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Photovoltaic Panel Controller Hysteresis Control-Based Internet of Things Environment Design for Massive Solar Electricity Use in Urban Areas

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Abstract

A controller for photovoltaic panels was developed to take advantage of solar electric power, to make it more accessible, and to promote its use in urban areas; the controller communicates with a server to send data about its status and to request important information that will change the hysteresis, which will increase the autonomy and efficiency of the system; the information provided by the server is based on statistical analysis; the variables analysed are the voltage on the photovoltaic panel that is directly proportional to the amount of sunlight received In its most basic form, a solar energy controller manages solar electric energy, decides when solar electric power is given to a load and when to switch a circuit to supply power from the conventional electric grid, among other things.

Keywords: solar electric energy, photovoltaic panel, controller, hysteresis, urban areas, Internet of Things.

1. Introduction

Adoption of renewable energy sources is one of the most current and vital ways to minimise energy consumption and environmental effect today. Renewable energy sources like solar and wind power are being used to alleviate power shortages in states around the country. The government is encouraging the private sector to build new power plants. The International Energy Agency (IEA) has said that renewable energy sources [1] may be introduced as the fastest-growing alternative energy sources in the present time in order to meet the needs of the existing population. Wind and solar PV are two of the most common renewable energy sources. Several private enterprises are constructing solar power plants and selling the produced power to the national grid in order to enhance their revenue and meet the nation's growing need for energy. In the literature review, the solar power plant and align factor of power production are briefly examined, as well as typical techniques of solar power plant monitoring in fully described. These renewable energy sources [1] are both technologically advanced and economically viable. Because of technological progress and modernisation, the cost of renewable energy equipment has dropped dramatically. As a result, the construction and maintenance of solar PV power plants are becoming more simpler. Visited "Dr. Babasaheb Ambedkar solar power plant, Osmanabad, and Maharashtra, India" to learn more about solar photovoltaic plants and how they function. In order to better understand solar power plants, it is beneficial to consider a wide range of elements and concerns. Power output of 1.5 million units per year is generated at this solar electricity plant, which is capable of producing 1 MW of power. Various types of solar power plant monitoring systems, both old and new, are described in depth in the introduction and review of the literature.

