SLOVENSKI STANDARD
oSIST prEN 50728:2023

01-maj-2023

Železniške naprave - Vozna sredstva - Preskušanje elektromagnetne združljivosti s tirnimi tokokrogi

Railway applications - Rolling stock - Testing for electromagnetic compatibility with track circuits

Applications ferroviaires - Matériel roulant - Essais pour la compatibilité électromagnétique avec les circuits de voie

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ICS:

29.280	Električna vlečna oprema	Electric traction equipment
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English Version

Railway applications - Rolling stock - Testing for electromagnetic compatibility with track circuits

To be completed To be completed

This draft European Standard is submitted to CENELEC members for enquiry.
Deadline for CENELEC: 2023-06-16.

It has been drawn up by CLC/SC 9XB.

If this draft becomes a European Standard, 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.

This draft European Standard was established by CENELEC in three official versions (English, French, German).
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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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

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European foreword

This document (prEN 50728:2023) has been prepared by CLC/SC 9XB “Electromechanical material on board rolling stock” of CLC/TC 9X “Electrical and electronic applications for railways”.

This document is currently submitted to the Enquiry.

The following dates are proposed:

• latest date by which the existence of this document has to be announced at national level	(doa)	dor + 6 months
• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	dor + 12 months
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	dor + 36 months (to be confirmed or modified when voting)

This document has been prepared under a Standardization Request given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s) / Regulation(s).

For relationship with EU Directive(s) / Regulation(s), see informative Annex ZZ, which is an integral part of this document.

Introduction

This document defines the testing, measurement and evaluation methods for rolling stock interference current emissions to demonstrate compatibility with track circuits. The evaluation is done at the interface between rolling stock and infrastructure (the total interference current of the IU), and not at the receiver of a track circuit.

In the context of European interoperability, interference current limits for rolling stock are defined in the TSI Interface document ERA/ERTMS/033281.

Outside European interoperability, individual limits and summation rules are defined in other documents such as NNTRs and PD CLC/TS 50238-2. In specific application cases outside the scope of Interoperability Regulations, limit values may be notified by the track circuit manufacturer, according to the process defined in EN 50617-1.

Proof of compliance of rolling stock with the interference current limits is done in three main steps. First, a test plan shall be defined, based on the specific characteristics of rolling stock to be tested (see 5). This shall ensure that the final results give a sufficient confidence level of compliance. Then the tests are performed according to the plan. Finally, the results shall be evaluated under a defined set of rules, in order to demonstrate compliance with the given limits (see 6).

Tests for the demonstration of vehicle compatibility are type tests and shall be performed before the first unit is put into regular service. When done according to this document, it is the goal to perform measurements only once per electric traction power supply system voltage and frequency.

As far as possible, common requirements are defined for both AC and DC electric traction power supply systems. However, these differ in several aspects. In AC systems, the impedance of the electric traction power supply system is small compared with the impedance of the vehicle, but resonance effects have to be considered. The main source of interference is the rolling stock. In DC systems, the impedance and, therefore, the distance from substations, is important, but resonance effects are largely neglectable. Rectifier substations have a significant contribution to the total interference current in DC systems, and also the traction and auxiliary systems of DC rolling stock are normally different from those of AC. Where necessary or appropriate, this document differentiates between AC and DC systems.

In order to limit the influence from static converters (AC) and substations (DC) on track circuits, a minimum rolling stock impedance is required. This document defines how to prove conformity with such requirements as well.

1 Scope

This document defines the measurement and evaluation methods of rolling stock interference current emissions to demonstrate compatibility with track circuits. This includes rolling stock with or without traction equipment. The established limits for compatibility are defined in ERA/ERTMS/033281, PD CLC/TS 50238-2 or NNTRs as current flowing between the vehicle and the electric traction power supply system that can disturb the track circuit receiver, as part of the track circuit system. Additionally, the referred documents can define a minimum rolling stock impedance in order to guarantee compatibility between the electric traction power supply system and track circuits.

This document is relevant to the interference current limits defined in the 'frequency management' for track circuits as defined in ERA/ERTMS/033281. It is also applicable to the demonstration of compatibility with all other types of track circuits which have established compatibility according to EN 50617-1. Finally, the methodology defined in this document can also be applied to other track circuit types, including those for which the only requirements are defined in National Notified Technical Rules.

NOTE Interface parameters between rolling stock and track circuits other than interference currents and impedance are out of the scope of this document.

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.

