EO Attenuator

User Manual

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Contents

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1. Introduction 4
1.1. EO Attenuator short description 4
1.2. General safety requirements 4
1.3. Symbols 4
1.4. Regulation 4
1.5. Operating and storage conditions 5
2. Operation Principle 6
3. Package contents 6
3.1. Optics (dis)assembling 6
4. EO Attenuator Software Description 7
4.1. Computer requirements 7
4.2. Software installation 7
4.3. Program first run 9
4.4. EO Attenuator “Selector” window 9
4.5. Calibration 10
4.6. EO Attenuator “Control” window 11
4.7. Program preferences 15
4.7.1 GUI input method options 15
4.7.2 Controller buttons. Speed of attenuation 15
4.8. Red error signs in control window 16
5. EO Attenuator Controller Hardware 17
5.1. Controller specifications 17
5.2. Controller usage 17
5.3. EO Attenuator connector pin out Error! Bookmark not defined.
6. Main dimensions 17
6.1. EO Attenuator 18
6.2. EO Attenuator Controller 18

EO Attenuator

May 2016

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1. Introduction

This user manual is designed to help to install and operate EO Attenuator. Before installing and operating EO Attenuator please read installation and operation instructions carefully. Safety instructions must be read carefully. If there are any questions about contents of this manual please contact info@edmundoptics.com. *Edmund Optics* reserves the right to update contents of this manual without any notification.

1.1. EO Attenuator short description

Compact motorized attenuator - EO Attenuator is a computer controlled laser beam attenuation device. It attenuates a free space laser beam/pulse continuously without introducing additional energy fluctuations. EO Attenuator is controlled by a computer via USB. Also it has “STEP/DIR INTERFACE” connector for controlling via other devices.

1.2. General safety requirements

Compact motorized attenuator is designed to operate in conjunction with laser systems. All applicable rules and regulations for safe operation of lasers must be known and applied while installing and operating EO Attenuator. The customer is solely responsible for laser safety while using EO Attenuator as a standalone device or integrated into system. The customer must consider protective measures.

While assembling or operating EO Attenuator, do not stare at the direct or scattered laser light even with safety goggles. All parts of the body must be kept away from the laser radiation. While adjusting laser beam through EO Attenuator, laser power must be kept as low as possible. Hazardous laser radiation can increase while optical components or instruments are used in combination with EO Attenuator. Appropriate eye protection must be worn at all times. Electrical safety requirements must be complied while assembling and operating EO Attenuator.

1.3. Symbols

Warning!

Sections marked with this symbol explain dangerous situations that can result as personal injury or death. Always read the associated information carefully, before performing indicated procedure.

Attention!

Paragraphs preceded by this symbol explain hazards that could damage the instrument and connected equipment or may cause loss of data.

Note

This manual also contains “NOTES” and “HINTS” written in this form.

1.4. Regulation

Attention!

The following statement applies to the products covered in this manual, unless otherwise specified herein. The statement for other products will appear in the accompanying documentation.

These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can create radio frequency energy and, if not installed and

used in accordance with the instructions, may cause harmful interference with radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment causes harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Edmund Optics is not responsible for any radio or television interference caused by modifications of this equipment or the substitution or attachment of connecting cables and equipment other than those specified by *Edmund Optics*. The correction of interference caused by unauthorized modification, substitution or attachment will be treated as responsibility of the user.

Attention!

Cellular phones or other radio transmitters are not recommended to be used within the range of three meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to IEC 61326-1.

1.5. Operating and storage conditions

For proper EO Attenuator functioning please use the assigned controller (found in the same package). Using unassigned controllers might be harmful to the device.

Environmental conditions that must be hold while storing, servicing and operating are:

- Storage temperature should be between -25 °C and +60 °C.
- Operating temperature is 25 °C ± 10 °C.
- EO Attenuator must be protected from humidity, dust and corrosive vapors to avoid damaging optical components and electronics.
- Avoid strong static electricity and electromagnetic fields.

2. Operation Principle

EO Attenuator incorporates a rotating quartz λ/2 phase waveplate and one polarizer which separate s-polarized and p-polarized beams (fig. 1). The intensity ratio of the two beams may be continuously varied without alteration of other beam parameters by rotating the waveplate. Proper functioning of EO Attenuator requires optimal configuration of optical elements regarding to incident laser beam polarization contrast. Higher incident laser beam polarization contrast leads to higher EO Attenuator output polarization contrast.

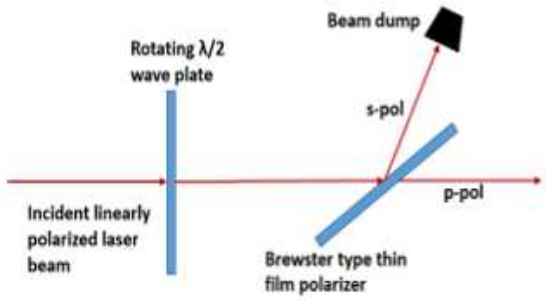


Figure 1. EO Attenuator operation principle. The intensity of the incident beam is varied by means of a λ/2 phase waveplate and a polarizer.

