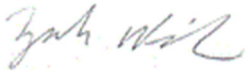
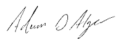
Test Report # 3434 C

Equipment Under Test:	Sterling LWB
Requirement(s):	RSS-102, FCC 1.1310, KDB 447498
Test Date(s):	July 22nd, 2021 to August 19th, 2021
Prepared for:	Laird Connectivity Attn: Jonathan Kaye 50 South Main Street, Suite 1100 Akron, OH 44308

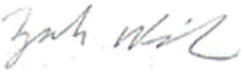
Report Issued by: Zach Wilson, EMC Engineer

Signature:  Date: 8/26/2021

Report Reviewed by: Adam Alger, Laboratory Manager

Signature:  Date: 8/24/2021

Report Constructed by: Zach Wilson, EMC Engineer

Signature:  Date: 8/19/2021

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Laird Connectivity Test Services in Review

The Laird Connectivity, Inc. 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 **July 22nd, 2021 to August 19th, 2021** the Equipment Under Test (EUT), **Sterling LWB**, as provided by **Laird Connectivity, Inc.** was tested to the following requirements of the **Federal Communications Commission** and **Innovation, Science and Economic Development Canada**:

Mobile Device

Requirement	Description	Method	Result
FCC 1.1307, 2.1091, 2.1093	Radiofrequency Radiation Exposure Limits	KDB 44798	Reported
RSS-102	Radiofrequency Radiation Exposure Limits	RSS-102	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	1 dB below specified limit
Emissions – Frequency	1% less than the specification
Immunity	Tested at specified level

2 CLIENT INFORMATION

Company Name	Laird Connectivity, Inc.
Contact Person	Jonathan Kaye
Address	50 South Main Street, Suite 1100 Akron, OH 44308

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	Sterling LWB
Model Number	Sterling LWB
Serial Number	Engineering Sample
FCC ID	TFB-1003
IC ID	5969A-1003

2.2 Product Description

Laird 2.4 GHz WLAN and BT/BLE radio module. Radios cannot transmit simultaneously.

The PCB trace width has been altered from the original filing.

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 Programming Information

The BTC/BLE radios were programmed using CyBluetool v0.1.55.1. The WLAN radio was programmed with client provided commands using TeraTerm v4.99

2.6 Antenna Information

Johanson Technology high frequency ceramic chip antenna, part number 2450AT18D0100. The chip antenna has a peak gain of 1.5dBi.

2.7 Channels and Data Rates/Modulations

Bluetooth Classic

Channels: 0 (2402 MHz), 39 (2440 MHz), 79 (2480 MHz)

Data Rate/Modulations: GFSK 1Mbps BR, QPSK 2Mbps EDR2, 8PSK 3Mbps EDR3

WLAN 2.4 GHz

Channels: 1 (2412 MHz), 6 (2437 MHz), 11 (2462 MHz)

Data Rates/Modulations: 802.11b 1 Mbps, 802.11b 11Mbps, 802.11g 6Mbps, 802.11g 54Mbps, 802.11n HT20 MCS0, 802.11n HT20 MCS7

Bluetooth Low Energy (BLE)

Channels: 0 (2402 MHz), 19 (2440 MHz), 39 (2480 MHz)

Data Rate/Modulation: GFSK 1Mbps

2.8 Distance to End User

The radios will be 20 cm or further from the end user per the instructed manufacturer installation.

