

INTERNATIONAL STANDARD

**Railway applications - Electronic power converters for fixed installations -
Part 2-2: DC Traction applications - Controlled converters**

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

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

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**Railway applications -
Electronic power converters for fixed installations -
Part 2-2: DC Traction applications - Controlled converters**

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

This first edition partially cancels and replaces IEC 62589 and IEC 62590. This edition constitutes a technical revision.

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

Draft	Report on voting
9/3312/FDIS	9/3328/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. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62590 series, published under the general title *Railway applications - Electronic power converters for fixed installations*, 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 in the data related to the specific document. At this date, the document will be

- reconfirmed,
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INTRODUCTION

Semiconductor converters for traction power supply differ from other electronic power converters for industrial use due to special electrical service conditions and due to the large range of load variation and the particular characteristics of the load.

Controlled rectifiers supply a DC traction network from a three-phase power network using controllable semiconductor valves. Inverters allow the recuperation of power from a DC traction network into a three-phase power network. Reversible converters combine the functions of a rectifier and an inverter.

DC converters are self-commutated converters for connecting the DC traction network to other DC networks or storage devices.

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1 Scope

This part of IEC 62590 describes functions and working principles, specifies requirements, interfaces, and test methods for controlled converters for DC electric traction power supply systems:

- AC/DC converters:
 - rectifiers,
 - inverters,
 - combinations.
- DC converters.

The purpose of the converters can be a power connection to other power networks or energy storages.

The common characteristic of this equipment is the possibility to influence the power flow in the DC electric traction power supply system. The converters can be:

- line-commutated;
- self-commutated.

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

- railway networks,
- metropolitan transport networks including metros, tramways, trolleybuses and fully automated transport systems, magnetic levitated transport systems, and 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 60071-1, *Insulation co-ordination - Part 1: Definitions, principles and rules*

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

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

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

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

3 Terms, definitions, symbols, and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC 62590-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1 Terms and definitions

3.1.1 Semiconductor devices and combinations

3.1.1.1 rated current

I_{Nd}

<of a controlled converter> value of a DC current a controlled converter is designed for, referring to the DC electric traction power supply system

Note 1 to entry: All rated values of the components are derived from this value.

Note 2 to entry: A converter can have a rated continuous current and rated currents in conjunction with a duty class.

3.1.1.2 rated DC power

<of a controlled converter> rated current multiplied with nominal DC voltage

Note 1 to entry: This value refers to DC electric traction power supply system side.

3.1.1.3 reversible converter

converter in which the direction of the power flow is reversible

[SOURCE IEC 60050-551:1998, 551-12-37, modified – Figure 1 has been omitted.]

3.1.2 Line-commutated converters

3.1.2.1 trigger delay angle

time expressed in angular measure by which the trigger pulse is delayed with respect to the reference instant in the case of phase control

Note 1 to entry: With line, machine or load commutated converters the reference instant is the zero crossing instant of the commutating voltage. With AC controllers it is the zero crossing instant of the supply voltage. For AC controllers with inductive loads the trigger delay angle is the sum of the phase shift and the current delay angle.

[SOURCE: IEC 60050-551:1998, 551-16-33, modified – In the definition, “the” has been deleted.]

3.1.2.2 commutation failure

failure to commute the current from a conducting arm to the succeeding arm

[SOURCE: IEC 60050-551:1998, 551-16-59, modified – In the definition, “a” has been deleted]

3.1.3 Self-commutated converters

3.1.3.1

switched valve device

controllable valve device which can be turned on and off by a control signal

[SOURCE: IEC 60050-551:1998, 551-14-08, modified – In the definition, “a” has been deleted, “may” has been replaced with “can”.]

3.1.3.2

free-wheeling diode

diode parallel to a switched valve device in reverse direction fulfilling the purpose of a free-wheeling arm

3.1.3.3

buck converter

direct DC converter providing an output voltage which is lower than the input voltage

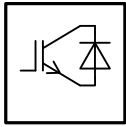
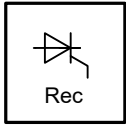
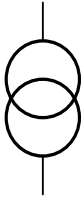
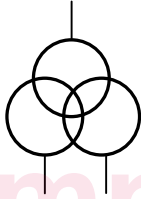

[SOURCE: IEC 60050-551:1998, 551-12-33]

3.2 Graphical symbols

Table 1 lists all symbols used in this document. These symbols are based on symbols registered in IEC 60617.

