4th National Conference on Green Technology and Science for Sustainable Development
© 2023 IJSRST | Volume 10 | Issue 10 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
International Journal of Scientific Research in Science and Technology

Semi-integrated Solar LED Street Light

Muhammad Nomaan Barudgar, Sairaj Dhangar, Nidhi Lad, Varad Marathe, Ashwini Katkar
Department of Electronics and Telecommunication Engineering, Vidyavardhini's College of Engineering and Technology (VCET), Vasai (West), Mumbai - 401 202, Maharashtra, India

ABSTRACT

Solar energy is one of the most significant and promising renewable sources of energy, and it has a lot of potential in street lighting systems. Solar street lights have become increasingly popular in recent years due to their many advantages over traditional street lights. An LED lamp is powered at night by a rechargeable battery that is charged by solar panels. As everyone knows, foreign nations have dominated our Indian market. It is past time for India to be self-sufficient in these items and to support the Government of India's Make in India effort. Furthermore, the items should not be harmful to the environment. Use of natural resources such as sunlight and wind are a must. So Semi-integrated solar LED street lighting is proposed. This Semi-Integrated Solar Street Lights have dusk to down sensors, has an adjustable brightness setting, is water resistant, has good energy storage and has a long battery life. The lamp technology uses solar energy to generate electrical energy from solar radiation during the day and then uses that energy to generate light at night. This makes it less expensive and easier to install. Because it is solar-powered, it may also be deployed in remote areas. This undertaking will be focused on maximizing usage and minimizing possible energy loss.

Keywords—Solar panel, LED street light.

I. INTRODUCTION

According to research, majority of the Indian market is dominated by Chineseitems. It's time to wean our country off of Chinese imports and back the Make in Indiaprogram of the Indian government. India has a wealth of natural resources, including solarand wind energy. Governments across the world are focusing on sustainable and renewableenergy sources to reduce carbon emissions and combat climate change. This has led to anincreased demand for solar-powered products, including semi-integrated solar street lights,which can help to reduce energy consumption and carbon footprint. Consequently, it ismore economical to use natural resources as opposed to synthetic ones. A solar street lampis a type of lighting system that makes use of solar cells to harvest electrical energy fromsolar radiation inthe day time and use it to provide light at night. The recommended smartsolar LED street light could be utilized for free if the solar panels have enough time tochargethem.

The dependability of the system will increase by using the auto change over method, inwhich the utility supply is automatically switched from the streetlight. if not, enoughcharge has been applied to the battery storage. During the day, the battery starts to chargeusing a PV solar panel. At dusk, street lights are turned on automatically with a 30%intensity and battery depletion starts due to the light sensor. Every time a person orvehicle moves, the light intensity will increase for a predetermined period of time, from30% to 100%. The

intensity will gradually decrease to 30% after this set period. Theintensity will again increase if any movement is detected in the interim. This ensures bothoptimal lighting and energy efficiency. This automated solution requires a battery with asubstantially smaller capacity than conventional solar LED lamps. Semi-integrated bulbsare more affordable and convenient to install with this arrangement, making themidealforrurallocations.Ingeneral,thereare3categoriesofsolarstreetlights lamps:

(1) Unintegrated lamp
(2) Fully integrated lamp
(3) Semi-integrated lamp

- Anun-integratedstreetlighthasitslight,solarcell,controller,andbatteryallseparatefromoneanother.
- Asemi-integratedsolarstreetlightonlyhasasolarcell,controller,andbatteryintegrated; the lamp is connected to other lamps via a cable. Semi-integrated lamps aremoreaffordableandconvenient toinstallwiththisdesign.
- Fully-integrated lamp has integrated all the components of each lamp, because they are notconnected, they are readily stolen. The danger of theft is increased since it has a largermonetary value than standard street lighting. Snow, dust, and moisture may collect onhorizontal PV panels. Asa result, energy production is decreased or completely halted.

