**Stand-alone solar optic device based on aps-photodeciver**

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Abstract. This paper discusses a detailed description of the design of a special physical device of a helioptocoupler aimed at receiving solar radiation with its subsequent conversion, as well as output in the form of an anomalously high photovoltage. All processes are considered from the point of view of physical and mathematical modeling and detailed analysis of the physical processes used in the design. The analysis from the calculation and design side coincides with the general description of the design of the solar optron device.

**Key words:** solar optron, detailed analysis, APS films, anomalous photovoltage, physical and mathematical modeling, generation, solar radiation.

1 Introduction

The entire device of a solar optocoupler includes a whole circuit, presented in the form (Fig. 1), where there are a large number of very different components, which are worth discussing in detail, just like all the physical methods that are actively used during their operation [1-3].

![Diagram of the solar optocoupler device](https://example.com/diagram.png)

**Fig. 1.** Diagram of the solar optocoupler device, 1, 2, 3 – optoelectronic circuits, 4, 5, 6 – electrical connecting circuits, 7, 8 – electrical circuits for feedback, VVB – high-voltage unit, FEB – photovoltaic unit, TEB – thermoelectric block, FMB – photo-magnetic-electric block, PSI – solar radiation receiver, EX – electronic switching system, ASU – output operating device with dielectric load, SI – solar radiation, OBS – feedback.

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2 Guided radiation

The design of the device initially begins with the direction of solar radiation to a special receiver, which is a technology for increasing the luminous flux, after which it is directed towards the electronic switching system of the solar optron. Let's consider the physical and mathematical modeling of the process of increasing the light directed flux of solar radiation.

It is worth noting the fact that by its nature it consists of a connection of almost all wavelengths, carrying a certain energy value, now defined as a constant $1,367 \text{ W/m}^2$, and already after passing through the atmosphere $–1,020 \text{ W/m}^2$ at the equator.

However, here it is necessary to take into account that this value is peak at the equator at noon, when at the time of twilight or sunrise this value decreases to $420 \text{ W/m}^2$.[4 - 6]. The same circumstance should be taken into account when indicating the distance of the point where the measurement is to be made from the equator, where the peak values are known, and closer to the poles this value comes down to $400 \text{ W/m}^2$ at noon, and in the early morning or late evening it goes up to $170 \text{ W/m}^2$.

To prove this statement, we assume that the given empirical data fits into a plane with the canonical equation (1) and the definition of coordinates (2), where the first indicators are the central angle of deviation from the equator, where it is assumed that the zero value along the abscissa is this is an indication of the time at noon, as a setting of the prime meridian at this time, and as an ordinate, an indication of the corresponding longitude or, more precisely, the sine of this value, which also corresponds to the maxima of the indicated points.

$$Ax + By + Cz + D = 0$$

From the above definitions, it becomes sufficient to substitute the presented values into the transition equation in the form of a system of equations, which can be, for solution by the Gaussian method [7 - 14], transformed into a 5 by 4 matrix in (3).

$$\begin{align*}
0A + 0B + 1020C + D = 0 \\
0A + B + 400C + D = 0 \\
A + 0B + 420C + D = 0 \\
A + B + 170C + D = 0
\end{align*}$$

$$\begin{pmatrix}
0 & 0 & 1020 & 1 & 0 \\
0 & 1 & 400 & 1 & 0 \\
1 & 0 & 420 & 1 & 0 \\
1 & 1 & 170 & 1 & 0
\end{pmatrix} = \begin{pmatrix}
0 & 0 & 1020 & 1 & 0 \\
0 & 1 & 400 & 1 & 0 \\
1 & 0 & 420 & 1 & 0 \\
1 & 1 & 170 & 1 & 0
\end{pmatrix}$$

$$= \begin{pmatrix}
0 & 0 & 1020 & 1 & 0 \\
0 & 1 & 400 & 1 & 0 \\
1 & 0 & 420 & 1 & 0 \\
1 & 1 & 170 & 1 & 0
\end{pmatrix}$$

