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Bahnanwendungen - Ortsfeste Anlagen - Leistungselektronische Stromrichter für Unterwerke

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat 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 Central Secretariat has the same status as the official versions.

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CENELEC

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

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Foreword

This European Standard was prepared by SC 9XC, Electric supply and earthing systems for public transport equipment and ancillary apparatus (fixed installations) of Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50328 on 2002-09-01.

This European Standard supersedes EN 60146-1-1:1993 for the specific products concerning railway applications as mentioned in the scope of this standard.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2003-09-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2005-09-01

Annexes designated "informative" are given for information only.
In this standard, Annexes A, B and C are informative.

Contents

Introduction **5**

1 General **6**
1.1 Scope 6
1.2 Normative references 6
1.3 Classification of traction supply power converters and valve 7
1.4 List of principal letter symbols 8
1.5 Definitions 9

2 Service conditions **20**
2.1 Code of identification of cooling method 20
2.2 Environmental conditions 21
2.3 Electrical service conditions 23

3 Converter equipment and assemblies **25**
3.1 Electrical connections 25
3.2 Calculation factors 26
3.3 Losses and efficiency 27
3.4 Power factor 27
3.5 Direct voltage harmonic content 28
3.6 Electromagnetic compatibility (EMC) 28
3.7 Rated values for converters 28
3.8 Mechanical characteristics 31
3.9 Marking 32

4 Tests **33**
4.1 General 33
4.2 Test specifications 34

Annex A (informative) **Information required** **40**
A.1 General 40
A.2 Diode rectifiers 40
A.3 Controlled converters and inverters 41
A.4 Frequency converters (direct and d.c. link converters) 43

Annex B (informative) **Determination of the current capability through calculation of the virtual junction temperature** **45**
B.1 General 45
B.2 Approximation of the shape of power pulses applied to the semiconductor device 45
B.3 The superposition method for calculation of temperature 46
B.4 Calculation of virtual junction temperature for continuous load 46

Annex C (informative) **Index of definitions** **50**
Bibliography **53**

Figure 1 - Illustration of angles 13
Figure 2 - Voltage drop 17
Figure 3 - A.C. voltage waveform 24
Figure B.1 - Approximation of the shape of power pulses 46
Figure B.2 - Calculation of the virtual junction temperature for continuous load 47
Figure B.3 - Calculation of the virtual junction temperature for cyclic load 48

Table 1 - Immunity levels 19
Table 2 - Letter symbols for cooling mediums and heat transfer agents 20
Table 3 - Letter symbols for methods of circulation 20
Table 4 - Connections and calculation factors for line commutated converters 26
Table 5 - Standardized duty classes 30
Table 6 - Semiconductor device failure conditions 31
Table 7 - Summary of tests 34
Table 8 - Insulation levels for a.c./d.c. converters 36
Table B.1 - Examples for typical applications 49

Introduction

Semiconductor 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 variation and the peculiar characteristics of the load.

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

Converter transformers for fixed installations of railway applications are covered by EN 50329.

Harmonization of the rated values and tests of the whole converter group are covered by EN 50327.

1 General

1.1 Scope

This European Standard specifies the requirements for the performance of all fixed installations electronic power converters, using controllable and/or non-controllable electronic valves, intended for traction power supply.

The devices can be controlled by means of current, voltage or light. Non-bistable devices are assumed to be operated in the switched mode.

This European Standard applies to fixed installations of following electric traction systems:

– railways,

– guided mass transport systems such as: tramways, light rail systems, elevated and underground railways, mountain railways, trolleybusses.

This European Standard does not apply to

– cranes, transportable platforms and similar transportation equipment on rails,

– suspended cable cars,

– funicular railways.

This European Standard applies to diode rectifiers, controlled rectifiers, inverters and frequency converters.

The equipment covered in this European Standard is the converter itself.

1.2 Normative references

This European Standard incorporates by dated or undated reference provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed below. For dated references, subsequent amendments or revisions of any of these publications apply to this European Standard only when incorporated into it by amendment or revision. For undated references, the latest edition of the publication referred to applies (including amendments).

