



BSI Standards Publication

Low-voltage switchgear and controlgear

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

National foreword

This British Standard is the UK implementation of EN IEC 60947-4-3:2024. It is identical to IEC 60947-4-3:2020. It supersedes BS EN 60947-4-3:2014, which will be withdrawn on 31 December 2027.

The UK participation in its preparation was entrusted to Technical Committee PEL/121/1, Low voltage switchgear and controlgear.

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

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For the Great Britain market (England, Scotland and Wales), if UK Government has designated this publication for conformity with UKCA marking (or similar) legislation, it may contain an additional National Annex. Where such a National Annex exists, it shows the correlation between this publication and the relevant UK legislation. If there is no National Annex of this kind, the relevant Annex ZA or ZZ in the body of the European text will indicate the relationship to UK regulation applicable in Great Britain. References to EU legislation may need to be read in accordance with the UK designation and the applicable UK law. Further information on designated standards can be found at www.bsigroup.com/standardsandregulation.

For the Northern Ireland market, UK law will continue to implement relevant EU law subject to periodic confirmation. Therefore Annex ZA/ZZ in the European text, and references to EU legislation, are still valid for this market.

UK Government is responsible for legislation. For information on legislation and policies relating to that legislation, consult the relevant pages of www.gov.uk.

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

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Amendments/corrigenda issued since publication

Date	Text affected
<hr/>	

English Version

Low-voltage switchgear and controlgear - Part 4-3: Contactors
and motor-starters - Semiconductor controllers and
semiconductor contactors for non-motor loads
(IEC 60947-4-3:2020)

Appareillage à basse tension - Partie 4-3: Contacteurs et
démarreurs de moteurs - Gradateurs et contacteurs à
semiconducteurs pour charges autres non moteurs
(IEC 60947-4-3:2020)

Niederspannungsschaltgeräte - Teil 4-3: Schütze und
Motorstarter - Halbleiter-Steuergeräte und Halbleiter-
Schütze für nichtmotorische Lasten
(IEC 60947-4-3:2020)

This European Standard was approved by CENELEC on 2024-10-16. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard 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 CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard 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 CEN-CENELEC Management Centre has the same status as the official versions.

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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 121A/357/FDIS, future edition 3 of IEC 60947-4-3, prepared by SC 121A "Low-voltage switchgear and controlgear" of IEC/TC 121 "Switchgear and controlgear and their assemblies for low voltage" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60947-4-3:2024.

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2025-12-31
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2027-12-31

This document supersedes EN 60947-4-3:2014 and all of its amendments and corrigenda (if any).

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

This document has been prepared under a standardization request addressed to CENELEC by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative Annex ZZ, which is an integral part of this document.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 60947-4-3:2020 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 standard indicated:

IEC 60068-2-2:2007	NOTE	Approved as EN 60068-2-2:2007 (not modified)
IEC 60079 (series)	NOTE	Approved as EN IEC 60079-7:2015/A1 (series)
IEC 60085	NOTE	Approved as EN 60085
IEC 60146 (series)	NOTE	Approved as EN 60146 (series)
IEC 60269-1:2006	NOTE	Approved as EN 60269-1:2007 (not modified)
IEC 60269-1:2006/A1:2009	NOTE	Approved as EN 60269-1:2007/A1:2009 (not modified)
IEC 60269-1:2006/A2:2014	NOTE	Approved as EN 60269-1:2007/A2:2014 (not modified)

IEC 60364-1	NOTE	Approved as HD 60364-1
IEC 60664 (series)	NOTE	Approved as EN 60664 (series)
IEC 60947-2	NOTE	Approved as EN 60947-2
IEC 60947-3	NOTE	Approved as EN IEC 60947-3
IEC 60947-4-2	NOTE	Approved as EN IEC 60947-4-2
IEC 60990:2016	NOTE	Approved as EN 60990:2016 (not modified)
IEC 61000-4 (series)	NOTE	Approved as EN 61000-4 (series)
IEC 61032	NOTE	Approved as EN 61032
IEC 61439 (series)	NOTE	Approved as EN IEC 61439 (series)
IEC 62314	NOTE	Approved as EN 62314
IEC 62477-1:2012	NOTE	Approved as EN 62477-1:2012 (not modified) + A11:2014
IEC 62477-1:2012/A1:2016	NOTE	Approved as EN 62477-1:2012/A1:2017 (not modified)
IEC/TR 63201	NOTE	Approved as CLC IEC/TR 63201

