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VERY LARGE TELESCOPE

ELECTRONIC DESIGN SPECIFICATION

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CHANGE RECORD

ISSUE	DATE	SECTION AFFECTED	REMARKS
Issue 1	18 Jul 91	2.1.1	tbd's settled
		2.1.3	applicability t.b.d.
		other	"xx" into t.b.d.
		4.8	section added
Issue 2	09 Apr 92	all	doc. reformatted, new ch.:"Grounding" some t.b.d.'s settled
Issue 3	30 Mar 93	2.1.1	new reference
		2.2.2	Ethernet spec
		2.1.1,3.4.3,3.5.2	Thermal req. changed
		Drawings	Ground symbols IEC 617
		3.9.3.1	Some tbd VME settled
		3.9.4	Sauter PLC
		3.9.5	Max height defined
		3.3.2.1	'xx' corrected.
		3.10->3.14	new chapters
Draft 4, 5			Intermediate drafts
Issue 4	9 Dec. 96	All:	Changes compared with Iss. 3: see VLT-TRE-ESO-10000-1265, Iss. 1, Dated: 3 Dec. 1996.

1. SCOPE

This document describes the design requirements for all electronic boxes of the VLT. Main goal of this document is to supply design rules in order to achieve electrical and electronic integrity of each subsystem and inside each subsystem.

Verification of each requirement is given in square brackets just above each requirement. This according to the following table:

ROD	Review of design
I	Inspection
T	Test
TT	Type test

The "type test" is used for a commercially available unit. It indicates that the requirement must be fulfilled by the type testing as described on the data sheet of the unit.

2. APPLICABLE DOCUMENTATION

2.1. SPECIFICATIONS

2.1.1. ESO specifications

- VLT-SPE-ESO-10000-0001
  "VLT Program Requirements"
- VLT-SPE-ESO-10000-0003.
  "Electro Magnetic Compatibility and Power Quality Specification. Part 2, Electromagnetic disturbance emission and immunity limits of electric and electronic equipment"
- VLT-SPE-ESO-17300-0376.
  "VLT Time Reference System Specification"
- VLT-SPE-ESO-17120-0270
  “VLT LAN's specification.”

2.1.2. Connector procurement specifications

2.1.2.1. Power connectors 230 VAC and 400 VAC

- CENELEC Harmonization Document HD 196 S1 (1975) (CEE-el17)
  "Three phase 400 VAC with earthing contact. Plugs, socket-outlets and couplers for industrial purposes."
- CENELEC Harmonization Document HD 196 S1 (1975) (CEE-el17)
  "Single phase 230 VAC with earthing contact. Plugs, socket-outlets and couplers for industrial purposes."
- CEE-el 7/VII (SCHUKO)
  "Single phase 230 VAC with earthing contact plugs and socket outlets."
- CENELEC EN 60320
  "Appliance couplers for household and similar general purposes." (CENELEC version of IEC 320).
- DIN VDE 0620

"Plugs and socket outlets up to 250 V, 25 A."

2.1.2.2. Multipole signal connectors specifications

- MIL-C-28748.
  (Rectangular multipole signal connectors.)
- IEC 603-2(1988) Part 2
  "Two-part connectors for printed circuit boards, for basic grid of 2.54 mm (0.1 in) with common mounting features". (Parallel of DIN 41612).
- MIL-C-26482
  (Circular multipole signal connectors.)
- MIL-C-24308 B
  (Sub-D connectors)

2.1.2.3. Coaxial connectors

From IEC 169, "Radio frequency connectors", the following parts:

- MIL-C-39012/IEC 169-8/CECC 22120.
  "R.F. coaxial connectors with inner diameter of outer conductor 6.5 mm (0.256 in) with bayonet lock - Characteristic impedance 50 Ohms (Type BNC)".
- MIL-C-39012/IEC 169-15/CECC 22110.
  "R.F. coaxial connectors with inner diameter of outer conductor 4.13 mm (0.163 in) with screw coupling - Characteristic impedance 50 Ohms (Type SMA)".
- MIL-C-39012/IEC 169-9/CECC 22140.
  "R.F. coaxial connectors with inner diameter of outer conductor 3 mm (0.12 in) with screw coupling - Characteristic impedance 50 Ohms (Type SMC)".

2.1.2.4. Optical fibre connectors

- From IEC 874; "Connectors for optical fibres and cables":
  IEC 874-2
  "Part 2: Sectional specification. Fibre optic connector type F-SMA."
  Note: this norm is applicable to a family of connectors for optical fibres and cables so-called F-SMA which has a 1/4" 36 UNS thread based upon the electrical SMA connector. Provides information and rules for the preparation of detail specifications for single way optical fibre connector sets, with a screw thread coupling for fibres of not less than 125 micrometer nominal cladding diameters, and covering a number of methods of manufacture.
- ‘ST’ connectors.
- FDDI MIC (Medium Interface Connector)
  According to ANSI FDDI PMD (Physical Layer Medium Dependant Document)

2.1.3. Wires and cables specifications

2.1.3.1. Coding for conductors of power cables

- CENELEC Harmonization Document HD 3 S2.
  "Identification and use of cores of cables".
- CENELEC Harmonization Document HD 308 S1.
  "Identification and use of cores of flexible cables".

- CENELEC Harmonization Document HD 186 S2.
  "Marking by inscription for the identification of cores of electric cables having more than 5 cores.

2.1.3.2. Coding for conductors of signal cables

- CENELEC Harmonization Document HD 402 S2 (IEC 304)
  "Standard colors for insulation for low-frequency cables and wires."

2.1.3.3. Fibre cables

- DIN VDE 0888.
  "Lichtwellenleiter fuer Fernmelde- und Informationsverarbeitungsanlagen."

2.2. STANDARDS

2.2.1. Electrical safety standards

- IEC Publication 364.
  "Electrical installations of buildings".
- IEC 536.
  "Classification of electrical and electronic equipment with regard to protection against electric shock."
- IEC Publication 664-1 (1992).
  "Insulation co-ordination for equipment within low voltage systems, Part 1: Principles, requirements and tests."
- IEC Publication 950 (1986)
  "Safety of information technology equipment including electrical business equipment." Amendment No. 1 (1988), Amendment No. 2 (1990).
- IEC Publication 1010.
  "Safety requirements for electrical equipment for measurement, control, and laboratory use."; 1010 Part 1 (1990): General requirements, amendment No. 1 (1992).

2.2.2. Communications standards

- ANSI/IEEE Std 1014-1987.
  "IEEE Standard for a Versatile Backplane Bus: VME bus."
- ISO/IEC 8802-3: 1992
  "Information Processing Systems - Local Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD). Access methods and Physical Layer Specifications."
  "Ethernet standard."
- ANSI working committee X3T9.5, standards X3.139-1987, X3.148-1988, DIS 9314-3 R8 and R4.
  "FDDI standard"
- Field bus specification
  DIN V 19245 "Profibus".
- EIA Standard RS-232-C.
  "Interface between data terminal and data communication equipment employing serial binary data interchange".
  August 1969, reaffirmed June, 1981.
- EIA Standard RS-422-A.
  "Electrical characteristics of balanced voltage digital interface circuits".
  December 1978.

- EIA Standard RS-485.
- ANSI/IEEE Std 488-1987.
  "IEEE Standard Digital Interface for Programmable Instrumentation".

2.2.3. Mechanical mounting units for electronic equipment

- IEC 297.
  "Dimensions of mechanical structures of the 482.6 mm (19 in) series":
  - IEC 297-1 (1986) Part 1: Panels and racks.
  - IEC 297-2 (1982) Part 2: Cabinets and pitches of rack structures.
  - IEC 297-3 (1984) Part 3: Subracks and associated plug-in units.

  Note: IEC 297 is a parallel of DIN 41494.
- IEC 529 (1989).
  "Degrees of protection provided by enclosures (IP code)"

2.2.4. Other standards

- IEC 1131 Programmable controllers.
  Part 1: General information.
  Part 2: Equipment characteristics.
  Part 3: Programming languages.

3. DESIGN REQUIREMENTS

3.1. GENERAL

The electronic equipment for the VLT shall be designed according to the following list. Each item of this list is described in detail in this chapter.

- Compliant with specifications and standards as described in chapter 2.
- Have electrically safe and reliable signal interconnections to other electronic units, without risk of "latch-up" or propagation of failures in case of faults.
- Have reliable and easy to maintain cabling between electronic units.
- Mounted on standardized printed circuit boards in standardized boxes and cabinets.
- Have connectors which are of high quality and standardized.
- Have local control units that control all functions and that have standardized computer boards.
- Powered by the VLT electric power supply system.

[ROD,I]

All the electronic units shall be such that all functions and all status signals are accessible via the Local Area Network, i.e. local adjustments, other than those which are only adjusted during installation, are not allowed.

3.2. SIGNAL INTERCONNECTIONS BETWEEN ELECTRONIC BOXES

3.2.1. Logic signals.

3.2.1.1. Signal levels

[ROD]

Depending on the application, one of the two possible signal level voltages shall be chosen:

- 5 Volt, TTL compatible switching levels.
- 24 Volt, switching levels dependent on the application.

3.2.1.2. Interconnection methods with 5 V supply

[ROD,T]

An interconnection method with galvanic isolation is recommended in general and is required in the case of:

- connection to a high power unit as described in chapter 3.9.1.

The isolation shall meet the requirements as described in chapter 3.7.

[ROD]

An interconnection method with differential signals is required in the case that all conditions that follow are valid:

- a cable length of longer than 3 meters.
- galvanic isolation is not required.

[ROD]

The interconnection method with single ended driver and single ended receiver is not recommended in general and shall only be used in the case that all conditions that follow are valid:

- a cable length of not more than 3 meters.
- galvanic isolation is not required.
- the receiver has a Schmitt trigger input.

[ROD,I]

The interconnection cable shall be shielded twisted pair.

[ROD]

Recommended ways of interconnection are given in chapter 3.2.1.4. Alternatives shall comply with this specification.

3.2.1.3. Interconnection methods with 24 V supply

[ROD,T]

The 24 V system is intended for interconnection with relays or opto couplers and shall therefore be galvanically isolated.

The isolation shall meet the requirements as described in chapter 3.7.

[ROD,I]

The interconnection cable shall be shielded twisted pair.

[ROD]

Recommended ways of interconnection are given in chapter 3.2.1.4. Alternatives shall comply with this specification.

3.2.1.4. Recommendations.

Recommended interconnection methods for logic signals are:

- Contact status.

- Optocoupler.
- Active driver.

The contact status and optocoupler can be galvanically isolated and are therefore the preferred methods. The active driver allows the highest speed.

a. Contact status interconnection.

The recommended way of implementation is shown in fig. 1. The interconnection is galvanically isolated if the contact is not connected to the chassis ground of the source.
For a supply voltage of 24 V, the destination can contain a relay or optocoupler.

b. Optocoupler interconnection.

