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COMPUTER MODELLING OF LIGHTING POWER CONTROLLER OPERATION DISTURBED BY 1.2/50 μs VOLTAGE LIGHTNING STROKE

The article presents a computer simulation of a lighting installation disturbed by lightning surge. Modelled impulse voltage generator 1.2/50 μs, system with coupling/decoupling system and a power semiconductor regulator used in light engineering have been described. The aim of the work was to investigate the influence of the surge impulse on the current flowing through the installation.

KEYWORDS: surge impulse, computer simulations, lighting installation, power regulator.

1. INTRODUCTION

All products placed on Polish or European market should be CE marked. Therefore, the products should fulfill the international standards for electromagnetic compatibility (EMC) [2, 9, 10]. Equipment manufacturers are required to carry out appropriate tests and issue a certificate of conformity to the Standards prior to placing the devices on sale [2].

EMC compliance device do not guarantee that the device installed in the environment with other devices as a fixed installation will also be electromagnetic compatible. Consequently, additional tests should be carried out after completing the fixed installation. Installation immunity tests can cause damage to one or many components. Computer simulations of the disturbed system can reduce the losses and show necessity to install additional security measures.

The paper presents computer simulation of the operation of a part of the lighting installation using the Matlab/Simulink software. In addition, a model of the lightning generator with the coupling and decoupling system, according to the Standard [6] was performed.

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2. SURGE IMMUNITY TEST

Voltage lightning surge is characterized by the following parameters: peak value, the duration of the forehead T_1, contractual onset of surge O_1 and time to half peak T_2. Normal lightning stroke, is a surge with the 1.2 µs duration of the forehead and 50 µs time to half peak. Surge current, in turn, is characterized by: the value of the current generally understood as the peak value and next the same set of parameters T_1, O_1 and T_2, as in voltage surge. Normal surge currents with high exponential attenuation were categorized as strokes: 1/20, 4/10, 8/20 and 30/80 µs [3, 11].

Voltage surge is given by equation (1):

$$\upsilon(t) = Ae^{(-\alpha(|t-t_1|))} \cdot u(t-t_1) \qquad (1)$$

where: A is the impulse magnitude, α is the damping factor, t_1 is the time when the impulse starts, t is the time function, and u is the impulse rise step function.

Lightning surges caused by lightning fast transients include [6, 9]:

– a direct lightning strike to the external circuit (located in the open air) induce large currents, which generate a voltage as a result of flow through ground resistance or an external circuit impedance;
– indirect lightning strike (discharge between clouds or within, or to nearby lightning, electromagnetic fields) which induces voltages/currents in the conductors outside and/or in the building;
– the flow of lightning current in the ground as a result of nearby direct discharges, coupled to common lines of grounding system of the installation.

The laboratory test of immunity of surges is performed at the station containing [6, 9]:

– tested device,
– auxiliary equipment (if required),
– coupling - decoupling system,
– generator,
– reference ground plane.

Surge generator in accordance with Standard [6] was modelled in Matlab/Simulink software [8, 12]. The lightning impulse model can be implemented using MATLAB Function block, clock block, constant block, and step function block as shown in Figure 1.

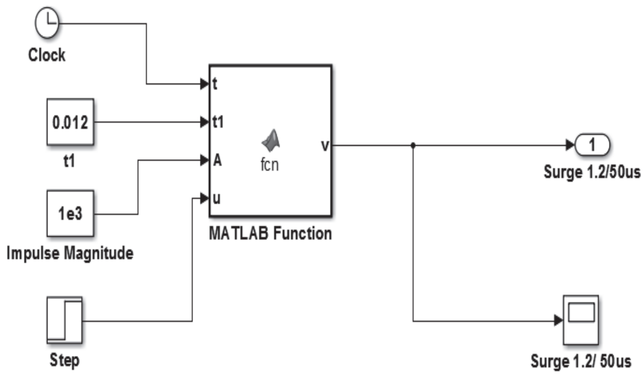

Fig. 1. Scheme of a lightning surge generator

The MATLAB Function block is coded using Equation (1). Damping factor α was 14200. At sample 12000, which is 0.012 second the impulse rise to the peak magnitude of 1000, and at 12,050 sample, which is 50 μs later, the impulse magnitude decays to 503,6.

The shape of the impulse waveform from the generator is shown in Figure 2.

