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Accidental interruption of the Neutral connection and surge protection!

The problems and severe damage caused by accidental interruption of the neutral conductor in installations where many single phase equipment loads are connected to a star point-coupled three phase transformer are known, but not very well described in the standards and regulations.

If the Neutral connection is interrupted up stream in installations where several single-phase equipment's are connected to the three different phases, an uneven load on the phases will give a voltage over the single equipment, determined by different sizes of the load on the three different phases.

If loads were similar (or equal) on all three phases, the voltage at star point would be zero, and there would still be the nominal 230 V voltage over the individual equipment.

But if the loads are greater on one phase than on the other phases, the voltage at the star point will raise toward the voltage of this phase, reducing the voltage over the load. Consequently the voltage will rise over the equipment with the lower loads, and in the worst case, it will approach the phase-phase voltage of 400 V.

This will quickly lead to an overload of the power supplies in the equipment, often starting with the active components in the entrance filters for achievement of EMC , and this problem would proceed to the power supplies at the other phases, and finally burn most power supplies of, like a domino effect.

The problem can easily be simulated and demonstrated graphical!

Protection against damages caused by the disruption of the neutral connection can simply be achieved, only by a voltage monitoring between the star point and Earth, providing and immediate interruption of the supply.

An overlooked but effective solution of this problem is the use of delta connected transformer for single-phase loads, with nominal voltage of 230 V rms between the phases.

One of the phases can be connected to earth, and the system is defined as TN-system, but it can also be defined as insulated (IT-system), supervised with insulation monitoring equipment connected to one phase, increasing the operation safety making it possible to continue the operation by a single earth fault.

No interruptions of neutral or phases will course overvoltage.

Surge Protection:

Surge protection has none, or only very limited protective effect when the conductor to the neutral is interrupted.

If surge protection is installed before the neutral breakage, the SPDs will experience no voltage increase.

If the surge protection, however, is added after the neutral breakage, they will not in this case within a sufficiently short time cause the fuses to blow and thus interrupt the supply.

According to the standards, the SPDs must be selected for a rated voltage that takes temporary overvoltage into account, instead of the operational problems with arresters failures under normal operating conditions, see IEC 60364-5-53, copied in beneath.
In note 2 is mentioned directly; that loss of Neutral are not covered, but that installed arresters (SPDs) must fail "safely" by an overload. Which means; must function correctly under this condition

534.2.3.3 Selection with regard to temporary overvoltages (TOVs)

The SPDs selected according to 534.2.3 shall withstand the temporary overvoltages due to faults within low-voltage systems (see clause 442 of IEC 60364-4-44).

This is confirmed by the selection of SPDs which comply with the relevant test requirements of 7.7.6 of IEC 61643-1.

To fail safely in case of TOVs due to earth faults within the high-voltage system (see IEC 60364-4-44, clause 442), the SPDs connected to the PE shall pass the test of IEC 61643-1 subclause 7.7.4.

In addition, SPDs installed in location 4a according to figure B.2 shall withstand such TOVs as defined in test of IEC 61643-1 subclause 7.7.4.

