DESIGN AND CONSTRUCTION OF AN AUTOMATIC SOLAR PANEL CLEANER WITH A SPRINKLER SYSTEM

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NOVEMBER 2011

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SUBMITTED TO

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SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA,

NIGER STATE

IN PARTIAL FUFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) DEGREE IN ELECTRICAL AND ELECTRONICS ENGINEERING

NOVEMBER 2011

DEDICATION

This report is dedicated to Almighty Allah (S.W.T) who in his infinite mercies has made my journey a success. I also dedicate this report to the entire members of the Adamu ma'aji's family for their investment into my education.

DECLARATION

I Adamu Abdullahi. B declares that this work was done by me and has never been presented elsewhere for the award of a degree; also hereby relinquish the copyright to the Federal University of Technology, Minna.

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ACKNOWLEDGEMENT

I will like to start by saying "ALHAMDULILAH" and all thanks and appreciation to ALMIGHTY ALLAH; the Beneficent and the Merciful from whom I continuously receive grace and strength to overcome all challenges of life.

My special appreciation goes to my parents Alhaji Adamu Ma'aji (Barayan Bosso) and Hajiya Rukayat Adamu Ma'aji for their relentless investments into my education and also their moral supports and advice they have given me. I am very grateful and may Allah in his infinite mercy continue to grant all your heart diseres.

To my big brother and also my best friend Abubakar Sadiq Adamu (General); for always being there to carry me through my rough times, there are no words to tell you. Thank you for all the love and care you have shown me; also to my two dearest sisters, Aishat .P Adamu and Amina .L Adamu; you ladies are the best sisters ever.

My special thanks to my supervisor Mr. Imoru Odunayo for his encouragement, patience, and moral support he has given me during the time of my project work

My special grantitude to my favourite uncles Muhammed Aliyu, Nuhu Aliyu Ango and Abubakar A. Ango. for your moral, spiritual and financial support towards fulfillment of my degree programme; and not forgetting Haj. Oyedotun.

And to my close friends, Tunde (Rico), Umar Alfa (Zeze), Umar Shiyaki (randy), and Hussiena, for being there for me through my rough moments in school. The rest credit to my friends and coursemates for the support and understanding, to mention but few Leonard, Dmeji, Suleman, Amaka, Kamal

ABSTRACT

The efficiency of the solar panels refers to the amount of sunlight that can be converted by a solar panel to electricity, the more sunlight absorbed means the more electricity produced and the better the solar panel efficiency. It is always ideal to plan for a periodic cleaning of the solar panel to remove the dirt and dust accumulated on top of the surface of the solar panel, so that the solar panel functions properly and none of the sunlight get lost. To increase the efficiency of the solar cells, the panel must be kept clean at all times, so as to provide a wide surface area for absorption of energy from the sun. This project explores the use of a microcontroller programmed for automatic cleaning of the solar panel so as to eliminate the risk of injuries, damages of roof tops or even the solar panel surface and to provide a less stressful and a more reliable means of cleaning the panel.

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CHAPTER ONE

1.1 INTRODUCTION

Electricity plays on important role in the socio-economic and technological development of every nation, the electricity demand in Nigeria is far more than the generation power, the power is available to consumers is epileptic in nature. Nigeria is faced with problem of insufficient electricity supply.

Generally, it is foreseen that the economic development among developing countries is accelerated by the stability of their power sector. In Nigeria, power failure and its epileptic nature has become really ramped throughout the country, the country is faced with frequent blackout which is really a big problem the federal government has not really found a suitable solution. Nigeria as a developing country is anxious to grow and is faced with domestic energy supply problems. This has resulted in the consumers embarking on the use of expensive local fuel which is not readily available and very risky also lantern, candles are also used as substitutes, which seem to be unsafe and constitute several hazards to the environment.

The solution lies in using renewable energy sources such as solar energy, wind energy, etc. Nowadays, solar energy is widely used in our environment, and its use is growing very fast these days. Solar energy is advantageous because it does not require fuel, no pollution; it has no moving parts to wear out, adaptable for on-site installation, and also its simple and very efficient. The solar panel is a package interconnected assembly of solar cells known as photovoltaic cells. The solar panel is a device which tends to utilize the energy of the sun by converting solar energy to generate and supply

electricity both commercially and residential; the panel system includes an array of solar panels, an inverted with a battery and interconnection of wiring.[1]

Once you get your solar panel installed, you will find them rarely maintained; most are rated for a 30 year lifetime. If you really take time to observe, the solar panels can get dirty by pollen bird droppings, dirt and dust from the environment can build up on the surface of the solar panel. At least this problem is minimal during the raining season as a result of constant and huge amount of rainfall, but during the dry season the panel really gets dirty due to compilation of dirt and even pollen from nearby evergreens which maybe bond to the panel after a period of time. Research found that when the solar panel is dirty, it decreases its efficiency by 15- 30% and thereby immediately increased the power generated on the inverters.[2, 3]

After observing that the surface of the solar panels installed in Nigeria environment today, they get dusty after sometimes due to lack of maintenance of the surface, which surely reduces the intensity of the sun reaching the surface by shielding the panel from the sun. Hence this project provides a way of solving the stated limitations by designing and constructing an electrical device capable of cleaning the surface of the solar panel automatically twice a week. This is to improve the performance of the solar panel. And it is illustrated by the block diagram below.

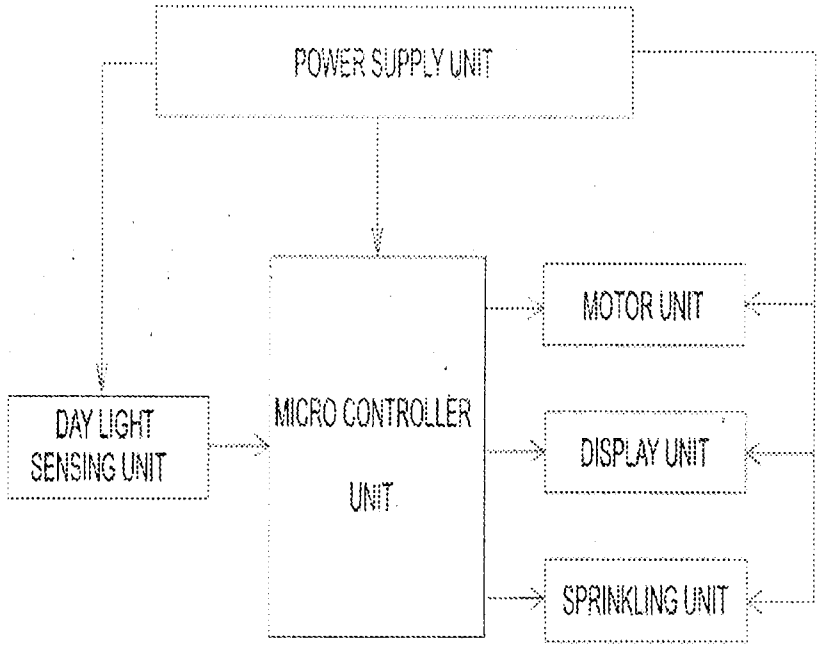


Fig. 1.1 Block Diagram of the Automatic Solar panel Cleaner

1.2 OBJECTIVES

This project is aim to design and construct an electronic circuit capable of cleaning the surface of a solar panel automatically. It is realized solar panel in Nigeria lacks maintenance and get dirty easily by birds droppings, dirt, dust and even pollen from nearby evergreens and also to clean accumulated dirt and debris from building up on the panel, furthermore for situations where the solar panel are installed in an extremely difficult position for a person to reach and clean it manually so as to improve the working performance of the solar panel. [3]

Therefore, the main objectives of this project work are;

- To eliminate the risk of injury or liability to the person conducting the manual operation.
- To avoid damage to the roof top or even the solar panel.
- To provide a less stressful and a more reliable means of cleaning the panel.

1.3 SCOPE OF WORK

This work centered on designing and construction a device which can continuously provide a regular clean up to a solar panel. It is a model which can be used as a prototype towards construction of a real solar panel cleaner. Hence a solar panel was not actually used in this work but a flat plastic was used to illustrate the surface of the solar panel. A light Dependent Resistor (LDR) is used to sense day light and a signal is sent to the microcontroller which is used to time, and control the sprinkle and also the motor to which the cleaner (wiper) is attached to.