EN 50388-1:2022, *Railway Applications - Fixed installations and rolling stock - Technical criteria for the coordination between electric traction power supply systems and rolling stock to achieve interoperability - Part 1: General*

EN 50163:2004,[1] *Railway applications. Supply voltages of traction systems*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

UIC 550:2005-04, *Power supply installations for passenger stock*

3 Terms, Definitions and Abbreviations

3.1 Terms and Definitions

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

3.1.1
infrastructure
all fixed railway installations

Note 1 to entry: In the given context it includes the electric traction power supply system and train detection systems.

[1] As impacted by EN 50163:2004/A1:2007, EN 50163:2004/corrigendum May 2010, EN 50163:2004/AC:2013, EN 50163:2004/A2:2020, EN 50163:2004/A3:2022.

3.1.2
electric traction power supply 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,

— running rails of non-electric traction systems, which are in the vicinity of, and conductively connected to the running rails of an electric traction system,

— 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 – “power supply” has been added in the term

3.1.3
substation
installation which supplies a contact line

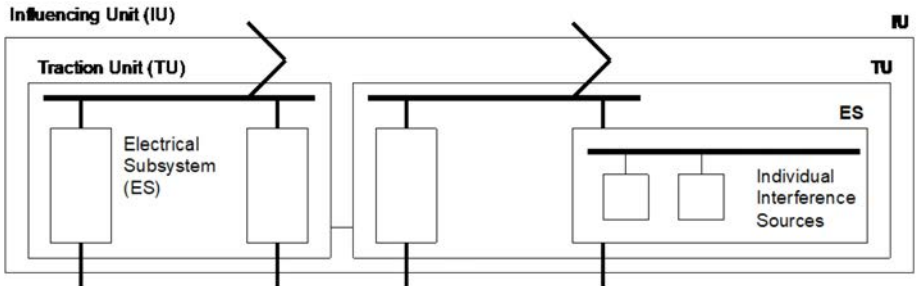
Note 1 to entry: The voltage of a primary supply system, and in certain cases the frequency, is converted by the substation to the voltage and frequency of the contact line.

3.1.4
influencing unit
IU
rolling stock influencing the train detection system

Note 1 to entry: One influencing unit comprises all coupled / connected vehicles, e.g. complete train with single or multiple traction, single vehicle, multiple connected / coupled vehicles and wagons, e.g. one complete passenger train, consisting of one or more TUs and coaches.

Note 2 to entry: The influencing unit can consist of several “Traction Units“ (TU).

See Figure 1 for clarification.



Individual sources may not be accessible for measurement directly.

Figure 1 — Definition of IU, TU and Electrical Subsystem (ES)

[SOURCE: CLC/TS 50238-2:2020, modified – Note 1 amended, Note 2 added, Figure 1 added]

3.1.5
traction unit
TU
locomotive, motor coach or train-unit

Note 1 to entry: Each TU is fed from one pantograph or collector (or UIC busbar in case of coaches / wagons). One TU may be

— one locomotive;

— one electric multiple unit, with one or several Electrical Subsystems (ES) in one or several cars;

— one complete passenger train, consisting of individual passenger coaches with or without a locomotive;

— one complete freight train, consisting of individual freight wagons with or without a locomotive.

See Figure 2 for clarification.

