Self-Cleaning Technology for solar PV Panel

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CHAPTER 1

INTRODUCTION

Solar dynamism is one of the main energy sources in imminent of the world. The knowledge of Photovoltaic PV is always on incessant developing in many presentations, so it generates electricity without dangerous effect on environment. The entire world now was faced short supplying electric power due to not enough sources to generate electric power. Usually source that uses to generate energy or electric power is not renewable source such as fossil. Besides that, using fossil will lead to environment destruction to our planet such as global warming. The environment issue was being regarded by most critical problem when using fossil to generate the electricity. Therefore, the goal is to emphasize to obtain the clean energy supplies of the electric energy. Renewable source is now an alternative solution to generate the electric energy for example, sunlight. A free sunlight will produce energy that environmental friendly.

In recent times strength and environmental troubles coexist. The development of latest strength sources is pressured by the disaster of power and surroundings. As a source of clean power, solar power has to be greater successfully and rationally used energy. In current years, solar PV information has made fantastic development. However, most a part of the research at domestic and abroad targeted specifically on theoretical studies, design and construction, along with layout of photovoltaic panels in the direction of the inclination, effect of dust shelter on the performance and temperature of the battery and so forth. Inside the domestic "Technical specs about Civil software of sun Photovoltaic systems", there are many applicable provisions about production website, geography, weather, sun resources, safe haven, effect of temperature on the energy era and so forth. But studies at the impact of dirt, air cleanliness, rainfall and other elements on PV tasks are also little or no.

The name photo voltaic is resulting from photo, the Greek phrase for light and volt, relating to strength, photo voltaic chambers are made-up of a fabric known as semiconductors, the most usually used semi-conductor fabric in solar panel is silicon. While the mild falls on the solar panel, it moves directly to the sun cellular which absorbs the sun radiation. These solar cells converts radiation into direct electric powered present day, every photo voltaic chamber in the solar panel can produce 0.5 volts of most present day. The maximum power may be finished by using putting these cells In-series and in-parallel can growth the total modern. Whilst manufacturing a sun panel it's far essential to vicinity an antireflective coating including glass plate is susceptible to dirt from the surrounding surroundings. While this plate will become dirty, as a result strength performance of PV panels will reduces. The performance of these solar panel is reduces due to results likes shadow, snow fall, outside high temperature, bird droppings, dust and dirt. The solar panel cleansing technology can enhance the performance via putting off dirt and other impurities from the surface of the sun panel. There are several viable techniques like wind clearing, rainfall, washing with various liquids, wiping, rotating, vibrating the surface, dry cleansing, wet cleansing, Electrostatic cleaning, robot cleansing, heliotex generation, ability cleansing robotic. Here the dry cleansing and wet cleansing technologies are used to eliminate the dust and different impurities by using self-cleansing technology to get advanced efficiency.

Most of the applications in recent times like heating water, agriculture and industrial programs use the solar panels as an electrical energy source in preference to relying on the generators or the everyday sources for electricity. The maximum important a part of those systems is the sun panel in which the solar energy is transformed to warmness for water heating or converted to electricity for the others. There are many forms of the sun panels. In the nations those have dusty surroundings accumulation of dust at the solar panels leads to reduction of the transmittance of the panel. Sun desalination flowers in a number of the middle-east countrikes like the solar desalination plant of Abu Dhabi suffers from the deposition of dirt on its solar plates. The effect of the gathered dirt might be decreased with the increasing

of tilt angle, due to the fact that the lean angle will affect the publicity time to the sunlight also. But the first-class manner to remove the impact of the accumulated dirt on the solar panels is to smooth the panels. Cleansing the solar panels is typically with the aid of washing that's tedious and cumbersome and additionally high priced in phrases of the labour involved and time. In practice cleansing of solar panels should be regularly executed which makes the technique greater exhausting and steeply-priced.

Solar power is excellent to be had as a maximum essential electricity source. The sun cells are used for plenty applications, such as road lighting fixtures to generate luminescent night. The buildup of dirt debris, deposits left by means of birds or the fallen leaves, at the floor of picture-voltaic PV panel will mirror the incident mild falling at the panel, preventing a part of the radiation from getting used. This trouble ought to reduce the potential of cells to permit free entrance of photons and soak up sun electricity, which greatly impacts its performance, lowering the lifetime of its garage electricity after a few months from its instillation, leading to an everlasting or long-time period failure, mainly inside the wilderness regions. Different elements along with panel orientation or panel floor material can make a contribution to the deposition of the impurities.

The method involves the Mechanical and electric sections. The Mechanical element includes DC motor controlled through a power unit which moves a cleaning head on the panel upwards and downwards without or with the use of liquid spraying structures. Electrical part includes software programming which operates and controls the circuit structures of the self-cleaning technology. The software program specially includes two elements. One is essential programs and some other is interrupt process. The output strength is measured for the panels before and after cleaning and efficiency is calculated with the assist of voltage and contemporary graphs.

Hence this is an innovative method of automatic cleaning of solar panel has been suggested.

CHAPTER 2

LITERATURE SURVEY

Many research studied the effect of dust and other impurities on the solar panel and much experiments have been carried out to clear up this troubles. Under are a few theories and researches which can be related to this mission.

The phenomenon of converting light directly into electricity was discovered by Henri Becquerek back in year 1839. Then Albert Einstein explained the principle of photovoltaic in year 1905 using quantum theory. Significant use of PV power systems has started in space application in the 1905's and its modest use in global application began in the 1960"s. However, at the start of 1970"s and 80 saw a superior and substantial use of PV power system.

Hottel and Woertz et al. [1]: first studied the dust effect on sun panel presentation with the aid of analyzing the dust collecting on such panels. A 3 month test becomes done in a business location close by a four-tune railroad 90m away from Boston, Massachusetts. They located a mean of one% loss of occurrence solar radiation changed into caused by dirt that accumulated on the surface of the sun panel with a slant attitude of 30°. The very best dilapidation defined for the duration of the check duration become 4.7%. The researchers found out a correction issue, defined as the ratio of the transference from an polluted or exposed glass plate to clean one, of zero. Ninety nine, with a 45° slant angle; this value changed into general and hooked up in the layout of flat plate collectors till 1970.

Kimber et al. tested the consequences of soiling on large grid-linked PV panels in California, USA in 2011. The goal of the have a look at became to deliver a better model to correctly are expecting soiling patients all through the 12 months barely than presumptuous a continual annual fee. Every other objective changed into to illustrate the final results of soiling on PV arrangement for general area slightly than for a particular area. For that examine, to illustrate soiling losses over the dry season, a linear deterioration version changed into used. After except for websites with nonlinear conduct of soiling and large rainfall of

the web sites, the information from 250 sites have been accumulated and later filtered to 46 machine records sets.

Ali Omar Mohamed, Abdulazez Hasan et al. [2], considered the southern area of Libya which usually carries the dust and sand in the period from February to May, which is also called as seasonal wind. So the small particles of the sand, trees, debris and droppings of birds are accumulated on the PV model surface, which yield a shading sunlight on the modules. Here the area of study divided as rural desert, where the amount of solar irradiance is large over the year. Thus it inspires to adopt the clean energy resource on desert region. Hence a framework of weekly cleaning on PV modules throughout the period involves the experimental set up and a simultaneous measuring is implemented in maximum operating voltage and currents on each module for both before and after washing modules. Weekly water washing is carried out through periods of February to May in order to evaluate performance of PV panels. So the maximum current and voltage is measured at the terminal using the digital multi-meter device, before and after washing in order to gain the maximum power at the operating point generated by PV module.

During study water wash is done once in a week on module without any automatic cleaning technologies, manually by mixed detergents with water and use of hand cleaning materials. Furthermore to wash surface module, spry nozzle is fixed at the top. Approximately each module consumes around 5 liters of water. In fact it is necessary to maintain an optimum performance in desert region by regular cleaning of PV module. However accumulated dust causes the impact on output power and the system efficiency. Hence periodically cleaning, maintained performance losses between 2 to 2.5%. The cleaning interval is different from one place to another, hence it is very important to schedule such program to have a fully awareness of region environment contamination type and it is occur period.

