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Investigating the effect of Sun Tracking on PV Voltage in Solar Installation using Microcontroller Prototype Model

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Abstract*— Weather monitoring is a global phenomenon and its impact world-wide cannot be over emphasized. The monitored parameters are always factored into result-based performance and efficiency. This efficiency can also be determined by the solar irradiance. Solar energy installations are some of the alternative energy generation strategy adopted globally, hence it is important to determine the location, size and position of the panel to ensure maximum solar irradiance. This work is aimed to study the effect of sun tracking solar installation on charging voltage using microcontroller. AT89S52 microcontroller was adopted to implement a model prototype for sun tracking solar installation during cloudy morning and sunny weather conditions. Readings from the prototype were used to characterize the cloudy and non-cloudy weather conditions. From the characteristic curves plotted, it was established that the optimum performance could be obtained during the cloudy morning and sunny afternoon. This further elucidates the impact of sun tracking in solar installations which could be beneficial to solar installation managers and scientists.

Index Terms*— Charging voltage, cloudy, Microcontroller, Prototype model, solar installation, sunny, Sun Tracking.

I. INTRODUCTION

Energy, especially electrical energy, is an important component of a technology driven age. As noted by [1], the global economic growth of today depends much on the availability of electrical energy. It is well established that the availability of the sun and has being the major breakthrough in the development of photovoltaic (PV) cells which aid the conversion of solar energy (also known as green energy [2]) into electricity. It has been previously reported that the development of solar energy still faces some challenges. For example, the variance of solar irradiance at different time and part of the world [3]. At the same time, Oloka in [4], attributed this variation to the movement of the earth, which alters the direction and angle of the sun on the earth surface at different times of the day. The implication of this on the installation of a solar system is that PV modules would not receive sufficient sun light at certain periods of the day. This implies that the required voltage to charge the battery bank will vary and therefore can have serious effect on the performance of such installations.

Kumar in [5] simulated the solar panel based on the different colors (i.e Red, Blue and green) in order to change the wavelength of the panel based on wavelength and temperature was presented. The authors reported that for solar systems, the maximum efficiency can be obtained if the wavelength of the sun ray is high and the temperature on the panel surface is low. It therefore means that an increased wavelength can be achieved when maximum light is exposed to the surface of the PV cells. Usta in [6] adopted the Matlab/Simulink dynamic system simulation software to implement a fuzzy logic control designed to achieve the required solar tracking for effective performance analysis of the system. In the same vain, Huang [7], presented a paper in which the main goal was to design and implement a solar tracking control system using field programmable gate array (FPGA) and the CdS light sensitive resistors. The feedback signals were delivered to the assigned chip through an ADC. A fuzzy controller was developed and implemented on the FPGA platform. The result shows that higher generating power efficiency is indeed achieved using the solar tracking system. The proposed method is verified to be highly beneficial for the solar power generation. Rohit [8] used the concept of Mechanical Solar Tracking System to increase the efficiency of the system by using solar tracking mechanism. Atmega and Aduino board were used by [4] to simulate and implemented the varying resistance of LDR under varying sunny conditions to determine the efficiency of solar tracking. From the reviewed literature, the optimum weather conditions during extreme cases were note adequately captured. Also the adoption AT89S52 microcontroller for tracking solar panel has not been addressed. This work aims at investigating the effects of sun tracking on solar installation with respect to the voltage produced by the PV module to track optimum weather conditions during extreme cases using AT89S52 microcontroller.

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II. METHODOLOGY

The present work adopted the electromechanical concept as against the mechanical approach used by Rohit [8] for developing an experimental prototype. A microcontroller as proposed by [4], [7], [6] and [5]. Figure 1 below is a block diagram model of the prototype used in this experiment. The model was actualized using the circuit shown in figure 2.

