Dayananda Sagar University
School of Engineering
Kudlu Gate, Bengaluru-560068

A Project Report

on

"AUTOMATION OF SOLAR PANEL CLEANING SYSTEM ENABLED WITH MONITERING AND CONTROLLING APPLICATION"

Submitted in partial fulfilment of the requirements for the award of the degree

BACHELOR OF TECHNOLOGY

in

ELECTRONICS AND COMMUNICATION ENGINEERING

by

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CERTIFICATE

This is to certify that the ***Project*** *entitled* ***"AUTOMATION OF SOLAR PANEL CLEANING SYSTEM ENABLED WITH MONITERING AND CONTROLLING APPLICATION"*** *has been successfully carried out by* ***VISHAL G YADAV[ENG16EC0095],TOUHEED KAZMI[ENG16EC0092],MOHAMMED YAQUB G S[ENG17EC1005],AVINASH S N[ENG17EC1001]*** *in partial fulfilment of the requirement for the award of the degree* ***BACHELOR OF TECHNOLOGY*** *in* ***ELECTRONICS & COMMUNICATION ENGINEERING*** *by* ***DAYANANDA SAGAR UNIVERSITY*** *during the academic year 2019-20.*

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DECLARATION

I hereby declare that the thesis entitled "**AUTOMATION OF SOLAR PANEL CLEANING SYSTEM ENABLED WITH MONITERING AND CONTROLLING APPLICATION**" submitted to the Department of Electronics and Communication Engineering of Dayananda Sagar University, Bangalore for the award of B. Tech in Electronics and Communication Engineering is a record of original research work carried out by us under the supervision of Dr. Payal Verma, Associate Professor, Dept. of ECE, Dayananda Sagar University, Bangalore. To the best of my knowledge, this work is not submitted for any degree in any University or Institute.

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ABSTRACT

Renewable Energy is one of the major factors and severe issues that are being faced in India and other various 3rd World countries due to densely populated hotspots. The consumption and utilization of this energy has led to critical concerns with the government and other private sectors and in both urban and rural households and industrial factories that rely and function on energy related equipments.

About 60% to 70% of the energy requirement and demand of the country are met by the non-renewable resources such as the conventional burning of the fossil fuels, wood and agricultural residues. The use of the renewable resources such and solar energy, hydro energy, geo-thermal energy, wind energy and other sources have been considered the least of demand in the world.

In our major project, we have considered and are promoting the use of solar energy as one such demand in one of our diurnal activities for example, in cleaning application. As the renewable energy is essential to replace the use of electric energy generated by petroleum products. Solar power has become a source of renewable energy and solar energy application should be enhanced. The solar Photo-voltaic modules are generally employed in open field environments such as deserts with hot summers, saline areas with corrosive salts, rainy weathers in tropical seasons. For ideal condition we are considering mostly dusty ambience especially in respect to India.

The dust which gets accumulated on the glass surface of the solar panel module and as it blocks the ray of incident light projected from the sun. This dusty surface reduces the power generation capacity of the module. The output power reduces as much as by 100% efficiency, if the panel module is not cleansed for about a week. This limitation of the solar panel creates a requirement for designing a self- sustained cleaning system, which cleans the panel at a specified time which is set by the user with the help of Real Time Clock (RTC).

Keywords- Solar PV module, Renewable Energy, Real Time Clock (RTC), incident ray

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CHAPTER 1

INTRODUCTION

1.1NON-RENEWABLE RESOURCES

The non-renewable resources is the finite resource that will get exhausted and not replenished over a period of time due to the constant usage of these sources with the speed at which it is used and consumed for performing our day-to-day activities. Most of the nonrenewable resources are structured from certain organic carbon compound materials which is treated with heat and compressed over a marginable period of time, changing their visibility into crude oil, natural gas or petroleum.([4][5][6])

The term nonrenewable resource also refers to natural minerals and metals that are found from the ore mining of earth, such as gold, silver, iron and other metal ores. These are similarly formed by a long-term geological process and earth's tectonic plate shifts over millions of years. The mining of these valuable minerals are drawn out with sophisticated mining techniques which will disappear when the origin source will get drained over time, as they are usually deep within the Earth's crust. But they are much more abundant than fossil fuels.

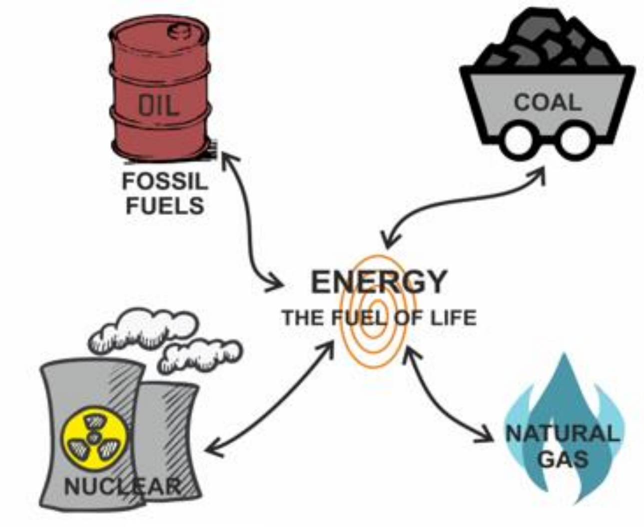


Fig:1.1 : The sources of Non-Renewable Resources

The Fig:1.1 mainly shows the four classification of nonrenewable resources namely-crude oil, natural gas, coal, and nuclear energy. Crude oil, natural gas, and coal are collectively known as fossil fuels. Fossil fuels were originated from within the Earth's crust from deceased plants and animals over millions of years—hence the name "fossil" fuels. They are found in underground layers of rock and sediment. Pressure and thermal source worked together to transform the plant and animal remains into crude oil also known as petroleum, coal, and natural gas.

