

Test Report # TR 316356 A (DTS)

Equipment Under Test: Sterling-LWB5

Test Date(s): February 7, 2017 to May 6, 2017

Prepared for: Laird Technologies, Inc.
Attn: Bill Steinike
W66N220 Commerce Court
Cedarburg, WI 53012

Report Issued by:

Signature: 

Date: 5/9/2017

Report Reviewed by: Adam Alger, Quality Systems Engineer

Signature: 

Date: 5/9/2017

Report Constructed by:

Signature: 

Date: 5/3/2017

This test report may not be reproduced, except in full, without written approval of Laird Technologies, Inc.

Company: Laird Technologies, Inc.	Page 1 of 73	Name: Sterling-LWB5
Report: TR 316356 A (DTS)		Model: Sterling-LWB5
Job: C-2602		Serial: WLAN-00008,00035 BLE-00009, 00015, 00019, 00032

CONTENTS

Laird Technologies 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.....	6
3 References	7
4 Uncertainty Summary	8
5 Test Data	9
5.1 Antenna Port Conducted Emissions.....	9
5.1.1 Antenna Port Conducted Emissions – Duty Cycle	10
5.1.2 Antenna Port Conducted Emissions – Bandwidth	13
5.1.3 Antenna Port Conducted Emissions – Power Out.....	20
5.1.4 Antenna Port Conducted Emissions – PSD.....	25
5.1.5 Antenna Port Conducted Emissions – 100 kHz Band Edge	30
5.1.6 Antenna Port Conducted Emissions – Restricted-Band Band-Edges	34
5.1.7 Antenna Port Conducted Emissions – 100 kHz Spurious Emissions	40
5.1.8 Antenna Port Conducted Emissions – Spurious Emissions	46
5.2 Radiated Emissions	55
5.2.1 Radiated Emissions – Restricted-Band Band-Edges.....	56
5.2.2 Radiated Emissions – Spurious Emissions.....	62
5.3 AC Mains Conducted Emissions	69
5.3.1 AC Mains Conducted Emissions	70
6 Revision History	73

Laird Technologies 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:



A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025: 2005 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 recognition of two 3 meter Semi-Anechoic Chambers

Accredited Test Firm Registration Number: 953492



**Government
of Canada**

Innovation, Science and Economic Development Canada

ISED Site listing of two 3 meter Semi-Anechoic Chambers based on RSS-GEN – Issue 4

File Number: IC 3088A-2

File Number: IC 3088A-3

Company: Laird Technologies, Inc.	Page 3 of 73	Name: Sterling – LWB5
Report: TR 315356 A (DTS)		Model: Sterling – LWB5
Job: C-2602		Serial: WLAN – 00008, 00035 BLE – 00009, 00015, 00019, 00032

1 TEST REPORT SUMMARY

During **February 7, 2017-May 6, 2017** the Equipment Under Test (EUT), **Sterling-LWB5**, as provided by **Laird Technologies, Inc.** was tested to the following requirements:

FCC 15.247 / RSS-247

Requirement	Description	Specification	Method	Result
FCC: 15.247 (a)(2) ISED: RSS-247 5.2 (a)	Digital Modulation System 6 dB bandwidth	500 kHz	ANSI C63.10	Pass
FCC: 2.1049 ISED: RSS-GEN 6.6	Occupied Bandwidth	Reported	ANSI C63.10	Reported
FCC: 15.247 (b)(3) ISED: RSS-247 5.4 (d)	Maximum Conducted Output Power	30 dBm	ANSI C63.10	Pass
FCC: 15.247 (e) ISED: RSS-247 5.2 (b)	Digital Modulation System Power Spectral Density	8 dBm / 3 kHz	ANSI C63.10	Pass
FCC: 15.247 (d) ISED: RSS-247 5.5	RF Spurious Emissions at the Transmitter Antenna Terminal	20 dBc	ANSI C63.10	Pass
FCC: 15.247 (d) ISED: RSS-GEN 8.10	Spurious Radiated Emissions in Restricted Bands	FCC 15.209 RSS-GEN 8.9	ANSI C63.10	Pass
FCC: 15.207 ISED: RSS-GEN 8.8	AC Power Line Conducted Emissions	0.150-30 MHz	ANSI C63.10	Pass

Notice:

The results relate only to the item tested and described in this report. Any modifications made to the equipment under test after the specified test date(s) may invalidate the data herein.

If the resulting measurement margin is seen to be within the uncertainty value, as listed in this report, the possibility exists that this unit may not meet the required limit specification if subsequently tested.

