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DESIGN AND REALIZATION OF AUTONOMOUS CLEANING ROBOT FOR SOLAR PANEL APPLICATONS

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ABSTRACT:

Deposition of tiny dust particles on the solar panels has reduced the efficiency of solar panels. To improve the efficiency of solar panels, an autonomous cleaning robot is designed and implanted in the proposed system. Cleaning robot is designed with IoT (Internet of Things) enabled Node MCU ESP8266 on Arduino IDE controller. Motion of the robot is achieved through DC gear motors placed on four sides of robot. Straight forward-reverse movement and the 360^{o} rotation of the robot are activated using IoT systems. Ultrasonic sensors are placed on the front and back side of the robot to identify the obstacles. A system is designed in such way to soak the water on the solar panels through the nozzle arrangement fixed on the front end of the robot. In the proposed system, a brush arrangement is fixed at the back the water nozzle to clean the dust and tiny particles deposited on the solar panels. Cleaning robot system is designed similar to that of line follower robot. The entire operation of the proposed system is validated through the hardware experimentation.

Key Words- Solar panel, Internet of Things, Arduino controller, ultrasonic sensor

1. INTRODUCTION

One of the renewable energy sources, solar energy, has a significant impact on the rise in the demand for electrical energy in our overall economy. Researchers have been researching solar energy resources to increase the efficiency and energy extracted from the sun, control and power electronics, and establish many countries' energy policies based on solar energy. The production of electrical energy extracted from sun rays. Due to environmental conditions, dust is affected the solar panel to reduce the amount of electrical power. The proposed system implements the solar panel cleaning robot. Solar energy has gained widespread acceptance worldwide as non-renewable energy sources rapidly deplete themselves, and environmental concerns grow. Solar energy has a tremendous potential of all renewable energy sources because it is so widely accessible. Many scientists studying this area have become interested in its utilization because it is safe and pollution-free for the environment. Many different solar-powered applications can be found on the market nowadays. Due to their reasonable prices and increasing market demand, these solar PV-based devices are becoming more popular. These products are solar heaters, blowers, networking tools, coolers, clocks, lights, and calculators. Shortly, it is anticipated that this usage trend for solar PV cells will continue to grow. It will only be one if only a tiny percentage of this energy is used, especially when other sources around the country are running low. It will be one of the most critical energy sources. The global energy demand is 1013 watts. It is vital to store this plentiful energy so that it can be used when it is most needed. It is crucial to store solar energy because it is time-dependent due to environmental conditions like cloud formation, rainfall, floods, sandstorms in desert regions, etc. There are various ways to gather and store solar energy, but

solar cells and the photovoltaic effect allow for the direct conversion of solar energy into electrical energy. As a result, solar energy is increasingly being used, and PV arrays are installed in significant numbers, but maintaining its efficiency is just as crucial. The biggest issue that limits the use of solar energy is the buildup of dust on PV modules, which lowers the efficiency of solar panels. This study primarily concerns how dirt and dust buildup on PV modules impacts their effectiveness, effective operating methods, design, production, and successful installation. PV modules are hindered by the dirt and layers of dust that has built up on solar panels. Due to the local environment, dust forms with varying particle sizes can be found in other places. However, because solar panels are not always easy to access, cleaning them is not always straightforward. It is unsafe and challenging to reach out there to physically clean solar panels because they are situated in locations with extreme temperatures, such as desert regions. It also takes time to accomplish it safely. Leaving solar panels up might shorten their lifespan and cause irreparable damage to the glass. Therefore, creating a system that can automatically clean the panel array is preferable.