The plants and animals that became fossil fuels lived in a time called Carboniferous Period, around 300 to 360 million years ago. The energy in the plant and animal remains originally came from the sun; through the process of photosynthesis, solar energy is stored in plant tissues, which animals then consume, adding the energy to their own bodies. When fossil fuels are burned, this trapped energy is released.

Crude oil is a liquid fuel fossil fuel that is used mostly to produce gasoline and diesel fuel for vehicles, and for the manufacturing of plastics. It is found in rocks below Earth's surface and is pumped out through wells.

Natural gas is widely used for cooking and for heating homes. It consists mostly of methane and is found near oil deposits below Earth's surface. Natural gas can be pumped out through the same wells used for extracting crude oil.

Coal is a solid fossil fuel that is used for heating homes and generating power plants. It is found in fossilized swamps that have been buried beneath layers of sediment. Since coal is solid, it cannot be extracted in the same manner as crude oil or natural gas; it must be dug up from the ground.

Nuclear energy comes from radioactive elements, mainly uranium, which is extracted from mined ore and then refined into fuel and other energy substances.

1.2 RENEWABLE RESOURCES

The renewable resource is also known as natural resource that can be used repeatedly and infinitely and it does not run out of time because it is naturally replaced by the existing elements of the earth. A renewable resource, essentially, has an endless supply such as , wind energy, geothermal pressure, hydropower energy, biomass energy and solar energy.

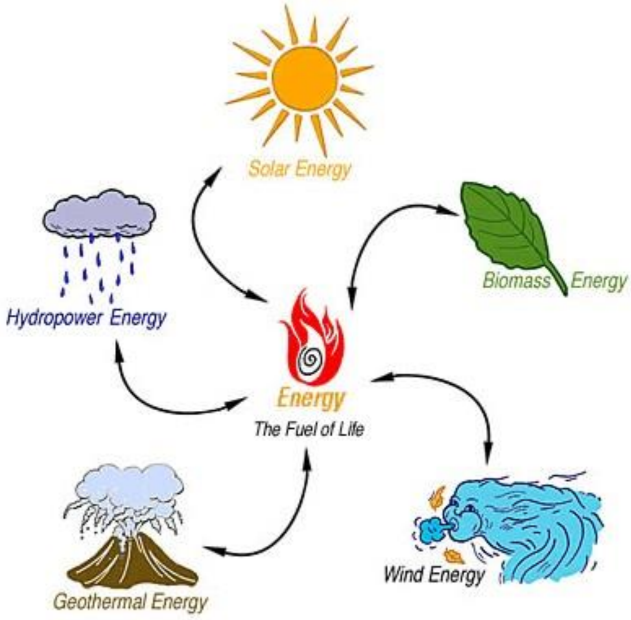


Fig:1.2 : The sources of Renewable Resources

The renewable energy can be briefly divided as per Fig:1.2 mainly states the sources of renewable energy resources.([1][2][3])

Wind energy generates power electricity by turning on the wind turbines mills. The wind pushes the turbine’s blades in the direction of wind, and a generator converts this mechanical energy into electricity. This electricity can supply power to local homes and other buildings, and it can even be stored in the power grids.

Geothermal energy comes from the heat generated from deep within the Earth’s core. Geothermal reservoirs can be found at tectonic plate boundaries near active volcanic activity or deep underground. Geothermal energy can be harnessed by drilling wells to pump hot water or steam to a power plant. This energy is then used for heating and electricity applications.

Hydropower is one of the vintage renewable resources and has been used for several thousands of years. Today, every U.S. state uses some amount of hydroelectricity. With hydropower, the mechanical energy from flowing water is used to generate electricity. Hydroelectric power plants use the flow of rivers and streams to turn a turbine to power a generator, releasing electricity.

Biomass refers to organic material from plants or animals. This includes wood, sewage, and ethanol (which comes from corn or other plants).Biomass can be used as a source of energy because this organic material has absorbed energy from the Sun. This energy is, in turn, released as heat energy when burned.

Solar radiation from the Sun can be used as a renewable power source as well. Photovoltaic cells or solar cells can be used to convert this solar energy into electrical energy. Individually, these solar panel modules can only generate enough energy to power a calculator, but when combined to create solar panels or even larger arrays, they provide much more electricity in solar emergency lamps and solar water heaters. From home rooftops to utility-scale farms, solar power is a kind of reshaping energy in the global markets. In the decade from 2007 and 2017 the world's total installed energy capacity from photovoltaic panels increased a whopping 4,300 percent even when compared to the usage of other renewable resources.

In addition to solar panels, which convert the sun's light to electricity, concentrating solar power (CSP) plants use glass platforms to concentrate the sun's heat, deriving the maintain the maximum energy efficiency. Asian countries like India, China, Japan, and the U.S.A are leading the solar transformation, but solar still has a long journey to transform and introduce the world with a better future, accounting for around just two percent of the total electricity generated in the U.S. in 2018. Solar thermal energy is also being used worldwide for hot water, heating, and cooling.

