UniPG

Family of Products

Reference Guide

Rev. 2105

2022
Lithuania

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Thank you for using EKSPLA products!

1.1. Legal Disclaimer

1.2. Errors & Omissions

EKSPLA lasers and other products are under constant improvement. Many systems are heavily customized to suit the needs of the customer. Due to this:

- The contents of this document may be outdated, incomplete, or erroneous.
- Some information in this document about specific products may be omitted.
- Some information in this document may be excessive and not related to the particular system.

We kindly ask you to inform us if you notice any errors and/or omissions: support@ekspla.com.

1.3. Contacts

1.3.1. Manufacturer

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Phone:	+370 5 2649629
Fax:	+370 5 2641809
E-mail:	ekspla@ekspla.com
Website:	www.ekspla.com

1.3.2. Service

We have a responsive customer service staff that will be pleased to assist you. Do not hesitate to contact them, having the serial number of your product(s) ready.

Phone:	+370 5 2649623
Fax:	+370 5 2641809
E-mail:	support@ekspla.com

1.3.3. Spares

For spare parts, contact:

E-mail: spares@ekspla.com

This document describes the UniPG family of hardware and software products.

UniPG	
Software	*Hardware*
NPar7loader.exe	MaxiOPG
PgHardw.exe	MidiOPG
PgSoftw.exe	MiniOPG
Custom FastScan software	FastMini

Figure 1 UniPG family of products

Your EKSPLA laser system contains one or more optical parametric generators or similar functional elements. These elements change output radiation parameters (wavelength, pulse duration), measure energies and perform other tasks. UniPG products control these elements (devices).

UniPG hardware and software work together:

- Software applications program, debug and control the hardware controllers.
- Hardware controllers manage devices, such as motors, crystal ovens, and delay lines.
- These devices change mirror angles, crystal temperatures and perform other tasks.
- In the end, all this changes laser output parameters.

2.1. Overview

Below is a short overview of UniPG products.

- Hardware controllers manage devices.
    - Maxi-/Midi-/MiniOPG/FastMini controllers are programmable PCBs (printed circuit boards) with various functions. Controllers manage one or more devices (such as motors). CAN bus interconnects the controllers with each other, other system components and control devices. A system may contain one or more controllers in various master-slave configurations.
    - Most controllers hold a kernel, a driver, controlled device settings and all parameters of these components:
        - Kernel communicates between software and hardware parts of the controller.
        - Driver contents describe the connected devices (e.g., type of motor, current and voltage levels, stepper parameters, etc.). I.e., driver describes what to control.
        - The controlled device settings, such as *.OPG files for crystal motors, describe how to control the devices.
- Software applications program, debug and control hardware.
    - NPAR7loader.exe allows programming and loading the kernel into the controller.

- PgHardw.exe allows programming and loading driver settings for various devices into the controller.
- PgSoftw.exe allows programing and loading the control logic, theoretical curves and other parameters into the controller. This application has two modes with different capabilities – „Adjuster" for the end-user and „Constructor" for EKSPLA employees.
- Custom applications, such as custom FastScan software, may be available.

A typical system schematic is given in the figure below.

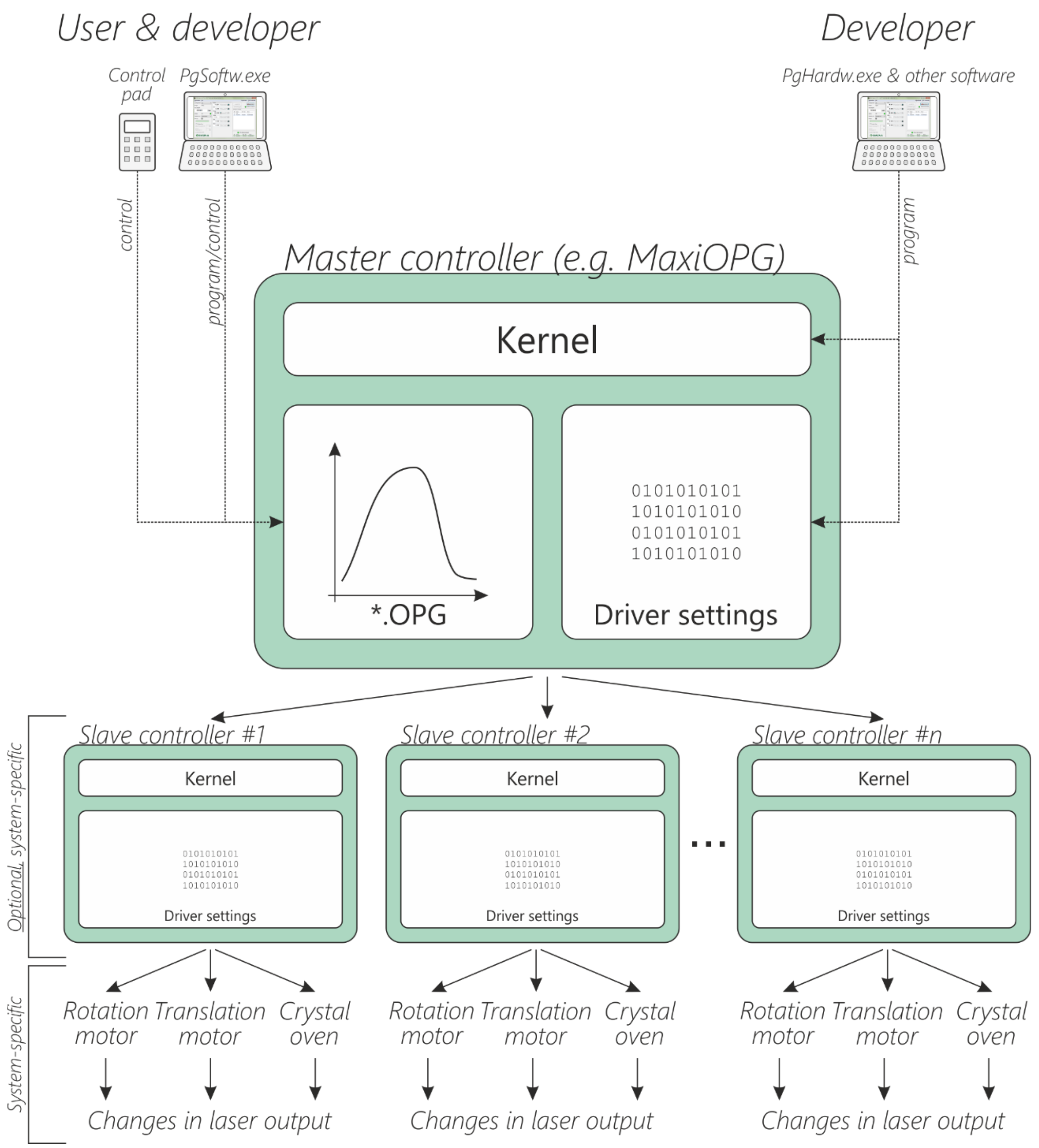
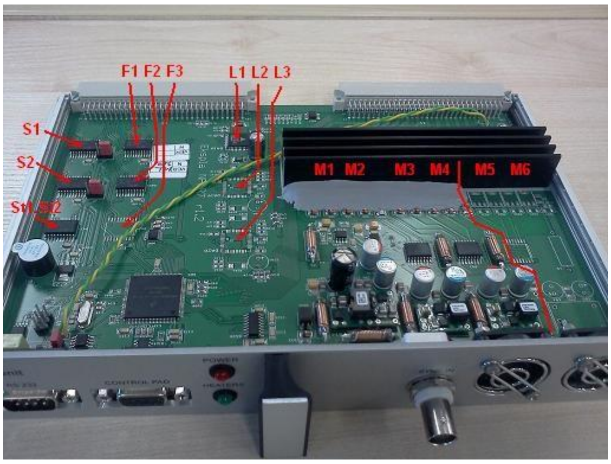


Figure 2 Schematic of system with UniPG products

UniPG controllers allow changing angles, positions, temperatures of system elements depending on the set wavelength or other parameters.

Some controllers may perform as a master controller for one or more slave controllers. Your laser system has a specific configuration of master and slave controllers. UniPG controllers may manage other types of boards. Low-speed controllers can't manage high-speed controllers (related to FastScan capability, see CHAPTER 5 FASTSCAN, p.29).

