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VERY LARGE TELESCOPE

MACAO-VLTI

INSTRUMENT CONTROL ELECTRONICS (LCU)

DESIGN REPORT

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1 INTRODUCTION

1.1 Purpose

This report presents the *Instrument Control Electronics hardware of the MACAO-VLTI* at the occasion of the Final Design Review.

1.2 Scope

The document describes the electronics hardware for the instrument controlled functions, and defined as part of the *IC-LCU*, *RTC-LCU* and the *VLTI-LCU*. The majority of the instrument functions are related to motion control or positioning.

The APD and associated counters as well as the de-formable mirror (DM) and HV amplifiers, tip-tilt units are not described in this report. Only the interface aspects with the IC cabinet are considered.

As the VLTI-LCU is located in the MACAO IC-cabinet, this chassis is also described in this report. The VLTI-LCU is for the control of a technical CCD system and of a STRAP unit, an additional filter wheel for STRAP and the three motorised axis of the M10 mirror.

The last chapter of the design report is related to the cabling aspect of the instrument and to its connection to the SCP.

For an enhanced comprehension of this report, some additional technical document or user manuals have to be consulted. This includes the following *ESO standard* sub-systems:

- Motion controller MACCON
- DC and stepper motor amplifier ESO
- STRAP
- Technical CCD
- Cabinet Thermal control unit

1.3 Applicable and reference Documents

AD 1	VLT-SPE-ESO-10000-0015	VLT Electronic Design Specifications
AD 2	VLT-SPE-ESO-10000-0002	EMC and power quality specification - Part 1.
AD 3	VLT-SPE-ESO-10000-0003	EMC and power quality specification - Part 2.
AD 4	VLT-TRE-ESO-15600-2274	MACAO-VLTI Preliminary Mechanical Design report
AD 5	VLT-TRE-ESO-15600-2269	MACAO-VLTI Electronics – APD
AD 6	VLT-TRE-ESO-15600-2271	MACAO-VLTI Electronics – DM Control
AD 7	VLT-SPE-ESO-11535-1656	VLT UT Coude Relay Optics Technical Specifications
RD 1	VLT-MAN-ESO-11670-1794	STRAP electronics Hardware Manual
RD 2	VLT-MAN-ESO-11700-1775	Technical CCD system
RD 3	VLT-SPE-ES0-15600-2056	MACAO-VLTI Functional Requir. & Operational Concepts
RD 4	VLT-SPE-ESO-15600-2082	Top Level Requirements for MACAO-VLTI
RD 5	VLT-MAN-ESO-17130-0273	4 Channels DC Servo-amplifier ESO-VME4SA-X1
RD 6	VLT-MAN-ESO-17130-0274	ESO-VME4SA Backplane
RD 7	VLT-MAN-ESO-17130-0991	ESO VME4ST 4-channel Stepper Motor Driver
RD 8	VLT-MAN-ESO-17130-0992	ESO VME4ST Backplane
RD 9	VLT-MAN-ESO-17130-1603	Electronic Cabinet cooling system
RD 10	VLT-MAN-ESO-17300-0473	Time reference system TIM

1.4 Acronyms

AD	Applicable Document
AIT	Assembly, Integration and Tests
AO	Adaptive Optics
APD	Avalanche Photo Diode
CCD	Charged Coupled Device
DM	Deformable Mirror
ESO	European Southern Observatory
HV	High Voltage
HW	Hardware
IC	Interface Control
ICS	Instrument Control Software
INC	Incremental (Encoder)
JB	Junction Box
LCU	Local Control Unit
MACAO	Multiple Applications Curvature Adaptive Optics
ND	Neutral Density filter
NO/NC	Normally Open / Normally Closed (Contact)
RD	Reference Document
RTC	Real Time Computer
SCP	Service Connection Point
STRAP	System for Tip-tilt Removal with Avalanche Photodiodes
SW	Software
TBC	To Be Confirmed
TBD	To be determined
TIM	Time Interface Module
TRS	Time Reference System
VLT	Very Large Telescope
VLTI	VLT Interferometer
VME	Versa Module Eurocard
WFS	Wave Front Sensor

2 Instrument control functions

2.1 Overview

This table summarises the functions of MACAO-VLTI IC with reference to the LCU's from which these functions are controlled and the descriptive paragraph. The annexed schematic "MACAO.skd" shows the general layout of the IC-cabinet and of the controlled functions.

Table 1: List of instrument control functions

Acronym	Functions	LCU	Paragraphe
WFS-X	WFS table X translation	IC	2.2
WFS-Y	WFS table Y translation	IC	2.2
WFS-BRAKE	WFS table Brake system	IC	2.3
DEROT	Derotator unit	IC	2.5
MSEL	Mode selector translation stage	IC	2.6
MMDIAPH	WFS Membrane mirror diaphragm	RTC	2.7
WFSFWH	WFS ND filter wheel	RTC	2.8
STRAPFWH	STRAP filter wheel	VLTI	2.9
STRAPDIAPH	STRAP diaphragm	VLTI	2.10
MMTIP	Membrane mirror Tip motion	IC	2.10
MMTILT	Membrane mirror Tilt motion	IC	2.10
MMFOC	Membrane mirror focus	IC	2.11
MMPIST	Membrane mirror piston	RTC	2.12
WFSSHUT	WFS entry shutter	RTC	2.13
DM	Interface with deformable mirror system	RTC	2.14
APD	Interface with APD system	RTC	2.15
STRAP	Strap unit	VLTI	2.16
TCCD	Technical CCD	VLTI	2.17
M10TRANS	M10 mirror translation	VLTI	2.18
M10TIP	M10 mirror tip rotation	VLTI	2.19
M10TILT	M10 mirror tilt rotation	VLTI	2.19

The next paragraphs (2.2 to 2.19) resume for each function:

- the requirements as defined by the following document:

AD 4 VLT-TRE-ESO-15600-2274 MACAO-VLTI Preliminary Mechanical Design report
RD 4 VLT-SPE-ESO-15600-2082 Top Level Requirements for MACAO-VLTI
AD 5 VLT-TRE-ESO-15600-2269 MACAO-VLTI Electronics – APD
AD 6 VLT-TRE-ESO-15600-2271 MACAO-VLTI Electronics – DM Control

- the components as defined according to AD 4 for most of the MACAO functions, or from the ESO VLT standard sub-system directly (e.g: STRAP, Technical CCD).

- the cabling and connection to list the number and size of the cable, the cable routing and the type of connectors.

- the control that defines from which LCU the function is supervised and the type of VME board involved.

The purpose of this chapter 2, is to collect for each function, and from the various source of information (see list of reference document), the appropriate parameters that will define the realisation of the control. It provides in a single paragraph a global overview for all of these aspects.

In progressing in the design and later on during the assembly and testing phases, these paragraphs will be modified or completed to take to consideration new requirements, changes in the definition of the components, and finally the performances (electrical) achieved.

2.2 WFS X-Y table translation stage (2 axis)

Table 2: WFS X-Y table translation

Requirements		Remarks
Translation range	250 mm	
Absolute positioning accuracy	±100 µm (slew mode)	
Relative positioning accuracy	± 8 µm	
Minimum speed (Tracking)	0 to 0.025 mm/s	
Maximum speed	2.0 mm/s	
Drive components		
Mechanics	ESO-made	
Expected torque	0.16 Nm	300% margin
DC-direct drive motor	INLAND QT-3103-B	
Estimated max. motor current	2A	at max. speed
Maximum speed	30 rpm	pitch = 5mm
Maximum back e.m.f	2 V	at max. speed
DC resistance	3.95 Ohms	
DC-tachometer	INLAND TG-1318-C	0.180V per rad/sec
Maximum e.m.f	0.56 V	at max. speed
Linear encoder	Heidenhain LS106 - Cl 3 - 20 µm - Length 340 mm	
Interpolation unit	Heidenhain EXE 610 C (5x or 10x)	EXE unit located in IC-Cabinet
Resolution (with 4x MACCON)	1 or 0.5 µm	
Stage initialisation	Reference mark on the rule	
Limit switch (UU-LL)	2x IFRM08N1501	
Home switch	None	
Cabling	for each axis	
Motor	1x cable (2x0.5+sh) from table to JB (IC-Cabinet) - dia. 6mm with in-line connector DIN-2 poles Amphenol C091	JB = Junction box in IC cabinet
Tacho	1x cable (2x0.25+sh) from table to JB (IC-Cabinet) - dia. 5mm with in-line connector: BINDER 712 - 3 pole	
Switches	2x cable from table to JB (IC-Cabinet) - dia. 5mm In-line connector: BINDER 712 - 4 poles	
Encoder	1x Heidenhain cable from table to EXE602 (IC-cabinet) - dia14mm. Cable protected in flexible conduit	
Encoder	1x Heidenhain cable from EXE-602 to JB (IC-Cabinet) - dia 8mm	IC-LCU Internal
Servo-amplifier	1x cable (Elocab EHRK 2914 rev 2) from JB to VME4SA backplane - dia. 10mm with connectors MIL-851-18-32 / Molex Omnigrid 2.5	IC-LCU Internal
Brake (Interlock)	Brake interlocks with limit-switches supply	IC-Cabinet Internal
Control		
LCU	IC-LCU	
Position control	MAC-INC WFS-X : Board set 3 = Ch 1 WFS-Y : Board set 3 = Ch 2	
Speed control	VME4SA-type II WFS-X : Board set 3 = Ch 1 WFS-Y : Board set 3 = Ch 2	
Interlock (Brake)	Relay contact to enable limit-switches	

- The WFS X-Y table is driven by two direct drive dc-motors coupled to a linear actuator (ball screw).
- The positioning in slow speed tracking mode is achieved by the selection of a high precision and high-resolution linear glass rule incremental encoders combined with the an interpolation unit (EXE610).
- Two mechanical switches are for the end limit (upper and lower) sensing.
- The initialisation of the unit is by driving the stage to the reference mark on the linear rule (home position). No reference switch is foreseen.
- The two motorised axis are interlocked with the pneumatic brake mechanisms (X&Y) directly to the limit-switch supply lines (5V). The definition of the brake interlocks is given in the next paragraph.
- All servo-drive signals (Motor, Tacho, Switches and Encoder) are brought together in the WFS-table connection chassis on terminal blocks. Each signal is conducted by an single cable terminated on both ends with connector. From the terminal blocks, all signals continue to the VME4SA backplane through a single cable (ELOCAB EHRK 2914 rev 2) terminated by a MOLEX Omnigrid 2.5 connector.
- To minimise the heat dissipation, the interpolation and digitising electronics (EXE610) are placed in the IC-cabinet (Side 2) in the WFS table connection chassis.

