A Review on: IoT based solar charge controller

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Abstract— For both the consumer and society as a whole, solar home systems have a lot to offer. It's a realistic option because of the ease with which it may be used. The energy conversion is the responsibility of the Solar Charge Controller (SCC), which is a component of the Solar Home System. It is our primary goal to create a low-cost, high-efficiency SCC that does not sacrifice performance in any way. Solar power tracking and modulation network is one of the many uses of IoT. In IoT, an energy-saving method can be delineated, which reduces both the amount of energy used and the amount of effort required to complete the operation. The PWM-based solar charge controller and its reaction have been incorporated into the proposed system via web-servers and laptops/cell phones. The W5100 is utilized as an IoT platform, and a web server is installed on the W5100 module. Web servers are platform-independent, thus they may be used in mobile devices such as smart phones or laptop computers, and they can sequentially calculate solar charge controllers using the W5100 module. Solar power tracking is the focus of the proposed system, which uses web servers to relay information to a laptop or cell phone. Because of the variability of the surrounding environment, solar photovoltaic (PV) energy output is unable to meet increasing demand. As a result, PV systems must make use of MPPT, which tracks the solar panel's peak output in real time. An IoT-enabled MPPT solar charge controller (SCC) is discussed in this study.

Keywords— SCC, MPPT, IoT, IoT Based Solar Charge Controller.

I. Introduction

Solar, wind, rain, and geothermal heat are all examples of renewable sources of energy. When compared to conventional energy sources, renewable energy sources are virtually limitless and extremely clean. Renewable resources make up about 16 percent of worldwide final energy consumption. Demand for solar photovoltaic energy is increasing due to its many advantages such as free and abundant energy, environmental friendliness, cheap operating costs, and low operating costs, etc. Grid-connected and freestanding Photovoltaic power converters have been created to reduce utility power and provide the load power without relying on the utility. Batteries are needed for energy storage if a stand-alone system is used. Solar panel output is strongly correlated with the strength of the sun's rays. The intensity, however, is not constant. Because of this, charge efficiency is a critical issue in solar systems. There are charge controllers meant to increase charge efficiency and safety. The major role of a charge controller in a stand-alone photovoltaic system is to prevent the battery from overcharging and overdischarging. It has recently been proposed that hybrid vehicles (HV) and remote-operated gadgets are at the end of the line for heterogeneous battery-based systems. The products that have a lot of promise aren't generally used because of their long charging times and expensive investment. The devices that constantly monitor and modulate the network's solar power tracking can help much in reducing energy waste. When the device is connected and charged, this system can detect whether or not the design is on or off and scan other gadgets. There will be a wide selection of modules that can be accessed by IoT-operated devices like Arduino Ethernet, Atmega 328p, solar panel and battery charging unit. It is made up of battery management microcontroller units as indicated above in the solar charge controller's fundamental architecture Consider the usage of Remote Monitoring and Control in order to increase the availability of manufacturing and process plants (RM&C). A lot of people are looking for industrial monitoring systems. There must be a real-time data acquisition, storage, analysis, and processing capability in the Industrial System It is also required to adjust the parameters of the process in order to change environmental components and monitor from afar in order to obtain precise control. We can achieve these objectives with the help of the ATmega328 microcontroller and the Internet of Things (IoT). The Internet of Things (IoT) marks a massive revolt against the digitalization-based commercialization of countless modules and goods. Internet-enabled devices can be controlled remotely, while others can be watched from any location. IoT is a network of physical objects or "things" that are integrated with electronics, software, sensors and connectivity in order to communicate data with the manufacturer, operator or other connected devices to increase the value and service of the network. Everything has a unique identifier encoded in it, yet it can still communicate with the rest of the Internet. Using a smart phone or the internet, anyone may now control their devices in a safe and secure manner.

II. Literature Review

Sheikh Hasib et. All (2021) IoT-based real-time solar power monitoring was created using sensors (INA219), a microcontroller (Node MCU), a PV panel, and a battery charger module in this study A GUI on a connected device can be used to monitor the voltage, current, temperature, and light intensity of PV panels in remote locations or far from the control centre. Real-time data monitoring is essential to effectively forecasting future power generation potential as well as other consequences through data analysis using the Internet of Things (IoT). [1]

Youssef Cheddadi et. All (2020) In this study, current solar plant monitoring technologies are analysed. An inexpensive IoT solution for monitoring the electrical and environmental properties of photovoltaic installations is also offered. Prototypes of the proposed remedy are tested in a laboratory to demonstrate its efficiency. Smart sensors, a cutting-edge controller, and an algorithm for monitoring solar arrays are provided in this paper. A low-cost indirect measurement method is described in order to further lower the cost of the measuring instruments. The experimental test bench includes alarms for PV station anomalies. For the proposed system to be cost-effective, it relies on low-cost edge sensors, open source software, and processing technologies. The conclusions of the study are supported by an economic evaluation of the proposed acquisition and monitoring system. [2]

