COURSE 8

EARTHING AC LOW VOLTAGE INSTALLATIONS

LV network types according the active conductor are as follows:

AC – single phased 2-wire
- single phased 3 wire
- three-phased 3-wire
- three-phased 4-wire
- three-phased 5-wire

CC – with 2 or 3 wires.

According to earthing connection type, there are 3 standard LV installations (AC and CC): TN, TT and IT. Literary symbols used in their notation have the following meanings:

- the first letter refers to the situation of supply network in relation to the earth (*the source*):

T = direct bonding (connection) of an active point to the ground - the neutral point, where it is accessible, or a phase conductor, in the case where the neutral point is not available.

I = isolation of all active points from the ground, or earthing one of these points through a very high impedance.

- the second letter refers to grounding-points' situation in relation to the earth (*the receiver*):

T= linking directly to the ground the masses of electrical system, independent of any earthing of a point of supply.

N = indicates the treatment of neutral and protective conductors functions; it can be N-C or N-S.

- other letters refer to the arrangement (layout) of neutral conductor and protective conductor in TN network:

C = the functions of neutral conductor and protective conductor can be combined in a single conductor (named PEN)

S = the protective function is ensured through a conductor (named PE), separately from active earthed conductors.

Obs:

The main equipotential bonding system

The bonding is carried out by protective conductors and the aim is to ensure that, in the event of an incoming extraneous conductor (such as a gas pipe, etc.) being raised to some potential due to a fault external to the building, no difference of potential can occur between extraneous-conductive-parts within the installation. The bonding must be effected as close as possible to the point(s) of entry into the building, and be connected to the main earthing terminal.

Supplementary equipotential connections

These connections are intended to connect all exposed-conductive-parts and all extraneous-conductive-parts simultaneously accessible, when correct conditions for protection have not been met, i.e. the original bonding conductors present an unacceptably high resistance.

Connection of exposed-conductive-parts to the earth electrode(s)

The connection is made by protective conductors with the object of providing a low-resistance path for fault currents flowing to earth.

