JOURNAL OF NANO- AND ELECTRONIC PHYSICS
Vol. 10 No 5, 05045(3pp) (2018)

ЖУРНАЛ НАНО- ТА ЕЛЕКТРОННОЇ ФІЗИКИ
Том 10 № 5, 05045(3cc) (2018)

Short Communication

Electrical Performance of $CuInSe_2$ Solar Panels Using Ant Colony Optimization Algorithm

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(Received 15 August 2018; revised manuscript received 24 October 2018; published online 29 October 2018)

Electricity is an essential factor of economic development for all the countries. In recent years the share of renewable energy in electricity production is growing significantly all over the world. Among these solar energy plays a vital role in the production of power. In this work an Ant Colony Optimization (ACO) technique is proposed which successfully tracks the global peak and thereby improving the performance of PV array. The suggested work is realized in MATLAB/Simulink and simulation results of ACO.

Keywords: Electricity production, CIS Cells, Ant Colony Optimization, Photovoltaic module.

DOI: 10.21272/jnep.10(5).05045 PACS numbers: 78.20.Bh, 81.05.Hd, 84.60.Jt

1. INTRODUCTION

A Copper indium selenide ($CuInSe_2$) cells based thin film solar cells are used in electric power generation from abundantly available sunlight. Unlike conventional crystalline silicon cells based on a homojunction [1-5], the structure of CIS cells is a more complex heterojunction system [6-10]. $CuInSe_2$ (CIS) is one of three mainstream thin film PV technologies, the other two being cadmium telluride (CdTe) and amorphous silicon [11-13]. Like these materials, CIS various layers are thin enough to be flexible, allowing them to be deposited on flexible substrates. However, as all of these technologies normally use high-temperature deposition techniques, the best performance normally comes from cells deposited on glass, even though advances in low-temperature deposition of CIS cells have erased much of this performance difference.

This paper presents the simulation studies on the energy generated by a CIS photovoltaic (PV) module as a function of the amount of irradiation received and the angle of optimum orientation of the panels placed in Tebessa, Algeria. The calculations were made for the city of Tebessa, Algeria. It has a hot desert climate with long and extremely hot summers whereas winters are short, warm with little rainfall throughout the year [14, 15].

2. THEORY

The ant colony optimization (ACO) is a probabilistic algorithm used to determine the global optimal solution for all nonlinear problems. The ACO implemented in [16, 17] has formulated to operate continuously and easily adjust to changing in environmental conditions. The major benefit is, it needs only one combination of voltage and current sensors that increases the system reliability and at considerably lower cost and it increases the efficiency of the PV system, even though is not applied to the distributed MPPT controllers. It is a set of associated parameters with graph components which either nodes or edges whose values are modified at runtime by the ants.

An ant will move from node i to j with probability:

$$P_{ij} = \frac{T_{ij}^{\alpha}\eta_{ij}^{\beta}}{\sum T_{ij}^{\alpha}\eta_{ij}^{\beta}},$$

where T_{ij} is the amount of pheromone on edge i, j; α – a parameter to control the influence of T_{ij}; η_{ij} is the desirability of edge I, j (typically $1/d_{ij}$); β is a parameter to control the influence of η_{ij}.

Amount of pheromone is updated according to the equation:

$$T_{ij} = \rho \cdot T_{ij} \cdot (t-1) + \Delta T_{ij} / t = 1, 2, 3 \ldots T,$$

where ρ is pheromone concentration rate (0-1); T_{ij} is the amount of pheromone deposited.

Since the output from Solar panels is a DC voltage, DC/DC converter is used to provide the flexibility to amend the DC voltage or current at any point in the circuit. The buck converter is designed to step down a fluctuating solar panel voltage to a lower constant DC voltage. It uses voltage feedback to keep the output voltage constant. These are often preferred as they are smaller, light weight, and provide a high quality output, and more efficient than the traditional linear power regulators and more compatible with battery loads. The fundamental equation of buck converter is given:

$$D = (V_{out}/V_{in});\ I_{out} = (I_{in}/D);\ R_0 = (R_{in}/(1\text{-}D^2)),$$

where V_{out} is output voltage of the converter; R_0 the output resistance, V_{in} is input voltage of the converter; R_{in} is the input resistance; D is duty cycle of the switch.

