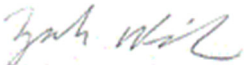
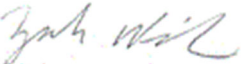


Test Report # 3434 A

Equipment Under Test:	Sterling LWB
Requirement(s):	FCC 15.247, RSS-247, FCC 15.209, RSS-GEN (WLAN/BLE DTS) Class 2 Permissive Change
Test Date(s):	July 22 nd , 2021 to August 19 th , 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: 11/10/2021
Report Reviewed by: Adam Alger, Laboratory Manager	
Signature: 	Date: 8/23/2021
Report Constructed by: Zach Wilson, EMC Engineer	
Signature: 	Date: 8/19/2021

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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 Programming Information	5
2.6 Antenna Information	5
2.7 Channels and Data Rates/Modulations	6
3 References	7
4 Uncertainty Summary	8
5 Test Data	9
5.1 Antenna Port Conducted Emissions.....	9
5.2 Radiated Emissions	14
6 Revision History	22

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



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

Company: Laird Connectivity, Inc.	Page 3 of 22	Name: Sterling LWB
Report: TR3434 A		Model: Sterling LWB
Job: C-3434		Serial: Engineering Sample

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**:

FCC 15.247 / RSS-247 DTS

Requirement	Description	Specification	Method	Result
FCC: 15.247 (b)(3) IC: RSS-247 5.4 (d)	Maximum Conducted Output Power	30 dBm	ANSI C63.10	Compliant
FCC: 15.247 (d) IC: RSS-GEN 8.10	Spurious Radiated Emissions in Restricted Bands	FCC 15.209 RSS-GEN 8.9	ANSI C63.10	Compliant

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 Bluetooth/BLE radio was programmed using CyBluetool v0.1.55.1. The WLAN radio was programmed 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.

Company: Laird Connectivity, Inc.	Page 5 of 22	Name: Sterling LWB
Report: TR3434 A		Model: Sterling LWB
Job: C-3434		Serial: Engineering Sample

2.7 Channels and Data Rates/Modulations

WLAN 2.4 GHz Channels: 1 (2412 MHz), 6 (2437 MHz), 11 (2462 MHz)

WLAN 2.4 GHz 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 Channels: 0 (2402 MHz), 19 (2440 MHz), 39 (2480 MHz)

Bluetooth Low Energy Data Rate/Modulation: GFSK 1Mbps

3 REFERENCES

Publication	Edition	Date	AMD 1	AMD 2
FCC eCFR	-	2021	-	-
RSS-247	2	2017	-	-
RSS-GEN	5	2018	2019	2021
ANSI C63.10	-	2013	-	-
KDB 996369 D04	01	2019	-	-

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 $\pm$
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

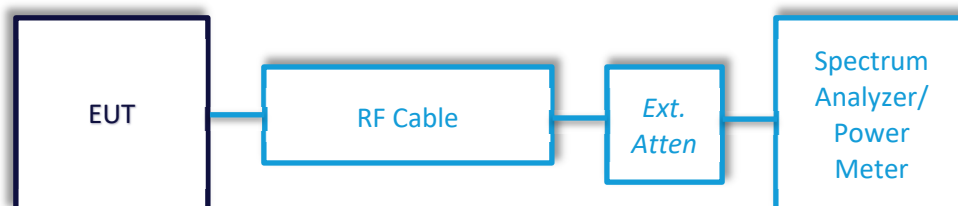
Parameter	ETSI U.C. $\pm$	U.C. $\pm$
Radio Frequency, from F0	1×10^{-7}	0.55×10^{-7}
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
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 Peak 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

