Вісник Тернопільського національного технічного університету
https://doi.org/10.33108/visnyk_tntu
Scientific Journal of the Ternopil National Technical University
2024, № 4 (116) https://doi.org/10.33108/visnyk_tntu2024.04
ISSN 2522-4433. Web: ***visnyk.tntu.edu.ua***

УДК 621.32

OPERATION OF LED LIGHT SOURCE CONTROL DEVICES AT HIGH TEMPERATURES

Iryna Beliakova; Vadim Piscio; Volodymyr Savkiv; Oleksandr Shovkun; Volodymyr Medvid; Andriy Palyukh

Ternopil Ivan Puluj National Technical University, Ternopil, Ukraine

Abstract. *The temperature of the environment significantly affects the electrical and luminous parameters of LEDs in LED light sources, such as forward and reverse current, forward voltage, and LED luminous flux. The effect of environment temperature on the parameters of LEDs with control devices (drivers) based on both current and voltage stabilisers under conditions of high eenvironment temperature is investigated in this pape. The influence of the environment temperature on the electrical and luminous parameters of LEDs when they are powered from the constant voltage source is analysed. The characteristics of LEDs were investigatedin order to determine the most optimal mode of their operation in LED lighting devices. The most optimal mode of operation of LEDs in which their luminous flux and luminous efficacy are the least dependent on the environment temperature was determined.*

Key words: *LED lamp, LED searchlight, experimental characteristics, temperature dependence of LED parameters, driver circuits, current stabilisers, voltage stabilisers, luminous flux, luminous efficacy.*

https://doi.org/10.33108/visnyk_tntu2024.04.090 *Received 01.10.2024*

1. INTRODUCTION

LED light sources (LED lamps, LED luminaires, etc.) in most cases are used under conditions of changes in the temperature mode of their operation. Electronic LED control devices (drivers) as a part of LED lighting devices are classified in the following way [1, 2, 3]:

1) Linear drivers are simple linear driver circuits without current stabilisation;

2) Linear IC linear drivers are circuits with LED current stabilisation based on current stabilisers;

3) IC pulse drivers are built on the basis of converters with pulse width modulation (PWM) of the voltage on LEDs.

In most driver circuits in order to stabilise the electrical parameters of LEDs [4, 5, 6, 7] the following methods are used:

- stabilisation of LED current,
- voltage stabilisation on LEDs,
- stabilisation of LED current and voltage.

In general, drivers with LED current stabilisation [8,9,10,11] are used on integrated current stabilisers.. Voltage stabilisation on LEDs requires the application of high-precision stabilisers with high stabilisatin factor, the circuits of which are much more complex compared to current stabilisers and the cost is higher. This is due to the structure of LED's volt-ampere characteristic: when the supply voltage changes by 10%, the LED current changes by approximately the same 10%, while its voltage changes by no more than 1...1.5%.

The third method of the stabilization of LEDs electrical parameters combines previous two ones and is used in LED light sources for more complex lighting systems, when their higher cost and more complex circuitry is justified.

 Corresponding author: Iryna Beliakova; e-mail: i_belyakova@ukr.net

At the same time, current stabilization does not always result in the stabilization of luminous flux of LEDs or LED matrices when the temperature mode of their operation changes [1, 2, 3].

The temperature effect on the luminous flux of LEDs is the greatest when they are used under the conditions of industrial production or outdoor environments, where high environment temperatures result in the decrease of luminous flux.

The decrease in the luminous flux of LEDs with temperature is explained by the fact that when the temperature of the environment increases and, as a result, the temperature of the p-n junction of LEDs increases, the intensity of their radiation decreases, which occurs mainly due to the recombination on the surface and thermal losses of carriers in the barrier layers of the p-n junction [3].

The objective of this paper is to analyse:

- the effect of temperature on the light parameters of LEDs during current stabilisation;
- the effect of temperature on the light parameters of LEDs during voltage stabilisation;
- electrical and light parameters of the LED device with the driver based on LED current stabiliser when the temperature mode of its operation changes;
- electrical and light parameters of the LED device with the driver based on voltage stabiliser on LEDs when the temperature mode of its operation changes;
- temperature dependence of the luminous flux and luminous efficacy of LEDs when their current is stabilised and to compare it with the change in these parameters when the voltage is stabilised.

2. MATERIALS AND METHODS

In order to carry out the tasks, the experimental installation block diagram of which is shown in Fig. 1 was created. The basis of the installation is the thermostable chamber «TERMOSTAT», which is used for measuring the illuminance of the investigated LED or LED lighting device, which are located in the middle of the chamber on a special holder. Its walls are painted black from the inside.

