EKSPLA

NL230 Series

Laser

Technical Description
User's Manual

NL230 Rev. 1710

2021
Lithuania

CONTENTS

**Some chapters may not appear in PDF version of this manual; they may be available as separate file(s).*

List of Figures

List of Tables

This page is intentionally left blank

Chapter 1 PREFACE

1.1. Legal Disclaimer

All original content in this Manual, including, but not limited to, texts, diagrams, schemes and datasheets, is an intellectual property of EKSPLA and is eligible for protection under copyright.

Any redistribution, retransmission or publication of any material is strictly prohibited without the express written consent of the copyright owner.

1.2. Statement of Use

The laser system is designed as scientific and/or OEM device and is intended for laboratory use for research, measurements, and as an optical source. It is classified as a Class 4 laser device and should only be used in a controlled environment with properly installed safety measures and operated by properly equiped and trained personnel.

Use in any other way and/or for any other purpose will be deemed improper. Ekspla cannot accept any responsibility for the consequences of improper use.

1.3. Generalized and/or Incomplete Information in the Manual

Some general information in this manual may be excessive and not related to the particular system. For example, the *Safety* chapter may contain information about hazards presented by flash lamps, even if the system has diode pumping only.

EKSPLA laser systems are under constant improvement and modification; many systems are heavily customized to suit the special needs of the customer. Because of this the manual may occasionally contain information which is outdated, incomplete, or erroneous; or it may omit some information about the specific system.

Please inform the manufacturer if such errors and/or omissions were noticed.

1.4. Special Attention

Please pay special attention to Chapter 4 Safety for information about safe handling and usage of the NL230 series laser systems.

Various notes and warnings that are present in this manual should be studied and followed to ensure the safe and effective handling of the system.

1.5. Manufacturer Contacts

EKSPLA
Savanoriu Ave 237
02300 Vilnius, Lithuania
Phone: +370 5 2649629
Fax: +370 5 2641809
E-mail: ekspla@ekspla.com
Web: http://www.ekspla.com

Chapter 2 WARRANTY

This chapter contains warranty statement and service contact information.

2.1. Warranty Statement

EKSPLA warrants to the original purchaser that laser devices are free from defects in parts and workmanship. *EKSPLA* will make any necessary repairs or replacement of parts to remedy any defect according to the conditions drawn up in the contract.

The foregoing warranty does not cover equipment that is damaged by accident or improper use. *EKSPLA* does not assume any liability if adaptations are made or accessories attached to the equipment that impair or alter the normal functioning of the equipment. The limited warranty and remedy contained in this paragraph are the only warranty and remedy pertaining to the equipment. *EKSPLA* DISCLAIMS ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. *EKSPLA* is not liable for any accidental, consequential or other damages or costs, lost profits or inconvenience occasioned by loss of the use of the equipment or labor expended by persons not so authorized by EKSPLA.

WARRANTY VOID IF *EKSPLA* STICKER IS REMOVED.

2.2. Coating Inhomogeneity

Small coating inhomogeneities, color change/discoloration marks on optical components are signs of light-material interaction during normal routine operation and as such are not to be treated as defects, as long as specified output parameters of the device are not altered.

2.3. Service Contact Information

We have a responsive Customer Service staff that will be pleased to help you. Please do not hesitate to contact them at:

Phone: +370 5 2649623

Fax: +370 5 2641809

E-mail: service@ekspla.com

This page is intentionally left blank

3.1. General Information

3.1.1. Model

NL231-100-SH/TH

3.1.2. Manufacturer

EKSPLA

3.1.3. Intended Fields of Use

OPO, TI:Sapphire and dye laser pumping, TFT-LCD repair, mass spectroscopy, remote sensing, light detection and ranging (LIDAR), light-induced fluorescence (LIF), particle image velocimetry (PIV), light-induced breakdown spectroscopy (LIBS), electronic speckle pattern interferometry (ESPI), medical, photo-acoustic imaging.

3.1.4. Main Components of the System

Component	*Quantity*
Laser head NL231-100-SH/TH **S/N DNL038**	1
PS8000 series power supply	1
SMC cooling unit	1
Control pad with cable	1
Set of cables and accessories	1
User's manual with software CD	1

3.2. Beam Output Characteristics

Parameter		***Specifications***
Wavelength, *nm*		1064, 532, 355
Pulse energy, *mJ*	1064 nm	>150
	532 nm	>90
	355 nm	>40
Pulse energy stability, *StdDev*	1064 nm	<1.0
	532 nm	<2.5
	355 nm	<3.5
Repetition rate, *Hz*		100
Pulse duration, *ns @ FWHM*		3…6
Beam profile		Hat-top in near field Close to Gaussian in far field
Beam divergence, *mrad (full angle @ 1/e²)*		<0.8
Polarization		Linear, >90%
Beam diameter, *mm*		~5
Jitter relative to internal SYNC pulse, *ns*		<0.4 (StDev)

3.3. Power Supply Requirements

Parameter	***Specifications***
Supply voltage	100…240 VAC
Frequency	47-63 Hz
Phase	1
Amps	10 A
Power consumption	<500 W
Ambient operation temperature	18…27 °C
Relative humidity	20…80 % (non-condensing)

3.4. Liquids and Gases

Fluid/gas	***Specifications/Information***
Distilled water	See 4.11 LIQUIDS AND GASES (p.15)
Pre-mixed solution of CoolFlow IGE and distilled/deionized water (25%:75%)	

3.5. Environmental Conditions

Equipment is designed to be safe under following environmental conditions according to 1.4.1.31010-1@IEC:

1. Indoor use.

2. Altitude up to 3000 m.
3. Temperature within 18…25 °C (64…77 °F).
4. Relative humidity up to 80% at temperatures below 31 °C.
5. Mains supply voltage fluctuations within ±10% from nominal.
6. Air contamination level – ISO 9 (room air) or better.
7. Pollution degree 1: no pollution or only dry non-conductive pollution.
8. For water-cooled systems with external water supply – presence of a tap water source with water temperature ≤20 °C, flow at least 8 l/min (pressure 1…8 bars).

3.6. Mechanical Dimensions

All external dimensions are given with ±3 mm tolerance.

3.6.1. Laser External dimensions

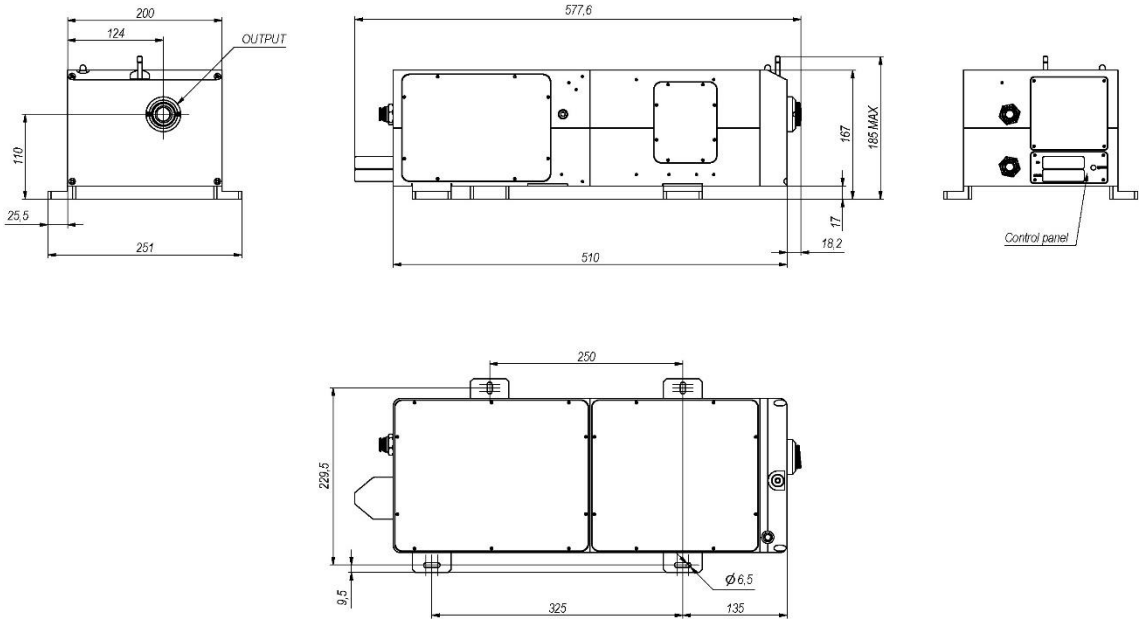


Figure 1 Outline drawing and dimensions of NL230 series laser

3.6.2. Weight

~15 kg.

3.6.3. Beam(s) position

See **Figure 1**.

3.6.4. Power Supply Dimensions

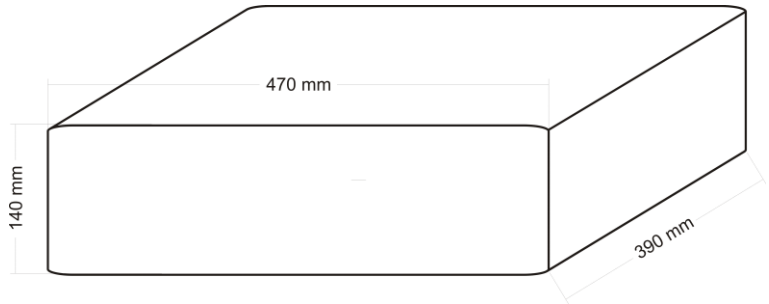


Figure 2 Outline drawing and dimensions of PS8000 series power supply

3.6.5. Placing and Fixing

The laser is intended to be placed on a flat solid surface.

This chapter provides information about safe handling and usage of the NL230 series lasers.

> ***Caution:***
> ***Use of controls and adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.***

4.1. Safety Class

This laser is a **Class 4** laser product according to the IEC60825 standard, and, by definition, relates to certain safety and fire hazards.

