E U R O P E A N S O U T H E R N O B S E R V A T O RY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
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LA SILLA-PARANAL OBSERVATORY

3P6 LATERAL PADS CONTROL ELECTRONICS CONCEPTUAL DESIGN

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CHANGE RECORD

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1. INTRODUCTION

The actual 3p6 main mirror support comprises an open loop pneumatic lateral pad supporting system that, as a function of the telescope tube inclination, adjusts the air pressure inside several rubber chambers evenly distributed at the periphery of the mirror. These chambers maintains the mirror radially constraint inside the cell by an **approximately** correct, inclination dependent, supporting force distribution around it.

The actual system incorporates:

- Load cells at the 60 mirror supports (3 fixed lateral, 3 fixed axial, 21 adjustable lateral and 33 adjustable axial). These load cells are connected to local A/D conversion modules that transmit the values via serial RS485 bus at 9600 baud to a control PC (for monitoring purposes only).
- Three linear displacement sensors distributed at 120º inside the central mirror hole. These sensors are Mitutoyo standard and transmit the displacement values via RS-232 to the control PC (for monitoring purposes only).
- Two analogue inclination sensors connected to the control PC via an ISA bus A/D converter.
- Eighteen proportional pneumatic valves with built in pressure sensor. The control and monitoring of the valves is done by the control PC via ISA bus D/A A/D converters.

The actual control PC at the telescope cage is responsible of:

- Reading via RS485 and displaying the load cell values.
- Reading via RS232 and displaying the mirror displacement values.
- Acquire the inclination sensors and compute the telescope tube inclination.
- As a function of the tube inclination adjust the pressure at the eighteen pneumatic valves.
- Acquire the eighteen air pressure values at the valve sensors and display them.

Obsolescence and the unavailability of spare parts for the PC together with the need of extracting the last drop of optical quality possible with such a telescope motivated the design of a VLT complaint lateral pad control system. The idea is to implement a VME system with superior computing power together with VLT standard hardware modules and software. Such a system will, during presets keep the force distribution **approximately** correct as done with the actual system. However, during tracking the system will use the actual force readout from the load cells for, closing a control loop and maintaining exactly the required force distribution at every instant. Please refer to [RE2][AP2].

1.1. PURPOSE AND SCOPE

This document, presents a conceptual design for a VLT complaint 3p6 lateral pads control electronics system. Starting with a presentation of the technical requirements it finally develops the design concept at a block diagram level.

1.2. REFERENCE DOCUMENTS

[RE1] VLT-SPE-ESO-10000-0015 VLT Electronic Design Specification Issue 4.0 09/12/96.
[RE2] Mikro Elektronik gmbh-Nürnberg www.men.de

1.3. APPLICABLE DOCUMENTS

[AP1] "Control Electronics Upgrade for the 3p6 Mirror Support" J. Alonso 20-OCT-2005
[AP2] "ESO 360 M1 Lateral Pad Upgrade User Requirements" Doc. No. 3P6-URS-ESO-90400-0002 Issue 1.2 29/03/2005 E. Barrios.
[AP3]

1.4. ACRONYMS & ABBREVIATIONS

A/D	Analogue to Digital
D/A	Digital to Analogue
PC	Personal Computer
RITZ	Remote Instrument and Telescope Zentrum
LCU	Local Control Unit
I/O	Input Output
VME	Versa Module Europe
MEN	Mikro Elektronik gmbh-Nürnberg
DC	Direct Current
LED	Light Emitting Diode
TBD	To Be Defined
TBM	To Be Measured
ISA	Industry Standard Architecture
VME	Versa Module Europe

2. REQUIREMENTS

Lateral pads electronics control system relevant requirements are presented below. Following each point text in italics explains up to which extent each requirement could be fulfilled. Please refer to [AP2] for further details on the user requirements.

1- Pressure regulation as a function of telescope orientation using current inclinometer system. It should be working all the time and following telescope movement with response time better than 2 seconds.

The A/D and D/A boards chosen for the system could acquire the 2 inclinometer values, command the 18 valves and acquire back the 18 pressure values from the valves in 3.8ms under VLT software with 16 bit resolution and 14 bit precision. The sampling time of this loop will be limited by the response time of the valve-pad pneumatic circuit and the inclinometer. The response time of the valve-pad pneumatic circuit shall be measured experimentally. The response time of the inclinometer is 200ms.

2- The inlet air pressure should be in the range of 2.8 to 3.2 bar. If not an alarm must be triggered for action.

Two air pressure sensors with contact output will be installed at the air inlet of the system (sensor1 opens contact when pressure <2.8 bar, sensor 2 opens contact when the pressure > 3.2 bar). Simultaneously, if the air pressure is out of range, the open contacts will directly trigger an acoustical alarm both at the observing floor and RITZ together with LCU reporting of the condition via digital I/O bits.