3. Package contents

- Compact motorized attenuator - EO Attenuator
- Controller
- USB cable (2m length recomended but no longer than 3m)
- 12V power supply
- Software, installation instructions in USB flash
- Polarizer – (already in the attenuator)
- Waveplate – (already in the attenuator)

3.1. Optics (dis)assembling

In order to get maximum possible attenuation polarizer adjustment is necessary. The back cover with beam dump can be removed by untightening two screws showed in fig. 2. After removing the closure, 3 microscrews will be uncovered (circled in red). Adjusting them while measuring laser power output, will allow to reach maximum attenuation.

If necessary, the waveplate and polarizer holder can be removed for example for cleaning purposes. To remove the waveplate just untighten the retaining ring and take out the waveplate. For removing the polarizer holder please remove 3 steel screws and carefully pull it from the main EO Attenuator body.

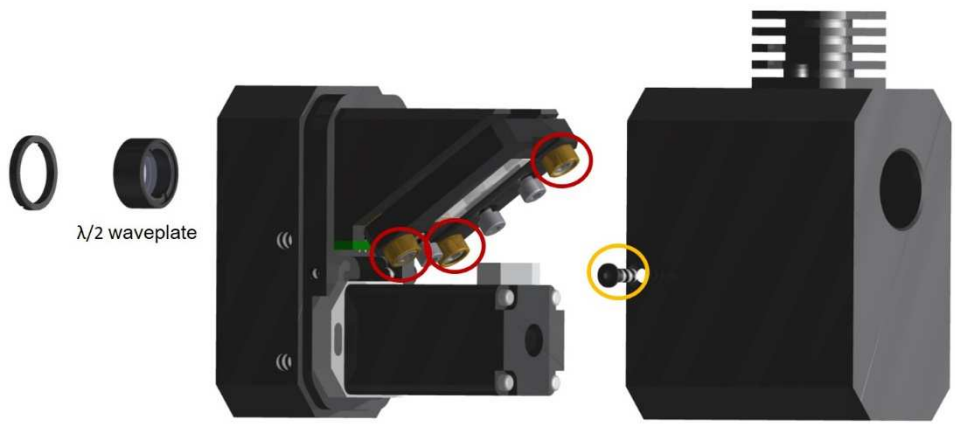


Figure 2. Disassembly of EO Attenuator. Adjustment microscrews circled in red. To remove the cover loosen two screws on each side of EO Attenuator (marked with yellow circle)

4. EO Attenuator Software Description

4.1. Computer requirements

- Free USB port. EO Attenuator is compatible with USB 1.1, USB 2.0 and USB 3.0 Computer administrator rights (only for installation)
- Windows XP sp3 (32-bit)
- Windows Server 2003 sp2 (32-bit)
- Windows Vista sp1 (32/64-bit)
- Windows Server 2008 (32/64-bit)
- Windows 7(32/64-bit)
- Windows 8(32/64-bit)
- Microsoft.Net framework 4.0 redistributable (installs automatically)

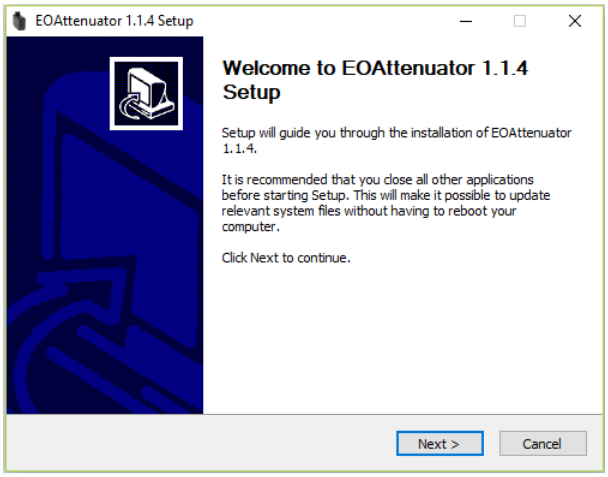
4.2. Software installation

1. Check for and download the latest "EO Attenuator" software installer package from

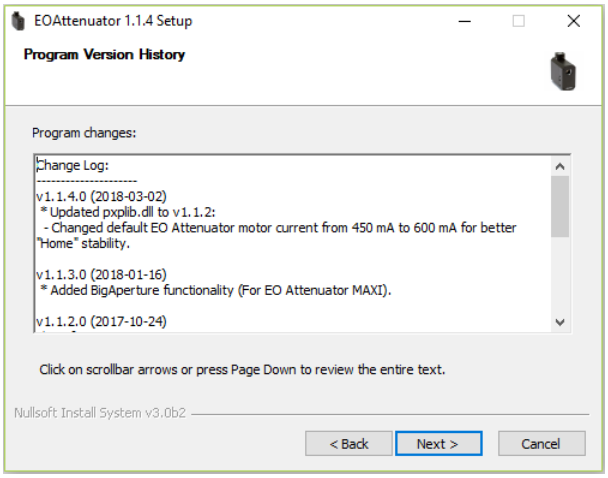
   EO LINK here http://....

2. Run the downloaded "EOAttenuator-Setup.exe" installation file. In case the software is installed on an operating system that does not meet requirements, only USB drivers will be installed. Click "Yes" to continue.

