BS EN 50617-1:2015

BSI Standards Publication

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 50617-1:2015.

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

A list of organizations represented on this committee can be obtained on request to its secretary.

Published by BSI Standards Limited 2015

ISBN 978 0 580 76386 1

ICS 29.280

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2015.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 50617-1

April 2015

ICS 29.280

English Version

Railway applications - Technical parameters of train detection systems for the interoperability of the trans-European railway system - Part 1: Track circuits

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

Bahnanwendungen - Technische Parameter von Gleisfreimeldesystemen - Teil 1: Gleisstromkreisen

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 50617-1:2015 E

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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- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2018-03-09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.

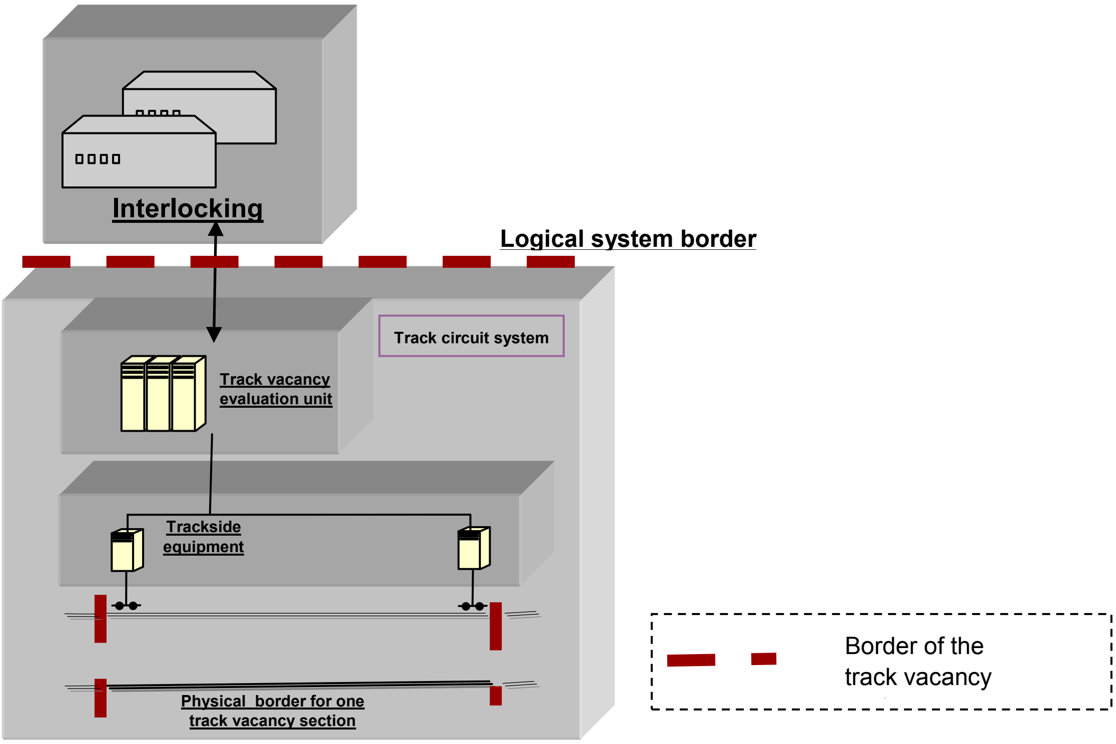


Figure 1 – System boundary for track circuit system

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.

6.4 IRJ failure detection

6.4.1 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.

6.4.2 Requirement

If the IRJ failure detection function is required, the failure of an IRJ shall be analysed in the safety case. See also 8.4.

6.5 Frequency management and relevant parameters of the track circuit

6.5.1 Frequencies and immunity limits

6.5.1.1 General

FrM for RST concerning emission limits for compatibility with track circuit is under development (see index 77 of CCS TSI). For the future interoperable system, this FrM will allow on one hand common frequency ranges for the operational channels of track circuit in all EU member states, on the other hand define the compatibility limits for RST authorised into service in any EU member state.

The FrM will be expressed in terms of a limit of conducted emission in the return current path from RST versus frequency. So a compatibility margin between RST emissions limits and TC susceptibility threshold shall be applied.

The coupling between the RST emission and the TC receiver represents a certain transfer function. The compatibility margin and the transfer function depend on many factors:

- consideration of WSF and/or RSF interference cases dictate different compatibility margins;
- return current unbalance between the two rails (see 8.8.2);
- presence of harmonics from the railway power supply (e.g. from substation or other vehicles) and impedance of the RST limiting the current (see informative Annex F for more details);
- number of influencing units into 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).

More explanations and a FrM proposal are given in the informative Annex E.

6.5.1.2 Requirements

The working frequency range of the track circuit and the limits for compatibility with the rolling stock shall be defined from the FrM for the conducted interference as defined in index 77 of CCS TSI (when published).

As long as the FrM is not published in index 77 of CCS TSI:

- The working frequency range and the immunity limits shall be defined jointly by the manufacturer and the infrastructure manager. Existing limits for compatibility (e.g. at national level, or as per CLC/TS 50238-2) can be considered as the basis to define a working frequency range and immunity level of track circuit.

- If, for the selected working frequency range, no limits for RST emission already exist on the IM network, a study on the existing RST emission shall be performed. This study can be based on measurement of the current in the rail or emission from the existing RST (e.g. according to the test method defined in CLC/TS 50238-2). These limits shall be defined in the same way as the existing limits defined in CLC/TS 50238-2.

- It is recommended to use only the frequency ranges allowed in the informative Annex E.

In any way, acceptance process as defined in EN 50238-1 for RST shall be used for TC compatibility. The compatibility case shall consider the transfer function from the RST emission (including harmonics from power supply system and transients) to the TC REC. The applied compatibility margin and detailed scenarios of the transfer function shall be presented in the compatibility case.

Immunity testing shall be conducted. An example test specification is proposed in E.1.6. The compatibility case shall include the test report.

6.5.2 Number of operational channels

The number of operational channels permitted for track circuit application shall be specified by the track circuit manufacturer by considering the allowed frequency bandwidth defined in 6.5.1.

6.5.3 Separation between operational channels / channel bandwidth

The centre working frequencies with the associated frequency bandwidth shall be placed only at certain locations of the spectrum, in order to avoid:

- cross-talk between track circuit channels;
- correspondence with low-order natural harmonics of the power supply frequency (which are always present during transients, see also Table 1);
- preferred converter harmonic bands from traction units and auxiliaries (see Table 1).

Table 1 - Forbidden frequencies

Frequency ranges	Forbidden frequencies	Justification
up to 300 Hz (16,7 Hz system)	N x 16 $^2/_3$ Hz	avoids multiples of power supply harmonics in all networks
up to 300 Hz (50 Hz systems)	N x 50 Hz	
up to 3,2 kHz (50 Hz systems)	N x 100 + 50 Hz	avoids odd harmonics of traction power supply in 50 Hz networks
up to 3,2 kHz (DC systems)	N x 300 Hz	avoids harmonics of ripple from rectifier on power supply in DC networks
300 Hz to 3,2 kHz (16,7 Hz system)	All frequencies	avoids harmonics of traction power supply in 16,7 Hz networks
NOTE N is any natural number.		

6.6 Coding

6.6.1 General

The function of each type of AFTC is based on the use of defined number of frequencies per track circuit. To keep each track circuit separated from each other electrical bonds will be used. At one physical extreme of the track circuit the frequency signal will be generated by a transmitter, which will be received by the receiver at the other extreme. To avoid a disturbance from another track circuit using the same frequency (F1) of operation or cross talk from adjacent lines, a frequency independent coding is deployed.

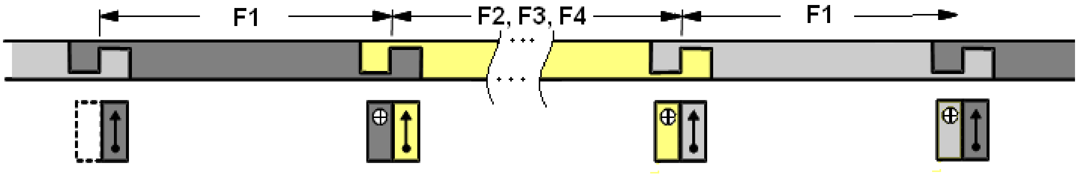


Figure 2 – Installation of AFTC (example)

6.6.2 Type of coding

6.6.2.1 Fixed coding

Historically, the coding was done by hardware coding plugs. A number of defined fixed codes per type of track circuit were used by different manufacturers. In this case, careful consideration of the codes used at the system border between different TC types shall be applied by each manufacturer, to avoid disturbances.

The number of codes is normally restricted e.g. different fixed coding plugs are defined.

6.6.2.2 Dynamic coding

By using modern board controllers a fixed coding can be avoided. In that case the number of codes is not restricted any more. Cross talking between each track circuit with the same frequency can be avoided by producing a different code per transmission session.

6.6.2.3 Principle for a frequency shift keying method

The transmitter of the track circuit builds a bit pattern by using permitted tolerances for one frequency which can only be decoded by the receiver unit of the TC. The figure below shows a principle of using frequency shift.

9 564 Hz 9 436 Hz 9 564 Hz 9 436 Hz

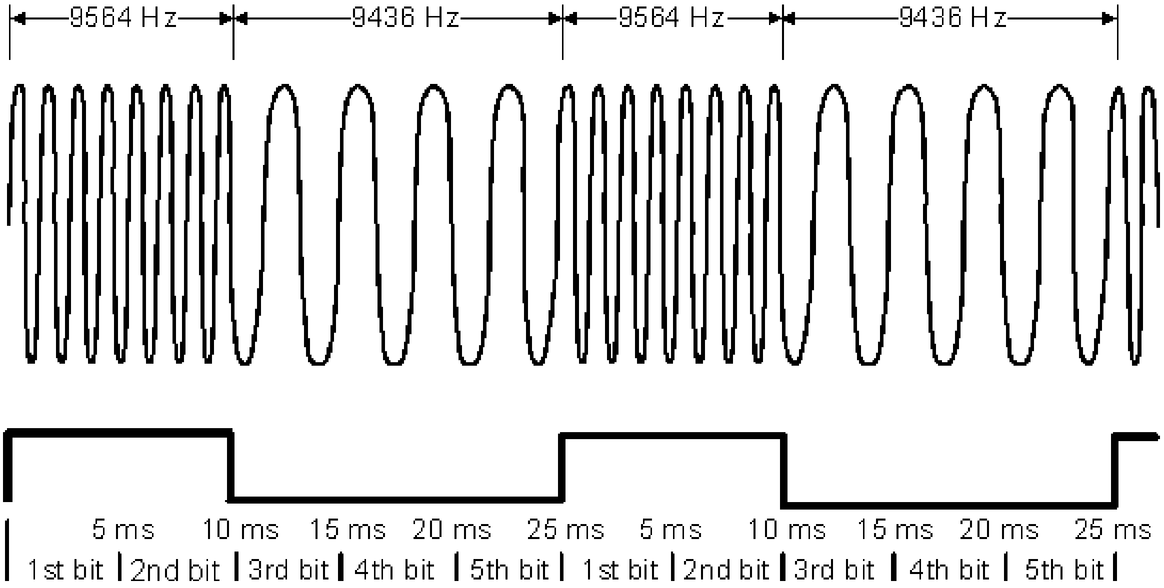


Figure 3 – Example for a frequency of 9 500 Hz ± 64 Hz

This is independent of using fixed or dynamic coding.

6.6.3 Requirements

Coding shall be used to prevent the cross talk between adjacent TC on the same line and on adjacent lines. Additional requirements may be applied by the manufacturers of TCs.

The method of coding shall be declared by the manufacturer. The manufacturer shall specify any applicable minimum separation distance between adjacent track circuits using the same code at the same frequency.

In the case of using different models of TC, and more particularly TC using fixed coding, the codes used shall be known by the IM at the system borders of the different TC-types of each manufacturer. It shall be demonstrated that disturbances between the different TCs are avoided.

It shall be shown in the safety case that by using the codes and the defined numbers of coding the safety integrity level required can be reached. The safety case shall demonstrate that the selected coded messages cannot be reproduced by rolling stock emissions. If needed, the probability of a rolling stock emission reproducing the TC coding and modifying the output state of the track circuit shall be integrated into the determination of the TC SIL.

6.7 Response of the receiver to transient disturbances

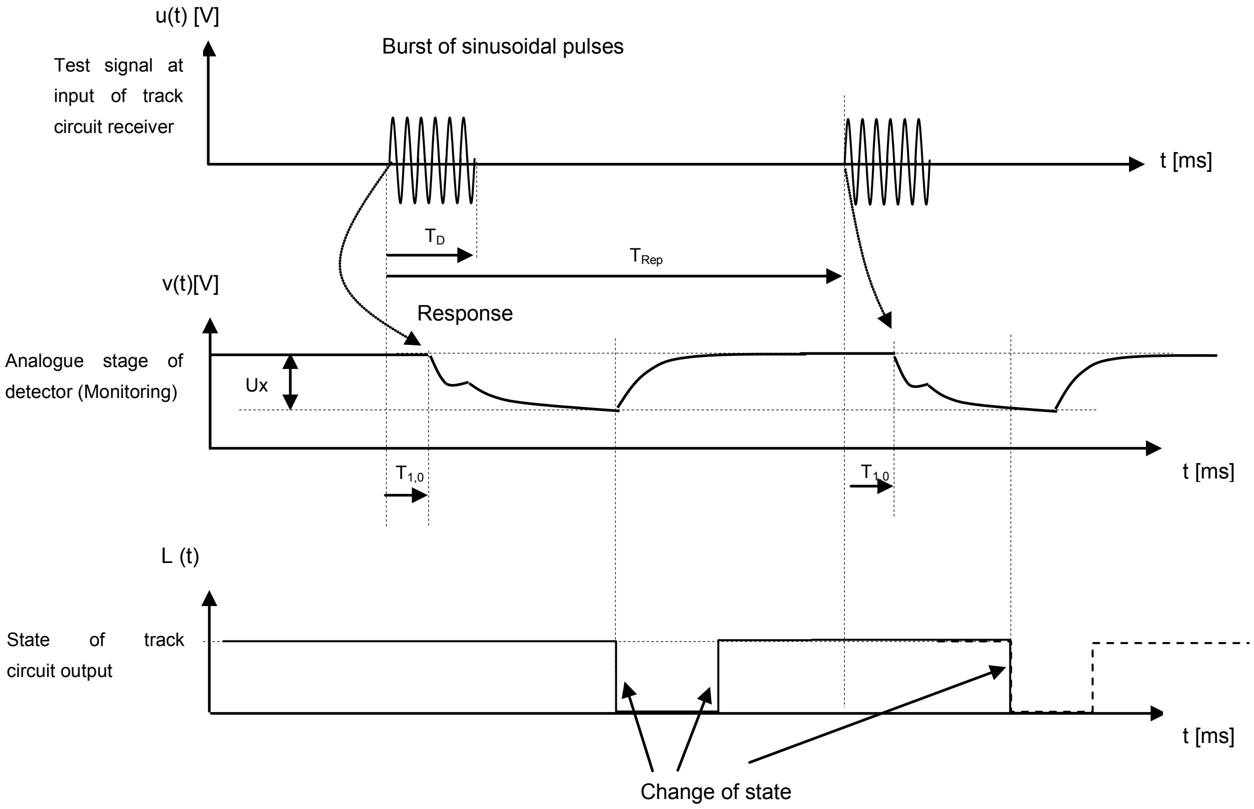
6.7.1 General

A complete set of requirements for laboratory testing is being studied within the European project EUREMCO. The final set of test signals and the testing procedure will be included in a further edition of this standard.

However, the following test specification is recommended to establish the response of the receiver to transient disturbances.

6.7.2 Switched sinusoidal signal

For dynamic susceptibility, the switched sinusoidal signal in Figure 4 is recommended to be used as a test signal to establish the behaviour of the track circuit receiver in the presence of transient interference.



Key

T_{Rep}.	Repetition time (in ms)
T_D	Duration of interference
$T_{1,0}$	System reaction time, negative slope
Ux	Product specific threshold

Figure 4 – Receiver response to sinusoidal pulses

To cover the phenomenon of transient interference when train(s) is traversing a neutral section, the following steps should be taken to establish dynamic susceptibility:

a) the sensitive part of the track circuit is the receiving input (input voltage is mainly symmetrical, some small asymmetric amplitudes can be considered);

b) set the frequency of generator to the centre frequency of the receiver, for each operational channel;

c) set T_{Rep} to at least 500 ms;

d) set the duration time to the smaller of the integration time (if known) or 20 ms;

e) reduce the time T_{Rep} and repeat until $T_{Rep} \leq 20$ ms, or the integration time is established.

Steps c) to d) are repeated to simulate bouncing of the pantograph by reducing T_D (100 µs is recommended as the lowest value for T_D). The amplitude should be increased until the track circuit reacts to the waveform.

6.7.3 Other signals

Additional specific signal shapes are provided below for the following transient events:

- 1,5 kV traction cut-off – 4 000 A for 5 ms to 20 ms

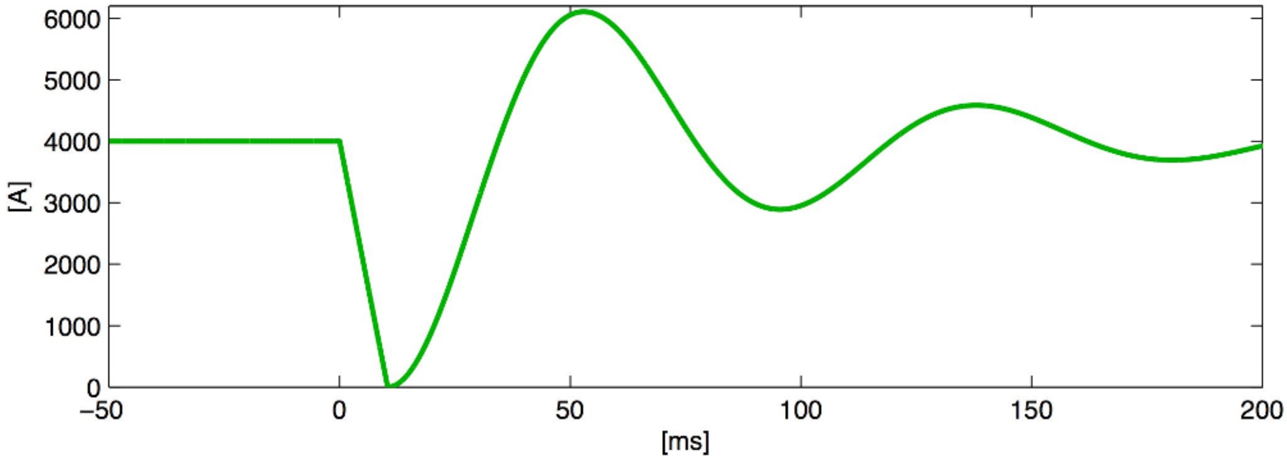


Figure 5 – Cut-off in a 1500 V DC System (4 000 A, 10 ms)

- 3 kV traction cut off – 2 500 A for 5 ms.

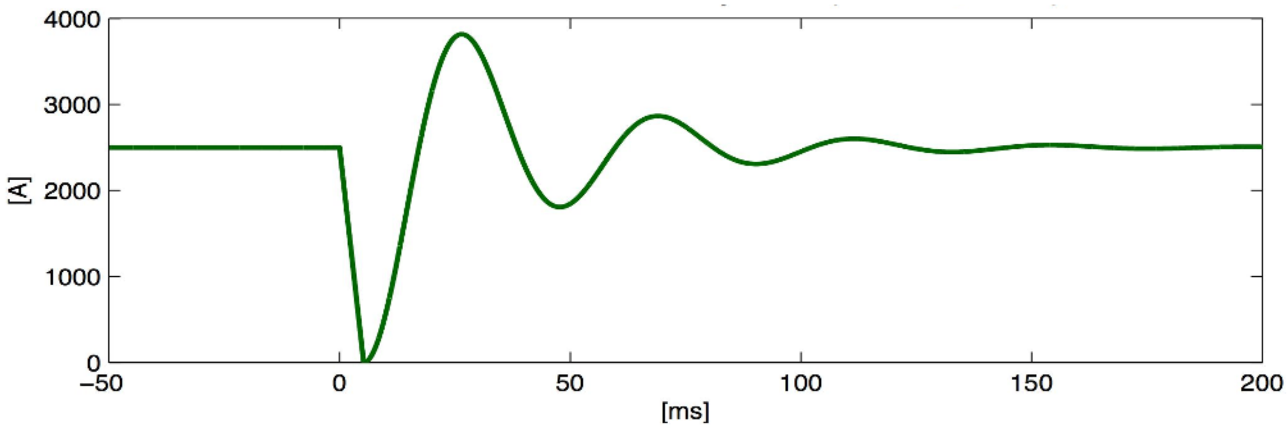


Figure 6 – Cut-off in a 3000 V DC System (2 500 A, 5 ms)

The oscillation frequency after 10 ms (in Figure 5) or 5 ms (in Figure 6) is between 8 and 35 Hz, with typical values from 15 Hz to 20 Hz. These signal shapes should be included in the immunity testing in the laboratory.

