

INTERNATIONAL STANDARD

IEC
1131-2

First edition
1992-10

Programmable controllers –

Part 2: Equipment requirements and tests

Automates programmables –

*Partie 2:
Spécifications et essais des équipements*



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- IEC 27: *Letter symbols to be used in electrical technology*;
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and for medical electrical equipment,

- IEC 878: *Graphical symbols for electromedical equipment in medical practice*.

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IEC publications prepared by the same technical committee

The attention of readers is drawn to the end pages of this publication which list the IEC publications issued by the technical committee which has prepared the present publication.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PROGRAMMABLE CONTROLLERS –

Part 2: Equipment requirements and tests

FOREWORD

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

This part of International Standard IEC 1131 has been prepared by sub-committee 65A: Devices, of IEC technical committee No. 65: Industrial-process measurement and control.

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

Six Months' Rule	Report on Voting
65A(CO)22	65A(CO)27

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

Annexes A, B and D form an integral part of this part of IEC 1131.

Annex C and E are for information only.

IEC 1131 will consist of the following parts, of which this is the second, under the general title: Programmable controllers :

- Part 1: 1992, General information.
- Part 2: 1992, Equipment requirements and tests.
- Part 3: Programming languages (*being printed*).
- Part 4: User guidelines (*under consideration*).
- Part 5: Messaging service specification (*under consideration*).

INTRODUCTION

This part of IEC 1131 constitutes part 2 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 Parts 1 and 2 of this standard cannot be claimed unless *all tests and verifications required in part 2 are complied with*. See 5.4 for details.

Terms of general use are defined in part 1. The more specific terms are defined in a dedicated clause of each part.

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PROGRAMMABLE CONTROLLERS –

Part 2: Equipment requirements and tests

1 General

1.1 Scope

This International Standard applies to programmable controllers and their associated peripherals such as programming and debugging tools (PADTs), test equipment (TE) and man-machine interfaces (MMIs), etc.

Equipment covered in this standard is intended for use in overvoltage category II (see IEC 364-4-443), in low voltage installations, where the rated mains supply voltage does not exceed 1 000 V a.c. (50/60 Hz), or 1 500 V d.c., for the control and command of machines and industrial processes.

Programmable controllers and the associated peripherals are considered as components of a control system and may be provided as enclosed or open equipment. Therefore, *this standard does not deal with the automated system* in which the programmable controller system is but one basic component among many others including its application program.

Since programmable controllers are component devices, overall automated system safety including installation and application is beyond the scope of this standard. For further information, refer to IEC 1131-4 which is intended to help users in reducing the risks. However, electrical noise immunity and error detecting of the PC-system operation such as the use of parity checking, self-testing diagnostics, etc., are addressed.

1.2 Object of the standard

The purposes of this standard are:

- to establish the definitions and identify the principal characteristics relevant to the selection and application of programmable controllers and their associated peripherals;
- to specify the minimum requirements for the functional characteristics, service conditions, construction characteristics, general safety, and tests applicable to programmable controllers and the associated peripherals;
- to define, for each of the most commonly used programming languages: major field of application, syntactic and semantic rules, simple but complete basic sets of programming elements, applicable tests and means by which manufacturers may expand or adapt those basic sets to their own programmable controller implementations;
- to give general tutorial information and application guidelines to the user;

- to define the communication between programmable controllers and other electronic systems using the Manufacturing Message Specification (MMS) defined in ISO/IEC 9506.

1.3 *Object of this part*

This part specifies

- the electrical, mechanical and functional* requirements for programmable controllers and the associated peripherals and the service, storage and transportation conditions that apply;
- the information that the manufacturer is required to supply;
- the test methods** and procedures that are to be used for the verification of compliance of programmable controllers and their associated peripherals with the requirements.

1.4 *Definitions*

NOTE - This clause contains the definitions of terms which are more specific to the object of this part in order to make it more self-contained. Terms of general use are defined in part 1.

1.4.1 **accessible part:**

- 1) A part which can be touched by the standard jointed test finger (see IEC 529) .
- 2) A conductive part which can readily be touched and which is not normally live, but which may become live under fault conditions. [IEV 441-11-10 modified]

1.4.2 basic PC-system(s): Representative configuration(s) used for type tests. See figure 1, in 3.1 and 6.3.1

1.4.3 battery: An electrochemical energy source which may be rechargeable or non-rechargeable.

1.4.4 circuit, class I, class II, class III: see equipment (1.4.16).

1.4.5 clearance: The shortest distance between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured through air. The bounding surface is the outer surface of the enclosure considered as though metal foil is pressed into contact with accessible surfaces of insulating material.

1.4.6 coating, protective: A coating of suitable insulating material that covers the clearance and/or creepage distance of the printed 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.

* Functional requirements are contained in both the electrical and mechanical clauses.

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

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

1.4.7 comparative tracking index (CTI): The numerical value of the maximum voltage at which a material withstands 50 drops of NH_4Cl solution (ammonia chloride) without tracking (see IEC 112).

1.4.8 coverage factor (for modules, units, external wiring, internal wiring, removable cables, interconnections and functions): The percentage of modules, units, external wirings, internal wirings, removable cables, interconnections, functions, whose removal, absence or failure is detected by built-in test functions or by a suitable test program along with a proper functioning verification procedure. See 6.3.2.

1.4.9 creepage distance: The shortest path between two conductive parts, or between a conductive part and bounding conducting surface of the equipment, measured along the surface of the insulation.

1.4.10 current sinking: The act of receiving current.

1.4.11 current sourcing: The act of supplying current.

1.4.12 diversity factor (of an output module): Ratio of the permissible total current (total output current) to the sum of all maximum rated currents of multi-channel output module operating at the most adverse combination of normal service conditions.

1.4.13 earth: The conducting mass of the Earth, whose electric potential at any point is conventionally taken as zero. [IEV 151-01-07] (Synonymous with protective earth.)

1.4.14 earth, functional, protective:

1) **functional earth:** A low impedance path between electrical circuits and earth for non-safety purposes such as noise immunity improvement.

2) **protective earth:** A low impedance path under fault conditions including high voltage and/or current between the electrical circuit and earth to minimize the risk to the operator.

