International Journal for Modern Trends in Science and Technology
Volume: 03, Issue No: 04, April 2017
ISSN: 2455-3778
http://www.ijmtst.com

Influence of Dust Removal Mechanism on Solar Power Plant and Its Performance

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To Cite this Article
K.Sai Lalitha Chowdary, G.Prameela, Jayaharsha.K and Dr.D.Ravi Kishore, "Influence of Dust Removal Mechanism on Solar Power Plant and Its Performance", *International Journal for Modern Trends in Science and Technology*, Vol. 03, Issue 04, 2017, pp. 11-15.

ABSTRACT

Sun is a vast source of energy which emits energy in the form of light and heat. Best places to exploit that free, abundant, and environmentally friendly energy are deserts, arid regions, open places and roof tops. But, the main problem with these deserts and open places is dust or dirt. Accumulation of dirt or particles like dust, water, sand and moss on the surface of solar photovoltaic panel obstruct or distract light energy from reaching the solar cells. This is a major problem since the light obstruction materials pose as external resistances that reduce solar photovoltaic performance. We made a microcontroller and voltage sensing integrated system to clean solar panels. Our system is integrated with wiper and provision to add other facilities like water and detergent. The system can work in the night, so there will be no obstruction for the generation of power during the day time. And practically analyzed on 2.2KW plant. Economic analysis with payback period is done. Deploying it ends up being lot of extra power generation, economical and most reliable.

KEYWORDS: *Photovoltaic panels, Microcontroller ,wiper, payback period.*

I. INTRODUCTION

The present mechanism relates to an automatic solar panel cleaning system. Currently, the use of solar panels for the collection of solar energy is a common practice. Obviously, these solar panels are installed outdoors in order to achieve a direct impact from the solar light, and when dealing with facilities of a certain scope, in the countryside or rural areas. Dust and particles forms a layer or film which makes the impact of the solar rays on the surface of the solar panel and consequently considerably reduces its performance. In order to achieve an optimal performance of the solar panel it is necessary to clean it periodically and eliminate the dirt accumulated thereupon. This operation is currently carried out manually, which poses several drawbacks, such as: high maintenance personnel costs, risk of accidents . To address this problem, an automated solar panel cleaning system is designed for roof top solar plant. This is easy to operate and scalable system and can be deployed for single panel to massive plant. Apart from the environmental benefits and cost savings from reduced power consumption, the automated cleaning system eliminates the risks associated with having to manually clean the panels. So in this paper we are implementing the dust removal mechanism and collecting real time data of plant and doing economic analysis to indicate the money savings and energy savings potential.

II. SOLAR PHOTOVOLTAIC ENERGY

Energy from the sun is caused from thermonuclear explosions deep within the sun.. Our sun generates an enormous amount of energy, and potentially, we

could harvest huge amounts of energy. This energy is converted to electrical energy using photo voltaic cells and modules. A photovoltaic module or photovoltaic panel is a packaged interconnected assembly of photovoltaic cells, also known as solar cells. The photovoltaic module, known more commonly as the solar panel, is then used as a component in a larger photovoltaic system to offer electricity for commercial and residential applications.

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III. EFFECT OF DUST ON PV PANELS

Dust causes light attenuation. The main issue with dust is the attenuation of the incident solar spectrum due to dust accumulation. This causes distraction of light and reaches less light to cells. So power generation reduces. Reduces efficiency of plant. In addition to non-optimal cleaning, dust and soil deposition can cause **permanent damage to solar PV modules**. If even a single cell becomes shaded it acts as a resistance to the current generated from the other cells. Consequently, the shaded cell heats up and becomes a hot spot that can eventually damage the entire module.