EN 50121 Series	2000	Railway applications - Electromagnetic compatibility
EN 50123-7-1	2003	Railway applications - Fixed installations - D.C. switchgear Part 7-1: Measurement, control and protection devices for specific use in d.c. traction systems - Application guide
EN 50124-1	2001	Railway applications - Insulation coordination Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment
EN 50163	1995	Railway applications - Supply voltages of traction systems
EN 50327	2003	Railway applications - Fixed installations - Harmonisation of the rated values for converter groups and tests on converter groups
EN 50329	2003	Railway applications - Fixed installations - Traction transformers
EN 60529	1991	Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)
EN 60721	Series	Classification of environmental conditions (IEC 60721 series)

EN 61000-2-4	1994	Electromagnetic compatibility (EMC) - Part 2-4: Environment - Compatibility levels in industrial plants for low-frequency conducted disturbances (IEC 61000-2-4:1994 + corr. August 1994)
IEC 60050-551	1998	International Electrotechnical Vocabulary Chapter 551: Power Electronics
IEC 60050-811	1991	International Electrotechnical Vocabulary Chapter 811: Electric traction
IEC 60146-1-2	1991	Semiconductor converters - General requirements and line commutated converters - Part 1-2: Application guide
IEC 61000-2-12	[1)]	Electromagnetic compatibility (EMC) - Part 2-12: Environment - Compatibility levels for low-frequency conducted disturbances and signalling in public medium voltage power supply systems

1.3 Classification of traction supply power converters and valve

1.3.1 Types of traction supply power converters

A) a.c. to d.c. conversion:
   1) diode rectifier;
   2) controlled rectifier.

B) d.c. to a.c. conversion:
   1) inverter.

C) a.c. to a.c. conversion:
   1) direct frequency converter;
   2) d.c. link frequency converter:
      i) supply side;
      ii) traction side.

1.3.2 Purpose of conversion

A converter changes or controls one or more characteristics such as

1) frequency (including zero frequency),
2) voltage,
3) number of phases,
4) flow of reactive power,
5) quality of load power.

[1)] To be published.

1.3.3 Classification of semiconductor valves

Semiconductor valves can be turned off either by commutation implying that the current of the valve is transferred to another valve or by quenching if the current of the valve falls to zero.

Valves used in traction supply power converters can be divided into the following categories:

1) non controllable valve with a conductive forward and a blocking reverse characteristic (diode);
2) valve with a controllable forward and a blocking reverse characteristic (e.g. reverse blocking thyristor);
3) valve with a controllable forward and a conductive reverse characteristic (e.g. reverse conducting thyristor);
4) valve with a controllable forward and / or reverse characteristic which can be turned on and/or off via a signal applied to the gate (e.g. gate turn-off thyristor, insulated gate bipolar transistor);
5) valve with controllable forward and reverse characteristic (e.g. bi-directional thyristors).

1.4 List of principal letter symbols

d_{xtB}	inductive direct voltage drop due to converter transformer referred to U_{di}
e_{xB}	inductive component of the relative short-circuit voltage of the converter transformer corresponding to the basic current on the supply side of the transformer
f_N	rated frequency
g	number of sets of commutating groups between which I_{Bd} is divided
h	order of harmonic
I_{Bd}	basic direct current
I_{BV}	basic service current on the supply side of a converter
I_d	direct current (any defined value)
I_{Nt}	rated current on the traction side of a frequency converter
K	coupling factor
p	pulse number
P	active power
q	commutation number
s	number of series connected commutating groups
u	angle of overlap (commutation angle)
U_a	power frequency withstand voltage
U_{Bdx}	total inductive direct voltage drop at basic direct current
U_d	direct voltage (any defined value)
U_{d0}	conventional no load direct voltage
$U_{d0\alpha}$	value of U_{d0} with trigger delay angle α
U_{d00}	real no-load direct voltage
U_{di}	ideal no-load direct voltage
$U_{di\alpha}$	controlled ideal no-load direct voltage
U_n	nominal voltage
U_{Nd}	rated direct voltage
U_{Ni}	Impulse voltage
U_{Nm}	rated insulation voltage
U_{Nt}	rated a.c.voltage on the traction side of a frequency converter