Mark N. Horenstein et al. [3] supplied EDS (Electro dynamic screen) understanding for the automated and unceasing removal of dirt without water or shifting elements. They find the values of electrode association, excitation frequency, and voltage scale that harvest most detail elimination performance. Sun panel's floor, predominantly of the kind engaging semiconductor photo transducers, should be enduringly free of dirt to operate resourcefully; the value of washing might need to be accounted for inside the gross end of the solar panel's financial assistances. There are several strategies are advised such as rain fall, washing with beverages of various type, wind clearing, shacking, air blowing, Wiping, rotating, Nano era containing sun sheet coat are suggested and surface vibration to put off the dirt particles from the surface of sun panel.

R.Sharma, C.A.Wyatt et al. [4]: obtainable an electro-dynamic display, the overall performance of electrodynamics for superficial cleansing became categorized with admire to the efficiency of a display screen with diverse costs of dirt deposition; electric influence requirements on the display procedure with admire to dirt removal efficiency and the optical transmission efficiency of the translucent electrodynamics display screen and the corresponding power loss, while those monitors have been placed on sun panels.

Chandima gomes et al. [5]: supplied a small experimental set up to smooth the sun strength. Many parameters of surroundings impact the efficiency of the photovoltaic. A good way to evaluate the impact of dirt debris from the PV two restore Flat Photovoltaic (FFP) became installed on the college putra Malaysia. The regularly cleaned array is known as "easy array" and the opposite array taken for the duration of in the examine became "dusty array". Statistics become gathered from 1st April – 2013 December for both arrays at the c language every of 30 minutes. Output strength and power yield for each array were considered. The overly strength and power decreases because of dust have been observed from the studies. The results proven that the total electricity generated from the smooth array turned into greater than that of generated electricity from the dusty panel. it can be said that the dust is one of the main issue that can decreased energy yield from that studies.

S. B. Halbhavi et al. [6], added an automated cleansing device, which senses the dirt on the sun panel as a way to easy the dirt frequently. If the panel isn't wiped clean then 50% of the module performance might be reduced. The 8051 microcontroller is used to control the tools motor and to implement the automated gadget. The mechanism consists of a sensor and also consists of the sliding brushes while cleansing the PV modules. The analysis of the dust can be examined below the different conditions with the deposition of the unique pollutants like ash, sand, silica, calcium carbonate and crimson soil. Later retaining the PV model

cool and clean, effects are acquired for effective device presentation. The strength generation in each instances become experimentally determined. Sooner or later by way of the use of the above said computerized cleaning scheme the power output can be expanded approximately 30%, as compared to other cleansing technologies. Also recurrent periodic cleansing guarantees that the panel works with true conduction step by step.

A. Salam Al-Ammri, Areej Ghazi et al. [7], lately in 2015, solar strength studies middle, Renewable strength Directorate and Salam Al-Ammri, Areej Ghazi were worked to give a layout of self-cleansing module, build a moist and dry cleansing gadget to the street light sun panel. It changed into simple, inconsequential, small to maintain, transportable, withstand the ecosystem; low-fee, lengthy existence, takes its strength from the battery of the solar panel, and controlled robotically, by using a far off manage or a timer. The investigational version changed into primarily based on a DC motor perceptively controls by way of a devoted pressure unit that circulate a cleaning head on the panel upwards and downwards without the use of, spraying system. The performance and characteristics of the self-cleaning device is experimentally analyzed. In that examine an independent simple and coffee estimate cleansing device which can smooth one avenue mild panel became advanced. The electronic par and mechanical part were separately built and later both are assembled using microcontroller. The output power is measured in both the conditions i.e. after cleaning and before cleaning of the panel for dry and wet conditions. Finally the results obtained from output tables clearly shows that the dry, wet and solution, which are used in this process increases the efficiency and removes all the dirt from the surface. By that way, the water consumption and loss of power can be reduced.

CHAPTER 3

PROPOSED SYSTEM

3.1 Circuit Description

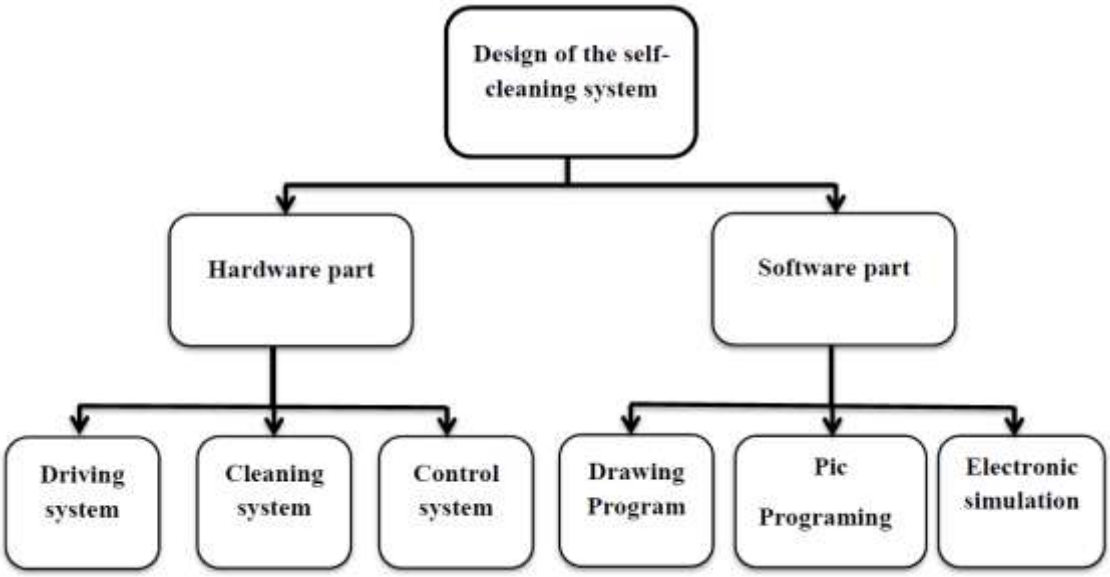

Fig. 3.1:Block Diagram

The scheming of self-cleaning structure contains of hardware and software parts. The hardware structure includes of driving, cleaning and control arrangements is shown in the fig 3.1

The hardware classification components are a Solar Panel (specifications- 100W,12V), DC motor of 12V and 60RPM ratings, DC motor which has ratings of 12V and 60RPM, Microcontroller (AT89S52) and Battery of 100Ah).

The self-enough solar panel washing shape consists of a solar panel together with a software program device and cleansing rolling brush. Due to the fact that sun panel is positioned somewhere in the

outside ecosystem and collects the daylight hours continuously. Whilst glass panel now not being wiped clean often it turns into dirty. This dust on sun panels may be noticed based totally upon the most strength effectiveness of sun cellular, if sun mobile electricity output is low and it can feel software and pledge the DC motor to start the cleaning technique of sun panels.

3.2 Working Principle:

The PV Solar cleaning equipment consists of a DC motor, gear system or conveyor belt system, software system, battery, solar panel, rolling brush. In this, supply is given by the battery where the battery is being charged by the sun's energies i.e., through the solar panel which provides dc supply of variable voltage. This voltage is used for charging the battery then battery provides supply to the software system, DC motor. Once the supply is given to the dc motor, gear system starts to operate, thereby moving the rolling brush and thus cleaning solar panel where the operation is controlled by the software system being supplied by a battery.

