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NON-LINEAR RECEIVER REACTION OF IRRADIATION WITH COMPLEX SPECTRAL COMPOSITION

Zhivko Zhekov, Garo Mardirossian

SPACE RESEARCH AND TECNNOLOGY INSTITUTE, BULGARIAN ACADEMY OF SCIENCES, SOFIA 1113, ACAD. GEORGI BONCHEV ST., BL.1

e-mail: zhekov_z@abv.bg, garo@space.bas.bg

Abstract. *One of the basic problems in elaboration of spectro-photometer for atmospheric ozone exploration at the Space Research Institute - Bulgarian Academy of Sciences seems to be the necessity of calculation of output signal of the irradiating receiver by fixed spectral composition and intensity. The calculation wouldn't be difficult if the intensity values range is situated on the linear part of the irradiating receiver energetic characteristic. To the end, the absolutely spectral characteristic of receiver sensibility and spectral density of the treated receiver intensity has to be known.*

The paper is dedicated to the elaboration and the obtained results by offering and creating a method for definition the non-linear irradiating receiver output signal by fixed spectral composition and intensity.

In the paper the obtained schemes and equations in the process of elaboration are presented characterizing the reaction of the photo-receiver complex spectral composition with nonlinear energetic characteristic.

Key words: *turbulence, optical measurement*

At spectro-photometer for atmospheric ozone exploration development at the Space Research Institute – Bulgarian Academy of Sciences [1-7] come into being be necessity of calculation of the output signal of the irradiating receiver by fixed spectral composition and intensity. The calculation would not be difficult if the density values range is situated on the linear part of the irradiating receiver spectral characteristic. To the end, the absolutely spectral characteristic of receiver sensibility and spectral density of the treated receiver intensity has to be known [8-11].

(1) $$N = \varphi(\lambda_0) \int_\lambda r_\lambda \varphi(\lambda) d\lambda,$$

where: N – the irradiating receiver output signal;

$\varphi(\lambda_0)$- the irradiating receiver sensibility in the maximum of the sensibility $\varphi(\lambda)$ relative spectral characteristic.

The paper is dedicated to the elaboration and the obtained results by offering and creating a method for definition the non-linear irradiating receiver output signal by fixed spectral composition and intensity. Because of that the irradiating receiver energetic characteristic and sensibility relative spectral characteristic has to be known.

Consecutively it is calculated the irradiating receiver output signal in the wave lengths λ_0 and λ_1. According to [12] the non-linear receiver energetic characteristics can be made as follows:

$$N_0 = \varphi^I (\lambda_0)F, \quad (2)$$
$$N_1 = \varphi^I(\lambda_1)F_\lambda(\lambda_1)\Delta\lambda,$$

or

$$N_o = (\lambda_0)[F_\lambda(\lambda_0)\Delta\lambda]^{\chi_0}, \quad (3)$$

$$N_1 = (\lambda_1)[F_\lambda(\lambda_1)\Delta\lambda]^{\chi_1}.$$

Where $N_0$and N_1 - the treated receiver output signal with the respective fluxes $F_0 = F_\lambda(\lambda_0)\Delta\lambda$; $F_1 = F_\lambda(\lambda_1)\Delta\lambda$ and $F_\lambda(\lambda_0)$;

$F_\lambda(\lambda_1) -$ spectral density of the flux in wave length λ_0;

$\Delta\lambda$ - wave lengths range in the limits of which $F_\lambda(\lambda_0, \lambda_1) \approx$ const;

$\varphi^I(\lambda_0), \varphi^{II}(\lambda_1)$ - the irradiating receiver sensibility to the irradiation in the wave lengths λ_0, λ_1 and intensity F_0, F_1;

$\varphi(\lambda_0)$, $\varphi(\lambda_1)$ – the $\varphi^I(\lambda_0), \varphi^{II}(\lambda_1)$ limited values;

χ_0, χ_1 - index, characterizing the extent of the irradiating receiver energetic characteristic non-linearity, depends on the output signal level.

The phrase (3) is good for the spectral characteristics description of the irradiating receiver.

It is shown the energetic characteristics of an irradiating receiver to its irradiation with lengths λ_0 and λ_1 on the fig. 1.

For definition the non-linear irradiating receiver output signal through making an effect with total irradiation on it, it can put in writing:

$$F_\Sigma = F_0 + F_1. \quad (4)$$

The F_0 flux respects of the energetic characteristic working point 1 for λ_0 (fig.1). Through irradiation on receiver with additional flux F_1 with the length λ_1 the abscise working point relative to the F_1 value moves into the point 2.

