ANKA e-DERGİ
Journal of Phoenix
(Cilt 1/Sayı 1/Yıl 2016)

PV And Solar-Tracking System for Meteorology Station in Isparta/Turkey

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Abstract:
This paper describes a simple photo-voltaic (PV) tracking system which has been designed and manufactured using a mobile stand as a base. In the design of a sun-tracking system, the movement of two photo-voltaic modules was controlled by programmable interrupt controller to follow the sun's radiation using a microcontroller unit (PIC). The photo-voltaic (PV) tracking system has a charge control unit which consists of a DC-DC (12 V-5 V) converter, DC-AC (12 V-220 V) inverter and two batteries. The modules are able to provide a maximum power of ~ 240 W, which feeds the converter, inverter and actuators. PV modules supply energy to sensors of meteorology systems and illumination of measurement area. The total area of the two modules is 1,527696 m². The system can track solar motion with an error of ± 5º. A micro control unit is employed to control and monitor the mechanical movement of the PV modules and to collect data related to the sun's radiation. It was found that the daily output power of the PV was increased by more than 28% in comparison with that of a fixed module.
Key words: Solar energy, photo-voltaic, solar cell, solar tracking system

Isparta/Türkiye için PV Meteroloji İstasyonu ve Güneş Takip Sistemi

Özet:
Bu çalışmada temel olarak mobil standı kullanılarak tasarlanmış ve imal edilmiş basit bir fotovoltaik (PV) izleme sistemini anlatmaktadır. Güneş izleme sistemi tasarımında, iki foto-voltaik modüllerinin hareketi mikro işlemci (PIC) kullanarak güneşin radyasyon takibi programlanabilir kesme denetleyicisi tarafından kontrol edilmiştir. Foto-voltaik (PV) takip sistemi DC-DC (12 V-5 V) çevirici, DC-AC (12 V-220 V) çevirici ve iki pilden oluşan bir şarj kontrol ünitesine sahiptir. Modüller dönüştürücü, İnverter ve çalıştırıcıları beslemeleri ~ 240 W, maksimum güç sağlamak mümkün. PV modülleri meteoroloji sistemleri ve ölçüm alanının aydınlatma sensörlere enerji kaynağı. Iki modülden toplam alanı 1,527696 m² dir. Sistem ± 5ºhata payı ile güneş hareket izlemektedir. Bir mikro kontrol birimi kontrol etmek ve PV modüllerinin mekanik hareketini izlemek ve güneşin radyasyon ile ilgili veri toplamak için kullanılır. Bu PV günlük çıkış gücü sabit bir modül ile karşılaştırıldığında daha sonra da% 28 oranında bir artış olduğu bulunmuştur.
Anahtar Kelimeler: Güneş enerjisi, fotovoltaik, güneş pili, güneş takip sistemi

1. Introduction

Today, new and renewable energy sources have become more important because of decrease in conventional energy sources and ecological factors. As a result of increase in the population of the world, it is estimated that conventional energy sources will be consumed in the time of 100 years. So, some parts of the energy requirement of the world have been begun to supply by the renewable energy sources recently.

At present, photo-voltaic (PV) technology is used for conversion of solar energy into electrical energy in many countries around the world (Karimov et al., 2005). PV cell and module production increased to 314,4 MW in 2004 in Europe. At the same time, PV production in the rest of the world increased by 67% to 140 MW in 2004 (Maycock, 2005). The solar electricity finds applications in a number of systems; for instance, rural electrification, water pumping, satellite communications, grid connected applications and corrosion protection such as cathodic protection for bridges, pipeline protection ,well-head protection, lock-gate protection and steel-structure protection, etc (Karimov et al., 2005).

A photovoltaic module receives the maximum solar radiation when the sun's rays strike it at right (Mohamad, 2004). There are several factors which affect the efficiency of a PV system. These are; (a) Meteorological conditions of the places where the system is to be used, (b) optimal operating of the system with the load, (c) appropriate spatial placement of the PV modules, i.e. placing the modules at an optimal inclination angle to the horizontal plane, and (d) the availability of solar tracking in the chosen system (Karimov et al., 2005).

