SLOVENSKI STANDARD
SIST EN 50533:2012

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Železniške naprave - Napetostne karakteristike trifaznega glavnega voda na tirnem vozilu

Railway applications - Three-phase train line voltage characteristics

Bahnanwendungen - Eigenschaften der dreiphasigen (Drehstrom-) Bordnetz-Spannung

Applications ferroviaires - Caractéristiques de la tension de la ligne de train triphasée

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ICS:

29.280	Električna vlečna oprema	Electric traction equipment
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Railway applications - Three-phase train line voltage characteristics

Applications ferroviaires - Caractéristiques de la tension de la ligne de train triphasée

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CENELEC
European Committee for Electrotechnical Standardization
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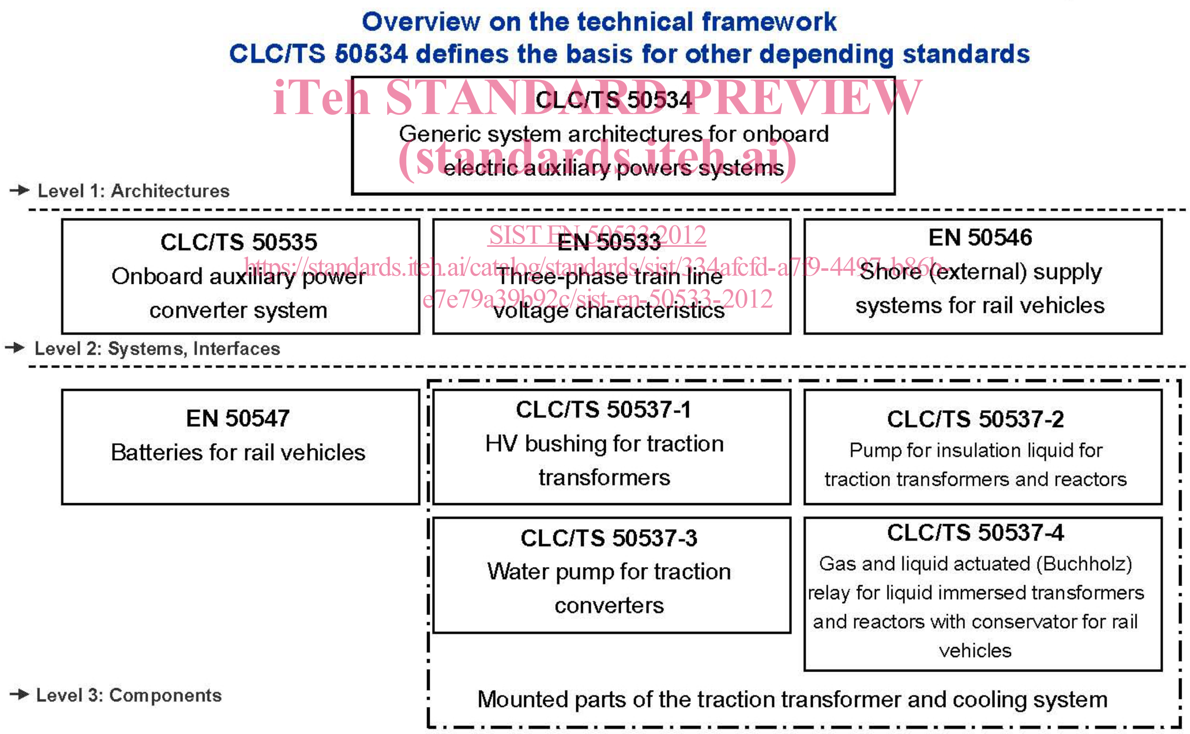
Foreword

This document (EN 50533:2011) has been prepared by Working Group 18 of SC 9XB, "Electromechanical material on board rolling stock", of Technical Committee CENELEC TC 9X, "Electrical and electronic applications for railways".

