Rolling Stock Subsystem and Interfaces to AC Energy Subsystem

Synopsis

This document defines interface requirements to the alternating current (AC) energy subsystem for all rolling stock operating over the AC electrified railway.
Rolling Stock Subsystem and Interfaces to AC Energy Subsystem

Issue Record

<table>
<thead>
<tr>
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<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>December 2014</td>
<td>Original document. This document has been developed under project 09/013a to identify existing in-scope requirements and reduce costs associated with establishing compatibility between energy and rolling stock subsystems. The document retains in scope requirements from GERT8025 issue one, GMRT2181 issue three and GMRT2304 issue three and specifies new requirements needed to establish electrical compatibility between the two subsystems.</td>
</tr>
<tr>
<td>Two</td>
<td>07/12/2019</td>
<td>Replaces issue one. Revisions to sections 4.7-4.9 relating to pantograph/overhead contact line (OCL) mechanical interaction to align with TSI requirements and compatibility with non-TSI OCL.</td>
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</tbody>
</table>

Revisions have been marked by a vertical black line in this issue. Definitions and References may also have been updated but these are not marked by a vertical black line.

Superseded Documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

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<tbody>
<tr>
<td>GMRT2111 issue one</td>
<td>All</td>
<td>07/12/2019</td>
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Supply

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Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This document contains requirements for all rolling stock operating over the alternating current (AC) electrified railway, in order to manage interfaces with the AC energy subsystem.

1.1.2 This document contains an ‘open point’, as set out in Appendix A, to address requirements that have not yet been specified but which are within the scope of the document. It applies to both 25 kV electric rail vehicles and non-electric rail vehicles such as coaches and freight wagons.

1.2 Introduction

1.2.1 Background

1.2.1.1 This document contains requirements based upon existing practice for rolling stock operating on 25 kV AC electrification, together with those requirements for new rolling stock in line with European Union (EU) requirements for interoperability and a migration towards operation on electrification systems that are compliant with the uniform system for the Great Britain (GB) mainline 25 kV AC electrified railway, while continuing to give compatibility with existing infrastructure. The application of this document to rail vehicles is as set out in Part 5.

1.2.1.2 The rolling stock requirements in this document describe the compatibility requirements with all existing and future 25 kV electrified systems. As the existing 25 kV electrification system which predates GLRT1210 is not TSI compliant, this has resulted in additional rolling stock requirements to this interface.

1.2.2 Supporting documents

1.2.2.1 The following Rail Industry Guidance Note supports this Railway Group Standard:

- GMGN2611 ‘Guidance on Rolling Stock Subsystem and Interfaces to AC Energy Subsystem’

1.3 Approval and authorisation

1.3.1 The content of this document was approved by RST Standards Committee on 06 September 2019.

1.3.2 This document was authorised by RSSB on 04 October 2019.
Part 2 Requirements for All Rail Vehicles Required to Operate Over 25 kV AC Electrified Lines

2.1 Short circuit fault protection

2.1.1 Short circuit fault protection - provision of bonding

2.1.1.1 Bonding shall be provided on all rail vehicles that operate over the 25 kV AC system, except as set out in 2.1.1.2. The bonding shall be provided as set out in BS EN 50153:2002 clause 6.4.

2.1.1.2 It is permissible for rail vehicles that also operate over 750 V direct current (DC) electrified lines to have only a single protective bonding path between the main body structure of the rail vehicle and the running rail.

2.1.1.3 The running rail(s) shall not be used to return currents between loads and their supply either within a single vehicle or between vehicles of a train.

2.1.2 Short circuit fault protection - bonding capacity

2.1.2.1 Bonding of all rail vehicles shall be compatible with an energy subsystem having the parameters for the maximum fault current and maximum fault durations, as set out in Table 1.

<table>
<thead>
<tr>
<th>Maximum rms fault current [BS EN 50388:2012 clause 11.2]</th>
<th>Maximum fault duration with back-up protection</th>
<th>Maximum fault duration with main protection operating</th>
<th>Maximum number of reclosures permitted</th>
<th>Maximum cumulative fault duration with main protection operating and maximum number of reclosures</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 kA</td>
<td>1 s</td>
<td>200 ms</td>
<td>2</td>
<td>600 ms</td>
</tr>
</tbody>
</table>

Table 1: Fault current characteristics - target system

2.1.2.2 It is permissible for the bonding of rail vehicles that are not intended to operate on lines provided with an energy subsystem having the parameters as set out in Table 1, to be compatible with an energy subsystem having the parameters for the maximum fault current and maximum fault durations as set out in Table 2.
Maximum rms fault current [BS EN 50388:2012 clause 11.2]  

<table>
<thead>
<tr>
<th>Maximum fault duration with back-up protection</th>
<th>Maximum fault duration with main protection operating</th>
<th>Maximum number of reclosures permitted</th>
<th>Maximum cumulative fault duration with main protection operating and maximum number of reclosures</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 kA</td>
<td>1 s</td>
<td>250 ms</td>
<td>2</td>
</tr>
<tr>
<td>12 kA</td>
<td>1 s</td>
<td>250 ms</td>
<td>1</td>
</tr>
<tr>
<td>15 kA</td>
<td>0.65 s</td>
<td>150 ms</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2: Fault current characteristics for compatibility with existing rail vehicles

2.2 Clearance to 25kV overhead contact line

2.2.1 Except where permitted under 2.2.2, the minimum electrical clearance between all rail vehicle parts not intended for connection to the 25 kV overhead contact line (OCL), including any parts that have been disconnected from the 25 kV OCL, and any exposed live part of the 25 kV OCL shall be the maximum reasonably practicable, and no less than the ‘normal’ values, as set out in GLRT1210 clause 3.1.7, taking into account the gauge for the routes over which it will operate.

2.2.2 Where adequate flashover withstand performance is demonstrated and with the application of appropriate safety measures, it is permissible to use lower electrical clearance values than those set out in GLRT1210 clause 3.1.7 at particular infrastructure features where ‘normal’ clearances cannot be achieved.

2.3 Protection of personnel - warning line

2.3.1 A continuous warning line 25-30 mm wide, at least 600 mm from exposed live parts of the OCL, shall be shown on all rail vehicles, except steam locomotives and wagons, operating over the 25 kV AC electrified railway. In addition, on electric rail vehicles, the warning line shall be no closer than 600 mm to the nearest train-mounted, exposed live electrical equipment. The line shall be continuous, except where this is prevented by physical features. Appendix D sets out a method for positioning the warning line.

2.3.2 A ‘Danger: electricity’ warning sign as defined in The Health and Safety (Safety Signs and Signals) Regulations 1998 – Statutory Instruments, 1996 No. 341 (Schedule 1), with the supplementary text ‘Overhead Live Wires’, shall be fitted adjacent to any steps or ladders on vehicles in a position such that it is clearly visible to anyone who is about to use the steps or ladder concerned.
2.4 Shore supplies

2.4.1 Where AC shore supply systems are fitted to vehicles, they shall be compatible with the relevant fixed equipment provided on the network, as set out in 2.4.2 and 2.4.3. The shore supply shall incorporate a safety interlock circuit to ensure that it is not possible to:

a) Disconnect or connect shore supplies to and from vehicles while energised;

b) Access live parts of jumper plugs or receptacles; or

c) Connect a fixed shore supply to the vehicle system while it is already powered from another source.

