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Change Record from previous Version

Issue	Date	Section / Paragraph affected	Reason / Initiation Documents / Remarks
1	18.10.2011	All	First Issue
2	11.12.2012	1.1 Applicable documents 3.5.1 Signal Levels	Addition of AD11: EN ISO13850 (E- stop) Analog connections
3	28.1.2014	3.5.1, 3.7.1, 3.7.6, 3.8.5, 3.12.2.1.1, 3.14.3, 4.2.2	Restricted/forbid the use of some general standards for the E-ELT projects.
4	26.2.2016	3.8.5, 3.11, 5, 6	Harmonised between VLT and E-ELT after adoption of PLC standards. Remaining VLT legacy standards pushed to a separate chapter at the end

Contents

1. Related Documents

177 /// The following documents, of the exact issue shown, form part of this Specification to the extent specified herein. Where no issue or date is indicated, the latest edition of the referenced document (including any amendments) at the start of design applies. In the event of conflict between the documents referenced herein and the content of this document Specification, the content of this document Specification shall be considered as a superseding requirement.

1.1 Applicable Documents

179 /// AD1 EN 60204-1, “Safety of machinery - Electrical equipment of machines - Part 1: General requirements”.

180 /// AD2 EN 60364 series, “Low-voltage electrical installations”.

181 /// AD3 EN 60445, “Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors”, 2010.

182 /// AD4 EN 60664 series, “Insulation coordination for equipment within low-voltage systems”.

183 /// AD5 EN 61000 series, “Electromagnetic Compatibility (EMC)”.

184 /// AD6 EN 61010-1, “Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements”.

185 /// AD7 EN 62061, “Safety of machinery, Functional safety of safety-related electrical, electronic and programmable electronic control systems”.

186 /// AD8 SAF-INS-ESO-00000-3444, “ESO Safety Conformity Assessment Procedure”.

187 AD9 GEN-ESO-SPE-50000-0072, “Technical Specification – Earthing, Bonding and
/ / / Protection against Lightning and LEMP of ESO Buildings and Structures”.

188 AD10 GEN-ESO-SPE-50000-5044, “Technical Specification – Power Quality (compatibility
/ / / levels)”.

190 AD11 EN ISO 13850, “Safety of Machinery – Emergency Stop – Principles for design”
/ / /

1.2 Reference Documents

192 RD1 EN 60332 series, “Tests on electric and optical fibre cables under fire conditions”.
/ / /

193 RD2 EN 61508 series, “Functional safety of electrical/electronic/programmable electronic
/ / / safety-related systems”.

194 RD3 EN 61800-5-2, “Adjustable speed electrical power drive systems - Part 5-2: Safety
/ / / requirements - Functional”.

195 RD4 VG 95374 series “Electromagnetic Compatibility (EMC) including Electromagnetic
/ / / Pulse (EMP) and Lightning Protection“.

2. Introduction

2.1 Scope

198 /// The present specification describes the design requirements for electrical and electronic equipment and systems of ESO projects. Main goal of this document is to provide design rules in order to achieve electrical and electronic compliance of each system and the parts it consists of.

2.2 Glossary, Definitions and Conventions

200 /// Definitions may be found in IEC 60050 (International Electrotechnical Vocabulary).

2.2.1 General

202 /// **Machinery, machine -** assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and power circuits, joined together for a specific application, in particular for the processing, treatment, moving or packaging of a material. The term "machinery" also covers an assembly of machines which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole.

2.2.2 Definitions related to EMC

204 /// **Burst** - A sequence of a limited number of distinct pulses or an oscillation of limited duration.

205 /// **Electromagnetic compatibility (EMC)** - The ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

206 **Electromagnetic interference (EMI)** - Degradation of the performance of an equipment,
/// transmission channel or system caused by an electromagnetic disturbance.

Note: Disturbance and interference are respectively cause and effect.

207 **Emission level (of a disturbing source)** - The level of a given electromagnetic disturbance
/// emitted from a particular device, equipment or system in a specified way.

208 **Emission limit** - The specified maximum emission level of a source of electromagnetic
/// disturbance.

209 **Enclosure port** - The physical boundary of the apparatus through which electromagnetic
/// fields may radiate or impinge.

210 **Harmonic (component)** - A component of order greater than one of the Fourier series of a
/// periodic quantity.

211 **(Total) harmonic factor** - The ratio of the r.m.s. value of harmonic content to the r.m.s. value
/// of an alternating quantity.

212 **Immunity (to a disturbance)** - The ability of a device, equipment or system to perform
/// without degradation in the presence of an electromagnetic disturbance.

213 **Immunity level** - The maximum level of a given electromagnetic disturbance incident on
/// particular device, equipment or system for which it remains capable of operating at a required degree of performance.

214 **Immunity limit** - The specified minimum immunity level.
///

215 **Machinery -** An assembly of linked parts or components, at least one of which moves, with
/// the appropriate actuators, control, and power circuits, etc., joined together for a specific application.

216 **Port -** Particular interface of the specified apparatus with the external electromagnetic
/// environment.

217 **(Electromagnetic) susceptibility** - The inability of a device, equipment or system to perform
/// without degradation in the presence of an electromagnetic disturbance.

218 **Inter-harmonics** - Discrete or wide-band spectrum frequencies which are not integer multiples of the power frequency fundamental.

219 **Short (supply) voltage interruption** - The disappearance of the supply voltage for a period of time not exceeding 3 min.

220 **Voltage dip** - A sudden reduction of the voltage to a value of less than 90% of the reference voltage at a point in an electrical system, followed by voltage recovery after a short period of time, from half of a cycle to a few seconds.

221 **Voltage fluctuation** - A cyclical variation of the voltage envelope or a series of random voltage changes.

222 **Voltage surge** - A transient voltage wave characterized by a rapid increase followed by a slower decrease.

223 **Voltage unbalance (imbalance)** - In a polyphase system, a condition in which the r.m.s. values of the phase voltages or the phase angles between consecutive phases are not all equal.

2.3 Abbreviations and Acronyms

225

1oo1	One out of one
1oo2	One out of two
AC	Alternating Current
ATM	Asynchronous Transfer Mode
BOM	Bill of Material
CAN	Controller Area Network
CB	Circuit Breaker
CE	Conformité Europeenne
CEN	European Standards Coordinating Committee
CENELEC	European Committee for Electrotechnical Standardisation
CiA	CAN in Automation
COTS	Commercial Off-The-Shelf (product)
DC	Direct Current
DOC	Declaration of Conformity

DRD	Design Requirements Document
EHSR	Essential Health and Safety Requirements
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EN	European Norm
ESD	Electrostatic Discharge
ESO	European Organisation for Astronomical Research in the Southern Hemisphere
EU	European Union
EUT	Equipment Under Test
FC	Frequency Converter
HF	High Frequency
HFT	Hardware Failure Tolerance
I/O	Input/Output
IEC	International Electrotechnical Commission
ILS	Interlock and Safety System
IP	International Protection (EN 60529)
ISO	International Organisation for Standardisation
ITE	Information Technology Equipment
LAN	Local Area Network
LCU	Local Control Unit
LED	Light Emitting Diode
LEMP	Lightning Electromagnetic imPulse
LPZ	Lightning Protection Zone
LRU	Line Replaceable Unit
LSZH	Low-Smoke Zero-Halogen
LV	Low Voltage
MTTR	Mean time to repair
N/A	Not applicable
n.c.	Normally closed
n.o.	Normally open
PBC	Protective Bonding Circuit
PCB	Printed Circuit Board
PDM	Product Data Management

PELV	Protective Extra Low Voltage
PFD	Probability of Failure on Demand
PFH	Probability of dangerous Failure per Hour
PE	Protective Earth
PLC	Programmable Logic Controller
POE	Power over Ethernet
RAMS	Reliability, Availability, Maintainability and Safety
RCCB	Residual Current Circuit Breaker
RCD	Residual Current Device
RF	Radio Frequency
rms / r.m.s.	root mean square
ROHS	Restriction of Hazardous Substances
SELV	Safety Extra Low Voltage
SIL	Safety Integrity Level
SPD	Surge Protective Device
SRCF	Safety Related Control Function
SRECS	Safety-Related Electrical, Electronic and Programmable Electronic Control System
SRS	Safety Requirements Specification
SUP	Supervisory System
TBC	To be confirmed
TBD	To be determined
TCF	Technical Construction File
UPS	Uninterruptible Power Supply

3. Design requirements

3.1 Principle design requirements

228 Any device, equipment or system containing electrical and/or electronic parts shall be
D/ / / designed taking into account the requirements noted down in this chapter. The following list gives a generic overview of these requirements. A more detailed description is then given in the sections that follow.

229 Electrical and electronic equipment and/or systems shall:
D/ /I/

- comply with relevant specifications and standards described in section 2 and the requirements given in the following sections of this chapter;
- have electrically safe and reliable signal interconnections to other electronic units;
- have reliable and easy to maintain cabling between electronic units;
- be mounted on standardized printed circuit boards in standardized boxes and cabinets;
- have connectors which are of high quality and standardized;
- be provided with local control and monitoring capabilities using to the maximum convenient extent standardized Local Control Units (LCUs);
- be suitable to be powered by the ESO Observatory electric power supply system;
- take into account environmental conditions applicable to the current project including seismic stresses and altitude;
- make use of SRECS satisfying the appropriate SIL for functional safety if needed (in case these aren't already properly implemented by non-electrical/electronic systems);
- be designed as much as convenient on a modular concept, making use of Line Replaceable Units (LRU) to minimize the repair time;
- have provisions to centrally access necessary functions and status signals of electronic units.

569 In general any control system compliant with the specific requirements listed in this document
/ / / will fulfil the generic requirements listed above.

3.2 Safety

3.2.1 General

12 D/ /I/ Systems and subsystems (made up of components and equipment) shall, in addition to the requirements explicitly stated in this document, comply with the essential health and safety requirements (EHSR) contained in all applicable EU Directives.

13 D/ /I/ To ensure a safe design compliance with these EHSRs shall be verified using harmonised standards that are listed in the most recent Official Journal of the EU and that are applicable to the (sub)system (included but not limited to the most common ones listed in section 1.1).

14 D/ /I/ In case a system can be defined as 'machinery' one shall use AD1 as a basis to presume compliance with the Machinery Directive and Low Voltage Directive plus any additional harmonised standards that may fall under the scope of the specific system.

15 D/A/I/ Components and equipment used on systems shall comply with their harmonised EN product or product-family standard or -in case this is not available- a generic standard. Commercially available equipment (COTS) shall bear the CE mark. In case suitable equipment with a CE mark is not available, the usage of non CE marked equipment shall receive explicit approval by ESO, and shall be in compliance with the EHSRs of the applicable EU directives.

16 D/ /I/ Custom made products shall be checked for compliance to the most appropriate harmonised standards under the scope of the applicable Directives*. Manufacturers shall provide to ESO the relevant CE declaration of conformity sheet together with the technical construction file (see section 3.15.8).

* For example, custom made electrical equipment for laboratory type applications shall be verified acc. to AD6.

17 D/ / / A Hazard Analysis and Risk assessment shall be part of the scope of work. The procedure noted down in AD8 shall be followed and complied with. Additionally the Hazard Analysis and Risk Assessment shall cover risks to the equipment/system itself.

18 D/ / / ROHS compliance is mandatory for all COTS equipment.

232 /// The following diagram displays the sequence of ESO's compliance engineering tasks (not only limited to electrical design).

233 ///

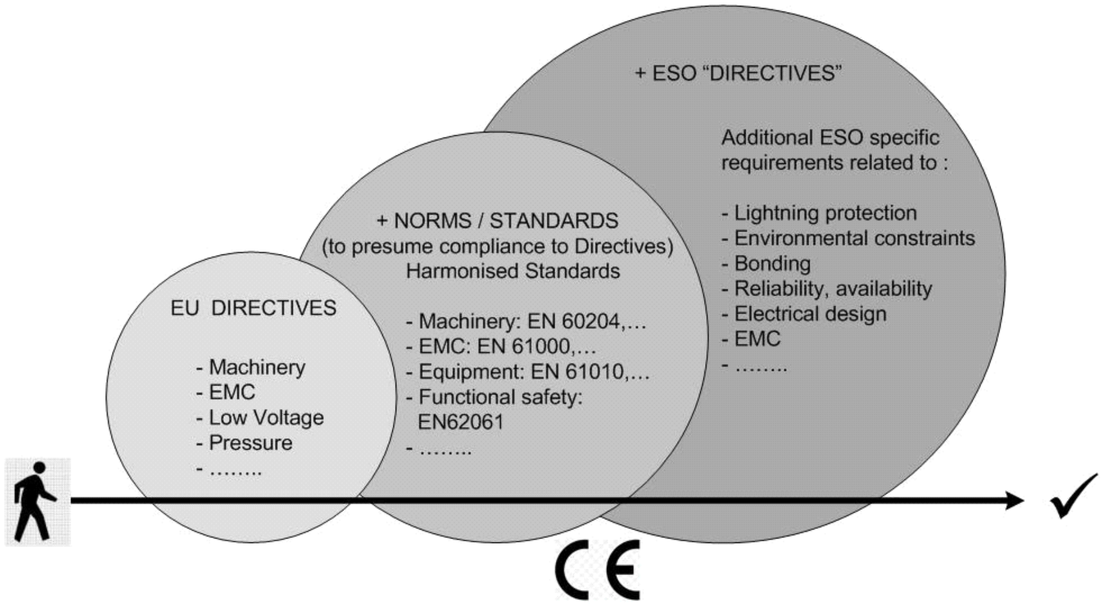


Figure 1: Path a project has to follow to reach compliance with ESO requirements

3.2.2 EU Directives

235 /// ESO projects will be comprised of a variety of equipment and systems that shall be designed in compliance with the essential health and safety requirements (EHSR) contained in the various applicable EU Directives*. In order to judge which of the Directives apply to a certain system or equipment the scope of the Directive shall be consulted.

Below a non-exhaustive list of EU Directives is given applying to most of the equipment and systems developed for ESO projects.

* The latest edition/revision in effect at the start of design shall be taken as valid.

3.2.2.1 Machinery Directive

238 The Machinery Directive 2006/42/EC applies to machinery (see definition in section 2.2.1).

/// In its Annex 1 it specifies essential health and safety requirements (EHSR) that are to be complied with. Harmonised standards that fall under the scope of the Machinery Directive provide the means to presume compliance with the EHSR.

The Machinery Directive requires a hazard analysis / risk assessment to be completed for all products falling under its scope. The hazard analysis / risk assessment procedure for ESO projects is outlined in AD8.

3.2.2.2 Low Voltage Directive

240 The Low Voltage Directive (LVD) 2006/95/EC specifies EHSRs to ensure that electrical
/ / / equipment within certain voltage limits provide an acceptable level of protection. The Directive covers electrical equipment designed for use with a voltage rating of between 50 and 1000 V for alternating current and between 75 and 1500 V for direct current referring to the voltage of the electrical input or output.

3.2.2.3 EMC Directive

242 The EMC Directive 2004/108/EC states requirements to ensure that the electromagnetic
/ / / disturbance generated by apparatus does not exceed a level allowing radio and telecommunications equipment and other apparatus to operate as intended, and that apparatus has an adequate level of intrinsic immunity to electromagnetic disturbance to enable it to operate as intended.

The EMC Directive applies to most electrical and electronic apparatus, that is, finished products and systems that include electrical and electronic equipment.

A specific set of requirements has been formulated in section 3.3 of this document.

3.2.3 Safety-related control systems on machines

3.2.3.1 Introduction

245 Rapid development in networks used for industrial automation has made it possible to
/ / / integrate the necessary levels of safety into process control systems that do not exclusively rely on hardwired components anymore. It enables the integration of safety features into automation systems and allows the existence of communication data and safety data on the same distributed network.

19 In order to implement the operation of machine safety functions using electrical, electronic
D/ / / and/or programmable electronic control systems (see item R9 in section 3.1), the series of standards EN 62061 (AD7) or EN ISO 13849-1 (AD11) shall be applicable.

3.2.3.2 EN 62061

247 / / / EN 62061 (AD7: Safety of machinery, Functional safety of safety-related electrical, electronic and programmable electronic control systems) is a harmonised standard to the Machinery Directive.

248 / / / EN 62061 is a product family standard written specifically for the machinery sector and is based on the generic EN 61508, 'Functional safety of electrical/electronic/programmable electronic safety-related systems'(RD2).

249 / / / It specifies requirements and makes recommendations for the design, integration and validation of safety-related electrical, electronic and programmable electronic control systems (SRECS) for machines.

250 / / / It takes a quantitative risk-based approach similar to that found in EN 61508 (RD2), which provides a more methodical approach than the classical EN 954-1 leading to more predictable performance, greater reliability and availability, and improved documentation.

251 / / / In terms of a design procedure, the following items are handled:

- identify the danger zones on the machine;
- define the risk parameters;
- identify the required Safety Integrity Level (SIL);
- design and implement the necessary safety functions;
- determine the SILs;
- compare the achieved SIL with the required SIL.

