Modeling of Lightning Transient Overvoltage by Using Different Models of Grounding System

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Abstract. The behavior of simple or complex grounding systems excited by lightning strokes considerably differs from that at low frequency and at low-current: inductive behavior can become more and more important with respect to resistive behavior and, in addition, these currents can generate soil breakdown (which makes the impulse response typically non-linear. In the present paper the simulation of transient behavior of grounding system is done by ATP.

Key words
Grounding system, Lightning Transient, ATP, Surge

1. Introduction

The steady state of grounding system is well known [1] – [3], however, the transient response is a more complex problem due to multiple factors that influence the behaviour of the grounding arrangement.

The simulation of transient behaviour of grounding systems can be carried out by means of various models mainly based on the circuit theory [1] – [4].

2. Simulation

In order to simulate behaviour of diffent groundin system model during lightning transient, a circuit same as fig. 1 is simulated on ATP.

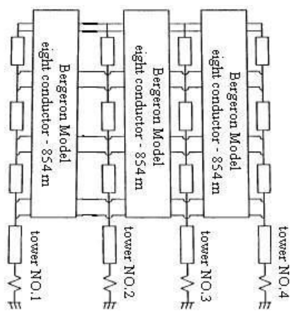

Fig. 1: Simulated circuit.

In this simulation different models are considered for grounding system as follow:

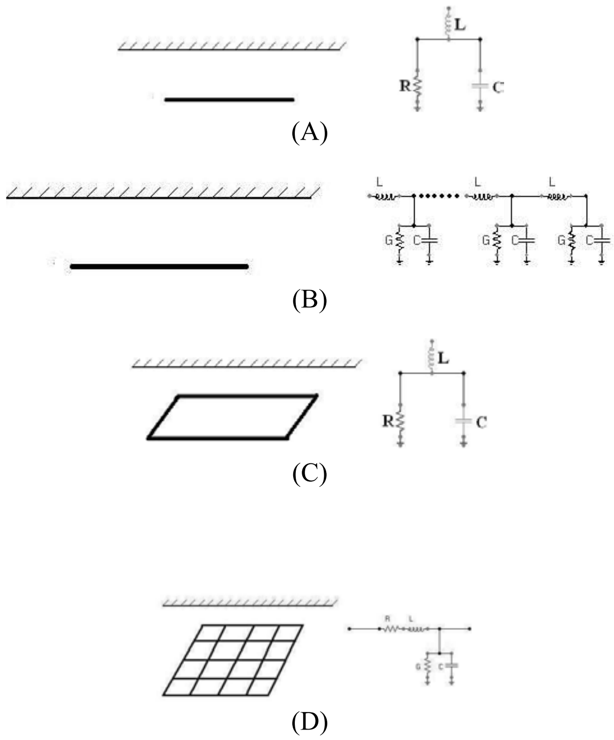

Fig. 2. Different model for tower footing ground system.

A lightning current (2/70 μs) of 30 kA is simulated by current source in ATP. This lightning stroke the tower No. 2 of transmission line. The tower is simulated as well. Transient voltage on grounding system and tower is obtained for different cases.

The towers configuration is shown in fig. 3.

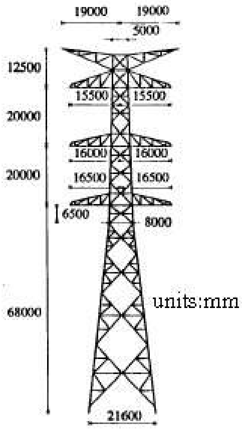

Fig. 3. Configuration of towers

Fig. 4 shows the tower model and its parameters are presented in ref. [5].

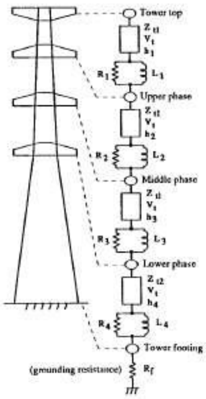

Fig. 4. Tower model.

3. Simulation Results

The effects of different grounding systems on lightning overvoltage is obtained by simulation.

A. Results for Grounding System Same as Fig. 2 (A)

For this model paramers are as follow [2]:

$$R = \frac{\rho}{\pi l} \ln\left(\frac{2l}{a}\right) \quad [\Omega] \qquad (1)$$

$$L = 2l.\ln\left(\frac{2l}{a}\right)10^{-7} \quad [H] \qquad (2)$$

$$C = \frac{\rho\varepsilon}{R} \quad [F], \qquad \varepsilon = \varepsilon_0 \varepsilon_r$$

a = 7.5 mm, radius of rod

l = 100 m, length of rod

$\rho = 100\ \Omega m$

$\varepsilon_r = 10$

Fig. 5 shows voltage on the top of tower no. 2.

