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DEVELOPMENT OF MODELS OF THE MAXIMUM POWER OF THE SOLAR ENERGY TRACKING SYSTEM BASED ON A PHOTOPANEL

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ABSTRACT

Solar tracking system is the most common method to improve the efficiency of solar PV modules. This study presents the energy conversion efficiency of a PV module with a solar PV module tracking system. The proposed model of the solar tracking system uses MPT. With the help of the MPT, the solar panel becomes more energy efficient, and with the use of the tracking system it is more sensitive to the sun's rays, and this allows for a more accurate detection of the sun location. A comparative analysis was carried out between a stationary PV module and a PV module with a tracking system. The results showed that a two-axis solar tracking system power production has increased by a total of 1.5%. compared to power produced by stationary PV module. Additionally, the average efficiency of our PV module varies within 12-20%. But still, in the age of rapid development of science and technology, these indicators are not the limit. There are a number of alternative ways to increase these numbers which many scientists from different countries are working hard. In our study, in order to increase the efficiency of the photo module, we considered the optimization of the production of a solar battery with tracking system, which should track the Sun. Because the incidence of the sun rays on the surface of the panel at 90 degrees increases the efficiency of the production of PV modules.

The article considers the software and hardware for the control of the solar panel with a rotating mechanism, and solves scientific and applied problems for mathematical modeling and information support of the photo panel (PP) with a solar control system in order to increase PP energy efficiency. The photo panel model was implemented in the Lab View MatLab software package through the Matlab block library.

Key words: *Photopanel, Support Rotary Mechanism (SRM), Solar Energy, Maximum Power Generation Technology (MPT)*

1. INTRODUCTION

The main problems of the energy source are the low efficiency of energy conversion and the high cost of the unit. Numerous studies have been conducted to improve the efficiency of solar panels. Therefore, different types of solar panels have been designed and implemented. Knowing that a solar panel is an important part of a photovoltaic system that converts solar energy into electricity, it also has non-linear I-V curves. Modeling of a photovoltaic system involves the electrical action of the system in different environmental and load conditions. To accurately predict the electrical performance of a system, all parts of the system, especially their solar panels, must have comprehensive and accurate models. Due to the unregulated voltage of the solar panel, the DC-DC converter is often used in photovoltaic systems to regulate this voltage. As mentioned above, due to the high cost of installing a photovoltaic system, the system must have high-efficiency parts. Therefore, the maximum power source control device is often used in photovoltaic systems. Different types of MPT have been introduced and developed. Uncertain logic is one of the most convenient ways to find the maximum power point of a solar panel, which has good stability and high response speed.

A new photovoltaic system was introduced and implemented. In addition, the new and accurate model of the solar panel is based only on the manufacturer's data. There are two common models for a solar panel: one diode and two diode models.

The single-diode model requires less data from manufacturers to be suitable for this study. Numerous articles have been published in the literature on solar panel modeling and maximum power control

The reference offers two separate models of solar panels, in which the dependence of the parameters of the models on environmental conditions is not fully developed. Therefore, the models are not accurate enough. With a few caveats, we create a solar panel model based on the values in the data table. The serial and shunting stability of the model was considered stable and their dependence on environmental conditions was not taken into account. In addition, the dark saturation current of the model was described as a temperature-dependent variable, and its dependence on radiation was not taken into account. The reference provides an analytical single-diode model for the solar panel. The serial and shunting stability of the model is indicated by the slopes at the open and short-circuit points of the IV curves of the solar panel, respectively. The dependence of the sample parameters on environmental conditions is summarized. Therefore, the model is not suitable for applications that require high accuracy.

It should be noted that the first purpose of the study was to introduce a model of the solar panel with maximum accuracy using the values of the data table. In addition, the current of the proposed model depends on both radiation and temperature. The dependence of the parameters of other models on environmental conditions is also developed as accurately as possible. The second purpose of this study is to create a new method based on the MPT based on fuzzy logic. There are many published studies about MPT based on fuzzy logic. The reference is based on an ambiguous logic for a photovoltaic system with variable temperature and isolation. The results of the modeling show that a system with MPT based on fuzzy logic increases the efficiency of energy production from a system without MPT. MPT checks the performance of fuzzy logic with various functions for optimization. The results show that the performance of fuzzy logic MPTs with five functions is better than MPTs based on fuzzy logic with three functions. PP offers a wide range of MPTs based on fuzzy logic for measurement and efficiency.

In this section, the Newtonian method is chosen to solve nonlinear mathematical expressions and nonlinear model equations for the model. Modifications were made to the solution method to achieve better convergence. Obtaining the initial values of the model parameters is based on the data provided by the manufacturers. Then the exact description of the model parameters is made on the basis of their dependence on environmental conditions. The results of modeling of an amplified converter and MPT based on fuzzy logic and their interpretations are given.

The proposed model and method of angular deviation, adapted to the conditions of construction, is provided with a sufficiently high definition of MPT at a minimum level of calculation costs associated with training. In addition, in this work, the method of discrete optimization for the effective solution of problems that provide the technology of tracking the maximum power source PP SRM; methods and tools of simulation modeling for the implementation of developed models; updated principles and methods of object-oriented programming are used to create application software.

