

BS EN 60947-4-3:2014



BSI Standards Publication

Low-voltage switchgear and controlgear

Part 4-3: Contactors and motor-starters —
AC semiconductor controllers and
contactors for non-motor loads

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National foreword

This British Standard is the UK implementation of EN 60947-4-3:2014. It is identical to IEC 60947-4-3:2014. It supersedes BS EN 60947-4-3:2000+A2:2011 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee PEL/17, Switchgear, controlgear, and HV-LV co-ordination, to Subcommittee PEL/17/2, Low voltage switchgear and controlgear.

A list of organizations represented on this committee can be obtained on request to its secretary.

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(IEC 60947-4-3:2014)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 121A/2/FDIS, future edition 2 of IEC 60947-4-3, prepared by SC 17B "Low-voltage switchgear and controlgear" of IEC/TC 17 "Switchgear and controlgear" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60947-4-3:2014.

The following dates are fixed:

- latest date by which the document has to be (dop) 2015-03-11
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standard or by endorsement
- latest date by which the national (dow) 2017-06-11
standards conflicting with the
document have to be withdrawn

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of EU Directive 2004/108/EC.

For relationship with EU Directive(s), see informative Annex ZZ, which is an integral part of this document.

This document supersedes EN 60947-4-3:2000.

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This standard covers the Principle Elements of the Safety Objectives for Electrical Equipment Designed for Use within Certain Voltage Limits (LVD - 2006/95/EC).

Endorsement notice

The text of the International Standard IEC 60947-4-3:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60085:2007	NOTE	Harmonized as EN 60085:2008 (modified).
IEC 60146 (series)	NOTE	Harmonized as EN 60146 (series) (not modified).
IEC 60664 (series)	NOTE	Harmonized as EN 60664 (series) (not modified).
IEC 60947-4-2:2011	NOTE	Harmonized as EN 60947-4-2:2012 (modified).
IEC 61439 (series)	NOTE	Harmonized as EN 61439 (series) (not modified).

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60269-1	2006	Low-voltage fuses -- Part 1: General requirements	EN 60269-1	2007
IEC 60410	1973	Sampling plans and procedures for inspection by attributes	-	-
IEC 60947-1	2007	Low-voltage switchgear and controlgear -- Part 1: General rules	EN 60947-1	2007
+A1	2010		+A1	2011
IEC 61000-4 (series)	-	Electromagnetic compatibility (EMC) -- Part 4-1: Testing and measurement techniques (series) - Overview of IEC 61000-4 series	EN 61000-4	-
IEC 61000-4-5	2005	Electromagnetic compatibility (EMC) -- Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	2006
CISPR 11 (mod)	2009	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement	EN 55011	2009
CISPR 11:2009/A1	2010		EN 55011:2009/A1	2010

Annex ZZ (informative)

Coverage of Essential Requirements of EU Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers protection requirements of Annex I Article 1 of the EU Directive 2004/108/EC.

Compliance with this standard provides presumption of conformity with the specified essential requirements of the Directives concerned.

NOTE: Other requirements and other EU Directives may be applicable to the products falling within the scope of this standard.

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INTRODUCTION

This part of IEC 60947 covers low-voltage a.c. semiconductor controllers and contactors (solid-state contactors) intended for the use with non-motor loads. As controllers, they have many capabilities beyond the simple switching on and off of non-motor loads. As contactors, they perform the same functions as mechanical contactors, but utilize one or more semiconductor switching devices in their main poles.

The devices may be single-pole or multi-pole (see 2.3.1 of IEC 60947-1:2007,). This standard refers to complete devices rated as a unit incorporating all necessary heat-sinking material and terminals. It includes devices with all necessary terminals, which are supplied with or without heat-sink in knocked-down form for combination by the users, when the manufacturer gives with the device detailed information about choosing the heat-sink and mounting the device on the heat-sink.

