EKSPLA

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Tunable Diode Pumped Laser System

NT242-SH/SFG

TECHNICAL DESCRIPTION

&

USER'S MANUAL

2013

Lithuania

WARRANTY

The Warranty section provides a packing list containing everything shipped with the product and general warranty information.

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*.

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

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Components

Nd:YAG Laser unit **SN PGD084**	1
Power supply *PS6100 series*	1
Cooler	1
Control pad with double-cable	1
CD with software for PC	1
User's manual	1
Mains cable	1
USB cable	1

STANDARD SPECIFICATIONS

Pump laser requirements

Wavelength	**355 nm**
Pulse width	~ 7 ns
Pulse energy	< 3.5 mJ
Pulse energy stability	2.5%
Pulse repetition rate	1000 Hz
Beam diameter (full width at 0.1 level)	~ 0.8 mm
Beam divergence	< 3 mrad (full angle @$1/e^2$)
Beam profile	TEM_{00}
Polarization	vertical
Jitter (with respect to internal SYNC pulse)	± 1 ns
Beam profile	Close to Gaussian

OPG output specification

Tuning range:	355 nm, 400 – 709.9 nm, 710 – 2600 nm
Pulse duration	~ 5 ns
Max. conversion efficiency	~ 15%
Polarizations: 355 nm	Vertical
400 – 709.9 nm	Horizontal
710 – 2600 nm	Vertical
Output beam mode	Elliptical

OPG general specification

Power	90-240 VAC, 50/60 Hz
Required power	< 1000 W
Dimensions:	
NT242	See Figure 2-1
PS6100 Series power supply	See Figure 2-2
Weight	
NT242	~80 kg
PS6100 Series power supply	~20 kg

Figure 2-1 Outline drawings of *NT242* system

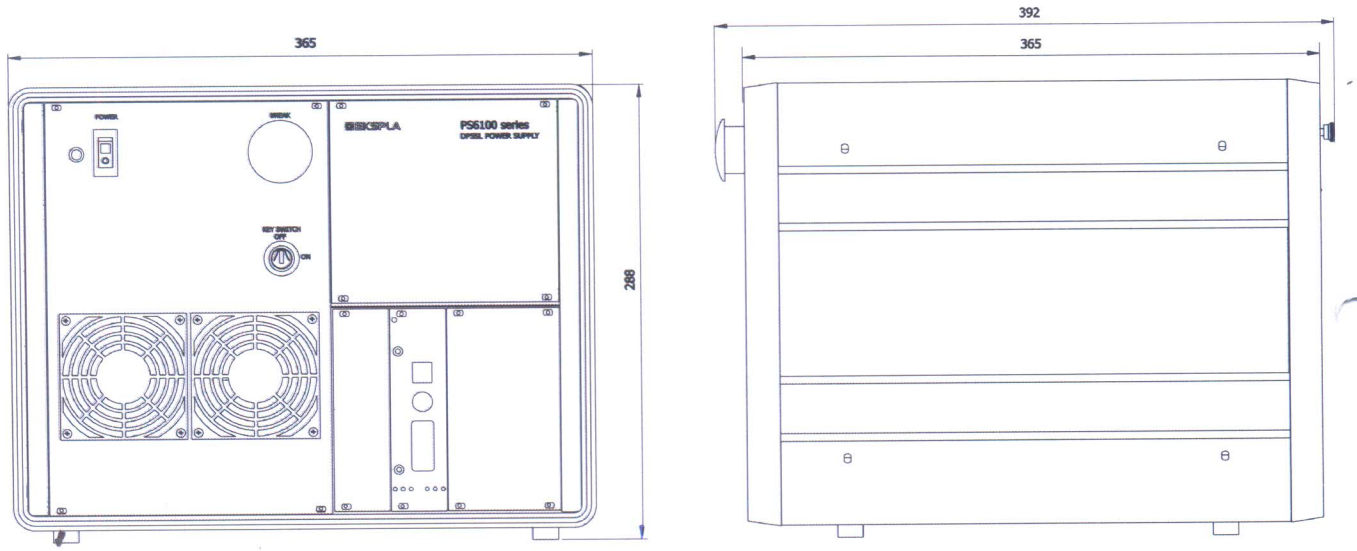


Figure 2-2 Outline drawings of *PS6100 Series* power supply

SAFETY

The *Safety* chapter provides information about safe handling and usage of the *NT242* laser system.