4.2. Safety Features and Government Requirements

EKSPLA incorporates various safety features into products to conform to government requirements. United States Government requirements are contained in Code of Federal Regulations Title 21 (21 CFR), Chapter I, Subchapter J (Radiological Health). European Community requirements for product safety are specified in the Low Voltage Directive (2014/35/EU), which requires that lasers comply with EN 60825-1 (Safety of Laser Products-Part 1) and EN 61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use-Part 1).

The laser product has a protective housing which, when in place, prevents human access to laser radiation (including errant) in excess of the AEL for Class 1 radiation, except for the output beam(s), which is Class 4 (21 CFR § 1040.10 (f) (1) 2019 / EN 60825-1:2014, clause 6.2).

A fail-safe or redundant warning device (emission indicator) gives a visible signal - amber light, clearly visible through protective eye wear specifically designed for the emitted wavelengths - when the laser system is switched on or if any capacitor banks of a pulsed laser are being charged or have not positively discharged. All operational controls (control pad, software) provide a clearly visible radiation warning for the persons in the vicinity. (21 CFR § 1040.10 (f) (5) 2019 / EN 60825-1:2014, clause 6.7)

A permanently attached beam attenuator (shutter), other than energy source switch, supply main connector or key master control, prevents human access to laser (and collateral) radiation (21 CFR § 1040.10 (f) (6) 2019 / EN 60825-1:2014, clause 6.8).

The laser controls are located so that human exposure to laser (or collateral) radiation is unnecessary for operation or adjustment of such controls (21 CFR § 1040.10 (f) (7) 2019 / EN 60825-1:2014, clause 6.9).

4.3. Electromagnetic Compatibility

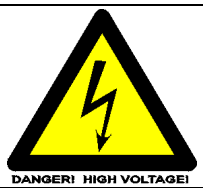
This *NL230* laser system complies with the European requirements for electromagnetic compatibility as defined in the Electromagnetic Compatibility Directive 2014/30/EU.

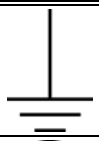
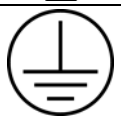
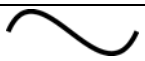
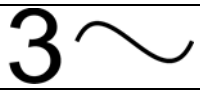
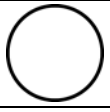
This laser system is intended for use in an ISM (Industrial, Scientific and Medical) Environment. Operation of this laser system in a different EMC environment may require that the user take remedial action in addition to the normal installation and operation described in this manual to resolve potential electromagnetic compatibility problems. *EKSPLA* makes no claims beyond those listed below concerning the compatibility of this laser system in EMC environment other than ISM environment.

4.4. Labeling

Tables in this subchapter list and explain the labels attached to the equipment. The numbers in the leftmost columns of the tables refer to the images below, illustrating the positions of the labels on devices.

Table 1 System labelling

# in image(s) below	Label	Explanation
	Identification labels	
1	EKSPLA Savanoriu Av. 237, 02300 Vilnius, Lithuania MANUFACTURED: MONTH _____ YEAR _____ MODEL _____ SERIAL# _____ THIS LASER PRODUCT COMPLIES WITH 21 CFR 1040.10 AND 1040.11 AS APPLICABLE EXCEPT FOR DEVIATIONS PURSUANT TO LASER NOTICE NO.50, JUNE 24, 2007	**Laser product certification and identification** Located on the rear panel of the laser frame.
	Laser radiation warning labels	
2	VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION **CLASS 4 LASER PRODUCT** IEC 60825-1:2007 MAX OUTPUT: **1mJ** PULSE DURATION: **~30 ps** WAVELENGTH: **1064, 532 nm** LASER MEDIUM: **Nd:YAG/YVO** LASER DIODE: **808 nm; max. 70 W**	**Laser hazard label** Located on the top cover of laser head; also duplicated on the front (output) panel of laser head. *Example only. Check the sticker(s) on the frame for actual values!*
3	**CAUTION - CLASS 4** VISIBLE AND INVISIBLE LASER RADIATION WHEN COVER OPEN AND INTERLOCK DEFEATED AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION	**Cover interlock label** Located on the top cover of laser head.
4	**AVOID EXPOSURE** VISIBLE AND/OR INVISIBLE LASER RADIATION EMITTED FROM THESE APERTURE(S)	**Aperture label** Located adjacent to the laser apertures.
5		**Laser hazard label** Located on front panel of laser head next to the beam output apertures.
	Electrical and magnetic warning labels	
		**Electric shock labels** Located on covers of high voltage switches, negative feedback boards and laser pump chambers.

# in image(s) below	Label	Explanation
		**Strong magnet labels** Located on top of Faraday rotators.
		**Electrical hazard labels** Located on the top covers and rear panels of power supply cabinets, on rear panels of power supplyies and on the rear panels of cooling units.
		**Caution label** **L**ocated on the bottom of the power supply (cabinet) rear panel, above the protective ground clamp.
		**Earth (ground) terminal symbol**
		**Protective conductor terminal symbol**
		**Single-phase alternating current symbol**
		**Three-phase alternating current symbol**
		**On (Supply) symbol**
		**Off (Supply) symbol**
Other possible symbols and labels used in this manual and on the system		
		**Hot surface labels** Located on some crystal ovens.
		**Risk of danger label**
		**Do Not Touch label** *Do not attempt to adjust the marked component. System is especially sensitive to its position; changing it may cause a loss of generation that is difficult to restore, or similar problems.*

# in image(s) below	Label	Explanation
		**Adjustable knob label** Indicates the relevant knob to be adjusted on some system parts, e.g. harmonic crystals.

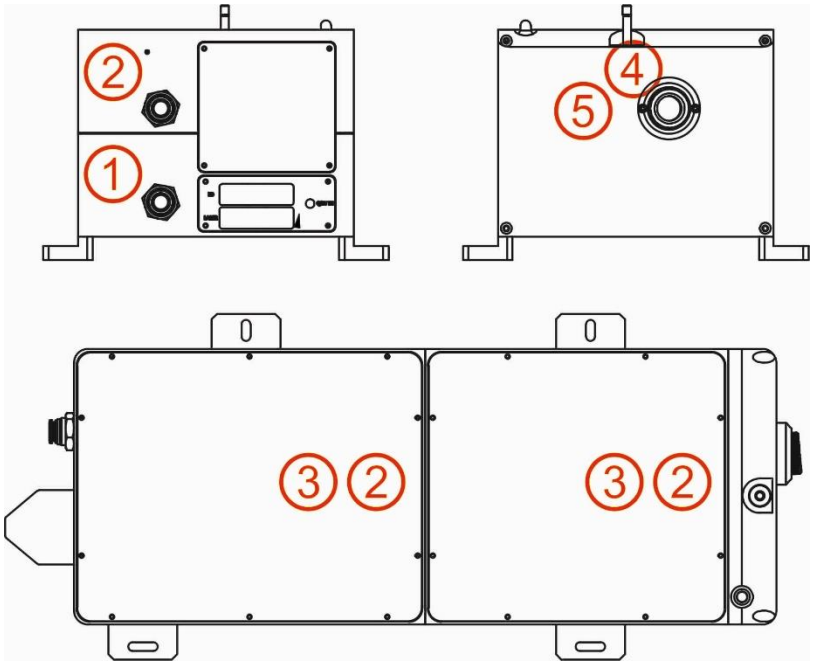


Figure 3 General warning label positions on the NL230 series laser

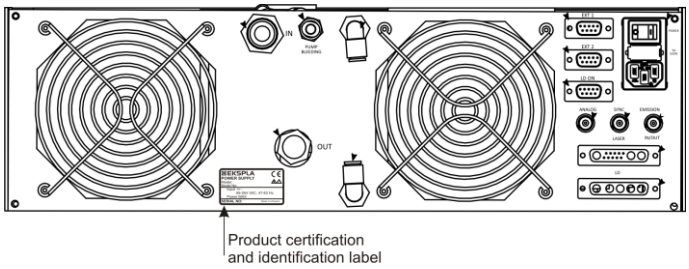


Figure 4 Warning label positions on the power supply (example)

4.4.1. Laser Radiation

This laser can emit laser radiation of different wavelengths:

Table 2 Emitted radiation

Radiation name	Wavelength(s), nm	Spectral range(s)	Visibility
Laser diode radiation	808	Infrared (IR)	Invisible
Fundamental	1064	IR	Invisible

Radiation name	Wavelength(s), nm	Spectral range(s)	Visibility
2nd harmonic	532	Visible (VIS)	Visible
3rd harmonic	355	Ultraviolet (UV)	Invisible

The wavelength(s) emitted by a particular laser system are specified on the warning label. All reflections, whether specular or diffuse, from optical components such as steering mirrors and prisms, are dangerous. Human eye transmits most of the laser radiation directly to the retina, which can be severely damaged. When in doubt about the distribution of laser radiation within an external optical system, relevant detecting equipment must be used. Damage to other body parts is a function of the laser power level and exposure time.

> ***Caution***
> ***All personnel are required to wear the proper eye protection when in the proximity of an operating laser. Be certain that the eye protection is rated for the wavelength and energy density output of the laser in operation.***

Not all lasers emit visible light and extra precautions should be taken when utilizing a laser that emits invisible radiation. Invisible radiation behaves in the same manner as visible radiation when encountering reflective surfaces and great care should be taken when manipulating such laser beams, both for personnel safety and potential damage to equipment.

For increased personnel safety, access to laser areas should be restricted only to the personnel whose work requires the operation of the laser, and these personnel should be fully trained in laser safety. Warning signs should be placed at all access points to the restricted areas.

EKSPLA recommends that experiments be set up in a way where no beam path is at eye level. This reduces the potential for accidental eye damage from stray beams.

Care must be taken when using optics external to the laser system, as mirrors or lenses can reflect the beam back into the laser system and potentially damage the components of the laser. A He-Ne laser mounted collinear to the optical axis of the laser system can serve as a convenient and safe way to check the beam path for potentially harmful reflections.

Before operating a laser, read the specific warning information attached to the laser system and described in this chapter.

