

PAKISTAN STANDARD

Switches for Household and Similar Fixed Electrical Installations

Part 2-1: Particular Requirements - Electronic Switches



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**PAKISTAN STANDARDS AND QUALITY CONTROL AUTHORITY,
STANDARDS DEVELOPMENT CENTRE,
PSQCA Complex Street 7 A Block –3
Scheme –36 Gulistan –e- johar Karachi**

Switches for Household and Similar Fixed Electrical Installations**Part 2-1: Particular Requirements - Electronic Switches****0. FOREWORD**

- 0.1 This Pakistan Standard was adopted by the authority of the Board of Directors for Pakistan Standards and Quality Control Authority after approval by the Technical Committee for "Electric Switches, Plugs & Socket (TC-18)" had been approved and endorsed by the Electrotechnical National Standards Committee on _____.
- 0.2 This Pakistan Standard is prepared with the help of IEC Standard named it Switches for household and similar fixed electrical installations Part 2-1: Particular requirements - Electronic switches". Hence it was deemed suitable to adopt it.
- 0.3 This Pakistan Standard is on the basis of IEC: 60669-2-1 "Switches for household and similar fixed electrical installations Part 2-1: Particular requirements - Electronic switches" and its use hereby acknowledged with thanks.
- 0.4 This standard is subject to periodical review in order to keep pace with the development in industry. Any suggestions for improvement shall be recorded and placed before the revising committee in due course.
- 0.5 This standard is intended chiefly to cover the technical provisions relating to this standard and it does not include all the necessary provisions of a Contract.

CONTENTS

FOREWORD.....	
1 Scope.....	
2 Normative references.....	
3 Definitions	
4 General requirements	
5 General notes on tests.....	
6 Rating.....	
7 Classification	
8 Marking	
9 Checking of dimensions.....	
10 Protection against electric shock.....	
11 Provision for earthing.....	
12 Terminals	
13 Constructional requirements	
14 Mechanism	
15 Resistance to ageing, protection provided by enclosures of switches, and resistance to humidity.....	
16 Insulation resistance and electric strength.....	
17 Temperature rise	
18 Making and breaking capacity	
19 Normal operation.....	
20 Mechanical strength.....	
21 Resistance to heat	
22 Screws, current-carrying parts and connections	
23 Creepage distances, clearances and distances through sealing compound.....	
24 Resistance of insulating material to abnormal heat, to fire and to tracking	
25 Resistance to rusting	
26 EMC requirements	
101 Abnormal conditions	
102 Components	
Annex A (normative) Survey of specimens needed for tests	
Annex B (normative) Additional requirements for switches having facilities for the outlet and retention of flexible cables	
Annex AA (informative) Examples of types of electronic switches and their functions	
Annex BB (informative) Circuit development: subclause 19.109 explained.....	
Annex CC (normative) Additional requirements for electronic switches using DLT-technology according to IEC 62756-1	
Bibliography	
Figure 101 – Test pin for checking the protection against electric shock	

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Figure 102 – Circuit diagram for testing electronic switches according to 101.3
Figure 103 – Circuit diagrams for testing switches according to subclauses 19.102 and 19.109
Figure BB1 – 120 V 15 W (LT spice model)
Figure BB.2 – 230 V 15 W (LT spice model)
Figure BB.3 – Model for multiple lamp loads
Figure BB.4 – I_{peak} and I^2t for multiple lamp loads
Table 101 – Number of specimens
Table 102 – Permissible temperature rise values (This table is based on table 3 of IEC 60065)
Table 103 – Relationship between rated current and capacitance
Table 104 – Immunity tests (overview).....
Table 105 – Voltage dip and short-interruption test values
Table 106 – Fast transient test values
Table 107 – Capacitors
Table 108 – Values for I_{peak} and I^2t depending on the type of distribution system
Table 109 – Calculated circuit parameters
Table 110 – Surge immunity test voltages.....
Table B.1 – Maximum current and minimum cross-sectional area
Table BB.1 – Lamp

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SWITCHES FOR HOUSEHOLD AND SIMILAR FIXED ELECTRICAL INSTALLATIONS –

Part 2-1: Particular requirements – Electronic switches

1 Scope

This clause of part 1 applies except as follows.

Replacement:

This standard applies to electronic switches and to associated electronic extension units for household and similar fixed electrical installations either indoors or outdoors.

It applies to electronic switches for a.c. only, for the operation of lamp circuits and the control of the brightness of lamps (dimmers) as well as the control of the speed of motors (for example, those used in ventilating fans) and for other purposes (for example, heating controls), with a rated voltage not exceeding 250 V and a rated current not exceeding 16 A.

The operation and/or control as mentioned above are performed by a person via an actuating member, a sensing surface or a sensing unit, by means of touch, proximity, turn, optical, acoustic, thermal or any other influence.

This standard also applies to general purpose electronic switches with included automatic functions where the operation and/or the control is initiated by a change of a physical quantity, for example light, temperature, humidity, time, wind velocity, presence of persons, etc.

This standard also applies to boxes for electronic switches, with the exception of mounting boxes for flush-type electronic switches.

This standard also applies to electronic RCS and electronic TDS with a rated voltage not exceeding 440 V and a rated current not exceeding 25 A, intended for household and similar fixed electrical installations, either indoors or outdoors.

NOTE 1 Switches including only passive components such as resistors, capacitors, inductors, PTC and NTC components, varistors, printed wiring boards and connectors are not considered as electronic switches.

NOTE 2 Electronic switches may have control circuits with a.c. or d.c. rated control voltages.

Electronic switches complying with this standard are suitable for use at ambient temperature not normally exceeding 25 °C but occasionally reaching 35 °C.

In locations where special conditions prevail, such as in ships, vehicles and the like and in hazardous locations, for example, where explosions are liable to occur, special constructions may be required.

NOTE 3 This standard is not intended to cover devices which are designed to be incorporated in appliances or are intended to be delivered together with a specific appliance and which are within the scope of IEC 60730 or IEC 61058-1.

Examples of designs of electronic switches and functions are shown in annex AA.

NOTE 4 Electronic switches without a mechanical switch in the main circuit do not provide a “full off-state”. Therefore, the circuit on the load side should be considered to be live.

2 Normative references

This clause of part 1 applies except as follows.

Addition:

IEC 60065:2001, *Audio, video and similar electronic apparatus – Safety requirements*

IEC 60085:1984, *Thermal evaluation and classification of electrical insulation*

IEC 60127 (all parts), *Miniature fuses*

IEC 60227-5:1997, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 5: Flexible cables (cords)¹⁾*

IEC 60317 (all parts), *Specifications for particular types of winding wires*

IEC 60317-0-1:1997, *Specifications for particular types of winding wires – Part 0: General requirements – Section 1: Enamelled round copper wire¹⁾*

IEC 60384-14:1993, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

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

IEC 60669-2-2:2006, *Switches for household and similar fixed electrical installations – Part 2-2: Particular requirements - Electromagnetic remote-control switches (RCS)*

IEC 60669-2-3:2006, *Switches for household and similar fixed electrical installations – Part 2-3: Particular requirements - Time-delay switches (TDS)*

IEC 60730 (all parts), *Automatic electrical controls for household and similar use*

IEC 60998-2-1, *Connecting devices for low-voltage circuits for household and similar purposes - Part 2-1: Particular requirements for connecting devices as separate entities with screw-type clamping units*

IEC 61000-2-2:2002, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

IEC 61000-3-2:2000, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current $\leq 16\text{A}$ per phase)¹⁾*

IEC 61000-3-3:1994, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current $\leq 16\text{ A}$ ¹⁾*

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IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test¹⁾*

IEC 61000-4-3:2002, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test*

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test¹⁾*

IEC 61000-4-6:1996, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radio-frequency fields¹⁾*

IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 8: Power frequency magnetic field immunity test¹⁾*

IEC 61000-4-11:1994, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 11: Voltage dips, short interruptions and voltage variations immunity tests¹⁾*

IEC 61032, *Protection of persons and equipment by enclosures – Probes for verification*

IEC 61558-2-6, *Safety of power ~~transformers~~^{systems}, power supply units and similar – Part 2: Particular requirements for safety isolating transformers for general use*

IEC 62756-1, *Digital ~~load~~^{for} side transmission lighting control – Part 1: Basic requirements*

CISPR 14 (all parts), *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus*

CISPR 15:2013, *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment*

ISO 306:1994, *Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)*

3 Definitions

This clause of part 1 applies with the following additions.

Addition, after the first paragraph:

The term “electronic switch” is used as a general term to cover both electronic switching and control devices.

3.101

rated load

load assigned to the electronic switch by the manufacturer

3.102**minimum load**

lowest load at which the electronic switch still operates correctly

3.103**minimum current**

lowest current at which the electronic switch still operates correctly

3.104**electromechanically operated contact mechanism**

component which operates the parts used to open and close the circuit electromechanically

3.105**semiconductor switching device**

switching device designed to make or break the current in an electric circuit by means of the controlled conductivity of a semiconductor in that circuit

NOTE 1 In a circuit where the current passes through zero (periodically or otherwise) the effect of "not making" the current following such a zero value is equivalent to breaking the current.

NOTE 2 Typical examples of semiconductor switching devices are:

- electronic switching devices using the phase-cut-on principle to control the load by electronic switching on the current at any phase angle at or after zero crossing in each half-wave, for example, by a thyristor;
- electronic switches using the phase-cut-off principle to control the load by switching off the current at any phase angle after zero crossing in each half-wave, for example, by a transistor in a diode bridge.

3.106**electronic momentary contact switch**

electronic switch with an electromechanical switching mechanism or a semiconductor switching device which returns automatically to the initial state after operation

3.107**mechanical control unit**

~~unit directly adjustable~~ unit directly adjustable by mechanical means (for example, potentiometer) which controls the output via electronic components

3.108**electronic output control unit**

unit adjustable by other than mechanical means (for example, sensing unit), containing electronic components and controlling the output via electronic components

3.109**electronic extension unit**

unit permitting the control of an electronic switch from a distance

3.110**protective impedance**

impedance connected between live parts and accessible conductive parts, of such value that the current, in normal use and under likely fault conditions in the electronic switch, is limited to a safe value, and which is so constructed that the reliability is maintained throughout the life of the electronic switch.

3.111**external flexible cable**

cable, a part of which is external to the electronic output control unit.

NOTE Such cable may either be a supply cable or a connecting cable between separate parts of an accessory.

3.112**RCS****remote controlled switch**

switch intended to be operated from a distance

3.112.1**electromagnetic RCS**

RCS provided with a coil which is operated by means of impulses or which may be permanently energized by means of a control circuit

NOTE These devices are covered by IEC 60669-2-2.

3.112.2**electronic RCS**

electronic switch providing the function, markings and connection configuration of an RCS according to IEC 60669-2-2, but containing electronic components and/or a combination of electronic components and a coil or coils, which is operated by means of an electronic extension unit or units

NOTE This electronic RCS may for example be used as a look alike replacement for RCS according to IEC 60669-2-2.

3.113**rated control voltage**

the voltage assigned to the external control circuit by the manufacturer

3.114**switching circuit**

the circuit which contains the parts which allow the rated current to flow through the RCS or TDS

3.115**control circuit**

the circuit which includes electrical parts to actuate the switching mechanism

3.116**control mechanism**

mechanism which includes all the parts which are intended for the operation of the RCS or TDS

3.117**incorporated hand-operated device**

device incorporated in the switch which allows the switching circuit to be operated, directly or indirectly. This device is not intended for the normal operation of the RCS or TDS

3.118**rated control current**

current required for the initiation of the electronic RCS assigned to the control circuit by the manufacturer

3.119**bistable electronic RCS**

electronic RCS containing a control mechanism which, when not initiated electrically or actuated mechanically, remains stable in its operating position and will change its operating position on initiation or actuation

3.120**monostable electronic RCS**

electronic RCS containing a control mechanism which, on electrical initiation or mechanical actuation, changes the operating position of the switch which remains in this condition while the

electronic RCS is initiated or actuated, and returns to the position prior to initiation or actuation of the electronic RCS after initiation or actuation is discontinued

3.121

priority electronic RCS

electronic RCS used to operate directly or indirectly a first load circuit or group of load circuits the use of which at times can be dispensed with, and where the control circuit of the electronic RCS is influenced by or connected to a second circuit or group of circuits (priority or circuits) which when energized will thus initiate the control circuit of the electronic RCS to de-energize the first load circuit or circuits for the time during which the second circuit or group of circuits is energized

NOTE The electronic RCS may have a means for adjusting the sensitivity of the electronic RCS control circuit to initiate the electronic RCS depending on the total load or current delivered to any part of the circuits (priority switch with current coil) or be sensitive to the voltage (priority switch with voltage coil) applied to the second load or group of loads.

3.122

TDS

time delayed switch

switch provided with a time-delay device which operates for a certain time (the delay time). It may be either manually actuated and/or remotely electrically initiated

3.123

electronic TDS

electronic switch providing the function, markings and connection configuration of a TDS according to IEC 60669-2-3, but containing electronic components

NOTE This electronic TDS may for example be used as a look alike replacement for TDS according to IEC 60669-2-3.

3.124

delay time

period during which the switching circuit(s) is (are) kept closed. Any time taken for the decreasing of the voltage (e.g. to reduce the light) at the end of the delay period is included within the delay time

3.125

delay device

all components which have an influence on the delay time. The delay time may be adjustable

3.126

self ballasted lamp

unit which cannot be dismantled without being permanently damaged which is provided with a lamp cap or caps and incorporating a light source and any additional elements necessary for starting and stable operation of the light source

NOTE In the text self ballasted lamp are also called CFLi or LEDi where "i" means that the control gear is incorporated in the lamp.

3.127

externally ballasted lamp

lamp other than an incandescent lamp which cannot be dismantled without being permanently damaged which is provided with a lamp cap and incorporating a light source to be controlled by a separate lamp control gear

NOTE For lamp control gear, see definitions in IEC 61347-1

3.128

conduction angle

- for a leading edge (forward phase) dimmer, phase angle measured from the point where conduction begins to the end of the half wave (zero crossing)

- b) for a trailing edge (reverse phase) dimmer, phase angle measured from the beginning of a half wave (zero crossing) to the point where conduction is switched off

4 General requirements

This clause of part 1 applies.

5 General notes on tests

This clause of part 1 applies except as follows.

5.4 Addition

The number of test specimens is shown in table 101.

Table 101 – Number of specimens

Type of electronic switch	Number for general tests	Additional specimens for clause or subclause						
		18.2	19.101	19.102	10.103	24	26	101 and 102
Marked with one rated current and one rated voltage	3	3 ^a	3 ^a	3 ^a	3 ^a	3	1	3 ^c
two rated voltages	6	6 ^a	6 ^a	6 ^a	6 ^a	6	1	6 b,c,d

^a Only for electronic switches with mechanical and electromechanical switching devices; only the complete contact mechanism may be submitted.
^b It may be necessary to provide three additional specimens for the test of 101.3.
^c When the tests of Clause 26 have been passed successfully, the specimens can be used for these tests.
^d It may be necessary to provide 3 additional specimens for the test of 101.1.1.2.

