

Ushine Photonics Corporation

TEST REPORT

SCOPE OF WORK:

47 CFR FCC Part 15.247 – Radio Spectrum report

Model:

UP100-US915-USB-B, UP100-US915-USB,
UP100-US915-SPI-B, UP100-US915-SPI

REPORT NUMBER

220200295THC-001

ISSUE DATE

Mar. 23, 2022

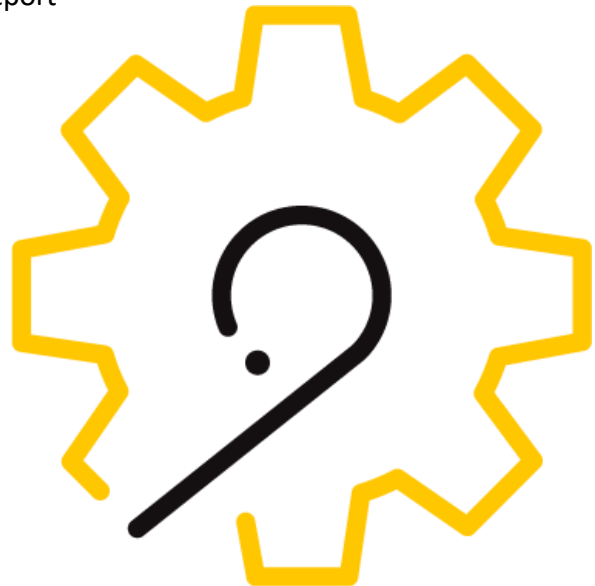
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DOCUMENT CONTROL NUMBER

GFT-OP-10h (28-Nov-2018)

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Radio Spectrum TEST REPORT

Applicant:	Ushine Photonics Corporation No. 199, Sec. 3, Huanbei Rd., Zhubei City, Hsinchu County 302004, Taiwan
Product:	LoRaWAN Gateway Module
Model No.:	UP100-US915-USB-B, UP100-US915-USB, UP100-US915-SPI-B, UP100-US915-SPI
FCC ID:	2A5CK-UP100
Test Method/ Standard:	47 CFR FCC Part 15.247 & ANSI C63.10 2013 KDB 558074 D01 v05r02
Test By:	Intertek Testing Services Taiwan Ltd., Hsinchu Laboratory No. 11, Lane 275, Ko-Nan 1 Street, Chia-Tung Li, Shiang-Shan District, Hsinchu City, Taiwan



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TEST REPORT

Revision History

Report No.	Issue Date	Revision Summary
220200295THC-001	Mar. 23, 2022	Original report

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Summary of Test Data

Test Requirement	Applicable Rule (Section 15.247)	Result
Minimum 6 dB Bandwidth	15.247(a)(2)	Pass
Maximum Peak Conducted Output Power	15.247(b)(3)	Pass
Power Spectral Density	15.247(e)	Pass
Emissions In Non-Restricted Frequency Bands	15.247(d)	Pass
Emissions In Restricted Frequency Bands (Radiated emission measurements)	15.247(d), 15.205, 15.209	Pass
AC Power Line Conducted Emission	15.207	N/A
Antenna Requirement	15.203	Pass

Note: Please note that the test results with statement of conformity, the decision rules which are based on: Safety Testing: the specification, standard or IEC Guide 115.

Other Testing: the specification, standard and not taking into account the measurement uncertainty.

1. General Information

1.1 Identification of the EUT

Product:	LoRaWAN Gateway Module
Model No.:	UP100-US915-USB-B
Operating Frequency:	903.0 MHz, 904.6 MHz, 906.2 MHz, 907.8 MHz, 909.4 MHz, 911.0 MHz, 912.6 MHz, 914.2 MHz, 923.3 MHz, 923.9 MHz, 924.5 MHz, 925.1 MHz, 925.7 MHz, 926.3 MHz, 926.9 MHz, 927.5 MHz,
Channel Number:	16 channels
Rated Power:	DC 5V
Power Cord:	N/A
Sample receiving date:	2022/02/25
Sample condition:	Workable
Test Date(s):	2022/03/07 ~ 2022/03/11

1.2 Additional information about the EUT

The customer confirmed the models listed as below were series model to model UP100-US915-USB-B (EUT), the difference between main model and series model are listed as below.

Brand Name	Model Number	Different
Ushine	UP100-US915-USB	without IC(ATECC608A)
Ushine	UP100-US915-SPI-B	without MCU(STM32L412xx)
Ushine	UP100-US915-SPI	without MCU(STM32L412xx) and ATECC608A

1.3 Antenna description

Antenna: SP-12K0915GS01-01 (Test with this antenna)

Antenna Gain : 3 dBi
Antenna Type : Dipole Antenna
Connector Type : I-pex

Antenna: EX02-8922-B2-SMA-MR

Antenna Gain : 2 dBi
Antenna Type : Dipole Antenna
Connector Type : I-pex

1.4 Operation mode

The EUT connected to Notebook USB port, executing “Tera Term” and enter command to select different frequency and modulation.

Mode	Channel	Frequency (MHz)	Data rate	Signal on time(ms)	Signal on & off time(ms)	Duty cycle	Duty Cycle factor
LoRa	16	927.5	1	100.00	100.00	1.000	0.0

1.5 Peripherals equipment

Peripherals	Brand	Model No.	Serial No.	Data cable
Notebook PC	ASUS	N81V	N/A	RJ-45 STP Cat.5 0.5m
Adapter (Customer provided)	CSEC	CS6F050100FUF	N/A	N/A
Fixture (Customer provided)	N/A	N/A	N/A	1. RJ-45 STP Cat.5 0.5m 2. Micro USB shielded cable 1m
Host (Customer provided)	Ushine	UP100 TEST BOARD	N/A	
AP (Customer provided)	D-Link	DIR-605L	N/A	RJ-45 STP Cat.5 0.5m

