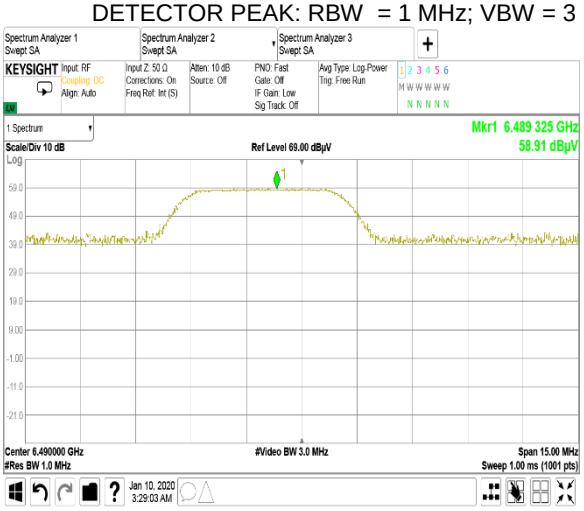


DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz

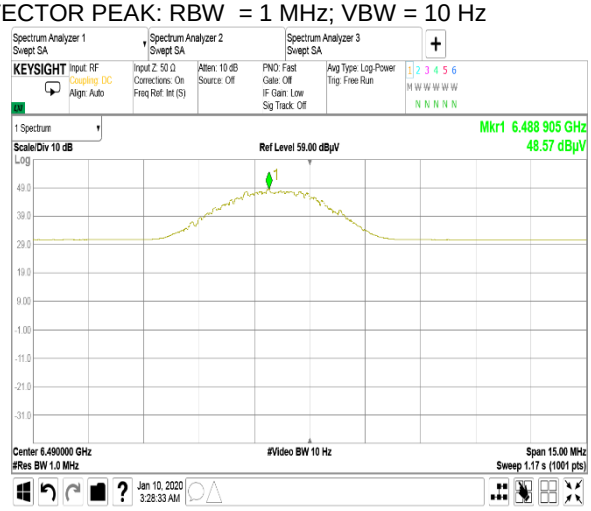


Plot 7.3.34 Radiated emission measurements at the seventh harmonic of high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz



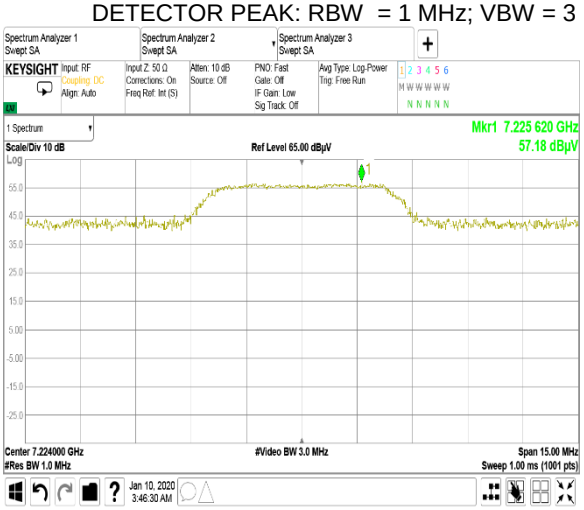
DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz

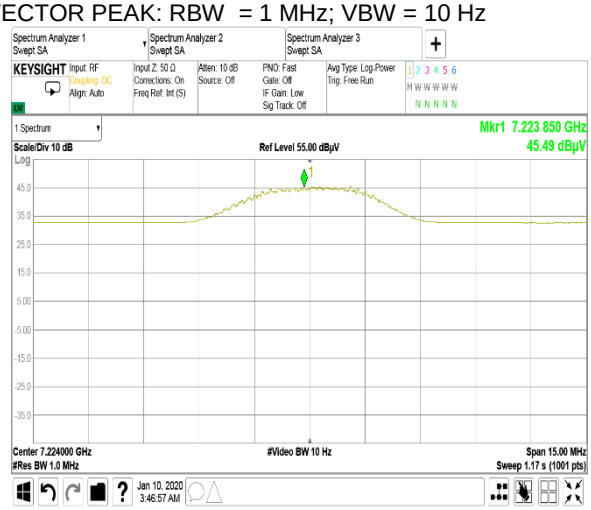


Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.35 Radiated emission measurements at the eighth harmonic of low carrier frequency