$$= \begin{pmatrix}
1 & 0 & 420 & 1 & 0 \\
0 & 1 & 400 & 1 & 0 \\
0 & 0 & 1020 & 1 & 0 \\
0 & 0 & -650 & -1 & 0
\end{pmatrix}$$

$$= \begin{pmatrix}
1 & 0 & 420 & 1 & 0 \\
0 & 1 & 400 & 1 & 0 \\
0 & 0 & 1020 & 1 & 0 \\
0 & 0 & -650 & -1 & 0
\end{pmatrix}$$

The next step towards finding a solution is to divide line 3 by 1020, after which from line 1 we subtract line 3 multiplied by 420, and from line 2 we subtract 3 multiplied by 400, and to line 4 we add line 3 multiplied by 650 (5).
\[
\begin{pmatrix}
1 & 0 & 420 & 1 & 0 \\
0 & 1 & 400 & 1 & 0 \\
0 & 0 & 1 & \frac{1}{1020} & 0 \\
0 & 0 & -650 & -1 & 0 \\
\end{pmatrix}
\Rightarrow
\begin{pmatrix}
1 & 0 & 0 & 10 & 0 \\
0 & 1 & 0 & \frac{31}{51} & 0 \\
0 & 0 & 1 & \frac{1}{1020} & 0 \\
0 & 0 & 0 & -\frac{37}{102} & 0 \\
\end{pmatrix}
\]  \quad (5)

\[
\begin{pmatrix}
1 & 0 & 0 & \frac{10}{17} & 0 \\
0 & 1 & 0 & \frac{31}{51} & 0 \\
0 & 0 & 1 & \frac{1}{1020} & 0 \\
0 & 0 & 0 & 1 & 0 \\
\end{pmatrix}
\Rightarrow
\begin{pmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 \\
\end{pmatrix}
\]  \quad (6)

\begin{align*}
A_1x^2 + A_2y^2 + A_3z^2 + 2A_4yz + 2A_5zx + 2A_6xy + 2A_7xy + 2A_8xy + 2A_9z + A_{10} &= 0 \\
\Rightarrow (0; 0; 0; 0) &
\end{align*}  \quad (7)

\begin{align*}
(x^2; y^2; z^2; yz; zx; xy; x; y; z) &= > \\
&\Rightarrow (0; 0; 1 040 400; 0; 0; 0; 0; 1 020), \\
&\quad (0; 8 100; 176 400; 37 800; 0; 0; 90; 420), \\
&\quad (0; 8 100; 176 400; -37 800; 0; 0; -90; 420), \\
&\quad (0; 2025; 384 400; 27 900; 0; 0; 45; 620), \\
&\quad (8 100; 0; 160 000; 0; 36 000; 0; 90; 0; 400), \\
&\quad (8 100; 0; 160 000; 0; -36 000; 0; -90; 0; 400), \\
&\quad (8 100; 8 100; 28 900; 15 300; 15 300; 8 100; 90; 90; 170), \\
&\quad (8 100; 8 100; 28 900; 15 300; -15 300; -8 100; -90; 90; 170), \\
&\quad (8 100; 8 100; 28 900; -15 300; 15 300; -8 100; 90; -90; 170), \\
&\quad (8 100; 8 100; 28 900; -15 300; -15 300; 8 100; -90; -90; 170) \\
\end{align*}  \quad (10)
Thus, by means of these conclusions one can come to a solution \(14\).

As a result of this part of the analysis, it was possible to come to the proof of the impossibility of representing the pattern of changes in the solar flux in a generally accurate form, resorting to general approximations according to \(15\).

\[
E_s = E_{1.2} \pm \frac{E_1 - E_2}{181} \cdot d = \begin{cases} E_1 + \frac{E_1 - E_2}{181} \cdot d, \\ E_2 - \frac{E_1 - E_2}{181} \cdot d \end{cases}
\]

Where, \(E_s\) is the daily value of constant luminosity; \(E_1\) - luminosity at the beginning of January; \(E_2\) is the luminosity at the beginning of July; \(d\) is the number of days from the beginning of the year.

