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MAOP-700

MagAO Electronics

Prepared By: Name(s) and Signature(s)		Date
Jared R. Males		2012-Feb-8
Approved By Name and Signature	Title	Date
Laird Close	PI	
Victor Gasho	Program Manager	

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1. Applicable Documents

- [RD1] Dell Precision R5400 Rack Workstation Technical Guide
- [RD2] Netgear GS716t V1 user manual
- [RD3] MAOP-703 The MagAO Network
- [RD4] ProSafe 5-port and 8-port Gigabit Desktop Switches 10/100/1000 Mbps GS105v3, GS108v3 Data Sheet
- [RD5] APC Back-UPS RS1500 User Manual
- [RD6] MAOP-704 MagAO Software
- [RD7] MAOP-705 VisAO Software
- [RD8] The "Little Joe" Digital Camera Rev C (2008)
- [RD9] MAOP-701 Configuration and Characterization of the MagAO CCD39
- [RD10] MAOP-702 Configuration and Characterization of the MagAO CCD47
- [RD11] Faulhaber Brushless DC Servomotors Series 1628...B (Spec. sheet)
- [RD12] Faulhaber Motion Controller Series MCBL 3003/06 S (Spec. sheet)
- [RD13] Faulhaber Motion Controller MCBL 3003/06 S Instruction Manual
- [RD14] Honeywell SS345PT/SS445P Unipolar Hall-Effect Digital Position Sensors With Built-in Pull-up Resistor (Spec. sheet).
- [RD15] PI S-330 Piezo Tip/Tilt Platform Specifications
- [RD16] PI S-330 Tip/Tilt Platform User Manual
- [RD17] <http://www.pimicos.com/web2/en/1,5,100,dt65n.html>
- [RD18] Pollux High Resolution Positioning Drive Manual
- [RD19] Piezo Jena Series PXY Specifications
- [RD20] Parker Ultra Series Screw Driven Table Specifications
- [RD21] Metronix Servomotor Characteristics
- [RD22] Copley Controls Xenus Micro Digital Servo Drives Specifications
- [RD23] Xenus XTL User's Guide
- [RD24] Copley ASCII Interface Programmer's Guide
- [RD25] Haydon Kerk 35000 SERIES SIZE 14 STEPPER MOTOR LINEAR ACTUATORS (Spec Sheet)
- [RD26] Interinar Electronics BSD-02 Step Motor Driver Manual
- [RD27] IPC34XX Setup Guide (Eaton Corporation)
- [RD28] Xgen Xcite 400W 700W 1000W 1200W AC/DC power supply specifications.
- [RD29] Xgen Designers Manual.
- [RD30] PortServer I Configuration Guide and Reference Manual
- [RD31] VS14 and VS25 Shutter Specifications, Uniblitz
- [RD32] VCM-D1 Single Channel Shutter Driver Controller Specifications, Uniblitz
- [RD33] VCM-D1 Shutter Driver User Manual, Uniblitz.
- [RD34] SMC100CC Single-Axis Motion Controller/Driver for DC or Stepper Motor
- [RD35] Moxa EtherDevice Switch EDS-308/309 Hardware Installation Guide
- [RD36] Moxa NPort 5400 Quick Installation Guide
- [RD37] Moxa NPort 5400 Series User's Manual
- [RD38] Moxa ioLogik E1200 Series User's Manual
- [RD39] Microgate BCU-39 Documentation (TBD)



- [RD40] P6X58D-E Motherboard Manual (e5435_P6X58D-E.pdf)
- [RD41] Acromag Series PMC464, APC464, AcPC464 User's Manual
- [RD42] EDT Digital Video Framegrabbers User's Guide
- [RD43] Camera Configuration Guide for the PCI DV family.
- [RD44] Microgate: W-Unit Nasmyth Electronic Boxes Design Report, MAG-MIC-TRE-0002. [and Annexes]
- [RD45] Carnegie Observatories Dwg #55456-4
- [RD46] VisAO Box Cut Drawing
- [RD47] Carnegie Observatories Dwg #55464-9 With VisAO Modifications.
- [RD48] VisAO Panel Drawing

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
W-Unit	Wavefront Sensing Unit

3. Scope and System Overview

This document describes the electronics for the Magellan AO System (MagAO). Here we list each component, describe its function, and where applicable document any modifications and customizations made. This document is not intended as an exhaustive source for specifications for all components, rather it serves as an index for the appropriate documentation such as specification sheets and user's manuals for each component. The last section contains connector pinouts for cables not documented elsewhere.

