

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Programmable controllers –
Part 2: Equipment requirements and tests**

**Automates programmables –
Partie 2: Exigences et essais des équipements**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PROGRAMMABLE CONTROLLERS –

Part 2: Equipment requirements and tests

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61131-2 has been prepared by subcommittee 65B: Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation.

This third edition of IEC 61131-2 cancels and replaces the second edition published in 2003 and constitutes a technical revision.

This third edition includes the following significant technical changes with respect to the previous edition.

- a) DC power port requirements have been moved from Clause 8 to Clause 5.
- b) Correction of the following tests of Clause 6:
 - voltage range test;
 - fast supply voltage variation test;
 - slow supply voltage variation test;
 - gradual shut-down/start-up test.

- c) Change of EMC requirements in Clause 8:
- requirements for radiofrequency interference in Table 33 changed from 3 V to 10 V for Zone B equipment;
 - reference to EMC basic standards with the last version;
 - reference to generic standards 61000-6-x;
 - cable length aligned to generic standards.
- d) Correction of the following tests in Clause 9:
- voltage dips and interruptions – power port type tests and verifications.
- e) New organization of Clause 11:
- equipment types and protection;
 - open PLC-system equipment;
 - enclosed PLC-system equipment:
 - Class I equipment;
 - Class II equipment;
 - Class III equipment;
 - protection against electric shock;
 - definition of secondary circuits which do not pose a risk of electric shock:
 - Class 2 circuit;
 - limited voltage/current circuit;
 - limited voltage circuit;
 - limited energy circuit ≤ 30 V a.c. or 42,2 V peak;
 - limited impedance circuit;
 - protection against the spread of fire within limited power circuits;
 - protective earthing requirements for enclosed equipment;
 - minor improvements in different subclauses;
 - impulse test only for verification of clearances.

This bilingual version (2012-05) corresponds to the monolingual English version, published in 2007-07.

The text of this standard is based on the following documents:

FDIS	Report on voting
65B/623/FDIS	65B/636/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The list of all parts of the IEC 61131 series, under the general title *Programmable controllers*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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INTRODUCTION

IEC 61131-2 is part of a series of standards on programmable controllers and the associated peripherals and should be read in conjunction with the other parts of the series.

Where a conflict exists between this and other IEC standards (except basic safety standards), the provisions of this standard should be considered to govern in the area of programmable controllers and their associated peripherals.

Compliance with IEC 61131-2 cannot be claimed unless the requirements of 7.2 are met.

Service and physical environment requirements are specified in Clause 4. Functional requirements are specified in Clause 5. Electromagnetic compatibility requirements are specified in Clause 8. Safety requirements are specified in Clause 11.

Terms of general use are defined in IEC 61131-1. More specific terms are defined in each part.

Withdrawn

PROGRAMMABLE CONTROLLERS –

Part 2: Equipment requirements and tests

1 General

1.1 Scope and object

This part of IEC 61131 specifies requirements and related tests for programmable controllers (PLCs) and their associated peripherals (for example, programming and debugging tools (PADTs), human-machine interfaces (HMIs), etc.) which have as their intended use the control and command of machines and industrial processes.

PLCs and their associated peripherals are intended to be used in an industrial environment and may be provided as open or enclosed equipment. If a PLC or its associated peripherals are intended for use in other environments (light industrial, commercial, residential), then the specific requirements, standards and installation practices for those other environments should be additionally applied to the PLC and its associated peripherals.

This standard also applies to any products performing the function of PLCs and/or their associated peripherals.

Equipment covered in this standard is intended for use in overvoltage category II (IEC 60664-1) in low-voltage installations, where the rated equipment supply voltage does not exceed a.c. 1 000 V r.m.s. (50/60 Hz), or d.c. 1 500 V. (If PLCs or their associated peripherals are applied in overvoltage category III installations, then additional analysis will be required to determine the suitability of the equipment for those applications.)

This standard does not deal with the functional safety or other aspects of the overall automated system. PLCs, their application programme and their associated peripherals are considered as components of a control system.

Since PLCs are component devices, safety considerations for the overall automated system including installation and application are beyond the scope of this standard. Refer to IEC 60364-1 or applicable national/local regulations for electrical installation and guidelines.

However, PLC safety as related to electric shock and fire hazards, electrical interference immunity and error detecting of the PLC-system operation (such as the use of parity checking, self-testing diagnostics, etc.), are addressed.

The object of this standard is

- to establish the definitions and identify the principal characteristics relevant to the selection and application of PLCs and their associated peripherals;
- to specify the minimum requirements for functional, electrical, mechanical, environmental and construction characteristics, service conditions, safety, EMC, user programming and tests applicable to PLCs and the associated peripherals.

This standard also specifies

- a) service, storage and transportation requirements for PLCs and their associated peripherals (Clause 4);
- b) functional requirements for PLCs and their associated peripherals (Clause 5);

- c) EMC requirements for PLCs and their associated peripherals (Clause 8);
- d) safety requirements for PLCs and their associated peripherals (Clause 11);
- e) information that the manufacturer is required to supply (Clauses 7, 10 and 14);
- f) test methods and procedures that are to be used for the verification of compliance of PLCs and their associated peripherals with the requirements (Clauses 6, 9 and 12).
- g) safety routine tests for PLCs and their peripherals (Clause 13).

The tests are type tests or production routine tests, and not tests related to the ways PLC systems are applied.

1.2 Compliance with this standard

When compliance with this standard is indicated without qualification, compliance with all clauses, including all tests and verifications required in this standard, should be verified. Moreover, the manufacturer's obligations expressed in this standard are not waived if no type test is required, or if the test conditions are restricted for practical reasons.

When compliance with some portion of this standard is indicated, it is only necessary to verify compliance with those clauses against which the compliance claim is made. The manufacturer's obligations as indicated above are still applicable. The smallest unit of this standard for compliance purposes should be a clause, such as Clauses 5, 8 or 11.

Compliance with a portion of this standard is provided to facilitate efforts with respect to particular conformity assessment requirements (for example, Clause 8, 9 and 10 as the compliance requirements for the EU electromagnetic compatibility directive or Clause 11, 12, 13 and 14 as the compliance requirements for the EU low-voltage directive).

Compliance with constructional requirements and with requirements for information to be provided by the manufacturer should be verified by suitable examination, visual inspection and/or measurement.

All requirements not tested according to the clauses on tests and verifications should be verifiable under a procedure to be agreed to by the manufacturer and the user.

The manufacturer shall provide, on request, compliance verification information for all requirements referenced in the claims of compliance with all or a portion of this standard.

It is the manufacturer's responsibility to ensure that delivered PLC equipment and associated peripherals are equivalent to the sample(s) which have been type-tested according to this standard and therefore that they comply with all requirements of this standard.

Significant modifications shall be indicated through the use of suitable revision level indexes and markings (see 5.11 and 11.15) and shall comply with this standard.

NOTE A new type test may be required to confirm compliance.

Where the manufacturer is allowed to select among several options, he shall clearly specify in his catalogues and/or datasheets those to which any portion of the PLC-system equipment complies. This applies to severity classes of voltage dips (i.e. PS1 or PS2) and types of digital inputs (i.e. Type 1 or Type 3).

1.3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60060-1:1992, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

IEC 60068-2-27:1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30:2005, *Environmental testing – Part 2: Tests – Test Db: Damp heat, cyclic (12 h + 12-hour cycle)*

IEC 60068-2-31:1969, *Environmental testing – Part 2: Tests – Test Ec: Drop and topple, primarily for equipment-type specimens*

IEC 60068-2-32:1975, *Environmental testing – Part 2: Tests – Test Ed: Free fall*

IEC 60364-1:2005, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60417, *Graphical symbols for use on equipment*

IEC 60529:2001, *Degrees of protection provided by enclosures (IP Code)*¹
Amendment 1 (1999)

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*²

Amendment 1 (2000)

Amendment 2 (2002)

IEC 60664-3:2003, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60695-2-11:2000, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products*

IEC 60695-11-10:1999, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60947-5-1:2003, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 60947-5-2:2004, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*

IEC 60947-7-1:2002, *Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors*

¹ There exists a consolidated edition 2.1 that includes edition 2.0 (2001) and its amendment.

² There exists a consolidated edition 1.2 that includes edition 1.0 (1992) and its amendments.

IEC 60950-1:2001, *Information technology equipment – Safety – Part 1: General requirements*

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated radio-frequency electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2003, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances induced by radio-frequency fields*

IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity test*

IEC 61000-4-18:2006, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory waves immunity test*

IEC 61000-4-29:2000, *Electromagnetic compatibility (EMC) – Part 4-29: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations on d.c. input power port immunity test*

IEC 61000-6-1:2005, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments*

IEC 61000-6-2:2005, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61000-6-4:2006, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61010-1:2001, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61131-1:2003, *Programmable controllers – Part 1: General information*

IEC 61131-3:2003, *Programmable controllers – Part 3: Programming languages*

IEC 61131-4:2004, *Programmable controllers – Part 4: User guidelines*

CISPR 14-1:2005, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 16-1-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*

CISPR 16-1-4:2004, Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Radiated disturbances

CISPR 16-2-1:2005, Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements

CISPR 16-2-3:2006, Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements

2 Type tests

The object of this clause is to define how to verify compliance of the PLC and the associated peripherals with the requirements set forth in this standard. This compliance verification includes

- verification by type tests given in Clauses 6, 9 and 12;
- verification by suitable examination, visual inspection or/and measurement.

These tests are qualification tests and not tests related to the ways PLCs are employed. According to the scope of this standard, the above compliance verification may not cover the verification of the ability of the PLC-system to satisfy the intended automated system requirements. Where needed, special tests, not covered by this standard, shall be agreed to by the manufacturer and the user.

In addition, routine tests are specified in Clause 13.

NOTE Peripherals, used in the same environment as the PLC-system, should meet the same requirements as the PLC-system.

2.1 Equipment to be tested (equipment under test/EUT)

PLC-systems span the range from stand-alone products to modular designs; this leads to an infinite variety of user-built actual PLC-system configurations. For obvious practical reasons, in most cases type tests cannot be conducted on EUT identical to user-built PLC-systems, and engineering judgement is necessary. Therefore, the manufacturer is required to define the EUTs and document the corresponding test plan and test programmes to meet the following principles.