3 REFERENCES

Publication	Edition	Date	AMD 1
FCC eCFR	-	2021	-
RSS-102	5	2015	2021
KDB 447498 D01	06	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

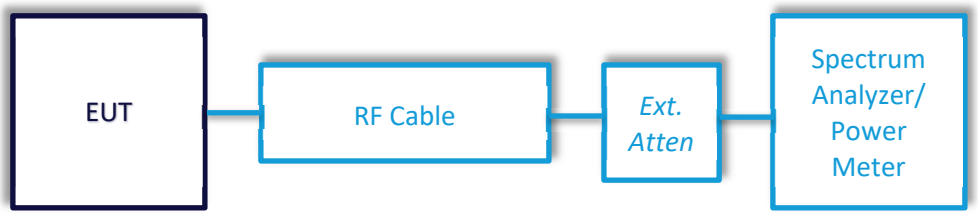
Parameter	ETSI U.C. ±	U.C. ±
Radio Frequency, from F0	$1x10^{-7}$	$0.55x10^{-7}$
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %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

5 TEST DATA

5.1 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 Fundamental Emission Output Power – Bluetooth Classic

Operator	Anthony Smith	**QA**	Zach Wilson
Temperature	22°C	**R.H. %**	52.10%
Test Date	8/19/2021	**Location**	Conducted RF Bench
Requirement	FCC 15.247, RSS-247	**Method**	ANSI C63.10 §7.8.5

Limits: 30 dBm / 1 Watt

Test Parameters

Frequency	2402 MHz, 2440 MHz, 2480 MHz	**Setup**	Conducted
Detector(s)	Peak, Max Hold	**RBW**	1 MHz (GFSK) 3 MHz (QPSK, 8PSK)
VBW	3 MHz (GFSK) 8 MHz (QPSK, 8PSK)	**Span**	5 MHz

Instrumentation

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/21/2021	4/21/2022	Active Calibration
2	AA 960172	Cable	A.H. Systems, Inc	SAC-26G-1	387	4/19/2021	4/19/2022	Active Calibration

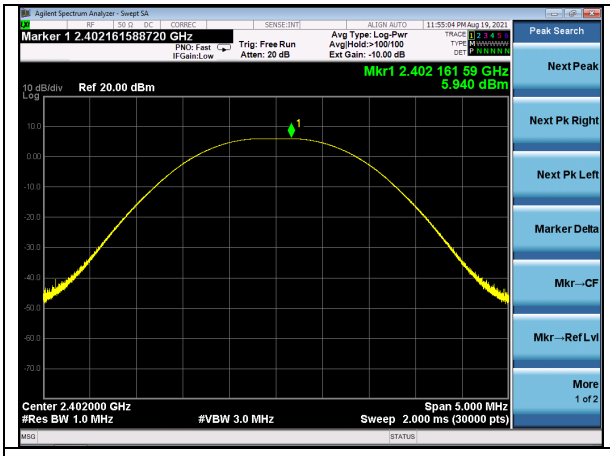
EUT Parameters

Input Power	3.7VDC	**Mode**	BTC Modulated Transmit, Single Channel
Frequency	2402-2480 MHz	**Channel**	0, 39, 79
Data Rates/Mods	GFSK 1Mbps BR QPSK 2Mbps EDR2 8PSK 3Mbps EDR3		

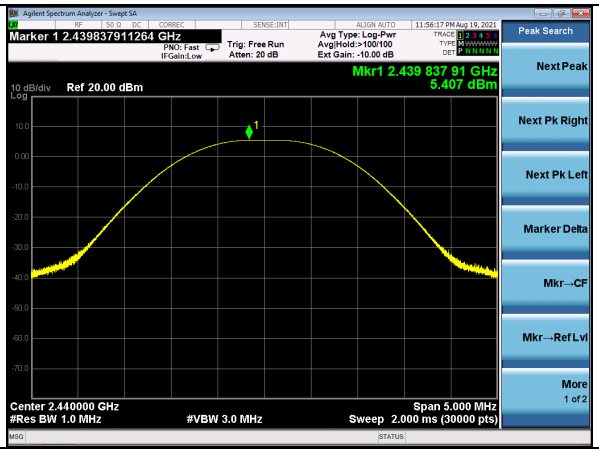
Data Table

Channel	Radio Mode	Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
0	GFSK	5.9	30.0	24.1
39	GFSK	5.4	30.0	24.6
79	GFSK	4.0	30.0	26.0
0	QPSK	5.6	30.0	24.4
39	QPSK	5.1	30.0	24.9
79	QPSK	4.2	30.0	25.8
0	8PSK	6.1	30.0	23.9
39	8PSK	5.5	30.0	24.5
79	8PSK	4.5	30.0	25.5