2.4.2 The interface parameters of the 415 V 3-phase system shall be:

a) Three phase with no neutral (unearthed);

b) 600 A per phase maximum;

c) 400/415 V 3-phase – 3 – pin plug / socket;

d) BR Catalogue number 64 / 724 or compatible for the train interface (receptacle); and

e) BR Catalogue number 64 / 725 or compatible for the shore interface (plug).

2.4.3 The interface parameters of the 1000 V single phase and neutral system, normally used for electric train heating, shall be:

a) Single phase two wire (unearthed);

b) 600 A maximum;

c) 1000 V two single pole plugs / sockets;

d) BR Catalogue number 64 / 360 or compatible for the vehicle plug interface;

e) BR Catalogue number 90 / 11401 or compatible for the vehicle receptacle interface;

f) BR Catalogue number 64 / 2419 or compatible for the shore interface plug; and

g) BR Catalogue number 64 / 2418 or compatible for the shore interface (receptacle).

The train interface fitted at each end of the vehicle consists of receptacles on the right (facing the vehicle), and a lead and plug on the left (facing the vehicle).
Part 3  Electrical Requirements for 25 kV Electric Rail Vehicles

3.1  System frequency

3.1.1  25 kV electric rail vehicle(s) shall be able to operate continuously over the frequency range 47 Hz to 52 Hz, as set out in BS EN 50163:2004 +A1:2007 clause 4.2.

3.2  System voltage

3.2.1  25 kV electric rail vehicle(s) shall be able to operate over the voltage range, as specified in BS EN 50163:2004 +A1:2007 clause 4.1, including the special national condition for UK low voltage as specified in Annex B of BS EN 50163:2004 +A1:2007.

3.2.2  It is permissible to omit compliance with the special national condition for UK low voltage, as set out in Annex B of BS EN 50163:2004 +A1:2007 if the overhead line voltage at the pantograph is compliant with BS EN 50163:2004 +A1:2007 clause 4.1, for all the routes over which the 25 kV electric rail vehicle operates.

3.2.3  Electric rail vehicle(s) shall not be damaged if the supply voltage falls to any value below $U_{\text{min2}}$.

3.3  Power factor

3.3.1  25 kV electric rail vehicle(s) shall meet the requirements for power factor, as set out in BS EN 50388:2012 clauses 6.2 and 6.3.

3.4  Maximum allowable train current and limitation

3.4.1  The maximum allowable train current ($I_{\text{max}}$) shall not exceed 300 A, except where a higher value is compatible with the OCL supply provided on the routes over which a 25 kV electric rail vehicle operates.

3.4.2  25 kV electric multiple units, fixed formation units and locomotives, with power higher than 2 MW, including the declared fixed and predefined formations, shall be equipped with a power or current limitation function.

3.5  Current regulation

3.5.1  25 kV electric vehicle(s) that operate over lines that do not conform to the Energy subsystem Technical Specification for Interoperability (ENE TSI) shall regulate current demand so that:

a)  At supply voltages at or above 20 kV, current regulation is not required; and

b)  At supply voltages below 20 kV and above 12.5 kV, regulation is required. The regulation shall be implemented so that the maximum allowable train current ($I_{\text{max}}$) is reduced by the ratio of the line voltage divided by 20 kV, that is, $I_{\text{max}} = \frac{(I_{\text{max}} \times V_{\text{line}} \text{(kV)})}{20 \text{kV}}$.

3.5.2  For 25 kV electric rail vehicle(s) that operate exclusively over lines that comply with the ENE TSI, automatic regulation, as set out in BS EN 50388:2012 clause 7.2, shall be provided.
3.6 Regenerative braking requirements

3.6.1 25 kV electric rail vehicle(s) equipped with regenerative braking shall meet the following requirements:

- Regenerative braking shall not be initiated if the OCL voltage at the pantograph is less than 17.5 kV.
- Regeneration shall cease when the OCL voltage at the pantograph falls below 14 kV.
- Regeneration shall not be initiated or continue when the OCL voltage at the pantograph is above a predetermined value within the range of 27.5 kV to 29 kV. This setting shall be selectable in a maximum of 500 V steps.
- Manual inhibition of regenerative braking in the train shall be controlled from a position on the train accessible to the train driver and shall apply to the whole train.

3.7 Control of the train in-feed circuit breaker, pantograph and associated interlocks

3.7.1 Each pantograph shall only be permitted to be raised when its associated train in-feed circuit breaker is in the open state.

3.7.2 The train in-feed circuit breaker associated with that pantograph shall not close until the associated pantograph is in contact with the live OCL.

3.7.3 When pantograph lowering has been initiated, the associated train in-feed circuit breaker shall open immediately.

3.8 Automatic connection and disconnection of 25 kV loads

3.8.1 A 25 kV voltage measurement device shall be electrically connected directly to each pantograph. This device is not considered a 25 kV load.

3.8.2 Each pantograph shall be able to be disconnected from all 25 kV loads that it supplies using a circuit breaker. This circuit breaker is called the train in-feed circuit breaker.

3.8.3 Each pantograph shall have a train in-feed circuit breaker associated with it.

3.8.4 The train in-feed circuit breaker associated with a pantograph shall open on the application of an automatic power control (APC) pulse from the APC system associated with that pantograph, only if that train in-feed circuit breaker is closed at the time the APC pulse is applied.

3.8.5 A train in-feed circuit breaker associated with a pantograph opened by an APC system, as set out in clause 3.8.4, shall open within 150 ms of the associated APC receiver passing over a magnet.

3.8.6 The train in-feed circuit breaker associated with a pantograph shall open, within three seconds, on loss of the 25 kV OCL supply detected by the voltage measurement device electrically connected to that pantograph.
3.8.7 Each train in-feed circuit breaker associated with a pantograph shall close on the application of an APC pulse from the APC system associated with that pantograph, when both the conditions in a) and b) below are met:

a) The 25 kV OCL supply is energised; and
b) The train in-feed circuit breaker associated with that pantograph is open.

3.8.8 Any train in-feed circuit breaker shall be inhibited from being automatically closed for a period of 15 minutes after detection of the 25 kV overhead line supply, excepting as set out in 3.8.7.

3.9 Prevention of bridging neutral section

3.9.1 Trains fitted with more than one pantograph shall not permit the pantographs to be electrically interconnected when raised for current collection.

3.10 Correct system selection

3.10.1 On dual voltage electric rail vehicles the 25 kV AC energy subsystem shall not be connected to the 750 V DC energy subsystem via the vehicle.