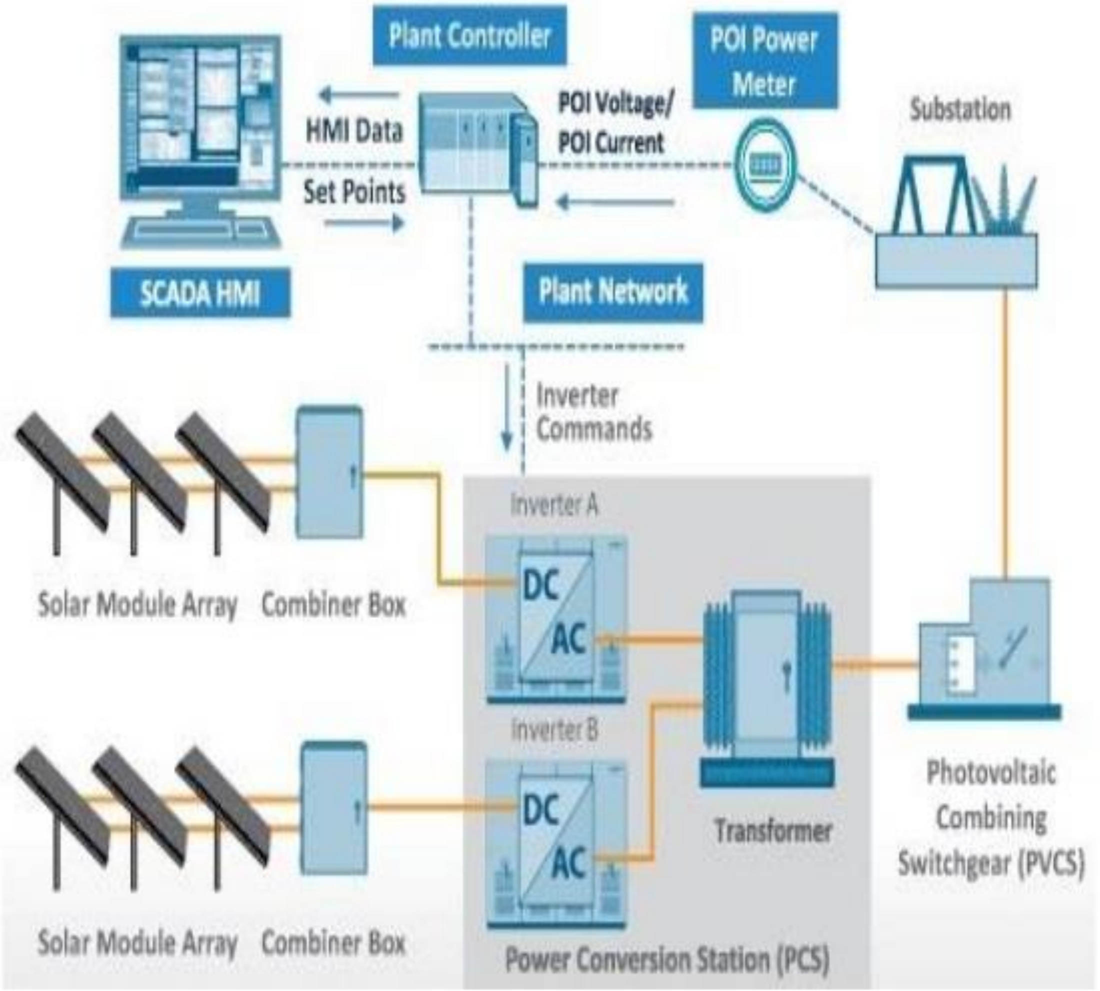

Figure.1. General structure of Solar Power Plant Monitoring system

Figure 1 depicts the overall layout of a solar power plant monitoring system. It is common practise for solar panels to be organised in a systematic way to maximise energy production and improve power generating efficiency. The inverter and solar panels are connected via a device called a combination box. One of the most fundamental electrical devices, an inverter serves as a converter of DC to AC. PVCS, or photovoltaic combining switchgear, is created by the use of a transformer. To turn off our solar-generated electricity, we'll need switchgear or a DC circuit breaker. To perform numerous transformations at the plant, like as generation and distribution, the substation relies on SCADA. Voltage and current measurements are used to determine how much electricity is being consumed. The SCADA system is used to capture and store the visual results and data. This data and visualisations may also be utilised by students for educational purposes. For more than only monitoring the temperature of solar panels, SCADA systems have also been utilised to manage the release of stored electrical energy. Keep in mind that the converted electrical energy is stored in batteries in all PV systems. In earlier photovoltaic systems, this stored energy is generally released manually or continually. SCADA applications have enabled for the automatic release of electric energy via the advent of automation. The fishing business is one that makes use of automated electrical energy release.