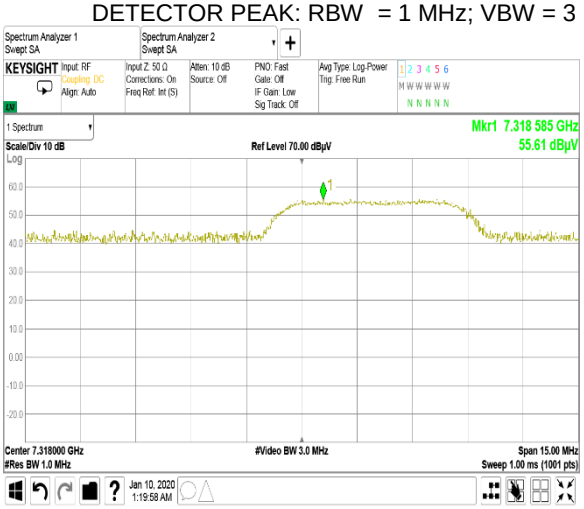
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz

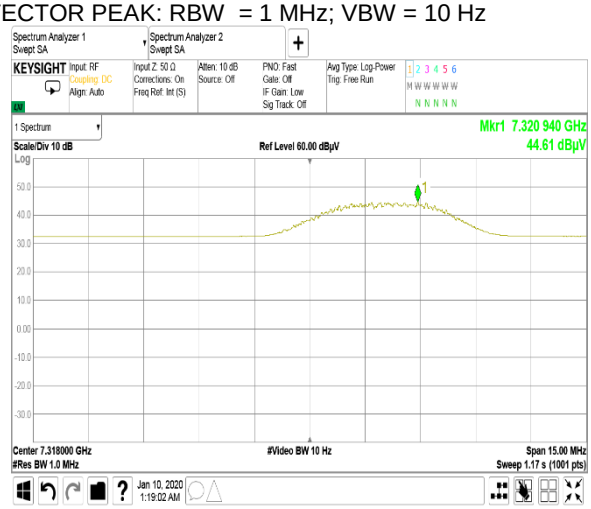




Plot 7.3.36 Radiated emission measurements at the eighth harmonic of mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz

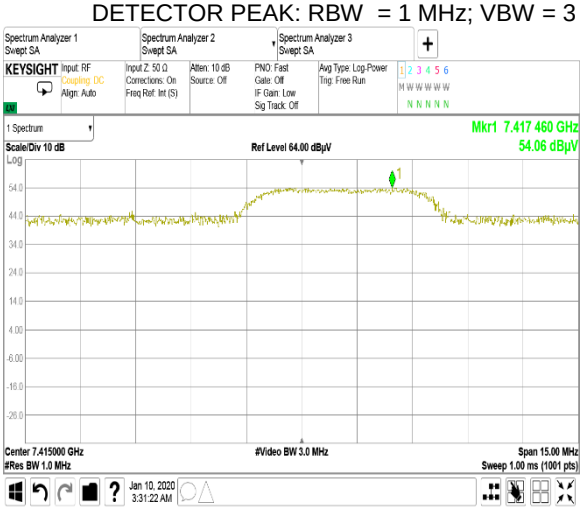




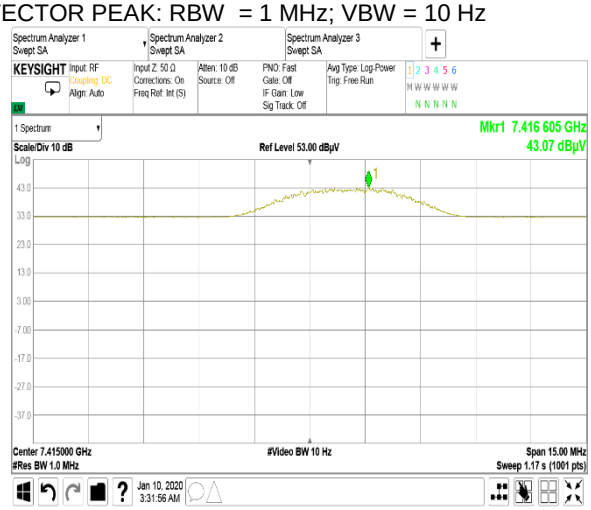
Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.37 Radiated emission measurements at the eighth harmonic of high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
DETECTOR PEAK: RBW = 1 MHz; VBW = 3 MHz