3.11 Fault current clearance requirements

3.11.1 25 kV electric rail vehicle(s) shall be fitted with train in-feed circuit breakers that:

a) Disconnect all 25 kV loads on the train, except for essential voltage measurement devices;
b) Meet all the requirements of BS EN 60077-4:2003, where:
   i) The short circuit current is the maximum root mean squared (rms) current for the route in a circuit having a maximum time constant. The maximum time constant of the infrastructure is an ‘open point’.
   ii) Capability to withstand the traction power supply reclosure strategy is as set out in GLRT1210 clause 2.1.5.

c) Trip immediately, without any intentional delay, except as set out in 3.11.2, on detection of a short circuit fault on the 25 kV equipment of the electric rail vehicle.

3.11.2 Where a holdover feature is provided, which holds the train in-feed circuit breaker closed under faults greater than the circuit breaker’s rating, it is permissible to inhibit a trip of the train in-feed circuit breaker when the holdover feature is activated.

3.12 Insulation coordination

3.12.1 All high voltage electrical equipment on 25 kV electric rail vehicle(s) connected to the 25 kV system, except for surge suppression devices, shall have a minimum dielectric withstand rating (impulse \( U_{\text{Ni}} \) and power frequency \( U_{\text{a}} \)) selected in accordance with BS EN 50124-1:2001 +A2:2005 clauses 2, 3, 4, and 6.2.
3.13 Power frequency harmonic requirements

3.13.1 Except for the vehicle switching frequency related harmonics set out in Table 4, the rms harmonic current generated by a train as a percentage of the rms fundamental current at any frequency shall not exceed the values set out in Table 3.

<table>
<thead>
<tr>
<th>Harmonic</th>
<th>Harmonic current as a percentage of current at the fundamental frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>15.50</td>
</tr>
<tr>
<td>5</td>
<td>7.60</td>
</tr>
<tr>
<td>7</td>
<td>3.50</td>
</tr>
<tr>
<td>9</td>
<td>1.40</td>
</tr>
<tr>
<td>11</td>
<td>0.70</td>
</tr>
<tr>
<td>13</td>
<td>0.50</td>
</tr>
<tr>
<td>15</td>
<td>0.33</td>
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<tr>
<td>17</td>
<td>0.30</td>
</tr>
<tr>
<td>19</td>
<td>0.20</td>
</tr>
<tr>
<td>21</td>
<td>0.15</td>
</tr>
<tr>
<td>50 &gt; h &gt; 21</td>
<td>0.10</td>
</tr>
<tr>
<td>&gt; 50</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Table 3: Harmonic current

3.13.2 It is permissible to exceed the values above where the harmonic frequency current is the switching frequency of the rail vehicle.

3.13.3 The permitted switching frequency harmonics are set out in Table 4.

<table>
<thead>
<tr>
<th>Switching frequency related harmonics</th>
<th>Harmonic current as a percentage of maximum current demand.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 300 Hz</td>
<td>15.50</td>
</tr>
<tr>
<td>300 Hz to 450 Hz</td>
<td>1.50</td>
</tr>
<tr>
<td>Above 450 Hz</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4: Harmonic current at switching frequency

3.14 High frequency requirements (overhead contact line resonance)

3.14.1 An assessment shall be undertaken in accordance with the process set out in BS EN 50388:2012 clause 10, to demonstrate that impedance of the OCL does not cause high frequency voltage instability with rolling stock.
3.14.2 For the assessment, a worst case (maximum) OCL impedance of 15 k-ohms, at frequencies between 2 kHz and 20 kHz, shall be assumed for operation over all routes.

3.15 Clearance between 25 kV exposed live parts of a vehicle and the infrastructure

3.15.1 Except where permitted under 3.15.2, the minimum electrical clearance between all rail vehicle exposed live parts intended for connection to the 25 kV OCL, including any parts that have been disconnected from the 25 kV OCL and any part of the infrastructure not intended to be energised at 25 kV, shall be the maximum reasonably practicable and no less than the ‘normal’ values, as set out in GLRT1210 clause 3.1.7, taking into account the gauge for the routes over which it will operate.

3.15.2 Where adequate flashover withstand performance is demonstrated and with the application of appropriate safety measures, it is permissible to use lower electrical clearance values than those set out in GLRT1210 clause 3.1.7 at particular infrastructure features where ‘normal’ clearances cannot be achieved.

3.16 Clearance between 25 kV exposed live parts of a vehicle and persons

3.16.1 Personnel shall be protected from access to high voltage (25 kV) equipment with exposed live parts mounted on the roof, either by clearance, as specified in BS EN 50122-1:2011 +A1:2011 clause 5.2, using the public area dimension set out in Figure 4, or by an obstacle for standing surfaces in public areas, as specified in BS EN 50122-1:2011 +A1:2011 clause 5.3. The UK special national condition relating to clause 5.2.1, as set out in BS EN 50122-1:2011 +A1:2011 Annex G, shall not to be used.
Part 4 Mechanical and Pantograph Bonding Requirements for 25 kV Electric Rail Vehicles

4.1 Disconnecting and additional bonding of a pantograph to running rail potential

4.1.1 In addition to the requirements set out in Part 2, electric rail vehicles shall have the capability of:
   a) Lowering the pantograph to its stowed position;
   b) Discharging any residual electrical charge in the vehicle’s HV electrical equipment;
   c) Bonding the disconnected normally live parts of the rail vehicle’s HV electrical equipment and the pantograph to running rail potential; and
   d) Preventing the pantograph from being raised.

4.2 Pantograph geometry and profile

4.2.1 The pantograph profile shall comply with BS EN 50367:2012 Figure B.6 (with non-insulated horns), except as set out in 4.2.2.

4.2.2 It is permissible to use the pantograph profile set out in BS EN 50367:2012 Figure A.6 where this is compatible with the routes on which the 25 kV electric rail vehicle is to operate.

4.3 Pantograph head width (along track)

4.3.1 The pantograph head along track width shall be between 200 mm and 450 mm, except as set out in 4.3.2.

4.3.2 It is permissible to use a pantograph head with an alternative along track width where this is compatible with the routes on which the 25 kV electric rail vehicle is to operate.

4.4 Pantograph force distribution

4.4.1 Where heads with multiple collector strips are used, the contact force shall be evenly distributed across all collector strips.

4.5 Working height range of pantograph for current collection

4.5.1 Pantographs mounted on rail vehicle(s) shall collect current over the range between 150 mm above the kinematic gauge of the vehicle and 6200 mm above rail level.

4.5.2 Each pantograph shall be fitted with a maximum reach detection device to fully lower the pantograph if a height of 6240 mm above rail level is exceeded.

4.6 Pantograph contact strip material

4.6.1 The pantograph contract strip shall be composed of either:
   a) Plain carbon; or
b) Carbon impregnated with copper or copper alloy, up to 35\% by weight.

### 4.7 Pantograph location on rail vehicles

#### 4.7.1 The distance between successive pantographs and their position relative to the front of the leading vehicle in any combination shall be defined in the technical file for the vehicle.