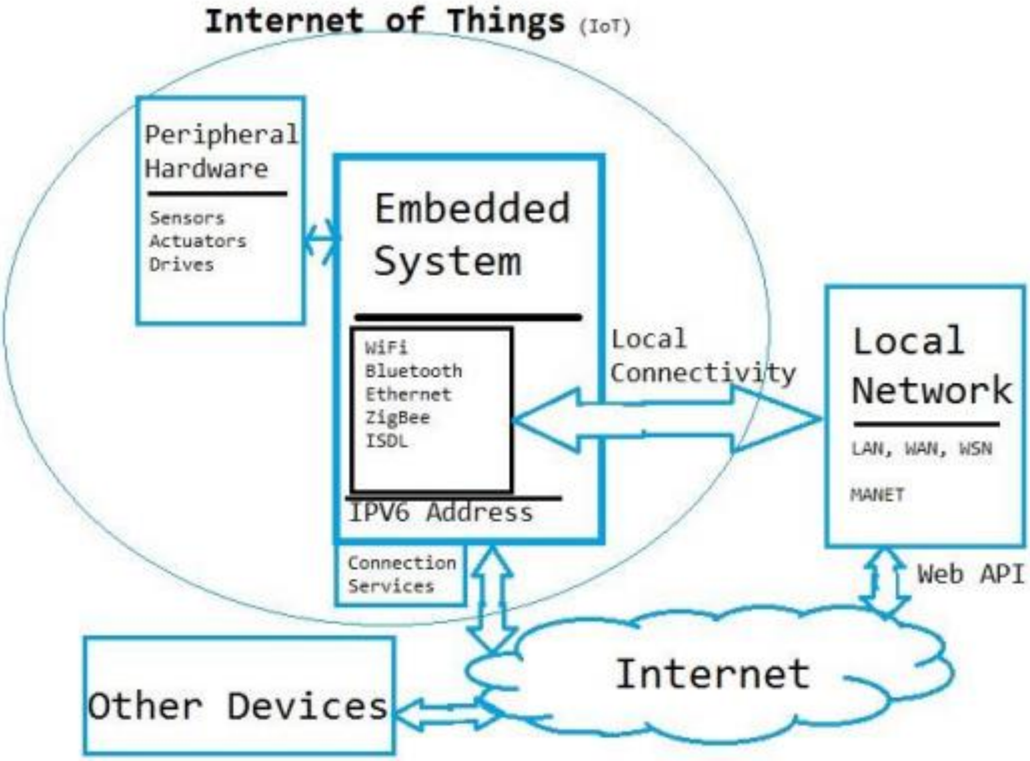

Figure.2. Internet of Things (IoT) System

The suggested approach, the design of the remote monitoring system, and the interface development of the IoT-based control system are all described in detail in following section. Incorporating the physical world into laptop-based systems is now possible because to the Internet of Things, which enables devices to be sensed and/or operated remotely through the existing community infrastructure. The Internet of Things (IoT) is used to share data across different devices on a network. In the Internet of Things (IoT), the web, or network, serves as the system's backbone, while "Things" refers to actual items. A key function played by the Internet of Things (IoT) is to combine physical devices with the web to achieve maximum and optimal power production while using solar energy. It's very uncommon to run into issues with solar power performance due to things like bad panels or bad connections, as well as panels that aren't producing enough energy. The introduction of IoT [8], which has a propensity to monitor and regulate panels automatically, may alleviate these issues. At Mega Microcontroller has been utilised to monitor the solar array's performance. System-friendly development, operational modifications, and enhanced renewable energy [1] for casting are among the system's many benefits. Obviously, this means more planning for power stations, energy storage, and more flexible generation. Smart cities, Smart villages, Small greeds, Street lightweight, Water heating system, Home lighting system, and Smart mobile charger are all examples of IoT applications. Including a smart oven, LED lighting, and more.

2. Literature Survey

At this time, we're talking about a review of an IoT-based smart solar PV system, thus the first step is to gather relevant literature. AR al Ali's research on the importance of IoT in renewable energy sources served as the literary inspiration for this piece. The advantages of the World Wide Web in solar energy monitoring have been briefly highlighted by the author. He also highlighted how IoT may be used to control the application process [8]. The Internet of Things (IoT) may also aid smart cities. This paper also discusses the use of IPV4 and IPV6 for energy monitoring. This paper discusses IIoT and CIoT, two new IoT topics. In addition, the IoT framework based on NIST standards is described. It is important to understand older techniques like PLCs, SCADAs, Zigbees and Bluetooth before going on to IoT Review.