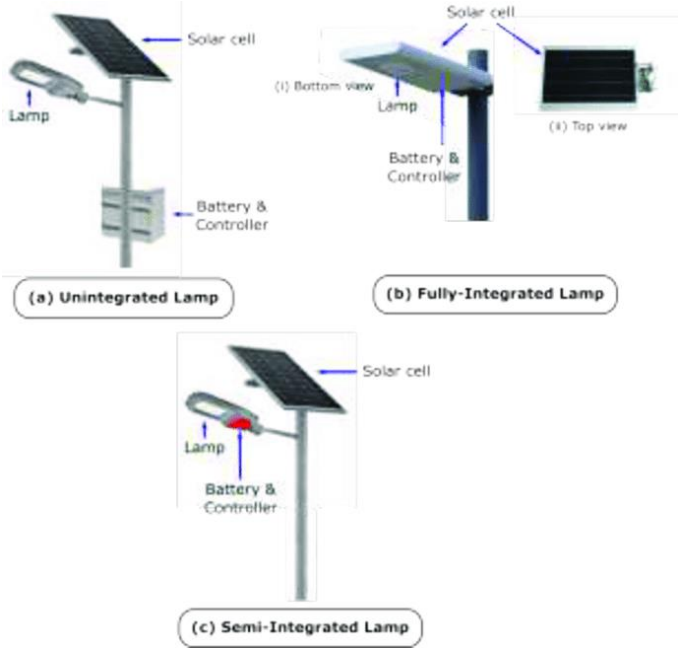

Fig.1. Different types of solar street lamps[13]

A semi-integrated solar street lamp only has a solar cell, controller, and battery integrated;the lamp is connected to the lamp via a cable. Semi integrated lamps are more affordableand convenient to install with this design. Semi-integrated solar street lights are a type ofoutdoor lighting system that uses solar energy to power its lighting fixtures. These lightsare designed to provide illumination for streets, pathways, and other outdoor areas, whilealsobeingenergy-efficientandenvironmentallyfriendly.Furthermore,thesolarstreet[3].lamps power was determined to fulfill the lamp's energy demands up to 12 hours. A Semi-Integrated Solar Lamp is designed differently from a standard solar street lamp. The typical solar street lamp isolates every component, such as the bulb, solar cell, controller, and battery. However, as a result, this solar lamp can be readily put on the lamp pole. This design allows for greater flexibility in terms of placement and installation, as the solar

panel can be positioned to capture maximum sunlight and the lighting fixture can be mounted at the most suitable height and angle for optimal illumination. The controller circuit will be linked to the battery and solar cell through a wire. When the battery is charged and the light is switched on, the flow of current is controlled by the lamp controller. Several DC lamps powered by photovoltaic (PV) power in the prototype smart street lighting system are presented in this study. When a solar panel generates more power than it needs, a panel is added to store the extra energy so it can be used at night or when it's cloudy or otherwise. In other weather, to prevent the battery from being overcharged and to regulate the operation of the whole system, a charge controller is used. Overall, semi-integrated solar street lights are a versatile and reliable option for outdoor lighting, offering the benefits of solar energy while also providing high-quality illumination for various outdoor applications [4].

II. LITERATURE SURVEY

LiewPokHuaiet al. [1] researched solar streetlight systems. This research paper is to explain a proposed Solar Street Light (SSL) design for energy efficiency development for managing facility planning. For commuters and nighttime pedestrians alike, street lighting is an essential public utility that creates a safer atmosphere. However, there are several drawbacks to conventional street lighting (CSL), including excessive energy usage and instances of electrocution. Therefore, in light of the issues, this research aims to create a new framework for creating a contemporary SSL design. The study also examined the two forms of street lighting in depth, finding that SSL has the potential to save 64.7% of the whole cost compared to CSL. One of SSL's distinctive qualities is its DC 12V operating voltage, which is stable and ensures human safety because there is no risk of electrocution. This study so presented a framework consisting of a 30 m separation distance between street light poles, a 9 m height, a light management system, a 90 W LED bulb, a 5.4 kWh volume of rechargeable battery, and a 2 ft2 solar panel.

Badri Narayan Mohapatra, etal.[2] researched on power saving solar streetlight system. This research paper aims to discuss a proposed power-saving Solar Street Light; the idea of guaranteeing optimal use and least loss of available energy serves as the basis for this article. The streets are illuminated at night using solar energy that is abundantly accessible during the day and is stored in solar cells. The system also provides a power-saving mode of operation by modifying the automation strategy. A dark sensor and a light sensor enable the street lights to automatically switch on when necessary (i.e., when the surrounding area is dark) and off when necessary (i.e., when there is enough light in the area). The auto intensity control system has again been employed, this time with the aid of a microcontroller, to control the luminaries' light output according to the circumstance. The energy waste brought on by the unnecessary glare of the street lights may therefore be avoided.Shaik Shushma, etal.[3] researched solar street lightsystems. This research paper is to explain a proposed Solar based led street light with auto intensity control this paper is based on the idea of maintaining maximum utilization and minimum loss of available energy. A solar cell stores a significant amount of solar energy that is accessible during the day, and this energy is then used to illuminate the streets at night. By adjusting the automation approach, the system also offers a mode of operation that conserves energy. The street lights' automated "ON"/"OFF" capability is provided by a dark sensor and a light sensor. This means that the street lights will automatically switch on when necessary (i.e., when the surrounding area is dark) and turn off automatically if there is enough light in the area. In order to adjust the luminaries' light intensity in