The generic term, "controller", is used in this standard wherever the unique features of the power semiconductor switching elements are the most significant points of interest. The generic term "contactor" is used in this standard wherever the feature of simple switching on and off is the most significant point of interest. Specific designations (for example, form 4, form HxB, etc.) are used wherever the unique features of various configurations comprise significant points of interest.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 4-3: Contactors and motor-starters – AC semiconductor controllers and contactors for non-motor loads

1 Scope

This part of IEC 60947 applies to a.c. semiconductor non-motor load controllers and contactors intended for performing electrical operations by changing the state of a.c. electric circuits between the ON-state and the OFF-state. Typical applications are classified by utilization categories given in Table 2.

As controllers, they may be used to reduce the amplitude of the r.m.s. a.c. voltage on the load terminals from that of the applied voltage – either continuously or for a specified period of time. The half-wave period of the a.c. wave form remains unchanged from that of the applied voltage.

They may include a series mechanical switching device and are intended to be connected to circuits, the rated voltage of which does not exceed 1 000 V a.c.

This standard characterizes controllers and contactors for use with or without bypass switching devices.

The semiconductor controllers and contactors dealt with in this standard are not normally intended to interrupt short-circuit currents. Therefore, suitable short-circuit protection (see 8.2.5) should form part of the installation but not necessarily of the controller itself.

In this context, this standard gives requirements for semiconductor controllers and contactors associated with separate short-circuit protective devices.

This standard does not apply to:

- operation of a.c. and d.c. motors;
- low-voltage a.c. semiconductor motor controllers and starters covered by IEC 60947-4-2;
- electronic a.c. power controllers covered by the IEC 60146 series;
- all-or-nothing solid-state relays.

Contactors and control-circuit devices used in semiconductor controllers and contactors should comply with the requirements of their relevant product standard. Where mechanical switching devices are used, they should meet the requirements of their own IEC product standard and the additional requirements of this standard.

The object of this standard is to state

- a) the characteristics of semiconductor controllers and contactors and associated equipment;
- b) the conditions with which semiconductor controllers and contactors should comply with reference to:
 - their operation and behaviour;
 - their dielectric properties;
 - the degrees of protection provided by their enclosures, where applicable;

- their construction;
- c) the tests intended for confirming that these conditions have been met, and the methods to be adopted for these tests;
- d) the information to be given with the equipment or in the manufacturer's literature.

2 Normative references

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

IEC 60269-1:2006, *Low-voltage fuses – Part 1: General requirements*

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*
Amendment 1:2010

IEC 61000-4 (all parts), *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques*

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

CISPR 11:2009, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*
Amendment 1:2010

3 Terms, definitions, symbols and abbreviations

For the purposes of this document, the terms and definitions given in Clause 2 of IEC 60947-1:2007, Amendment 1 (2010), as well as the following additional terms and definitions apply:

	Reference
A	
AC semiconductor controller	3.1.1.1
B	
Bypassed controller	3.1.24
C	
Current-limit function	3.1.3
D	
Defined-point switching (of a semiconductor controller)	3.1.14.4.1
F	
Full-on (state of controllers)	3.1.10
H	
Hybrid controllers or contactors, form HxA (where $x = 4$ or 5)	3.1.2.1
Hybrid controllers or contactors, form HxB	3.1.2.2
I	
Instantaneous switching function	3.1.14.3
L	
Load control	3.1.4
M	

Minimum load current	3.1.11
Minimum load current detection	3.1.11.1
O	
OFF-state	3.1.12
OFF-state leakage current	3.1.13
OFF-time	3.1.23
ON-state	3.1.9
ON-time	3.1.22
OPEN position	3.1.2.3
Operating capability	3.1.16
Operating cycle (of a controller)	3.1.15
Operation (of a controller)	3.1.14
Overcurrent protective means OCPM	3.1.21
Overload current profile	3.1.17
R	
Ramp-down	3.1.6
Ramp-up	3.1.5
Random point switching (of a semiconductor controller)	3.1.14.4.3
Rating index	3.1.18
S	
Semiconductor controller (form 4)	3.1.1.1.1
Semiconductor direct-on-line (DOL) controller (form 5)	3.1.1.1.3
Switching function	3.1.14.1
Switching point	3.1.14.4
T	
Trip-free controller	3.1.20
Tripping operation (of a controller)	3.1.19
Z	
Zero-point switching (of a semiconductor controller)	3.1.14.4.2