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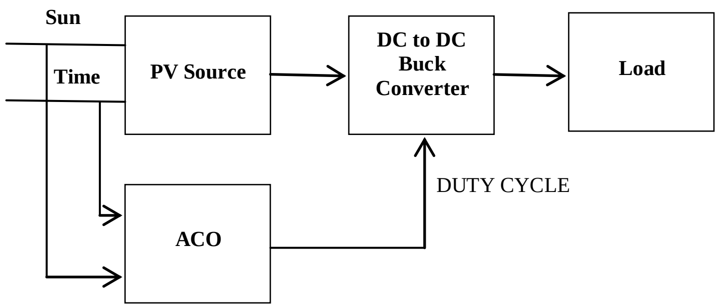

Fig. 1 – Block diagram of the proposed system

3. RESULTS AND DISCUSSION

Fig. 2 shows that the performance of an off-grid solar system varies between 105 and 280 Wh/day with almost nonlinear power generation from month of March to October. The energy generation decreases to a minimum of 105 Wh/day during the winter months. The power generation increases to 280Wh/day during the summer months. Also, there is a direct correspondence between the available radiation and the solar power generated using the photovoltaic cells. Energy production still depends on the solar energy received and both are random. So it is not possible to proportionate the size of the photovoltaic systems by balancing powers of the generator (photovoltaic generator) and that of user equipment. The balance that determines the correct operation of a photovoltaic system must be made between energy produced and energy consumed over a given period, per day in general. The batteries have been employed to compensate the gap between energy generation and energy consumption. On a high generation day, the batteries can be charged and used on a lean day.

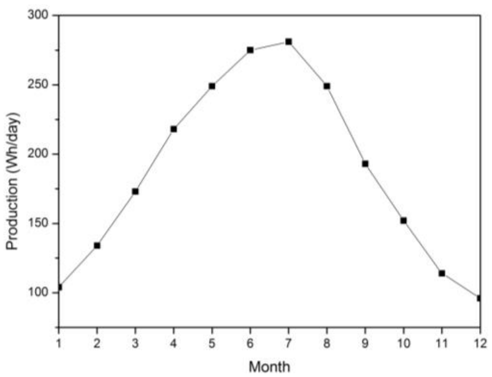

Fig. 2 – Estimated energy production throughout the year

Fig. 3 shows the studies that have been conducted to take all of the above factors into account and give the average energy output for PV system performance connected to the network in locations around Tebessa. The amount of electrical energy (kWh) a 14 kW grid connected solar PV system will generate on an average day (kWh/day).

Fig. 4 shows the variation of the average monthly energy production throughout the year presented as the electricity generated as a function of the month for different inclinations as 1o (vertical axis); 32° (fixed

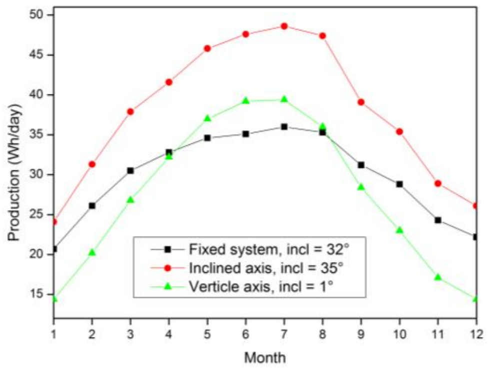

Fig. 3 – Average daily energy production throughout the year with various angles

system); 35º (inclined axis). It can be observed that, there is a direct correspondence between the available and the solar power generated using the photovoltaic cells. The power generated varies from 445-745 kWh/month in the month of January to a maximum between 1110-1510 kWh/month during July and reaching to a value between 446-810 kWh/month during December. The power production is maximum for the inclination of 35° throughout the year.

During the months of January to March and September to October, the power production is minimum for vertical inclination May to July the power production from power panel inclined at 32° produces minimum power. The change may be due to the decrease in the efficiency due to the high incident thermal energy on the panel inclined at 32° compared to the vertical panel.

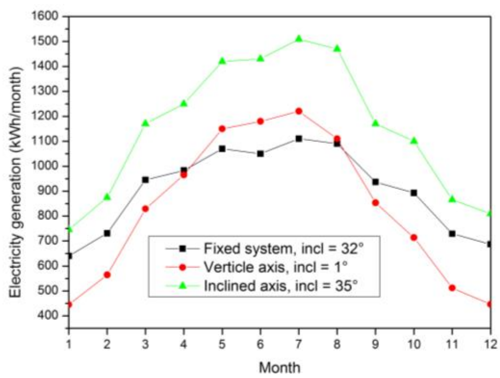

Fig. 4 – Average monthly energy production throughout the year

Energy production still depends on the solar energy received and both random. So it is not possible to size photovoltaic systems by balancing powers of the generator and power requirements of the user equipment. The balance that determines the correct operation of a photovoltaic system must be made between energy produced and energy consumed over a given period, per day in general.

4. CONCLUSIONS.

In this paper, the simulation of the $CuInSe_2$ (CIS) cells has been successfully implemented in the Matlab/Simulink. CIS modules increase in power output after exposure to light during the first few days of operation. Solar panels are affected by heat. Some technologies are better at handling it than others. CIS delivers high yields even in desert environments. This is indicated by the lower temperature coefficient of CIS.

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