2.3 WFS X-Y table brake mechanism

Table 3: WFS X-Y table brake mechanism

Drive components		Remarks
Mechanics	ESO-Made	
Pneumatic actuator	FESTO ADVU 50-10 PA	
Electro-pneumatic valve for brake	FESTO 24Vdc-1.8W	Located in IC cabinet
Air pressure status	Pressure switch FESTO type PEV-1/4-B with NO/NC	Located in IC cabinet
Brake position	2x Limit switches	
Cabling	for both axis	
Brake switch (2x)	2x cable from table to JB (IC-Cabinet) - dia. 5mm Inline connector: BINDER 712 - 2 poles	JB = Junction box in IC cabinet
Pressure switch	1x cable to JB - dia 5mm BINDER 712 - 2 poles	IC-LCU Internal
Electro-valve (Coil)	1x cable to JB - dia 6mm BINDER 712 - 3 poles	IC-LCU Internal
Brake controller	1x cable from Brake controller to JB - dia 10mm terminated with MIL-851-14-15	IC-LCU Internal
Brake (Interlock)	Internal in A01-JB	
Control		
LCU	IC-LCU	
Interface	Brake controller ESO-made CS-P-1873 between DIO Acromag board and the brake unit.	
Control	Acromag AVME 9481 - one command bit (Output) Port 6 Channel 0 : Brake Open/Close command	
Status	Acromag AVME 9481 - five status bits (Input) Port 6 Channel 2 : Remote/manual status Port 6 Channel 3 : Fault status Port 6 Channel 4 : Air Pressure status Port 6 Channel 5 : X Brake status Port 6 Channel 6 : Y Brake status	
Interlock	Local interlock between brake switches, pressure switch and the motor limit-switch supply lines.	

- For each axis of the table, a single action piston actuator (with return spring) acts on the brake mechanism. The pressurised air (SCP) feeds the single action piston chambers through a electro-magnetic valve.
- The brake mechanism is engaged when the WFS unit is not in operation (e.g: Daytime). In normal operation, it is the IC software that sends the command to the IC-LCU to release the brakes.
- The brakes are "normally closed" . Therefore also, the brakes are automatically engaged in case of a power lost or of an air pressure lost or leak (detection by a pressure switch).
- To minimise the heat dissipation in the Coude atmosphere, the electro-valve is placed in the IC-cabinet (cooled).
- The brake position for each axis (two switches) and the air pressure (pressure switch) are monitored by the IC-LCU and are duplicated for the interlock circuit (supply lines of the motor limit switches).
- Both X and Y axis are controlled from the same Brake controller unit located in the IC-LCU. The brake controller receives the brake and pressure status interlock signals, displays these signals and send these information to the digital in/out VME I/F board (Acromag).
- All brake signals (Electro-valve, Pressure switch, Position switches) are brought together in the WFS-table connection chassis on terminal blocks. Each signal is conducted by a single cable terminated on both ends with connector. From the terminal blocks, the signals continue to the brake controller through a single cable terminated by a MIL-851-14-15 connector.

2.4 Derotator unit

Table 4: Derotator rotation

Requirements		Remarks
Rotation range	Continuous	
Absolute positioning accuracy	±0.18°	
Tracking speed	0 to 0.44°/s	
Slew speed	2°/s	
Drive components		
Mechanics	Newport RV160 - High torque CCHL	
Max speed	16 °/s	
Encoder resolution	0.010°	
Max. range	+/- 360° (with limits disabled)	
DC-direct drive motor	UE511CC (for RV160)	
Rated output	110W	
Rated arm voltage	48 V	
Rated arm current	3A	
Arm resistance	1.6 Ohms	
Voltage constant	21.8 mV/rpm	
Torque constant	2.13 kg-cm/A	
DC tachometer	7 V/Krpm	
Limit switch (UU-LL)	none	
Home switch	1	
Cabling/Connection		
Motor, Tacho, Encoder, Switches	1x cable (Elocab EHRK 2914 rev 2) - dia 10 mm	
Connectors	Sub-D 25 poles connector to HAR-PAK/Molex	
Control		
LCU	IC-LCU	
Position control	MAC-INC Board set 3 = Ch 3	
Speed control	VME4SA-type II (5 Amps) Board set 3 = Ch 3	

- "Off-the-shell" drive unit.
- The derotator unit is driven by a high torque/low speed dc-motor.
- The rotation in slow speed tracking mode is achieved by the selection of a high resolution rotating incremental encoder combined with a tachometer.
- Continuous rotation (No end-switches).
- The initialisation of the unit is by driving the stage to the reference position (home switch).

2.5 Mode exchanger translation stage

Table 5: Mode exchanger translation stage

Requirements		Remarks
Translation range	100 mm	
Number of position	5	
Absolute positioning accuracy	±0.5 mm	
Stability	4 µm	
Drive components		
Mechanics	OWIS LIMES 90	
Travel range	100 mm	
Max speed	40 mm/s (no/load) - with OWIS control system	
Encoder	HEDL-5540 - 500 lines	
Resolution (calculated)	0.5 µm - with OWIS control system	
Max. range	+/- 360° (with limits disabled)	
DC-direct drive motor	DS28	
Rated output	/	
Rated arm voltage	24 V	
Rated arm current	399 mA at rated torque	
Arm resistance	21 Ohms	
Voltage constant	/	
Stall Torque	5.01 Ncm	
Continuous torque	2.0 Ncm	
DC tachometer	yes	
Limit switch (UU-LL)	2x	
Home switch	1x	
Cabling & Connection		
Motor, Tacho, Encoder, Switch	1 x cable (Elocab EHRK 2914 rev 2) from stage to IC-LCU	
Connection	D-Sub15-poles to HAR-PAK/Molex	
Control		
LCU	IC-LCU	
Position control	MAC-INC Board set 1 = Ch 2	
Speed control	VME4SA-type I (2 Amps) Board set 1 = Ch 2	

- Modified "off-the-shell" translation stage with additional tachometer.
- Optimise linear measuring stage (mechanics)

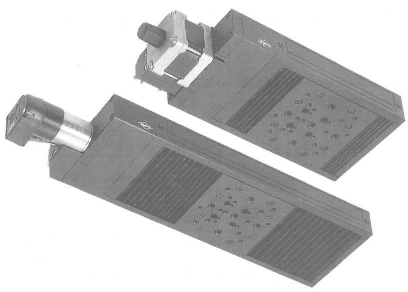

Figure 1 – OWIS translation stage

2.6 WFS membrane mirror diaphragm

Table 6: WFS membrane mirror diaphragm

Requirements		Remarks
Aperture range	1 - 12 mm	
Speed	> 1.0 mm/s	
Operating time	11 seconds	
Drive components		
Mechanics	Melles Griot 1-18 mm max	
DC micro-motor	Faulhaber type 1624	
Nominal motor voltage	24 Vdc	
Incremental encoder	5Vdc	
Limit switch (UU-LL)	Micro-switch	
Cabling & Connection		
Motor, Encoder & switches	1 x cable from WFS-box to IC-cabinet Lemosa 5x2x0.14+Sh - dia 6mm	
Connection	Lemosa 10-pins Harpak/Molex	
Control		
LCU	RTC-LCU	
Position control	MAC-INC Board set 1 = Ch 1	
Speed control	VME4SA-type I (2 Amps) Board set 1 = Ch 1	
Remarks		
Home position	defined with limit switch (UU or LL)	
Tacho signal	tapped from the motor voltage with resistances	

- The type of unit and motorization is a shared design with the STRAP diaphragm unit.

2.7 WFS ND Filter wheel

Table 7: WFS ND Filter wheel

Requirements		Remarks
Rotation range	360°	
Number of positions (min.)	11	
Rotating speed	36 °/sec	Bi-directional
Drive components		
Mechanics	ESO-made design	Belt mechanism
Number of positions	8	
DC- motor	Faulhaber 3042W024C	
Motor voltage	24 V	
Motor current (max)	800 mA	
Tachometer	C001G	
Tacho sensitivity	1mV/rpm	
Incremental encoder	Heidenhain ROD 426 - 3600 ct/turn	Direct mounted on the filter wheel axis
Resolution after interpolation (4x)	0.025 deg	
Home switch	Baumer IFRM 08N1501	
Cabling & Connection		
Motor, Home switch	1x cable (Elocab EHRK 2914 rev 2) from WFS-box to IC-cabinet	
Connector	MIL-851-18-32-S to HAR-PAK/Molex	
Control		
LCU	RTC-LCU	
Position control	MAC-INC Board set 1 = Ch 2	
Amplifier	VME4SA-type I (2 Amps) Board set 1 = Ch 2	

