BS EN 50617-1:2024



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Railway applications — Technical parameters of train detection systems for the interoperability of the trans-European railway system

Part 1: Track circuits

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National foreword

This British Standard is the UK implementation of EN 50617-1:2024. It supersedes BS EN 50617-1:2015, which will be withdrawn on 30 November 2027.

The UK participation in its preparation was entrusted to Technical Committee GEL/9/1, Railway Electrotechnical Applications - Signalling and communications.

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Bahnanwendungen - Technische Parameter von Gleisfreimeldesystemen für die Interoperabilität des transeuropäischen Eisenbahnsystems - Teil 1: Gleisstromkreise

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European foreword

This document (EN 50617-1:2024) 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)	2025-11-30
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2027-11-30

This document supersedes EN 50617-1:2015.

EN 50617-1:2024 includes the following significant technical changes with respect to EN 50617-1:2015:

— Clause 6: Technical parameters have been enhanced to provide the requirements to demonstrate compliance with the Frequency Management published in ERA/ERTMS/033281 v4.0;

— Clause 7: It is now amended and consistent with ERA/ERTMS/033281 v4.0;

— Clause 8: Track parameters have been re-defined;

— Clause 9 has been enhanced with practical examples;

— Annex A: Parameters are revisited for consistency;

— Annex E: New Table has been added for parameters of track circuits which are already defined as compatible with the Frequency Management in ERA/ERTMS/033281 v4.0. A subclause is introduced to define the link between the current standard and the new standard being developed for Measurements of RST emissions for compatibility with track circuits by SC9XB/WG34;

— Annex F “Vehicle Impedance / guidance for RST design to support the FrM” has been deleted, consequently the Annexes G to K have been renumbered as Annexes F to J;

— New Annex K: New informative annex which defines proposed Out of Band Frequency Limits for 25 kV 50 Hz and DC power networks.

— Annex L has been deleted. A new Annex L was added.

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

— Part 1: Track circuits;

— Part 2: Axle counters.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN-CENELEC shall not be held responsible for identifying any or all such patent rights.

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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, ERA/ERTMS/033281 v4.0 defines the relevant parameters for compatibility of rolling stock with track circuits and axle counter systems.

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 ERA/ERTMS/033281 v4.0. ERA/ERTMS/033281 v4.0 specifies the parameters for rolling stock relevant to compatibility with the infrastructure. This document covers all relevant technical parameters of train detection systems (track circuits) in a manner that provides a presumption of conformity with interoperability requirements, but is not limited to interoperable lines. This document refers whenever needed to ERA/ERTMS/033281 v4.0. 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 document 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 specification CLC/TS 50238-2 can be used to ascertain conformity of rolling stock with existing individual (preferred) track circuits.

In this document, 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 document – in a separate table.

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1 Scope

This document specifies the technical parameters of track circuits associated with the interference current emissions limits for RST in the context of interoperability defined in the form of Frequency Management in ERA/ERTMS/033281 v4.0. The limits for compatibility between rolling stock and track circuits addressed in this document allow provision for known interference phenomena linked to traction power supply including associated protection (over voltage, short-circuit current and basic transient effects like in-rush current and power cut-off), and other known sources of interference.

This document is intended to be used to assess compliance of track circuits 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 document 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 (ERA/ERTMS/033281 v4.0). 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 document – in a separate table.

This document is applicable to track circuits on all lines, including non-electrified lines. However, for track circuits intended to be installed only on non-electrified lines, some parameters can be disapplied.

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 13146-5:2012[1], *Railway applications - Track - Test methods for fastening systems - Part 5: Determination of electrical resistance*

EN 50121-4:2016[2], *Railway applications - Electromagnetic compatibility - Part 4: Emission and immunity of the signalling and telecommunications apparatus*

EN 50122-1:2011[3], *Railway applications - Fixed installations - Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock*

[1] As impacted by EN 13146-5:2012/AC:2017.

[2] As impacted by EN 50121-4:2016/A1:2019.

[3] As impacted by EN 50122-1:2011/A1:2011, EN 50122-1:2011/A2:2016, EN 50122-1:2011/A3:2016, EN 50122-1:2011/A4:2017 and EN 50122-1:2011/AC:2012.