Safety Features and Government Requirements

This laser is a fourth class laser product according to the degree radiation danger, and by definition, relates to certain safety and fire hazards. The following features are incorporated into the laser to conform to several government requirements. The applicable United States Government requirements are contained in 21 CFR, chapter 1, subchapter J, administered by the Center for Devices and Radiological Health (CDRH). The European Community requirements for product safety are specified in the Low Voltage Directive (LVD) (published in73/23 EEC and amended in 93/68 EEC). The Low Voltage Directive requires that lasers comply with the EN-60825-1 (Radiation Safety of Laser Products) and IEC-1010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use).

The laser head is enclosed in a protective housing that prevents human access to radiation in excess of the limits of Class I radiation as specified in 21 CFR , subchapter J, Section 1040.10(f) (1) and Table 1-A/EN60825-1, clause 4.2 except for the output beam, which is Class IV.

The appropriately labeled indicator on the laser head illuminates before laser emission can occur. Amber light is used so that it is visible when the proper type of safety glasses are used (21 CFR, subchapter J, Section 1040.10(f) (5) /EN60825-1, clause 4.6).

A beam shutter prevents contact with laser radiation without the need to switch off the laser (21 CFR, subchapter J, Section 1040.10(f) (6) /EN60825-1, clause 4.7).

The laser controls are positioned so that the operator is *not* exposed to laser emission while manipulating the controls (21 CFR, subchapter J, Section 1040.10(f) (7) /EN60825-1, clause 4.8).

Labeling

This manual contains user information for the *NT242* laser system. Read this manual carefully before operating the laser system for the first time. Special attention should be given to the material Chapter 3, *Safety*, which describes the safety features built into the laser.

The further listed are the labels attached to the equipment.

Laser Radiation Warnings

①

A **laser hazard label** is located on the top of laser system cover. This label is also duplicated on the end panel of laser head frame at the beam output.

②

Cover interlock label is located on the top of laser system cover.

③

An **aperture label** is located above the system apertures with an arrow pointing to the aperture.

④

Laser hazard label is located on end panel of laser system cover, beside the output aperture.

Electrical Warnings / Identifications

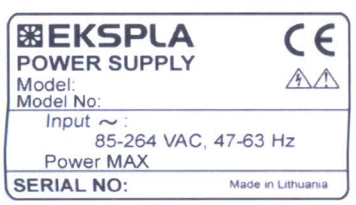
⑤

A **product certification and identification label** is located on the end panel of laser system frame, near the power supply conduit.

⑥

Electrical shock label is located on the cover of high voltage driver on the top of laser head.

⑦



A **product certification and identification label** is located on the rear panel of power supply.

Electrical Warnings

Electrical shock label is located on the cover of high voltage driver on the top of laser head.

Symbols and Other Labels May Be Used in this Manual and on the Laser System

Hot surface labels are located on the some crystal ovens.

Risk of danger label.

Earth (ground) TERMINAL symbol.

PROTECTIVE CONDUCTOR TERMINAL symbol.

Alternating current symbol.

Three-phase alternating current symbol.

On (Supply) symbol.

Off (Supply) symbol.

Do Not Touch symbol.

(Do not attempt to justify a marked component. System is especially sensitive to its position; changing it may cause a difficult to restore loss of generation, etc.)

