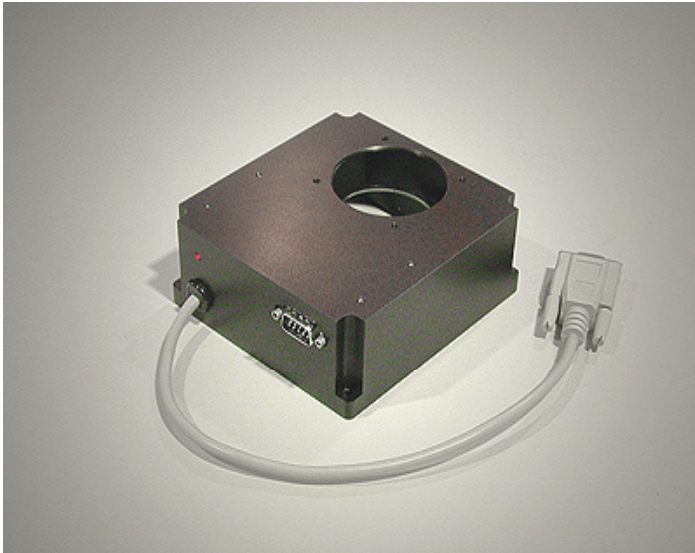


SBIG
Model AO-8
Adaptive Optics



Installation and Operation
Manual

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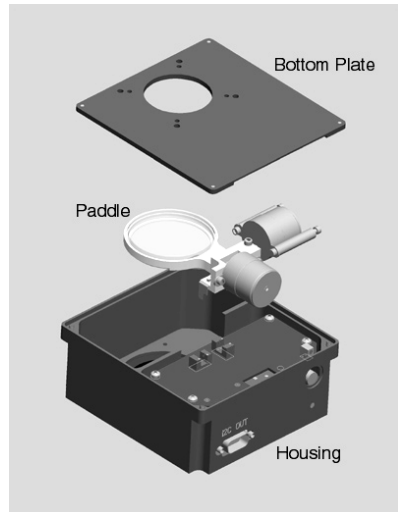
Introduction

Congratulations on your purchase of the AO-8, a second-generation Adaptive Optics device for your dual sensor ST series camera. Please take the time to read these instructions and carefully review your software's operating instructions for an SBIG AO. Each software program that supports the AO will have its own unique menu and set of commands. We therefore limit the instructions in this manual to installation of the device and an overview of its operation.

Important: Remove the bottom cover and take any foam or packing material out of the unit before operation.

AO-8 Design

SBIG's previous adaptive optics accessory, the AO-7, consumed quite a bit of back focus due to the use of a mirror at 45 degrees. It's alignment was quite critical since it could shift the optical axis considerably if misaligned, and it was also somewhat delicate due to the use of a membrane under tension in two axes to support the mirror. In addition, it had an issue with image rotation at large deflections, which becomes serious for large CCDs, but was not a problem for the smaller CCDs of the ST series. For these reasons SBIG designed a new Adaptive Optic device for high speed beam steering called the AO-L (Adaptive Optic – Large Format), which could cover the larger CCDs. The same approach has been extended to the ST camera line with the AO-8, a less expensive unit for smaller CCDs, but operating in much the same way. It is shown in an exploded view above.



Incoming light passes through a 6 mm thick plane parallel plate that can be tilted by the action of two geared stepper motors. The total amount of tilt in each direction is ± 9.6 degrees. The light beam is deviated by 36 microns per degree of tilt, so the maximum deviation is ± 346 microns, or ± 38 pixels with an ST-7/8. We have done careful ray tracing to convince ourselves that no focal shift or significant aberration occurs as the plate is tilted over these small angles, nor is there any distortion, rotation, or change in magnification. Our testing has verified these results. The window is AR coated with the same high quality coating on our ST chamber window, and has less than 1% reflection per surface from 400 to 900 nm wavelength.

The AO-8 is somewhat slower than an AO-7, since the motor and gearbox can only tip the motor at 18.75 degrees per second, or 75 pixels per second. In this design moves are slew-rate limited. What this means to the user is that the user should use a focal length that does not produce too large of a star image. For example, if the seeing is bad and the star is 9 pixels across, it is probably jumping around by 4.5 pixels or so with each look, which would take 60 milliseconds to move. If under such conditions you reduced your focal length to where the star was only three pixels across, only 20 milliseconds are spent making the move, and you can achieve a higher update rate with the AO-8. The total overhead in the software for an AO-8 move is 45 milliseconds. If, for example, you are taking 50 millisecond exposures with an optimized focal length (~ 3 pixel Full Width Half Maximum stars), the total cycle time is $45 + 50 + 20$ ms, or 115 ms (8 updates per second). The AO-7 advantage was that a move of any length is 20 milliseconds, but the exposure and overhead times were similar. Based on our experience and knowledge, the corrections made by the AO-8 help with reducing ground layer atmospheric turbulence, and are quite effective in reducing guide errors and wind buffeting. The smallest increment of move for the AO-8 is 0.075 degrees per axis, or 2.7 microns, about a third of a pixel. A spring is included to take up the backlash in the motor gearboxes.

