An Automatic Solar Panel Cleaning System

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Abstract - Renewable sources of energy are solar, wind and geothermal which are inexhaustible. Solar energy is abundant in nature and is proving its existence for many applications like street lighting, house hold appliances, water heating, agricultural and industrial purpose. One of the ways to harness solar energy is done by using solar panels. Limitation of solar energy is its efficiency for any application due to the factors like dust, humidity, temperature etc. Electrical parameters of solar panel are sensitive to accumulated dust density and will affect the transmittance of the solar panel thereby reduce its efficiency. In order to overcome this problem, it is necessary to clean the solar panels regularly. One of the method is to increase the efficiency of solar panel is by removing the dust accumulated on solar panel. Cleaning of solar panels is difficult task. The normal way to clean the solar panels is washing them manually but it is not reliable and economical. In this regard a work is taken up to design and implement the automatic dust cleaning mechanism for solar panel. The designed automatic cleaning mechanism consists of Voltage Sensor, LDR arrangement in order to sense the dust accumulated on solar panel. The efficiency of solar panel is determined by taking the readings of voltage and current of particular panel with and without dust for various days, weeks and months. By the recorded values efficiency comparison of solar panel with dust and without dust is made. The designed automatic cleaning system produces an effective, non-abrasive cleaning and avoids irregularities in the generation of power due to the deposition of dust on the solar panel. From the study it is proved that average efficiency of solar panel increases about 1.6% to 2.2% by regular cleaning. Thus developed model maximizes the efficiency.

Keywords: Solar panel, cleaning, sensor network, Node MCU, automatic cleaning.

I.INTRODUCTION

The renewable energy industry has been growing remarkably in the last years and the Fukushima event has given a further incentive. In this context, solar radiation represents one of the most accessible and clean energy resources. For this reason the number and size of the photovoltaic (PV) systems is growing and consequently the amount of the investments and the related opportunities and risks are increasing. Therefore, the optimization of electrical performances of PV plants and the assessment of their quality and reliability are important for both the investors and the manufacturers. The sun emits energy at an extremely large rate hence there is abundant availability of solar energy in the nature. If all solar energy could be converted into usable forms, it would be more enough to supply the world's energy demand. However, this is not possible because of conditions in the atmosphere such as effect of clouds, dust and temperature. Solar energy can be converted to more usable energy forms through solar panel. There is unprecedented interest in renewable energy, particularly solar energy, which provides electricity without giving rise to any carbon dioxide emission. Of the many alternatives, photovoltaic method of extracting power from solar energy have been considered has promising toward meeting the continuously increasing demand for energy. The efficiency of solar panel is limited due natural conditions so it is very much essential to take care of parameters like dust, humidity and temperature. In this regard the work has been taken up to study the efficiency of solar panel with and without dust collected on it. The developed project includes design and implementation of microcontroller based dust cleaning system. The main aim of the project is to provide automatic dust cleaning mechanism for solar panel. The arrangement keeps the modules clean and thereby improving its efficiency. Traditionally cleaning system was done manually. The manual cleaning has disadvantages like risk of staff accidents and damage of the panels, movement difficulties, poor maintenance etc. The automatic dust cleaning system of solar panels has taken to overcome the difficulties arise in the traditional cleaning and also produces an effective, nonabrasive cleaning and avoids the irregularities in the productivity due to the deposition of dust. The studies carried out to evaluate the efficiency of solar panel for dust collected on it for one day, one week and a month. The efficiency of solar panel also calculated after cleaning the surface for one day, one week and a month. And finally comparing both the efficiencies it is proved that solar panel efficiency increases considerably. Thus the developed model enhances the solar panel performance.

II.OBJECTIVE

1. To record the measured voltage and current for efficiency calculation of SPV panel with and without dust.
2. To compare the calculated efficiency of SPV panel with and without dust.
3. To design and implement the microcontroller based dust cleaning system.
4. To maximize the efficiency.

III.PROPOSED SYSTEM

Project proposed system divided into two parts:
1. Mechanical part
2. Electronic part

The chassis, brushing system, vacuum cleaning, and dirt disposal mechanisms make up the mechanical body.

A. Chassis

Acrylic board, two encoder motors with Teflon tyres with O-rings for preventing friction, two ball casters with frictionless steel balls, aluminum angular braces, and aluminum holders for two lead acid batteries with 12V and 1.2Ah ratings make up the body's foundation. These motors are driven independently and positioned diagonally, with two ball casters on the opposite diagonal of the acrylic board, allowing the motors to freely travel along their axes and carry more weight than a chain mechanism. A DC geared motor, sprockets for moving the chain from the geared motor to the spinning brush, and two aluminum rods for supporting the vacuum cleaner mechanism and dirt compartment are all included in the cleaning assembly. This DC geared motor is mounted on one side of an acrylic board, with an aluminum holder and sprockets attached to the shaft of the motor. Both components are mounted on the lower side of the acrylic sheet to keep the robot's centre of gravity low and stable.

B. Brushing

One rolling brush, a steel sheet for the cover, two aluminum holders, two ball bearings, and one mild steel strip make up the brushing mechanism. One rolling brush, set on bearing-filled aluminum holders. This mechanism is connected to the robot's base through a mild steel strip. In the case of a carpeted solar panel, a brush is used to broom the dirt particles into the vacuum chamber for effective cleaning.