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE 1 Where 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.cencenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60445	-	Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors	EN IEC 60445	2021
IEC 60715	-	Dimensions of low-voltage switchgear and controlgear - Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories	EN 60715	2017
IEC 60730-1 (mod)	-	Automatic electrical controls - Part 1: General requirements	EN 60730-1	2016
			+ A1	2019
IEC 60947-1	2020	Low-voltage switchgear and controlgear - Part 1: General rules	EN 60947-1	2020
IEC 60947-4-1	-	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters	EN IEC 60947-4-1	2019
IEC 61000-3-2	-	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)	EN IEC 61000-3-2	2019
IEC 61000-3-3	-	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection	EN 61000-3-3	2013
			+ A1	2019

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61000-3-11	-	Electromagnetic compatibility (EMC) - Part 3-11: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current ≤ 75 A and subject to conditional connection	EN IEC 61000-3-11	2019
IEC 61000-3-12	-	Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase	EN 61000-3-12	2011
IEC 61000-4-5	-	Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test	EN 61000-4-5	2014
			+ A1	2017
IEC 61140	2016	Protection against electric shock - Common aspects for installation and equipment	EN 61140	2016
CISPR 11 (mod)	2015	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement	EN 55011	2016
+ A1	2016		+ A1	2017
ISO 2859-1	1999	Sampling procedures for inspection by attributes - Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection	-	-
+ A1	2011		-	-

Annex ZZ (informative)

Relationship between this European standard and the essential requirements of Directive 2014/30/EU [2014 OJ L96] aimed to be covered

This European standard has been prepared under a Commission's standardisation request as regards harmonised standards in support of Directive 2014/30/EU relating to electromagnetic compatibility, 'M/552' / C(2016) 7641 final of 30.11.2016¹, to provide one voluntary means of conforming to essential requirements of Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility [2014 OJ L96].

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZZ.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

Table ZZ.1 — Correspondence between this European standard and Annex I of Directive 2014/30/EU [2014 OJ L96]

Essential requirements of Directive 2014/30/EU	Clause(s) / sub-clause(s) of this EN	Remarks / Notes
Annex I. 1(a) (electromagnetic disturbances)	8.3.1, 8.3.3, 9.4.1, 9.4.3	
Annex I. 1(b) (electromagnetic immunity)	8.3.1, 8.3.2, 9.4.1, 9.4.2	

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

¹ COMMISSION IMPLEMENTING DECISION C(2016) 7641 final of 30.11.2016 on a standardisation request to the European Committee for Standardisation, to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards harmonised standards in support of Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility.

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
2 Normative references	11
3 Terms, definitions, symbols and abbreviated terms.....	11
3.1 General.....	11
3.2 Alphabetical index of terms	12
3.3 Terms and definitions concerning the types of semiconductor controllers and semiconductor contactors (see Figure 1).....	12
3.4 Terms and definitions concerning characteristics of semiconductor controllers and semiconductor contactors	13
3.5 Terms and definitions concerning safety aspects	16
3.6 Symbols and abbreviated terms	16
4 Classification.....	17
5 Characteristics of semiconductor controllers and semiconductor contactors	17
5.1 Summary of characteristics	17
5.2 Type of equipment	17
5.2.1 Kind of equipment.....	17
5.2.2 Number of poles	18
5.2.3 Kind of current	18
5.2.4 Interrupting medium (air, vacuum, etc.).....	18
5.2.5 Operating conditions of the equipment.....	18
5.3 Rated and limiting values for main circuits	20
5.3.1 Rated voltages.....	20
5.3.2 Currents.....	20
5.3.3 Rated frequency	20
5.3.4 Duty cycle values and symbols	20
5.3.5 Normal load and overload characteristics.....	21
5.3.6 Rated conditional short-circuit current.....	21
5.3.7 Controller power losses	22
5.4 Utilization category	22
5.4.1 General.....	22
5.4.2 Assignment of ratings based on the results of tests	23
5.5 Control circuits.....	23
5.6 Auxiliary circuits.....	23
5.7 Vacant	24
5.8 Coordination with short-circuit protective devices (SCPD).....	24
6 Product information	24
6.1 Nature of information	24
6.2 Marking.....	25
6.3 Instructions for installation, operation, maintenance, decommissioning and dismantling	26
6.4 Environmental information	26
7 Normal service, mounting and transport conditions.....	26
7.1 Normal service conditions	26
7.1.1 Ambient air temperature	26
7.1.2 Altitude	27