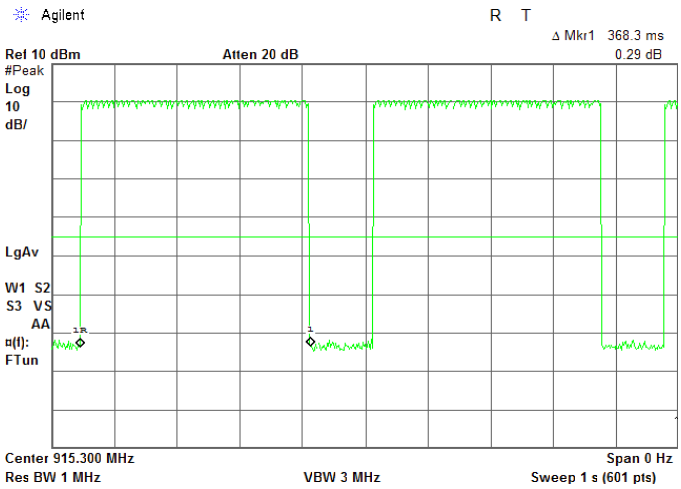


DETECTOR PEAK: RBW = 1 MHz; VBW = 10 Hz

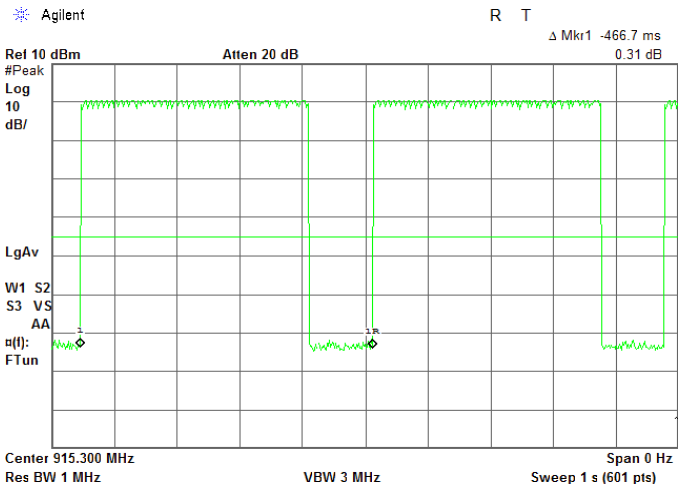


Test specification:	Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10 section 11.12.1		
Test mode:	Compliance	Verdict:	PASS
Date(s):	03-Feb-20 - 19-Mar-20		
Temperature: 19.8 ºC	Relative Humidity: 39 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.3.38 Transmission pulse duration



Plot 7.3.39 Transmission pulse period



Test specification:	Section 15.247(e), / RSS-247 section 5.2(b), Peak power density		
Test procedure:	ANSI C63.10 section 11.10.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	06-Feb-20		
Temperature: 23.7 ºC	Relative Humidity: 35 %	Air Pressure: 1015 hPa	Power: 3.6 VDC
Remarks:			

7.4 Peak spectral power density

7.4.1 General

This test was performed to measure the peak spectral power density at the transmitter RF antenna connector. Specification test limits are given in Table 7.4.1.

Table 7.4.1 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

7.4.2 Test procedure

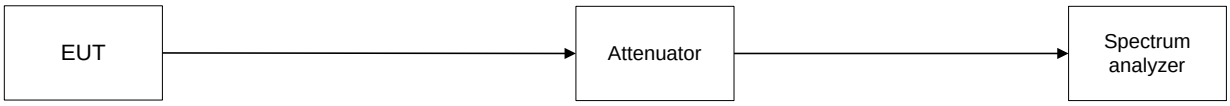
7.4.2.1 The EUT was set up as shown in Figure 7.4.1 energized and its proper operation was checked.

