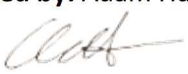
Test Report TR3664 BL652C

Equipment Under Test:	BL652-SC
Requirement(s):	FCC 2.1091 RSS-102
Test Date(s):	3/9/2023 – 3/21/2023
Prepared for:	Laird Connectivity Attn: Jonathan Kaye W66 N220 Commerce Ct. Cedarburg, WI 53012

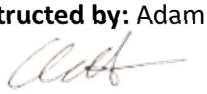
Report Issued by: Adam Hauke, EMC Engineer

Signature:  Date: 09/11/2023

Report Reviewed by: Adam Alger, Laboratory Manager

Signature:  Date: 09/11/2023

Report Constructed by: Adam Hauke, EMC Engineer

Signature:  Date: 09/11/2023

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Laird Connectivity Test Services in Review

The Laird Connectivity LLC laboratory located at W66 N220 Commerce Court Cedarburg, Wisconsin, 53012 USA is recognized through the following organizations:

Certificate #1255.01

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025:2017 with Electrical (EMC) Scope

A2LA Certificate Number: 1255.01

Scope of accreditation includes all test methods listed herein unless otherwise noted

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Federal Communications Commission (FCC) – USA

Accredited Test Firm Registration Number: 953492

Recognition of two 3 meter Semi-Anechoic Chambers

Innovation, Science and Economic Development Canada

Accredited U.S. Identification Number: US0218

Recognition of two 3 meter Semi-Anechoic Chambers

1 TEST REPORT SUMMARY

During **March 9th, 2023 to March 22nd, 2023** the Equipment Under Test (EUT), **BL652-SC**, as provided by **Laird Connectivity** was tested to the following requirements for the purpose of a Class 2 Permissive Change to add an antenna:

Requirements	Description	Method	Compliant
FCC 1.1307, 2.1091, 2.1093	Radiofrequency Radiation Exposure Limits	FCC KDB 447498	Yes
ISED Canada: RSS-102	Radiofrequency Radiation Exposure Limits	RSS-102 § 2.5.2	Yes

Notice:

The results relate only to the item tested as configured and described in this report. Any additional configurations, modes of operation, or modifications made to the equipment under test after the specified test date(s) are at the decision of the client and may not apply to the data seen in this test report.

The decision rule for Pass / Fail assessment to the specification or standard listed in this test report has been agreed upon by the client and laboratory to be as follows:

Measurement Type	Rule
Emissions – Amplitude	1 dB below specified limit
Emissions – Frequency	1% less than the specification
Immunity	Tested at specified level

2 CLIENT INFORMATION

Company Name	Laird Connectivity
Contact Person	Jonathan Kaye
Address	W66N220 Commerce Court Cedarburg, WI, 53012

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	BL652-SC
Model Number	BL652-SC
Serial Number	1222195
FCC ID	SQGBL652
IC ID	3147A-BL652

2.2 Product Description

Bluetooth Low Energy Module operating in the 2.4 GHz range.

2.3 Modifications Incorporated for Compliance

None noted at time of test

2.4 Deviations and Exclusions from Test Specifications

None noted at time of test

2.5 Additional Information

Bluetooth LE (Low Energy) 1 and 2 Mbps. Channels tested: 0 (2402 MHz), 17 (2440 MHz), and 39 (2480 MHz).

3 AAA 1.5 V Batteries. Laird Connectivity Bluetooth Development Tools – 802.15.1 Dev Kit w/ BL652-SC used for programming. Dell Latitude 5480 laptop used to program radio.

BTLRU (Bluetooth Laird Regulatory Utility) Version 10.0.0.178 utilized to control radio.

2.6 Additional Information

This testing is for a permissive change to add the iFlex-Pifa Antenna, with an antenna gain of 3.1 dBi, to the list of antennas usable by the BL652-SC. EUT tested via Cabinet Radiation method.

3 REFERENCES

Publication	Edition	Date	AMD 1
eCFR	-	2023	-
RSS-247	2	2017	-
RSS-GEN	5	2018	2019
ANSI C63.10	-	2013	-
KDB 178919 D01	6	2015	-
RSS-102	5	2015	2021
KDB 447498	-	2015	-

4 UNCERTAINTY SUMMARY

Using the guidance of the following publications the calculated measurement uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k = 2.

References
CISPR 16-4-1
CISPR 16-4-2
CISPR 32
ANSI C63.23
A2LA P103
A2LA P103c
ETSI TR 100-028

Measurement Type	Configuration	Uncertainty ±
Radiated Emissions	Biconical Antenna	5.0 dB
Radiated Emissions	Log Periodic Antenna	5.3 dB
Radiated Emissions	Horn Antenna	4.7 dB
AC Line Conducted Emissions	Artificial Mains Network	3.4 dB
Telecom Conducted Emissions	Asymmetric Artificial Network	4.9 dB
Disturbance Power Emissions	Absorbing Clamp	4.1 dB
Radiated Immunity	3 Volts/meter	2.2 dB
Conducted Immunity	CDN/EM/BCI	2.4/3.5/3.4 dB
EFT Burst/Surge	Peak pulse voltage	164 volts
ESD Immunity	15 kV level	1377 Volts