7.1.3	Atmospheric conditions	27
7.1.4	Shock and vibrations	27
7.2	Conditions during transport and storage	27
7.3	Mounting	27
7.4	Electrical system disturbances and influences	27
8	Constructional and performance requirements	28
8.1	Constructional requirements	28
8.1.1	General	28
8.1.2	Materials	28
8.1.3	Current-carrying parts and their connections	29
8.1.4	Clearances and creepage distances	29
8.1.5	Actuator	29
8.1.6	Indication of the contact position	29
8.1.7	Additional requirements for equipment suitable for isolation	29
8.1.8	Terminals	29
8.1.9	Additional requirements for equipment provided with a neutral pole	30
8.1.10	Provisions for protective earthing	30
8.1.11	Enclosures for equipment	30
8.1.12	Degrees of protection of enclosed equipment	30
8.1.13	Conduit pull-out, torque and bending with metallic conduits	30
8.1.14	Limited energy source	30
8.1.15	Stored charge energy circuit	32
8.1.16	Fault and abnormal conditions	32
8.1.17	Short-circuit and overload protection of ports	33
8.2	Performance requirements	33
8.2.1	Operating conditions	33
8.2.2	Temperature-rise	34
8.2.3	Dielectric properties	35
8.2.4	Normal load and overload performance requirements	36
8.2.5	Coordination with short-circuit protective devices	41
8.3	EMC requirements	41
8.3.1	General	41
8.3.2	Immunity	41
8.3.3	Emission	43
9	Tests	43
9.1	Kinds of tests	43
9.1.1	General	43
9.1.2	Type tests	43
9.1.3	Routine tests	44
9.1.4	Sampling tests	44
9.1.5	Special tests	44
9.2	Compliance with constructional requirements	45
9.2.1	General	45
9.2.2	Electrical performance of screwless-type clamping units	45
9.2.3	Ageing test for screwless-type clamping units	45
9.2.4	Limited energy source test	45
9.2.5	Breakdown of components	46
9.2.6	Wire flexing test	47
9.3	Compliance with performance requirements	47

9.3.1	Test sequences	47
9.3.2	General test conditions	48
9.3.3	Performance under no load, normal load and overload conditions	48
9.3.4	Performance under short-circuit conditions	56
9.4	EMC tests	59
9.4.1	General.....	59
9.4.2	EMC immunity tests	60
9.4.3	EMC emission tests	61
9.5	Routine and sampling tests	63
9.5.1	General.....	63
9.5.2	Operation and operating limits	63
9.5.3	Dielectric tests	63
Annex A	(normative) Marking and identification of terminals	65
A.1	General.....	65
A.2	Marking and identification of terminals of semiconductor controllers and semiconductor contactors	65
A.2.1	Marking and identification of terminals of main circuits.....	65
A.2.2	Marking and identification of terminals of control circuits.....	65
Annex B	(informative) Typical service conditions for semiconductor controllers and semiconductor contactors	66
B.1	Control of resistive heating elements	66
B.2	Switching of electric discharge lamp controls	66
B.3	Switching of incandescent lamps	66
B.4	Switching of transformers.....	67
B.5	Switching of capacitor banks.....	67
Annex C	Vacant.....	68
Annex D	Vacant.....	69
Annex E	Vacant	70
Annex F	(informative) Operating capability.....	71
Annex G	Vacant.....	74
Annex H	Vacant.....	75
Annex I	(normative) Modified test circuit for short-circuit testing of semiconductor contactors and semiconductor controllers	76
Annex J	(informative) Vacant	78
Annex K	(normative) Examples of overvoltage category reduction	79
K.1	General.....	79
K.2	Insulation to the surroundings	79
K.2.1	Circuits connected directly to the supply mains	79
K.2.2	Insulation between circuits.....	80
Annex L	(normative) Additional requirements and tests for equipment with protective separation.....	84
L.1	General.....	84
L.2	Terms and definitions.....	84
L.3	Requirements	84
L.3.1	Test method for implementing protective impedance	84
L.3.2	Touch current measurement	85
Bibliography		87

