Technical Note

Express 250
Site Electrical Recommendations: Use of RCDs

Scope

This document provides guidance where there may be unfamiliarity with installing DC EV charging equipment such as the Express 250 in publicly available locations.

When designing and constructing an Express 250 site, first carefully read the guidance for wiring and grounding provided in the ChargePoint *Express 250 Site Design Guide*. If the site still requires an RCD despite that guidance, consult this Technical Note.

Important: Installations of Electric Vehicle Supply Equipment (EVSE) must always follow local regulations or codes. For non-standard installations, please contact ChargePoint Solutions Engineering for assistance.

Use of RCDs

ChargePoint strongly recommends the use of a TN-S earthing (grounding) scheme to avoid the installation and associated nuisance tripping of an RCD.

In DC EVSE supply equipment, high power AC/DC power converters are used to convert the AC input to a DC output current supply for the EV. This power conversion might produce leakage current flowing via the PE conductor to the ground/earth installation system. This might cause unwanted tripping if an RCD located upstream of the DC EVSE has too low of a trip current setpoint.

If the characteristics of the installation prevent the use of a TN-S earthing scheme, read this Technical Note for the use of RCDs for DC EVSE installations.

All chargers designed and distributed by ChargePoint are compatible with those installations where an RCD is required according to the definitions provided in IEC 61851-1:2018 Ed 3.0, IEC 61851-23: 2014 Ed 1.0, and IEC 60364-7-722:2018. For DC chargers, such as the Express 250 station, RCD use is not recommended. This high power EVSE might cause nuisance tripping, especially during transient conditions such as power restoration, line surge, line dips, or phase loss.

The requirement for RCDs, and specifically the distinction between mode 4 DC and mode 1,2,3 AC charger installations, is often misinterpreted.

For European countries, the requirements are described in the following clauses:

- IEC 61851-23:2014-03 Ed 1
  - Section 6.2 EV charging mode:

    Pluggable d.c. EV charging stations, which are intended to be connected to the a.c. supply network (mains) using standard plugs and socket outlets, shall be compatible with residual current device with characteristics of type A. The pluggable d.c. EV charging station shall be provided with an RCD, and may be equipped with an overcurrent protection device

The Express 250 is not a pluggable product and therefore does not require an RCD.

- Section 7.6 Additional requirements:

  The d.c. EV charging station shall be compatible with RCD Type A in the installation, i.e. a.c. supply network (mains).

  Class II chargers may have a lead through protective conductor for earthing the EV chassis.

  - The Express 250 is compatible with RCD Type A. The ΔIn value depends on the installation criteria and the limits provided by this Technical Note.
  - The Express 250 is a Class I charger. All conductive parts (including the chassis) are grounded, and a ground terminal is provided in the AC input.
  - The Express 250 provides Basic Insulation between AC input and ground/earth parts.

- IEC 61851-1:2017 Ed3, Section 8.5 Residual current protective devices

  EV supply equipment that include an RCD and that does not use the protective measure of electrical separation shall comply with the following:

  The Express 250 does not include an RCD, and does provide electrical isolation between mains and output, so the following clauses do not apply.

Shock Protection

To protect the driver from shock when charging a vehicle, the Express 250 provides:

- Galvanic (reinforced) isolation for the DC output cable. If the output was touched (between person and ground), for example due to output cable insulation damage, it does not result in current flow to earth ground and the risk of shock is reduced.
- An output isolation monitor interrupter (IMI)
  - If the isolation level is compromised, charging is halted or prevented from starting, and the output is de-energized. The isolation monitor operates continuously during charging. This ensures the output is always galvanically isolated.
  - UL 2231-1 requires that an IMI be provided in the product and its operation evaluated as part of the testing to be a listed product.
  - IEC 61851-23:2014 Ed 1.0 requires that an IMI or similar be provided in the product and its operation evaluated as part of the testing to be a CE marked product.

Current IEC or UL standards mandate the use of an RCD for AC chargers. However, this requirement is not mandatory for Mode 4 permanently connected DC chargers, where the RCD requirement is referred to the installation side and always follows the local wiring rules and earthing schemes.

RCD Settings

The general rules for RCD installation can be found in the IEC 60364-4-41 standard, where the different earthing systems are described and the ways to protect the circuit and the people against faults are provided. This is an international standard and from this many national requirements for electrical installation are derived.

