



IEC 62590-2-1

Edition 1.0 2025-12

# INTERNATIONAL STANDARD

---

**Railway applications - Electronic power converters for fixed installations -  
Part 2-1: DC traction applications - Uncontrolled rectifiers**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2025 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.

IEC Secretariat  
3, rue de Varembé  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://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 corrigendum or an amendment might have been published.

#### IEC publications search -

[webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

The advanced search enables 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 It also gives information on projects, replaced and withdrawn publications.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](http://webstore.iec.ch/justpublished)

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

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://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: [sales@iec.ch](mailto:sales@iec.ch).

#### IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

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

## CONTENTS

|  |    |
|--|----|
| FOREWORD.....  | 3  |
| INTRODUCTION.....  | 5  |
| 1 Scope.....   | 6  |
| 2 Normative references .....                             | 6  |
| 3 Terms, definitions, symbols and abbreviated terms..... | 6  |
| 3.1 Terms and definitions .....                          | 6  |
| 3.2 Symbols.....   | 9  |
| 3.3 Abbreviated terms .....                              | 9  |
| 4 System configurations and characteristics.....         | 10 |
| 4.1 General.....   | 10 |
| 4.2 Main interfaces .....                                | 10 |
| 4.3 Transformer main values.....                         | 11 |
| 4.3.1 General .....                                      | 11 |
| 4.3.2 Impedance voltages .....                           | 11 |
| 4.3.3 Coupling factor .....                              | 12 |
| 4.4 Electrical connections .....                         | 13 |
| 4.5 Voltage characteristic.....                          | 14 |
| 4.6 Current characteristic.....                          | 15 |
| 4.7 Current imbalance.....                               | 16 |
| 4.8 Short time withstand capability .....                | 16 |
| 4.9 Direct voltage harmonic content .....                | 17 |
| 4.10 3AC power network harmonic current .....            | 17 |
| 5 Design and integration.....                            | 17 |
| 5.1 General.....   | 17 |
| 5.2 To be defined by user specification.....             | 18 |
| 5.2.1 Electrical data .....                              | 18 |
| 5.2.2 Mechanical requirements .....                      | 19 |
| 5.3 To be indicated by manufacturer.....                 | 19 |
| 5.4 Marking.....   | 20 |
| 5.4.1 Rating plate .....                                 | 20 |
| 5.4.2 Main circuit terminals .....                       | 21 |
| 6 Tests.....   | 21 |
| 6.1 General.....   | 21 |
| 6.2 Test specifications .....                            | 22 |
| 6.2.1 Visual inspection.....                             | 22 |
| 6.2.2 Test of accessory and auxiliary components .....   | 22 |
| 6.2.3 Insulation test .....                              | 23 |
| 6.2.4 Checking the protective functions .....            | 23 |
| 6.2.5 Light load functional test .....                   | 23 |
| 6.2.6 Load test .....                                    | 23 |
| 6.2.7 Inherent voltage drop .....                        | 23 |
| 6.2.8 Temperature-rise test.....                         | 25 |
| 6.2.9 Short time withstand current.....                  | 26 |
| 6.2.10 Power loss determination .....                    | 26 |
| 6.2.11 Audible sound .....                               | 27 |
| 6.2.12 Harmonic test .....                               | 27 |

|  |    |
|--|----|
| 6.2.13 Power factor measurement.....   | 27 |
| 6.2.14 Mechanical test.....  | 27 |
| Annex A (informative) Determination of the voltage drop and the short-circuit currents of uncontrolled rectifiers.....   | 28 |
| A.1 General.....   | 28 |
| A.2 Description of the method.....   | 29 |
| A.3 Example of a six-pulse rectifier or twelve-pulse rectifier with magnetically not coupled transformer windings ( $K \approx 0$ ).....   | 34 |
| A.4 Example of a twelve-pulse rectifier with closely coupled secondary windings of the converter transformer ( $K \approx 1$ ).....  | 36 |
| Annex B (informative) Examples of power factors of uncontrolled rectifiers .....   | 39 |
| B.1 General.....   | 39 |
| B.2 Considerations on the variation of the fundamental current and power factor in rectifiers.....   | 39 |
| B.2.1 Basic considerations .....   | 39 |
| B.2.2 First working zone.....  | 39 |
| B.2.3 Second working zone .....  | 40 |
| Annex C (informative) Interphase transformer.....  | 41 |
| C.1 General.....   | 41 |
| C.2 Voltage and currents .....   | 41 |
| C.3 Intermittent current conditions .....  | 42 |
| C.4 Current imbalance.....   | 42 |
| Annex D (informative) Example of a protection curve .....  | 43 |
| Bibliography .....   | 45 |
| <br>Figure 1 – General configuration .....   | 10 |
| Figure 2 – Reactances of a rectifier transformer .....   | 11 |
| Figure 3 – Voltage characteristic .....  | 15 |
| Figure 4 – Measurement of inherent voltage drop .....  | 25 |
| Figure A.1 – Typical characteristic of an uncontrolled rectifier.....  | 29 |
| Figure A.2 – External characteristics of six-pulse (three-phase bridge) rectifiers and twelve-pulse rectifiers with magnetically non-coupled transformer windings ( $K = 0$ ) .....      | 32 |
| Figure A.3 – External characteristics of twelve-pulse rectifiers with closely coupled secondary windings of the converter transformer ( $K \approx 1$ ).....                             | 33 |
| Figure A.4 – Determination of the short-circuit currents of a six-pulse rectifier or a twelve-pulse rectifier with magnetically not coupled transformer windings ( $K \approx 0$ ) ..... | 36 |
| Figure A.5 – Determination of the short-circuit currents of a twelve-pulse rectifier with closely coupled transformer windings ( $K \approx 1$ ) .....                                   | 38 |
| Figure C.1 – Interphase transformer.....   | 41 |
| Figure D.1 – Example protection curve .....  | 43 |
| <br>Table 1 – Connections and calculation factors for uncontrolled rectifiers .....  | 14 |
| Table 2 – Main rectifier design data.....  | 18 |
| Table 3 – Mechanical requirements .....  | 19 |
| Table 4 – Summary of tests .....   | 22 |
| Table A.1 – Method of use of the charts in Figure A.2 and Figure A.3 .....   | 30 |
| Table A.2 – Example of the application of Table A.1 for a six-pulse rectifier or a twelve-pulse rectifier with magnetically not coupled transformer windings ( $K \approx 0$ ) .....     | 34 |
| Table A.3 – Example of the application of Table A.1 for a twelve-pulse rectifier with closely coupled secondary windings of the converter transformer ( $K \approx 1$ ) .....            | 37 |