5.1.2 Peak 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



5.2 Radiated Emissions

Description of Measurement	The frequency spectrum is investigated for intentional and / or unintentional signals emanating from the EUT by use of a standardized test site and measurement antenna. The antenna, cable, pre-amp, and other necessary measurement system correction factors are loaded onto the EMI receiver / spectrum analyzer when the measurements are performed allowing the data to be gathered and reported as corrected values. The maximum emissions from the EUT are determined by turn-table azimuth rotation (360°) and scanning of the measurement antenna. Maximized levels are noted at degree values of azimuth, measurement antenna height, and measurement antenna polarity.
Example Calculations	Measurement (dBμV) + Cable factor (dB) + Other (dB) + Antenna Factor (dB/m) = Corrected Reading (dBμV/m) Margin (dB) = Limit (dBμV/m) - Corrected Reading (dBμV/m) Example at 4000 MHz: Reading = 40 dBμV + 3.4 dB + 0.9 dB + 6.5 dB/m = 50.8 dBμV/m Average Limit = 20 log (500) = 54 dBμV/m Margin = 54 dBμV/m - 50.8 dBμV/m = 3.2 dB

Block Diagram



5.2.1 Radiated Emissions – WLAN 2.4 GHz

Operator	Ivan Alvarez	QA	Anthony Smith
Temperature	23.3C	R.H. %	51.40%
Test Date	7/22/2021, 8/5/2021	Location	Chambers 3 and 5
Requirement	FCC 15.247, RSS-247, FCC 15.209, RSS-GEN	Method	ANSI C63.10

Limits:

Peak: 74 dBμV/m

Average: 54 dBμV/m

Test Parameters

Frequency	2310-2390 MHz 2483.5-2500 MHz 4-25 GHz	Distance	3m
Detector(s)	Peak max hold for plots. Average band edge measurements taken with a VBW of 820 Hz. Average harmonics measurements taken with a VBW of 120 Hz.	Table height	150cm
RBW	1 MHz	VBW	30 kHz for locating emissions 820 kHz for average band edges 120 kHz for average harmonics 3 MHz for peak
Notes	802.11n MCS0 used for band edges. 802.11b 1Mbps used for harmonics.		

Instrumentation

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	AA 960158	Antenna - Double Ridge Horn	ETS Lindgren	3117	109300	12/7/2020	12/7/2021	Active Calibration
2	AA 960154	Filter - High Pass 2.4 GHz	KWM	HFF-L-14186	7272-02	4/21/2021	4/21/2022	Active Calibration
3	AA 960176	Cable	A.H. Systems, Inc	SAC-26G-6	395	2/3/2021	7/24/2022	Active Calibration
4	EE 960085	Analyzer - EMI Receiver	Agilent	N9038A	MY51210148	5/14/2021	5/14/2022	Active Calibration
5	EE960196	Meter - Hygro-Thermometer	Control Company	90080-03	180045462	5/14/2021	5/14/2021	Active Calibration
6	EE 960203	Analyzer - EMI Receiver	Keysight	N9038A	MY56400072	4/20/2021	4/20/2022	Active Calibration
7	LSC-500	Cable	Chamber 5 Emiss -	-	-	9/14/2020	9/14/2021	Active Calibration
8	AA 960081	Antenna - Double Ridge Horn	EMCO	3115	6907	10/29/2020	10/29/2021	Active Calibration
9	EE 960159	Antenna - Low Noise Amplifier	Mini-Circuits	ZVA-213X-S+	691801732	12/7/2020	12/7/2021	Active Calibration

EUT Parameters

Input Power	3.7VDC	Mode	WLAN Modulated Transmit
Channels	1, 6, 11	Data Rates/Modulations	802.11b 1Mbps (Harmonics) 802.11n MCS0 (Band Edges)

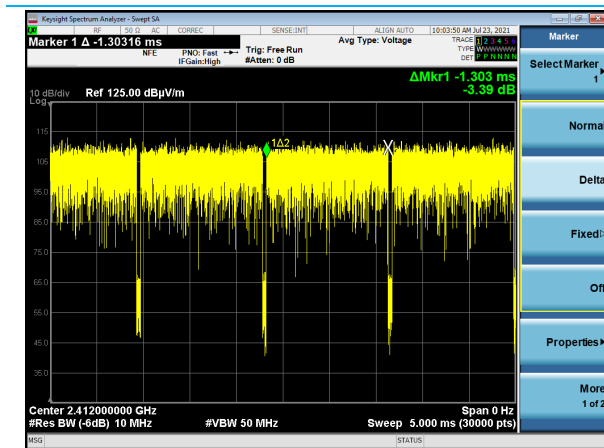
Data Tables

Frequency (GHz)	Antenna Height (cm)	Azimuth (Deg)	EUT Orientation	Antenna Polarity	Channel	Average Reading (dBμV/m)	Average Limit (dBμV/m)	Average Margin (dB)
2.3899867	150	150	Vertical	Horizontal	1	47.4	54.0	6.6
2.4835209	150	30	Vertical	Horizontal	11	44.4	54.0	9.6