U_{NV} rated a.c. voltage on the supply side of a converter
U_{V0} no-load phase to phase voltage
α trigger delay angle
α_p inherent delay angle
β trigger advance angle
γ extinction angle
δ number of commutating groups commutating simultaneously per primary
λ total power factor
ν deformation factor
$\varphi 1$ displacement angle for the fundamental component of I_{BV}

1.5 Definitions

For the purpose of this European Standard, the following definitions apply. In this standard, IEV definitions are used wherever possible, particularly those in IEC 60050-551.

The policy adopted is as follows:

1) when a suitable IEV definition exists, the title and reference are given without repeating the text;
2) when an existing IEV definition needs amplification or additional information, the title, the reference and the additional text are given;
3) when no IEV definition exists, the title and the text are given;
4) the definitions appear under
   A) for general terms (1.5.1 to 1.5.28),
   B) for service conditions (1.5.29 to 1.5.30),
   C) for definitions concerning compatibility (1.5.31 to 1.5.33).

An alphabetical index is given in Annex C.

A) General terms

1.5.1
semiconductor device
device whose essential characteristics are due to the flow of charge carriers within a semiconductor

1.5.2
Combination of semiconductor devices

1.5.2.1
(valve device) stack (IEV 551-14-12)

1.5.2.2
(valve device) assembly (IEV 551-14-13)

1.5.2.3
electronic power converter
an operative unit for power conversion comprising one or more assemblies of semiconductor devices (IEV 551-12-01, modified)

1.5.2.4
trigger equipment (gating equipment)
equipment which provides suitable trigger pulses from a control signal for controllable valve devices in a converter or power switch including timing or phase shifting circuits, pulse generating circuits and usually power supply circuits

1.5.2.5
system control equipment
equipment associated with a converter equipment or system which performs automatic adjustment of the output characteristics as a function of a controlled quantity

1.5.3
Converter circuit elements

1.5.3.1
(valve) arm (IEV 551-15-01)

1.5.3.2
principal arm IEV 551-15-02)

1.5.4
converter connection (IEV 551-15-10)

1.5.4.1
basic converter connection (IEV 551-15-11)

1.5.4.2
single-way connection (of a converter) (IEV 551-15-12)

1.5.4.3
double-way connection (of a converter) (IEV 551-15-13)

1.5.4.4
uniform connection (IEV 551-15-15)

1.5.4.5
non-uniform connection (IEV 551-15-18)

1.5.4.6
series connection
a connection in which two or more converters are connected in such a way that their voltages add

1.5.4.7
boost and buck connection
a series connection in which the converters are controlled independently (IEV 551-15-21, modified)

1.5.4.8
parallel connection
a connection in which two or more converters are connected in such a way that their currents add

1.5.5
Controllability of converter arms

1.5.5.1
controllable arm
converter arm including controllable semiconductor element(s) as valve device(s)

1.5.5.2
non-controllable arm
converter arm including no controllable semiconductor element(s) as valve device(s)

1.5.6
quadrants of operation (on d.c. side)
each quadrant of the voltage current plane is defined by the d.c. voltage polarity and the current direction

1.5.6.1
one quadrant converter (IEV 551-12-34)

1.5.6.2
two quadrant (single) converter (IEV 551-12-35)

1.5.6.3
four quadrant (double) converter (IEV 551-12-36)

1.5.6.4
reversible converter (IEV 551-12-37)

1.5.6.4.1
single converter (IEV 551-12-38)

1.5.6.4.2
double converter (IEV 551-12-39)

1.5.6.4.3
converter section of a double converter (IEV 551-12-40)

1.5.7
Commutation and quenching

1.5.7.1
commutation
transfer of current from one conducting arm to the next to conduct in sequence, without interruption of the d.c. current. During a finite interval of time both arms are conducting simultaneously (IEV 551-16-01, modified)

1.5.7.2
quenching (IEV 551-16-19)

