

Low-voltage switchgear and controlgear —

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

ICS 29.130.20

National foreword

This British Standard is the UK implementation of EN 60947-4-3:2000+A2:2011. It is identical to IEC 60947-4-3:1999, incorporating amendments 1:2006 and 2:2011. It supersedes BS EN 60947-4-3:2000 which will be withdrawn on 18 April 2014.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated in the text by **A1** **A1**.

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 PEL/17/2 can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for their correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Amendments/corrigenda issued since publication

Date	Comments
28 February 2007	Implementation of IEC amendment 1:2006 and its CENELEC endorsement A1:2006
30 November 2011	Implementation of IEC amendment 2:2011 and its CENELEC endorsement A2:2011.

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**Low-voltage switchgear and controlgear -
Part 4-3: Contactors and motor-starters -
AC semiconductor controllers and contactors for non-motor loads
(IEC 60947-4-3:1999/A2:2011)**

Appareillage à basse tension -
Partie 4-3: Contacteurs et démarreurs de
moteurs -
Gradateurs et contacteurs à
semiconducteurs pour charges, autres
que des moteurs, à courant alternatif
(CEI 60947-4-3:1999/A2:2011)

Niederspannungsschaltgeräte -
Teil 4-3: Schütze und Motorstarter -
Halbleiter-Steuergeräte und -Schütze für
nichtmotorische Lasten für
Wechselspannung
(IEC 60947-4-3:1999/A2:2011)

This amendment A2 modifies the European Standard EN 60947-4-3:2000; it was approved by CENELEC on 2011-04-18. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this amendment the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This amendment exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document 17B/1000/FDIS, future edition 1 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 was approved by CENELEC as EN 60947-4-3 on 1999-12-01.

This European Standard, together with EN 60947-4-2:2000, supersedes HD 419.2 S1:1987.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2000-09-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2002-12-01

This standard is to be used in conjunction with EN 60947-1:1999.

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A, D and ZA are normative and annexes B, E, F, G and H are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60947-4-3:1999 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 17B/1486/FDIS, future amendment 1 to IEC 60947-4-3:1999, 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 was approved by CENELEC as amendment A1 to EN 60947-4-3:2000 on 2006-11-01.

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Annex ZA has been added by CENELEC.

Endorsement notice

The text of amendment 1:2006 to the International Standard IEC 60947-4-3:1999 was approved by CENELEC as an amendment to the European Standard without any modification.

Foreword to amendment A2

The text of document 17B/1727/FDIS, future amendment 2 to IEC 60947-4-3:1999, 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 was approved by CENELEC as amendment A2 to EN 60947-4-3:2000 on 2011-04-18.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

- | | | |
|---|-------|------------|
| – latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2012-03-02 |
| – latest date by which the national standards conflicting with the amendment have to be withdrawn | (dow) | 2014-04-18 |

Endorsement notice

The text of amendment 2:2011 to the International Standard IEC 60947-4-3:1999 was approved by CENELEC as an amendment to the European Standard without any modification.

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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). 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.

The provisions of the general rules (IEC 60947-1) are applicable to this standard, where specifically called for. Clauses and subclauses thus applicable, as well as tables, figures, and annexes, are identified by reference to IEC 60947-1, for example 1.2.3, table 4 of IEC 60947-1 or annex A of IEC 60947-1.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –**Part 4-3: Contactors and motor-starters –
AC semiconductor controllers and contactors
for non-motor loads****1 Scope and object**

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 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.

A1 This standard characterizes controllers and contactors for use with or without bypass switching devices. **A1**

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

- A1** – operation of a.c. and d.c. motors; **A1**
- low-voltage a.c. semiconductor motor controllers and starters covered by IEC 60947-4-2;
- electronic a.c. power controllers covered by IEC 60146;
- 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

A1 The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. **A1**

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

A1 Amendment 1 (1997)

Amendment 2 (1998) **A1**

A2 IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

IEC 60269-1:2006, *Low-voltage fuses – Part 1: General requirements* **A2**

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

A1 IEC 60439-1:1999, *Low-voltage switchgear and controlgear assemblies – Part 1: Type-tested and partially type-tested assemblies*

