Electro-Optics Technology, Inc.

TORNOS Compact
User Guide

Optical Isolators
532 nm to 850 nm

Thank you for purchasing your TORNOS **Compact** Optical Isolator from EOT. This user guide will help answer questions you may have regarding the safe use and optimal operation of your Optical Isolator.

TABLE OF CONTENTS

I. TORNOS Compact Optical Isolator Overview

Your TORNOS **Compact** Optical Isolator is essentially a unidirectional light valve. It is used to protect a laser source from destabilizing feedback or actual damage from back-reflected light. Figure 1 and 2 below identifies the main elements of your Optical Isolator.

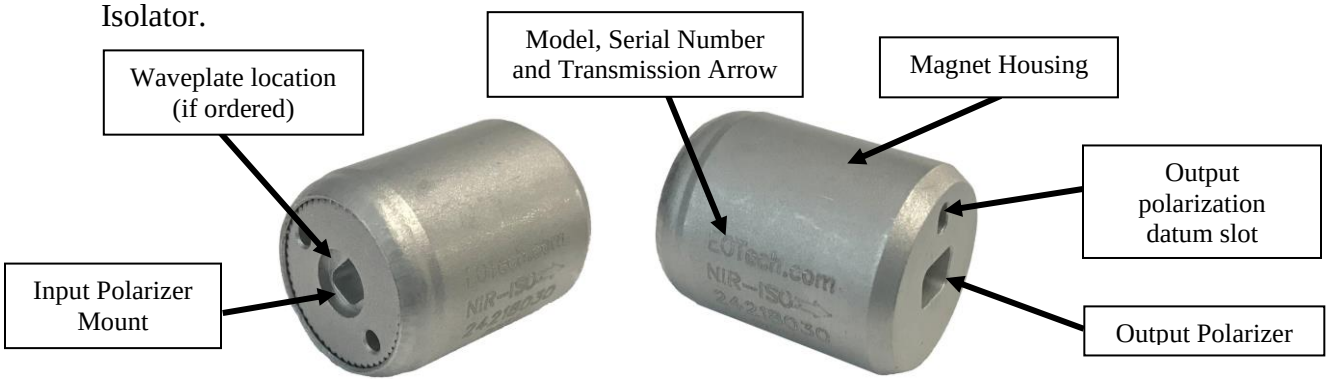


Figure 1: 2 mm TORNOS Compact Optical Isolator

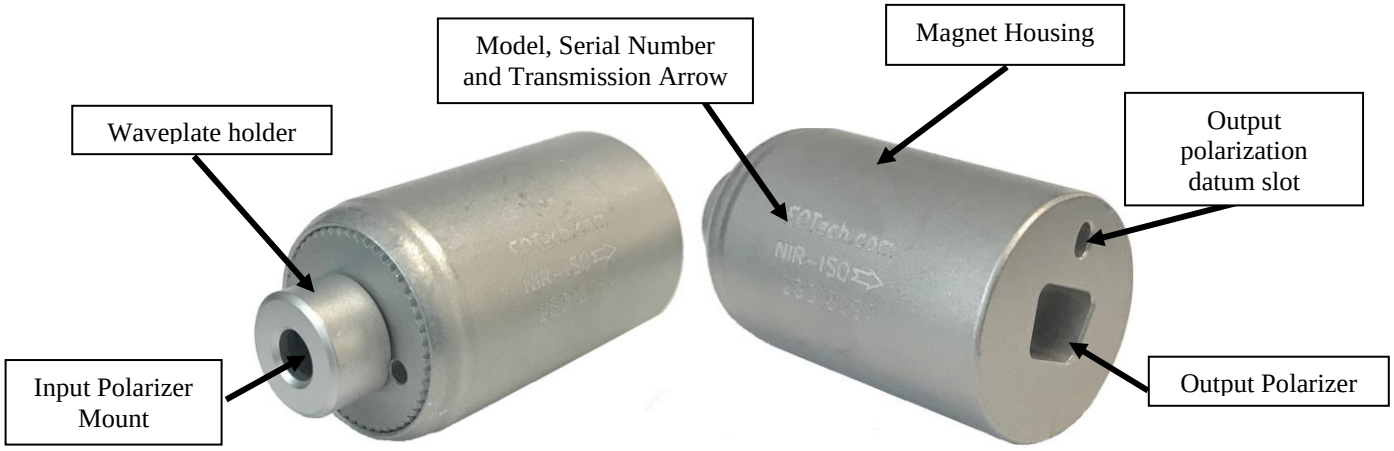


Figure 2: 4 mm TORNOS Compact Optical Isolator

The Optical Isolator is a cylindrically-shaped magneto-optic device. Strong Neodymium Iron Boron permanent magnets are used to generate high (>10,000 Gauss) axially-oriented fields within the magnet housing. The strong longitudinal field causes 45 degrees of non-reciprocal polarization rotation for propagating light via the Faraday Effect in the terbium gallium garnet (TGG) crystal located within the magnet housing. In operation, the magnet housing is sandwiched between input and output polarizers that have their transmission axis oriented 45 degrees relative to each other to account for the 45 degrees of Faraday rotation in the TGG crystal in the forward (transmission) direction. In the reverse (isolation) direction, the non-reciprocal Faraday rotation and the 45 degree polarizer transmission axis angle add so that the polarization transmitted by the output polarizer is rejected at the input polarizer.

Your TORNOS **Compact** Optical Isolator is labeled with a serial number on the magnet body of the device.

II. Safe use of your TORNOS Compact Optical Isolator

The operational hazards presented to operating personnel by the use of your TORNOS **Compact** Optical Isolator are listed below. An explanation of how the Optical Isolator is designed together with procedures users can employ to eliminate or minimize these hazards is presented.

1. Danger of sharp ferromagnetic objects being attracted to the residual permanent magnet fields outside of the Faraday Rotator. This hazard is of most concern if such fields cause flying objects when being handled.

