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Power Analysis of non-tracking PV system with low power RTC based sensor independent solar tracking (SIST) PV system*

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Abstract

Solar energy is a renewable resource that is clean, economical, and less polluting. It is rapidly gaining importance among various renewable energy resources. This paper evaluates the performance of static and tracking-type photovoltaic systems. Comparative analysis of the existing tracking system with present proposed tracking system was done. Further, numerical assessment of energy consumed of the tracking device gives an account of percentage of energy consumed only for tracking. In the proposed system, concept of real time clock (RTC) in the design and implementation of a solar tracking system makes a replacement of algorithm-based systems pertaining to data base stored already and sensor based systems for rotating the assembly. Because of its versatility, this system can be installed any part of the world irrespective of topography and other parametric conditions. The SIST PV system is a low power consuming system and is independent of non-linearity of components of conventional systems.

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Keywords: Sun tracking, PV system, RTC, SIST

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1. Introduction

Energy from sun is available in abundance which can be harnessed for societal needs as thermal energy or electrical energy. Technological developments offer us the opportunity to generate clean, continuous and low cost electricity from a renewable source, solar energy. The tracking systems were able to provide better efficiency and so better output were obtained but, the constraint is the geographical location which demands that the system have modified data base for each location to be chosen globally[1]. To receive the maximum of solar energy, proper north south angle is required which is fixed. Photo voltaic panels can generate electric power which is related to sun radiation, incident angle of solar beam. In addition, Sun tracking systems increase the power output of the PV system [2]. Study of various types of sun tracking systems shows that in each of these systems enough of power and time is consumed by the control circuit driving the tracking mechanism which reduces the precision [3-5]. The phototransistors (as sensors) give prediction sensitivity to locate the sun in spatial coordinate. Even though, precise tracking can be done using sensors but dependence on sensor is the main problem [6]. Microcontroller based open loop algorithm eradicates the need for a sensor dependence. The Self alignment procedure (SAP) is introduced in each axis [7]. The programming method of control is used in this system to control the dual axis tracking system. Compared to the fixed PV system with 32^0 tilt, PLC based open loop tracking system gives daily energy collection increase of 41.34% [8]. Dual axis system requires two motors for tracking. But, introduction of new single axis heliotrope sliding mechanism works similar to a dual axis system, though there is single motor [9]. Further, algorithm in tracking mechanism based on a program is found to increase the energy output from the PV system. [10]. There is a good amount of increase in power production using the sensor based sun tracker. The daily output of the PV panel will be improved by 12% – 20% photo sensor based tracking system, whereas sensor independent tracking system used here gives output of the PV panel range of 15-20% which is a slight improvement over previous method [11].The hardware requirements are also minimum in the proposed SIST PV system, as components such as limit switches and related mechanism controlling it will not be required.

Nomenclature	
STC	Standard Test Conditions
NOCT	Nominal Operative Cell Temperature
Voc	Open Circuit Voltage
Isc	Short Circuit Current
Vmpp	Maximum Power Point Voltage
Impp	Maximum Power Point Current
P_{max}	Maximum Power
RTC	Real Time Clock
SIST	Sensor Independent Solar Tracking

2. Experimental System

Two pv systems are used for experimenting. One is fixed pv system and another one is pv system with sun tracking. Fig 1 shows the control unit of the experimental system. Fig 2 demonstrates the prototype of the developed system. It consists of single axis sun tracking system. The tracking system can rotate the motor from east to west direction. A battery 12 v-7.2A h is used in both systems. The characteristics of the pv is reported in table 1.

