AN ELECTRO-MAGNETIC TRANSIENT (EMT) ANALYSIS ON A 132 kV RATED CU/XLPE/SCW/MDPE CABLE SYSTEM AND ITS RELATED NETWORKS

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ABSTRACT

For the past few decades, underground cables have been extensively used to replace overhead line system which is prone to damages due to environmental phenomena. Given the wide range of advantages it offers, there is also a need to investigate whether or not lightning transient can cause underground cable insulation puncture or breakdown as it does to the overhead lines. This project was performed to investigate the likelihood of insulation failures on underground cables due to lightning currents and its induced voltages. Analysis and simulation were carried out using CDEGS software programming to determine whether or not electromagnetic transient induced by lightning can initiate overvoltages and overcurrent hence causing failure on the underground cables. A network system consisting of 132 kV Cu/XLPE/SCW/MDPE cable with a span of 150 meters was modeled into the HIFREQ module and a lightning surge was injected into the system. The significant and critical conditions of a 132 kV rated cable system that can cause insulation failure or breakdown was examined, taking into consideration the electric breakdown characteristics and some other important parameters of the system. The induced electromagnetic fields and voltages were obtained in time domain representation using Inverse Fast Fourier Transform method. The studies showed that for the varied parameters, there is no event severe enough to commence any insulation puncture in the underground cable system.

ABSTRAK

Kebelakangan ini, kabel bawah tanah telah mula digunakan secara meluas bagi mengantikan kabel talian biasa yang sangat mudah terdedah kepada bahaya yang berpunca dari fenomena alam semulajadi seperti kilat. Walaupu kabel bawah tanah sering dikaitkan dengan pelbagai kelebihan, kita masih perlu meneliti samada kilat boleh mengakibatkan kerosakan pada penebatnya sebagaimana yang selalu berlaku pada kabel talian yang biasa. Analisa ini telah dijalankan untuk mengkaji kemungkinan berlakunya kerosakan penebat pada kabel bawah tanah yang diakibatkan oleh arus kilat dan voltan yang terhasil daripadanya. Simulasi komputer dijalankan dengan menggunakan perisian CDEGS bagi mengesahkan samada ketidakstabilan elektromagnet yang terhasil dari kejadian kilat mampu mengakibatkan voltan atau arus lampau sekaligus merosakkan kabel bawah tanah tersebut. Sebuah rangkaian sistem mengandungi kabel Cu/XLPE/SCW/MDPE dengan kadar 132 kV sepanjang 150 meter telah dimodelkan ke dalam modul HIFREQ dan kejutan kilat disuntik kepadanya. Sebarang kondisi yang utama untuk sistem tersebut yang boleh menjadi punca kepada kerosakan penebat telah dikaji dengan mengambilkira faktor-faktor yang boleh menyumbang kepada kemusnahan elektrik dan beberapa parameter penting yang lain. Medan elektromagnet dan voltan yang terhasil telah diperolehi dalam bentuk masa dengan menggunakan cara IFFT. Kajian ini mendapati bahawa dengan parameter yang telah divariasikan nilainya, tidak terdapat sebarang aktiviti bahaya yang boleh mengakibatkan kemusnahan penebat pada sistem kabel bawah tanah tersebut.

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CHAPTER 1

INTRODUCTION

1.1 Lightning Induced Voltage On Underground Cable System

Underground cable systems are built out of reach and eyesight which make observation, detection and fixing of its design and installation problems not as easy as it is for the overhead cable system. When installing for an underground cable system, proper selection and installation of materials should be considered. To reduce possibilities of future failures, cable systems should be placed in a hospitable environment.

Being out in the open, an overhead cable system is prone to environmental phenomena such as lightning strikes. Although underground cables are not exposed to direct lightning strikes the way an overhead system does, there are a number of ways that lightning can induce currents and voltages into the underground power lines. There are there major ways over which lightning strokes can cause secondary transients namely by earth currents, atmospheric transients and electromagnetic pulses.

During a strike, all charges dissipate to the extinction point very rapidly. This dissipation becomes an induced mini-stroke that looks like a transient current on the ground and on electrical systems. Due to the fast discharge, the rate of change of current will generate transient voltages across the inductance of wires and the earth.

Insulated materials will also engage with these charges which are not able to be released within the strike neutralization period (usually less than 100 microseconds) and will be bounded on the material. When the surroundings are neutralized, the potential difference between them results in secondary arc and is a major cause of flammables related fires.

Varying electrostatic field between the lightning storm cell and earth causes atmospheric transients. The varying electric field induces high voltage transients on any wires within the field. An increase in the elevation of these wires will increase the induced voltage.

Electromagnetic pulse created by lightning within a magnetic field will induce voltages on any nearby conductors. A maximum rate of change of current value 500 kV/μs can be reached with induced voltages of millions of volts but with low energy level.

1.2 Objectives of Analysis

This analysis was carried out with the intention to investigate the effects of lightning currents and its induced voltages on an underground cable system over various conditions.

This analysis also aimed to verify whether or not the electromagnetic transient induced by lightning can initiate any over voltages or over currents within the system thus causing failure on the underground cables.

1.3 Problem Formulation

The analysis was carried out on a 132 kV Cu/XLPE/SCW/MDPE underground cable having a span of 150 meters. The single phase circuit has its sheath grounded with both-end-bonding method. Along the cable span, two straight-through joints were installed.

There are undoubtedly many possible factors that can cause failure to the system but this analysis particularly intended to prove that lightning currents and its induced voltages on the conductor are the main reasons for the recently observed and reported insulation failure.

1.4 Scope of Project

This project emphasizes on the significance of voltages and electromagnetic transients induced when lightning currents were injected into the aforesaid system. A series of software simulations were carried out and the results were thoroughly analyzed for the determination of any significant or critical conditions of the system that can cause insulation failure or breakdown.

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