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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Fixed installations – Electronic power converters – Part 3-1: AC traction applications – Electronic power compensators

Applications ferroviaires – Installations fixes – Convertisseurs electroniques de puissance – Partie 3-1: Applications de traction en courant alternatif – Compensateurs électroniques de puissance

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RAILWAY APPLICATIONS – FIXED INSTALLATIONS – ELECTRONIC POWER CONVERTERS –

Part 3-1: AC traction applications – Electronic power compensators

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

Draft	Report on voting
9/2843/FDIS	9/2864/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 – 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 in the data related to the specific document. At this date, the document will be

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- withdrawn,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

INTRODUCTION

Single-phase AC traction systems are typically used for railway lines with high power load up to the double-digit MW range. The nature of the loads serving the intended traffic in those railway lines leads to permanent power fluctuations. Due to their inherent structure, single-phase traction systems are prone to having difficulty with power quality indicators such as power factor, voltage fluctuation and/or imbalance within the electric traction system and/or the feeding three-phase power network. In order to improve the power quality, an electronic power compensator can be applied.

Components of electronic power compensators especially electronic power converters must withstand the more rugged electric environment when compared with those for other industrial use, due to the nature of electric traction systems mentioned above. This includes not only high load fluctuation, but also frequent switching operation with inrush current and short circuits caused by faults on the overhead contact line systems. Therefore, specific requirements are needed in addition to the common requirements for converters for other industrial use.

This document defines typical system configurations and basic requirements as well as appropriate test methods for electronic power compensators used for single-phase AC traction systems. This document is intended for the use by railway operators, manufacturers and system integrators.

RAILWAY APPLICATIONS – FIXED INSTALLATIONS – ELECTRONIC POWER CONVERTERS –

Part 3-1: AC traction applications – Electronic power compensators

1 Scope

This document specifies the requirements and test methods for electronic power compensators for 1AC traction systems. This equipment is used to improve electric power quality inside the electric traction system and/or at the interface to the 3AC power network, applying power electronics technology.

This document applies to equipment which is installed to achieve one or more of the following objectives as its function(s):

- to mitigate voltage fluctuation;
- to improve power factor;
- to reduce imbalance at the interface to the 3AC power network.

NOTE In some cases, this type of equipment is used to reduce harmonics from the traction load towards the 3AC power network, and for energy saving.

The equipment designed to conform to each particular installation site and the packaged equipment for generic use both fall within the scope of this document.

This document applies to equipment with all possible configurations to implement different technical solutions for compensation, but equipment consisting of only passive components is excluded.

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 60050-151:2001, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices*
IEC 60050-151:2001/AMD1:2013
IEC 60050-151:2001/AMD2:2014
IEC 60050-151:2001/AMD3:2019
IEC 60050-151:2001/AMD4:2020
IEC 60050-151:2001/AMD5:2021

IEC 60146-1-1:2009, *Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements*

IEC 60146-2:1999, *Semiconductor converters – Part 2: Self-commutated semiconductor converters including direct d.c. converters*

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

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

IEC 61000-4-30:2015, *Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods*
IEC 61000-4-30:2015/AMD1:2021

IEC 61936-1, *Power installations exceeding 1 kV AC and 1,5 kV DC – Part 1: AC*

IEC 62236-2, *Railway applications – Electromagnetic compatibility – Part 2: Emission of the whole railway system to the outside world*

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

IEC 62313, *Railway applications – Power supply and rolling stock – Technical criteria for the coordination between power supply (substation) and rolling stock*

IEC 62590:2019, *Railway applications – Fixed installations – Electronic power converters for substations*

IEC 62695:2014, *Railway applications – Fixed installations – Traction transformers*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62590:2019 and the following apply.

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

- IEC Electropedia: available at http://www.electropedia.org/
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3.1.1
power quality
characteristics of the electric current, voltage and frequency at a given point in an electric power system, evaluated against a set of reference technical parameters

Note 1 to entry: These parameters might, in some cases, relate to the compatibility between electricity supplied in an electric power system and the loads connected to that electric power system.

[SOURCE: IEC 60050-614:2016, 614-01-01]

3.1.2
power factor
under periodic conditions, ratio of the absolute value of the active power P to the apparent power S:

$$\lambda = \frac{|P|}{S}$$

Note 1 to entry: Under sinusoidal conditions, the power factor is the absolute value of the active factor.

[SOURCE: IEC 60050-131:2002, 131-11-46]

3.1.3
compensate
<electric power>improve power quality at a certain point of the circuit

3.1.4
electric traction system
railway electric distribution network used to provide energy for rolling stock

Note 1 to entry: The system includes:

– contact line systems,

– return circuit of electric traction systems,

– electric installations, which are supplied from contact lines either directly or via a transformer,

– electric installations in power plants and substations, which are utilized solely for generation and distribution of power directly to the contact line,

– electric installations of switching stations.

[SOURCE: IEC 60050-811:2017, 811-36-21, modified − third dash in the list of the Note 1 to entry was removed.]

3.1.5
1AC traction system
single phase traction system
electric traction system operating with single phase AC

Note 1 to entry: The system includes auto-transformer system.

3.1.6
near end
<of electric traction system> area in electric traction system close to the traction substation

Note 1 to entry: This term is typically used for the single-side-fed electric traction systems.

3.1.7
far end
<of electric traction system> area in electric traction system most distant from the traction substation, typically near a sectioning post

Note 1 to entry: This term is typically used for the single-side-fed electric traction systems.

3.1.8
feeding section
electric section of the route fed by individual track feeder circuit-breakers within the area supplied by one or more substations

[SOURCE: IEC 60050-811:2017, 811-36-25]

3.1.9
3AC power network
three phase power network
three-phase electric circuit or set of electric circuits, interconnected or having intentional capacitive or inductive coupling between them

Note 1 to entry: In this document, this term is used to indicate an upstream power supply network.

