

Ancillaries
Earthing Systems
Information Sheet

EVSE (Electric Vehicle Supply Equipment) earthing

This document is provided to inform system designers and engineers alike on earthing arrangements of EVSE. This guidance is provided after many years of experience of installing EVSE and from many sources of information including electrical contractors, internal electricians, and British and IEC standards. This guidance is applicable to all Pod Point chargers.

There are numerous earthing systems provided in the UK and they all have characteristics that have an impact on the installation of EVSE. However, little guidance is provided by manufacturers on earthing systems to be used for EVSE. For installers new to this industry, this presents difficulties in deciding the safest method chosen for earthing.

A recent industry study of newly installed EVSE revealed 40% of EVSE installations where TT earthing arrangements provided were either outside of specifications or electrodes were badly located. It remains the responsibility of the system designer or engineer to decide the best method for installing an EVSE on a case-by-case basis. Where references are made to Pod Point-specific products, these should not be used with any other makes of EVSE.

Vehicle charging risks associated with PME and TT earths

If an EVSE is installed inside a garage and charging a vehicle can only be performed inside the garage, the existing earthing system of the property is recommended.

Where a vehicle may be charged outside of a garage the risk of a failed PME neutral may be hazardous as the vehicle is outside of the equipotential zone of the garage/dwelling. The voltage difference between true earth (where vehicle is parked) and vehicle chassis can become dangerous to touch. This is true for all PME earthing systems where the vehicle is located outside, with the exception of multi-storey car parks (upper exposed levels) and similar locations.

Where a TT earthing system is provided for the dwelling, a failed electrode may result in no earth being provided to the vehicle or, worse still, a badly located electrode near a failed PME connected service. The vehicle could become live as step voltage increases away from the earthing electrode. A failure of this type can result in the same risk as a failed PME system.

To eliminate the above risk, it is recommended earth electrodes are not installed close to a building or any underground PME connected service. DNOs recommend a 10m distance from any earthed HV underground service. BS7671 recommends at least 2m from any other services to minimise electrode touch voltage to no more than 40V if the nearby PME service were to become live. Applying these measures in practice may be difficult. A document search of buried services may not reveal accurate drawings; therefore, a scanner should be used to locate any potential underground risks before installing an electrode.

BS7671: Creating a TT earthing system for charging equipment or the whole installation as an alternative to using a PME earthing facility with one of methods (i) to (v) above may not be an appropriate solution due to the inability to provide sufficient separation from buried metalwork connected to the supply PEN conductor.

Where it is decided the safe fitment of a TT electrode is not possible, a standard Mode 3 EVSE should not be installed. This can create greater risks as EV owners may then rely on PME connected Mode 2 EVSE for charging (bizarrely this is allowed). Using Mode 2 equipment adds the risks of fire where old domestic sockets are used, which is a common occurrence when using Mode 2 equipment.

Pod Point design

Being fully aware of the risks of TT earthing systems, in 2016 Pod Point designed into its hardware a system that monitors the incoming earth for abnormal readings. If detected, an earth isolation relay used in conjunction with the power switching contacts isolates the vehicle from the supply and the earth. A later software update also included the detection of failed PME systems. At this time, PME connection was still permitted by BS7671 under the exception of “not practicable”.

BS7671 does not permit the switching of the protective earth conductor to an appliance. Pod Point’s internal electronics monitor the status of the internal earth switching relay to ensure it remains safe. IEC61861:2017 (BS EN61851:2019) allows the switching of protective earth conductor for isolation purposes inside the EVSE (section 8.4 indent b).

Where rapid chargers or standard EVSE that cannot not provide their own galvanic isolation are desired, BS7671 regulations may be breached if installed with an additional “earth isolating” device. In these cases, the device manufacturer’s liability should be gained.

A failed PME neutral (single or three-phase systems) on EVSEs that perform voltage checks between line and neutral conductors will result in a greater than 90% detection rate where the neutral and line phase shifts beyond approximately 15° and a 100% detection rate where it does not. The risk is further reduced as the danger is not present when the vehicle is not charging but connected. These minority cases do require unique phase loads not consistent with constant current EV charging. The risks associated with TT faults is higher. It is also misreported in these minority cases that the fault condition results in a touch voltage of up to 400V being present. This maximum would actually be approximately 125V due to the voltage detection systems operation. EVSEs that also monitor the earth cable current may not allow sufficient current to flow through the human body before isolation is provided.

Pod Point compliance

To meet the requirements of BS7671: 722.411.4.1 Pod Point chargers are designed with at least 6mm creepage distances for pseudo-class 2 operation and provides redundant power contacts to ensure clearances are not compromised. When in “charging mode” Pod Point chargers becomes a class 1 device (minimum requirement for any Mode 1, 2 or 3 EVSE).