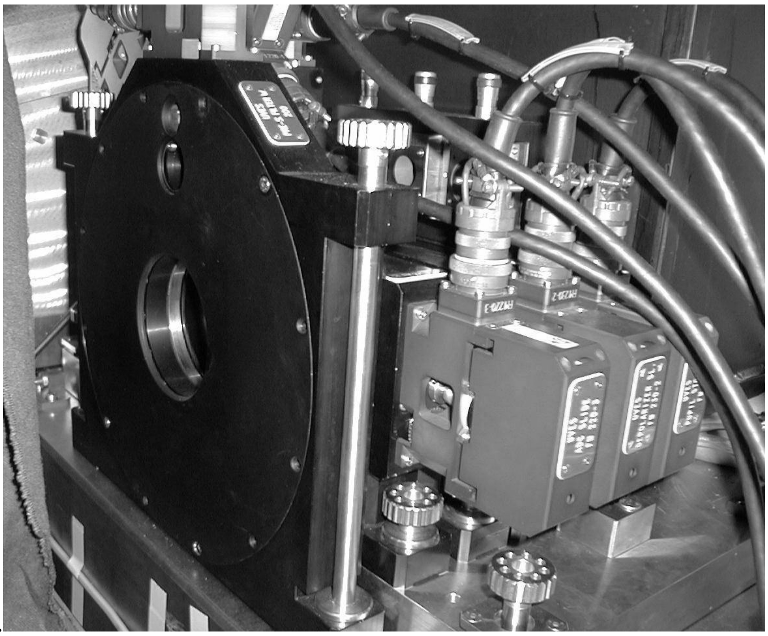

Figure 2 - Exemple of filter wheel with SD-40

2.8 STRAP Filter wheel

Table 8: STRAP Filter wheel

Requirements		Remarks
Rotation range	360°	
Number of positions	8x8 = 64	
Rotating speed	36 °/sec	
Operating time	20 sesonds	
Drive components		
Mechanics	ESO-made design	Belt mechanism
Number of positions	8	
DC- motor	Faulhaber 3042W024C	
Motor voltage	24 V	
Motor current (max)	800 mA	
Tachometer	C001G	
Tacho sensitivity	1mV/rpm	
Incremental encoder	Heidenhain ROD 426 - 3600 ct/turn	Direct mounted on the filter wheel axis
Resolution after interpolation (4x)	0.025 deg	
Home switch	Baumer IFRM 08N1501	
Cabling & Connection		
Motor, Home switch	1x cable (Elocab EHRK 2914 rev 2) from WFS-box to IC-cabinet	
Connector	MIL-851-18-32-S to HAR-PAK/Molex	
Control		
LCU	VLTI-LCU	
Position control	MAC-INC Board set 1 = Ch 1	
Amplifier	VME4SA-type I (2 Amps) Board set 1 = Ch 1	

- "Off-the-shell" filter wheel unit with two combined wheels offering 2 sets of filter positions, with a modified motorisation (DC motor with incremental encoder).
- The unit is equipped with a reference position switch for the initialisation of the stage.

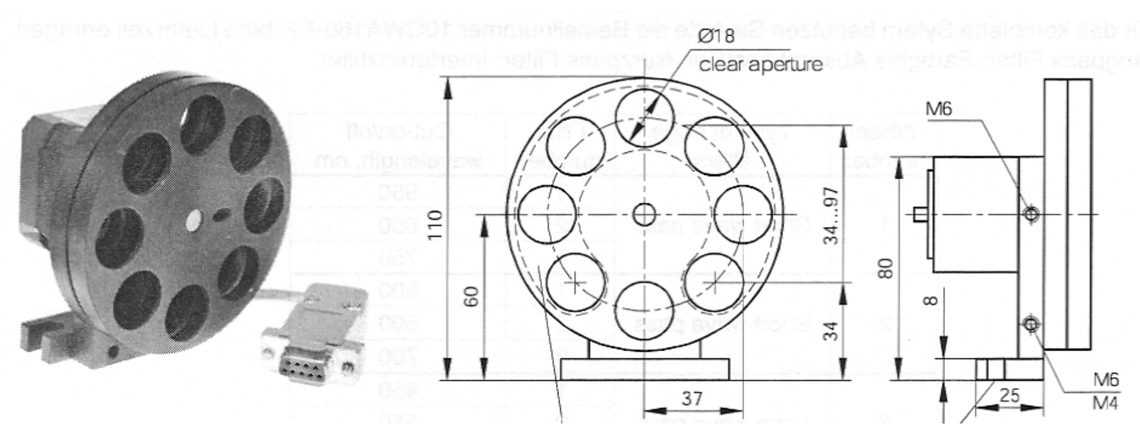

Figure 3 - STRAP filter wheel

2.9 STRAP Diaphragm

Table 9: STRAP Diaphragm

Characteristics		Remarks
Rotation range	90°	
Operating time	8 seconds (open to closed)	
Drive components		
Mechanics	ESO-Made Internal part of STRAP	
DC micro-motor	24 Vdc - 3W - Maxon	
Running motor voltage	12.4 Vdc	
Running motor current	25 mA	
Incremental encoder	5Vdc - 32 pulses/turn - placed before gear reductor	
Resolution	45000 cts/turn after interpolation	
Limit switch (UU-LL)	Micro-switch	
Cabling & Connection		
Motor, Encoder & switches	1 x from WFS-box to IC-cabinet Lemosa 5x2x0.14+Sh dia. 6mm	
Connection	Lemosa 10-pins Harpak/Molex	
Control		
LCU	VLTI	
Position control	MAC-INC Board set 1 = Ch 2	
Amplifier	VME4SA-type I (2 Amps) Board set 1 = Ch 2	
Remarks		
Home position	defined with limit switch (UU or LL)	
Tacho signal	tapped from the motor voltage with resistances	

- The diaphragm driving system is part of STRAP unit (ESO Standard). Refer to [RD 1] for more detailed information.

2.10 Membrane mirror motion -Tip-Tilt (2 axis)

Table 10: Membrane mirror motion (Tip-Tilt)

Requirements		Remarks
Translation range	20 mrad	
Absolute positioning accuracy	TBD	
Stability	0.4 mrad/s	
Speed	2 mrad/s	
Drive components		
DC- linear micro motor	Physik Instrument M-222-50	M-222
Motor rated voltage	12Vdc	
Motor power	2 W	
DC-tachometer	None	
Maximum travel speed	0.71 mm/s	
Incremental encoder resolution	0.06 µm	
Limit switch (UU-LL)	2x External	
Home switch	1x External	
Cabling & Connection		
Motor, Encoder, Switch	1x from unit to IC-LCU	
Connector	TBD / HAR-PAK/Molex	
Control		
LCU	IC-LCU	
Position control	MAC-INC Board set 2 Tip unit : Ch 1 Tilt unit : Ch 2	
Speed control	VME4SA-type I (2 Amps) Tip unit : Ch 1 Tilt unit : Ch 2	
Remarks		
Switch	External to the motor unit	
Tacho signal	tapped from the motor voltage with resistances	

- "Off-the-shell" linear drive with DC-micro motor and magnetic encoder.
- Motor, encoder and limit switched signals are combined locally into a single connector, including an encoder quadrature signal converter circuit (if required).

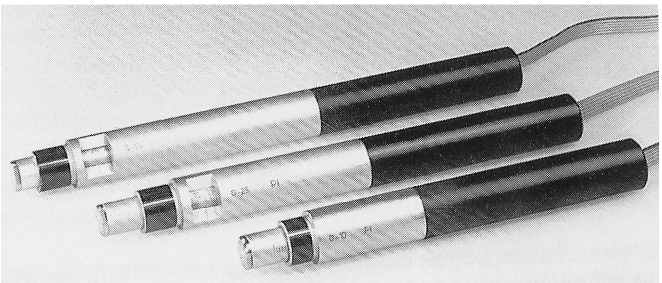

Figure 4 - Membrane mirror Tip-Tilt motors

2.11 Membrane mirror focus

Table 11: Membrane mirror focus

Requirements		Remarks
Translation range	± 15 mm	
Speed (min.)	0.1 mm/s	
Drive components		
Mechanics	OWIS LIMES 30	
Travel range	30 mm	
Max speed	40 mm/s (no/load) - with OWIS control system	
Encoder	500 lines	
Resolution (calculated)	0.5 µm - with OWIS control system	
DC-direct drive motor	DS28	
Rated output	/	
Rated arm voltage	24 V	
Rated arm current	399 mA at rated torque	
Arm resistance	21 Ohms	
Voltage constant	/	
Stall Torque	5.01 Ncm	
Continuous torque	2.0 Ncm	
DC tachometer	yes	
Limit switch (UU-LL)	2x	
Home switch	1x	
Cabling & Connection		
Motor, Tacho, Encoder, Switch	1 x cable (Elocab EHRK 2914 rev 2) from stage to IC-LCU	
Connection	D-Sub15-poles to HAR-PAK/Molex	
Control		
LCU	IC-LCU	
Position control	MAC-INC Board set 1 = Ch 1	
Speed control	VME4SA-type I (2 Amps) Board set 1 = Ch 1	

- Modified "off-the-shell" translation stage with additional tachometer.
- Optimise linear measuring stage

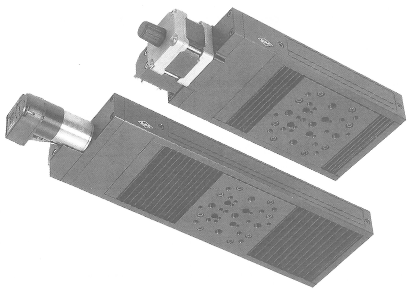

Figure 5 - Membrane mirror focus motorised stage

2.12 Membrane mirror Piston

Table 12: Membrane mirror piston

Cabling & connection		
Coil drive	1x cable between Membrane and Amplifier (located with APD counter unit)	
Connector	TBD	
Control		
LCU	RTC	
VME board	Fiber link I/F	

- The low impedance voice-coil type membrane mirror is driven from the Timing Unit, as part of the APD system and controlled by the RTC-LCU
- A single cable between the IC cabinet and the membrane mirror unit is foreseen

2.13 WFS entry shutter

Table 13: WFS entry shutter

Electro-components		Remarks
Electronic Shutter	COMPUR - Size 0 - Dia. 24mm	
Coil	Two coils with pulse control	
Properties for 2Vdc coil	24Vdc	
Operation pulse (open or close)	100 msec	
Shutter status	Two build-in micro-switches	
Cabling		
To shutter	1x(4x0.5 + 4x2x0.14) sqmm + Shield Type: SAB-SL803 dia. 10 mm Connector: MIL-851-14-12	
To control	Internal RTC-LCU	
Control		
LCU	RTC-LCU	
VME board	Acromag AVME9481	
Control	Acromag AVME 9481 - one command bit (Output) Port 6 Channel 0 : Shutter Open/Close command	
Status	Acromag AVME 9481 - three status bits (Input) Port 6 Channel 1 : Remote/manual status Port 6 Channel 2 : Shutter open/close status Port 6 Channel 3 : Fault status	
Power adapter	Shutter controller ESO made CS-P-1873 between the DIO Acromag board and the shutter unit	

- Shutter unit controlled by two coils (open & close)
- No heat production when the shutter is in open position
- Two limit-switches (open-close) monitor the shutter status

2.14 Deformable mirror system

Table 14: Deformable mirror system

Control		Remarks
LCU	RTC	
VME board	Fibre link I/F	
	RS-232	
Cabling		
High speed link	1x2 Fibre Optic cable	
Housekeeping (RS-232)	1x2 Fibre Optic cable	
Remarks		
RTC-LCU	Digital I/O between Fibre link I/F and RTC-CPU	

- The interface with this sub-system of MACAO consists to optical fibre link (2 cables) between the DM control cabinet and the IC-cabinet.