1.4.15 enclosure: A final mounting housing which provides protection against accidental contact with live and/or moving parts. (See equipment, open and equipment, enclosed.)

1.4.16 equipment (or circuit) class I, class II, class III: Class numbers designate the means by which electric shock protection is maintained in normal use and likely fault conditions of the installed equipment.

1) **class I circuit or equipment:** Circuit or equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in that accessible conductive parts are connected to the protective

earthing conductor in the fixed wiring of the installation in such a way that they cannot become live in the event of a failure of the basic insulation. For equipment intended for use with a flexible cord, this provision includes the protective earthing conductor as part of the flexible cord.

NOTE - Class I equipment may have parts with double insulation or reinforced insulation, or parts operating at safety extra-low voltage.

2. class II circuit or equipment: Circuit or equipment in which protection against electric shock does not rely on basic insulation, but in which additional safety precautions, such as double insulation or reinforced insulation are provided, there being no provision for protective earthing or reliance upon installation conditions.

Such equipment may be of one of the following types:

- i) insulation-encased class II equipment: equipment having a durable and substantially continuous enclosure of insulating material which envelops all conductive parts, with the exception of small parts, such as nameplates, screws and rivets, which are isolated from parts at hazardous voltage by insulation at least equivalent to reinforced insulation;
- ii) metal-encased class II equipment: equipment having a substantially continuous metal enclosure, in which double insulation is used throughout, except for those parts where reinforced insulation is used;
- iii) equipment which is a combination of types i) and ii).

NOTES

- 1 The insulated enclosure of a class II equipment may form a part of the whole of the supplementary insulation or of the reinforced insulation.
- 2 If equipment with double insulation and/or reinforced insulation throughout has a protective earthing terminal or contact, it is deemed to be of class I construction.
- 3 class II equipment may have parts operating at safety extra-low voltage.

3) class III circuit or equipment: Circuit or equipment in which protection against electric shock is provided by circuits supplied by safety extra-low voltage (SELV) and where voltages generated do not exceed the limits for SELV.

1.4.17 equipment, enclosed: 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).

1.4.18 equipment, fixed: Equipment which is part of the permanent installation.

1.4.19 equipment, hand-held portable: Equipment which is intended to be held in one hand while being operated with the other hand.

1.4.20 equipment, open: Equipment which may have live electrical parts accessible, e.g. a main processing unit. An open equipment is to be incorporated into other assemblies manufactured to provide safety.

1.4.21 equipment, on-line pluggable: Equipment which can be plugged or unplugged from the PC-system at any time including when the PC-system is operating, without disturbing or disrupting the normal operation of the PC-system and without any increased risk to the operator and the application.

1.4.22 equipment, portable: Enclosed equipment which is intended to be transported by hand-carrying, such as programming and debugging tools (PADTs) and test equipment (TE).

1.4.23 hazardous voltage: Voltage exceeding 42,4 V peak or d.c., existing in a circuit which does not meet the requirement for a limited energy circuit.

1.4.24 immunity: Ability of the PC-system to be unaffected or to maintain its operation within limits specified by the manufacturer when submitted to influencing quantities specified in this standard.

1.4.25 input, digital, type 1/type 2 (type 1 digital input, type 2 digital input):

1) **type 1 digital input:** Digital input for sensing signals from mechanical contact switching devices, such as relay contacts, pushbuttons, switches, etc.; type 1 digital inputs may not be suitable for use with solid state devices such as sensors, proximity switches, etc.

2) **type 2 digital input:** Digital input for sensing signals from solid state switching devices such as 2-wire proximity switches. This class could also be used for type 1 applications.

1.4.26 Insulation (basic, supplementary, double, reinforced):

1) **basic insulation:** Insulation applied to live parts to provide basic protection against electric shock.

2) **supplementary insulation:** Independent insulation applied in addition to basic insulation in order to ensure protection against electric shock in the event of a failure of the basic insulation.

3) **double insulation:** Insulation comprising both basic insulation and supplementary insulation.

4) **reinforced insulation:** Single insulation system applied to live parts which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this standard.

NOTE - The term "insulation system" does not imply that the insulation must be in one homogeneous piece. It may comprise several layers which cannot be individually tested as supplementary or basic insulation.

1.4.27 interface: Shared boundary between a considered system and another system, or between parts of a system, through which information is conveyed. See 3.1.

1.4.28 isolated (devices, circuits): Devices, circuits with no galvanic connection between them.

1.4.29 live part: Any conductor or conductive part which is at a voltage in normal use.

1.4.30 mains power supply: Power from the conductors/mains of the permanent installation of the building at the supply voltage to the PC-system.

1.4.31 main processing unit (MPU): The portion of the PC-system which interprets or executes the (main part of the) application program. The MPU may include power supply, memory, and I/Os. See annex B of IEC 1131-1 and 3.1, 3.6 and annex A of this part.

1.4.32 man-machine interface (MMI): Manufacturer's catalogued peripheral equipped with pushbuttons, lamps, keyboards, displays or equivalent, intended as operator interface, such as motor control/monitor panel, general purpose operator interface, etc.

MMIs may be part of the permanent installation (e.g. mounted on front panels, doors, boards, etc.) or not.

1.4.33 material group: Classification of insulating materials in terms of comparative tracking index (CTI) range (see 4.3.3).

1.4.34 micro-environment: Ambient conditions which surround the clearance or creepage distance under consideration.

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. (See IEC 664 for further information.)

1.4.35 module: Device such as an I/O board assembly which plugs into a back plane or base.

1.4.36 multi-circuit module: Module containing multiple isolated circuits. With respect to I/O modules, a module containing multiple isolated user signal interfaces.

1.4.37 multi-channel module: Module containing multiple input and/or output user signal interfaces. A multi-channel module may or may not be a multi-circuit module.

1.4.38 output, not-protected, protected, short-circuit proof:
See 3.3.2.2 and 3.3.3.2.

1.4.39 overvoltage category (of a circuit or within an electrical system): A conventional number 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.