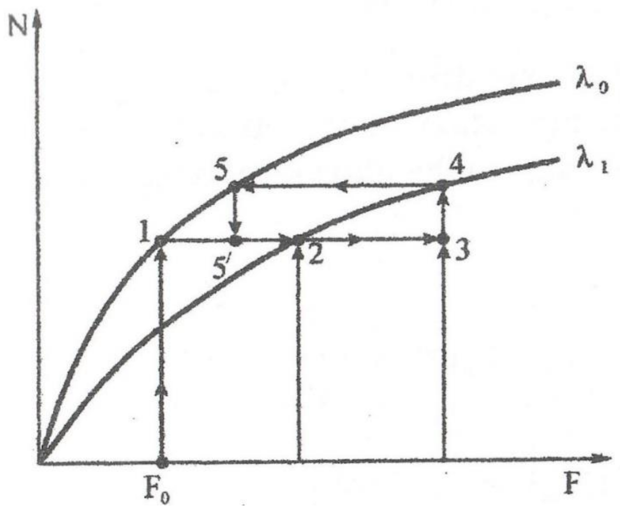

Fig. 1

The output signal value N_{Σ} corresponding to the ordinate point 4. The ratio of the intervals lengths 1-5 and 2-3 is $\varphi(\lambda_0)/\ \varphi(\lambda_1)$ and for N_{Σ} definition it can be used the energetic characteristic only:

(5) $$N_{\Sigma} = \varphi(\lambda_0)\left[F_{\lambda}(\lambda_0)\Delta\lambda + F_{\lambda}(\lambda_1)\frac{\varphi(\lambda_1)}{\varphi(\lambda_0)}\Delta\lambda\right]^{\chi_{\Sigma}}.$$

With the increasing of the spectral parameters number and proceeding from $\Delta\lambda$ to dλ is as follows:

(6) $$N_{\Sigma} = \varphi(\lambda_0)\left[\int_{\lambda} F_{\lambda}(\lambda)\varphi(\lambda)d\lambda\right]^{\chi_{\Sigma}},$$

Where: $\varphi(\lambda)$ – the relative sensibility spectral characteristic of a non-linear irradiating receiver;

χ_{Σ} – non-linearity energetic characteristic index of λ_0 in a point of the abscise equal to $\varphi(\lambda_1)/\ \varphi(\lambda_0)$.

From phrases (5) and (6) can be made important practical concluisions:

1. A family of all wave lengths energetic characteristics from a total energetic characteristic can be replaced, in relative coordinates $N = \varphi(\lambda_0)$ constructed, where $F_e = \int_{\lambda} F_{\lambda}\varphi(\lambda)d\lambda$, falling on the receiver effective flux.
2. The output signal calculations N_i of a non-linear irradiating receiver of with a fixed spectral composition and intensity F_{li} irradiation are got in the formula:

(7) $$N_i = N_0\frac{F_{e_i}{}^{\chi_i}}{F_{e_0}{}^{\chi_0}},$$

Where N_0 of a non-linear irradiating receiver output signal from a standard source with effective flux F_{io}.

If in a fixed range of the output signal change the non-linearity index $\chi_i - \chi_o = \chi =$ const, so the phrase (7) turns on

$$N_i = N_0 \left(\frac{F_{e_i}}{F_{e_o}}\right)^{\chi}, \tag{8}$$

and the χ value characterizes a tangent-slope of the irradiating receiver energetic characteristics.

3. The value $\varphi(\lambda_0)$ is not depending on the effective flux F_i value.

At recording an irradiation of the optical spectrum visible and ultraviolet range the output signal value in the ultraviolet range N and Φ in the visible range is as follows:

$$N_1 = \varphi(\lambda)_{max}\left[\int_\lambda F_{1\lambda}\varphi(\lambda)d\lambda\right]^{\chi_1}, \tag{9}$$

$$N_2 = \varphi(\lambda)_{max}\left[\int_\lambda F_{2\lambda}\varphi(\lambda)d\lambda\right]^{\chi_2},$$

$$\Phi_1 = k(\lambda)_{max}\int_\lambda F_{1\lambda}k(\lambda)d\lambda, \tag{10}$$
$$\Phi_2 = k(\lambda)_{max}\int_\lambda F_{2\lambda}k(\lambda)d\lambda.$$