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EN 50122-2:2010, *Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 2: Provisions against the effects of stray currents caused by d.c. traction systems*

EN 50122-3:2010, *Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 3: Mutual Interaction of a.c. and d.c. traction systems*

EN 50124-2:2017, *Railway applications - Insulation coordination - Part 2: Overvoltages and related protection*

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

EN 50126-1:2017, *Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 1: Generic RAMS Process*

EN 50126-2:2017, *Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 2: Systems Approach to Safety*

EN 50128:2011[4], *Railway applications - Communication, signalling and processing systems - Software for railway control and protection systems*

EN 50129:2018[5], *Railway applications - Communication, signalling and processing systems - Safety related electronic systems for signalling*

EN 50160:2010, *Voltage characteristics of electricity supplied by public electricity networks*

EN 60529:1991[6], *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*

EN IEC 60721-3-4:2019, *Classification of environmental conditions - Part 3-4: Classification of groups of environmental parameters and their severities - Stationary use at non-weatherprotected locations (IEC 60721-3-4:2019)*

ERA/ERTMS/033281 v4.0 — *Interfaces between control-command and signalling trackside and other subsystems*

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

[4] As impacted by EN 50128:2011/AC:2014, EN 50128:2011/A1:2020, and EN 50128:2011/A2:2020.

[5] As impacted by EN 50129:2018/AC:2019-04.

[6] As impacted by EN 60529:1991/A1:2000, EN 60529:1991/A2:2013, EN 60529:1991/A2:2013/AC:2019-02, EN 60529:1991/AC:2016-12, and EN 60529:1991/corrigendum May 1993;

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3.1.1
ballast resistance
insulation of the track, or insulation between both rails

Note 1 to entry: Its value is linked to the environment of the track circuit (weather conditions, hygrometry, cleanliness of the ballast, crosstie type, etc.).

Note 2 to entry: Admittance between both rails being proportional to track circuit zone length, ballast resistance Rb is inversely proportional to the track circuit length and measured in Ω.km.

Note 3 to entry: The ballast resistance is defined for 1 km track length.

3.1.2
broken rail
complete disconnection in one rail which results in electrical isolation

3.1.3
dynamic shunt impedance
equivalent impedance seen from the TC REC for a detection of RST wheelset

Note 1 to entry: It includes the electrical resistance between the running surfaces of the opposite wheels of a wheelset, resistance between wheel and rail, and track impedance.

Note 2 to entry: A maximum allowed shunt impedance (static conditions) shall be defined by the manufacturer/designer.

3.1.4
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.

3.1.5
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).

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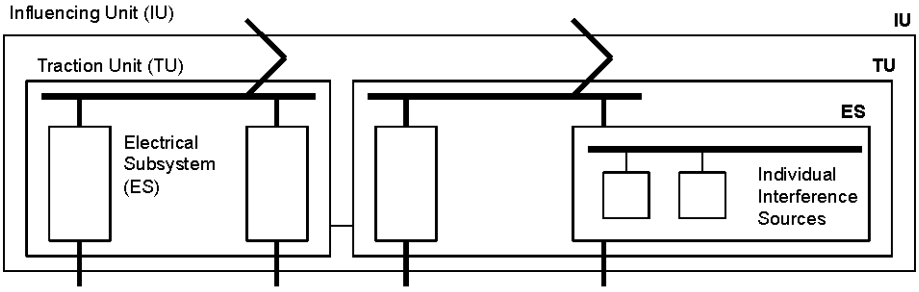


Figure 1 — Definition of IU, TU and ES

[SOURCE: CLC/TS 50238-2:2020, 3.1.2, modified - Notes 1 and 2 to entry have been amended. Note 3 to entry has been omitted. Figure 1 has been replaced.]

3.1.6
maximum allowed shunt impedance
value which guarantees the occupation of the track circuit (defined by the manufacturer/designer)

3.1.7
neutral section
section of a contact line provided with a sectioning point at each end to prevent successive electrical sections differing in voltage, phase or frequency being connected together by the passage of current collectors

[SOURCE: IEC 60050-811:2017, 811-36-16]

3.1.8
return current unbalance
ratio of the difference of current in the 2 rails

$\left|\left(\frac{I_{r1}-I_{r2}}{I_{r1}+I_{r2}}\right)\right| \times 100\%$, where I_{r1}, I_{r2} are the currents in both rails

Note 1 to entry: Other definition of return current unbalance: $I_{r1} - I_{r2}$. It shall be documented in the TC descriptions which definition has been considered to define the limit of TC.

3.1.9
S-bond
equipotential cable in some electrical joint type

3.1.10
track section clear
state of the track section which the TC output state gives the information that the track section is clear of RST

3.1.11
track section occupied
TC output state which corresponds to the information either that the track section is occupied by a vehicle or that the TC is not able to clear the track section (e.g. in case of failure)

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3.1.12
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.