To model a photovoltaic system, it is necessary to choose the modeling environment, the convenience of describing and modifying the model, taking into account the suitability of the model, as well as the visibility of the calculated results. The purpose of the study is to deliver the maximum output power of the solar panel in any environmental conditions. In addition, the output power of the solar panel is considered instead of adjusting its output voltage. Thus, a photo panel (PP) converter has been developed and implemented that provides the maximum output power available. This adjustable PP converter can also be used in the satellite power subsystem between the power generation unit and the power conversion unit (DC-DC converter).

2. RESEARCH METHODS

In order to increase the efficiency of the photo module, methods of optimized conversion of solar energy on the installation of solar batteries based on tracking the Sun were considered, since the incidence of the sun beam on the surface of the panel at 90 degrees increases the efficiency of the production of photo modules.

Efficiency in practice means the ratio of the maximum power P_{max}, which can be removed from a unit area of the converter, to the total power of solar radiation W, incident perpendicularly to a unit of the operating surface of the converter, expressed as a percentage:

$$W = A * \lambda \cos\theta \quad (1)$$

$$\eta = (P_{max}/W) * 100\% \quad (1.a)$$

Here, θ is the angle of incidence of the sunbeam, A - represents some limiting conversion

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factor in the design of the group, because they cannot convert 100% of the sunlight absorbed into electricity.

For a photon to create an electron-hole pair in a semiconductor, a certain energy is required. In silicon, it is 1 eV, which corresponds to a wavelength of 1.a microns. Longer wavelength photons (outside the infrared region of the spectrum) have lower energy and are therefore completely useless. Photons with a shorter wavelength can also generate electron-hole pairs, but the efficiency in this case decreases, since the excess of photon energy over 1.12 eV is dissipated in the form of heat. It can be shown that the theoretical efficiency is silicon cell for the solar spectrum should be approximately equal to 22 - 23%. In this case, the internal losses are neglected and it is assumed that all electron-hole pairs formed in the material under the action of light are used. Real photoconverters have a much lower efficiency, since some factors reduce this figure. These factors are quite numerous and can be divided into two groups. One of them can be attributed to factors caused by the imperfection of devices, and the other - depending on the operating conditions.

A permanently installed PV module can only produce a high percentage of available energy at noon, substantial power is available in the early mornings and afternoons between 8.30 - 15.00. Thus, the main benefit of the tracking system is to collect as much solar energy as possible during the longest period of the day with the most accurate tracking mode of the photovoltaic converter.

Due to the rotational motion, the support rotary mechanism (SRM) provides a certain direction in the pursuit of sunlight. SRM is divided into several types depending on the structure of one-axis and two-axis:

- SRM moving in azimuth (SRM moving horizontally; SRM moving horizontally);
- SRM providing angular rotation (SRM with vertical rotational motion);
- SRM with progressive vertical movement;
- azimuth - SRM providing angular rotation (SRM rotating in horizontal and vertical motion);
- SRM, which rotates stepwise in horizontal and vertical motion.

The photo panel tracking system has two actuators azimuth and two-axis SRM, which provides angular rotation. PP stabilization (location) control and motion angle sensors (encoders) are installed. With the help of optoelectronic sensors (encoders) PP monitors the movement and direction of the Sun in solar tracking.

Control simulation model of the solar panel (SP) with supporting rotary mechanism (SRM) shown in Figure 1 below. The maximum power point (MPP) in the circuit tracks the maximum solar radiation stabilization based on an algorithm developed in a cubic polynomial system and stabilizes the PP at a given coordinate. The rotary point motor transmits the signal to the PP and is controlled by the algorithm.

The maximum height angle is also used in a simple PP system, more precisely the modeling of the PP system requires knowledge that the height angle can be found using the formula for the height angle (17b) that varies throughout the day.

$$\beta_{s=}sin^{-1(cos\gamma cos\delta cos\phi+sin\delta sin\phi)} \quad (1\ b)$$

Where γ - is the hour angle, δ - is the local latitude and δ - is the angle of rotation of the Earth

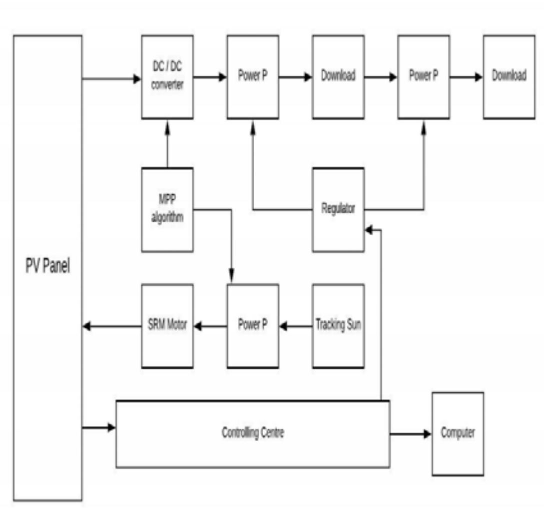

Figure 1 - Schematic Diagram Of SRM Used In The Model

The azimuth can be calculated using Equation (2), but to determine this angle, the slope of the Earth δ - with respect to the equator, is calculated first (3).

