

PHOTO VOLTAIC EFFICIENCY MONITORING SYSTEM USING EMBEDDED CONTROLLER

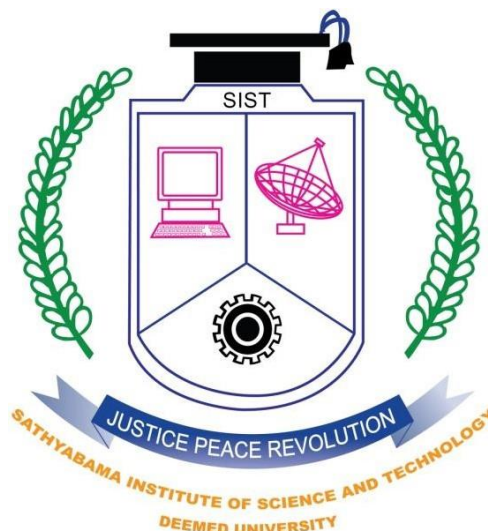
Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree in
Electrical and Electronics Engineering

By

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade “A” by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

APRIL 2021



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **JAYAPRAKASH M** (Reg. No. 37140051) and **ROHITH** (Reg. No. 37140041) who carried out the project entitled "**PHOTO VOLTAIC EFFICIENCY MONITORING SYSTEM USING EMBEDDED CONTROLLER**" under our supervision from December 2020 to April 2021.

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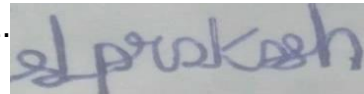
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DECLARATION

We **JAYAPRAKSH M** (Reg.No.37140051) and **ROHTIH K** (Reg.No.37140041) hereby declare that the Project Report entitled "**PHOTO VOLTAIC EFFICIENCY MONITORING SYSTEM USING EMBEDDED CONTROLLER**" done by us under the guidance of **Mrs. M. PREETHI PAULINE MARY** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

1.



2.



DATE: 09/04/2021

PLACE: Chennai

SIGNATURE OF THE CANDIDATES

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ABSTRACT

The main consideration in the present field technologies is automation. Also, a demonstration with a real-time prototype model involving costs and implementation procedure has been developed using the internet of things (IoT) to visualize the real-time updates. Major advantages of monitoring solar panels are to include the prevention of damage and an increase in maximum efficiency of the panel. Studies have shown that according to NREL, modules can fail because of unavoidable elements like thermal cycling, damp heat, humidity freeze, and UV exposure. Thermal cycling can cause solder bond failures and cracks in solar cells. Damp heat has been associated with delamination of encapsulants and corrosion of cells. Humidity freezing can cause junction box adhesion to fail. UV exposure contributes to discoloration and back sheet degradation. These things just happen, and it's difficult to determine how bad the degradation will be., power consumption, and cost-effectiveness. Automation is intended to reduce manpower with the help of intelligent systems. The use of renewable sources of energy is crucial because sources of energy are limited whereas energy consumption has increased. By using renewable energy, it can facilitate the high-power demand. The project aims to describe a method for proper monitoring of solar energy by using sensors at minimum electrical energy consumption. Monitoring the health of solar panels gives a which is very much useful in massive energy-savings are envisioned.

"Solar panel degradation and failure is not a clear-cut situation". There are lots of different reasons why they degrade and why they fail."

Module manufacturers are looking into every piece of the solar panel puzzle, all the way down to the encapsulants and adhesion materials, to try to slow degradation.

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CHAPTER-1

INTRODUCTION

1.1 NEED FOR SOLAR ENERGY

The sun is a reliable, non-polluting, and inexhaustible source of energy. Since the beginning of life on earth, the energy that was received by all living forms was radiated from the sun. It is the time now when mankind is on a standpoint to again depend and rely upon the sun as the main source of energy. With the rapid rise in fossil fuel prices, concern over pollution, depletion of resources, and environmental degradation the awareness for limited resources around the world has increased dramatically. The use of fossil fuels which causes greenhouses emission, inefficient use of energy, and release of harmful pollutants to the atmosphere causing threat such as acid rain must be addressed seriously in new buildings. Government with vision have come to realize that generation of electrical power through non-renewable sources of energy is not enough. The power of the future must be environment friendly as well. Photovoltaic is a way by which energy from the sun can be directly used for power generation. This method for electricity generation causes no environmental pollution, has no rotating or moving parts and causes no material depletion. Photovoltaic is also multifunctional. It can generate and operate illuminations, pump water, operate any household equipment and appliances can operate any electric gadgets and communication equipment. The photovoltaic finds its wide application in village electrification in developing countries like India and electricity production for the building, commercial areas, and industrial sector in cities. When Hurricane Maria tore through Puerto Rico in 2017 causing the longest power outage in U.S. history, a lot of press coverage soon after the storm focused on the need to get electricity to hospitals and emergency responders. This turns out to be an ideal use case for a microgrid.

The impact of losing electricity varies widely depending on who or what is losing power.

If an individual home loses electricity for a couple of hours, it might be a nuisance, but far from life-threatening. However, a loss of electricity at a hospital is absolutely a life-threatening scenario. Between a higher electric load and an often spread out geographical footprint, it makes sense to create an interconnected network of solar panels and storage to continue to power these types of buildings in the event of an outage. In a word: a microgrid.

There are several applications of microgrids, from powering emergency response buildings to providing grid resiliency for communities with a large population of people whose health would be put at risk by a prolonged power outage. One of the major benefits of a microgrid is that it can extend beyond a single house or building and create a tiny electricity-isolated island within a community. A perfect example of this would be a microgrid between a fire department, a school, and a senior center, which could provide benefits to first responders, the at-risk population, and a possible shelter from the storm all under one interconnected and resilient grid system. With the help of a microgrid, we can reduce the cost of installation and erection of poles and wires over a long-range, to remote locations which not only saves the cost but also reduces the transmission losses and it also aims in solving the problem of erecting the transmission lines in the forest areas which involves a lot of work which involves sag calculation.

1.2 ADVANTAGES OF SOLAR ENERGY

Solar cells are long-lasting sources of energy that can be used almost anywhere. They are particularly useful where there is no national grid and also where there are no people such as remote site water pumping or in space. Solar cells provide cost-effective solutions to energy problems in places where there is no mains electricity. Solar cells are also totally silent and non-polluting. As they have no moving parts they require little maintenance and have a long lifetime. Compared to other renewable sources they also possess many advantages; wind and water power rely on turbines which are noisy, expensive, and liable to breaking down. Rooftop power is a good way of supplying energy to a growing community. More cells can be added to homes and businesses as the community grows so that energy generation is in line with demand. Many large-scale systems currently end up over generating to ensure that everyone has enough. Solar cells can also be installed in a distributed fashion, i.e. they don't need large-scale installations. Solar cells can easily be installed on the roofs which means no new space is needed and each user can quietly generate their energy. The sun provides more than enough energy to meet the whole world's energy needs, and unlike fossil fuels, it won't run out anytime soon. As a renewable energy source, the only limitation of solar power is our ability to turn it into electricity efficiently and cost-effectively. No greenhouse gas emissions are released into the atmosphere when you use solar panels to create electricity. And because the sun provides more energy than we'll ever need, electricity from solar power is a very important energy source in the move to clean energy production. After solar panels have been installed, operational costs are quite low compared to

other forms of power generation. Fuel isn't required, and this means that solar power can create

large amounts of electricity without the uncertainty and expense of securing a fuel supply.

1.3 LITERATURE SURVEY

Anila Devi Y et al. [2017] worked on GSM Based Remote Control System of a High-Efficiency Intelligent Panel Monitoring System Using a Zigbee Network of Devices and sensors. A new intelligent and smart street light system is designed with wireless technology for maintenance and a network of sensors for controlling. In which, they used different sensors which consume less energy with high lifetime and which are supplied with renewable energy of solar panels ideals about a control network. The use of Sensors is being considered a promising solution to modern systems, due to their longer lifetime, higher efficiency, and higher CRI. The proposed control network enables disconnection of the system from the mains during the peak load time, reducing its impact in the distributed power system automatically consumption, decrease the management cost and monitor the status information of each street lighting unit. To meet the system requirements, a wireless sensor network based on the IEEE 802.15.4TM standard is employed. Its network layer is implemented using a geographic routing strategy, which provides slow overhead and high scalability features. However, due to the well-known drawbacks of the existing techniques, a novel routing algorithm is proposed. Simulations show that this algorithm leads to a significant improvement of routing performance when applied to sparse large-scale scenarios, which is the case of a street lighting system. Field tests have been performed on IEEE 802.15.4-compliant wireless control units. The obtained experimental results show that the proposed control network can meet the requirements of a system.

B. K. Subramanyam et al. [2016] have developed a model which provides a smart lighting system on streets that is mainly solar-based. The people work late nights and also most of the criminal activities occur during the nights. Under these situations, to provide security, controlling and monitoring of street lights is developed together with GUI. Even the usage of the solar panel helps save power and money. On the PC side, a graphical user interface (GUI) takes part in controlling the street light. For monitoring and controlling the lamps on streets, Zigbee technology is used. More power and energy are saved by using LDR and IS sensors. This proposed model works on the two

operational modes. They are Auto and Manual mode. In Auto-mode On-Off of the light are done by using LDRs which measures the intensity of light. Controlling is by use of relays. In the Manual mode, the controlling and monitoring of the street lights are made successful by using the specially designed GUI and by using the Zigbee technology. This proposed system is helpful to provide street lighting in the rural and urban areas where the traffic is low at times. This system maintains user satisfaction and is versatile.

Fares S. El-Faouri [2015] demonstrated a prototype of a smart street system with a photovoltaic source, battery, charge controller, motion sensor, and a dust cleaning circuit. Depending upon the system size it can be implemented as a grid-connected or standalone off-grid system. Cleaning circuit is one of the new technique which is implemented to obtain the maximum efficiency of the PV system. It also improves the operation of the system. The operation of the system is explained by MATLAB Simulink and the results are obtained. This result is then compared with the normal system without a dust cleaning circuit and proved that the dust cleaning circuit has a higher efficiency. The writing survey gives compact learning about the current framework and why we are proposing another road lighting framework. The essential issues related to the present ones are higher crude material cost and ecological issues. So the makers cultivate three answers to break this issue. They are the most recent LED innovation, microcontroller tech, and ZigBee arrange. The proposed framework consolidated these innovations, for example, LED innovation, Remote control innovation, and ZigBee innovation consequently building up a superior power sparing framework

Michele Mango et al. [2015] proposed a low-cost, wireless, adaptable sensor-based smart lighting system that makes use of PIR sensors and motion sensors. It helps control the light intensity and power consumption using LED light. Dimming of light is achieved using a PIR sensor only in presence of obstacles around. The main advantage of this system is energy conservation. In this paper, we are planning to propose a system that makes use of a Passive Infrared (PIR) sensor, CO2 sensor & Light sensors (LDR). The dimming of the light is achieved using a PIR sensor. Intensity measurement and power consumption are measured by using Light sensors. The microcontroller platform used is Arduino UNO R3 at the sender side and the receiver end PIC16F877a is used.

PIC microcontroller usage helps in linear programming. The intensity, CO2 emission, power consumption comparisons are displayed using an LCD. These

sensors are helpful for energy saving. The usage of solar panels further helps to save some more power and energy.

P. Nithya et al. [2017] worked on the Design of Wireless Framework for Energy Efficient Street Light Automation suggested Intelligent management of the lamp posts by sending data to a central station by ZigBee wireless communication. propose about The core technology of the street light control system is an AT89S52 single-chip microcomputer. It integrates a power circuit, a fault detect circuit, a photosensitive detection circuit, an infrared detect circuit, an LCD circuit, a street light control circuit, an alarm circuit, a pressed key control circuit, and so on. This system can automatically turn on or off the lights and controls the switches according to traffic flow. It expands the fault detect circuit and the corresponding alarm circuit. It also has a convenient and flexible button control circuit to switch on and off functions mentioned above. The main weakness is that they didn't say about the working principle behind the system. It is also said to use a fault detection circuit which when it is damaged, the voltage is zero, so it will create a problem. This paper is an theoretical proof and shows only simulation results but not as real-time setup experiments. The focus of this paper to build a way for the framework which may lead to many follow-up research activities in the Low-rate and also plan to investigate the applicability of this proposal to detect performance. With the suggested system, maintenance can be easily and efficiently planned from the central station, allowing additional savings.

Rich Sam Alex et al. [2015] discussed the power consumption of the street lighting system to reduce 20-35 % compared to conventional design. This system is fully automated and is using ZIGBEE so that the control station can analyze all the performance of the system describes a comparative analysis of photovoltaic (PV) street lighting system in three different lamps. Namely, a low-pressure sodium lamp, a high-pressure sodium lamp, and a fluorescent lamp have been used for installation in each mast to determine the suitable system to install in a typical rural area of Thailand. All three systems have been mounted with the same module type and wattage in different places within the Rajamangala Institute of Technology, Thanyaburi district, Pathumthani

province of Thailand. An operation of solar street lighting system can be divided into 2 periods of time, namely, at 18.00-22.00 hours and 05.00-06.00 hours. The design of a control circuit was experimentally done in this work. Protection of the battery from damage for deep discharge and overcharge by a controller was also considered. The life cycle cost analysis (LCCA) is the appropriate method for

comparing three different lamps. The present worth of each system can be compared and the least cost option selected. LCCA was based on the key assumptions.

A.C. Kalaiarasan [2016] dealt with solar energy-based street lights with an auto-tracking system for maximizing power output from a solar system is desirable to increase efficiency. To maximize the power output from the solar panels, one needs to keep panels aligned with the sun. As such a means of tracking the sun is required. This is a far most cost-effective solution than purchasing additional solar panels. It has been estimated that the yield from solar panels can be increased by 30 to 60 percent by utilizing a tracking system instead of a stationary array. This paper describes an automatic tracking system that will keep the solar panels aligned with the sun to maximize efficiency. The sun tracking sensor is the sensing device, which senses the position of the sun from the time to time continuously and it gives the sensing output to the amplifier based on the light density of the sun. Here the sun tracking sensor is LDR (light dependent resistor). The amplifier unit is used to amplify the LDR signals, which makes the low-level signal into high-level signals and this output is given to the comparator. The LM324 IC is used as an amplifier. The comparator compares the signals and gives the command to the AT89C51 microcontroller. The system presented in this paper will be an efficient method to use solar energy in remote areas. This system consumes very low power and high-efficiency lighting. We employ the auto sun tracking system; this can improve the energy stored in a battery. This system does not affect the environment because it is pollution-free. Our system also consisting of automatic ON, OFF control of the LED lamp, so there is no manual operation and it is not required, operators.

CHAPTER-2

2.1 SOLAR PANEL EFFICIENCY MONITORING SYSTEM

2.1.1 BLOCK DIAGRAM OF SOLAR EFFICIENCY MONITORING SYSTEM

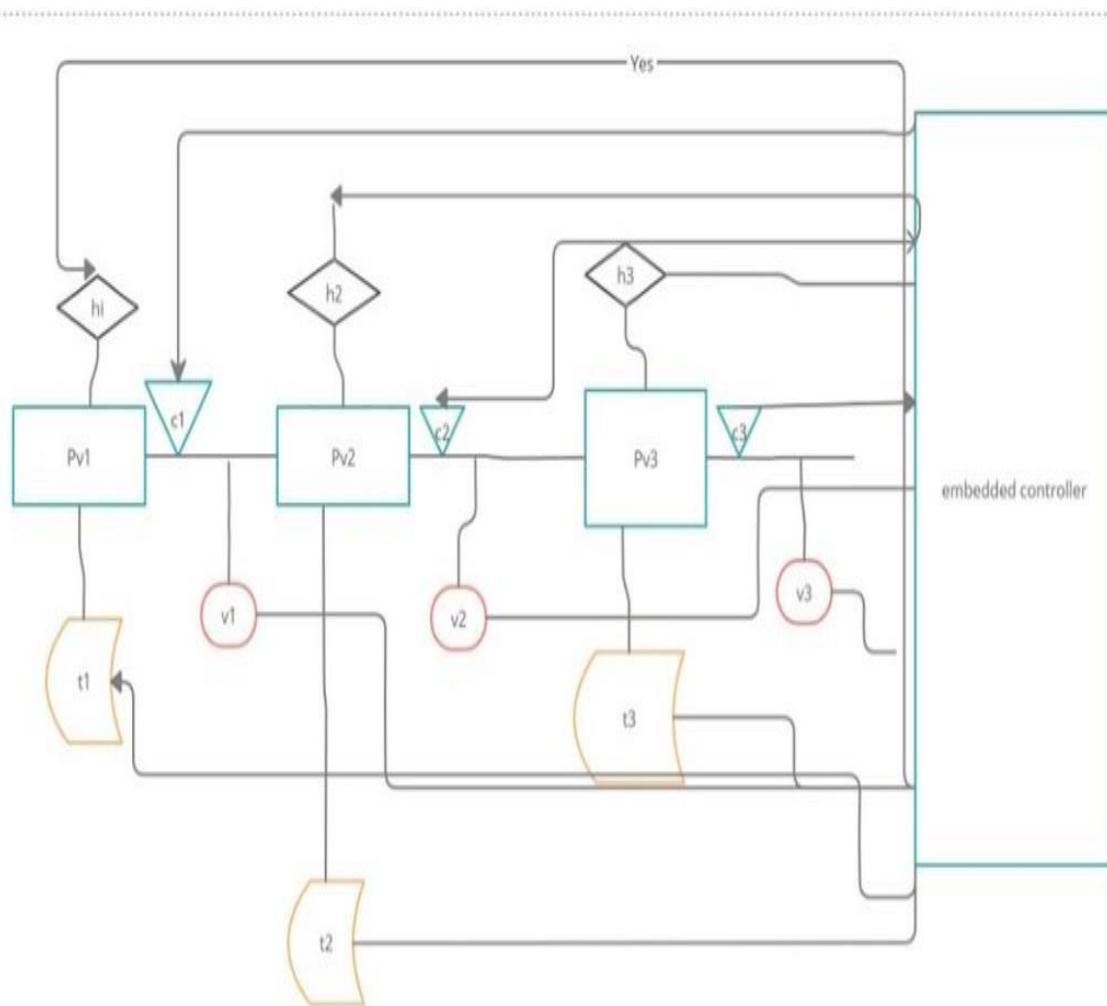


Fig: 2.1 Block diagram of the proposed system

Fig:2.1 shows the block diagram of a solar panel efficiency monitoring system that involves various components to regulate power delivery. An Arduino UNO board connected with dth11 Sensor at the base of the panels in a small area around the panels. The data from the sensor is sent to the Arduino microcontroller which forms the brain of the circuit. The Arduino then commands to

switch between depending upon the requirement and thus monitoring can be done easily. A battery eliminator is used to supply 5V inputs to the sensors and Arduino.