**Rationale**

G 4.7.2 To support the assessment of compatibility with the OCL infrastructure for specified routes demonstrated in accordance with RIS-8270-RST.

**Guidance**

G 4.7.3 The spacing between pantographs on coupled units and their distance from the leading vehicle affect the potential to span a section insulator or booster overlap, and this condition is part of the compatibility assessment.

G 4.7.4 The distance between pantographs depends on the relative orientation of fixed configuration units and the orientation of the pantograph vehicle within the unit.

G 4.7.5 Clause 4.2.8.2.9.8 in the Locomotive and Passenger Rolling Stock (LOC&PAS) TSI requires the train to be designed so that it can move from one phase or system section to another without bridging the sections. Furthermore, specific route issues are managed under route compatibility assessment.

### 4.8 Static contact force

**Guidance**

G 4.8.1 Clause 4.2.8.2.9.5 (2) of the LOC&PAS TSI requires that the static contact force is adjustable within a range of 60-90N (for AC systems). This force range is compatible with the permitted range of mean contact forces at zero speed for all lines whether they comply with corresponding TSI requirements or not.

### 4.9 Dynamic contact force, current collection and pantograph spacing

#### 4.9.1 Performance requirements for individual pantographs

**Guidance**

G 4.9.1.1 The TSI process and parameters ensure compatibility when both subsystems comply with corresponding TSI requirements, but do not give an assurance of compatibility when one subsystem does not comply.

G 4.9.1.2 The LOC & PAS TSI refers to the ENE TSI with respect to key parameters concerning dynamic behaviour and current collection quality.

G 4.9.1.3 Compliance with the respective TSIs for the LOC&PAS and ENE subsystems assures compatibility between these subsystems through controls within compatible parameters. For example: the maximum permitted contact force exerted by the
pantograph against the OCL is less than the minimum contact force that the OCL is required to withstand.

G 4.9.1.4 In the case of a new or modified vehicle introduced on infrastructure that has not been designed to, or assessed against, the ENE TSI, it is necessary to assess compatibility between the interfacing systems for the attributes defined in the TSIs.

G 4.9.1.5 The current collection behaviour is assessed via simulations and verification of the model on a representative section of overhead contact system.

G 4.9.1.6 Details of a representative section of overhead contact system provided by the infrastructure manager will facilitate the analysis.

G 4.9.1.7 There can be a significant difference between the variation in contact forces generated by a single pantograph and multiple pantographs raised in tandem. Vibrations induced in the OCL by a leading pantograph generate additional disturbance at the OCL/head interface resulting in increased force variation.

G 4.9.1.8 Each pantograph in a train consist is expected to operate within the dynamic contact force limits and therefore the ‘worst-case’ pantograph location is determined by analysis and used for compliance demonstration.

4.9.2 Minimum pantograph spacing

Guidance

G 4.9.2.1 Compatibility assessments for pantograph/OCL interaction take into account the number and relative position of raised pantographs and the speed at which they are intended to operate.

G 4.9.2.2 The ENE TSI categorises OCL types according to their nominal capability with respect to running speed and pantograph spacing. The OCL designs typically used on the GB network are intended to conform with type A.

4.10 Pantograph automatic dropping device

4.10.1 Each pantograph shall be equipped with an automatic dropping device (ADD) that lowers the pantograph, as defined in BS EN 50206-1:2010 clause 4.8, and meet the requirements set out in 4.10.2 to 4.10.6.

4.10.2 The pantograph ADD shall be capable of achieving the minimum dynamic insulating distance of 150 mm within three seconds of activation.

4.10.3 The pantograph shall reach the parked position within 10 seconds, starting with the head at 6240 mm above rail level.

4.10.4 The ADD shall be initiated by detection of loss of pressure in the auto-drop detection sensor.

4.10.5 The ADD system shall open the associated train in-feed circuit breaker immediately when operated.

4.10.6 The ADD system shall incorporate a facility to allow a driver to isolate the ADD after activation.
4.11 Automatic power control

4.11.1 Each 25 kV electric rail vehicle fitted with a pantograph shall be fitted with an independently operating APC receiver to control the circuit breaker(s) associated with that pantograph, as set out in 3.8.

4.11.2 The APC receiver shall be positioned, vertically and laterally (across track), in accordance with the dimensions set out in Appendix B.

4.11.3 The along track longitudinal distance between the receiver and its associated pantograph shall not exceed 7.75 m.

4.11.4 Detection of a vertically oriented south polarity magnetic flux of greater than 2.5 mT at the base of the receiver shall initiate the operation of the train in-feed circuit breaker.

4.11.5 For 25 kV electric rail vehicles capable of a maximum speed exceeding 100 mph (160 km/h), but not greater than 125 mph (225 km/h), the receiver shall detect the magnetic flux presence within 2.5 ms.

4.11.6 For 25 kV electric rail vehicles not capable of a maximum speed exceeding 100 mph (160 km/h) the receiver shall detect the magnetic flux presence within 4.5 ms.

4.11.7 On detection of a ‘south pole’ field by the APC receiver, the APC system shall apply an APC pulse to control the associated train in-feed circuit breaker, as set out in 3.8.

4.12 Trackside pantograph monitoring sites - rail vehicle identification

4.12.1 A tag compatible with trackside pantograph monitoring sites shall be provided on the train to identify each vehicle fitted with a pantograph.

4.13 Pantograph camera

4.13.1 Where a vehicle based camera is used to record the overhead line / pantograph interface it shall have a storage device associated with it that shall fulfil the following requirements:
   a) Record at least 10 frames per second (fps);
   b) Record the pantograph / contact wire interface at all wires heights;
   c) Record the full width of the pantograph (including pantograph horns);
   d) The recorded data shall be stored on the vehicle and shall have a minimum capacity of eight days;
   e) The data shall be downloadable and in a ‘.mp4’ format; and
   f) The data shall contain the vehicle identification and shall be date and time stamped.
Part 5  Application of this Document

5.1  Scope

5.1.1  If a vehicle is considered new, renewed or upgraded as defined in the Railways (Interoperability) Regulations 2011 (as amended), then all or part of the vehicle is required to comply with the relevant TSIs and notified national technical rules, unless given exemptions allowed for in the Regulation.

5.1.2  The requirements of this document as national technical rules are relevant to components of the vehicle that interfaces with the AC Energy subsystem to which 5.1.1 applies.

5.1.3  Action to bring an existing vehicle into compliance with the requirements of this document is not required.

5.2  Exclusions from scope

5.2.1  The requirements in this document are not applicable to the following types of vehicles:

a)  Possession-only rail vehicles; or
b)  General contract of use (GCU) wagons.

5.3  General enter into force date

5.3.1  The requirements in this document enter into force from 07 December 2019.

5.4  Exceptions to general enter into force date

5.4.1  There are no exceptions to the general enter into force date.

5.5  Applicability of requirements for projects already underway

5.5.1  The Office of Rail and Road can be contacted for clarification on the applicable requirements where a project seeking authorisation for placing into service is already underway when this document enters into force.