1.4 JUSTIFICATION FOR THE PROJECT

When carefully observed the surface of a solar panel gets dirty easily, either by dust, pollen from the environment and also leaves and flowers from nearby trees, which might really, affect the efficiency of the solar panel. Dirty solar panel means less or reduced amount of light intensity on the solar panel cell, which means that if one part of one panel is dirty, then the output of the entire string is reduced and also potential energy loss can range as high as a 25%.To increase the efficiency of the solar cells, the panel must be kept clean at all time, so as to provide a wide surface area for absorption of energy from

the sun, and also avoid risk involved with the potential physical damage to your roof, your panels and mostly, yourself

1.5 METHODOLOGY.

The solar panel cleaner was archive using LM555 timer together with a light dependent resistor to sense the day light and night using the light dependent resistor (LDR) as alight sensor, the resistance of an LDR varies with the intensity of light, and a microcontroller chip was used as the control that trigger the DC motor to roll both clockwise and anticlockwise direction to clean up the solar panel while a sprinkling system was also employ to sprinkle water on the solar panel before the cleaner roll through the surface of the solar panel for effective cleaning of the panel, thereby preventing spreading of dust on the surface of the panel.

The solar panel cleaner was program to clean the panel every morning i.e. any time the LDR sense the presence of day light it send a signal to the LM555 which notify the microcontroller to drive the motor.

1.6 CONSTRAINTS

Several hinderers have been encountered during the design and construction of this project work, include unavailability of desired components that were to be used for the construction, most of the components were gotten from the available ones found in the surrounding around, for example the sprinkler system used is gotten from the cars wiper system, and the wiper was manually constructed using plastic and pieces cloths.

CHAPTER TWO

LITERATURE REVIEW

2.1 Background Information

Power has been one of the most important problems facing Africa today especially Nigeria, In Nigeria power supply is insufficient and unreliable, power failure and outage has become really ramped throughout the country and this could be as a result of increase in demand for electricity for domestic and industrial purposes, It is estimated that only 20 - 40% of the population is connected to the national electricity grid. The nation suffers enormous energy crisis manifesting in various forms about 60 – 70% of the nation population are excluded from the national grid is plagued by rather frequent power outages that the last for as long as about 20 hours daily in places that are connected to the grid. After repeated optimistic projections by successive government administration, the situation is yet to improve although more settlements have now been connected to the national grid. The privatization exercise which has begun with NEPA now been transformed to PHCN before its full taken over by private sector investors has remains practically unrealistic to have the entire country's population connected to this grid, even in the nearest future. An alternative solution considered to this problem was use of fuel generators, which was not also reliable due to instability and variation of the voltage level, pollution, increase on global warming, increase in cost of fuel and more importantly safety; you even see on television and newspapers the rate at which generator accidents has taken several family lives is increasing daily. The safest and more reliable solution to this entire problem is the use of the solar panel system.

Whenever the sun is shining on you; it is sending a lot of energy in your direction. As we can feel the burning heat from the sun on our skin, if we could place a solar cell to directly face the sun everyday from sun rise to sunset, then it would be receiving the maximum amount of sunlight possible and converting it into electricity. The solar panel is device which tends to utilize the energy of the sun by converting solar energy to generate and supply electricity in commercial and residential applications; the panel system typically includes an array of solar panels, an inverted with a battery and interconnection of wiring. Every year, Earth's atmosphere absorbs a total of 3,850,000 extra joules of sun heat. Solar energy is free energy people can utilize. About 174 per watts of solar energy from the sun is received by our planet. 30% of the sun's radiation is reflected back to space and the remaining 70% is absorbed by the clouds, land and other bodies of water. [2]

Man has used sun power, which comes from the heat of the sun, since the olden times. Solar energy is free energy source for the people. It does not require fuel and does not cause pollution.

Compared to natural gas, coal and oil that takes a long time to be harvested in huge amount, this power has no shortage of supply. With this advantage, modern solar applications are being developed to harness the heat. Some of these solar applications that are used nowadays include water heating, heating and cooling architectures, electricity production and those used for industrial purposes.

With the use of tilted curved mirrors, parabolic-through collect energy from the sun. Pipes with oil are being focused on with light and heat. The oil heats the water used

in generators. The generators in turn produce electricity. Mirrors are also used to collect light for the dish system and power tower system in order to generate electricity.

Another use of the heat from sun is through the sun collector. This is used in order to cool a building. The cooling system operates like that of an air conditioner. It uses the collector to get power from the sun. Evaporative coolers as well use this kind of power collection.Water heating with the use of this heat is also another application which uses glass panels to collect heat. Glass panels are placed on roofs where pipes with water are pumped from the bottom in order to propel the hot water from the top. This way gas or electricity is saved.

As a free source of power, the cells are utilized by our satellites as it orbits the earth. With these satellites, we are able to use TV, telephones, internet and different navigation system. We are able to enjoy these different applications everyday with the help of solar cell powered satellites.

We may not have taken notice of it but mankind has been using solar energy is free source of energy. Heat from sun has been used for drying clothes and foods. In the past, the heat from sun has not been fully utilized. But with the help of our modern technologies, we are able to use the heat as our free source of power. [2.3]

After installation of the solar panel system, for high performance of the system maintenance of the solar panels is of high prime importance as the surface of the solar panel contain a lot of dirt which may effects the system from working efficiently. Hence it is essential to keep the panels free of dirt, dust and other debris built up on the solar panel surface.

Dust and dirt getting collected on the top of the solar panel will reduce the intensity of the sun light from reaching the solar panel, thereby reducing its working efficiency and performance. Solar panel system has to store the sun light received from the sun without losing any fraction of the sun light. By proper maintenance of the solar panels, the efficiency of the solar panel gets increased.[3]

2.1.1 Solar Panel Cleaning Maintains Efficiency

Dirty solar panels result in power loss as grime and debris detract from the solar arrays ability to perform at full capacity:

- Solar arrays are comprised of several solar modules, wired together, which are made up of solar cells.
- Solar cells are semiconductor materials (e.g. silicon), with one side positive and the other side negative.
- When the light from the sun hits the solar cell, the electrons in the solar cell are "excited" thereby releasing energy in the form of electricity.
- Dirty cells means less sunlight is able to be absorbed and thus less electricity is produced. This loss of energy could reach 25 to 30 percent.[4]

Methods of Cleaning Solar Panels

Solar panels can be cleaned either manually or through use of an automatic cleaning system:

- *Manual Cleaning*: One option for keeping your solar panels clean is to roll up your sleeves and get a good cleaning kit to help you easily and quickly clean your panels. Solar panels can be cleaned by applying warm water and dish washing soap to the glass surface and frame. There are a number of risks associated with this approach, namely personal injury and potential damage to the panels.

  The manual steps involves in cleaning the surface of the solar panel, firstly the location of the solar panel plays an important part in the cleaning of the solar panel system. If the solar panel is installed on a roof top of the facility then there should be some provision for the person to reach the roof of the facility. The person would have to secure a position at the roof top so that the cleaning of the solar panel surface can be performed more safely, and if there is no place for the person to secure, then the person may fall from the roof top and gets injured. After the person gets a secure position near the solar panel, the cleaning of the solar panel commences.

  Secondly, the solar panel glass surface is dipped in water and the cleaning solution to a considerable amount of time, the water and the cleaning liquids combination would not affect any part using the solar panels, as the glass surface of the solar panels safely insulate the underlying electrical connection

from getting wet. After allowing sufficient time for the liquid solution to remove the dirt and dust from the solar panel surface, the sponge is used to clean the liquid the liquid from the solar panel glass surface.

The sponge will then remove the liquid along with the dirt from the surface of the solar panel system, the person has to take sufficient care to ensure that only the required force is applied to remove the dirt and the amount of dust that has been collected on the top of the surface of the solar panel, when a person applies more force there are chances of damaging the surface of the solar panel, and for the cleaning solution, it has to be environmental friendly solution which is capable of removing the dirt and the dust accumulated on top of the solar panels; while cleaning the dirt and dust the have been collected on the surface of the solar panels, the cleaning person would also have to remove other debris such as the wooden sticks, leaves and even flowers from the neighboring tress found in between the solar panel and also on the top of the solar panel surface.[5]

However, if you have a roof mount system, considered the logistics of manual cleaning:

i. **Efficiency factor:** climbing up to the roof with a bucket and long-handled brush. Which may, or may not, reach all your panels. If your water is hard and you don't use softened water, you may end up with permanent calcium spots which further reduce the panel's efficiency.

ii. **Time and money factor:** you either spend your Saturday mornings rinsing off your panels to keep them at their peak, or hire someone to do it for you.

iii. **The risk factor:** consider the potential physical risks for damage to your roof, your panels and mostly, yourself,[5]

- *Automatic Cleaning*: this option involved employing an automated cleaning system that will be programmed to clean your solar panels at a set interval. An automated cleaning system is a good option to cut down on the cleaning care for your system. There are a number of automatic systems available, all requiring professional installation. However, once in place, the only action required of the home owner or operator is to periodically refill the soap concentrate and replace the filter.[5.6]

2.2 LITERATURE REVIEW

The solar panels efficiency refers to the amount of sunlight that is converted by a panel to electricity (as in the case of photovoltaic technologies). The sunlight is absorbed – and the more produced electricity – the better the solar panels efficiency. The sunlight to electricity conversion rate is one of the pressing issues at the root of the solar panel discussion – today, some of the good solar panels can only create 14% of the sunlight absorbed; the best ones, 19%. Furthermore, some of the 19% is expended on other sources, such as the necessary tools used to determine the solar panels efficiency. Thus, more than 81% of the sunlight absorbed by the solar panels is wasted. Because of this

predicament, more and more scientists are attempting to increase solar panels efficiency without sacrificing the necessary functions to regulate and transfer solar energy to storage devices. However, despite this seeming success, improving solar panels efficiency remains one of the hindrances to completely accepting solar power as an alternative source of renewable energy. One of the main issues with solar panels efficiency is the seemingly small amount of energy that it produces. Many critics of the technology state that because of the small amounts of energy that are converted by solar panels, it takes more time to change devices powered by this manner.