Combination of tests/EUTs/test programmes shall be such that one may reasonably think that any configuration built by the user according to the manufacturer's specifications and installation instructions would pass satisfactorily the same tests, and will properly function in normal operation, which these tests are intended to reflect.

Unless otherwise specified in this standard, the manufacturer may elect to use various EUTs to achieve the objectives of a given type test.

If an EUT representing a basic PLC or a remote I/Os (RIOS) is of modular structure, it shall fulfil the following minimum requirement.

All types of modules shall be represented in one (1) or several EUT configurations in which any mix of modules is permissible.

All types of modules shall be configured in the EUTs and tested at least once.

NOTE It may be appropriate to consider statistical criteria based on samples for a large number of I/Os (for example, >100).

If there are too many families to be included into a single EUT, the manufacturer will define several EUTs as follows.

- For the type test of a family with very similar modules (i.e. modules using the same schematic and basic manufacturing and differing mainly by, for example, the number of inputs and outputs), the manufacturer may elect to include in the basic PLC-system only one (1) arbitrarily chosen member of the family. If the type test is dependent on the differences between the modules, then a single family member may not be used.
- Appropriate catalogued options, such as power supply units, application memory(ies), processing unit(s) etc. shall be used to build the relevant EUT(s).
- If a local bus extension is part of the PLC-system and if its maximum cable length is less than, or equal to, 3 m, it is considered to be an internal PLC bus. As such, it should not be considered a port for test.
- If a local bus extension is part of the PLC-system and is capable of driving cables with a length of >3 m, then only one (1) end of the link is part of the EUT and it is considered as a communication port.

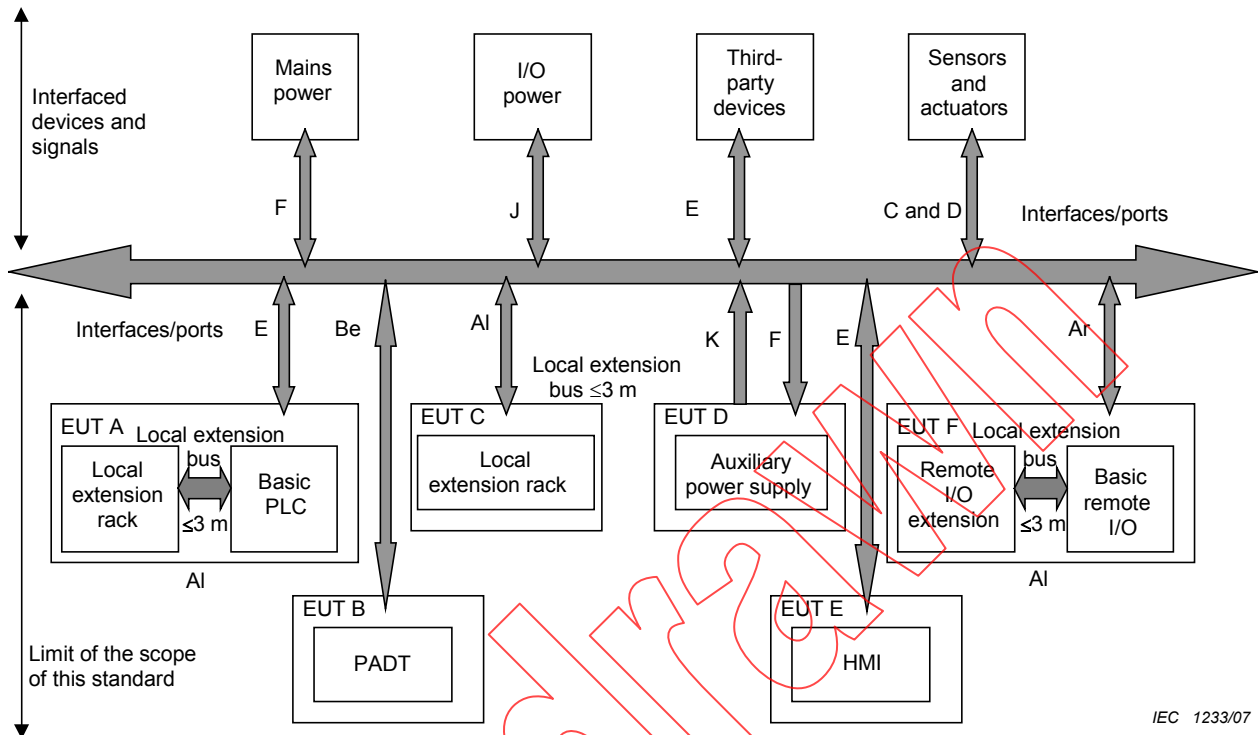
When new units/modules are introduced after initial release of a PLC-system catalogue, which has already been satisfactorily tested according to this standard, EUT(s) simpler than those originally used can be defined. This is only permissible if such EUTs and the associated test programmes provided by the manufacturer allow proper verification as if these new units/modules had been tested within the originally tested EUTs.

Unless otherwise specified in this standard, the manufacturer may elect either that each type test be conducted on a new EUT or that several type tests be performed successively on the same EUT.

Certain tests can be easily targeted at a single item, others are more appropriate to a set of items configured together. Equipment to be tested must reflect this need. See specific test clauses for recommendations for EUTs.

2.2 Special features for immunity and EMC tests

Interfaces/ports shown are meant to represent major/example links not all links. Most EUTs will have multiple interface/ports active during testing.



IEC 1233/07

Figure 1 – EUT configurations

Each subpart of the PLC-system as shown in Figure 2 may constitute an EUT represented in Figure 1 as EUT A, B, C, D, E and/or F. To exercise the different ports of each EUT, the manufacturer may define subsystems and the different EUTs are tested in turn.

Only one (1) subsystem is under test at any time, the others being considered as auxiliary equipment.

For instance, to achieve a given test on the EUT A, equipment of the other EUTs may be connected but are not in the test bed.

For example, to check the electrical interference immunity of the PLC-system, the manufacturer may choose between the following, as applicable:

- to build a single global EUT including the PADT/TE/RIOSs, and check the whole configuration; or
- to define a suite of simpler EUTs (for example, a PLC-system without any PADT/TE/RIOS, and a single PADT and a single RIOS and a single PADT and a single TE, or any other suite of partial combinations of them which make sense) but correspondingly exercise the appropriate ports of each EUT with an equipment part of the test bed (the laboratory equipment necessary to test the EUT) as would do the missing PADT/TE/RIOSs. For practical reasons, the manufacturer may elect to use actual PADTs/TEs/RIOSs to exercise the EUT ports.

At least one (1) of each type or a representative number of I/O ports of the EUT shall be connected and be functional.

A selection of the representative functional modes shall be made considering that only the most typical functions of the PLC can be tested.

2.3 Withstand test conditions

In general, the module which is in the manufacturer's catalogue should be tested alone, providing that mixing several modules does not affect the result of the test. Those clauses dealing with withstand tests for specifics should be referred to.

2.4 Verification procedure

Type tests shall be conducted on the EUT(s) defined in 2.1, unless otherwise specified.

For each test, the manufacturer shall

- specify how this configuration shall be installed and externally connected;
- provide the suitable test programmes which shall be run during the test;
- provide the proper operation verification procedure including the way to measure accuracy and temporary deviations of analogue I/Os.

The appropriate test programmes and proper functioning verification procedures provided by the manufacturer shall satisfy the requirements given in 2.5.

2.5 Requirements for test programmes and proper functioning verification procedures (PFVPs) to be provided by the manufacturer

During the type tests, there shall be no

- destruction of hardware, unless required by the test;
- modification of the operating system and test programmes and/or alteration of their execution;
- unintended modification of system and application data stored or exchanged;
- erratic or unintended behaviour of the EUT;
- deviation of the analogue I/Os out of the limits specified in item 4 of 7.10.2 and item 3 of 7.11.2.

All relevant functions and parts of the EUT (i.e. units and modules) shall be functioning in such a way that the information paths to/from these functions and parts are exercised.

All the I/O and communication channels of the EUT shall be exercised.

NOTE It is acceptable to apply statistical criteria based on samples, for large number of I/Os, etc. (for example, >100).

All external and internal product status information reporting means, such as displays, lamps, alarm signals, self-test result registers, shall be exercised. The test procedures shall include conditions to verify the related activities.

All various PLC-system operation modes significant for the user's implementation such as start-up and shut-down, cold/warm/hot restart, "normal run", "normal stop", "programme/monitor with PADTs", etc., as applicable, shall be verified for performance and behaviour.

Initialization and reset conditions of all system components shall be checked for controlled start-up and shut-down. The various modes, such as "run", "programme", "monitor", shall be verified for performance and behaviour.

Any special feature/performance not covered in this standard but necessary for the proper operation of the basic PLC-system shall be exercised and tested.

2.6 General conditions for tests

The tests shall be carried out in accordance with the appropriate test procedure.

The tests shall be carried out under the general test conditions given in Table 1, unless otherwise specified.

Unless otherwise specified, no sequence is imposed for type tests.

Table 1 – General conditions for tests

	Test conditions
Equipment power supply	Rated voltage and frequency
Temperature	15 °C to 35 °C
Relative humidity	≤75 %
Barometric pressure	86 kPa to 106 kPa (650 mm Hg to 800 mm Hg)
Output loads	Outputs loaded to rated load
Pollution	Pollution degree 2

3 Terms and definitions

For the purposes of this document, the following terms and definitions, in addition to those given in IEC 61131-1, apply.

3.1

analogue input

device which converts a continuous signal to a discretely valued multi-bit binary number, for use by the PLC-system

3.2

analogue output

device which converts a multi-bit binary number from the PLC-system to a continuous signal

3.3

accessible

able to be touched by the jointed test finger or test pin, when installed as intended; see 12.1.2, 12.1.3 and Annex C

3.4

basic PLC (-system)

configuration which consists, at a minimum, of a processing unit, power supply and I/O; see Figure 2

3.5

battery

electrochemical energy source which may be rechargeable or non-rechargeable

3.6

clearance

shortest distance in air between two conductive parts

[IEC 60664-1, 1.3.2]

3.7**coating, protective**

covering of suitable insulating material that encloses the clearance and/or creepage distance of the printed wiring board and conforms to the surface of the board in such a manner that the environment is excluded and the clearance and/or creepage distance can withstand the required impulse and continuous potential

NOTE Coating is normally applied to exclude the effects of atmosphere and to increase the dielectric properties of the clearance and/or creepage distances that would not normally be adequate without coating. A less effective coating may exclude the atmosphere, but cannot be relied on to enhance the dielectric properties.