4.5. Pump Source Radiation

The design of the laser ensures that the operator is protected from pump source (flash lamp and/or laser diode) radiation. Specifically:

- the beam path is shrouded within the laser cavity.
- the construction of the pump chamber's protective housing restricts from getting in a direct contact with the pump source radiation. This radiation contains UV and

IR components that are hazardous to the eye. Also, laser eyewear may **not** filter some hazardous wavelengths.

Caution:
Avoid looking in or around the laser apertures. It is essential to use protective goggles when handling flash lamps.

4.6. Back Reflection Safety

The back reflections from filter plates, prisms, etc. may form additional resonator with uncontrollable radiation profiles.

High energy radiation focused inside the laser resonator may cause severe damage of optical elements: both on surfaces and in bulk.

Optical parts in the laser, such as harmonic generator and output mirrors, are vulnerable to severe damage if a small percentage of the output laser beam is reflected and focused back into the laser. For instance, a common, uncoated, positive, simple lens will reflect about 4% of the beam at each surface. The first surface reflection will diverge in the backward direction, **but the second surface reflection will focus and at the focus the intensity will be very high, often enough to cause optical damage**. Even surfaces with anti-reflection coatings may back reflect focused energy enough to cause damage.

To avoid this hazard, minimize focused back reflections direct them off-axis to a harmless area or into an energy trap. Damage due to back reflections is not covered by any *EKSPLA* warranty.

4.7. Safety Interlock

The top cover of this laser is *not* interlocked, in accordance with European Standard IEC60825-1:2014 (*6.3. Access panels and safety interlocks),* because removal or displacement of top cover is not required for maintenance or operation.

4.8. Remote Interlock Connector

In accordance with European Standard IEC 60825-1:2014 (*6.4. Remote interlock connector)*, external interlock ability is provided through the EXT sockets on the rear of the power supply.

One of the sockets (typically, EXT1) has a shorting plug. It is used if operation without the remote interlock is required. Use pins #3 and #8 to short the circuit. However, regional safety standards often require the use of a remote interlock.

No AC or DC current is allowed to supply to these contacts. External interlock circuitry must be isolated from other electrical circuits or grounds. The circuit current does not exceed 10 mA and voltage does not exceed 5 V.

The other EXT socket (typically, EXT2) is internally shorted. Contact EKSPLA if your application requires a second remote interlock connection. Otherwise, the EXT2 socket may be used for regular CAN connections.

4.9. Key Control

The laser cannot be operated until the key switch on power supply is in *ON* position. Removal of the key prevents operation of the laser.

Switching the key switch to *OFF* position cuts the power from all laser modules and units except crystal heaters and motors.

If mains power is connected after the key switch is set to *ON* position, the laser will not operate. Turn the key switch to *OFF* and again to *ON* position to get the laser to working state. The same will be needed if mains power dips for a short time.

4.10. Main Disconnect Switch

POWER switch located on the rear panel of the power supply can cut off power to the entire laser.

Main disconnect switch supplements laboratory switch or circuit-breaker but does not replace it, see regulations below.

Requirements according IEC 610010-1 (safety requirements for electrical equipment for measurement, control and laboratory use) p.6.11.2.1 (permanently connected equipment and multi-phase equipment) are following:

- a switch or circuit-breaker shall be included in the building installation;
- it shall be in close proximity to the laser and within easy reach of the operator;
- it shall be marked as the disconnecting device for the laser.

4.11. Liquids and Gases

Note:
Do not used dyed CoolFlow products (e.g. those that have a blue tint).

CoolFlow IGE may be used in this system as a coolant.

CoolFlow IGE by Hydratech is an industrial grade secondary refrigerant with antifreeze and inhibitor functions designed for use in process cooling, refrigeration and HVAC systems.

Please download the relevant safety data sheets from https://www.hydratech.co.uk/coolflow-cooling-fluids.

Information below is limited and for reference only.

- Hazard statements:
  - H302 - Harmful if swallowed
  - H373 - May cause damage to organs - Kidneys - through prolonged or repeated exposure if swallowed
- Precautionary statements
  - P260 - Do not breathe dust/fumes/gas/mist/vapors/spray
  - P264 - Wash hands thoroughly after handling

- P270 - Do not eat, drink or smoke when using this product
- P301+P312 - IF SWALLOWED: Call a POISON CENTRE or doctor/physician if you feel unwell
- P301+P330+P331 - IF SWALLOWED: Rinse mouth. Do NOT induce vomiting

– Other hazards
  - This product does not meet the PBT/vPvB criteria of REACH, annex XIII.

Classification of the substance or mixture Classification - Regulation (EC) No. 1272/2008 (CLP)	
Physical and chemical hazards	Not classified as a physical or chemical hazard
Human health	Acute Tox. 4 - H302, STOT RE 2 - H373
Environment	Not classified as an environmental hazard

4.12. Electrical Safety

This section contains information and warnings that must be observed to keep the laser operating in a correct and safe condition. You are required to follow generally accepted safety procedures in addition to the safety precautions specified in this section.

4.12.1. Laser head

a) Electrical hazards

Pockels cell driver. Voltages may reach 8 kV and up, with current >2 mA. High voltages are present in the laser head when power is on and key is in ON position. Circuits with high voltage are closed by additional cover inside of the laser and are inaccessible in normal operation.

Flash lamp wiring. Voltages peaks up to 30 kV at ignition phase. Voltages, currents and stored energies may be lethal for human.

b) Safety requirements

Flash lamp service procedures may be started only after the laser has been fully de-energized.

4.12.2. Power supply

a) Electrical hazards

Voltages, currents:

- Mains circuits up to 400 V AC 50/60 Hz.
- Flash lamp power supply ignition pulses up to 30 kV.
- Flash lamp power supply discharge pulse up to 2 kV and peak currents up 1000 A.
- Flash lamp power supply simmer free running voltage 1200 V DC, current >100 mA.

Stored energies. High energy capacitors are used to store energies up to 100 J at voltage 2000 kV. Storing lethal amounts of electrical energy and pose a serious danger even if the power source has been disconnected. Power supply needs 2 min at least to bleed charge to the safe level.

Cooling water spills on power circuits. Proximity of water and high voltage circuits create isolation breakdown risk.

b) Safety requirements

Equipment is designed to be grounded through mains power ground connection and does not have a separate ground terminal. Ensure that mains power connection provides an adequate grounding.

Any interruption of the protective conductor inside or outside of the cabinet/power supply unit, or disconnection of the safety ground terminal creates a hazardous situation.

The Laser can only be placed in a complete power off state by setting laboratory switch/circuit-breaker to off position.

4.13. Safety Guide

1. Set up controlled access areas for laser operation.
2. Limit access to the laser to personnel whose presence is not necessary.
3. Never look directly into the laser beam.
4. Survey the area where the laser beam traverses and block all unnecessary specular reflections and scattering.
5. Terminate the laser beam.
6. Avoid blocking the output beams or their reflections with any part of your body.
7. Operate the laser at the lowest beam intensity possible for a given application.
8. Wear safety goggles; choose a model consistent with use conditions and visual function required.
9. Expand the laser beam whenever possible to reduce beam intensity.
10. Absorb secondary reflections with energy-absorbing filters.
11. Work in high ambient illumination when possible. This keeps the eye's pupil constricted, thus reducing the possibility of eye damage.
12. Place any external optical components with a flat or negative curved surface looking toward the laser, so that reflections are not focused back or are directed into an energy trap.
13. Double check that the laser is turned off. Use a positive check method such as an IR card or energy detector.

14. Follow the instructions in this manual.
15. Unplug the laser power cord and short internal components when working on the power supply.
16. Only attempt electrical service if you are experienced in high voltage/current circuits and understand the circuitry and related hazards.
17. Be especially careful when working with IR or UV radiation. Although you cannot see it, this radiation can focus on the retina and cause damage.
18. Never look directly into the end of a connected fiber optic cable when the laser is in operation.

5.1. Main Functional Parts

The laser system is comprised of following functional parts:

- Pump laser NL230
- Harmonics module

Optical layout of the system is presented in **Figure 5**.

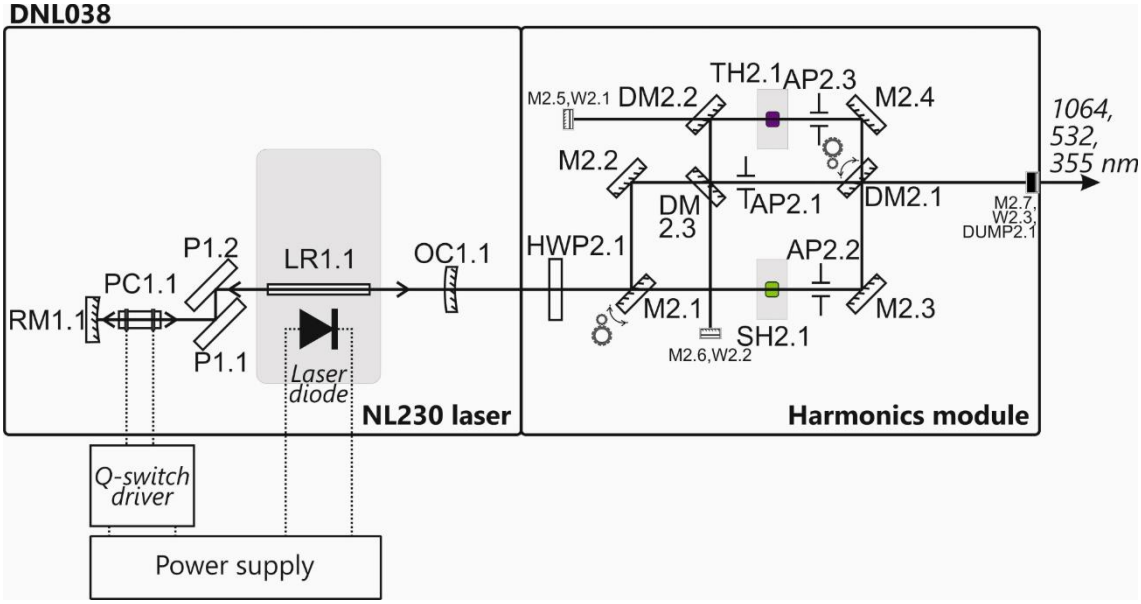


Figure 5 NL230 pump laser

The power supply unit (and optional external chiller) contains the necessary components to power-up and cool the laser heads. It is directly connected to the mains power supply.