6.7.4 Validation of the response of the receiver to transient disturbances

The response of the track circuit to transient interference shall be established through laboratory testing as defined in 6.7.2 and 6.7.3 and documented. The established immunity level of the track circuit to transient interference shall form part of the application safety case argument for the track circuit.

6.8 RAMS

6.8.1 Reliability

Reliability cannot be defined as an individual parameter for track circuits as it is a combination of qualitative and quantitative arguments.

NOTE In service, reliability depends on a number of other subsystems and their ongoing maintenance, one of them being track infrastructure.

Reliability requirements can be harmonised in the context of EN 50126 series but can only be achieved with different measures concerning other railway subsystems.

6.8.2 Availability

6.8.2.1 General

The availability goal can be calculated by taking into account the MTTR and MTBF values, as follows:

$$Availaibility = \frac{\mathrm{MTBF}}{(\mathrm{MTBF} + \mathrm{MTTR})} \times 100\%$$

MTBF is product specific and is defined for the equipment of the track detection system required for a single detection section (indoor and outdoor).

Mean Time to Repair (MTTR) varies from 30 min to 300 min (typical worst case).

NOTE 1 In addition to the defined MTBF of train detection equipment, the availability of the track circuit as part of the complete system depends on the physical conditions within the environment it is installed. Availability targets for track circuits cannot be defined independently from the rest of the infrastructure elements of which it comprises.

NOTE 2 Typically, availability of 10^{-5} per hour is observed.

Other factors affecting availability:

1. In addition to the defined MTBF of train detection equipment, the availability of the track circuit as part of the complete system depends on the physical conditions in-situ, as specified in individual parameters.
2. The immunity of the track circuit to RST conducted disturbances, as defined from the FrM (see 6.5).

6.8.2.2 Requirements

In case of loss of availability, the track circuit shall consider the area ‘occupied’.

The MTBF shall be provided by the TC manufacturer. The MTBF shall comprise all hardware and software of the TC, except trackside cables and tracks/rails.

6.8.3 Maintainability

6.8.3.1 General

In order to guarantee proper functioning of the track circuit as a train detection system, maintenance is essential to sustain safety.

The maintainability of the track circuit is part of the complete railway system maintenance and depends on the physical conditions of the individual elements of the system used by the track circuit (e.g. ballast, rails, etc.).

For example, correct functioning depends on the impedances, which exist in parallel and in series to the measured track circuit in-situ.

Different elements of maintenance for some existing track circuits are described in Annex G (informative).

6.8.3.2 Requirements

Maintenance requirements for all components of the track circuits shall be derived from EN 50126.

MTBF of the complete system shall be the responsibility of the supplier and shall be defined in the safety case. TC suppliers shall provide all information related to equipment failure modes and the rate of occurrence in the safety case. The implications from failure effects shall be clearly identified so that they can be captured in the SMS of the respective entity responsible for the installation (this entity need not be the track circuit manufacturer).

The track circuit elements considered during maintenance activity may be specific to each type of track circuit. However, a maintenance interval for track circuit hardware of one year is recommended. At least the following elements shall be considered:

- Trackside:
    1) insulating joints (if present);
    2) bonding;
    3) interconnections;
    4) ballast resistance;
    5) broken rail;

- Other Elements:
    1) supplier specific test equipment;
    2) cabling/wiring/connection boxes;
    3) time between train movements.

6.8.4 Safety

The safe movement of the trains on railways is usually based on the definitive "track section clear" or "track section occupied" indication. The SIL can be specified for "track section clear" indication provided by train detection systems.

This parameter shall be validated / proven in the safety case for the track circuit. It shall be shown in the safety case that the required SIL can be achieved. Limits and requirements are described in EN 50126, EN 50128 and EN 50129.

Examples of application for different safety requirements are given in Annex L.

Clause 5 and Annex A concern the safety relevance of parameters defined in this standard.

6.8.5 Validation of all RAMS parameters

The safety case shall demonstrate that all RAMS parameters required for the intended application can be achieved. EN 50126, EN 50128, EN 50129 shall apply.

7 Train based parameter - Shunt impedance

7.1 General

The shunt impedance in this standard is defined in relation to vehicle mass / axle load.

The train shunt is defined as the total impedance including the contact impedance between wheel and rail, the resulting impedance of the wheelsets of a vehicle. The train shunt is known to be strongly affected by the dynamic behaviour of the wheel-rail contact.

Sanding, leaves and other non-conductive pollution strongly affect the resulting impedance. The parameters axle load, quality of wheel surface, quality of track surface, electric traction or not and e.g. the presence of tread brakes also affect the resulting impedance.

Indeed, improper use of on-board flange lubrication and the use of the composite brake blocks negatively affect the quality of the dynamic behaviour of the wheel-rail contact.

Concerning the tracks, oxidation due to a too low number of train passes adversely affects the wheel/rail contact quality.

Studies carried out in France have shown that most of rail's pollution causing non-shunting is composed of sand and rust. It has been shown that the sand is more isolating than the rust. In consequence, the sand is the main reason for non-shunting events. Some rules concerning its use are detailed in 9.3 of this document.

The train shunt is only partly defined by the maximum allowed wheel to wheel impedance. The non-linear nature of the rail-wheel impedance with respect to rail to rail voltage is a specific track circuit parameter and cannot be standardised.

The maximum electrical impedance between the running surfaces of the opposite wheels of a RST wheelset is defined in index 77 of CCS TSI. In practice the shunt seen by the track circuit is increased in value by the amount of pollution on the wheel and rail surfaces.

7.2 Requirements

The track circuit shall be able to detect rolling stock compliant with index 77 of CCS TSI. Sensitivity of track circuit to shunt impedance shall take into account all of the complex and other related parameters given in 7.1. Annex H provides an example of how this parameter can be managed.

A test with a control shunt shall be performed at all ends of the TC in order to demonstrate correct operation. To demonstrate reliable detection of a train by the track circuit, 0,5 Ω is recommended for this control shunt, as an appropriate worst case value. If the track circuit is demonstrated to detect a train only with a lower shunt value, additional restrictions shall be in place to maintain safe operation in accordance with the SMS of the IM.

NOTE 1 Lower shunting capability may be needed by certain track circuits designs which have broken rail detection as part of their functionality.

NOTE 2 In some applications, higher value of control shunt may be required by the IM.

To maintain the correct operation of the track circuit, this parameter shall be managed by the IM and Railway Undertakings who operate the trains, to keep this parameter within the limitations of the safety case.

8 Track based parameters

8.1 Total impedance of the track

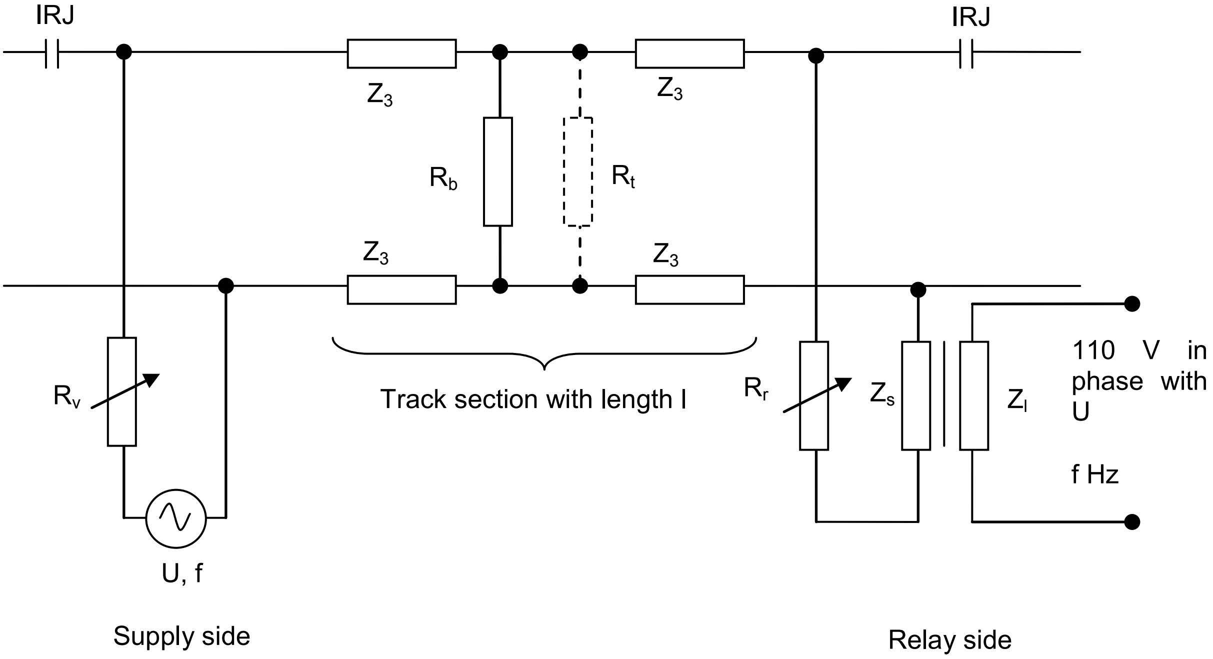
8.1.1 General

The worst case value of the total impedance of the track is used to calculate the allowed interference currents in the track circuits.

Ballast impedance, as part of the total impedance of track, is an important parameter for maintenance and can affect correct functioning of the track circuit as defined in 6.8.3. The following example describes a typical approach for determination of the total impedance of the track.

EXAMPLE

The maximum allowed interference current is defined based on the equivalent electrical diagram shown in Figure 7:



Key

R_b : Ballast impedance
R_V : Tuning resistor of the TR
R_r : Tuning resistor of the REC
Z_3: longitudinal impedance of the track
Z_l: Impedance of the transformer at the REC, interlocking side
Z_s : Impedance of the transformer at the REC, track side

Figure 7 – Ballast impedance

The limits for the total impedance of the tracks are derived from two scenarios:

- WSF when the track is occupied by the vehicle but due to interference it shows a 'track section clear' status;
- RSF when the track is free of train but due to interference it shows an 'occupied' status.

The derivation of these limits is based on different subsets of the parameters. As Figure 7 shows, there are two conflicting parameters influencing the detection of a train; the actual (dynamic) train shunt (R_t) and the ballast impedance (R_b). Both impedances are in parallel, thus the resulting impedance will determine whether or not the track circuit will function correctly.

8.1.2 Requirements

The specific value for total track impedance shall be determined depending on the TC's frequency of operation. The maximum impedance of the track shall be defined in the safety case for the track circuit.

The WSF scenario for interference shall be determined for the maximum train shunt as defined in Clause 7. The following values shall also be defined:

- the maximum transmitter voltage;
- the maximum ballast impedance;
- the maximum interference current limit (see 6.5);

- the maximum unbalance (for double rail track circuit).

The ballast impedance shall be controlled by the SMS of the IM.

8.2 Rail to Earth impedance

8.2.1 General

Rail to earth impedance is a fundamental part of the rail-rail impedance. The exact definition is the impedance seen between a rail and the electrical ground underneath it. Rail to earth analyses are provided in Annex I (informative). The parameter is of relevance to track circuits. If the track quality is maintained to the limits defined by the index 77 of CCS TSI (min 5 kΩ per connection point to ground) detrimental effects can be excluded.

Rail to ground impedance is a factor in several phenomena which affect the railway:

- The rail to ground impedance is a fundamental controlling factor in determining the detection range of a track circuit.
- The rail to ground impedance affects the balance of current flow in the rails; thereby having an indirect effect on the interference seen by a track circuit.
- The rail to ground impedance is of importance on DC railways to limit electrochemical corrosion effects.
- The rail to ground impedance affects the touch potential generated in the return rails.

Calculations indicate that 90 % of the inter-rail impedance (in the absence of trains, cross-bonds etc) is in the pad under the rails (and track clip insulator). This can be bridged by the rail-ground capacitance at higher frequencies and by any contamination, water, oil, metal dust etc. The major current path between rails is not via the ballast but flows down into the soil beneath the railway and crosses between the rails via ‘earth’.

8.2.2 Limits and requirements

8.2.2.1 Introduction

There are several existing standards which include or imply definitions of ground impedance requirements for various effects.

8.2.2.2 Ground impedance: track circuits

Index 77 of CCS TSI minimum electrical impedance of fastening is 5 kΩ with fastener spacing of 600 mm gives a rail-ground impedance of 3 Ω.km. Local variations are calculated between 2 Ω.km and 10 Ω.km.

8.2.2.3 Ground impedance: local contamination

Index 77 of CCS TSI minimum electrical impedance of fastening is 5 kΩ: this can be interpreted as local contamination impedance should be ≥ 5 kΩ 1).

8.2.2.4 Ground impedance: Corrosion

One of the factors for corrosion is stray current. Limitation of stray current shall be achieved by applying EN 50122-2.

8.2.2.5 Ground impedance: touch potential

Ground impedance influences the touch potential on cables connected to track circuits. Limits of acceptable touch potentials are given in EN 50122-1 and EN 50122-3.

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1) TSI states that some components of the CCS subsystem may require higher values.

8.2.3 Validation

The validation of this parameter is included as part of the ballast impedance tests in 8.6.

8.3 Rail surface resistance / track quality

The quality of rail surface is part of the total track impedance value, covered in 8.1.

NOTE The quality of the rail surface affects the dynamic shunt and thus becomes part of the total impedance.

8.4 Insulation value of IRJ

8.4.1 General

For reliable operation of the track circuits which use insulating joints as a separation between adjacent block sections, a minimum value of the rail insulated joint needs to be maintained.

The purpose of the insulated rail joints is to prevent the current from a track circuit flowing in an adjoining track circuit and causing a wrong side failure condition thus affecting safety or availability.

8.4.2 Requirements and validation

8.4.2.1 Method of validation

The values for IRJ are defined in 8.4.2.2 and 8.4.2.3 and shall be verified by the corresponding test as part of type approvals.

The validation of the requirements and the limits shall be part of the submission to a notified body.

8.4.2.2 Electrical test

An As-new IRJ shall withstand the following dielectric strength test: 4 kV_{AC} 50 Hz for 60 s. The type test is carried out in the laboratory with the IRJ insulated from ground.

An As-new IRJ shall fulfil the requirements for electrical resistance values shown in Table 2 with a DC voltage test between 250 V_{DC} and 500 V_{DC}.

The following values in Table 2 shall be achieved for different levels of humidity.

Table 2 – Insulation values at different humidity

Humidity (%)	Insulation (MΩ)
60	600
65	70
70	7
75	3
80	1,5

NOTE Although insulation values of as-new IRJs are defined, once installed IRJs can be bridged. Therefore, the condition of the track affects the insulation value.

8.4.2.3 Mechanical test

The mechanical strength of IRJ is a track quality parameter. A set of requirements for mechanical tests is provided as an example in Annex J.

8.5 Type of sleepers / track structure

8.5.1 General

For the use of track circuits on the track the impedance between the rails shall be higher than the minimum impedance needed for the availability level of the track circuit.

The type of sleepers and their isolation to the rails will influence the impedance between the rails.

For its normal function, the track circuit needs minimum impedance between the rails dependent on:

- the maximum length of the track circuit;
- the power of the transmitter;
- the working frequency;
- the impedance of the receiver seen from the track.

These minimum impedances are product depending.

8.5.2 Definition of the parameter

This parameter defines the requirements for the sleepers used in the track circuit environment.

There are three main types of sleepers used in the railway infrastructure:

- wooden sleepers;
- concrete sleepers;
- metal sleepers.

Each has its typical form and isolation.

Metallic bridges are effectively covered by the tests of metal sleepers.

The whole construction (sleepers, isolations between sleepers and rails, distance between the sleepers, isolations to earth, ballast, and metal bridges) gives certain impedance between the rails.

8.5.3 Requirement and validation

For each type of sleeper, a test shall be carried out with the sleeper mounted on its isolation pad but without ballast. It shall also be tested under the influence of salty water poured over it (worst case conditions).

These tests shall be performed according to EN 13146-5.

The TC shall work as intended when installed on tracks using any type of sleepers.

The minimum value for acceptance depends on the type of track circuits that are used and the distance between two sleepers. The Infrastructure TSI 2011/275/EU requires minimum impedances between rails and of the complete mounted sleeper. The IM can require higher values to suit other TC types.

The impedance shall be tested according to EN 13146-5.

Examples are provided in Annex K.

NOTE This parameter is considered in conjunction with 8.6 to formulate a basic parameter for track circuits.

8.6 Ballast resistance

8.6.1 General

In order to ensure correct functioning of the track circuit, a minimum ballast resistance between the rails is required to be maintained.

This minimum ballast resistance is required to achieve the expected availability level of the track circuit.

8.6.2 Definition of the parameter

This parameter defines the requirement for ballast resistance necessary in the track circuit environment.

The whole construction of track (sleepers, isolations between sleepers and rails, distance between the sleepers, isolations to earth, ballast, and metal bridges) gives a certain impedance between the rails.

8.6.3 Requirements for validation

Following the verified values of sleepers' impedances according to EN 13146-5, the equivalent track-to-ground (ballast) impedance shall be calculated for the track circuit length.

The IM shall ensure that a minimum ballast resistance between the rails is achieved. An example of existing requirement for the ballast resistance depending on the type of sleepers and track structure is given in Annex K.

For new designs, the signalling manufacturer shall define the minimum acceptable ballast resistance required.

If the specified ballast resistance cannot be achieved, it may be necessary to install a system with respect to EN 13481, to ensure the following minimum value of an alternative parameter: 5 kΩ resistance per sleeper for high speed and conventional lines.

8.7 Maximum time between train movements

8.7.1 General

Without regular passage of wheels, the state of the rail gets contaminated by various pollutants and the rail/wheel contact degrades.

8.7.2 Definition of the parameter

This parameter defines the minimum number of daily runs in nominal condition in order to ensure correct functioning and reliable operation of the TC.

This parameter also defines the maximum time without train runs with the track in degraded condition beyond which the functioning of TC is no longer reliable.

8.7.3 Requirements and validation

As per the Safety Management System of the Infrastructure Manager, specific limits shall be defined by individual Infrastructure Managers in conjunction with suppliers.

8.8 Unbalance of the return current

8.8.1 General

The unbalance of the return current circulating in one rail compared to the second one creates a residual voltage seen by the track circuit receiver as an image of the RST current.

Considered unbalance is located within the length of the TC section and is coming from external factors. Any unbalance caused by in-situ installation of the track circuit elements which is compensated during the track circuit set-up is excluded from this definition.

8.8.2 Requirements and validation

Currently, a different level of unbalance is maintained by different infrastructure managers, based on their SMS and as an extra application design requirement.

From a reliability point of view, the typical value of unbalance observed in normal situations shall be defined by the IM. The TC shall work as intended with this typical value when the RST emit the maximum current in the frequency range of the TC (see FrM, 6.5).

NOTE Typical values are 10 % to 20 % for double rail return system.

From a safety point of view, in the case of high levels of unbalance (e.g. in case of broken rail, see section 6.3), the TC shall indicate the track as ‘occupied’ when the RST emit the maximum current in the frequency range of the TC (see FrM, 6.5).

The safety case shall include the unbalanced values to be considered.

9 Environmental and other parameters

9.1 Signalling power supply quality with respect to availability

9.1.1 General

Signalling power supply provides the energy to the track circuit system.

According to EN 50160, the power supply quality can be characterised by the following parameters:

- Variation of the voltage magnitude
- Variation of the mains frequency of the AC power systems
- Voltage dips and power interruptions
- Voltage harmonic and distortion level of the AC power systems
- AC ripple on DC power systems
- Other EMC related phenomena

9.1.2 Requirements and validation

The characteristics of the power supply shall be adapted to the needs of the TC system, and the TC system shall tolerate some natural variations of these characteristics.

Power supply characteristics and quality levels shall be defined by agreement between the infrastructure manager and the track circuit manufacturers.

Tests can be performed on the track circuit component according to the relevant standard from the EN 61000-4 series, or other testing methods defined by agreement between the infrastructure manager and the track circuit manufacturer.

Short interruptions to the power supply of TDS shall not lead to unsafe situations and are considered as part of the safety case for the signalling subsystem.

For EMC phenomena, EN 50121-4 shall be applied (see also 9.5).

