The Automated Multispectral LED Illuminator for Imaging Applications

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Abstract

he article describes laboratory light source, which represents a multi-spectral cluster based on a standard LED with a capacity of 1–3 W. The design of the cluster makes possible fast replacement emitting components. The spectral power distribution of the cluster can be easily modified for a specific research task. Brightness control components are performed with an automated system based on the drivers with pulse width modulation. Developed by the cluster, it is intended for multi-spectral photography and to view printing images in the process of colorimetric research. In this case, using the automated control system of the cluster can be modeled with standard light sources.

1 Introduction

Light sources are a critical element of human color perception system. Their impact on the visual system generates a luminance and chromatic adaptation, changes in the spectral composition of light can significantly change the color of reflective objects. Devices, based on light-emitting diodes (LEDs) have a broad management capabilities of emission spectrum [1]. In this context, there are two complementary areas of scientific and technological research.

First and foremost, there is a creation of specialized lighting conditions for the study of color perception [2]. This also should include the problem of obtaining spectra, similar to the standard sources of the International Commission on Illumination (CIE) [2, 3], as their classification and
standardization was carried out primarily from the standpoint of light perception by man.

The second is the use of LEDs for the creation of lighting conditions, which would be optimal in various practical tasks [4–6]. Technical solution for some tasks, such as multi-spectral photography, becomes possible through the LEDs implementation. Compared to systems, based on various filters [7, 8], multispectral lighting has a number of advantages. Lack of mechanical filter replacement increases the speed of work and reduces the vibrations of the entire system. It simplifies the alignment of images. Unlike LEDs, the use of interference filters is complicated by the strong dependence

of a transmission spectrum on incident angle of a luminous flux. In relation to absorbent filters, LEDs provide the best spectral selectivity.
Thus, the purpose of this paper is to develop multispectral cluster (MC), which allows the listed problems to be solved.

2 Cluster Design

The design of MC is presented in photos (Fig. 1–2). The possibility of components replacement depending on a task is the basis for MC. The basis is a platform -radiator in size of 100 by 100 mm (1 in Fig. 1). LEDs from 1 to 3 watts can be used in the cluster. They are attached to the radiator-platform with clips with the contacts (2–3 in Fig. 1). LEDs are soldered on a standard aluminum board, “star” (4 in Fig. 1).

Figure 1: Emitter design: 1 – platform-radiator of MC with LEDs, fixed on it; 2 – plastic clip; 3 – contact pads; 4 – LED, soldered on a standard aluminum board, “star”.

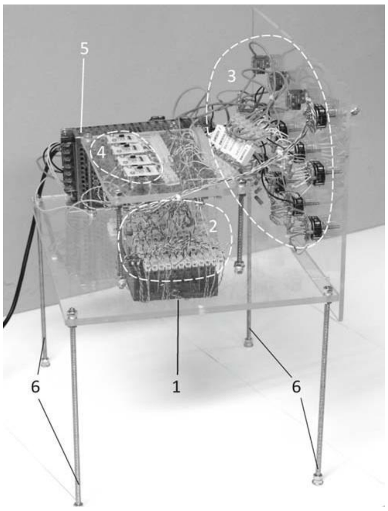

Figure 2: Systems of MC, providing the work of LEDs: 1 – platform-radiator with LEDs fixed on it; 2 – LEDs switching system, 3 – system of regulated ballast resistors, 4 – blocks of PWM-drivers of LEDs, 5 – main power supply, 6 – rack for fixing various options of reflectors and diffusers. Additional DC-DC converters are located behind the power supply unit 5 and are not visible in the photo.

LEDs have different operating voltages and currents. LEDs emitting in the shortwave and mediumwave parts of the visible range usually requires operating voltages of 3.0–3.7 V, while the longwave LEDs need about 2.5 V. Switching system is provided to pair non-uniform elements with standard power supply. It allows us to combine individual LEDs in serial chain (1 in Fig. 2).

MC is powered by switched mode power supply unit (150 with stabilized voltage of 12 V (4 in Fig. 2). Operating currents in the chains of used in MC LEDs, are limited depending on LED’s power, with the set of discretely adjustable ballast resistors (2 in Fig. 2).

Several DC-DC converters are also provided in a design of MC (5 in Fig. 2). They allow to create the optimal set of supply voltage and reduce the power, dissipated in the ballast.

3 Cluster Management System

MC design makes it possible to combine elements in typical circuits, similar to shown in scheme (Fig. 3). LED brightness control in a chain can be automated. Brightness control of LEDs is carried out by means of the pulse width modulation (PWM), based on WS2811D driver and field transistors IRLML2502. They allow continuous drain current of about 4 A, to 30 A in impulse mode to be switched. Resistance of open IRLML2502 is 0,045 Ohms.

