ALPAO AOS-0 Datasheet_revB

1. General introduction

The AOS-0 is a complete adaptive optics system based on the ALPAO Core Engine software. It includes a fast and large-stroke deformable mirror (Hi-Speed DM69-15) and a high-precision Shack-Hartman wavefront sensor, manufactured by Imagine Optic.

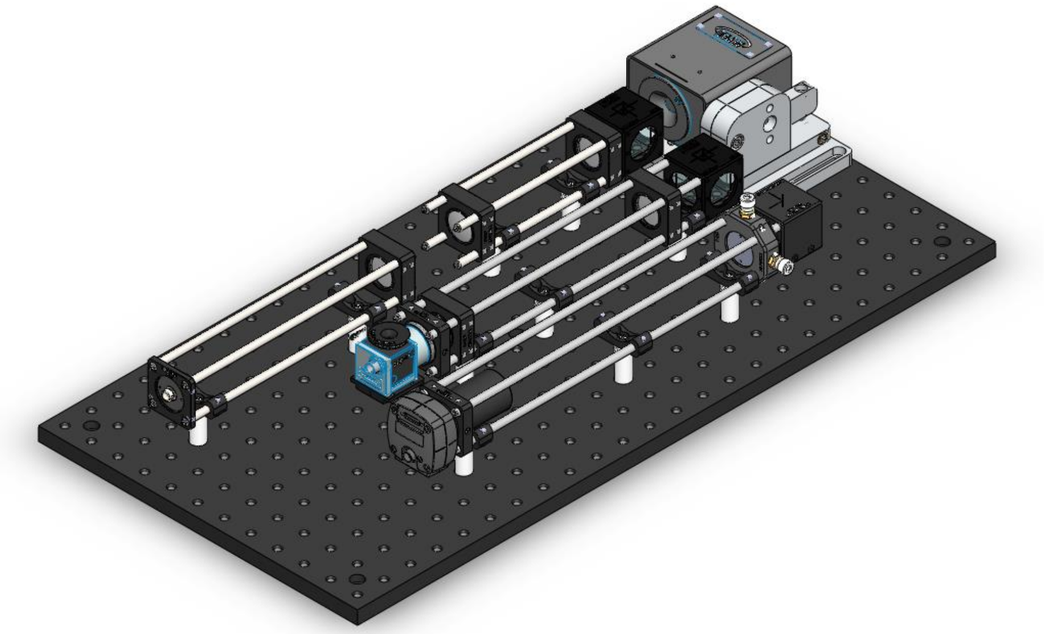

Figure 1 : The AOS-0 system

The AOS-0 system offers you:

- a ready-to-use approach for learning or teaching adaptive optics.
  - All components are included, even the breadboard and PC, with all drivers and software pre-installed.
  - A user-friendly graphical interface showing synthesized information while all of your data (e.g. raw images, calibration matrices) remain available at all time for deeper analysis.
  - Complete online documentation including step-by-step tutorials.
  - Delivered pre-assembled (fragile components are detached to avoid damage during shipment).
  - All little details that make the difference between a do-it-yourself kit and a ready-to-run system are included, even alignment tools, cable clamps, hexagonal keys, baffles to avoid parasitic light, etc…
- a powerful open-architecture tool for research:
  - All components use standard Thorlabs® optomechanical parts. It's easy to modify, upgrade or to tweak the AOS-0 system. A detailed guide to the alignment procedure and dedicated alignment tools allow you to quickly restore the system to its original state when needed.
  - Behind the graphical user interface, the ALPAO Core Engine (ACE) toolbox performs all necessary

computations. All data and commands can be started from user-defined scripts.

- The ACE toolbox runs within the standard Matlab® environment. You don't need a computer geek in order to operate the system. Using the provided examples and online documentation, you can easily write your own scripts or modify existing functions. For example, you can implement your own centroid algorithm, or your own sensor-less iterative algorithm. If you can code it in Matlab®, then you can run it for real on AOS-0.

Thanks to the flexible and ergonomic architecture, it is easy to learn and test ideas to control adaptive optics. The two different strategies described next provide an example. The first strategy consists in using the Shack-Hartmann wavefront sensor.