3.8**comparative tracking index (CTI)**

numerical value of the maximum voltage at which a material withstands 50 drops of NH_4Cl solution (ammonia chloride) without tracking.

[IEC 60112, 3.5, modified]

3.9**creepage distance**

shortest distance along the surface of a solid insulating material between two conductive parts

[IEV 151-15-50]

3.10**current sinking**

property of receiving current

3.11**current sourcing**

property of supplying current.

3.12**digital input, type 1**

device for sensing signals from mechanical contact switching devices, such as relay contacts, push-buttons, switches, etc. Converts an essentially two-state signal to a single-bit binary number

NOTE Type 1 digital inputs may not be suitable for use with solid-state devices such as sensors, proximity switches, etc.

3.13**digital input, type 2**

device for sensing signals from solid-state switching devices such as 2-wire proximity switches. Converts an essentially 2-state signal to a single-bit binary number

NOTE 1 Two-wire proximity switches described here are designed to IEC 60947-5-2.

NOTE 2 This class could also be used for Type 1 or Type 3 applications.

3.14**digital input, type 3**

device for sensing signals from solid-state switching devices such as 2-wire proximity switches. Converts an essentially 2-state signal to a single-bit binary number

NOTE 1 This class could also be used for Type 1 applications.

NOTE 2 Type 3 digital inputs offer lower power characteristics than Type 2 digital inputs. Generally, this allows much higher input channel densities per module or product. Type 3 differs from Type 2 in that it is compatible with those IEC 60947-5-2 devices that offer low current in the off state. See Table 8 for details of operating ranges.

Proximity switch compatibility is such that a high percentage of proximity switches having Type 2 compatibility will also have Type 3 compatibility.

3.15

digital output

device which converts a single-bit binary number to a 2-state signal

3.16

earth

conducting mass of the Earth, whose electric potential at any point is conventionally taken as zero

[IEV 195-01-01]

3.17

EMC (electromagnetic compatibility)

ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[IEV 161-01-07]

3.18

enclosed equipment

equipment which is enclosed on all sides with the possible exception of its mounting surface to prevent personnel from accidentally touching live or moving parts contained therein and to protect the equipment against ingress of medium-size solid foreign bodies, and meeting requirements of mechanical strength, flammability, and stability (where applicable). Protection degree must be $\geq$ IP20

3.19

enclosure

housing affording the type and degree of protection suitable for the intended application

[IEV 195-02-35]

3.20

equipment under test (EUT)

representative configuration(s), as defined by the manufacturer, used for type tests (see Clause 2)

3.21

external wiring

wiring of the PLC-system equipment, which is installed by the user

3.22

field wiring

external wiring

3.23

functional earthing conductor

conductor that is in electrical contact with, for example, Earth, for purposes of interference immunity improvement

3.24

hand-held equipment

equipment which is intended to be held in one hand while being operated with the other hand

3.25**hazardous live**

capable of rendering an electric shock or electric burn in normal condition or single-fault condition.

NOTE See 11.2.1.1 for values applicable to normal condition and 11.2.1.2 for the values applicable to single-fault condition.

3.26**immunity (to a disturbance)**

ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[IEV 161-01-20]

NOTE Not used exclusively to refer to EMC in this standard. It may also refer, for example, to vibration, humidity, etc.

3.27**immunity type test (immunity test)**

type test verifying that the basic PLC-system operation is not altered by the application of specified influencing quantities that are intended to approximate normal operation

3.28**insulation**

all the materials and parts used to insulate conductive elements of a device

[IEV 151-15-41]

NOTE 1 Insulation can be a solid, a liquid, a gas (for example, air), or any combination. [IEV 151-03-30]

NOTE 2 (To) insulate – To prevent conduction between separate conductive bodies. [IEV 151-03-28]

NOTE 3 (To) isolate – To disconnect completely a device or circuit from other devices or circuits.

– To provide (by separation) a specified degree of protection from any live circuit. [IEV 151-03-29]

3.29**basic insulation**

insulation of hazardous live parts, which provides basic protection.

[IEV 195-06-06]

NOTE This concept does not apply to insulation used exclusively for functional purposes.

3.30**double insulation**

insulation comprising both basic insulation and supplementary insulation

[IEV 195-06-08]

3.31**reinforced insulation**

insulation of hazardous live parts which provides a degree of protection against electric shock equivalent to double insulation

NOTE Reinforced insulation may comprise several layers which cannot be tested singly as basic or supplementary insulation.

[IEV 195-06-09]

3.32**supplementary insulation**

independent insulation applied in addition to basic insulation, for fault protection

[IEV 195-06-07]

**3.33
interface**

shared boundary between a considered system and another system, or between parts of a system, through which information or electrical energy is conveyed

**3.34
internal wiring**

wiring which is inside the PLC-system equipment, which is installed by the manufacturer

**3.35
isolated (devices, circuits)**

devices or circuits without galvanic connection between them

**3.36
live part**

conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor

NOTE This concept does not necessarily imply a risk of electric shock.

[IEV 195-02-19]

NOTE 1 PEN conductor – conductor combining the functions of both a protective earthing conductor and a neutral conductor. [IEV 195-02-12]

NOTE 2 PEM conductor – conductor combining the functions of a protective earthing conductor and a mid-point conductor. [IEV 195-02-13]

NOTE 3 PEL conductor – conductor combining the functions of both a protective earthing conductor and a line conductor. [IEV 195-02-14]

**3.37
material group**

classification of insulating materials in terms of comparative tracking index (CTI) range (see 11.4.3)

**3.38
micro-environment**

ambient conditions which surround the clearance or creepage distance being reviewed

NOTE The micro-environment of the clearance or creepage distance and not the environment of the equipment determines the effect of the insulation. The micro-environment may be better or worse than the environment of the equipment. It includes all factors influencing the insulation, such as climatic, electromagnetic, pollution, etc. (IEC 60664).

**3.39
module**

part of the PLC-system containing an identified function(s) (MPU, analogue input, etc.), which may plug into a backplane or base

**3.40
multi-channel module**

module containing multiple input and/or output signal interfaces which could be isolated or not isolated from each other

**3.41
normal use**

operation, including stand-by, according to the instructions for use or for the obvious intended purpose

NOTE Normal service conditions are stated in Clause 4.

3.42

normal condition

condition in which all means for protection against hazards are intact that is, a fault-free condition

3.43

open equipment

equipment that may have live electrical parts accessible, for example, a main processing unit. Open equipment should be incorporated into other assemblies manufactured to provide safety

3.44

operator

person commanding and monitoring a machine or process through an HMI connected to the PLC. The operator does not change the PLC hardware configuration, software or the application programme. A PLC is not intended for use by untrained personnel. The operator is assumed to be aware of the general hazards in an industrial environment

3.45

overvoltage category (of a circuit or within an electrical system)

classification based on limiting (or controlling) the values of prospective transient overvoltages occurring in a circuit (or within an electrical system having different nominal voltages) and depending upon the means employed to influence the overvoltages.

[IEC 60664-1, 1.3.10, modified]

NOTE 1 In an electrical system, the transition from one overvoltage category to another of lower category is obtained through appropriate means complying with interface requirements. These interface requirements may be an overvoltage protective device or a series-shunt impedance arrangement capable of dissipating, absorbing, or diverting the energy in the associated surge current, to lower the transient overvoltage value to that of the desired lower overvoltage category.

NOTE 2 Equipment covered in this standard is intended for use in overvoltage category II.

3.46

permanent installation

portion of the PLC-system which is required to perform the intended application function

NOTE See Annex A.

3.47

pollution degree (in the micro-environment)

for the purpose of evaluating clearances and creepage distances, three degrees of pollution in the micro-environment are established

NOTE 1 The conductivity of a polluted insulation is due to the deposition of foreign matter and moisture.

NOTE 2 The minimum clearances given for pollution degrees 2 and 3 are based on experience rather than on fundamental data.

3.48

pollution degree 1

no pollution or only dry, non-conductive pollution occurs. The pollution has no influence

3.49

pollution degree 2

normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected

3.50

pollution degree 3

conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation, which is expected

3.51

port

access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

NOTE Most commonly used with respect to EMC.

[IEV 131-12-60]

3.52

portable equipment

enclosed equipment that is moved while in operation or which can easily be moved from one place to another while connected to the supply

NOTE Examples are programming and debugging tools (PADTs) and test equipment (TE).

3.53

protective conductor

conductor provided for purposes of safety, for example, protection against electric shock

[IEV 195-02-09]

3.54

protective extra-low voltage (PELV) circuit

electrical circuit in which the voltage cannot exceed a.c. 30 V r.m.s., 42,4 V peak or d.c. 60 V in normal and single-fault condition, except earth faults in other circuits.

A PELV circuit is similar to an SELV circuit that is connected to protective earth

3.55

protective impedance

single component regarded as fault-free, a combination of components, or a combination of basic insulation and a current or voltage-limiting device, the impedance, construction and reliability of which are such that when connected between parts which are hazardous live and accessible conductive parts, it provides protection to the extent required by this standard in normal and single-fault condition

3.56

public mains

power from the conductors/mains of the permanent installation of the building

3.57

recurring peak voltage

peak value of a generated voltage whose characteristic is recurring at some specified period

3.58

routine test

conformity test made on each individual item during or after manufacture

[IEV 151-16-17]

3.59

safety extra-low voltage circuit (SELV circuit)

electrical circuit in which the voltage cannot exceed a.c. 30 V r.m.s., 42,4 V peak or d.c. 60 V in normal and single-fault condition, including earth faults in other circuits.

An SELV circuit is not connected to protective earth

3.60

service personnel

person changing or repairing the PLC hardware configuration or the application programme

The service person may also install software updates provided by the manufacturer. They are assumed to be trained in the programming and operation of the PLC equipment and its use.

They are persons having the appropriate technical training and experiences necessary to be aware of hazards – in particular, electrical hazards – to which they are exposed in performing a task and of measures to minimize danger to themselves or to other persons or to the equipment.