5.101 All ~~not~~ measurements shall be carried out by methods which are suitable for the purpose, which do not appreciably affect the values to be measured and which are not affected by factors such as waveform.

NOTE Care should be taken to use instruments giving true r.m.s. indications.

5.102 If the electronic circuitry is so enclosed that the short-circuiting or disconnecting of components is impossible or difficult, the manufacturer shall provide one additional test specimen with leads connected for measurements, short-circuiting, etc.

It is not necessary to connect leads to the interior of hybrid and monolith integrated circuits.

5.103 It may be necessary to disconnect electronic components for tests.

5.104 For electronic switches equipped with cut-outs, it may be necessary to provide three additional specimens for the test of 102.4.1.

5.105 If an electronic RCS or electronic TDS is provided with an incorporated hand-operated device, it shall be tested as specified in Clause 19.

NOTE 1 During the making and breaking capacity tests and the normal operation tests, switching at the same phase angle should be avoided, as this may give misleading results.

NOTE 2 Precautions should be taken when using combinations equipped with synchronous motors and similar operating devices.

5.106 In the case of an electronic TDS for which the control and the switching circuits have no common point, the test is made with the circuits supplied with the rated voltages which are declared by the manufacturer.

6 Rating

This clause of part 1 applies except as follows.

Replacement:

6.1 Preferred rated voltages are 110 V, 120 V, 130 V, 220 V, 230 V and 240 V.

6.2 This subclause of part 1 does not apply.

6.3 The preferred rated supply frequencies are 50 Hz and/or 60 Hz.

Addition:

For electronic RCS, Clause 6 of IEC 60669-2-2 is applicable.

For electronic TDS, Clause 6 of IEC 60669-2-3 is applicable.

7 Classification

7.1 This subclause of part 1 applies except as follows.

7.1.1 *Addition:*

For electronic TDS, Subclause 7.1.1 of IEC 60669-2-3 applies.

7.1.5 *Addition:*

- touch;
- proximity;
- optical;
- acoustic;
- other external influences.

NOTE Actuating the electronic switch includes on/off operation, and/or regulating the brightness of lamps or speed of motors.

Addition:

For electronic RCS, Subclause 7.1.5 of IEC 60669-2-2 is applicable.

For electronic TDS, Subclause 7.1.5 of IEC 60669-2-3 is applicable.

7.1.6 *Addition:*

- electronic switches only intended to be mounted at a height greater than 1,7 m.

7.1.101 according to the kind of load intended to be controlled by the electronic switch:

- incandescent lamps;
- externally ballasted lamps (e.g. fluorescent lamps, CFL, LED);
- motors;
- self ballasted lamps (e.g. CFLi, LEDi);
- declared load.

7.2 This subclause of part 1 does not apply.

7.101 For electronic RCS, Subclause 7.101 of IEC 60669-2-2 is applicable.

7.102 For electronic RCS, Subclause 7.102 of IEC 60669-2-2 is applicable.

7.103 Electronic RCS or electronic TDS having a SELV- or PELV-circuit.

8 Marking

This clause of part 1 applies except as follows.

8.1 Replacement:

Electronic switches shall be marked with

- rated voltage in volts;
- rated current in amperes or rated load in volt-amperes or watts;
- symbol for nature of supply;
- manufacturer's or responsible vendor's name, trade mark or identification mark;
- type reference, which may be a catalogue number;
- symbol for mini-gap construction, if applicable;
- symbol for micro-gap construction, if applicable;
- symbol for semiconductor switching device, if applicable;
- first characteristic numeral for the degree of protection against access to hazardous parts and against harmful effects due to ingress of solid objects, if declared higher than 2, in which case the second characteristic numeral shall also be marked;
- second characteristic numeral for the degree of protection against harmful effects due to ingress of water, if declared higher than 0, in which case the first characteristic numeral shall also be marked.

NOTE 1 Marking of the pattern number given in 7.1.1 is recommended if the connections are not clear from an inspection of the electronic switch; this pattern number may be part of the type reference.

NOTE 2 If a base carries two or more electronic switches with separate operating devices, marking with the pattern numbers is recommended, for example 1+6 or 1+1+1.

NOTE 3 For electronic switches suitable for more than one type of rated load, see 8.3.

In addition, electronic switches shall be marked with

- rated frequency in hertz, unless the electronic switch is designed for both 50 Hz and 60 Hz;
- rating and type of any fuse incorporated in the electronic switch;
- symbols for the kind of load (see 8.2);
- the term "extension unit", if applicable, or the relevant translation in the official language(s) of the country in which the product is to be sold, followed by the identifying reference;
- the minimum height for mounting the electronic switch shall be indicated in the installation instruction of the manufacturer if there is a restriction (see 10.1).

In addition, electronic switches with screwless terminals shall be marked with an indication of the suitability to accept rigid conductors only, for those electronic switches having this restriction. This information may be put on the electronic switch and/or on the packaging unit.

For electronic switches with included automatic function if the manufacturer's declared number of operations is higher than that indicated in subclauses 19.101, 19.102, 19.104 and 19.109, then this shall be stated in the accompanying instruction sheet.

In addition,

- for electronic RCS, Subclause 8.1 of IEC 60669-2-2 applies;
- for electronic TDS, Subclause 8.1 of IEC 60669-2-3 applies.

8.2 Addition:

Volt-ampere VA

Watt W

Hertz Hz

Terminal for regulated load 

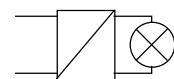
Type of load:

Incandescent lamps 

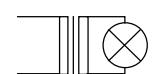
Externally ballasted fluorescent lamps 

Motors 

Electronic step-down converter for extra low-voltage incandescent lamps
(for example, halogen)



Iron core transformer for extra low-voltage incandescent lamps
(for example, halogen)



NOTE The rating and type of any fuse may be marked with symbols (see IEC 60127).

If other particular symbols are used, they shall be explained in the installation instructions.

In addition,

- for electronic RCS, Subclause 8.2 of IEC 60669-2-2 applies;
- for electronic TDS, Subclause 8.2 of IEC 60669-2-3 applies.

8.3 Replacement of the first paragraph:

The following marking shall be placed on the main part of the electronic switch:

- the rated current or rated load, rated voltage, symbol for nature of supply, rated frequency (if required by 8.1), at least one type of load, the rating and type of any incorporated fuse (this shall be marked on the fuse-holder or in the proximity of the fuse),
- either the name, trade mark or identification mark of the manufacturer or of the responsible vendor,
- length of insulation to be removed before the insertion of the conductor into the screwless terminal, if any,

- symbol for mini-gap construction, micro-gap construction or semiconductor device, if applicable,
- the type reference.

NOTE 1 The type reference may be the series reference only.

Where an electronic switch is suitable for more than one type of load if not already marked on the electronic switch, the information concerning these shall be stated in the accompanying instruction sheet. In addition, the minimum and the maximum current or the minimum and the maximum load in volt-ampere or watt shall be stated for each type of load.

Addition:

If a dimmer is intended to be used together with an iron core transformer, information shall be given in the manufacturer's instructions that only a transformer intended to be used with a dimmer shall be used.

8.4 Addition:

If there are more than two terminals, the load terminal shall be marked with an arrow pointing away from the terminal or with one of the symbols mentioned in 8.2 and any other terminals shall be marked corresponding to the installation instructions.

Unless the installation of the electronic switch is made clear by the markings of the terminals, a wiring diagram shall be provided with each electronic switch.

In addition,

- for electronic RCS, Subclause 8.4 of IEC 60669-2-2 applies;
- for electronic TDS, Subclause 8.4 of IEC 60669-2-3 applies.

8.6 Addition:

The off-state shall not be marked with an "O" if the circuit on the load side is considered as live, in accordance with clause 10.

8.6.101 It is recommended that the actual state of the electronic switch intended to control the brightness of lamps be indicated when used as intended. This can be achieved either

- with marking on the on-/off-state position, or
- with an indicator lamp, or
- by adjusting the lamp dimmer so that at the lowest control state and at rated voltage minus 10 %, the light is still visible.

NOTE A test to verify that the light is still visible is under consideration.

When the indication of the electronic switch state is given only by the lamp, adjustment of the lamp at the lowest control state is made as specified in the following:

- for incandescent lamps, the adjustment of lamp dimmers shall be made by the manufacturer. It shall not be possible to reduce the lowest setting without a tool;
- for fluorescent lamps, the adjustment of lamp dimmers shall be made by the manufacturer. It may, however, be possible for the installer to alter the lowest setting if such an adjustment is indicated in an installation instruction.

8.8 Addition after the second paragraph:

If an electronic switch containing a viewing window (lens) for a sensing device is intended to be mounted at a height greater than 1,7 m, this information shall be stated in the instruction sheet.

Addition to note 2:

- information concerning external, directly associated fuses/current limiting devices, where applicable.

9 Checking of dimensions

This clause of part 1 applies except as follows.

Addition:

Electronic switches may be of dimensions other than those specified in the standard sheets (if any) provided they are supplied with suitable boxes.

10 Protection against electric shock

This clause of part 1 applies except as follows.

10.1 Addition:

NOTE 1 For the purpose of this standard, metal sensing surfaces which are connected to live parts by means of protective impedances (see 10.2) are not considered to be live parts.

Replacement of the 6th and 7th paragraphs:

During this additional test, the electronic switches are subjected for 1 min to a force applied through the tip of test probe 11 of IEC 61032.

This probe, with an electrical indicator as described above, is applied with a force of 75 N to all places where yielding of the insulating material could impair the safety of the electronic switch, but is applied to thin-walled knock-outs with a force of 10 N.

Viewing windows or the like on electronic switches intended to be mounted at a height greater than 1,7 m are subjected to a force of 30 N.

The test probe is not applied to membranes and the like. These parts are tested according to 13.15.1.

NOTE 2 For the purposes of this standard, parts connected to a supply operating at SELV with a voltage up to and including 25 V a.c. or 60 V d.c. ripple free are not considered to be hazardous live parts.

10.2 Addition:

For touch sensitive electronic switches, the associated protective impedance does not have to comply with the requirements of clauses 16 and 23.

For electronic switches classified according to 7.1.4, first dash, accessible parts which are needed for the operation of electronic switches (for example, sensing surfaces) may be connected to live parts. If they are connected to live parts, it shall be by means of a protective impedance.

The protective impedance shall consist of at least two resistors or independent capacitors in series, of the same nominal value or a combination of both. The resistors shall comply with the requirements given in 102.3, and the capacitors shall comply with the requirements given in 102.2.

The removal of protective impedance shall only be possible by destruction of the electronic switch or by rendering it unusable.

Compliance is checked by inspection and by the following test.

The measurements are carried out between either a single accessible metal part or any combination of accessible metal parts and earth, through a non-inductive resistor of $2\text{ k}\Omega$ at rated voltage (and rated load in on-state), in on- and off-state, and/or at lowest and highest setting values. During the measurements, each one of the resistors and all other components, if any, in the protective impedance, are alternatively short-circuited.

The current shall not exceed, in any measurement, 0,7 mA (peak value) for a.c. up to 1 kHz or 2 mA for d.c.

For frequencies above 1 kHz, the limit of 0,7 mA is multiplied by the value of the frequency in kilohertz, but shall not exceed 70 mA.

10.101 If a cover or cover-plate, or a fuse can be removed without the use of a tool, or if the installation instructions for the user indicate that, for the purpose of maintenance, when replacing the fuse, covers and cover-plates fastened by means of a tool have to be removed, the protection against contact with live parts shall be assured even after removal of the cover or cover-plate.

This requirement does not apply when the electronic switch must be dismounted from its supporting means for the replacement of the fuse-link.

NOTE The conditions for the replacement of the fuse should be specified in the manufacturer's instruction.

Compliance is checked by applying test probe B according to IEC 61032 with a force not exceeding 10 N. The test probe shall not touch live parts.

10.102 If an electronic switch is provided with a hole for adjusting the setting of the electronic and this hole is indicated as such, the adjustment shall not involve the risk of an electric shock.

Compliance is checked by applying a test pin according to figure 101 through the hole. The pin shall not touch live parts.

10.103 Ventilation openings over live parts shall be so designed that a foreign body introduced into these openings shall not come into contact with any live parts with the electronic switch installed as in normal use.

Compliance is checked by applying the test probe 13 of IEC 61032 through the openings. The pin of the test probe shall not touch live parts.

11 Provision for earthing

This clause of part 1 applies except as follows.

Addition:

This clause does not apply to SELV electronic switches.

11.101 The printed conductors of printed circuit boards may be used to provide protective earthing continuity only under the following conditions:

- at least two tracks are used each having independent soldering points which will withstand a single short circuit test similar to 101.3 and immediately after the switch shall fulfill the requirements of 11.4, or
- a single track is used with two independent means of connection on each end which will withstands a single short circuit test similar to 101.3 and immediately after the switch shall fulfill the requirements of 11.4.

In addition,

- the material of the printed circuit board shall consist of epoxide woven glass fabric copper-clad laminated sheet and
- the printed circuit board shall comply with the overload test according to 101.1.1.2.

12 Terminals

This clause of part 1 applies except as follows.

12.1 Addition to the end of the subclause:

NOTE The connecting capacity of terminals for other circuits than the main circuit (load circuit) is not in relation to the rated current of the electronic switch. That means that the terminals for the conductors to an external sensing unit may not necessarily have the same connecting capacity as the supply and load side terminals of the electronic switch.

Addition after the 3rd paragraph:

Terminals having screw clamping which are in compliance with IEC 60998-2-1 can be used.

Addition after the last paragraph:

Terminals having screw clamping complying with IEC 60998-2-1 are considered to be in compliance with the requirements and tests of Subclause 12.2, except those of 12.2.6 and 12.2.7 and 12.2.8, provided they are chosen according to Table 2.

12.2 Addition to note 2 of Table 2:

This requirement may be achieved using terminal(s) with two separate clamping units.

13 Constructional requirements

This clause of part 1 applies except as follows.

13.4 Addition after the first paragraph:

Free openings according to 10.102 and 10.103 are accepted.

13.5 Replacement:

Knobs of electronic switches shall be securely fixed in a reliable manner so that they will not work loose in normal use, if loosening may result in a hazard.

If knobs are used to indicate the position of electronic switches, it shall not be possible to fix them in a wrong position, if this may result in a hazard.

Compliance is checked by inspection and by the following tests.

Where it is possible to apply an axial pull in normal use, an axial pull shall be applied for 1 min to try to pull off the knob.

The pull force to be applied is normally 15 N, but if the knob is intended to be pulled in normal use this is increased to 30 N.

An axial push of 30 N for 1 min is then applied to all knobs.

During and after these tests, the electronic switch shall show no damage, nor shall a knob have moved so as to impair compliance with this standard.

NOTE Sealing compound and the like, other than self-hardening resins are not considered to be adequate to prevent loosening.

