

Australian Standard[®]

Electronic equipment for use in power installations



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The following are represented on Committee EL-027:

- Australian Communications and Media Authority
 - Australian Electrical and Electronic Manufacturers Association
 - Bureau of Steel Manufacturers of Australia
 - Department of Defence (Australia)
 - Energy Networks Association
 - Monash University
-

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STANDARDS AUSTRALIA

RECONFIRMATION

OF

AS 62103—2006

Electronic equipment for use in power installations

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NOTES

Australian Standard[®]

Electronic equipment for use in power installations

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PREFACE

This Standard was prepared by the Standards Australia Committee EL-027, Power Electronics.

The objective of this Standard is to provide designers, manufacturers and purchasers with generic requirements for electronic power equipment. This Standard applies where there is no product specific Standard available.

This Standard is identical with, and has been reproduced from IEC 62103, Ed.1.0 (2003), *Electronic equipment for use in power installations*.

Informative notes have been added in Clauses 5.2.11.1 and 9.2.

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INTRODUCTION

As the title indicates this International Standard applies where electronic equipment (EE) is to be installed or is used in power installations. The term electronic equipment denotes equipment which may contain information technology equipment as well as power electronic equipment and non-electronic components. Electronic equipment may be designed and used as stand-alone-equipment or as sub-assemblies built as cubicles, plug-in-units or assembled printed circuit boards. However the EMC requirements are always to be fulfilled on the apparatus or system level.

The term power installation as used in this standard denotes an installation with assembled electrical and electronic equipment in a given location and designed for coordinated operation and connected to an electricity supply system. Although the use of the installation is not specified it is expected that the main purpose will be controlling, regulating and converting electrical energy. In all cases in this standard a power installation is interacting with the electricity supply system, either directly e.g. by means of control, regulating and protection system, or indirectly e.g. by means of measurements leading to intervention by personnel. However, power installation as used in other standards may have other definitions.

This standard mainly applies where electronic equipment is integrated into or is used in power installations. As the standard is also concerned with the design and testing of electronic equipment, the appropriate clauses within it apply in cases where no other applicable specifications exist in individual product standards.

Beyond that the main intention of the standard is to stipulate minimum requirements for the design and manufacture of electronic equipment, for protection against electric shock, for testing and for the integration into systems for power installations. Right from the beginning and reflecting the experiences of the experts it seems necessary to use minimum requirements in order to achieve a certain technical level with respect to safety and reliability. This is especially true where electronic equipment is assembled into power installations.

In all cases where more severe requirements are defined in individual product standards or purchasing specifications they shall take precedence over the requirements of this standard. This may be true for special safety related applications of electronic equipment or applications under special environmental conditions.

In the other cases where a product standard does not meet the minimum requirements of this standard and therefore prevents the direct use of electronic equipment designed and manufactured fulfilling the requirements of those product standards additional means have to be considered in power installations. One possibility is to influence the environmental conditions in which the electronic equipment is operating so that they are compatible with the requirements of this standard. This can be done by special casing or means of filtering for example. The other possibility is to improve the electronic equipment so that it meets the requirements of this standard.

STANDARDS AUSTRALIA

Australian Standard**Electronic equipment for use in power installations****1 Scope**

This International Standard applies to ~~the use of~~ electronic equipment (EE) in power installations where a uniform technical level ~~with respect to~~ of safety and reliability is ~~necessary~~ required. This standard also applies to EE which are not covered by a specific product standard.

This standard defines the minimum requirements for the design and manufacture of EE connected to low-voltage (not exceeding 1 000 V a.c. or 1 500 V d.c.) mains supplies, for protection against electric shock, for testing and its integration into systems for power installations.

This standard does not cover the following applications: Electrical accessories and electrical appliances for household and similar purposes, medical equipment, electric railway equipment, data processing without control on systems and processes, public and private non-industrial telecommunication and radio communication equipment and networks, protection relays, residual-current-operated protective devices, uninterruptible power supplies, lighting equipment and public charging equipment for electrical vehicles.

2 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.

References to international standards that are struck through in this clause are replaced by references to Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is identified as such.

~~IEC 60050-151, International Electrotechnical Vocabulary (IEV) — Part 151: Electrical and magnetic devices~~

AS 1852.151, *International electrotechnical vocabulary, Part 151: Electric and magnetic devices* (identical to IEC 60050-151)

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) — Chapter 161: Electro-magnetic compatibility*

IEC 60050-195, *International Electrotechnical Vocabulary — Part 195: Earthing and protection against electric shock*

~~IEC 60050-826, International Electrotechnical Vocabulary (IEV) — Chapter 826: Electrical installations of buildings~~

AS 1852.826, *International electrotechnical vocabulary, Part 826: Electrical installations of buildings* (identical to IEC 60050-826)

~~IEC 60060-1:1989, High voltage test techniques — Part 1: General definitions and test requirements~~

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~~IEC 60068-2-2:1974, Basic environmental testing procedures — Part 2: Tests — Test B: Dry heat
Amendment 1 (1993) —
Amendment 2 (1994)~~

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

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~~IEC 60068-3-4:2001, Environmental testing — Part 3-4: Supporting documentation and guidance — Damp heat tests~~

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~~IEC 60071-1:1993, Insulation co-ordination — Part 1: Terms, definitions, principle and rules~~

AS 1824.1, *Insulation coordination, Part 1: Definitions, principles and rules*

IEC 60071-2:1996, *Insulation co-ordination — Part 2: Application guide*

~~IEC 60112:1979, Method for determining the comparative and the proof tracking indices of solid insulation materials under moist conditions~~

AS/NZS 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

~~IEC 60146-1-1:1991, Semiconductor — General requirements and line-commutated — Part 1-1: Specifications of basic requirements~~

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IEC 60227 (all parts), Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V

~~IEC 60269-1:1998, Low-voltage fuses — Part 1: General requirements~~

AS/NZS 60269.1, Low-voltage fuses, Part 1: General requirements (identical to IEC 60269-1)

IEC 60297-1:1986, Dimensions and mechanical structures of the 482,6 mm (19 in) series – Part 1: Panels and racks

IEC 60352-1:1997, Solderless connections – Part 1: Wrapped connections – General requirements, test methods and practical guidance

~~IEC 60352-2:1990, Solderless connections — Part 2: Solderless crimped connections — General requirements, test methods and practical guidance~~

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~~IEC 60364-4-41:2001, Electrical installations of buildings — Part 4-41: Protection for safety — Protection against electric shock~~

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~~IEC 60364-4-43:2001, Electrical installations of buildings — Part 4-43: Protection for safety — Protection against overcurrent~~

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~~IEC 60364-5-54:1980, Electrical installation of buildings — Part 5: Selection and erection of electrical equipment — Chapter 54: Earthing arrangements and protective conductors — Amendment 1 (1982)~~

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~~IEC 60364-6-61:2001, *Electrical installations of buildings – Part 6-61: Verification – Initial verification*~~

AS/NZS 3000 (Section 6), *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

~~IEC 60417-1:2001, *Graphical symbols for use on equipment – Part 1: Overview and application*~~

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IEC 60721-3-2:1997, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 2: Transportation*

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Amendment 2 (1992)

~~IEC 60990:1999, *Methods of measurement of touch current and protective conductor current*~~

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AS/NZS 61000.6.1, *Electromagnetic compatibility (EMC) Part 6.1: Generic standards—Immunity for residential, commercial* (identical to IEC 61000-6-1)

~~IEC 61000-6-2:1999, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards—Immunity for industrial environments*~~

AS/NZS 61000.6.2, *Electromagnetic compatibility (EMC), Part 6.2: General standards—Immunity for industrial environments* (identical to IEC 61000-6-2)

~~IEC 61000-6-3:1996, *Electromagnetic compatibility (EMC) — Part 6: Generic standards—Section 3: Emission standard for residential, commercial and light industrial environments*~~

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IEC 61136-1:1992, *Semiconductor power converters – Adjustable speed electric drive systems – General requirements – Part 1: Rating specifications, particularly for d.c. motor drives*

IEC 61140:2001, *Protection against electric shock – Common aspects for installation and equipment*

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AS 4362.1, *High-voltage test techniques for low-voltage equipment, Part 1: Definitions, test and procedure requirements* (identical to IEC 61180-1)

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ISO 9000 (all parts), *Quality management systems*

AS/NZS ISO 9000 (all parts), *Quality management systems—Fundamentals and vocabulary*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

adjacent circuits

electric circuits which are separated from the considered circuit by the necessary basic or double/reinforced insulation

NOTE Circuits which are separated by far more than double or reinforced insulation are not considered to be adjacent.

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3.2**ambient air temperature**

temperature measured at half the distance from any neighbouring equipment, but not more than 300 mm distance from the enclosure, at middle height of the equipment, protected from direct heat radiation from the equipment

[IEC 60146-1-1]

3.3**apparatus**

a finished product with an intrinsic function intended for the final user and intended to be placed on the market or put into service as a single commercial unit

3.4**basic insulation**

insulation applied to hazardous-live parts to provide basic protection against electric shock under fault-free conditions

[IEC 61140, modified]

3.5**(electrical) circuit**

current paths of components or assemblies, conductors, terminals and items of equipment located within the EE and connected to each other by electrically conducting connections

NOTE 1 If electrical systems are conductively connected via earth only, then they are regarded as separate circuits.

NOTE 2 The clause "conductively connected" means the direct electrical connection and the connection via components such as resistors, capacitors, choke-coils, semiconductor devices, switches and fuses, but not, however, coupling by means of transformers or opto-electronic devices or similar.

NOTE 3 A protectively separated circuit of EE has protective separation from all adjacent circuits.

3.6**closed electrical operating area**

room or location which is exclusively used as an enclosure for operation of electrical installations and is kept locked; the lock is only opened by authorized persons, and access whilst energised is allowed only to skilled persons

NOTE To these locations belong for example closed switch plants, distribution plants, switchgear cells, transformer cells, distribution systems in metal-sheet enclosures or in other closed installations.