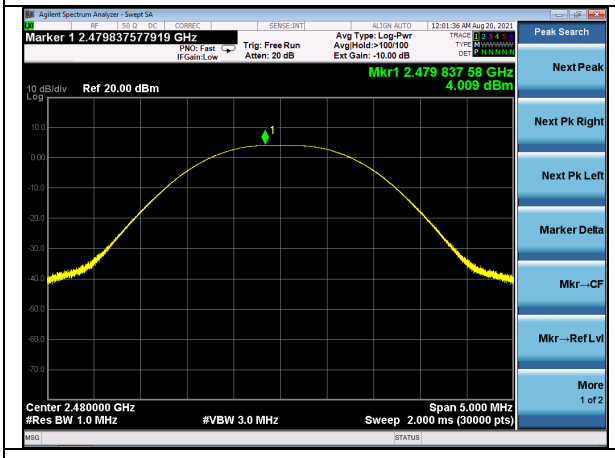
Plots



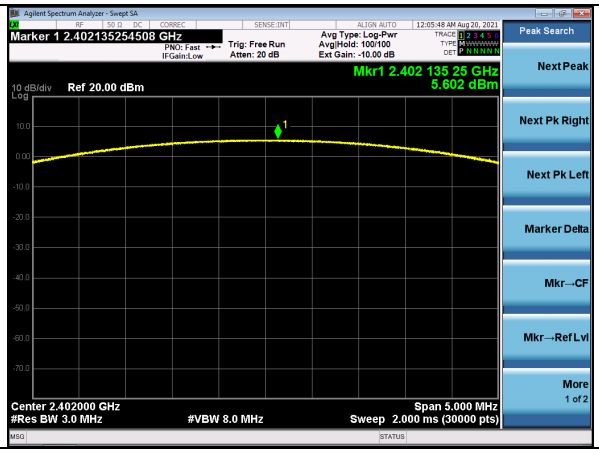
Output Power, BT Classic, GFSK
Channel 0



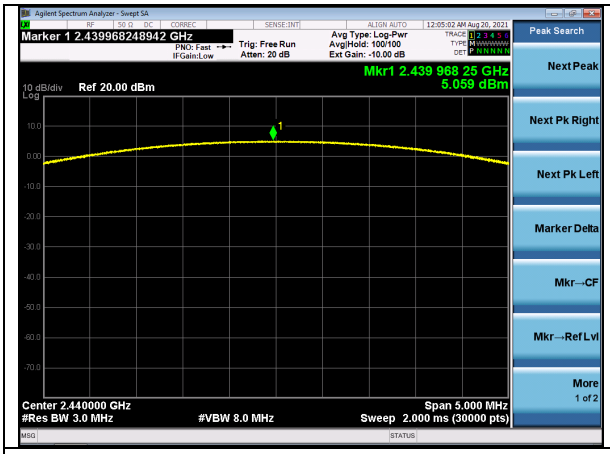
Output Power, BT Classic, GFSK
Channel 39



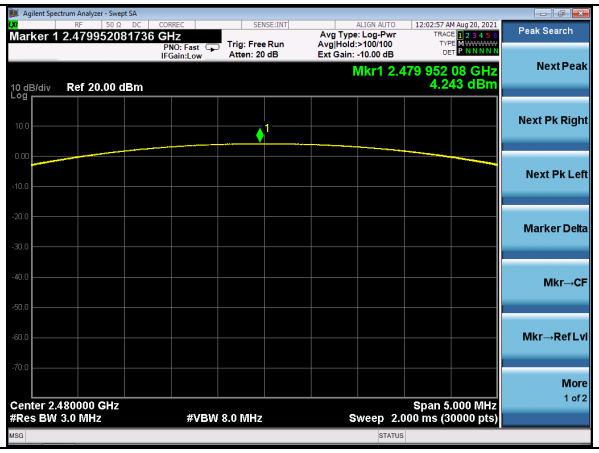
Output Power, BT Classic, GFSK
Channel 79