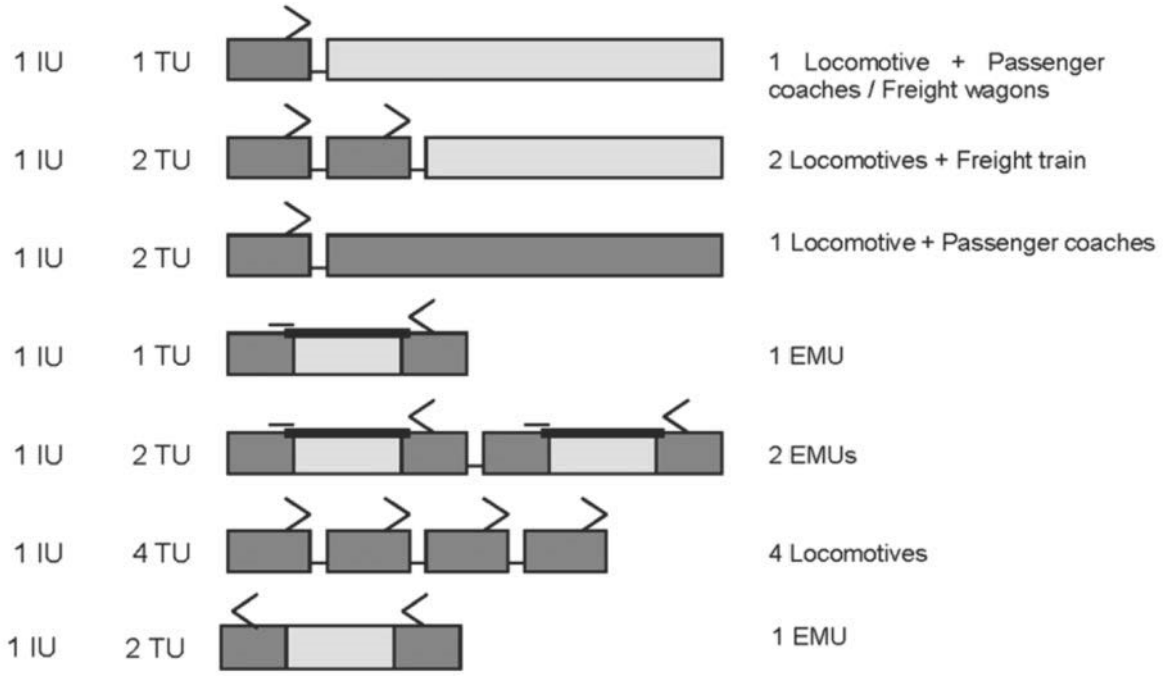


Figure 2 — Term clarification for Traction unit (TU) and Influencing Unit (IU)

[SOURCE: IEC 60050-811:2017, 811-02-04, modified – The Note 1 to entry has been added. Figure 2 has been added.]

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
EMC	Electromagnetic compatibility

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EMU	Electrical multiple unit
ERA	European Railway Agency
ERTMS	European Rail Traffic Management System
EUREMCO	European Electromagnetic Compatibility project
ES	Electrical subsystem
I_0	Steady-state interference current limit for RST (one influencing unit)
FFT	Fast Fourier Transform
FrM	Frequency management
IM	Infrastructure manager
IP	Ingress Protection Rating
IRJ	Insulated rail joint
ITU	International Telecommunications Union
IU	Influencing unit
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
Rb	Ballast resistance
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
TU	Traction unit
WSF	Wrong side failure

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4 Description of train detection system

Train detection systems for route proving are fully automatic and are integrated into railway signalling and safety systems. The train detection is part of the route proving procedure and contributes to safe railway operation.

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

This document applies to train detection systems using the rails to detect the presence of a vehicle, also known as track circuits.

Rails are the transmission path between the TC TR and REC. When the RST is standing over the track circuit, any of its wheelsets present a short circuit between the two rails causing the status of the track circuit to change to ‘occupied’.

Figure 3 defines the logical components of a track circuit system. This includes the track evaluation units, the track connection units (receivers and transmitters) and the track connections. The track connection units contain also coupling units providing electrical coupling (e.g. filtering) between the rails and the receiver/transmitter.

The logical system boundary of a track circuit system is given by an interface to the next level operational train control system (e.g. Interlocking). The physical boundaries of a track section are given by insulated mechanical or electrical based joints.