Figure 1 – Semiconductor control devices	13
Figure 2 – Methods of connecting	19
Figure F.1 – Thermal stability test profile	71
Figure F.2 – Overload withstand test profile	72
Figure F.3 – Blocking and commutating capability test profile	73
Figure I.1 – Modified circuit for short-circuit testing of semiconductor devices	76
Figure I.2 – Timeline for the short-circuit test of 9.3.4.1.6	77
Figure K.1 – Basic insulation evaluation for circuits connected directly to the origin of the installation mains supply	79
Figure K.2 – Basic insulation evaluation for circuits connected directly to the mains supply	80
Figure K.3 – Basic insulation evaluation for equipment not permanently connected to the mains supply	80
Figure K.4 – Basic insulation evaluation for insulation between circuits connected directly to the origin of the installation mains supply and that are declared galvanically separated	81
Figure K.5 – Basic insulation evaluation for insulation between circuits connected directly to the mains supply and that are declared galvanically separated	81
Figure K.6 – Basic insulation evaluation for insulation between circuits not permanently connected directly to the mains supply and that are declared galvanically separated	82
Figure K.7 – Basic insulation evaluation for insulation between circuits connected directly to the origin of the installation mains supply and that are declared galvanically separated where internal SPDs are used	82
Figure K.8 – Basic insulation evaluation for insulation between circuits connected directly to the mains supply and that are declared galvanically separated where internal SPDs are used	83
Figure K.9 – Basic insulation evaluation for insulation between circuits connected directly to the mains supply and that are declared galvanically separated	83
Figure L.1 – Protection by means of protective impedance	85
Figure L.2 – Measuring instrument	86
Table 1 – Utilization categories	23
Table 2 – Relative levels of severity	23
Table 14 – Limits for limited energy sources without an over-current protective device	31
Table 15 – Limits for limited energy sources with an over-current protective device	31
Table 16 – Limits for limited energy source with current limiting impedance	32
Table 3 – Temperature-rise limits for insulated coils in air and in oil	35
Table 4 – Minimum overload current withstand time (T_X) in relation to overload current ratio (X)	37
Table 5 – Minimum requirements for thermal stability test conditions	37
Table 6 – Minimum requirements for overload current withstand test conditions	38
Table 7 – Making and breaking capacity test – Making and breaking conditions according to utilization categories for the mechanical switching device	39
Table 8 – Conventional operational performance – Making and breaking conditions according to utilization categories for the mechanical switching device	40
Table 9 – Specific performance criteria when EM disturbances are present	42
Table 10 – Thermal stability test specifications	52
Table 11 – Blocking and commutating capability test specifications	54

Table 12 – Terminal disturbance voltage limits for conducted radio-frequency emission (AC mains power port)	62
Table 13 – Radiated emissions test limits	63
Table A.1 – Main circuit terminal markings	65
Table K.1 – Drawing keys	79

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60947-4-3 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low-voltage.

This third edition cancels and replaces the second edition published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) scope exclusions;
- b) editorial correction of notes and hanging paragraphs;

- c) safety aspects related to:
 - general aspects;
 - limited energy circuits;
 - electronic circuits;
- d) mention of dedicated wiring accessories;
- e) power consumption measurement;
- f) alignment to IEC 60947-1:2020;
- g) alignment with IEC 60947-4-2 when appropriate.

The provisions of the general rules dealt with IEC 60947-1 are applicable to this part of IEC 60947 series where specifically called for. Clauses and subclauses, tables, figures and annexes of the general rules thus applicable are identified by reference to IEC 60947-1:2020.

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

FDIS	Report on voting
121A/357/FDIS	121A/368/RVD

Full information on the voting for the approval of this document can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60947 series, published under the general title *Low-voltage switchgear and controlgear*, can be found on the IEC website.