NOTE - In an electrical system, the transition from one overvoltage category to another of lower category is obtained through appropriate means complying with interface requirements, such as 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.

1.4.40 PC-system: Synonymous with programmable controller system as defined in 2.5.1 of IEC 1131-1, see annex A of IEC 1131-1 and annex A of this part.

1.4.41 **permanent installation:** See annex A of IEC 1131-1 or annex A of this part.

1.4.42 **pollution degree** (in the micro-environment): For the purpose of evaluating clearances and creepage distances, the following three degrees of pollution in the micro-environment are established:

1) **pollution degree 1:** No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

2) **pollution degree 2:** Normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation shall be expected.

3) **pollution degree 3:** Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation which is expected.

NOTES

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

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

1.4.43 **protective earthing conductor, terminal, connection:** See earth, protective (1.4.14).

1.4.44 **rated supply voltage:** Mains voltage (for three-phase supply, the line-to-line voltage) for which the manufacturer has designed the apparatus.

1.4.45 **recurring peak voltage:** Peak value of a generated voltage whose characteristic is recurring at some specified period. Such recurring peak voltages are generally generated in switch-mode power supply circuits (a.c. or d.c. to d.c. converters). See 4.3.3.2.

1.4.46 **removable connector:** Connecting means intended to be used for operation or maintenance servicing of the PC-system by the user. Pluggable modules, peripherals, etc. are generally connected to the rest of the PC-system by such means.

1.4.47 **safety extra-low voltage (SELV):** A voltage which, under all operating conditions does not exceed 42,4 V peak or d.c. between conductors, or between any conductor and earth, in a circuit which is isolated from the mains power supply by means of a safety isolating transformer or an equivalent means. National regulations have to be considered for a correct isolation voltage rating.

1.4.48 **safety extra low-voltage circuit (SELV circuit):** Circuit which is so designed and protected that under normal and single fault conditions the voltage between any two accessible parts, one of which may be earth or a conductive accessible part connected to earth, does not exceed the safety extra-low voltage and in which overvoltages higher than SELV are not generated.

1.4.49 **Subassembly:** Synonymous with unit (1.4.53).

1.4.50 temperature (ambient air):

- 1) For enclosed non-ventilated equipment that is cooled by natural air convection, the equipment ambient air temperature is the room temperature 1 m away from the surface of the enclosure on a horizontal plane located at the vertical mid-point of the enclosure.
- 2) For enclosed ventilated equipment, the equipment ambient temperature is the temperature of the incoming air.
- 3) For open equipment, the ambient air temperature is the temperature of the incoming air immediately below the equipment.

1.4.51 total output current (of an output module): The current that a multi-channel module operating at the most adverse combination of normal service conditions 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.

1.4.52 test (routine, type, immunity type, withstand type):

- 1) **routine test:** Test to which each individual catalogued device is subjected during or after its manufacturing process to ascertain whether it complies with certain criteria.
- 2) **type test:** Laboratory test to which one or several basic PC-systems or samples of catalogued devices is (are) subjected to ascertain that its (their) design(s) meet requirements expressed in this standard.
- 3) **immunity type test (immunity test):** Type test verifying that the basic PC-system operation is not altered by the application of specified influencing quantities which are intended to approximate normal service conditions.

During the test, the basic PC-system executes appropriate test programs to be provided by the manufacturer (see 6.3.2.2).

NOTE - Some tests may allow temporary alteration of the basic PC-system operation within limits that must be then specified by the manufacturer.

- 4) **withstand type test (withstand test):** Type test verifying that the application of more severe influencing quantities to the basic PC-system does not impair its ability to assume its intended mission. Unless otherwise specified, the basic PC-system is not energized during the withstand test. After a specified recovery period, a proper functioning verification procedure is performed as specified to check visually and/or by measurement that the test had no detrimental effect on the basic PC-system.

NOTE - The impact test (see 6.3.5.5.1) is classified as withstand test though it may affect the operability of the basic PC-system.

1.4.53 unit: For the purpose of this standard, a unit is an integral assembly (which may consist of modules plugged in or otherwise connected within the assembly) and which is connected to other units within the system by means of cables for permanently installed units and cables or other means for portable units.

1.4.54 wiring (internal, external):

- 1) **Internal wiring:** Wiring which is inside the open or enclosed PC-system equipment.
- 2) **external wiring:** Wiring of the PC-system equipment which is normally installed by the user.

1.5 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 1131. At the time of publication, the editions indicated were valid. All documents are subject to revision, and parties to agreements based on this part of IEC 1131 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 38: 1983, *IEC standard voltages*.

IEC 50(151): 1978, *International Electrotechnical Vocabulary – Chapter 151: Electrical and magnetic devices*.

IEC 50(441): 1984, *International Electrotechnical Vocabulary – Chapter 441: Switchgear, controlgear and fuses*.

IEC 60-1: 1989, *High-voltage test techniques – Part 1: General definitions and test requirements*.

IEC 68-2-1: 1990, *Environmental testing – Part 2: Tests – Tests A: Cold*.

IEC 68-2-2: 1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*.

IEC 68-2-3: 1969, *Environmental testing – Part 2: Tests – Test Ca: Damp heat, steady state*.

IEC 68-2-6: 1982, *Environmental testing – Part 2: Tests – Test Fc and guidance: Vibration (sinusoidal)*.

IEC 68-2-14: 1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*.

IEC 68-2-27: 1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*.

IEC 68-2-30: 1980, *Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)*.

IEC 68-2-31: 1969, *Environmental testing – Part 2: Tests – Test Ec: Drop and topple, primarily for equipment-type specimens*.

