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Solar Panel Cleaning Robot

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Abstract:- The dust particles accumulating on the solar panels will prevent the solar energy from reaching the solar cells, thereby reducing the overall power generation. Power output is reduced as much as by 50%, if the module is not cleaned for a month. In order to regularly clean the dust, an automatic cleaning system which removes the dust on the solar panel is developed. In this paper, the problem is reviewed and the method for dust removal is discussed. A robot cleaning device is developed and it travels the entire length of the panel. A PIC microcontroller is used to implement robots control system. The robot provided a favourable result and proved that such a system is viable by making the robotic cleaning possible, thus helping the solar panel to maintain its efficiency.

Keywords:- PV panels, Brush, DC motors, microcontroller, battery, Dust effects.

I. INTRODUCTION

After the invention of the solar cell, the solar technology reached the skies by implementing solar panels that use the solar energy to generate electrical energy. Renewable energy is used in all the industries and they use huge solar panels in more numbers in the form of an array. On the other hand it has also started playing a major role in the household usage. Now the problem with the implementation of solar panels is, their maintenance. Different cleaning methods are used to clean the solar panels to maintain their efficiency [1]. After one year of exposure without cleaning, the systems were cleaned using pressurized distilled water spray with brushing for one of the plant that showed 6.9% energy generation efficiency [2].There are many factors that affect PV panel's power efficiency, such as, shadow, snow, high temperatures, pollen, bird droppings, sea salt, dust and dirt. The main factor that affects a PV panel's efficiency is dust, which can reduce its efficiency by up to 50%, depending on the environment.

Cleaning dirty panels with commercial detergents can be time consuming, costly, hazardous to the environment or even corrode the solar panel's frame. Ideally, solar panels should be cleaned every few weeks to maintain peak efficiency, which is especially hard to do for large solar panel arrays. There is a need for an automated cleaning solution to this problem which can service large ground based solar array up to an operating park of 22,000 panels (20,000 Square meters).

The cleaning of dust particles on the solar panel is a huge problem because it's time consuming process and requires lot of man power and money. To remove this limitation, robotics can be used as it eliminates human labour and at the same time more economical and autonomous.

Fig.1:- solar panel

II. ANALYSIS OF DUST ON PANEL

The accumulation of dust on the surface of a photovoltaic module, decreases the radiation reaching the solar cell and causes loss in the generated voltage and power. Dust doesn't only reduce radiation on the solar cell, but also changes the dependence on the angle of incidence of such radiation. According to research, daily energy loss along a year caused by dust deposited on the surface of the PV module is around 4.4%. During long periods without rain, daily energy loss can be higher than 20%. In addition, the irradiance loss is not constant throughout the day and is strongly dependent on the sunlight incident angle and the ratio between diffuse and direct radiations. When studied as a function of solar time, the irradiance loss is symmetric with respect to noon, where they reach the minimum value.

PV module performance has been tested under the deposition of different pollutants (red soil, ash, sand, calcium carbonate and silica). According to the obtained results, a drop of PV module's voltage and output power is observed when dust particles are deposited on the PV module depending on the mass accumulated and the type of pollutant. Moreover, larger reduction occurs when the PV module's temperature is increased. In addition to that, keeping the PV modules clean and cool, results inefficient system performance. Power generation in the solar panel with dust and without dust with varying load resistance is experimentally determined. [4]

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III. NEED FOR AN AUTOMATIC PANEL CLEANER

Accumulation of dust on even one panel, reduces their efficiency in energy generation. That is why; the panel's surface should be kept as clean as possible. Current human based cleaning methods for Solar panels are costly in terms of time, water and energy usage. No automation has taken place in cleaning the solar panels, so, there exists a need for developing automatic cleaning machines which can clean and move easily on the glass surface of the panels.

IV. PV EFFICIENCY

Efficiency in photovoltaic solar panels is measured by the ability of a panel to convert sunlight into usable energy for human utility. Maximum efficiency= {(max power output)/(incident radiation flux*area of collector)}*100.

V. METHODOLOGY

The proposed solar panel cleaning robot is used to remove the dirt and dust deposited on the solar panel thus helping the solar panel to absorb the maximum quantity of energy.

The proposed system consists of two main parts, the first is the cleaning robot and the second is the carrier robot. The carrier robot acts as a carrier that carries a cleaning robot by moving from one panel to another. The cleaning robot travels along with the carrier robot, covering the entire length of the panel. The brush which is attached to the cleaning robot takes away the dirt and dust from the panel. The robot is programmed with a microcontroller which controls its operations and its movement from one panel to the other panel.

The main criterion of the cleaning system design is its ability to clean multiple panels in a solar farm using a single robot. Such a system is considerably much simpler than having multiple robots in the same farm working simultaneously.

In practice, cleaning of solar panels should be frequently done which makes the process more laborious and expensive [5].In this paper, the effects of accumulated dust on the performance of the solar panels are investigated by referring the results obtained by experimentation in dusty atmosphere of different levels [3]. An auto cleaning robot to work as the auto cleaner which is equipped on the solar panel is also proposed.

