

Test Report C-3596C

Equipment Under Test: Lasair Pro

Requirement(s): FCC 1.1310, KDB 447498
ISED RSS-102

Test Date(s): 09/06/2023

Prepared for: Particle Measuring Systems
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Date: 10/20/2023

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Date: 09/06/2023

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Laird Connectivity Test Services in Review

The Laird Connectivity LLC 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 17025:2017 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

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1 TEST REPORT SUMMARY

During **09/06/2023** the Equipment Under Test (EUT), **LasairPro**, as provided by **Particle Measuring Systems** was tested to the following requirements:

Mobile Device

Requirements	Description	Method	Compliant
1.1310(e)(1)	Radiofrequency Radiation Exposure Limits	KDB 447498	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

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2 CLIENT INFORMATION

Company Name	Particle Measuring Systems
Contact Person	Joan Legerski
Address	5475 Airport Blvd Boulder, CO 80301

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	Lasair Pro
Model Number	5100, 310, 360
Serial Number	163810
FCC ID	2BCDH-LPRO
IC ID	31142-LPRO
Contains FCC ID	SQG-60SIPT
Contains IC ID	3147A-60SIPT

2.2 Product Description

Airborne particle counter implementing 2.4 GHz and 5 GHZ WLAN and NFC.

2.3 Antenna Information

NFC utilizes a board trace antenna.

60SIPT module using preapproved antenna – LSR/FlexPIFA

Gain @ 2400-2483.5 – 2.5 dBi

Gain @ 5150-5850 – 3.0 dBi

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2.4 Test Channels

Radio	Channel	Frequency (MHz)	Bandwidth (MHz)	Modulation
2.4 GHz WLAN	1	2412	20	1 Mbps
	6	2437	20	1 Mbps
	11	2452	20	1 Mbps
5 GHz WLAN	36	5180	20	6 Mbps
	44	5220	20	6 Mbps
	60	5300	20	6 Mbps
	64	5320	20	6 Mbps
	100	5500	20	6 Mbps
	120	5600	20	6 Mbps
	157	5785	20	6 Mbps

2.5 Firmware Versions

Lasair Pro FW: 01.02.03wi

Labtool Version: 1.1.0.188

Labtool Wireless Device Firmware Version: 88w8997.16.80.205.p208

Dut labtool Version: 1.0.0.164

2.6 Programming Information

EUT device was programmed via ethernet connected to a wireless network hub. VxWorks.bin firmware was loaded onto the EUT in order to operate Labtool to control the radio module. Putty command “debug set net 1” enabled the EUT to communicate with Labtool via the ethernet port. Labtool interface was accessed using clariFi debugger software by inputting the following commands in the Lua Command Line window:

“dofile “c:/ClariFi/labToolBridge.luac””

“labToolBridge()”

The following commands were then entered into windows cmd window:

“cd c:\labtool”

“DutApiSisoACDualif.exe”

The windows cmd window was then used to program the radio module Tx modes for testing.

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3 REFERENCES

Publication	Edition	Date	AMD 1
FCC eCFR	-	2023	-
RSS-102	5	2015	2021
KDB 447498	06	2015	-

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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

CISPR 16-4-1

CISPR 16-4-2

CISPR 32

ANSI C63.23

A2LA P103

A2LA P103c

ETSI TR 100-028

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 %

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5 FCC AND ISED EXEMPTION LIMITS FOR ROUTINE EVALUATION

5.1 FCC MPE Limits for General Population/Uncontrolled Exposure

5.1.1 Standalone

Table 1 1.1310(e)(1)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(i) Limits for Occupational/Controlled Exposure				
0.3–3.0	614	1.63	*(100)	≤6
3.0–30	1842/f	4.89/f	*(900/f ²)	<6
30–300	61.4	0.163	1.0	<6
300–1,500			f/300	<6
1,500–100,000			5	<6
(ii) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	<30
1.34–30	824/f	2.19/f	*(180/f ²)	<30
30–300	27.5	0.073	0.2	<30
300–1,500			f/1500	<30
1,500–100,000			1.0	<30

f = frequency in MHz. * = Plane-wave equivalent power density.

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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

5.1.2 Simultaneous Transmission KDB 447498 7.2

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0 .

$$\sum_1^a \frac{S_a}{S_{alimit}} < 1.0$$

5.2 ISED SAR Test Exclusions per IC RSS-102 Issue 5

5.2.1 Standalone SAR Test Exclusion

2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz⁶ and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

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5.2.2 Simultaneous Transmission SAR Test Exclusion

Compliance of devices with multiple transmitters capable of simultaneous transmission shall be assessed in accordance with the latest version of IEEE 1528. However, other recognized methods — such as the procedures¹⁶ published by the FCC proven to provide a conservative estimate of the SAR value — can also be used. Applicants shall include in the RF exposure technical brief all information relevant to the exact test methodology used.

