RF Exposure Evaluation Declaration

Product Name	:	Bluetooth 5.0 BLE Data Module
Trade Name	:	Laird Connectivity
Model No.	:	BL653

Applicant	:	Laird Connectivity, Inc.
Address	:	W66N220 Commerce Court, Cedarburg, Wisconsin 53012, USA

Date of Receipt	:	Mar. 02, 2020
Issued Date	:	Jun. 02, 2020
Report No.	:	2030001R-RFASP05V00
Report Version	:	V1.0

Testing Laboratory
3024

Test Result for Inspection

Issued Date : Jun. 02, 2020

Report No. : 2030001R-RFASP05V00

Product Name	:	Bluetooth 5.0 BLE Data Module
Applicant	:	Laird Connectivity, Inc.
Address	:	W66N220 Commerce Court, Cedarburg, Wisconsin 53012, USA
Manufacturer	:	Laird Connectivity, Inc.
Trade Name	:	Laird Connectivity
Model No.	:	BL653
EUT Voltage	:	DC 3.3V
Testing Voltage	:	DC 3.3V
Applicable Standard	:	AS/NZS 2772.2:2016/Amdt 1:2018 Radiofrequency fields - Principles and methods of measurement and computation - 3 kHz to 300 GHz
Test Result	:	Complied

Tested By : Elwin Lin

(Elwin Lin / Engineer)

Approved By : Louis Hsu

(Louis Hsu / Deputy Manager)

Revision History

Report No.	Version	Description	Issued Date
2030001R-RFASP05V00	V1.0	Initial issue of report	Jun. 02, 2020

1.1. Test Facility

Ambient conditions in the laboratory:

Items	Test Item	Required	Test Site
Temperature (°C)	RF Exposure	15 - 35	3
Humidity (%RH)		25 - 75	

Note: Test site information refers to Laboratory Information.

Laboratory Information

The address and introduction of DEKRA Testing and Certification Co., Ltd. laboratories can be founded in our Web site : http://www.dekra.com.tw

If you have any comments, please don't hesitate to contact us. Our test sites as below:

Test Laboratory	DEKRA Testing and Certification Co., Ltd.
Address	1. No. 75-2, 3rd Lin, WangYe Keng, Yonghxing Tsuen, Qionglin Shiang, Hsinchu County 307, Taiwan, R.O.C. 2. No.372, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County 31061, Taiwan, R.O.C. 3. No.372-2, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County 31061, Taiwan, R.O.C.
Phone number	1. +886-3-592-8858 2. +886-3-582-8001 3. +886-3-582-8001
Fax number	1. +886-3-592-8859 2. +886-3-582-8958 3. +886-3-582-8958
E mail address	info.tw@dekra.com
Website	http://www.dekra.com.tw

1.2. List of Test Equipment

RF Exposure / SR10-H

Instrument	Manufacturer	Model No.	Serial No.	Cal. Date	Next Cal. Date
Temperature & Humidity Test Chamber	KSON	THS-B4T-150	A0401	2020/01/06	2021/01/06
USB Power Sensor	Keysight	U2021XA	MY54110016	N/A	N/A
USB Power Sensor	Keysight	U2021XA	MY54070005	N/A	N/A
USB Power Sensor	Keysight	U2021XA	MY54080017	N/A	N/A
USB Power Sensor	Keysight	U2021XA	MY54120005	N/A	N/A
MIMO Power Switch Box	Pallas	4PS6A-1	TW5451093	N/A	N/A

Note: All equipment upon which need to calibrated are with calibration period of 1 year.

1.3. Uncertainty

Test item	Uncertainty
RF Exposure	± 1.27 dB

Note: Determining compliance shall be based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty.

2. Standards, Regulations and Definitions

2.1. Reference Standards and Regulations

Human Exposure Standard published by ARPANSA

The Radiation Protection Standard for Maximum Exposure Levels to Radio frequency Fields –3 kHz to 300 GHz (2002), published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and referred to as the ARPANSA standard, sets limits for human exposure to RF fields to prevent adverse health effects. The ARPANSA Standard specifies limits for occupational and general public exposure. It also stipulates equipment and usage parameters in order to assist in the determination of compliance with the specified limits.

Portable Radio Transmitters, Mobile Stations and RF Transmitter Devices

The Australian Communications Authority (ACA) Radiocommunications (Electromagnetic Radiation - Human Exposure) Standard 2003 is the mandatory standard for equipment compliance with the Radiocommunications Act 1992. It mandates the provisions of the ARPANSA standard for specific devices equipment employing radio transmitters. Examples include mobile phones, cordless phones, walkie-talkies, wireless local area network equipment and wireless microphones.

Apparatus and Transmitters

The ACA Radiocommunications Licence Conditions (Apparatus Licence) Determination 2003 known as the LCD, sets out the conditions for the ACA licence to operate transmitting equipment. To ensure that members of the general public are not exposed to potentially hazardous RF fields, the LCD mandates the General Public/non-occupational limits of the ARPANSA standard for individual transmitting antennas.
The ACA website has further information:
http://www.aca.gov.au/standards/index.htm.