13.15.1 Replacement:

Membranes, lenses and the like shall be reliably fixed and shall not be displaced by the mechanical and thermal stresses occurring in normal use.

Compliance is checked by the following tests.

Membranes, lenses and the like are tested when assembled in the electronic switches.

First, the electronic switches are fitted with the membranes, lenses and the like which have been subjected to the treatment specified in 15.1.

The electronic switches are then placed for 2 h in a heating cabinet as described in 15.1, the temperature being maintained at $(40 \pm 2)^\circ\text{C}$.

Immediately after this period, a force of 30 N is applied for 5 s to various parts of the membranes, lenses and the like, by means of the tip of test probe 11 to IEC 61032.

During these tests, the membranes, lenses and the like shall not deform to such an extent that live parts become accessible.

For membranes, lenses and the like likely to be subjected to an axial pull in normal use, an axial pull of 30 N is applied for 5 s.

During this test, the membranes, lenses and the like shall not come out.

The test is then repeated with membranes, lenses and the like which have not been subjected to any treatment.

13.101 Cut-outs in electronic switches for motor speed control circuits shall be non-self-resetting.

Compliance is checked by inspection.

13.102 Electronic switches for the control of the voltage of iron core transformers for extra low-voltage incandescent lamps (for example, halogen) shall have a maximum tolerance of the phase-control angle between the positive and negative half-wave of $\pm 2^\circ$.

NOTE 1 Higher tolerances will generate a d.c. current influencing the temperature rise in the windings of the iron core transformer.

NOTE 2 The maximum tolerance between the phase-control angle of the positive and negative half-wave may be measured directly or as d.c. voltage in per cent of the rated voltage. This corresponds at 90° to 1,1 % of the peak value of the rated voltage.

Compliance is checked by measurement.

13.103 For electronic TDS, Subclause 13.101 of IEC 60669-2-3 applies.

14 Mechanism

This clause of part 1 only applies to electronic switches provided with mechanical switching devices.

14.101 For electronic RCS, Subclause 14.101 of IEC 60669-2-2 applies.

For electronic TDS, Subclause 14.101 of IEC 60669-2-3 applies.

15 Resistance to ageing, protection provided by enclosures of switches, and resistance to humidity

This clause of part 1 applies.

16 Insulation resistance and electric strength

This clause of part 1 applies except as follows.

Addition after the first paragraph:

Insulation resistance and electric strength are measured with the protective impedances according to 10.2 disconnected.

Addition to table 14:

NOTE 101 The test according to item 3 is carried out only on electronic switches combined with mechanical switches.

Addition to Table 14:

9 Between switching circuit(s) and control circuit(s) if they are electrically separated	5	2 000	3 000
10 Between SELV/PELV circuits and other circuit(s) having a higher voltage than SELV/PELV	7	2 500	3 750
11 Between two SELV/PELV circuits	5	500	500

17 Temperature rise

This clause of part 1 applies except as follows.

Replacement:

Electronic switches shall be so constructed that the temperature rise in normal use is not excessive.

The metal and the design of the contacts, if any, shall be such that the operation of the electronic switch is not adversely affected by oxidation or any other deterioration.

The design and the material of the electronic switch shall be such that the material and the components in the electronic switch are not adversely affected by the temperature rise in normal use.

Compliance is checked by the following test, where applicable.

The electronic switches are fitted with the conductors as specified in table 15, the cross-sectional area being not less than 1,5 mm²; the terminal screws or nuts, if any, are tightened with a torque equal to two-thirds of that specified in 12.2.8.

For electronic switches which can be loaded with incandescent lamps (lamps rated for the supply voltage, including halogen lamps) the following applies:

- If the rated power of some of the loads is expressed in W and is higher or equal to the rated power of other loads expressed in VA, electronic switches shall be loaded with halogen lamps or tungsten filament lamps so that, at the rated voltage of the load, the rated load will be obtained.

NOTE 1 As the characteristics of halogen lamps of different power are equivalent, lamps of any power can be used to reach the rated load.

- If the rated power of some of the loads is expressed in W and is lower than the rated power of other loads expressed in VA, electronic switches shall be loaded with all types of load in accordance with the manufacturer's instructions.
- If the rated power of the self ballasted lamps, or externally ballasted lamps, expressed in W is higher than 25 % of the rated power of the incandescent lamps the test shall be done with all types of load.

For electronic switches which are not designed for incandescent lamps the following applies:

- Electronic switches for self ballasted lamps (e.g. LEDi, CFLi) are loaded with lamps so that, at the rated voltage of the load, the rated load will be obtained. Dimmers shall be loaded with dimmable self ballasted lamps. If for these types of electronic switches, the maximum number of self ballasted lamps and the rating of the lamp are given by the manufacturer, the electronic switch is loaded accordingly. If more than one configuration is given by the manufacturer, the test is repeated for all configurations.
- Electronic switches for other types of lamp are tested in accordance with the manufacturer's instructions.

not for self ballasted lamps
Other electronic switches shall be loaded with the type of load as stated in the manufacturer's instructions.

NOTE 2 The rated loads are verified with the electronic switch short-circuited.

For electronic TDS, 17.1 of IEC 60669-2-3:2006 is applicable.

The electronic switches are loaded until steady-state temperature is reached at a voltage between 0,9 and 1,1 times rated voltage, whichever is the more unfavourable.

Dimmers operating with leading and trailing edge shall be tested in both modes with the relevant load.

In lamp dimmers and speed controllers, the setting is adjusted such that the highest temperature rise will occur.

Flush-mounted electronic switches are mounted in flush-mounted boxes. The box is placed in a block of wood filled around the box with plaster, so that the front edge of the box does not protrude and is not more than 5 mm below the front surface of the wood block.

The test assembly shall be allowed to dry for not less than seven days when first made.

The size of the pinewood block, which may be fabricated from more than one piece, shall be such that there is at least 25 mm of wood surrounding the plaster, the plaster having a thickness between 10 mm and 15 mm around the maximum dimensions of the sides and rear of the box.

NOTE 3 The sides of the cavity in the pinewood block may have a cylindrical shape.

The cables connected to the electronic switch shall enter through the top of the box, the point(s) of entry being sealed to prevent the circulation of air. The length of each conductor within the box shall be (80 ± 10) mm.

Surface-type electronic switches shall be mounted as in normal use, centrally on the surface of a wooden block, which shall be at least 20 mm thick, 500 mm wide and 500 mm high.

The other types of electronic switches shall be mounted according to the manufacturer's instructions or, in the absence of such instructions, in the position of normal use considered to give the most onerous conditions.

The test assembly shall be placed in a draught-free environment for the test.

The temperature is determined by means of melting particles, colour-changing indicators or thermocouples, so chosen and positioned that they have negligible effect on the temperature being determined.

During the test, the electronic switch state shall not change, fuses and other protective devices shall not operate and the permissible temperature rises determined in table 102, column concerning clause 17, shall not be exceeded.

After this test, the electronic switch shall be in operating condition.

If sealing compounds are used, they shall not have flowed to such an extent that live parts are exposed.

Compliance is checked by inspection.

NOTE 4 For the purpose of the test of 21.3, the temperature rise of external parts of insulating material not necessary to retain current-carrying parts and parts of the earthing circuit in position, even though they are in contact with them, is also determined.

NOTE 5 Undue oxidation of contacts may be prevented by sliding action or by the use of silver or silver-faced contacts.

NOTE 6 Pellets of beeswax (melting-point 65 °C) with a diameter of 3 mm may be used as melting particles.

NOTE 7 In the case of combination of electronic switches, the test is carried out separately on each electronic switch.

For the purposes of the tests of 102.2, 102.3 and 102.4.1, the reference temperature surrounding a component in an electronic switch is the maximum temperature rise measured on the component during the test plus 25 °C.

Table 102 – Permissible temperature rise values
 (This table is based on table 3 of IEC 60065)

Parts of the electronic switch	Permissible temperature rise K	
	Clause 17	Clause 101
External parts		
Metal parts	Knobs, handles, sensing surfaces, etc.	40 75
	Enclosure (note 1)	50 75
Non-metallic parts	Knobs, handles, sensing surfaces, etc. (note 2)	60 75
	Enclosure (notes 1 and 2)	70 75
Inside of enclosures of insulating material	(Note 3)	(Note 3)
Windings (note 4)		
Class A	75	115
Class E	90	130
Class B	95	140
Class F	115	155
Class H	140	175
Class 200	160	195
Class 220	180	215
Class 250	210	245
Core laminations	As for relevant windings	
Supply cable and wiring:		
Insulated with ordinary polyvinyl chloride (note 8)		
– not under mechanical stress	70	110
– under mechanical stress	55	110
Insulated with natural rubber	55	110
Other insulations (notes 4 and 7) except thermoplastic		
Non-impregnated paper	65	80
Non-impregnated cardboard	70	90
Impregnated cotton, silk, paper and textile, urea resins	80	100
Laminates bonded with phenol-formaldehyde resins, phenol-formaldehyde mouldings with cellulose fillers	95	120
Phenol-formaldehyde mouldings with mineral fillers	105	140
Laminates bonded with epoxy resins	130	160
Natural rubber	55	110
Thermoplastic materials (note 5)	(Note 6)	
Terminals and parts which may come into contact with cable insulation when installed	55	110
The values of the temperature rises are based on an ambient temperature of 25 °C, but the measurements are made under normal conditions.		
NOTE 1 For areas not exceeding 5 cm ² and which are not likely to be touched in normal use, temperature rises up to 75 K are allowed under normal operating conditions.		
NOTE 2 If these temperature rises are higher than those allowed by the class of the relevant insulating material, the nature of the material is the governing factor.		
NOTE 3 The permissible temperature rises for the inside of enclosures of insulating material are those indicated for the relevant materials.		
NOTE 4 For the purpose of this standard, the permissible temperature rises are based on the recommendations in IEC 60085. The materials quoted above are shown only as examples. If materials other than those listed in IEC 60085 are used, the maximum temperatures must not exceed those which have been proved to be satisfactory.		
NOTE 5 Natural and synthetic rubbers are not considered as being thermoplastic materials.		
NOTE 6 Due to their wide variety, it is not possible to specify permissible temperature rises for thermoplastic materials. While the matter is under consideration, the following method shall be used.		
a) The softening temperature of the material is determined on a separate specimen, under the conditions specified in ISO 306, modified as follows:		
– the depth of penetration is 0,1 mm;		
– the total thrust of 10 N is applied before the dial gauge is set to zero or its initial reading noted.		

b) The temperature limits to be considered for determining the temperature rises are:

- under normal operating conditions, a temperature 10 °C lower than the softening temperature as obtained under a);
- under fault conditions, the softening temperature itself.

NOTE 7 The table does not apply to components which comply with relevant IEC standards.

NOTE 8 The possibility of raising the values for wires and cables insulated with heat-resistant polyvinyl chloride is under consideration.

18 Making and breaking capacity

This clause of part 1 applies except as follows.

Replacement of the text before 18.1:

Electronic switches shall have adequate making and breaking capacity.

NOTE 1 Where the term "switch" is used in part 1, this term is replaced by "contact mechanism" as appropriate.

NOTE 2 In the case of electronic switches using relays, the relay is operated at the specified rate of operation with the appropriate load(s) as in normal use.

This test is carried out only on electronic switches provided with mechanically or electro-mechanically operated contact mechanisms.

Contact mechanisms shall have adequate making and breaking capacity.

The test is made on three separate specimens of the complete contact mechanism.

Compliance is checked by the following tests:

- for electronic switches for the control of fluorescent lamps loads, as specified in 18.1 of part 1;
- for electronic switches for the control of motor speed control circuits, as specified in 18.1 of part 1 and, additionally, in 18.101;
- for electronic switches for the control of the voltage of iron core transformers for extra low-voltage incandescent lamps, as specified in 18.1, 18.2 of part 1 and 18.102;
- for electronic switches for the control of the voltage of electronic step-down converters for extra low-voltage incandescent lamps, as specified in 18.2 of part 1;
- for electronic switches for the control of other types of loads, as specified in 18.1 and 18.2 of part 1.
- for electronic switches for the control of self ballasted lamps, as specified in 18.1 of part 1.

NOTE 3 For electronic switches whose cycle of operation is limited by their application (for example, passive infrared, time delay electronic switches, etc.), the rate of operation during the tests may be specified by the manufacturer.

The tests are made by means of an apparatus the principle of which is shown in figure 12 and which is arranged to simulate normal operation.

The connections are as shown in figure 13.

Electronic switches are fitted with conductors as for the test of clause 17.

For electronic RCS, Clause 18 of IEC 60669-2-2 applies.

18.1 Addition after the second paragraph:

For electronic switches whose rate of operation is limited by their application (for example, heat or light sensors), the rate of operation is as follows. The electronic switch is set to the shortest cycle time possible. The electronic switch is re-activated at the end of each cycle within a time of $(2 \pm 0,5)$ s.

Addition:

For electronic TDS, Subclause 18.1, 2nd paragraph, of IEC 60669-2-3 applies at the following conditions:

For electronic TDS whose rate of operation is limited by their application (for example, heat or light sensors), the rate of operation is as follows. The electronic TDS is set to the shortest cycle time possible. The electronic switch is re-activated at the end of each cycle within a time of $(2 \pm 0,5)$ s.

All other electronic TDS are subjected to 200 operations at a uniform rate of

- 30 operations per minute if the rated current does not exceed 10 A;
- 15 operations per minute if the rated current exceeds 10 A but is less than 25 A;
- 7,5 operations per minute if the rated current is 25 A.

18.101 *The contact mechanism is subjected to tests of 50 cycles of operation, each at rated voltage and at the rate of operations specified in 18.1 of part 1:*

- the contact mechanism closes a circuit through which a current of $9 I_n$ ($\cos \varphi = 0,8 \pm 0,05$) passes, this current being interrupted by means of an auxiliary switch 50 ms to 100 ms after each closure;
- the circuit through which a current of $6 I_n$ ($\cos \varphi = 0,6 \pm 0,05$) passes is closed by an auxiliary switch and opened by the contact mechanism 300 ms to 500 ms after each closure.

NOTE 1 I_n is the rated current of the electronic switch.

NOTE 2 If the electronic switch has a rated load instead of a rated current, I_n is calculated under the assumption that the power factor ($\cos \varphi$) of the motor load is 0,6.

During the tests, no sustained arcing shall occur.

After these tests, the specimens shall show no damage impairing their further use.

18.102 *Electronic switches for control of the voltage of iron core transformers for extra low-voltage incandescent lamps (for example, halogen) shall be subjected to the following test.*

The test is made on three specimens.

The contact mechanism is subjected to 50 making operations, each at rated voltage and at the rate of operation as specified in 18.1 of part 1.

To simulate making, the test circuit shall be adjusted to a test current 10 times the rated current of the electronic switch for one half-cycle of the power supply frequency.

During the tests, no sustained arcing shall occur.

After the tests, the specimens shall show no damage impairing their further use.