2 CLIENT INFORMATION

Company Name	Laird Technologies, Inc.
Contact Person	Bill Steinike
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	Sterling-LWB5
Model Number	Sterling-LWB5
Serial Number	WLAN – 00008, 00035 BLE – 00009, 00015, 00019, 00032
FCC ID	TFB-1004
IC ID	5969A-1004

2.2 Product Description

The Sterling-LWB5 is a multi-standard module with support for 2.4 GHz WLAN (802.11 b/g/n), 5.0 GHz WLAN (802.11 a/ac/n), Bluetooth V2.1+EDR, Bluetooth 3.0, and Bluetooth with multiple antenna options.

Chip Antenna: Johanson Part # 2450AD14A5500 peak gain 1.0 dBi (2.4 GHz) / 4.0 dBi (5.5 GHz)

U.FL Antenna port utilizes the following antenna options:

LSR Part #001-0009 2.4 GHz Dipole Antenna peak gain 2.0 dBi (2.4 GHz & 5.5 GHz)

LSR Part #001-0016 2.4 GHz FlexPIFA peak gain 2.5 dBi (2.4 GHz) / 3.0 dBi (5.5 GHz)

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

Module was powered at 3.3VDC using a variable DC power supply.

WLAN settings were programmed using Sterling WLAN RF Eval Tool Version 2.8.0.0. WLAN modes, data rates and frequencies used for testing: 802.11b, HT-20, 1 Mbps, 2412 MHz, 2437 MHz, 2462 MHz; 802.11g, HT-20, 6 Mbps, 2412 MHz, 2437 MHz, 2462 MHz; 802.11n, HT-20, MCS0, 2412 MHz, 2437 MHz, 2462 MHz; 802.11n, HT-40, MCS0, 2422 MHz, 2442, MHz, 2462 MHz.

BLE settings were programmed using Bluetooth RF Eval Tool Version 8.7.0.0. Frequencies used: 2402 MHz, 2440 MHz, 2480 MHz.

Company: Laird Technologies, Inc.	Page 6 of 73	Name: Sterling – LWB5
Report: TR 315356 A (DTS)		Model: Sterling – LWB5
Job: C-2602		Serial: WLAN – 00008, 00035 BLE – 00009, 00015, 00019, 00032

3 REFERENCES

Publication	Edition	Date	AMD 1	AMD 2	Type
47 CFR, Parts 0-15 (FCC)		2017			
RSS 247	2	2017			
RSS GEN	4	2014			
ANSI C63.10		2013			
FCC KDB 558074 D01 v04		2017			

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 %

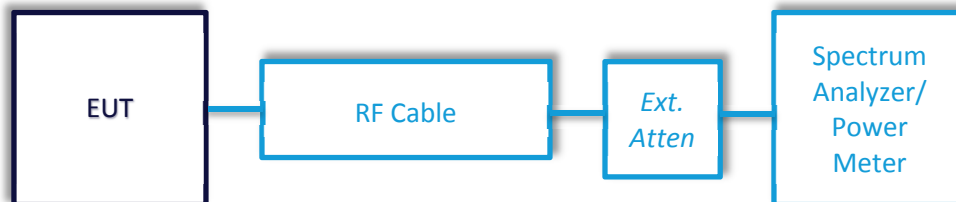
Company: Laird Technologies, Inc.	Page 8 of 73	Name: Sterling – LWB5
Report: TR 315356 A (DTS)		Model: Sterling – LWB5
Job: C-2602		Serial: WLAN – 00008, 00035 BLE – 00009, 00015, 00019, 00032

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 – Duty Cycle

Operator	Kimberly Bay / Shane Dock
QA	John Johnston / Kimberly Bay
Test Date	February 7, 2017 / March 1, 2017 / March 29, 2017
Location	Conducted RF Test Bench
Temp. / R.H.	21°C / 34-35% RH
Method	ANSI C63.10 2013 Section 11.6

Test Parameters

Settings	RBW = 8 MHz, VBW = 50 MHz, zero span
EUT	1 channel each: 802.11b, 802.11g, 802.11n, 802.11n HT-40, BLE
Example Calculations	$\text{Duty Cycle} = (\text{on-time}) / (\text{on-time} + \text{off-time})$ $\text{Ex: } (390.5 \mu\text{s}) / (390.5 \mu\text{s} + 234.5 \mu\text{s}) = 0.625$ $\text{Duty Cycle Correction} = 10 \log (1/\text{duty cycle})$ $\text{Ex: } 10 \log (1/0.625) = 2.04$