3.61

total output current (of an output module)

current that a multi-channel module operating at the most adverse combination of normal operation can supply without any part of it (insulation, terminals, exposed conductive parts, etc.) exceeding the specified temperature limits

NOTE For a multi-channel module, the total output current is generally less than the sum of the output currents of the channels.

3.62

type test

conformity test made on one or more items representative of the production

[IEV 151-16-16]

3.63

unit

integral assembly (which may consist of modules plugged in or otherwise connected within the assembly) connected to other units within the system by means of cables for permanently installed units and cables or other means for portable units

3.64

withstand type test (withstand test)

type test verifying that the application of more severe influencing quantities to the basic PLC-system does not impair its ability to assume its intended mission

3.65

working voltage

highest value of the a.c. (r.m.s) or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage (U_e)

Transients are disregarded.

Both open-circuit conditions and normal use are taken into account.

4 Normal service conditions and requirements

It is the user's responsibility to ensure that the equipment service conditions are not exceeded. The PLC and PLC-system is intended to be used in an industrial environment.

The user shall ensure the installation conditions match the environmental conditions given in this standard.

4.1 Climatic conditions and requirements

4.1.1 Operating ambient air temperature

The equipment shall be suitable for the operating temperature ranges given in Table 2.

Table 2 – Operating ambient air temperature of PLC-systems

	Type of limit	Enclosed equipment	Open equipment
Temperature range	Max.	40 °C	55 °C
	Min.	5 °C	5 °C

For non-ventilated equipment that is cooled by natural air convection, the equipment ambient air temperature is the temperature at a point not more than 50 mm away from the equipment, on a horizontal plane located at the vertical mid-point of the equipment.

For ventilated equipment, the equipment ambient temperature is the temperature of the incoming air, at a point not more than 50 mm from the plane of the equipment's air flow entry point.

No forced external cooling is assumed. Open peripherals, which are intended to be permanently installed as part of the PLC-system, shall meet the operating temperature range of the PLC.

Some types of equipment (for example, panel-mounted HMI, etc.) can use a combination of open and enclosed characteristics.

The requirements of this subclause are verified in accordance with 6.2 and 6.2.1.

4.1.2 Relative humidity

The equipment shall be suitable for a relative humidity level from 10 % to 95 %, non-condensing.

The requirements of this subclause are verified in accordance with 6.2.2.

4.1.3 Altitude

The equipment shall be suitable for operation up to 2 000 m.

No test required.

4.1.4 Pollution degree

Where not otherwise specified by the manufacturer the equipment is designed for use in pollution degree 2.

4.2 Mechanical service conditions and requirements

Vibration, shock and free-fall conditions vary widely depending on the installation and environment and are very difficult to specify.

For the purpose of this standard, the service conditions are indirectly defined by the following requirements which apply to fixed equipment as well as to unpackaged portable and hand-held equipment (see exceptions in 4.2.2). They do not apply to equipment containing assemblies other than PLC-systems and/or associated peripherals.

Experience shows that equipment meeting these requirements is suitable for industrial use on stationary installations.

Fixed equipment is equipment which is part of the permanent installation.

4.2.1 Vibrations

Immunity requirements are as shown in Table 3.

Table 3 – Sinusoidal vibrations service conditions for PLC-systems

Frequency range Hz ²	Continuous ¹	Occasional ¹
$5 \leq f < 8,4$	1,75 mm displacement, constant amplitude	3,5 mm displacement, constant amplitude
$8,4 \leq f \leq 150$	0,5 g acceleration, constant amplitude	1,0 g acceleration, constant amplitude
¹ All amplitude figures are peak values. ² The crossover frequency, approximately 8.4 Hz, should be adjusted to yield a smooth cross-over without discontinuity, from the constant amplitude displacement requirement to the constant amplitude acceleration requirement. NOTE $g_{\text{peak}} = 0,004024 f^2 D_{\text{peak}}$		

Vibration is applicable to each 3 mutually perpendicular axes.

The manufacturer shall specify the method of mounting portable and hand-held peripherals on the test equipment.

The requirements of this subclause are verified in accordance with 6.3.1.

4.2.2 Shock

Immunity requirements are occasional excursions to 15 g, 11 ms, half-sine, in each of 3 mutually perpendicular axes.

Devices containing CRTs are excluded from this requirement.

Electromechanical relays may temporarily respond to 15 g shocks. Temporary malfunctioning is allowed during the test, but equipment should be fully functional after the test.

The requirements of this subclause are verified in accordance with 6.3.2.

4.2.3 Free falls (portable and hand-held equipment)

Immunity requirements for free falls are as shown in Table 4.

Table 4 – Free fall on concrete floor for portable and hand-held equipment

	Portable and hand-held (any weight) (withstand)	Hand-held (any weight) (immunity)	Normative items
Random drops		1 000 mm; 2 trials	1, 2, 4
Flat drops	100 mm; 2 trials		1, 4
Supported drops	30° or 100 mm; 2 trials		1, 3, 4

¹	Caution: temporary malfunctioning is allowed at the impact, but equipment shall be fully functional after the test. Therefore, if equipment is operating during the fall, erroneous operation could be introduced upon impact which may require operator correction.
²	From prescribed altitude (normal position of use) Table 18.
³	See Table 18.
⁴	Random drops are drops on any edge, surface or corner. Flat drops are only on surfaces. Supported drops are only on edges.

The requirements of this subclause are verified in accordance with 6.3.3.

4.3 Transport and storage conditions and requirements

The following requirements apply to PLC units placed within manufacturer's original packaging.

Transport and storage of unpackaged portable equipment should not exceed the requirements of 4.2.

When components are included in the equipment, that have particular limitations (for example, CMOS components, batteries, etc.), the manufacturer shall specify the arrangements to be made for transport and storage.

4.3.1 Temperature

The allowable temperature range is -40°C to $+70^{\circ}\text{C}$.

The temperature range -25°C to $+70^{\circ}\text{C}$ is acceptable, but is not recommended for future designs.

The requirements of this subclause are verified in accordance with 6.2.

4.3.2 Relative humidity

The relative humidity range is 10 % to 95 %, non-condensing.

The requirements of this subclause are verified in accordance with 6.2.2.

4.3.3 Altitude

The design atmospheric pressure for transportation shall be equivalent to 0-3000 m altitude (minimum 70 kPa).

No test required.

4.3.4 Free falls (PLC units in manufacturer's original packaging)

Withstand requirements for PLC units within manufacturer's original packaging are given in Table 5. After the test, they shall be fully functional and shall show no evidence of physical damage.

Table 5 – Free fall on concrete floor in manufacturer's original packaging

Shipping weight with packaging kg	Random free-fall drop height mm		Number of falls
	With shipping package	With product package	
<10	1000	300	5
10 to 40	500	300	5
>40	250	250	5

The requirements of this subclause are verified in accordance with 6.3.4.

4.3.5 Other conditions

The user should reach agreement with the manufacturer for any mechanical conditions that are not specified in this standard. This may include items such as extra-low temperature storage, higher altitude transportation, etc.

4.4 Electrical service conditions and requirements

4.4.1 AC and d.c. equipment power supply

Refer to 5.1.1.

4.4.2 Overvoltage category, control of transient overvoltages

The nature of the installation shall be such that overvoltage category II conditions shall not be exceeded.

Transient overvoltages at the point of connection to the equipment power supply shall be controlled not to exceed overvoltage category II, i.e. not higher than the impulse voltage corresponding to the rated voltage for basic insulation. The equipment or the transient suppression means shall be capable of absorbing the energy in the transient.

4.4.3 Non-periodic overvoltages

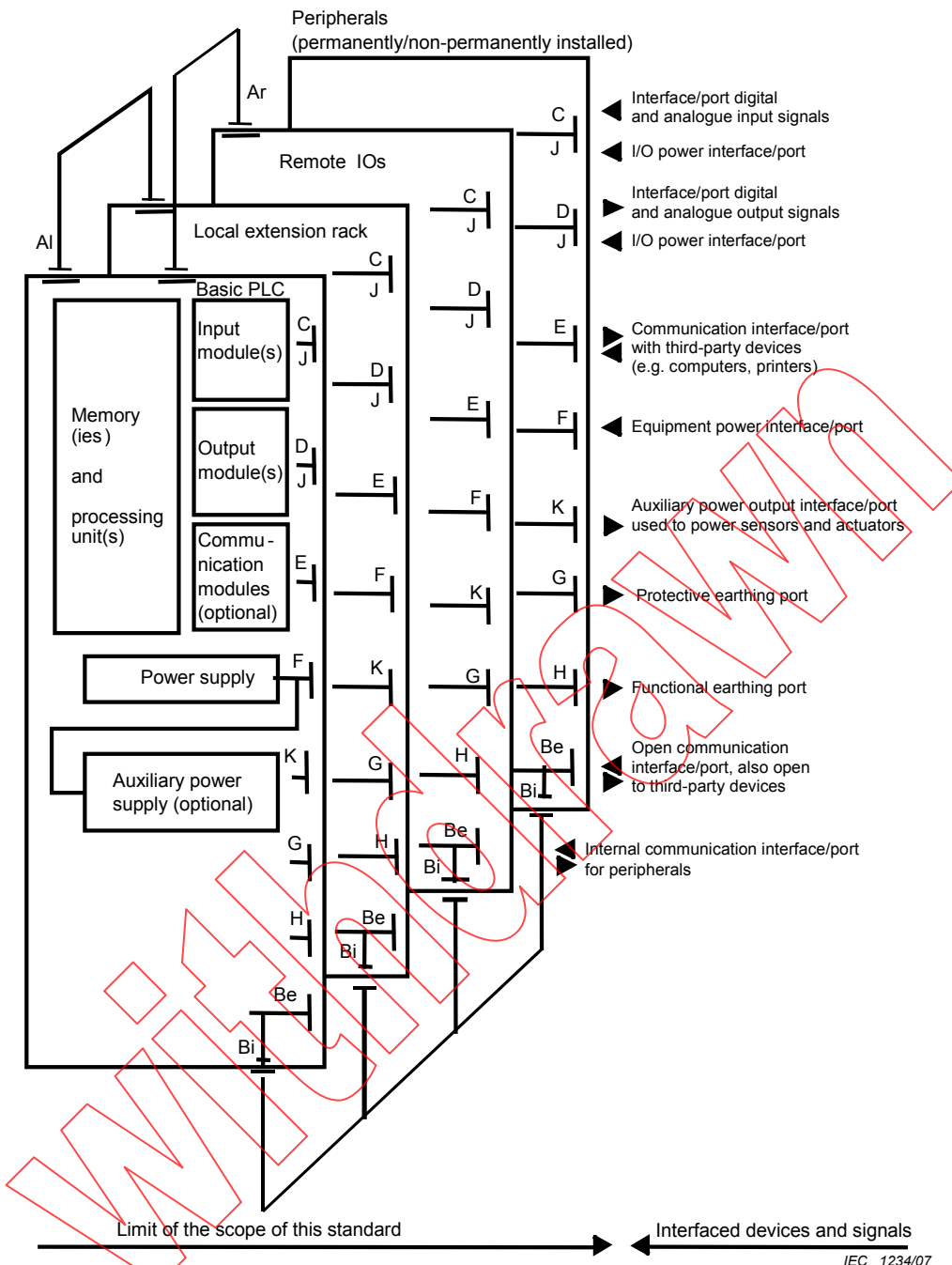
In the industrial environment, non-periodic overvoltage peaks may appear on equipment power supply lines as a result of power interruptions to high-energy equipment (for example, blown fuse on one branch in a 3-phase system). This will cause high current pulses at relatively low voltage levels (approximately $2 \times U_{\text{peak}}$). The user shall take the necessary steps to prevent damage to the PLC-system (for example, by interposing a transformer).