3.7**(electromagnetic) compatibility**

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

[IEV 161-01-07]

3.8**(electromagnetic) compatibility level**

the specified electromagnetic disturbance level expected to be impressed on a device, equipment or system operated in particular conditions

[IEV 161-03-10]

NOTE In practice, the electromagnetic compatibility level is not an absolute maximum, but may be exceeded by a small probability.

3.9**component**

item used in the composition of a device or apparatus and without intrinsic function for the final user

3.10**considered circuit**

electrical circuit which is under consideration concerning its dielectric tests or its insulation to accessible surfaces or to adjacent circuits

3.11**control (action)**

manual or automatic control of processes

NOTE It would apply to EE in which control action is incorporated within supervisory control and data acquisition systems and other process control systems.

3.12**cooling medium**

liquid (for example water) or gas (for example air) which removes heat from the equipment

3.13**cooling medium temperature for air or gas cooling**

average temperature measured outside the equipment at points 50 mm from the inlet to the equipment

3.14**cooling medium temperature for liquid cooling**

temperature measured in the liquid pipe 100 mm upstream from the liquid inlet

3.15**decisive voltage**

voltage, taking into account non-sinusoidal waveforms (see 5.2.13), defining the borderlines to be used between extra-low-voltage, low voltage and high voltage

NOTE These borderlines are used to determine the requirements of protective earthing when designing clearances and creepage distances for the arrangement of protective measures.

3.16**device**

combination of components having a given function, forming a part or a piece of an equipment, apparatus or system

NOTE 1 For example, thermostat, relay, push buttons, switch or contactor.

NOTE 2 The terms "component" and "device" are used side by side in this standard.

3.17**direct contact**

contact of persons or livestock with live parts

[IEV 826-03-05]

3.18**(electromagnetic) disturbance**

electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter

[IEV 161-01-05]

NOTE An electromagnetic disturbance may be an electromagnetic noise, an unwanted signal or a change in the propagation medium itself.

3.19**double insulation**

insulation comprising both basic insulation and supplementary insulation

[IEV 195-06-08]

NOTE Basic and supplementary insulation are separate, each designed for basic protection against electric shock.

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3.20**electrical equipment**

item used for such purposes as generation, conversion, transmission, distribution or utilization of electrical energy, such as machines, transformers, apparatus, measuring instruments, protective devices, equipment for wiring systems, appliances

[IEV 826-07-01]

NOTE This includes sub-assemblies, equipment (such as assembled printed circuit boards, plug-in units, cubicles) and installations as defined in the contract.

3.21**electricity supply system**

distribution system through which various electricity users are fed from one or more electricity producers

NOTE The users may be independent of each other, their number and type are various and they may be connected or disconnected arbitrarily.

3.22**electronic equipment****EE**

electrical equipment the main function of which is performed by the use of components using electron or ion conduction in semiconductors, in vacuum or in gases

NOTE 1 Electronic equipment contains data processing equipment and/or power electronic equipment according to its main function. It may contain non-electronic components or equipment.

NOTE 2 This includes sub-assemblies and equipment, such as assembled printed circuit boards, plug-in units, cubicles.

3.23**extra low voltage****ELV**

voltage not exceeding a limit which is generally accepted to be 50 V a.c. and 120 V d.c. (ripple free)

3.24**(electromagnetic) emission**

phenomenon by which electromagnetic energy emanates from a source

[IEV 161-01-08]

3.25**(electromagnetic) emission level (of a disturbing source)**

level of a given electromagnetic disturbance emitted from a particular device, equipment or system, measured in a specified way

[IEV 161-03-11]

3.26**equipotential bonding**

electrical connection putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential

[IEV 826-04-09]

3.27**exposed conductive part**

conductive part of electrical equipment, which can be touched and which is not normally live, but which may become live under fault conditions

[IEV 826-03-02]

3.28**extraneous conductive part**

conductive part not forming part of the electrical installation and liable to introduce a potential, generally the earth potential

[IEV 826-03-03]

3.29**FELV-system (functional extra low voltage)**

electrical system in which

- the voltage cannot exceed ELV, and
- the safety requirements for SELV or PELV systems are not satisfied

3.30**forced circulation of the cooling medium or the heat transfer agent (forced cooling)**

method of circulating the cooling medium or heat transfer agent by means of blower(s), fan(s) or pump(s)

3.31**functional earthing**

earthing of a point in an equipment or in a system which is necessary for a purpose other than safety

3.32**functional insulation**

insulation between conductive parts which is necessary only for the proper functioning of the equipment

[IEC 60664-1]

3.33**heat transfer agent**

liquid (for example water) or gas (for example air) within the equipment to transfer the heat from its source to a heat exchanger from where the heat is removed by the cooling medium

3.34**(electromagnetic) 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]

3.35**(electromagnetic) immunity level**

maximum level of a given electromagnetic disturbance, incident in a specified way on a particular device, equipment or system, for which it remains capable of operating at a required degree of performance

[IEV 161-03-14, modified]

3.36**(electromagnetic) immunity margin**

the difference between the immunity limit of a device, equipment or system and the electromagnetic compatibility level

[IEV 161-03-16]

3.37**indirect contact**

contact of persons or livestock with exposed conductive parts which have become live under fault conditions

[IEV 826-03-06]

3.38**indirect cooling**

method of cooling in which the heat transfer agent is used to transfer heat from the part to be cooled to the cooling medium

3.39**installation**

several combined items of apparatus or systems put together at a given place to fulfil a specific objective but not intended to be placed on the market as a single functional unit

3.40**(electromagnetic) interference**

degradation of the performance of an equipment, transmission channel or system caused by an electromagnetic disturbance

[IEV 161-01-06]

3.41**leakage current (in an installation)**

current which, in the absence of a fault, flows to earth or to extraneous conductive parts in a circuit

[IEV 826-03-08]

NOTE This current may have a capacitive component including that resulting from the deliberate use of capacitors.

3.42**live part**

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

[IEV 826-03-01]

3.43**mains-circuit**

electrical circuit which is conductively connected to and energized directly from the supply mains

3.44**malfunction**

operation of EE which is outside of the specification

3.45**natural circulation of the cooling medium or the heat transfer agent (convection)**

method of circulating the cooling fluid (cooling medium or heat transfer agent) which uses the change of volumetric mass (density) with temperature

3.46**nominal value**

value of a quantity used to designate and identify a component, device equipment or system

[IEV 151-16-09]

3.47**non-mains-circuit**

electrical circuit which is not energized directly from the supply mains but is for example isolated by a transformer for particular EE(s) or supplied by a battery

3.48**over voltage category**

numeral defining an impulse withstand level

[IEC 60664-1]

NOTE Over voltage categories I, II, III and IV are used, see 5.2.16.

3.49**PELV-system (protective extra low voltage)**

electrical system

- in which the voltage cannot exceed ELV, and
- with protective separation from systems other than PELV, and
- with provisions for earthing of the PELV-system, or its exposed conductive parts, or both

3.50**PEN conductor**

earthed conductor combining the functions of both protective conductor and neutral conductor [IEV 826-04-06]

NOTE The acronym PEN results from the combination of the symbols PE for the protective conductor and N for the neutral conductor.

3.51**performance criteria**

performance specification for the operation of the EE throughout the environmental conditions stated in this specification namely

- mechanical,
- climatic,
- electrical conditions

3.52**power electronic equipment**

EE, the main function of which is conversion of energy

NOTE 1 A static switch, where the main switching function is carried out by electronic components, converts the energy from input to output:

- without any transformation (except introduction of losses) in the ON state,
- to no energy available on the output in the OFF state,

is a power electronic equipment.

NOTE 2 Switchgear, using electronics for triggering protection is not a power electronic equipment and is not an EE. (The main function is to establish or eliminate a contact performed by use of mechanical components.)

3.53**power installation**

installation with assembled electrical equipment or electronic equipment or a combination of electric and electronic equipment in a given location and designed for coordinated operation and connected to an electricity supply system

NOTE 1 The use of the installation is not specified, but it is interacting with the electricity supply system, either directly for example by means of control, regulating and protection equipment, or indirectly for example by means of measurements leading to intervention by personnel.

NOTE 2 Instead of "power installation" sometimes the wording "electrical installation" may be used.

3.54**protective bonding**

electrical connection of exposed-conductive-parts or of protective screening to provide electrical continuity by means of connection to an external protective conductor which is securely returned to earth

3.55**protective class 0**

equipment in which protection against electric shock relies upon basic insulation, which implies that there are no means for the connection of accessible conductive parts, if any, to the protective conductor in the fixed wiring of the installation, reliance in the event of a failure of the basic insulation being placed upon the environment

3.56**protective class I**

equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in such a way that means are provided for the connection of accessible conductive parts to the protective (earthing) conductor in the fixed wiring of the installation in such a way that accessible conductive parts cannot become live in the event of a failure of the basic insulation

3.57**protective class II**

equipment in which protection against electric shock does not rely on basic insulation only, 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

3.58**protective class III**

equipment in which protection against electric shock relies on supply at safety extra-low voltage (SELV) and in which voltages higher than those of ELV are not generated

3.59**protective conductor**

conductor required for protection against electric shock by electrically connecting any of the following parts:

- exposed conductive parts;
- extraneous conductive parts;
- main earthing terminal;
- earth electrode;
- earthed point of the source or artificial neutral

[IEV 826-04-05, modified]

3.60**protective earthing**

earthing of a point in a system, installation or equipment for protection against electric shock in case of a fault

3.61**protective impedance device**

component or assembly of components the impedance and construction of which are such as to ensure that the steady-state touch-current and charge are limited to non-hazardous levels

[IEC 61140]

3.62**protective screening**

separation of circuits from hazardous live-parts by means of an interposed conductive screen, connected to the means of connection for an external protective conductor

[IEC 61140, modified]

3.63**protective separation**

separation between circuits by means of basic and supplementary protection (basic insulation plus supplementary insulation or protective screening) or by an equivalent protective provision (for example reinforced insulation)

[IEC 61140, modified]

3.64**rated insulation voltage (RIV)**

voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified (long-term) withstand capability of its insulation

[IEC 60664-1, modified]

NOTE 1 The rated insulation voltage is higher than or equal to the rated voltage of the equipment, or to the rated voltage of the concerned part of the equipment, which is primarily related to functional performance.

