Temperature Effect On The Load Of The Panel To Be Controlled By The PID For Utility Independent PV Systems

*[1]Goksu Gorel, [2]Ertugrul Cam and[3]Ismail H. Altas
*[1]Çankırı Karatekin University,Electrical and Energy Department,Çankırı, Turkey
[2]Kırıkkale University, Electrical and Electronic Engineering Department, Kırıkkale, Turkey
[3]Karadeniz Technical University, Electrical and Electronic Engineering Department, Trabzon-TURKEY,

Abstract

Photovoltaic energy sources are harmless to environment.Photovoltaic (PV) energy technologies are increasingly developed in the last decade. As known, PV systems are generally set up a roof. Therefore, this systems temperature is increasing in time. This result causes to a decrease in energy efficiency. In a huge PV systems, this is an important effect for coast of energy. Thus, the panel's temperature must kept constant.

In this study, surface temperature on a photovoltaic cell is kept via a cooling systems. Therefore, efficiency of PV systems is aimed to be increased. First, the PV cell system is modelled as array. Later, variable air temperature is used for a input of PV cell. For kept constant this temperature, some water flows on the PV panel with using PMDC motor. A PI controller is designed for keeping constant panel's temperature. All systems is simulated with Matlab-Simulink.

Key words: Photovoltaic Systems, PI Control, Cooling, Heat.

1. Introduction

Recently, increasing energy demand and the high cost of energy of different energy sources revealed efficient use of energy resources is imperative. The main one of these resources are renewable energy sources and the continuity of renewable energy sources to the energy problem is the most logical alternative. Especially in Figure 1 showing the off-grid systems to remote or island settlements located in the system to operate independently from the network should be established. Photovoltaic energy systems are the top of them. In such places the resulting increase in energy consumption from renewable sources with the existing photovoltaic (PV) energy systems become more efficient as a solution. Photovoltaic Panels (FVP) environmental conditions are an influential role in the performance of the power system. Temperature value of PV panels is the right fit and to have sufficient strength values to be designed with an ideal is a requirement for PV panels. However, climatic conditions, air temperature and environmental conditions such as shadowing effects it is not always possible. [3] Solar Cells producing firm Standard Environmental Conditions is testing under the PV cells. (Spectrum AM 1.5, radiation 1000 W / m^2, cell temperature 20 °C) [4] Many researchers under ideal environmental conditions are not suitable for increasing the performance of PV panels as projects. Low radiation and

*Corresponding author: Address: [1]Electrical and Energy Department, Çankırı Karatekin University, Tasmescit, Cankırı, TURKEY. E-mail address: goksugorel@karatekin.edu.tr, Phone: +903762132626-(6177)

temperature under the maximum power point tracking (MPPT) is the most important method to obtain high yields. [5] The source of the error is one of the MPPT methods and observation method was optimized by fuzzy logic. High temperature during the hot season to reach a high of PV modules reduce power values are obtained. [6] The high temperature at the source by placing the panels around the cooling fan was made to reduce the temperature of the air. Another method of keeping the temperature at an optimum level of water to be made to the panel surface and the cooling mechanism. In this article, the temperature on the surface of the water balance were studied using the FV. Substrate temperature water to be increased with the PI controller is designed for the flow to perform a simulation of PV solar cell.