NOTE Tests for electronic switches which can be operated with a transformer on no-load are under consideration.

19 Normal operation

This clause of part 1 applies except as follows.

Replacement:

Electronic switches shall withstand, without excessive wear or other harmful effect, the mechanical, electrical and thermal stresses occurring in normal use.

Compliance is checked by the tests of 19.101, 19.102, 19.103, 19.104, 19.105 and 19.109, during which the electronic switches are tested at their rated voltage and loaded as specified in clause 17, unless otherwise specified.

For electronic switches with included automatic function the number of operations for tests of subclauses 19.101, 19.102, 19.104 and 19.109 is that specified in the relevant subclause. If a manufacturer declares a number of operations higher than those indicated in the relevant subclause, the tests shall be made according to the declared value.

NOTE 1 The correlation between the tests of 19.102 and 19.109 is under consideration.

Sticking of the contacts, which does not prevent the next operation of the switch, is not regarded as welding.

Sticking of contacts is permitted if the contacts can be separated with a force applied to the actuator of a value which does not damage the switch mechanically.

Electronic switches including electronic circuits which close the contact of the contact mechanism always at zero-crossing $\pm 20^\circ$ phase angle, shall be tested together with their electronic circuit.

NOTE 2 For the purpose of this test, the manufacturer can provide the specimens with a special circuit that simulates the automatic operations.

For electronic RCS, Subclause 19.1 of IEC 60669-2-2 applies.

For electronic TDS, Subclause 19.1 of IEC 60669-2-3 applies.

NOTE 3 For electronic switches whose cycle of operation is limited by their applications (for example, passive infrared, time delay electronic switches, etc.), the rate of operation during the tests may be specified by the manufacturer.

During the test, the specimens shall function correctly.

After the tests, the specimen shall withstand the following:

- an electric strength test as specified in clause 16, the test voltage of 4 000 V being, however, reduced by 1 000 V and the other test voltages by 500 V, except for the specimens tested in 19.102 where no electric strength test is performed;
- a temperature rise test as specified in clause 17.

The specimens shall then not show

- wear impairing their further use;
- discrepancy between the position of the actuating member and that of the moving contacts, if any, if the position of the actuating member is indicated;
- deterioration of enclosures, insulating linings or barriers to such an extent that the electronic switch cannot be further operated or that the requirements of clause 10 are no longer complied with;
- loosening of electrical or mechanical connections;
- seepage of sealing compound;

- relative displacement of the moving contacts of electronic switches of pattern number 2.

NOTE 4 The humidity treatment according to 15.3 is not repeated before the electric strength test of this subclause.

NOTE 5 During the test, the specimens are not lubricated.

19.101 Contact mechanisms incorporated in electronic switches intended for incandescent lamp circuits with or without step down converters are subjected to the following test.

The test is made on three separate specimens of the complete contact mechanism.

The circuit details and the manner of operation of the selector switch S are as described in 18.1, unless otherwise specified.

The number of operations is 40 000.

The rate of operation is as specified in 18.1.

For rotary electronic switches intended to be operated in either direction, the actuating member is turned in one direction for half the total number of operations and in the reverse direction for the remainder.

While testing one part, the other part is in the “off” position. The test is followed by the test of 14.3, if applicable.

Contact mechanisms incorporated in electronic switches intended for motor speed control circuits are tested as above, but they close a circuit through which a current of $6 \times I_n$ ($\cos \varphi = 0,65 \pm 0,05$) passes and open a circuit through which a current of I_n ($\cos \varphi = 0,65 \pm 0,05$) passes, the ratio of recovery voltage U_s and rated operational voltage U_e being 1,00 ($\pm 10\%$).

19.102 Contact mechanisms incorporated in electronic switches, intended for externally ballasted lamps (e.g. fluorescent lamps, CFL, LED) are checked by the test circuit indicated in Figure 102, Load A with the following test conditions.

NOTE The test with Load B is not applicable.

The prospective short-circuit current (rms) of the supply shall be between 3 kA and 4 kA at $\cos \varphi = 0,9 \pm 0,05$ (lagging). F is a copper-wire fuse of 0,1 mm nominal diameter having a length not less than 50 mm.

R1 is a resistor limiting the current to approximately 100 A.

The twin-core cable shall have a suitable length to give a resistance R3 equal to 0,25 Ω in the test circuit to the load. It shall have a cross-sectional area of 1,5 mm² when switches with rated current up to and including 10 A are being tested and 2,5 mm² when switches with rated current over 10 A up to and including 16 A are being tested.

The load shall consist of:

- a capacitor bank C_1 , giving a capacitance according to table 103. The capacitors shall be connected with 2,5 mm² conductors having the shortest possible length;
- an inductor L_1 and a resistor R_2 , adjusted to give the power factor $0,9 \pm 0,05$ (lagging) and the test current $I_n^{+5} \text{ } 0 \text{ } \% \text{ through the specimen.}$

Table 103 – Relationship between rated current and capacitance

Rated current A	Capacitance μF
Up to and including 1	12
Up to and including 2	24
Up to and including 3	35
Up to and including 4	48
Up to and including 5	58
Up to and including 6	70
Up to and including 7	77
Up to and including 8	96
Up to and including 9	105
Up to and including 10	140
Up to and including 16	140
NOTE The circuit parameters have been chosen to represent the lamp loads used in the most practical applications.	

Compliance is checked by the following test.

For the test, new specimens are used.

The tolerance of the test voltage is $\pm 5\%$. The circuit details and the manner of operation of the selector switch S are as described in 18.1.

The number of operations is as follows.

For electronic switches with a rated current up to and including 10 A: 10 000 operations with 30 operations per minute.

For electronic switches with rated current above 10 A up to and including 16 A: 5 000 operations with 15 operations per minute.

The test specimens shall be connected to the test circuit with cables of length $(1 \pm 0,1)$ m so that the temperature rise measurement can be made without disturbing the terminals.

The metal support of the switch, if any, on which the switch is mounted, and the accessible metal parts of the switch, if any, shall be earthed through a wire fuse which shall not blow during the test. The fuse element shall consist of a copper wire of 0,1 mm diameter and not less than 50 mm in length.

During this test, the switch shall be operated so that the test apparatus does not interfere with the normal action of the switch mechanism and the free movement of the actuating member.

There shall be no forced actuation. The on-period shall be $25 (+5 \text{ } 0) \%$ of the total cycle and the off-period $75 (-5 \text{ } 0) \%$.

19.103 Semiconductor switching devices and/or electronic regulating units incorporated in electronic switches are subjected to the following tests.

NOTE Examples of electronic regulating units are controls used for the adjustment of time, light level, sensitivity, etc, of the device.

The electronic switch is loaded with rated load until steady-state temperature at 1,1 times rated voltage is reached.

The switch state of the electronic switch is changed 10 times and/or the setting value is altered 10 times over the whole range from minimum to maximum and back to minimum by means of the sensing surface or unit.

Additionally, where appropriate, the switch state of the electronic switch is changed 10 times and/or the setting value is altered 10 times over the whole range from minimum to maximum and back to minimum by means of an electronic extension unit.

19.104 Mechanical control units incorporated in electronic switches are subjected to the following test.

The electronic switch is loaded with its rated load and the voltage is then increased to 1,1 times the rated voltage, the setting is altered 10 000 times over the whole range from minimum to maximum and back to minimum by means of its control unit, the rate of operation being between 10 and 15 operations per minute.

Mechanical control units are push buttons, potentiometers etc, requiring a manual operation.

19.105 For electronic switches for which a minimum load or current is specified by the manufacturer, the characteristic is additionally tested with the specified minimum load or current at 0,9 times rated voltage.

The switch state of the electronic switch is changed 10 times and/or the setting value is altered 10 times over the whole range from minimum to maximum and back to minimum.

In addition, where appropriate, the switch state of the electronic switch is changed 10 times and/or the setting value is altered 10 times over the whole range from minimum to maximum and back to minimum by means of an electronic extension unit.

19.106 ~~not for sale~~ For electronic RCS, Subclause 19.101 of IEC 60669-2-2 applies.

For electronic TDS, Subclause 19.101 of IEC 60669-2-3 applies.

19.107 For electronic TDS, Subclause 19.102 of IEC 60669-2-3 applies.

19.108 For electronic TDS, Subclause 19.103 of IEC 60669-2-3 applies.

19.109 Contact mechanisms incorporated in electronic switches intended for self ballasted lamps are tested as in 19.102 except for the requirements related to the power supply which are given for information only.

NOTE 1 The calculations are based on the following parameters in order to have the required values for inrush current and I^2t

- a prospective short-circuit current (rms) of the supply of 3 kA at $\cos \varphi = 0,9$ (lagging).
- a resistance R_3 equal to $0,25 \Omega$ and an inductance L equal to $20 \mu\text{H}$ simulating the twin-core cable in the test circuit.

Compliance is checked by connecting the load B as given in Figure 103 via the electronic switch under test to a power supply. The values for the maximum peak value and the maximum I^2t of the inrush current are given in Table 108.

NOTE 2 The test with Load A is not applicable.

For electronic switches with rated power for SBL lamps up to and including 250 W: 40 000 operations with 30 operations per minute.

For electronic switches with rated power for SBL lamps higher than 250 W: 40 000 operations with 15 operations per minute.

NOTE 3 R1 is the total series resistance in the lamp circuit including the ESR (equivalent series resistance) value of the capacitor.

The values of R1 and C in load B shall be chosen in order to reach the values ($\pm 5\%$) for I_{peak} and I^2t as given in Table 108 when the switching contact closes at $(90 \pm 5)^\circ$ phase-angle. The value of R2 shall be chosen to reach the rated power in W ($\pm 5\%$).

Table 108 – Values for I_{peak} and I^2t depending on the type of distribution system

Rated Power (W)	I_{peak} A	I^2t A ² s	I_{peak} A	I^2t A ² s
	Distribution system: 220/380, 230/400 240/415	Distribution system: 220/380, 230/400 240/415	Distribution system: 120/208 127/220	Distribution system: 120/208 127/220
15	22	0,08	69	0,56
30	41	0,3	109	1,9
60	73	1,2	162	5,9
100	108	2,8	200	11,5
150	142	5,5	231	18,5
200	170	9	248	24,5
250	192	13	255	30
300	209	16,5	260	35
350	223	20,5	262	39
400	235	24,5	263	43

NOTE For values not given in the table the test values are determined by interpolation.

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Table 109 – Calculated circuit parameters

Rated power (W)	R1 (Ω)	C (μF)	R1 (Ω)	C (μF)
	230 V	230 V	120 V	120 V
15	13	20	1,36	70
30	6,5	40	0,65	140
60	3,25	80	0,28	280
100	1,9	125	0,17	445
150	1,25	180	0,11	640
200	0,95	240	0,10	830
250	0,8	310	0,10	1000
300	0,7	355	0,11	1250
350	0,64	420	0,13	1500
400	0,59	480	0,135	1660

The values in Table 109 are given for information only. The circuit shall be adjusted to reach the I_{peak} and I^2t values of Table 108.

20 Mechanical strength

This clause of part 1 applies.

21 Resistance to heat

This clause of part 1 applies.

22 Screws, current-carrying parts and connections

This clause of part 1 applies.

23 Creepage distances, clearances and distances through sealing compound

This clause of part 1 applies except as follows.

Addition:

The values given in items 1, 2, 6 and 7 of table 20 apply to terminals for external wiring and do not apply to other live parts which are protected by a directly associated fuse with adequate breaking capacity or other current-limiting means, under the provision that the requirements of clause 101 are fulfilled. If there is no directly associated fuse, or other current-limiting means, the electronic switch shall comply with table 20.

NOTE 1 Directly associated fuses and current-limiting means are devices inserted in the circuit whose primary function is to protect the electronic switch.

NOTE 2 A directly associated fuse and/or current-limiting means need not necessarily be incorporated in the electronic switch.

Addition of the following items to Table 20:

<i>Creepage distances</i>		
101	For creepage distances across which nominal voltages up to 50 V a.c. or d.c. occur ^{a)} ^{b)} , and which voltages are generated in a circuit by supply from a safety isolating transformer according to IEC 61558-2-6 or by a supply equivalently separated from the mains supply – on printed wiring material - pollution degree 1: – on printed wiring material - pollution degree 2 – on other insulating material- across insulating material of Material Group I – on other insulating material - across insulating material of Material Group II – on other insulating material - across insulating material of Material Group III	0,025 0,04 0,6 0,85 1,2
<i>Clearance distances</i>		
102	For clearance distances across which nominal functional voltages up to 50 V a.c. or d.c. occur ^{a)} , and which voltages are generated in a circuit by supply from a safety isolating transformer according to IEC 61558-2-6 or by a supply equivalently electrically separated from the mains supply in an equally effective manner: – pollution degree 1: – pollution degree 2:	0,1 mm 0,2 mm
NOTE 1 The values for the clearances are based on IEC 60664-1, Table F.2, using as input: – the rated impulse voltage of 800 V derived from IEC 60664-1, Table F.1, for a line to neutral voltage of 50 V a.c. or d.c. and overvoltage category III and Case A (inhomogeneous field), – pollution degrees 1 and 2.		
The values for creepages are based on IEC 60664-1 Table F.4 with the input of voltage rationalized for Table F.4 of 50 V r.m.s from IEC 60664-1 Table F.3a for a nominal voltage of the supply system of 50 V.		
NOTE 2 For the definition of nominal voltage, see IEV 601-01-21.		
NOTE 3 Items 101 and 102 apply to electronic RCS and TDS only.		
^{a)} For the purposes of this standard the following applies (taken from IEC 60664-1): Micro-environment: the immediate environment of the insulation which particularly influences the dimensioning of creepage distances (IEC 60664-1) Pollution degree: a numeral characterizing the expected pollution of the micro-environment (IEC 60664-1) Pollution degree 1: no pollution or only dry, non-conductive pollution occurs. The pollution has no influence. On printed wiring boards of RCS, it is acceptable to use pollution degree 1 if the printed wiring board is protected against any occurrence of condensation and deposition of conductive, hydroscopic, or soluble dust. This usually can be achieved only if the printed wiring board and/or circuits are coated and the coating complies with the specifications of IEC 60664-3 and an additional encapsulation, or by sealing of the whole printed wiring board assembly by a protective coating. Pollution degree 2: only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected (see IEC 60664-1). On printed wiring boards of RCS, it is acceptable to use pollution degree 2, if the printed wiring board and/or circuit is coated and the coating complies with the specifications of IEC 60664-3. This standard classifies insulating materials according to their PTI values into four groups: Material Group I $600 \leq \text{PTI}$ Material Group II $400 \leq \text{PTI} < 600$ Material Group IIIa $175 \leq \text{PTI} < 400$ Material Group IIIb $100 \leq \text{PTI} < 175$ Material Group III includes Material Group IIIa and Material Group IIIb A material shall be included in one of the four groups above on the basis that its PTI, established by the method of IEC 60112 using solution A is equal or greater than the lower value specified for the group. ^{b)} Values of creepage distances for printed wiring boards are given for pollution degrees 1 and 2. For other insulating materials only the values for creepage distances for pollution degree 2 are allowed.		

