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AUTOMATIC CONTROL OF LIGHTING

The system of automatic control of artificial lighting has been developed, the system provides colour temperature and brightness of lighting, close to solar light in real time.

***Key words**: artificial lighting, automatic control, colour temperature, RGB-light emitting.*

Problem consideration and set-up

Natural lighting is of paramount importance for human being, for improvement of his psychophysical state and increase of labour productivity. Change of light intensity and spectral composition of the light, characteristic for solar radiation during the day is a natural regulator of human life. In day hours solar light is characterized by high intensity, high colour temperature and considerable share of blue radiation. In the evening, the intensity of these components considerably decreases. People adapted to such variations of light parameters and their biologic cycles, on which change of intellectual and physical activity depends on during the day are mainly determined by three parameters: intensity, colour temperature and blue component of solar radiation [1, 2].

The aim of the given research is the development of automatic system of lighting control, enabling to reproduce basic parameters of natural light atmosphere – change of colour temperature and brightness – in real time.

Substantiation of the results

Nowadays it is practically impossible to reproduce completely the parameters of natural light, using the existing sources of light. It is connected with the problems of construction of sources of light, having the spectrum, analogous to the spectrum of natural light. RGB-light emitting diodes have the spectrum the most suitable for the sensitivity of human eye, and allows to regulate colour temperature.

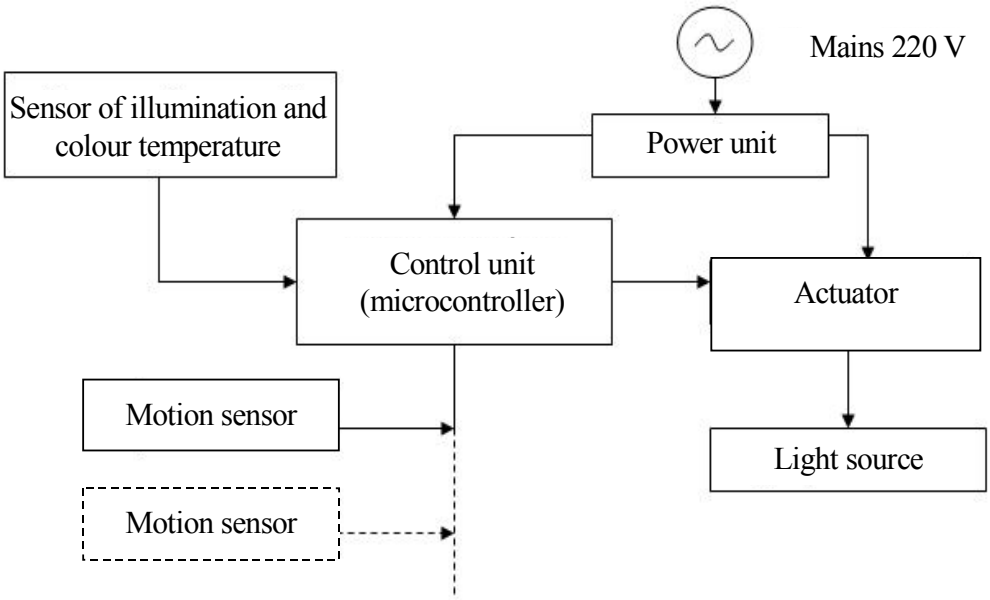

Fig. 1. Functional diagram of automatic system of lighting control

The principle of system operation is the following (Fig. 1). The presence of a man in the room, where the system is installed, is registered by the motion sensor, and obtained data are sent to control unit. On obtaining these data, microcontroller reads out the information from illumination

sensor regarding the level of intensity of emission spectra of red, green and blue components separately and total value of natural illumination level. The obtained value is compared with preset value and in case of discrepancy the value of intensity of each colour is proportionally corrected. This allows to change the level of illumination at stable colour temperature. From microcontroller the information, regarding the intensity of each colour glow is sent to actuator, forming the control pulses of light emitting diode crystals.

Let us consider the operation of each component of the system.

The basic component of the system is control unit on the basis of microcontroller ATmega16L-8PU, manufactured by ATMEL [3] (Fig. 2).

Usage of microcontroller in the given system as control device allows to perform the processing of the information, received from the sensors, its comparison with the data, regarding the necessary level of illumination, correction of light parameters and creation of control pulses for sources of light control.

