Atmospheric overvoltages in low voltage networks

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Abstract – **This paper studies the operation of SPDs type metal oxide surge arresters (MOSA) in the power systems low voltage TN and IT at the origin of overvoltages due to direct stroke over the lightning diversion of the building (external lightning protection system). The researches are based on the Matlab Simulink**

Keywords – **Atmospheric overvoltages, Surge Protective Devices**

I. Introduction

Electrical equipment should be protected against the overvoltages, which can originate at the entrance of installation. They can be transient lightning overvoltages, transferred on the electrical grid and switching overvoltages, originated by electrical equipment. Other parameters of protection are preliminary fixed keraunic level (the number of the hours with atmospheric activity during one year), the installing points and characteristics of the surge protective devices (SPDs). The aim is to reduce possible incidents due to lightning and switching overvoltages to a level, accepted for people's safety and their property, as well as the interruption of the supply or equipment's faults.

According to the origin, the atmospheric overvoltages are:

- Due to direct lightning strokes on the medium voltage (MV) line and transferred through the medium voltage – low voltage transformer to the low voltage (LV) network;
- Due to direct lightning strokes on the low voltage line;
- Due to a stroke to the ground close to the LV networks;
- Due to direct lightning stroke on the lightning diversion of the building or on structures close to it.

The classification of the influence of overvoltages in the electrical installation in the building is done in [4]:

TABLE I
VALUATION OF THE ATMOSPHERIC OVERVOLTAGES

Description	Characteristics	Example
1	2	3
Insignificant AQ1	≤ 25 h /year	–
Indirect AQ2	> 25 h /year Dangers from the supply system	Installations supplied from the overhead power lines
Direct AQ3	Dangers from the disposition of the equipment	Parts of the installation are outside of the building. AQ2 and AQ3 are in the area with high lightning danger.

TABLE II
LIGHTNING OVERVOLTAGES IN ms AND μs RANGE [5]

Description	Characteristics	Example
Initial level	Equipment protected by lightning diversion	Certain conditions
Medium level	Lightning stroke at the distance greater than 1km and the wave shape 10/1000 ms.	Lightning stroke far away from the underground line.
High level	Lightning stroke at the distance to 1km and the wave shape 1,2/50μs.	Lightning stroke close to overhead power line or building.

In [1,2,3] researches of the operation of SPDs at the atmospheric overvoltages due to direct stroke over the LV networks (TN-C-S, TT and IT) are made using simulation model in Matlab Simulinк. In [6] all cases of lightning overvoltages are considered but the case of overvoltage due to stroke over the lightning diversion is not completely taken into consideration.

The aim of this paper is to study the operation of SPDs type metal oxide surge arresters (MOSA) in the power systems LV (TN) at the origin of overvoltages due to direct stroke over the lightning diversion of the building (outside lightning protection system).

II. Simulation models for implemented researches

According to [4] for outside influences AQ2 the protection against atmospheric overvoltages is ensured by one or more SPDs, corresponding to the rate voltage of the supply, installed at the entrance of the installation and connected between the conductors and the ground, as follows:

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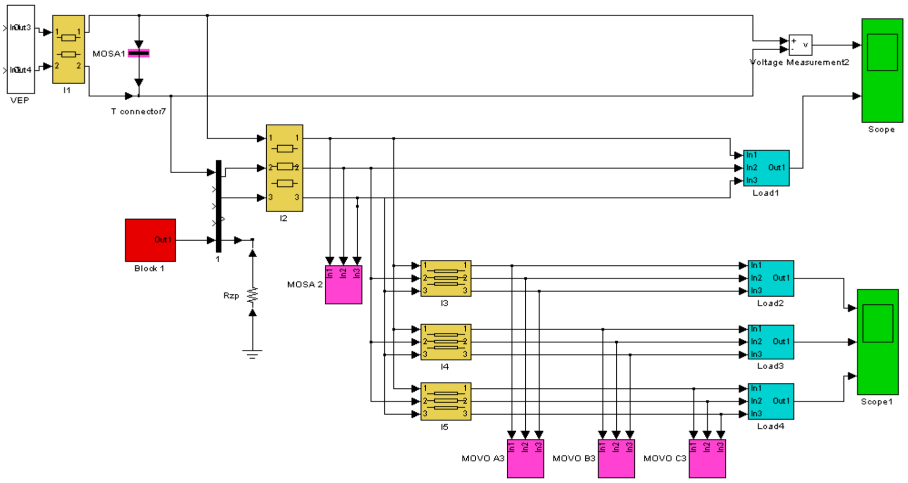


Fig. 1. Simulation model for TN-C-S network

a) In the systems TN and TT, when the neutral conductor is grounded at the entrance- between each phase conductor and the ground;
b) In the systems TN and TT, when the neutral conductor is not grounded at the entrance - between each phase conductor and the neutral on one hand and the ground- on the other hand;
c) In the system IT - between each phase conductor and the ground and when the neutral is distributed - between the neutral and the ground.

The recommendations of the producers of the SPDs are also taken into account.

The simulation models for TN-C-S [1] network and for IT [3, 8] network are used after.

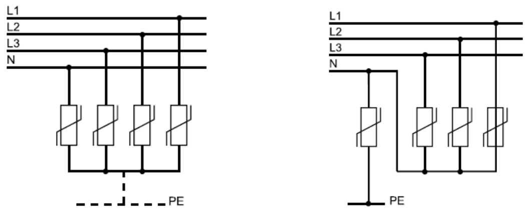
Fig. 1 shows the simulation scheme for TN-C-S system. Block 1 models the lightning current via the lightning protection system. For the objects with explosive hazardous areas Zone 0 and Zone 20 the impulse earthing rod R_{imp} is not connected with the main earthing bar of the building and for the objects with explosive hazardous areas Zone 1, Zone 2, Zone 21 and Zone 22 - R_{imp} is connected.

Parameters of the SPDs (MOSA) are :

TABLE III
PARAMETERS OF THE SPDS

SPD	Protection level U_p, kV	Nominal discharge current (types 2 and 3), kA Impulse discharge current (type 1), kA	U_c,V
	TN- C- S		
Type 1	2,5	25 kA (10/350)	255
Type 2	1,8 (N/PE) 1,2 (L/N)	5 (8/20)	255 (N/PE) 275 (L/N)
Type 3	0,7	5 (8/20)	220

There are two methods of connection of SPs: [7]
- C1: install between each phase and PE conductors and likewise between neutral and PE conductors (fig. 2,a);
- C2: install between each phase and neutral conductor and likewise between neutral and PE conductors (fig. 2,b).



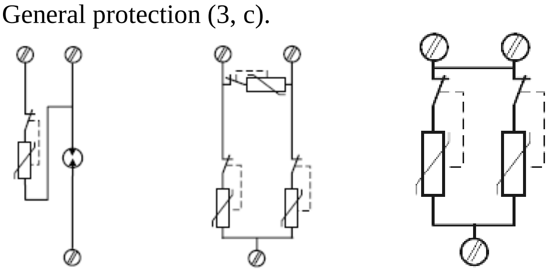
a) b)
Fig. 2. Methods of connection of SPs

III. SIMULATION RESEARCHES

Variant studies of the limitation of the lightning overvoltages from direct stroke of lightning over the protection system of the building, supplied from LV grid, are fulfilled. The wave shape 10/350 μs for Type 1 are modeled. Referenced voltages of the SPDs are monitored.

The following cases are considered:

TN-C-S system:
1) Scheme of connection type C2 of SPDs (fig. 3, a);
2) General and differential protection (fig. 3, b);
3) General protection (3, c).



a) b) c)

Fig. 3. Connection schemes of SPDs [7] for research cases

Figures 4,5 and 6 show the results for this cases.

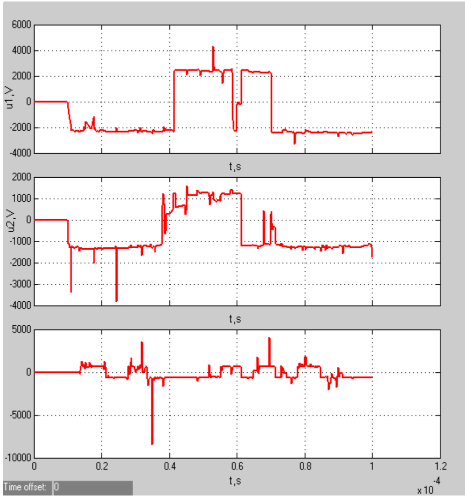


Fig. 4. Residual voltages of SPDs (of fig. 3,a) at a lightning current of 100 kA (10/350 µs)

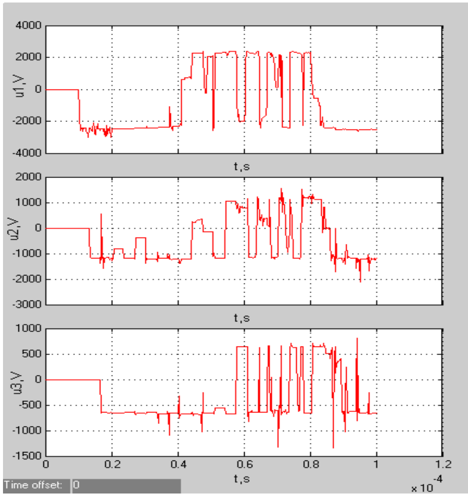


Fig. 5. Residual voltages of SPDs (of fig. 3,b) at a lightning current of 100 kA (10/350 µs)

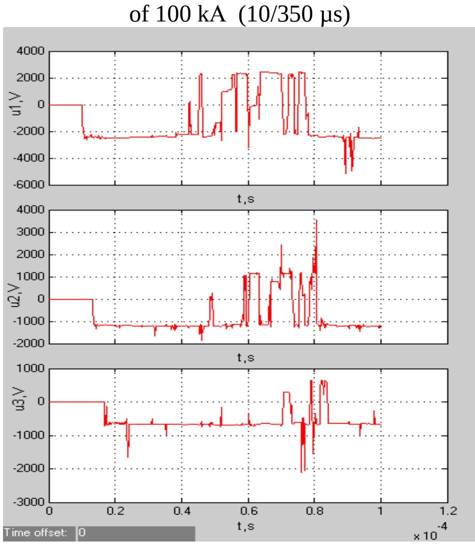


Fig. 6. Residual voltages of SPDs (of fig. 3,c) at a lightning current of 100 kA (10/350 µs)

IV. Analysis and Conclusion

Only 1,27 % of the lightning currents have amplitude over 100 kA. For all that SPDs are projected to stand such loading. On the base of the researches and received results can be made the conclusion that the SPDs protection level depends of theirs connection schemes. When the general and differential protection are used the lightning overvoltages are limited the most reliable (fig. 3,b and fig. 5). SPDs can't limit the overvoltages in other two studied cases and do not stand the energy loading. SPDs limit the overvoltages to the set catalogue values when the lightning currents have lower amplitude.

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