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PARAMETRICAL OPTIMIZATION OF AN OPTIC – ELECTRONIC DEVICE IN PROCESS OF DISCOVERING DISTANT OBJECTS

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Abstract: *The process of discovering distant objects through the use of optic – electronic device has been examined, with an optical device – visir – for preliminary "rough" targeting. Methods for optimization and determining the optimal values of the crucial parameters of the device in regime for discovering of distant objects has been proposed, thus ensuring its maximum sensitivity.*

Keywords: *Discovering, Distant objects*

For ensuring the high level of protection against noise, accuracy of object-following, determining the coordinates of the object and decreasing the amount of time for its discovering[1, 2], it would be necessary in parallel with the precise – accurate system for identification and object – following[3, 4], the preliminary discovering and determining the coordinates of the object to be done through the use of optical device - visir.[5, 6]

This way, the possibility for discovering the distant object in definite direction is assumed to be known and in most cases equal to one.

Figure 1 shows the part of the structural scheme of optic – electronic device, which is necessary in the process of discovering distant objects, which are the main theme in this document.

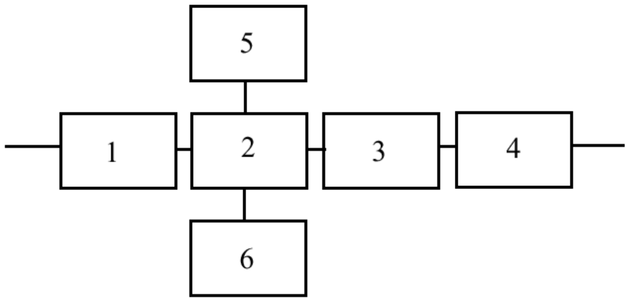

Figure 1. Structural scheme of optic – electronic device in process of discovering distant objects: 1 – optical system; 2 – optic – electronic transformer; 3 – coordinating filter; 4 – signal – identifying device; 5 – block scanning; 6 – block power supply.

Figure 2 shows an image of the object in the plain of photo-cathode of the optic – electronic transformer /dissector/.

The coordinate axis X and Y correspond to the axis of the optical visir, and its crossing point coincide with the center of the visible area, the scanning equipment has square shape with a face dα, that moves with constant speed V, creating square raster with face h and overlapping factor δ = χ/ dα.

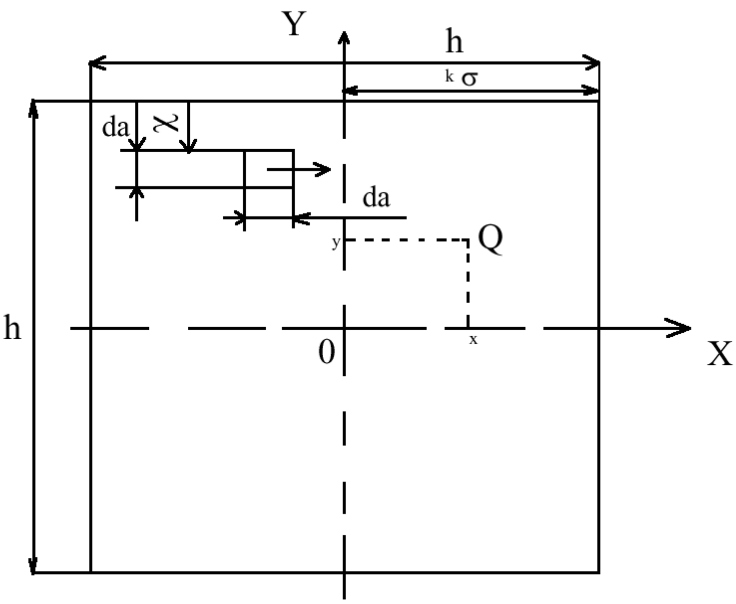

Figure 2. Image of the object in the plain of the photo cathode of the dissector

Q identifies the projection of the image of the object with coordinates X and Y. The object will be discovered if the equipment crosses the projection of the image of the object and in the end of its signal – identifying device appears an impulse. This development will be marked with A. It appears only when, the projection of the image of the object is in the range of the raster (development B), the speed of the object on axis Y doesn't exceeds exact value Vo, in order the object not to be missed for the period of the scanning (development C), and the signal of the object exceeds the level of noise (development D).

When the process for discovering of distant objects is investigated for non – definite time, developments B and C are independent. In this case the possibility for discovering of the object (development A) will be:

(1) $$P(A) = P(B)P(C)P(D/B,C),$$

where: P(B), P(C) – possibilities for developments B and C respectively;

P(D/B,C) – possibility for discovering of the signal (development D) in accordance with developments B and C.

The possibility for development B is equal to:

(2) $$P(B) = \int_{-k}^{k}\int_{-k}^{k} \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} dxdy,$$

where: 2k=h/σ - relative size of the dissector's field

$\sigma^2 = \sigma_x^2 = \sigma_y^2 = \frac{1}{2\pi}\int_0^{\infty} S(\varpi)d\varpi$ - Dispersion of the coordinates X and Y;

S(ϖ) – spectral density of the process of alteration of the coordinates X or Y through time.