Nearly all of the reference documents cited herein are available online at <http://visao.as.arizona.edu>.

4. Components

4.1. Supervisor Computers

The supervisor computers are twin Dell R5400 rack mounted workstations. They each contain dual Xeon quad-core processors (E5450), 8 MB of RAM, and two 1 TB hard drives in a RAID-1 configuration. These computers are used for operational control and telemetry monitoring of the AO system. Table 1 lists the main specifications of the supervisors. Technical details of the computers can be found in RD1.

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Component	Description
Processor	2x Quad Core Xeon Proc E5450, 3.0GHz,2X6MB L2 Cache,1333MHz
RAM	8GB, DDR2 ECC SDRAM Memory 667MHz, 4X2GB
Monitor	2x Dell Professional P2010H, Widescreen, 20in Viewable Image Size,HAS,VGA/DVI/ DP,CLIENT/ENT
Video	nVidia Quadro FX1700 512MB dual DVI Graphics Card, Dell Precision R5400
HDD	1TB SATA 3.0Gb/s, 7200RPM HardDrive with 16MB DataBurst Cache (Seagate Barracuda 7200.12)
Optical Drive	8X DVD-ROM, Data Only
Extra NIC	Broadcom 5709 Dual Port 1GbE NIC with TOE, PCIe-4

Table 1: Main specifications of the supervisor workstations.

The supervisor computers each have a Broadcom 5709 Dual Port 1GbE NIC with TOE, PCIe-4, 2 port ethernet adapter. Including the 2 on-board ports, the supervisors each have a total of 4 gigabit ethernet ports.

4.2. MagAO Switch

The main MagAO switch is a Netgear GS716t (V1) 16 port gigabit ethernet switch. The current switch is version 1 hardware, which does not contain good support for static ARP tables. An upgrade to a switch with such support may be required. Technical details of the switch are contained in RD2. See RD3 for further information about the MagAO network, including VLAN configuration of this switch.

4.3. www Switch

A Netgear GS105 ProSafe 5 Port Gigabit Desktop Switch. This device connects the computers in the MagAO system to the external network. See RD4 for technical specifications.

4.4. Computer Rack

The MagAO computer rack is an Anvil 1/2" ATA 20 Space Rackmount case with 30" of rackable depth, an inner rack shell with 2" foam shockmounting, recessed handles and latches, front pre-tapped rack rails, ABS exterior and front and rear removable lids. Rackable area with front and rear lids removed: 19.25 x 30 x 35" high. Estimated Outside Dimensions: 26 x 38 x 42" high. It is mounted on 3.5" Casters (225# capacity ea). One of the lids is attachable to either side of case to serve as a table

4.5. MagAO UPS

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Battery backup to the MagAO electronics is provided by one APC Back-UPS RS 1500VA (BR1500). Specifications and installation information are contained in RD5. See RD6 for details of software configuration of the computers regarding the UPS.

4.6. The CCD39 Camera

The SciMeasure CCD39 camera is the sensor of the MagAO wavefront sensor (WFS). Technical details of the Little Joe controller are contained in RD8. Further information regarding the configuration and characterization of the CCD39 is given in RD9.

4.7. The CCD47 Camera

The SciMeasure CCD47 camera is the scientific sensor of the VisAO camera, and also serves as the acquisition camera for MagAO. Technical details of the Little Joe controller are contained in RD8. Further information regarding the configuration and characterization of the CCD47 is given in RD10.

4.8. MagAO Beam-Splitter Wheel (Filter Wheel 1)

After visible light passes through input lens (L1) and the ADC, it encounters a beam-splitter (BS) housed in the MagAO Beam-Splitter Wheel (a.k.a. Filter Wheel 1). This wheel holds various BSs and an aluminum blank used for taking WFS darks. Light that passes through the BS goes on to the pyramid WFS, while reflected light enters the VisAO camera.