2.2 FUNCTIONAL DESCRIPTION

The simulation result is a three-stage process. The very first results are taken on the third of march using a dht11 sensor. The dht11 Sensor is likely to be beneficial to detect the higher temperature and humidity around the panel.

Whenever the fault is detected in the panel of these records is likely to be delivered to the Arduino. From Arduino, the information is likely to be delivered to the bottom station via the things speak channel. Here we use the switch as opposed to the dht11 sensor limited to simulation. This step would be to calculate the intensity of light. So the 2nd stage could be the sensor simulation that's primarily employed for the objective of detecting the intensity of the radiation. In day time intensity of light is likely to be high so no need for a light system. The working principle of the dht11 sensor offers an indisputable fact that all the stuff whose temperature is higher compared to the absolute zero emit energy in the shape of radiation. In the proposed system, this communication device can be used to monitoring the health of solar panels. Once there is any fault, during the period it's necessary that led has to be switched on to indicate that there is a fault in the panel.

The design includes two working modes

- OFF mode: When there is no fault in the panels compared with the humidity and temperature values around the solar array, the led will not be glown.
- ON MODE: When there is a fault in the panel the controller has been coded in such a way that the LED is glown automatically with high intensity.

2.3 COMPONENTS OF SOLAR STREET LIGHT

The solar street light system consists of various components that are discussed below in detail.

2.3.1 SOLAR PANEL

Solar panels are those devices that are used to absorb the sun's rays and convert them into electricity or heat. A solar panel is a collection of solar (or photovoltaic) cells, which can be used to generate electricity through the photovoltaic effect. These cells are arranged in a grid-like pattern on the surface of solar panels. Thus, it may also be described as a set of photovoltaic modules, mounted on a structure supporting it. A photovoltaic (PV) module is a packaged and connected assembly of 6×10 solar cells. When it comes to wear-and-tear, these panels are very hardy. Solar panels wear out extremely slow. In a year, their effectiveness decreases only about one to two percent (at times, even lesser). Most solar panels are made up using

crystalline silicon solar cells. Installation of solar panels in homes helps in combating the harmful emissions of greenhouse gases and thus helps reduce global warming. Solar panels do not lead to any form of pollution and are clean. They also decrease our reliance on fossil fuels (which are limited) and traditional power sources. These days, solar panels are used in wide-ranging electronic types of equipment like calculators, which work as long as sunlight is available. However, the only major drawback of solar panels is that they are quite costly. Also, solar panels are installed outdoors as they need sunlight to get charged.

2.3.1.1 SOLAR CELLS

A solar cell is an electronic device that catches the sunlight and turns it directly into electricity. It's about the size of an adult's palm, octagonal in shape, and colored bluish-black. Solar cells are often bundled together to make larger units called solar modules, themselves coupled into even bigger units known as solar panels (the black- or blue-tinted slabs you see on people's homes—typically with several hundred individual solar cells per roof) or chopped into chips (to provide power for small gadgets like pocket calculators and digital watches). Just like the cells in a battery, the cells in a solar panel are designed to generate electricity; but where a battery's cells make electricity from chemicals, a solar panel's cells generate power by capturing sunlight instead. They are sometimes called photovoltaic (PV) cells because they use sunlight ("photo" comes from the Greek word for light) to make electricity (the wor

"voltaic" is a reference to Italian electricity pioneer Alessandro Volta, 1745–1827). We can think of light as being made of tiny particles called photons, so a beam of sunlight is like a bright yellow fire hose shooting trillions upon trillions of photons our way. Stick a solar cell in its path and it catches these energetic photons and converts them into a flow of electrons—an electric current. Each cell generates a few volts of electricity, so a solar panel's job is to combine the energy produced by many cells to make a useful amount of electric current and voltage. Virtually all of today's solar cells are made from slices of silicon (one of the most common chemical elements on Earth, found in sand), although as we'll see shortly, a variety of other materials can be used as well (or instead). When sunlight shines on a solar cell, the energy it carries blasts electrons out of the silicon. These can be forced to flow around an electric circuit and power anything that runs on electricity.

2.3.1.2 Manufacturing of Solar Cells

Silicon is the stuff from which the transistors (tiny switches) in microchips are made and solar cells work similarly. Silicon is a type of material called a semiconductor. Some materials, notably metals, allow electricity to flow through them very easily; they are called conductors. Other materials, such as plastics and wood, don't let electricity flow through them at all; they are called insulators. Semiconductors like silicon are neither conductors nor insulators: they don't normally conduct electricity, but under certain circumstances, we can make them do so. A solar cell is a sandwich of two different layers of silicon that have been specially treated or doped so they will let electricity flow through them in a particular way. The lower layer is doped so it has slightly too few electrons. It's called p-type or positive-type silicon (because electrons are negatively charged and this layer has too few of them). The upper layer is doped the opposite way to give it slightly too many electrons. It's called n-type or negative-type silicon. (You can read more about semiconductors and dope in our articles on transistors and integrated circuits). When we place a layer of n-type silicon on a layer of p-type silicon, a barrier is created at the junction of the two materials (the all-important border where the two kinds of silicon meet up). No electrons can cross the barrier so, even if we connect this silicon sandwich to a flashlight, no current will flow: the

bulb will not light up. But if we shine light onto the sandwich, something remarkable happens. We can think of light as a stream of energetic "light particles" called photons. As photons enter our sandwich, they give up their energy to the atoms in the silicon. The incoming energy knocks electrons out of the lower, p-type layer so they jump across the barrier to the n-type layer above and flow out around the circuit. The light that shines, the more electrons jump up and the more current flows. This is what we mean by photovoltaic—light making voltage—and it's one kind of what scientists call the photoelectric effect. The photoelectric effect occurs due to the solar cells which are shown in fig 2.2.

Fig 2.2 Solar Cell



2.3.1.3 TYPES OF SOLAR CELLS

1. Amorphous silicon solar cell

Amorphous silicon is a non-crystalline form of silicon. It is used in the market for more than 15 years. It is mainly used in pocket calculators. It is a substrate material such as glass or metal. Amorphous silicon can also be deposited at very low temperatures, as low as 75 degrees Celsius, which allows for deposition on plastic as well. In its simplest form, the cell structure has a single sequence of p-in layers. However, single it is the most well developed the thin-film technologies have been on the market for more

than 15 years. It is widely used in pocket calculators, but it also powers some private homes, buildings, and remote facilities. United Solar Systems Corp. (Unisolar) pioneered amorphous-silicon solar cells and remains a major maker today, as does Sharp and Sanyo. Amorphous silicon panels are formed by vapor-depositing a thin layer of silicon material – about 1 micrometer thick – on layer cells suffer from significant degradation in their power output (in the range 15-35%) when exposed to the sun. The mechanism of degradation is called the Staebler-Wronski Effect, after its discoverers. Better stability requires the use of thinner layers to increase the electric field strength across the material.

2. Biohybrid solar cell

A biohybrid solar cell is a solar cell made by the combination of organic matter and inorganic matter. This biohybrid solar cell is a new type of renewable energy. A biohybrid solar cell is a solar cell made using a combination of organic matter (photosystem I) and inorganic matter. Biohybrid solar cells have been made by a team of researchers at Vanderbilt University. The team used photosystem I (a photoactive protein complex located in the thylakoid membrane) to recreate the natural process of photosynthesis to obtain greater efficiency in solar energy

conversion. These biohybrid solar cells are a new type of renewable energy. Multiple layers of photosystem I gather photonic energy, convert it into chemical energy, and create a current that goes through the cell. The cell itself consists of many of the same non-organic materials that are found in other solar cells except the injected photosystem I complexes which are introduced and gathered for several days in the gold layer. After some days the photosystem is made visible and appears as a thin green film. It is this thin film that helps and improves energy conversion.

3. Buried contact solar cell

The buried contact solar cell is a high-efficiency commercial solar cell technology based on a plated metal contact inside a laser-formed groove. The buried contact solar cell is a high-efficiency commercial solar cell technology based on a plated metal contact inside a laser-formed groove.

The buried contact technology overcomes many of the disadvantages associated with screen-printed contacts and this allows buried contact solar cells to have performance up to 25% better than commercial screen-printed solar cells. A key high-efficiency feature of the buried contact solar cell is that the metal is buried in a laser-formed groove inside the silicon solar cell. This allows for a large metal height-to-width aspect ratio. A large metal contact aspect ratio in turn allows a large volume of metal to be used in the contact finger, without having a wide strip of metal on the top surface. Therefore, a high metal aspect ratio allows a large number of closely spaced metal fingers, while still retaining high transparency.

4. Cadmium telluride solar cell

It describes the PV technology based on the use of the cadmium telluride, a thin semi-conductor later designed to absorb and convert solar energy into electrical energy. Cadmium telluride (CdTe) photovoltaics describes a photovoltaic (PV) technology that is based on the use of cadmium telluride, a thin semiconductor layer designed to absorb and convert sunlight into electricity. Cadmium telluride PV is the only thin-film technology with lower costs than conventional solar cells made of crystalline silicon in multi-kilowatt systems. On a lifecycle basis, CdTe PV has the smallest carbon footprint, lowest water use, and shortest energy payback time of all solar technologies. CdTe's energy payback time of less than a year enables faster carbon reductions without short-term energy deficits. The toxicity of cadmium is an environmental concern mitigated by the recycling of CdTe modules at the end of their lifetime, though there are still uncertainties and the public opinion is skeptical

towards this technology. The usage of rare materials may also become a limiting factor to the industrial scalability of CdTe technology in the mid-term future.

5. Toxicity of cadmium

Cadmium is one of the top 6 deadliest toxic materials known. Here cadmium telluride is known to be less toxic than cadmium element. So here we use cadmium telluride for better performance. Cadmium is one of the top 6 deadliest and toxic materials known. However, CdTe appears to be less

toxic than elemental cadmium, at least in terms of acute exposure. This is not to say it is harmless. Cadmium telluride is toxic if ingested, if its dust is inhaled, or if it is handled improperly (i.e. without appropriate gloves and other safety precautions). The toxicity is not solely due to the cadmium content. One study found that the highly reactive surface of cadmium telluride quantum dots triggers extensive reactive oxygen damage to the cell membrane, mitochondria, and cell nucleus. Besides, the cadmium telluride films are typically recrystallized in a toxic compound of cadmium chloride. The disposal and long-term safety of cadmium telluride is a known issue in the large-scale commercialization of cadmium telluride solar panels.

6. Concentrated PV cell

A concentrated photovoltaic cell converts solar energy into electrical energy as a normal conventional photovoltaic cell but used an advanced optical system to focus a large area of sunlight onto each of the solar cells for high efficiency. Following the sun, a Concentrating Photovoltaic (CPV) system converts light energy into electrical energy in the same way that conventional photovoltaic technology does, but uses an advanced optical system to focus a large area of sunlight onto each cell for maximum efficiency. Different CPV designs exist, sometimes differentiated by the concentration factor, such as low-concentration (LCPV) and high concentration (HCPV). Concentrator photovoltaic's (CPV) is a photovoltaic technology that generates electricity from sunlight. Contrary to conventional photovoltaic systems, it uses lenses and curved mirrors to focus sunlight onto small, but highly efficient, multi-junction (MJ) solar cells. Besides, CPV systems often use solar trackers and sometimes a cooling system to further increase their efficiency. Ongoing research and development are rapidly improving their competitiveness in the utility-scale segment and areas of high solar insulation.

7. Copper indium gallium selenide solar cell

One of the most interesting and controversial materials in solar is copper indium gallium selenide. It is a thin solar cell used to convert the solar energy into electrical

energy. They are manufactured by depositing a thin layer of copper, indium, gallium, selenide. One of the most interesting and controversial materials in solar is Copper-Indium-Gallium-Selenide or CIGS for short. It was part of a solar thin-film-hype cycle where some CIGS companies such as Solyndra, Nanosolar, and MiaSole almost became household names. A copper indium gallium selenide solar cell (or CIGS cell, sometimes CI (G) S or CIS cell) is a thin-film solar cell used to convert sunlight into electric power. They are manufactured by depositing a thin layer of copper, indium, gallium, and selenide on glass or plastic backing, along with electrodes on the front and back to collect current. Because the material has a high absorption coefficient and strongly absorbs sunlight, a much thinner film is required than other semiconductor materials.

8. Dye-sensitized solar cell

The dye-sensitized solar cell is a third-generation photovoltaic cell. This will convert any visible light energy into electrical energy. This is an advanced technology of photovoltaic cells. Dye-Sensitized solar cells (DSSC), also sometimes referred to as dye-sensitized cells (DSC), are a third-generation photovoltaic (solar) cell that converts any visible light into electrical energy. This new class of advanced solar cells can be likened to artificial photosynthesis due to how it mimics nature's absorption of light energy. Dye-Sensitized solar cells (DSSC) were invented in 1991 by Professor Michael and Dr. Brian Regan at EPFL, Switzerland, and are often referred to as the cell, we call it G Cell.

9. Gallium arsenide germanium solar cell

It consists of two base elements gallium and arsenic. By mixing these two compounds a new compound is formed with many different characteristics. Gallium arsenide is a semiconductor with greater electron mobility and electron velocity. So this is used more in solar cells. Gallium arsenide is composed of 2 base elements; gallium and arsenic. When these two individual elements bind together, they form the aforementioned compound, which displays many interesting characteristics. Gallium arsenide is a semiconductor with a greater saturated electron velocity and electron

mobility than that of silicon W. A semiconductor is a material that has electrical conductivity between an insulator and a conductor; it may vary its ability to conduct electricity when it is cool versus when it is hot. This makes it very useful in many applications. Another novel quality of gallium arsenide is that it has a direct bandgap.

This is a quality that denotes a compound that can emit light efficiently. Gallium arsenide (GaAs) is a compound of the elements gallium and arsenic. It is an III-V direct bandgap semiconductor with a zinc blende crystal structure. Gallium arsenide is used in the manufacture of devices such as microwave frequency integrated circuits, monolithic microwave integrated circuits, infrared light-emitting diodes, laser diodes, solar cells, and optical windows

10. Hybrid solar cell

Hybrid solar cell combines advantages of both organic and inorganic semiconductors. The organic materials consist of polymers which will transport holes and the inorganic materials act as an electron acceptor. Hybrid solar cells combine the advantages of both organic and inorganic semiconductors. Hybrid photovoltaic have organic materials that consist of conjugated polymers that absorb light as the donor and transport holes. Inorganic materials in hybrid cells are used as the acceptor and electron transporter in the structure. The hybrid photovoltaic devices have the potential for not only low-cost roll-to-roll processing but also for scalable solar power conversion. In hybrid solar cells, organic material is mixed with a high electron-transport material to form the photoactive layer. The two materials are assembled in a hetero junction-type photoactive layer, which can have greater power conversion efficiency than a single material. One of the materials acts as the photon absorber and exciton donor. The other material facilitates exciton dissociation at the junction. The charge is transferred and then separated after an exciton created in the donor is delocalized on a donor-acceptor complex. The energy required to separate the exciton is provided by the energy offset between the Lumos or conduction bands of the donor and acceptor. After dissociation, the carriers are transported to the respective electrodes through a percolation

network. The average distance an exciton can diffuse through the material before annihilation by recombination is the exciton diffusion length. This is short in polymers, on the order of 5– 10 nanometers. The time scale for radiative and nonradiative decay is from 1 picosecond to 1 nanosecond. Excitons generated within this length close to an acceptor would contribute to the photocurrent. To deal with the problem of the short exciton diffusion length, a bulk heterojunction structure is used rather than a phase-separated bilayer. Dispersing the particles throughout the polymer matrix creates a larger interfacial area for charge transfer to occur.