The umbilical connecting the laser head to the power supply contains laser diode power, Q-switch triggering, power cables and safety interlock line.

5.2. NL230 Pump Laser

The pump laser contains the laser cavity and Pockels cell driver with HV power supply. The pump laser cavity body is machined from a single aluminum alloy piece, to ensure stable operation. The body of the laser cavity is bolted to the laser base plate and sheltered by the cover.

The laser cavity assembly includes the laser pumping chamber, cavity mirrors, Q-switch, thin-film polarizers and Q-switch electronics. The compact laser pumping head employs six water-cooled laser diode bars arranged radially around Nd:YAG laser rod.

5.2.1. Generation of Optical Pulses

The laser operates in the regime of resonator quality modulation (also referred to as resonator loss modulation). The geometry is an unstable resonator comprising of a concave rear mirror RM1.1 (99% reflection) and a convex output coupler OC1.1 – variable reflectivity mirror. Divergence of the output beam depends on the radius of curvature of the rear mirror and the thermo-induced lens in the laser rod LR1.1. Thermally induced lensing is proportional to pump power.

The Pockels cell PC1.1 together with a proprietary driver induces considerable steady losses in the resonator. While PC voltage is present, generation is not possible (Q-switch is closed). When a high voltage pulse with opposite polarity is applied to PC, losses in the resonator get minimized and laser pulse is generated (Q-switch is opened).

The external triggering pulse applied to the input IN (chart ①) or triggering pulse generated by the internal control unit at T_1 starts the LD supply current pulse (chart ②) and closes the Q-switch (chart ③), inducing high resonator losses. The Q–switch remains closed until maximum inversion in the Nd: YAG rod is achieved. At this moment the Q–switch opens (chart ③), losses in the resonator are minimized, and a very short and powerful optical pulse is generated (chart ④).

The delay between firing the LD pump pulse and opening the Q–switch is adjusted at the factory for each individual laser.

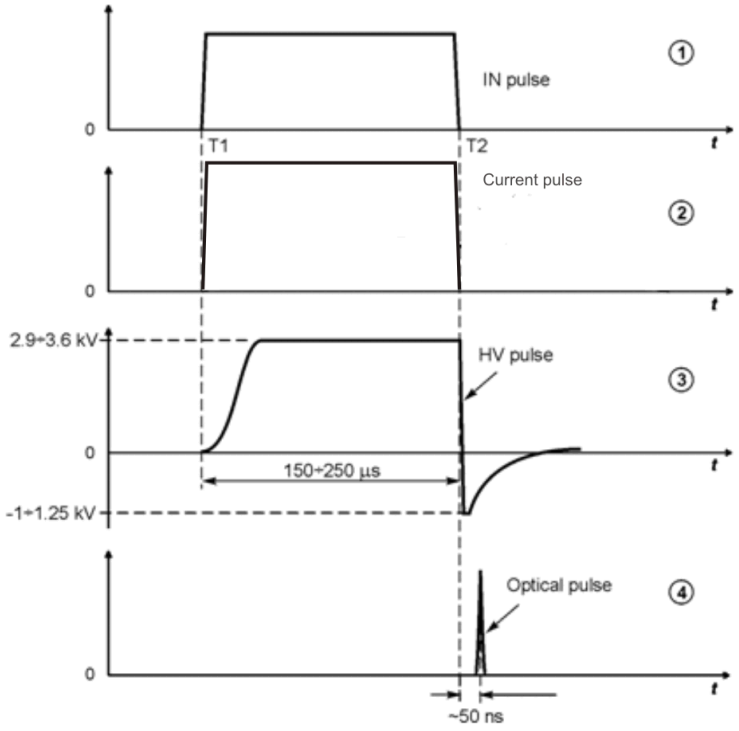


Figure 6 Laser timing charts

5.3. Harmonics Module

The harmonics module provides 2nd and 3rd harmonics outputs in addition to the fundamental 1064 nm output. Output selection is motorized, and an electronic shutter is available.

When the output wavelength is changed, it takes approx. 2 minutes for the output energy to stabilize – different outputs require different crystal temperatures.

This page is intentionally left blank

This chapter provides information about connecting and configuring the NL230 series system.

Be aware that this laser product is complex and requires qualified personnel with experience to perform adequate product service. *EKSPLA* highly recommends contacting *EKSPLA* customer service, or a qualified service person, for assistance at laser installation. For the end user, procedures in this chapter are given for reference only.

> ***Warning:***
> ***You should not attempt to start up the laser prior to installation by EKSPLA authorized personnel. Damage due to usage before proper installation is not covered by the EKSPLA warranty.***

6.1. General Requirements

Laser operation is optimal in a temperature-stabilized environment. Ideally, operate the laser in an air-conditioned room, provided that the laser is placed away from air conditioning outlets.

Position the laser on a solid worktable with access to the laser from all sides. The place for power supply cabinet/unit must be provided as well within the length of connecting cables and ensuring easy access.

For air-water cooled systems, the cooling unit must be installed in a way that a sufficient air circulation can be maintained. Ensure that the air inlet and outlets are completely unrestricted during later operation. A restriction of the air flow will have an adverse effect on the cooling capacity of the unit.

The actual required line power is specified in the laser technical protocol and on the equipment labelling. The equipment must be operated only from the line power stated; these supply specifications cannot be ignored or changed.

Always ensure proper ground/earth connection.

> ***Attention:***
> ***Do not operate the cooling system below air condensation temperature (dew point) at the laser head. Tihs may damage the pump heads.***

6.2. Laser System Layout

The NL230 series laser system typically is comprised of a freestanding power supply unit and a laser head that are interconnected by a flexible umbilical. An optional cooling unit may also be used. A remote control pad is attached to the power supply unit for remote access to various functions.

6.3. Laser Installation Procedure

1. Inspect the shipping container for damage related to transportation. If any damage is present, inform EKSPLA and the transportation agency.
2. Moisture may damage the device. Inside the shipping box, the laser is separately wrapped in plastic packaging. Prevent condensation forming on the device: allow laser packaging inside the shipping box to warm up to room temperature (at least 4 hours).
3. Unpack and inspect contents for exterior damage related to transportation. If any damage is present, inform EKSPLA and the transportation agency.
4. Fix laser head to optical table. Place the power supply unit adjacent to the laser head.
5. Study the separate cooling unit manual and prepare it for operation.
6. Interconnect the laser with the power supply and cooling unit by connecting the cables as marked.
7. Interconnect the cooling unit with the power supply by the interlock cable.
8. Connect mains cables.
9. Run laser according to *Routine operation*.

   Do not install the system in an environment where other equipment is likely to cause a high ambient temperature. The system operates efficiently with an ambient temperature of up to 35°C. Above this temperature, the cooling capacity will not be maintained, as the refrigerant cannot be sufficiently cooled.

   The power supply and cooling unit must be installed in a way that a sufficient air circulation can be maintained. Ensure that the air inlets and outlets are completely unrestricted during later operation. A restriction of the air flow will have an adverse effect on the cooling capacity of the units.

This chapter provides information about control interfaces and electrical connections of the system.

Caution

Use of controls and adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

7.1. General Description

The laser system is controlled from a remote control pad or by several PC applications (via USB, CAN, LAN, RS232 protocols).

External synchronization control with user-supplied signals is available using connectors on the power supply.

