MODELING OF THE ELECTRICAL DISCHARGE OF LIGHTING ON OVERHEAD POWER LINE

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Abstract. *The electrical discharge of lightning, which strikes down the wires of overhead power line for high voltage – 110 kV is investigated. Electrostatic discharge model of lightning is created. Simulations of emergency mode of the power line in the case of direct hit of lightning are made. The harmonic composition of the current of lightning discharge is investigated. The electrical discharge of the lightning creates a high voltage level of the power line. These surges and the availability of harmonic currents violate electromagnetic compatibility. They create disturbing effects of the overhead power line for high voltage and other electrical equipment in the vicinity.*

Keywords: *electrostatic discharge, overhead line, high-voltage, modelling, SPICE simulation, electromagnetic compatibility*

1. INTRODUCTION

The lightning is an eternal source of charge of Earth electric field. Source of lightning are electric charges of the storm clouds. At any time, at different points of the Earth's lightning flashes over 2,000 thunderstorms. In every second of about 50 lightning strikes the surface of the earth, and on average, each square kilometre of its lightning strikes six times per year. More Benjamin Franklin showed that lightning hitting on the ground from the storm clouds - are electrical discharges that carry a negative charge on it.

Formation of storm clouds according to the modern theory of thunderstorms is done in the following way. In an atmosphere of saturated steam under the influence of a strong air flow occurs spray of water droplets. The received as a result of spray water mist is loaded with negative charges, and the remaining drops with positive charges.

Lightning - greetings from the space, and X-ray source. However cloud unable itself so electrify itself to cause a discharge between its lower part and ground. The electric field in the thundercloud never exceeds 400 kV/m, and the electric breakdown in air occurs when the tension more 2500 kV/m. Therefore for the occurrence of lightning need something else other than the electric field. In 1992 Russian scientist Alexander Gurevich of Physics Institute Lebedev (LPI RAS) has suggested that a kind of lightning-ignition may be cosmic rays- high energy particles raining down on Earth from space at nearly the light speed [7].

2. LIGHTNING ELECTROMAGNETIC PULSE

The current of the lightning has the shape of a pulse shown in Fig. 1 [8] and is characterized by three parameters:

– I_m is amplitude of the lightning current;
– $\tau_в$ is wavelength;
– $\tau_ф$ is length of the front
– $\alpha = \dfrac{I_m}{\tau_ф}$ is average steepness of the current.

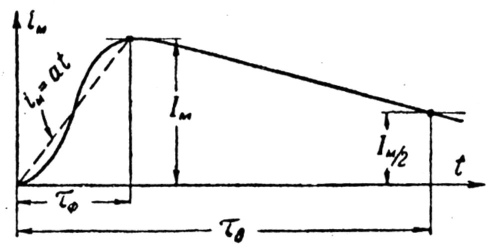

Fig. 1. Electromagnetic wave form of lightning current

The amplitude value of the current is 20kA up to 200 kA. The steepness of the wave front of the current is about 300 kA / μs. The electric field intensity in the cloud is about $E_0 \approx 10^4 V/m$. At certain points the electric field intensity can reach 1 MV/m ÷ 3 MV/m.

3. MODELING OF THE LIGHTNING CURRENT

Circuit model of the lightning current is created. The software package PSpice (ORCAD) [9] is used. The lightning current is represented by a piece-wise linear current source.

The shape of the lightning current has the form shown in Figure 2.

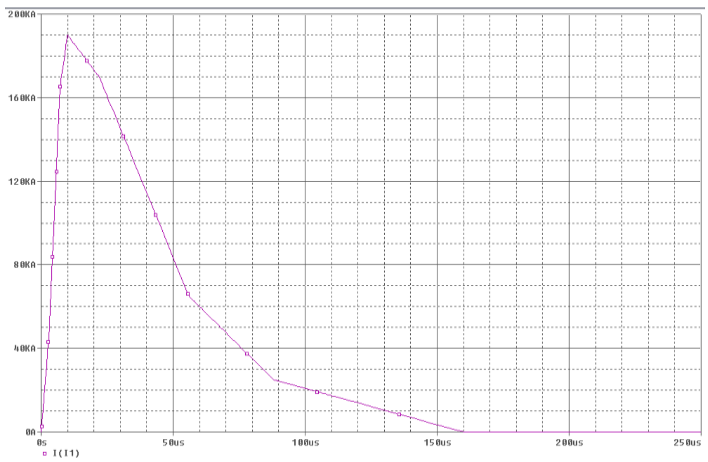

Fig. 2. The shape of the lightning current model

4. MODEL OF THE ELECTRIC DISCHARGE OF LIGHTNING ON THE POWER LINE

A lightning strike on the final stretch of overhead high voltage power line 110 kV is considered. The electrical discharge of lightning strike on the power line wires is investigated.