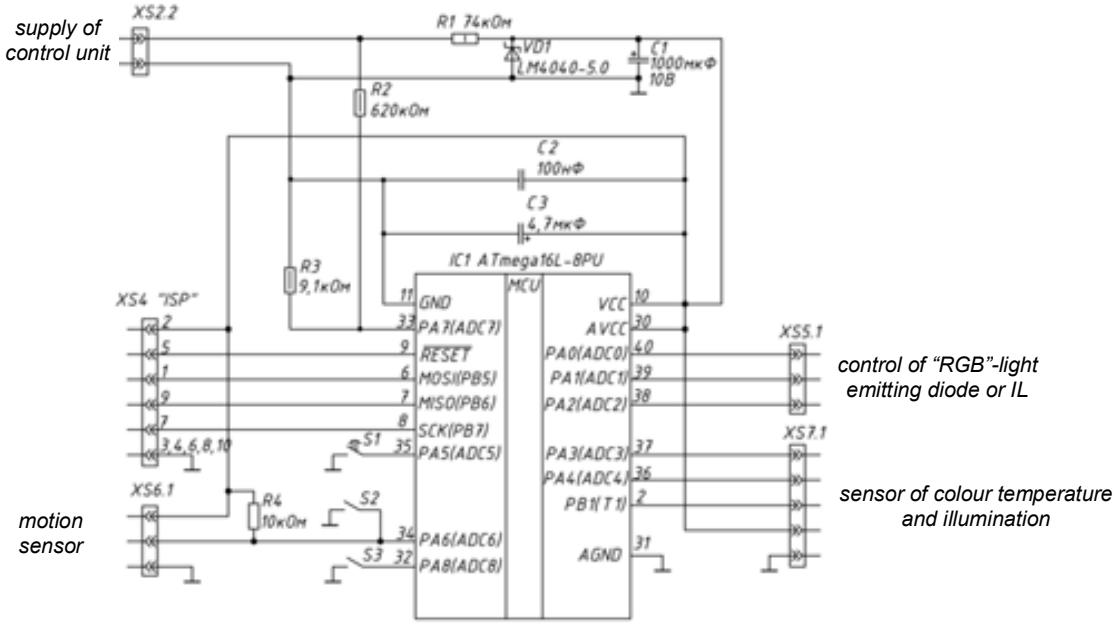

Fig. 2. Schematic diagram of microcontroller control unit

Change of colour temperature of the light source became technically possible recently, due to development and introduction of RGB-light emitting diodes. Their characteristic feature is location of three light emitting crystals in one housing with optic system. It enabled, changing the values of current independently for each crystal, to obtain all possible shades of colours, differentiated by man. To reproduce the necessary colour temperature it is sufficient to have numerical value of two coordinates on the plane of chromaticity diagram (Fig. 3). Horizontal axis of the diagram characterizes colour saturation, and vertical axis – its hue.

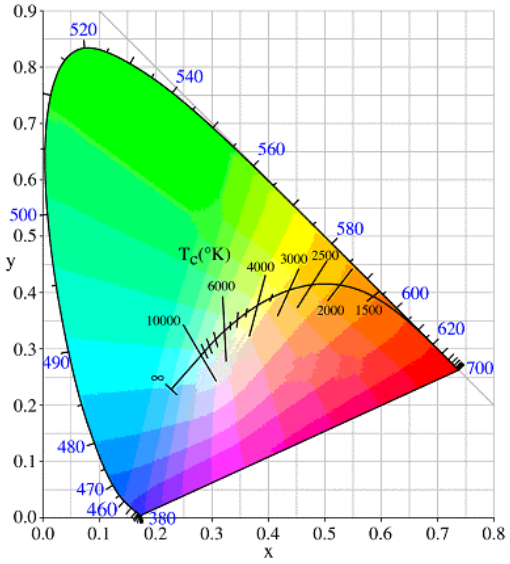

Fig. 3. Chromaticity diagram in x, y system

The basic component of schematic diagram (Fig. 4) is light emitting driver HV9961, enabling to stabilize the current across light emitting diode independently on external factors, such as: voltage oscillations and temperature changes. Additional advantage of light emitting diode use is its radiation spectrum, corresponding to sensitivity of human eye [4].