2. Experimental Design

2.1. Photo-voltaic Panel

The experiment is set up near the clean energy house of Süleyman Demirel University located in Isparta, Turkey. The designed PV solar tracking system has two modules of monocrystalline silicon cells(Model 1S120, ISTAR SOLAR, S.R.L., ITALY). The photo-voltaic module 1S120 is composed of 72 high efficiency monocrystalline solar cells 103x103 mm with antireflecting coating. Table 1 shows the electrical parameters for the PV modules (Istar, 2005).

Table 1. *Typical electrical parameters for experimental PV modules**

Peak power (Wp)	W	120
Nominal voltage	V	12
Current at maximum power (Imp)	A	7
Short circuit current (Isc)	A	7,2
Open circuit voltage (Voc)	V	21,2
Voltage at maximum power (Vmp)	V	17,1
Nominal operating cell temp. (NOCT)	ºC	46 (±2)
Temperature range	ºC	-40 to +90
Tolerance on technical data	± 10 % output valves.	

*STC: I = 1000 W/sqm, T_0 = 25ºC

2.2. Programmable Interrupt Controller (PIC)

A PIC type PIC16F877 is used to process signals of sensors. This unit is considered to be brain of the solar tracker system. A computer program is developed for this PIC.

The signal processing diagram which is used in the design of the sun-tracking system to follow the sun's radiation is shown Figure 1.

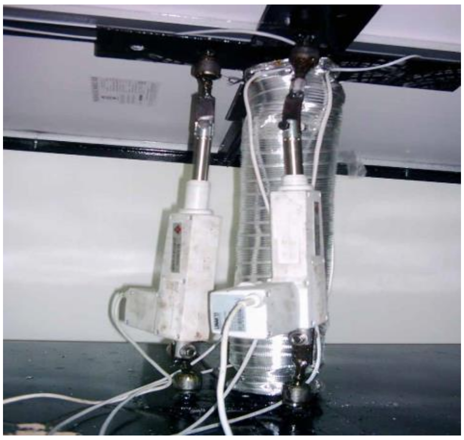

Figure 1. *Signal processing diagram*

2.3. Sensors

Four symmetric LDRs were used to track the sun's position. Each sensor was positioned on the corners of PV modules. Figure 2. shows positions of LDRs.