252 / / / For the required calculations - such as for the failure rate – reliability data is to be collected from suppliers for specific components or, alternatively, generic data may be used.

253 D/ / / Requirements for the performance of non-electrical (e.g. hydraulic, pneumatic) control elements for machines are not covered by EN 62061 and shall be verified using EN ISO 13849-1.

3.2.3.3 Safety integrity levels

255 / / / EN 62061-5, Requirements for the specification of Safety Related Control Functions (SRCFs), explains how the functional requirements specification and safety integrity requirements for each SRCF should be compiled to create a safety requirements specification (SRS). Furthermore, the three safety integrity levels (SIL1/2/3) require that the probability of dangerous failures per hour (PFH/PFD) must fall between certain target values as follows:

256 <u>Low Demand Mode</u>

/ / / SIL 1: 10-2 ≤ PFD < 10-1 (or 1 failure in 10 years)

SIL 2: 10-3 ≤ PFD < 10-2 (or 1 failure in 100 years)

SIL 3: 10-4 ≤ PFD < 10-3 (or 1 failure in 1000 years)

257 <u>High Demand Mode</u>

/ / / SIL 1: 10^{-6} ≤ PFH < 10^{-5} (or 1 failure in 100,000 h)

SIL 2: 10^{-7} ≤ PFH < 10^{-6} (or 1 failure in 1,000,000 h)

SIL 3: 10^{-8} ≤ PFH < 10^{-7} (or 1 failure in 10,000,000 h)

258 Based on that the safety related electrical control system is designed.

/ / /

3.2.4 Protection against electric shock

3.2.4.1 General requirements

261 Protection of persons against electric shock from direct and indirect contact shall be achieved by:

D/ /I/

20 protective measures for direct contact (also called 'protection under normal conditions'):

D/ /I/
- Protection by enclosure
- Protection by insulation of live parts
- Protection against residual voltages
- Protection by barriers (double/reinforced insulation)
- Protection by placing out of reach or use of obstacles

21 protective measures for indirect contact (e.g. existing in case of a single fault condition):

D/ /I/
- Prevention of the occurrence of a touch voltage
- Protection by automatic disconnection of supply

22 use of protective or safety extra low voltage (PELV/SELV) where applicable

D/ / /

23 D/ /I/ The measures taken shall follow the requirements described in harmonised standards that are most applicable to the (sub)system. For machinery (see definition in section 2.2) the standard EN 60204-1 (AD1) shall be conformed to.

24 D/ / / In case no product family standard exists the generic standard series EN 60664 shall be chosen (AD4).

262 / / / The following section describes examples of protective measures used to provide electric shock protection against indirect contact on machinery.

25 D/ / / Requirements related to the protection against electric shock shall be complied with by following the applicable harmonized standard(s).

3.2.4.2 Protective bonding

264 D/ /I/ Protective bonding is a basic provision for fault protection to enable protection of persons against electric shock from indirect contact. In each situation where protection against electric shock relies on a safe connection to earth, a systems metallic enclosure shall be earthed via the protective earth of the power distribution. The protective bonding circuit (PBC) that is then formed provides the return current path upon which the power distribution circuitry can react in case of a short circuit.

26 D/ /I/ All requirements related to protective bonding shall be complied with, for this purpose ESO Specification AD9 is to be followed including possible additional requirements from applicable harmonized standard(s).

265 / / / Below an excerpt of the most important issues regarding protective bonding to be addressed for machinery (taken from AD1) is given. Please consult the standard and ESO Specification AD9 for a complete picture.

266
/ / /

PROTECTION AGAINST ELECTRIC SHOCK – PROTECTIVE BONDING CIRCUIT (EXAMPLE MACHINERY)
General • The protective bonding circuit (PBC) consists of : – PE terminal(s) – the protective conductors in the equipment of the machine including sliding contacts where they are part of the circuit – the exposed conductive parts and conductive structural parts of the electrical equipment – those extraneous conductive parts which form the structure of the machine • All parts of the protective bonding circuit shall be so designed that they are capable of withstanding the highest thermal and mechanical stresses that can be caused by earth-fault currents that could flow in that part of the protective bonding circuit. • Where the conductance of structural parts of the electrical equipment or of the machine is less than that of the smallest protective conductor connected to the exposed conductive parts, a supplementary bonding conductor shall be provided. This supplementary bonding conductor shall have a cross-sectional area not less than half that of the corresponding protective conductor.
Continuity of the protective bonding circuit • All exposed conductive parts shall be connected to the PBC. • Where a part is removed for any reason (for example routine maintenance), the PBC for the remaining parts shall not be interrupted. • Connection and bonding points shall be so designed that their current-carrying capacity is not impaired by mechanical, chemical, or electrochemical influences. Where enclosures and conductors of aluminium or aluminium alloys are used, particular consideration should be given to the possibility of electrolytic corrosion. • Metal ducts of flexible or rigid construction and metallic cable sheaths shall not be used as protective conductors. Nevertheless, such metal ducts and the metal sheathing of all connecting cables (for example cable armouring, lead sheath) shall be connected to the protective bonding circuit. • Where the electrical equipment is mounted on lids, doors, or cover plates, continuity of the protective bonding circuit shall be ensured and a protective conductor is recommended. Otherwise fastenings, hinges or sliding contacts designed to have a low resistance shall be used. • The continuity of the protective conductor in cables that are exposed to damage (for example flexible trailing cables) shall be ensured by appropriate measures (for example monitoring).

PROTECTION AGAINST ELECTRIC SHOCK – PROTECTIVE BONDING CIRCUIT (EXAMPLE MACHINERY)
Exclusion of switching devices from the protective bonding circuit • The PBC shall not incorporate a switching device or an overcurrent protective device (for example switch, fuse). • No means of interruption of the protective bonding conductor shall be provided. • Where the continuity of the protective bonding circuit can be interrupted by means of removable current collectors or plug/socket combinations, the protective bonding circuit shall be interrupted by a first make last break contact.

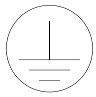
Protective conductor connecting points
• The protective conductor connecting points shall have no other function and are not intended, for example, to attach or connect appliances or parts. • Each protective conductor connecting point shall be marked or labelled as such using the symbol EN 60417-5019 (displayed at the right) or with the letters PE, the graphical symbol being preferred, or by use of the bicolour combination GREEN-AND-YELLOW, or by any combination of these. 

Table 1: Requirements on protective bonding (taken from AD1)

3.3 Electromagnetic compatibility (EMC)

3.3.1 Requirements

3.3.1.1 General

27 / / / A basic set of general requirements for EMC is formulated in the following sections and is to be complied with for each (sub)system and its equipment in ESO projects.

28 / / /T Verification of the requirements shall be done by conducting tests on complete subsystems and/or parts of such subsystem.

29 / / / In exceptional cases, based on an evaluation of the EM environment and the peculiarities of the subsystem or parts of it, specific requirements may have to be added or may be relaxed. Also a relaxation on certain tests may be considered. In such cases a contractor shall consult ESO.

3.3.1.2 Commercial equipment

30 D/ /I/ Commercial equipment shall have a CE mark and information on EMC compliance contained in its conformance data sheet (DOC).

3.3.1.3 Intra- and inter-system EMC

31 D/ / /T The (sub)system shall exhibit complete electromagnetic compatibility (EMC) among its parts, components, devices and equipment (intra-system electromagnetic compatibility).

32 D/A/I/ Prevention of electromagnetic interference (EMI) between the (sub)system and systems in its environment (inter-system electromagnetic compatibility) shall be a major driver in the design and construction of the (sub)system.

272 / / /

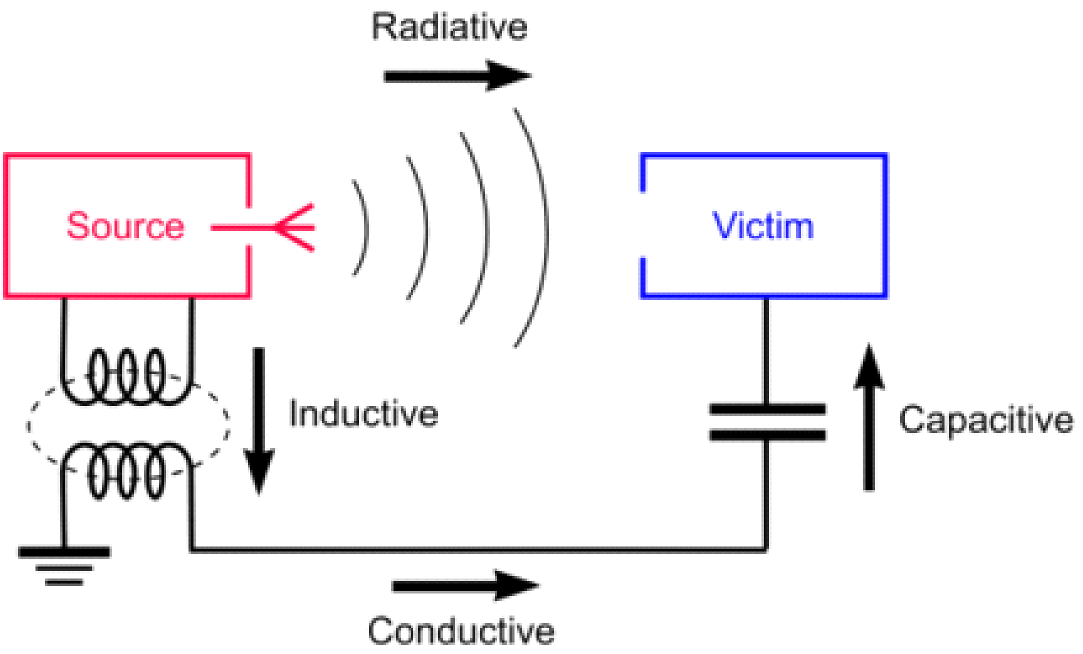


Figure 2: Electromagnetic Interference paths between two systems

3.3.1.4 Immunity requirements

3.3.1.4.1 Performance criteria

275 / / / As a general rule for all immunity tests, the test result is positive if the equipment shows its immunity, based on the applicable performance criterion given in the following table, for the entire period of application of the test. At the end of the tests the equipment under test (EUT) functions as it is supposed to work under normal conditions.

Performance criteria are:

276 / / /

PERFORMANCE CRITERION	DESCRIPTION
A	The apparatus shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the apparatus is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation

	and what the user may reasonably expect from the apparatus if used as intended.
B	The apparatus shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the apparatus is used as intended. The performance level may be replaced by a permissible loss of performance. During the test, degradation of performance is however allowed. No change of actual operating state or stored data is allowed. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product documentation and what the user may reasonably expect from the apparatus if used as intended.
C	Temporary loss of function is allowed, provided the function is self-recoverable or can be restored by the operation of the controls.

Table 2: Performance criteria for immunity tests (acc. to part 6-2 of AD4)

3.3.1.4.2 Conducted immunity - Voltage tolerance envelope (ITI(CBEMA) curve)

33 D/A/ /T As a minimum requirement of immunity, all electrical and electronic equipment to be connected to the electric power supply networks of ESO observatories shall be able to operate satisfactory as long as the "magnitude - duration" of the voltage swell is below the red curve (respectively, the "magnitude - duration" of the voltage dip is above the blue curve) of the so-called ITI (CBEMA) curve for equipment (see also AD10).

278 / / /

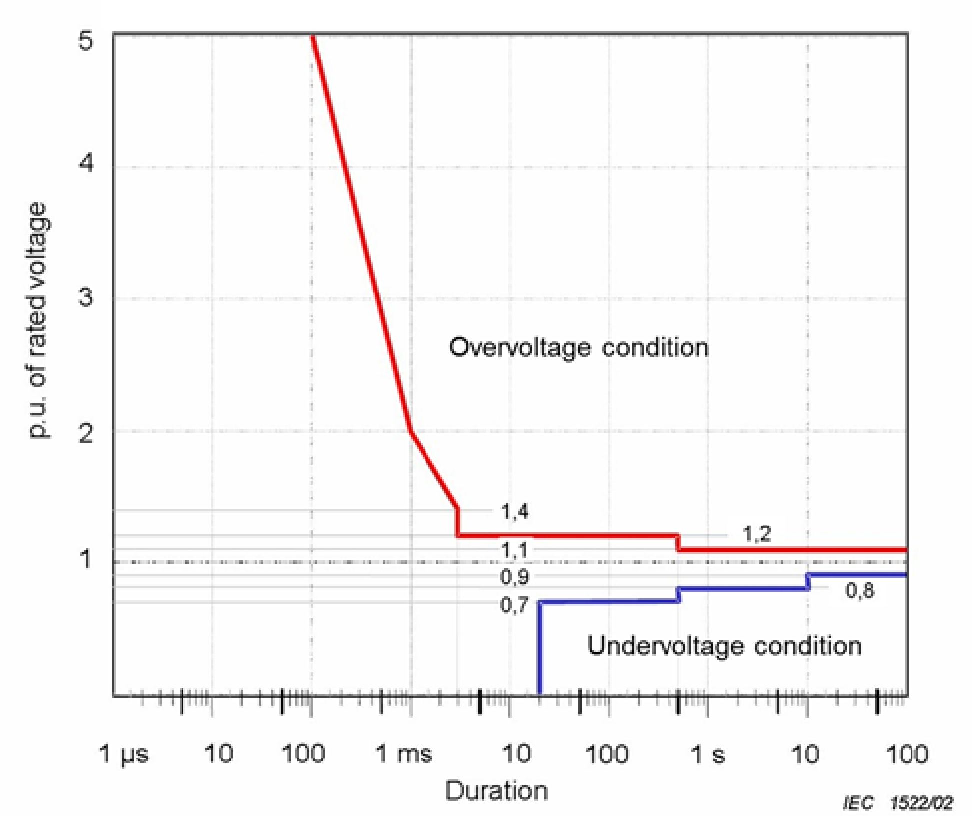


Figure 3: ITI(CBEMA) curve – Voltage tolerance envelope

279 / / / Performance criterion: A (see 3.3.1.4.1).

280 / / / Verification to be done by test, alternatively the DOC of applicable parts or equipment may provide evidence of compliance.

3.3.1.4.3 Conducted immunity - Voltage dips

34 D/A/ /T The immunity limit for voltage dips on AC mains voltage lines to subsystems and equipment shall be:

- 0% residual voltage (ΔU1 = 100%) for 1 cycle (20 ms) – performance criterion B (see section 3.3.1.4.1 for the definition of performance criteria);
- 40% residual voltage (ΔU2 = 60%) for 10 cycles (200 ms) – performance criterion C;
- 70% residual voltage (ΔU3 = 30%) for 25 cycles (500 ms) – performance criterion C.

Verification to be done by test, alternatively the DOC of applicable parts or equipment may provide evidence of compliance.

3.3.1.4.4 Conducted immunity - Voltage interruptions

35 D/A/ /T The immunity to short voltage interruptions (0% residual voltage, ΔU_1 = 100%) for 250 cycles (5s) on AC mains voltage lines shall be according to performance criterion C. This requirement only applies to non-UPS supplied equipment. Verification to be done by test, alternatively the DOC of applicable parts or equipment may provide evidence of compliance.

3.3.1.4.5 Conducted immunity - Voltage (current) surges

36 D/ / / Subsystems and equipment shall be required to contain a level of immunity to high-energy disturbances on power and inter-connection lines caused by overvoltages from switching and lightning transients.

284 / / / Switching transients can be separated into transients associated with:

- major power system switching disturbances, such as capacitor bank switching;
- minor switching activity near the instrumentation;
- load changes in the power distribution system;
- resonating circuits associated with switching devices, such as thyristors;
- system faults such as short circuits or arcing faults to the earthing system.

285 / / / Major mechanisms by which lightning produces surge voltages are:

- a direct lightning stroke to an external circuit (outdoor) injecting high currents which produce high voltages by either flowing through earth resistance or flowing through the impedance of the external circuit;
- An indirect lightning stroke (e.g. between or within clouds) that induces voltages / currents on the conductors outside and/or inside a building;
- lightning earth current flow resulting from nearby direct-to-earth discharges coupling into the common earth paths at the earthing system of the installation.

286 / / / The rapid change of voltage and flow of current, which may occur when a protector is excited, may couple into internal circuits.

287 / / / The following classes of installation are defined according to annex B of EN 61000-4-5 (part 4-5 of AD5).

288 / / /

CLASS	DESCRIPTION
0	Well-protected electrical environment, often within a special room.
1	Partly protected electrical environment.
2	Electrical environment where cables are well separated, even at short runs.

3	Electrical environment where cables run in parallel.
4	Electrical environment where the interconnections are running as outdoor cables along with power cables, and cables are used for both electronic and electric circuits.
5	Electrical environment for electronic equipment connected to telecommunication cables and overhead power lines in a non-densely populated area.

