

Protective Multiple Earthing and the Radio Amateur

1 Purpose of this Leaflet

This leaflet is intended for members of the RSGB who have passed the Radio Amateur's Examination or who are studying for it. It assumes a knowledge of electrical principles and safety practice. RSGB Leaflets are made available on the understanding that any information is given in good faith and the Society cannot be responsible for any misuse or misunderstanding.

2 Purpose of this leaflet

The leaflet discusses the background to the safety issues involved in connecting a Radio Frequency (RF) earth to an amateur radio installation and directs the reader to the appropriate sections of the current IEE Wiring Regulations (BS7671) 17th Edition [1]. There are a number of well-produced books on electrical installation, typical are [2], [3] and [4]. These or similar books will be available through the public library service. The assumption is that where the requirements of the Regulations are complied with, then the installation will be satisfactory. However where there is any question of the appropriateness or legality of any particular installation, a qualified electrical contractor should be consulted.

The first version of leaflet EMC 07 was published over ten years ago and was based on discussions between the RSGB and the Electricity Council and its successor the Electricity Association. Since then deregulation and privatisation has caused considerable change in the administration of the electricity supply industry. At the same time new safety legislation has become a major factor in so many household activities that it is no longer possible to give a clear-cut statement on what would, at one time, have been a simple technical issue.

3 Nomenclature

In this leaflet:

“Protective earth” is used for the mains earth conductor- now officially known as the “circuit protective conductor” (CPC). This is the earth wire going to the earth pins on the UK three pin sockets, and (under recent regulations) to lighting and other fittings.

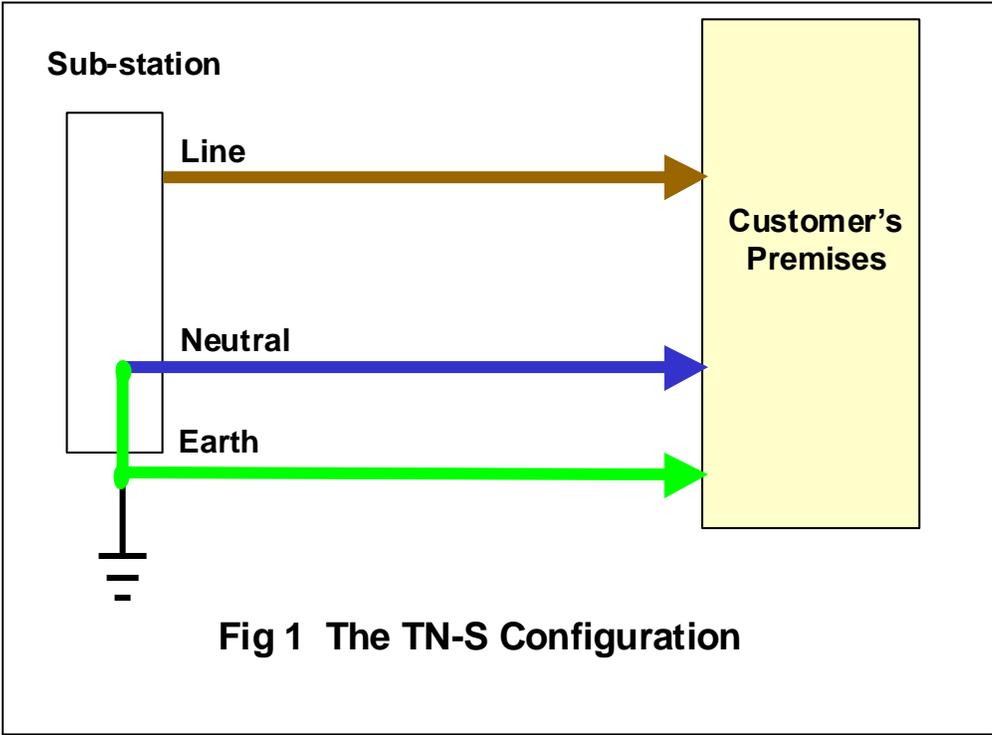
“Radio Frequency (RF) earth” means earths which are part of the antenna/earth system of an amateur radio installation.