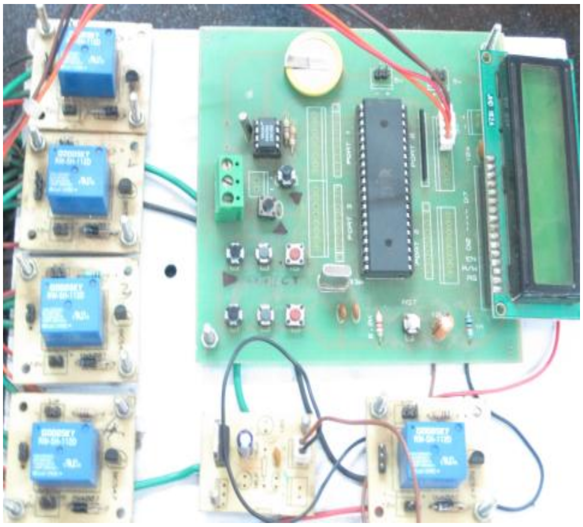

Fig 1 Control Unit for the Tracking System

Fig 2 Sun Tracking PV System

Table 1 : Characteristics of PV

PV Panel Characteristics	STC (Starting Value)	NOCT (Nominal Value)
Maximum Power, P_{max}	25 W	20.2
Open Circuit Voltage,V_{oc}	21.5 V	20.3 V
Short Circuit Current, I_{sc}	1.57 A	1.38 A
Maximum Power Point Voltage, V_{mpp}	17.1 V	16.39 V
Maximum Power Point Current, I_{mpp}	1.41 A	1.23 A
Performance of Thermal Characteristics		
Temperature Co-efficient	NOCT(^{0}C)45	
Power [P_{max}]	-0.43 %/K	
Open Circuit Voltage, V_{oc}	-0.36 %/K	
Short Circuit Current, I_{sc}	+0.06 %/K	

The tracking system contains control unit, driver unit, and mechanical unit along with software. It is a low cost and low power solar following system. The tracking system is an open loop system using real time clock. The main disadvantage in closed loop system is that the closed loop system consumes more energy than the energy produced by the pv system [9]. The RTC, IC can give time, date, day and year. The panel can rotate up to 180^0 from east to west direction. The position of the sun is predefined in terms of time by the software. According to time, the PV panel angle will be adjusted and moved. Initially, the panel is rotated to position corresponding to 8 am in east direction. The panel is rotated every 15 min at an angle of 3.6^0 till 4.00 pm. The entire set up is software driven. The advantage of the proposed system is sensor independence and the reduction of power. The mechanical unit accepts the inputs from the controller and rotates the motor into specified degree. Controller unit sends command to the stepper motor depending upon the time from the Real Time Clock. When the system reaches predefined end time for rotation per day, it will stop the automation. Here, instead of limit switches, the total steps of the motor is taken into account from morning to evening which can be chosen by the user and programmed as well. The panel will re-orients itself for next day's starting position. For carrying out test for determining energy consumed by motor alone, the experimental block diagram used and energy measuring system required for driver unit is shown in fig 3.

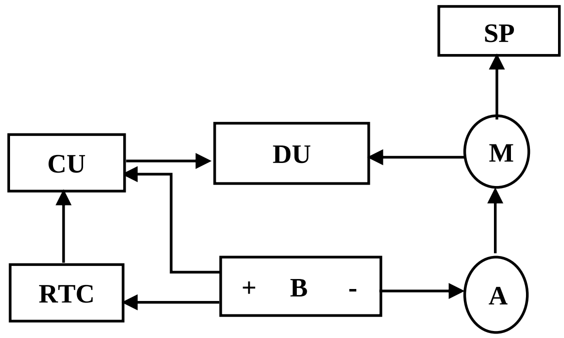

Fig.3: Measuring unit of the driver unit

In, Fig 3, SP represents the solar panel, M represents DC motor, B represents battery, RTC indicates the real time clock for the system, DU represents Driver Unit and A represents the ammeter.

Table 2: The following table shows the results of experimented tests

Time(m)	Day 1 I(Ampere)	Day 2 I(Ampere)	Angle of Rotation (^{0})
8.00 am	0.52	0.67	0
8.30 am	0.72	0.76	7.2
9.00 am	0.86	0.32	14.4
9.30 am	0.99	0.77	21.6
10.00 am	1.12	0.62	28.8
10.30 am	1.18	1.17	36
11.00 am	1.18	1.19	43.2
11.30 am	1.18	1.11	50.4
12.00 pm	1.2	1.16	57.6
12.30 pm	1.23	1.2	64.8
1.00 pm	1.25	1.23	72
1.30 pm	1.26	1.22	79.2
2.00 pm	1.15	1.04	86.4
2.30 pm	1.1	1	93.6
3.00 pm	1.03	0.81	100.8

3. Results and Discussion

Study of the performances of the fixed and tracking PV system were started at the same time and a phenomenal difference in performance was noted. The study report was done for the month of May and June 2016. The data was recorded from morning till evening. Based on the received data the power was calculated between fixed and tracking PV systems. Fig 4 shows the outputs of the particular day and efficiency. We could see the usefulness of solar tracking. The power is almost same at mid-range of afternoon in both systems. Based on similar experiments the test report was generated.