2. CLEANING ROBOT

2.1 *Block Diagram of Proposed System*

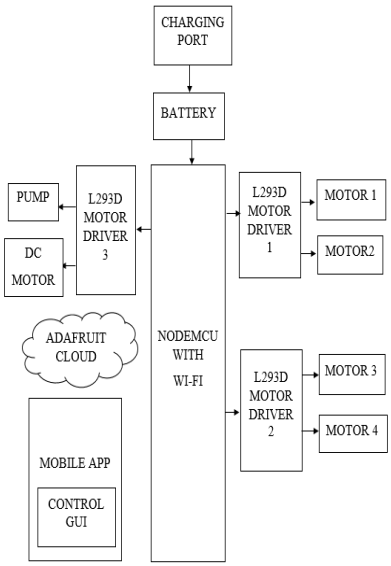

Fig.1 Block diagram of cleaning robot

A cleaning robot is a mechanical system that synergistically integrates mechanical systems to clean solar panels. One of the world's most innovative and well-known products for robotic solar panel cleaning systems. PV module cleaning involves using a cleaning robot, which is expensive. This robot uses intelligent technology, such as a mobile application and data-driven programming, to perform the cleaning task. A base circuit-controlled automatic drive system that works with the solar panels' length and uses switches to turn on the cleaning system for them. As a result, it helps solar panels return to being as effective as they were at generating solar electricity for usage at work. Three motor drivers, five motors, a relay, a pump, and Internet of Things apps make up the solar panel cleaning robot.

2.2 *Circuit Diagram*

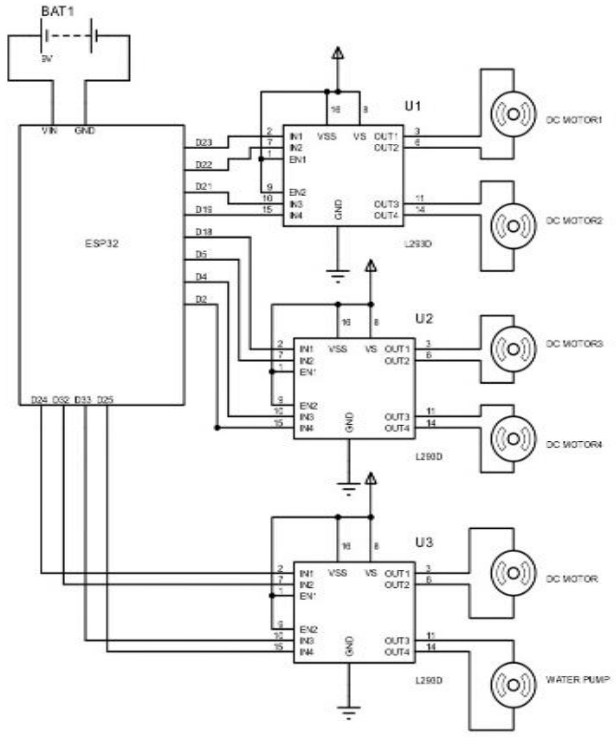

Fig.2 Equivalent circuit of cleaning robot

Motor driver1 control the two motors (i.e., motor1and motor2), motor Driver 2 contains the two motor (Motor3 and Motor4), and motor driver controls motor 5 and the pump. During the operation, the commands through by mobile application move the robot in directions such as forward, reverse, left and right. The purpose of the pump is to spray the water and DC motor to clean the solar panel. The NODEMCU controls all processes and information through Wi-Fi. The AD fruit Io receives the commands and transmits them to the chain robot. Block diagram and circuit of the cleaning robot is shown in Fig.1 and Fig.2 respectively.

3. HARDWARE DESCRIPTION

3.1 Controller

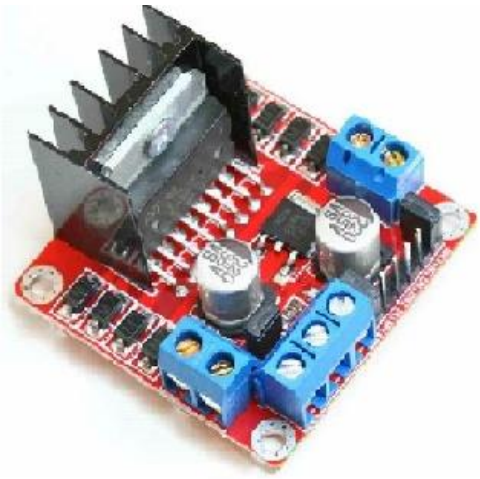

Fig.3 Driver unit of robot

The H-bridge idea underlies how it works. A voltage may go in either direction thanks to a circuit design known as an H-bridge. Since voltage must change its direction to rotate a DC motor correctly or anti - clockwise direction, an H-bridge IC is ideal for this task.