Table 3: Installation classes for electrical environments

289 /// Compliance levels following the above mentioned different installation classes are given in the following table

290 ///

INSTALLATION CLASS =>	TEST VOLTAGE LEVELS							
	Power supply coupling mode		Unbalanced operated circuits/lines, LDB coupling mode		Balanced operated circuits/lines coupling mode		SDB, DB[1] coupling mode	
	Line to line(kV)	Line to earth(kV)	Line to line(kV)	Line to earth(kV)	Line to line(kV)	Line to earth(kV)	Line to line(kV)	Line to earth(kV)
0	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	0.5	0.5	0.5	NA	0.5	NA	NA
2	0.5	1.0	1.0	1.0	NA	1.0	NA	0.5
3	1.0	2.0	2.0	2.0[3]	NA	2.0[3]	NA	NA
4	2.0	4.0[3]	2.0	4.0[3]	NA	2.0[3]	NA	NA
5	[2]	[2]	2.0	4.0[3]	NA	4.0[3]	NA	NA
Acronyms : DB = copper data bus/line,SDB = short-distance bus, LDB = long distance bus								

1) Limited distance, special configuration and layout, 10-30 m max. : no test up to 10 m, class 2
2) Depends on the class of the local power supply system
3) Normally tested with primary protection

Table 4: Compliance levels for surge immunity test

291 D//T As a general rule subsystems and equipment shall withstand class 3 severity levels as given in Table 3 taking into account performance criterion B as defined in Table 1.

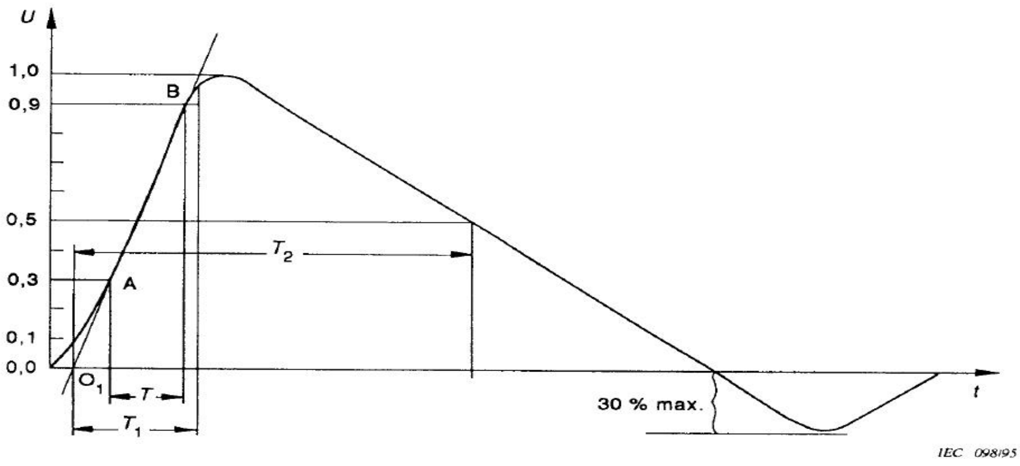
Exceptions to this rule may be handled according to #108 and may involve the choice for a different installation class according to Table 2.

It is typically necessary to install surge protective devices to meet this requirement.

293 //T A test (see requirement R28) to verify immunity to surges according to the above said classes shall typically involve the injection of surges with a rise time T_r is1,2 ms and hold time T_h is 50

ms (8/20 ms for current injection) as displayed on the next figure and the above mentioned voltage levels (see part 4-5 of AD4 for further details).

294 / / /



Front time: $T_1 = 1{,}67 \times T = 1{,}2$ µs ± 30 %
Time to half-value: $T_2 = 50$ µs ± 20 %

Figure 4: Standardized waveform of the surge event according to EN 61000-4-5

3.3.1.4.6 Conducted immunity - Electrical Fast Transient (EFT) / Burst

38 D/ / /T Subsystems and equipment shall be required to contain a level of immunity when subjected to types of transient disturbances such as those originating from switching transients (interruption of inductive loads, relay contact bounce, etc.)*.

This repetitive fast transient test is a test with bursts consisting of a number of fast transients, coupled into the power supply, control and signal ports of electrical and electronic equipment.

The recommended selection of required levels noted down in the following table shall be done according to the characteristics of the electromagnetic environment the system is in (e.g. well-protected environments like computer control rooms versus industrial environments where higher levels are applicable). For I/O, control, signal and data ports it is required to choose half the test voltage value applied on power supply ports.

* Designers shall follow proper design practice to avoid such disturbances being emitted from their equipment.

296 / / /

Environment[1)]	Voltage level (kV)
1 (well–protected environment)	0.5
2 (protected environment)	1.0
3 (typical industrial environment)	2.0
4 (severe industrial environment)	4.0

[1)] See EN 61000-4-4 (part 4-4 of AD5) for a detailed description on levels 1-4.

Table 5: EFT environments and required levels

39 D/ / /T As a general rule subsystems and equipment shall withstand class 2 severity levels as displayed in Table 5 taking into account performance criterion B as defined in Table 2.

297 / / / Exceptions to this rule may be handled according to R29 and may involve the choice for a different installation class according to Table 3.

298 / / / Verification of this requirement (see R28) involves tests as described in EN 61000-4-4 (typical parameters for the injected surge are: rise time T_r = 5 ns, hold time T_h = 50 ns and repetition rate = 5 kHz).

299 / / /

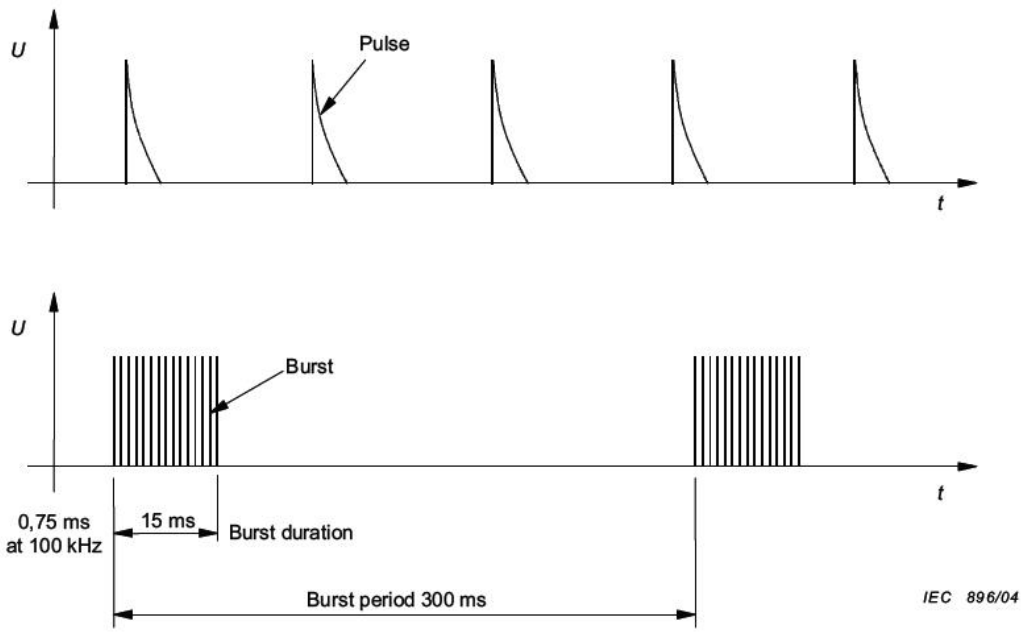


Figure 5: Standardized waveform of the EFT event (burst) according to EN 61000-4-4

3.3.1.4.7 Immunity to conducted disturbances induced by RF fields

40 D/ / /T Subsystems and equipment shall be required to contain a level of immunity to EM fields, coming from intended RF transmitters (e.g. hand-held radios), that may act on the whole length of cables connected to installed equipment (cables then may act as passive receiving antenna networks of several wavelengths). Verification of this requirement involves tests as described in EN 61000-4-6 (part 4-6 of AD6) where the frequency range shall typically be

from 150 kHz – 80 MHz and levels shall be similar to section 3.3.1.4.9 according to the appropriate class.

301 / / / The test method to verify immunity to such conducted disturbances can typically involves the use of a ferrite clamp to inject RF signals into cables while inspecting system behaviour.

3.3.1.4.8 Electrostatic Discharge (ESD) requirements

42 D/ / /T Subsystems and equipment shall be required to contain a level of immunity to electrostatic discharge (ESD) according to part 4-2 of AD4.

303 / / / Compliance levels according to EN 61000-4-2 (part 4-2 of AD4) are:

304 / / /

Level	Contact discharge test voltage (kV)	Air discharge test voltage (kV)
1) Relative humidity as low as 35%, anti-static material	2	2
2) Relative humidity as low as 10%, anti-static material	4	4
3) Relative humidity as low as 50%, synthetic material	6	8
4) Relative humidity as low as 10%, synthetic material	8	15

Table 6: ESD levels

43 D/ / /T As a general rule subsystems and equipment installed shall withstand the following levels of ESD when injected to any accessible points outside of a closed cabinet (e.g. door handles or removable panels) and other parts representing an ESD risk (for a complete description of applicable points see EN 61000-4-2).

305 / / /

Method	Level	Criteria
Air-Discharge	3) 2 to 8 kV in 2kV increments.	Criteria B up to 8kV
Contact	4) 2 to 6 kV in 2kV increments.	Criteria B up to 6kV

Table 7: ESD requirements

306 / / / Exceptions to these levels may be handled according to R29 and may involve another choice of level according to Table 6.

307

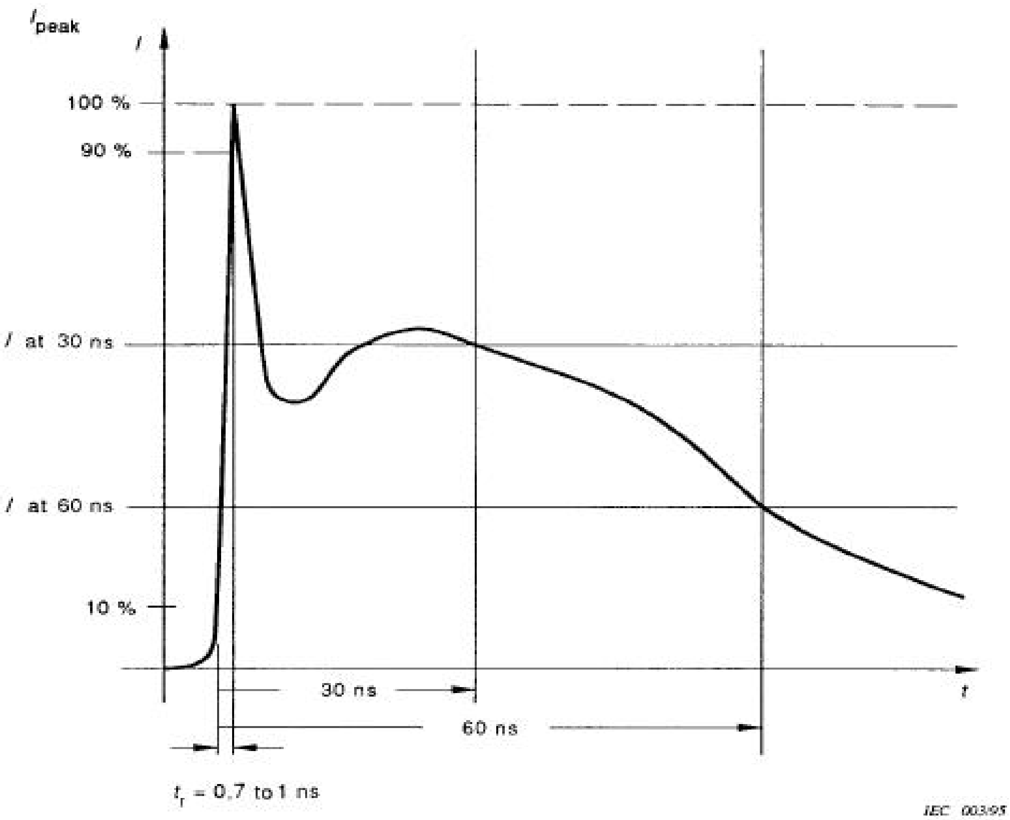


Figure 6: Standardized waveform of an ESD pulse (according to EN 61000-4-2)

3.3.1.4.9 Radiated immunity - EM fields.

44 Systems and subsystems shall be required to comply with the limits on radiated EM field immunity according to the limits set forth in the generic EMC standard for immunity in industrial environments EN 61000-6-2 (part 6-2 of AD4)

309

CLASS	DESCRIPTION
1	Low-level EM radiation environment. Levels typical of local radio/television stations located at more than 1 km, and transmitters/receivers of low power.
2	Moderate EM radiation environment. Low power portable transceivers (typically less than 1 W rating) are in use, but with restrictions on use in close proximity to the equipment. A typical commercial environment.
3	Severe EM radiation environment. Portable transceivers (2 W rating or more) are in use relatively close to the equipment but not less than 1 m. High power broadcast transmitters are in close proximity to the equipment and ISM equipment may be located close by. A typical industrial environment.

Table 8: Classes of EM radiation environments

311
D/ / /T

Level	Test Field Strength (V/m)	Test Parameters
1	1	80% AM (amplitude modulated) with 1 kHz sinewave, acc. to EN 61000-4-3
2	3	
3	10	

Table 9: Radiated EM field immunity test levels from 80-1000, 800-960 and 1400-2000 MHz

313
D/ / /T
For the frequency range from 800-960 MHz and 1.4 – 2 GHz (the measurement range 1,4 GHz to 2,0 GHz may be reduced to cover just the specific frequency bands allocated to digital mobile telephones in the country of use) , bands that are related to the protection against RF emissions from digital radio telephones, the applicable related field strength the system shall be immune to (according to the appropriate class) is similar to what is given in Table 9.

45
/ / /T
In general, systems in ESO projects shall be considered to be placed in a class 3 environment (immunity to a field strength of 10 V/m) and shall obey performance criterion B. Verification of this requirement involves tests and test parameters (frequency, modulation, etc.) as described in EN 61000-4-3.

314
/ / /
Exceptions to these levels may be handled according to R29.

3.3.1.5 Emission requirements

47
D/ / /T
The radiated and conducted electromagnetic disturbances emitted shall not exceed the limits set in the sections below. Margins for emission shall be provided based on system operational performance requirements, tolerances in system hardware, and uncertainties involved in verification of system-level design requirements.

3.3.1.5.1 Conducted emission - Harmonic currents

48
D/ / /T
For rated currents ≤ 16A per phase the harmonic current emission limits shall satisfy the values given in EN 61000-3-2 (in AD5 series) according to the applicable class.

49
D/ / /T
For rated currents > 16A the harmonic currents injected into the power distribution system shall not exceed the percent ratios given in IEC 61000-4-3 and noted down in the following Table 10 where I_1 = rated fundamental current and I_n = harmonic current*.

* Note: Higher emission values may be allowed, provided the short-circuit ratio Rsce is > 33.

317
/ / /

Harmonic number n	Admissible harmonic current I_n/I_1 (%)	Harmonic number n	Admissible harmonic current I_n/I_1 (%)
3	21.6	21	≤ 0.6
5	10.7	23	0.9
7	7.2	25	0.8
9	3.8	27	≤ 0.6
11	3.1	29	0.7
13	2	31	0.7
15	0.7	≥33	≤ 0.6
17	1.2		
19	1.1	Even	≤ 8/n or ≤ 0.6

Table 10: Harmonic current emission limits (simplified connection, rated current > 16A)

3.3.1.5.2 Conducted emission - RF disturbance voltage

50
D/ / /T
Conducted radio-frequency terminal disturbance voltages on low voltage AC mains power ports shall not be emitted in excess of the values given below taken from the generic EMC standard EN 61000-6-3 (part 6-3 of AD4) for emission in residential commercial and light industrial environments and noted down in the following Table 11. DC power ports (if applicable) shall conform to the limits noted down in the same standard.

319
/ / /

LOW VOLTAGE AC MAINS TERMINAL DISTURBANCE VOLTAGE LIMITS dB(µV)		
Frequency band (MHz)	Quasi-peak	Average
0.009 – 0.15	See EN 61000-6-3	See EN 61000-6-3
0.15 – 0.50	66 Decreasing linearly with logarithm of frequency to 56	56 Decreasing linearly with logarithm of frequency to 46
0.50 – 5	56	46
5 – 30	60	50

Table 11: Mains terminal RF disturbance voltage limits (acc. to class B ITE - CISPR22)

320
D/ /I/T
It is typically necessary to install power mains filters to meet this requirement.

321
/ / /
The test method to verify emission of such conducted disturbances can be found in EN 61000-6-3 (part 6-3 of AD4).

3.3.1.5.3 Conducted emission - Voltage fluctuations and flicker

51 /A/ /T Voltage fluctuations and flicker injected into a power distribution system shall not exceed the limits in current industrial practice to avoid misoperation of monitors and the like. Verification may be done by test or analysis

3.3.1.5.4 Radiated emission - Radiated field emission limits

52 D/ / /T Systems and subsystems shall be required to comply with the limits on radiated field emission according to the generic EMC standard EN 61000-6-3 (part 6-3 of AD4) for emission in residential commercial and light industrial (or domestic) environments and noted down in Table 12.