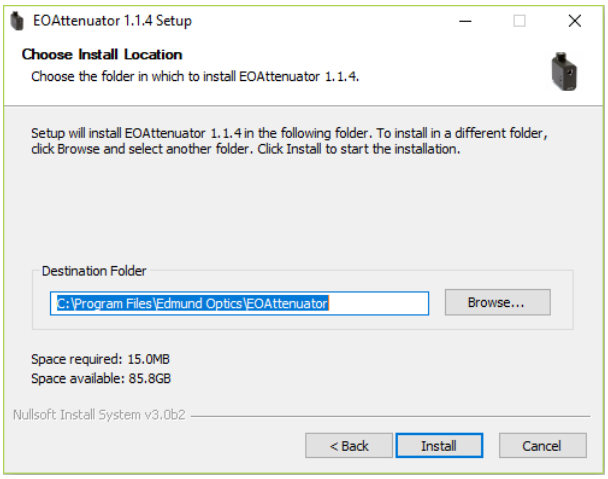
3. Installation window will appear, click "Next" to continue:



4. Click "Next":



5. Select installation directory and click "Next" to begin installation:

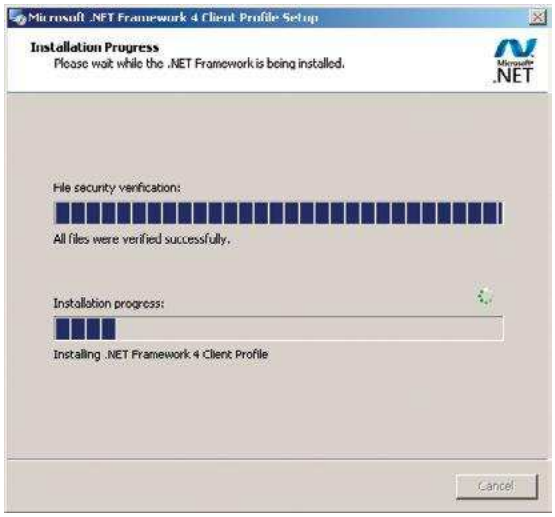


6. "EO Attenuator" software requires "Microsoft.NET Framework 4 Client Profile" or higher version to be installed. Setup will offer to download it, choose "Yes" if active internet connection is available. Choose "No" to download it from www.microsoft.com/en-us/download/details.aspx?id=17113 and install it manually. One should choose "No" if newer version of Microsoft.NET framework is unwanted, or working

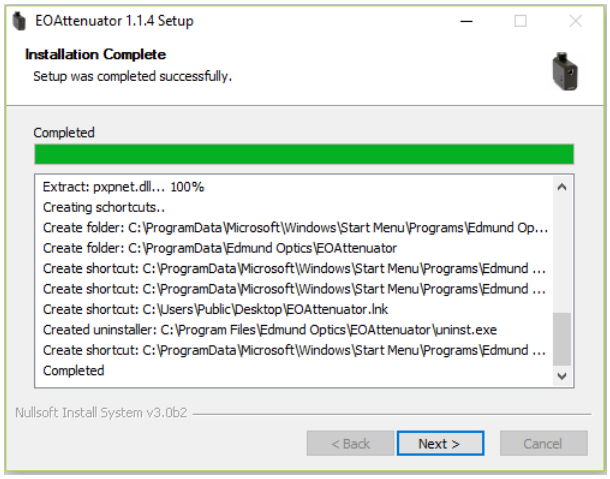
internet connection is not available. This dialog will not appear if framework is already installed. Download size is 42 Mbytes.

7. Setup will download “Microsoft .NET Framework 4 Client Profile”.

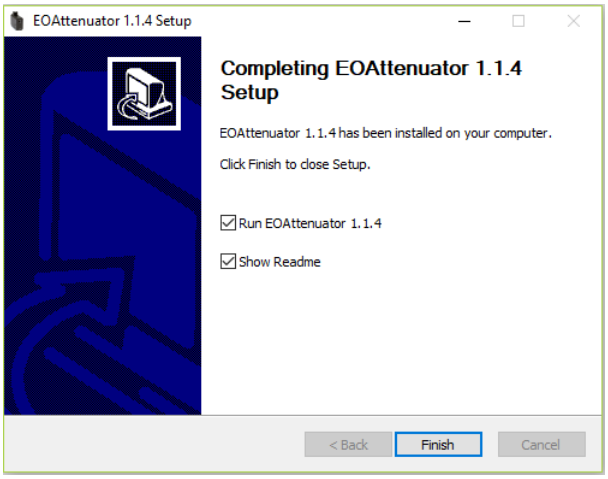
8. After download is finished, “Microsoft .NET Framework 4 Client Profile” will be installed, wait for it to complete. This can take more than 10 minutes on slower machine.



9. Setup will finish by installing drivers. Click “Next” to continue:“



10. Click “Finish” to end installation. The program cannot be opened if only drivers were installed (see step 2 for details).



11. “EO Attenuator” software icon will appear on “All Users” desktop and “All Users” start menu.

12. Connect EO Attenuator to it’s controller.

13. Connect EO Attenuator controller and PC via USB cable.

14. Plug in EO Attenuator power supply jack.

15. Windows will detect new hardware. Wait until windows configures new device.

4.3. Program first run

Launch “EO Attenuator” program using “EO Attenuator” icon on desktop or from “Start Menu → All Programs → Edmund Optics → EO Attenuator → EO Attenuator”. EO Attenuator “Selector” window will appear. At least one device must be displayed on the list. If the list is empty, please check USB cable, power connection. Blue LED must be active if power is OK. Click “File → Search For Devices” to refresh. For more information about EO Attenuator “Selector” window see section”

EO Attenuator “Selector” window”.

