Solar Tracking System with Automated Cleaning of Solar PV Modules on Virtual Instrument

B. Vamsikrishna

Department of Electrical and Electronics Engineering, Bharath University, Chennai, Tamilnadu, India

Abstract: The solar tracking system is generally used in dusty environments which is the case in tropical countries like India. The dust gets accumulated on the front surface of the solar panel and blocks the incident light from the sun. It reduces the power generation capacity of the solar panel. The power output reduces as much as by 50% if the panel is not cleaned for a month. In order to regularly clean the dust, a solar tracking-cum-cleaning system has been designed, which not only tracks the sun but also cleans the modules automatically. In this automated system using 8051 microcontroller which controls the stepper motor coupled with the gear box (40:1 ratio). This mechanism does not require any sensor or synchronization for tracking the sun. While for cleaning the PV modules, a mechanism consists of a sliding brushes has been developed. In this mechanism, the solar panels make a rotation in a day, which results in sliding of cleaning brushes over the PV panels. In terms of daily energy generation, the presented tracking-cum cleaning scheme provides about 30% more energy output as compared to the flat PV plate and 15% more energy output as compared to PV module with single axis tracking. The Implementation and working of solar tracking system with automated cleaning is described in this fossil combustibles. In fact, it is expected in the near future, that the demand for energy will grow faster than the finding out of new available fossil resources. This market behavior brings a positive challenge to the scientific community as more funds are allocated for the research and development of new alternatives to the usual main energetic sources (fossil combustibles). In this context we have assisted, in the last decades, to a concentrated focus on renewable energy research. Among these renewable energetic sources, the international scientific community has devoted intense efforts to wind, solar photovoltaic and biomass. Some investigations and hardware developments on wave energy have been led by Great Britain and Portugal. In this paper an intelligent sun-tracking system for efficiency maximization referring photovoltaic energy production is developed. Nowadays photovoltaic energy has a low efficiency ratio concerning the complete distribution chain from production to consumption (ca. 12%).

Key words: Bridge Rectifier • DPDT • Lead Acid • Battery • PV Cells • Real Time Clock • Tracking Systems

INTRODUCTION

According to market economy, the increasing worldwide demand for energy, forces a continuous rise on the price of In optimized environments (materials, electric inverters, tracking systems, etc) an input of 1000W of solar incident energy can bring ca [1-3]. 190W in electricity (efficiency of 19%). This low performance ratio implies big Earth surface consumption when it is intended to install industrial photovoltaic units with significant production impact (50MW-100MW) [4-8]. Today it is being built in Portugal a photovoltaic plant with 64MW production capacity which occupies a huge area of ca. 400 ha (4 Km²).

The more relevant side effect of the low efficiency of photovoltaic systems is its poor competition related to traditional combustibles in both economic and financial aspects.

It is urgent to improve the production efficiency of electricity from the Sun as this energetic source is the most powerful in our planet [9] and it is expected that the Sun will become the main electricity production source by the year 2100, according to the study presented by the German Advisory Council on Global Change.
This paper focuses on the optimization of the electric energy production by photovoltaic cells through the development of an intelligent sun-tracking system. The developed tracking system is innovative in relation to the usual sun tracking systems available in the market.

The usual available solutions for tracking systems rely on the knowledge of the geographical position of the solar panel on the earth surface. With this knowledge it is possible to know the relative position of the sun, on a time basis, according to the well known solar tables [10]. Modern solutions incorporate a GPS system to calculate the position of the solar panel on the Earth surface. The orientations to be followed by the photovoltaic panel, on a regular time-base, are then pre-programmed, on an open loop approach. There are significant efforts on the optimization of sun tracking systems as it is documented by several registered international patents. These solutions are based either on the above described principle either on the quantification of the received solar energy, either on the maximization of the solar incident radiation through the use of light concentration lens.

The solution developed in this paper is innovative related to the above referred approaches as this system is autonomous regarding the information needed to process the optimal orientation and it is intelligent in a way that it monitors, on a real-time base [11], the photovoltaic energy production and it avoids systematic failures coming from changes on the assumed values (position, initial infrastructure orientation, cleanliness of the photovoltaic cells, etc.).

**Implementation of the Sun Tracking and Self-cleaning of Solar PV Modules:** Sun tracking systems are designed in a way to track the solar azimuth angle on a single axis. In single axis tracking system the collector is rotated around only one axis, the sun moves tracing an angle from the sunrise to the sunset. This angle traced by the sun is called the azimuth angle ($\gamma$) is defined as the angle between the lines due south and projection of normal to the collector as shown in Figure 1. Here we have used vertical axis with movement in the east-west (E-W) direction. The automated cleaning and tracking systems are implemented using a stepper motor, gear box (40:1), shaft and sliding rod solar PV modules and circular metal rings for contacts as shown in Figure 3. The control of the stepper motor and the cleaning arrangement is done using a microcontroller [12]. The implementation of Sun tracking cum cleaning mechanism for Solar PV module is explained in the two steps (A and B) mentioned in next paragraph.