3.1. MaxiOPG



Usually acts as the master controller. Low-speed. Alternative name: NPAR7. Some PCB components may not be soldered. User connection via control pad (directly to board) or via CAN bus.

Possible device connections:

- 6 micro stepper motors (M1-M6):
  - With zeroing.
  - Step division ratio (SDR)=512.
- 3 small step motors (L1-L3):
  - With zeroing.
  - SDR=1-64.
  - Usually for rotation or translation tables.
- 2 step motors (S1, S2):
  - No zeroing.
  - SDR=2.
  - 5/12V.
- 2 step motors (F1-F3):
  - No zeroing.
  - SDR=2.
  - 12V.
- 2 shutters (St1, St2):
  - 12V.

- 3 energy meters
    - One – with synchronization.

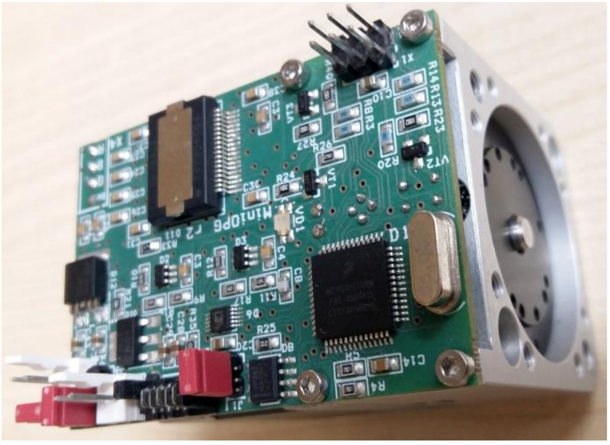
3.2. MidiOPG

Low-speed.

Possible device connections:

- 3 small step motors (L1-L3):
    - With zeroing.
    - SDR=1-64.
    - Usually for rotation or translation tables.
- 2 step motors (S1, S2):
    - No zeroing.
    - SDR=2.
    - 5/12V.
- 2 step motors (F1-F3):
    - No zeroing.
    - SDR=2.
    - 12V.
- 2 shutters (St1, St2):
    - 12V.

3.3. MiniOPG



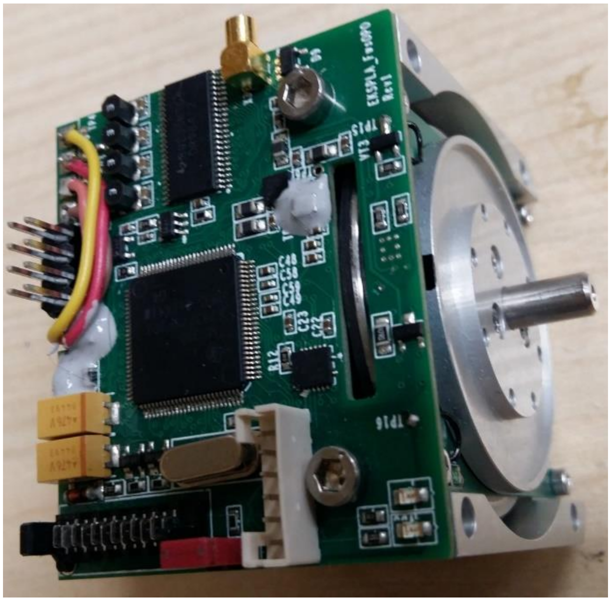
Low-speed. Mounted together with a motor and a crystal thermostat. Motor and thermostat power supplies may be connected via CAN or separate power connections.

Thermostat temperature range: 40-50°C.

Two controller modes:

- 0.9°/512 micro steps ±112.5°.
- 0.9°/256 micro steps ±170°.

3.4. FastMini



Alternative name: fwsopo. Usually provides FastScan capability. High-speed. Mounted together with a motor, one or two encoders and a crystal thermostat.

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4.1. Routine Operation

Note:
Take notes about any changes in the Comments *window.*
Save any changes by clicking OPG Controller>Program *in the* Top menu.

1. In your PC, launch the PgSoftw.exe application.
2. Load the required *.opg file:
    a. In the Top menu, click File>Open OPG.
    b. Select the file and press Enter.
3. Connect to the master controller of your laser system:
    a. In the Main window, click Connection type and configure your connection, then click Ok.
    b. Click Connect - software attempts to connect to the controller.
4. (Recommended) Calibrate the sensors (see 4.3.3.C) CALIBRATION OF SENSORS, p.14).
5. Edit the optical zeros (see 4.3.3.A) OPTICAL ZEROS, p.12):
    a. In the Top menu, click Adjustment>Optical Zeros>Go To Zero and select the required range. The system moves the relevant motors.
    b. In the relevant input field of a device, edit values.
    c. Click the optical zero input button.
    d. Perform this procedure for all ranges of the system.
6. Enter corrections (see 4.3.3.B) CORRECTIONS, p.12):
    a. Set the desired wavelength.
    b. In the relevant input fields of devices, edit values.
    c. Click the correction input buttons for the edited devices.
    d. Perform this procedure for other wavelengths as needed.

To re-enter corrections:

1. Check and re-adjust optical zeros (if needed).
2. Change the existing corrections - delete or edit them.
3. Make new corrections only when the neighboring corrections are verified to be correct.

4.2. General Information

Each master controller has an associated *.opg file. All configuration changes are automatically stored in two locations – on the controller and on the PC. File name and path are stored on the controller, ensuring data redundancy if one of the locations becomes inaccessible.

PgSoftw application requires a *.opg file. It may be loaded from the controller ("on-board") or the PC. When settings are loaded from on-board storage, the software looks for an associated file. If the file is not found, software prompts for a new filename and/or path.

When settings are loaded from the file, software checks all devices on the CAN network for an associated OPG driver and then links the driver with the settings.

It is recommended to always have one unique file in an easily accessible location on the PC.

Different access levels are implemented in the PgSoftw application. Developer („constructor") access level allows designing and debugging firmware for the controller. This is performed by the manufacturer. User („adjuster") access level allows adjustments and corrections within the ranges set at developer level.

The image below shows a typical PgSoftw main window. There are several control areas in the window. They are described below.

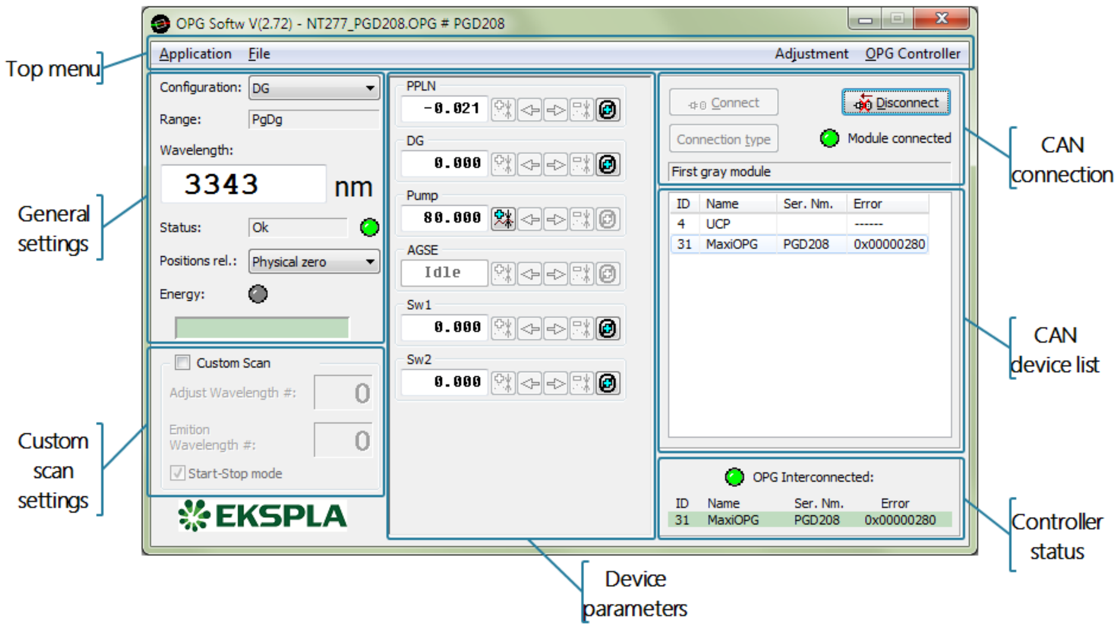
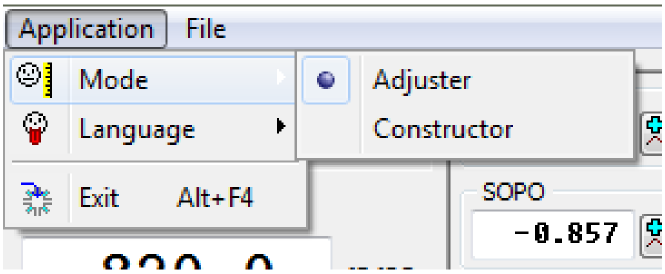


Figure 3 PgSoftw main window

4.3. Top Menu

4.3.1. Application



a) Mode

The Mode menu switches between different access levels:

- Adjuster - access level for end-user. Limited permissions.
- Constructor - access level for the developer. All permission. Password required.