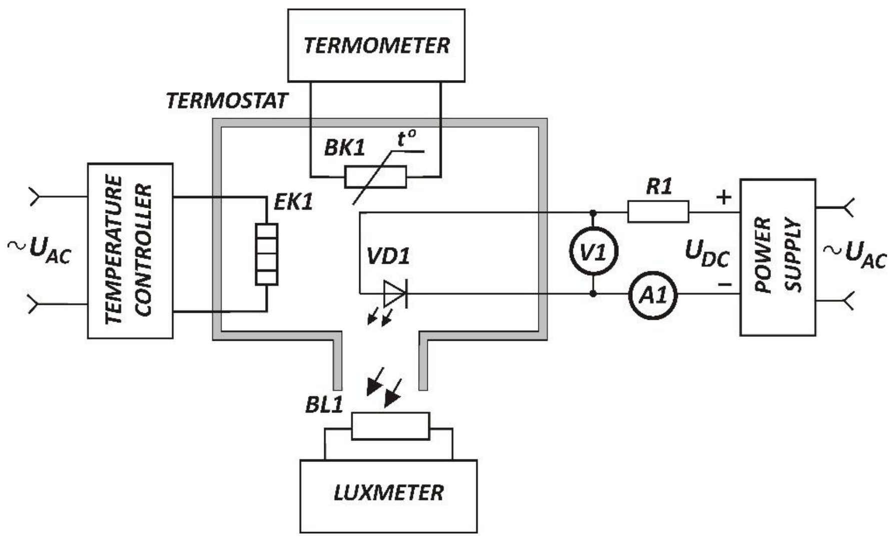

Figure 1. Block diagram of the experimental installation

The temperature in the chamber varied within the range +20...+60°C by means of *EK1* heater located in its lower part. The chamber was cooled by the flow of air from the outside by the fan.

The electronic thermometer *BK1* was used to measure the temperature. The current of the investigated device (e.g., *VD1* LED) was changed by U_{DC} voltage of the constant voltage source POWER SUPPLY and measured by milliammeter *A1*. Voltmeter *V1* measured the voltage on the investigated device.

The illuminance of the light source was measured by luxmeter, and its *BL1* sensor element was isolated from external light.

The electrical and light parameters of the devices were measured 5 minutes after connecting to the power source to determine their operating mode, the temperature was changed gradually with +5ºC step. Measurements were performed when the temperature reached the desired value. At the beginning, the voltage was measured, and then the current and illuminance values. In order to reduce the instrumental measurement error, the relative units of the obtained results were used in relation to their values at temperature +25ºC.

3. RESULTS AND DISCUSSION

3.1. Investigation of the characteristics of smd2835 and smd5050 LEDs when they are powered by constant voltage source

Before the investigation of the parameters of LED lighting devices, the electrical and luminous parameters of smd2835 LEDs were investigated at temperature changes within the range of +20…+60ºC for different values of current and voltage on the LED.

LED parameters: nominal voltage 18.5V, power 1W, nominal current 50mA [11].

LED was placed in the "TERMOSTAT" (Fig. 1) current at POWER SUPPLY output was changed by U_{DC} voltage and, if the circuit had limiting resistor *R1*, voltage on the LED was changed as well.. The values of the environment temperature T_c, voltage on the LEDs U_d, current through the LEDs I_d , and illuminance *E* were measured at temperature changes within the range +20…+60ºC with step +5ºC.

Illuminance *E* of the LED was measured by luxmeter. Using the relative values of illumination E/E_{25^o} (E_{25^o} is the illumination at +25ºC temperature) made it possible to move to the relative values of the corresponding luminous fluxes Φ/Φ_{25^o} ($E=\Phi/A$, Φ is the value of luminous flux at the given temperature, Φ_{25^o} is the luminous flux at +25ºC temperature, *A* is the illuminated surface area).

3.1.1. Measurement of LED parameters at a constant value of the current, equal to its nominal value

Constant current value was maintained by changing the voltage of U_{DC} power supply. The obtained temperature dependences in relative units for smd2835 LED are presented in Fig. 2, where I_{d0} is the current, U_{d0} is the voltage, Φ_0 is the luminous flux, $I_{d0\,25^oC}$, $U_{d0\,25^oC}$ and $\Phi_{0\,25^oC}$ are, respectively, the nominal current, nominal voltage, and nominal luminous flux of the LED at environment temperature T_c =+25 ºC.

At constant value of the LED current, the graph for the relative change in its power $P_{d0}/P_{d0\,25^oC}$ on temperature, where P_{d0} is the current power value for a given temperature, $P_{d0\,25^oC}$ is the nominal power of the LED at +25 ºC, coincides with the graph for the relative change in the LED voltage $U_{d0}/U_{d0\,25^oC}$.

Taking this into account, we build temperature dependence for $\eta_0/\eta_{0\,25^oC}$, where $\eta_0 = \Phi_0/P_{d0}$, a $\eta_{0\,25^oC} = \Phi_{0\,25^oC}/P_{d0\,25^oC}$ using the curves for $\Phi_0/\Phi_{0\,25^oC}$ and $U_{d0}/U_{d0\,25^oC}$.

It is evident from Fig. 2 that with the same LED current, the voltage on the LED decreases with temperature increse up to 3%, the light flux decreases significantly, up to 12%, and the luminous efficacy decreases by 10% at +60°C compared to its value at +25°C.

Dependencies similar to the characteristics for smd2835 LED were obtained for smd5050 LED with nominal voltage of 3.1V, nominal current of 60mA, and power dissipation 0.2W [12].