6 STANDALONE TRANSMISSION SAR EXCLUSION EVALUATION

6.1 Justification for using 20 cm MPE evaluation

The device is a tabletop device with a touch screen. Only the user's hand and arm would come within 20cm of the radio module when operating the touch screen. This interaction would be infrequent and would not last for more than 10 seconds.

6.2 FCC SAR Exclusion Calculations

6.2.1 NFC Exclusion Calculations

Prediction frequency	13.56 MHz
Output power	-34.7 dBm
Tune-up tolerance	N/A
Maximum peak output power at antenna input terminal	0.00034 mW
Antenna gain	N/A
Prediction distance	20 cm
MPE limit at prediction frequency	1.0 mW/cm²
Power density at prediction frequency	6.76x10⁻⁸ mW/cm²

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the power density of **6.76x10⁻⁸ mW/cm²** is lower than the MPE limit of **1.0 mW/cm²**.

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6.2.2 BLE Exclusion Calculations

Prediction frequency	2402 MHz
Output power	10.8 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	12.8 dBm
Maximum peak output power at antenna input terminal	19.1 mW
Antenna gain	2.5 dBi
Numeric antenna gain	1.78
Prediction distance	20 cm
MPE limit at prediction frequency	1.0 mW/cm²
Power density at prediction frequency	0.00676 mW/cm²

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the power density of **0.00676 mW/cm²** is lower than the MPE limit of **1.0 mW/cm²**.

6.2.3 2.4 GHz WLAN Exclusion Calculations

Prediction frequency	2402 MHz
Output power	29.41 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	31.41 dBm
Maximum peak output power at antenna input terminal	1383.6 mW
Antenna gain	2.5 dBi
Numeric antenna gain	1.78
Prediction distance	20 cm
MPE limit at prediction frequency	1.0 mW/cm²
Power density at prediction frequency	0.49 mW/cm²

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the power density of **0.49 mW/cm²** is lower than the MPE limit of **1.0 mW/cm²**.

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6.2.4 5.0 GHz WLAN Exclusion Calculations

UNII-1

Prediction frequency	5240 MHz
Output power	21.6 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	22.6 dBm
Maximum peak output power at antenna input terminal	182.0 mW
Antenna gain	3.0 dBi
Numeric antenna gain	2.0
Prediction distance	20 cm
MPE limit at prediction frequency	1.0 mW/cm²
Power density at prediction frequency	0.072 mW/cm²

UNII-2a

Prediction frequency	5260 MHz
Output power	18.77 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	20.77 dBm
Maximum peak output power at antenna input terminal	119.4 mW
Antenna gain	3.0 dBi
Numeric antenna gain	2.0
Prediction distance	20 cm
MPE limit at prediction frequency	1.0 mW/cm²
Power density at prediction frequency	0.048 mW/cm²

UNII-2c

Prediction frequency	5580 MHz
Output power	21.01 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	23.01 dBm
Maximum peak output power at antenna input terminal	200.0 mW
Antenna gain	3.0 dBi
Numeric antenna gain	2.0
Prediction distance	20 cm
MPE limit at prediction frequency	1.0 mW/cm²
Power density at prediction frequency	0.080 mW/cm²

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UNII-3

Prediction frequency	5825 MHz
Output power	21.28 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	23.28 dBm
Maximum peak output power at antenna input terminal	212.8 mW
Antenna gain	3.0 dBi
Numeric antenna gain	2.0
Prediction distance	20 cm
MPE limit at prediction frequency	1.0 mW/cm²
Power density at prediction frequency	0.085 mW/cm²

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the power density of **0.085 mW/cm²** is lower than the MPE limit of **1.0 mW/cm²**.

6.3 ISED SAR Exclusion Calculations

6.3.1 NFC Exclusion Calculations

Frequency	13.56 MHz
Output power	-34.7 dBm
Tune-up tolerance	N/A
EIRP output power	0.00034 mW

$$EIRP_{limit} = 1W$$

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the maximum EIRP of **0.00034 mW** is lower than **1.0 W**

6.3.2 BLE Exclusion Calculations

Frequency	2402 MHz
Output power	10.8 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	12.8 dBm
Maximum peak output power at antenna input terminal	19.1 mW
Antenna gain	2.5 dBi
EIRP output power	144.5 mW

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$$EIRP_{limit} = 1.31 \times 10^{-2} * f^{0.6834} W = 1.31 \times 10^{-2} * 2402^{0.6834} W = 2.68 W$$