2.3.2 CHARGE CONTROLLER

A solar charge controller in fig 2.4 is fundamentally a voltage or current controller to charge the battery and keep electric cells from overcharging. It directs the voltage and current hailing from the solar panels setting off to the electric cell. Generally, 12V boards/panels put out in the ballpark of 16 to 20V, so if there is no regulation the electric cells will damage from overcharging. Generally, electric storage devices require around 14 to 14.5V to get completely charged. The solar charge controllers are available in all features, costs, and sizes. The range of charge controllers is from 4.5A and up to 60 to 80A.

Types of Solar Charger Controller:

There are three different types of solar charge controllers, they are:

- 1 Simple 1 or 2 stage controls
2. PWM (pulse width modulated)
3. Maximum power point tracking (MPPT)

Simple 1 or 2 Controls: It has shunt transistors to control the voltage in one or two steps. This controller just shorts the solar panel when a certain voltage is arrived at. Their main genuine fuel for keeping such a notorious reputation is their unwavering quality – they have so not many segments, there is very little to break.

PWM (Pulse Width Modulated): This is the traditional type charge controller, for instance, anthrax, Blue Sky, and so on. These are essentially the industry standard now.

Maximum power point tracking (MPPT): The MPPT solar charge controller is the sparkling star of today's solar systems. These controllers truly identify the best working voltage and amperage of the solar panel exhibit and match that with the electric cell bank. The outcome is an extra 10-30% more power out of your sun-oriented cluster versus a PWM controller. It is usually worth the speculation for any solar electric system over 200 watts.

Features of Solar Charge Controller

- Protects the battery (12V) from overcharging
- Reduces system maintenance and increases battery lifetime
- Auto charged indication

- Reliability is high
- 10amp to 40amp of charging current
- Monitors the reverse current flow

The function of the Solar Charge Controller

The most essential charge controller controls the device voltage and opens the circuit, halting the charging, when the battery voltage ascends to a certain level. More charge controllers utilized a mechanical relay to open or shut the circuit, halting or beginning power heading off to the electric storage devices.

Generally, solar power systems utilize 12V of batteries. Solar panels can convey much more voltage than is obliged to charge the battery. The charge voltage could be kept at the best level while the time needed to completely charge the electric storage devices is lessened. This permits the solar systems to work optimally constantly. By running higher voltage in the wires from the solar panels to the charge controller, power dissipation in the wires is diminished fundamentally.

The solar charge controllers can also control the reverse power flow. The charge controllers can distinguish when no power is originating from the solar panels and open the circuit separating the solar panels from the battery devices and halting the reverse current flow.

Applications

In recent days, the process of generating electricity from sunlight is having more popularity than other alternative sources and the photovoltaic panels are absolutely pollution free and they don't require high maintenance. The following are some examples where solar energy is utilizing.

- Street lights use photovoltaic cells to convert sunlight into DC electric charge. This system uses a solar charge controller to store DC in the batteries and uses it in many areas.
- Home systems use PV modules for household applications.
- Hybrid solar system uses multiple energy sources for providing full-time backup supply to other sources.

Types of Solar Charge Controller

From the below example, a solar panel is used to charge a battery. A set of operational amplifiers are used to monitor panel voltage and load current

continuously. If the battery is fully charged, an indication will be provided by a green LED. To indicate undercharging, overloading, and deep discharge condition a set of LEDs are used. A MOSFET is used as a power semiconductor switch by the solar charge controller to ensure the cut-off load in low condition or loading condition. The solar energy is bypassed using a transistor to a dummy load when the battery gets full charging. This will protect the battery from overcharging.

This unit performs 4 major functions:

1. Charges the battery.
2. Indicates when the battery is fully charged.
3. Monitors the battery voltage and when it is minimum, cuts off the supply to the load switch to remove the load connection.
4. In case of overload, the load switch is in off condition ensuring the load is cut off from the battery supply.



2.3.3 Arduino UNO

An Arduino is an open-source microcontroller development board. In plain English, you can use the Arduino to read sensors and control things like motors and lights. This allows you to upload programs to this board which can then interact with things in the real world. With this, you can make devices that respond and react to the world at large.

For instance, you can read a humidity sensor connected to a potted plant and turn on an automatic watering system if it gets too dry. Or, you can make a stand-alone chat server that is plugged into your internet router. Or, you can have it tweet every time your cat passes through a pet door. Or, you can have it start a pot of coffee when your alarm goes off in the morning.

If there is something that is in any way controlled by electricity, the Arduino can interface with it in some manner. And even if it is not controlled by electricity, you can probably still use things which are (like motors and electromagnets), to interface with it.

The possibilities of the Arduino are almost limitless. As such, there is no way that one single tutorial can cover everything you might ever need to know. That said, I've done my best to give a basic overview of the fundamental skills and knowledge that you need to get your Arduino up and running. If nothing more, this should function as a springboard into further experimentation and learning.

Some people think of the entire Arduino board as a microcontroller, but this is inaccurate. The Arduino board is a specially designed circuit board for programming and prototyping with Atmel microcontrollers.

The nice thing about the Arduino board is that it is relatively cheap, plugs straight into a computer's USB port, and it is dead-simple to set up and use (compared to other development boards).

Some of the key features of the Arduino Uno include:

- An open-source design. The advantage of it being open source is that it has a large community of people using and troubleshooting it. This makes it easy to find someone to help you debug your projects.
- An easy USB interface. The chip on the board plugs straight into your USB port and registers on your computer as a virtual serial port. This allows you to interface with it as though it were a serial device. The benefit of this setup is that serial communication is an extremely easy (and time-tested) protocol, and USB makes connecting it to modern computers convenient.
- Very convenient power management and built-in voltage regulation. You can connect an external power source of up to 12v and it will regulate it to both 5v and 3.3v. It also can be powered directly off of a USB port without any external power.
- An easy-to-find, and dirt cheap, microcontroller "brain." The ATmega328 chip retails for about \$2.88 on Digikey. It has a countless number of nice hardware features like timers, PWM pins, external and internal interrupts, and multiple sleep modes. Check out the official datasheet for more details.
- A 16mhz clock. This makes it not the speediest microcontroller around, but fast enough for most applications.
- 32 KB of flash memory for storing your code.

- 13 digital pins and 6 analog pins. These pins allow you to connect external hardware to your Arduino. These pins are key for extending the computing capability of the Arduino into the real world. Simply plug your devices and sensors into the sockets that correspond to each of these pins and you are good to go.
- An ICSP connector for bypassing the USB port and interfacing the Arduino directly as a serial device. This port is necessary to re-bootload your chip if it corrupts and can no longer talk to your computer.
- An on-board LED attached to digital pin 13 for fast and easy debugging of code.
- And last, but not least, a button to reset the program on the chip.

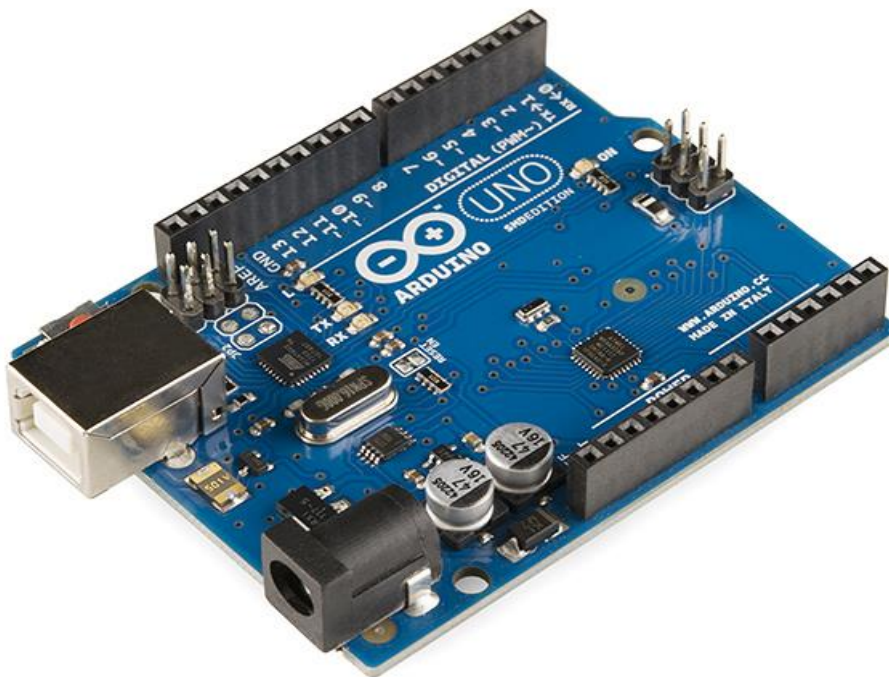


Fig:2.3 Arduino UNO

2.3.4 CURRENT SENSORS

A current sensor is a device that detects electric current in a wire and generates a signal proportional to that current. This current sensor is shown in fig 2.10. The generated signal could be analog voltage or current or even a digital output. The generated signal can be then used to display the measured current in an ammeter, or can be stored for further analysis in a data acquisition system, or can be used for control.

The sensed current and the output signal can be:

1. Alternating current input,
2. Analog output, which duplicates the wave shape of the sensed current.
3. Bipolar output, which duplicates the wave shape of the sensed current.
4. Unipolar output, which is proportional to the average or RMS value of the sensed current.
5. Direct current input,
 - unipolar, with a unipolar output, which duplicates the wave shape of the sensed current
 - digital output, which switches when the sensed current exceeds a certain threshold

TYPES OF CURRENT SENSORS:

1. Hall effect sensor.
2. Transformer or current clamp meter, (suitable for AC only).
3. Fluxgate Transformer Type, (suitable for AC or DC).
4. Resistor, whose voltage is directly proportional to the current through it.
5. Fiber-optic current sensor, using an interferometer to measure the phase change in the light produced by a magnetic field.
6. Rogowski coil, an electrical device for measuring alternating current (AC) or high-speed current pulses.

The Hall Effect current sensor is a type of current sensor which is based on the Hall Effect phenomenon discovered by Edwin Hall in 1879.

Hall Effect current sensors can measure all types of current signals (i.e. AC, DC, or pulsating current).

These sensors are currently being used widely in many industries because of their vast applications and the type of output they provide, which can be manipulated and can be used for various applications.

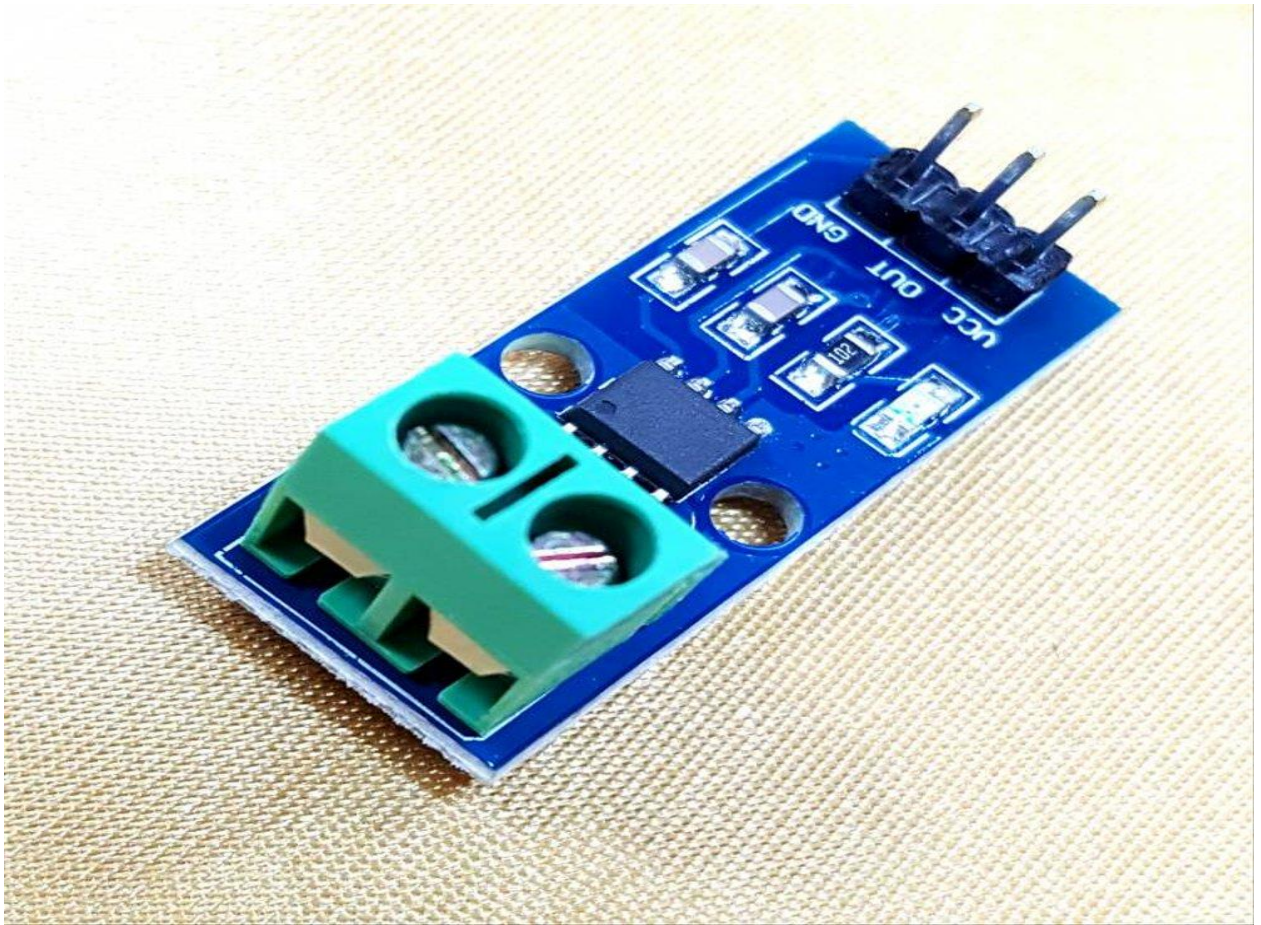


Fig:2.5 Current Sensors

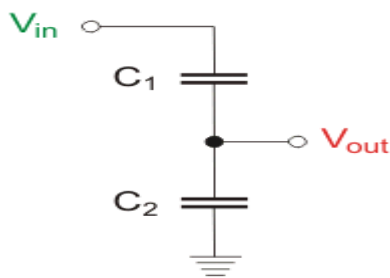
2.3.7 VOLTAGE SENSORS

Sensors are a device which can sense or identify and react to certain types of electrical or some optical signals. Implementation of the voltage sensor and current sensor techniques has become an excellent choice for the conventional current and voltage measurement methods. These voltage sensors are shown in fig 2.13.

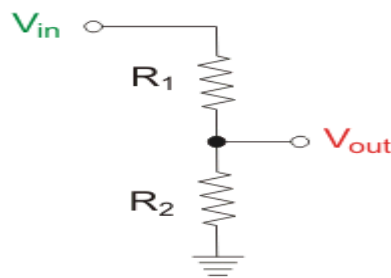
Advantages of Sensors Over Conventional Measuring Techniques

- Small in weight and size.
- Personnel safety is high.
- Degree of accuracy is very high.
- It is non- saturable.
- Wide dynamic range.
- Eco-friendly.
- It is possible to combine both the voltage and current measurement into a single physical device with small and compact dimensions.

In this article, we can discuss in detail the voltage sensor. A voltage sensor can determine, monitor, and can measure the supply of voltage. It can measure AC level or/and DC voltage level. The input to the voltage sensor is the voltage itself and the output can be analog voltage signals, switches, audible signals, analog current level, frequency, or even frequency-modulated outputs. That is, some voltage sensors can provide sine or pulse trains as output and others can produce Amplitude Modulation, Pulse Width Modulation, or Frequency Modulation outputs. In voltage sensors, the measurement is based on the voltage divider. Mainly two types are of voltage sensors are available- Capacitive type voltage sensor and Resistive type



$$V_{out} = \frac{C_1}{C_1 + C_2} \times V_{in}$$



$$V_{out} = \frac{R_2}{R_1 + R_2} \times V_{in}$$

Capacitive Voltage Sensor As we know that a capacitor comprises of two conductors or simply two plates and in between these plates, a non-conductor is kept. That non-conducting material is termed dielectric. When an AC voltage is provided across these plates, the current will start to pass owing to either the attraction or the repulsion of electrons through the voltage present on the opposite plate. The field among the plates will create a complete AC circuit without any hardware connection. This is how a capacitor works. Next, we can discuss the voltage division in two capacitors which are in series. Usually, in series circuits, the high voltage will develop across the component which is having a high impedance. In the case of capacitors, capacitance and impedance

(capacitive reactance) are always inversely proportional. The relation between voltage and capacitance is $Q \rightarrow \text{Charge (Coulomb)}$ $C \rightarrow \text{Capacitance (Farad)}$ $X_C \rightarrow \text{Capacitive reactance } (\Omega)$ $f \rightarrow \text{Frequency (Hertz)}$ From the above two relations, we can clearly state that the highest voltage will build up across the smallest capacitor. The capacitor voltage sensors work based on this simple principle. Consider we are holding the sensor in our hand and then placing the tip of it near a live conductor as shown. Here, we are inserting the sensing element of high impedance into a series capacitive coupling circuit. At this moment, the tip of the sensor is the smallest capacitor which is coupled to the live voltage. Thus the whole

voltage will develop across the sensing circuit and it can detect voltage and indicator like light or buzzer sound is turned on...