Pod Point chargers may be safely connected to TT (if this can be done without introducing any risk and a compliant low earth impedance is achieved), TN-C-S, TN-S or PME earthing system. It does not require any special arrangements. Pod Point’s system complies with BS7671: 722.411.4.1 exception (v) - in which it does not result in a lesser degree of safety than using exception (iii) or (iv) and its single-phase devices are safe to use on three-phase systems, satisfying all concerns raised in the Code of Practice for Electric Vehicle Charging Equipment Installations section 5.3.5 ‘Installation equipment that detects open-circuit PEN conductor faults’. Installers should note the following additional requirement related to three-phase supplies run to Pod Point hardware.

Single-phase Pod Point chargers should not be installed where a three-phase supply feed has been provided to the unit. See BS7671 annex A722.4; only three-phase Pod Point chargers should be installed where a three-phase supply is run to the unit.

Recently, other EVSE manufacturers have adopted similar systems for PME fault protection, but not all are able to also detect failed TT earthing systems.

Pod Point’s Array Charging solution

For Array Charging connected Pod Point chargers, the PME fault protection system may not work. These units must be connected to a TT system if located outside. This is due to a hardware limitation. When installed, the main earth input and output must be linked on the Pod Point charger.

Twin Chargers and DC rapid chargers (also see special locations)

For Twin Chargers where it is typical to connect “street furniture” to a TT earthing arrangement, it is advisable to do so. In general, the TT arrangement is provided when groundworks are conducted and does not adversely affect the installation cost or time.

Where the Twin Charger is fitted close to a PME metal clad building or structure and the introduction of a TT system may compromise an equipotential zone safety, it is advisable the Twin unit be connected to the same PME earthing service used locally (not for Array enabled Twin Pod Point chargers).

DC chargers that do not provide PME fault protection or galvanic isolation should include fitment of an additional PME protection device. These chargers should not be directly fixed to PME connected metal clad buildings or structures.

Types of earthing arrangements and associated risks

TN-S (Terra Neutral - Separate)

TN-S systems use a separate earth connection originating at the substation. This is generally regarded as the safest method of earthing as it provides a low impedance path for fault currents and has proven to be very reliable.

TN-C-S (Terra Neutral - Combined then Separated)

TN-C-S, similarly to TN-S, provides a low impedance earth return path but is shared using a combined neutral connection which again has been a very reliable system.

PME (TN-C-S) with Protective Multiple Electrodes/Earths

PME systems work on a similar basis to TN-C-S but external electrodes are also provided along the external supply cables. This system has proven to be reliable, but as the system ages problems do occur at the electrode junctions (corrosion etc.). If the Neutral fails the earth will also fail, potentially placing a dangerous voltage on the earthing system to a property.

TT Terra Terra (earthed at each end of supply)

TT systems are not provided with an earth conductor. The Neutral at the origin (substation or transformer) is connected to a local earth electrode, but an additional electrode should be provided at the property. This system is generally safe but can suffer from electrode failure. If a “new” TT electrode fitted is providing a much lower than expected reading for the local area, it may be due to close proximity to a buried PME service.

IT Independent Terra - No earth or neutral provided at supply source

IT systems are quite rare. They do not have any earth connection at the substation or transformer and they can suffer a direct short circuit to GND (1st fault condition) but remain operative. This may be of high importance where the loss of supply can be catastrophic (life support equipment fails etc.). All IT systems require a local earthing arrangement (typically a GND electrode) and MCB protection is required on all supply poles as all cables are live (there is no neutral).

IMPORTANT NOTE:

Potential network “upgrades” in future may result in TN-S or TN-C-S system becoming PME systems. It is therefore advisable to treat all other systems than TT and IT as PME.

Special locations

For properties that are of metal construction or have metal clad exteriors that are PME connected, a risk already exists, so the fitment of EVSE with PME fault protection would provide a far lesser risk to that of an EVSE that does not. Installing a TT electrode close to a PME connected structure would greatly increase the risk if the PME system were to fail. "Standard" EVSE should not be fitted in these locations. Step voltage increasing with distance from a building or structure must be considered. EVSE that **do not** include PME protection may energise the chassis of vehicles that are standing on true ground away from the structure. In these cases, the inclusion of an isolation transformer or additional unit providing PME fault protection should be considered. For car ferries or other earth-free locations, a galvanically isolated supply transformer should be used that complies with BS EN 61558-2-4 (BS7671: 722.413.1.2). Ships and ferries fall outside the requirements of BS7671 and operators adopt their own standards - these should be adhered to where appropriate.

Equipotential zone risks

Some metallic lighting columns are provided with a PME supply. Unless assurances can be provided that these cannot fail, the location of these if within the equipotential zone should be taken into consideration if the EVSE is to be connected to a TT earthing system.

BS7671 section 722.410.3.5 should be used with a common sense approach - the location of a bollard or other means of restriction ensuring such an object is outside the equipotential zone would be sufficient. An example maybe a bollard, fence or wall that prevents vehicles parking close to the lighting column (within 2m touch distance).

BS7671 issues

Three-phase supply load characteristics

Section 722.411.4.1 (i) should not be considered in a domestic property. Annex 722.2 calculations do not consider differing single, bi and three-phase vehicle loads (dependant on connected vehicle). Calculations require a constant balanced load current in excess of 50 amps per phase which is unrealistic for a domestic property.

