

Earth loops

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What is an earth loop?

Also called a 'ground loop' in American, an earth loop is a closed loop of conductors (wires and maybe the metalwork of equipment or racks or of anything else, really), which is all supposed to be at 'earth potential', the 'zero-volts reference' for normal voltage measurements.

What is it for?

It usually isn't 'for' anything; it's not created intentionally, it just happens. For example, if we have two pieces of equipment that have 3-core mains leads, and we connect the output of one to the input of the other by a screened cable, we have created a loop (Figure 1).

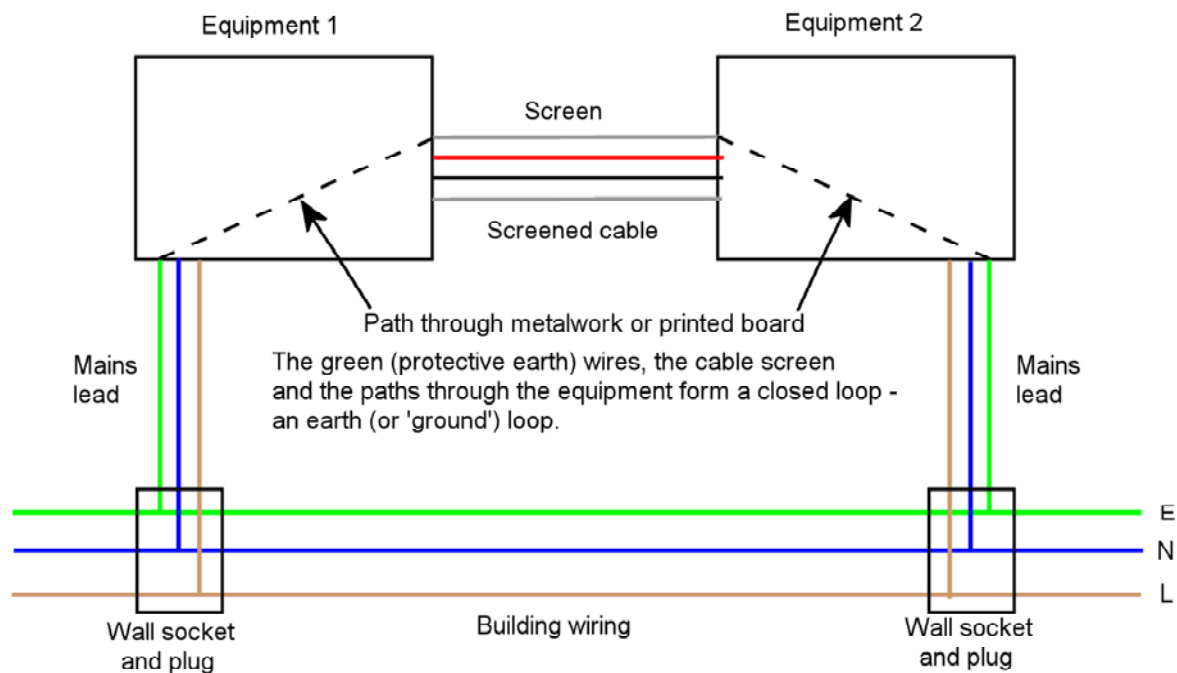


Figure 1 Plan of an earth loop

What does it do?

It's liable to cause mains hum and maybe the pick-up of AM radio signals. The causes are circulating currents flowing in the closed loop of conductors. It looks as though there is no source of voltage to produce these currents, but there are two ways in which the currents can be produced:

- magnetic fields passing through the loop induce voltages in it;

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- current in the protective earth conductor of the building wiring causes a voltage difference between the earth connections at the wall-sockets.

This current in the protective conductor *should* be only a few milliamps, but often it's larger, especially if there is heavy machinery or large heating equipment in the building.

Only small voltages are needed to cause large currents, because the resistance of the loop is very low - much less than 1 ohm is typical.

How does that cause a problem?

The voltage drops caused by these currents, across internal earth connections inside the equipment, are very likely to be effectively in series with the wanted signal, so they appear at the output as hum or interference. In addition, the magnetic fields due to the currents can induce hum or interference in other internal circuits, even those not very close to the earth paths.

What can we do about it causes a problem?

The most important point is that **the protective earth wires in the mains leads must NEVER be disconnected, because that could easily cause a fatal accident.**

The best solution is to use balanced signal connections (as shown in Figure 1) between the equipment boxes. The two signal wires have *equal impedances to earth*, and the source and load impedances form a balanced bridge (like a Wheatstone Bridge), so that signals induced from the currents flowing in the screen don't appear *between* the two signal wires, which is where the wanted signal is.

In a really bad case, the circulating currents may be large enough to heat up the screen of the signal cable, or break through in spite of the use of a balanced connection, in which case there are two solutions:

- disconnect the screen at the *receiving* end. There are good, but rather complicated, reasons why this end is best. If radio pickup then occurs, connect the screen to earth at the receiving equipment through a low-inductance capacitor (with very short wires or a surface-mount component). 10 nF is often an effective value to use;
- connect the metal cases of the equipment with a THICK bonding wire, at least 4 mm² and preferably thicker. This diverts the current away from the screen of the cable.

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