5.6  Deviations

5.6.1  Where it is considered not reasonably practicable to comply with the requirements of this document (including any requirement to comply with a TSI requirement referred to in the Scope), permission to comply with a specified alternative should be sought in accordance with the deviation process set out in the Railway Group Standard Code.

5.6.2  In the case where TSI compliance is required for a new, renewed or upgraded vehicle or structural subsystem, the derogation process to be followed is set out in the Railways (Interoperability) Regulations 2011 (as amended).
5.7 Health and safety responsibilities

5.7.1 Users of documents published by RSSB are reminded of the need to consider their own responsibilities to ensure health and safety at work and their own duties under health and safety legislation. RSSB does not warrant that compliance with all or any documents published by RSSB is sufficient in itself to ensure safe systems of work or operation or to satisfy such responsibilities or duties.
Appendices

Appendix A  Open Points

A.1 Open Points

Note: The content of this appendix is not mandatory and is provided for guidance only.

A.1.1 List of open points in GMRT2111.

A.1.2 The open points in GMRT2111 are set out in Table 5, which also indicates where information on industry practice relating to each open point is given.

<table>
<thead>
<tr>
<th>Open point</th>
<th>Section of GMRT2111</th>
<th>Additional information</th>
</tr>
</thead>
<tbody>
<tr>
<td>The maximum circuit time constant of the infrastructure is an open point.</td>
<td>3.11.1 b) i)</td>
<td>See GMGN2611 clauses G 3.11.7, G 3.11.8, G 3.11.9 and G 3.11.10</td>
</tr>
</tbody>
</table>

Table 5: List of open points
Appendix B  Relationship Between the Automatic Power Control Receiver (Train Mounted) and Track Magnet

B.1 Relationship Between the Automatic Power Control Receiver (Train Mounted) and Track Magnet

Note: The content of this appendix is mandatory

B.1.1 Relationship between the automatic power control (APC) receiver and the APC track magnet.

Figure 1: Relationship between the APC receiver and the APC track magnet

Note: The content of this section of the appendix not mandatory and is provided for guidance only.

B.1.2 Position of the APC magnet.
B.1.3 The rail vehicle-mounted APC receiver is usually fixed to a bogie frame to achieve the appropriate height above rail level and the lateral distance from the centre line of the track.

B.1.4 The distance from the track magnets to the neutral sections depends on the maximum permitted line speed. Typical distances are set out in Table 6:

<table>
<thead>
<tr>
<th>Line speed limit km/h (mph)</th>
<th>Distance from the APC track magnet to the center-line of the neutral section</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 (20)</td>
<td>14 m</td>
</tr>
<tr>
<td>60 (40)</td>
<td>18 m</td>
</tr>
<tr>
<td>100 (60)</td>
<td>22 m</td>
</tr>
<tr>
<td>120 (80)</td>
<td>26 m</td>
</tr>
<tr>
<td>160 (100)</td>
<td>30 m</td>
</tr>
<tr>
<td>180 (110)</td>
<td>30 m</td>
</tr>
<tr>
<td>200 (125)</td>
<td>30 m</td>
</tr>
<tr>
<td>225 (140)</td>
<td>30 m</td>
</tr>
</tbody>
</table>

Table 6: APC magnet spacing
Appendix C   AC System Electrical Characteristic for Rolling Stock Compatibility

C.1   AC System Electrical Characteristic for Rolling Stock Compatibility

Note: The content of this appendix is not mandatory and is provided for guidance only

C.1.1   This appendix summarises the values set out in 2.1.2.1, 2.1.2.2, 3.1.1, 3.2.1, 3.2.2, 3.2.3 and 3.11.1) of this document, and GLRT1210 clauses 2.1.1.2 and 2.1.8.1.

<table>
<thead>
<tr>
<th>Ref</th>
<th>System characteristic</th>
<th>Symbol</th>
<th>Value</th>
<th>EN source</th>
<th>GMRT2111</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Nominal voltage.</td>
<td>U_n</td>
<td>25,000 V AC</td>
<td>BS EN 50163:2004</td>
<td>3.2.1</td>
</tr>
<tr>
<td>1.2</td>
<td>Highest permanent voltage.</td>
<td>U_max1</td>
<td>27, 500 V AC</td>
<td>BS EN 50163:2004 +A1:2007, clause 4.1 and Table 1</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>Highest non-permanent voltage. (Maximum duration five minutes.)</td>
<td>U_max2</td>
<td>29, 000 V AC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Lowest permanent voltage.</td>
<td>U_min1</td>
<td>19, 000 V AC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>Lowest non-permanent voltage. (Maximum duration two minutes.)</td>
<td>U_min2</td>
<td>17, 500 V AC</td>
<td></td>
<td>3.2.3</td>
</tr>
</tbody>
</table>
### Table 7: Summary of contact line voltage parameters

<table>
<thead>
<tr>
<th>Ref</th>
<th>System characteristic</th>
<th>Symbol</th>
<th>Value</th>
<th>EN source</th>
<th>GMRT2111</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6</td>
<td>Lowest non-permanent voltage (existing lines only). (Maximum duration 10 minutes.)</td>
<td>$U_{\text{min}_2}^a$</td>
<td>14,000 V AC</td>
<td>BS EN 50163:2004 +A1:2007, clause 4.1, Table 1 and Annex B</td>
<td>3.2.2</td>
</tr>
<tr>
<td>1.7</td>
<td>Lowest non-permanent voltage (existing lines only). (Maximum duration two minutes.)</td>
<td>$U_{\text{min}_2}^b$</td>
<td>12,500 V AC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td>Mean useful voltage (at the pantograph) ($v \leq 200$ km/h).</td>
<td>$U_{\text{mean useful}}$</td>
<td>22,000 V AC</td>
<td>BS EN 50388:2012, clause 8.3</td>
<td>GLRT1210 2.1.1.2</td>
</tr>
<tr>
<td>1.9</td>
<td>Mean useful voltage (at the pantograph) ($v &gt; 200$ km/h).</td>
<td></td>
<td>22,500 V AC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.10</td>
<td>Rated impulse voltage (basic insulation).</td>
<td>$U_{\text{Ni}}$</td>
<td>200 kV peak</td>
<td>BS EN 50124-1:2001+A2:2005 Table A.2, 2.1.8.1b)</td>
<td>GLRT1210 2.1.8.1</td>
</tr>
<tr>
<td>1.11</td>
<td>Rated impulse voltage (functional insulation).</td>
<td></td>
<td>$\geq 145$ kV peak</td>
<td>BS EN 50124-1:2001+A2:2005 Table A.2, 2.1.8.1a)</td>
<td></td>
</tr>
</tbody>
</table>
### 2 Contact line frequency