9.2 Traction power supply quality

9.2.1 General

Power supply quality (i.e. harmonic voltages) at the pantograph of trains has an influence on the interference currents seen by the track circuit. Harmonic voltages in the power supply will lead to higher or additional interference currents through rolling stock, depending on the impedance of traction units.

The interference current limits for RST are defined at absolute frequencies. The measured RST interference current is dependant on the mains frequency variations and harmonics from the power supply.

Frequency variations are defined in EN 50163. Practical limits are defined in CLC/TS 50238-2.

Currently, there is no harmonised set of limits for harmonic distortion of the power supply.

NOTE Parameters “frequency management / separation of operational channels” and “vehicle impedance” have been defined also under this aspect, including all individual values (frequencies, current limits etc.). However, power supply quality is usually not measured during operation of railway systems, and improving power supply quality can be complex and costly (e.g. installation of additional high-voltage damping devices). Therefore, it will be essential to define a consistent frequency management for the target system, as part of Interoperability requirements for the Rolling Stock and Energy subsystems.

9.2.2 Definition of the parameter

For DC power supply networks, the infrastructure managers shall be responsible for the quality of the power supply if RST emissions are found to exceed the limits in the FrM.

This shall be the case:

- when measured with the RST connected to a substation with a defined output impedance value;
- the input impedance of the RST is shown to be within stated values.

For AC power supply the contribution of power supply harmonics to the RST emissions seen by the track circuit, is very small. Whilst the main source of interference to track circuits is the RST, it is required to specify a limit for the capacitive input impedance of RST (due to roof cables) to limit potential excitation in the AC power network.

9.2.3 Requirements and validation

- RST impedance – open point for Interoperability;
- number of vehicles fed from one substation – open point for Interoperability;
- summation rules applicable for evaluation – open point for Interoperability.

9.3 Amount of sand

9.3.1 General

Sand when applied to the rail to improve adhesion levels for traction and braking may affect the safe performance of the track circuit. For reliable train detection by track circuits, the density or thickness of the layer of sand on the rail and the associated electrical resistance it presents should be limited.

If the amount of sand is too much, track circuit failures - due to the isolation layer of sand between wheel and rail – may appear. This means that the train may not be detected reliably by the track circuit system, and in the worst case, the track circuit may report/qualify the track section as “clear” in the presence of train.

9.3.2 Definition of parameter

There is no specific requirement if the sanding equipment complies with index 77 of CCS TSI.

9.3.3 Requirements and validation

No requirements for the track circuit can be defined.

9.4 Weather, ice and other environmental conditions

9.4.1 Temperature

9.4.1.1 General

The ambient temperature range is a basic requirement for all technologies to ensure the correct functionality and reliability of electric and electronic equipment in the target application environment.

The ambient temperatures for signalling equipment are described in EN 50125-3. EN 50125-3 offers a list of temperature categories.

Therefore there are different ambient temperature ranges to be applied for these kinds of track circuit components.

9.4.1.2 Ambient temperature for track circuit evaluator component – Requirements and validation

The track circuit evaluator component shall work in the temperature range and under the conditions which are described in EN 50125-3, class T1 and T2 (for containers or in buildings) either with or without temperature control.

Depending on the location of application the given temperature ranges shall be applied.

9.4.1.3 Ambient temperature for track circuit trackside equipment – Requirements and validation

The track circuit trackside equipment located in a junction box or in a cubicle near to the track shall work in the temperature range and under the conditions as defined in EN 50125-3, class T1 and T2 in a cubicle.

These temperature ranges cover the following thermal influences:

- ambient temperature at the ground-level on railway tracks (including thermal radiation from the ground of the track);
- inside outdoor cubicles local power dissipation and the influence of insolation may cause higher operating temperatures. These should be taken into account.

If the trackside equipment is located in a cubicle together with other equipments, it shall be made sure that the internal temperature of the cubicle will not exceed the specified temperature range.

9.4.2 Pressure/Airflow

9.4.2.1 General

a) Height-level
Air-pressures above and below the range specified in 9.4.2.2 may cause malfunction or damage of the equipment (isolation).

b) Aerodynamic forces at the lineside / Aerodynamic forces in tunnels

Aerodynamic forces may lift the cabling, loosen lids of electronic housing or parts of the equipment in general.

c) Wind
Very strong winds may lift the cabling, loose up lids of electronic housing or parts of the equipment in general.

9.4.2.2 Requirements and validation

Test of the correct operation and the resistance against air flow in wind-tunnels or by putting mechanical pressure on certain points of the housing shall be performed.

According to EN 60721-3, category 4 Z10, and according to EN 50125-3:2003, Table 1, category A1, the track circuit shall work within the air-pressure (height-level) range of:

- min. air-pressure: 84 kPa
- max. air-pressure: 106 kPa

(corresponding to altitude range relative to sea level up to 1 400 m)

The maximum resulting aerodynamic forces at the lineside/in tunnels shall be calculated/defined for the individual situations by the manufacturer on the basis of data from the infrastructure manager.

9.4.3 Humidity

9.4.3.1 General

Humidity – especially inside the equipment or its electronic parts – may cause malfunction as well as damage (short circuit, etc.).

9.4.3.2 Requirements and validation

Test shall be performed according to EN 50125-3:2003, Table 3 ‘Humidity ranges at different sites, Climatic class T1’.

The track circuit shall work within the following humidity range:

- permanent minimum relative air humidity: 15 %
- permanent maximum relative air humidity: 100 %

9.4.4 Precipitation

9.4.4.1 General

Laboratory tests shall be performed so far as it is possible for different categories of precipitation - rain, hail, snow, ice. In addition, tests on the track under real conditions (e.g. winter) shall be applied.

The track circuit shall be demonstrated to perform reliably up to the maximum precipitation levels defined in 9.4.4.2, 9.4.4.3, 9.4.4.4 and 9.4.4.5.

9.4.4.2 Rain

Rain together with air flow may get in the equipment or electronic parts (see also 9.4.2 and 9.4.3).

Tests shall demonstrate that the track circuit operates reliably under permanent rain level of 6 mm/min in combination with air flow defined according to EN 50125-3:2003, 4.6.

9.4.4.3 Snow

Tests shall demonstrate that the track circuit operates reliably and permanently withstands all types of snow parallel to the air flow, defined according to EN 50125-3:2003, 4.7.

9.4.4.4 Hail

Hail may cause physical damage, especially if the hail stones have a diameter larger than 15 mm. Consequently, water may get into the equipment case and reach the electronic parts inside. The humidity levels will build up as a result (see also 9.4.3 on effects of humidity).

Tests shall demonstrate that the track circuit operates reliably under permanent hail conditions with hail stones of 15 mm diameter.

NOTE Exceptionally large diameter hail stones are possible according to EN 50125-3:2003, 4.7.

9.4.4.5 Ice

Ice can form underneath the train and if it becomes loose and falls over the track circuit equipment it may cause physical damage. Consequently, water may get into the equipment case and reach the electronic parts inside. The humidity levels will build up as a result (see also 9.4.3 on effects of humidity).

Tests shall demonstrate that the track circuit operates reliably under permanent icy conditions specified according to EN 50125-3:2003, 4.8.

NOTE Ice, falling off the trains and any risk to the following trains is outside the scope of this standard.

9.4.5 Solar radiation

Solar radiation may influence the quality of material (cabling, fixing of cabling, plastic covers, etc.). The track circuit shall not be damaged, otherwise, water digress may occur and humidity may built up and affect electronic parts (see 9.4.3).

The effect of solar radiation is covered by the parameter "Ambient temperature" in 9.4.1.

According to EN 50125-3:2003, 4.9, the track circuit components destined for lineside installation, shall be designed to operate reliably over their expected life time with a maximum solar radiation of 1 120 W/m^2.

9.4.6 Protection level (IP)

In certain local areas and for some extreme climate conditions, it may be possible that water stands in the area of the track circuit. If any water gets into the equipment housing, the electronic parts may be damaged and the track circuit will be disturbed or not work correctly (see also 9.4.3).

The track circuit component located on the track should be protected against water at a depth of 820 mm from the top of the housing for duration of one hour.

The track circuit shall operate reliably after the test performed according to EN 60529, category IP65 for any trackside mounted equipment, and IP68 for any rail mounted equipment. The track circuit rail mounted components shall be tested under water at a depth of 820 mm from the top of the housing for duration of one hour.

9.4.7 Vibrations / shock

9.4.7.1 General

Any track circuit component mounted on the rail shall withstand very high impulses and accelerations. Vibrations / impulses may loosen electronic parts, connectors, or destroy electronic components etc. with the result of malfunction.

9.4.7.2 Requirements and validation

The component shall operate properly during and after the tests defined in EN 50125-3. The test limits shall be chosen according to the specific location of the track circuit component under test, e.g. sleeper mounted, ballast mounted, box mounted outside the track.

9.5 EMC

9.5.1 General

The track circuit may be influenced by different magnetic / electromagnetic fields resulting from the current in the rail, from electromagnetic sources on board the passing trains and from its external environment e.g. radio transmitters or lightning. Depending on the magnitude of the source, correct functionality may be lost temporarily, or in very extreme cases the track circuit may be damaged.

9.5.2 Requirement and validation for EMC with respect to vehicles

The track circuit should fulfil the requirements in 6.5 and be compatible with the frequency management described in Annex E.

NOTE Magnetic Fields generated by eddy current brake are not covered in the standard. The interaction between the track circuit and active / passive eddy current brakes will be described by the European research on eddy current brakes (ECUC). The possible influences on the infrastructure, including track and layout, will probably be the subject of another standard working group on eddy current brakes. Once these interfaces are defined, the intention is to include the relevant results for the impact on track circuit design here in a dedicated subclause of this document.

9.5.3 Requirement and validation for EMC with radio transmitters

The track circuit shall be immune to electromagnetic fields, specified according to EN 50121-4.

9.5.4 Requirement and validation for overvoltage protection (including indirect lightning effects)

Beforehand, the IM should provide information to the TC manufacturer about the grounding and lightning protection management plan applied to the affected infrastructure.

The manufacturer shall provide details of overvoltage protection provided by the design of the track circuit.

NOTE Overvoltage protection (e.g. over voltage limit devices, grounding system) are also used for electrical safety of workers and public people. Such protections are part of the whole infrastructure design and are usually defined in a grounding and lightning protection management plan.

EN 50124-2 shall be considered.

Annex A
(informative)

Guidance for safety relevance of parameters

In the following table, the normal safety relevance of each parameter is indicated. The safety relevance indicated in this table is only informative and should be confirmed in the safety case, as requested in Clause 5.

In case of loss of availability, the track circuit considers the area ‘occupied’. In case a train is approaching the track circuited section controlling the signal, emergency braking may be activated. In this case, the availability problem can lead to a safety problem.

Table A.1 – Safety relevance for track circuits parameters (1 of 2)

Subclause	Safety relevant
6.1 TC non-detection zone	Yes
6.2 Track circuit length	Yes
6.3 Broken rail detection	No, for first broken rail, it affects availability Yes, for second broken rail in the same rail, it affects safety
6.4 IRJ failure detection	No, except in some cases
6.5.1 Frequencies and immunity limits	Yes, for single frequency track circuits No, for track circuits using coding or other criteria for frequency discrimination against interference
6.5.2 Number of operational channels	N/A
6.5.3 Separation between operational channels / channel bandwidth	No
6.6 Coding	Yes
6.7 Response of the receiver to transient disturbances	Yes
6.8.2 Availability	No, except in some cases
6.8.3 Maintainability	Yes
6.8.4 Safety	Yes

Table A.1 – Safety relevance for track circuits parameters (2 of 2)

Subclause	Safety relevance
Clause 7	Yes
8.1 Total impedance of the track	Yes, linked to maintainability
8.2 Rail to Earth impedance	Yes
8.3 Rail surface resistance / track quality	Yes, linked to maintainability
8.4 Insulation value of IRJ	Yes, for single frequency track circuits
8.5 Type of sleepers / track structure	Yes
8.6 Ballast resistance	Yes
8.7 Maximum time between train movements	Yes
9.1 Signalling power supply quality with respect to availability	No, except in some cases
9.2 Traction power supply quality	No, except in some cases
9.3 Amount of sand	Yes
9.4.1 Temperature	No
9.4.2 Pressure/Airflow	No
9.4.3 Humidity	No
9.4.4 Precipitation	No
9.4.5 Solar radiation	No
9.4.6 Protection level (IP)	No
9.4.7 Vibrations / shock	No
9.5 EMC	Yes

Annex B
(informative)

Scenarios for non-detection zone

The following scenarios explain the requirement:

B.1 Overlap of two detection zones using isolated rail joints (distance x in figure below)

In S&C areas, the isolated rail joints can be staggered such that there is a difference between their longitudinal line references. The maximum stagger allowed should be 3 m, which is the shortest distance between the first and the last axle of a vehicle allowed on the track, as defined in 3.1.2.4 of index 77 of CCS TSI (usually a maintenance vehicle).

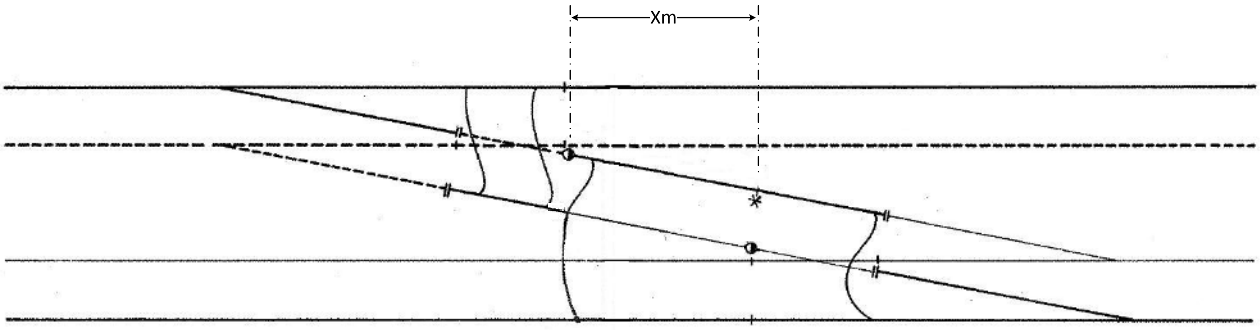

Figure B.1 - Overlap of two detection zones using IRJ

B.2 Overlap of a dead zone in S&C area

Each axle is required to be detected, even if it is situated at the end of the track in the diversion track (see Figure B.2). If the impedance of the spur (acting as diverted track) together with the impedance of the axle, is higher than the drop shunt of the track, the axle will not been detected (see Figure B.3). For frequencies up to 2,5 kHz, this requirement translates into a maximum spur length of 15 m measured from the centre point of the S&C.

In case of a broken rail (see Figure B.4) the equivalent electrical circuit is modified to incorporate the impedance of the spur controlled by the track circuit. If the impedance is too high (the spur is too long) broken rail detection cannot be achieved for a considerable length of the track circuit. Therefore in practice, the maximum total length of the spur is limited to 50 m. If the layout doesn’t allow this, a second receiver is needed (see Figure B.5).

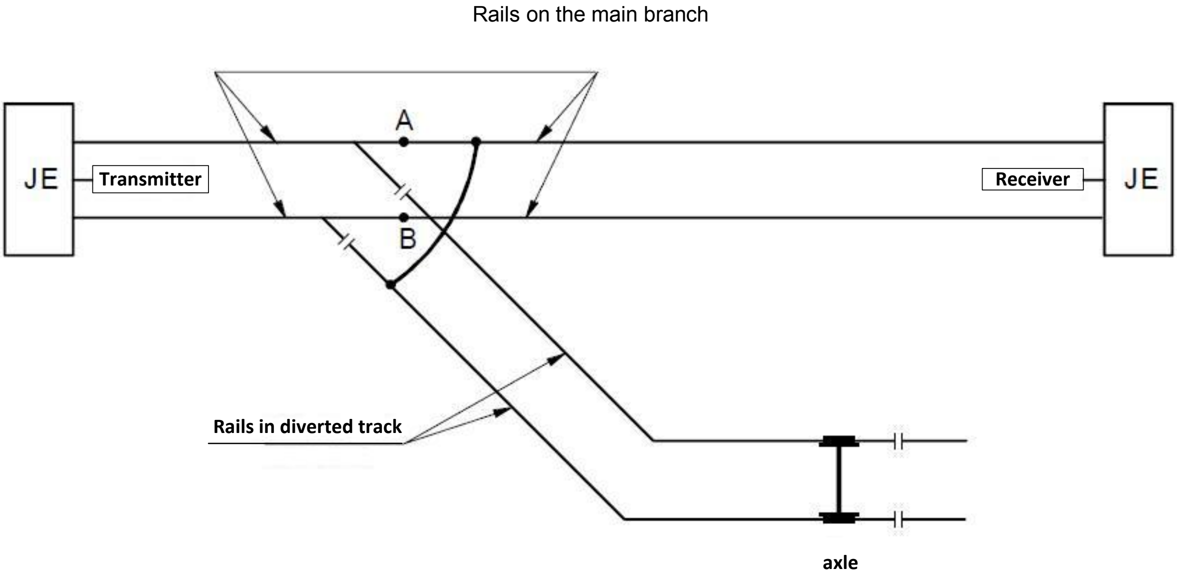

Figure B.2 – Detection of one axle in diversion track

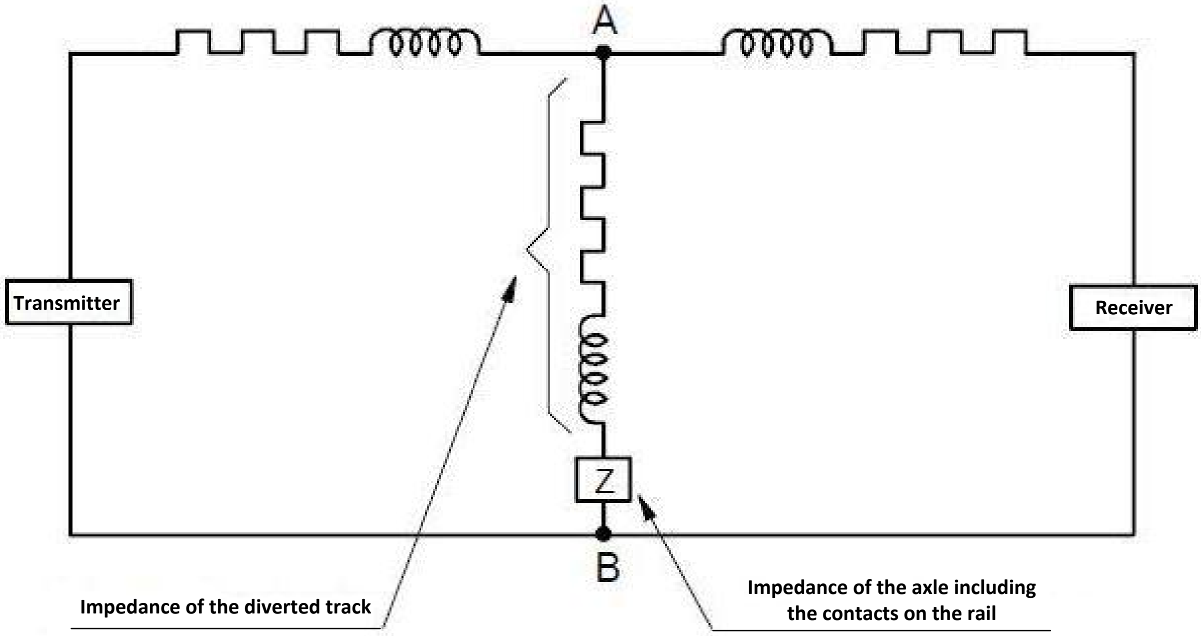

Figure B.3 – Equivalent circuit

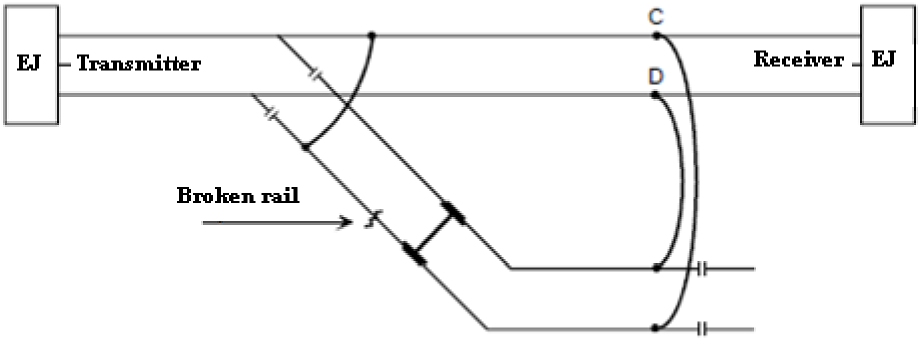

Figure B.4 – Detection of one axle in diverted track with a broken rail

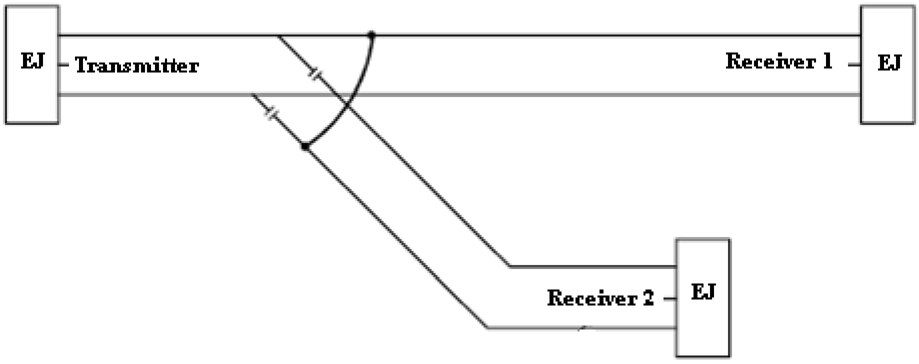

Figure B.5 – Configuration with a second receiver

B.3 Equipotential wires in S&C area

The layout in Figure B.6 addresses all scenarios from B.1 and B.2.

