

BCycle, LLC BBT v2 27243 rev1.0 11411

Antenna Gain Report

Gain calculation based on RF Conducted and Effective Radiated Power (e.r.p.) measurements

(For the purpose of applying MPE-Based RF Exposure Test Exemption evaluation)

FCC ID: 2AHXD-5267706

Formal Name:	BBT
Kind of Equipment:	Bluetooth Low Energy (BLE) Transceiver
Frequency Range(s):	2402 – 2480 MHz
Test Configuration:	Table top, Stand-alone RF Conducted with temporary antenna port Radiated with on-board PCB trace antenna
Model Number(s):	BBT v2
Model(s) Tested:	BBT v2
Serial Number(s):	N/A
Date of Tests:	March 16, 2021, and August 22, 2022
Test Conducted For:	BCycle, LLC 801 W. Madison Street Waterloo, WI 53594, USA

NOTICE: This test report contains test data, photos, equipment lists, and/or other information regarding only the sample provided by the client for testing. This test report shall not be used to claim product approval or endorsement by any governmental, regulatory, or accrediting agency. Please see the "Description of Test Sample" page listed inside of this report.

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SIGNATURE PAGE

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CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

DLS Electronic Systems, Inc.

1250 Peterson Drive Wheeling, IL 60090 (and satellite locations as shown on the scope)

Fulfills the requirements of

ISO/IEC 17025:2017

and

U.S. Federal Communication Commission (FCC) EMC and Telecommunications (EC&T) Testing Designation Program

and Recognition of Telecommunications Testing - Innovation, Science, and Economic Development (ISED) Canada

and

FDA Accreditation Scheme for Conformity Assessment (ASCA) Pilot Program -Basic Safety and Essential Performance of Medical Electrical Equipment, Medical Electrical Systems, and Laboratory Medical Equipment

In the field of

TESTING

This certificate is valid only when accompanied by a current scope of accreditation document. The current scope of accreditation can be verified at <u>www.anab.org</u>.

R. Douglas Leonard Jr., VP, PILR SBU Expiry Date: 23 April 2024 Certificate Number: AT-1859



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-1AF Communiqué dated April 2017).

SATELLITE SITE

DLS Electronic Systems, Inc. (Oats site) 166 South Carter Genoa City, Wisconsin 53128 www.dlsemc.com

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1.0 Description of Test Sample

This module is part of a "kiosk" assembly located outdoors. The BLE module is connected to a PC through a USB cable. The PC is located inside the metal kiosk box, with the module mounted to the outside in a weathertight enclosure. The module scans for BLE devices with a particular service ID, connects to them and downloads a small amount of data, disconnects and then sends the data to the PC when requested. It is continuously scanning for BLE devices with which to connect.

2.0 Introduction

On March 16, 2021, and August 22, 2022, Peak Output Power measurements of the BBT, model BBT v2, as provided by BCycle, LLC were performed by personnel of D.L.S. Electronic Systems, Inc. These measurements were then ussed to calculate the antenna gain of the BBT's on-board PCB trace antenna. This calculated antenna gain will then be used (in a separate report) to show RF Exposure compliance using MPE-Based RF Exposure Test Exemptions.

3.0 Test Facilities

D.L.S. Electronic Systems, Inc. is a full-service EMC/Safety Testing Laboratory accredited to ISO 17025. ANAB Certificate and Scope can be viewed at <u>http://www.dlsemc.com/certificate</u>. Our facilities are registered with the FCC, ISED Canada, and VCCI.

Wisconsin Test Facility:

D.L.S. Electronic Systems, Inc. 166 S. Carter Street Genoa City, Wisconsin 53128

FCC Registration #497383 ISED Registration #2060A-1 Wheeling Test Facility: D.L.S. Electronic Systems, Inc. 1250 Peterson Drive Wheeling, IL 60090



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4.0 Test Equipment

A list of the equipment used can be found in the tables below. All primary equipment was calibrated against known reference standards with a verified traceable path to NIST.