Amendment 1 (2004) **A1**

IEC 60664 (all parts), *Insulation coordination for equipment within low-voltage systems*

A2 IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules* **A2**

A1 IEC 60947-4-2:1999, *Low-voltage switchgear and controlgear – Part 4-2: Contactors and motor-starters – AC semiconductor motor controllers and starters*

Amendment 1 (2001)

Amendment 2 **A1**

IEC 61000-2-1:1990, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 1: Description of the environment – Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems*

A2 IEC 61000-3-2:2005, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

Amendment 1 (2008)

Amendment 2 (2009) **A2**

A1 Text deleted **A1**

■^{A2} IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3 : Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
Amendment 1 (2007)
Amendment 2 (2010)

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*
Amendment 1 (2010)

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

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests* ■^{A2}

IEC 61131-2:2003, *Programmable controllers – Part 2: Equipment requirements and tests*

■^{A2} CISPR 11:2009, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*
Amendment 1 (2010) ■^{A2}

CISPR 14-1, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission* ■^{A1}

3 Definitions, symbols and abbreviations

For the purposes of this part of IEC 60947, relevant definitions of clause 2 of IEC 60947-1 apply with the following additional definitions:

		Reference
	A	
AC semiconductor controller		3.1.1.1
	B	
Burst (of pulses or oscillations)		3.2.7
Bypassed controller		3.1.24
	C	
Controlled operation		3.1.7
Current-limit function		3.1.3
	D	
Defined-point switching (of a semiconductor controller)		3.1.14.4.1
	E	
Electromagnetic compatibility, EMC (abbreviation)		3.2.1
Electromagnetic disturbance		3.2.3
(electromagnetic) Emission		3.2.2
	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	
Immunity (to a disturbance)		3.2.9
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	
Radio (frequency) disturbance		3.2.4
Radio frequency interference, RFI (abbreviation)		3.2.5
Ramp-down		3.1.6
Ramp switching function		3.1.14.2
Ramp-up		3.1.5
Random point switching (of a semiconductor controller)		3.1.14.4.3
Rating index		3.1.18 



Reference

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

Transient (adjective and noun)	3.2.6
Trip-free controller	3.1.20
Tripping operation (of a controller)	3.1.19

V

Voltage surge	3.2.8
---------------------	-------

Z

Zero-point switching (of a semiconductor controller)	3.1.14.4.2
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3.1 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 (see 2.2.3 of IEC 60947-1) that provides a switching function for an a.c. electrical load (non-motor load) and an OFF-state

NOTE 1 – 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 – 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.

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 (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).

It is a device (see 2.2.13 of IEC 60947-1) which performs the function of a contactor by utilizing a semiconductor switching device (see 2.2.3 of IEC 60947-1). 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