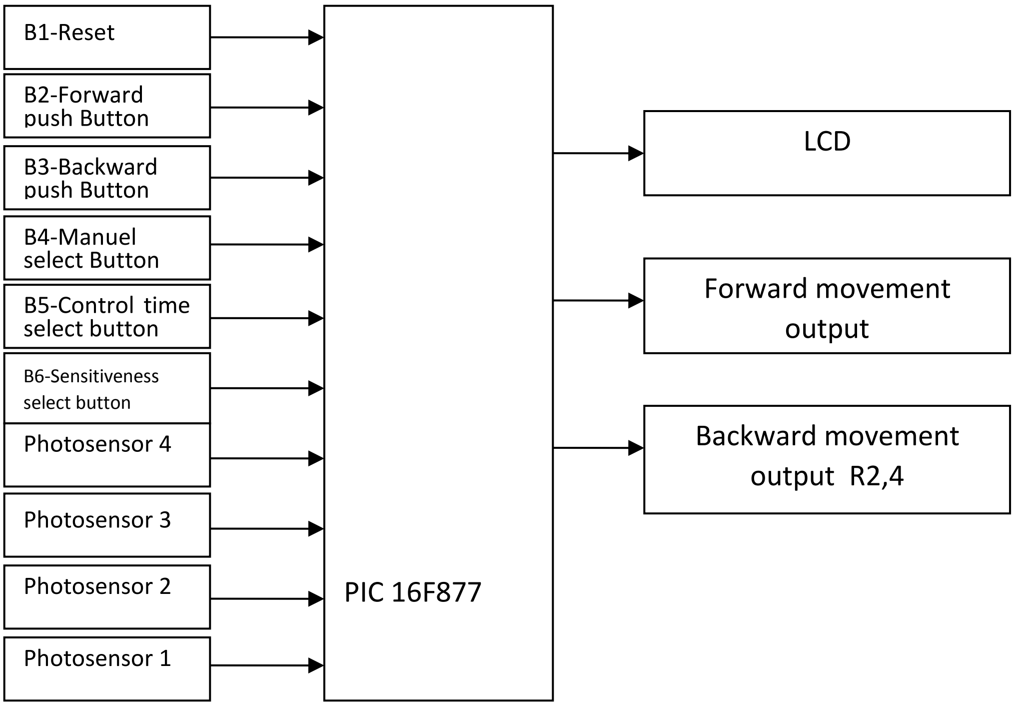

Figure 2. *LDR positions*

Sensors	Actuators	Axis
A – B	1	X (Altitude Angle)
C – D	2	Z (Module Azimuth Angle)

2.4. Electro-Mechanical Movement Mechanism

In this project, two actuators were used for mechanical movement. These actuators were mounted between frame and panels. Figure 3 shows positions of actuators on the frame.

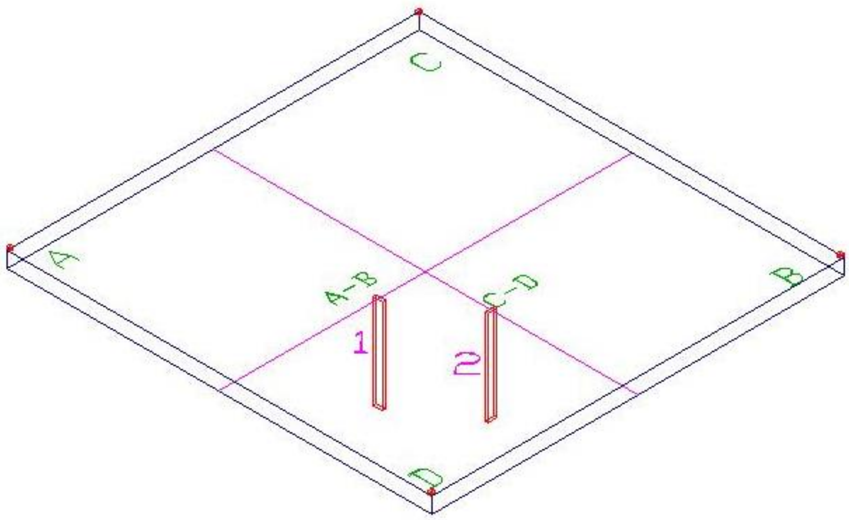

Figure 3. *Positions of actuators*

The system can be operated manually or automatically. B1,B2,B3,B4,B5 and B6 were reset, forward, backward, manual select, control time select, sensitiveness select buttons for manual operation, respectively (Figure 1). Four relays were used to change the rotation direction. In the automatic operation mode, the PIC compares the values of its four analog inputs and then produces the correct output on forward movement (R1,3) or backward movement (R2,4).

