Protective Multiple Earthing (PME) - Advice for radio amateurs

Purpose of this leaflet

When a potentially dangerous situation could arise, but in practice is very unlikely to do so, misunderstandings and false ideas can lead to suggestions being made which are much more dangerous than the small risk which they are intended to avoid. These notes have been compiled to clear away some of the mystery surrounding Proctective Multiple Earthing (PME), and to put it into its proper perspective. As with any aspect of electricity supply, anyone who does not have the necessary knowledge should take advice from a qualified electrician or consult their Regional Electricity Company (REC).

1. A Summary

Q. What difference does PME make to an amateur station?

A. If an RF earth is used it must be connected to the (PME) earth bonding point at the consumer unit, using a conductor of at least $10mm^2$.

Radio amateurs should also be aware that external parts of the station, such as antennas and their associated metalwork, could under certain rare fault conditions, rise above earth potential (See 4c below).

Q. What is bonding?

A. Bonding, more correctly called 'equipotential bonding', is the connection of metalwork within the building, to the earth bonding point (usually at the consumer unit). This includes services such as gas and water pipes, central heating and structural metalwork.

Q. Is bonding special to PME systems?

A. No, bonding is required in modern "conventional" installations but it is considered more important in PME installations, and more stringent conditions apply.

Q. Where can I get information about bonding?

A. The IEE Regulations [1] are a formal statement of the requirements. The IEE also publish the "IEE On-site Guide" which explains the applications of the regulations to practical situations [2].

Q. Should I disconnect the mains earth from my radio equipment, and rely on the RF earth?

A. No. Definitely not! This can only be done in very special circumstances. (See 6.b below).

2. What is protective multiple earthing?

Protective multiple earthing (PME) systems started to be installed on a wide scale in the mid ’seventies. If your house is more modern than this, it is likely that it is wired on this system. Older houses may have been changed to PME if the supply system in the area has been renovated.

In a PME system, the main earthing terminal of an installation is connected to the neutral of the electricity service at the consumers premises (Fig 1). All metallic surfaces within the building, including gas pipes, water pipes, central heating systems and accessible structural steelwork are bonded together at the consumer unit. This gives the consumer an earth of very high reliability and of low impedance.

Under normal circumstances a small voltage may appear between a PME earth and the true earth potential measured outside the building as a result of voltage drop in the neutral of the electricity supply company's system. Under very rare fault conditions, such as a rupture of the neutral conductor on the supply company’s system, a higher potential difference may appear which could, in theory, rise to phase-to-neutral voltage (240V). Because all the metalwork in the building is bonded together, the shock hazard is minimised because everything is at the same potential - even though this may be different from the outside earth potential.

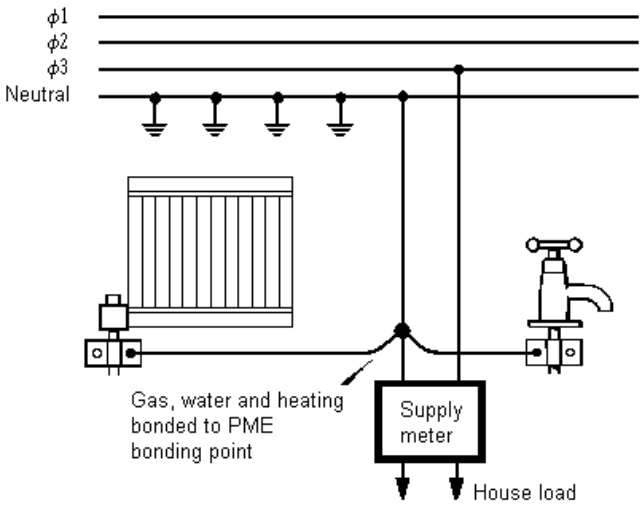

Fig 1. Protective Multiple Earthing

It is permissible to connect other means of earthing to the main earthing terminal of the installation provided certain precautions are taken. Where a low-impedance earth, such as might be used in an amateur radio installation is connected to the earth system, a very large current could flow down the earth wire in the unlikely event of rupture of the neutral (Fig 2). This current could be as high as several tens of amps and could be a fire risk.

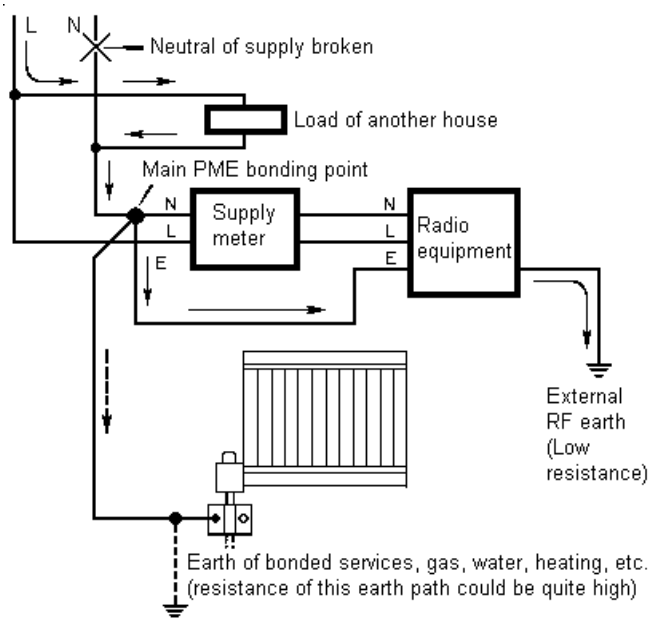

Fig. 2 A ruptured supply neutral could cause a large current to flow in a low-resistance RF earth