1.2.1 Solar Cell/ Photovoltaic Cell

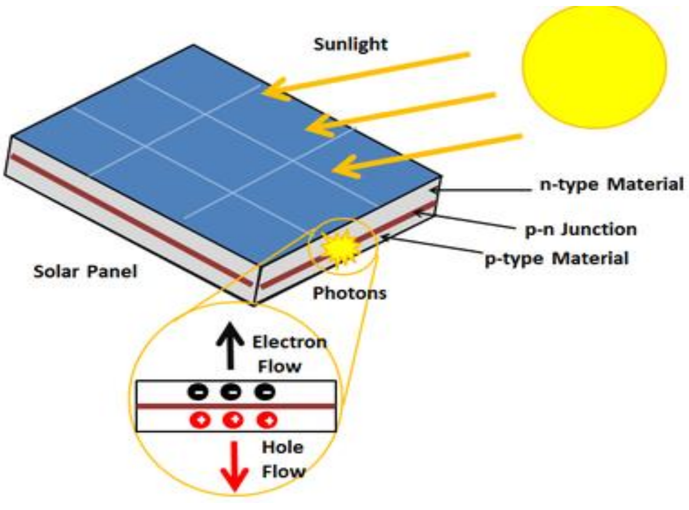


Fig:1.2.1 : The diagram of solar cell

A solar cell (also known as a photovoltaic cell or PV cell) is defined as an electrical device that converts light energy into electrical energy through the photovoltaic effect. A solar cell is basically a p-n junction diode. Solar cells are a form of photoelectric cell, defined as a device whose electrical characteristics – such as current, voltage, or resistance – vary when exposed to light.

Individual solar cells can be combined to form modules commonly known as solar panels. The common single junction silicon solar cell can produce a maximum open-circuit voltage of approximately 0.5 to 0.6 volts. By itself this isn't much – but remember these solar cells are tiny. When combined into a large solar panel, considerable amounts of renewable energy can be generated.([22][23])

CHAPTER 2

AIM AND SCOPE, LITERATURE SURVEY

2.1 VISIBLE FACTORS AFFECTING THE SOLAR PANELS

2.1.1 Dust Particle Accumulation

Fig: 2.1.1 : The dust accumulation on the solar panels

Fig: 2.1 shows that the effect of dust on the power output and performance of monocrystalline and polycrystalline modules will reduces the performance of the module in term of power output by 50% in a period of over 2 months. Characterization of dust sample for its particle size distribution and elemental composition.

Dust accumulation on the surface of solar PV modules, mirrors, reflectors and other solar collectors is of great concern due to occasional to frequent dust storm in the gulf region. The performances of such devices are significantly affected by dust accumulation. The effect of dust accumulation on the power output of solar PV modules indicates that power decrease by as much as 50% can be experienced for solar PV modules that are left unclean for a period of over six months. This is one of major issues found in tropical areas like India.

2.1.2 Sand Particle Accumulation

In the widespread solar power generation power-plants are constructed in deserts such as Mojave at low altitudes where the sun shines the brightest. However, sand storms occur frequently in deserts, and solar panels will get covered by stirred-up sand, causing a drastic decrease in the output power of a photovoltaic power generation plant. Because sand on the panel is not cleaned by rain over a long period of time in an arid region, the capacity utilization of the power plant is reduced if the panels are not cleaned as shown in the Fig: 2.1.2.([27][29])

Fig: 2.1.2 : The sand particles accumulation on the solar panels

2.1.3 Sea Salt accumulation

Fig: 2.1.2 : The sea salt particles accumulation on the solar panels

The solar panels installed in the coastal regions near the marine location such as n Sambhar Lake, Rajasthan state (India). Salt crystals in the sea air can affect solar panels through accumulation. Over time, a thin film of salt can cover a solar panel which, left unchecked, will gradually block light out from the panel. This has a negative effect on panel efficiency. Secondly, salt in the sea air can affect solar panels by eroding the frame around the panel. This in turn can lead to the panel frame allowing water to penetrate into the panel itself. Obviously, water and electricity is not a good mix. This will lead to the failure of that panel and possibly other panels due to them being linked. ([8][28][29])

2.1.4 Bird poop accumulation

Fig: 2.1.4 : The bird poop accumulation on the solar panels

Fig: 2.1.4 shows that the birds that solar panels have become a modern haven for small families of pigeons living under residential arrays. But roofs and water are attractive to huge colonies of seagulls and migratory birds who find warmth, shelter and ideal nesting areas. Nesting areas mean massive bird dropping problems where solar panels are present. Bird droppings on solar panels are an all too often an underestimated and overlooked problem. As bird droppings blight solar panels, in some cases to the point of rendering a whole solar array virtually useless. As well as this, removing hard, baked-on bird droppings effectively has become an extreme task, providing a steep learning curve even for solar panel cleaning specialists.

2.1.5 Solar Panel cleaning Solution

In order to mitigate all these problems and to maintain the efficiency of the solar panel modules, in which we have mentioned in all our previous cases is to develop an automatic cleaning system that is used to clean the dust, sand, sea salt and bird poop particles by both monitoring and controlling a custom built solar panel cleaning system installed and with controlled by an

Embedded C program embed into a PIC controller, Real Time Clock(RTC) and dusting/water spraying/ wiping system. The cleaner first moves in forward direction to dust the panel and then in second operation sprays water and later in the third function it wipes the panel by ensuring that there is no accumulation of hard/soft particles inclining to decrease the efficiency of the solar panel. To avoid the particles to accumulate, the system needs to operate at a three regular intervals of time which is commanded by the RTC via PIC microcontroller. This helps the panel free from dust or other hardened particles to accumulate over a long period of time. This automatic cleaning system is remotely controlled and monitored with a mobile application that basically displays both battery voltage and current and the option for number of times the cleaning system has to clean the solar panel over a range of 10-15 meters within the WIFI range of the mobile.

