

Eigenstate Calibration Set User Manual

Revision 1.03

Eigenstate Calibration Set

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Precautions

- Do not attempt to tighten or loosen any screws on the ECS housings. This will alter the orientation of the optical element and void the calibration and warranty.
- Use only reagent grade alcohol or acetone and optics cleaning swabs to remove dust and oils from the mating surfaces of the alignment pins and the platform grooves.
- Do not submerge any part of the housing into acetone or other cleaning agents, as this will deteriorate the adhesive between the alignment pins and the mount.
- Use care when mating and demating the ECS housing and the platform as excessive mechanical shock may cause the alignment pins to detach from the housing. **If the alignment pins detach, contact Meadowlark Optics, DO NOT attempt to reattach the pins as this will void the ECS calibration.**
- Avoid scratching or other damage to the ECS baseplate. Any damage or contamination of the alignment grooves will void the calibration and result in unacceptable calibration of the Polarimeter.
- Contact Meadowlark Optics if the platform becomes scratched or otherwise damaged, as this will void the calibration of the ECS.
- Align the beam to the center of and normal to the Polarimeter entrance aperture.
- Use dry, filtered nitrogen to gently remove dust from the optical surfaces.

1.0 Overview

The Eigenstate Calibration Set (ECS) is a precision tool that can be used to calibrate the Meadowlark Optics Polarimeter, or most other polarimeters, to obtain optimal accuracy. It consists of a precision linear polarizer (black housing), a precision quarter-wave retarder (blue housing) and a precision machined alignment and mounting plate. The housings are precision machined and use a quasi-kinematic scheme to mate to a V-groove and a flat groove in a stainless steel alignment plate. A magnet provides the attachment force to allow accurate and repeatable mating to the alignment plate and arrows on the housings indicate the polarization axis of the polarizer and fast axis of the waveplate for reference. The alignment pins, which are attached to the housings, are critical to proper alignment of the components. In the event a pin detaches from housing, DO NOT attempt to reattach the pins as it will void the calibration of the device. Contact Meadowlark Optics for assistance.

The ECS provides the six eigenstates (polarization states) necessary to calibrate your Meadowlark Optics Polarimeter: linearly polarized light at angles of 0° , 90° , $+45^\circ$, and -45° as well as right- and left-handed circular polarized light.

2.0 Setup

The precision-machined ECS alignment and mounting plate is designed to interface with an optical table or breadboard. The plate should be fastened to two steel posts or directly to an optics table using the provided $\frac{1}{4}$ -20 shoulder screws. The shoulder screws need to be tight enough so that the alignment plate does not move during a calibration sequence. Verify any intermediate mounting interfaces are secure to mitigate any movement during calibration and verify your beam is centered on and normal to the ECS clear apertures.

3.0 Usage

Carefully clean the alignment pins on the ECS housings and the grooves on the alignment and mounting plate using acetone and an

optics swab. DO NOT immerse the ECS in any cleaning solution as this will dissolve the adhesives critical to maintaining the calibration of the ECS! Verify that the optics within the housings are clean and use dry, filtered nitrogen to blow off any dust particles. Gently place the polarizer and waveplate housings onto the alignment and mounting platform in the sequence prescribed in the Polarimeter user's manual. For a quick reference, see Figures 1 and 2. The recommended procedure to mate the ECS housings to the alignment and mounting plate is to first place one pin into the V-groove and then slowly allow the housing to rotate down until it gently contacts the flat groove. The demate procedure is simply the reverse of the mating procedure.