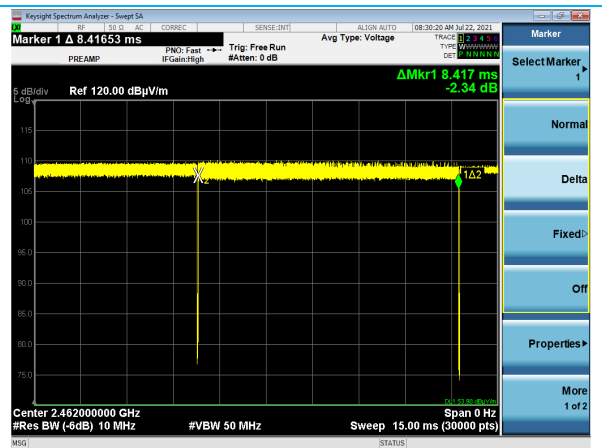
Frequency (GHz)	Antenna Height (cm)	Azimuth (Deg)	EUT Orientation	Antenna Polarity	Channel	Peak Reading (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)
2.389912	150	150	Vertical	Horizontal	1	58.2	74.0	15.8
2.4835022	150	30	Vertical	Horizontal	11	57.0	74.0	17.0

Frequency (MHz)	Antenna Polarity	Height (cm)	Azimuth (degree)	EUT Orientation	Peak Reading (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	Average Reading (dBμV/m)	Average Limit (dBμV/m)	Average Margin (dB)
17367.5	Horizontal	150	0	Vertical	48.9	74.0	25.1	38.5	54.0	15.5
17133.4	Vertical	150	0	Vertical	50.1	74.0	23.9	40.0	54.0	14.0
4924.0	Horizontal	150	0	Vertical	45.8	74.0	28.2	34.2	54.0	19.8
4823.9	Horizontal	150	0	Flat	44.8	74.0	29.2	30.3	54.0	23.7
4823.9	Vertical	150	0	Vertical	43.4	74.0	30.6	33.0	54.0	21.0
4823.9	Horizontal	150	0	Horizontal	39.8	74.0	34.2	31.0	54.0	23.0