As a result, instead of wasting resources, users of solar-powered devices are unintentionally wasting time. Many users of solar-powered cars have complained that the power stored in their batteries are severely depleted after a shorter length of time, or due to overexertion on the road, such as driving on highly elevated terrain. This limitation on solar panels efficiency is one of the main problems that scientists currently wish to improve on. [7]

2.2.1 Factors affecting Solar cell efficiency

The efficiency of a solar cell may be broken down into reflectance efficiency, thermodynamic efficiency, charge carrier separation efficiency and conductive efficiency. The overall efficiency is the product of each of these individual efficiencies.Due to the difficulty in measuring these parameters directly, other parameters are measured instead: thermodynamic efficiency, quantum efficiency, integrated quantum efficiency, V_{OC} ratio, and fill factor. Reflectance losses are a portion of the quantum efficiency under "external quantum efficiency". Recombination losses make up a portion of the quantum efficiency,

V_{OC} ratio, and fill factor. Resistive losses are predominantly categorized under fill factor, but also make up minor portions of the quantum efficiency, V_{OC} ratio. [8]

The efficiency of a solar cell depends on many factors. It is therefore possible that a single solar cells performance varies widely depending on its location. The solution was found in the wattpeak (Wp). The power of a solar cell is almost always expressed in this unit, which represents its efficiency under laboratory conditions. These conditions are set at a temperature of 25°C, a light travel distance of 1.5 air mass and a light intensity of 1 kw/m2. Some of the most important effects influencing solar cell (and thus: solar panel) efficiency include;

I. The sun's intensity

The first factor is probably the most obvious. The brighter the sunlight, the more there is for the solar cell to convert. It is for this reason that a solar cell performs best during spring and summer; in fall and winter the sunlight is less intense and thus less able to 'kick loose' the electrons from their parent atoms (see solar cells). This mainly reduces the flow of current; the voltage is usually not that much affected. It is also due to this factor, that a solar cell will be able to deliver more energy in the sunnier areas. for example, a person in Far North receives from 5 to 6 hours of sunshine per day, than a person from Lagos, or Rivers State.

II. Temperature

Contrary to popular belief, the efficiency of a solar cell decreases with increasing temperature. The reason for this is that a higher temperature increases the conductivity of the semiconductor. This balances out the charge within the material, reducing the magnitude of the electric field at the junction. This in turn inhibits charge separation, which lowers the voltage across the cell. It should be noted that a higher temperature increases the mobility of electrons, which causes the flow of current to increase slightly. This increase is however minor and insignificant compared to the decrease in voltage.

The listed power of a solar cell is the power measured under ideal laboratory conditions, which prescribe a temperature of 25 °C (77 °F). However, on a typical hot summer day, it is not uncommon for a solar cell to reach a temperature of 70 °C (158 °F). A general rule of thumb is that the efficiency of a solar cell decreases with 0.5% for every 1 °C (1.8 °F) above 25 °C (77 °F). This means that on a hot summer day, the efficiency of a solar cell could drop as much as 25%. It is therefore extremely important to keep your solar panels well ventilated. Make sure the wind is able to cool on all sides, including the underside. Another very clever option might be to implement liquid cooling, using the heat captured by the liquid for household heating purposes

III. Series resistance

When tying solar cells together, it is important to keep series resistance of the circuit to a minimum. Resistance directly influences both voltage and current, and an increasing resistance will cause the voltage-current curve of the solar cell to move away

from the so-called maximum power point (MPP). At this point, a solar cell produces maximum output (through the equation P=V*I) and it is thus advantageous to maintain this point. Since the material in a solar cell acts as a resistor to current flow, it is often advisable to limit the amount of serially connected solar cells. By wiring individual 'serial batches' of solar cells in parallel, one can overcome this limitation. Note that by increasing series resistance, the solar cell moves away from the maximum efficiency point.

IV. Shading

Since batches of solar cells are connected in series, the entire batch will operate at the current level of the weakest cell. By (partly) shading a single cell, one can thus adversely influence the output of all other cells! Note that the same goes for solar panels as a whole: since solar panels are generally wired in series, the (partly) shading of a single solar panel will adversely affect the entire array! It is often impossible to wire solar panels in parallel, since this will cause voltage compatibility problems with the inverter.

Therefore, make sure your solar array is as little possible affected by shadows cast by trees, other buildings or other element of your solar array. When installing the system, remember that the angle of the sun changes throughout the day (and the year)! And also this can be corrected through automatic sun tracker [8-10]

V. Dirty solar panel

Dirty solar panels result in power loss as grime and debris detract from the solar arrays ability to perform at full capacity, reducing the ability of your system to perform at full capacity. When the panels are dirty, less sunlight is able to be absorbed into the cells

and less electricity is generated. The potential energy loss can range as high as a 25%.Each solar panel is only as effective as the weakest panel on its string which means that if one part of one panel is dirty, then the output of the entire string is reduce [5, 7]

Research has been done by HelioTex, a company in California, also responsible for installation, cleaning and maintenance of solar panel system. Design an Automatic Solar Panel Cleaning Systems which uses low-volume spray nozzles, connected to each panel, an existing water supply such as an outdoor water faucet and a programmable controller (which runs on a 110 volt power supply). The systems use a specially-formulated, biodegradable soap concentrate that is mixed into the water line during wash cycles. A second rinse follows the wash cycle. It is fully programmable to wash and rinse; or rinse only as frequently as your environment requires. Normally, the company recommends washing the panels every one to two weeks and rinse every two or three days to help minimize the buildup of dirt and other debris. But also if you observe carefully you will still find the surface of the panel not clean enough, it has been practicalised using a plain window glass and even a car windscreen. After washing your glass with just soap and water without using any sponge or wiper, when the surface of the glass dry off you will find stains on the surface. [5, 12, 13]

Since all the automatic solar panel system use just detergent and water to clean the surface of the solar panel system (which has not been effective enough) hence the need for a new automated system that will use a bidirectional motor to drive the cleaning mechanism which will be mounted on the surface of the solar panel, so that when the water is spraying, the mechanism is moving to and fro, cleaning the panel similar to the wiper system on the windscreen of vehicles. Thus, to eliminate all the problems

associated with cleaning and to avoid the risk of injury and also potential damage to the surface of the solar panel through cleaning by the person carrying the operation, the system operates similarly to the wiper, but here the whole cleaning system automatic and self-controlled.

After installing and programming of the automated cleaning system, it requires no further attention except the occasional refilling of the soap concentration, the system can be programmed to wash and clean as often as you feel is necessary. The spray nozzle (sprinkler) is place on the surface of the panel, connected to an existing water supply with a specific formulated soap concentration will be mixed into the line for the wash cycle. And a microcontroller chip will be used as the control that will triggers the DC motor to roll both clockwise and anticlockwise direction to clean up the solar panel. The panels will be washed approximately every morning to keep all the accumulated dirt and debris built up on the panel, and also increase the efficiency of the solar system.

CHAPTER THREE

3.0 DESIGN AND IMPLEMENTATION

In this section the design analysis of various stages and steps undertaken to archive the project is presented in this chapter.

The designed circuit was firstly simulated on multism (an electronic work bench application software) to ensure the designed circuit is working perfectly before proceeding to the breadboard work (temporary construction) to temporarily test the project and to be sure that all the component used are in good working condition, then proceeded to the vero board stage (the permanent construction), i.e soldering of the components on veroboard.