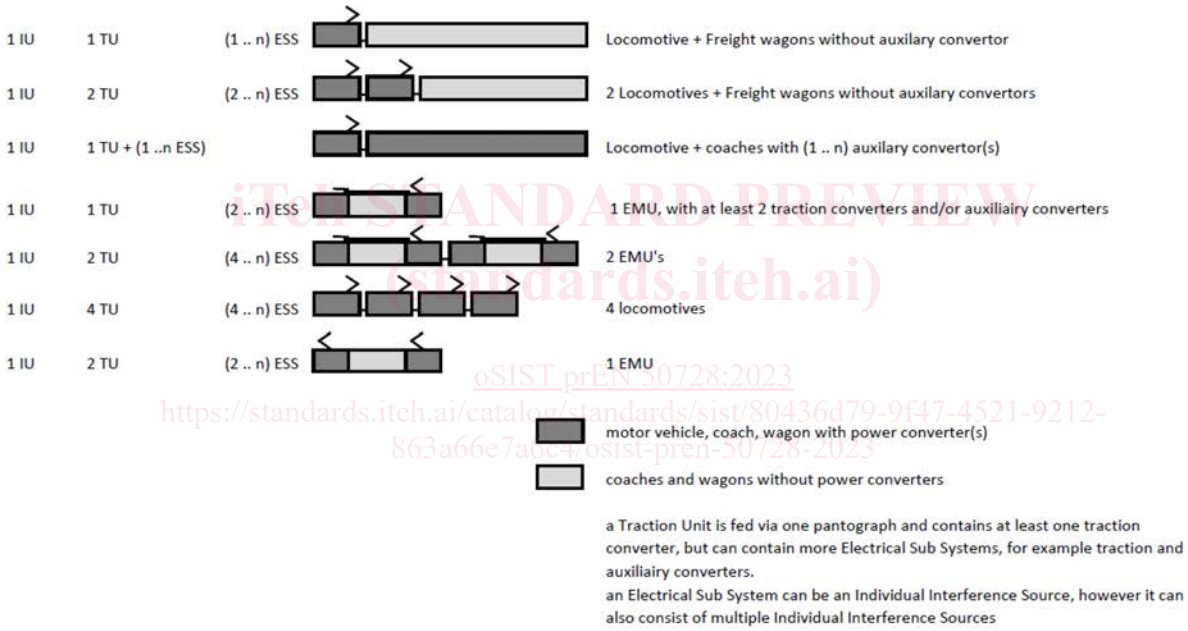


Figure 2 — Term clarification for Traction unit (TU) and Influencing Unit (IU)

[SOURCE: IEC 60050-811:2017, 811-02-04, modified – The note to entry has been added. Figure 2 has been added.]

3.1.6
electrical subsystem
ES
smallest unit which is practicably accessible for interference current measurements

Note 1 to entry: See Figure 1 and Figure 2.

Note 2 to entry: An ES is fed from the line voltage via distribution lines inside a TU. Internally, an ES may consist of one or several interference sources (such as traction and / or auxiliary converters) which cannot practicably be evaluated individually.

3.1.7
individual interference source
IIS
smallest subset of an electrical subsystem that can be identified and characterised as an interference current source

Note 1 to entry: The individual interference source is the basis for evaluation of the total interference current produced by an influencing unit.

Note 2 to entry: Individual interference sources can be various types of components and their control.

3.1.8
UIC busbar
single-pole line for the supply of auxiliaries through a whole train according to UIC 550:2005-04

Note 1 to entry: The return current flows through the rails.

3.1.9
normal operating mode
mode of operation of rolling stock with all electrical subsystems in fault-free working configuration

3.1.10
degraded mode
mode of operation of rolling stock with a reduced number of electrical subsystems, which has been anticipated in the design

Note 1 to entry: Degraded modes (failure modes) are operating modes which can be activated in order to isolate a defect and continue the operation of the rolling stock. When operating in a degraded mode the system performance might be reduced. Examples of degraded modes are deactivated traction motors or traction converters that have an impact on the remaining ones, such as increasing power and / or traction, changing the interlacing strategy or switching frequency, etc.

[SOURCE: IEC 60050-821:2017, 821-01-52, modified – reworded and note added]

3.1.11
line current
current that flows from the contact line via the pantograph(s) (or current collectors) through the IU, TU or ES to the traction return circuit

Note 1 to entry: In this document, line current is used in a more general sense and not only to the pantograph current to one TU.

3.1.12
interference current
undesired frequency content in the line current, which is in the operating frequency range of the track circuits

3.1.13
interference current limit
maximum interference current which an influencing unit is allowed to produce at a given frequency to remain compatible with a track circuit

Note 1 to entry: Interference current limits are defined in ERA/ERTMS/033281, NNTRs or PD CLC/TS 50238-2.

Note 2 to entry: Interference current limits are defined by a number of evaluation parameters, such as FFT parameters, or bandpass filter centre frequency and bandwidth and integration time.

3.1.14
interference current budget
part of the interference current limit, based on the summation rules, which can be used by an IU, TU, ES or IIS

3.1.15
summation rule
calculation method to scale a set of measurements on traction unit or electrical subsystem level to the maximum interference current for an IU with a specified confidence level

3.1.16
controlled impedance
increase of impedance by appropriate control of a connected converter

Note 1 to entry: The resulting controlled impedance is equal to the frequency response of the small signal ratio voltage divided by current.

3.1.17
interference current monitor
system or function that monitors the interference current production of an influencing unit, traction unit or electrical subsystem

Note 1 to entry: The interference current monitor is not part of the test specification as given in this European document. It might, however, be one of the safety measures required.

