VERY LARGE TELESCOPE

TECHNICAL SPECIFICATION
ESO Adaptive Optics System
Deformable Mirror Control

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1. INTRODUCTION

When light passes through the atmosphere, it is often distorted due to inhomogeneous air temperature and other effects. This distortion is undesirable for astronomical observations. It is, however, possible to compensate for this in real-time with a system that analyzes the distortion and improves the image by acting on a deformable mirror in the optical path. Such a system is referred to as an Adaptive Optics System.

A central element in this Adaptive Optics System is a Deformable Mirror (DM). To the backside of this mirror several bimorph piezo elements are attached forming an array. By applying voltage to each of those piezo elements, the mirror profile can be adjusted thus reducing image distortion significantly.

A relatively high voltage is required to drive the bimorph elements to the required deflection. A High Voltage Driver (HV Driver) generates this. The HV Driver is considered as a self-contained standalone unit, interfacing to a supervisory computer, and it connects directly to the Piezo array. Output values are passed to the HV driver from the Supervisory Computer as digital words over an optical fiber. Digital to analog conversion is done inside the HV driver.

1.1 Purpose

ESO will need to acquire HV amplifiers required for the ESO in-house developed AO system MACAO. This document lists technical requirements for the HV Driver, and also presents a delivery schedule.

1.2 Scope

Electronics requirements are outlined in Chapter 2, and Chapter 3 contains interface requirements. In Chapter 4 mechanical requirements are found. Deliverable documentation is listed in Chapter 5 and delivery schedule in Chapter 6.

1.3 Applicable Documents

None.

1.4 Reference Documents

None.

2. Electronics Requirements

2.1 System requirements

The HV driver shall consist of a number of separate, independent high voltage amplifiers, each capable of driving one Bimorph piezo element as specified in Section 2.2. One HV amplifier is referenced to as a channel. It is envisaged to group several such channels into groups that form a unit (number 8 in Figure 2.1). The system shall be expandable (modular) so that any number of channels can be configured. A typical system would need 60 channels, but it shall be possible to expand the system to drive up to 240 channels.

The Supervisory Computer (1) calculates HV output voltage values. Values are passed to the HV driver over a high-speed optical fiber interface (2 and 3) as a vector of 16-bit words. After a complete vector has been received, all HV drivers (8) should change their respective outputs simultaneously. A synchronization mechanism must be implemented.

A second optical fiber connection (4 and 5) between Supervisory Computer and HV driver shall serve as a service channel. This link needs only to be low to medium speed. Via this link the Supervisory Computer can read back actual output voltages and other status information. This information will be used for diagnostic and system self-test purposes.

2.1.1 Hardware Deliverables

A system block diagram is found in Figure 2.1. Parts inside the dashed line are deliverables, and considered as part of the HV driver system. These are:

- High-speed fiber link with interfaces (2 and 3)
- Service link with interfaces (4 and 5)
- HV amplifier Link Receiver and Controller board (6)
- HV amplifier internal backplane (7)
- HV amplifier boards (8)
- HV amplifier box (10)
- HV Power Supply (11)

Numbers within brackets refer to Figure 2.1.

2.1.2 ESO defined and supplied parts

The following parts are outside scope of work, and will be supplied by ESO:

- Supervisory computer Motorola PPC Model 2604 (1)
- Auxiliary board (9)