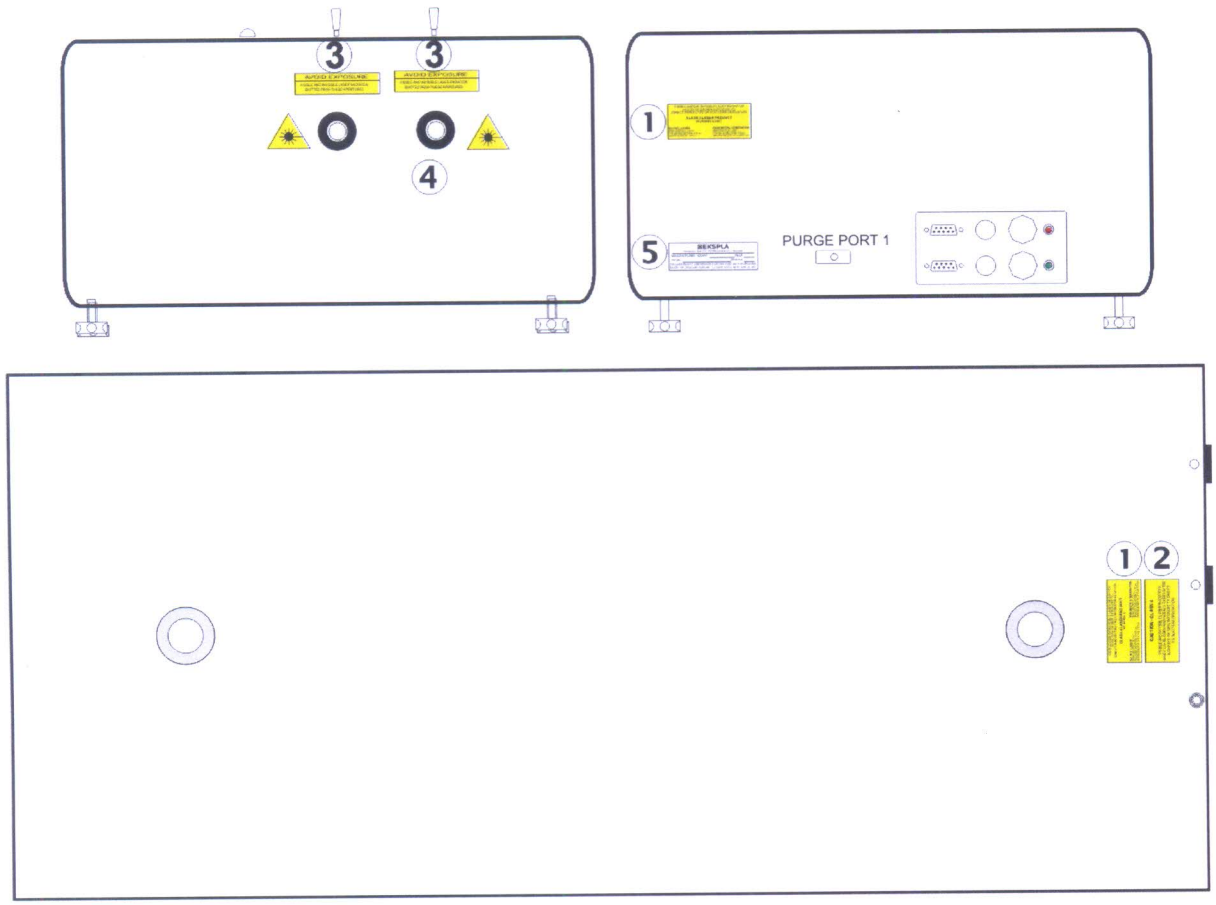


Figure 3-1 Warning label positions on the *NT242* laser system

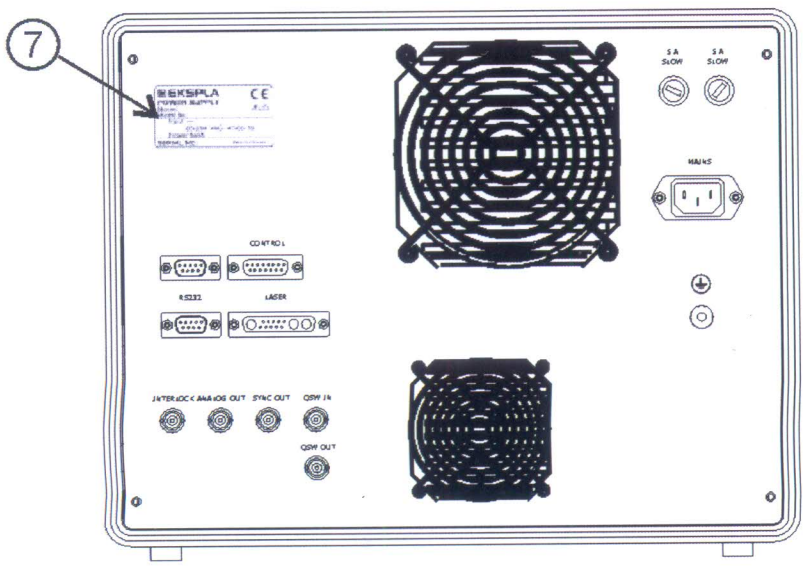


Figure 3-2 Warning label positions on the *PS6100 Series* power supply

Laser Radiation

The wavelength emitted by a particular laser system is specified on the warning label. All reflections, whether specular or diffuse, from optical components such as steering mirrors and prisms, are dangerous. The 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 parts of the body 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 to only 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 such a way that 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 Section 1 Chapter 3, *Safety*.

Electrical Safety

When you operate the equipment with all safety covers in place, the controls available on the power supply cabinet do not present an electrical hazard. The equipment **must not** be operated with any covers removed and/or interlocks by-passed or defeated. Only qualified personnel can access the equipment.

Do not operate with suspected failure. If you suspect there is damage to this laser, have it inspected by qualified service personal.

Use only the power cord specified for this laser and certified for the country of use.

This power supply is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground.

Use only the fuse type and rating specified for this power supply.

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PRINCIPLE OF OPERATION

Principle of Operation of *NT242* System

Tuneable Nd:YAG Laser System comprises of the pump laser *NL220*, harmonics generators (SHG, THG), optical parametric oscillator (OPO), connected in a single device.

The optical layout of the *NT242* system is presented in a Figure 4-1 below.