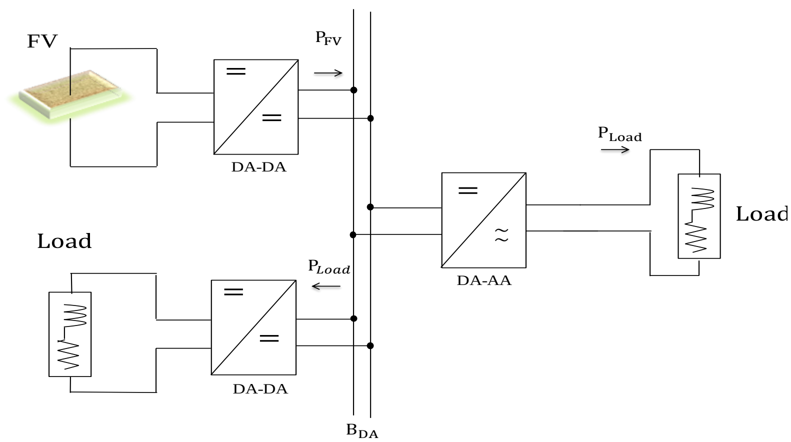

Figure 1. Off-Grid renewable systems model

2. PV Equivalent Circuit Panel Structure and Modelling

Circuit model is required ranging from 1960 to the present modeling was carried out. Public static equivalent circuit models of solar cells connected in parallel or in series on the PV cells to be connected to variable light intensity and temperature changes will be carried out to respond to a dynamic model should have such a model with a dynamic realize importance of protecting the long-term is a subject by researchers. FV at a simplified equivalent circuit of the solar cell is shown in Figure 2. PV solar cell in Figure 2, a current source (I_{FV}) is represented by. [7] With the current source of the incident photons of light obtained by the action of electrical current is shown as current sources. I_D, the PV solar cell formed in the reverse saturation current, R_s resistance is an important part of this article forming operation, heat losses at the point represents PN. Output voltage circuit of Figure 2 to be obtained by Equation (1) are also shown.

$$V_{pil}=\frac{A*k*T_{pil}}{e}\ln\left(\frac{I_{FV}+I_0-I_{pil}}{I_0}\right)-R_s*I_{pil} \qquad (1)$$

Where the symbols are defined as follows;

I_{pil} : Cell output current (A)
I_0 : Reverse saturation current of diode (A)
I_{FV} : Photocurrent, function of irradiation level and junction temperature (A)
V_{pil} : Cell output voltage (V)
R_S : Series resistance of cell (Ω)
e : Electron charge (C)
K : Boltzmann constant (J/ºK)
T_{pil} : Reference cell operating temperature (ºK)

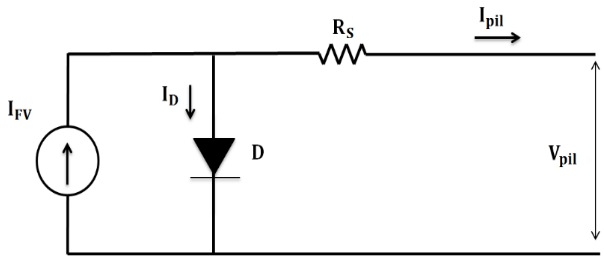

Figure 2. Solar cells have been reduced to the simplest equivalent circuit

3. Water Transmission System Modeling

Photovoltaic panels at an ideal working temperature of the surface temperature in a system designed to bring Permanent Magnet DC Motor (PMDC Motor) is used. PMDC motors, with a low temperature causes the water to flow over the panel surface. [10] Photovoltaic panels due to the increase in surface temperature also increases engine speed. Depending on the speed of PMDC motors increasing water flow rate through the flow PV surface temperature is stabilized.

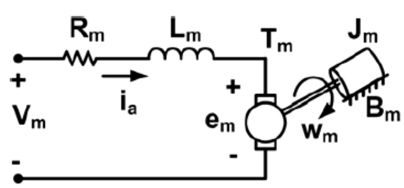

Figure 3. PMDC motor equivalent circuit

PMDC motors, DC motors supplied from the voltage source type is one of the magnetic coupling of the electrical energy into mechanical energy using the method of the rotating rotor. PMDC motor equivalent circuit is shown in Figure 3.

Table 1. PMDC motors used in the system inputs

N=	2.6
R_a=	1.4Ω
L_a=	0.0805H
K_t=	0.095Nm/A
K_m=	0.095v/rad
F_m= B_m=	0.000431V.s/rad
J_m=	0.0007432 kgm^2
V=	36V

PMDC motors used in modelling the system parameters are shown in Table 1. Direct current motor winding, the inductance connected in series, with the voltage source resistance is expressed in contrast to the induced voltage. According to the equivalent circuit of electrical circuit theory of differential equations of equation (2) as in shown.

$$V_m(k) = R_m I_a(k) + L_m \frac{d\, I_a(k)}{dt} + E_m(k) \qquad (2)$$

Where:

1. $E_m(k) = K_E\, \omega_m(k)$

2. i_1 = constant; so $K_E = K_T$

Total motor torque must be zero. This condition equation (3) are expressed.