324 / / /

RADIATED FIELD EMISSION LIMITS dB(μV/m)		
Frequency band (MHz)	Quasi-peak at 10m	Quasi-peak at 3m
30-230	30	40
230-1000	37	47
	Average at 3m	Peak at 3 m
1000-3000	50	70
3000-6000	54	74

Table 12: Radiated field emission limits (according to class B ITE as per CISPR22).

325 / / / The following conditions apply to the applicability of the frequency range in Table 12 (the highest internal source of an EUT is defined as the highest frequency generated or used within the EUT or on which the EUT operates or tunes):

326 / / /

Highest frequency f of the internal sources of the EUT	Measurement range
f < 108 MHz	up to 1 GHz
108 MHz ≤ f < 500 MHz	up to 2 GHz
500 MHz ≤ f ≤ 1000 MHz	up to 5 GHz
f > 1000 MHz	up to 6 GHz

Table 13: Applicability of radiated field emission measurement ranges.

3.3.1.6 EMC Control Plan

53 D/ / / The manufacturer of a system or equipment shall submit an EMC Control Plan that describes the design measures implemented to conform to the requirements set in the project on EMC,

grounding, protection against lightning and LEMP. The EMC Control Plan shall be prepared according to the procedures and purposes set in RD4 or a similar reference standard.

3.4 Digital (logic) signals

3.4.1 Signal levels

54 D/ / / The voltage level of logic signals shall be 24 VDC. Other lower voltage levels may be chosen if strictly necessary, however are not preferred.

3.4.2 Interconnection methods with 24V supply

55 D/ /I/ The 24V system for non-safety related applications is intended for interconnection with relays or optocouplers and shall therefore be galvanically isolated according to the applicable norms. The interconnection cable shall be shielded. Recommended ways of interconnection are given in section 4.2.1. For interconnections of safety related applications see section 3.12.2.1.2.

3.4.3 Interconnection methods with voltage levels lower than 24V

56 D/ /I/ An interconnection method with galvanic isolation is required in case of a connection between a UPS powered control system and machinery that is not supplied by UPS.

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

- Cable length above 3 meters.
- Galvanic isolation is not implemented.

58 D/ /I/ The interconnection method with single ended driver and single ended receiver is generally not recommended and shall only be used in case all following conditions are valid:

- A cable length of not more than 3 meters.
- Galvanic isolation is not required.
- The receiver has a Schmitt trigger input.

3.5 Analog signals

3.5.1 Signal levels

59 Analog signals shall either be of voltage or current type. Voltage-type analog signals shall be
D/ / / restricted to local interconnect to fieldbus I/O modules or inside electrical cabinets. Cables used for these connections shall provide the proper shielding properties to fully ensure electromagnetic compatibility (EMC) of the carried signal. Current-type analog signals shall be used for long cable interconnects and restricted to 4-20mA level.

3.5.2 Interconnection methods

60 The interconnection cable shall be shielded and twisting is recommended.
D/ /I/

3.6 Lightning protection

338 Section 3.3.1.4.5 formulates requirements on lightning overvoltage/over-current surges for
/ / / electrical equipment.

339 Further requirements on lightning protection for large structures, buildings and equipment
/ / / within a lighting protection zone (LPZ) are formulated in a separate document, see AD9.

3.7 Cabling

3.7.1 General

342 / / / Apart from the general design requirements noted down in 3.1 that are valid for cabling, this subsection contains additional requirements. Cabling guidelines on EMC are given in section 4.4.4.

61 D/ /I/ Any type of electrical cable (power, control, telecommunication, data, signal, etc.) shall be shielded. If the use of unshielded cables is needed in exceptional cases this shall be communicated to ESO for approval.

3.7.2 Fire properties

344 D/ / / Any cable installed for any purpose and application (power, control, telecommunication, data, signal, etc.) whether electrical or optical shall not propagate fire. To this purpose it shall conform and have been successfully type tested to the series of EN 60332-1 (RD1).

345 D/ / / The same non fire propagating property shall be exhibited by any cable routing means made of non-metallic materials.

346 D/ /I/ When cables are laid in bunches additional fire propagation protection measures shall be taken (as e.g. use of cables conforming to the series of EN 60332-3 (RD1), use fire blocking and partitioning materials, separate the cables of the bunch, use of automatic fire alarm - detection and extinguishing system, etc) in order eliminate the risk of fire propagation through the cable bunch.

347 D/ /I/ In locations where fire hazards exists, in all installations where people might be concentrated or where equipment having high property value exists, in addition to the above mentioned fire properties requirements any cable and cable routing means used shall be of the low-smoke zero-halogen (LSZH) type.

348 D/ /I/ To this purpose they shall conform and have been successfully type tested to the following standards:

- IEC 60754-1, “Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content”;
- IEC 60754-2, “Part 2: Determination of acidity (by pH measurement) and conductivity”;

•EN 61034-2, “Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements”.

3.7.3 Cable dimensions

62 D/ /I/ The minimum cross sectional area of copper conductors shall be according to Table 14 (taken from AD1). Conductors with smaller cross-sectional areas or other constructions than shown in that table may be used in equipment provided adequate mechanical strength is achieved by other means and proper functioning is not impaired.

350 / / /

Type		Minimum cross sectional areas				
	Application	Single core		Multicore		
		Flexible class 5 or 6	Solid or stranded	Two core, shielded	Two core, not shielded	Three or more cores
Wiring outside enclosures	Power circuits, fixed	1.0	1.5	0.75	0.75	0.75
	Power circuits, subject to frequent movements	1.0	-	0.75	0.75	0.75
	Control circuits	1.0	1.0	0.2	0.5	0.2
	Data communication	-	-	-	-	0.08
Wiring inside enclosures	Power circuits (connects not moved)	0.75	0.75	0.75	0.75	0.75
	Control circuits	0.2	0.2	0.2	0.2	0.2
	Data communication	-	-	-	-	0.08

Table 14: Minimum cross sectional area in mm^2 of copper conductors (from AD1)

63 D/ /I/ The current carrying capacity of cables and conductors shall be according to EN 60364-5-52 (AD2) for a given method of installation. Since current-carrying capacity depends on factors like insulation material, number of conductors in a cable, design (sheath), methods of installation, grouping and ambient temperature, correction factors shall apply*.

* In cases where cables are laid close to the optical path in a Telescope it is to be reminded that over-dimensioning may be needed to avoid hot spots.

351
D/ /I/

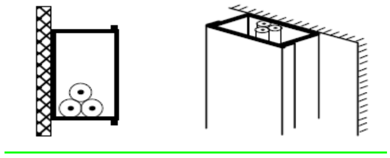
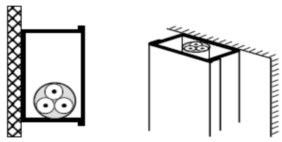
Cross section [mm^2]	Method of installation			
	B1 (closed duct)		B2 (multi-core closed duct)	
				
	conductor in a cable duct	for 3x grouping (70%)	for single phase cables	for 9x grouping (50%)
≤1	See other standards like e.g. VDE 0298-4/2003			
1.5	20 A	14 A	19.5 A	9.75 A
2.5	28 A	19.6 A	26 A	13 A
4	37 A	25.9 A	35 A	17.5 A
6	48 A	33.6 A	44 A	22 A
10	66 A	46.2 A	60 A	30 A
16	88 A	61.6 A	80 A	40 A
25	117 A	81.9 A	105 A	52.5 A

Table 15: Example of current carrying capacity numbers (taken from EN 60364-5-52)

3.7.4 Cable routing

354 D/ /I/ Cable routing shall be reliable and maintenance friendly and shall be done according to the following basic principles:

64 D/ /I/ Cables and cable bunches outside cabinets, racks or enclosures shall be put in metallic conduit or metal ducts. Other methods, if intended to be used, need to get prior ESO approval.

65 D/ /I/ Wiring inside enclosures shall be placed in conduits or ducts. If this may not be possible or impractical, conductors and cables that do not run in ducts shall still be adequately supported.

66 D/ /I/ Cables shall be protected against damage from abrasion, contact with sharp edges or protrusions and environments.

67 D/ /I/ Accessibility of cables shall be provided to the maximum extent possible.

68 D/ /I/ Cable arrangement and connector bracket design shall allow rapid operational disconnection.

69 The cabling supporting devices shall provide the possibility for removal and replacement of cables for maintenance.
D/ /I/

70 The cabling routing shall ensure connector replacement capability.
D/ /I/

71 The bending radius shall not be smaller than the minimal value as specified by the cable manufacturer. Flexible cable shall be used for functions requiring movements. Frequently moved cables like the ones laid in cable wraps shall be specifically designed for this purpose.
D/ /I/

72 In conduit and ducts a recommended amount of 40% spare space shall be reserved for future use.
D/ /I/

73 The most direct routing of cables and ducts compatible with structural provisions shall be applied. However, EMC requirements prevail over practical considerations, convenience of mounting and aesthetic aspects.
D/ /I/

74 Power and signal should be isolated one form another in order to avoid cross-coupling. EMI considerations should prevail over convenience. Boundary conditions like power, voltage (AC or DC), distance and the type of signal (analogue or digital) shall be considered when making the decision.
D/ /I/

75 All cables/ducts shall be positioned as close as possible to structural components.
D/ /I/

76 Earthed conductors shall be routed parallel to live conductors to keep earth loop areas small.
D/ / /

77 Cable routing shall be planned and designed to comply with the installation and mitigation guidelines contained in EN 61000-5 (part 5 of AD4), in particular, but not exclusively, with those specified in part 61000-5-2, “Earthing and cabling”.
/ / /

355 If not already mentioned in the above list, possible additional requirements set forth by a harmonised standard that is applicable to the (sub)system (see section 3.2.1) shall also be complied with.
D/ / /

3.7.5 Cable/conductor identification

78 Conductors of any cable terminated at terminal blocks shall be individually identifiable by means of alphanumeric codes attached to the conductor. As an alternative, identification through colour coding alone may be used. This method however can only be accepted in case the cable number or the terminal block number is unambiguously identifiable and visible.
D/ /I/

Other methods shall always allow unique conductor identification and require prior approval by ESO.

357
/ / /

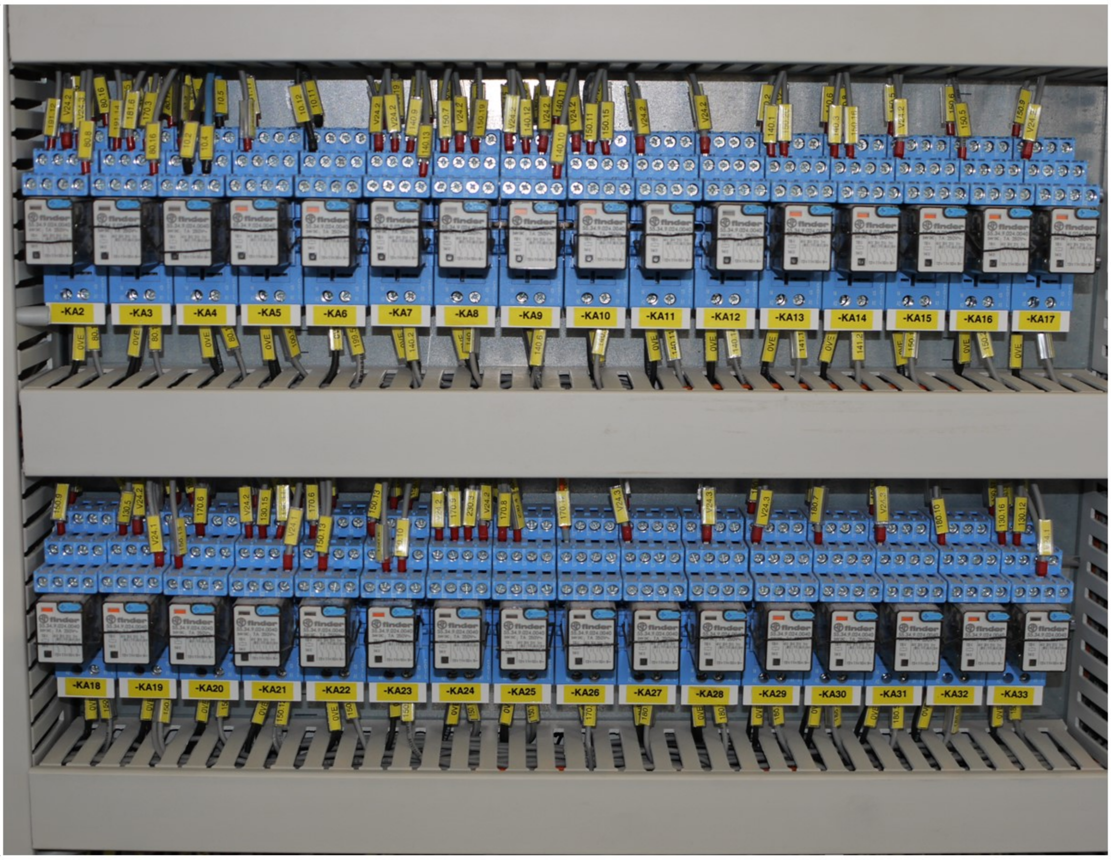


Figure 7: Identification of conductors by means of alphanumeric codes

79 D/ /I/ Identification tags shall be legible, permanent and appropriate for the environment, resistive to wear from abrasion, from presence of water, oils, etc. No paper or any type of hand written labels or stickers is allowed.

80 D/ /I/ The cable labelling scheme, whenever feasible, shall allow identifying as to which subsystem, equipment or part the cable belongs to. It shall be consistent with the technical documentation.

81 D/ /I/ Where UPS or safety power is present the relevant items shall be identified (e.g. by labels).

3.7.5.1 Power cables

359 D/ /I/ Low voltage AC power distribution systems are implemented as a TN-S system. AC power cables shall therefore contain:

L1, L2, L3, N (neutral) and PE (protective earth) for three phase power cables.

L (line conductor), N (neutral) and PE (protective earth) for single phase power cables.

84 D/ /I/ All power cables (AC or DC) and relevant connection terminals shall bear identification in full compliance with the requirements of EN 60445.

3.7.5.1.1 Colours of power cables

85 D/ /I/

	Single phase			Three phase				
Conductor:	PE	N	L	PE	N	L1	L2	L3
Colour:	Green/ yellow	Light blue	Brown	Green/ yellow	Light blue	Brown, Black **or** Grey		
								

Table 16: Colours of power cables according to AD3

86 D/ /I/ Where identification is by colour alone, the protective earth (PE) conductor shall be coloured green-and-yellow throughout its whole length. This colour identification is strictly reserved for the PE conductor and the colours green as well as yellow shall be avoided for other wiring in case this may cause confusion.

87 D/ /I/ Where a circuit includes a neutral conductor identified by colour, the colour shall be light-blue. This colour shall be avoided on other conductors in case confusion may arise.

88 D/ /I/ Where a circuit includes a cable supplied from an external power source the cable shall be identified by orange colour.

3.7.5.2 Signal cables

3.7.5.2.1 Colour coding of signal conductors

89 D/ / / In case colour coding is chosen identification shall be done by an internationally accepted standard.

364
/ / /

Pair #	Colour of a-conductor	Colour of b-conductor	Pair #	Colour of a-conductor	Colour of b-conductor
1	white	Brown	13	white/black	brown/black
2	green	yellow	14	grey/green	yellow/grey
3	grey	pink	15	pink/green	yellow/pink
4	blue	red	16	green/blue	yellow/blue
5	black	violet	17	green/red	yellow/red
6	grey/pink	red/blue	18	green/black	yellow/black
7	white/green	brown/green	19	grey/blue	pink/blue
8	white/yellow	yellow/brown	20	grey/red	pink/red
9	white/grey	grey/brown	21	grey/black	pink/black
10	white/pink	pink/brown	22	blue/black	red/black
11	white/blue	brown/blue	23-44	see 1-22	see 1-22
12	white/red	brown/red	45-66	see 1-22	see 1-22

Table 17: Colour identification for paired cables (acc. to DIN 47100)

366
/ / /

Conductor number	Colour	Conductor number	Colour	Conductor number	Colour
1	white	12	red/blue	23	white/red
2	brown	13	white/green	24	brown/red
3	green	14	brown/green	25	white/black
4	yellow	15	white/yellow	26	brown/black
5	grey	16	yellow/brown	27	grey/green
6	pink	17	white/grey	28	yellow/grey
7	blue	18	grey/brown	29	pink/green
8	red	19	white/pink	30	yellow/pink
9	black	20	pink/brown	31	green/blue
10	violet	21	white/blue	32	yellow/blue
11	grey/pink	22	brown/blue	33-61	see DIN 47100

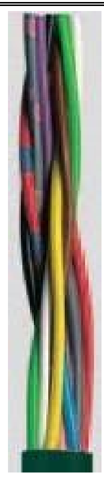


Table 18: Identification for single signal conductors (without colour repetition)

368 Local Area Network (LAN) cabling

/ / / Preferred colour for a straight cable of TIA/EIA 568A type using RJ45 connectors (also for 'Power over Ethernet' if applicable):

370
/ / /

Pin #	Colour
1	White with green stripe
2	Green
3	White with orange stripe
4	Blue
5	White with blue stripe
6	Orange
7	White with brown stripe
8	Brown

Table 19: Colour identification for LAN cabling

3.7.6 Fibre optic cables

90 Fibre optic cables shall be able to withstand movement and bending where applicable and
D/ /I/ shall be compliant with their harmonised product standard.