In this case, a value is indicated that defines it throughout the entire year, that is, taking the beginning of June or 181 days of the year as the peak, making some errors for a leap year. And for daily indicators it is defined as \(16\).

\[
E_t = \left(\frac{|t_{12} - t|}{t_{12}} + \frac{\alpha - \alpha_0}{\alpha_0}\right) \cdot E_s
\]

Where, \(t_{12}\) is the exact time of noon; \(t\) is the time of measurement, action; \(\alpha_0\) - zero latitude (equator), equal to 90 degrees; \(\alpha\) - latitude at which the measurement is taken (South or North does not matter).

At the same time, it is worth paying tribute to the real model, which, even with all its approximateness, has a fairly high level of correlation with real empirical data. And if the analysis of the passage of radiation from the Sun to the receiver has been mo\(4\)re or less analyzed, it is worth paying attention to the photometric characteristics. Of course, it is important to consider the issue from a variety of angles, including the wave and corpuscular theory, according to which the radiation flux is a set of quanta of real radiation, which ultimately form its flow, in this case the flux of light radiation \(17\), determined by through known constants, and the expression itself for determining the radiation flux, which is the ratio of the directed power over a certain period of time, is presented somewhat differently \(18\).

\[
\Phi_v(\lambda) = K_m \sum_{i=1}^{N} V(\lambda_i) \cdot \Phi_e
\]

\[
\Phi_e(j) = \frac{dQ}{dt} = \frac{1}{dt} \int_{\nu_1}^{\nu_2} j(\lambda, \nu) \sum_{k=1}^{n_j(\lambda)} h \nu \, d\nu = \frac{1}{dt} \int_{\lambda_1}^{\lambda_2} j(\lambda) \sum_{k=1}^{n_j(\lambda)} \frac{hc}{\lambda} \, d\lambda = \Phi_e(\lambda)
\]

\[
d\Phi_v(\lambda) = K_m \sum_{i=1}^{N} V(\lambda_i) \cdot d\Phi_e(\lambda)
\]

\[
\Phi_v = K_m \int_{380 \, \text{nm}}^{780 \, \text{nm}} \sum_{i=1}^{N} V(\lambda_i) \cdot \Phi_e(\lambda) \, d\lambda
\]
The obtained result may indicate that an increase in the concentration of directed radiation in a certain region through systems of lenses and also mirrors can lead to the fact that the number of quantum photons in this region will also increase. So, if we analyze real radiation as a two-dimensional projection, then at a distance within a certain radius, the area that the radiation will cover is proportional to the magnitude of the arc formed, in turn proportional to the scattering angle in radians (21).

\[ \alpha = \frac{l}{r} = \left( \sum_{u=0}^{u} \int f(u, r) du dr \right) \cdot \left[ \lim_{\Delta r \to 0} r \right]^{-1} \]  

(21)

However, moving to three-dimensional projection, it turns out that radiation (in each of the positions) comes from a certain point, falling from there onto an imaginary spherical surface, on which there is a certain two-dimensional Riemannian region or Riemannian plane on this spherical surface, to each point of which are drawn radii of the formed imaginary sphere. In this case, the area of this area with a known radius becomes known, and then the amount of energy or the number of photons released during such scattering from the specified point becomes proportional to the formed solid angle, which in turn is determined in (22).

\[ \Omega = \frac{S}{r^2} = \left( \sum_{u'=0}^{u'} \int_{D'} S(u', r') dD' \right) \cdot \left[ \lim_{\Delta r' \to 0} r' \right]^{-2} \]  

(22)

This conclusion is drawn from the fact that in a two-dimensional projection, during a decrease by 2 times, the length of the arc also decreases by 2 times, however, when measuring proportionality, for example, by the same 2 times, the area decreases by 4 times, that is, quadratically.

