E-ELT PROGRAMME

# MICADO Phase A
# Control Electronics Design

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AC | Alternating Current |
| CAN | Controller Area Network |
| CAS | Centralized Alarm System |
| CBA | Component Based Automation |
| COTS | Commercial of the Shelf (product) |
| DAU | Data Acquisition Unit |
| DC | Direct Current |
| E-ELT | European Extremely Large Telescope |
| EMC | Electromagnetic Compatibility |
| ESO | European Southern Observatory |
| HMI | Human Machine Interface |
| IHE | Instrument Housekeeping Electronics |
| ICE | Instrument Control Electronics |
| I/O | Input/Output |
| LAN | Local Area Network |
| LCU | Local Control Unit |
| LRU | Line Replaceable Unit |
| MCAO | multiconjugate adaptive optics |
| MICADO | The Multi-AO Imaging Camera for Deep Observations |
| MPE | Max-Planck-Institut für extraterrestrische Physik |
| MPIA | Max-Planck-Institut für Astronomie |
| NOVA | Nederlandse Onderzoekschool voor Astronomie |
| OAPD | Osservatorio Astronomico di Padova |
| OPC | OLE for Process Control |
| OPC UA | OPC Unified Architecture |
| PCB | Printed Circuit board |
| PLC | Programmable Logic Controller |
| RTE | Realtime Ethernet |
| SCP | Service Connection Point |
| SIL | Safety Integrated Level |
| TBC/D | To be confirmed/defined |
| TCS | Telescope Control System |
| UPS | Uninterruptible Power Supply |
| USM | Universitäts-Sternwarte München |
| VLT | Very Large Telescope |
| VME | Versatile Module Eurocard |

# 1 SCOPE

This report is intended to detail more the principles of the control electronics for MICADO. It should be read as a proposal of the control principles which may be detailed and where a decision will be taken during the next design stages of the project. The rationale for the taken concept will be outlined in a transparent way based on the experience gained during previous instrumentation projects with ESO.

# 2 APPLICABLE AND REFERENCE DOCUMENTS

## 2.1 Applicable Documents

The following applicable documents form a part of the present document to the extent specified herein. In the event of conflict between applicable documents and the content of the present document, the present document shall be taken as superseding.

AD1 Common definitions and acronyms , E-ESO-SPE-313-0066, Issue 1

AD2 E-ELT Instrument Interfaces and General Instrument Requirements, E-ESO-TRE-284/586-0093, version 1

AD3 Statement of Work for the Phase A Design of MICADO, E-SOW-ESO-561-0127, v1.0

AD4 Design Specification for Electrical Systems, E-SPE-ESO-061-0051, Issue 1, 19-09-2008

AD5 Service Connection Point Technical Specification, E-SPE-ESO-284-205, Issue 2, 31-03-2009

AD6 E-ELT Interfaces and General Requirements for Scientific Instruments, E-TRE-ESO-284/586-0093, issue 1.0

## 2.2 Reference Documents

RD1 MICADO System Overview, E-TRE-MCD-561-0009, v 2.0

RD2 MICADO Design Trade-Off and Risk Assessment, E-TRE-MCD-561-0010, v 2.0

RD3 MICADO Opto-Mechanical Design and Analysis, E-TRE-MCD-561-0011, v 5.0

RD4 ESO Technical Note, INS-09/03, v1

RD5 Presentation E-ELT Instrumentation at Mid Term at ESO: Hardware Control Electronics for Instrument, Guidelines and possible standardization, T. Erm, 10-02-2009

RD6 MICADO-EELT Phase A Interface Information and Requests, E-SPE-MCD-561-0015, Issue 1.0

# 3 ELECTRONICS CONTROL - NEW DESIGN CHALLENGES

MICADO may be a first light camera for the E-ELT project of ESO. The challenging nature of this project is due to the transition from the well defined set of standard electronic components from the VLT (which might become obsolete) to a new control architecture design. This document gives the progress made since the phase A1 report where new market trends and development that are capable to meet the control tasks for the electronics were studied. The intention of this report is to present in more detail a possible control design solution. According to the information given during the ESO workshop on E-ELT Instrumentation at Phase A Mid Term in February 2009 a skeleton on the future E-ELT standards based on the TCS design were given. Based on this, the experience gained during former instrumentation projects for ESO and the requirement coming from the instrument this report aims to demonstrate a control electronics conception capable to meet the required demands. The proposed concept does allow for implementation of new ESO standards during the next project phases.

### 3.1 MICADO Instrument Overview

MICADO is the Multi-AO Imaging Camera for Deep Observations, which is being designed to work with adaptive optics on the E-ELT. The instrument is compact and is supported underneath the AO systems so that it rotates in a gravity invariant orientation. MICADO has two arms, the primary arm is a high throughput imaging camera and an auxiliary arm to provide for a simple, medium resolution and longslit spectroscopic capability. MICADO could be considered as a first light instrument for the E-ELT.

MICADO will be located on the NASMYTH B platform of the E-ELT.

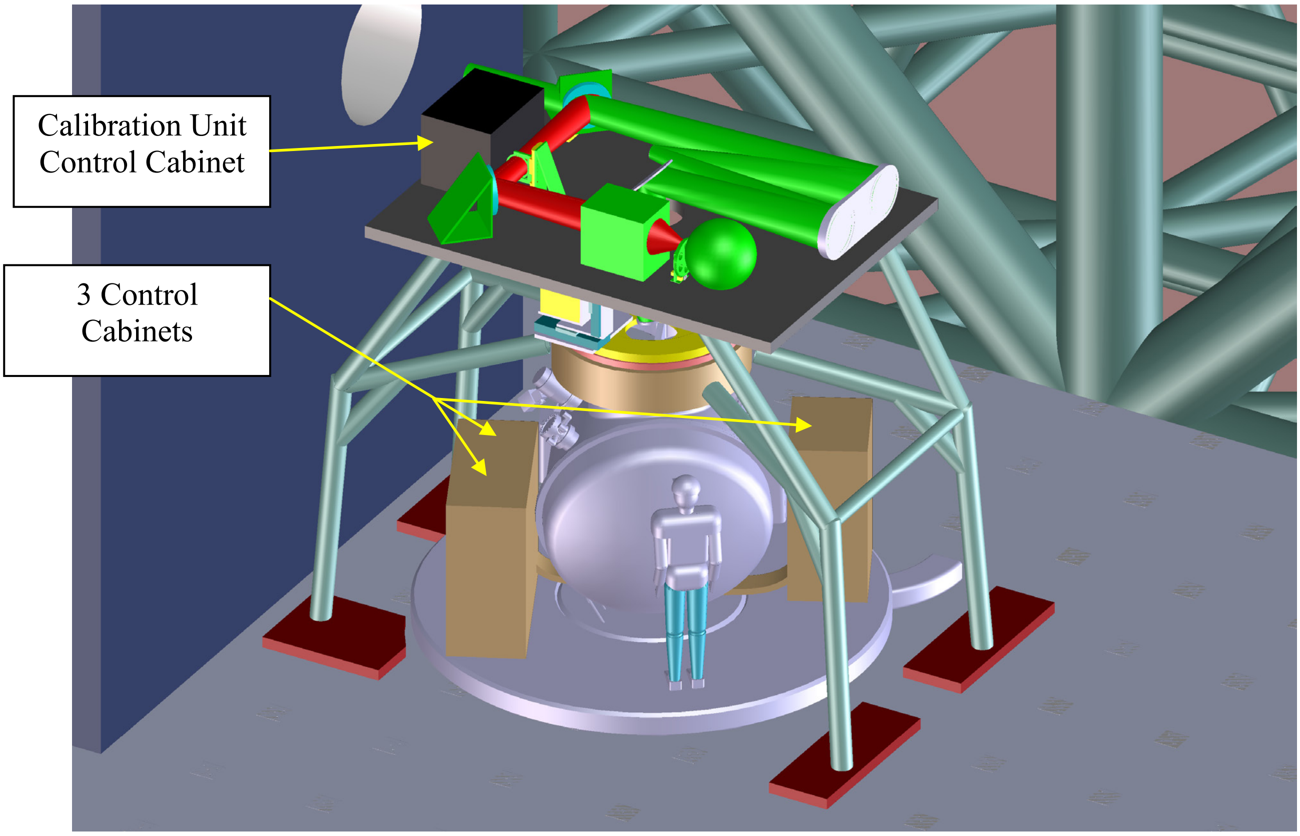


**Figure 3-1 MICADO Instrument mounted to SCAO module on Nasmyth Platform**

## 3.2 Overview on the Instrument Control Electronics Requirements

MICADO will be located on the NASMYTH B platform of the E-ELT. The mechanical functions are integrated into a vacuum cryostat. The Calibration Unit mechanisms are located on the bench of the SCAO module. The design and control architecture considerations have to take into account the cryogenics environment and highly sensitive detectors.