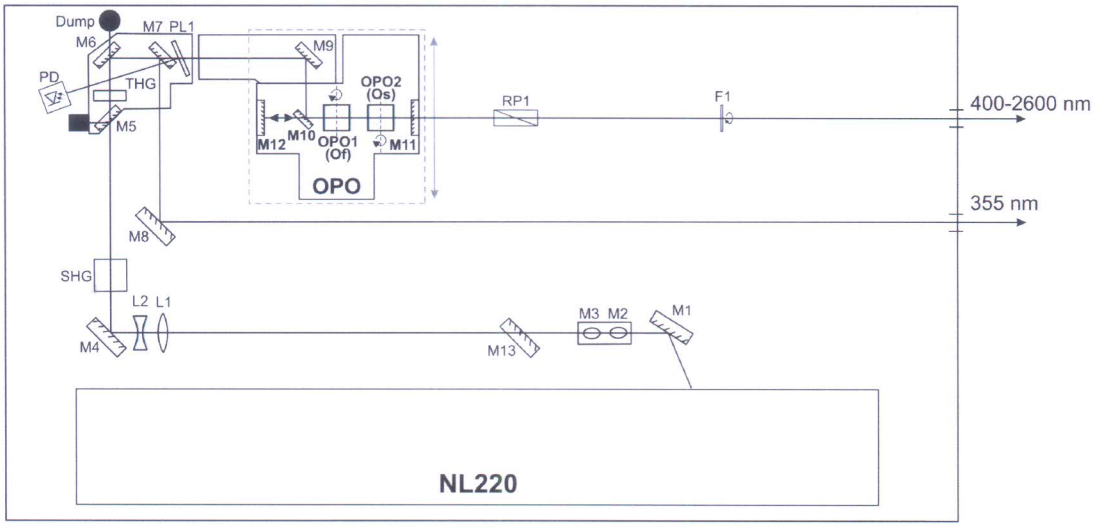


Figure 4-1 Optical layout of the system

Part of the 3rd harmonic radiation is directed to its' own output by mirrors M7-M8.

Photodiode PD1 uses radiation reflected from quartz plate PL1 to monitor pump beam energy entering the *OPO*. This input energy must not exceed the specified value. If this energy limit is violated, a warning beep sounds.

The optical parametric oscillator is a solid state continuously tuneable source of visible and near IR radiation. Based on type II BBO nonlinear crystals, the *OPO* covers 400–2600 nm wavelengths with up to 15% conversion efficiency when pumped by third harmonic of a pulsed Nd:YAG laser. The pumping beam is directed by dichroic mirrors to *OPO* cavity. The *OPO* resonator consists of mirrors M11 and M12. Wavelength tuning is achieved by rotation of nonlinear crystals OPO1 and OPO2. The part of 400-2600 nm wavelengths energy is emitted through the mirror M11 towards the output.

Signal and idler waves are separated by the Rochon prism RP1 (Figure 4-1).

BBO crystals are highly hygroscopic. To prevent condensation they must constantly be maintained at an elevated temperature.

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.

OPERATION CONTROLS

There are two ways to control the device: from its control pad and by external PC. Before operating the device, study this chapter carefully.

Initialization

After power is switched on, the device performs self-testing and initial *Power On* sequence. When initialization successfully completes, the device sets the wavelength to the last value (before the power was switched off) and awaits the further commands.

Control from control pad

To enable the control pad, it must be connected before switching on the device power. Figure 5-1 shows a control pad. It contains eleven buttons and an alphanumeric display.

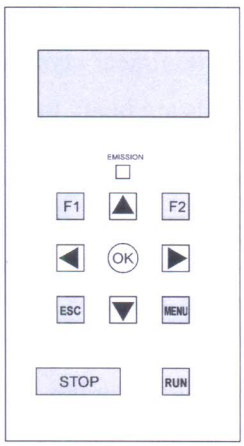


Figure 5-1 Control pad

Push-button MENU sets and executes commands.

Push-buttons ▲, ▼, ◄ and ► tune the wavelength, drive motors and select commands.

The device manages crystal angles automatically. To obtain output at the required wavelength, simply switch the device on and enter the wavelength value using buttons ▲, ▼, ◄ and ►.

The button MENU provides access to individual components of the device and permits changing regimes of operation. Changing regimes should only be done by a person familiar with operation of the device.