The following differing practices of a less permanent nature exist in the countries indicated below.

5.5 USA and Canada

8.1.14.1 Canada

Table 14 USA

Table 15 USA

9.4.3.2 USA

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This document covers low-voltage semiconductor controllers and semiconductor contactors (solid-state contactors) intended for the use with non-motor loads. As semiconductor controllers, they have many capabilities beyond the simple switching on and off of non-motor loads. As semiconductor 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 3.5.1 of IEC 60947-1:2020). This document 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.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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

1 Scope

This document applies to semiconductor controllers and semiconductor contactors for non-motor load intended to be connected to circuits, the rated voltage of which does not exceed 1 000 V AC.

It covers their use:

- for operations of changing the state of AC electric circuits between the ON-state and the OFF-state;
- with or without bypass switching devices;
- as controller, for reducing the amplitude of the RMS AC voltage.

This document does not apply to:

- electromechanical contactors (see IEC 60947-4-1);
- short-circuit protective device associated with semiconductor controllers and semiconductor contactors (see IEC 60947-4-1 (MPSD), IEC 60947-2 and IEC 60947-3);
- semiconductor motor controller or soft-starter equipment (see IEC 60947-4-2);
- semiconductor converters (see IEC 60146 (all parts));
- solid-state relays (see IEC 62314);
- use of the product within explosive atmospheres (see IEC 60079 (all parts));
- software and firmware requirements (see IEC TR 63201);
- cyber security aspects (see IEC TS 63208).

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

The object of this document is to state as follows:

- the characteristics of semiconductor controllers and semiconductor contactors;
- the conditions with which semiconductor controllers and semiconductor contactors comply with reference to:
 - a) their operation and behaviour in normal and abnormal operating conditions including overcurrent operating conditions;
 - b) their dielectric properties;
 - c) the degrees of protection provided by their enclosures, where applicable;
 - d) their construction including safety measures against electric shock, fire hazard and mechanical hazard;
- the tests intended for confirming that these conditions have been met, and the methods to be adopted for these tests;
- the information to be given with the equipment or in the manufacturer's literature.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60715, *Dimensions of low-voltage switchgear and controlgear – Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories*

IEC 60730-1, *Automatic electrical controls – Part 1: General requirements*

IEC 60947-1:2020, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-4-1, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

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

IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

IEC 61000-3-11, *Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection*

IEC 61000-3-12, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase*

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

IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*
CISPR 11:2015/AMD1:2016

ISO 2859-1:1999, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*
ISO 2859-1:1999/AMD1:2011

3 Terms, definitions, symbols and abbreviated terms

3.1 General

For the purposes of this document, the terms and definitions given in Clause 3 of IEC 60947-1:2020, as well as the following terms, definitions, symbols and abbreviated terms apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.2 Alphabetical index of terms

Term		Reference
A	Abnormal operating condition	3.5.1
	Accessible part	3.5.2
B	Bypassed semiconductor controller	3.4.18
C	Current-limit function	3.4.1
F	FULL-ON	3.4.6
G	Galvanic opening	3.4.20
	Galvanic separation	3.4.21
H	Hazardous-live-part	3.5.3
I	Instantaneous switching	3.4.9
L	Limited energy source	3.5.4
	Load control	3.4.2
O	OFF-state	3.4.7
	OFF-state current	3.4.8
	OFF-time	3.4.17
	ON-state	3.4.5
	ON-time	3.4.16
	Operating capability	3.4.11
	Operating cycle	3.4.10
	Overcurrent protective means OCPM	3.4.15
	Overload current profile	3.4.12
P	Protective impedance	3.5.5
R	Ramp-down	3.4.4
	Ramp-up	3.4.3
	Rating index	3.4.13
	Reasonably foreseeable misuse	3.5.6
S	Semiconductor controller	3.3.1
	Semiconductor contactor	3.3.2
	Semiconductor controller power losses	3.4.19
	Single fault condition	3.5.7
T	Trip-free semiconductor controller	3.4.14

3.3 Terms and definitions concerning the types of semiconductor controllers and semiconductor contactors (see Figure 1)

3.3.1

semiconductor controller

semiconductor switching device that provides a switching function for an AC electrical load and an OFF-state

Note 1 to entry: Because hazardous levels of the OFF-state current (3.4.8) exist in a semiconductor controller, the load terminals are considered as live parts 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 3.4.3 of IEC 60947-1:2020 for the definition of semiconductor switching device.

