Rob's web

The killing ground

Earth your station safely

Most modern houses, especially on estates, have the ac mains wired to them on the protective multiple earth (pme) system. This can present particular hazards to the radio amateur who wishes to provide an external earth to the station for rf purposes, and more so to those who need to apply an external earth to other equipment to overcome emc. But first, what is pme?

Protective multiple earthing

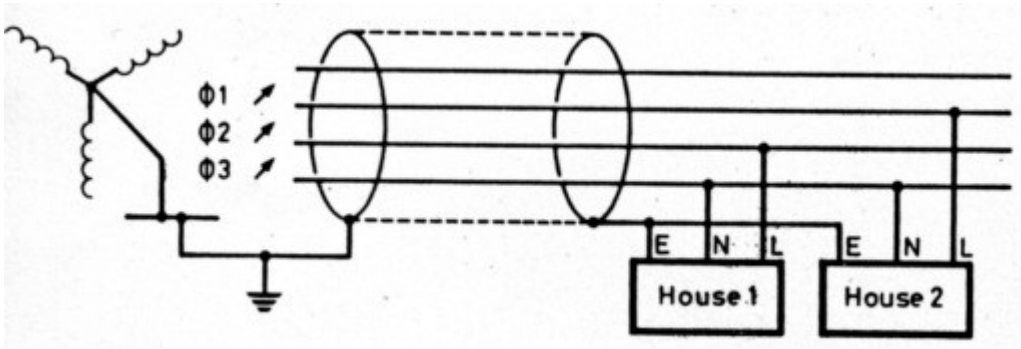

Fig 1. Three-phase neutral plus earth

PME started to be used extensively in the sixties. Before this, electricity supply systems used three-phase supplies with neutral and earth, and the earth was usually provided by metallic sheathing of the cable. The main earth was at the sub station, and this could have a high resistance. The neutral is at (or near) earth potential anyway, so the idea of pme was born. Here the neutral is the earth, Fig 2.

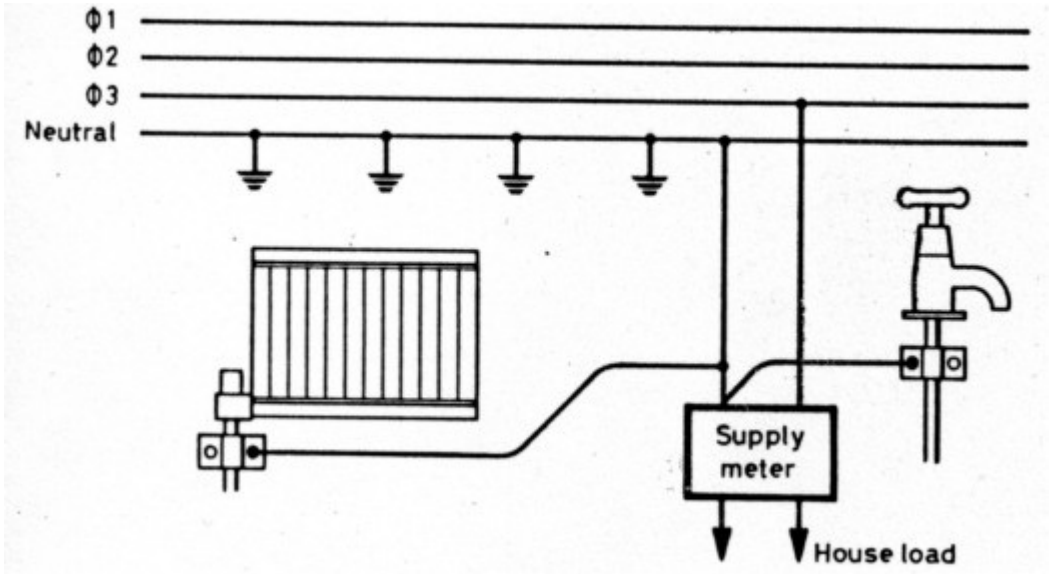

Fig 2. Protective multiple earthing

By bonding the neutral conductor to earth, not only at the substation but at many other points, the earth resistance is now much lower. In a pme system, the water and gas pipes bonded at the house to the neutral conductor and an earth is provided every so often along the run of the neutral. With the sixties change to

plastic water pipes, the old capabilities of providing a good earth tended to disappear, so bonding of the water pipes is important if, for example, a faulty immersion heater or washing machine is not to make the whole plumbing system live. So in a modern house, the gas and plumbing are all connected to the neutral of the mains near the consumer unit (fusebox), and the neutral is connected to earth in many places along the cable run from the sub-station. This is pme. By measuring the current in live and neutral, it is easy to detect an unbalanced load - such as a radio amateur!, see Fig 3.