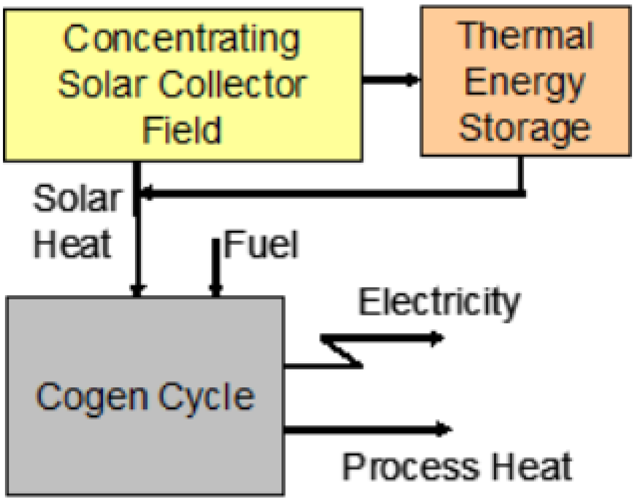

Figure.3. Principle of solar thermal co-generation of heat and power

The diagram above illustrates how a solar power plant may produce both heat and electricity. For the most part, solar power plants rely on photovoltaic (PV) panels, which come in different sizes (from tiny to huge). In arid regions, very large panels with a range of up to 1.5 GW are employed. Typical PV panels vary from a few watts to tens of kilowatts. In 2010, it was predicted that by 2016, 310 GW of annual energy output will be possible; recent projections put the figure at even greater levels. As demand for PV systems grows, efforts are being made to improve their energy storage and delivery capabilities. Inventors and scientists are always working to improve present PV systems, which have a wide range of limitations. Efforts by PV system manufacturers are being made to improve the efficiency and dependability of their systems in terms of generating power. As a result, PV plants must raise their energy production rate, the availability and longevity of PV system components, and lower their maintenance and operating costs [4]. Solar power production relies on global irradiance as a critical input. In general, grid-connected and off-grid PV systems are both options. With the grid, several power stations also include a backup facility. The price of solar energy has decreased significantly over the last decade, allowing for a significant increase in the amount of solar power available. In this way, technology becomes more efficient. Solar power and other renewable energy sources are being used by millions of houses and towns throughout the world to meet their electrical needs. The production of solar cells is facilitated by the use of semiconductors. After being exposed to the sun, this substance produces electrons that may be detected. In 1883, a scientist named Charles Fritz created the first selenium solar cell, which ushered in a new era in solar technology. Solar technology would not have advanced without Einstein's discovery of the photoelectric effect. In the field of solar panels, Clarence Kemp and Aleksandr Stoletov made a significant contribution. More electricity may be generated by adjusting the tilt of the solar panel. Several studies have shown that there are several options for determining the best orientation for the panels in relation to the sun. Only if our PV panels are aligned with the sun's path will we be able to generate more electricity. One of the most common techniques to adjust PV panels is to put them in set order, while the other is to tilt the panels slightly. A 40 percent increase in summer efficiency and a 10 percent increase in winter efficiency are possible when using the fixed panel approach. The location of the power plant is also a factor in the generating efficiency. If the solar panel is situated in the northern hemisphere, the panel should face true south at all times. In the southern hemisphere, solar panels should be placed such that they face true north at all times. It is because of the declination of the magnetic field that there is a discrepancy between true north and magnetic north. Latitude plus fifteen degrees should be the horizontal tilt angle in the winter, while latitude minus fifteen degrees should be the tilt angle in the summer. We all know it's easy to have fixed panels [64], but manufacturers are choosing for the approach of tilting the panels according to the season in order to get the most out of their panels. As previously stated, this is due to the fact that the sun is higher in the summer and lower in the winter as a result of the seasonal changes in its location.