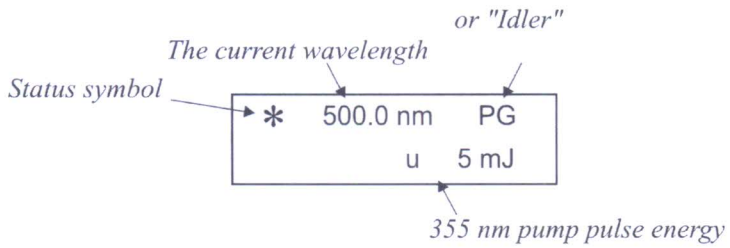
To select the required command, use push-buttons ▲, ▼, ◄ and ►. Pushing the button ESC at any menu point brings you one level back.

To save any numeral parameter into NVRAM, select the required command, press the button OK. Parameter is saved after the beep. Unsaved parameters will be valid for the current session only; after restarting the device, the last set of saved parameters will be used.

Description of commands

Home window (setting of wavelength)

The display shows:



Status symbol meanings:

✻ – Stepper motors of the nonlinear crystals are in the proper positions

⧖ – The nonlinear crystals are being tuned by stepper motors

► – Wavelength setting

! – Stepper motors are not in the proper positions or not connected

The wavelength is adjustable by buttons ▲ and ▼. You can change individual digits: after you press either of buttons ◄ or ►, a cursor will appear, and you will be able to change the digit under the cursor by buttons ▲ and ▼. After the required number has been entered, push the button OK, and the device will set to that wavelength.

Display shows an average energy of the last 10 UV (ultraviolet) pump pulses. The energy meter receives signals from energy monitor. If there is no signal, the averaged power value of the 10 last detected pulses is repeated.

If the energy meter detects a pulse exceeding the maximum allowed value a message 'ENERGY LIMIT' is displayed together with a warning beep. After the energy is reduced to the level allowed, push any button and proceed with your work.

To set a 355 nm output, reduce the wavelength below OPO range, i.e.400 nm.

Control through RS232

Device control through RS232 is provided for service purposes. It is possible to use RS232 commands in software extensions, made either by EKSPLA or by user. For more detailed information about RS232 commands in general and in a specific device, please contact EKSPLA.

SET UP PROCEDURE

Note:
Pease read and understand the previous chapters before proceeding with this chapter.

Attention:
Remember that this device is a complex product requiring a certain personnel experience to perform the service adequately. So, we would highly recommend to call for EKSPLA assistance at laser installation (or an assistance of authorised serviceman).

General Requirements

You must not attempt to start up the laser system prior to installation by *EKSPLA* personnel. Damage occurring due to usage before installation is not covered by the *EKSPLA* warranty.

1. Inspect the shipping container for injuries caused by transportation. When any of such are present, inform *EKSPLA* and the transportation agency.
2. To avoid condensation forming after bringing the shipping container from the cold storage or transportation site, allow the box to warm up to room temperature (approx. 3–4 hours) before opening it.
3. Unpack the laser. Inspect it for presence of all components and for injuries caused by transportation. When any of such are present, inform *EKSPLA*.

The laser and auxiliary units must be placed in an area void of dust and aerosols, labels and other indicators adhere to regulations specified in Chapter 3, and the area complies with the following conditions:

Temperature:	within 18–25 °C
Humidity:	below 80%

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

Position the laser system on a solid worktable with access to the laser from all sides.

The actual line power required is specified in the laser technical protocol and on the equipment labeling. The equipment must be operated only from the line power stated. You cannot change the supply specifications.

The equipment must be adequately earth grounded.

Connecting

1. Fix the laser system to the optical table. Place the power supply and *Cooler* near the laser system in a convenient place.
2. Do not install the *Cooler* in an environment where other equipment is likely to cause a high ambient temperature. The *Cooler* operates efficiently with an ambient temperature of up to

40°C. Above this temperature, the cooling capacity will not be maintained, as the refrigerant cannot be sufficiently cooled.

3. The *Cooler* must be installed in such 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.

4. Interconnect the *NT242* laser system with the power supply *PS6100* and *Cooler*:
   - Connect the water cooling pipe from *NT242* (upper) to OUT on the *Cooler*. Connect the water cooling pipe from *NT242* (lower) to PROCESS IN on the *Cooler*. The quick connect water couplers accept 1/4" ID PVC fiber reinforced hose.
   - Connect cable from *NT242* (upper) to socket LD on the *PS6100*.
   - Connect cable from *NT242* (lower) to socket LASER on the *PS6100*. Connect attached connector to socket CONTROL on the *PS6100*. Connect attached connector to socket 'Signals' on the *Cooler*.

5. Short the socket 'INTERLOCK' on the power supply *PS6100*.

6. Connect the *Cooler* to the facility power.

7. Fill a reservoir following instructions of a *Cooler* manual.

Attention!
We recommend using distilled water with OptiShield II corrosion inhibitor. Use other corrosion inhibitor on your own responsibility.

