

DESIGN OF GROUNDING SYSTEMS IN SUBSTATIONS BY ETAP INTELLIGENT SOFTWARE

N.M. Tabatabaei¹ S.R. Mortezaei²

¹ Electrical Engineering Department, Soraj Higher Education Institute, Tabriz, Iran, n.m.tabatabaei@gmail.com

² Electrical Engineering Department, Azarbaijan University of Tarbiat Moallena, Tabriz, Iran

Young Researchers Club, Islamic Azad University, Gonabad Branch, Gonabad, Iran, rmortezaei@yahoo.com

Abstract- Under ground-fault conditions, the flow of current will result in voltage gradients within and around the substation, not only between structures and nearby earth, but also along the ground surface. In a properly designed system, this gradient should not exceed the limits that can be tolerated by the human body. The purpose of a ground mat study is to provide for the safety and well-being of anyone that can be exposed to the potential differences that can exist in a station during a severe fault. The general requirements for industrial power system grounding are similar to those of utility systems under similar service conditions. The differences arise from the specific requirements of the manufacturing or process operations. Some of the factors that are considered in a ground-mat study are the following:

- a) Fault-current magnitude and duration
- b) Geometry of the grounding system
- c) Soil resistivity
- d) Probability of contact
- e) Human factors such as
 1. Body resistance
 2. Standard assumptions on physical conditions of the individual

Keywords: System Studies, Intelligent Software, ETAP5.0.3, Grounding Study.

I. INTRODUCTION

In designing and construction of an electric substation, one of the most important issues that must be considered is designing of protective system to the earth. Flow of the earth system, cause voltage gradients ground level which cause different parts of the earth and the reference (ground round). The potential difference should be carefully and automatically designed. This may have enough voltage to reach the safety of people in place and causes risk. In this situation, people feel exposed to high voltages between the location of two steps (Step voltage) and also if a person at this moment in contact with the ground is a metal device, the voltage between that point and exposed earth place your foot (contact voltage).

Earth system must be designed so that the order should contact voltages and maximum values possible

step event and substation where conditions are faulty. The maximum values of contact and step voltages tolerated human body should be less.

A method for designing the earth system is based on the use of the land network in the same intervals. The results using this method largely increases system costs and the need for land will be provided in addition to better meet the safety conditions, will prevent the additional costs.

In the past, papers presented for optimizing the land in these articles, but only for optimizing the parameters are considered, the length conductors earth system. In reference [1] related to voltage changes and call the number step conductors earth system to determine efficiency in reducing conductors increased contact and step voltages provided the tolerance values, has been compared to evaluate safety. In references [2, 3 and 4] study on compression ratio and its relationship with the conductors and the voltage step was to contact and appropriate compression ratio achieved with minimal contact voltage compared with the values of tolerance not to evaluate safety is. In reference [5] the help of genetic algorithm optimization of the network but the number conductors and earth have already been fixed and the purpose of minimizing voltage contact, but not compared with the values of tolerance. In reference [6] for optimizing the relationship between the earths system during consecutive meshes is considered. But the only optimization variable, the total length of network Conductors earth.

In references [7-9] genetic algorithm optimization performed by the reference [8]. The vertical rods considered but the authorities only as total length conductors earth system optimization point is variable. Considering the above observation is that all articles provided for optimizing the system, earth, only during the earth system as a whole Conductors variable optimization is considered if the studies done, other parameters of the immune system of the earth effective.

II. GROUND NETWORK DESIGN ALGORITHM

Block diagram in Figure 1 is the sort earthing studies of power networks and the algorithm can be expressed as follows:

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Optimization Methods Applied to Power Systems Francisco G. Montoya, Raúl Baños Navarro, 2019-07-26 This book presents an interesting sample of the latest advances in optimization techniques applied to electrical power engineering It covers a variety of topics from various fields ranging from classical optimization such as Linear and Nonlinear Programming and Integer and Mixed Integer Programming to the most modern methods based on bio inspired metaheuristics The featured papers invite readers to delve further into emerging optimization techniques and their real application to case studies such as conventional and renewable energy generation distributed generation transport and distribution of electrical energy electrical machines and power electronics network optimization intelligent systems advances in electric mobility etc