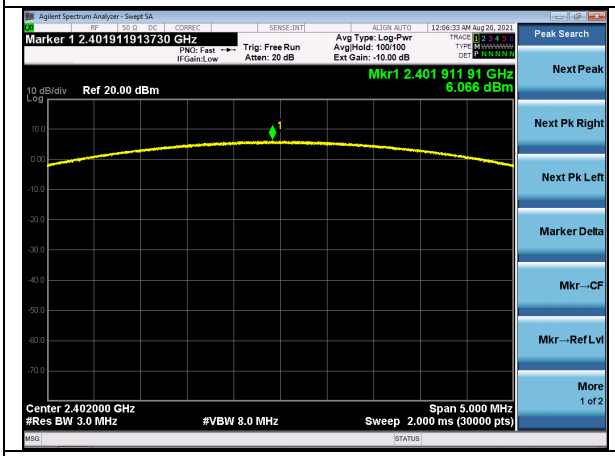
Output Power, BT Classic, QPSK
Channel 0



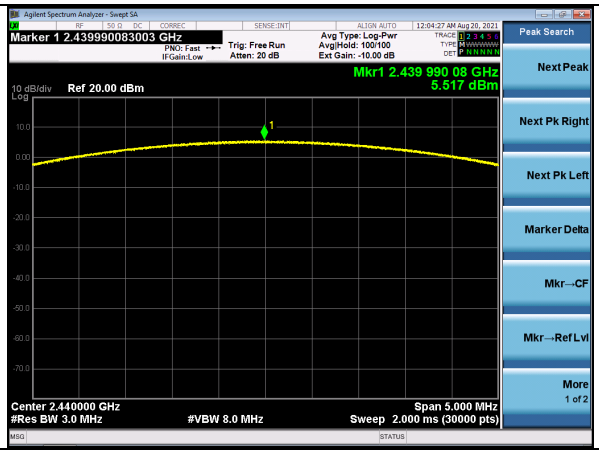
Output Power, BT Classic, QPSK
Channel 39



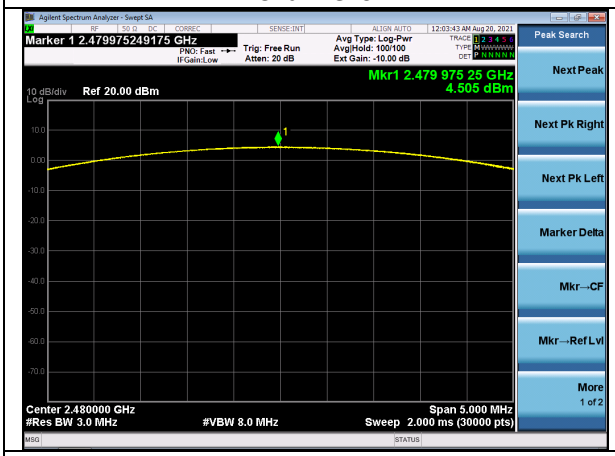
Output Power, BT Classic, QPSK
Channel 79



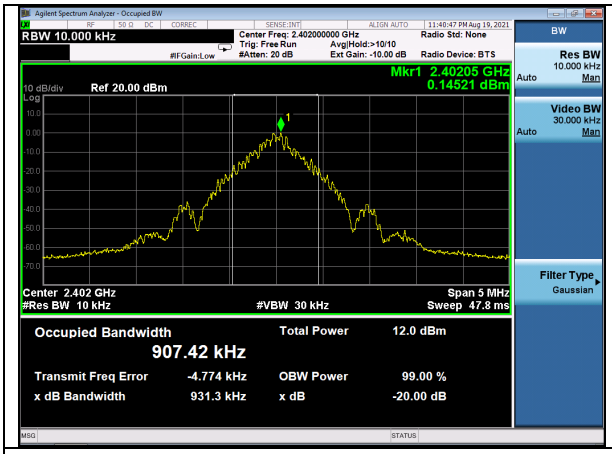
Output Power, BT Classic, QPSK
Channel 0



