Earthing and Bonding for Common Bonded AC Electrified Railways

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Induction

Lineside conductor

cable capacitance to earth

\[ V_L \]

\[ V_T \]
Effects of Coupling

Secondary safety concerns

Occupational safety hazard
- Hazardous touch potential
- Equipment malfunction
- Equipment damage

Delays
- System Unavailable

Noise on voice circuits
- Errors in digital/data circuits

Traction current
- Magnetic field

$V_L$ $V_T$
**Touch Voltage Limits – EN 50122-1**

- **EN 50122-1 AC Body Voltage RMS**
- **EN 50122-1 AC Eff Touch Voltage RMS**

- **Effective touch voltage with shoes on**: 645 V, 200 ms
- **Actual voltage across the body**: 60 V continuous

*Graph showing触电电压极限 - EN 50122-1.*
Mutual Screening Conductor

- Earthed every 1 km using earth electrodes
- MSC reduces induction to cables by ~50 %
- Must be close to S&T cable
- Earth electrodes are a pain
- 19/3.25 (158 mm²) Al
Return Screening Conductor

- RSC – performance similar to MSC
  ~ 50-60 % reduction
- Installation & maintenance costs lower (no earth electrodes)
- Less risk of spiking cables
- More tolerant of bond loss
- Conductor must be rated for normal and fault currents
- Typical size: 19/4.22 (266 mm²) Al
- Generic safety case pending
- If MSC is already installed it can be left – no need to maintain
- AT+RSC ≡ BT+MSC
RSC Connections to the Rail

Axle counters / No track circuits

Double-rail track circuits

Single-rail track circuits

Spider plates

Impedance bonds

Traction Rail
Signal Rail
Traction Rail
Signal Rail

NetworkRail
Signalling Power Earthing Issues

• Locs – 10 Ω earth farm
difficult to maintain low resistance
compliance with BS 7671 disconnection times

• Circuit protective conductor (CPC)

• Class II

• LOCs in OCLZ
move outside OCLZ
bond to traction return

• Common bonding using RSC as CPC
disconnection times
traction return under dewirement
reduction in differential voltages
Bond sizes based on fault

• Bonds liable to carry traction fault:
  - 6 kA 200 ms fault: 16 mm² Cu, 25 mm² Al
  - 12 kA 200 ms fault: 35 mm² Cu, 50 mm² Al

• Al is preferred – ½ capital cost, 1/7 scrap value

• Voltage drop across the bond must not exceed EN 50122-1 limits.
  - Only a problem for long conductors
Earth conductor max lengths based on size

<table>
<thead>
<tr>
<th>Size (mm²)</th>
<th>Max Length Cu (m)</th>
<th>Max Length Al (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>105</td>
<td>-</td>
</tr>
<tr>
<td>50</td>
<td>155</td>
<td>95</td>
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<td>70</td>
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<td>95</td>
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<td>180</td>
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<tr>
<td>120</td>
<td>370</td>
<td>225</td>
</tr>
<tr>
<td>158 (19/3.25)</td>
<td>490</td>
<td>300</td>
</tr>
<tr>
<td>266 (19/4.22)</td>
<td>825</td>
<td>505</td>
</tr>
</tbody>
</table>

Based on 645 V max voltage drop for 12 kA 200 ms fault. Double length for 6 kA, 200 ms fault.
LOCs, Signalling Power & Earthing
Common Bonding on the Railway

Enhanced Insulation 2-core

19/3.25 Al 158 mm²

50 mm² Al or 35 mm² Cu

>10 m from FSP

FTE

18 February, 2014 Earthing and Bonding of Electrified Railways

RSC

AEW

AEW

RSC
Classic Railway 6 kA

Two Track 25 kV Classic Lines with Return Conductors 6 kA Fault Level Location Open Route

Ground Potentials (V)

© Roger White
12 kA Railway: Common Bonded

Two Track 25 kV Railway with AEWs & BEWs
12 kA Fault Level
Location Signalling Equipment Remote BEW

Ground Potentials (V)

Potential Difference Signalling equipment to remote Earth

Human Touch Potential to Mast

Earth Potential Rise in Rails plus Vehicle Body

Ue Earth Potential Rise

AEW – Aerial Earth Wire
BEW – Buried Earth Wire

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• ‘Earthing and Bonding for AC Electrification Schemes applying Common Bonding’

  – System approach to E&B to achieve
    • compliance to EN 50122-1
    • minimise interference to systems

  – Substantial industry consultation

  – Publication: Feb/March 2014
    (subject to approval of derogations)