

INTERNATIONAL STANDARD

NORME INTERNATIONALE



GROUP SAFETY PUBLICATION
PUBLICATION GROUPÉE DE SÉCURITÉ

Safety requirements for power electronic converter systems and equipment – Part 1: General

**Exigences de sécurité applicables aux systèmes et matériels électroniques
de conversion de puissance –
Partie 1: Généralités**

This is a preview. [Click here to purchase the full publication.](#)



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2012 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, 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 either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,...).

It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,...).

Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



GROUP SAFETY PUBLICATION
PUBLICATION GROUPEE DE SÉCURITÉ

Safety requirements for power electronic converter systems and equipment – Part 1: General

**Exigences de sécurité applicables aux systèmes et matériels électroniques
de conversion de puissance –
Partie 1: Généralités**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

XJ

ICS 29.200

ISBN 978-2-83220-194-7

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	8
INTRODUCTION.....	10
1 Scope.....	11
2 Normative references.....	12
3 Terms and definitions	14
4 Protection against hazards.....	23
4.1 General.....	23
4.2 Fault and abnormal conditions	24
4.3 Short circuit and overload protection	25
4.3.1 General	25
4.3.2 Specification of input short-circuit withstand strength and output short circuit current ability.....	26
4.3.3 Short-circuit coordination (backup protection).....	27
4.3.4 Protection by several devices	27
4.4 Protection against electric shock.....	27
4.4.1 General	27
4.4.2 <i>Decisive voltage class</i>	27
4.4.3 Provision for <i>basic protection</i>	32
4.4.4 Provision for <i>fault protection</i>	34
4.4.5 <i>Enhanced protection</i>	40
4.4.6 Protective measures	41
4.4.7 Insulation.....	43
4.4.8 Compatibility with residual current-operated protective devices (RCD)	58
4.4.9 Capacitor discharge	58
4.5 Protection against electrical energy hazards.....	59
4.5.1 Operator access areas.....	59
4.5.2 Service access areas.....	60
4.6 Protection against fire and thermal hazards.....	60
4.6.1 Circuits representing a fire hazard.....	60
4.6.2 Components representing a fire hazard	60
4.6.3 <i>Fire enclosures</i>	61
4.6.4 Temperature limits	65
4.6.5 Limited power sources	68
4.7 Protection against mechanical hazards	69
4.7.1 General	69
4.7.2 Specific requirements for liquid cooled <i>PECS</i>	70
4.8 Equipment with multiple sources of supply	71
4.9 Protection against environmental stresses	72
4.10 Protection against sonic pressure hazards	73
4.10.1 General	73
4.10.2 Sonic pressure and sound level.....	73
4.11 Wiring and connections	73
4.11.1 General	73
4.11.2 Routing.....	73
4.11.3 Colour coding	73
4.11.4 Splices and connections	74

4.11.5	Accessible connections	74
4.11.6	Interconnections between parts of the <i>PECS</i>	74
4.11.7	Supply connections	75
4.11.8	Terminals	75
4.12	<i>Enclosures</i>	76
4.12.1	General	76
4.12.2	Handles and manual controls	76
4.12.3	Cast metal	77
4.12.4	Sheet metal	77
4.12.5	Stability test for <i>enclosure</i>	80
5	Test requirements	81
5.1	General	81
5.1.1	Test objectives and classification	81
5.1.2	Selection of test samples	81
5.1.3	Sequence of tests	81
5.1.4	Earthing conditions	81
5.1.5	General conditions for tests	81
5.1.6	Compliance	82
5.1.7	Test overview	83
5.2	Test specifications	84
5.2.1	Visual inspections (<i>type test</i> , <i>sample test</i> and <i>routine test</i>)	84
5.2.2	Mechanical tests	84
5.2.3	Electrical tests	88
5.2.4	Abnormal operation and simulated faults tests	102
5.2.5	Material tests	106
5.2.6	Environmental tests (<i>type tests</i>)	110
5.2.7	Hydrostatic pressure test (<i>type test</i> and <i>routine test</i>)	115
6	Information and marking requirements	115
6.1	General	115
6.2	Information for selection	117
6.3	Information for installation and commissioning	118
6.3.1	General	118
6.3.2	Mechanical considerations	118
6.3.3	Environment	118
6.3.4	Handling and mounting	118
6.3.5	<i>Enclosure</i> temperature	118
6.3.6	Connections	119
6.3.7	Protection requirements	119
6.3.8	Commissioning	121
6.4	Information for use	121
6.4.1	General	121
6.4.2	Adjustment	121
6.4.3	Labels, signs and signals	121
6.5	Information for maintenance	123
6.5.1	General	123
6.5.2	Capacitor discharge	124
6.5.3	Auto restart/bypass connection	124
6.5.4	Other hazards	124
6.5.5	Equipment with multiple sources of supply	124

