

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 intensity modulation systems with high frequency capabilities beyond 400MHz on a custom basis.

Modulator Design Features

Conoptics Modulators are transverse field type Pockels Cells. In the original Pockels Cell design, the optical beam is parallel 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*

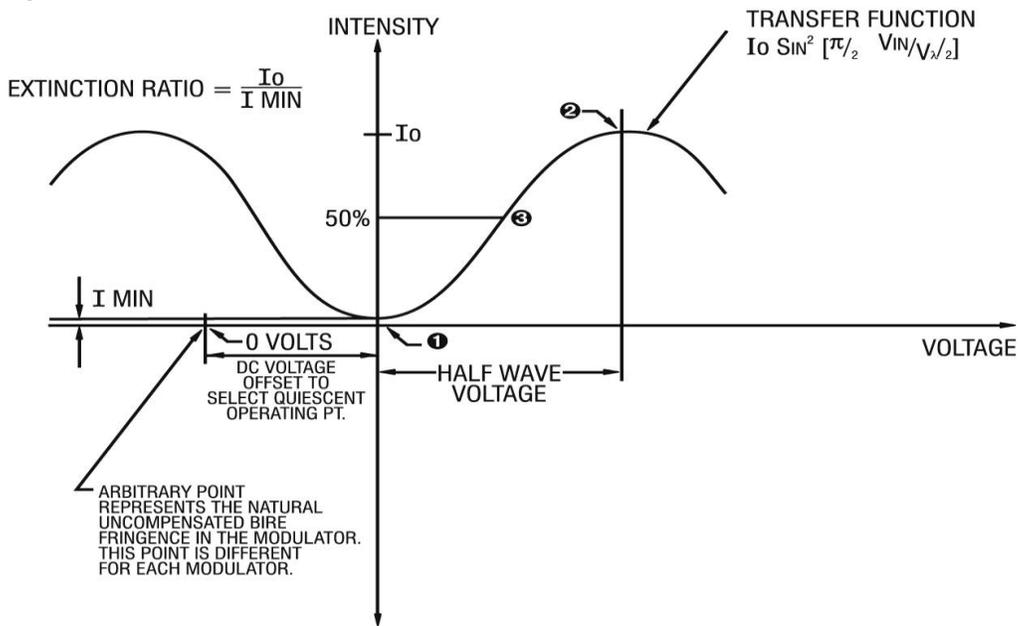
Conoptics incorporates four types of crystals materials in our modulators:

- 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 45° 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