2.15 APD system

Table 15: APD system

Power		Remarks
Mains - 230 VAC	Max. power = 800 W (60x2Ax5Vdc)@75% DC/DC efficiency Nom. power = 200 W (60x0.5Ax5Vdc)@75% DC/DC efficiency	
Thermal power for cooling	Estimation: 200 W	
Cabling & connector		
230VAC from Macao IC-Cabinet	1x 2 + PE 0.75 sqmm - Connector TBD	
Signals	2 x cables (30 signals each) - dia. TBD SCSI (TBD) connector	
Control	1x cable (6 signals) - dia TBD Control connector: TBD	
Control		
LCU	RTC-LCU	
I/F VME board	SHAKTI Size: 6HE-4TE VMEbus: J1 + J2 I/F: Front panel connectors for 60 counting channels	
Digital I/O	Acromag AVME9481	
Control	Acromag AVME 9481 - two command signal (Output) to APD cabinet - Relay Siemens V23042-DPDT (5VDC) Port 0 Channel 0 : APD Relay 1 command Port 0 Channel 1 : APD Relay 2 command	
Status	Acromag AVME 9481 - three status bits (Input) Port 7 Channel 0 : APD Status 1 Port 7 Channel 1 : APD Status 2 Port 7 Channel 2 : APD Status 3	

2.16 STRAP

Table 16: STRAP

Cabling		Remarks
Head HV	1x 15m - 5x0.35 sqmm - dia 6mm	
Head control	1x 15m - 20 x 0.22 sqmm - dia 9mm	
Head signals	1x 15m - 8x2x 0.22 sqmm - dia 9mm	
Control		
LCU	VLTI-LCU	
Size of VME controller	6 HE x 14 TE	
VME supply	+5V @ 5A max (typ. 1.5A) ±12V @ 1.5 A max (typ. 0.5A)	
Remarks		
Cooling	STRAP sensor head is water cooled	

- The STRAP unit is a "standard ESO components" provided with all necessary hardware: sensor head, VME board, cables and cooling lines. Refer to AD 7 VLT-SPE-ESO-11535-1656 VLT UT Coude Relay Optics Technical Specifications
- RD 1 for a complete description of the STRAP system.
- Refer to the paragraph 2.9 for the definition of the STRAP motorised diaphragm.

2.17 Technical CCD

Table 17: Technical CCD

Cabling		Remarks
Between ACE and VLTI-LCU		
24Vdc power	2x two pair shielded cable - 0.5sqmm - dia 6mm	
Signals	1 x Optical fibre cable with 8 fibres - dia 12mm	
Between CCD head and ACE		
Signal, power and control	3x ESO made cables	
Control		
LCU	VLTI	
LIB board	6 HE x 4 TE	
LAB board	6 HE x 4 TE	
	P2 backplane between CPU and LIB/LAB boards with an flat cable between LIB and LAB - P2 connector	
VME supply	+5V ±12V	
24 V supply	+24 V - 1.5 Amps	
Remarks		
Cooling	ACE and CCD head are water cooled	

- The technical CCD is a "standard ESO components" provided with all necessary hardware: sensor head, front-end electronics ACE, VME board, cables and cooling lines (Partial).
- Refer to RD 2 for a complete description of the technical CCD system.

2.18 M10 mirror - Focus unit

Table 18: M10 mirror - Translation unit

Requirements		Remarks
Translation range	+/- 10 mm	
Positioning resolution	10 µm	
Drive components		
Mechanics	Micro-controle - VM4CC	
Travel	25.4 mm	
Maximum speed	200 µm/s	
Resolution	0.05 µm	
Accuracy	6 µm	
DC- linear micro motor	UE17CC	
Motor rated voltage	12Vdc	
Encoder	Magnetic - Differential output	
Limit switch	Upper and lower	
Cabling & Connection		
Motor, Encoder, Switch	1 x cable from Stage to IC-LCU	
Connector	D-Sub 25 to HAR-PAK/Molex	
Control		
LCU	VLTI-LCU	
Position control	MAC-INC Board set 2 = Ch 1	
Speed control	VME4SA-type I (2 Amps) Board set 2 = Ch 1	

- Motorised unit provided by the supplier of the M10 unit.

2.19 M10 mirror - Tip & Tilt unit (2 axis)

Table 19: M10 mirror - Tip & Tilt unit (2 axis)

Requirements		Remarks
Translation range	+/- 16 arcmin	
Positioning resolution	[4 arcsec	
Absolute accuracy	[20 arcsec	
Speed	step of 1 arcmin within +/-10arcsec in 1 second	
Drive components		
Mechanics	Micro-controle - VM4CC	
Travel	4 mm	
Maximum speed	200 μm/s	
Resolution	0.05 μm	
Accuracy	6 μm	
DC- linear micro motor	UE17CC	
Motor rated voltage	12Vdc	
Encoder	Magnetic - Differential output	
Limit switch	Upper and lower	
Cabling & Connection		
Motor, Encoder, Switch	1 x cable from Stage to VLTI-LCU	
Connector	D-Sub 25 to HAR-PAK/Molex	
Control		
LCU	VLTI-LCU	
Position control	MAC-INC Board set 2 M10 Tip: Ch 2 M10 Tilt: Ch 3	
Speed control	VME4SA-type I (2 Amps) Board set 2 M10 Tip: Ch 2 M10 Tilt: Ch 3	

- Motorised unit provided by the supplier of the M10 unit.

3 LCU's description

3.1 IC-LCU

3.1.1 IC-LCU functionality's

- The IC-LCU contains all the VME electronic boards needed for the control of the motion controlled functions here listed:
  - WFS table X translation stage
  - WFS table Y translation stage
  - Derotator unit
  - Mode selector translation stage
  - Membrane mirror focus unit
  - Membrane mirror Tip motion
  - Membrane mirror Tilt motion

- The control electronics for the following functions is also part of the IC-LCU:
  - the WFS XY table brake mechanisms
  - the cabinet thermal control system (1 serial line + 1 digital input alarm)

- The AC/DC power supplies for the VME bus (+5V, +12V, -12V), for the motors (+/-24V, +/-12V) and for the encoder (+5V) are part of the IC-LCU, to form a complete "autonomous" rack.

- All external cables are terminated with connector.

- Dimension and type of chassis: 19" – 6HE – depth 420 mm - VERO/KM6II

- Three cooling fans (230AC) in a drawer with axial air inlet blow air from below the VME boards

- Mains supply: 230VAC with RFI/fuse/swicth

3.1.2 IC-LCU front panel description

See annexed drawing: IC-LCU, IC-LCU-B, IC-LCU-01, IC-LCU-02.skd

Table 20: IC-LCU front panel description

Slot	Function	Manufacturer	Type	Description
1	CPU	MOTOROLA	MVME2604/43 31-712I/O	64B RAM memory Ethernet and RS-232 interface J2: DINC96 to Transition module MVME712
2	Time Interface Module	ESO	TIM	Interface board to the Co-ordinated Universal Time (UTC) from the Time-Bus J2: Backplane receiver for TIM
3	Digital Input and Output board	ACROMAG	AVME 9481	Interface 64 digital input/output signals. J2: DINC96 with soldered terminal
4	Motion controller	MACCON	MAC4/INC	4 axis per board with interface for incremental encoder
5	DC Servo-amplifier	ESO	VME4SA type 01	Size 2 Amp /motor – 4 axis per board – 4TE
4-5	DC Servo-amplifier backplane	ESO	VME4SA backplane	Backplane (P2) between MAC4/INC and VME4SA boards where the motor cables are terminated
6	Motion controller	MACCON	MAC4/INC	4 axis per board with interface for incremental encoder
7	DC Servo-amplifier	ESO	VME4SA type 01	Size 2 Amp /motor – 4 axis per board – 4TE
6-7	DC Servo-amplifier backplane	ESO	VME4SA backplane	Backplane (P2) between MAC4/INC and VME4SA boards where the motor cables are

				terminated

Continue next page

Slot	Function	Manufacturer	Type	Description
8	Motion controller	MACCON	MAC4/INC	4 axis per board with interface for incremental encoder
9-10	DC Servo-amplifier	ESO	VME4SA type 02	Size 5 Amp /motor – 4 axis per board. – 8TE
8-9	DC Servo-amplifier backplane	ESO	VME4SA backplane	Backplane (P2) between MAC4/INC and VME4SA boards where the motor cables are terminated
11	Spare 1			
12	Spare 2			
	VME Power supply	KNIEL	FPM 1603 300W	VME power voltage (+5,+/- 12 Vdc) required by the VME bus system.
	VME BUS	BICC-VERO	VMEXCEL	12 Slots VME bus motherboard (J1 only)
	Brake controller	ESO	CS-P-1873	Controller with switches for manual command and status display LED's

3.1.3 IC-LCU rear side panel description

Table 21: IC-LCU rear side panel

Size	Function	Manufacturer	Type	Description
4 TE	Encoder Supply	KNIEL	CP5-4	AC/DC supply: 5Vdc - 4 Amps
8 TE	12 Vdc Motor supply	KNIEL	CPD12.2	AC/DC supply: 2x12 Vdc - 2Amps
20 TE	24 Vdc Motor Supply	KNIEL	CP24.8	2 x AC/DC supply: 24 Vdc - 8 Amps
	Transition module.	MOTOROLA	CPUIO MVME712M	Panel with the Ethernet and RS-232 ports – DSub 25 poles - mounted on the rear side of the IC-LCU.
4TE	IC-LAN connection ST for optical fibre	ESO		Ethernet tranceiver. Flat cable to the CPU transition module MVME712M
4TE	Time Reference System connection ST for optical fiber and with Dsub-9	ESO		Plate with ST optical fibre connected to the TIM backplane connector. The Dsub-9 pole connector is to continue the electrical distribution (RS-422) of the TRS to another LCU
8TE	Patch panel connector for brake control and CTC alarm	ESO		Plate with connector SOURIAU 851-14-15 and Lemo size 0 - 2p
14TE	230VAC - Mains CEE-22 with strain relief			Connection to the 230 VAC mains UPS.