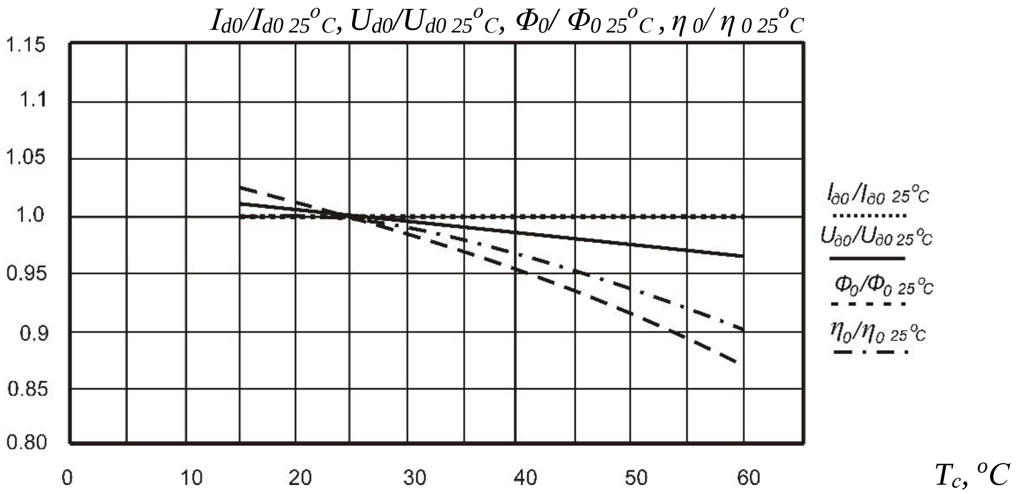

Figure 2. Dependences $I_{d0}/I_{d0\ 25^oC}$, $U_{d0}/U_{d0\ 25^oC}$, $\Phi_0/\Phi_{0\ 25^oC}$ and $\eta_0/\eta_{0\ 25^oC}$ on the temperature T_c for smd2835 LED. $I_{d0\ 25^oC}$ =50mA=const

Graphs of voltage and luminous flux for smd5050 in relative values at constant current value through the LED (60mA) in temperature range +20…+60ºC are shown in Fig. 3.

Using the same principle as in the previous case (Fig. 2), we build temperature dependence for the relative values of luminous efficacy $\eta_0/\eta_{0\ 25^oC}$ within the range +20…+60 ºC.

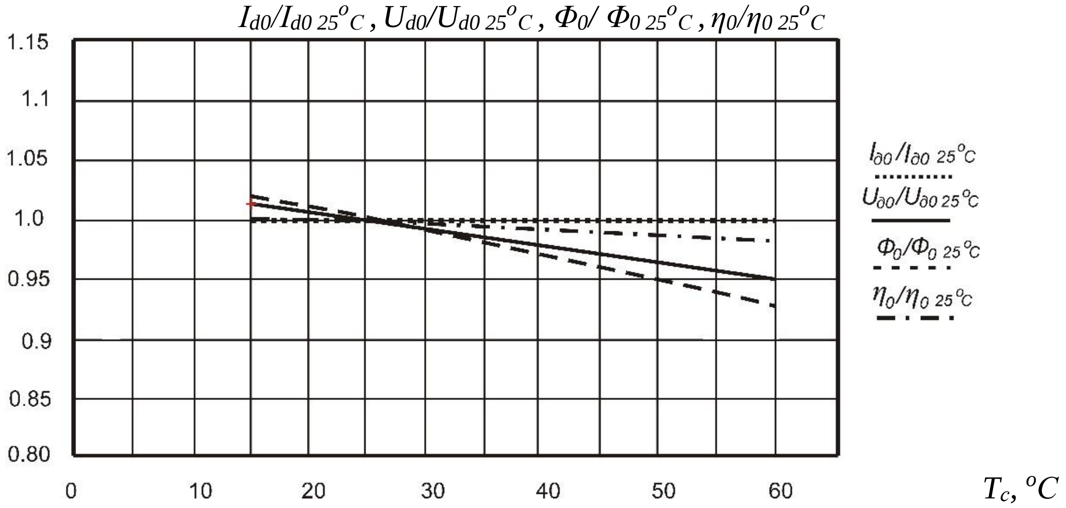

Figure 3. Dependences $I_{d0}/I_{d0\ 25^oC}$, $U_{d0}/U_{d0\ 25^oC}$, $\Phi_0/\Phi_{0\ 25^oC}$ and $\eta_0/\eta_{0\ 25^oC}$ on temperature T_c for smd5050 LED. $I_{d0\ 25^oC}$ =60mA=const

With temperature increase up to +60ºC, the voltage on smd5050 LED drops by 5%, the luminous flux decreases by 8% and the luminous efficacy by 2% compared to the values at temperature +25ºC like for smd2835 LED.

3.1.2. Measurement of LED parameters at constant voltage value equal to the nominal value

Constant value of the voltage on LEDs was maintained by changing the voltage of U_{DC} power supply. Initially, the parameters were measured for the smd2835 LED.

With constant value of direct voltage on the LED (Fig. 4), the current increases with temperature increase up to 25% at T_c=+60°C, and the luminous flux within the temperature range +20…+60°C almost does not change. Its drop at +60°C is not more than 1.5%.