“DC earth impedance (resistance)” Is the impedance of the earth path to DC or 50Hz .

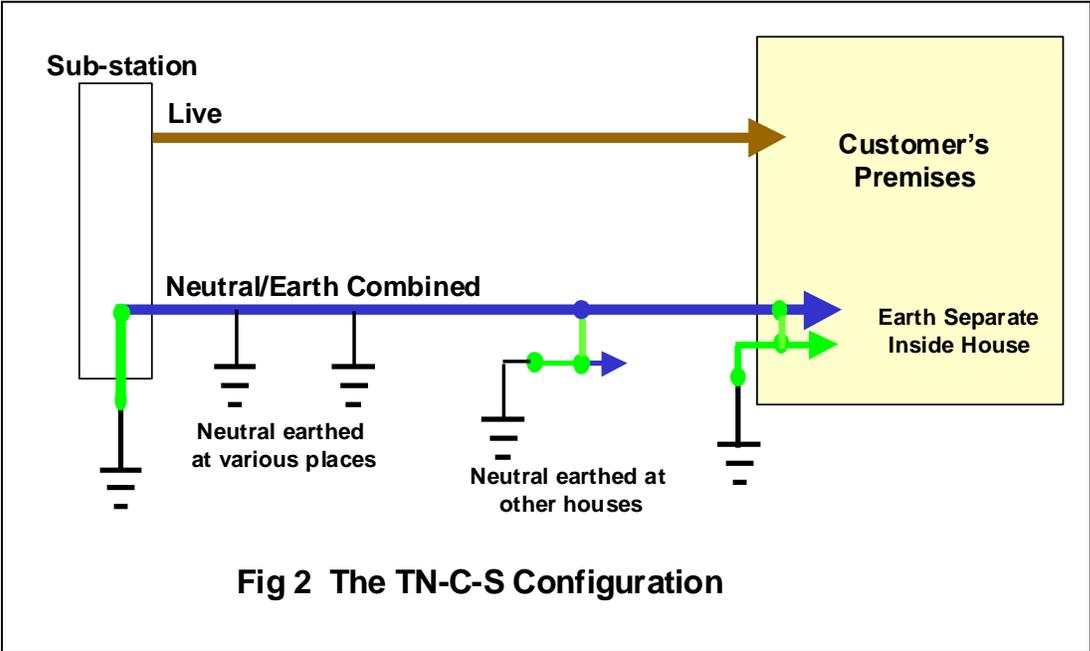
4 UK Domestic Installations

With very few exceptions electricity installations in the UK will be one of three types. These are TN-S, TN-C-S and TT. The letters stand for T = Earth (Terre in French); N = Neutral, C = Combined and S = Separate. The three configurations are shown in Figs 1, 2 and 3.

