Test Report # 318246 C

Equipment Under Test:	IoT LoRa Module
Test Date(s):	May 25th – July 11th, 2019
Prepared for:	Georgia Pacific Attn: Kim Cannon 1915 Marathon Avenue Neenah, WI 54956

Report Issued by: Adam Alger, Quality Manager
Signature: Date: 9/18/2020

Report Reviewed by: Adam Alger, Quality Manager
Signature: Date: 8/20/2020

Report Constructed by: Zach Wilson, EMC Engineer
Signature: Date: 7/10/2019

CONTENTS

Laird Connectivity Test Services in Review

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

ACCREDITED
TESTING CERT #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

---

Federal Communications Commission (FCC) – USA

Accredited Test Firm Registration Number: 953492

Recognition of two 3 meter Semi-Anechoic Chambers

Government of Canada

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 **May 25th – July 11th, 2019** the Equipment Under Test (EUT), **IoT LoRa Module**, as provided by **Georgia Pacific** was tested to the following requirements of the **Federal Communications Commission** and **Innovation, Science and Economic Development Canada** :

Test Requirements	Description	Specification	Method	Compliant
RSS-102	Radio Frequency Exposure Compliance of Radiocommunication Apparatus	Reported	RSS-102 Section 2.5.2	Reported
FCC Part 1.1307, 2.1091, 2.1093	RF Exposure and equipment authorization requirements	Reported	FCC KDB 447498 D01	Reported

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	N/A
Emissions – Frequency	N/A
Immunity	N/A

2 CLIENT INFORMATION

Company Name	Georgia Pacific
Contact Person	Kim Cannon
Address	1915 Marathon Avenue Neenah, WI 54956

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	LoRa Collector
Model Number	A-101129
Serial Number	Engineering Sample
LoRa Radio FCC ID	2AALY-529GP
LoRa Radio IC ID	21620-529GP
BLE Radio FCC ID	SQGBL654
BLE Radio IC ID	3147A-BL654

2.2 Product Description

The EUT contains a custom LoRa radio. The EUT also contains the pre-certified Laird BL654 BLE radio utilizing an internal PCB F-type antenna with a maximum gain of -1.0 dBi.

There are two PCB versions of the EUT. The Laird Rev_B contains a Johanson 0900AT43A0070 chip antenna, peak gain -0.5 dBi. The Laird Rev_B1 has the PCB configured for a SMA connector and is fitted with the Molex 206764 Flexible Dipole Antenna, peak gain of 1.3 dBi.

Both versions of the EUT were tested.

The EUT input voltage was 3.3 VDC provided by a lab power supply. The EUT can also be powered by removable batteries.

The radios can transmit simultaneously.

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 Radio Programming Information

EUT programmed using Tera Term v4.99. The radio manufacturer provided the commands to put the radio into the correct test modes. The firmware version was PRT-0000000174. The tested LoRa channels were, 903.0 MHz (Low), 907.8 MHz (Mid), and 914.2 MHz (High). The tested BLE channels were 2402 MHz (Low), 2440 MHz (Mid), and 2480 MHz (High). The EUT voltage was 3.3 VDC via battery power.

2.6 Radio Power Information

The end user will have the capability of changing the power levels of the Laird Rev_B LoRa radio. The minimum power setting is -17. The maximum power setting is 18.

The end user will have the capability of changing the power levels of the Laird Rev_B1 LoRa radio. The only power setting used is 12.

2.7 Distance to User and Use Environment

Per customer, the radio will be greater than 20cm from the user's body/head. The EUT is a mobile device used in an uncontrolled environment.