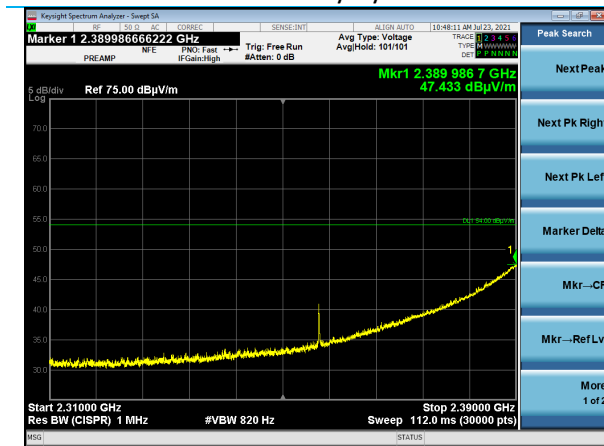
Plots



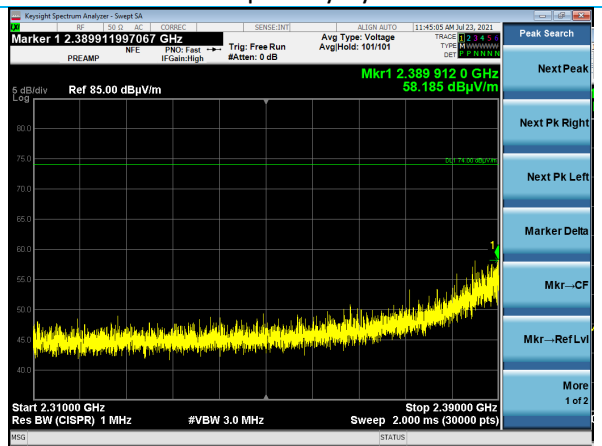
802.11n MCS0 Duty Cycle On Time



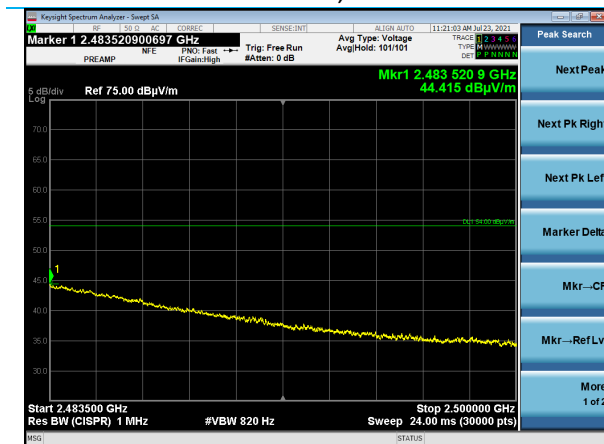
802.11b 1Mbps Duty Cycle On Time



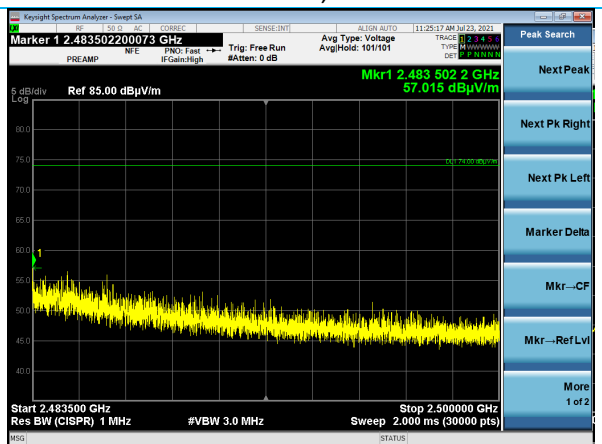
2310-2390 MHz, Average
802.11n MCS0, Channel 1



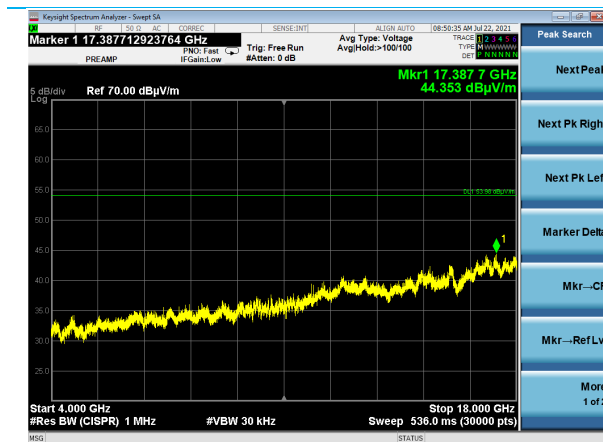
2310-2390 MHz, Peak
802.11n MCS0, Channel 1



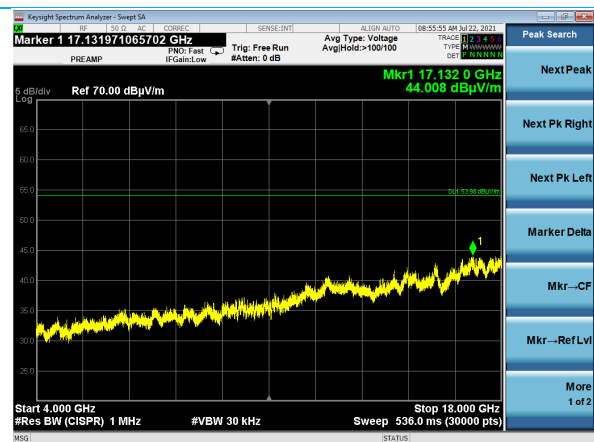
2483.5-2500 MHz, Average
802.11n MCS0, Channel 11