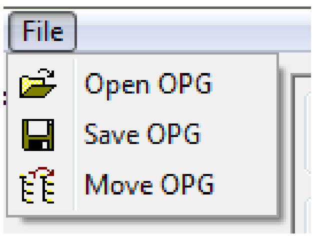
b) Language

The language menu changes the user interface language (English or Lithuanian).

c) Exit

The Exit button closes the program.

4.3.2. File



a) Open OPG

The Open OPG button opens an .OPG file.

b) Save OPG

The Save OPG button saves the .opg file in an emergency, if the OPG driver is inaccessible. Under normal circumstances, data is saved in the on-board memory and the .opg file is created automatically.

c) Move OPG

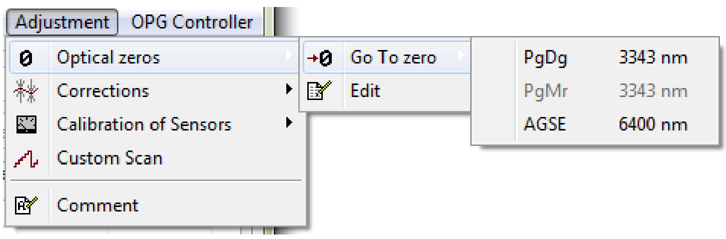
The Move OPG button moves the .opg file to a new location and allows changing its name. If the file is moved, it is necessary to re-program the driver and save the new location/name in the driver.

4.3.3. Adjustment

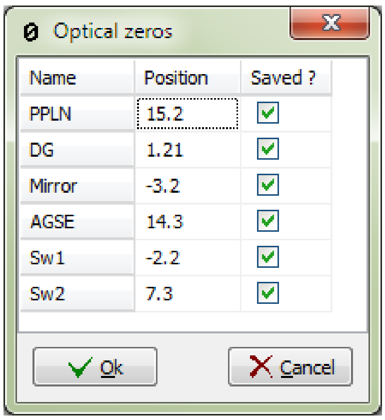
a) Optical Zeros

The Optical Zeros submenu allows performing the following tasks:

- Go To Zero - moves the optical elements to their optical zero positions for the selected range. The resulting position change is reflected in the motor information pane. The wavelength corresponding to optical zero is set by the manufacturer at the developer level and cannot be edited by the user.

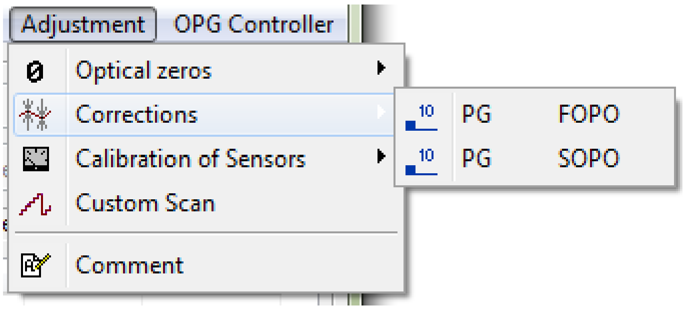


- Edit - opens a window to edit optical zero positions for various elements. The Saved? checkbox indicates that a position is stored and used. Another way to edit and store optical zero positions is to use the optical zero input button in the motor information pane.



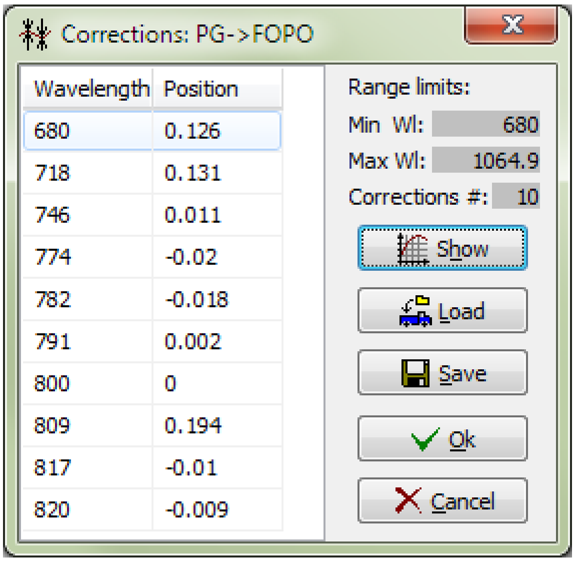
b) Corrections

The Corrections submenu opens a list to pick a range-motor combination.



The combinations, names and range wavelengths are set by the developer and cannot be changed by the user.

Pick a combination to open the Corrections window.



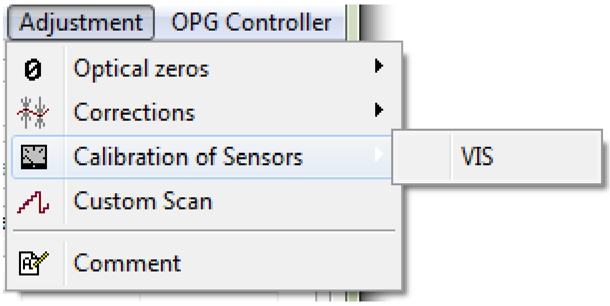
This window is used to edit correction values; to save them as a .csv file; to load from a .csv file.

Clicking Show opens a separate graph window.

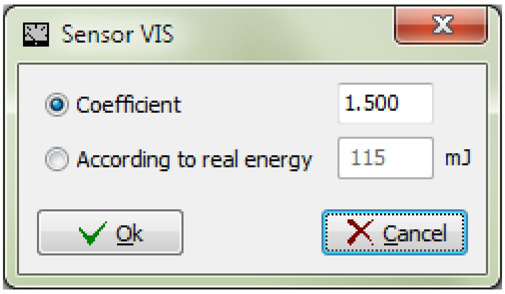
In the corrections graph window, numerical values are shown by pressing ALT+CTRL. Select a region with the mouse to zoom in.

c) Calibration of Sensors

The Calibration of Sensors submenu presents a list of sensors.



Pick a sensor from the list. An energy calibration window opens.



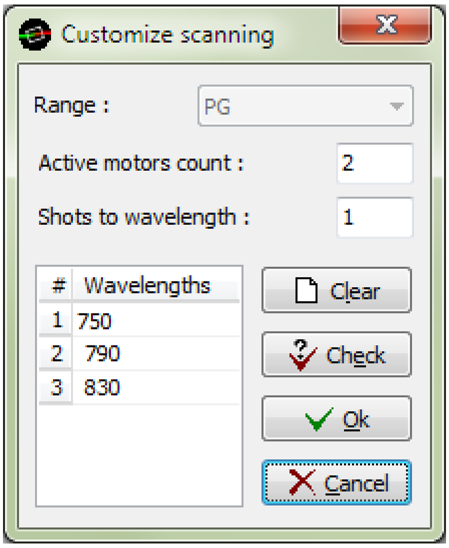
This window provides two ways of calibrating the sensor:

- Coefficient - The energy calibration coefficient value can be changed in the range of 1...2. This field also accepts mathematical operations: e.g. if the calibration coefficient needs to be increased by 10%, enter "*1.1".
- According to real energy - Another way to adjust calibration is by using a known real energy value. Select According to real energy button and enter the energy. The calibration coefficient will be calculated and set automatically.

d) Custom Scan

Optional submenu - only available if custom scan is enabled for your product. This option works together with CANBrowser and/or control pad.

A window opens after clicking the Custom Scan button.