Fig:2.12 Detection of Current using Sensing Element

Resistive Voltage Sensor There are two ways in converting the resistance of the sensing element to the voltage. The first one is the simplest method that is to provide a voltage to the resistor divider circuit comprised of a sensor and a reference resistor which is represented below. The voltage that is developed across the reference resistor or sensor is buffered and

then given to the ADC. The output voltage of the sensor can be expressed as

The drawback of this circuit is the amplifier present here will amplify the whole voltage developed across the sensor. But, it is better to amplify only the voltage change due to the change in resistance of the sensor. This is achieved by the second method implementing the resistance bridge which is shown below.

Here, the output voltage is When $R_1 = R$, then output voltage becomes approximately

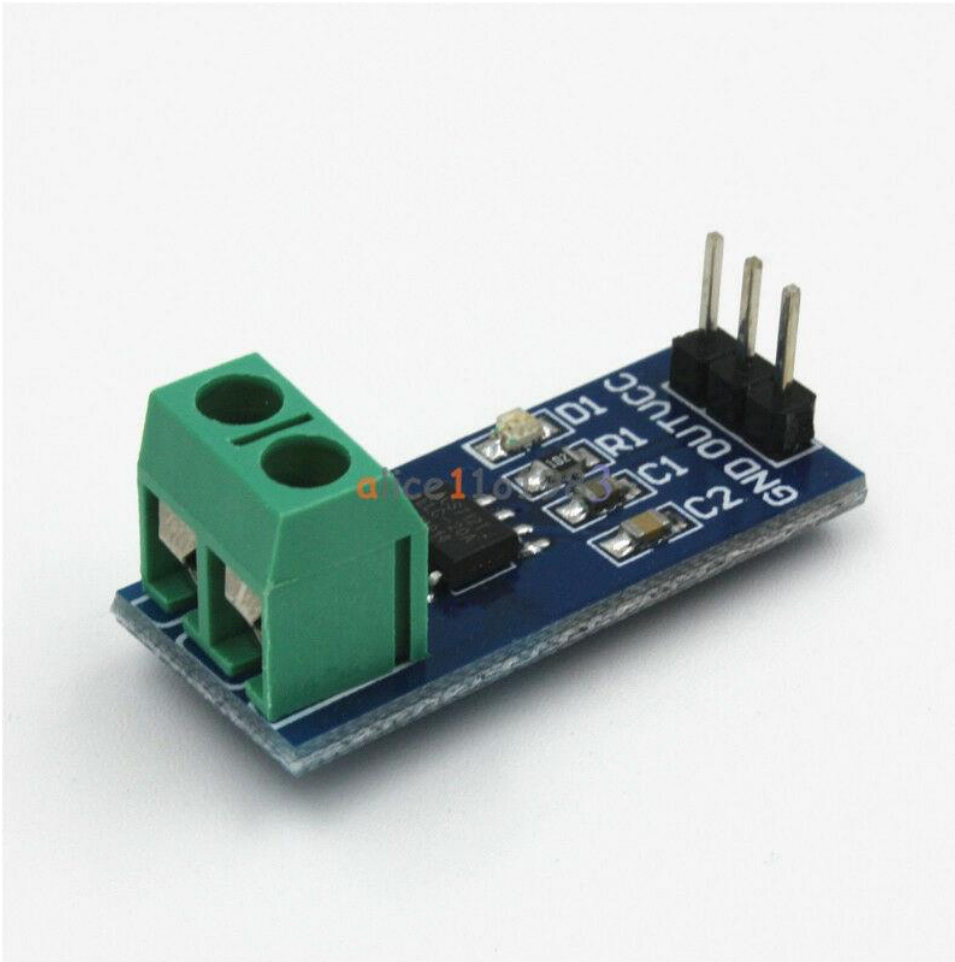


Fig:2.13 Voltage Sensor

Application of Voltage Sensor

The application of the voltage sensor is shown below

- Power failure detection.
- Load sensing.
- Safety switching.
- Temperature control.
- Power demand control.
- Fault detection etc.

2.3.8 DHT11 SENSOR

DHT11 - Humidity and Temperature Sensor The DHT11 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds.

Features

- Full range temperature compensated
- Relative humidity and temperature measurement
- Calibrated digital signal
- Outstanding long-term stability
- Extra components not needed
- Long transmission distance
- Low power consumption
- 4 pins packaged and fully interchangeable

Details This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability, and cost-effectiveness. Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programs in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption, and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. VV

DHT11's power supply is 3-5.5V DC. When power is supplied to the sensor, do not send any instruction to the sensor within one second to pass the unstable status. One capacitor valued at 100nF can be added between VDD and GND for power filtering.

Communication Process: Serial Interface (Single-Wire Two-Way) The interesting thing in this module is the protocol that uses to transfer data. All the sensor readings are sent using a single wire bus which reduces the cost and extends the distance. To send data over a bus you have to describe the way the data will be transferred, so that transmitter and receiver can understand what says each other. This is what a protocol does. It describes the way the data are transmitted. On DHT-11 the 1-wire data bus is pulled up with a resistor to VCC. So if nothing has occurred the voltage on the bus is equal to VCC. Communication Format can be separated into three stages

- 1) Request
- 2) Response
- 3) Data Reading

1) Request: To make the DHT-11 send you the sensor readings you have to send it a request. The request is, to pull down the bus for more than 18ms to give DHT time to understand it and then pull it up for 40uS.

2) Response: What comes after the request is the DHT-11

response. This is an automatic reply from DHT which indicates that DHT received your request. The response is ~54uS low and 80uS high. 3) Data Reading: What will come after the response is the sensor data. The data will be packed in a packet of 5 segments of 8-bits each. Totally $5 \times 8 = 40$ bits. First two segments are Humidity read, integral & decimal. Following two are Temperature read in Celsius, integral & decimal and the last segment is the Check Sum which is the sum of the 4 first 5 segments. If Check Sum's value isn't the same as the sum of the first 4 segments that means that data received isn't correct. How to Identify Bits: Each bit sent is a follow of ~54uS Low in the bus and ~24uS to 70uS High depending on the value of the bit. Bit '0' : ~54uS Low and ~24uS High Bit '1' : ~54uS Low and ~70uS High End Of Frame: At the end of packet DHT sends a ~54uS Low level, pulls the bus to High and goes to sleep mode.

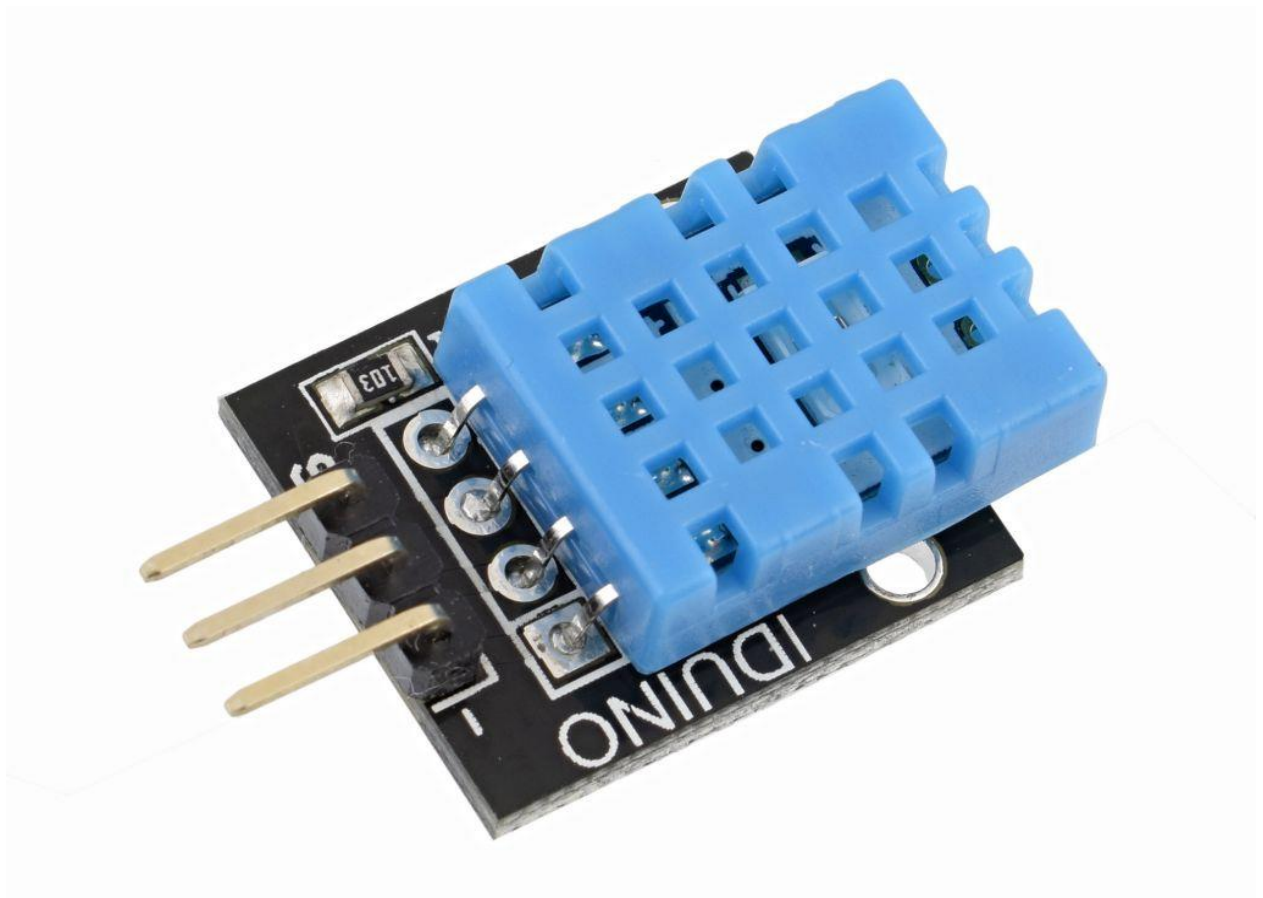
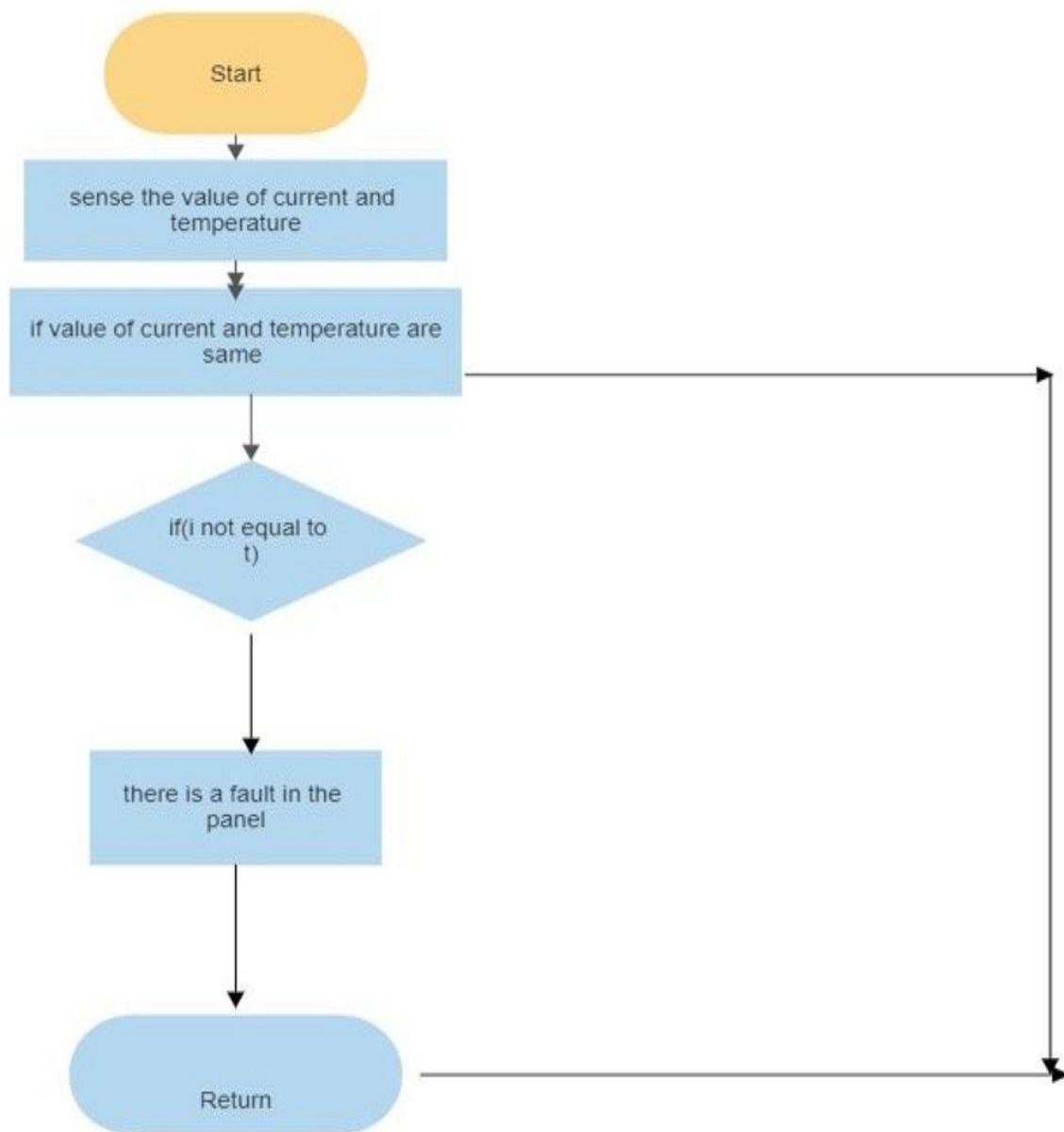


FIG:2.14 Dht11 sensor

3.5 SYSTEM MONITORING

Fig 3.1 FLOWCHART FOR SYSTEM MONITORING



HARDWARE

4.1 Hardware

Implementation of solar street lighting system is done according to the design procedure .The shows how the LED is glowing with full-length intensity. If the PIR sensor senses any living being, then it will glow with full-length intensity and after some time, the light automatically reduces its intensity

Fig.4.1 ARDUINO UNO

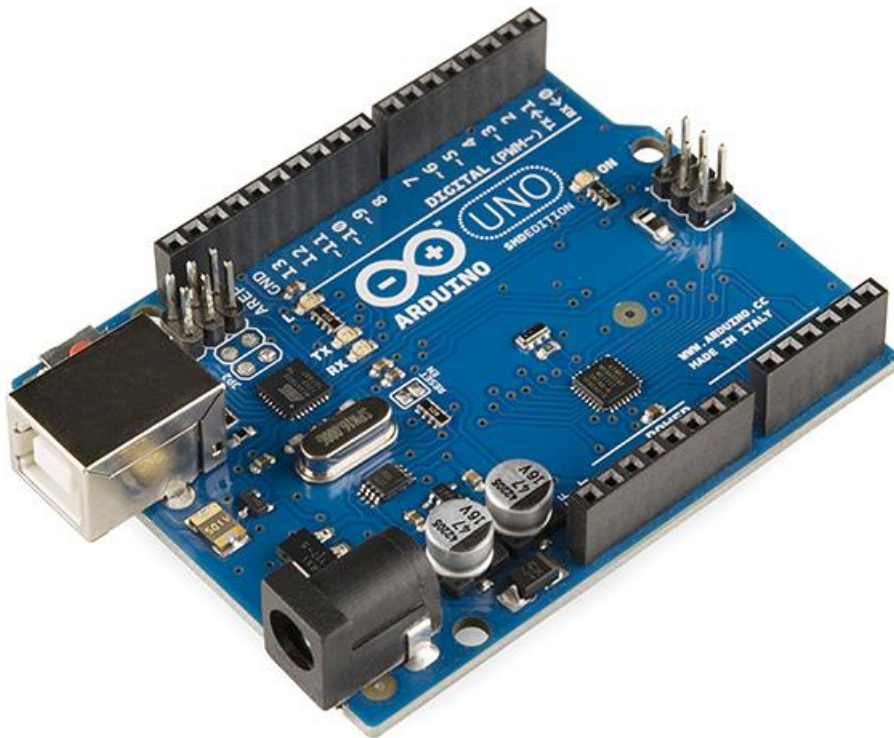


Fig.4.2 PANEL



Fig:4.3 system modules

Fig 4.2 illustrates the led bulb which has a specific characteristic that it has an inbuilt charge controller and the status of the charge controller can be easily known by the symbol of red and a green light present in the led the red light indicates that it is in an off position. Also, there is one green light present that tells that the charge controller is in working status.

This fig shows the IoT part which is connected with raspberry pie, current sensor, DHT11. The sensors will give us the amount of current utilized and the amount that is produced.