23.101 For electronic switches having a control circuit suitable for connection to a SELV supply, the switching circuit being supplied with a voltage greater than the SELV, creepage distances and clearances between control and switching circuits shall not be less than 5,5 mm.

In case of electronic RCS and electronic TDS classified according to 7.103, see the relevant requirements in IEC 60669-2-2 and IEC 60669-2-3 for clearance and creepage distances between SELV and mains.

23.102 If the enamel of the wire is at least grade 1 according to the IEC 60317 series, the clearances between the wire of the control coil, the live parts of different polarity and exposed conductive parts may be reduced to a value equal to two-thirds of the clearances required in the absence of enamel.

24 Resistance of insulating material to abnormal heat, to fire and to tracking

This clause of part 1 applies.

25 Resistance to rusting

This clause of part 1 applies.

26 EMC requirements

This clause of part 1 applies except as follows.

Replacement:

Electronic switches ~~shall~~ be designed to operate correctly under the conditions of electromagnetic environment in which they are intended to be used. This applies particularly for electronic switches intended to be connected to a.c. low-voltage public supply systems where the design shall take into account the normal disturbances on the supply system, as defined by the compatibility levels given in IEC 61000-2-2.

The tests are carried out with one new specimen (see table 101).

For electronic switches, the manufacturer shall specify all details related to the load.

Compliance is checked by the tests of 26.1 and 26.2.

26.1 Immunity

Electronic switches shall be designed so that the switch state (on or off) and/or the setting value are protected against interference. The operation of the switch shall be protected against continuous interference (e.g. IEC 61000-4-3; IEC 61000-4-6; IEC 61000-4-8).

For the following tests, the electronic switch is mounted as in normal use in the relevant box, if any, and loaded with all kinds of loads according to the manufacturers specifications, unless otherwise stated in the relevant paragraph of Clause 26.

The electronic switch is loaded at 100 % of the rated load for dimming devices and with a functional load for other electronic switches.

The electronic switch shall be tested according to Table 104 with or without operation as specified in the relevant paragraph of Clause 26.

If the load connected to the electronic switch is controlled by mechanical switching devices (e.g. relays), and no semiconductor devices are present in the load circuit, the test is conducted with a resistive load only.

For the tests without operation, the electronic switch is tested in the following states:

a) in the on-state

For electronic switches where the setting can alter (e.g. dimming devices) the conduction angle is set at $(100 \pm 5)^\circ$ which results in an output power (rms).

A variation of P_o less than $\pm 10\%$ is not considered to be a change of the setting.

b) in the off-state.

For the tests with operation, the electronic switch shall be switched ON/OFF with a minimum operating rate of 1 operation/second. As an alternative, where the setting can alter (e.g. dimming devices), the setting value can be changed e.g. from minimum to maximum.

For electronic switches whose cycle of operation is limited by their application (for example, passive infrared, time delay electronic switches, etc.), the rate of operation during the tests shall be specified by the manufacturer.

Table 104 – Immunity tests (overview)

EM phenomena	Test specification	Test set-up	Subclause
Voltage dips and short interruptions	Table 105	IEC 61000-4-11:1994	26.1.1
Surge	Table 110	IEC 61000-4-5:1995	26.1.2
Fast transients (burst)	Table 106	IEC 61000-4-4:1995	26.1.3
Electrostatic discharge	± 4 kV contact discharge ± 8 kV air discharge	IEC 61000-4-2:1995	26.1.4
Radiated electromagnetic field test	3 V/m	IEC 61000-4-3:2002	26.1.5
Radio frequency voltage	3 V r.m.s.	IEC 61000-4-6:1996	26.1.6
Power frequency magnetic field	3 A/m, 50 Hz	IEC 61000-4-8:1993	26.1.7 ^a

^a This test is applicable only to electronic switches containing devices susceptible to magnetic fields, for example, Hall elements, electrodynamic microphones, etc.

26.1.1 Voltage dips and short interruptions

The electronic switch shall be tested with the test equipment specified in IEC 61000-4-11 as specified in 26.1, in accordance with table 105, with a sequence of three dips/interruptions with intervals of 10 s minimum between each test event.

The test shall be done on the power supply lines of the electronic switch.

During the test, the electronic switch is not operated.

Abrupt changes in supply voltage shall occur at zero crossings.

The output impedance of the test voltage generator shall be low, even during the transition.

The change between the test voltage U_T and the changed voltage is abrupt.

NOTE 100 % U_T is equal to the rated voltage.

A test level of 0 % corresponds to a total supply voltage interruption.

Table 105 – Voltage dip and short-interruption test values

Test level % U_T	Voltage dip/interruptions % U_T	Duration (number of cycles at rated frequency)
0	100	10
40	60	10
70	30	10

During the test, the state and setting of the electronic switch may alter, flickering is neglected.

After the test, the electronic switch shall be in the original state and setting and shall operate as intended.

After the test, the general purpose electronic switch with included automatic functions shall operate as intended.

26.1.2 Surge immunity test for 1,2/50 wave impulses

Electronic switches shall be tested for resistance to unidirectional surges caused by overvoltages from switching and lightning transients.

During the test, the electronic switch is not operated.

The test is carried out according to IEC 61000-4-5 by applying two positive discharges and two negative discharges at each of the following angles 0°, 90°, 180° and 270°, at a repetition rate of (60 ± 5) s with an open-circuit test voltage according to Table 10.

A test with lower voltages is not required.

If the product has a metallic mounting surface when mounted as in normal use, the test is repeated between line and earth with a test voltage according to Table 10.

Table 110 – Surge immunity test voltages

Conductors / Terminals	Coupling	Test voltage kV
Mains	Line to line	1
	Line to earth	2

During the test, the state and setting of the electronic switch may alter, flickering is neglected.

After the test, the electronic switch shall be in the original state and setting and shall operate as intended.

After the test, the general purpose electronic switch with included automatic functions shall operate as intended.

26.1.3 Electrical fast transient/burst test

Electronic switches shall be tested for resistance to repetitive fast transients/bursts on supply and control terminals/terminations.

During the test, the electronic switch is not operated.

The test is carried out according to IEC 61000-4-4 with the following specification.

The levels of the repetitive fast transients consisting of bursts coupled into the supply and control terminals/terminations of the electronic switch is specified in Table 106.

Table 106 – Fast transient test values

Open-circuit output test voltage $\pm 10\%$		
Level	Supply terminals/terminations kV	Control terminals/terminations kV
2	± 1	$\pm 0,5$

The repetition rate is 5 kHz.

The duration of the test shall be 60^{+5}_0 s, but not less than the time necessary for the electronic switch to respond for each positive and negative polarity.

During the test, the state and setting of the electronic switch may alter, flickering caused by the electronic switch is allowed.

After the test, the electronic switch shall be in the original state and setting and shall operate as intended.

After the test, the general purpose electronic switch with included automatic functions shall operate as intended.

26.1.4 Electrostatic discharge test

Electronic switches mounted as in normal use shall withstand electrostatic contact and air discharges. The test shall be carried out with resistive load. If the electronic switch is not intended to operate incandescent lamps, the test shall be carried out with only one load of the loads specified within the manufacturer's instructions.

During the test, the electronic switch is not operated.

A test with lower voltages is not required.

The test is carried out according to IEC 61000-4-2 by applying 10 positive and 10 negative discharges in the following manner:

- contact discharge to the conductive surfaces and to coupling planes,
- air discharge at insulating surfaces, if applicable.

The static electricity discharges shall be applied only to such points and surfaces of the electronic switch which are accessible in normal use.

The discharges are applied to the pre-selected points designated by the manufacturer, which shall include different material, if any.

The following levels apply:

- test voltage of contact discharge: 4 kV,
- test voltage of air discharge: 8 kV.

During the test, the state and setting of the electronic switch may alter, flickering is neglected.

After the test, the electronic switch shall be in its original state and setting and shall operate as intended.

Electronic switches with an adjustable time delay (for example, passive infra-red switches) shall be adjusted in such a way that the time delay is higher than the testing time.

After the test for electronic switches with a sensing surface intended to be operated by touch, the state and/or setting may be altered, but it shall be possible to operate the electronic switch as intended.

After the test, the general purpose electronic switch with included automatic functions shall operate as intended.

26.1.5 Radiated electromagnetic field test

This test is applicable only to electronic switches containing infra-red (IR) receivers, radio-frequency receivers, passive infra-red (PIR) devices, devices containing microprocessors or similar.

Electronic switches shall be loaded with resistive load only.

Electronic switches shall withstand the radiated electromagnetic field test.

The test is carried out according to IEC 61000-4-3 by applying a field strength of 3 V/m in the frequency range 80 MHz to 1 000 MHz and 1 400 MHz to 2 000 MHz with the exception of the exclusion band as defined in the relevant product standard for transmitters, receivers and duplex transceivers.

During the test, the electronic switch is operated, if it contains automatic functions or can be remotely controlled.

During and after the test, the electronic switch shall operate as intended, flickering is not allowed.

Flickering of lamps or irregular running of motors due to switching transients caused by frequency changes of the test equipment during the test procedure is neglected.

After the test, the general purpose electronic switch with included automatic functions shall operate as intended.

26.1.6 Radio-frequency voltage test

This test is applicable only to electronic switches containing infra-red (IR) receivers, radio-frequency receivers, passive infra-red (PIR) devices, devices containing microprocessors or similar.

Electronic switches shall be loaded with resistive load only.

Electronic switches shall withstand the radio-frequency voltage test.

The test is carried out according to IEC 61000-4-6 by applying a conducted radio-frequency voltage of 3 V r.m.s. on supply lines and control lines.

During the test, the electronic switch is operated, if it contains automatic functions or can be remotely controlled.

During and after the test, the electronic switch shall operate as intended, flickering is not allowed.

Flickering of lamps or irregular running of motors due to switching transients caused by frequency changes of the test equipment during the test procedure is neglected.

After the test, the general purpose electronic switch with included automatic functions shall operate as intended.

26.1.7 Power-frequency magnetic field test

This test is applicable only to electronic switches containing devices susceptible to magnetic fields, for example, Hall elements, electrodynamic microphones, etc.

Electronic switches shall be loaded with resistive load only.

Electronic switches shall withstand the power frequency magnetic field test.

The test is carried out according to IEC 61000-4-8 by applying a magnetic field of 3 A/m, 50 Hz.

During the test, the electronic switch is operated, if it contains automatic functions or can be remotely controlled.

During and after the test, the electronic switch shall operate as intended, flickering is not allowed.

Flickering of lamps or irregular running of motors due to switching transients caused by frequency changes of the test equipment during the test procedure is neglected.

After the test, the general purpose electronic switch with included automatic functions shall operate as intended.

26.2 Emission

26.2.1 Low-frequency emission

Electronic switches shall be so designed that they do not cause excessive disturbances in the network.

Requirements are deemed to be met if the electronic switch complies with IEC 61000-3-2 and IEC 61000-3-3.

This requirement applies to each channel of a multichannel dimmer provided that the channels are independent from each other.

NOTE 1 Electronic switches other than those incorporating automatic controls giving rise to fluctuation of the firing angle, for example, automatic systems to be used in dance halls, discos and the like, are deemed to meet the requirements of IEC 61000-3-3 without need for testing.

NOTE 2 Independent dimmers designed to dim different kinds of loads including incandescent lamps are considered as dimmers for incandescent lamps and according to IEC 61000-3-2 they need not to be tested with all different kinds of load according to Clause 7 of IEC 61000-3-2:2009, if their rated power per channel (provided that the control of the channels are independent) is less than or equal to 1000 W. Electronic switches with semiconductor switching for the load current are regarded as dimmers.

Load terminals/terminations of electronic switches with electromechanically operated contact mechanism (for example, a relay), do not cause harmonic current emissions and are deemed to meet the requirements of IEC 61000-3-2 without need for testing. Therefore only the mains supply terminals/terminations of those products shall be tested.

26.2.2 Radio-frequency emission

Electronic switches shall be so designed that they do not cause excessive radio interference.

The electronic switch shall comply with the requirements of CISPR 14 or CISPR 15. For electronic switches used for electrical lighting application, CISPR 15 applies.

Subclauses 8.1.3.1 and 8.1.3.2 of CISPR 15 are applicable with the following modifications.

Compliance is checked as follows:

a) *At the main terminals (8.1.4.2 of CISPR 15:2013)*

An initial survey or scan of the complete frequency range 9 kHz to 30 MHz shall be made in on-state at the highest setting. In addition, the following frequencies and at all frequencies at which there is a local maximum disturbances found in the original survey above the predetermined level of 6 dB and below the limits given in CISPR 15, the control setting shall be varied for maximum disturbance while connected to the maximum load:

9 kHz, 50 kHz, 100 kHz, 160 kHz, 240 kHz, 550 kHz, 1 MHz, 1,4 MHz, 2 MHz, 3,5 MHz, 6 MHz, 10 MHz, 22 MHz and 30 MHz.

b) *At the load and/or control terminals (8.1.4.3 of CISPR 15:2013).*

An initial survey or scan of the complete frequency range 160 kHz to 30 MHz shall be made in on-state at the highest setting. In addition, the following frequencies and at all frequencies at which there is a local maximum disturbances above the predetermined level of 6 dB below the limits given in CISPR 15, the control setting shall be varied for maximum disturbance while connected to the maximum load:

160 kHz, 240 kHz, 550 kHz, 1 MHz, 1,4 MHz, 2 MHz, 3,5 MHz, 6 MHz, 10 MHz, 22 MHz and 30 MHz.

101 Abnormal conditions

~~Electronic~~ *not* ~~for sale~~ shall not create hazard under abnormal conditions.

If in case of failure the maximum power taken by the electronic switches is less than 0,5 W, the requirements of the abnormal conditions are deemed to be met.

Compliance is checked by the tests specified in 101.1, 101.2 and 101.3.

NOTE For these tests, additional components of the electronic switch may be necessary.

101.1 When electronic switches are operated under abnormal conditions no part shall reach such a temperature that there is danger of fire to the surroundings of the electronic switches.

Compliance is checked by subjecting the electronic switches to a heating test under fault conditions, as described in 101.1.1.

During the test, the temperature rises shall not exceed the values given in table 102, column concerning clause 101.

101.1.1 *Unless otherwise specified, the tests are made on electronic switches while they are mounted, connected and loaded as specified in clause 17.*

Each of the abnormal conditions indicated in 101.1.1.1 and 101.1.1.2 is applied in turn.

NOTE Other faults may occur during the test, which are a direct consequence.

The abnormal conditions are applied in the order which is the most convenient for testing.

101.1.1.1 The following fault conditions shall be simulated:

- short circuit across creepage distances and clearances, other than those complying with the requirements in clause 23, if they are less than the values given in Figure 10 of IEC 60065;
- short circuit across insulating coating consisting, for example, of lacquer or enamel.