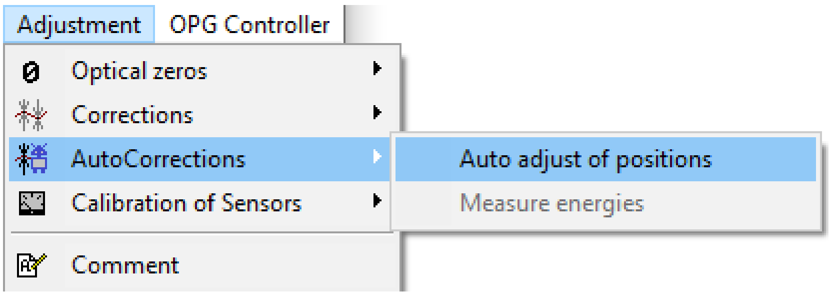
Enter custom scan parameters.

After selecting the scan range, number of active motors and shots per wavelength, enter the sequence of wavelengths into the table. If "Single" scan is set via CANBrowser/control pad, the system will return to a static starting wavelength. If "Continuing" is selected, the scan will continue until it is stopped by the user.

e) AutoCorrections

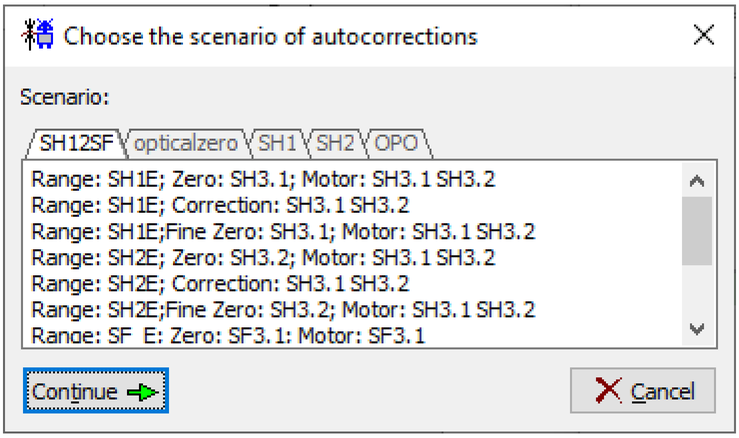
Optional submenu - only available if the option is enabled for your product.

> *Note:*
> *Before performing autocorrections:*
> *Set* Laser stopping>On motors Moving *(see 4.3.4.E) LASER STOPPING, p.19).*

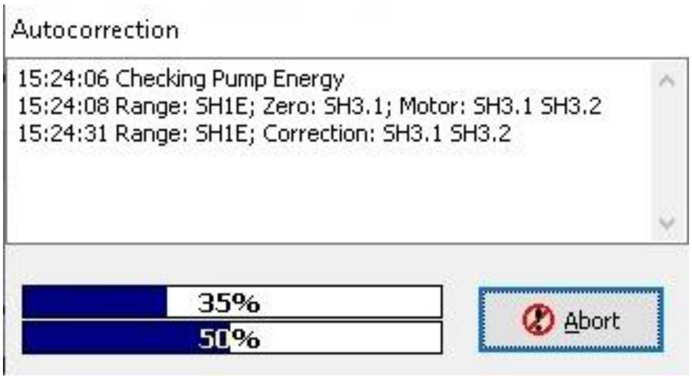


The AutoCorrections option (also called autocalibration) provides a quick and convenient way to restore lowered output energy by automatically redoing the tuning curves (automatically entering corrections). The procedure automatically scans the selected range(s), measures energies and fine-tunes crystal parameters (positions) to maximize output energy. After the procedure, the system returns to the previous configuration and wavelength.

After clicking Auto adjust of positions, a scenario window pops up:



The scenario window lists pre-programmed sequences for different ranges. See the laser manual for explanation of scenario names. Select a scenario and click Continue. The procedure starts.



If the autocorrections procedure results in an error:

- The system returns to the previous configuration and wavelength.
- All corrections made up to the error are not lost and may be saved by programming.

A prompt is displayed upon completion of the autocorrections procedure. To save the changes:

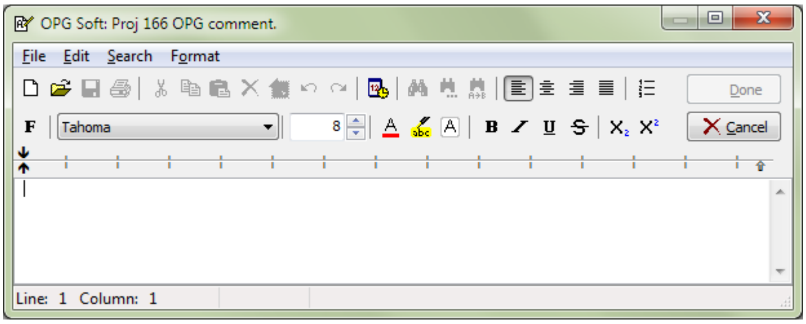
1. Stop the laser.
2. Program (see 4.3.4.B) PROGRAM, p.18).
3. A prompt pops up, asking to restart the controller. Restart the controller.
4. Cycle the key on power supply.
5. If another autocorrection procedure is required (e.g., in a different range (scenario)), repeat from step #3 above.
6. To proceed using the laser normally:
    a. Disconnect the software.
    b. A prompt appears, asking to restart the controller – restart the controller.

c. Cycle the key on the power supply unit.

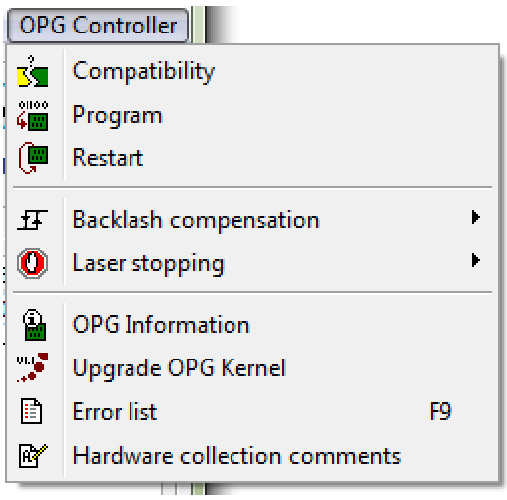
d. Use the laser.

f) Comment

Use the Comment window to enter comments (e.g., notes about adjustments and changes).



4.3.4. OPG Controller



a) Compatibility

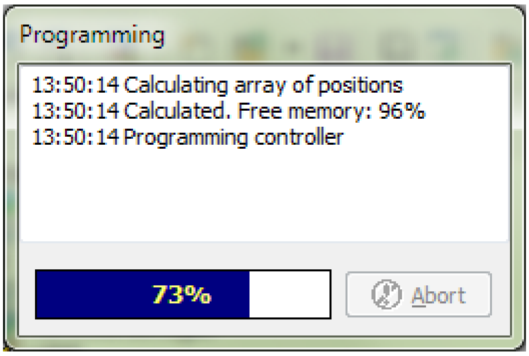
The Compatibility window shows the main driver and software parameters and their compatibility.

Color indicators:

Indicator color	*Description*
Gray	Warning.
Green	Compatible.
Red	Incompatible.

b) Program

If the system is fully compatible and no warnings are indicated, programming starts.