4.5 Special conditions and requirements

When the service conditions are more severe than those given in 4.1, 4.2, 4.3 and 4.4 or other adverse environmental conditions exist (for example, air pollution by dust, smoke, corrosive or radioactive particles, vapours or salts, attack by fungi, insects or small animals), the manufacturer should be consulted to determine suitability of the equipment or the steps to be taken.

5 Functional requirements

A typical PLC-system and its interfaces/ports are shown in Figure 2.



Key

- Al Communication interface/port for local extension rack
- Ar Communication interface/port for remote I/O station, control network, fieldbus
- Be Open communication interface/port, also open to third-party devices; e.g. PADT, personal computer used for programming
- Bi Internal communication interface/port for peripherals
- C Interface/port for digital and analogue input signals
- D Interface/port for digital and analogue output signals
- E Serial or parallel communication interfaces/ports for data communication with third-party devices; e.g. computers, printers
- F Equipment power interface/port. Devices with F ports have requirements on keeping downstream devices intelligent during power up, power down and power interruptions.
- G Protective earthing port
- H Functional earthing port
- J I/O power interface/port
- K Auxiliary power output interface/port used to power sensors and actuators

Figure 2 – Typical interface/port diagram of a PLC-system

5.1 Functional power supply and memory back-up requirements

5.1.1 AC and d.c. power supply

The requirements of this subclause are verified in accordance with 6.4.1, 6.4.2 and 6.4.3.

5.1.1.1 Rated values and operating ranges

Incoming power supplies to the PLC-system and to the externally powered I/O modules shall be as shown in Table 6.

Table 6 – Rated values and operating ranges of incoming power supply

Voltage		Frequency		Recommended use (R)		Normative items and note ³
Rated U_e	Tolerance min./max.	Rated F_n	Tolerance min./max.	Power supply	I/O signals ⁵	
DC 24 V	–15 %/+20 %			R	R	1
DC 48 V				R	R	1, 2
DC 125 V						
AC 24 V r.m.s.	–15 %/+10 %	50 Hz or 60 Hz	–6 %/+4 %			(NOTE)
AC 48 V r.m.s.						(NOTE)
AC 100 V r.m.s.				R	R	
AC 110 V r.m.s.				R	R	
AC 120 V r.m.s.				R	R	(NOTE)
AC 200 V r.m.s.				R	R	
AC 230 V r.m.s.				R	R	(NOTE)
AC 240 V r.m.s.				R	R	
AC 400 V r.m.s.				R		⁴ , (NOTE)
¹ In addition to the voltage tolerances, a total a.c. component having a peak value of 5 % of the rated voltage is allowed. The absolute limits are d.c. 30/19,2 V for d.c. 24 V and d.c. 60/38,4 V for d.c. 48 V.						
² See footnote 5 of Table 8 if Type 2 digital inputs are likely to be used.						
³ For incoming voltages other than those given in the table such as d.c. 110 V etc., the tolerances given in the table and its note apply. These voltage tolerances shall be used to calculate the input limits of Table 8, using the equations in Annex B.						
⁴ Three-phase supply.						
⁵ For power supplies for analogue I/Os, see item 5 of 7.10.3 and item 3 of 7.11.3.						
NOTE The rated voltages are derived from IEC 60038.						

The requirements of this subclause are verified in accordance with 6.4.1.

5.1.1.2 Voltage harmonics

AC voltage is in terms of the total r.m.s. voltage values measured at the point of entry to the equipment.

Total r.m.s. content of true harmonics (integral multiple of nominal frequency) less than 10 times nominal frequency may reach 10 % of the total voltage. Harmonic and other frequency content for higher frequencies may reach 2 % of the total voltage. However, to provide constant comparative results, the equipment shall be tested at the third harmonic only (10 % at 0° and at 180° phase angle).

The total content of harmonics of the power supply to the PLC-system may be affected when the energy source output impedance is relatively high with regard to the input impedance of the PLC-system power supply; sizing a dedicated power source such as an inverter for a PLC-system may require an agreement between the user and the manufacturer. The use of line conditioner should be considered. See IEC 61131-4.

The requirements of this subclause are verified in accordance with 6.4.1.2.

5.1.1.3 Voltage interruptions power ports

These limits apply to the equipment power interface/port (F) in Figure 2.

For short disturbances of the supply as defined in Table 7, the PLC-system (including RIOSs (see 5.6) and non-permanently installed peripherals) shall maintain normal operation.

For longer interruptions of the supply(ies), the PLC-system shall either maintain normal operation or go to a predefined state and have a clearly specified behaviour until normal operation is resumed.

NOTE Outputs and fast responding inputs energized by the same supply(ies) may respond to these power supply variations.

Table 7– Voltage interruptions (functional requirements)

Supply type ⁵	Severity level ^{3,4}	Maximum interruption time	Low voltage, $U_{e \min}$ to % U_e ²
DC	PS1	1 ms	0 %
DC	PS2	10 ms	0 %
AC	PS2	0,5 period ¹	0 %

¹ Any arbitrary phase angle, $F_n = 50$ Hz or 60 Hz (see 6.4.2.3).

² $U_{e \min}$ is the U_e at minimum tolerance in Table 6.

³ PS1 applies to PLC-systems supplied by battery.

⁴ PS2 applies to PLC-systems energized from a.c. supplies, rectified a.c. supplies and d.c. supplies.

⁵ Voltage interruptions are from $U_{e \min}$

The requirements of this subclause are verified in accordance with 6.4.2.3.

5.1.2 Memory back-up

Power back-up for volatile memories shall be capable of maintaining stored information for at least 300 h under normal use, and 1 000 h at a temperature not greater than 25 °C when the energy source is at rated capacity. (For power back-up needing replacement, the rated capacity is the value used to designate the procedure and time interval for replacement.)

The manufacturer should specify storage time information relative to volatile memory if different from stated durations.

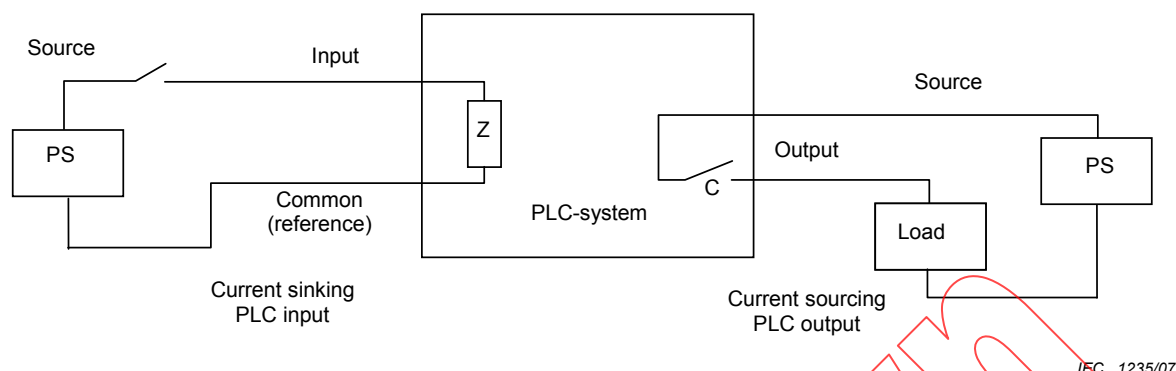
It shall be possible to change or refresh power back-up without loss of data in the backed-up portions of memory. (See also 4.3, 7.6 item 8 and 7.13 item 4.)

If a memory back-up battery is provided, a warning of “low battery voltage” shall be provided.

The requirements of this subclause are verified in accordance with 6.4.4.

5.2 Digital I/Os

Figure 3 gives an illustration of definitions of some I/O parameters.



Key

C Output; mechanical or static contact (for example, dry relay contact, triac, transistor or equivalent)

Z Input; input impedance

PS External power supplies

NOTE Some applications may use only 1 PS common to inputs, outputs and PLC-system.

Figure 3 – I/O parameters

Digital I/Os shall comply with the following requirements.

The PLC-system shall be provided with at least 1 type of input interface and 1 type of output interface among those defined respectively in 5.2.1, 5.2.2 and 5.2.3.

Digital inputs shall comply with the requirements of the standard voltage ratings given in 5.2.1. Non-standard voltage digital inputs should be in accordance with the design equation given in Annex B.

Digital outputs shall comply with the requirements of the standard ratings given in 5.2.2.1 for a.c. or 5.2.3.1 for d.c.

It shall be possible to interconnect inputs and outputs by means of a correct selection of the above digital I/Os, resulting in proper PLC-system operation. (Additional external load shall be specified by the manufacturer if necessary.)