3.3.2

semiconductor contactor

<solid-state contactor> semiconductor controller, in which the switching function is limited to FULL-ON

Note 1 to entry: A semiconductor contactor can also contain mechanical switching devices.

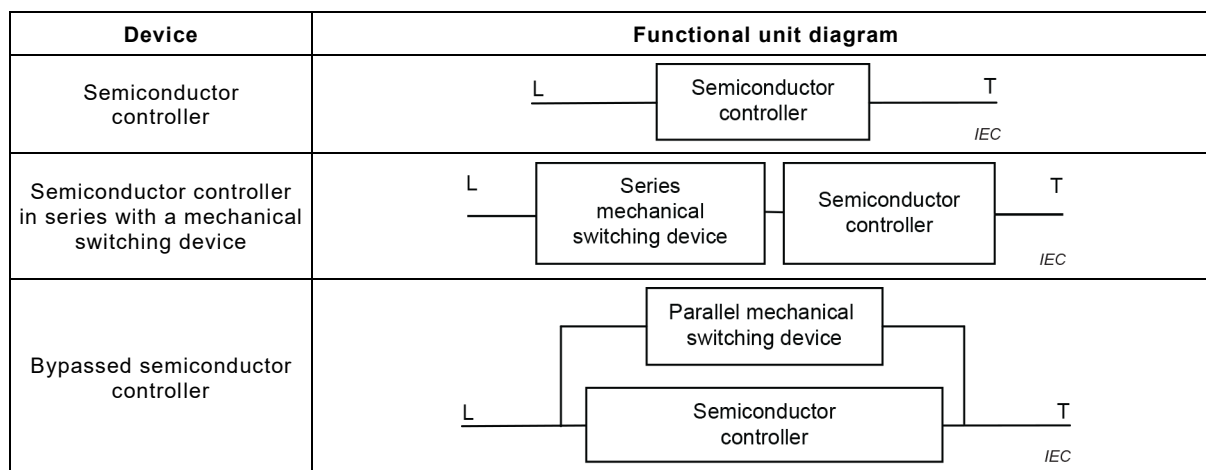


Figure 1 – Semiconductor control devices

3.4 Terms and definitions concerning characteristics of semiconductor controllers and semiconductor contactors

3.4.1

current-limit function

ability of the semiconductor 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.

3.4.2

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
- 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 semiconductor contactor, 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).

3.4.3

ramp-up

switching (switch-on) function which causes the transition from the OFF-state (or from the open state, in the case of a semiconductor controller in series with a mechanical switching device) 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)

3.4.4

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 a semiconductor controller in series with a mechanical switching device) over a defined period of time (ramp-down time)

3.4.5

ON-state

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

3.4.6

FULL-ON

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

3.4.7

OFF-state

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

3.4.8

OFF-state current

I_{OFF}

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

3.4.9

instantaneous switching

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 a semiconductor controller with mechanical switching device) 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 3.7.39 of IEC 60947-1:2020).

Note 2 to entry: In the case of switch-on, the term "instantaneous" is used to mean make time (see 3.7.43 of IEC 60947-1:2020) plus the transient time determined only by external circuit impedance.

3.4.10

operating cycle

<of a semiconductor 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.

3.4.11

operating capability

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

3.4.12

overload current profile

current-time coordinate specifying the requirement to accommodate overload currents for a period of time (see 5.3.5.2)

3.4.13

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))

3.4.14**trip-free semiconductor controller**

semiconductor 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 semiconductor controller in series with a mechanical switching device, the term "OFF-state condition" is replaced by the term "OPEN position".

3.4.15**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

3.4.16**ON-time**

period of time during which the semiconductor controller is on-load

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

3.4.17**OFF-time**

period of time during which the semiconductor controller is off-load

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

3.4.18**bypassed semiconductor 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

Note 1 to entry: The means of bypassing the semiconductor controller or semiconductor contactor can be integral or installed separately.