A single L293D chip contains two H-Bridge circuits that may independently rotate two DC motors as shown in Fig.3. It is increasingly utilized in robotic applications to operate DC motors due to its size.

3.2 Water Pump with Nozzle

Fig.4 Water pump of cleaning robot

Micro Submersible Pump DC 3-12V DIY is used this project as shown in Fig.4. Mini water pump for a water feature in the garden. This compact, inexpensive submersible pump motor can be powered by a 3 to 6 V power source. It can use up to 120 litres per hour and only use 220 mA of current. You only need to attach a tube pipe to the motor output, submerge it in water, and then power it. Make sure the motor is never submerged beneath the water. A dry run will make noise and could heat-relatedly damage the engine.

3.3 DC Gear Motor

A DC motor is an electrical machine that converts electrical energy into mechanical energy. In a DC motor, the input electrical energy is the direct current transformed into automatic rotation.

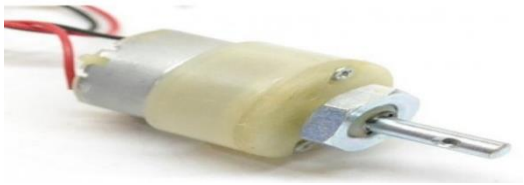

Fig.5 DC gear motor of robot

When exposed to a magnetic field, a current-carrying conductor suffers a torque and an inclination to move. In other words, a mechanical force is created when an electric field and a magnetic field interact. Based on this theory, a DC motor, also known as a direct current motor, operates as represented in Fig.5.

3.4 NODE MCU ESP 8266 WIFI Module

The ESP8266 Node MCU CP2102 board contains the well-integrated ESP8266 chip, which was developed to meet the needs of a newly linked world. Thanks to its complete and independent Wi-Fi networking solution, it can either host the application or assign all Wi-Fi networking responsibilities to another application processor.

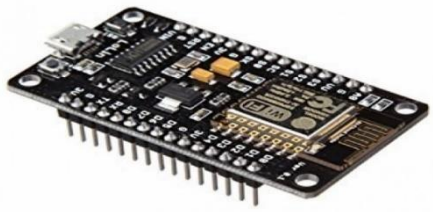

Fig.6 NODEMCU with WIFI module

The ESP8266 can be connected to sensors and other application-specific devices through its Operating system with little to no setup required and with minimal runtime impact on its strong internal processing and storage resources. It only needs a tiny amount of external circuitry because to its high level of on-chip integration, and the complete solution including the front-end module—is designed to occupy a modest amount of PCB space. The ESP8266 Node-MCU development board is a great plug-and-play choice for low-cost Wi-Fi applications. The breadboard-friendly ESP-12 Lua Node-MCU WI-FI Board Internet of Things board comes with a full ESP8266 Wi-Fi module with all the Outputs isolated, a full USB-serial connection, and a power source. The module has a pre-flashed Node-MCU code. This board features a multi-with with Node-MCU, firmware for the ESP8266 that is based on Lua and offers simple control using that interface.