DESIGN ANALYSIS

This project is subdivided into six main units in with the block diagram shown below starting from;

i. The power supply
ii. the light sensor
iii. the microcontroller
iv. the display
v. motor unit
vi. The sprinkling unit.

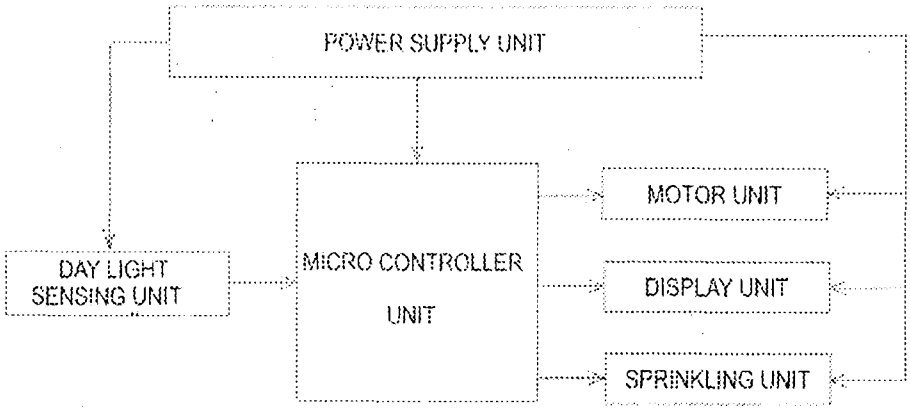


Fig 3.1 Block diagram of the Design unit

3.1 THE POWER SUPPLY UNIT

Most electronic devices and circuits require a DC or AC source for their proper operation, and a typicalregulator to fix the voltage and to make it constant for the load. The power supply unit comprise of the following listed below:

- A 12V DC Battery supply
- Voltage regulators

3.1.1 The DC Battery supply

A battery is a device that converts chemical energy directly to electrical energy. [14]. It consists of a number of voltaic cells; each voltaic cell consists of two half cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the electrode to which anions (negatively charged ions) migrate, i.e., the anode or negative electrode; the other half-cell includes electrolyte and the electrode to which cations (positively charged ions) migrate, i.e., the cathode or

positive electrode. In the redox reaction that powers the battery, cations are reduced (electrons are added) at the cathode, while anions are oxidized (electrons are removed) at the anode. [15]. the electrodes do not touch each other but are electrically connected by the electrolyte. Some cells use two half-cells with different electrolytes. A separator between half cells allows ions to flow, but prevents mixing of the electrolytes. Below you can see a voltaic cell for demonstration purposes. In this example the two half-cells are linked by a salt bridge separator that permits the transfer of ions, but not water molecules. For this project a 12V DC battery is used as the power supply, to supply the voltage regulator, the motor control unit and also the sprinkler system.

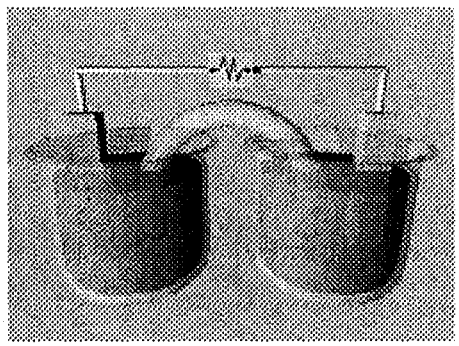


Fig. 3.2 A two half-cells linked by a salt bridge separator that permits the transfer of ion.

3.1.2 Voltage regulators

A voltage regulator is an electrical regulator designed to automatically maintain design or may include negative feedback control loops. It may use an electromechanical mechanism or electronic components. Depending on the design, it could be used to regulate one or more AC or DC voltage.

Electronic voltage regulator is found in device such as computer power supplier where they stabilize the DC voltage used by the processor and other elements.

A 7805 voltage regulator was used to regulate the 12V DC supply to 5V to power the daylight sensor and the microcontroller, and then feed the relay with the 12V supply which will be used to control the DC motor and the sprinkler system.

3.2 Light Dependent Resistor (LDR)

This a special type of resistor whose resistance depends on the variation of light intensity, it senses with its ohmic value (0–10kiloohms). Its resistance is inversely proportional to the light intensity. External potentiometers or resistors are used to set the operating parameters for sensitivity, on-time, brightness, fade, daylight sensor, and environment temperature correction. All signal processing is performed digitally. LDRs are commonly used for outdoor and indoor motion sensor lights, high end lighting switches, automatic bedroom night lights, and energy saving circuits.

3.2.1 THE 555 TIMER

The 555 monolithic timing circuits is a highly stable controller capable of producing an accurate time delays, or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200mA.[18]

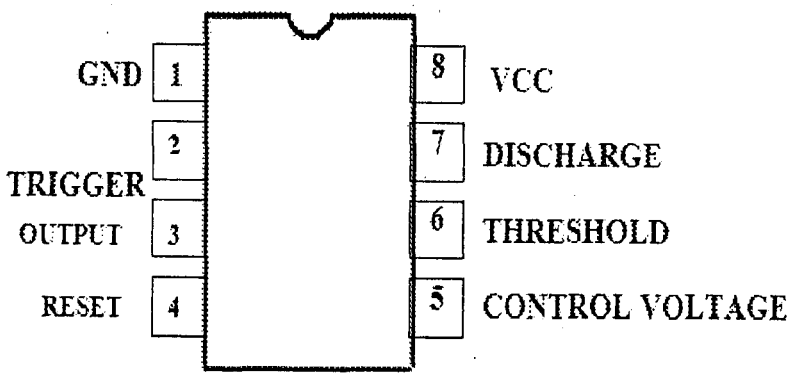


Figure 3.3 Diagram of a 555 timer

FEATURES OF LE555 TIMER

- Turn-off time less than 2μs
- Maximum Operating frequency greater than 500kHz
- Its timing from microseconds to hours
- Its operates in both astable and monostable modes
- High output current
- Adjustable duty cycle
- TTL compatible
- Temperature stability of 0.005% per °C

In this project an LDR (Light Dependent Resistor) was connected to a 555 timer that is neither monostable nor astable connection because no timing or frequency is required only to detect day light, and the LM 555 is designed to deliver an output any time the pin 2 and 6 are high, the IN4148 diode is to prevent back flow of current to pin 7 and pin 6 was loop with pin 2 to make the output remain high in as long as the pin 2 is high and goes low immediately pin 2 goes low, pin 2 need about 2V to be high while the

voltage produce at the output is 5V which was interfaced with the microcontroller for monitoring, the circuit of the day light sensor is shown below:

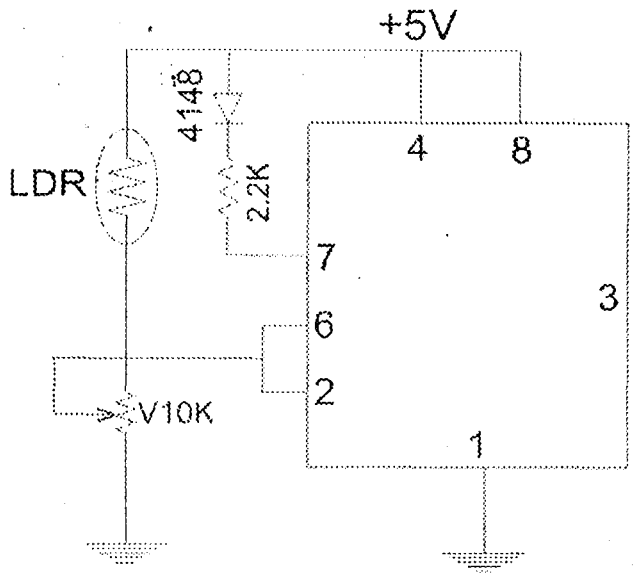


Figure 3.4 the circuit diagram of the day light sensor

3.3 MICROCONTROLLER UNIT

This unit is sub divided into two i.e. the software part and the hardware part

3.3.1 Software Part

An application soft ware, Keil was used to achieve the software development tools for 8051 based microcontrollers. With the Keil tools, it was possible to generate an HEX file from an Assembly language commonly used in embedded applications for virtually every 8051 derivative after being assembled. The supported microcontrollers are listed in the μ-vision; the picture of the software is shown below

to appliances to automobiles. For example, a single vehicle can use 70 or more microcontrollers. The pictures below describe a general block diagram of microcontroller. [19]

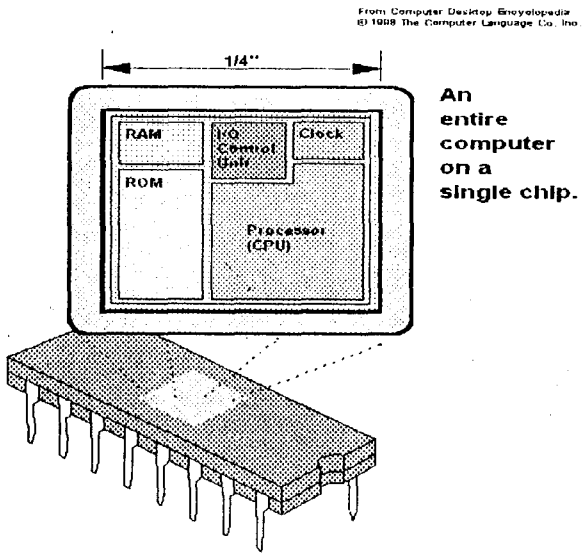


Figure 3.7 Internal Block diagram of a microcontroller [22]

3.3.3 AT89S52:

The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes.