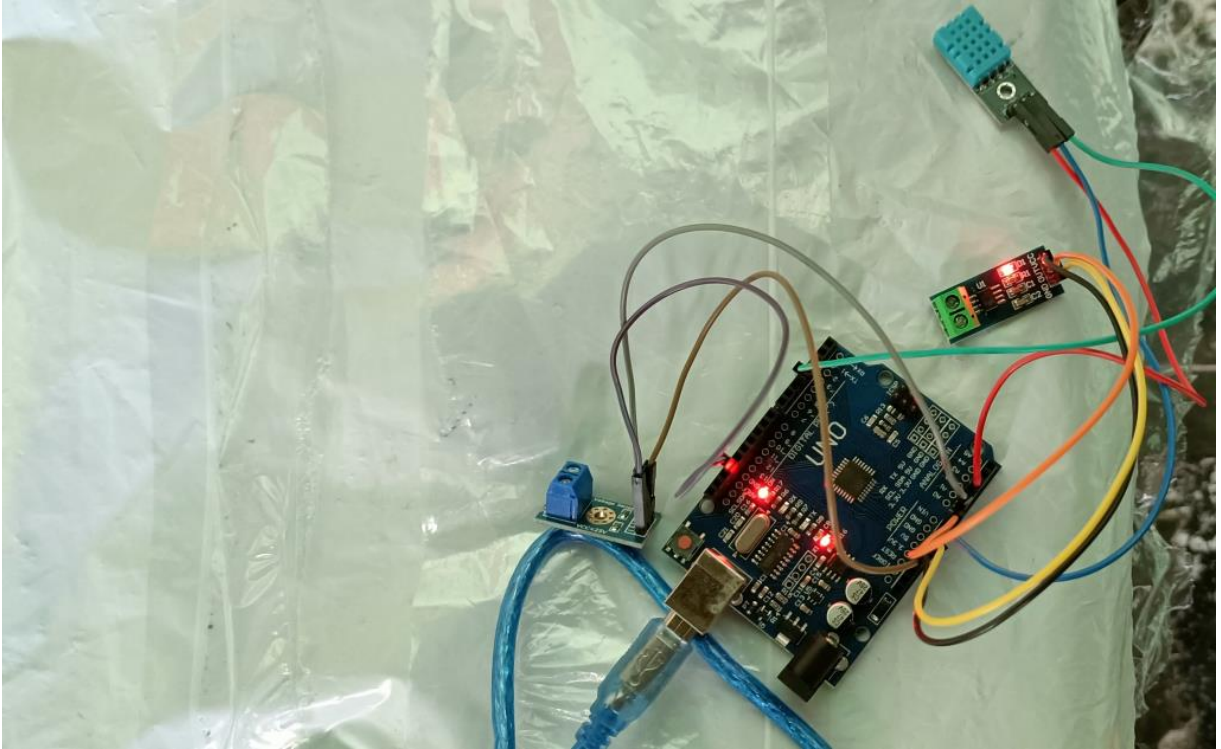


Fig:4.3. circuit board

4.2 SPECIFICATIONS

SPECIFIC CHARACTERISTICS

4.2.2 PANEL SPECIFICATIONS

ELECTRICAL SPECIFICATIONS *STC : IRRADIANCE 1000 W/m^2 , AM1.5 SPECTRUM ,MODULE TEMP 25.C

MODEL TYPE CSS-MSP-075M-36

PEAK POWER (Pmax) 75W

CELL EFFICIENCY 14.01%

MAXIMUM POWER VOLTAGE(Vmp) 17.56 V

MAXIMUM POWER CURRENT(Imp) 4.27 A

OPEN CIRCUIT VOLTAGE (Voc) 21.17 V

CAPACITY(25.C) 10 HOURS RATE 40 Ah 5 HOURS RATE 32 Ah 1 HOUR RATE 24 Ah 1.5HOUR DISCHARGE TO 10.5V 16 A

SHORT CIRCUIT CURRENT(ISC) 4.74 A

POWER TOLERANCE $\pm 3\%$

MAXIMUM SYSTEM VOLTAGE 1000 V

SERIES FUSE RATING(A) 7

NUMBER OF BYPASS DIODE 2

4

The graph in fig.4.4 gives us the appropriate value of the humidity of the entire area value whenever the user wants to know about the details time where the user wants to know the status of the data. This data will be stored in the things speak online account.

DATA OF HUMIDITY AND TEMPERATURE

The graph in fig.4.5 gives us the appropriate value of the temperature and temperature of the entire area whenever the user wants to know about the details time

where the user wants to know the status of the data. This data will be stored in the things speak online account.

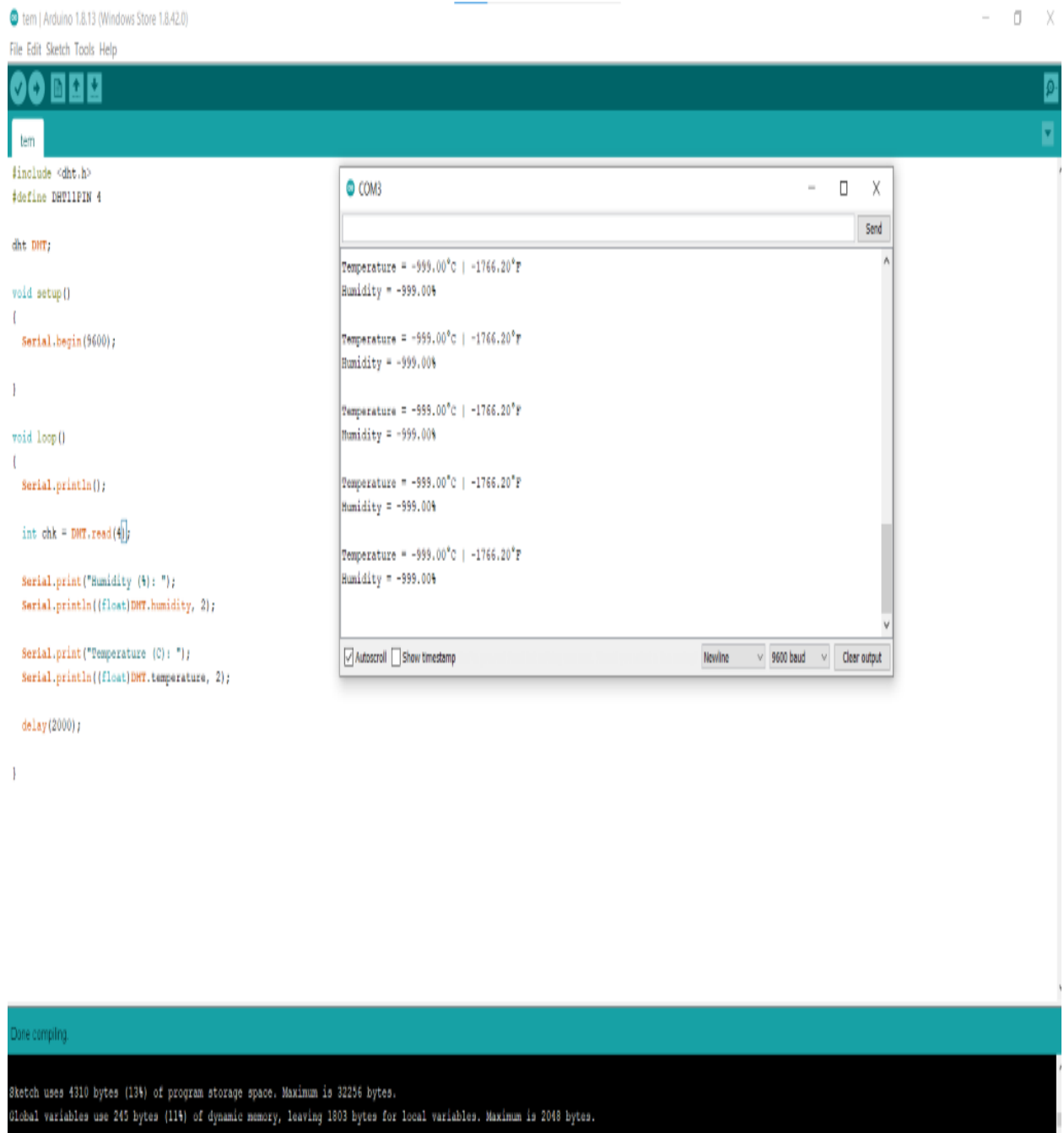


Fig 4.5 DATA OF CURRENT

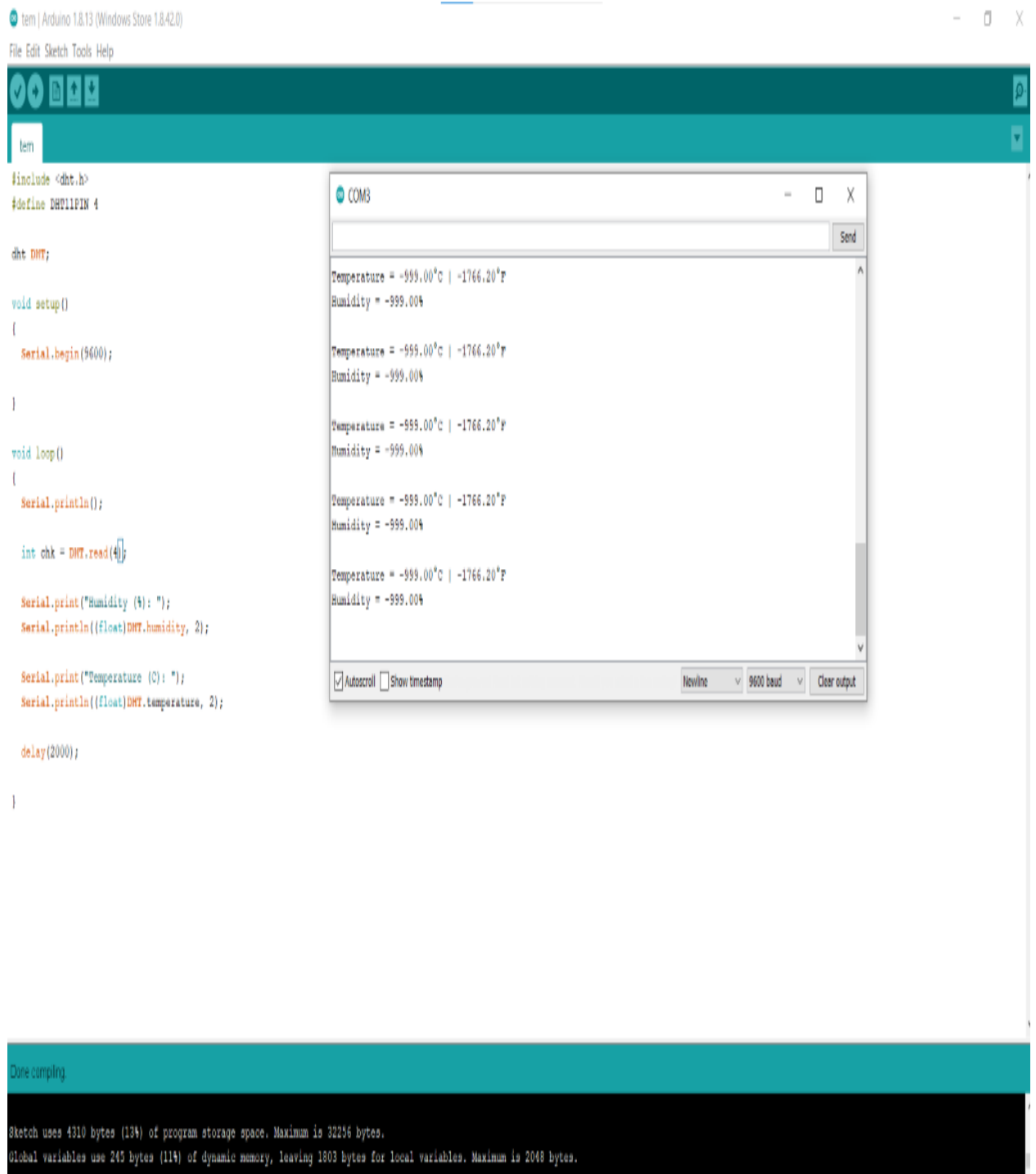


Fig 4.6 given below is the pic taken when the raspberry Arduino board is in running condition and when the panel is not connected when any motion is sensed near it.

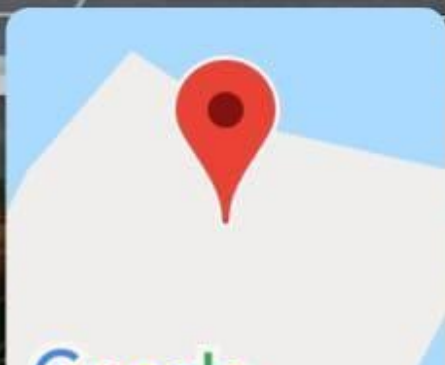
CHAPTER-5

CONCLUSION

The smart solar efficiency monitoring system is presented. As this system keeps continuous track of solar power plant, the daily weekly and monthly analysis becomes easy and efficient also with the help of this analysis it is possible to detect any fault that occurred within the power plant as the generated power may show some inconsistency in data of Solar power plant.

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Kondapi, Andhra Pradesh, India

Andhra Pradesh 523270, India

Lat N 15° 24' 3.456"

Long E 79° 50' 17.0376"





Kondapi, Andhra Pradesh, India

Kamepalli - Kondapi Rd, Kondapi, Andhra Pradesh 523270, India

Lat N 15° 23' 52.1448"

Long E 79° 50' 55.5216"

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ABSTRACT

The main consideration in the present field technologies is automation, power consumption, and cost-effectiveness.

Automation is meant to scale back manpower with the assistance of intelligent systems. The use of renewable sources of energy is crucial because sources of energy are limited whereas energy consumption has increased. By using renewable energy, it can facilitate the high-power demand. The project aims to describe a method for proper monitoring of solar energy by using sensors at minimum electrical energy consumption. Monitoring the health of solar panels gives a which is very much useful in massive energy-savings are envisioned. Also, a demonstration with a real-time prototype model involving costs and implementation procedure has been developed using the internet of things (IoT) to visualize the real-time updates. Major advantages of monitoring solar panels Are to include the prevention of damage and an increase in maximum efficiency of the panel. Studies have shown that according to NREL, modules can fail because of unavoidable elements like thermal cycling, damp heat, humidity freeze, and UV exposure. solder bond failures and cracks in solar cells. Damp heat has been related to delamination of encapsulants and corrosion of cells. Humidity freezing can cause junction box adhesion to fail . UV exposure contributes to discoloration and backsheet degradation. These things just happen, and it's difficult to determine how bad the degradation will be.

"Solar panel degradation and failure is not a clear-cut situation". There are many different reasons why they degrade and why they fail."

"Module producers are looking into each piece of the sun panel puzzle, all of the way down to the encapsulants and adhesion substances, to try to slow degradation rates."

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CHAPTER•1
INTRODUCTI
ON
1.1 NEED FOR solar power

The sun could even be a reliable, non-polluting, and inexhaustible source of energy. Since the start of life on earth, the energy that was received by all living forms was radiated from the sun. It's the time now when mankind is on a standpoint to again depend and depend on the sun because the foremost source of energy. With the rapid rise in fuel prices, concern over pollution, depletion of resources, and environmental degradation the notice for limited resources round the world has increased dramatically. the utilization of fossil fuels which causes greenhouses emission, inefficient use of energy, and release of harmful pollutants to the atmosphere causing threat like acid precipitation must be addressed seriously in new buildings. Government with vision have come to understand that generation of electric power through non-renewable sources of energy isn't enough. the facility of the end of the day must be environment friendly also . Photovoltaic could even be how by which energy from the sun are often directly used for power generation. This method for electricity generation causes no environmental pollution,"this approach for energy generation causes no environmental pollutants, has no rotating of shifting components and causes no material depletion." . Photovoltaic is additionally multifunctional. It can generate and operate illuminations, pump water, operate any household equipment and appliances can operate any electric gadgets and communication system . The

photovoltaic finds its wide application in village electrification in developing countries like India and electricity production for the building, commercial areas, and industrial sector in cities. When Hurricane Maria tore through Puerto Rico in 2017 causing the longest power failure in U.S. history, many press coverage soon after the storm focused on the necessity to urge electricity to hospitals and emergency responders. This seems to be a perfect use case for a microgrid.

The impact of losing electricity varies widely counting on who or what's losing power. If a private home loses electricity for a few of hours, it might be a nuisance, but faraway from life-threatening. However, a loss of electricity at a hospital is completely a life-threatening scenario. Between a much better electric load and an often opened geographical footprint, it's sensible to make an interconnected network of solar panels and storage to still power these sorts of buildings within the event of an outage. during a word: a microgrid.

There are several applications of microgrids, from powering emergency response buildings to providing grid resiliency for communities with an outsized population of individuals whose health would be put in peril by a protracted power failure. one among the foremost benefits of a microgrid is that it can extend beyond one house or building and make a little electricity-isolated island within a community. an ideal example of this is often able to be a microgrid between a fire department, a school, and a senior center,

which could provide benefits to first responders, the at-risk population, and a possible shelter from the storm all under one interconnected and resilient grid system. With the assistance of a microgrid, we'll reduce the price of installation and erection of poles and wires over a long-range, to remote locations which not only saves the price but also reduces the transmission losses and it also aims in solving the matter of erecting the transmission lines within the forest areas which involves many labor which involves sag calculation.

