IDA Elteknik

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”Global Earthing”

Global Earthing; based at bonding is the future bonding and earthing philosophy!

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The earth is lovely, and as an electrical conductor and electrical reference, we cannot get around it!

Compared to metallic conductors, however, the soil is about 10^6 x worse

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With global earthing, the highest level of personal and plant safety is achieved under all fault conditions, regardless of the resistivity of the soil and the measured transition resistance to neutral earth/ground!

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Global earthing is defined in the new standards for supply systems with voltages above 1 kV ac, DS/EN 50522 and DS/EN 61936-1 with effect in DK from 1 July 2017. Bonding is made between all exposed and extraneous conductive parts as well as to all naturally earthed parts such as reinforcement in concrete foundations and to other conductive structures in electrical contact with earth (steel profiles) belonging to the utilities system, both on the high- and low voltage side.

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The bonding between the systems covered by the global earthing must be carried out in such a way that dangerous earth potentials rise, and thus dangerous contact voltages, cannot occur!

The use of cables with earth contact (submarine cables) or of a earth conductor (uninsulated together with cables in the ground) ensures that the current over neutral ground is negligible!

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Risk scenarios:

Danger to persons, pets and property:

Lightning strikes that can be fatal to people and animals, as well as cause fire and extensive damage to electrical installations and equipment!

Insulation faults in utilities and electrical installations that cause earth fault currents and dangerous touch voltages!

The first time we see earthing systems is around year 1760

Before the first IEC lightning protection standard was published in 1991, most national standards required max. 10 Ω and it's still a considered opinion!

Benjamin Franklin

In the current standard for lightning protection DS/EN 62303-3, there is a recommendation of 10 Ω in transition resistance, in the sense that in areas where the resistivity is > 500 Ω·m, the extent of the earthing system must be increased if protection class I or II is desired. However, if you achieve 10 Ω before the specified extent is achieved, it is ok!

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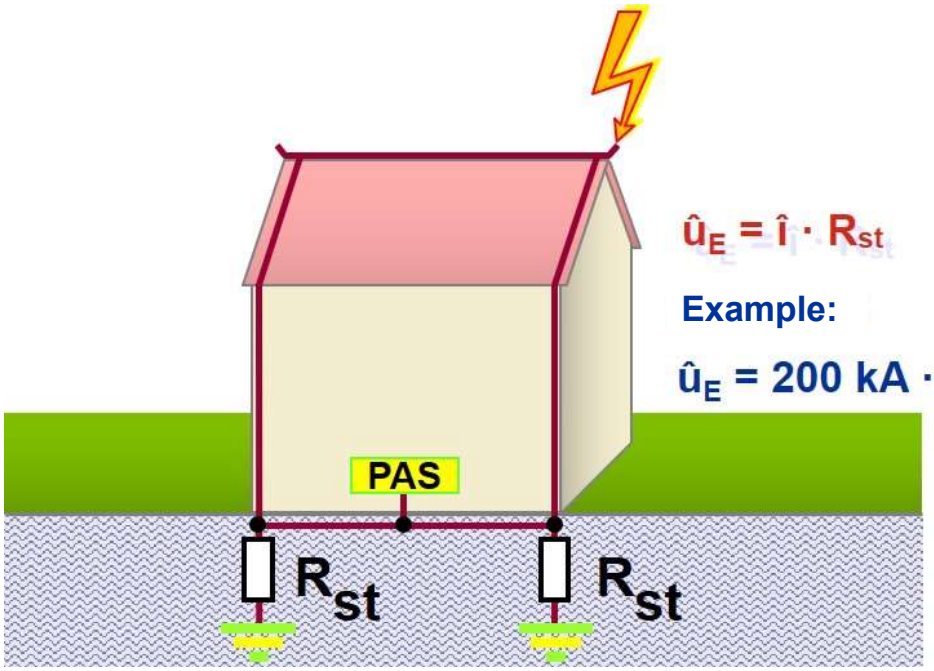
Earth potential rise EPR by lightning current:



$\hat{u}_E = \hat{i} \cdot R_{st}$

Example:

$\hat{u}_E = 200\ kA \cdot 1\ \Omega = 200\ kV$

The effective depth of the earth rods for lightning current is only approx. 5 m at resistivity < 500 Ω·m!

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Lightning strikes are impulse currents to earth that charge the earth, negatively or positively!

Earth fault current in supplies systems or installations, is currents flowing from the fault site back to the system earthing.