In order to control the instrument presently 3 cabinets are foreseen which are located on the co-rotating platform and a fourth one which is on the bench of the SCAO/MAORY module.

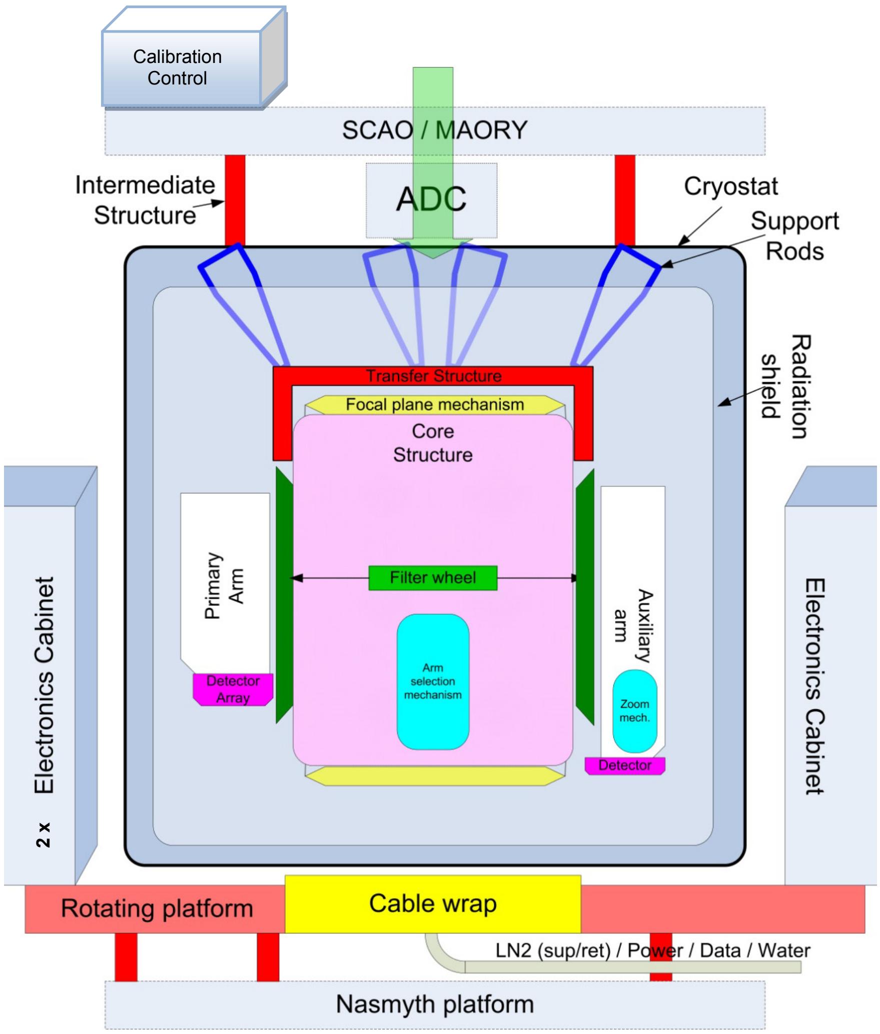


**Figure 3-2 MICADO Instrument Functional Overview**

**List of top level requirements and boundary conditions**

- Cryogenic temperature range between 50K - 130K
- Control of 6 cryogenic mechanism, 6 mechanisms at ambient temperature
- Control of Calibration Unit ( on SCAO bench, of later within MAORY module TBC)
- Monitor and maintain cryostat health and performance
- low emissions and high immunity according to EMC requirements and detectors (limited or no movement during integration)
- Reliability, safety and easy maintainability
- Designed to reduce maintenance activities
- COTS components where applicable
- Comply with Environmental Specification
- New safety standards implementation (SIL)
- 10 years operational lifetime
- Robust and earthquake proof

### 3.2.1 General Design Architecture

This design study proposes a ‘classical control’ concept with decentralized control topology. This gives more flexibility for control electronics arrangements for the ICE and IHE also in case changes become necessary during next project phases. This is achievable by applying standard industrial Ethernet based field-bus connections between the various function controllers (e.g. to control motion, digital and analog I/O signals) on the one side and to the OPC server (TBC ESO) on the other side. With this concept flexible connection schemes to various sensors, actuators and motors are achievable. The controls for the instrument and the controls for the cryogenics are located around the instrument. The calibration units are controlled by an enclosed subsystem located close to the lamps and drives. The number of controlled function mechanisms is six cryogenically motorized, and six which are working in ambient conditions. The six rotational movements axis are driven by cryogenic stepper motors. The position feedback for the various functions will be realized with resolvers on the main shaft of the mechanism. This gives the absolute position of the part even after a power failure (no initialization required). The positioning for the cryogenic mechanisms will be executed in open loop. To achieve undisturbed operations the servicing supply and the functions wiring must have sufficient separation and for the electrical design the Design Specification for Electrical Systems [AD4] have to be taken into account. The mechanical layout of the functions is made in a way that the mechanisms are self locking into a V-groove without the need for energy when in its desired position. For details please refer to the MICADO Opto-Mechanical Design and Analysis [RD3]. The control functions are implemented widely with standard COTS technology from well recommended suppliers. To control the instrument functions it is proposed to use PLC based systems coming from a large industry standard by SIEMENS. The decision was also taken respecting the requirement that the whole safety related functions are already standardized to be implemented with fail-safe PLC concepts, please refer to Presentation E-ELT Instrumentation at Mid Term [RD 5] by ESO. This gives a more homogeneous control design solution. As indicated in the E-ELT Design Specification for Electrical Systems [AD4] the use of following field busses is recommended (TBC ESO): EtherCAT or Profinet. At the time this report is written it was the choice to go with SIMATIC SPS communicating via PROFINET to control motion and field I/O signals. This is a widely spread industry standard, with a very low risk of technology becoming obsolete. Another advantage is the worldwide distribution and availability and robust and wide range and scalability of function devices. These are the main drives for using them in the whole electronics (control and housekeeping system) as far as possible.

For the cryogenics housekeeping control the task which was formerly realized with an DAU (Yokogawa Data Acquisition Unit) and numerous relay logic will now be implemented within a fail-safe PLC, communicating via a graphical display (HMI) and if necessary with an standard alarm annunciator which is connected to an alarm system. All kind of status information is also transmitted to the MASTER Local Control (PLC) which communicates the values to the OPC server (TBC ESO). This server is the interface to the higher level control SW.

### 3.2.2 Design Control Architecture with PLC

As E-ELT instrumentation projects have the challenge to propose new control electronics it is suggested to use the wide spread industry standards of PLC architecture. These are very common in industrial plants and are worldwide supported.

**Principal functions covered by a PLC design:**

1. Controller/Master (CPU)
2. Motion Control
3. Digital I/O
4. Analog I/O
5. Cryogenic/Housekeeping Control
6. Safety System
7. Alarm System

Please refer to the next page for an overview on the MICADO control electronics strategy.