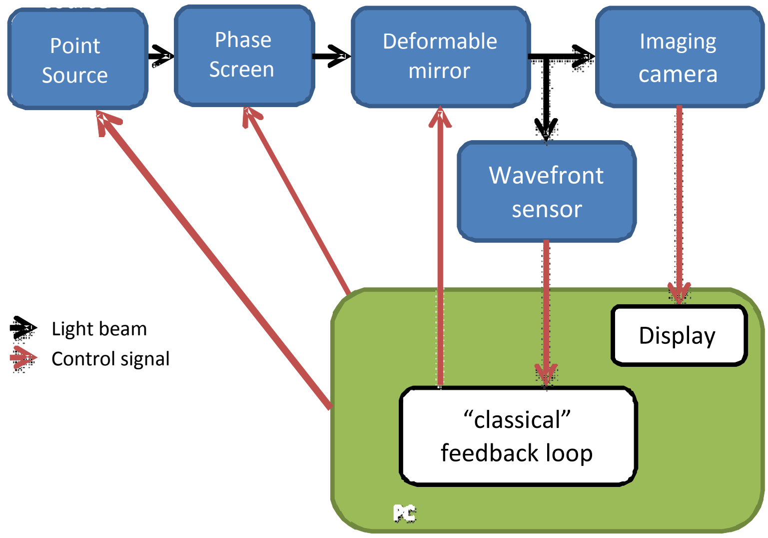

Figure 2: Classical Loop

The second strategy uses an imaging camera interfaced directly within ACE with all the data available in the Matlab® environment. Now you are ready to develop phase diversity or iterative algorithms.

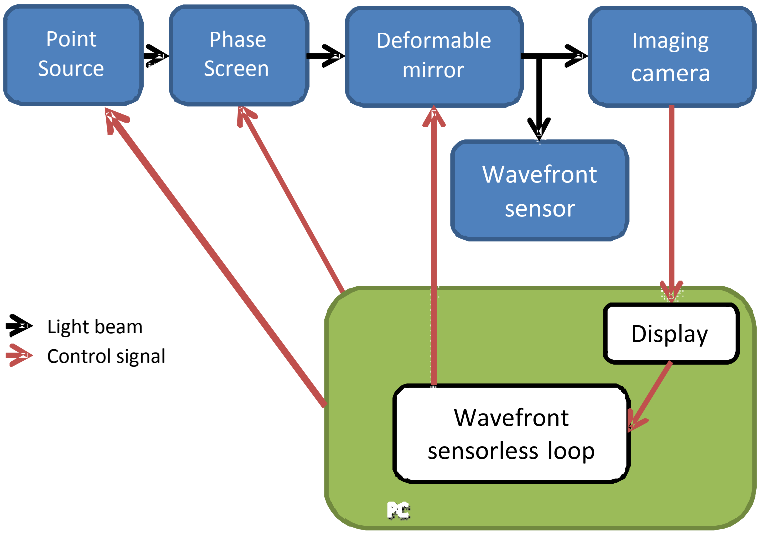

Figure 3: Loop with signal from a camera

Opto-electronic devices, such as the deformable mirror, the wavefront sensor, and the imaging camera are easily controlled through Matlab methods and properties. For example, in Matlab® type the following to quickly get data from the wavefront sensor:

```
[wavefront]= wfs.GetPhase()
```

The AOS-0 is delivered with built-in example scripts making it easy to get started. Our online help answers your questions to help you using the system efficiently. Our alignment tools and procedures helps you deal with the optics, even if you are not a specialist. Here are more examples to show you how easy it is to get started using AOS-0.

To get slopes from the wavefront sensor:

```
[sx,sy]= wfs.GetSlope() ;
quiver(sx, sy)
```

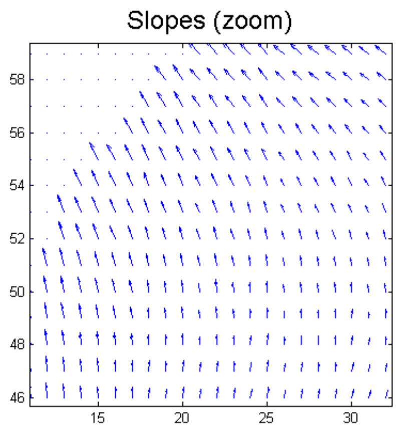

Figure 4: Enlarged View of the Slopes

<u>To get an image from the wavefront sensor detector:</u>

```
imWfs = wfs.GetImage() ;
imagesc(imWfs);
title('Raw Image');
```