The BS wheel has a Faulhaber 1628 motor (1628T024BK1155+16/7 66:1+MG10) controlled by a Faulhaber MCBL 3006 S controller. RD11 documents the specifications of the motors, and RD12 documents the specifications for the controller. See RD13 for detailed configuration and operating instructions for the controller, and RD6 for further information on operation of the MagAO Beam-Splitter Wheel.

The BS wheel has a homing switch, which consists of a permanent magnet in the wheel and a magnetic reed switch on the base. Note that a significant difference between the BS wheel and the VisAO filter wheels is the use of 24V PLC logic for the BS wheel switch. This is a configuration option in the MCBL 3006S controllers.

4.9. VisAO Filter Wheels

The VisAO camera has 2 filter wheels. The first generally contains band pass filters, such as the SDSS r' , i' , and z' filters. The second wheel contains custom SDI filters (filters with two bandpasses on a common substrate) and various occulting masks for coronagraphy. In keeping with the LBT convention, where the beam-splitter wheel is

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considered #1, the VisAO wheels are labeled #2 and #3 respectively. Wheel #3 is an addition over the LBT baseline.

The two VisAO filter wheels are on a common mount. Each has a Faulhaber 1628 motor (1628T024BK1155+16/7 66:1+MG10) controlled by a Faulhaber MCBL 3006 S controller. RD11 documents the specifications of the motors, and RD12 documents the specifications for the controller. See RD13 for detailed configuration and operating instructions for the controller, and RD7 for further information on operation of the VisAO filter wheels.

Each filter wheel has a homing switch, which consists of a permanent magnet in the wheel and a Honeywell SS445P unipolar hall sensor on the mount. RD14 contains detailed information about the SS445P sensors. Note that a significant difference between the VisAO filter wheels and the LBT baseline is use of 5V TTL logic with these hall sensors, compared to 24V PLC logic in the LBT wheels using reed switches. This is a configuration option in the MCBL 3006S controllers.

4.10. ADC

The atmospheric dispersion corrector (ADC) consists of two rotating triplet-prisms in a common mount. The prisms are each rotated by one Faulhaber 1628 motor (1628T024BK1155+16/7 66:1+MG10) controlled by a Faulhaber MCBL 3006 S controller housed in the driver box. RD11 documents the specifications of the motors, and RD12 documents the specifications for the controller. See RD13 for detailed configuration and operating instructions for the controller, and RD6 for further information on operation of the ADCs.

Each ADC wheel has a homing switch, which consists of a permanent magnet in the wheel and a magnetic reed switch on the base. Note that a significant difference between the ADC and the VisAO filter wheels is use of 24V PLC logic for the ADC switches. This is a configuration option in the MCBL 3006S controllers.

4.11. Tip/Tilt Modulation Mirror Stage

The Tip/Tilt modulation mirror stage is a PI 330.4SL platform. It is driven by a custom Microgate current driver. RD15 documents the specifications of the PI 330.4SL, and the user's manual (RD16) contains additional information.

4.12. Pupil Rerotator

The Magellan AO Pupil Rerotator is a PI miCos DT-65N rotation stage with a 2 phase stepper motor, driven by a Pollux D Type 15 controller. See RD17 for details of the stage, and RD18 for operating instructions for the controller.



4.13. Camera Lens Stage

The Magellan AO WFS camera lens is mounted in a Piezo Jena PXY 200 SG (T-227-01) positioning stage. RD19 lists the specifications of the stage. The stage is driven by the custom Microgate current driver.

4.14. X-Y-Z Stages

X-Y-Z translation of the W-Unit is provided by a Parker U300-200 screw driven table. See RD20 for specifications of the Parker stages. The X-Y-Z stages are each actuated by a Metronix APM-SB02ADK2 servomotor. Specifications of the motors can be found in RD21.

The motors are driven by Xenus Micro XSJ-230-10 digital servo drives. Specifications for the Xenus drivers are provided in RD22, RD23 is the user manual, and RD24 is the ASCII programming guide for controlling the Xenus over RS232 serial. Additional documentation for the Xenus controllers can be found on the Copley Controls website.

