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Maintaining the efficiency of solar panels using IoT

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***Abstract*---**The efficiency of Solar Photovoltaic panel is affected by various factors such as dust sedimentation, shading, high temperature and damaged PV panels. Hence this paper proposes a system to eliminate the main factors that majorly affects the efficiency of solar panels, thereby maintaining the efficiency of solar panels. Cleaning of panels can considerably increase the efficiency of electricity generated and also increase the durability of Solar panels. The shading problem can be addressed by using solar tracking mechanism. Over heating of PV panels can be reduced by various cooling techniques and damaged PV panels can be identified using real time monitoring. Data collection and cloud computation can be done on that data to provide a better working environment for this proposed system.

***Keywords*---**solar panel, PV-cleaning, solar tracking, IoT- real time monitoring, efficiency maintenance.

Introduction

Photovoltaic module is one which generates electricity from solar radiation. Photovoltaic module consist of semiconductors, with the help of which, solar radiations are converted into direct current. Series of PV modules are connected to form a solar panel. According to our world in data case study report for 2021,

12.7% of total energy consumed in world is from renewable energy sources in which solar energy ranks third behind hydro and wind energy[1]. But the recent advancements in the development of solar panel technologies will change the trend in the production of solar energy. There is gradual increase in the power dependent on solar over the years; hence it is necessary to look into the efficiency of solar power generation. The main external factors that affect the efficiency of solar panel are temperature of solar panels, shading on solar panels, dust and particles sedimentation on solar panels [2]. The proposed system will eradicate those above factors and provide the real time remote monitoring and control over the solar panel setup through the use of internet. Using IoT we can monitor and control the system in real time, this data can be recorded to analyze the pattern and to predict the action of the controller [3]. Mega solar power plants are already installed in various countries like Australia, the Middle East, USA, Europe, and China. The on-site issues which usually overlooked are bird droppings, deposition of dusts and water stains, which would reduce the solar panel efficiency significantly. Also there is 10-25% of efficiency reduction due to losses in wiring, module soiling and inverter. It has been analyzed that the dust accumulation is mainly depending on the slope, orientation, type of coating, surface roughness etc. Factors influencing dust settlement. It is reported that energy loses are huge in fixed horizontal panels, which is around 8-22%, than compared to tilted panels (45◦), here the losses around 1-8% only. Also, other external parameters like humidity, temperature, wind speed and regional characteristics like traffic, air pollution and plants play crucial role in dust deposition. Further the biological, electrostatic and chemical properties of dust, also shape, size and weight of the dust particles influence the accumulation of dust on the surface of panels [4]. The performance was much affected due to local problem of bird droppings, which would result in dropping in efficiency.

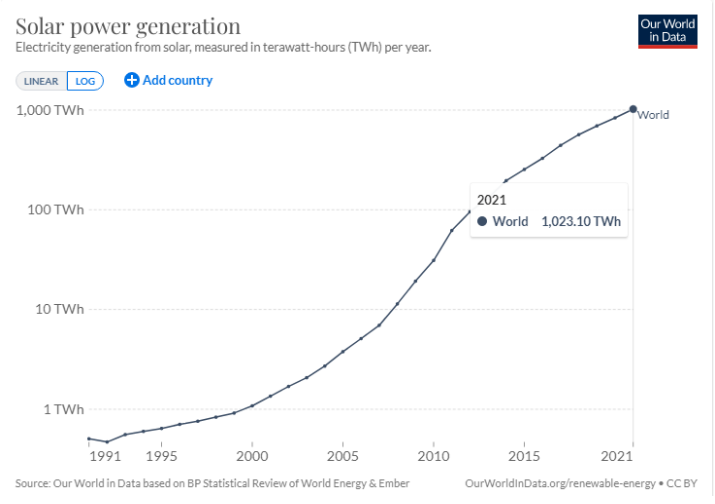


Fig.1. Total solar power generated and consumed by all countries from 1991 – 2021

Related works

Literature survey of the works related to tracking the efficiency of solar panels, real time monitoring of system using IoT, solar tracking system, cleaning of solar panel are discussed in this section. The authors of [5] M.Catelani et al discuss the effects of dust on solar panels that affects the efficiency of solar power generation using solar panels. The authors of [6] B.Abilash et al highlights the effect of tracking and dust that invariably affects the efficiency of solar panel and published the comparison result of output power and efficiency of panels with and without tracking and dust sedimentation.