$$\alpha_s = \cos -1 \frac{(cos\delta sin\phi - cos\gamma sin\delta\ cos\phi c\ )}{cos\beta_s} \quad (2)$$

$$\delta = 23{,}45^0\ sin\left[\frac{2\pi}{365}(284+d)\right] \quad (3)$$

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d −day of the measurement year

The modulus of the curved PP of the total hourly radiation of sunlight on the Earth's surface consists of three components. These include vertical beam I_{VB}, which is the main component; I_D diffusion radiation identification and reflected radiation I_{RR}. The most commonly used model for the calculation of direct radiation is given by the equation given by ASHRAE [1].

$$I_{VB} = \left(1160 + 75 \sin\left[\frac{2\pi}{365}(d - 275)\right]\right) e^{-km} \quad (4)$$

where k and m are the ratio of air mass and optical depth. They are calculated using equations (5) and (6), respectively.

$$k = 0.174 + 0.035 \sin\left[\frac{2\pi}{365}(d - 100)\right] \quad (5)$$

$$m = \frac{1}{\sin\beta_S} \quad (6)$$

Now the amount of direct sunlight perpendicular to the curved surface is determined by Equation (7).

$$I_B = I_{VB}\left[\cos\beta_S \cos(\alpha_s - \alpha_p)\sin\tau + \sin\beta_S \cos\tau\right] \quad (7)$$

I_B is the diffuse radiation on the horizontal surface, and the curved surfaces can only see part of the sky, so the diffuse radiation in the inclined surface is determined as given in Equation (8).

$$I_D = CI_{Vb}\left(\frac{1 + \cos\tau}{2}\right) \quad (8)$$

where C is as follows

$$C = 0.095 + 0.04 \sin\left[\frac{2\pi}{365}(d - 100)\right] \quad (9)$$

Similarly, the radiation of the earth on a curved surface is determined by equation (10), where ρ is the reflection of the earth, τ is the angle of inclination of the surface.

$$I_{Ш} = \rho I_B(\sin\beta_S + C)\left(\frac{1 - \cos\tau}{2}\right) \quad (10)$$

Therefore, the total radiation obtained in the planes of inclined PP modules or arrays at any time of the day is combined with equations (7), (8) and (10).

$$\mathrm{I_T = I_B + I_D + I_{RR}} \quad (11)$$

It is necessary to evaluate the effectiveness of the control system, given in the form of the calculation of percentage energy growth (PEG) (12).

$$PEG = \frac{\mathrm{E_{PP-(E_{FX}+E_{\mathit{SRM}})}}}{\mathrm{E_{FX}}} \times 100\% \quad (12)$$

where E_{PP} is a system of energy produced under daily control, energy produced without control, and E_{SRM} is energy consumed by a control system. When calculating the rated power of the E_{PP}, the motor is 22 W per 210 sec (for example 90) at a height and 1.3 W per 120 seconds on the azimuth axis. The equivalent circuit of a two-diode model for solar PP provides a general current-voltage characteristic.

$$i = I_{PP} - I_0\left(e^{\frac{(v+iR)}{V_T}} - 1\right) - \frac{v + iR}{R}, V_T = \frac{nkT}{q} \quad (13)$$

The model has five unknown parameters: I_{PP}, I_0, n, $R_к$ and R_P. As we know, a solar panel consists of a parallel combination of several cell sequences, and there are several cells in a row. So you can create a model for a solar panel. The single-diode model for the solar panel is based on the values of the data table and is made without any measurements. The photo panel consists of np rows, each row is supposed to consist of ns series cells. Equation (14) can be extended to describe the total current-voltage characteristics for PP [2]. Consider

$$i = I_{PP} - n_p I_0\left(e^{\frac{(v+iR_к)}{a}} - 1\right) - \frac{v + iR}{R}, a = \frac{n_S nkT}{q} \quad (14)$$

As mentioned above, the parameters five, I_{PP}, I_0, n, $R_к$ and R_P are required to describe the model of the sun sign. To obtain the sample parameters (15) are considered at three operating points; short circuit, open circuit and maximum power point (MPP). Equations (15) - (18) explain the operation of the model at these points. Since the product of the current in the MPP is zero, the fourth ratio can be expressed by the product (14). The derivative is then considered in the MPP and it leads to (17). Consider

$$\mathrm{I}_{PP} = \mathrm{I}_{PP} - \mathrm{n_p I_0}\left(\mathrm{e}^{\frac{(\mathrm{I_{sc}R_к})}{\mathrm{a}}}\right) - \frac{\mathrm{I_{sc}R_п}}{\mathrm{R_к}} \quad (15)$$