Only currents over neutral ground cause earth potential rises (EPR) and dangerous touch voltages!

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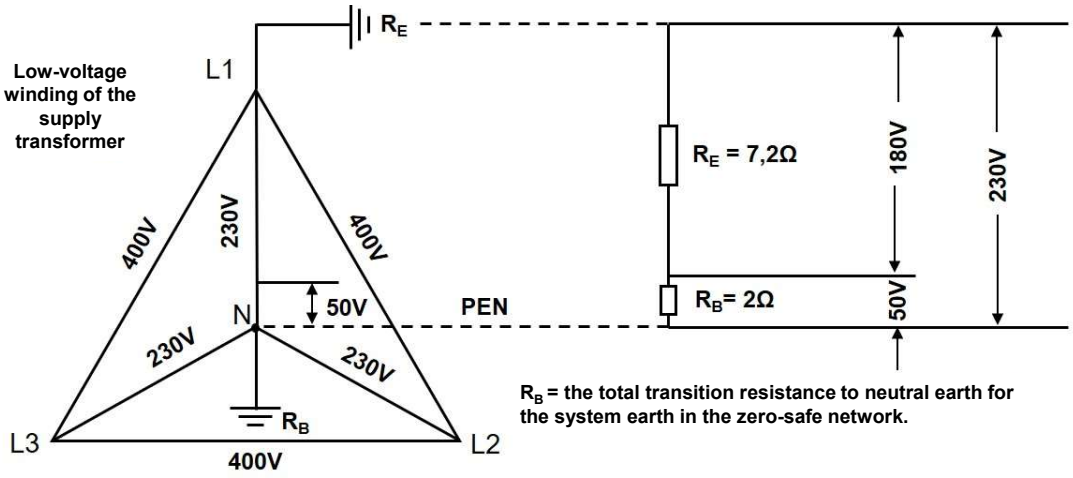
Potential displacement in the event of an earth fault to extraneous conductive parts that are not equipotential bonded in TN - C – grid.

R_E= the resistance to neutral earth in the fault from L1, through the extraneous conductive part in the installation that is not bonded.



R_B = the total transition resistance to neutral earth for the system earth in the zero-safe network.

$R_B \leq R_E \times 50/230 + 50 \leq R_E \times 1/3.6$, which means that all extraneous conductive parts must be equipotential bonded if the transition resistance is ≤ 3.6 x the system's transition resistance to earth.

In connection with "Extra protection“ (fault protection) by "Nulling", (TN - C - net) there has always been a requirement for equipotential bonding?

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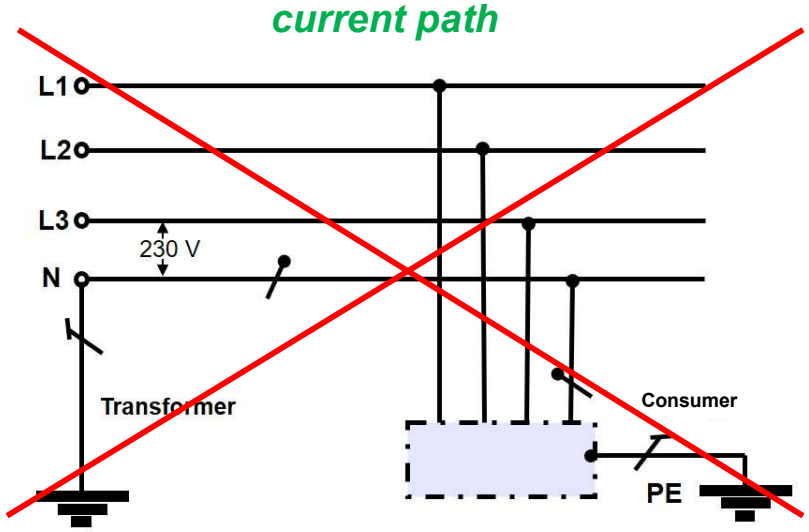
It is important to state that in the event of an earth fault in a TT-network, the nominel voltage will be divided over the transition resistance that are part of the fault current path



R_B = 2 Ω; U_E= 115 V

R_E= 2 Ω; U_E= 115 V

The story of the 2 Ω. The touch voltage was earlier maximum 48 V, and R_E had to meet the requirements at the 5 sec. tripping time for the fuse. At a 6 A fuse, the current at 5 s is ≤ 24 A.