Circuit model of overhead power line 110 kV, presented with concentrated parameters is used [10].

A model of electrostatic discharge lightning is created.

The SPICE model of the lightning discharge on overhead power line110 kV is shown in Fig. 3.

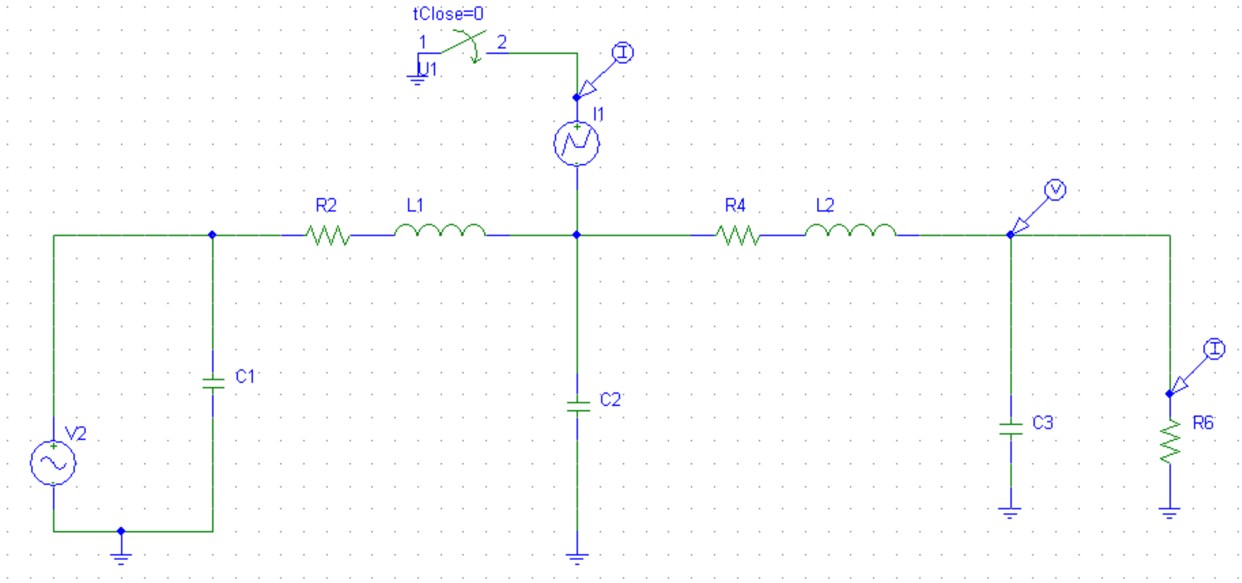

Fig. 3. Model of the lightning discharge in power line for HV

5. SIMULATIONS REZULTS

Simulations are carried on the work of the power in emergency mode at discharge in the power of lightning. The power line is supplied from a voltage source 110 kV from the nearest substation is loaded with load lowering substation 110/20 kV.

When lightning strikes occurs emergency mode in which the voltages and the currents in the power line significantly exceed the nominal values.

The results of the simulations of discharge through the power line of the bolt shown in Fig. 4 and Fig. 5.

The voltage on the 110 kV power line even for a very short time reaches too high values of the order of several MB. These surges can disrupt the normal operation of the power line, due to the appearance short-earth compounds. As a result will be reduced the operation resource of the insulation.

In terms of electromagnetic compatibility for other electrical equipment located in vicinity, the power line can creates surges, which can create dangerous levels of electric intensity and disrupt their normal operation. As a consequence, the radioelectronic equipment will create harmful interference, which will briefly interrupt its work.

