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Neutral grounding

Studies on the selection and optimization of transformer neutral grounding in electrical networks

At a glance

During the normal operation of an electrical network, the method of neutral treatment is not decisive. In the case of a ground fault, however, it is of crucial importance. More than 80 per cent of all faults in electrical networks start as ground faults. In many regions and networks the preferred method for neutral treatment has remained unchanged for decades. In many cases, the selected method is no longer the optimum solution due to increasing demands on the networks and changes to the network structures.

Siemens Power Technologies International (Siemens PTI) offers explicit solutions for the review and optimization of neutral grounding, which is an essential task in sustainable network planning. The Siemens PTI portfolio includes:

- Measurements in the network for analyzing the present situation, data collection and verification
- Evaluation and optimization of the present method of neutral treatment
- Selection and sizing of neutral grounding equipment
- Analysis of concepts for fault localization and protection (protection coordination)
- Recommendations for future operation
- Detailed analysis of documented faults

The challenge

The selection of the optimum neutral grounding method for an individual network strongly depends on its size and structure, shares of cables and overhead lines, and also on quality requirements regarding the energy supplied.

A technical and economical optimization of the neutral treatment is particularly required in the following situations:

- Erection of a new (partial) network, e. g. in the industrial sector
- Enlargement of a network due to expansion projects or integration of neighboring networks
- Replacement of overhead lines by cables or other measures which increase the line-to-ground capacities
- Increasing level of network automation
- High investment costs for keeping the present type of neutral grounding
- Unsatisfactory level of supply reliability due to the number of outages, poor ground fault detection / localization

Our solution

In close cooperation with the client, the optimum method of neutral grounding is developed for an individual network. The following describes a typical roadmap for optimizing the neutral grounding of a distribution network:

- Technical comparison of the pros and cons of the different types of neutral grounding
- Measurements in the network including zero-sequence impedances, reduction factors, inductive coupling ground potential rise and touch voltages, as well as ground fault tests
- Review of the neutral grounding equipment and dimensioning of new equipment
- Calculation of the ground fault currents
- Analysis of the existing protection concept and requirements for new devices
- Evaluation of selectivity in case of ground faults (primary and backup protection)
- Selection of devices for ground fault localization
- Evaluation of the grounding systems of substations and ring main units
- Assessment of inductive coupling on telecommunication lines
- Compilation and comparison of equipment costs for the considered variants
- Proposals for network conversion actions

Application example 1

In this project, the network operator had to decide whether to invest in the adaptation of resonant grounding (RNG) or in the installation of low-impedance neutral grounding (LNG). The assessed 20 kV partial networks mainly were of urban character with only a small share of overhead lines (figure 1).

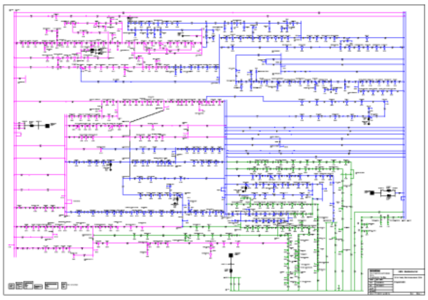

Figure 1: Present status of the three partial networks (schematic view)

First, the zero-sequence impedances of the decisive cable types were measured
(figure 2). The inductive coupling on telecommunication lines and the grounding conditions at typical and critical ring main units were determined.

Secondly, appropriate equipment for neutral grounding was selected and network calculations were performed for both options.

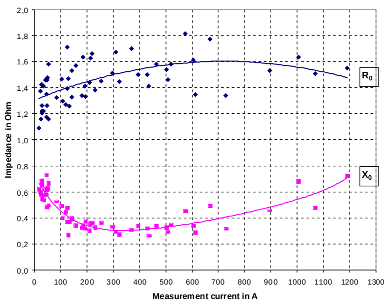

Figure 2: Measured zero-sequence impedance of a selected cable type

After a detailed assessment of both variants, it was recommended to convert one partial network immediately and to temporarily operate two partial networks with short-term LNG. These were to be converted in medium term after adequate measures had been taken.

Application example 2

In this project, the effectiveness of the Petersen coil controller for optimum setting of arc suppression coils had to be investigated for an industrial network operated with resonant grounding.

At the beginning, the phase-to-ground voltages and the neutral-to-ground voltage were measured. Then the resonance curve of the network was recorded (figure 3). Finally, the control process was verified by partial shutdown of cable sections in the network.

It was found that the installed Petersen coil controller was not capable of dealing with the present conditions, and thus, an automatic control process was not initiated. Therefore, the installation of an appropriate new Petersen coil controller was recommended.

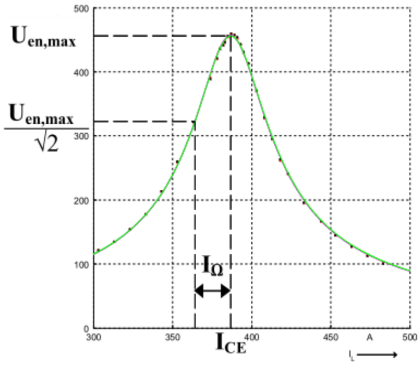

Figure 3: Resonance curve analysis

Application example 3

For a planned offshore wind farm the suitable method for neutral grounding for the 33kV level had to be determined. Both, the damping of ground fault currents and the proposed protection concept had to be considered. It was recommended to operate the 33 kV level with low-impedance neutral grounding and limit the single-phase short-circuit current to a maximum of 500 A. For this concept, location and parameters of the required grounding transformers were determined. Furthermore, guidelines for normal operation and emergency operation were developed. Figure 4 shows the recommended approach.

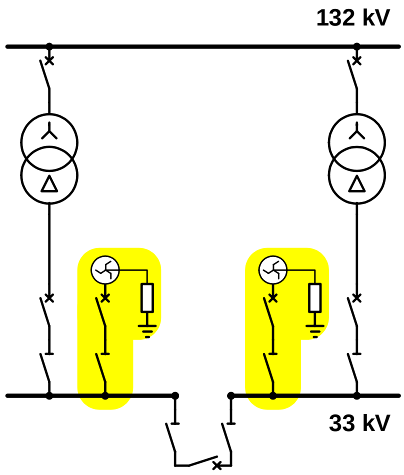

Figure 4: Recommended concept

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