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Railways applications - Basic parameters of train detection systems - Part 1: Track circuits

Bahnanwendungen - Basic Parameters der Gleisfreimeldesystemen - Teil 1: Gleisstromkreisen

Applications ferroviaires - Paramètres de base des systèmes de détection des trains - Partie 1: Circuits de voie

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Bahnanwendungen - Technische Parameter von Gleisfreimeldesystemen - Teil 1: Gleisstromkreisen

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CENELEC

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Foreword

This document (EN 50617-1:2015) has been prepared by CLC/SC 9XA "Communication, signalling and processing systems" of CLC/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) 2016-03-09
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2018-03-09

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For relationship with EU Directive 2008/57/EC amended by Commission Directive 2011/18/EU, see informative Annex ZZ, which is an integral part of this document.

EN 50617, *Railway applications – Technical parameters of train detection systems*, will consist of

- Part 1: Track circuits;
- Part 2: Axle counters.

Introduction

The working group SC9XA WGA4-2 has developed the limits for electromagnetic compatibility between rolling stock and train detection systems, specifically track circuits and axle counter systems and correspondingly published two technical specifications CLC/TS 50238-2 and CLC/TS 50238-3. These limits and associated measurement methods are based on preferred existing systems (as defined in CLC/TS 50238-2 and CLC/TS 50238-3) which are well established and still put forward for signalling renewals by infrastructure managers.

To meet the requirements for compatibility between train detection systems and rolling stock in the future and to achieve interoperability and free movement within the European Union, it is necessary to define a “Frequency management” including the complete set of interface requirements.

The train detection systems, track circuits and axle counters, are an integral part of the CCS trackside subsystem in the context of the Rail Interoperability Directive. The relevant technical parameters are enumerated in the CCS and LOC&PAS TSI and specified in the mandatory Specification (index 77 of CCS TSI). This standard refers whenever needed to this document. Although the demand for FrM is driven by Interoperability requirements, it is independent from the drive to introduce systems like ERTMS level 3 or level 2.

This standard is based on the current understanding of the railway experts represented at WGA4-2 that track circuits and axle counter systems will continue to be the essential two train detection systems for the foreseeable future.

The published specifications CLC/TS 50238-2 and CLC/TS 50238-3 can be used in the interim period, to ascertain conformity of individual train detection systems to the requirements of the Frequency Management. The published specifications CLC/TS 50238-2 and CLC/TS 50238-3 can be used to ascertain conformity of individual train detection systems to the requirements of the TSIs, that will be in place for the parameters still declared “open points” in index 77 of CCS TSI.

The Frequency Management requirements presented in this standard are informative at this stage until introduced in document Index 77 of CCS TSI.

In this European Standard, the defined parameters are structured and allocated according to their basic references as follows:

- track circuit system parameters;
- train based parameters;
- track based parameters;
- environmental and other parameters.

Where possible, the parameters as defined are consistent with other European Standards.

Each parameter is defined by a short general description, the definition of the requirement, the relation to other standards and a procedure to show the fulfilment of the requirement as far as necessary. An overview of the safety relevance of each parameter is given – in the context of this European Standard – in a separate table.

1 Scope

This European Standard specifies the technical parameters of track circuits associated with the disturbing current emissions limits for RST in the context of interoperability defined in the form of Frequency Management. The limits for compatibility between rolling stock and track circuits currently proposed in this standard allow provision for known interference phenomena linked to traction power supply and associated protection (over voltage, short-circuit current and basic transient effects like in-rush current and power cut-off). These effects are assessed using modelling tools that have been verified by the past European research project RAILCOM.

This European Standard is intended to be used to assess compliance of track circuits equipment and other forms of train detection systems using the rails as part of their detection principles, in the context of the European Directive on the interoperability of the trans-European railway system and the associated technical specification for interoperability relating to the control-command and signalling track-side subsystems.

The European Standard describes technical parameters to consider for achieving the compatibility of the track circuit with the emissions limits defined in the frequency management for rolling stock. These parameters are structured and allocated according to their basic references as follows:

- Technical track circuit parameters;
- Train based parameters;
- Track based parameters;
- Environmental and other parameters including EMC.

Each parameter is defined by a short general description, the definition of the requirement, the relation to other standards and a procedure to show the fulfilment of the requirement as far as necessary. An overview of the safety relevance of each parameter is given – in the context of this European Standard – in a separate table.