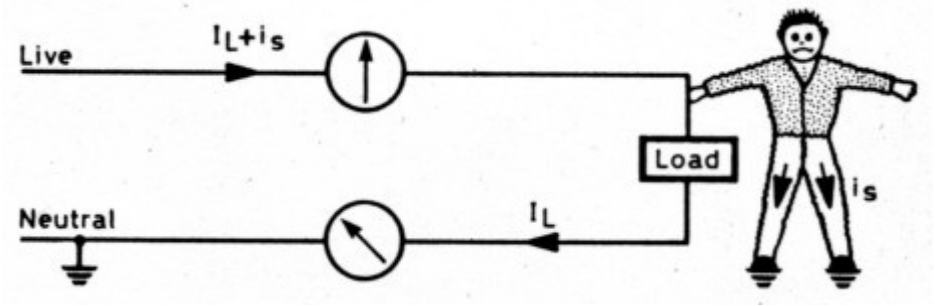

Fig 3. Unbalanced current flow when an earth load is connected

The current flowing to earth from the live conductor does not flow back through the neutral, and by measuring the difference, it is easy to switch off the supply if an unbalanced load is presented. This is done by an earth leakage trip. There are two forms of earth leakage trip. One is called a voltage trip and is actuated by a rise in the neutral-earth voltage. (Actually by current in the earth lead.) These are only fitted in older installations. The other form is a current operated trip which is also known as a residual current device (rcd) or a residual current circuit breaker (rccb). This is more usual, but isn't normally fitted in the house.

One problem that can occur is with mains filters as shown in Fig 4. Since the 240V appear across C1 and C2 but no volts appear across C3 and C4. Thus an unbalanced load is provided, and most earth leakage trips are set for about 30mA which provides for filters and some leakage, such as immersion heaters etc. But very good rf filters, such as used in professional screened rooms for instance, have leakages of 1.5A or more, and thus can cause problems. Medical electronics have much lower leakage requirements, making rf filtering very difficult.

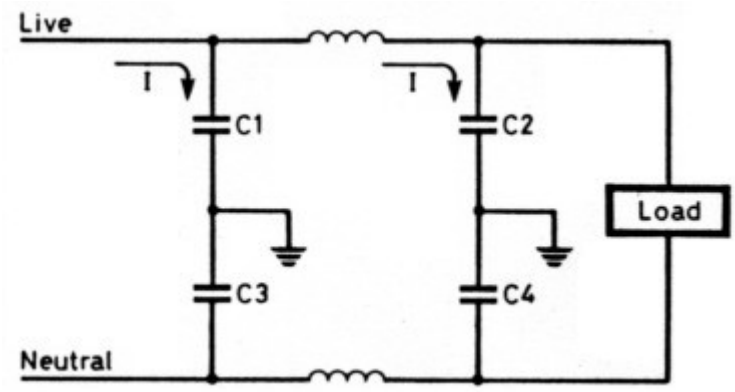

Fig 4. Mains filter with unbalanced current flow

A disadvantage of pme lies in the effect that results if the neutral, but not the live, is broken. In the worst case, the neutral at the consumer unit can reach 240V above earth; see Fig 5. As all the metal work in the house is connected together, no shock hazard exists, because nobody can contact true earth and the metalwork. Because all the metalwork in the house is floating, the occupants are in a Faraday Cage and it doesn't matter what potential they are at. In pme systems, precautions are taken to minimize breakage of the neutral, but it can - and does - occur.

Where's the problem?