Select EO Attenuator from a list and click “File → Connect

Once connected to EO Attenuator, dialog will pop up informing that no calibration file is found for new attenuator:

Figure 3. Dialog box, shown if EO Attenuator calibration file is not found.

Select “OK”, calibration window will appear. Use instructions in section “Calibration” to setup calibration. After calibration is done, “EO Attenuator “control” window will appear. Use slider to select and set required power. See section “EO Attenuator “Control” window” window if more information is needed.

4.4. EO Attenuator “Selector” window

EO Attenuator “Selector” window contains a list of currently connected and powered attenuators. This window is used to choose device to work with if there are several controllers connected to a single computer. Functions of this window are described in the picture below.

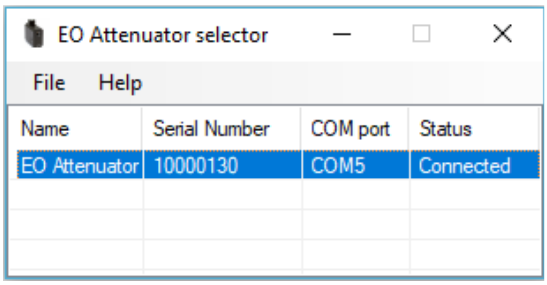


Figure 4. EO Attenuator “Selector“ window. It is displayed every time program is started. There is one device attached to PC in

Column description:

- Name

  It is useful to give meaningful titles for each EO Attenuator, if more than one is used in the same system. For example, name can be set to “1st Harmonic WP”, and another attenuator can be named as “2nd Harmonic WP”. New name is saved into controller’s internal memory, so new name will be maintained on any computer. Name length is restricted to 20 characters maximum. EO Attenuator can be renamed from “EO Attenuator control” window “Options->EO Attenuator Name...” menu option.

- Serial Number

  This column shows unique EO Attenuator controller hardware serial number. It is used to identify hardware at low level. Serial number must be used for hardware identification when contacting the developers.

- COM port

  Each EO Attenuator gets unique serial port name after first enumeration with computer. This column shows USB-serial port name assigned by Windows.

- Status

  This column shows “Connected” if attenuator control window is active. Otherwise it is blank.

“File” menu description:

- Connect

Opens control window for selected EO Attenuator, (the same effect as double-click on the device in the list. If only one device is connected during program startup, control window will be opened automatically. See chapter “EO Attenuator “Control” window” on page 13 for information.

- Search For Devices

  Starts searching for EO Attenuator devices attached to computer. It can help if not all devices are detected and listed automatically.

- Close

  Closes EO Attenuator “Selector” window, but leaves control windows opened.

- Exit

  Closes EO Attenuator “Selector” and all control windows.

“Help” menu description:

- User Manual

  Opens user manual

- About

  Shows software version and contact information.

4.5. Calibration

In order to correctly change the output power, the software needs to know the angle of the λ/2 waveplate’s fast axis. It can be fixed in any angle with respect to the rotator. The purpose of calibration is to fix angular offset between the λ/2 waveplate and the rotator hardware zero position. Calibration window is opened automatically on first use of EO Attenuator, or can be found in menu “Options → Calibration…” in “EO Attenuator control” window. Make sure that the attenuator is correctly aligned before calibrating.

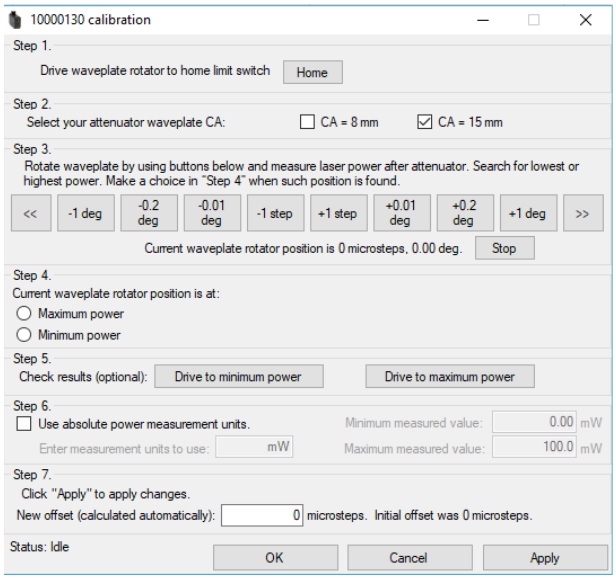


Figure 5. Calibration window.

Calibration procedure:

1. Homing. Click “Home” button in section “Step 1” and wait till motor stops. This will drive the waveplate holder to hardware limit switch (zero position). Step 1 must be performed every time the device is turned on or after extensive period of usage to eliminate any accumulated position error.

2. At “Step 2” select correct clear aperture (CA) of currently connected attenuator. Waveplate CA could be 8 or 15 mm in diameter.

3. Rotate waveplate by using buttons in section “Step 3”, and measure laser power after the attenuator. Numbers on the buttons represent motor moving distance (expressed in stepper motor steps) and rotation direction. One step equals 0.003125.

Note

It is advised to search for lowest power (max attenuation) position, because usually it can be spotted more easily and accurately.

4. Find minimum or maximum signal power and select the appropriate option in “Step 4”. It will be called “Home position” in the control window. Angular offset is recalculated and shown in “Step 7” field every time “Step 4” selection is clicked. At this moment, main calibration goal is completed and “Apply” button can be clicked to

apply changes. Further steps are not mandatory, but should be considered for convenience.