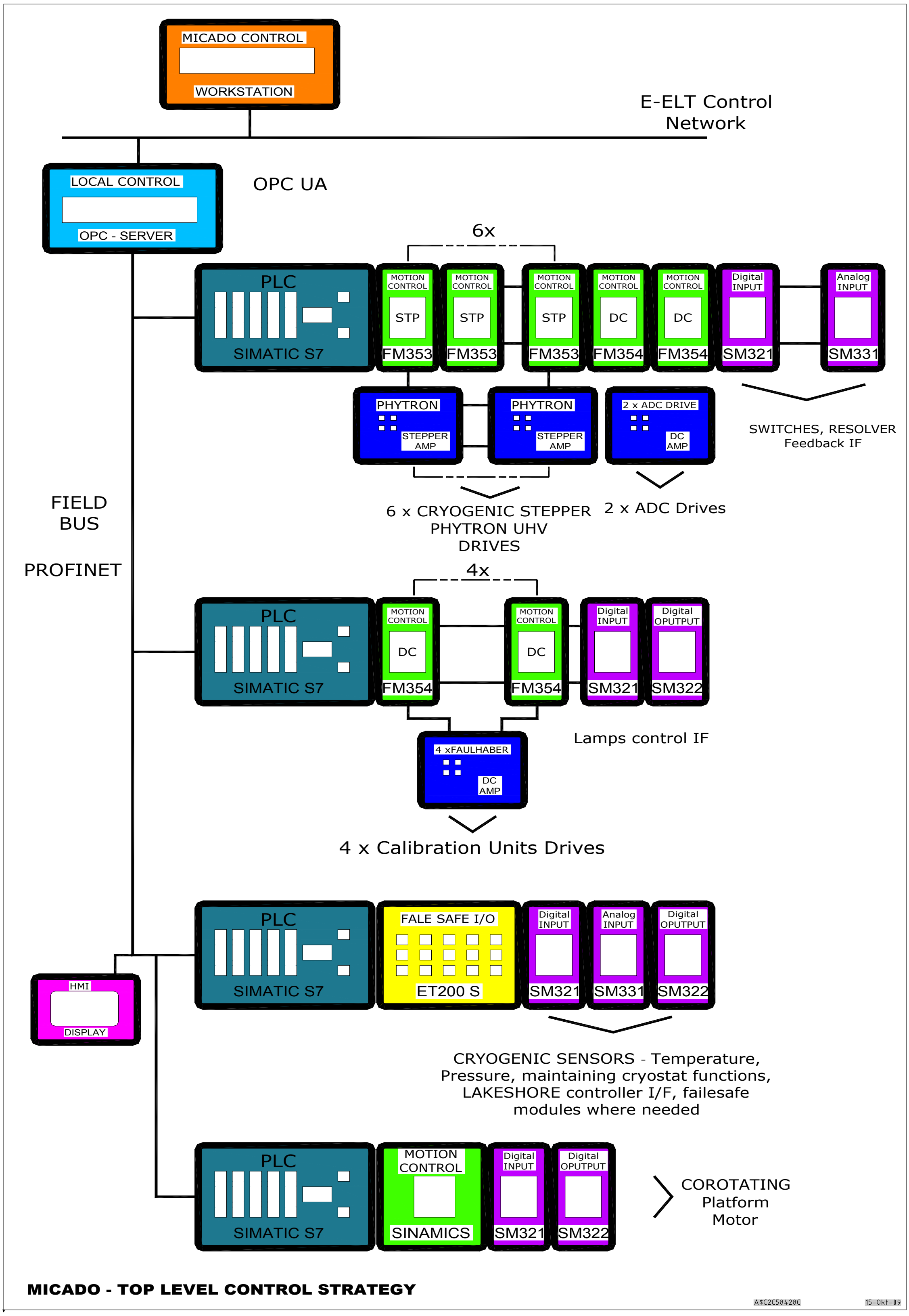


**Figure 3-3 MICADO - Control Strategy**

Note: This concept was roughly consistency checked with the CBA configuration tool and Profinet components

### 3.3 Cabinet and components concept and layout

The cabinets to control the instrument functions are located on the co-rotating platform below the instrument. There are two cabinets responsible to control the instrument, the main control cabinet for the cryogenics and ADC drive functions and the Housekeeping Cabinet to control the cryostat monitoring and health and the detectors temperature control.

The third cabinet is responsible to control the co-rotating platform and the fourth controls the calibration units on the SCAO module platform.

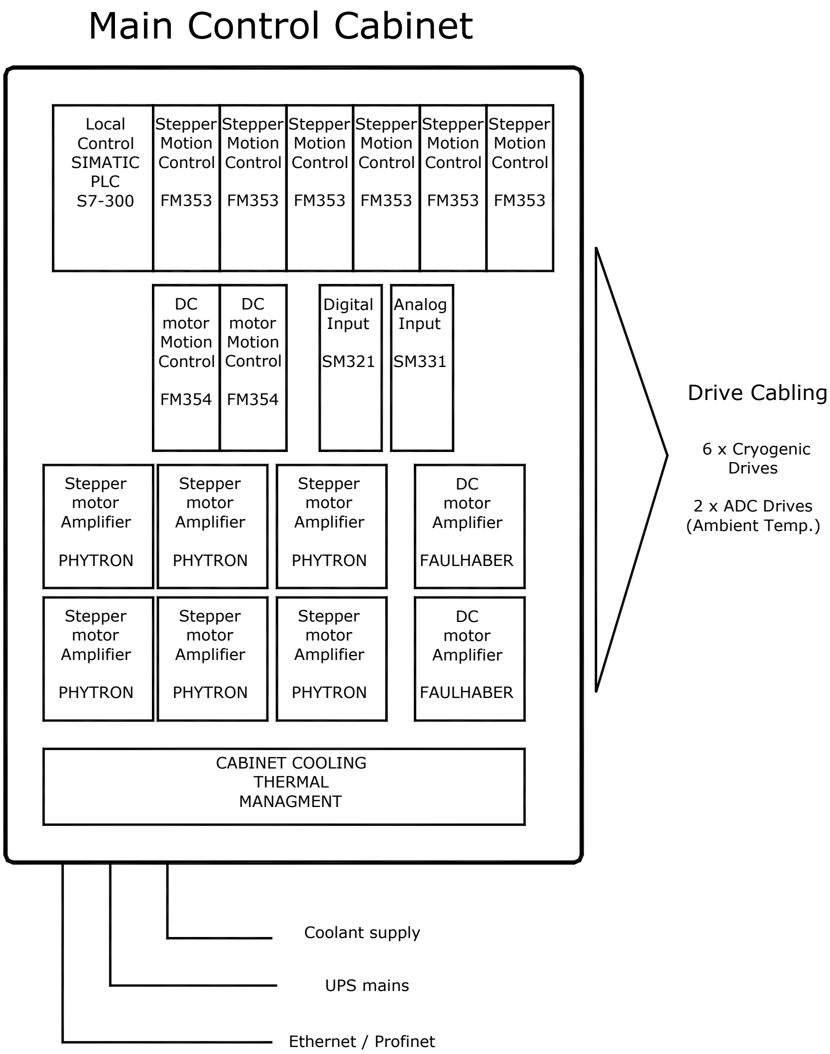


**Figure 3-4 Components of Cabinet 1 (Main instrument control)**

All the ‘co-rotating’ drive functions are controlled by the main instrument cabinet.

