IT 002 – SOBRETENSÕES EM SISTEMAS DE ENERGIA ELÉTRICA

Trabalho Final

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11 de junho de 2021

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Fazer uma apresentação em grupo (4 pessoas) sobre o conteúdo de um artigo a ser selecionado.
Duração para cada grupo: 25minutos, sendo 15 de apresentação e 10 para perguntas do professor e colaborador da disciplina.
Dia da apresentação: 25/06/2021;

Perguntas relacionadas sobre o objetivo do artigo, relação com a disciplina IT002 e as contribuições do trabalho;

Artigos serão disponibilizados no site da disciplina IT 002;

Artigo 1

General Formulas for Lightning Impulse Impedance of Horizontal and Vertical Grounding Electrodes

Leonid Grcev, *Life Fellow, IEEE*, Blagoja Markovski, Mirko Todorovski, *Senior Member, IEEE*

***Abstract*—Voltage drop developed between the grounding electrode under lightning current and distant neutral ground determines the protection efficiency. The peak value of such voltage can be computed from known impulse impedance and current peak value. For the first time, in this paper, general formulas are derived for impulse impedance of horizontal and vertical electrodes valid for any length up to 100 m, soil's resistivity of 30 to 1000 Ωm, and current impulse front time of 0.2 to 10 µs. Waveforms of typical lightning impulses given in IEC standards are used, but it is shown that results are also relevant for other impulse waveforms. Soil ionization effects are taken into account, and the accuracy of the formulas is investigated. New formulas enable an estimate of lightning protection grounding's surge efficiency in a wide range of practical situations.**

Index Terms—Grounding, lightning, modeling, transient response.

I. INTRODUCTION

$$i(t) = \frac{1}{\eta} \cdot \frac{t^{10}}{t^{10} + \tau_1^{10}} \cdot e^{-t/\tau_2} \qquad (1)$$

The parameters η, τ_1, and τ_2 are chosen so that the impulse front time T_1 (see Fig. 1) has values given in the next section. The only parameters used in the formulas are T_1 and current peak value I_m.

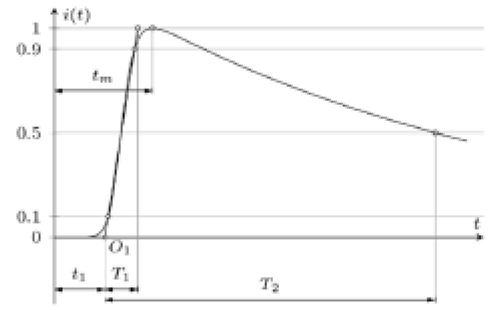

Fig. 1. Typical lightning current impulse waveform given in IEC standard [7].

Artigo 2

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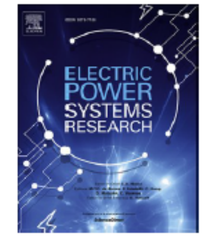

On the use of the frequency domain in assessing resonant overvoltages during transformer energization.☆

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A B S T R A C T

Resonant temporary overvoltages during transformer energization may result in damage to the transformer itself or surrounding equipment. These overvoltages are caused by the interplay between the transformer energization currents and the grid impedance. Current practice to assess the risk of transformer energization is by classifying grid scenarios into potentially problematic or non-problematic based on the magnitude of the grid impedance at frequencies coinciding with the grid harmonic frequencies. At the moment, this approach lacks a proof of validity. Therefore, this paper investigates the use of frequency domain characteristics, and more in general, linear analysis of the grid impedance, for assessing the risk associated with transformer energization. Findings show that the magnitude of the frequency domain grid impedance may not provide sufficient information for classifying problematic and non-problematic cases.

Artigo 3

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Lightning performance of a critical path from a 230-kV transmission line with grounding composed by deep vertical electrodes

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ARTICLE INFO

Keywords:
Backflashover
Grounding
Lightning
Multilayer soils
Vertical electrodes

ABSTRACT

This work presents the impacts related to the addition of deep vertical electrodes on grounding meshes to transmission line performance. For soils with electric resistivity value lower at below layers, to use deep vertical electrodes can be a very interesting procedure to improve the grounding resistance and impedance characteristics for fast transients. A proposed installation procedure is presented as well as a brief cost comparison to the commonly use of surge arresters. A critical path from a 230-kV transmission line is evaluated for the direct incidence at the top of structures and mid span of first and subsequent lightning strokes. The results suggest a remarkable improvement of TL performance due to the use of deep vertical electrodes, particularly for first strokes, and the possibility of being added with other techniques, as underbuilt wires.