7.2. PS8000 Series Power Supply

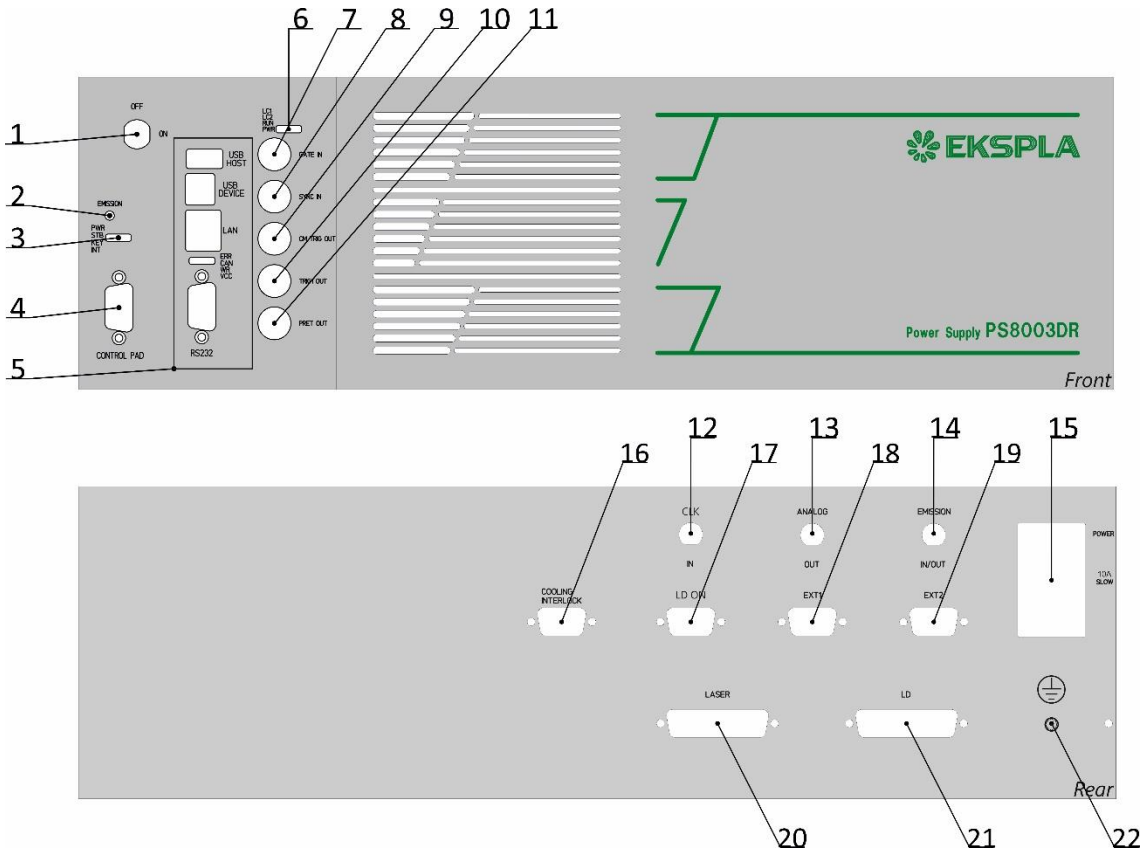


Figure 7 Front and rear panels of the power supply

7.2.1. Front Panel

Table 3 Power supply front panel connections

#	Control/connection	Description
1	Key switch	The laser cannot be operated until the key switch on control panel is in the OFF position. Removal of the key prevents operation of the laser.
2	EMISSION indicator	*Emission ready* indicator.
3	POWER, STANDBY, KEY, INTERLOCK indicators	**PWR** Red LED. Power is being supplied to laser electronics circuits. Key needs to be in ON position. **STB** Green LED. Standby power is provided. **KEY** Yellow LED. Always on. **INT** Blue LED. Always on.
4	CONTROL PAD (DB9F)	Alternative port for control pad connection.
5	CONVERTER	See separate manual.
6	Indicator LEDs	POWER: DC Power indication
		RUN: Is ON when SY4000 board is on.
		LC2: PLL2 status. Is ON when PLL2 is locked.
		LC1: PLL1 status. Is ON when PLL1 is locked. PLL1 is optional. Is ON when 10MHz precision time base module is present. Because of LED intensity is much lower compared to neighbor red LED usually ON state is hardly visible.
7	GATE IN	Laser synchronization input for frequency divider in external synchronization mode. LVTTL, tolerates 5V. Repetition rate of GATE IN must be $FREQUENCY_{SYNC\ IN}/N$, where N=integer. SYNC IN and GATE IN must be simultaneous. *Note:* *For frequency division to work with GATE IN in external synchronization mode,* Frequency divider *value in Control pad menu must be greater than 1.*
8	SYNC IN	Laser synchronization input for external triggering. LVTTL, tolerates 5V.
9	CM TRIG OUT	Common trigger output from SY4000 synchronization board. Repetition rate is equal to laser repetition rate (100 Hz). 4.5V @ 50Ω.
10	TRIG1 OUT	Synchronization output from SY4000 synchronization board. Repetition rate is equal to laser repetition rate (100 Hz). Laser output pulse follows the falling edge of TRIG1 OUT pulse ($\Delta t \sim 10^2$ ns). 4.5V @ 50Ω.
11	PRET OUT	Not used.

7.2.2. Rear Panel

Table 4 Power supply rear panel connections

#	Control/connection	Description
12	CLK IN, BNC	Not used.
13	ANALOG OUT, BNC	Laser diode driver current sensor output. 1V=40A
14	EMISSION IN/OUT, BNC	Emission indicator circuit.

#	Control/connection	Description
15	POWER switch, fuse, mains socket	
16	COOLING INTERLOCK	Interlock connection for an external cooling device, such as a chiller. Interconnect the external cooling device and the power supply with the supplied cable.
17	LD ON, DB9M	Shorted at factory via DB9 plug.
18	EXT1, DB9F	See 4.8 Remote Interlock Connector.
19	EXT2, DB9F	
20	LASER, D-SUB 13W3 F	DC power, safety circuits and CAN bus connection.
21	LD, D-SUB 5W5	Laser diode driver output.
22	GROUND	Located below the power socket, provides an additional ground connection.

7.3. Laser Controls and Connections

The following connections and controls are accessible on the laser:

7.3.1. Laser Head Rear Panel

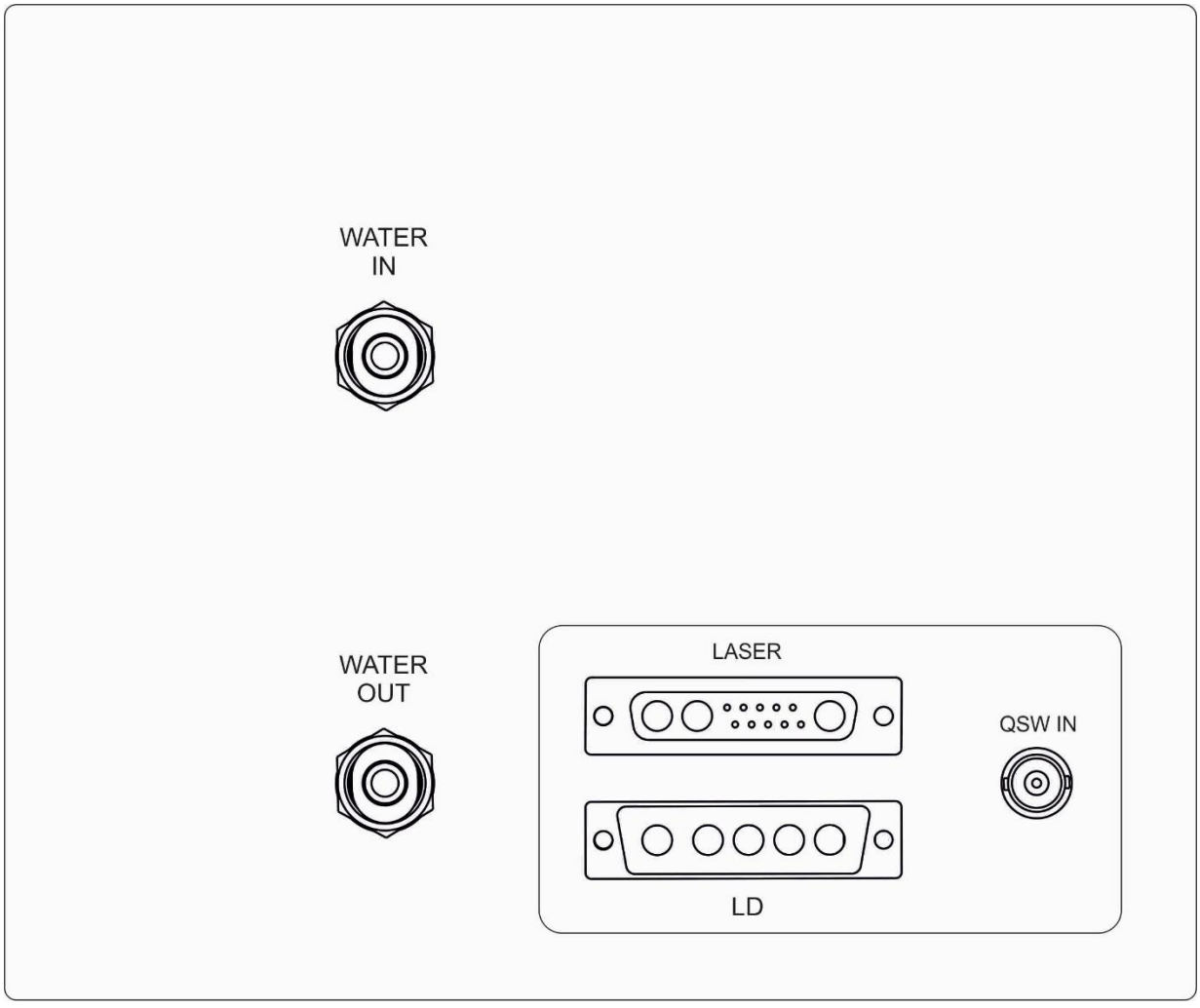


Figure 8 Laser head rear panel connections

Table 5 Laser head rear panel connections

Connection	*Description*
WATER IN fitting	To the laser head. Accepts ∅10 mm tubes.
WATER OUT fitting	Used coolant from laser head. Accepts ∅10 mm tubes.
QSW IN connector	Signal for Pockels cell driver.
LD socket	Laser diode driver input.
LASER connector	DC power, safety circuits and CAN bus connection.

7.3.2. Emission Indicator

Emission indicator lamp is located on the top of the frame (or on the side containing output apertures) close to the output apertures. It illuminates when laser emission is about to occur. Amber light is used so that it is visible when the proper type of safety glasses is used.Control Pad

7.4. Laser Control from Control Pad

7.4.1. Main Window

Laser control main window is displayed on the control pad after switching the power by default. To return to the main window display from menu, press *ESC* repeatedly until main window appears.

The main window is divided into fields A, B, C and D (see **Figure 9** for an example). Fields B, C and D may be further divided into shorter fields

Navigation between the fields is done by pressing keys ◄/► and goes cyclically. Selected field is indicated by a solid border. *Hidden* field is used to hide the cursor.

Field A is a laser status symbol field. The following symbols may be displayed:

☐ Laser operation is stopped and it is not ready for operation.

▒ Laser operation is stopped but it is ready for operation.

▷ Laser is operating but not firing, because something is switched off, i.e. quality switch.

⋗ Laser is firing.

☒ An error occurred.

7.4.2. Factory Setup of the Main Window

The laser is shipped in the following factory recommended configuration of the main window:

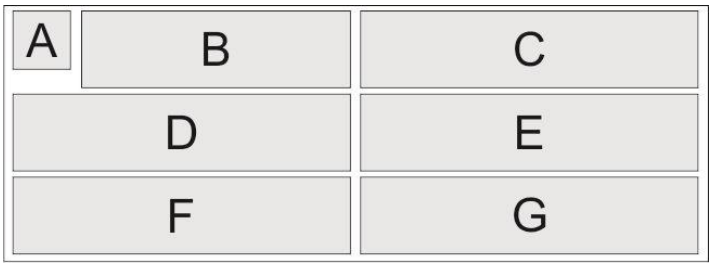


Figure 9 Control pad main window layout

Table 6 Factory setup of the main window

Field	*Normal operation*	*Error*
A	Laser status symbol	Error code.
B	Laser state machine status: Idle, Running or Error	
C	Laser radiation emission indicator. Displays EMISSION when it is occurring.	
D	-	Error message.
E	-	
F	Burst trigger	REPORT button. Generates an error report.
G	Wavelength	RESET button. Resets the error.