The recommended ways of implementation are shown in fig. 2.

c. Active driver interconnection

The recommended ways of implementation are shown in fig. 3 for a single ended interconnection and fig. 4 for differential interconnection.
Pull-up and / or pulldown resistors can be added to prevent latch-up and to provide a defined logic level in case of a fault (opening) in the interconnection.

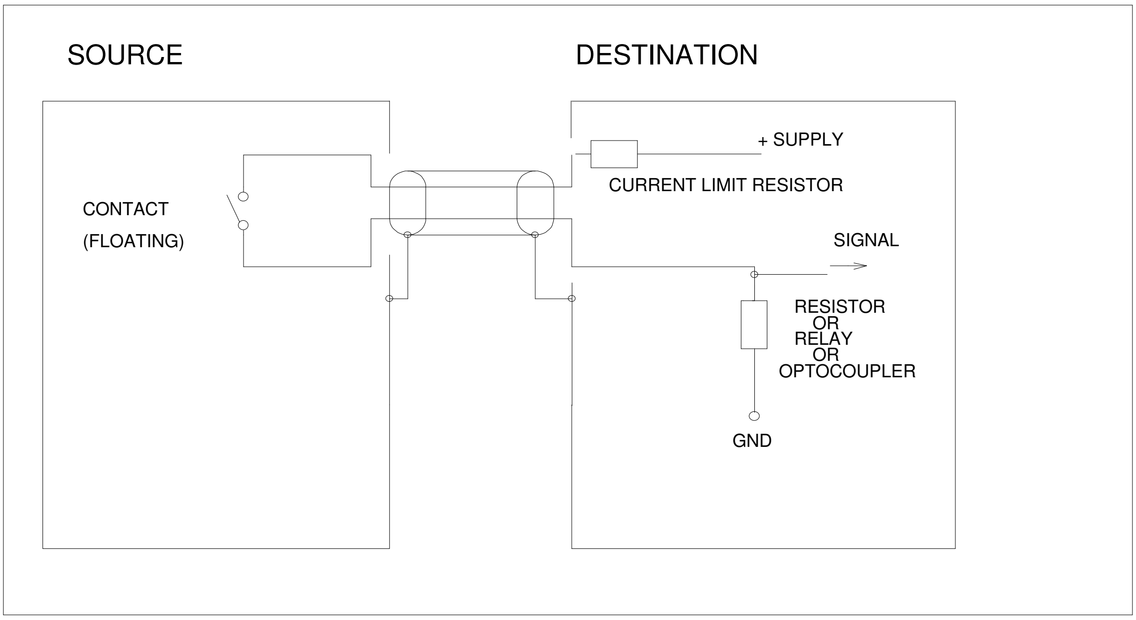

Fig. 1: CONTACT STATUS INTERCONNECTION

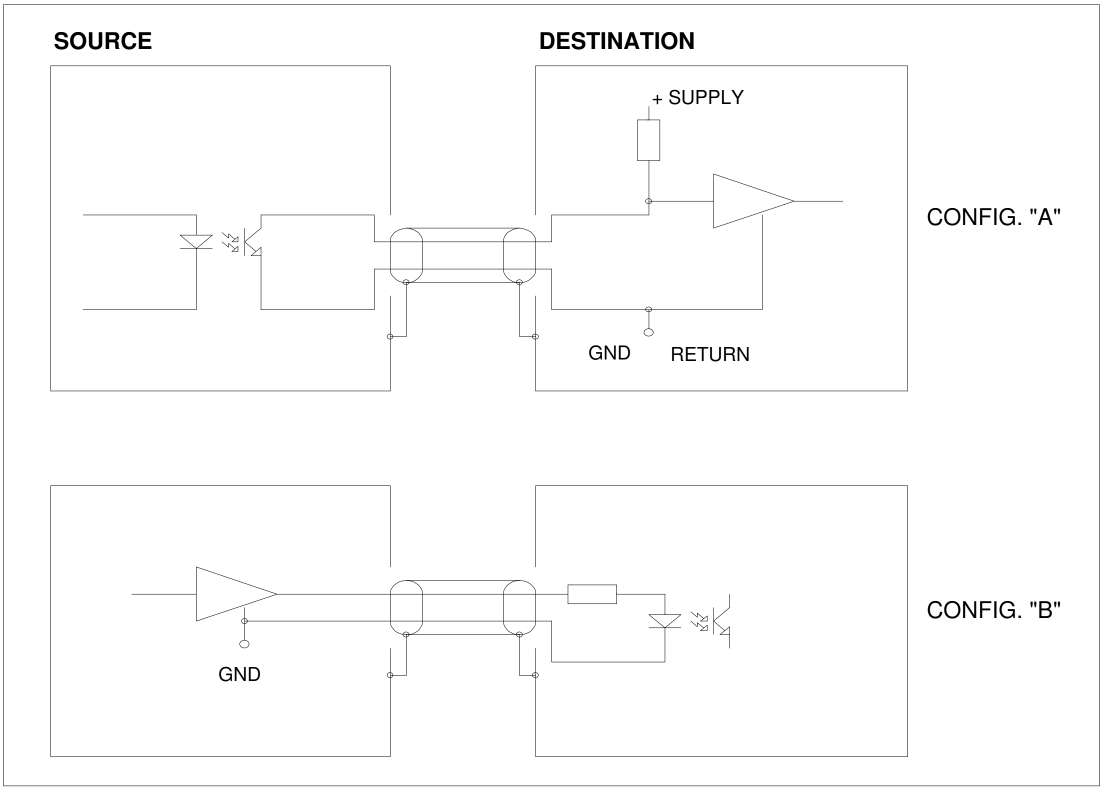

Fig. 2 : OPTOCOUPLER INTERCONNECTION

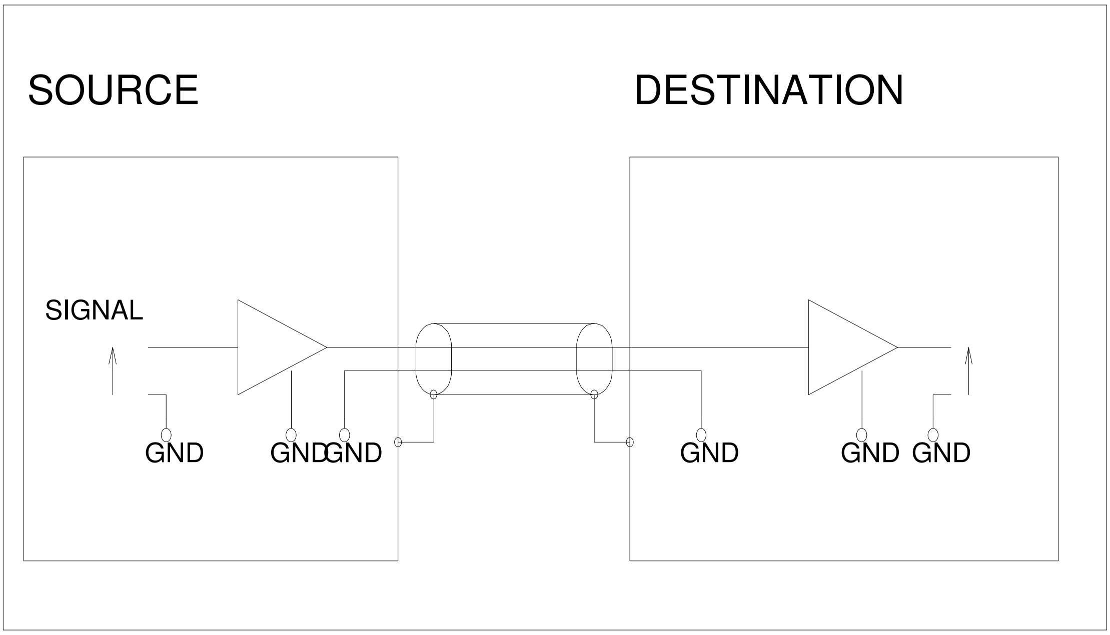

Fig. 3: ACTIVE DRIVER FOR SHORT CABLES

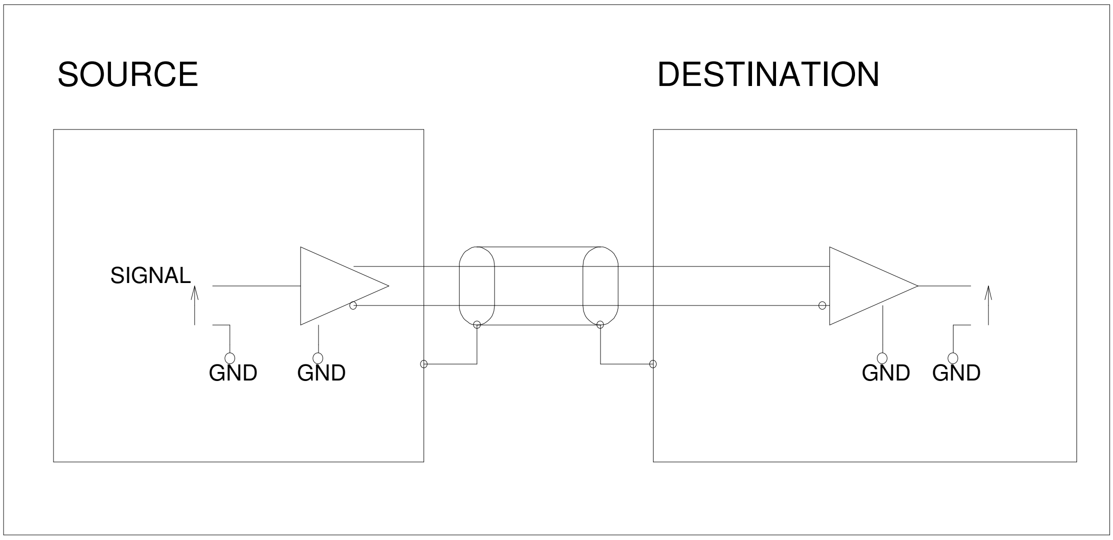

Fig. 4 : ACTIVE DRIVER FOR LONG CABLES

3.2.2. Analog signals, interconnected without coax cable.

3.2.2.1. Signal levels.

[ROD]

The supply voltage of the analog driver and receiver circuits shall be + and - 15 Volt.

3.2.2.2. Interconnection methods

[ROD,T]

Interconnection methods with galvanic isolation are recommended in general and are required in the case of:

- connection to a high power unit as described in chapter 3.9.1.

The isolation shall meet the requirements as described in chapter 3.7.

[ROD]

Interconnection without galvanic isolation shall be done with a differential receiver.

[ROD]

In cases where a high degree of noise immunity is required the driver shall be also differential.

