ABSTRACT

Optoelectronic sensors based on anomalous photo-voltage (APV) curtains derived from semiconductor compounds are attracting the attention of many experts today. The use of APV receiver as the first converter in automated systems allows to increase the efficiency of a number of parameters of the system, such as energy saving, reliability, speed, accuracy.

KEYWORDS

APV, sensor, photosensitive, spectrum, mathematical model, light, autonomous, frequency, sensors-sound power, photochemical.

INTRODUCTION

Regardless of the type of sensors, the following basic technical requirements are imposed on them: accuracy, sensitivity, fastness, reliability, dimensions, weight. Conditionally, the sensors can be considered consisting of receiving, intermediate and executive parts. The receiving part is affected by the change in the amount of input X, changing it to some intermediate amount. This amount is compared with the etalon (sample) value of a similar physical quantity. Then the output y signal is formed by influencing this sensor to the executive part. Depending on the physical composition of the input X quantity,
they allocate electrical, thermal, mechanical, optical, acoustic, liquid and gas sensors. Electric sensors—current, voltage, power, frequency, magnetic current; thermal sensors—temperature and amount of heat; mechanical sensors—power, pressure, wiper, speed, acceleration; optical sensors—light power, illumination; acoustic sensors—sound power, its frequency, power; liquid and gas sensors—measure pressure and speed. Each type of sensors, in turn, are also classified according to the principle of operation of the receiving part, that is, they are divided into groups. For example, optical sensors are divided into photoelectric, photochemical, photothermic and photomechanical groups.

Figure 1. Structural view of film

MAIN PART

We can take semiconductor optical light receivers as sensitive elements. To date, different models of semiconductor optical light receivers have been developed, which vary in performance. The importance of optical light-sensitive elements in automated systems is enormous. These sensitive elements receive incoming light and convert it into electrical signals in a photoelectric manner. The optical sensor with the highest sensitivity in terms of spectral properties is the anomalous photo (APV) receiver. Today, it has been proven that an APV receiver can be obtained from any semiconductor material. But even an APV receiver made of any semiconductor material does not achieve high sensitivity. The advantage of APV receivers over other optical sensors is that they can operate autonomously. That is, the operation of APV receivers does not require absolute electricity, it can provide a self-powered source by generating incoming light [3,4].
If we look at the mathematical model of the APV receiver, it is a multi-variable function, and this function is expressed in terms of luminous flux $F$, spectral composition of optical radiation $L$, temperature $T$ and humidity $V$.

$$U\Phi = f(\Phi, T, L, B)$$

The coefficient of variation of optical radiation of light sources (irradiated diode, laser diode) of APV receivers:

$$K = \frac{\int_{0}^{\infty} \varphi_{\varepsilon, \lambda}(\lambda) S_{\text{отн}}(\lambda) d\lambda}{\int_{0}^{\infty} \varphi_{\varepsilon, \lambda}(\lambda) d\lambda}$$ (1)

$\varphi_{\varepsilon, \lambda}(\lambda)$ – the relative dispersion spectrum of light flux coming out of the source; $S_{\text{отн}}(\lambda)$ - relative spectral characteristics of APV receptor sensitivity.

Spectral connectivity of light flow with integrated sensitivity of APV receiver:

$$S_{\text{интф}e} = S_{\lambda, \varphi_{\varepsilon, \lambda} \text{max}} K,$$ (2)

$S_{\lambda, \varphi_{\varepsilon, \lambda} \text{max}}$ - Maximum spectral sensitivity of APV receiver to light flow.

Relative spectral sensitivity of APV receiver:

$$S_{\text{отн}} = S_{\lambda, \varphi_{\varepsilon, \lambda} \text{abc}} / S_{\lambda, \text{max}},$$ (3)

$S_{\lambda, \varphi_{\varepsilon, \lambda} \text{abc}}$ - Absolute spectral sensitivity of APV receiver;

$S_{\lambda, \text{max}}$ - APV receiver maximum spectral sensitivity.

Sensitivity of the APV receiver to the initial frequency:
The initial specific sensitivity of the APV receiver:

$$\Phi_n^* = \Phi_n \sqrt{A} \Delta f = \Phi_n. I \sqrt{A}, \quad (5)$$

Where:
- $$\Phi_n$$ - the initial specific sensitivity of the APV receiver.
- $$A$$ - the surface of the APV receiver;
- $$\Delta f$$ - the frequency bandwidth of the amplified field.

Recommended frequency band for the measured area in APV photodetector certification:

$$\Delta f = 0.2 \, f_m, \quad (6)$$

$$f_m$$ - frequency modulation in passporting.

The specific detection capability of the APV receiver:

$$D^* = \frac{1}{\Phi_n^*}, \quad (7)$$

Recalculation of the spectral sensitivity of the APV receiver to the luminous flux to the spectral sensitivity to the luminous flux:

$$S_{\lambda, \Phi_e} = S_{\lambda, \Phi_v} \, K_{\text{max}} \, V(\lambda), \quad (8)$$

Spectral relative light efficiency for day vision of monochromatic radiation

| $\lambda$, nm | 300  | 400  | 500  | 600  | 700  |
|--------------|------|------|------|------|------|
| 0            | -    | 0.004| 0.323| 0.631| 0.0041|
| 10           | -    | 0.012| 0.503| 0.503| 0.0021|
| 20           | -    | 0.040| 0.710| 0.381| 0.0105|
| 30           | -    | 0.016| 0.862| 0.265| 0.0052|
| 40           | -    | 0.023| 0.954| 0.175| 0.0025|
| 50           | -    | 0.038| 0.995| 0.107| 0.0012|
| 60           | -    | 0.060| 0.995| 0.061| 0.0006|
| 70           | -    | 0.091| 0.952| 0.032| 0.0003|
| 80           | 0.000039 | 139 | 870 | 0.017 | 0.00010 |
| 90           | 0.00012 | 208 | 757 | 0.0082 | - |

Recalculation of the parameters of the APV receiver in the given light PM (photometric magnitude), in the energy FMK parameters:

$$S_{\text{int}, \Phi_e} = S_{\text{int}, \Phi_v} \, K_{\text{max}} \, k_r; \quad (9)$$
The use of photosensitive sensors in automated systems plays a key role in system optimization and ensures system stability. In general, the use of photosensitive sensors in automated systems plays an important role with low energy consumption, noiseless operation, speed, high accuracy and reliability. The use of APV receivers as autonomous optical light receivers in automated optoelectronic systems is promising in the field.
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