   Your Isolator requires strong internal magnetic fields to operate properly. Efforts have been made to minimize external fields from the device while still maintaining a relatively small and cost-effective package. The external fields are designed to be well within federal safety guidelines which limit external fields from magnetic devices to be less than 2 K Gauss at a radial distance of 5cm from the outside of the device. However, such fields can be sufficient to attract nearby objects such as knives and razor blades. Should attraction of such objects begin to occur, there would be a strong attractive force directing these objects towards the interior of the magnet housing. This could be particularly likely to result in injury (e.g. a cut or puncture wound) if such attraction occurred while the device was being handled – particularly if a body part of the operating personnel is near a beam aperture (i.e. end) of the device.

   To minimize the above risks, remove all loose ferromagnetic objects from the path over which your TORNOS **Compact** Optical Isolator is to be moved prior to attempting to move it. **Do not** pick up the isolator by its ends (i.e. apertures) where the attractive magnetic fields are strongest. Always pick the isolator up along its sides.

2. Never attempt to disassemble the magnetic housing of your Faraday Isolator. Serious injury could result.

3. Failure of operating personnel to observe standard laser safety by sighting down through the Faraday Rotator when laser radiation is present.

   The optical elements within the TORNOS **Compact** Optical Isolators can be transmissive throughout the visible and near infrared. Consequently, it is never appropriate to view through the device in either the transmission or isolation direction when laser radiation is present – even with laser safety goggles.

   Never sight through your Optical Isolator in either direction when there is any possibility of laser radiation being present.

4. Harm caused by external magnetic fields.

   Your TORNOS **Compact** Optical Isolator has been designed to meet existing federal safety guidelines for external fields as noted previously. Such guidelines could change in the future as more information becomes known or reviewed regarding the interaction between magnetic fields and human health. Since various claims exist regarding the potential harmful (and beneficial!) effects of magnetic fields on humans it is prudent to limit interaction with these fields as much as possible.

   Personnel with any magnetically-sensitive implants such as pacemakers should present a copy of this report and consult their medical doctor regarding any potential complications which could arise from the isolator external magnetic fields.

