

Prüfbericht-Nr.: <i>Test report No.:</i>	50351183 001	Auftrags-Nr.: <i>Order No.:</i>	168154565	Seite 1 von 33 <i>Page 1 of 33</i>
Kunden-Referenz-Nr.: <i>Client reference No.:</i>	N/A	Auftragsdatum: <i>Order date.:</i>	02.03.2020	
Auftraggeber: <i>Client:</i>	Ring LLC 1523 26th Street, Santa Monica, California 90404, United States			
Prüfgegenstand: <i>Test item:</i>	Pathlight			
Bezeichnung / Typ-Nr.: <i>Identification / Type No.:</i>	5LP1Y8 (Trademark: Ring)			
Auftrags-Inhalt: <i>Order content:</i>	FCC and IC approval			
Prüfgrundlage: <i>Test specification:</i>	CFR47 FCC Part 15: Subpart C Section 15.247 CFR47 FCC Part 15: Subpart C Section 15.207 CFR47 FCC Part 15: Subpart C Section 15.209 CFR47 FCC Part 15: Subpart B Section 15.107 CFR47 FCC Part 15: Subpart B Section 15.109 CFR47 FCC Part 2: Section 2.1091 RSS-247 Issue 2 February 2017 RSS-Gen Issue 5 April 2018 ICES-003 Issue 6 January 2016 RSS-102 Issue 5 March 2015			
Wareneingangsdatum: <i>Date of receipt:</i>	25.02.2020	Please refer to photo documents		
Prüfmuster-Nr.: <i>Test sample No.:</i>	A001069826-002,003			
Prüfzeitraum: <i>Testing period:</i>	26.02.2020 - 18.08.2020			
Ort der Prüfung: <i>Place of testing:</i>	TÜV Rheinland (Shenzhen) Co., Ltd.			
Prüflaboratorium: <i>Testing laboratory:</i>	TÜV Rheinland (Shenzhen) Co., Ltd.			
Prüfergebnis*: <i>Test result*:</i>	Pass			
geprüft von / tested by:		kontrolliert von / reviewed by:		
 23.09.2020 Bell Hu / Project Manager		 23.09.2020 Winnie Hou / Technical Certifier		
Datum <i>Date</i>	Name/Stellung <i>Name/Position</i>	Unterschrift <i>Signature</i>	Datum <i>Date</i>	Name/Stellung <i>Name/Position</i>
Sonstiges / Other:				
FCC ID: 2AEUPBHAPB001 IC: 20271-BHAPB001 HVIN: 5LP1Y8 FVIN: 1.7.16-56				
Zustand des Prüfgegenstandes bei Anlieferung: <i>Condition of the test item at delivery:</i>		Prüfmuster vollständig und unbeschädigt <i>Test item complete and undamaged:</i>		
* Legende: 1 = sehr gut 2 = gut 3 = befriedigend 4 = ausreichend 5 = mangelhaft P(ass) = entspricht o.g. Prüfgrundlage(n) F(ail) = entspricht nicht o.g. Prüfgrundlage(n) N/A = nicht anwendbar N/T = nicht getestet Legend: 1 = very good 2 = good 3 = satisfactory 4 = sufficient 5 = poor P(ass) = passed a.m. test specifications(s) F(ail) = failed a.m. test specifications(s) N/A = not applicable N/T = not tested				
Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens. <i>This test report only relates to the a. m. test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.</i>				

V04

Test Summary

5.1.1 ANTENNA REQUIREMENT*RESULT: Pass***5.1.2 MAXIMUM PEAK CONDUCTED OUTPUT POWER (FOR DTSS AND FHSS)***RESULT: Pass***5.1.3 CONDUCTED POWER SPECTRAL DENSITY (FOR DTSS)***RESULT: Pass***5.1.4 6dB BANDWIDTH (FOR DTSS)***RESULT: Pass***5.1.5 99% BANDWIDTH (FOR DTSS AND FHSS)***RESULT: Pass***5.1.6 20dB BANDWIDTH (FOR FHSS)***RESULT: Pass***5.1.7 CARRIER FREQUENCY SEPARATION (FOR FHSS)***RESULT: Pass***5.1.8 NUMBER OF HOPPING FREQUENCY (FOR FHSS)***RESULT: Pass***5.1.9 CHANNEL OCCUPANCY TIME (FOR FHSS)***RESULT: Pass***5.1.10 CONDUCTED SPURIOUS EMISSIONS (FOR DTSS AND FHSS)***RESULT: Pass***5.1.11 RADIATED SPURIOUS EMISSION (FOR DTSS AND FHSS)***RESULT: Pass***5.1.12 CONDUCTED EMISSION ON AC MAINS (FOR DTSS AND FHSS)***RESULT: N/A***5.1.13 RADIATED EMISSION***RESULT: Pass***6.1.1 ELECTROMAGNETIC FIELDS***RESULT: Pass*

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1 General Remarks

1.1 Report Version History

Primary Version	March 18, 2020	/
Rev 01	May 5, 2020	Added duty cycle information and note the sub-sections for each test item; Revised the antenna compliant statement.
Rev 02	Aug 19, 2020	Updated Power data and RF exposure evaluation; Corrected IC and FCC ID information.