<table>
<thead>
<tr>
<th>Ref</th>
<th>System characteristic</th>
<th>Symbol</th>
<th>Value</th>
<th>EN source</th>
<th>GMRT2111</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Nominal frequency.</td>
<td>$F_n$</td>
<td>50 Hz</td>
<td>BS EN 50163:2004+A1:2007, clause 4.2</td>
<td>3.1.1</td>
</tr>
<tr>
<td>2.2</td>
<td>Maximum frequency for 99.5% of the year.</td>
<td>$F_{\text{max}1}$</td>
<td>50.5 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>Minimum frequency for 99.5% of the year.</td>
<td>$F_{\text{min}1}$</td>
<td>49.5 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>Maximum frequency for 100% of the time.</td>
<td>$F_{\text{max}2}$</td>
<td>52 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>Minimum frequency 100% of the time.</td>
<td>$F_{\text{min}2}$</td>
<td>47 Hz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 8:** Summary of contact line frequency parameters
### 3 Contact line fault current

<table>
<thead>
<tr>
<th>Ref</th>
<th>System characteristic</th>
<th>Symbol</th>
<th>Value</th>
<th>EN source</th>
<th>GMRT2111</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Maximum rms fault current. (Maximum duration one second.)</td>
<td>$I_{sc, rms}$</td>
<td>15 kA (target)</td>
<td>BS EN 50388:2012, clause 11.2</td>
<td>2.1.2.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 kA, 12 kA, 15 kA (existing)</td>
<td>BS EN 60077-4:2003, clause 5.3.6.1</td>
<td>2.1.2.2</td>
</tr>
<tr>
<td>3.2</td>
<td>Maximum peak fault current in the first half cycle.</td>
<td>$I_{sc, peak}$</td>
<td>2.5 times maximum rms fault current</td>
<td>BS EN 62271-100:2009+A1:2012, clause 4.101.2</td>
<td>3.11.1 b)</td>
</tr>
<tr>
<td>3.3</td>
<td>Maximum circuit time constant at the contact line.</td>
<td>T</td>
<td>Open point</td>
<td>BS EN 62271-100:2009+A1:2012, clause 4.101.2</td>
<td>3.11.1 b) i)</td>
</tr>
</tbody>
</table>

**Table 9:** Summary of contact line fault current parameters
Appendix D  Warning Line (Previously Known as Cant Rail Warning Line)

Note: The content of this appendix is not mandatory and is provided for guidance only.

D.1  Warning line

D.1.1  This appendix gives information on the warning line which provides a clear indication of the upper limit above which it is not safe to work on rail vehicles in overhead electrified areas without isolation of the OCL.

D.2  Application to rail vehicles

D.2.1  The warning line is applied to vehicles required to operate over 25 kV AC electrified lines, except steam locomotives.

D.3  Colour

D.3.1  The target colour should be light orange (BS 381C:1996 Reference No. 557).

D.3.2  Black or white for the warning line should be used in place of the light orange colour where either:

a)  The livery in the area where the warning line is to be applied is itself orange, such that a warning line as set out in D.3.1 would not be clearly visible; or

b)  The livery contains areas of orange in close proximity to the area where the warning line is to be applied, such that the warning line, although clearly visible, may not be recognised as such.

D.3.3  Black or white is not substituted for light orange merely because it gives a sharper contrast with the livery. Orange is widely recognised as the colour of the warning line on rail vehicles and it should be used in all cases unless there is a problem of visibility of the warning line, or of recognising it as a warning line.

D.4  Height of the warning line above rail level

D.4.1  The warning line should be positioned taking into account the following requirements:

- The warning line is clearly visible when viewed from standing at rail level.
- The top of the warning line mandated is no closer than 600 mm to the nearest train-mounted, exposed live electrical equipment, as set out in 3.16, and is measured as a ‘taut string’ distance. All parts of insulators are considered live for this purpose.
- For vehicles that have a static height exceeding 3775 mm, the top of the warning line should not exceed an absolute maximum value of 3565 mm above rail level when the rail vehicle is in a tare condition with new wheels, and the suspension is in the in-service condition.
- For vehicles that have a static height not exceeding 3775 mm, the top of the warning line should not exceed an absolute maximum value of 3390 mm above rail level when the rail vehicle is in a tare condition with new wheels, and the suspension is in the in-service condition.
• Except as set out in page 30, the warning line should be placed within the range normally reached by carriage washing machines (not higher than 3300 mm above rail level) with the rail vehicle in tare condition with new wheels.

• In circumstances where placing the line at or below 3300 mm prevents the warning line being carried over the top of areas which cannot be liveried, the height of the line, where it passes over such areas, should be kept to a value less than the absolute maximum value set out in page 29 or page 29, as appropriate.

D.4.2 Except under the conditions set out in D.4.4, the warning line should be continuous and positioned so that it is not less than 3100 mm above rail level, when the rail vehicle is in tare condition with new wheels and the suspension is in the service condition.

D.4.3 Where practicable, the warning line should be placed above body side doors and windows, rail vehicle end doors and windows, horns and destination and route indicators.

D.4.4 Where there are glazed areas, ventilators, grilles, rubber elements or other parts of the rail vehicle that cannot be liveried and which are of such a height that D.4.2 cannot be met, then one of either the following conditions should be applied:

a) Carry the warning line below 3100 mm in cases where it can be positioned sufficiently high for it to be readily recognisable as a warning line, or

b) The warning line should be terminated immediately either side of the obstruction. Whenever the warning line is terminated to avoid an obstruction a ‘Danger: electricity’ warning sign, as defined in The Health and Safety (Safety Signs and Signals) Regulations 1996 - Statutory Instruments, 1996 No. 341 (Schedule 1), with the supplementary text ‘Overhead Live Wires’, should be fitted within 200 mm of each termination of the warning line, where practicable, on the rail vehicle end and at the same level as the warning line.
Appendix E  Bonding of Rail Vehicles’ 25kV Equipment

E.1  Bonding of Rail Vehicles’ 25kV Equipment

Note: The content of this appendix is not mandatory and is provided for guidance only.

E.1.1  This appendix provides information on the methods that have been used for the earthing and bonding of rail vehicles to the running rail potential.

E.1.2  To facilitate safe working on the high voltage electrical equipment on rail vehicles which can be supplied from an OCL, system protection is provided traditionally by an isolating cock and mechanically interlocked earthing switch. This system is provided mainly to protect depot staff when working on the roof equipment of trains.

E.1.3  A manual isolating cock (isolating device) is provided to remove the air supply from the pantograph up valve and to prevent the pantograph from being raised. When the device is operated, this isolates the air supply from the pantograph up valve and so makes it impossible to raise the pantograph when it is isolated.

E.1.4  An earthing (safety bonding) switch is provided to bond all high voltage equipment and when it is placed in the closed (earthed) position, it bonds both:

a) The pantograph, roof connections and any other equipment on the supply side of the train in-feed circuit breaker to the rail vehicle main body structure, and

b) The roof input bushing, high voltage cable and any other primary circuit equipment on the load side of the train in-feed circuit breaker, to the rail vehicle main body structure.

E.1.5  The earthing (safety bonding) switch has two moving elements, each one making contact with a matching fixed element on the train in-feed circuit breaker, on each side of its open contact.