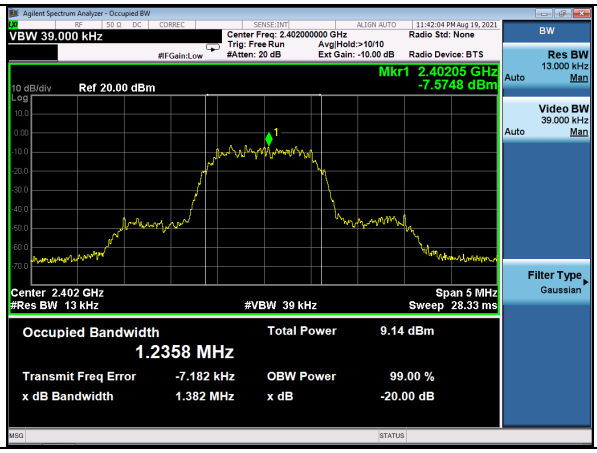
Output Power, BT Classic, 8PSK
Channel 39



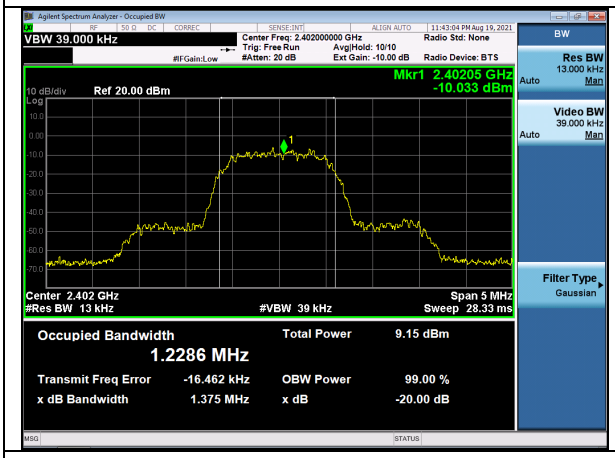
Output Power, BT Classic, 8PSK
Channel 79



20dB Bandwidth, BT Classic, GFSK
931.3 kHz



20dB Bandwidth, BT Classic, QPSK
1.382 MHz



20dB Bandwidth, BT Classic, 8PSK
1.375 MHz

5.1.2 Fundamental Emission Output Power – WLAN 2.4 GHz

Operator	Anthony Smith	**QA**	Zach Wilson
Temperature	21.8°C	**R.H. %**	48.70%
Test Date	8/12/2021	**Location**	Conducted RF Bench
Requirement	FCC 15.247, RSS-247	**Method**	ANSI C63.10 §11.9.1.3 PKPM1

Limits: 30 dBm / 1 Watt

Test Parameters

Frequency	2412 MHz, 2437 MHz, 2462 MHz	**Setup**	Conducted Power Meter
Detector(s)	Peak		

Instrumentation

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	EE 960090	Meter - RF Power	Anritsu	ML2495A	1335006	4/21/2021	4/21/2022	Active Calibration
2	EE 960091	Sensor - RF Power	Anritsu	MA2491A	1249277	4/19/2021	4/19/2022	Active Calibration
3	AA 960143	Cable	Gore	EKD01D01048.0	5546519	2/3/2021	2/3/2022	Active Verification

EUT Parameters

Input Power	3.7VDC	**Mode**	WLAN Modulated Transmit
Frequency	2412-2462 MHz	**Channel**	1, 6, 11
Data Rates/Mods	802.11b: 1Mbps, 11Mbps 802.11g: 6Mbps, 54Mbps 802.11n: MCS0, MCS7		