1.2 Complementary Materials

All attachments are integral parts of this test report. This applies especially to the following appendix:

Appendix A: Photographs of the Test Set-up

Appendix B: Test Results of DTSS

Appendix C: Test Results of FHSs

Appendix D: Test Results of Radiated

Appendix E: Test Results of Part 15B and ICES 003

2 Test Sites

2.1 Test Facilities

TÜV Rheinland (Shenzhen) Co., Ltd.

362 Huanguan Road Middle Longhua District, Shenzhen 518110 People's Republic of China

FCC accredited testing laboratory: CN1260

ISED wireless device testing laboratory: 25069

2.2 List of Test and Measurement Instruments

Table 1: List of Test and Measurement Equipment

TÜV Rheinland (Shenzhen) Co., Ltd.

Radio Spectrum Testing (TS8997)					
Equip. No.	Equipment	Manufacturer	Model	Serial No.	Cal. until
1825795	Signal Analyzer	R & S	FSV 40	101441	20.08.2020
1825798	OSP	R & S	OSP 150	101017	17.12.2020
1825799	Control PC	DELL	OptiPlex 7050	FTJZ9P2	N/A
1825800	Test Software	R & S	WMS32 (V10.40.10)	N/A	N/A
1825801	Power Meter	R & S	NRP2	107105	17.12.2020
1825802	Wideband Power Sensor	R & S	NRP-Z81	105350	17.12.2020
1826431	Shielding Room 8#	Albatross	SR8	APC17151-SR8	23.07.2020
Unwanted Emission Testing (TS9975)					
Equip. No.	Equipment	Manufacturer	Model	Serial No.	Cal. until
1826021	EMI Test Receiver	R & S	ESR 7	102021	19.08.2020
1826023	Signal Analyzer	R & S	FSV 40	101439	21.08.2020
1826024	System Controller Interface	R & S	SCI-100	S10010038	N/A
1826025	Filterbank	R & S	Wlan	100759	21.08.2020
1826026	OSP	R & S	OSP 120	102040	N/A
1826028	Pre-amplifier	R & S	SCU08F1	08320031	20.08.2020
1826029	Amplifier	R & S	SCU-18F	180070	20.08.2020
1826030	Amplifier	R & S	SCU40A	100475	20.09.2020
1826031	Trilog Broadband Antenna (30 MHz - 7 GHz)	Schwarzbeck	VULB 9162	193	02.09.2020
1826032	Double-Ridged Antenna (1 -18 GHz)	ETS-LINDGREN	3117	00218717	02.09.2020
1826033	Wideband Ridged Horn Antenna (18-40 GHz)	Steatite	QMS-00880	19067	02.09.2020
1826034	Active Loop Antenna	Schwarzbeck	FMZB 1513	302	01.09.2020

1826035	Wideband Ridged Horn Antenna (12-18 GHz)	Steatite	QMS-00208	18313	02.09.2020
1826036	Test software	R&S	V10.40.10-EMC32	N/A	N/A
1826037	Control PC	Dell	OptiPlex 7050	36NV9P2	N/A
1826433	3m Semi-Anechoic Chamber	Albatross	SAC-3m	APC17151-SAC	06.07.2020
Conducted Emission on AC Mains					
Equip. No.	Equipment	Manufacturer	Model	Serial No.	Cal. until
1822625	EMI Test Receiver	R&S	ESR3	102428	03.09.2020
1822627	Artificial Mains Network	R&S	ENV216	102333	19.08.2020
Radiated Emission (3m chamber)					
Equip. No.	Equipment	Manufacturer	Model No.	Serial No.	Cali. until
1822620	3m SAC	ETS	SAC3	CT001632-Q1362	23.08.2021
1825044	EMI Test Receiver	R&S	ESR7	102111	04.01.2021
1825004	Horn Antenna	R&S	HF907	102706	01.09.2020
1825005	Preamplifier	FIT	SCU-18F	180077	19.08.2020
1825042	Trilog-Broadband antenna	SCHWARZBECK	VULB9168	0945	12.09.2020
1825090	EMC Measurement Software	R&S	EMC32(Ver.10.30.01)	N/A	N/A

2.3 Traceability

All measurement equipment calibrations are traceable to NIM (National Institute of Metrology) or where calibration is performed in other countries, to equivalent nationally recognized standards organizations.

2.4 Calibration

Equipment requiring calibration is calibrated periodically by the manufacturer or according to manufacturer's specifications. Additionally all equipment is verified for proper performance on a regular basis using in house standards or comparisons.

2.5 Measurement Uncertainty

The estimated combined standard uncertainty for radiated emissions and conducted emissions measurements as below table.