accordance with the situation, the auto intensity control mechanism has once again been used with the aid of a microcontroller. Therefore, the loss of it is possible to prevent the energy used by superfluous street lighting.
Fares S. El-Faouri, etal.[4] researched on solar streetlight system. In this study, an automatic intensity-controlling smart solar street light is presented. Several DC lamps are powered by a photovoltaic (PV) source in the prototype smart street lighting system shown in this study. When a solar panel produces more energy than it needs, a battery is added to store the extra energy so that it may be used at night or when clouds or other types of shade are blocking the sun. To prevent the battery from being overcharged and to regulate how the system functions as a whole, a charge controller is employed. A motion-sensing circuit and a dust-cleaning circuit are also added to the system, which further expands its capabilities. As a whole, the system produces smart, effective street lighting that may be used independently of the grid. As a component of a larger system, it may be linked to the rest of the grid.

III. PROPOSED ARCHITECTURE & METHODOLOGY

The objective of this system is to develop an approach including procedures and methods for a Semi-Integrated Solar Street Light.
Proposed system block diagram is shown in Fig.2, Solar panel is composed of Photovoltaic modules. During the day, the sunlight hits the solar panel and solar energy is collected from the sun. Then, it is transformed into electrical energy by solar cells, which are then stored in the battery. Before the battery is charged, the Photovoltaic module's generated electricity passes via a charge controller circuit.

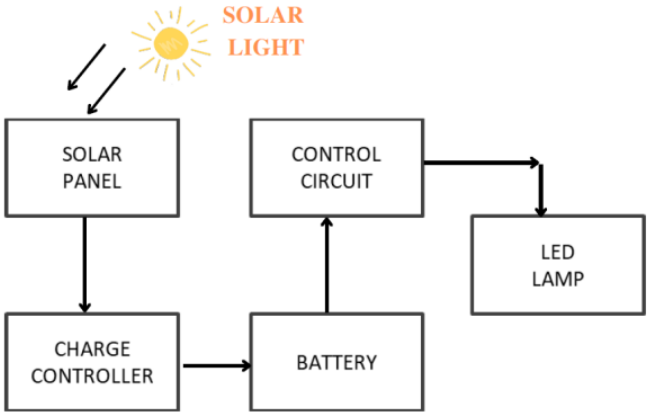

Fig.2. Proposed system Block Diagram of Solar LED Street light

The solar panels collect Solar Energy composed of PV models and receive light throughout the day.The solar street light operates based on solar cells. Solar cells transfer this solar energy into electrical energy, which is then stored in the battery. It takes around 5 to 6 hours for the battery to fully be charged. The in-charge controller in the IC CN3722 protects the battery from overvoltage which might shorten in lifespan. The LED Street light turns ON at night and uses the energy that has been stored in the battery. Sensors are installed on the street light to detect any motion. When there is no motion lightintensity of the LED street light is at 30% when motion is detected, its intensity increases to a maximum of 100%. By doing this a lot of electricity is saved. And this cycle repeats.

IV. HARDWARE COMPONENTS

Various hardwarecomponents used in this project areexplained below in brief:

1) **Polycrystalline solar panel:** The Fig.3, Polycrystalline solar panels are made up of multiple polycrystalline silicon crystals, giving them a distinctive blue colour and a square shape. These panels contain many cells, with each cell made up of many silicon crystals. Because of this, there is a limit to the amount of electron mobility within the cells. When sunlight hits the solar panel, the PV cells within it collect energy from the sun's rays. This energy causes electrical charges to move, creating an internal electrical field that allows electricity to flow. This flow of electricity can then be harnessed for a variety of applications, including powering homes, businesses, and other types of infrastructure.