Warning:
Do not operate coolant system below air condensation temperature (dew point) at laser head. Condensation on the diode arrays can seriously damage the pumping heads.

8. Connect the power supply *PS6100* to the facility power.

9. Connect the remote control pad to the sockets on the front panel of *PS6100* and *NT242*.

10. *NT242* might also be connected to an external PC by a cable supplied with the device. See Appendix A and contents of CD for details of operation from PC.

Warning:
Connect/disconnect the power cable to/from the device exclusively with power off!

11. Unscrew the transporting bolts (from both laser ends) depicted in Figure 6-1 below.

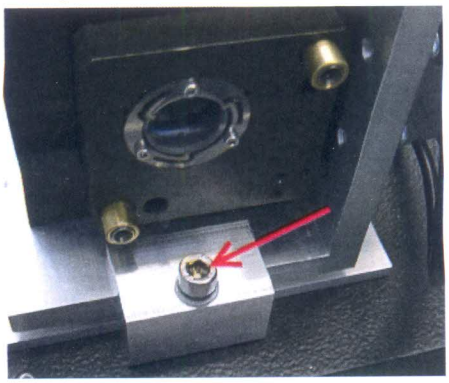


Figure 6-1 Transporting bolts of the laser

12. Relieve the bolts fixing both end panels to the inner breadboard pedestal to the extent (roughly for 90 degrees) that panels can move freely a little, see Figure 4-2. This makes breadboard less sensitive to tensions caused by thermal expansion of the panels.

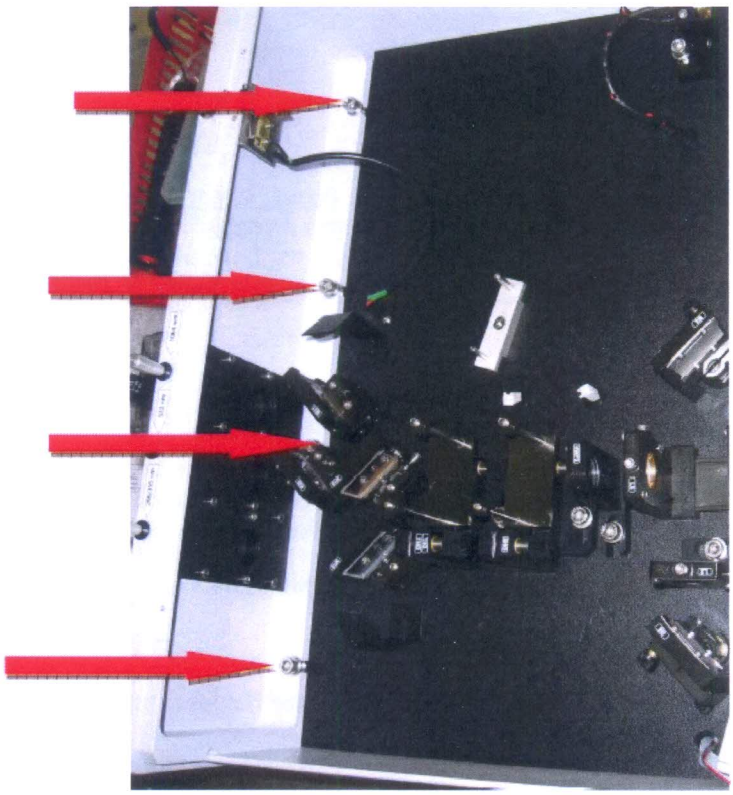


Figure 6-2 Relieve the fixing bolts

13. Switch the power switch to position ON on *PS6100.*
14. Turn on the *Cooler* according to the manual.
15. Switch on the pump laser, examine if the pump beam meets requirements in Chapter 2 of this Section.
16. Run laser and check if the output parameters correspond with specified parameter in Chapter *Testing Data.*

Installation

To put the device into operation, follow the sequence of steps:

1. Switch the *NT242* system on by pushing the power switch. Control unit starts self-testing and *Power On* sequence of procedures. If everything completes OK, the device will stop in a position as before the last power switching off. If not, the control pad displays a message '...ERROR...' (See Chapter 8 of this Section).
2. Set the device to 355 nm wavelength. For this, set the wavelength at '3H' *(go below 400 nm)* from control pad.
3. Switch on the pump laser *NL220* and run it in **Max** mode (see Chapter 2 in *NL220* laser's manual).
4. If energy level is too low, adjust SHG and THG crystals temperature (Chapter 1 of Section 2).

5. Set the required pump energy not exceeding the maximum allowed value.

6. Check if the device generates specified output energy in 400-2600 nm spectra range according to *Testing Data* (see Chapter 9 of this Section). Check output energy at several wavelengths only.