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2012-10-10
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2014-10-10

This standardization project was derived from the EU-funded Research project MODTRAIN (MODPOWER). It is part of a series of standards, referring to each other. The hierarchy of the standards is intended to be as follows:



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Introduction

This European Standard defines the characteristics of the on board three-phase train line which delivers the electrical energy to the auxiliary power system. The following European Standards and Technical Specifications refer to the defined target energy supply system in this European Standard:

CLC/TS 50534	Railway applications – Generic system architectures for onboard electric auxiliary power systems
CLC/TS 50535	Railway applications – Onboard auxiliary power converter systems *Auxiliary converter interfaces applicable for the different options defined in the target system architectures.*
CLC/TS 50537 (series)	Railway applications – Mounted parts of the traction transformer and cooling system *Standardized products used in conjunction with traction transformers and traction cooling systems.*
EN 50546 [1)]	Railway applications – Shore (external) supply system for rail vehicles *Interface description of the shore supply including protection functions.*
EN 50547 [1)]	Railway applications – Batteries for rail vehicles *Standardized batteries for rail vehicles and charging characteristics.*

The three-phase voltage characteristics depend on the performances of the auxiliary converters which supply the train line but also on the AC load characteristics connected to this train line. In railway applications the available auxiliary power of the train line is generally slightly higher than the power needed by the consumer loads, consequently tight interactions between the auxiliary power converter system and the loads are common and have to be taken into consideration for a proper operation at train system level.

The main objective followed by this European Standard is to define as much as possible the static characteristics and the dynamic behaviour of the on-board three-phase supply network to assure the best electrical compatibility with the AC loads connected to.

This European Standard is a guideline for specifying and designing the different parts of the auxiliary power supply system namely the different auxiliary converters and the AC loads (i.e. 3 AC motors, converters, filters, transformers, etc.) connected to the grid.

Some specific characteristics of the train line voltage may impact the reliability and the life time of the AC loads if they are not taken into consideration during the design phase of the AC loads.

The three-phase train line voltages are never perfectly balanced and pure sinusoidal waveform voltages, as examples:

1) Under development.

- the switching of the semi-conductors within the static auxiliary converters may generate voltage harmonics and dU/dt steps on the train line;
- the line-to-earth voltage level can vary with the auxiliary supply architecture and the type of faults in the train line;
- a common mode voltage can appear to the star point of the 3 AC loads;
- the non linear AC loads can be a source of current harmonics, those currents combined with the train line impedance create voltage harmonics too (mainly the input rectifiers of certain AC loads).

In summary:

- voltage harmonics can generate noise, additional Joule or iron losses in auxiliary motors and transformers;
- high dU/dt and the common mode voltage are at the origin of motor bearing currents which may lead to a reduced bearing lifetime;
- voltage spikes and overvoltages may cause an early ageing of the winding insulation materials.

1 Scope

This European Standard describes the electrical characteristics of the three-phase train line which delivers the electrical energy from the auxiliary power converter system to the auxiliary loads. It applies to:

- locomotive hauled passenger trains,
- electric multiple units,
- diesel electric multiple units.

This European Standard may apply to other rolling stock types (e.g. light rail vehicles, tramways, metros, etc.) if they are not in the scope of another specific standard.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 50160:2007	*Voltage characteristics of electricity supplied by public distribution networks*
EN 50546 [2)]	*Railway applications – Shore (external) supply system for rail vehicles*
EN 60034-26:2006	*Rotating electrical machines – Part 26: Effects of unbalanced voltages on the performance of three-phase cage induction motors (IEC 60034-26:2006)*
EN 60077-1:2002	*Railway applications – Electric equipment for rolling stock – Part 1: General service conditions and general rules (IEC 60077-1:1999, mod.)*
EN 60146-2:2000	*Semiconductor converters – Part 2: Self-commutated semiconductor converters including direct d.c. converters (IEC 60146-2:1999)*
EN 61000-2-2:2002	*Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems (IEC 61000-2-2:2002)*
IEC/TS 60034-17:2006	*Rotating electrical machines – Part 17: Cage induction motors when fed from converters – Application guide*
IEC 60038:2009	*IEC standard voltages*
UIC 554-1:1979	*Power supply to electrical equipment on stationary railway vehicles from a local mains system or another source of energy at 220 V or 380 V, 50 Hz*

2) Under development.