Such coatings are ignored in assessing the creepage distances and clearances.

If enamel forms the insulation of a conductor and withstands the voltage test prescribed for grade 2 in clause 13 of IEC 60317-0-1, it is considered as contributing 1 mm to those creepage distances and clearances.

NOTE 1 The change of grade 2 is under consideration.

- short circuit or interruption of semiconductor devices;

NOTE 2 Semiconductors (for example, microcontrollers, integrated circuits, etc.) used in the control circuit of an electronic switch are only short-circuited and interrupted at the supply pins.

- short circuit of electrolytic capacitors;
- short circuit or interruption of capacitors or resistors which do not comply with the requirements of clause 102;
- short circuit of the terminals on the load side.

If a fault condition simulated during the test influences other fault conditions, all these fault conditions are applied simultaneously.

If the temperature of the electronic switch is limited by the operation of automatic protective devices (including fuses), the temperature is measured 2 min after the operation of the device.

If no temperature-limiting device operates, the temperature is measured after a steady state has been reached or after 4 h, whichever is the shorter time.

If the temperature is limited by a fuse, in case of doubt, the following additional test is carried out: the fuse is short-circuited and the current under the relevant fault conditions is measured.

The electronic switch is then switched on for a duration corresponding to the maximum fusing time of the type of fuse as specified by IEC 60127 corresponding to the current measured above. The temperature is measured 2 min after the end of the period.

101.1.1.2 The following overload tests are carried out, where applicable.

The tripping current of the protective devices (e.g. fuses, automatic protective devices, etc.) to be used for the verification of electronic switches without incorporated temperature-limiting devices and without incorporated fuses shall be in relation with the rated current of protective device, specified by the manufacturer, intended to protect the electronic switch. The manufacturers should specify in their instruction sheets the information of the protective device which is intended to protect the electronic switch (see 8.8 of IEC 60669-1:1998).

Electronic switches without incorporated temperature-limiting devices and without incorporated fuses are loaded for 1 h with the conventional tripping current for the fuse which, in the installation, will protect the electronic switch.

Electronic switches protected by automatic protective devices (including fuses) are loaded in such a way that the current through the electronic switch is 0,95 times the current with which the protecting device releases after 1 h.

The temperature rise is measured after a steady state has been reached or after 4 h, whichever is the shorter time.

Electronic switches protected by incorporated fuses complying with IEC 60127 shall have those fuses replaced by links of negligible impedance and shall be loaded in such a manner that the current through the links shall be 2,1 times the rated current of the fuse.

The temperature rise is measured after the electronic switch has been loaded for 30 min.

Electronic switches protected both by enclosed fuses and by automatic protective devices are loaded either as described above with incorporated fuses or with another automatic protective device, choosing the test requiring the lower load.

Electronic switches protected by automatic protective devices which will short-circuit only in case of overload shall be tested both as electronic switches with automatic protective devices and as electronic switches without automatic protective devices.

If any of the tests specified above turn off the electronic switch before the temperature has been steady state, the following additional test shall be performed on a new set of specimens:

- The electronic switch shall be loaded to 1,1 times the rated current.
- The current is then increased by 10 % and then the temperature is allowed to stabilize. This is repeated until the conventional tripping current of the protective device is reached or the electronic switch is destroyed (no longer functioning properly or safety is impaired within the meaning of this standard).

101.2 Protection against electric shock is required, even though an electronic switch is being used or has been used during fault conditions.

Compliance is checked by carrying out the tests of clause 10 immediately following the test of 101.1.

101.3 Electronic switches shall, without endangering their surroundings, withstand the short circuits currents they may be subjected to in the load circuit.

Compliance is checked by the following test.

The electronic switch is mounted as in normal use. If additional boxes or enclosures are used they shall be tested in an enclosure complying with the relevant Part of the IEC 60670 series.

NOTE 1 In the following countries boxes and enclosures shall comply with both IEC 60670-1 and BS 4662: UK.

The electronic switch is tested in a substantially non-inductive circuit in series with a load impedance and a device for limiting the let-through I^2t .

The prospective short-circuit current of the supply shall be 1 500 A r.m.s. at a voltage equal to the rated voltage of the electronic switch under test.

The prospective let-through I^2t minimum value shall be 15 000 A²s.

NOTE 2 The prospective current is a current that would flow in the circuit if the electronic switch, the limitation device and the load impedance were replaced by links of negligible impedance without any other change in the circuit.

NOTE 3 The prospective I^2t value is a value that would be let through by the current limiting device if the electronic switch and the load impedance were replaced by links of negligible impedance. The I^2t value may be limited by using an open wire fuse, an ignitron or other suitable devices.

NOTE 4 The I^2t value of 15 000 A²s corresponds to an unfavourable let-through I^2t value of 16 A miniature circuit-breakers measured at 1 500 A prospective short-circuit current.

The diagram of the circuit in which the electronic switch is tested is shown in Figure 102.

The impedance Z_1 (short-circuit impedance) shall be adjusted to satisfy the specified prospective short-circuit current.

The impedance Z_2 (load impedance) shall be adjusted that the electronic switch is loaded with its minimum load or with approximately 10 % of the rated load, whichever is the higher.

NOTE 5 A load is necessary for the electronic switch to be in the on-state.

The circuit is calibrated with the following tolerances: current 0/+5 %, voltage 0/+10 %, frequency ± 5 %.

The automatic overcurrent protective device including fuses, if any, incorporated or not incorporated in the electronic switch, recommended by the manufacturer, is inserted into the circuit which is loaded. The variable control, if any, is set at the position of maximum output.

The short circuit is applied six times by the auxiliary switch A without any synchronization with respect to the voltage.

NOTE 6 Six tests are made in order to avoid the complication of point-on-wave timing.

During the test, emission of flames or burning particles, if any, shall not be dangerous to the environment.

The above requirement is fulfilled if during the test there are no emissions of flames or burning particles visible with normal or corrected vision without additional magnification.

If there is visible emission of flames or burning particles, the test shall be repeated on new specimens. Before repeating the test, a clear polyethylene film ($0,05 \pm 0,01$) mm thick, of a size at least 50 mm larger in each direction than the area where the flames or burning particles were seen, is fixed and reasonably stretched in a frame. The film is placed approximately perpendicular to the trajectory of the flame at a maximum distance of 10 mm from the surface of the product where the flame was emitted.

The film should have the following physical properties:

- Density at +23 °C ($0,915 \text{ g/cm}^2$ up to $0,935 \text{ g/cm}^2$);
- Melting point between +110 °C to +120 °C.

After the test

- accessible metal parts shall not be live (see Clause 10);
- emissions of flames or burning particles have not visibly perforated the film when examined by normal or corrected vision without additional magnification and the film shall be in one piece;
- the conductors, the flush mounting box and the mounting surface shall not show traces of burns. Traces which can be cleaned and do not prevent the further use of the cables or housing are ignored.

It is not necessary for the specimens to remain in operating condition. However, the contacts of any incorporated automatic protective device shall not be welded, unless the electronic switch is obviously useless.

After the short circuit test the specimen is re-energized in its normal operating position, incorporated fuses if any being replaced, and its behaviour is monitored for 4 hours. The specimen shall show no dangerous behaviour during this period such as smoke or excessive heat. In case of doubt the maximum temperature rise values given in table 102 shall not be exceeded.

The six tests may be carried out on the same specimen provided that, with the replacement of an incorporated fuse, the electronic switch is still capable of operation. Otherwise, new specimens shall be used until a total of six tests have been completed.

Moreover, the electronic switch shall withstand the dielectric strength test according to Clause 16 when the specimen has reached the temperature of the environment after the short-circuit test with the voltages prescribed in Clause 19. This test shall not be applied according to item 3 of Table 14.

Overcurrent protective devices which can be manually reset shall be switched on before the test.

101.4 For electronic RCS, Clause 101 of IEC 60669-2-2 applies.

For electronic TDS, Clause 101 of IEC 60669-2-3 applies.

101.5 Dimmers classified for incandescent and/or self ballasted lamps shall be so designed that no part shall reach such a temperature that there is danger of fire to the surroundings of the dimmer when non-dimmable self ballasted lamps are installed in the load circuit.

The tests are made on dimmers mounted and connected as specified in Clause 17.

The dimmer is loaded with a number of lamp simulation circuits as given in Figure 103 Load B providing the rated self ballasted lamp load of the dimmer. The simulation circuit represents a 25 W non dimmable self ballasted lamp.

In case of dimmers not classified for self ballasted lamps the dimmer is loaded with a number of lamp simulation circuits as given in Load B of Figure 103 having a total power equivalent to 1/5th of the declared incandescent lamp load.

For example, if an electronic switch has a calculated power of 110 W for self-ballasted lamps, then the electronic switch is loaded with 5 simulation circuits.

Where:

$$R1 = 4,4 \Omega \pm 5 \%$$

$$C = 14 \mu F \text{ capacitor}$$

R2 is adjusted to give a power of 25 W.

Compliance is checked by subjecting the electronic switches to a heating test. The test procedure is as specified in Clause 17 unless otherwise stated.

The setting is adjusted to a stable condition so that the maximum current peaks occur.

During the test, emission of flames or burning particles shall not occur and the temperature rises shall not exceed the values given in Table 102, column concerning Clause 101.

After the test, accessible metal parts shall not be live.

It is not necessary for the specimens to remain in operating condition. However, the contacts of any incorporated automatic protective device shall not be welded, unless the electronic switch is obviously useless.

102 Components

Components which, if they fail, may impair the safety of the electronic switch shall comply with the safety requirements specified in the relevant IEC standards as far as applicable.

If components are marked with their operating characteristics, the conditions under which they are used in the electronic switch shall be in accordance with these markings, unless a specific exception is made in this standard.

The testing of components which have to comply with other standards is, in general, carried out separately, according to the relevant standard, as follows.

If the component is marked and used in accordance with its marking, the number of specimens is that required by the relevant standard.

Where no IEC standard exists, or where the component is not marked or is not used in accordance with its marking, the component is tested under the conditions occurring in the electronic switch, the number of specimens being, in general, that required by the relevant standard.

Components incorporated in the electronic switch are subjected to all the tests of this standard as parts of the electronic switch.

102.1 Fuses

Fuses, if any, shall comply with IEC 60227 or other relevant IEC publications and have a rated breaking capacity of 1 500 A, unless any fault current through the fuse is limited to 35 A.

102.2 Capacitors

Capacitors,

- the short-circuiting or disconnection of which would cause an infringement of the requirements under fault conditions with regard to shock or fire hazard,
- the short-circuiting of which would cause a current of 0,5 A or more through the terminals of the capacitor,
- for suppression of electromagnetic interference,

shall comply with IEC 60384-14 and shall be in accordance with table 107.

NOTE Capacitors passing the damp heat steady-state test specified in 4.12 of that standard with a duration of not less than 21 days are considered acceptable

These capacitors shall be marked with their rated voltage in volts (V), their rated capacitance in microfarads (μ F) and their reference temperature in degrees Celsius ($^{\circ}$ C).

When determining the current, fuses and relevant capacitors are considered to be short-circuited.

For other protective devices, the resistive element is to be replaced by an equivalent impedance.

Table 107 – Capacitors

Application of capacitor	Approved type(s) of capacitor according to IEC 60384-14		
	$U_n \leq 125 \text{ V}$	$125 \text{ V} < U_n \leq 250 \text{ V}$	
		Without overcurrent protection	With overcurrent protection ^a
Between live conductors (L or N) and earth (PE)	Y4	Y2	Y2
Between live conductors (L and N or L1 and L2): <ul style="list-style-type: none"> – without impedance in series – with impedance in series, which, when capacitor(s) is (are) short-circuited, limits the current to a value of <ul style="list-style-type: none"> • 0,5 A and higher • below 0,5 A 	X2 X3 Any type	X1 X2 Any type	X2 X3 Any type

^a External to the capacitor or built into the capacitor (for example, a fusing resistor).

102.3 Resistors

Resistors, the short-circuiting or interruption of which would cause an infringement of the requirements with regard to the protection against fire and electric shock in case of a defect, shall have an adequately constant value under the overload conditions prevailing in the electronic switch.

These resistors shall comply with the requirements of 14.1 of IEC 60065, modified with regard to the reference temperature of the resistor in the electronic switch (see clause 17).

NOTE Additional requirements are under consideration for composite-type resistors.

102.4 Automatic protective devices (other than fuses)

Automatic protective devices shall be in compliance with IEC 60730, as far as that standard is applicable and with additional requirements specified in 102.4.1 for automatic protective devices which switch off the current (hereinafter called cut-outs) and in 102.4.2 for automatic protective devices which only decrease the current.

102.4.1 Cut-outs shall have adequate making and breaking capacity.

Compliance is checked by subjecting three specimens to the tests of 102.4.1.1 or 102.4.1.2.

If the cut-out in the electronic switch is subjected to a reference temperature above 55 °C, according to clause 17, the specimens are tested at this reference temperature.

During the test, the other conditions shall be similar to those occurring in the electronic switch.

During the test, no sustained arcing shall occur.

After the test, the specimens shall show no damage impairing their further use or the safety of the electronic switch.

The switching frequency of the cut-out may be increased above the normal switching frequency inherent to the electronic switch, provided that no greater risk of failure of the cut-out is induced.

If it is not possible to test the cut-out separately, it will be necessary to submit additional specimens of the electronic switch in which the cut-out is used.

102.4.1.1 Non-self-resetting cut-outs in the load circuit of the electronic switch are tested at 1,1 times the rated voltage of the electronic switch and with loads as specified below.

The cut-outs are reset after each operation and thus caused to operate 10 times successively.

- Cut-outs in electronic switches for incandescent lamps are tested in a non-inductive circuit and are loaded with 2,1 times the rated current of the protecting fuse (if this fuse is in accordance with IEC 60127) or with the relevant conventional fusing current for other fuses.
- For cut-outs in electronic switches for fluorescent lamps, tests shall be carried out in the same way as for electronic switches for incandescent lamps.
- Cut-outs in electronic switches for speed control circuits are subjected to two series of 10 operations.

In the first series, the cut-out under test closes a circuit through which a current of $9 I_n$ ($\cos \varphi = 0,8 \pm 0,05$) passes, this current being interrupted by means of an auxiliary switch 50 ms to 100 ms after each closure.

In the second series, the circuit through which a current of $6 I_n$ ($\cos \varphi = 0,6 \pm 0,05$) passes is closed by an auxiliary switch and opened by the cut-out under test.

NOTE 1 The values $6 I_n$ and $9 I_n$ are provisional.

NOTE 2 " I_n " is the rated current of the electronic switch. If the electronic switch has a rated load instead of a rated current, I_n is calculated under the assumption that $\cos \varphi$ of the load is 0,6.