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

7.4.2.3 The frequency span of spectrum analyzer was set to capture the entire 6 dB band of the transmitter, in peak hold mode with resolution bandwidth set to 3.0 kHz, video bandwidth wider than resolution bandwidth, auto sweep time and sufficient number of sweeps was allowed for trace stabilization.

7.4.2.4 The average detector with power averaging mode was used over a minimum of 100 traces. The peak marker function was used to determine the maximum power spectral density. To compute the average PSD during the actual transmission time the average factor was added to the measured values of PSD and the results provided in Table 7.4.2 and associated plots.

Figure 7.4.1 Peak spectral power density test setup



Test specification:	**Section 15.247(e), / RSS-247 section 5.2(b), Peak power density**		
Test procedure:	ANSI C63.10 section 11.10.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	06-Feb-20		
Temperature: 23.7 ºC	**Relative Humidity:** 35 %	**Air Pressure:** 1015 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.4.2 Peak spectral power density test results

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
MODULATION: LoRA
BIT RATE: 1500 bps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Average
RESOLUTION BANDWIDTH: 3 kHz
VIDEO BANDWIDTH: 10 kHz

Carrier frequency, MHz	SA reading, dBm	External attenuation, dB	Cable loss, dB	DC factor, dB	PSD**, dB(mW/3 kHz)	Limit, dBm	Margin*, dB	Verdict
903	1.75	included	included	1.03	2.78	8.0	-5.22	Pass
915	0.90	included	included	1.03	1.93	8.0	-6.07	Pass
927	2.66	included	included	1.03	3.69	8.0	-4.31	Pass

* - Margin = Peak power density – specification limit.
** - Peak output power = SA reading + DC factor, where
DC Factor = 10*log(1/(Txon / Txon+Txoff)) = 1.03dB

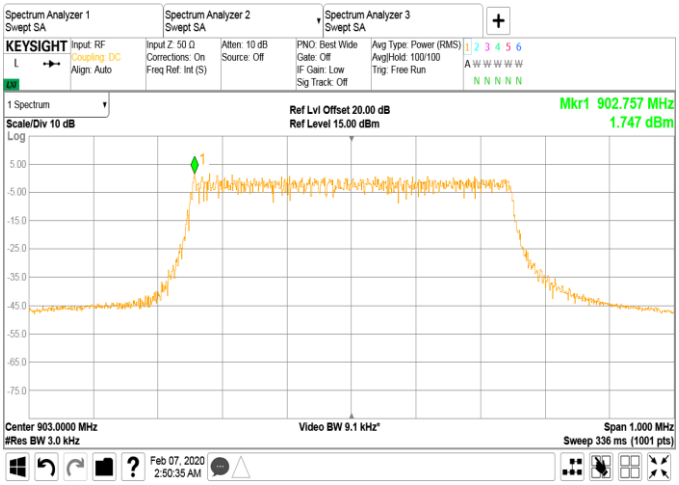
Reference numbers of test equipment used

HL 4071	HL 5376	HL 5410	HL 4136	HL 1809			

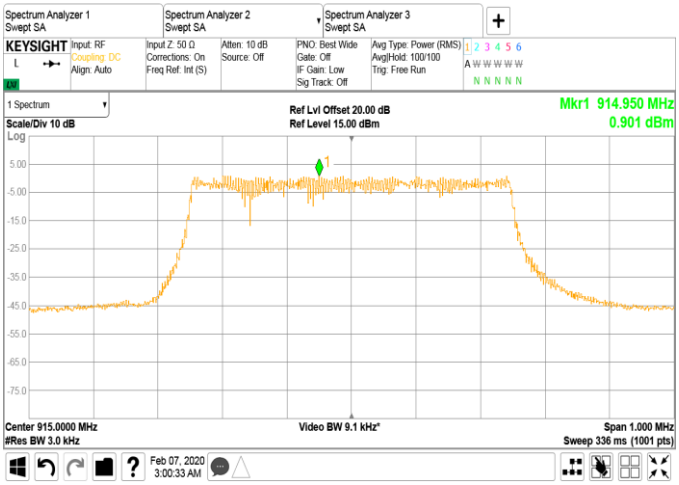
Full description is given in Appendix A.