IV. PROPOSED METHOD

The main aim is automatic dust cleaning mechanism of solar panel surface. In order to sense the dust on panel voltage sensing circuit, microprocessor arrangement is used. Voltage of solar panel continuously measured on the panel and given back to microprocessor. If there is any dust on the panel, sun rays continuously falling on the panel are less thus the output of panel goes low and these signals are fed to microcontroller. Depending upon input signal the controller compares those signals with preprogrammed data for motor movement and drives the motor driving circuit to rotate the motor in clock wise, anti-clock wise direction as per requirement. Wiper is connected to motor wiper which rotates in clockwise and anti-clockwise direction. Thus the cleaning is carried. Transformer (centre tapped step down) which is connected to AC mains and fed to the rectifier (convert AC to DC) circuit which further provides the signal to the voltage regulator which provides the constant voltage for all the circuits. Here it is important to consider dust sensor and LDR which are used to sense the dust on surface. But here we are using voltage sensing circuit which directly detects panel voltage instead of sensors. Because sensors need to be cleaned every time or must be reset . For this process we need separate mechanism, so to avoid that we are using voltage sensing circuit. Depending on panel voltage we can judge the performance of panels. So we can feed pre determined values to microprocessor so that it compares actual value to pre determined values and drives motor. The signal given to motor through motor driving circuit. So we need a power controller circuit and microprocessor to operate it and motor to drive it. Switches are placed at both ends to make motor to stop and run in reverse direction.

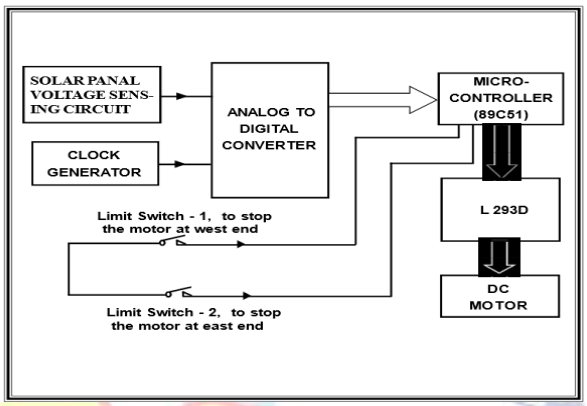


Fig 1 : Block Diagram

Here we can power the system using solar panel itself but solar panel cannot give power during night. So if it is powered through solar panel then it must be operated only in day time. So we powered through AC supply.

Dust can be sensed using different methods like sensing voltage with reference to light intensity or using dust sensors or can be operated manually by switching.

Working :-

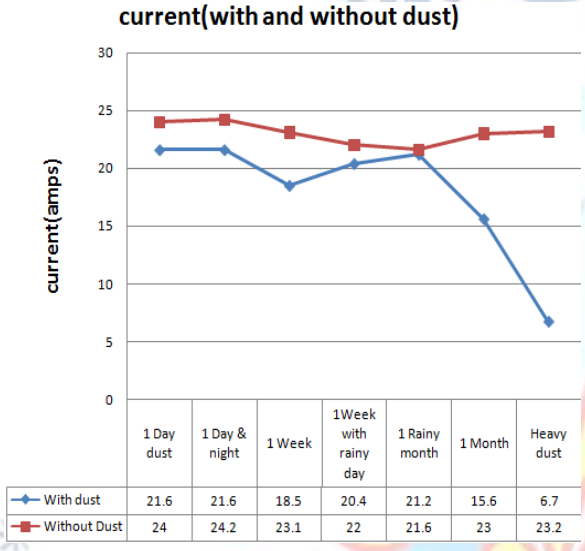
Combination of all these parts and circuits to perform whole operation is crucial. And its working is observed in step by step analysis. First dust falls on panel surface. Them voltage will be less because of intensity of light falling on surface will decrease. So next this signal will be sent to microprocessor. Microprocessor compares voltages and send signal either to run the motor or not. Then power is sent to motor through motor driving circuit. Motor runs in pre defined path with help of frame fixed to panel.

