

Transient voltages induced in signal lines by direct lightning strikes on the high voltage substations

Direct lightning strike to the earthed components of high voltage HV substation can cause severe interference problems in electronic equipment and systems. In this case lightning current flows through the conductive-earthed structures over the ground and in earthing grids and induced transient voltages and currents in low-voltage cables. The problem with damages or misoperation caused by lightning transients has been observed in control buildings with electronic devices in measuring and controlling systems inside HV substation.

Definition of existing lightning risk and develop the protection method required the study of lightning currents distributions in conductive elements of HV substation. The knowledge of these distributions allows the transient voltages in signal lines.

The energetic system being modeled consists with 3 HV substation and underground transmission HV lines between them. On each substation were the same arrangements of HV equipment and control cables. The 3D model of HV substation, the arrangements of control cables and same part of substation, which were used in calculation, are presented in fig. 1 and 2.

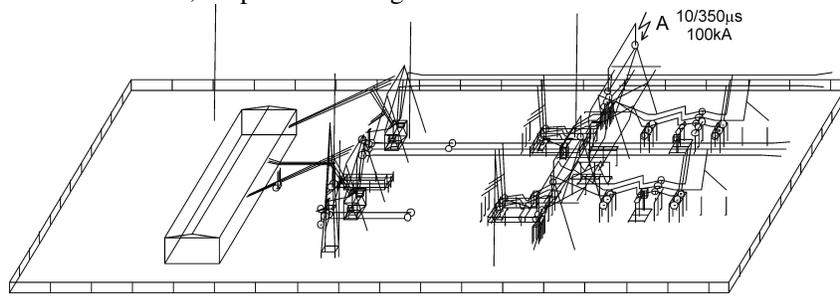


Fig. 1. 3D substation model used in calculation

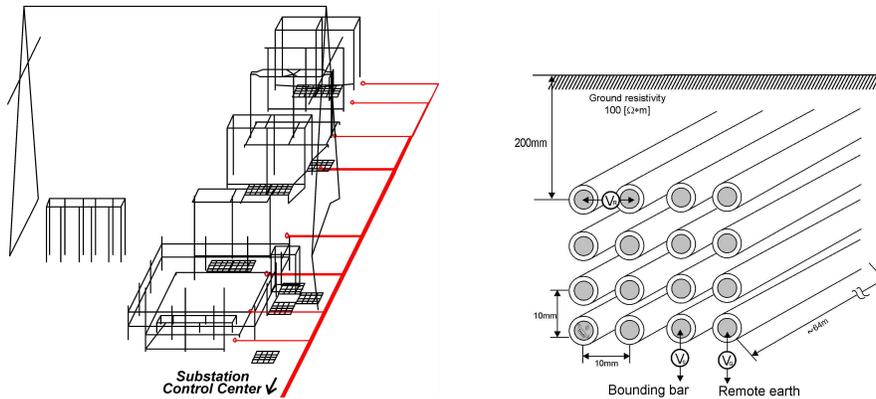


Fig.2. The part of substation model with control circuit wiring

Mathematical model was employed for the prediction of induced voltages in signal cables over and under the ground (fig. 2.) during a direct lightning stroke to the area of substation. In analysis, the lightning current has the following mathematical expression:

$$i(t) = \frac{I}{\eta} (e^{-\alpha t} - e^{-\beta t})$$

where: t - time, α - reciprocal of time constant, β - reciprocal of time constant, I - peak current and η - correcting factor

The parameters of the lightning current, for the first and subsequent lightning strokes, were taken according to the IEC 61312-1 for the III-IV protection level. In investigations the surge currents were injected to the different points of earthed structures in HV substation and this current is divided into:

- earthing system of this substation,
- grounding wires of HV lines,
- the earthing systems in substations, which were connected with substation in which the lightning danger was analyzed.

The transient voltages at equipment's interfaces in control building have been computed for cables, which have lengths 62m and distances between them 10 mm (Fig.2.).

Some results of these calculations were presented in fig.3 and fig.4.

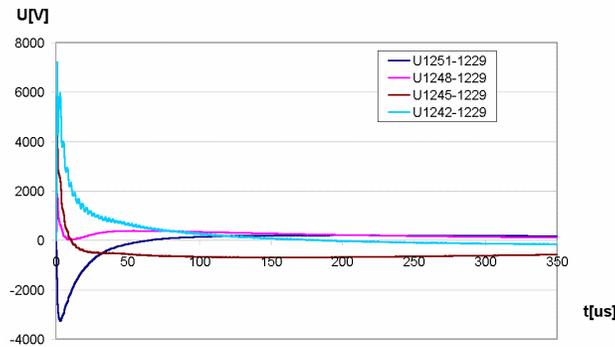


Fig. 3. Voltage relationship between data transmission lines

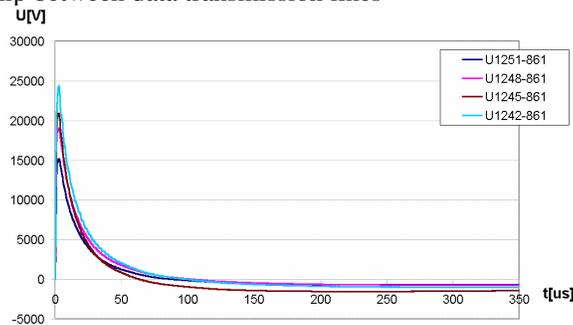


Fig. 4. Transmission lines voltage depth relationship with reference to the bounding bar

The mathematical method, which was used in calculations allows consider all possible configurations of conductive elements on the station, different points of lightning stroke to the station's area and different arrangements of signal lines.