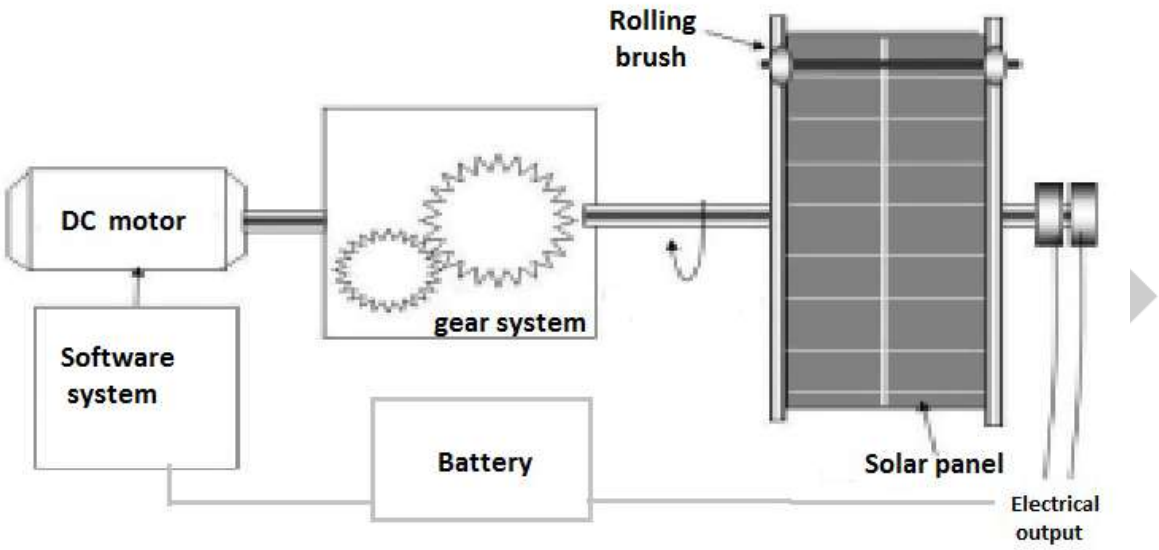

Fig 3.2: Proposed Design

This project contains a simple preparation of electronic circuit. It contains the basic components which deal with the Solar Panel, DC Motor, DC Gear Motor or conveyor belt, Microcontroller (AT89S52) and battery.

3.3 DC Motor:

Motor is an actuator device which converts direct electric cutting-edge into mechanical power. It is very critical in lots of commercial and non-industrial displays nowadays.

A simple motor has six components, as proven inside the illustration below

- Commentator
- Axle
- DC power supply
- Armature or rotor
- Brushes

- Field magnet

Fig 3.3: DC Motor

An electric motor is all approximately magnetic body and magnetism. A motor makes use of magnets to create motion. Right here the recognition of superfluous regulation of all magnets were achieved i.e. Opposites attract and likes repel each other. So when you have bar magnets with their ends marked North and South, then the north end of 1 magnet will repel the north stop of the opposite. Inside an electric motor, these attracting and repelling forces create rotational movement.

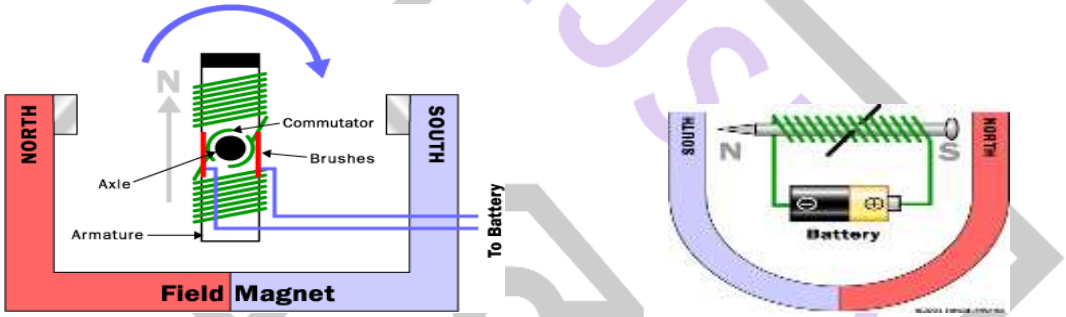

Fig 3.4: Principle of Working of Motor

Within the above example, it could be see that two magnets in the motor, the armature is an electromagnet and the sphere magnet is a permanent magnet. To recognize how an electric motor works, the secret's to apprehend how the electromagnet works. An electromagnet is the premise of an electric motor. Here it can be recognize how things work within the motor by imagining the following improvement. The spike would come to be a magnet and have a north and south pole even as the battery is coupled.

3.4 Solar Cell

Photovoltaic energy is the transformation of sunlight into energy. A photovoltaic cell, usually called a sun portable or PV, is the information used to convert sun strength immediately into electrical power. A photovoltaic mobile is a non- mechanical scheme typically made from silicon composite.

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Fig 3.5: Solar Cell

The photovoltaic chamber is the basic construction block of a photovoltaic organization. Individual can differ in size from around 0.5 inches to about 4 inches through. Yet, one cell only yields 1 or 2 watts, which isn't adequate power for most submissions.

3.5 Types of Solar Panels

Photovoltaic (PV) is a technology that changes light directly into electricity. Photovoltaic is also the field of study linking to this technology and there are many research institutes devoted to work on photovoltaic. Due to the rising need for solar energy, the manufacture of solar cells and solar photovoltaic array has expanded dramatically since 2002 making it the world's fastest growing energy technology. There are 3 types of solar panels and are explained below

3.5.1 Mono Crystalline:

Mono crystalline sun panels are made from a huge crystal of silicon. These varieties of solar panels are the maximum green as in absorbing sunlight and converting it into strength; but they may be the maximum high priced. They do particularly higher in decrease light conditions then the alternative types of solar panels.

Fig 3.6: Mono Crystalline Solar Plate

3.5.2 Poly Crystalline:

Poly crystalline sun panels are the maximum common types of solar panels available on the market today. They appearance plenty like shattered glass. They're slightly much less efficient than the mono crystalline sun panels and much less highly-priced to supply. Instead of one massive crystal this kind of solar panel includes more than one quantities of smaller silicon crystal.

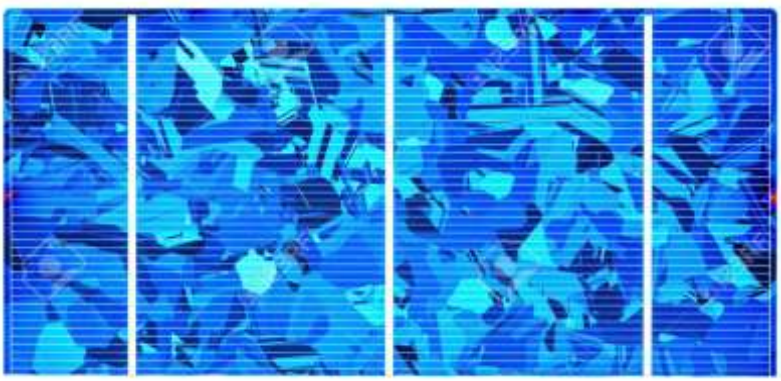

Fig 3.7: Polycrystalline Solar Plate

3.5.3 Amorphous Solar Plates:

Amorphous solar panel includes a thin film crafted from molten silicon this is spread directly throughout massive plates of stainless steel or similar cloth. Those kinds of solar panels have lower performance than the alternative varieties of sun panels, and the cheapest to produce. One advantage of amorphous sun panels over the alternative two is that they may be shadow blanketed. That means that the sun panel keeps to rate at the same time as part of the sun panel cells is in a shadow. Those paintings excellent on boats and different types of transportation.