The whole cleaning system is powered up with a solar enabled rechargeable lithium ion battery cells, as there is no requirement of physical battery charging method. The battery is automatically charged from the same solar panel when the battery goes low. The power consumption of this system is extremely low. This technology is expected to increase the efficiency of mega solar power generation plants constructed in any environments such as even in domestic, private sector and public sectors.([30][32])

2.2 AUTOMATIC SOLAR PANEL CLEANING ROLLER

Fig: 2.2.1: The automatic Solar Panel Cleaning Roller

The power output delivered by photovoltaic module highly depends on the amount of photovoltaic rays which reaches the solar cells. Solar power generation can be influenced by many factors. However, the major factors which reduce the generation of solar power are snow, sand, dust, dirt, sea salt. When these particles accumulated on solar panel blocks the sunlight. The result shows that it affects the voltage provided by the module.

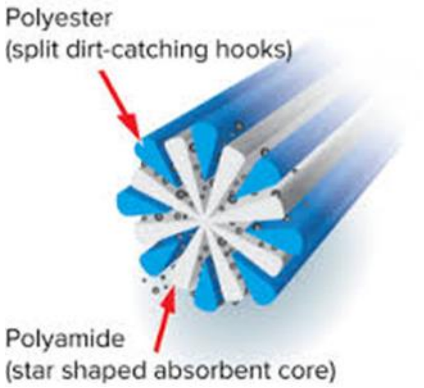


Fig: 2.2.2: Microfiber Cleaning Roller

A cleaning system has been developed that uses microfiber technology to remove dust particles from the surface of solar panels. A low DC voltage is applied to DC motors which are mounted on two different sides of solar panel and connected in anti-parallel connection. It has been demonstrated that more than 90% of dust particles are repelled from the solar panel after cleaning operation. It was demonstrated that the energy consumption by accessories of cleaning system is less. This technology is expected to increase the efficiency of mega solar power plants. The merits of using the automatic solar panel cleaning is that the cleaning system has light weight and compact structure.([30])

2.3 DESIGN & MANUFACTURING OF SOLAR PANELS CLEANING SYSTEM

Fig: 2.3: Cleaning Slider Mechanism

The Solar Panels Farms are generally situated in dirt and dust areas which is mostly in case of tropical countries. The performance of solar panels depends on various factors, the power generated by farm can decreased if there is dust and dirt on panels and this is the main factor for reduction. One can generally assume a reduction of about 40% - 50%, if the panels are not clean properly for 1-2 months. So to overcome this problem and to increase the efficiency of power production cleaning of module on regular basis is necessary. To clean the dust, an automatic cleaning robot is developed, which will clean the panels on regular interval of time. The mechanism is based on control circuit, DC motor; microfiber (bristles) to clean the panels. The paper provides you with the idea how the robot will work and its effect on the energy production by solar farms. It will also to help to understand the problem arise due to not cleaning of solar cells.([33])

2.4 MICROCONTROLLER BASED AUTOMATIC CLEANING OF SOLAR PANEL

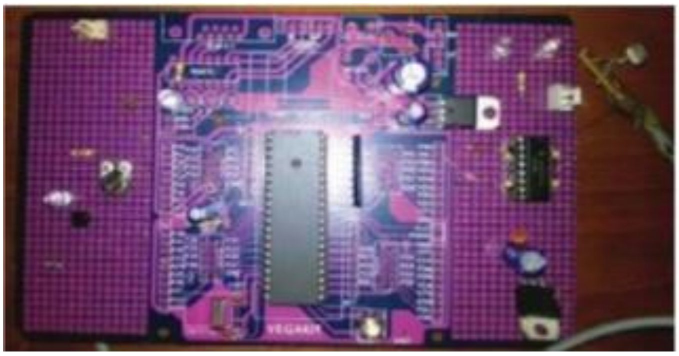


Fig: 2.4: LDR controlled microcontroller for Cleaning of Solar Panel

The solar PV modules are generally employed in dusty environments which is the case in tropical countries like India. The dust gets accumulated on the front surface of the module and blocks the incident light from the sun. It reduces the power generation capacity of the module. The power output reduces as much as by 50% if the module is not cleaned for a month.

In order to regularly clean the dust, a automatic cleaning system has been designed, which senses the dust on the solar panel and also cleans the module automatically. This automated system is implemented using 8051 microcontroller which controls the DC gear motor. This mechanism consists of a sensor (LDR). While for cleaning the PV modules, a mechanism consists of a sliding brush has been developed. In terms of daily energy generation, the presented automatic-cleaning scheme provides about 30% more energy output when compared to the dust accumulated PV module (module kept stationary on ground).([34])

2.5 DUST REMOVAL FROM SOLAR PV CARPORTS BY AUTOMATED CLEANING SYSTEMS

Dust accumulation on solar photovoltaic (PV) modules reduces light transmission from the outer surfaces to the solar cells reducing photon absorption and thus contributing to performance reduction of PV systems. In regions such as the Middle East where dust is prevalent and rainfall is scarce, remedial measures are needed to reduce such impacts. Currently, various techniques are being employed to address such sand soiling ranging from mechanical (brushing) to active and passive electrical interventions. This research focuses on mechanical approaches encompassing module vibration, air and water jets, and combinations of these. A reconfigurable pilot-scale testbed of 8 kWp PV plant was installed on a carport shading system within the campus of King Abdulaziz University (KAU), Jeddah, Saudi Arabia.