V. ANALYSIS ON 2.2 KW PLANT

Our plant is connected with digital inverter. Which shows input voltage, current, power and output voltage, load current and other parameters. So values are noted before cleaning and after cleaning and values are noted at same time. So on

both cases light intensity is almost same and values are taken at different days.

Here we have analyzed for one day , one day and night, 1 week , one rainy week, one month, one rainy month and heavy dust storm conditions. Because dust on panels first forms as layer and then on first layer another layer forms like this dust accumulates for days. Then continuous deposition may lead to soiling of panels. So to consider all these conditions we have noted values from all conditions and calculated average values to get more reliable values.

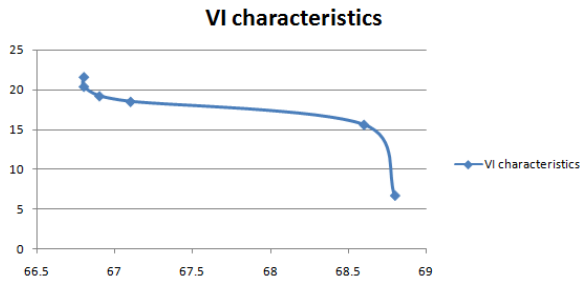


This is the graph for current before and after cleaning the dust. Current value increases when dust is cleared. Current increases because of this cleaning mechanism. Current developed is directly proportional to light intensity and indirectly proportional to dust accumulated on panel. So, when dust increases current decreases and voltage slightly increases.

Solar cells produce direct current (DC) electricity and current times voltage equals power, so we can create solar panel I-V curves representing the current versus the voltage for a photovoltaic device.

TABLE : V-I Characteristics

VOLTAGE(v)	CURRENT(A)
68.6	15.6
67.1	18.5
66.9	19.2
66.8	20.4
66.8	21.6
68.8	6.7



Solar Cell I-V Characteristics Curves are basically a graphical representation of the operation of a solar cell or module summarising the relationship between the current and voltage at the existing conditions of irradiance and temperature. I-V curves provide the information required to configure a solar system so that it can operate as close to its optimal peak power point (MPP) as possible

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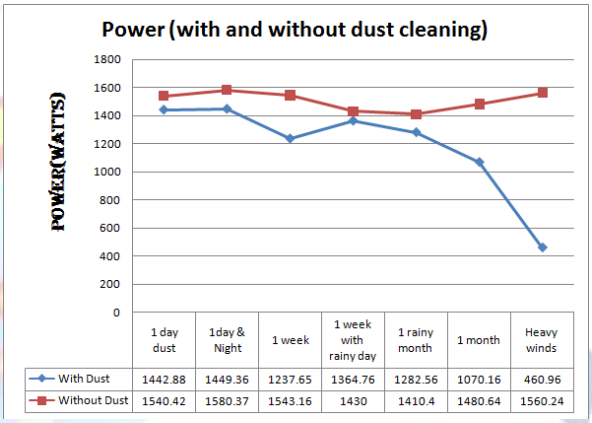

Graph : Power with and without dust

Here we have to consider power we are saving using this system, that is 98w/day in normal days, 131w/day in day and night, 306w/day in a week,66w/day in rainy season,128w/day if not cleaning for month,410 w/day in summer month, 1100w/day in heavy dust storms.

So on an average power saved per day= (98 + 131 + 306 + 66 + 128 + 410 + 1100)/7 = 2239/7

= 319.85 or 320 watts/day

For one month we can save 320 * 30 = 9600watts per month ,Approximately 10 units per one month. we can take average of all these values so that the result is more reliable because we are considering all conditions like normal layer, Accumulation of dust, soiling of panel also. So we can take average of all these values so that the result is more reliable because we are considering all conditions like normal layer, Accumulation f dust, soiling of panel also. By considering all these power values we can observe the improvement. So efficiency of plant

also increases as for same input output is increased. Efficiency is the ratio of the useful work performed by a machine or in a process to the total energy expended or heat taken in. here in our plant sun energy as light is taken as input. Initially power values are 1442,1449,1237,1364,1282,1070,460 watts in different conditions before cleaning the dust. After cleaning 1540,1580,1543,1430,1410,1480,1560 watts.

