

INTERNATIONAL STANDARD

IEC 60947-2

Third edition
2003-04

Low-voltage switchgear and controlgear –

Part 2: Circuit-breakers

Withdrawn

© IEC 2003 Copyright - all rights reserved

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembe, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch



Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

CONTENTS

FOREWORD	13
1 General.....	15
1.1 Scope and object	15
1.2 Normative references.....	17
2 Definitions.....	21
3 Classification	27
4 Characteristics of circuit-breakers	29
4.1 Summary of characteristics	29
4.2 Type of circuit-breaker	31
4.3 Rated and limiting values of the main circuit.....	31
4.4 Utilization categories	39
4.5 Control circuits.....	39
4.6 Auxiliary circuits	41
4.7 Releases	41
4.8 Integral fuses (integrally fused circuit-breakers).....	43
5 Product information.....	43
5.1 Nature of the information.....	43
5.2 Marking	45
5.3 Instructions for installation, operation and maintenance.....	47
6 Normal service, mounting and transport conditions.....	47
7 Constructional and performance requirements.....	47
7.1 Constructional requirements.....	47
7.2 Performance requirements.....	51
7.3 Electromagnetic compatibility (EMC)	63
8 Tests	63
8.1 Kind of tests.....	63
8.2 Compliance with constructional requirements	65
8.3 Type tests.....	65
8.4 Routine tests.....	119
Annex A (normative) Coordination under short-circuit conditions between a circuit-breaker and another short-circuit protective device associated in the same circuit.....	129
Annex B (normative) Circuit-breakers incorporating residual current protection	147
Annex C (normative) Individual pole short-circuit test sequence	213
Annex D Vacant	215
Annex E (informative) Items subject to agreement between manufacturer and user.....	217
Annex F (normative) Additional tests for circuit-breakers with electronic over-current protection	219
Annex G (normative) Power loss	265
Annex H (normative) Test sequence for circuit-breakers for IT systems	271

Annex J (normative) Electromagnetic compatibility (EMC) – Requirements and test methods for circuit-breakers	275
Annex K (informative) Glossary of symbols related to products covered by this standard	317
Annex L (normative) Circuit-breakers not fulfilling the requirements for overcurrent protection	321
Annex M (normative) Modular residual current devices (without integral current breaking device).....	331
Annex N (normative) Electromagnetic compatibility (EMC) – Additional requirements and test methods for devices not covered by annexes B, F and M.....	417
Figure 1 – Test arrangement (connecting cables not shown) for short-circuit tests.....	127
Figure A.1 – Over-current coordination between a circuit-breaker and a fuse or back-up protection by a fuse: operating characteristics	139
Figure A.2 and Figure A.3 – Total discrimination between two circuit-breakers	141
Figure A.4 and Figure A.5 – Back-up protection by a circuit-breaker – Operating characteristics	143
Figure A.6 – Example of test circuit for conditional short-circuit breaking capacity tests showing cable connections for a 3-pole circuit-breaker (C_1)	145
Figure B.1 – Test circuit for the verification of the operating characteristic (see B.8.2).....	197
Figure B.2 – Test circuit for the verification of the limiting value of the non-operating current under over-current conditions (see B.8.5).....	199
Figure B.3 – Test circuit for the verification of the behaviour of CBRs classified under B.3.1.2.2 (see B.8.9).....	201
Figure B.4 – Current ring wave 0,5 μ s/100 kHz	203
Figure B.5 – Example of test circuit for the verification of resistance to unwanted tripping.....	205
Figure B.6 – Surge current wave 8/20 μ s	205
Figure B.7 – Test circuit for the verification of resistance to unwanted tripping in case of flashover without follow-on current (B.8.6.2).....	207
Figure B.8 – Test circuit for the verification of the correct operation of CBRs, in the case of residual pulsating direct currents (see B.8.7.2.1, B.8.7.2.2 and B.8.7.2.3).....	209
Figure B.9 – Test circuit for the verification of the correct operation of CBRs, in the case of a residual pulsating direct current superimposed by a smooth direct residual current (see B.8.7.2.4)	211
Figure F.1 – Representation of test current produced by back-to-back thyristors in accordance with F.4.1.....	239
Figure F.2 – Test circuit for emission tests, immunity to harmonics, current dips, electrostatic discharges and radiated electromagnetic fields in accordance with F.4.1.3, F.4.2.1, F.4.3, F.4.4, F.5.4 and F.6.2. – Two phase poles in series.....	241
Figure F.3 – Test circuit for emission tests, immunity to harmonics, current dips, electrostatic discharges and radiated electromagnetic fields in accordance with F.4.1.3, F.4.2.1, F.4.3, F.4.4, F.5.4 and F.6.2. – Three phase poles in series	243