If warnings are found, the Compatibility window opens to show the warnings and the user is prompted to confirm the start of programming. Programming is denied if compatibility issues are detected.

c) Restart

Restarts the associated driver motor(s):

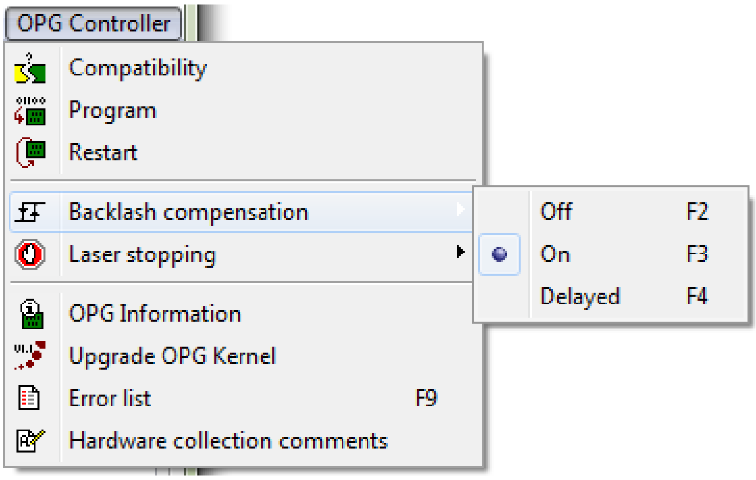
- Motors find zero positions.
- Backlash compensation turns on.

d) Backlash Compensation

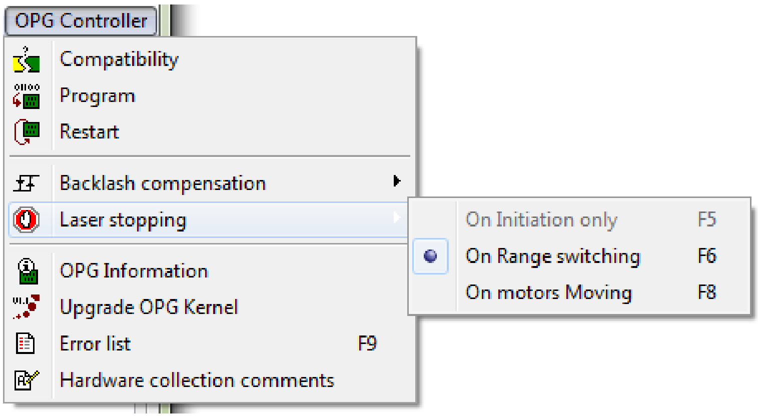
Sets the backlash compensation mode, which may have different implementation for different motor types:

- Off – no backlash compensation - motors do not shake after arriving to target position.
- On – active and performed immediately for every move - motors shake immediately after arriving to target position.
- Delayed – performed when motors have been idle for 0.8 seconds. Recommended when modifying motor positions using the incremental input method to avoid excess motor movements.

The default mode is On.



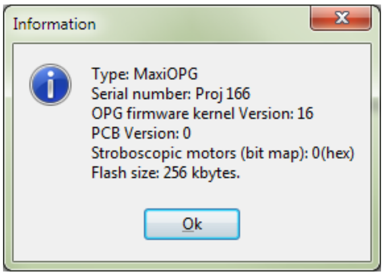
e) Laser Stopping



Allows automatically stopping the laser during range switching or motor movements. Select options to stop the laser only when changing range, or to stop during any motor movement (e.g. when changing wavelength in the same range). The On Initiation only option is not accessible by the user.

f) OPG Information

Shows the driver type, serial number, kernel version and other parameters.



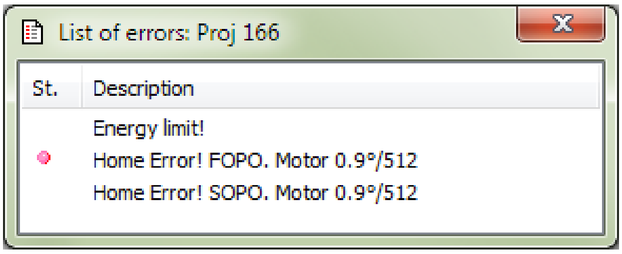
g) Upgrade OPG Kernel

Allows upgrading the kernel (currently only for FastMini drivers/motors) via an *.ffl file.

MaxiOPG kernel may be upgraded via RS232, NPAR7Loader.exe.

h) Error List

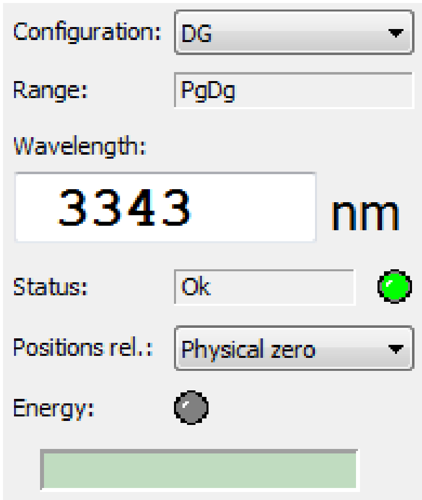
The Error list window shows a list of possible errors. A red bullet indicates an active error.



i) Hardware Collection Comments

Comments about motor connections. Loaded from the driver. Read-only for the user.

4.3.5. General Settings



a) Configuration

Some drivers may have two or more configurations – different ways to generate some of the same wavelengths. Select the required configuration in this drop-down list.

b) Range

Indicates the range at which the system is operating at a given moment. Ranges are named after generating modules and will usually have different combinations of steering optics, filters, etc.

c) Wavelength

A field to enter the desired wavelength in indicated units.

d) Status

Indicates status of the associated driver:

Indicator color	Status	Description
Gray	Off	No electrical current on motors.
	Not connected	Driver not connected.
Blue	Initiation	Motors search for zero positions.
Yellow	Tuning...	Motors are turning to set positions or a scan is taking place.
Green	Ok	Wavelength is set.
Red	Fail	Program error.

e) Positions Rel.

Optical components are mounted on motors or stages. Both the optical component and the motor usually have a "zero" position, e.g. some optimal position of a harmonic crystal or a starting position of a motor. This requires calculating several possible relative positions.

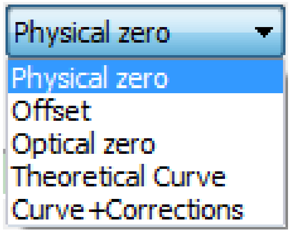
All components are positioned according to a table containing the wavelengths and corresponding positions of stepper motors. Each motor has a pre-set calibration point called Optical 0 (optical zero).

The motors are positioned relative to a fixed "physical zero", which is a characteristic of a given motor. Usually, the physical zero does not match the optical zero of the optical element mounted on the motor, as it is problematic to mount an element for both zero positions to match. Because of this, the optical zero is defined as an offset from the physical zero position.

The following variables are used:

- abs – absolute position, relative to motor physical zero.
- tab – offset of an element relative to the optical zero when turning from optical zero wavelength to another wavelength. Values for various elements are determined by theoretical curves, programmed and stored during manufacturing.
- cor – correction value.
- Opt'0' – position of optical zero (offset from physical zero). Corresponds to a pre-determined wavelength.
- ofs – an additional offset.

The drop-down list shows the possible position types. Please note that the user can use positions relative to all possible reference points, but is able to edit only the optical zero position and corrections; other offsets and curves are set by the manufacturer.



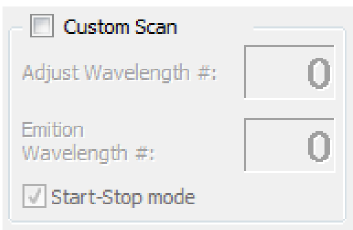
Item	Description
Physical zero	Absolute position of the crystal relative to physical zero.
Offset	An optional additional offset, usually used when two crystals are actuated by the same motor.
Optical zero	Position relative to optical zero: Optical zero = abs – Opt'0' – ofs
Theoretical Curve	Position for the currently set wavelength relative to the value logged to table during manufacturing. Positions between logged points are extrapolated. Theoretical curve = abs – tab – Opt'0' – ofs
Curve+Corrections	Position for the currently set wavelength relative to the value logged to table during manufacturing, with added corrections. Positions between logged points are extrapolated. Curve+Corrections = abs – tab – Opt'0' – cor – ofs

f) Energy

Energy level in indicated units. Corresponds to the value shown on the remote control pad. See laser system manual for the point at which the energy level is measured.

Indicator color	Description
Gray	No output.
Green	Laser is operating.
Red	Energy is above pre-set limit.

4.3.6. Custom Scan Settings



Custom Scan Settings only appear in the Main Window if this option is available for your product.

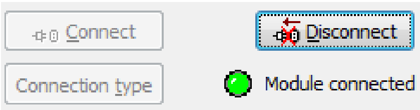
For more information on custom scanning, see 4.3.3.D) CUSTOM SCAN (p.14).

The controls in Custom Scan Settings are:

- "Adjust Wavelength #" field - shows the wavelength number in which motor positions are adjusted. FirstWl synchronization pulse will occur at this wavelength number.
- "Emission Wavelength #" field - shows the wavelength at which emission is occurring.

"Start-Stop mode" checkbox - toggles between start-stop and non-stop modes, where applicable.