NOTE The allocated bands for track circuits and emission limits for rolling stock defined in the Frequency Management are currently used as input information to define mandatory requirements to be stated in index 77 of CCS TSI. The evaluation is conducted by the European Railway Agency.

The immunity limits of the track circuits installed on non-interoperable lines, or on interoperable lines built before the publication date of this document, are not defined in this European Standard and remain the responsibility of individual infrastructure managers, NSAs and/or suppliers of train detection systems. In this case, the limits for compatibility are usually given in the infrastructure registers and/or the notified national rules.

This European Standard is applicable to track circuits installed on all traction power supply lines, including non-electrified lines. However, for track circuits intended to be installed only on non-electrified lines, some parameters may be not applicable.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13146-5, *Railway applications — Track — Test methods for fastening systems — Part 5: Determination of electrical resistance*

EN 50121-4, *Railway applications — Electromagnetic compatibility — Part 4: Emission and immunity of the signalling and telecommunications apparatus*

EN 50122 (all parts), *Railway applications — Fixed installations — Electrical safety, earthing and the return circuit*

EN 50124-2, *Railway applications — Insulation coordination — Overvoltages and related protection*

EN 50125-3:2003, *Railway applications — Environmental conditions for equipment — Part 3: Equipment for signalling and telecommunications*

EN 50126 (all parts), *Railways applications — The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)*

EN 50128, *Railway applications — Communication, signalling and processing systems — Software for railway control and protection systems*

EN 50129, *Railway applications — Communication, signalling and processing systems — Safety related electronic systems for signalling*

EN 50238-1, *Compatibility between rolling stock and train detection systems — Part 1: General*

CLC/TS 50238-2:2010, *Railway applications — Compatibility between rolling stock and train detection systems — Part 2: Compatibility with track circuits*

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

EN 60721-3 (all sections), *Classification of environmental conditions — Part 3: Classification of groups of environmental parameters and their severities (IEC 60721-3, all sections)*

IEC 60050-161, *International Electrotechnical Vocabulary — Chapter 161: Electromagnetic compatibility*

IEC 60050-811, *International Electrotechnical Vocabulary — Chapter 811: Electric traction*

IEC 60050-821, *International Electrotechnical Vocabulary — Part 821: Signalling and security apparatus for railways*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-161, IEC 60050-811, IEC 60050-821 and the following apply.

3.1.1
dynamic shunt
represents the equivalent impedance seen from the TC REC for a detection of RST axle

Note 1 to entry: It includes the axle shunt value, the impedance of the contact rail-wheel, and the impedance characteristic of the track.

Note 2 to entry: Dynamic shunt is determined in the TC safety case.

3.1.2
influencing unit
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 traction units (as defined in CLC/TS 50238-2) and up to 16 coaches.

3.1.3
neutral section
separates two sections of OHS, which are supplied from two different substations (can be different type of electrification / different phase angle)

3.1.4
return current unbalance
current unbalance is the ratio of the difference of current in the 2 rails, as defined using the following formula:

$$\left| \left(\frac{I_{r1} - I_{r2}}{I_{r1} + I_{r2}} \right) \right| \times 100\% ,$$

where I_{r1}, I_{r2} are the currents in both rails

3.1.5
S-Bond
equipotential cable in some electrical joint type

3.1.6
track section clear
state of the track section which the TC output state should give the information that the track section is clear of RST

3.1.7
track section occupied
TC output state which corresponds to the information either that the track section is occupied by a RST or that the TC is not able to clear the track section (e.g. in case of failure)

3.2 Abbreviations

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

AC	Alternating current
AFTC	Audio Frequency Track Circuit
CCS	Control-command and signalling
DC	Direct current
EJ	Electrical joint
EMC	Electromagnetic compatibility
ERA	European Railway Agency
ERTMS	European Rail Traffic Management System
EUREMCO	European Electromagnetic Compatibility project
f_0	Centre frequency of measuring filter used for train emission evaluation
f_c	Centre frequency of the signal generated by the transmitter of the track circuit
I_0	Steady state interference current limit for RST (one influencing unit)