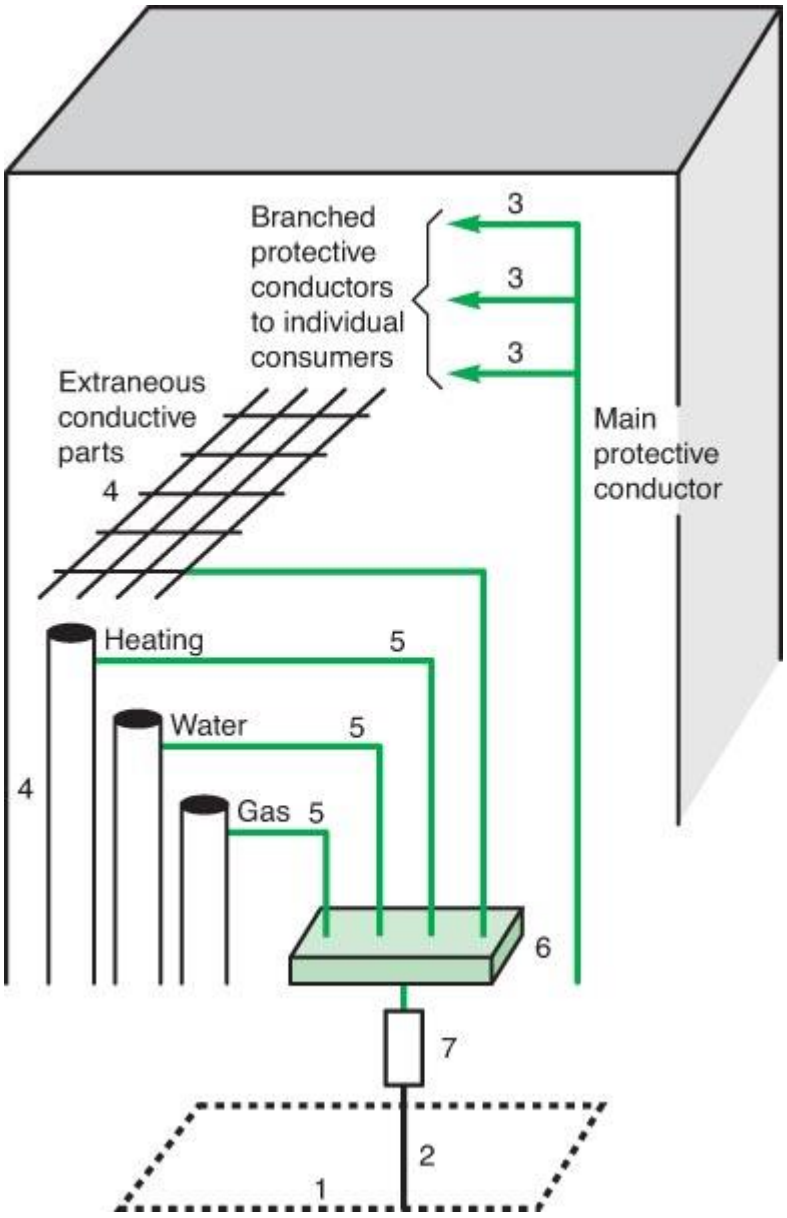


Figure 8.1 - Example of a block of flats in which the main earthing terminal (6) provides the main equipotential connection; the removable link (7) allows an earth-electrode-resistance check

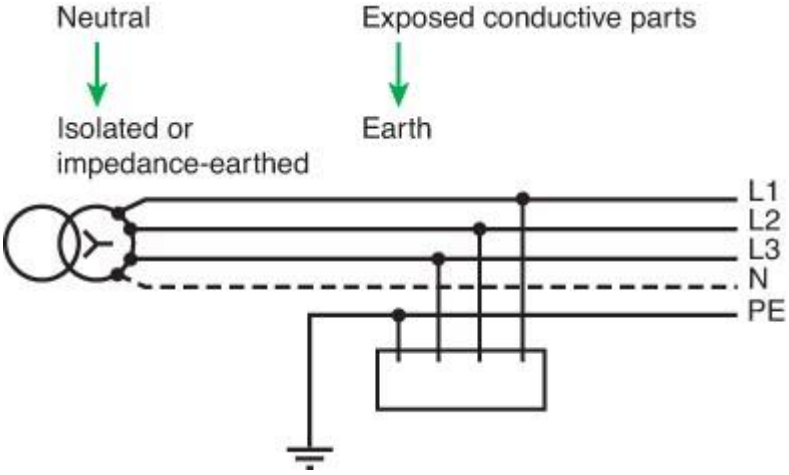
- Earth: The conductive mass of the Earth, whose **electric potential at any point is conventionally taken as zero**
- Earth electrode (1): A conductor or group of conductors in intimate contact with, and providing an electrical connection with Earth.
- Electrically independent earth electrodes: Earth electrodes located at such a distance from one another that the maximum current likely to flow through one of them does not significantly affect the potential of the other(s).
- Earth electrode resistance: The contact resistance of an earth electrode with the Earth.
- Earthing conductor (2): A protective conductor connecting the main earthing terminal (6) of an installation to an earth electrode (1) or to other means of earthing (e.g. TN systems);
- Exposed-conductive-part: A conductive part of equipment which can be touched and which is not a live part, but which may become live under fault conditions.

- Protective conductor (3): A conductor used for some measures of protection against electric shock and intended for connecting together any of the following parts:
  - Exposed-conductive-parts
  - Extraneous-conductive-parts
  - The main earthing terminal
  - Earth electrode(s)
  - The earthed point of the source or an artificial neutral
- Extraneous-conductive-part (4): A conductive part liable to introduce a potential, generally earth potential, and not forming part of the electrical installation (non-insulated floors or walls, metal framework of buildings, metal conduits and pipework (not part of the electrical installation) for water, gas, heating, compressed-air, etc.).
- Bonding conductor (5): A protective conductor providing equipotential bonding.
- Main earthing terminal (6): The terminal or bar provided for the connection of protective conductors, including equipotential bonding conductors, and conductors for functional earthing, if any, to the means of earthing.