Fig: 2.5: Functional PV carport for Cleaning of Solar Panel

The functional PV carport was configured to allow water recovery and re-use within the testbed. Here, we discuss the overall cleaning design philosophy and approach, systems design, and how multiple cleaning configurations can be realised within the overall PV carport. Results indicate that in this location, sand soiling has a significant effect on performance of PV modules on a timescale of days. In addition, water jets optimised for high volume and low pressure were effective at reducing sand soiling with array power output increasing by over 27%, whilst air jets and module vibration were less effective in reducing soiling to an acceptable level. Overall, the testbed has provided a new approach to testing a combination of cleaning solutions in the field coupled with used water recovery. The proposed approach is important, as currently, there are a large number of solar PV projects being built in Saudi Arabia with more being planned for the future.([30])

2.6 IMPLEMENTATION OF AUTOMATIC SOLAR TRACKING AND CLEANING SYSTEM

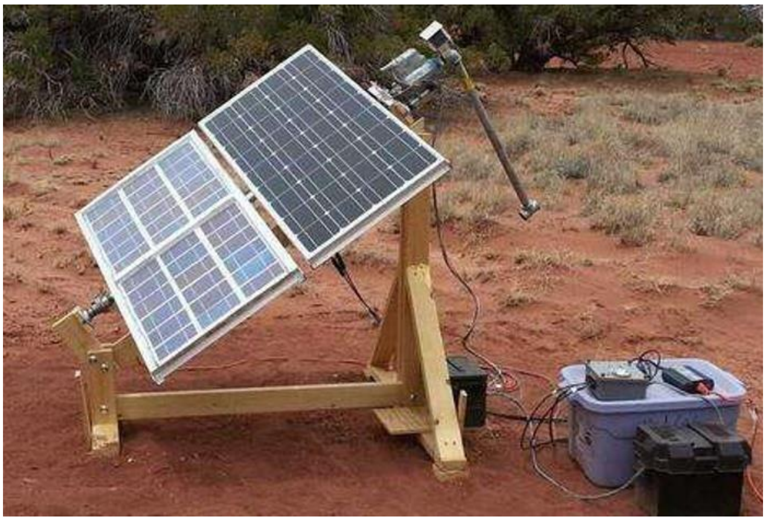


Fig: 2.6: Solar Tracking and Cleaning System

With the growing requirement of electricity and concern for the environmental impact of fossil fuels, implementation of eco-friendly energy sources like solar power is rising. The solar PV modules are generally employed in dust environments which is the case in tropical countries like India. The dust gets accumulated on the front surface of the module and blocks incident light from the sun. The power output reduces as much as by 30% if the module is not cleaned for a month. Accumulation of dust on even one panel in an array reduces their efficiency in energy generation considerably and need to keep the panel surface as clean as possible. In this paper, we designed a system which not only tracks sun but also clean module automatically. This mechanism required an LDR for tracking the sun. While cleaning the solar panels, a mechanism consists of sliding brushes has been developed. In terms of daily energy generation, the present tracking -cum cleaning scheme provides about 30% more energy output as compared to the stationary PV module. This paper gives an idea about the combination of tracking and cleaning system.

2.7 ENERGY FREE AUTONOMOUS ROBOT BY ECOPPIA

Fig: 2.7: Automatic Free Energy Cleaning robot by Ecoppia

The company's E4 robot removes 99% of soiling on a daily basis using a combination of three factors: A special microfiber that gently wipes soiling away, controlled airflow over the panel surface, and gravity to ensure soiling is moved downwards and off panel rows. The robots do not need external energy sources: They have their own on-board dedicated solar module, allowing the batteries to get quickly charged every morning. A patented eco hybrid technology developed to facilitate a minimal use of the batteries.

The Robot's sensors collect weather data, and initiate cleanings based on weather conditions. Machine-learning software optimize the E4's own maintenance schedule – ensuring that the E4 has over 99% availability for the lifetime of your site. It comes with a remote management system that monitors and manages the E4 fleet on-site from anywhere in the world. It is also enhanced by a simple SMS interface, allowing to send commands and receive status updates from a mobile phone. (source=www.eccopia.com)

2.8 OTHER CONVENTIONAL HUMAN CLEANING METHODS

Fig: 2.8: Manual Labour involving the cleaning Solar Panels

There are a lot of solar panel cleaning companies that are popping up selling solar panel cleaning as a service. They sign customers up for monthly cleanings and come out in big vans filled with buckets, proprietary soaps, and fancy cleaning tools. It may not be worth it to pay a company to come out and clean your panels on a regular basis.

But, if you have a large home, a lot of panels, or have trouble with mobility one shouldn’t hire a professional to take care of that cleaning. If they came out once or twice a year to clean your solar panels.