1.2 ADVANTAGES OF solar power

Solar cells are long-lasting sources of energy which may be used almost anywhere. they're particularly useful where there's no national grid and also where there are not any people like remote site water pumping or in space. Solar cells provide cost-effective solutions to energy problems in places where there's no mains electricity. Solar cells also are totally silent and non-polluting. As they need no moving parts they require little maintenance and have an extended lifetime. Compared to other renewable sources they also possess many advantages; wind and water power believe turbines which are noisy, expensive, and susceptible to breaking down. Rooftop power could even be a superb way of supplying energy to a growing community. More cells are often added to homes and businesses because the community grows so as that energy generation is in line with demand. Many large-scale systems currently find yourself over generating to make sure that everybody has enough. Solar cells also can be installed during a distributed fashion,

i.e. they're doing not need large-scale installations. Solar cells can easily be installed on the roofs which suggests no new space is required and every user can quietly generate their energy. The sun provides quite enough energy to satisfy the entire world's energy needs, and in contrast to fossil fuels, it won't run out anytime soon. As a renewable energy source, the sole limitation of solar energy is our ability to means it into electricity efficiently and cost-effectively. No greenhouse emission emissions are released into the atmosphere once you use solar panels to make electricity. and since the sun provides more energy than we'll ever need, electricity from solar energy could even be a crucial energy source within the move to wash energy production. After solar panels are installed, operational costs are quite low compared to other forms of power generation. Fuel isn't required, and this suggests that solar energy can create large amounts of electricity without the uncertainty and expense of securing a fuel supply.

1.3 LITERATURE SURVEY

Anila Devi Y et al. [2017] worked on GSM Based remote System of a High-Efficiency Intelligent Panel Monitoring System employing a Zigbee Network of Devices and sensors. a replacement intelligent and smart street light system is meant with wireless technology for maintenance and a network of sensors for controlling. In which, they

Microgrid Energy Management System, Smart Microgrid Solar ... A perfect example of this would be a microgrid between a fire department, a hospital, a school, and a senior center, which could provide benefits to first responders, the at-risk population, and a possible shelter from the storm all under one interconnected and resilient grid system. Microgrids built on solar plus storage are expected to expand very rapidly as a part of climate action plans at ... https://day1solar.com/what•microgrids•are•how•they•work/	5%
Solar energy • facts and advantages about solar power Fortum No greenhouse gas emissions are released into the atmosphere when you use solar panels to create electricity. And because the sun provides more energy ... https://www.fortum.com/about•us/our•company/our•energy•production/solar•power•unlimited•source•energy	3%

BUSINESS REPORT (1).docx • 1 Page 2 Page Firstly I would ... Fuel isnâ€™t required, and this suggests that solar energy can create large amounts of electricity without the uncertainty and expense of securing a fuel supply. Solar power and therefore the environment As a renewable CO₂-free power source, the environmental impact of alternative energy is significantly smaller than other power generation methods. https://www.coursehero.com/file/86734361/BUSINESS-REPORT-1docx/	3%
What do people think about solar energy? â€” Stephen Allerton Â• Fuel isnâ€™t required, and this means that solar power can create large amounts of electricity without the uncertainty and expense of securing a fuel supply. Solar power and the environment As a renewable CO₂-free power source, the environmental impact of solar power is significantly smaller than other power generation methods. https://www.stephenallerton.com/what-do-people-think-about-solar-energy/	3%



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used different sensors which consume less energy with high lifetime and which are furnished with renewable energy of solar panels ideals a few control network. the utilization of Sensors is being considered a promising solution to modern systems, thanks to their longer lifetime, higher efficiency, and better CRI. The proposed control network enables disconnection of the system from the mains during the height load time, reducing its impact within the distributed power grid automatically consumption, decrease the management cost and monitor the status information of every street lighting unit. to satisfy the system requirements, a wireless sensor network supported the IEEE 802.15.4TM standard is used . Its network layer is implemented employing a geographic routing strategy, which provides slow overhead and high scalability features. However, thanks to the well-known drawbacks of the prevailing techniques, a completely unique routing algorithm is proposed. Simulations show that this algorithm

results in a big improvement of routing performance when applied to sparse large-scale scenarios, which is that the case of a street lighting system. Field tests are performed on IEEE 802.15.4-compliant wireless control units. The obtained experimental results show that the proposed control network can meet the wants of a system.

B. K. Subramanyam et al. [2016] have developed a model which provides a sensible lighting system on streets that's mainly solar-based. The people work late nights and also most of the criminal activities occur during the nights. Under these situations, to supply security, controlling and monitoring of street lights is developed along side GUI. Even the usage of the solar array helps save power and money. On the PC side, a graphical interface (GUI) takes part in controlling the road light. For monitoring and controlling the lamps on streets, Zigbee technology is employed . More power and energy are saved by using LDR and IS sensors. This proposed model works on the 2 operational modes. they're Auto and Manual mode. In Auto-mode On-Off of the sunshine are done by using LDRs which measures the intensity of sunshine . Controlling is by use of relays. within the Manual mode, the controlling and

monitoring of the road lights are made successful by using the specially designed GUI and by using the Zigbee technology. This proposed system is useful to supply street lighting within the rural and concrete areas where the traffic is low sometimes . this technique maintains user satisfaction and is flexible . Fares S. El•Faouri [2015] demonstrated a prototype of a sensible street system with a photovoltaic source, battery, charge controller, motion sensor, and a dust cleaning circuit. Depending upon the system size it are often implemented as a grid•connected or standalone off•grid system. Cleaning circuit is one among the new technique which is implemented to get the utmost efficiency of the PV system. It also improves the operation of the system. The operation of the system is explained by MATLAB Simulink and therefore the results are obtained. This result's then compared with the traditional system without a dust cleaning circuit and proved that the dust cleaning circuit features a higher efficiency. The writing survey gives compact learning about the present framework and why we are proposing another road lighting framework. The essential issues associated with this ones are higher crude material cost and ecological issues. therefore the makers



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cultivate three answers to break this issue. They are the most recent LED innovation, microcontroller tech, and ZigBee arrange. The proposed framework consolidated these innovations, for example, LED innovation, Remote control innovation, and ZigBee innovation consequently building up a superior power sparing framework

Michele Mango et al. [2015] proposed a low•cost, wireless, adaptable sensor•based smart lighting system that makes use of PIR sensors and motion sensors. It helps control the light intensity and power consumption using LED light.

Dimming of light is achieved using a PIR sensor only in presence of obstacles around. The main advantage of this system is energy conservation. In this paper, we are planning to propose a system that

makes use of a Passive Infrared (PIR) sensor, CO2 sensor & Light sensors (LDR). The dimming of the light is achieved using a PIR sensor. Intensity measurement and power consumption are measured by using Light sensors. The microcontroller platform used is Arduino UNO R3 at the sender side and the receiver end PIC16F877a is used.

PIC microcontroller usage helps in linear programming. The intensity, CO2 emission, power consumption comparisons are displayed using an LCD. These sensors are helpful for energy saving. The usage of solar panels further helps to save some more power and energy.

P. Nithya et al. [2017] worked on the Design of Wireless Framework for Energy Efficient Street Light Automation suggested Intelligent management of the lamp posts by sending data to a central station by ZigBee wireless communication. propose about The core technology of the street light control system is an AT89S52 single-chip microcomputer. It integrates a power circuit, a fault detect circuit, a photosensitive detection circuit, an infrared detect circuit, an LCD circuit, a street light control circuit, an alarm circuit, a pressed key control circuit, and so on. This system can automatically turn on or off the lights and controls the switches consistent with traffic flow. It expands the fault detect circuit and therefore the corresponding alarm circuit. It also has a convenient and flexible button control circuit to switch on and off functions mentioned above. The main weakness is that they didn't say about the working

principle behind the system. It is also said to use a fault detection circuit which when it is damaged, the voltage is zero, so it will create a problem. This paper is and theoretical proof and shows only simulation results but not as real-time setup experiments. The focus of this paper to build a way for the framework which may lead to many follow-up research activities in the Low-rate and also plan to investigate the applicability of this proposal to detect performance. With the suggested system, maintenance can be easily and efficiently planned from the central station, allowing additional savings.

Rich Sam Alex et al. [2015] discussed the power consumption of the street lighting system to reduce 20-35 % compared to conventional design. This system is fully automated and is using ZIGBEE so that the control station can analyze all the performance of the system describes a comparative analysis of photovoltaic (PV) street lighting system in three different lamps. Namely, a low-pressure sodium lamp, a high-

Sources	Similarity
Automatic street light • SlideShare · Software development based on the proposed design will be detail out in software part where the flow of the system operation will be detailed out elaborated. 2.2 LITERATURE SURVEY Hengyu Wu, Minli Tang, propose about The core technology of the street light control system is an AT89S52 single-chip microcomputer. https://www.slideshare.net/AnuAntony19/automatic-street-light-64727362	7% Page 2
33_Survey Street Light Lighting It also has a convenient and flexible button control circuit to switch on and off fictions mentioned above. Main weakness is that they didn't say about the working principle behind the system. It also said to use fault detection circuit whichwhen it is damaged, the voltage is zero, so it will create a problem. https://www.scribd.com/document/236251896/33-Survey	5%



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pressure sodium lamp, and a lamp are used for installation in each mast to figure out the suitable system to place in during a typical country of Thailand. All three systems are mounted with the same module type and wattage in several places within the Rajamangala Institute of Technology, Thanyaburi district, Pathumthani

province of Thailand. An operation of solar street lighting system are often divided into 2 periods of your time , namely, at 18.00•22.00 hours and 05.00•06.00 hours. the planning of an impact circuit was experimentally wiped out this work. Protection of the battery from damage for deep discharge and overcharge by a controller was also considered. The life cycle analysis (LCCA) is that the acceptable method for comparing three different lamps. this worth of each system are often compared and thus the smallest amount cost option selected. LCCA was supported the key assumptions.

A.C. Kalaiarasan [2016] addressed solar energy-based street lights with an auto-tracking system for maximizing power output from a system is desirable to extend efficiency. to maximise the power output from the solar panels, one must keep panels aligned with the sun. intrinsically how of tracking the sun is required. this is often a far most cost-effective solution than purchasing additional solar panels. it's been estimated that the yield from solar panels are often increased by 30 to 60 percent by utilizing a tracking system rather than a stationary array. This paper describes an automatic tracking system which can keep the solar panels aligned with the sun to maximise efficiency. The sun tracking sensor is that the sensing device, which senses the position of the sun from the time to time continuously and it gives the sensing output to the amplifier supported the sunshine density of the sun. Here the sun tracking sensor is LDR (light dependent resistor). The amplifier unit is employed to amplify the LDR signals, which makes the low-level signal into high-level signals and this output is given to the comparator. The LM324 IC is employed as an amplifier. The comparator compares the signals and provides the command to the AT89C51 microcontroller. The system presented during this paper are going to be an efficient method to use solar power in remote areas. this technique consumes very low power and high-efficiency lighting. We employ the auto sun tracking system; this will improve the energy stored during a battery. this technique doesn't affect the environment because it's pollution-free. Our system also consisting of automatic ON, OFF control of the LED lamp, so there is no manual operation and it isn't required, operators.

CHAPTER-2
 2.1 solar array EFFICIENCY MONITORING SYSTEM
 2.1.1 diagram OF SOLAR EFFICIENCY MONITORING SYSTEM

Sources	Similarity
Aman Singhal • IJAREM ontrol circuit was experimentally done in this work. Protection of the battery from damage for deep discharge and overcharge by a controller was also considered. The life cycle cost analysis (LCCA) is the appropriate method for comparing three different lamps. LCCA was based on the key assumptions (year 2002). The results http://www.ijarem.org/papers/v1-i8/1.pdf	13%
ANALYSIS OF SOLAR ENERGY BASED STREET LIGHT WITH AUTO ... The sun tracking sensor is the sensing device, which sense the position of the sun at the time to time continuously and it gives the sensing output to the amplifier based on light density of the sun. Here the sun tracking sensor is LDR (light dependent resistor). https://www.rroij.com/open-access/analysis-of-solar-energy-basedstreet-light-with-auto-trackingsystem.php?aid=41825	7%

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Fig 2.1 diagram of the proposed system

Fig 2.1 shows the diagram of a solar array efficiency monitoring system that involves various components to manage power delivery. An Arduino UNO board connected with dht11 Sensor at the bottom of the panels during a small area round the panels. the info from the sensor is shipped to the Arduino microcontroller which forms the brain of the circuit.

The Arduino then commands to

switch between depending upon the need and thus monitoring are often done easily. A battery eliminator is employed to provide 5V inputs to the sensors and Arduino.

2.2 FUNCTIONAL DESCRIPTION

The simulation result's a three-stage process. The very first results are taken on the third of march employing a dht11 sensor. The dht11 Sensor is probably going to be beneficial to detect the upper temperature and humidity round the panel.

Whenever the fault is detected within the panel of those records is probably going to be delivered to the Arduino. From Arduino, the knowledge is probably going to be delivered to rock bottom station via the items speak channel. Here we use the switch as against the dht11 sensor limited to simulation. This step would be to calculate the intensity of sunshine . therefore the 2nd stage might be the sensor simulation that's primarily employed for the target of detecting the intensity of the radiation. In day time intensity of sunshine is probably going to be high so no need for a light-weight system. The working rule of the dht11 sensor offers an incontrovertible fact that each one the things whose temperature is higher compared to absolutely the zero emit energy within the shape of radiation. within the proposed system, this communication device are often wont to monitoring the health of solar panels. Once there's any fault, during the amount it is necessary that led has got to be switched on to point that there's a fault within the panel.

The design includes two working modes

- OFF mode: When there's no fault within the panels compared with the humidity and temperature values round the solar battery , the led won't be glown.
- ON MODE: When there's a fault within the panel the controller has been coded in such how that the LED is glown automatically with high intensity.

2.3 COMPONENTS OF SOLAR STREET LIGHT

The solar street light system consists of varied components that are discussed below intimately .

2.3.1 solar array

Solar panels are those devices that are wont to absorb the sun's rays and convert them into electricity or heat. A solar array may be a collection of solar (or photovoltaic) cells, which may be wont to generate electricity through the photovoltaic effect. These cells are arranged during a grid-like pattern on the surface of solar panels. Thus, it's going to even be described as a group of photovoltaic modules, mounted on a structure supporting it. A photovoltaic (PV) module may be a packaged and connected assembly of 6×10 solar cells. When it involves wear-and-tear, these panels are very hardy. Solar panels wear out extremely slow. In a year, their effectiveness decreases only about one to 2 percent (at times, even lesser). Most solar panels are made up using crystalline silicon solar cells. Installation of solar panels in homes helps in combating the harmful emissions of greenhouse gases and thus helps reduce heating . Solar panels don't cause any sort of pollution and are clean. They also decrease our reliance on fossil fuels (which are limited) and traditional power sources. lately , solar panels are utilized in wide-ranging electronic sorts of equipment like calculators, which work as long as sunlight is out there . However, the sole major drawback of solar panels is that

they're quite costly. Also, solar panels are installed outdoors as they have sunlight to urge charged.

2.3.1.1 SOLAR CELLS

Sources	Similarity
Solar Energy VISIONHOOD FOUNDATION Most solar panels are made up using crystalline silicon solar cells. Installation of solar panels in homes helps in combating the harmful emissions of greenhouse gases and thus helps reduce global warming. Solar panels do not lead to any form of pollution and are clean. https://visionhood.org/home/enviromental•work/solar•energy	7%



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A photovoltaic cell is an device that catches the daylight and turns it directly into electricity. It's about the dimensions of an adult's palm, octagonal in shape, and colored bluish•black. Solar cells are often

bundled together to form larger units called solar modules, themselves coupled into even bigger units referred to as solar panels (the black• or blue•tinted slabs you see on people's homes—typically with several hundred individual solar cells per roof) or chopped into chips (to provide power for little gadgets like pocket calculators and digital watches) a bit like the cells during a battery, the cells during a solar array are designed to get electricity; but where a battery's cells make electricity from chemicals, a solar panel's cells generate power by capturing sunlight instead. they're sometimes called photovoltaic (PV) cells because they use sunlight ("photo" comes from the Greek word for light) to form electricity (the wor

"voltaic" may be a regard to Italian electricity pioneer Alessandro Volta, 1745–1827). we will consider light as being made from tiny particles called photons, so a beam of sunlight is sort of a bright yellow hose shooting trillions upon trillions of photons our way. Stick a photovoltaic cell in its path and it catches these energetic photons and converts them into a flow of electrons—an current . Each cell generates a couple of volts of electricity, so a solar panel's job is to mix the energy produced by many cells to form a useful amount of electrical current and voltage. Virtually all of today's solar cells are made up of slices of silicon (one of the foremost common chemical elements on Earth, found in sand), although as we'll see shortly, a spread of other materials are often used also (or instead). When sunlight shines on a photovoltaic cell , the energy it carries blasts electrons out of the silicon. These are often forced to flow around an electrical circuit and power anything that runs on electricity.