2. Minimum 6 dB Bandwidth

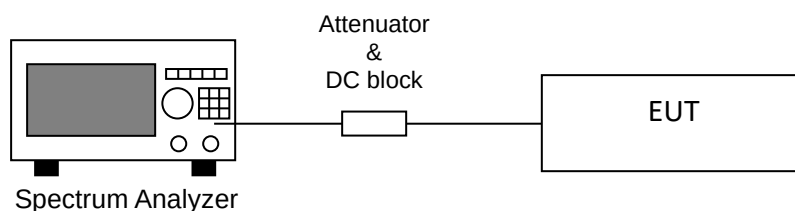
2.1 Instrument Setting

Spectrum Parameter	Setting
Detector	Peak
RBW	100kHz
VBW	$\geq 3 \times \text{RBW}$
Sweep	Auto couple
Trace	Allow the trace to stabilize.
Span	Between two times and five times the occupied bandwidth
Attenuation	Auto

2.2 Test Procedure

Step 1	The transmitter output was connected to the spectrum analyzer.
Step 2	Test was performed accordance with ANSI C63.10.
Step 3	Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission

2.3 Test Diagram



2.4 Limit

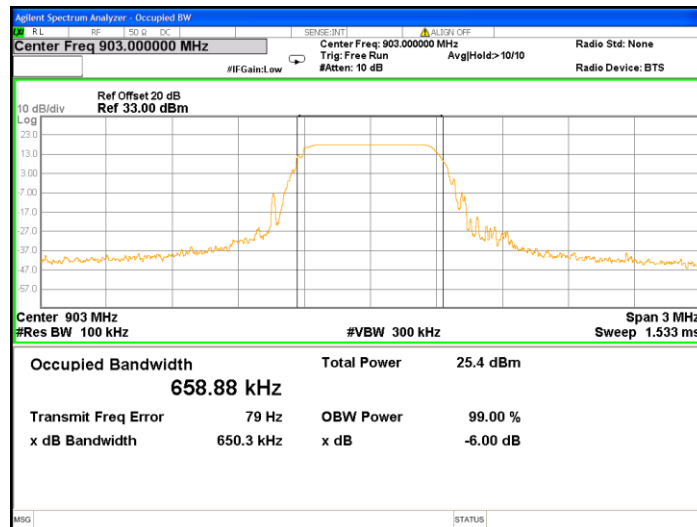
The minimum 6 dB bandwidth shall be at least 500 kHz.

2.5 Test Results

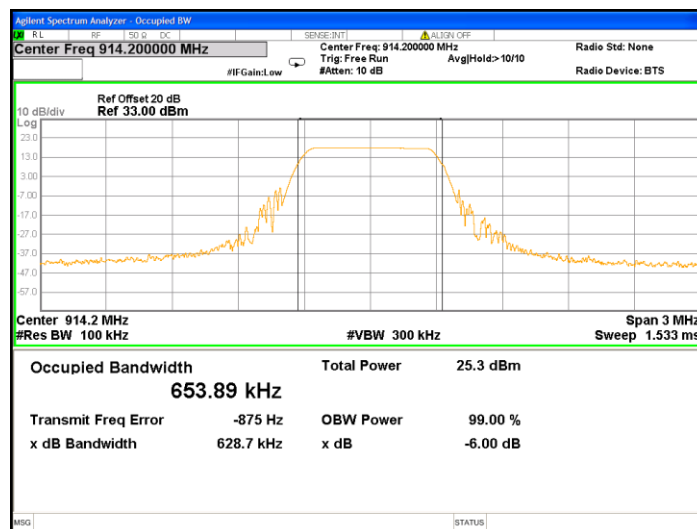
Temperature (°C) :	22
Relative Humidity (%) :	60
Test date :	2022/3/11

Mode	Channel	Frequency (MHz)	6dB Bandwidth (MHz)	Limit (MHz)	Result
LoRa	1	903	0.650	>0.5	Pass
	8	914.2	0.629	>0.5	Pass
	16	927.5	0.627	>0.5	Pass

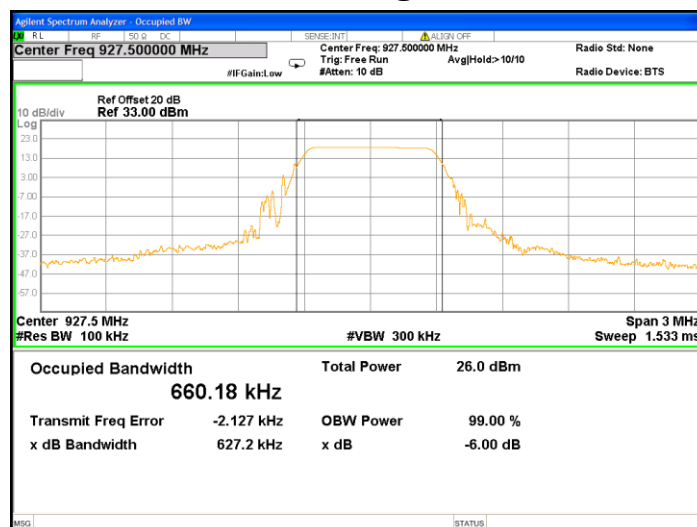
Chain0 : 6dB Bandwidth @ Lora Mode Ch 1



Chain0 : 6dB Bandwidth @ Lora Mode Ch 8



Chain0 : 6dB Bandwidth @ Lora Mode CH 16



3. Maximum Peak Conducted Output Power

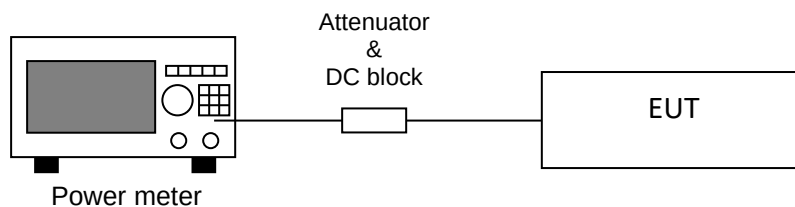
3.1 Instrument Setting

Power Meter Parameter	Setting
Bandwidth	65MHz bandwidth is greater than the EUT emission bandwidth
Detector	Peak & Average

3.2 Test Procedure

The preferred methodology is to use integrated average power measurements, as described in 11.9.2 and 11.13.3 of ANSI C63.10. The peak integrated band power methods of 11.9.1.2 and 11.13.3.2 of ANSI C63.10 are not applicable for FCC compliance testing purposes.