5. Other non-health related hazards.

   The Optical Isolator external magnetic fields can draw ferromagnetic objects into the magnet housing which can damage the optical elements within the device. Keep a suitable area from the Optical Isolator in all directions clear of any loose ferromagnetic objects. Ideally, use non-magnetic tools (such as stainless steel or titanium) and hardware to secure the Optical Isolator. If only ferromagnetic tools are available use extreme care when using them around the Optical Isolator. It is always helpful to bring such tools towards an aperture (or end) radially rather than along the optical beam path. Doing this ensures that the fields will tend to pull such objects into the magnet housing endplate rather than into the optical aperture. Where possible use two hands, one to hold the tool and the other to guide it to the desired destination.

   Another concern regarding external magnetic fields is their effect on magnetically-sensitive devices. The external fields are strong enough to induce a pulse of current in electronic devices (such as digital watches) that can destroy them. The fields can also disrupt the operation of other mechanical devices with ferromagnetic parts in them. Finally, the external fields can erase information from magnetic strips such as those found on credit and ID cards. Remove all magnetically-sensitive materials and

devices such as watches, computer hard drives and magnetic strips from operators prior to working in the proximity of an isolator.

III. The TORNOS Compact Optical Isolator

A polarizing beamsplitter cube (PBSC) can be seen inside the input polarization mount. The inscribed arrow on the magnet body shows the transmission direction. The output PBSC is seen to be oriented with its transmission axis rotated 45 degrees relative to the input PBSC. The input polarization shown is horizontal. The central magnet housing together with the TGG crystal residing in its center forms a Faraday Rotator. The Faraday Rotator rotates the input horizontal transmission axis by 45 degrees so that transmitted light has a polarization aligned with the output transmission axis. The input and output PBSCs work in conjunction with the central Faraday Rotator to form an Optical Isolator as described previously in Section I. Though the overall size of the device varies depending on the wavelength dependent model, the size and operation of the PBSC mounts are identical. Figures 3 below shows output views of a TORNOS **Compact** Optical Isolator. Figure 4 shows EOT's polarization orientation reference.