Two main attributes must be considered to select equipment for protection against electric shock:

- The current level that causes the device to trip. This may depend on the type of earthing system, the ground impedance value, and the maximum contact voltage.
- The maximum disconnection time, which depends on the earthing system, nominal voltage, maximum contact voltage, and nominal current of the installation.

NOTE: The mandatory use for an RCD with a maximum trip of 30 mA, regardless the type of system installation (TT, TN-S, TN-C or IT) or type of load used, is up to 32 Amps per phase. Check national and international codes for more information.

TT Earthing Systems

For TT earthing systems, using an RCD upstream of the installation is recommended due to the possibility of high earth impedance[1] in the earthing circuit. Considering the maximum contact voltage[2] according to the installation location (dry or wet environment), the maximum impedance of the PE installation depending on the RCD trip should be:

Zs Maximum Value Depending on Maximum Voltage and RCD Trip Current					
	10 mA	30 mA	100 mA	300 mA	500 mA
24 Vrms	2400 *Ω*	800 *Ω*	240 *Ω*	80 *Ω*	48 *Ω*
50 Vrms	5000 *Ω*	1666 *Ω*	500 *Ω*	166*Ω*	100 *Ω*

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[1] *Some countries do not allow exceeding certain limits of earth resistance for TT schemes.*
[2] *The maximum contact voltage can vary from one country to another. Always refer to local code.*

Figure 1 shows an example of a TT installation:

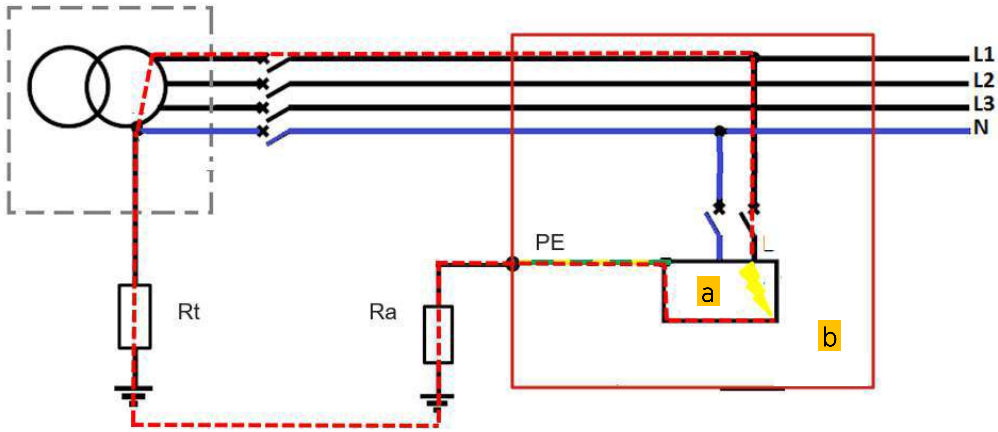

Figure 1: Isolation Fault in TT Scheme

- a = EVSE
- b = Building
- Rt (transformer center) = 1 Ω
- Ra (installations earth electrode) = 10 Ω
- Rc (conductor) = Negligible

Voltage from the grid = 230/400 VAC.

$$\mathrm{Id} = \frac{\mathrm{Uo}}{\mathrm{Ra} + \mathrm{Rt} + \mathrm{Rc}} = \frac{230\ \mathrm{V}}{10 + 1\ \Omega} = 20.9\ \mathrm{Amps}$$

An MCB will not trip with this current level. However, the contact voltage will be:

$$\mathrm{Uc} = \mathrm{Id} * \mathrm{Ra}$$

$$\mathrm{Uc} = 20{,}9\ \mathrm{A} * 10\ \Omega = 209\ \mathrm{V} \rightarrow \textbf{Danger}$$

With an RCD of 100 mA, 300 mA, or 500 mA:

$$\mathrm{Uc} = 0{,}1\ \mathrm{A} * 10\ \Omega = 1\ \mathrm{V} \rightarrow \textbf{Safe}$$

$$\mathrm{Uc} = 0{,}3\ \mathrm{A} * 10\ \Omega = 3\ \mathrm{V} \rightarrow \textbf{Safe}$$

$$\mathrm{Uc} = 0{,}4\ \mathrm{A} * 10\ \Omega = 5\ \mathrm{V} \rightarrow \textbf{Safe}$$

To guarantee the correct RCD selection, check the loop impedance of the TT scheme.