3.3 Test Diagram



3.4 Limit

For systems using digital modulation in the 2400-2483.5 MHz: 1 Watt (30dBm)

3.5 Test Results

Temperature (°C) :	22
Relative Humidity (%) :	60
Test date :	2022/3/9

Mode	Channel	Frequency (MHz)	Output Power [AV] (dBm)	Total Power [AV] (mW)	Maximum power [PK] (dBm)	Maximum power [PK] (mW)	Limit (dBm)	Margin (dB)
LoRa	1	903	19.94	98.63	20.12	102.80	30	-9.88
	8	914.2	19.96	99.08	20.13	103.04	30	-9.87
	16	927.5	20.56	113.76	20.91	123.31	30	-9.09

4. Power Spectral Density

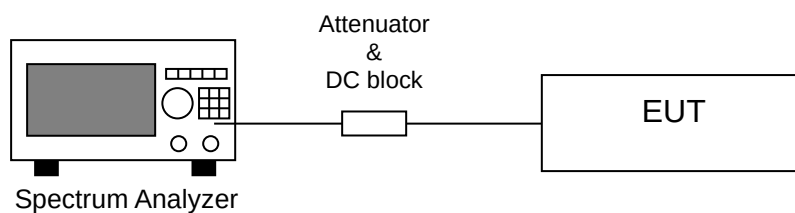
4.1 Instrument Setting

Spectrum Function	Setting
Detector	Peak
RBW	≥ 3 kHz
VBW	$\geq 3 \times$ RBW
Sweep	Auto couple
Trace	Max hold
Span	1.5 times x 6dB bandwidth
Attenuation	Auto

4.2 Test Procedure

Step 1	Test procedure refer to subclause 11.10 of ANSI C63.10.
Step 2	Using the maximum conducted output power in the fundamental emission demonstrates compliance. The EUT must be configured to transmit continuously at full power over the measurement duration.
Step 3	Use the peak marker function to determine the maximum amplitude level within the RBW.

4.3 Test Diagram



4.4 Limit

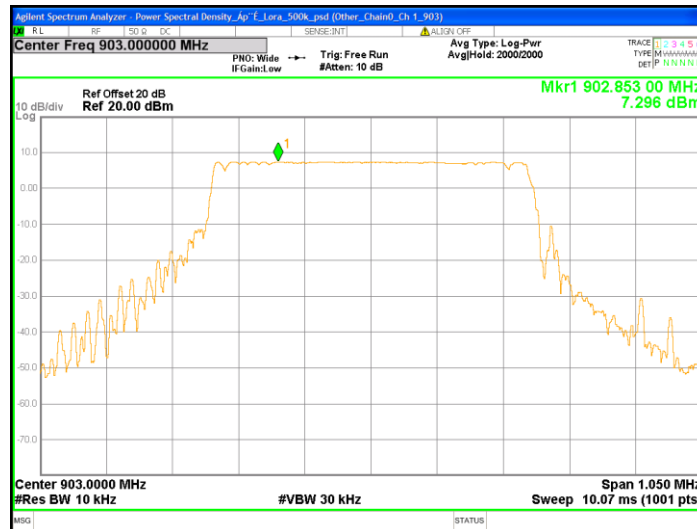
For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 10 kHz band during any time interval of continuous transmission

4.5 Test Results

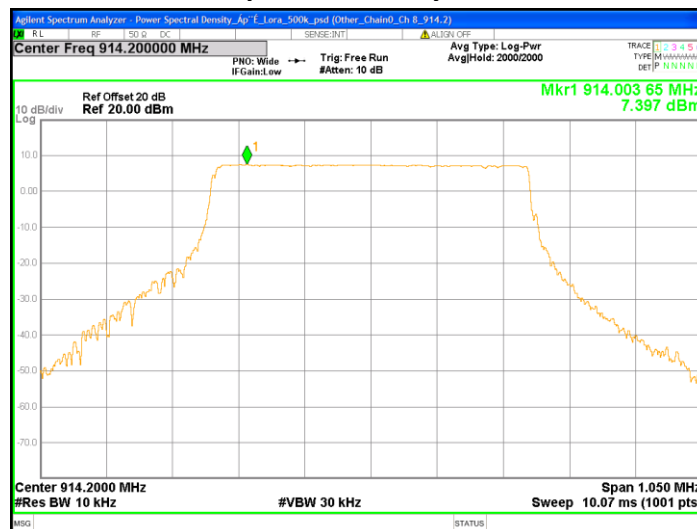
Temperature (°C) :	22
Relative Humidity (%) :	60
Test date :	2022/3/11

Mode	Channel	Frequency (MHz)	PSD (dBm)	Limit (dBm)	Margin (dB)
LoRa	1	903	7.296	8	-0.704
	8	914.2	7.397	8	-0.603
	16	927.5	7.941	8	-0.059

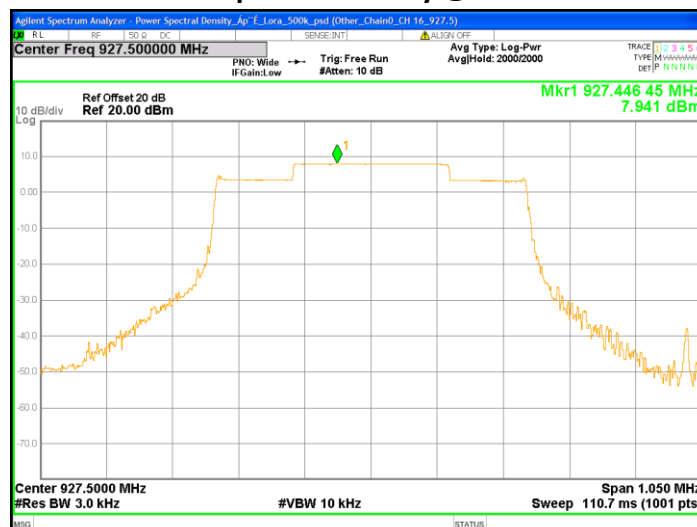
Chain0 : Power Spectral Density @ Lora Mode Ch 1



