KEEP CONTROL: PULPO 2

ESO's new cryostat housekeeping unit

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Abstract: *PULPO 2 is ESO's new housekeeping unit to monitor and control temperature, pressure and shutter of the CCD systems. In particular, it can monitor up to 125 temperature sensors and control the focal plane temperature with up to 8 independent heaters. PULPO2 features a set of configurable alarm outputs for temperature and vacuum which can be connected to a Central Alarm System and/or a dialer. Self recovery feature ensures that the CCDs are protected in case of an alarm condition. System monitoring and debugging is guaranteed by intensive sensor data logging.*

Key words: CCD, vacuum control, temperature control, shutter control, safety

1. INTRODUCTION

Mosaics put tough requirements on temperature control and housekeeping functions. So far ESO has used PULPO (Haddad et al, 1998) for this purpose - 33 units have been built for 16 instruments - but today's mosaics like ESO's OmegaCAM (see Iwert et al., these proceedings) with 36 CCDs in the focal plane require a new approach (Reyes-Moreno et al, 2004; Iwert et al., these proceedings).

For this reason, ESO has developed a new housekeeping unit, PULPO 2 (Cumani et al, 2004).

Key features of PULPO 2 are:

- Monitoring of 29 PT100 sensors (4 wire system) by default and up to 125 with external multiplexer board.

- Temperature control of the focal plane with up to 8 independent heaters.
- Monitoring of the vacuum in the cryostat (by means of Balzers or Edwards vacuum gauges).
- Separate alarm outputs for temperature and vacuum.
- Shutter handling with control of the exposure time and measurement of open and close delays.
- Internal logging of numerous system parameters over time (up to 65000 records), thereby making PULPO 2 a valuable trouble shooting and optimizing tool.
- Backwards compatibility with PULPO.

The PULPO 2 control software exploits all capabilities of the hardware to implement further functionality for system monitoring and recovery to a safe state in case of failure.

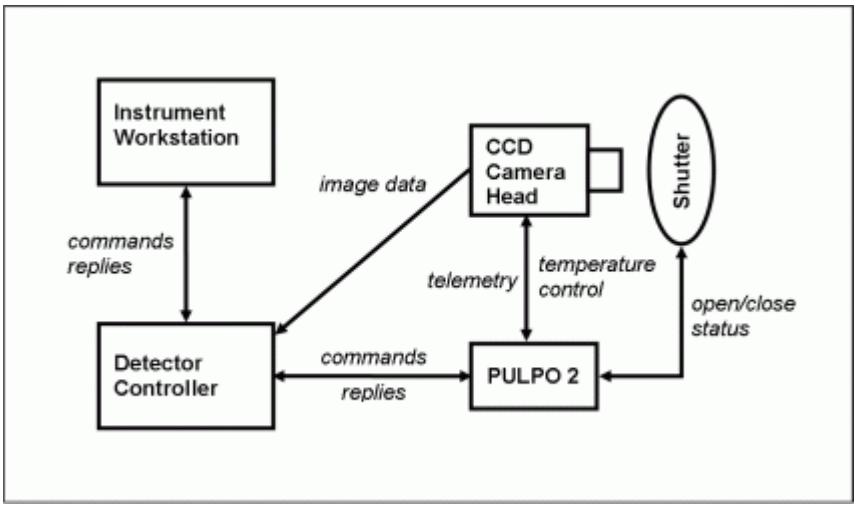

Figure 1. PULPO2 in the VLT environment

2. DESCRIPTION

PULPO 2 is a compact unit (230mm by 105mm by 120mm) containing two Eurocard size (160mm by 100mm) boards.

The CPU board contains an embedded PC running the PULPO 2 control software under Linux and provides power to the rest of the unit.

The peripheral board contains all circuitry needed to fulfill the required housekeeping functions: PT100 inputs, amplifiers and 16-bit ADC, shutter interface, alarm output, vacuum monitoring and temperature regulation.

The communication between the two boards follows the ISA bus standard (as defined in the "IBM PC/AT Technical Reference Manual").

3. THE HARDWARE

The PULPO 2 CPU board (Figure 2) is a Eurocard size board. The core component is a credit card size embedded PC module from Compulab. It hosts a complete PC with 486 processor, integrated 16 MB flash disk, 32 MB of RAM, Ethernet controller and all standard PC peripherals (serials, parallel port, IDE controller, etc).