Data Table

Channel	Radio Mode	Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
1	802.11b 1Mbps	19.4	30.0	10.6
6	802.11b 1Mbps	18.8	30.0	11.2
11	802.11b 1Mbps	18.4	30.0	11.6
1	802.11b 11Mbps	19.6	30.0	10.4
6	802.11b 11Mbps	19.1	30.0	10.9
11	802.11b 11Mbps	18.7	30.0	11.3
1	802.11g 6Mbps	22.2	30.0	7.8
6	802.11g 6Mbps	21.5	30.0	8.5
11	802.11g 6Mbps	21.1	30.0	8.9
1	802.11g 54Mbps	21.2	30.0	8.8
6	802.11g 54Mbps	21.3	30.0	8.7
11	802.11g 54Mbps	20.6	30.0	9.4
1	802.11n MCS0	20.9	30.0	9.1
6	802.11n MCS0	20.3	30.0	9.7
11	802.11n MCS0	21.3	30.0	8.7
1	802.11n MCS7	19.0	30.0	11.0
6	802.11n MCS7	19.5	30.0	10.5
11	802.11n MCS7	18.6	30.0	11.4

5.1.3 Fundamental Emission Output Power – Bluetooth Low Energy

Operator	Anthony Smith	**QA**	Zach Wilson
Temperature	22°C	**R.H. %**	52.10%
Test Date	8/19/2021	**Location**	Conducted RF Bench
Requirement	FCC 15.247, RSS-247	**Method**	ANSI C63.10 §11.9.1.1

Limits: 30 dBm / 1 Watt

Test Parameters

Frequency	2402 MHz, 2440 MHz, 2480 MHz	**Setup**	Conducted Power Meter
Detector(s)	Peak, Max Hold	**RBW**	1 MHz
VBW	3 MHz	**Span**	3 MHz

Instrumentation

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/21/2021	4/21/2022	Active Calibration
2	AA 960172	Cable	A.H. Systems, Inc	SAC-26G-1	387	4/19/2021	4/19/2022	Active Calibration

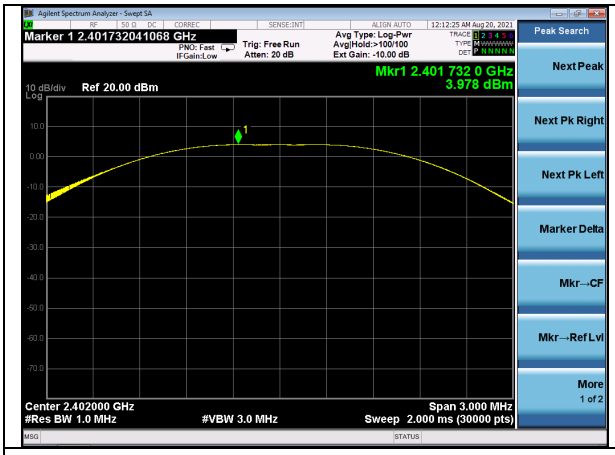
EUT Parameters

Input Power	3.7VDC	**Mode**	BLE Modulated Transmit
Frequency	2402-2480 MHz	**Channel**	0, 19, 39
Data Rates/Mods	GFSK 1 Mbps		