IEC 68-2-32: 1975, *Environmental testing – Part 2: Tests – Test Ed: Free fall.*

IEC 85: 1984, *Thermal evaluation and classification of electrical insulation.*

IEC 112: 1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions.*

IEC 255-4: 1976, *Electrical relays – Part 4: Single input energizing quantity measuring relays with dependent specified time.*

IEC 364-4-443: 1990, *Electrical installations of buildings – Part 4: Protection for safety – Chapter 44: Protection against overvoltages – Section 443: Protection against overvoltages of atmospheric origin or due to switching.*

IEC 417: 1973, *Graphical symbols for use on equipment – Index, survey and compilation of the single sheets.*

IEC 445: 1988, *Identification of equipment terminals and of terminations of certain designated conductors, including general rules of an alphanumeric system.*

IEC 529: 1989, *Degrees of protection provided by enclosures (IP Code).*

IEC 664: 1980, *Insulation co-ordination within low-voltage systems including clearances and creepage distances for equipment.*

IEC 695-2-1: 1980, *Fire hazard testing – Part 2: Test methods – Glow-wire test and guidance.*

IEC 707: 1981, *Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source.*

IEC 801-2: 1991, *Electromagnetic compatibility for industrial-process measurement and control equipment – Part 2: Electrostatic discharge requirements.*

IEC 801-3: 1984, *Electromagnetic compatibility for industrial-process measurement and control equipment – Part 3: Radiated electromagnetic field requirements.*

IEC 801-4: 1988, *Electromagnetic compatibility for industrial-process measurement and control equipment – Part 4: Electrical fast transient/burst requirements.*

IEC 801-5: 199X, *Electromagnetic compatibility for industrial-process measurement and control equipment – Part 5: Surge immunity requirements (under consideration).*

IEC 947-1: 1988, *Low-voltage switchgear and controlgear – Part 1: General rules.*

IEC 947-5-1: 1990, *Low-voltage switchgear and controlgear – Part 5: Control circuit devices and switching elements – Section One: Electromechanical control circuit devices.*

IEC 947-5-2: 1992, *Low voltage switchgear and controlgear – Part 5: Control circuit devices and switching elements – Section 2: Proximity switches.*

IEC 950: 1991, *Safety of information technology equipment, including electrical business equipment.*

ISO/IEC 9506-1, 1990: *Industrial automation systems – Manufacturing Message Specification – Part 1: Service definition.*

ISO/IEC 9506-2: 1990, *Industrial automation systems – Manufacturing Message Specification – Part 2: Protocol specification.*

2 Service conditions and physical environment related requirements

2.1 Normal service conditions

It is the user's responsibility to ensure that the following service conditions are not exceeded.

2.1.1 Physical environmental conditions

2.1.1.1 Operating ambient air temperature

Operating temperature ranges are given by the following table 1.

Table 1 – Operating ambient air temperature of PC-systems (°C) (note 1)

		Enclosed equipment (ventilated/non-ventilated)		Open equipment (note 2)	
	Type of limit	Permanent installation	Non-permanent installation	Permanent installation	Non-permanent installation
Temperature range	Max. Min.	40 5	40 5	55 5	$T_{\max.}$ (note 3) $T_{\min.}$ (note 3)
Average temperature over 24 h	Max.	35	35	50	T_{av} (note 3)
NOTES 1 See definitions in 1.4.50 and in annex A. 2 Open equipment is designed to be mounted within an enclosure where the equipment ambient air temperature which is measured immediately below each individual assembly may be up to 15 °C above the maximum room ambient air temperature. No forced external cooling is assumed (see 4.5.1). Open peripherals which are intended to be permanently installed as part of the PC-system shall meet the operating temperature range of the PC. 3 Equipment ambient air temperature limits ($T_{\max.}$, T_{av}, $T_{\min.}$) for open peripheral equipment not intended to be permanently installed shall be specified by the manufacturer.					

2.1.1.2 *Storage temperature*

The allowable temperature range is –25 °C to +70 °C.

2.1.1.3 *Relative humidity*

The manufacturer may select one of the two following levels.

Table 2 – Operating ambient air relative humidity (notes 1 and 2)

Relative humidity severity level	Relative humidity range
RH-1	50 % to 95 %
RH-2	5 % to 95 %
NOTES 1 Non-condensing. 2 See 2.1.2.2 for electrostatic discharge requirements.	

2.1.1.4 *Pollution degree*

The manufacturer shall specify the pollution degree for which the equipment is suitable.

2.1.1.5 *Corrosion immunity*

Corrosion conditions vary widely depending on the application and it is not possible to specify normal conditions of use. In case of severe service conditions, see 2.2.

The manufacturer shall specify the corrosion immunity of the equipment according to IEC 68.

2.1.1.6 *Altitude*

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

2.1.2 *Electrical service conditions and requirements*

2.1.2.1 *A.C. and d.c. mains power supply*

Refer to 3.2.

2.1.2.2 *Electrical noise conditions*

Electrical noise conditions vary widely and depend on the installation wiring and other installed equipment and its proximity to the PC-system.

For the purpose of this standard, the minimum noise conditions to which the PC-system shall be immune are indirectly expressed by the requirements given in 3.9.1.

For electrostatic discharge (ESD) the manufacturer may select one of the severity levels of the following table 3. Refer to IEC 801-2 for description of classes of installation.

Table 3 – Electrostatic discharge service conditions

ESD severity levels (coordinated with relative humidity severity levels) (note)		Class of installation (according to IEC 801-2)
Level RH-1	Level ESD-3	3
Level RH-2	Level ESD-4	4
NOTE – See table 2 for definition of relative humidity severity levels.		

2.1.2.3 *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 mains 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. (See 3.10.2.)

2.1.2.4 *Non-periodic overvoltages*

In the industrial environment, non-periodic overvoltage peaks may appear on mains power supply lines as a result of power interruptions to high energy equipment (e.g. blown fuse on one branch in a 3-phase system). This will cause high current pulses at relatively low voltage levels (approximately $2 \times U_{peak}$). The user shall take the necessary steps to prevent damage to the PC-system (e.g. by interposing a transformer). See IEC 1131-4 for additional information.

2.1.3 *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 test requirements which apply to fixed equipment as well as to unpackaged portable and hand-held portable equipment (see exceptions in 2.1.3.2). They do not apply to equipment containing assemblies other than PC-systems and/or associated peripherals.

Experience shows that equipment passing these tests are suitable for industrial use on stationary installations.