3 REFERENCES

Publication	Edition	Date
CFR Title 47	-	2020
RSS-102	5	2015
FCC KDB 447498 D01	v06	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	Version / Date
CISPR 16-4-1	Ed. 2 (2009-02)
CISPR 16-4-2	Ed. 2 (2011-06)
CISPR 32	Ed. 1 (2012-01)
ANSI C63.23	2012
A2LA P103	February 4, 2016
A2LA P103c	August 10, 2015
ETSI TR 100-028	V1.3.1 (2001-03)

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 LoRa Fundamental Emission

Operator	Zach Wilson	QA	Jeysson Gonzalez
Temperature	21.0C	R.H. %	44.10%
Test Date	6/3/2019	Location	Conducted Radio Bench
Requirement	FCC 15.247	Method	ANSI C63.10

Test Parameters

Frequency	903-914.2 MHz
RBW	1 MHz
VBW	3 MHz
EUT Power	3.3VDC
EUT Mode	LoRa Transmit, Single Channel, DTS Mode as Worst Case, Power Setting 18
Example Calculation	Conducted Power (e.i.r.p.) = Conducted Power (dBm) + Antenna Gain (dBi)

Instrumentation

Laird

Date : 26-Nov-2019 Test : Conducted Radio Job : C-3164

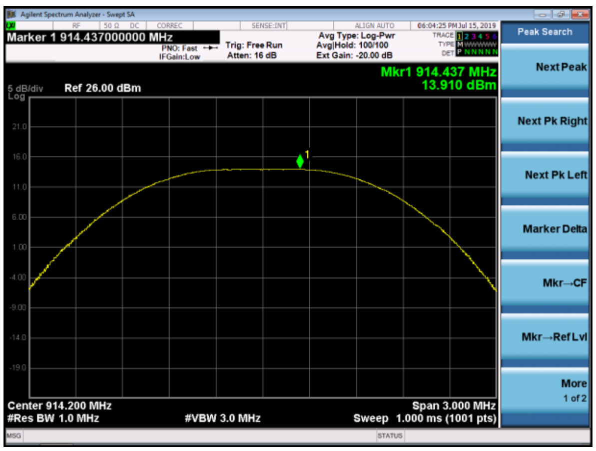
PE : Zach Wilson Customer : Georgia Pacific Quote : 318246

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	AA 960172	Cable	A.H. Systems, Inc	SAC-26G-1	387	6/4/2018	6/4/2020	Active Verification
2	EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/24/2019	4/24/2020	Active Calibration

Table

LoRa Radio Peak Output Power					
Frequency (MHz)	Data Rate	Power Setting	Peak Output Power (dBm)	Antenna Gain (dBi)	e.i.r.p (dBm)
903.0	DR4	18.0	13.9	-0.5	13.4
907.8	DR4	18.0	13.9	-0.5	13.4
914.2	DR4	18.0	13.9	-0.5	13.4

Plots



Worst Case Conducted Peak Output Power
DR4, 500 kHz, DTS Mode, 914.2 MHz

5.2 BLE Fundamental Emission

Operator	Zach Wilson	QA	Anthony Smith
Temperature	20.5C	R.H. %	31.6%
Test Date	11/26/2019	Location	Conducted Radio Bench
Requirement	FCC 15.247	Method	ANSI C63.10

Test Parameters

Frequency	2402 MHz, 2440 MHz, 2480 MHz
RBW	1 MHz
VBW	3 MHz
EUT Power	3VDC
EUT Mode	BLE Single Channel, Max Power
Example Calculation	Conducted Power (e.i.r.p.) = Conducted Power (dBm) + Antenna Gain (dBi)

Instrumentation

Laird

Date : 26-Nov-2019 Test : Conducted Radio Job : C-3164

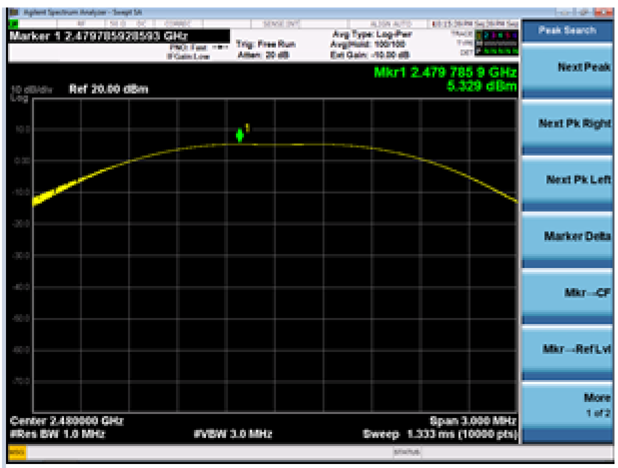
PE : Zach Wilson Customer : Georgia Pacific Quote : 318246

