

## **User's Guide**

### **Modulator Alignment Procedure**

Models 350, 360, 370, 380, 390 series

## **Warranty Information**

ConOptics, Inc. guarantees its products to be free of defects in materials and workmanship for one year from the date of purchase.

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## Introduction

ConOptics, Inc. manufactures an extensive line of low voltage electro-optic light modulators, drive electronics, and associated components to satisfy your diverse requirements.

E-O modulators and modulation systems are used for pulse selection, regen-switching, video disk mastering and data recording. Products include E-O phase modulators, beam deflectors, associated drivers, transverse field modulators, laser noise-reduction systems, and optical isolators. We also manufacture, on a custom basis, intensity modulation systems with high frequency capabilities beyond 400MHz.

## Modulator Design Features

ConOptics Modulators are transverse field type Pockels Cells. In the original Pockels Cell design the optical beam is longitudinal to the electric field. In the ConOptics transverse design the optical beam is orthogonal to the electric field. The advantage of the transverse design is that it requires approximately 100 volts as opposed to the kilovolts required by the original design.

ConOptics Modulator design elements include:

- 2 or 4 crystal configurations
- Designed to minimize the natural net birefringence
- Require DC offset voltage to set the quiescent operating point
- Are supplied with an output polarizer, pre-aligned to the crystal axes
- Require either that the input laser is polarized or use of an auxiliary polarizer at the input
- Are filled with index matching fluid.
  - *Note: Window assemblies should not be removed*

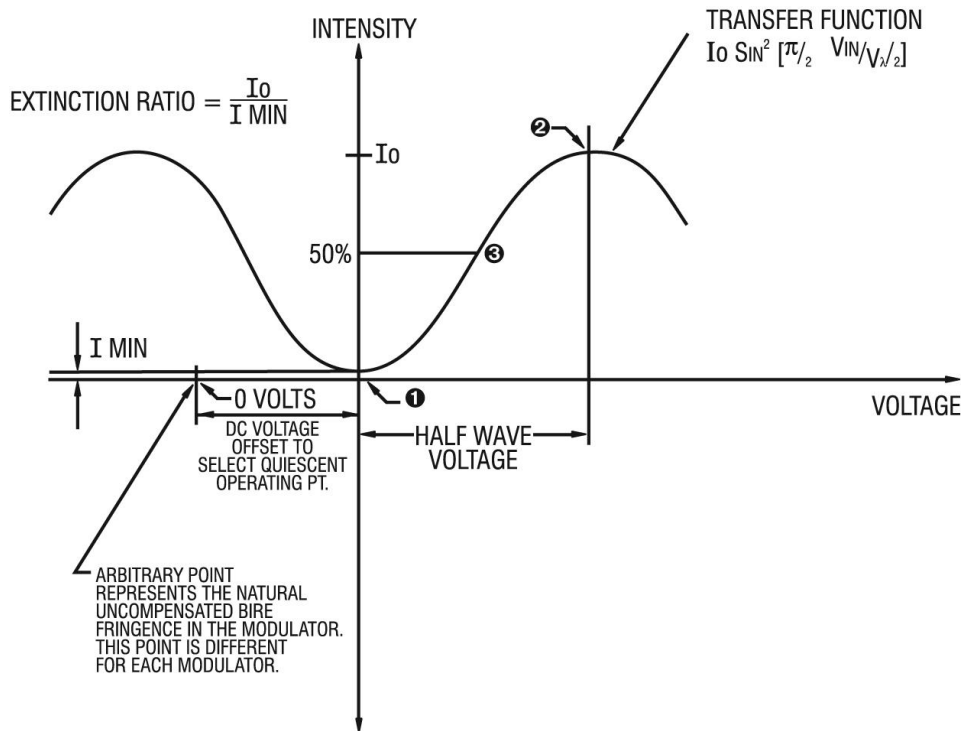
ConOptics incorporates four types of crystals materials in our modulators:

- Ammonium Dihydrogen Phosphate (ADP) crystals for use in the Model 370, 380, and 390 series
- Potassium Dideuterium Phosphate (KD\*P) crystals for use in the Model 350 series
- Lithium Niobate or Lithium Tantalate crystals for the Model 360 series

ConOptics modulators are used in variety of applications. The most common use is **Amplitude Modulation**. In this mode the polarizer is aligned to the crystal axis which converts polarization modulation to intensity modulation. The transfer function is Sine squared.