3.1 Terms and definitions concerning a.c. semiconductor (non-motor-load) control devices

3.1.1 AC semiconductor controllers and contactors (solid-state contactors) (see Figure 1)

3.1.1.1

a.c. semiconductor controller

semiconductor switching device that provides a switching function for an a.c. electrical load (non-motor load) and an OFF-state

Note 1 to entry: Because dangerous levels of leakage currents (see 3.1.13) can exist in a semiconductor controller in the OFF-state, the load terminals should be considered to be live at all times.

Note 2 to entry: In a circuit where the current passes through zero (alternately or otherwise), the effect of "not making" the current following such a zero value is equivalent to breaking the current.

Note 3 to entry: See 2.2.3 of IEC 60947-1:2007 for the definition of semiconductor switching device.

3.1.1.1.1

semiconductor controller (form 4)

a.c. semiconductor controller in which the switching function may comprise any method specified by the manufacturer. It provides control functions which may include any combination of ramp-up, load control or ramp-down. A full-on state may also be provided

3.1.1.1.2

Vacant

3.1.1.1.3**semiconductor direct-on-line controller** (form 5)**semiconductor DOL controller** (form 5)

special form of a.c. semiconductor controller in which the switching function is limited to the full-voltage, unramped method only and where the additional control function is limited to providing FULL-ON (also known as a semiconductor contactor or solid-state contactor)

Note 1 to entry: It is a device (see 2.2.13 of IEC 60947-1:2007) which performs the function of a contactor by utilizing a semiconductor switching device (see 2.2.3 of IEC 60947-1:2007). It has only one position of rest (OFF-state or Open state in the case of an HxB hybrid controller) and is operated by the application of a control signal. It is capable of carrying load currents as well as changing the state of the said load (electrical circuit) between the FULL-ON and the OFF-states (Open) under normal circuit conditions including operating overload conditions.