NOTE 2 The rated insulation voltage refers to the insulation between electric circuits, between live parts and exposed conductive parts and within an electric circuit.

NOTE 3 For clearances and solid insulation, the peak value of the voltage occurring across the insulation or clearance is the determining value for the rated insulation voltage. For creepage distances the r.m.s. value is the determining value.

3.65**rated value**

value of a quantity used for specification purposes established, for a specified set of operating conditions of a component, device, equipment or system

[IEV 151-16-08]

3.66**rated voltage**

value of voltage assigned by the manufacturer, to a component, device or equipment and to which operation and performance characteristics are referred

[IEC 60664-1]

NOTE Equipment may have more than one rated voltage value or may have a rated voltage range.

3.67**reference conductor**

conductor to which the potential of other conductors is related

3.68**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 the relevant IEC standard

[IEC 61140, modified]

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

3.69**relative short-circuit power**

ratio of the short-circuit power of the source to the fundamental apparent power on the line side of the converter(s)

[IEC 60146-1-1]

NOTE This refers to a given point of the network, for specified operating conditions and network configuration.

3.70

SELV-system (safety extra low voltage)

electrical system

- in which the voltage cannot exceed ELV, and
- with protective separation from systems other than SELV, and
- with no provision for earthing the SELV-system, or its exposed conductive parts, and
- with simple separation from earth

3.71

shields/screens

fully or partly closed electrically or magnetically conductive coverings which limit the reception or radiation of noise signals to some defined level

3.72

short supply interruption

disappearance of the supply voltage for a period of time not exceeding 1 minute

NOTE Short supply interruptions can be considered as voltage dips with 100 % amplitude.

3.73

simultaneity factor

ratio of the sum of the fundamental apparent power of power converters, connected to a section of the supply mains, which inevitably commutate during the same time, to the sum of the rated values of the fundamental apparent power of all power converters connected to the same section of the supply mains

3.74

supplementary insulation

independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation

[IEC 61140, modified]

NOTE Basic and supplementary insulation are separate, each designed for basic protection against electric shock.

3.75

supply voltage variation

change, the duration of which can be short or long, of the supply voltage to a higher or lower value than the nominal voltage

3.76

system

several items of apparatus combined to fulfil a specific objective and intended to be placed on the market as a single functional unit

3.77

used as intended

powered up, and in the operational state(s) stated in the relevant performance specifications of the EE concerned

3.78

voltage dip

sudden reduction of the voltage at a point in the electrical system, followed by voltage recovery after a short period of time, from half a cycle to a few seconds

3.79**voltage notch**

voltage change with a duration much shorter than the a.c. period, which may appear on an a.c. voltage, for example due to the commutation process in a converter

[IEV 161-08-12, modified]

3.80**voltage unbalance**

condition in a polyphase system in which the r.m.s values of the phase voltages or the phase angles between consecutive phases are not all equal

[IEV 161-08-09, modified]

3.81**withstand**

state of survival of the EE to the related imposed environmental or test condition (for example impulse withstand voltage)

3.82**working life**

total time for which EE is expected to be operational

NOTE This is defined by all the following factors:

- equipment maintenance has not yet reached the stage of being uneconomic;
- replacement parts are still available;
- the failure rate is still below a specified level;
- the performance of the equipment has not degraded to a point where even with replacement of components and application of maintenance procedures, it no longer meets its specification requirements.

EE is considered to have come to the end of its working life when any one of the above criteria is no longer true.

4 Requirements for the entire system

The requirements of this standard are minimum requirements and apply to the design and manufacture of EE and its erection in public, commercial or industrial locations.

To achieve a uniform technical level with respect to safety and reliability, this standard defines the minimum requirements which are necessary when EE(s) are assembled into these locations.

- Where an EE does not meet the requirements of this standard, and is therefore prevented from direct use in these locations, either:
 - a) the environmental conditions for the EE shall be made compatible by additional means;
 - or
 - b) the EE shall be improved, or an EE selected to meet the requirements of this standard.
- Where an EE has to meet more severe requirements as defined in its individual product standards, these requirements shall take precedence over the requirements of this standard.

4.1 Normal function

Electronic EE shall be designed and manufactured so that it fulfils its function and does not endanger persons and property in normal operation when set up as specified and used as intended. This also applies to the interaction of EE(s) with the entire installation.

For testing, see 9.1.3 and 9.4.7.

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4.2 Damage to persons or material

4.2.1 Damage to persons

The requirements for limiting the effects of fault conditions are the same for EE as for other EE.

However, in the context of EE, the breakdown/shorting of components (such as semiconductor junctions) shall be taken into account in a design. The application of safety techniques shall be considered, such as:

- within EE itself by safe practice, circuit arrangement and other measures, for example, fail-safe techniques, redundancy, diversity

and/or:

- by additional independent EE or measures (for example by another EE which adopts the function of the failed EE); or
- by electrical or non-electrical protective arrangements (for example, interlocks in the power section, mechanical lock-out); or
- by measures that cover the entire system (for example automatic disconnection in case of fire); or
- by human action (where this is not the only measure).

When designing the entire installation, it shall be determined which safe practice measures should be applied assuming that no such safe practice measure has been applied within EE itself.

NOTE In the fifth bullet point above, "human action" assumes that the person assigned for this purpose can recognize a fault function which endangers persons and can immediately take measures to avoid danger.

4.2.2 Material damage

Depending on the requirements, measures shall be taken to avoid material damage in the event of failure of an EE.

4.3 EE connected to unearthed supply mains under earth fault conditions

According to 8.3.1, a monitoring device for the insulation resistance is required in an IT-network, giving an alarm signal in case of an earth fault. This limits the risk that another earth fault occurs before the first earth fault is attended to.

NOTE It is assumed here that the EE is connected to a supply mains with normal earth capacitances not exceeding 5 μF per phase and that the over voltages caused by the earth fault do not exceed the values of the standards referred to in A.6.3.5.1. Special agreements would be required in the case of large supply mains with higher earth capacitances.

4.3.1 Earth fault in the supply mains

An earth fault in the supply mains to which the EE is connected with or without electrical isolation (transformer), shall neither cause any damage to the EE nor cause any protective device (for example fuse) of the EE to operate. The EE should be able to continue its operation trouble-free when an earth fault occurs, throughout the fault condition and when it is cleared.

4.3.2 Earth fault at the output

If required in the purchasing specification, a single earth fault at the power output of an EE connected to unearthed supply mains shall neither cause any damage to the EE nor cause any protective device (for example fuse) of the EE to operate, regardless of whether the power output is conductively coupled to the supply mains or not. The EE should be able to continue its operation when an earth fault occurs, during the earth fault and when it is cleared. However, the tolerance limits of the normal operation may be exceeded.

Tripping or fuse blowing in the EE caused for example by double earth fault in the installation shall be accepted in agreed cases.

4.4 Earthing requirements

Earthing in EE is required not only to reduce the effects of interference, but also, and more importantly, for reasons of safety. Where there is any conflict between these two requirements, safety shall always take precedence. (see Annex A)

4.5 Wires and cables for interconnection

Wires and cables specified in accordance with IEC standards for telecommunication systems and broadcasting systems may be used between components, sub-assemblies and equipment; etched printed wiring may also be used inside sub-assemblies.

The following shall apply for connections between components, sub-assemblies and equipment:

Conductors and their cross sections shall comply with the electrical, mechanical and climatic requirements of this standard. Furthermore, the structure of the conductors and their cross sections shall be matched to the connection method used (for example connection method without screws or soldering shall be according to the series of IEC 60352-1 or IEC 60352-2).

4.6 Fuses in neutral and protective conductors

Fuses in protective conductors are not permitted. Neutral and protective conductors shall not be connected together in any assembly or piece of equipment.

Generally it is not permitted to use a fuse in a neutral conductor. However the following exceptions are permitted:

- a) A fuse may be used in the neutral conductor if the phase conductors are automatically disconnected at the same time as the neutral conductor.
- b) Fuses which function as overload protection in EE which is designed for connection to any type of mains-circuit, may be located in any live conductor. Short-circuit protection shall be ensured by other means (see Figure 1).

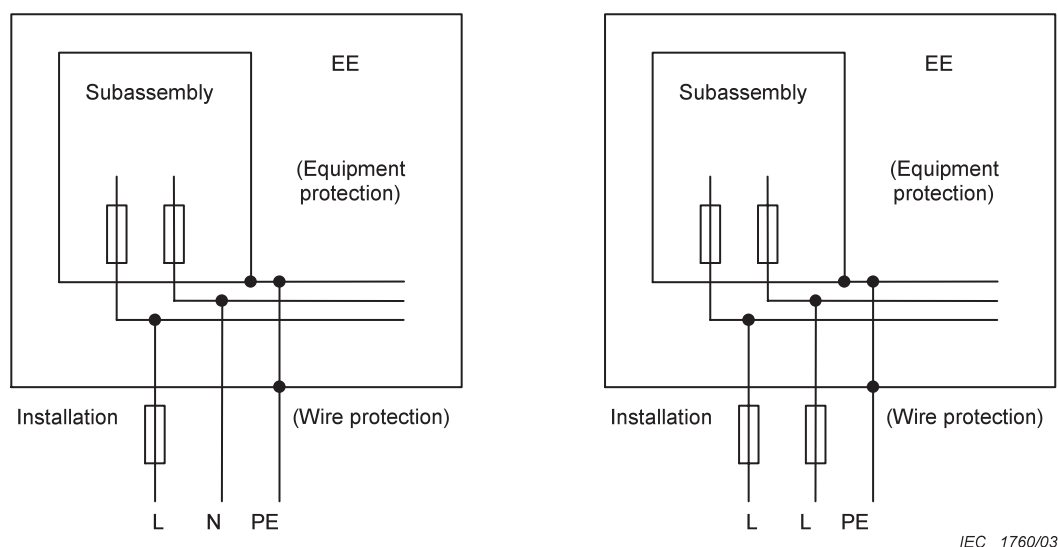


Figure 1 – Arrangement of fuses in sub-assemblies and in installations

5 Safety requirements

5.1 General requirements

The protection of persons against electric shock shall in the case of EE be arranged so that a single fault does not cause a hazard. This is considered to be fulfilled if the requirements of 5.2 and 5.3 are satisfied.