[ROD]

Current type interconnections (e.g. 0-20 mA) are allowed, however not recommended. The interconnection shall comply with this specification.

[ROD,I]

The interconnection cable shall be shielded twisted pair.

[ROD]

Recommended ways of interconnection are given in chapter 3.2.2.3. Alternatives shall comply with this specification.

3.2.2.3. Recommendations.

Recommended methods for analog signal interconnections are:

a. An analog isolation amplifier.
b. A differential driver.
c. A single ended driver.

- Signal levels.
  A full scale voltage in the range of 9 to 10 Volt is recommended.

a. Isolation amplifier

The recommended schematic diagram for an isolation amplifier is shown in fig. 5. Alternatives to this diagram are:

- use of a DC/DC converter to eliminate the power connection between source and destination.
- placing the isolation amplifier in the destination instead of in the source.

b. Differential driver

The recommended schematic diagram for a differential driver is shown in fig. 6. This interconnection provides a high degree of noise immunity.

c. Single ended driver

The recommended schematic diagram for a single ended driver is shown in fig. 7.

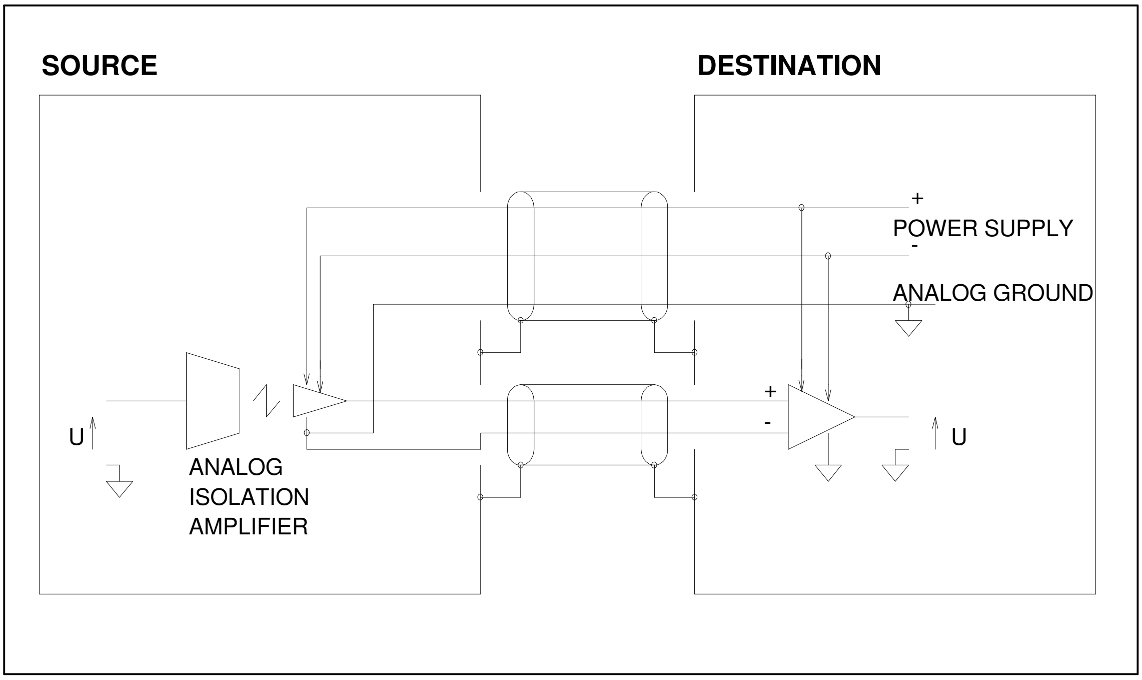

Fig. 5 : ISOLATED ANALOG INTERCONNECTION

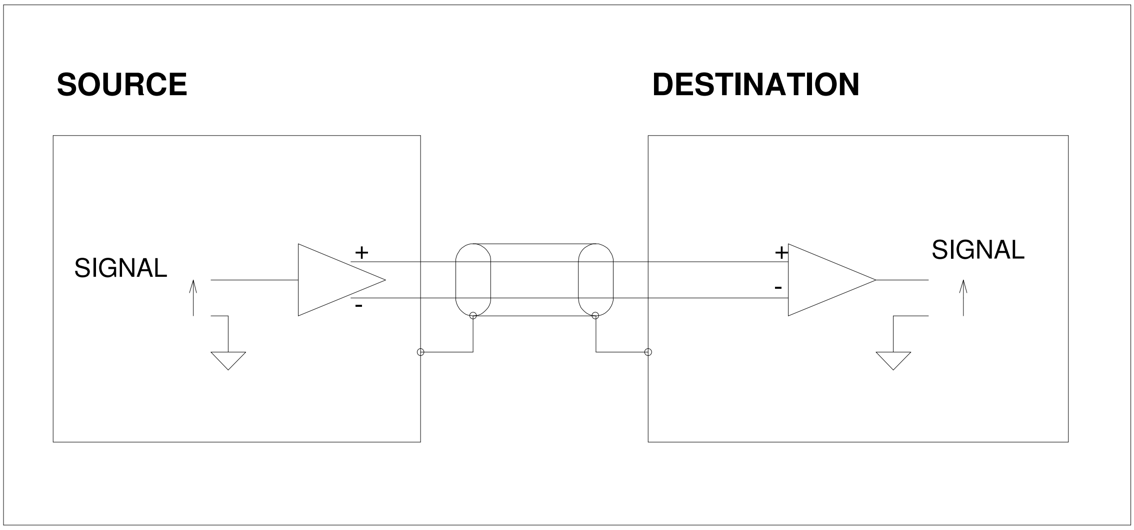

Fig. 6 : DIFFERENTIAL DRIVER ANALOG INTERCONNECTION

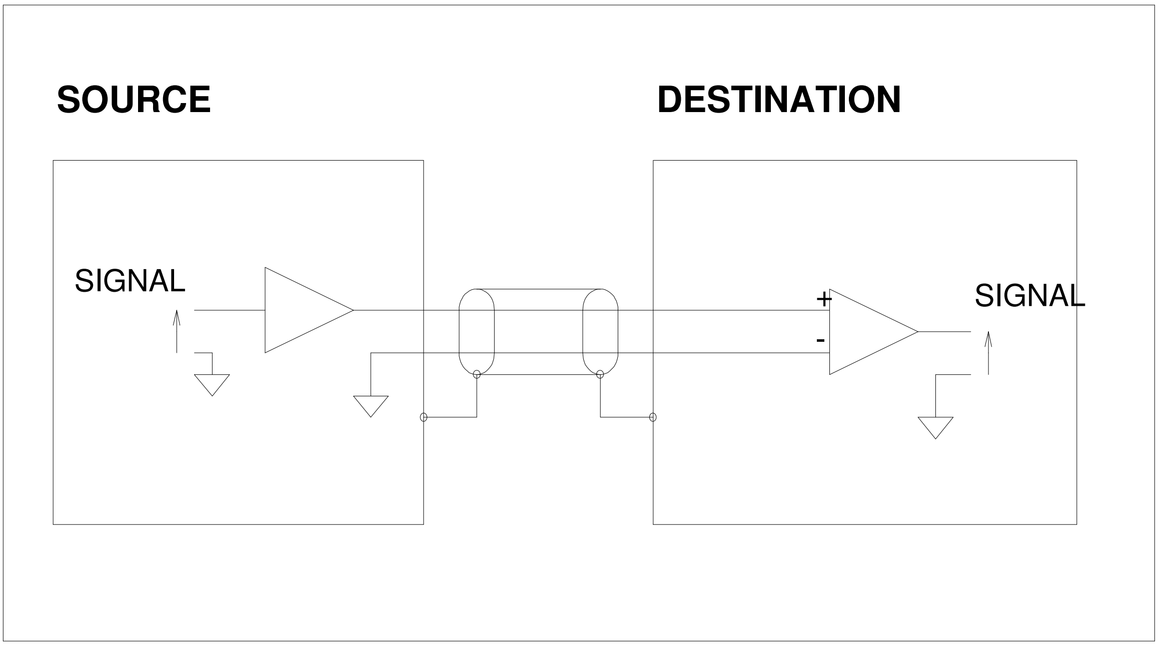

Fig. 7 : SINGLE ENDED DRIVER ANALOG INTERCONNECTION

3.2.3. Analog signals, interconnected with coax cable.

[ROD]

The interconnection with coaxial cable is only allowed if all conditions that follow are valid:

- the cable length is not more than 3 meters.
- galvanic isolation is not required.

3.2.3.1. Recommendations

t.b.d.

3.2.4. Serial data

3.2.4.1. RS-232 interface.

[ROD,T]

The interface RS-232 with galvanic isolation is recommended in general and is required in the cases where at least one of the following conditions are true:

- one or both of the units to be interconnected is a high power unit as described in chapter 3.9.1.
- the cable length between the units is more than 5 meters.

The isolation shall meet the requirements as described in chapter 3.7.

The recommended protocol and data format is:

Protocol	XON/XOFF
Baudrate	9600
Start	1 bit
Data length	8 bit
Parity	None
Stop bit	1

3.2.4.2. RS-422 interface

t.b.d.

3.2.4.3. RS-485 interface

t.b.d.

3.2.4.4. Local Area Network

[ROD,I]

Communication between different subsystems shall be done with one of the standardized Local Area Networks, Ethernet or FDDI, as defined in chapter 2.

a. Ethernet.

[ROD,I]

The cabling options of Ethernet are:

- 'Thin' Ethernet with RG58 cable and BNC connectors (10BASE2 implementation).
- Fiber Ethernet with fibre cable according DIN VDE 0888 with the following characteristics:
  Multimode 62.5/125 micrometer.
  Damping: 3.2 dB at 850 nm.
  Bandwidth/length product: 200 MHz x km.

It is recommended to use optical fibre cables for the implementation of the Ethernet cable.

[ROD,T]

If a part of the communication network is made with coaxial cable, extra care shall be taken for correct implementation according to the ISO/IEC 8802, especially:

- The length of each segment shall be measured and recorded.
- The grounding of the shield of the coax cable shall be at one point only, which shall be indicated on the drawings and verified after installation .

- Galvanic isolation of the coaxial cable (also the shield) from the LCU shall be verified for the equipment which will be selected.

b. FDDI

Cabling for FDDI shall be done with MIC (FDDI media interface connector) connectors and fibre according to DIN VDE 0888 with the following characteristics:

Multimode 62.5/125 micrometer.
Damping: 1.0 dB at 1300 nm
Bandwidth/length product: 500 MHz x km.

c. ATM

The use of ATM as alternative to FDDI is under investigation. It uses the same physical medium as FDDI.

3.2.4.5. Field bus

The standardised Field bus is "Profibus", DIN V 19245 as mentioned in chapter 2.
If applicable, this bus may be used as control below the LCU level, i.e. it is not intended as an alternative for the LCU, but as a possibility (if technically justified) to accommodate standardized distributed control inside a subsystem.
The use of the Profibus requires approval from ESO.

