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Level 3

Target Earth Calculation Methodology for Signalling Power Systems

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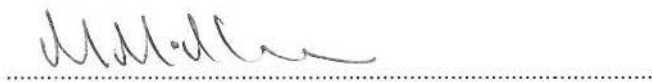
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User information

This Network Rail standard contains colour-coding according to the following Red–Amber–Green classification.

Red requirements – *No variations, could stop the railway*

- **Red requirements shall** always be complied with and achieved.
- Red requirements shall be presented in a red box **with the word “shall” or expressed as a direct instruction**.
- Accountability for the efficacy of red requirements lies with the Professional Head/Standard Owner.
- Red requirements are monitored for compliance.
- Corrective actions shall be enforced if variations are discovered through functional checks (e.g., engineering verification visits, audit or Operations Self-Assurance).

Amber requirements – *Controlled variations, approved risk analysis and mitigation*

- **Amber requirements shall** be complied with unless variation has been approved in advance.
- Amber requirements shall be presented with an amber sidebar **and with the word “shall” or expressed as a direct instruction**.
- Accountability for the efficacy of these requirements lies with the Professional Head/Standard Owner, or their nominated Delegated Authority.
- Amber requirements are monitored for compliance.
- Variations **may** be permitted. Variations are approved by the Standard Owner or through existing Delegated Authority arrangements.
- Corrective actions shall be enforced if **non-approved** variations are discovered through functional checks (e.g., engineering verification visits, audit or Operations Self-Assurance).

Green – *Guidance*

- Guidance is based on good practice. Guidance represents supporting information to help achieve **Red** and **Amber** requirements.
- Guidance shall be presented with a dotted green sidebar **and with the word “should” (usually in notes) or as a direct instruction**.
- Guidance is **not mandatory** and is not monitored for compliance.
- Alternative solutions may be used. Alternative solutions do not need to be formally approved.
- Decisions made by a competent person to use alternative solutions should be backed up by appropriate evidence or documentation.

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Issue record

Issue	Date	Comments
1	June 2015	First issue

Compliance

This Network Rail standard is mandatory and shall be complied with by Network Rail and its contractors if applicable from 6 June 2015.

When this standard is implemented, it is permissible for all projects that have formally completed GRIP Stage 3 (Option Selection) to continue to comply with the issue of any relevant Network Rail standards current when GRIP Stage 3 was completed and not to comply with requirements contained herein, unless stipulated otherwise in the scope of this standard.

Reference documentation

2015-0080	ERA Report: Capacitance of Signalling Power Distribution Cables and Target Earth Values
BS EN 50122-1	Railway applications — Fixed installations — Electrical safety, Earthing and the Return Circuit – Part 1: Protective provisions against electric shock
BS 5467	Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V
BS 6346	Electric cables. PVC insulated, armoured cables for voltages of 600/1000V and 1900/3300 V
BS 7671	Requirements for Electrical Installations
NR/L2/SIGELP/27408	Product Specification for Signalling Power Distribution Cables
NR/L2/SIGELP/27410	Specification for Class II Based Signalling Power Distribution Systems
NR/L2/SIGELP/27419	Product Specification for Distribution Interface Transformer Assemblies (DITA) for Signalling Power Distribution Systems
NR/L2/SIGELP/30007	Product Specification for Power Transformers for Signalling Systems
RT/E/PS/00005	Railway Signalling Cable (also referred to as NR/L2/SIG/00005 and NR/PS/SIG/00005)
N/A	Power Cables and Their Application: Part 1 – Lothar Heinhold

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1 Purpose

This standard sets out a method for calculating the maximum target earth value at signalling apparatus housings and power supply sources to afford protection against electric shock in the event of a first earth fault in Class I and Class II signalling power distribution systems using IT electrical systems.

2 Scope

This standard defines the method for calculating the maximum permissible earth resistance value to control touch voltages, either to BS 7671 or BS EN 50122-1, at a signalling apparatus housing comprising a functional supply point (FSP) in a Class I IT electrical system used in signalling power distribution systems.

The method detailed is also applicable for calculating the maximum permissible earth resistance value to control touch voltages to BS 7671 or BS EN 50122-1 on:

- the armour which forms parts of armoured BS 5467 and BS 6346 cable when used as part of an IT electrical system; and
- power sources distributing IT electrical systems, normally comprising principal supply points (PSPs) and distribution interface transformer assemblies (DITAs) in either Class I or Class II signalling power distribution systems, in accordance with NR/L2/SIGELP/27410.

