The Influence of the Horizontally Stratified Conducting Ground on the Lightning-Induced Voltages

Lightning Detection Technologies

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The accurate evaluation of lightning-induced voltages on the power line networks is very important for ensuring the quality of the electric power supply. There are mainly three approaches proposed in the literature concerning the calculation of indirect lightning-induced transients. The first are some approximate analytical formulas. The second approach is based on the computed calculation of the lightning electromagnetic pulse (LEMP) and its field-to-line coupling model. The third approach is based on the 3-D Finite-Difference Time-Domain (FDTD) method for simulating the voltages induced on the overhead wire above lossy ground. Above all, all of the results assumed the ground as the homogeneously conducting ground. It is generally known that the natural ground is always represented by horizontally or vertically stratified models. So it is more valuable to analyze the influence of the horizontally stratified conducting ground on the lightning-induced voltages on an overhead line .

In this paper, we have analyzed the influence of the horizontally stratified conducting ground on the lightning-induced voltages on an overhead line in detail by using 2-D FDTD method and the Agrawal coupling model. First we split the induced overvoltage into the scattered induced wave (U_s) and the incident induced wave (U_i). Then we further decomposed the U_s component into two sub-components as surface impedance term (U_{SIT}) and perfectly conducting term (U_{IFT}) according to the C-R formula. The first subcomponent term U_{SIT} is closely related to the stratified ground, the second subcomponent term U_{IFT} corresponds to perfectly conducting earth and has nothing to do with the finitely conducting earth. The results show that, when the conductivity of the first layer (σ_1= 0.001 S/m, ε_{r1}=10) is less than that of the second layer (σ_2= 0.1 S/m, ε_{r2}=10), it is noted that the lightning-induced overvoltage obviously increases with the increase of the depth of the first layer due to the increase of the total effective impedance, and the influence of the stratified ground on the induced wave cannot be ignored if the depth of the first layer is more than 2 m. However, when the conductivity of the first layer (σ_1= 0.1 S/m, ε_{r1}=10) is more than that of the second layer (σ_2=0.001 S/m, ε_{r2} =10), the lightning-induced wave peak decreases sharply with the increase of the depth of the first layer. In the case of such high conductivity of the first layer, if the depth of the first layer is over 2 m, we can nearly regard the ground as a homogeneous layer with the first layer's conductivity.

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