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable flash memory. The device is manufactured

using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 8051 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller, which provides a highly flexible and cost-effective solution to many, embedded control applications.

The hardware is driven by a set of program instructions, or software. Once familiar with hardware and software, the user can then apply the microcontroller to the problems easily. [19, 20]

The pin diagram of the 8051 shows all of the input/output pins unique to microcontrollers:

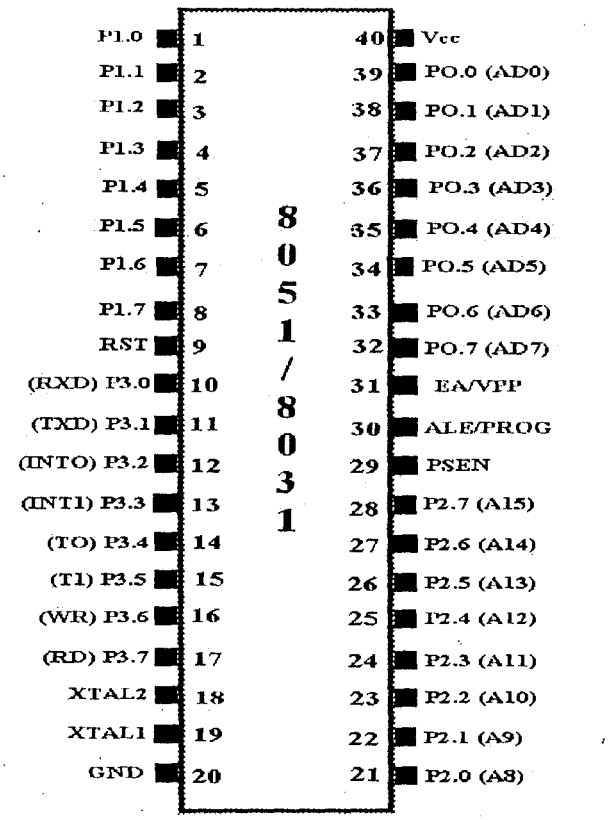


Figure 3.7 Pin configuration of an 8051 microcontroller

The following are some of the capabilities of 8051 microcontroller.

- ✓ Internal ROM and RAM
- ✓ I/O ports with programmable pins
- ✓ Timers and counters
- ✓ Serial data communication

The 8051 architecture consists of these specific features:

- 16 bit PC & data pointer (DPTR)
- 8 bit program status word (PSW)
- 8 bit stack pointer (SP)
- Internal ROM 4k
- Internal RAM of 128 bytes.
- 4 register banks, each containing 8 registers
- 80 bits of general purpose data memory
- 32 input/output pins arranged as four 8 bit ports: P0-P3
- Two 16 bit timer/counters: T0-T1
- Two external and three internal interrupt sources Oscillator and clock circuits. [21]

The assembly language program written for this project was to:

- Monitor the output of the LM555 to know whether its day time or night
- Display the situation on the LCD.
- Produce a control signal for the sprinkler.
- Produce a control signal for the DC motor

3.4. DISPLAY UNIT

3.4.1 Liquid Crystal Display (LCD)

This is an electro-optical amplitude modulator realized as a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It is often utilized in battery-powered electric devices because it uses very small amounts of electric power.

Each pixel of an LCD typically consists of a layer of molecules aligned between two transparent electrodes, and two polarizing filters, the axes of transmission of which are (in most of the cases) perpendicular to each other. With no liquid crystal between the polarizing filters, light passing through the first filter would be blocked by the second (crossed) polarizer.

The surfaces of the electrodes that are in contact with the liquid crystal material are treated so as to align the liquid crystal molecules in a particular direction. This treatment typically consists of a thin polymer layer that is unidirectional rubbed using, for example, a cloth.

The direction of the liquid crystal alignment is then defined by the direction of rubbing. Electrodes are made of a transparent conductor called Indium Tin Oxide. This display unit uses a 16 character by 2 lines to display the state of the solar panel and the condition of the weather. It has maximum character length of 16 displayed on two lines, and an operating voltage of 5V. LCD displays designed around Hitachi's LCDHD44780 module, are inexpensive, easy to use, and it is even possible to produce a readout using the 8x80pixels of the display.

They have a standard ASCII set of characters and mathematical symbols. Foran8-bit data bus, the display requires a +5V supply plus 11 I/O lines. For a 4-bit data bus it only requires the supply lines plus seven extra lines. In this project, the 8-bit data bus was used. When the LCD display is not enabled, data lines are tri-state and they do not interfere with the operation of the microcontroller. [22, 23]

3.4.2 Signals to LCD

TheLCDalsorequires3controllinesfromthemicrocontroller:

a. **Enable:**

This line allows access to the display through R/W and RS lines. When this line is low, the LCD is disabled and ignores signals from R/W and RS. When (E) line is high, the LCD checks the state of the two control lines and responds accordingly. [24]

b. **Read/Write:**

This line determines the direction of data between the LCD and microcontroller. When it is low, data is written to the LCD. When it is high, data is read from the LCD.

c. **Register select**

With the help of this line, the LCD interprets the type of data on data lines. When it is low, an instruction is been written to the LCD. When it is high, a character is being written to the LCD. [24]

3.4.3 Writing and Reading the Data from the LCD

Writing data to the LCD is done in several steps:

1. Set R/W bit to low
2. Set RS bit to logic 0 or 1(instruction or character)
3. Set data to data lines (if it is writing)
4. Set E line to high
5. Set E line to low

Read data from data lines (if it is reading):

1. Set R/W bit to high
2. Set RS bit to logic 0 or 1 (instruction or character)
3. Set data to data lines (if it is writing)
4. Set E line to high
5. Set E line to low [24]

3.4.4 Pin Description

Most LCDs with 1 controller has 14 Pins and LCDs with 2 controller has 16 Pins (Two pins are extra in both for back-light LED connections).

Table 3.9 Shows the summary of the functions of a LCD pin.

Pin No.	Symbol	Level	Description
1	V_{SS}	0V	Ground
2	V_{DD}	5.0V	Supply Voltage for logic
3	VO	(Variable)	Operating voltage for LCD
4	RS	H/L	H: DATA, L: Instruction code
5	R/W	H/L	H: Read(MPU→Module) L: Write(MPU→Module)
6	E	H,H→L	Chip enable signal
7	DB0	H/L	Data bit 0
8	DB1	H/L	Data bit 1
9	DB2	H/L	Data bit 2
10	DB3	H/L	Data bit 3
11	DB4	H/L	Data bit 4
12	DB5	H/L	Data bit 5
13	DB6	H/L	Data bit 6
14	DB7	H/L	Data bit 7
15	A	-	LED +
16	K	-	LED -

3.5 MOTOR CONTROL UNIT

3.5.1 Principle of a relay

A relay is an electromagnetic device that when current flow through the coil a magnetic field is generated at the knob and attracts the terminal of the common to itself, it has five terminals as illustrated below:

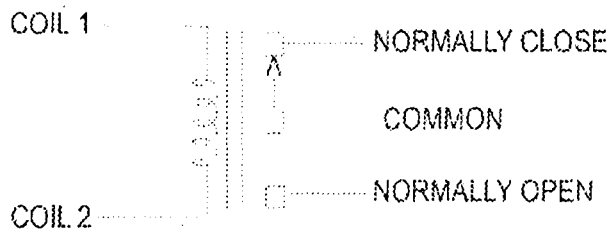


Figure 3.7 Terminals of a relay

The common is usually connected to the normally close and only when current flow through the coil the common disconnect from the normally close and connect to the normally open and the switching time is around 300 mili seconds that the changes can hardly be notice.