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$$I_{OC} = 0 = I_{PP} - n_p I_0 \left(e^{\frac{V_{oc}}{a}}\right) - \frac{V_{oc}}{R_п} \quad (16)$$

$$I_{MPP} = I_{PP} - n_p I_0 e^{\frac{(V_{MPP}+I_{MPP}R_к)}{a}} - \frac{V_{MPP} + I_{MPP}R}{R} \quad (17)$$

$$I_{MPP} + V_{MPP} \frac{-(\left(\frac{n_p I_0}{a}\right) e^{\frac{(V_{MPP}+I_{MPP}R_п)}{a}} + \frac{1}{R_P})}{1 + R_к(\left(\frac{n_p I_0}{a}\right) e^{\frac{(V_{MPP}+I_{MPP}R_п)}{a}} + \frac{1}{R_п})} = 0 \quad (18)$$

There are two ways to determine the last required relationship. In [3-7], the model of the I-V curve at the short-circuit point was considered as a parallel barrier. Some used the temperature coefficients claimed by the manufacturers [4]. The slope of the I-V curves at the short-circuit point is also used in this study, as a result

$$\frac{-1}{R_п} = +V_{MPP} \frac{-(\left(\frac{n_p I_0}{a}\right) e^{\frac{(I_{sc}R_S)}{a}} + \frac{1}{R_п})}{1 + R_к(\left(\frac{n_p I_0}{a}\right) e^{\frac{(I_{sc}R_S)}{a}} + \frac{1}{R_к})} \quad (19)$$

In this study, the serial and maneuverable stability of the model is considered to be unchanged due to limitations in the manufacturer's data. Using the data provided by the manufacturers in the standard case, the five linear equations are solved, and the model is clear in the standard case (radiation = 1000 W / m^2; temperature = 25C). Newton's method is chosen to solve the following nonlinear equations [7]:

$$R = f_i(I_{ph}, I_0, a, R_S, R_P) = 0, i = 1,2,\dots,5, \quad J = (R) = \frac{\partial(f_1,\dots,f_5)}{\partial(I_{ph}, I_0, a, R_к, R_п)} \quad (20)$$

In this study, a modification of the solution method is proposed to achieve convergence in the solution of the above five linear equations. To solve the equations, the starting point $x0 = I$ph, $I0$, a, Rs, Rp] must be determined, and the matrices R and J are considered at the same point. Thus, δx (19) and therefore (20) is a new estimate of the root of equations. Consider

$$J^k \delta x^k = -R^k \quad (21)$$

$$x_{new} = x_{last} + \delta x \quad (22)$$

The previous iteration is repeated at the new starting point (x_{new}) until the error is less than the sent level. Finally, it was found that a modification factor ($0 < \alpha < 1$) was required to add (23) to achieve the corresponding convergence. Consider

$$x_{new} = x_{last} + \alpha \times \delta x \quad (23)$$

The modified approach responds well to the solution of the model equations of the solar panel by adjusting the proposed coefficient.

Derivation of parameters of initial models. The model equations and the solution are implemented in the MATLAB Simulink environment, and the initial values of the unknown parameters are taken as standard.

Table 1 - Electrical Characteristics Of Solar Panel Under Study In The Standard Case.

Model parameters	Value
I_{PP}(A)	2.98
V_{oc}(V)	20.5
I_{MPP}(A)	2.703
V_{MPP}(V)	16.5
P_{MPP} (W)	42
η_s	36
η_p	1
k_i (%/°C)	0.007
k_u (%/°C)	−0.038
I_{PP}(A)	2.9611
I_0(A)	4/7561*10^5
α	1.3205
$R_к$ (Ω)	0.2362
R_{PP}(Ω)	617.5891

Table 1 - shows the initial values of the model parameters obtained in the standard case, based on the method of solving nonlinear equations. In addition, model parameters must be known to predict the performance of solar panels in environmental conditions.

Short-circuits and currents generated by PP are linearly related to radiation, which are shown below [2-4]:

$$I_{sc}(G) = I_{sc}(G_0) \times \frac{G}{G_0} \quad (24)$$

$$I_{ph}(G) = I_{ph}(G_0) \times \frac{G}{G_0} \quad (24.1)$$

The temperature dependence of the short-circuit current is as follows: [4-9]:

$$I_{sc}(T) = I_{sc}(T_0)\left(1 + \frac{k_i}{100}(T - T_0)\right) \quad (25)$$

Therefore (24) refers to the comprehensive relationship of the short-circuit current to the environmental conditions, where ki is the temperature coefficient of Isc and its manufacturers. Consider

$$I_{sc}(G,T) = I_{sc}(G_0,T_0) \times \frac{G}{G_0} \times \left(1 + \frac{k_i}{100}(T - T_0)\right) \quad (26)$$

The previous equation can also be used to describe the dependence of the photocurrent on the environment [1-5]. The dependence of the dark saturation current and the open circuit voltage on the environmental conditions can be used (3.3) and (3.4). Reference [6] (27) shows that the dark saturation current depends on both radiation and temperature. This equation is obtained with infinite parallel resistance of the model (26). Consider

$$I_0(G,T) = \frac{I_{ph}(G,T)}{e^{\frac{V_{oc}(T)}{V_T}} - 1} \quad (27)$$

Saturated current depends only on the temperature [8,9]:

$$I_0(T) = I_0(T_1)\frac{T}{T_1}\ e^{-(\frac{qE_g}{nk})(\frac{1}{T_1}-\frac{1}{T})} \quad (28)$$