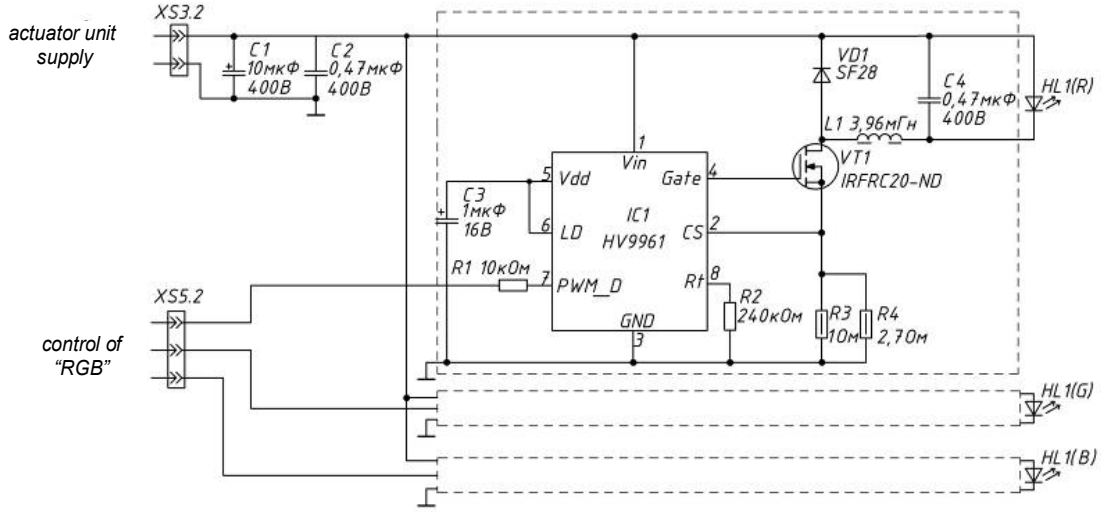

Fig. 4. Schematic diagram of actuator unit, using RGB-light emitting diode

Taking into account considerable (as compared with other sources of light) price of light emitting diodes, actuator unit was developed for the work with incandescent lamp (Fig. 5). Program realization of smooth switching allows to increase considerably service life of the lamp and partially neutralize its negative characteristics. However, after the usage of incandescent lamp, the system loses its main advantages – regulation of colour temperature.

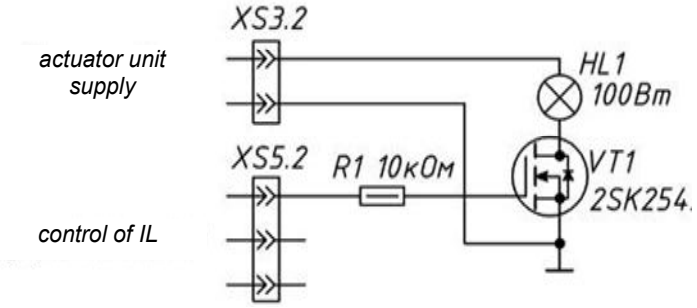

Fig. 5. Schematic diagram of actuator unit, using incandescent lamp

Microcircuit TCS3200 converter «illumination – frequency» is used as the sensor of colour temperature and illumination (Fig. 6, a). It consists of the matrix of photodiodes 8x8 and operation amplifier, converting illumination change into frequency change. Photodiode matrix consists of 16 photodiodes with blue filters, 16 photodiodes with red filters, 16 photodiodes with green filters and 16 photodiodes without filters, which, for minimization of non-uniformity effect, are placed in staggered order.

