PME SUPPLIES

Looking at the principles of protective multiple earthing (PME) and the issues to be considered when PME electrical supplies are used outdoors or to supply external buildings.

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THIS ARTICLE looks at the widely used Protective Multiple Earthing (PME) system and Protective Earth-Neutral (PEN) conductors. PME provides a robust and reliable means of distributing electricity but, under certain fault-conditions, a potential can develop between the conductive parts connected to the PME earthing terminal and the general mass of Earth.

First, let's look at the definitions of the terms:

- **CNE** – Combined neutral and earth;
- **DNO** – Distribution network operator;
- **Earth** – Capital 'E' to imply the general mass of Earth, i.e. true Earth, e.g. the ground that you walk on;
- **earth** – Lower-case 'e' to imply the earth of the electrical installation;
- **PEN conductor** – A conductor combining the functions of both protective conductor and neutral conductor;
- **PME (Protective multiple earthing)** – An earthing arrangement, found in TN-C-S systems, in which the supply neutral conductor is used to connect the earthing conductor of an installation with Earth, in accordance with the Electricity Safety, Quality and Continuity Regulations 2002 (as amended)
- **TN system** – A system having one or more points of the source of energy directly earthed, the exposed-conductive parts of the installation being connected to that point by protective conductors
- **TN-C-S** – A system in which neutral and protective functions are combined in a single conductor in part of the system
- **TN-C** – A system in which neutral and protective functions are combined in a single conductor throughout the system.

Where: T – Terre (from the French, meaning 'Earth'), N – Neutral, C – Combined and S – Separate.

How do the terms fit together?

On the low-voltage distribution network, the earthing and neutral functions are combined in the same conductor of the supply cable; this is known as a PEN conductor and the distribution arrangement is TN-C; note that DNOs can refer to the PEN conductor as CNE. Along the length of the low-voltage distribution cable the PEN conductor is earthed, using earth electrodes at regular intervals. To supply the electrical installation, the neutral and earthing functions of the PEN conductor are separated out to create neutral and earth provisions (see fig 1, p34).

Combining the neutral and earth functions in one conductor means that the cable costs are reduced and any fault between conductors will be line-to-line or line-neutral so that, owing to the low value of earth fault loop impedance, the protective device will operate very quickly to remove the fault. Compare this to a TN-S distribution arrangement where a neutral-to-earth fault could exist for a long period.

History

PME has almost universally been adopted by distributors in the UK as an effective and reliable method of providing customers with an

earth connection. According to National Grid, PME has become increasingly common on 400V distribution circuits in the UK since it was first introduced with pilot schemes in the 1930s and is now applied to about 85 per cent of overhead circuits, 65 per cent of underground circuits and 30 per cent of supplies to individual consumers in England and Wales (www.emfs.info/Sources+of+EMFs/distribution/UK/).

In cases where homes do not officially have a PME earthing arrangement, up to 20 per cent, probably more, may have accidental neutral-to-earth connections.

Legal requirements

The Electricity Safety, Quality and Continuity Regulations 2002 (as amended) (ESQCR) permits the distributor to combine neutral and protective functions in a single conductor provided that, in addition to the neutral to Earth connection at the supply transformer, there are one or more other connections with Earth. The notes of guidance to the Electricity Safety, Quality and Continuity Regulations refer to Electricity Association (now Energy Networks Association Limited) publication G12/3 1995 for details of suitable earthing arrangements.

Note that suppliers are not obliged to provide an earth terminal to a consumer; 24(4) of the ESQCR states:

"Unless he can reasonably conclude that it is inappropriate for reasons of safety, a distributor shall, when providing a new connection at low voltage, make available his supply neutral conductor or, if appropriate, the protective conductor of his network for connection to the protective conductor of the consumer's installation."

Low-voltage distribution network

The term 'protective multiple earthing' describes the method of earthing as used on the low-voltage distribution network. On the underground/buried network, electrodes are used to earth the neutral conductor at regular intervals, usually 25-40m apart, hence the term 'multiple earthing'. Where the low-voltage distribution network is overhead, earth electrodes are installed at transformers and at regular intervals at distribution poles.

It is important to note that in a TN-C-S (PME) system the neutral and protective earth conductor functions are combined in the supply and then are separated in the installation (see fig 1). The exposed-conductive-parts of the installation are connected by this separate protective conductor in the installation to the combined neutral and protective conductor of the supply back to the source. This installation protective conductor provides a return path for earth fault current to flow for the duration of a line-to-earth fault occurring in the installation. The combined neutral and >

protective conductor of the supply provides a return path both for neutral conductor current to flow under normal conditions and for earth fault current to flow for the duration of a line-to-earth fault occurring in the installation.

Issues to consider with PME supplies

A PME earthing terminal provides an effective and reliable earthing facility for the majority of electrical installations. However, under certain supply system fault conditions, i.e. PEN conductor of the supply becoming open circuit external to the installation, a potential can develop between the conductive-parts connected to the main earthing terminal and the general mass of Earth. As there are multiple earthing points on the supply network, and provided that bonding within the building complies with BS 7671, it is unlikely that such a potential would in itself constitute a hazard. The situation is different outdoors.