Test specification:	Section 15.247(e), / RSS-247 section 5.2(b), Peak power density		
Test procedure:	ANSI C63.10 section 11.10.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	06-Feb-20		
Temperature: 23.7 ºC	Relative Humidity: 35 %	Air Pressure: 1015 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.1 Peak spectral power density at low frequency within 6 dB band

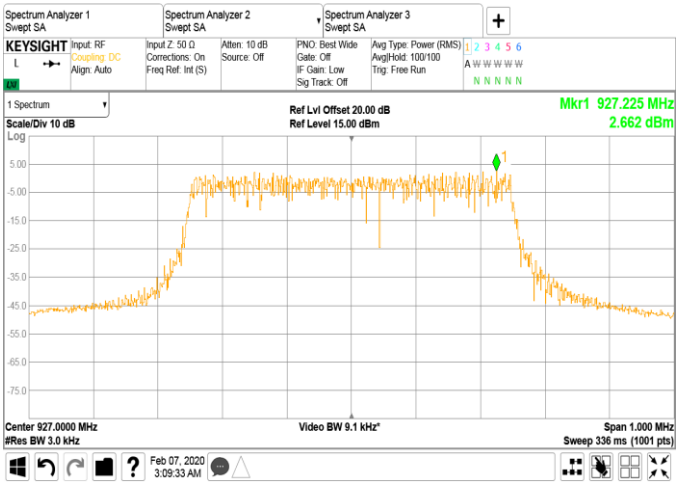


Plot 7.4.2 Peak spectral power density at mid frequency within 6 dB band



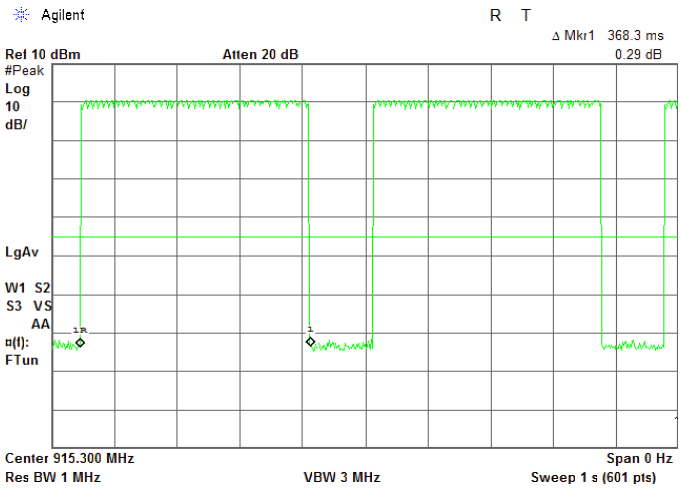
Test specification:	**Section 15.247(e), / RSS-247 section 5.2(b), Peak power density**		
Test procedure:	ANSI C63.10 section 11.10.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	06-Feb-20		
Temperature: 23.7 ºC	**Relative Humidity:** 35 %	**Air Pressure:** 1015 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.4.3 Peak spectral power density at high frequency within 6 dB band

