EARHTHING PERFORMANCE OF HV/MV SUBSTATION AND ITS EFFECT ON NEARBY STRUCTURES

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A project report submitted in partial fulfilment
of the requirements for the award of the degree of
Master of Engineering (Electrical-Power)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JUNE 2015

Specially dedicated to my beloved parent,

Rahimin bin Ismail and Norhayati binti Lop Ahmad,

my lovely wife Noriratul Mazuin Binti Mazani,

my doughter Nurin Auni Irdina, in-laws parents, families and siblings,

whom endlessly supporting me throughout my journey of education.

ACKNOWLEDGEMENT

In the name of Allah, Most Gracious, Most Merciful, Praise be to Allah, the Cherisher and Sustainer of the Worlds. With His permission I have completed my Master Degree of Electrical Engineering (Power) and hopefully this works will benefit the development of the Ummah all over the world.

I would like to express my sincere gratitude to my supervisor, Prof. Dr. Zulkurnain Abdul Malek, who has supported me throughout my work with his guidance, patience, motivation, enthusiasm and enormous knowledge whilst allowing me the room to work in my own way. I attribute the level of my Master Degree to his encouragement and effort which without him this report would not have been possible to be written and completed. It is an honor for me having this opportunity doing the project under his supervision.

In preparing this project report, I was in contact with several people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts In particular, I would like to convey my deep sense of appreciation to TNB staff from Transmission Division and TNBR for their guidance, helps, and advices throughout the progress of the project.

Last but not least, my sincere appreciation also extends to all my family, colleagues, administrative staffs at Faculty of Electrical Engineering, UTM and others who have provided assistance at various occasions. Their views and tips are useful indeed. I owe my deepest appreciation to my beloved wife Noriratul Mazuin Bt Mazani for supporting me spiritually throughout my life. May Allah s.w.t will bless all of you.

ABSTRACT

Nowadays, with more of suburban area developed into an urban area, power system for transmission and distribution have become more critical with the growing of load demand in the area. A substation, previously located away from other other structures, are now standing next to residential buildings and other public structures, raising concerns over public safety factor. Increasing energy demands have caused the utility company to increase the capacity of a substation, and hence consequently increases the system fault current level. The existing and installed earthing grid systems had incorporated the safety factor based on the old fault current level, which is now may not be sufficient for the new fault current level capacity. During the propagation of fault current, there exist the earth potential rise (EPR) along the conductor at the surface of the soil, the touch potential (TP), and the step potential (SP), all of which may become lethal when over a certain level. The values of ERP, TP and SP must comply to the safety level as described in the IEEE 80-2000 standard. Several factors that contribute to the ERP value are the fault current level, soil resistivity and grid geometry. The CDEGS (Current Distribution, Electromagnetic Fields, Grounding and Soil Structure Analysis) software was used to analyse the effects of changes in the fault current level, soil resistivity and grid geometry to a substation earthing grid performances as well as to the earthing grids of nearby structures. Simulation results show that TP and SP values at nearby structure are significantly increased with the increasing of fault current and soil resistivityIn the worst case, the TP increases to more than 4000% and the SP to more than 5000%.Appropriate improvements to the existing substation earthing grid system, namely, increment in the mesh conductor numbers, increment in the number of installed vertical rods, and incremment in the depth of the vertical rod, were proposed. Simulation results shows the proposed improvement methods significantly improve the TP and SP values.

ABSTRAK

Pada masa ini, banyak kawasan pinggir bandar telah membangun menjadi kawasan bandar, sistem kuasa untuk penghantaran dan pengagihan telah menjadi lebih kritikal dengan pertambahan permintaan beban di kawasan tersebut. Sebuah pencawang dahulunya terletak jauh dari struktur-struktur lain lain, kini terletak bersebelahan dengan bangunan-bangunan kediaman dan struktur-struktur awam lain dan ianya telah menimbulkan kebimbangan terhadap faktor keselamatan awam. Keperluan tenaga yang bertambah telah memaksa syarikat utiliti meningkatkan keupayaan pencawang terlibat, dan ini telah sekaligus meningkatkan tahap arus rosak sistem sedia ada. Sistem grid pembumian pencawang sediada telah menggabungkan faktor keselamatan berdasarkan tahap arus rosak lama, yang berkemungkinan tidak mencukupi untuk kapasiti paras arus rosak yang baru. Semasa pengagihan arus rosak, wujud kenaikan potensi bumi (EPR) di permukaan tanah di sepanjang konduktor. Potensi sentuhan dan potensi langkah (SP) (TP) akan terhasil, yang mana ianya mungkin membawa maut apabila melepasi satu tahap tertentu. Nilai ERP, TP dan SP mestilah mematuhi tahap selamat sebagai ditetapkan di dalam piawaian IEEE 80-2000. Beberapa faktor yang menyumbang kepada peningkatan nilai ERP ialah tahap arus rosak, kerintangan tanah dan geometri grid. CDEGS (Current Distribution, Electromagnetic Fields, Grounding and Soil Structure Analysis) ialah perisian yang digunakan untuk menganalisis kesan dari perubahan tahap arus rosak , kerintangan tanah dan geometri grid kepada kecekapan grid pembumian sebuah pencawang, serta grid pembumian struktur-struktur berdekatan. Keputusan simulasi menunjukkan bahawa nilai TP and SP di struktur berdekatan nyata sekali bertambah dengan penambahan arus rosak dan nilai kerintangan tanah, di dalam kes terburuk, nilai TP bertambah sebanyak lebih 4000% dan SP bertambah lebih daripada 5000% daripada nilai normalnya. Penambahbaikan yang bersesuaian boleh dilakukan kepada sistem grid pembumian pencawang sediada, iaitu dengan menambah bilangan konduktor pada grid, meningkatkan jumlah dipasang rod menegak dan mendalamkan kedalaman rod menegak, telah dicadangkan. Keputusan simulasi menunjukkan kaedah penambahbaikan ini dapat memperbaiki nilai TP and SP.