Instrumentation



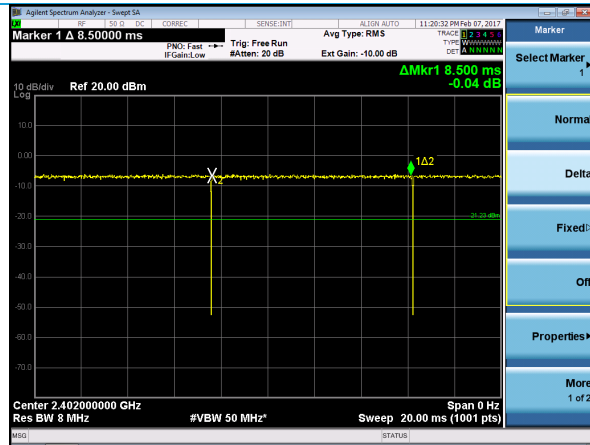
Date: 6-Feb-2017 Type Test: DTS Conducted RF Measurements Job #: C-2602
 Prepared By: Kim/Shane Customer: Laird Technologies, Inc. Quote #: 316356

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960087	Spectrum Analyzer	Agilent	N9010A	MY53400296	12/22/2016	12/22/2017	Active Calibration
2	AA 960143	Phaseflex	Gore	EKD01D01048.0	5548519	6/26/2015	6/25/2017	Active Calibration
3	AA 960172	Cable - low loss 1m	A.H. Systems, Inc	SAC-26G-1	387	5/16/2016	5/16/2017	Active Verification
4	EE 960085	EMI Receiver	Agilent	N9038A	MY51210148	5/12/2016	5/12/2017	Active Calibration

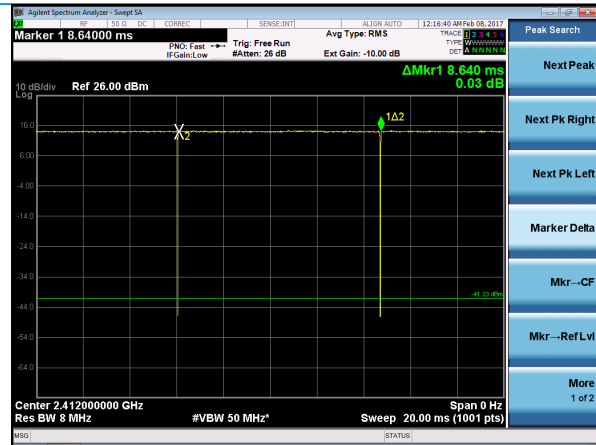
Table –Duty Cycles and Duty Cycle Correction Factors

Mode	Duty Cycle	Correction Factor
802.11b	0.98	0
802.11g	0.96	0.18
802.11n	0.958	0.19
802.11n HT-40	0.93	0.315
BLE	0.625	2.04