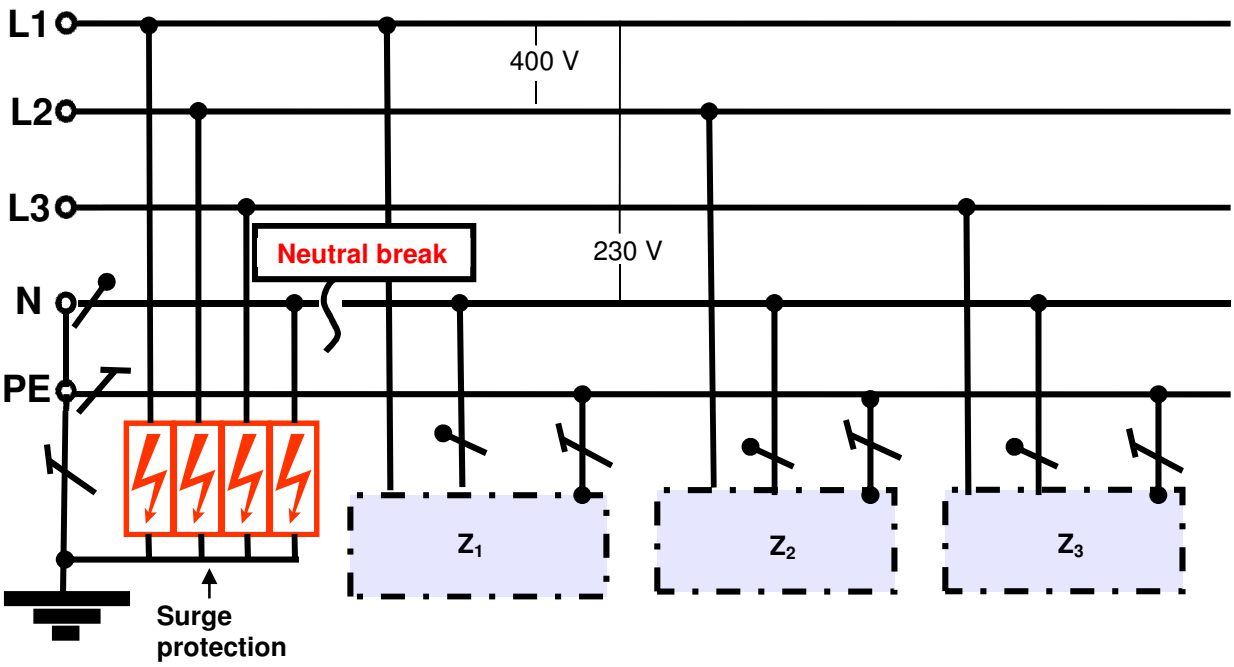
NOTE 1 Appropriate pass criteria are under consideration to define the meaning of withstand.

NOTE 2 The loss of neutral is not covered by these requirements. Though there is currently no specific test in IEC 61643-1, SPDs are expected to fail safely.

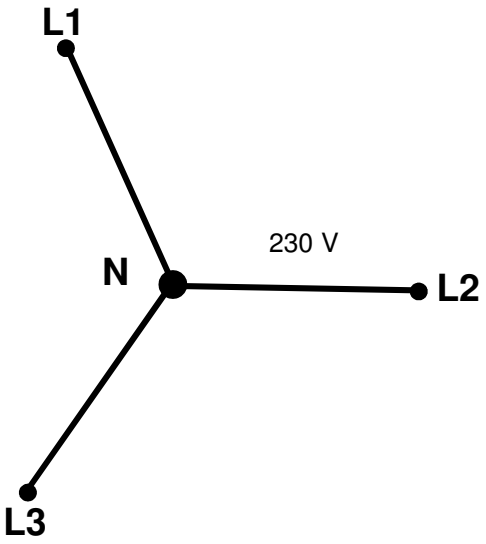
An SPD for 230 V (Ur 275) will typically be able to withstand a TOV (temporary overvoltage) at 315 V in 5 sec, but during this time duration, the small ZnO- varistors in the filters of the power supplies of the equipment, will be overloaded.

View principle sketches and graphic representation:

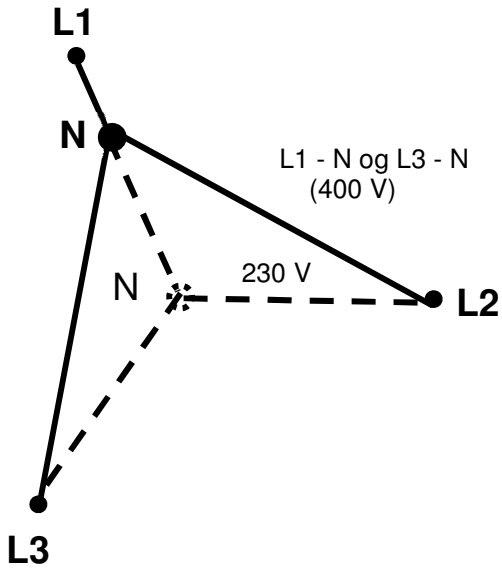
TN-S system; Tree phase star-coupled transformer