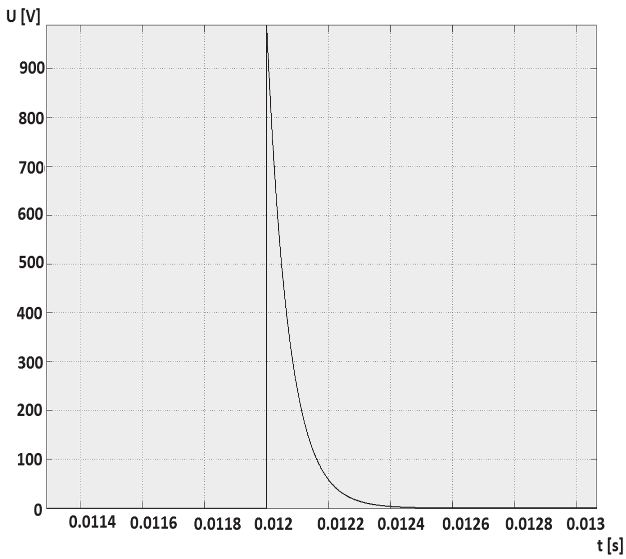

Fig. 2. Shape of lightning impulse

For the construction of the entire system introducing disturbances to the installation, additionally coupling and decoupling system, according to the Standard [6] was modelled (Fig. 3).

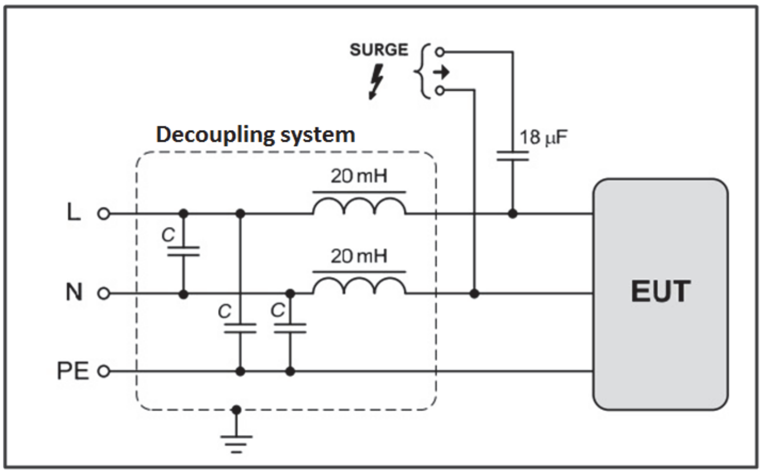

Fig. 3. Coupling - decoupling system

3. MODEL OF LIGHTING INSTALLATION DISTURBED BY LIGHTNING SURGE

The work involved simulation of the lighting installation equipped with an overcurrent switch, power regulator and incandescent light fixture, disturbed by lightning surge. Figure 4 presents a simulated system. Two systems of voltages and currents measurement - measuring system 1, seen from the power source and measuring system 2, seen from the load side were used.

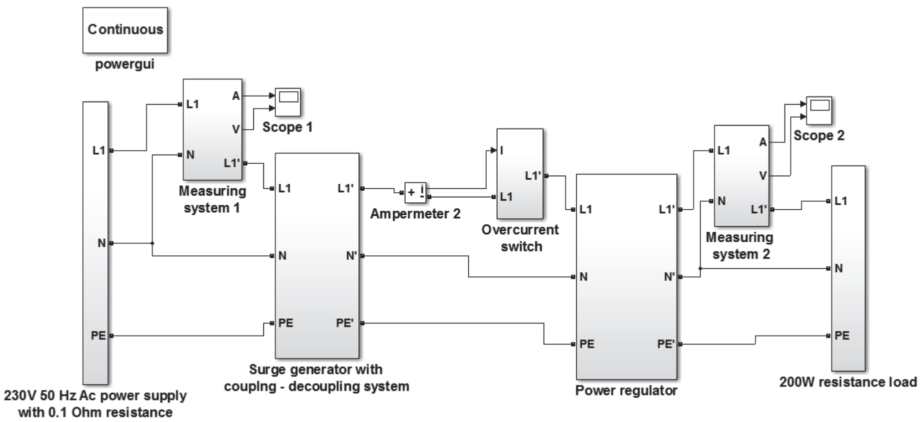

Fig. 4. Model of tested circuit

In the circuit a semiconductor power regulator was used. In system the resistors, capacitors, diodes and thyristors connected in the circuit as triac controlled by a diac were used. Its scheme is shown in Figure 5.