**Tracking Mechanism:** A single axis tracking of the solar PV module is implemented along with the automated cleaning mechanism. The module starts its rotation from vertical position at the time of sunrise facing towards east (perpendicular to ground) and rotates as shown in Figure 4.
Cleaning Mechanism: The automated cleaning mechanism is implemented using brush, rod & sliding wheels as shown in Figure 5. The brush is fitted in the rod. The rod is fitted with the wheels at both the ends, which are fitted in the channel in which they rotate. When panel comes in a vertical position at 6 am and 6 pm the brush fitted on the rod rotates on the panel from upwards direction due to gravity and cleans the panel two times in a day. In this way the cleaning mechanism works.

The proposed Sun tracking and self-cleaning of solar PV modules are a complete product and can be implemented with any existing solar PV system. This arrangement has capacity to enhance the energy output of the system and reduces the maintenance required for regular cleaning of the PV modules. This system cleans the modules twice in a day automatically.

Block Diagram

The phenomenon of block diagram is as follows here PIC 16F877A microcontroller is connected with RTC, Voltage sensing, Power Supply, LCD and Stepper motor which control Solar panel Position and cleaning mechanism. Here first we see that power supply is given to the microcontroller. So, 230v AC we convert in 12v AC by using Step-down Transformer. Then by using bridge rectifier we convert 12v AC into 5v DC. But this DC is impure so we pass this current through a capacitor which filters the DC and we get pure DC. So, the obtained pure 5v pure dc we supply into the PIC 16F877A micro controller. RTC means real time clock is linked with microcontroller to control the solar panel position with help of embedded C program which already installed in microcontroller. Through this we rotate the panel at fixed position through the day at the angle of 15° per hour. Voltage sensor sense the voltage which is gain by the solar tracking system and the whole data is shown on LCD. Now this obtained voltage from panel is been stored in battery backup and we use this backup at any time by connecting load [13]. Here DPDT switch is used to control the incoming power from panel to battery.
RESULTS AND DISCUSSION

**Pic Microcontroller:** High-Performance enhanced PIC Flash micro controller in 40-pin PDIP. The PIC16F877A CMOS FLASH-based 8-bit microcontroller is upward compatible with the PIC16C5x, PIC12Cxxx and PIC16C7x devices. It features 200 ns instruction execution, 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, two capture, compare, PWM functions a synchronous serial port that can be configured as either 3-wire SPI or 2-wire I2C bus, a USART and a Parallel Slave Port. The 40 pins make it easier to use the peripherals as the functions are spread out over the pins. This makes it easier to decide what external devices to attach without worrying too much if there enough pins to do the job. One of the main advantages is that each pin is only shared between two or three functions so it’s easier to decide what the pin function (other devices have up to 5 functions for a pin) [13].

**RESULTS**

To observe the effectiveness, performances of tracking system some experiments were conducted. The experiments consisted of measuring the performance of the solar PV modules which are (case1) dusty, (case2) cleaned and (case3) tracked as well as cleaned modules. The energy output performance of PV modules has been measured under following three cases:

**Case 1:** Kept stationary without cleaning (Dusty) Vs Kept stationary but manually cleaned regularly (Cleaned).

**Case 2:** Kept stationary but manually cleaned regularly (Cleaned) Vs Kept in this tracking system with automatic cleaning (Tracked as well as cleaned).

**Case 3:** Kept in this tracking system with automatic cleaning (Tracked as well as cleaned) Vs Kept stationary without cleaning (Dusty).

The comparison of energy output for three different cases is presented in Table 1.

The Table 2 shows the Average number of units generated per day from 1MW power plant and the generation cost per unit of electricity in cents. The difference between the generation costs is quite significant.

**Graph of Performance Index of Module:** Comparison between the performances of dusty and stationary panel with the tracked and automatically cleaned panel which is our tracking system as shown in Figure 7.
Fig. 7: Graph of comparison of dusty and stationary, tracked and cleaned the around 45 day’s period.

The above graph is performance index vs. number of days which shows that the performance of the panel which is not cleaned had decreased approximately up to 50% in approximately 50 days, where as the performance of panel kept with this tracking-cum-cleaning system remains almost the same.

CONCLUSION

A novel mechanism of sun tracking with automatic cleaning of PV modules is presented and cleaning mechanism of the PV modules consists of sliding brushes, which slides over module and cleans it twice a day, wherein PV panel makes a rotation of 180° clockwise and 180° anticlockwise in a day. It is observed that the daily energy generation of a flat PV module (kept stationary on ground) increases by about 30% and 15% for case of tracking-cum-cleaning and just single axis tracking, respectively. This demonstrated the effectiveness of tracking-cum-cleaning mechanism. The mentioned tracking-cum-cleaning system is most suitable for today’s industrial need. The difference is quite significant as we can see from Table 2 the difference in number of units generated per day and cost of per kwhr. Above system can be kept inclined in the north or the south direction accordingly to achieve better energy generation from the PV modules of given wattage ratings. This axis can also be implemented manually or automatically using motor, microcontroller etc [14-18].

REFERENCES