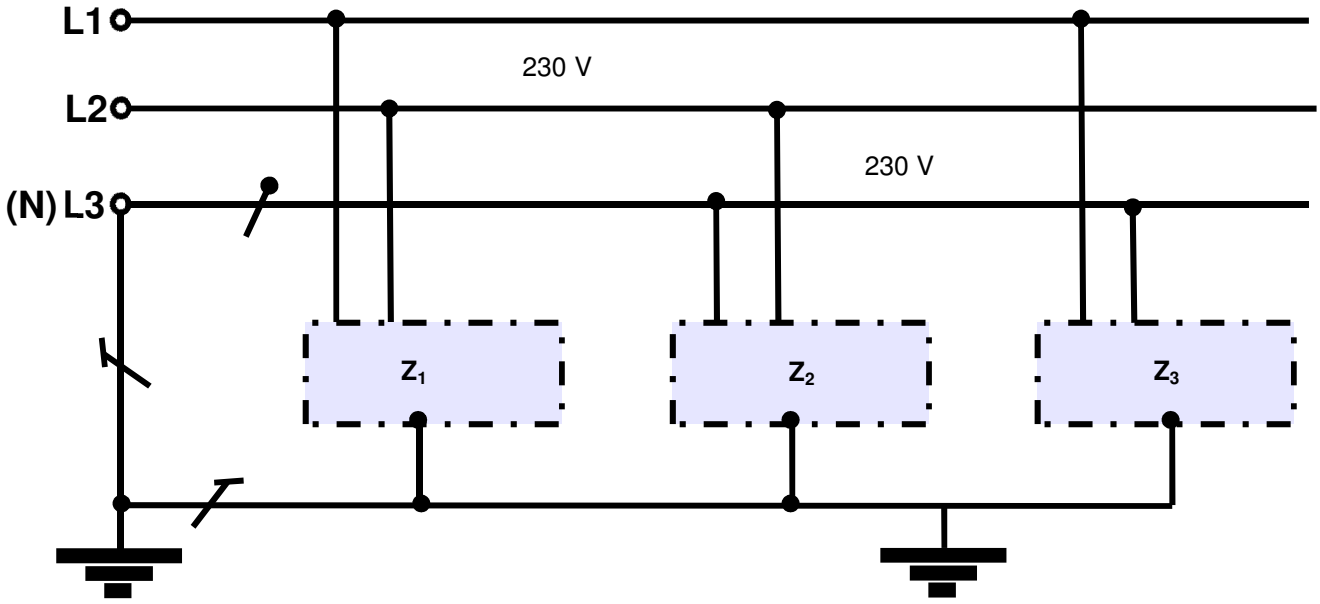
$Z_1 = Z_2 = Z_3$

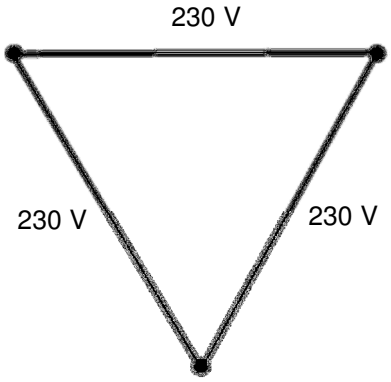


$Z_1 < Z_2$ og Z_3



TN-S-system; Tree phase delta-coupled transformer





No risk of voltage increase by fractures of Neutral conductor!

The first edition of this article was written in 2006 by Ernst Boye Nielsen, and translated to English in 2014!

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