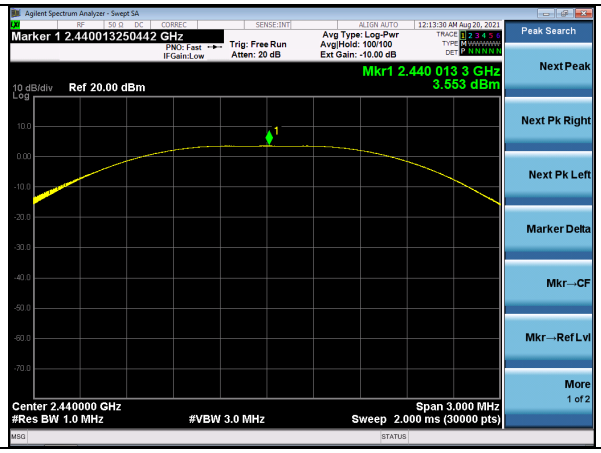
Data Table

Channel	Radio Mode	Peak Output Power (dBm)	Limit (dBm)	Margin (dB)
0	BLE	4.0	30.0	26.0
19	BLE	3.6	30.0	26.4
39	BLE	2.2	30.0	27.8

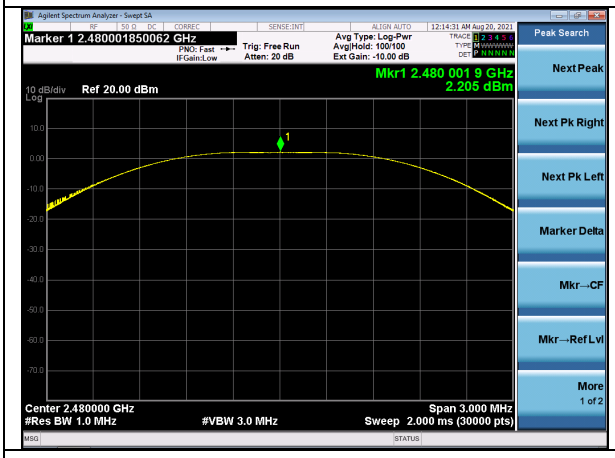
Plots



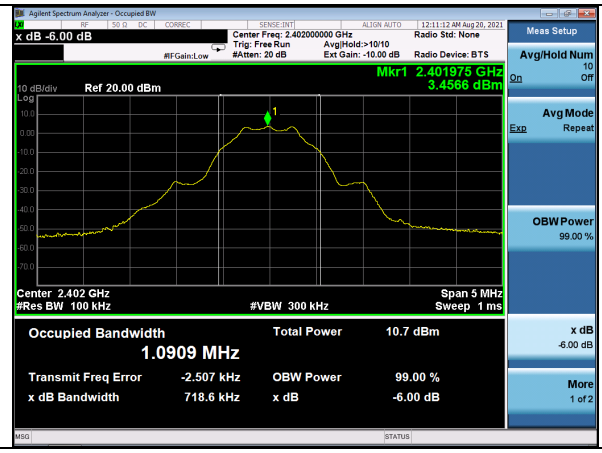
Output Power, BLE, GFSK
Channel 0



Output Power, BLE, GFSK
Channel 19



Output Power, BLE, GFSK
Channel 39



DTS Bandwidth, BLE GFSK
718.6 kHz

6 FCC Exclusion Calculation

6.1.1 Highest Power Test Cases

Bluetooth Classic: 6.1 dBm at 2450 MHz (Tune up Tolerance = +/- 2 dB)
2.4 GHz WLAN: 22.2 dBm at 2450 MHz (Tune up Tolerance = +/- 2 dB)
Bluetooth Low Energy: 4.0 dBm at 2450 MHz (Tune up Tolerance = +/- 2 dB)

Antenna Gain: 1.5 dBi @ 2450 MHz

6.1.2 FCC – Bluetooth Classic Exclusion Calculation

Worst Case Scenario: 6.1 dBm at 2450 MHz
Tune-Up Tolerance: 2.0 dB
Total Power: 8.1 dBm = 6.4565 mW
Peak Antenna Gain: 1.5 dBi

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:	8.10	(dBm)
Maximum peak output power at antenna input terminal:	6.457	(mW)
Antenna gain(typical):	1.5	(dBi)
Numeric Antenna Gain:	1.413	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2450	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1.0	(mW/cm^2)
Power density at prediction frequency:	0.001814	(mW/cm^2)

Result
The EUT's Bluetooth Classic radio is exempt from routine SAR evaluation as the power density of **0.001814 mW/cm^2** is lower than the MPE limit of **1.0 mW/cm^2**.