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the maximum EIRP of **144.5 mW** is lower than **2.68 W**

6.3.3 2.4 GHz WLAN Exclusion Calculations

Frequency	2402 MHz
Output power	29.41 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	31.41 dBm
Maximum peak output power at antenna input terminal	1383.6 mW
Antenna gain	2.5 dBi
EIRP output power	2.46 W

$$EIRP_{limit} = 1.31 \times 10^{-2} * f^{0.6834} W = 1.31 \times 10^{-2} * 2402^{0.6834} W = 2.68 W$$

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the maximum EIRP of **2.46 W** is lower than **2.68 W**

6.3.4 5.0 GHz WLAN Exclusion Calculations

UNII-1

Frequency	5240 MHz
Output power	21.6 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	22.6 dBm
Maximum peak output power at antenna input terminal	182.0 mW
Antenna gain	3.0 dBi
EIRP output power	363.1 mW

$$EIRP_{limit} = 1.31 \times 10^{-2} * f^{0.6834} W = 1.31 \times 10^{-2} * 5240^{0.6834} W = 4.56 W$$

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the maximum EIRP of **363.1 mW** is lower than **4.56 W**

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UNII-2a

Frequency	5260 MHz
Output power	18.77 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	20.77 dBm
Maximum peak output power at antenna input terminal	119.4 mW
Antenna gain	3.0 dBi
EIRP output power	238.2 mW

$$EIRP_{limit} = 1.31 \times 10^{-2} * f^{0.6834} W = 1.31 \times 10^{-2} * 5260^{0.6834} W = 4.57 W$$

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the maximum EIRP of **238.2 mW** is lower than **4.57 W**

UNII-2c

Prediction frequency	5580 MHz
Output power	21.01 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	23.01 dBm
Maximum peak output power at antenna input terminal	200.0 mW
Antenna gain	3.0 dBi
Power density at prediction frequency	399.0 mW

$$EIRP_{limit} = 1.31 \times 10^{-2} * f^{0.6834} W = 1.31 \times 10^{-2} * 5580^{0.6834} W = 4.76 W$$

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the maximum EIRP of **399.0 mW** is lower than **4.76 W**

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UNII-3

Prediction frequency	5825 MHz
Output power	21.28 dBm
Tune-up tolerance	2.0 dBm
Maximum peak output power at antenna input terminal	23.28 dBm
Maximum peak output power at antenna input terminal	212.8 mW
Antenna gain	3.0 dBi
Power density at prediction frequency	424.6 mW

$$EIRP_{limit} = 1.31 \times 10^{-2} * f^{0.6834} W = 1.31 \times 10^{-2} * 5825^{0.6834} W = 4.90 W$$

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the maximum EIRP of **424.6 mW** is lower than **4.90 W**

Result

The EUT's NFC radio is exempt from routine SAR evaluation as the power density of **0.085 mW/cm²** is lower than the MPE limit of **1.0 mW/cm²**.

7 SIMULTANEOUS TRANSMISSION SAR EXCLUSION EVALUATION

7.1 NFC and BLE simultaneous exclusion calculation

$$\frac{6.76 * 10^{-8}}{1.0} + \frac{0.00676}{1.0} = 0.0068$$

Result

The EUT's NFC and BLE simultaneous transmission is exempt from routine SAR evaluation as the power density ratio of **0.0068** is lower than the power density ratio limit of **1.0**.

7.2 NFC and 2.4 GHz WLAN simultaneous exclusion calculation

$$\frac{6.76 * 10^{-8}}{1.0} + \frac{0.49}{1.0} = 0.49$$

Result

The EUT's NFC and BLE simultaneous transmission is exempt from routine SAR evaluation as the power density ratio of **0.49** is lower than the power density ratio limit of **1.0**.

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7.3 NFC and 5.0 GHz WLAN simultaneous exclusion calculation

UNII-3 Worst Case

$$\frac{6.76 * 10^{-8}}{1.0} + \frac{0.085}{1.0} = 0.085$$

Result

The EUT's NFC and BLE simultaneous transmission is exempt from routine SAR evaluation as the power density ratio of **0.085** is lower than the power density ratio limit of **1.0**.

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8 REVISION HISTORY

Version	Date	Notes	Person
0.0	09/06/2023	Initial Draft	Adam Hauke
1.0	09/08/2023	Final Draft	Adam Hauke
1.1	09/14/2023	Updated SAR Calculations	Adam Hauke
1.2	09/18/2023	EIRP Added for ISED Calculations	Adam Hauke
1.3	10/11/2023	Recalculation of SAR Values	Adam Hauke
1.4	10/20/2023	Updated calculations to MPE	Adam Hauke

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