3.1.1.2

Vacant

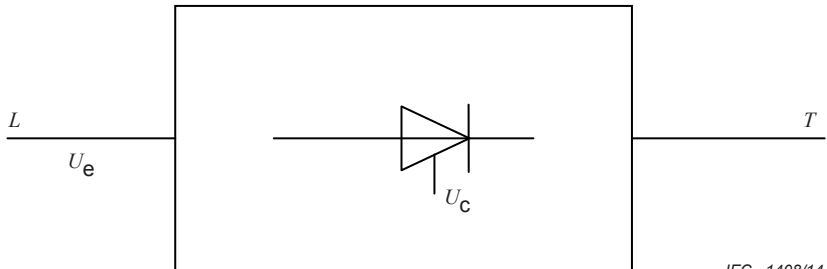
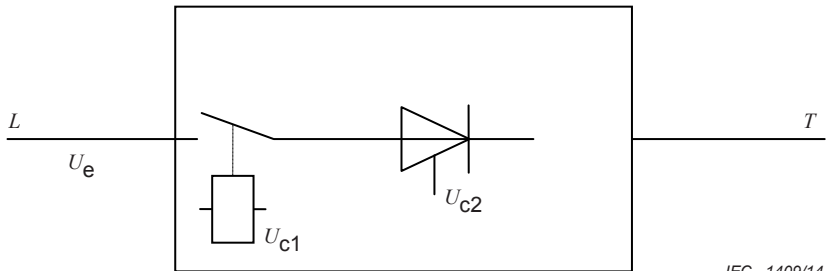
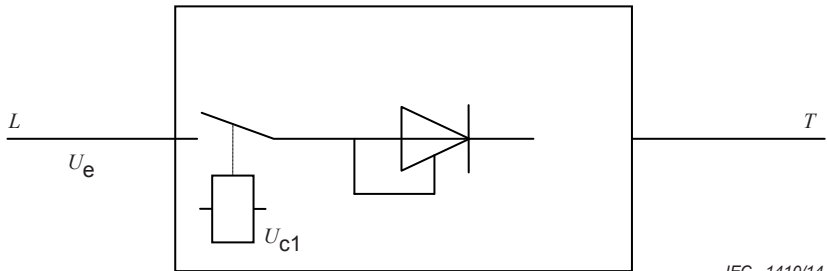
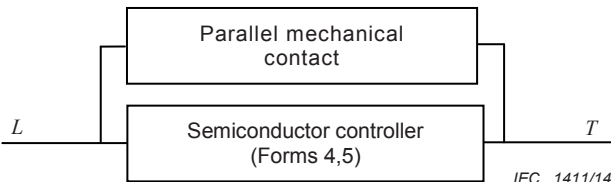
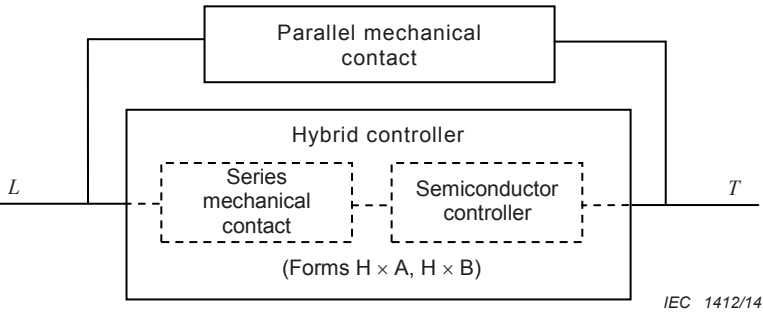
Device	
Controller (all forms)	 IEC 1408/14
Hybrid controller HxA ^a where x = 4 or 5	 IEC 1409/14
Hybrid controller HxB ^b where x = 4 or 5	 IEC 1410/14
Bypassed controller	 IEC 1411/14
Bypassed hybrid controller ^c	 IEC 1412/14
^a Two separate controls for the controller and the series mechanical switching device respectively. ^b One control only for the series mechanical switching device. ^c For other configurations, tests can be suitably adapted by agreement between the user and the manufacturer.	

Figure 1 – Graphical possibilities of controllers

Table 1 – Functional possibilities of controllers and contactors

Device	Form 4	Form 5
Semiconductor controller	OFF-state Ramp-up Load control FULL-ON state Ramp-down	Not available
Semiconductor DOL contactor	Not available	OFF-state Switch-on function FULL-ON state
Hybrid controller H _x A ^a where $x = 4$ or 5	H4A: – open state – OFF-state – ramp-up – load control – FULL-ON state – ramp-down	H5A: – open state – OFF-state – switch-on function – FULL-ON state
Hybrid controller H _x B ^b where $x = 4$ or 5	H4B: – open state – ramp-up – load control – FULL-ON state – ramp-down	H5B: – open state – switch-on function – FULL-ON state
^a Two separate controls for the controller and the series mechanical switching device, respectively. ^b One control only for the series mechanical switching device.		

3.1.2 Hybrid controllers and contactors (see Figure 1)

3.1.2.1

hybrid controllers form H_xA (where $x = 4$ or 5)

hybrid contactors form H_xA (where $x = 4$ or 5)

form 4, or form 5 semiconductor controller in series with a mechanical switching device all rated as a unit

Note 1 to entry: Separate control commands are provided for the series mechanical switching device and the semiconductor controller or contactor. All the control functions appropriate to the form of controller specified are provided together with an OPEN position.

3.1.2.2

hybrid controllers form H_xB (where $x = 4$ or 5)

hybrid contactors form H_xB (where $x = 4$ or 5)

form 4 or form 5 semiconductor controller in series with a mechanical switching device all rated as a unit

Note 1 to entry: A single control command is provided for both the series mechanical switching device and the semiconductor controller or contactor. All the control functions appropriate to the form of controller specified are provided with the exception of an OFF-state.