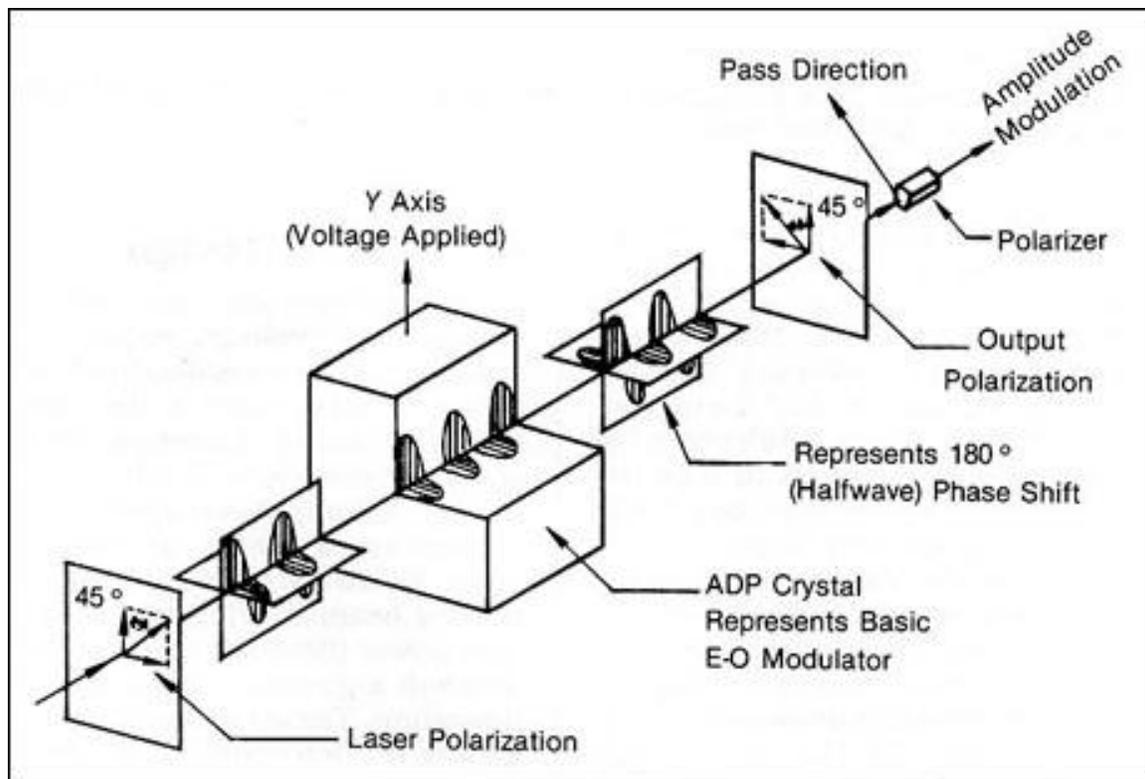


MODULATORS OPERATING POINT [BIAS SET]

- 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 **Voltage 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 configured 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 15 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 $1/e^2$ intensity 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 polarizers, so the output polarization is 90° to the input polarization, the transmitted laser power will be close to a minimum with 0 volts DC bias
- Modulators are built to be close to zero wave plates, operating between crossed polarizers.
 - They are built to operate **close to zero**, not exactly zero. In order to properly align the input polarization to the crystal axis, you must apply a DC bias while rotating the assembly. **Please follow the instructions as outlined in our manual.**
- When splitting the laser into two channels via polarizing beam splitter, the polarization purity may be degraded. The straight through component will remain unaffected while the reflected component (90 degrees) is degraded.
 - The degraded polarization will limit the modulators ER (extinction ratio) and transmission.
 - The addition of an input polarizer will improve the modulator's performance.
- Any optical components installed between the lasers output and the modulators input may degrade the lasers polarization purity and angle. The addition of an input polarizer will resolve this problem.
- The beam diameter is specified at $1/e^2$ points and divergence as <1.0 mrad full angle. For a Gaussian, the beam diameter at the 1% points is $1.5 \times 1/e^2$ points.
 - In order to not overfill the modulators aperture, one must take into account the laser beam diameter at the 1% points and the beam divergence.
- If the modulator is operated between parallel polarizers, 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

Please note:

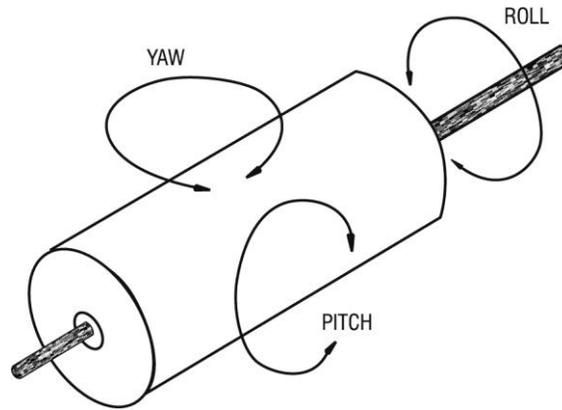
The two crystal 350 series (350-50/350-80/350-80LA and 350-105) are close to being zero wave-plates when operated between crossed polarizer's. Since they are close to a null or minimum transmission with no voltage, the bias voltage for a null is relatively low. Maintaining a low DC bias voltage is important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

- A DC power supply is required. If you have purchased a complete system with driver from Conoptics then the BIAS power supply is included
- Always use minimum laser power during the alignment process
- Avoid reflections
- Terminate the rejected beam away from the modulator
- Pre-read the operational manuals for all components of your system
- Use the QA Sheet included with EO Modulator as a baseline for your measurements
- Use an infrared sensor card for alignment
- Remove all protective red plastic caps from the EO Modulator
- Do not turn on the amplifier with the cables detached.