4.15. Focus Stage

The VisAO focus stage moves the CCD47, shutter, and VisAO filter wheel assembly in the z direction. The actuator is a E35H4N-12 stepper motor with external lead screw (see RD25). The stepper driver is an Interinar Electronics BSD-02 Step Motor Driver (see RD26). The combination of these two components provides a resolution of 3/16mm per step.

The focus stage has 2 hall sensor based limit switches, a forward and back switch. These switches share a common magnet. It has been found that these devices provide precision to only a few hundred microns. So a middle home switch is wired but is not used, and now serves as an installed spare. The forward and back limit switches still provide an important safety feature.

The BSD-02 is controlled via digital TTL signals from the VisAO computer (see below), which also receives the digital output of the hall sensor limit switches. For more information about the control software and various safety interlocks see RD7.

The focus stage stepper motor has extensions permanently soldered to its 4 wires, to eliminate the need for a bulky connector near the optical beam. The extension has also been pre-soldered to the spare motor wires. The extension increases the load on the wires so extra care should be taken when handling the focus stepper to avoid damaging the motor wires.

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4.16. VisAO Power Strip

The VisAO Power Strip is an Eaton IPC3402-NET, an 8 outlet network controlled power strip. RD27 describes the steps required to assign an IP address to this device, which is part of the wfs network (see RD3). In brief: to configure the Eaton from its factory default settings, directly connect to the ethernet port of the Eaton, and follow step 2 of RD27. Once configured, using the telnet interface issue the following commands (following prompts, etc): AE0 <enter>, IS0 <enter> P <enter> 001<enter> 002<enter> 003<enter> 000<enter> 000<enter> 000<enter> 000<enter> 000<enter> 000<enter>. No saving is necessary.

The following table lists the outlet assignments.

Outlet	Component	Notes
J1	VisAO Switch	Auto on. Remotely can only cycle power with 5 second delay
J2	VisAO Computer	Auto on
J3	VisAO ts8	Auto on
J4	VisAO Motors	One power supply powers three motors.
J5	Shutter Driver	
J6	Gimbal Controllers	Controllers are chained, so only 1 power supply is used.
J7	Fan	
J8	Fan	

Table 2: Outlet assignments for the VisAO Power Strip.

The power strip is configured such that the first 3 outlets turn on when power is supplied. This will provide network access to the power strip via the switch (outlet J1), boot the VisAO computer, and power up the VisAO ts8. The remaining outlets remain off until a command is sent over the network.

The power strip is intentionally placed under control of a remote computer, other than the VisAO computer (nominally the WFS Supervisor workstation), so that the VisAO computer itself can be remotely powered down in the event of a system hang, and brought back up. For this to work the VisAO Computer BIOS must be configured to start on restoration of AC power.

So that network control cannot be inadvertently interrupted by powering down the switch, it is placed on outlet J1 which will only have its status cycled with a 5 second “reboot” period. See RD27 for further details of this feature.

The Eaton has on one occasion so far lost its telnet configuration for unknown reasons. The symptom is a refusal to connect, either on telnet port 23 or on http port 80.

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To correct, telnet to port 9999, and choose the menu option to reset factory defaults. Disconnect the ethernet, power cycle the main breaker, and reconfigure the unit as above.

4.17. VisAO DC Power Supply

DC power for the VisAO filter wheel motors and the focus stage motors is provided by one Excelsys XCC4444-00 power supply. This device accepts standard 110V power, and has slots for up to 6 power supply modules. Detailed specifications of the power supply are contained in RD28 and RD29.

The VisAO system currently uses 3 of the 4 modules, the fourth being left out of the unit as a spare. The power supply is mounted in the upper tray. The power supply outputs are adjusted for 12.5V for the two filter wheel controllers (MCBL 3006S) and 12.0V for the focus motor driver.

In addition to the complete unit, if necessary a replacement main board can be ordered under part number XCC-00 (which includes the case and fans, but no modules). Individual xg4 modules can also be procured.

4.18. VisAO Portserver (TS8)

Serial over ethernet control of the VisAO Filter Wheels and the Gimbal is provided via a Digi TS8 Portserver. RD30 provides details on configuring a Digi TS8. See RD3 for network configuration. Port assignments are shown in Table 3.

Port	Function
1	Filter-wheel 1
2	Filter-wheel 2
3	Gimbal
4	unassigned
5	unassigned
6	unassigned
7	unassigned
8	unassigned

Table 3: VisAO TS8 port assignments.