Annex A (normative) Additional information for protection against electric shock	125
Annex B (informative) Considerations for the reduction of the pollution degree.....	145
Annex C (informative) Symbols referred to in IEC 62477-1.....	146
Annex D (normative) Evaluation of clearance and creepage distances	147
Annex E (informative) Altitude correction for clearances	155
Annex F (normative) Clearance and creepage distance determination for frequencies greater than 30 kHz.....	156
Annex G (informative) Cross-sections of round conductors	162
Annex H (informative) Guidelines for RCD compatibility.....	163
Annex I (informative) Examples of overvoltage category reduction	167
Annex J (informative) Burn thresholds for touchable surfaces	174
Annex K (informative) Table of electrochemical potentials	177
Annex L (informative) Measuring instrument for <i>touch current</i> measurements	178
Annex M (informative) Test probes for determining access	179
Bibliography	182
Figure 1 – Touch time-d.c. peak voltage zones of <i>ventricular fibrillation</i> in dry skin condition	30
Figure 2 – Touch time- d.c. peak voltage zones of <i>ventricular fibrillation</i> in water-wet skin condition	31
Figure 3 – Touch time- d.c. peak voltage zones of <i>ventricular fibrillation</i> in saltwater-wet skin condition	31
Figure 4 – Example of a <i>PECS</i> assembly and its associated <i>protective equipotential bonding</i>	36
Figure 5 – Example of a <i>PECS</i> assembly and its associated <i>protective equipotential bonding</i>	37
Figure 6 – <i>Fire enclosure</i> bottom openings below an unenclosed or partially enclosed fire-hazardous component	63
Figure 7 – <i>Fire enclosure</i> baffle construction	64
Figure 8 – Supported and unsupported <i>enclosure</i> parts	78
Figure 9 – Impact test using a steel ball.....	86
Figure 10 – Voltage test procedures	93
Figure 11 – Protective equipotential bonding impedance test for separate unit with power fed from the <i>PECS</i> with protection for the power cable	99
Figure 12 – Protective equipotential bonding impedance test for sub-assembly with accessible parts and with power fed from the <i>PECS</i>	100
Figure 13 – Circuit for high-current arcing test.....	107
Figure 14 – Test fixture for hot-wire ignition test	108
Figure A.1 – Protection by <i>DVC As</i> with <i>protective separation</i>	125
Figure A.2 – Protection by means of <i>protective impedance</i>	126
Figure A.3 – Protection by using limited voltages	127
Figure A.4 – Touch time- d.c. voltage zones for dry skin condition	130
Figure A.5 – Touch time- d.c. voltage zones for water-wet skin condition	130
Figure A.6 – Touch time- d.c. voltage for saltwater-wet skin condition	131
Figure A.7 – Touch time- d.c. voltage zones of dry skin condition.....	132
Figure A.8 – Touch time- d.c. voltage zones of water-wet skin condition	132