Figure F.4 – Test circuit for emission tests, immunity to harmonics, current dips, electrostatic discharges and radiated electromagnetic fields in accordance with F.4.1.3, F.4.2.1, F.4.3, F.4.4, F.5.4 and F.6.2. – Three-phase connection.....	245
Figure F.5 – Test current for the verification of the influence of the current dips and interruptions in accordance with F.4.2.1	247
Figure F.6 – Circuit for electrical fast transients/bursts (EFT/B) immunity test in accordance with F.4.5 – Two phase poles in series	249
Figure F.7 – Circuit for electrical fast transients/bursts (EFT/B) immunity test in accordance with F.4.5 – Three phase poles in series.....	251
Figure F.8 – Circuit for electrical fast transients/bursts (EFT/B) immunity test in accordance with F.4.5 – Three-phase connection	253
Figure F.9 – Test circuit for the verification of the influence of surges in the main circuit (line-to-earth) in accordance with F.4.6 – Two phase poles in series	255
Figure F.10 – Test circuit for the verification of the influence of surges in the main circuit (line-to-earth) in accordance with F.4.6 – Three phase poles in series.....	257
Figure F.11 – Test circuit for the verification of the influence of surges in the main circuit (line-to-earth) in accordance with F.4.6 – Three-phase connection	259
Figure F.12 – Test circuit for the verification of the influence of current surges in the main circuit in accordance with F.4.6 – Two phase poles in series	261
Figure F.13 – Test circuit for the verification of the influence of current surges in the main circuit in accordance with F.4.6 – Three phase poles in series.....	261
Figure F.14 – Test circuit for the verification of the influence of current surges in the main circuit in accordance with F.4.6 – Three-phase connection	263
Figure F.15 – Temperature variation cycles at a specified rate of change in accordance with F.9.1	263
Figure G.1 – Example of power loss measurement according to G.2.1	269
Figure G.2 – Example of power loss measurement according to G.2.2 and G.2.3	269
Figure J.1 – EUT mounted in metallic enclosure – Two phase poles in series.....	293
Figure J.2 – EUT mounted in metallic enclosure – Three phase poles in series	297
Figure J.3 – EUT mounted in metallic enclosure – Three-phase connection.....	301
Figure J.4 – Test set-up for the verification of immunity to electrostatic discharges	303
Figure J.5 – Test set-up for the verification of immunity to radiated electromagnetic fields	305
Figure J.6 – Test set-up for the verification of immunity to electrical fast transients/bursts (EFT/B)	307
Figure J.7 – Test set-up for the verification of immunity to conducted disturbances induced by radio-frequency fields (common mode) – Two phase poles in series	309
Figure J.8 – Test set-up for the verification of immunity to conducted disturbances induced by radio-frequency fields (common mode) – Three phase poles in series	311
Figure J.9 – Test set-up for the verification of immunity to conducted disturbances induced by radio-frequency fields (common mode) – Three-phase connection.....	313
Figure J.10 – Test set-up for radiated emissions.....	315
Figure K.1 – Relationship between symbols and tripping characteristics	319