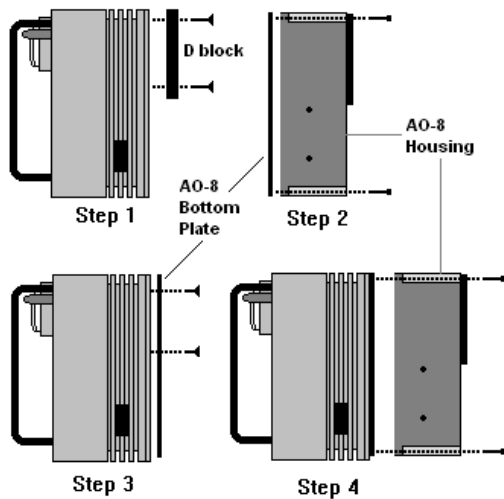
AO-8 Installation

The AO-8 is designed to be bolted directly to the front of an ST series camera with or without a filter wheel. In the case of the

CFW8A filter wheel, an adapter is required to provide the correct bolt pattern.

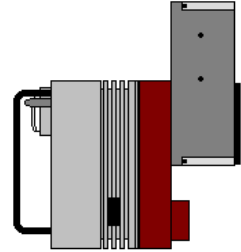
To attach the AO-8 to an ST camera without a filter wheel:

1. Remove the “D” block from the camera by unscrewing the four Phillips head screws that attach the D block to the ST camera body.
2. Remove the bottom plate of the AO-8 by removing the 4 hex head screws at the corners of the AO-8 housing. Remove any pieces of neoprene or foam that were inserted between the window paddle and the bottom plate during shipment. Save these in case the unit ever needs to be returned to SBIG.
3. Using the 4 screws provided, attach the bottom plate of the AO-8 to the camera. The smooth, featureless side of the bottom plate faces the camera and the side with the cut out faces away from the camera.
4. Attach the AO-8 housing to the AO-8 bottom plate
5. Plug the cable from the AO-8 into the I2C-AUX port on the camera. If the CFW-9 or CFW-10 is already plugged into the I2C-AUX port on the camera, remove its connector and plug the AO-8 into the camera instead. The filter wheel will then connect to the I2C-AUX OUT port on the AO.



To attach the AO-8 to an ST camera with CFW9 filter wheel:

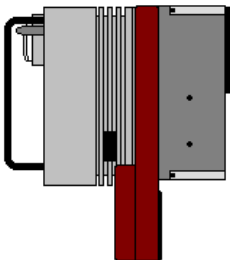
Basically you follow the steps for attaching the AO-8 to the camera, except that you attach the AO-8 bottom plate to the front cover of the filter wheel. The CFW9 has the same bolt hole pattern as the ST camera body. However, you will see that the filter wheel motor prevents the AO-8 from being oriented the same way as it is on a camera without a filter wheel. In this case, rotate the AO-8 bottom plate 180 degrees so that it clears the motor cover. This way, no adapter is required. (If, for any reason this orientation presents a problem for your imaging system, the same adapter that is required for the CFW8A may also be used with the CFW9). Attach the AO-8 bottom plate to the filter wheel in this orientation making sure that the smooth, featureless side of the AO-8 bottom plate faces the filter wheel and the side with the cut out faces away from the filter wheel. Finally, attach the AO-8 housing to the AO-8 bottom plate making sure that the aperture in the housing is aligned with the aperture in the bottom plate and you can see through the AO-8 and the filter wheel to the camera window.



Camera + CFW9 + AO-8

To attach the AO-8 to an ST camera with a CFW10 filter wheel:

Follow the steps for attaching the AO-8 to the camera, except attach the AO-8 bottom plate to the front cover of the filter wheel.



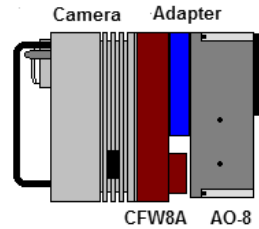
Camera + CFW10 + AO-8

The CFW10 has the same bolt hole pattern as the ST camera body, so no adapter is required. Also, the CFW10 cover is large enough that the AO-8 can be attached to it in the same orientation as it is when the AO-8 is attached to the camera body without a filter wheel.

To attach the AO-8 to an ST camera with CFW8A filter wheel:

Unlike the CFW9 and CFW10, the CFW8A filter wheel does not have the 4-hole bolt pattern on its cover to allow a direct connection of the AO-8.

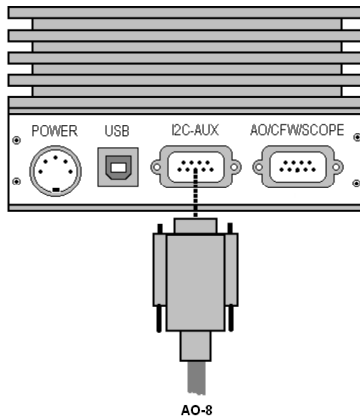
Therefore, an adapter is required. This adapter picks up the bolt pattern around the perimeter of the CFW8A on one side and provides the same 4-hole bolt pattern as the ST camera on the other side. It also acts as a spacer allowing the AO-8 to clear the motor on the filter wheel so that the AO-8 does not have to be rotated 180 degrees as it does when attached to a CFW9 without an adapter, although it can be rotated if desired.