Depending on the size or your solar energy system, the area in which you live, and the different tiers of cleaning packages your company offers, solar panel cleaning services can cost anywhere from $100-$600 a visit. The most important thing is that you monitor them to ensure they’re working properly because if it does not function efficiently, there is no use of even installation of these panel.([10][11])

CHAPTER 3

METHODOLOGY

3.1 BLOCK DIAGRAM

3.1.1 Block Diagram of Cleaning System

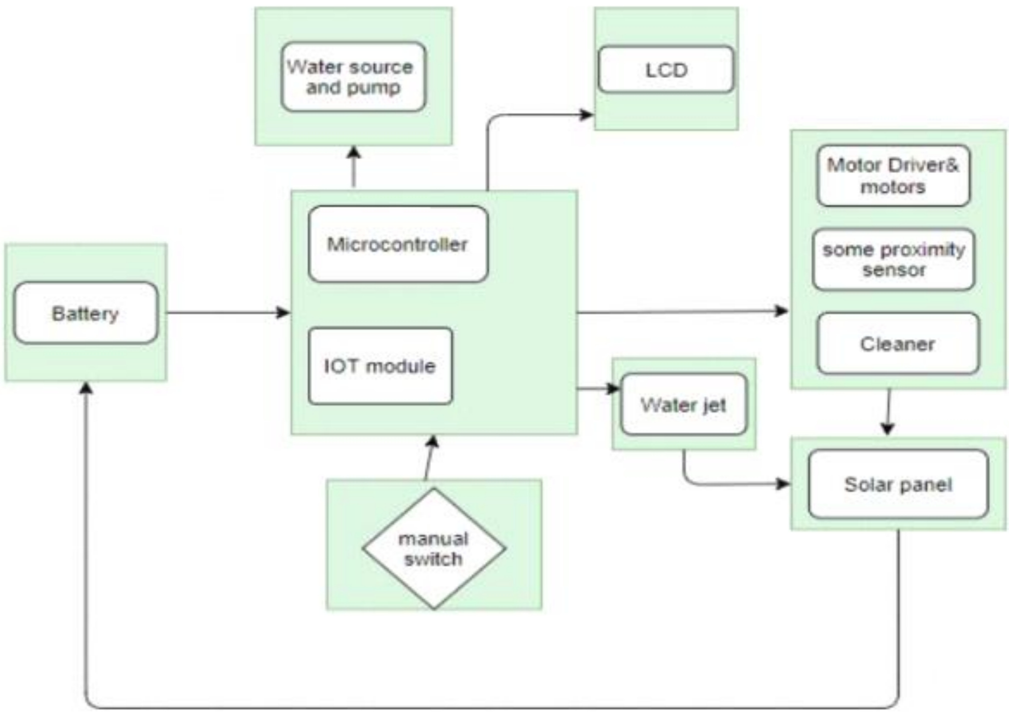


Fig: 3.1.1: Block Diagram of Cleaning System

This the block diagram of the cleaning system enabled with battery, microcontroller, IOT module, water jet, moving robot, LCD display, water source and a manual switch. Battery is used to power up the module which in turn uses the solar power to recharge from the battery. The microcontroller gets on and control the work which has to be carry out like when the robot should. Start or stop water level and when the water pump should start and it will also display the current and voltage reading in the LCD display IOT module is used to remotely monitoring and controlling of the system like when the robot has started When it is stop and value of current and voltage when can be monitored and controlled in phone with the help of app. Water source and pump is used to clean the hard dirt with the help of water jet it is controlled by the microcontroller like water level in it and when the pump should start to avoid the wastage of water LCD display is used to display the current and voltage value. Solar panel is used to capture the solar energy and convert it to the electric energy with the help of solar cells which is placed in solar panel. Robot consist of motor driver which is used to run the robot and a proximity sensor is used to sense the end points of the solar panel it is placed at the end and at the starting point of the solar panel. Robot also consist of cleaner which is used to clean any dust which can be hard dirt. Water jet is used to clean the hard particle like bird poop or any hard particle which cannot be cleaned by a dry dirt cleaner. Manual switch is used to manually control the whole system in case of any emergency.

3.2 COMPONENTS USED

3.2.1 PIC Microcontroller

Fig:3.2.1 PIC18F4520 Microcontroller

- In our project we are using PIC18F4520 which has Up to 10 MIPS Performance at 3V C compiler optimized RISC architecture
- 8x8 Single Cycle Hardware Multiply
- Internal oscillator support-31 kHz to 8MHz with 4xPLL
- EUSART module including LIN bus support
- Four Timer modules
- Up to 5 PWM outputs
- Up to 2 Capture / Compare

We are using this pic controller because it can be easy programmed and has Fail-safe

Clock Monitor-which allows safe shut down if clock fail and it also has Watchdog Timer with separate RC oscillator Master Synchronous Serial Port supports SPI™ and I2C™ master and slave mode which help in running motor drivers more smoothly.

3.2.2 NodeMCU

Fig: 3.2.2: ESP8266 NodeMCU Wifi Devkit

The ESP8266 is the name of a micro controller designed by Espressif Systems. The ESP8266 itself is a self-contained WiFi networking solution offering as a bridge from existing micro controller to WiFi and is capable of running self-contained applications. This module comes with a built in USB connector and a rich assortment of pin-outs. With a micro USB cable, we can connect NodeMCU devkit to your laptop and flash it without any trouble, just like Arduino. It is also immediately breadboard friendly. It has a Voltage: 3.3V.Wi-Fi Direct (P2P), soft-AP. Current consumption: 10uA~170mA. Flash memory attachable: 16MB max (512K normal). Integrated TCP/IP protocol stack. Processor: Tensilica L106 32-bit. Processor speed: 80~160MHz. RAM: 32K + 80K. GPIOs: 17 (multiplexed with other functions). Analog to Digital: 1 input with 1024 step resolution. +19.5dBm output power in 802.11b mode • 802.11 support: b/g/n. Maximum concurrent TCP connections: 5.

3.2.3 DC Motor

Fig: 3.2.3: DC Motors

A DC motors with gear, single axis, with DC 3-6V operating voltage and an RPM of 100R / minute. This gear box is ideal for robotic car or line-tracing robot. With plastic construction and colored in bright yellow, the DC gear motor measures approx. 6.5cm long, 2.5cm wide and 1.8cm thick.