Parameter	Uncertainty
Radio Frequency	$\pm 1 \times 10^{-7}$
RF Power (conducted)	± 2.5 dB
Radiated Emission of Transmitter, valid up to 26.5 GHz	± 6 dB
Radiated Emission of Receiver, valid up to 26.5 GHz	± 6 dB
Conducted Emission, (9kHz to 150kHz)/(150kHz to 30MHz)	± 3.70 dB / ± 3.30 dB
Radiated Emission (3m SAC), 30MHz to 1000MHz	± 4.52 dB
Radiated Emission (3m SAC), above 1000MHz	± 4.37 dB
Temperature	± 1 °C
Humidity	± 5 %
Voltage (DC)	± 1 %
Voltage (AC, <10kHz)	± 2 %

2.6 Location of Original Data

The original copies of all test data taken during actual testing were attached at Appendix A & B & C & D & E of this report and delivered to the applicant. A copy has been retained in the TÜV Rheinland (Shenzhen) Co., Ltd. file for certification follow-up purposes.

2.7 Status of Facility Used for Testing

The TÜV Rheinland (Shenzhen) Co., Ltd. Test facility located at 362 Huanguan Road Middle Longhua District, Shenzhen 518110 People's Republic of China is listed on the US Federal Communications Commission list of facilities approved to perform measurements.

3 General Product Information

3.1 Product Function and Intended Use

The EUT is a Pathlight, which supports Bluetooth Low Energy and 902-928MHz ISM Band (DTSS + FHSs) wireless technologies.

For details refer to the User Manual, Technical Description and Circuit Diagram.

3.2 Ratings and System Details

Table 2: Technical Specification of EUT

General Information of EUT	Value
Kind of Equipment	Pathlight
Type Designation	5LP1Y8
Trademark	Ring
FCC ID	2AEUPBHAPB001
IC	20271-BHAPB001
HVIN	5LP1Y8
FVIN	1.7.16-56
PMN	Pathlight
Operating Voltage	DC 6V (1.5V*4 Cells)
Testing Voltage	Fully charged battery
Technical Specification of DTSS#1 (Bluetooth Low Energy)	
Operating Frequency	2402 MHz to 2480 MHz
Type of Modulation	GFSK
Channel Number	40 channels
Channel Separation	2MHz
Antenna Type	Integral antenna
Antenna Gain1 of Bluetooth	1 dBi
Technical Specification of DTSS#2	
Operating Frequency	902.5 MHz to 926.5 MHz
Type of Modulation	LoRa DTS
Channel Number	31 channels
Channel Bandwidth	500 KHz
Channel Separation	800 KHz
Antenna Type	Integral antenna
Antenna Gain2	3 dBi

Technical Specification of FHSs#1	
Operating Frequency	902.2 MHz to 927.8 MHz
Type of Modulation	LoRa FHSS
Channel Number	129 channels
Channel Bandwidth	125 KHz
Channel Separation	200 KHz
Antenna Type	Integral antenna
Antenna Gain2	3 dBi
Technical Specification of FHSs#2	
Operating Frequency	902.2 MHz to 927.8 MHz
Type of Modulation	FSK FHSS
Channel Number	129 channels
Data Rate	50 Kbps
Channel Separation	200 KHz
Antenna Type	Integral antenna
Antenna Gain2	3 dBi
Technical Specification of FHSs#3	
Operating Frequency	902.4 MHz to 927.6 MHz
Type of Modulation	FSK FHSS
Channel Number	64 channels
Data Rate	150 Kbps
Channel Separation	400 KHz
Antenna Type	Integral antenna
Antenna Gain2	3 dBi
Technical Specification of FHSs#4	
Operating Frequency	902.5 MHz to 927.5 MHz
Type of Modulation	FSK FHSS
Channel Number	51 channels
Data Rate	250 Kbps
Channel Separation	500 KHz
Antenna Type	Integral antenna
Antenna Gain2	3 dBi

Table 3: Operating Frequencies/Channels of EUT

Technology	Modulation	Channel Number	Channel Separation (MHz)	Channel Bandwidth (MHz)	Data Rate (Kbps)	Low CH (MHz)	Middle CH (MHz)	High CH (MHz)
DTSs #1 (BLE)	GFSK	40	2.0	1	1000	2402.0	2440.0	2480.0
DTSs #2	LoRa DTS	31	0.8	0.5	--	902.5	914.5	926.5
FHSs #1	LoRa FHSS	129	0.2	0.125	-	902.2	915.0	927.8
FHSs #2	FSK FHSS	129	0.2	--	50	902.2	915.0	927.8
FHSs #3	FSK FHSS	64	0.4	--	150	902.4	914.8	927.6
FHSs #4	FSK FHSS	51	0.5	--	250	902.5	915	927.5

3.3 Independent Operation Modes

The basic operation modes are:

- A. On
 - 1. Bluetooth Low Energy transmitting mode
 - 1) Low Channel
 - 2) Middle Channel
 - 3) High Channel
 - 2. DTSS transmitting mode
 - 1) Low Channel
 - 2) Middle Channel
 - 3) High Channel
 - 3. FHSs transmitting mode
 - 1) Low Channel
 - 2) Middle Channel
 - 3) High Channel
- B. On, Transmitting on Hopping channel
- C. On, Bluetooth connecting mode
- D. On, DTSS connecting mode
- E. On, FHSs connecting mode
- F. On, Lighting mode

3.4 Noise Generating and Noise Suppressing Parts

Refer to Circuit Diagram for further details.

