Self-Cleaning and Tracking Solar Photovoltaic Panel for Improving Efficiency

Bandam Abhilash,
Department of Electrical Engineering
Indian Institute of Technology, Bombay
Powai, Mumbai-400076
abhilash2all@gmail.com

Ashish K Panchal
Department of Electrical Engineering
National Institute of Technology
Surat, Gujarat-395007
akp@ee.svnit.ac.in

***Abstract*— Now-a-days electricity is one of the basic necessities of mankind. As the demand of electricity is increasing, there is need to exploit renewable sources of energy. In the current era of power shortage in India, the use of solar energy could be beneficial to great extent. For this reason, the number and size of the Photovoltaic (PV) systems are growing and consequently the amount of the investments and the related opportunities and risks are increasing [1]. To make solar energy more fruitful, the efficiency of solar array systems must be maximized [2]. For the efficiency evaluation of PV panels, that has been discussed with particular attention to the presence of dust and maximum intensity of light on the panel surface. Mainly, the effects of the dust and intensity of light on the efficiencies of the PV panels have been highlighted. This paper gives the brief description of the design and construction of microcontroller based cleaning and tracking system.**

***Index Terms*— cleaning, tracking, microcontroller, efficiency, dust, pollution.**

I. INTRODUCTION

TO make the Solar panel much effective, the solar PV panel should always receive the maximum intensity of light. For that the panel should always face perpendicular to the sun and there should not be any dust particles on the panel [3, 4]. But in some heavy pollution areas the dust particles are directly deposited on the solar panel, so that most of the light coming from the sun is reflected rather than refracting because of the dust deposited on the panel by making the front portion of the panel shaded [5, 6], the dust deposited panel can be shown in the Fig.1.

The efficiencies of the panels descend because of the dust depositing even though the panel is tracking the sun [7]. This paper explains the efficient self-cleaning and tracking mechanism and obtains the results of the panel for the different conditions such as cleaned panel without tracking, dusty panel without tracking, dusty panel with a tracking and cleaned panel with tracking, dusty panel without tracking, dusty panel with tracking and cleaned panel with tracking.

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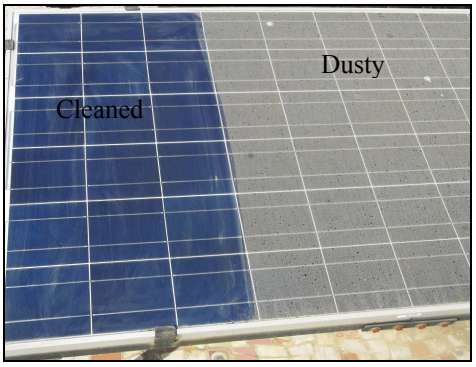

Fig. 1 Picture showing dust on the panel

The rest of this paper is described as follows: First, we provide the design development in the Section II. In section III, we represent the implemented algorithm. Experimental setup is shown in the section IV. Finally, we give the conclusion in the section V.

II. DESIGN DEVELOPMENT

A. Prototype

The prototype for the solar panel cleaning and tracking mechanism for the better efficiency power output is illustrated in the Fig. 2.

This prototype consists of two dc motors of 1000rpm for cleaning and 10rpm for tracking mechanism. The wiper which is placed on the panel is used for cleaning the dust particles which are deposited on that. These dc motors can be controlled by the microcontroller. The 1000rpm dc motor which is used for cleaning is connected to the threaded rod. When the motor is in forward direction, the threaded rod rotates and the wiper connected to the road moves downwards and when the motor rotates in opposite direction the wiper moves upwards as the threaded rod rotates in opposite direction.

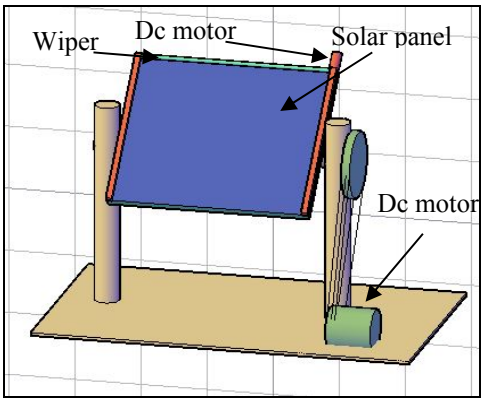

Fig. 2. Prototype for the proposed model

B. *Microcontroller*

The total system which is automatically tracks and cleans the panel, using the microcontroller (P89V51RD2) is used to achieve the requirement with the low cost. The microcontroller controls the dc motors that are mounted to make the panel to track the sun and to clean the panel by receiving the information from the light dependent resistors that are placed on the panel.

C. *Light Dependent Resistor*

A Light Dependent Resistor is a resistor that changes in value according to the light falling on it. LDR is very high-resistance, sometimes as high as 10MΩ, when they are illuminated with light resistance drops dramatically. It has a high resistance in the dark, and a low resistance in the light. Two LDR's are used which are placed on the top of the panel as shown in the Fig.5. When the sunlight falls on the LDR's, the resistance of the LDR's are checked and 10rpm motor connected to the panel rotates in the direction whose resistance of the LDR is less till the resistance on both the LDR's become equal.