The assumptions underpinning the derivation of first earth fault leakage current (I_{ff}) for different cable sizes and types are detailed, along with the key relationships to be utilised for deriving the total network capacitance (C_E) and the maximum permitted earth resistance value (R_{Amax}).

The calculation method detailed is applicable to the following signalling power distribution systems:

- single-phase, IT-individual with 2-core unarmoured cable;
- single-phase, IT-individual mixed with IT-group, with 2-core unarmoured cable mixed with either 2-core or 3-core armoured cable;
- single-phase, IT-collective with 3-core armoured cable;
- single-phase Class II signalling power distribution systems designed and installed in accordance with NR/L2/SIGELP/27410.

This standard does not set out the requirements for calculating the target earth resistance value for protection against electric shock in the event of second earth fault on an IT system, lightning protection, test and functional earths.

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3 Definitions

For the purpose of this standard, the following terms and definitions apply.

Class II based signalling power distribution system	Signalling power distribution system using Class II equipment and associated components.
Class II hybrid FSP isolating transformer	Transformer in which the primary side, including its terminals, meet the requirements for Class II and the secondary side meets the requirements for Class I, allowing ready access to the secondary tapplings for adjustment in service, as defined in NR/L2/SIG/30007.
DITA	Distribution interface transformer assembly in accordance with NR/L2/SIGELP/27419. Assembly consisting of switchgear, isolating transformer and protection and control unit (PCU).
Enhanced unarmoured cable	A cable having increased insulation and sheath thickness intended to provide a degree of protection against crushing and impact damage as defined in NR/L2/SIGELP/27408.
EPR	Ethylene propylene rubber.
Exposed-conductive-part	Conductive part of equipment which can be touched and which is not normally live, but which can become live when basic insulation fails, as defined in BS 7671.
Fault protection	For low voltage installations, systems and equipment, fault protection generally corresponds to protection against indirect contact, mainly with regard to failure of basic insulation. Indirect contact is contact of persons or livestock with exposed-conductive-parts which have become live under fault conditions as defined in BS 7671.
Functional supply point (FSP)	The point that the power supply distribution system connects with the signalling load. May be co-located with signalling equipment.
IT system	An electrical distribution system having no direct connection between live parts and earth.
IT individual	An IT system in which all exposed conductive parts are earthed individually. An individually-earthed FSP has its own local earth electrode system.

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IT collective	An IT system in which all exposed conductive parts are earthed collectively. A collectively-earthed FSP has its own local earth electrode system and all such FSPs on the same feeder have their earths interconnected via a continuous conductor, the circuit protective conductor.
IT grouped	A group (or grouped) earth FSP has its own local earth electrode system, and a limited number of adjacent FSPs on the same feeder have their earths connected together.
PVC	Polyvinyl chloride.
Principal supply point (PSP)	The point of common connection of one or more electrical sources from which energy may be distributed. For the purposes of this document, references to PSPs shall also include auxiliary supply points and signalling supply points.
Signalling supply point	A point of common connection of one or more electrical sources from which energy may be distributed to supply signalling power distribution systems.
TECM	Target earth calculation model.
Uninterruptible power supply (UPS)	A single or multiple module power supply system which constitutes all physical equipment contained between input and output terminals, exclusive of manual and/or automatic UPS equipment bypass switching facilities, which will both maintain and continue to provide an adequate a.c. power supply to the operational infrastructure, inclusive of an energy source, such as a battery, in the event of failure of the incoming and/or alternative supply.
XLPE	Cross-linked polyethylene.

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4 Control of touch voltages in signalling power distribution systems

4.1 General

Regulation 411.6.2 of BS 7671 has a requirement for earthing of exposed conductive parts of an IT system to minimise the risk of danger in the event of a first earth fault. The requirement is given by the equation:

$$R_A \times I_d \leq 50 \text{ V} \dots (1)$$

Where:

R_A is the sum of the resistances of the earth electrode and the protective conductor connecting it to the exposed conductive parts (in Ω).

I_d is the total first earth fault leakage current (in amperes) of the first earth fault of negligible impedance between a line conductor and an exposed conductive part.

The value of I_d takes account of first earth fault leakage current and the total earthing impedance of the electrical installation. This specification uses I_{ff} to replace I_d as the resistance of the bonding conductors to the earthing system has been excluded due to its negligible impact.

50 V is the maximum permissible permanent touch voltage in accordance with BS 7671.

BS EN 50122-1 specifies a permissible permanent touch voltage of 60 V. Hence equation (1) can be adjusted to:

$$R_A \times I_{ff} \leq 60 \text{ V} \dots (2)$$

Where 60 V is the maximum permissible permanent touch voltage in accordance with BS EN 50122-1.