3.1.2.3

OPEN position

condition of a hybrid semiconductor controller when the series mechanical switching device is in the OPEN position

Note 1 to entry: See 2.4.21 of IEC 60947-1:2007 for the definition of open position.

3.1.3

current-limit function

ability of the controller to limit the load current to a specified value

Note 1 to entry: It does not include the ability to limit the instantaneous current under conditions of short circuit.

3.1.4

load control

any deliberate operation which causes changes in the effective power available to the load through variation of either

- an imposed operating cycle (i.e. variation of the cyclic duration factor F and/or the number of operating cycles per hour S , see 5.3.4.6)
or
- the load terminal voltage (for example, through phase-angle control)
or
- a combination of these

Note 1 to entry: Switch-on is a mandatory form of load control that is recognized separately.

Note 2 to entry: Load control can be performed by a form 5 controller, if an external switching device or control circuit causes the cyclic transition from the OFF-state to the FULL-ON state and back again (i.e. load control by operating cycle).

3.1.5

ramp-up

switching (switch-on) function which causes the transition from the OFF-state (or from the open state, in the case of a HxB hybrid controller) to the ON-state (i.e. to the FULL-ON state or to a load control operation) over a defined period of time (the ramp-up time)

3.1.6

ramp-down

switching (switch-off) function which causes the transition from the ON-state (i.e. either from FULL-ON or from a load control operation) to the OFF-state (or the open state, in the case of an HxB hybrid controller) over a defined period of time (ramp-down time)

3.1.7

Vacant

3.1.8

Vacant

3.1.9

ON-state

condition of a semiconductor controller when the conduction current can flow through its main circuit

3.1.10

FULL-ON

condition of a controller when the controlling functions are set to provide normal full-voltage excitation to the load

3.1.11

minimum load current

minimum operational current in the main circuit which is necessary for correct action of a controller in the ON-state

Note 1 to entry: The minimum load current should be given as the r.m.s. value.

3.1.11.1

minimum load current detection

ability of the controller to detect and signal that the load current is below a specified minimum value, for which signalling can be achieved by the OFF or open states

3.1.12

OFF-state

condition of a controller when no control signal is applied and no current exceeding the OFF-state leakage current flows through the main circuit

3.1.13

OFF-state leakage current

I_L

current which flows through the main circuit of a semiconductor contactor in the OFF-state

3.1.14

operation of a controller

operation of a controller

transition from the ON-state to the OFF-state or the reverse

3.1.14.1

switching function

function designed to make or break the current during the operation of a controller

3.1.14.2

Vacant

3.1.14.3

instantaneous switching function

switching function which causes the instantaneous transition from the ON-state (i.e. either from FULL-ON or from a load control operation) to the OFF-state (or the open state, in the case of an HxB hybrid controller) or vice versa

Note 1 to entry: In the case of switch-off, the term "instantaneous" is used to mean the minimum opening time (see 2.5.39 of IEC 60947-1:2007).

Note 2 to entry: In the case of switch-on, the term "instantaneous" is used to mean make time (see 2.5.43 of IEC 60947-1:2007) plus the transient time determined only by external circuit impedance.

3.1.14.4

switching point

point on the wave form of the applied voltage at which the semiconductor switching device becomes conductive during a switch-on operation

Note 1 to entry: Applied voltage is defined in 2.5.32 of IEC 60947-1:2007.

3.1.14.4.1

defined-point switching

defined-point switching of a semiconductor controller

ability of a semiconductor controller to permit the flow of current through the main circuit only as from the instant the a.c. applied voltage or alternatively the a.c. control circuit voltage reaches a specified point on its wave form

Note 1 to entry: Applied voltage is defined in 2.5.32 of IEC 60947-1:2007.

Note 2 to entry: This form of optimized switching may be used for rush-current damping or the "soft switching" of transformers.