V. Kavitha et. All (2019) A low-cost smart microcontroller is used to construct a virtual solar energy monitoring system based on the Internet of Things. Blynk, a cloud-based smartphone application, displays real-time measurements of solar parameters. Optimized results are shown in the monitored parameters, which roughly match the electrical ratings of a solar module evaluated in Standard Test Condition (STC). The Solar PV module's performance can be predicted with remote access to the intended work. Preventive intervention can be taken by routinely monitoring the performance of a large-scale solar installation. Industrial and commercial use will greatly benefit from this. [3]

Md. Rokonuzzaman et. All (2021) Because of the variability of the surrounding environment, solar photovoltaic (PV) energy output is unable to meet increasing demand. As a result, PV systems must make use of MPPT, which tracks the solar panel's peak output in real time. A new MPPT solar charge controller (SCC) with internet of things (IoT) capabilities is conceived and implemented in this study. The suggested circuit system makes use of Internet of Things (IoT) sensors to transmit critical data to the cloud for remote monitoring and control. The IoT platform makes it possible to remotely monitor the system. An MPPT-SCC controller utilizing the P&O approach and a bespoke Buck-Bop converter is built using thePIC16F877A main controller. The MATLAB/SIMULINK environment and a laboratory setup are used to simulate and implement the suggested system in order to validate its functionality. At a voltage of 12 volts, the suggested MPPT-SCC can manage a maximum current of 10 a. During a month of performance testing, the proposed system's efficiency hits 99.74 percent. [4]

Akila.A et. All (2019) Energy storage systems use battery sensors connected to the Internet of Things (IoT) to keep tabs on the health of their batteries in real time. A cloud platform is used to handle the IoT system established here. The user of the car can check the location of the charging station and monitor the amount of battery voltage that is being drained from the system at any time. The Arduino's memory can hold data until the battery dies. E-vehicle station users are recorded and improved in a database for future use so that different users can be monitored for their usage. [5]

Aldrin Claytus Vaz et. All (2019) The SCC is built to be as efficient as possible while yet being inexpensive for those without regular access to electricity. To begin, an explanation of the SCC concept is provided. The Methodology of the SCC design is explained in depth in the next section, emphasizing the target specifications. The developed SCC has been thoroughly tested in terms of functioning, and the output results have been analyzed and summarized. The design has some flaws, such as the fact that the PWM charging pulses are not completely square waves because of certain peaks. In addition, the system does not automatically identify 12V and 24V batteries. In order to avoid overcharging, the SCC was built to use the PWM control mechanism. All of these elements can be used as a starting point for further design work. [6]

S. Madhubala et. All (2018) An IoT-based monitoring and control of industrial parameters using solar power has been achieved by providing input to the PIC controller through the IoT module utilising IoT module so that users may observe and manage their devices by providing input to PIC controller through IoT module. As a result, the solar panel was put to good use powering the sensors, resulting in a significant drop in electricity usage. [7]

Rekha P S et. All (2021) Over the past two to three decades, solar power has developed as a viable source of renewable energy. The photovoltaic effect is used to convert this solar energy into electrical power using a sun panel. Sun power is one of the most widely used renewable energy resources. To put it another way, it's simple and straightforward to implement in the family. Using a solar tracker, a solar panel may be rotated to align with the sun's beams. Sun trackers are deployed in order to make use of this renewable source of solar energy. There may be no movement in the panel itself if it is a static solar panel. However, the position of the sun changes throughout the growing and setting process (solar rises within side the east and units within side the west). A single axis sun tracker is used because it can rotate the solar panel in both east and west directions. As a result, we don't always get the same amount of sun rays throughout the year. [8]

Dr. H Ravishankar Kamath et. All (2018) To meet the demands of everyone and every place in India, we decided to use renewable energy sources. Pollution-free and low maintenance costs are two advantages of solar electricity, but the poor conversion efficiency and high fabrication costs mean that solar panels have a tiny conversion efficiency. However with an efficient solar charge controller we may reduce the overall system cost. Solar panels. Using the proposed technique, a system's charging can be automated. Because it makes use of pulse-width modulation, or PWM, solar charge controllers can operate more reliably and for longer periods of time. The hardware performance of systems can be improved with further improvements. [9]