- Motor Detailed parameters:
- No load speed (6V): 60RPM
- No load current (6V): 60mA
- Motor speed: 60 r/min
- Motor Size: approx. 6.5×2.2×1.8cm
- Voltage: 6V

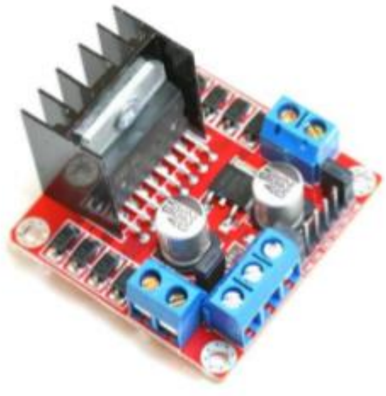
3.2.4 Wheel

Fig: 3.2.4: Wheel

Wheels are used to move the robot upward and downward for cleaning the solar panel.

- Diameter:66mm
- Width:28mm
- Color: Yellow

3.2.5 Motor Driver



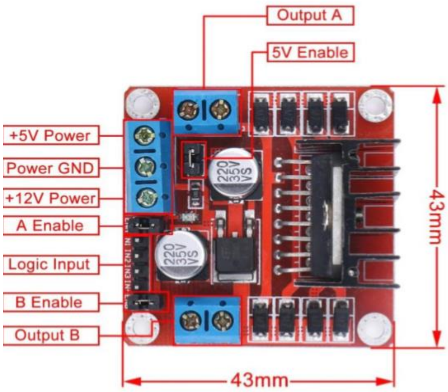


Fig: 3.2.5: L298D Motor Driver

This dual bidirectional motor driver, is based on the very popular L298 Dual H-Bridge Motor Driver Integrated Circuit. The circuit will allow you to easily and independently control two motors of up to 2A each in both directions. It is ideal for robotic applications and well suited for connection to a microcontroller requiring just a couple of control lines per motor. It can also be interfaced with simple manual switches, TTL logic gates, relays, etc. This board equipped with power LED indicators, on-board +5V regulator and protection diodes.

3.2.6 RTC Module

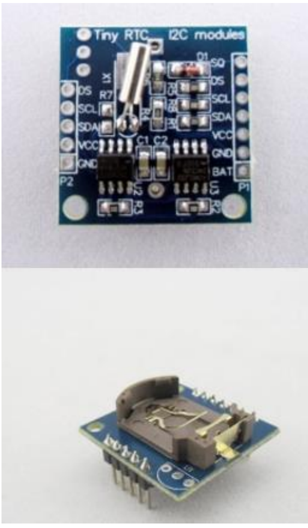


Fig: 3.2.6: RTC Module

This tiny RTC module is based on the clock chip DS1307 which supports the I2C protocol. It uses a Lithium cell battery (CR1225). The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with AM/PM indicator.It consist of 5V DC supply Programmable Square-Wave output signal Automatic Power-Fail detect and switch circuitry Consumes less than 500nA in Battery-Backup Mode with Oscillator Running 56-Byte, Battery-Backed, Nonvolatile (NV)RAM for data storage.

3.2.7 Water Pump

Fig: 3.2.7: 6V Water Pump

This is a low cost, small size Submersible Pump Motor which can be operated from a 6V power supply. It can take up to 120 liters per hour with very low current consumption of 220mA. Just connect tube pipe to the motor outlet, submerge it in water and power it. Make sure that the water level is always higher than the motor. Dry run may damage the motor due to heating and it will also produce noise.

- Operating Voltage : 2.5 ~ 6V
- Operating Current : 130 ~ 220mA
- Flow Rate : 80 ~ 120 L/H
- Maximum Lift : 40 ~ 110 mm
- Continuous Working Life : 500 hours
- Driving Mode : DC, Magnetic Driving
- Material : Engineering Plastic
- Outlet Outside Diameter : 7.5 mm

- Outlet Inside Diameter : 5 mm

3.2.8 Solar Panel

Fig: 3.2.8: Solar Panel

Built to last From mountaintops to off-shore platforms, on weather stations in the bitter cold of Antarctica and on telephone signal repeaters in the hot Australian outback, the technology has been proven in the harshest environments Accessible junction box for off grid connections J-type junction box has accessible terminals for easier module interconnections in off grid applications, and it allows fitting cable glands for various cable sections Improved reliability with effective cooling Cell interconnections and diode placement use well-established industry practice and are field-proven to provide excellent reliability.

Thick, durable, scratch resistant back sheet the thick back sheet provides extra insulation and increased resistance to protect your module against rough handling. The white polyester material lasts longer and increases energy production

3.2.9 Battery

Fig: 3.2.9: 12V Lead Acid Battery

Lead-acid batteries are inexpensive compared to newer technologies, lead–acid batteries are widely used even when surge current is not important and other designs could provide higher energy densities.

3.2.10 Powerbank

Fig: 3.2.10: 20000 mAh powerbank

- Huge 20000 mAh capacity to charge your devices multiple times.
- Faster (input): Advanced 2A fast recharging input technology.
- Faster (output): Superfast charging with 5V/2A USB output port.
- Modern design: Classy look, premium finish with long-lasting performance.
- Quality accessories: Durable last long cable.
- Smarter: Intelligent PCBs circuits mechanism.

3.2.11 Bump Switch

Fig: 3.2.11: Bump Switch

Switch works on maximum voltage of 40VDC and maximum current of 3A. Whenever the switch is pressed against a surface it gives high signal to the microcontroller.