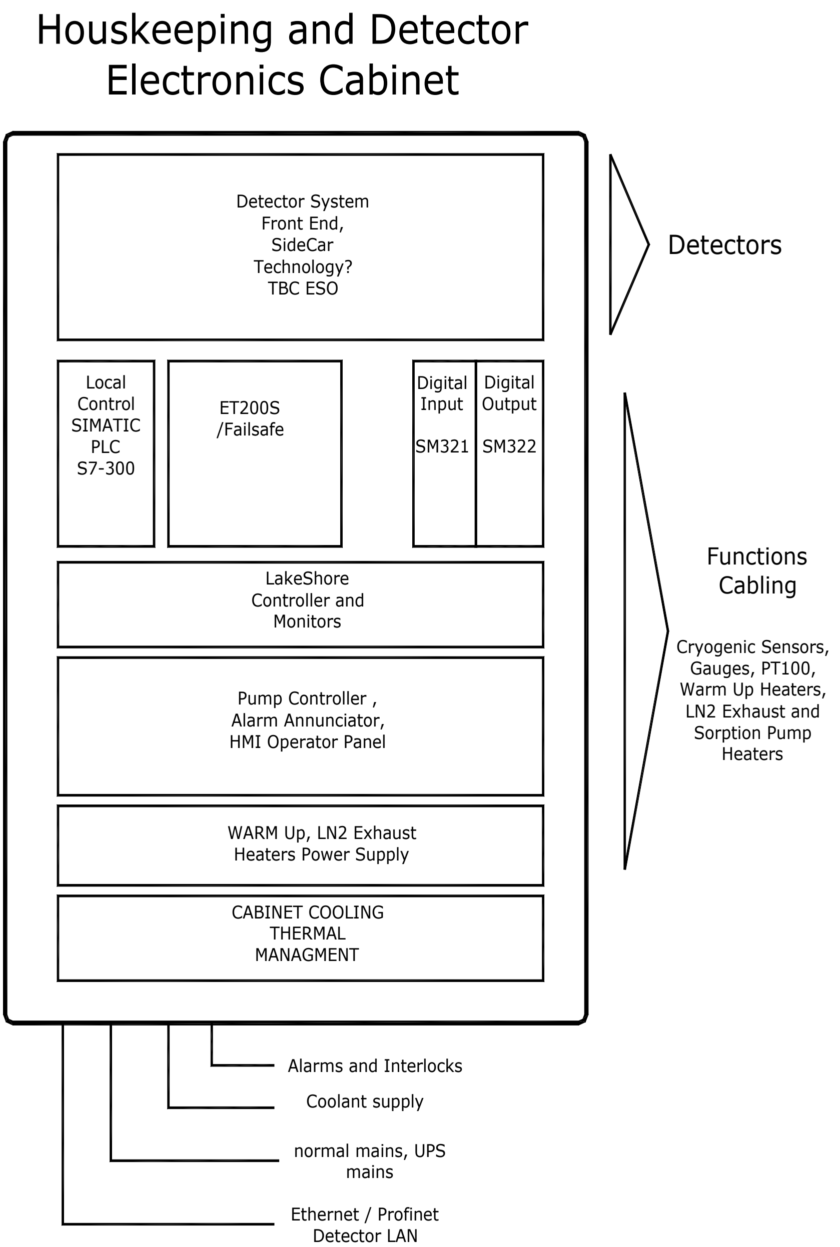


**Figure 3-5 Components of Cabinet 2 (Housekeeping and Detector control)**

Note: There might be the chance that there will be a slightly different approach to read out the detectors. The detector front end electronics with a NGC interface card connects to the Detector ASICs. This has to be confirmed by ESO during the next project stages.

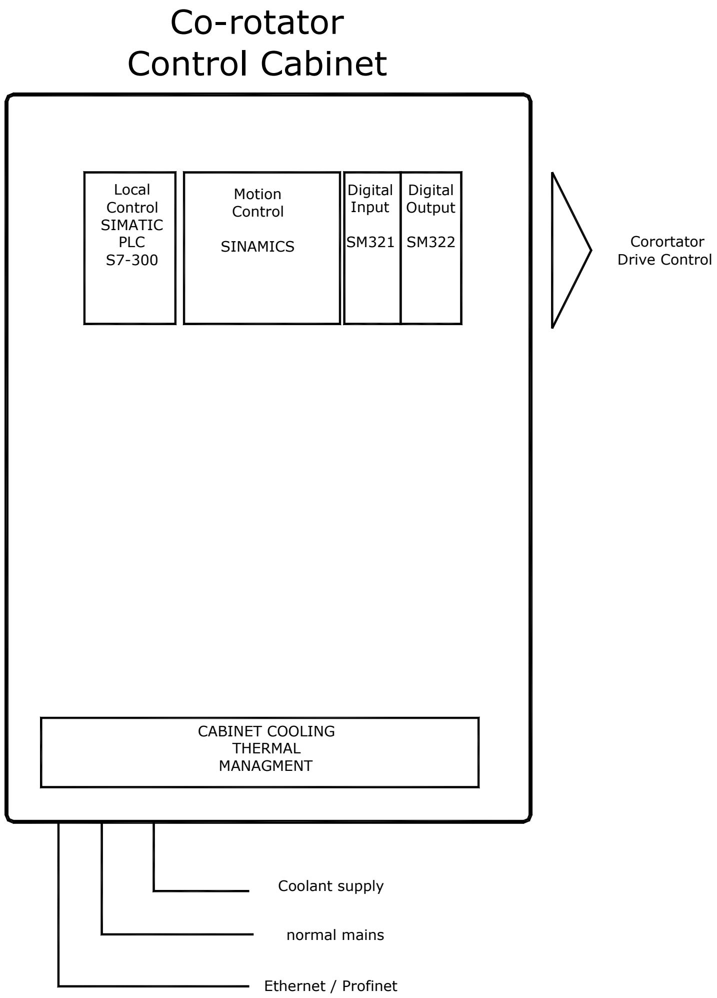


**Figure 3-6 Components of Cabinet 3 (Co-rotator Control)**

This cabinet controls the co-rotating platform drive. However the drive is not located directly in the vicinity of the control cabinet and need wiring through the cable chain of the co-rotator platform which is not desirable and leads to relatively long cables. To avoid this and taking the advantage of distributed control systems it could become feasible to implement the control of this drive in dedicated small cabinets or control panels/interfaces outside the space envelope suggested for this study. This will be presented in more detail during the next project stage.

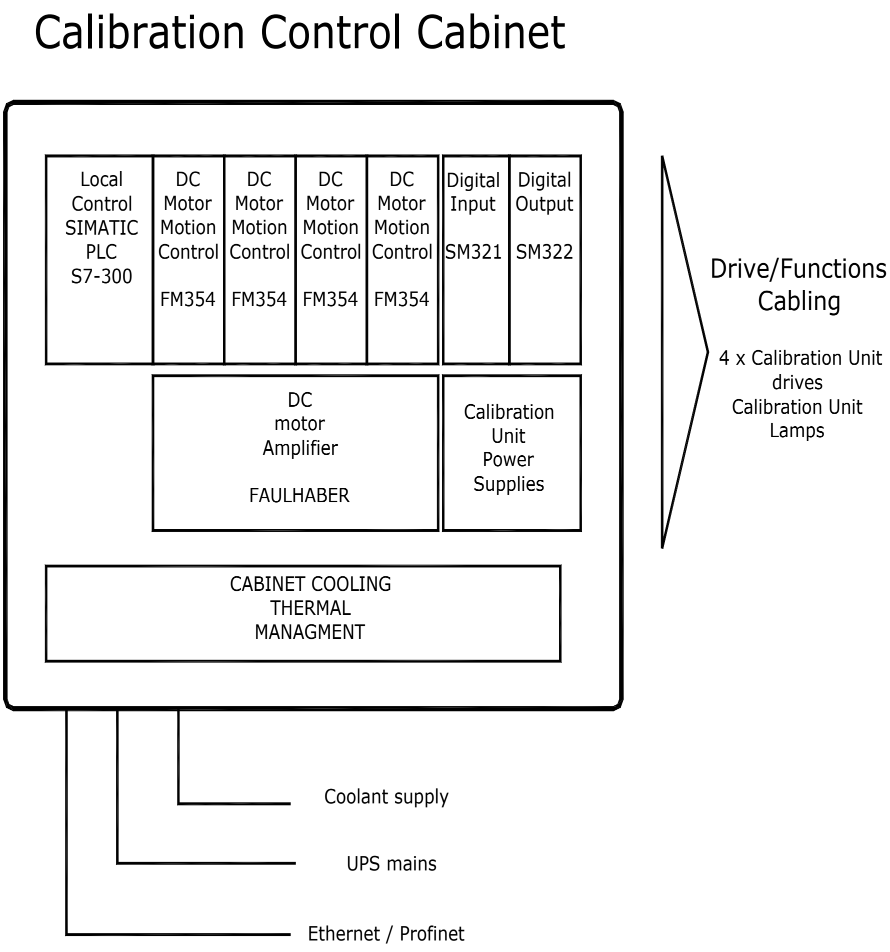


**Figure 3-7 Components of Cabinet 4 (Calibration Unit Control)**

The Calibration Unit will be controlled by a dedicated cabinet which is located on the platform for the SCAO module. The lamps and drives are connected via short connections to the control cabinet.

### 3.3.1 Cabinets wiring concept

The functions wiring will be made through top or side entry panel, the supply wiring is fed through the bottom entry panels with the cabinet mounted on feet.

To allow for the slightly differential movements between the cabinets and the cryostat function all cables should have some extra length and have strain relief fixations. The distribution of the wiring has to be done in separated areas for sensitive control and power lines according to the E-ELT specifications.

For the wiring inside the cabinets either standard wiring frames will be used with terminal strips on or in case of space limitations and compact performance it could be offered to tailor high reliable solutions with flexible PCBs.

### 3.3.2 Cabinets maintenance, thermal concept and safety

In order to maintain the back to back positioned cabinets either they have to be movable or the wiring has to be implemented such way that only access from the front will be necessary. The components are mostly COTS and the design is orientated at the LRU concept similar to the VLT instruments.

The cabinet are thermally isolated and have cooling systems installed to keep their outside within the allowable deviation of the specified ambient temperature range also considering the maximum allowable energy dissipation. They need chilled water with the specification please refer to MICADO-EELT Phase A Interface Information and Request [RD6].

The cooling performance will be monitored and in case of major malfunction the cabinet has a temperature protection installed to avoid self overheating.