3.3. GROUNDING

3.3.1. General

[ROD]

Grounding of electronic units shall comply with the safety and EMC specifications, mentioned in chapter 2.

3.3.2. Grounding principles

3.3.2.1. Unit level (Box level)

[ROD]

Each box which needs safety earthing according to IEC 536 shall be earthed via the protective earth of the power distribution, which is described in chapter 3.6.
Equipotential bonding of boxes to structural parts is allowed, if it is not for safety reasons.

Note: this requirement implies that 'single point' grounding, as defined in Military Standard MIL-STD-188-124B (1 Feb 92), cannot be used for the VLT Observatory. In practice, this 'single point' is not feasible for equipment which use higher frequencies as is the case with modern electronic equipment. Potential danger is then the risk of "ground loop coupling" interference, which is controlled by careful design of interconnections between units (boxes) as defined in this specification.

3.3.2.2. Subsystem level

(e.g. M1, M2, main structure, instrument)

[ROD,I]

Galvanic connection between subsystems shall not be made, except for mains power.

3.3.2.3. System level/observatory level

[ROD,I]

Galvanic connection between hotel and telescope area shall not be made.

3.3.3. Grounding recommendations

A recommended method of grounding of electronic units with a built in power supply is shown in fig. 8. The power return of analog and digital circuits is kept separated except for one point, close to where the mains power cable enters the unit. At that location, there is one junction of:

- analog signal ground,
- digital signal ground,
- protective earth (PE) of the power supply or supplies, and
- protective earth (PE) of mains supply connection.

Note that this method can only be used if the unit is protected with a residual current circuit breaker that trips at 10 mA maximum. Otherwise, extra measures according IEC 364-7-707 need to be taken.

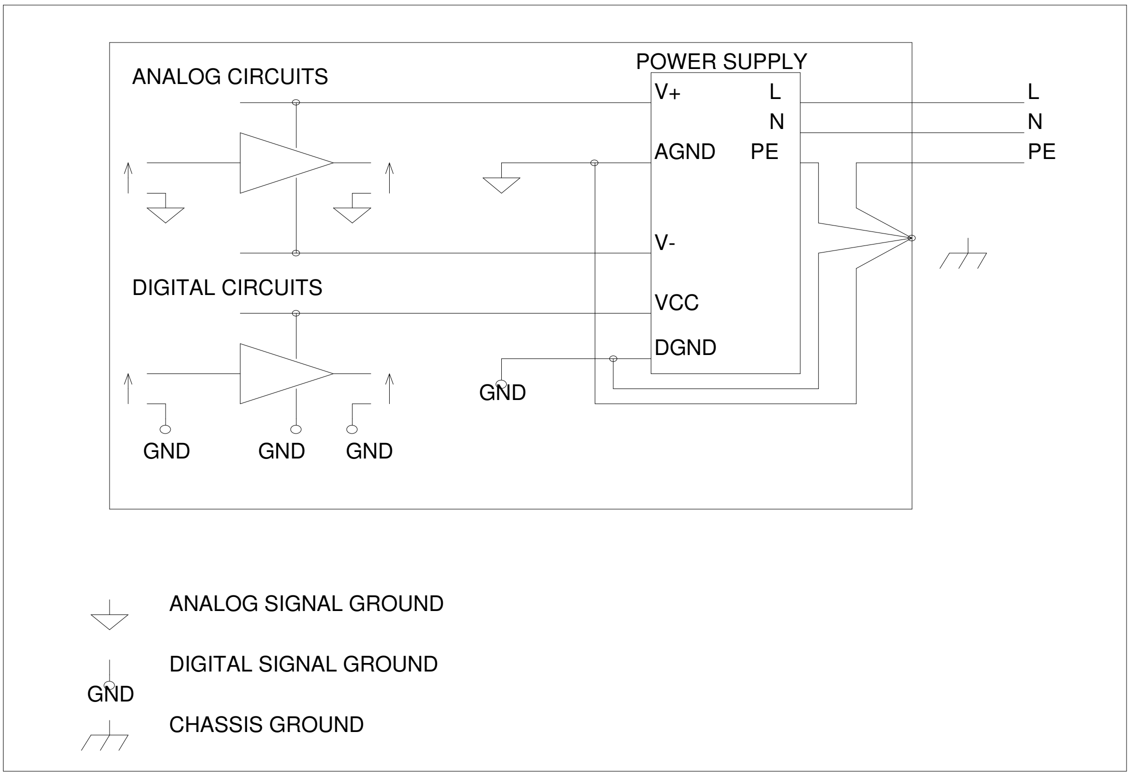

Fig. 8 : GROUNDING CONNECTIONS

3.4. CABLING

3.4.1. Safety

[ROD]

Cabling design shall follow the safety specifications as mentioned in chapter 2.

3.4.2. EMC

[ROD]
Cabling design shall follow the EMC specification as mentioned in chapter 2.

[ROD,I]
Cables shall be shielded.

[ROD,I]
The shielding shall be terminated to the chassis ground at both ends of the cable.

3.4.3. Thermal design

[ROD]
Thermal design shall be comply with the thermal requirements of the subsystem of which the cable is a part.

3.4.4. Core identification

3.4.4.1. Power cables

[ROD,I]
Color coding of cores of power cables shall be according to CENELEC Harmonization Documents HD 3 S2 and HD 308 S1, see chapter 2.

[ROD,I]
Inscription coding of the cores of power cables shall be according to CENELEC Harmonization Document HD 186 S2, see chapter 2.

3.4.4.2. Low frequency signal cables

[ROD,I]
Color coding shall be according to CENELEC Harmonization Document HD 402 S2 (IEC 304), see chapter 2.

3.4.5. Cable routing.

[ROD,I]
The cable routing shall be reliable and maintenance friendly.

[ROD,I]
Cable routing implementation shall comply with the following requirements:

- Cables shall be put in ducts where possible.
- The most direct routing of cables and ducts compatible with structural provisions shall be applied.
- All cables/ducts shall be positioned to the structure as close as possible.
- Dynamic envelope clearance shall be insured at all corners and sharp edges.
- Cables shall be protected against damage from abrasion, contact with sharp edges or protrusions and environments.
- Accessibility of cables shall be provided to the extend possible due to structural restrictions.
- Cable arrangement and connector bracket design shall allow rapid operational disconnection.
- The cabling supporting devices shall provide the possibility for removal and replacement of cables for maintenance.
- The cabling routing shall insure connector replacement capability.
- Power and signal cables shall be routed as far as possible away from each other.

- The bending radius shall not be smaller than the minimal value as specified by the cable manufacturer.

3.5. MOUNTING FOR ELECTRONIC UNITS

3.5.1. Printed circuit boards

[ROD]

Printed circuit boards (PCB) shall be with dimensions and connectors according to IEC 297, see chapter 2., except in cases of space limitations.

Recommended dimensions of printed circuit boards (PCB) with dimensions according to the IEC 297 are:

- height 100 mm, depth 160 mm.
- height 100 mm, depth 220 mm.
- height 233 mm, depth 160 mm.

3.5.2. Cabinets

[ROD]

Cabinets for mounting of electronic equipment shall be according to IEC 297, see chapter 2. The type of cabinet is standardized, see chapter 3.9.5.
In cases of space limitations, the use of another type or custom designed system is allowed.

[ROD,I]

In the cases that the cabinets are exposed to the outside environment during telescope observation, the protection shall be:

- IP54 or better according to IEC 529 for cabinets with a variable vertical orientation (e.g. Mounted to Nasmyth adapter/rotator).
- IP53 or better according to IEC 529 for cabinets with a fixed vertical orientation (e.g. Mounted on Azimuth platform).

The type of cabinet is standardized, see chapter 3.9.5.

Note: EMC requirements might imply the use of HF screened cabinets. This is not standardised.

[ROD,T]

Thermal control shall be compliant with the thermal requirements of the subsystem of which the cabinet is a part.
Note: LCU control of the cooling is specified in chapter 3.13.

3.6. ELECTRICAL POWER

3.6.1. Electrical mains supply

[ROD]

Electronic units in the VLT shall be powered by the VLT electrical power supply system.

The following electrical supplies are available in the VLT:

- 400 VAC three-phase, 50 Hz + neutral(N) + protective conductor (PE).
- 230 VAC single phase, 50 Hz + protective conductor (PE).

- Uninterruptable power supply (UPS), i.e. no-break automatic supply. 230 VAC single phase, 50 Hz + protective conductor (PE).

The allowable load on the UPS supply is limited and is to be agreed between ESO and the contractor. This implies that in a lot of subsystems, the load will be split between UPS and non-UPS supply. In this case, the non-UPS load is by definition a high power load, see chapter 3.9.1.

3.6.2. Power quality

Power quality is specified in reference document "Electro Magnetic Compatibility and Power Quality Specification", see chapter 2.

[ROD]

All electronic units of the VLT shall comply with that specification.

3.6.3. Electro magnetic compatibility

Electro Magnetic Compatibility is specified in reference document "Electro Magnetic Compatibility and Power Quality Specification", see chapter 2.

[ROD]

All electronic units of the VLT shall comply with that specification.

3.7. GALVANIC ISOLATION

[ROD]

The galvanic isolation shall meet the following specifications:

Isolation test voltage	> 1500 VAC, 50 Hz
Isolation resistance	> 100 M Ohms
Isolation capacitance	< 50 pF

3.8. OPTICAL INDICATORS

[ROD,I]

Optical indicators, like lamps or LED's, shall cause no light pollution, i.e. they shall be:

- totally protected with a cover, e.g. the door of a cabinet, or
- be switchable.

3.9. COMMERCIAL ELECTRONIC EQUIPMENT

3.9.1. High power unit

Definition: A high power unit is an electrical or electronic unit which is controlled by an LCU but not powered by the UPS.

3.9.1.1. Procurement requirements

[ROD,TT]

If a commercial available high power unit is planned to be used, it shall be selected with extra care on Electro Magnetic Compatibility. Especially in the field of motion control equipment, many commercially available units are not compliant with the EMC specification, see chapter 2., and are therefore not acceptable.

3.9.1.2. Signal interconnections

[ROD,T]

Galvanic isolation between the UPS and non-UPS supply must be made at the load side as shown in fig. 9. This implies that all signal interconnections between high power units and LCU shall be done by using galvanic isolation methods as described in this specification.

3.9.1.3. Power connections

[ROD,I]

Connection of the high power unit to the mains power shall be done as shown in fig. 10. This figure shows a 3 phase supply; the same principle shall be used in the case of a 1 phase supply. The following features shall be implemented:

- power shall be switchable by an LCU.
- inrush current shall be limited. No load greater than 3 kVA shall directly be connected to the power distribution system.
- the power of the 1 phase or 3 phase supply shall be checked with relays or equivalent devices and the signal shall be available in the LCU.