Artigo 4

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Influence of tower modeling on the assessment of backflashover occurrence on transmission lines due to first negative lightning strokes☆

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ARTICLE INFO

Keywords:
Backflashover
Lightning performance of transmission lines
Tower modeling

ABSTRACT

This paper assesses the influence of tower modeling on the calculation of voltages across insulator strings, critical currents and percentage of backflashover occurrence for typical 138-, 230- and 500-kV towers. Three different model types are considered: geometric, multistory and multiconductor models. The results are compared to those obtained with the Hybrid Electromagnetic Model (HEM), which is taken as reference. The extended Jordan model belonging to the multiconductor model type is responsible for the results closest to those provided by HEM. The geometric and multistory models also lead to consistent results but with some limitations. The former provides good results for tower-footing impedance above 20 Ω, for the 138-kV tower, and above 40 Ω for the 230- and 500-kV towers. The latter is more appropriate to represent towers with geometry close to the one adopted on the development of its formulation, such as double circuit transmission towers with heights above 60 m.

Artigo 5

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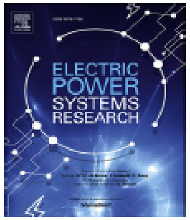

Comparison of Backflashover performance between a novel composite pylon and metallic towers☆☆

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A R T I C L E I N F O

Keywords:
Backflashover rate
Fully composite pylon
Lightning overvoltages
Monte Carlo method
PSCAD
Frequency-dependent footing model

A B S T R A C T

A design of a fully composite pylon with external grounding down-leads has been proposed for new-generation 400 kV transmission towers, able to save lines corridors and to reduce visual impact. This paper investigates and compares the backflashover performance of a composite pylon and two conventional metallic towers, which have been widely installed in Denmark. The transient models of overhead lines and all three towers were established respectively and the transient analysis was carried out in PSCAD. Monte Carlo method was used to estimate backflashover rate. The backflashover rate of composite pylon is 0.4526 cases per 100 km per year, which is in the same range, but slightly higher than that of metallic towers. The separated grounding down-leads of double circuits on composite pylon eliminates the danger of simultaneous backflashover of double circuits, which exists in transmission lines supported by metallic towers. After comparing the overvoltages to three phases of the three towers from backflashover, it is worthy considering that the installation of surge arresters at all three phases of composite pylon has a strong impact on the backflashover rather, but for the two metallic towers only the surge arresters at the upper phase has an impact.

Artigo 6

Impact of Frequency-Dependent Soil Models on Grounding System Performance for Direct and Indirect Lightning Strikes

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***Abstract*—The goal of this article is to investigate the effect of frequency-dependent soil models on the performance of grounding electrodes subjected to lightning strikes. Several soil models are examined while accounting for the variation of soil resistivity and permittivity as a function of the lightning current frequency spectrum. The analysis is performed for a homogeneous soil and a two-layer horizontally stratified soil. The impact of the frequency-dependent soil parameters on the ground potential rise (GPR) of simple grounding electrodes subjected to lightning is analyzed and discussed. The analysis is performed in the frequency domain and in the time domain. A wind turbine and its grounding system are also considered in this article. Special attention is given to the case of indirect lightning, rarely mentioned in the literature. The GPR of the grounding electrodes is examined when the frequency dependence of the soil is taken into account and the lightning channel is located at close distances to the electrodes. Indeed, the level of induced electromagnetic fields caused by a nearby lightning channel can still be too high and potentially dangerous. The computations are performed using an efficient Method of Moments (MoM) numerical tool based on surface-wire integral equations for a stratified medium in the frequency range from dc to several MHz. Numerical results demonstrate that the frequency dependency of the soil parameters results in a decrease of the potential rise of the grounding electrodes, with respect to the case where the parameters are assumed constant.**

***Index Terms*—Frequency dependence of soil, grounding systems, lightning, method of moments, stratified medium.**

may deteriorate at higher frequencies, particularly at the wide frequency spectrum associated with lightning. Consequently, the frequency dependence of soil resistivity and permittivity should be considered to correctly determine the response of grounding systems subjected to lightning currents.

The frequency dependence of the electrical parameters of soil depends on a combination of different atomic properties of the soil as well as various mechanisms of conduction and losses occurring at different frequency intervals [1]. A detailed investigation of these mechanisms, their interpretation and their dependence on frequency can be found in [2]–[6]. It should be noted that many publications have reported measurements of the frequency dependence of the electrical parameters of soil and its effects on grounding systems. All these publications have shown that the general trend of the frequency dependence of the electrical parameters of soil leads to a decrease of both the resistivity and permittivity compared to low-frequency values [1]. However, the frequency-dependence of soils is generally ignored for estimating the network operating frequency and lightning performance of grounding systems [7].

Visacro and Portela [8] proposed an empirical formulation to model the electrical parameters of soils in the frequency range of transient phenomena on power networks. Portela [9]