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Solar Panel Cleaning Robot

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Abstract: *As climate change and global warming threaten the future of our planet, it is becoming increasingly crucial to find sustainable ways to fulfill our energy requirements. One of the most efficient ways of moving towards renewable and non-polluting energy sources is to generate electricity using solar panels to harness the sun's energy. Since they have no moving parts, solar panels are one of the most cost-effective and low-maintenance ways of generating. Despite all their benefits, the efficiency of solar panels can plummet if dust, dirt, and grime are allowed to accumulate. If maximum efficiency in power generation is to be maintained, solar panels need to be cleaned timely. However, manually cleaning solar panels is hazardous and time-consuming. This Solar Panel Cleaning Robot aims to maintain the efficiency of solar power production by making sure the Solar panels are kept clean without putting humans at risk. This robot comes equipped with a roller brush and a water sprayer to clean all dirt and grime from the surface of the panels. The sprayer gets its supply of water through an on-board tank. The rubber caterpillar tracks ensure that this robot can adhere to the slick surface of solar panels. This robot operates remotely and wirelessly. Along with large-scale industrial applications such as dedicated solar power plants, this robot can also help boost the efficiency of solar panels in smaller applications such as rooftop solar panels in homes and offices.*

Key Word: *Solar Panel, Solar panel Cleaning, Robot, Solar Panel Cleaner Machine.*

I.INTRODUCTION

Renewable energy solutions are becoming increasingly popular. A photovoltaic (solar) system is one example. Maximizing power output from a solar system is desirable to increase efficiency. In order to maximize power output from the solar panels, one needs to keep the panels clean. As such, a means of solar panel cleaning system is required. This is a far more cost effective solution than employing extra man power to clean the panel. It has been estimated that the yield from solar panels can be increased by 30 to 60 percent by maintaining the solar panel clean all the time. This project develops a semi-automatic solar panel cleaning robotic system that will keep the solar panels clean in order to maximize efficiency.

Features of Solar Panel Cleaning Robot:

- Maintains efficiency of solar panels by keeping them clean.
- Remote and wireless operation ensures workers aren't put in danger
- Roller brush cleans all dust, dirt, grime, and debris.
- Equipped with water sprayer supplied with on-board water tank.
- Compact, portable, and user-friendly design.

The solar panel cleaner robot makes use of a water tank with motorized pump along with 4x DC motors to achieve vehicle motion using caterpillar wheel motion. The robotic vehicle is built over a metal chassis with a controller circuitry operated over RF wireless remote.

A remote controller is used to wirelessly transmit control movement data to the robotic vehicle. The controller receives the data and operates the wheel motors in desired directions to achieve the desired movement. The front brush is fixed to the main chassis front and operated by a geared DC motor. The front panel also has an integrated water pipe that is used to drive water for cleaning using a dc pump to the front of the brush. The system thus allows for easy solar panel cleaning using wireless control.

II.BLOCK DIAGRAM

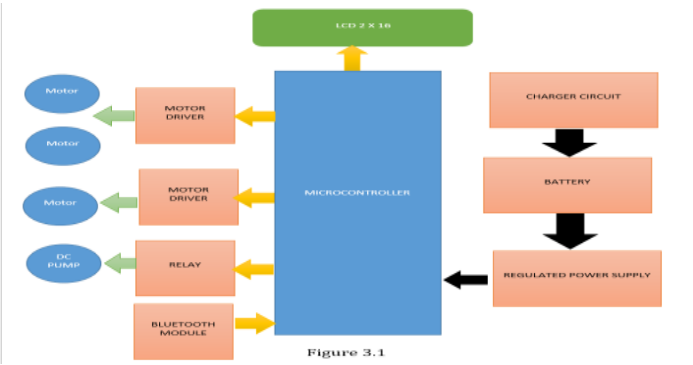


Figure 3.1

III. BLOCK DIAGRAM EXPLANATION

Microcontroller: It is a low power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash Programmable and Erasable Read Only Memory ROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the MCS-51. Instruction set and pin out. The on chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, it provides a highly flexible and cost effective solution so many embedded control applications.