3.2.12 Wiper/cleaner

Fig: 3.2.12: wiper

It is used to clean the dust which get accumulate on the solar panel it cleans both dry and wet dust with help of brushes and water spray.

CHAPTER 4

RESULTS

We have successfully implemented the code for running the solar panel cleaning robot which is held by the frame around the solar panel. The Robotic panel moves on the solar panel using DC motors and wheels. The DC motor driver circuit is used to control the direction and speed of motors. The robot moves to and fro upward and downward of the solar panel to clean it with the help of wipers mounted on it against the glass of solar panel. An electronic sensor is used for sensing the end of panel and provides information to microcontroller to change the direction of robot. A water pump is used for spraying the water onto solar panel. The complete system is also controlled via an Android application through an IOT device. The same application monitors the voltage generated by solar panel and battery voltage.

4.1 MOBILE APPLICATION

We have successfully implemented an android application for remotely monitoring the battery and voltage of the solar panel and the battery that stores the electricity generated by the solar panel with the help of MIT App Inventor.

Fig: 4.1: User Interface of the android application

The authorized user has to enter his username and the password to login into the application shown in fig 4.1. Once the user logins the window on the right opens up. It displays the battery voltage and the battery current, solar voltage and the solar current once it get connected to the IP address of wifi module (NodeMCU) that is present on the solar panel. The authorized user can also control the working of solar panel cleaning process through app.

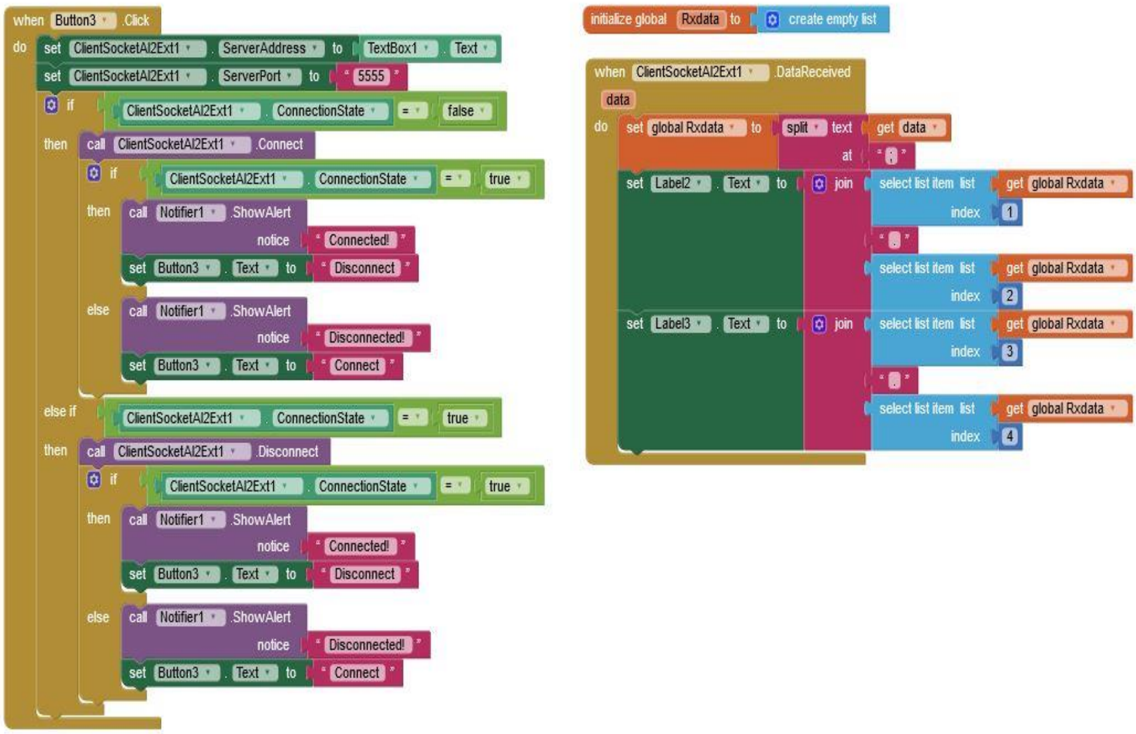


Fig: 4.2: Block of Code for the Backend of the App

CHAPTER 5

CONCLUSION

The losses of the output power of the fixed solar panel can be higher depending on the dust formed. The dirt and bird drop make a hot spot in the panel, and it can make temporary fail in the panel. Dry cleaning can’t remove all the dirt on the surface of solar panel, but it is able to remove the outer layers of the dust. Cleaning solar panel with water increases cleaning efficiency by removing majority of the dirt deposited on the panel. Comparing the costs of cleaning by manual operation and automatic operation the costs of automatic cleaning is proved to be more economic and significantly less difficult particularly in systems having large number of solar panels. Also frequent periodic cleaning ensures that the solar panel works with a good consistency at all times. The designed system also allows the user to monitor the output of the solar panel in terms of voltage, current and power with the help of mobile application. The user can monitor the status of the panel and also start cleaning operation remotely with this mobile application.

The Solar panel cleaning system would clean the Solar panel at a specified time. The cleaning system is also controlled and monitored by an IOT application installed in any of the Android mobile. This system would enable solar panel to convert solar energy to electrical energy with full efficiency.

5.1 FUTURE SCOPE

- Development to full-sized real time prototype for large solar panel
- Currently the monitoring of solar panel through the mobile application is limited to local network which could be later implemented of internet remotely.
- Giving the user to set the time gap between which solar panel cleaning process takes place.

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