3.5 Submitted Documents

- FCC/IC Label and Location Info
- User Manual

4 Test Set-up and Operation Modes

4.1 Principle of Configuration Selection

Radio Spectrum: The equipment under test (EUT) was configured at its highest power output in order to measure its highest possible radiation and conducted level. The test modes were adapted accordingly in reference to the instructions for use.

Emission: The equipment under test (EUT) was configured to measure its highest possible radiation level. The test modes were adapted accordingly in reference to the instructions for use.

4.2 Test Operation and Test Software

Test operation refers to test setup in chapter 5. All tests were performed according to the procedures in KDB 558074 D01 DTS Meas Guidance v05r02, ANSI C63.10: 2013 and ANSI C63.4: 2014.

The device was configured to transmit continuously (*i.e.*, with a duty cycle of greater than or equal to 98 %) at the maximum power control level over a random symbol set.

4.3 Special Accessories and Auxiliary Equipment

Table 4: Cables Used during Test

Description	Manufacturer	Model	Quantity	Length (m)
USB cable	N/A	N/A	N/A	1.0

Table 5: Auxiliary Equipment Used during Test

Description	Manufacturer	Model	S/N	Rating
PC	Lenovo	T480	N/A	/

4.4 Countermeasures to Achieve EMC Compliance

The test sample which has been tested contained the noise suppression parts as described in the Technical Construction File (TCF).

No additional measures were employed to achieve compliance.

4.5 Test Setup Diagram

Diagram of Measurement Configuration for Radiation Test (Below 1GHz)

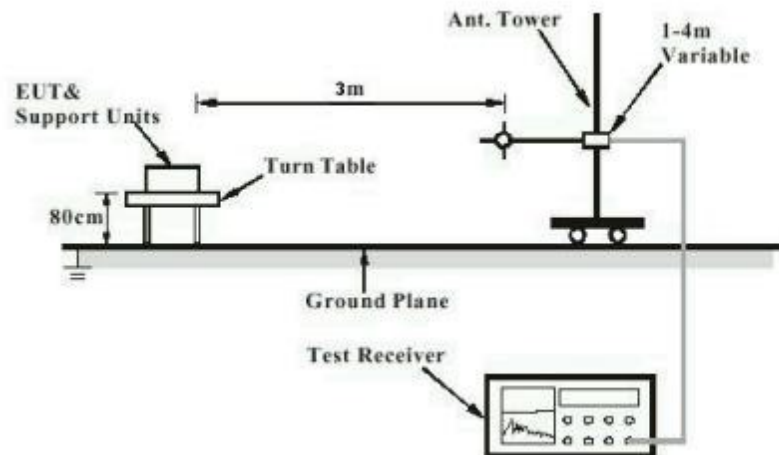


Diagram of Measurement Configuration for Radiation Test (Above 1GHz)

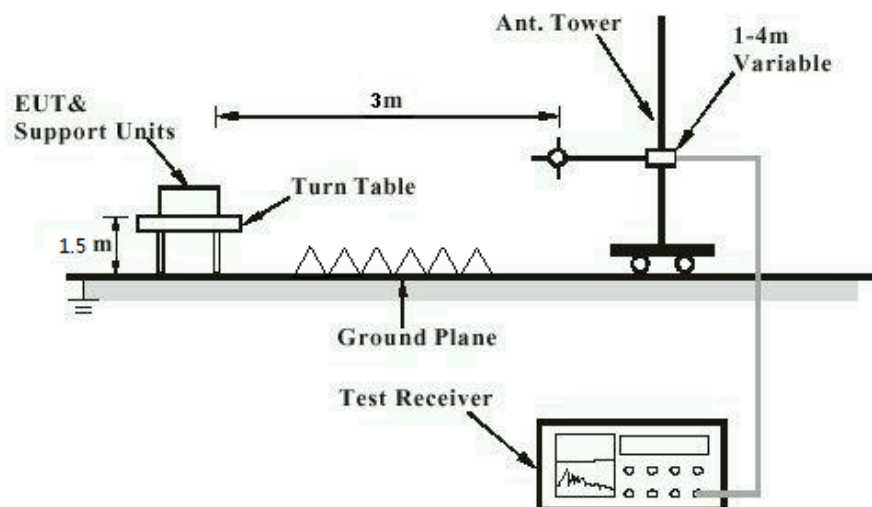


Diagram of Measurement Configuration for Mains Conduction Measurement

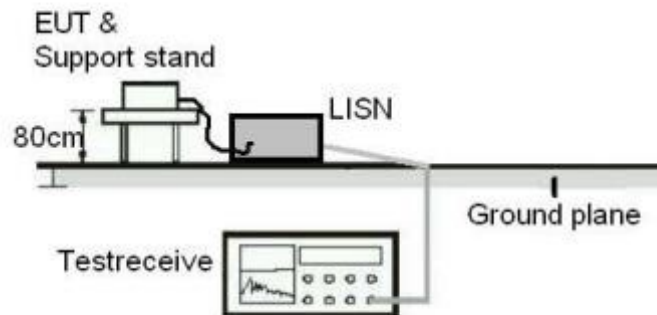
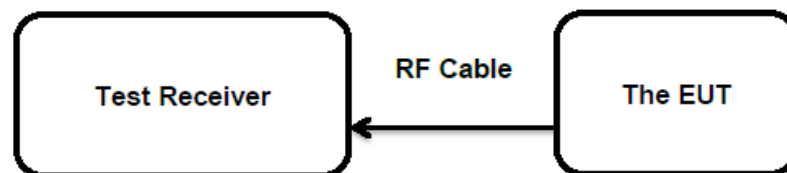