Chain0 : Power Spectral Density @ Lora Mode Ch 8



Chain0 : Power Spectral Density @ Lora Mode CH 16



5. Emissions in Non-Restricted Frequency Bands

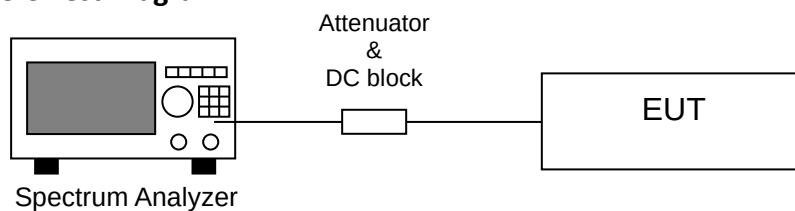
5.1 Instruments Setting

Spectrum Function	Setting (Reference Level)	Setting (Emission Level)
Detector	Peak	Peak
RBW	≥ 100 kHz	≥ 100 kHz
VBW	$\geq 3 \times$ RBW	$\geq 3 \times$ RBW
Sweep	Auto couple	Auto couple
Trace	Max hold	Max hold
Span	≥ 1.5 time 6dB bandwidth	
Attenuation	Auto	Auto

5.2 Test Procedure

- Step 1 The procedure was used in antenna-port conducted and connected to the spectrum analyzer.
- Step 2 Set instrument center frequency to center frequency.
- Step 3 Use the parameter configured in subclause 11.11 of ANSI C63.10 to measure.
- Step 4 Use the peak marker function to determine the maximum amplitude level.

5.3 Test Diagram



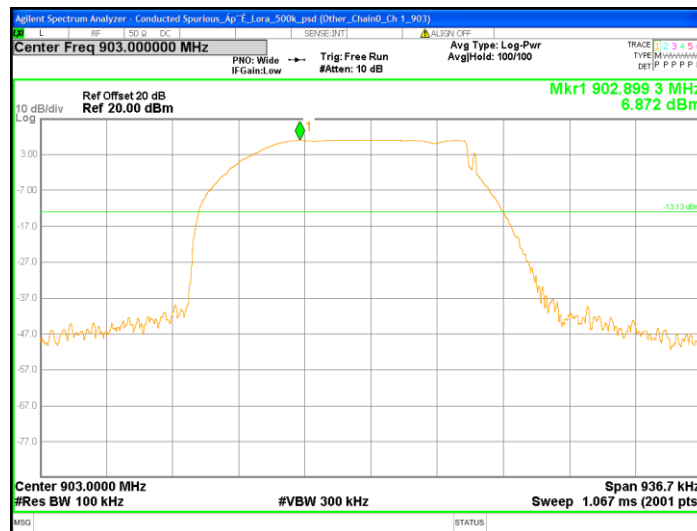
5.4 Limit

The peak output power measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz

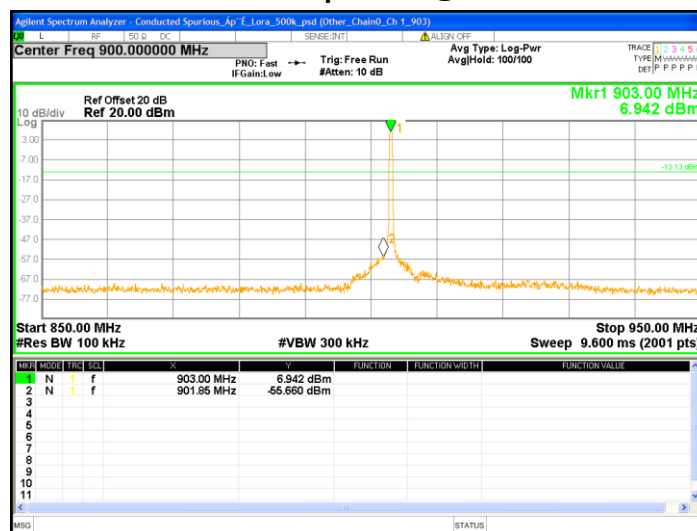
5.5 Test Results

Temperature (°C) :	22
Relative Humidity (%) :	60
Test date :	2022/3/11

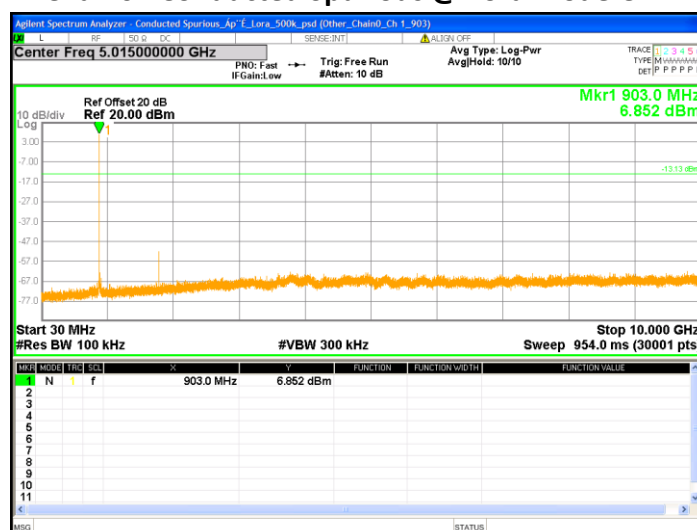
Chain0 : Conducted Spurious @ Lora Mode Ch 1



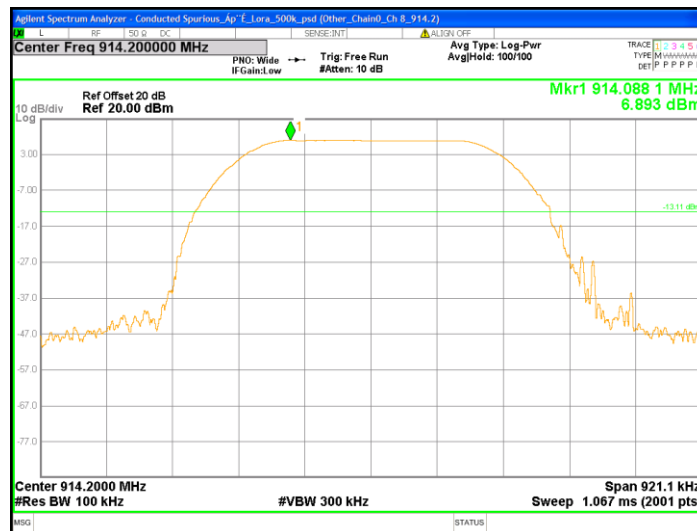
Chain0 : Conducted Spurious @ Lora Mode Ch 1