4. RESULTS AND DISCUSSION

A Robot cleaner test setup is planned and simulated in phyton and development tool is thonny as shown in Fig. 7 to Fig. 9. designed Robot cleaner test setup. Every component accessible in the intended test

setup such as Dc motor, wheel, gear box and rigid body etc. are given and connected according to the test setup

Fig.7 Serial Port Input Value

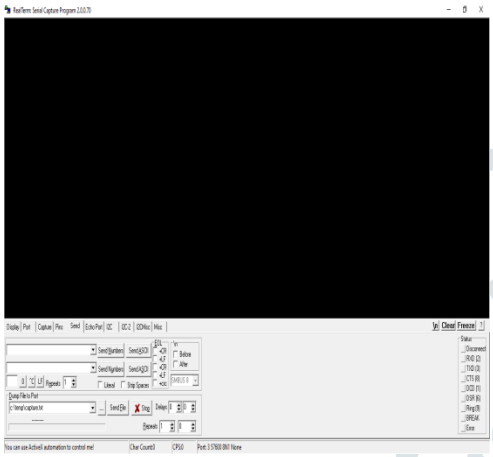

Fig.8 Port activation module

The input and output ports are activated based on the output of the sensor as represented in Fig.7. Each and all ports of the controller are activated and provides the binary value to the driver circuit as shown in Fig. 8.

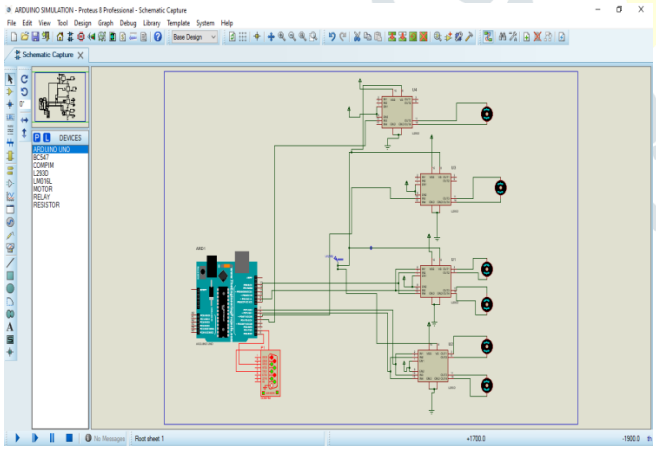

Fig.9 Driver based DC motor system

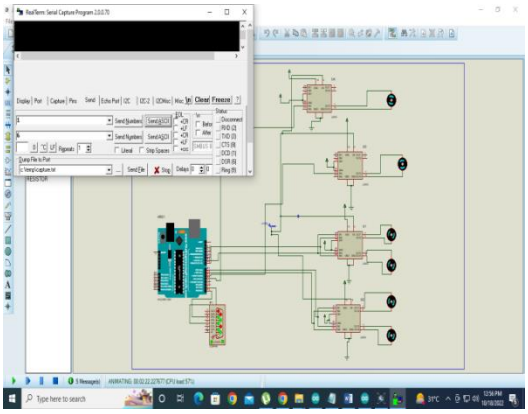

Fig.10 Driver based DC motor system with port activation module

Fig.11 Snapshot of cleaning robot

DC gear motors are activated through the driver circuit as shown in Fig. 9. For driver modules, ports are get activated for forward and reverse operation of the robot as represented in the Fig. 10. The entire components are assembled in single board and the snapshot of the same is represented in Fig. 11.

5. CONCLUSION

By automating the cleaning procedure, manufacturers can maintain efficiency without sacrificing the solar panel's efficacy. The solar panel must be frequently cleaned to maintain maximum performance. The original solar panel cleaning system was constructed with the design objectives in mind. The analysis of our model produced the following findings. Dust buildup on the panels caused power loss, which may be remedied by following. Robotized cleaning methods. As an outcome, the solar panels' capacity to produce energy has increased. This method has a few benefits, including simple maintenance, low cost, and minimal power use. Using this methodology may also lessen the fall in peak power generation. Because of its numerous uses and heterogeneous mix of multiple communications and embedded technologies in its design, the Internet of Things is a fresh Internet revolution and a crucial study area for academics in integrated computer science and

information technology. They all expect to offer this process a new dimension and usher in the concept of anytime, anywhere, any media, anything for communications by allowing communication with and among intelligent gadgets.

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