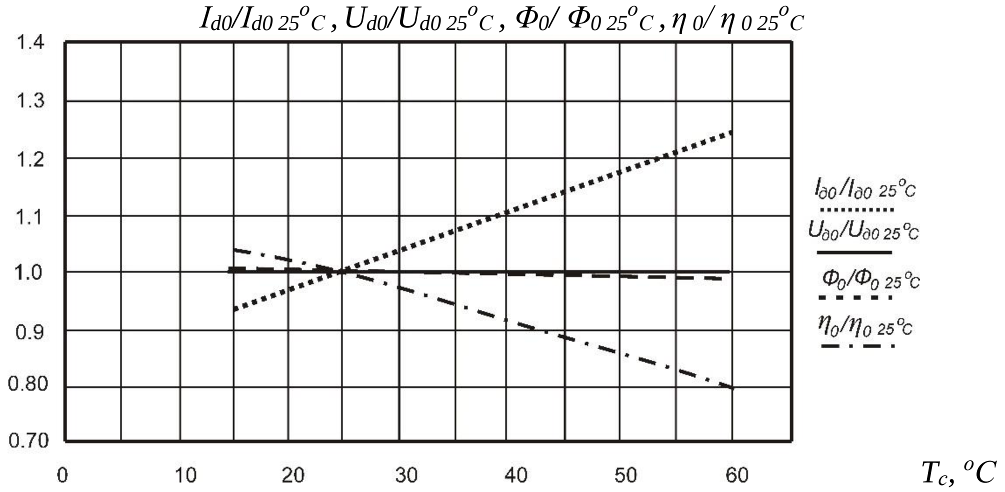

Figure 4. Dependencies $I_{d0}/I_{d0\ 25^oC}$, $U_{d0}/U_{d0\ 25^oC}$, $\Phi_0/\ \Phi_{0\ 25^oC}$ and $\eta_0/\ \eta_{0\ 25^oC}$ on temperature T_c for smd2835 LED. $U_{d0\ 25^oC}$ =18,5B=const

At constant value of the voltage on the LED, the graph for the relative change of its power $P_{d0}/P_{d0\ 25^oC}$ on temperature coincides with the graph for the relative change of the current for LED I_{d0}/I_{d025^oC}.

Taking this into account, we also build the temperature dependence for the relative values of luminous efficacy $\eta_0/\eta_{0\ 25^oC}$ within the range +20…+60°C.

It is evident from the graph (Fig. 4) that the increase of current with the increase in temperature at constant voltage value on the LED compensates for the drop in its luminous flux. But at the same time, the luminous efficacy of the LED decreases to 20% relative to its value at +25°C.

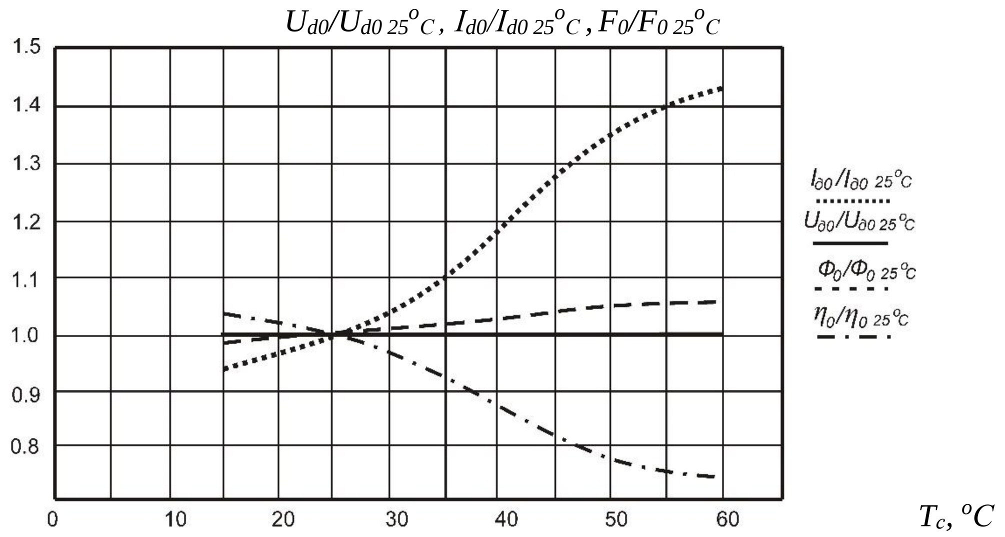

Figure 5. Dependencies $I_{d0}/I_{d0\ 25^oC}$, $U_{d0}/U_{d0\ 25^oC}$, $\Phi_0/\ \Phi_{0\ 25^oC}$ and $\eta_0/\ \eta_{0\ 25^oC}$ on temperature T_c for smd5050 LED. $U_{d0\ 25^oC}$ =3,1B=const

Similar to the electrical and light characteristics for smd2835 LED, dependencies were also obtained for smd5050 LED with nominal voltage 3.1V, nominal current 60mA, and power 0.2W [13].

Dependences obtained at constant value of voltage on smd5050 LED are shown in Fig. 5. It can be seen from the graphs that the current through the LED increases with temperature up to 30% at +60°C, but the luminous flux does not decrease and even increases slightly. Therefore, for this LED, the increase in current with increasing temperature compensates the decrease in luminous flux. But, similar to the case with smd2835 LED, the luminous efficacy compared to the values at +25°C decreases significantly, by 26%.