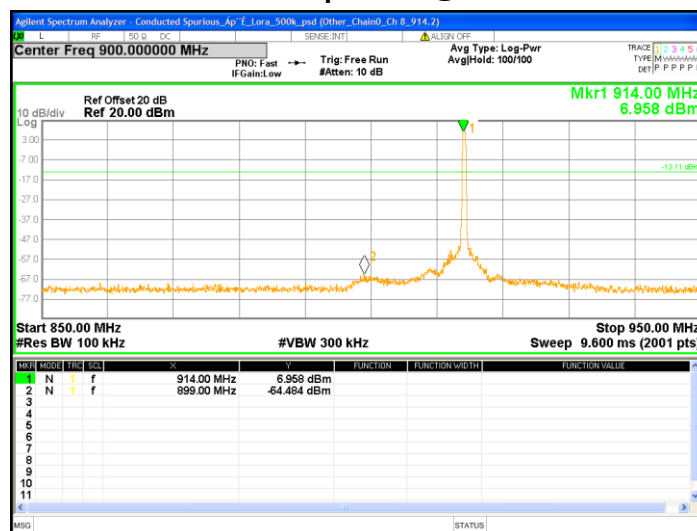
Chain0 : Conducted Spurious @ Lora Mode Ch 1



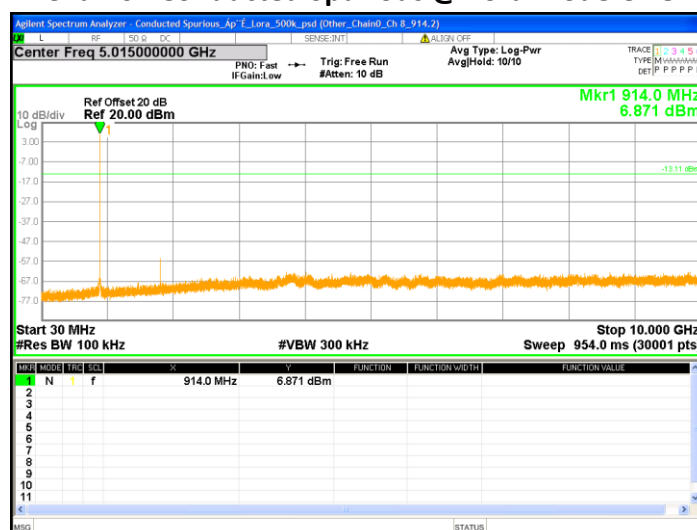
Chain0 : Conducted Spurious @ Lora Mode Ch 8



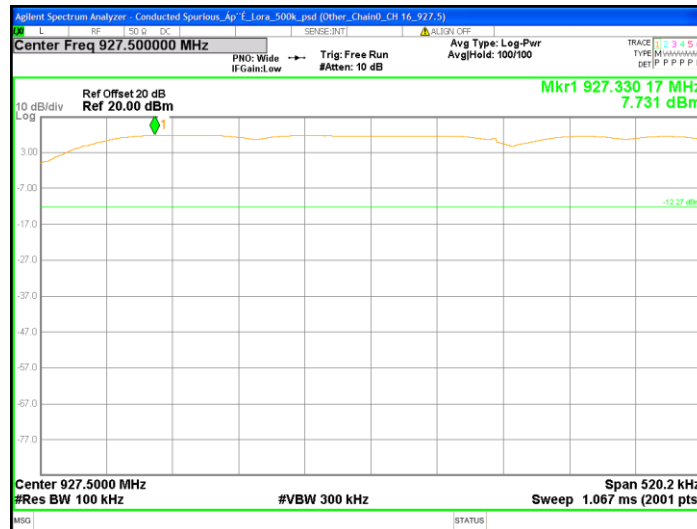
Chain0 : Conducted Spurious @ Lora Mode Ch 8



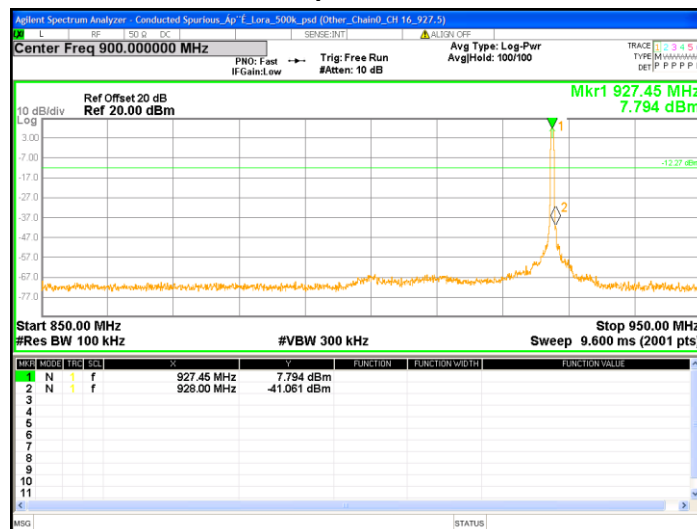
Chain0 : Conducted Spurious @ Lora Mode Ch 8



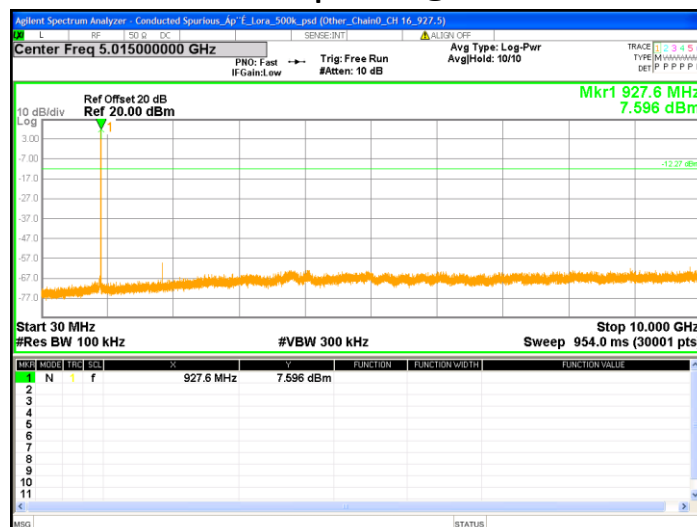
Chain0 : Conducted Spurious @ Lora Mode CH 16