102.4.1.2 Self-resetting cut-outs in the load circuit of the electronic switch are tested at 1,1 times the rated voltage of the electronic switch and with loads as specified below:

- cut-outs in electronic switches for incandescent lamps are operated automatically for 200 cycles in a non-inductive circuit and are loaded with 2,1 times the rated current of the protective fuse (if this fuse is in accordance with IEC 60127) or with the relevant conventional fusing current for other fuses.

NOTE For cut-outs in electronic switches for fluorescent lamps, tests are under consideration.

During the tests of 102.4.1, no sustained arcing shall occur.

After the tests of 102.4.1, the specimens shall show no damage impairing their further use or the safety of the electronic switch.

The cut-outs shall withstand for 1 min a test voltage between the open contacts, the voltage being

- for cut-outs in electronic switches for lighting circuits: 500 V;
- for cut-outs in electronic switches for speed control circuits: 1 200 V for rated voltages up to 130 V and 2 000 V for rated voltages above 130 V.

102.4.2 Automatic protective devices which only decrease current to the electronic switch are tested as follows.

The electronic switch is loaded for 4 h with a current as given in clause 17. At the end of this period, the load is increased by closing an auxiliary switch which increases the load so that the prospective current through the electronic switch will be 2,1 times the rated current of the protective fuse (if the fuse is in accordance with IEC 60127) or the relevant conventional tripping current for other fuses.

The auxiliary switch is closed for 30 min and then opened until the current through the electronic switch is stabilized to the original value, after which the auxiliary switch is closed again.

This procedure is repeated 10 times.

After this test, the device shall function correctly.

Compliance is checked by an additional test according to clause 17.

102.5 Transformers

Transformers intended for SELV circuits shall be of the safety isolating type and shall comply with the relevant requirements of IEC 61558-2-6.

NOTE For the use of SELV and PELV, see IEC 61140 and IEC 60364-4-41.

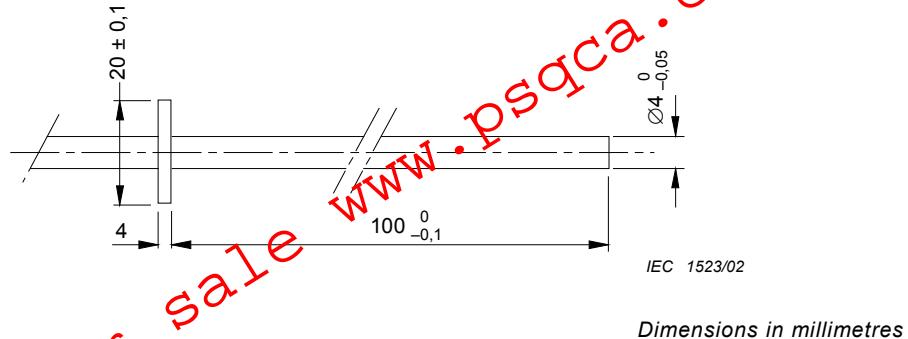
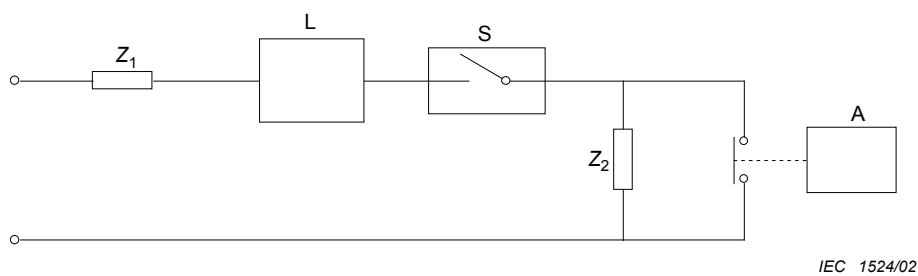


Figure 101 Test pin for checking the protection against electric shock



Components

- Z_1 impedance for adjusting the prospective short-circuit current (non-inductive)
- Z_2 impedance for adjusting the load current (non-inductive)
- L limiting device for the prospective let-through I^2t
- S specimen
- A auxiliary switch for causing the short circuit

Figure 102 – Circuit diagram for testing electronic switches according to 101.3

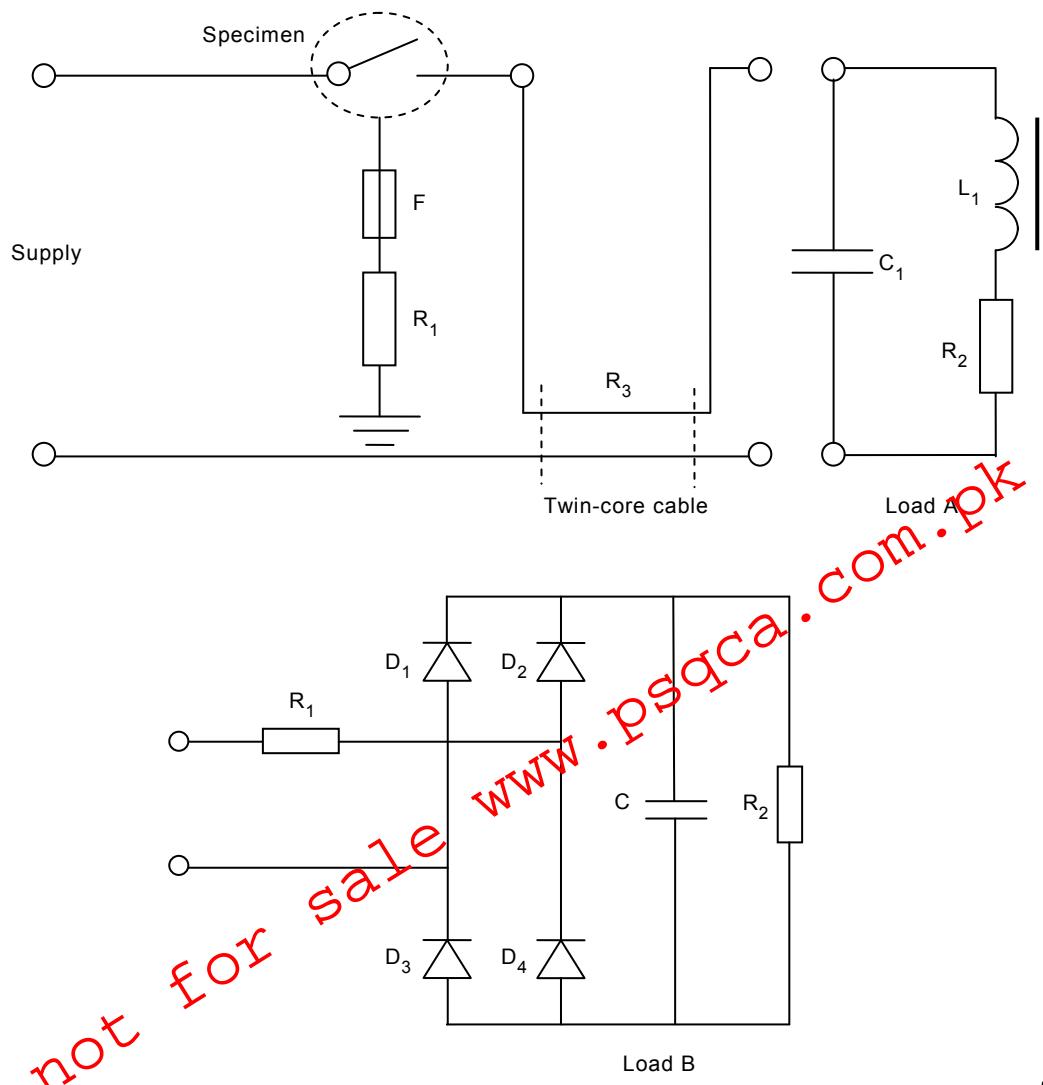


Figure 103 – Circuit diagrams for testing switches according to subclauses 19.102 and 19.109

IEC

Annex A
(normative)

Survey of specimens needed for tests

Annex A of part 1 applies.

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Annex B (normative)

Additional requirements for switches having facilities for the outlet and retention of flexible cables

Annex B of part 1 applies except as follows.

13 Constructional requirements

13.16 Addition after the first paragraph:

The cross-sectional area of external flexible cables connected between electronic switches and its associated control units and the like can be less if the current in the unit is limited by current limiting means. The minimum cross-sectional area is shown in Table B.1. Flexible cables shall comply with IEC 60245-4, code designation 60245 IEC 66, or IEC 60227-5, code designation 60227 IEC 53.

NOTE The requirement for the insulation of the cable is not applicable to flexible cables supplied at SELV.

Table B.1 – Maximum current and minimum cross-sectional area

Maximum current A	Minimum cross-sectional area mm ²
Up to and including 0,2	No requirements
Up to and including 6	0,75
Up to and including 10	1,0
Up to and including 16	1,5

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Annex AA
(informative)

Examples of types of electronic switches and their functions

Electronic switches*	Functions
Touch switch, etc.	Electronically operated semiconductor switching device
	Electronically operated mechanical switching device
Light dimmer, etc. Speed controller, etc.	Mechanically operated regulator with an electronic control circuit
	Electronically operated regulator with an electronic control circuit
Light dimmer, etc., with switch Speed controller, etc., with switch	Mechanically operated regulator with an electronic control circuit and a mechanical switching device
	Mechanically operated regulator with an electronic control circuit and an electronically operated mechanical switching device
	Mechanically operated regulator with an electronic control circuit and a semiconductor switching device
	Electronically operated regulator with an electronic control circuit and a semiconductor switching device
	Electronically operated regulator with an electronic control circuit and an electronically operated mechanical switching device
DLT control devices	Electronically operated controller with an electronic control circuit and a semiconductor switching device
Electronic switches incorporating heat or light sensors	Electronically operated semiconductor switching device
	Electronically operated mechanical switching device

* All electronic switches can be operated by auxiliary control circuits.

Annex BB (informative)

Circuit development: subclause 19.109 explained

BB.1 Rationale

Due to the phasing out of incandescent lamps and the replacement of these lamps by self ballasted lamps, a work was done by the Technical Committees concerned to address the technical consequences of this change.

One of the main impacts for electronic switches is the change in inrush currents when switching these energy efficient lamps in comparison to incandescent lamps. Especially electronic switches incorporating electromechanical contact mechanisms are affected (e.g. sticking of contacts).

The joint forum fixed the maximum values for one lamp. The source impedance Z_{mains} was added to be able to test the lamp. This will be covered by the lamp standards (e.g. IEC 60969).

Table BB.1 – Lamp

P	V _{mains}	I _{peak}	I ² t	Z _{mains}
[W]	[V _{rms}]			
P≤15	120	60	0,5	0,450 Ω + 100 μH
P≤15	230	20	0,08	0,2 Ω + 400 μH
15 < P ≤ 25	120	60	0,5	0,450 Ω + 100 μH
15 < P ≤ 25	230	35	0,15	0,2 Ω + 400 μH

The value of I_{peak} and I^2t represent the highest value that can occur at the moment the contact mechanism closes.

BB.2 I_{peak} and I²t for normal operation tests

Where subclause 19.102 is based on the principle to define an equivalent circuit which results in an I_{peak} and I^2t value, subclause 19.109 uses the values of I_{peak} and I^2t as the reference. The approach of subclause 19.109 has been preferred, as within testing environments it is not always possible to reach the ideal parameters of Z_{mains} . In this approach equivalent circuits can be adjusted to reach the required values within the tolerances given in the standard.

BB.3 Switching a single lamp

For the purpose of this test the lamp with a $P = 15 \text{ W}$ has been used. This load results in the higher I_{peak}/W ratio compared to the 25 W lamp and is used for Clause BB.4 when added to get higher loads.

The network impedance which is given in 19.102 is also used for 19.109. Table 108 gives in the first line the value of I_{peak} and I^2t when the lamp ($P < 15 \text{ W}$) from Table BB.1 is used in the network of subclause 19.102. As a result the I_{peak} and I^2t values are higher in Table 108.

For the calculation a prospective short circuit current of 3000 A was used which was considered adequate.

The R and C values of the equivalent circuit of the lamps in Figure BB.1 and Figure BB.2 are calculated from Table BB.1.

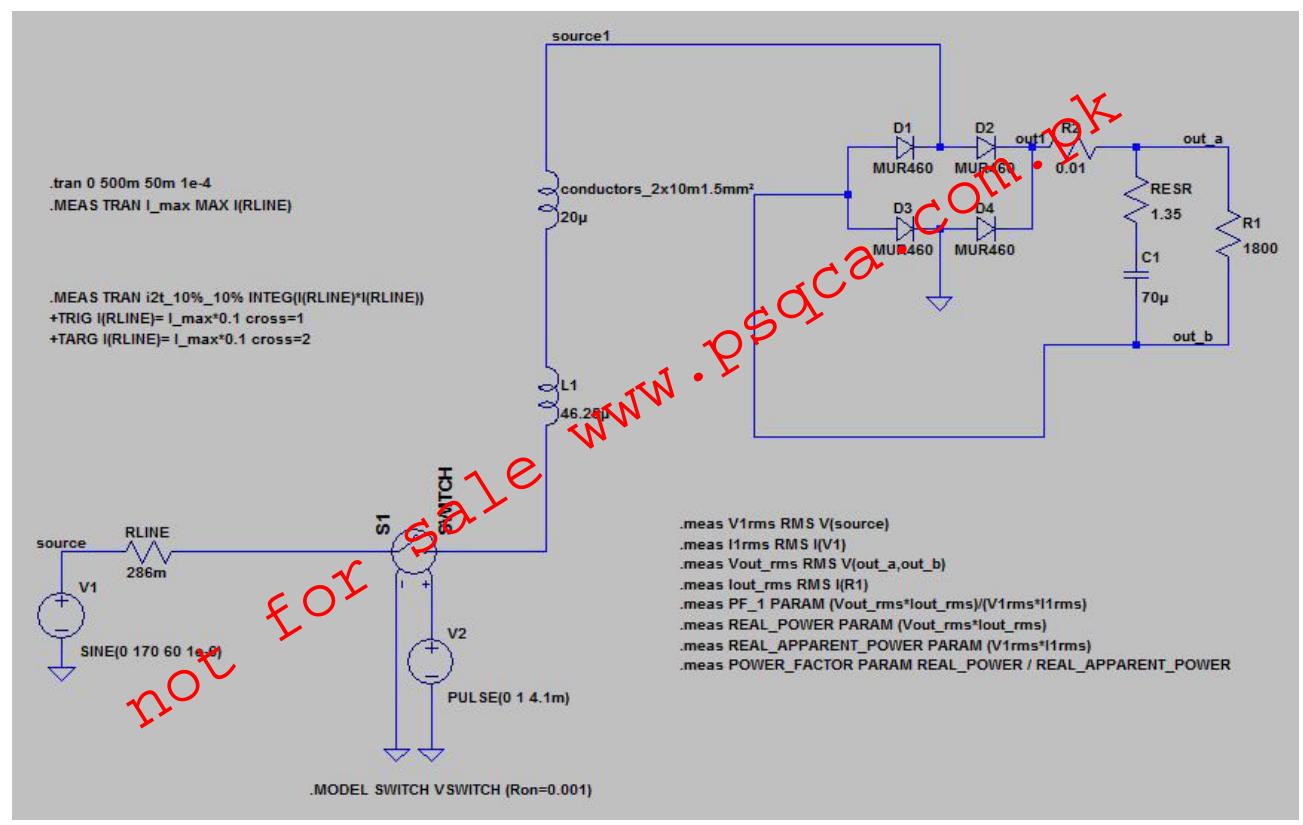
The Z_{mains} of these networks are:

b) 120 V; 60 Hz; $I_{\text{pscc}} = 3000 \text{ A}$; $\cos\phi = 0,9$:

$$0,036 \Omega + 46,25 \mu\text{H} + \text{cables } 0,25 \Omega + 20 \mu\text{H} = 0,286 \Omega + 66,25 \mu\text{H}$$