3.2. Investigation of LED light sources characteristics when they are powered by industrial network

Slightly modified experimental installation (Fig. 1) was used to investigate LED light sources, its block diagram is shown in Fig. 6.

The light source was placed in TERMOSTAT, the voltage of U_{AC} alternating current network was maintained constant by means of transformer *T1*, and the temperature varied within +20…+60°C with interval of +5°C. At the same time, the current values of the environment temperature T_c, the voltage on the LEDs U_d, the current through the LEDs I_d and the illuminance *E* were measured.

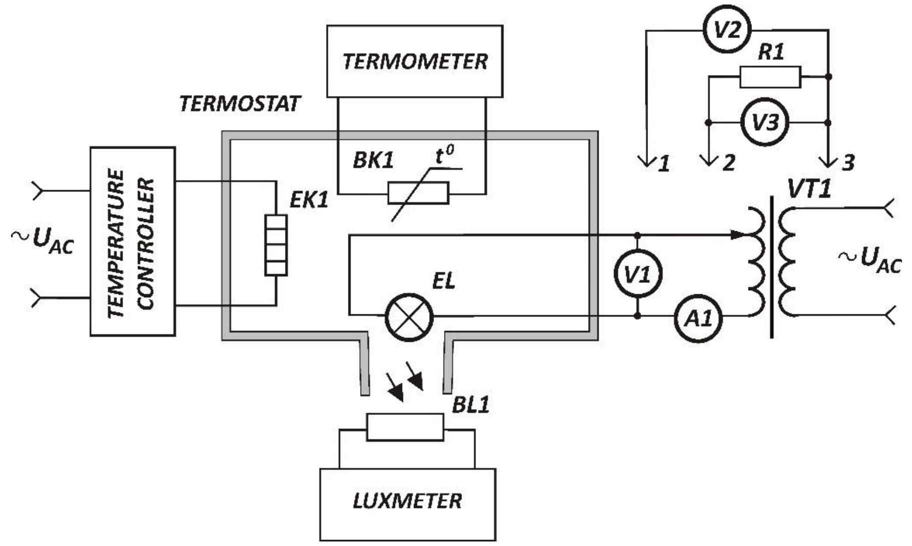

Figure 6. Block diagram of the experimental installation for the investigation of LED light sources parameters

In the diagram (Fig. 6), *A1,V1* are alternating current ammeter and voltmeter, *V2,V3* are direct current voltmeters, *R1* is 1 Ohm resistor. Voltmeter *V2* is connected in parallel to the LEDs of lighting device *EL*, resistor *R1* is connected in series with the LEDs of the current control device by the voltmeter *V3*. *EK1* – heating element, *BL1* – luxmeter sensor, *BK1* – thermosensor for temperature measurement. The LED current was measured by the voltage drop on resistor *R1*.

3.2.1. Investigation of temperature dependence of current, voltage and luminous flux of LedEX E27B lamp with 6 W power

The investigated lamp is constructed according to *Linear* driver scheme (Fig. 7), which does not provide stabilization of the LED current when the voltage of the power source changes.

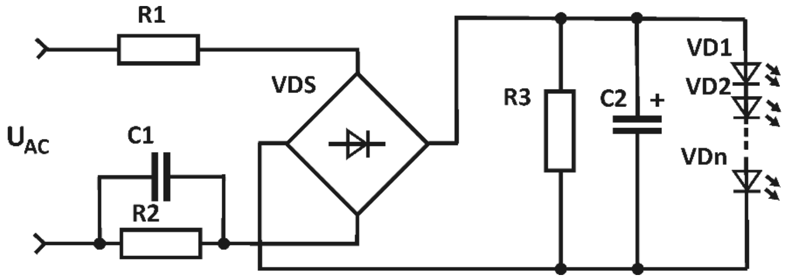

Figure 7. Electrical scheme of the LED lamp with linear driver named as «*Linear»*

Illuminance *E* of the LED light sources was measured by Temperature dependences of the relative values of illuminance E/E_{25^o} were equated to the relative values of the corresponding luminous fluxes Φ/Φ_{25^o}.

LedEX E27B lamp with 6W power contains eleven smd2835 LEDs [13] (their nominal voltage is 18V, current 30mA, power 0.5W, color temperature 4000K). The LEDs of the lamp are turned on in series.

Dependences of the relative values $I_{d0}/I_{d0\,25^oC}$, $U_{d0}/U_{d0\,25^oC}$, $\Phi_0/\Phi_{0\,25^oC}$ та $\eta_0/\eta_{0\,25^oC}$ of the LED lamp on the environment temperature T_c at AC power supply voltage of ~220V are shown in Fig. 8. In our previous investigations of this lamp [2], it was established that the LED current at constant value of the supply voltage practically did not change within the temperature range +20…+60°C although it underwent significant changes when the supply voltage changed.