III. IMPLEMENTED ALGORITHM

The algorithm for implementation of tracking and cleaning arrangement have been explained by the two flow charts one for the tracking and another for the cleaning the panel. These flow charts are explained.

A. *Flow chart for cleaning the panel*

Fig.3 shows the flow chart for cleaning procedure of the panel. Here the motor which is connected to the panel will rotate in clockwise direction so, that the wiper attached to the motor will moves down and when it touches the pin situated down, the motor starts rotating in the anticlockwise direction, then the wiper starts moves upwards and rests.

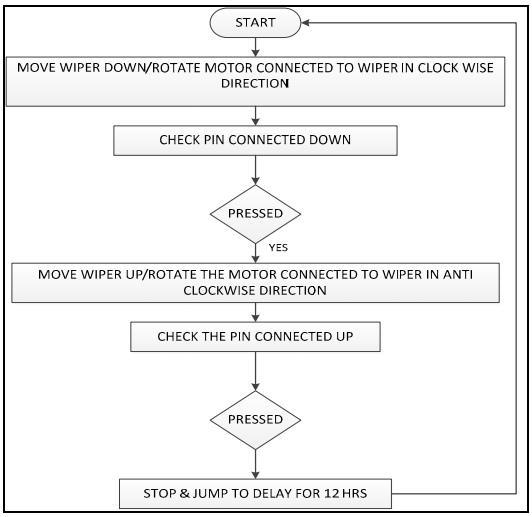

Fig. 3. Flow chart for Cleaning

B. *Flow chart for tracking the sun*

The algorithm for tracking the sun is simple to understand, it works by using the microcontroller which compares the light intensity illuminated onto the LDRs. The logic that works on the Microcontroller to detect the signal is based on a resistance Once the signal is fed into the input, the program compares the two input values and then the difference is detected and sends an output signal to let the motor moves clockwise and counter clock wise respectively. The flow chart for the panel tracking the sun is shown in the Fig. 4.

IV. EXPERIMENTAL SETUP

The setup which is shown in the Fig.5 is installed on the roof top of the building. The data taken from this setup that is cleaned panel with tracking has been compared with the

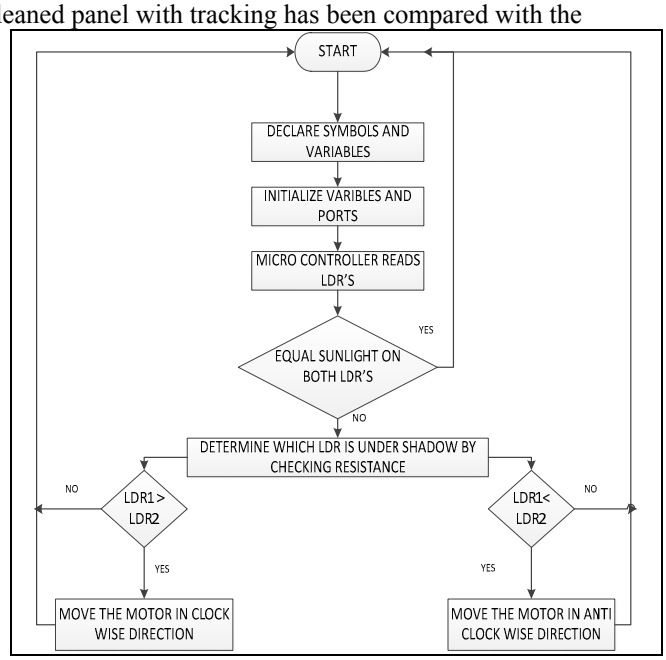

Fig 4. Flow chart for tracking the sun

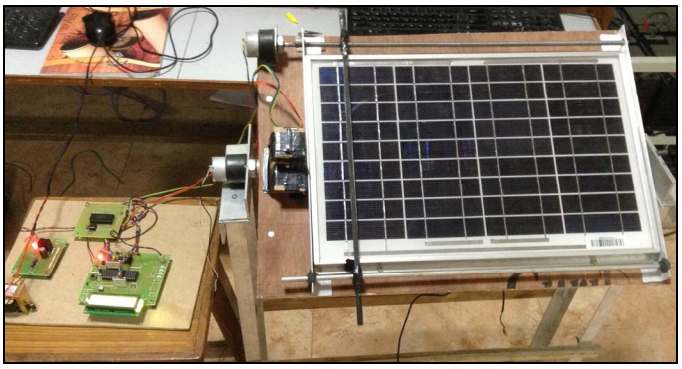

Fig 5. Solar tracking and cleaning system

cleaned panel without tracking, dusty panel without tracking and dusty panel with tracking and tabulated in Table I,II,III,IV respectively. For the different conditions different panels are used with the same rating and with the same manufacturer. These results are taken for the whole day from 7am to 7pm with an interval of 1hour time. By observing the Tables I, II, III and IV the maximum intensity of the light is falling on the fixed panel only once in a day. But for the tracking panel the maximum intensity of light is falling every time. Moreover, it is receiving the maximum light, but because of the dust particles that are deposited make the efficiency to decrease. The average efficiencies and the power for the different conditions are compared and tabulated in the Table V.