Table 1
Comparision between efficiency panels of various conditions

System	Cleaned panel with tracking	Cleaned panel without tracking	Dusty panel with tracking	Dusty panel without tracking
P_{max}	7.48W	6.39W	3.99W	2.819W
% efficiency	7.13%	6.08%	3.8%	2.65%

The authors of [7] P.Visconti et al discuss the methods to control the bi-axial solar tracking by using software. By using biaxial solar tracking we can control the movement of solar panel in both axes that is in all four directions. The authors of [8] D.Saravanan et al describes the method of monitoring and controlling of solar panel in real time using iot. The authors of [9]Narang er al explains the mechanism used in robotic arm used to clean the dusty solar panels. And this robotic arm is activated and controlled using internet of things. Narang et al reviews the process and working of that robotic arm.

Proposed System

The proposed system consist of three individual sub-systems which acts together to achieve the desired results. First sub-system is the cleaning mechanism which consists of a frame that covers the area of solar panel. A rotating bar which sweeps over the panel is covered with micro fiber brush with nozzles in it, through which water is sprayed using water pump. Second sub-system is bi-axial solar tracker mechanism. It is a bar frame in which the panels are placed. Third sub-system is the IoT setup with which real time monitoring and controlling of the solar panel is achieved. A temperature sensor is placed to read the real time temperature of the solar panel. If the temperature reaches above 47^0 C, then cooling of panels is necessary hence water cooling can be done using the nozzles placed on the rotating bar. This can be done twice and if the temperature still high then we can tilt the panels using the tracking mechanism to cause artificial shading on solar panels thereby reducing the temperature and keeping it in a nominal values. Since biaxial tracker is used, we can control the movement of solar panel in all four directions. The tracking is done using software. The required value to rotate the solar panel to obtain a high efficiency is computed using internet and updated to the tracker using IoT. Remote real time monitoring

and controlling can be achieved through IoT. The output voltage of each panel is updated to IoT by measuring the voltage of the panel using voltage sensor. This can be used to find the faulty panels if the particular voltage of the panels drop.

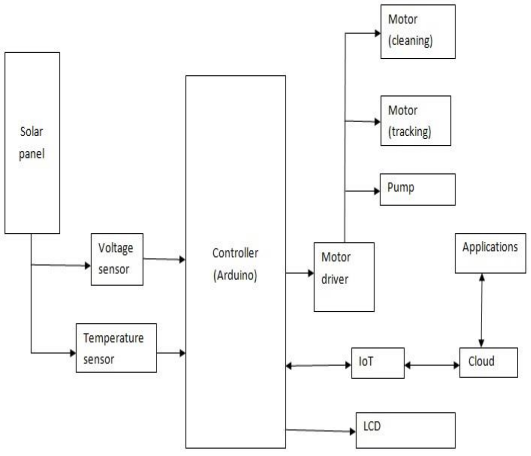
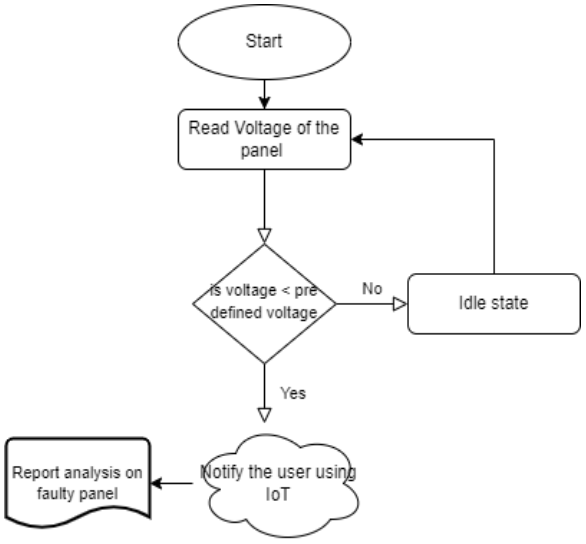