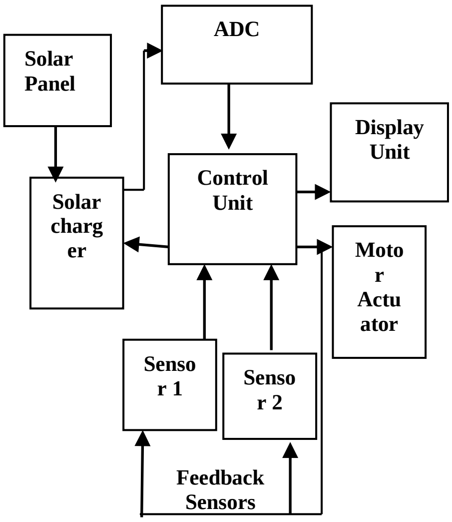

Figure 1 Block diagram of the prototype

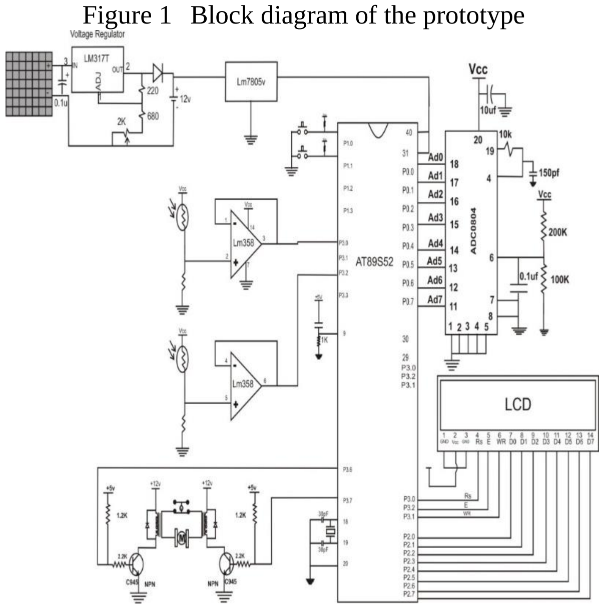

Figure 2 circuit diagram of the prototype model

The circuit diagram of figure 2 is an implementation of the model in figure 1 using AT89S52 microcontroller. The circuit consist of two LDR sensor interfaced through LM358 operational amplifier. The sensors are used to track the direction of the sun, while the actuator is a motor that rotates to reposition the panel in the direction of the sun. ADC converts the PV voltage to digital values, which was then processed and displayed on the LCD.

III. RESULT

The measured voltage displayed on the LCD were read and recorded. The values for the fixed panel (Fx(v)) and Tracking panel (Tr(v)) voltages were recorded as shown in table 1. It should be noted that the values were readings taken for selected days.

Table 1: Values of measure parameters

	Cloudy morning and sunny afternoon		Cloudy Day		Sunny Day	
Time	**Fx (V)**	**Tr (V)**	**Fx (V)**	**Tr (V)**	**Fx (V)**	**Tr (V)**
06:30	0.784	5.948	0.588	1.096	2.716	5.908
07:30	0.996	7.356	0.644	2.188	3.168	11.216
08:30	0.9	11.732	1.096	4.36	7.116	12.812
09:30	2.892	15.132	1.74	4.908	12.668	15.96
10:30	2.932	15.192	2.288	5.084	13.684	16.52
11:30	12.844	15.876	4.164	6.472	18.416	18
12:30	19.552	19.96	8.7	8.66	19.96	19.96
13:30	15.212	19.96	7.9	7.392	19.92	19.552
14:30	13.824	19.94	4.476	4.36	19.552	19.904
15:30	15.72	19.568	4.088	3.928	17.652	19.764
16:30	7.996	18.376	2.172	3.048	15.74	19.492
17:30	4.36	11.924	1.056	2.188	10.556	15.856
18:30	2.872	3.872	0.256	1.308	6.276	10.832

To analyze these data, the percentage difference between the PV voltage of the fixed panel setup and tracking setup was computed as in equation 1.

$$\frac{\left(\frac{\sum Tr(v)}{n} - \frac{\sum Fx(v)}{n}\right)}{\sum Fx(v)} \times 100 \quad -- \quad (1)$$

Where

Fx (V) = PV charging voltage reading for fixed panel (non-tracking setup)

Tr (V) = PV charging voltage reading for sun tracking setup

n = Total size of data sample

A. Cloudy Morning and Sunny Afternoon

The result obtained through measurement for the cloudy morning and sunny afternoon reveals that for a fix panel installation, on a cloudy morning and sunny afternoon, PV voltage begins to rise from 2.93V at 10:30 am and reaches its peak of 19.96V at 12:30 pm then begins to decline from that time till the sun set at 6:30 pm as shown in figure 3. Whereas for tracking setup, at 10:30 am the tracking panel PV voltage has reached 11.73V. During the peak period of the day (12:30 pm), the PV voltage of both setups were the same at 19.96V shown in figure 3. However, the PV voltage of the tracking panel remained at the peak value until 4:30 pm when it began to drop until the sun set at 6:30 pm. This result shows that for the weather condition being considered, it is better to track the sun to enable the panel receive maximum sunlight in order to produce more charging voltage.

