ELECTROLUMINESCENT LIGHT SOURCE EMISSIVITY SIMULATION

Alexander M. Kabyshev, Evgeny N. Kozyrev, Igor N. Goncharov,
Roman O. Askerov, and Vladimir V. Urumov

The North Caucasian Mining and Smelting Institute (State Technological University), Vladikavkaz
E-mail: asker2005@rambler.ru

ABSTRACT

Characteristics that define luminous and electrical features of flexible electroluminescence light sources (ELLS) are discussed. A computer model of ELLS in combination with a power supply unit was designed. A serial RC-circuit served as a load in the model. The model is highly adequate to the real object and that was proved by measured oscillograms of voltage and current.

Keywords: electroluminescent light source, luminance, phosphor, computer simulation, electric capacity, RC-circuit, timing diagram of voltage and current

1. INTRODUCTION

Electroluminescent light source (ELLS) is an up-to-date highly efficient source of uniform optical radiation which may have large area and generate light of various wavelengths. This product may be used to illuminate instrument panels of different steady-state and mobile devices; in signalling and long-lasting emergency lighting systems; in advertising displays with wide composing abilities. An ELLS may light from below an image printed on a transparent film and provide a picture with a quality and brightness similar to monitor display.

An ELLS is a solid-state source of optical radiation, which transforms electrical power into light with an efficacy of 80 %. Rather simple design, thinness, diversity of dimensions and shapes, low power consumption, resistance to vibration, damp, cuts and punctures – are additional benefits of ELLS. Its main characteristics are as follows: supply voltage U (about 150V); supply frequency ($f \approx 1000$Hz); luminance B (reaching 45cd/m^2 under f=50Hz and U=220B, and 200 cd/m^2 under f=1000 Hz and U=150 V).

2. TEST DESCRIPTION

A luminous panel consists of two main layers located between plane electrodes. As a matter of fact, electroluminescent panel is a capacitor with two transmitting (transparent and non-transparent) surfaces, i.e. electrodes. A layer of zinc sulphide phosphor with binder and dielectric sheet are placed between the electrodes. The ZnS luminescent solid D512C-GG was made in China and radiated a turquoise light. The second dielectric sheet comprised a thin plate of porous aluminium oxide in an epoxide binder mixed with a barium titanate BaTiO3 ferroelectric taken in a weight ratio of 2.5: 1, and a wetting agent – hydroxyethyl phenol OP-10.

The luminescence of this source follows the Lambert law, i.e. its luminance does not depend on the viewing direction. The glow starts when an alternating voltage is applied to two conducting layers. This is an electroluminescence process (Destrio effect). The phosphor emits light quanta during both half periods of voltage, and its instant luminance is a periodic function of time [1, 2, 4]. The ELLS luminance depends on the magnitude, shape, frequency, and duration of current pulses running through the panel. Thus it is related to the operation of power supply unit, which has to provide an advantageous combination of amplitude and fre-
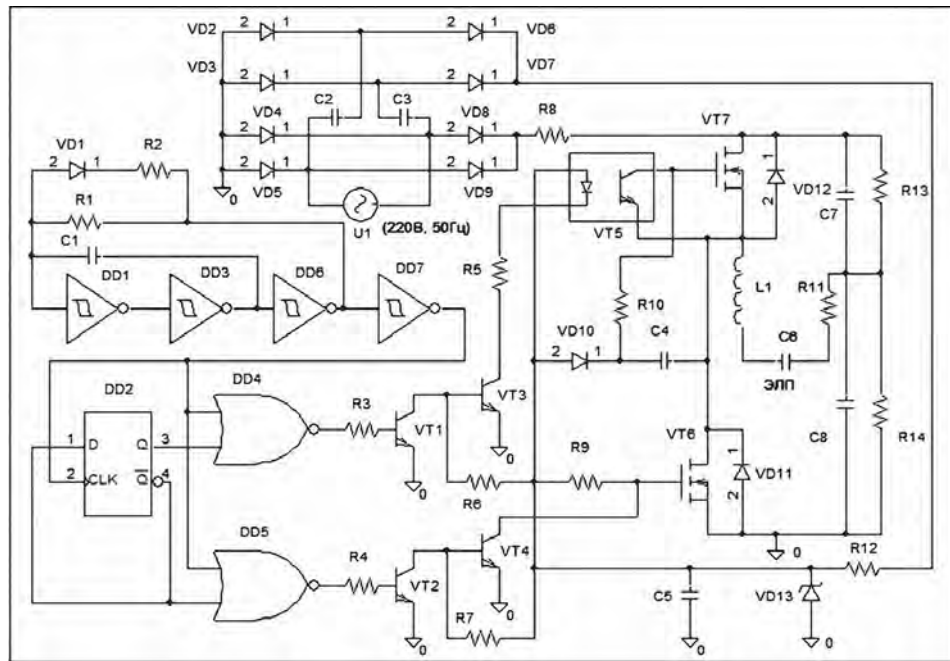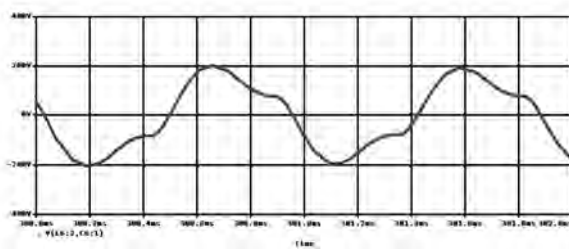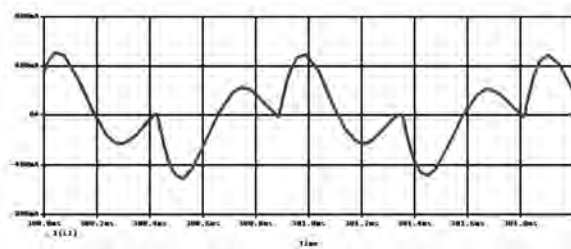
Fig. 1. Computer model of power supply unit