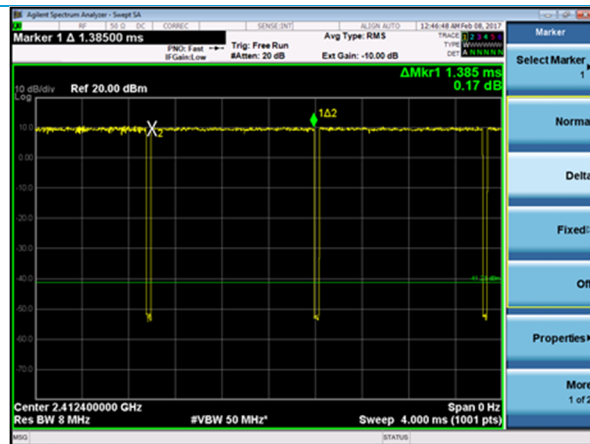
Plots – Duty Cycle



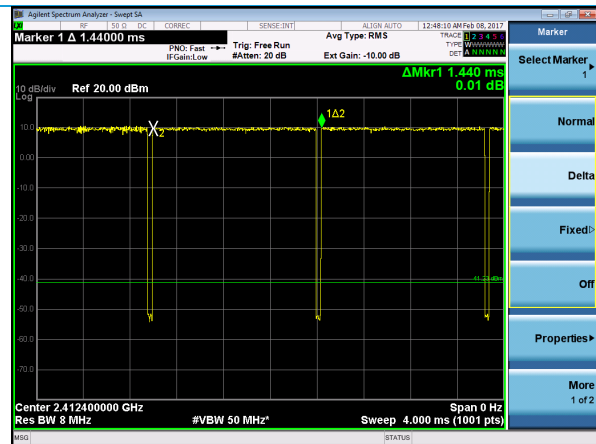
802.11b On-Time



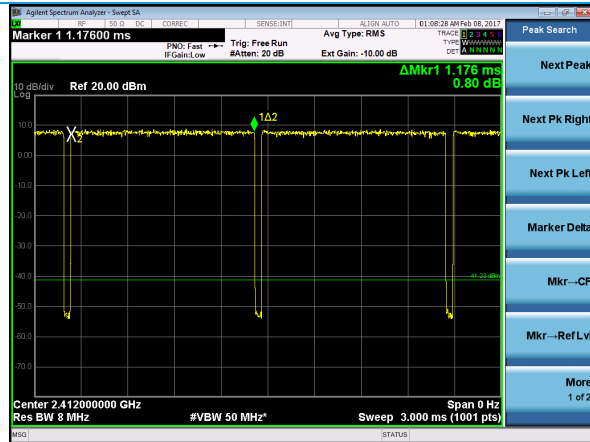
802.11b – On + Off-Time



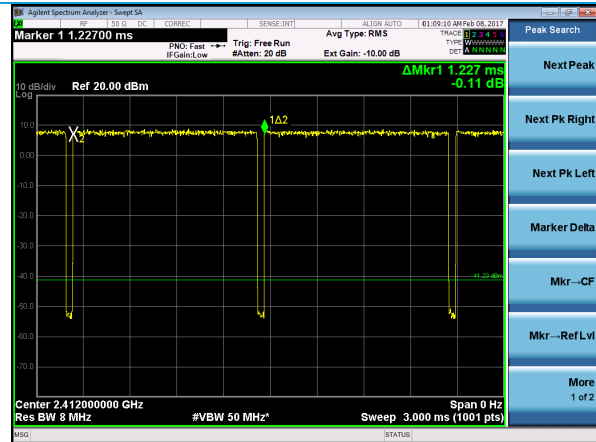
802.11g On-Time



802.11g – On + Off-Time



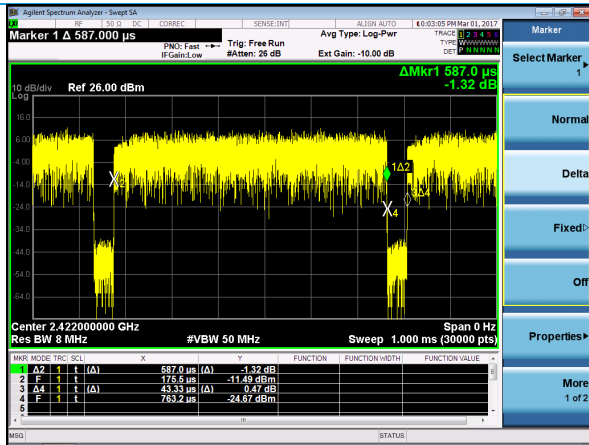
802.11n On-Time



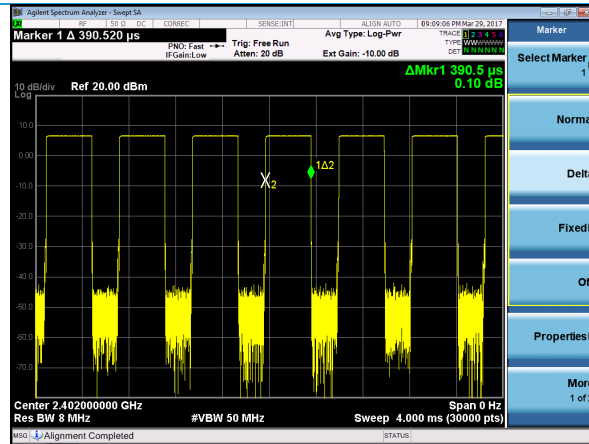
802.11n – On + Off-Time

Company: Laird Technologies, Inc.	Page 11 of 73	Name: Sterling – LWB5
Report: TR 315356 A (DTS)		Model: Sterling – LWB5
Job: C-2602		Serial: WLAN – 00008, 00035 BLE – 00009, 00015, 00019, 00032

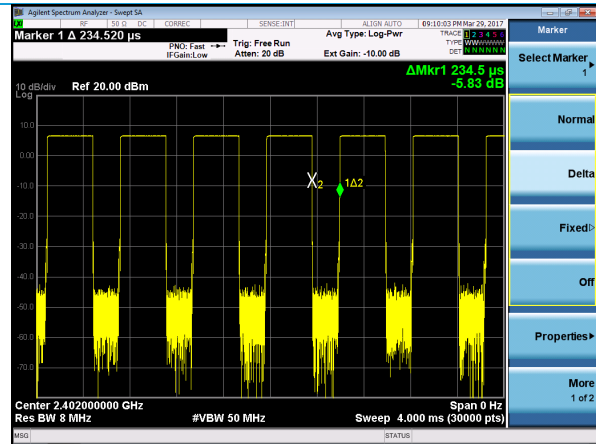
Plots – Duty Cycle, continued



802.11n HT-40 On & Off-Times



BLE On-Time



BLE Off-Time

Company: Laird Technologies, Inc.	Page 12 of 73	Name: Sterling – LWB5
Report: TR 315356 A (DTS)		Model: Sterling – LWB5
Job: C-2602		Serial: WLAN – 00008, 00035 BLE – 00009, 00015, 00019, 00032

