Model Research of Atmospheric Electric Effects in Electrical Low Voltage Network with Local Photovoltaic System

Margreta Vassileva[1] and Dimitar Dimitrov[2]

Abstract **– The problem solved in this paper is to conduct variant research on the occurrence and limit atmospheric overvoltages in low voltage electrical networks with local photovoltaic system.**

The options are determined by place of installation of protective devices and cable length between inverter and photovoltaic panels.

Keywords **– overvoltage, protective devices, low voltage networks.**

I. Introduction

Overvoltages in low voltage power supply networks threaten electrical facilities. They can not be designed with sufficiently high dielectric strength for economic reasons. Economical and secure network operation requires adequate protection of the equipment of the unacceptable impact of overvoltages. This applies to networks of high and low voltage networks.

II. Research Variants and Results

The task of this study is to conduct variant research on the occurrence and limit atmospheric overvoltages in low voltage electrical networks with local photovoltaic system. It is necessary find technically and economically viable solution to install surge protective devices in a residential building [1].

Protective devices must meet the requirements of standard IEC 61643-11. They are mounted between each lightning protection zones and must have an appropriate protective level.

According to standard IEC 60364-4-44, endurance levels of overvoltages of the equipment are classified into four categories. Protective devices must limit overvoltages under these levels.

Figure 1 shows one scheme of the research grid. The model integrate the following structural elements: power system (S); power lines 0,4 kV - air and cable, main switchboard (GRT); surge arresters - type metaloxide (MOSA), low voltage installation, consumers with different power (C_1, C_2, C_3). Subsystem of DC consists of a source of direct voltage (PV), which are modeled by photovoltaic panels, inverter, grounding resistors. Voltage of photovoltaic panels is 240 V. Parameters of the protective devices are [3,4]: MOSA1 between inverter and the photovoltaic panel – U_c=600 V DC , I_{max}=70 kA; MOSA2 before inverter - U_c=600 V AC, I_{max}=40 kA; U_p= 1,5 kV; MOSA3 in main switchboard - U_c=255 V AC, I_{max}=25 kA; U_p= 1,5 kV; MOSA4 - U_p= 1190 V.

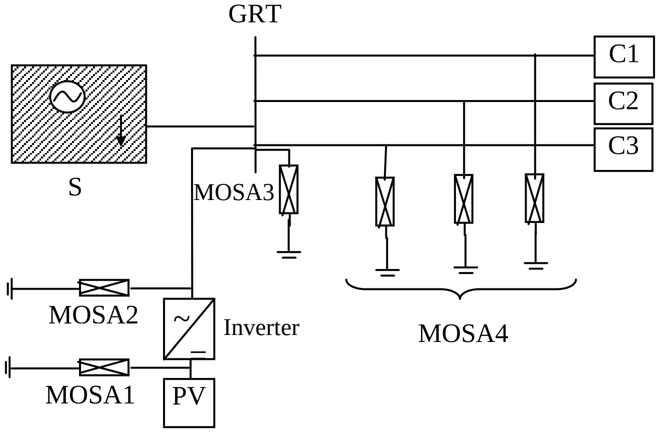

Fig. 1. One-line diagram of the research grid

Examined a case of direct hit of lightning in phase conductor of the power line in the system S. Observe the effects of lightning with parameters 40 kA and 1 /10 µs.

The voltage of the incoming wave and residual voltages of protective devices are controlled. Model scheme of low voltage network is presented in [2].

Studies have been made for the following cases:
1) Presence of MOSA in main switchboard, in the AC and DC parts of inverter and before consumers (fig. 1);
2) Presence of MOVO in main switchboard, in the AC and DC parts of inverter, without protective devices to consumers;
3) Presence of MOVO only in main switchboard;
4) Protective devices is not included.
5) Different cable length (10, 20, 50 m) between inverter and photovoltaic panels for case 1.

[1] Margreta Vassileva, Technical University of Varna, Department of Electric Power Engineering, Studentska 1, Varna, 9010, Bulgaria, m.vasileva@tu-varna.acad.bg.

[2] Dimitar Dimitrov, Technical University of Varna, Studentska 1, Varna, 9010, Bulgaria.