3.5.2 Switching transistors

The coil of a relay have about 100 ohms resistance and 12V their by requiring a current of about 150mA which a switching transistor cannot allow, there is a need to cascade two transistors, when the 2N3906 is **''ON''**, the base of the D882 is pull high with the aid of the 10K resistor which will disallow current from flowing through the coil of the relay and when the transistor is **''OFF''** the base of D882 is pulled to the ground which allow current to flow through the coil of the relay,[17] the two condition are determine by the microcontroller and the circuit diagram is shown below

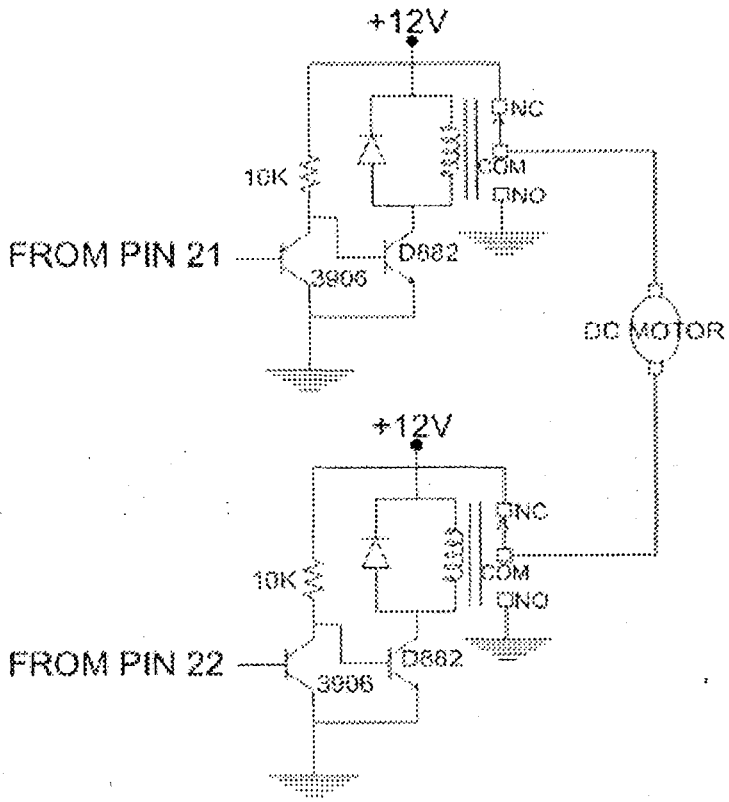


Figure 3.8 circuit diagram of the switching transistors

3.5.3 THE DC MOTOR

Considering the operation of this device, a stepper motor is in best position to be used to roll the cleaner on the solar panel, no brushes or contacts are present, low cost, high reliability, high toque at low speed, and high accuracy of motion as compared to a bidirectional DC motor [14]. But all efforts to get a stepper motor proved abortive; hence a bidirectional DC motor was used. A bidirectional DC motor is a motor that have the ability to roll in both direction i.e.in clockwise direction and also in anti clockwise direction, this is done by reversing the polarity of the supply voltage which was archived using the electromagnetic relay.

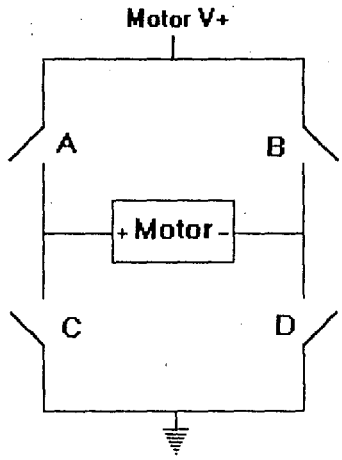
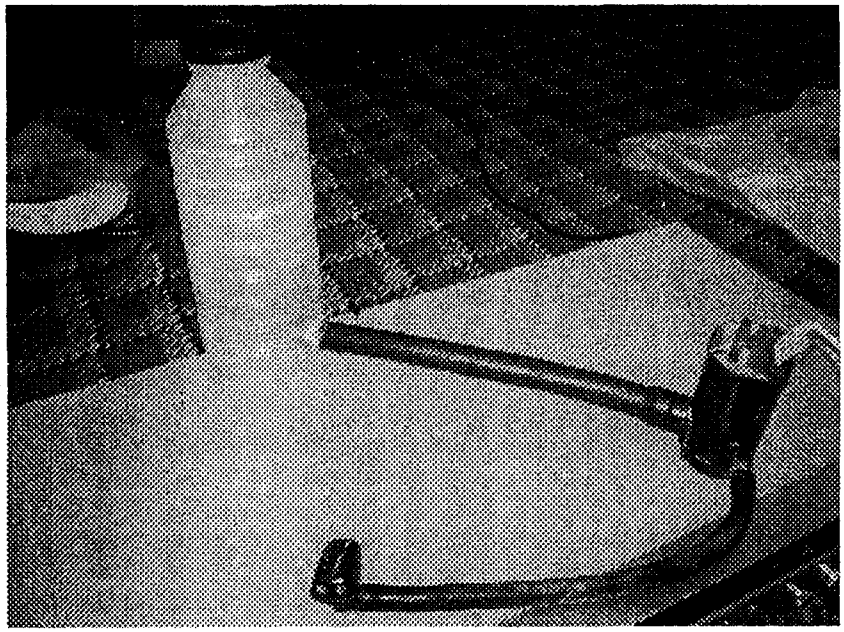


Fig 3.9 H-Bridge configuration of a motor

This configuration is called an **H-Bridge** due to its shape. Let's say that the motor runs forward when its + terminal is connected to Motor V+ and its - terminal is connected to ground. It will run in reverse when the opposite is true. Turn on switch A and switch D and the motor will run forward. Turn on switch B and switch C and it will run in reverse. [25]

3.6. SPRINKLER CONTROL UNIT

The sprinkler unit is designed to pump water from a reservoir onto the surface of the solar panel. It is made up of an N- channel MOSFET switching circuit with a DC electric motor load. The logic control unit, send a high logical level to the GATE terminal of the N- channel device whenever day light is detected by the sensor. The electric motor merely pumps water from a reservoir, and it is powered by an auxiliary 12V supply unit due to high current requirement of the DC motor. [26]



3.10 Picture of a sprinkler system

CHAPTER FOUR

Tests, Results and Discussion

4.1 Construction And Testing

The first stage of the construction was carried out on a bread board first; all the required components were first tested and subsequently mounted on the breadboard. Various testing were performed during each stage of the construction. A digital multimeter was used to carry out readings and measurements of the various components, the LDR was both tested in a dark room and later in a light environment, and the LCD was tested displaying Matric number, the DC motor was tested using a DC power supply And the sprinkler system was also tested to sprinkle water from the reservoir. After test running, and all the components are in good working condition, and all error detected were corrected, the construction done on the bread board was later transferred to a vero board for permanent soldering. Using the circuit diagram as guide, all the components to be used were separately soldered on the vero board. Thereafter, the entire circuit was connected to the power supply unit and tested accordingly.

4.2 Discussion of Result

The subsequent modules of the circuit design were tested at various stages of the project design implementation. These tests were repeatedly done to ensure the reliability of the components. The final test of the entire system design implementation was conducted by placing the system in a dark room then later gradually opening the door to allow sunlight into the room. It was observed that immediately the LDR senses the presence of the sun rays, it send a signal that it is day break, and the situation is being display on the LCD, and a control signal is sent to the sprinkler unit, to sprinkle

water. Then lastly a control signal is sent to the motor control unit to drive the wiper to and fro for the entire cleaning session.

4.3 LIMITATIONS

During the design and construction of the project work so many challenges were encounter. Some of the most noticeable limitations encountered involved;

- The wiper system that was manually constructed could not clean the solar panel effectively as expected, it still leave traces of water on the solar panel.
- The sensor unit was programmed to sense daylight, but it was observed any source of light it senses either Flashlight or even Lightening storm it send an out to the microcontroller which triggers a new cleaning section.
- The power system initially designed of the project, could not power the current required by the transformer, voltage regulator and the motor of the sprinkler system.
- The project was not design to charge the battery, so the battery has to be charged externally.
- Due to the unavailability of some components in the market, the alternate components used fail to function as in the ideal case.
- Improper alignment/isolation of wires causes unnecessary triggering of the device.

CHAPTER FIVE

Conclusions and Recommendations

5.1 Conclusion

The main objective of this project was to design and construct an electromechanical system capable of cleaning the surface of your solar panel automatically. This aim was achieved because the system was able to; Increase the efficiency of the solar panel, eliminate the risk of injury or liability to the person conducting the manual operation, avoid damage to the roof top or even the solar panel, and to provide a less stressful and a more reliable means of cleaning the panel. The system can also be used for both domestic and industrial purposes.