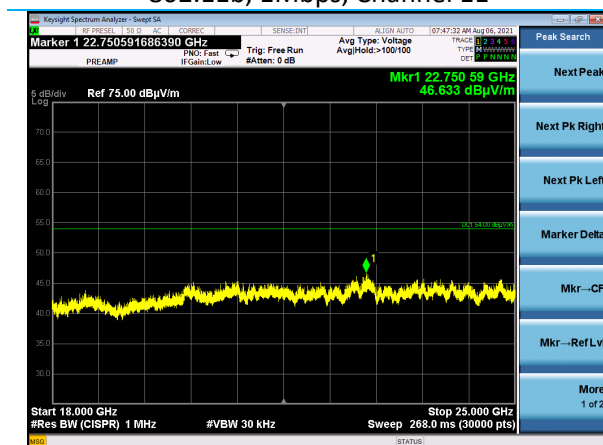
2483.5-2500 MHz, Peak
802.11n MCS0, Channel 11



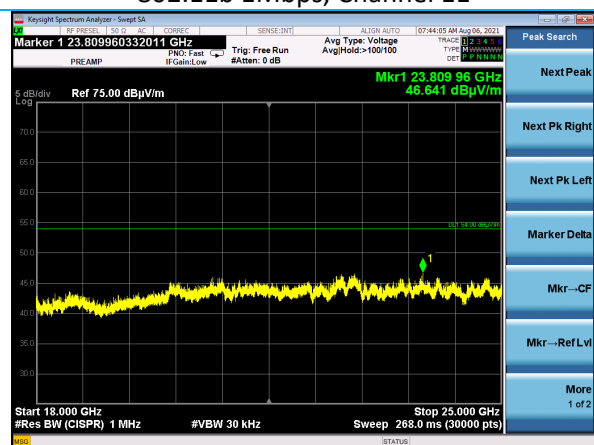
4-18 GHz, Horizontal Antenna
802.11b, 1Mbps, Channel 11



4-18 GHz, Vertical Antenna
802.11b 1Mbps, Channel 11



18-25 GHz, Horizontal Antenna
802.11b 1Mbps, Channel 6



18-25 GHz, Vertical Antenna
802.11b 1Mbps, Channel 6

5.2.2 Radiated Emissions – Bluetooth Low Energy

Operator	Ivan Alvarez	QA	Anthony Smith
Temperature	23.3C	R.H. %	51.40%
Test Date	7/22/2021, 8/5/2021	Location	Chambers 3 and 5
Requirement	FCC 15.247, RSS-247, FCC 15.209, RSS-GEN	Method	ANSI C63.10

Limits:

Peak: 74 dBμV/m

Average: 54 dBμV/m

Test Parameters

Frequency	2310-2390 MHz 2483.5-2500 MHz 4-25 GHz	Distance	3m
Detector(s)	Peak max hold for plots. Average band edge measurements taken with a VBW of 300 Hz.	Table height	150cm
RBW	1 MHz	VBW	300 Hz for Average 3 MHz for Peak

Instrumentation

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	AA 960158	Antenna - Double Ridge Horn	ETS Lindgren	3117	109300	12/7/2020	12/7/2021	Active Calibration
2	AA 960154	Filter - High Pass 2.4 GHz	KWM	HPF-L-14186	7272-02	4/21/2021	4/21/2022	Active Calibration
3	AA 960176	Cable	A.H. Systems, Inc	SAC-26G-6	395	2/3/2021	7/24/2022	Active Calibration
4	EE 960085	Analyzer - EM Receiver	Agilent	N9038A	MY51210148	5/14/2021	5/14/2022	Active Calibration
5	EE960196	Meter - Hygro-Thermometer	Control Company	90080-03	180045462	5/14/2021	5/14/2021	Active Calibration
6	EE 960203	Analyzer - EM Receiver	Keysight	N9038A	MY56400072	4/20/2021	4/20/2022	Active Calibration
7	LSC-500	Cable	Chamber 5 Emiss -	-	-	9/14/2020	9/14/2021	Active Calibration
8	AA 960081	Antenna - Double Ridge Horn	EMCO	3115	6907	10/29/2020	10/29/2021	Active Calibration
9	EE 960159	Antenna - Low Noise Amplifier	Mini-Circuits	ZVA-213X-S+	691801732	12/7/2020	12/7/2021	Active Calibration

