



## MAOP-706

### VisAO Focus Stage Operations

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## 1. Applicable Documents

[RD1] MAOP-700 MagAO Electronics  
[RD2] MAOP-705 VisAO Software

## 2. Acronyms and Abbreviations

AOS Adaptive Optics System  
ASM Adaptive Secondary Mirror  
MagAO Magellan Adaptive Optics  
TBC To Be Confirmed  
TBD To Be Determined  
TBR To Be Reviewed  
VisAO The MagAO Visible wavelength science camera  
VLAN Virtual Local Area Network  
W-Unit Wavefront Sensing Unit

## 3. Introduction


The VisAO focus stage provides for translating the CCD47 in optical Z independent of the pyramid wavefront sensor (WFS). The stage holds the CCD47, the shutter, F/W 2, F/W 3, and in the future will also hold the Luca EMCCD camera.

Details of the stage electronics, such as the controller and motor, are provided in RD1. The stage has electronic limit switches, which are hall sensors mounted on the non-moving WFS optical board and a single magnet attached to the moving stage. The stage is not encoded, so the electronic limit switches are the interior limits (first to be encountered). Next software limits attempt to prevent contact of the hard limits. Finally, safety is provided by hard limits. Contacting the hard limits will cause the stage control software to no longer have accurate knowledge of stage position, so these are used for mechanical safety only. Figure 1 illustrates the mechanical limits.

See RD2 for details of the software control of the focus stage.

The following table lists the basic specifications of the VisAO focus stage.

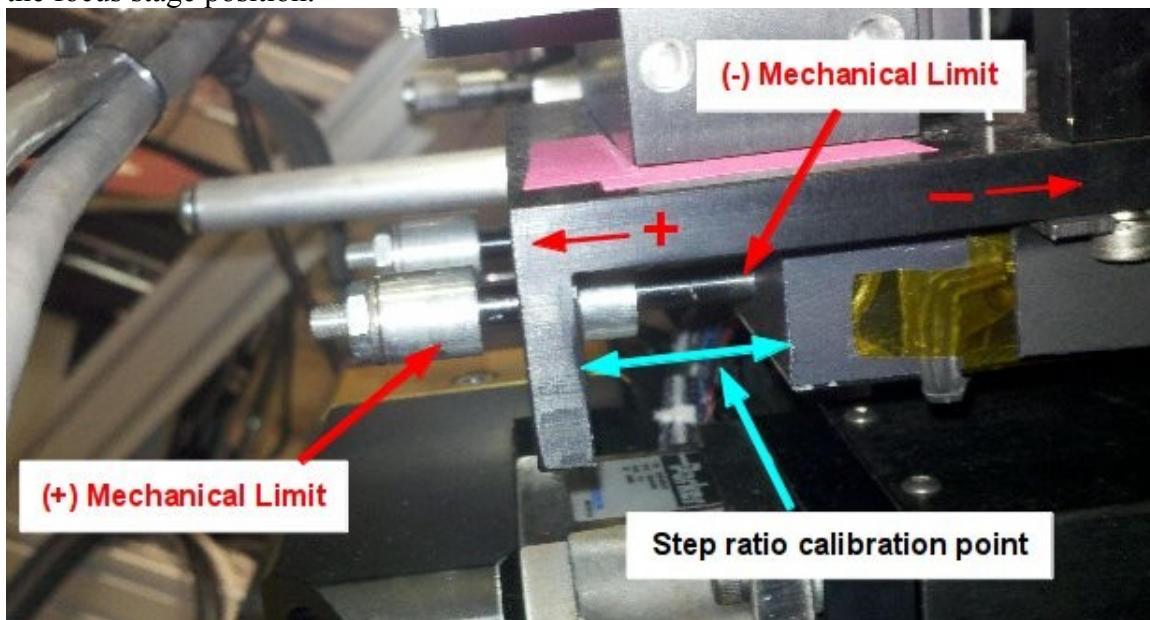
	Specification	Notes
Step ratio	3/8 $\mu\text{m}$ per step	Nominal, see calibration
Electronic travel range	2.13 cm	Nominal, depends on magnetic limit switches.
Software travel range	2.18 cm	A configuration setting.
Mechanical travel range	~2.2 cm	Mechanical stops provide

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		hard limits.
Speed	375 $\mu\text{m}/\text{sec}$	Based on typical software configuration of 1ms per step.

#### 4. Stage Initialization

The focus stage does not have an encoder, consequently the position of the stage reported by the software controller is determined by counting steps. The position of the stage is stored persistently on disk so that software restarts do not affect the accuracy of the focus stage position.