5.2 Recommendations

The design, through a prototype is constructed with the most suitable available components; the design can be develop for further work either for commercial or domestic purposes. The following suggestions should be considered, the following recommendations were made;

- ✓ To improve the project, some changes could also be made to the battery supply, in such a way that the battery could also be charged from the solar panel.
- ✓ The wiper system that would be used for cleaning the panel should be made effected enough.

REFRECES

1. I .J .Nagrath and D. P .Kothari, Power System Engineering. Tata McGraw-Hill, New Delhi, 1994, pp. 1, 2
2. T. T. Isqun, Assessment of Energy Resources of the country'', 2004 Ministerial Press Briefing, Federal Ministry of science and technology, Abuja, July 2004, pp 25,26
3. http://www.diysolarhomes.com/blog/diy-solarpanels/maintenance
4. http://science.howstuffworks.com/environmental/green-tech/sustainable/solar-panel-cleaning-system1.htm
5. http://www.heliotex.com/solar_panel_cleaner
6. http://www.energyauthority.net/solar-panel-cleaning/
7. http://ehowtomakesolarpanels.com/
8. http://en.wikipedia.org/wiki/solar cell
9. http://solarpanelsathome.org/factors-that-affect-solar-cell-efficiency
10. http://www.solarpower2day.net/solar-panels/
11. http://www.allelectric-solarinstallations.com/heliotex-solarpanelcleaning.html
12. http://4solarpower.net/2011/04/
13. http://gigaom.com/cleantech/are-dirty-solar-panels-a-big-problem
14. ^ "battery" (def. 6), The Random House Dictionary of the English Language, the Unabridged Edition (2nd edition), 1996 ed. By Stuart Berg Flexner.
15. http://cn.wikipedia.org/wiki/Battery
16. B.L Theraja and A.K Theraja, a text book of Electrical Technology, S.Chand and Company Limited, Ram Nagar, New Delhi-110055, 2003.
17. Boylestad, R. L &Nasheisky, L. , Electronic Devices and circuit theory, 8th Ed, published by Dorling Kindersly (India) private limited, 2007.
18. V. K. Mehta, Rohit Mehta, PRINCIPLES OF ELECTRONICS, Published By Chand & Company Ltd.
19. http://www.play-hookey.com/digital/timer_555.html
20. The 8051 Microcontroller by Kenneth j. Ayala
21. The 8051 Microcontroller and Embedded Systems by Muhammed Ali Mazidi

22. http://www.8051fordummies.com

23. http://en.wikipedia.org/wiki/Liquid_crystal_display

24. http://www.howstuffworks.com/lcd.htm

25. http://www.lcdinterfacing.info

26. http://www.learn-c.com/index.html

APENDIX A

Program (Assembly Language)

```
ORG 0000H
DATABUS EQU P1
MOTOR1 EQU P2.2
MOTOR2 EQU P2.1
SPRINKLER EQU P2.0
RS EQU P3.0
EN EQU P3.1
SENSOR EQU P3.2
MOV R0, #00H
MOV R1, #00H
        ACALL START
MAIN:JNB SENSOR, $
        JB SENSOR, $
        ACALL RUB_LCD
        ACALL OVER_V
        ACALL LINE2C
        ACALL OVER1_V
        ACALL SPRIN
        ACALL ROLL
        ACALL SPRIN
        ACALL ROLL
        ACALL SPRIN
        ACALL ROLL
```

```
        ACALL RUB_LCD
        ACALL UNDER_V
        ACALL LINE2C
        ACALL UNDER1_V
        ACALL DELAY
        ACALL RUB_LCD
        ACALL EMI7
        ACALL LINE2C
        ACALL EMI8
        AJMP MAIN
SPRIN:  CLR SPRINKLER
        ACALL DELAY1
        SETB SPRINKLER
        ACALL DELAY1
        RET
ROLL: CLR MOTOR1
        ACALL DELAY1
        SETB MOTOR1
        ACALL DELAY1
        CLR MOTOR2
        ACALL DELAY1
        SETB MOTOR2
        ACALL DELAY1
        RET
START:  ACALL INI_LCD
```

```
        ACALL WELCOME
        ACALL LINE2C
        ACALL LINE2D
        ACALL DELAY
        ACALL RUB_LCD
        ACALL EMI1
        ACALL LINE2C
        ACALL EMI2
        ACALL DELAY
        ACALL RUB_LCD
        ACALL EMI3
        ACALL LINE2C
        ACALL EMI4
        ACALL DELAY
        ACALL RUB_LCD
        ACALL EMI5
        ACALL LINE2C
        ACALL EMI6
        ACALL DELAY
        ACALL RUB_LCD
        ACALL EMI7
        ACALL LINE2C
        ACALL EMI8
        RET
INI_LCD:MOV DPTR, #INIT
```

```
A1:         CLR A
            MOVC A, @A+DPTR
            ACALL COMMAND
            INC DPTR
            JZ BACK1
            SJMP A1
BACK1:      RET
WELCOME:MOV DPTR, #WEL
A2:         CLR A
            MOVC A, @A+DPTR
            ACALL WRITE
            INC DPTR
            JZ BACK2
            SJMP A2
BACK2:      RET
LINE2C: MOV DPTR, #LINE2CS
A3:         CLR A
            MOVC A, @A+DPTR
            ACALL COMMAND
            INC DPTR
            JZ BACK3
            SJMP A3
BACK3:      RET
LINE2D      :MOV DPTR, #LINE2DS
A4:         CLR A
```

```
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BACK4
        SJMP A4
BACK4:  RET
EMI1: MOV DPTR, #LOAD1
B1:     CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BAK1
        SJMP B1
BAK1:RET
EMI2: MOV DPTR, #LOAD2
B2:     CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BAK2
        SJMP B2
BAK2:RET
EMI3: MOV DPTR, #LOAD3
B3:     CLR A
        MOVC A, @A+DPTR
```

```
        ACALL WRITE
        INC DPTR
        JZ BAK3
        SJMP B3
BAK3: RET
EMI4: MOV DPTR, #LOAD4
B4:     CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BAK4
        SJMP B4
BAK4: RET
EMI5: MOV DPTR, #LOAD5
B5:     CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BAK5
        SJMP B5
BAK5: RET
EMI6: MOV DPTR, #LOAD6
B6:     CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
```

```
        INC DPTR
        JZ BAK6
        SJMP B6
BAK6: RET
EMI7: MOV DPTR, #LOAD7
B7:     CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BAK7
        SJMP B7
BAK7: RET
EMI8: MOV DPTR, #LOAD8
B8:     CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BAK8
        SJMP B8
BAK8: RET
OVER_V: MOV DPTR, #OVER
A7:     CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
```

```
        JZ BACK7
        SJMP A7
BACK7:  RET
OVER1_V:MOV DPTR, #OVER1
A8:     CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BACK8
        SJMP A8
BACK8:  RET
UNDER_V: MOV DPTR, #UNDER
A9:     CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BACK9
        SJMP A9
BACK9:  RET
UNDER1_V:MOV DPTR, #UNDER1
A10:  CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BACK10
```

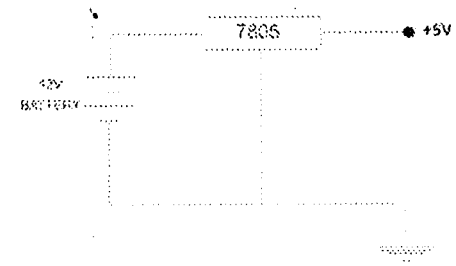
```
        SJMP A10
BACK10: RET
NOR_V:  MOV DPTR, #NOR
A11:    CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BACK11
        SJMP A11
BACK11: RET
NOR1_V: MOV DPTR, #NOR1
A12:    CLR A
        MOVC A, @A+DPTR
        ACALL WRITE
        INC DPTR
        JZ BACK12
        SJMP A12
BACK12: RET
RUB_LCD: MOV DPTR, #RUB
F1:     CLR A
        MOVC A, @A+DPTR
        ACALL COMMAND
        INC DPTR
        JZ BACKF1
        SJMP F1
```