LCD Display: LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD, each character is displayed in 5x7-pixel matrix. This LCD has two registers, namely, Command and Data.The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

Motor Driver IC (L293D): The Device is a high voltage, high current four channel driver designed to accept standard DTL or TTL logic levels and drive inductive loads (such as relays solenoids, DC and stepping motors) and switching power transistors. The Device is a monolithic integrated high voltage, high current four channel driver designed to accept standard DTL or TTL logic levels and drive inductive loads (such as relays solenoids, DC and stepping motors) and switching power transistors. To simplify use as two bridges each pair of channels is equipped with an enable input. A separate supply input is provided for the logic, allowing operation at a lower voltage and internal clamp diodes are included. This device is suitable for use in switching applications at frequencies up to 5 kHz

Using the L293D motor driver, makes controlling a motor as simple as operating a buffer gate IC. It totally isolates the TTL logic inputs from the high current outputs. Putting logic 1 on the pin In_1 will make Out_1 pin goes to V_{power} (36 Volts MAX.), while a logic 0 will make it go to 0V. Each couple of channels can be enabled and disabled using E_1 and E_2 pins. When disabled a channel provide very high impedance (resistance) to the motor, exactly as if the motor was not connected to the driver IC at all, this makes this feature very useful for PWM speed control.

Relay: The relay is a device by means of which an electrical circuit can be controlled (opened or closed) by sensing a change in the circuit in which it is connected. In this circuit the electromagnetic relay is used to ON or OFF the device. It works on the principle of electromagnetic attraction and electromagnetic induction.

Bluetooth Module: This module enables you to wireless transmit & receive serial data. It is a drop in replacement for wired serial connections allowing transparent two way data communication. You can simply use it for serial port replacement to establish connection between MCU or embedded project and PC for data transfer.

DC Motor: A machine that covert DC power into mechanical power is known as DC motor. It mainly consist of three main parts, i.e. magnetic field system, armature and commentator. The other part of DC motor is yoke, pole shoe, field or exciting coil, armature core and windings, baring and shaft.

DC machine works on principle that "When a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force." The direction of force is given by Fleming's left hand rule and magnetic field given by;

$$F = BIL \text{ newton}$$

In this project DC motor is used to make rotational torque on a vehicle. It is usually changed into a linear motion.

Charger Circuit: Charger circuit is designed using variable voltage regulator IC LM317and some other electronic components like capacitors, variable resistor etc. Charger circuit is used to charge the 12 V battery. The circuit automatically cut off the charging once battery gets fully charged.

Battery: In this project we are use sealed lead acid rechargeable battery. Lead acid is the oldest rechargeable battery in existence lead acid was the first rechargeable for commercial use. Basically two battery set, one battery set initially charged and power delivered to the motor and another battery set initially discharged it used to store the power. One battery set consisting the three 4V batteries connected in series.

Power Supply: It is a dc regulated power supply consists of bridge rectifier, filter and regulator ic7805.
Power supply block consists of following units:

- Step down transformer
- Bridge rectifier circuit
- Input filter
- Voltage regulators

- Output filter
- Indicator unit

IV.PROBLEM DEFINITION

Most of the time roof top solar not generating the power as per its capacity, the main reason behind is the dust cover over the solar panel. In summer season also due to dust storm over all generation reduces. Maintaining the efficiency is challenge for the solar plant user. They need to appoint someone to clean the panel, manual cleaning the panel is difficult task and also takes much more time.

V.PROPOSED SOLUTION

Panel cleaning can be done by schedule cleaning through water Pipeline arrangement but this method is expensive and there is wastage of water. The proposed solution is Semi-Automated Panel Cleaning Robot. It is very easy to handle and takes little power to clean the Panel without wasting the water also. It can be controlled by Android App by seating somewhere else within its range.

Primary Objective: The main objective of this project is build a Robot used to clean the solar panel and one can control it remotely through an Android App.

Secondary Objective: Besides the main objective, following are our secondary objectives.