C. Vacuum

Cleaning and Disposal of Dirt The vacuum cleaning and dirt disposal system is made up of a vacuum motor, propeller, steel motor holders, filter mounted on two steel rods, aluminum alloy sheet, steel sheet, servo motor, aluminum brackets, and aluminum strips. Filters are positioned on the inside of the aluminum alloy and are mounted to a vacuum motor by steel holders. A robot was created by moulding steel sheet in the form of a robot. Aluminum alloy is shaped into a form similar to steel sheet, but on a larger scale. When both sheets are joined together, a small tunnel appears on the front side and a wide compartment appears on the back side. A narrow tunnel is needed for better dirt suction, and a wide compartment serves as the dirt compartment. To dispose of dirt, at the very end of both sheets, there is an aluminum strip operated by a servo motor mounted on the upside of aluminum alloy right behind the vacuum cleaner. The inner side of the Vacuum Cleaner battery holder is spot welded to accommodate an 18.1V, 5AhLiPo battery.

Circuits were implemented on PCB after component values were optimized.

This project uses five main circuits, including three batteries, and all of them are engineered, evaluated, and implemented in compliance with IEEE Standard 1621. The following is an explanation of both of these circuits:

A. Motor Controllers

Motor controls, also known as H-Bridges, are used to drive motors in both clockwise and counterclockwise directions with a current rating of 15 amps. There are two pieces to this controller. The first part is to use an Node MCU controller to trigger relays and drive motors, while the second part is to regulate the speed of the motors. Switching is done with relays, while speed control is done with transistors. The relays in this circuit have a 12V dc coil rating and a 15A current rating, while the lead acid battery has a 12V and 1.2Ah rating. Since encoder motors have a stall current of 7A, 15A relays were used for safety. In a flyback diode configuration, two diodes are used. The term "free-wheeling diode" refers to a situation in which a diode is placed in reverse between battery terminals. When a relay is de-energized, a large voltage is emitted in the backward state, which can affect other components. To prevent this, a diode in a flyback configuration is used in conjunction with the relay. For speed control, pulse width modulation (PWM) is used. PWM is applied to the transistor BJT 2N2222, along with a duty cycle, to force the motor to start at predetermined intervals, resulting in speed regulation. This circuit is operated by a separate battery that is connected to an ON/ OFF switch and a fuse to provide safety, as well as a red LED that glows if the circuit is disconnected according to IEEE Std. 1621 section 4.

B. Vacuum Cleaning Controller

One transistor, one relay, one diode, and two batteries are used in the vacuum cleaner control circuit. One 12V 1.2Ah lead acid battery is used to control the vacuum cleaner's power (ON/OFF) by energizing the coil of a relay with a diode in the fly back position, and one 18V 5Ah LIPO battery is used to supply power to the vacuum cleaner with different ground terminals to avoid short circuit currents and properly isolate the batteries from the circuit, including a separate Yellow LED for Disconnect. The Node MCU controller sends a signal to the BJT 2N2222 transistor, which energizes the relay and relay switches. Following the switch, the relay allows the 18V battery to supply power to it and switches on the vacuum cleaner with an ON/ OFF switch. Since currents can exceed 7A, this circuit is properly insulated to ensure safety. Two transistors make up the circuit. The Node MCU controller sends a signal to one transistor, which drives the other transistor. The transistor that receives the signal is the BJT 2N2222, and the other is the TIP-122. Since a single TIP- 122 has a high current rating and cannot be powered directly by Node MCU, two transistors are used. The BJT 2N2222 transistor is not used solely because the brush motor's stall current is extremely high, and the BJT cannot have the required current. As a result, combining these two results in a good brush motor driving circuit.

C. Power Supply to Sensors

Many of the sensors are 5V, but the batteries are 12V and 18V. This circuit was designed and implemented to provide 5V to five IR sensors, two encoder sensors, one magnetometer, and one Bluetooth module. The IC 7805 regulator is used to convert 12V to 5V with current in the milli ampere scale. Capacitors are often used for voltage control, and if an impulse occurs that causes power to be disconnected from sensors, these capacitors can serve as a source to keep the sensors connected. Because of section 3.1.14 of IEEE Standard 1621, when the power supply to the sensors is disconnected, the White LED glows and is labelled as disconnected.

D. Precautionary Circuit

Bridge rectifiers, relays, transistors, diodes, fuses, Positive voltage adjustable regulator, LEDs, terminal lines, and slim headers make up this main circuit. There are three sections to this circuit. The first is for motor battery safety and voltage regulation, the second is for circuit battery voltage safety, and the third is for controlling motor battery via circuit battery and powering the Node MCU controller. One relay with a flyback diode, one transistor, one fuse, terminal blocks, one regulator, and a variable resistor are used in the first section. To begin, the battery terminals are connected to a terminal block that is shorted with the inputs of a bridge rectifier, the KBPC 5040, which has a voltage rating of 1000V and a current rating of 50A. If the battery terminals are attached in the positive or negative direction, a bridge rectifier is used to hold the supply voltage positive and protect the circuits. The Node MCU controller sends a signal to the transistor BJT 2N2222, which energizes the relay, allowing the motor voltage to flow to the fuse from the rectifier and then to the regulator input. The LM338k is a positive adjustable voltage regulator with a 15A rating that can control voltage between 12V and 6V. This regulator is used to ensure that the output does not fluctuate and that the motor runs smoothly. After changing the voltage to 12V, the output will be shorted with a terminal block, and that block will now be used for both encoder and brush motor battery output. Fuse holders are used for added protection so that if there is some shot circuiting, it would not damage other components and the fuse can be quickly adjusted. Since the encoder motor's stall current is 7A and the brush motor's stall current is 5A, the fuse used is rated at 10A. Just