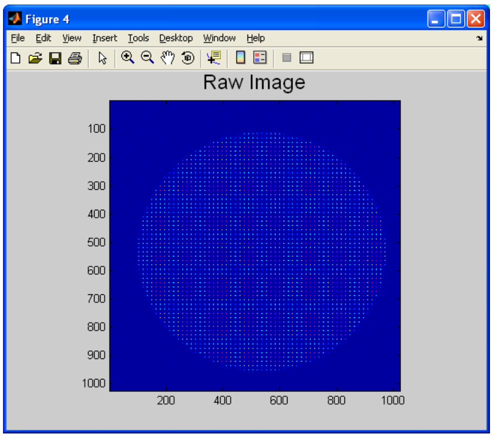

Figure 5: Raw Image Acquired by the Camera

<u>To get the wavefront measured by the wavefront sensor:</u>

```
phase = wfs.GetPhase() ;
imagesc(phase);
title('Wavefront')
colorbar;
```

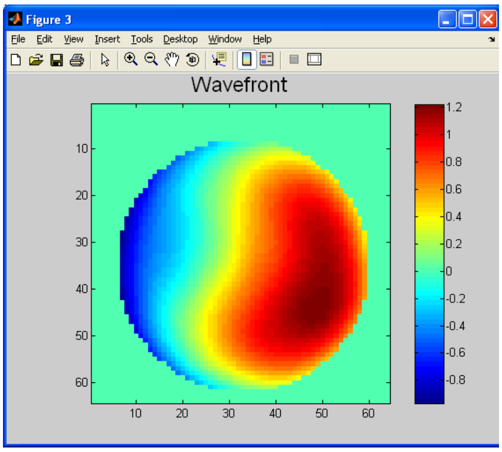

Figure 6: Reconstructed Wavefront

You operate the AOS-0 using an appealing graphical user interface.

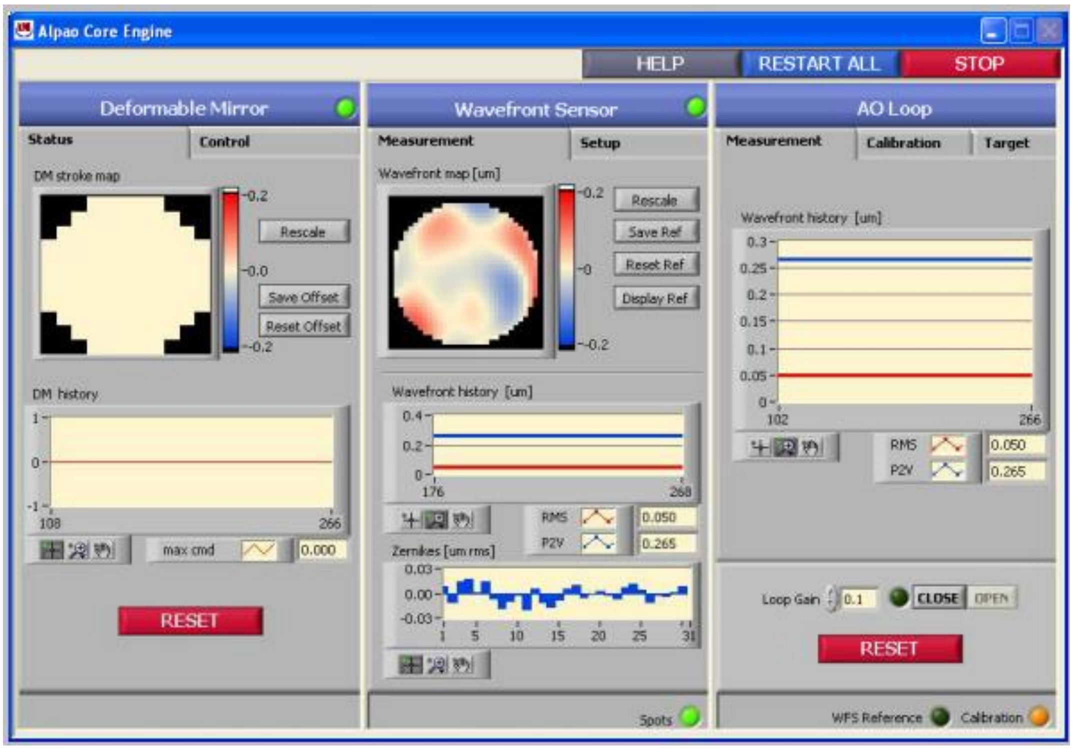

Figure 7: The AOS-0 Graphical User Interface

2. AOS-0 Main Elements

2.1. ALPAO DM69-15/DM97-15

Description	Specifications	Units
Useful pupil diameter	10.5 +/- 0.1 (DM69-15) 13.5 +/- 0.1 (DM97-15)	mm
Actuators	69 on a square grid (DM69-15) 97 on a square grid (DM97-15)	N/A
Pitch between actuators	1.5	mm
Wavefront tip/tilt stroke	+/- 60	µm
Wavefront inter-actuator stroke (P-V)	>3.0	µm
Bandwidth	> 750	Hz
Settling time (+/- 5%)	1.0	ms
Coating	Protected Silver	N/A
Non linearity errors	<3%	
Mechanical best flat (while driven)	<7	nm RMS
Dimensions (without cables)	84.6 x 74 x 53.1	mm