STANDARDISED EARTHING SCHEMES

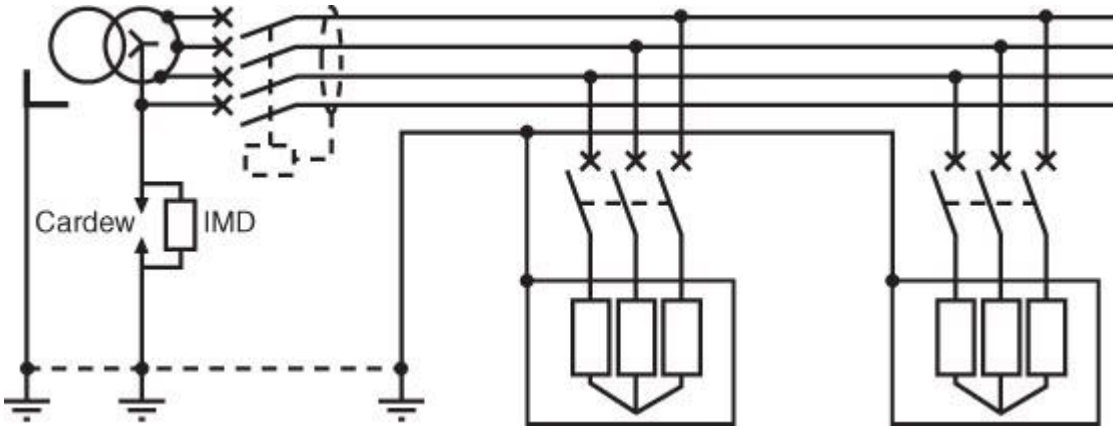
1. IT (isolated or impedance-earthed neutral)

There is no intentional connection between the neutral point of the supply source and earth.



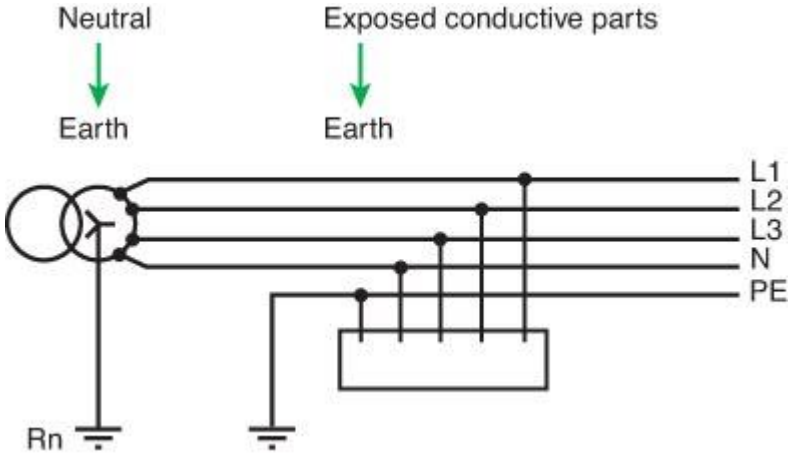
Main characteristics:

- IT offers the best continuity of service during operation
- Indication of the first insulation fault, followed by mandatory location and clearing, ensures systematic prevention of supply outages
- Generally used in installations supplied by a private MV/LV or LV/LV transformer
- Requires maintenance personnel for monitoring and operation
- Requires a high level of insulation in the network (implies breaking up the network if it is very large and the use of circuit-separation transformers to supply loads with high leakage currents)
- The check on effective tripping for two simultaneous faults must be carried out by calculations during the design stage, followed by mandatory measurements during commissioning on each group of interconnected exposed conductive parts.