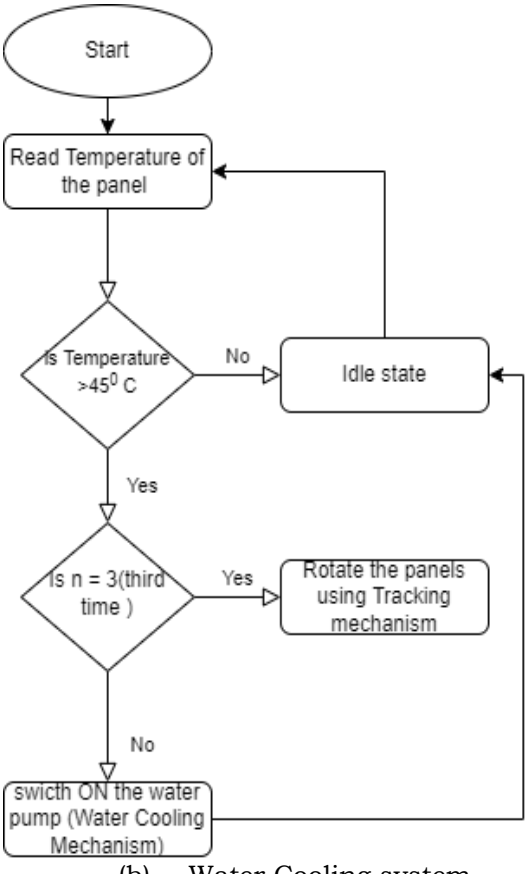
Fig. 2. Block Diagram of the proposed system

Workflow

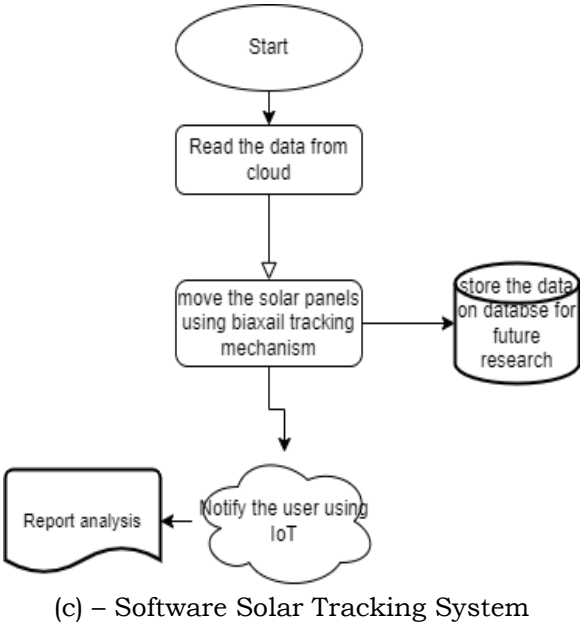
The following are the workflow of the four subsystems namely cooling system, cleaning system, tracking system, fault detection system. Though all these four subsystems takes place simultaneously, the workflow is given separately to each subsystem for better understanding.