Figure 3: Horizontal Input Polarization

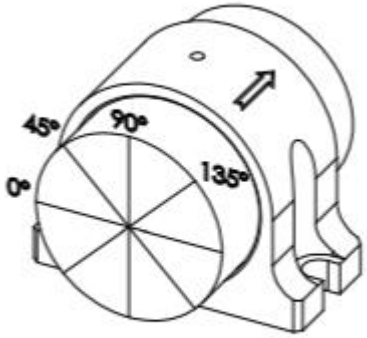


Figure 4: Polarization Reference

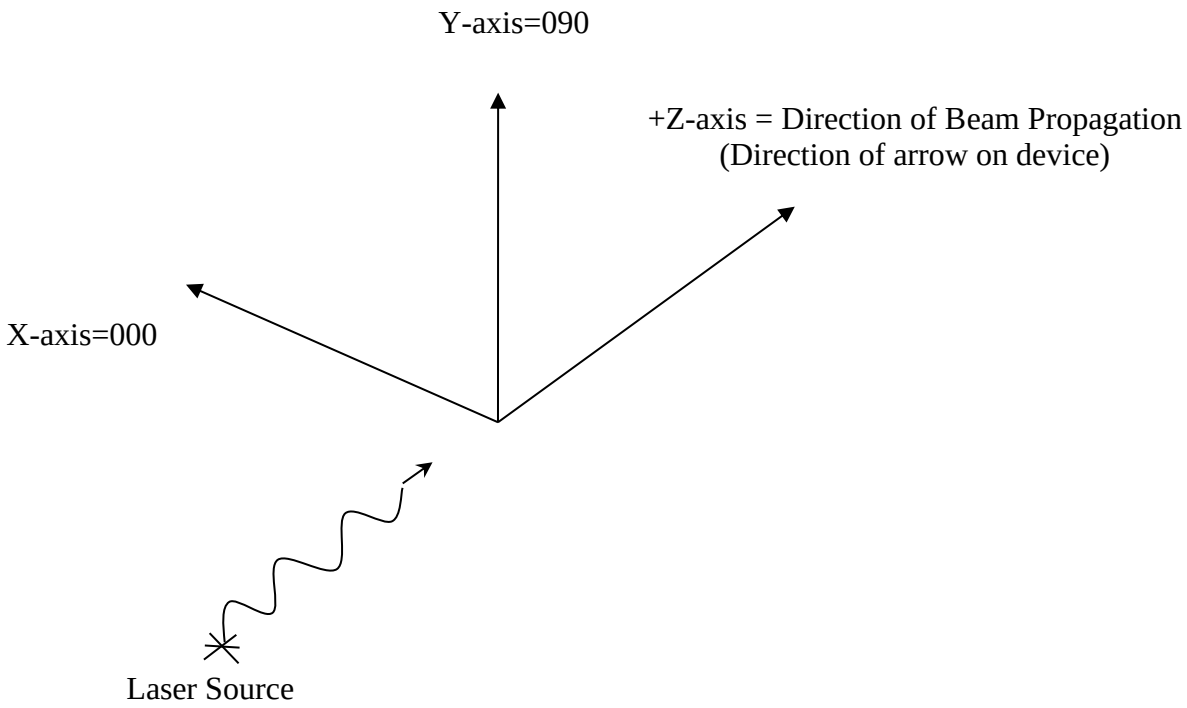
The polarization (vertical or horizontal) is controlled by the slot on the output of the device. When the locating slot is vertical as shown in Figure 3, the output polarization is 90 degrees. This can be changed by simply rotating the device such that the slot is angled to that of the desired output polarization. The cubes cannot be adjusted, they are set at the factory and the rotation is optimized to 45 degrees. These principals are valid with all sizes of TORNOS **Compact** Optical Isolators. For all 4 mm devices, the waveplate holder will be included on your device whether a waveplate is ordered or not. For the 2 mm devices, there will be no waveplate holder present, whether or not a waveplate is ordered.

Numbering Fields and Coordinate System for TORNOS Compact Optical Isolator

General Format for Numbering Field: AAAA-BB-C-DDD-EEE-FFF

Field Description:

1. "AAAA" is the product type. cLDI
2. "BB" is 04 for a 4 mm aperture size.
3. "C" is the device type. I=isolator; R=rotator
4. "DDD" is the operating wavelength in nm.
5. "EEE" is the input polarization axis angle. A right hand X, Y, Z Cartesian coordinate system is used in which the direction of beam propagation away from the laser source is along the positive Z axis. The X axis is in the plane of the base clamp. The Y axis is vertical, normal to the plane of the base clamp. The XY plane forms the plane of polarization. The XZ plane forms the plane of the base clamp. As an example, a horizontal input polarization is 000 or 0 degrees. A vertical polarization is 090, or 90 degrees. If no polarization is selected by the customer, 000 will be assigned. For rotators, this field does not apply.
6. "FFF" is the output polarization, which is 45 degrees from the input polarization if no waveplate is used. If a waveplate is used and no output polarization is specified, the default setting is the input polarization plus 90 degrees. The angle convention is the same as described for "EEE". For rotators, this field does not apply.



IV. Using your TORNOS Compact Optical Isolator

Observe the guidelines for safe use of your Optical Isolator found in Section II above when removing your isolator from its shipping container. Do not remove from shipping container until the device is in a clean, relatively dust-free environment. Save the packaging container in the event that the device should ever need to be returned to EOT.

With the source laser off, or running at very low power (less than 250 mW), position the Optical Isolator such that the source laser beam can be directed through the input aperture. Critical alignment of the Optical Isolator should be done at low power (less than 250 mW) in order to prevent optical damage to your isolator or laser source.

Use IR cards, IR viewers, or heat-sensitive film to ensure that the source laser beam is centered on the input and output apertures. It is also preferable to use an IR viewer to ensure that weak reflections from AR coated optical surfaces in the Optical Isolator are not being directed back into the source laser. The optical surfaces in the Optical Isolator are angled slightly to reduce these reflections. Increasing the distance between the Optical Isolator and the source laser can also help ensure that no reflections couple back into the source laser if necessary.

At this point, the Optical Isolator should be secured into the final location.