3.1.4 IC-LCU supplies

3.1.4.1 VMEbus supply

The 5VDC, +12 VDC and –12VDC VME voltages are provided by a KNIEL – FPM 1603 unit, installed in the IC-LCU rack. The following table gives the consumption of the VME rack:

Table 22: IC-LCU VMEbus supply

Board	Nber	5VDC	12VDC	-12VDC
MVME2604 + MVME712	1	9.5	0.50 A	0.25 A
TIM	1	0.5	0.1 A	/
ACROMAG AVME	1	1.6	/	/
MAC4/INC	3	2.5	/	/
VME4SA	3	0.4	0.110 A	0.070 A
EXCEL-12 slot	1	1	/	/
Total		21.3 Amps	0.93 Amps	0.46 Amps
KNIEL FPM 1603 capacity		40 Amps	6 Amps	2 Amps

3.1.4.2 Auxiliary supplies

The 5VDC for the encoder, the +24VDC and –24VDC for the motor are provided by KNIEL – CP unit, installed in the IC-LCU rack. The following table gives an estimation of the consumption:

Table 23: IC-LCU auxiliary supply

Functions	**5Vdc Encoder**	**+/-24Vdc Motor**	**+/-12Vdc Motor**	**Servo-amplifier**
WFS table X translation	0.250	2		10 W
WFS table Y translation	0.250	2		10 W
Derotator unit	0.250	2		10 W
Mode selector translation stage	0.250	0.25		3 W
Membrane mirror focus	0.250	0.25		3 W
Membrane mirror tip unit	0.250		0.1	
Membrane mirror tilt unit	0.250		0.1	
WFS X-Y table brake		0.10		
Total	**1.75 Amps**	**6.6 Amps**	**0.2 Amps**	**31 W**
KNIEL capacity	4 Amps	8 Amps	2 Amps	

- All above values are only estimation that will be reviewed when the first prototype units are put in operation. The sizing of the supply units and of the servo-amplifiers provide still some comfortable margin, if the expected load is increasing. On contrary, and based on prototype testing, these estimations can also be revised to lower value. The selection of the electronic components will be then optimised accordingly.

3.1.4.3 Heat dissipation

The power dissipation by the IC-LCU is estimated as follow:

- VME supply: 160 W
- Aux supply : 60 W
- Fan drawer : 45 W

Total: 265 W

3.1.5 WFS XY table brake mechanisms

WFS table connection chassis
This chassis (19" - 6HE), located under the IC-LCU rack, is for the connection all components part of the X-Y table on block screw terminals:

- Motor, Tacho, Upper and Lower limit switches, Encoder and EXE unit signals (All two times)
- Brake status switches (2x), Pressure switch (1x), Electro-valve (1x)

The wiring of the interlocking between the brake mechanisms and the motors is also part of the chassis, as well as the connector (MIL-851-14-15) to the brake controller (located in the IC-LCU).

All field cables are terminated with entry connectors. The two function cables to the MACCON/VME4SA are made with ELOCAB 2914 rev 2 terminated with a Molex Omnigrid connector.

To minimise the head produce by the electronics on the Coude platform, the two-encoder digitalisation and interpolation units (EXE 610) are located in this chassis. The pressure switch and the brake electro-valve are for the same reason located in the IC-cabinet.

Field signal definitions

Identification	**Designation**	**Function**
PRESS	Pressure status	Pressure-switch signal indicating that the air pressure level is high enough to release the brake jaws.
X-BR-ST	X Brake status	Switch signal from X brake indicating that the jaw is released (free)
Y-BR-ST	Y Brake status	Switch signal from Y brake indicating that the jaw is released (free)

Command signal

Identification	**Designation**	**Function**
BR-CMD	Remote brake command	Command from DIO to release or close the brake (both axis) when the brake controller is turn in remote mode
BR-MANU	Manual brake command	Manual command from the brake controller front panel to operate the brake mechanisms when in local mode

Control logic definition
The motor rotation (both axes) is enable only if the pressure is normal (high enough) and if both X/Y status switches indicate that the both brakes are released (open).

The brake status signals are send by the DIO-Acromag board to the IC software.

The local command of the brakes from the brake controller front panel is to allow moving the X-Y table using the handset connected to the VME4SA servo-amplifier. The status of the brakes and of the air pressure is also locally indicated.

3.2 RTC-LCU

3.2.1 RTC-LCU functionality's

- The RTC-LCU contains all the VME electronic boards needed for the control of the motion controlled functions as listed:

    - WFS ND filter wheel
    - Membrane mirror diaphragm

- The electronics for the control of the following functions is also part of the RTC-LCU:

    - the WFS entry shutter
    - the APD counter
    - the APD supply control
    - the DM high speed fibre links
    - the cabinet cooling system (1 serial line + 1 digital input alarm)

- The AC/DC power supplies for the VME bus (+5V, +12V, -12V), for the motors and shutter (+24V, -24V) and for the encoder (+5V) are also part of the RTC-LCU.

- All external cables are terminated with connector.

- Dimension and type of chassis: 19" – 6HE – depth 420 mm - VERO/KM6II

- Three cooling fans (230AC) in a drawer with axial air inlet blow air from below the VME boards

- Mains supply: 230VAC with RFI/fuse/swicth

3.2.2 RTC-LCU front panel description

See annexed drawing: RTC-LCU, RTC-LCU-01, RTC-LCU-02.skd

Table 24: RTC-LCU front panel description

Slot	Function	Manufacturer	Type	Description
1	CPU - Supervision	MOTOROLA	MVME2604/43 31-712I/O	64B RAM memory Ethernet and RS-232 interface
2	CPU - Real time computer	MOTOROLA	MVME2604/43 31-712I/O	256 MB RAM memory Ethernet and RS-232 interface
3	Reflective memory	VMIC	VMICVME-5576	Fibre-Optic Reflective Memory with Interrupts
4	Spae			
5	APD counter board	SHAKTI		60 Channels counter board for APD
6	Time Interface Module	ESO	TIM	Interface board to the Co-ordinated Universal Time (UTC) from the Time-Bus
7	Digital Input and Output board	ACROMAG	AVME 9481	Interface 64 digital input/output signals.
8	Motion controller	MACCON	MAC4/INC	4 axis per board with interface for incremental encoder
9	DC Servo-amplifier	ESO	VME4SA type 01	Size 2 Amp /motor – 4 axis per board – 4TE
8-9	DC Servo-amplifier backplane	ESO	VME4SA backplane	Backplane (P2) between MAC4/INC and VME4SA boards where the motor cables are terminated

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Slot	Function	Manufacturer	Type	Description
10	Spare			
11	Spare			
12	Spare			
	VME Power supply	KNIEL	FPM 1603 300W	VME power voltage (+5,+/- 12 Vdc) required by the VME bus system
	VME BUS	BICC-VERO	VMEXCEL	12 Slots VME bus motherboard (J1 only)
	Shutter controller	ESO	CS-P-1873	

3.2.3 RTC-LCU rear side panel description

Table 25: RTC-LCU rear side panel

Size	Function	Manufacturer	Type	Description
4TE	Encoder Supply	KNIEL	CP5-4	AC/DC supply: 5Vdc - 4 Amps
14TE	Motor Power Supply	KNIEL	CP24.5	2 x AC/DC supply: 24 Vdc - 5Amps
	Transition module.	MOTOROLA	CPUIO MVME712M	Panel with the Ethernet and RS-232 ports – DSub 25 poles - mounted on the rear side of the IC-LCU.
4TE	IC-LAN connection ST for optical fibre			Ethernet tranceiver. Flat cable to the CPU transition module MVME712M
4TE	Time Reference System connection with Dsub-9			The Dsub-9 pole connector is to receive and continue the electrical distribution (RS-422) of the TRS from/to another LCU
8TE	Patch panel connector for shutter control and CTC alarm	ESO		Plate with connector SOURIAU 851-14-12 and Lemo size 0 - 2p
4TE	Patch panel connector for APD supply control			Plate with Dsub-15 poles to the APD cabinet
14TE	230VAC - Mains CEE-22 with strain relief			Connection to the 230 VAC mains UPS

3.2.4 RTC-LCU supplies

3.2.4.1 VMEbus supply

The 5VDC, +12 VDC and –12VDC VME voltages are provided by a KNIEL – FPM 1603 unit, installed in the RTC-LCU rack. The following table gives the consumption of the VME rack:

Table 26: RTC-LCU VMEbus supply

Board	Nber	5VDC	12VDC	-12VDC
MVME2604 + MVME712	2	9.5	0.50 A	0.25 A
VMICVME-5576	1	5.0	/	/
APD Counter (Estimated)	1	5.0	/	/
TIM	1	0.5	0.1 A	/
ACROMAG AVME	1	1.6	/	/
MAC4/INC	1	2.5	/	/
VME4SA	1	0.4	0.110 A	0.070 A
EXCEL-12 slot	1	1	/	/
Total		35.0 Amps	0.71 Amps	0.32 Amps
KNIEL FPM 1603 capacity		40 Amps	6 Amps	2 Amps

3.2.4.2 Auxiliary supplies

The 5VDC for the encoder, the +24VDC and –24VDC for the motor are provided by KNIEL – CP unit, installed in the RTC-LCU rack. The following table gives a first estimation of the consumption:

Table 27: IC-LCU auxiliary supply

Functions	**5VDC-ENCODER**	**24VDC MOTOR**	**24VDC MOTOR**	**Servo-amplifier**
Membrane mirror diaphragm	0.01	0.1	0.1	2 W
WFS ND filter wheel	0.250	0.25	0.25	3 W
WFS entry shutter	/	1	/	/
Total	**0.26 Amps**	**0.35 Amps**	**0.35 Amps**	**5 W**
KNIEL capacity	4 Amps	5 Amps	5 Amps	

3.2.4.3 Heat dissipation

The power dissipation by the RTC-LCU is estimated as follow:

- VME supply: 225 W
- Aux supply : 20 W
- Fan drawer : 45 W

Total : 290 W

3.2.5 WFS Entry shutter

3.2.5.1 Shutter unit

The WFS Entry shutter is a bi-stable shutter (Model Compur), made of a "double coils" mechanism. Short single pulse commands are needed to open or close the blades, there fore avoid any heat dissipation. The Compur shutter is equipped with micro-switches that indicate the Open/Closed status of the blades.

