



# SLOVENSKI STANDARD

## SIST EN 61287-1:2014

01-november-2014

---

**Železniške naprave - Močnostni pretvorniki na železniških vozilih - 1. del:  
Karakteristike in preskusne metode (IEC 61287-1:2014)**

Railway applications - Power converters installed on board rolling stock - Part 1:  
Characteristics and test methods

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

Ta slovenski standard je istoveten z: <sup>SIST EN 61287-1:2014</sup> **EN 61287-1:2014**  
<https://standards.iteh.ai/catalog/standards/sist/18062e2c-22fd-4339-86bb-67c366f064a2/sist-en-61287-1-2014>

---

**ICS:**

29.200	Usmerniki. Pretvorniki. Stabilizirano električno napajanje	Rectifiers. Convertors. Stabilized power supply
45.060.01	Železniška vozila na splošno	Railway rolling stock in general

**SIST EN 61287-1:2014**

**en**

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

SIST EN 61287-1:2014

<https://standards.iteh.ai/catalog/standards/sist/1b062e2c-22fd-4339-86bb-67c366f064a2/sist-en-61287-1-2014>

EUROPEAN STANDARD

EN 61287-1

NORME EUROPÉENNE

EUROPÄISCHE NORM

September 2014

ICS 45.060

Supersedes EN 61287-1:2006

English Version

## Railway applications - Power converters installed on board rolling stock - Part 1: Characteristics and test methods (IEC 61287-1:2014)

Applications ferroviaires - Convertisseurs de puissance  
embarqués sur le matériel roulant - Partie 1:  
Caractéristiques et méthodes  
(CEI 61287-1:2014)

Bahnanwendungen - Stromrichter auf Bahnfahrzeugen -  
Teil 1: Eigenschaften und Prüfverfahren  
(IEC 61287-1:2014)

This European Standard was approved by CENELEC on 2014-08-14. 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.

SIST EN 61287-1:2014

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

## Foreword

The text of document 9/1918/FDIS, future edition 3 of IEC 61287-1, prepared by IEC/TC 9 "Electrical equipment and systems for railways" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61287-1:2014.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2015-05-14
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2017-08-14

This document supersedes EN 61287-1:2006.

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

**iTeh STANDARD PREVIEW**  
(standards.iteh.ai)

### Endorsement notice

[SIST EN 61287-1:2014](https://standards.iteh.ai/catalog/standards/sist/1b062e2c-22fd-4339-86bb-67c366f064a2/sist-en-61287-1-2014)

[https://standards.iteh.ai/catalog/standards/sist/1b062e2c-22fd-4339-86bb-](https://standards.iteh.ai/catalog/standards/sist/1b062e2c-22fd-4339-86bb-67c366f064a2/sist-en-61287-1-2014)

[67c366f064a2/sist-en-61287-1-2014](https://standards.iteh.ai/catalog/standards/sist/1b062e2c-22fd-4339-86bb-67c366f064a2/sist-en-61287-1-2014)

The text of the International Standard IEC 61287-1:2014 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 standards indicated:

IEC 60112	NOTE	Harmonized as EN 60112.
IEC 60146-1-1	NOTE	Harmonized as EN 60146-1-1.
IEC 60216	NOTE	Harmonized in EN 60216 series (not modified).
IEC 60384-1	NOTE	Harmonized as EN 60384-1.
IEC 60587	NOTE	Harmonized as EN 60587.
IEC 60664-1:2007	NOTE	Harmonized as EN 60664-1:2007 (not modified).
IEC 60747-15	NOTE	Harmonized as EN 60747-15.
IEC 61377-1	NOTE	Harmonized as EN 61377-1.
IEC 61377-2	NOTE	Harmonized as EN 61377-2.
IEC 61377-3	NOTE	Harmonized as EN 61377-3.
IEC 62520	NOTE	Harmonized as EN 62520.

## Annex ZA (normative)

### Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When 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.cenelec.eu](http://www.cenelec.eu).

