Formulation of the modern indicator devices modelling problem

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Abstract. This work is dedicated to study of the structural characteristics and parameters in advanced electroluminescent structures. The important problems in this area are the high complexity and the slowness of the design calculation processes. The problem can be solved by developing a mathematical model of the system based on equivalent circuits. First step in developing a mathematical model is formulation.

1. Introduction

One of the most important elements of the «human-machine» systems functioning are the means of displaying information. Those devices provide information in a form suitable for visual perception. Indicator technology refers to the means of displaying information. One of the most promising indicators are those what based on electroluminescent emitters, which occupy a special place among active indicator devices due to their high speed and wide range of operating temperatures.

For hardware implementation of various specialized systems, it is necessary to develop or improve information display facilities that include a wide range of devices. Volumetric (such as CRT – cathode ray tube indicator) and flat displays are the modern means of information display. The most promising modern flat display devices include liquid crystal (LCD) indicators, indicators based on organic light-emitting diodes (OLED) and thin-film electroluminescent (TFEL) indicators [1].

The work of modern flat displays is most often associated with the phenomenon of electroluminescence. The phenomenon of electroluminescence is the non-thermal conversion of electrical energy into luminous energy. There are two classes of electroluminescent devices. In the light emitting diode (LED) devices, light is generated by electron-hole pair recombination near a p-n junction. In the LCD manufacturing LEDs are often used as a backlight for subpixels of the screen matrix. Commercial LEDs have been fabricated from inorganic materials like GaAs, but recently there has been significant progress in the development of organic LED devices (OLEDs). Another class of EL devices – is the one in which light is generated by impact excitation of a light emitting center (called the activator) by high energy electrons in materials like ZnS:Mn. The electrons gain their high energy from an electric field, and thus, this type of EL is often called high field electroluminescence. This article will focus on thin film electroluminescent (TFEL) devices and its structural and technological design [2, 3].
2. Comparative analysis of the modern information displays

One of the most important elements of the specialized system’s workplace are information display tools that ensure the functioning of the human-machine interface. The design of the indicators determines their electrical and lighting characteristics and as a result their safety and ergonomics. General requirements for security and ergonomics for information display facilities have to be harmonized with the international standards ISO 9241-3:2003 [4], ISO 9241-8:2007 [5] and GOST R 50948-2001 [6]. For accurate reading of information and providing comfortable conditions for its perception, work with displays should be carried out with optimal combinations of values of brightness, contrast of the image, the external illumination of the screen, the angular size of the sign, the viewing angle of the screen and electrical characteristics [7].

The choice of the optimal means of information displaying for the specialized system's workplace in terms of manufacturability, ergonomics and safety implies the consideration of the main modern information displays. The comparative analysis of the main display devices were made and presented in the table 1 [1 – 3, 7].

**Table 1.** Formatting sections, subsections and subsubsections.

| Parameter                     | Information display devices |
|-------------------------------|-------------------------------|
|                              | LCD                          | OLED            | TFEL            |
| Brightness                   | 250 cd/m²                    | 1000 cd/m²      | 400 cd/m²      |
| Temperature range            | -30…+50                      | -40…+70         | -50…+85        |
| Viewing angle                | 160°                         | 170°            | >160°           |
| Response time                | 15 ms                        | 0.1 ms          | <1 ms           |
| Contrast                     | 1300:1                       | 100000:1        | 20000:1        |
| Mean time between failures   | 50000 h                      | 35000 h         | 100000 h       |
| Radiation resistance         | Low                          | Low             | High            |
| Shock and vibration resistance| Low                          | High            | High            |
| Reducing brightness as using | Low                          | High            | Low             |
| Uniformity                   | Often the image is brighter along the edges | The image is uniform | The image is uniform |
| Geometric / linear distortions| No                           | No              | No              |

Comparison of parameters of flat displays allows to draw a conclusion that TFEL displays surpass LCDs in lighting characteristics, but they yield OLED displays, which, however, is compensated by their high design-technological and operational parameters (mean time between failures, operating temperature range, radiation resistance, etc.). Thus, it is possible to use TFEL indicator devices not only in general-purpose equipment, but also in the military, medical, space industries, where specific and sometimes stringent requirements are imposed to equipment. Due to the listed advantages, thin film electroluminescent indicator devices are widely used in the means of displaying information.
The advantages of TFEL indicators are high brightness, contrast, resolution, radiation resistance, wide viewing angle, etc.

3. **Formulation of the modern indicator devices modelling problem**
Comparison of the presented displays for a number of features will allow us to analyze them and draw conclusions about the applicability of indicators in various technical systems and the prospects for the development of indicator technology. This paper proposes a comparison of the parameters of exclusively flat panel displays. Typical structures are shown on figures 1-3.

![Figure 1. Typical TFEL device structure.](image1)

![Figure 2. Typical LCD device structure.](image2)
All of the above types of displays are strikingly different from each other in the indicating technology and in the mathematical apparatus of electrical and lighting parameters and characteristics engineering calculations. However, a comparative analysis of flat panel display technologies allows us to speak about some similarity of displays. Flat panel displays are a collection of layers obtained using various technological tools. Each of these layers is a material (metal, dielectric, semiconductor) with different electrical and magnetic properties. Such representation will make it possible to draw up an equivalent circuit diagram of the device.

This representation of the display as a physical system allows us to create a mathematical model of the system. In such a model, electric voltages and currents act as phase variables. System components can be bipolar elements. These two-terminal devices include both passive elements (resistance, capacitance, inductance) and active (diodes, stabilizers). The nominal values of the circuit elements can be calculated with corresponding values for real structures. The component equations in such a model will be known relations for calculating the basic parameters of an element (calculation of resistance, capacitance, inductance, etc.), and Kirchhoff’s laws for voltages and currents will act as topological equations. The description of the indicator as a set of series-connected elements allows, when investigating the electrical properties of a device, to go from mathematical models of the micro-level (distributed models) to mathematical models of the macro-level (lumped models) by discretizing the research space.

Drawing up a mathematical model of the system based on equivalent circuits will unify the calculation of design parameters and electrical and lighting parameters and characteristics of the indicator components, which in turn will allow the developed technique to be applied in computer-aided design systems for indicator devices.

Indicator devices structures equivalent circuits are presented on figures 4-6.
4. Conclusion

Comparison of the presented displays for a number of features will allow us to analyze them and draw conclusions about the applicability of indicators in various technical systems for their prospects.
References

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