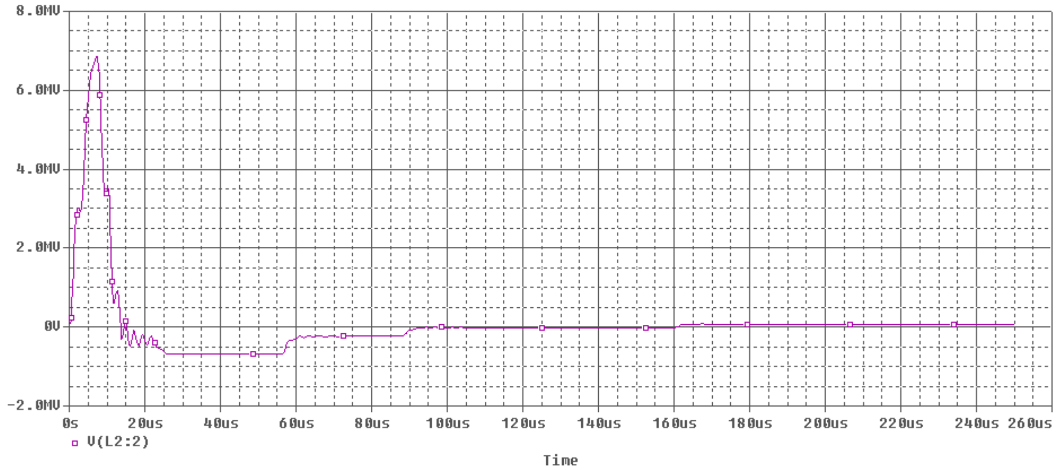

Fig. 4. Surge of lightning discharges on the 110 kV power line

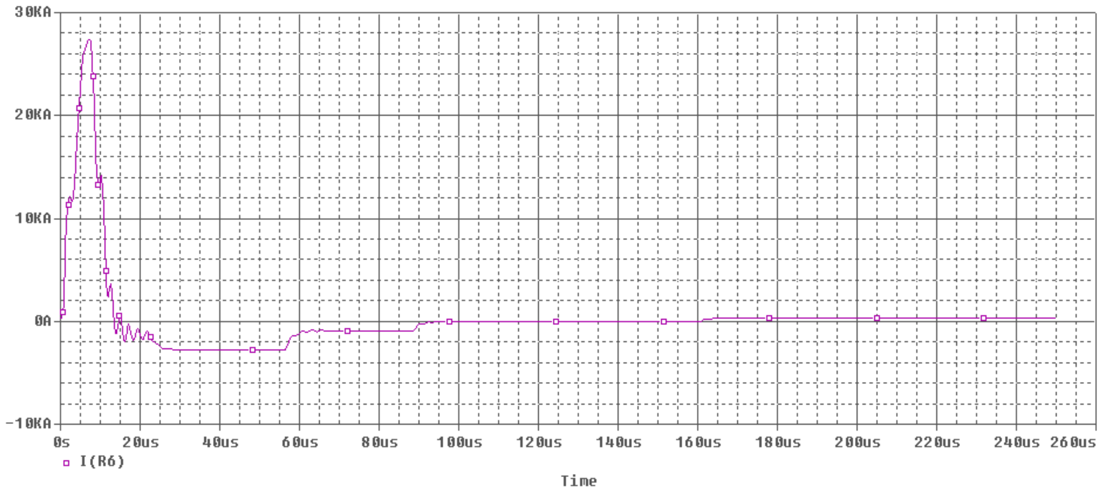

Fig. 5. Electricity lightning current in 110 kV power line

The induced overcurrents from the lightning of range of several kA can disrupt the normal operation of the power line. They can increase the power losses and voltage in the power line wires 110kV Albeit for a short time they will be given a large amount of energy. This affects the performance of power line.

These large currents, even for a short time will create strong magnetic fields around 110 kV power line. This will also lead to distortions of normal operation of other electrical equipment around the power lines.

6. CONCLUSION

The electrical discharge of lightning striking on overhead power high voltage 110 kV is investigated.

A model of current electrostatic discharge of lightning is created.

Circuit model of the power line of high voltage in a lightning strike is composed.

Simulations are carried on the work of the power line in emergency mode in the case of discharge of lightning in the power line.

Electrical discharge of lightning creates a high voltage in the power line. These surges and the presence of harmonic currents violate the electromagnetic compatibility of high voltage power lines and other electrical equipment located in the vicinity of lightning strikes on power lines.

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Reviewer: Prof. PhD Zh. Georgiev