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D.2.7. Modélisation et prise en compte du champ magnétique pour les câbles de transport souterrains

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Resume

Dans cet article, les champs magnetiques produit par les cables de transmission souterrains sont etudies et quantifies. Les methods d'investigation pour gerer les valeurs du champ magnetique sont presentees. L'objectif principal de l'etude de la gestion du champ magnetique est de determiner quelles methods pour reduire les valeures du champ magnetique sont techniquement et economiquement faisable en utilisant la technology existante. Un autre objectif est de donner des directives aux engenieurs de cable concernant la reduction des champs magnetique pour des circuits nouveaux et existant. Plusieurs facteurs qui affectent le champ magnetique a proximite des cables de transmission souterrains sont etudies dans cet article . Les facteurs qui ont ete etudie par order de leur importance sont: phase, amplitude du courant , espace de phase, amplitude du courant a sequence positive , configuration du cables , system de masse du cable, profondeur de la resistance enterree de protection. Les tests du cable ont ete fait pour valider la variation des parametres qui seuvent influencer les forces du champ sons diverses combinaisons des variables.

INTRODUCTION

Public concerns about the magnetic fields produced by power transmission and distribution facilities has resulted in increased research activities to determine if there are adverse health effects which result from magnetic fields as well as investigations to quantify and possibly reduce the magnetic fields produced by power system equipment. Concerns about these fields have generated requests from cable designers and construction engineers for methods to reduce fields in transmission cable installations where levels are modest to high. The interplay of field reduction , installation and operating cost , and high ampacity is of prime interest [1-7] .

Magnetic fields produced by underground transmission lines are investigated and quantified. Investigation methods to manage magnetic field values produced by these cables are done thoroughly to determine which methods of reducing the magnetic field values are technically and economically feasible and to provide guidelines to cable engineers concerning the reduction of magnetic fields for new and existing installations [3-7,8-13] .

Factors affecting the magnetic field near underground transmission cables are studied. These factors , in order of their importance, are : phase current magnitudes, phase spacing, positive sequence current magnitude, cable configuration , cable system grounding , depth of burial, and shield/sheath resistance. Some of these factors ,such as depth of burial, have the most significant effect on the magnetic field near the cable, while others, such as zero sequence currents have a significant impact at distance farther away from the cable. These factors can cause a variation of approximately 5 to 1 for single circuit cable configuration and by up to 10 to 1 for double circuits. The soil had little or no effect on the above ground fields produced by underground cables [5-7].

Transmission cables magnetic fields may be calculated using existing calculation procedures. The accuracy of the calculation results is determined primarily by the accuracy with which the dimensions of the cable circuits and electrical parameters are known. The magnetic field produced by a cable system at any location vary linearly with the current in the high voltage conductors [9-11]. Methods of reducing magnetic fields in the vicinity of transmission cables are identified to give alternatives for commercial installations, as most of these methods result in reductions in current-carrying capacity of transmission cables either through increased mutual heating between the cables or through increased losses or increase of circuits costs [11-13].

D.2.7. Magnetic field modelling and management for transmission underground cables

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Abstract

In this paper, magnetic fields that are produced by underground transmission lines are investigated and quantified. Investigation methods to manage magnetic field values are done. The primary objective of the magnetic field management investigation is to determine the technically and economically feasible methods of reducing the magnetic field values , using existing technology. Another objective, is to provide guidelines to cable engineers concerning the reduction of magnetic fields for new and existing circuits. Numerous factors which affect the magnetic field near underground transmission cables are studied and experiments to verify these factors were done. The factor which have been studied, in order of their importance, are: phase current magnitude, phase spacing, positive sequence current magnitude, cable configuration, cable system grounding, depth of burial and shield/sheath resistance. Methods of magnetic field reduction are identified to give alternatives for commercial installations. Cable testing was done to validate varying the parameters that might affect field strengths under many combinations of variables.

Cable testing was done to validate varying the parameters that might affect field strength, such as phase current magnitude, zero sequence current (unbalance current), and return current path. Measurements of magnetic field strengths under many combinations of variables were done [5-7,11-13]. A few fairly conventional suburban installation configurations are cost-effective compared with most others and result in only modest ampacity decreases . Several ferromagnetic shielding options may be cost-effective. A prime example is the use of steel pipes in urban areas .

FACTORS AFFECTING MAGNETIC FIELDS

There are numerous factors which affect the values of the magnetic fields produced by underground transmission cables. These factors may be grouped into the following general areas :

(i) System parameters ; such as current magnitude and phase balance , and system grounding ,
(ii) Cable installation parameters ; such as depth of burial , installation configuration , and relative placement of the cable phases where there is more than one circuit ,
(iii) Cable construction parameters ; primarily shield/sheath resistance and type of material for non-pipe type cables , and
(iv) External factors ; such as the presence of nearby underground conductors or sources of current which may flow on the cable shield / sheath or ground continuity conductor .

(I) System Parameters

The most obvious parameters which affect the magnitude of the magnetic field in the vicinity of an underground transmission line is the magnitude of the current in the phase conductors. The materials of the cable its surrounding soil have a constant magnetic permeability which makes the magnetic field values at a given location is a linear function of the conductors phase currents. Zero sequence currents flowing in cable circuits have significant effects on magnetic field magnitude and how rapidly it decreases with the distance from the center line of the circuit. Magnetic field magnitudes for positive sequence currents decrease approximately as one over the distance squared from the circuit center line , while magnitudes for zero sequence currents decrease approximately with the reciprocal of the distance as in Figure (1) . The manner in which the cable system is grounded has also an effect on the magnetic field values due to the fact that induced currents