7.4.3. Menu System

Table 7 Menu tree

Menu item	*Submenu(s)*	*Description*
Energy level	OFF, Adjustment, Maximum	Adjusts the laser energy level setting: Max – maximum energy; Adj – adjustment mode with reduced energy; Off – no generation.
Wavelength	1064nm, 532nm, 355nm	Switches output wavelength.
Shutter control	LID CLOSE, LID OPEN	Controls the motorized shutter position.
Adjustment delay	*Read/Set Value*	Sets Q-switch delay in respect to LD pulse. Used to control the energy level in Adj mode (see above).
Synchroniz. Mode	Internal, External	Sets the synchronization method. When external mode is set, laser is triggered by external signal.
Frequency divider	*Read/Set Value*	Quality switch repetition rate is divided by a factor set here, while retaining the pump repetition rate unchanged.
Burst mode	OFF, ON	Toggles burst mode.
Burst length	*Read/Set Value*	Sets the number of optical pulses in burst mode.
Trigger burst	-	Not used.
Store User Values	Store User	Stores the user-set parameter values to memory for later use.
Load User Values	Load User	Loads the user-set parameter values from memory.
Load Default Values	Load Defaults	Loads the factory-set default values.

Menu item	Submenu(s)	Description
IP of laser	*Read Value*	Shows laser IP.
Generate Report	Generate	Generates error report.
Set SHG Temperature	*Read/Set Value*	Sets temperature of SH2.1 crystal (optimized for third harmonic output).
Set THG Temperature	*Read/Set Value*	Sets temperature of TH2.1 crystal.

7.5. Control from PC

7.5.1. Connecting the PC

To control the system from PC, the PC must be connected to the CAN bus. Typically, the connection is made to connector *USB* on the power supply front panel.

EKSPLA laser control modules are hooked on single serial bus – CAN bus, so in general PC may be connected to any connector on a CAN bus, like *EXT1/2* connectors on a laser control panel, provided that all modules are hooked on a bus properly. Some devices may be more specific about connection.

7.5.2. Control via the Converter

A USB-CAN-LAN-RS232 CONVERTER is installed in the power supply. For more information about its features and functions, see the attached manual.

A command set for the RS232 interface of your product is provided in the table below.

Note
The same set of commands works for LAN REST API. The only difference is: before all commands, add http://IPofLaser:8081/REST/HTTP_CMD. *For more information about communication please read manuals in the provided CD.*

Table 8 RS232 command set

Function	Request	Answer	Description
Retrieve Laser state	*/?RDVAR/State*	0, "Idle"#13#10#03	Laser ready for operation
		In case of error, answer will be: 0, "Error"#13#10#03	Laser is not ready for operation
	/?RDVAR/FaultCode	0, 0#13#10#03 – no error; 0, n#13#10#03 – if n ~= 0, n – error code	Retrieve error code
	/?RDVAR/FaultMsg	0, #13#10#03 – no error; 0, "Decoded Error"#13#10#03 – in case of error	Retrieve error code description
	/?RDVAR/EnergyLevel	0, "X"#13#10#03	Retrieve energy level.
	/?RDVAR/Wavelength	Same as before.	Retrieve set output wavelength.

Function	Request	*Answer*	*Description*
	/?RDVAR/ShutterStatus		Retrieve shutter status.
	/?RDVAR/QSWAdjDelay		Retrieve Q-switch adjustment delay value.
	/?RDVAR/SyncMode		Retrieve laser sync. mode (X)
	/?RDVAR/PRR		Retrieve laser repetition rate value.
	/?RDVAR/BurstMode		Retrieve burst mode status (X)
	/?RDVAR/BurstLength		Retrieve burst length in burst mode (X)
	/?RDVAR/SHGTemp		Retrieve temperature of SH2.1 (X)
	/?RDVAR/THGTemp		Retrieve temperature of TH2.1 (X)
Set Laser into operation	/?EXE/Run	0, 1180588698.790228(timestamp example)#13#10#03	Run laser
	/?EXE/Stop	Same as before (timestamp for ?CES request)	Stop laser
	/?EXE/TriggerBurst		Start burst.
	/?EXE/SetOutLev/X		Toggle between outputs, where X – OFF, Adjustment, Maximum
	/?EXE/SetWl/X		Set output wavelength, where X – 1064nm, 532nm, 355nm
	/?EXE/ShutterCtr/X		Toggle between shutter status, where X – LID CLOSE, LID OPEN
	/?EXE/SetAdjDelay/X		Sett Q-switch adjustment delay, where X – 151…1000
	/?EXE/SetSyncMode/X		Set laser sync. mode, where X – Internal, External
	/?EXE/SetPRR/X		Set laser repetition rate, where X – 1..1000
	/?EXE/BurstMode/X		Toggle burst mode, where X – OFF, ON
	/?EXE/BurstLn/X		Sets the laser burst length, where X - 1…65535
	/?EXE/StoreUser		Stores current user values. During next startup current values will be loaded automatically
	/?EXE/LoadUser		Loads user values.
	/?EXE/LoadDefaults		Loads default values.
	/?EXE/GenerateReport		Generates error report.
	/?EXE/SetSHGTemp/X		Sets temperature of SH2.1 crystal, where X – 30…70.
	/?EXE/SetTHGTemp/X		Sets temperature of

Function	Request	*Answer*	*Description*
			TH2.1 crystal, where X – 30…70.
	/?EXE/ReportFAULT		Report error state
	/?EXE/ResetFAULT		Reset error state
Laser diagnostics	/?RDVAR/TotalShots	0, 36963#13#10#03 – there 36963 total shots made in this example	Shot counter (where x=Number of shots divided by 1000)
	/?LIST/MLOG	0, data#13#10#03	Retrieve events log, where data – log data
Laser IP	/?RDVAR/IP	0, “192.168.0.150”#13#10#03	Retrieves laser IP when LAN connection in use
Laser serial number	/?RDVAR/ProductSN	0, “XXX999”#13#10#03	Serial number of laser system

7.5.3. CANBrowser

Ekspla products are organized as a set of modules hooked on a single serial bus – CAN bus. Control of the system is performed by reading and editing various parameters stored in registers of those modules.

Proprietary *CANBrowser* software is used to get a full access to registers on a CAN bus. It is intended mainly as a diagnostic tool for system adjustment and service; routine control is more convenient using a remote control pad or *Remote Control Application*.

CANBrowser is supplied on a software CD attached to the system. Please see *Readme* files about installation and more general information.

After launching the application, *CANBrowser* main window is shown (see **Figure 10**). After launching application for the first time, choose menu option *Options* and in a new window pick a connection type corresponding to the one implemented in a specific device.

Pick menu option *Connect* to connect to the modules; choose *Load All* to connect to all modules. Modules in the system and their registers will be shown in a tree view in area *(1)*. Expand the view to see the registers of a specific module by clicking on a + sign.

> *Note:*
> *End user has an access to a limited set of registers only. Full access requires a password and is available for service personnel.*

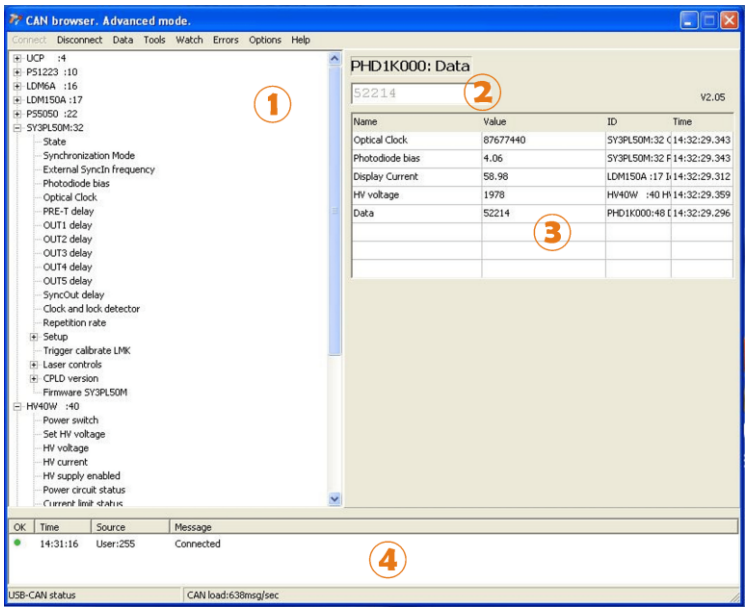


Figure 10 CANBrowser main window.

1 – Tree view of modules in a system; 2- edit area; 3- watch area; 4- message area. Generic view is shown here; in general, each device may have different setup of modules and their displayed registers.

Double-click the selected register for its value to be indicated in edit area *(2)*. Value will be greyed out if it is read-only. If it can be changed, graphical *Enter* button will appear; edit the value in the field and press the button to set it. This sets the value for current session only (until the power off). For registers, which values can be saved into NV memory and be used in the next session, the *Program* button will also appear.

To monitor more values at once, right-click the register in a tree, and choose *Watch*; register name and value will appear in a watch area *(3)*. Values can't be edited in this area.

> *Note:*
> *Setup of watch and edit areas is valid for the current session only, it is not saved at the exit.*

System messages, including error messages, appear in message area *(4)* at the bottom part of the window.

7.5.4. "SM Control" Application

A dedicated SM Control application is provided to control the laser.

"SM Control" software controls the state machine. The state machine itself and control via LAN is described in "StateMashineControlLazServ.pdf"; RS232 control is described in "ASCII_serial_protocol_description(RS232).pdf" (see the Software CD). The state machine controls laser functions such as delays, outputs, etc. It repeats the same settings available in control pad (see **Table 7**, p.29). To use the software, connect via LAN or RS232 ports on the power supply (do not use USB).