Within all cabinets electrical safety will be made in accordance with the specified rules in the Design Specification for Electrical Systems [AD4].

## 3.4 Control Concept Components

To control the cryogenic and ambient drives, the calibration units, the co-rotator and the housekeeping system for MICADO the control concept is divided into four PLCs for local control of the corresponding function group. The following sections give the logical assembly of the functions rather than their control arrangement within the cabinets.

### 3.4.1 – Components of Cryogenic Drive Axis

In order to control the cryogenics drive it is foreseen to have a local PLC within a control cabinet on the rotating platform. This PLC handles the coordination of the motion control and the analogue/digital I/O modules. To control the motion of the six axis an individual motion controller per axis is foreseen, type is FM353 form the SIMATIC range. The output signals for

STEP and DIRECTION are connected to the stepper power amplifiers from the Phytron product range. Positioning will be implemented in open loop, after the end of the movement the position will be compared with the demanded one. This position feedback is realized with resolvers of the LTN type product range. These are already implemented at ESO instruments and might be also suitable. The idea is for the most cryogenic drives to have a resolver on the large driven mechanism rather than on the output shaft of the motor. This gives in the case of an accidental power loss during the first phase of investigation some feedback how the mechanism is positioned. Other solution might be investigated during the next project phases if these are simpler and more reliable. Of course mechanical constrains have to be taken into account.

Mechanisms to be controlled in the common path:

- Focal plane selection
- Primary / auxiliary arm selection

Function in the primary arm

- Filter wheel

Functions in the auxiliary arm

- Filter wheel
- Scale change mechanism A
- Scale change mechanism B

The cryogenic drives have following requirements:

| Function / mechanism | FP selection | Prim / Aux arm sel. | FW primary | FW auxiliary | Scale change A | Scale change B |
|---|---|---|---|---|---|---|
| Motor type | 2-phase stepper Phytron VSS52 or 57 | 2-phase stepper Phytron VSS52 or 57 | 2-phase stepper Phytron VSS52 or 57 | 2-phase stepper Phytron VSS52 or 57 | 2-phase stepper Phytron VSS52 or 57 | 2-phase stepper Phytron VSS52 or 57 |
| Axis type SW | Rotational | Linear | rotational | rotational | linear | Linear |
| Movement range | Full circle | Less than full circle | Full circle | Full circle | Quarter circle | Quarter circle |
| Position determined | V-grooves | V-grooves | V-grooves | V-grooves | V-grooves | V-grooves |
| Reference | Switch | Switch | Switch | switch | switch | Switch |
| Limits | No | UL/LL | No | no | UL/LL | UL/LL |
| Amplifier type | Phytron | Phytron | Phytron | Phytron | Phytron | Phytron |

**Table 3-1 Cryogenic Drives**

To achieve the position from the resolver a interface board will be connected to provide a standard analogue voltage signal to an SM331 input module from the SIMATIC range. Other solutions might be investigated during the next project stages.

### 3.4.2 - Calibration unit drives

The calibration units are controlled by a dedicated PLC which will be located in the fourth control cabinet to the calibration units in at the SCAO module. The advantage is to avoid long control cabling to the units which has to be routed through the co-rotator. The PLC handles the control of the DC-Motors which are driven in closed loop feedback with standard encoders and the FM354 motion control module from the SIMATIC range. It is possible to use standard PI stages with either onboard Active Drive or to use a separate DC-motor amplifier within the cabinet. This concerns the fold mirror and the calibration mask drives. The intensity adjust drive is a rotational axis with a standard DC motor with gear from Faulhaber and a standard encoder. This has to be commanded to six discrete positions.

The calibration unit drives have following requirements:

| Function / mechanism | Fold mirror drive | Calibration mask X | Calibration mask Y | Intensity adjust |
|---|---|---|---|---|
| Motor type | DC motor from PI stage | DC motor from PI stage | DC motor from PI stage | DC motor and gear Faulhaber |
| Axis type SW | linear | Linear | linear | Rotational |
| Movement range | Between limits | Between limits | Between limits | Full circle |
| Position determined | Encoder | Encoder | Encoder | Encoder |
| Reference | detection | detection | detection | Switch |
| Limits | UL/LL | UL/LL | UL/LL | No |
| Amplifier type | Active Drive / PI | Active Drive / PI | Active Drive / PI | Faulhaber |

**Table 3-2 Calibration Unit Drives**

### 3.4.3 - ADC drives

The ADC drives are controlled within the same PLC as the cryogenic drives so located within this cabinet. The mechanisms are driven by large DC motors with an Encoder feedback to close the loop.

The ADC drives have following requirements:

| Function / mechanism | ADC mechanism vertical | ADC mechanism inclination |
|---|---|---|
| Motor type | DC motor with Gear / Faulhaber | DC motor with Gear / Faulhaber |
| Axis type SW | rotational | rotational |
| Movement range | Full circle | Full circle |
| Position determined | Encoder | Encoder |
| Reference | Switch | switch |
| Limits | No | no |
| Amplifier type | TBD demand | TBD demand |

**Table 3-3 ADC drives**

## 3.5 Calibration lamps control

Besides handling the motion control task the PLC for the Calibration Units also has a Digital I/O control realized. This is implemented with the SM321 for the digital inputs and the SM322 for the digital outputs from the SIMATIC range. To control the lamps it is likely to use either the standards from ESO if available or simply connect the digital input to the status signal and the outputs to the corresponding lamp power supply. The other signal will be connected to the corresponding inputs. To control that the lamps are working monitoring devices are foreseen.

The calibration lamps have following requirements:

| Function / Type | Calibration Lamp1 | Calibration Lamp2 |
|---|---|---|
| Lamp type | Halogen | Discharge tube |
| Status / Input | 3 | 3 |
| Output | 1 | 1 |
| Voltage | 12 V | 230V – HV converter |

**Table 3-4 Calibration Lamps**

## 3.6 Housekeeping of the Cryostat

MICADO cryostat has following modes to be controlled:

- Pumping
- Cool down
- Operate
- Warm up
- Regeneration
- Safe State

During these modes all sensors, gauges and heater in combination with control circuits, safety I/O signals and logic have to take care for following tasks

### 3.6.1 General tasks for the Housekeeping

1. Generating interlocks, alarms and warnings in case there are not normal conditions, determined by required SIL Level.
2. Monitoring of the cryostat pressure and temperature, thermal control and protection of the detectors in all operating modes.
3. Control evacuation of the cryostat and maintaining pressure.
4. Cool down and warm up control of the cryostat and protection of the heating circuits
5. Provide control of secure regeneration and flushing mode with internal interlocks

Additionally safety circuits and advices could be displayed on request to guide the user in case of an abnormal event has occurred.

### 3.6.2 Components and Control for the housekeeping system

| **Device/Function** | |
|---|---|
| Detector Temperature Control | LakeShore controller 340, monitor 218 |
| Temperature Diode | DN470 |
| Heater | Resistor |
| Temperature Sensors | PT100 |
| Vacuum Gauges | ESO standard |
| TMP | Leybold TurboVac |
| Roughing Pump | Busch Cobra |
| Warm Up Heater | TBD |
| Control Unit | Fail-Safe PLC, ESO standard |
| User Display | HMI SIMATIC |

**Table 3-5 Components for Housekeeping System**

### 3.6.3 New design concept for Housekeeping

There is a dedicated cabinet for the housekeeping control on the co-rotating platform. This includes a PLC to handle the control and an ET200S system in its failsafe version. To allow the user to check for the various states, measurements, logs and alarms a dedicated HMI panel is foreseen. For the safety and non safety relevant input the cabinet includes further digital I/Os, analog I/Os wherever applicable. This has to be determined by a separate safety study which will largely take into account the concepts from actual delivered instruments and the new concepts which came from the EC – IEC, ISO and other ESO standards mentioned in the Design Specifications for Electrical Systems [AD4]. This will be implemented during the next project phase.

In order to make the whole development process more efficient a safety template protocol for the programming rules has to be provided in order to know the requirements on the PLC instruction and command set.