Table 1 – Graphical symbols

Symbol	Explanation
	<p>AC/DC converter with optional indication of power flow direction</p> <p>SOURCE: IEC 60617-S00213:2001-07; IEC 60617-S01402:2001-09; IEC 60617-S01403:2001-09 IEC 60617-S00099:2001-07; IEC 60617-S00100:2001-07; IEC 60617-S01407:2001-10.</p>
	<p>DC converter</p> <p>SOURCE: IEC 60617-S00213:2001-07; IEC 60617-S01402:2001-09.</p>
	<p>DC converter with isolation between 2 electrical circuits</p> <p>SOURCE: IEC 60617-S00213:2001-07; IEC 60617-S01402:2001-09; IEC 60617-S01407:2001-10</p>
	<p>diode rectifier (valve device) assembly</p> <p>SOURCE: IEC 60617-S00641:2001-07;</p>

Symbol	Explanation
	IGBT converter (valve device) assembly SOURCE: IEC 60617-S00616:2001-07; IEC 60617 S00621:2001-07; IEC 60617-S00624:2001-07; IEC 60617-S00641:2001-07.
	thyristor converter (valve device) assembly SOURCE: IEC 60617-S00654:2001-07.
	Transformer with two windings SOURCE: IEC 60617-S00841:2001-07.
	Transformer with three windings SOURCE: IEC 60617-S00844:2001-07.
	Group of connections SOURCE: IEC 60617-S00002:2001-07.

3.3 Abbreviated terms

3AC	three phase alternating current
AC	alternating current
ACTB	apparatus for connecting the ESU to the DC bus
DC	direct current
ESS	energy storage system
ESU	energy storage unit
IGBT	insulated gate bipolar transistor
U_a	power frequency test voltage for power frequency withstand voltage test
U_{dN}	nominal DC voltage
U_{v0}	no load transformer voltage, valve side

4 System configurations

4.1 General

The main purpose of controlled electronic power converters for DC electric traction power supply systems is to establish an intended power flow. The power can flow from a 3AC power network to the DC electric traction system or vice versa. This can also be a bidirectional power flow to energy storages or other equipment using regenerated power.

4.2 Purpose of converters

4.2.1 AC/DC converters

4.2.1.1 General

The AC/DC converters connect a 3AC power network with a DC electric traction power supply system as shown in Figure 1. Requirements from both networks shall be applied, see 5.3.

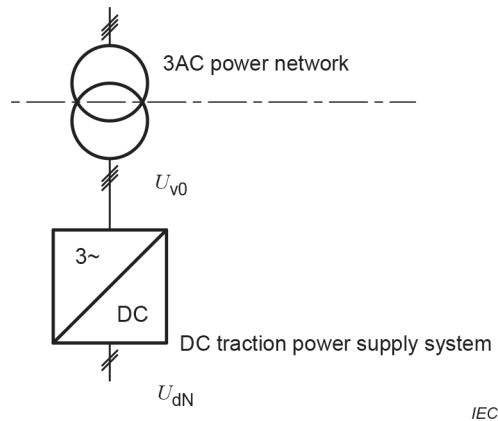


Figure 1 – General arrangement of AC/DC converters

4.2.1.2 Rectifiers

The purpose of rectifiers is to have a power flow from the 3AC power network to the DC electric traction power supply system.

Controlled rectifiers operate on an adjustable characteristic curve in the current versus voltage plane. This characteristic can be adjustable. Examples are given in Annex A. Limits can be included.

Controlled rectifiers can be line-commutated or self-commutated.

A suitable duty class should be chosen from IEC 62590-1:2025, 5.7.2.

4.2.1.3 Inverters

The purpose of inverters is to enable a power flow from the DC electric traction power supply system to the 3AC power network to improve the energy efficiency of the railway system.

Inverters operate on an adjustable characteristic curve in the current versus voltage plane. This characteristic can be adjustable. Examples are given in Annex A. Limits can be included.

Inverters can be line-commutated or self-commutated.

The definition of a load cycle is appropriate in most cases, see IEC 62590-1:2025, 5.7.3.

4.2.1.4 Reversible converters

The purpose of the combination of a rectifier and an inverter is to enable a bidirectional power exchange between a 3AC power network and the DC electric traction power supply system.

Reversible converters operate on an adjustable characteristic curve in the current versus voltage plane. This characteristic can be adjustable. Examples are given in Annex A. Limits can be included.

There is a broad variety of combinations using line-commutated and self-commutated converters, see Table 2.

Figure 2 to Figure 5 show various possible combinations of rectifiers and inverters that can be installed in a reversible substation. They can share the same transformer, the same control, or the same filter.

Commonly used parts of the reversible converter are subject to a combined load requirement.

For the rectifier part a suitable duty class should be chosen. For the inverter part a suitable load cycle or a suitable duty class should be chosen according to the application, see Figure 2 to Figure 5. This can result in an asymmetric load for 3 winding transformers in special cases shown in Figure 3 and Figure 4.

IEC 62590-2-1 applies to the uncontrolled part of the reversible converter, if any, and this document applies to the inverter part.

Table 2 – Rectifiers, inverters and combinations

	Rectifier	Inverter	Reversible converter
General symbol			
Examples of associated transformer and valve device assembly	 	 	
NOTE 1	The symbols represent typical valve devices used in the respective application.		
NOTE 2	"Rec" indicates the use of a rectifier and "Inv" the use of an inverter.		

