## Optical Isolator Instructions

Optical Isolators protect lasers from optical feedback. An optical isolator is comprised of two polarizers and a Faraday rotator (magneto-optic material in a magnet). Optical isolators by design transmit maximum energy in forward direction and block energy "Isolate" in the reverse direction. This is analogous to an electronics diode.


Optical Faraday Isolators

- The unique feature of the Faraday Effect is the plane of polarization's rotation (CW or CCW) is dependent on the magnetic field direction not the direction of light (left to right or right to left) passing through the Faraday Rotator magneto-optic material.


## The forward direction (Transmission):

- Laser light enters the isolator with plane of polarization parallel to the input polarizer's transmission axis. The long face of the rectangular end face is parallel to the transmission axis. As factory shipped the isolator will accept horizontal polarized light. To change this, rotate the isolator in the holder or simply adjust the input polarizer. Loosen the knurled locking screw and adjust the blue isolator housing until the input polarizer is oriented for maximum transmission.
- The light then enters the Faraday rotator and is rotated about 45 degrees. The input of isolator has north facing magnet which defines the FR counter clockwise "CCW" rotation as view looking at the input polarizer. Facing the output polarizer, the output polarizer axis is 45 degrees CW from horizontal.
- The output polarizer's transmission axis is aligned to the laser plane of polarization exiting the Faraday rotator.


## The reverse direction (Isolation):

- Random feedback and reflections from the optical system will reflect back towards the laser. They will first enter the output polarizer of isolator which blocks all reflections/energy except the light linear polarized parallel to the output polarizer's transmission axis.
- This linear light then enters the FR and is rotated so the energy (linear polarization) is crossed relative to the input polarizer. The isolator's input polarizer blocks this remaining energy.
- The back reflections or feedback are therefore isolated and do not reach the laser.

Faraday Rotation Angle Optimal isolation occurs when the output polarizer's axis is oriented at $\mathbf{9 0}$ degrees- actual FR angle of the isolator's Faraday rotator, relative to the input polarizer axis. The best case/design is when the Faraday rotation is 45 degrees so maximum isolation and maximum transmission occur when output polarizer is oriented at 45 degrees relative to input polarizer.

As the Faraday rotation deviates from the ideal 45 degrees rotation the transmission degrades defined by the polarizer misalignment using the Cosine Square Law.

Example: A Faraday rotator with 48 degrees rotation means the output polarizer is oriented at 42 degrees relative to the input polarizer's axis. The output polarizer is oriented at 42 degrees for optimal isolation. The light exiting the $F R$ is at 48 degrees and enters the output polarizer which is oriented at 42 degrees and we lose energy due to the 6 degrees difference in polarizer orientation. The drop in transmission is determined using the equation 1-Cos $[2(45-42)]{ }^{* *} 2=1.1 \%$ This small $1.1 \%$ drop in transmission is strictly the extra loss due to the Faraday rotation not being exactly 45 degrees.

The direction of magnet/s and type of magneto optic material define clockwise CW or CCW anti-clockwise.
Adjusting the output polarizer +/- 45 degrees relative to input polarizer will result in max and min transmission.

## Align your isolator

The base has M4 and 8-32 tap holes for post mounting. The base notch outs allow for clamp or washers to be used to hold isolator to lowest 1 " center line $C / L$ height.

1. The isolator should be mounted away from magnetic materials (ferrous materials "iron/steel") unless it is spaced so magnet does not pull on isolator. Weakening the magnetic field significantly will cause the Faraday rotator from working properly. If something in the mounting location pulls strongly on the isolator housing "magnet" then it may be a problem.
2. BE CAREFUL with Hex Key/wrench, alloy "black" screws and other magnetic items near the isolator.
3. Loosen the knurl locking ring and rotate the isolator blue housing until the laser power is maximized this is when input polarizer's axis is parallel to the lasers plane of polarization. Lock the input polarizer gently and the blue housing.
4. Adjust the output polarizer (loosen the M 3 screw/s with the provided 1.5 mm Hex wrench) so max transmission is realized this will occur with output polarizer at $45+/-3$ degrees relative to the input polarizer. This gives you initial alignment with isolation approximately >=20dB.
5. Turn the isolator backwards (output polarizer facing the laser) and rotate isolator body so the output polarizer transmission axis is nearly parallel to laser's plane of polarization. This can be done crudely by eye to within +/-10 degrees this is adequate. Temporarily gently lock the isolator housing in base using the Knurled Screw.
6. Adjust the output polarizer a small amount $+/-3$ degrees ONLY until reverse transmission is minimized, lock the output polarizer position by tightening the M3 set screw/s (with provided 1.5 mm BLUE Hex wrench). This is the max isolation position for the output polarizer. The polarizers are now set relative to each other for max isolation defined by the faraday rotation angle.
7. Turn the isolator back so the input polarizer faces the laser and rotate the complete blue isolator housing (polarizers are locked) for maximum transmission with the input polarizer axis parallel to the laser's plane of polarization.
8. NOTES: The polarizer set screws are size M3 one set screw is adequate to hold the polarizer cell. Each polarizer can be rotated in 2 positions 180 degrees from each other. Meaning for example the input polarizer can be horizontal or rotated 180 degrees, so it is horizontal again. You can optimize transmission by trying both rotational orientations. The tilt of the isolator to removed unwanted back reflections may require this polarizer orientation change to select best orientation given the polarizers field of view.

The input or output polarizer can be rotated to any desired orientation. The other polarizer then must be adjusted to optimize isolation. For example, the output polarizer can be vertical in which case the input polarizer is at +/-45 degrees.

The isolator is arbitrary standard with magnet north face as input and FR is CCW. If you flip isolator front to back and adjust the polarizers you can have the Faraday rotation direction clockwise (CW). Mechanically the output side of barrel is "open" so you can see edges of magnets when output polarizer is removed.