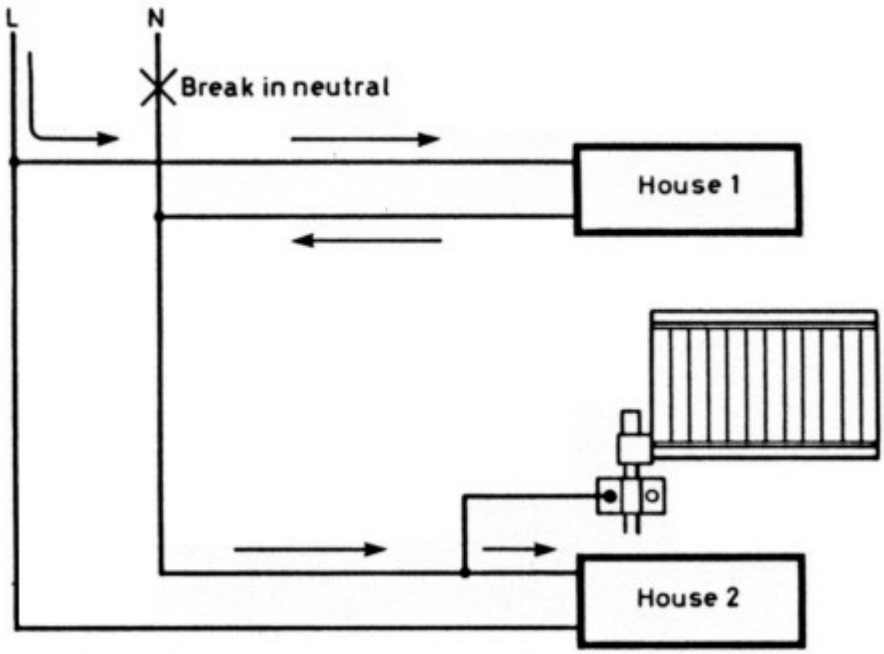

Fig 5. PME fault - all bonded network at live potential

Enter John Q Newham. He reads in the books about needing a good earth, separate from the mains earth for earthing his station. He knows - or should know - that a good earth can help prevent emc problems. So, down goes an earth stake, lots of copper wire is bonded to it and buried, and John runs a thick lead into the station, and connects it to the equipment. This is where the problem comes. Look at Fig 5 again. Supposing a fault existed when John brought in his rf earth. With the equipment, radiators and all metalwork floating at 240V, it is likely that John would be electrocuted when he touched his rig. But assume a ruptured neutral occurs later, and look at the set up that John has now got; Fig 6. Current flows from the neighbour's house to earth through John's house, and through the mains lead to his rig and down to his earth. The electricity supply may have a number of earths on the neutral in parallel with John's earth, which will reduce the current, but in the worst case John could have two or three house loads feeding current into his earth. The likelihood of his mains wiring or lead from the wall socket melting are high and earth leads must NEVER ever be fused.