TN Earthing Systems

For TN earthing systems, the use of an RCD might not be necessary[3] due the low fault impedance. This low impedance value causes a high current flowing through the PE (a line-neutral short circuit appears), and the protection may be provided by an overcurrent or short circuit device installed (fuse or MCB).

An RCD shall not be used in a TN-C system. Check with your DNO (Distribution Network Operator) to determine the system in use.

NOTE: Some national regulations may require the installation of an RCD at the origin of installation. When that happens, the general requirements listed in the section "RCD Settings" apply. Check the national codes for more information and contact ChargePoint if the problem persists.

Figure 2 shows an example of a TN installation:

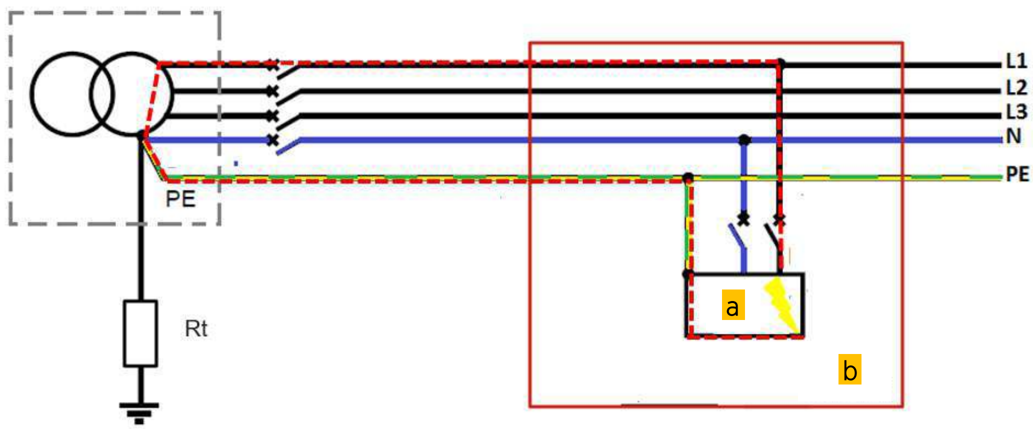

Figure 2: Isolation fault in TN-S Scheme

- a = EVSE
- b = Building
- Rt (transformer center) = 1 Ω (Not applicable)
- Ra (installations earth electrode) = 0 Ω (does not exist)
- Rc (conductor) = 0.1 Ω (Negligible)

Voltage from the grid = 230/400 VAC

$$\mathrm{Id} = \frac{\mathrm{Uo}}{\mathrm{Ra} + \mathrm{Rc}} = \frac{230\ \mathrm{V}}{0.1\ \Omega} = 2300\ \mathrm{Amps}$$

This high current should only be interrupted by short circuits or an overcurrent protection device (such as an MCB or fuse).

[3] *Some EU countries force the use of RCDs in their national wiring regulations. Usually, this requirement applies to equipment up to 32 Amps.*

The rated current of the overcurrent device shall be less than the expected current during the fault and the device must trip within the maximum time allowed[4].

The TN-S, TN-C and TN-C-S earth systems could be used for EVSE installations in some countries. Refer to local code to verify the minimum requirements.

IT Earthing Systems

For IT earthing systems, where only the load has the earth electrode, protection against fault insulation by using an IMD, alarms, and switching elements may apply during a single fault isolation. For a double fault isolation, an MCB or fuse can be used to protect and disconnect the circuit. An RCD might not be needed[5] in this application, although one is permitted.

This earthing scheme is recommended for locations where the interruption of the supply is not desirable.[6]