E.1.6  The earthing (safety bonding) switch operating handle and the pantograph isolating cock handle are interlocked to provide all of the following:

a) When the isolating cock is in the open position, that is to say, normal service, the safety bonding switch is locked open.

b) When the safety bonding switch is in the bonded position, the isolating cock is locked in the isolated position.

c) With air applied to the pantograph, the safety bonding switch is locked in the open position and remains so until the air pressure in the pantograph air motor is reduced to a value well below that at which the pantograph leaves the wire.

E.1.7  Where rail vehicles are fitted with more than one pantograph and the pantographs are permanently electrically connected together, their isolation and earthing (safety bonding) is provided as if they were a single pantograph.

E.1.8  Where rail vehicles are fitted with more than one pantograph and the pantographs are not permanently electrically connected together, their isolation and earthing (safety bonding) is provided individually for each pantograph location.
### Appendix F  Speed conversions

#### F.1  Speed conversions

**Note:** The content of this appendix is mandatory

#### F.1.1 Where there is a reference in any EN or TSI to a speed in km/h, the following conversions to mph are to be used.

<table>
<thead>
<tr>
<th>km/h</th>
<th>mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
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<tr>
<td>3</td>
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<td>5</td>
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<tr>
<td>250</td>
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</table>
### Infrastructure subsystem (INF), Rolling Stock subsystem (RST) and Energy subsystem (ENE) speed conversions

<table>
<thead>
<tr>
<th>km/h</th>
<th>mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>280</td>
<td>175</td>
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<tr>
<td>300</td>
<td>190</td>
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<td>320</td>
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<td>350</td>
<td>220</td>
</tr>
<tr>
<td>360</td>
<td>225</td>
</tr>
</tbody>
</table>

**Table 10:** INF, RST and ENE speed conversions
Definitions

alternating current (AC)  
energy subsystem

The Energy (ENE) TSI states that the AC energy subsystem consists of:

Substations: connected on the primary side to the high-voltage grid, with transformation of the high-voltage to a voltage and/or conversion to a power supply system suitable for the trains. On the secondary side, substations are connected to the railway contact line system.

Sectioning locations: electrical equipment located at intermediate locations between substations to supply and parallel contact lines, and to provide protection, isolation and auxiliary supplies.

Separation sections: equipment required to provide the transition between electrically different systems or between different phases of the same electrical system.

Contact line system: a system that distributes the electrical energy to the trains running on the route and transmits it to the trains by means of current collectors. The contact line system is also equipped with manually or remotely controlled disconnectors which are required to isolate sections or groups of the contact line system according to operational necessity. Feeder lines are also part of the contact line system.

Return circuit: all conductors which form the intended path for the traction return current and which are additionally used under fault conditions. Therefore, so far as this aspect is concerned, the return circuit is part of the energy subsystem and has an interface with the infrastructure subsystem.

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basic insulation

Insulation of hazardous-live-parts, which provides basic protection.

Note: This concept does not apply to insulation used exclusively for functional purposes. Source: IEV 195-06-06

contact force

Vertical force applied by the pantograph to the OCL. Source: BS EN 50367:2006

contact line system

The system that distributes the electrical energy to the trains running on the route and transmits it to the trains by means of current collectors. Source: ENE TSI

contact wire uplift

Vertical upward movement of the contact wire due to the force produced from the pantograph. Sources: EN 50119:2009+A1:2013, ENE TSI

current collector

Equipment fitted to the vehicle and intended to collect current from a contact wire or conductor rail. Source: IEC 60050-811, definition 811-32-01

electric shock

Physiological effect resulting from an electric current passing through a human or animal body Source: IEV 195-01-04
European Register of Authorised Types of Vehicles (ERATV)  
The Register of Types of Vehicle authorised by EU Member States for placing in service is referred to in Article 34 of Directive 2008/57/EC, now addressed by Commission Decision 2011/665/EU. It contains the technical characteristics of vehicles’ types as defined in the relevant TSIs, the manufacturer’s name, dates, references and Member State granting authorisations, restrictions and withdrawals.

failure  Loss of ability to perform as required. Source: IEV 192-03-01

Note: A failure of an item is an event that results in a fault of that item.

Note: Qualifiers, such as catastrophic, critical, major, minor, marginal and insignificant, may be used to categorise failures according to the severity of consequences, the choice and definitions of severity criteria depending upon the field of application.

Note: Qualifiers, such as misuse, mishandling and weakness, may be used to categorise failures according to the cause of failure.

fixed formation units  25 kV or dual voltage fixed formation unit. A fixed formation unit is only operated with a single pantograph raised at any one time:

- AC fixed formation units – 25 kV-only fixed formation unit.
- AC / DC fixed formation units – dual voltage fixed formation unit.

functional insulation Insulation between conductive parts, necessary for the proper functioning of the equipment Source: 195-02-41

gauge Set of rules, including a reference contour and its associated calculation rules allowing defining the outer dimensions of the vehicle and the space to be cleared by the infrastructure. Source: ENE TSI.

Note: According to the calculation method implemented, the gauge will be a static, kinematic or dynamic.

GB mainline railway Mainline railway has the meaning given to it in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended) and the associated exclusions. GB Mainline Railway is the mainline railway network excluding any railway in Northern Ireland, the Channel Tunnel, the dedicated high-speed railway between London St Pancras International Station and the Channel Tunnel, and any other exclusions determined by the member state.

lateral deviation Deviation of the contact wire from the track centre line under action of a crosswind. Source: EN 50367:2012, ENE TSI.
line speed: Maximum speed measured in kilometres per hour for which a line has been designed. Source: ENE TSI.

live part: Any conductor and any conductive part of electrical equipment intended to be energised in normal use. Source: IEV 195-02-19 modified

Note: Insulators are considered to be live parts

maximum contact wire height: Maximum possible contact wire height, which the pantograph is required to reach, in all conditions. Source: EN 50119:2009+A1:2013

mean contact force: Statistical mean value of the contact force. Source: BS EN 50367:2006

mean useful voltage train: Voltage identifying the dimensioning train and enables the effect on its performance to be quantified. Source: ENE TSI

mean useful voltage zone: Voltage giving an indication of the quality of the power supply in a geographic zone during the peak traffic period in the timetable. Source: ENE TSI

minimum contact wire height: A minimum value of the contact wire height in the span in order to avoid the arcing between one or more contact wires and vehicles in all conditions. Source: EN 50119:2009+A1:2013, ENE TSI

nominal contact wire height: A nominal value of the contact wire height at a support in the normal conditions. Sources: EN 50119:2009+A1:2013, ENE TSI

nominal voltage: Value of the voltage by which the electrical installation or part of the electrical installation is designated and identified. Source: IEV 826-11-01

normal service: Planned timetable service. Source: ENE TSI

on-track machine (OTM): Any rail-mounted machine, whose primary function is for the renewal, maintenance, inspection or measurement of the infrastructure, meeting the requirements of GMRT2400 and permitted by the Rule Book to be moved, either self-propelled or in train formation, outside a possession.

