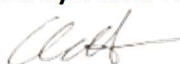




Test Report TR3664 BL652C

| | |
|------------------------------|---|
| 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 |

This test report may not be reproduced, except in full, without approval of Laird Connectivity LLC

| | | |
|-----------------------------|--------------|-----------------|
| Company: Laird Connectivity | Page 1 of 14 | Name: BL652-SC |
| Report: TR3664 BL652C | | Model: BL652-SC |
| Quote: NBO-12-2022-005678 | | Serial: 1222195 |

CONTENTS

| | |
|--|----|
| Contents..... | 2 |
| Laird Connectivity Test Services in Review | 3 |
| 1 Test Report Summary | 4 |
| 2 Client Information..... | 5 |
| 2.1 Equipment Under Test (EUT) Information..... | 5 |
| 2.2 Product Description | 5 |
| 2.3 Modifications Incorporated for Compliance..... | 5 |
| 2.4 Deviations and Exclusions from Test Specifications | 5 |
| 2.5 Additional Information..... | 5 |
| 2.6 Additional Information..... | 6 |
| 3 References | 7 |
| 4 Uncertainty Summary | 8 |
| 5 Test Data | 9 |
| 5.1 Antenna Port Conducted Emissions..... | 9 |
| 6 FCC Rf Exposure | 12 |
| 6.1 Calculations..... | 12 |
| 7 ISED Canada RF Exposure..... | 13 |
| 7.1 Calculations..... | 13 |
| 8 Revision History | 14 |

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:



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



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

| | | |
|-----------------------------|--------------|-----------------|
| Company: Laird Connectivity | Page 3 of 14 | Name: BL652-SC |
| Report: TR3664-BL652C | | Model: BL652-SC |
| Quote: NBO-12-2022-005678 | | Serial: 1222195 |

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.

| | | |
|-----------------------------|--------------|-----------------|
| Company: Laird Connectivity | Page 5 of 14 | Name: BL652-SC |
| Report: TR3664-BL652C | | Model: BL652-SC |
| Quote: NBO-12-2022-005678 | | Serial: 1222195 |

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.

| | | |
|-----------------------------|--------------|-----------------|
| Company: Laird Connectivity | Page 6 of 14 | Name: BL652-SC |
| Report: TR3664-BL652C | | Model: BL652-SC |
| Quote: NBO-12-2022-005678 | | Serial: 1222195 |

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 |

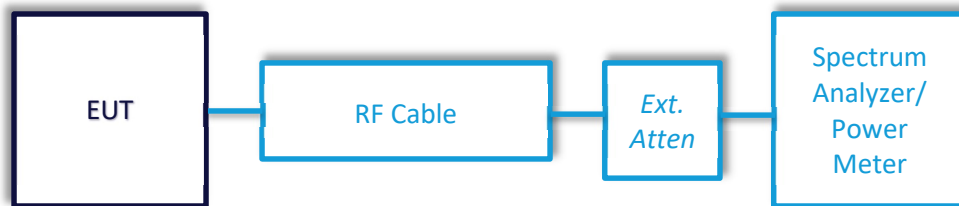
| Parameter | ETSI U.C. ± | U.C. ± |
|--|--------------------|-----------------------|
| Radio Frequency, from F0 | 1x10 ⁻⁷ | 0.55x10 ⁻⁷ |
| Occupied Channel Bandwidth | 5 % | 2 % |
| RF conducted Power (Power Meter) | 1.5 dB | 1.2 dB |
| RF conducted emissions (Spectrum Analyzer) | 3.0 dB | 1.7 dB |
| 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 | <p>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.</p> <p>The cable and attenuator factors are loaded into the analyzer or power meter allowing for direct measurement readings without the need for further corrections.</p> |
| Example Calculations | <p>Measurement (dBm) + Cable factor (dB) + External Attenuator (dB) = Corrected Reading (dBm)</p> <p>Margin (dB) = Limit (dBm) – Corrected Reading (dBm)</p> |

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 |

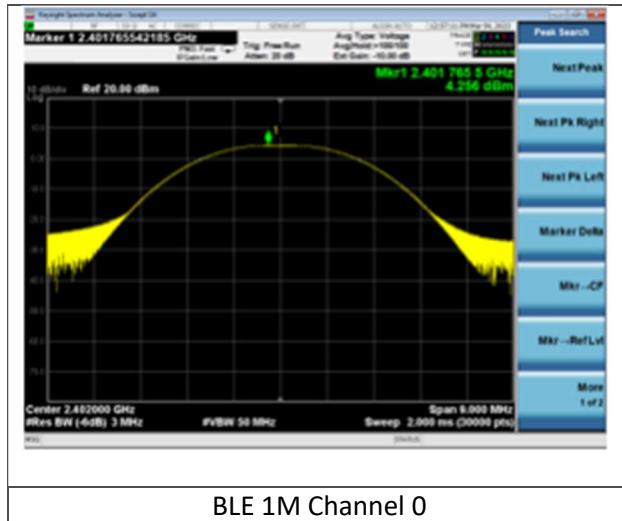
EUT Parameters

| | | | |
|--------------------|-------|----------------|-----------|
| 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