2.3.1.2 Manufacturing of Solar Cells

Silicon is that the stuff from which the transistors (tiny switches) in microchips are made and solar cells work similarly. Silicon may be a sort of material called a semiconductor. Some materials, notably metals, allow electricity to flow through them very easily; they're called conductors. Other materials, like plastics and wood, don't let electricity flow through them at all; they're called insulators. Semiconductors like silicon are neither conductors nor insulators: they do not normally conduct electricity, but under certain circumstances, we will make them do so. A photovoltaic cell may be a

sandwich of two different layers of silicon that are specially treated or doped in order that they will let electricity flow through them during a particular way. The lower layer is doped so it's slightly too few electrons. It's called p•type or positive•type silicon (because electrons are charged and this layer has too few of them). The upper layer is doped the other thanks to provides it slightly too many electrons. It's called n•type or negative•type silicon. (You can read more about semiconductors and dope in our articles on transistors and integrated circuits). once we place a layer of n•type silicon on a layer of p•type silicon, a barrier is made at the junction of the 2 materials (the all•important border where the 2 sorts of silicon meet up). No electrons can cross the barrier so, albeit we connect this silicon sandwich to a flashlight, no current will flow: the bulb won't illuminate . But if we shine light onto the sandwich, something remarkable happens. we will consider light as a stream of energetic "light particles" called photons. As photons enter our sandwich, they provide up their energy to the atoms within the silicon. The incoming energy knocks electrons out of the lower, p•type layer in order that they jump across the barrier to the n•type layer above and effuse round the circuit. the sunshine that shines, the more electrons jump up and therefore the more current flows. this is often what we mean by photovoltaic—light making voltage—and it's one quite what scientists call the photoelectric effect. The photoelectric effect occurs thanks to the solar cells which are shown in fig 2.2.

Fig 2.2 photovoltaic cell

2.3.1.3 sorts of SOLAR CELLS

1. Amorphous silicon photovoltaic cell

Amorphous silicon may be a non-crystalline sort of silicon. it's utilized in the marketplace for quite 15years. it's mainly utilized in pocket calculators. it's a substrate material like glass or metal. Amorphous silicon also can be deposited at very low temperatures, as low as 75 degrees Celsius, which allows for deposition on plastic also . In its simplest form, the cell structure features a single sequence of p-in layers. However, single it's the foremost well developed the thin-film technologies are on the marketplace for more

than 15 years. it's widely utilized in pocket calculators, but it also powers some private homes, buildings, and remote facilities. United Solar Systems Corp. (Unisolar) pioneered amorphous-silicon solar cells and remains a serious maker today, as does Sharp and Sanyo. Amorphous silicon panels are formed by vapor-depositing a skinny layer of silicon material – about 1 micrometer thick – on layer cells suffer from significant degradation in their power output (in the range 15-35%) when exposed to the sun. The mechanism of degradation is named the Staebler-Wronski Effect, after its discoverers. Better stability requires the utilization of thinner layers to extend the electrical field intensity across the fabric .

Sources	Similarity
How do solar cells work? • Explain that Stuff Aug 15, 2020 — Each cell generates a few volts of electricity, so a solar panel's job is to combine the energy produced by many cells to make a useful amount of ... https://www.explainthatstuff.com/solarcells.html	9%
Solar cells – BABA AUTOMOBILE But if we shine light onto the sandwich, something remarkable happens. We can think of the light as a stream of energetic "light particles" called photons. As photons enter our sandwich, they give up their energy to the atoms in the silicon. https://babaautomobile.com/solar-cells/	4%



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2. Biohybrid photovoltaic cell

A biohybrid solar cell could also be a solar cell made by the mixture of organic matter and inorganic matter. This biohybrid photovoltaic cell may be a new sort of renewable energy. A biohybrid solar cell could also be a solar cell made employing a mixture of organic matter (photosystem I) and inorganic matter. Biohybrid solar cells are made by a team of researchers at Vanderbilt University. The team used photosystem I (a photoactive protein complex located

within the thylakoid membrane) to recreate the natural action of photosynthesis to get greater efficiency in solar power conversion. These biohybrid solar cells are a replacement sort of renewable energy. Multiple layers of photosystem I gather photonic energy, convert it into energy, and make a current that goes through the cell. The cell itself consists of the many of an equivalent non-organic materials that are found in other solar cells except the injected photosystem I complexes which are introduced and gathered for several days within the gold layer. After some days the photosystem is formed visible and appears as a skinny green film. It's this thin film that helps and improves energy conversion.

3. Buried contact photovoltaic cell

The buried contact solar cell could also be a high-efficiency commercial solar cell technology supported a plated metal contact inside a laser-formed groove. The buried contact solar cell could also be a high-efficiency commercial solar cell technology supported a plated metal contact inside a laser-formed groove.

The buried contact technology overcomes many of the disadvantages related to screen-printed contacts and this enables buried contact solar cells to possess performance up to 25% better than commercial screen-printed solar cells. A key high-efficiency feature of the buried contact photovoltaic cell is that the metal is buried during a laser-formed groove inside the silicon photovoltaic cell. This enables for an outsized metal height-to-width ratio. An outsized metal contact ratio successively allows an outsized volume of metal to be utilized in the contact finger, without having a good strip of metal on the highest surface. Therefore, a high metal ratio allows an outsized number of closely spaced metal fingers, while still retaining high transparency.

4. Cadmium telluride photovoltaic cell

It describes the PV technology supported the utilization of the cadmium telluride, a skinny semiconductor layer designed to soak up and convert solar power into electricity. Cadmium telluride (CdTe) photovoltaics describes a photovoltaic (PV) technology that's supported the utilization of cadmium telluride, a skinny semiconductor layer designed to soak up and convert sunlight into electricity. Cadmium telluride PV is that the sole thin-film technology with lower costs than conventional solar cells made up of crystalline silicon in multi-kilowatt systems. On a lifecycle basis, CdTe PV has the tiniest carbon footprint, lowest water use, and shortest energy payback time of all solar technologies. CdTe's energy payback time of but a year enables faster carbon reductions without short-term energy deficits. The toxicity of cadmium is an environmental concern mitigated by the recycling of CdTe modules at the top of their lifetime, though there are still uncertainties and therefore the popular opinion is skeptical towards this technology. The usage of rare materials can also become a limiting factor to the economic scalability of CdTe technology within the mid-term future.

5. Toxicity of cadmium

Cadmium is one among the highest 6 deadliest toxic materials known. Here cadmium telluride is understood to be less toxic than cadmium element. So here we use cadmium telluride for better performance. Cadmium is one among the highest 6 deadliest and toxic materials known. However, CdTe appears to be less

toxic than elemental cadmium, a minimum of in terms of acute exposure. This is often to not say it's harmless. Cadmium telluride is toxic if ingested, if its dust is inhaled, or if it's handled improperly (i.e. without appropriate gloves and other safety precautions). The toxicity isn't solely thanks to the cadmium content. One study found that the highly reactive surface of cadmium telluride quantum dots triggers extensive reactive oxygen damage to the cell wall, mitochondria, and nucleus. Besides, the cadmium telluride films are typically recrystallized during a toxic compound of cadmium chloride. The disposal and long-term safety of cadmium telluride may be a known issue within the large-scale commercialization of cadmium telluride solar panels.

6. Concentrated PV cell

A concentrated solar cell converts solar power into electricity as a traditional conventional solar cell but used a complicated optical system to focus an outsized area of sunlight onto each of the solar cells for top efficiency. Following the sun, a Concentrating Photovoltaic (CPV) system converts light energy into electricity within an equivalent way that conventional photovoltaic technology does, but uses a sophisticated optical system to focus an outsized area of sunlight onto each cell for max efficiency. Different CPV designs exist, sometimes differentiated by the concentration factor, like low-concentration (LCPV) and high concentration (HCPV). Concentrator photovoltaic's (CPV) could also be a photovoltaic technology that generates electricity from sunlight. Contrary to plain photovoltaic systems, it uses lenses

and curved mirrors to focus sunlight onto small, but highly efficient, multi-junction (MJ) solar cells. Besides, CPV systems often use solar trackers and sometimes a cooling system to further increase their efficiency. Ongoing research and development are rapidly improving their competitiveness within the utility-scale segment and areas of high solar insolation.

7. Copper indium gallium selenide photovoltaic cell

One of the foremost interesting and controversial materials in solar is copper indium gallium selenide. it's a skinny photovoltaic cell wont to convert the solar power

into electricity . they're manufactured by depositing a skinny layer of copper, indium, gallium, selenide.

one among the foremost interesting and controversial materials in solar is

Copper•Indium•Gallium•Selenide or CIGS for brief . it had been a part of a solar thin•



Buried Contact Solar Cells PVEducation The buried contact solar cell is a high efficiency commercial solar cell technology based on a plated metal contact inside a laser-formed groove. https://www.pveducation.org/pvcdrom/manufacturing/si-cells/buried-contact-solar-cells	9%
Types of Solar Energy: Get the Most Out of It Linquip Unlike conventional photovoltaic systems, it uses lenses or curved mirrors to focus sunlight onto small, highly efficient, multi-junction (MJ) solar cells. Besides, CPV systems often use solar trackers and sometimes a cooling system to further increase their efficiency. https://www.linquip.com/blog/types-of-solar-energy/	3%



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film-type cycle where some CIGS companies like Solyndra, Nanosolar, and MiaSole almost became household names. A copper indium gallium selenide photovoltaic cell (or CIGS cell, sometimes CI (G) S or CIS cell) may be a thin-film photovoltaic cell wont to convert sunlight into electrical power . they're manufactured by depositing a skinny layer of copper, indium, gallium, and selenide on glass or plastic backing, along side electrodes on the front and back to gather current. Because the fabric features a high coefficient of absorption and strongly absorbs sunlight, a way thinner film is required than other semiconductor materials.

8. Dye-sensitized photovoltaic cell

The dye-sensitized solar cell may be a third-generation photovoltaic cell. this may convert any light energy into electricity . this is often a complicated technology of photovoltaic cells. Dye-Sensitized solar cells (DSSC), also sometimes mentioned as dye-sensitized cells (DSC), are a third-generation photovoltaic (solar) cell that converts any light into electricity . This new class of advanced solar cells are

often likened to artificial photosynthesis thanks to how it mimics nature's absorption of sunshine energy. Dye-Sensitized solar cells (DSSC) were invented in 1991 by Professor Michael and Dr. Brian Regan at EPFL, Switzerland, and are often mentioned because the cell, we call it G Cell.

9. Gallium arsenide germanium photovoltaic cell

It consists of two base elements gallium and arsenic. By mixing these two compounds a replacement compound is made with many various characteristics. Gallium arsenide may be a semiconductor with greater electron mobility and electron velocity. So this is often used more in solar cells. Gallium arsenide consists of two base elements; gallium and arsenic. When these two individual elements bind together, they form the aforementioned compound, which displays many interesting characteristics. Gallium arsenide may be a semiconductor with a greater saturated electron velocity and electron mobility than that of silicon W. A semiconductor may be a material that has electrical conductivity between an insulator and a conductor; it's going to vary its ability to conduct electricity when it's cool versus when it's hot. This makes it very

useful in many applications. Another novel quality of gallium arsenide is that it's an immediate bandgap. this is often a top quality that denotes a compound which will emit light efficiently. Gallium arsenide (GaAs) may be a compound of the weather gallium and arsenic. it's an III•V direct bandgap semiconductor with a blende crystal structure. Gallium arsenide is employed within the manufacture of devices like microwave frequency integrated circuits, monolithic microwave integrated circuits, infrared light•emitting diodes, laser diodes, solar cells, and optical windows

10. Hybrid photovoltaic cell

Hybrid photovoltaic cell combines advantages of both organic and inorganic semiconductors. The organic materials contains polymers which can transport holes and therefore the inorganic materials act as an electron acceptor. Hybrid solar cells combine the benefits of both organic and inorganic semiconductors. Hybrid photovoltaic have organic materials that contains conjugated polymers that absorb light because the donor and transport holes. Inorganic materials in hybrid cells are used because the acceptor and electron transporter within the structure. The hybrid photovoltaic devices have the potential for not only low•cost roll•to•roll processing but also for scalable solar energy conversion. In hybrid solar cells, organic material is mixed with a high electron•transport material to make the photoactive layer. the 2 materials are assembled during a hetero junction•type photoactive layer, which may have greater power conversion efficiency than one material. one among the materials acts because the photon absorber and exciton donor. the opposite material facilitates exciton dissociation at the junction. The charge is transferred then separated after an exciton created within the donor is delocalized on a donor•acceptor complex. The energy required to

separate the exciton is provided by the energy offset between the Lumos or conduction bands of

acceptor. After dissociation, the carriers are transported to the respective electrodes through a percolation network. the typical distance an exciton can diffuse through the fabric before annihilation by recombination is that the exciton diffusion length. this is often short in polymers, on the order of 5– 10 nanometers. The duration for radiative and nonradiative decay is from 1 picosecond to 1 nanosecond. Excitons generated within this length on the brink of an acceptor would contribute to the photocurrent. To affect the matter of the short exciton diffusion length, a bulk heterojunction structure is employed instead of a phase-separated bilayer. Dispersing the particles throughout the polymer matrix creates a bigger interfacial area for charge transfer to occur.

2.3.2 CHARGE CONTROLLER

A solar charge controller in fig 2.4 is fundamentally a voltage or current controller to charge the battery and keep electric cells from overcharging. It directs the voltage and current hailing from the solar panels setting off to the electrical cell. Generally, 12V boards/panels put call at the ballpark of 16 to 20V, so if there's no regulation the electric

cells will damage from overcharging. Generally, electric storage devices require around 14 to 14.5V to urge completely charged. The solar charge controllers are available altogether features, costs, and sizes. The range of charge controllers is from 4.5A and up to 60 to 80A.

Types of Solar Charger Controller:

There are three differing types of solar charge controllers, they are:

- 1 Simple 1 or 2 stage controls
2. PWM (pulse width modulated)
3. Maximum point tracking (MPPT)

Simple 1 or 2 Controls: it's shunt transistors to regulate the voltage in one or two steps. This controller just shorts the solar array when a particular voltage is received .

Sources	Similarity
Types of Solar Cells and Application :: Science Publishing ... · When these two individual elements bind together, they form the aforementioned compound, which displays many interesting characteristics. Gallium arsenide is a semiconductor with a greater saturated electron velocity and electron mobility than that of siliconW. A semiconductor is a material that has electrical conductivity between an insulator ... http://article.sciencepublishinggroup.com/html/10.11648.j.ajop.20150305.17.html	5%
Summary • Next Generation Energy Laboratory Hybrid solar cells combine advantages of both organic and inorganic semiconductors. Hybrid photovoltaics (PV) have organic materials that consist of conjugated polymers that absorb light as the donor and transport holes. https://sites.google.com/site/ngelaboratory/summary	4%
Hybrid solar cell • Wikipedia The energy required to separate the exciton is provided by the energy offset between the LUMOs or conduction bands of the donor and acceptor. After dissociation, the carriers are transported to the respective electrodes through a percolation network. https://en.wikipedia.org/wiki/Hybrid_solar_cell	3%
Solar Charge Controller Types, Working Functionality and ... A solar charge controller is fundamentally a voltage or current controller to charge the battery and keep electric cells from overcharging. It directs the voltage and current hailing from the solar panels setting off to the electric cell. https://www.elprocus.com/solar-charge-controller/	3%

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· About solar power controller Nowadays solar charge controller are fundamentally a voltage or current controller to a charge, the battery keep electric cells from overcharging. It directs the voltage and current hailing from the solar panels setting off to the electrical cell.

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Their main genuine fuel for keeping such a notorious reputation is their unwavering quality – they have so not many segments, there's little or no to interrupt .

PWM (Pulse Width Modulated): this is often often the normal type charge controller, as an example , anthrax, Blue Sky, and so on. These are essentially the industry standard now.

Maximum point tracking (MPPT): The MPPT solar charge controller is that the sparkling star of today's solar systems. These controllers truly identify the only working voltage and amperage of the solar battery exhibit and match that with the electrical cell bank. the result is an extra 10•30% more power out of your sun•oriented cluster versus a PWM controller. it is often well well well worth the speculation for any solar electric system over 200 watts.

Features of Solar Charge Controller

- Protects the battery (12V) from overcharging
- Reduces system maintenance and increases battery lifetime
- Auto charged indication
- Reliability is high
- 10amp to 40amp of charging current
- Monitors the reverse current flow

The function of the Solar Charge Controller

The most essential charge controller controls the device voltage and opens the circuit, halting the charging, when the battery voltage ascents to a selected level. More charge controllers utilized a mechanical relay to open or shut the circuit, halting or beginning power avoiding to the electrical storage devices.

Generally, solar energy systems utilize 12V of batteries. Solar panels can convey much more voltage than is obliged to charge the battery. The charge voltage might be kept at the sole level while the time needed to completely charge the electrical storage devices is lessened. this permits the solar systems to figure optimally constantly. By running higher voltage within the wires from the solar panels to the charge controller, power dissipation within the wires is diminished fundamentally.