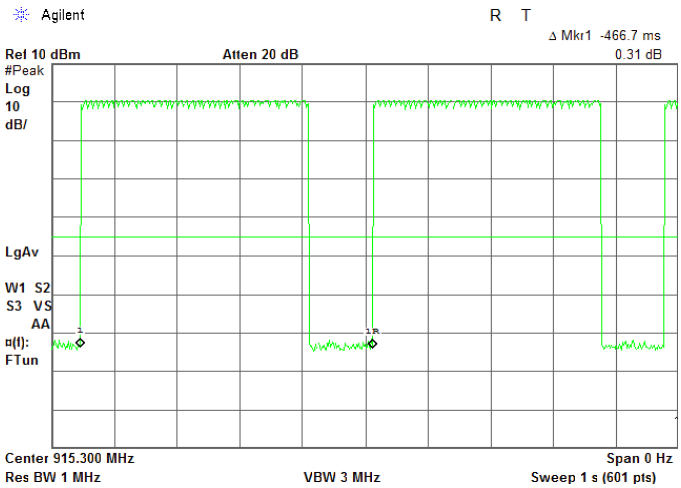


Test specification:	Section 15.247(e), / RSS-247 section 5.2(b), Peak power density		
Test procedure:	ANSI C63.10 section 11.10.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	06-Feb-20		
Temperature: 23.7 ºC	Relative Humidity: 35 %	Air Pressure: 1015 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.4.4 Transmission pulse duration



Plot 7.4.5 Transmission pulse period



Test specification:	**Section 15.247(d) / RSS-247 section 5.5, Band edge emissions**		
Test procedure:	ANSI C63.10 section 11.13.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	06-Feb-20		
Temperature: 23.7 ºC	**Relative Humidity:** 35 %	**Air Pressure:** 1015 hPa	**Power:** 3.6 VDC
Remarks: Done			

7.5 Band edge emissions at RF antenna connector

7.5.1 General

This test was performed to measure band edge emissions at RF antenna connector. Specification test limits are given in Table 7.5.1.

Table 7.5.1 Band edge emission limits

Output power	Assigned frequency, MHz	Attenuation below carrier*, dBc
Peak	902.0 – 928.0	20.0
Averaged over a time interval	**902.0 – 928.0**	**30.0**

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

7.5.2 Test procedure

7.5.2.1 The EUT was set up as shown in Figure 7.5.1, energized normally modulated at the maximum data rate and its proper operation was checked.

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

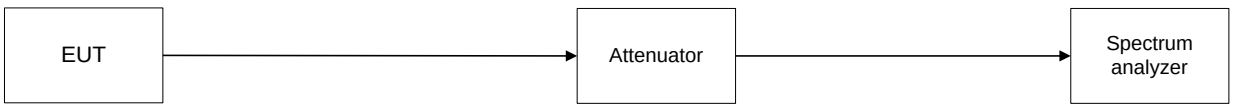
7.5.2.3 The spectrum analyzer span was set to capture the carrier frequency and associated modulation products. The resolution bandwidth was set wider than 1 % of the frequency span.

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

7.5.2.5 The maximum band edge emission and modulation product outside of the band were measured as provided in Table 7.5.2 and associated plots and referenced to the highest emission level measured within the authorized band.

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

Figure 7.5.1 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 11.13.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	06-Feb-20		
Temperature: 23.7 ºC	**Relative Humidity:** 35 %	**Air Pressure:** 1015 hPa	**Power:** 3.6 VDC
Remarks: Done			

Table 7.5.2 Band edge emission test results

ASSIGNED FREQUENCY RANGE: 902.0 -928.0MHz
DETECTOR USED: Average
MODULATION: LoRa
BIT RATE: 1.5 kbps
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: ≥ RBW

Frequency, MHz	Band edge emission, dBm	Emission at carrier, dBm	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
Low carrier - Peak power						
902.00	-28.79	21.06	49.85	30.0	19.85	Pass
High carrier - Peak power						
928.00	-26.49	21.15	47.64	30.0	17.64	Pass

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

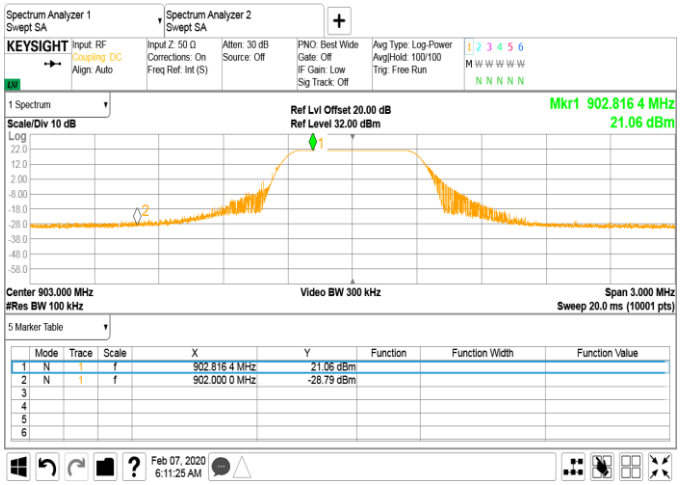
Reference numbers of test equipment used