a) Voltage time chart   *б)* Current time chart

Fig. 2. Time charts of voltage and current

quency of voltage, and optimum shape and duration of pulses [1,2].

Since ELLS is a plane capacitor, electric capacity C is its main feature. Let us derive the equation for calculating capacity C.

Ignoring leakage current of ELLS, the complex resistance may be equal to the resistance of equivalent capacitor X_C:

$$X_C = \frac{1}{2\pi fC} = \frac{U}{I}, \qquad (1)$$

where f is a frequency of alternating current, Hz, I – a current running through ELLS, A.

The value of C may be expressed as follows:

$$C = \frac{I}{2\pi fU}. \qquad (2)$$

The capacity makes a significant effect on the magnitude and shape of running current, and hence, on the luminance of a panel and operating modes of power supply unit [3].

Knowing the capacity C of a panel, phase shift φ between current and voltage, one may determine the active resistance of luminescent layer:

$$R = \frac{1}{2\pi fc \cdot tg\phi}. \qquad (3)$$

For example, if panel capacity calculated from the equation (1) equals to 0.24 mkF, then under $f=$ 1000 Hz and $\phi = 66^0$ the active resistance of fluorescent layer in ELLS is 290 Om.

Fig. 1 shows circuit diagram of designed converter for power supply of ELLS. The diagram is adapted for computer simulation within OrCad software.
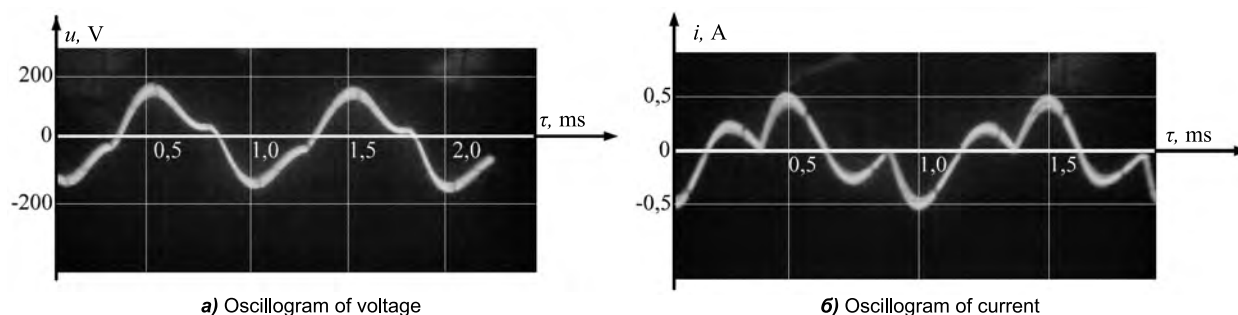
a) Oscillogram of voltage   *б)* Oscillogram of current

Fig.3. Oscillograms of voltage and current under
$L1=16$ mHn

The scheme elements: VD2 – VD9, C2, C3 are the part of a rectifier (R). Stand-alone voltage inverter is built on the base of transistor switches VT1 – VT6 and capacitors C7, C8. The control system consists of generator of rectangular pulses based on "not"-logic elements (DD1, DD3, DD6, DD7), pulses distributor (DD2 trigger) and "or-not" logic elements (DD4, DD5) that provides the time period ("dead period") when the transistor switches VT6, VT7 are closed. Variation of the resistance R2 enables to change time interval and generator pulses duty cycle and thus to control the shape of the current running through ELLS.