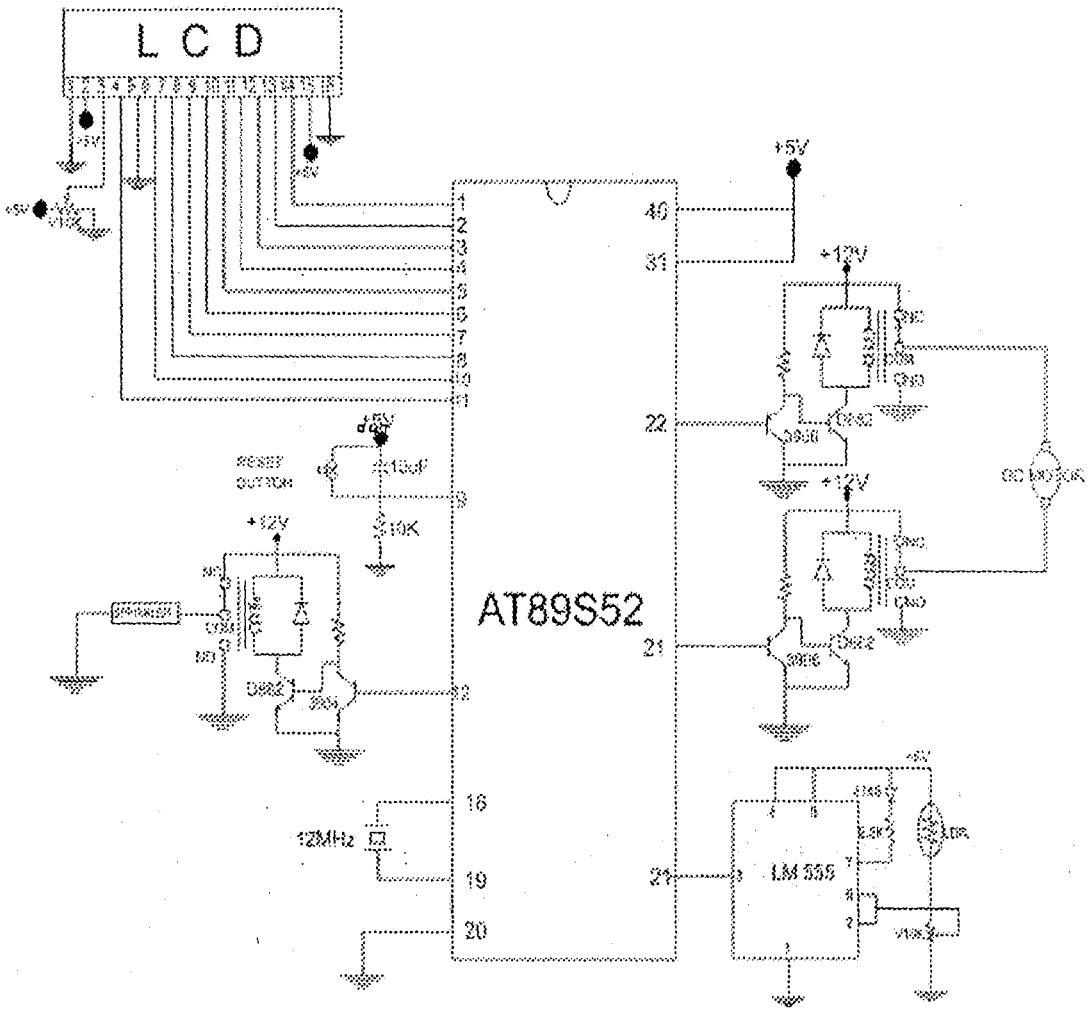
```
BACKF1:   RET
READY:    MOV R5, #50
HERE:MOV R0, #255
          DJNZ R0, $
          DJNZ R5, HERE
          RET
COMMAND:CLR RS
          MOV DATABUS, A
          SETB EN
          CLR EN
          ACALL READY
          RET
WRITE:    SETB RS
          MOV DATABUS, A
          SETB EN
          CLR EN
          ACALL READY
          RET
DELAY:    PUSH 00H
          PUSH 01H
          PUSH 02H
          MOV 00H, #30
ABDUL2:   MOV 01H, #255
ABDUL1:   MOV 02H, #255
          DJNZ 02H, $
```

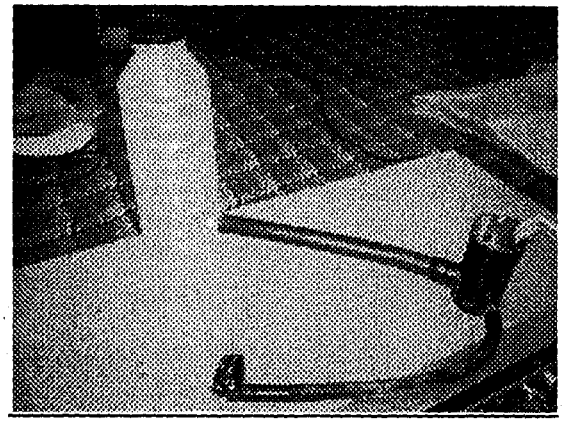
```
        DJNZ 01H, BOLA1
        DJNZ 00H, BOLA2
        POP 02H
        POP 01H
        POP 00H
        RET
DELAY1: PUSH 00H
        PUSH 01H
        PUSH 02H
        MOV 00H, #10
ABDUL2: MOV 01H, #255
ABDUL1: MOV 02H, #255
        DJNZ 02H, $
        DJNZ 01H, ABDUL1
        DJNZ 00H, ABDUL2
        POP 02H
        POP 01H
        POP 00H
        RET
INIT:  DB 38H,0CH,01H,06H,0
RUB:  DB 01H,0
WEL:  DB "AUTOMATIC SOLAR ",0
LINE2CS:DB 0C0H,0
LINE2DS:DB " PANEL CLEANER  ",0
LOAD1:  DB "WITH A SPRINKLER",0
```

```
LOAD2:  DB "   SYSTEM...  ",0
LOAD3:  DB "  DESIGNED AND  ",0
LOAD4:  DB "CONSTRUCTED BY  ",0
LOAD5:  DB "ADAMU ABDULLAHI ",0
LOAD6:  DB " 2005 / 21988EE ",0
LOAD7:  DB "SYSTEM READY FOR",0
LOAD8:  DB "   OPERATION.   ",0
OVER:   DB "  CLEANING IN   ",0
OVER1:  DB "   PROGRESS...  ",0
UNDER:  DB "CLEANING PROCESS",0
UNDER1: DB "  COMPLETED...  ",0
NOR:    DB " NORMAL VOLTAGE ",0
NOR1:   DB "LOADS CONNECTED ",0
END
```

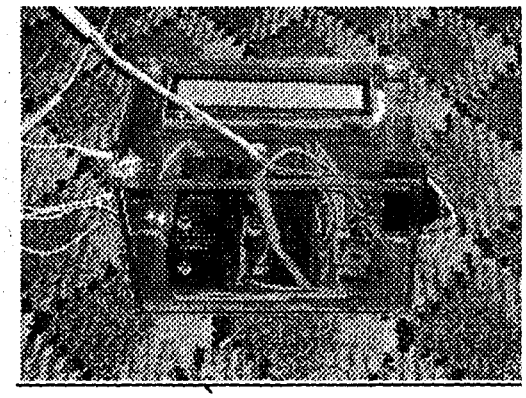
APENDIX B



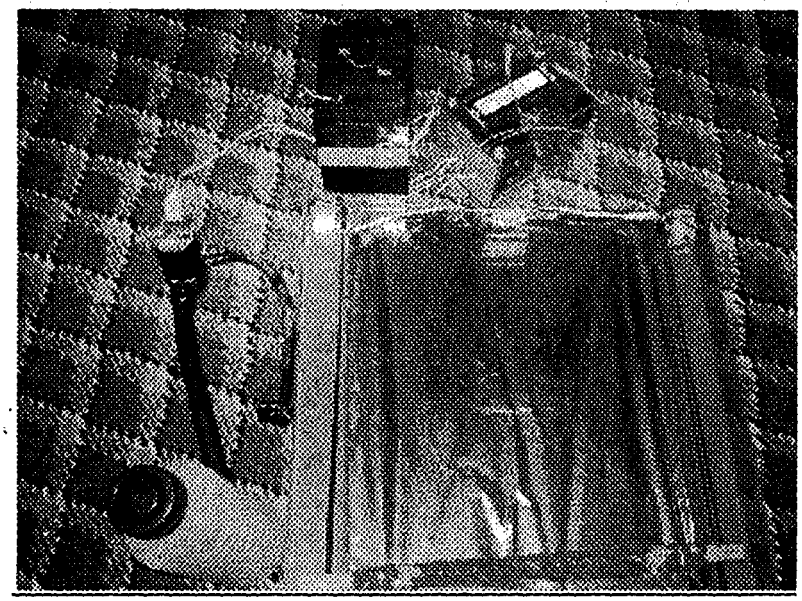




Sprinkler System



The Electrical Unit



The complete System