Consulting-specifying Engineer, 1998 **Design Analysis for Power Substation Grounding Systems** Brett Simpson Allsup, 1991 **AC Substation Grounding Design** Mamadou Keita, Arnel Q. Molina, California State University, Sacramento, 2013 This paper presents AC substations grounding system for either conventional or gas insulated The design of grounding systems of substations has the primary purpose of ensuring the safety and well being of personnel who may become electrically coupled to the grounding mats during unbalanced fault conditions El Dessouky El Aziz Khamis 1998 Phan 1990 In general an unbalanced fault will cause a ground potential rise of the system neutral and any conductive medium electrically connected to the neutral The approach of this design is based on the IEEE Standard 80 2000 which discusses the following subjects safety in grounding tolerable body current limit primary and auxiliary ground electrodes grounding enclosure sizing of conductors and materials soil characteristics ground resistance types of ground faults installation of connections pigtails ground rods and ground grid integrity test In this project general system structure as well as rules and data representations are discussed An illustrative example is presented using 15 kv medium voltage switchgear for Tri Met Portland Westside light rail Thomas Pham 1999 The ac substations grounding system design presented in this project can assist grounding system engineer to obtain a safe grounding system which is one of most important design aspects of substations Design of Substation Grounding System in a Uniform Soil Tolulope A. Dina, California State University, Sacramento, 2007 Substation Grounding System Design Ali Hamed Al-Ghafri, 1985 Calculation of Important Design Parameters for Grounding Systems in Substations Arun Balakrishnan, 1990 **Design of an AC Substation Grounding System** Farakh Nasim, California State University, Sacramento, 2007 Design of AC Substation Grounding System Ra Meas, California State University, Sacramento, 2013 The purpose for this paper is to understand the basic foundation used to safely design a substation grounding system for AC systems The following criteria that needs to be address regarding the grounding system includes field data from the site such as soil analysis the earth and grid resistance maximum fault current the conductor material size and joining methods ground rods resistivity of the soil common fault types the hazard tolerable shock voltage consisting of touch step and mesh voltage and tolerable body current limits Based on the formula and criteria

from the IEEE Standard 80 2000 calculations will be used to determine whether the substation grounding is safe by design The information provided here will help to ensure a safe environment for those working in or around the substation while protecting equipment from dangerous electrical shock under normal and faulted condition **Substation Grounding** Inna Baleva, California State University, Sacramento, 2012 Designing a proper substation grounding system is quite complicating Many parameters affect its design In order for a grounding design to be safe it needs to provide a way to carry the electric currents into the ground under both normal and faulted conditions Also it must provide assurance that a person in the vicinity would not be endangered The grounding portion of substation design will be explored In order to properly plan and design the grounding grid calculations of the following will be done maximum fault current grid resistance grid current safe touch and step voltages ground potential rise as well as expected touch and step voltage levels Background information and guidelines to design a substation grounding grid will be provided A set of equations will be presented to calculate whether the design is safe and finally an example will be provided that can be used as a template Sources of Data IEEE Std 80 2000 A safe substation ground grid was designed **Analysis techniques for power-substation grounding systems : volume 1, design methodology and tests** E. B. Joy, **Optimum Design of Grounding System of High Voltage Substations** Ossama Gouda, 2011-03 The main purpose of this article is to study the optimum design of grounding system of high voltage substations by using artificial neural network The proposed study will implement the following important contributions 1 Performance of grounding system under uniform and non uniform soil resistivity 2 Grounding by using equal and non equal spacing grids studying the performance of non equal spacing grid incase of uniform and non uniform soil 3 Grounding by grids and rods in non uniform soil and unequally spaced grids 4 Safety analysis of grounding grid with different structures 5 Designing of ANN as a tool to select the optimum grounding system 6 Performance of grounding system under transient conditions *A Study of HV Electric Power Substation Grounding System Design* Benjamin Kinyua Muita, 1983 *Grounding Systems for Electric Substations in Non-Uniform Soil* Ahmed Thabet Mohamed, Osama El-Sayed Gouda, 2014-11-14 As the number and complexity of AC substation increase the need for accurate design procedures for the grounding systems becomes more important both from safety point of view and from financial considerations The boring test samples and other geological investigations often provide useful information on the presence of various layers and the nature of soil material as its resistivity and the range of values at the site THIS BOOK discuss New theoretical developed methods for calculation the earthing resistance and earth surface potentials of variant electric substation earthing systems i e starting from a grid consists of one mesh or rod to a final design consisting of many regular meshes or rods respectively An experimental work is carried out on an improved scale model to study the behavior of earthing systems in non uniform soil structure *Grounding Grid Design for High Voltage Substations* Farhan bin Hanaffi, 2016 An electrical grounding system is an important element to ascertain a safe environment for both humans and equipment during fault or transient conditions