3. How to Identify a PME Installation

In theory a PME installation should have a notice close to the meter and distribution panel, indicating that it is PME. Of course one cannot rely on this, because it may have been detached or for some reason or other may not have been fitted. If there is no notice and you have any doubts, get a qualified electrician to have a look at the supply arrangements, or contact your Regional Electricity Company (REC) for advice.

4. The practical risks of PME

(a) In PME systems the supply authorities take great care to ensure that supply faults, such as ruptured neutrals, do not occur, and that if they do, the risk of serious accident is minimal. In practice, serious accidents due to supply faults on PME systems are very rare – so rare that there are no real cases to discuss, and the following notes are based on purely hypothetical considerations. The fact that the risk is insignificant is, however, dependent on sensible precautions being taken where an installation is non-standard – for instance, if an RF earth is being used for a radio station.

(b) The risks from a PME installation stem from the possibility of a ruptured neutral in the supply to the consumer's premises. The break in the neutral could occur anywhere in the supply, and could affect just one house or several houses, depending on the supply arrangements. This could cause the neutral, and the mains earth which is bonded to it, to rise above the 'true' earth potential. To avoid the possibility of metalwork inside the house being at a different potential from the mains earth (which in this case is at neutral potential), the IEE regulations state that all metalwork such as central heating systems, water pipes, gas pipes etc should be securely bonded to the neutral at the PME bonding point near the consumer unit, as in Fig 1.

In the unlikely event of a ruptured supply neutral, the current which would normally return via the neutral will attempt to return by way of all the other earthed conductors – including the RF earth to amateur radio equipment (Fig 2).

(c) Any conductor which is connected to bonded metalwork inside the house, and which passes out though the walls to the outside of the house, could rise to a significant potential with respect to the true earth, should a ruptured neutral occur. In a properly installed PME system, the risk of a severe shock from such metalwork is very small. However a relatively mild shock could have a secondary effect such as causing someone to jump back, and fall from a ladder.

(d) If a ruptured neutral were to cause a significant voltage to exist between the neutral/mains earth and the true earth, the existence of a fault will be revealed by the drop in the supply voltage between live and neutral. In other words, the mains voltage will have dropped, the loss being roughly the same as the voltage between the neutral/mains earth and the true earth. This is doubtless another reason why accidents are very rare – any faults on the supply are likely to be reported and corrected very quickly.

5. How PME affects the radio amateur

(a) If an RF earth connection is brought into the house and connected to the metalwork of equipment which is otherwise earth-free, a hazard is created because under the supposed supply fault conditions a voltage could exist between metal connected to the RF earth and the other metalwork inside the house which is bonded to the supply neutral.

(b) If an RF earth is connected to apparatus which is itself earthed to the mains earth system, then in the case of the supposed fault, very large currents (e.g. several tens of amps) could flow through the mains earth system and down the RF earth lead, giving rise to a fire risk.

(c) There is a general requirement, arising out of (a) and (b) above, that any external earth (in our case the RF earth) should be bonded to the PME bonding point using a conductor of not less than $10mm^2$. This prevents a significant difference in potential existing, and also provides an adequate path for prospective fault currents. Further information on bonding can be found in the IEE Wiring Regulations[1], and the IEE On-site Guide [2].

(d) Antennas which are effectively connected to the equipment metalwork, and therefore to the mains neutral/earth, are conductors passing through the walls of the house as mentioned in 4c above. While the risk of severe shock is small, it is a wise precaution to ensure that such metalwork is out of normal reach, or suitably insulated.

Avoid touching antennas, earths or any external metalwork bonded to the PME bonding point if there is an obvious fault on the electricity supply, for instance if the voltage is much lower than normal. This could indicate a neutral to earth potential problem on the supply.

6. What you can do if you have a PME installation?

There are four options:

(a) The proper procedure is to bond the RF earth to the PME bonding point at the consumer unit. The earth bonding conductor must be at least $10mm^2$ (7/1.35mm) and all parts of the RF earth must be of suitably heavy conductors, in order to ensure that mechanical damage to the earth system will not lead to excessive current density in the event of a fault.

If the station is installed with EMC in mind, following the recommendations of Chapter 3 of [3], then RF currents entering the mains earth system through the bonding conductor should not be a problem. If it is, the station "radio housekeeping" should be reviewed. In some instances interference may be brought into the station through the mains earth.