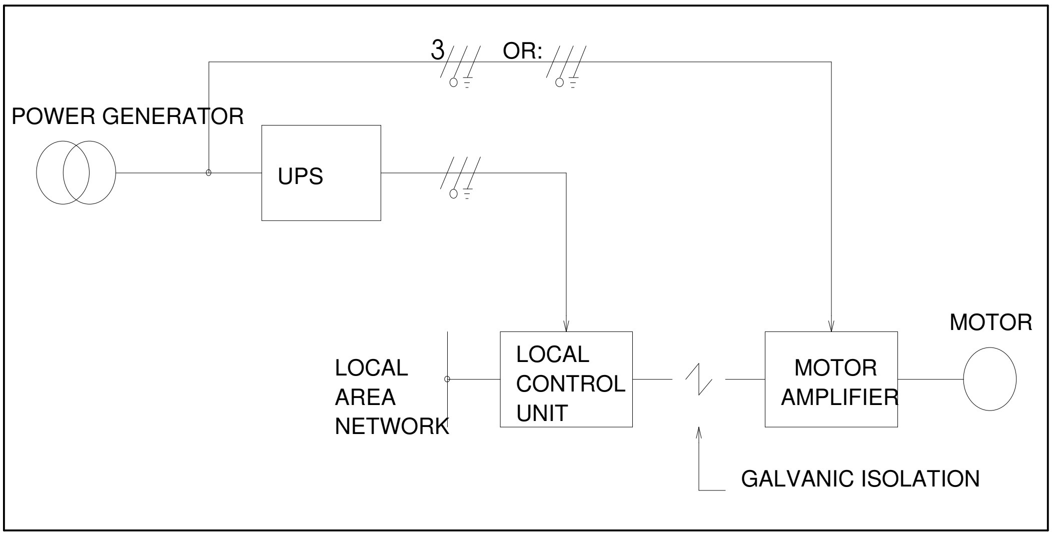

Fig. 9: UPS/NON-UPS POWER DISTRIBUTION

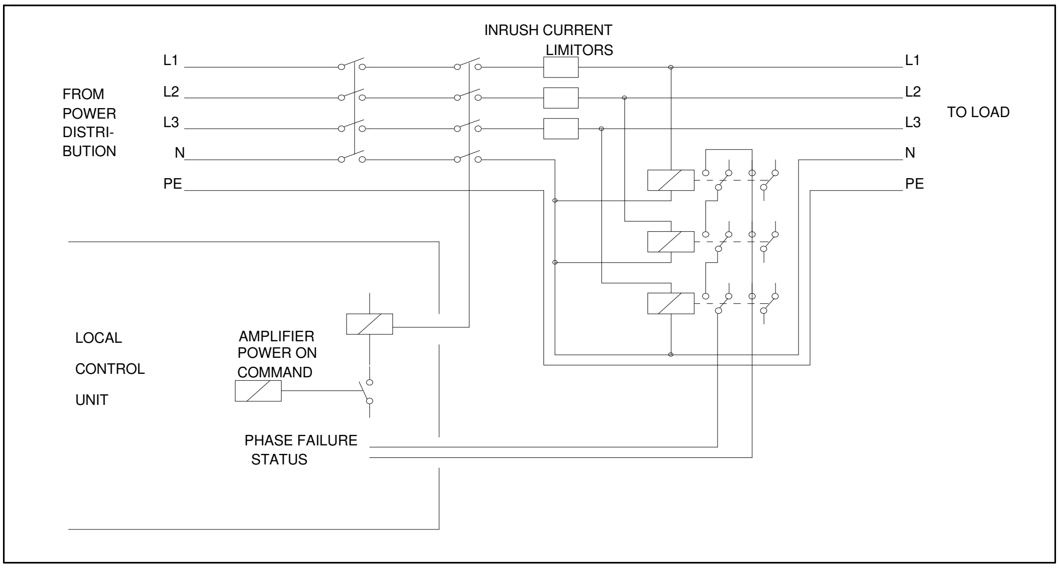

Fig. 10: POWER CONNECTION OF A HIGH POWER UNIT

3.9.2. Electrical connectors

3.9.2.1. General

[ROD]

Electrical connections shall be made with screw terminals where possible.

[ROD,I]

Electrical connectors used for the VLT shall meet the requirements of one of the connector procurement specifications referenced in chapter 2.

[ROD,I]

For each type of connector, a break-out box, shall be made.

[ROD,T]

The break out box shall have a principle schematic as in fig. 11. This figure shows the break-out box for a 9 contact D connector.
The break-out box shall have the following features:

- the break-out box can be inserted into the system without changing its electronic characteristics.
- each connection can be opened individually with banana contacts.
- the shielding shall be fed through.
- box material shall be electrically conducting.

3.9.2.2. Terminal type connections

[ROD,I]

The following types shall be used where possible:

- for power connections: WEIDMUELLER WDU series, size given by the required wire diameter.
- for signal connections: WEIDMUELLER SAK series for general applications and WEIDMUELLER AKZ series for high density applications.
- for connector to screw terminals: WEIDMUELLER RS series.

3.9.2.3. Electric power connectors

[ROD,I]

Three phase 400 VAC connectors:

- CENELEC Harmonization Document HD 196 S1 (1975) (CEE-el 17).
  3P+N+E, 240/415V (red type), earthing contact at 6h.
  Rated current according to application.

[ROD,I]

Single phase 230 VAC connectors.
Depending on the application, one of the following:

- CENELEC Harmonization Document HD 196 S1 (1975) (CEE-el 17).
  2P+E, 220/250V (blue type), earthing contact at 6h.
  Rated current according to application.
  This type shall only be used in cases where the CEE-el 7/VII (SCHUKO) type connector can not be used.
  The connectors which are used for the Uninterruptable Power Supply (UPS) shall have the color: t.b.d.
- CEE-el 7/VII (SCHUKO).
  The connectors which are used for the UPS shall have the color: t.b.d.

[ROD,I]

Single phase 230 VAC connectors for equipment.

- EN 60320.
  Preferred type: 2P+E, 65 Celsius.
  The use of a cable clamp is recommended.
- DIN VDE 0620.
  Preferred types:
  - Hirschmann ST series:
    STAK 20, cable connector, socket contacts.
    STASEI 2, chassis connector, pin contacts.

  The use of a cable clamp is recommended.
  This connector series shall only be used if the EN 60320 type cannot be used, e.g. in the case of required protection IP54 according to DIN 40050.

3.9.2.4. Signal connectors

[ROD,I]

If a signal connector from the following list is applicable for the application, it shall be chosen.

- MIL-C-28748.
  (Rectangular multipole signal connectors.)
  Preferred type: 104 contacts.
  Supplier: Radiall, series MMC HE 622.
- IEC 603-2(1988) Part 2
  (Signal connectors for printed circuit boards.)
  Shall be used only <u>inside</u> boxes:
  Preferred types:
  C 96 poles, row A+B+C
  C 64 poles, row A+C
  D 2 x 16 poles
  H11 11 poles power

H15 15 poles power
Supplier: Panduit.

- MIL-C-26482
(Circular multipole signal connectors.)
Supplier: SOURIAU (series 851).
- MIL-C-24308 B
(Sub-D connectors)
The connector shell shall provide the possibility for feed through of the shield.
The connector shell shall be fixed with screws.
Machined contacts shall be used.
Supplier: ITT/Cannon

  Note that the use of Sub-D connectors in combination with flat cables results in a different numbering for the conductors in the flat cable than given by the conductor sequence in the flat cable. See fig. 12 for a 15 contact connector. The connector contact numbering shall always be as in the MIL specification.
- MIL-C-5015.
Supplier: LEMO, series B (Crimp contacts).
- Insulation displacement connectors.
These connectors shall only be used inside boxes.
Supplier: 3M, Thomas & Betts, AMP.

3.9.2.5. Coax connectors

[ROD,I]

If a coax connector from the following list is applicable for the application, it shall be chosen.

- MIL-C-39012/IEC 169-8/CECC 22120.
(BNC coaxial connectors).
Preferred types: for RG 58, RG59 and RG178 cable.
Supplier: Radiall.
- MIL-C-39012/IEC 169-1/CECC 22110.
(SMA coaxial connectors).
Supplier: Radiall.
- MIL-C-39012/IEC 169-9/CECC 22140.
(SMC coaxial connectors).
Supplier: Radiall, series SMC-Subvis.
- t.b.d.
Supplier: LEMO (miniature 50 Ohm coax)
- t.b.d.
Triax and / or twinax connectors.

3.9.2.6. Optical fibre connections

[ROD,I]

If an optical fibre connectors from the following list is applicable for the application, it shall be chosen:

- IEC 874-2.
(SMA style).
Supplier: t.b.d.
Note: this connector is not recommended for new designs, use the ST connector instead.
- ‘ST’ connector.

Supplier: t.b.d.

- FDDI MIC.
  Supplier: t.b.d.