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At 115 V and 2 Ω you can conduct a current of max. 57.5 A, a 20 A fuse can carry that for several hours!

Today, in the new "Regulations" and standards for power installations and LV-installations, including electrical railways, within the European territory, there is no requirement for a fixed maximum transition resistance to neutral earth. There are specific requirements for maximum touch voltages and earth potential rises (EPR) with reference to the failure disconnect time. Therefore, fault current and time of interruption must be known in the design phase so that the requirements for the earthing system, transition resistance, equipotential bonding and possibly the potential graduation control are determined from the start!

PE conductors must be fed in all new electrical installations and residual current circuit breakers, today called (RCDs) or (RCCBs), must be used regardless of the system earthing. It is the tripping current and the permissible touch voltage and the time of disconnection that are dimensioned.

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If a bare earth conductor is fed together with the high-voltage cable, you get the same effect as oil-paper lead cables or submarine cables, and this is defined in standards today as "global earthing", which means that so little current passes through neutral earth that it is harmless to humans and animals!

The bare earth conductor is an effective earth electrode for lightning protection and at the same time protects the HV- cable's sheath from perforation (pin holes) by lightning!

All requirements for protection against indirect contact or fault protection, as it is called today, are thus met!

No requirements for measuring transition resistance or earth resistivity, only a requirement for continuity measurement (resistance) as well as calculation of maximum voltage drop and EPR at highest fault current!

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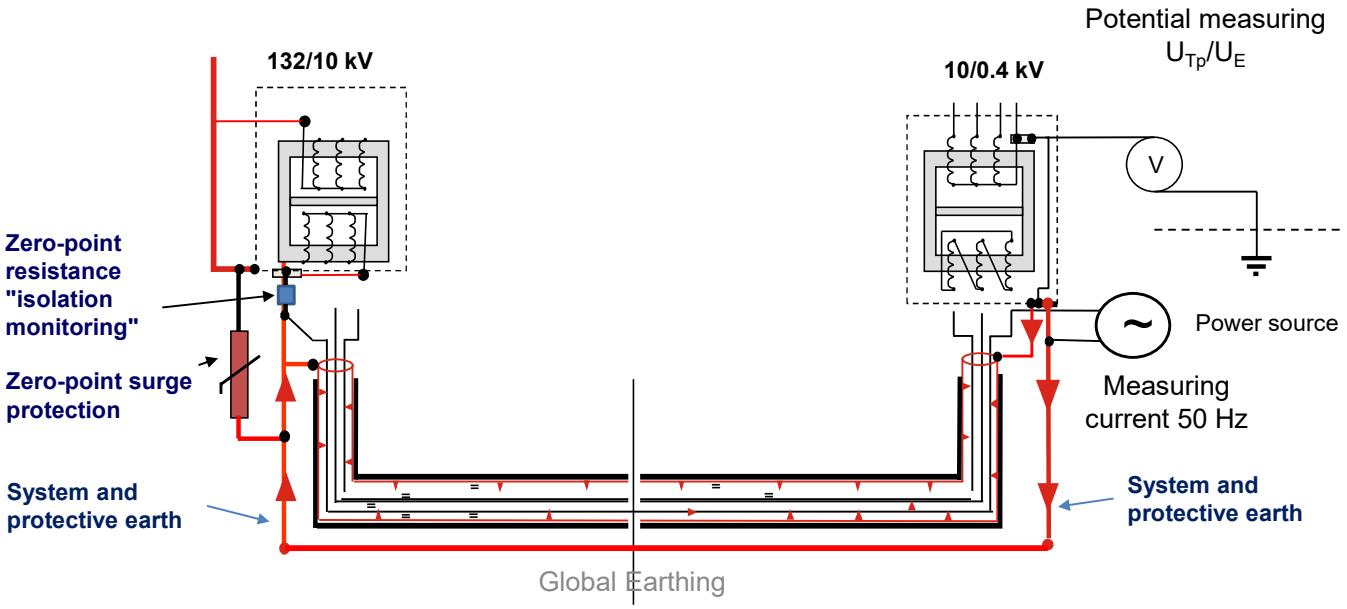
Utilities supply system