5.1.2 Antenna Port Conducted Emissions – Bandwidth

Operator	Shane Dock / Kimberly Bay
QA	Kimberly Bay / Shane Dock
Test Date	February 22, 2017 / March 17, 2017 / March 29, 2017
Location	Conducted RF Test Bench
Temp. / R.H.	21-22°C / 34-35% RH
Requirement	6 dB BW – FCC 15.247 (a)(2) / RSS-247 Section 5.2 (a)
Method	6dB BW - ANSI C63.10 2013 Section 11.8.1 Option 1 OBW (99%) – ANSI C63.10 2013 Section 6.9.3

Limits:

6 dB BW

The minimum 6 dB bandwidth shall be at least 500 kHz.

Test Parameters

EUT	<u>802.11b HT-20, 1 Mbps:</u> 2412, 2437, 2462 MHz
EUT	<u>802.11g HT-20, 6 Mbps:</u> 2412, 2437, 2462 MHz
EUT	<u>802.11n HT-20, MCS0:</u> 2412, 2437, 2462 MHz
EUT	<u>802.11n HT-40, MCS0:</u> 2422, 2442, 2462 MHz
EUT	<u>BLE:</u> 2402, 2440, 2480 MHz

Instrumentation



Date : 6-Feb-2017 Type Test : DTS Conducted RF Measurements Job # : C-2602
 Prepared By: Kim/Shane Customer : Laird Technologies, Inc. Quote #: 316356

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960087	Spectrum Analyzer	Agilent	N9010A	MY53400296	12/22/2016	12/22/2017	Active Calibration
2	AA 360143	Phaseflex	Gore	EKD01D01048.0	5546519	6/26/2015	6/25/2017	Active Calibration
3	AA 360172	Cable - low loss 1m	A.H. Systems, Inc	SAC-26G-1	387	5/16/2016	5/16/2017	Active Verification
4	EE 960085	EMI Receiver	Agilent	N9038A	MY51210148	5/12/2016	5/12/2017	Active Calibration

Table – WLAN 6 dB BW

Channel	802.11b (MHz)	802.11g (MHz)	802.11n (MHz)	802.11n - HT40 (MHz)
Low	8.1	16.4	17.6	36.5
Mid	8.1	16.4	17.6	36.4
High	8.1	16.4	17.6	36.5

Table – WLAN 99% BW

Channel	802.11b (MHz)	802.11g (MHz)	802.11n (MHz)	802.11n - HT40 (MHz)
Low	11.0	17.4	18.4	36.3
Mid	11.1	17.4	18.3	36.3
High	11.3	17.5	18.4	36.3