Diagram of Measurement Configuration for Conducted Transmitter Measurement



5 Test Results

5.1 Transmitter Requirement & Test Suites

5.1.1 Antenna Requirement

RESULT:**Pass****Test Specification**

Reference standard : Part 15.203

The EUT has two internal antennas, which permanently attached and no consideration of replacement.

Therefore, the EUT is considered sufficient to comply with the provision.

Refer to EUT Photo for further details.

5.1.2 Maximum Peak Conducted Output Power (for DTSS and FHSs)

RESULT:
Pass
Test Specification

Reference standard : FCC Part 15.247(b)(1), (2) and (3)
RSS-247 Clause 5.4(a), (b) and (d)

Test method : Sub-clause 11.9.1.3 of ANSI C63.10: 2013
Sub-clause 8.3.1.3 of KDB558074 D01v05r02

Limits : DTSS < 1.0 Watts, FHSs < 0.25 Watts

Test standard	Technology	Frequency (MHz)	Limit (W)	Channel No.
FCC 15.247	DTSS	902-928 2400-2483.5	1.0	--
	FHSs	902-928	1.0	≥ 50
			0.25	25 ≤ channels < 50
RSS-247	DTSS	902-928 2400-2483.5	1.0(e.i.r.p < 4.0)	--
	FHSs	902-928	1.0(e.i.r.p < 4.0)	≥ 50
			0.25(e.i.r.p < 1.0)	25 ≤ channels < 50

Kind of test site : Shielded Room

Test Setup

Date of testing : 17.08.2020

Input voltage : Fully charged battery

Operation mode : A

Test channel : Low / Middle / High

Ambient temperature : 25 °C

Relative humidity : 56 %

Atmospheric pressure : 101 kPa

For details refer to following test result.

Table 6: Test Result of Maximum Peak Conducted Output Power

Test Mode	Test Channel	Measured Peak Power		Limit (W)
		(dBm)	(W)	
DTSS#1 (BLE)	Low CH	-9.82	0.00010	< 1
	Middle CH	-10.11	0.00010	
	High CH	-10.45	0.00009	
DTSS#2 (LoRa)	Low CH	16.01	0.03990	< 1
	Middle CH	15.94	0.03926	
	High CH	15.89	0.03882	
FHSs#1 (LoRa)	Low CH	15.99	0.03972	< 1
	Middle CH	16.17	0.04140	
	High CH	15.98	0.03963	
FHSs#2	Low CH	16.20	0.04169	< 1
	Middle CH	16.05	0.04027	
	High CH	15.88	0.03873	
FHSs#3	Low CH	16.19	0.04159	< 1
	Middle CH	16.06	0.04036	
	High CH	15.87	0.03864	
FHSs#4	Low CH	16.23	0.04198	< 1
	Middle CH	16.07	0.04046	
	High CH	15.91	0.03899	

Note:

- 1) The cable loss is taken into account in results.
- 2) Antenna gain(G) of BLE: 1 dBi
- 3) Antenna gain(G) of DTSS: 3 dBi
- 4) Antenna gain(G) of FHSs: 3 dBi

The Maximum peak conducted output power (e.i.r.p.)= $P_{(\text{Peak power})} + G$, which is far below the 4 W

5.1.3 Conducted Power Spectral Density (for DTSSs)

RESULT:
Pass
Test Specification

Reference standard	: FCC Part 15.247(e) RSS-247 Clause 5.2(b)
Test method	: Sub-clause 11.10.2 of ANSI C63.10 Sub-clause 8.4 of KDB558074 D01v05r02
Limits	: < 8 dBm / 3kHz
Kind of test site	: Shielded Room

Test Setup

Date of testing	: Refer to test data
Input voltage	: Fully charged battery
Operation mode	: A.1, A.2
Test channel	: Low / Middle / High
Ambient temperature	: 25 °C
Relative humidity	: 56 %
Atmospheric pressure	: 101 kPa

For details refer to following test result.

Table 7: Test Result of Power Spectral Density

Test Mode	Test Channel (MHz)	Measured Peak Power Spectral Density (dBm/3kHz)	Limit (dBm/3kHz)
DTSS#1 (BLE)	Low CH	-17.06	8 dBm / 3kHz
	Middle CH	-17.22	
	High CH	-18.04	
DTSS#2 (LoRa)	Low CH	-3.75	
	Middle CH	-3.75	
	High CH	-4.65	

Note: The cable loss is taken into account in results.

For the measurement records, refer to the appendix B.