RF Conducted Peak Output Power – Site G1 – Test Equipment: (Date Tested: March 16, 2021)

Description	Manufacturer	Model	Serial	Frequency Range	Cal	Cal Due
		Number	Number		Dates	Dates
Receiver	Rohde & Schwarz	ESI 40	837808/005	20 Hz-40 GHz	1-29-21	1-29-22
Cable	Micro-Coax	UFC142A	CBL-101	30 MHz – 40 GHz	5-12-20	5-12-21
Test Software	Rohde & Schwarz	ESK1	V1.7.1	N/A	N/A	N/A

Peak Effective Radiated Power (e.r.p.) – Site G1 – Test Equipment: (Date Tested: August 22, 2022)

Description	Manufacturer	Model Number	Serial Number	Frequency Range	Cal Dates	Cal Due Dates
Receiver	Rohde & Schwarz	ESI 40	837808/005	20 Hz-40 GHz	2-8-22	2-8-23
Horn Antenna	EMCO	3115	9502-4451	1 GHz-18 GHz	10-7-21	10-7-23
Cable	Micro-Coax	UFB311A	CBL-096	30 MHz-18 GHz	5-24-22	5-24-23
Signal Generator	Rohde & Schwarz	SMR40	100092	1 GHz-40 GHz	3-29-22	3-29-23
Substitution Horn Antenna	EMCO	3115	6204	1 GHz-18 GHz	10-7-21	10-7-23
Substitution Cable	Mini-Circuits	APC-15FT- NMNM	0813A	30 MHz-18 GHz	5-23-22	5-23-23
Test Software	Rohde & Schwarz	ESK1	V1.7.1	N/A	N/A	N/A



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5.0 Test Arrangements

All measurements were performed at D.L.S. Electronic Systems, Inc. and set up according to ANSI C63.10-2013. See Section A for photos of the test set up.

Radiated Measurement Arrangement:

ANSI C63.10-2013, Section 6.3 – Radiated emissions testing, and Section G.5.3 – EUT power measured in a radiated test configuration using the signal (antenna) substitution techniques.

RF Conducted Measurement Arrangement:

ANSI C63.10-2013, Section 6.7 – Antenna-port conducted emission measurements, and Section 11.9.1.1 – Maximum peak conducted output power, RBW \geq DTS bandwidth.

6.0 Test Conditions

Temperature and Humidity:

72 °F at 51% RH

7.0 Additional Descriptions

In following ANSI C63.10 requirements, the EUT was programmed for continuous transmission (100% duty cycle) on the lowest, middle, and highest channels of operation in the 2.4 GHz BLE frequency band. The test equipment was set up with a detector bandwidth that is greater than the emission bandwidth of the EUT. All measurements were taken with a Peak detector and Maxhold function.

For RF Conducted measurements, a temporary SMA connector was soldered in place of the antenna. An RF cable was connected to the SMA connector and directly to the input of the spectrum analyzer. The output power of the EUT is low enough that no external attenuators were needed. Correction factors for the loss of the RF cable were downloaded into the spectrum analyzer so that the values displayed on the spectrum analyzer are already corrected for cable loss, and no further corrections are needed.



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Additional Descriptions – continued

For Radiated measurements, the EUT was tested while transmitting from the on-board trace antenna. The device was set up on a non-conductive table for testing purposes. The EUT was rotated through three orthogonal axes to find worst-case field strength levels which are recorded in this report.

8.0 **Results**

Measurements were performed using both RF conducted and Effective Radiated Power (e.r.p.) methods. From these measurements, the antenna gaind in dBd was calculated. Graphical and tabular data can be found in Sections B and C at the end of this report. See Section D for measurement uncertainty.

The highest peak gain of the EUT antenna was measured and calculated to be 3.64 dBd.

9.0 Conclusion

Peak Output Power measurements of the BBT, model BBT v2, as provided by BCycle, LLC were performed both with and without the antenna connected (e.r.p. and RF conducted). From these measurements the maximum peak antenna gain of the on-board PCB trace antenna was determined. This antenna gain will be used (in a separate report) to show RF Exposure compliance using MPE-Based RF Exposure Test Exemptions.



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Section A – Test Setup Photos

Date:	03-16-2021
Photo Description:	<u>RF Conducted Measurements</u>





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Photo Description:	Radiated (e.r.p.) Measurements
Date:	08-22-2022
Name:	BBT
Model:	BBT v2
Company:	BCycle





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Name:	BBT
Date:	08-22-2022
Photo Description:	Radiated (e.r.p.) Measurements – Position 1





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Company:	BCycle
Model:	BBT v2
Name:	BBT
Date:	08-22-2022
Photo Description:	Radiated (e.r.p.) Measurements – Position 2





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Photo Description:	Radiated (e.r.p.) Measurements – Position 3
Date:	08-22-2022
Name:	BBT
Model:	BBT v2
Company:	BCycle





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Company:	BCycle
Model:	BBT v2
Name:	BBT
Date:	08-22-2022
Photo Description:	Radiated (e.r.p.) Measurements – Back





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Company:	BCycle
Model:	BBT v2
Name:	BBT
Date:	08-22-2022
Photo Description:	Radiated (e.r.p.) Measurements – Substitution





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Section B – Measurement Data

B.1 Peak Output Power – RF Conducted

Rule Part:

N/A Informative only.

