



IEC 60947-4-3

Edition 3.0 2020-07

INTERNATIONAL STANDARD

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.130.20; 31.180

ISBN 978-2-8322-8550-3

Warning! Make sure that you obtained this publication from an authorized distributor.

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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 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