4.3.7. CAN Connection



a) Connect

Upon clicking the "Connect" button, PgSoftw connects to the device communication network. If the driver software is loaded and the driver is accessible, PgSoftw attempts to connect to the driver. When PgSoftw connects to the driver, "PC mode" starts - system control via control pad is not available.

b) Disconnect

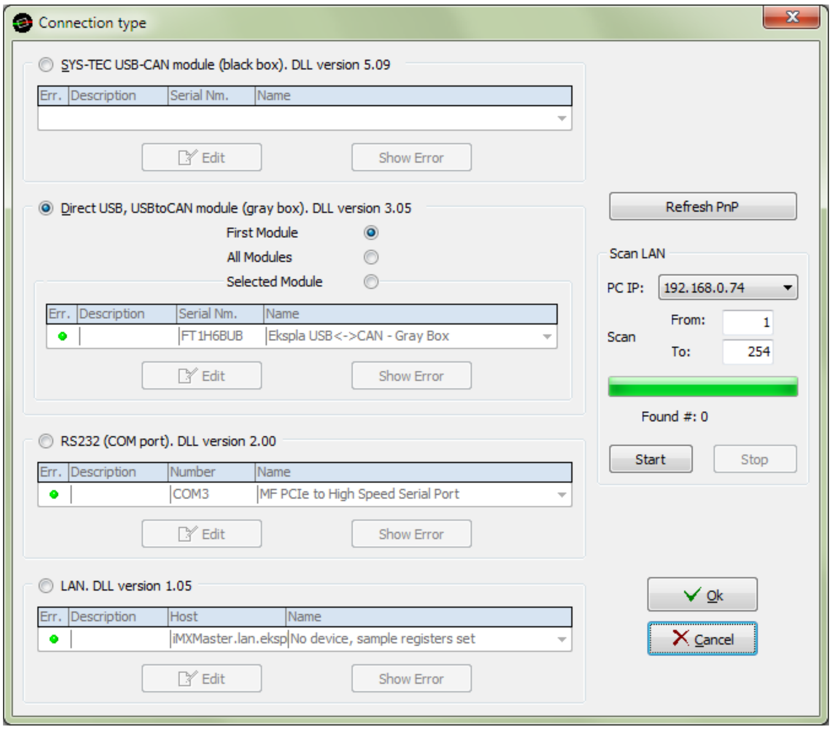
If the driver was associated, the software will prompt to restart the motor. If the motor is restarted, it will go to normal mode (control via control pad). The software then disconnects from the device network.

c) Connection Type

Allows setting the connection type.

Four ways to connect:

- SYS-TEC USB-CAN module (black box).
- Direct USB/USB-CAN module (gray box).
- RS232 port.
- LAN network.

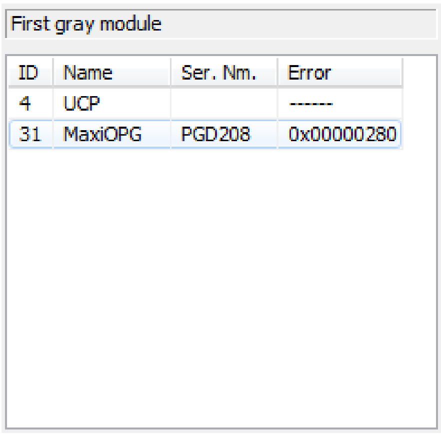


d) Module Connected

Green when USB-CAN module is connected.

4.3.8. CAN Device List

The device table shows all connected units and their IDs. If the unit is an OPG driver, the serial number and any possible error code are also shown.

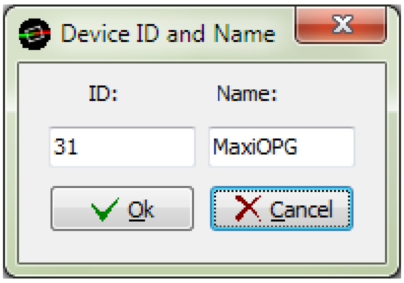


Select a unit by clicking.

Press ENTER or double-click to open the Device ID and Name window.

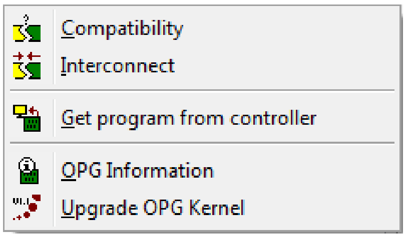
Press SPACE or right-click to open the device submenu.

a) Device ID and Name



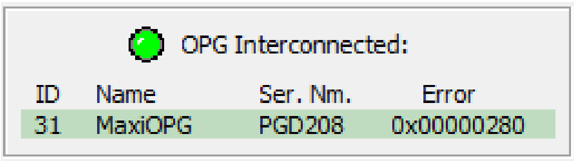
The Device ID and Name window allows changing these parameters. Changes for the driver occur immediately. For other device changes to occur, restart the system.

b) Device Submenu



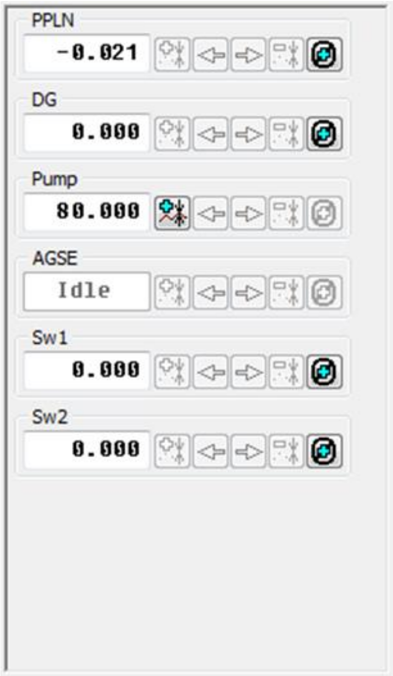
- Compatibility - see 4.3.4.a) Compatibility(p.17).
- Interconnect - the driver is linked with PC software if possible.
- Get program from controller - loads a program from on-board controller memory and looks for the associated file. If the file is not found, the software prompts for a new file path and/or filename.
- OPG Information - see 4.3.4.f) OPG Information (p.19).
- Upgrade OPG Kernel - see 4.3.4.g) Upgrade OPG Kernel (p.19).

4.3.9. Controller Status



When the driver is successfully interconnected, the indicator is green and driver information is shown below.

4.3.10. Device Parameters



The Device Parameters panel is in the middle of the PgSoftw Main Window.

a) Input Fields

PgSoftw treats all devices as "motors". Each device has a dedicated input field and buttons.

Item	*Description*
SOPO	Device name. Devices are generally named after the optical elements they control, e.g. SOPO is the second OPO crystal in the system. See the optical layout of your system.
1.065	"Position" input field
	Optical zero input button
	Correction input button
	Correction delete button
	Move to previous correction point (shorter wavelength)
	Move to next correction point (longer wavelength)

For rotation motors, the positions are measured in degrees of arc. For linear motors - millimeters. For temperature controllers, the "position" is degrees centigrade.

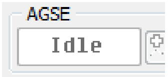
Maximal values for motor positions are limited at ±500. Limits for wavelength values vary from device to device. Shortcut CTRL+TAB moves the cursor between position and wavelength input field.

Input fields may also be Idle and Disabled.

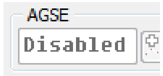
Values can be entered into input fields in two ways – calculated and incremental.

I. Idle & Disabled Fields

An input field may be inactive when it is either in Idle or Disabled mode. The field is idle when the associated parameter is not defined in the current wavelength range.



Disabled fields are used for planned upgrades, when the associated motor is not yet implemented. Both modes are set by the developer and cannot be changed by the user.



II. Input Methods

Switch the input method using the SPACE key on keyboard or with the mouse middle button.

i. Calculated Input Method

Using this method, values are entered into the field directly or by writing arithmetical expressions. When using arithmetical expressions, the letter v indicates the former value in the expression. See the table below for examples.

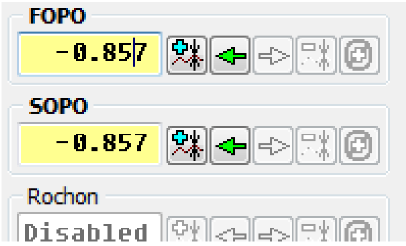
Old value ("v")	*Input line*	*Result*
10.5	v+1.5	12
-4	v-3	-7
Any value	1+2*(10-8)	5
1	2^2/2-v*2	0
Any value	5+2*25^(1/2)	15

ii. Incremental Input Method

In this method, the active digit may be incremented/decremented by using the up/down arrow keys on the keyboard, or by scrolling the mouse wheel. The active digit is selected using right/left arrow keys or by left-clicking. This method is indicated by a highlighted input field.