FFT	Fast Fourrier Transform
FrM	Frequency Management
GRS	General Railway Signal
IM	Infrastructure Manager
IP	Ingress Protection Rating
IRJ	Insulated rail joint
ITU	International Telecommunications Union
LOC&PAS	Locomotives and passenger rolling stock
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
NSA	National Safety Authority
OHS	Overhead system
RAMS	Reliability, Availability, Maintainability and Safety
REC	Receiver
RSF	Right Side Failure
RST	Rolling Stock
S&C	Switch and crossing
SIL	Safety Integrity Level
SMS	Safety Management System
T_{pi}	Pick-up delay time of the track circuit
TC	Track Circuit
TDS	Train Detection System
TR	Transmitter
TSI	Technical Specification for Interoperability
WSF	Wrong Side Failure
Xm	Length of the electrical joint

4 Description of train detection system

Train detection systems for route proving as a fully automatic train detection system are integrated into railway signalling and safety systems. The train detection is part of the route proving procedure and contribution of trouble-free railway operation.

The train detection equipment provides information about whether track sections are ‘clear’ or ‘occupied’.

This standard applies to train detection systems using the rails to detect the presence of a vehicle.

Rails are the transmission path between the TC TR and REC. The short-circuiting of the two rails by an axle leads to the status track ‘occupied’ of the section.

The figure below defines the system boundaries of a train detection system using track circuit systems.

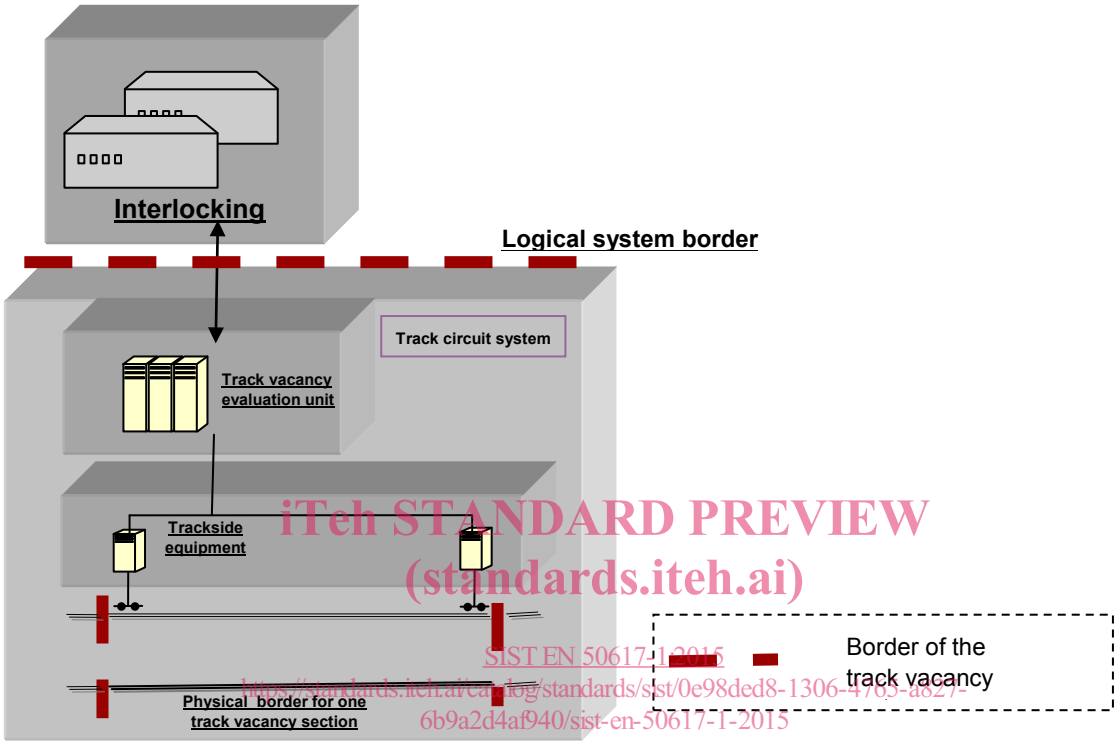

Figure 1 – System boundary for track circuit system

Track circuit is a general description of a whole range of train detection equipment based on the shunt caused by the wheel sets of a train. Today there are many different types in use throughout Europe.

5 Safety relevance of parameters

The safety case of track circuit shall be determined according to EN 50126.

Non-detection of a train present on the track circuit shall be considered as a hazardous situation.