5. Calibration result can be verified by using buttons in “Step 5” panel. Usage example: click “Drive to minimum power” button and wait till the rotator stops. Use buttons “-0,01” and “0,01” (located in “Step 2”) to ensure if current position is really of lowest power. If it is, click “Apply”, else select “Minimum power” in “Step 4” again, to redefine offset. The same can be done with maximum power point.

6. Alignment of the polarizer and waveplate is critical for ensuring optimal performance, thus during the calibration EO Attenuator should be aligned to reach maximum performance. Real maximal and minimal transmitted power should be obtained by adjusting the polarizer with adjustment microscrews in the motorized attenuator (figure 2). Once measured, these extreme values should be entered in relevant fields of “Step 6”. Usage example: one uses 1 W laser, and 20 mW is measured as minimal power, and 0.99 W as maximal power. In such case firstly “Use absolute power measurement units” should be checked, then value “0.02” should be entered into field “Minimum measured value:”, and “0.99” – into “Maximum measured value:”, and “W” should be enreted into “Enter measurement units to use:” textbox, because measurement units are “Watts”.

7. Click “OK” button to accept calibration or “Cancel” to discard. If dialog, window-request go to zero position will appear, click “Yes” for correct device operation.

4.6. EO Attenuator “Control” window

EO Attenuator “Control” window is used to change laser power after EO Attenuator attenuator. Main components of this window are described below.

- EO Attenuator name and serial number is shown on each attenuator control window caption. Serial number is unique for each EO Attenuator controller and cannot be changed as it is used to identify hardware at low level.

- Power meter panel always shows existing power after the attenuator. Percentage range is from 0 % to 100 % of transmission. Zero percent means that waveplate occurs at 45 degrees angle, beam polarization is rotated by 90 degrees and is maximally attenuated. Display reading “100%” means that waveplate is rotated at minimum attenuation – maximum transmission angle.

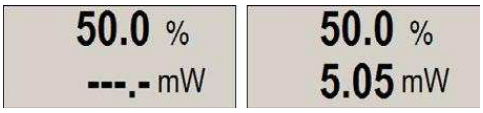


Figure 6. Power meter panel: right - “Use absolute power measurement units” checkbox is set in “Options → Preferences”, left - checkbox is unset.

If “Use absolute power measurement units” checkbox is set in “Options → Preferences” or during calibrating, numeric display, showing “mW” becomes active. Absolute power reading is converted from percentage value with respect to minimal and maximal measured power using power meter. Correct min and max power values must be set in program preferences or calibration windows.

- Lower slider changes power from 0 % to 100 % with resolutuion of 0.25%. Values in lower numeric fields will alter according to slider position. There is a triangle-shaped marker above lower slider which shows current power setting, which serves as convenient reference for slider usage.

- Enter required value (%) field is used to manually enter percentage of EO Attenuator transmission. Decimal point symbol is “.” (dot), two decimal places can be used. Valid range is 0.00 % .. 100.00 %.

- Absolute required power field is available if “Use absolute power measurement units” option is set in “Options → Preferences…” or “Options → Calibration…”. Decimal point symbol is “.” (dot). Valid

range is from “Minimum measured value” to “Maximum measured value” set in program preferences.

- **Preset buttons** can be used to quickly set discreet values of output power if absolute value was predefined in calibration stage. Left click on any of them and appropriate value will appear in (4) or (5) text boxes.

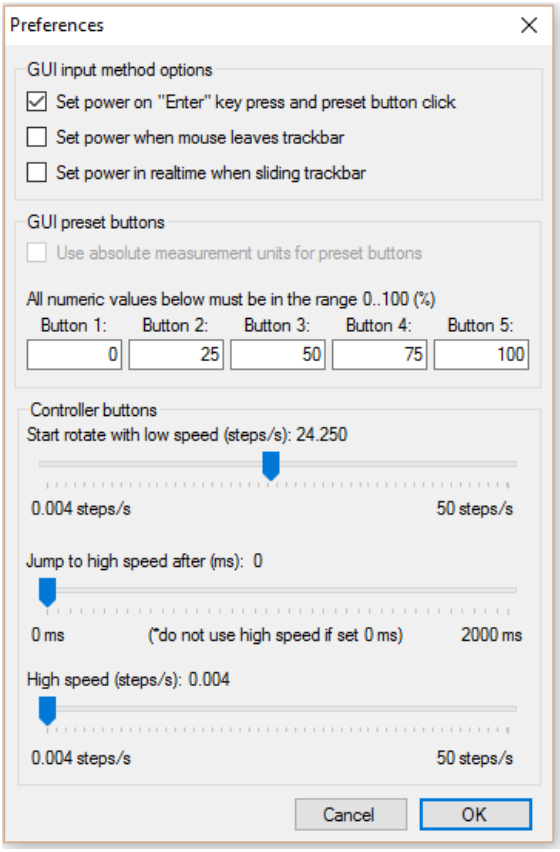


Figure 7. “Edit Preset Buttons at Preferences” window. Currently preset values are 0%, 25%, 50%, 75%, 100% of transmission, because checkbox is unchecked. Otherwise all values would represent absolute power in user selected units.

“GO” button. Click to set power (rotate waveplate).