6.1.3 **FCC –** WLAN 2.4 GHz Exclusion Calculation

Worst Case Scenario: 22.2 dBm at 2450 MHz
Tune-Up Tolerance: 2.0 dB
Total Power: 24.2 dBm = 263.0279 mW
Peak Antenna Gain: 1.5 dBi

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:	24.20	(dBm)
Maximum peak output power at antenna input terminal:	263.0	(mW)
Antenna gain(typical):	1.5	(dBi)
Numeric Antenna Gain:	1.413	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2450	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1.0	(mW/cm^2)
Power density at prediction frequency:	0.073915	(mW/cm^2)

Result
The EUT's Bluetooth Classic radio is exempt from routine SAR evaluation as the power density of **0.073915 mW/cm^2** is lower than the MPE limit of **1.0 mW/cm^2**.

6.1.4 FCC – Bluetooth Low Energy Exclusion Calculation

Worst Case Scenario: 4.0 dBm at 2450 MHz
Tune-Up Tolerance: 2.0 dB
Total Power: 6.0 dBm = 3.9811 mW
Peak Antenna Gain: 1.5 dBi

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:	6.00	(dBm)
Maximum peak output power at antenna input terminal:	3.9811	(mW)
Antenna gain(typical):	1.5	(dBi)
Numeric Antenna Gain:	1.413	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2450	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1.0	(mW/cm^2)
Power density at prediction frequency:	0.001119	(mW/cm^2)

Result
The EUT's Bluetooth Classic radio is exempt from routine SAR evaluation as the power density of **0.00119 mW/cm^2** is lower than the MPE limit of **1.0 mW/cm^2**.

7 ISED EXCLUSION CALCULATION

7.1.1 **ISED** – Bluetooth Classic

Per Section 2.5.2 of RSS-102:
Maximum EIRP Limit = (f(MHz)^0.6834)*1.31*10^-2 W = (2450^0.6834)(0.0131)W = 2.712 W

Calculation
Max Output Power: 6.1 dBm
Antenna Gain: 1.5 dBi
Tune Up Tolerance: ±2 dBm
EIRP: 9.6 dBm = 9.1201 mW

Result
The EUT's Bluetooth Classic radio is exempt from routine SAR evaluation at 20 cm as the maximum **9.1201 mW EIRP** is less than **2.712 W.**

7.1.2 ISED – WLAN 2.4 GHz

Per Section 2.5.2 of RSS-102:
Maximum EIRP Limit = (f(MHz)^0.6834)*1.31*10^-2 W = 2.712 W

Calculation
Max Output Power: 22.2 dBm
Antenna Gain: 1.5 dBi
Tune Up Tolerance: ±2 dBm
EIRP: 25.7 dBm = 371.5352 mW

Result
The EUT's Bluetooth Classic radio is exempt from routine SAR evaluation at 20 cm as the maximum **371.5352 mW EIRP** is less than **2.712 W.**

7.1.3 ISED – Bluetooth Low Energy

Per Section 2.5.2 of RSS-102:
Maximum EIRP Limit = (f(MHz)^0.6834)*1.31*10^-2 W = 2.712 W

Calculation
Max Output Power: 4.0 dBm
Antenna Gain: 1.5 dBi
Tune Up Tolerance: ±2 dBm
EIRP: 7.5 dBm = 5.6234 mW

Result
The EUT's Bluetooth Classic radio is exempt from routine SAR evaluation at 20 cm as the maximum **5.6234 mW EIRP** is less than **2.712 W.**

8 REVISION HISTORY

Version	Date	Notes	Person
0	8/19/2021	Initial Draft	Zach Wilson
1	8/24/2021	Revised per internal review – updated ISED limits	Zach Wilson

END OF REPORT