The following diagram (Figure 1) identifies “uni-polar “input signals and bi-polar input signals.

**Figure 1**

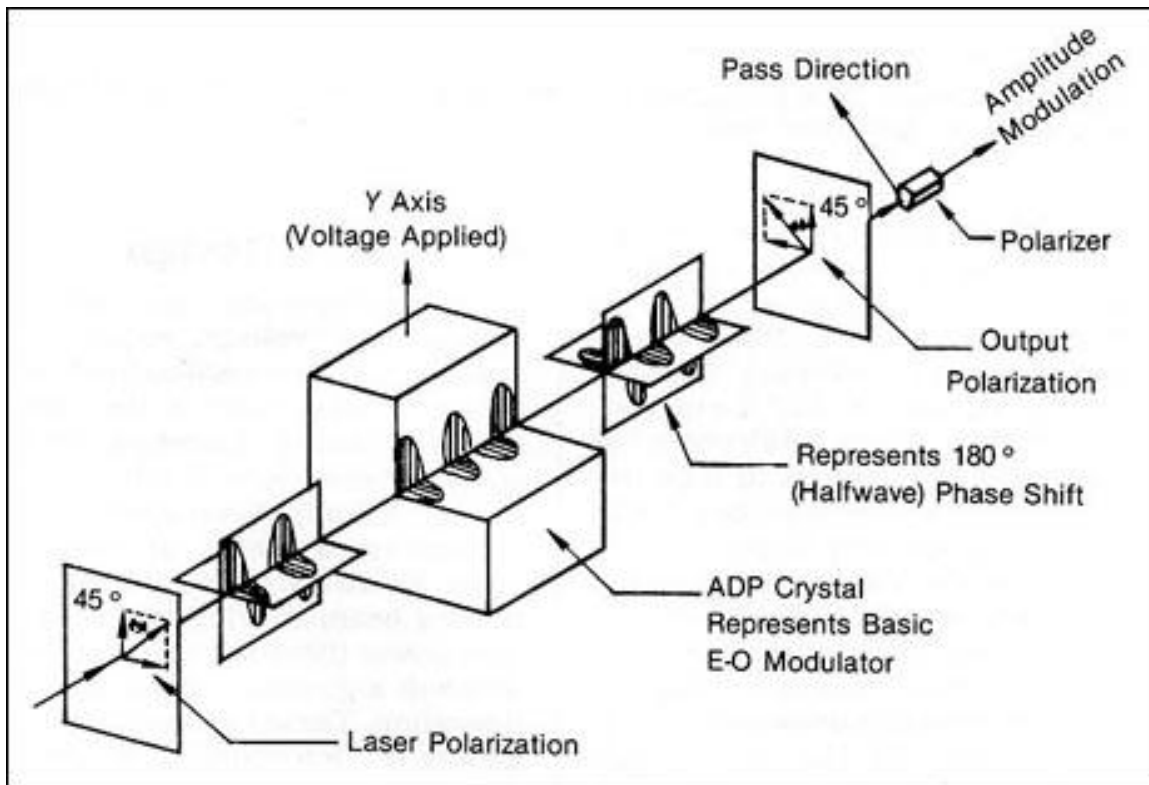


MODULATORS OPERATING POINT [BIAS SET]

- ❶ UNI-POLAR POSITIVE INPUT
- ❷ UNI-POLAR NEGATIVE INPUT
- ❸ BI-POLAR INPUT

This configuration can also be used as a **Polarization Rotator** or a **Variable Wave Plate**. This is identified during the order process and includes a removable polarizer. In the event that this was not identified during the ordering process, align the modulator with the polarizer facing the laser source, and then simply rotate the complete assembly for maximum transmission. If the application is to include linear polarization rotating in azimuth as a function of the applied voltage a  $\frac{1}{4}$  wave-plate is required (at the lasers wavelength) to the output of the modulator. The diagram (Figure 2) below identifies this process.

**Figure 2**



Our modulator can also be used for **Phase Modulation**. This configuration requires the crystals axis to be aligned from crystal to crystal. Phase Modulators are typically used to generate frequency side bands on the lasers carrier. The modulation frequency and amplitude of the modulation will transfer the power from the carrier to first order sidebands. The maximum power that can be transferred is roughly 34% when the peak phase shift is equal to 1.8 radians. The Phase Modulation Alignment process is provided on page 13 of this manual.