Open Point: Parameters that have been formally identified as in scope of a TSI or Railway Group Standard for which no common requirement has been agreed.

overhead contact line (OCL): Contact line placed above (or beside) the upper limit of the rail vehicle gauge and supplying vehicles with electric energy through roof-mounted current collection equipment. Sources: IEV 811-33-02, ENE TSI

Note: Where this includes, in addition to all current-collecting conductors, the following elements: reinforcing feeders; cross-track feeders; disconnectors; section insulators; overvoltage protection devices; supports that are
not insulated from the conductors; insulators connected to live parts; along-track feeders; conductors connected permanently to the contact line for supply of other electrical equipment; earth wires and return conductors.

pantograph exclusion zone  The length of track relative to a defined OCL feature (for example, an overlap) within which the pantograph of an electric train does not touch the contact wire when the train is stationary or moving at a slow speed, in order to prevent electrical arcing.

passing electrical clearance  The distance, being created by a momentary reduction of the static electrical clearance, caused by the dynamic interaction of the pantograph and the OCL during the passage of electric trains.

rail vehicle  Any vehicle, moving either under its own power (locomotives fixed formation units and multiple units) or hauled by another vehicle (coaches, railcar trailers, vans and wagons), on-track machine, road-rail vehicle or rail-mounted maintenance machine.

rated impulse voltage \( (U_{Ni}) \)  Impulse voltage value assigned to the system or part of it, characterising the specified withstand capability of its insulation against transient overvoltages. Source: EN 50124-1:2001+A2:2005, 1.3.2.7 modified

register of infrastructure (RINF)  A register that shall be maintained for each TSI-certified line that describes the main features and requirements of each subsystem and their correlation with the relevant TSI. https://rinf.era.europa.eu/RINF/

return circuit  All conductors which form the intended path for the traction return current and the current under fault conditions. Source: EN 50122-1:2011+A1:2011

All conductors which form the intended path for the traction return current. Source: ENE TSI

static contact force  Mean vertical force exerted upwards by the pantograph head on the OCL, and caused by the pantograph-raising device, while the pantograph is raised and the vehicle is at a standstill. Source: BS EN 50367:2006

static electrical clearance  The distance forming insulation in air between:

\[ \text{a)} \text{ Exposed live parts of the OCL system and the parts of rail vehicles that are earthed via the fixed installation.} \]

\[ \text{b)} \text{ Exposed live parts of the OCL system and earthed parts of the OCL system.} \]

\[ \text{c)} \text{ Exposed live parts of the OCL system and fixed assets.} \]

\[ \text{d)} \text{ Exposed live parts of electric rail vehicles and earthed parts of the OCL system.} \]
e) Exposed live parts of electric rail vehicles and fixed assets.

subsystem

One of the subsystems (of the European railway system) identified by the Interoperability Directive. Subsystems can be structural or functional.

switching frequency related harmonics

These are the frequencies that appear as a group of frequencies and are related to the switching frequency of the line converter.

train

A train is defined as (a) traction unit(s) with or without coupled railway vehicles, including light locomotive and self-propelled rail vehicle operating in rail mode, with train data available operating between two or more defined points.
### Rolling Stock Subsystem and Interfaces to AC Energy Subsystem

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AC</td>
<td>Alternating current.</td>
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<tr>
<td>ADD</td>
<td>Auto dropping device.</td>
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<tr>
<td>APC</td>
<td>Automatic Power Control.</td>
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<tr>
<td>ARL</td>
<td>Above rail level.</td>
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<tr>
<td>AVI</td>
<td>Automatic Vehicle Identification.</td>
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<tr>
<td>DC</td>
<td>Direct current.</td>
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<tr>
<td>ENE</td>
<td>Energy Subsystem.</td>
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<tr>
<td>ERTMS</td>
<td>European Rail Traffic Management System.</td>
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<tr>
<td>ETCS</td>
<td>European Train Control System.</td>
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<tr>
<td>IEV</td>
<td>International Electrotechnical Vocabulary.</td>
</tr>
<tr>
<td>IM</td>
<td>Infrastructure Manager.</td>
</tr>
<tr>
<td>INF</td>
<td>Infrastructure Subsystem.</td>
</tr>
<tr>
<td>LOC &amp; PAS</td>
<td>Locomotives &amp; Passenger Carriages. Part of the RST subsystem.</td>
</tr>
<tr>
<td>OCL</td>
<td>Overhead Contact Line.</td>
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<tr>
<td>RINF</td>
<td>Register of Infrastructure.</td>
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<tr>
<td>rms</td>
<td>Root mean squared.</td>
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<td>RST</td>
<td>Rolling Stock subsystem.</td>
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<td>TMS</td>
<td>Train Management System.</td>
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<tr>
<td>TSI</td>
<td>Technical Specification for Interoperability.</td>
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<tr>
<td>VCB</td>
<td>Vacuum circuit breaker.</td>
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</tbody>
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References

The Standards Catalogue gives the current issue number and status of documents published by RSSB. This information is available from http://www.rssb.co.uk/railway-group-standards.co.uk.

RGSC 01 Railway Group Standards Code
RGSC 02 Standards Manual

Documents referenced in the text

Railway Group Standards

GLRT1210 AC Energy Subsystem and Interfaces to Rolling Stock Subsystem
GMRT2400 Engineering Design of On-Track Machines in Running Mode

RSSB Documents

GMGN2613 Guidance on Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem
GLGN1610 Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem
GMGN2611 Guidance on Rolling Stock Subsystem and Interfaces to AC Energy Subsystem
RIS-8270-RST Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure

Other References

BS 381C:1996 Specification for colours for identification, coding and special purposes
BS EN 50119:2009 +A1:2013 Railway applications — Fixed installations — Electric traction overhead contact lines
BS EN 50153:2002 Railway applications — Rolling stock — Protective provisions relating to electrical hazards
BS EN 50206-1:2010 Railway applications — Rolling stock — Pantographs: Characteristics and tests Part 1: Pantographs for main line vehicles
Rolling Stock Subsystem and Interfaces to AC Energy Subsystem

BS EN 50317:2012  Railway applications — Current collection systems — Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line

BS EN 50367:2012  Railway applications — Current collection systems — Technical criteria for the interaction between pantograph and overhead line (to achieve free access)

BS EN 50388:2012  Railway Applications — Power supply and rolling stock — Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability

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IEV 60050 series  International Electrotechnical Vocabulary (IEV) available on line as ‘Electropedia’

ENE TSI  COMMISSION REGULATION (EU) No 1301/2014 of 18 November 2014 on the technical specifications for interoperability relating to the ‘energy’ subsystem of the rail system in the Union

The Health and Safety (Safety Signs and Signals) Regulations 1996 - Statutory Instruments, 1996 No. 341

Other relevant documents

Railway Group Standards

GMRT2111  Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem

RSSB Documents

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BS 7671:2008+A1:2011  Requirements for electrical installations. IET Wiring Regulations

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