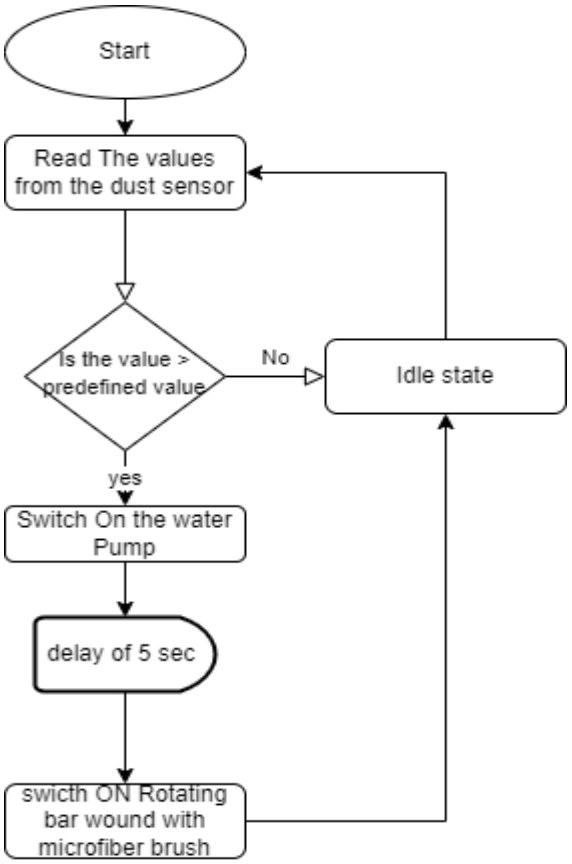
(a) – Fault detection system



(b) – Water Cooling system



(c) – Software Solar Tracking System



(d) – panel cleaning system

Fig 3. Workflow diagram of all four subsystems.

Simulation

The simulation of the proposed project is done using Proteus simulation software and the following are the simulation results.

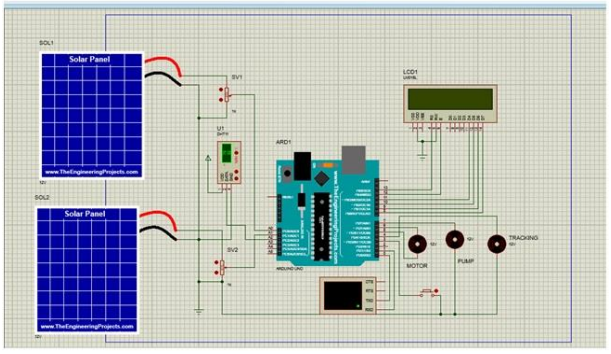


Fig. 4. Simulation- idle state

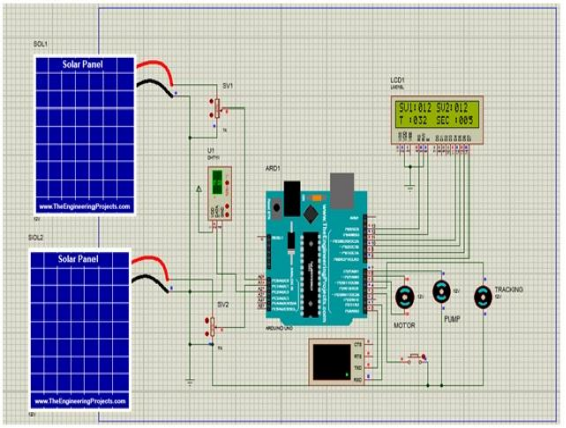


Fig 5. Simulation - running state

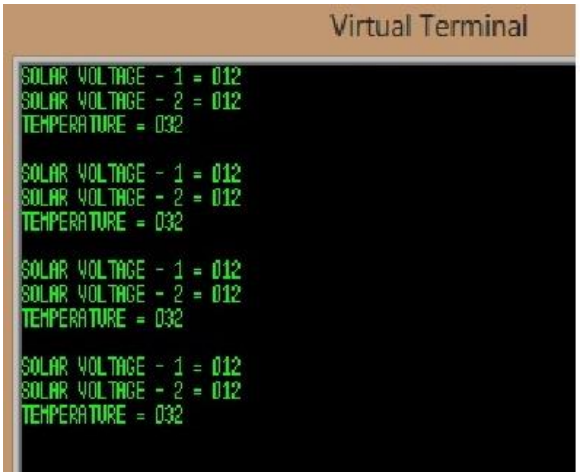


Fig 6. Report on Voltage readings (Fault detection subsystem)

Conclusion

By using this proposed method, we can identify the faulty panels easily in solar power plants where large number of panels is available. By cleaning the panels regularly we can maintain the efficiency of solar power generation and thereby producing reliable power generation using soar power panels. Cleaning the panels also increase the lifetime of the panels since it is also a part of maintenance of the panels. The biaxial tracker is used to track the sun thereby having the control of rotation in all four directions, and it is software controlled, hence it is very reliable. Water cooling method to cool down the temperature of panels also contributes to cleaning soft dust particles on the surface of the panels. The cleaning process is carried out only when necessary thereby reducing the amount of water and energy wasted in the process.

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