Trojan Home – Electrical Safety and Simultaneous Contact

Purpose

The purpose of this document is to describe:

- Protective Multiple Earthing (PME) arrangement
- Fault conditions which can arise as a result of a broken or open Protective Earth and Neutral conductor;
- Simultaneous contact implications for Electric Vehicle (EV) charging;
- Protective Earth Neutral (PEN) fault mitigation and the implications for **Trojan HOME.**

Scope and Overview of Trojan Home Electrical Configuration

This document is limited in scope to the deployment of the Trojan Energy home-connected, cross pavement EV charging solution: Trojan HOME (see https://trojan.energy/trojanhome). As illustrated below, Trojan HOME consists of a wall box assembly (control electronics), fed from the domestic consumer unit in a manner consistent with typical driveway charging solutions. The wall box feeds the proprietary Trojan Energy 'flat and flush' charge point via sub-surface cabling. The wall box is cloud connected and incorporates at mid-qualified meter. Drivers connect to the charge point via the adaptor - each adaptor is unique to the user, enabling the charge point to be shared with other users.

Trojan HOME integrates control, safety and communications electronics.

Safety functions include:

- Residual Current Protection
- Protective Earth Continuity Protection
- Overcurrent Protection
- **Open Protective Earth Neutral Protection**
- Diverted Neutral Current Protection

This document describes the **Open Protective Neutral Protection** deployed in a **Trojan Home** charger and why this is necessary for safe operation of a cross-pavement charger.

UK Electricity Context

In the UK, most homes are connected to the electricity network using a system called PME (Protective Multiple Earthing). Electricity is brought from the DNO to properties through a cable. Within that cable, the neutral wire (which carries electricity back) and the earth wire (which keeps you safe by directing dangerous electricity away) are actually the same wire for most of the cable path. This shared wire is called Protective Earth Neutral [PEN].

When the cable reaches a house / property, the shared PEN wire is split into two separate connections: one for neutral and one for earth. Along the route of the main cable from the DNO to different properties the cable might also be connected to the ground in several places (like through water pipes or metal rods in the ground at different houses). This is called Protective Multiple Earthing [PME] and helps keep the system safe.

Normally, electricity flows into the house through the live wire and goes back out through the PEN wire (the combined neutral and earth). In this setup, there is no difference in voltage between neutral and earth, so it's safe. If the PEN wire breaks somewhere between the transformer and the house, the electricity must find another way back. This can make the metal parts of things connected to the house's earth (like water pipes) become "live" and could carry the full 230 volts, which is highly dangerous if touched.