91 Optical fibre type shall be single-mode (OS2 transmission standard). All fibres shall be
D/ /I/ certified for 10Gbit/s operation according to ANSI/TIA-568-C.3. In some specific applications, after ESO approval, 1Gbit/s certification may be considered.

3.8 Connections

3.8.1 General

92 Electrical connections to terminal blocks shall be made with screw terminals using ferrules
D/ /I/ with insulating collar for fine stranded wires. As an alternative, subject to prior approval by ESO, cage-clamp (spring) terminals without the use of ferrules may be used.

3.8.2 Marking

93 All connectors shall be marked in order to uniquely identify them. All mating sockets shall also
D/ /I/ be correspondingly marked.

94 Cable connectors have to be labelled on the cable, just behind the connector, or directly on
D/ /I/ the connector if possible. The panel sockets have to be labelled on the panels where they are mounted.

95 A cable identification label shall be permanently marked at each end of the cable. If the total
D/ /I/ length of the cable is less than 30 cm and the cable is visible in its full size without removal of any other parts, then only one cable identification label is acceptable.

375
/ / /

Figure 8: Example of proper identification of cables and sockets/connectors.

3.8.3 Electric power connectors

96 Electric power shall be supplied from the following standardised set of connectors:
D/ /I/

377 <u>Three phase 400 VAC connectors according to EN 60309</u>
D/ /I/ EN 60309-2 type. 3L+N+PE, 240/415V (red type), earthing contact at 6h. Rated current according to application.

378 ///

Figure 9: EN 60309-2, 3L+N+PE 6h.

379 Single phase 230 VAC connectors

/// According to CEE 7/4 (SCHUKO type F). Rated current 16A.

380 ///

Figure 10: SCHUKO plug/socket

381 /// L+N+PE, 220/250V blue type (acc. to EN 60309), earthing contact at 6h. May be used in cases where the CEE-el 7/VII (SCHUKO) type connector can't be used.

382 ///

Figure 11: L+N+PE 6h, single phase

383 Single phase 230 VAC connectors for non-COTS equipment

/ / / According to EN 60320. Preferred type: C13, L+N+PE.

The use of a cable clamp is recommended.

384
/ / /

Figure 12: EN 60320 C13/14 connectors

385
/ /I/ Note: When, e.g. during a commissioning phase, it is unavoidable to make use of other types of plugs, the use of them shall always involve adapters to the SCHUKO system and shall be of a temporary nature.

3.8.4 Signal connectors

97
D/ /I/ Signal connectors shall make use of crimped pins/terminals, no soldered connections.

570
/ / / In general the connectors shall be selected according to the environment, accessibility and intended use, with preference for MIL standard type connector.

3.8.5 Optical fibre connectors

99
D/ /I/ For E-ELT project, optical fibre shall be exclusively equipped with LC-type connectors.

391 ///

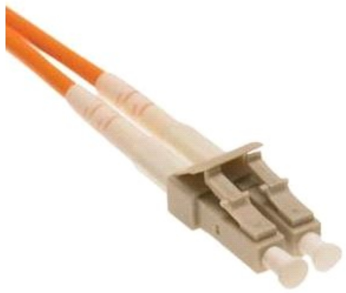


Figure 16: Optical connector types: LC

3.8.6 Break-out box

100 D/ /I/ In case a break-out box is needed it shall be of metal and it shall have the principle schematic as shown in the following figure for a 9 pin D connector and the following characteristics

393 ///

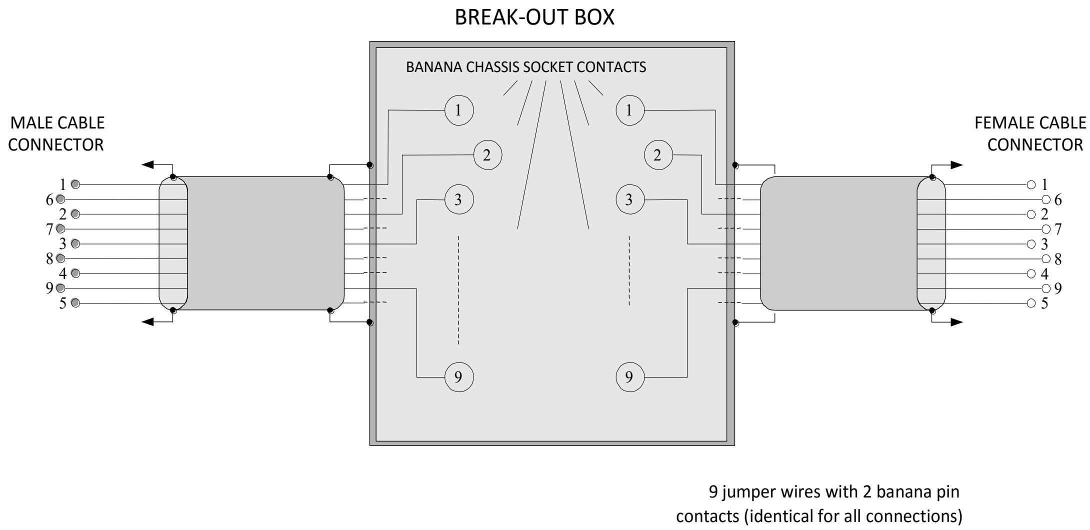


Figure 17: Break-out box principle

394 D/ /I/ Characteristics:

- 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 Printed circuit boards (PCBs)

396 Printed circuit boards (PCB) shall be developed with dimensions and connectors according to
D/ /I/ EN 60297-3, except in cases of space limitations. Recommended dimensions of printed circuit boards (PCB) are:

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

101 Insulation shall be designed according to relevant safety standards (see section 3.2.1) so as
D/ /I/ to provide proper creepage and clearance distance (taking into account the environmental conditions) as well as appropriate distance through insulation.

397 EMC recommendations on PCB design are given in section 4.4.3.
/ / /

3.10 Cabinets and devices

102 Cabinets for mounting of electronic equipment shall be according to EN 60297. The type of
D/ /I/ cabinet shall be standardised and shall be of metal. The use of another type or custom designed cabinet is allowed after explicit approval by ESO.

103 IP protection of a cabinet shall be appropriate for its expected environment according to EN
D/ / / 60529.

104 All cabinets in an environment where light pollution is forbidden (especially inside
D/ /I/T astronomical telescopes and/or instruments) shall have opaque metallic doors and panels in order to eliminate such pollution. If LEDs or other light indicators are mounted on the exterior of such cabinets there must be a switch to disable them.

399 EMC requirements may imply the use of HF screened-, custom made cabinets.
/ / /

3.10.1 Accessibility

105 D/ /I/ In order to facilitate maintenance, service and repair of equipment, cabinets shall generally not have a height above 2 meters. Deviation of this requirement may only be granted after prior approval of ESO.

106 D/ /I/ All elements inside electrical or electronic cabinets (including terminal blocks) must have good access in order to allow trouble-shooting and easy replacement.

107 D/ /I/ When the cabinet is installed in its final location, doors shall allow to be opened by at least 90 degrees. For safety reasons open cabinet doors shall not block the escape path from inside the cabinet.

108 D/ /I/ At the back of a cabinet access shall be provided in order to allow access for possible maintenance and repair.

109 D/ /I/ Indicators, displays, control actuators and the like shall be mounted on the front panel. Preferred location is 120-140 cm above floor for control elements and 160 cm for screens, meters, etc. All other elements and devices (including screw terminals) shall be mounted on the back panel of the cabinet; mounting on the side walls should be avoided. Other methods shall be agreed with ESO.

110 D/ /I/ The mounting method of devices shall allow easy replacement (e.g. DIN-rails). Devices mounted on DIN-rail (and similar) should be prevented from slipping sideways by means of mechanical hold-downs at both ends of the device(s) as specified in EN 60715.

3.10.2 Connection of field devices

111 D/ /I/ All field devices connections shall be terminated on screw type terminal strips or cage-clamp (spring) terminals. An alternative way to interface specific LCU level signals to the field (e.g. motor control functions) could be by using intermediate mating connectors mounted directly on the rear panel of the LCU chassis or on a mounting plate/DIN-rail.

3.10.3 Space

112 D/ /I/ In case it can be reasonably expected that future additions or changes may be added cable ducts and cabinets must have enough capacity to allow for additional installation.

3.10.4 Labelling

113 / /I/ All devices and components like terminal blocks, switches, relays, circuit breakers, etc. shall have a unique label consistent with the technical documentation.

114 / /I/ Labels shall be of permanent type. They shall be either engraved or silk-screen printed. No hand written labels are allowed.

115 / /I/ In the case of removable equipment, labels shall not be attached to the device itself, unless a second label is placed internally to ensure correct replacement.

116 D/ /I/ Identifiers for electrical schematics shall be according to EN 81346 (see next table) and shall be used in the label number as much as possible.

404 / / /

Identifier	Description
A	PLC modules, devices with no single purpose.
B	All sensor types: temperature, proximity switch, pressure measure device, photo resistor.
C	Capacitor, coil buffer battery, CD ROM, EPROM.
E	Laser, heaters, lamp, chiller.
F	Fuse, RCD, CB, overvoltage protector.
G	Tacho generator, fan (generator of air), oscillator, battery.
K	Relay, opto-coupler, analog digital converter.
M	Motor, electromagnetic valve, mechanical unit controlled by electrical signal.
P	Acoustic indicator/alarm, alarm flash light (attached to instrument cabinet), display, pulse generator, pulse counter, multi-meter.
Q	Power switch, contactor to switch power, on/off valve.
R	UPS, diode, resistor, inductor, proportional valves.
S	Command unit (button, switch).
T	Power supply, transformer, media converter (Ethernet/Fibre), signal converter (current to voltage), amplifier, frequency converter, antennas.
U	Cabinets, rooms, ducts cable wrap, casing.
V	Filter, semiconductor.
W	Cable, fiber, busbar, antenna.
X	Terminal, connector, socket, multi-sockets.
Y	Electrically controlled flow valves (as used for temperature control in cabinets).

Table 20: Identifiers for electrical schematics acc. to EN 81346

117 D/ /I/ A cabinet, instrument and system itself shall have a label containing the following information (according to AD1):

- name or trade mark of supplier;

- certification mark, when required;
- serial number, where applicable;
- rated voltage, number of phases and frequency (if AC), and full-load current for each supply;
- short-circuit rating of the equipment;
- the electrical diagram number(s) or the number of the index to the electrical drawings.

3.11 Power distribution

3.11.1 Electric power distribution system

407 / / / Preamble: Requirements related to the electric power supply in ESO projects may also be found in AD9.

118 D/ / / Inrush current or current transients at start up shall be limited. Motors greater than 3 kVA shall apply modern soft starting means (e.g. no star-delta starters) in their connection to the power distribution system.

119 D/ /I/ Overvoltage protective means and RF mains filters shall be installed. As a general rule overvoltage protection in cabinets for instrumentation shall contain SPDs of class II.

120 D/ / / Protection of low-voltage installations against temporary overvoltage and faults between high and medium voltage systems and earth shall be accomplished according to EN 60364 (AD4), in particular according to EN 60364-4, which is a part of AD9

121 D/ /I/ For cabinets that do not have natural cooling an adjustable thermal switch shall be installed that may act as an interlock to the electrical supply upon the event of an over temperature. For naturally cooled cabinets this feature is optional.

122 / / /T The true r.m.s. power factor λ (=P/S) shall not be smaller than 0.85 for loads bigger than 0.5 kW.

123 D/ / /T Cabinet power state (ON/OFF) shall be remotely controllable preferably over Ethernet using a cabinet power management system

124 D/ / /T Temperature of the cabinet shall be monitored by the cabinet power management system to allow corrective action if outside normal operational range

125 D/ / /T Undervoltage and surge protective devices conditions shall be monitored on all used main phases by the cabinet power management system to allow corrective action if outside normal operational range

3.11.2 AC mains supply

126 D/ / / Electronic units shall be powered by the ESO Observatory electric power supply system according to the TN-S power distribution principle.

409 / / / The following electrical supplies are available:

- 400 VAC three-phase, 50 Hz including neutral (N) and protective earth (PE) conductor;
- 230 VAC single phase, 50 Hz including N and PE conductor.

3.12 Common functions related to the safety of a system

3.12.1 Requirements

413 / / / The following sections provide detailed requirements on the implementation of certain safety functions.

127 D/ / / Possible additional requirements set forth by a harmonised standard that is applicable to the (sub)system (usually AD1) shall also be complied with.

3.12.2 Interlock

128 D/ /I/T Where an operating limit (for example speed, pressure, position) can be exceeded leading to a hazardous situation, means shall be provided to detect when a predetermined limit(s) is exceeded and initiate an appropriate automatic control action.

129 D/ /I/T The reclosing or resetting of an interlocking safeguard shall not initiate hazardous machine operation.

130 The 'hazardous situation' in the definition shall be analysed and documented beforehand in a hazard analysis according to AD8.

D/ / /

131 D/ / /T All contactors, relays, and other control devices that control elements of the machine and that can cause a hazardous situation when actuated at the same time (for example those which initiate contrary motion), shall be interlocked against incorrect operation.

415 / / / [info] 'Interlock' is intended to detect these situations in an early stage and to prevent damage in such a situation e.g. by stopping of a moving part.

416 / / / AD1 defines three categories of stop functions as follows:

- stop category 0: stopping by immediate removal of power to the machine actuators;
- stop category 1: a controlled stop with power available to the machine actuators to achieve the stop and then removal of power when the stop is achieved;
- stop category 2: a controlled stop with power left available to the machine actuators.

132 D/ / /T In case of moving machinery an interlock shall lead to either a category 0,1 or 2 stop in the definition of EN 60204-1 (AD1) as indicated by the risk assessment and the functional requirements of the machine.

133 D/ / /T Stop functions shall override related start functions.

134 D/A/ / The implementation of the interlock function shall meet the required Safety Integrity Level (SIL) determined as outlined in section 3.2.3.2; safety logic shall be implemented in software running on safety-certified Programmable Logical Controller (PLC).

135 D/ / /T 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 centrally.

417 / / / Note that Interlock is not intended to protect against electric shock. For this hazard the applicable safety standards shall be consulted according to section 3.2.4.

3.12.2.1 Implementation requirements

3.12.2.1.1 Simple interlock schemes: basic hardware components

136 D/A/ /T The implementation of the interlock function shall meet the required SIL (Safety Integrity Level) determined as outlined in section 3.2.3.2.

137 D/ / / The safety function shall be implemented either by making use of electrical/electronic (safety relays) or by using PLC's.

138 D/ / / In the case PLC control systems are used, safety logic shall be implemented using safety certified software running only on safety-certified Programmable Logical Controllers (PLC's).

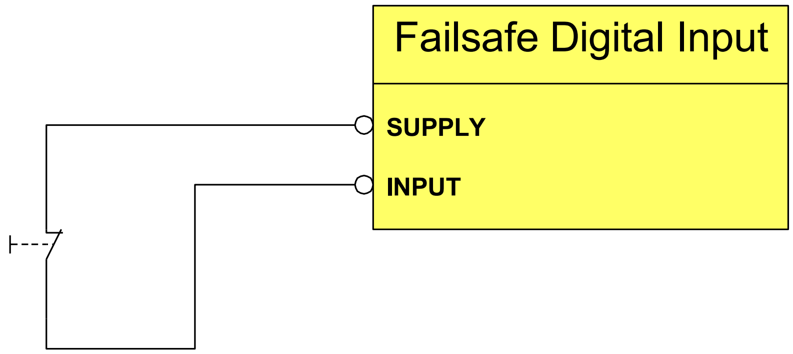
3.12.2.1.2 Standard interlock scheme solution: safety related electrical control system

139 D/ / / Depending on the required SIL, related variables and all other applicable safety related concerns the SRCF (Safety Related Control Function) shall be suitably designed.

140 / / / Special care has to be taken to properly select sensors in order to achieve the appropriate SIL.

421 / / / The following examples of programmable electronic control systems are given for clarity and are not necessarily suitable to all applications. In general, recommendations of suppliers shall be followed.

422 / / / Safety relevant signals from sensors shall be connected to failsafe input-modules (Shown on the right: 1oo1 sensor evaluation).