It shall be possible to feed isolated multi-channel a.c. input modules from different phases and the modules shall then comply with the maximum voltage difference likely to occur between phases, or the user manual shall include a note indicating that all channels shall be fed from the same phase.

If a multi-channel a.c. circuit is intended for multi-phase use, the circuit shall comply with the clearance and creepage distance requirements and the dielectric test corresponding to the voltage between phases.

A PLC-system may be offered with interfaces that are not covered in this standard, i.e., interfaces for TTL and CMOS circuits, etc. In such a case, the manufacturer's data shall give all relevant information to the user.

NOTE Current-sourcing inputs and current-sinking outputs which may be required for certain applications are not covered in this standard. Special care should be exercised in their use. Where positive logic, current-sinking inputs and current-sourcing outputs are used, any short-circuit to the reference potential or wire-breakage is interpreted by the inputs and loads as the "off state". Where negative logic, current-sourcing inputs and current-sinking outputs are used, earth faults are interpreted as the "on state". See Figure 3.

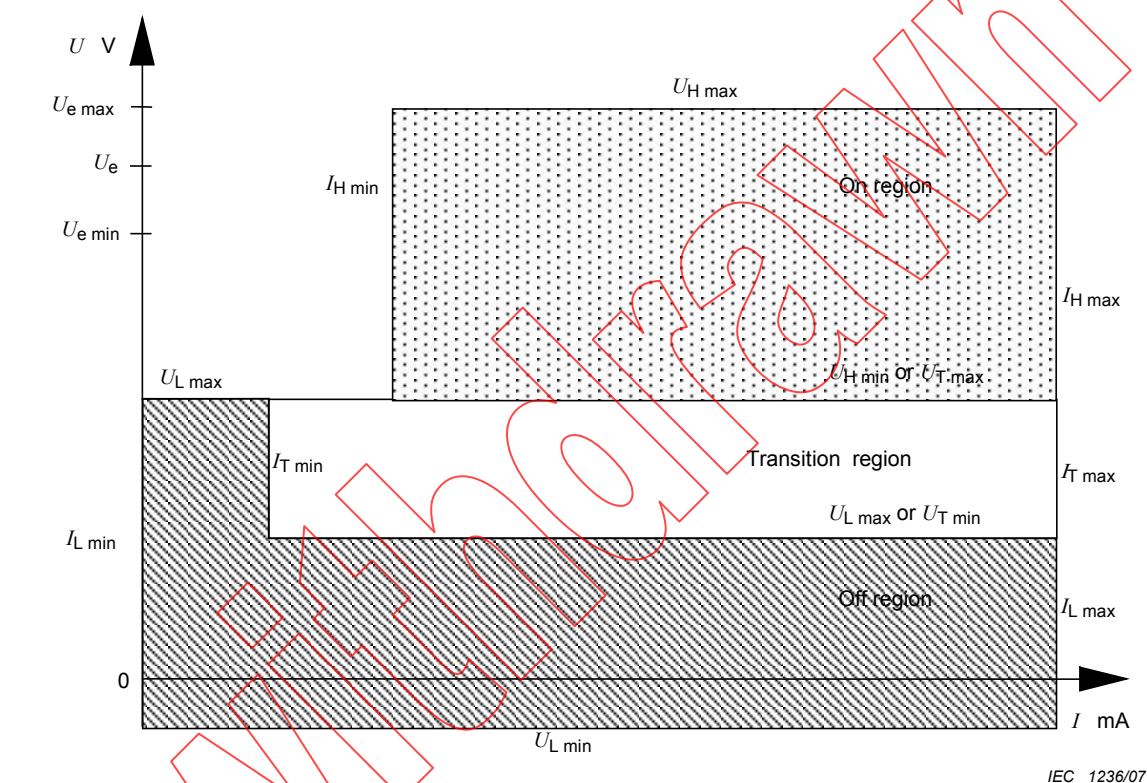
5.2.1 Digital inputs (current sinking)

The requirements of this subclause are verified in accordance with 6.5.2.

5.2.1.1 Terminology (U/I operation regions)

Figure 4 represents graphically the limits and operating ranges which are used herein to characterize current sinking digital input circuits.

The operating region consists of “on region”, “transition region” and “off region”. It is necessary to exceed both $U_{T\min}$ and $I_{T\min}$ to leave the “off region”, and to exceed both $I_{H\min}$ and $U_{H\min}$ to enter the “on region”. All input U - I curves shall remain within these boundary conditions. The region below zero volts is a valid part of the “off region” for d.c. inputs only.



$U_{H\max}$ and $U_{H\min}$ are the voltage limits for the on conditions (state 1)
 $I_{H\max}$ and $I_{H\min}$ are the current limits for the on conditions (state 1)
 $U_{T\max}$ and $U_{T\min}$ are the voltage limits for the transition state (on or off)
 $I_{T\max}$ and $I_{T\min}$ are the current limits for the transition state (on or off)
 $U_{L\max}$ and $U_{L\min}$ are the voltage limits for the off conditions (state 0)
 $I_{L\max}$ and $I_{L\min}$ are the current limits for the off conditions (state 0)
 $U_{L\max}$ equals $U_{H\min}$ to $I_{T\min}$ and equals $U_{T\min}$ above $I_{T\min}$
 U_e , $U_{e\max}$ and $U_{e\min}$ are the rated voltage and its limits for the external power supply voltage

Figure 4 – U - I operation regions of current-sinking inputs

5.2.1.2 Standard operating ranges for digital inputs (current sinking)

Current-sinking digital inputs shall operate within the limits presented in Table 8.

Table 8 – Standard operating ranges for digital inputs (current sinking)

Rated voltage U_o	Rated frequency F_n Hz	Type of limit	Type 1 limits (7)						Type 2 limits (7), (Note)						Type 3 limits (7)						Normative items
			State 0		Transition		State 1		State 0		Transition		State 1		State 0		Transition		State 1		
			UL V	IL mA	UT V	IT mA	UH V	IH mA	UL V	IL mA	UT V	IT mA	UH V	IH mA	UL V	IL mA	UT V	IT mA	UH V	IH mA	
d.c. 24V		Max.	15/5	15	15	15	30	15	11/5	30	11	30	30	30	11/5	15	11	15	30	15	(1), (2), (4), (5)
		Min.	-3	ND	5	0,5	15	2	-3	ND	5	2	11	6	-3	ND	5	1,5	11	2	
d.c. 48V		Max.	34/10	15	34	15	60	15	30/10	30	30	30	60	30	30/10	15	30	15	60	15	(1), (2), (4)
		Min.	-6	ND	10	0,5	34	2	-6	ND	10	2	30	6	-6	ND	10	1,5	30	2	
a.c. 24V V r.m.s.	50/60	Max.	14/5	15	14	15	27	15	10/5	30	10	30	27	30	10/5	15	10	15	27	15	(1), (3)
		Min.	0	0	5	1	14	2	0	0	5	4	10	6	0	0	5	2	10	5	
a.c. 48 V r.m.s.	50/60	Max.	34/10	15	34	15	53	15	29/10	30	29	30	53	30	30/10	15	30	15	53	15	(1), (3)
		Min.	0	0	10	1	34	2	0	0	10	4	29	6	0	0	10	2	30	5	
a.c. 100	50/60	Max.	79/20	15	79	15	1,1 U_o	15	74/20	30	74	30	1,1 U_o	30	74/20	15	74	15	1,1 U_o	15	(1), (3), (4), (6)
a.c. 110		Min.	0	0	20	1	79	2	0	0	20	4	74	6	0	0	20	2,5	74	5	
a.c. 120 V r.m.s.																					
a.c. 200	50/60	Max.	164/40	15	164	15	1,1 U_o	15	159/40	30	159	30	1,1 U_o	30	159/40	15	159	15	1,1 U_o	15	(1), (3), (4), (6)
a.c. 230		Min.	0	0	40	2	164	3	0	0	40	5	159	7	0	0	40	2,5	159	5	
a.c. 240 V r.m.s.																					
(1) All logic signals are in positive logic. Open inputs shall be interpreted as state 0 signal. See Annex B for equations and assumptions used in developing values in this table and for additional comments. (2) The given voltage limits include all alternating voltages components. (3) Static switches may affect the total r.m.s. content of true harmonics of the input signals and therefore affect the compatibility of the input interface with proximity switches, especially for Type 2, a.c. 24 V r.m.s. See 5.1.1.1 for requirements. (4) Recommended for common usage and future designs. (5) The minimum external power supply voltage for Type 2, d.c. 24 V inputs connected to 2-wire proximity switches should be higher than d.c. 20 V or $U_{H \min}$ lower than d.c. 11 V to allow sufficient safety margin. (6) As allowed by current technology, and to encourage the design of single input modules compatible with all commonly used rated voltages, limits are absolute and independent of rated voltage (except $U_{H \max}$) and based on equations given in Annex B and respectively a.c. 100 V r.m.s. and a.c. 200 V r.m.s. (7) See definitions 3.12, 3.13 and 3.14. ND = Not defined NOTE Compatibility with 2-wire proximity switches according to IEC 60947-5-2 is possible with Type 2. See also (3) above.																					

5.2.1.3 Additional requirements

Each input channel shall be provided with a lamp or equivalent means to indicate the state 1 condition when the indicator is energized.

5.2.2 Digital outputs for alternating currents (current sourcing)

The requirements of this subclause are verified in accordance with 6.5.3.

5.2.2.1 Rated values and operating ranges (a.c.)

Digital a.c. outputs shall comply with the ratings given in Table 9, at the output voltage(s) stated by the manufacturer according to 5.1.1.1.