Note

If “Automatically execute “GO” after required power change” is selected in “Options → Preferences” waveplate would rotate automatically after any of aforedescribed power control option is used (button pressed, slide moved, power value enteres, etc. Otherwise click “GO” button to actually set power

- **“STOP” button** cancels rotation.
- **Buttons “<<” and “>>”** will continuously decrease/increase power. Controller firmware must be up to date for these buttons to appear.
- **“Home” button** will drive waveplate rotator to home limit switch and back to “Home position”, set in “Options → Preferences…”. Usually this should be executed every time when device is turned on.

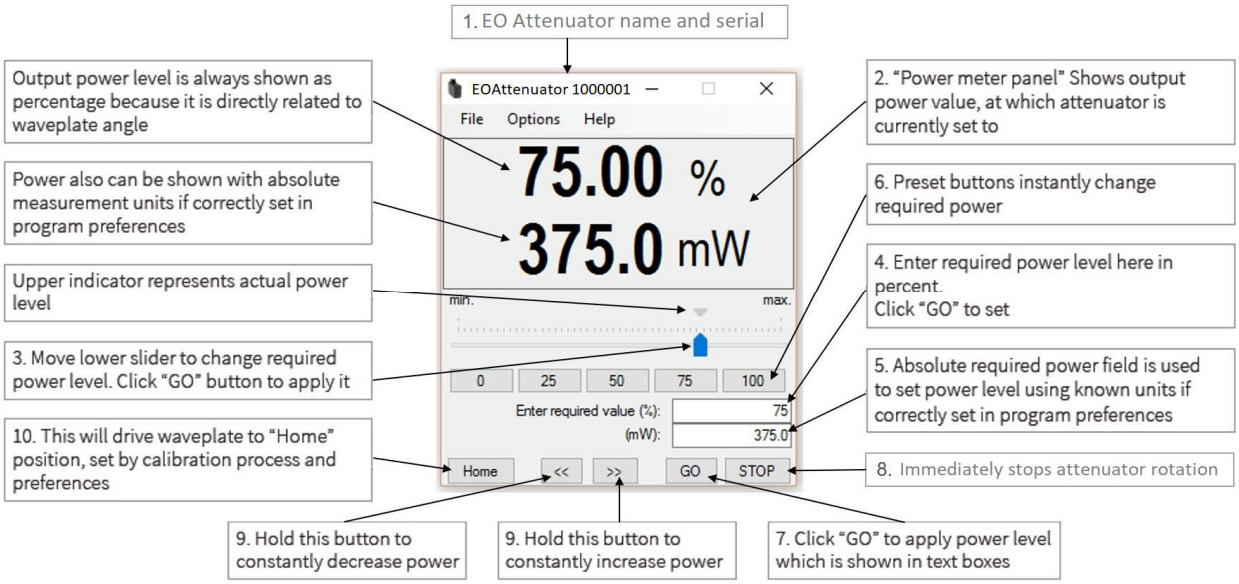


Figure 8. EO Attenuator "Control" window. Currently laser power is set to 375 mW or 75 % of full calibrated range. Measurement units are available because absolute minimal and maximal power values are set in program preferences during calibration process.

“File” menu description:

- Save Calibration…

Current program settings can be saved to file. Configuration file includes all options in “Options → Preferences”, preset values and calibration offset. Run time program configuration files are saved in folder “AppData\Local\Temp\EO_temp\”.

- Load Calibration…

Program settings can be restored from file. Configuration file includes all options in “Options → Preferences”, preset values and calibration offset. Current configuration will be overwritten.

- Show Device Selector

Opens EO Attenuator “Selector” window.

- Close This Window

Disconnects from EO Attenuator and closes active “Control” window.

“Options” menu description:

- Calibration…

Opens EO Attenuator calibration window. See chapter “Calibration” on page 12 for details.

- Preferences

Opens program configuration window. See chapter “Program preferences description” on page 15 for details.

- EO Attenuator Name…

- Opens “Rename Device” window. Use up to 20 characters for name. Enter new name and click “OK” to accept.

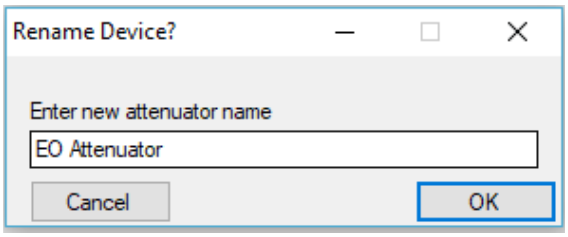


Figure 9. “Rename Device” window.

“Help” menu description:

- User Manual

Opens user manual.

- About…

Shows software version and contact information. Please include software version and controller serial number when contacting manufacturer.

4.7. Program preferences

Preferences window can be accessed by “Options → Preferences” menu item in EO Attenuator control window.