[3] used to describe the dependence of current on the environment in equations (25) and (26). The shadow current depends only on temperature, as described in (29), and some factors in the equation do not depend on temperature, consider some corrections:

$$I_0(T) = \left(I_{sc}(T) - \frac{V_{oc}(T) - I_{sc}(T)R_S}{R_p}\right) e^{-\frac{V_{oc}(T)}{n_s V_T}} \quad (29)$$

In this study, using (3) and (4), the dependence of dark saturated current on radiation and temperature is fully developed. [7]. Consider

$$I_0(G,T) = \left(\frac{I_{sc}(G,T) - (V_{oc}(G,T) - \frac{I_{sc}(G,T)R_S}{R_p})}{n_p\ (e^{\frac{V_{oc}(G,T)}{a}} - e^{\frac{I_{sc}(G,T)R_S}{a}})}\right) \quad (30)$$

The use of (25) leads to the dependence of the voltage on radiation at standard temperature (T_0). Consider

$$V_{oc}(G,T_0) = a\ \ln\left(\frac{I_{ph}(G,T_0)R_p - V_{oc}(G,T_0)}{n_p I_0(G,T_0)R_p}\right),\ a = \frac{n_S nkT_0}{q} \quad (31)$$

The two recursive nonlinear equations (30) and (31) at any modified environmental conditions to determine the shadow current and open circuit voltage at standard temperature are solved by Newton's method of voltage dependence (G, T) at any radiation level:

$$V_{oc}(G,T) = V_{oc}(G,T_0) + k_v(T - T_0) = V_{oc}(G,T)\ln\left(\frac{I_{ph}(G,T_0)R_p - V_{oc}(G,T_0)}{n_p I_0(G,T_0)R_p}\right) \times a + k_v(T - T_0) = \frac{n_S nkT_0}{q} \quad (32)$$

where kv is the temperature coefficient of V_{oc}, which is also stated by the manufacturers. Therefore, when the resulting $V_{oc}(G,T)$ that was obtained it is set to (18), a dark saturated current is displayed in all environmental conditions. Therefore, using all these equations, the model is based only on the values of the data table

$$i = I_{ph}(G,T) - n_p I_0(G,T)\left(e^{\frac{(v+iR_S)}{a}} - 1\right) - \frac{v + iR_S}{R_P},\ a = \frac{n_S nkT}{q} \quad (33)$$

Using the main components of the scheme (31) [7] are selected as follows:

$$D_{min} = 1 - \frac{V_{in\ max}}{V_{out\ min}},\ D_{max} = 1 - \frac{V_{in\ min}}{V_{out\ max}},\ L > \frac{D * V_{in} * (1 - D)}{f * 2 * I_{out}},\ C > \frac{I_{out}}{V_{ripple} * f} \quad (34)$$

where D, f and V_{ripple} - are the turn power, switching frequency and output voltage, respectively. In this study, based on the characteristics of the solar panel (Table 1), the following initial data for the circuit are given:

$$8V < V_{in} < 22V, 30 < V_{out} < 150V, V_{ripple-max} = 0.3V \quad (35)$$

Optimal values of L (10 mG) and C (5 μF) are selected so that the transducer has sufficient speed under the control of the MPP. Typically, two parameters dP / dI and its variations Δ (dP / dI) are used as an ambiguous input in the MNC. In the model developed in this study, Δ (dP / dI) is an inappropriate parameter, and another parameter is selected. These are the input variables of the proposed controller

$$\Delta V = V_i - V_{max}, \qquad \Delta P = P_i - P_{max} \quad (36)$$

where Vi and Pi are the voltage and power controllers of the solar panel, respectively [6]. If Vi is far from V_{MPP}, then the blurred controller uses only one input (ΔV), and if Vi is close to V_{MPP}, then another parameter ΔP is used, and the controller has two inputs. This controller responds well to the previous value in terms of accuracy and stability. [8-10].

By defining the goals and objectives of the study and defining the boundaries of the system, Figure 2 shows a block diagram of the system proposed for this study, in which all parts of the system are considered and modeled. Preliminary angular deviations were calculated according to the calculated algorithm.

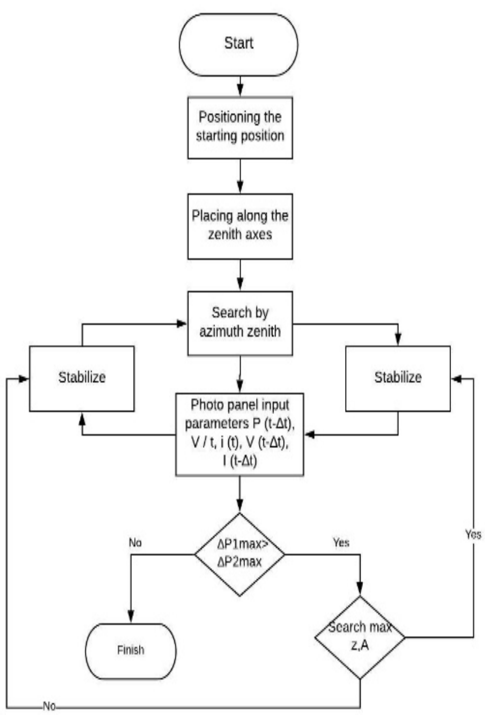

Figure 2 –SRM Photopanel Algorithm Used In The Model

Figure 2 shows a block diagram of a system proposed for this study, in which all parts of the system are considered and modeled by defining the goals and objectives of the study and defining the boundaries of the system. Preliminary angular deviations were calculated according to the calculated algorithm.

