Toward the Improvement of Earth Potential Distribution in Electrical Substations under Fault Conditions

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***Abstract*— Earthing systems in electrical substation should be of the highest integrity and of robust construction in order to help with the protection of equipment without endangering the health and safety of individuals. For this purpose, several parameters are described by international standards to meet earthing requirements. These parameters include not only earthing resistance, but also touch and step voltages as well as the transfer voltage. In this light, minimizing the high values of potential on earth surface become a challenging issue in earthing system design, especially at high frequencies or in less conductive soils. The performance of several arrangements is studied in this paper to extract better design practices and mitigating dangerous earth potential. Simulations using CDEGS are conducted using combinations of earth electrodes subjected to currents of variable frequency up to ten megahertz. Earthing impedance along with potential distribution, touch and step voltages are presented and discussed. The results show that dangerous potential can be developed at the injection point, which require a special attention to properly define the requirements at this location under different conditions.**

Background & Main Results

During fault conditions, electrical currents may flow from an energized conductor to the earth. This flow can generate potential gradients within and around the impact point (generally near to transformer or surge arrester). Unless proper precautions are taken in design, the maximum potential gradients along the earth's surface may be of a considerable magnitude to endanger a person within the corresponding area [1]. Therefore, a properly designed earthing installation is the first thing to think about in any protection measures against these currents as well as the associated risk. In this light, different earthing arrangements are considered in this work where the same quantity of conductor is selected, aiming to find the best configuration in terms of impedance and potential distribution, increasing the effective length of each earth electrode [2]. Figure 1 illustrates an example on how potential distribution (and consequently the safety measures) can be improved under the same conditions.

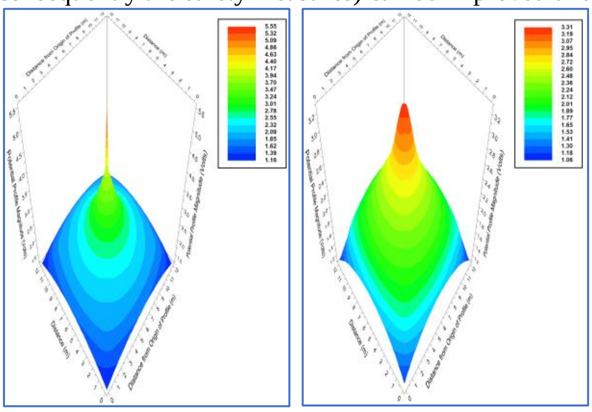

Figure 1: Earth surface potential for 1 MHz current and 10x10 m^2 earth grid of 100 meshes. (left) original system, and (right) adjusted system.

Under the same conditions, a considerable reduction in earthing impedance can be obtained at low frequencies by increasing the burial depth. At this frequency range, potential distribution is approximately uniform across the system. However, potential distribution is no longer uniform and a peak of very high magnitude is characterising the injection point, especially at high frequencies. In order to reduce such a peak of potential, earthing arrangements are adjusted to increase the effective length of the earth conductors with additional insulated conductors at the injection point. Further details and results will be presented.

Conclusions

Numerous configurations and techniques can be used to reduce the potential distribution on earth surface under low frequency currents. For higher frequencies, however, inductive behaviours can characterise the injection point systems, especially for large-scale systems buried in conductive soils. In order to minimize the significant impedance rise at higher frequencies, a solution technique is used to improve the current division in earthing conductors and improve the performance of systems.

References

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