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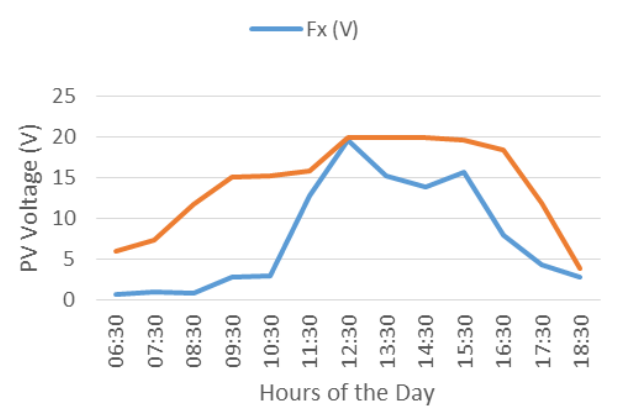

Figure 3 Cloudy morning and sunny afternoon

B. *Cloudy day*

The effect of the cloudy day for both fixed and tracking setup were captured. The peak PV voltage for that day is 8.66v at 12:30 pm. From that time until sun set at 6:30 pm the value was dropping for both fixed and tracking setup as shown figure 4. It is observed that the tracking setup only improved the PV voltage between 7:30 am and 11:30 am.

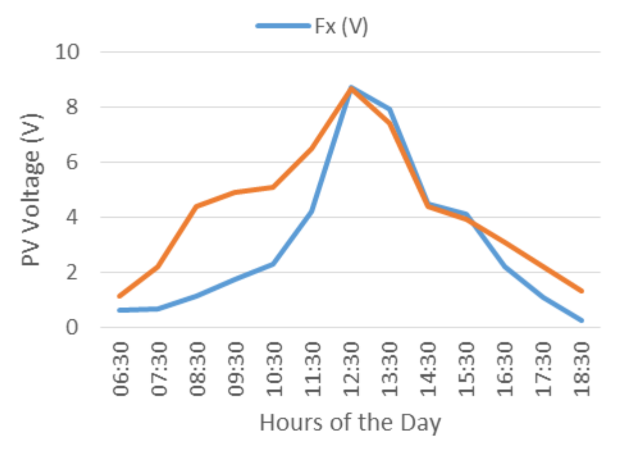

Figure 4 Cloudy day

C. *Sunny day*

During a sunny day as is represented in the curve of figure 5, it can be seen that both the fixed and tracking setups reached their respective peak voltage of 19.96v at 12:30 pm. However, the tracking setup produced more PV voltage in the morning hours compared to fixed setup. Also, from 12:30 pm until 4:30 pm, the PV voltage of the tracking setup remained constant but the fixed setup PV voltage witnessed systematic drop from 12:30 pm, which continued until sun set at 6:30 pm.

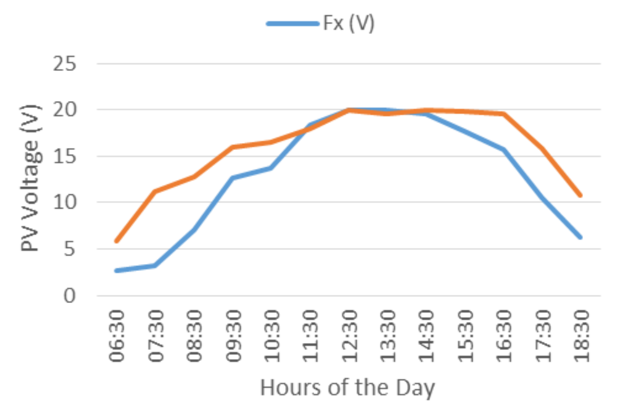

Figure 5 Sunny day

IV. CONCLUSION

This work has investigated the impact assessment of sun tracking PV voltage on solar installations. The adoption of AT89S52 microcontroller has been of particular advantage, and as a result, enables easy manipulation of the tracking device. The following conclusions can be deduced:

1. The results from this study has shown that in all the weather conditions studied, tracking the sun in solar installation produced more charging voltage than for fixed setup or installation.
2. It is observed that this setup has about 41% improvement on the PV voltage for a cloudy day, since only the morning hours (6:30 to 11:30 am) received the boost on charging voltage.
3. For cloudy morning and sunny afternoon, the boost was about 83%, while about 23% boost for a sunny day. Hence, it is clear that tracking the sun in all these weather conditions produced a boost on the PV voltages and thus enhance battery charging.
4. For sustainable alternative energy generation, where solar energy installations are required, it is recommended that a solar tracker be adopted during cloudy morning and sunny afternoon.

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