*Please note:*

*This configuration must be specified when ordering. A Phase Modulator cannot be used as intensity or voltage variable wave plate.*

## Modulator Aperture Size

Laser beams typically do not have sharp edges like the cone of light that passes through the aperture of a lens. Instead, the irradiance falls off gradually away from the center of the beam. It is very common for the beam to have a Gaussian profile (bell-shaped). Laser beam diameters are typically specified at  $1/e^2$  irradiance points. If the beam is specified as 1.5 mm at  $1/e^2$  points, the diameter at which its irradiance falls to 1% will be 50% larger or 2.25 mm.

ConOptics Modulator apertures are 2.7 mm, 3.1 mm and 3.5mm in diameter. The maximum beam diameter for the 2.7 mm product is 1.8 mm at  $1/e^2$  points or 2.4 mm at 1% of maximum points. ConOptics Modulators do not include a hard aperture so overfilling can cause damage to the product. The modulator should be positioned as close as possible to the laser's output. This will minimize the beam growth caused by the laser's natural divergence.

The modulator can be installed such that the output polarization is vertical or horizontal. The exit port of the output polarizer determines the plane of polarization exiting the modulator. With the exit port facing up or down the output will be vertical. If the exit port faces horizontally, the output will be horizontal.

*Please note:*

- 1. Do not overfill the modulator aperture*
- 2. Do not block the rejected components on the modulator assembly. Use a stop at least a few cm away*

## Modulator Alignment Procedure

The prerequisites for Modulator Alignment are listed below:

- If the modulator is operated between crossed polarizer's, so the output polarization is  $90^{\circ}$  to the input polarization, the transmitted laser power will be close to a minimum with 0 volts DC bias
- If the modulator is operated between parallel polarizer's, the transmission will be close to a maximum with 0 volts DC bias. Choose this configuration only if the modulator will be open or at maximum transmission most of the time
- A DC power supply is required. If you have purchased a complete system with driver from ConOptics then the power supply is included

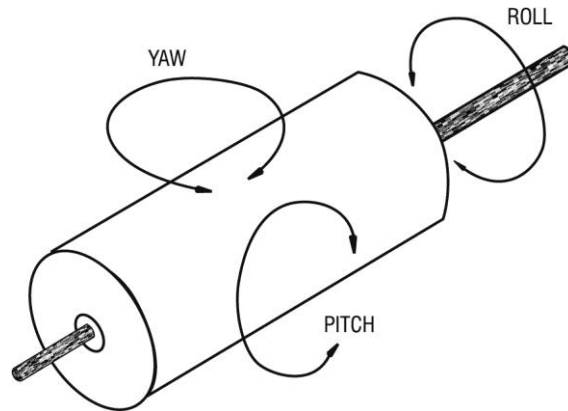
*Please note:*

*The two crystal 350 series (350-50/350-80/350-80LA and 350-105) are close to being zero wave-plates when operated between crossed polarizer's. Since they are close to a null or minimum transmission with no voltage, the bias voltage for a null is relatively low. Maintaining a low DC bias voltage is important to the longevity of the modulator.*

### Modulator Support

A suitable modulator support must be provided so that roll, pitch and yaw adjustments can be performed as shown in the (Figure 3) below.

**Figure 3**



ConOptics has developed a modulator mount which makes roll, pitch and yaw adjustments effortless. The image below illustrates our modulator installed in the Model 102 Mount.