Operating temperature	min: 10 max 35	°C
Drive electronics		
PCI I/O Board		

2.2. Wavefront sensor (Imagine Optics HASO4 First)

Description	Value	Units
Absolute accuracy	λ/100 RMS	N/A
Repeatability	λ/200 RMS	N/A
Spatial resolution	32x40	sub-pupils
Pupil size	3.6 x 4.6	mm^2
Connection	USB 3.0	N/A
Single wavelength calibration	λ/100 RMS within +-50nm	N/A
Max. Acquisition frequency	100	Hz
included: HASOv3, wavefront analysis software Full detection area. Calibration wavelength to be confirmed when placing P.O.		

Figure 8 : WFS Haso4 First

2.3. Imaging camera specifications (IDS UI-3240ML-M-GL)

Description	Specifications	Units
Chip	CMOS Monochrome	N/A
Size	6.782 x 5.427	Mm
Sensor bit depth	10	bit
Resolution	1280 x 1024	N/A
Pixel Size	5.3	µm
Frame rate	60	fps

Dynamic range	60	dB
Dimensions	47 x 46 x 28	mm
Connection	USB 3.0	N/A

Figure 9: Imaging camera IDS UI-3240ML-M-GL

2.4. Turbulence module

To generate turbulence in the optical path, two options are available. A phase screen, introducing atmosphere-like turbulence or a set of trial lenses, generating lower order aberration like astigmatism and defocus.

2.4.1. Phase screen (Lexitek)

A turbulence phase screen including a manual rotator is provided. This phase screen introduces time-dependent aberrations with appropriate spatial frequencies.

Description	Specifications	Units
Technology	Near-Index-Match	N/A
Diameter	100	mm
Active area	83	mm
Coating	R<0.75% @ 500-1000nm	N/A

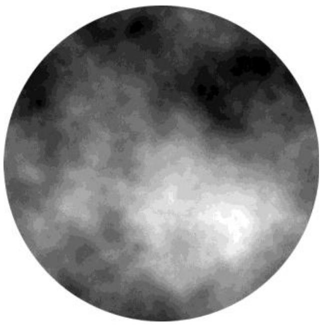

Figure 10: Typical Phase plate pattern, Lexitek.com®

2.4.1. Trial lenses

This very cost-effective solution enables the user to introduce low-order aberrations like astigmatism and defocus using a set of standard optician trial lenses. Together with the trial lenses , ALPAO provides a lens support allowing you to conveniently manipulate the lenses during AO loop operation.

Figure 11: Set of trial lenses

2.5. Light source

The light source provided is a fiber-coupled single-mode laser diode, emitting at 632nm.

Description	Value	Units
Wavelength	635	nm
Typical power output	2.5	mW
Fiber connectors	FC/PC	N/A
Fiber type	Single mode	N/A
Mode diameter @ $1/e^2$	4.3	µm

3. Miscellaneous elements included

- All opto-mechanical parts including the breadboard
- A set of procedures to drive the system from Matlab® and a LabView® graphical user interface.
- A computer with pre-installed software (keyboard, mouse and screen not included)
- Microsoft Windows 7 (32 bit)

4. Adaptive Optics (AO) simulator

An AO simulator is provided with the AOS-0. The simulator is based on the ALPAO Core Engine (ACE) and uses the same commands and graphical user interface. It allows you to develop scripts, user interfaces, and applications even when you are far from your optical set-up. This reduces the time needed for including adaptive optics in your instrument.

5. Document properties

Property	Value
Revision	B
Date	28/08/2014
Author	VHA, ASC

6. AOS-0 Options

Serial number	DM Type	Turbulence module
AOS-69-TL	DM69-15	Trial lenses
AOS-97-TL	DM97-15	Trial lenses
AOS-69-PS	DM69-15	Phase screen
AOS-97-PS	DM97-15	Phase screen