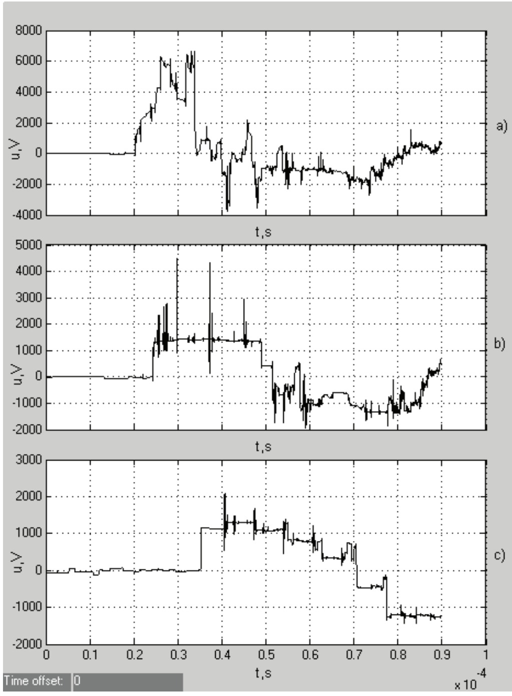

Fig. 2 Voltage of the incoming wave (a), residual voltage of MOSA3 (b) and of MOSA2 (c)
(20 m cable length between inverter and photovoltaic panels)

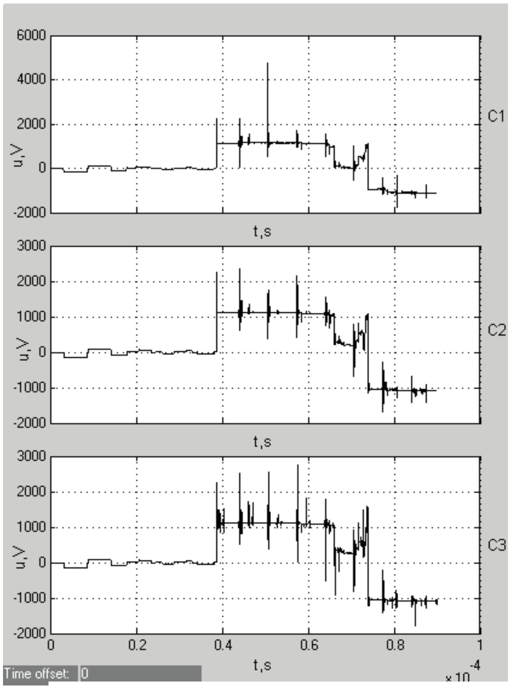

Fig. 3 Residual voltage of MOSA4
(20 m cable length between inverter and photovoltaic panels)

Figures 2 and 3 show the results for case 1.

Common pattern in the resulting time dependencies of voltages is that they develop as harmony fading fluctuations, which in steady pass to form the working voltages. All MOSA begin to work, limiting overvoltages to the corresponding protection levels (Fig. 2 and 3). The results for case 2 and 3 have the same character development as well as for case 1. Voltages of the consumers in cases 2 and 3 exceed the insulation level (1500 V) for first class facilities.

In case 3 voltage to the AC side of inverter also increase and exceeds the permissible level of insulation. MOSA 3 in GRT limited the overvoltages to the corresponding protection level, but its operation becomes unstable.

The results of controlled voltages when not using the protective devices (case 4) show that the insulation levels for all facilities are exceeded.

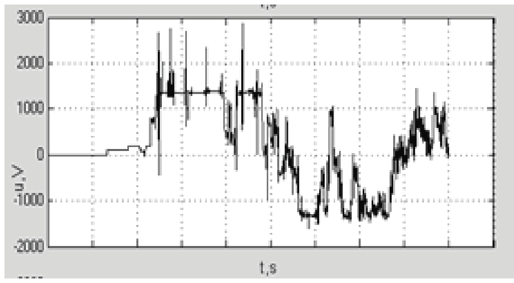

Fig. 4 Residual voltage of MOSA3
(50 m cable length between inverter and photovoltaic panels)

Concerning study on the influence of cable length between inverter and photovoltaic panels can be concluded that the frequency of the process in the network increases with increasing cable length. Protective devices restrict overvoltages to their set security levels, as in the 50 m length the action of MOVO in GRT is highly unstable (Figure 4).

III. Conclusion

From analytical studies can be made the following major conclusions:

1) The presence of MOSA only in main switchboard can not provide protection from overvoltages of equipment in lower installation category.

2) The presence of a DC circuit in the scheme and in particular the inverter brings additional disturbances of the operation of the protective devices.

3) It is necessary to include protective devices for all types of facilities to ensure their protection.

References

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