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1 three-phase train line

typically a 3-wire or 3-wire and neutral wire line which distributes all along the train the three-phase electrical energy to the auxiliary loads, namely the loads dedicated to the traction systems and the loads for passenger comfort

3.1.2 fundamental frequency

frequency in the spectrum obtained from a Fourier transform of a time function, to which all the frequencies of the spectrum are referred

For the purpose of this European Standard, the fundamental frequency is the one delivered by the auxiliary converters installed on board.

3.1.3 harmonic frequency

frequency which is an integer multiple of the fundamental frequency

3.1.4
harmonic component

component having a harmonic frequency. Its value is normally expressed as an r.m.s. value

3.1.5 interharmonic frequency

frequency which is not an integer multiple of the fundamental frequency, e.g. the switching frequency of the auxiliary converters and all the associated harmonics which are not multiple of the fundamental frequency

3.1.6 interharmonic component

component having an interharmonic frequency. Its value is normally expressed as an r.m.s. value

3.1.7 harmonic order

ratio of the harmonic to the fundamental frequency is the harmonic order

3.1.8 total harmonic distortion (*THD*)

ratio of the r.m.s. value of the sum of all the harmonic components up to a specified order to the r.m.s. value of the fundamental component:

$$THD = \sqrt{\frac{\sum_{h=2}^{h=40} U_h^2}{U_1^2}}$$

where

U_1 is the r.m.s. value of the fundamental voltage component;

h is the harmonic order;

U_h is the r.m.s. value of the harmonic voltage component of order h

3.1.9 total distortion content (TDC)

quantity remaining when the fundamental component is subtracted from an alternating quantity, all being treated as functions of time

$$TDC = \sqrt{Q^2 - Q_1^2}$$

where

Q_1 is the r.m.s. value of the fundamental component;

Q is the total r.m.s. value;

Q can represent either current or voltage. It includes both harmonic and interharmonic components.

In this European Standard TDC refers to the line voltages, that is:

$$TDC = \sqrt{U^2 - U_1^2}$$

where

U_1 is the r.m.s. value of the fundamental voltage component;

U is the total r.m.s. value of voltage

3.1.10 total distortion ratio (TDR)

ratio of the r.m.s. value of the total distortion content of an alternating quantity to the r.m.s. value of the fundamental component of the quantity:

$$TDR = \frac{TDC}{Q_1} = \frac{\sqrt{Q^2 - Q_1^2}}{Q_1}$$

In this European Standard TDR refers to the line voltages, that is:

$$TDR = \frac{TDC}{U_1} = \frac{\sqrt{U^2 - U_1^2}}{U_1}$$

3.1.11 voltage unbalance

condition in a three-phase system in which the r.m.s. values of the line-to-line voltages (fundamental component), or the phase angle between consecutive line-to-line voltages, are not all equal. The degree of the inequality is usually expressed as the ratios of the negative sequence (U_2) and the zero sequence (U_0) components to the positive sequence component (U_1):

$$U_0 = \frac{1}{3}(U_{12} + U_{23} + U_{31})$$

$$U_1 = \frac{1}{3}\left(U_{12} + a.U_{23} + a^2.U_{31}\right)$$

$$U_2 = \frac{1}{3}\left(U_{12} + a^2.U_{23} + a\ .U_{31}\right)$$

U_o, U_1, U_2 formula according to the Fortescue transformation

where

$U_{12,}$ $U_{23,}$ U_{31} are the line-to-line voltages;

a phasor 120° $a = e^{j\frac{2\pi}{3}}$;

a^2 phasor 240° $a = e^{j\frac{4\pi}{3}}$