## 3.7 Co-rotator Control Description

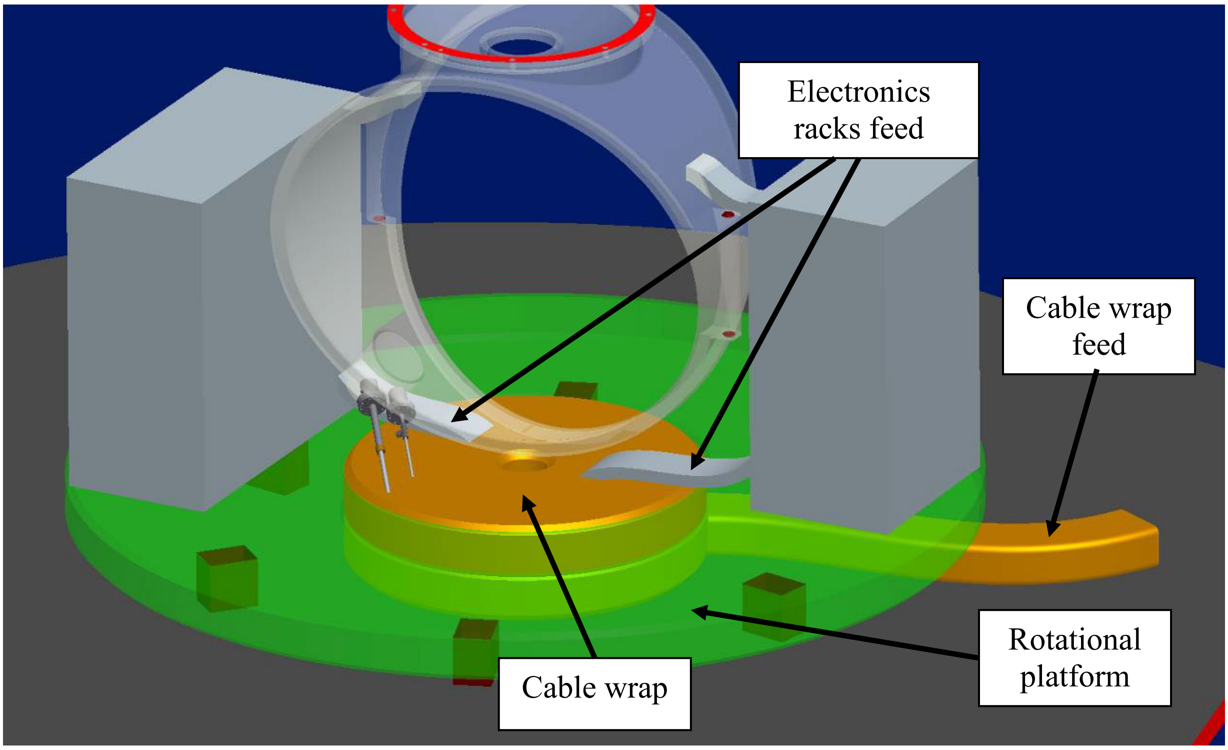


**Figure 3-8 Co-rotating platform**

The co-rotating platform contains the supply cable chain and the mechanics to carry the platform with the cabinets on. The main requirements are:

- Follow the movement of the instrument rotator within a specified angular difference
- In case there is no synchronicity between the instrument and the co-rotator an interlock stops both, the rotator and the platform co-rotator
- Manual operations and emergency stops have to be implemented

In order to synchronize the instrument rotator and the platform co-rotator a sensor/sensors have to provide the angular position of the mechanisms. This could either be done by direct contact, to say it simple a potentiometer which is mounted at the centre axis on the floor and the lever heading to and being turned by the instrument. By comparing the output to a set value a correction to the platform will be send so that it follows the master i.e. instrument. A small hysteresis will prevent permanent movement all the time, to have the system not always running. There is a dedicated motion controller from the SINAMICS range foreseen to control the motor. As the communication will be handled via a SIMATIC PLC the whole control for it could be offered to implement some manual control off the platform with some HMI and control interface and including motion stop functionality.

In case there is a malfunction of any system two levels of limit switches will disable at the first level the power to the amplifier stages of the platform and in the second stage issue a interlock to the rotator of the instrument.

### 3.8 Power, weight budget assessment

The cabinets mass is roughly estimated to 180 kg each in their seismic rated version. The external cabling is not included. This gives for all three cabinets a total weight of roughly 0.6 t on the platform. This might be reduced if components could be distributed into other areas.

The power needed from the SCP(s) is dependent on the operational states, the dynamic state for the control electronics and the housekeeping operations.

| Operational state | Standby [W] | Moving / On [W] |
|---|---|---|
| Cabinet 1 | 500 | 1000 |
| Cabinet 2 including calibrations w/o co-rotator | 500 | 700 |
| Cabinet 3 including Detector supply w/o warm up heaters, pumps | 800 | 800 |
| Total | 1800 | 2.500 |

**Table 3-6 Electronics cabinet power consumption from UPS w/o housekeeping**

## 3.9 Interfaces

There are electrical interfaces to the various mechanisms and interfaces with the mechanical parts and space envelopes to be taken into account. There are also interfaces to the control and supply lines to the E-ELT SCPs. All interfaces will be kept in documents under control of the systems engineering.

The electrical interfaces to the cryogenic mechanical functions have all a similar layout. The drives are kept nearly identical; the major difference is the SW definition into a linear or a rotational axis.

The interface with the calibration unit is divided into the lamps and the drives control. Three out of four drives are kept similar; the fourth needs the power amplifier in the calibration unit cabinet which gives a different cabling layout. The lamps control will be kept similar for both lamps.

The connections type used will be done in accordance with the Design Specifications for Electrical Systems [AD4].

The interface to the E-ELT SCP for the various supplies will be done with following components according to the Service Connection Points Technical Specifications document [AD5].

230VAC: TBD ESO

400VAC: TBD ESO

230VAC UPS: TBD ESO

Coolant Supply: TBD ESO

LAN: TBD ESO

For the consumption requirements on the E-ELT SCP please refer to the MICADO-EELT Phase A Interface Information and Requests [RD6] documentation.

When more detailed power calculations during the next project stage become available it can be decided if one SCP will be sufficient.

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# 4 APPENDIX: COMPLEXITY ASSESSMENT SHEET

| Subsystem | Dig Input | Dig Output | Ana Input | Ana Output | Fieldbus | Cycle time | Accuracy | Resolution | Stroke | Power (Torque) at motorshaft | Comments | ESO Standard announced to be available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CRYO & VACUUM Housekeeping** | | | | | | | | | | | **DATE: 16.10.2009** | |
| **Analog Signals** | | | | | | | | | | | | |
| (1) Temp PT100 ADC compartment 1 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (2) Temp PT100 ADC compartment 2 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (3) Temp PT100 V-rods Mounting 1 (+spare) | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (4) Temp PT100 V-rods Mounting 2 (+spare) | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (5) Temp PT100 V-rods Mounting 3 (+spare) | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (6) Temp PT100 V-rods Shield 1 (+spare) | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (7) Temp PT100 V-rods Shield 2 (+spare) | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (8) Temp PT100 V-rods Shield 3 (+spare) | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (9) Temp PT100 Cryostat shield 1 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (10) Temp PT100 Cryostat shield 2 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (11) Temp PT100 Central structure support 1 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (12) Temp PT100 Central structure support 2 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (13) Temp PT100 Central structure support 3 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (14) Temp PT100 Central structure interface 1 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (15) Temp PT100 Central structure interface 2 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (16) Temp PT100 Central structure interface 3 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (17) Temp PT100 Collimator (PRIMARY path) 1 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (18) Temp PT100 Collimator (PRIMARY path) 2 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (19) Temp PT100 Camera (PRIMARY path) 1 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (20) Temp PT100 Camera (PRIMARY path) 2 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (21) Temp PT100 Camera channel A (AUXILIARY path) 1 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (22) Temp PT100 Camera channel A (AUXILIARY path) 2 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (23) Temp PT100 Camera channel B (AUXILIARY path) 1 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (30) Temp PT100 Camera channel B (AUXILIARY path) 2 | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| ... | | | | | | | | | | | | |