EUT Parameters

Input Power	3.7VDC	Mode	BLE Modulated Transmit
Channels	0, 19, 39	Data Rates/Modulations	GFSK 1Mbps

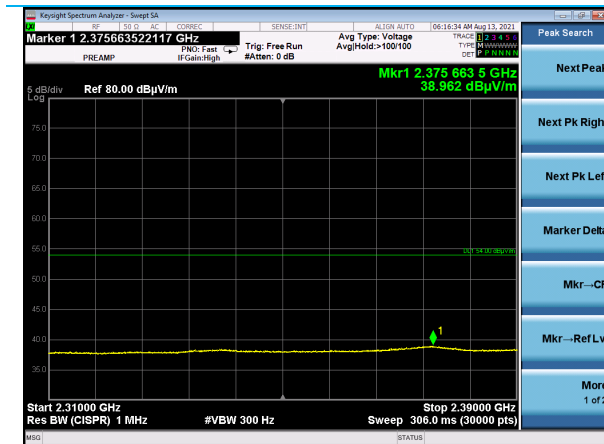
Data Tables

Frequency (MHz)	Antenna Polarity	Height (cm)	Azimuth (degree)	Average Reading (dBμV/m)	Average Limit (dBμV/m)	Average Margin (dB)	Channel
2375.7	Horizontal	210	157	39.0	54.0	15.0	0
2486.8	Horizontal	210	157	39.1	54.0	14.9	39

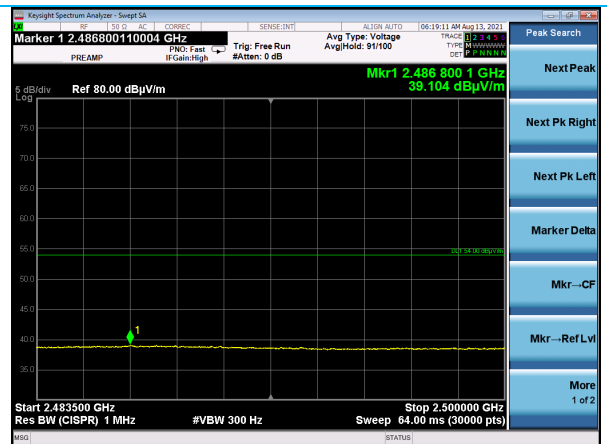
Frequency (MHz)	Antenna Polarity	Height (cm)	Azimuth (degree)	Peak Reading (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	Channel
2375.7	Horizontal	210	157	49.3	74.0	24.7	0
2486.8	Horizontal	210	157	49.7	74.0	24.3	39

Frequency (MHz)	Antenna Polarity	Height (cm)	Azimuth (degree)	Peak Reading (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	Average Reading (dBμV/m)	Average Limit (dBμV/m)	Average Margin (dB)	Channel
17067.6	Vertical	150	0	50.6	74.0	23.4	40.4	54.0	13.6	0
16820.1	Horizontal	150	0	48.3	74.0	25.7	39.9	54.0	14.1	0
17072.0	Horizontal	150	0	49.8	74.0	24.2	41.6	54.0	12.4	0
17892.3	Horizontal	150	0	49.8	74.0	24.2	39.9	54.0	14.1	39
17087.7	Vertical	150	0	50.0	74.0	24.0	39.8	54.0	14.2	39
17067.6	Vertical	150	0	50.6	74.0	23.4	40.4	54.0	13.6	39