The mathematical model should be presented in a form that is convenient for the use of numerical methods. Then it is necessary to determine the sequence of computational and logical operations for the search for unknown quantities. The calculation algorithm should not distort the basic properties of the model, and therefore the original object. The algorithm must be economical and adapt to the specifics of the problem to be solved.

3. RESEARCH RESULTS AND PRESENTED MODEL SOFTWARE

A model of the MPP with PP installations with a centralized control and management system was developed,by determining the accuracy of the software in the Lab View virtual environment.Based on the algorithm, the equation (3.34) was obtained [16].

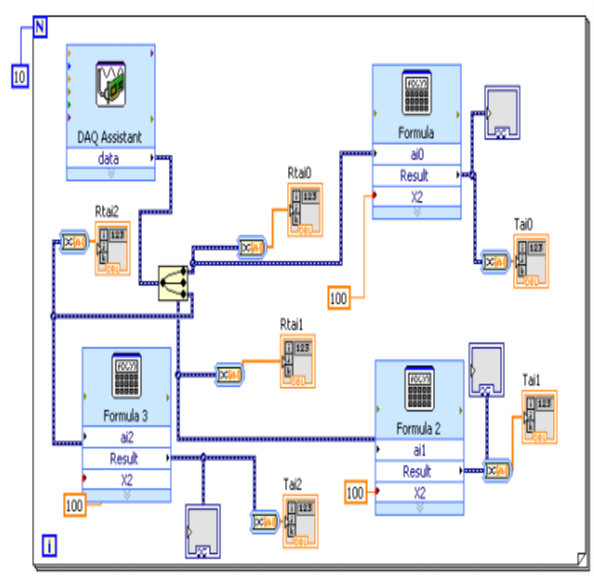

Figure 3.1 - Execution of the simulation in the virtual environment Lab View

In this study, a set of functions of a triangular polynomial is selected, and determined by

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an ambiguous logical approach based on the features of the solar panel and empirical imitation. The developed equations are included in the MATlab environment to obtain the dependence of the model parameters of the solar panel on different environmental conditions. In the first step, the dependence of the calculated current and the open circuit voltage on the coefficient of angular deviation is obtained on the basis of the manufacturer's data.

In the study, the I-V curves were obtained over a wide range of environmental conditions. The different levels of sunlight obtained were achieved by changing the direction of the solar panel horizontally and vertically by controlling two SRM engines. Measurements were taken on different days of the year to cover a wide range of temperatures.

When obtaining the I-V curve, sunlight and temperature were measured to ensure that the environmental conditions did not change. To obtain the I-V curves, it is sufficient to change the current in the panel from zero (open circuit) to its maximum value (short circuit) continuously or stepwise. Then a new algorithm for monitoring the maximum power point of the solar panel was proposed and compared with the methods of growth and comparison of its control with the method of speed control and speed control.

To model a photovoltaic system, it is necessary to choose the modeling environment, the convenience of describing the model and making changes to it, as well as the visibility of the calculated results, taking into account the suitability of the model.

To validate the obtained results, experiments were conducted in the LabView software environment in a virtual laboratory. The model based on the choice of method αa=αh7 shows the value of the angle of deviation to the definition accuracy (Table 3.1) at a 7-step angle with a value of the deviation angle of 6.0.

Table 3.1 - The results of experimental research of the software system PP SRM

$\alpha_a = \alpha_h$, angle.min.	ФЭС - HOMER, Hybrid 2.	PVSIM	SOLAR CELL MODEL TESTING	PV model based on location and methodology choices
	0.05	0.25	0.7	1.0
	$\Delta F/F_{\beta=0} = (1-F_\beta/F_{\beta=0})*100\%$			
0	0	0	0	0
0.7	0	-0,1	-0,1	-0,03
1.4	0,6	0,1	0,1	0,08
2.1	0,6	0,7	0,6	0,3
2.8	0,8	1,5	1,2	0,8
3.5	1,4	2,7	2,2	1,3
4.2	2,8	4,2	3,4	1,9
4.9	4,6	5,9	4,8	2,8
5.6	7	8,0	6,5	3,7
6.3	8,8	10,0	8,3	4,8
7	12	13	10,4	6,0

In the LabView virtual environment, the studied variation range of the specified parameters of the 3 mechanisms can be seen in the conditions K = 08.00 , K = - 20.00, t = 25-32 C°, the difference from the efficiency of test samples (Table 3.2) [15].