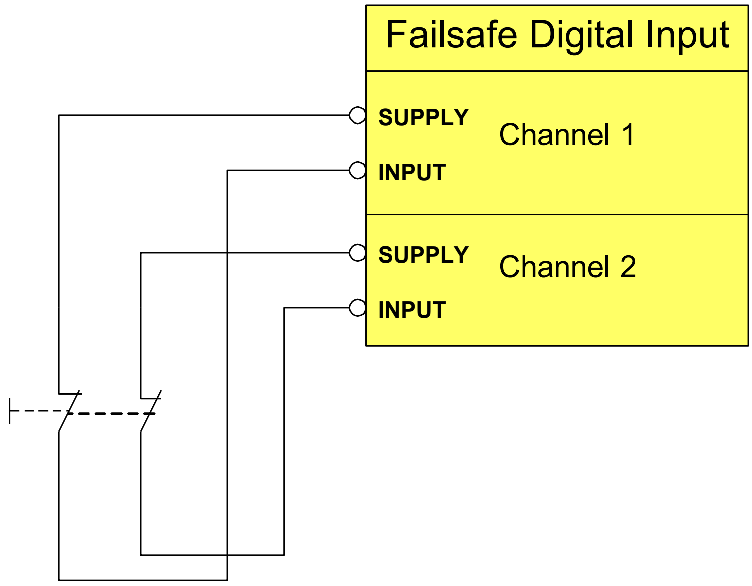


423 / / / Examples of input signals:

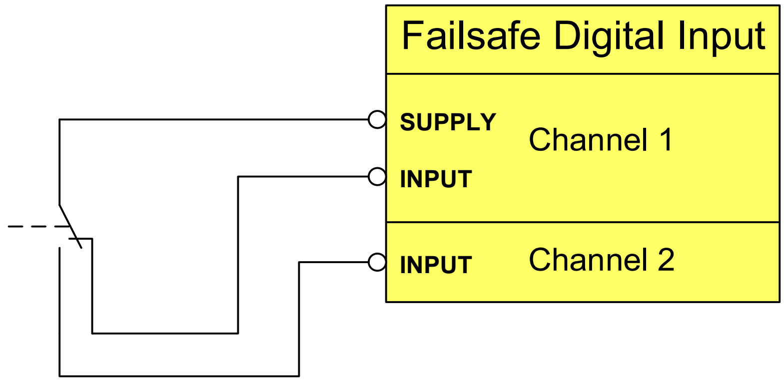
- Overspeed
- Overtemperature
- Positive limit
- Negative limit

425 / / / Examples:

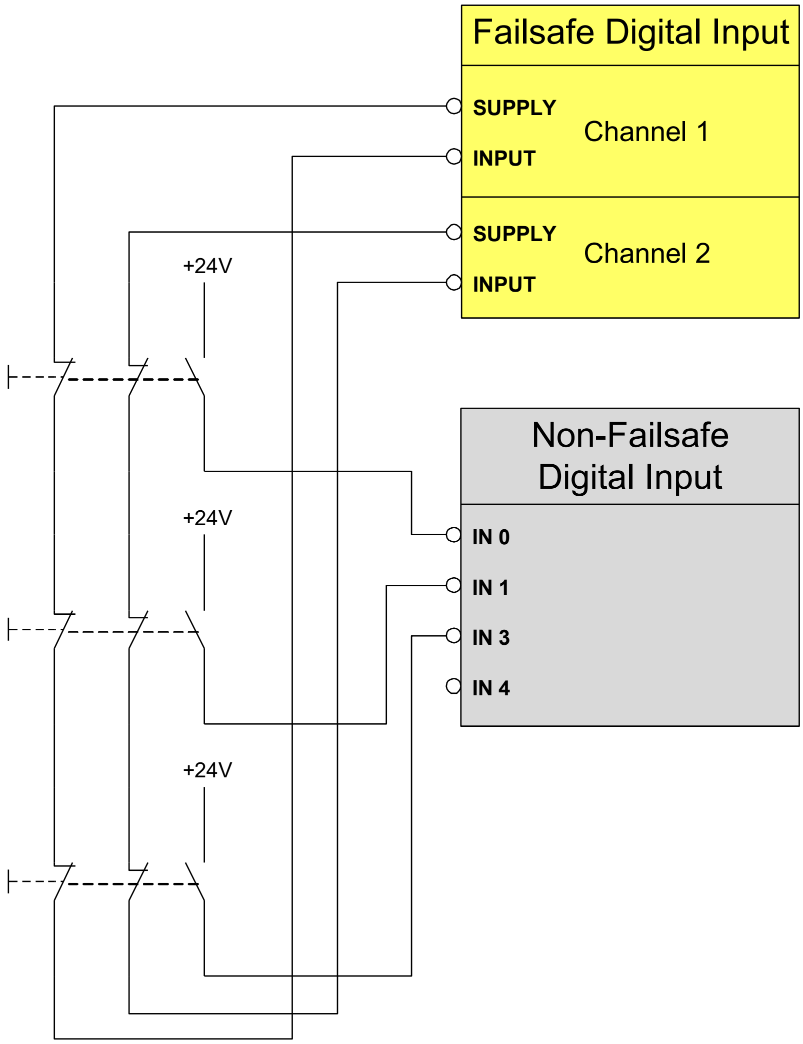
To achieve SIL 3, it is usually necessary to apply a two-channel sensor. A 1oo2 sensor evaluation with discrepancy analysis is preferred. To avoid undesirably activation of the discrepancy analysis, single sensors with 2 separate, mechanically coupled contacts (both n.c. or n.o.) should be used. In cases, where more than one sensor can be expected to be activated at the same time, series connection is not allowed.



426 Alternatively a non-equivalent signal design (single sensor with change-over-contact) could
/ / / be used.

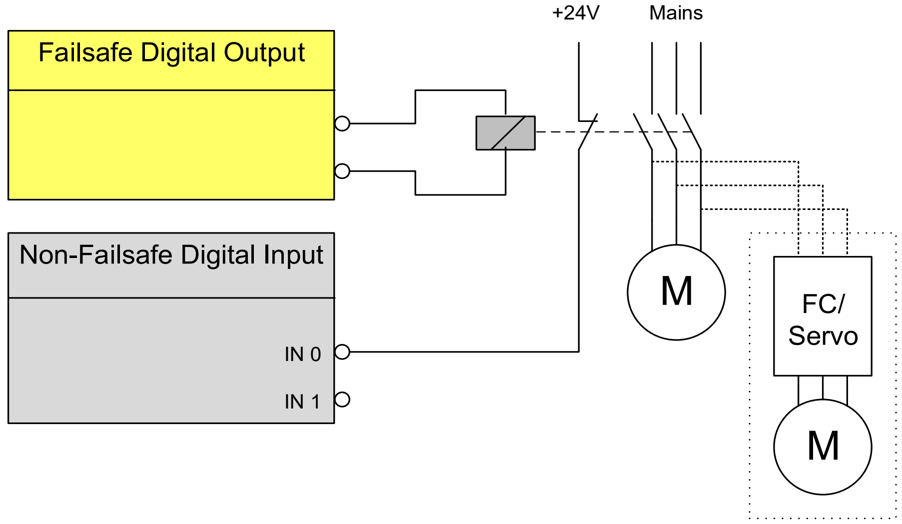


427 If multiple two-channel-sensors are connected together in a chain (e.g. emergency stop
/ / / buttons), only equivalent contacts can be applied. In this case, a third contact on each sensor for (non failsafe) status signalling to the PLC is required, allowing a detailed identification of the triggered sensor.



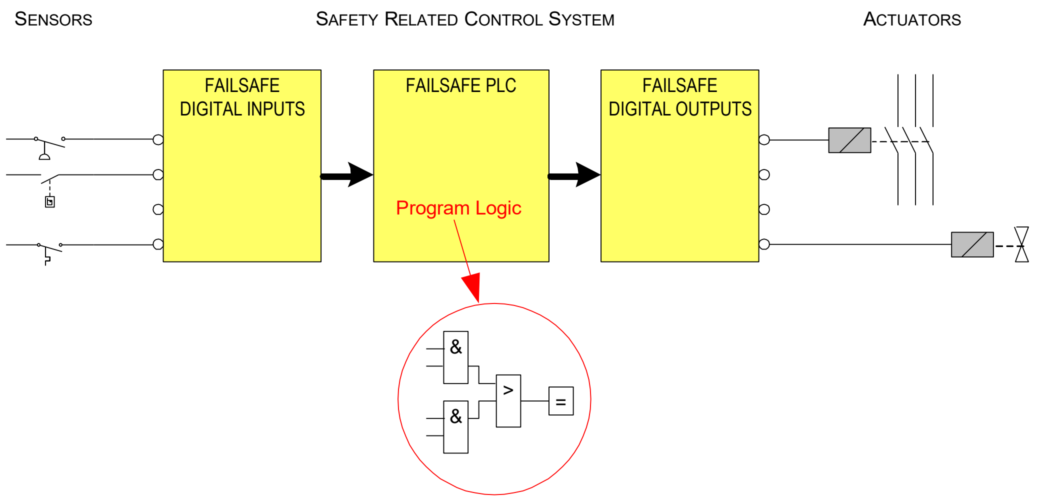
428 Failsafe power switching with a single relay (HFT = 0) and readback-signal.
/ / /

Possibly up to SIL 2.



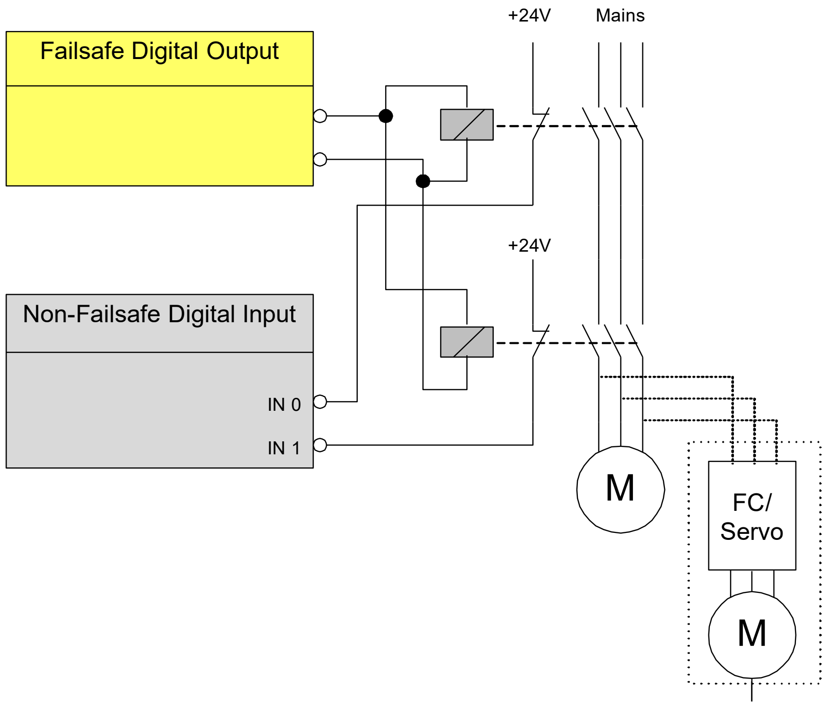
429 Failsafe power switching with two separate relays, coils connected to a single failsafe output
/ / / (HFT = 1) and separate readback-signals

Possibly up to SIL 3.



430 When using failsafe frequency converters or servo drives, the interconnection with the failsafe
/ / / PLC preferably should be implemented by a failsafe bus-system. Occasionally this design can replace relays and discrete failsafe I/O's or, at least, part of them.

The achievable SIL mainly depends on used components.



431 Instead of hard-wired interlocks, motion stops and safety-switch-off, the safety relevant sensors
/ / / and actuators are connected to failsafe input / output modules. The logic is implemented in the failsafe PLC-program, allowing the realization of more complex and extensive safety logic, increasing the flexibility and simplifying error diagnostics.

432
/ / /

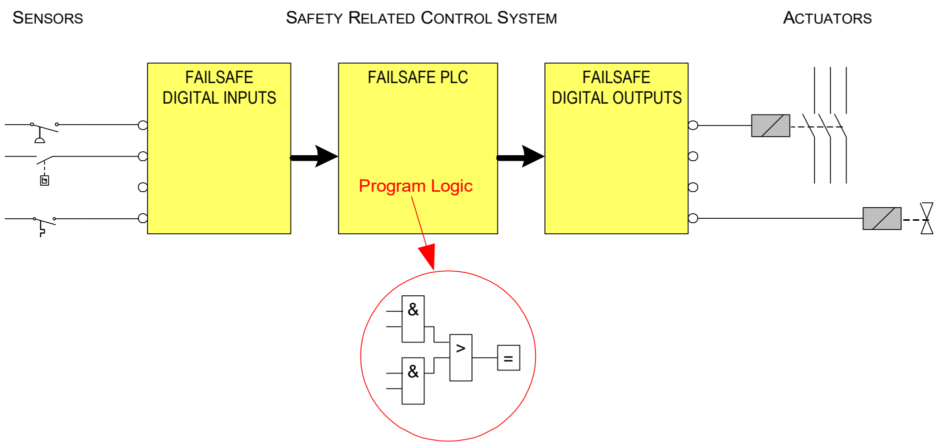


Figure 18: Safety related programmable electronic control system principle

141 Interlock-signals between failsafe PLCs shall be interchanged by failsafe bus-communication,
/ / / as well as the data transfer to / from the remote I/O's.

433 / / /

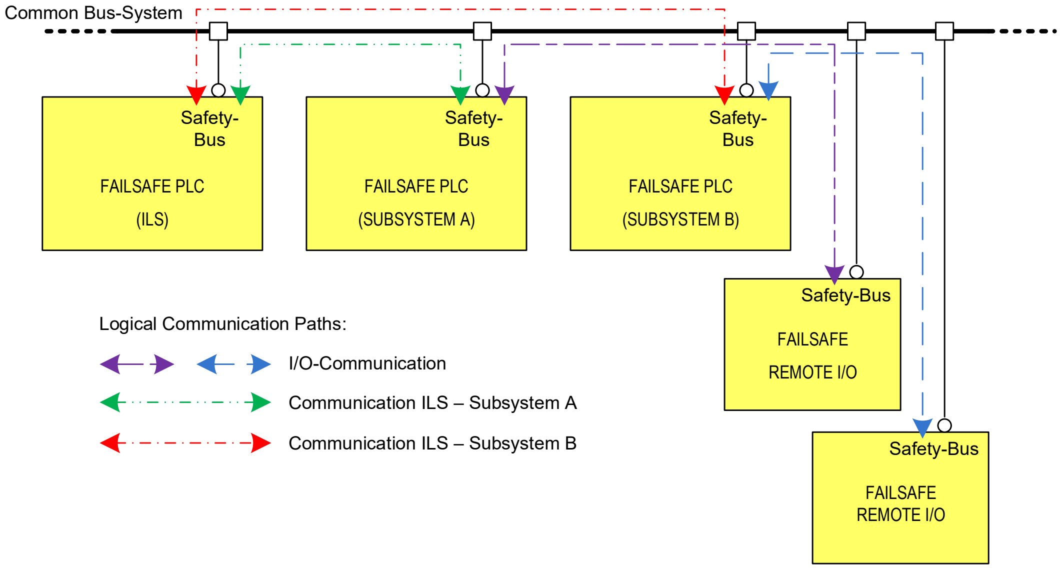


Figure 19: Communication path example in a failsafe programmable electronic control system

3.12.2.2 Override/suspension of safeguards

435 / / / In the case of crossing over operational limits, an override/suspension of safeguards is necessary to move the unit out of the limit.

142 D/ / / When it is necessary to suspend safety functions/protective measures, protection shall be ensured by:

- disabling all other operating modes;
- one or more of the following:
  - initiation of operation by hold-to-run device (or similar);
  - portable control station with emergency stop and enabling device where motion can only be controlled from that station;
  - cableless control station with stop device/enable/exclusive control;
- limitation of speed or power of motion or the range of motion.

143 D/ / / This override function shall be such that the moving unit can be seen from the point where the override function is implemented.

3.12.2.3 Brake

144 D/ / / The brake shall be of a safety break type of the right SIL level.

145 D/ / /T No power means that the brake is engaged.

146 D/ /I/T The brake shall have status signals (engaged/disengaged, etc.) so that its state can be monitored. The type of state signal shall be according to the selected SIL level.

3.12.3 Emergency stop

3.12.3.1 Requirements

147 D/ / / The requirement for amount a location of emergency stops is an outcome of the analysis made according to AD8. As a basic requirement the distribution and number of emergency stops shall allow action by the affected persons as well as witnesses at a distance.

148 D/ /I/ The emergency stop device shall be a push-button operated switch, shall be of the self-latching type and shall have positive (or direct) opening operation (see EN 60947-5-1).

149 D/ /I/ The actuator shall be coloured red while the background immediately around the device actuator shall be coloured yellow. The actuator shall be of the palm or mushroom head type.

150 D/ /I/ It shall not be possible to restore the emergency stop device until it has been manually reset. Where several emergency stop devices are provided in a circuit, it shall not be possible to restore that circuit until all emergency stop devices that have been operated have been reset.

151 D/ / / Emergency stopping shall always be achieved through a Category 0 or a Category 1 stop with a preference for category 1 if the risk assessment allows this.