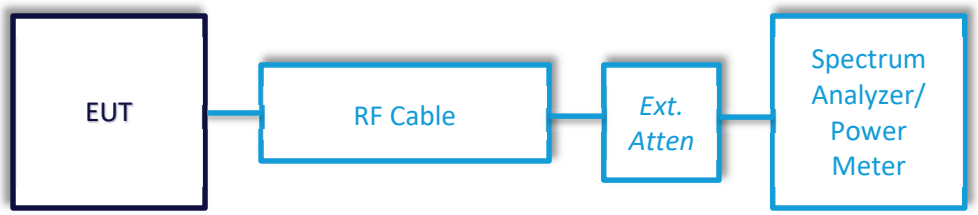
Parameter	ETSI U.C. ±	U.C. ±
Radio Frequency, from F0	$1x10^{-7}$	$0.55x10^{-7}$
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %

5 TEST DATA

5.1 Antenna Port Conducted Emissions

Description of Measurement	The direct measurement of emissions at the antenna port of the EUT is achieved by use of a RF connection to a spectrum analyzer or power meter. The cable and attenuator factors are loaded into the analyzer or power meter allowing for direct measurement readings without the need for further corrections.
Example Calculations	Measurement (dBm) + Cable factor (dB) + External Attenuator (dB) = Corrected Reading (dBm) Margin (dB) = Limit (dBm) – Corrected Reading (dBm)

Block Diagram



5.1.1 Antenna Port Conducted Emissions – RF Output Power

Operator	Anthony Smith	**QA**	Adam Alger
Temperature	20.8°C | 22.2°C	**R.H. %**	29.0% | 30.5%
Test Date	3/8/2023 | 03/22/2023	**Location**	RF Conducted Bench
Requirement	FCC 15.247 RSS-247	**Method**	ANSI C63.10

Limits: <30dBm

Test Parameters

Frequency	2400-2483.5 MHz	**Setup**	Conducted
RBW	3 MHz	**VBW**	50 MHz
Detector(s)	Peak	**Settings**	Trace Max Hold

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960172	Cable	A.H. Systems, Inc.	SAC-26G-1	387	3/22/2022	3/22/2023	Active Verification
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/12/2022	4/12/2023	Active Calibration

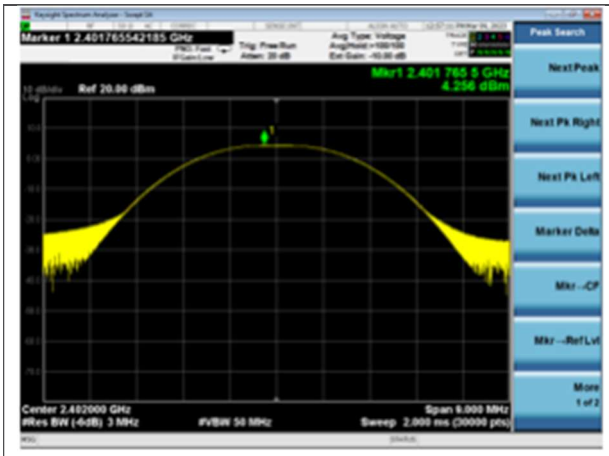
EUT Parameters

Input Power	12VDC	**Mode**	BLE 1Mbps
Frequency	2402	**Channel**	0

Data Table

Mode / Channel	Antenna Gain (dBi)	Output Power (dBm)	Limit (dBm)	Margin (dB)	Meas. Type
BLE 1M / 0	3.1	4.3	30.0	25.7	Peak

Plots



BLE 1M Channel 0

6 FCC RF EXPOSURE

6.1 Calculations

Prediction of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density
P = power input to the antenna
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

Maximum peak output power at antenna input terminal:	4.3 (dBm)
Tune up tolerance:	1.00 (dB)
Maximum peak output power at antenna input terminal:	2.692 (mW)
Antenna gain:	3.1 (dBi)
Maximum Antenna gain:	2.042 (numeric)
Prediction distance:	20 (cm)
Prediction frequency:	2402 (MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1.00 (mW/cm^2)
Power density at prediction frequency:	0.00166 (mW/cm^2)

7 ISED CANADA RF EXPOSURE

7.1 Calculations

Prediction of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density
P = power input to the antenna
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

Maximum peak output power at antenna input terminal:	4.3 (dBm)
Maximum peak output power at antenna input terminal:	0.002692 (mW)
Antenna gain:	3.1 (dBi)
Maximum Antenna gain:	2.042 (numeric)
Prediction distance:	0.2 (m)
Prediction frequency:	2402 (MHz)
MPE limit for uncontrolled exposure at prediction frequency:	2.68 ($1.31x10^{-2}*f^{0.6834}$)(W/m^2)
Power density at prediction frequency:	0.017 (W/m^2)

8 REVISION HISTORY

Version	Date	Notes	Person
0	09/11/2023	Initial Draft	Adam Hauke
1	09/11/2023	Final Draft	Adam Hauke

END OF REPORT