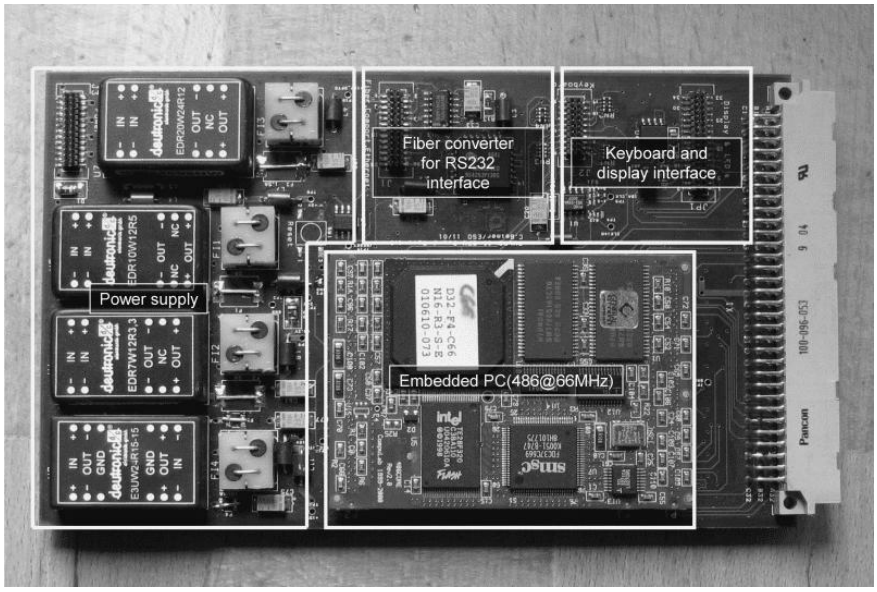

Figure 2. PULPO 2 CPU Board

PULPO 2 is supplied with +24V from the FIERA (Beletic et al, 1998) linear power supply. All internal voltages (+5V, +3.3V, ±15V and +12V) are generated on the CPU board by means of DC/DC converters. Each voltage has autoresetting SMD fuses. Standard bypassing plus additional PI filters are used to smoothen the supply voltages. A voltage supervisor, MAX 814, on the 5V supply is used to generate a reset on power-up and in case of a power failure. The MAX814 also provides the option of a manual reset via a button on the front panel. A 3V lithium battery - 3 years lifetime - is used to

keep the RTC (real time clock) on the 486Core running in case of a power failure.

The RS232-to-fiber interface is built around a ML4624 chip. It drives an Agilent HFBR 1414 transmitter and receives commands via a HFBR 2416 receiver. The fiber can be up to 1500m long.

The display on the front panel is a Varitronix MGLS 12864T.

The PULPO 2 Peripheral Board (Figure 3) contains all interfaces to the cryostat and the shutter. The core component here is a PLD, that controls all the interfaces on the board and takes care of the communication to the CPU board.

The sensor interface contains a multiplexer group with 32 inputs. One channel is used for monitoring the vacuum in the cryostat (Balzers or Edwards gauges - set by software), another one for the onboard sensing of the heater current and for an internal calibration resistor. The other 29 channels can be used to connect external PT100 sensors (4 wire system).

The output of the multiplexers goes via a two-stage amplifier with programmable gain into a 16-bit ADC. Low gain (G=8) is used for heater current and vacuum sensing. High gain (G=72) is used for PT100 input.