Figure 2 presents a summary for the design, construction and assembly of EE with regard to protection against electric shock arising from direct and indirect contact.

This Figure is expanded upon, and complemented by Figures 8 to 13, (see 5.2.15.1) which lead to identification of the grade of insulation. This, together with Tables 3 to 6 (see 5.2.16 to 5.2.17) leads to the selection of the clearance, creepage distance and puncture strength of solid insulation which are required to satisfy this standard.

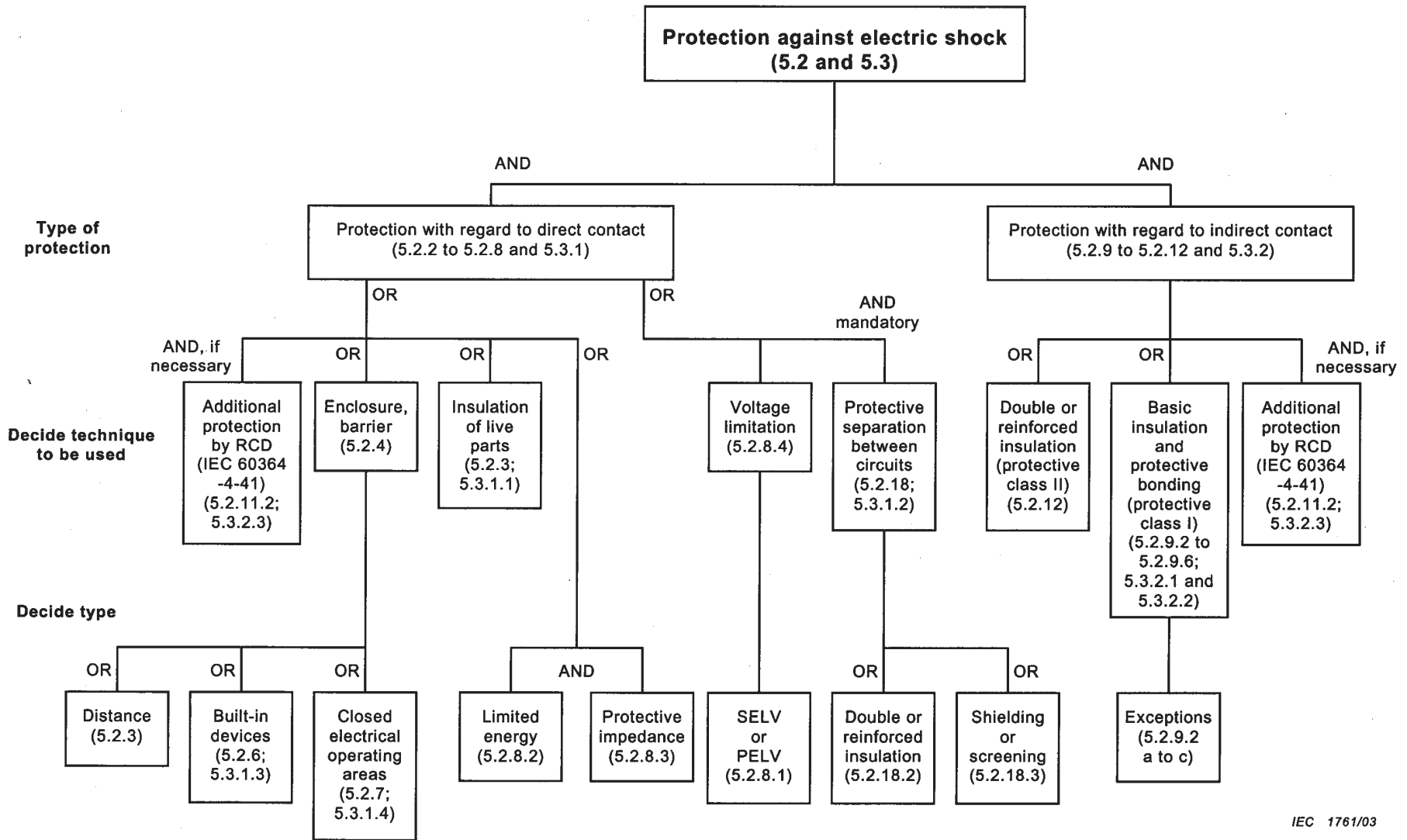


Figure 2 – Functional summary of protective measures against electric shock

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5.2 Requirements for EE with regard to protection against electric shock

5.2.1 Requirements for protection against electric shock

IEC 60364-4-41 covers protection against electric shock within electrical installations of buildings and IEC 61140 covers protection against electric shock from electrical equipment. IEC 61140 contains guidelines for the requirements for installation and equipment with regard to protection against electric shock.

This standard provides additional requirements regarding special operational conditions for EE where the relevant information is not available within the above or other international standards.

The principle of the above mentioned standards is:

The protection of persons and livestock against electric shock shall be maintained in single fault conditions as well as under normal conditions. This protection shall be achieved by the application of 5.2 to the design and construction of EE.

The testing of components and equipment with regard to protection against electric shock shall be conducted as **type tests** and **routine tests** as defined in clause 9.

5.2.2 Protection against direct contact

Protection against direct contact is employed to prevent the live parts of EE being touched by persons. It shall be provided by one or more of the measures given in 5.2.3 to 5.2.7.

Any conductive part that is not separated from the live parts by at least basic insulation shall be considered to be a live part.

A metallic accessible part is considered to be conductive, if its surface is bare or is covered by an insulating layer which does not comply with the requirements of basic insulation.

With respect to testing of **components and equipment**, the measures taken in accordance with 5.2.2 to 5.2.7 shall be checked for compliance by visual inspection. These requirements shall also apply to devices constructed or installed during the implementation of the installation.

5.2.3 Protection by means of insulation of live parts

Live parts shall be completely surrounded with permanent (non removable) insulation. This insulation shall be designed for a rated insulation voltage (RIV) according to

- 5.2.14.1.
- Table 3 or Table 4.

The grade of insulation – basic, double or reinforced – depends upon

- the decisive voltage U_M (see 5.2.13) of the circuit under consideration;
- the limits for extra-low voltage 50 V a.c. or 120 V d.c.;
- the use of extra-low voltage systems (SELV or PELV).

The choice of insulation shall be determined from list a) or b) 1), b) 2), b) 3) and b) 4) below (referring also to Figure 3):

- a) Basic insulation with the rated insulation voltage (RIV) of the circuit (case 1a))
 - when it is positioned between live parts and accessible conductive parts of EE that are connected to the protective conductor via protective bonding.
- b) 1) Double or reinforced insulation with the rated insulation voltage of the circuit (cases 1b) or 1c))
 - when it is located between live parts and the surface of accessible parts of EE that are non-conductive or conductive, but are not connected to the protective conductor, and
 - when live parts have a decisive voltage $U_M > 50 \text{ V a.c. or } 120 \text{ V d.c.}$
- b) 2) Basic insulation for the rated insulation voltage (RIV) corresponding to the highest RIV of adjacent circuits
 - when it is positioned between live parts and the surface of accessible parts of EE that are non-conductive or conductive, but are not connected to the protective conductor, and
 - when live parts have a decisive voltage $U_M \leq 50 \text{ V a.c. or } 120 \text{ V d.c.}$ and are separated by basic insulation from adjacent circuits which have a $U_M > 50 \text{ V a.c. or } 120 \text{ V d.c.}$
- b) 3) Basic insulation for the rated insulation voltage of the circuit corresponding to $25 \text{ V a.c. or } 60 \text{ V d.c.} < U_M \leq 50 \text{ V a.c. or } 120 \text{ V d.c.}$
 - when it is positioned between live parts and the surface of accessible parts of EE that are non-conductive or conductive, but are not connected to the protective conductor, and
 - with live parts of the circuits at $25 \text{ V a.c. or } 60 \text{ V d.c.} < U_M \leq 50 \text{ V a.c. or } 120 \text{ V d.c.}$ that have protective separation (see 5.2.18) from adjacent circuits with decisive voltage $U_M > 50 \text{ V a.c. or } 120 \text{ V d.c.}$
- b) 4) No insulation required for live parts designed according to 5.2.8 with a decisive voltage of $U_M \leq 25 \text{ V a.c. or } 60 \text{ V d.c.}$ that have protective separation from adjacent circuits.

A flow chart for determination of insulation between live parts and accessible surface is given in Figure 9.

NOTE Examples for insulation between live and accessible parts are shown in Figure 3 and for insulation between separate electrical circuits and accessible parts are shown in Figures A.4 and A.5.

Basic insulation and double or reinforced insulation shall be subjected to voltage tests as given in Table 17 and/or Table 18.

As an alternative to solid insulation, a clearance according to 5.2.15.1 and 5.2.16 or a distance corresponding to a clearance as shown by L_1 and L_2 in Figure 3 of 5.2.3, cases 2, may be totally or partially provided (see Figure 3, cases 2 a., 2 b. or 2 c.).

Testing shall be by visual inspection and/or if necessary by applying the probe test according to clause 12 of IEC 60529.