Fig 3.8: Amorphous Crystalline Solar Plate

3.5.4 Solar Panel Efficiency Details:

Mono crystalline -18 Percent

Poly crystalline-15 Percent

Amorphous (thin)-10 Percent

CHAPTER 4

METHODOLOGY

4.1 SOFTWARE IMPLMENTATION:

4.1.1 Microcontroller Architecture

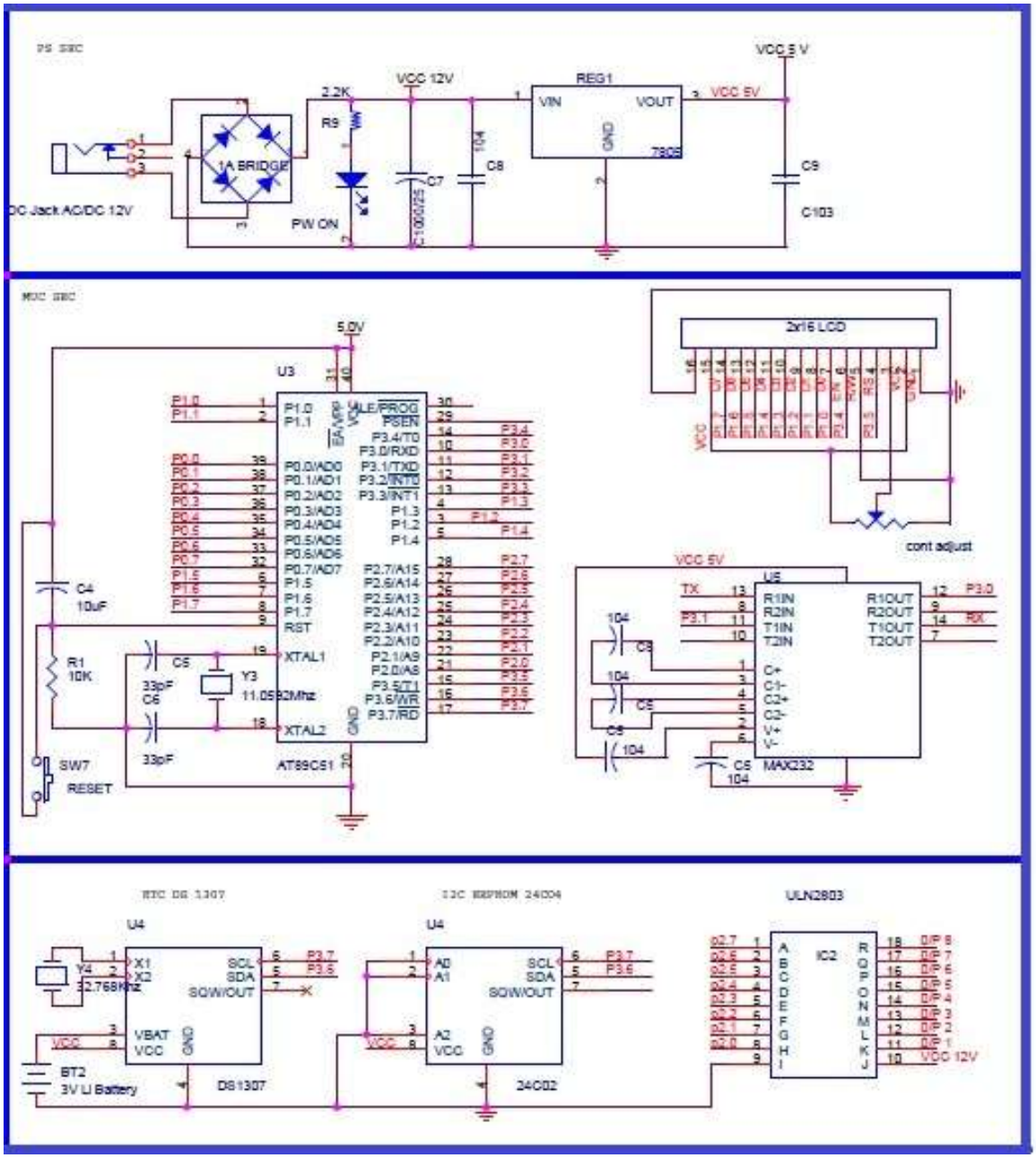

Fig 4.1: Architecture

Uses	. Part of electronics procedures, small plant power source.	

4.1.2 Circuit

Features:

Availability of components	Easy to get, uses only very common basic components.
Power supply voltage	220V 50Hz
Circuit complexity	Very simple and easy to build.
Brief explanation of operation	Gives out well controlled +12V output, production capability of 1A current
Circuit performance	Very stable +5V output voltage, reliable operation.
Power source current	1 AMPS

Table 4.1: Specifications of microcontroller

4.1.3 Working Principle:

An energy deliver with 12 V is sufficient for overall circuit. Transformer primary aspect has 220V, 50Hz AC voltage while on the secondary winding the voltage is steped down to 12V, 50Hz AC and this voltage is rectified the usage of complete wave rectifier. The rectified output is given to a filter out circuit to clear out the undesirable ac in the sign.

A step down transformer is used to convert 220V, 50Hz line voltage to 12V AC input to the supply pin of the circuit. The AC voltage is transformed to pulsated DC using full wave rectifier. Any ripples if gift are removed the use of a capacitive clear out at the output of the overall wave rectifier.

The output from the transformer is fed to the Microcontroller unit. The proper operation of the unit is ensured by using connecting it to the LCD display. The output from the microcontroller is fed because the enter to the L293D driving force circuit which controls the operation of the DC tools motor.

4.1.4 The Microcontroller

A microcontroller is a general cause tool, however is supposed to examine records, perform restricted calculations on that statistics and manipulate its surroundings based totally on those calculations. The high use of a microcontroller is to govern the operation of a gadget using hard and fast software this is saved in ROM and that doesn't trade over the lifetime of the system.

The microcontroller design makes use of a mile extra restricted set of unmarried and double byte instructions which are used to transport records and code from internal memory to the ALU. The microcontroller is worried with getting information from and to its personal pins; the structure and coaching set are optimized to address records in bit and byte length.

The AT89S52 is a low-power, high-overall performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash reminiscence. The tool is synthetic the use of Atmel's excessive-density nonvolatile memory technology and is compatible with the enterprise trendy 80C51 guidance set and pin out.

4.1.5 AT89S52 MICROCONTROLLER FEATURES

- Compatible with MCS-51 Products
- Fully Static Operation: 0 Hz to 24 MHz
- 8K Bytes of In-System Reprogrammable Flash Memory
- 4.0V to 5.5V operating range
- 256 x 8-bit Internal RAM
- Three-level Program Memory Lock
- 32 Programmable I/O Lines
- Three 16-bit Timer/Counters
- Eight Interrupt Sources
- Low-power Idle and Power-down Modes
- Full Duplex UART Serial Channel
- Programmable Serial Channel
- Fast Programming Time
- Packages available:
    - 40-pin PDIP
    - 44-pin PLCC
    - 44-pin TQFP