RF Field Measurements and Evaluations- Methodology

The Australian Standard AS/NZS 2772.2: 2011 Radio Frequency Fields-
Principles and methods of measurement and computation 3 kHz to 300 GHz, specifies techniques and instrumentation for the measurement of potentially hazardous electromagnetic sources. The measurements were performed in accordance with this standard.

2.2. Definitions

Occupational Exposure

No occupationally exposed person, aware user or person in a controlled area, is to be exposed to RF fields that exceed the occupational exposure limits. Occupational exposure may only occur when the person being exposed is a trained RF worker.

An RF worker is a person who may be exposed to RF fields under controlled conditions, in the course of and intrinsic to the nature of their work. Such persons are subject to the requirements of Section 5.1 of the ARPANSA standard.

General Public Exposure

No member of the general public is to be exposed to RF fields in excess of the general public limits.

This definition excludes occupational exposure, exposure of aware users, and medical exposure.

This definition includes all persons that are not trained RF workers that may be exposed to RF fields.

Reference Levels – General Public/Non-occupational

Reference levels for Non-occupational/General Public Exposure means the reference levels mentioned in section 2.4 of the ARPANSA standard and in Tables 7 and 8, and the notes to Tables 7 and 8 of the ARPANSA standard.

2.3. Exposure Limits for This Survey

The worst case maximum exposure levels (Non Occupational) are give in Table 7 of the ARPANSA standard as shown below.

The limits are given as Reference Levels which vary with the frequency. The General Public exposure category is applicable for this survey.

Figure 1

ARPANSA Standard, Table 7: Reference Levels for Time Averaged Exposure to RMS Electric and Magnetic Fields (Unperturbed Fields)

Exposure category	Frequency range	E-field strength (V/m rms)	H-field strength (A/m rms)	Equivalent plane wave power flux density Seq (W/m²)
Occupational	100 kHz – 1 MHz	614	1.63 / f	-
	1 MHz – 10 MHz	614 / f	1.63 / f	1000 / f (see note 5)
	10 MHz – 400 MHz	61.4	0.163	10 (see note 5)
	400 MHz – 2 GHz	$3.07 \times f^{0.5}$	$0.00814 \times f^{0.5}$	f / 40
	2 GHz – 300 GHz	137	0.364	50
General	100 kHz – 1 MHz	86.8	4.86	-
	100 kHz – 1 MHz	86.8	0.729 / f	-
	1 MHz – 10 MHz	$86.8 / f^{0.5}$	0.729 / f	-
	10 MHz – 400 MHz	27.4	0.0729	2 (see note 6 and 7)
	400 MHz – 2 GHz	$1.37 \times f^{0.5}$	$0.00364 \times f^{0.5}$	f / 200
	2 GHz – 300 GHz	61.4	0.163	10

Notes:

1) f is the frequency in MHz.
2) For frequencies between 100 kHz and 10 GHz, Seq, E² and H² must be averaged over any 6 minute period.
3) For frequencies exceeding 10 GHz, Seq, E² and H² must be averaged over any 9.6 × 104 / f1.05 minute period (see note 1).
4) Spatial averaging of the time averaged reference levels of Table 7 should be performed according to the requirements of clause 2.7.
5) For occupational exposure, E and H reference levels of Table 7 are given in plane wave ratio at frequencies greater than or equal to 1 MHz. However, for many occupational exposure situations, equivalent plane wave power flux density is not an appropriate metric if 'far-field' exposure conditions do not apply. Survey meters may be calibrated in terms of W/m², but both E and H will generally require independent measurement and evaluation if measured in the near-field.
6) For general public exposure E and H reference levels of Table 7 are given in plane wave ratioat frequencies greater than or equal to 10 MHz. However, equivalent plane wave power flux density is not an appropriate metric if 'far-field' exposure conditions do not apply. Survey meters may be calibrated in terms of W/m², but both E and H will generally require independent measurement and evaluation if measured in the near-field.
7) This note is not an extract from the ARPANSA standard. The frequency range 10 MHz to 400 MHz has the most conservative (lowest) reference levels. When broadband measurements are performed using a broadband field probe, compliance is established for the frequency range of the broadband probe if the E-field level is less than 27.4 V/m and the H-Field level is less than 0.0729 A/m.