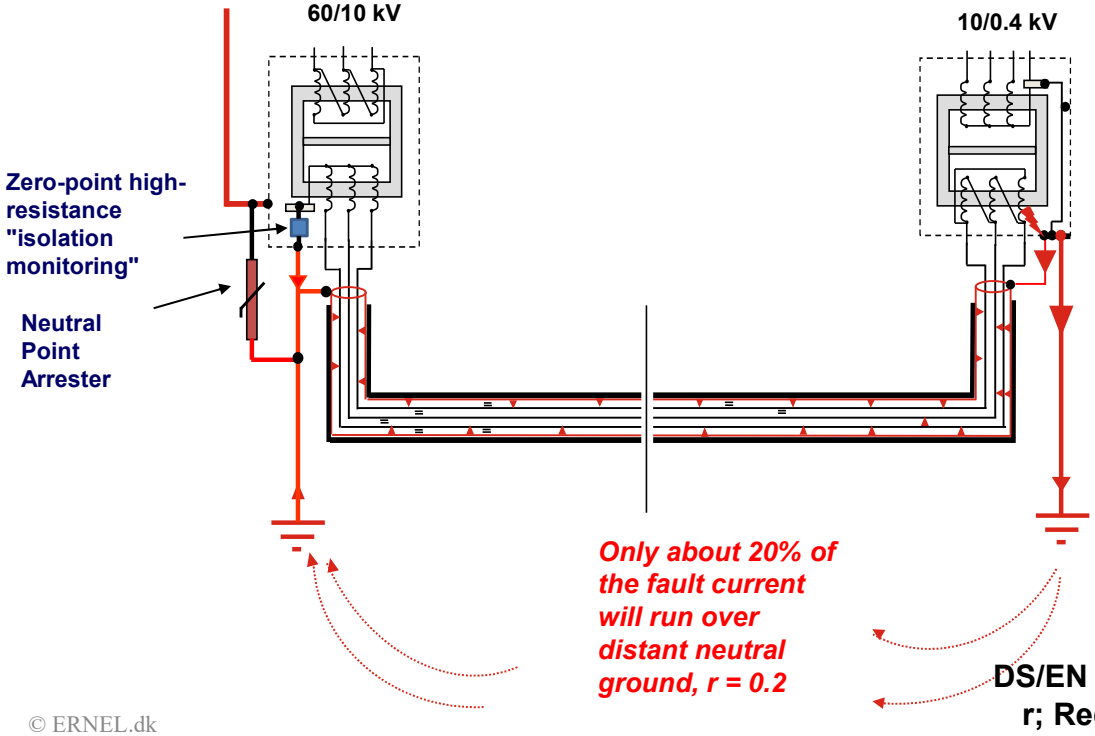
Measuring Earth Potential Rise EPR



(Source; ERNEL)

Utilities supply system

Isolated neutral, used in a number of larger cities in Denmark



DS/EN 50522. $I_E = r \times I_C$, r; Reduction factor

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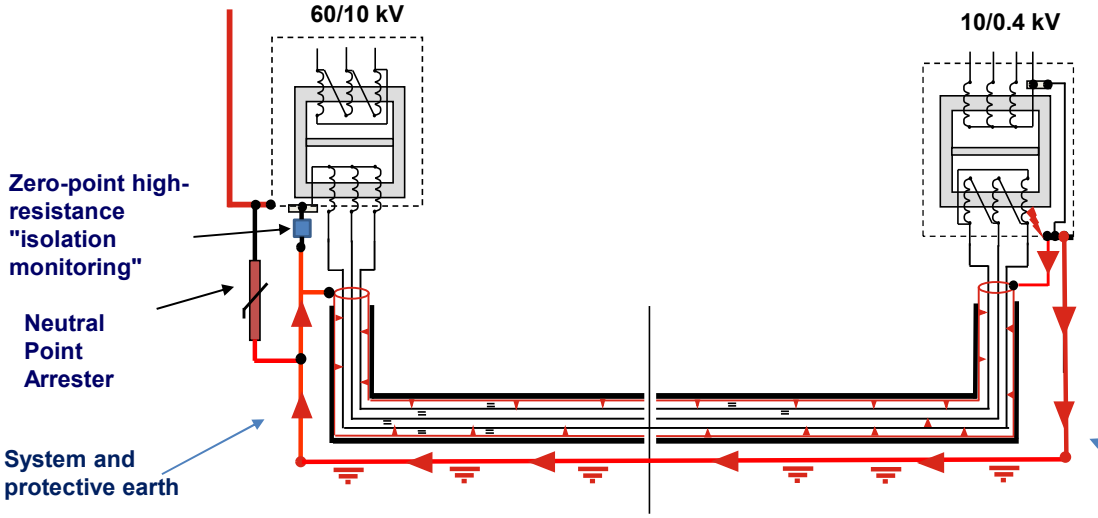
Utilities supply system