## Alignment

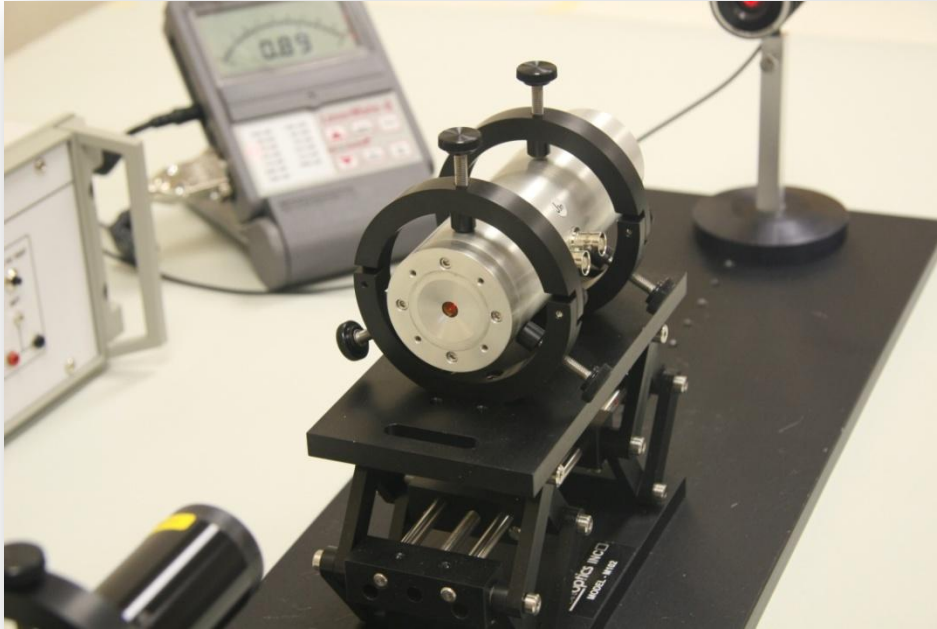
Align the modulator such that the beam enters and exits without any beam distortion. This should be done at a power level of less than 200 mw. If you cannot adjust the laser power to this level, use an auxiliary polarizer at the input to lower the power. The Model 103 alignment tool is used to bore sight the laser to the mount. Adjustments can be made using the Model 102 Mount. Coarse adjustments use lab jack for height and for fine adjustment use (4) thumb screw as shown in (Figure 4) for maximum signal.

Figure 4



After obtain the maximum signal from the alignment tool, install the modulator. Be sure the beam exiting the modulator is clear with no vignetting or scatter, illustrated in (Figure 5) below.

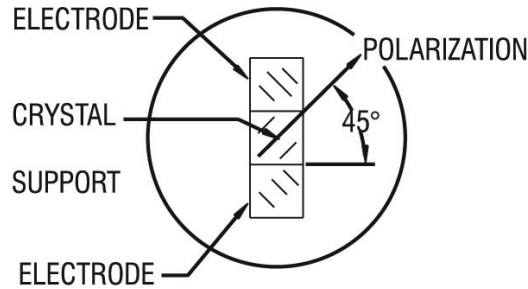
**Figure 5**



### Polarization Alignment

Then rotate the cell about its axis to align the polarization so that it bisects the crystal axis at a 45° angle as shown in the (Figure 6) below.

**Figure 6**

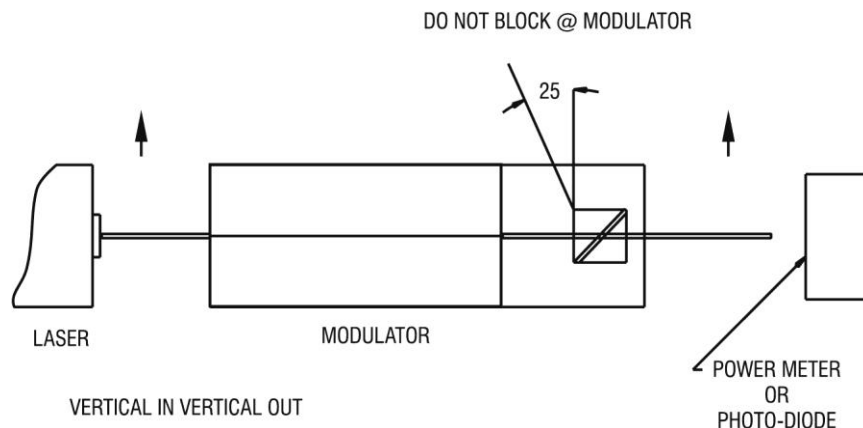


*Please note:*

*If you've used an auxiliary polarizer at the input for power attenuation, it will have to be removed for this step.*

If the laser polarization is vertical, and you want the output to be vertical, then the rejected component will be directed to the ceiling or table top (Figure 7) below. To obtain a horizontal plane of polarization (vertical in), position the rejected component in a plane parallel to the tabletop.