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 Steps:

Preface:

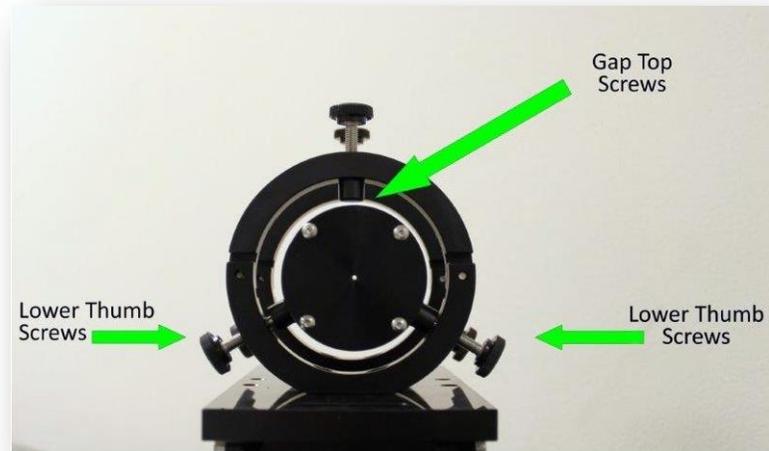
In order to properly align the input polarization to the crystal axis within the pockels cell you must apply a DC voltage while measuring the output with a photo detector and adjusting the rotation of the pockels cell for maximum transmission.

Steps:

1. Turn on laser. Laser power should be less than 100mW
2. Align your power meter and identify power readings
3. Use Conoptics Model 103 Alignment Tool for initial alignment. This tool is used to bore sight alignment of the laser to the mount



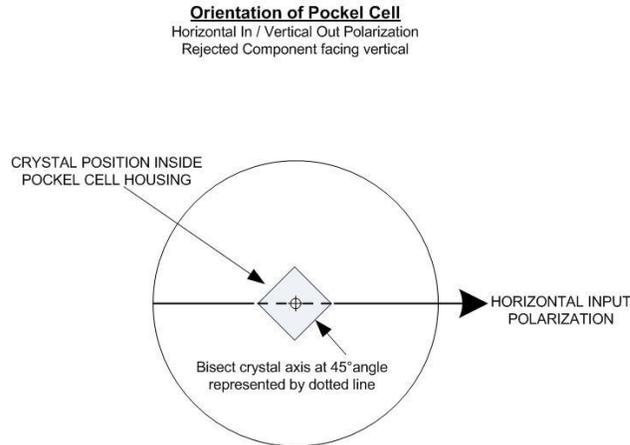
4. If using the Model 102 Adjustable mount, adjust for proper height and use the thumb screws for fine-tune adjustments, while looking at the power meter to achieve maximum transmission.



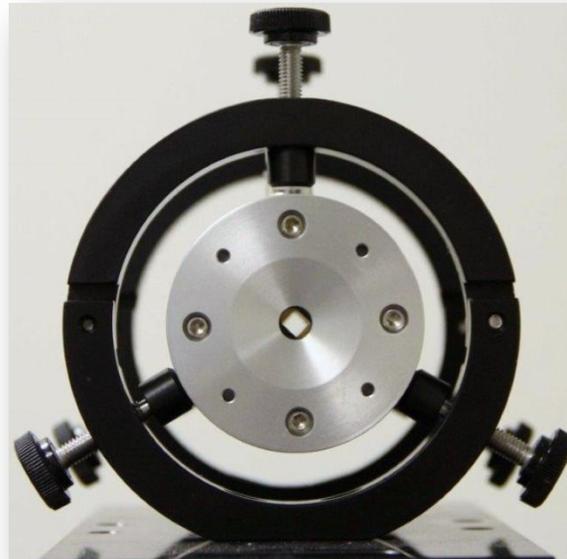
5. Align the Model 103 such that the beam enters and exits without any beam distortion. This should be done at a power level of less than 100 mw.
6. Record the output power with the Model 103. The reading should be very close to the results from step 2. Note: Depends on beam diameter
7. After obtain the maximum signal from the Model 103 Alignment Tool, install the E-O Modulator (pockel cell). Be sure the beam exiting the modulator is clear with no vignetting or scatter.
8. With the **amplifier power off**, connect the cables to the EO Modulator
9. With cables connected, turn on the amplifier

10. Polarization Alignment

- a. Rotate the EO Modulator to align the “Input” polarization so that it bisects the crystal axis at a 45° angle



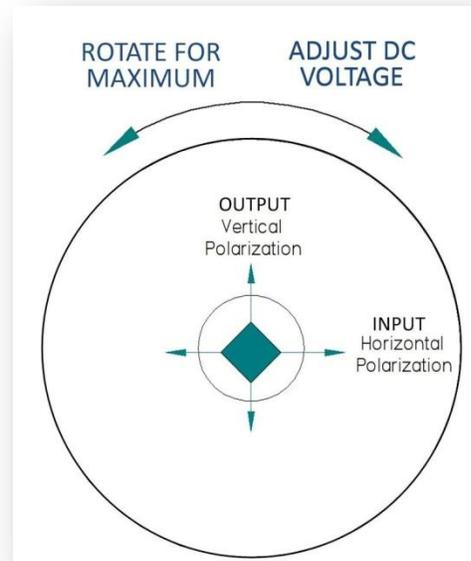
If not properly aligned the ER and Transmission will be degraded.