Consider the situation where an electrical supply is being used at the end of a long garden (see fig 2). The supply to the property is PME and the last earth electrode on the low-voltage distribution network is 40m prior to the service cable entering the property. With such a long distance between the position of use and the last point of earthing on the distribution cable, a potential difference is possible between the earth of the electrical system and true Earth in normal operating conditions, i.e. no faults on the electrical installation of the property. Such a potential difference is common but a problem occurs when body contact resistance is low (little clothing, damp/wet conditions) and/or there is relatively good contact with true Earth; in such cases the potential difference may be perceptible.

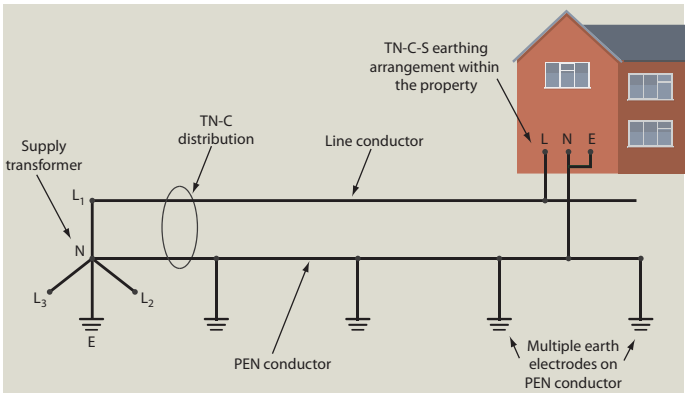


Fig 1: TN-C low-voltage distribution network

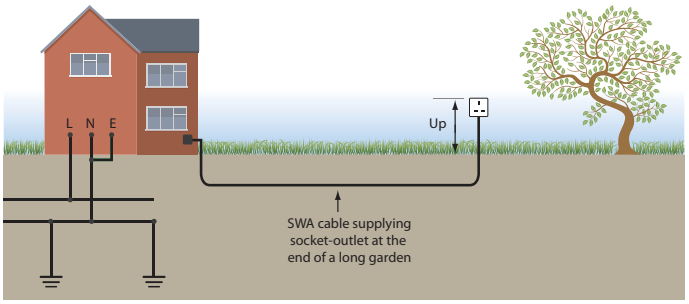
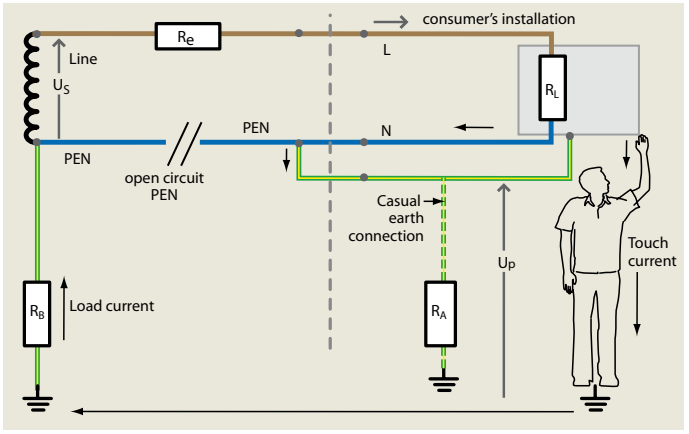


Fig 2: Example of a PME supply with a socket-outlet in use at the end of a long garden



U_s is the nominal supply (source) voltage
U_p is the touch voltage
R_e is the external line supply resistance
R_L is the load resistance (V^2/wattage)
R_A is the resistance of the additional earth electrode including any parallel earths (e.g. water and gas pipes
R_B is the resistance to Earth of the neutral point of the power supply

Fig 3: Open circuit PEN conductor

The main issue with PME supplies is the potential risk of loss of the neutral conductor. This is relatively uncommon, but could arise when, for example, groundwork has damaged a low-voltage distribution cable or when a vehicle has come into contact with an overhead cable and, in each case, the neutral conductor has been severed.

Fig 3 shows how the current path would look should the neutral conductor be severed (open circuit) and a person was to make contact with an exposed conductive part and true Earth; the route back to the transformer being by means of the person and the general conductive mass of the earth.

In a building, the risks are mitigated by protective equipotential bonding of extraneous-conductive-parts and the fact that persons are unlikely to be in contact with true Earth. Outside though, contact with true Earth is always possible and, if exposed-conductive-parts and/or extraneous-conductive-parts connected to the PME earthing terminal are accessible, people may be subjected to a voltage difference appearing between these parts and true Earth.

Where PME electrical supplies are used outdoors or to supply external buildings, it may be pertinent for the electrical installations of these areas to form part of a TT system. This is recognised in BS 7671:2008(2011) as requirements of Regulation 708.411.4, for example, prohibits the use of a PME earthing facility for caravans; the Regulation does, however, permit the use of a PME earthing facility for use within permanent buildings. The IET publication 'Code of Practice for Electric Vehicle Charging Equipment Installation' guides installers on the risk assessment process, primarily for electrical vehicle charging, but may be used for all electrical supplies used outdoors. It is important to note that no tragedies have occurred in the UK due to loss of the PEN conductor.

Further reading:

IET Guidance Note 5 – Protection against electric shock

IET Guidance Note 8 – Earthing and Bonding

IET - Code of Practice for Electric Vehicle Charging Equipment Installation

Electricity Safety, Quality and Continuity Regulations 2002

ENA Engineering Recommendation G12/3 Requirements for the application of protective multiple earthing to low voltage networks