The performance of grounding systems under lightning current is quite different from the conventional frequency based power In order to understand the grounding grid behaviour under lightning current researchers typically carry out experiments on actual grounding systems or on laboratory scaled models Although experiments can provide insights of the actual grounding operation the shortcoming is that a large area of lab space is required which reflects into high costs As an alternative computer simulation has been introduced and can be categorised into three different approaches namely circuit approach transmission line approach or electromagnetic approach In this work the simulations are performed based on the electromagnetic approach under three dimensions 3D mode due to its accurate results For further understanding a comparison between circuit and electromagnetic approaches is also carried out where the resulting outcome shows that the circuit approach underestimates the impulse impedance at injection point compared with simulations by the electromagnetic approach When the electromagnetic approach is applied a finite element method is used to solve the partial differential electromagnetic equations in the time domain Thereafter the simulations results are validated with the existing published results covering the electromagnetic simulations by using the method of moment MOM and as well as actual field experiments In addition simulations are performed to understand the effect of different parameters including lightning current soil parameters grounding design and location of injection point of lightning current Moreover a comparison study is carried out for potential rise between power frequency and impulse current at different grid sizes The study shows the potential generated at injection point for both current and saturation point when the grid size reaches a certain point It s important to consider both types of current to get better grounding grid design Besides that empirical equations are used out to calculate the effective area under lightning conditions where the effect of the down conductor is taken into consideration as part of the grounding model The effective area is an important parameter for the optimization of the grounding grid design when increasing grounding size does not improve the impulse impedance Transient ground potential rise TGPR above the ground is another interesting parameter to analyse In this work a good correlation is shown between the effective area and the impulse impedance at the injection point with rising transient ground potential It is found that the TGPR is larger when it is closer to the injection point but only lasts for a few microseconds Step voltage evaluations are performed for different standing positions of the human above the grid including the distance of the step voltage location from the injection point and the effect of grid size to step voltage value

Substation Grounding Optimization Vadim Balev, Pravesh Charan, California State University, Sacramento, 2013 Substation grounding is a critical part of the overall electric power system It is designed to not only provide a path to dissipate electric currents into the earth without exceeding the operating limits of the equipment but also provide a safe environment for any people that are in the vicinity Design of a proper grounding system will be discussed as well as performing of calculations necessary to ensure a safe design Aspects of soil resistivity measurements area of the ground grid calculation of tolerable limits of current to the body typical shock situations

tolerable touch and step voltages maximum fault current grid resistance grid current ground potential rise and benefits of surface materials will be discussed Simulation software will also be discussed and its functionality in a step by step manner Sources of Data IEEE Std 80 2000 was used as the primary source of information Conclusions Reached An adequate grounding grid has been designed using concepts outlined in IEEE Std 80 2000 and applied into programming and simulating results in MATLAB *High Voltage Grounding Systems* Gary Gilbert,2011 Minimization of Construction Costs of Substation Grounding Grids In every electrical installation one of the most important aspects is adequate grounding in particular the grounding of high voltage substations to protect people and equipment in the event of an electrical fault Well designed grounding systems ensure the performance of power systems and safety of personnel It is desirable that the substation grounding provides a near zero resistance to remote earth The prevailing practice of most utilities is to install a grid of horizontal ground electrodes buried bare copper conductors supplemented by a number of vertical ground rods connected to the grid and by a number of equipment grounding mats and interconnecting cables The grounding grid provides a common ground for the electrical equipment and for all metallic structures at the station It also limits the surface potential gradient Currently the IEEE 80 2000 standard for substations grounding limits the determination of the grounding parameters namely step touch and ground potential rise to that of a uniform soil model unless the Sunde graphical method is used With the Sunde graphical method it relies on interpretation to obtain a two layer soil model Without the use of the graphical method the IEEE 81 1983 has several empirical equations that can be used for the two layer model however these equations rely on the use of images which retard the speed of calculations to the point where the overall optimization of the grounding grid with respect to size and shape has yet to be determined The goal of the thesis was to improve upon the current restrictions for the grounding grid design while minimizing the material i e copper conductors and installation costs of a grid

Calculating and Testing of Substation Grounding Systems Alexander Farber,2013-09-29 **Design Parameters of Electrical Network Grounding Systems** El-Sayed Gouda, Osama,2017-12-01 As the demand for efficient energy sources continues to grow around the globe electrical systems are becoming more essential to meet these increased needs As these systems are being utilized more frequently it becomes imperative to find ways of optimizing their overall function Design Parameters of Electrical Network Grounding Systems is a critical scholarly resource that examines safe grounding designs of electrical networks Featuring coverage on a broad range of topics such as cathodic protection of grounding grids grounding connections and soil resistivity evaluation this book is geared towards academicians practitioners and researchers seeking current research on electrical networks *Practical Methods for Analysis and Design of HV Installation Grounding Systems* Ljubivoje M. Popovic,2018-02-20 Practical Methods for Analysis and Design of HV Installation Grounding Systems gives readers a basic understanding of the modeling characteristics of the major components of a complex grounding system One by one the author develops and analyzes each component as a standalone element but then puts them together considering

their mutual disposition or so called proximity effect This is the first book to enable the making and analysis of the most complex grounding systems that are typical for HV substations located in urban areas that uses relatively simple mathematical operations instead of modern computers Since the presented methods enable problem solving for more complex issues than the ones solved using National IEC and or IEEE standards this book can be considered as an appendix to these standards Develops general equations of lumped parameter ladder circuits Includes the analytical expression for determination of ground fault current distribution for a fault anywhere along a cable line Presents measurement and analytical methods for the determination of actual ground fault current distribution for high voltage substations located in urban areas Provides the analytical procedure for the determination of the critical ground fault position for faults appearing in outgoing transmission lines Defines testing procedure for the correct evaluation of grounding systems of substations located in urban areas

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