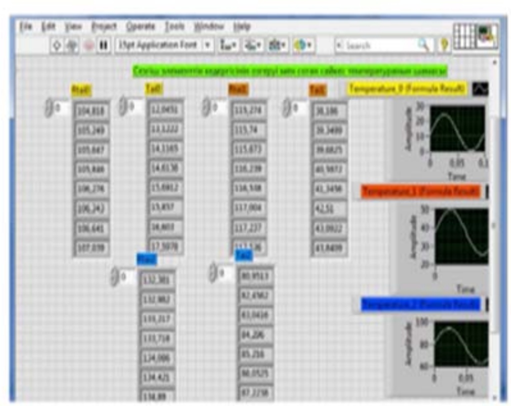
Table 3.2 - Comparison of the effectiveness of the proposed technologies

Condition	SRM		MPPT	
Pass the first test	130,32	26.32	149.07	44.49
Pass the second test	134,76	28,33	152,25	43,92
Pass the third test	107,39	19,02	126,59	42,05
Mean value	126,14	23,89	148,23	42,98

The analysis in the table shows that the study of the range of values K revealed the following:

- At present, the average efficiency of the photocell is 12-15%. This shows that the accuracy of the MPP has increased by a total of 1.5%.

This means an increase of 15% of the PP capacity of the SRM. This is a very good indicator.



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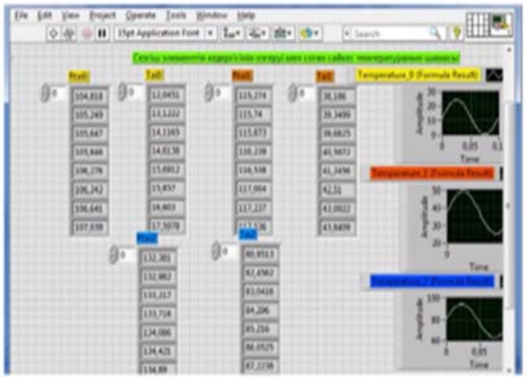

Figure 3.2 - change in the resistance of the SRM PP and the corresponding temperature value

This guide is designed to adjust the operation of the thin reflector and control PP. The following functions are performed during the management and control of the PP:

- Transition to full readiness mode of the receiving PP;
- Transition to the execution of commands (means that the PP is in the process of performing control and management functions);
- Analysis of received information;
- Perform functions depending on the received information: positioning, orientation depending on the location of the sun, switch to off mode, on mode, orientation depending on weather parameters, positioning to the initial position, positioning to the repair mode, positioning to manual control mode;
- Switching to the mode of SRM PP ready to receive information.

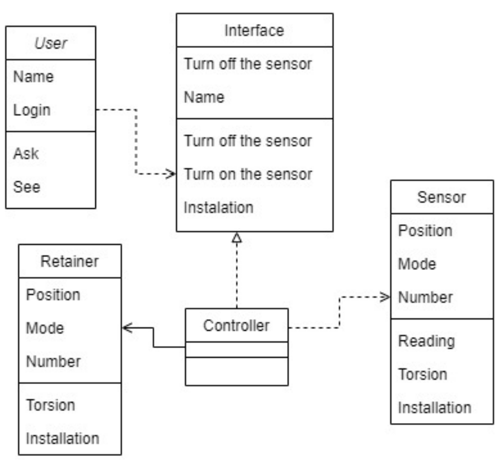

Figure 3.2 Diagram of the main classes of KorSun software

Wireless transmitter and receiver electronic devices are used to switch to transmitter and receiver mode. These devices are part of the oriented and positioned controller.

As you can see, the nature of the deviation depends on the location of the azimuth axis. Thus, we obtain the effect of maximum non-verticality when the azimuth axis is in the meridional plane, and in this case, at maximum (color), the angle of deviation of the beam is equal to two of the axis reflected from the vertical. We get the least effect when reflected from the latitudinal plane. However, in this case the deviation of the beam is practically in accordance with the non-vertical axis ε. It should also be noted that the process of accumulation of the angle of deviation during the day does not take place, as shown in [93].

According to the analysis, the change of the azimuth axis ε up to 10 'by means of non-vertical angle constraints, the nature of the curves does not change, and the parameters of the non-vertical angle of reflection of the reflected beam are applied to the given angles in mathematical modeling (Fig. 3.4).

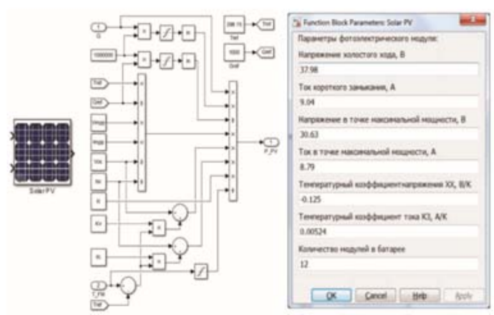

Figure 3.4– Photo panel model in MatLab / Simulink

In general, as you can see, the azimuth axis has a lot of requirements for non-verticality, the axis of deviation of the axis ε should not exceed 1 '- 3' from the vertical in the meridian plane.

The developed scheme and the results of experiments can be implemented in two ways to completely eliminate the impact on software inaccuracies. The first method has a high accuracy of the azimuth axis during installation, the deviation of the axis from the vertical should not be less than 1 angle. The second method is to measure the angles of the azimuth axis and enter them into the control algorithm. Currently, we can use the existing PP azimuth axis to assess the effect of inaccuracy in the location of the azimuth axis of the point heliostat during the observation in the plane.