3.1.14.4.2**zero-point switching****zero-point switching of a semiconductor controller**

special form of defined point switching applicable only in the case of single pole semiconductor controllers for non-motor loads

Note 1 to entry: The transition from the OFF-state to the ON-state after application of the control signal in such a way, that the semiconductor switching device becomes conductive at the instant a.c. applied voltage passes through zero

Note 2 to entry: Applied voltage is defined in 2.5.32 of IEC 60947-1:2007.

Note 3 to entry: This type of operation is particularly suitable for resistive and incandescent light loads. It should not be used for inductive or capacitive loads since the angular displacement between load current and driving voltage in these loads would cause severe transient current peaks.

3.1.14.4.3**random point switching****random point switching of a semiconductor controller**

absence of the ability of a semiconductor controller to permit the flow of current through the main circuit only as from the instant the a.c. applied voltage or alternatively the a.c. control circuit voltage reaches a specified point on its wave form

Note 1 to entry: Applied voltage is defined in 2.5.32 of IEC 60947-1:2007.

3.1.15**operating cycle****operating cycle of a controller**

succession of operations from one state to the other and back to the first state

Note 1 to entry: A succession of operations not forming an operating cycle is referred to as an operating series.

3.1.16**operating capability**

under prescribed conditions, ability to perform a series of operating cycles without failure

3.1.17**overload current profile**

current-time coordinate specifying the requirement to accommodate overload currents for a period of time (see 5.3.5.1)

3.1.18**rating index**

rating information organized in a prescribed format unifying rated operational current and the corresponding utilization category, overload current profile, and the duty cycle or OFF-time (see 6.1 e))

3.1.19**tripping operation****tripping operation of a controller**

operation to establish and maintain an OFF-state (or open position in the case of a form HxB controller) initiated by a control signal

3.1.20**trip-free controller**

controller which establishes and sustains an OFF-state condition which cannot be overridden in the presence of a trip condition

Note 1 to entry: In the case of form HxB, the term "OFF-state condition" is replaced by the term "OPEN position".

3.1.21**overcurrent protective means
OCPM**

means that cause a switching device to revert to the OFF-state or open position with or without time-delay when the current exceeds a predetermined value

3.1.22**ON-time**

period of time during which the controller is on-load

Note 1 to entry: For example as in Figure F.1.

3.1.23**OFF-time**

period of time during which the controller is off-load

Note 1 to entry: For example as in Figure F.1.

3.1.24**bypassed controller**

equipment wherein the main circuit contacts of a mechanical switching device are connected in parallel with the main circuit terminals of a semiconductor switching device, and wherein the operating means of the two switching devices are co-ordinated

3.2 Vacant**3.3 Symbols and abbreviations**

A_f	Final ambient temperature (9.3.3.3.4)
C_f	Final case temperature (9.3.3.3.4)
EMC	Electromagnetic compatibility
EUT	Equipment under test
I_c	Current made and broken (Table 10)
I_e	Rated operational current (5.3.2.3)
I_F	Leakage current after the blocking and commutating capability test (9.3.3.6.4)
I_L	OFF-state leakage current (3.1.13)
I_o	Leakage current before the blocking and commutating capability test (9.3.3.6.4)
I_{th}	Conventional free air thermal current (5.3.2.1)
I_{the}	Conventional enclosed thermal current (5.3.2.2)
I_u	Rated uninterrupted current (5.3.2.4)
SCPD	Short-circuit protective device
U_c	Rated control circuit voltage (5.5)
U_e	Rated operational voltage (5.3.1.1)
U_i	Rated insulation voltage (5.3.1.2)
U_{imp}	Rated impulse withstand voltage (5.3.1.3)
U_r	Power frequency recovery voltage (Table 8)
U_s	Rated control supply voltage (5.5)

4 Classification

All data which could be used as criteria for classification is given in 5.2.