If it is necessary to prevent radio frequency currents from entering or leaving the main PME earth system, the RF earth can be isolated from the PME earth (so far as radio frequencies are concerned) by winding the bonding cable round a stack of ferrite rings to make a ferrite choke as described in chapter 5 of [3]. The high current capacity makes the bonding cable inflexible so that it may be necessary to use fewer turns and more cores to achieve the required inductance. Needless to say the arrangement must be mechanically and electrically sound and its function as a low resistance, high current capacity, bonding conductor must not be impaired.

(b) It is possible to operate a station with an earthing system independent of the PME installation, but this is not a safe option, unless you have a room where all the electricity wiring can be on an independent earthing system. The reason for this is that metalwork connected to the PME earth and the non-PME earth system could be at different potentials and to avoid the danger of shock must be separated by at least two metres. (A little thought will show that it is not really practical to have the two earth systems in the same room because it would be necessary to ensure that earthed portable items on the different systems could not come within 2m of each other). If an independent earthing system is used, a residual current circuit breaker (RCD) is essential. The new earth arrangements would have to be to IEE Regulations standard, and suitably marked as a safety earth. Take advice from a qualified electrician before considering this solution.

(c) Likewise it is possible to have the PME removed from the whole house installation, but this is most definitely a job for the professional.

(d) It is possible to operate a station without an RF earth. This is common with VHF installations and is possible, under the right circumstances, on HF.

7. Earth-free antenna systems

It is possible to make an HF antenna system that has no connection to any outside earths. The metalwork of the station ***must*** be connected to the mains earth in the normal way, including the case of the ATU and the braid of any coaxial feeders. Wires coming into the house from outside must have a DC connection to the metal work of the station and hence to mains earth, or where this is not practical, the antenna arrangement must be such that there is no chance of any part coming into contact with the earth outside. Any parts of the antenna which is within reach from the ground should be insulated.

Because no external earth is being used, particular care must be taken to avoid RF currents passing into the mains earth system. This means that balanced antennas are essential, except perhaps for very low power. In particular any sort of antenna which tunes against earth should be avoided (see Chapter 3 of [3]). For low power operation the use of a suitably insulated counterpoise might be considered.

8. Lightning protection with an earth-free antenna

Where an antenna system is earth-free then we have the problem of discharging voltages caused by static build up, and by surges caused by nearby direct strikes, without actually connecting the earth to the antenna system. This can be achieved by using spark gaps, or gas-discharge devices, as indicated in Fig 3. (It should be noted that this will not protect against a direct strike. If such protection is thought to be necessary, then lightning protection for the whole property should be considered [4]). Information on the use of gas discharge devices will be found in [5] and [6], and constructional details for spark gaps can be found in references [7] and [8]. The spark gaps or gas discharge devices must be installed outside the house and in a PME installation there is the added requirement that they should be constructed and protected as if mains voltages were involved. Under the supposed supply fault conditions this might be the case. Where gas discharge devices are used, they must be capable of handling the currents and voltages which may exist under any fault conditions.

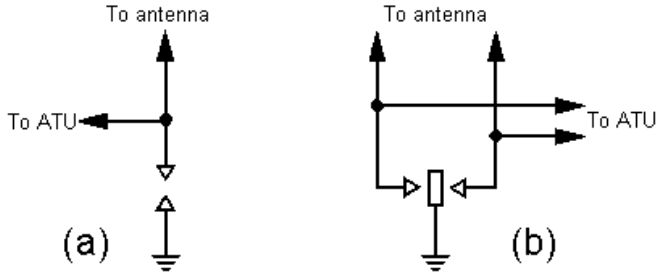

Fig 3. Using spark gaps or gas-discharge devices to give lightning protection. (a) Single wire antenna; (b) balanced feeder.

References

[1] *Regulations for Electrical Installations* (Edition 16). The Institution of Electrical Engineers

[2] *IEE On-site Guide*. The Institution of Electrical Engineers.

[3] *The RSGB Guide to EMC.* RSGB

[4] BS6651 – Code of Practice for Protection of Structures against Lightning. British Standards Institution.

[5] 'Lightning and EMP protection of amateur radio equipment', G R Jessop, *Radio Communication* December 1982.

[6] 'Lightning and your antenna', G R Jessop, *HF Antenna Collection* G6JP RSGB

[7] *Radio Communication Handbook*, 6th edn, RSGB.

[8] *ARRL Antenna Handbook*, 16th edn, ARRL, Chapter 4.

Acknowledgement

The author wishes to acknowledge the assistance of the Electricity Association in the preparation of this leaflet. The Association was supplied with a copy of the leaflet, and asked to comment on the aspects which come within its province. They were good enough to supply the following:

"The Electricity Association, which is responsible for publication of Engineering Recommendation G12/3 – National Code of Practice on the Application of PME to Low Voltage Networks, agrees with the references in the leaflet which are particular to mains supply and the provision of earthing facilities from PME systems. Regional electricity supply companies (RECs) publish their own guides on the connection and use of PME earthing facilities and these should be consulted by consumers."

Footnote

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