Figure M.1 – Test circuits for the verification of operation in the case of a steady increase of residual current.....	379
Figure M.2 – Test circuits for the verification of operation in the case of a sudden appearance of residual current (with breaking device).....	381
Figure M.3 – Test circuits for the verification of operation in the case of a sudden appearance of residual current (without breaking device).....	383
Figure M.4 – Test circuits for the verification of the limiting value of non-operating current under overcurrent conditions.....	385
Figure M.5 – Test circuits for the verification of the resistance to unwanted tripping in the case of loading of the network capacitance	387
Figure M.6 – Test circuit for the verification of the resistance to unwanted tripping in the case of flashover without follow-on current.....	389
Figure M.7 – Test circuits for the verification of operation in the case of a continuous rise of a residual pulsating direct current.....	391
Figure M.8 – Test circuits for the verification of operation in the case of a sudden appearance of residual pulsating direct current (without breaking device).....	393
Figure M.9 – Test circuits for the verification of operation in the case of a sudden appearance of residual pulsating direct current (with breaking device).....	395
Figure M.10 – Test circuits for the verification of operation in the case of a residual pulsating direct current superimposed by smooth direct current of 6 mA.....	397
Figure M.11 – Test circuits for the verification of operation in the case of a slowly rising residual smooth direct current.....	399
Figure M.12 – Test circuits for the verification of operation in the case of a sudden appearance of residual smooth direct current (without breaking device)	401
Figure M.13 – Test circuits for the verification of operation in the case of a sudden appearance of residual smooth direct current (with breaking device).....	403
Figure M.14 – Test circuits for the verification of operation in the case of a slowly rising residual current resulting from a fault in a circuit fed by a three-pulse star or a six-pulse bridge connection.....	405
Figure M.15 – Test circuits for the verification of operation in the case of a slowly rising residual current resulting from a fault in a circuit fed by a two-pulse bridge connection line-to-line.....	407
Figure M.16 – Test circuit for the verification of the behaviour of MRCDs with separate sensing means in the case of a failure of the sensor means connection.....	409
Figure M.17 – Test circuit for the verification of the behaviour of MRCD with separate sensing means under short-circuit conditions	411
Figure M.18 – Test circuit for the verification of the behaviour of MRCD with integral sensing means under short-circuit conditions	413
Figure M.19 – Test circuit for the verification of the behaviour of terminal type MRCD under short-circuit conditions	415
Table 1 – Standard ratios between I_{CS} and I_{CU}	35
Table 2 – Ratio n between short-circuit making capacity and short-circuit breaking capacity and related power factor (for a.c. circuit-breakers)	37

Table 3 – Minimum values of rated short-time withstand current.....	37
Table 4 – Utilization categories	39
Table 5 – Preferred values of the rated control supply voltage, if different from that of the main circuit.....	39
Table 6 – Characteristics of the opening operation of inverse time-delay over-current opening releases at the reference temperature	55
Table 7 – Temperature-rise limits for terminals and accessible parts.....	59
Table 8 – Number of operating cycles	61
Table 9 – Overall schema of test sequences	69
Table 9a – Applicability of test sequences according to the relationship between I_{CS} , I_{CU} and I_{CW}	71
Table 10 – Number of samples for test	77
Table 11 – Values of power factors and time constants corresponding to test currents	81
Table 12 – Test circuit characteristics for overload performance.....	101
Table B.1 – Operating characteristic for non-time-delay type.....	157
Table B.2 – Operating characteristic for time-delay-type having a limiting non-actuating time of 0,06 s	159
Table B.3 – Requirements for CBRs functionally dependent on line voltage.....	167
Table B.4 – Additional test sequences	173
Table B.5 – Tripping current range for CBRs in case of an earth fault comprising a d.c. component.....	183
Table F.1 – Test parameters for current dips and interruptions.....	227
Table J.1 – EMC – Immunity tests	279
Table J.2 – Reference data for the application of the figures for immunity tests	281
Table J.3 – EMC – Emission tests	287
Table J.4 – Reference data for the application of the figures for emission tests	287
Table M.1 – Product information	343
Table M.2 – Requirements for MRCDs with voltage source	347
Table M.3 – Test sequences.....	351
Alphabetical index of tests.....	67

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 2: Circuit-breakers

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 the 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 National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60947-2 has been prepared by subcommittee 17B: Low-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

This third edition of IEC 60947-2 cancels and replaces the second edition published in 1995, amendment 1 (1997) and amendment 2 (2001).

The document 17B/1269/FDIS, circulated to the National Committees as amendment 3, led to the publication of this new edition.

The text of this standard is based on the second edition, its amendments 1 and 2 and the following documents:

FDIS	Report on voting
17B/1269/FDIS	17B/1278/RVD

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

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

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

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

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 2: Circuit-breakers

1 General

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

1.1 Scope and object

This standard applies to circuit-breakers, the main contacts of which are intended to be connected to circuits, the rated voltage of which does not exceed 1 000 V a.c. or 1 500 V d.c.; it also contains additional requirements for integrally fused circuit-breakers.