Table – BLE 6 dB BW

Channel	BW (MHz)
Low	0.722
Mid	0.720
High	0.718

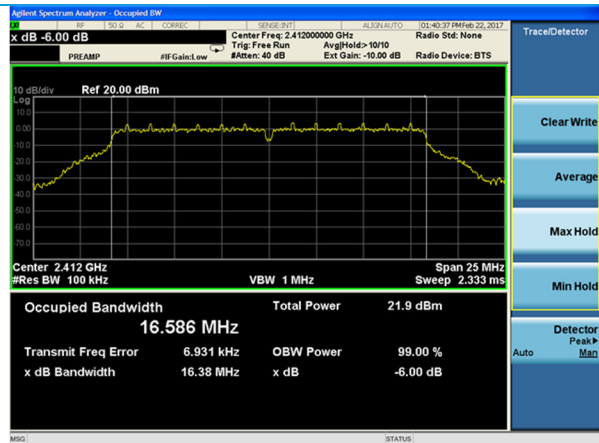
Table – BLE 99% BW

Channel	BW (MHz)
Low	1.05
Mid	1.06
High	1.05

Plots – WLAN 6 dB BW



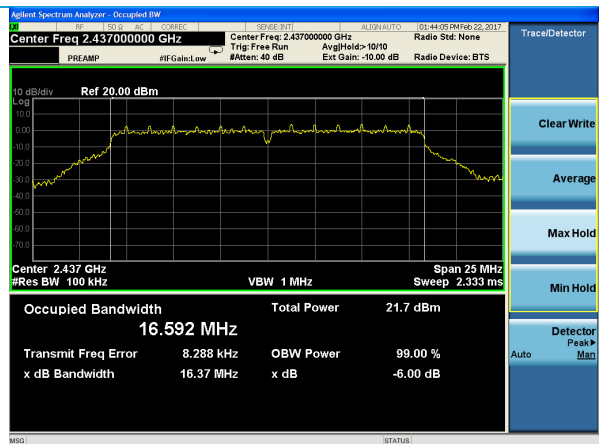
802.11b – Low Channel



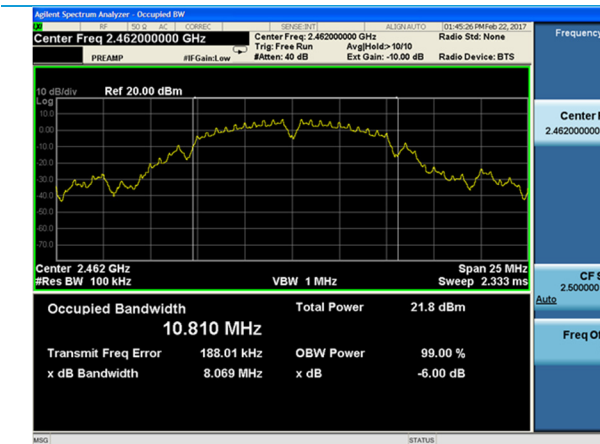
802.11g – Low Channel



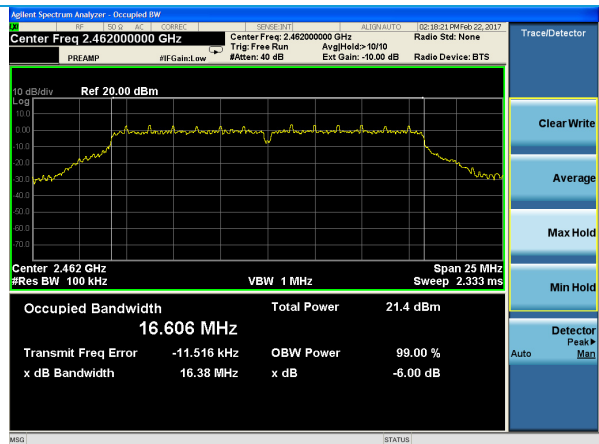
802.11b – Mid Channel



802.11g – Mid Channel



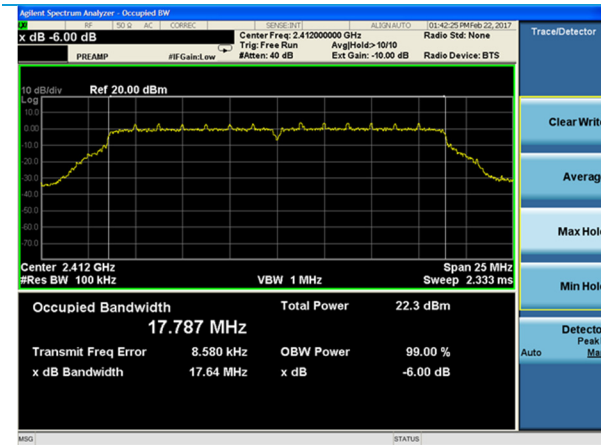
802.11b – High Channel



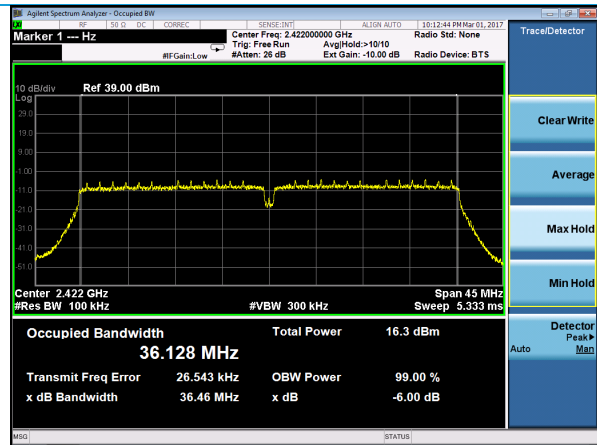
802.11g – High Channel

Company: Laird Technologies, Inc.	Page 15 of 73	Name: Sterling – LWB5
Report: TR 315356 A (DTS)		Model: Sterling – LWB5
Job: C-2602		Serial: WLAN – 00008, 00035 BLE – 00009, 00015, 00019, 00032