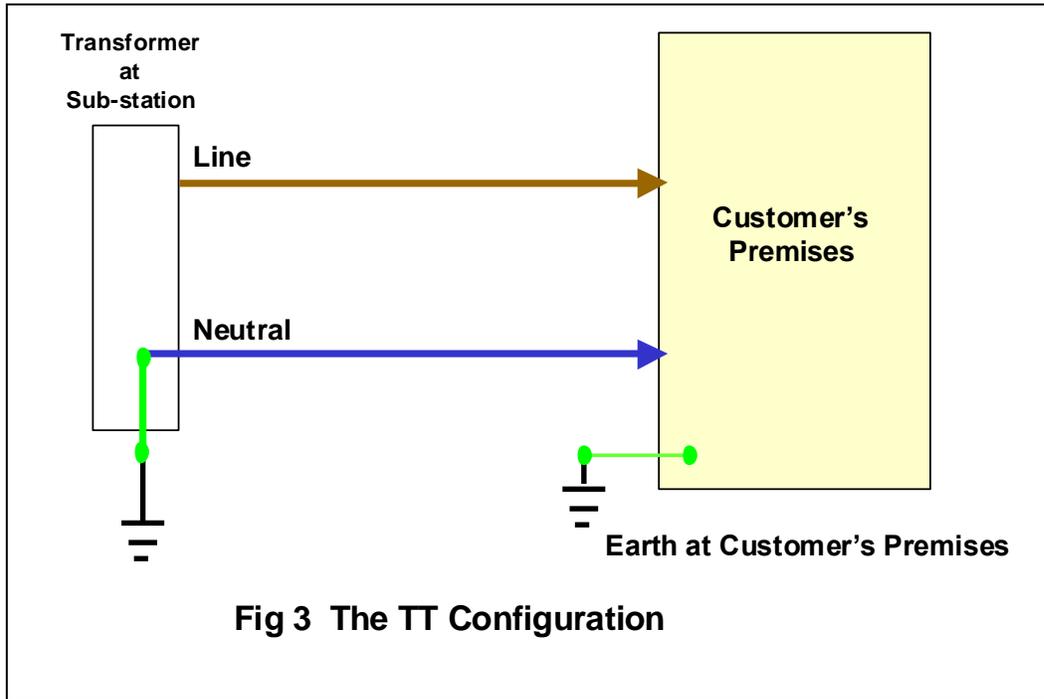
At one time almost all houses in the UK were wired on the TN-S system where the earth and neutral are separate all the way back to the sub-station (Fig 1)



Since the 1970s an increasing number of houses have been wired on the TN-C-S system, as a Protective Multiple Earth (PME) installation. In these installations the same conductor is used to carry earth and neutral from the sub-station to the house. Earth and neutral are separate inside the premises, the two being bonded together near the Consumer Unit (Fig 2).



In a TT system there is no metallic earth connection back to the sub-station, and a suitable earth is provided at the Customer's premises. In the past the difficulty of providing an earth of low enough impedance has limited the use of this configuration; however the availability of reliable Residual Current Devices (RCDs) has meant that a higher impedance earth path is permissible. It seems likely that TT installations will become more common in future.



5 The Function of Earth in Electrical Installations

The primary function of the earth is to provide protection when a fault causes the live conductor to come in contact with the exposed metal parts of electrical equipment. The earth must be of sufficiently low impedance to blow the appropriate fuse (or activate the overload trip) in a very short time. Achieving a sufficiently low impedance has always been a problem, and traditionally it was solved by using the armouring of the supply cable as an earth conductor back to the sub-station earth point (the TN-S system). Later supply cables where the neutral and earth were combined became popular (the TN-C-S system.). Often these cables use a neutral/earth conductor, co-axially arranged over the three phase-conductors. This lowers cost and makes tapping into the cable, to make connections, much easier. Both the TN-S and the TN-C-S arrangements give a very low impedance earth.

The problems of providing a sufficiently low impedance earth path without a metallic connection back to the sub-station made TT systems impractical in most domestic situations, but recently the availability of reliable Residual Current Devices (RCDs) has changed things. The RCD will trip at relatively small effective earth currents, so that a higher earth impedance, well within the range possible with earth rods, or similar devices, is permissible. It seems likely that such installations will become more common.

6 PME and the Radio Amateur

Where TN-C-S is used in domestic supplies the neutral is earthed at convenient places along the run from the sub-station. This is a safety measure to minimise the risk of the neutral conductor rising to a significant voltage above earth under fault conditions - hence the name "Protective Multiple Earthing". The neutral is also effectively earthed at all the houses supplied by that sub-station. In a PME installation the earth/neutral combined conductor may be at a slightly different potential from the earth outside in the garden. This is very small and would normally not be noticed. There is a very slight risk that the voltage difference could rise to a significant, even dangerous, level if a broken neutral should occur in the supply path. To avoid problems of this sort special earth-bonding requirements apply to PME installations.

7 What is Bonding?

Bonding or more correctly equipotential bonding, involves connecting all nominally earthed items such as water pipes, gas pipes, central heating etc to the Main Earthing Terminal (MET). This is usually near the Consumer Unit. All the installation configurations require bonding, but in PME the regulations are more rigorous.