Chain0 : Conducted Spurious @ Lora Mode CH 16



Chain0 : Conducted Spurious @ Lora Mode CH 16



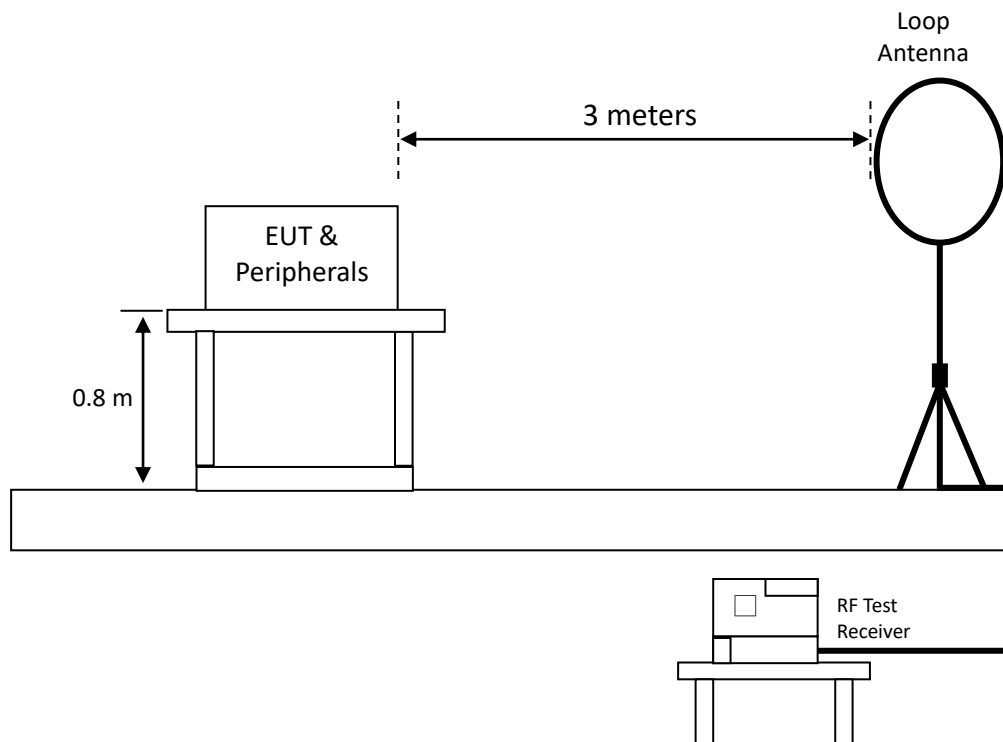
6. Emissions in Restricted Frequency Bands (Radiated emission measurements)

6.1 Instrument Setting

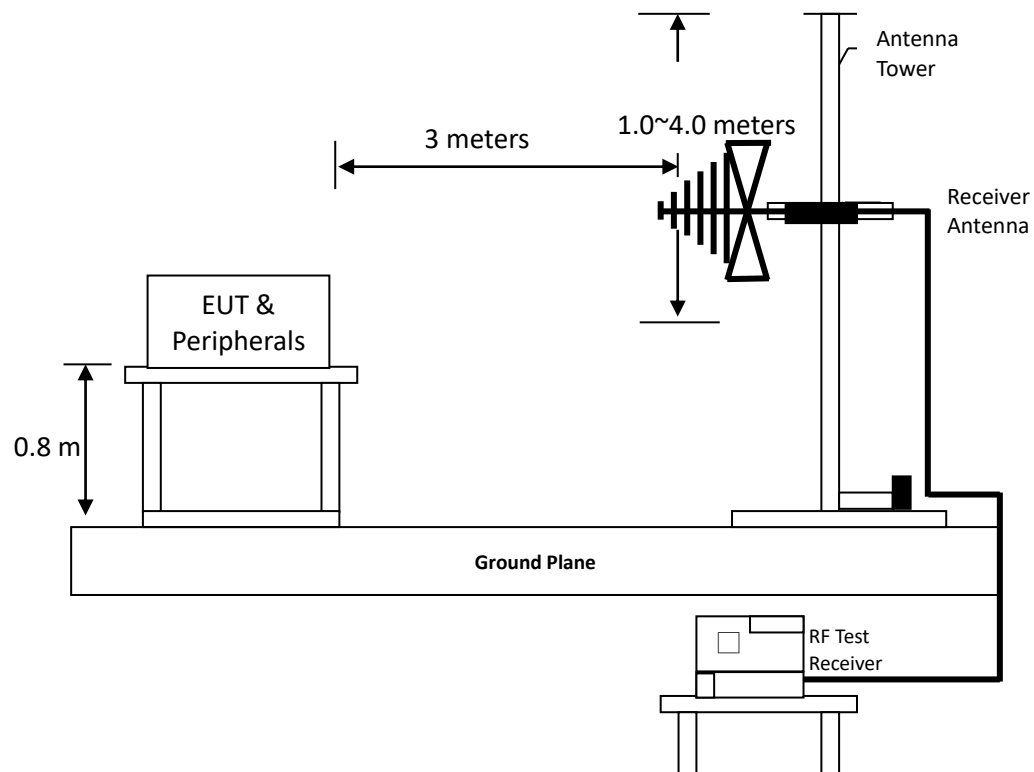
Receiver Function	Setting (Below 1GHz)	Setting (Above 1GHz)
Detector	QP	Peak and Average
RBW	9-150 kHz ; 200-300 Hz 0.15-30 MHz; 9-10 kHz 30-1000 MHz; 100-120 kHz	1MHz
VBW	$\geq 3 \times \text{RBW}$	3MHz & 1/T minimum kHz
Sweep	Auto couple	Auto couple
Start Frequency	9 kHz	1GHz
Stop Frequency	1 GHz	Tenth harmonic
Attenuation	Auto	Auto