Fig.3. Polycrystalline Solar Panel[8]

Polycrystalline solar panel working principle: As shown in Fig.3, Solar panels consist of multiple photovoltaic cells, each of which comprises silicon crystals functioning as a semiconductor device. As photons from the sun hit the PN junction, they energize the electrons and enable them to flow as an electric current. P-type materials have fewer electrons, whereas N-type materials have an excess of electrons. the PV cells have two electrodes, with the top electrode comprising small wires and the bottom electrode resembling foil.

2) **IC CN3722 Module:** The CN3722 is a maximum power point tracking photovoltaic cell that can power a PWM switch-mode battery charger controller. It is made to charge lithium- ion or LiFePO4 batteries in a constant current and constant voltage mode for single or multiple cells. The external resistor divider controls the regulation voltage when operating in constant voltage mode. Using a single current sense resistor, the constant charging current may be programmed. For deeply drained batteries, the CN3722 additionally offers a trickle charging feature that charges them at 15% of the programmed constant charging current until the cell voltage is more than 66.7% of the regulation voltage. When operating in constant voltage mode, the charging current gradually declines, and the charge cycle is finished when it reaches 9.5% of the initial charging current. the current at its maximum. In constant voltage mode, a new charge cycle will begin automatically if the battery voltage drops below 95.8% of the regulatory voltage. Under voltage lockout, battery temperature monitoring, and status indicator are further characteristics of the CN3722. The CN3722 is a well-liked option for a variety of battery 16-pin design.

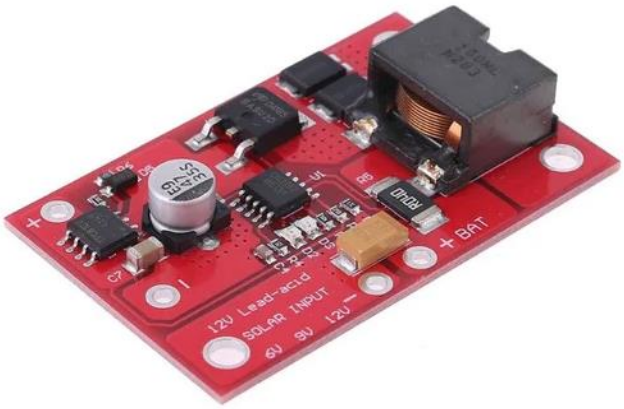

Fig.4.IC CN3722Module [12] [1c7]

On visiting several industries and gaining knowledge about all the equipment one of the industry-The Tropical Electronic Equipment factory, Mumbai, Maharashtra they suggested using an IC module, i.e. CN3722 Module.

Specifications of CN3722 MPPT Module
There are several great features of this IC such as:

1. Maximum Power Point Tracking (MPPT) capability by input Voltage regulation
2. Programmable MPPT setting
3. 5-V to 28-V Input solar panel
4. 600-kHz NMOS-NMOS Synchronous buck controller • Resistor programmable float voltage
5. Accommodates Li-Ion/Polymer, LiFePO4, and lead acid chemistries
6. Accuracy –
   ±0.5% Charge voltage regulation
   ±3% Charge current regulation
   ±0.6% Input voltage regulation

3) **Arduino Nano:** The ATmega328P microprocessor-based Arduino Nano is a compact and versatile development board that shares the same specifications and connectivity as the widely recognized Arduino Uno board. However, it comes in a smaller form factor and is designed to be user-friendly and highly modifiable.

Fig.5. Arduino NanoSensor [14]

4) **Nrf24l01:** The Nrf24L01 is a single-chip 2.4GHz transceiver engineered for wireless applications that demand ultra-low power consumption. It is equipped with the Enhanced Shock Burst baseband protocol engine.the Nrf24L01 is intended to operate in the 2.400 - 2.4835GHz global ISM frequency band. The global ISM frequency band, which is frequently used for wireless communication, is where the Nrf24L01 wireless transceiver module works. It is made for ultra-low power wireless applications and transmits data using GFSK modulation. The module uses an active radio frequency to broadcast and receive data.

Fig.6.Nrf24l01[15]

5) **PIR Sensor:** PIR sensors are an importantcomponent of many security and automation systems, as they provide a reliable and cost-effective way to detect motion and presence without the need for complex or expensive equipment. They work by detecting the heat energy emitted by living beings and converting it into an electrical signal that can be used to trigger an alarm, turn on lights, or activate other devices. PIR sensors are a popular option for both residential and business applications since they are simple to install and require little upkeep.

