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Comparison of power loss due to corona phenomena model with Peek's formula in high voltage 115 kV and 230 kV system

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Abstract

This paper studied the power loss due to corona phenomenon with Gary's model and Peek's formula using Matlab program for the power loss simulation in 115 kV and 230 kV system that the corona loss varies with transmission conductor radius and spacing. The corona phenomenon effects on leakage capacitance and inductance of transmission line. The leakage current would increase in the condition of the corona incepted. The power loss due to corona has an inverse variation with radius and spacing of conductor. The Gary's model is not suitable for 115 kV. Due to the operating point of power system, the model losses had the value 7.5% with difference from the formula for 115 kV system and 14.5% for 230 kV system.

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Keywords: Corona; Corona Loss; Gary's Model; High Voltage; Peek's Formula; Transmission Line

1. Introduction

One of fundamental phenomenon in electric transmission is corona. Corona is a phenomenon caused by the partial discharging caused by high electrical stress collided with gas molecules in the air when electrical field stress exceeds critical level cause of audible noise, frequency noise to communication system and power loss in overhead transmission line. There are many researches that are model a corona character and power loss predication in difference environment such as Gary's model[1] or Peek's formula[2]. The authors interest to study power loss results in each model in northeast of Thailand transmission line between Khon Kaen and Nakhon Ratchasima with the 115 and the 230 kV with the purpose to reduce the power loss of the transmission line system.

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2. Model of high voltage transmission line

For high voltage system, transmission line can be replaced by circuit model including two divided part are series part and shunt part. In series part includes by resistor and inductor or L and R in Fig.1. There are longitudinal resistance and inductance of the transmission line. And shunt part includes by shunt resistor and capacitor or Rs and Cs in Fig.1. There is leakage between transmission line and ground.

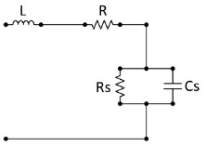

Fig. 1 High voltage transmission line equivalent circuit by using EMTP

3. Corona discharge model

For equivalent circuit of transmission line, if there is corona effect on transmission line, the shunt capacitance and resistance will be replaced by nonlinear capacitor and resistor.

3.1. Gary's model

The corona capacitance can be described by Gary's model as[1]

$$C_c = \begin{cases} C_0 & \frac{dv}{dt} > 0 \text{ , } v < U_c \\ C_0 \eta \left(\frac{v}{U_c}\right)^{\eta-1} & \frac{dv}{dt} > 0 \text{ , } v > U_c \\ C_0 & \frac{dv}{dt} < 0 \end{cases} \quad (1)$$

where C_0 is geometric capacitance, U_c is corona inception voltage can be defined by Peek's equation (5) and η is coefficient for a single conductor can defined as

$$\eta = 0.22r + 1.2 \quad (2)$$

3.2. Corona current loss

In the similar condition as the capacitance. Corona shunt conductance of transmission line can be described by resistive current loss though shunt conductance can define by[1]

$$G_c = \begin{cases} G_0 & \frac{dv}{dt} > 0 \text{ , } v < U_c \\ K_r \left(1 - \left(\frac{v}{U_c}\right)^2\right) & \frac{dv}{dt} > 0 \text{ , } v > U_c \\ G_0 & \frac{dv}{dt} < 0 \end{cases} \quad (3)$$

where

$$K_r = \delta_G \sqrt{\frac{r}{2h}} \times 10^{-11} \quad (4)$$

where δ_G is corona loss constant and h is conductor height in cm

4. Power loss due to corona phenomenon

The ionized charges near the conductor surface take energy from the supply system and thus there is a loss of some energy due to corona. This is resistive loss. It is not possible to derive any formula for the exact loss that occurs due to corona. Several researchers gave empirical formulas based on the experiments for calculating the corona loss.