6.2 Test setup & procedure

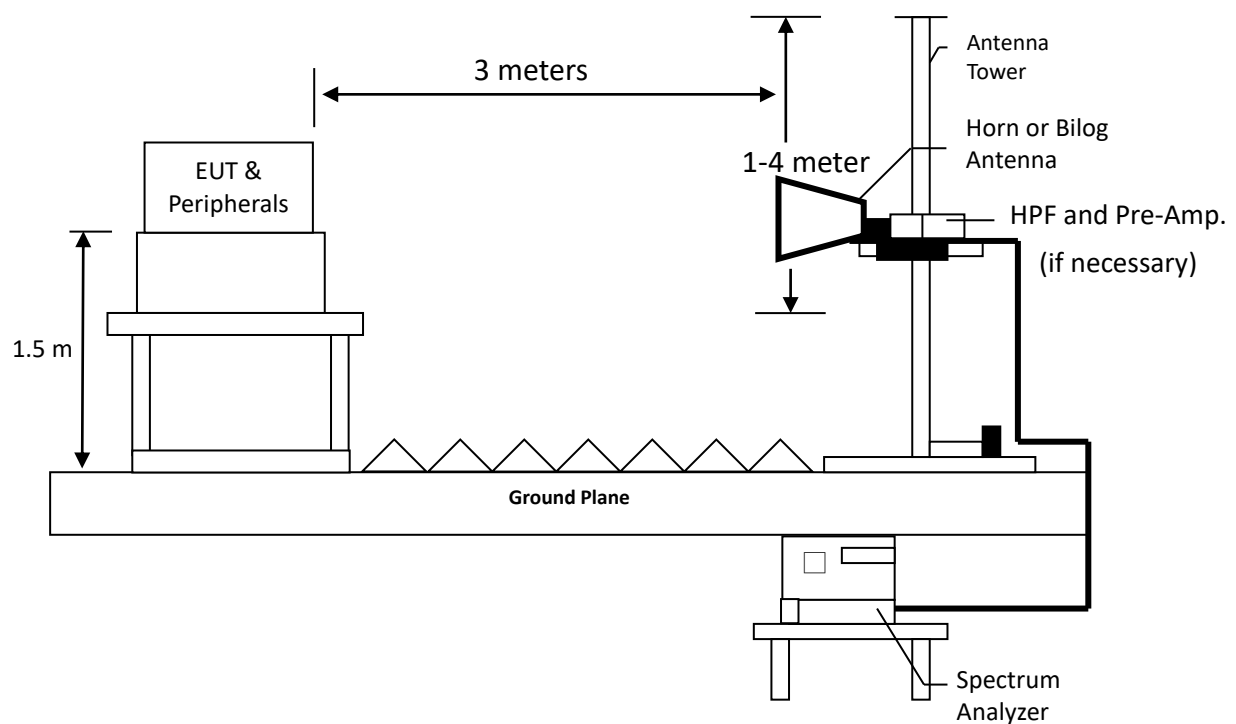
Radiated emission from 9kHz to 30MHz uses Loop Antenna:



Radiated emission below 1GHz using Bilog Antenna



Radiated emission above 1GHz using Horn Antenna



TEST REPORT

Radiated emissions were investigated cover the frequency range from 30MHz to 1000MHz using a receiver RBW of 120kHz record QP reading, and the frequency over 1GHz using a spectrum analyzer RBW of 1MHz and 1/T minimum kHz VBW record Average reading. (15.209 paragraph), the Peak reading (1 MHz RBW/ 3 MHz VBW) recorded also on the report.

The EUT for testing is arranged on a turntable. If some peripherals apply to the EUT, the peripherals will be connected to EUT and the whole system. During the test, all cables were arranged to produce worst-case emissions. The signal is maximized through rotation. The height of antenna and polarization is changing constantly for exploring for maximum signal level. The height of antenna can be up to 4 meters and down to 1 meter.

The measurement for radiated emission will be done at the distance of three meters unless the signal level is too low to measure at that distance. In the case of the reading under noise floor, a pre-amplifier is used and/or the test is conducted at a closer distance. And then all readings are extrapolated back to the equivalent three meter reading using inverse scaling with distance.

6.3 Limit

Frequency(MHz)	Field Strength(uV/m)	Measurement distance(m)
0.009~0.490	2400/F(kHz)	300
0.490~1.705	24000/F(kHz)	30
1.705~30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Remark:

1. In the above table, the tighter limit applies at the band edges.
2. Distance refers to the distance in meters between the measuring instrument antenna and the closed point of any part of the device or system

6.4 Test Result

6.4.1 Measurement results: frequencies 9kHz to 30MHz

Temperature (°C) :	21
Relative Humidity (%) :	60
Test date :	2022/3/5

The test was performed on EUT under continuously transmitting mode. The worst case occurred at 927.5MHz Ch16.

Antenna Polarity	Frequency (MHz)	Detector	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
Perpendicular	0.07	AV	19.08	51.35	70.43	114.73	-44.30
Perpendicular	0.16	AV	18.57	48.60	67.17	103.63	-36.46
Perpendicular	0.40	AV	18.85	41.59	60.44	95.59	-35.15
Perpendicular	0.52	QP	19.39	39.80	59.19	73.34	-14.15
Perpendicular	0.67	QP	19.44	29.53	48.97	71.18	-22.21
Perpendicular	0.79	QP	19.64	25.84	45.48	69.68	-24.20

Remark: Corr. Factor = Antenna Factor + Cable Loss

Antenna Polarity	Frequency (MHz)	Detector	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
Parallel	0.099	QP	18.32	52.34	70.66	107.84	-37.18
Parallel	0.159	AV	18.57	51.53	70.10	103.63	-33.53
Parallel	0.249	AV	18.74	46.46	65.20	99.69	-34.49
Parallel	0.489	AV	19.34	41.79	61.13	93.82	-32.69
Parallel	0.549	QP	19.37	37.38	56.75	72.86	-16.11
Parallel	0.609	QP	19.34	35.43	54.77	71.93	-17.16

Remark: Corr. Factor = Antenna Factor + Cable Loss

Antenna Polarity	Frequency (MHz)	Detector	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
Ground-parallel	0.139	AV	18.49	51.37	69.86	104.72	-34.86
Ground-parallel	0.226	AV	18.75	46.72	65.47	100.51	-35.04
Ground-parallel	0.444	AV	19.09	41.30	60.39	94.66	-34.27
Ground-parallel	0.618	QP	19.35	32.01	51.36	71.79	-20.43
Ground-parallel	0.704	QP	19.50	27.28	46.78	70.65	-23.87
Ground-parallel	1.183	QP	19.49	17.29	36.78	66.14	-29.36

Remark: Corr. Factor = Antenna Factor + Cable Loss

6.5.2 Measurement results: frequencies below 1 GHz

Temperature (°C) :	21
Relative Humidity (%) :	60
Test date :	2022/3/5

The test was performed on EUT under continuously transmitting mode. The worst case occurred at 927.5MHz Ch16.