Supplementary earth electrodes

Section 722.411.4.1 (ii) should **NOT** be considered when installing EVSE. The calculations of BS7671 annex A722.3 cannot be achieved as there is no way of knowing the total external fault current the electrode may be exposed to. The supplementary electrode could be the only neutral return for many properties and exposed to many hundreds of amps, introducing a further risk of fire. In addition, a shallow fitment of an electrode may result in a high local step voltage.

It should be noted some DNOs do fit supplementary PME electrodes in this way.

If supplementary electrodes are fitted, the electrode should be buried well below ground level and the connection point to the PME system be made outside of the dwelling to minimise fire hazards.

Where livestock maybe present, it is recommended the location of supplementary electrode(s) be fenced off to a minimum radius of 2m to reduce the potential step voltage becoming dangerous to the animal(s).

The following table provides guidance on allowed earthing methods for EVSE.

	TN-S	TN-C-S	TN-C-S (PME)	TT	IT
Risks/comments	Lowest risk ideal earthing system	Lower risk	Rare but possible risk of neutral open circuit fault	Electrode corrosion, Poor GND resistivity, buried nearby PME service risk	Reliability of supply of high importance (hospitals etc) TT arrangement
Special precautions	Ensure no other earthing arrangement is used in the location of EVSE and vehicle (Equipotential zone), this includes taps, pipes and metal light fittings.				Local TT earth arrangement commonly used
Suitability for standard EVSE Installed INSIDE	YES	YES	YES	YES	YES
Suitability for "standard" EVSE Installed OUTSIDE (not considering future PME upgrades)	YES	YES	NO	YES	YES
Suitability of "standard" EVSE Installed OUTSIDE if changed to PME	All TN-x systems may become PME in future.			YES	YES
	NO	NO	NO	TT earth or galvanic isolation arrangement must be provided (isolation TX or PME protective device)	
				TT earth	
Suitability of Pod-Points Solo with PME fault protection	YES	YES	YES	YES	NO - see note

Notes:

- It is assumed pre-existing earthing is used and no other earthing system exists in the equipotential zone.
- If an IT supply is provided, a "non-UK" Pod Point charger should be installed. Fault protection will always detect and report a supply fault for UK versions (reversed polarity or open circuit earth).
- The use of a Tethered EVSE inside a garage limiting the charging location of the vehicle can be installed with PME earthing.

Additional notes on earthing and the uses of accessories

It remains the responsibility of the installer to conduct a risk assessment of the immediate area to a minimum range of 10m (equipotential zone) to ensure no other conductive metal fixings pose risks (mixture of TT/TN-S and TN-C-S). This is important where the charging cable length may enable charging inside or outside of a building/garage and where the vehicle is within touch distance of the object(s).

The customer should be made aware of any existing sources of danger, light fittings, water taps and metallic pipes bonded to a PME earth. It is advised any issues identified should be addressed irrespective of whether the EV is charging or not.

BS7671: 722.410.3.5 states "*The protective measures of obstacles and placing out of reach shall not be used*". This implies such fittings must be removed or replaced with plastic parts. In the case of an outside water tap, the pipe could be changed to plastic but should be long enough to factor in water conductivity (e.g. 1m).

TT earthing if existing should be checked for an impedance of less than 100 ohms. This is to ensure seasonal changes do not adversely affect its performance (BS7671: 542.2.4 states "*The type and embedded depth of an earth electrode shall be such that soil drying and freezing will not increase its resistance above the required value*"). In addition, any electrodes or earth cables should be visually checked for a good state of repair and any potential defects found should be rectified.

Varying locations throughout the UK have a large bearing on the impedance of TT systems. Areas that are built on bedrock are notorious for poor TT readings. If a TT earth is found to have an unusually lower than typically expected for the local area, it is advisable to check the electrode is not installed close to a buried PME connected service. Relocation of the electrode(s) may be required.

Where certain conditions dictate an earth electrode must be used, it shall be independent from the distributor's earth system with no direct interconnection (the incoming supply SWA protective earth should be isolated from the housing and/or earth electrode). The electrical installer shall install a suitable electrode complete with termination housing and covers where appropriate. Warning labels should be attached and be clearly visible, e.g. close to any unconnected SWA protective earth.

The earth connection shall be made from the electrode to the EVSE via copper conductor earth wire of an appropriate CSA for the installation. The earth wire shall be installed in conduit where there is a risk of mechanical damage or prolonged UV exposure.

If a cable passes through any metallic parts (signage etc.) these will also require bonding to earth unless SWA is used.

Smart cables and "adaptors" used with Pod Point chargers (and other EVSE manufacturers) are not allowed as BS EN61851 forbids their use. These non-compliant "smart" cables can and do override safety features of Mode 3 EVSE and should not be used. Only "adaptors" (those that do not change charging modes) approved by EVSE and/or vehicle manufacturers may be used.

Smart cables will keep the EV connected to an earth system longer than is necessary without a significant supply load.