Figure A.9 – Touch time- d.c. voltage zones of saltwater-wet skin condition	133
Figure A.10 – Touch time- d.c. voltage zones of dry skin condition	134
Figure A.11 – Touch time- d.c. voltage zones of water-wet skin condition	134
Figure A.12 – Touch time- a.c. voltage zones for dry skin condition	135
Figure A.13 – Touch time- a.c. voltage zones of water-wet skin condition	136
Figure A.14 – Touch time- a.c. voltage of saltwater-wet skin condition	136
Figure A.15 – Touch time- a.c. voltage zones of dry skin condition	137
Figure A.16 – Touch time- a.c. voltage zones of water-wet skin condition	138
Figure A.17 – Touch time- a.c. voltage zones of saltwater-wet skin condition	138
Figure A.18 – Touch time- a.c. voltage zones of dry skin condition	139
Figure A.19 – Touch time- a.c. voltage zones of water-wet skin condition	140
Figure A.20 – Typical waveform for a.c. <i>working voltage</i>	141
Figure A.21 – Typical waveform for d.c. <i>working voltage</i>	141
Figure A.22 – Typical waveform for pulsating <i>working voltage</i>	142
Figure F.1 – Diagram for dimensioning of clearances	157
Figure F.2 – Diagram for dimensioning of creepage distances	159
Figure F.3 – Permissible field strength for dimensioning of solid <i>insulation</i> according to Equation (1)	161
Figure H.1 – Flow chart leading to selection of the RCD type upstream of a <i>PECS</i>	163
Figure H.2 – Fault current waveforms in connections with power electronic converter devices	165
Figure I.1 – <i>Basic insulation</i> evaluation for circuits connected to the origin of the <i>installation mains supply</i>	167
Figure I.2 – <i>Basic insulation</i> evaluation for circuits connected to the <i>mains supply</i>	168
Figure I.3 – <i>Basic insulation</i> evaluation for single and three phase equipment not <i>permanently connected</i> to the <i>mains supply</i>	168
Figure I.4 – <i>Basic insulation</i> evaluation for circuits connected to the origin of the <i>installation mains supply</i> where internal <i>SPDs</i> are used	168
Figure I.5 – <i>Basic insulation</i> evaluation for circuits connected to the <i>mains supply</i> where internal <i>SPDs</i> are used	169
Figure I.6 – Example of <i>protective separation</i> evaluation for circuits connected to the <i>mains supply</i> where internal <i>SPDs</i> are used	169
Figure I.7 – Example of <i>protective separation</i> evaluation for circuits connected to the <i>mains supply</i> where internal <i>SPDs</i> are used	170
Figure I.8 – Example of <i>protective separation</i> evaluation for circuits connected to the <i>mains supply</i> where internal <i>SPDs</i> are used	170
Figure I.9 – <i>Basic insulation</i> evaluation for circuits not connected directly to the <i>mains supply</i>	170
Figure I.10 – <i>Basic insulation</i> evaluation for circuits not connected directly to the supply mains	171
Figure I.11 – Functional <i>insulation</i> evaluation within circuits affected by external transients	171
Figure I.12 – <i>Basic insulation</i> evaluation for circuits both connected and not connected directly to the <i>mains supply</i>	172
Figure I.13 – <i>Insulation</i> evaluation for accessible circuit of DVC A	172
Figure I.14 – <i>PEC</i> with mains and non- <i>mains supply</i> without galvanic separation	173