Fig.7. PIR Sensor[10]

6) **Lithium-ion Battery**: Lithium-ion, is a type of rechargeable battery that uses a cathode made of lithium-ion phosphate. Lithium-ion batteries are known for their high energy density, light weight, and long lifespan. Lithium-ion batteries are considered safer due to their inherent stability and resistance to

overheating and are widely used in various applications such as electric vehicles, renewable energy storage systems, portable electronic devices, and backup power supplies.

Fig.8Lithium-ion Battery[9]

7) **LED PCB:** A light-emitting diode (LED) PCB (Printed Circuit Board) shown inFig.9 is a circuit board that is specifically built to accommodate the placement andfunctioning of LEDs. LED PCBs feature a unique architecture that allows for optimalLED positioning, allowing them to output lightefficiently and effectively.LED PCBscanbeconstructedinarangeofshapesandsizes,andtheycanbeusedinbothsingleLED applications and larger LED arrays. These boards are often built of a hard material,such as fiberglass or Aluminum, which aids in heat dissipation and keeps the LEDs coolduring operation. LED PCBs are often designed using copper lines and pads that connectthe LEDs to the power source, as well as additional components like as resistors andcapacitors that may be required for the circuit to function roperly. LED printed circuitboards are widely utilized in a wide range of applications, including lighting, signage,automotive,and electronics.

Fig.9 LED PCB

V. FLOWCHART

The flowchart of working process is shown below in Fig.10, Energy produced by a solar panel is harnessed throughout the day and stored in a battery.When the microcontroller receives commands from the Dark sensor. The light will be turned off in accordance with the instructions when it is daylight. If it is nighttime, the dark sensor will pass the command to the motion sensor, which will then carry it out and turn the LED on to 30% of its maximum intensity if there is no motion beneath the streetlight.

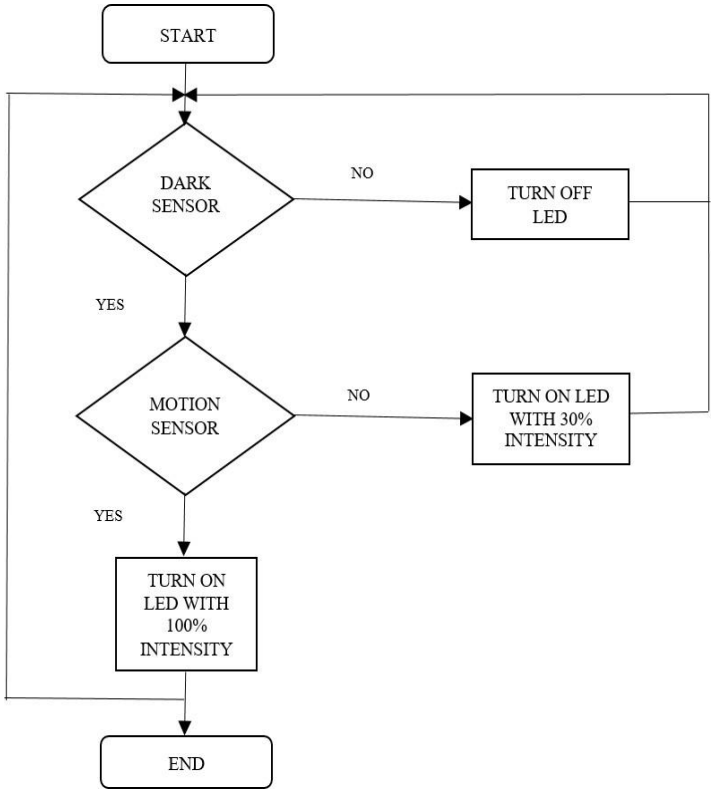

Fig.10Flow Chart of working process of Solar LED Street lightT

Whenever a human or vehicle passes by a nearby streetlight, the motion sensor triggers and sends an instruction to the microcontroller to increase the brightness to 100%.If no movement is observed during the predetermined period, intensity to 30% reduction over time. The street light will switch off in the early hours when the Nrf sends an instruction to the microcontroller. In the normal course of things, streetlights run on battery-stored power. Furthermore, if the battery is not fully charged due to overcast weather, an automatic switchover to the utility supply will occur for the streetlight.

VI. RESULT

Results of the proposed system consist of the schematics, LED with its controller design and overall layout view of the semi integrated solar streetlight.