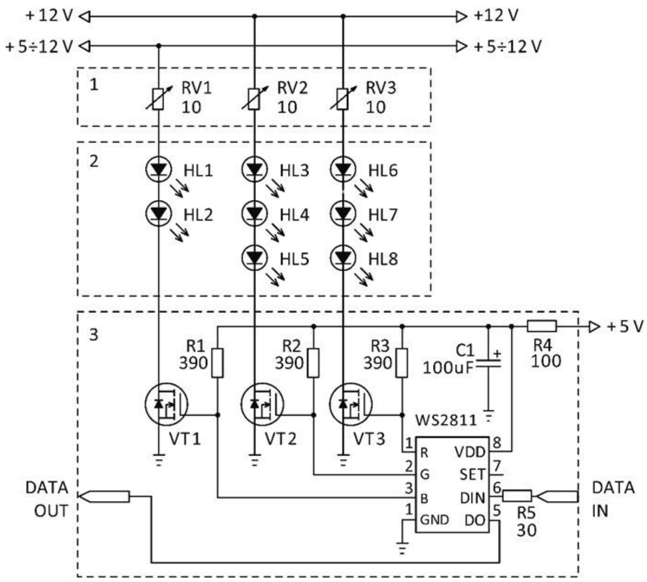

Figure 3: LED brightness control scheme. 1 – LED switching system, 2 – adjustable ballast resistors system. 3 – block of LED PWM-drivers.

These parameters are more than enough to control 3W LED chains with summary current of about 700 mA.

PWM driver units are connected in a serial chain. Exit of the first block is connected to the entrance of the second, etc. In this circuit the data transfer about the required values of pulse ratio PWM in each channels of driver blocks is carried out. Serial communication protocol is specified in the documentation for the chip WS2811. Coding and transmission of data to the input of the first unit of MC in the chain are carried out by ATmega328P microcontroller on command from the host computer.

4 Obtained Photometric Parameters

Spectral characteristics of the tested set of MC components are shown in Fig. 4. For convenience the ranges of all chromatic LEDs (except for white) are normalized to one. White LED for convenience is normalized to a value of 0.5, as the part of its spectrum is almost identical with the spectrum of the blue LED.

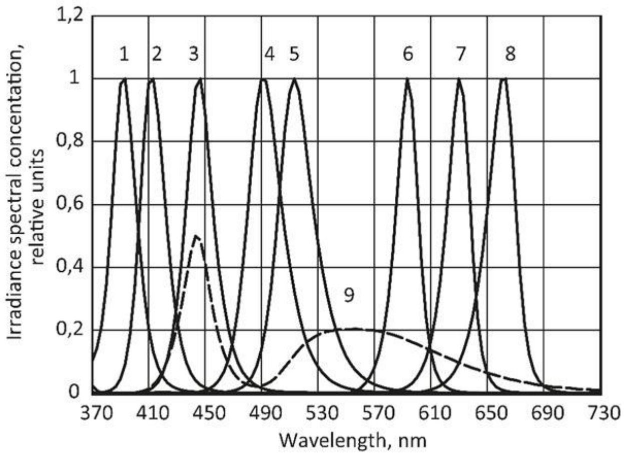

Figure 4: Normalized spectra of MC components. 1–8 — spectra of chromatic LEDs, 9 — spectrum of white LED.

The distribution of the LED spectra at visible range is quite uniform, and allows us to solve the problems of multispectral photographing. For the best synthesis of the spectra of a standard D-Series sources MC may be complemented with LED with a dominant wavelength of 470 nm, filling the gap between the spectra of 4 and 5 (Fig. 4). The replacement of white LED (9 in Fig. 4) to “warm white”, with considerably less shortwave peak is also recommended. Due to flexible solutions, by the design of the MC, these modifications are quite easy to be implemented. The spectral composition of emission in general should not be attributed to “constant” characteristics of a described device, as a set of LEDs can easily be modified for a specific task.

5 Conclusions

The multispectral LED cluster on the basis of standard chromatic and white 1–3 W LEDs with a possibility of quick changeover of emitting components is developed. The spectral composition of the cluster can be easily modified for a particular research problem.

The designed cluster was tested experimentally applying multi-spectral photography. Furthermore, the cluster can be used for viewing prints and other colored reflective objects during colorimetric studies. In this case, while applying an automated control system, a cluster may simulate standard light sources.

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