Figure I.15 – Transformer (basic) isolated <i>PEC</i> inverter with <i>SPD</i> and transformer to reduce impulse voltage for functional and <i>basic insulation</i>	173
Figure J.1 – Burn threshold spread when the skin is in contact with a hot smooth surface made of bare (uncoated) metal	174
Figure J.2 – Rise in the burn threshold spread from Figure J.1 for metals which are coated by shellac varnish of a thickness of 50 µm, 100 µm and 150 µm	175
Figure J.3 – Rise in the burn threshold spread from Figure J.1 for metals coated with the specific materials	175
Figure J.4 – Burn threshold spread when the skin is in contact with a hot smooth surface made of ceramics, glass and stone materials	176
Figure J.5 – Burn threshold spread when the skin is in contact with a hot smooth surface made of plastics	176
Figure K.1 – Electrochemical potentials (V)	177
Figure L.1 – Measuring instrument	178
Figure M.1 – Sphere 50 mm probe (IPXXA)	179
Figure M.2 – Jointed test finger (IPXXB)	180
Figure M.3 – Test rod 2,5 mm (IP3X)	181
Table 1 – Alphabetical list of terms	15
Table 2 – Selection of <i>DVC</i> for touch voltage to protect against <i>ventricular fibrillation</i>	28
Table 3 – Selection of body contact area	29
Table 4 – Selection of humidity condition of the skin	29
Table 5 – Steady state voltage limits for the <i>decisive voltage classes</i>	29
Table 6 – Protection requirements for circuit under consideration	32
Table 7 – <i>PE conductor</i> cross-section ^a	38
Table 8 – Definitions of pollution degrees	43
Table 9 – Impulse withstand voltage and <i>temporary overvoltage</i> versus system voltage	46
Table 10 – Clearance distances for <i>functional</i> , <i>basic</i> or <i>supplementary insulation</i>	51
Table 11 – Creepage distances (in millimetres)	53
Table 12 – Generic materials for the direct support of uninsulated <i>live parts</i>	55
Table 13 – Permitted openings in <i>fire enclosure</i> bottoms	64
Table 14 – Maximum measured total temperatures for internal materials and components	66
Table 15 – Maximum measured temperatures for accessible parts of the <i>PECS</i>	68
Table 16 – Limits for sources without an overcurrent protective device	69
Table 17 – Limits for power sources with an overcurrent protective device	69
Table 18 – Environmental service conditions	72
Table 19 – Wire bending space from terminals to <i>enclosure</i>	76
Table 20 – Thickness of sheet metal for <i>enclosures</i> : carbon steel or stainless steel	79
Table 21 – Thickness of sheet metal for <i>enclosures</i> : aluminium, copper or brass	80
Table 22 – Test overview	83
Table 23 – Pull values for handles and manual control securement	88
Table 24 – Impulse voltage test	89
Table 25 – Impulse test voltage	90
Table 26 – AC or d.c. test voltage for circuits connected directly to <i>mains supply</i>	91

Table 27 – A.c. or d.c. test voltage for circuits connected to <i>non-mains supply</i> without <i>temporary overvoltages</i>	92
Table 28 – Partial discharge test	95
Table 29 – Test duration for <i>protective equipotential bonding</i> test	101
Table 30 – Environmental tests	111
Table 31 – Dry heat test (steady state)	112
Table 32 – Damp heat test (steady state)	113
Table 33 – Vibration test	114
Table 34 – Salt mist test.....	114
Table 35 – Dust and sand test.....	115
Table 36 – Information requirements	116
Table A.1 – Selection of touch voltage sets to protect against <i>ventricular fibrillation</i>	128
Table A.2 – Selection of touch voltage sets to protect against <i>muscular reaction</i>	129
Table A.3 – Selection of touch voltage sets to protect against <i>startle reaction</i>	129
Table A.4 – Examples for protection against electrical shock	144
Table C.1 – Symbols used.....	146
Table D.1 – Width of grooves by pollution degree	147
Table E.1 – Correction factor for clearances at altitudes between 2 000 m and 20 000 m	155
Table E.2 – Test voltages for verifying clearances at different altitudes	155
Table F.1 – Minimum values of clearances in air at atmospheric pressure for inhomogeneous field conditions (Table 1 of IEC 60664-4:2005)	158
Table F.2 – Multiplication factors for clearances in air at atmospheric pressure for approximately homogeneous field conditions	158
Table F.3 – Minimum values of creepage distances for different frequency ranges (Table 2 of IEC 60664-4:2005)	160
Table G.1 – Standard cross-sections of round conductors	162

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY REQUIREMENTS FOR POWER ELECTRONIC CONVERTER SYSTEMS AND EQUIPMENT –

Part 1: General

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 62477-1 has been prepared by IEC technical committee 22: Power electronic systems and equipment.

It has the status of a group safety publication in accordance with IEC Guide 104.

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

FDIS	Report on voting
22/200/FDIS	22/204/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.

[This is a preview. Click here to purchase the full publication.](#)

A list of all the parts in the IEC 62477 series, published under the general title *Safety requirements for power electronic convertor systems and equipment* can be found on the IEC website.

In this standard, terms in *italic* are defined in Clause 3.

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

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

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.