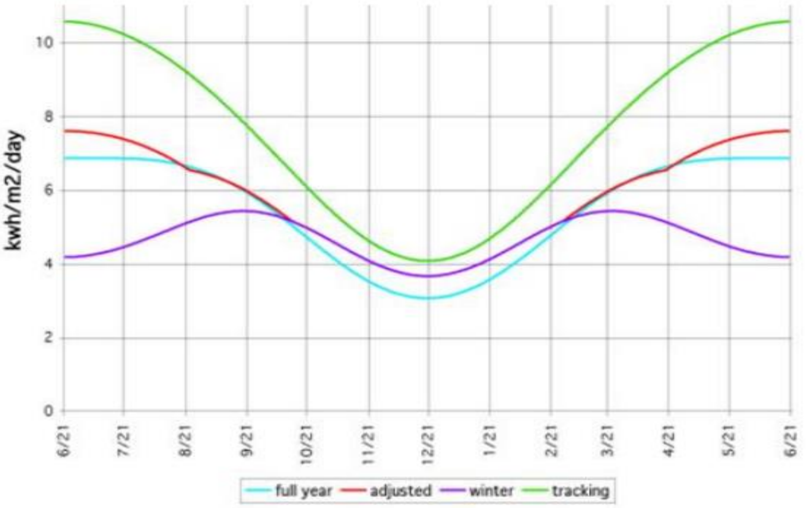

Figure.4. Comparison of adjustments of tilts in year

This graph compares the amount of tilt adjustments made over the course of a year. Power generation is shown in purple, and solar energy output is shown in red for one-time and two-time tilt adjustments in a year. The two-axis tracker findings are shown in green. We may conclude from the data in the table and graphs that two-times tilt adjustment for PV panels is effective. To compensate for the issue of having to manually tilt this system, a new system is needed that automatically senses weather conditions and tilts in response. In addition to idealised conditions, solar panel adjustment is also reliant Panels should be installed somewhat west if there are trees or hills to the east, and vice versa if there are no trees. If, on the other hand, there are clouds in the afternoon on a regular basis, tilting the panels slightly east is a good idea.

Here, a Delta PLC is used to automatically track the solar panels. Effective and efficient solar array tracking is achieved using this PLC technology. In any weather, it has extremely simple and precise control structures. This approach is used to determine the maximum amount of energy that can be extracted. By use of magnetic reed switches and sensors that may be employed for DC gear motor direction and speed controls. These are connected to solar panels through an adapter. These methods are used in order to get large economic returns and to compensate for power needs in a shorter period of time. Parts of this solar power tracking system include PV Module, relay module, magnetic reed switches CPU of PLC, sensors and electromechanical speed and motion control units. This system's power supply module is likewise crucial and fundamental. Photovoltaic modules based on OMRON PLC are studied in this research because of the low density of solar energy, intermittent solar beams, and the need to shift direction over time. Solar power plants may be monitored as well using the Android OS platform. Low-cost Android tablets are used to regulate renewable energy sources. Connected to a Power Conditioning Unit, LCD monitors and modems for the internet (PCU). Higher-level graphic depiction and a more user-friendly touch screen interface are made possible. The system's major needs are internet connection and Bluetooth connectivity. The Power Conditioning Unit (PCU) provides support for the UART interface on the FPGA and DSP hardware platforms (PCU). Automation and data recording are two of the most common functions of a SCADA platform in a PV system. A PV system's efficiency and lifespan are greatly enhanced by automation. PV systems that are compact and light in weight often employ dyes and other metal alloys to harvest the sun's energy. The sun's light has a wide range of electromagnetic energy with various wavelengths and frequencies, therefore the dye and alloy in the PV system are subject to varying effects [9]. As the temperature rises, dyes and metals lose their ability to absorb energy. When sunlight strikes a solar panel, it should be converted to electrical energy in its entirety. In actuality, a large portion of the sun's rays are transformed into heat. While part of this heat is emitted into the atmosphere, resulting in a rise in local temperature, some of this heat is trapped inside solar panels. When the dye in the solar panels breaks down and the band-gap in the alloys widens, the whole energy conversion process is disrupted. Because of the heat that accumulates, the solar panels may be permanently damaged [10]. Temperature sensors have been added to PV systems in recent years because of the issue of heat buildup [11].