$$T_e(k) - J\frac{d\,\omega_m(k)}{dt} - B\omega_m(k) - T_L(k) = 0 \qquad (3)$$

Electromagnetic torque, is proportional to the current flowing in the armature windings and the equation (4) are expressed with.

$$T_e = K_T\, i_a \qquad (4)$$

The armature current and angular velocity in the form of the state space equation for the differential equation (5) is shown. [11]

$$\frac{d}{dt}\begin{bmatrix} i_a \\ \omega_m \end{bmatrix} = \begin{bmatrix} -\frac{R_m}{L_m} & -\frac{K_t}{L_m} \\ \frac{K_t}{J} & -\frac{B}{J} \end{bmatrix}\begin{bmatrix} i_a \\ \omega_m \end{bmatrix} + \begin{bmatrix} \frac{1}{L_m} & 0 \\ 0 & -\frac{1}{J} \end{bmatrix}\begin{bmatrix} V_m \\ T_1 \end{bmatrix} \qquad (5)$$

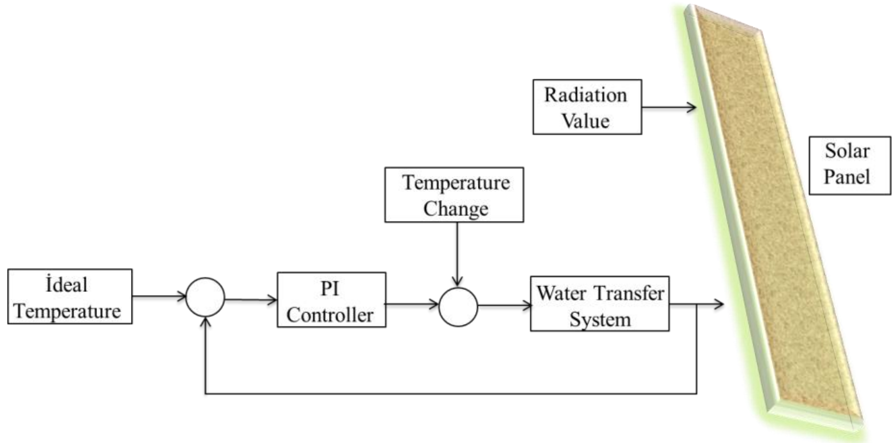

Figure 4. Water Transfer System Applied to Solar Panels.

4. Results

Today photovoltaic power systems are systems as high as the initial installation cost. These costs, increasing the efficiency of the operation of the system during the installation, the cost of their time can be shortened to tolerate. Efficiency of solar cells by reducing losses increased mainly speaks. The most important of FV determined the surface temperature of the battery can be kept constant at the ideal temperature. In this article studies of the surface temperature of FV system can be obtained by balancing the amount of increase in power was observed. When performing the simulation with a 75 mW / cm^2 value of solar radiation and changes are assumed to have been taken. Photovoltaic solar panels depending on the temperature and radiation level voltage generated from the panel will undergo changes in direct proportion. Simulation program was run for 2 seconds P panel surface temperature is controlled and uncontrolled exchange is shown in Figure 5. As shown in Figure 5 PI controlled system the minimum the influence of the impact of ambient temperature up to around 23 °C panel temperature is up. Under normal conditions, the panel temperature is in the range 20-40 °C. Figure 6 is fed a constant load value given photovoltaic panels to the load voltage is observed. As shown in the figure, when the PI controller is included in the system by minimizing the effect of temperature in the range of voltage change is seen that the 320-317V. When the water flow control system is designed to be inversely proportional to the voltage value in the temperature range from 320-303V seen. This high voltage change would adversely affect the load range.