5 Characteristics of a.c. semiconductor controllers and contactors

5.1 Summary of characteristics

The characteristics of controllers and contactors shall be stated in the following terms, where such terms are applicable:

- type of equipment (see 5.2);
- rated and limiting values for main circuits (see 5.3);
- utilization category (see 5.4);
- control circuits (see 5.5);
- auxiliary circuits (see 5.6);
- types and characteristics of relays and releases (under consideration);
- coordination with short-circuit protective devices (see 5.8).

5.2 Type of equipment

The following shall be stated.

a) Form of equipment

Forms of controllers and contactors (see 3.1.1 and 3.1.2).

b) Number of poles

- 1) Number of main poles
- 2) Number of main poles where the operation is controlled by a semiconductor switching element

c) Kind of current

AC only.

d) Interrupting medium (air, vacuum, etc.)

Applicable only to mechanical switching devices of hybrid controllers and contactors.

e) Operating conditions of the equipment

1) Method of operation

For example:

- symmetrically controlled controller (such as semiconductor with fully controlled phases);
- non-symmetrically controlled controller (such as thyristors and diodes).

2) Method of control

For example:

- automatic (by pilot switch or sequence control);
- non-automatic (that is push-buttons);
- semi-automatic (that is partly automatic, partly non-automatic).

3) Method of connecting

For example (see Figure 2):

- load in star, thyristors connected between load and supply;

- load in delta, thyristors connected between load and supply;
- single-phase load, thyristors connected between load and supply.

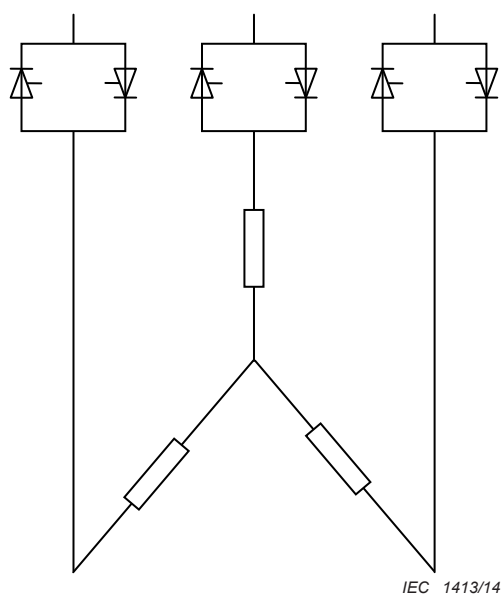


Figure 2a – Load in star Thyristors between load and supply

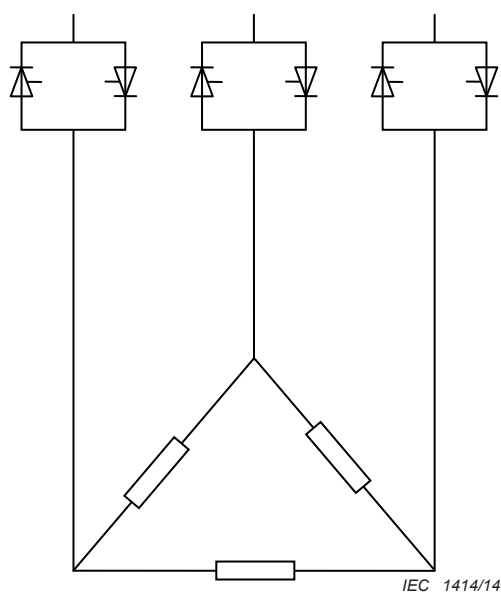


Figure 2b – Load in delta Thyristors between load and supply

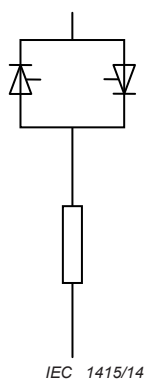


Figure 2c – Single-phase load Thyristors between load and supply

Figure 2 – Methods of connecting

5.3 Rated and limiting values for main circuits

The rated and limiting values established for controllers and contactors shall be stated in accordance with 5.3.1 to 5.3.6, but it may not be necessary to establish all applicable values by tests.