3. IoT & Machine Learning Approaches for Solar Power Control Systems

Cap-Gemini released a research on energy management in the industrial and commercial sectors. The utility business is facing an unprecedented upheaval in the previous 100 years as a result of IoT-enabled energy management advances for industrial and commercial clients. With increased financial problems and high operational expenses, utilities are compelled to embrace new digital technologies and concentrate on value generation via customer-centric operations as well as new income sources. Using sensors, business applications, and IoT devices, the Open XIoT-based solution creates a trans-active energy platform that links and manages the ecosystem of multiple utility partners and decentralised energy sources. Bundled energy management services that are cost-effective and dependable are created using a wide network of suppliers.

4. Circuit Diagram of IOT Based Solar Control System

AtMega328 is the primary processor in this design, with ESP8266 serving as a backup (secondary processor). Microcontroller ESP8266 is 32-bit and has an embedded 32-bit microcontroller, thus the main Atmega328 processor was only used for sensors (voltage sensor and current sensor) and a display screen for data processing, and the ESP8266 processor was utilised solely as a secondary processor. We've simply used it to upload data to the Cloud and to set off actions. Solar panels in this circuit harness the power of the sun's rays and transform it into usable electric power. The Microcontroller is the target of the output current and voltage sensors. LDR and Wi-Fi Modules employ microcontrollers for processing and data processing. ESP8266 silently connects to any internet, Wi-Fi, access point, hotspot, or other Wi-Fi network to deliver data to a database utilising the Wi-Fi module as a quiet gateway. The data is stored on the cloud, and we may access it anytime we need it. And then show the information on the LCD screen.