2.5. System Power Supply

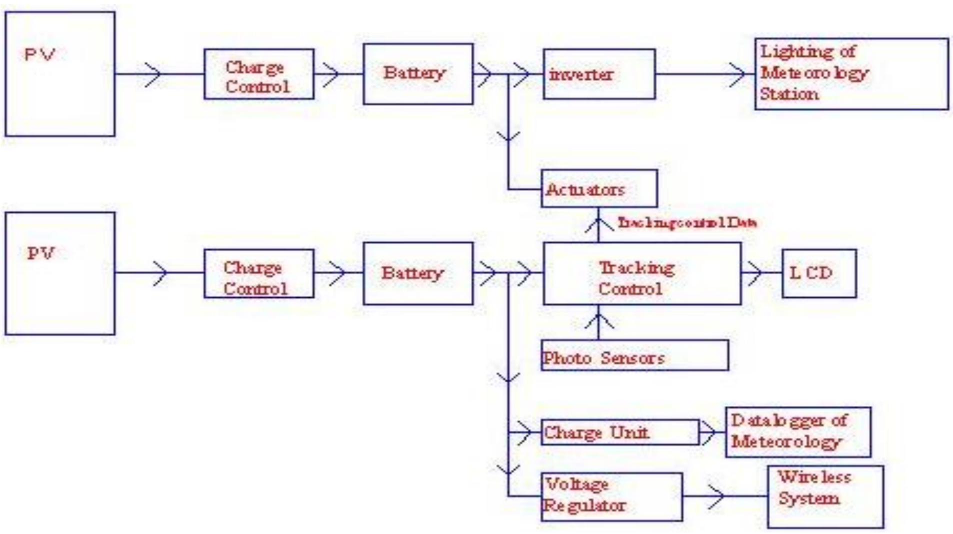

Figure 4. *Block diagram for system*

Figure 4. shows block diagram for the tracking and meteorology systems. System has two batteries 12V, 110 Ah, which were used to power supplying for electronic and mechanical components of tracking system and sensors of meteorology system, wireless components and illumination components. Almemo 2590-9 data logger is used for meteorology system. But this power of data logger is supplied from system batteries. Because battery of data logger is not enough for measurement period of 24h. So there isn't meteorological data loss after this modification. Two charge control cards (15V, 10A) are designed for charging batteries with PV modules. The charge control cards disconnect load from batteries when the battery voltage is low level or high level. So, batteries have been assured and battery life will be long. An inverter card was designed for illumination of meteorology system environment. Inverter 220V, 50 Hz modified sinus and 300W.

Figure 5. *PV and sun-tracking system for mobile meteorology station project*

Figure 5 shows PV and sun-tracking system for mobile meteorology station project, which is located in the clean energy house in Isparta, Turkey.

3. Experimental Results

An experiment is implemented on a clear day on 10.06.2005 from 9 a.m. to 18 p.m. with one panel fixed tilt angle of 25^o facing true south while two axis solar tracking is applied to the second panel following azimuth and altitude angles of the sun throughout the day.

Table 2. *Average hourly solar radiation values, which are measured on tracking panels and fixed (25° south) panel surface 10.06.2005.*

Hours	**Hourly average solar radiation Tracking panel W/m^2**	**Hourly average solar radiation fixed panel W/m^2**
between 9am-10am	985,71	447,5714286
between10am -11am	1006,7	664,6666667
between11am -12am	1041,2	862,5
between12am-13pm	1136	1057,333333
between13pm-14pm	1095,4	1021,428571
between14pm-15pm	1037,1	990
between15pm-16pm	1004,3	847,5
between16pm-17pm	923,86	655
between17pm-18pm	770	456
Total	9000,3	7002