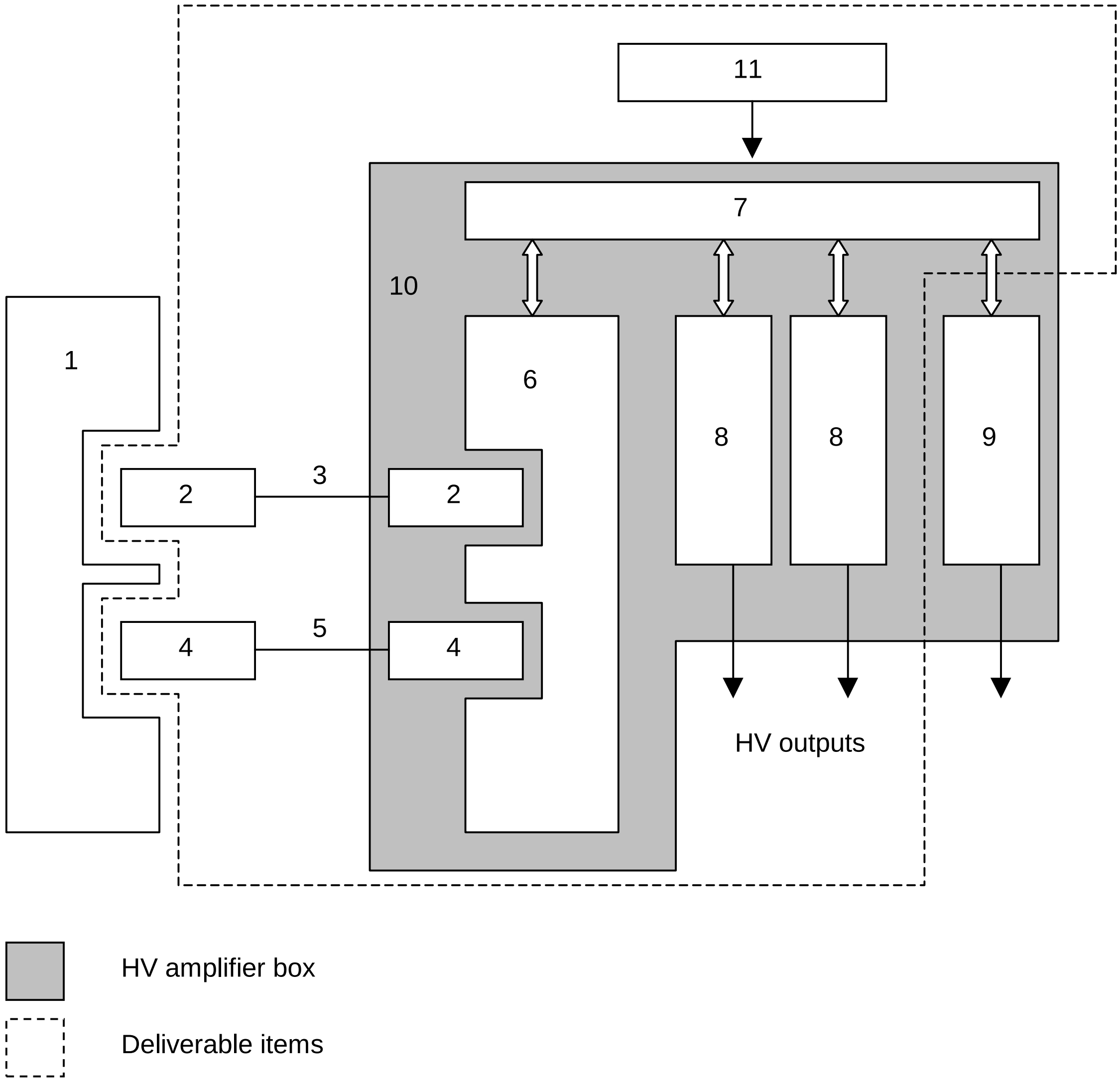

Figure 2.1 System block diagram

Figure 2.1 details:

#	**Description**	**See section**
1	Supervisory computer	3.1
2	High speed link interface	3.1-3.1.4
3	High speed link fiber	3.1-3.1.4
4	Service channel interface	3.2-3.2.5
5	Service channel fiber	3.2-3.2.5
6	HV amplifier controller board	
7	HV amplifier backplane	
8	HV amplifier boards (each with multiple channels)	2.2 , 2.4
9	Auxiliary board	2.5
10	HV amplifier box	4.1-4.2
11	HV power supply	2.4 , 2.9

2.2 Channel specification

Each channel shall comply with the following specifications:

- Single-ended bipolar output +/-400 V[1]
- Output current capability > +/- 10mA
- Electronic current limit +/- 6mA
- Amplifier bandwidth (-3dB) 2kHz
- Maximum phase delay 15 degrees @ 1 kHz
- Noise on HV outputs : < 100 mV P-P
- Output Linearity within 0.1 % over +/- 400 Volt output
- An output relay shall be provided, controlled from the Supervisory computer via commands through the service channel (described in section 3.2)
- D/A resolution 14 bit
- D/A update rate > 1.5 kHz (all HV outputs update synchronously)
- Output drive capacity: 10 nF.

2.3 Telemetry

The supervisory computer must be able to read back the following parameters, for each individual channel. Telemetry may be done off-line only, i.e. while not receiving and processing values over the high-speed link. It must be possible to retrieve all status information in less than 100 ms.

- Channel output voltage
- Channel relay status (open/closed)
- High voltage power supply level
- If possible, HV Amplifier board(s) temperature

2.4 Power consumption

This unit will be physically located close to the telescope optical path. For this reason, power dissipation shall be kept as low as possible. In particular, HV output stage quiescent current must be as low as possible. The HV driver will be mounted inside a liquid-cooled rack, where heat generation must be minimized.

[1] This specification is to be considered as a minimum value. If this value can be increased to +/- 600V it would be considered an important advantage.