Antenna Polarity (H/V)	Frequency (MHz)	Spectrum Analyzer Detector	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
Horizontal	54.25	QP	21.10	3.22	24.32	40.00	-15.68
Horizontal	144.46	QP	20.66	4.85	25.51	43.50	-17.99
Horizontal	250.19	QP	20.30	16.45	36.75	46.00	-9.25
Horizontal	358.83	QP	23.41	3.43	26.84	46.00	-19.16
Horizontal	467.47	QP	26.30	4.10	30.40	46.00	-15.60
Horizontal	585.81	QP	28.94	4.25	33.19	46.00	-12.81

Antenna Polarity (H/V)	Frequency (MHz)	Spectrum Analyzer Detector	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
Vertical	42.61	QP	20.55	6.49	27.04	40.00	-12.96
Vertical	65.89	QP	19.25	6.15	25.40	40.00	-14.60
Vertical	109.54	QP	17.55	3.04	20.59	43.50	-22.91
Vertical	144.46	QP	20.66	3.86	24.52	43.50	-18.98
Vertical	250.19	QP	20.30	10.75	31.05	46.00	-14.95
Vertical	500.45	QP	27.04	3.92	30.96	46.00	-15.04

Remark: Corr. Factor = Antenna Factor + Cable Loss

6.5.3 Measurement results: frequency above 1GHz to 25GHz

Temperature (°C) :	21
Relative Humidity (%) :	60
Test date :	2022/3/5

Mode	Frequency (MHz)	Spectrum Analyzer Detector	Antenna Polarity (H/V)	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
LoRa Ch1	1806	PK	H	-21.08	73.05	51.97	74	-22.03
	1806	PK	V	-21.08	77.97	56.89	74	-17.11
	1806	AV	V	-21.08	74.02	52.94	54	-1.06
	2710	PK	V	-17.16	61.43	44.27	74	-29.73
LoRa Ch8	1828.4	PK	H	-20.92	70.69	49.77	74	-24.23
	1828.4	PK	V	-20.92	74.15	53.23	74	-20.77
	1828.4	AV	V	-20.92	72.8	51.88	54	-2.12
LoRa Ch16	1855	PK	H	-20.71	67.58	46.87	74	-27.13
	1855	PK	V	-20.71	69.61	48.9	74	-25.1

Remark: Correction Factor = Antenna Factor + Cable Loss + High Pass Filter Loss - Pre_Amplifier Gain

7. AC Power Line Conducted Emission

Since the EUT is not connected to AC source, therefore, the test can be waived.

Appendix A: Test equipment list

Test Equipment/ Test site	Brand	Model No.	Serial No.	Calibration Date	Next Calibration Date
EMI Test Receiver	Rohde & Schwarz	ESR7	101822	2021/08/16	2022/08/15
Signal Analyzer	Agilent	N9030A	MY51380492	2021/08/17	2022/08/16
Active Loop Antenna	SCHWARZBECK MESS-ELEKTRONIC	FMZB1519	1519-067	2021/04/14	2022/04/13
Broadband Antenna	SHWARZBECK	VULB 9168	9168-172	2022/01/20	2023/01/19
Horn Antenna	EMCO	BBHA 9120 D	9120D-456	2022/01/21	2023/01/20
Horn Antenna	SCHWARZBECK	BBHA 9170	BBHA9170159	2021/04/08	2022/04/07
Broadband Amplifier	SGH	SGH118(45dB)	20220105-1	2022/01/07	2023/01/06
Pre-amplifier	SGH	SGH184	20201124-1	2021/12/06	2022/12/05
Power Meter	Anritsu	ML2495A	0844001	2021/10/17	2022/10/16
Power Sensor	Anritsu	MA2411B	0738452	2021/10/17	2022/10/16
966-2(A) Cable	SUHNER	SMA / EX 100	N/A	2021/03/08	2022/03/07
966-2(B) Cable	SUHNER	SUCOFLEX 104P	CB0005	2021/03/08	2022/03/07
966-2 Cable	SUHNER	SUCOFLEX 104P	9403/4P	2021/11/30	2022/11/29
RF Cable	SUHNER	SUCOFLEX 104P	CB0006	2021/04/29	2022/04/28
966-2_3m Semi-Anechoic Chamber	966_2	CEM-966_2	N/A	2022/01/14	2023/01/13
20dB Attenuator	Mini-Circuits	BW-S20W5+	N/A	2021/05/26	2022/05/25
Test software	Audix	e3	V9	NCR	NCR

Note: No Calibration Required (NCR).

Appendix B: Measurement Uncertainty

This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level using a coverage factor of $k=2$.

Item	Uncertainty
Vertically polarized radiated disturbances from 30MHz~1GHz in a semi-anechoic chamber at a distance of 3m	5.16 dB
Horizontally polarized radiated disturbances from 30MHz~1GHz in a semi-anechoic chamber at a distance of 3m	5.02 dB
Radiated disturbances from 1GHz~18GHz in a semi-anechoic chamber at a distance of 3m	5.17 dB
Vertically polarized Radiated disturbances from 18GHz~26.5GHz in a semi-anechoic chamber at a distance of 1m	2.39 dB
Horizontally polarized Radiated disturbances from 18GHz~26.5GHz in a semi-anechoic chamber at a distance of 1m	2.39 dB
Radiated disturbances from 9kHz~30MHz in a semi-anechoic chamber at a distance of 3m	3.70 dB
Emission on the Band Edge Test	4.32 dB
Occupied Bandwidth	7.78 %
Maximum Peak Conducted Output Power	0.44 dB
Power Spectral Density	1.27 dB
Emissions In Non-Restricted Frequency Bands	1.27 dB
AC Power Line Conducted Emission	3.08 dB