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CHAPTER 1

INTRODUCTION

1.1 Background

By definition, earthing is the practice of establishing electrical connection between metallic frame of equipment, structures or electrical circuits, and a metallic grid which is normally buried in the soil. The purpose of the earthing practice is to maintain such parts at zero potential or at the same potential with respect to the earth, thereby preventing the presence of dangerous or undesirable potential differences between adjacent parts. Earthing systems also used as earth fault currents detection by protective relaying systems beside provide low impedance paths through the earth for load currents. In other application, earthing systems are used to shield control cables and other low voltage wiring from the effects of electromagnetic interference (EMI) and capacitive coupling by minimizing system the voltages. Electrical surge, such as lightning discharges, fault currents caused by earth fault conditions, and switching currents caused by normal system operations can caurse potential differences in elsectrical substations and other facilities. In the event of fault current travel through the earth grid and other metallic earth conductors produces earth potential rise (EPR) which can be dangerous to humans and may cause damage and malfunction to equipment and systems.

Electrical substations, being electrical facilities meant for transformation of system voltages from one level to the other are common places for generation of EPR during earth faults and other system abnormalities. Therefore, it is very crucial to provide an effective earthing system in this facilities. In normal practice, an earth grid is installed in the form of horizontal conductor meshes and sometimes combined with vertical earth rods to ensure the safety of personnel and equipment within the substation and also the safety of humans and livestock in its vicinity area. There are three main purpose of the substation erthing grid which is to safely carry and dissipate fault currents into the earth both under normal and short-circuit conditions, discharge lightning strokes to earth and reduce step and touch potentials to safe levels and facilitate fault detection by protection relays.

To design an effective grounding system, these basic requirement should be take into consideration.

(a) The resistance of the earthing grid to remote earth must be sufficiently low to ensure operation of the earth fault protective relays at the substation and along lines and cables connected to it.

(b) The earth potential gradient within and near the substation should be such that under earth fault conditions, ‘step’ and ‘touch’ voltages are confined to safe levels.

(c) The earthing grid must be isolated from services entering the substation to prevent transfer of earth potentials to telephone lines, water mains, railway sidings in event of earth potential rise (EPR) in the substation, which may be in kilovolts at times.

(d) The earthing grid should have sufficient capacity to carry the maximum earth fault currents liable to be imposed on it without overheating, suffering mechanical damage or undue ionization of soil around buried earth electrodes and conductors.

1.2 Problem Statement

Required power of the big cities keeps growing every years. With this significant numbers of growth, it is necessary to establish new high voltage (HV) or medium voltage (MV) substation to satisfy power demand in densely populated urban areas. The area available for installing HV/MV substation is restricted and becomes more and more expensive in the city.

Considering this condition, earthing resistance of the substations must be low enough to satisfy safety (step voltage, touch voltage, earth potential rise) and electromagnetic compatibility requirements (earth potential rise, potential difference inside the station affecting the secondary wiring). With more of suburban area developed into urban area, substation which are previously located far from other building are now standing side-by-side with other residential and public building. This situation can not be avoided due to limitation of available land for development. This can get even worse when the current substation have to be upgraded with higher capacity of transformer to cater for increased of energy demand in the area. In order to provide a safety condition for adjacent facilities, the current grid system have to be re-analysed to include these factors. This work aims to provide safety analysis on the adjacent earthing grid system.

1.3 Objectives

The objectives of this work are:

1. To simulate and analyse the performance of substation earthing grid system with the changes of fault current level and soil resistivity value. The observed parameters are ERP, TP and SP.
2. To simulate and analyse ERP, TP and SP values on nearby structures affected by changes of fault current and soil resistivity.
3. To propose methods to improve the substation grid performance and to carry out simulation of the proposed methods to evaluate their effectiveness.

1.4 Scope of the Project

The main scopes of this research are as follow:

i. Study and analysis is based on 132/33kV Substation grid system which is typically installed in TNB system.

ii. Analysis on soil resistivity are based on example of actual reading from new in construction 132/33kV Setia Alam Substation.

iii. Substation grid system for urban area are assumed as 100mx50m area to simplify the simulation study.

iv. Simulation and analysis performance of substation grounding system by using CDEGS software as for below case study:

   a. Increase of fault current level from 10kA to 30kA.

   b. Improvement of the substation earthing grid design to meet IEEE standard of safety level.

v. The simulation result and discussion will focus on Step Potential and ground potential rise.

1.5 Report Outline

Report writing is conducted in order to document the project's objectives, scopes, methodology and the results. All methodology involved is documented and explained in detail for understanding purposed.

This project report consists of six chapters. In Chapter 1, the project is elaborated clearly including the objectives and scopes of the project. In Chapter 2, the literature review of previous study and gap. In this chapter also will explain principles of Earth potential Rise (EPR) thoroughly for deeper understanding. Chapter 3 will explain the development model used in CDEGS simulation and simulation steps. In Chapter 4, all the result obtain from CDEGS simulation for all 4 study cases and in chapter 5 will focus on improvement method to main earthing grid. Chapter 6, will elaborate the conclusion and recommendation for future work

4.2 Recommendation for Future Study

For the future study, it is recommended that study can focus on improvement of earthing grid system performance under worst case scenario with soil4 characteristic and 30kA fault current level. This project can be improve by performing the following:

i. Research on soil improvement material, a technique to improve soil resistivity.
ii. Research on earthing grid improvement method, in example Sphere type earthing and plate type earthing.
iii. Research on other method to improve earthing grid system performance.

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