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DEPENDENCE OF CURRENT HARMONICS OF GREENHOUSE IRRADIATORS ON SUPPLY VOLTAGE

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ABSTRACT

The article describes the results of the study concerning the effect of the voltage level on current harmonic composition in greenhouses irradiators. It is found that its change affects the level of current harmonics of all types of the studied greenhouse irradiators. With decrease of nominal supply voltage by 10 %, the total harmonic distortion THD_i decreases by 9 % for emitters equipped with high pressure sodium lamps (HPSL), by 10 % for emitters with electrode-less lamps and by 3 % for LED based emitters. With increase of nominal supply voltage by 10 %, THD_i increases by 23 % for lighting devices equipped with HPSL, by 10 % for irradiators with electrode-less lamps and by 3 % for LED based emitters. Therefore, changes of supply voltage cause the least effect on the level of current harmonics of LED based emitters and then the emitters with electrode-less lamps. Change of the level of supply voltage causes the greatest effect on the level of current harmonics of HPSL based irradiators. Mathematical models of dependence of THD_i on the level of supply voltage for greenhouse emitters equipped with LED, electrode-less lamps and HPSL lamps were formulated. These mathematical models may be used for calculations of total current when selecting transformers and supply cable lines for greenhouse lighting devices, for design of new or reconstruction of existing irradiation systems of greenhouse facilities, and for calculation of power losses in power supply networks of greenhouse facilities during feasibility studies for energy saving and energy efficiency increasing projects.

Keywords: greenhouse irradiators, supply voltage, total harmonic distortion of current

1. INTRODUCTION

Application of irradiators equipped with light emitting diodes (LED) and electrode-less fluorescent lamps (EFL) the radiation spectra of which may be defined by content of LED and phosphor respectively is promising for greenhouse horticulture. When growing plants in a photo-culture, there is a capability to monitor and control physiological processes in plants. The analysis of the works by Russian and foreign scientists [1–12] has shown that close data on plant performance may be obtained when using LED and EFL based irradiators with red and blue radiation with installed capacity lower by (30–50)% than that of HPSL based devices for greenhouse facilities and nurseries used currently.

Due to the new prospects, the mutual effect of the prospective emitters and power supply systems as compared to that of existing HPSL based systems is of scientific and practical interest. Greenhouse irradiators are non-linear power consumers generating higher harmonic components of current. The latter may reduce quality of functioning of different devices and electric installations or inflict damage to them, increase additional power losses in power consumers and networks [13]. The studies of the quality of electric power received from a centralised electric network have shown that the range of volt-

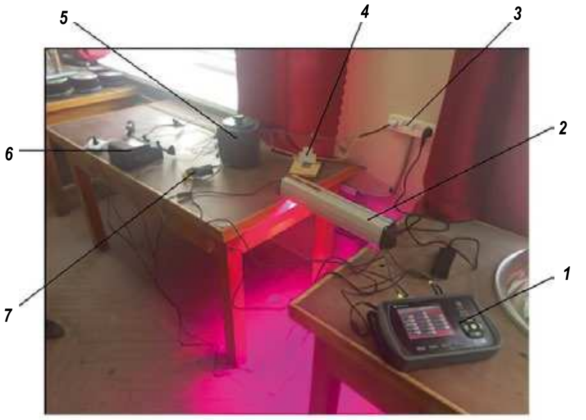

Fig. 1. The electro-technical set for measurement of electric parameters of greenhouse emitters

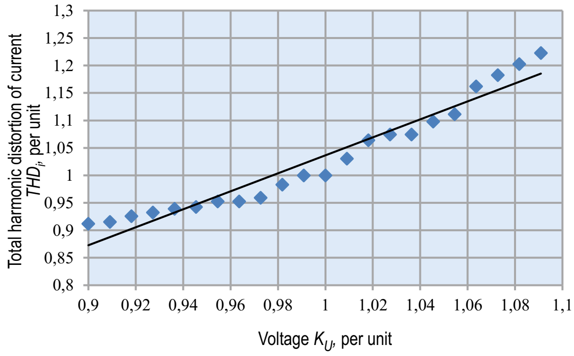

Fig. 2. Dependence of THD_i on K_U for the HPSL based irradiator

age level varies within a wide range in many Russian agricultural facilities [14].

The goal of this work is to study the impact of the level of supply voltage on harmonic composition of current in greenhouse emitters.

2. MATERIALS AND METHODOLOGY

The study subjects are ZhSP-series devices equipped with HPSL with a reflector (DNaZ series) manufactured by KETZ LLC, DSO-series LED based emitters manufactured by OKB Luch LLC, and EFL based irradiators manufactured by *S&O*.

The appearance of the measurement electro-technical set is shown in Fig. 1. The measurement electro-technical set includes the following elements: *1* – *AR-6* power quality analyser by *Circutor*, *2* – greenhouse irradiator, *3* – ~220V power supply unit, *4* – automatic switch, *5* – RNO-250–2-M voltage controller, *6* – ammeter, *7*–5A current measuring pliers. Adjustment of supply voltage for the light source was performed by means of a line automatic transformer. The electric parameters were read by means of a power quality analyser. The measurements were performed for 2 light sources of each type, 3 measurements were made for each point. Over the first hour after switching on, the emitters were reaching the nominal operation mode, no measurements were made. Then harmonic composition of emitter currents was measured in the nominal operation mode. After it, the harmonics level was measured after changing the level of supply voltage with a step of 2 V.