| Subsystem | Dig Input | Dig Output | Ana Input | Ana Output | Fieldbus | Cycle time | Accuracy | Resolution | Stroke | Power (Torque) at motorshaft | Comments | ESO Standard announced to be available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CRYO & VACUUM Housekeeping** | | | | | | | | | | | DATE: 16.10.2009 | |
| **Analog Signals** | | | | | | | | | | | | |
| (31) Temp PT100 Detector Damping mass | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| ... | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| (1) Temp Si_DT470 Detector 1 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (2) Temp Si_DT470 Detector 2 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (3) Temp Si_DT470 Detector 3 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (4) Temp Si_DT470 Detector 4 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (5) Temp Si_DT470 Detector 5 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (6) Temp Si_DT470 Detector 6 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (7) Temp Si_DT470 Detector 7 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (8) Temp Si_DT470 Detector 8 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (9) Temp Si_DT470 Detector 9 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (10) Temp Si_DT470 Detector 10 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (11) Temp Si_DT470 Detector 11 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (12) Temp Si_DT470 Detector 12 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (13) Temp Si_DT470 Detector 13 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (14) Temp Si_DT470 Detector 14 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (15) Temp Si_DT470 Detector 15 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (16) Temp Si_DT470 Detector 16 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| (17) Temp Si_DT470 Detector 17 | | | ? | | RS232/Profinet? | s? | µ V? or K? | mK? | N/A | N/A | LakeShore monitor to ET 200 TBC ESO | under Investigation ESO |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| ... | | | | | | | | | | | | |
| (1) Coolant flow Control Cabinet 1 | ? | | √? | | RS232/Profinet? | s? | V? or L? | 12 bit? | 4(0) -20 mA | N/A | to Analog Input Module or Cooling Unit / ET200S | √ |
| (2) Coolant flow Control Cabinet 2 | ? | | √? | | RS232/Profinet? | s? | V? or L? | 12 bit? | 4(0) -20 mA | N/A | to Analog Input Module or Cooling Unit / ET200S | √ |
| (3) Coolant flow Control Cabinet 3 | ? | | √? | | RS232/Profinet? | s? | V? or L? | 12 bit? | 4(0) -20 mA | N/A | to Analog Input Module or Cooling Unit / ET200S | √ |
| ... | | | | | | | | | | | | |
| (1) Pressure in Cryostat (+ spare) | | | √ | | Profinet? | s? | 10-6mb? | 16 bit? | 0-10V? | N/A | Pfeiffer Gauge / ET200S | √ |
| | | | | | | | | | | | | |
| ... | | | | | | | | | | | | |

| Subsystem | Dig Input | Dig Output | Ana Input | Ana Output | Fieldbus | Cycle time | Accuracy | Resolution | Stroke | Power (Torque) at motorshaft | Comments | ESO Standard announced to be available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CRYO & VACUUM Housekeeping** | | | | | | | | | | | DATE: 16.10.2009 | |
| **Analog Signals** | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Cryostat control:** | | | | | | | | | | | | |
| (32) Temp PT100 LN2 in (one per circle) | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| | | | | | | | | | | | | |
| (33) Temp PT100 Outlet splitter block (one per circle, for value and exhaust heater control with OMEGA controller)? | | | | | | s? | K? | 15 bit? | 300K | N/A | OMEGA / JUMO controller | √ |
| | | | | | | | | | | | | |
| (3) Temp PT100 (tbc) for sorption pump control | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| | | | | | | | | | | | | |
| (1) N2 gas flow meter 1 (Elster Instromet) tbc | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | Analog Input Module / ET200S | √ |
| (2) N2 gas flow meter 2 (Elster Instromet) tbc | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | Analog Input Module / ET200S | √ |
| | | | | | | | | | | | | |
| (34) Temp PT100 Windows defogging | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| (35) Temp PT100 Sorption Pump | | | √ | | Profinet? | s? | K? | 15 bit? | 300K | N/A | PT 100 to Analog Input Module / ET200S | √ |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **warming up ?** | | | | | | | | | | | | |
| LN2 exhaust heating | | | | | | | | | W? | | LOCAL OMEGA / JUMO controller | √ |
| Sorption Pump heating | | | | | | | | | W? | | LOCAL OMEGA / JUMO controller | √ |
| ... | | | | | | | | | | | | |
| (1) Analog Inp. Absolute Resolver Foc. Plane TBC | | | √ | | Profinet? | TBD | TBD | 15 bit? | 0-10V? | | Analog Input Module / ET200S | ? |
| (2) Analog Inp. Abs. Resolver Primary / auxiliary arm select TBC | | | √ | | Profinet? | TBD | TBD | 15 bit? | 0-10V? | | Analog Input Module / ET200S | ? |
| (3) Analog Inp. Abs. Filter Wheel primary TBC | | | √ | | Profinet? | TBD | TBD | 15 bit? | 0-10V? | | Analog Input Module / ET200S | ? |
| (4) Analog Inp. Abs. Filter Wheel auxiliary TBC | | | √ | | Profinet? | TBD | TBD | 15 bit? | 0-10V? | | Analog Input Module / ET200S | ? |
| (5) Analog Inp. Abs. Resolver Scale change mechanism A TBC | | | √ | | Profinet? | TBD | TBD | 15 bit? | 0-10V? | | Analog Input Module / ET200S | ? |
| (6) Analog Inp. Abs. Resolver Scale change mechanism B TBC | | | √ | | Profinet? | TBD | TBD | 15 bit? | 0-10V? | | Analog Input Module / ET200S | ? |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| ... | | | | | | | | | | | | |

| Subsystem | Dig Input | Dig Output | Ana Input | Ana Output | Fieldbus | Cycle time | Accuracy | Resolution | Stroke | Power (Torque) at motorshaft | Comments | ESO Standard announced to be available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Motion Control** | | | | | | | | | | | Master Controller and Slaves or RemotPLC with Motion Control | |
| **Common path (cryogenic mechanism)** | | | | | | | | | | | | |
| (1) Focal plane selection | | | | | Profinet? | 120s? | deg? | deg? | tp./360 ° or mm | 0,4...0,6Nm | PLC controlled Open loop, Phytron VSS 52 (or 57) UHVC, direct drive motor pinion to FP ring gear (i~20)[1], Reference switch(es), resolver on output shaft, position determined by V-grooves and locking wheel | ? |
| (2) Primary / auxiliary arm selection | | | | | Profinet? | every h/ 30s | 5µm | 5µm | 90+/-20° | 0,4...0,6Nm | PLC controlled Open loop, Phytron VSS 52 (or 57) UHVC, direct drive motor pinion to FP ring gear (i~20)[1], Reference + UL and LL switch(es), resolver on mechanism output shaft, position determined by V-grooves and locking wheel | ? |
| **Functions primary arm** | | | | | | | | | | | | |
| (3) Filter Wheel | | | | | Profinet? | 120s? | deg? | deg? | tp./360 ° or mm | 0,4...0,6Nm | PLC controlled Open loop, Phytron VSS 52 (or 57) UHVC, direct drive motor pinion to FP ring gear (i~20)[1], Reference switch(es), resolver on output shaft, position determined by V-grooves and locking wheel | ? |
| **Functions auxiliary arm** | | | | | | | | | | | | |
| (4) Filter Wheel | | | | | Profinet? | 120s? | deg? | deg? | tp./360 ° or mm | 0,4...0,6Nm | PLC controlled Open loop, Phytron VSS 52 (or 57) UHVC, direct drive motor pinion to FP ring gear (i~20)[1], Reference switch(es), resolver on output shaft, position determined by V-grooves and locking wheel | ? |
| (5) Scale change mechanism A | | | | | Profinet? | 30s? | 5µm | 1µm | 90+/-20° | 0,4...0,6Nm | PLC controlled Open loop, Phytron VSS 52 (or 57) UHVC, direct drive motor pinion to FP ring gear (i~20)[1], Reference + UL and LL switch(es), resolver on mechanism output shaft, position determined by V-grooves and locking wheel | ? |
| (6) Scale change mechanism B | | | | | Profinet? | 30s? | 5µm | 1µm | 90+/-20° | 0,4...0,6Nm | PLC controlled Open loop, Phytron VSS 52 (or 57) UHVC, direct drive motor pinion to FP ring gear (i~20)[1], Reference + UL and LL switch(es), resolver on mechanism output shaft, position determined by V-grooves and locking wheel | ? |
| ... | | | | | | | | | | | | |