Schematics of implemented system: The hardware implementation involves assembling the required components, including the micro controller, sensors, and power supply. The sensors include a PIR, a voltage and current sensor, the various components were interfaced with the Arduino. The system works on a 12Vbattery and is charged through solar panels. The Fig.11 shows the schematics of thesystem.

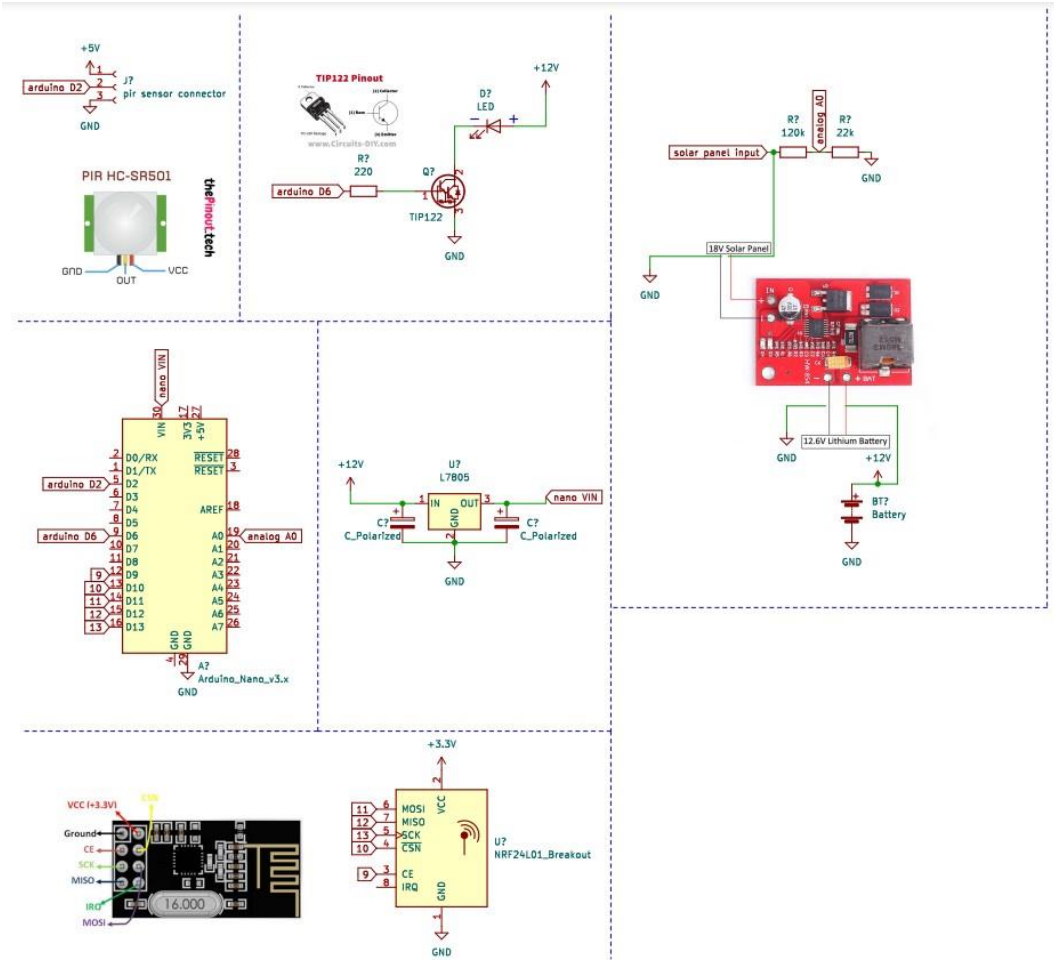

Fig.11:Schematicsofimplemented system

LED Controller Design: In Fig.12 PCB with all the components installed over it the PCB was first designed using Ki-CAD software and then further implemented on PCB. The MPPT controller is connected to theArduinoNano andalso themotionsensor is connected to the controlcircuit