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-551	1998	International Electrotechnical Vocabulary (IEV) - Part 551: Power electronics	-	-
IEC 60050-811	1991	International electrotechnical vocabulary (IEV) - Chapter 811: Electric traction	-	-
IEC 60076-10	2001	Power transformers - Part 10: Determination of sound levels	EN 60076-10	2001
IEC 60077-1 (mod)	1999	Railway applications - Electric equipment for rolling stock - Part 1: General service conditions and general rules	EN 60077-1	2002
IEC 60270	-	High-voltage test techniques - Partial discharge measurements	EN 60270	-
IEC 60310	-	Railway applications - Traction transformers and inductors on board rolling stock	EN 60310	-
IEC 60322	-	Railway applications - Electric equipment for rolling stock - Rules for power resistors of open construction	EN 60322	-
IEC 60349-1	-	Electric traction - Rotating electrical machines for rail and road vehicles - Part 1: Machines other than electronic converter-fed alternating current motors	EN 60349-1	-
IEC 60349-2	-	Electric traction - Rotating electrical machines for rail and road vehicles - Part 2: Electronic converter-fed alternating current motors	EN 60349-2	-
IEC 60349-4	-	Electric traction - Rotating electrical machines for rail and road vehicles - Part 4: Permanent magnet synchronous electrical machines connected to an electronic converter	EN 60349-4	-

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60384-4	-	Fixed capacitors for use in electronic equipment - Part 4: Sectional specification - Aluminium electrolytic capacitors with solid (MnO <sub>2</sub> ) and non-solid electrolyte	EN 60384-4	-
IEC 60529	-	Degrees of protection provided by enclosures (IP Code)	EN 60529	-
IEC 60571	-	Railway applications - Electronic equipment used on rolling stock	-	-
IEC 60721-3-5	-	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 5: Ground vehicle installations	EN 60721-3-5	-
IEC 60747	series	Semiconductor devices	EN 60747	series
IEC 60850	-	Railway applications - Supply voltages of traction systems	-	-
IEC 61148	-	Terminal markings for valve device stacks and assemblies and for power conversion equipment	EN 61148	-
IEC 61373	-	Railway applications - Rolling stock equipment - Shock and vibration tests	EN 61373	-
IEC 61881	series	Railway applications - Rolling stock equipment - Capacitors for power electronics	EN 61881	series
IEC 61991	-	Railway applications - Rolling stock - Protective provisions against electrical hazards	-	-
IEC 62236-3-1	-	Railway applications - Electromagnetic compatibility - Part 3-1: Rolling stock - Train and complete vehicle	-	-
IEC 62236-3-2	-	Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus	-	-
IEC 62278	-	Railway applications - Specification and demonstration of reliability, availability, maintainability and safety (RAMS)	-	-
IEC 62497-1 + A1	2010 2013	Railway applications - Insulation coordination - Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment	-	-
IEC 62498-1	2010	Railway applications - Environmental conditions for equipment - Part 1: Equipment on board rolling stock	-	-



IEC 61287-1

Edition 3.0 2014-07

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

**Railway applications – Power converters installed on board rolling stock –  
Part 1: Characteristics and test methods**

**Applications ferroviaires – Convertisseurs de puissance embarqués sur  
le matériel roulant –  
Partie 1: Caractéristiques et méthodes d'essais**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

PRICE CODE  
CODE PRIX

**XA**

ICS 45.060

ISBN 978-2-8322-1658-3

**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.....	5
1 Scope.....	7
2 Normative references.....	7
3 Terms and definitions .....	9
3.1 General.....	9
3.2 Terms and definitions related to equipment .....	9
3.3 Terms and definitions related to electrical parameters .....	11
4 Common clauses .....	12
4.1 General.....	12
4.1.1 Design .....	12
4.1.2 Marking .....	12
4.1.3 Technical documentation .....	12
4.1.4 Reliability, availability, maintainability and safety .....	13
4.1.5 Useful lifetime.....	14
4.2 Service conditions .....	14
4.2.1 General .....	14
4.2.2 Altitude .....	14
4.2.3 Temperature.....	14
4.2.4 Other environmental conditions .....	15
4.2.5 Mechanical stress.....	15
4.2.6 Load profile.....	15
4.2.7 Supply-system characteristics.....	16
4.2.8 Interference .....	17
4.2.9 Input current limitations.....	18
4.2.10 Influence on the environment .....	18
4.3 Characteristics .....	19
4.3.1 Characteristics of components .....	19
4.3.2 Characteristics of semiconductor devices.....	19
4.3.3 Characteristics of transformers, reactors and capacitors .....	19
4.3.4 Characteristics of converters.....	20
4.4 Technical requirements .....	22
4.4.1 Insulation co-ordination.....	22
4.4.2 EMC requirements for converters .....	22
4.4.3 Fault effects.....	23
4.5 Tests .....	23
4.5.1 General .....	23
4.5.2 Converter tests .....	24
4.5.3 Description of tests .....	27
4.5.4 Failure of components during type tests .....	36
5 Direct traction converters .....	36
5.1 Line-commutated converters for DC motors.....	36
5.1.1 General .....	36
5.1.2 Characteristics.....	36
5.1.3 Tests .....	37
5.2 Choppers for DC motors.....	40
5.2.1 Characteristics.....	40