WHAT DO THE REGULATIONS SAY?

Clause 4.11.3.1.2 of the IEE Regulations states that for a PME installation:
In each installation mains equipotential bonding conductors complying with Chapter 54 shall connect to the mains earthing terminal extraneous-conductive-parts of that installation including the following:

*water service pipes
gas installation pipes
other service pipes and ducting
central heating and air conditioning systems
exposed metallic structural parts of the building
the lightning protection system*

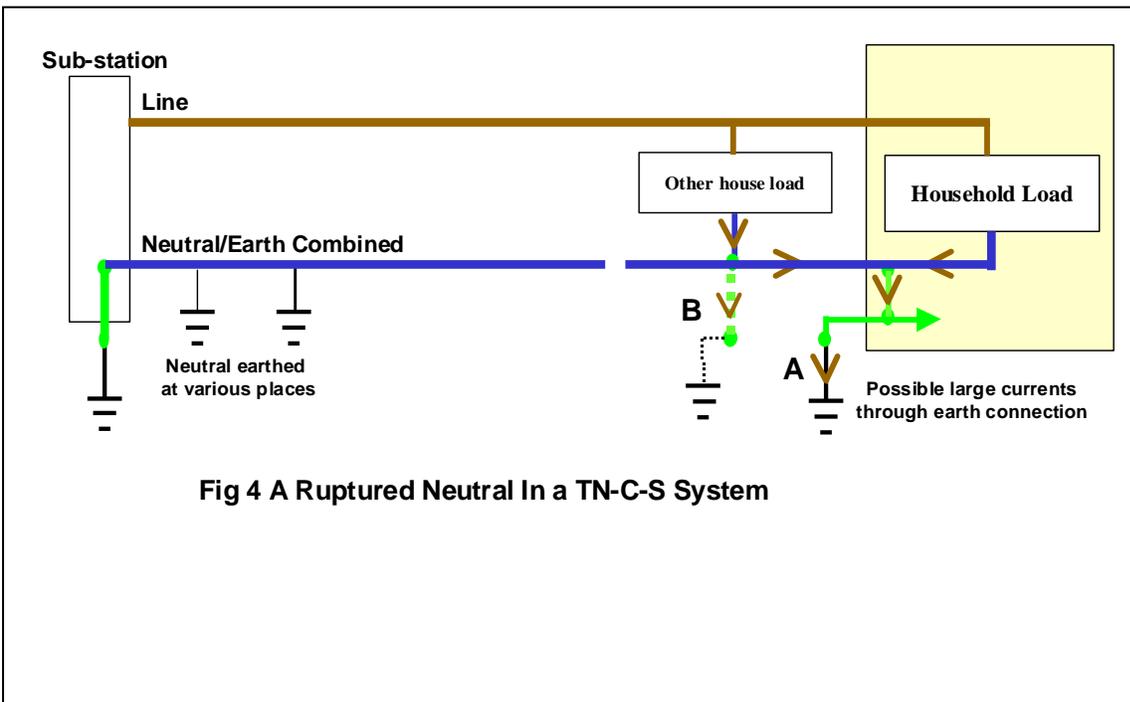
An "extraneous-conductive-part" is defined as:
A conductive part liable to introduce a potential, generally earth potential, and not forming part of the electrical installation

In effect this means that "extraneous-conductive-parts" such as an amateur radio earth/antenna system should be bonded to the Main Earth Terminal by a suitable conductor.

8 Special Requirements for PME Installations

With PME installations there is specific problem, in that under certain rare fault conditions such as a break in the neutral supply cable, the neutral/earth could be at a different potential to the earth outside as represented by the RF earth. For this reason, greater attention must be paid to bonding in PME installations.