5.1.4 6dB Bandwidth (for DTSSs)

RESULT:
Pass
Test Specification

Reference standard : FCC Part 15.247(a)(2)
 RSS-247 Clause 5.2(a)

Test method : Sub-clause 8.3.1.1 of KDB558074 D01v05r02
 Sub-clause 11.9.1.1 of ANSI C63.10

Limits : > 500 KHz

Kind of test site : Shielded Room

Test Setup

Date of testing : Refer to test data

Input voltage : Fully charged battery

Operation mode : A.1, A.2

Test channel : Low / Middle / High

Ambient temperature : 25 °C

Relative humidity : 56 %

Atmospheric pressure : 101 kPa

For details refer to following test result.

Table 8: Test Result of 6dB Bandwidth

Test Mode	Test Channel	6dB Bandwidth (kHz)	Limit
DTSSs#1 (BLE)	Low CH	542.0	> 500KHz
	Middle CH	539.5	
	High CH	532.0	
DTSSs#2 (LoRa)	Low CH	624.4	
	Middle CH	621.9	
	High CH	629.4	

For the measurement records, refer to the appendix B.

5.1.5 99% Bandwidth (for DTSSs and FHSs)

RESULT:
Pass
Test Specification

Test standard	: RSS-Gen Clause 6.7
Test method	: Sub-clause 6.9.3 of ANSI C63.10: 2013
Kind of test site	: Shielded Room

Test Setup

Date of testing	: Refer to test data
Input voltage	: Fully charged battery
Operation mode	: A
Test channel	: Low / Middle / High
Ambient temperature	: 25 °C
Relative humidity	: 56 %
Atmospheric pressure	: 101 kPa

For details refer to following test result.

Table 9: Test Result of 99% Bandwidth

Test Mode	Test Channel	99% Bandwidth (KHz)	Limit
DTSS#1 (BLE)	Low CH	1038.35	/
	Middle CH	1041.97	
	High CH	1041.97	
DTSS#2 (LoRa)	Low CH	506.99	
	Middle CH	514.49	
	High CH	534.47	
FHSs#1 (LoRa)	Low CH	126.63	
	Middle CH	126.63	
	High CH	126.63	
FHSs#2	Low CH	104.20	
	Middle CH	104.20	
	High CH	104.20	
FHSs#3	Low CH	156.48	
	Middle CH	157.38	
	High CH	158.29	
FHSs#4	Low CH	252.35	
	Middle CH	251.45	
	High CH	253.26	

For the measurement records, refer to the appendix B and C.

5.1.6 20dB Bandwidth (for FHSs)

RESULT:
Pass
Test Specification

Test standard : FCC Part 15.247(a)(1)(i)
RSS-247 Clause 5.1(c)

Test method : Sub-clause 6.9.2 of ANSI C63.10: 2013

Limits : < 500KHz

Kind of test site : Shielded Room

Test Setup

Date of testing : Refer to test data

Input voltage : Fully charged battery

Operation mode : A.3

Test channel : Low / Middle / High

Ambient temperature : 25 °C

Relative humidity : 56 %

Atmospheric pressure : 101 kPa

For details refer to following test result.

Table 10: Test Result of 20dB Bandwidth

Test Mode	Test Channel (MHz)	20dB Bandwidth (kHz)	Limit
FHSs#1 (LoRa)	Low CH	144.86	< 500KHz
	Middle CH	143.61	
	High CH	143.61	
FHSs#2	Low CH	113.39	
	Middle CH	107.89	
	High CH	107.89	
FHSs#3	Low CH	166.71	
	Middle CH	167.33	
	High CH	167.96	
FHSs#4	Low CH	256.62	
	Middle CH	255.37	
	High CH	255.37	

For the measurement records, refer to the appendix C.

5.1.7 Carrier Frequency Separation (for FHSs)**RESULT:****Pass****Test Specification**

Test standard	: FCC Part 15.247(a)(1) RSS-247 Clause 5.1(b)
Test method	: Sub-clause 7.8.2 of ANSI C63.10: 2013
Limits	: $\geq 25\text{kHz}$ or 20dB bandwidth, whichever is greater
Kind of test site	: Shielded Room

Test Setup

Date of testing	: Refer to test data
Input voltage	: Fully charged battery
Operation mode	: B
Test channel	: Low / Middle / High
Ambient temperature	: 25 °C
Relative humidity	: 56 %
Atmospheric pressure	: 101 kPa

For details refer to following test result.

Table 11: Test Result of Carrier Frequency Separation

Test Mode	Test Channel	Measured Channel Separation (KHz)	Limit (kHz)
FHSs#1 (LoRa)	Low Channel	199.99	≥ 144.86
	Adjacency Channel		
	Middle Channel	199.99	
	Adjacency Channel		
	High Channel	200.00	
	Adjacency Channel		
FHSs#2	Low Channel	199.99	≥ 113.39
	Adjacency Channel		
	Middle Channel	200.0	
	Adjacency Channel		
	High Channel	200.0	
	Adjacency Channel		
FHSs#3	Low Channel	399.96	≥ 167.96
	Adjacency Channel		
	Middle Channel	399.99	
	Adjacency Channel		
	High Channel	400.00	
	Adjacency Channel		
FHSs#4	Low Channel	499.98	≥ 256.62
	Adjacency Channel		
	Middle Channel	499.97	
	Adjacency Channel		
	High Channel	499.99	
	Adjacency Channel		

For the measurement records, refer to the appendix C.