| Subsystem | Dig Input | Dig Output | Ana Input | Ana Output | Fieldbus | Cycle time | Accuracy | Resolution | Stroke | Power (Torque) at motorshaft | Comments | ESO Standard announced to be available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Motion Control** | | | | | | | | | | | Master Controller and Slaves or RemotPLC with Motion Control | |
| **Calibration Unit (warm mechanism)** | | | | | | | | | | | | |
| (7) Fold mirror drive | | | | | Profinet? | couple t / at sev. Hours | mm? | mm? | 750 mm | 0,4...0,6Nm | PLC controlled In closed loop, Linear stage (PI M531), driven by DC motor without gear (ActiveDrive), linear encoder with reference + UL and LL switch | ? |
| (8) Calibration mask x | | | | | Profinet? | couple t / at sev. Hours | mm? | mm? | 750 mm | 0,4...0,6Nm | PLC controlled In closed loop, Linear stage (PI M531), driven by DC motor without gear (ActiveDrive), linear encoder with reference + UL and LL switch | ? |
| (9) Calibration mask y | | | | | Profinet? | couple t / at sev. Hours | mm? | mm? | 750 mm | 0,4...0,6Nm | PLC controlled In closed loop, Linear stage (PI M511), driven by DC motor without gear (ActiveDrive), linear encoder with reference + UL and LL switch | ? |
| (10) Intensity adjust. | | | | | Profinet? | couple t / at sev. Hours | deg? | deg? | 360deg | TBD | PLC controlled In closed loop, with DC motors, e.g. Faulhaber 3257 024CR with gear 32A, i=25, encoder on output shaft and reference switch(es) | ? |
| **ADC (warm mechnism)** | | | | | | | | | | | | |
| (11) ADC mechanism 1 (vertical) | | | | | Profinet? | 10s/1s? | 1 min | min | endless | ? | PLC controlled In closed loop, with DC motors, e.g. Faulhaber 3257 024CR with gear 32A, i=25, encoder on output shaft and reference switch(es) | ? |
| (12) ADC mechanism 2 (inclination) | | | | | Profinet? | 10s/1s? | 1 min | min | endless | ? | PLC controlled In closed loop, with DC motors, e.g. Faulhaber 3257 024CR with gear 32A, i=25, encoder on output shaft and reference switch(es) | ? |
| ... | | | | | | | | | | | | |

| Subsystem | Dig Input | Dig Output | Ana Input | Ana Output | Fieldbus | Cycle time | Accuracy | Resolution | Stroke | Power (Torque) at motorshaft | Comments | ESO Standard announced to be available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| Digital Input and Output | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Power management warmup heaters | | | | | | | | | | | | |
| (1) Switching Heater OB | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| (2) Switching Heater OB | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| (3) Switching Heater OB | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| (4) Switching Heater OB | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| (5) Switching Heater OB | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| (6) Switching Heater OB | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| | | | | | | | | | | | | |
| (7) Switching Heater SHIELD | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| (8) Switching Heater SHIELD | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| (9) Switching Heater SHIELD | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| (10) Switching Heater SHIELD | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| (11) Switching Heater SHIELD | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| (12) Switching Heater SHIELD | | √ | | | Profinet? | min? | K? | N/A | ? kW | | Output of ET200S? | √ |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Status Flat-field lamp | √ | | | | Profinet? | s? | ? | N/A | 24V | | Input ET200S? | √ |
| Auto/Man TBC | √ | | | | Profinet? | s? | ? | N/A | 24V | | Input ET200S? | √ |
| Local/Remote TBC | √ | | | | Profinet? | s? | ? | N/A | 24V | | Input ET200S? | √ |
| Status Arc lamp 2 | √ | | | | Profinet? | s? | ? | N/A | 24V | | Input ET200S? | √ |
| Auto/Man TBC | √ | | | | Profinet? | s? | ? | N/A | 24V | | Input ET200S? | √ |
| Local/Remote TBC | √ | | | | Profinet? | s? | ? | N/A | 24V | | Input ET200S? | √ |
| ... | | | | | | | | | | | | √ |
| Flat-field lamp on/off | | √ | | | Profinet? | s? | V? | N/A | 24V | | Output of ET200S? | √ |
| Arc lamp status on/off | | √ | | | Profinet? | s? | V? | N/A | 24V | | Output of ET200S? | √ |
| ... | | | | | | | | | | | | |
| ... | | | | | | | | | | | | |

| Subsystem | Dig Input | Dig Output | Ana Input | Ana Output | Fieldbus | Cycle time | Accuracy | Resolution | Stroke | Power (Torque) at motorshaft | Comments | ESO Standard announced to be available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| … | | | | | | | | | | | | |
| ALARMS and Interlocks | | | | | | | | | | | | |
| Integrated Safety | | | | | | | | | | | | |
| Interlocks on rotator | | | | | | | | | | | | |
| (1) Interlock/CAS alarm - Cable Wrap alarm (Corotator out of sync.) | √ | | | | Profinet? | ms? | | | 24V | | Fail Safe PLC | √ |
| (2) Interlock/CAS alarm - Person on co-ro platform | √ | | | | Profinet? | ms? | | | 24V | | Fail Safe PLC | √ |
| (3) Interlock/CAS - Cryostat door open | √ | | | | Profinet? | ms? | | | 24V | | Fail Safe PLC | √ |
| (4) Interlock/CAS- co rotator power failure | √ | | | | Profinet? | ms? | | | 24V | | Fail Safe PLC | √ |
| (5) Interlock/CAS- co rotator manual stop | √ | | | | Profinet? | ms? | | | 24V | | Fail Safe PLC | √ |
| | | | | | | | | | | | | |
| Local Interlocks on Instrument | | | | | | | | | | | | |
| (1) Local Interlock - overpressure due to closed continuous flow | | | | | | | | | 24V | | | |
| (2) Local Interlock - atm pressure - blocked continuous flow | | | | | | | | | 24V | | | |
| | | | | | | | | | | | | |
| (1) CAS alarm – Over temperature in cabinet 1 | √ | | | | Profinet? | s? | | | 24V | | Fail Safe PLC | √ |
| (2) CAS alarm – Over temperature in cabinet 2 | √ | | | | Profinet? | s? | | | 24V | | Fail Safe PLC | √ |
| (3) CAS alarm – Over temperature in cabinet 3 | √ | | | | Profinet? | s? | | | 24V | | Fail Safe PLC | √ |
| (4) CAS alarm – Over temperature in Calibr. Unit cabinet | √ | | | | Profinet? | s? | | | 24V | | Fail Safe PLC | √ |
| (8) CAS alarm - Exhaust heater function | √ | | | | Profinet? | ms? | | | 24V | | Fail Safe PLC | √ |
| (8) CAS alarm - Cryostat door open | | | | | | | | | | | | √ |
| (3) CAS alarm - Door open cabinet 1 | √ | | | | Profinet? | ms? | | | 24V | | Fail Safe PLC | √ |
| (4) CAS alarm - Door open cabinet 2 | √ | | | | Profinet? | ms? | | | 24V | | Fail Safe PLC | √ |
| (5) CAS alarm - Door open cabinet 3 | √ | | | | Profinet? | ms? | | | 24V | | Fail Safe PLC | √ |
| … | | | | | | | | | | | | |

| Subsystem | Dig Input | Dig Output | Ana Input | Ana Output | Fieldbus | Cycle time | Accuracy | Resolution | Stroke | Power (Torque) at motorshaft | Comments | ESO Standard announced to be available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| **WARNINGS** | | | | | | | | | | | | |
| **ICE** | | | | | | | | | | | | |
| (1) Warning-Cooling out of ctrl. cab. 1 (cab-amb diff. > 1.5 C°) | √ | | | | Profinet? | s? | | | 24V | | Input ET200S? | √ |
| (2) Warning-Cooling out of ctrl. cab. 2 (cab-amb diff. > 1.5 C°) | √ | | | | Profinet? | s? | | | 24V | | Input ET200S? | √ |
| (3) Warning-Cooling out of ctrl. cab. 3 (cab-amb diff. > 1.5 C°) | √ | | | | Profinet? | s? | | | 24V | | Input ET200S? | √ |
| (4) Warning-Cooling out of ctrl. calibr. (cab-amb diff. > 1.5 C°) | √ | | | | Profinet? | s? | | | 24V | | Input ET200S? | √ |
| (5) Warning - Door Open Cabinet 1 | √ | | | | Profinet? | s? | | | 24V | | Input ET200S? | √ |
| (6) Warning - Door Open Cabinet 2 | √ | | | | Profinet? | s? | | | 24V | | Input ET200S? | √ |
| (7) Warning - Door Open Cabinet 3 | √ | | | | Profinet? | s? | | | 24V | | Input ET200S? | √ |
| (8) Warning - Door Open Calibration Unit Cabinet | √ | | | | Profinet? | s? | | | 24V | | Input ET200S? | √ |
| (9) Warning - COROT manual stop | √ | | | | Profinet? | s? | | | 24V | | Input ET200S? | √ |
| (10) Warning - COROT 3-phase power failure to motor | √ | | | | Profinet? | s? | | | 24V | | Input ET200S? | √ |
| ... | | | | | | | | | | | | |

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