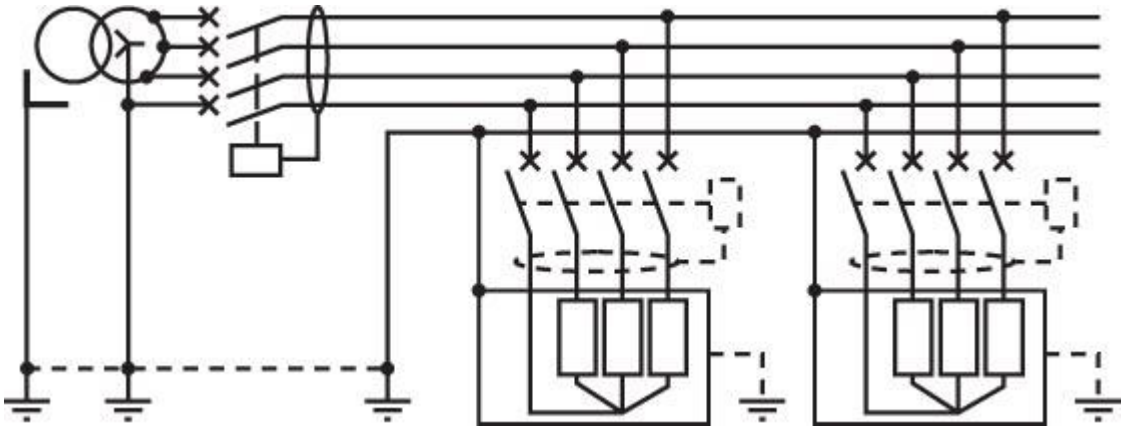
2. TT (earthed neutral)

One point at the supply source is connected directly to earth. All exposed- and extraneous-conductive-parts are connected to a separate earth electrode at the installation. This electrode may or may not be electrically independent of the source electrode. The two zones of influence may overlap without affecting the operation of protective devices.



Main characteristics:

- TT represents the simplest solution in designing an installation. Is used in installations supplied directly by the public LV distribution network.
- Does not require continuous monitoring during operation (a periodic check on the RCDs may be necessary).
- Protection is ensured by special devices, the residual current devices (RCD), which also prevent the risk of fire when they are set to ≤ 500 mA.
- Each insulation fault results in an interruption in the supply of power, however the outage is limited to the faulty circuit by installing the RCDs in series (selective RCDs) or in parallel (circuit selection).
- Loads or parts of the installation which, during normal operation, cause high leakage currents, require special measures to avoid nuisance tripping, i.e. supply the loads with a separation transformer or use specific RCDs.



3. TN (exposed conductive parts connected to the neutral)

The source is earthed as for the TT system (above). In the installation, all exposed- and extraneous-conductive-parts are connected to the neutral conductor.

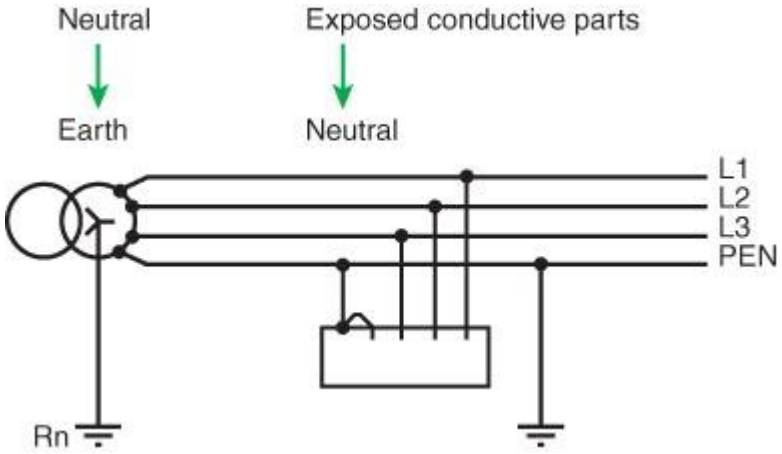
3.1. **TN-C scheme**

The neutral conductor is also used as a protective conductor and is referred to as a PEN (Protective Earth and Neutral) conductor. This system is not permitted for conductors of less than 10 mm2 or for portable equipment.

The TN-C system requires an effective equipotential environment within the installation with dispersed earth electrodes spaced as regularly as possible since the PEN conductor is both the neutral conductor and at the same time carries phase unbalance currents as well as 3rd order harmonic currents (and their multiples).