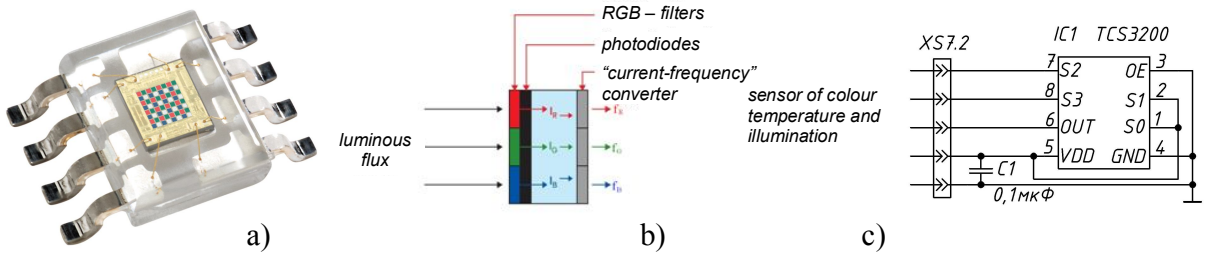

Fig 6. Sensor of colour temperature and illumination TCS320

Principle of operation is the following (Fig. 6 b). RGB-filters decompose incident light into red, green and blue components. Photodiode, located under corresponding filter, converts brightness into current, after that operation amplifiers with current input convert current change into frequency change. Schematic diagram of switching is shown in Fig. 6 c. Main advantages of the given microcircuit are linear dependence of the frequency on illumination (approximately 1 KHz per 1 Lx) and spectral sensitivity, close to sensitivity of human eye.

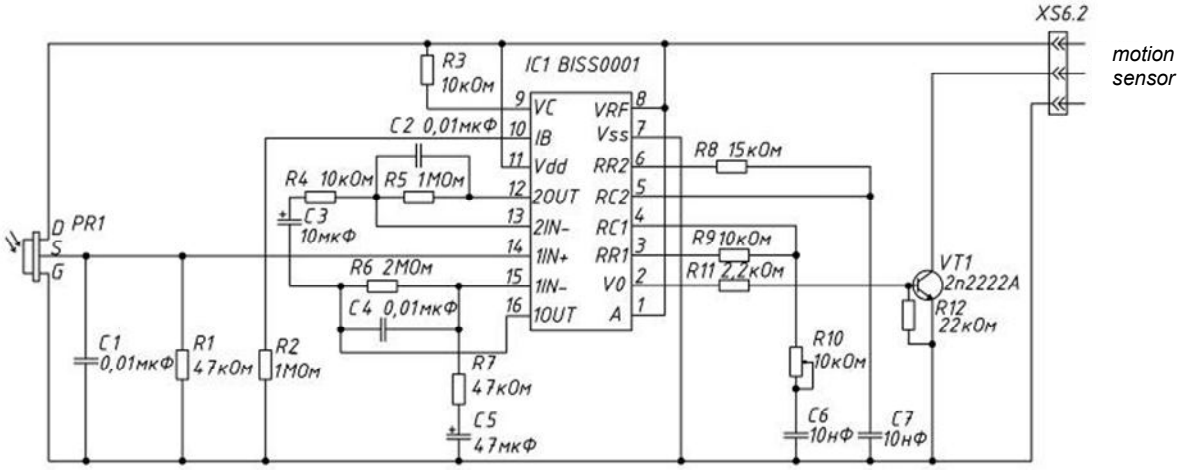

Fig. 7. Schematic diagram of motion sensor switching

Passive infrared sensor is used as motion detector. It consists of three elements:

1) optic system, forming directional pattern of the sensor and determining the form and shape of space zone of sensitivity. Fresnel lens is used in the given system;

2) pyroelectric sensor, registering human thermal radiation;

3) unit of sensor signals processing, generating signals, caused by motion of a human being on the background of noise of natural and artificial origin [5]. Its diagram is shown in Fig. 7.

Signal of man's motion emerges at the output of pyroelement when man crosses the ray of sensitivity zone. Sensitivity and selectivity of sensor action is formed by means of Fresnel lens with different directional patterns.

Main advantages of the suggested system of illumination control are:

– change of colour temperature of the light during the day, according to changes of natural lighting;

– exact support of the preset level of illumination;

– account of people presence;

– availability of smooth switching of light source, excluding light emitting diodes;

– small overall dimensions and mass;

– module structure;

– low energy consumption.

Conclusions

The given system has wide practical application, since it can be used in all spheres of human activity where it is necessary to create artificial lighting during long period of time. As a result of application of modern energy efficient technologies, besides positive impact on labour productivity, physical and intellectual activity of a man, the given system allows to save considerably electric energy as compared with existing systems of lighting. Systems, based on other sources of light can be completely replaced as a result of further progress in light emitting diodes technology due to higher operation parameters of the suggested system.

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