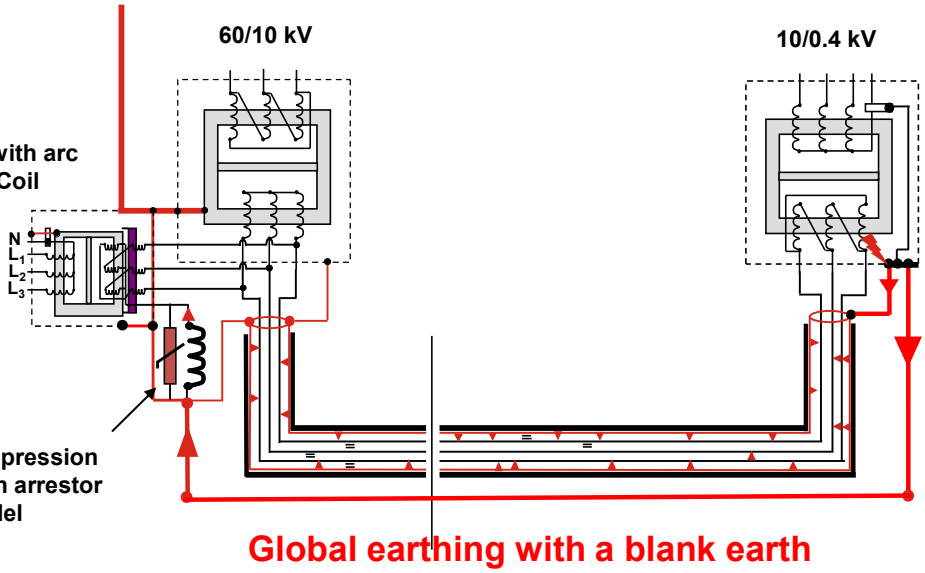
(Source; ERNEL)

Global earthing with a blank earth conductor throughout!
There will not be a measurable current of I_E over distant neutral earth!

Reduction factor;
r = <0.001

Utilities supply system

Compensated/ arc suppression coil earth system, mostly used in Denmark



Common earth

The majority of the fault current returns from the screen and the failed phase to the non-faulty phaes

(Source; ERNEL)

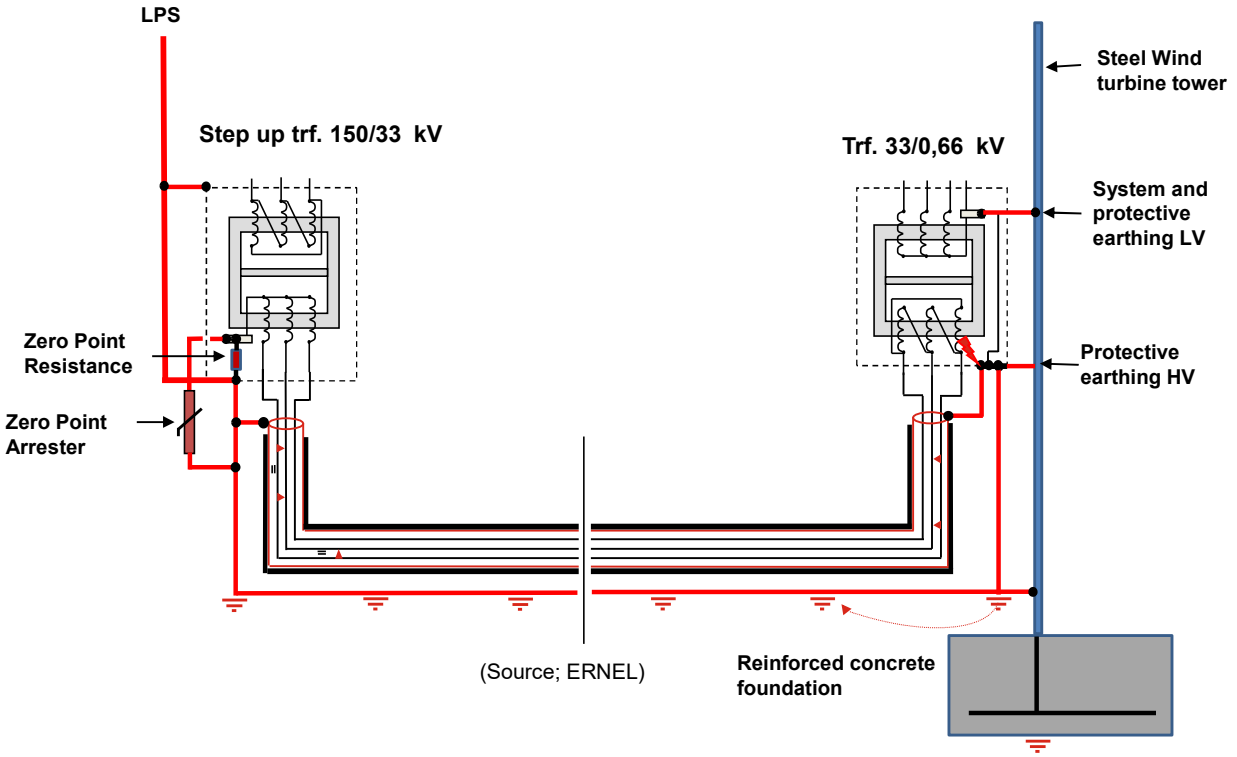
Global earthing with a blank earth conductor throughout!
There will not be a measurable current of I_E over distant neutral ground!