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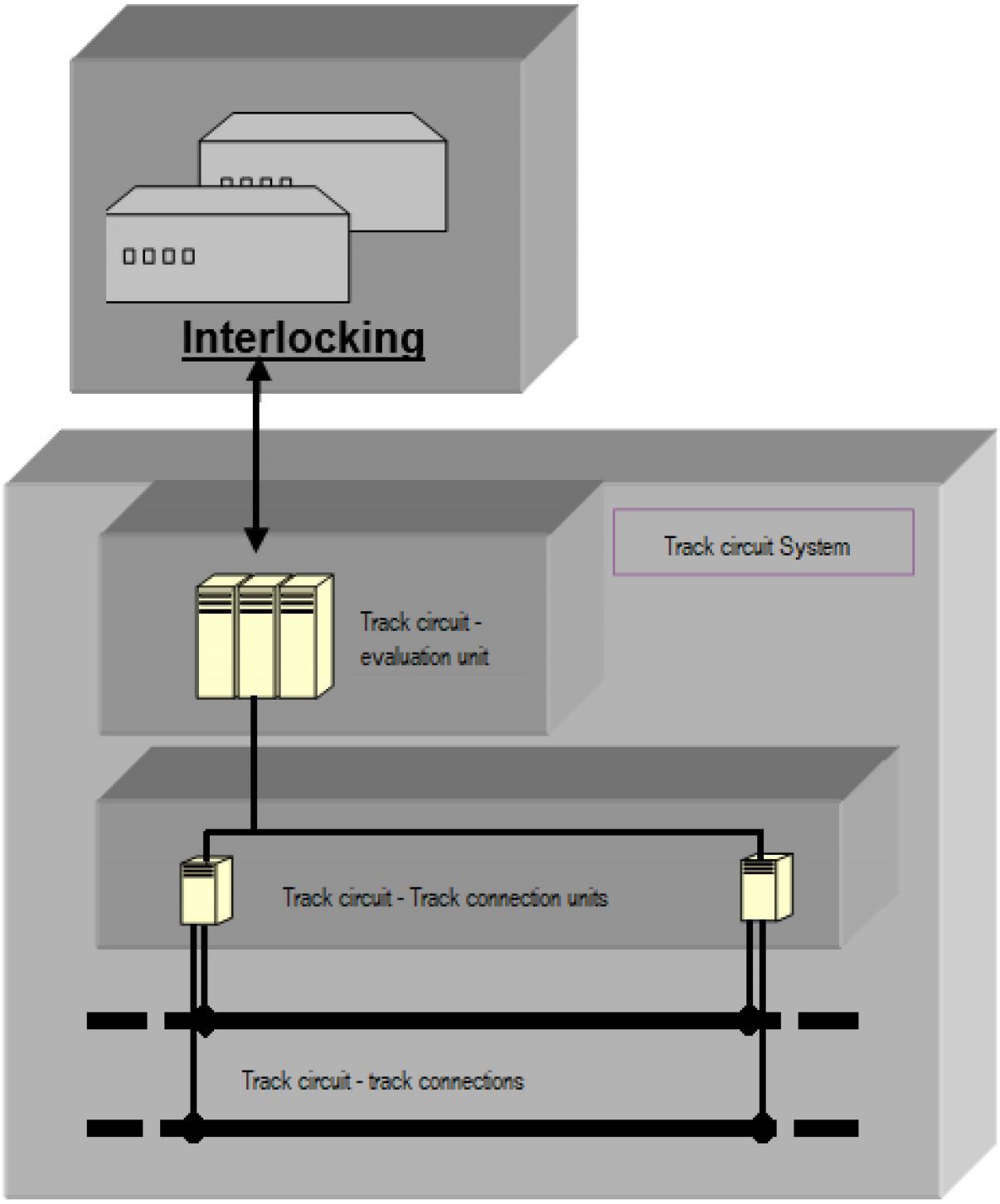


Figure 3 — System boundary for track circuit system

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.

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5 Safety relevance of parameters

The safety case of track circuit shall be determined according to EN 50129:2018.

Each parameter described in the following clauses may or may not have an influence on the safety level. According to the design of the track circuit and the specific technical environment for the application, 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 Dynamic shunt impedance

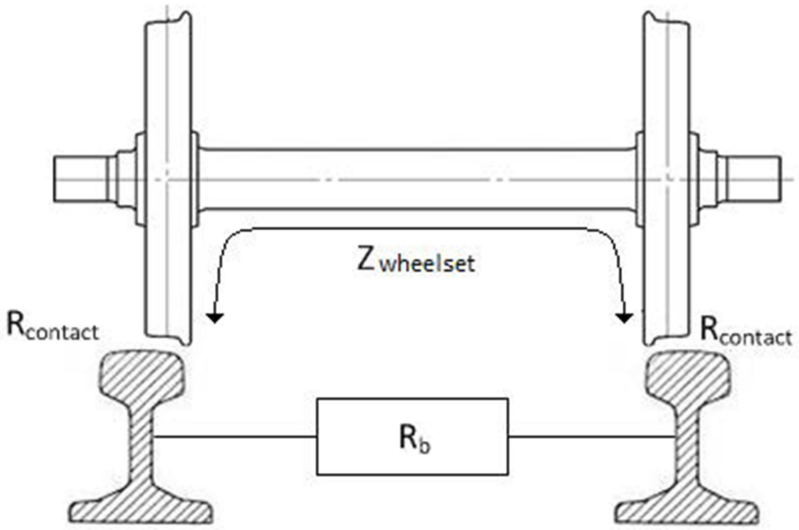
6.1.1 General

The dynamic shunt is a complex parameter that is crucial for the safe operation of a track circuit. This subclause defines the primary parameters for track circuit design.