Note 2 to entry: In case interference currents can result in a wrong side failure, an interference current monitor which is able to switch off an interference current source is a possible mitigation measure.

3.1.18
transient
<adjective> pertaining to a phenomenon or quantity which passes from one steady state to another consecutive steady state during a time interval short compared to the timescale of interest

Note 1 to entry: The term “transient” is also used as a noun to mean a transient phenomenon or quantity.

[SOURCE: IEC 60050-103:2009, 103-05-02, modified]

3.1.19
transient
<noun> phenomenon or quantity which varies between two consecutive steady states during a time interval short compared to the timescale of interest

[SOURCE: IEC 60050-702:2009, 702-07-781]

3.1.20
steady state
operating condition of a system in which the system state variables can considered to be constant compared to time interval of interest

Note 1 to entry: For example, a varying speed should be considered as potentially constant if a train can stay at a certain speed for a longer time than the time interval of interest.

[SOURCE: IEC 60050-603:1986, 603-02-06, modified]

3.1.21
integration time
window size over which the root mean square (RMS) of the output of the bandpass filter is calculated

[SOURCE: CLC/TS 50238-2:2020, 3.1.3)

3.1.22
vehicle impedance
minimum allowed impedance of an influencing unit seen between pantograph(s) and wheels

Note 1 to entry: The minimum impedance is defined in ERA/ERTMS/033281 or NNTRs.

Note 2 to entry: The minimum impedance may be defined in terms of inductance and capacitance.

3.1.23
wrong side failure
WSF
mode of failure which may compromise the safety of trains

3.1.24
right side failure
RSF
mode of failure which does not directly compromise the safety of trains but may reduce availability

3.1.25
number of tests
number of times that a condition defined in the test specification is met

Note 1 to entry: This is not necessarily equal to the number of test runs.

3.1.26
small input filter
low pass passive input filter with a cut-off frequency which is higher than 1/3 of the centre frequency f_0 of the considered track circuit

Note 1 to entry: 1/3 is set so that the filter cut-off frequency is well below the lowest track circuit centre frequency.

Note 2 to entry: For an LC filter the cut-off frequency is $\frac{1}{2\pi\sqrt{LC}}$

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

AC	Alternating Current
DC	Direct Current
EC	European Commission
EU	European Union
ERTMS	European Rail Traffic Management System
EMU	Electric Multiple Unit
FFT	Fast Fourier Transform
GPS	Global Positioning System
LC	Inductor-Capacitor
NNTR	National Notified Technical Rules
PWM	Pulse Width Modulation
RMS	Root Mean Square

TSI	Technical Specification for Interoperability
UIC	International Union of Railways

4 Test specification

4.1 Preparation

4.1.1 General

Rolling stock and their traction and auxiliary system configurations as well as control systems and parameters can be very diverse. It is, therefore, necessary to prepare for interference current measurements by a pre-analysis for the specific rolling stock. The compiled data serve as input to the test plan and will guarantee an efficient performance and evaluation of the measurements.

The following sections specify this data collection and its analysis.

4.1.2 Vehicle data

The following data characterize the vehicle to be tested:

— Rolling stock configuration (locomotive, or EMU, number of coaches);

— Electric traction power supply system(s) under which the rolling stock is intended to operate;

— Main circuit diagram (traction and auxiliaries);

— Main data: maximum speed, tractive effort and power at wheel;

— Dynamic braking systems (regenerative, rheostatic, mixed);

— Operational configurations (double or multiple traction, traction battery if applicable);

— Degraded modes of operation (e.g. traction or auxiliary converters isolated);

— Maximum currents of IU, TU, traction and auxiliary converters, and voltage dependency of these maxima.

Based on this information, one Influencing Unit (IU) shall be defined. Traction units (TU) and Electrical Subsystems (ES) shall be identified according to 3.1.4. This will be part of the documentation of the pre-analysis (4.1.4).

The following information about control shall be compiled:

— For each operating point, the Switching / pulse width modulation (PWM) method and frequency;

— Interlacing of PWM, including information whether after failure of one converter corresponding parameters are reassigned to the others automatically or whether remaining converters continue operation with the original parameter set;

— Use of controlled impedance;

— Limitations which can have an influence on interference current generation.

This information is not part of the documentation for interference current measurements. However, it may be shared with the other involved parties. It will remain internal with the vehicle manufacturer. However, it is essential to perform the pre-analysis (see 4.1.4).