4.19. Shutter and Shutter Driver

The VisAO shutter is a Uniblitz VS-25, with a reversed coil for normally open operation, and the optional housing. The part number is VSR25S2T1-CR32509SP1, and

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it was procured from Vincent associates. General specifications for the VS-25 are contained in RD31.

The Shutter driver is the VCM-D1 single channel driver, also procured from Vincent associates. It is powered from the VisAO power strip. General specifications for the VCM-D1 are contained in RD32, details of VCM-D1 operation and configuration are contained in RD33. For VisAO the front panel switches should be set to Normally Open (NO) and Remote, and the LED synch circuit should normally be disabled on the back panel using the appropriate switch.

The Shutter is controlled in pulse mode using the digital I/O subsystem from the VisAO computer. The LED synch feature is normally disabled since the light is detected by the CCD47, but when it is on the synch signal is captured by the digital I/O subsystem as well.

The shutter is liquid-cooled by a custom designed heat sink. Replacing a failed shutter requires removing the heat sink from the old and reattaching it to the new shutter. New thermal pasted should be applied whenever the shutter is changed.

4.20. Gimbal Mirror

The VisAO gimbal mirror is a Newport VGM-2N. The X and Y actuators are Newport TRA6CC, each controlled by a Newport SMC100CC. See RD34 for specifications, configuration, and programming information for the controller. The controllers have a common power supply, a Newport SMC-PS80, which is powered from the VisAO power strip.

4.21. PI Driver (Planned)

A fast tip-tilt mirror, to replace or augment the gimbal mirror, is planned but not yet implemented. This will require the addition of a new high voltage driver.

4.22. VisAO Switch

A Netgear GS108 ProSafe 8-Port Gigabit Ethernet Desktop Switch. This switch is part of the wfs network (see RD3). No configuration is required for this switch. See RD4 for technical specifications.

4.23. CCD and Driver Box Switches

The CCD and Driver boxes each contain a Moxa Gbit Ethernet convert switch, with 2 fiber ports and 6 copper ports. The manufacturers part number is EDS-G308-2SFP-T. See RD35 for specifications and hardware details. See RD3 for a description of the MagAO network.



4.24. CCD and Driver Box Serial Converters

The CCD and Driver Box use Moxa 5450 4-port RS-232/422/485 serial device servers. The CCD Box contains one and the Driver box contains three. See RD36 for an installation overview and RD37 is the user's guide.

4.25. CCD and Driver Box Moxa Digital I/O

The CCD and Driver boxes use Moxa ioLogik E1212 Ethernet Remote I/O modules for digital I/O. These devices are used to control the power relays. See RD38 for detailed information.

4.26. BCU-39

Documentation for the BCU-39, the framegrabber for the CCD-39, is to be provided by Microgate. It will listed here as RD39.

4.27. VisAO Computer

The VisAO computer consists of a custom mounted ATX motherboard and Intel Core i7-980x processor. It houses the CCD 47 framegrabber and the digital I/O distribution board. These components are documented further below.

4.27.1. Computer Components

Table 4 lists the main components of the VisAO Computer.

Component	Make & Model	Notes
Processor	Intel i7-980x	
Motherboard	ASUS P6X58D-E	See RD40
RAM	12 GB G-Skill 3x4GB DDR3 1600	Corsair 3x4GB DDR3 1600 also works (spared)
Hard Drives	2x WD Caviar Black 1TB	RAID 1 Configuration
Video	VGA Galaxy GeForce GTX465	
Ethernet	Startech.com 4 port PCIe	
Power Supply	Corsair TX750W	
CPU Heatsink	Thermaltake-Universal CPU Cooler-CL-P0540	

Table 4: The main components of the VisAO computer.

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4.27.2. Analog and Digital I/O

Digital input and output is provided using an Acromag APC464 64 channel Digital I/O and Counter Timer Board (PCI). The outputs drive the shutter and the focus stage motor. The inputs currently read are the shutter synch signal (when activated) and the focus stage limit switches. Access to the card is via an Acromag 5025-288 termination panel, which has 68 pins. See RD41 for more information about the APC464.