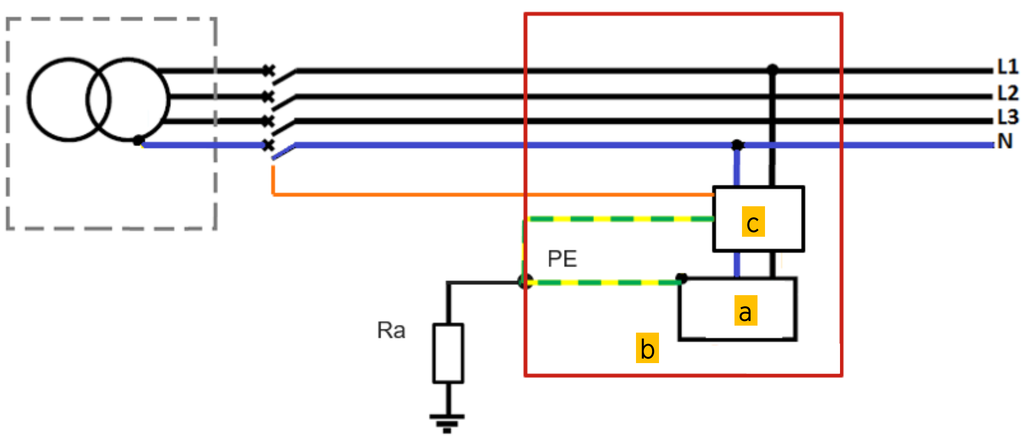

Figure 3: IT Scheme

- a = EVSE
- b = Building
- c = IMD

If the value of the impedance between Line or Neutral to PE decreases from a certain value (based on local regulations), the IMD shall send an alarm to the tech service and/or trip a switching device, and no charge shall be allowed.

Additional Setting Notes

- The Express 250 represents a Class I construction, balanced 3-phase load >500 W.
- For a TT earthing scheme where the use of an RCD (RCCB or RCBO) cannot be avoided, the following settings are recommended:
    - Type: A, F, or B (Type A with high immunity preferred)

[4] *Always check the type curve of the MCB or fuse to verify the time tripping under a fault current, and always consider temperature derating factors. Maximum type tripping is 5 seconds. Check with local authorities for lower times.*

[5] *Some EU countries force the use of RCDs in their national wiring regulations. Usually, this requirement applies to equipment up to 32 Amps.*

[6] *This earthing system is commonly used in Norway. Confirm with local code before implementing.*

- Trip threshold: 300 mA
- Trip delay: 150 ms

Lower values may cause false tripping, especially during AC input line transients.

- For Paired 250 installations where an RCD is employed, each station must have a separate RCD. If an upstream breaker equipped with an RCD feeds more than one Express 250 station, the trip threshold must be adjusted for the sum of the individual trip thresholds.
- The Express 250 might present values between 50 ≤ ∆In ≤ 70 mA under normal operation.
- ChargePoint recommends that the installer requests a TN-S earthing system from the Distribution Network Operator (DNO).
- It is also possible to provide a TN-C or TN-C-S with a Protective Multiple Earthing (PME) terminal[7], to avoid the requirement for a TT earthing arrangement and associated 300 mA RCD. This requirement may not be possible due to limitations of the installation or country code.
- Installations at petrol stations are a special case. Contact ChargePoint for more information.

[7] *For the UK, BS 7671-7-722:2018 allows the use of PME under certain circumstances. For these cases, a maximum contact voltage of 70 Vrms can be applied.*

Reference Standards

- IEC 60364-4-41:2017 – Low-voltage electrical installation – Protection for safety – Protection against electric shock - (Clause 411.3)
- IEC 60364-7-722: 2018 RLV – Low-voltage electrical installation – part 7 -722 : Requirements for special installations or locations – Supplies for electric vehicles - (Clause 722.411.3.3)
- IEC 60364-7-722: 2018 RLV – Low-voltage electrical installation – part 7 -722 : Requirements for special installations or locations – Supplies for electric vehicles - (Clause 722.413.3.2)
- IEC 60364-7-722: 2018 RLV – Low-voltage electrical installation – part 7 -722 : Requirements for special installations or locations – Supplies for electric vehicles - (Clause 722.531.2.101)
- IEC 61851-1:2017 Ed. 3.0 - Electric vehicle conductive charging system – Part 1: General requirements
- IEC 61851-23:2014 Ed 1.0 - Electric vehicle conductive charging system - Part 23: DC electric vehicle supply equipment
- IEC 62477-1:2016 – Safety requirements for power electronic converter systems and equipment – Part 1: General
- UK:
    - BS 7671:2018 - Requirements for Electrical Installation
    - BS 7671:2018 – Requirements for Electrical Installation – Amendment 1:2020
- Spain: ITC-BT-52 – Instalaciones con fines especiales – Recarga de Vehículo eléctrico
- France:
    - NF C15 100 - Installations électriques à basse tension
    - UTE C15-722 – Installations d’alimentation de véhicules électriques ou hybrides rechargeables par socles de prises de courant
- Germany : DIN VDE 0100-410:2018-10: Part 4-41: Protection for safety – Protection against electric shock (IEC 60364-4-41:2005, modified + A1:2017, modified); German implementation of HD 60364-4-41:2017 + A11:2017