2.5 Auxiliary board

For support systems other than Deformable Mirror HV drive, it must be possible for ESO to add an auxiliary board to the system, that will receive data sent from the Supervisory computer via the high-speed optical fiber link. At present there is a need to transmit two 16-bit words to this auxiliary board, but any number should be possible.

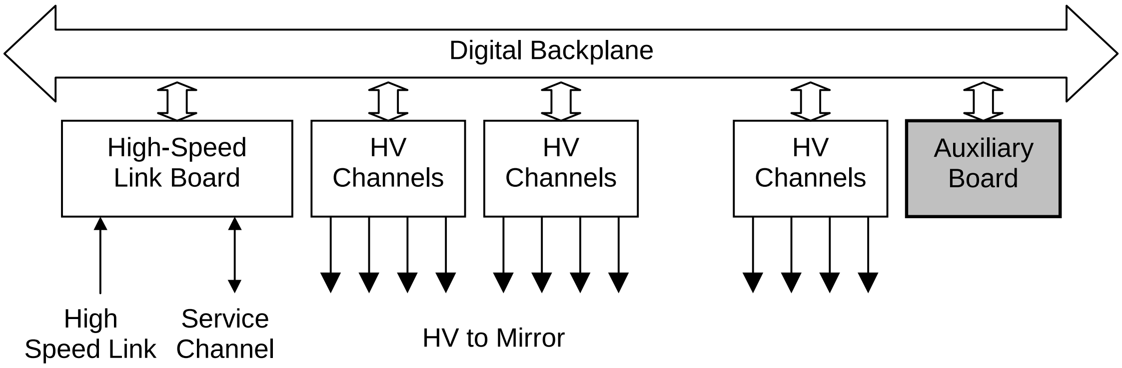

Figure 2.5 Auxiliary board

It is assumed that the HV amplifier system will be using some kind of electrical backplane for passing of digital data from the High-Speed link receiver board to the HV Amplifiers D/A-converters. The data for the Auxiliary Board should simply be passed from the High-Speed link to on-board registers. The parameters have the same format as data to the HV channels, and should be updated at the same rate.

The Auxiliary board will be designed and manufactured by ESO. For this reason it is important that the backplane protocol used is clearly defined and documented.

2.6 Service and maintenance

Measuring points shall be provided at D/A outputs and HV outputs. Self-test capability is considered important. Any fault detected should be flagged to the Supervisory Computer, and, if possible, displayed locally on a fault display or LED.

2.7 EMC

As this unit will operate with high voltage levels close to sensitive CCD readout electronics, it is extremely important to minimize any EM radiation. Shielding and proper grounding schemes are essential.

For maintenance personnel safety, a mechanism should be provided that disconnects all HV amplifiers output if the connecting cable from HV amplifier to Deformable Mirror is disconnected.

2.8 Plug'n'play

It must be possible to replace any board without re-calibration or board configuration (exception: board address coding).

2.9 Power supply

High voltage power supplies are required for the high voltage outputs. If possible, these power supplies should be integrated in the same 19-inch chassis as the amplifiers. If this is not judged possible, they should be housed in a separate 19-inch chassis that can be mounted either above or below the HV amplifier chassis. Care must be taken to assure appropriate cooling air circulation to the power supplies.

Power supply to the HV amplifier crate and HV power supplies shall be 230 VAC 50 Hz.

2.10 Altitude

The amplifier system must be capable of operating at an altitude of 2.800 metres above sea level (Paranal observatory).

3. Interface Requirements

3.1 Supervisory computer link

The Supervisory computer link should be a fiber link. The host end of the fiber link will be a PMC card mountable in the host computer, which is a Motorola PPC Model 2604 running VxWorks 5.3.

One example of a board implementing a PMC to fiber link using the Cypress HOTLink chipset is the FPMC-HL266 from TEK Microsystems

http://www.tekmicro.com/products.fastlinks.fpmc-hl266.html.

- Transfer Rate: > 30 Mbyte/s
- Latency: Time from first data word being sent from the Supervisory Computer to values being output from HVA < 150 us
- Distance: The fiber link should be capable of being at least 300m in length

3.1.1 Data Format

Frames of (N) 14 bit values, the data are packed into the lower 14 bits, top two bits are zero. The value of (N) is set by command over the service link.

The (N) values correspond to values for high voltage channels 1 to (N - NAux) and for AUX channels (N-NAux) to N. NAux is defined as the number of words to be passed to the AUX board, this value is set in via a command passed over the service channel.

At the start of each frame a synch word will be sent with the top two bits set to 1, this sync word should be used to resynchronize frames in case of data loss.

The 14 data bits should be interpreted such that 0x0 = -F.S. output and 0x3FFF = +F.S. output.