Set up of *OPO*

Attention:
The OPO is very sensitive to the input energy value. To avoid damage of optical components, constantly control the pump energy: whether performing the calibration or set-up procedure and in routine operation as well. In any case, it must not exceed the maximum value specified in Chapter 9 Testing Data of this Section. Follow this requirement rigorously!

Routine operation

Important:
The upper energy limit of 355 nm pump pulses is determined from the point of probable damage of some optical components. This device was tested with maximum average pump energy specified in Chapter 9 of this Section. We do not recommend to exceed this value.

1. Open the output shutters by pulling the knobs up.

2. Wait until *NT242* starts.

3. Switch on the pump laser and run it (see the laser manual for details).

4. Set the minimum pump energy sufficing your application by adjusting ***Tadj delay*** or using external polarizing attenuator.

Note:
If the control unit beeps and indicates a pump energy limit fault, you will need to reduce the pump level below the maximum allowed level that is indicated on the factory settings page of this manual. Once this is done, push any button and proceed with your work.

Note:
As the nonlinear crystals are heated by the pump beam inside the NT242, it will take 20-30 minutes of warm up time after turning on the pump laser or making an energy change for the output energy and wavelength to stabilize. The pump specifications for the NT242 are specified in Chapter 2. Note that changes to other pumping energies may affect the wavelength of your output.

5. Select the required wavelength from *Home* window on the control pad display (see in Chapter 5 *Home window (setting of wavelength)*).

6. After your work is finished, close the shutters.

Attention:
Do not unplug the power cable and PS6100 Series Power Supply from mains! Leave it connected at all times. The green LED on the side of system frame must remain lit, indicating that crystals heaters are on.

MAINTENANCE

Attention:
Only qualified personnel should attempt maintenance.

Maintenance Schedule

- **Daily**

After your work is finished, do not forget to close all the shutters (lower the knobs).

- **Weekly**

Thoroughly inspect all optical components. If dust is found on their surfaces, blow it away with a blower (blower-brush).

The filtering out of all particles within the coolant water circuit will eventually lead to blockage of the filter. Once the filter has turned grey, it should be replaced. The maximum time of use of a filter should not exceed 6 months. The water quality must be checked at regular intervals (every 12 months). The water circuit should be drained and rinsed *(refer to the chiller manual)*.

Inspection & cleaning of optical surfaces

A dust particle or dirt, if not removed in time, may cause costly damage of optical surfaces. Examine the cleanness of optics in the system regularly and with special care. Following you will find details of how to maintain some critical components.

Open the cover of the system to access the output mirror. First, try to blow any detected dust particle(s) away using pressurised gas (filtered dry nitrogen). If to no avail, attempt cleaning surface with a lint-free cotton swab moistened with a few droplets of pure acetone or methanol.

Note:
Use cotton swabs only with wooden or plastic stems. In case the contaminants endure, the drag method of cleaning can be used. That is, slowly drag a lens tissue or cotton swab saturated with isopropyl alcohol (or methanol) across the surface. If done correctly, the solvent will evaporate uniformly without leaving any streaks or spots.

Caution:
Hygroscopic crystals, such as harmonic crystals must be cleaned only with a squirrel-tail brush, or dust may be blown away with a pressurised gas. In critical cases, use water-free pure ethyl-alcohol or butyl-acetate.

TROUBLESHOOTING GUIDE

Following are some suggestions to assist you in locating the source of problems that may occur when operating *NT242*.

	Symptom	Explanation and remedy
1.	One of stepper motors does not move	- the motor cable is detached - the motor is hindered mechanically - the device power has been turned on with the stepper motor disconnected Check the motionless motor's cable. Check for mechanical constraints. Press three buttons – ESC, MENU and OK – at once.
2.	Everything seems moving OK, nevertheless the generation is absent	Press three buttons – ESC, MENU and OK – at once.
3.	Note 'NVRAM ERROR + ...' is displayed after the device has been turned on; here '...' indicates a list of constants which values have overrun the set limits. The list may include: NM - Name WL - Wavelength CP - Number of corrections Of - Offsets KU - EM calibrate MU - Maximum energy	- NVRAM failure - transients in the powering circuitry The NM, WL, Of, KU, MU errors can be caused by the customer's inaccuracy in setting the relevant parameters (they happen beyond the limits allowed). Turn the device off and on again. If the note persists, it is an evidence of NVRAM failure. If not, perform the calibration procedures and you are ready to proceed with your work.
4.	Output wavelength differs from the set one.	Consult Chapter 6 *Installation* of this Section. Call to *EKSPLA*.
5.	Output energy is considerably less than specified thought pumping energy is nominal.	Surface of the nonlinear crystals can be damaged and/or an increased scattering appears inside the device. Turn the OPO movement knob one full rotation counterclockwise (see Figure 10-1). The damaged crystals places will be moved out of the beam trace. Don't turn the knob clockwise!