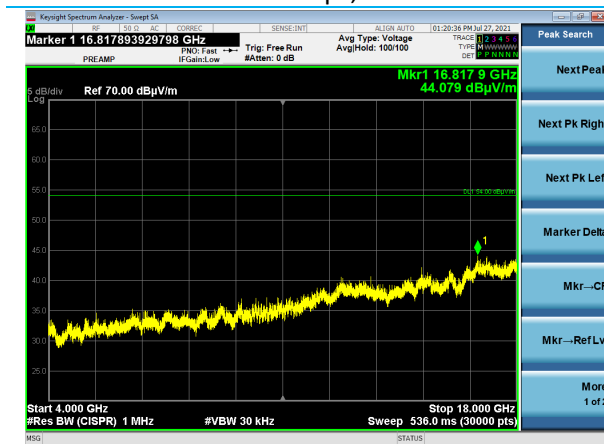
Plots



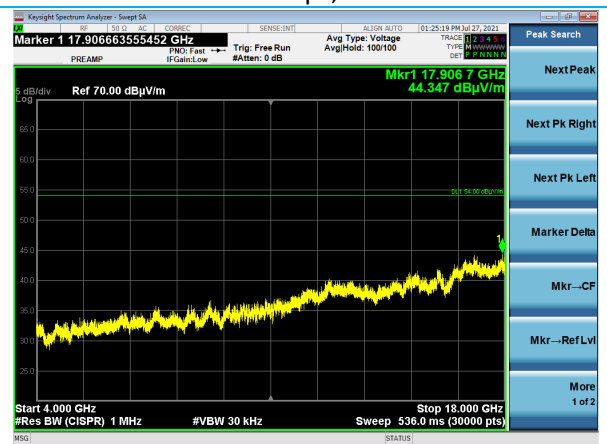
2310-2390 MHz, Average
BLE GFSK 1Mbps, Channel 0



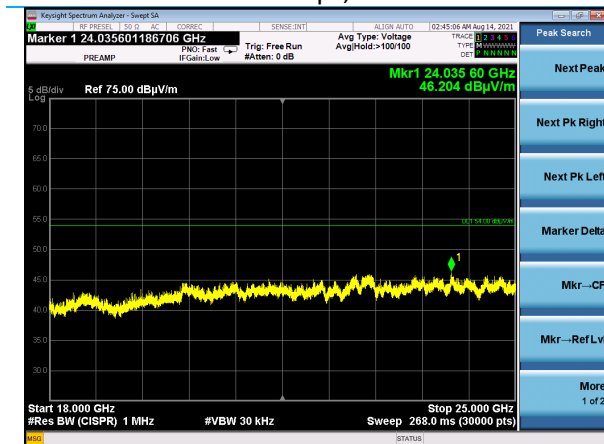
2483.5-2500 MHz, Average
BLE GFSK 1Mbps, Channel 39



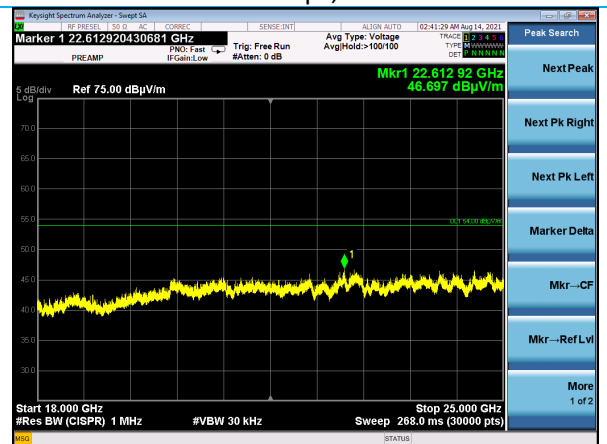
4-18 GHz, Horizontal Antenna
BLE GFSK 1Mbps, Channel 19



4-18 GHz, Vertical Antenna
BLE GFSK 1Mbps, Channel 19



18-25 GHz, Horizontal Antenna
BLE GFSK 1Mbps, Channel 39



18-25 GHz, Vertical Antenna
BLE GFSK 1Mbps, Channel 39

6 REVISION HISTORY

Version	Date	Notes	Person
0	8/18/2021	Initial Draft	Zach Wilson

END OF REPORT