2.1.3.1 *Vibrations*

Immunity requirements are:

Table 4 – Sinusoidal vibrations service conditions for PC-systems (notes 1, 2 and 3)

Frequency range Hz	Continuous	Occasional
$10 \leq f < 57$	0,0375 mm amplitude	0,075 mm amplitude
$57 \leq f \leq 150$	0,5 g constant acceleration	1,0 g constant acceleration
$150 < f$	Not defined	Not defined
NOTES 1 Applicable to each of three mutually perpendicular axes. 2 Test according to IEC 68-2-6, test Fc. 3 The manufacturer shall specify the method of mounting portable and hand-held portable peripherals on the test equipment.		

2.1.3.2 Shocks

Immunity requirements are: Occasional excursions to 15 g, 11 ms, half-sine, in each of three mutually perpendicular axes (IEC 68-2-27).

NOTES

- 1 Devices containing CRTs are excluded from this requirement.
- 2 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.

2.1.3.3 Free falls

Immunity requirements for type tests are:

Table 5 – Free fall on concrete floor
(Applicable to portable and hand-held portable equipment)

	Portable and hand-held portable (Any weight) (Withstand)	Hand-held portable (Any weight) (Immunity)	Notes
Random drops	–	1 000 mm; 2 trials	1 and 2
Flat drops	100 mm; 2 trials	–	1
Supported drops	30° or 100 mm; 2 trials	–	1 and 3
NOTES 1 Caution: Temporary malfunctioning is allowed at the impact, but equipment shall be fully functional after the test and not cause a shock hazard. 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) see IEC 68-2-32, Procedure 1. 3 From prescribed values given in 3.2.1 of IEC 68-2-31.			

2.2 Special service conditions

When the service conditions are more severe than those given in 2.1, or other adverse environmental conditions exist, (e.g. 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.

2.3 Requirements for transport and storage of modules and subassemblies

The following requirements apply to PC-units placed within manufacturer's original packaging. Transport and storage of unpackaged portable equipment should not exceed the requirements of 2.1.

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

2.3.1 Temperature

The allowable temperature range is -25°C to $+70^{\circ}\text{C}$. See test procedure in 6.3.4.2.

2.3.2 Relative humidity

The relative humidity range is 5 % to 95 % (non-condensing).

2.3.3 Atmospheric pressure

The minimum atmospheric pressure for transportation shall be not less than 70 kPa (equivalent to 3 000 m altitude).

2.3.4 Free falls

Withstand requirements for PC-units within manufacturer's original packaging are given in table 6 below. After the test, they shall be fully functional and shall show no evidence of physical damage. See test procedure in 6.3.5.4.

Table 6 – Free fall on concrete floor
(Applicable to PC-units under manufacturer's original packaging)

Shipping weight without packaging kg	Random free fall drop height mm	Number of falls
< 10	1 000	5
10 to 40	500	5
> 40	250	5
NOTE – According to IEC 68-2-32, procedure 1.		

2.3.5 *Other conditions*

The user should reach agreement with the manufacturer for any mechanical conditions that are not specified in this standard.

2.3.6 *Information to be provided by the manufacturer*

The manufacturer shall provide shipping and storing instructions.

2.4 *Transport and storage conditions of PC-systems incorporated in complete control assemblies*

These conditions are not part of this standard and therefore the manufacturer should be consulted.

3 **Electrical requirements**

NOTE - Functional requirements for PC-systems including those relating to basic and advanced functions of PADTs are given in 3.6, 3.7 and 3.8.

3.1 *General*

A typical PC-system and its interfaces are shown in figure 1 below.