Monika.N et. All (2015) Battery charging in solar-powered homes can now be improved with a new prediction-based technique described in this research. Through the use of this method, more solar energy may be harnessed while using less grid power while yet maintaining high levels of battery charging reliability. The hardware findings show that the system is superior in terms of performance, and it can be simply implemented in pre-existing systems with minimal design tweaks. In this way, the developed technique is adaptable, efficient, and simple to execute.. Solar charge controllers have been presented that are low cost and high performance microcontrollers. The input and output of the proposed system were a solar PV module and a DC load. An upgrade option is included in the proposed system, which when connected to the solar charger, will change to a solar inverter/ups with solar charge as the primary priority. [10]

III. Modelling of Charge Controller

Single-stage and multi-stage regulators are often divided into constant current and constant voltage regulators, respectively. We can use a MATLAB-based load switching control programme to implement a series and shunt charge controller for both constant current and constant voltage purposes, as shown in the following sections, which are described in more depth. The solar PV module has been modelled according to the guidelines specified in the.

3.1 Series Charge Controller

Solar panel and battery voltage and current flow can be controlled by a series charge controller. It can also prevent overcharging of the battery by shutting off the current flow when the battery is fully charged.

The figure below depicts a simulation schematic for a series charge controller. Using the diodes D1 and D2 with switches S1 and S2 allows for free-wheeling operation. The switching parts are connected in series to charge the battery. Activation and deactivation of switches S1 and S2 are controlled by the battery level. The suggested series charge controller's operation will be determined by the system's load conditions. Charge on = 1 for Switch S1 and load on = 0 for Switch S2 when battery state of charge drops below 20%; this causes the battery to begin charging and continues until full charge. When the battery is fully charged, the load is set to 1 and the charging is set to 0, and this remains the case throughout the charging cycle. Switch S1 and S2 are able to operate as illustrated in Fig. 1 because the battery's state of charge and load switching controller's programme are used to determine their switching conditions, as previously stated. In this controller, instead of MOSFETs, you can use relays. With their advantages and lower power losses compared to a relay, MOSFET's have become the most used switching devices in charge controllers.

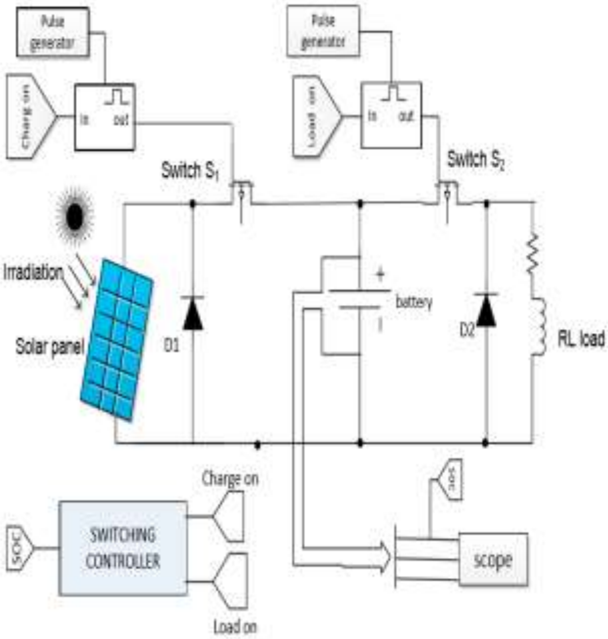

Figure: 1 Development of series charge controller using SIMULINK

3.2 Shunt charge controller

To manage voltage and current flow between the battery and load, a shunt charge controller can be used in conjunction with this device. A shunt load (such as an electric water heater) receives its power from the surplus charge, which is routed via the device. The diagram below demonstrates the simulation of a shunt charge controller, which connects the switching parts in shunt to link the load to the battery in most situations. The sole difference between a shunt charge controller and a series charge controller is that a shunt charge controller's switching element is wired in parallel rather than series. When the switching controller is used, the proposed shunt charge controller will function properly. In order to ensure that switches operate automatically, the programme was created with consideration for battery charge levels. When the battery level hits 80%, the switches S1 and S2 turn on simultaneously. As a result, when the load is turned on and the charging is turned on, both switches are turned on and off at the same time. Both switches are off at the same time, and the battery begins charging immediately. When the battery is fully charged, the switching controller sends out discharge signals, and the battery begins discharging. Its main drawback is that continuous current flow causes a hot stop in the PV module, which causes additional power loss at the panel side. It is mostly utilized for low power applications in a real-time setting. Combined series and shunt charge controllers are developed to solve the drawbacks of each type of controller.