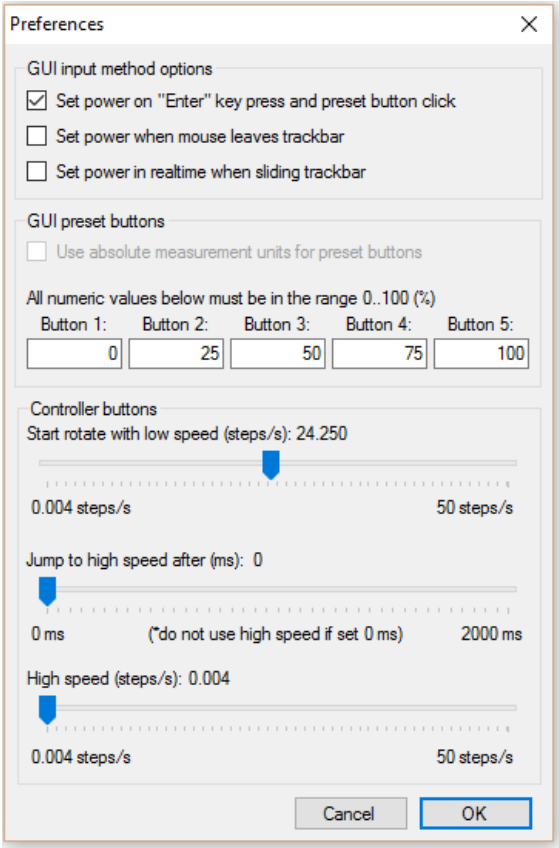


Figure 10. Program preferences window. Can be found under menu “Options → Preferences”.

4.7.1 GUI input method options

- **Set power on ”Enter” key press and preset button click.** If checked, the power value will change by clicking “Enter” key after entering a required value.
- **Set power when mouse leaves trackbar.** If checked, the power value will change when mouse leaves the trackbar.
- **Set power in realtime when sliding trackbar.** If checked, the power value will change while sliding the trackbar.

4.7.2 Controller buttons. Speed of attenuation

Start rotate with low speed

In this section rotation speed of attenuator could be easily changed by using a slider “…” (see Figure 10). Speed:

- Minimum speed is 0,004 steps/s.
- Maximum speed is 50 steps/s.

Jump to high speed after

You can set a time delay in ms for controller to change the speed to fast motion. Time before speed gets higher:

- Minimum time 0ms.
- Maximum time 2000ms.

If using a value >0ms it is necessary to set the speed value using a slider of **High speed.**

While using this option (value is >0ms) it is more accurate and easier to set the right value of attenuation when using buttons on a controller Left/Right or Min/Max (Figure 13). The rotator firstly will move with speed of “Start rotate with low speed” value, after set time it will start to move faster with set “High speed” value.

Note:

“Automatically execute “GO” after required power change” must be checked for this options to be enabled.

- **Use absolute measurement units for preset buttons.** If this is set, preset button values are shown as absolute power values, otherwise, preset button values mean percentage (%) of transmitted power. Option “Use absolute power measurement units” must be set for this option to be enabled (see in calibration). Preset button values are recalculated automatically with respect to min and max measured power.

4.8. Red error signs in control window

Red error signs are dislplayed in control window:

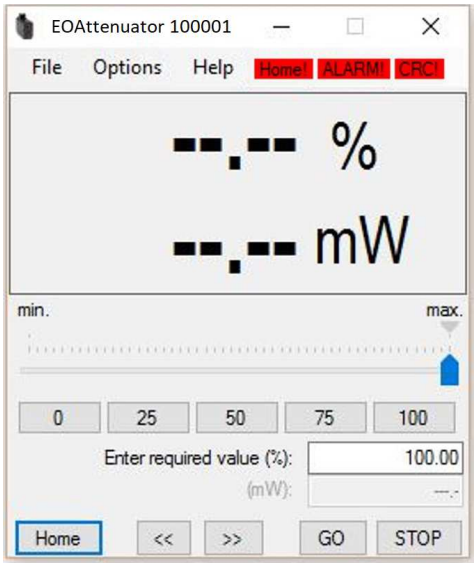


Figure 11. EO Attenuator “Control” window with error signs (Home Alarm, Crc).

• HOME!

Device is not homed after power on, so there is no accurate position reference point for the waveplate. Ratio readings are inaccurate, so ratio change is prohibited. Execute homing first (hold MIN/MAX buttons for 5sec or push home button in control window)

• ALARM!

Impossible to move motor - hardware error. Please check wiring, overheating, power supply.

• CRC!

Controllers calibration/settings are corrupt. Data corruption can occur due to power supply loss during calibration process. Please run calibration process.

5. EO Attenuator Controller Hardware

5.1. Controller specifications

EO Attenuator controller is bipolar stepper motor driver withspecifications listed in Table 1 below.

Table 1. Controller specifications

Characteristic	Rating
Max output voltage	+12 V
Max output current	2 A
Current regulation type	Pulse Width Modulation
Microstepping capability	Steps 1/256
Position feedback	Open loop operation (no external position feedback encoder)
Controller protection	Driver have overheating and over current (2A) protection
Device can be operated by	Computer software via USB port
Limit switch	One limit switch can be connected and used only for homing
Connector	7 pin circular connector, 712 series

5.2. Controller usage

BACK VIEW

The following connections are situated in the back of EO Attenuator controller: power jack (12V), and 7 pin circular connector (712 series) for EO Attenuator (Figure 12).

Figure 12. Back view of EO Attenuator Controller.

TOP VIEW

There are two buttons in the top of the EO Attenuator controller: MIN and MAX.

- MIN – while holding turns the waveplate to a minimum attenuation.
- MAX – while holding turns the waveplate to a maximum attenuation.
- HOME - holding both MIN/MAX buttons for 5sec. moves attenuator to home position.