3.1.2 Heartbeat

The HVA box should keep a running count of the number of data frames, which have been received, this count will be accessible through the service link. This number shall be a 32-bit integer.

3.1.3 Watchdog

If the HVA box does not receive a frame within 2 seconds, the HV output relay should be opened (HV outputs disconnected).

3.1.4 General

Fiber link must not be emitting (leaking) light at any wavelength.

3.2 Service channel

The service link should take the form of a fiber RS232 link, the host end of the link should be a male D-SUB 25 connector.

3.2.1 Line Protocol

- Baud rate: 9600, 19200 or 38400 Baud (selectable)
- 1 start bit
- 1 stop bit
- No parity

3.2.2 Command format

Commands should be ASCII, CR terminated with a checksum. All commands should be acknowledged with a success or failure indication.

3.2.3 Supported commands

- Retrieve the current value of channel N currently output
- Get the status of the relay controlling the high voltage outputs
- Set the status of the relay controlling the high voltage outputs
- Get the value of the current high voltage supply
- Get the operating temperature of the HVA box (goal)
- Reset the HVA electronics box, set the HV relay off
- Inform the HVA box of the number of channels, which will be transmitted with each frame
- Inform the HVA box how many of the N channels should be passed to the AUX board. The last N channels should be passed and not treated as HV values
- Get heartbeat counter value
- Invoke selftest

3.2.4 Distance

Fiber link should be capable of being at least 300m.

3.2.5 General

Fiber link must not be emitting (leaking) light at any wavelength.

3.3 Connectors

For fiber interface connectors, refer to Section 3.1 and 3.2. High voltage output should use one ore more circular MIL-connector(s), rated at least two times the maximal output voltage. Power supply (230VAC) connector(s) shall be of DIN 49457 type.

4. Mechanical Requirements

4.1 Form factor

The boards shall be mounted in a 19-inch chassis. Chassis height shall be 6U, or 7U if cooling fans are an integrated part of the chassis. Maximal depth 500 mm. Industry standard 19" chassis hardware shall be used.

Power supplies shall preferably be integrated in the same 6U chassis. See also Section 3.4.

4.2 Cooling

It is important to keep power dissipation as low as possible. It is foreseen to mount a fan tray underneath the HV chassis to ensure sufficient cooling airflow. This fan tray may or may not be mechanically integrated with the HV amplifier chassis.

4.3 Unit identification label

Each unit shall be clearly labelled for identification purposes. At least the following information shall be included:

- Unit name
- Unit serial number
- Manufacturer
- Manufacturing date
- Power supply voltage, frequency and current

5. Documentation

The following documentation shall be delivered with each HV Amplifier system:

- Users manual
- Installation manual
- Maintenance and troubleshooting manual
- Acceptance test protocol

To be delivered with the first system:

- Schematics for all boards
- Backplane protocol description

All documentation shall be in english. If possible, in addition to paper documentation, electronic documentation is considered valuable. All documentation must be delivered before, or together with the delivery of the first system.

6. Project schedule

6.1 Project phase definition

The following milestones (**in bold**) and project phases (*italic*) are identified:

T0	**Kick-off meeting**
Phase 1	*Design phase*
T0 + 3-4 months	**Design report submitted to ESO for review**
Phase 2	*Manufacturing phase*
T0 + 6 months	**Delivery and acceptance test of Unit #1 and documentation according to Section 5 of this document**
Phase 3	*Series manufacturing of unit #2-#8*

6.2 Delivery schedule

A total of 8 fully tested units are reqiured. The first unit shall be delivered at the latest six months after contract award. Following delivery and acceptance of the first unit, ESO will require one unit every three months. Earlier delivery than proposed, or delivery of more than one unit at once, is accepted and encouraged. The above delivery scheme is to be considered as maximum delivery times.

The supplier shall propose a development and production planning which will meet the above schedule. This information is to be considered as a part of the bid, and must be presented clearly and separately.

7. Acceptance procedure

Each unit shall be going through an acceptance test upon delivery to ESO, and a test report shall be written for each unit. The test shall be performed by the supplier, in co-operation with ESO. The test procedure shall be produced by the supplier, and submitted to ESO for approval before delivery of the first unit

The following tests shall be performed for each unit:

7.1 Performance according to section 2.2 of this document (using simulated output load)
7.2 High speed link functionality
7.3 Service link functionality
7.4 Telemetry functionality as specified in section 2.3 of this document

The following tests shall be performed for the first unit only:

7.5 Power consumption at idle condition
7.6 Conducted EMC test (performed by ESO specialist using ESO test equipment)
7.7 Electrical safety check (performed by ESO specialist using ESO test equipment)
7.8 Review of documentation according to section 5 of this documentation

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