Type of insulation	Insulation configuration		
	a. Accessible parts conductive and connected to PE	b. Accessible parts not conductive	c. Accessible parts conductive, but <u>NOT</u> connected to PE
1. Solid or liquid insulation			
2. Insulation totally or partially by air clearance			
3. Requirements for apertures in enclosures			

Key

A live part	L_1 clearance for basic insulation	S surface of EE
B basic insulation	L_2 clearance for reinforced insulation	T test finger
D double insulation	M conductive part	V reinforced insulation
I insulation less than B	PE protective earth	Z supplementary insulation

* also applies to plastic screws † no direct contact

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Figure 3 – Examples for protection against direct contact

5.2.4 Protection by means of enclosures and barriers

EE shall comply with the relevant requirements of IEC 60364-4-41 and IEC 61140.

Live parts shall be arranged in enclosures or located behind barriers that meet at least the requirements of IP2X according to IEC 60529. The top surfaces of enclosures or barriers that are easily accessible shall meet at least the requirements of IP4X.

The minimum protection provided shall take account of the particular circumstances of the installation and in addition, such protection shall be provided in accordance with the expected environmental conditions as given in clause 6 (see Annex A).

Testing shall be by visual inspection. In case of doubt, remeasurement of the enclosure openings and testing with a probe according to clause 12 of IEC 60529 shall be conducted. In this context, the test procedure laid down in 12.2 of IEC 60529 (i.e., with test lamp and voltage at least 40 V) can be used when it is ensured that contact of the probe with a live part of the circuit in the EE to be tested will in fact result in a test indication. If this is not the case, then non-contact of the probe with live parts shall be determined in another manner.

5.2.5 Discharge of capacitors

After switching-off the EE, capacitors shall be discharged within 5 s to a residual charge of 50 μC (see A.5.2.8.2) or to a voltage of 60 V. If such a measure interferes with the operation of the EE, a warning sign shall be placed where it is easily observable, indicating that the discharging time is greater than 5 s. In the case of installed EE, where the voltage at the plug-and-socket devices of EE can be touched and these devices may be pulled out when live without the use of tools, the capacitors shall be discharged within 1 s to a charge of 50 μC , or to a voltage of 60 V.

With respect to the above two discharge cases, testing shall be by re-calculation of the energy or measurement of the voltage 5 s or 1 s after switching off of the EE. Where several capacitors are interconnected throughout the circuit, this shall be allowed for in such calculations.

5.2.6 Built-in devices

Sub-assemblies and devices that are intended for inclusion within a larger device or enclosure which offers the required protection do not themselves need a protective measure against direct contact. However, where there are components requiring manual operation on or close to them, IEC 61140 shall be taken into consideration.

5.2.7 EE for closed electrical operating areas

EE which is intended for installation in closed electrical operating areas need not have a protective measure itself against direct contact (however, see note 2 in A.5.2.8). Where EE requires manual intervention (for example for repair, replacements of bulbs, fuses, batteries etc.), IEC 60364-4-41 shall be consulted.

5.2.8 Protection in the case of direct contact

Protection in the case of direct contact is required to ensure that contact with live parts of EE does not produce any dangerous shock current.

The protection against direct contact according to 5.2.3 through 5.2.7 may be waived if the contact with the live parts does not produce any dangerous shock current. This applies to circuits according to one of the measures given in 5.2.8.1 to 5.2.8.5 provided that protective separation according to 5.2.18 from all other circuits is ensured.

Any external terminals which belong to EE circuits dealt with in 5.2.8 shall be identified in the operating manuals.

These clauses apply to the entire circuit including power supplies and if necessary associated peripheral devices (see Annex A).

Testing for protective separation shall be according to 9.4.5.1, 9.4.5.2.2, 9.4.5.2.3, 9.4.5.3 and 9.4.5.5 if applicable.

5.2.8.1 Protection by means of extra-low voltage with protective separation (SELV- and PELV-system)

Where SELV- or PELV-systems are applied in EE or in parts of EE, the respective requirements shall be fulfilled.

When the decisive voltage according to 5.2.13 is not higher than 25 V a.c. or 60 V d.c. (see Figure A.1 a)), and equipment is used within a zone of equipotential bonding, then protection against direct contact is not necessary.

In an area of limited space where the live parts are protected against direct contact according to 5.2.2, the decisive a.c. voltage may vary between 25 V and 50 V in order to produce a supply voltage of up to 60 V d.c.

For testing protection using extra-low voltage with protective separation, the decisive voltage (as determined by 5.2.13) shall, in case of doubt be re-measured. If applicable, the area of limited space as defined in clause 3 above shall be tested for protection against direct contact in accordance with 5.2.2 to 5.2.5.

5.2.8.2 Protection by means of limitation of the discharging energy

The stored charge available between simultaneously accessible parts protected by protective impedance shall not exceed 50 μC (see IEC 61140). According to 6.5 of IEC 61201, the charging voltage and capacitance should be limited as given in Table A.1 (see Annex A).

When testing protection which uses limitation of the discharging energy, calculations and/or measurements shall be performed to determine the charge or the voltage and capacitance.

5.2.8.3 Protection by means of protective impedance

The connection of accessible live parts to a circuit having a higher decisive voltage (5.2.13) than 25 V a.c. or 60 V d.c. as mentioned in 5.2.8.1 shall only be made through a protective impedance.

The same constructional provisions as those for protective separation (see 5.2.18) shall be applied for the construction and arrangement of the protective impedance. The current value stated below shall not be exceeded in the event of failure of a single part. When capacitors are connected to the protective impedance, the residual charge shall be in accordance with 5.2.5.

The protective impedance shall be designed so that the current through the protective impedance does not exceed a value of 3,5 mA a.c. or 10 mA d.c. It shall be noted that the decisive voltage (see 5.2.13) of the circuit having the higher voltage appears across the protective impedance.

The voltage endurance for the protective impedance shall be designed in such a manner that the protective impedance withstands the impulse withstand voltage 1,2/50 μs in accordance with column 8 in Table 3 or column 8 in Table 4, as appropriate (see Annex A).

This protection method shall be verified by visual inspection and by fault simulation. During fault simulation, calculations shall be performed to determine whether the current remains below the limits laid down above.

For details of testing see 9.4.5.1 and 9.4.5.5.

5.2.8.4 Protection by using limited voltages in control circuits

This type of protection is applicable only in control circuits for the purpose of forming reference and actual values (see Figure A.1 d)). This type of protection shall not be used in EE of protective class II, because of the provision of earthing (PE) at the basepoint of the voltage divider.

This part of a control circuit shall be designed reliably in such a way that, even if a fault occurs in the EE, the voltage across its output terminals as well as the voltage to earth will not become higher than the decisive voltage of 25 V a.c. or 60 V d.c. according to 5.2.8.1. The same constructive measures as in protective separation (see 5.2.18) shall be employed in this case.

When providing disconnection points for a circuit with protective separation, A.5.2.8.3 should apply, where relevant.

When testing protection by means of voltage limitation, it shall be verified by visual inspection and by fault simulation. During fault simulation, calculations shall be performed to determine whether the voltage remains below the limits laid down above.

5.2.8.5 Connectors

In addition to the measures as given in 5.2.8.1 to 5.2.8.4, (SELV, PELV, limited discharging energy, protective impedance, limited voltage) it shall be ensured that in the event of error or polarity reversal of connectors no voltages that exceed 25 V a.c. or 60 V d.c. can be connected into a circuit with protective separation. This applies for example to plug-in-sub-assemblies or other plug-in devices which can be plugged-in without the use of a tool (key) or which are accessible without the use of a tool. This does not apply to EE which is intended for assembly in closed electrical operating areas (see 5.2.7). See also 7.1.9.

If required, testing of non-interchangeability and protection against polarity reversal of connectors, plugs and socket outlets shall be confirmed by visual inspection and trial insertion.

5.2.9 Protection with regard to indirect contact

Protection against indirect contact is required to prevent shock currents which can result from exposed conductive parts of EE during an insulation failure. This protection shall be designed according to the following requirements:

For EE constructed to protective class I the requirements as given in 5.2.9.1 to 5.2.11 apply.

The content of 5.2.12 deals with particular aspects of protective class II.

Protective class III is rarely applicable for EE.

Protective class 0 is not acceptable for EE.

At a decisive voltage higher than 1 400 V a.c. or 2 000 V d.c., only protective class I is acceptable.

All conductive parts which are not separated from live parts by at least basic insulation shall be treated as live parts.

With respect to testing of components and equipment, the measures taken according to 5.2.9 to 5.2.12 shall be checked for compliance by means of visual inspection. These requirements shall also apply to devices constructed or installed during the implementation of the installation.

5.2.9.1 Insulation between live parts and exposed conductive parts

Exposed conductive parts of EE shall be separated from live parts at least by basic insulation or by clearances in accordance with Table 3 or Table 4, as appropriate.

Testing shall be by visual inspection. In case of doubt, re-measurement of clearances, creepage distances and solid insulation shall be made.

5.2.9.2 Protective bonding

Protective bonding shall always be provided between exposed conductive parts of EE and the means of connection for the protective conductor; it is not however essential when one of the following applies:

- a)1) when exposed conductive parts are exclusively related to electrical circuits with protection in case of direct contact according to 5.2.8, with the limiting value of the decisive voltage increased to 50 V a.c. or 120 V d.c. for SELV- or PELV-systems (see 5.2.8.1), or
- a)2) where protection is provided by means of voltage limitation (see 5.2.8.4); or
- b) when magnet cores are used, for example, transformers, chokes and contactors; or
- c) when exposed conductive parts of small dimensions (about 50 mm x 50 mm) cannot be touched or grasped when the EE is used as intended and which have a low probability of contact. Such exposed conductive parts are, for example, screws, rivets, nameplates and cable clamps.

NOTE Conductive parts which are separated from live parts using double or reinforced insulation (see 5.2.18.2) are no longer considered to be exposed conductive parts and therefore, require no protective bonding.