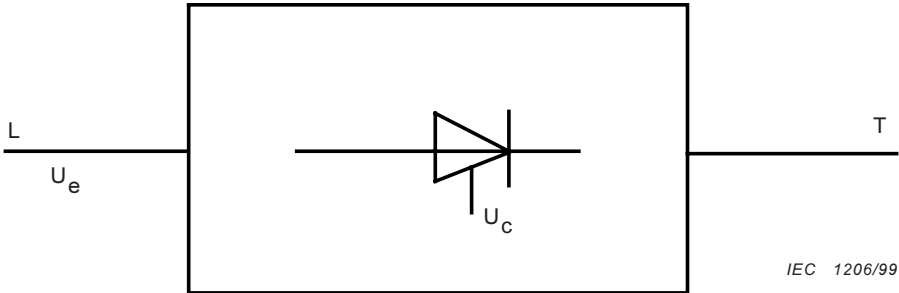
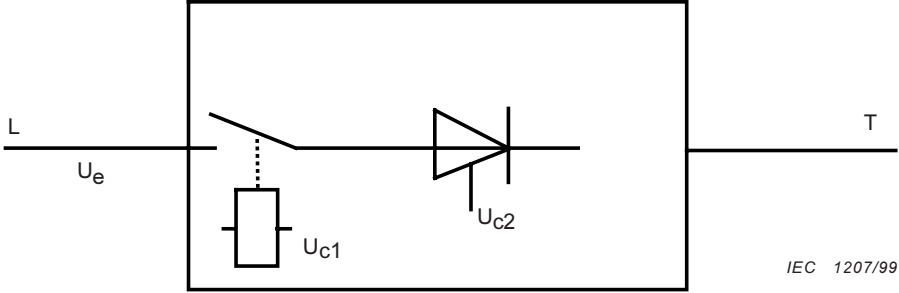
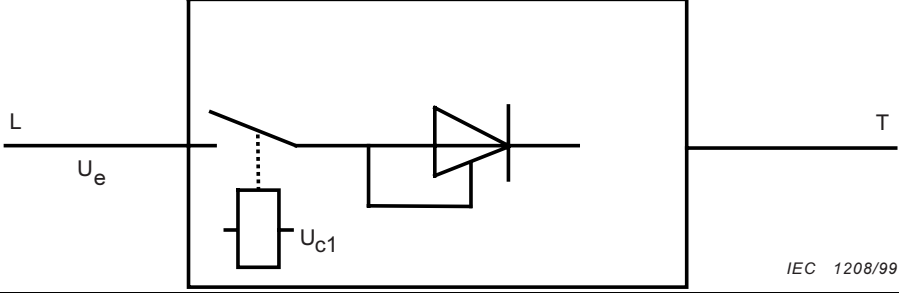
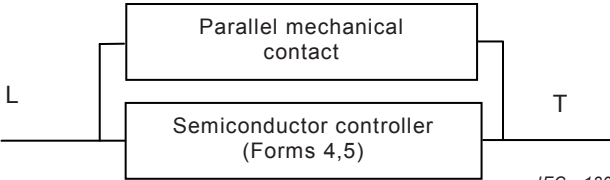
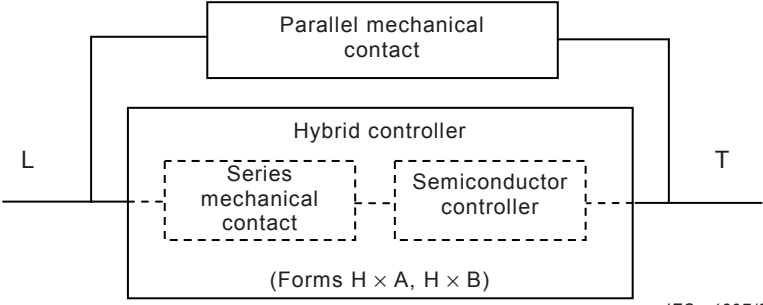
Device	
Controller (all forms)	 IEC 1206/99
Hybrid controller HxA* where x = 4 or 5	 IEC 1207/99
Hybrid controller HxB** where x = 4 or 5	 IEC 1208/99
 Bypassed controller	 IEC 1896/06
Bypassed hybrid controller ^C	 IEC 1897/06 
* Two separate controls for the controller and the series mechanical switching device respectively. ** One control only for the series mechanical switching device.  ^C For other configurations, tests may 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 HxA* 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 HxB** 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
* Two separate controls for the controller and the series mechanical switching device, respectively. ** 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 or contactors form HxA (where x = 4 or 5)

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

form 4 or form 5 semiconductor controller in series with a mechanical switching device all rated as a unit. 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 (see 2.4.21 of IEC 60947-1)

3.1.3

current-limit function

ability of the controller to limit the load current to a specified value. 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 – Switch-on is a mandatory form of load control that is recognized separately.

NOTE 2 – 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

controlled operation

Not defined (see 3.1.4)

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 (state of controllers)

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 – 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)**

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**ramp switching function**

See ramp-up and ramp-down

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.

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).