4.1.6 Flow Chart:

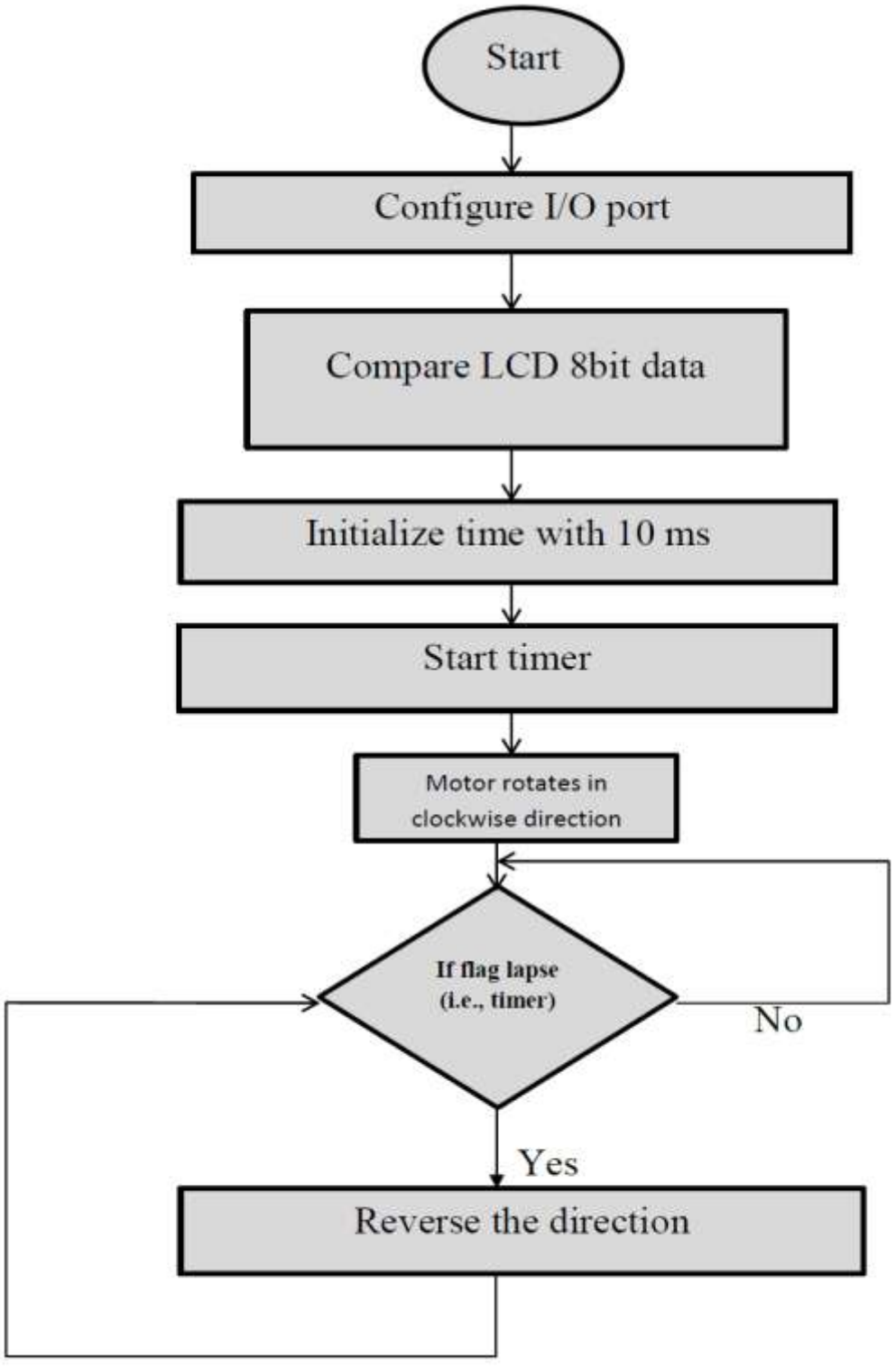

Fig 4.2: Flow Chart

4.2 Hardware Assembly

In accord with the measurements of the flat plate panel, the model consists of brushes pushed with the aid of DC motors via belt gadget. The movement of the brushes is managed by using sign generated through a microcontroller with the suitable sensor used to sense the amount of dust collected on the panel. But here we aren't using sensor rather than that the timer is ready the use of microcontroller to clean the panel routinely on time base. The DC-motor will produce a rotational motion that's converted in to linear movement over belt. Via belt device, the rotational movement is transformed into linear movement which is produced by way of DC motor. The electrical strength which is applicable to pressure the DC motor may be furnished from the solar plate itself however right here the external ac supply is used to avoid the energy loss, since the operation of the cleansing meeting is not non-stop.

Following steps are involved in the methodology

(a) Gathering and analyzing more extra info concerning the effects of gathered dust at the flat solar panels.

b) Designing the basic model of the automobile cleaning gadget.

c) Deciding on the right microcontroller to govern the auto cleansing version and timer to easy the dust at the sun panel.

d) Designing the microcontroller's set of rules such that the microcontroller can manage the assembly within the accurate route.

4.2.1 Circuit Diagram:

It mainly consists of solar panel and brush assembly. The solar panel is placed on stand so that it inclined at 45° and circuit is made using voltmeter connected in parallel and ammeter is connected in series to get voltage and current reading. The load is connected across the circuit depending upon the power generated by the module. The circuit is shown below.

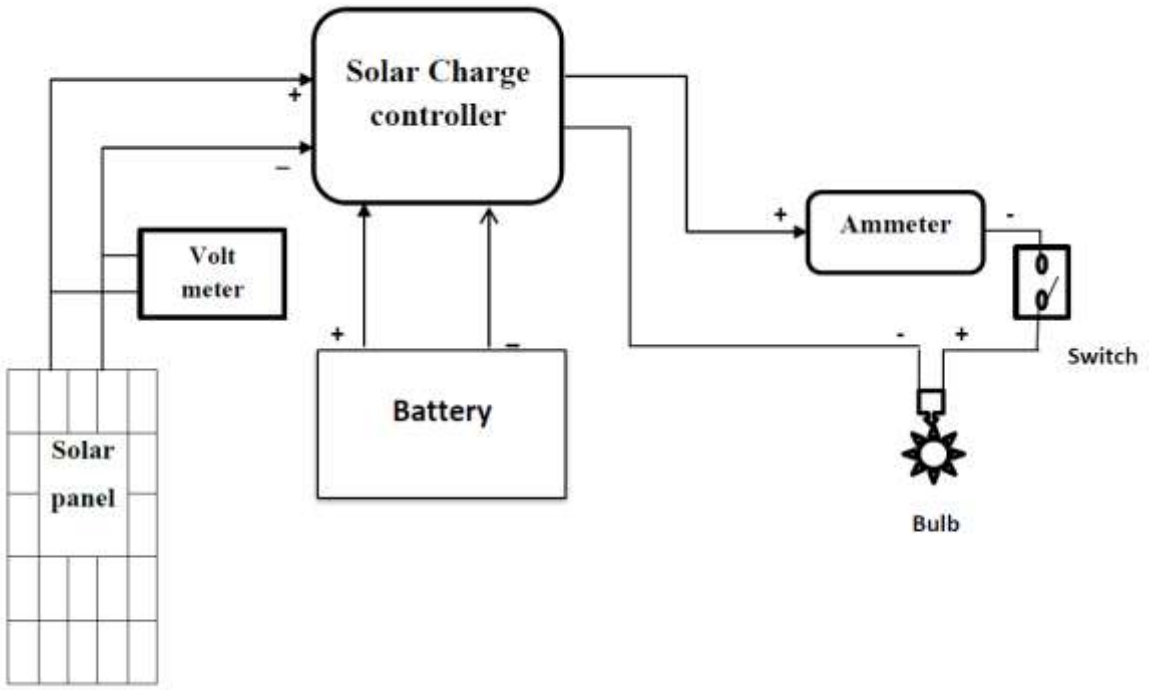

Fig 4.3: Circuit Diagram for Hardware Arrangement

In the hardware assembly the drive motor is used to drive the brush gathering along the surface of the PV panel. Meanwhile brush is rotated using another series motor. The voltage and current reading were used to draw the output graph using Microsoft excel.

4.2.2 Calculation:

Here, the Electrical measurements were studied in the two ways. Namely,

- **Power**: The instantaneous amount of using or generating Electrical energy is called power. The unit used to measure power is watts.
- **Energy:** the total amount of power produced or castoff over a period of interval is known as strength. The unit used to measure power is kWh, or kilowatt-hours.

"Electricity is the rate at which energy is transferred from one point to another factor or from one shape of energy to another shape"

The formula which connects power and energy is as follows:

Power = voltage (V) x Current (I)

Energy = Power (W) x Time (t).

The joule is the unit of power, watt is the unit of power, and 2d is the unit of time. If the equipment power is in watts and also range of seconds it consumes is known, we are able to calculate electrical power in joules that has stayed transformed.

By means of decision, Productivities of the solar cell are confined beneath general check situations (STC) unless specified else. STC stipulates a temperature of 25°C and an irradiance of 1000 W/m² with an air mass 1.5 (AM1.5) spectrums. These circumstances corresponds to a clear day with daylight prevalence upon a solar-going through 37° tilted surface with the solar at an perspective of forty one.81° above the chance. This characterizes solar noon near the spiral and season equinoxes within the continental us with floor of the cellular pointed directly at the solar. Beneath the ones take a look at conditions a solar mobile of 20% productiveness with a 100 cm² (zero.01 m²) surface vicinity might yield 2.0W.