Testing shall be by visual inspection. When claiming one of the exceptions from the requirements of providing protective bonding in accordance with a), b) or c), it shall be confirmed by documentation that these requirements are met. (For bonding connection arrangements, see A.5.2.9.2.)

5.2.9.3 Rating of protective bonding

Protective bonding shall withstand the highest thermal and dynamic stresses that can occur to the EE item(s) concerned when they are subjected to a fault connecting to exposed conductive parts.

In order to avoid thermal overload, the requirements of 8.3.3.4 shall be applied to the design of the protective bonding (see Annex A).

For testing, the resistance of protective bonding shall in case of doubt be measured in accordance with the third paragraph of A.5.2.9.3, the voltage drop in case of short-circuit with respect to an exposed conductive part shall then be determined from this measurement.

5.2.9.4 Protection against corrosion

Protective connections shall be protected against corrosion under the specified ambient conditions (see Annex A).

5.2.9.5 Protective bonding conductor with low cross-section

Where the exposed conductive parts of EE are connected to the protective conductor of EE using a protective bonding conductor with a small cross-section, care shall be taken that a fault between these exposed conductive parts and live parts with a larger cross-section is prevented. This can be achieved by a suitable construction or by double or reinforced insulation.

NOTE This applies for example for data processing equipment within power electronic equipment.

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5.2.9.6 EE with voltage above 1 400 V a.c. or 2 000 V d.c.

In EE with a decisive voltage (5.2.13) of more than 1 400 V a.c. or 2 000 V d.c., accessible and non-accessible conductive parts which are not live parts shall be included within the protective bonding. Excepted are conductive parts with small dimensions or those assigned to circuits with protective separation and extra-low voltage or magnet cores according to 5.2.9.2 a) to c).

5.2.9.7 Interruption

The protective bonding of EE shall be permanently connected and not be interrupted by a switch or an electronic device.

Where the protective connection to a sub-assembly of EE is made by a plug-and-socket device when it is live or conducting, the protective connection shall not be broken before the live conductors. On re-connection the protective conductor shall re-connect before the live connection, or at the latest, together with the live conductors.

5.2.9.8 Marking

Protective bonding conductors shall be easily recognizable from their shape, location (for example short visible pieces of conductors) or colour coding; exceptions are the protective bonding conductors on printed circuit boards and protective bonding conductors such as those in wire-wrap and similar back wiring of electronic sub-assemblies which cannot be unfastened without destruction. When marking by colours, the colour combination green-yellow shall be used. Insulated single-core protective bonding conductors shall be green-yellow along their entire length. The colour coding green-yellow shall be used only for the protective bonding conductors and for the protective conductors.

5.2.10 Means of connection for the protective conductor

EE with internal protective bonding shall have means of connection for the external protective conductor near the terminals for the respective live conductors. They shall be corrosion-resistant and shall be suitable for the connection of the protective conductor cross-section which is determined from the dimension of the live conductors according to IEC 60364-5-54, unless a larger cross-section is required according to 8.3.3.4. The means of connection for the protective conductor shall not be used as a part of the mechanical assembly of the EE.

The means of connection for the protective conductor should be marked in an easily recognizable way, with:

- the symbol No. 5019  of IEC 60417-1; or
- the letters "PE"; or
- the colour coding green-yellow.

Marking should not be done on easily changeable fixtures such as screws. This marking is not necessary for connectors. The content of 7.1.9 applies to the external connectors.

5.2.11 Leakage current and fault current

5.2.11.1 High leakage current

Where an EE has a continuous leakage current of more than 3,5 mA a.c. or 10 mA d.c. in normal use, a fixed connection is required for protection; this shall be stated in the operating manuals.

The combination of a residual-current-operated protective device (RCD) with in particular several EEs may be incompatible if the resulting leakage current drawn by their radio frequency filters is so high that the RCD is triggered.

When several items of EE are connected to a source of supply, the total leakage current of 3,5 mA a.c. or 10 mA d.c. in the protective conductor may be exceeded. In these cases and where the protective conductor is interrupted, it is possible for a person to become exposed to a leakage current higher than the limit 3,5 mA a.c. or 10 mA d.c. Under such conditions, and as long as no international standard exists on the measures to be taken to prevent this, the following shall be provided:

- duplication of the protective conductor, or
- automatic disconnection of the supply in case of discontinuity of the protective conductor, or
- incorporation of a double-wound transformer (or equivalent) in the supply with the circuit protective conductor connected to the exposed conductive parts of the EE and to the secondary winding of the transformer.

Measurement of leakage current is required on EE which is not intended for permanent connection.

NOTE: The requirements specified in this subclause are deemed supplementary to and not alternative to the relevant requirements for protection by residual current devices in AS/NZS 3000.

The EE shall be set up in an insulated state without connection of the protective earth conductor and shall be operated at rated voltage. Under these conditions, the current shall be measured at the following points:

- a) for an EE which is intended for connection to a TT or TN system, between the protective terminal conductor and the protective earth conductor itself;
- b) for an EE which is intended for connection to an IT system, between the protective terminal conductor and each outer conductor.

The current measuring circuit shall be according to Figure 3 of IEC 60990.

5.2.11.2 Compatibility with residual-current-operated protective devices in case of low leakage current

A residual-current-operated protective device (RCD) with rated fault current $I_{fn} \leq 30$ mA may be used to provide protection in case of indirect contact and/or supplementary protection in case of direct contact. It is presupposed that the leakage current of the EE(s) according to 5.2.11.1 is low enough not to unintentionally trigger the RCD connected in series.

Before connecting an EE to a supply protected by an RCD, the compatibility of the EE with the RCD shall be verified, by reference to Figure 4 and the paragraphs below.

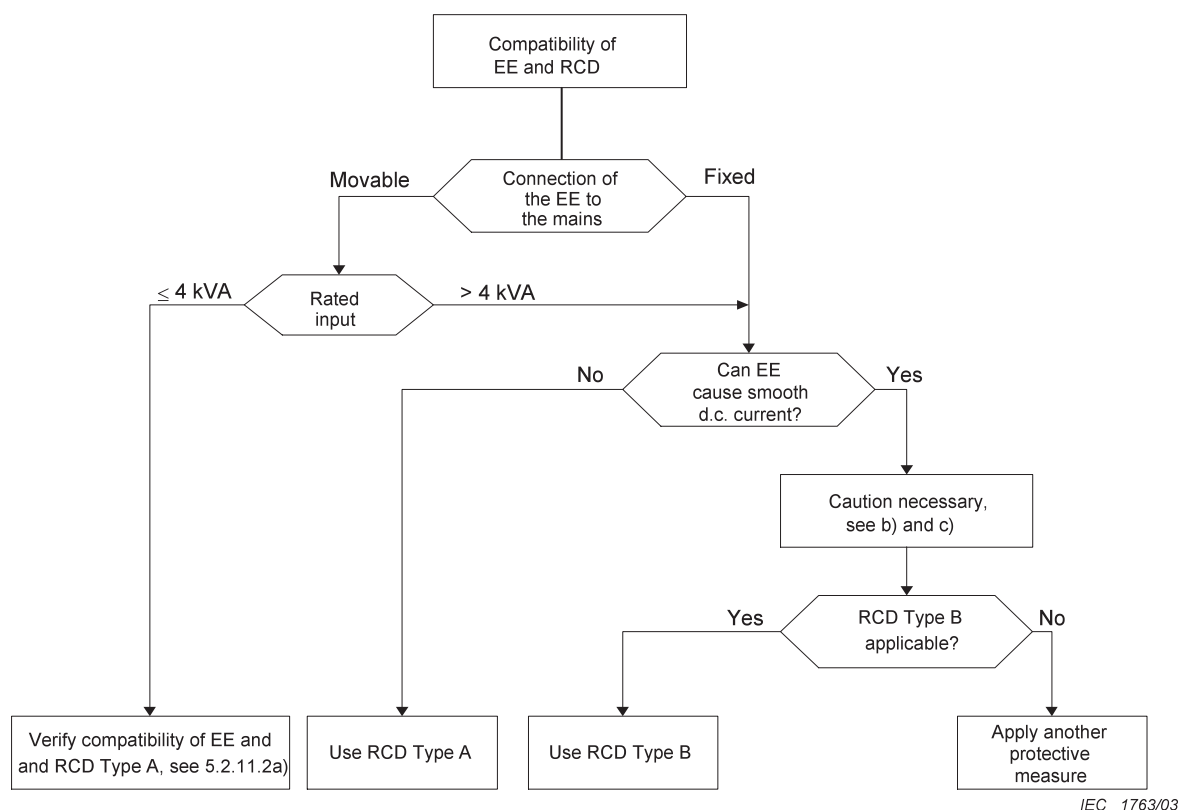


Figure 4 – Flow chart leading to requirements when using EE(s) behind an RCD

Depending on the supply side circuitry of the EE and the type of RCD (Type AC, A or B according to IEC 60755), EE and RCD may be compatible or incompatible. Figure 4 indicates

- 1) when an EE is required to be compatible with the RCD;
- 2) when a design notice as given below shall be fitted to the EE requiring the use of an RCD Type B or of another protection.

Design notice: where a residual-current-operated protective device (RCD) is used for protection in case of direct or indirect contact, only a Type B RCD is allowed on the supply side of this EE. Otherwise another protective measure shall be applied such as separation of the EE from the environment by double or reinforced insulation or isolation of EE and supply system by a transformer.

- c) Movable EE with a rated input ≤ 4 kVA shall be designed to be compatible with a Type A RCD – protection in case of indirect and/or direct contact.
- d) Movable EE with a rated input > 4 kVA, shall have the design notice (see above) fitted to the equipment and written in the operating manual.
- e) Permanently connected EE shall have the design notice (see above) fitted to the equipment and written in the operating manual.

In particular, operation of an RCD connected in series with EE shall not be prevented by a d.c. component in the fault current.