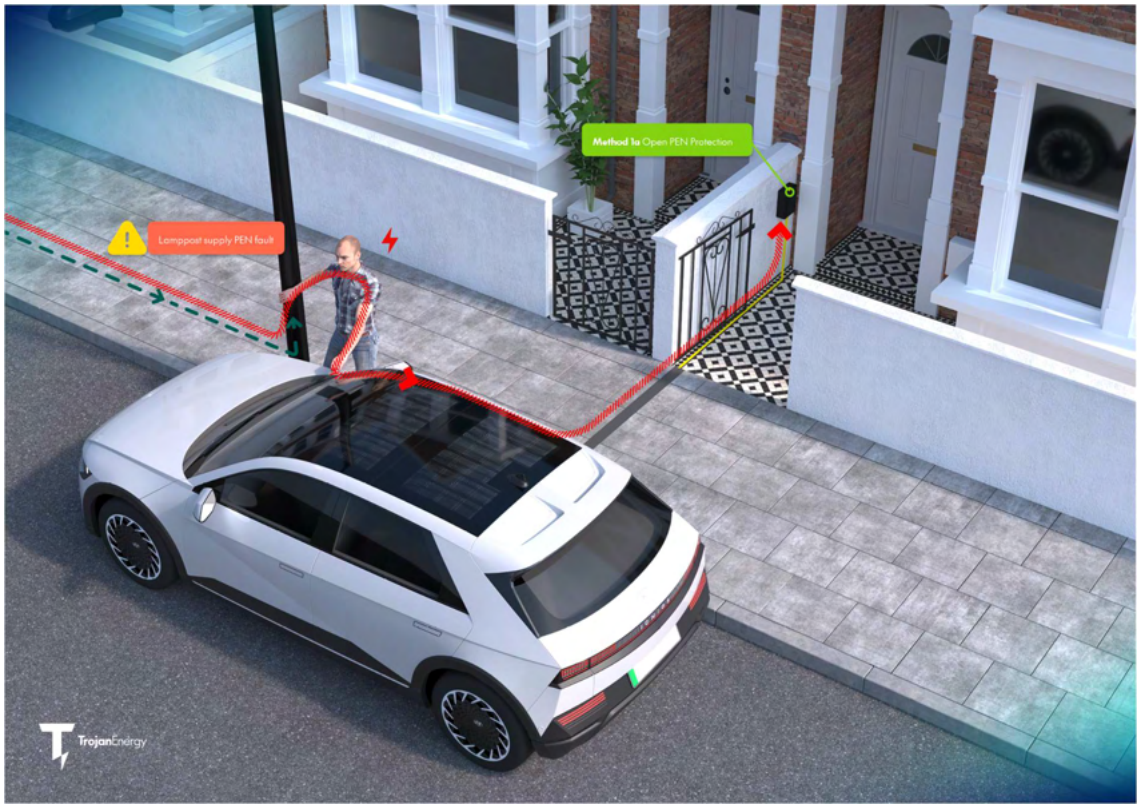
The Simultaneous Touch problem

If the PEN (Protective Earth and Neutral) conductor breaks in a PME (Protective Multiple Earthing) system, electricity will attempt to return to source through any available path. Under this fault condition, the protective earth can rise to a dangerously high potential.

If a person then comes into contact with a conductive surface connected to that system (such as a lamppost, water tap, or charging vehicle) while also providing an alternative return path, they may complete the circuit. In such a scenario, as much as 230 V could pass through the person's body — a voltage far exceeding the 70 V threshold at which ventricular fibrillation (cardiac arrest) becomes a serious risk.

Open PEN Monitoring

Special safety devices called Open PEN Detection Devices (OPDDs) can spot when the PEN wire (the shared earth/neutral) has broken. When they detect this kind of fault, they trigger a switch (called a contactor). This switch disconnects all the wires (live, neutral, and earth) going into the affected equipment. By cutting everything off, it removes the risk of dangerous voltages appearing. However, most current Open PEN devices only monitor the incoming supply into the property. If the fault happens somewhere else, for example, in a lamppost (see illustration below), dangerous voltages could still flow back through the earth connection of an Open PEN protected charger. In that case, the device won't protect the person.



To improve this, the IET (Institution of Engineering and Technology) recently published a guidance for better protection (IET01:2024). These improvements, if implemented correctly, will monitor for externally sourced fault currents. The guidance explains five possible ways these devices can work. For the **Trojan Home charger**, two of those methods have been incorporated:

Method M1b: Increased Supply Voltage Range

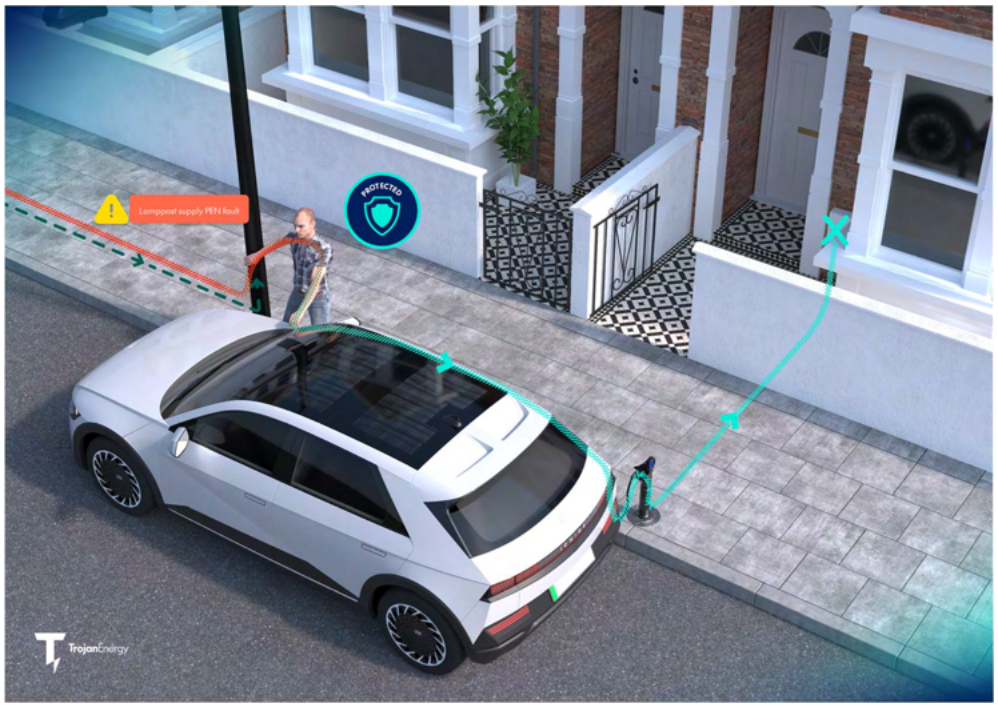
- When the voltage between the live wire (line) and the neutral wire goes too high (above 262.2 V AC) or too low (below 184 V AC) it suggests there might be a problem with the PEN conductor
- Method M1b shall only be used in conjunction with method M3

Method M3: Protective Conductor Current

- When the protective conductor current is 21 mA or more, adding extra safety
- Method M3 shall not be used as the sole method of operation

Compared to the present standard (Method 1a) used in most driveway chargers, Method M1b provides protection over wider voltage ranges, which will be required for V2G technologies. Due to the wider range, Method 1b must be used in conjunction with Method 3 which activates on earth leakage above 21mA and adds additional protection, against external faults flowing back through the earth of the charger e.g. by simultaneous contact with another device. The illustration below, shows that with Method 1b & 3 protection, a PEN fault which can cause

dangerous touch voltages on a lamppost will not be allowed to flow back through the charger's earth, thereby protecting from the simultaneous contact risk.



Additional Safety Benefits with Trojan Home

Trojan Home was designed with safety at its core. Additional safety features of Trojan Home are summarised below and compared with alternative cross pavement solutions below

1. **Trip hazard**: because the cables in Trojan Home are fully sub-surface from the property to the charge point at the kerbside, trip hazards are reduced compared with cable mats and cable gulleys.
2. **Solar degradation of exposed cables**: a related point is that Trojan Home experiences no cable degradation over time due to solar degradation. Solar heating and heat build-up on exposed cables and gulleys can potentially lead to damaged cables, reduced insulation resistance and increased risk; calculations indicate metal gulleys could exceed 60^{0}C on hot days when charging.
3. **Charger sharing**: the unique adaptor design of Trojan Home allows users to access any charge point on the street (still charging at their home EV tariff). In addition, one Trojan charger can cover two parking bays. Both features relieve parking pressure for residents on busy streets. By contrast, when the resident is only able to charge directly outside their home there is a greater tendency for cables to be stretched creating unsafe conditions.
4. **Cloud connectivity**: all Trojan Energy chargers are cloud connected, facilitating automatic detection and rapid reporting of earthing faults and PEN faults to the DNO.

5. **Risk assessment**: every site and every installation is different and requires an individual risk assessment and safety certification by a qualified electrician. Each Trojan Home installation has this, with an auditable record.
6. **Ongoing maintenance**: Trojan Home chargers are fully maintained by Trojan Energy with 24:7 customer support, remote monitoring of charger performance and periodic on-site testing of the chargers. Other cross pavement solutions will normally require that councils are responsible for this (or liable if they don't organise it).
7. L**iability for faults or misuse**: Trojan Energy maintains, insures and takes full responsibility for the Trojan Home hardware and installation. Responsibility and liability between the resident, council and hardware provider is less clear for other cross pavement solutions.