Test Procedure:

ANSI C63.10-2013, Section 11.9.1.1 Maximum peak conducted output power RBW \geq DTS bandwidth method

Limit:

N/A Informative only.

Results:

The maximum RF conducted peak output power measured **-2.35 dBm** at the frequency found to have the highest antenna gain (middle channel, 2440 MHz).

Notes:

Per ANSI C63.10 Section 5.11, the EUT was programmed for continuous transmit, modulated, with a 100% duty cycle. Power setting 0 was used per manufacturer's instruction. This test was performed using the RF Conducted test configuration. The EUT was tested at the low, middle, and high channels of operation.



Company:BCycle, LLCProduct Tested:BBT v2Report Number:27243 rev1.0Project Number:11411

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Section B.1

Test Date:	03-16-2021
Company:	Trek Bicycle
EUT:	BBT Module
Test:	Output power – RF Conducted
Operator:	cbrandt

Comment: Power setting 0 Low Channel: 2402 MHz

Marker 1 [T3] RBW 2 MHz RF Att 20 dB Ref Lvl -2.10 dBm VBW 10 MHz 5 dBm 2.40248497 GHz SWT 5 ms Unit dBm А -10 -20 IN1 -30 ЗМА **3MAX** -40 PO -50 TDF -60 -70 -80 -90 -95 Center 2.402 GHz 400 kHz/ Span 4 MHz Date: 16.MAR.2021 13:19:21

Peak Output Power = -2.10 dBm



Company:BCycle, LLCProduct Tested:BBT v2Report Number:27243 rev1.0Project Number:11411

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Section B.1

Test Date:	03-16-2021
Company:	Trek Bicycle
EUT:	BBT Module
Test:	Output power – RF Conducted
Operator:	cbrandt

Comment: Power setting 0 Mid Channel: 2440 MHz

Peak Output Power = -2.35 dBm





Company:BCycle, LLCProduct Tested:BBT v2Report Number:27243 rev1.0Project Number:11411

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Section B.1

Test Date:	03-16-2021
Company:	Trek Bicycle
EUT:	BBT Module
Test:	Output power – RF Conducted
Operator:	cbrandt

Comment: Power setting 0 High Channel: 2480 MHz

Peak Output Power = -3.13 dBm





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B.2 Maximized Field Strength

Rule Part:

N/A Informative only.

Test Procedure:

ANSI C63.10-2013

Section 6.3 – Radiated emissions testing Section 6.3 – EUT power measured in a radiated test configuration using the signal (antenna) substitution techniques.

Limit:

N/A Informative only.

Results:

The maximum peak field strength measured $98.90 \text{ dB}\mu\text{V/m}$ (3-meter distance) at the frequency found to have the highest antenna gain (middle channel, 2440 MHz).

Notes:

Per ANSI C63.10 Section 5.11, the EUT was programmed for continuous transmit, modulated, with a 100% duty cycle. Power setting 0 was used per manufacturer's instruction. This test was performed using the Radiated test configuration. The EUT was tested at the low, middle, and high channels of operation, and rotated through three orthogonal axes to find worst-case field strength levels.



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Section B.2

Test Date: Company:	08-22-2022 BCycle, LLC
EUT:	BBT v2
Test:	Maximized Field Strength (for substitution measurement)
Operator:	cbrandt

Comment: Power setting 0 Peak detector, Max-hold Low Channel: 2402 MHz

VERTICAL:

Maximized Field Strength = $97.77 \text{ dB}\mu\text{V/m}$ at 3 meters





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Section B.2

Test Date:	08-22-2022
Company:	BCycle, LLC
EUT:	BBT v2
Test:	Maximized Field Strength (for substitution measurement)
Operator:	cbrandt

Comment: Power setting 0 Peak detector, Max-hold Low Channel: 2402 MHz

HORIZONTAL:

Maximized Field Strength = $98.81 \text{ dB}\mu\text{V/m}$ at 3 meters





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Section B.2

Test Date:	08-22-2022
Company:	BCycle, LLC
EUT:	BBT v2
Test:	Maximized Field Strength (for substitution measurement)
Operator:	cbrandt
-	

Comment: Power setting 0 Peak detector, Max-hold Mid Channel: 2440 MHz

VERTICAL:

Maximized Field Strength = $97.86 \text{ dB}\mu\text{V/m}$ at 3 meters





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Section B.2

Test Date:	08-22-2022
Company:	BCycle, LLC
EUT:	BBT v2
Test:	Maximized Field Strength (for substitution measurement)
Operator:	cbrandt

Comment: Power setting 0 Peak detector, Max-hold Mid Channel: 2440 MHz

HORIZONTAL:

Maximized Field Strength = $98.90 \text{ dB}\mu\text{V/m}$ at 3 meters





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Section B.2

Test Date:	08-22-2022
Company:	BCycle, LLC
EUT:	BBT v2
Test:	Maximized Field Strength (for substitution measurement)
Operator:	cbrandt

Comment: Power setting 0 Peak detector, Max-hold High Channel: 2480 MHz

VERTICAL:

Maximized Field Strength = $96.91 \text{ dB}\mu\text{V/m}$ at 3 meters





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Section B.2

Company: Product Tested: Report Number: Project Number: BCycle, LLC BBT v2 27243 rev1.0 11411

Test Date:	08 22 2022
Test Date.	08-22-2022
Company:	BCycle, LLC
EUT:	BBT v2
Test:	Maximized Field Strength (for substitution measurement)
Operator:	cbrandt

Comment: Power setting 0 Peak detector, Max-hold High Channel: 2480 MHz

HORIZONTAL:

Maximized Field Strength = $97.56 \text{ dB}\mu\text{V/m}$ at 3 meters





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Section C – Calculated Data – Peak e.r.p. and Antenna Gain

Rule Part:

N/A Informative only.

Sample Calculations:

e.i.r.p. $(ref. to \frac{1}{2}\lambda dipole)$ = Signal generator output - cable loss + antenna gain = -3.0 dBm - 2.98 (dB) + 9.43 dBi = 3.44 dBm

 $\frac{\text{e.r.p.}_{(\text{ref. to } \%\lambda \text{ dipole})}}{= 3.44 \text{ dBm} - 2.15 = 1.29 \text{ dBm}}$

<u>Antenna Gain</u> (dBd) = e.r.p. - RF conducted power = 1.29 dBm - (-2.35) dBm = **3.64 dBd**

Limit:

N/A Informative only.

Results:

The maximum peak e.r.p. is **1.29 dBm** at the frequency found to have the highest antenna gain (middle channel, 2440 MHz).

The maximum antenna gain is **3.64 dBd** at the frequency found to have the highest antenna gain (middle channel, 2440 MHz).

Notes:

MPE-Based RF Exposure Test Exemptions call for the RF conducted output power, e.r.p., or the maximum rated output power (including production / tune-up tolerances), whichever is worst-case.



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Section C

DLS Electronic Systems, Inc.

Company:	BCycle, LLC
Operator:	cbrandt
Date of test:	08/22/2022
Temperature	: 72 deg. F
Humidity:	51% R.H.
Notes:	Continuous Tx (100% duty cycle); modulated; Output power setting 0.
	RBW 3 MHz, VBW 10 MHz; Peak Detector; Maximized through 3
	orthogonal axes of rotation.

e.r.p. - Substitution Method

Model: BBT v2							
Channel: Low (2402 MHz), Middle (2440 MHz), High (2480 MHz)							
Frequency and Polarization (MHz)	Max. Field Strength of EUT @ 3 meters (dBuV/m)	Output of Signal Generator when field strength equals that of EUT (dBm)	Correction factor for cable between Signal Gen. and subst. antenna (dB)	Gain of subst. antenna (dBi)	Strength of emission [e.r.p.] (dBm)	Measured RF conducted power (dBm)	Antena Gain (dBd)
2402 vertical	97.77	-4.2	2.95	9.33	0.03	-2.10	2.13
2402 horizontal	98.81	-2.9	2.95	9.33	1.33	-2.10	3.43
2440 vertical	97.86	-4.2	2.98	9.43	0.09	-2.35	2.44
2440 horizontal	98.90	-3.0	2.98	9.43	1.29	-2.35	3.64
2480 vertical	96.91	-5.3	3.00	9.56	-0.89	-3.13	2.24
2480 horizontal	97.56	-4.0	3.00	9.56	0.41	-3.13	3.54

e.r.p._(ref. to ½λ dipole) = Signal generator output - cable loss + antenna gain - 2.15



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Section D – Measurement Uncertainty

Our calculated measurement uncertainty including the measurement instrumentation, associated connections between the various instruments in the measurement chain, and other contributions, are provided in this section of the test report.

Parameter	Expanded Uncertainty (K=2)
Occupied Channel Bandwidth	+/-1.14%
RF Output Power, Conducted	+/-0.89 dB
Power Spectral Density, Conducted	+/-1.26 dB
Unwanted Emissions, Conducted	+/-2.62 dB
All Emissions, Radiated	+/-3.43 dB
DC and Low Frequency Voltages	+/-2.42%
Time	+/-0.01%
Duty Cycle	+/-0.05%



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END OF REPORT

Revision #	Date	Comments	By
1.0	08-30-2022	Initial Release	CB