**Figure 7**



*Please note:*

*It is very important to avoid blocking the rejected component at the modulator.*

### **Fine polarization adjustment**

Fine polarization alignment, is used to ensure the polarization bisects the crystal axis which avoids performance degradation. Align a power meter or photo-diode to accept the beam exiting the modulator. For parallel operation (vertical in-vertical out), adjust the bias voltage and the rotation of the cell for a minimum. For crossed operation, adjust the bias voltage and rotation for a maximum.

The laser's polarization should be at least 100:1. This means that no more than 1% of the light is polarized in a different plane than the main polarization. Since the modulator is a cylinder there's no need to employ polarization rotation optics prior to the modulator. The use of beam folding optics prior to the modulator should be avoided because these components typically change the polarization purity and angle. If folding optics is employed, an input polarizer should be installed before the modulator.

### **Fine pitch and yaw adjustment**

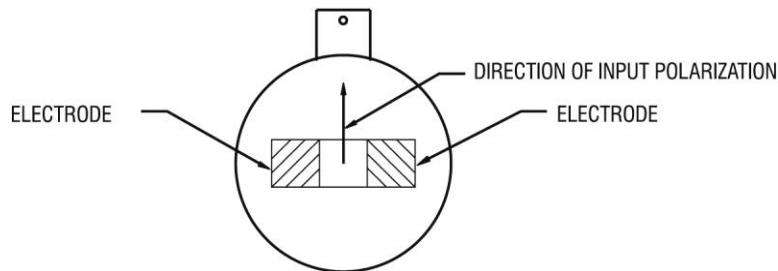
The fine pitch and yaw adjustment is performed to optimize the extinction ratio, the ratio of maximum to minimum transmission. Adjust the voltage for a maximum and note the extinction ratio. Adjust the voltage for a minimum. Then adjust the cell in pitch and yaw, slightly, while reducing the minimum as possible. You will have to re-adjust the voltage to perform this last step. Re-check the maximum to be sure that you have not reduced it. Repeat if necessary until you have achieved the highest possible extinction ratio.

The extinction ratio and transmission measurements should be made with an iris before the detector to eliminate background light. The modulator's operating point is set with the driver's bias supply. This should be done without any signal into the driver's input. The modulator's operating point can be set for bipolar or unipolar input. For positive unipolar input set the modulator for minimum transmission at the lowest DC value. For negative unipolar input set the modulator for maximum transmission. For bipolar input set the modulator at 50% transmission.

### Phase Modulator Alignment

Linearly polarized light must be passed through the modulator so that the plane of polarization is orthogonal to the applied electric field. This is illustrated in (Figure 8) below.

**Figure 8**

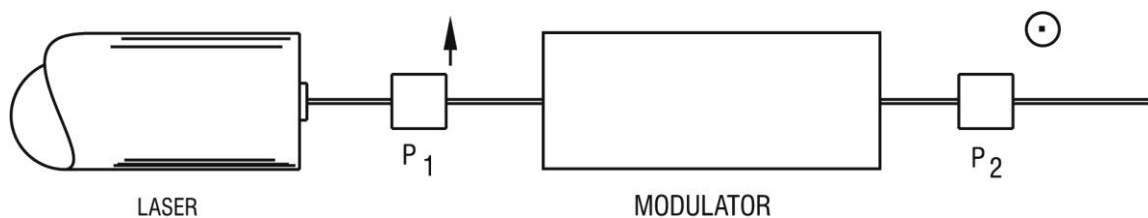


*Please note:*

*This process should be followed for the Model 350, 370, 380, 390 Series. For the 360 Series the plane of polarization is parallel to the electric field.*

To perform the alignment of the phase modulator, the optical setup must contain a polarized laser (or an input polarizer ( $P_1$ ) if the laser is unpolarized) and an output polarizer ( $P_2$ ) positioned so that its pass direction is orthogonal to the input. This is illustrated in (Figure 9) below.

**Figure 9**



Align the phase modulator (with the connector vertical or parallel to the input polarization) so that the laser beam is centered on the input and exit crystal faces. Rotate the modulator until a null is observed, after  $P_2$ . This will align the input polarization parallel to the induced index change. Then remove  $P_2$ .

A suitable modulator support must be provided so that the adjustments of the modulator can be made in roll, pitch and yaw.