Withdawn

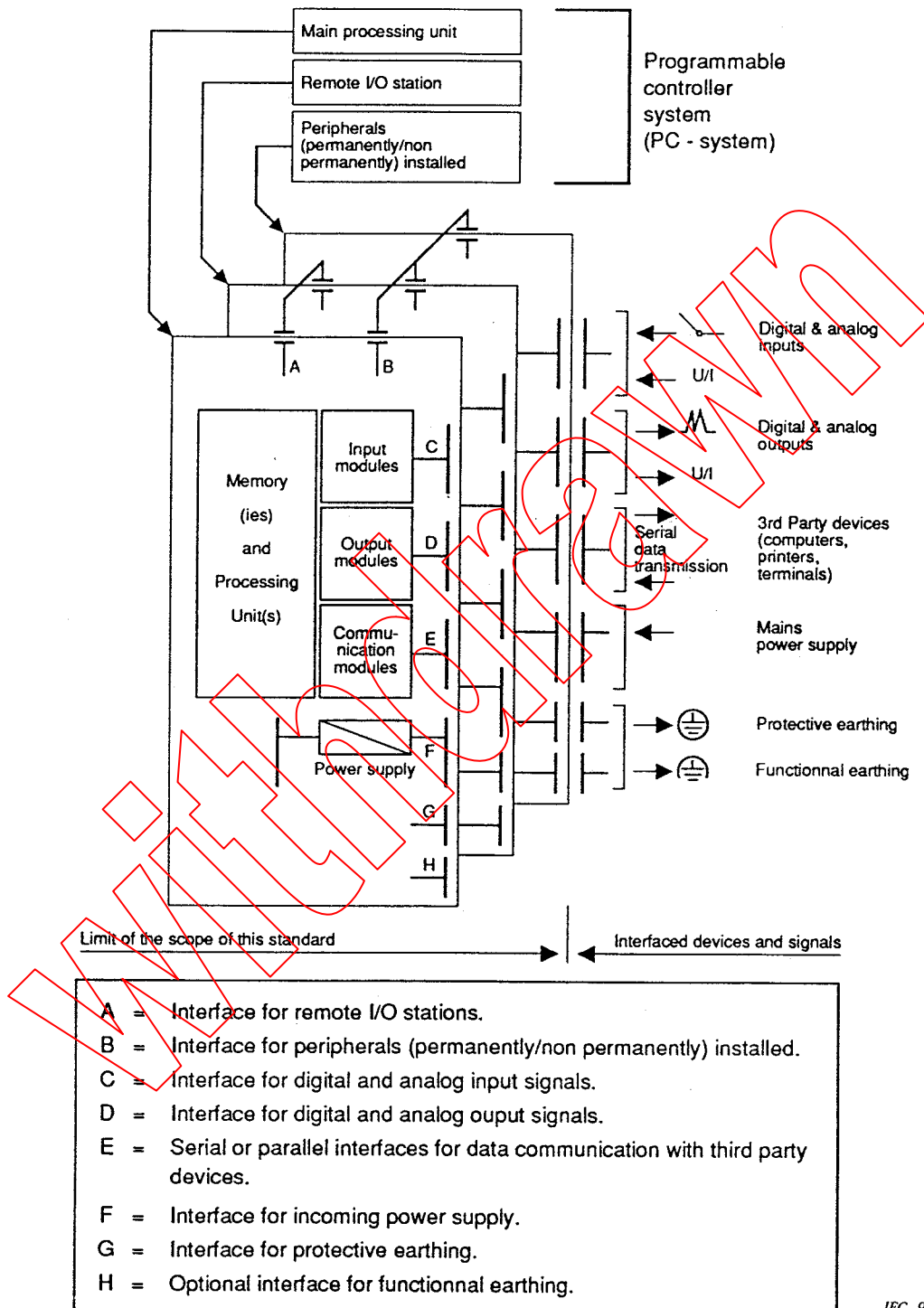


Figure 1 – Typical interface diagram of a programmable controller system

3.2 A.C. and d.c. power supply

3.2.1 Incoming power supply

3.2.1.1 Rated values and operating ranges

Incoming power supplies to the PC-system and to the externally powered I/O modules shall be as shown in table 7 below:

Table 7 – Rated values and operating ranges of incoming power supply

Voltage		Frequency		Recommended use: R		Notes
Rated (U_e)	Tolerance Min. / Max.	Rated (F_n)	Tolerance Min. / Max.	Power supply	I/O signals	5
24 V d.c.	–15 % / +20 %	–	–	R	R	1
48 V d.c.	id	–	–	R	R	1, 2
24 V a.c.	–15 % / +10 %	50 Hz or 60 Hz	–5 % / +5 %	–	–	3
48 V a.c.	id	id	id	–	–	3
120 V a.c.	id	id	id	R	R	3, 4
230 V a.c.	id	id	id	R	R	3, 4
400 V a.c.	id	id	id	R	–	3, 4, 6

NOTES

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 30/19,2 V d.c. for 24 V d.c. and 60/38,4 V d.c. for 48 V d.c.

2 See item 5 of 3.3.1.2 if type 2 digital inputs are likely to be used.

3 A.C. 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 PC-system may be affected when the energy source output impedance is relatively high with regard to the input impedance of the PC-system power supply; sizing a dedicated power source such as an inverter for a PC-system may require an agreement between the user and the manufacturer. Use of line conditioner should be considered. See IEC 1131-4.

4 These rated voltages are derived from IEC 38.

5 For incoming voltages other than those given in the table such as 100 V a.c., 110 V a.c., 200 V a.c., 240 V a.c., 380 V a.c. or 110 V d.c., 125 V d.c., the tolerances given in the table and notes 1 and 3 apply. These voltage tolerances shall be used to calculate the input limits of 3.3.1.2, using the equations in annex B.

6 Three-phase supply.

7 For power supplies for analog I/Os, see item 5 of 3.4.1.2.3 and item 3 of 3.4.2.2.3.

3.2.1.2 Voltage drops and interruptions

1) For short disturbances of the supply as defined in table 8 below, the PC-system (including RIOSs and non-permanently installed peripherals, see 3.7) shall maintain normal operation.

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

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

Table 8 – Normal service conditions: Voltage drops and interruptions

		Interruption time	Time interval between drops	Low voltage
D.C. supply	Severity level PS1	$\leq 1 \text{ ms}$	$\geq 1 \text{ s}$	Any voltage under lower operational limit $U_{\min}$ (note 2)
	Severity level PS2	$\leq 10 \text{ ms}$	$\geq 1 \text{ s}$	
A.C. supply		$\leq 0,5 \text{ period}$ (note 1)	$\geq 1 \text{ s}$	

NOTES

1 Any arbitrary phase angle – (see test procedure in 6.3.7.2).

2 $U_{\min}$ is the U_e at minimum tolerance in table 7.

3 PS1 applies to PC-systems supplied by battery.
PS2 applies to PC-systems energized from rectified a.c. supplies and/or long d.c. lines.

3.2.1.3 Non-periodic overvoltages

See 2.1.2.4.

3.2.2 Memory back-up

Power back-up for volatile memories shall be capable of maintaining stored information for at least 300 h under normal service conditions, 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.)

It shall be possible to change or refresh power back-up without loss of data in the backed-up portions of memory. (See also 2.3, 3.6.3 and 4.11.)

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

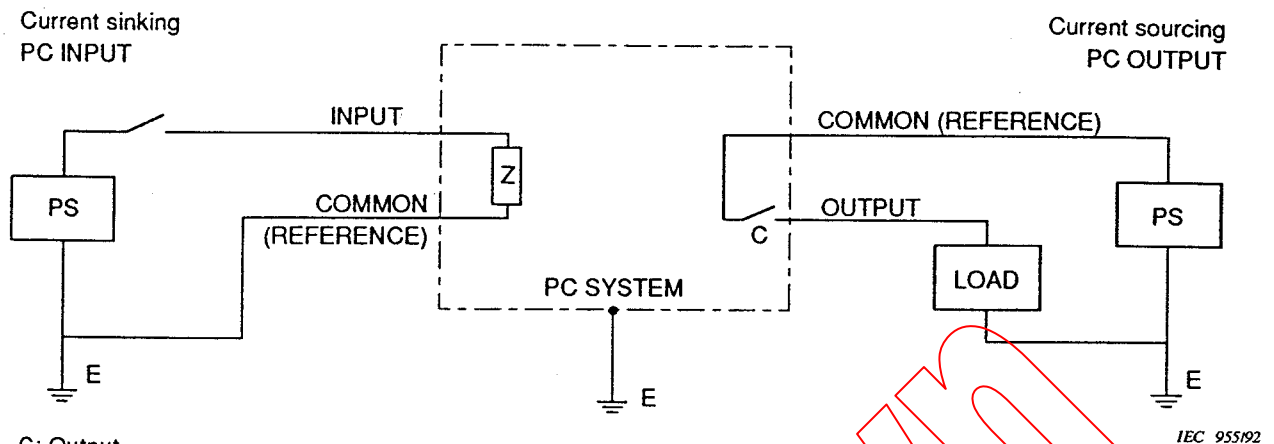
3.2.3 *Information to be provided by the manufacturer*