In the case of switch-on, the term "instantaneous" is used to mean make time (see 2.5.43 of IEC 60947-1) 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 (see 2.5.32 of IEC 60947-1) at which the semiconductor switching device becomes conductive during a switch-on operation

3.1.14.4.1

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 (see 2.5.32 of IEC 60947-1) or alternatively the a.c. control circuit voltage reaches a specified point on its wave form

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 (of a semiconductor controller)

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

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 (see 2.5.32 of IEC 60947-1) passes through zero

NOTE – 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 (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 (see 2.5.32 of IEC 60947-1) or alternatively the a.c. control circuit voltage reaches a specified point on its wave form

3.1.15

operating cycle (of a controller)

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

NOTE – 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 (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 – 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, for example as in figure F.1 of annex F

3.1.23**OFF-time**

period of time during which the controller is off-load, for example as in figure F.1 of annex F

A1 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 A1

3.2 EMC definitions

Various EMC definitions are given in IEC 60050, particularly chapter 161. Further explanations are given in IEC 61000-2-1. For convenience and to avoid confusion, some of the key definitions from IEC 60050(161) are reproduced here.

3.2.1**electromagnetic compatibility, EMC (abbreviation)**

ability of an equipment or system to function satisfactorily in its *electromagnetic environment* without introducing intolerable *electromagnetic disturbances* to anything in that environment [IEV 161-01-07]

3.2.2**(electromagnetic) emission**

phenomenon by which electromagnetic energy emanates from a source [IEV 161-01-08]

3.2.3**electromagnetic disturbance**

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

NOTE – An electromagnetic disturbance may be an *electromagnetic noise*, an *unwanted signal* or a change in the propagation medium itself. [IEV 161-01-05]

3.2.4**radio(frequency) disturbance**

electromagnetic disturbance having components in the radiofrequency range [IEV 161-01-13]

3.2.5**radiofrequency interference; RFI (abbreviation)**

degradation of the reception of a wanted signal caused by *radiofrequency disturbance*

NOTE – The English words "interference" and "disturbance" are often used indiscriminately. The expression "radiofrequency interference" is also commonly applied to a radiofrequency disturbance A1 or A1 an *unwanted signal* [IEV 161-01-14]

3.2.6**transient** (adjective and noun)

pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval short compared with the time-scale of interest [IEV 161-02-01]

3.2.7**burst** (of pulses or oscillations)

sequence of a limited number of distinct *pulses* or an oscillation of limited duration [IEV 161-02-07]

3.2.8**voltage surge**

transient voltage wave propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease of the voltage [IEV 161-08-11]

3.2.9**immunity** (to a disturbance)

ability of a device, equipment or system to perform without *degradation* in the presence of an *electromagnetic disturbance* [IEV 161-01-20]

A1 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 8)
I_e	Rated operational current (5.3.2.3)
I_F	Leakage current after the blocking and commutating capability test (9.3.3.6.3)
I_L	OFF-state leakage current (3.1.13)
I_O	Leakage current before the blocking and commutating capability test (9.3.3.6.3)
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 6)
U_s	Rated control supply voltage (5.5) A1

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 (see 5.7);
- coordination with short-circuit protective devices (see 5.8);

A1 *Text deleted* A1

5.2 Type of equipment

The following shall be stated.

5.2.1 Form of equipment

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

5.2.2 Number of poles

5.2.2.1 Number of main poles

5.2.2.2 Number of main poles where the operation is controlled by a semiconductor switching element

5.2.3 Kind of current

AC only.

5.2.4 Interrupting medium (air, vacuum, etc.)

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

5.2.5 Operating conditions of the equipment

5.2.5.1 Method of operation

For example:

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

5.2.5.2 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).

5.2.5.3 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.