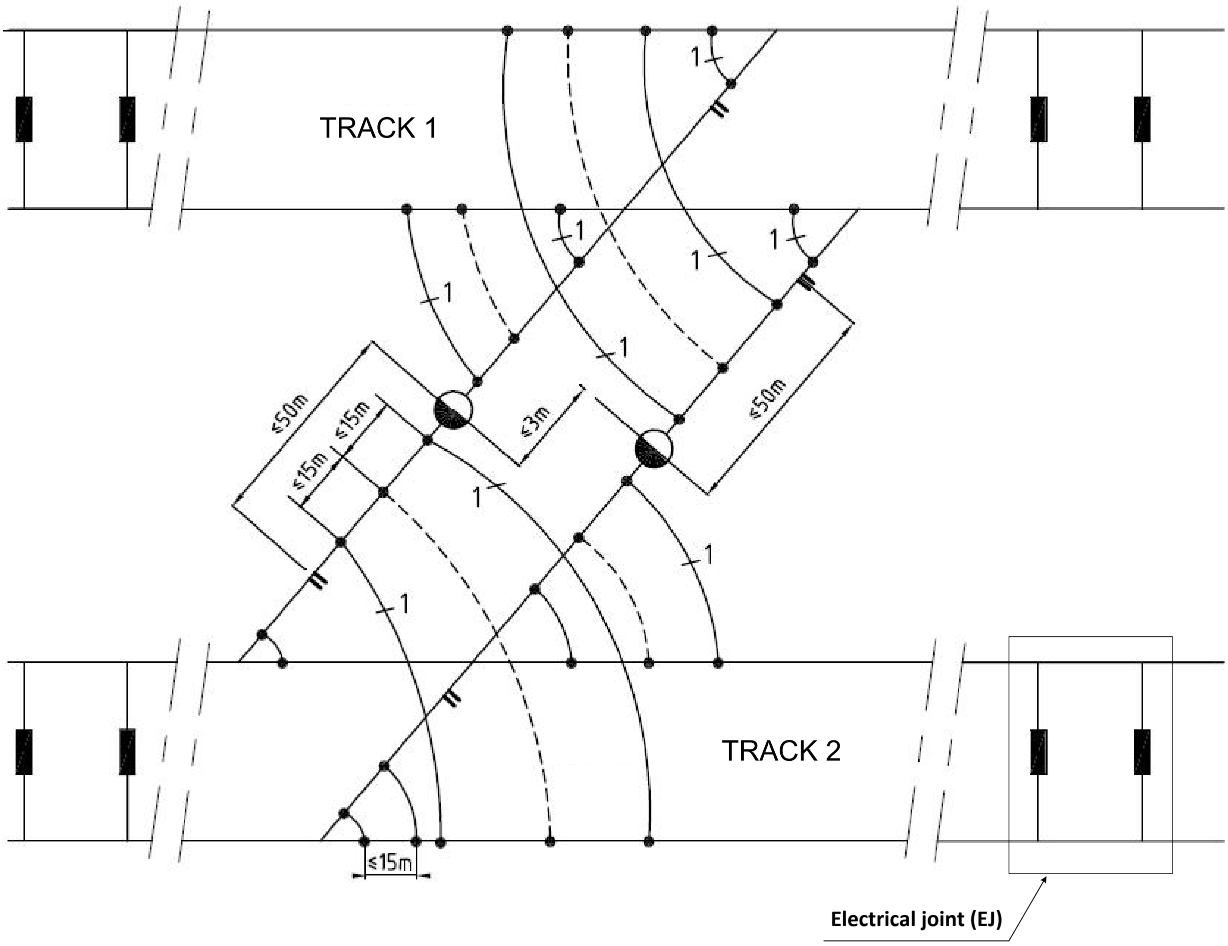

Figure B.6 – Summary of the scenarios B.1 and B.2

B.4 Zone without detection in electrical joints

In this example three track circuits (TC) with electrical tuning units are considered. The pink zone indicates the track voltage at the frequency of the TC. The length of the electrical joint (Xm) and the maximum length of the TC can be different for different manufacturers. Placing a shunt (or axle) in the track between the transmitter (TR) and the receiver (REC) will change the status to 'occupied' (REC becomes red), see Figure B.7. Placing one axle (or a shunt) in the electrical joint (see Figures B.8 and B.9) will influence one or two TC depending on its position in the tuning zone of the electrical joint.

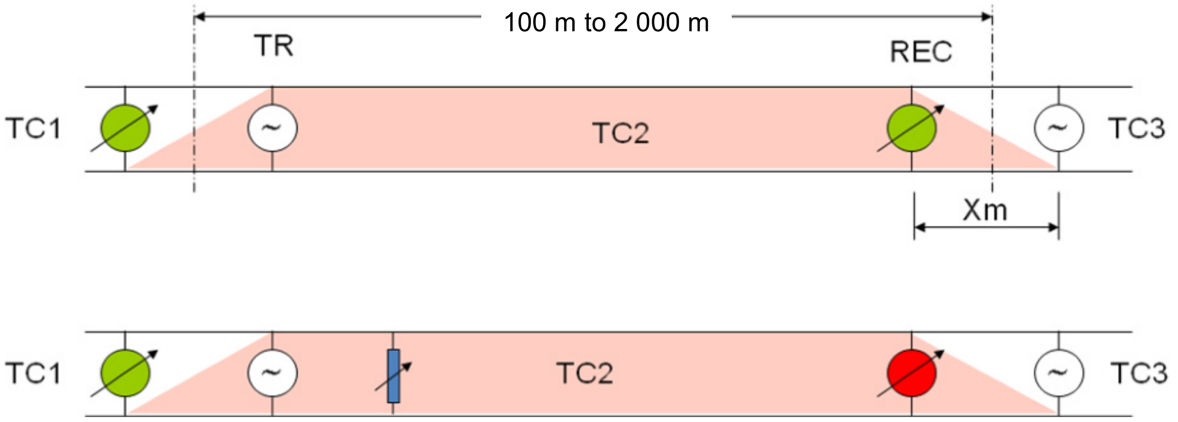

Figure B.7– Track circuit with electrical joints

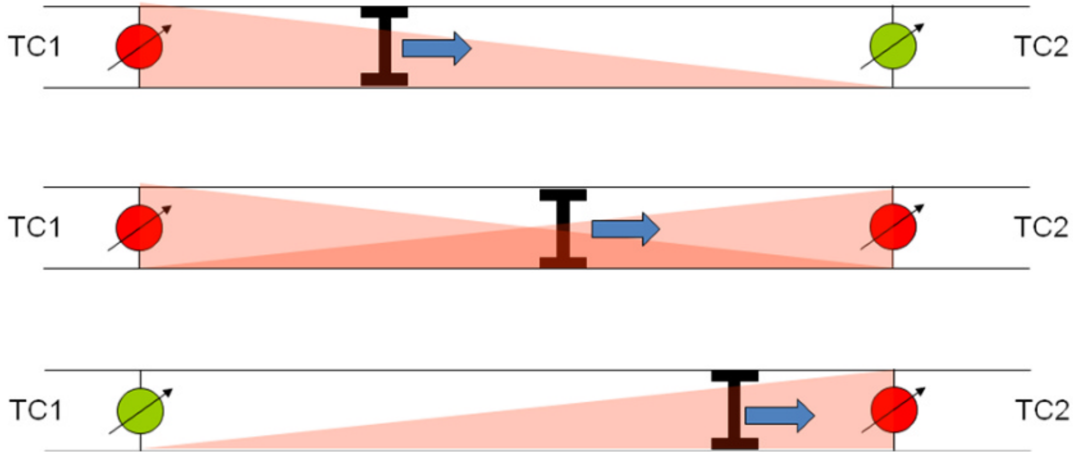

Figure B.8 – Detection within the electrical joint

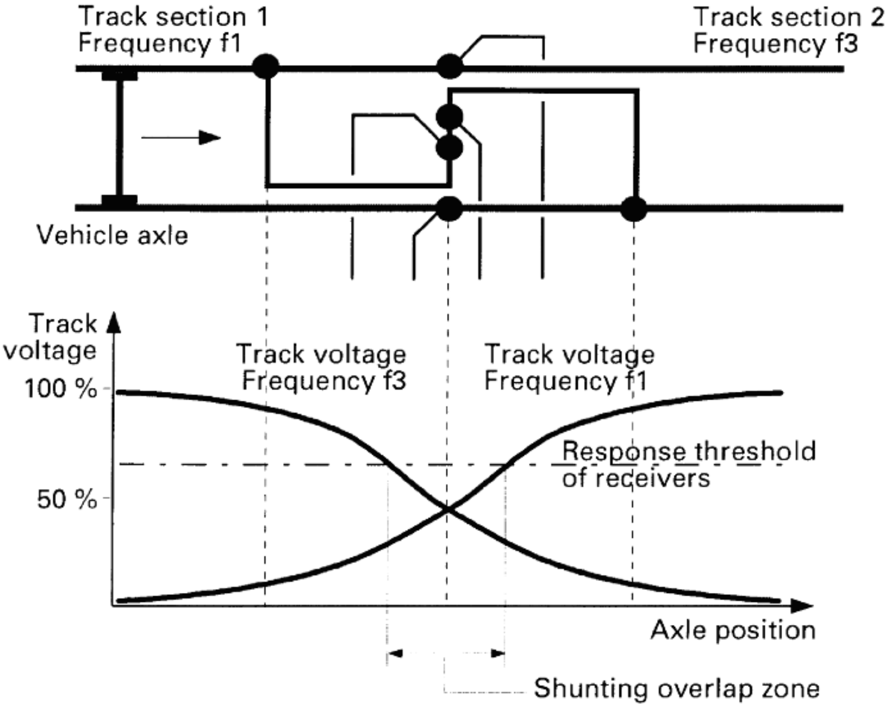

Figure B.9 – Example of overlapping zone in S-bond

Annex C
(informative)

Track circuit length

C.1 Introduction

Track circuits supply the interlocking with details of whether the individual track section is 'clear' or 'occupied'. If a train enters the track section there is a reaction time while the system state is changed from 'clear' to 'occupied' or vice versa.

For safety reasons, the minimum track circuit length should be larger than the maximum axle to axle distance of one train. If not, a 'clear' – 'occupied' – 'clear' message sequence can be produced which will lead to route release by the interlocking.

The following example describes the technical reasons of the 30 m minimum length for TC with S-bond

C.2 Example of TC with S-bond

C.2.1 Introduction

By design, the length 'I1' in Figure C.1 is at least 6 m long. Therefore, for physical reasons, the minimum track section length cannot be less than 12 m if using normal S bonds at both extremes of the track circuit. In addition, S-bonds are able to electrically influence each other if the distance between them is less than 30 m. For this reason, a minimum length of 30 m is used if using S-bonds to separate between adjacent track circuits.

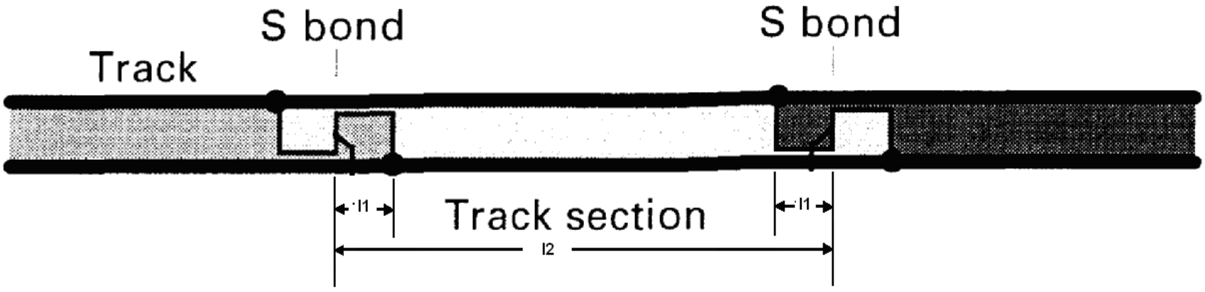

Figure C.1 – Track section length

But, by using short cut bonds or mechanical joints a smaller minimum distance can be achieved. In that case the distances I1 and I2 can be nearly zero. Consequently, the absolute minimum length of the track circuit can be determined by using the highest value obtained from:

- The S-bond length (see C.2.2)
- The reaction time of the track circuit including the interlocking delay, depending on the speed of the train (see C.2.3).
- The maximum distance between the axles of the train (see C.2.4).

C.2.2 TC minimum length depending on the S-bond length

If using S-bonds, for physical reasons, the minimum track section length cannot be less than twice the S-bond length 'I1' (see Figure C.1).

$$I2 > 2 \times I1$$

Minimum length of track circuit ‘Length_{TC}’ using s-bonds is defined as

$$\text{Length}_{TC} = 2 \times l1 + l2$$

C.2.3 TC minimum length depending on the speed of the train, drop-away delay, route release delay and tolerances

NOTE This example does not take into account the route release delay.

For normal operation, the drop-away delay ‘Tpi’ of the track circuit relay of 0,25 s is taken into account in the example calculations below.

The distance ‘S_{move}’ (in m) covered by the train while the system reacts, can be calculated, from the speed ‘v’ of the train in km/h, using the formula:

$$S_{move} = v \times 1\,000 / 3\,600 \times Tpi$$

A margin of 25 % on top of the physical minimum track length ‘Length_{TCmin}’ is used.

$$\text{Length}_{TCmin} = S_{move} \times 1{,}25$$

In Table C.1, the previous considerations have been applied for different speeds of the train, rounded to the higher half integer.

Table C.1 – TC minimum length including pick-up delay and tolerances depending on the speed of the train

T_{pi} [s]	v [km/h]	S_{move} [m]	Length TC_{min} [m]
0,250	45	3,2	4
0,250	50	3,5	4,5
0,250	100	7	9
0,250	150	10,5	13,5
0,250	200	14	18
0,250	250	17,5	22
0,250	300	21	27

C.2.4 TC Minimum length relating to RST

If part of the train bridges the detection section (i.e. no axle in the section), the train detection system will qualify the section as ‘clear’. Consequently, the length of the track circuit should be bigger than the distance travelled by the train before the system reacts, to avoid not detecting the train (see Figure C.2).

This length is described in index 77 of CCS TSI for interoperable rolling stock.

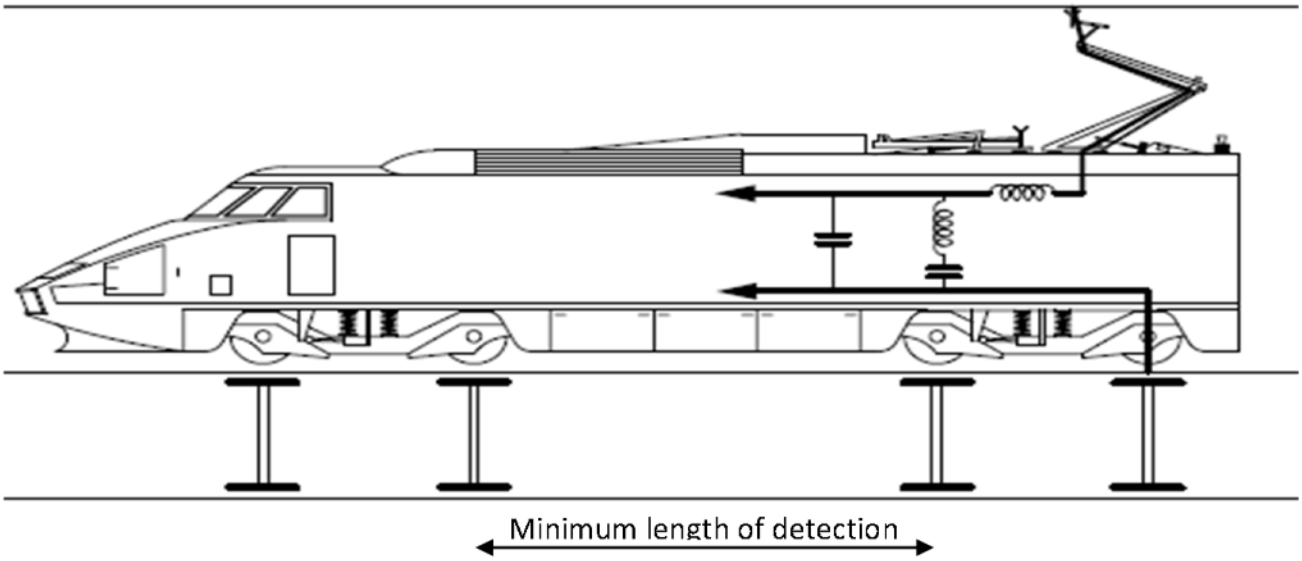

Figure C.2 – Definition of minimum length of detection

Annex D
(informative)

Scenarios for broken rail
Relation Track circuit – Broken rail detection

D.1 Basic principle

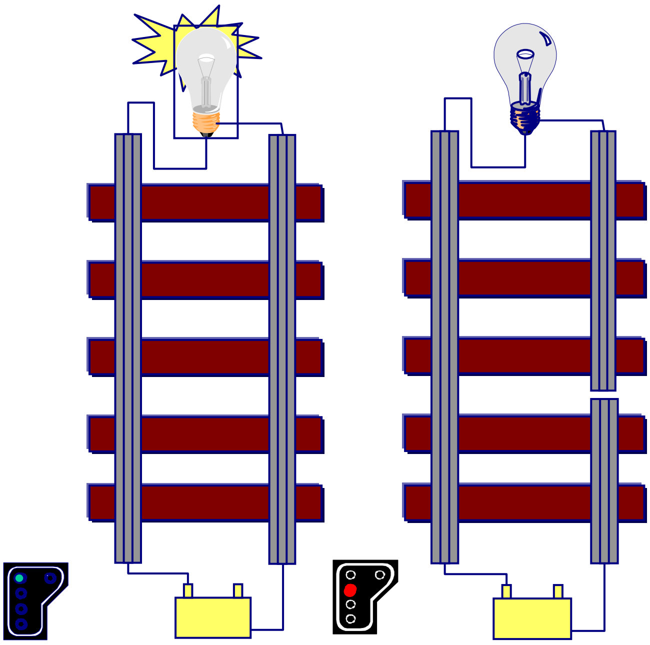

Figure D.1 – Broken rail basic principle

In case of a single track circuit, each track circuit will detect a broken rail, even when with single rail insulation.

D.2 Fail safe system

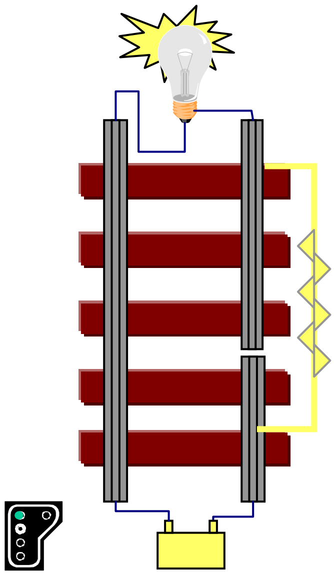

Figure D.2 – No detection of the first failure

A fail safe system is a system that will experience a RSF with a single failure (i.e. it is detected) before the second failure (together with the first one), which will lead to a WSF.

When there is a path parallel to the broken rail having lower impedance, the first broken rail may not be detected. However, the vehicle will still be detected.

If a second rail break occurs on the same rail, the vehicle will be lost. The failure will be termed as WSF, see Figure D.3.