III. Linked Devices

Some motors are intended to be controlled simultaneously, using the same theoretical curve. To make the input easier, the input fields may be linked, forming linked motor groups. Developer performs the linking, the user may activate the linked input mode by pressing and holding the CTRL key or mouse right button. Different linked motor groups are represented by different field colors.



Only the incremental method may be used in linked mode. The active digit in the selected field and corresponding digits in linked fields will be changed simultaneously.

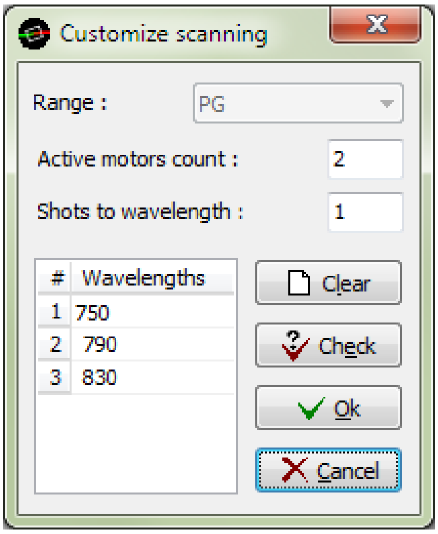
FastScan functionality is optional. It may not be available for your device.

5.1. FastScan Routine Operation

5.1.1. Control Pad

When in laser mode on your control pad, press the ESC button for two seconds to enter the parametric mode. Press MENU and select the options for your scan.

5.1.2. PgSoftw

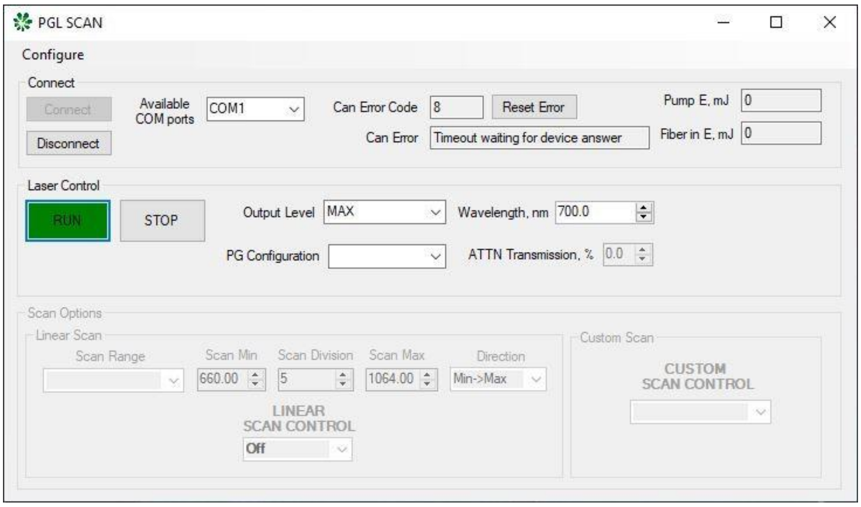


1. Go to Adjustment→Custom Scan. A separate window appears.
2. In the Customize scanning window, enter scan parameters.
3. Click Check to check for any errors before pressing Ok.
4. Proceed using the dedicated software or control pad to run the scan

   Note:
   To change the scanned range, click Clear before entering the new wavelengths into the Customize scanning window.

5.1.3. Custom Application

Dedicated software may be available for your laser. The software combines functions of PgSoftw and control pad into one convenient window.



5.2. General Information

The FastScan option allows quickly performing a scan in a selected range of wavelengths produced by the optical parametric oscillator (OPO) of your laser. The available wavelength range is determined by the laser model, and is reflected in the dedicated software or other available controls.

Your laser manual describes the basic operation principle of the OPO, e.g.:

> *The optical parametric oscillator is a solid state continuously tunable source of visible and near IR radiation. Based on nonlinear crystals, the OPO covers the wavelengths with up to 30% conversion efficiency when pumped by second/third harmonic of a pulsed Nd:YAG laser. The pumping beam is directed to the OPO cavity by a dichroic mirror. The resonator with image rotation and double-passing of the pump beam is used to reduce OPO beam divergence and linewidth. The retroprism/mirror (and optional half-wave plate) form the rear mirror of resonator. The output coupling mirror reflects back the pump beam and partially reflects the OPO beam. Wavelength tuning is achieved by rotation of nonlinear crystals OPO1 and OPO2.*

As in regular operation described above, FastScan also operates by rotating the nonlinear crystals and any other motorized components required for an output in the desired wavelength range to be produced. Regular operation requires the laser electronics to calculate a destination position for the motor(s) and perform a single rotation. With FastScan, this motion of one or multiple motors quickly becomes complicated and requires special solutions.

5.2.1. Trajectory Calculation & Motor Movement

The motors and mounted optical components are a complicated physical system with multiple physical, optical and electronic parameters affecting their motion and the produced wavelength. E.g., each motor-optical element assembly has a particular mass distribution, inertia, etc. The task of quickly and precisely setting a wavelength (changing motor position(s)) quickly becomes challenging - to set a position and execute the movement, fast calculations are needed. FastScan employs two methods of trajectory calculation/motor movement:

- "Start-Stop": the motor rotates from its initial position to a destination position in a start-stop manner – no parameters (speed, acceleration, angular motion parameters, etc.) are calculated, the motor starts, achieves maximal speed, and then stops at the destination. This method is usually used to change static positions (regular operation) or in linear scanning. In FastScan, this may result in situations when a motor arrives at the destination with a delay and a laser pulse is skipped.
- "NonStop": all relevant parameters are calculated to enable the motor to precisely assume its position and be ready to transition to a new one. The motor may never fully stop moving during a non-stop fast scan, as feedback loops constantly monitor and adjust its position and other parameters to optimally control its current and future positions. This method enables achieving quick and precise fast scanning.

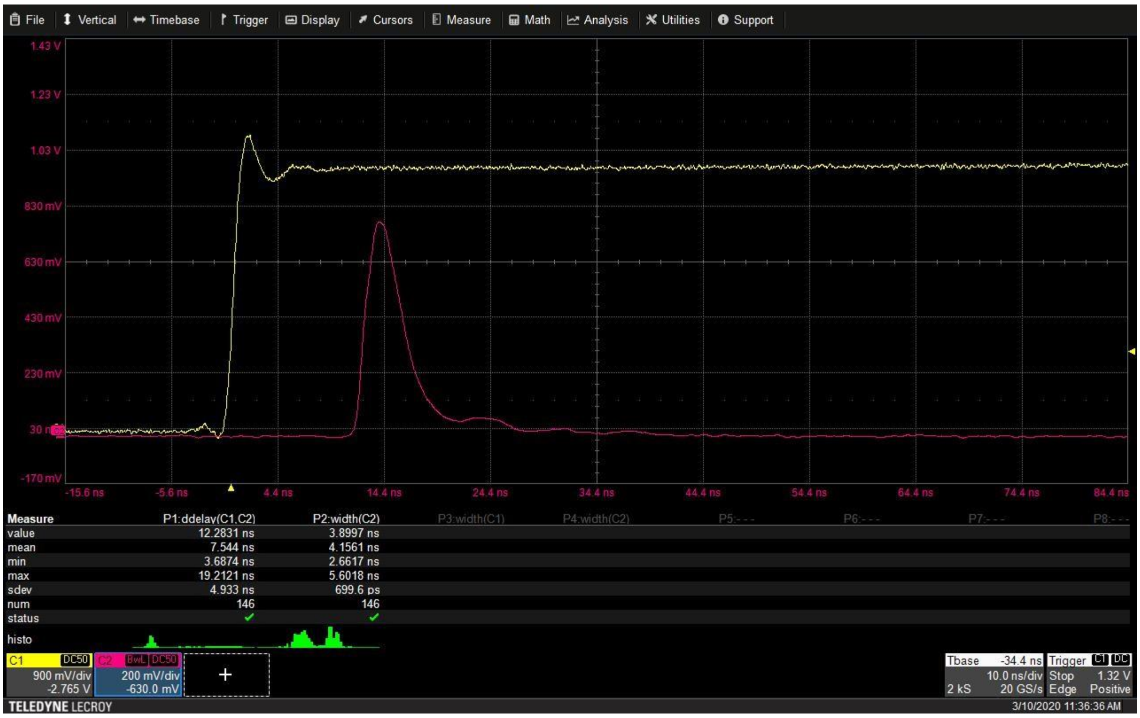
5.2.2. Synchronization Signals

As the motors move, laser electronics, firmware and software constantly exchange control signals. Two of these signals, specifically related to FastScan, are available for the user at physical connectors (BNC) for synchronization of measurement or any other equipment:

- "WL Ok Sync" (WLOK): indicates that the laser has fired at the set wavelength. If no WL Ok Sync signal is received, the laser has not fired at the currently set wavelength (this may be because the motors did not arrive at the destination on time).
- "First WL Sync" (FWL): indicates that the emitted wavelength is the first in the sequence of wavelengths of the scanned range.