On an average (1442 + 1449 + 1237 + 1364 + 1282 + 1070 + 460) /7 = 1186.28 watts

After cleaning (1540 + 1580 + 1543 + 1430 + 1410 + 1480 + 1560) / 7 = 1506.14 watts
Difference in power generated
1506.14 – 1186.28 = 319.86 watts

Actually power generated on normal conditions is 1600 watts.
Improved power = 319.86/1600 = 19% improved.
So power plant is optimized by nearly 19%.

VI. ECONOMIC ANALYSIS

Total cost of integrated system to use on 2.2 kw plant = Rs. 3305
DC Motor – Rs.450 , Micro controller – Rs.90 , Frame – Rs.1000 , Electronic board and components – Rs.1765
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= 2239/7
= 319.85 or 320 watts/day
For one month we can save 320 * 30 = 9600watts per month
Approximately 10 units per one month.
Power consumed will be very less ,so we can take one unit per one month. So on an average total power saved per one month is 9 units. And for one year it is 108 units.
For small scale of production like roof top plants and for home consuming purpose in India price per unit is Rs. 4 to Rs. 8. We can take Rs 5.5 as average unit cost.
Total power saves per yeat = 12* 10 units/month = 120 units.
So per year savings will be units saved * unit cost
120 units * Rs. 5.5(unit cost) = Rs.660 per year
Net annual cash flow = 108 units saved * Rs 5.5(unit cost) = Rs 594 per year.

A. Pay Back Period

The payback period is the length of time required to recover the cost of an investment. The payback period of a given investment or project is an important determinant of whether to undertake the position or project, as longer payback periods are typically not desirable for investment positions. The payback period ignores the time value of money, unlike other methods of capital budgeting, such as net present value, internal rate of return or discounted cash flow.

$$\text{Payback Period} = \frac{\text{Cost of the investment}}{\text{Annual net cash flow}}$$

Total cash investment = Rs.3305
Annual net cash inflow = Rs 594
Pay back period = 3305/594 = 5.56 years
Approximately 5 Years six months. And life time of this system is 10 years. So we have scope of earning lot of money through it.
Here we have to consider that it is very scalable and can be applied to megawatt scale plants with small additions. But major components will be same. So as the size of the plant increases then money saved will also increases.

VII. CONCLUSION

In India's exciting and evolving solar industry, smart solutions for utility cleaning not only make good environmental sense but are increasingly crucial to staying competitive. This drives all people to choose best and cheapest systems in the market. Our work is of same type with minimum investments maximize the output of plant. In this work we have studied in general the energy losses due to accumulated dust on the surface of photovoltaic modules. And especially when we tested the system and noted the results it is very clear that using dust cleaning mechanism we are able to save lot of energy per day. In the same way if we are able to apply this system for mega watt scale then the difference will be huge. Overall cost of power produced will be automatically reduces with minimum investments. We conclude that the

estimation of energy losses produced by the presence of dust have to be calculated in a different way for photovoltaic systems with fixed modules and presented the energy losses produced by the dust on the system energy performance. By cleaning the panels with this dust removal mechanism we can improve power generated by 19% practically on 2.2KW plant built at our college GIET, Rajahmundry. And by doing economic analysis we can forecast the savings and potential of our proposed method. Pay back period for a typical 2.2 KW plant cleaning mechanism is five and half years and beyond that lot of money, energy and effort are saved. The problem of **water**: given the dire scarcity of water in Rajasthan and other regions around the country, it should no longer be acceptable that it be sloshed, endlessly, onto solar panels for cleaning. This problem is addressed in our paper. So if we concentrate on cleaning systems which are suitable for arid, desert conditions and other local conditions, customized systems will increases the efficiency of plant. Which in turn increases the rate of returns.

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