3.2.5.2 Shutter controller

The shutter controller is a compact stand-alone electronic unit made to interface with the shutter (UVES design). The controller unit is inserted between the digital input/output VME board and the shutter unit. The main functions of the shutter controller are:

- Power adaptation
- Mode of command adaptation (Logic control)
- Manual operation (Local mode)
- EMC/ESD protection

A single supply voltage of 24Vdc is needed. The unit is made off a compact metallic 3HE size cassette – 6TE – 160mm with standard DIN-F connector, to facilitate is integration in a 19" rack with direct plug-in and out.

The controller is made of two PCB's:

- A main board which holds all the low level logic control circuits, the front panel with toggle switches and status LED indicators and the back side connector. A EPLD chip is programmed according to the type of shutter (or of lamp) to be controlled.
- A power adapter mezzanine board with the power circuits specific to each type of shutter or lamps. The power adapter board is stacked on the main board trough two series of 10 high-power pins. The shutter power adapter has been configured so that the board generates only a peak current of 60msec with no-holding current.

3.3 VLTI-LCU

3.3.1 VLTI-LCU functionnality's

- The VLTI-LCU contains all the VME electronic boards needed for the control of three VME motion controlled functions:

  - STRAP filter wheel
  - STRAP diaphragm
  - M10 mirror (3 axes)

- The electronics for the control of the following functions is also part of the VLTI-LCU:

  - technical CCD
  - STRAP

- The AC/DC power supplies for the VME bus (+5V, +12V, -12V), for the motors (+/-12Vdc) , the ACE unit (+24V) and for the encoder (+5V) are also part of the VLTI-LCU.

- All external cables are terminated with connector.

- Dimension and type of chassis: 19" – 6HE – depth 420 mm - VERO/KM6II

- Three cooling fans (230AC) in a drawer with axial air inlet blow air from below the VME boards

- Mains supply: 230VAC with RFI/fuse/swicth

3.3.2 VLTI-LCU front panel description

See annexed drawing: VLTI-LCU, VLTI-LCU-01, VLTI-LCU-02.skd

Table 28: VLTI-LCU front panel description

Slot	Function	Manufacturer	Type	Description
1	CPU	MOTOROLA	MVME2604/43 31-712I/O	64 MB RAM memory Ethernet and RS-232 interface
2	LIB	ESO		Technical CCD
3	LAB	ESO		Technical CCD
4	Spare			
5	Time Interface Module	ESO	TIM	Interface board to the Co-ordinated Universal Time (UTC) from the Time-Bus
6	Motion controller	MACCON	MAC4/INC	4 axis per board with interface for incremental encoder
7	DC Servo-amplifier	ESO	VME4SA type 01	Size 2 Amp /motor – 4 axis per board – 4TE
6-7	DC Servo-amplifier backplane	ESO	VME4SA backplane	Backplane (P2) between MAC4/INC and VME4SA boards where the motor cables are terminated
8	Motion controller	MACCON	MAC4/INC	4 axis per board with interface for incremental encoder
9	DC Servo-amplifier	ESO	VME4SA type 01	Size 2 Amp /motor – 4 axis per board – 4TE
8-9	DC Servo-amplifier backplane	ESO	VME4SA backplane	MAC4/INC and VME4SA boards are connected together by means of a dedicated backplane (P2) and on which arrive the motor cables
10	Spare			

11	Spare			
12	STRAP	ESO		STRAP - VME board
	VME Power supply	KNIEL	FPM 1603 300W	VME power voltage (+5,+/- 12 Vdc) required by the VME bus system. The nominal output power for the VME-crate is estimated to 200 Watts
	VME BUS	BICC-VERO	VMEXCEL	12 Slots VME bus motherboard (J1 only)

3.3.3 VLTI-LCU rear side panel description

Table 29: RTC-LCU rear side panel

Size	Function	Manufacturer	Type	Description
4TE	Encoder Supply	KNIEL	CP5-4	AC/DC supply: 5Vdc - 4 Amps
14TE	Motor Power Supply	KNIEL	CP24.5	2 x AC/DC supply: 24 Vdc - 5Amps
	Transition module.	MOTOROLA	CPUIO MVME712M	Panel with the Ethernet and RS-232 ports – DSub 25 poles - mounted on the rear side of the LCU.
4TE	IC-LAN connection ST for optical fibre			Ethernet transceiver. Flat cable to the CPU transition module MVME712M
4TE	Time Reference System connection with Dsub-9			The Dsub-9 pole connector is to receive the electrical distribution (RS-422) of the TRS from another LCU
14TE	230VAC - Mains CEE-22			Connection to the 230 VAC mains UPS.

3.3.4 VLTI-LCU supplies

3.3.4.1 VMEbus supply

The 5VDC, +12 VDC and –12VDC VME voltages are provided by a KNIEL – FPM 1603 unit, installed in the VLTI-LCU rack. The following table gives the consumption of the VME rack:

Table 30: RTC-LCU VMEbus supply

Board	Nber	5VDC	12VDC	-12VDC
MVME2604 + MVME712	1	9.5	0.50	0.25
LIB	1	1.0	/	/
LAB	1	1.0	/	/
TIM	1	0.5	0.1	/
STRAP	1	5	0.5	0.5
MAC4/INC	2	2.5	/	/
VME4SA	2	0.4	0.1	0.07
EXCEL-12 slot	1	1	/	/
Total		**23.8 Amps**	**1.3 Amps**	**0.89 Amps**
KNIEL FPM 1603 capacity		40 Amps	6 Amps	2 Amps

3.3.4.2 Auxiliary supplies

The 5VDC for the encoder, the +24VDC and –24VDC for the motor are provided by KNIEL – CP unit, installed in the VLTI-LCU rack. The following table gives a first estimation of the consumption:

Table 31: IC-LCU auxiliary supply

Functions	**5Vdc Encoder**	**24VDC ACE**	**+/-12Vdc Motor**	**Servo-amplifier**
STRAP filter wheel	0.01		1	2 W
STRAP diaphragm	0.01		0.1	2 W
M10 Translation	0.01		0.1	2 W
M10 Tip	0.01		0.1	2 W
M10 Tilt	0.01		0.1	2 W
Technical CCD	/	1.5	/	/
Total	0.05 Amps	1.5 Amps	1.5 Amps	10 W
KNIEL capacity	4 Amps	5 Amps	5 Amps	

3.3.4.3 Heat dissipation

The power dissipation by the VLTI-LCU is estimated as follow:

- VME supply: 180 W
- Aux supply : 20 W
- Fan drawer : 45 W

Total: 245 W

4 Instrument Control Cabinet

4.1 Cabinet layout

- The instrument control electronics hardware for the MACAO-VLTI is located in two cabinets called *Instrument Control cabinet* (IC cabinet), located near the WFS and APD cabinet, and fixed on the Coude platform.
- The cabinet is made of two "standard" enclosures (600x800x1200 mm) bolted to each other to form a single unit when mounted. The height of the cabinet is 1200 mm (or 23HE). The cabinets are directly bolted to the Coude platform.
- Each cabinet is equipped with front and rear doors and one removable side/top panel.
- To limit the heat transfer between the cabinet external surfaces to the ambient air, the cabinet is actively temperature controlled. A heat exchanger is located inside each of the cabinet (bottom).
- The cabinet are thermally insulated (internal panel insulation)
- All the cables and the optical fibres enter by the bottom of the cabinet through access holes pre-made in the Coude platform.

The cabinet characteristics are:

Manufacturer	KNURR
Model	MIRACELL
Type	19" with front steel door
External dimensions	600x800x1200 mm (WxDxH)
Available height	23 HE (1052mm)
Available depth	640 mm
Weight	58 Kg (empty)
Protection	IP55

The IC-cabinet hosts the following chassis and components:

Name	**Description**	**Height**
Side 1	**(Left hand)**	
Spare	Spare place to collect hot air	1 HE
IC-LCU	LCU-VME chassis	6 HE
FAN	Fan and air inlet drawer	1 HE
WFS-table	WFS table connection chassis	6 HE
Spare	Spare	1 HE
Spare	Spare place to conduct cold air from heat exchanger	3 HE
CTC	Cabinet thermal control	4HE
Spare	Spare place to bring hot air into the heat exchanger	1 HE
	Total	**23 HE**
Side 2	(Right hand)	
Spare	Spare place to collect hot air	1 HE
RTC-LCU	LCU-VME chassis	6 HE
FAN	Fan and air inlet drawer	1 HE
VLTI-LCU	LCU-VME chassis	6 HE
FAN	Fan and air inlet drawer	1 HE
Spare	Spare place to conduct cold air from heat exchanger	3 HE
CTC	Cabinet thermal control	4HE
Spare	Spare place to bring hot air into the heat exchanger	1 HE
	Total	**23 HE**

4.2 Mains distribution

- The total electrical power consumption for MACAO-VLTI is estimated to 1500 Watts. This power is provided by the Mains-UPS VLT network from the SCP-A.
- One single-phase cable (2x1.5sqmm +Shield) runs between the SCP (Internal connection) and the IC-cabinet main entry isolator switch (Klockner Moeller 2 poles – 16A 4KW – Red) located on the side panel of the cabinet. The power line is protected with a residual current breaker with over-current protection (RCBO rated 16A - 30mA). The electrical equipment is protected with a surge protector-filter (PGEP 16A – wave 5KA 8/20 µs, max. surge current 10KA).
- All electrical equipment connected to the mains are fuse protected and have RFI/EMI line filters.
- The power for the APD cabinet is taken from the IC-cabinet distribution system.
- A thermostat (KNURR-1.113.384.3) located on top of each the cabinet trips the mains power in the case of a too-important increase of the temperature (45 deg.C) inside the electronic cabinet. A manual local reset of the main power supply switch is than required.