DS/EN 50522;

$$I_E = r \times \sqrt{I^2_L + I^2_{Res}}$$

I_L = Sum of rated currents of the parallel arc-suppression coils in the relevant substation
I_{RES} = Earth fault residual current of the of the system, r = reduction factor

Advantages of the "GLOBAL" bonding/ earthing system.



- The fault current will be limited to max. 2000 A of the zero point resistance 10-15 Ω, cut-off max. 0.5 s
- At 50 Hz, the resistance in 50 mm2 copper is about 350 mΩ per Km
- If all the fault current runs in the 50 mm2 copper, it gives a voltage drop of < 1 V pr/m
- "EPR" U_T will not be measurable

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Green Power! Wind and sun!

Global earthing is the optimal solution!

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"Green Power"! Wind and sun!

Global earthing is the optimal solution!

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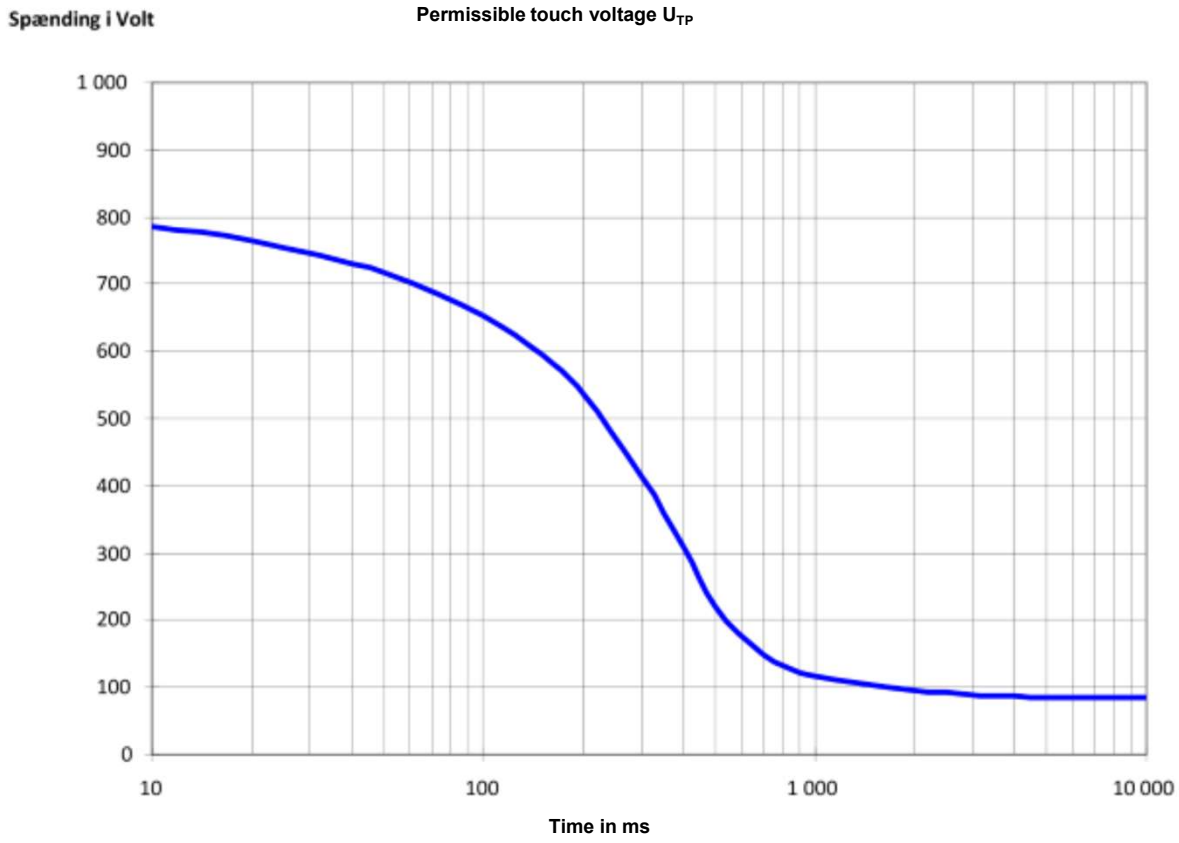
A few simple calculations in conclusion:

We have from a RE plant 2 km 150 kV 3x 1 conductor cables, 630 mm2/95 mm^2
We have placed a 1 x 95 mm^2 copper in the cable trace. It is a direct system-grounded network with a switch-off time of 0.3 s. I_K max. is 20 kA. 95 mm^2 copper has a resistance of 200 mΩ per 1000 m, so the total resistance is 400 mΩ.
At the 20,000 A, this gives a voltage drop of 8000 V, i.e. 4 V per m. Since the current is shared by a total of 4 pcs. 95 mm^2, it gives a maximum of 1 V per m!

Figure 4 in DS/EN 50522



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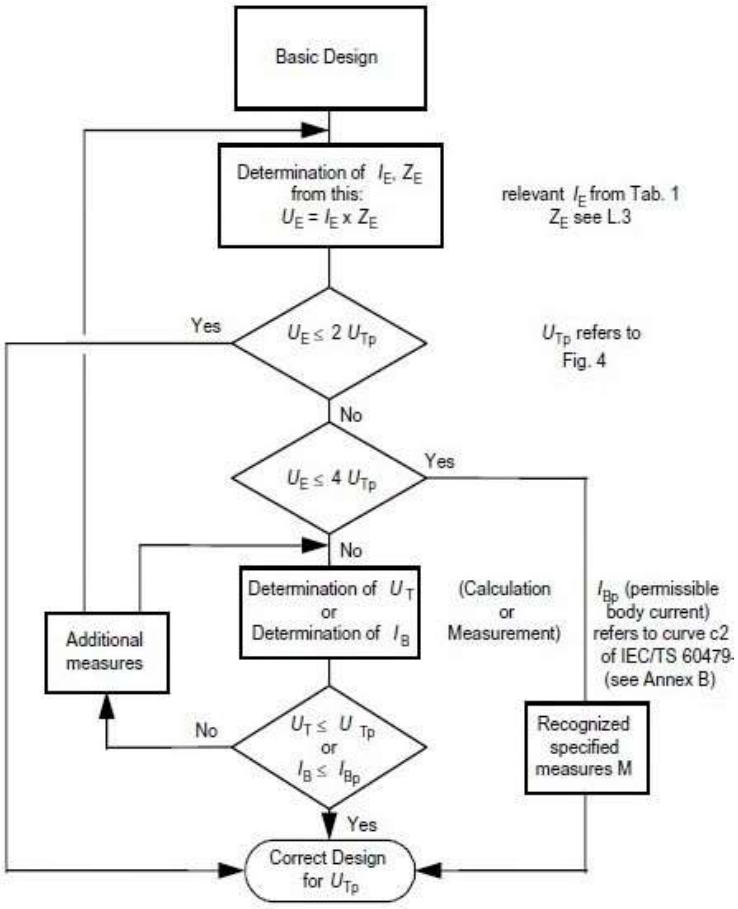

Figure 5 - Design of earthing systems, if not part of a global earthing system (C1 of 5.4.2), with regard to permissible touch voltage U_{Tp} by checking the earth potential rise U_E or the touch voltage U_T

Flow diagram for basic design DS/EN 50522

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New terms for power plants and electrical installations in place of; “earthing and bonding"?

Bonding and global earthing!
No PEN conductors!

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It is reference and thus equipotential bonding that is the most important measures which ensures the achievement of EMC and optimal personal protection!

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