5.1.8 Number of Hopping Frequency (for FHSs)

RESULT:
Pass
Test Specification

Test standard	: FCC part 15.247(a)(1)(i) RSS-247 Clause 5.1(c)
Test method	: Sub-clause 7.8.3 of ANSI C63.10: 2013
Limits	: ≥ 50 hopping frequencies for 20dB BW less than 250kHz : ≥ 25 hopping frequencies for 20dB BW greater than 250kHz
Kind of test site	: Shielded Room

Test Setup

Date of testing	: Refer to test data
Input voltage	: Fully charged battery
Operation mode	: B
Ambient temperature	: 25 °C
Relative humidity	: 56 %
Atmospheric pressure	: 101 kPa

For details refer to following test result.

Table 12: Test Result of Number of Hopping Frequency

Test Mode	Frequency Range	Measured Quantity of Hopping Channel	Limit
FHSs#1(LoRa)	902.2 MHz to 927.8 MHz	129	≥ 50
FHSs#2	902.2 MHz to 927.8 MHz	129	≥ 50
FHSs#3	902.4 MHz to 927.6 MHz	64	≥ 50
FHSs#4	902.5 MHz to 927.5 MHz	51	≥ 25

For the measurement records, refer to the appendix C.

5.1.9 Channel Occupancy Time (for FHSs)

RESULT:
Pass
Test Specification

Test standard : FCC part 15.247(a)(1)(i)
RSS-247 Clause 5.1(c)

Test method : Sub-clause 7.8.4 of ANSI C63.10: 2013

Limits : < 0.4s

Kind of test site : Shielded Room

Test Setup

Date of testing : Refer to test data

Input voltage : Fully charged battery

Operation mode : B

Test channel : Low / Middle / High

Ambient temperature : 25 °C

Relative humidity : 56 %

Atmospheric pressure : 101 kPa

Note:

Dwell time = Pulse width x Number of channels in Period

For details refer to following test result.

Table 13: Test Result of Time of Occupancy

Test Mode	Test Channel	Pulse Width(ms)	Number of Channels	Period (S)	Channel Occupancy Time(s)	Limit (s)
FHSs#1(LoRa)	Middle CH	330.0	1	20s	0.330	0.4s
FHSs#2	Middle CH	290.0	1	20s	0.290	0.4s
FHSs#3	Middle CH	308.8	1	20s	0.309	0.4s
FHSs#4	Middle CH	310.0	1	10s	0.310	0.4s

For the measurement records, refer to the appendix C.

5.1.10 Conducted Spurious Emissions (for DTSS and FHSs)**RESULT:****Pass****Test Specification**

Test standard	: FCC Part 15.247(d) RSS-247 Clause 5.5
Test method	: Sub-clause 8.5 of KDB 558074 D01 v05r02 Sub-clause 11.11 of ANSI C63.10: 2013
Limits	: 20dB (below that in the 100kHz bandwidth within the band that contains the highest level of the desired power); In addition, radiated emissions which fall in the restricted bands, must also comply with the radiated emission limits specified in 15.209(a)
Kind of test site	: Shielded Room

Test Setup

Date of testing	: Refer to test data
Input voltage	: Fully charged battery
Operation mode	: A
Test channel	: Low / Middle / High
Ambient temperature	: 25 °C
Relative humidity	: 56 %
Atmospheric pressure	: 101 kPa

Test results of 100kHz Bandwidth of Frequency Band Edge by Conducted method refer to test plots, and compliance is achieved as well.

For the measurement records, refer to the appendix B and C.

5.1.11 Radiated Spurious Emission (for DTSS and FHSS)**RESULT:****Pass****Test Specification**

Test standard	: FCC Part 15.247(d) & FCC Part 15.205 RSS-247 Clause 3.3
Test method	: Sub-clause 8.6 of KDB 558074 D01 v05r02 Sub-clause 11.12.1 of ANSI C63.10: 2013
Limits	: FCC Part 15.209(a) RSS-Gen Table 5
Kind of test site	: 3m Semi-anechoic Chamber

Test Setup

Date of testing	: Refer to test data
Input voltage	: Fully charged battery
Operation mode	: A
Test channel	: Low / Middle / High
Ambient temperature	: 24 °C
Relative humidity	: 45 %
Atmospheric pressure	: 101 kPa

Remark:

Testing was carried out within frequency range 9kHz to the tenth harmonics. Only the worst case spurious emissions configuration of the each mode were reported.

For the measurement records, refer to the appendix D.

5.1.12 Conducted Emission on AC Mains (for DTs and FHSs)**RESULT:****N/A****Test Specification**

Test standard	: FCC Part 15.207(a) & FCC Part 15.107(a) RSS-Gen Clause 8.8 & ICES-003
Test method	: Sub-clause 6.2 of ANSI C63.10: 2013 Sub-clause 7 of ANSI C63.4: 2014
Frequency range	: 0.15 – 30MHz
Limits	: FCC Part 15.207(a) & FCC Part 15.107(a) RSS-Gen Clause 8.8 Table 4 & ICES-003 Table 2
Kind of test site	: Shielded Room

Battery powered device, no test required.