3.1.10
traction unit
locomotive, motor coach or train-unit

[SOURCE: IEC 60050-811, 811-02-04]

3.1.11
voltage drop
<of electric traction system> change of the voltage at the location of traction unit due to impedance of electric traction system as well as impedance of the 3AC power network, measured when traction current flows from or into traction units

3.1.12
voltage fluctuation
<of electric traction system> series of supply voltage changes or continuous variation of the RMS or peak value of the voltage

Note 1 to entry: Whether the RMS or peak value is chosen depends upon the application, and which is used should be specified.

[SOURCE: IEC 60050-161:1990, 161-08-05, modified – “series of voltage” was replaced with “series of supply voltage”.]

3.1.13
voltage imbalance
in a polyphase system, condition in which the RMS values of the phase voltages or the phase angles between consecutive phases are not all equal

[SOURCE: IEC 60050-161:1990, 161-08-09]

3.1.14
negative sequence component
<of a three-phase system> one of the three symmetrical sequence components which exists only in an unsymmetrical three-phase system of sinusoidal quantities and which is defined by the following complex mathematical expression:

$$X_2 = \frac{1}{3}\left(X_{L1} + a^2 X_{L2} + a X_{L3}\right)$$

where a is the 120-degree operator, and X_{L1}, X_{L2} and X_{L3} are the complex expressions of the phase quantities concerned, and where X denotes the system current or voltage phasors

[SOURCE: IEC 60050-448:1995, 448-11-28]

3.1.15
electronic power converter
operative unit for electronic power conversion, comprising one or more electronic valve devices, transformers and filters if necessary and auxiliaries if any

[SOURCE: IEC 60050-551:1998, 551-12-01, modified – Note and Figure 1 were removed.]

3.1.16
self-commutation
commutation where the commutating voltage is supplied by components within the converter or the electronic switch

[SOURCE: IEC 60050-551:1998, 551-16-15]

3.1.17
line-commutation
external commutation where the commutating voltage is supplied by the line

[SOURCE: IEC 60050-551:1998, 551-16-12]

3.1.18
electronic power compensator
EPC
equipment to improve power quality of the circuit to which it is connected, controlling current and/or voltage by use of electronic power converters

3.1.19
static var compensator
SVC
electronic power compensator adjusting reactive power

Note 1 to entry: The whole arrangement consists of fixed elements and adjustable elements. Line-commutated or self-commutated converters are examples of adjustable elements.

3.1.20
balancer
<of traction substation> electronic power compensator to reduce imbalance

Note 1 to entry: A positive side effect of a balancer is reducing voltage fluctuation and/or improving power factor in the 1AC traction system as well as the 3AC power network.

3.1.21
railway static power conditioner
RPC
set of converters which exchanges active power between different sections in the electric traction system as well as injects reactive power

Note 1 to entry: Currently, the only configuration that has been used in the already commissioned RPC is that which consists of a pair of self-commutated single-phase inverters connected back-to-back to each other through a common DC link.

Note 2 to entry: It is used to connect two feeding sections supplied by two traction substations, as well as two feeding sections supplied by two single-phase voltage sources of different phases from the same traction substation.

3.1.22
STATCOM
SVG
static var compensator using set of self-commuted converters

Note 1 to entry: “STATCOM” is used in Europe and “SVG” is used in Japan.

3.1.23
Steinmetz principle
principle for balancing voltage and/or current of an unbalanced 3AC circuit by applying reactive load between two or more pairs of phases

3.1.24
Scott connection
method of interconnecting the windings of two single-phase transformers for the transformation of three-phase voltages to two-phase voltages or vice versa

Note 1 to entry: The voltage and current of 3AC side will balance when the two loads of two 1AC side circuits are equal.

[SOURCE: IEC 60050-421:1990, 421-10-06, modified – Note 1 to entry was added.]

3.1.25
V-connection
two single phase loads between 2 different pairs of phases of a 3AC power network

Note 1 to entry: This leads statistically to a better-balanced load than one combined single-phase load.

3.1.26
rated capacity
<of electronic power compensator> capacity of electronic power compensator to fulfil its main purpose, where calculation method and condition of equipment for measurement are defined depending on the purpose and configuration of the equipment

Note 1 to entry: Typical rated capacity is expressed in active power, reactive power, apparent power or current.

3.1.27
rated voltage
<of electronic power compensator> voltage of electronic power compensator to operate, where part and condition of equipment for measurement are defined depending on the purpose and configuration of the equipment

3.1.28
rated current
<of electronic power compensator> current of electronic power compensator to operate, where part and condition of equipment for measurement are defined depending on the purpose and configuration of the equipment

3.1.29
rated frequency
<of electronic power compensator> frequency of electronic power compensator to operate, where part and condition of equipment for measurement are defined depending on the purpose and configuration of the equipment

Note 1 to entry: Intended operational frequency of the electronic power converter is taken from IEC 60850.

3.1.30
conventional efficiency
η
power efficiency determined from calculation and/or measurement using the specified method

Note 1 to entry: Especially for large equipment as explained in 7.1.4, it is sometimes difficult to measure the power efficiency directly by testing equipment with rated load due to various restrictions.

3.1.31
control function
function intended to regulate the behaviour of equipment or systems

[SOURCE: IEC 61892-2:2019, 3.9]

3.1.32
protective function
<of electric traction system> function that operates to prevent harm to persons and/or damage to equipment

3.1.33
immunity level
<for compensator> specified value of an electrical disturbance below which the equipment is designed to meet the required performances or continue operation or avoid damage

[SOURCE: IEC 62590:2019, 3.11.2, modified − converter was replaced with equipment.]