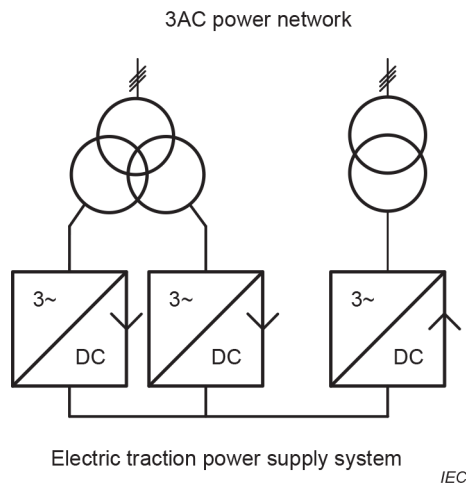
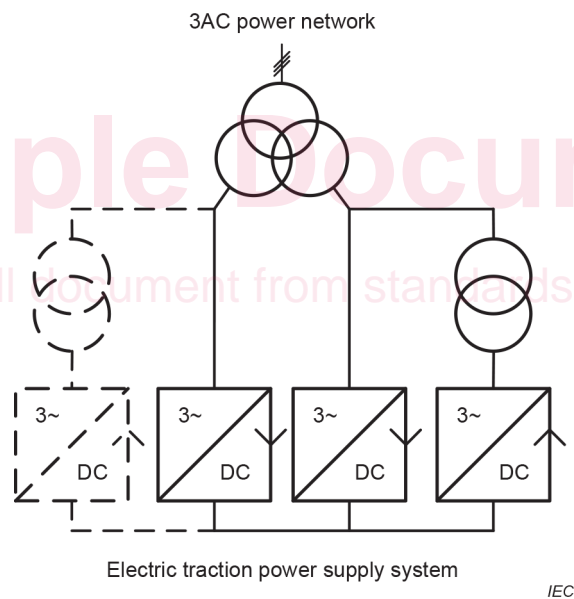


Figure 2 – Connection with separate transformers

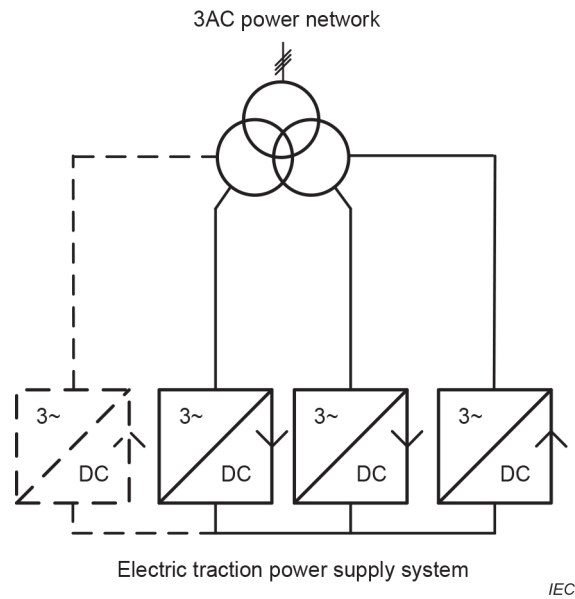
A reversible converter configuration can consist of a separated rectifier and inverter. Figure 2 shows such a configuration. Both can be connected to the same 3AC power network or to different 3AC power networks. The function and design are as independent as possible.



NOTE Dashed symbols represent optional components to achieve symmetry.

Figure 3 – Connection with combined transformer

A reversible converter configuration can share the same main transformer. Such a configuration is shown in Figure 3. In this case an additional transformer is used to adapt the inverter 3AC voltage to the rectifier 3AC voltage. If a three-winding transformer with two traction side windings is used, a single inverter or multiple inverters can be connected to one or both windings equally. The main transformer shall be designed for both power flow directions.



NOTE Dashed symbols represent optional components to achieve symmetry.

Figure 4 – Connection with combined transformer with taps

Figure 4 shows a configuration with a combined transformer with taps. No additional transformer is used for the adaptation of the inverter and rectifier voltage.

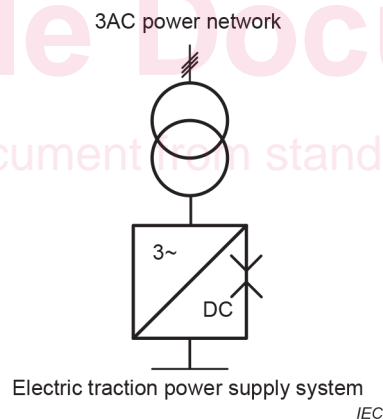


Figure 5 – Converter with reversible valve device assembly

Figure 5 shows the configuration of a reversible converter using a unique all-in-one reversible valve device assembly associated with a unique transformer. In this case, the control for both flow directions is integrated.

More than one traction side transformer winding can be used.

4.2.1.5 Reversible AC/DC converters for energy storages

The purpose of a reversible converter for an energy storage is to connect the DC electric traction power supply system to an energy storage unit. In this case the ESU is a rotating machine.

IEC 62924 covers reversible converters for energy storage. The converter fulfils the function of the ACTB.

The configuration is shown in Figure 6.