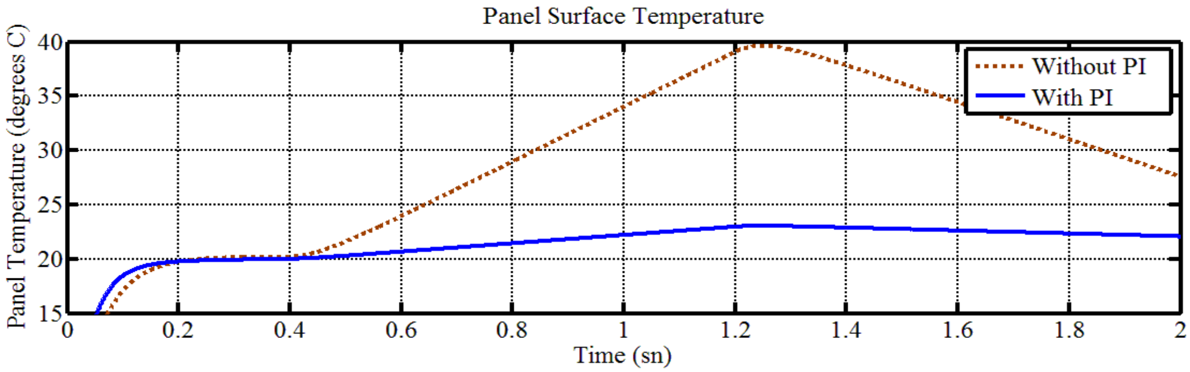

Figure 5. Panel surfacetemperaturecontrolledanduncontrolledchange of thevalue of PI

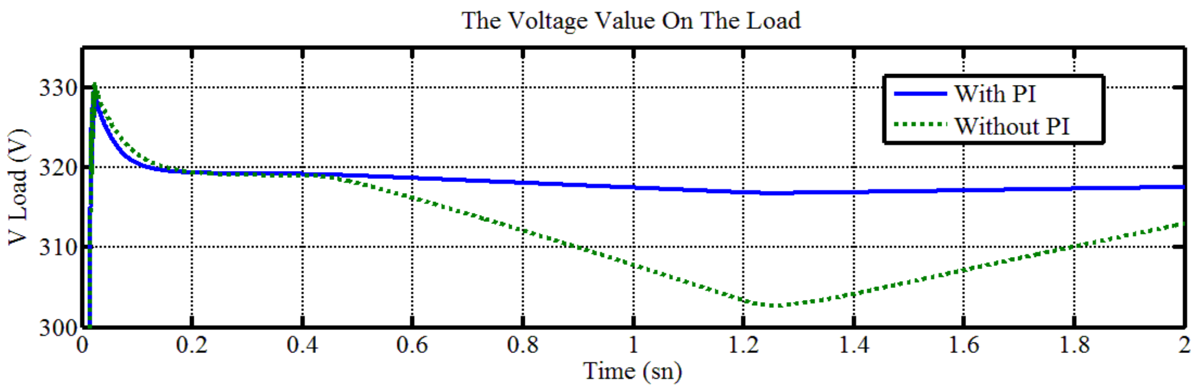

Figure 6. PV panels directly attached to the ends of the temperature-dependent voltage on the load change

PV system power values transmitted from the load change in the range 0-2 seconds are shown in Figure 7. At the peak of temperature change uncontrollably with the proposed system conventional system in Figure 5 is between 17 °C difference is observed. This master power, showing corresponding differences are shown in Figure 7. In Figure 7, the force transmitted at that moment it is seen that the difference approximately 60W. Every 1 °C temperature variation on the system of about 3.5W 'is understood that a power of loss. PV panels with controlled and uncontrolled IV characteristic curve of the PV curve is illustrated in Figure 8 and Figure 9. Figure 8-b) the uncontrolled system as seen in the IV characteristics of the PV panels Operating voltage and current values is greater than a negative variation. Figure 9 a), b), worked by the PV panels shows changes of the maximum power point. Here the change in PV curves of the controlled system is trying to keep the minimum rate that arises.