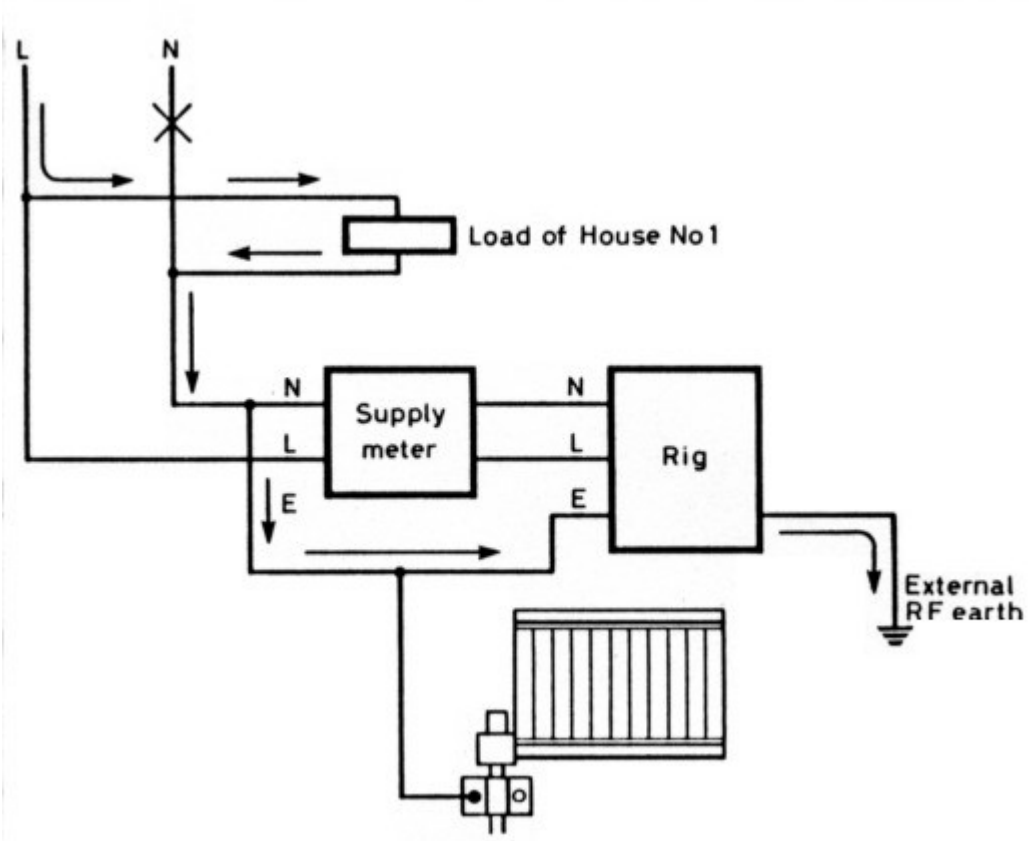

Fig 6. Current flow in pme with fault and external earth

Let's say that John does not connect the earth lead in the 13A mains plug. Now the metalwork in the house, such as radiators, electric fires, kettles, coffee-pots etc, will sit at 240V above true earth. John's rig is earthed and the chance of 240V appearing across John is high. True the elcb, if fitted, night protect him. When did you last check your elcb? Press the test button once a month - in daylight, as the house supply should vanish.

So John Q Newham could rapidly be a silent key by having an earth lead.

Safe earthing

There are two ways round this problem. One is to have an earth-free room, in which everything connected to the rf earth is a minimum of 2m away from anything bonded to the electricity earth, and then disconnect the earth lead from the plug on the equipment mains lead. Fit a circuit breaker (eg RS Part No 334-094 on the cable) or replace the wall socket with one incorporating a breaker (eg RS 331-095 or 33l-102). Then remember that 'nothing connected to the mains earth is allowed within 2m of the equipment. This includes light switches where an exposed metal screwhead connects to the mains earth. No kettles, coffee pots, vacuum cleaners, soldering irons - nothing connected to the mains earth. So if a fault occurs, it is impossible to get a shock. But don't disconnect the earth lead until you've fitted a circuit breaker. It is vital that the earth lead doesn't flap around inside the plug - so bring it back through the cord grip and insulate it outside the plug. Then attach a label to the plug saying "**DANGER, NOT EARTHED**". This means that if you lend your rig to someone - or send it away for repair - the people plugging it in are aware that it isn't earthed. Attach a label to the rf earth where it's joined to the rig saying: "**SAFETY EARTH - DO NOT REMOVE**".

If you can't establish an Earth-free zone, then a simple way out exists. This is to bond the rf earth to the electricity supply earth at the consumer unit and nowhere else. The earth lead must be at least 80/0.44mm so that it can carry a heavy current (a less-flexible ($10mm^2$) lead is 7/1.35mm). When the extra earth lead is installed, it should conform to the IEE wiring regulations. These will be found in your local library - but if in doubt, consult a competent electrician.

The problem still exists of keeping rf noise that is on the mains away from the rig. Here the use of ferrite rings is indicated. These are available from RSGB HQ, and by winding the earth lead around the rings, an rf choke is formed. The product of turns x number of rings should be about 20, and with a thick earth lead it is best to use about 3 to 4 turns with 5 to 8 rings. Now, the earth lead is connected at the wall socket, and it is a good idea to use a circuit breaker. The mains lead to the rig is wrapped around ferrite rings to keep rf noise out. But don't forget the label where the added earth lead from the mains supply joins the rf earth. John Q Newham's installation now looks like Fig 7. If the earth lead is very long, it is often worthwhile screening it; Fig 8. The screening is only connected at the earth end.