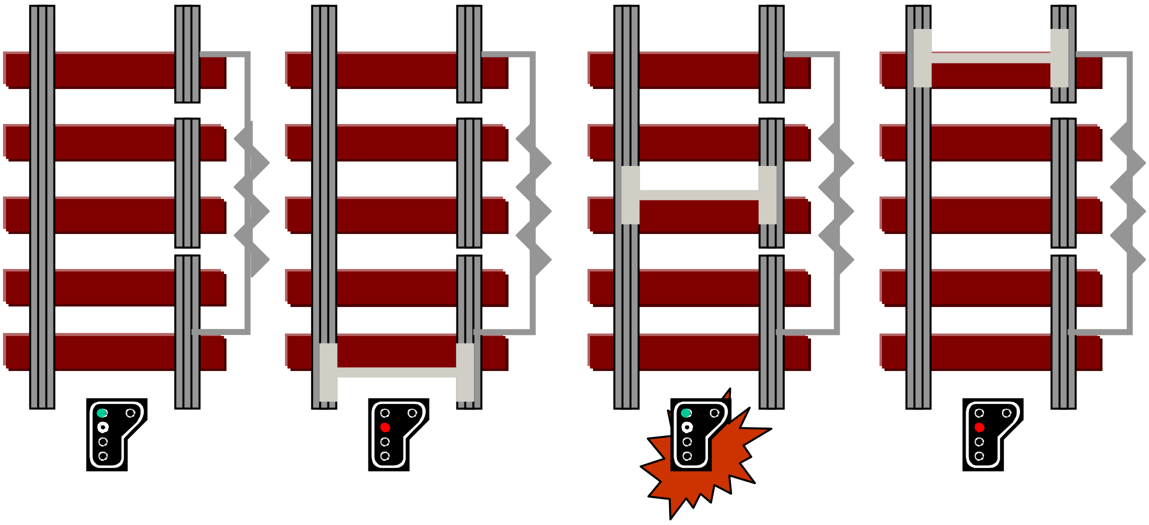

Figure D.3 – Scenario of WSF: no detection of the train

D.3 Examples where the broken rail detection is not possible.

D.3.1 S&C area

In each S&C area where a parallel electrical path exists along the rails.

D.3.2 Single rail isolation

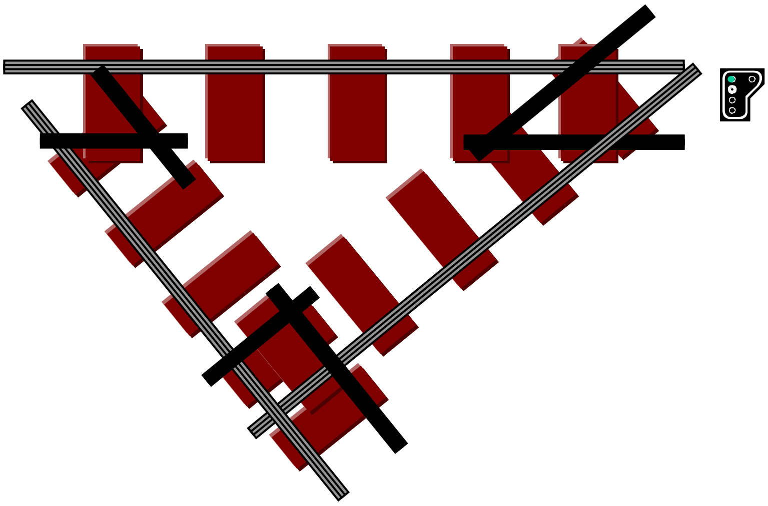

Figure D.4 – Single rail isolation

With single rail isolation the earthed rails appear in parallel.

D.3.3 Parallel paths of other tracks circuits or (and) earthing connections

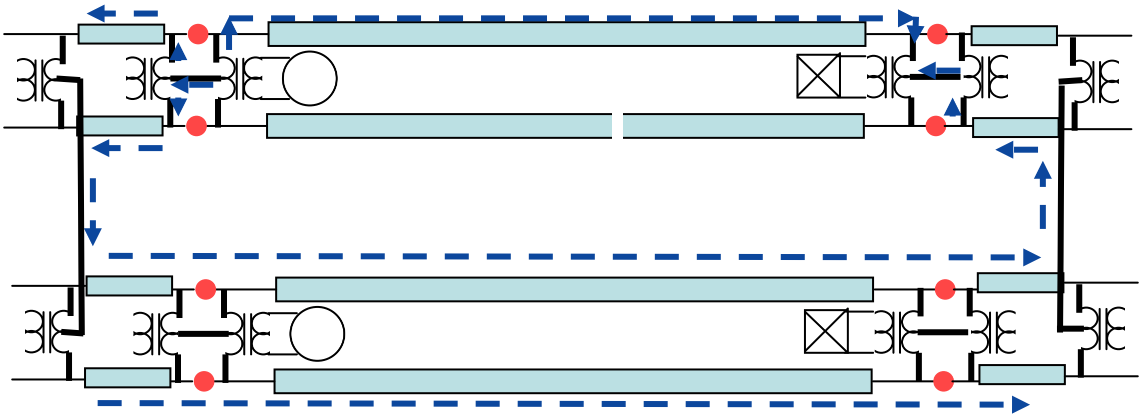

Figure D.5 – Parallel paths

Annex E
(informative)

Frequency management

E.1 Frequencies and immunity limits

E.1.1 Frequency bands of operation

Following a technical evaluation of known RST emissions deemed compatible with the infrastructure, UNIFE (European Rail Industry Association) has developed a FrM proposal for the three main types of power networks – DC, 16,7 Hz and 50 Hz.

The proposal is based on the emission limits that shall be respected today by one influencing unit (measurement at pantograph) to be authorised with respect to compatibility with track circuits listed in CLC/TS 50238-2.

Not all the bands of track circuits listed in CLC/TS 50238-2 are considered further: Some 75 Hz track circuits used in CZ have a very large bandwidth and the proposal only takes into account the 75 Hz track circuits with a smaller bandwidth (i.e., to push in the future a more efficient use of the frequency range) and a higher limit (as applicable to the 25 kV 50 Hz network. Similarly, GRS track circuits (NL Class B system) have a very high sensitivity, that is considered excessive. Also 50 Hz track circuits and any operating at multiples of 300 Hz up to 3 kHz are excluded from the FrM proposal for DC traction.

The FrM proposed by UNIFE justifies the extended use of UGSK (specific type of track circuit used on 16,7 Hz network) frequencies in DC and 25 kV areas.

E.1.2 Parameters for evaluation

Pending

E.1.3 TC Compatibility limits

The compatibility limits for the proposed target interoperable track circuits have been selected, based on the following criteria:

- Results from the technical evaluation as presented in E.1.1.
- Consideration of the accuracy of this technical evaluation:
  - Centre frequencies f_c: definitions are clear, and established FrM rules should be followed (see footnote 6).
  - Evaluation methods - based on existing technology of track circuits.
  - Steady-state current limit I_0 - the results of the technical evaluation (see footnote 6) allows some tolerances, mainly due to different combinations of the number of identical rolling stock and their location in one network. A lower value by a factor of up to 1,5 for I_0 can be justified in order to adapt the proposed FrM to existing products.
- Economic aspects are covered in the proposal in a qualitative manner. It is envisaged that most commonly used modern types of track circuit do comply with the proposed FrM.
- The following evaluation method, integration time / window length and 20 dB bandwidth are proposed as a minimum compatibility requirement for TC which are compliant with the FrM presented in E.3:

Table E 1 – Measurement parameters for compatibility

Frequency area	Evaluation method	Integration time / window length	20 dB Bandwidth
Up to 300 Hz	Time domain	0.5 s	≤ 10 % of f_0
	FFT	TBD	≤ 10 % of f_0
1,5 kHz to 2.65 kHz	Time domain	40 ms	≤ 90 Hz
	FFT	1 s window length	≤ 90 Hz
2,65 kHz to 19,5 kHz	Time domain	40 ms	≤ 10 % of f_0
	FFT	1 s window length	≤ 10 % of f_0

E.1.4 Immunity to in-band interference

For the worst case current distribution, the total RST current from one influencing unit can flow through one TC REC.

NOTE This assumption is pessimistic. In reality, the coupling mechanisms of the spurious current from the rolling stock is shared between different paths of the return current (e.g. feeder lines of the power network, adjacent tracks connected with equipotential bonds).

The track circuit is expected to be immune to the RST emissions as defined in 6.5.1, i.e. the track circuit should not change state in the presence of such emissions. The limits of emission for RST are specified in the hot path of the train (see Figure 2 from CLC/TS 50238-2:2010, measured at the pantograph, or point of interface to the power supply) and apply to a single influencing unit.

The presence of multiple influencing units in the same feeding section are considered within the margin of compatibility between the RST emission for one influencing unit and the susceptibility threshold of the TC, see Figure E.1.

According to Kirchhoff's voltage laws, the total unbalance of the return current path (see 8.8) plays an important factor in the coupling mechanism from the rolling stock emission to the track circuit receiver and in deriving the final values of susceptibility threshold, see E.1.6.

Track circuit immunity limits are defined under worst case credible failure conditions such as unbalance and broken bonds or rails. WSF and RSF analyses are conducted for a realistic set of conditions that provide the most frequent causes of failure.

The process for assigning compatibility margins is visualised in Figure E.1 below:

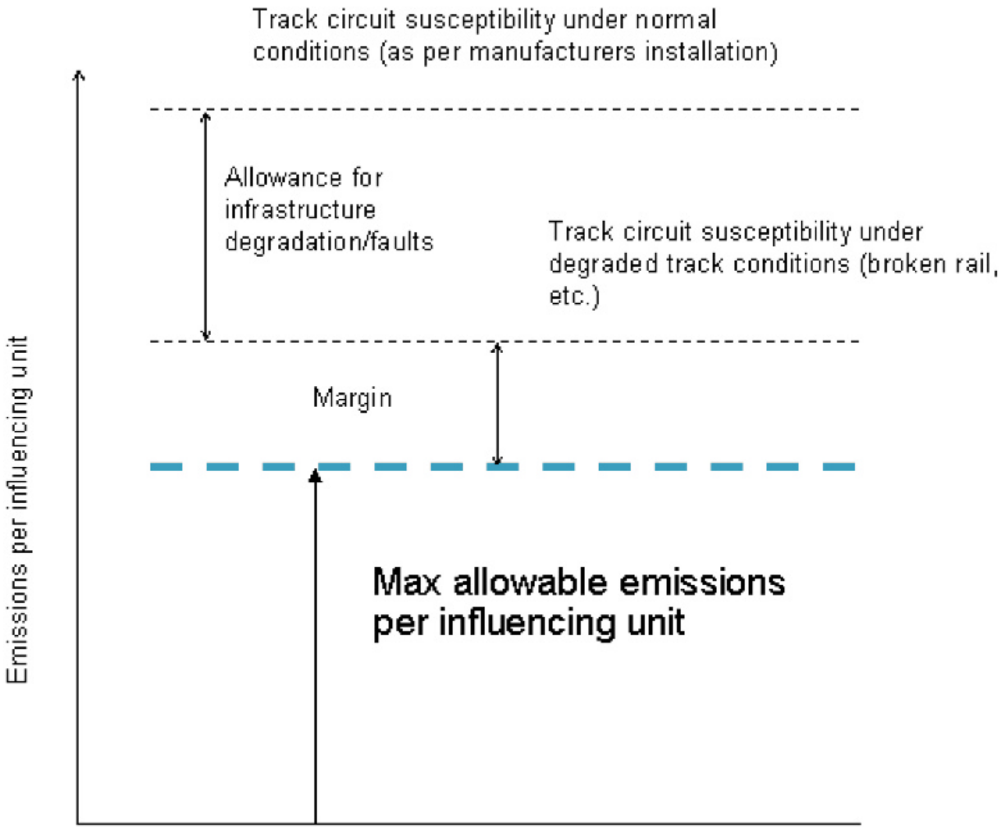

Figure E.1 – Compatibility margins for track circuit immunity to RST interference current limits

This process is applied to both WSF and RSF analyses of track circuits. For the design of the track circuit, the susceptibility threshold should be higher than the spurious level from RST emission received by the TC REC added of the compatibility margin, to account for additional factors as specified in the application case.

E.1.5 Immunity to harmonics frequency from traction power supply (1,5 kHz to 2,65 kHz in DC and 50 Hz power systems only)

The immunity of the track circuit to odd multiples from the AC supply frequency and to multiple of the residual ripple frequency from DC rectifier should be established through laboratory testing. The proposed test limits should be further defined by the manufacturer/infrastructure manager from the RST emission limits of 4 A, including the frequency variation of the fundamental for the power supply and 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 50 Hz variation in the model is assumed as ± 0,1 % of the fundamental frequency.

NOTE 1 Although EN 50163 is the applicable standard, from a pragmatic point of view, the 50 Hz network the power frequency variation is assumed to be a lot more stable and in accordance with the assumptions of ± 0,1 %.

NOTE 2 it is considered that DC rectifiers are powered by 50 Hz primary source. The fundamental frequency for the ripple at the DC substation output is 300 Hz (6-pulses rectifier) or 600 Hz (12-pulses rectifier). This frequency varies proportionally with the 50 Hz from the primary source.

Therefore, the allocation of operational frequency bands for track circuits should take into account the allowed variances of odd harmonics and the limit of 4 A. The frequency variance is in accordance with B.1 of CLC/TS 50238-2:2010. The quoted values are supported by real data as an average variance, although it should be noted that they can be exceeded instantaneously.

E.1.6 Validation of immunity

E.1.6.1 Introduction

The immunity of the track circuit should be established through laboratory testing and further validated by field testing. The applicable test limits should be further defined by the manufacturer/infrastructure manager from the RST emission limits, 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 difference between RST emission limits and established immunity level of the track circuit should form part of the application safety case argument for the track circuit.

The purpose of the following test procedure is just to 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.

E.1.6.2 Test configuration in laboratory

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.

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 E.2. The test consists of injecting current in a typical track circuit, to establish the track circuit susceptibility to rolling stock interference.

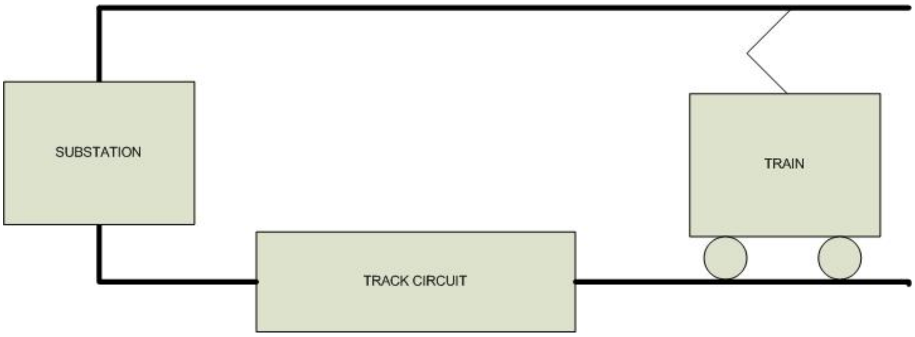

Figure E.2 – RSF interference scenario

The source of disturbance (current generator) produces sinusoidal signals (See Figure E.3). 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.

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

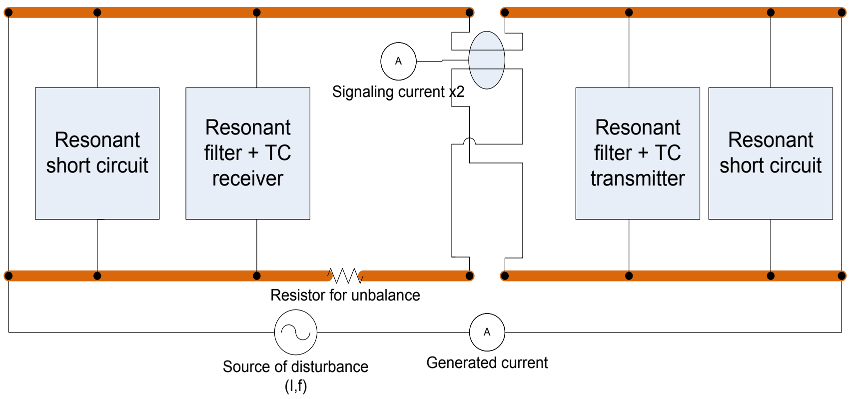

Figure E.3 – Block diagram for the simulation of disturbance

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

E.1.6.3 Testing equipment specification

The testing equipment should cover the whole dynamic range in terms of level and frequency as defined in CLC/TS 50238-2 for the type of track circuit.

E.1.6.4 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 E.3. The TC complies with the FrM if the susceptibility limits and the 20 dB frequency response established from the tests are higher than the RST emission limits for the relevant frequency band with a compatibility margin [2]. This is true for all considered configurations.

- Preparation of test:
    - The unbalance [3] should be configured in one rail. The generated interference current and the track circuit own signalling current are measured as defined in E.1.6.2. The track circuit signalling current is the resultant current measured as differential current between the rails.
    - Without disturbance, the track circuit should be calibrated as 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 should 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 should be lower than 1 % of the working frequency.
    - The time of exposure t_{exp} to each testing frequency f_{test} ,which is different from the working frequency f_w should be at least equal to

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

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[2] The compatibility margin shall be selected according to the RAMS analysis and shall include measurement uncertainty.

[3] The unbalance level shall be selected according to the RAMS analysis.

In all cases, the minimum time of exposure should be at least equal to 150 % of the track circuit response time established from laboratory.

  - The susceptibility threshold at each frequency should be defined to correspond to the track circuit changing state and with granularity no more than 1 dB (≈ 10 %). The lowest established level at which the track circuit changes state is considered its susceptibility level.
  - The laboratory should note all frequencies tested and, for each frequency, the susceptibility threshold.

- Immunity to a transient disturbance, as defined in 6.7:
  - At the most susceptible frequency, the susceptibility threshold should be confirmed with a duty cycle corresponding with the respective requirement from 6.7.

E.1.6.5 In situ validation of the laboratory tests

The test should be reproduced in some configuration in a real railway site in order to qualify the methodology applied in the laboratory.

Some configurations should be selected from the most significant results obtained in laboratory (for example: lowest and highest working frequency of TC).

The parallel track may be used to transmit the signal. In this case, to avoid unwanted mutual coupling from the source of disturbance line to the tested track circuit, the outside rail should be used, and the inside rail should be earthed (see Figure E.4).

The tests performed on laboratory are validated when the level of susceptibility are the same more or less uncertainty [4].

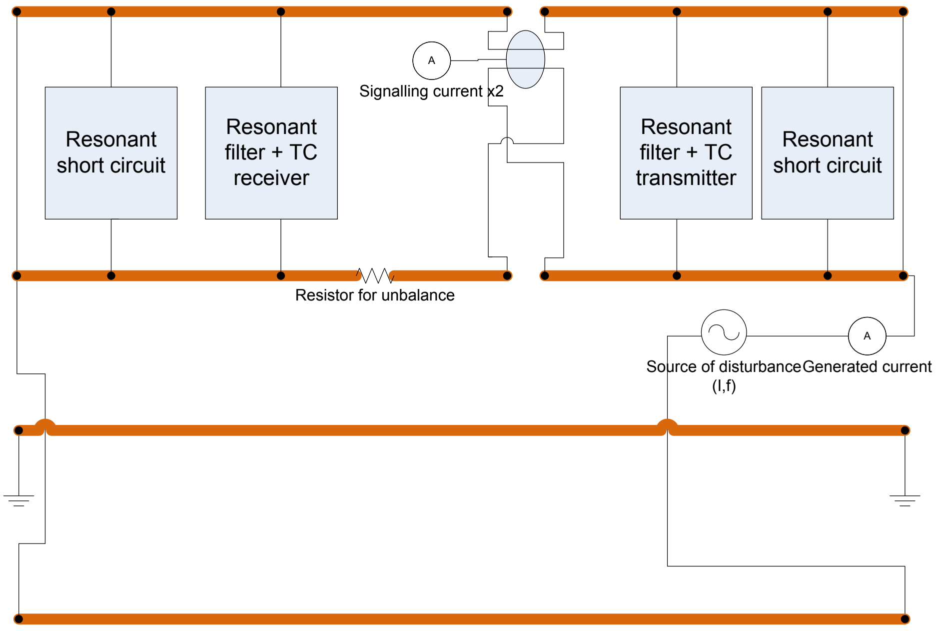

Figure E.4 – Example of block diagram for the simulation of disturbance on site

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[4] Due to the real condition, the environment is not as well controlled as in a laboratory. Inevitably, the results from the tests will differ from the results taken in laboratory. However, the susceptibility level of the track circuit shall always be higher than the emission limits for RST.