5.1.13 Radiated Emission**RESULT:****Pass****Test Specification**

Test standard	: FCC Part 15.109(a) ICES-003
Test method	: Sub-clause 8 of ANSI C63.4: 2014
Frequency range	: 30 - 6000MHz
Classification	: Class B
Limits	: FCC Part 15.109(a) ICES-003 Table 5 & Table 7
Kind of test site	: 3m Semi-anechoic Chamber

Test Setup

Date of testing	: Refer to test data
Input voltage	: Fully charged battery
Operation mode	: F
Earthing	: Not connected
Ambient temperature	: 24 °C
Relative humidity	: 53 %
Atmospheric pressure	: 101 kPa

For the measurement records, refer to the appendix E.

6 Safety Human Exposure

6.1 Radio Frequency Exposure Compliance

6.1.1 Electromagnetic Fields

RESULT:**Pass****Test Specification**

Test standard

: CFR47 FCC Part 2: Section 2.1091
CFR47 FCC Part 1: Section 1.1310
FCC KDB Publication 447498 v06, section 7
RSS-102 Issue 5 March 2015, section 2.5.2

➤ FCC requirements

FCC requirement: Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess limit for maximum permissible exposure. In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1091 this device has been defined as a mobile device whereby a distance of 20cm normally can be maintained between the user and the device.

MPE Calculation Method according to KDB 447498 v06Power Density: $S_{(mW/cm^2)} = PG/4\pi R^2$ or $EIRP/4\pi R^2$

Where:

S = power density (mW/cm²)

P = power input to the antenna (mW)

G = power gain of the antenna in the direction of interest relative to an isotropic radiator

R = distance to the center of radiation of the antenna (cm)

From the peak RF output power, the minimum mobile separation distance, d=20 cm, as well as the antenna gain (Max. 1.0 dBi for BLE, Max 3 dBi for DTSS and FHSs), the RF power density can be calculated as below:

$$S_{(mW/cm^2)} = PG/4\pi R^2$$

a) EUT RF Exposure Evaluation standalone operations

Test Mode	Measured Peak Power		Antenna Gain (dBi)	Measured e.i.r.p (mW)		$S_{(mW/cm^2)} = \frac{PG}{4\pi R^2}$	Limit (mW/cm ²)
	(dBm)	(mW)		(dBm)	(mW)		
DTSS#1(BLE)	-9.82	0.104	1	-8.82	0.131	0.00003	1.0
DTSS#2(LoRa)	16.01	39.902	3	19.01	79.616	0.01585	0.601
FHSS#1(LoRa)	16.17	41.400	3	19.17	82.604	0.01644	0.601
FHSS#2	16.20	41.687	3	19.20	83.176	0.01656	0.601
FHSS#3	16.19	41.591	3	19.19	82.985	0.01652	0.601
FHSS#4	16.23	41.976	3	19.23	83.753	0.01667	0.601

b) EUT RF Exposure Evaluation simultaneous transmission operations

Simultaneous transmission mode	The sum of the ratios	Result
BLE + DTSSs	$0.00003/1 + 0.01585/0.601 < 1$	Pass
BLE + FHSSs	$0.00003/1 + 0.01667/0.601 < 1$	Pass

➤ **IC requirements:** The EUT shall comply with the requirement of RSS-102 section 2.5.2.

Exemption from Routine Evaluation Limits – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;

- RF exposure evaluation exempted power for BLE: 2.670 W
- RF exposure evaluation exempted power for DTSSs and FHSs: 1.37 W

a) EUT RF Exposure Evaluation standalone operations:

Test Mode	Measured Peak Power		Antenna Gain (dBi)	Measured e.i.r.p (mW)	
	(dBm)	(W)		(dBm)	(W)
DTSSs#1(BLE)	-9.82	0.10	1	-8.82	0.00013
DTSSs#2 (LoRa)	16.01	39.90	3	19.01	0.07962
FHSs#1(LoRa)	16.17	41.40	3	19.17	0.08260
FHSs#2	16.20	41.69	3	19.20	0.08318
FHSs#3	16.19	41.59	3	19.19	0.08299
FHSs#4	16.23	41.98	3	19.23	0.08375

b) EUT RF Exposure Evaluation simultaneous transmission operations

Simultaneous transmission mode	The sum of the ratios	Result
BLE + DTSSs	$0.00013/2.67 + 0.07962/1.37 < 1$	Pass
BLE + FHSs	$0.00013/2.67 + 0.08375/1.37 < 1$	Pass

The e.i.r.p. for BLE, DTSSs and FHSs are less than the RF exposure evaluation exempted power. So RF exposure evaluation is not required.

“RF Radiation Exposure Statement Caution: This Transmitter must be installed to provide a separation distance of at least 20 cm from all persons.”

7 Photographs of the Test Set-Up

For photographs of the test set-up, refer to the appendix A.

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