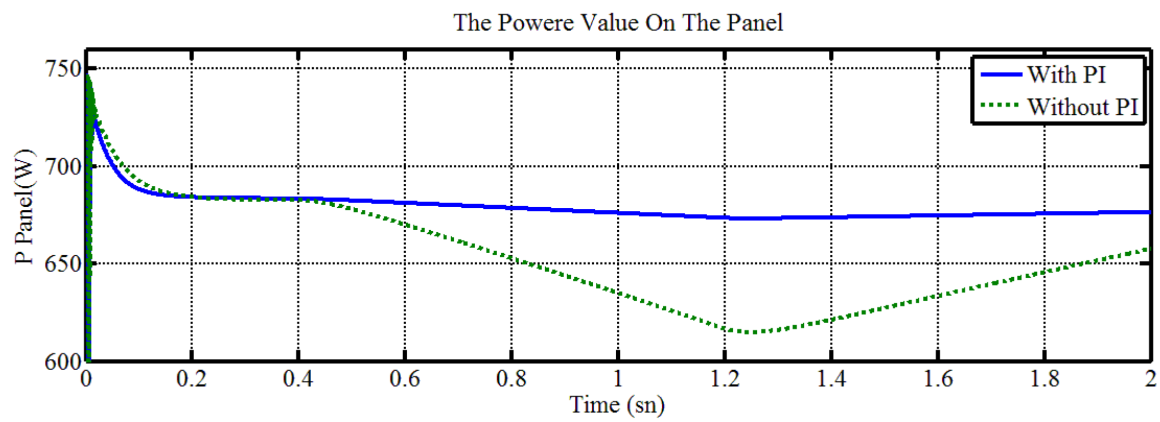

Figure 7. The power delivered to the load from the PV system values change

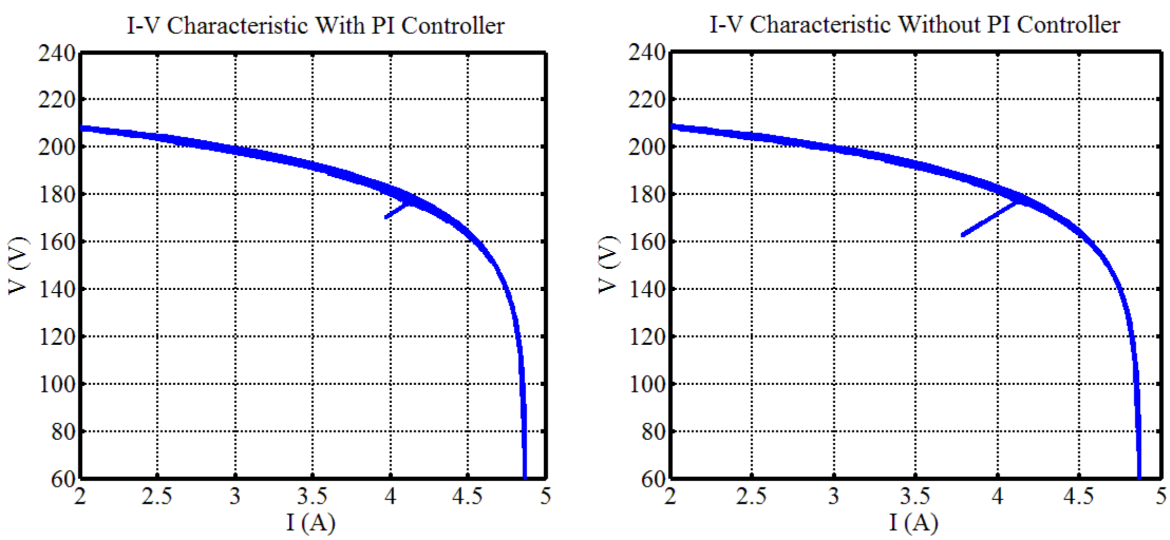

Figure 8. I-V characteristics of PV panels

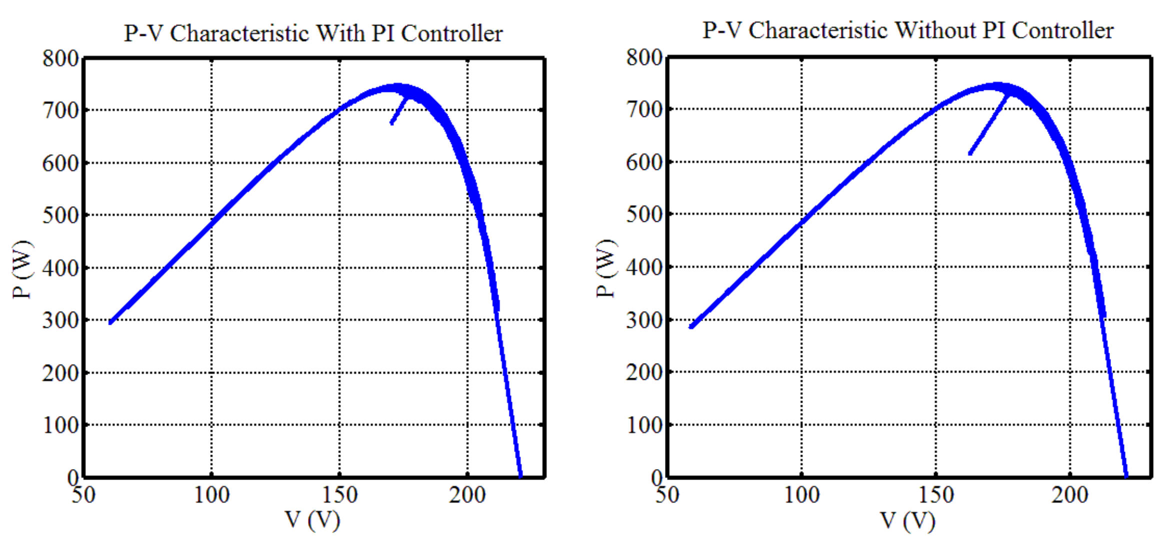

Figure 9. P-V characteristics of PV panels

Conclusions

This article Matlab / Simulink environment through simulation studies carried out in the optimum photovoltaic panels worth of work in order to keep the surface temperature of PMDC motors controlled using a PI was carried out with a water cooling system. PV panels, due to the increase in surface temperature of the panel water released on the surface of the speed controlled. According to the results obtained in 680W a PV power system 3.5W 1 °C temperature rise a power of it is found to lead to a decrease.

References

Reference to a journal publication:

[1]Hersch P,Zweibel K, Basic Photovoltaic Principles and Methods, U.S. Department of Energy by the Midwest Research Institute, 1982.

[2]Mengi, O Ö,Altaş İ H, Fotovoltaik GüneşPanellerindenBeslenenYüklerÜzerindekiGerilimGenliğiDenetimi, EVK’09 – 3. EnerjiVerimliliğiveKalitesiSempozyumu, Mayıs 2009, Kocaeli, BildirilerKitabı: 18-22.

[3]Eduardo O R, and Fang Z, Algorithms to Estimate the Temperature and Effective Irradiance Level over a Photovoltaic Module using the Fixed Point Theorem, Power Electronics Specialists Conference, 2006. PESC '06. 37th IEEE.