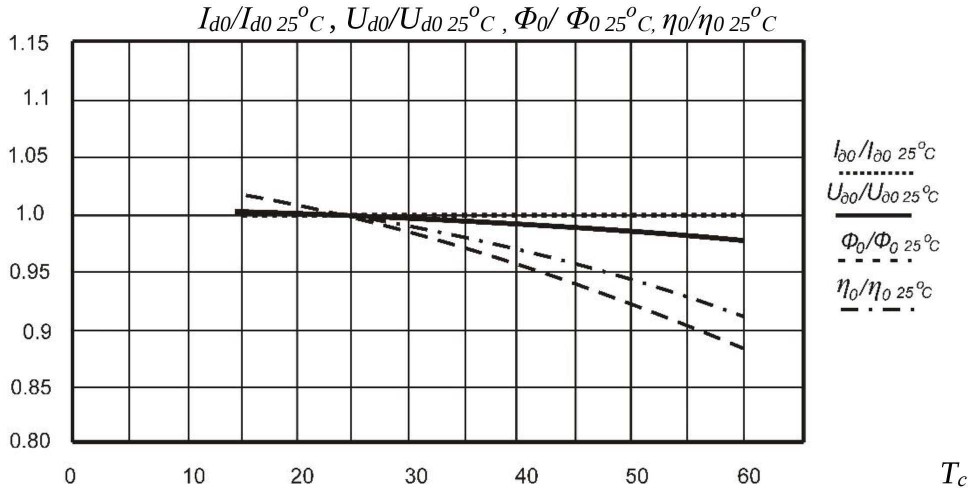

Figure 8. Dependencies $I_{d0}/I_{d0\,25^oC}$, $U_{d0}/U_{d0\,25^oC}$, $\Phi_0/\Phi_{0\,25^oC}$ and $\eta_0/\eta_{0\,25^oC}$ on temperature T_c for the lamp *P*=6W. U_{AC}=const=220 V

As follow from the graphs in Fig. 8, it is evident that the drop in the luminous flux of the lamp with temperature increase up to +60 °C is larger than 10%, the voltage on the lamp changes slightly, and the luminous efficacy decreases by 8%.

3.2.2. Investigation of the temperature dependence of electrical and light parameters for Premier-10 E27 LED lamp with 10W power

LED lamp produced by HOROZ ELECTRIC with *IC* driver, which provides pulse width regulation of the voltage on the LEDs, was investigated.

The lamp contains nine smd2835 LEDs with nominal voltage 12V, current 75mA, power 1W, color temperature 4000K [14]. The lamp schematic diagram are shown in Fig. 9.

In previous investigations of this lamp [2], it was established that the current through the LEDs changed only by ±1% when the supply voltage changed by ±10% and the temperature remained unchanged at +25ºC.

Temperature dependences of the lamp parameters are shown in Fig. 10. The lamp is constructed on the basis of high-frequency converter BP2863 (D1) with pulse-width regulation of the output voltage (DRAIN output) [15], from which constant voltage is supplied through filter elements L2, C2 to the sequentially switched on LEDs (Fig. 9).

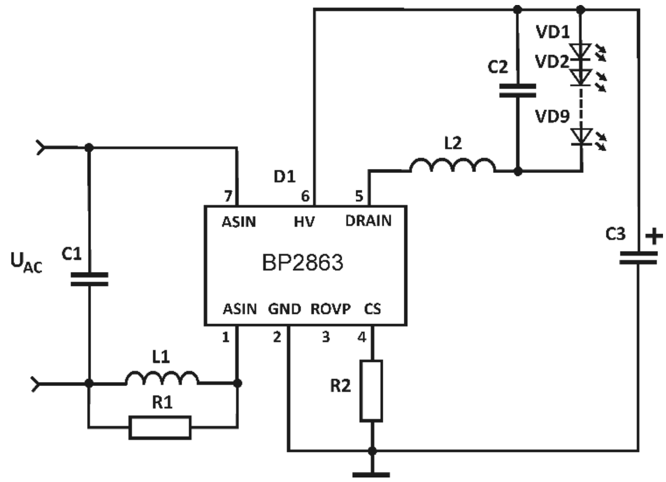

Figure 9. Schematic diagram of Premier-10 lamp with 10W power

Dependencies of the relative values of current $I_{d0}/I_{d0\ 25^oC}$, voltage $U_{d0}/U_{d025\ ^oC}$, luminous flux $\Phi_0/\Phi_{0\ 25^oC}$, power $P_0/P_{0\ 25^oC}$ and luminous efficacy (було efficiency) $\eta_0/\eta_{0\ 25^oC}$ on the temperature T_c are shown in Fig. 10. Voltage on the lamp LEDs practically does not depend on U_{AC} supply voltage and decreases by 1.5% at +60^{0}C. In this case, the luminous flux drops to 5% (Fig. 10), but much less than in lamps with linear driver without current stabilization.