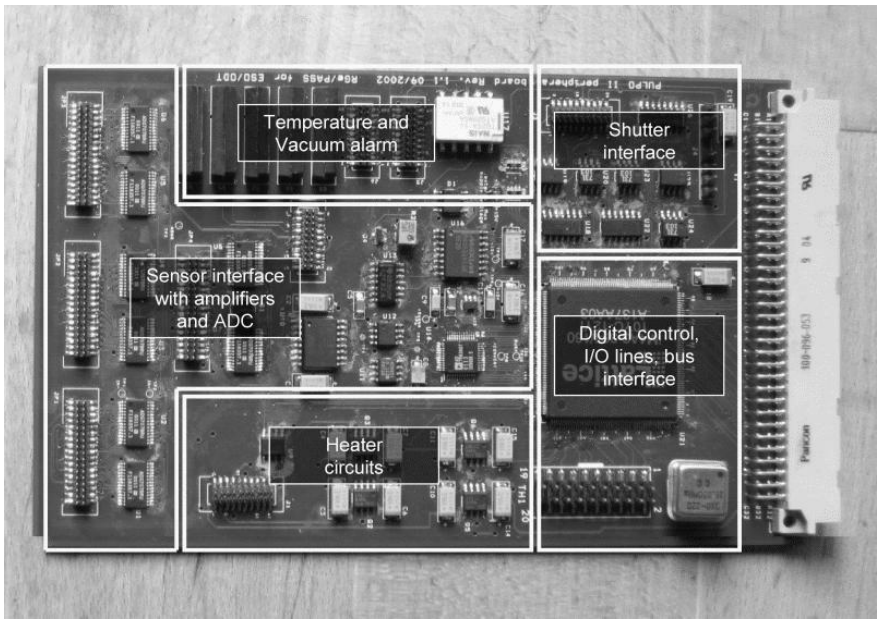

Figure 3. PULPO 2 Peripheral Board

PULPO 2 uses PWM (Pulse Width Modulation) for the heater control. The power dissipation inside the unit is therefore very small (~30mΩ per

heater). A total of 8 independent - or jointly used - heaters are available. The heaters are operated with the linear +24V supply in order to avoid switching noise (from the DC/DC converters) in the focal plane. The maximum heater current is 3A giving a maximum heating power of up to 72W.

PULPO 2 also features a set of alarm outputs for temperature and vacuum. Four independent alarm outputs are available (2 for temperature and 2 for vacuum problems). The alarm values for temperature and vacuum can be configured by software and can be connected to a Central Alarm System and/or a dialer.

Optical detectors normally require a mechanical shutter: to control a shutter, PULPO 2 offers 1 output (Open command) and 4 inputs (Open status, Close status, Remote and Fail). All of them are optically isolated in order to avoid ground loops. Exposure time counting and the measurement of the open and close delays are handled by the PLD. The logic for the I/O lines is programmable via the software enabling PULPO 2 to interface with almost any type of shutter.

4. THE SOFTWARE

PULPO 2 runs a customized version of embedded Linux. The code has been written in C and assembler. Different threads keep control of the temperature sensors and heaters, the shutter, the user interfaces (serial port, display, keyboard), using - on average - 4% of the CPU.

Most of the features offered by PULPO 2 are implemented via the control software on the CPU-Board.

The communication between the SLCU and PULPO 2 goes through a simple serial link (RS232).

The protocol consists of a two character command followed by several parameters (e.g.: the command *SP,1,153* sets the temperature control for heater 1 to 153 K). Currently there are 60 commands available. Several status bytes can be retrieved via the serial to get information about the current status of the device.

The software controls the peripherals via a set of registers that are implemented in the PLD. The PID tuner that is required for accurate temperature control is also implemented in Software. The accuracy of the temperature regulation is typically ±0.1 K for the control sensor assigned to a heater.

Other valuable software features are Data Logging and Self Recovery.

4.1 Data Logging

The 486Core runs embedded Linux. Therefore only 60% of the flash disk is used for the OS, leaving approximately 9MB free to store the data from the connected sensors. The logging interval is adjustable. The number of records than be stored on the flash disk is currently 65000. In the case of OmegaCAM this is sufficient to log all 101 sensors for almost 7 days if the log interval is set to 15 minutes.

The log file is cyclic, which means that the first entries will be overwritten as soon as the number of 65000 records is reached. It is written in plain ASCII format and can be easily analyzed through standard tools like, for instance, Microsoft Excel.

4.2 Self Recovery:

The self recovery feature ensures that the CCDs are protected in case of an alarm condition. One of the sensors connected to PULPO 2 can be selected to trigger the self recovery. As soon as the alarm from this sensor is triggered PULPO 2 will start to heat the CCDs in order to ensure that the CCDs are always warmer than the rest of the cryostat. This will avoid contamination.

5. STATUS

So far, two PULPO 2 units have been assembled and intensively tested with the OmegaCam instrument (Iwert et al., these proceedings). Temperature control through 103 sensors and 4 heaters in the CCD camera head has shown a good level of temperature distribution (±1,25 K across the mosaic), while the alarm and self recovery system has been proven to be safe and reliable.

References

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