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	AA 960172	Cable	A.H. Systems, Inc	SAC-26G-1	387	6/4/2018	6/4/2020	Active Verification
2	EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/24/2019	4/24/2020	Active Calibration

Table

BLE Radio Peak Output Power				
Frequency (MHz)	Data Rate	Peak Output Power (dBm)	Antenna Gain (dBi)	e.i.r.p (dBm)
2402	BLE	5.1	-1.0	4.1
2440	BLE	4.9	-1.0	3.9
2480	BLE	5.3	-1.0	4.3

Plots



Worst Case Conducted Peak Output Power
BLE, 2480 MHz

6 EXCLUSION CALCULATION

6.1 Technical Brief

LoRa Worst Case: **13.9 dBm** (Pout) + **1 dB** (Tune-Up Tolerance) = **14.9 dBm**

BLE Worst Case: **5.3 dBm** (Pout) + **1 dB** (Tune-Up Tolerance) = **6.3 dBm**

Test Separation Distance: **Greater than 20cm**

6.2 FCC – LoRa MPE Calculation

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:	14.90	(dBm)
Maximum peak output power at antenna input terminal:	30.903	(mW)
Antenna gain(typical):	1.3	(dBi)
Numeric Antenna Gain:	1.349	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	900	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	0.6	(mW/cm^2)
Power density at prediction frequency:	0.008293	(mW/cm^2)
Power density at prediction frequency:	0.082934	(W/m^2)

6.3 FCC – BLE MPE Calculation

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:	5.30	(dBm)
Maximum peak output power at antenna input terminal:	3.388	(mW)
Antenna gain(typical):	-1	(dBi)
Numeric Antenna Gain:	0.794	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2400	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1.0	(mW/cm^2)
Power density at prediction frequency:	0.000535	(mW/cm^2)
Power density at prediction frequency:	0.00535	(W/m^2)

6.4 FCC – Simultaneous Transmission MPE total

MPE 900 MHz Limit = (frequency in MHz)/1500 = **0.6**

MPE 2400 MHz Limit = **1.0**

$$\frac{MPE\ 900}{MPE\ Limit\ 900} + \frac{MPE\ 2400}{MPE\ Limit\ 2400} < 1$$

$$\frac{0.008293\ mW/cm^2}{0.6\ mW/cm^2} + \frac{0.000535\ mW/cm^2}{1.0\ mW/cm^2} = 0.014356$$

Routine SAR testing is ***excluded*** as 0.014356 is less than 1.

6.5 Industry Canada

MPE Limit @ 2450 MHz: 0.02619*($2450^{0.6834}$) = 5.423649 W/m^2
MPE Limit @ 900 MHz: 0.02619*($902^{0.6834}$) = 2.739830 W/m^2

Simultaneous Transmitter Equation for RF Exposure Evaluation

$$\frac{MPE\ 900}{MPE\ Limit\ 900} + \frac{MPE\ 2400}{MPE\ Limit\ 2400} < 1$$

$$\frac{0.0892934\ W/m^2}{2.739830\ W/m^2} + \frac{0.00535\ W/m^2}{5.423649\ W/m^2} = 0.033577$$

Routine SAR testing is ***excluded*** as 0.033577 is less than 1.

7 REVISION HISTORY

Version	Date	Notes	Person
v0.0	8-9-2019	Initial Draft	Zach Wilson
v0.1	8-19-2020	Revised Draft	Zach Wilson
v1.2	8-28-2020	Revised per TCBC comments	Zach Wilson
v1.3	9-18-2020	Released as final (no other changes)	Adam Alger

END OF REPORT