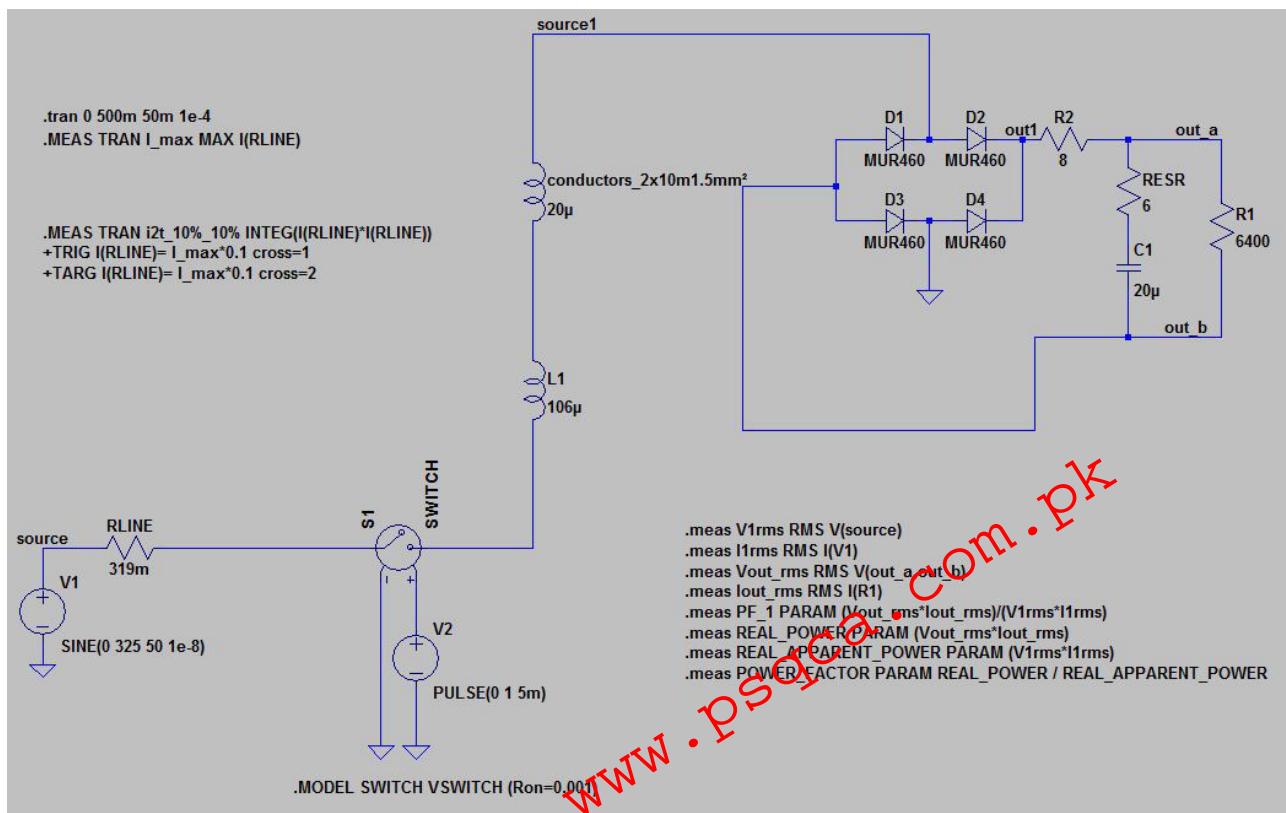
c) 230 V; 50 Hz; $I_{\text{pscc}} = 3000 \text{ A}$; $\cos\phi = 0,9$:

$$0,069 \Omega + 106 \mu\text{H} + \text{cables } 0,25 \Omega + 20 \mu\text{H} = 0,319 \Omega + 126 \mu\text{H}$$



NOTE R1 is not the R1 of Figure 103 and Table 109.

Figure BB1 – 120 V 15 W (LT spice model)



NOTE R1 is not the R1 of Figure 103 and Table 109.

Figure BB.2 – 230 V 15 W (LT spice model)

BB.4 Switching ~~multiple~~ lamps

~~Multiple lamp loads are obtained by combining single lamps with a power of 15 W.~~

The I_{peak} and I^2t values (see Figure BB.4) for multiple lamps are based on the following principles:

Up to 60 W (4 lamps) the worst conditions apply

- 15 W lamps which give the highest I_{peak} and I^2t value as given in Table BB.1
- The network impedance as given in Clause BB.3.

For higher power lamp loads:

- For every 3 additional lamps 3 m of cables have been added ($75 \text{ m}\Omega + 6 \mu\text{H}$)
- The bulk capacitor within each additional lamp uses the nominal value and not the worst case as given in Table BB.1.
- The values have been interpolated to fit the nominal values of Table 108.

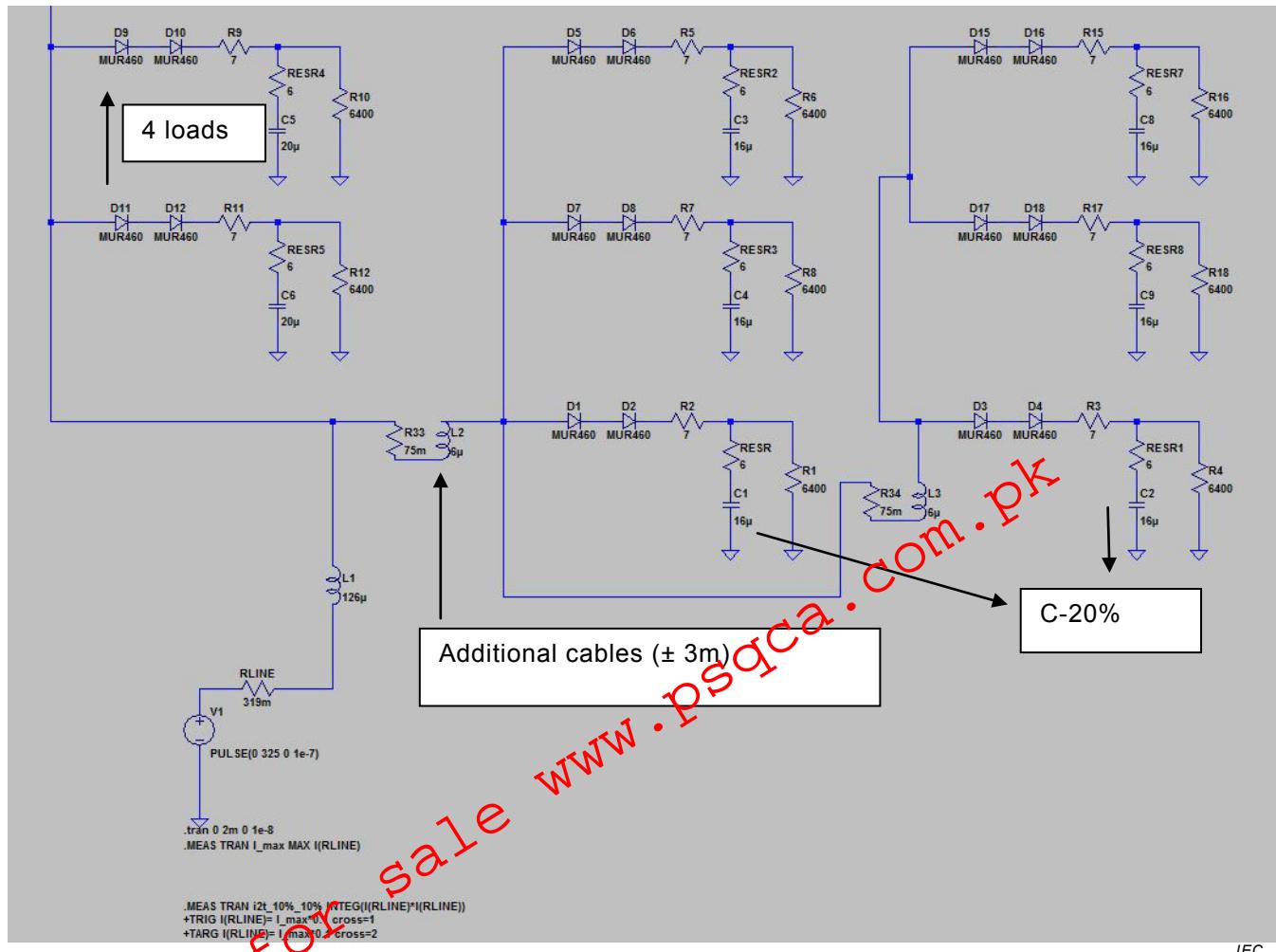


Figure BB.3 – Model for multiple lamp loads

Table 108 stops at 400 W because higher inrush currents would result in the tripping of circuit breakers.

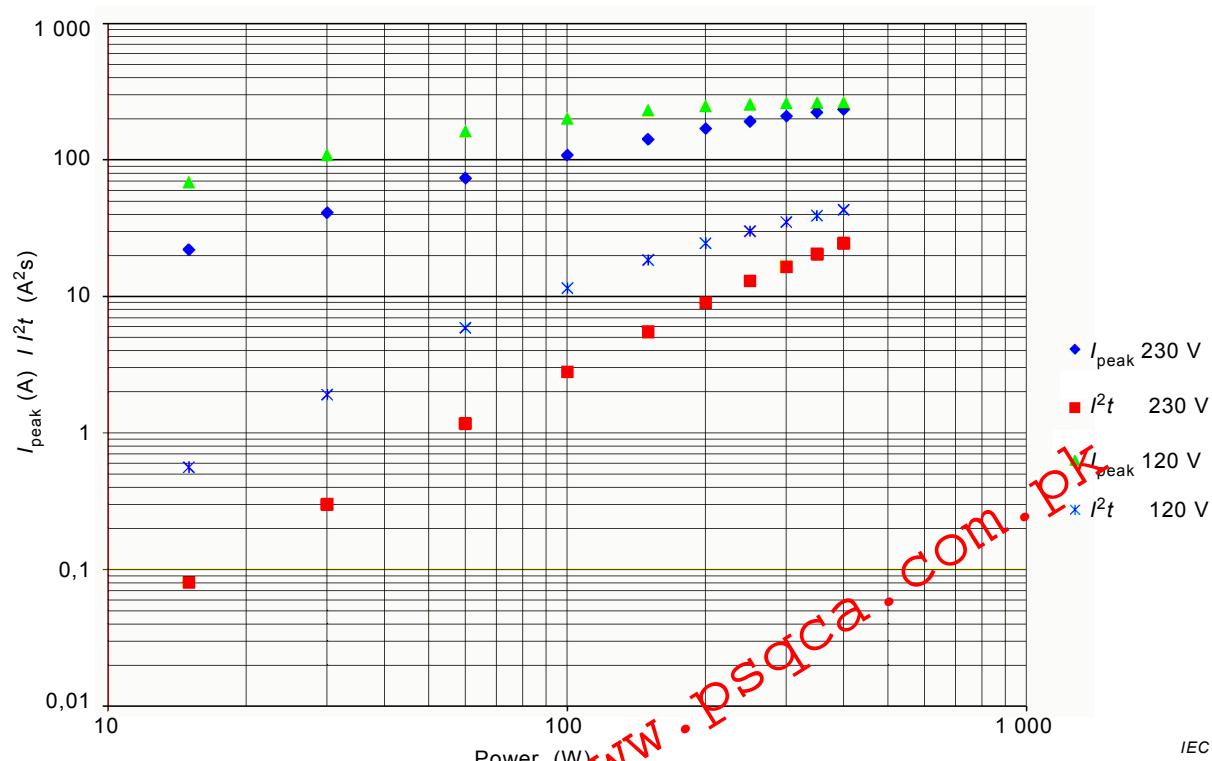


Figure BB.4 – I_{peak} and I^2t for multiple lamp loads

Annex CC (normative)

Additional requirements for electronic switches using DLT-technology according to IEC 62756-1

NOTE The clause numbering of this annex refers to the clauses of this standard IEC 60669-2-1.

CC.3 Definitions

Clause 3 applies *except as follows*.

Additional terms and definitions:

CC.3.101

DLT

Digital control of electronic lighting equipment by digital signals over the load side mains wiring

CC.3.102

DLT control device

Electronic switch, using DLT technology according to IEC 62756-1, that is connected to the interface and sends commands to at least one control gear

CC.8 Marking

Clause 8 applies *except as follows*.

CC.8.1 Add at the end:

In addition, the telegram types, supported by DLT control units, shall be marked on the control device. A complete explanation of the telegram types according to IEC 62756-1 shall be stated in the accompanying instruction sheet.

Add in a separate dash under the paragraph "In addition" following Note 3:

- The symbol for DLT control device

CC.8.2 Add after the line starting with "Terminal for regulated loads":

DLT control device with the letters DLT

Supported telegram types for DLT control devices TPx.

Add after the line starting with "Fluorescent lamps":

DLT controlled load DLT

CC.8.103 Replace in the first dash "at least one type of load" by "at least one type of loads except for DLT devices"

Add at the end of the subclause:

The maximum cable length between DLT control device and DLT load shall also be given in the instruction sheet.

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- 59 -

CC.17 Temperature rise

Clause 17 applies except as follows:

Replace the fourth paragraph after Note 1 by:

In lamp dimmers, DLT control devices and speed controllers, the setting is adjusted such that the highest temperature rise will occur.

Add before the tenth paragraph starting with "Other electronic equipment":

DLT control devices shall be tested with DLT loads, in accordance with the manufacturer instructions.

CC.19 Normal operation

Clause 19 applies except as follows.

Replace the first paragraph of 19.103 by:

CC.19.103 Semiconductor switching devices and/or electronic regulating devices including DLT control devices incorporated in electronic switches are subjected to the following tests.

Add after the Note:

For DLT control devices, a cable, having the maximum cable length, as declared in 8.3, is installed between the control device and the loads.

CC.26 EMC requirements

Clause 26 applies except as follows.

CC.26.2 Emission

CC.26.2.1 Low-frequency emission

Add at the end:

DLT control devices shall be tested with maximum resistive load.

NOTE 3 As soon as IEC 61000-3-2 covers this principle, this requirement is obsolete.