Each parameter described in the following chapters may or may not have an influence on the safety level. According to the design of the track circuit and each particular technical environment, the safety relevance of parameters shall be defined on a case by case basis. Guidance for usual safety relevance of each parameter is given in Annex A.

6 Technical track circuit parameters

6.1 TC non-detection zone

6.1.1 General

The TC non-detection zone is an area of the TC where the RST is not detected.

If a vehicle with a very short distance between the first and the last axle (e.g. maintenance car) does not interact with at least one of the two adjacent track circuits, the train detection system will qualify the two adjacent corresponding track sections as clear.

NOTE This is a temporary effect (except if the train remains stationary in this position).

The scenarios for non-detection zone are given in informative Annex B.

The length of the TC non-detection zone will depend on the position of IRJ on the 2 rails, and/or the dynamic shunt.

6.1.2 Requirements

The maximum length of a non-detection zone between two adjacent track circuits shall not be longer than the minimum distance between first and last axle defined in index 77 of CCS TSI.

The assessment shall be performed by field test with the dynamic shunt.

6.2 Track circuit length

6.2.1 General

The track circuit length is the length within which a RST is detected.

Examples of minimum track circuit length determination are given in informative Annex C.

6.2.2 TC Minimum length of detection - Requirement

The minimum length of a detection zone shall be longer than the maximum axle to axle distance defined in index 77 of CCS TSI.

The minimum length of a detection zone shall be long enough to ensure that the interlocking systems have seen the passing train:

- when using relay technique, taking into account the delay-time of each relay in the complete circuit;
- when using programmable logic control technology (incl. microprocessors), taking into account the maximum cycle time of the control system.

It shall be shown in the safety case that the track circuit is able to react properly for the requested maximum speed for its application.

6.2.3 TC maximum length of detection - Requirement

The maximum length of detection depends on the dynamic shunt. It shall be determined in the safety case that the track circuit is able to react properly with the maximal length defined in the specification of the TC.

6.3 Broken rail detection

6.3.1 General

TCs are able to detect a broken rail if specified by design.

The first broken rail may not be detected, if there is a parallel path with low impedance. In this case the broken rail causes a RSF but the train is detected. In case of a second broken rail in the same rail, the vehicle may not be detected leading to a WSF. In the context of overall railway safety, broken rails may lead to a potential derailment.

The track circuit considers a rail as broken when there is no more electrical contact between the two parts of the rail at each side of the crack (i.e. vertical crack). When only part of the rail is lost (only the feet or only the head), the track circuit is not able to detect this kind of cracks because electrical continuity is still maintained along the broken rail.

According to index 77 of CCS TSI, the minimum distance between the axles of a vehicle is 3 m. Consequently, when the distance between the two cracks is less than 3 m, theses cracks are considered as only one broken rail. Otherwise, two broken rails are considered because the smallest vehicle may be lost. For a list of scenarios, see Annex D.

6.3.2 Requirements

If broken rail detection is required to be provided as part of the functionality of TDS, the track circuit shall be able to detect the first broken rail.

For broken rail detection, single rail track circuits based on single rail insulation are not allowed.

The risk of broken rail detection in S&C areas shall be minimised by design (for example, from parallel path interference, see Annex D).

A test or simulation shall be done for the worst case conditions. The test shall be conducted as part of the initial type test of the track circuit.

The validation of the following requirements and the limits may be requested by an approval body (notified body). Compensation of the inductance of the rail or putting high impedances in the parallel way to detect the broken rail.

The minimum impedance of the parallel path shall be defined considering the following factors:

- The working frequency of the track circuit and the infrastructure environment.
- The margin of the sensitivity level of the receiver between the tuning of the track circuit receiver and the considered worst case to detect the first broken rail. The first failure shall not lead to a WSF but shall be detected reliably, or else the required safety will be compromised.

EXAMPLE The following examples of parameters for broken rail detection may be deemed as acceptable by design:

- In S&C areas, the parallel path is limited to 50 m, to facilitate broken rail detection.
- The rail insulation is maintained as specified, and not lower than 5 Ω.km.
- 95 % of broken rails within the TC are detected by the track circuit. If 95 % detection cannot be achieved for a particular application, the track circuit shall be split in two.
- A special national case exists in the Czech Republic, where 100 % broken rail detection is required. Specific parameters for design and installation of track circuits are therefore applicable, which cannot be harmonised.