If the Optical Isolator will be used with average powers in excess of 12 W transmitted or 0.5 W rejected backward propagating radiation please consult damage threshold specifications for operating range. Since there is no way for the rejected polarizations to escape, at higher power it can cause the device to heat up. Such heat can degrade the performance of the Optical Isolator, or in severe cases, cause damage to optical components in the isolator.

V. Tuning your TORNOS Compact Optical Isolator

A. *Adjusting Input Polarization*

The transmission axis of the output polarizer is 45 degrees from the slot position on the magnet body on the output side of the device. If the linear polarization of the laser source is geometrically known, aligning the input polarization of the Optical Isolator to that of the laser source is straightforward. Simply rotate the magnet housing until the input polarizer transmission axis is aligned to that of your laser source. Wear laser safety glasses or goggles. Protect your colleagues by ensuring that they are wearing safety glasses or goggles as appropriate.

B. *Fine Wavelength Adjustment*

The wavelength of the device is determined at time of order and optimized to that during the device assembly. The device cannot be tuned by the customer. Please consult the data sheet to usable wave ranges.

C. *Waveplate Option and Adjustment*

The waveplate is installed at the factory and cannot be adjusted. Should you need to adjust the waveplate please contact EOT.

VI. Warranty Statement and Repair

EOT warrants its products to be free from defects in material and workmanship and complies with all specifications. EOT will at its option, repair or replace any product or component found to be defective during the warranty period. This warranty applies only to the original purchaser, and is not transferrable, for a period of one year after date of original shipment. The foregoing warranties shall not apply, and EOT reserves the right to refuse warranty service, should malfunction or failure result from:

a. Damage caused by improper installation, handling or use.
b. Unauthorized product modification or repair.
c. Operation outside the environmental or damage specifications of the product.
d. Contamination not reported to EOT within 30 days of the original ship date.
e. EOT's output isolators contain a "spacer" at the end of the isolator. Under certain conditions, an off-axis back-reflection from the workpiece could focus down onto the output displacer or polarizer inside the isolator. The purpose of the spacer is to eliminate the conditions under which this could happen. Should EOT's output isolators be purchased without the spacer, or should the spacer be removed, damage to the output displacer or polarizer will not be covered under warranty and the customer will be responsible for all costs associated with such an occurrence.

This warranty is exclusive in lieu of all other warranties whether written, oral, or implied. EOT specifically disclaims the implied warranties of merchantability and fitness for a particular purpose. In no event shall EOT be liable for an indirect, incidental, or consequential damages in connection with its products.

If the customer believes there is a problem with the rotator/isolator, they should immediately contact EOT's Sales/Customer department at 231-935-4044 or customerservice@eotech.com. EOT's Customer Service department will either issue an RMA for the device, or provide the customer with a procedure and authorize the customer to modify the device. All returns should reference the RMA number on the outside of the shipping container and should be sent to:

Electro-Optics Technology, Inc.
Attn: Sales/Customer Service
3340 Parkland Ct.
Traverse City, MI 46986 USA

EOT reserves the right to inspect rotators/isolators returned under warranty to assess if

the problem was caused by a manufacturer defect. If EOT determines the problem is not due to a manufacturer defect (an example would be damage to an optical element caused by impact from a loose ball driver or exceeding the damage threshold of the device), repairs will be done at the customer's expense. EOT will always provide a written quote for repair prior to performing repairs at the customer's expense. **Never attempt to disassemble the magnetic housing of your Faraday Rotator/Isolator. Injury could result.** Any indications that an attempt to disassemble the magnetic housing was made will render the warranty null and void.

Notes:

1. **Operating Temperature:** Performance of EOT's Faraday Rotators/Isolators is related to operating temperature. For information on the effect of operating temperature on EOT's Faraday rotators/isolators, please review our application note, *Thermal Lensing Analysis of TGG.*

2. **For higher incident powers or aperture sizes other than those specified, or other custom requirements, please consult EOT.** You may either contact EOT's sales department at sales@eotech.com or view our *Custom Solutions* page on our website, eotech.com. EOT has a designated Custom Solutions department with the expertise and capability of manufacturing custom Faraday Rotators and Isolators.