In addition to the requirements stated in clause 5, the manufacturer shall provide the following information:

- 1) data to allow selection of a suitable power distribution network to provide specified voltage at each power utilization point. This information includes peak inrush, repetitive peak and steady-state r.m.s input currents under full load conditions;
- 2) external terminal identification for power supply interfaces;
- 3) typical example(s) for power supply system(s);
- 4) special supply installation requirements, if any, for PC-systems energized through multiple power supplies or supply voltages and frequencies not included in 3.2.1.1;
- 5) the effect of the following incorrect connections of power to the supply(ies):
 - reverse polarity;
 - improper voltage level and/or frequency;
 - improper lead connection;
- 6) complete information on PC-system behaviour for typical power up/down sequences;
- 7) data to allow evaluation of the maximum values of interruption time which do not affect the normal operation of any PC-system configuration; PS class (PS-1 or PS-2) of d.c. supplied devices;
- 8) memory back-up time with respect to temperature and maintenance requirements;
- 9) recommended time interval between replacement of energy sources, if applicable, and recommended procedure and subsequent effects on the PC-system.

3.3 Digital I/Os

The following figure 2 gives an illustration of definitions of some I/O parameters.



C: Output

– Mechanical or static contact (e.g. dry relay contact, triac, transistor or equivalent).

E: Earthings

– The earth shown are optional.

– Earthings is dependent on national regulations and/or application needs.

Z: Input

– Input impedance.

PS: External power supplies.

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

Figure 2 – I/O parameters

Digital I/Os shall comply with the following requirements:

- 1) the PC shall be provided with at least one type of input interface and one type of output interface among those defined respectively in 3.3.1, 3.3.2 and 3.3.3;
- 2) digital inputs shall comply with the requirements of the standard voltage ratings given in 3.3.1. Non-standard voltage digital inputs should be in accordance with the design equation given in annex B;
- 3) digital outputs shall comply with the requirements of the standard ratings given in 3.3.2.1 for a.c. or 3.3.3.1 for d.c.;
- 4) it shall be possible to interconnect inputs and outputs by means of a correct selection of the above digital I/Os, resulting in proper PC-system operation. (Additional external load shall be specified by the manufacturer if necessary);
- 5) it shall be possible to feed multi-circuit 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 must be fed from the same phase;

6) 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.

NOTES

1 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 and wire-breakage are interpreted by the inputs and loads as the "off state"; on the other hand, for current sourcing inputs and current sinking outputs, earth faults are interpreted as the "on state".) (See figure 2).

2 A PC-system may be offered with interfaces which 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.

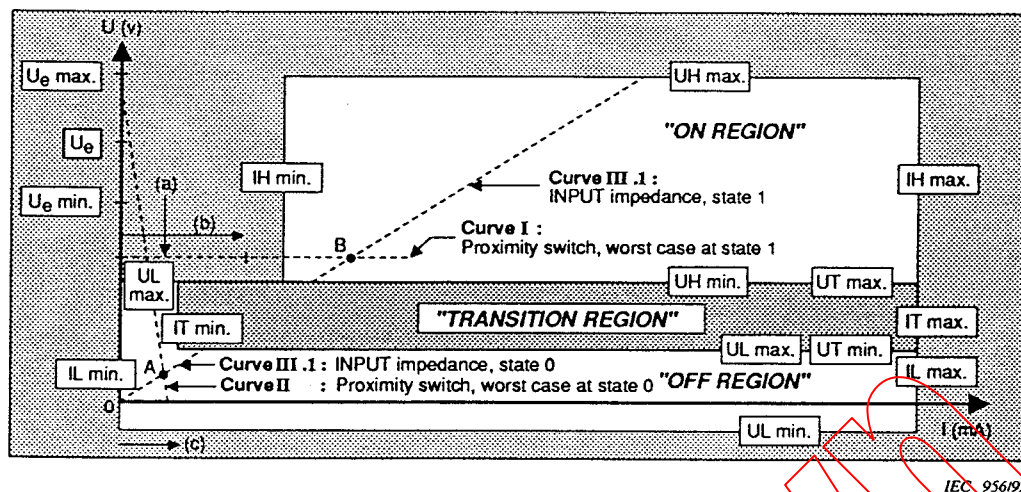
3.3.1 Digital inputs (current sinking)

3.3.1.1 Terminology (U/I operation regions)

Figure 3 below represents graphically the limits and operating ranges which are used herein to characterize current sinking digital input circuits.

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 I_H min. before 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.

The figure also presents a graphical illustration of the method explained in 3.3.1.5 for determination of compatibility between a 2-wire proximity switch (curve I: worst case at state 1, curve II: worst case at state 0), and a given input impedance curve (curve III).



- $U_H \text{ max.}$ and $U_H \text{ min.}$ are the voltage limits for the ON conditions (state 1)
- $I_H \text{ max.}$ and $I_H \text{ min.}$ are the current limits for the ON conditions (state 1)
- $U_T \text{ max.}$ and $U_T \text{ min.}$ are the voltage limits for the transition state (ON or OFF)
- $I_T \text{ max.}$ and $I_T \text{ min.}$ are the current limits for the transition state (ON or OFF)
- $U_L \text{ max.}$ and $U_L \text{ min.}$ are the voltage limits for the OFF conditions (state 0)
- $I_L \text{ max.}$ and $I_L \text{ min.}$ are the current limits for the OFF conditions (state 0)
- $U_L \text{ max.}$ equals $U_L \text{ min.}$ to $I_T \text{ min.}$ and equals $U_T \text{ min.}$ above $I_T \text{ min.}$
- U_e , $U_e \text{ max.}$ and $U_e \text{ min.}$ are the rated voltage and its limits for the external power supply voltage
- I, II, III, (a), (b), (c), A, B relate to the example described in 3.3.1.5.