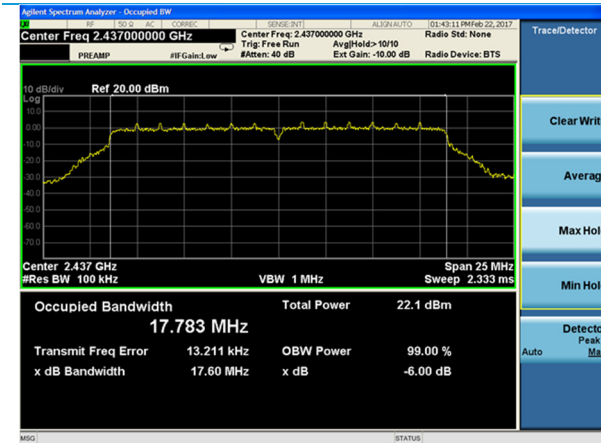
Plots – WLAN 6 dB BW, continued



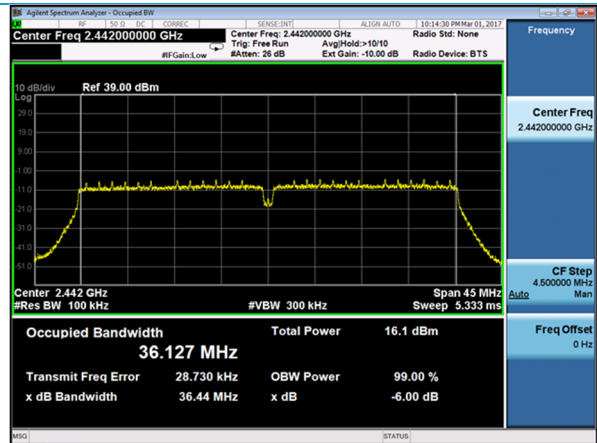
802.11n – Low Channel



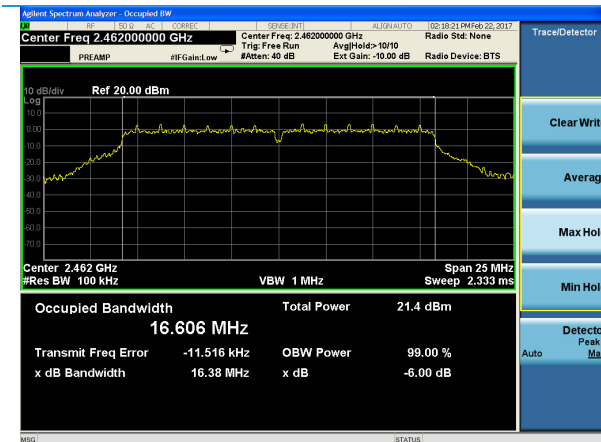
802.11n – HT40 – Low Channel



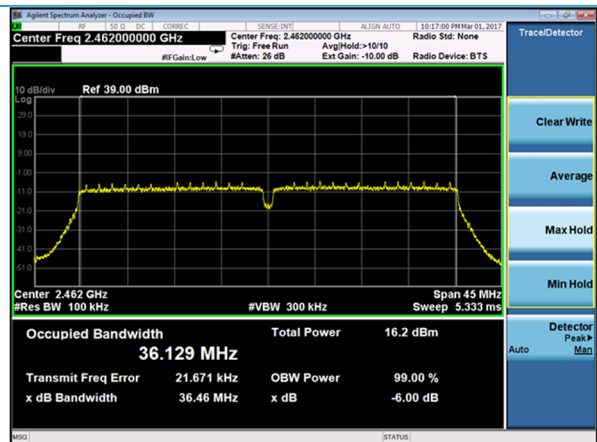
802.11n – Mid Channel



802.11n – HT40 – Mid Channel

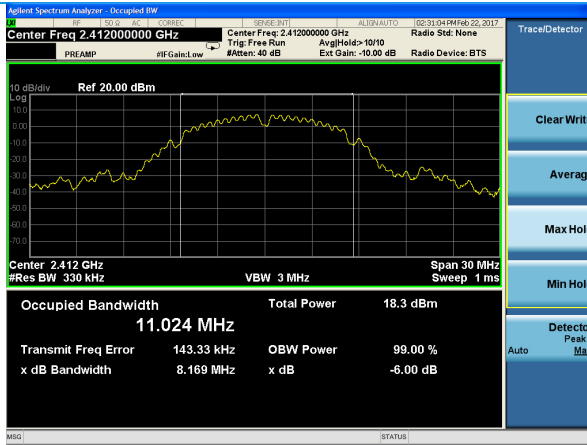


802.11n – High Channel

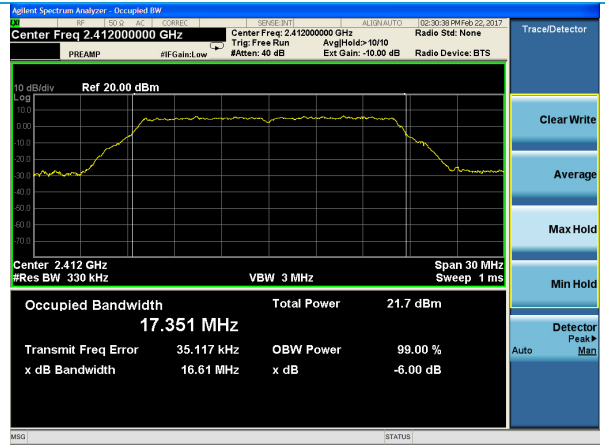


802.11n – HT40 – High Channel

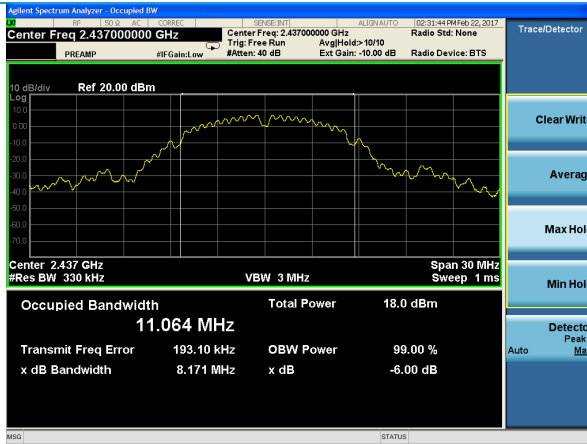