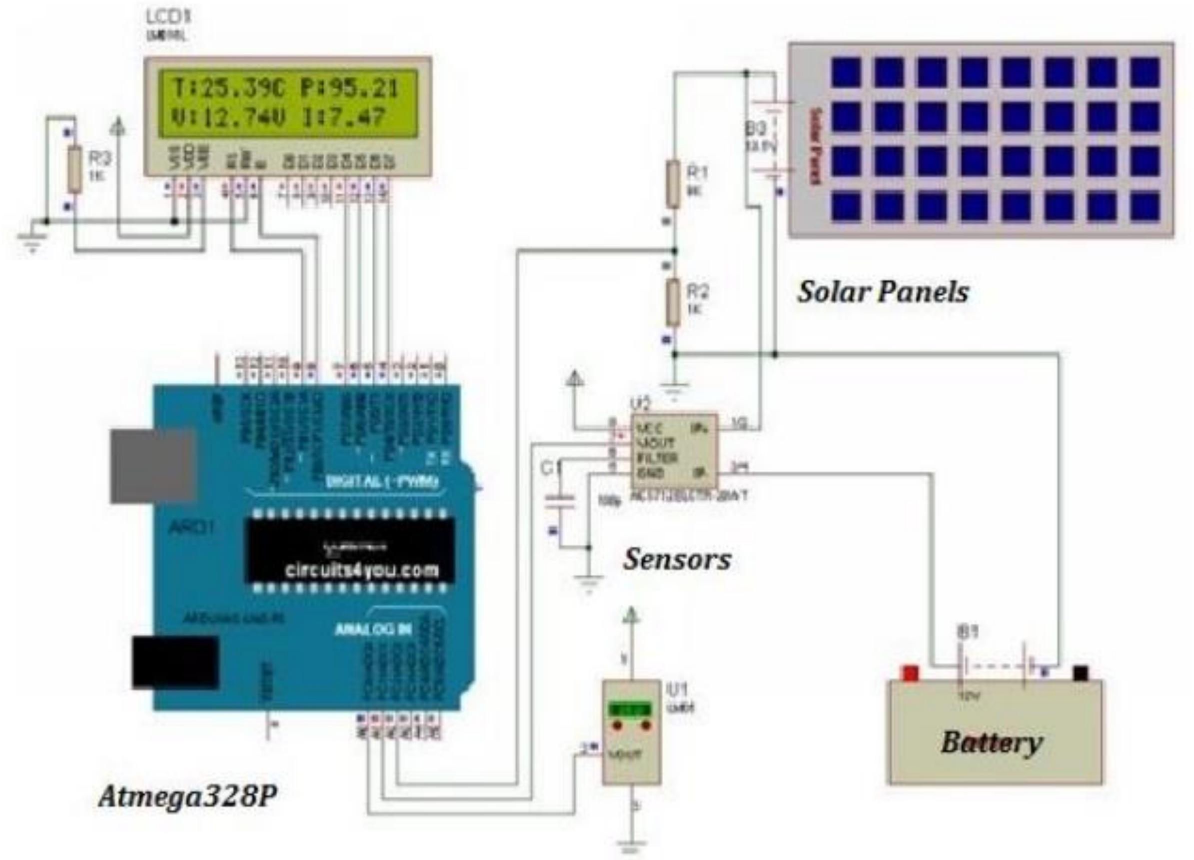

Figure.5. Circuit Diagram

The power supply component of the PCB was developed in the first session of PCB design. This PCB contains all of the rectification, filtering, and voltage regulator components. The cabinet for this PCB, which houses the voltage and current sensors and powers the secondary main board, was also constructed by us. The ESP8266 Wi-Fi module and the microprocessor are both housed on this main circuit board. This is the primary PCB layout, which includes all of the components and sensors. Because the Wi-Fi module has both a microprocessor and an antenna, we were able to use male and female headers to connect it directly to the PCB. The single-sided copper covered PCB design has been used. And we've drilled all of our holes using a 1mm drill bit.

5. Implementation

Figure 6 depicts the schematic diagram of the new prototype controller design, which excludes the network modules and the GPS. An Arduino UNO board's ATmega328P microcontroller was utilised. The photovoltaic panel's variable voltage range, with a peak of almost 20 volts in direct current, is converted to a stable voltage range by a voltage regulator consisting of the resistor R9, the zener diode 1N4744A, and the potentiometer R8 set to 90%. This voltage regulator is directly connected to the photovoltaic panel. The analogue input A0 of the microcontroller was used to obtain voltage data from the photovoltaic panel using a voltage divider consisting of R1 and R2. The voltage divider's purpose is to convert the photovoltaic panel's peak voltage of 20 volts to a voltage that the microcontroller can accept, which is 5 volts. Analog input A1 measured battery voltage using a voltage divider with resistors R3 and R4. In order to switch the system to utilise the 220 volt alternating current grid or a battery and an inverter to supply 220 volt alternating current, the relays are controlled by digital outputs D6 and D7. They perform the function of switching the circuit. Photovoltaic panel 60W, battery 12 volts, 60 amps/hour, inverter 12 to 14 volts, 500 watts Each test requires around 30 watts of power from the load.

Figure.6. Implementation Model

The solar panel, microprocessor, WIFI Module, voltage and current sensors, as well as LDR sensors with LCD display, are all shown in the figure. The device also makes use of a servomotor to rotate the solar panels.

6. Conclusion

A photovoltaic panel controller based on hysteresis control may be used to construct an Internet of things environment for widespread usage of solar electric energy in metropolitan areas. Controllers can cooperate with one another to increase efficiency and independence. The traditional electric grid and the user's economics have both been saved as a result of this technology. This article discusses briefly the design and modelling of several modules of a remote monitoring system. Component selection and specification for a remote solar monitoring system is detailed in great depth. Everything you'll need to carry out your project is covered in detail here. We'll talk about how to choose a microcontroller and its specifications, as well as how to use sensors to gather voltage and current data for power calculations. Discussions on the specifications of LCD displays and Wi-Fi modules, and the specifics of Cloud Computing, are included.

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