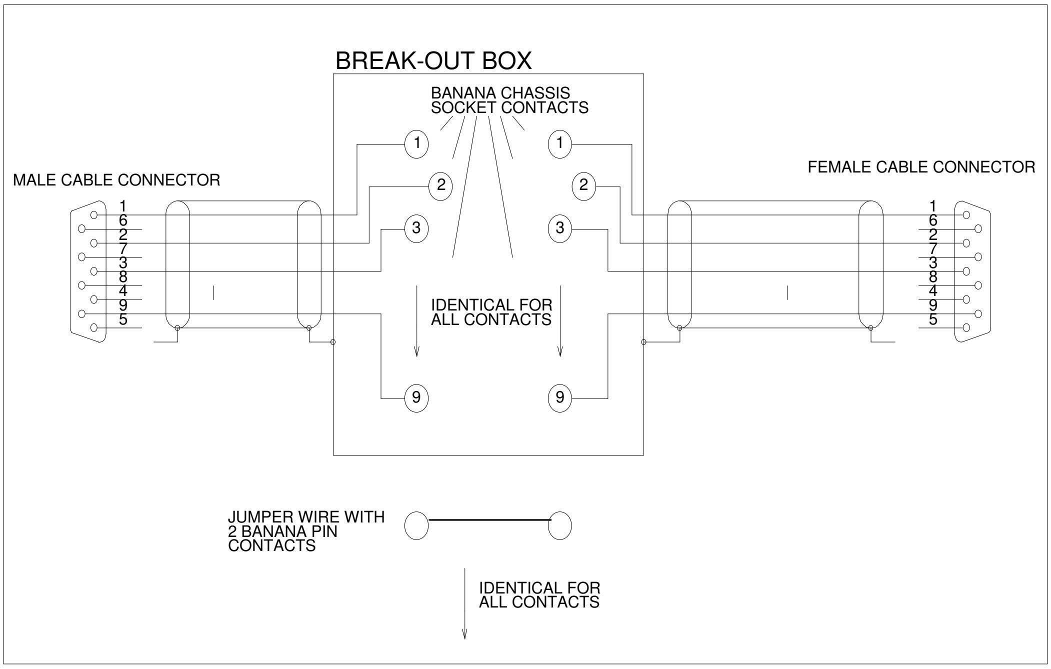

Fig. 11 : Break-out box

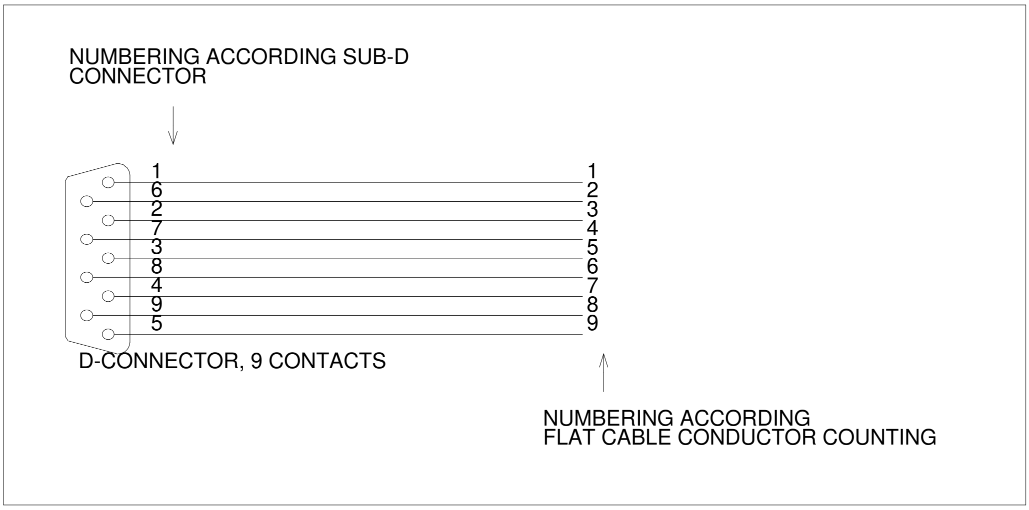

Fig. 12 : Sub-D connector contact numbering

3.9.3. Local control unit

[ROD,T]

The LCU shall be powered by the UPS supply.

3.9.3.1. LCU boards

[ROD]

LCU boards shall comply with the VME specification, see chapter 2.

[ROD,I]

The following VME boards are ESO de-facto standard and shall be used where possible, the use of a non-standard board shall be justified and agreed with ESO:

ITEM:	MANUF.:	TYPE:
CPU board	Motorola	MVME 167
Transputer board	INMOS	IMS B016
Analog I/O board (16in, 2 out)	VMIC	VMIVME-3111
Digital Input/Output board	Acromag	AVME 9481
Motion controller board:		
for incr. encoder:	MACCON	VME MAC4-INC
for serial absolute encoder:	MACCON	VME MAC4-SSI
for stepper motor:	MACCON	VME MAC4-STP
DC motor drive amplifier:		ESO
for low power:	ESO	VME4SA-01
for higher power:	ESO	VME4SA-11
Stepper motor amplifier	ESO	VME4ST
Encoder interface		t.b.d.
Async. comm. board (RS 232/422/485)	ESD GmbH	VME-ISER8
Profibus board (note 2) (note 3)	PEP Modular Computers	VIUC
IEEE 488 board		t.b.d.
Time Interface Module	ESO	TIM
Ethernet board (note 1), preliminary	N.A.T. GmbH	Net01
FDDI board, preliminary	N.A.T. GmbH	FDDI29

Note 1: The MVME 167 CPU has one Ethernet connection on board. A separated Ethernet board is only needed in the case of connection to different LAN's.
Note 2: The use of Profibus requires approval from ESO.
Note 3: The Profibus board is not supported with a software driver from ESO.

3.9.3.2. LCU power supplies

[ROD]

LCU power supplies shall comply with the VME specification, see chapter 2.

[ROD,I]

The following LCU power supplies are standardized and shall be used where possible:

- Combined supply for +5, +12 and -12 Volt:
  Kniel type FPM 1603, article number with VME: 358-008-02.
- Other voltages:
  Kniel series CP-xx

3.9.3.3. Signal abbreviations

[ROD]

Functional LCU signals, i.e. signals that have an entry in the LCU data base, shall have an signal name that is unique for a given LCU.

Note: the name of the LCU shall not be part of the signal name, this is done in the 'environment name' as described in the LAN specification, see chapter 2.

[ROD]

The signal name shall be made from the characters:

- A through Z
- 0 through 9

Either upper or lower case is allowed, mixed case shall not be used. There shall not be 2 different signals, one with uppercase and the other one with same lower case characters.
Note: The software might have to use different case because of software requirements.

[ROD]

The amount of characters for a signal name shall be 19 at maximum.

[ROD]

Signals names shall be build up according the following scheme:

aabbccccccde

in which:

aa — Field for main group, which is a functional unit in cases where one LCU controls more than one function:

e.g.	WS	windscreen
	AC	air conditioner
	AS	axial support

Other main group codes shall follow this principle.

bb — Field for subgroup, organised physically (note: if an LCU controls 1 function, this group moves 1 level up):

e.g.	PA	power amplifier
	AE	absolute encoder
	IE	incremental encoder
	IL	interlock
	MS	motion stop
	MT	motor
	PI	proportional integral controller
	LS	limit switch
	VC	velocity controller

Other subgroup codes may be defined as necessary, but for the listed type of equipment, the listed codes shall be used.

cccccc — Field for further details of the signal. May be split into lower level groups according to the scheme as for 'aa' and 'bb' above. Length: variable, respecting the maximum amount of characters.

d — Field of 1 character for the direction, which shall be:

I	for VME input.
O	for VME output.

e — Optional field of 1 character. It indicates a negation symbol for logic signals: * or /
Although not part of the signal name, this symbol shall be added to the signal name, if it is logically true at low voltage level.
Note that this does not appear in the VME data base: it is used during the software signal assignment.

Recommended is to use 2 character for fields 'aa' and 'bb'.

[ROD]

Each of these fields may be followed by a sequence number. If this is done, this number field shall have a constant amount of characters.

3.9.4. Programmable Logic Controller

[ROD]

A PLC shall not be directly connected to the LAN, but always via a LCU.

[ROD,I]

The following PLC's are standardized:

- Siemens Simatic Series.
- Sauter EY 2400 Series.

It is recommended that the PLC software development environment complies with IEC 1131, as mentioned in chapter 2.

3.9.5. Cabinets

The following cabinets are standardized:

[ROD,I]

Cabinets according IEC 297 and of protection class IP53 according to IEC 529 shall be:

- Unirack "Door Softline" system, manufactured by Knuerr.
  Max. height: 2 meters.

Cabinets according IEC 297 and of protection class IP54 according to IEC 529 shall be:

- Miracel, manufactured by Knuerr.
  Max. height: 2 meters.

[ROD,I]

Cabinets for control rooms shall be:

- DACOBAS system, in the color grey, manufactured by Knuerr.
  Max. height: 2 meters.

3.9.6. Miscellaneous electronic units and components

The list of ‘Preferred Electronic Parts’, reference t.b.d., shall be used as selection source.
ESO recommends to use components from that list if they are suitable for the application.

3.10. INTERLOCK

3.10.1. Description

Interlock is defined as: An automatic and immediate stop of an individual unit in case of a dangerous situation, or to avoid a dangerous situation. The signal triggering the interlock action is a hardware signal (e.g. limit switch, pressure switch etc), and the action is completely performed by hardware.
Two categories are foreseen: Interlocks in a subsystem and interlock between subsystems.

The 'dangerous situation' in the definition can be from optical, electro-mechanical or thermal nature.
'Interlock' is intended to detect these situations in an early stage and to prevent damage in such a situation.

The action is that it stops the corresponding unit by switching the power to the drive system off and by engaging the brake (if present).

Examples for conditions:

a. fault in the 3 phase supply voltage.
b. moving unit is close to its mechanical end.
c. moving unit is close to a collision with another moving unit.
d. hydraulic pressure loss.
e. operator errors, e.g. lock-pin inserted.

Interlock is *not* intended to protect against electric shock. Other and better means are available for this.

Motion stop is a pushbutton system. It is described in chapter 3.11. Pressing of a button results in power-off of *drive amplifiers* of a defined set of units, LCU's stay under power.
'Motion stop' performs a similar action as interlock.
Note however that 'Motion stop' is a <u>manual</u> (pushbutton) action, 'Interlock' is automatic. 'Motion stop' stops a defined <u>set</u> of units, Interlock usually only one.

3.10.2. General requirements

[ROD]

Conditions that must cause interlock (to be defined in the specifications of the subsystem) shall:

a. be (or be transformed into) logic signals: o.k. versus error.
b. not need 'difficult' logic. (IF .. AND .. OR .. THEN).
c. shall be 'fail safe' designed.

[ROD,T]

An interlock status shall switch-off the power to the drive amplifier and engage the brake (if present) of a unit.

[ROD]

The interlock operation shall not be dependent of any software.

[ROD]

The status of all *individual* interlock conditions shall be fed to the LCU of the subsystem that controls the unit, so that it can be monitored by the LCU software.
Note: this requirement can be fulfilled in the easiest way if the interlock chain is mounted close to the LCU.

[ROD]

Note: Due to the basic nature of interlock, it performs only a crude action: immediate stop of the unit. This has 3 consequences:

a. If higher level actions are needed (e.g. move the unit to a certain position), they shall be controlled by the LCU and/or higher level software. To prevent mixing up of definitions, those conditions shall not be called interlock.
b. The amount of conditions that cause interlock shall be minimized. Minor faults that do not cause direct dangerous situation shall not generate interlock.
c. If possible, there shall be a detection of the fault *before* the interlock status is entered. This detection signal shall be fed to the LCU that controls the unit, so that it can be monitored by the LCU software.

3.10.3. Implementation requirements

[ROD]

Interlock shall be implemented as:

a. a relay which controls power to the drive amplifier and controls the brake (if present).
b. Each interlock condition shall be a relay contact, contact closed if the status is o.k. All these contacts shall form a series connection, the 'interlock chain', which controls the relay mentioned under a.
c. each unit shall have its own interlock chain.

3.10.3.1. Interlock inside a subsystem

Fig. 13 shows an example of a typical interlock system.

3.10.3.2. Interlock between different subsystems

There are 2 possibilities:

a. An interlock status, generated in subsystem A that must stop a unit in subsystem B.
b. An interlock status, generated in subsystem A that must stop a unit in subsystem A and subsystem B.