The dynamic shunt can only partially be affected by the track circuit design; the higher the transmitter voltage, the less likely that debris between wheel and track will prevent the current to flow with Loss of Shunt as result. The dynamic shunt can only partially be affected by the vehicle design; the impedance of the wheelset is generally a small part of the total impedance of the dynamic shunt, the number of wheelsets, the more wheelsets the less likely the chance that all wheelsets become isolated with Loss of Shunt as result. Any exercise to clean the railhead or the wheel can remove many, but not all sorts of debris. The major factor for Loss of Shunt however is debris, like sand, rust, leaves and compressed smashed leaves forming an isolating resin on the track, the wheels or both, resulting in varying impedances between the wheelset and tracks. In addition, rail traffic (number of wheelsets per day, different type of wheel profiles, classic block brakes) can also reduce the formation of debris. Non-detection of a railway vehicle present over the section controlled by the track vacancy detection system shall be considered as a hazardous situation also known as a wrong side failure. This is very much dependent on the dynamic shunt impedance.

The dynamic shunt is the resulting impedance between the two rails of the track circuit as depicted in Figure 4. The dynamic shunt consists of all parallel wheelsets including the resistance between wheels and rail. The dynamic shunt is called dynamic because both the number of wheelsets and the resistance between the running surfaces of the opposite wheels of a wheelset and the rail can vary per wheelset. The only constant is the electrical resistance between the running surfaces of the opposite wheels of a wheelset which is defined in [ERA/ERTMS/033281 v4.0, 3.1.9].

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Key

R_b	ballast resistance
$R_{contact}$	resistance between wheel and rail (amongst others depending on contamination (e.g. rust)) and the dimension of contact area
$Z_{wheelset}$	impedance between the running surfaces of the opposite wheels of a wheelset

NOTE 1 $R_{contact}$ can also have non-linear behaviour, caused by for example voltage dependent mechanisms.

NOTE 2 The electrical resistance (real part of the impedance) between the running surfaces of the opposite wheels of a wheelset is usually measured. In addition, the electrical reactance between the running surfaces of the opposite wheels of a wheelset can be measured due to the relevance for audio and higher frequency track circuits.

Figure 4 — Ballast resistance/Shunt impedance

Shunt impedance is made of $R_{contact} + Z_{wheelset} + R_{contact}$.

The value of the dynamic shunt impedance cannot be specified. Therefore, it is necessary to specify the maximum allowed shunt impedance which shall not be exceeded to avoid WSF.

6.1.2 Requirements

The maximum allowed shunt impedance is specified by the track circuit manufacturer in the safety case prepared according to EN 50129:2018.

The influence of (short) Loss of Shunt shall be included in the SMS of the IM or design of the interlocking, this is an exported constraint for the infrastructure manager.

6.2 TC non-detection zone

6.2.1 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 wheelset (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.

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

This parameter only applies to countries where these non-detection zones are operationally permissible.

The scenarios for non-detection zones are given in 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.

6.2.2 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 ERA/ERTMS/033281 v4.0.

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

6.3 Track circuit length

6.3.1 General

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

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

6.3.2 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 ERA/ERTMS/033281 v4.0.

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.

6.3.3 TC maximum length of detection - Requirement

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.

NOTE The maximum length of detection depends, among other things, on the maximum shunt resistance and ballast resistance for the specific track circuit.

6.4 Broken rail detection

6.4.1 General

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

The first broken rail might not be detected if there is a parallel path with low impedance. In this case the broken rail causes an RSF but the train is detected. In case of a second broken rail in the same rail, the vehicle might 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),

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the track circuit is not able to detect this kind of cracks because electrical continuity is still maintained along the broken rail.

According to ERA/ERTMS/033281 v4.0, 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, these 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.

This parameter only applies to countries where broken rail detection is implemented/required. The national rules and/or (customer) requirements shall be transferred to specific parameters/values for the track circuit.