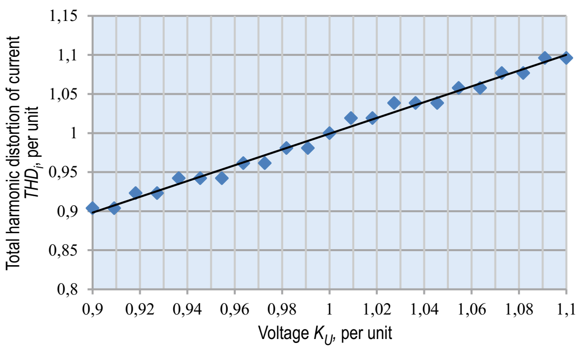

Fig. 3. Dependence of THD_i on K_U for the irradiator with an electrode-less lamp

3. RESULTS

The value of harmonic composition of an alternate current signal which includes harmonic composition of currents is characterised by, in particular, the THD_i[1] ratio.

Fig. 2 shows the results of the studies of the effect of the level of supply voltage (SV) on THD_i of a ZhSP greenhouse emitter equipped with a HPSL. With decrease of nominal SV by 10 %, total harmonic distortion of current decreases by 9 %. With increase of nominal SV by 10 %, total harmonic distortion of current increases by 23 %.

On the basis of the results of the studies, using *MS Excel* software, the mathematical expression of change of *THDi* after change of SV level was obtained:

$$THD_i = THD_{i_{nom}} \cdot (1{,}6 \cdot K_U - 0{,}6),$$

$$R^2 = 0.9414,$$

where $THD_{i_{nom}}$ is the nominal THD_i,%; $K_U = U_f / U_{nom}$ is the change of the level of SV, per unit; U_f is

[1] In foreign literature, *THD* stands for *Total Harmonic Distortion*.

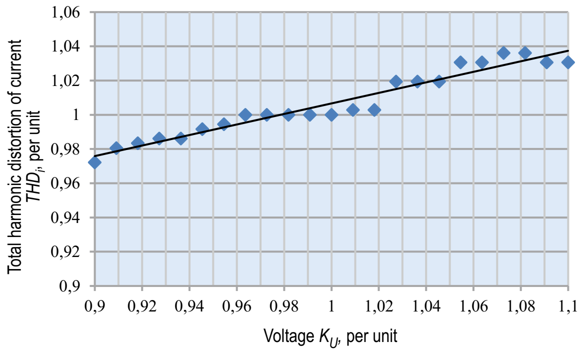

Fig. 4. Dependence of THD_i on K_U for the LED based emitter

the actual SV, V; U_{nom} is the nominal SV, V; R^2 is the determination coefficient, per unit.

Fig. 3 shows the results of the studies of the effect of the SV level on THD_i of a greenhouse irradiator manufactured by *S&O* equipped with EFL. With decrease of nominal SV by 10 %, THD_i decreases by 10 %. With increase of nominal SV by 10 %, THD_i increases by 10 %.

On the basis of the results of the studies, using *MS Excel* software, the mathematical expression of change of THD_i after change of SV level was obtained:

$$THD_i = THD_{i_{nom}} \cdot K_U,$$

$$R^2 = 0.9896.$$

Fig. 4 shows the results of the studies of the effect of the SV level on THD_i of a DSO greenhouse emitter manufactured equipped with LED. With decrease of nominal SV by 10 %, THD_i decreases by 3 %. With increase of nominal SV by 10 %, THD_i increases by 3 %.

On the basis of the results of the studies, using *MS Excel* software, the mathematical expression of change of THD_i after change of SV level was obtained:

$$THD_i = THD_{i_{nom}} \cdot (0,3 \cdot K_U + 0,7),$$

$$R^2 = 0.9435.$$

4. DISCUSSION

The change of SV level affects the level of current harmonics of all types of the studied greenhouse irradiators. For instance, with decrease of nominal supply voltage by 10 %, THD_i decreases by 9 % for emitters equipped with HPSL, by 10 % for emitters with EFL, and by 3 % for LED based irradiators. With increase of nominal SV by 10 %, THD_i increases by 23 % for irradiators equipped with HPSL, by 10 % for systems with EFL and by 3 % for LED based emitters. Therefore, changes of the level of SV cause the least effect on the level of current harmonics in LED based emitters and then on that of EFL based devices. Change of the level of SV causes the greatest effect on the level of current harmonics of HPSL based irradiators.

5. CONCLUSION

Mathematical models of dependence of THD_i on the level of supply voltage for greenhouse lighting devices equipped with LED, EFL and HPSL lamps were formulated; they may be used:

– For calculations of total current when selecting transformers and supply cable lines of greenhouse emitters and for design of new or reconstruction of existing irradiation systems of greenhouse facilities;

– For calculation of power losses in power supply networks of greenhouse facilities during feasibility studies for energy-saving and energy efficiency increasing projects.

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