4.2.3 Module description:

The array is used for massive scale of generation from solar panel. That array is made from several modules and each module is crafted from different kinds of modules as noted in previous bankruptcy's i.e. Mono crystalline, Poly crystalline and amorphous solar panels. But on this observe the single Poly crystalline module of 36 cells is hired with 100wp technology capability and 1080mm* 655mm. the same old trying out situations (STC) is 1000 w/m², 25°C is considered.

Consistent with the table 1, the PV module made of Sitara Akshaya Urja 100wp Poly crystalline module. Similarly, this requires the use of parameter of PV module. Together with open circuit voltage at STC, quick circuit contemporary at STC, Voltage, and current and temperature energy coefficients. Right here the sun module is attached to the weight lamp.

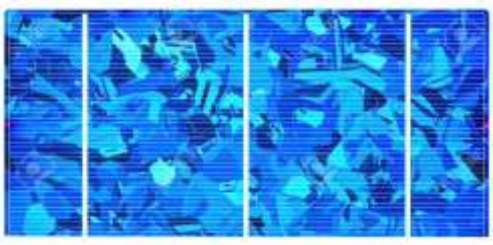

Fig 4.4: Experimental module

Sl. no.	Parameter	Pmax
1	Maximum power (w)	100wp
2	Voltage (V)	17.28V
3	Current (I)	5.40A
4	Short circuit current	5.7A
5	Open circuit voltage	21.87V
6	Maximum system voltage	600V

Table1 4.2: Characteristics of PV module.

4.2.4 Components of self cleaning system:

Fig. 4.5: Dc Motor Controlled by Microcontroller

Fig. 4.6: Solar charge controller

Fig. 4.7: Cleaning Brush

Fig. 4.8: Ammeter with load current

Fig. 4.9: Belt use to convert the Rotational motion of DC- motor to linear motion

4.2.5 Tabular columns:

Reading 1:

A) Before cleaning:

Sl. No	Time in AM/PM	Voltage in volt	Current in amps	Power in watt
1	10	19.0	4.1	77.9
2	11	19.2	4.1	78.72
3	12	19.5	4.1	79.95
4	13	20.1	4.1	82.41
5	14	20.4	4.1	83.64
6	15	19.8	4.1	81.18
7	16	19.4	4.1	79.54

Table 4.3: Tabulated readings before cleaning

B) After cleaning:

Sl. No	Time in AM/PM	Voltage in volt	Current in amps	Power in watt
1	10	19.1	4.1	78.31
2	11	19.3	4.1	79.13
3	12	19.6	4.1	80.36
4	13	20.15	4.1	82.61
5	14	20.5	4.1	84.05
6	15	20.0	4.1	82.00
7	16	19.6	4.1	80.36

Table 4.4: Tabulated readings after cleaning

Reading 2:

C) Before cleaning:

Sl. No	Time in AM/PM	Voltage in volt	Current in amps	Power in watt
1	10	19.8	4.1	81.18
2	11	20.0	4.1	82.00
3	12	20.3	4.1	83.23
4	13	20.5	4.1	84.05
5	14	20.6	4.1	84.46
6	15	20.4	4.1	83.64

7	16	20.3	4.1	83.23

Table 4.5: Tabulated readings before cleaning

D) After cleaning:

Sl. No	Time in AM/PM	Voltage in volt	Current in amps	Power in watt
1	10	19.85	4.1	81.38
2	11	20.1	4.1	82.41
3	12	20.35	4.1	83.43
4	13	20.55	4.1	84.25
5	14	20.65	4.1	84.66
6	15	20.45	4.1	83.84
7	16	20.32	4.1	83.31

Table 4.6: Tabulated readings after cleaning

Reading 3:

E) Before cleaning:

Sl. No	Time in AM/PM	Voltage in volt	Current in amps	Power in watt
1	10	19.6	4.1	80.36
2	11	19.8	4.1	81.18
3	12	20.1	4.1	82.41
4	13	20.4	4.1	83.64
5	14	20.2	4.1	82.82
6	15	20.05	4.1	82.20
7	16	19.9	4.1	81.59

Table 4.7: Tabulated readings before cleaning

F) After cleaning:

Sl. No	Time in AM/PM	Voltage in volt	Current in amps	Power in watt
1	10	19.65	4.1	80.56
2	11	19.85	4.1	81.38

3	12	20.15	4.1	82.61
4	13	20.43	4.1	83.76
5	14	20.24	4.1	82.98
6	15	20.10	4.1	82.41
7	16	19.95	4.1	81.79

Table 4.8: Tabulated readings after cleaning

Reading 4:

G) Before cleaning:

Sl. No	Time in AM/PM	Voltage in volt	Current in amps	Power in watt
1	10	19.8	4.1	81.18
2	11	20.0	4.1	82.00
3	12	20.1	4.1	82.41
4	13	20.3	4.1	83.23
5	14	20.4	4.1	83.64
6	15	20.2	4.1	82.82
7	16	20.0	4.1	82.00

Table 4.9: Tabulated readings before cleaning

H) After cleaning:

Sl. No	Time in AM/PM	Voltage in volt	Current in amps	Power in watt
1	10	19.85	4.1	81.38
2	11	20.05	4.1	82.20
3	12	20.15	4.1	82.61
4	13	20.35	4.1	83.43
5	14	20.43	4.1	83.76
6	15	20.22	4.1	82.90
7	16	20.03	4.1	82.12

Table 4.10: Tabulated readings after cleanin

Reading 5:

I) Before cleaning:

Sl. No	Time in AM/PM	Voltage in volt	Current in amps	Power in watt
1	10	19.9	4.1	81.59
2	11	20.1	4.1	82.41
3	12	20.5	4.1	84.05
4	13	20.8	4.1	85.28
5	14	20.4	4.1	83.64
6	15	20.2	4.1	82.82
7	16	20.1	4.1	82.41

Table 4.11: Tabulated readings before cleaning

J) After cleaning:

Sl. No	Time in AM/PM	Voltage in volt	Current in amps	Power in watt
1	10	19.93	4.1	81.71
2	11	20.15	4.1	82.61
3	12	20.53	4.1	84.17
4	13	20.84	4.1	85.44
5	14	20.43	4.1	83.76
6	15	20.25	4.1	83.02
7	16	20.14	4.1	82.57

Table 4.12: Tabulated readings after cleaning

CHAPTER 5:
RESULTS AND DISCUSSIONS

Graphs:

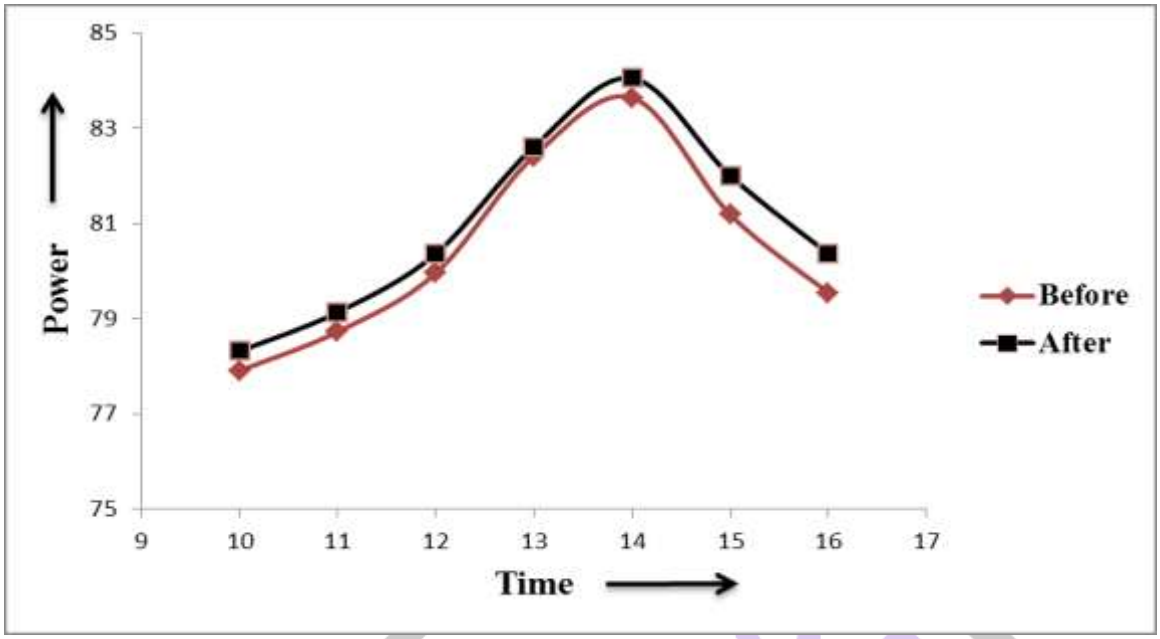

Fig 5.1: power measurement of panel by considering readings in Tables (A) and (B)

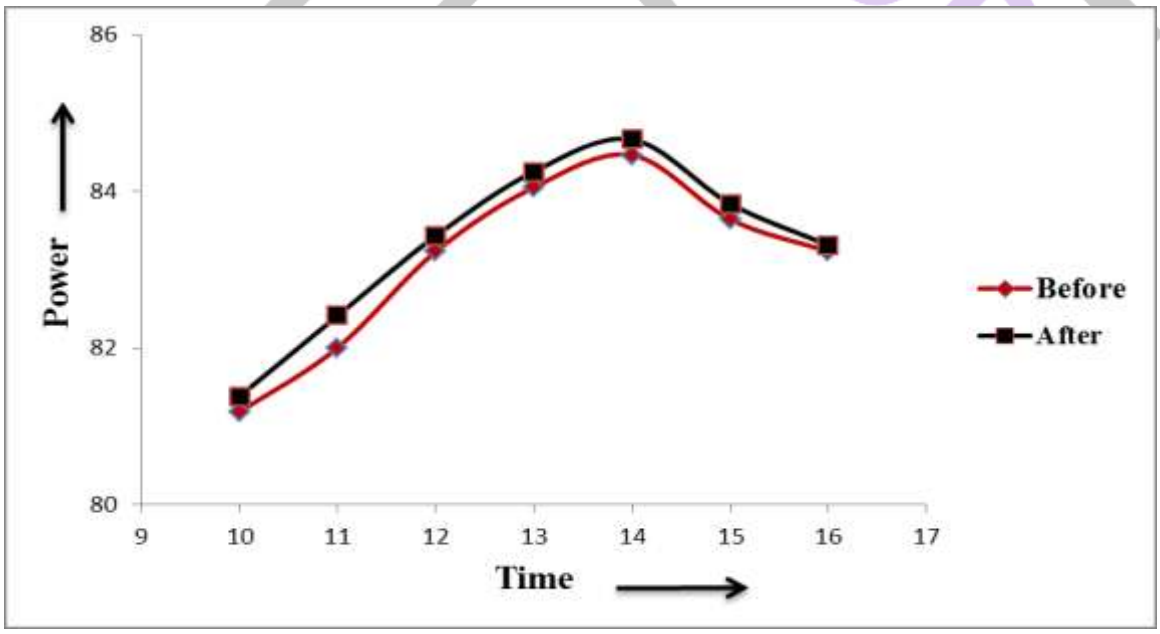

Fig 5.2: power measurement of panel by considering readings in Tables (C) and (D)

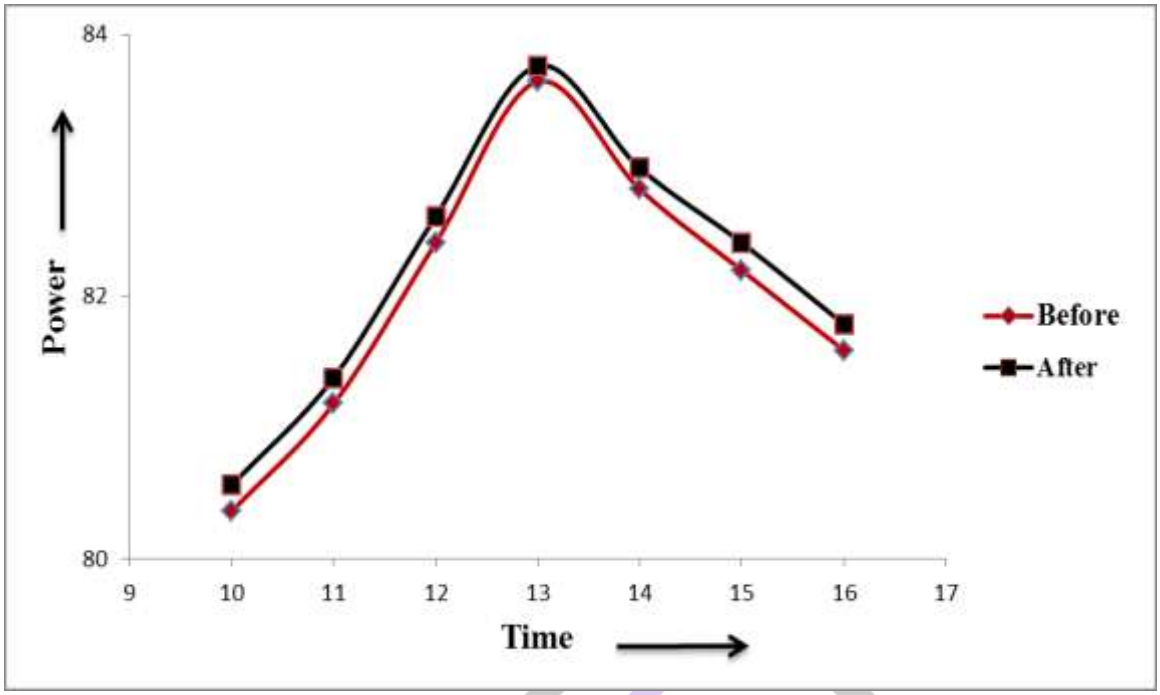

Fig 5.3: power measurement of panel by considering readings in Tables (E) and (F)