6.4.2 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 non-detection in S&C areas shall be minimized by design (for example, due to parallel paths, 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 compensation of the inductance of the rail or the use of high impedances in the parallel way may be implemented to detect the broken rail. The manufacturer shall specify limit values in these cases.

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 can 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 needs to 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 harmonized.

6.5 IRJ failure detection

6.5.1 General

IRJ are placed to stop the TC signal within the TC section borders. Depending on the design, they can be used in place of electrical joints.

In case of an IRJ failure, the signal from the TR of the adjacent TC section can power REC of the considered TC section.

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6.5.2 Requirement

If the IRJ failure detection function is required, the failure of an IRJ shall be analysed in the safety case. See also 8.3.

6.6 Frequency management and relevant parameters of the track circuit

6.6.1 Frequencies and immunity limits

6.6.1.1 General

FrM for RST concerning emission limits for compatibility with track circuit are defined by ERA/ERTMS/033281 v4.0 document. For the future interoperable system, this FrM allows on one hand, common frequency ranges for the operational channels of track circuits in all EU member states protected by compatibility limits for RST authorized into service, and on the other hand defines frequency ranges with less restrictions for power converter harmonics of RST.

The FrM is expressed in terms of interference current limits versus frequency that are applicable for a single influencing unit of RST to be considered under normal and foreseeable degraded conditions.

The coupling between the RST emission and the TC receiver represents a certain transfer function. This transfer function depends on many factors:

— consideration of WSF and/or RSF interference cases dictate different compatibility margins;

— return current unbalance between the two rails (see 8.6.2);

— presence of harmonics from the railway power supply (e.g. from substation or other vehicles) and impedance of the RST limiting the current;

— number of influencing units in the same feeding section;

— parallel way for the return current path (e.g. equipotential bonding);

— resonance effect of the infrastructure;

— design of the track circuit (e.g. transformers or tuning ratio);

— modulation within a DC substation of traction harmonics and substation harmonics.

Frequency Management defined by the ERA/ERTMS/033281 v4.0 inherently includes the complex envelope of the several transfer functions related to European preferred track circuits recognized throughout the standardization process established for the document CLC/TS 50238-2:2020.

The parameters used to demonstrate compliance to the Frequency Management are listed in Annex E.

6.6.1.2 Requirements for out of band limits

The out of band limits are still under technical evaluation from European Railway Agency.

An informative proposal is included in Annex K.

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6.6.2 Validation of immunity

6.6.2.1 Introduction

The immunity of the track circuit shall be established through laboratory testing. Field tests can be skipped, if comparable information can be shown or know how from former field tests exists. The applicable test limits shall be further defined depending on the application of track circuit (single/double rail or single/multiple track layout), unbalance in the return cold path, multiple receivers and hysteresis in the receiver, if applicable. The environmental conditions of the application shall be covered in the test and the safety case for the track circuit.

6.6.2.2 Track circuit receiver immunity test in laboratory

For the immunity test the whole train detection system can be taken into account. The different application scenarios to be evaluated against FrM limits shall be documented without having to repeat any practical testing, so long as there is good confidence and a suitable margin for uncertainty in the models that the transfer functions are based upon.

This flow diagram of Figure 5 is intended to be followed:

— for each noise frequency step,

— for RSF condition immunity test (i.e. with track circuit is set and track circuit is empty),

— for receiver input signal only; to translate into rail current limit, additional transfer function between receiver current and rail current may be required (depending on the track circuit),