E.2 Background to development

E.2.1 Introduction

The Frequency Management for track circuits and rolling stock is a concept proposed to define the compatibility limits between RST and track circuits in this document. The frequency bands and limits are derived from commonly available TC limits combined with calculated emissions of state-of-the-art RST. This includes effects of several identical trains in the same power supply feeding section which cannot always be guaranteed to provide optimum interlacing between individual traction units. Characteristic emissions from the traction power supply are also included in the FrM calculations. It is acknowledged that the harmonised evaluation of transient effects is still under development. Typical transients are included in the FrM calculations and evaluated against known filter bandwidth defined for existing track circuits in the relevant range.

NOTE Additional work is expected on this topic from EUREMCO project.

The basic conflict between rolling stock and detection systems is:

- Rolling stock uses electrical switching power for traction and auxiliary systems, which results in high return currents at the fundamental frequency and its harmonics corresponding to the main switching frequency;

- TCs use the rails to connect between the receiver and transmitter. TCs signals are low power compared to the return currents of the rolling stock.

Combining rolling stock and detection systems requires robust EMC management to achieve a safe and reliable interface between the individual subsystems (RST, CCS and Energy supply ENE). The status quo of available compatibility limits across member states is plotted in Figure E.5.

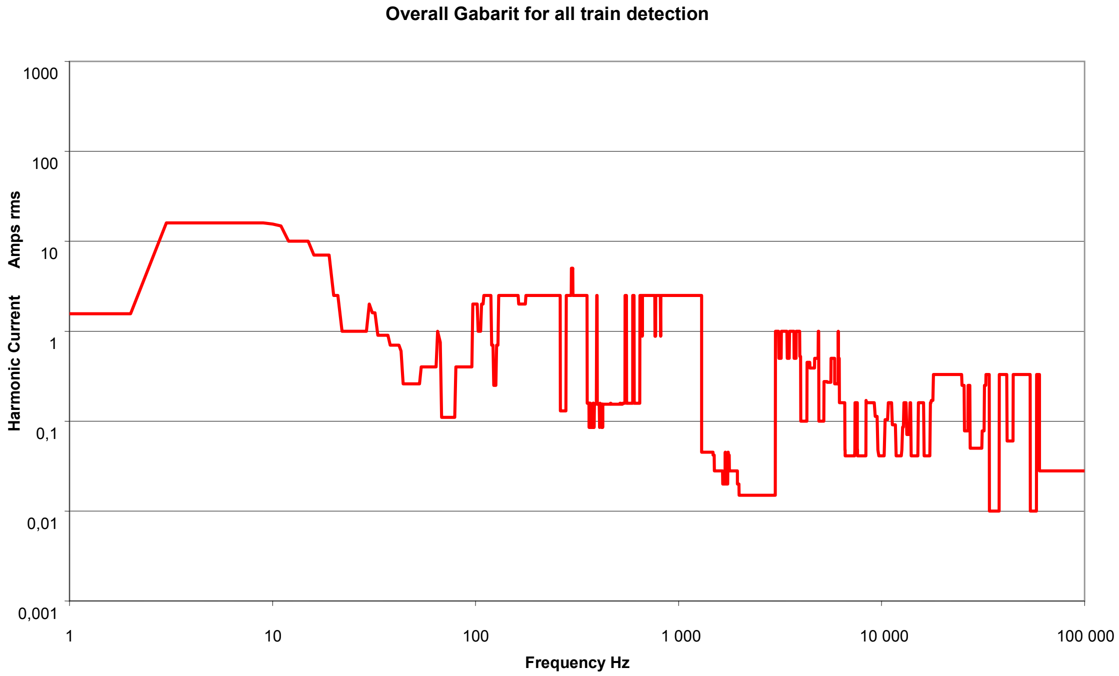


Figure E.5 – Overall gabarit for all train detection systems

E.2.2 Approach to Frequency Management

In the proposed FrM, the compatibility limits for TCs are specified as current taken from the catenary by a single RST influencing unit.

The FrM as presented in this standard will be used to develop the FrM for RST which ERA requires to close one of the open points in index 77 of CCS TSI, for the purposes of interoperability.

Frequency management provides a solution to the basic conflict defined above. It offers the following benefits for the future:

It allows infrastructure managers to use more than one train detection system on any route without the need for individual compatibility cases,

It offers manufacturers of train detection systems objective criteria to design and construct new systems

It offers rolling stock manufacturers the use of a standard approach to demonstrate compatibility with (all) detection systems.

Although every effort was made to have the same emissions and limits for the following Power Supply Systems – 25 kV 50 Hz, 15 kV 16.7 Hz, 3 000 V DC and 1 500 V DC, some differences remain. This reflects the existing situation, where vehicles and signalling systems are designed for a specific Power Supply System.

The proposed FrM needs to be evaluated for potential limitations to Asset Management Policies of IM, designers of TC and designers of RST.

E.2.3 Future Track Circuits and Frequency Management

Manufacturers of future Track Circuits are expected to observe the FrM defined under CCS TSI Index 77 under normal and foreseeable degraded conditions.

NOTE 1 The obvious choice of a track circuit to meet the requirements of FrM will be a coded train detection system with frequencies of operation within the identified bands, because coding is currently the only proven viable alternative to avoid wrong side failure due to interference currents from RST.

NOTE 2 The TC installed on non-electrified lines are supposed to be identical to those installed on existing electrified lines of the same IM's network. Consequently, no specific FrM for non-electrified lines is needed.

E.2.4 Future RST and Frequency Management

Manufacturers of future RST are expected to observe the FrM defined under CCS TSI Index 77 under normal and foreseeable degraded conditions.

E.2.5 Application of FrM to existing generation Track Circuits

The immunity of a TC is not a simple single parameter. The immunity depends on the type of TC, the implementation on the infrastructure and the worst-case assumptions under which the TC should perform safely and/or reliably. Both the TC types as well as these assumptions are different in the various European countries.

EXAMPLE Two examples are provided to clarify the above statement:

- The immunity limits as currently defined in CLC/TS 50238-2 for the 75 Hz GRS type TC, suggest the TC is very sensitive to transients. This is due to the filter bandwidth and the defined integration time, which causes any step change in current (a transient) to easily exceed the limit. At the same time, the same step changes in current are known to regularly occur in practice without any known impact on track circuit operation. In the Netherlands research is being done to further define and quantify allowable transients to redefine the limit.

- The immunity limit for double rail TC with IRJs in the Netherlands is 2,3 A. This limit is reached under the worst-case assumption of 20 % unbalance of current seen by the TC receiver. In practice the average value of the unbalance is less than 1 to 2 %, so the practical immunity will be at least 23 A, although this limit is only used as an unquoted safety margin.

Current unbalance as seen by the track circuit receiver is defined in 8.8.

E.3 Frequency management – Emission limits for rolling stock

E.3.1 General

The following graphs are a simplified representation of limits within the FrM. This version of FrM is pending further development following an economic evaluation to be conducted by ERA. It shall be considered in conjunction with Table E.1.

The proposed FrM defines the interference current limits for one influencing unit of RST. The absolute immunity of the TC to steady state interference is not shown on the following graphs and can be established following the guidelines in E.1.4 and 6.5.1.2.

E.3.2 Emission limits for rolling stock supplied under DC power systems

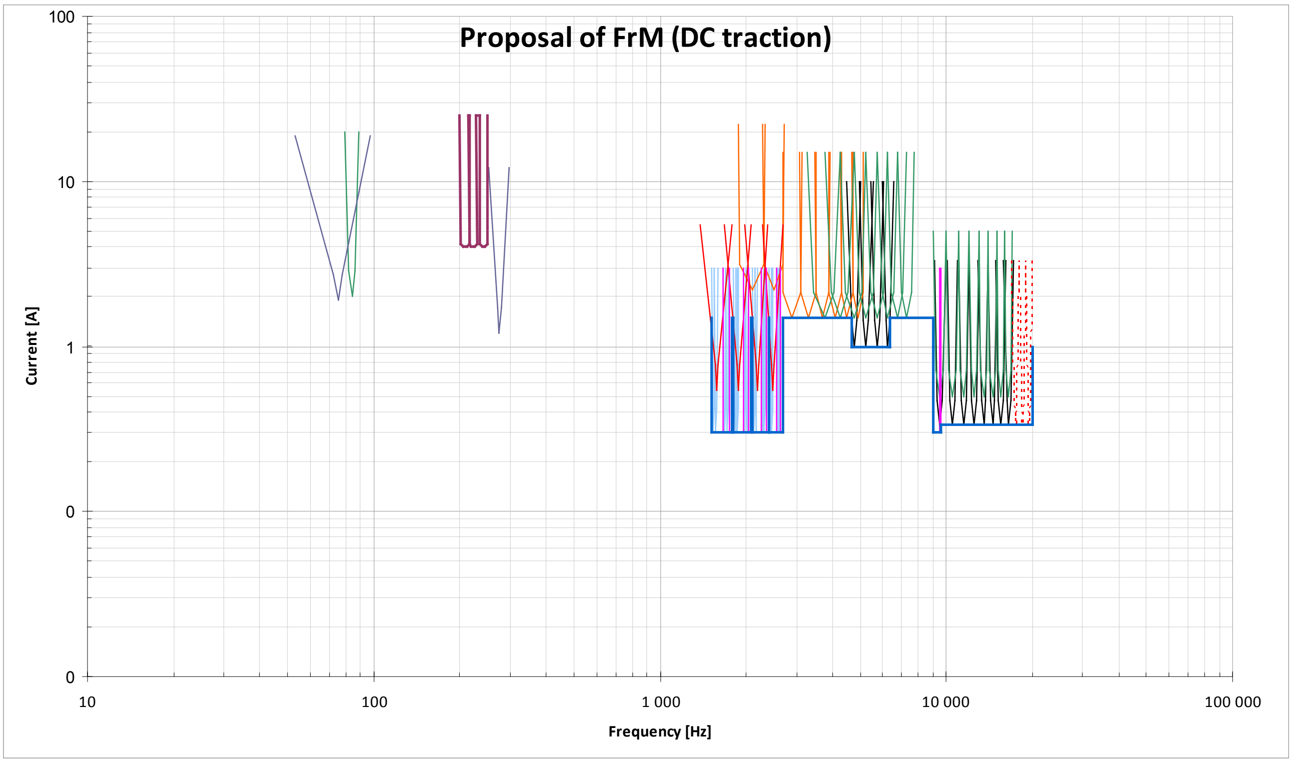


Figure E.6 – Interference current limits for DC power systems

E.3.3 Emission limits for rolling stock supplied under 16,7 Hz power systems

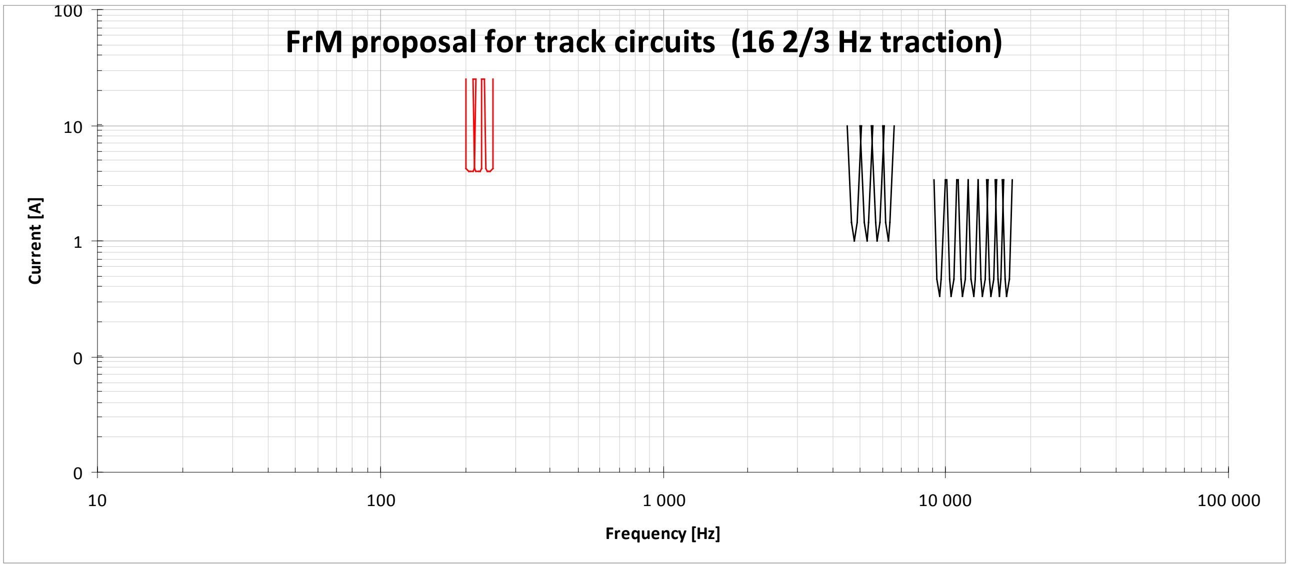


Figure E.7 – Interference current limits for 16.7 Hz power systems

E.3.4 Emission limits for rolling stock supplied under 50 Hz power systems

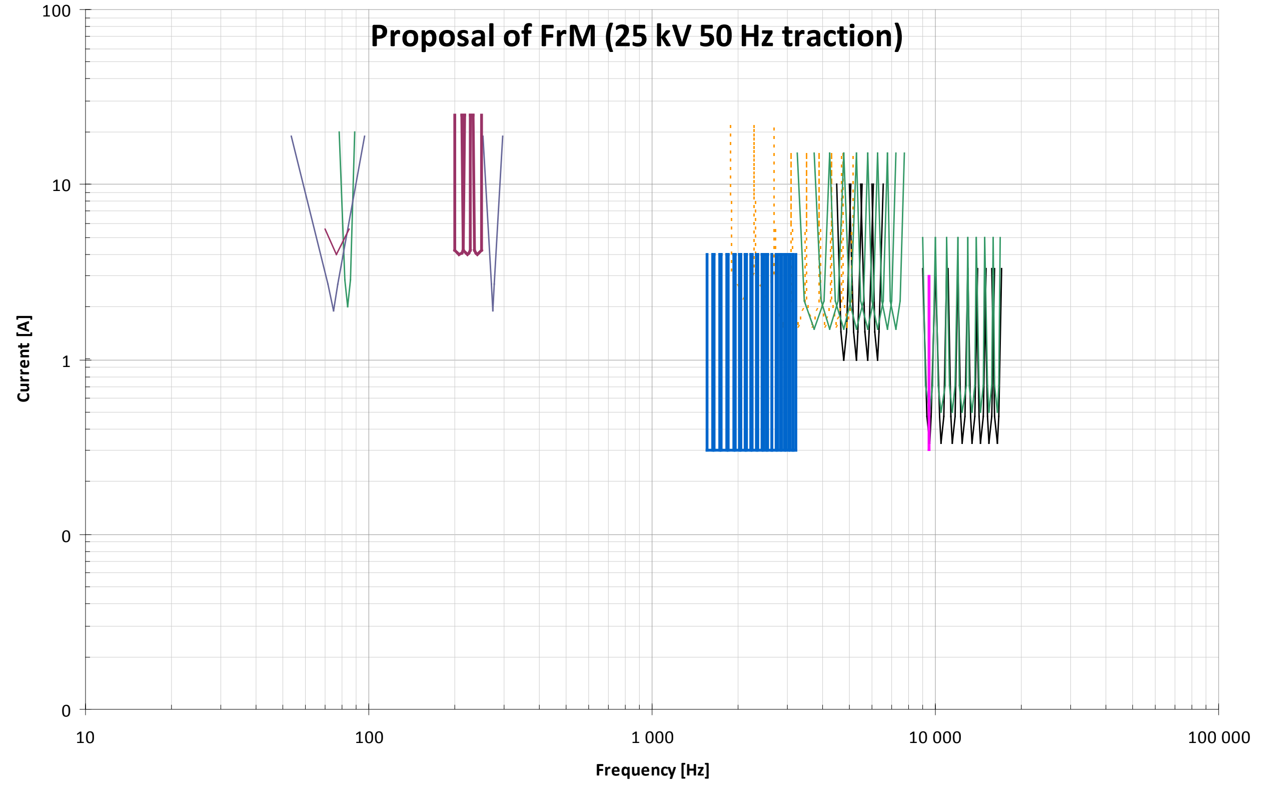


Figure E.8 – Interference current limits for 50 Hz power systems

Annex F
(informative)

Vehicle Impedance / guidance for RST design to support the FrM

F.1 Definition of the parameter

The impedance of a traction unit is a frequency-dependent value which can be interpreted as the reaction (change in line current **I**) of the traction unit to harmonics on the line voltage:

$$Z(f) = 1 / Y(f)$$

with

$$Y(f) = \Delta I(f) / \Delta U(f)$$

This consideration is valid for all frequencies except the fundamental power supply frequency (where power consumption is controlled separately). For low frequencies, influence of the converter control may be present in Z(f). For higher frequencies, the impedance is only given by parameters of the passive components (transformers, inductors, capacitors, cables).

F.2 Justification of the parameter

The systematic frequency management between rolling stock and track circuits will work only if the rolling stock holds minimum requirements for the impedance seen from the power supply. Otherwise, the quality of the railway power supply could be poor (e.g. in case of high level of harmonics produced by rolling stock), or the high interference currents could be flowing through individual trains.

F.3 Limits and RST requirements

F.3.1 For DC traction:

Minimum inductive input impedance (value to be defined) in order to limit currents at characteristic substation rectifier harmonics (applicable to one influencing unit), so that the limits seen by the track circuit are not exceeded.

NOTE Output impedance of the substation is still under consideration.

F.3.2 For both AC and DC traction:

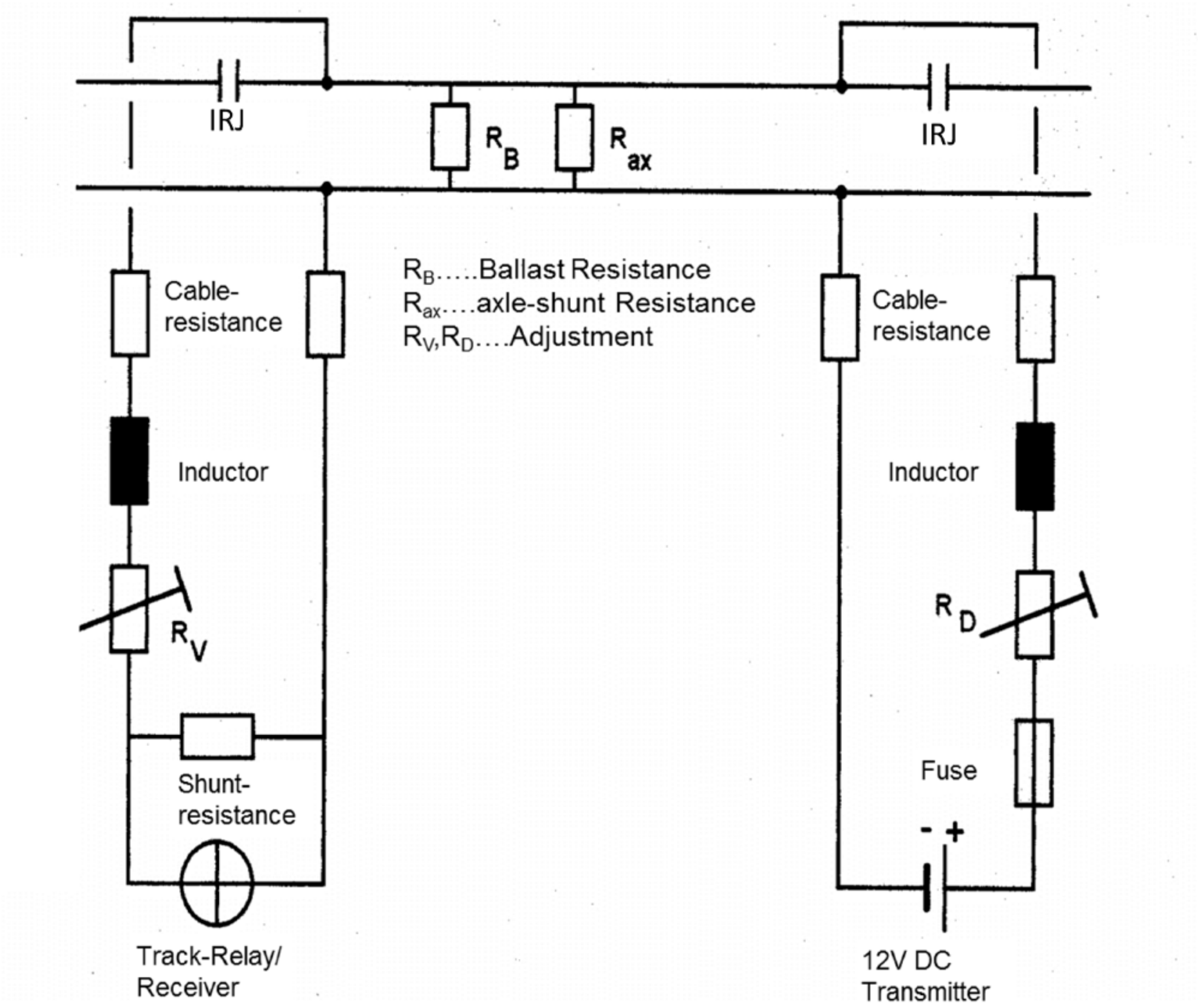
For AC vehicles, the input capacitance introduced by roof cables per meter of train length shall be defined (value is still under discussion), to avoid excitation.
Maximum input capacitance (e.g. from shielded roof cables) for one influencing unit (value to be defined).