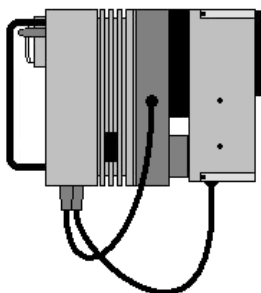


First attach the adapter to the CFW8A following the instructions that are supplied with the part. Then, attach the AO-8 to this adapter the same way as described in the previous sections.

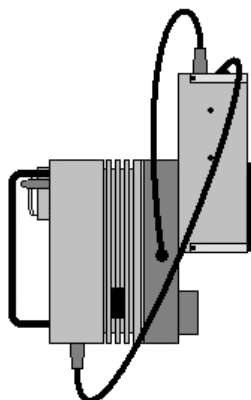
Electrical Connections

Plug the AO-8 connector into the I2C port of the camera. The AO-8 gets its power and communicates through this one port. If a filter wheel is already using this port, unplug the filter wheel and plug in the AO-8, then you can plug the filter wheel connector into the I2C OUT jack on the AO-8 (See diagrams on next page).

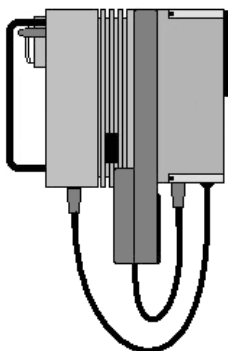




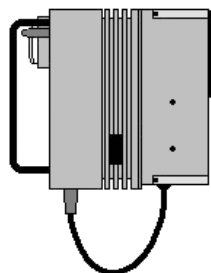
AO-8 with CFW8A
 Connect the AO-8 to the I2C-AUX port on the camera.
 Connect the CFW8A to the AO/CFW/SCOPE port on the camera.



AO-8 with CFW9
 Connect the AO-8 to the I2C-AUX port on the camera.
 Connect the CFW9 to the I2C-OUT port on the AO-8.



AO-8 with CFW10
 Connect the AO-8 to the I2C-AUX port on the camera.
 Connect the CFW9 to the I2C-OUT port on the AO-8.



AO-8 without filter wheel
 Connect the AO-8 to the I2C-AUX port on the camera

Operation of the AO-8:

Most programs (CCDOPS, CCDSOFT, and Maxim DL) can perform guiding with an SBIG AO device. Check the program manuals to see how this is done. Options to just guide with the AO-8, or to guide with a combination of the AO-8 and mount moves are available. In the past AO devices have required calibration, but this is not necessary with the AO-8, once all programs implement a default calibration. At the time of this writing, only CCDOPS has a built-in default calibration so you should check with the vendor of the software you are using to see if this feature has been implemented. If the camera and AO-8 are attached to each other so that the cables all exit the units in the same direction, then the default calibration should work. If the AO-8 is attached with the cables facing the opposite direction from the camera cables (e.g., using a CFW-9 without an adapter), then use the “180 degrees” default calibration numbers. Of course, one can always do a fresh calibration with an AO-8, but it should not be required.

If the user has a good mount with accurate PEC correction then it is quite possible that the AO-8 can do all of the guiding, and no connection need be made to the mount. The BIG advantage of this is that if you need to rotate the camera-AO-8 assembly to find a guide star, you do not need to recalibrate! This is very helpful when imaging through color or narrowband filters.

Hints/Troubleshooting:

Cleaning: If the window ever needs cleaning do not remove the paddle assembly from the AO. If one removes the AO-8 housing from the camera then both sides of the glass can be reached with cotton swabs. Use cotton swabs and isopropyl (rubbing) alcohol to clean the window. Never re-use a cotton swab. Keep using fresh ones, and eventually all oil on the window will be removed. The AR coating on the window makes any residual oil very apparent.

Exercise mode: the AO-8 should re-center every time it is powered up. You can also exercise the AO-8 over its full range of operation using the AO exercise command in CCDOPS with 1 second per axis. We have never had an assembly get lost and jam at the extremes of its range, but you should contact SBIG if this should happen.

Vibration: the AO-L does vibrate substantially in exercise mode, with an easily felt buzz. This is not a problem for the much shorter moves typical of actual operation.

Dimensional Data: Back Focus: The AO-8 is 1.9 inches (48.3 mm) thick. The T-thread adapter plate adds 0.2 inches (5 mm) to this. The thick glass plate inside the AO-8 optically reduces the apparent thickness by 2 mm, so the AO-8 plus adapter plate optical thickness is a total of 2.02 inches (51.3 mm). The CFW8A adapter plate adds 0.66 inches (16.8 mm) back focus. Weight (w/o adapter): 21 ounces (0.6kg).



AO-8 attached to ST camera with 2" nosepiece (not supplied) screwed into the T-thread adapter plate.