HL 5376	HL 4135	HL 3901	HL 5616	HL 5609	HL 1809		

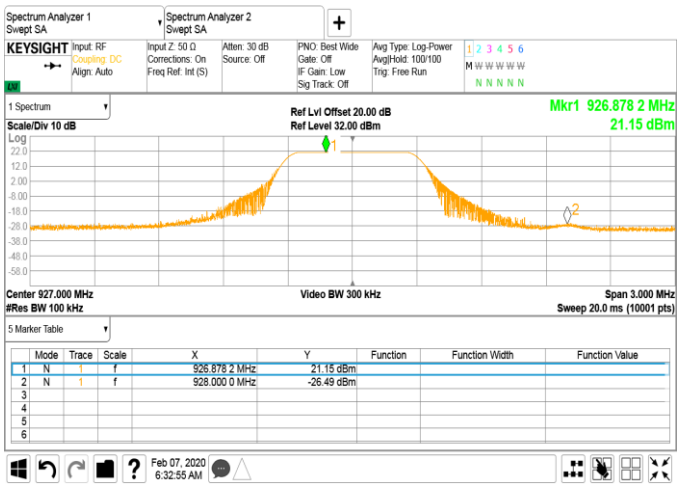
Full description is given in Appendix A.

Test specification:	Section 15.247(d) / RSS-247 section 5.5, Band edge emissions		
Test procedure:	ANSI C63.10 section 11.13.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	06-Feb-20		
Temperature: 23.7 ºC	Relative Humidity: 35 %	Air Pressure: 1015 hPa	Power: 3.6 VDC
Remarks: Done			

Plot 7.5.1 The highest band edge emission at low carrier frequency



Plot 7.5.2 The highest band edge emission at high carrier frequency



Test specification:	Section 15.203 / RSS-Gen section 6.8, Antenna requirement		
Test procedure:	Visual inspection		
Test mode:	Compliance	Verdict:	PASS
Date(s):	09-Feb-20		
Temperature: 20.2 ºC	Relative Humidity: 41 %	Air Pressure: 1022 hPa	Power: 3.6 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	Pass

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 (9) kHz - 30 MHz	EMCO	6502	2857	24-Feb-20	24-Feb-21
1809	HygroThermometer, Min/Max Memory	Delta TRAK	13301	NA	11-Aug-19	11-Aug-20
3346	High Pass Filter, 50 Ohm, 5000 to 11000 MHz.	Mini-Circuits	VHF-4600+	NA	05-Jun-19	05-Jun-20
3901	Microwave Cable Assembly, 40.0 GHz, 3.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1225/2A	07-Apr-19	07-Apr-20
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1226/2A	07-Apr-19	07-Apr-20
4011	Temp. & Humidity Meter, (-50 - +70) deg, (20 - 99)% RH	Mad Electronics	HTC-1	NA	11-Aug-19	11-Aug-20
4071	Attenuator, SMA, 30 dB, DC to 18 GHz, 5 W	Weinschel	WA7	NA	12-Aug-19	12-Aug-20
4135	Shield Box	TESCOM CO., LTD	TC-5916A	5916A000136	24-Apr-19	24-Apr-20
4136	Shield Box	TESCOM CO., LTD	TC-5916A	5916A000137	24-Apr-19	24-Apr-20
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	20-Jan-20	20-Jan-21
4917	High Pass Filter, 50 Ohm, 3150 to 6500 MHz, SMA-FM / SMA-M	Mini-Circuits	VHF-2700+	NA	05-Jun-19	05-Jun-20
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	06-Jan-20	06-Jan-21
5085	Attenuator, 4 dB, DC - 6 GHz, 1 W	Mini-Circuits	UNAT-4+	NA	08-Feb-19	08-Feb-20
5284	Band Pass Filter, 50 Ohm, 1590 to 2770 MHz, SMA/M-SMA/F	A-INFOMW	WBLB-T-BP-2180-1180-17C	J10800000297	05-Jun-19	05-Jun-20
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	08-Feb-19	08-Feb-22
5309	Antenna Mast, 1-4 meter, Pneumatic polarization	Dolev Ltd	FMB 1-4	NA	24-Apr-19	24-Apr-20
5311	Controller	Dolev Ltd	FC-06	FC06.1-2016-024	24-Apr-19	24-Apr-20
5372	MXE EMI receiver, 3 Hz to 44 GHz	Keysight Technologies	N9038A	MY57290155	18-Jun-19	18-Jun-20
5376	EXA Signal Analyzer, 10 Hz - 32 GHz	Keysight Technologies	N9010B	MY57470404	18-Mar-20	18-Mar-21
5405	RF cable, 18 GHz, N-N, 6 m	Huber-Suhner	SF118/11N(x2)	500023/118	11-Aug-19	11-Aug-20
5410	RF cable, 40 GHz, SMA-SMA, 5.5 m	Huber-Suhner	SF102EA/11SK/11SK/5500MM	503974/EA	11-Aug-19	11-Aug-20
5609	Precision Fixed Attenuator, 50 Ohm, 5 W, 10 dB, DC to 18 GHz	Mini Circuits	BW-S10W5+	NA	24-Sep-19	24-Sep-20