5.3.1 Rated voltages

A controller or a contactor is defined by the following rated voltages.

5.3.1.1 Rated operational voltage (U_e)

Subclause 4.3.1.1 of IEC 60947-1:2007 applies with the following addition.

The rating of a.c. equipment shall include the number of phases except that the rating of equipment obviously intended for single-phase use only is not required to include the number of phases.

5.3.1.2 Rated insulation voltage (U_i)

Subclause 4.3.1.2 of IEC 60947-1:2007 applies.

5.3.1.3 Rated impulse withstand voltage (U_{imp})

Subclause 4.3.1.3 of IEC 60947-1:2007 applies.

5.3.2 Currents

A controller or a contactor is defined by the following currents.

5.3.2.1 Conventional free air thermal current (I_{th})

Subclause 4.3.2.1 of IEC 60947-1:2007 applies.

5.3.2.2 Conventional enclosed thermal current (I_{the})

Subclause 4.3.2.2 of IEC 60947-1:2007 applies.

5.3.2.3 Rated operational current (I_e)

The rated operational current, I_e , of controllers and contactors is the normal operating current when the device is in the FULL-ON state and takes into account the rated operational voltage (see 5.3.1.1), the rated frequency (see 5.3.3), the rated duty (see 5.3.4), the utilization category (see 5.4), the overload characteristics (see 5.3.5) and the type of protective enclosure, if any.

5.3.2.4 Rated uninterrupted current (I_u)

Subclause 4.3.2.4 of IEC 60947-1:2007 applies.

5.3.3 Rated frequency

Subclause 4.3.3 of IEC 60947-1:2007 applies.

5.3.4 Rated duty

The rated duties considered as normal are as follows.

5.3.4.1 Eight-hour duty

A duty in which the controller remains in the FULL-ON state while carrying a steady current long enough for the equipment to reach thermal equilibrium but not for more than 8 h, without interruption.

5.3.4.2 Uninterrupted duty

A duty in which the controller remains in the FULL-ON state while carrying a steady current without interruption for periods of more than 8 h (weeks, months, or even years).

5.3.4.3 Intermittent periodic duty or intermittent duty

Subclause 4.3.4.3 of IEC 60947-1:2007 applies except that the first paragraph is changed to read:

"A duty with on-load periods in which the controller remains in the FULL-ON state (or load control state), having a definite relation to off-load periods, both periods being too short to allow the equipment to reach thermal equilibrium."

5.3.4.4 Temporary duty

Duty in which the semiconductor controller remains in the FULL-ON state (or load control state) for periods of time insufficient to allow the equipment to reach thermal equilibrium, the current-carrying periods being separated by no-load periods of sufficient duration to restore equality of temperature with the cooling medium. Standard values of temporary duty are:

30 s, 1 min, 3 min, 10 min, 30 min, 60 min and 90 min.

5.3.4.5 Periodic duty

Subclause 4.3.4.5 of IEC 60947-1:2007 applies.

5.3.4.6 Duty cycle values and symbols

For the purpose of this standard, the duty cycle is expressed by two symbols, F and S . This describes the duty and also sets the time that must be allowed for cooling.

F is the ratio of the on-load period to the total period, expressed as a percentage.

The preferred values of F are:

$F = 1 \%, 5 \%, 15 \%, 25 \%, 40 \%, 50 \%, 60 \%, 70 \%, 80 \%, 90 \%, 99 \%$.

S is the number of operating cycles per hour. The preferred values of S are:

$S = 1, 2, 3, 4, 5, 6, 10, 20, 30, 40, 50, 60$ operating cycles per hour.

NOTE Other values of F and/or S can be declared by the manufacturer.

5.3.5 Normal load and overload characteristics

Subclause 4.3.5 of IEC 60947-1:2007 applies with the following additions.

5.3.5.1 Overload current profile

The overload current profile gives the current/time coordinates for the controlled overload current. It is expressed by two symbols, X and T_X .