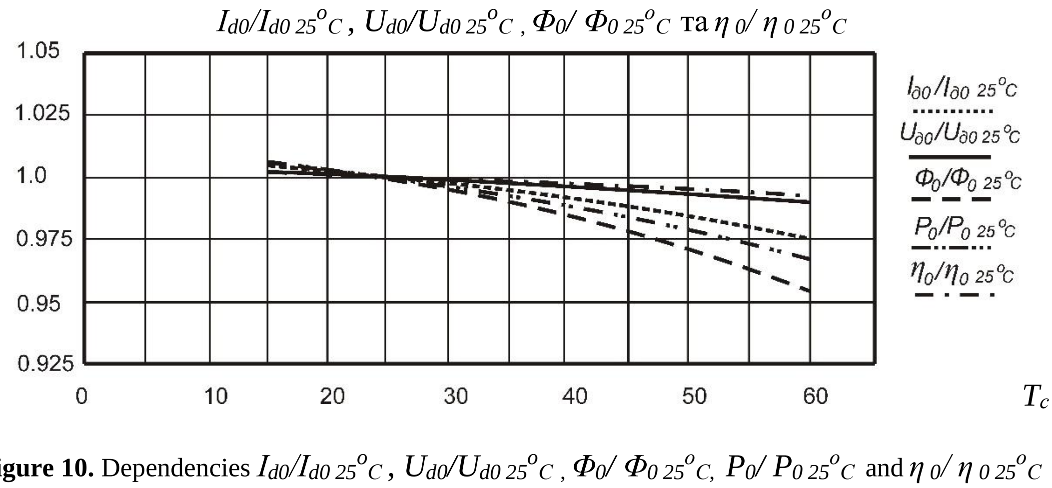

Figure 10. Dependencies $I_{d0}/I_{d0\ 25^oC}$, $U_{d0}/U_{d0\ 25^oC}$, $\Phi_0/\Phi_{0\ 25^oC}$, $P_0/P_{0\ 25^oC}$ and $\eta_0/\eta_{0\ 25^oC}$ on temperature T_c at supply voltage 220V for Premier-10 lamp

It should be noted that the investigation of the characteristics of both LEDs themselves and LED lighting devices was carried out when they were powered by constant voltage (current). Even in driver circuits where pulse converters with pulse-width voltage (current) regulation are used, the rectified voltage is applied directly to the LEDs.

4. CONCLUSIONS

1. The obtained experimental dependencies of the electrical and light parameters of smd2835 and smd5050 LEDs showed that with unchanged current value, their direct voltage with temperature increase up to +60^{0}C relatively to the value at +25^{0}C decreases slightly (up to 1.5%), the luminous flux drops significantly, up to 10% , and the luminous efficacy decreases by 8%. With unchanged value of the direct voltage on LEDs, the current increases by 15...20% with temperature increasing at T_c=+60^{0}C, the drop of luminous flux at +60 ^{0}C is not more than 1.5%, and the luminous efficacy decreases significantly, up to 26%.

2. Investigations of LED lamps performed according to the scheme of linear drivers without current stabilization proved that they do not provide stabilization of the luminous flux when the environment temperature changes and the supply voltage is constant, although the LEDs current practically does not change. The drop in luminous flux within the temperature range +20…+60^{0}C at 220V voltage is up to 13%, and the luminous efficacy is up to 8%.

3. Investigations of LED lamps with current stabilization showed that when the environment temperature changes, the stabilization of the luminous flux does not occur as well. The smallest changes in electrical and light parameters were obtained for LED lamps with current stabilization due to PWM of the output voltage. For them, the luminous flux drops to only 5%, and the luminous efficacy – by 1..1.5% when the temperature rises up to +60^{0}C.

4. For cases when it is necessary to obtain constant luminous flux under the conditions of the environment temperature changewithin the range +20…+60^{0}C, it is proposed to perform schemes of LED light sources with stabilization not of current, but of voltage on LEDs. It will make it possible to compensate the drop in luminous flux with temperature increase. Although, the luminous efficacy of the LED device is significantly reduced.

References

1. Belyakova I., Medvid V., Piscio V., Mykhailyshyn R., Savkiv V., Markovych M. Optimization of LED Drivers Depending on the Temperature of Their Operation in Lighting Devices. EEE 3rd Ukraine Conference on Electrical and Computer Engineering (UKRCON), 2021 p, Lviv, Ukraine, pp. 266–271. https://doi.org/10.1109/UKRCON53503.2021.9575876
2. Belyakova I., Piscio V., Maruschak P., Shovkun O., Medvid V., Markovych M. (2023) Operation of Electronic Devices for Controlling Led Light Sources when the Environment Temperature Changes. *Appl. Syst. Innov.*, *6*, 57. Available at: https://doi.org/10.3390/asi6030057. https://doi.org/10.3390/asi6030057
3. Karas V. I., Electrical properties of LEDs/ [Electronic resource]. Available at: https://eprints.kname.edu.ua/25946/2/%D0%A7%D0%90%D0 %A1 %D0%A2%D0%AC3-5.pdf.
4. Nazarenko L. A., Kolesnyk A. I. (2021). Physics and technology of light-emitting diodes: a study guide. Kharkiv: XNUMX named after O. M. Beketova, 255 p. [In Ukrainian].
5. CIE 69–1987. Methods of charactering Illumunance Meters and Luminance Meters. Performance, characteristics and specifications.
6. Broeck H.; Sauerlander G.; Wendt M., Power Driver Topologies and Control Schemes for LEDs, Applied Power Electronics Conference, APEC 2007 – Twenty, Second Annual IEEE, 2007, pp. 1319–1325. https://doi.org/10.1109/APEX.2007.357686
7. Davis J. L. and Niederberger A. A. Reliable LED lighting technologies key factors and procurement guidance," 2015 IEEE Global Humanitarian Technology Conference (GHTC), Seattle, WA, USA, 2015, pp. 191–198, Doi: 10.1109/GHTC.2015.7343972. https://doi.org/10.1109/GHTC.2015.7343972
8. Sun B. The Lifetime Prediction of LED Drivers and Lamps, 2017. Available at: https://doi.org/10.4233/uuid:e83b184cc972-402a-a0c6-418222cf11ad.
9. Sun B., Fan X., Li L., Ye H., van Driel W. and Zhang G. A (2017) Reliability Prediction for Integrated LED Lamp with Electrolytic Capacitor-Free Driver, IEEE Transactions on Components, Packaging and Manufacturing Technology, 7 (7), pp. 1081–1088. Doi: 10.1109/TCPMT.2017.2698468. https://doi.org/10.1109/TCPMT.2017.2698468
10. Sun B., Fan X., Qian C. and Zhang G. (2016) “PoF-Simulation-Assisted Reliability Prediction for Electrolytic Capacitor in LED Drivers” in IEEE Transactions on Industrial Electronics, vol. 63, no. 11, pp. 6726–6735. https://doi.org/10.1109/TIE.2016.2581156