Circuits 2, 3, 6 and 7 in Figure A.2, may contain a high d.c. component in the residual current and reduce the sensitivity of the Type AC and A RCDs, therefore these combinations are unacceptable. Suitable and acceptable are combinations of the circuits mentioned with RCDs of Type B, which are triggered by all waveforms of residual current occurring (see Figure A.2).

NOTE RCDs suitable to be triggered by differing waveforms of residual current should be marked with symbols as defined in IEC 60755 as follows:



Type A

- a.c. current sensitive and pulse current sensitive (suitable for circuits 1, 4, 5, 8, 9 according to Figure A.2)



Type B

- universal current sensitive (suitable for all circuits according to Figure A.2).

For design and construction of electrical installations, care shall be taken with Type B RCDs, see 5.3.2.3 and design example in Figure A.3.

If necessary, re-checking should be carried out to confirm the compatibility of the RCD (according to IEC 61008-1 or IEC 60755) with the circuitry employed in the EE (see Figure A.2).

5.2.12 Special features in EE for protective class II

If EE is designed to use double or reinforced insulation between live parts and accessible surfaces of an EE in accordance with 5.2.3 b) 1) or 5.2.4, then the design is considered equivalent to protective class II if the following also apply:

- EE designed to protective class II shall not have means of connection for the protective conductor (PE or PEN). However this does not apply if the protective conductor is passed through the EE to equipment series-connected beyond it. In the latter event, the protective conductor and its means for connection shall be insulated with basic insulation against the accessible surface of the EE and against circuits which employ protective separation, extra-low voltage, protective impedance and limited discharging energy, according to 5.2.8. This basic insulation shall correspond to the rated insulation voltage of the series-connected equipment.
- Metal-encased EE of protective class II may have provision on its enclosure for the connection of an equipotential bonding conductor.
- EE of protective class II may have provision for the connection of a functional earthing conductor or for the damping of over voltages; it shall, however, be insulated as though it is a live part.
- EE of protective class II shall be classified on the name plate with the symbol No. 5172  of IEC 60417-1.

5.2.13 Decisive voltage

The decisive voltage of a circuit in respect of the protective measures to be employed against electric shock is the highest voltage which occurs continuously between any two arbitrary live parts of the EE during rated worst operating conditions when used as intended. If continuous direct earthing of the circuit of the EE is provided through conductors of sufficiently low impedance, then the decisive voltage is the highest voltage which occurs continuously between any arbitrary live part of this circuit and earth (for example circuits connected to an earthed three-phase supply).

The decisive voltage applies to all parts of circuits of the EE under consideration.

No agreed procedure is available for the calculation of the decisive voltage at the present time. Therefore the method of calculation which follows shall be used to determine the measures to be taken to provide adequate protection. These measures fall into categories described by the limit levels according to the classifications in column 1 of Table 1.

The actual classification of a circuit of EE with regard to protection against electric shock is dependent upon the decisive voltage U_M which relates to the a.c. and d.c. voltage of the circuit. U_M is also affected by the nature of the voltage waveforms and these shall be taken into consideration when calculations are performed (i.e. the ripple voltage, chopped voltage, and recurring overshoots that may occur).

It should be understood that the method of calculation in the procedure to be adopted below does not lead to a definite solution for a value for decisive voltage U_M . It does however allow a decision to be made as to which classification of Table 1 the value of U_M fits.

Three cases a), b) and c) of waveforms are given for deciding which classification of a circuit shall be chosen from Table 1.

Case a) for a.c. voltage (see Figure 5) where:

U_{AC} = an a.c. voltage (r.m.s.) in volts, with

U_{ACP} = a repetitive peak value in volts, and a value of

U_{ACL} = the limit of the a.c. voltage (r.m.s.) chosen from column a) of Table 1.

If $U_{AC}/U_{ACL} \leq 1$, and $U_{ACP}/(\sqrt{2} \times U_{ACL}) \leq 1$, then: $U_M \leq U_{ACL}$.

But if one or both conditions are not true, then repeat the calculation with the next higher value of U_{ACL} in Table 1.

The value for U_{ACL} for which both conditions are true shall be used to decide which range in Table 1 applies to the circuit considered. If one of the conditions is not true even with $U_{ACL} = 1400$ V a.c., then the higher voltage range applies (Table 1, last row).

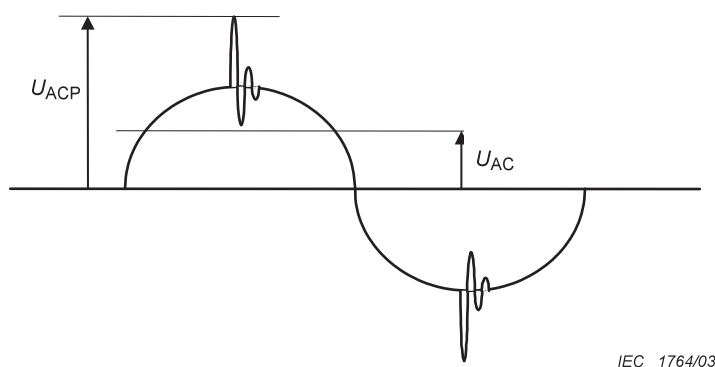


Figure 5 – Typical waveform for case a) a.c. voltage

Case b) for d.c. voltage (see Figure 6) – where:

U_{DC} = a d.c. voltage of mean value in which the ripple content giving rise to U_{DCP} is not more than 10 % (10 % r.m.s. ripple content resulting from the ratio of the r.m.s. values of the superimposed a.c. voltage and of the smooth d.c. voltage),

U_{DCP} = the repetitive peak value of the d.c. voltage in volts,

U_{DCL} = the limit of the d.c. voltage mean value in volts, chosen from column b) of Table 1.

If $U_{DC}/U_{DCL} \leq 1$, and $U_{DCP}/(1,17 \times U_{DCL}) \leq 1$, then: $U_M \leq U_{DCL}$.

But if one or both conditions are not true, then repeat the calculation with the next higher value of U_{DCL} in Table 1.

The value for U_{DCL} for which both conditions are true shall be used to decide which range in Table 1 applies to the circuit considered. If one of the conditions is not true even with $U_{DCL} = 2\,000\text{ V d.c.}$, then the higher voltage range applies (Table 1, last row).

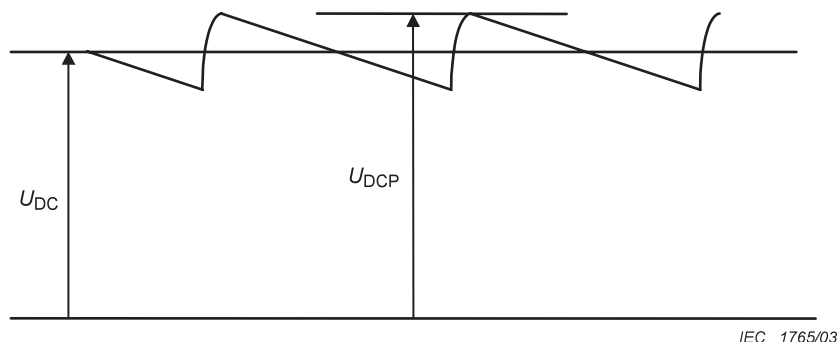


Figure 6 – Typical waveform for case b) d.c. voltage

Case c) for pulsating voltage (see Figure 7)

For a pulsating voltage (d.c. voltage where the ripple content is more than 10 %), the evaluation of both components is made separately according to the formula below, where:

U_{AC} = a.c. voltage component (r.m.s. value), in volts;

U_{DC} = d.c. voltage component (mean value), in volts;

U_{ACP} = repetitive peak value of the a.c. voltage component, in volts.

If $(U_{AC}/U_{ACL} + U_{DC}/U_{DCL}) \leq 1$, and $((U_{ACP}/\sqrt{2} \times U_{ACL}) + (U_{DC}/1,17 \times U_{DCL})) \leq 1$, then $U_M \leq U_{DCL}$ and U_{ACL} .

But if one or both conditions are not true, then repeat the calculation with the next higher values of U_{ACL} and U_{DCL} in Table 1.

The values for U_{ACL} and U_{DCL} for which both conditions are true shall be used to decide which range in Table 1 applies to the circuit considered. If one of the conditions is not true even with $U_{ACL} = 1\,400\text{ V a.c.}$ or $U_{DCL} = 2\,000\text{ V d.c.}$, then the higher voltage range applies (Table 1, last row).

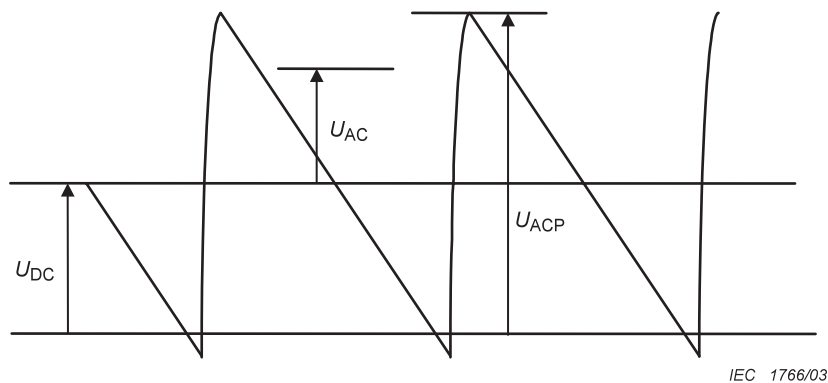


Figure 7 – Typical waveform for case c) pulsating voltage

The following give additional information relating to the limit voltages of cases a), b) and c) of Table 1:

U_{ACL} limit of a.c. voltage (see Table 1):

$U_{ACL} = 25 \text{ V}$ as the upper limit of protective extra-low voltage (SELV or PELV) according to 5.2.8.1 and 5.2.8.4.

$U_{ACL} = 50 \text{ V}$ as the upper limit for circuits with exposed conductive parts without protective bonding according to 5.2.9.2 a).

$U_{ACL} = 1\,400 \text{ V}$ as limit of the a.c. voltage according to 5.2.9, 5.2.9.6 and 5.2.14.2.