6.	Low energy at 355 nm	Check second harmonic crystal temperature and Q-SW delay (see Chapter 10 *Factory settings*). Slightly change SHG or THG temperature following output energy. Turn the THG movement knob one full rotation in case a crystal surface is locally damaged.

Note:

The confusion No.1 also occurs, because of if the device has been turned on with either of motors uninstalled, that motor is not further controlled at all. Then that particular motor does not ever turn, and its axis is easily turned by hand.
The similar situation may occur if the device cannot turn the motors due to a mechanical hindrance.

TESTING DATA

Optical parametric system *NT242*

System serial number: **PGD084**

Laser parameters:

Wavelength. nm	Output energy. mJ	Energy stability. % (standard deviation)
355*	2.633	1.2

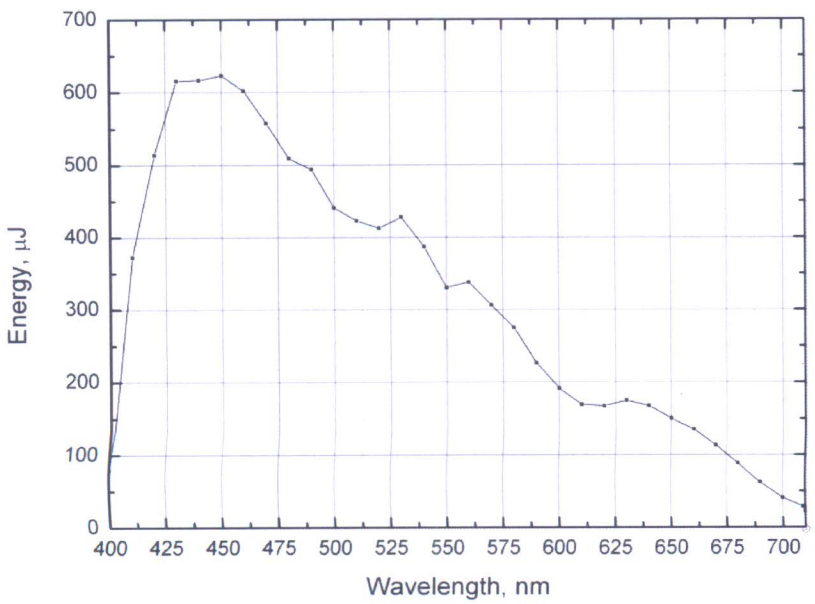
*-optimized for parametric generation

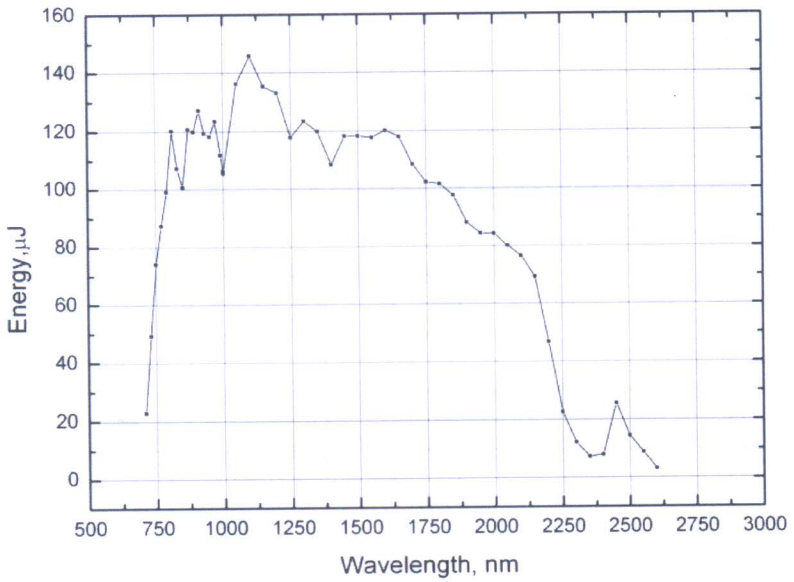
Pulse duration (FWHM) @ 450 nm, ns: 5 ns

Optical pulse jitter (standard deviation), ns: 0.3 ns

OPO parameters:

Output energy versus wavelength measurement pumped by mJ @ 355 nm





Linewidth measurement, pumped by mJ @ 355 nm

λ, nm	Δν, cm^{-1}
420	3.2
450	3.2
520	3.1
610	3.0
680	3.1
700	2.9
709	3.0

Test officer J. Butkus
(Name. signature)

Date of approval 2013.11.15