[4]Benda V, Machacek Z, A Note On Parameters Of Photovoltaic Cells İn Dependence On İrradiance And Temperature, 7th Mediterranean Conference and Exhibition on Power Generation, Transmission, Distribution and Energy Conversion, 7-10 November 2010, Agia Napa, Cyprus.

[5]Chim CS, Neelakantan P, Yoong HP, Teo KTK, Fuzzy Logic Based MPPT for Photovoltaic Modules Influenced by Solar Irradiation and Cell Temperature, 2011 UKSim 13th International Conference on Modelling and Simulation, March 30 2011-April 1 2011, Emmanuel College Cambridge, United Kingdom.

[6]Matsukawa H,Kurokawa K, Temperature Fluctuation Analysis of Photovoltaic Modules at Short Time Interval, Photovoltaic Specialists Conference, 2005. Conference Record of the Thirty-first IEEE, Lake Buena Vista, FL, USA.

[7]Applebaum J, The Qualıty Of Load Matchıng In A Dırect-Couplıng Photovoltaıc System, IEEE Transactions on Energy Conversion, Vol. EC-2, No. 4, December 1987.

[8]Altaş İH, Fotovoltaik GüneşPilleri: YapısalÖzellikleriveKarakteristikleri, Enerji, Elektrik, Elektromekanik-3e, Sayı 47, 1998, 66-71.

[9]Altaş İH, Fotovoltaik GüneşPilleri: EşdeğerDevreModelleriveGünIşığı İle SıcaklığınEtkileri, Enerji, Elektrik, Elektromekanik-3e, Sayı 46, 1998, 86-91.

[10]Sharaf AM, Altas IH, Ozkop E, A Novel Multi-Loop PID Controller for Photovoltaic-Grid Interface DC Energy Utilization Farm, International Conference on Renewable Energies and Power Quality (ICREPQ’09) Valencia-Spain, April 15-17, 2009.

[11]Sharaf AM, Altas İH, Ozkop E, ElektrikliAraçlariçinÇiftÇevrimDestekli DA Motor KontrolUygulaması, XII. EEBB MühendisliğiUlusalKongresiVeFuarı, EskişehirOsmangaziÜniversitesi, Eskişehir. Kasım 14-18, 2007.