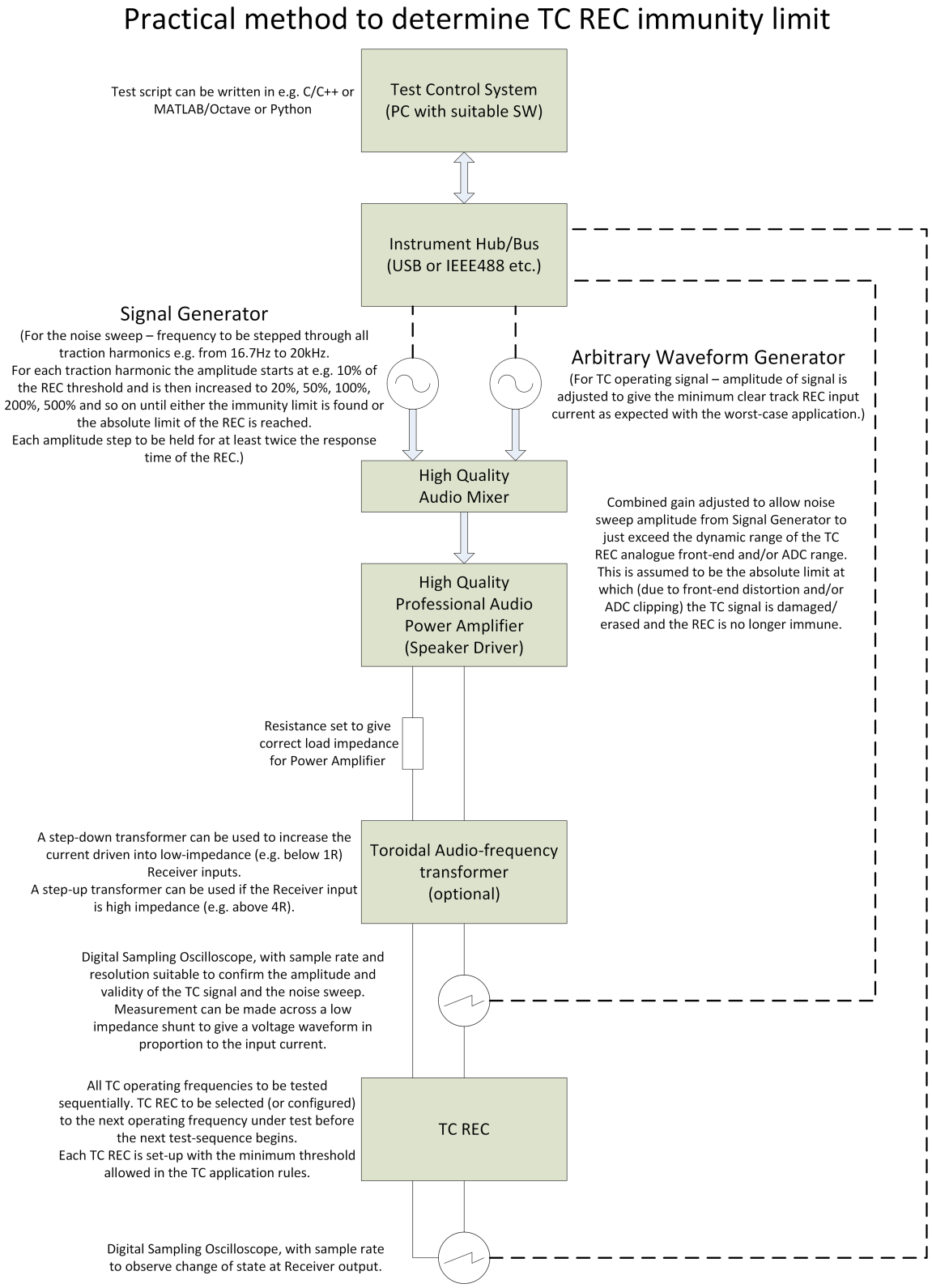
— the diagram is suitable for both in-band and out of band receiver characterization. The only difference is the selection of frequencies and maximum interference signal.

A reasonable maximum level should be derived from either the maximum allowed receiver input current or maximum reasonable traction current in the out of band range. Note that the level at the receiver input and the level in the traction current are related to each other via an implementation specific transfer function.

NOTE For example, 1,4 A at receiver input can be considered reasonably high.

For the connection between Environment, track section length and frequency a margin shall be included in the documents of manufacturer.

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The frequency-domain receiver immunity limit, derived using this methodology, is then to be converted into the rail current limit (using transfer functions representative of the electrical-coupling from the TC rail connections to the TC Receiver) and compared with the Frequency Management limits. Where the immunity limit is found to exceed the defined in-band limits, the Track Circuit is considered compliant with the Frequency Management limit. For the out of band frequencies, the track circuit rail current immunity should exceed the Out of band immunity limit defined in EN 50617 or, where this is limit is undefined, the immunity should exceed the power supply traction current expected for the type of infrastructure for which the TC is rated (i.e. determined by characteristics of the specific power supply).

Figure 5 — Example for Track Circuit Receiver immunity test

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6.6.2.3 Test configuration in laboratory

The purpose of the following test procedure is to just understand and validate the immunity of the track circuit as a complete fixed installation, which is different from the immunity of the receiver alone. The use of a sine wave test signal is sufficiently justified for this purpose as the main purpose of this test is to establish the transfer function between the emission limit for RST defined in the FrM and the TC immunity

The tests in the laboratory are to research the susceptibility threshold of the TC REC with a simulated equivalent of the track. The following example concerns a test configuration for RSF.

If different test methods are used to measure the limits of a track circuit, they shall be described by the manufacturer in the track circuit description.

This is a quasi worst-case scenario for RSF with the substation connected at one end via the shorting bond and the RST connected via the other bond (see Figure 6). The test consists of injecting current in a typical track circuit, to establish the track circuit susceptibility to rolling stock interference.