1.5.8
Type of commutation

1.5.8.1
direct commutation (IEV 551-16-09)

1.5.8.2
indirect commutation (IEV 551-16-10)

1.5.8 3
external commutation (IEV 551-16-11)

1.5.8.3.1
line commutation (IEV 551-16-12)

1.5.8.3.2
load commutation (IEV 551-16-13)

1.5.8.4
self commutation (IEV 551-16-15)

1.5.9
commutation circuit (IEV 551-16-03)

1.5.9.1
commutating voltage (IEV 551-16-02)

1.5.9.2
commutation inductance
total inductance included in the commutation circuit, in series with the commutating voltage (IEV 551-16-07, modified)

NOTE For line or machine commutated converters the commutation reactance is the impedance of the commutation inductance at the fundamental frequency.

1.5.9.3
angle of overlap *u*
the duration of the commutation interval between a pair of principal arms, expressed in angular measure, where the two arms carry current (IEV 551-16-05, modified)

1.5.9.4
commutation notch
a periodic voltage transient that can appear in the a.c. voltage of a line or machine-commutated converter due to commutation (IEV 551-16-06, modified)

1.5.9.5
commutation repetetive transient
voltage oscillation associated with the commutation notch

1.5.9.6
commutating group (IEV 551-16-08)

1.5.9.7
commutation number q
the number of commutations from one principal arm to another, occurring during one period of the alternating voltage in each commutating group (IEV 551-17-03, modified)

1.5.9.8
pulse number p
the number of non-simultaneous symmetrical direct or indirect commutations from one principal arm to another, during one period of the alternating voltage (IEV 551-17-01, modified)

1.5.10
trigger delay angle α
the time expressed in angular measure by which the trigger pulse is delayed with respect to the reference instant (see Figure 1).

For line, machine or load commutated converters the reference instant is the zero crossing instant of the commutating voltage.

For a.c. controllers it is the zero crossing instant of the supply voltage.
For a.c. controllers with inductive load, the trigger delay angle is the sum of the phase shift and the current delay angle
(IEV 551-16-33, modified)

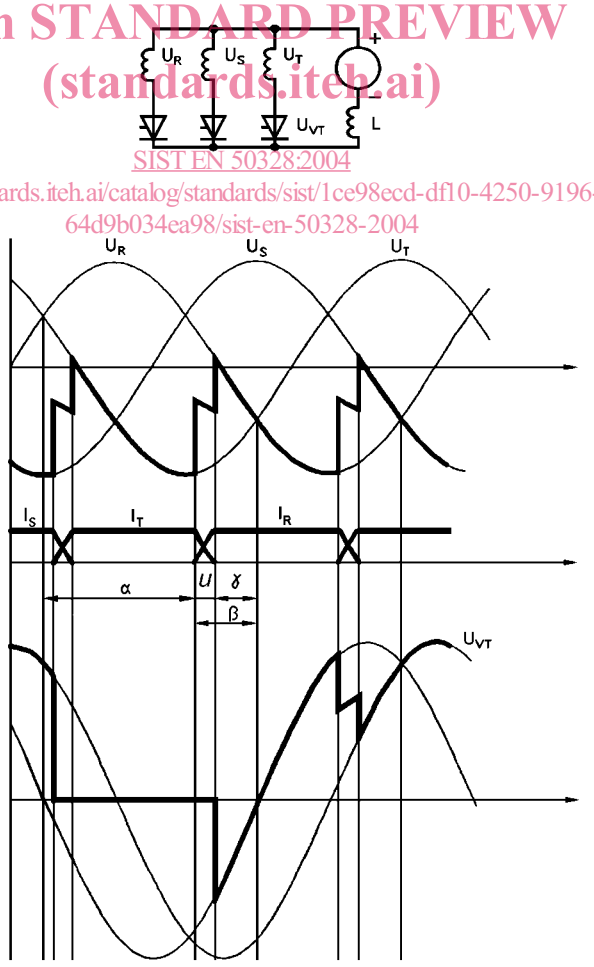

Figure 1 - Illustration of angles