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
5616	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

9 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 dBμV to obtain field strength in dBμA/m.

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

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

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

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

HL 5288: Trilog Antenna
Frankonia, model: ALX-8000E, s/n: 00809
30-1000 MHz

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

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

above 1000 MHz

Frequency, MHz	Antenna factor, dB/m	Frequency, MHz	Antenna factor, dB/m
1000	26.9	3600	38.9
1100	28.1	3700	39.4
1200	28.4	3800	39.4
1300	29.6	3900	39.6
1400	29.1	4000	39.7
1500	30.4	4100	39.8
1600	30.7	4200	40.5
1700	31.5	4300	40.9
1800	32.3	4400	41.1
1900	32.6	4500	41.4
2000	32.5	4600	41.3
2100	32.9	4700	41.6
2200	33.5	4800	41.9
2300	33.2	4900	42.3
2400	33.7	5000	42.7
2500	34.6	5100	43.0
2600	34.7	5200	42.9
2700	34.6	5300	43.5
2800	35.0	5400	43.6
2900	35.5	5500	44.3
3000	36.2	5600	44.7
3100	36.8	5700	45.0
3200	36.8	5800	45.0
3300	37.0	5900	45.3
3400	37.5	6000	45.9
3500	38.2		

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

10 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.

11 APPENDIX D Measurement uncertainties

Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements

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

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

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

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

12 APPENDIX E Test laboratory description

Tests were performed at Hermon Laboratories Ltd., which is a fully independent, private, EMC, Radio, Safety, Environmental and Telecommunication testing facility.
Hermon Laboratories is recognized and accredited by the Federal Communications Commission (USA) for relevant parts of Code of Federal Regulations 47 (CFR 47), Test Firm Registration Number is 927748, Designation Number is IL1001; Recognized by Innovation, Science and Economic Development Canada for wireless and terminal testing (ISED), CAB identifier is IL1001, ISED# number 2186A; Certified by VCCI, Japan (the registration numbers are R-10808 for OATS, R-1082 for anechoic chamber, G-10869 for RE measurements above 1 GHz, C-10845 for conducted emissions site and T-11606 for conducted emissions at telecommunication ports).
The laboratory is accredited by American Association for Laboratory Accreditation (USA) according to ISO/IEC 17025 for electromagnetic compatibility, product safety, telecommunications testing, environmental simulation and calibration (for exact scope please refer to Certificate No. 839.01, 839.03 and 839.04).

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13 APPENDIX F Specification references

FCC 47CFR part 15: 2019	Radio Frequency Devices
ANSI C63.10: 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
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: 2019	General Requirements for Compliance of Radio Apparatus

14 APPENDIX G 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(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