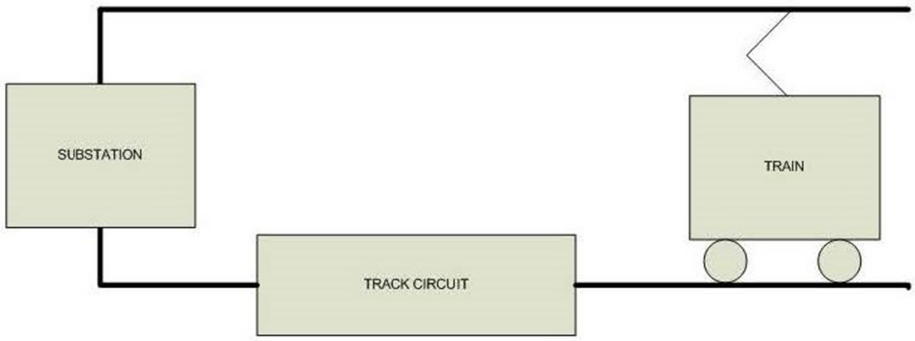


Figure 6 — RSF interference scenario

The source of disturbance (current generator) produces sinusoidal signals (see Figure 7). The interference source is applied between the two shorting bonds at the extremities of the track circuit. The track circuit rails are simulated with the nominal inductance and resistance depending on the length and type of the considered TC.

The current from the source of disturbance flows through both rails. The unbalance is simulated with a resistor placed between two sections of one rail.

This can only be done if the characteristic of the track is not influenced by the unbalance resistor (the unbalance resistor is much smaller than the source impedance of the sending side). Otherwise the unbalance shall be created with a cable loop over the track or with a cable through a toroidal transformer inducing the desired unbalance.

The test is performed for all working frequencies of TC, and for some most significant track circuit configurations (length, coding, unbalance).

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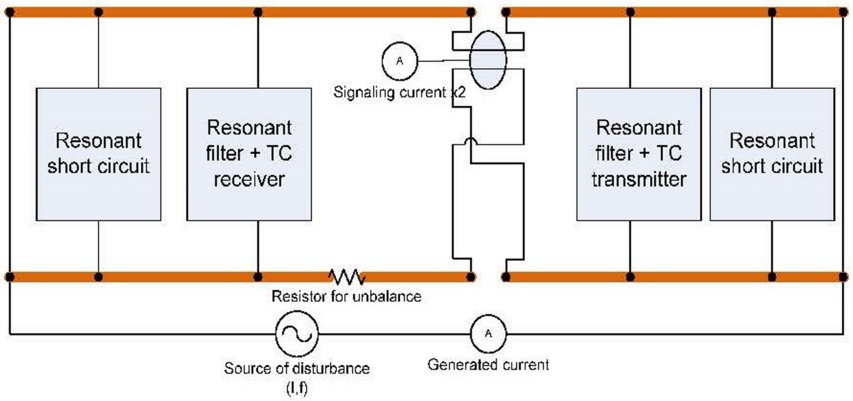


Figure 7 — Block diagram for the simulation of disturbance (example)

NOTE The ballast is considered as a perfect isolator for the needs of the test.

6.6.2.4 Testing equipment specification

The testing equipment shall cover the whole dynamic range in terms of level and frequency as defined in E.1 for the type of track circuit.

6.6.2.5 Testing procedure

This procedure may be followed when necessary to establish if individual track circuits defined in national rules or new track circuits are compliant with the FrM limits defined in ERA/ERTMS/032882. The TC complies with the FrM if the susceptibility limits established from the tests are higher than the defined limits in the TSI FrM for the relevant frequency band with a compatibility margin and the TC filter curve is inside the border of the FRM areas defined. This is true for all considered configurations.

— Preparation of test:

  — The unbalance shall be configured in one rail. The FrM level shall be selected according to the RAMS analysis. The generated interference current and the track circuit own signalling current are measured as defined in 6.6.2.3. The track circuit signalling current is the resultant current measured as differential current between the rails.

  — Without disturbance, the track circuit shall be calibrated according to the usual procedure with the lowest acceptable level from the transmitter and the worst acceptable signal/noise ratio on the receiver side.

— Determination of susceptibility threshold:

  — The frequency of the disturbance source shall be swept step by step starting from the lowest frequency in the relevant FrM band, or ± 10 % of the working frequency of the track circuit, to establish the filter curve for the 20 dB point.

  — The frequency step shall be lower than 1 % of the working frequency.

  — The time of exposure to each testing frequency, which is different from the working frequency by using the formula:

$$t_{\exp} = 2 \times \frac{1}{\left| f_w - f_{test} \right|}$$

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