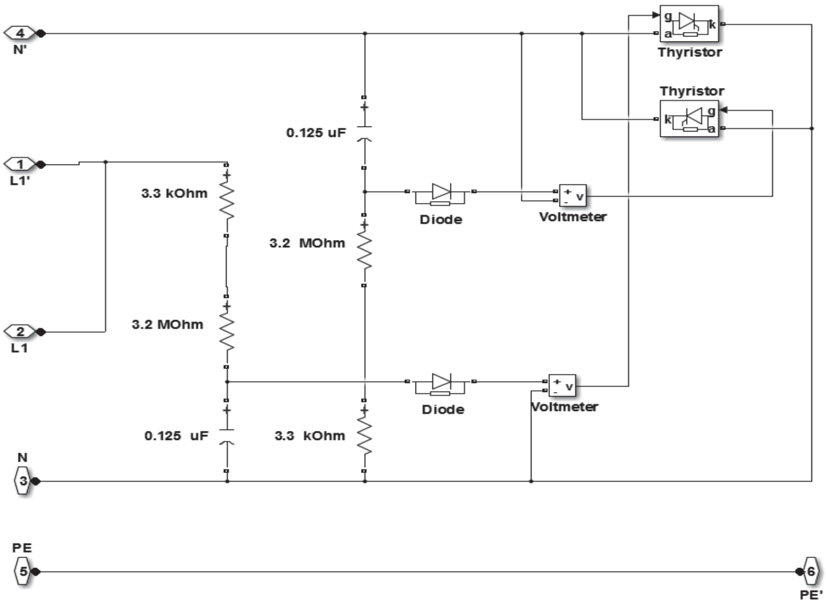

Fig. 5. Model of a power regulator

Figures 6, 7, 8 and 9 show currents and voltages characteristics of the undisturbed circuit. The voltage characteristic considered from the source side (measuring system 1) is an ideal sinusoidal wave. In contrast, the waveform of the current for the entire system is partially cut off by the semiconductor components used in the power regulator. The amplitude of the current in the system is approximately 1.7 A.

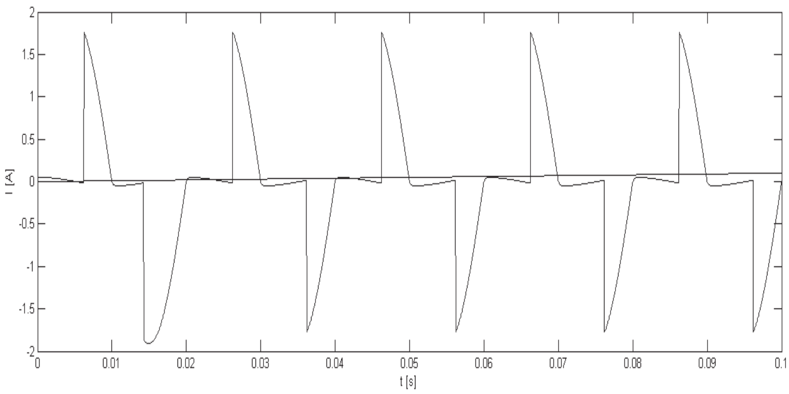

Fig. 6. Current waveform of the measuring system 1

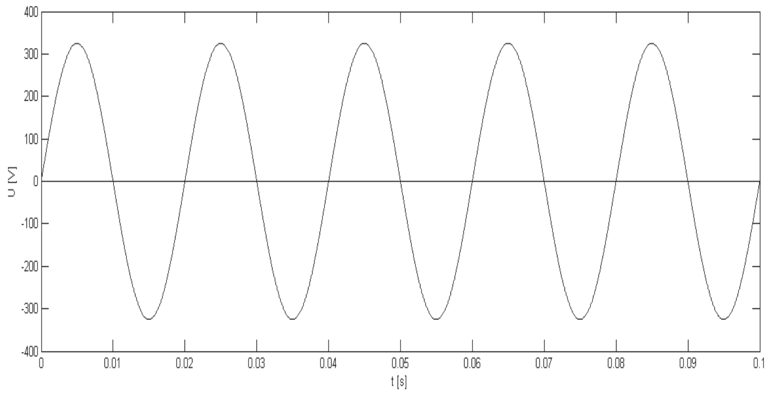

Fig. 7. Voltage waveform of the measuring system 1

The voltage characteristic considered of the load side (measuring system 2) similarly to the current characteristic of the circuit is partially cut off.