3- Air pressure lower than 2.0 bar, hardware or software problem should activate the mirror clamp system.

The actual clamp system is simply based on pneumatic cylinders plus springs. When the air pressure to the cylinders is >2 bar the system is unclamped and clamped when <2 bar.
At the air inlet of the actual clamping system we will add; an electro-valve combination for suspending the air supply and releasing the air pressure from the cylinder's chambers via an electrical signal and a pressure sensor with contact output (sensor open's contact when the pressure is <2 bar).
The electro-valve combination will be commanded via a simple watch-dog circuit refreshed by the LCU software via a digital output bit. In this way either if the LCU software dies or the LCU is switched off the clamping system will be activated. An additional LCU output bit will be "and" to the watch-dog circuitry to allow clamping of the system via a local switch or LCU software command.
The pressure sensor will be used both for reporting to the LCU and locally display the state of the clamping system.

4- As the current sequential load cells TOTAL read-out time is less than 0.214 seconds (9600 baud max.) see feasibility of lateral pad load cells parallel read-out to improve the sampling frequency.

The new system design is based on parallel VME bus interface A/D and D/A conversion modules. The typical conversion time under VLT software of these modules is 100µs. Therefore the total acquisition time for the 60 load cells including hardware offset calibration will be ~0.012 seconds.

5- The A/D and D/A converters for the system shall be 12 bit resolution together with 0.1% precision for the load cell acquisition. For the pneumatic electro-valves and inclinometers the resolution and precision requirement is less. Please refer to [AP1].

The M36 A/D and M37 D/A converter modules from MEN are perfectly compliant with the resolution and precision requirement. They exceed by considerable margin having a resolution of 16 bit and a precision of at least 14 bits. In fact the limiting factor will be the analogue conditioning electronics for the load cells with a worst case precision of 0.05%.

3. CONTROL ELECTRONICS

3.1. Overview

The new system electronics will comprise a connector's and terminal's patch panel and a VME LCU fitted with the following standard and custom modules:

- 1 unit MVME 712/M transition module (Motorola standard).
- 1 unit MVME 167 32mB CPU (Motorola standard).
- 1 unit A201 S-6U Carrier board fitted with 4 M36 A/D mezzanines (MEN standard).
- 1 unit A201 S-6U Carrier board fitted with 2 M36 A/D mezzanines and 2 M37 D/A mezzanines (MEN standard).
- 1 unit A201 S-6U Carrier board fitted with 3 M37 D/A mezzanines and 1 M58 32 bit TTL I/O mezzanine (MEN standard).
- 2 unit 6U load cell signal conditioning board. (LSO custom).
- 1 unit 6U load cell precision excitation voltage board. (LSO custom).

The electronics will be centralized inside the actual system cooled cabinet at the telescope cage. Since actually inside this cabinet resides the 18 pneumatic valves and inclinometers, this, will obviously simplify the wiring layout of the new system. The 60 load cell's signal cables will arrive to the rear of this cabinet and will be connected to a properly labelled and mechanically coded connector's and terminal's patch panel. In this way when the mirror cell and cage are dismounted during mirror aluminization the disconnection and connection will be very easy, practical and secure (impossible to make mistakes). For load cell testing with the mirror cell dismounted a Futek load cell laptop interface will be used.

3.2. Layout

As mentioned above the whole electronics system will be basically a PCB made connector's and terminal's patch panel and the VME chassis, nothing else.

The patch panel will also contain (fully silkscreen labelled PCB for easy assembly, disassembly and trouble shooting), the mirror clamp watchdog circuitry, pressure status signal connections, alarm signals output, engineering LED indicators, etcetera.

The implementation of the analogue signal conditioning will be in the form of a custom 6U VME format module (due to the limited amount of pins available at the VME P2 [64 pins] the task will be accomplished by 2 identical modules).
This module will contain 30 instrumentation amplifiers with input short circuiting mini relays commanded via digital I/O for dynamic calibration prior to conversion of each channel. An on module DC/DC converter will cleanly power the amplifiers properly isolating them from the noisy VME ground.

Doing the signal conditioning at the LCU itself has the advantage that the amplified signals could be inputted to the A/D converters in single ended format without compromising the performance, since the analogue grounds of both the output of the amplifier and the input of the A/D are very close and more or less under the same ground plane. In this way, using single ended inputs, we do the same job with half the number of M36 mezzanines.

The necessary excitation voltage for the load cells will be generated by a dedicated 6U VME module and the interconnection to the conditioning modules will be via P2. This module simply contains a DC/DC converter for VME ground isolation and a high stability, highly filtered linear regulator (short circuit protected).

For a better visualization of the new system electronics please refer to 5 BLOCK DIAGRAM.