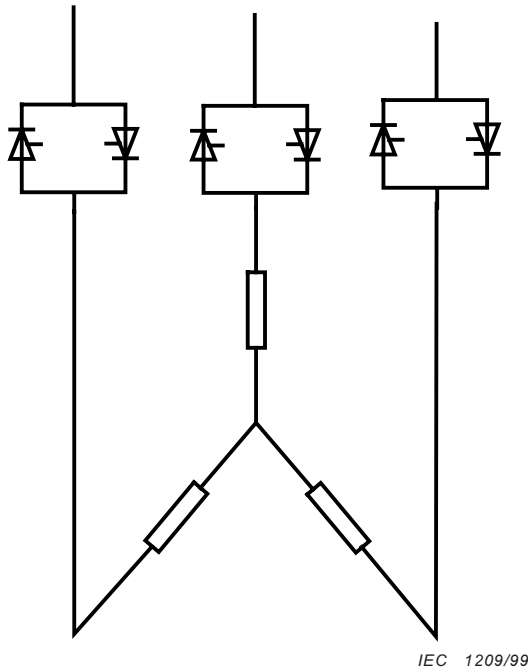


Figure 2a – Load in star
Thyristors between load and supply

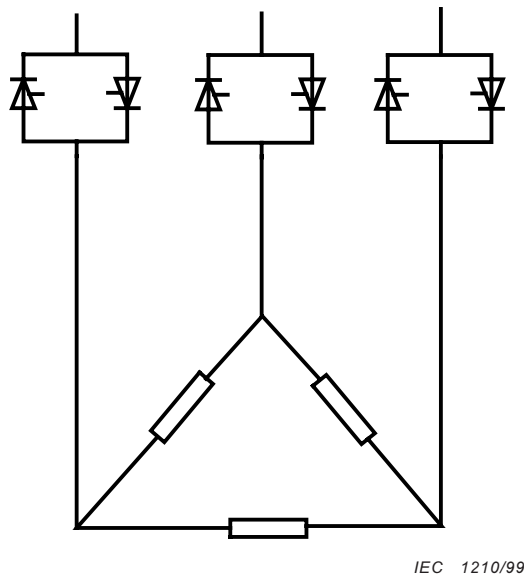


Figure 2b – Load in delta
Thyristors between load and supply

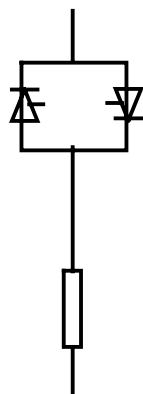


Figure 2c – Single-phase load
Thyristors between load and supply

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

A1 A controller or a contactor is defined by the following rated voltages. **A1**

5.3.1.1 Rated operational voltage (U_e)

A2 Subclause 4.3.1.1 of IEC 60947-1 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. **A2**

5.3.1.2 Rated insulation voltage (U_i)

Subclause 4.3.1.2 of IEC 60947-1 applies.

5.3.1.3 Rated impulse withstand voltage (U_{imp})

Subclause 4.3.1.3 of IEC 60947-1 applies.

5.3.2 Currents

A1 A controller or a contactor is defined by the following currents. **A1**

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

Subclause 4.3.2.1 of IEC 60947-1 applies.

5.3.2.2 Conventional enclosed thermal current (I_{the})

Subclause 4.3.2.2 of IEC 60947-1 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 applies.

5.3.3 Rated frequency

Subclause 4.3.3 of IEC 60947-1 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 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 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 may be declared by the manufacturer.

5.3.5 Normal load and overload characteristics

Subclause 4.3.5 of IEC 60947-1 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 .

X denotes the overload current as a multiple of I_e selected from the array of values in table 4 and represents the maximum value of operating current under operational overload conditions.

Deliberate overcurrents not exceeding ten cycles of the power-line frequency which may exceed the stated value of $X \cdot I_e$ are disregarded for the overload current profile.

T_x denotes the sum of duration times for the operational overload currents during the switching function (for example pre-heater elements of metal vapour lamps), load control and steady-state operating. See table 4.

5.3.5.2 Operating capability

Operating capability represents the combined capabilities of

- current commutation and current carrying in the ON-state, and
- establishing and sustaining the OFF-state (blocking),

at full voltage under normal load and overload conditions in accordance with utilization category, overload current profile and specified duty cycles.

Operating capability is characterized by

- rated operational voltage (see 5.3.1.1);
- rated operational current (see 5.3.2.3);
- rated duty (see 5.3.4);
- overload current profile (see 5.3.5.1);
- utilization category (see 5.4).

Requirements are given in 8.2.4.1.

5.3.5.3 Switch-on, ramp-up, ramp-down and load control characteristics

Typical service conditions for controllers and contactors are described in annex B.

5.3.6 Rated conditional short-circuit current

Subclause 4.3.6.4 of IEC 60947-1 applies.

5.4 Utilization category

Subclause 4.4 of IEC 60947-1 applies with the following addition.

For controllers and contactors the utilization categories as given in table 2 are considered standard. Any other type of utilization shall be based on agreement between manufacturer and user, but information given in the manufacturer's catalogue or tender may constitute such an agreement.