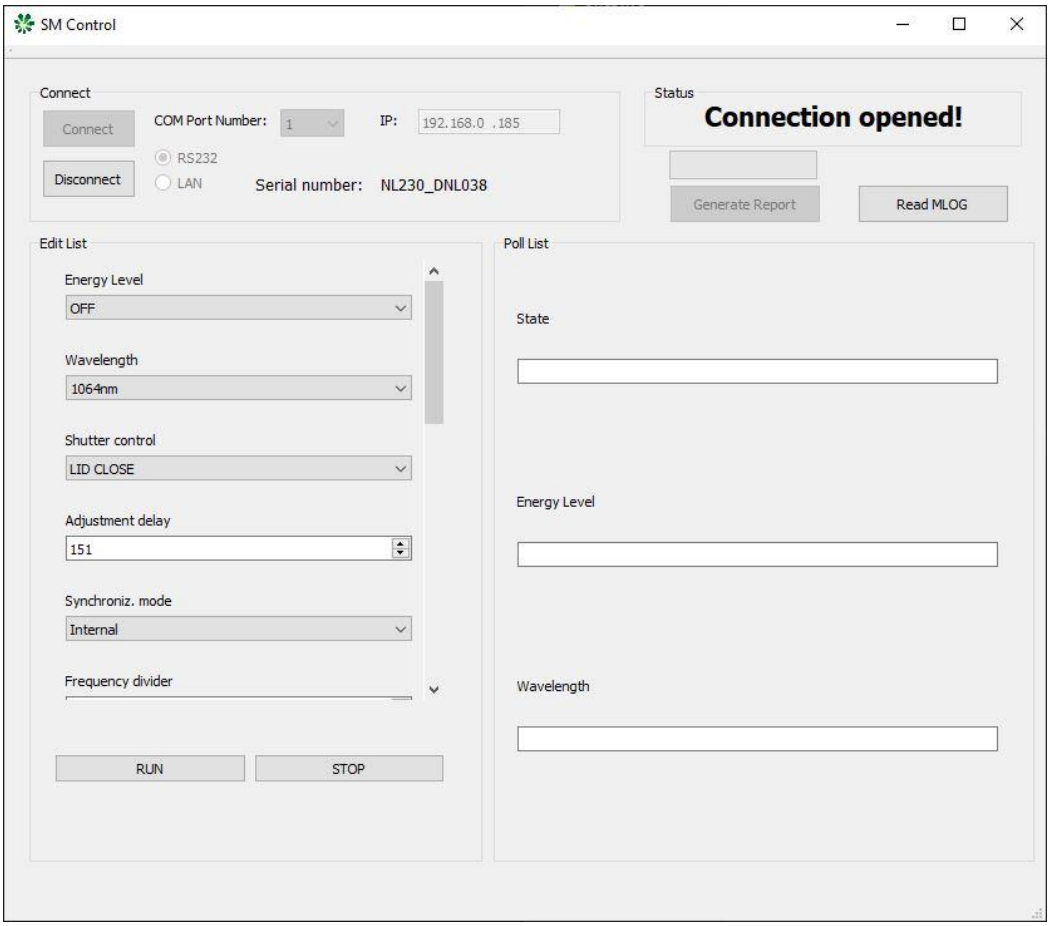


Figure 11 *SM Control* application

Fields in the application main window:

1. CONNECT – allows selecting connection type and connecting to laser.
2. STATUS – shows the status of the application.
3. EDIT LIST – controls the main laser functions. Set the required options and press RUN.
4. POLL LIST – indicates the state of the State machine: Idle (the laser is not running, the state machine is awaiting commands), Running (the laser is running, the state machine is awaiting commands), Error (the state machine has received an error; the control pad indicates the error code and meaning).
    a. READ MLOG – displays a log of the State machine states. This is used to diagnose any errors.

7.6. User Input and Output Signals (External Triggering)

7.6.1. Introduction

The laser can be triggered and controlled by external pulses. The laser must be set to external synchronization mode through the control pad or remote control software (see 7.4.2 FACTORY SETUP OF THE MAIN WINDOW and 7.5.4 "SM CONTROL" APPLICATION).

Attention

The system is designed to run at 100 Hz. Always make sure that your generator repetition rate is the same as laser repetition rate. Providing input signals with other repetition rates may damage the laser.

7.6.2. Inputs

- SYNC IN (BNC)
  - Used to externally trigger the NL230 pump laser.
  - The operation of the system is sensitive to the SYNC IN pulse rise. It is recommended to set your external generator to supply pulses with rise time of ~5 ns
  - Signal parameters:
    - 100±2 Hz
    - pulse width ≥10 ns
    - LVTTL (0…5 V, 1.3 V threshold, tolerates up to 5 V)
    - trigger slope – rising edge
    - 0.1 mA pull down to low level
    - insertion delay <80 ns
  - Optical pulse is emitted *QSWMaxDelay(µs)+100 ns* after SYNC IN rising edge when laser is in MAX mode (see Chapter 12 Factory Settings, p.C, for the exact value). The same applies for ADJ mode.
- GATE IN (BNC)
  - Works in external synchronization mode, in conjunction with SYNC IN, as an external frequency divider (analogous to *Frequency divider* setting in internal synchronization mode).
  - Used to gate the optical pulses externally. Optical pulse is emitted when GATE IN is supplied. This allows lowering the effective laser repetition rate by *N*, the division factor (N≥2, integer).
  - The Frequency divider setting in the control pad must be set to N beforehand.
  - Signal parameters:
    - GATE IN must be near-simultaneous with SYNC IN: GATE IN rising edge must have reached 1.3 V threshold value when SYNC IN starts
    - (100±2)/N Hz. Signals may be aperiodical, i.e. the user may use this to produce bursts and other output pulse patterns.
    - pulse width ≥20 ns
    - LVTTL (0…5 V, 1.3 V threshold, tolerates up to 5 V)
    - trigger slope – rising edge
    - 0.1 mA pull down to low level

7.6.3. Outputs

See **Table 3** (p. 26).

7.7. External Interlock

See 4.8 Remote Interlock Connector (p.14).

This page is intentionally left blank

The Routine Operation chapter provides basic operation instructions for the NL230 series laser including powering up, operating, pausing, and shutting down the system.

Caution:
Use of controls and adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Caution:
All personnel in the area must wear laser goggles/glasses of the approved type at all times during operation of the laser. This protective eyewear must be effective at the wavelengths generated by the laser. It is assumed that the operator has read the Safety chapter and is familiar with laser safety practices and the dangers involved.

8.1. Turning On the System (Cold Start)

Perform a cold start when running the laser for the first time or if the power supply was turned off. This procedure ensures that the heaters in the laser reach optimal temperatures; this ensures stable beam parameters at specified levels.

1. Prepare the cooling unit and turn it on.
2. Check for coolant leakage.
3. Plug the power supply unit into the mains and turn it on by pressing the power switch on the rear panel.
4. Wait for ~60 minutes for thermal equilibrium.
5. Proceed to warm start (see below).

Note:
It is recommended to keep the laser plugged in to the mains all the time. Nonlinear crystals are heated to maintain a stable temperature slightly above ambient. This controls humidity on optical surfaces and reduces self-misalignment of resonators due to 37hermos-cycling.

The laser system starts generating almost immediately; cold- and warm start warm-up times are needed to achieve stable beam parameters at a specified level.

8.2. Operating the System

8.2.1. Regular Laser Start (Warm Start)

1. Prepare the cooling unit and turn it on.
    a. Wait until coolant reaches SET temperature (see chiller user manual).
2. Turn the key-switch on power supply to position ON.

3. Ensure that laser output is directed at an intended target.
4. Select the required laser output mode, wavelength, and synchronization mode (see below for more information).
5. Press button RUN on the laser control pad or SM application. Automatic shutter opens and laser starts firing.

   Note:
   Radiation parameters of the laser stabilize after about 15 minutes warm-up time. This is faster if coolant temperature is nominal.
6. The laser system starts generating almost immediately; cold and warm start warm-up timers are needed to achieve stable beam parameters at a specified level.

8.2.2. Laser Output Mode

1. Access *Energy level* submenu on the laser control pad.
2. Press the button ▲ or ▼ to select the laser mode between '*Adj*' (reduced energy), '*Max*' (maximal energy) and '*Off*' (no output).
3. Press OK.

8.2.3. Synchronization Mode

1. Access *Synchroniz. Mode* submenu on the laser control pad.
2. Press ▲ or ▼ to select synchronization mode.
3. Press OK.

a)Laser Operation in External Triggering Mode

See 7.6 User Input and Output Signals (External Triggering) (p.34).

1. Stop the laser.
2. Pre-set your external signal generator and check that signals are as required by the laser system, especially the repetition rate (100 Hz in this system).

   The pulse repetition rate
3. If using external gating (GATE IN), set the *Frequency divider* parameter (≥2).
4. Connect the signal cables to their respective ports.
5. Start the external signal generator.
6. Start the laser.

8.2.4. Pausing Laser Operation

There are two scenarios for pausing the laser. Pressing *STOP* stops laser diodes from firing. This changes the thermal characteristics of the laser and some time may be required after resuming operation for laser parameters to stabilize. On the other hand, switching to *Off* energy level retains the nominal laser parameters but may degrade optical components over time if used excessively. Please choose the appropriate method for your daily operation.

1. Using the OFF energy level:
    a. Access **Energy level** submenu on the laser control pad.
    b. Press the button ▲ or ▼ to switch the laser mode to '*Off*' (no output).
    c. To restart operation, access **Energy level** submenu and switch the laser mode to '*Max*' or *'Adj'*.
2. Using the STOP button:
    a. Press the button STOP on the laser control pad to stop laser operation.
    b. Press the button RUN again to start laser operation.

8.2.5. Turning Off the Laser

Attention:
Do not unplug the power supply from mains! Leave it connected, when your work is over and you switch off the device. The green LED on the front of power supply must remain lighting, what indicates that crystal heaters are on.

1. Press the button STOP on the laser control pad to stop the laser.
2. Close the laser output shutter/(s).
3. Turn the key switch on the power supply to position OFF.