Note 2 to entry: A bypassed semiconductor controller is rated and tested as a unit.

3.4.19**semiconductor controller power losses**

power consumed by the semiconductor controller or semiconductor contactor at FULL-ON at the maximum power rating

3.4.20**galvanic opening**

<of a circuit> prevention of electric conduction within an electric circuit intended to provide power and/or signals

Note 1 to entry: Galvanic opening can be provided e.g. by a switch or a contactor.

3.4.21**galvanic separation**

prevention of electric conduction between two electric circuits intended to exchange power and/or signals

Note 1 to entry: Galvanic separation can be provided e.g. by an isolating transformer or an opto-coupler.

[SOURCE: IEC 60050-151:2001, 151-12-26]

3.5 Terms and definitions concerning safety aspects

3.5.1

abnormal operating condition

temporary operating condition that is not a normal operating condition and is not a single fault condition of the equipment itself

Note 1 to entry: An abnormal operating condition is a temporary condition which can be introduced by the equipment or by a person and can result in a failure of a component, a device or a safeguard.

Note 2 to entry: This definition is used in the context of component failure risk analysis.

3.5.2

accessible part

part which can be touched by means of the standard test finger

[SOURCE: IEC 60050-442:1998, 442-01-15]

3.5.3

hazardous-live-part

live part which, under certain conditions, can give a harmful electric shock

[SOURCE: IEC 60050-195:1998, 195-06-05]

3.5.4

limited energy source

source that is designed and protected that, under both normal operating conditions and single fault conditions, the current that can be delivered is not hazardous with respect to fire hazard

3.5.5

protective impedance

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

[SOURCE: IEC 62477-1:2012, 3.42]

3.5.6

reasonably foreseeable misuse

use of a product or system in a way not intended by the supplier, but which can result from readily predictable human behaviour

[SOURCE: ISO/IEC Guide 51:2014, 3.7, modified – Notes to entry have been deleted]

3.5.7

single fault condition

condition in which there is a fault of a single protection (but not a reinforced protection) or of a single component or a device

Note 1 to entry: If a single fault condition results in one or more other fault conditions, all are considered as one single fault condition.

[SOURCE: IEC Guide 104:2019, 3.8, modified – Deletion of the Note 2 to entry.]

3.6 Symbols and abbreviated terms

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 7)
I_e	Rated operational current (5.3.2.3)
I_F	OFF-state current after the blocking and commutating capability test (9.3.3.6.4)
I_o	OFF-state current before the blocking and commutating capability test (9.3.3.6.4)
I_q	Maximum conditional short-circuit test current
I_{lim}	Current setting of the current-limit function
I_{OFF}	Maximum OFF-state current
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 circuit supply voltage (5.5)

4 Classification

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

5 Characteristics of semiconductor controllers and semiconductor contactors

5.1 Summary of characteristics

The characteristics of semiconductor controllers and semiconductor 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);
- coordination with short-circuit protective devices (see 5.8).

5.2 Type of equipment

5.2.1 Kind of equipment

The type of semiconductor controller and semiconductor contactor shall be stated in the following terms:

- a) type of semiconductor switching device
 - semiconductor controller; or
 - semiconductor contactor;
- b) bypassed semiconductor controller or semiconductor contactor, if relevant;
- c) type of control (not limited to):

- FULL-ON;
- ramp-up;
- ramp-down;
- current-limit function.

5.2.2 Number of poles

- number of main poles;
- number of main poles where the operation is controlled by a semiconductor switching element.

5.2.3 Kind of current

Alternating current only.

5.2.4 Interrupting medium (air, vacuum, etc.)

Applicable only to mechanical switching devices.