In the cabinet, the UPS - 230 VAC mains is distributed as follows:

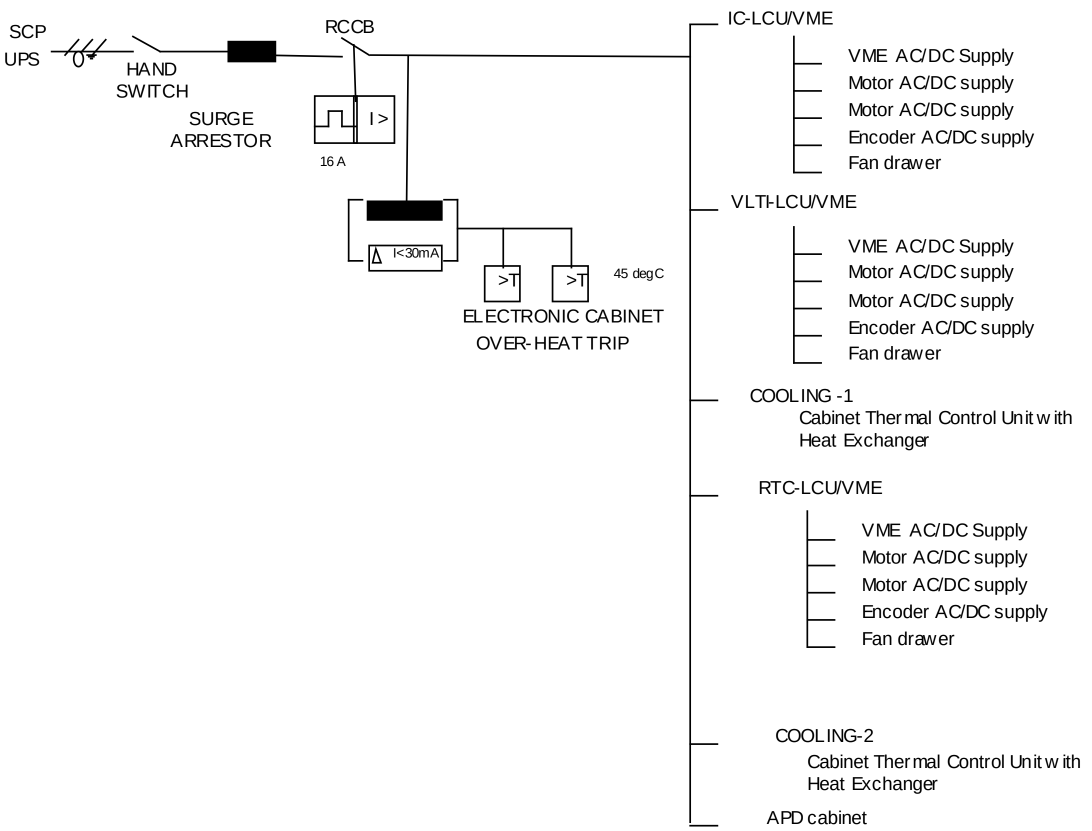

Figure 6 - 230 VAC Mains Distribution

4.3 Cabinet Thermal control

4.3.1 Power dissipation

The estimation of the electrical power dissipated (permanent) in the IC-cabinet is as follow:

- Side 1
  - IC-LCU = 265 W
  - Heat exchanger = 280 W
  - Total = 545W
- Side 2
  - RTC-LCU = 290 W
  - VLTI-LCU = 240 W
  - Heat exchanger = 280 W
  - Total = 810 W

4.3.2 Heat exchanger

- The thermal constraints for VLTI require that the temperature of the equipment in the telescope area is kept as close as possible to the environment. The specifications indicates +1°C –5°C or +10/-20 Watts radiation only on the Coude platform (See RD 4)

- The active cooling systems integrated in the electronic cabinets are to reduce, or ideally to “eliminate”, the amount of thermal energy produced by the electronics and to avoid any dissipation send out to the ambient.

- The cooling system consists in “*ESO standard heat exchanger*” – See RD 9, that transfers by liquid/air heat exchange, the thermal energy generated inside the cabinet to a coolant fluid supplied by the central chilling system of the VLT (SCP-part C).

- The heat exchangers are located at the bottom of the cabinet. The warmed air generated by the electronics is returned from the top of the cabinet to the heat exchanger, which releases it after cooling down through the electronic chassis.

- The forced ventilation inside the cabinet consists to the heat exchanger fans (4) and the fan drawers located under each chassis.

- The purpose of the *cabinet thermal controller* (micro-controller) is to control this heat transfer process in order to track system variations like ambient temperature, amount of power generated, cooling fluid temperature. The controller implements a feedback action calculated on the difference between the temperature of the ambient air and the cabinet surface temperature. The temperature regulation controls the coolant fluid flow by a two-ways valve so that the external cabinet surface is not more than 1.0°C from the ambient temperature.

- Additional parameters related to the thermal control of the IC cabinet are monitored, like:

  - the measurement of the inlet and outlet temperature of the coolant lines
  - flow of the coolant fluid passing through the heat exchanger

- The front panel display indicates the temperatures, the flow value, the valve position status and the warning messages. All data are transmitted via a RS-232 line, to the IC-LCU (side 1) and to the RTC-LCU (side 2).

4.3.3 Fan drawer

- A fan drawer equipped with three fans (450 m3/hr) is mounted under each of the sub-rack (e.g.: LCU).

- The warmed air is directed to the top of the cabinet from where it is returned to the heat exchanger. With such additional ventilation, no hot spot should appear inside the cabinet, and the efficiency of the heat exchanger is intensified.

- The fan drawers are fixed with the above chassis (e.g.: LCU) and supplied (45 W) from the same 230VAC source. They are equipped with dust filter.

4.3.4 Temperature Sensors

- For each of the cabinet heat exchanger, two temperature sensors (PT100- Heraeus Class B) are to measure the ambient temperature on the Coude platform and the cabinet surface temperature. The *ambient temperature sensor* is placed into a small protective housing fixed at about 1.5 meters height near the cabinet to sense the external temperature (Ambient air). The *cabinet surface temperature sensor* is fixed externally on the lateral side panel (topside).

- Both sensors are terminated on screw terminal blocks. Extension cables bring these signals on the rear side of the cabinet thermal control unit (CTC).

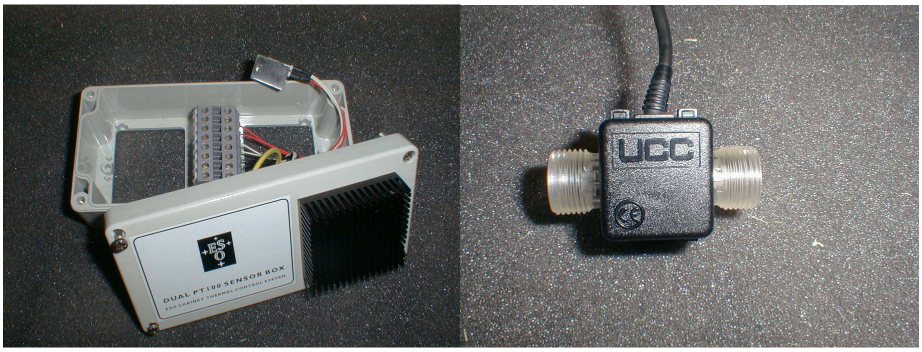

Figure 7 : Temperature sensor and flow meter

4.3.5 Flow rate sensors

- As part of the heat exchanger, a small turbine-meter measures the flow of the coolant liquid passing through the heat exchanger.

4.3.6 Thermal insulation of the cabinet

- All external surface of the cabinet are covered internally with insulation panel of 40 mm thick, made of "Armaflex" material.

5 SCP, Networks Distribution and Cabling

5.1 Coude arrangement

- The IC-cabinet is directly bolted to the Coude platform in the space allocated for MACAO-VLTI.

- Under the Coude platform floors, and already installed, various metallic cable ducts run between the SCP, the IC-cabinets and the WFS unit.

5.2 SCP

One of the SCP's of the Coude platform is exclusively assigned for the delivery of the necessary electrical power, the LAN's connection and the coolant fluid to MACAO-VLTI control systems (Excluding the DM control system).

5.2.1 Electrical Power distribution (SCP-Part A)

- The single phase 230 VAC (UPS) is distributed from the SCP to the IC cabinet.

- The power cable is terminated inside the SCP's using the internal block screw-terminals with cable shield connected inside the SCP to the PE-GND attachment screw.

5.2.2 Equipotential bonding and grounding network (SCP-Part A)

- An *instrument equipotential bonding and grounding network* starting from the SCP, and connected to the platform structure, links all conductive metallic parts like: cabinets, sub-racks, junction boxes, patch panels, feed-trough's, cable trays and instrument functions.

- The grounding network consists of a flexible 16 sqmm copper wire. Derivations (network branches) are made of smaller wire sections clamped with butt splice (" TEE " connection) to the main wires. The bonding of the equipment is made by bolting.

5.2.3 LAN's distribution (SCP-Part B)

- <u>Instrument LAN:</u>
    - All CPU's part of the IC-LCU, the RTC-LCU and the VLTI-LCU are connected to the *VLTI Auxiliary Optic Control* LAN. The total number is then four (3) in-out channels.
    - For each channel, one pair of optical fibres terminated with ST connectors (IN/OUT) runs between the SCP-Part B and the control electronics.
    - An Ethernet transceiver converts the signals from optical to electrical before connection to the CPU transition module.

- <u>Time reference system:</u>
    - Only the IC-LCU is connected to the *Time Reference System*, with one single ST connection. The other TIM boards are connected to the UTS by means of the RS-422 electrical connection (daisy chain).