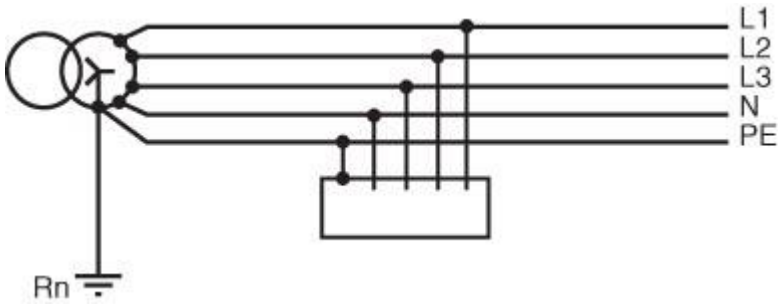
The PEN conductor must therefore be connected to a number of earth electrodes in the installation.

Caution: In the TN-C system, the “protective conductor” function has priority over the “neutral function”. In particular, a PEN conductor must always be connected to the earthing terminal of a load and a jumper is used to connect this terminal to the neutral terminal.



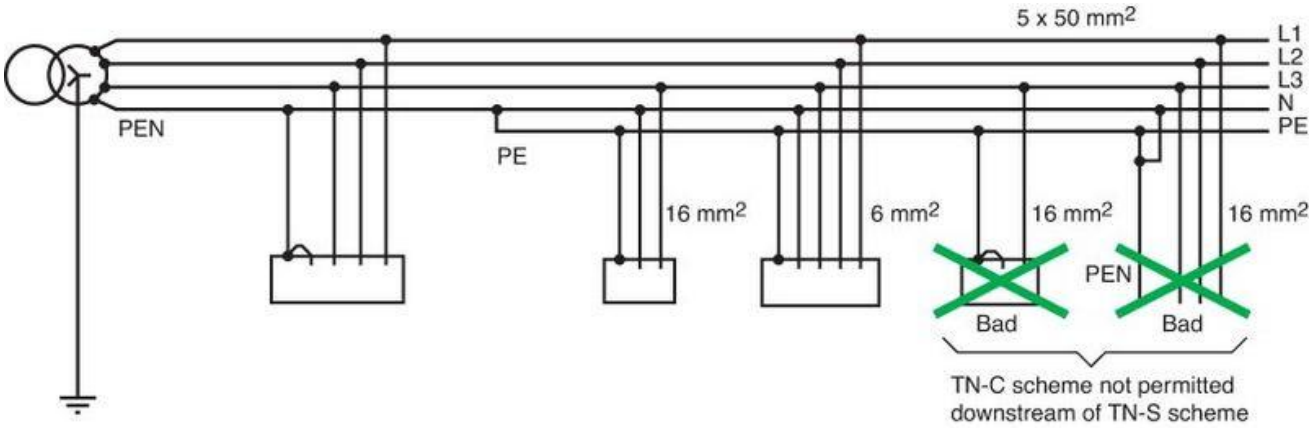
3.2. **TN-S scheme**

The protective conductor and the neutral conductor are separate. On underground cable systems where lead-sheathed cables exist, the protective conductor is generally the lead sheath. The use of separate PE and N conductors (5 wires) is mandatory for circuits with cross-sectional areas less than 10 mm2 for portable equipment.



3.3. **TN-CS scheme**

The TN-C and TN-S systems can be used in the same installation. In the TN-C-S system, the TN-C (4 wires) system must never be used downstream of the TN-S (5 wires) system, since any accidental interruption in the neutral on the upstream part would lead to an interruption in the protective conductor in the downstream part and therefore a danger.



Main characteristics:

Generally speaking, the TN system:

- Requires the installation of earth electrodes at regular intervals throughout the installation.
- Requires that the initial check on effective tripping for the first insulation fault be carried out by calculations during the design stage, followed by mandatory measurements to confirm tripping during commissioning.
- Requires that any modification or extension be designed and carried out by a qualified electrician.
- May result, in the case of insulation faults, in greater damage to the windings of rotating machines.
- May, on premises with a risk of fire, represent a greater danger due to the higher fault currents.

In addition, the TN-C system:

- At first glance, would appear to be less expensive (elimination of a device pole and of a conductor)
- Requires the use of fixed and rigid conductors
- Is forbidden in certain cases:
  - Premises with a risk of fire
  - For computer equipment (presence of harmonic currents in the neutral).

In addition, the TN-S system:

- May be used even with flexible conductors and small conduits
- Due to the separation of the neutral and the protection conductor, provides a clean PE (computer systems and premises with special risks).