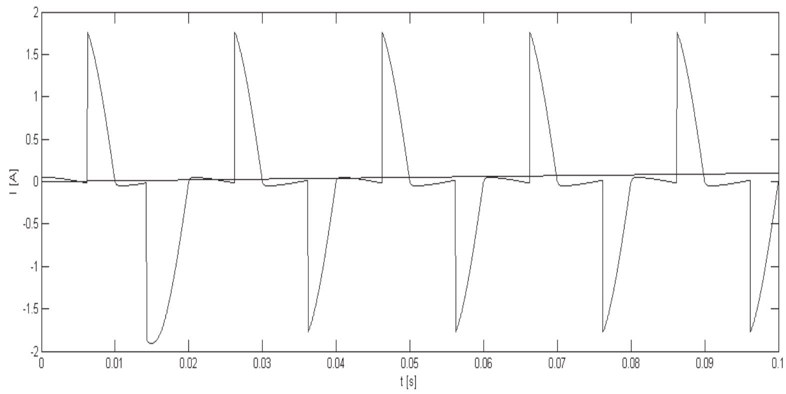

Fig. 8. Current waveform of the measuring system 2

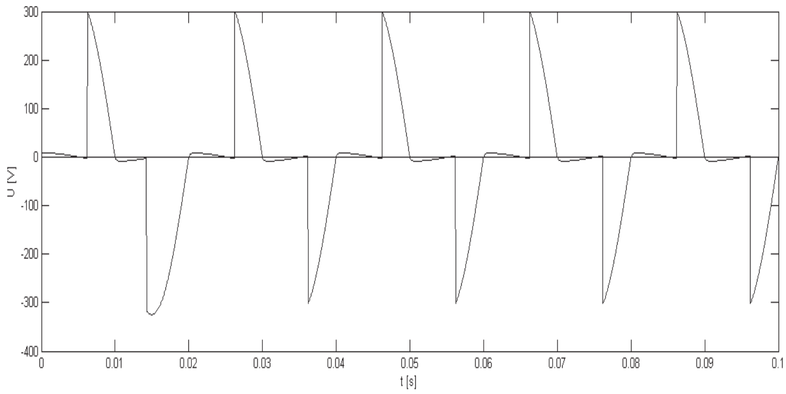

Fig. 9. Voltage waveform of the measuring system 2

The aim of the research was to investigate the influence of the surge impulse on the current flowing through the installation. The results of the simulation are presented in Figure 10, and 11.

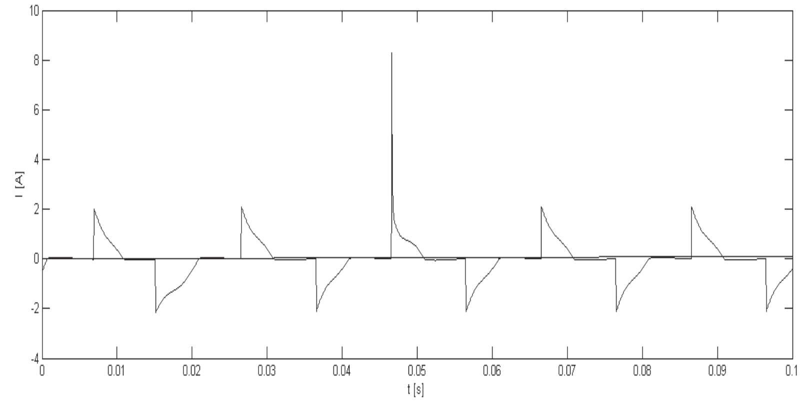

Fig. 10. Current waveform of the measuring system 2

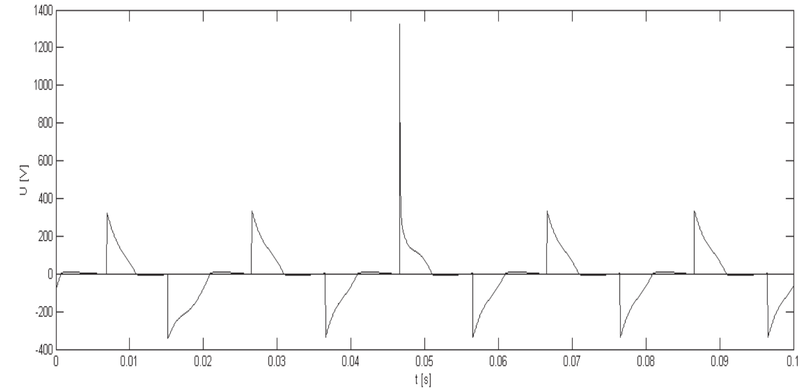

Fig. 11. Voltage waveform of the measuring system 2

On the voltage characteristic considered from the load side (measuring system 2) in the course of placing the surge disturbance is visible pulse with an amplitude of about 1325 V. The shape of the current waveform is similar to the voltage. The amplitude of the current pulse resulting from the introduced disturbance is about 8,26 A.

The amplitudes of the signals of both current and voltage considered from the load side are more than four times value of the amplitude of the undisturbed signal. Introducing the lightning surge disturbance to presented lighting circuit can cause its permanent damage.

4. SUMMARY

Due to possible harmfulness of the EMC tests performed on a fixed installation, it is justified to use computer simulation software to model the operation of the system [1, 4, 5]. This avoids unwanted component damage and shows requires the installation of additional components that improve system performance.

The article presents the simulation model developed and results of computer simulations of the operation of the lighting system subjected to electromagnetic disturbances according to the Standard [6, 10].

Matlab/Simulink software has been proved as a helpful tool for EMC tests simulations on fixed installations.

Currently, the work is carried out to improve the surge generator model. It is planned to implement a double-exponential equation, that will improve the voltage pulse parameters [7]. In addition, the simulation of the operation of subsequent electrical systems sensitive to disturbances is also envisaged.

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