Synchronization signal oscillograms are given below. Leading edges of WLOK, SYNC OUT and optical pulse are near-simultaneous. FWL signal precedes the other three by ~8 µs.

WLOK/FWL/SYNC OUT oscillogram (Yellow – WLOK, magenta – FWL, cyan – SYNC OUT)



WLOK/optical pulse oscillogram (Yellow – WLOK, magenta – optical pulse)

5.3. Scan Types

5.3.1. Linear Scan

Linear scan changes the wavelength evenly in time.

In linear scan, motors move in the “NonStop” method.

Newly entered scan parameters are applied for the next running scan.

Linear scan is described by 7 parameters, which can be edited using via the control pad or through the CAN network (e.g. via PC software). The only difference is that when editing from the control pad, the range and units are set according to the current static state.

The linear scan parameters:

- Range (e.g., Idler, Signal, Fiber, Direct, etc.). Depends on the OPG used. Only ranges where scan is technically possible are available.
- Units (nm/cm-1) (not editable from control pad).
- Repetition
  - Off – if the master/slave devices are not synchronized, a custom scan is running, or burst mode is on.
  - Continuing scan – the scan is repeated until turned off. A “First WL Sync” signal is emitted at each start of scan. If problems with synchronization occur, automatically sets to “Off”.
  - Single scan – a single pass of the range is performed. “First WL Sync” emitted at start of scan. Automatically sets to “Off” on completion.
- Minimal value (nm/cm-1, set within the range boundaries)
- Maximal value (nm/cm-1, set within the range boundaries)

- Direction
    - Min->Max
    - Max->Min
    - Min->Min
    - Max->Max
- Shots per scan (in a single pass of a range to either direction).

Examples:

SCAN PARAMETERS					***RESULTING OUTPUT***
Minimal value	***Maximal value***	***Shots per scan***	***Repetitio n***	***Direction***	
700 nm	800 nm	3	Single	Min->Max	700-750-800 nm
700 nm	800 nm	11	Single	Min->Max	700-710-720-730-740-750-760-770-780-790-800 nm
700 nm	800 nm	3	Single	Max->Min	800-750-700 nm
700 nm	800 nm	3	Single	Min->Min	700-750-800-800-750-700 nm
700 nm	800 nm	3	Continuin g	Min->Min	700-750-800-800-750-700-700-750-800-800-750-700… nm

When any of the first five parameters are changed, the controller will recalculate the minimal shots per scan number. If this number is higher than the set number of shots per scan – it will be increased. In any scenario, shots per scan can be between 2 and 30001. The minimal shots per scan number is calculated so that there would be no need to stop the laser during a unidirectional scan. The "WL Ok Sync" signal is not emitted when starting a scan, returning to starting position (in Continuous scan), changing the direction (in Min->Min or Max->Max directions) and at the finish of a scan (when changing to static state).

Below is a timing diagram illustrating laser operation with linear scan enabled. This diagram is specifically for NT277/PT277 series lasers, but general principles may apply for other devices.

- *Clock/Internal* – internal clock. 1 kHz repetition rate. T_{clock}=1 ms.
- *First WL/Output (First Wl)* – marks the first wavelength in the scan. Precedes *WL OK* by 8 µs. 16 µs width.
- *WL marker/Output (WL OK)* – leading edge of WL OK indicates location of the set wavelength. 8 µs width.
- *Laser blanking/internal* – internal signal, preventing emission during certain parts of laser operation cycle.
- *Modulation/Input (GATE IN)* – an optional input for output modulation.
- *Optical/Output* – control of laser emission. Laser is turned on immediately after the internal clock pulse preceding the scan start (see in figure below: vertical line from first Int. Clock pulse to Laser Out). Laser is turned off immediately after WL OK pulse

of last wavelength in scan (see in figure below: vertical line from WL OK pulse #5 to Laser Out).

- *Laser WL* – indicates the resulting output wavelength. Note that this does not always indicate actual output from the laser aperture, e.g. if modulation is used, not all wavelengths from the slope will be emitted, only those that are allowed by the modulating signal. In this case, all relevant motors will rotate and be positioned for the wavelengths to be emitted, but emission will occur only when the modulating signal allows.

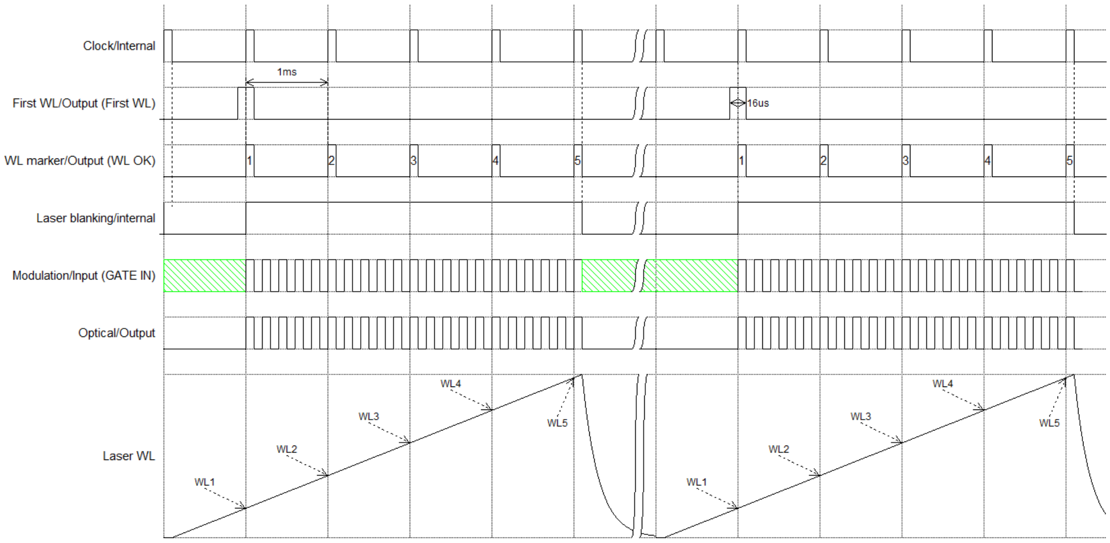


Figure 4 Timing diagram – linear scan

5.3.2. Custom Scan

Custom scan changes the wavelength according to user-provided wavelength sequences and other parameters.

In linear scan, motors can move in either (”NonStop”/”Start-Stop”) method. The methods can be changed during a scan.

All custom scan parameters are entered by the user via the PGSoftw application; control pad or CAN network only allows starting the custom scan. PGSoftw allows setting additional motor position corrections for each wavelength in the scan sequence. These parameters are programmable.

Custom scan can be started and stopped via control pad, PGSoftw or CAN network. PGSoftw application cannot be used simultaneously with control pad or CAN network – close the application and restart on prompt.

By default, "First WL Sync" is emitted with the first (in CAN – zeroth) wavelength in the sequence. This synchronization pulse may be tied to any wavelength in the scan sequence via PGSoftw or CAN. CAN also allows changing the wavelength index in real time.

Depending on the wavelengths and other scan settings, the motors may not be able to set the next wavelength in-between the laser pulses. In such a case, a laser pulse is skipped and “WL Ok Sync” is not emitted. I.e., the scan takes one duration step (100 ms in a 10 Hz laser) longer.

The maximal number of wavelengths is a sequence depends on the number of active (participating in scan) motors. Minimal number of wavelengths in a scan: 2. Maximal number of active motors: 6. Number of active motors × number of wavelengths ≤ 128.

Shots for one wavelength: 1…100.