F.4 Validation of the parameter

The validation of the vehicle impedance is done during rolling stock type tests. The initial impedance values are normally derived from type tests of the individual components, which are then compared / validated as design parameters of the train. No measurements with complete trains are required.

Annex G
(informative)

Example of elements of maintenance for existing track circuits



Adjusted by:

Rd: Output level

Rv: Sensitivity

Rb: Ballast resistance (to be as high as possible)

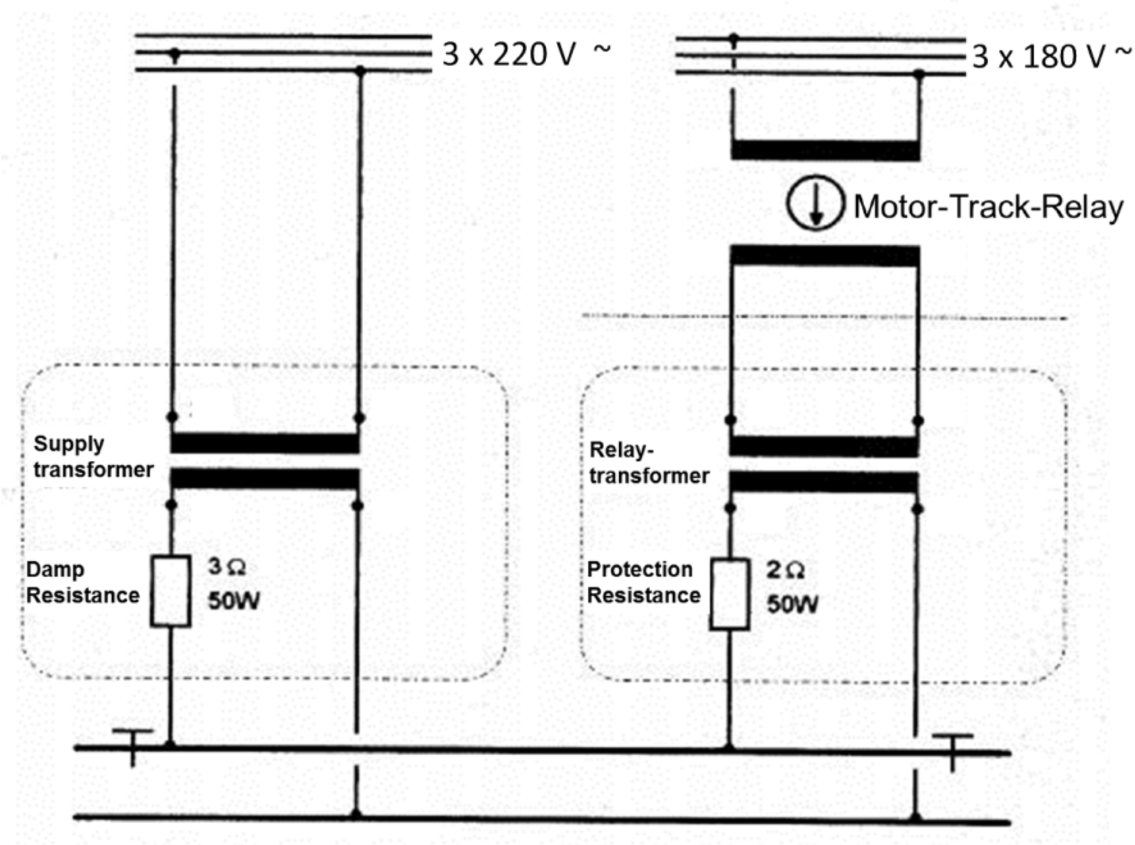
Rax: Axle resistance + resistance of twice interface axle-rail

Rj: Joint-resistance, to be high, danger of overrolling

Sensitive against parasitic voltage.

Short distance usage due to low DC-supply.

Figure G.1 – typical DC track circuit



Except Rd and Rv same parameter as above.

No DC connection, nearly immune against parasitic Voltages.

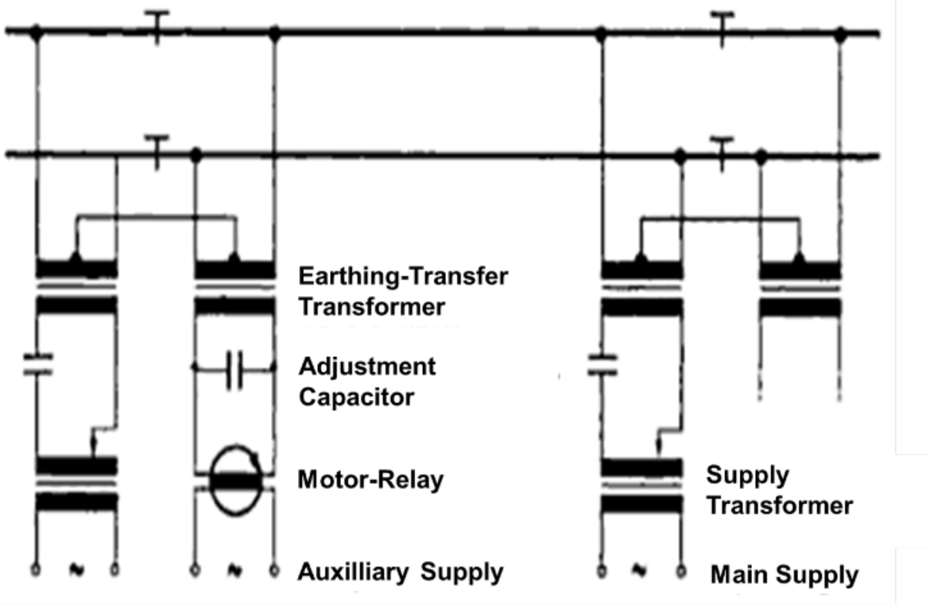
Failsafe due to phase-shift-design of neighbouring circuits.

Figure G.2 – Typical LF (40 – 125Hz) Track Circuit for Motor-Track-Relay or Transistor-Track-Relay

Table G.1 – Typical extension values of circuits

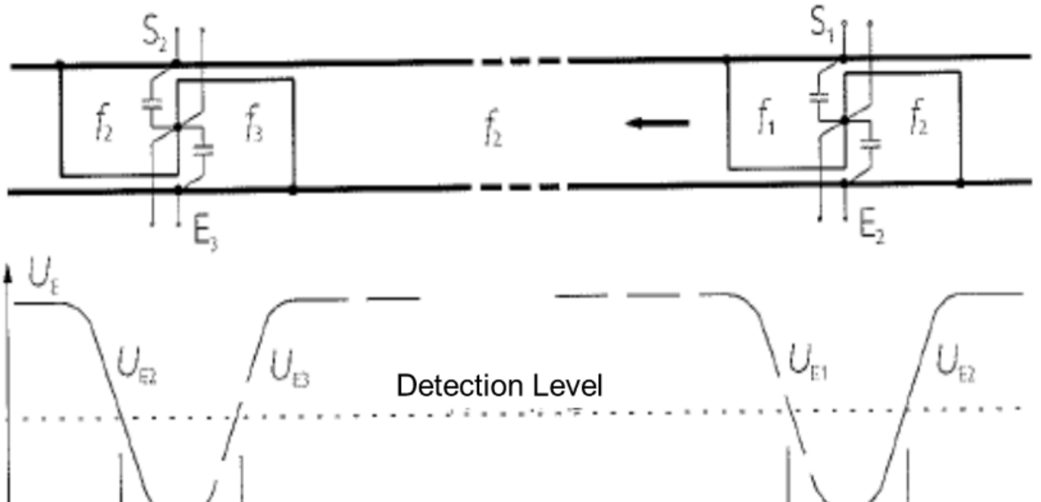
Number of neighbouring tracks for return current (ÖBB)	Category for Motor-Relay				Transistor-Relay	
	I	II	III	IV	100 Hz	106,7 Hz
1	45 m	90 m	155 m	370 m	130 m	250 m
2	65 m	130 m	230 m	580 m	240 m	450 m
3	80 m	185 m	335 m	860 m	350 m	650 m
4	95 m	230 m	425 m	1130 m	460 m	850 m
5	110 m	270 m	515 m	1400 m	570 m	1050 m

Category defines the proper wiring in the Motor-Relay-Trackside switchbox.



Parameters as seen in figures above

Figure G.3 – Double track insulation system with earthing-transfer transformers



Parameters as seen additional layout of S-joint and tuning of capacitor

Figure G.4 – Audio-frequency FTGS-Circuit with electric s-joints (jointless)

According to the previous figures, parameters can be seen as follows:

Rax	Axle-resistance, in series with 2x Rr
Rr	Resistance of Rust covering each rail
Rb	Ballast-resistance in parallel to (Rax + 2Rr), decreasing sensitivity if too low
Rj	Resistance over joints. If properly designed, Rj approaching 0 might lead to RSF. If not, it might lead to WSF

Justification of the parameter

The following generic parameters and consequences are defined:

- Insulating Joints:
    1) To separate different track circuits properly, and separate from earthed rail, IRJ is used. Failure might end in “over-rolling” (= short-circuit to neighbouring rail).
    2) Maintained by regular visual inspection, no diagnostic system available.
    3) Leads to RSF (detected), if the track circuit is properly designed and it is a single failure (e.g. “Earth-jumping” between abutting track circuits).
- Bonding:
    1) The quality and type of connection of cables to and between rails is maintained.
    2) Maintained by regular visual inspection.
    3) If properly designed (all bonds/connections connected in series), corrosion might lead to RSF. In case of breaking of contact leading to loss of a rail under survey, corrosion leads to WSF.
- Interconnections/cross-bonds:
    1) Interconnections will assure the proper connection of different rails, especially in S&C areas where different potential to earth potentially exist. The cross bonds provide serial connection between rails to equalise potential by providing a continuous traction return path.
    2) Short interconnections are prone to breaking, when bent.
    3) Maintained by regular visual inspection.
    4) A disconnected cross bond can give rise to RSF conditions, in the absence of any other failures. In case of a second failure occurring, for example a broken side lead of the receiver, this can eliminate the signal rail from the track circuit detection path (or create run-round paths) and lead to WSF of the track circuit.
- Ballast Resistance:
    1) Ballast resistance is the main influencing factor for reliable operation because it is connected in parallel to the relevant value of shunt detection on the equivalent electrical track circuit diagram.
    2) The ballast resistance depends on the ballast/sleeper quality, moisture and weather.
    3) Ballast resistance is maintained by regular visual inspection although automated diagnostic systems are feasible.
    4) When the minimum established values for reliable operation (in old systems: maximum values, too) are exceeded, this leads to RSF.
- Broken Rail:
    1) If broken rail detection is part of the functionality of the track circuit it results in RSF.

       NOTE To have this functionality, the track circuit is double rail and using IRJ. Jointless track circuits do not detect broken rail and work properly in the presence of single broken rail. The failure is not revealed.

    2) Second broken rail can potentially lead to WSF in jointless track circuits.
    3) Broken rail detection is a supplementary function of the track circuit. If not provided as part of the core functionality, surveys by various monitoring systems is feasible.

- In-house Equipment
  1) Any safety relevant system according to EN 50126 includes safety-cases, homologation, and, maintenance-plan for supplied equipment.
  2) System borders is clearly defined by supplier in joint discussion with the IM.
  3) Maintenance for the in-house equipment is defined according to the maintenance-plan provided by the supplier in conjunction with the IM.
  4) Any condition/combination of conditions that can lead to RSF or WSF are described in the safety-cases by the supplier.

- Cabling/Wiring/Connection Boxes
  1) Cabling on site is done under the responsibility of the nominated qualified supplier in charge.
  2) Proper earthing and insulation design is provided.
  3) Earthing of the cables and core-core and core-earth measurements is carried out as required by the safety case for the track circuit.
  4) The integrity of the wire-jumpers is monitored on a regular basis.
  5) Maintenance is done by regular visual inspection. Various diagnostic systems are also partly feasible.

- Time without train runs:
  1) Corrosion of the rail might lead to WSF if the train is not detected by the track circuit due to rust build up. Operational procedure for “resetting into service” after defined period of ‘system-standstill’ is introduced.
  2) Maintenance procedure is defined for “Resetting into service”.
  3) The axle resistance seen by the track circuit might increase in case of exceeding corrosion levels, which will lead to WSF.

Annex H
(informative)

Example of management of shunt impedance

In the Netherlands this is achieved by the so called Point Model. This model addresses the known critical aspects in a pragmatic, though not scientifically proven way. It is based on several decades of experience and measurements.

The point model and its parameters are described in the following table and most of the input parameters are described in the train based parameters.

If a train gets 43 points or more the train is homologated.

Table H.1 – Combination requirements only valid for electrical trains

Aspect	Weight	Factor		Score (weight x factor)
Traction type	5	Electrical Else	3 1	
Wheel profile	5	Conform EN 13715 S1002 Else	3 1	
Brake type	3	Cast iron brakes Else	3 1	
Axle load	2	< 5 tonnes 5 tonnes to 10 tonnes 10 tonnes to 15 tonnes 15 tonnes to 20 tonnes > 20 tonnes	1 2 3 4 5	
Axles	1	N axles	N	
Total score				

When the point model score is achieved and the train accepted to run, the surface quality as a contributing factor is covered if runs are scheduled every 24 h on the same section of track. The effect of leaves on the rails is excluded.

If the train does not reach 43 points the following rule will apply: The train will be accepted on a track if the train is operated in addition to an existing operation of a minimum of 36 trains in 24 h. This train consists of a minimum of 6 axles with an axle load of 6 tonnes or 4 axles with a minimum axle load of 18 tonnes.

To cover this uncertainty that can heavily affect the safety of the track circuit systems Prorail has a number of locations where the actual train shunt seen by a track circuit is permanently measured. When the values exceed the limit the train operation parties are informed that loss of shunt is to be expected. Safety is then achieved by more stringent procedures.

The train shunt is only partly defined by the maximum allowed wheel to wheel resistance.

In index 77 of CCS TSI, the electrical resistance between the running surfaces of the opposite wheels of a wheel set should not exceed:

- 0,01 Ω for new or reassembled wheel sets;

- 0,05 Ω after overhaul of wheel sets.

In practice this value is increased by pollution of the wheel and track surfaces. An appropriate worst case value used in the Netherlands is a train shunt of 0.5 Ω (ten times the shunt of a single wheel set). This worst case value is used to calculate the allowed interference currents in the track circuits.

Annex I
(informative)
Rail to ground impedance: Track Circuit Effects

I.1 Physical factors

An analysis of the physical factors which affect the rail-ground impedance suggests that about 90 % of the inter-rail resistance (in the absence of trains, cross-bonds, etc) is in the insulating pad under the rails (and clip insulator). This is effectively bridged by the rail-ground capacitance at higher frequencies and by any contamination water, oil, metal dust etc. Analysis shows that the major current path between rails is not via the ballast but flows down into the soil beneath the railway and crosses between the rails via ‘earth’. Analysis of the system by finite element techniques suggests that the conductivity rail-rail is approximately 8 kΩ.m. This accords well with the accepted values of between 2 Ω.km and 10 Ω.km used in calculations in various member states.

Rail to ground impedance (resistance) will be affected by contamination of the rail/sleeper interface. Contamination is often localised hence the rail-ground impedance is not constant along a track. An example of localised rail contamination is shown below.

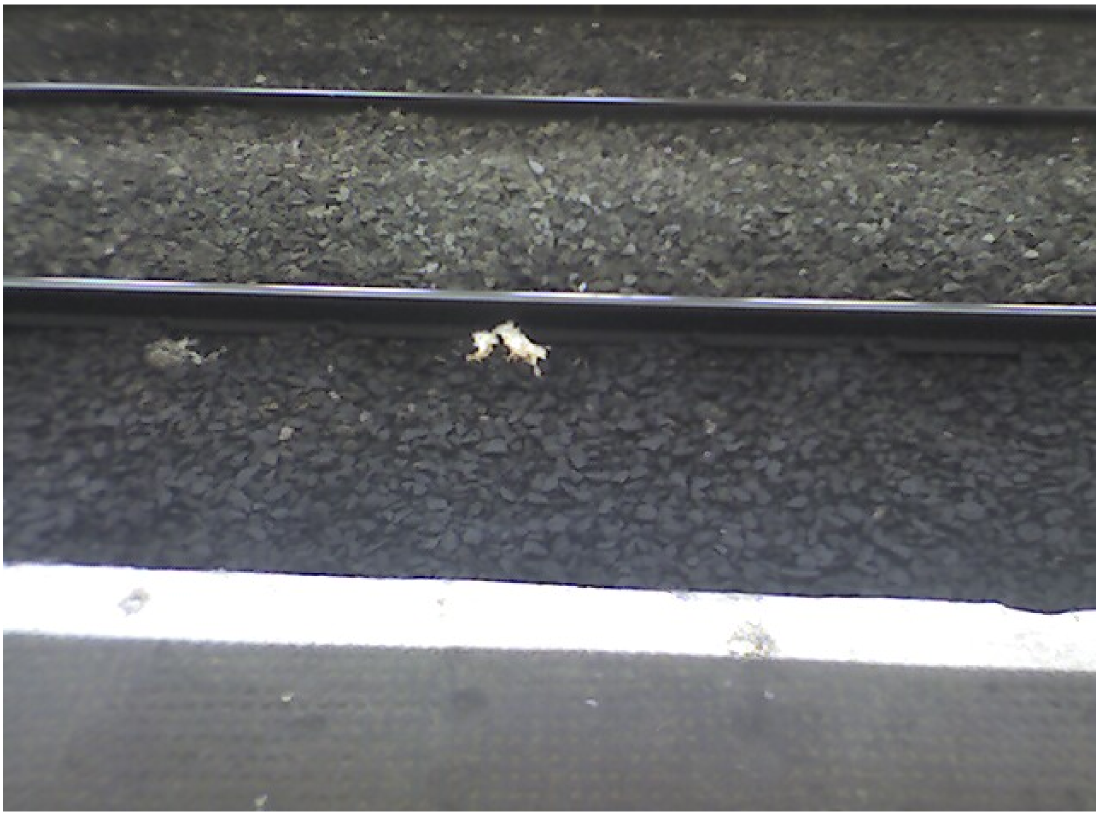


Figure I.1 – Example of ballast covering sleepers

The picture shows a situation where the ballast has been allowed to completely cover the sleepers. This not only changes the length of rail in contact with the ballast creating an alternative path which bypasses the rail pads but also allows surface debris to become lodged at rail level. In this instance the debris is a piece of aluminium foil which would form a highly conductive bridge across an isolation pad.

The rail to ground impedance can be represented by an equivalent circuit shown below. It should be noted that the major components in this circuit are resistive and capacitive. Current flow in the ground is normally not considered to be inductive however the ‘resistance’ can be frequency dependent due to eddy current phenomena. Such phenomena are used in sub-surface exploration however this effect is not considered to be of high significance in ground current flow at the frequencies of current track circuits.

When modelling ground phenomena for track circuits it is considered good practice to model both the length of track covered by the track circuit and also the track beyond the track circuit at either end. To do this an equivalent impedance, representing the asymptotic value of the track impedance beyond the section should be created.

The equivalent circuit of a section of track with its connections to ground is shown in the following figure.