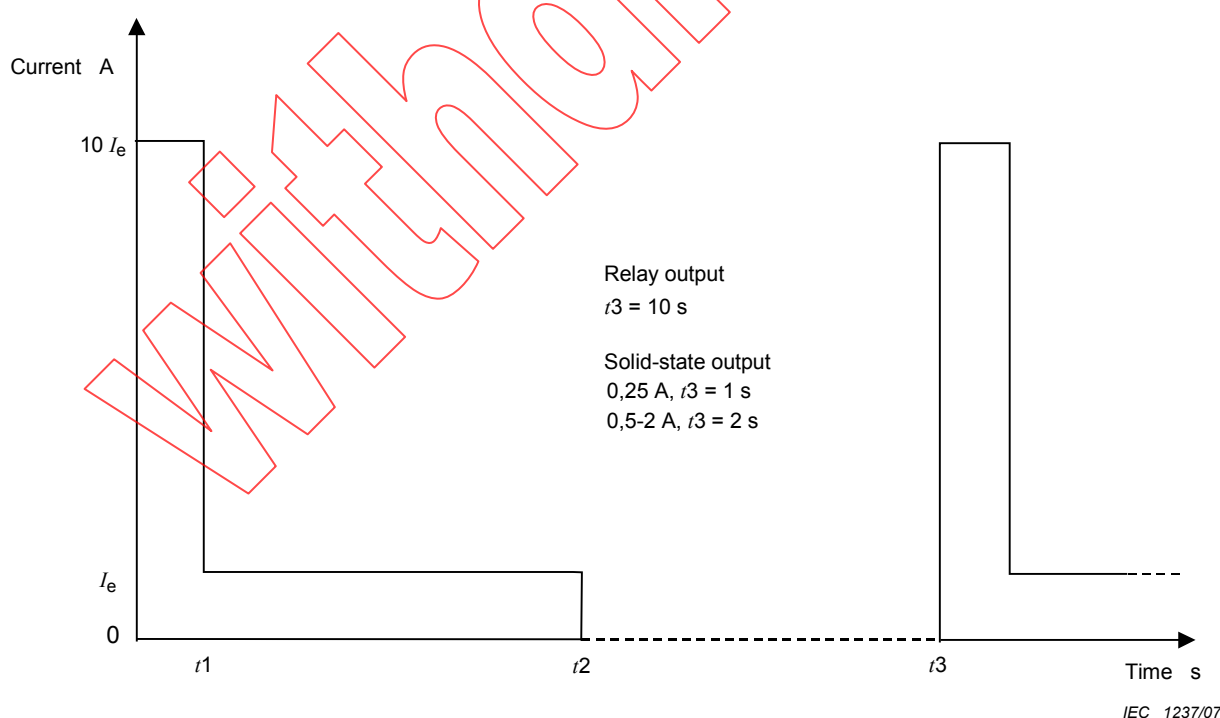
Table 9 – Rated values and operating ranges for current sourcing digital a.c. outputs

Rated current (state 1)		I_e A	0,25	0,5	1	2	Normative items
Current range for state 1 (continuous at max. voltage)		Min. (mA)	10 [5]	20	100	100	1, 2
		Max. (A)	0,28	0,55	1,1	2,2	1
Voltage drop, U_d for state 1	Non protected output	Max. (V)	3	3	3	3	1
	Protected and short-circuit proof	Max. (V)	5	5	5	5	1
Leakage current for state 0	Solid-state outputs	Max. (mA)	5 [3]	10	10	10	1, 2, 3
	Electromechanical outputs	Max. (mA)	2,5	2,5	2,5	2,5	1, 3
Operating cycle time repetition rate for temporary overload, (see Table 5)	Solid-state outputs	Max. (s)	1	2	2	2	
	Relay-based outputs	Max. (s)	10	10	10	10	

¹ RMS currents and voltages.

² Figures in square brackets apply to a module not equipped with RC network or equivalent surge suppressers. All other values apply to modules with suppression.

³ Leakage current for solid-state outputs greater than 3 mA implies the use of additional external loads to drive Type 2 digital inputs.



- $t1$: 2 cycles at F_n (F_n = rated line frequency)
 $t2$: ON time
 $t3 - t2$: OFF time (OFF time = ON time)
 $t3$: Operation time

Figure 5 – Temporary overload waveform for digital a.c. outputs

5.2.2.2 Additional requirements

5.2.2.2.1 Output indicators

Each output channel shall be provided with a lamp or equivalent means to indicate the output state 1 condition when the indicator is energized.

5.2.2.2.2 Protected outputs

For outputs stated by the manufacturer to be protected,

- the output shall either withstand and/or the associated protective device shall operate to protect the output for all steady-state values of output current greater than 1,1 times the rated value;
- after resetting or replacement of the protective device alone, as applicable, the PLC-system shall return to normal operation;
- optional restart capabilities may be selected among the 3 following types:
 - automated restart protected output: a protected output which automatically recovers after the overload is removed;
 - controlled restart protected output: a protected output which is reset through signals (for example, for remote control);
 - manual restart protected output: a protected output which implies a human action to recover (the protection may be fuses, electronic interlocks, etc.).

The requirements of this subclause are verified in accordance with 6.5.3.2.

NOTE 1 Operation under overload condition for an extended period of time may affect the operating life of the module.

NOTE 2 The protected outputs will not necessarily protect the external wiring. It is the user's responsibility to provide that protection when it is needed.

5.2.2.2.3 Short-circuit-proof outputs

For outputs stated by the manufacturer to be short-circuit-proof:

- a) for all output currents greater than $I_{e \max}$ and up to 2 times the rated value I_e , the output shall operate and withstand temporary overload(s). Such temporary overload(s) shall be specified by the manufacturer.
- b) for all output currents prospectively above 20 times the rated value, the protective device shall operate. After resetting or replacement of the protective device alone, the PLC-system shall return to normal operation.
- c) for output currents in the range of 2 times to 20 times I_e , or for temporary overload(s) beyond the limits specified by the manufacturer (item 1 above), the module may require repair or replacement.

The requirements of this subclause are verified in accordance with 6.5.3.2.

5.2.2.2.4 Non-protected outputs

For outputs stated by the manufacturer to be non-protected, if the manufacturer recommends an external protection device, then the outputs shall meet all the requirements stated for the short-circuit-proof outputs.

5.2.2.2.5 Electromechanical relay outputs

Electromechanical relay outputs shall be capable of performing at least 0,3 million operations with the load specified for AC-15 utilization category (durability class 0.3) according to IEC 60947-5-1.

The type test is not required if the relay components have been shown to comply with the requirements of IEC 60947-5-1.

5.2.3 Digital outputs for direct current (current sourcing)

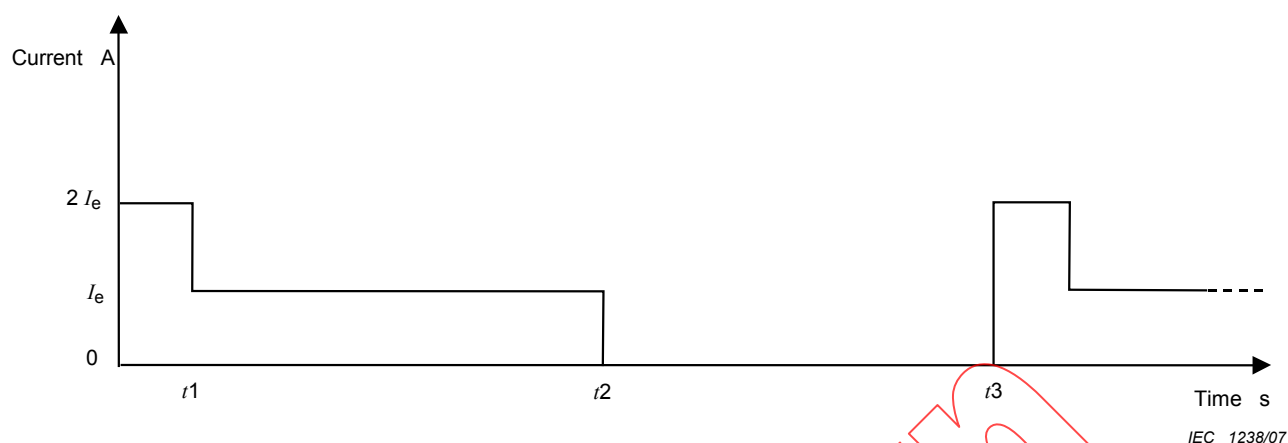
The requirements of this subclause are verified in accordance with 6.5.3.

5.2.3.1 Rated values and operating ranges (d.c.)

Digital outputs shall comply with the ratings given in Table 10, at the output voltage(s) stated by the manufacturer according to 5.1.1.1.

**Table 10 – Rated values and operating ranges (d.c.)
for current-sourcing digital d.c. outputs**

Rated current for state 1		I_e (A)	0,1	0,25	0,5	1	2	Norma- tive items
Current range for state 1 at maximum voltage (continuous)		Max. (A)	0,12	0,3	0,6	1,2	2,4	
Voltage drop, U_d	Non-protected output	Max. (V)	3	3	3	3	3	
	Protected and short-circuit-proof	Max. (V)	3	3	3	3	3	1
Leakage current for state 0		Max. (mA)	0,1	0,5	0,5	1	1	2, 3
Temporary overload		Max. (A)	See Figure 6 or as specified by manufacturer					
¹ For 1A and 2A rated currents, if reverse polarity protection is provided, a 5 V drop is allowed. This makes the output incompatible with a type 1 input of the same voltage rating.								
² The resulting compatibility between d.c. outputs and d.c. inputs, without additional external load, is as follows:								
Rated output current I_o (A): 0,1 0,25 0,5 1 2								
Type 1: yes yes yes no no								
Type 2: yes yes yes yes yes								
Type 3: yes yes yes yes yes								
³ With adequate external load, all d.c. outputs may become compatible with all Type 1, Type 2 and Type 3 d.c. inputs.								



t_1 = surge time = 10 ms
 t_2 = ON time
 $t_3 - t_2$ = OFF time (OFF time=ON time)
 t_3 = operation time = 1 s

Figure 6 – Temporary overload waveform for digital d.c. outputs

5.2.3.2 Additional requirements

Other requirements are the same as for current sourcing outputs for a.c. as defined in 5.2.2.2, except for

- protected outputs: the limit is $1,2 I_e$ instead of $1,1 I_e$;
- electromechanical relay outputs: AC-15 is replaced by DC-13.

5.3 Analogue I/Os

A PLC-system may be offered with interfaces that are not covered in this standard, i.e., interfaces for specialized circuits or devices, etc. In such a case, the manufacturer's data shall give all relevant information to the user.

The requirements of this subclause are verified in accordance with verification of analogue I/Os test in 6.5.4.

5.3.1 Analogue inputs

Rated values of signal range and impedance for analogue inputs to PLC-systems shall be as specified in Table 11.