4.27.3. CCD47 Frame Grabber

Data from the CCD47 is captured by an EDT PCI-DVK framegrabber card. See RD42 for detailed information about the card, and RD43 for instructions on configuring it. RD10 contains additional information about the CCD47 installed in the MagAO system.

4.27.4. SCSI Cables

Due to the tight clearance between the PCI card interfaces and the front of the VisAO Electronics box the connections between the Digital I/O card and breakout board, and between the framegrabber and Little Joe, are made with custom right angle SCSI cables. These were procured from CS Electronics. The part numbers are given in table 5.

Cable	CS Electronics Part Number
1 Meter (I/O)	HD68TR-HD68T/1M-UNIV (PIN 1 DOWN)
3 Meter (CCD47)	HD68TR-HD68T/3M-UNIV (PIN 1 DOWN)

Table 5: Custom right-angle SCSI cable part numbers.

4.27.5. Tip/Tilt Camera Frame Grabber (TBD)

This component is not yet installed, but is planned.

4.27.6. External Optical Drive

An external USB optical drive is provided for the VisAO computer. It is a Rosewill DVD/CD ROM ROD-EX001. See RD7 for instructions on mounting an external drive on the computer.

4.28. The Flower Pot

The flower pot contains the test and calibration source and related optics. The flower pot documentation is TBD.

4.29. CCD and Driver Electronics Boxes



The CCD and Driver Electronics boxes are from Hammond Manufacturing, P/N RCHS1901717. See RD44 for details of the layout, wiring, and cooling design of these boxes.

4.30. VisAO Electronics Box

The VisAO Electronics Box is a Hammond Manufacturing P/N RCHS1901717. RD45, RD46, and RD47 show the custom modifications made to the sides to support the cable interfaces and cooling.

4.30.1. Main Interface

The main interface panel has the power connection (120V C14 Plug), 2 USB ports, and 6 ethernet ports. It also has a cable-way where all of the VisAO cables enter the box from the W-Unit. RD48 contains a drawing of this panel.

4.30.2. Auxiliary Interface

The Auxiliary interface houses the ATX power and reset buttons for the VisAO computer and provides 4 USB ports. RD48 contains a drawing of this panel. Note that the installed panel was modified to fit after being fabricated to the specifications in RD48.

4.30.3. Cooling

The VisAO electronics box is cooled by a Lytron heat exchanger, model 6120G1SB. The heat exchanger is on the MagAO glycol chilled water circuit. Two 120V AC fans force air through the heat exchanger.

5. Wiring and Connector Pinouts

5.1. VisAO Filter Wheels

The VisAO filter wheel cables are terminated with standard DB-15 connectors. The following table shows the pin assignments in these connectors. Colors refer to the motor wire colors (see RD11), or the hall sensor wires, not the colors of wires in the cables.



Pin #	Function
1	Motor Ph C Hall Sensor (Grey)
2	Motor Ph B Hall Sensor (Blue)
3	Motor Ph A (Brown)
4	Motor Ph A Hall Sensor (Green)
5	-
6	-
7	Home switch VS +5V (White)
8	Home switch OUT (Purple)
9	Motor GND (Black)
10	Motor Ph C (Yellow)
11	Motor +5V (Red)Table6
12	Motor Ph B (Orange)
13	-
14	-
15	Home switch GND (white/blue)

Table 6: VisAO Filter Wheel DB-15 pinout.

5.2. Focus Stage

The following table documents the pin assignments in the Focus Stage DB-15 connector. The 4 motor phase power connections include the motor wire color, the color of the permanent extension wires, and the BSD-02 terminal to which they are connected.



Pin #	Function
1	Motor Red - Extension White - Controller PH X
2	Motor Red/White – Extension White/Blue – Controller Ph X
3	Limit Switch 1 VS +5V (White)
4	Limit Switch 1 OUT (Purple)
5	Limit Switch 2 VS +5V (White)
6	Limit Switch 2 OUT (Purple)
7	Limit Switch 3 VS +5V (White)
8	Limit Switch 3 OUT (Purple)
9	Motor Green/White – Exten. White/Orange – Cont. Ph X
10	Motor Green – Exten. White/Green – Cont. Ph X
11	Limit Switch 1 GND (White/Blue)
12	-
13	Limit Switch 2 GND (White/Blue)
14	-
15	Limit Switch 3 GND (White/Blue)

Table 7: Focus Stage DB-15 pinout.