TABLE I. RESULTS FOR CLEANED PANEL WITH TRACKING

SR.NO	Time	Voltage (V_{mp})	Current(I_{mp})	POWER(W)	%Efficiency
1	7am	15.62	0.38	5.9356	5.652952
2	8am	15.71	0.41	6.4411	6.134381
3	9am	16.01	0.46	7.3646	7.013905
4	10am	16.23	0.49	7.9527	7.574000
5	11am	16.37	0.53	8.6761	8.262952
6	12pm	16.25	0.55	8.9375	8.511905
7	1pm	16.03	0.54	8.6562	8.244000
8	2pm	15.92	0.53	8.4376	8.035810
9	3pm	15.81	0.51	8.0631	7.679143
10	4pm	15.51	0.50	7.7550	7.385714
11	5pm	15.45	0.48	7.4160	7.062857
12	6pm	15.01	0.46	6.9046	6.575810
13	7pm	14.98	0.32	4.7936	4.565333

TABLE II. RESULTS FOR CLEANED PANEL WITHOUT TRACKING

SR.NO	Time	Voltage (V_{mp})	Current(I_{mp})	POWER(W)	%Efficiency
1	7am	13.56	0.36	4.8816	4.649143
2	8am	14.23	0.38	5.4074	5.149905
3	9am	15.72	0.41	6.4452	6.138286
4	10am	15.87	0.44	6.9828	6.650286
5	11am	16.30	0.47	7.6610	7.296190
6	12pm	16.24	0.51	8.2824	7.888000
7	1pm	15.83	0.48	7.5984	7.236571
8	2pm	15.73	0.47	7.3931	7.041048
9	3pm	15.71	0.46	7.2266	6.882476
10	4pm	15.38	0.42	6.4596	6.152000
11	5pm	14.25	0.39	5.5575	5.292857
12	6pm	14.20	0.36	5.1120	4.868571
13	7pm	13.21	0.31	4.0951	3.900095

TABLE III. RESULTS FOR DUSTY PANEL WITHOUT TRACKING

SR.NO	Time	Voltage (V_{mp})	Current(I_{mp})	POWER(W)	%Efficiency
1	7am	13.005	0.09	1.17045	1.114714
2	8am	13.25	0.11	1.4575	1.388095
3	9am	13.91	0.17	2.3647	2.252095
4	10am	14.53	0.21	3.0513	2.906000
5	11am	15.25	0.24	3.6600	3.485714
6	12pm	15.01	0.31	4.6531	4.431524
7	1pm	14.1	0.31	4.3710	4.162857
8	2pm	13.98	0.3	4.1940	3.994286
9	3pm	13.73	0.27	3.7071	3.530571
10	4pm	13.51	0.21	2.8371	2.702000
11	5pm	13.02	0.18	2.3436	2.232000
12	6pm	12.98	0.13	1.6874	1.607048
13	7pm	12.86	0.09	1.1574	1.102286

TABLE IV. RESULTS FOR DUSTY PANEL WITH TRACKING

SR.NO	Time	Voltage (V_{mp})	Current(I_{mp})	POWER(W)	%Efficiency
1	7am	13.01	0.15	1.9515	1.858571
2	8am	13.93	0.19	2.6467	2.520667
3	9am	14.01	0.24	3.3624	3.202286
4	10am	15.12	0.30	4.5360	4.320000
5	11am	15.31	0.35	5.3585	5.103333
6	12pm	15.33	0.39	5.9787	5.694000
7	1pm	14.91	0.38	5.6658	5.396000
8	2pm	14.87	0.36	5.3532	5.098286
9	3pm	14.73	0.34	5.0082	4.769714
10	4pm	14.53	0.31	4.5043	4.289810
11	5pm	13.78	0.25	3.4450	3.280952
12	6pm	13.21	0.21	2.7741	2.642000
13	7pm	12.85	0.11	1.4135	1.346190

TABLE V. EFFICIENCIES FOR DIFFERENT CONDITIONS

SYSTEM	CPWT	CPWOT	DPWT	DPWOT
P_{max}	7.48W	6.39W	3.99W	2.819W
%EFFICIENCY	7.13%	6.08%	3.80%	2.653%

Where

1. CPWT – Cleaned panel with Tracking
2. CPWOT – Cleaned panel without Tracking
3. DPWT – Dusty panel with Tracking
4. DPWOT – Dusty panel without tracking

V. CONCLUSION

Two algorithms were studied one for cleaning and ne for tracking of the solar panel. The self-cleaning and tracking

mechanism has been implemented. Several cases were experimentally implemented and came to the conclusion. By the above results it can be observed that the tracking is best suited then the fixed one, only when the dust on the panel is cleaned. If we implement the tracking system without cleaning the panel the efficiency is less than of the panel which is fixed and cleaned. Moreover the efficiency of the panel is decreased by 50% even though it is tracking without cleaning. It is also concluded that from the Table V the efficiency of the panel has been improved when we are going with the tracking as well as cleaning system. This system can extend to dual axis tracking by that we can achieve more efficiency.

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