It applies whatever the rated currents, the method of construction or the proposed applications of the circuit-breakers may be.

The requirements for circuit-breakers which are also intended to provide earth-leakage protection are contained in annex B.

The additional requirements for circuit-breakers with electronic over-current protection are contained in annex F.

The additional requirements for circuit-breakers for IT systems are contained in annex H.

The requirements and test methods for electromagnetic compatibility of circuit-breakers are contained in annex J.

The requirements for circuit-breakers not fulfilling the requirements for overcurrent protection are contained in annex L.

The requirements for modular residual current devices (without integral current breaking device) are contained in annex M.

The requirements and test methods for electromagnetic compatibility of circuit-breaker auxiliaries are contained in annex N.

Supplementary requirements for circuit-breakers used as direct-on-line starters are given in IEC 60947-4-1, applicable to low-voltage contactors and starters.

The requirements for circuit-breakers for the protection of wiring installations in buildings and similar applications, and designed for use by uninstructed persons, are contained in IEC 60898.

The requirements for circuit-breakers for equipment (for example electrical appliances) are contained in IEC 60934.

For certain specific applications (for example traction, rolling mills, marine service) particular or additional requirements may be necessary.

NOTE Circuit-breakers which are dealt with in this standard may be provided with devices for automatic opening under predetermined conditions other than those of over-current and undervoltage as, for example, reversal of power or current. This standard does not deal with the verification of operation under such pre-determined conditions.

The object of this standard is to state:

- a) the characteristics of circuit-breakers;
- b) the conditions with which circuit-breakers shall comply with reference to:
 - 1) operation and behaviour in normal service;
 - 2) operation and behaviour in case of overload and operation and behaviour in case of short-circuit, including co-ordination in service (discrimination and back-up protection);
 - 3) dielectric properties;
- c) tests intended for confirming that these conditions have been met and the methods to be adopted for these tests;
- d) information to be marked on or given with the apparatus

1.2 Normative references

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.

IEC 60050(441):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*

IEC 60051 (all parts) *Direct acting indicating analogue electrical measuring instruments and their accessories*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests. Test N: Change of temperature*

IEC 60068-2-30:1980, *Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12+12-hour cycle)*

IEC 60364 (all parts), *Electric installations of buildings*

IEC 60364-4-41:1982, *Electric installations of buildings – Part 4: Protection for safety – Chapter 41: Protection against shock*

IEC 60695-2-10:2000, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60695-2-11:2000, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products*

IEC 60695-2-12:2000, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability test method for materials*

IEC 60695-2-13:2000, *Fire hazard testing – Part 2-13: Glowing/hot-wire based test methods – Glow-wire ignitability test method for materials*

IEC 60755:1983, *General requirements for residual current operated protective devices*

IEC 60898, *Circuit-breakers for over-current protection for household and similar installations*

IEC 60934, *Circuit-breakers for equipment (CBE)*

IEC 60947-1:1999, *Low-voltage switchgear and controlgear – Part 1: General rules*
Amendment 1 (2000)
Amendment 2 (2001)

IEC 60947-4-1:2000, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC 61000-3-2:2000, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

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

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test*
Amendment 1 (1998)
Amendment 2 (2000)

IEC 61000-4-3:2002, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated radio-frequency electromagnetic field immunity test*
Amendment 1 (2002)

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test*
Amendment 1 (2000)
Amendment 2 (2001)

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*
Amendment 1 (2000)

IEC 61000-4-6:1996, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radiofrequency fields*
Amendment 1 (2000)

IEC 61000-4-11:1994, *Electromagnetic compatibility (EMC) – Part 4: Testing and measuring techniques – Section 11: Voltage dips, short interruptions and voltage variation immunity tests*
Amendment 1 (2000)

IEC 61000-5-2:1997, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling*

IEC 61008-1:1990, *Residual current operated circuit-breakers without integral over-current protection for household and similar uses (RCCB's) – Part 1: General rules*

IEC 61009-1:1991, *Residual current operated circuit-breakers with integral over-current protection for household and similar uses (RCBO's) – Part 1: General rules*

CISPR 11:1997, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*
Amendment 1 (1999)

CISPR 22:1997, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*