The solar charge controllers can also control the reverse power. The charge controllers can distinguish power is originating from the solar panels and open the circuit separating the solar panels from the battery devices and halting the reverse current flow.

Applications

In recent days, the tactic of generating electricity from sunlight has more popularity than other alternative sources and thus the photovoltaic panels are absolutely pollution free which they're doing not require high maintenance. subsequent are some examples where solar power is utilizing.

- Street lights use photovoltaic cells to convert sunlight into DC charge . this technique uses a solar charge controller to store DC within the batteries and uses it in many areas.
- Home systems use PV modules for household applications.
- Hybrid system uses multiple energy sources for providing full•time backup supply to other sources.

Types of Solar Charge Controller

From the below example, a solar array is employed to charge A battery . a gaggle of operational amplifiers are wont to monitor panel voltage and cargo current continuously. If the battery is fully charged, a logo are becoming to be provided by a green LED. to point undercharging, overloading, and deep discharge condition a gaggle of LEDs are used. A

MOSFET is employed as an influence semiconductor switch by the solar charge controller to make sure the cut-off load in low condition or loading condition. The solar energy is bypassed employing a transistor to a dummy load when the battery gets full charging. this might protect the battery from overcharging. This unit performs 4 major functions:

1. Charges the battery.
2. Indicates when the battery is fully charged.
3. Monitors the battery voltage and when it's minimum, cuts off the availability to the load switch to urge obviate the load connection.
4. just just just in case of overload, the load switch is in off condition ensuring the load is stop from the battery supply.

Sources	Similarity
Solar power controller, types and features – solar system - Maximum point tracking (MPPT): The MPPT solar charge controller is that the sparkling star of today’s solar systems. These controllers truly identify the simplest working voltage and amperage of the solar array exhibit and match that with the electrical cell bank. Now, the outcome is extra 10•30% more power out of the sun oriented cluster versus a PWM controller. It is usually well worth the ... https://mysolarsystemin.wordpress.com/2020/06/19/solar•power•controller•types•and•features/	25%
elprocus.com Solar panels can convey much more voltage than is obliged to charge the battery. https://www.elprocus.com/solar•charge•controller/	19%



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An Arduino is an open•source microcontroller development board. In plain English, you'll use the Arduino to read sensors and control things like motors and lights. this enables you to upload programs to the present board which may then interact with things within the world . With this, you'll make devices that respond and react to the planet at large. For instance, you'll read a humidity sensor connected to a potted plant and switch on an automatic watering system if it gets too dry. Or, you'll make a stand•alone chat server that's plugged into your internet router. Or, you'll have it tweet whenever your cat passes through a pet door. Or, you'll have it start a pot of coffee when your alarm pops within the morning. If there's something that's in any way controlled by electricity, the Arduino can interface with it in some manner. And albeit it's not controlled by electricity, you'll probably still use things which are (like motors and electromagnets), to

interface with it.

The possibilities of the Arduino are almost limitless. As such, there's no way that one single tutorial can cover everything you would possibly ever got to know. That said, I've done my best to offer a basic overview of the elemental skills and knowledge that you simply got to get your Arduino up and running. If nothing more, this could function as a springboard into further experimentation and learning.

Some people consider the whole Arduino board as a microcontroller, but this is often inaccurate. The Arduino board may be a specially designed circuit card for programming and prototyping with Atmel microcontrollers.

The nice thing about the Arduino board is that it's relatively cheap, plugs straight into a computer's USB port, and it's dead-simple to line up and use (compared to other development boards).

Some of the key features of the Arduino Uno include:

- An open-source design. The advantage of it being open source is that it's an outsized community of individuals using and troubleshooting it. This makes it easy to seek out someone to assist you debug your projects.
- a simple USB interface. The chip on the board plugs straight into your USB port and registers on your computer as a virtual interface. This enables you to interface with it as if it were a serial device. The advantage of this setup is that serial communication is a particularly easy (and time-tested) protocol, and USB makes connecting it to modern computers convenient.
- Very convenient power management and built-in voltage regulation. you'll connect an external power source of up to 12v and it'll regulate it to both 5v and three .3v. It can also be powered directly off of a USB port with none external power.
- An easy-to-find, and cheap, microcontroller "brain." The ATmega328 chip retails for about \$2.88 on Digikey. it's a countless number of nice hardware features like timers, PWM pins, external and internal interrupts, and multiple sleep modes. inspect the official datasheet for more details.
- A 16mhz clock. This makes it not the speediest microcontroller around, but fast enough for many applications.
- 32 KB of non-volatile storage for storing your code.
- 13 digital pins and 6 analog pins. These pins allow you to attach external hardware to your Arduino. These pins are key for extending the computing capability of the Arduino into the important world. Simply plug your devices and sensors into the sockets that correspond to every of those pins and you're good to travel.
- An ICSP connector for bypassing the USB port and interfacing the Arduino directly as a serial device. This port is important to re-load your chip if it corrupts and may not ask your computer.

- An on-board LED attached to digital pin 13 for fast and straightforward debugging of code.
- And last, but not least, a button to reset the program on the chip.

Sources	Similarity
instructables.com Some of the key features of the Arduino Uno include: https://www.instructables.com/Intro-to-Arduino/	9%
An-Najah National University Very convenient power management and built-in voltage regulation. easy debugging of code. Prezi Our Future work add color sensor Prezi Why choose this project? Technology becomes more and more advanced in all areas. Smart phones technology and assistant robots can be devoted to help us and improve our life . Robots are smart machines that can be https://eng-old.najah.edu/sites/eng-old.najah.edu/files/yourprezi.pdf	5%



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Fig 2.3 Arduino UNO
2.3.4CURRENT SENSORS

A current sensor is a device that detects electric current in a wire and generates a signal proportional to that current. This current sensor is shown in fig 2.10. The generated signal might be analog voltage or current or maybe a digital output. The generated signal are often then wont to display the measured current in an ammeter, or are often stored for further analysis during a data acquisition system, or can be used for control.

The sensed current and therefore the output can be:

1. Alternating current input,
2. Analog output, which duplicates the wave form of the sensed current.
3. Bipolar output, which duplicates the wave shape of the sensed current.
4. Unipolar output, which is proportional to the typical or RMS value of the sensed current.
5. Direct current input,
 - unipolar, with a unipolar output, which duplicates the wave shape of the sensed current
 - digital output, which switches when the sensed current exceeds a particular threshold

TYPES OF CURRENT SENSORS:

1. Hall effect sensor.

2. Transformer or current clamp meter, (suitable for AC only).
3. Fluxgate Transformer Type, (suitable for AC or DC).
4. Resistor, whose voltage is directly proportional to the current through it.
5. Fiber-optic current sensor, using an interferometer to measure the phase change in the light produced by a magnetic field.
6. Rogowski coil, an electrical device for measuring alternating current (AC) or high-speed current pulses.

The Hall Effect current sensor may be a sort of current sensor which is predicated on the Hall Effect phenomenon discovered by Edwin Hall in 1879.

Hall Effect current sensors can measure all types of current signals (i.e. AC, DC, or pulsating current). These sensors are currently getting used widely in many industries due to their vast applications and therefore the sort of output they supply, which may be manipulated and may be used for various applications.

Fig.2.5 Current Sensors

2.3.7 VOLTAGE SENSORS

Sensors are a device which can sense or identify and react to certain types of electrical or some optical signals. Implementation of the voltage sensor and current sensor techniques has become a superb choice for the traditional current and voltage measurement methods. These voltage sensors are shown in fig 2.13.

Advantages of Sensors Over Conventional Measuring Techniques

- Small in weight and size.
- Personnel safety is high.
- Degree of accuracy is very high.
- It is non-saturable.
- Wide dynamic range.
- Eco-friendly.

- It is possible to combine both the voltage and current measurement into a single physical device with small and compact dimensions.

In this article, we can discuss in detail the voltage sensor. A voltage sensor can determine, monitor, and can measure the supply of voltage. It can measure AC level or/and DC voltage level. The input to the voltage sensor is the voltage itself and the output can be analog voltage signals, switches, audible signals, analog current level, frequency, or even frequency•modulated outputs. That is, some voltage sensors can provide sine or pulse trains as output et al. can produce AM , Pulse Width Modulation, or FM outputs. In voltage sensors, the measurement is predicated on the potential divider . Mainly two types are of voltage sensors are available• Capacitive type voltage sensor and Resistive type

Fig.2.11 Capacitive and Resistive type sensors

Capacitive Voltage Sensor As we know that a capacitor comprises of two conductors or simply two plates and in between these plates, a non•conductor is kept. That non•conducting material is termed dielectric. When an AC voltage is provided across these plates, the current will start to pass owing to either the attraction or the repulsion of electrons through the voltage present on the opposite plate. The field among the plates will create an entire AC circuit with none hardware connection. This is how a capacitor works. Next, we can discuss the voltage division in two capacitors which are in series. Usually, in series circuits, the high voltage will develop across the component which is having a high impedance. In the case of capacitors, capacitance and impedance (capacitive reactance) are always inversely proportional. The relation between voltage and capacitance is $Q \rightarrow \text{Charge (Coulomb)}$ $C \rightarrow \text{Capacitance (Farad)}$ $X_C \rightarrow \text{Capacitive reactance } (\Omega)$ $f \rightarrow \text{Frequency (Hertz)}$ From the above two relations, we can clearly state that the highest voltage will build up across the smallest capacitor. The capacitor voltage sensors work based on this simple principle. Consider we are holding the sensor in our hand and then placing the tip of it near a live conductor as sown in fig 2.12. Here, we are inserting the sensing element of high impedance into a series capacitive coupling circuit. At this moment, the tip of the sensor is the smallest capacitor

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en.wikipedia.org A current sensor is a device that detects electric current in a wire and generates a signal proportional to that current. https://en.wikipedia.org/wiki/Current_sensor	25%
Current sensing • Wikipedia unipolar, with a unipolar output, which duplicates the wave shape of the sensed current; digital output, which switches when the sensed current exceeds a certain threshold; Requirements in current measurement. Current sensing technologies must fulfill various requirements, for various applications. Generally, the common requirements are: https://en.wikipedia.org/wiki/Current_sensing	13%
ISSN No: 2456 •6470 www.ijtsrd.com Volume 1 Issue 6 The input to the voltage sensor is the voltage itself and the output can be analog voltage signals, switches, audible signals, analog current level, frequency or even frequency modulated outputs. That is some voltage sensors can provide sine wave or pulse trains as output and others can produce https://www.ijtsrd.com/papers/ijtsrd4632.pdf	5%



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selenide photovoltaic cell (or CIGS cell, sometimes CI (G) S or CIS cell) is a thin-film solar cell used to convert sunlight

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energy into electrical energy. This is an advanced technology of photovoltaic cells. Dye•Sensitized solar cells (DSSC), also sometimes referred to as dye•sensitized cells (DSC),

are a third-generation photovoltaic (solar) cell that converts any visible light into electrical energy. This new class of advanced solar cells can be likened to artificial photosynthesis due to how it mimics nature's absorption of light energy. Dye-Sensitized solar cells (DSSC) were invented in 1991 by Professor Michael and Dr. Brian Regan at EPFL, Switzerland, and are often referred to as the cell, we call it G Cell.

9. Gallium arsenide germanium solar cell

It consists of two base elements gallium and arsenic. By mixing these two compounds a new compound is formed with many different characteristics. Gallium arsenide is a semiconductor with greater electron mobility and electron velocity. So this is used more in solar cells. Gallium arsenide is composed of 2 base elements; gallium and arsenic. When these two individual elements bind together, they form the aforementioned compound, which displays many interesting characteristics. Gallium arsenide is a semiconductor with a greater saturated electron velocity and electron

mobility than that of silicon. A semiconductor is a material that has electrical conductivity between an insulator and a conductor; it's going to vary its ability to conduct electricity when it is cool versus when it is hot. This makes it very useful in many applications. Another novel quality of gallium arsenide is that it has a direct bandgap. This is a quality that denotes a compound which will emit light efficiently. Gallium arsenide (GaAs) may be a compound of the elements gallium and arsenic. It is an III-V direct bandgap semiconductor with a zinc blende crystal structure.

Gallium arsenide is employed within the manufacture of devices such as microwave frequency integrated circuits, monolithic microwave integrated circuits, infrared lightemitting diodes, laser diodes, solar cells, and optical windows

10. Hybrid solar cell

Hybrid solar cell combines advantages of both organic and inorganic semiconductors. The organic materials consist of polymers which will transport holes and the inorganic materials act as an electron acceptor. Hybrid solar cells combine the advantages of both organic and inorganic semiconductors. Hybrid photovoltaic have organic materials that consist of conjugated polymers that absorb light because the donor and transport holes. Inorganic materials in hybrid cells are used as the acceptor and electron transporter in the structure. The hybrid photovoltaic devices have the potential for not only low-cost roll-to-roll processing but also for scalable solar power conversion. In hybrid solar cells, organic material

is mixed with a high electron-transport material to form the photoactive layer. The two materials are assembled in a hetero junction-type photoactive layer, which can have greater power conversion efficiency than a single material. One among the materials acts because the photon absorber and exciton donor. The other material facilitates exciton dissociation at the junction. The charge is

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transferred and then separated after an exciton created in the donor is delocalized on a donor•acceptor complex. The energy required to separate the exciton is provided by the energy offset between the Lumos or conduction bands of the donor and acceptor. After dissociation, the carriers are transported to the respective electrodes

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annihilation by recombination is the exciton diffusion length. this is often short in polymers, on the order of 5– 10 nanometers. The time scale for radiative and nonradiative decay is from 1 picosecond to 1 nanosecond. Excitons generated within this length close to an acceptor would contribute to the photocurrent. To deal with the problem of the short exciton diffusion length, a bulk heterojunction structure is used rather than a phase-separated bilayer. Dispersing the particles throughout the polymer matrix creates a larger interfacial area for charge transfer to occur.

3.5 CHARGE CONTROLLER

A solar charge controller in fig 2.4 is fundamentally a voltage or current controller to charge the battery and keep electric cells from overcharging. It directs the voltage and current hailing from the solar panels setting off to the electric cell. Generally, 12V boards/panels put out in the ballpark of 16 to 20V, so if there's no regulation the electric cells will damage from overcharging. Generally, electric storage devices require around 14 to

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FIG dht11 sensor

3.5 SYSTEM MONITERING

Fig 3.1 FLOW CHART FOR STSTEM MONITORING

CHAPTER•

4

HARDWAR

E

4.1 Hardware

Implementation of solar street lighting system is done according to the design procedure The fig. shows how the LED is glowing with full•length intensity. If the PIR sensor senses any living being, then it will glow with full•length intensity and after some time, the light automatically reduces its intensity

Fig.4.1 ARDUINO UNO

Fig.4.2 PANEL

Fig 4.2 illustrates the led bulb which has a specific characteristic that it has an inbuilt charge controller and the status of the charge controller can be easily known by the symbol of red and a green light present in the led the red light indicates that it is in an off position. Also, there is one green light present that tells that the charge controller is in working status.

This fig shows the IoT part which is connected with raspberry pie, current sensor, DHT11. The sensors will give us the amount of current utilized and the amount that is produced.

Fig.4.3. circuit board

4.2 SPECIFICATIONS

SPECIFIC CHARACTERISTICS

4.2.2 PANEL SPECIFICATIONS

ELECTRICAL SPECIFICATIONS *STC : IRRADIANCE 1000 W/m² , AM1.5 SPECTRUM ,MODULE TEMP 25.C MODEL TYPE CSS•MSP•075M•36

PEAK POWER (P_{max}) 75W

CELL EFFICIENCY 14.01%

MAXIMUM POWER VOLTAGE(V_{mp})

17.56 V MAXIMUM POWER

CURRENT(I_{mp}) 4.27 A OPEN CIRCUIT

VOLTAGE (V_{oc}) 21.17 V

CAPACITY(25.C) 10 HOURS RATE 40 Ah 5 HOURS RATE 32 Ah 1 HOUR RATE 24 Ah 1.5HOUR DISCHARGE TO

10.5V 16 A

SHORT CIRCUIT CURRENT(ISC) 4.74

A POWER TOLERANCE +• 3%

MAXIMUM SYSTEM VOLTAGE 1000 V

SERIES FUSE RATING(A) 7

NUMBER OF BYPASS DIODE 2

The graph in fig.4.4 gives us the appropriate value of the humidity of the entire area value whenever the user wants to know about the details time where the user wants to know the status of the data. This data will be stored in the things speak online account.

DATA OF HUMIDITY AND TEMPERATURE

The graph in fig.4.5 gives us the appropriate value of the temperature and temperature of the entire area whenever the user wants to know about the details time

where the user wants to know the status of the data. This data will be stored in the things speak

online account. Fig 4.5 DATA OF CURRENT

Fig 4.6 given below is the pic taken when the raspberry Arduino board is in running condition and when the panel is not connected when any motion is sensed near it.

Fig 4.7 DATA OF VOLTAGE

CHAPTER•5

CONCLUSI

ON

The smart solar efficiency monitoring system is presented. As this system keeps continuous track of solar power plant, the daily weekly and monthly analysis becomes easy and efficient also with the help of this analysis it is possible to detect any fault that occurred within the power plant as the generated power may show some inconsistency in data of Solar power plant.

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