Plots – WLAN 99% BW



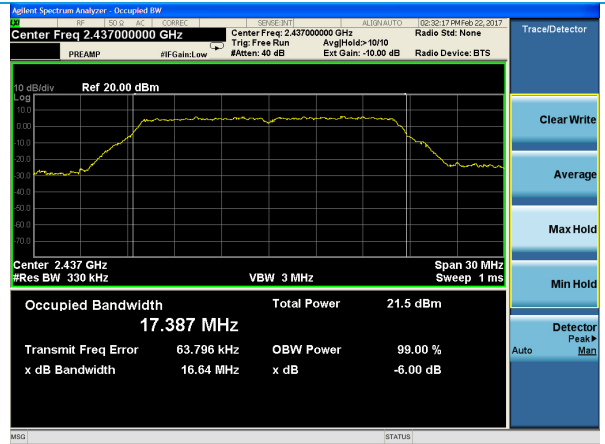
802.11b – Low Channel



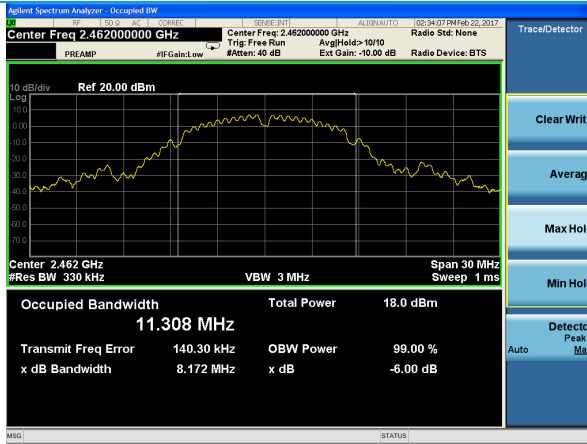
802.11g – Low Channel



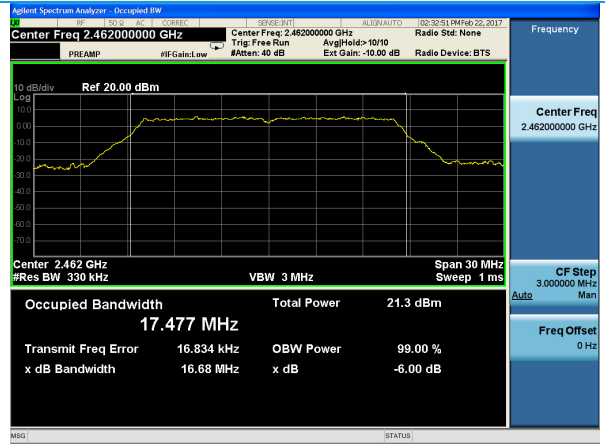
802.11b – Mid Channel



802.11g – Mid Channel



802.11b – High Channel



802.11g – High Channel

Company: Laird Technologies, Inc.	Page 17 of 73	Name: Sterling – LWB5
Report: TR 315356 A (DTS)		Model: Sterling – LWB5
Job: C-2602		Serial: WLAN – 00008, 00035 BLE – 00009, 00015, 00019, 00032