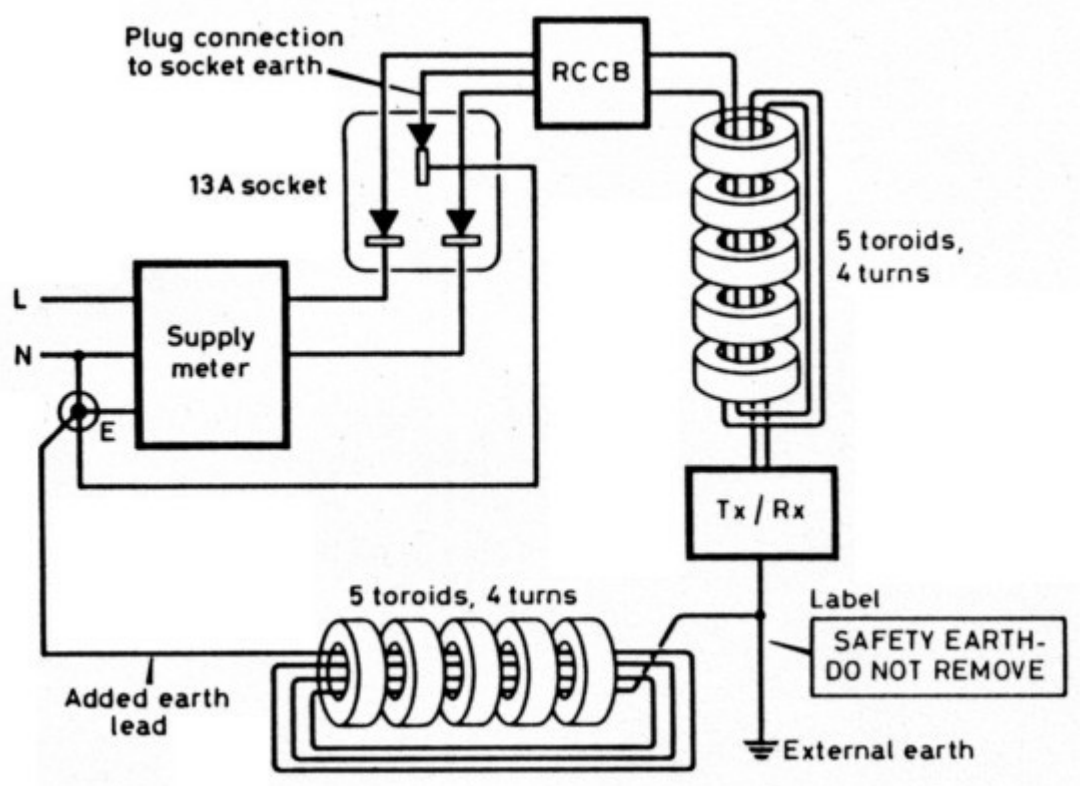

Fig 7. Earth lead for pme with rf choke - the SAFE method

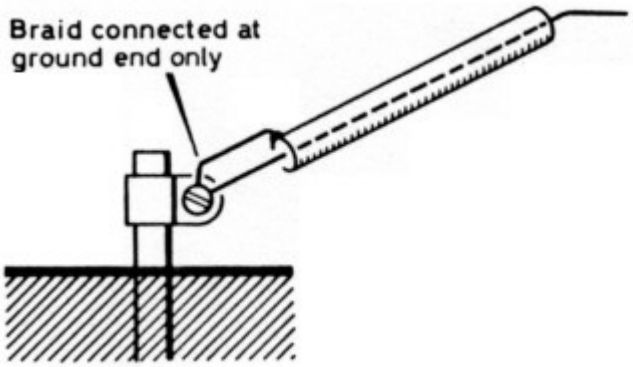

Fig 8. The screened earth lead

Earthing equipment externally in a modern house (or possibly even a recently rewired one) can lead to the danger of fire or electrocution. If these simple guidelines are followed, then there will be no safety problems.

Let's just go back to John Q Newham. Starting on 144MHz he says he doesn't need an earth, so this doesn't apply. If he doesn't mind his antenna floating at 240V in an accident, no. If he doesn't mind the lack of lightning protection, it doesn't apply. But a sensible installation will earth the antennas for dc where possible, and provide a good solid earth for lightning protection. Remember that nothing protects against a direct strike, but lightning conductors do provide a discharge of the atmosphere. Relying on the mains earth can be very expensive.

If you haven't got a good external earth on the antennas, disconnect them before you work on them. If a

neutral fault occurred while you were working on them it could kill! If you own an old-fashioned power tool with a metal case which is connected back to the mains earth, don't use it outside - or, of course, in an earth-free area. If you've got pme and an outside water tap, consult the Electricity Board.

You don't have to have pme. It is possible to have the pme bonding removed, but do get this done professionally. Have an rccb fitted to supply the total house load, and, for good measure, have some earth rods driven to provide a good earth. Ensure that the bonding of the rf earth to these is by a heavy conductor - it's unlikely that any rf on the earth will cause problems except in your house! Do make sure you test the rccb once a month!

Finally, how about the neighbour whose equipment is suffering because of emc difficulties? The same rules apply on earthing, only more so. Electrocuting a neighbour or setting fire to his house won't make you popular - even if it does stop him complaining! Earthing is easy - just as long as it is done correctly. That's how John becomes John Q Oldham.

G3RZP, Peter E Chadwick.