**Figure 1:** The rear section of the focus stage. The positive and negative directions of motion are shown. The (+) mechanical limit is formed by contact between the stage and the spacer. The (-) mechanical limit is formed by contact between the optical board and the front spacers. The step ratio is usually calibrated using a micrometer to measure the separation as shown.

From time to time the absolute position of the stage must be initialized to a known position. This should be an uncommon occurrence during normal operations. The most likely event to cause the need to initialize the stage will be disconnecting the gear from the stage for maintenance or shipping.

**Initial conditions:** To initialize the focus stage position counter the VisAO computer should be on, the VisAO software should be booted, and the VisAO engineering GUIs should be opened. The WFS Supervisor computer can be used to control the power state of the VisAO motors, or these can be turned on manually from the VisAO power strip.



**NOTE:** This procedure requires monitoring the position of the focus stage position by eye. This may require two people depending on where the computer used to control the stage is located.

**CAUTION: Initializing the focus stage requires disabling the positive limits in software. This should only be done for this procedure, and once complete the FocusMotorCtrl process must be restarted to restore limits to normal operations.**

**NOTE:** It is not possible to disable the negative limit.

Once the system is ready perform the following steps:

- 1) Using the GUI, take LOCAL control of the focus stage.
- 2) Open a terminal as user aosup on visaosup, and cd to ~/visao/fifos. Execute the command “echo disable\_pos\_limit > focusmotor\_com\_local\_in”. The GUI should now display a warning that the positive limit is disabled.
- 3) Now move the stage in the positive direction until it is close (half a mm or so) from contacting the back mechanical limits. See Figure 1.
- 4) When close to contacting the mechanical limits, begin moving in 100 micron steps in the positive direction. Test for contact using a screwdriver or hex wrench to agitate the spacer. Continue moving in 100 micron steps until it is not possible to move at least one of the spacers (they do not usually contact at exactly the same time).
- 5) When the stage is in contact with positive mechanical stops, edit the file ~/visao/init/focusmotor.init, changing the position to 12300.00. Save the file.
- 6) Restart the FocusMotorCtrl software. This can be done using the restart\_process python script: in the ~/visao/bin directory execute “./restart\_process.py focusmotor”. Once the restart is complete, the GUI should reconnect and now display 12300.00 as the current position. In addition to resetting the position counter, this also restores the (+) limit switch to normal.
- 7) The (+) limit switch should be active. Drive the stage in the negative direction by at least 700 microns to clear the (+) limit switch. Then attempt to move the stage in the positive direction by 300 microns. The (+) limit switch should stop the stage at approximately 11750 microns.
- 8) Now switch to the Advanced tab of the focus GUI, and press Home Negative. The (-) limit switch should stop the stage at approximately -9500 microns.



- 9) The stage is now initialized and ready for operations. A step ratio calibration should be performed if it has not been recently performed and is feasible.

## **5. Step Ratio Calibration**

The step ratio equates digital pulses to microns of motion. The nominal design step ratio, based on 3 micron lead screw pitch and a 1/8 step driver, is 3/8 microns per step. The as-built step ratio is around 0.38 microns per step.

The step ratio is calibrated by measuring the displacement of the stage with a micrometer at a convenient location. The FocusOps.calibration script in the FocusOps.py VisAOScript module automates stage motion and stores data manually entered. Figure 1 illustrates the point normally used to take measurements.

The outputs of the script are the parameters of the best fit line to the data. Residuals of the fit are usually better than 50 microns. The slope should be very near 1 if the calibration is good. If the fit is good and the slope is more than 0.01 different from 1, multiply the slope by the step\_ratio configuration parameter in focusmotor.conf and change the step\_ratio parameter. The FocusMotorCtrl process must be restarted for the new calibration to take effect.

After adjusting the step\_ratio parameter, the stage should be moved in both the positive and negative directions until the corresponding limit switch activates. Verify that this occurs at the values given in the initialization procedure above. If a significant change in step ratio occurs, it may be necessary to change the software limits.

## **6. Focusing The CCD47**

The CCD 47 camera is focused by moving the focus stage. The optimum position for a given camera configuration (i.e. beam splitter, filter, wollaston status) is determined using the FocusOps.focus python script. The script moves the stage a small amount (usually 250 or 500 microns), and stores a set of CCD 47 frames. After all data is taken, the data are analyzed using an IDL program (in the future this will be done automatically using a python routine).

Presets for common camera configurations are stored in the calib directory. These can then be selected anytime that configuration obtains, and the stage moved to the correct position. As of December 2011 it has not been determined how stable the focus position of the CCD 47 is relative to the WFS focus.