A method and design application is being developed to determine the software control location of the non-vertical heliostat of the azimuth axis [95-98].

The principles of selection and operation of SRM PP parameters are shown [15, 84-99].

1. Initialization of the type of photo panels, operating conditions and electrical characteristics of the battery. Determining the configuration of photo panels. During the initialization, it is necessary to enter data that quantify the semiconductor materials from which the photo panels are made. It is necessary to indicate the free line voltage, short-circuit current, maximum power, temperature coefficients provided by the manufacturer [39-43]. Environmental characteristics are given - temperature, lighting, ionizing radiation and shading coefficients. At this stage, data describing the serial-parallel integration of solar energy into the panel are entered. Sunlight loss coefficients, technological scattering of parameters and photopanel degradation are determined.

2. Calculation of the dependence of intermediate effects, taking into account the photocurrent and reverse saturation current, the external effects that affect these values. Calculation of values of small impedances of photo panels. Describe the relationships that allow to simulate the effects of ionizing radiation, the problems of illumination and irradiation of uneven photopanels, technological scattering of parameters and degradation of panel characteristics.

3. Determination of output parameters and efficiency values of dependencies I (V), P (V) t C (V), filling factor and maximum power.

4. Graphing the dependences (D), P (V)> C (Y).

5. Analysis of the input effects of the environment in which the output characteristics need to be determined. Repeat the calculations to create a group of volt-ampere characteristics and volt-watt characteristics under other conditions.

The modeling method is given below by the formula for angular deviation [1.7] (Figure 3.2) and requires a separate consideration.

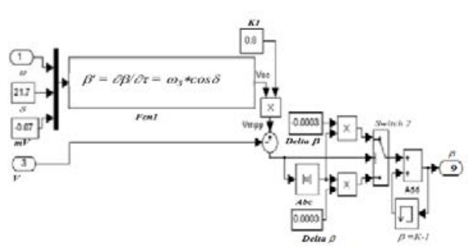

Figure Figure 3.4 – Angular deviation in the simulation model

The above algorithm, which includes important input factors in the structure of the developed method of solar panels, allows us to create a generalized model of photo panels and calculate the output parameters of photo panels. The algorithm can be implemented in various schematic modeling environments.

Simulation models usually have a very complex structure, characterized by many relationships between the elements of the system, many of which are subject to dynamic changes during program execution. The required model can be described, in general, by any universal programming language, but one of any special languages may have some or other advantages in certain characteristics of the model [84-99].

In the integration of generally accepted methods [85-96], the Ministry of Education and Science has provided an opportunity to propose a method of optimizing the parameters of the PP to form the principles of optimization with the limitations identified in the process of processing and implementation of SRM PP MPPT values. The proposed task model includes large library blocks that make it easy to create Simulink models and hierarchical models.

When implementing and testing a model, it is necessary to evaluate the advantages and disadvantages of modeling systems.

4. CONCLUSION

In this paper, an approach and a systematic design methodology to obtain a production and inventory control based on solar tracking system PV function and MPPT diagram scheme as presented. The advantage of this approach is to generate a planning system suited to the insolation system being studied based on its actual data. A powerful of this methodology is to take into consideration the real behavior of the solar production system.

The methodology contain 5 steps . The first step is to evaluate and validate the data acquisition transfer function, as well as control design: after extracting the insolation and output flux data from the KorSUN software, a set of system identification tools in MATLAB is used to evaluate and select the best model for the behavior of the FP line in next steps . At the fourth stage, PP surface controllers were successfully developed: LQR and PID controllers. Based on the results and analysis, it was concluded that both the control method, a modelling controller , can plan and control the maximum flow of insolation.

The simulation results show that the model has better performance compared to analogs when controlling the PP line.

Simulation models usually have a very complex structure, characterized by many relationships between the elements of the system, many of which are subject to dynamic changes during program execution. The required model can be described in general, using any universal programming language, but one of any special languages may have some or other advantages in certain characteristics of the model [11-14].

In the integration of generally accepted methods [15], the Ministry of Education and Science has provided an opportunity to propose a method of optimizing the parameters of the PP to form the principles of optimization with the limitations identified in the process of processing and implementation of PP maximum power technology (MPT). The proposed task model includes large library blocks that make it easy to create Simulink models and hierarchical models.

In the study, SRM PP provides the main scientific results of the development of models and methods for determining the accuracy of the tracking system

In order to stabilize the photo panel with a rotating mechanism of the support at the solar power plant, the problems of conducting experimental research aimed at confirming the validity of the main results of the dissertation, designed to solve the scientific and practical problems of solar system control, were solved;

1. Further developments of architectural solutions for the development of solar motion control systems were obtained in order to stabilize the photo panel with a rotating mechanism in the solar power plant, which differs from the known systems to ensure the accuracy of the conditions for the development of SRM PP.

2. Availability of developed experimental installations, aimed at verifying the correctness of the main results of the dissertation, providing the possibility of conducting experiments.

Studies have shown that the system is fully operational in terms of MPP, and the imitation model ratio increased by 1.5%.

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