11. Bridgelux® SMD 2835 1W 18V. Datasheet. [Electronic resource]. Available at: https://www.bridgelux.com/sites/default/files/resource_media/DS205%20SMD %202835%201W%2018V%20Data%20sheet%2020180307%20Rev%20A.pdf.
12. SB-SMD-5050-White Warm. [Electronic resource]. Available at: https://datasheetspdf.com/pdf-file/842958/ETC/SB-SMD-5050/1.
13. 18V 30mA 0.5W SMD 2835 LED. [Electronic resource]. Available at: https://www.led-moonlight.com/products/smd-led/18v-30ma-0-5w-smd-2835-led-mlt-smd-2835-18030dxx.html.
14. Bridgelux® SMD 2835 1W 12V. Datasheet. [Electronic resource]. Available at: https://www.bridgelux.com/sites/default/files/resource_media/DS204%20SMD%202835%201W%2012V%20Data%20sheet%20%20Rev%20A_20180824.pdf.
15. BP2863 Driver Datasheet PDF. [Electronic resource]. Available at: http://www.kingsunled.net/Data/kingsunled/upload/file/20201116/63741125635761952643 26178.pdf.

УДК 621.32

РОБОТА ПРИСТРОЇВ КЕРУВАННЯ СВІТЛОДІОДНИМИ ДЖЕРЕЛАМИ СВІТЛА ПРИ ВИСОКИХ ТЕМПЕРАТУРАХ

Ірина Белякова; Вадим Пісьціо; Володимир Савків; Олександр Шовкун; Володимир Медвідь; Андрій Палюх

Тернопільський національний технічний університет імені Івана Пулюя, Тернопіль, Україна

Резюме. *Температура навколишнього середовища істотно впливає на електричні та світлові параметри світлодіодів у світлодіодних джерелах світла, такі, як прямий і зворотний струм, пряма напруга та світловий потік світлодіодів. Досліджено вплив температури навколишнього середовища на параметри світлодіодів із пристроями керування (драйверами) на основі стабілізаторів струму та напруги в умовах підвищеної температури навколишнього середовища. Проаналізовано вплив температури навколишнього середовища на електричні та світлові параметри світлодіодів при їх живленні від джерела постійної напруги. Досліджено характеристики світлодіодів з метою визначення найоптимальнішого режиму їх роботи в світлодіодних освітлювальних приладах. Визначено найоптимальніший режим роботи світлодіодів, при якому їх світловий потік і світлова віддача найменше залежать від температури навколишнього середовища. Отримані експериментальні залежності електричних і світлових параметрів світлодіодів smd2835 і smd5050 показали, що при незмінному значенні струму їх пряма напруга з підвищенням температури до +60ºC дещо зменшується (до 1,5%) відносно значення при +25ºC, світловий потік падає, до 10%, а світлова віддача зменшується на 8%. При незмінному значенні постійної напруги на світлодіодах з підвищенням температури при Tc=+60ºC сила струму зростає на 15...20%, падіння світлового потоку при +60ºC становить не більше 1,5%, а світлова віддача зменшується на 26%. Дослідження світлодіодних ламп, виконаних за схемою лінійних драйверів без стабілізації струму, показали, що вони не забезпечують стабілізацію світлового потоку при зміні температури навколишнього середовища і незмінній напрузі живлення, хоча струм світлодіодів практично не змінюється. Падіння світлового потоку в діапазоні температур +20…+60ºC при напрузі 220В становить до 13%, а світлової віддачі – на 8%. Дослідження світлодіодних ламп зі стабілізацією струму показали, що при зміні температури навколишнього середовища стабілізація світлового потоку також не відбувається. Найменші зміни електричних і світлових параметрів отримано для світлодіодних ламп зі стабілізацією струму за рахунок ШІМ вихідної напруги. Для них світловий потік спадає всього – на 5%, а світлова віддача – на 1..1,5% при підвищенні температури до +60ºC.*

Ключові слова: *світлодіодна лампа, світлодіодний прожектор, експериментальні характеристики, температурна залежність параметрів світлодіодів, схеми драйверів, стабілізатори струму, стабілізатори напруги, світловий потік, світлова віддача.*

https://doi.org/10.33108/visnyk_tntu2024.04.090 *Отримано 01.10.2024*