A. Working Principle

The carrier robot, along with the cleaning robot moves towards the solar panel and stops its movement by sensing the solar panel. The carrier robot then sends the signal to the cleaning robot. By receiving the signal, the cleaning robot travels to the entire length of the solar panel in both forward and backward directions and cleans the panel for the specified time duration. After cleaning, it returns back to the carrier robot. The carrier robot moves to the next panel and the process is continued.

B. Carrier Robot

The carrier robot detects the solar panel with the help of IR sensor and stops when the sensor output becomes high. The sensors are used to sense the start and end of panels. It helps the robot to understand where to stop and where to start. When the carrier robot detects the panel, the output of the IR sensor becomes high and it stops the movement of the carrier robot. At this time, the transmitter sends the signal to the cleaning robot to perform its cleaning action.

The movement of the carrier robot is performed by the driver circuit. After cleaning the panel, the cleaning robot reaches the carrier robot and transmits the signal to the carrier robot. As soon as the carrier robot receives the signal, the carrier robot along with the cleaning robot travels to the next panel and the process is continued. The transmitter and the receiver action actions are carried out by means of the transmitter and the receiver module.

- *Block Diagram*

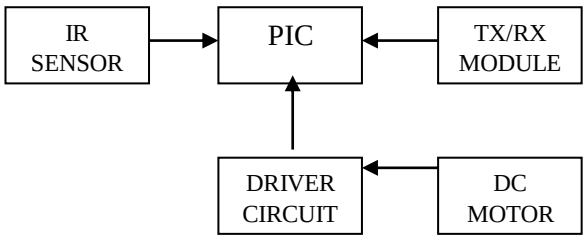

Fig. 2:- Block Diagram

C. Cleaning Robot

When the carrier robot stops its movement by detecting the panel, it transmits the signal to the cleaning robot. The cleaning robot, after receiving the signal from the carrier robot, travels to the entire length of the panel in forward directions.

On moving in forward direction, the cleaning robot removes the dust and dirt accumulated in the panel with a brush which is attached to it. After reaching the time duration, it travels in reverse direction and reaches the carrier robot. On reaching the carrier robot, it again transmits the signal to the carrier robot. The carrier robot after receiving the signal, starts to move and when it senses the panel, it stops again and the process is continued.

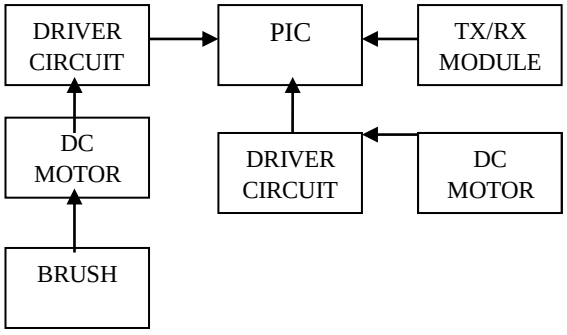

Fig. 3:- Cleaning Robot Block Diagram

D. RF Module – Transmitter & Receiver

The RF modules are 433 MHz RF transmitter and receiver modules [7][10]. The transmitter draws no power when transmitting logic zero while fully suppressing the carrier's frequency. It thus consumes significantly low power in battery operation. When logic one is sent, carrier is fully on 4.5mA with a 3volts power supply[9]. The data is sent serially from the transmitter which is received by the tuned receiver. Transmitter and the receiver are duly interfaced to two microcontrollers for data transfer [8]