[ROD,T]

In BOTH cases, the status shall be fed to the LCU's of BOTH subsystems. This makes each subsystem independent of each other for what concerns the check of the interlocks by the LCU.
This principle is shown in fig. 14.

3.10.3.3. Wiring

[ROD,T]

The wiring shall comply with this specification.
This requires:

a. individual relay contacts for connections between subsystems. (No galvanic connection between subsystem except for mains power).
b. intermediate relays in order to accommodate 24V and 5V logic (Wiring lengths for 5V logic). This relay is also necessary if the switch that senses the interlock status has 1 normally-closed contact. The principle is shown in fig. 15.

3.10.3.4. Radio links

[ROD]

In cases where it is technically possible, the interlock system of a unit shall be hard-wired.
Where this is not the case (i.e. where interlock signals have to be transported via radio links or similar means), the design shall be such that a single fault shall result in triggering of the interlock system (fail-safe design).

3.10.3.5. Override

Note: In the case of crossing over operational limits, an override is necessary to allow to move the unit out of the limit. (Obviously only *after* repair of the fault that caused the interlock).

[ROD,I,T]

For big units (t.b.d. in specifications for the subsystem), this shall be implemented as:

a. a spring loaded key switch that shall by-pass *only* the operational limit interlocks.
b. This switch shall be mounted such that the moving unit can be seen from the point where the switch is mounted.

[ROD,T]

For small units (t.b.d. in specifications for the subsystem) and where the amplifier does not need to be switched off in case of operational limits, this may be implemented as:

a. 2 relay contacts in the motor output: one prevents positive currents, the other prevents negative currents.

3.10.3.6. Local disable

[ROD]

A local disable function shall be available in each unit for maintenance purposes.
This shall be implemented either:

a. as a manual switch that switches the power to the amplifier, before the point where the 'power-ok' status is checked.
   Recommended implementation is to select the thermo-magnetic circuit breaker to perform this function,
   or:
b. a switch that acts on a contact in the interlock chain, with corresponding status signal to the LCU.

3.10.3.7. Brake

[ROD]

The brake shall be spring loaded: no power means brake engaged.

The brake shall have a status signal (engaged/disengaged) which shall be fed to the LCU, so that it can be monitored by the LCU software.
Note: a unit can be designed without a brake, namely by using non-reversible mechanics, like a worm gear or nut / spindle drive. However, this can lead to big forces if the amplifier is powered down during the motion.

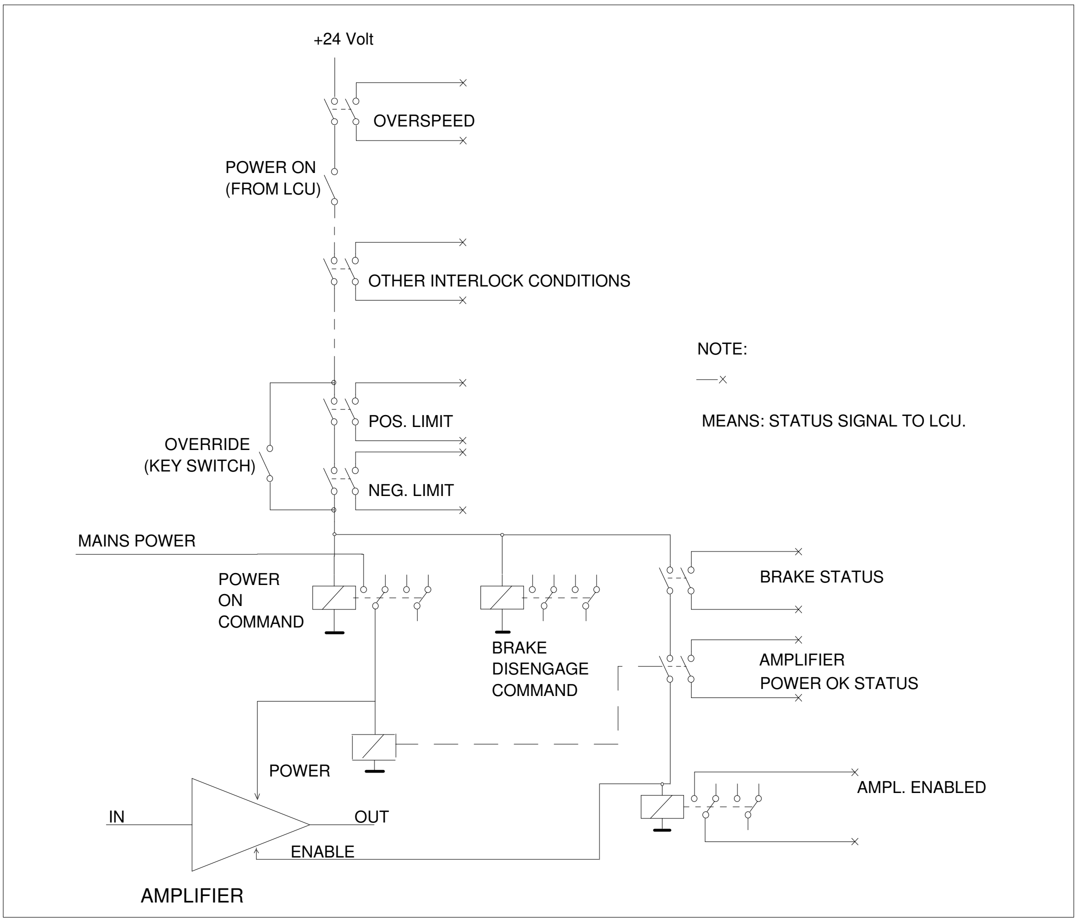

Fig. 13: Example of interlock.

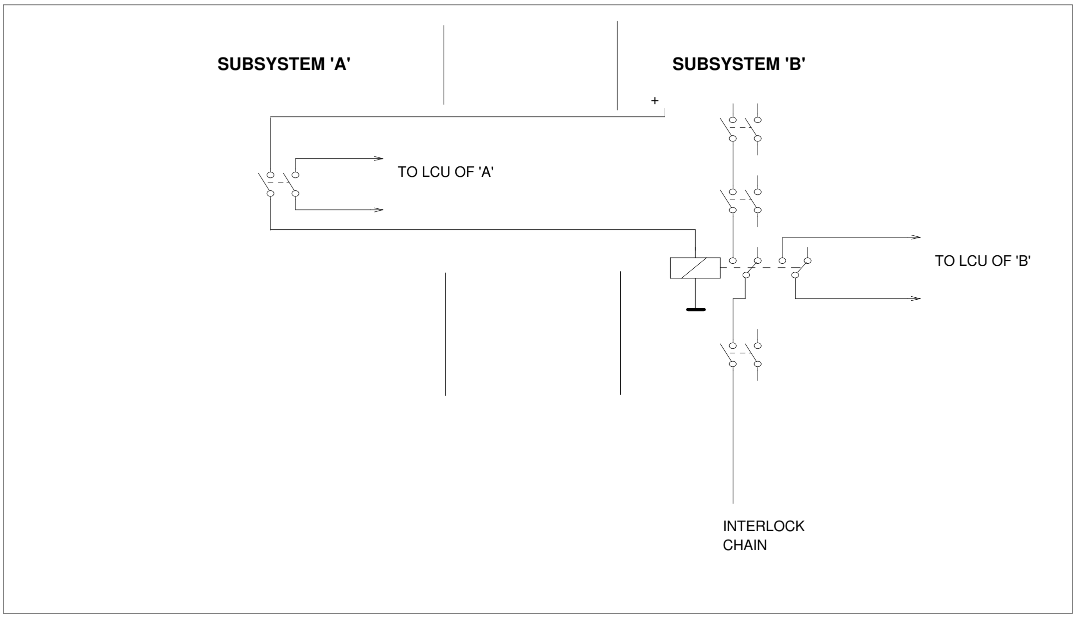

Fig. 14: Example of interlock between subsystems.

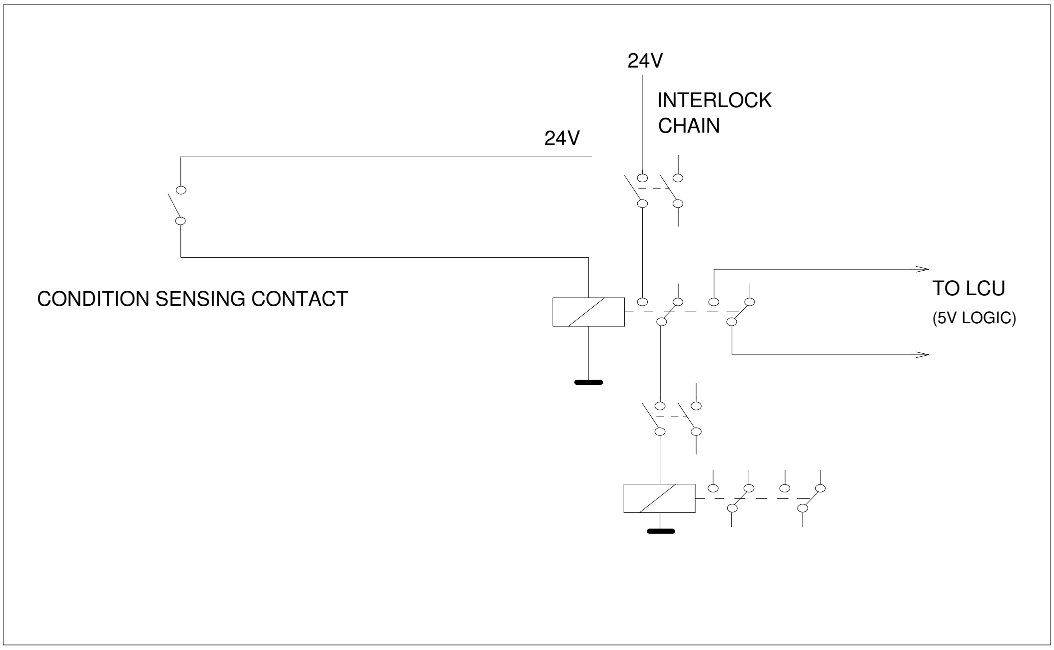

Fig. 15: Example of intermediate relay.

3.11. MOTION STOP

3.11.1. Description

Motion stop is a pushbutton system. Pressing of a button results in power-off of drive amplifiers of a defined set of units, LCU's stay under power.
Motion stop performs a similar action as interlock, however, motion stop is a manual (pushbutton) action, interlock is automatic. Motion stop stops a defined set of units, interlock usually only one.

3.11.2. Implementation requirements

[ROD,T]
Motion stop shall be integrated into the interlock system (as specified in chapter 3.10.) of a unit that must be stopped.

[ROD,T]
Each button shall have an extra contact which shall be fed to an LCU for unique identification.

Fig. 16 shows an example of the implementation of the motion stop.