- b. To obtain a horizontal plane of polarization (horizontal in), position the rejected component vertical to the tabletop (towards ceiling).

Note: If you are using an auxiliary polarizer at the input for power attenuation, it will have to be removed for this step

- c. 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 (horizontal in-vertical out) , adjust the bias voltage and rotation for a maximum

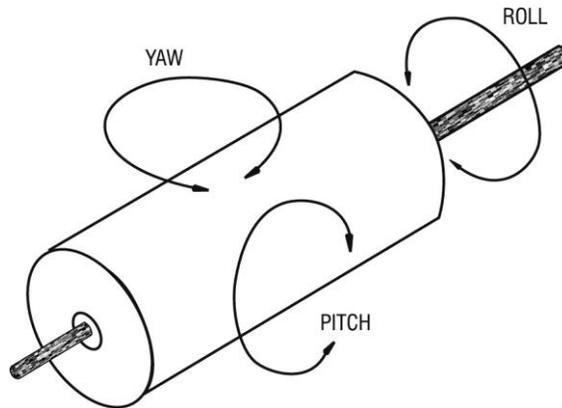


Note:

The laser's polarization should be at least 500:1. This means that no more than 0.2% 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. The modulators ER cannot be higher than the input polarization purity.

11. Using the Bias Knob on the front of the amplifier adjust to minimum voltage while reaching minimum power through power meter. Record this result
12. Next adjust the bias for maximum voltage, while using the power meter to identify maximum power. Record this result
13. The Extinction Ratio formula is $ER = \text{Intensity (max)} / \text{Intensity (min)}$
 - a. For example: 200mW at Bias Voltage of 346V / .50mW at Bias Voltage of - 85V. $ER = 400:1, (200mW/.50mW)$.
 - b. The ER result should be close to the QA Sheet
 - c. Notes: The ER Ratio will vary depending on each configuration, wavelength, beam diameter and alignment.
 - d. Note: Use an iris to stop off axis reflections

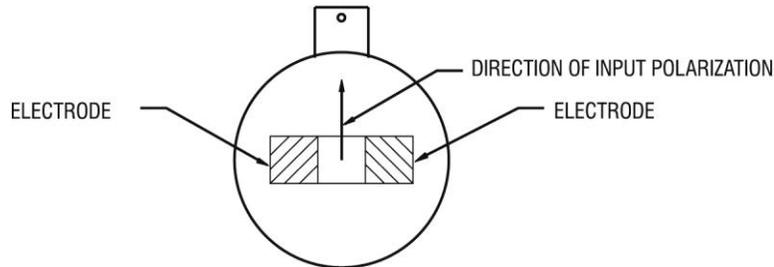
14. **Pitch & Yaw:** The fine pitch and yaw adjustment is performed to optimize the extinction ratio, the ratio of maximum to minimum transmission. Adjust the voltage for a maximum and note the extinction ratio. Adjust the voltage for a minimum. Then adjust the cell in pitch and yaw, slightly, while 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.



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

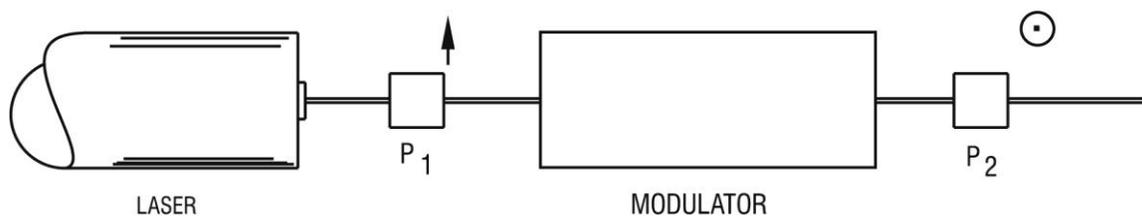


Please note:

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 .