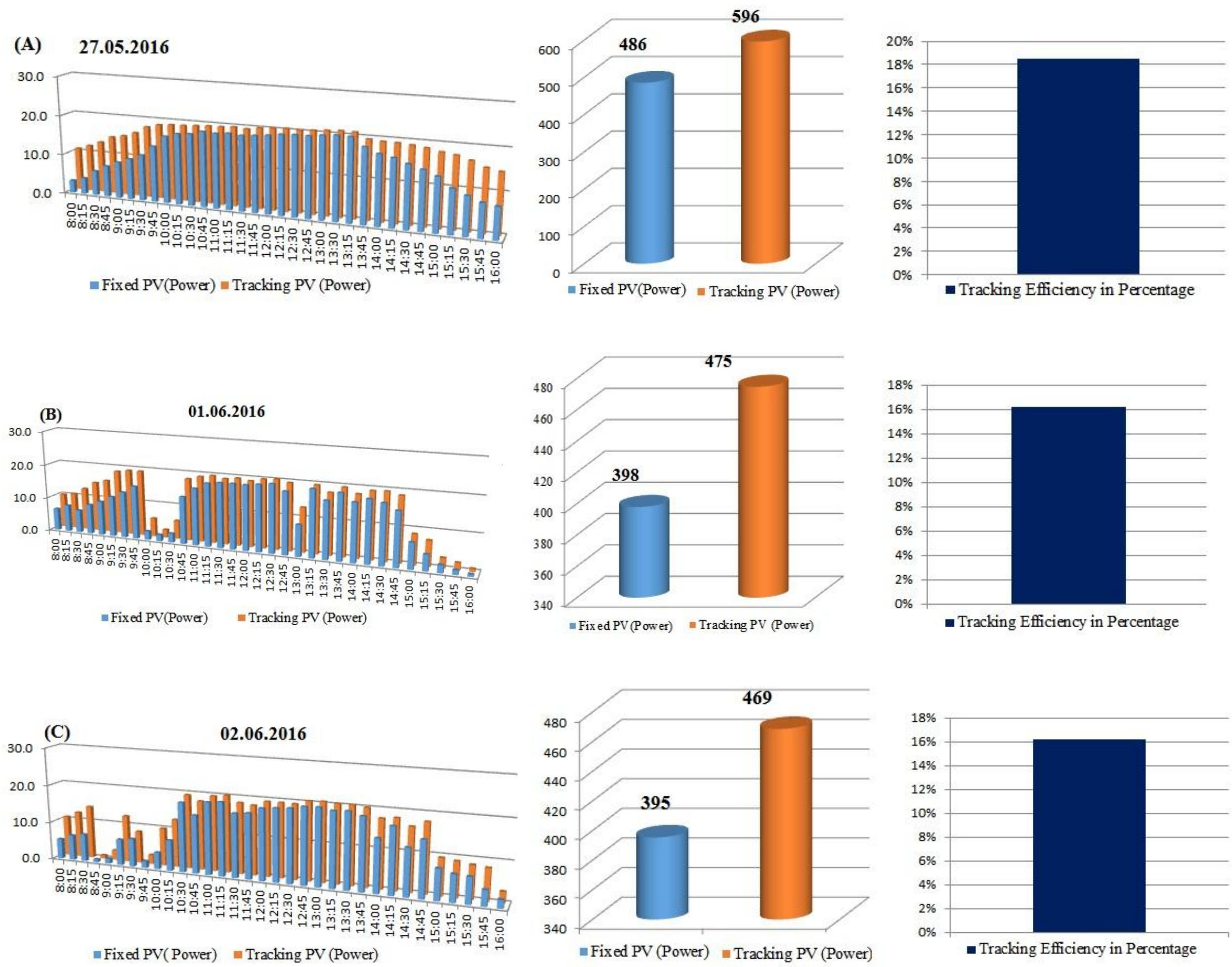

Fig.4. Output Power **(I)** Day 1-(27.05.2016) **(II)** Day 2-(01.06.2016) **(III)** Day 3-(02.06.2016)

4. Conclusion

Maximizing the energy yield of PV systems in order to generate the highest possible return on investment is an ongoing research for best energy management practice it is essential to maximize the production of electrical energy by the PV systems with least electrical energy consumption for tracking mechanism and control circuitry. Akin to these principles, the scope of our objective became to compare and analyses graphically the performance of fixed pv systems and SIST pv system using the RTC based algorithm. The system is able to track the sun in order to increase the solar cell output by aligning the solar panel at the maximum sun intensity. The proposed system is sensor independent based system, where the usage of power used by the sensor is reduced. The developed prototype system is used to compare the performances of the two pv systems. From the experimental results, it's clearly show that the tracking system output is increased 15-20% than the fixed one. Low cost and power tracking system. The reasons for enhanced performance are

1)regular compensation of mechanical error introduced by stepper motors while tracking done by introducing correction factor in software at end of every two hours of tracking

2) Presence of sensors also may introduce error due to physical, environmental and non linearity. This type of problems may not occur in proposed sensor independent system.

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