5.2.5 Operating conditions of the equipment

5.2.5.1 Method of operation

For example:

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

5.2.5.2 Method of control

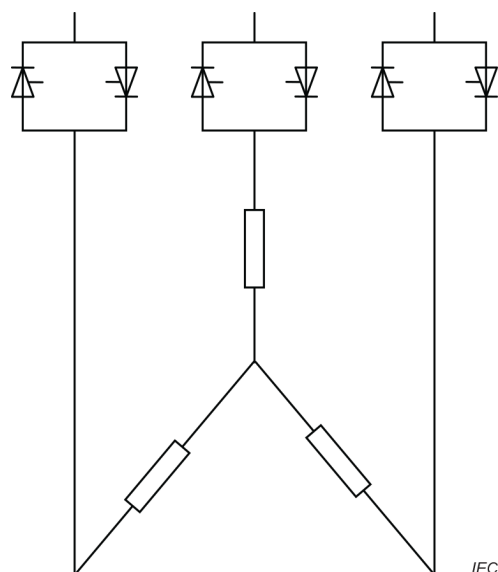
For example:

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

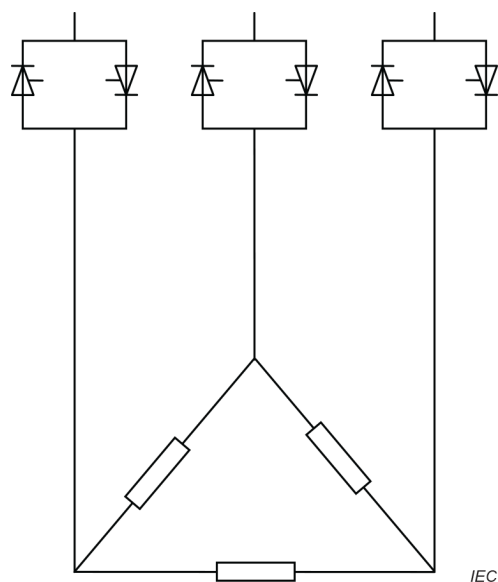
5.2.5.3 Method of connecting

For example (see Figure 2):

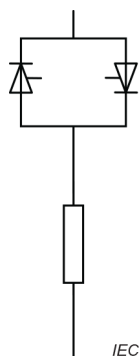
- load in star, semiconductor valve devices connected between load and supply (see for example Figure 2 a));
- load in delta, semiconductor valve devices connected between load and supply (see for example Figure 2 b));
- single-phase load, semiconductor valve devices connected between load and supply (see for example Figure 2 c)).



a) Load in star, semiconductor valve devices between load and supply



b) Load in delta, semiconductor valve devices between load and supply



c) Single-phase load, semiconductor valve devices between load and supply

Figure 2 – Methods of connecting

5.3 Rated and limiting values for main circuits

5.3.1 Rated voltages

5.3.1.1 Rated operational voltage (U_e)

Subclause 5.3.1.1 of IEC 60947-1:2020 applies with the following addition.

The rating of AC 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 5.3.1.2 of IEC 60947-1:2020 applies.

5.3.1.3 Rated impulse withstand voltage (U_{imp})

Subclause 5.3.1.3 of IEC 60947-1:2020 applies.

5.3.2 Currents

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

Subclause 5.3.2.1 of IEC 60947-1:2020 applies.

5.3.2.2 Conventional enclosed thermal current (I_{the})

Subclause 5.3.2.2 of IEC 60947-1:2020 applies.

5.3.2.3 Rated operational current (I_e)

The rated operational current, I_e , of semiconductor controllers and semiconductor 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 cycle (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 5.3.2.4 of IEC 60947-1:2020 applies.

5.3.2.5 Maximum OFF-state current (I_{OFF})

The maximum OFF-state current (I_{OFF}) is the maximum current flowing through the main circuit of the controller when it is in the OFF state, in the test condition of 9.3.3.6.3.

5.3.3 Rated frequency

Subclause 5.3.3 of IEC 60947-1:2020 applies.

5.3.4 Duty cycle values and symbols

For the purpose of this document, the duty cycle is expressed by two symbols, F and S . This describes the duty and also sets the time that shall 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

5.3.5.1 General

Subclause 5.3.5 of IEC 60947-1:2020 applies with the following additions.

5.3.5.2 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 $X \times I_e$ 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.

5.3.5.3 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 cycle (see 5.3.4);
- overload current profile (see 5.3.5.2);
- utilization category (see 5.4);
- the availability of a current-limiting function.

Requirements are given in 8.2.4.1.

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

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

5.3.6 Rated conditional short-circuit current

Subclause 5.3.6.4 of IEC 60947-1:2020 applies.