To find the possibility for development C we should know the speed of the object. As long as the coordinates of the object have normal distribution, the speed is distributed also according the normal law and dispersion σ_v^2, which is equal to:

$$\sigma_v^2 = \frac{1}{2\pi}\int_0^{\infty} S(\varpi)d\varpi.$$

The possibility P(C) is maximum, when the overlap is equal to δ=0,5. Then:

(3) $$P(C) = \int_{-m}^{m} \frac{1}{\sqrt{2\pi}\sigma v} e^{-\frac{v^2}{2\sigma_v^2}} dv,$$

where: m = Vo/σ_v – relatively admissible speed of object's motion on axis Y

The possibility for discovering of the signal is equal to:

(4) $$P(D/B,C) = \int_{\Delta H-\psi}^{\infty} \frac{1}{\sqrt{2\pi}} e^{-\frac{z^2}{2}} dz,$$

where: $\Delta H = \frac{U_H}{U_M}$ - relative level of noise;

Uм – semi-quadratic value of the noise at the exit of signal – identifying device;

$\psi = \frac{Uc}{U_M}$ - Interrelation between the amplitude of the signal of the noise at the exit of the праговo device, with certain values of k and м:

z = U/Uм.

The value of the relative level of noise ΔH could be calculated with the criteria of Neiman – Pirson, starting with the possibility for perceiving of wrong signal.

(5) $$P^{|} = \int_{\Delta H}^{\infty} \frac{1}{\sqrt{2\pi}} e^{\frac{z^3}{2}} dz.$$

The most difficult case for discovering of distant objects has been observed in this document, when the light of the background is great, and the contrast with the image is smaller. In this case the noise at the exit of the dissector could be considered as stationary and normal. From formula (1) considering formulas (2), (3) and (4) we observe, that the assigned value of the possibility for discovering of the object P(A) with fixed possibility for perceiving of a wrong signal $P^{|}$ is suitable for the multiplicity of values of k, м and ψ.

For securing the maximum sensitivity of the system, i.e. minimum light on the object, it is necessary the following condition to be fulfilled:

(6) $$\psi\sqrt{k\textit{м}} = \min\ .$$

It is not hard to see, that the speed of scanning of the equipment V is related with the receiving of optimal value of м in correlation:

$$V \geq \frac{2h}{a_c d_a} м \sigma_v ,$$

where: a_c – relative time for one – way movement for scanning on axis X.

The period for scanning of a whole frame with calculated optimal values of k and м is defined by the formula:

$$T = \frac{2\sigma k}{a_c \sigma_v м} .$$

The maximum value of the correlation signal/noise with optimal filtration is equal to:

(7) $$\psi = \sqrt{\frac{2E}{No}} ,$$

where: E – energy of the signal;

No – spectral density of white noise.

The energy of the signal is equal to:

(8) $$E = \gamma I_o^2 \tau_i ,$$

where: Io – maximum value of signal;

τ_I – duration of signal;

γ - coefficient, describing the form of the signal (in this case it is rectangular - γ = 1).

Using the already known correlation for the signal Io and the spectral density of the noise No at the exit of the dissector we have:

(9) $$Io = \varepsilon.So.Eo.q^n ,$$

(10) $$No = e.\varepsilon.Sa.E^{|} \frac{q^{2n+1}}{q-1} ,$$

where: ε - integral sensitivity of the photo cathode of the dissector;

So, Eo – surface of the object and the amount of light it receives in the plain of the photo cathode respectively;

q – coefficient of the secondary emission of the dynodes of the multiplier;

n – the amount of dynodes in the secondary – electronic multiplier in the dissector;

e – charge of the electron;

Sa, $E^{|}$ - surface of the scanning equipment and the amount of light of the background in the plain of the photo cathode respectively.

Duration of the impulse signal from object τ_I is equal to:

(11) $$\tau_I = \beta \frac{da}{V} ,$$

where: β - coefficient, defining the size of the object and the speed of its movement Vo

Taking into consideration, that Sa = d_a^2, V = $\frac{2h}{a_c d_a} Vo$, Vo = м.τ_v, h = 2kτ, formula (7) while considering of formulas (8)..(11) acquires the following visualization.

$$\psi = \text{SoEo}\sqrt{\frac{\varepsilon\gamma\beta(q-1)dc}{2eE^{|}q\sigma\sigma_v k_M}}$$

or

$$\text{Eo} = \psi\sqrt{k_M G}$$

where: $$G = \frac{1}{So}\sqrt{\frac{2eE^{|}q\sigma\sigma_v}{\varepsilon\gamma\beta(q-1)a_c}}$$

In conclusion we can add that:

1. The optimal values of the main parameters of the optic – electronic systems in regime of discovering distant objects has been defined. Size of the field for discovering of distant objects, speed of scanning according to a certain direction, period of frame scanning, securing maximum sensitivity.
2. It is shown that the possibility for perceiving of wrong signal does not in fact influence the optimal value of the size of the field for discovering of distant objects.

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