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SOME ASPECTS OF HARD MEASUREMENT ASSURANCE OF ELECTRO-MAGNETIC IRRADIATION CONVERTERS

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Abstract – The factors influenced on the inaccuracy of electromagnetic irradiation flux meters have been considered. The factors were divided onto informative, non-informative and destabilising. They can be systematic and random, spatial or temporal distributed. Totality of noninformative and especially destabilised factors, which acts in different ratio with signal measured, are the main source for decrease of accuracy of control of electromagnetic irradiation flux with use of optoelectronic converters of physical values. Introduction of additional correction channels, which uses the correlation of internal signals with destabilised and noninformative factors for minimisation of their influence, allows significantly increase the accuracy of control.

Keywords: Noninformative factor, destabilising factor, correction channel.

1. INTRODUCTION

The development of methods and devices for impartial analysis and control of electromagnetic irradiation energy (irradiation flux) of both natural and artificial objects in ultraviolet, visible and infrared ranges of spectra has not only the basic but applicable interest. First of all this has a certain attitude toward investigations of spatial and temporal distribution of both full flux of solar irradiation energy (or brightness of atmosphere during daylight hours) and its spectral components. Such investigations are especially important for weather forecasting of long duration and ecological conditions of environment responsible for development of alive on the Earth.

The most important tasks of metrological supply of electromagnetic irradiation flux meters (EIFM) are the following:

- increase of control accuracy for informative parameter due to decrease of influence of noninformative and destabilising factors;
- engineering methods of analysis of errors and calibration of measurement of informational systems.

In this article the possible inaccuracy of electromagnetic irradiation flux measurement is examined and the possible ways for decrease of this inaccuracy is proposed.

2. MODEL TYPES FOR OPTOELECTRONIC CONVERTERS OF PHYSICAL QUANTITIES

In general case, two models of optoelectronic converters of physical values (OCPV) were proposed [1] for analysis and estimation of metrological possibilities of any OCPV, including EIFM. They can be represented conditionally as active and passive. Analysis of active and passive models has shown that in both cases the initial signal is a multidimensional vector of informative X, non-informative Π and destabilised Ω parameters. It being known that all of these parameters are multidimensional functions of the initial coordinates (*x*, *y*, *z*, etc) and time *t.* It is hard to solve it analytically. Meantime, at small errors (that is practically possible) of functions *f(x, y, z, t, etc)* conditioned by naturally small values of absolute errors of initial parameters and time, each of them can be expanded in Taylor's series near the work points, and, limiting by the first terms only, it is possible to determine relative deviations of functions for the each of arguments, thus to find the factors of influence (sensitivity) at these points.

At the development of the optical irradiation meter (OIM) and doze meter (DM) one of the main tasks is the minimisation of influence of noninformative and destabilising factors that effect on the measured signals. They include [2-4]: illumination from the external (background) sources of radiation; selection of bands of the radiation that is under control; time drift of instrumental zero and other parameters of the device; electronic nose of the element base; environmental temperature; atmospheric pressure and density; mechanic vibrations; degradation of the sensitivity of photosensors and filters; short-time fluctuations in optics of atmosphere; effect of absorption from atmospheric components; non-uniformity of the flux of radiation energy in cross-section; short wavelength space radiation; errors in angular disagreement between the radiation source and detector; errors of calibration; errors on spectral response; errors in the model of radiation according to standards; errors in technique of measurements; errors in electrical response; errors in calculations and other geometric elements of errors.

It is possible to divide all gamut of these errors into two groups: systematic and occasional. The criteria here is the dependence (or independence) of error component on measured parameter or on time t.

The error components depending only on the time of observation (or spatial coordinates) are the random or fluctuation error. They include the first 12 above-mentioned destabilizing factors. If the error component is occasional function of the measured parameter in series of identical meters (but it is individual for the device) then such error component can be considered as systematic error. Such errors include the last 8 above-mentioned destabilizing factors. For the majority of devices the value of random error is in several times larger then the systematic error. Mean square of random error of the measuring device σ^2 is structural function of the process of measurement.

3. ERROR ANALYSIS

The analysis of the proposed model shows that metrological characteristics of photodetector are connected with the possibility of the extraction of the component which is proportional to those signal that is measured. Instrumentally, this task is solving in a relatively simple way, if, somehow or other, photosensor has structural redundancy of data due to additional measuring channels (correction channels) that is by correlation or functionally connected with the controlled parameter, and with non-informative and destabilising factors too. In the result, if two values correlate under the influence of the third factor well (correlation coefficient is positive) then their relation decrease (desensitise) considerably the influence of the third (destabilising) factor. Functionally, this is realised by means of the execution of different temporal and spatial transformations in the structural connectors of the measuring device: in generator, in detector, etc. In particular, it is worth to utilise feedback relations between the structural connectors of the device.

It is possible also to vary constructive and energetic parameters of the generator and sensor, putting into their structure different test, basic and other signals. All this allows to increase the precision of measurement of the controlled parameter, even in conditions of relatively small accuracy and stability of the signal in the measuring channel (or correction channels) thanks to practically inertial-free and automatic accounting of the effect of measurement errors, connecting with the influence of the destabilising factors on the useful controlled signal. Such functional, structural and scheme-technical decisions promote to increasing of the accuracy of the measuring device.

Below the example of concrete evaluation of error component contribution (separately the totality of all components of systematic and occasional errors) to total error of measurement of OCPV which is based on the joint analysis of referred and measured data.

Variation of parameters of last 8 destabilising factors, which gives the contribution to systematic error, has shown that the maximum value of relative component of non-exceptional remainders of systematic error was not more ±8 %. The most contribution to total non-exceptional part of systematic error of spectrophotometry of sun gives calibration light measurement lamp. Maximum value of error due to this factor reaches to 8% and practically is independent on wavelength. For Si sensor the experimental value of this factor is not exceed ±4%.

Mean-square deviation of totality of all occasional error components was not more than ±17 % with taking into account of first 12 destabilisation factors. Confidence bound of error of measurement results of optical irradiation flux has evaluated according formula

$$\Delta A = \frac{\varepsilon_x + \Theta}{\sigma + \frac{\Theta}{\sqrt{3}}} \sqrt{\sigma^2 + \frac{\Theta^2}{\sqrt{3}}} \quad ,$$

under presence totality both non-exceptional systematic error component Θ and occasional one σ for random excess. Here $\varepsilon_x = t\sigma$ is confidence bound of measurement error (t is the parameter what depend on measure number in the frame of access at given probability). The value ΔA was about ±25% [5].

5. CONCLUSION

Thus, totality of noninformative and especially destabilised factors, which acts in different ratio with signal measured, are the main source for decrease of accuracy of control of electromagnetic irradiation flux with use of optoelectronic converters of physical values. Introduction of additional correction channels, which uses the correlation of internal signals with destabilised and non-informative factors for minimisation of their influence, allows significantly increase the accuracy of control.

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