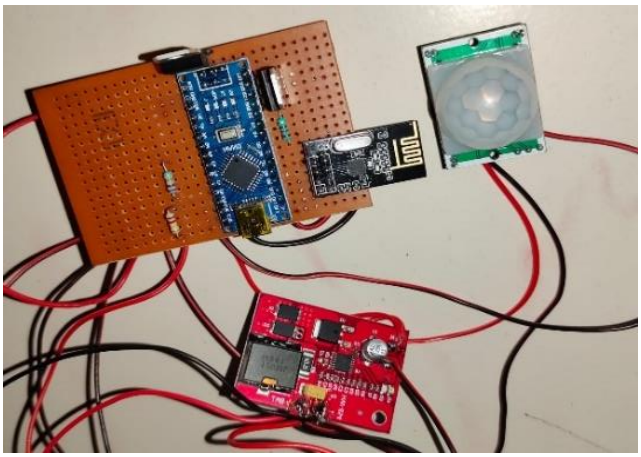

Fig.12 LEDController Circuit

Semi-Integrated Solar LED Street Light: In Fig.13 a semi-integrated solar LED streetlight is a type of outdoor lighting system that uses solar energy to power an LED lamp. The system includes a solar panel, which

captures sunlight and converts it into electrical energy, and a lithium-ion battery, which stores the energy generated by the solar panel. The LED lamp provides illumination during the night, while the controller manages the charging and discharging of the battery to ensure optimal performance and a longer lifespan. The solar panels are separate from the LED lamp, making it easier to install and maintain the system. The solar LED streetlight provides a reliable source of illumination while reducing energy consumption and costs and can improve safety and visibility on streets.

Fig.13Semi-Integrated Solar LED Street Light

VII. CONCLUSION

Among the various renewable energy sources, solar energy is considered one of the most significant and promising. It holds immense potential for application in street lighting systems. In recent years, solar streetlights have gained popularity owing to their numerous benefits over conventional Streetlights. These Solar streetlights use photovoltaic cells to convert solar energy into electrical energy, which is then stored in batteries for later use. This Semi-Integrated Solar Street lights have dusk to down sensors, has an adjustable brightness setting, is water resistant, has good energy storage and has a long battery life. Overall, solar streetlights are an innovative and sustainable solution for street lighting.

The future scope of semi-integrated solar streetlights is promising and is expected to grow due to several factors. Future versions of this system may have a circuit that alerts the appropriate authorities if electricity is stolen. The GSM/GPRS system can be password secured to prevent tampering by outsiders

VIII. REFERENCES

[1]. LiewPokHuai, Zainal AbidinAkasah, "A proposed standard design of solar street light system towards energy efficiency development for managing facility planning", International Conference on Industrial Technology and Management, 2019

[2]. Badri Narayan Mohapatra, Aishwarya Dash, Bipin Prasad Jarika, "power saving solar street lights" International Journal of Emerging Technologies in Engineering Research, 2017

[3]. ShaikShushma, Anusha Raj, Bhanupriya, DR.KrishnaSamalla, "solar-based led street light with auto intensity control", International Journal of Creative Research Thoughts, 2021

[4]. Fares S. El-Faouri, MuntherSharaiha, DaoudBargouth, Ayman Faza "smart street lighting system using solar energy", Institute of Electrical and Electronics Engineers, 2016
[5]. Dr.Anil S. Hiwale, MugdhaV.Patil, HemangiVinchurkar, "An Efficient MPPT Solar Charge Controller", International Journal of Advanced Research in Electrical, 2014
[6]. Nitish Kumar Jha, AnustupBiswal, "Advanced Street Lights", International Journal of Engineering Research & Technology, 2016
[7]. Amin Mirzaei, Majid Forooghi, Ali AsgharGhadimi, Amir Hossein Abolmasoumi, Mohammad Reza Riahi, "Solar Energy", The Official Journal of The International Solar Energy Society, 2017
[8]. https://www.indiamart.com/proddetail/solar-photovoltaic-panel-17377000388.html
[9]. https://www.indiamart.com/proddetail/11-1v-2200mah-lithium-ion-battery-pack-19371415962.html
[10]. https://www.techtonics.in/hc-sr501-pir-motion-detector-sensor-module
[11]. https://www.amazon.in/VIBRANIUM-LIGHT-Street-Driver-Protection/dp/B092ZNYWMN
[12]. https://www.ubuy.co.in/product/8IZB8QNM-solar-charge-controller-cn3722-solar-controller-12v-charging-management-18v-solar-charger-overvoltag
[13]. https://www.researchgate.net/figure/Three-different-type-of-solar-street-lamps-a-unintegrated-lamp-b-fully-integrated_fig1_329185621
[14]. https://www.indiamart.com/proddetail/arduino-nano-r3-16295092148.html
[15]. https://roboway.in/shop/nrf24l01-2-4ghz-wireless-transceiver-module/