Figure 2

ARPANSA Standard Table 8: Reference Levels for Exposure to Instantaneous RMS Electric and Magnetic Fields (Unperturbed Fields)

Exposure category	Frequency range	E-field strength (V/m rms)	H-field strength (A/m rms)	Equivalent plane wave power flux density Seq (W/m²)
Occupational	3 kHz – 65 kHz	614	25.0	-
	65 kHz – 100 kHz	614	1.63 / f	-
	100 kHz – 1 MHz	$3452 \times f^{0.75}$	$9.16 / f^{0.25}$	-
	1 MHz – 10 MHz	$3452 / f^{0.25}$	$9.16 / f^{0.25}$	$(109 / f)^{0.5}$ (see note 4)
	10 MHz – 400 MHz	1941	5.15	10 000 (see note 4)
	400 MHz – 2 GHz	$97 \times f^{0.5}$	$0.258 \times f^{0.5}$	25 × f
	2 GHz – 300 GHz	4340	11.5	50 000
General	3 kHz – 65 kHz	86.8	4.86	-
	65 kHz – 100 kHz	$488 \times f^{0.75}$	4.86	-
	100 kHz – 1 MHz	$488 \times f^{0.75}$	$3.47 / f^{0.178}$	-
	1 MHz – 10 MHz	$488 \times f^{0.25}$	$3.47 / f^{0.178}$	-
	10 MHz – 400 MHz	868	2.30	2 000 (see note 5)
	400 MHz – 2 GHz	$43.4 \times f^{0.5}$	$0.115 \times f^{0.5}$	5 × f
	2 GHz – 300 GHz	1941	5.15	10 000

Notes:

1) f is the frequency in MHz.
2) For the specific case of occupational exposure to frequencies below 100 kHz, and where adverse effects from contact with passively or actively energised conductive objects can be excluded such that Table 9 would not apply (refer Note 3 Table 9), the derived electric field strength can be increased by a factor of 2.
3) The E and H reference levels in Table 8 are instantaneous rms values and for purposes of compliance determination, measurements are to be rms averaged over any 1 μs period. However, at frequencies below 100 kHz, measurements may be rms averaged over any 100 μs period or, below 10 kHz, at least one single cycle of the carrier frequency.
4) For occupational exposure, E and H reference levels of Table 8 are given in plane wave ratio at frequencies greater than or equal to 1 MHz. However, for many occupational exposure situations, equivalent plane wave power flux density is not an appropriate metric if 'far-field' exposure conditions do not apply. Survey meters may be calibrated in terms of W/m², but both E and H will generally require independent measurement and evaluation if measured in the near-field.
5) For general public exposure E and H reference levels of Table 8 are given in plane wave ratio at frequencies greater than or equal to 10 MHz. However, equivalent plane wave power flux density is not an appropriate metric if 'far-field' exposure conditions do not apply. Survey meters may be calibrated in terms of W/m², but both E and H will generally require independent measurement and evaluation if measured in the near-field.

3. Human Exposure to the Electromagnetic Fields

3.1. Calculation Models

This model is applicable in the far-field region and over-estimates in the radiating near-field region.

The power flux: $S = \frac{PG_{(\theta,\phi)}}{4\pi r^2}$

The electric field strength: $E = \frac{\sqrt{30PG_{(\theta,\phi)}}}{r}$

The magnetic field strength: $H = \frac{E}{\eta_0}$

P = input power of the antenna
G = antenna gain relative to an isotropic antenna
θ,ϕ = elevation and azimuth angles (Figure 8)
r = distance from the antenna to the point of investigation
η_0 = free space wave impedance = 120 π Ω

3.2. Human Exposure Assessment

EUT parameter (data from the separate report)	
Max average output power in Watt (TP) = Transmitted Power in Watt (TP) *Antenna Gain(G)	7.98 dBm (6.281 mW)
Antenna gain (G)	2 dBi; {linear gain: 1.585}
Minimum distance in centimeter (D) (from transmitting structure to the human body)	20cm

Test Results

Since average output power at worst case is

BLE High Power (8dBm)				
Mode	E.I.R.P. (dBm)	E.I.R.P. (mW)	E-Field Strength (V/m)	Limit (V/m)
2402_1Mbps	9.900	9.772	2.707	67.389
2440_1Mbps	9.980	9.954	2.732	67.920
2480_1Mbps	9.890	9.750	2.704	68.474
2402_2Mbps	9.900	9.772	2.707	67.389
2440_2Mbps	9.980	9.954	2.732	67.920
2480_2Mbps	9.890	9.750	2.704	68.474

BLE Low Power (-40dBm)				
Mode	E.I.R.P. (dBm)	E.I.R.P. (mW)	E-Field Strength (V/m)	Limit (V/m)
2402_1Mbps	-39.640	0.0001	0.009	67.389
2440_1Mbps	-39.540	0.0001	0.009	67.920
2480_1Mbps	-40.230	0.0001	0.008	68.474
2402_2Mbps	-37.830	0.0002	0.011	67.389
2440_2Mbps	-38.150	0.0002	0.011	67.920
2480_2Mbps	-38.860	0.0001	0.010	68.474

Note:

1. The antenna information is from the customer declaration.
2. The EUT description is from the customer declaration.
3. The product specification and testing instructions for the EUT declared in the report are provided by the manufacturer who will take all responsibilities for the accuracy.
4. The results are evaluated using the maximum power.

The maximum E-field strength doesn't exceed the exempt condition, 61.4 V/m specified in ARPANSA Standard.

RF exposure assessment has been performed to prove that this unit will not generate the harmful EM emission above the reference level as specified in ARPANSA Standard.