One of the main elements of the circuit that determines its weight, dimensions, and running parameters, is a choke with inductance L1. The choke is designed to limit and smooth pulses of alternating current (AC) of ELLS and thus to provide the optimal luminous and thermal mode of operation of a panel.

At the circuit (see Fig.1.) capacitor C6 and resistor R11 serve as a load and take into account the panel capacity and fluorescent layer resistance.

Fig. 2 shows the time charts of voltage and current resulted from computer simulation.

The charts correspond to operational mode of power supply unit with a load (ELLS) having the following parameters: capacity – 0.25 mkF, resistance of fluorescent layer – 290 Om, inductance of a choke L1–16 mHn.

To validate the results of computer simulation we obtained the oscillograms of voltage and current running through ELLS (see Fig.3) while operating with a real power supply unit made by the scheme shown in Fig.1. The electrical capacity of the panel was 0.24 mkF.

A comparative analysis of results obtained from computer simulation and measurements (oscillograms) gives reason to make a conclusion that the computer model of power supply unit and ELLS (as a serial RC-circuit) corresponds to real physical objects.

It is possible to derive from calculated and measured oscillograms under given input electrical parameters of luminous structure the following output characteristics: actual voltage – 130 V, actual current – 300 mA, thus, according to data from [1] the luminance of ELLS with A3 dimensions will be about 140 cd/m^2 under the temperature of 35 °C.

ACKNOWLEDGMENT

REFERENCES

1. Goncharov I.N., Kabyshev A.M., Kozyrev E.N., Maldzigati A.I. Design and optimization of power supply unit for flexible electroluminescent panels. Svetotekhnika. 2016, № 6, pp.39–42.

2. Goncharov Igor N., Kabyshev Alexander M., Kozyrev Evgeny N., and Maldzigati Alan I. Development and Optimisation of a Power Supply for Flexible Electroluminescence Panels. Light & Engineering Journal, V. 25, #2, 2017, pp.126–130.

3. Goncharov I.N., Kabyshev A.M., Kozyrev E.N., Maldzigati A.I. Power supply unit for electroluminescent panels. Radio and Electronics Journal, 2017, V.62, № 6, pp.1–3.

4. Gusev A.I., Samokhvalov M.K. Electrical characteristics of thin-film electroluminescent indicators. Ed. Samokhvalov M.K. Ulyanovsk: USTU, 2006, 125 p.

Alexander M. Kabyshev,
Ph.D. He is a senior lecturer of the Industrial electronics chair of the North Caucasian Mining and Smelting Institute (State Technological University). Fields of scientific interest include converters of electric energy

Igor N. Goncharov,
Doctor of Technical Science, Professor of the Electronic Devices Chair of the FSBEI, North Caucasian Mining and Metallurgical Institute (State TechnologicalUniversity). Scientific interests: modern sources of optical radiation, optical quantum generators, image converters

Evgeny N. Kozyrev,
Doctor of Technical Science, Doctor of Economics, Professor, Academician of the Russian Academy of Natural Sciences, Academician of the International Academy of Ecology, Health and Safety, Head of the Electronic devices Chair of the FSBEI North Caucasian Mining and Metallurgical Institute (State Technological University). Scientific interests: theoretical and experimental studies of photoelectronic, electron beam, solid-state and microwave devices

Roman O. Askerov,
assistant of the Electronic Devices Chair of the FSBEI of Higher Education, the North Caucasian Mining and Metallurgical Institute (State Technological University). Scientific interests: modern sources of optical radiation and electric energy converters

Vladimir V. Urumov
At present he is an eengineer-designer at JSC "Gran", which is a plant specializing in the production of electro-optical converters for night vision devices, post graduate student, and his scientific interests are optoelectronic devices and instruments, industrial electronics