- *Transmitter Block Diagram*

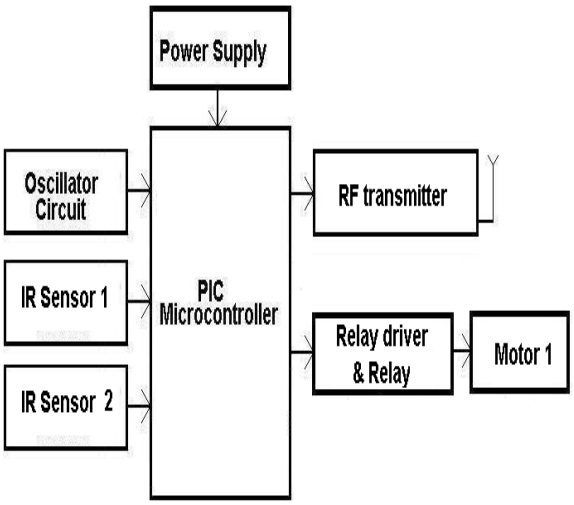

Fig. 4:- Transmitter Block Diagram

- *Circuit Diagram*

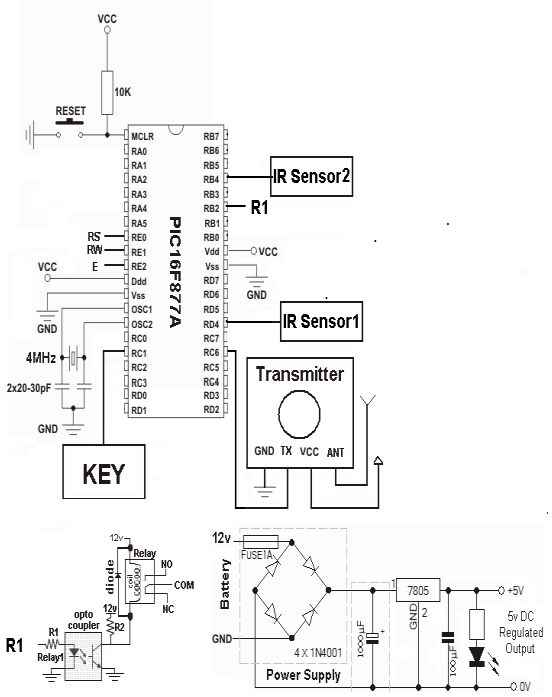

Fig. 5:- Transmitter Circuit Diagram

- *Receiver Block Diagram*

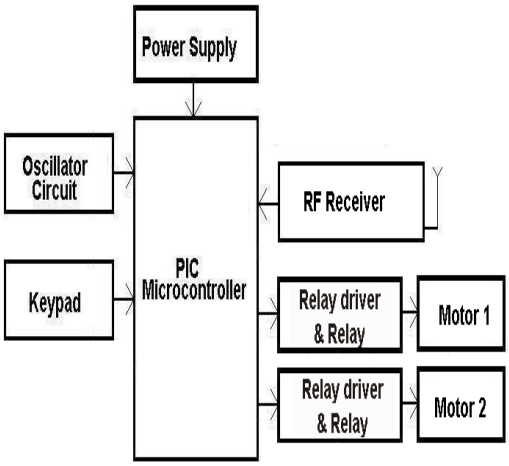

Fig. 6:- Receiver Block Diagram

- *Circuit Diagram*

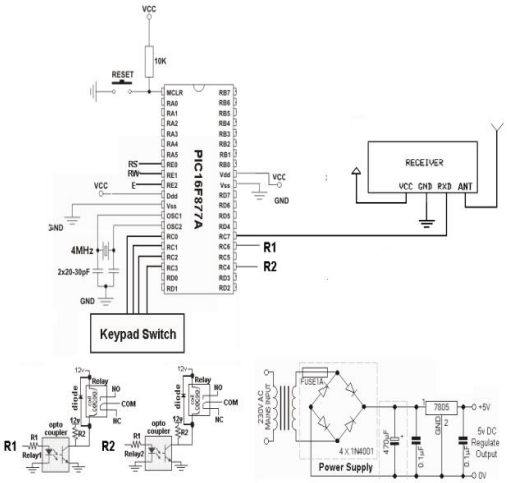

Fig. 7:- ReceiverCircuit Diagram

- *Flow Chart*

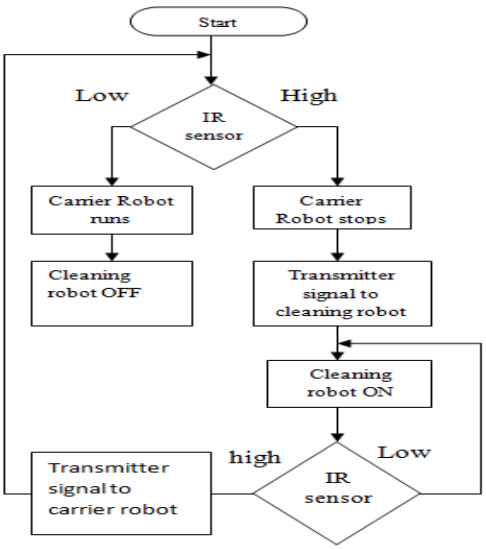

Fig. 8:- Flow Chart

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VI. CONCLUSION

This project highlights the effect of dust, dirt, pollen, sea salt, and bird droppings on the PV systems' efficiency. Dust has a major impact on the efficiency and performance of the solar panels. The reduction in the peak power generation can be up to 10 to 30%. Power reduction was observed due to dust accumulation on the panels and this can be improved by using robotic cleaning method. It has increased Power generation capacity of the solar panels. Easy maintenance, low cost and less power usage are few advantages of this process. Finally, the reduction in the peak power generation can also be overcome by using this cleaning system.

The device is lightweight because most of its material is made of aluminium. Comparing the costs of cleaning by Manual operation and Automatic operation, the cost for automatic cleaning is proved to be more economic and significantly less cumbersome, particularly, in systems with large number of solar panels. Frequent and periodical cleaning ensures that the solar panels work consistently with a good transmittance at all times [6].

VII. FUTURE SCOPE

The device that is developed, reduces the number of workers needed to clean the arrays significantly. Further development could be done to optimize the system to be smaller, lighter and easier to assemble in higher volumes and to become more user-friendly. The next focus will be on diversifying the robot's functionality by including auto-inspection, communication and self-diagnostic features.

The installation of a thermal camera module that will allow for inspection of the panels since the cleaning head is in direct contact with every individual panel. Cold spots just under the glass surface will indicate a section of panel that remains un-cleaned and will prompt the cleaner to make another pass if needed. Solar panel energy can be used instead of using individual battery. Wireless cameras can be also attached for perfect wireless operation.

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