5.2.2	Tests .....	41
5.3	Multiphase converters for AC motors (inverters) .....	43
5.3.1	General .....	43
5.3.2	Characteristics .....	43
5.3.3	Tests .....	44
6	Indirect traction converters .....	44
6.1	General .....	44
6.2	Line converter .....	44
6.2.1	General .....	44
6.2.2	Characteristics .....	45
6.2.3	Tests .....	45
6.3	Motor converter .....	46
6.3.1	Motor converter for DC motors (chopper or rectifier) .....	46
6.3.2	Motor converter for AC motors (inverter) .....	46
7	Auxiliary converters .....	46
7.1	General .....	46
7.2	Characteristics .....	46
7.2.1	Auxiliary converter starting conditions .....	46
7.2.2	Input conditions and characteristics .....	47
7.2.3	Output characteristics .....	47
7.3	Short-circuit protection .....	48
7.4	Choice of rated insulation voltage .....	48
7.5	Tests .....	49
7.5.1	General .....	49
7.5.2	Output characteristics test .....	49
7.5.3	Starting and restarting test .....	50
7.5.4	Short-circuit test .....	50
7.5.5	Voltage and frequency ranges verification .....	50
7.5.6	Overload capability test .....	50
7.5.7	Temperature rise test .....	51
7.5.8	Load break test .....	51
8	Semiconductor drive units (SDU) .....	51
8.1	Equivalent expressions .....	51
8.2	Printed circuit board assemblies .....	52
8.3	Function of the SDU .....	52
8.4	Particular requirements for the SDU .....	52
8.5	Service conditions .....	52
8.6	Insulation requirements for the SDU .....	52
8.7	Electromagnetic compatibility requirements .....	52
8.8	Tests of the SDU .....	52
Annex A	(normative) Arrangement of basic circuit diagrams .....	54
Annex B	(informative) Recapitulation of agreements between the manufacturer and the user .....	55
Annex C	(informative) Guidelines for magnetic field and induced voltage requirements .....	58
Bibliography	.....	59
Figure 1	– Partial discharge test – Voltage versus time .....	26
Figure 2	– Configuration of series motors .....	39

Figure A.1 – Examples of combinations .....	54
Table 1 – General classes of start-up load characteristics .....	15
Table 2 – Classes of acoustic noise .....	19
Table 3 – List of tests .....	27
Table 4 – Additional tests for direct traction converters .....	38
Table 5 – Additional tests for choppers for DC motors .....	41
Table 6 – Additional tests for auxiliary converters .....	49
Table B.1 – Recapitulation of agreements between the manufacturer and the user .....	55

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

SIST EN 61287-1:2014

<https://standards.iteh.ai/catalog/standards/sist/1b062e2c-22fd-4339-86bb-67c366f064a2/sist-en-61287-1-2014>

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RAILWAY APPLICATIONS –  
POWER CONVERTERS INSTALLED  
ON BOARD ROLLING STOCK –****Part 1: Characteristics and test methods**

## 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 61287-1 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This third edition cancels and replaces the second edition published in 2005. This edition constitutes a technical revision.

This edition includes the following main technical changes with regard to the previous edition: it includes updates as necessary in order to meet the current technical state of the art and to improve clarity. It also takes into account generic railway standards as relevant parts of IEC 62497 and IEC 62498. Especially the clauses considering temperature rise test and auxiliary converter characteristics have been revised.

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

FDIS	Report on voting
9/1918/FDIS	9/1946/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.

A list of all parts of IEC series 61287, under the general title *Railway applications – Power converters installed on board rolling stock*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site 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.

## iTeh STANDARD PREVIEW (standards.iteh.ai)

SIST EN 61287-1:2014

<https://standards.iteh.ai/catalog/standards/sist/1b062e2c-22fd-4339-86bb-67c366f064a2/sist-en-61287-1-2014>

# RAILWAY APPLICATIONS – POWER CONVERTERS INSTALLED ON BOARD ROLLING STOCK –

## Part 1: Characteristics and test methods

### 1 Scope

This part of IEC 61287 defines terminology, service conditions, general characteristics and test methods of electronic power converters onboard of rolling stock.

This International Standard is applicable to power electronic converters mounted on board railway rolling-stock and intended for supplying

- traction circuits;
- auxiliary circuits of power vehicles, coaches and trailers.

The application of this standard extends as far as possible to all other traction vehicles, including trolley-buses, for example.

