Chapter 8

Transient Response of Grounding Systems

ABSTRACT

This chapter describes a model used to simulate lightning current. Comparison of different approaches used for lighting simulation has been mentioned. Transmission line approach has been chosen to simulate the grounding system behavior under lightning condition. Two different types of the grounding system have been studied under lightning conditions vertical driven electrodes and buried grids. This chapter draws attention also to the following points: equivalent circuit of a vertical ground rod on lightning condition, sensitivity analysis of soil parameters and grounding rod dimensions, equivalent circuit of grounding grid on lightning conditions and sensitivity analysis of soil parameters and grounding grid dimensions.

LIGHTNING CURRENT IMPULSE MODEL

A typical lightning is an electrical discharge between:

1. Cloud and the earth (cloud-to-ground flash)
2. Within the cloud (intra-cloud flash)
3. Different clouds (inter-cloud flash).
Out of all the flashes occurring in the natures, only 10% of flashes are cloud-to-ground flashes. A typical cloud-to-ground lightning flash starts with a descending stepped leader after a preliminary discharge in the cloud. As the stepped leader propagates towards the ground, the electric field at the ground or at the tip of grounded objects is increased. At a certain instant, the field would be sufficiently high to launch upward connecting leaders from the ground or grounded structures. The upward connecting leaders have a polarity opposite to that of the downward leader. The incepted upward leader propagates in such a way that it seeks the tip of the descending leader. When the gradient between the two leader tips is sufficiently high (500 kV/m), then a final jump between the two occurs. The length of this final jump depends upon the charges in the above said two leaders. Because of the interception between the two leaders, the gap between the cloud and ground is bridged. At this instant, a ground potential wave called the return stroke propagates upward, discharging the leader channel. The return stroke current is the most important parameter for the transient behavior study of the grounding system. The properties of it have been summarized by Thottappillil R., (2002). Usually, the discharge current of return stroke increases from zero to a maximum in few μs (from 0.1 to 10 μs), then declines to half the peak value in about 20 to 1000 μs. The typical value of the peak current derivative $\frac{dI}{dt}$ is about 110 kA/μs. The peak value of the stroke current is about 15-30 kA (median value), and some stroke current could be about 250 kA (probability of occurrence less than 0.1%) as reported by Thottappillil R., (2002). The above said lightning return stroke current parameters forms the basis of the impulse current sources which will be used as an input for the transient analysis of grounding system in the present study. Table 1 gives two equations simulate the lightning current. (Figure 1) shows fast and slow impulses simulate the lightning current of 12 kA peak current.

### Table 1. Equations simulate the lightning current

<table>
<thead>
<tr>
<th>Type</th>
<th>Equation</th>
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<tr>
<td>Fast impulse</td>
<td>$I(t) = 1 \cdot \left( e^{-27000 \cdot t} - e^{-5600000 \cdot t} \right)$</td>
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<tr>
<td>Slow impulse</td>
<td>$I(t) = 1 \cdot \left( e^{-7924 \cdot t} - e^{-400109 \cdot t} \right)$</td>
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A Hybrid PSO-LEVY Flight Algorithm Based Fuzzy PID Controller for Automatic Generation Control of Multi Area Power Systems: Fuzzy Based Hybrid PSO for Automatic Generation Control