- To understand project planning and execution
- To understand the assembly process of Robotic machine
- To understand the programming and circuit designing
- To increase the solar panel efficiency by making cleaning process easy

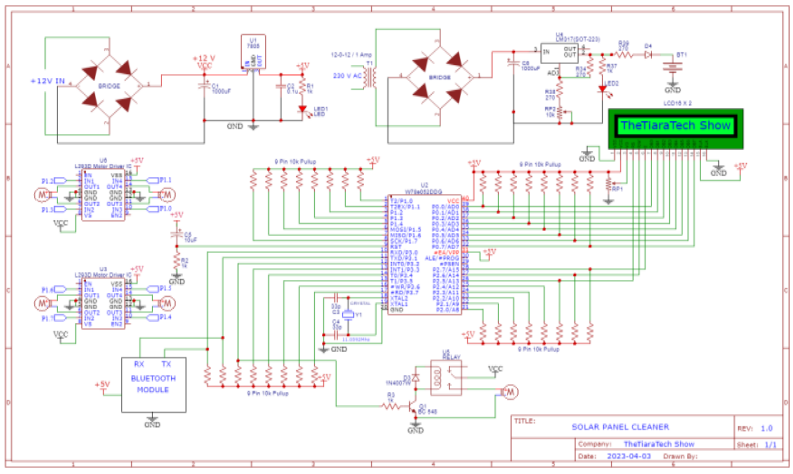
VI.METHODOLOGY

Methodology begins with market survey about the available products related to solar panel cleaning system and mechanism. Some big size automated Solar panel cleaning machines are available in the market but they are very costly. Another way of cleaning the panels are providing permanent water piping arrangement with timers and solenoid valves. Ultimately we come to the point for designing the new type of robot which can be easily operate through Android app and within the budget of the Rooftop solar system clients.

Project basically divided into Three Parts

1) Hardware designing (Circuit and PCB Layout, Mounting and Soldering).
2) Software designing (C code generation to run the project)
3) Mechanical Assembly (Box Cut-out, Motor and Gear arrangement)

VII. CONSTRUCTION AND WORKING



The Solar Panel Cleaning Robot is fabricated on a PVC box to make it light weight and rust free. Four 60 RPM DC Motors are mounted at the four corners of the box. Metallic Clamps are used for mounting the DC Motors. On the front side of the robot, one more DC Motor is used for cleaning mechanism. One round shaped brush is mounted to the front side plate along with some gear arrangement. PVC water tank is mounted on the centre of the base plate. Water tank consist of submersible DC pump. Pump get supply from the relay. PVC pipes and joints are used to spray water on the brush. Control circuit consist of Microcontroller, Motor Driver, Relay and HC-05 Bluetooth Module. The whole system works on 12 V DC rechargeable battery. Controller board consist of charger circuit build using LM317 variable voltage regulator IC. This robot receives the commands from the Bluetooth app. Robot can move front side, back side. It can also rotate left and right through a remote command. User can also control the cleaning motor by ON/OFF command. Pump automatically get switched OFF after

the 2 sec of the control command. Bluetooth module works on 9600 baud rate, whenever it receives the commands from android app, it transfer the code to microcontroller. Microcontroller then compares the code and check it for which command it needs to execute. According to that it turn on the DC Motors with the help of driver IC L293D. Similarly for switching ON or OFF the pump microcontroller activates/deactivates the RELAY.

VIII.ADVANTAGES

1. Maintains efficiency of solar panels by keeping them clean.
2. Remote and wireless operation ensures workers aren't put in danger
3. Roller brush cleans all dust, dirt, grime, and debris.
4. Equipped with water sprayer supplied with on-board water tank.
5. Compact, portable, and user-friendly design.

IX.DISADVANTAGES

1. Not entirely autonomous, requires human operators.

X.APPLICATIONS

1. Large scale solar power producing plants
2. Rooftop solar panels at homes and offices

XI.FUTURE SCOPE

As of now it is sufficient to clean any roof top solar system, but for large solar plant we need to make some design modification. Water container needs to be monitor through a Sensor and whenever it gets empty it gives alert or stop the pump. Bluetooth has some limitation of operation with respect to distance, for large plant we need to employ long range RF of WIFI controlling system. All these recommended things can be possible in future model.

XII.CONCLUSION

The designed Solar Panel Cleaning Robotic machine is very easy to operate and carry to any site or panel. The Water container is sufficient to clean 100 Watt panel at a time, so the wastage of water is minimizes as compare to Static Pipe Line and Solenoid arrangement. Robotic machine is a battery operated and charging the battery is also very convenient. It can be charged through AC Supply or from Solar panel itself.

Wheels are covered with Rubber so gripping is nice at solar panel. It is free to move throughout the panel with control commands so it is capable to clean each and every corner of the Solar Plate.

Auto cut of Pump also a good idea to make proper utilization of water stored in the container.

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