Figure 3 – U/I operation regions of current sinking inputs

3.3.1.2 Standard operating ranges for digital inputs (current sinking)

Current sinking digital inputs shall operate within the limits presented in the following table 9.

Table 9 – Standard operating ranges for digital inputs (current sinking)

ND: Not defined

Rated voltage U_e	Rated frequency F_n Hz	Type of limit	Type 1 limits (note 7)						Type 2 limits (note 7)						Notes
			State 0		Transition		State 1		State 0		Transition		State 1		
			U_L V	I_L mA	U_T V	I_T mA	U_H V	I_H mA	U_L V	I_L mA	U_T V	I_T mA	U_H V	I_H mA	
24 V d.c..	—	Max. Min.	15/5 -3	15 ND	15 5	15 0,5	30 15	15 2	11/5 -3	30 ND	11 5	30 2	30 11	30 6	1, 2, 4, 5
48 V d.c.	—	Max. Min.	34/10 -6	15 ND	34 10	15 0,5	60 34	15 2	30/10 -6	30 ND	30 10	30 2	60 30	30 6	1, 2, 4
24 V a.c.	50/60	Max. Min.	14/5 0	15 0	14 5	15 1	27 14	15 2	10/5 0	30 0	10 5	30 4	27 10	30 6	1, 3
48 V a.c.	50/60	Max. Min.	34/10 0	15 0	34 10	15 1	53 34	15 2	29/10 0	30 0	29 10	30 4	53 29	30 6	1, 3
100 V a.c. 110 V a.c. 120 V a.c.	50/60	Max. Min.	79/20 0	15 0	79 20	15 1	1,1 U_n 79	15 2	74/20 0	30 0	74 20	30 4	1,1 U_n 74	30 6	1, 3, 4, 6
200 V a.c. 230 V a.c. 240 V a.c.	50/60	Max. Min.	164/40 0	15 0	164 40	15 2	1,1 U_n 164	15 3	159/40 0	30 0	159 40	30 5	1,1 U_n 159	30 7	1, 3, 4, 6

NOTES

- 1 All logic signals are in positive logic. Open inputs shall be interpreted as state 0 signal. Compatibility with 2-wire proximity switches according to IEC 947-5-2 is possible with type 2 (see also note 3). 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 voltage 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, 24 V a.c. See 3.2.1.1 for requirements.
- 4 Recommended for common usage and future designs.
- 5 The minimum external power supply voltage for type 2, 24 V d.c. inputs connected to two-wire proximity switches should be higher than 20 V d.c. or U_H min. lower than 11 V to allow sufficient safety margin.
- 6 As allowed by the 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 100 V a.c. and 200 V a.c.
- 7 See definitions in 1.4.25.

3.3.1.3 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.

3.3.1.4 Information to be provided by the manufacturer

In addition to the requirements of clause 5, the manufacturer shall provide the following information:

- 1) volt-ampere curve over the full-operating range, with tolerances or equivalent;
- 2) digital input delay time (TID) for 0 to 1 and 1 to 0 transitions;
- 3) existence of common points between channels;
- 4) effect of incorrect input terminal connection;
- 5) isolation potentials between channel and bus and between channels under normal service conditions;
- 6) type of input (type 1 or type 2);
- 7) monitoring point and binary state of visual indicator;
- 8) effects when withdrawing/inserting input module under power;
- 9) additional external load when interconnecting inputs and outputs, if needed;
- 10) explanation of signal evaluation (for example static/dynamic evaluation, interrupt release, etc.);
- 11) recommended cable and cord lengths depending on cable type and electro-magnetic compatibility;
- 12) terminal arrangements;
- 13) typical example(s) of external connections.

3.3.1.5 Method for determination of compatibility with proximity switches

For a given proximity switch, the following characteristics shall be identified:

- i) when at state 1:
 - a) U_{drop} : maximum voltage drop at state 1
 - b) I_{hold} : minimum output current load at state 1
 - I: worst case output curve at state 1
- ii) when at state 0:
 - c) I_{leak} : maximum output current at state 0
 - II: worst case output curve at state 0.

A given proximity switch shall be compatible with a given standard input (curve III: impedance curve of the input) if:

- its curves I and II do not enter the "transition region", and
- its I_{hold} is smaller than I_H min.

Worst case steady states 0 and 1 shall be respectively at points A and B (at crossings of III with II and I).

NOTE - This method may be used for any other type of static switch, such as outputs, etc.

3.3.2 Current sourcing digital outputs for alternating currents

3.3.2.1 Rated values and operating ranges (a.c. r.m.s.)

Digital a.c. outputs shall comply with the ratings given in the following table 10, at the output voltage(s) stated by the manufacturer according to 3.2.1.1 and IEC 947-5-1, utilization category AC-15. See item 9 of 3.3.2.3, for other utilization categories.

Table 10 – 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	Notes
Current range for state 1 (continuous at max. voltage)	Min. (mA) Max. (A)	10 [5] 0,28	20 0,55	100 1,1	100 2,2	1, 2
Voltage drop (state 1) – Non-protected output – Protected and short-circuit proof	Max. (V) Max. (V)	3 5	3 5	3 5	3 5	1
Leakage current (state 0) – Solid state outputs – Electromechanical outputs	Max. (mA) Max. (mA)	5 [3] 2,5	10 2,5	10 2,5	10 2,5	1 2, 3
Repetition rate for temporary overload	Operating cycles/min					4
– Solid state outputs – Relay based outputs	Min. Min.	60 6	30 6	30 6	30 6	
NOTES 1 R.M.S. currents and voltages. 2 Figures between [] apply to module not equipped with RC network or equivalent surge suppressors. All other values apply to modules with suppression. 3 Leakage current for solid state outputs greater than 3 mA imply the use of additional external loads to drive type 2 inputs. 4 Typical waveform for temporary overloads ("normal conditions of use") are shown in figure 4. The test method given in IEC 947-5-1 applies to solid state outputs for "normal conditions of use" except that the repetition rate shall be as given in the table. For "abnormal conditions of use", the requirements given in IEC 947-5-1 apply.						