Note:
Fully turn off the laser if you intend it for a prolonged time. Otherwise, leave the POWER switch on to keep the crystal heaters operating. STANDBY indicator LED will be lit in this case.

This page is intentionally left blank

This chapter contains information on routine laser maintenance schedule and list of all the procedures intended for the user. Maintenance beyond listed in this chapter, or marked as requiring the special experience, should be performed by a trained engineer and requires a certain experience in this area.

9.1. Consumable Parts

Table 9 lists the consumable parts that require replacement after a recommended period of time.

Table 9 Consumable parts

Part name	*Type*	*Period of replacement*
Chiller particle filter	HEC-PF1	3 months
Coolant additive	CoolFlow IGE (clear)	1 year
Laser diode	QD-Q1903-L3-EKS	>3×10^9 shots
Output window	W2.3	Depends on the environment conditions
UV optics set	THG2.1, DM2.2, DM2.3	800 hours

9.2. Regular Maintenance

9.2.1. Schedule

a) Weekly

- Check that the system is powered (plugged in into the mains) – this ensures that crystals and other elements are heated.
- Inspect the cooling unit: check water level, condition of filters, signs of leakage.

b) Every three months

- Replace cooling unit filter.

Attention:
Inspect coolant level* daily *if using* CoolFlow IGE *mixture.

9.3. Power Supply Coolant Maintenance

9.3.1. General Notes

Note
If CoolFlow IGE *is used in the system, study the safety risks detailed in 4.11 LIQUIDS AND GASES (p.15) before performing coolant maintenance procedures.*

Coolant acts as an optical media in the laser rod assembly. It is critical to keep the coolant loop free of algae and corrosion residue.

Use only clean distilled/deionized water and clean utensils.

Do not turn the laser on while the cooling loop is empty – the pump will run dry and may be damaged.

If temperatures below freezing are possible in your facility, ask Ekspla service for routine operation and maintenance recommendations.

If the coolant in the cooling loop has frozen, do not turn on the laser, even for a short time. This may damage the system. Contact Ekspla service.

9.3.2. Coolant Recommendations

Both CoolFlowIGE and distilled/deionized water are close in terms of cooling specifications. Nevertheless, due to different refractive indexes and thermal capacities, system performance may change (within product specifications).

Distilled/deionized water.

It is widely available, inexpensive, non-toxic and odorless, but has several disadvantages:

- Serves as natural media for bacteria and algae.
- Increases corrosive effects.
- Freezes at 0°C.

Water is fully suitable for systems which are run daily, with guaranteed periodic coolant replacement once every 1...2 months.

Only purified water may be used as coolant. Common purification methods include reverse osmosis (RO), distillation, and deionization. If there is no water of specified purity available, distilled water is preferred over other types. Use class 1 or class 2 water according ISO 3696:1999 if this is available.

CoolFlow IGE

A pre-mixed solution of CoolFlow IGE and distilled/deionized water (solution ratio: 25%:75% CoolFlow IGE to water). It is a product of Hydratech (https://www.hydratech.co.uk/coolflow-cooling-fluids)[1].

[1] Online shops that sell CoolFlow:

CoolFlow IGE-based coolant is recommended for systems which are:

- Located in an environment with elevated ambient temperature (above 22°C).
- Have experienced bacteria/algae growth in the past.
- Often left in an inactive state for a period longer than a weekend.
- At risk of freezing temperatures.

Coolflow IGE has been especially formulated from Ethylene Glycol for use as an Industrial Grade Secondary Refrigerant Antifreeze for use in Process Cooling. Avoid water containing high levels of calcium salts or Chlorides [Cl-]. The dose of Coolflow IGE should be 25% of the system volume, with rest 75% of pure water. Because exact system volume is not known solution should be prepared in advance.

9.3.3. Coolant Compatibility

Water and CoolFlow IGE coolants are compatible, therefore switching from one to other is allowed.

If changing from CoolFlow IGE to water, simply drain the old coolant and fill the system with water.

If changing from water to CoolFlow IGE, additional cleaning procedure is required. Because CooFlow IGE has washing properties, it may produce a high flow of impurities in the coolant stream. Impurities tend to clog any particle filters very rapidly, making the system dysfunctional. Follow the instructions below:

1. Drain old coolant. Replace any particle filters. If a wire mesh filter is installed, replacement is not needed, just wash the filter under water. Fill the system with CoolFlow IGE premixed solution. Run the chiller for at least 8 hours, without running the laser. Turn the key-switch on, but do not fire the laser for power supplies that have the integrated cooling unit.
2. Drain the coolant, remove the filter. Wash wire mesh filter or replace other type filter.
3. Fill the cooling system with CoolFlow IGE premixed solution.

9.4. Maintaining Coolant Purity

If a system stays inactivated for a prolonged period (month or more), in certain environmental conditions, algae may grow in the system.

To prevent this growth, completely flush the system of the coolant and keep it dry for the period of inactivity.

> ***Attention:***
> ***EKSPLA does not accept responsibility for damage caused by algae infestation if the system was left without proper maintenance for a prolonged period of time.***

1. Ekspla: spares@ekspla.com
2. UK, Ireland: https://hydratech-shop.co.uk/products/coolflow-ige
3. Europe: http://www.hydratechbenelux.eu/webwinkel/coolflow-ige/
4. US: http://www.hydratech-usa.com/

9.5. Preparation for Transportation

Before transporting the laser:

1. *(water cooled systems only)* Remove the water from all water pipes and the cooling system.
2. *(water cooled systems only)* Flush the cooling system with a 40% ethyl alcohol and water mix. Then remove the mix.
3. Carefully repack the laser in the same way as it was packed by the manufacturer. Please follow the original packing list.

This chapter provides information and solutions for potential problems with the *NL230* series laser.

10.1. Errors

Table 10 Error list

Error code	*ID*	*Type*	*Description*
999		System	LD protection on! Overheat!
1001	44	System	Shutter travel timeout! Stuck!
1002	16	System	Cooling interlock!
1002	44	System	Shutter forced out from end possition!
1002	32	System	Loss of lock!
1004	16	System	External interlock!
1004	32	System	Sync in frequency too high!
1008	32	System	Sync in frequency too low!
1064	16	System	Max Current Exceded!
1128	16	System	Max LD Voltage Exceded!

10.1.1. Error Indication

Laser stops if one or more errors are detected.

Control pad shows error code and short description. If several errors have occurred simultaneously, only the first error in the sequence is shown.

Full list of errors occurred may be reviewed using CANBrowser software

CANBrowser also may be used to see the list of all possible errors and their descriptions, start the CANBrowser and choose menu option *Errors->List available*.

10.1.2. Resetting the Fault

If the error cause is simple, remedy it and press *RESET* on the control pad. Laser settings remain unchanged.

10.2. Fault Handling

- Laser stops in case one or more errors are detected. Fault indication does not mean that all hazards for the operator are removed. Watch emission indication.
- Control pad shows module name and error code. If several errors occurred at once, only the first one is shown. Go to Errors menu for comprehensive list.
- Press RUN button twice to reset fault mode and to start the laser again.

10.3. Reporting a Problem

If a problem cannot be explained and remedied using measures described above, please call the service. The following information is necessary to provide an effective support:

- serial number;
- short description of the problem and circumstances;
- dump of the state of CAN registers; see below;
- full list of errors occurred; see below.

10.3.1. Performing a Memory Dump

1. Put the laser in its' routine working condition, if available; for this:
    a. Perform a warm start;
    b. Press *RUN*, wait for approx. 5 minutes
2. Replicate the error.
3. Insert a flash drive into the USB HOST connector on the power supply front panel.
4. Press *REPORT* on control pad.
5. A folder is created in the inserted flash drive with all relevant files.
6. Attach the files to an email and send to Ekspla service at service@ekspla.com.

10.3.2. Generating an Error List

1. Start the CANBrowser.
2. Choose menu option *Connect-> Load all*.
3. Choose menu option *Errors -> Clear list*.
4. Reproduce the error.
5. Choose menu option *Errors->Save list*.
6. Save the file and attach it to the message.

11.1. System Identification

Model **NL231-100-SH/TH**

Serial No **DNL038**

11.2. System Components

Table 11 Electrical components

Component Name	*Type*	*Serial Number*
Power supply	PS8003DR	21-1308
Laser diodes	QD-Q1903-L3-EKS	CP10036, 55
Cooling unit	SMC HECR004-05-EP	ZR-0978 (Apr. 2021)

Table 12 Fuses

Fuse type	*Dimensions*	*Location*
10A SLOW	5×20 mm	Rear of power supply

Table 13 Optical components

Component Name	No in optical layout	Characteristics/Code
NL230 series laser		
Cavity mirror 0º	OC1.1	P5BK7-BK7MO75V664X8301-DP5
Pockels cell	PC1.1	P5BBO-BBOXS06C20Z1-AA0
Laser rod	LR1.1	P5YAG-G11N5-50W0/0A1
Cavity mirrors 0º	RM1.1	P5BK7-BK7SO73V32001-0H0
Thin-film Polarizers	P1.1, P1.2	P5UVS-UVSAR56D1-PA5
Harmonics generation		
Waveplate	HWP2.1	P5KKV-KKVTO4CL21-AA0
Mirror	M2.1, M2.2	P5UVS-UVSAO861-H15
Mirror	M2.3, M2.4	P5UVS-UVSAO8621-H05
Mirror	DM2.1	P5UVS-UVSAR5621-SA5-S
Mirror	DM2.2, DM2.3	P5UVS-UVSAO86321-SA5

Component Name	No in optical layout	Characteristics/Code
Crystal (second harmonic)	SHG2.1	P5LBO-LBOH1S214S1-AA0X
Crystal (third harmonic)	THG2.1	P5LBO-LBOH2S0915T1-A00
Window	W2.3	P5UVS-UVSAO73321-AA0
Dump mirror	M2.5, M2.6	P5BK7-BK7AR5621-H05
Dump mirror	M2.7	P5UVS-UVSAR76123-H15-S
Dump window	W2.1, W2.2	P5UVS-UVSAO42-11
Dump window	Dump2.1	P5M23-M23AO7221-A10