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

### Railway applications - Electronic power converters for fixed installations - Part 2-1: DC traction applications - Uncontrolled rectifiers

#### 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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62590-2-1 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways. It is an International Standard.

This first edition of IEC 62590-2-1, in conjunction with the other parts of the IEC 62590 series, cancels and replaces the first edition of IEC 62589 published in 2010 and the second edition of IEC 62590 published in 2019.

This document includes the following significant technical changes with respect to IEC 62589 and the former IEC 62590:

- a) Reduction of the requirements for uncontrolled rectifiers only;
- b) Interface model for the different systems connected;
- c) Energy efficiency addressed.

The text of this International Standard is based on the following documents:

| Draft       | Report on voting |
|-------------|------------------|
| 9/3224/FDIS | 9/3265/RVD       |

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

A list of all parts in the IEC 62590 series, published under the general title *Railway applications - Fixed installations - Electronic power converters*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn, or
- revised.

## INTRODUCTION

Electronic power converters for traction power supply differ from other converters for industrial use due to special electrical service conditions and due to the large range of load variations and the peculiar characteristics of the load.

For these reasons IEC 60146-1-1 does not fully cover the requirements of railway applications and the decision was taken to have a specific standard for this use.

Uncontrolled rectifiers consist of a rectifier diode assembly and a transformer. Both fulfil common requirements. The transformer determines the voltage versus current characteristic.

Converter transformers for fixed installations of railway applications are covered by IEC 62695.

## 1 Scope

This part of IEC 62590 describes functions and working principles, specifies requirements, interfaces and test methods of uncontrolled rectifiers for DC electric traction power supply systems. Uncontrolled rectifiers connect a 3AC power network with a DC electric traction system with a unidirectional power flow using diode assemblies.

The coordination between the transformer and the rectifier diode assembly is included.

This document applies to fixed installations of following electric traction power supply systems:

- railway networks;
- metropolitan transport networks including metros, tramways, trolleybuses and fully automated transport systems, magnetic levitated transport systems, electric road systems.

## 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 62695, *Railway applications - Fixed installations - Traction transformers*

IEC 62590-1:2025, *Railway applications - Electronic power converters for fixed installations - Part 1: General requirements*

## Bibliography

IEC 60050-551, *International Electrotechnical Vocabulary (IEV) - Part 551: Power electronics*

IEC 60076 (all parts), *Power transformers*

IEC 60076-1, *Power transformers - Part 1: General*

IEC 60076-11, *Power transformers - Part 11: Dry-type transformers*

IEC 60146-1-1, *Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements*

IEC TR 60146-1-2, *Semiconductor convertors - General requirements and line commutated convertors - Part 1-2: Application guidelines*

IEC 60529, *Degrees of protection provided by enclosures (IP code)*

IEC 60909-0:2016, *Short-circuit currents in three-phase a.c. systems - Part 0: Calculation of currents*

IEC 61000-2-12, *Electromagnetic compatibility (EMC) - Part 2-12: Environment; Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems; Basic EMC Publication*

IEC 61992 (all parts), *Railway applications - Fixed installations - DC switchgear*

IEC 62236-5:2018, *Railway applications - Electromagnetic compatibility - Part 5: Emission and immunity of fixed power supply installations and apparatus*

CEN/TR 17833, *Railway applications - Guidance for the use of simulations - Guidance for the use of simulations to demonstrate compliance with technical and regulatory requirements and on the introduction and development of simulation requirements into standards*

IEEE Std C37.2, *Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations*