Immunity of photovoltaic installation on electromagnetic surge disturbances

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Abstract. The work analyzes the correctness of the functioning of the photovoltaic system with a rated electrical power of 3500 W, consisting of 14 photovoltaic modules and a power electronic converter in the form of a single phase voltage inverter equipped with a maximum power point tracking system, disturbed by voltage stroke. The voltage surge with the parameters 1.2/50 μs, simulating a lightning discharge, was introduced into the system from the power grid side. For the purpose of computer simulation performed in Matlab/Simulink, the recommendations included in the PN-EN 61000-4-5 standard "Immunity of the surge disturbances" were used. Significant changes in the voltage and current on the AC side, related to the system of energy return to the power grid were shown.

1 Introduction

The immunity of a working device or system is understood as the ability to work during interaction of a certain electromagnetic disturbances. Nowadays, laboratory tests of equipment immunity to electromagnetic disturbances such as electrostatic discharge, electrical fast transients or surges are standardized [1].

The assumptions of Polish Energy Policy until 2030 put a lot of emphasis on electricity generation [2] including photovoltaic installations, which makes them popular and widely used in Poland and in the world [3-5].

Among the components of an on-grid and off-grid photovoltaic installations, the following power electronic devices can be distinguished: inverters, charge regulators, DC/DC converters, other photovoltaic optimization systems. These devices belong to the group of devices sensitive to electromagnetic disturbances. Failure to meet the requirements of electromagnetic compatibility and their improper installation (eg lack of equipotentialisation of potentials) can lead to their failure and shutdown of a part or whole operating system.

Due to the harmfulness of immunity tests for selected electromagnetic disturbances [6], it is reasonable to use computer simulation tools to make a model of a photovoltaic installation working during the disturbance [7].

2 Photovoltaic installation

The photovoltaic system is a combination of component devices that allow obtaining solar energy, its conversion into electricity based on the solar effect in the material structure and the adjustment of electrical signal parameters to the requirements of a AC grid or powered electric receivers. Regardless of the used configuration, it is necessary to expose the surface of photovoltaic modules to solar radiation, which increases the risk of adverse external factors, including direct lightning discharges or couplings generated in the vicinity of the photovoltaic installation site. This makes it necessary to use appropriate protection measures against direct lightning discharge and against possible electrical surges.

The model of the tested photovoltaic installation is shown in Fig. 1. The power supply circuit includes 14 PV modules connected in one string. The rated power of the entire photovoltaic installation is equal to 3500 W. The installation is equipped with a control system, which tracks the maximum power point.

Current and voltage DC values from the photovoltaic system are converted into AC current and voltage using an inverter system based on a controlled H - bridge.

The photovoltaic installation was disturbed by a voltage pulse 1.2/50 μs with a value of 20 kV. The surge disturbance is introduced into the system from the AC grid side.

The influence of a disturbances on the voltage and current waveforms in the power network is shown in Fig. 2 and 3. At the moment of the voltage surge, the value of voltage amplitude equals 15 kV.

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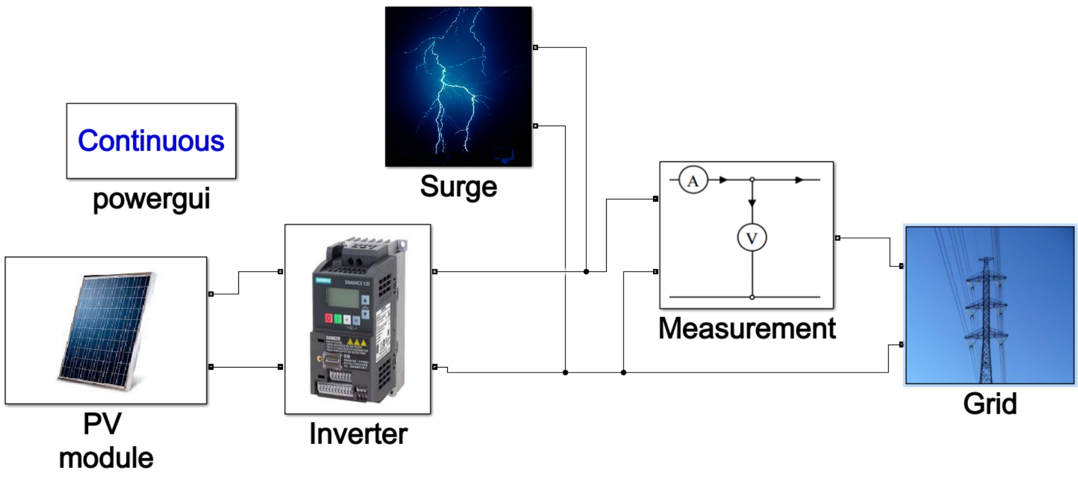

Fig. 1. Model of a tested photovoltaic installation.

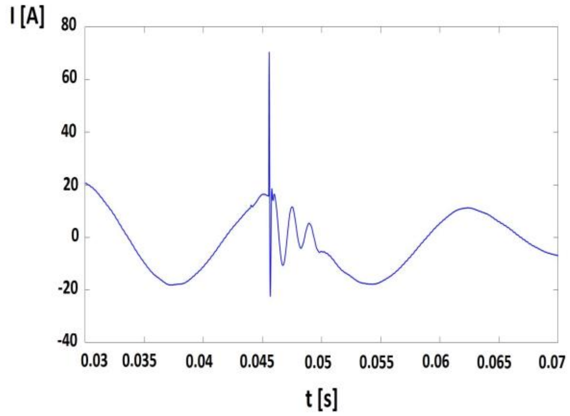

Fig. 2. Current waveform with a surge disturbance.

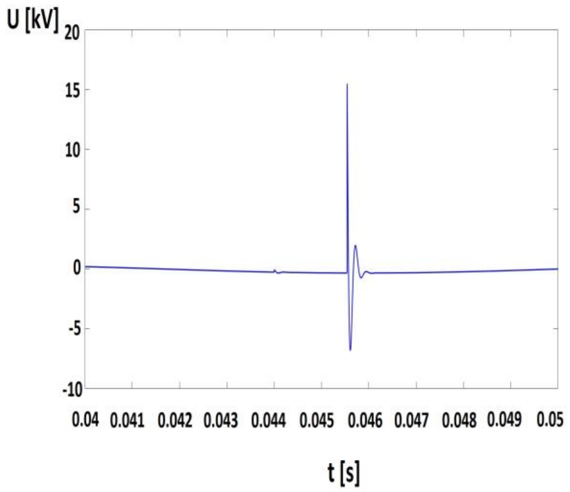

Fig. 3. Voltage waveform with surge disturbance.

The value of current increases dangerously to the amplitude of almost 70 A. With such a high current value, the components of the system may be destroyed.

3 Summary

Using of computer simulation tools, it is possible to check the behavior of the installation under influence of electromagnetic disturbances. This causes the detection of potential damage and gives the possibility of using additional security elements. Photovoltaic modules and DC / AC power converters cooperating together are a potential objects that can be destroyed in case of direct lightning discharge as well as couplings with objects in the immediate vicinity.

The issue of the analyzed phenomenon is significant, as approximately 20 stormy days and on average 2 lightning strikes on the area of 1 m^2, are recorded in Poland every year.

The photovoltaic devices installed on the walls of buildings and building objects should be protected.

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