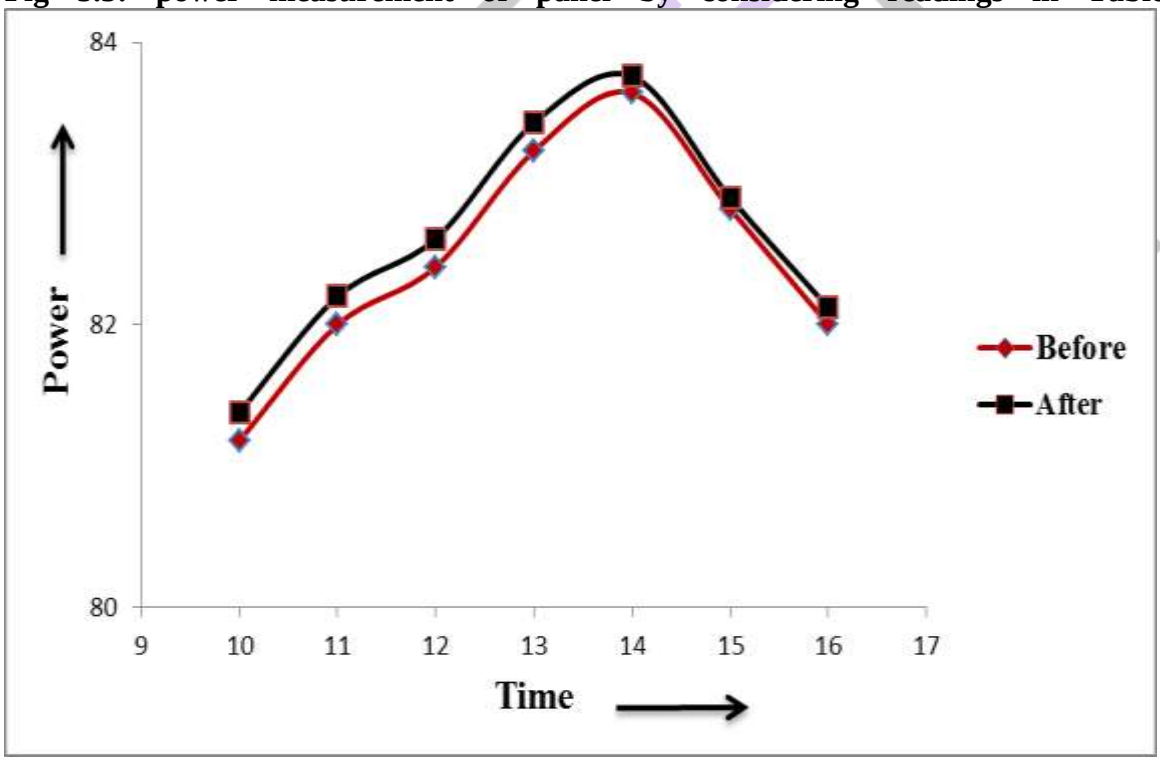

Fig 5.4: power measurement of panel by considering readings in Tables (G) and (H)

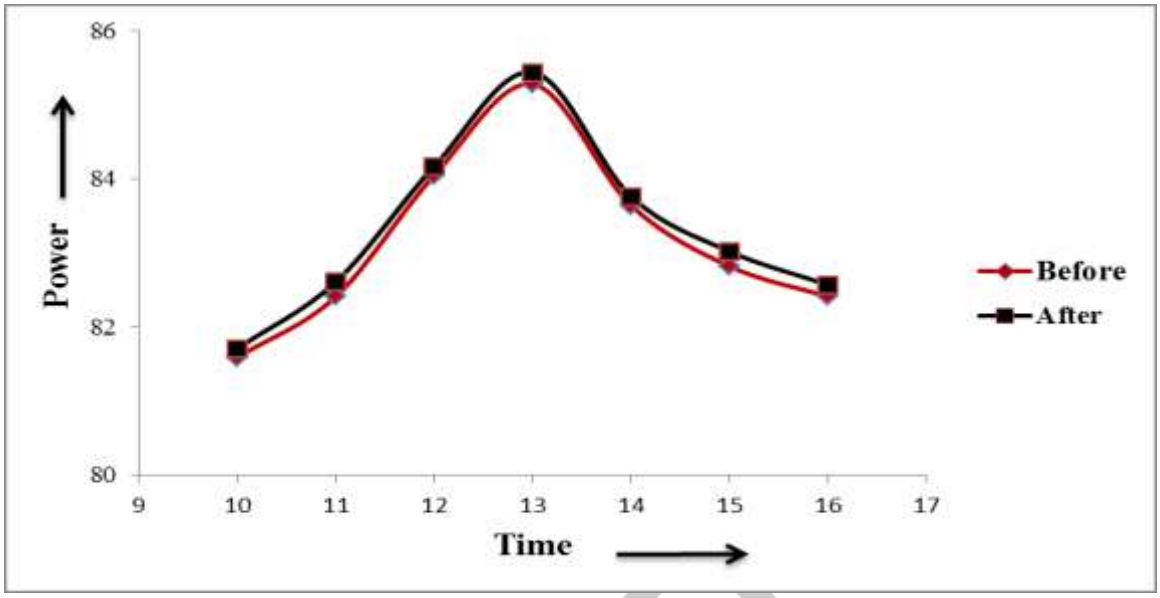

Fig 5.5: power measurement of panel by considering readings in Tables (I) and (J)

The graph is drawn by considering the readings taken from Table (A) to Table (J). The time is taken in x-axis and power generated by the solar panel is taken in y-axis. The red curve shown in all graphs is the power generated by the dusty panel i.e. before cleaning which is taken in watts, whereas the black curve in the graph is power generated by the panel after cleaning of the dust accumulated on the panel. The time interval is taken in hours from morning 10am to evening 4pm in the month of July and August. An assessment of result for the experimental module is evaluated by the study of above graphs.

Figure 1 shows the performance of the power generated by the solar panel for the reading 1. The power generated from morning to evening in one day is considered. The readings are tabulated separately as shown. Due to varying weather conditions in the month of July the minimum power generated is 77.9Wh before cleaning and 78.31Wh after cleaning. The maximum power generated is 83.64Wh before cleaning and after cleaning it is found to be 84.05Wh i.e. 0.41Wh is the increased power in the reading.

According to figure 2, the performance of the power generated by the solar panel for the reading 2 is considered. Here also the power generated from morning to evening in one day is taken. Due to same varying weather conditions in the month of July the minimum power generated is 81.18Wh before cleaning and 81.38Wh after cleaning. The maximum power generated is 84.46Wh before cleaning and after cleaning it is found to be 84.66Wh i.e.0.20Wh is the minimum power increased and 0.41Wh is the maximum increased power in the reading.

The highest number of power generated by the solar panel for the reading 3 is found according to the figure 3. The maximum power generated is 83.64Wh before cleaning and after cleaning it is found to be 83.76Wh at 1pm. The minimum power generated is 80.36Wh before cleaning and after cleaning it is found to be 80.56Wh at 10am. The power increase in both before and after cleaning is observed to be 0.12Wh and 0.20Wh respectively.

In the month of August, due to improved weather conditions the generation of power is increased in reading 4 and reading 5 as compared to previous readings. The optimum power is obtained from 12pm to 2pm. The maximum and minimum power generated is found to be 83.64Wh and 81.18Wh before cleaning of the panel. The power gets increased to 83.76Wh and 81.38Wh after cleaning. A quantity of 0.12Wh and 0.20Wh power is increased in the reading 4. Similarly in the reading 5 also the quantity is increased by 0.16Wh and 0.12Wh. in this case the maximum power generated before cleaning is 85.28Wh and the minimum power generated is found to be 81.59Wh. But after cleaning of the panel the maximum and minimum power generated in a day is observed to be 85.44Wh and 81.71Wh respectively.

Since the readings of all tables were not taken in definite intervals of days i.e. the gap between every reading is indefinite. But the readings of before and after cleaning were taken in two consecutive days. Hence we cannot find much difference in the variation of voltage generated by the panel. Since the load used in the circuit is lamp, the current drawn by the load is almost remains constant for all the readings.

Sl. No.	Before Cleaning	After cleaning
	Total mean power per day	Total mean power per day
Reading 1	80.47	80.97
Reading 2	83.11	83.32
Reading 3	82.02	82.21
Reading 4	82.46	82.62
Reading 5	83.17	83.32

Table 5.1: Comparison of power between before and after cleaning

CHAPTER 6:
CONCLUSIONS

The performance analysis of the experimental setup is purely based on the amount of power generated on the dusty panel and a cleaned panel. The output power may reduce considerably by the large amount of dust accumulation on the panel. Dry cleaning can eliminate the dust particles on the surface but the effective cleaning is observed in wet cleaning. A bulk of the dirt dropped on the panel can be removed by cleaning the solar panel with water. No external power supply is required for the cleaning technology because solar panel itself can generate the sufficient power required for the microcontroller operation, which can be stored in a battery. The assembly is found to be lightweight. In comparison of costs in manual operation cleaning and automatic cleaning, the cost for automatic cleaning is demonstrated to be more economic and significantly less burden particularly in the system having large number of solar panels. The microcontroller is used because of its applications by pic programming and also because of lower installation cost. The power output is varying for the different weather conditions. A regular periodic cleaning ensures the variation of power measured in both before and after cleaning conditions by showing the significant performance of the cleaning technology.

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