152 D/ / / Regardless of the outcome of the risk assessment the following requirements apply to the emergency stop system:

- it shall be implemented with a safety integrity level (SIL) of 2 or higher;
- it shall be implemented with a two line evaluation scheme (“1oo2”, see section 3.12.2.1“).
- it shall follow the principle implementation requirements as stated in AD11.

3.12.4 Lockout/Tagout

3.12.4.1 Description

441 / / / Lockout/Tagout is a means to avoid potentially hazardous energy (including motion, electrical, thermal, chemical, pneumatic, hydraulic, mechanical and gravitational energy) to be present in a (sub)system during installation, repair or maintenance.

153 D/ / / During installation, repair or maintenance a (sub)system must have the ability to lock out, block or release all forms of potentially hazardous energy. The system or equipment involved shall be designed to enable these features (e.g. by means of a mains switch that is lockable in the 'off' position for the electrical supply, visible isolation).

154 D/ / / A review shall be part of the risk analysis to determine which switches, valves, or other energy isolating devices apply to the equipment being locked out. More than one energy source (electrical, mechanical, hydraulic, pneumatic, chemical, thermal and gravitational) may be involved.

3.13 Safety functions

443 / / / <u>Note:</u> This section is usually not applicable to small moving systems.

155 D/ / / In all cases where drive applications may pose a hazard to people, environment or property, safety functions shall be implemented by means of adjustable speed electrical power drive systems (PDS) that are suitable for use in safety-related applications PDS(SR) following the procedures as explained in RD3[*]. The following sections contain examples of such safety functions.

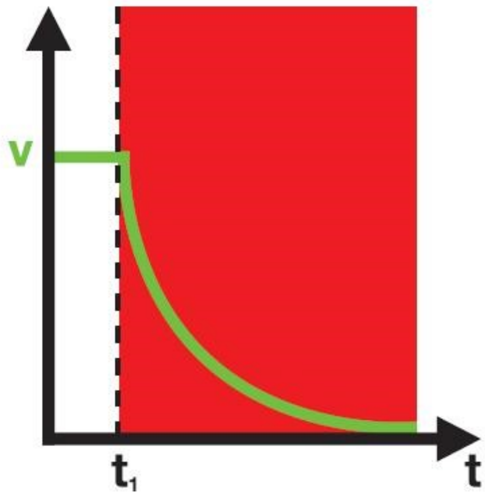
[*] EN 61800-5-2 (RD3) gives a methodology to identify the contribution made to identified safety functions by an adjustable speed electrical power drive systems (PDS) that are suitable for use in safety-related applications PDS(SR).

156 D/ / / The technical measures required to implement the safety functions shall depend on the SIL capability and the required probability of dangerous hardware failure.

3.13.1 Safe Torque Off (STO)

446 / / / With the Safe Torque Off function (STO), the power to the motor is safely removed directly within the servo amplifier. The drive cannot generate torque/force and so cannot trigger any hazardous movements. If any external forces influence the drive (e.g. suspended loads), additional measures (e.g. mechanical brakes) are required in order to eliminate hazards. If the STO is activated when the drive is moving, the motor will run down in an uncontrolled manner. For this reason, the Safe Stop 1 function (SS1) is generally preferable because the shutdown is preceded by a controlled stop.

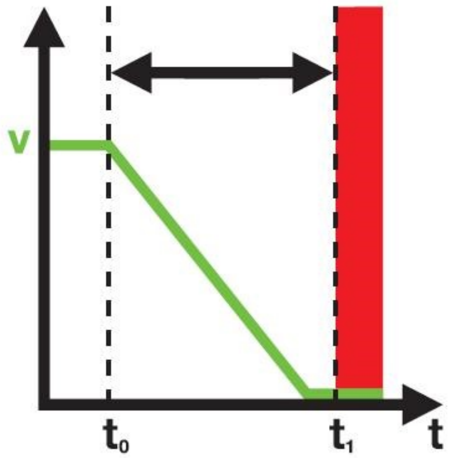
447 / / /



3.13.2 Safe Stop 1 (SS1)

449 / / / With a “Safe Stop 1” (SS1) function, the drive is brought to a controlled stop and then the power to the motor is safely removed. Once at standstill the drive cannot generate torque/force and so cannot trigger any hazardous movements. The Safe Stop 1 function corresponds to controlled braking in accordance with EN 60204-1, Category 1 (see section 3.12.2).

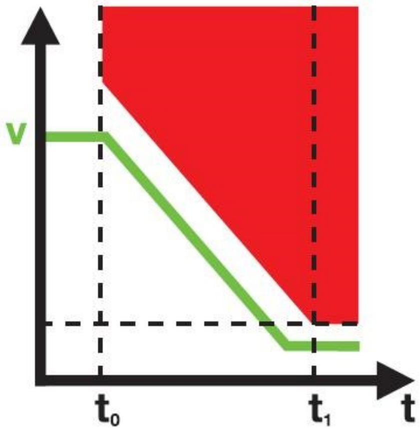
450 / / /



3.13.3 Safe Stop 2 (SS2)

452 / / / With a "Safe Stop 2" (SS2) function, the drive is brought to a controlled stop and then safe standstill monitoring is triggered. The drive's control functions are maintained in full (power is available to the motor). The Safe Stop 2 function corresponds to controlled braking in accordance with EN 60204-1, Category 2 (see section 3.12.2).

453 / / /

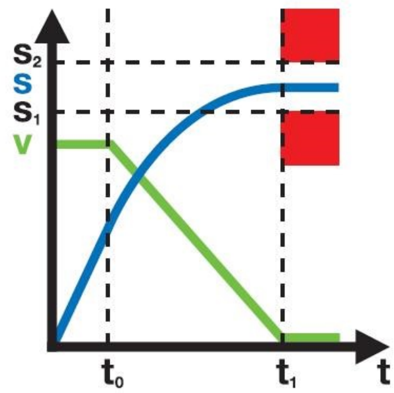


3.13.4 Safe Operating Stop (SOS)

455 / / / The "Safe Operating Stop" (SOS) function monitors the stop position that has been reached and prevents any deviation from this position outside a defined range (position window s1-s2).

The drive's control functions are maintained in full. If the position stays outside of the monitored window, the drive is shut down safely and an error message is triggered.

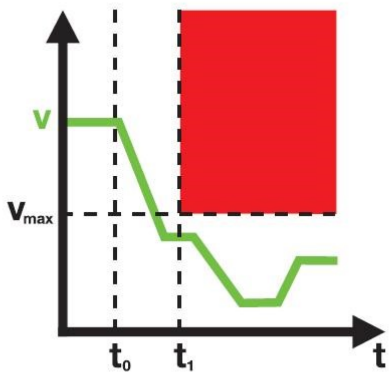
456 / / /



3.13.5 Safely Limited Speed (SLS)

458 / / / The “Safely Limited Speed” (SLS) function monitors the drive to check that it stays within a defined speed limit (vmax). If the speed limit value is exceeded, the drive is shut down safely and an error message is triggered.

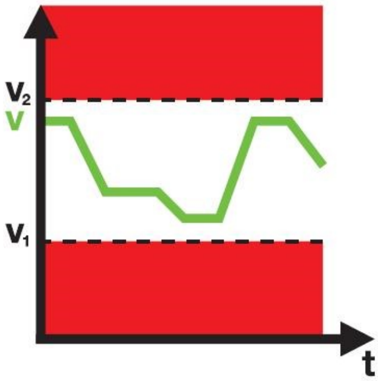
459 / / /



3.13.6 Safe Speed Range (SSR)

461 / / / With the “Safe Speed Range” (SSR) safety function, the drive's current speed value is monitored to ensure it stays within a maximum permitted limit value. If the speed limit value (v2) is exceeded, the drive is shut down safely and an error message is triggered.

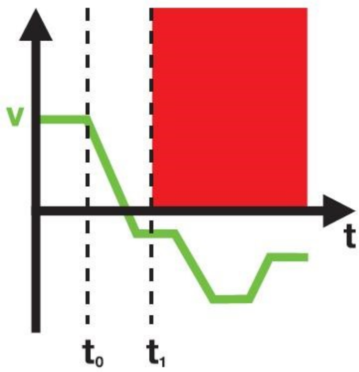
462 / / /



3.13.7 Safe Direction (SDI)

464 / / / The “Safe Direction” (SDI) function guarantees that a drive can only move in one (defined) direction. If the specified direction is violated, the drive is shut down safely and an error message is triggered.

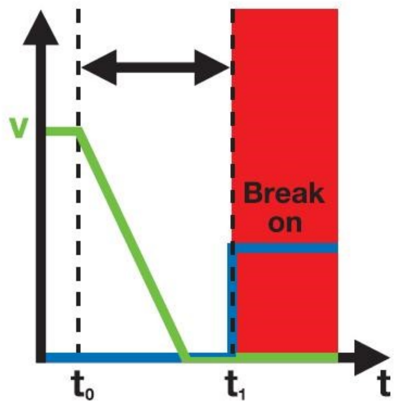
465 / / /



3.13.8 Safe Brake Control (SBC)

467 / / / The “Safe Brake Control” (SBC) function prevents suspended loads from falling. Because the drive torque no longer affects the mechanics when the output stage is shut down, on some applications (e.g. suspended loads) it is necessary to drive an external service brake. For safe brake control, the approvals body will always specify an additional safe brake test.

468
/ / /



469 The above designated safety functions are not considered to form an exhaustive list. In some
/ / / cases, further safety-related systems external to the PDS(SR) (for example a mechanical brake) may be necessary to maintain the safe condition when electrical power is removed.

157 The technical measures required to implement these functions shall depend on the SIL
/ / / capability and the required probability of dangerous hardware failure.

3.14 Network/Fieldbus systems

3.14.1 Control

158 In general, the connection between control units and field devices shall be established
D/ / / exclusively with an Ethernet-based fieldbus.

3.14.2 Power over Ethernet (PoE)

159 If Power over Ethernet (PoE) is used, the configuration (levels, connection, cables, etc.) shall
/ / / be of the following type:

•PoE requires category 5 cable or higher;

•Voltage is 44 V minimum with 350 mA rated current;

•12.95 W are normally available for each subsystem (deduced power dissipated by joule effect in cables);

•The POE system shall be in compliance with IEEE 802.3at. In this case all pairs are used in the cable to allow up to 25 W of power available for the subsystem.

3.14.3 Safety

160 D/ / / Connection between safety units and field devices shall be established either with Profisafe over Ethernet or Twinsafe

3.15 Technical Documentation

3.15.1 General

161 / / / The information provided may vary with the complexity of the electrical equipment. For very simple equipment, the relevant information may be contained in one document, provided that the document shows all the devices of the electrical equipment and enables the connections to the supply network to be made. Otherwise, documentation shall contain what is mentioned in the following sections.

162 / /I/ Data sheets and manuals of all COTS equipment shall be provided.

163 / /I/ Complete technical documentation in English language shall be part of the delivery, in both printed (2 copies) and electronic format (editable native + PDF). Technical documentation as described below is within the scope of work and acceptance can't be granted if it is partially missing.

3.15.2 Information to be provided with the electrical equipment

477 / /I/ The information provided with the electrical equipment shall include:

- clear/comprehensive description of equipment, installation & mounting.
- electrical supply requirements and description of connection to them.
- information on physical environment where appropriate.
- overview (block) diagram(s) where appropriate symbolically representing the electrical equipment together with its functional interrelationships.

- circuit diagram(s).
- information (as applicable) on :
- programming, as necessary for use of equipment
- sequence of operation
- frequency of inspection
- frequency and method of functional testing
- guidance on adjustment, maintenance and repair
- recommended spare parts list
- list of tools supplied
- final configuration, parameter set and application software (e.g. for variable speed drives).
- description (incl. interconnection diagrams) of the safeguards, interlocking functions, and interlocking of guards against hazards.
- description of the safeguarding and means provided where it is necessary to suspend safeguarding (e.g. for maintenance, setting).
- instruction on procedure for securing the machine for safe maintenance.
- information on handling, transportation and storage.
- info on load current, peak starting currents, permitted voltage drop.
- info on any residual risks due to protective measures adopted, indication of whether any training is required, specification of any necessary personal protective equipment.

3.15.3 Requirements applicable to all documentation

499 / /I/

- in accordance with relevant parts of EN 61082-1.
- reference designations: according to relevant parts of EN 81346.
- instructions/manuals in accordance with EN 82079.
- parts lists in accordance with EN 62027, class B providing info necessary for ordering spare or replacement parts required for preventive or corrective maintenance incl. those in stock by user.
- proper referencing.

3.15.4 Installation documents

505 / /I/

- shall give all info necessary to set up machine (incl. commissioning).

· Complete wiring lists, containing for each wire or cable at least the following:

· position, tye and cross-sectional area of supply cables indicated. Basic characteristics of wire or Cable, as e.g. type, cross section or Nr of conductors x cross section or Nr of fibre optics and nom. diameter, etc.

· colour of wire or cable conductor.

· first and second connection point ("Location code") so as to easily identify the origin and destination of the connection in the Layout diagram.

· Identification code of cable and terminal.

· approximate length of wire/cable.

· data supplied for choosing the type, characteristics, rated current and setting of the overcurrent protective devices.

· info on size, purpose and location of any ducts to be provided by user.

· info on size, type and purpose of any ducts/cable trays/cable supports between machine and associated equipment to be provided by user.

· indication on where space is required for removal or servicing.

· where appropriate, provision of interconnection diagram showing all info about external connections. Terminal diagrams defining connection terminals for all devices, equipment and subsystems.

3.15.5 Circuit diagrams

518 / /I/

· shows all electrical circuits on the machine and its associated equipment, especially in the case of custom made equipment and circuit boards (“non-COTS equipment").

· symbols not in EN 60617 shall be separately shown and described.

· where appropriate: diagram showing terminals for interface connections.

· switch symbols to be shown in the state where all supplies are turned off (e.g. electricity, water) and with the machine ready for a normal start.

· conductors identified in accordance with the requirements on identification.

· tag list, full bi-directional cross reference.

· Layout diagrams indicating the position and "Identification code" of all devices, equipment and subsystems. These codes shall be permanently marked near or on (if not removable) the devices, to facilitate device recognition. Layout diagrams shall incorporate also when applicable "Location codes" to define in the wiring lists the different physical locations of the system or equipment.

· Detailed schematic diagrams, mentioning "Identification codes" for non-COTS equipment.

· Detailed single line (power system) diagrams mentioning "Identification codes".

· Communication diagram (e.g. of network) when applicable.

· In case of custom made electronic boards, the complete circuit diagram for each board.

· If custom printed circuit boards are fabricated by consortia or 3rd parties, the original CAD files - schematic, layout, BOM (e.g. Altium, Cadstar, Mentor, etc.) shall be delivered including a complete set of Gerber and drill files for reproduction. In case of intellectual property rights claimed by third parties, this is not necessary.

3.15.6 Operating manual

531 / /I/ •Shall contain proper procedures for set-up and use of electrical equipment.

532 / /I/ Where the device/equipment/machine can be programmed detailed information on:

•methods of programming, tools and equipment required.

•program verification and safety procedures where required.

•full program documentation with English comments and a logic diagram.

3.15.7 Maintenance manual

534 / /I/ •proper procedures for adjustment, servicing, preventive inspection and repair, recommendation on maintenance/service intervals and records.

535 / /I/ •where methods for verification of proper operation (e.g. software testing programs) are provided: details on use of those methods.

3.15.8 Technical Construction File

537 / / / The Technical Construction File (TCF) is the complete documented supporting evidence of compliance of a system applying the steps explained in section 3.2.1.

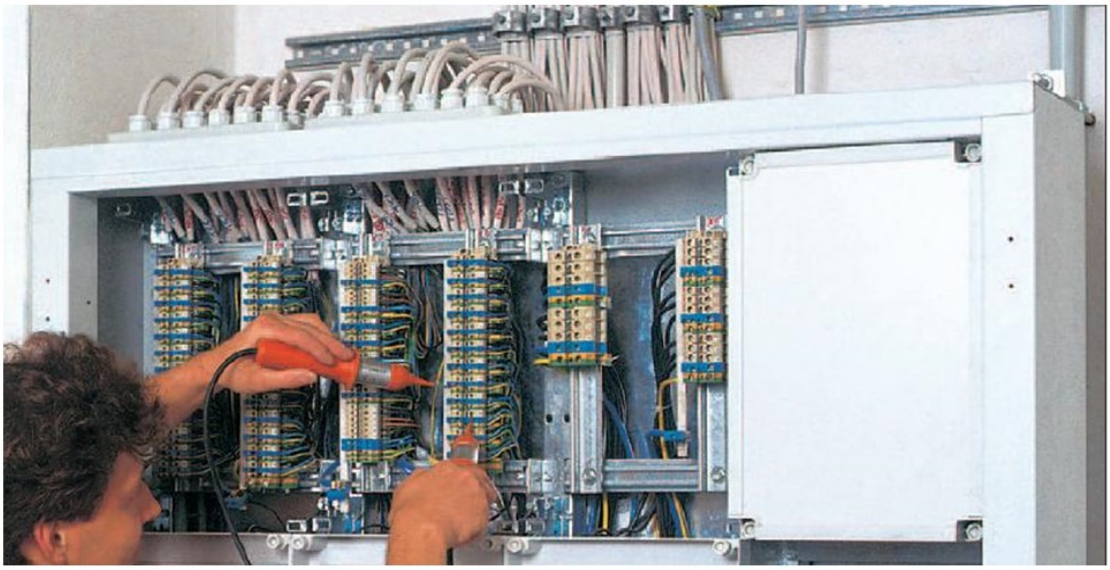
164 / /I/ All relevant information to presume compliance with the EHSRs of the Applicable Directives using harmonized standards and with the ESO requirements shall be delivered in the form of a TCF including the Declaration of Conformity (DOC) sheet.