U_{DCL} limit of d.c. voltage (see Table 1):

$U_{DCL} = 60 \text{ V}$ as the upper limit of protective extra-low voltage (SELV or PELV) according to 5.2.8.1 and 5.2.8.4.

$U_{DCL} = 120 \text{ V}$ as the upper limit for circuits with exposed conductive parts without protective bonding according to 5.2.9.2 a).

$U_{DCL} = 2\,000 \text{ V}$ as the limit of the d.c. voltage according to 5.2.9, 5.2.9.6 and 5.2.14.2.

These voltages are mean values allowing for a ripple content of not more than 10 % r.m.s.

Table 1 gives a summary of the limits of the decisive voltage.

Table 1 – Summary of the limits of the decisive voltage U_M

Classification of a circuit in EE	Limit of decisive voltage U_M			Subclause
	a) a.c. voltage (r.m.s. value)	b) d.c. voltage (mean value)	c) a.c. voltage (peak value)	
	U_{ACL} V	U_{DCL} V	$U_{ACL} \times \sqrt{2}$ V	
Electric circuits with protective separation and without protection against direct contact	25	60	35	5.2.8.1 5.2.8.4
Exposed conductive parts of circuits with protective separation and without protective bonding	50	120	71	5.2.9.2 a)
Circuits with higher voltage	1 400	2 000	2 000	5.2.9 5.2.9.6 5.2.14.2

NOTE The extra-low-voltage limits of decisive voltage are those from IEC 60364-4-41.

According to the three limit levels for the decisive voltage in Table 1, four voltage ranges exist:

1) $U_M \leq 25 \text{ V a.c. or } 60 \text{ V d.c.}$

applies to circuits without protection against direct contact, but with protective separation to adjacent circuits with $U_M > 50 \text{ V a.c. or } 60 \text{ V d.c.}$;

2) $25 \text{ V a.c. or } 60 \text{ V d.c.} < U_M \leq 50 \text{ V a.c. or } 120 \text{ V d.c.}$

applies to circuits with protection against direct contact and protective separation to adjacent circuits with $U_M > 50 \text{ V a.c. or } 120 \text{ V d.c.}$, but without protective bonding of the exposed conductive parts;

3) $50 \text{ V a.c. or } 120 \text{ V d.c.} < U_M \leq 1\,400 \text{ V a.c. or } 2\,000 \text{ V d.c.}$

applies to circuits with protection against direct contact and protective separation to adjacent circuits with $U_M > 1\,400 \text{ V a.c. or } 2\,000 \text{ V d.c.}$ and with protective bonding or double or reinforced insulation of exposed conductive parts. Basic insulation is required from adjacent circuits with $50 \text{ V a.c. or } 120 \text{ V d.c.} < U_M \leq 1\,400 \text{ V a.c. or } 2\,000 \text{ V d.c.}$

4) $U_M > 1\,400 \text{ V a.c. or } 2\,000 \text{ V d.c.}$

applies to circuits with protection against direct contact, with protective bonding of exposed conductive parts and with basic insulation to adjacent circuits with $U_M > 1\,400 \text{ V a.c. or } 2\,000 \text{ V d.c.}$

For the design of the insulation depending on these voltage ranges, see Figures 9 and 10 (see Annex A).

5.2.14 Solid insulation, insulation of circuits

Solid insulation shall be designed to resist the stresses, especially mechanical, electrical, thermal and climatic stresses that are to be expected in normal use and, it shall have a sufficient resistance to ageing during the lifetime of EE. This also applies to liquid insulation. Thin, easily damageable materials such as coating with lacquer or oxides and anode coatings are considered insufficient to satisfy these requirements.

The design requirements for solid insulation are determined from Figures 11 to 13 in relation to Figures 8 to 10. Additional requirements are given in 5.2.14.1 to 5.2.14.3.

Testing shall be by visual inspection. In case of doubt measurement of the thickness of the insulation and re-calculation of its dielectric strength shall be made.

5.2.14.1 Between circuits and exposed conductive parts or accessible surfaces of EE

Basic, supplementary, double or reinforced insulation shall be applied for the protection against electric shock.

This insulation shall be designed according to the rated insulation voltage (RIV) for an impulse withstand voltage, determined from Table 3 or 4, column 6 or 8, according to 5.2.16.1 or 5.2.16.2.

Where the appropriate clearances are not designed to meet over voltage category III (see Table 1 of IEC 60664-1) as set out in column 6 of Table 3, and it is decided to choose alternative clearances according to paragraph 3 or 4 of 5.2.16.1, then the impulse withstand voltage appropriate to these clearances determines the RIV.

The following shall apply for the insulation between live parts and the surface of accessible parts of EE according to 5.2.3 b)1) to b)4):

When a design involves subdivided basic and supplementary insulation or subdivided double insulation with an electrical circuit in between, then the highest of the RIVs shall be employed for design purposes, and not the voltage of the particular circuit. Figure A.4 shows an example.

The foregoing paragraph does not apply to parts with small dimensions (approximately 50 mm x 50 mm) which, when the EE is used as intended, are not required to be touched or cannot be grasped or where the danger of touch is not significant.

Figure A.5 shows examples for the insulation required for control elements.

For voltage tests, see 9.4.5.1 and 9.4.5.2.

5.2.14.2 Between circuits

Basic insulation shall be applied between separate circuits of an EE.

Exceptions are

- between circuits designed according to 5.2.8 and other circuits not designed according to 5.2.8;
- between circuits designed for a decisive voltage of more than 1 400 V a.c. or 2 000 V d.c. and other circuits designed for a lower decisive voltage.

These circuits shall be insulated as per the requirements of protective separation (see 5.2.18; double or reinforced insulation or protective screening).

NOTE In this case, earthing of the secondary transformer is not necessary.

The insulation shall be designed for an impulse withstand voltage which corresponds to the respective rated insulation voltage, determined from columns 6 or 8 in Tables 3 or 4.

For voltage tests, see 9.4.5.

5.2.14.3 Bridging of the insulation via conductive parts

Conductive parts, for example resistors and capacitors, which bridge over an insulation according to 5.2.14.1 or 5.2.14.2 shall withstand the same electric stress as that defined for the insulation concerned. If these components bridge over a double or reinforced insulation, then they shall correspond additionally to the requirements of protective impedance according to 5.2.8.3.

For voltage tests see 9.4.5.

5.2.15 Clearances and creepage distances, pollution degree

5.2.15.1 Clearances and creepage distances

Clearances and creepage distances shall be selected according to the principles of IEC 60664-1.

The determined clearances and creepage distances are minimum values. Manufacturing tolerances shall be taken into account, when installing or connecting EE on site. Greater clearances and creepage distances shall be provided particularly, when they may be newly created or changed by the type of mounting or method of wiring during installation or connection of the EE on site (see 8.2). The defined minimum values shall not diminish during the working life of the EE.

The design of clearances and creepage distances shall make allowance for the total degradation to be expected during the working life in the expected environment.

In addition, where there is a requirement for enhanced reliability, it is appropriate to increase the distances considerably.

The determination of clearances and creepage distances does not apply to the interior of enclosures which provide a sealed environment which has been proven to be impervious to pollution, or precipitation of moisture.

In addition, the determination of clearances and creepage distances does not apply to active or passive components when pollution, or precipitation of moisture is avoided by suitable construction methods. Examples are semiconductors, capacitors, and printed circuit boards which have been covered with varnish or protective coating of adequate and proven quality for protection of the item against pollution and moisture to the requirements of 4.1 of IEC 60664-3. In the case of use of items which have been covered with varnish or protective coating, the test of 9.4.4.4 shall be applied.

Eleven examples showing how to measure a clearance or a creepage distance are contained in 4.2 of IEC 60664-1.

Clearances and creepage distances shall be selected under consideration of the following influences:

- pollution degree;
- over voltage category;
- rated insulation voltage;
- type of insulation;
- location of insulation;
- type of circuit considered.

The type of insulation and the rated insulation voltage shall be determined using the flow charts in Figures 8 to 10.

The clearances and creepage distances shall be determined using the flow charts in Figures 11 to 13 and Tables 3 to 6 (see 5.2.16 to 5.2.17).

Tests shall be made by visual inspection. In case of doubt, re-measurement of clearances and creepage distances shall be made according to 9.4.4.1.

The following abbreviations are used in Figures 8 to 13:

- U_{RIV} Rated insulation voltage, as defined in 5.2.16.1 to 5.2.16.3 for clearances and in 5.2.17 for creepage distances.
- U_M Decisive voltage of circuit under consideration.
- U_{IW} Impulse withstand voltage.
- CTI Comparative tracking index.
- PWB Printed wiring board.

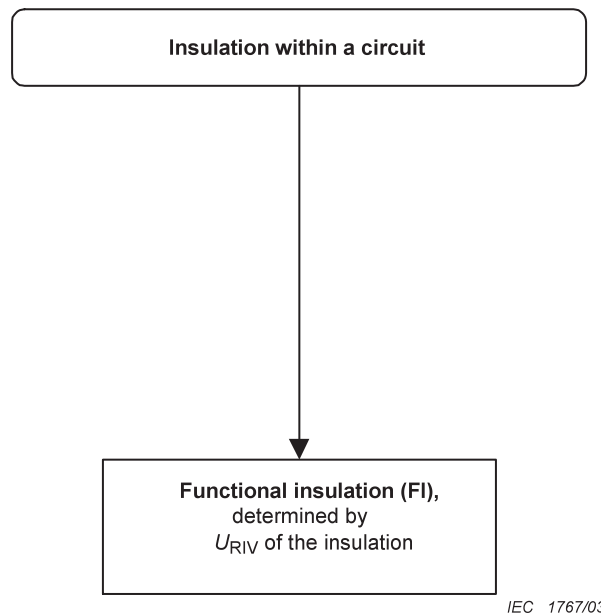


Figure 8 – Determination of functional insulation