Where $k(\lambda)$ – the relative spectral characteristic of the receiver sensibility in the visible range;
$\varphi(\lambda)$ – the relative spectral characteristic of the irradiating receiver sensibility in the ultraviolet range;
$k(\lambda)_{max}$ – the absolute spectral sensibility of the irradiating receiver in the visible range;
$\varphi(\lambda)_{max}$ – the absolute spectral sensibility of the irradiating receiver in the ultraviolet range
Solving the equations system in respect of N_2:

$$N_2 = N_1\left[\frac{\int_\lambda F_{1\lambda}k(\lambda)d\lambda}{\Phi_1\int_\lambda F_{1\lambda}\varphi(\lambda)d\lambda}\right]^{\chi_1}\left[\frac{\Phi_2\int_\lambda F_{2\lambda}\varphi(\lambda)d\lambda}{\int_\lambda F_{2\lambda}k(\lambda)d\lambda}\right]^{\chi_2}. \tag{11}$$

Reporting on the effectiveness coefficient [13] of the receiver sensibility in the ultraviolet range $k_1(F)$ and in the visible range $k_2(F)$, then for N_2 it is getting

$$N_2 = N_1 \frac{\left[\frac{\Phi_2 k_1(F_2)}{k_2(F_2)}\right]^{\chi_2}}{\left[\frac{\Phi_1 k_1(F_1)}{k_2(F_1)}\right]^{\chi_1}}. \tag{12}$$

For the examining receiver $\chi_1 = \chi_2 = 0{,}83$. The effectiveness coefficient of the receiver sensibility from the first and the second source in the ultraviolet range is 0,042 and 0,164 and in the visible range 0,017 and 0,112. From where

$$N_2 = N_1 \left[\frac{0{,}164\ 0.017}{0{,}112\ 0{,}042}\right]^{0{,}83} = 0,5926^{0{,}83} N_1 = 0{,}65 N_1.$$

A conclusion can be remarked, for the output signal determination of the non-linear irradiating receiver with a fixed spectral composition and a fixed intensity in the presented method in the formulas (7), (8) and (11), it is enough to be found its energetic characteristic in the whole expecting range and intensity of the source with a known irradiating spectrum, using the standard methods and the relative spectral characteristic of the irradiating receiver sensibility.

References:

[1]. Getsov P., St. Stoyanov, Research of the Background Influence on the Resolution and Definition of the Variations of the Background Luminance of Electronic-Optic Converters. Determination of the Angular Coordinates of Astronomical Objects. Journal Scientific and Applied Research. Vol. 9, 2016, p. 5-11

[2]. Getsov P., St. Stoyanov, Input Influences on an Optical-Electronic Device When Measuring Angular Coordinates of Distant Objects, Journal Scientific and Applied Research. Vol. 17, 2019, p. 5-8

[3]. Stoyanov St., A. Antonov. Discovery of Distant Objects by Means of Optic-Electronic Devices, Likelihood Ratio When the Signal is Absolutely Unknown. Journal Scientific and Applied Research. Vol. 17, p. 13-18

[4]. Getsov P., St. Stoyanov, P. Boyanov, Research of the Transparency Characteristics of the Atmosphere Which Influence the Flight Control of Flying Machines, Journal Scientific and Applied Research. Vol. 11, 2017, p. 5-9

[5]. Getsov P., St. Stoyanov, Determining the Amount of Electronic Scintillations of Electro-Optic Transformer of Images, Journal Scientific and Applied Research. Vol. 14, 2018, p. 11-16

[6]. Getsov P., St Stoyanov, A. Antonov, P. Boyanov. Visual Detection of Distant Objects Using Electronic Optical Devices at Irregular Background Luminance. Journal Scientific and Applied Research. Vol. 10, 2016, p. 5-10

[7]. Stoyanov St. Applied Optics. Publishing House Faber. 2009, 234 p.

[8]. Stoyanov St. Design of Optical Devices. Publishing House Faber. 2010, 348 p.
[9]. Zhekov Zh. Methods and Means for Discovery of Distant Objects from Space Aircraft, Konstantin Preslavski University Press. Shumen, 2006, 308 p.
[10]. Zhekov Zh. Satellite Ecological Monitoring of the Environment, Konstantin Preslavski University Press. Shumen, 2014, 293 p.
[11]. Zhekov Zh. Satellite Monitoring of the Atmosphere, Konstantin Preslavski University Press. Shumen, 2014, 165 p.
[12]. Novitzki P. V. Information Theory of the Measuring Devices Base, L., Energia, 1988
[13]. Kogelnik H. R., Bell. Syst. Techn. J., vol. 38, 1995, pp. 322–349