There are 4 LED indicators:

- Power – indicates power from USB connection with PC.
- Status:
  - If blinking slowly (1 blink in 1 sec.) – need homing;
  - If blinking fast (3 blinks in 1 sec.) – the waveplate is rotating;
  - If iluminating continiously – EO Attenuator is homed, the movement is stopped.
- MIN – the EO Attenuator is at it‘s minimum attenuation;
- MAX – the EO Attenuator is at it‘s maximum attenuation.

There is port for a USB cable.

6. Main dimensions

6.1. EO Attenuator

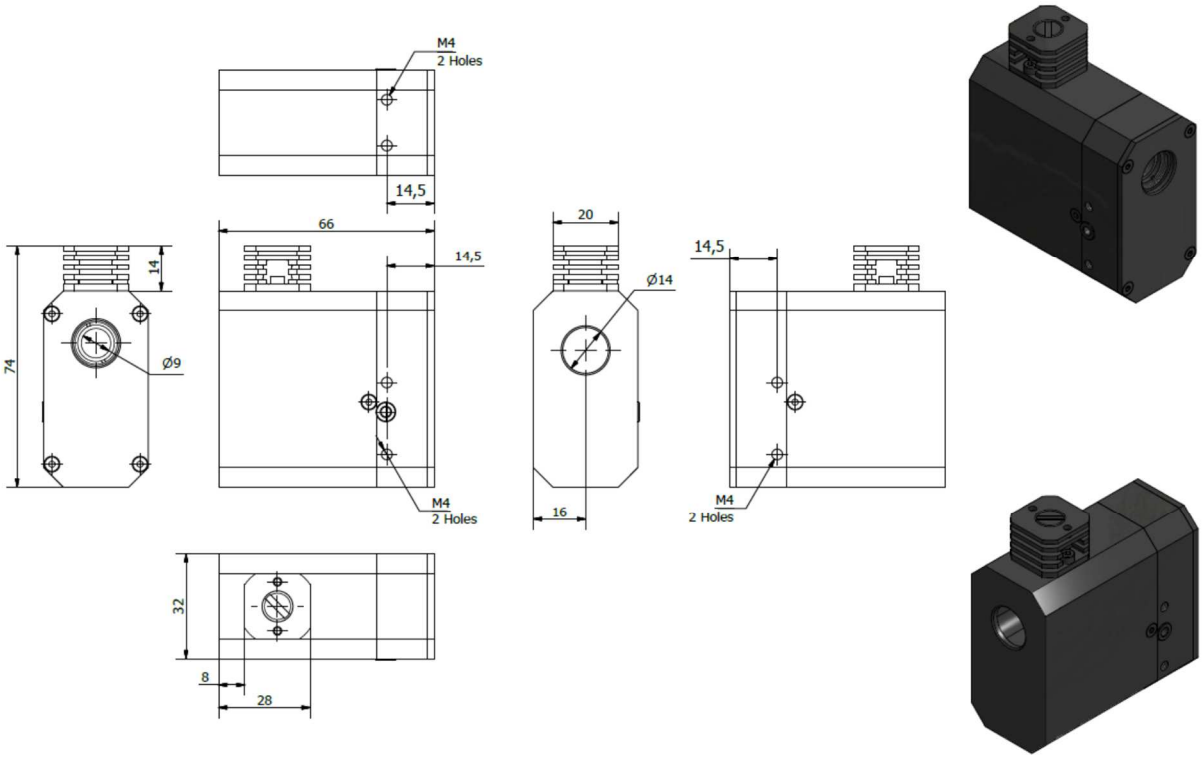


Figure 12. Main dimensions and mounting options of EO Attenuator.

6.2. EO Attenuator Controller

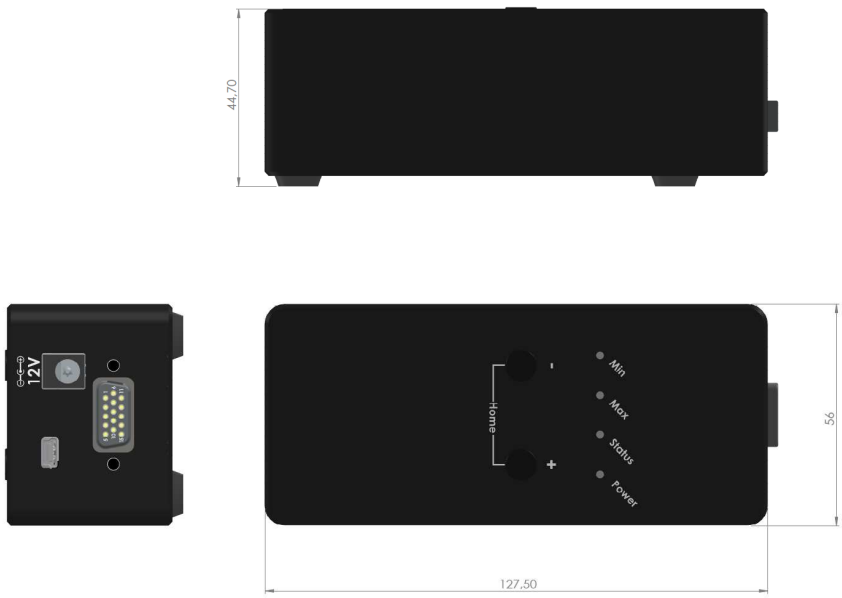


Figure 12. Main dimensions of EO Attenuator controller.

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