This standard covers the complete converter assembly together with its mounting arrangements containing

- semiconductor device assemblies;
- integrated cooling systems;
- integrated components like inductors, capacitors, transformers, resistors, contactors, switches;
- semiconductor drive units (SDU) and related sensors;
- incorporated protection circuits.

The following types of power sources are taken into consideration:

- AC contact lines,
- DC contact lines,
- on-board supplies such as generators, batteries and other electric power sources.

This standard excludes converters which provide the electronic control supply for semiconductor drive units (SDU) and other supplies relevant to the converter operation such as sensors.

NOTE 1 Electronic control equipment of converters and those sensors not related to semiconductor drive units and the printed circuit board assemblies of semiconductor drive units (SDU) are covered by IEC 60571.

NOTE 2 Combined tests with the whole traction system or auxiliary supply system are not within the scope of this standard. E.g. rules for combined tests of a motor fed by a converter are given in the IEC 61377 series.

### 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-551:1998, *International Electrotechnical Vocabulary (IEV) – Part 551: Power electronics*

IEC 60050-811:1991, *International Electrotechnical Vocabulary – Chapter 811: Electric traction*

IEC 60076-10:2001, *Power transformers – Part 10: Determination of sound levels*

IEC 60077-1:1999, *Railway applications – Electric equipment for rolling stock – Part 1: General service conditions and general rules*

IEC 60270, *High-voltage test techniques – Partial discharge measurements*

IEC 60310, *Railway applications – Traction transformers and inductors on board rolling stock*

IEC 60322, *Railway applications – Electric equipment for rolling stock – Rules for power resistors of open construction*

IEC 60349-1, *Electric traction – Rotating electrical machines for rail and road vehicles – Part 1: Machines other than electronic converter-fed alternating current motors*

IEC 60349-2, *Electric traction – Rotating electrical machines for rail and road vehicles – Part 2: Electronic converter-fed alternating current motors*

IEC 60349-4, *Electric traction – Rotating electrical machines for rail and road vehicles – Part 4: Permanent magnet synchronous electrical machines connected to an electronic converter*

IEC 60384-4, *Fixed capacitors for use in electronic equipment – Part 4: Sectional specification – Aluminium electrolytic capacitors with solid (MnO<sub>2</sub>) and non-solid electrolyte*

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

IEC 60571, *Railway applications – Electronic equipment used on rolling stock*

IEC 60721-3-5, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 5: Ground vehicle installations*

IEC 60747 (all parts), *Semiconductor devices – Discrete devices*

IEC 60850, *Railway applications – Supply voltages of traction systems*

IEC 61148, *Terminal markings for valve device stacks and assemblies and for power conversion equipment*

IEC 61373, *Railway applications – Rolling stock equipment – Shock and vibration tests*

IEC 61881 (all parts), *Railway applications – Rolling stock equipment – Capacitors for power electronics*

IEC 61991, *Railway applications – Rolling stock – Protective provisions against electrical hazards*

IEC 62236-3-1, *Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock – Train and complete vehicle*

IEC 62236-3-2, *Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus*

IEC 62278, *Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS)*

IEC 62497-1:2010, *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*

IEC 62497-1:2010/AMD1:2013

IEC 62498-1:2010, *Railway applications – Environmental conditions for equipment – Part 1: Equipment on board rolling stock*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-551:1998 and IEC 60050-811:1991, as well as the following, apply.

#### 3.1 General

##### 3.1.1

##### **user**

party which is responsible for the specification and the integration of the power converter into the railway vehicle

##### 3.1.2

##### **manufacturer**

party which designs and manufactures the power converter

##### 3.1.3

##### **railway authority**

organization which allows vehicle operators to operate railway vehicles and defines rules for safe operation

##### 3.1.4

##### **test specification**

document that specifies the requirements for one or more tests

Note 1 to entry: For instance test acceptance criteria, test conditions, test methods.

Note 2 to entry: According to the specific terminologies used in the quality management systems of various organisations that perform tests on power converters for rolling stock, this document may have another title e.g. test plan.

#### 3.2 Terms and definitions related to equipment

##### 3.2.1

##### **(electronic) (power) converter**

an operative unit for electronic power conversion, comprising one or more electronic valve devices, transformers and filters if necessary and auxiliaries if any

Note 1 to entry: A converter is defined by the input and output electrical characteristics. The converter may comprise a discrete chopper, inverter, etc. or a combination of these not necessarily in one cubicle.

Note 2 to entry: The converter is a part of the propulsion (or auxiliary) equipment. The converter may include, for example, a line circuit breaker, filter, transformer, cooling system, etc.

[SOURCE: IEC 60050-551:1998, 551-12-01]