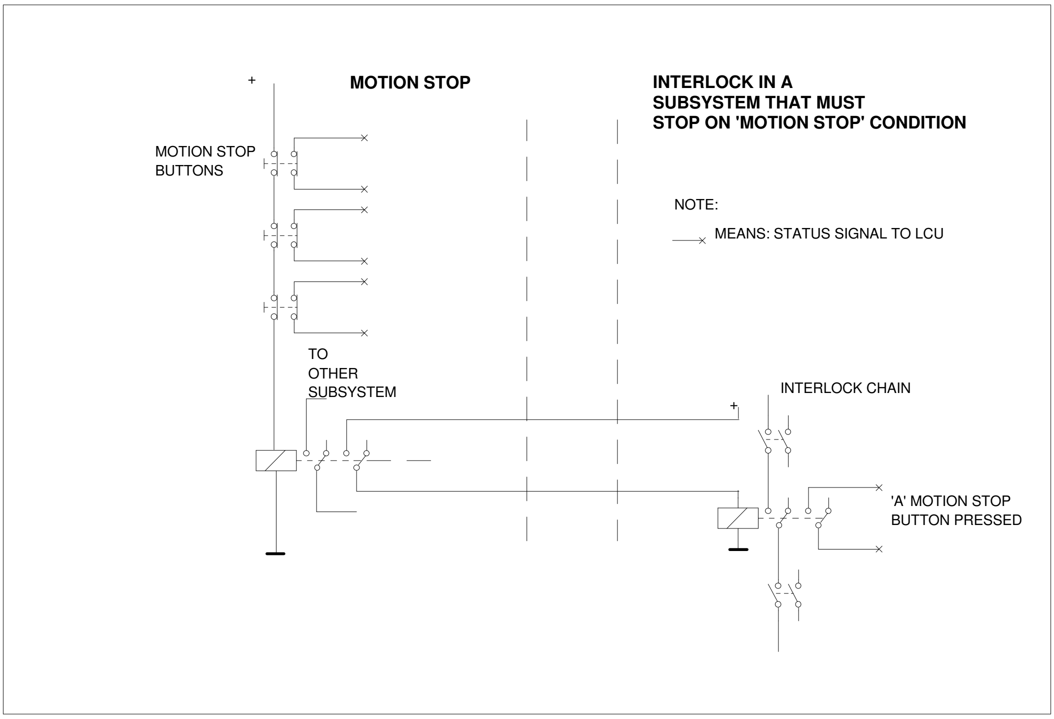

Fig. 16: Example of motion stop.

3.12. POWER SWITCHING

3.12.1. Description

Power switching under control of the LCU is interesting in the following situations:

a. If a unit is not 'continuously' in use.
b. The heat dissipation causes thermal problems. Applying on/off in combination with a brake can eliminate the need of cooling of the motor.
c. It has a 'high' electrical power.
d. It needs to be powered down in interlock situation anyway. ('Interlock' is described in chapter 3.10.).

Arguments opposing power switching are:

a. time loss from 'power-on' command to 'ready'.
b. in the case of rotations and translations: the necessity of a brake or non-reversible mechanics (nut/spindle, worm gear).
c. repeatability of the positioning is not obvious: activation of the brake and power-off of the drive system needs to be 'sequenced' in order to keep the axis in the final position.

In general, one can leave the following equipment always under power (these units will most likely be powered via the UPS in order to avoid electronic latch-up):

a. position encoders.
b. encoder interpolators.

Other units can be switched. If they are powered by the UPS or not is an open item and not directly relevant to the question of switching.

3.12.1.1. Combination with interlock

Power switching can be combined with interlock. In these cases the LCU power-on command is the first step to get the axis under servo control. The sequence is then for power-on (LCU I/O signals in italics, hard-wired conditions in normal style):

a. IF power-on command true,
   AND all interlock conditions (except
   amplifier power and brakes disengaged),
   are o.k.
   THEN disengage brake command and power-on
   command to servo amplifier.
b. IF amplifier power ok (hardware sets: *power ok*)
   AND brake disengaged (h/w sets: *brake diseng.*)
   THEN enable amplifier (h/w sets: *ampl. enabled*.
c. For a typical servo:
   set velocity reference to 0.
   close velocity loop.
   LCU checks that velocity servo behaves 'normal': check actual velocity, motor current.
   set position reference so that the position error is equal to 0.
   close position loop.
   LCU checks that position servo behaves 'normal': check position error.
d. axis is ready for operation.

This sequence must be successfully completed. If not, it has to be executed in the reverse order (with opposite logic for the bit I/O). Otherwise the servo stays in an undefined state.

Although this example describes a high power servo, similar procedures can be developed for e.g. pumps.

A big advantage of LCU control of the power is also the possibility for latching of the interlock: each interlock condition identifies itself to the LCU, the LCU clears the 'power-on' command. The repair of the fault does not result in an automatic h/w restart of the system.

3.12.1.2. Avoidance of thermal problems

There are two possibilities which are often used:

a. brake.
b. non-reversible mechanics.

The brake is normally of an electromagnetic type.
In order to achieve no motion after power-off of the servo amplifier, the following procedure can be applied (LCU I/O signals in italics):

a. Clear *Disengage brake* signal.
b. Wait till the brake is engaged.
c. Reset *amplifier enable* and *amplifier power-on* signals.

So in this case it is necessary to have two LCU output bits to control the positioning.

In the case of non-reversible mechanics, a few things are important to consider:

a. The mechanics have to be really non-reversible: the non-reversibility is theoretically defined by the mechanical friction angle and the pitch angle of the lead screw. In practice, however, it is also defined by the *load*. Moreover, high accuracy positioning requires low Coulomb friction. This means a low mechanical friction angle which is in contradiction to the non-reversibility.

b. The power-off of the amplifier should not introduce a 'kick' to the motor axis. The best way to solve this in practice is to have a relay contact in the output of the amplifier. The amplifier itself is kept under power. The heat dissipation problem of the motor is solved in this way.

3.12.2. Requirements

[ROD]

Power switching adds functionality to a subsystem which shall be visible in LCU interfacing.
This can be done by:

a. monitoring the status of all logic power switching signals in the LCU, and
b. monitoring a final power o.k. signal in the LCU, e.g. motor current, and
c. in the case of a 3 phase supply, monitoring of the three phases. See fig. 10.

Note: if one or two phases are missing, the servo amplifier can only deliver a limited current to the motor. This results in a dynamically unstable servo during normal operations.

[ROD]

The electronic design of the power switching shall prevent the possibility of electronic 'latch-up' of integrated circuits.

[ROD]

Transients in the mains supply due to power switching shall be limited so that the inrush current is compliant with the EMC specifications, see chapter 2.

3.13. COOLING CONTROL

3.13.1. LCU interfacing

[ROD]

The LCU shall monitor the cooling of the subsystem.

A recommended way of the control of a cooling process is shown in fig. 17. Which has the following features:

a. stand alone operation (i.e. runs also without LCU intervention, serial communication between LCU and cooling controller).
b. fine tuning possibility with the signal 'temperature offset'.
c. monitoring of the key status signals by the LCU.

3.13.2. Safety

[ROD]

In cases where faults in the cooling system would cause a temperature rise which either:

a. goes beyond what can be accepted for the electronic equipment, or
b. creates a hazard risk,

there shall be an independent temperature switch, which powers-off the whole unit. Note that this can mean also power-off of the LCU.

Note: The thermal requirements of a subsystem can imply thermal insulation of the units. The cooling design of the cabinet must therefore be such that the unit is not self-destructive in case of faults in the cooling system.

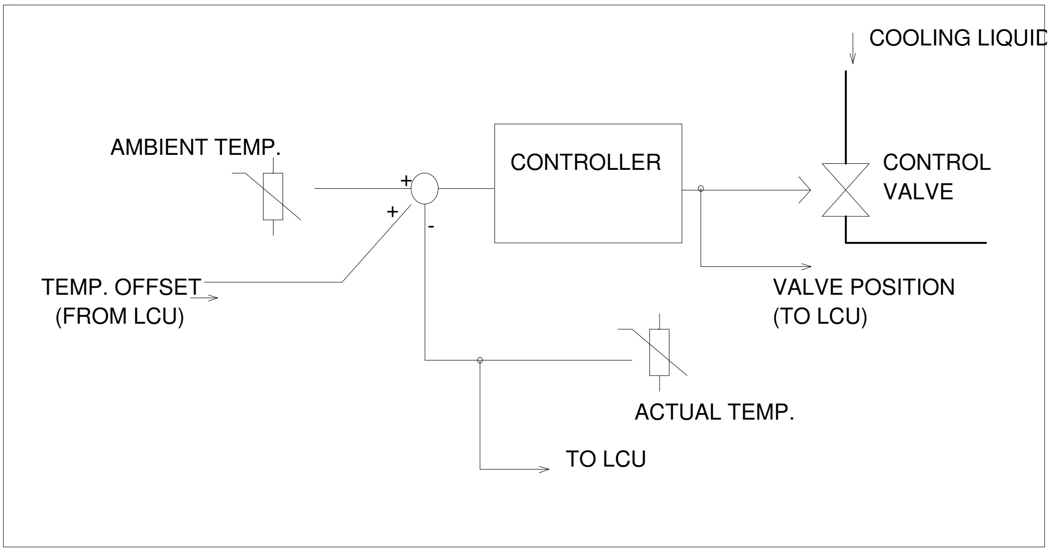

Fig. 17: Example of cooling control of a unit.

3.14. TIMING

3.14.1. Description

The VLT Observatory will have a system for reception and distribution of Universal Time Coordinated (UTC), called the Time Reference System. The UTC will be derived from a central Global Positioning System (GPS) satellite receiver with a back-up in the form of a rubidium or quartz oscillator.
The UTC will be coded to a serial signal and distributed over the VLT Observatory with a dedicated distribution system, called the Time Bus.
The Time Bus will be an optical fiber. A 'star' type distribution will be possible by means of Time Bus Distribution Boxes.
All LCU's that need accurate timing can be connected to the Time bus with a special LCU module, the Time Interface Module, TIM.
The daily variations of the earth's rotation with respect to the UTC will be transmitted over the LAN.

For reference, the detailed specifications can be found in the VLT Time Reference System Specification, mentioned in chapter 2.

3.14.2. Requirements

[ROD,I]

If the LCU needs accurate timing, the standardized Time Interface Module for the VLT Observatory shall be used (see chapter 3.9.3.1.).

4. ABBREVIATIONS

EMC	Electro Magnetic Compatibility
LAN	Local Area Network
LCU	Local Control Unit Definition: The Local Control Unit (LCU) is the computer in a subsystem which is connected to a LAN.
PCB	Printed Circuit Board

PLC	Programmable Logic Controller
UPS	Uninterruptable Power Supply

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