- <u>Fast link to DM control cabinet:</u>
    - The connection between RTC-LCU and DM controller will require 2 Duplex OF = 4 fibres. One pair for the high-speed connection and one pair for the RS232 "service link". The optical fibre links between the MACAO IC-cabinet and the DM control cabinet located on the azimuth platform is done through the SCP-B network.

- <u>Reflective memory:</u>
    - The optical fibre link between the RTC-LCU (Reflective memory board) and the VLTI is done through the SCP-B network (Two channels) and defined as *UT Rapid Guiding* LAN.

5.2.4 Coolant fluid distribution (SCP-Part C)

The coolant fluid provided by the SCP-Part C is distributed to the IC cabinet, the ACE/TCCD and the STRAP sensor head. The estimated cooling power is approx. 1.3 KW. The supply and return connections at the SCP-part C and at the IC-cabinets are made using quick couplings (self-sealing with automatic closing).

Cabinets	**Designation**	**Cooling Power**
IC-cabinet	Instrument control electronics cabinet	1300
TCCD	ACE/TCCD	30
STRAP	Strap sensor head	<5
APD cabinet	APD sensor cabinet	200
	TOTAL	**1335 Watt**

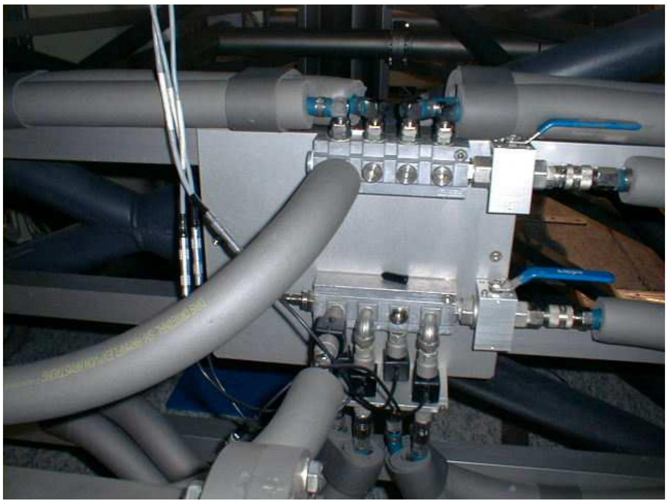

Figure 8 : Coolant fluid distribution (Example)

The coolant fluid distribution systems consists of the following elements:

- Isolation quarter-turn valves
- Flow limitor
- Pressure gauge
- Flexible reinforced tubes insulated with a minimum of PE 2cm thickness
- Quick couplings with self-sealing with automatic closing as connections to the SCP-part C and heat exchanger

5.3 Cabling

5.3.1 Cable sizing and definition

From	TO	Nature	Nber	Cable diameter
IC-Cabinet	SCP-A	Power (230VAC)	1	10 mm
IC-Cabinet	SCP-A	PE	1	6 mm
IC-Cabinet	SCP-B	O.F	6	6 mm
IC-Cabinet	SCP-C	Cooling	2	50 mm
IC-Cabinet	APD cabinet	Power (230VAC)	1	10 mm
IC-Cabinet	APD cabinet	Signals	1	6 mm
IC-Cabinet	APD cabinet	Signals (2x30)	2	TBD mm
IC-Cabinet	DM cabinet	O.F	2	6 mm
IC-Cabinet	WFS table	Motor	2	10 mm
IC-Cabinet	WFS table	Tachometer	2	5 mm
IC-Cabinet	WFS table	Switches	4	5 mm
IC-Cabinet	WFS table	Encoder	2	10 mm
IC-Cabinet	WFS table	Brake switches	2	5 mm
IC-Cabinet	ACE	Power (24Vdc)	2	6 mm
IC-Cabinet	ACE	O.F	1	12 mm
SCP-C	ACE	Cooling	2	50 mm
IC-Cabinet	WFS unit	Servo-drive	9	10 mm
IC-Cabinet	WFS unit	Shutter	1	6 mm
IC-Cabinet	WFS unit	STRAP	3	6-9-9 mm
IC-Cabinet	WFS unit	STRAP-cooling	2	50 mm
ACE	WFS unit	TCCD-cable	3	6
ACE	WFS unit	TCCD-cooling	2	50 mm
SCP-A	WFS unit	PE-GND	1	10 mm

5.3.2 Cable ducts

- All cables are laid in pre-installed metallic ducts, located under the floor of the Coude platform. The ducts are all equipped with covers. The cable ducts extend to the SCP, the IC-cabinet, and the instrument enclosure feed-through.

- Not withstanding that all cables are shielded, provision is taken to keep separation between the different types of cable (power and signal), when selecting the cable trays.

- All parts of ducts and covers are assembled by screw and bolt to ensure the electrical continuity and EMC shielding. The ducts are connected to the equipotential network at several points.

5.3.3 WFS feed-trough's

- Eight- (8) feed-trough's do provide access inside the WFS panels without degradation on the enclosure thermal performances and light tightness. Each feed-through can accommodate passages for three cables.

- Additional rubber sleeves are inserted around each cable at the level of the feed-trough passing holes to guarantee a total light tightness.

- The derotator unit is located out of the WFS box. Therefore the servo-drive cable goes directly from the IC-LCU to the drive unit, without the need of a feed trough.

Figure 9 : Enclosure feed-trough

Table 32 : Feed trough's distribution

Acronym	Designation	Type	F/T
SPARE			1.A
MSEL	Mode selector translation stage	Servo-drive	1.B
WFSFWH	WFS ND filter wheel	Servo-drive	1.C
STRAPFWH	STRAP filter wheel	Servo-drive	2.A
STRAPDIAPH	STRAP diaphragm	Servo-drive	2.B
SPARE			2.C
STRAP	Strap unit	Control	3.A
STRAP	Strap unit	H.V	3.B
STRAP	Strap unit	Signal	3.C
STRAP	Strap unit	Cooling	4.A
STRAP	Strap unit	Cooling	4.B
SPARE			4.C
MMTIP	Membrane mirror Tip motion	Servo-drive	5.A
MMTILT	Membrane mirror Tilt motion	Servo-drive	5.B
MMFOC	Membrane mirror focus	Servo-drive	5.C
MMDIAPH	WFS Membrane mirror diaphragm	Servo-drive	6.A
MMPIST	Membrane mirror piston	Coil	6.B
WFSSHUT	WFS entry shutter	Coil + switches	6.C
TCCD	Technical CCD	Signals	7.A
TCCD	Technical CCD	Signals	7.B
TCCD	Technical CCD	Signals	7.C
TCCD	Technical CCD	Cooling	8.A
TCCD	Technical CCD	Cooling	8.B
SCP-A	WFS unit	PE-GND	8.C

6 Annex

6.1 Equipment identification

Identification	Acronym	Denomination
A01	IC-Cabinet	Instrument Control cabinet
A01-01	IC-LCU	Instrument Control LCU (VMEbus)
A01-02	RTC-LCU	Real Time Computer LCU (VMEbus)
A01-03	VLTI-LCU	VLTI LCU (VMEbus)
A01-JB	WFS XY TABLE	Junction panel for WFS XY table
A01-05	CTC#1	Cabinet Thermal Control unit (side 1)
	TS-AMB-1	Ambient air Temperature Sensor (side 1)
	TS-CAB-1	Ambient air Temperature Sensor (side 1)
A01-06	CTC#2	Cabinet Thermal Control unit (side 2)
	TS-AMB-2	Ambient air Temperature Sensor (side 2)
	TS-CAB-2	Ambient air Temperature Sensor (side 2)
A01-10	MAINS-IN	230 VAC protection & distribution (side 1)
A01-11	MAINS-1	230 VAC distribution (side 1)
A01-12	MAINS-2	230 VAC distribution (side 2)
A01-14	DSB-2	Dual Sensor Box (side 2)
A01-15	TH-1	IC-cabinet thermostat (side 1)
A01-16	TH-2	IC-cabinet thermostat (side 2)
A02	ACE	Front electronics for technical CCD
A03	STRAP	STRAP sensor head
A04	APD	APD Cabinet
A05	DM	DM control cabinet

6.2 List of drawings

File name	Tittle
MACAO.skd	Control electronics : Overview
A01-Cabinet-01.skd	A01: IC cabinet layout with Part list
Mains.skd	IC-Cabinet power distribution 230VAC wiring diagram
Mains-2.skd	IC-Cabinet power distribution 230VAC wiring diagram
PT100.skd	A01-05: Cabinet Thermal Control - Temperature sensors - Wiring diagram
PT100B.skd	A01-06: Cabinet Thermal Control - Temperature sensors - Wiring diagram
IC-LCU.skd	IC-LCU - Rack Layout with Part list
IC-LCU-01.skd	IC-LCU - Internal wiring diagram (Part 1)
IC-LCU-02.skd	IC-LCU - Internal wiring diagram (Part 2)
IC-LCU-03.skd	CTC - Digital I/O - Wiring diagram
TABLE-JB.skf	WFS-XY Table - Junction box layout
A01-JB.skf	WFS-XY Table - Junction box - Internal layout
TERM.skd	WFS-XY Table interlock - Wiring diagram
A01-01-70.skd	Brake controller unit - Front panel layout
WFS-XY-Brake.skd	WFS-XY Table - Brake - Wiring diagram
FM-WFS-XY.skd	WFS-XY-Table - Drive - Wiring diagram
FM-CAB.skd	Motion function cable - Wiring diagram
RTC-LCU.skd	RTC-LCU - Rack Layout with Part list
RTC-LCU-01.skd	RTC-LCU - Internal wiring diagram (Part 1)
RTC-LCU-02.skd	RTC-LCU - Internal wiring diagram (Part 2)
RTC-LCU-03.skd	WFS Entry shutter - Wiring diagram
RTC-LCU-04.skd	APD&CTC - Digital I/O - Wiring diagram
RTC-Shutter-FP.skd	Shutter controller unit - Front panel layout
SHUT.skd	WFS Entry shutter - Connector and cable assembly
VLTI-LCU.skd	VLTI-LCU - Rack Layout with Part list
VLTI-LCU-01.skd	VLTI-LCU - Internal wiring diagram (Part 1)
VLTI-LCU-02.skd	VLTI-LCU - Internal wiring diagram (Part 2)