Voltage on the top of grounding system of tower no. 2 is shown in fig. 6.

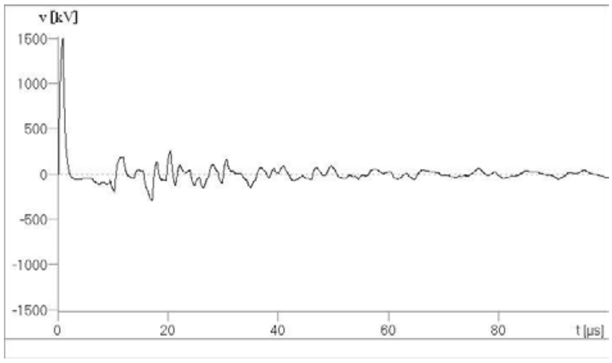

Fig. 5. Voltage on the top of tower no. 2.

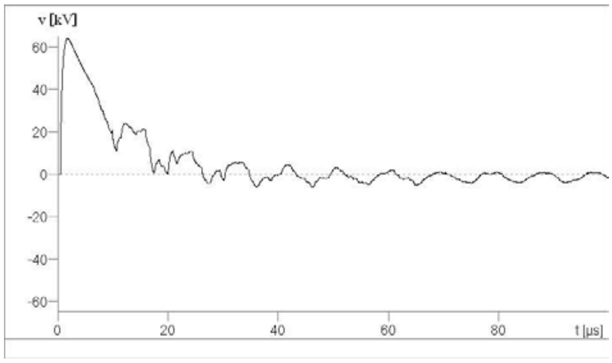

Fig. 6. voltage on the grounding system of tower no. 2.

B. Results for Grounding System Same as Fig. 2 (B)

For this model paramers are as follow [4]:

$$G = \frac{\pi}{\rho\left[\ln\frac{2l}{\sqrt{2ad}} - 1\right]} \quad \left(\frac{mohm}{m}\right) \qquad (3)$$

$$C = \frac{\pi\varepsilon}{\ln\frac{2l}{\sqrt{2ad}} - 1} \quad \left[\frac{F}{m}\right] \qquad (4)$$

$$L = \frac{\mu_0}{\pi}\left[\ln\frac{2l}{\sqrt{2ad}} - 1\right] \quad \left[\frac{H}{m}\right] \qquad (5)$$

a = 7.5 mm, radius of rod

l = 100 m, length of rod

$\rho = 100\ \Omega m$

d = buried depth, 1 m

Fig. 7 shows voltage on the top of tower no. 2.

Voltage on the top of grounding system of tower no. 2 is shown in fig. 8.

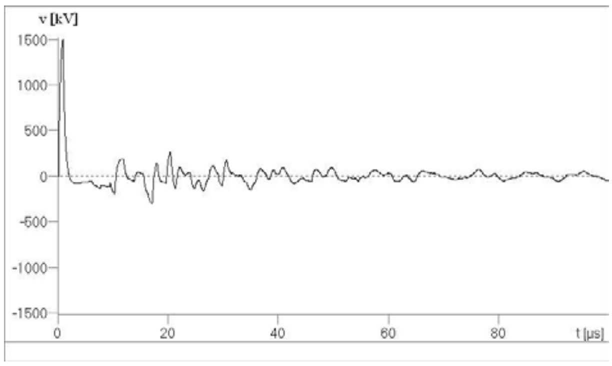

Fig. 7. Voltage on the top of tower no. 2.

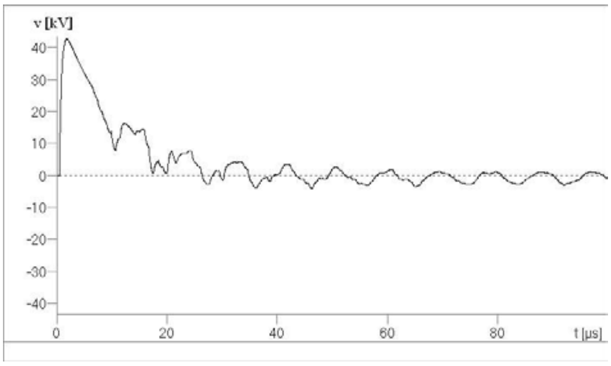

Fig. 8. Voltage on the grounding system of tower no. 2.