5.3. Inter-tray Connector

Digital I/O signals between the upper tray (motor controllers, power supply, and TS8) and lower tray (shutter driver, PI driver, and digital I/O breakout) of the VisAO Box pass through a DB-9 connector to allow the two trays to be racked out independently. The pin assignments are documented in the following table.

Pin	Function	DIO Ch.	Notes
1	Common	18	
2	Focus ENABLE	2	
3	Focus DIR	4	
4	Focus Hall Signal (FRONT)	13	
5	Focus Hall Signal (HOME)	12	Not used, is a spare.
6	-	-	
7	Focus STEP	3	
8	Focus +5V Out	10	Used for power-on indication.
9	Focus Hall Signal (BACK)	11	

Table 8: Inter-tray DB-9 pinout.

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5.4. Analog & Digital I/O Breakout Board

The APC pmc464 digital I/O PCI card is routed to a breakout board on the lower tray. The following table documents the pin assignments for this board. Note that directions are assigned in 8 pin blocks, and that only those terminals in use (out of 68) are documented here.

Terminal	Direction	Function	Notes
1	in	Shutter Pulse Input	To VCM-D1 shutter driver, BNC connector.
2		Focus ENABLE	
3		Focus STEP	
4		Focus DIR	
5		-	
6		-	
7		-	
8		-	
9	out	Shutter Sync Output	From VCM-D1. Normally disabled.
10		Focus +5V	
11		Focus FRONT	
12		Hall sensor	Spare. May be moved to the wollaston.
13		Focus BACK	
14		-	
15		-	
16		-	
17	common	Shutter BNC Grounds	
18	common	To GND	Also to inter-tray DB-9

Table 9: Terminal assignments for the digital I/O breakout board.

5.5. Hall Sensor Wiring

The following table documents the standard wire colors soldered onto the SS445P hall sensors used for limit switches in the VisAO filter wheels and focus stage.

Pin	Wire Color
VS	White
GND	White/Blue
OUT	Purple

Table 10: Hall sensor wiring colors.



6. Sparing Plan

Due to the remote nature of the LCO site, most of the components of the VisAO electronics system are spared. Table 11 documents the planned number of on-site spares for each component. It also documents the sparing plan for the testing period in Arcetri, Italy. In the priority column lower numbers indicate higher priority, which is set based on considering both criticality of the component to operation and the ease of obtaining a replacement. A current version of this plan, along with an inventory, is maintained at <http://visao.as.arizona.edu/>.

Subsystem	Component	Part	Testing Priority	On-site Priority	Spares Required
Focus Stage	Controller	BSD-02	2	1	1
Focus Stage	Motor/actuator		1	1	1
AO Supervisor Compu	Power supply		1	1	1
AO Supervisor Compu	Hard disks	Seagate Barr. 7200.12	2	1	2
AO Supervisor Compu	Ethernet adapter		2	2	1
AO Supervisor Compu	Motherboard		2	2	0
Power	Motor PS	Main board/chassis	2	1	1
Power	Motor PS	Fans	2	2	1
Power	Motor PS	Power module	1	1	1
Shutter	Shutter	VS-25	2	2	2
Shutter	Driver	VCM-D1	2	1	1
Filter Wheels	Controller		1	1	1
Filter Wheels	Motor		1	1	1
VisAO Computer	Motherboard		1	1	1
VisAO Computer	Hard disks		1	1	2
VisAO Computer	Power supply		1	1	1
VisAO Computer	CPU Heatsink/Fan		1	1	1
VisAO Computer	Memory Fans		2	2	2
VisAO Computer	Framegrabber	EDT PCI-DVK	1	1	1
VisAO Computer	Ethernet adapter		1	1	0
VisAO Computer	A to D IO Card	APC464	1	1	1
Network	Main Switch		1	1	1
Network	WWW Switch		2	1	1
Network	VisAO Switch		2	1	1
Network	VisAO TS-8		1	1	1
Little Joe	A/D board		1	1	1

Table 11: The MagAO Sparing Plan