Fig 4 illustrates how the household load current completes the circuit by passing through the earth connection at A. Some current from other houses could also flow by this route depending on the earth conditions in those houses, as at B in Figure 4. The current flowing through the earth impedance will cause the protective earth in the house to rise above the “outside” earth potential. In extreme cases this could approach the mains supply voltage. Additionally it is possible for large currents to flow through the bonding conductors giving rise to a potential fire risk. The magnitude of the current would depend on where the neutral break is, and the earthing conditions in the customer’s premises and in neighbouring houses. Needless to say such situations are very rare, and when they do occur the earth impedance of a properly bonded installation does not allow voltages to rise to dangerous levels.



9 How Does PME Affect the Radio Amateur

The important point from the radio amateur’s point of view is that, in a PME installation, any RF earths must be bonded to the Main Earthing Terminal with a suitable bonding conductor. IEE Regulations clause 544.1.2 and Table 54.8, give the minimum cross-sectional area of this bonding conductor. Where the neutral supply conductor is 35 sq mm or less, the conductor must have a cross-sectional area of not less than 10 sq mm, and where the neutral supply is 35 to 50 sq mm, the bonding conductor must be 16 sq mm. For most domestic installations a 10 sq mm bonding conductor should be adequate, but check if in doubt. Bonding conductor cable, with the distinctive yellow and green insulation can be found in the electrical sections of DIY stores.

10 Converting to a TT Installation

Where the financial and domestic situations permit the best option may be to convert the premises from PME to a TT installation. It may also be possible to convert a single room to TT. It is essential to have the advice of a qualified electrical contractor before considering anything of this sort. In particular do not be tempted to bodge things and disconnect the protective earth from a transceiver relying on the RF earth alone. This has sometimes been advocated in the past, but it is a dangerous practice and definitely contravenes all the regulations.

11 Damage to Equipment in PME Installations

While serious accidents due to supply faults in PME installations are extremely rare, the effect of the small potential difference between the protective earth in the house and the outside (RF) earth can damage radio equipment. For instance a transceiver could be damaged if the terminal for RF earth connects to the protective earth via the circuit board. Not good design practice but a case of this type has occurred. (Fortunately the amateur was able to locate the burnt-out track and repair it!). It is important to remember that, even where RF separation is required for EMC purposes, all earths terminals in the station should have a low resistance DC path to the mains protective earth.

12 Using Electrical Equipment Outside in PME Installations.

Equipment specifically intended for outdoor use such as hedge clippers, lawn mowers etc. is almost always double insulated and has no earth connection. However, inevitably people will take earthed equipment into the garden on occasions – even if they are advised not to. This again raises the possibility of the outside earth being at a different potential from the in-house protective earth to which the metal case of the appliance is connected. Again accidents are extremely rare. The minimal nature of the risk can be judged by considering the example of an outside tap. This will be connected to the protective earth via the bonding in the house, but is not considered a safety risk. It all comes down to acceptable risk and to correct bonding. It is worthwhile to check the bonding, particularly if you live in an older property where the bonding may not be up to modern standards.

13 Antennas in PME Installations

Antennas will normally have an indirect DC connection to earth and hence to the Main Earthing Terminal, so there is a small chance of a voltage existing between antenna and the outside earth. This is comparable to the outside tap situation, and while the risk of even a small shock is minimal, it is good practice to ensure that exposed conductive parts of the antenna are out of reach or suitably insulated.

14 Residual Current Devices (RCDs)

It is good practice to supply the radio installation from a socket protected with an RCD - however bear in mind that, officially, RCDs are classed as “additional protection”. They are not a substitute for compliance with all the appropriate regulations. It is particularly important to note that an RCD detects the balance of currents between line and neutral at the point where it is installed and does not provide protection from the earth potential faults in PME installations, discussed in 12 and 13 above.

References

- [1] IEE Wiring Regulations (BS7671) Institution of Engineering and Technology
- [2] IEE On site Guide (BS7671:2008) Institution of Engineering and Technology
- [3] Electrical Installation Work 6th edition. Scaddon B.
- [4] Electrician's Guide to the Building Regulations BS7671:2008 edition. Institution of Engineering and Technology

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