538 / / / To give an example, among others, the TCF includes documented safety relevant information like check lists, hazard analysis and risk assessment, test reports, etc.

4. Tests/verification

4.1 General

541 / / /



165 / /I/T Systems, subsystems and equipment shall be checked for compliance according to the requirements described in the harmonised standards that are most applicable to them. For machinery (see definition in section 2.2) the standard EN 60204-1 (AD1) provides the harmonised requirements in the electrical/electronic area. For non-COTS equipment usually EN 61010-1 (AD6) will be considered applicable.

166 / /I/T Low voltage electrical installations shall be checked for compliance according to AD2.

542 / / /T According to what has been said in section 3.2.1 a system or subsystem shall be exposed to safety verification tests that are required as per the most applicable standard. The following sections detail some of the most frequently required tests to be complied with.

4.2 Safety relevant tests

4.2.1 Continuity of protective bonding

167 / / /T All protective earth (PE) and bonding conductors must be tested to ensure that they are electrically safe and correctly connected. Provided that the supply is not yet connected, it is permissible to disconnect the protective and equipotential conductors from the main earthing terminal to carry out testing. Where the mains supply is connected, as will be the case for periodic testing, the protective and equipotential conductors must not be disconnected because if a fault occurs these conductors may rise to a high potential above earth. In this case, an earth-fault loop tester can be used to verify the integrity of the protective system. Where earth-fault loop impedance measurement of the installation is carried out, this will remove the need for protective conductor tests because that conductor forms part of the loop. However, the loop test cannot be carried out until the supply is connected, so testing of the protective system is necessary before supply connection, because connection of the supply to an installation with a faulty protective system could lead to danger.

4.2.2 Insulation resistance test

168 / / /T The Insulation Resistance Test consists in measuring the Insulation resistance of a device under test, while phase and neutral are short circuited together. The measured resistance has to be higher than the limit indicated by the international standards.

546 / / / An insulation resistance tester is used to measure the impedance value of an insulator supplied from a voltage source. To measure a high value resistance, techniques for measuring a low value current are used. A constant voltage source is applied to the resistance to be measured and the resulting current is read on a highly sensitive ammeter circuit that can display the resistance value.

4.2.3 Possible destructive tests for non-COTS equipment

548 /A/ / In general destructive tests that may be required by harmonised standardisation shall be avoided in case analysis shows that such tests are unreasonable.

4.3 EMC tests

550 See section 3.3.
/ / /

5. Legacy standards not for E-ELT designs

5.1 Optical fibre

169 Optical fibre type shall be multi-mode with 50µm core (OM4 transmission standard) for link
/ /I/ distances up to 400 meters and single-mode (OS2 transmission standard) for link distances over 400 meters. All fibres shall be certified for 10Gbit/s operation according to ANSI/TIA-568-C.3. In some specific applications, after ESO approval, 1Gbit/s certification may be considered.

170 For projects, like ALMA and VLT, the choice shall be made according to the following listed
/ /I/ types dependent on application.

•ST-type for 10 base FL Ethernet.

•SC-type for 155 Mbps ATM

•LC-type

•Connector types for 100 Mbps and 1000 Mbps Ethernet to be consulted with ESO

553 / / /

Figure 20: Legacy fibber optics standards

5.2 Network /Fieldbus system

171 D/ / / For the other projects like VLT, the communication between different subsystems shall make use of any of the standardised network or field-bus protocol listed below.

Selected bus systems:

- Ethernet;
- Ethercat;
- Profinet;
- CAN bus;
- Profibus (with prior approval of ESO).

5.3 LCU electric power

172 D/ /I/ As a basic principle a local control unit (LCU/PLC) shall be powered by the UPS supply of the ESO Observatory power supply system. Deviations of this principle shall require prior approval by ESO.

5.4 VLT cabinets Electric power distribution system

558 A general single phase power distribution scheme for cabinets taking into account the above
/ / / requirements on electric power distribution is displayed below. The mains filter may be placed
ahead of the RCD to prevent nuisance tripping due to filter leakage currents.

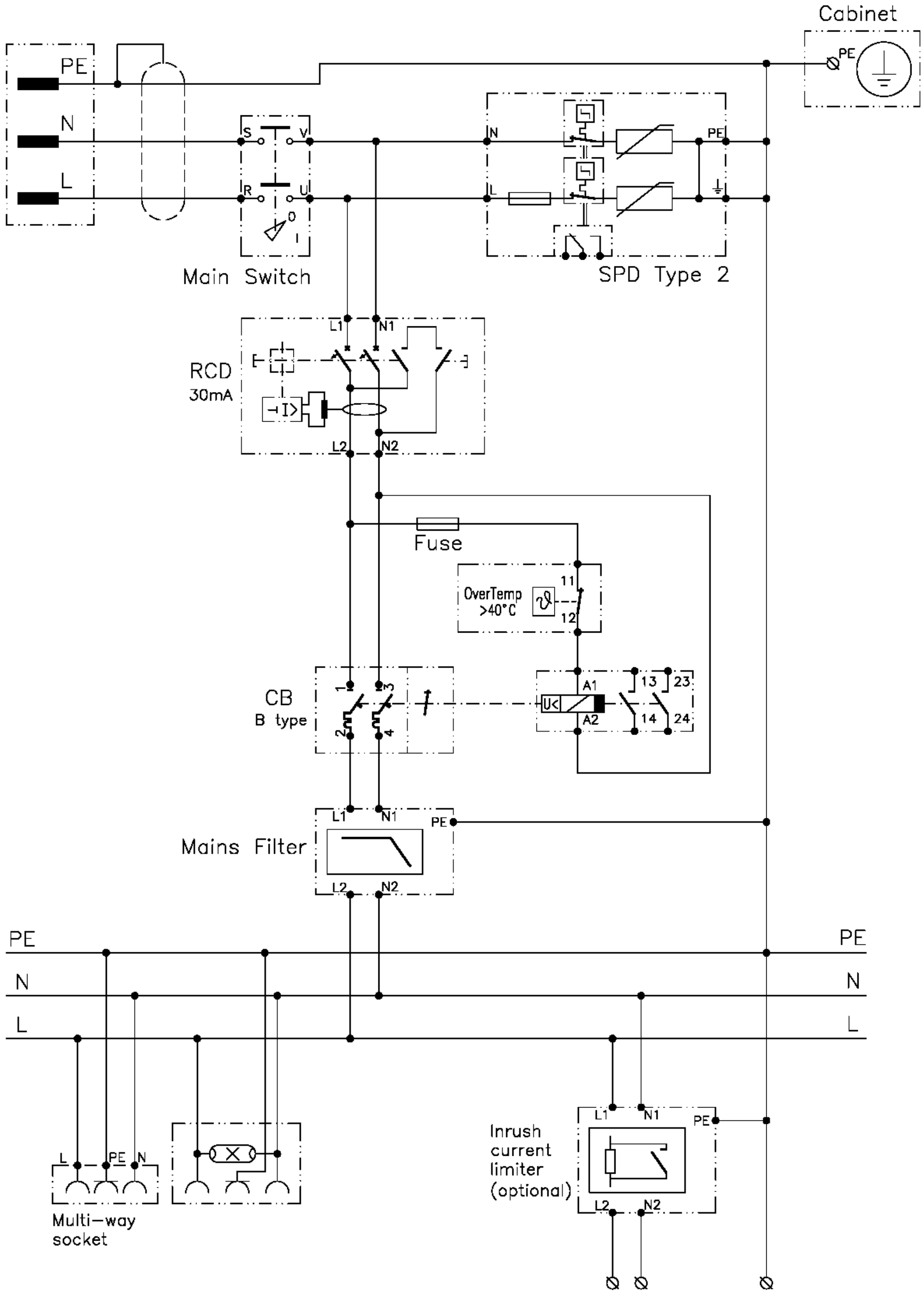


Figure 21: General electrical distribution scheme for single phase cabinets

5.5 VLT interlock and E-STOP

173 D/ /I/ For projects like VLT, the implementation of the interlock and emergency stop functions shall meet the required Safety Integrity Level (SIL) determined as outlined in section 3.2.3.2; safety logic could be implemented either in software running on safety-certified Programmable Logical Controller (PLC), or making use of certified safety relays and associated technologies.

6. Annex: E-ELT cabinet electric distribution scheme

562 / / / Single phase power distribution scheme for cabinets taking into account R123, R124, R125 requirements. The mains filter may be placed ahead of the RCD to prevent nuisance tripping due to filter leakage currents.

563
/ / /

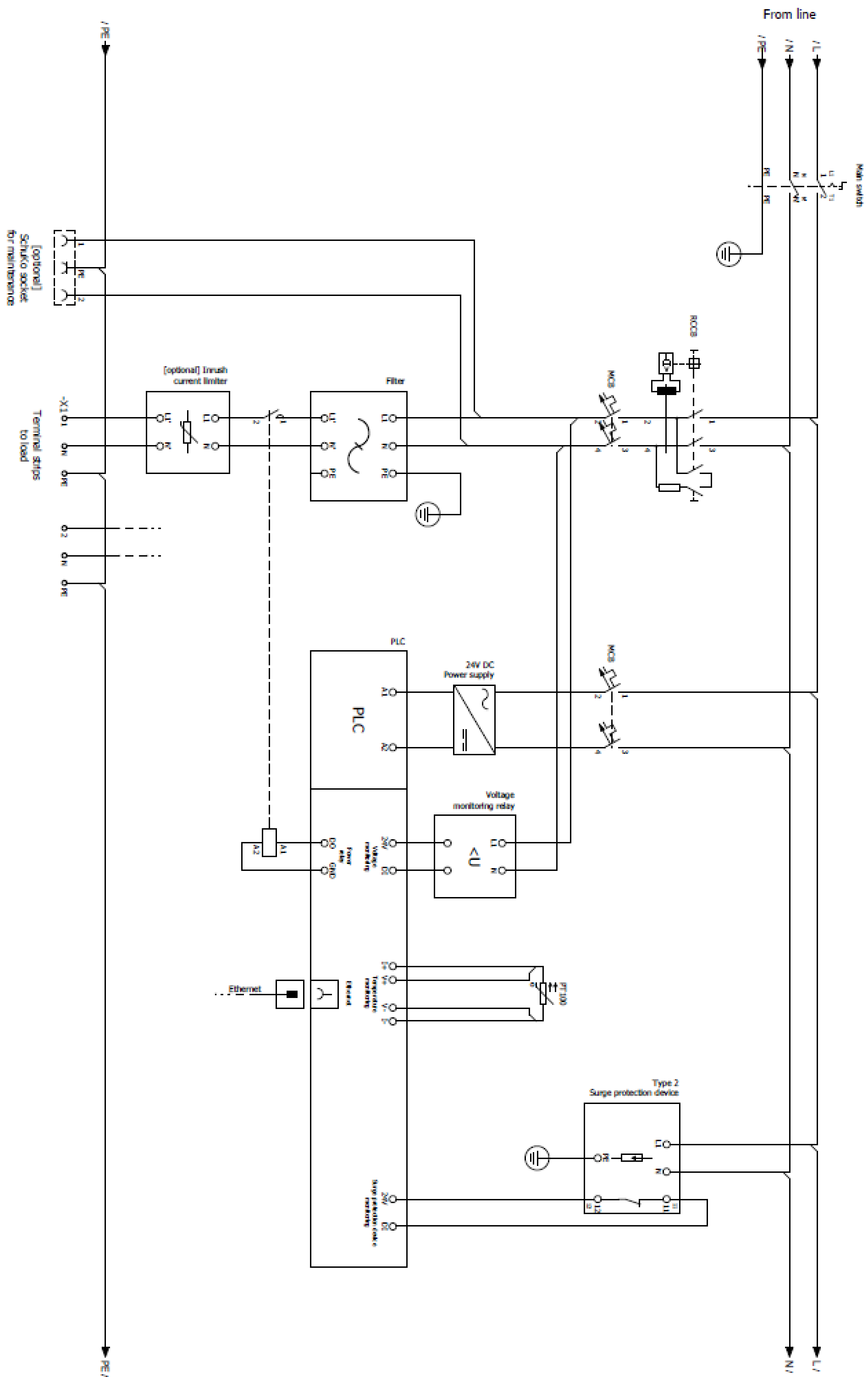


Figure 22: General electrical distribution scheme for single phase cabinets

564 Three phase power distribution scheme for cabinets taking into account R123, R124, R125
/ / / requirements. The mains filter may be placed ahead of the RCD to prevent nuisance tripping due to filter leakage currents.

565

/ / /

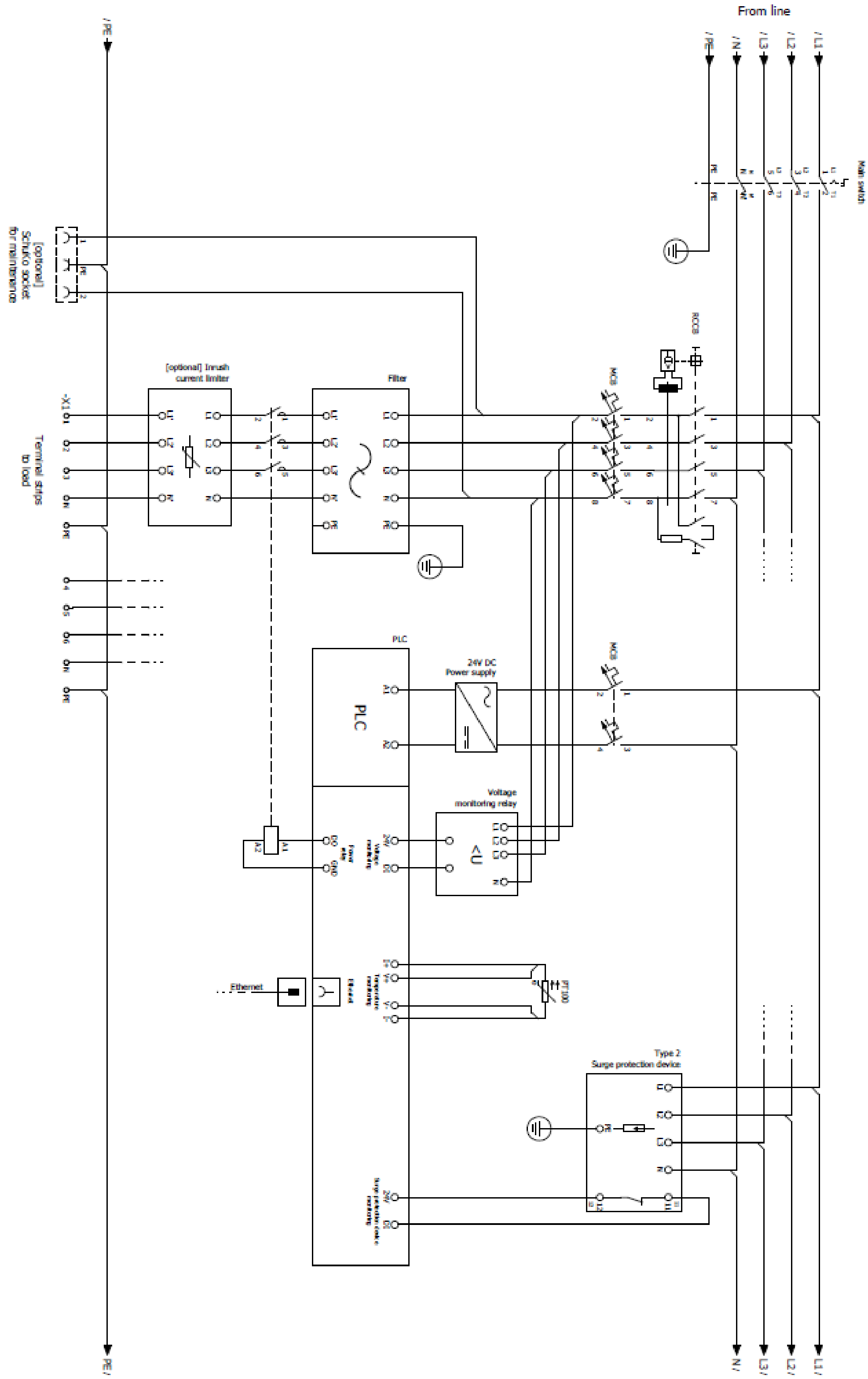


Figure 23: General electrical distribution scheme for three phase cabinets

566 **___End of document___**

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