C. Results for Grounding System Same as Fig. 2 (C)

For this model paramers are as follow [2]:

$$R = \frac{\rho}{4r} \quad [\Omega] \tag{6}$$

$$L = l_1 \left[\ln \frac{4l_1}{ak} + K \ln \frac{4k^2 l_1}{a} \right] 10^{-7} \quad [H] \tag{7}$$

$$C = \frac{\rho \varepsilon}{R} \quad [F], \qquad \varepsilon = \varepsilon_0 \varepsilon_r \tag{8}$$

l_1 = length major side of rectangular, 50 m
K = minor side divided by l_1, 10
r = radius of an equivalent circle for the area occupied by the mesh,
$\rho = 100\ \Omega m$
$\varepsilon_r = 10$
a = 7.5 mm, radius of rod

Fig. 9 shows voltage on the top of tower no. 2.
Voltage on the top of grounding system of tower no. 2 is shown in fig. 10.

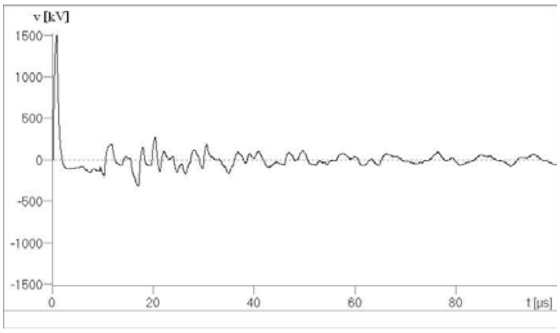

Fig. 9. Voltage on the top of tower no. 2.

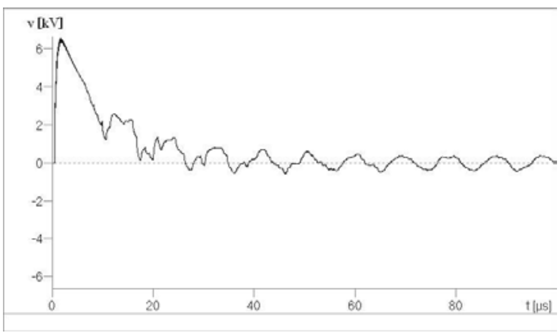

Fig. 10. Voltage on the grounding system of tower no. 2.

D. Results for Grounding System Same as Fig. 2 (D)

Formulas for this model are according to ref. [6].
For this model paramers are as follow [6]:
a = 7.5 mm, radius of rod
grid dimension = 5m*5m
cells dimension = 1m*1m
$\rho = 100\ \Omega m$

Fig. 11 shows voltage on the top of tower no. 2.
Voltage on the top of grounding system of tower no. 2 is shown in fig. 12.

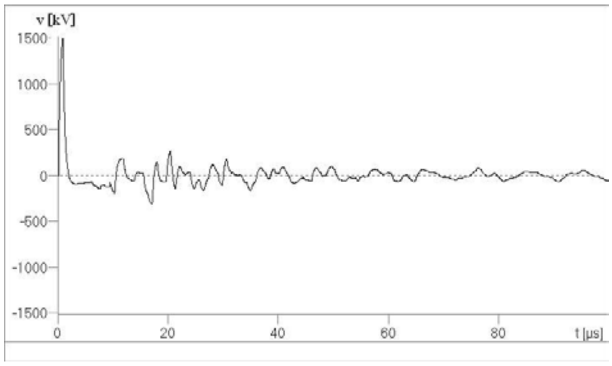

Fig. 11. Voltage on the top of tower no. 2.

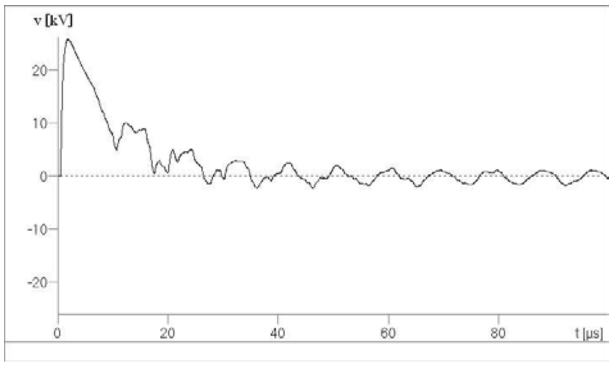

Fig.12. Voltage on the grounding system of tower no. 2.

4. Conclusion

For different model at different the simulation is done and the results is shown in graph forms.
Aim of this paper is investigating the effects of different models of tower grounding system on transient overvoltages that appear on different grounding systems. From results we can see that voltage on top of grounding system is different. In this model voltage on different arm of tower can be computed.

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