Table 11 – Rated values and impedance limits for analogue inputs

Signal range	Input impedance limits	Normative items
± 10 V	≥ 10 k Ω	
0-10 V	≥ 10 k Ω	
1-5 V	≥ 5 k Ω	
4-20 mA	≤ 300 Ω	
0-20 mA	≤ 300 Ω	¹
¹ Not recommended for future designs.		

Analogue inputs may be designed to be compatible with standard thermocouples or standard resistive temperature devices (RTDs) such as PT100 sensors. Thermocouple analogue inputs shall provide a method for cold-junction compensation.

5.3.2 Analogue outputs

Rated values of signals range and load impedance for analogue outputs of PLCs shall be as specified in Table 12.

Table 12 – Rated values and impedance limits for analogue outputs

Signal range	Load impedance limits	Normative items
± 10 V	$\geq 1\ 000\ \Omega$	¹
0-10 V	$\geq 1\ 000\ \Omega$	¹
1-5 V	$\geq 500\ \Omega$	¹
4-20 mA	$\leq 600\ \Omega$	²
0-20 mA	$\leq 600\ \Omega$	^{2, 3}
¹ Voltage analogue outputs shall withstand any overload down to short circuit. ² Current analogue outputs shall withstand any overload up to open circuit. ³ Not recommended for future designs.		

5.4 Communication interface requirements

The configuration tested according to Clause 2 of this standard shall be equipped with communication interface modules where applicable and with communication links specified by the manufacturer.

The requirements of this subclause are verified in accordance with 6.6.

5.5 Main processing unit(s) and memory(ies) of the PLC-system requirements

This subclause should be read in conjunction with IEC 61131-1 and with 5.6 and 5.7 of this standard (respectively, RIOSs and peripherals).

See Figure 2 and Annex A for the definition and illustration of the PLC-system, the main processing unit (MPU), the main memory and other terms used in this subclause.

Main processing unit(s) and memory(ies) are part of the permanent PLC installation and therefore tested accordingly.

The requirements of this subclause are verified in accordance with 6.7.

5.6 Remote input/output stations (RIOSs) requirements

RIOSs are part of the permanent PLC installation and therefore to be tested accordingly. However, for ease of testing, isolated RIOSs may be tested separately where appropriate.

Requirements for voltage dips and interruption of the power supply(ies) fully apply to RIOSs. These requirements are shown in 5.1.1.

In case of loss of communication with the MPU application programme, RIOSs shall be able to fix the states of their outputs to specified values, within specified delays and without passing through unspecified states and be capable of providing a fault indication signal.

The MPU system shall provide the user's application programme with relevant information on the current status of RIOSs.

The requirements of this subclause are verified in accordance with 6.8.

5.7 Peripherals (PADTs, TEs, HMIs) requirements

Peripherals which are not a permanent part of the PLC-system shall cause no malfunction of the system when making or breaking communication with an operating system.

The requirements of this subclause are verified in accordance with 6.3.5.

Connectors for the peripherals shall be polarized to prevent improper connection, or the PLC-system shall be so designed that no malfunction occurs if a connection is improper.

The system consisting of the peripheral and the PLC-system shall be designed to ensure that the edited programme executing in the PLC-system is functionally identical to the edited programme displayed on the peripheral.

If on-line modification of the application programme and/or the modes of operation of the PLC-system by a peripheral is possible (i.e. when the PLC-system is in active control of a machine or industrial process), then

- the peripheral shall automatically give clear warnings equivalent to “during on-line modification, programme display may differ from application programme, control of the machine/ process may be interrupted during... ms, etc.”, as applicable;
- the peripheral shall ask the operator “Do you really want to carry out this action?” or some similar words and execute the command only after a positive reply has been given by the operator;
- it shall be possible to upload the new application programme to the manufacturer's supplied data media and verify, on line, that the record is functionally equivalent to it; and
- means shall be provided to prevent unauthorized use of these functions (hardware or software).

The requirements of this subclause are verified in accordance with 6.9.

5.8 PLC-system self-tests and diagnostics requirements

The manufacturer shall provide means for self-tests and diagnostics of the PLC-system operation. Such means shall be built-in services of the PLC-system and/or recommended ways to implement the intended application.

The following shall be provided:

- a means for monitoring the user's application programme (i.e. watchdog timer, etc.);
- a hardware or software means to check the memory integrity;
- a means to check the validity of the data exchanged between memory(ies), processing unit(s) and I/O modules (such as an application loop-back test);
- a means to check that the power supply unit(s) do(es) not exceed the current and voltage limits allowed by the hardware design;
- a means to monitor the status of MPU.

The permanently installed PLC-system shall be capable of operating an alarm signal on an alarm output. When the system is monitored as “functioning correctly”, this alarm output shall be in a predetermined state; in the other case it shall go to the opposite state. The manufacturer shall specify the conditions of the “correct functioning state” and the self-tests which are executed to drive this alarm output.

RIOSs shall be capable of operating an alarm signal on an alarm output (for example, through a digital output module) in the event of loss of power or loss of normal communication with the MPU and go to a predetermined state (see 5.6).

The requirements of this subclause are verified in accordance with 6.10.

5.9 Functional earthing

There are no constructional requirements such as interference immunity control, RFI protection, etc., for functional earthing terminals (except for marking requirements as given in 5.11.3).

5.10 Mounting requirements

Provisions shall be made for securely mounting equipment to a supporting surface.

Alternate mounting methods, such as DIN rails, should also provide for secure mounting of the equipment.

A bolt, screw, or other part used to mount a component of the equipment shall not be used for securing the equipment to a supporting surface, DIN rail, etc.

5.11 General marking requirements

For all equipment, as a minimum, the information marked on the device shall identify the manufacturer (the company bringing the product to market) and the device. The remaining information shall be provided in the data sheet; see Clause 7.

The following information shall be provided by the manufacturer:

- manufacturer's name, trade mark or other identification;
- model/catalogue number, type designation or name;
- software serial number and/or revision level (see 1.2), where applicable;
- hardware serial number or series and/or revision level (see 1.2), and date code or equivalent.

The requirements of this subclause are verified in accordance with 6.11.

5.11.1 Functional identifications

The function of each I/O module shall be unambiguously identifiable when it is placed in its service position and operating, by means of a convenient manufacturer's mark.

All operator's switches, indicator lamps, and connectors shall be identified or have provisions for identification.

5.11.2 Module location and module identifications

Space shall be provided for identification of each module and I/O channel on or near to the modules.

5.11.3 Functional earth terminals markings

Functional earth terminals (i.e. used for non-safety purposes such as interference immunity improvement) shall be marked with the following symbol:



NOTE For proper dimensioning, see IEC 60417-5018 (2002-10).

5.12 Requirements for normal service and functional type tests and verifications

Test and verifications for normal service and function shall be performed by the manufacturer, in accordance with Clause 6.

5.13 Requirements for information on normal service and function

Information on normal service and function shall be provided by the manufacturer, in accordance with the requirements of Clause 7.

6 Normal service and functional type tests and verifications

6.1 Climatic tests

Tests are performed on unpackaged equipment.

Temperature-sensitive components that are normally serviced and removed by the user may be removed, if so requested by the manufacturer.

6.2 Dry-heat and cold withstand tests

Table 13 – Dry-heat and cold withstand tests

	Dry heat	Cold
Reference test	IEC 60068-2-2, test Bb	IEC 60068-2-1, test Ab
Preconditioning	According to manufacturer's specifications	
Initial measurement	According to PFVP, see 2.5	
Conditioning	Power supply unconnected	
Temperature ³	+70 °C ± 2 °C	−40 °C ± 3 °C ²
Duration of exposure	16 h ± 1 h	16 h ± 1 h
Measuring and/or loading during conditioning	None	
Recovery procedure		
Time	1 h minimum	
Climatic conditions	See 6.1 and 2.6 ¹	
Special caution		No condensation ¹
Power supply	Power supply unconnected	
Final measurements	According to PFVP, see 2.5	

¹ All external and internal condensation shall be removed by airflow, prior to connecting again the basic PLC-system to a power supply.

² −25 °C ± 3 °C is acceptable but not recommended for future designs.

³ Temperature is monitored either at a point not more than 50 mm from the plane of the equipment's air flow entry point, for ventilated equipment, or at a point not more than 50 mm away from the equipment on a horizontal plane located at the vertical mid-point of the equipment, for non-ventilated equipment.

6.2.1 Variation of temperature

Table 14 – Change of temperature, withstand and immunity tests

		Withstand test	Immunity test
Reference test		IEC 60068-2-14, test Na	IEC 60068-2-14, test Nb
Preconditioning		According to manufacturer's specification	
Initial measurements		According to PFVP, see 2.5	
Conditioning		Power supply unconnected	Power supply connected
Measurement and/or loading during conditioning		None	³
Low temperature ⁶		$-40\text{ °C} \pm 3\text{ °C}^5$	$+5\text{ °C} \pm 2\text{ °C}$
High temperature ⁶	Open equipment	$+70\text{ °C} \pm 2\text{ °C}$	$+55\text{ °C} \pm 2\text{ °C}$
	Enclosed equipment	$+70\text{ °C} \pm 2\text{ °C}$	$+40\text{ °C} \pm 2\text{ °C}$
Exposure time at each temperature		$3\text{ h} \pm 30\text{ min}$	
Transport time		Less than 3 min	Not applicable
Temperature variation speed		Not applicable	$3\text{ °C/min.} \pm 0,6\text{ °C/min.}$
Number of cycles		5	2
Recovery procedure			
Time		Less than 2 h	Not applicable
Climatic conditions		See 6.1 and 2.6 ⁴	Not applicable
Power supply		Power supply unconnected	Not applicable
Final measurements		¹	²
¹ PFVP according to 2.5 performed after recovery. ² PFVP according to 2.5 performed during test. ³ Multi-channel output modules shall be derated as specified by the manufacturer. ⁴ All external and internal condensation shall be removed by airflow, prior to connecting again the basic PLC-system to a power supply. ⁵ $-25\text{ °C} \pm 3\text{ °C}$ is acceptable but not recommended for future designs. ⁶ Temperature is monitored either at a point not more than 50 mm from the plane of the equipment's air flow entry point, for ventilated equipment, or at a point not more than 50 mm away from the equipment on a horizontal plane located at the vertical mid-point of the equipment, for non-ventilated equipment.			