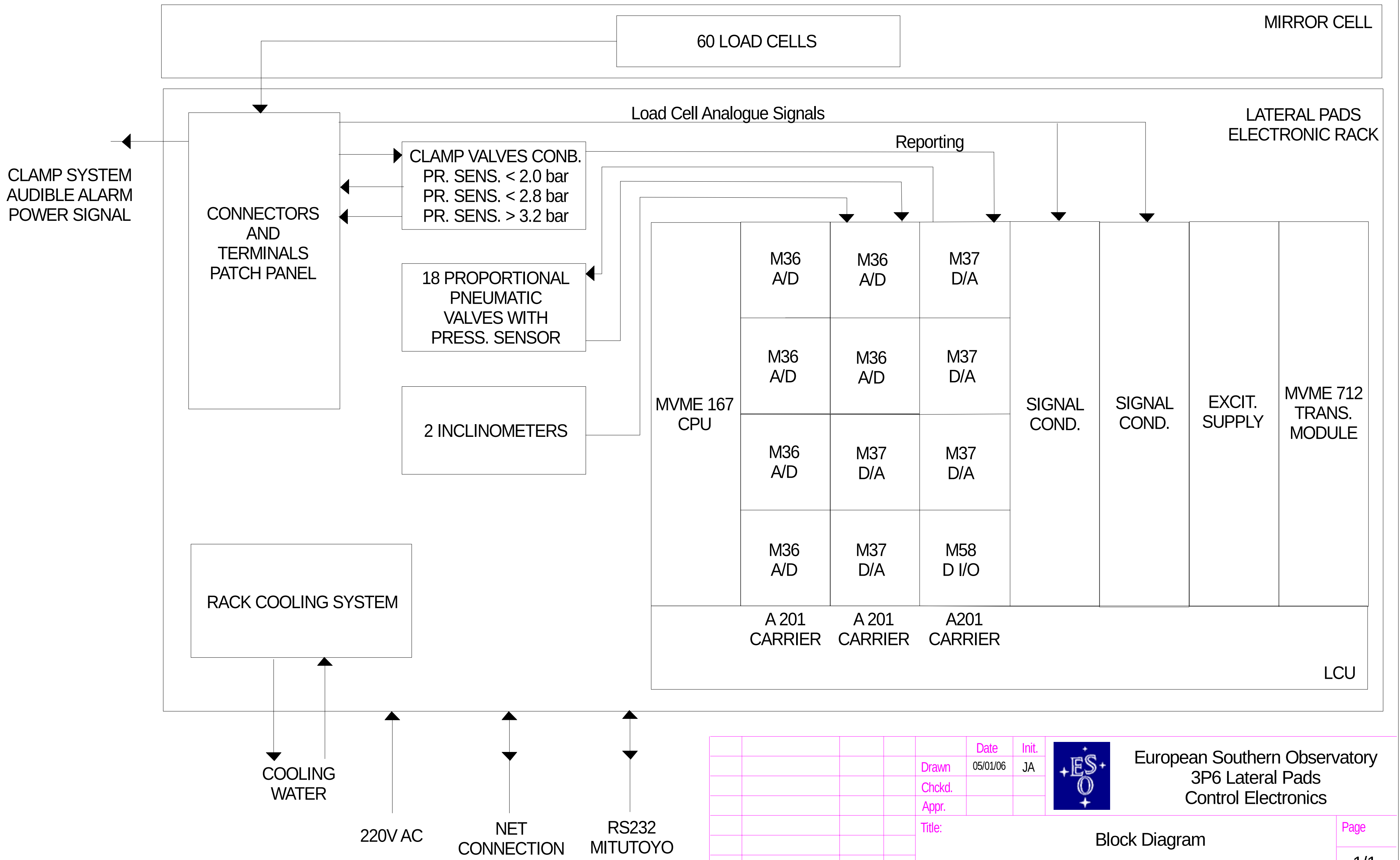
The Mitutoyo mirror displacement system will be interfaced to the VME system via VME CPU serial port 2, 3 or 4 (all three available at the transition module). Although this works perfectly just by redirecting the VLT software serial driver to one of these ports it is not a decent VLT software practice. The 100% VLT approach will cost ~2500 euros. This is in the form of a VME ISER12 module (1 RS232 serial port for 2500 euros. Not bad).

4. CAVEATS

Since the new system is different to the old one from the connectors and cabling distribution it will be not practical to switch between them during the test phase. Therefore the new system will be thoroughly tested and accepted at the laboratory before installation. After this the system will be, once for all, installed at the telescope emulating the old system only (after all this is a simple functionality to test and debug). Later and gradually during test time the force control close loop feature will be tested and commissioned (a pure software issue).

5. BLOCK DIAGRAM

Please see next page.



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