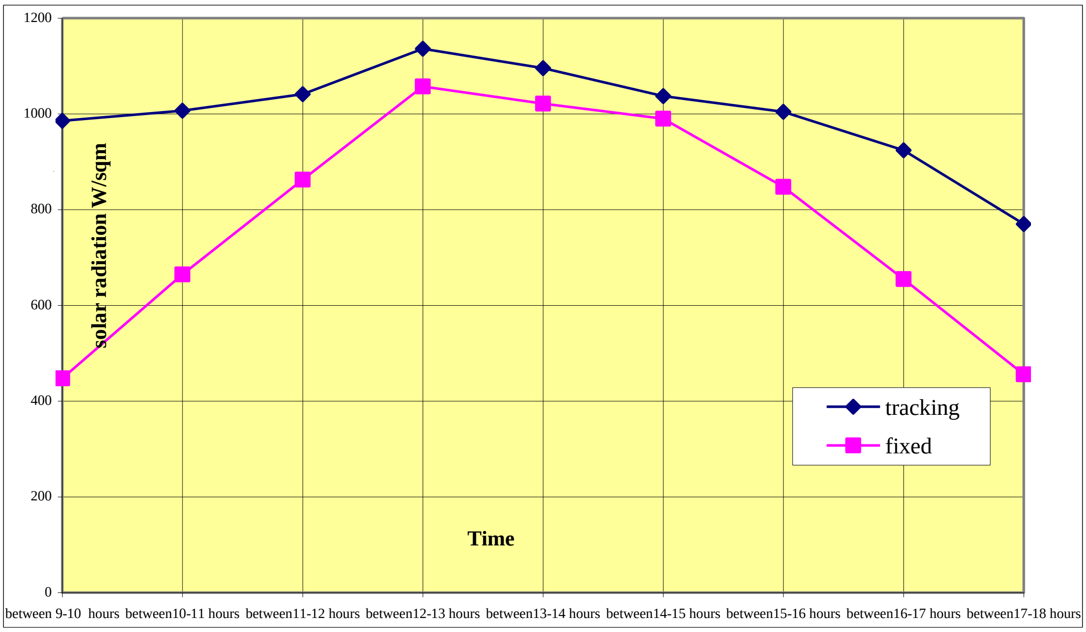

Figure 6. *Average hourly solar radiation values, which are measured on tracking panels and fixed (25o south) panel surface 10.06.2005.*

Table 2. and Figure 6. illustrate the amount of average hourly solar radiation values, which are measured on tracking panels and fixed (25^{o} south) panel surface.

Gain in the amount of average hourly solar radiation received by two axes tracking PV panel to that on the fixed panel is much more than 28%.

Solar radiation values, which are measured on tracking panels and fixed (25^{o} south) panel surface are shown in Figure 7.

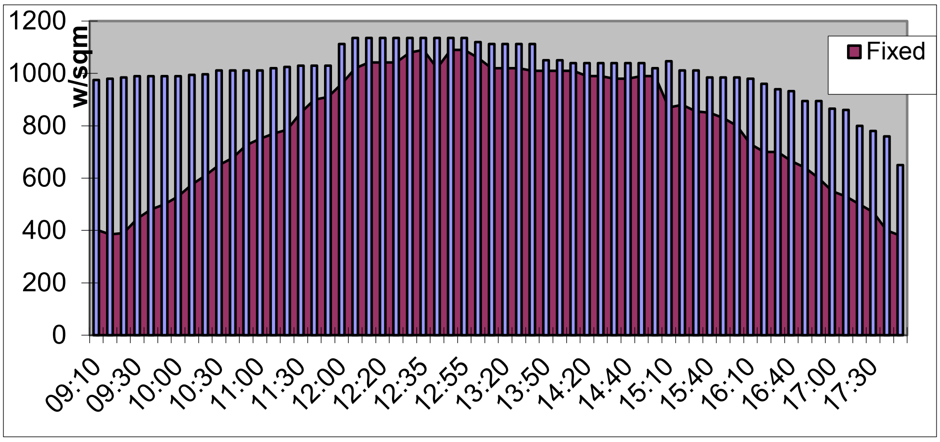

Figure 7. *Solar radiation values*

4. Discussion

In this study, the tracking system, which is developed, is compared with the fixed system. The tracking system collected sun radiation more of 28% than fixed system. Also, photovoltaic system which has tracking mechanism, supplied energy to station of meteorological measurement; thus meteorological data obtained uninterruptible. The data transferred simultaneously to head office with wireless system.

This developed system is suitable for every kinds of measurement station in rural area where the energy feed cannot be supplied from the grid.

Acknowledgements: *The present study was supported by the Scienticif and Technical Research Council of Turkey (TUBITAK), through Grant No. 104M375 and by the SDU-APYB under contract Project No:2003-14. Thank you to the staff SDU-YEKARUM.*

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