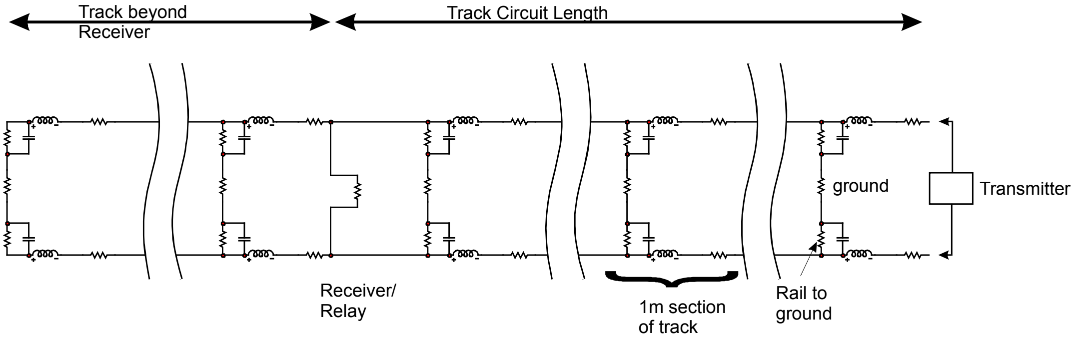


Figure I.2 – Equivalent circuit of a section track

I.2 Symmetric rail- ground resistance

Symmetric rail-ground analysis assumes that both rails have equal impedance to ground and, as such does not require any longitudinal component of ground resistance.

The effective length of detection for track circuits is limited by the rail-ground resistance. The detection length is frequency dependent. The effect is not length limiting for main power frequencies (i.e. 50 Hz or 16,7 Hz) it does affect audio frequency circuits and affects higher frequency circuits e.g. at higher than 50 kHz significantly reduces the effective detection length to approximately 100 m.

Calculations show that a Rail-Rail resistance of 2 Ω.km is sufficient to reduce the received signal at the receiver to 1/3 of that from the transmitter at audio frequencies.

I.3 Values from experience

The TSI mandates a minimum track fixing impedance between rail and ground of 5 kΩ. Assuming that clips are spaced at 600 mm intervals then this gives a minimum resistance of 3 Ω.km per rail.

Each country has its local conditions however all are of the order of Ω.km. The UK uses a range of values between 2 and 10 Ω.km and the Netherlands assumes values as low as 1,5 Ω.km. It can be seen that the TSI and other country values are above the theoretical minimum for track circuit operation. Hence a nominal value of 3 Ω.km may be adopted for future track circuit development as this is in line with the TSI.

I.4 Asymmetric rail- ground resistance

The longitudinal resistance of the ground path is low hence a simple iterated Ω.km model such as the one shown above should not be used.

More complex modelling shows that reducing the local resistance (as shown in the photograph) only has a small effect on the receiver signal (degrades by approx. 4 %) with unbalance but there is a much larger effect on the potential drop along the track. This can rise to 25 % of the transmitter voltage at low frequencies and can appear across adjacent tracks and can cause track circuit performance on these to be degraded. It is not possible to give an accurate figure for the limit to be applied to such local leakage to ground as it is highly dependent upon the overall circuit configuration of the track circuit. Instead the general condition given in the TSI of each track connection having a resistance of greater than 5 kΩ should be used.

Other phenomena on the railway do consider rail to ground resistance as a separate subject however these are not concerned with track circuit performance and are sometimes in contention with each other on different infrastructures. For example rail to ground resistance should be maximised on a DC railway to avoid the DC traction current causing electrochemical corrosion to buried services and pipework whereas on the AC railway asymmetric rail to ground resistance (bonding of one rail to earth) is normally used to limit high touch potentials generated by return AC current.

I.5 Touch Potential Effects

The high currents created under fault conditions on the railway can induce voltages into the track circuit interconnection cables. Such voltages are only of practical significance for long interconnection lengths.

The ITU produces a series of handbooks that examine interference from electrical systems to telecommunications cables. One of the scenarios examined covers the induction phenomenon created by fault currents on electrified railways. These effects apply to both AC and DC railways as the DC railway supply contains harmonic current due to the rectification process.

A typical OHS configuration is shown in the following figure.

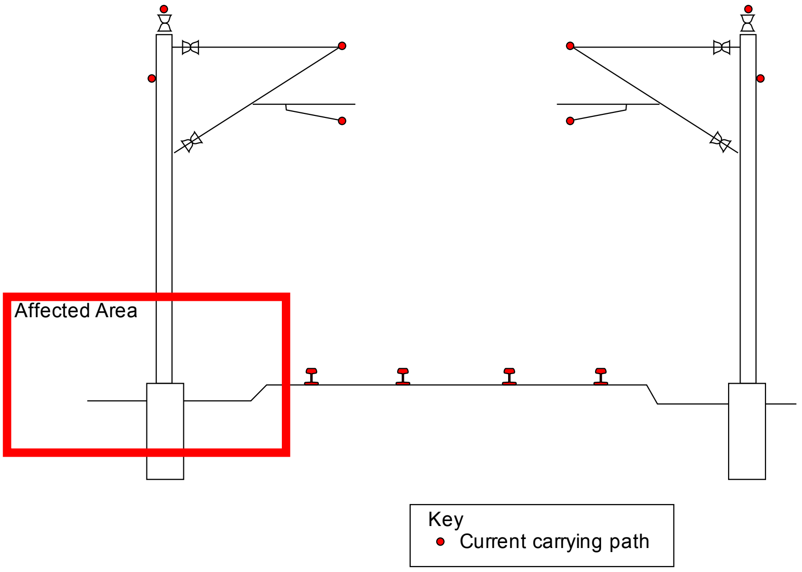


Figure I.3 – Typical cross-section of O.C.S. (Standard Cantilever type)

The configuration has many feed and return paths, one of which is through ground.

The coupling coefficients to circuits in the affected area depend upon the geometric separation and orientation between paths: some of which are through ground. It is not possible to define a specific configuration or geometry and any exact coupling may be calculated for individual cases using established techniques.

However a ranging approach can be considered using various coupling coefficients to give a best and worst case indication for a typical geometry shown in Figure I.4:

For a 1 km length the induced voltage ranges from 20 V (best case values for all variables) to 376 V (worst case values for all variables).

The variability caused by ground resistance variation is approximately 20 % of the range.

EN 50122 gives the basic permissible touch potentials for different exposure times. The shortest interval considered is 20 ms for which a figure of 370 V is permitted. The calculations indicate that this voltage could be instantaneously achieved under dry conditions for a 1 km exposure.

Hence the ranging calculations would suggest that longest interconnection distances for track circuit cabling (without isolation) would be between 1 km and 2 km.

Annex J
(informative)

Example of mechanical test for IRJ

J.1 General

Because of wheels running over the soft insulation-material between the IRJ-rails, steel at that edge has to withstand extraordinary mechanical forces. The conditions may be met by using high quality steel rails (R 350 HAT with Brinell hardness 355HB) or high durability welding at the edges (e.g. Boehler DUR 300). Heat treatment, or pertilisation of rail edges is another method to achieve Brunell hardness of 350HB. It should be noted that the quality of the weld doesn’t necessarily correspond to the quality of the IRJ. Practical evidence suggests that flashbutt welders are better than thermal welders. If welding is required close to the IRJ, minimum distances should be imposed, to maintain the discontinuity of the track and the supporting structure of sleepers.

J.2 Testing program

Table J.1 – IRJ testing program

Properties	Measurement unit	Reference value	Test method
Tensile strength (60E1)	kN [a]	≥ 2 000	EN ISO 527
Tensile strength (54E1)	kN	≥ 1 700	EN ISO 527
Tensile strength (49E1)	kN	≥ 1 500	EN ISO 527
Compressive strength	kN	See [b]	EN ISO 604
Percentage elongation to fracture	%	See [c]	EN ISO 527
Flexural strength (5 x 10^6 load changes at 20 Hz)	kN	+200 / -15, see [e]	EN ISO 178
Elastic Modulus	Mpa	See [c]	EN ISO 178
IZOD notched impact strength	Mpa	See [c]	EN ISO 180
Water absorption	%	≤ 0,4	EN ISO 62
Density	g/cm^3	1,34÷1,40	EN ISO 1183
Hardness	SHORE D	≥ 350 HB	EN ISO 868
Determination of ash	%	30÷33	EN ISO 3451-4
Volume resistivity	Ω x m	See [d]	UNI 4288
Min. Resistance (1000V)	M Ω	≥ 30	UNI 4288
Min. Insulation Resistance (-30°/+60 °C)	M Ω	≥ 1	UNI 4288
Disruptive Strength	V AC	4 000	UNI 4288

a. Force to be defined according to type of rail, not linear if given as pressure, therefore three lines/values for different types of rail

b. compressive strength alternatively given as measurement-procedure instead of tensile strength, insulation material in joint-gap has to be removed in this procedure

c. these terms are NOT defined as a precondition, at least in Austrian tendering → suggest to remove them

d. This term is NOT characteristic for IRJ behaviour, more specifically defined within the steel quality, therefore not defined separately.

e. Flexural Strength: 5 x 10^6 load changes at 20 Hz cycles, no residual deflection/deformation after test

The mechanical tensile type test (when using UIC 60 or UIC 49 rail) should be performed according to following steps:

a) Applying an axial load up to 1 000 kN with 1 kN/s gradient and waiting for 5 min;
    a. Decreasing load to 0 kN with 50 kN/s gradient;
    b. Measuring residual deformation that should be not more than 0,10 mm;
b) Applying an axial load up to 1 500 kN with 1 kN/s gradient and waiting for 5 min;
    a. Decreasing load to 0 kN with 50 kN/s gradient;
    b. Measuring residual deformation that should be not more than 0,14 mm;

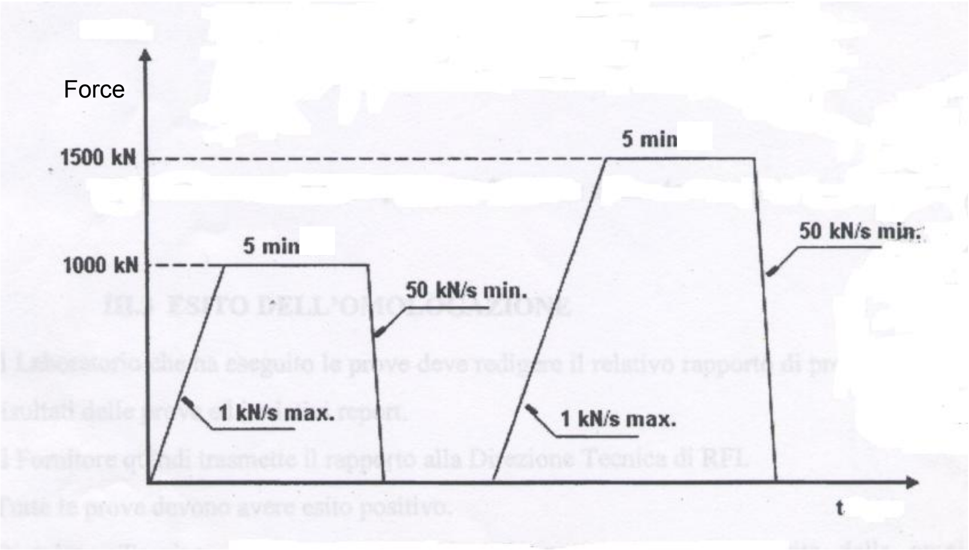


Figure J.1 – Test diagram for mechanical tensile test

The dynamic mechanical test is performed according to the following test set-up as part of the type test:

Values in mm

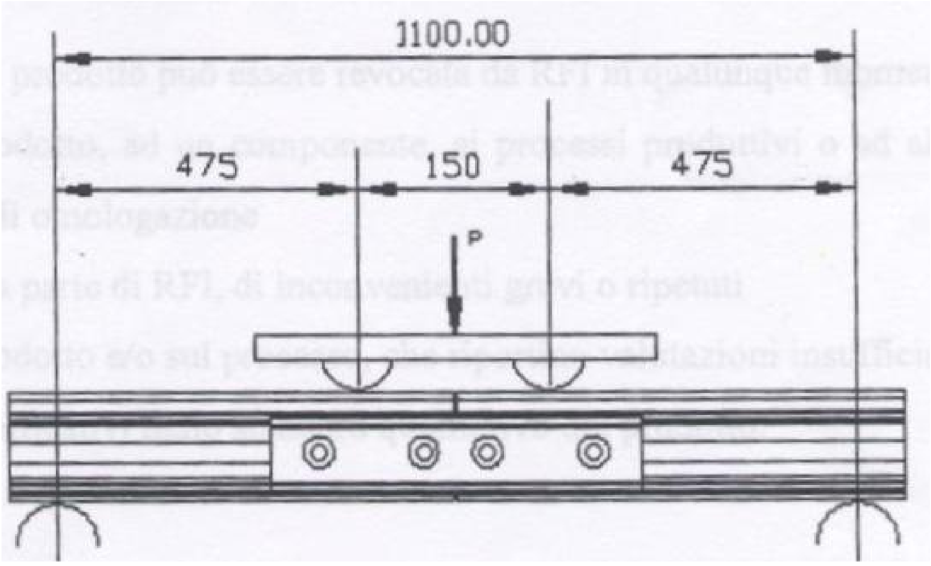


Figure J.2 – Test set-up for dynamic mechanical test

The dynamic mechanical type test should be performed applying a dynamic load between 30 kN and 300 kN with load frequency of 4 Hz.

After 2 Million cycles the IRJ should maintain the whole integrity by using penetrating liquid creep test or alternative method.

Annex K
(informative)

Example of existing requirement for the type of sleepers / track structure

K.1 Typical value for a ballast resistance

The following typical value are given:

- 3 Ω.km for conventional lines;
- 8 Ω.km for high speed lines.

NOTE 1 The values of 3 and 8 Ohm are normally only achievable with new track. With time the ballast resistance may decrease to, for example, 1,5 Ohm.

NOTE 2 In the past, values of 3 Ω.km to 6 Ω.km for ballast resistance were specified for track maintenance purposes. Higher values is also specified by individual IMs. The parameter is important for TDS, especially for new designs. Higher values allow longer lengths to be achieved. The max length of the track circuit is defined for the min ballast resistance that can be maintained.

K.2 Infrabel

Infrabel needs 6 Ω.km for the JADE track circuit for a maximum length of 2 000 m. The distance between the sleepers are 0,6 m, so there are 1 666 sleepers on one km track. The acceptance value for one mounted sleeper will be 10 kΩ (1 666 x 6).

K.3 DB

K.3.1 Wooden sleepers

- ballast resistance (complete calculation for 1 km for the two rails per single track) = 1,5 Ω.km
- distance between sleeper 20 cm ≥1 / 5 000 of a kilometer
    1) 1,5 / 2 x 5 000 = resistance per fastening
    2) 3,75 kΩ at one single fastening point (one track to one sleeper)
- distance between sleeper 65 cm
    1) 2,4 Ω.km insulation resistance as minimum (TSI = 3 Ω)
    2) Proposal 3 Ω.km

K.3.2 Concrete sleepers

- ballast resistance (complete calculation for 1km for the two rails per single track) = 2,5 Ω.km
- distance between sleeper 20 cm ≥1 / 5 000 of a kilometre
    1) 2,5 / 2 x 5 000 = resistance per fastening

   2) 6,25 kΩ at one single fastening point (track to sleeper)

- distance between sleeper 65 cm
   1) 4 Ω.km insulation resistance as minimum
   2) Proposal 5 Ω.km

K.3.3 Slab tracks

- 6 Ω.km insulation resistance (latest TSI request for high speed lines using of complete concrete ballast without sleepers)
- Proposal 5 km to 6 Ω.km

Annex L
(informative)

Example of application for different safety requirements

L.1 Lower safety integrity level (less than SIL 4)

For systems designed for functions with the lowest level of safety integrity, it can be stated that the system itself is not safety relevant. There is no level of route control that can be achieved with these systems. In such circumstances, the train driver is the only person who is responsible for the safe train movement. Based on the reaction time of any human being, the train speed should be restricted to allow a minimum of safety. A set of "drive by sight" rules should be defined. These types of low integrity train vacancy system are applicable for example on unprotected tram systems which share the track with normal road traffic vehicles.

Another point of view applies to systems where tracks are designed to transport freight only or with a very limited number of persons to be transported per day. In that case a risk of injures is limited to a minimum acceptable level. The system safety level is primarily required to protect the train and the driver. Examples of such applications can be for freight yards / depots, where driverless locomotive operation is permitted. In that case usually a safety level up to SIL 2 or in limited cases SIL 3 is required for the complete TDS.

L.2 Highest safety integrity level (SIL 4)

On lines defined to transport passengers and designed for speeds higher than 80 km/h or where the direct line of sight is not always assured (like in tunnels) the safety cannot be left only under the responsibility of the drivers and additional protection should be provided. Usually this scenario occurs on lines with mixed passenger and freight traffic. On this basis, a safety integrity level of SIL 4 for the complete train detection system is usually required, in the context of its application.

NOTE THR is a term used in evolving safety related standards and means a specific calculable failure rate, which can be converted to a defined SIL level.

Annex ZZ
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers all relevant essential requirements as given in Annex III of the EC Directive 2008/57/EC (also named as New Approach Directive 2008/57/EC Rail Systems: Interoperability).

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZZ.1 for “Control, Command and Signalling”, Table ZZ.2 for “Conventional Rail Locomotive and Passenger Rolling Stock” confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZZ.1 - Correspondence between this European Standard, the CCS TSI (published in the Official Journal L 51 on 23 February 2012, p. 1) and Directive 2008/57/EC

Clauses of this European Standard	Chapter / § / points / of CCS TSI	Essential Requirements (ER) of Directive 2008/57/EC	Comments
Clause 5 6.8.4	3.2.1	1. General Requirements 1.1. Safety	
Clause 6 (except 6.8) Clause 8	4.2.10. Track-side Train Detection Systems ERA/ERTMS/033281 Interfaces between CCS track-side and other Subsystems – version 1.0 (section 3.1)	2. Requirements specific to each sub-subsystem 2.3. Control Command and signalling 2.3.2 Technical compatibility	Version 2.0 of ERA/ERTMS/033281 has been published. Reference in the TSI will have to be updated.
9.5 Annex E (informative)	4.2.11. Electromagnetic Compatibility between Rolling Stock and Control-Command and Signalling track-side equipment ERA/ERTMS/033281 Interfaces between CCS track-side and other Subsystems – version 1.0 (section 3.2)		The Frequency Management described in informative Annex E is to be confirmed/replaced by results from work in progress within ERA which will be part of the revised CCS TSI or of a new version of its interface document ERA/ERTMS/033281
9.4	4.2.16 Environmental conditions		

Table ZZ.2 - Correspondence between this European Standard, the Conventional Rail TSI "Locomotive and Passenger Rolling Stock" (published in the Official Journal L 139 on 26 May 2011, p.1) and Directive 2008/57/EC

Clauses of this European Standard	**Chapter / § / points / of LOC & PAS TSI**	**Essential Requirements (ER) of Directive 2008/57/EC**	**Comments**
	4.2.3.3.1.1. ROLLING STOCK CHARACTERISTICS FOR COMPATIBILITY WITH TRAIN DETECTION SYSTEM BASED ON TRACK CIRCUITS	2. Requirements specific to each sub-subsystem 2.4. Rolling Stock 2.4.3. Technical compatibility	TSI amended according to decision 2012/88/EU
	ERA/ERTMS/033281 Interfaces between CCS track-side and other Subsystems – version 1.0		Version 2.0 of ERA/ERTMS/033281 has been published. Reference in the TSI will have to be updated.
6.2.2 TC Minimum length of detection - Requirement	Vehicle geometry Clause 3.1.2 Axles distances		
Clause 7 Train based parameter - Shunt impedance	Vehicle design Clause 3.1.7 Vehicle axle load and metal construction Clause 3.1.9 impedance between wheels Clause 3.2.2 Conducted interference		
9.3 Amount of sand 7.1 General	Isolating emissions Clause 3.1.4 Use of sanding equipment Clause 3.1.6 Use of composite brake blocks		
Clause 7 Train based parameter - Shunt impedance Annex E (informative) Annex F (informative)	EMC Clause 3.2.1 Electromagnetic fields Clause 3.2.2 Conducted interference		The requirements for electromagnetic fields related to compatibility of rolling stock with track circuits is an open point in ERA/ERTMS/033281

Table ZZ.3 - Correspondence between this European Standard, the Conventional Rail TSI "Rolling Stock Freight Wagons" (published in the Official Journal L 104 on 12 April 2013, p.1) and Directive 2008/57/EC

Clauses of this European Standard	**Chapter / § / points / of WAG TSI**	**Essential Requirements (ER) of Directive 2008/57/EC**	**Comments**
SEE TABLE ZZ.1	4.2.3 Gauging and track interaction 4.2.3.3. Compatibility with train detection systems	2. Requirements specific to each sub-subsystem 2.4. Rolling Stock 2.4.3. Technical compatibility	This requirement refers to the CCS TSI

WARNING: Other requirements and other EU Directives may be applicable to the products falling within the scope of this standard.

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[19] ITU-T *Directive volume V, Inducing currents and voltages in power transmission and distribution systems*

[20] ERA/ERTMS/033281 v1.0, *Interfaces between control-command and signalling trackside and other subsystems (index 77 of CCS TSI 2012/88/EU)*

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