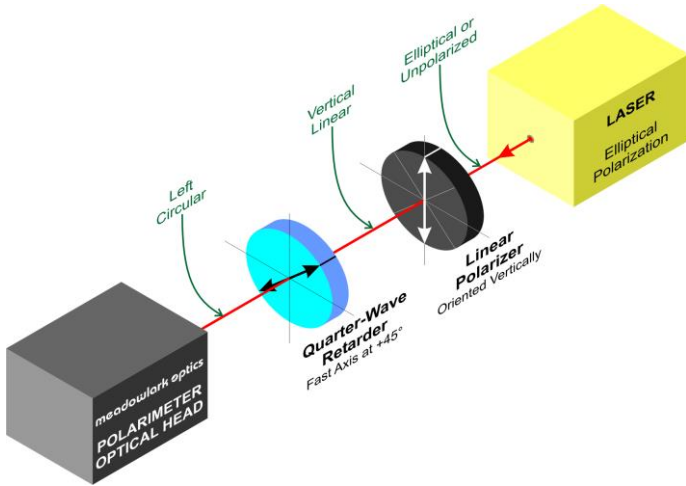


Figure 1 – Schematic for Polarimeter Calibration, Step 6

The linear polarizer is rotated during the calibration procedure; the quarter-wave retarder is removed for the first four steps. (As shown the quarter-wave plate is at +45°.)









Calibration Sequence	Stokes Vector	SOP Description	Polarizer Orientation	Waveplate Orientation
Step 1	(1, 1, 0, 0)	Horizontal		Removed
Step 2	(1, -1, 0, 0)	Vertical		Removed
Step 3	(1, 0, 1, 0)	+45°		Removed
Step 4	(1, 0, -1, 0)	-45°		Removed
Step 5	(1, 0, 0, 1)	Right Circular		
Step 6	(1, 0, 0, -1)	Left Circular		

Figure 2 – Polarization States for Polarimeter Calibration.

The rotational orientation of the polarizer and waveplate are from the perspective looking *toward the light source*.

4.0 Angular Accuracy

The angles of the ECS housings are machined to an accuracy of better than one arc-minute and the Eigen axis of the optic is aligned in the housing with an accuracy of better than two arc-minutes from the true angle. The reference frame of the true angle is defined as a plane containing the three contact lines created by the mating of the cylindrical alignment pins on the housing to the V- and flat grooves on the alignment and mounting platform. This yields an overall calibration accuracy of less than three arc-minutes.

5.0 Precision

Three important factors are critical to maintaining the accuracy for mating the housings to the alignment and mounting platform. The factors are as follows:

- (1) The alignment pins on the housings and the grooves on the alignment and mounting platform must remain free of any contaminants.
 - For example, a 20 μm dust particle on the flat groove can cause an angular error of 1.4 arc-minutes. [Note: Use acetone sparingly to remove dust and oils from the alignment pins and alignment and mounting platform, as it will dissolve the adhesive that holds some pins in place.]
- (2) The alignment pin and platform grooves must remain free of burrs and scratches to minimize friction.
 - If the pin does not contact both sides of the V-groove due to excessive friction, calibration precision will be significantly reduced. The alignment pins and the platform grooves are supplied with smooth, precision ground surfaces and should be handled and protected in a manner consistent with a precision alignment tool.
- (3) The optical axis must pass through the center of the optic in the housing.
 - The mounted optic is designed to have the same center regardless of orientation of the housing. This assures even subtle non-uniformities in the optic do not impact the overall calibration accuracy.

6.0 Options and Configurations

The ECS is available with several options and configurations, such as additional retarders within the wavelength range of the polarizer. The polarizer wavelength range is determined by type of polarizer material and antireflective coating performance. The nominal antireflective coating ranges are as follows:

- Visible (400-700nm)
- IR1 (650-950nm)
- IR2 (900-1250nm)
- IR3 (1200-1700nm)

For example, if you have an ECS at 532nm, you can purchase additional retarders at 488, 633 and 650nm to be used with the same ECS polarizer and alignment and mounting platform. Please note: If an added retarder is desired for an existing Eigenstate Calibration Set, the entire Eigenstate Calibration Set must be returned to Meadowlark Optics to allow the new retarder to be calibrated to the existing polarizer. This procedure is required to maintain the overall accuracy of your ECS.

Please contact a Meadowlark Optics Sales Engineer at 303-833-4333 or sales@meadowlark.com with any questions.

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