From here we can preserve the same law of proportionality (24) for the output energy for each of the points, from which we can talk about introducing a certain energy function that describes the change in different areas of the resulting area of concentration of different energy photons (23).

\[ E = h \nu = \frac{hc}{\lambda} \]  

(23)

\[ Q' \sim f(E, x) \int_{D} \frac{S(x, y)}{r^2} dx dy = f(E, x) \int_{x_0, y_0}^{x, y} \frac{S(x, y)}{r^2} dx dy \]  

(24)
\[ I = \frac{d\Phi}{d\Omega} \]  

3 High anomalous photovoltage block

\[ Q = UIt = \left( \iiint_1^k \prod_{j=1}^i \frac{\partial U'(x,y,z,t)}{\partial t} \, dx \, dy \, dz \lim_{i \to n} \sum_{t=1}^n \frac{\partial I(t)}{\partial t} \right)_{(q)} \]  

\[ I = \iiint_1^k \prod_{j=1}^i \frac{\partial U'(x,y,z,t)}{\partial t} \, dx \, dy \, dz \left( \lim_{i \to n} \sum_{t=1}^n \frac{\partial R(t)}{\partial t} \right)^{-1} = \frac{U}{R} \]  

\[ R = \iiint_1^\alpha^\beta \prod_{\gamma=1}^\alpha^\beta \frac{\partial p'(x,y,z)}{\partial c} \, dx \, dy \, dz \left( \lim_{i \to n} \sum_{t=1}^n \frac{\partial k(l)}{\partial l} \times \left( \frac{(\Delta s)}{\sin \varepsilon \, dt} \right)^{-1} \right) = \rho \frac{l}{s} \]  

\[ E = \frac{w'}{\partial w} \iiint_1^k \prod_{j=1}^i \frac{\partial F'(x,y,z,t)}{\partial t} \, dx \, dy \, dz \left( \lim_{i \to n} \sum_{t=1}^n \frac{\partial q(t)}{\partial t} \right)^{-1} = \frac{F}{q} \]  

\[ U = \varphi_2 - \varphi_1 = \]  

\[ = \iiint_1^k \prod_{k=1}^i \frac{\partial k'(x,y,z,t)}{\partial x} \, dx \, dy \, dz \left( \lim_{i \to n} \sum_{l=1}^n \frac{\partial r(x)}{\partial x} \right)^{-2} \left( \lim_{i \to n} \sum_{t=1}^n \frac{\partial q_1(t)}{\partial t} \right) - \left( \lim_{i \to n} \sum_{t=1}^n \frac{\partial q_2(t)}{\partial t} \right) = \frac{kq_1}{r^2} - \frac{kq_2}{r^2} \]
Finally, after passing through such a system, with a sufficiently high efficiency, it becomes possible to determine the output power (33) for a converted electric current with an abnormally high voltage and low current, which was required when designing the solar optron device system.

4 Conclusion

As a result of the analysis, it was possible to follow the entire design and algorithm, which analyzed this entire system from the physical and mathematical side.

A complete description of the helioptotron device, which receives solar radiation, was obtained to predict changes in the original flux shape throughout the year.

Subsequently, by a system for increasing the flux of light radiation, further transformation, by directing it through fiber optic and photoelectric connections to converters of this radiation into electric current.

An analysis of each of the processes is provided, from the photoelectric effect, operating in the first model with its own individual mathematical apparatus, also in the thermoelectric system, with a description of the method of using thermoelements with its own calculation algorithms.

Photoelectric and conductive connections are briefly described, with a further transition to the representation of a mathematical model for films with the generation of anomalous photovoltage, which was subsequently achieved by describing the presented quantum-molecular physical and mathematical systems of matrix-functional differential-integral equations. Thus, we can talk about conducting a complete analysis of the solar optron device system with all its features and aspects.

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