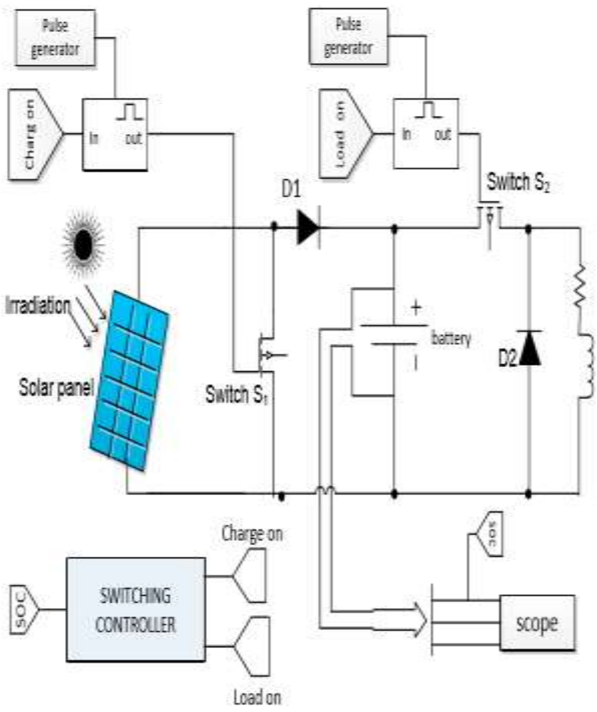

Figure: 2 Development of shunt charge controller using SIMULIN

IV. Methodology

Figure 3 depicts a block schematic of an Internet of Things (IoT)-based solar monitoring system. This is a visual representation of the general structure of our planned project. A monitoring system based on 125-watt solar panel Poly Crystalline Silicon is employed. The panel's voltage and current can be measured with the use of voltage and current sensors. On the solar PV module, a temperature sensor measures the current temperature, which significantly impacts the solar panel's performance. A pyranometer measures sun irradiance on a flat surface in units of watts per square meter. Because of its function in handling and transmitting data, the Microcontroller is critical in enabling real-time monitoring and decision-making on the cloud platform.

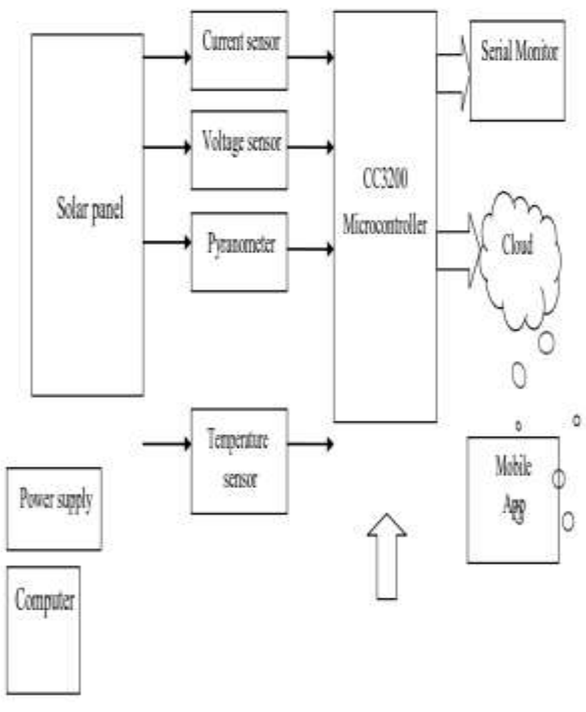

Figure: 3 Real-time Solar Energy Monitoring System

4.1 Modeling for tracking position

Whenever the sun's rays reach the PV cell, it converts them into electricity. Temperature, day and night, has a significant effect on the sun's angular location. Monocrystalline silicon is the primary component of a solar cell. They are extremely thin and delicate. The module is supported by an aluminum frame that can be simply attached and removed. Arraying a number of solar cells together is known as a solar panel or solar array. A solar cell is coupled to other cells in a PV module (i.e. 36 cells connected in series) A PV array consists of a number of solar panels that are linked together to form a larger PV installation known as an array. I The interconnection of mismatched solar cells will result in losses. (ii) (iii) The module's temperature, (iv) the PV module's failure modes. A servo motor turns the solar panel automatically in the direction of the sun's rays using an LDR (Light Dependent Resistor). The LDR sensor is positioned so that it receives maximum sunlight rays. A photo resistor, another name for LDR, is a device that is sensitive to light. The solar panel has two LDR sensors on each side. The servomotor rotates the solar panel. Solar panel tilting can be accomplished by using the LDR sensor and servomotor together. The electrical resistance of an LDR is directly proportional to the light's intensity when it strikes it.

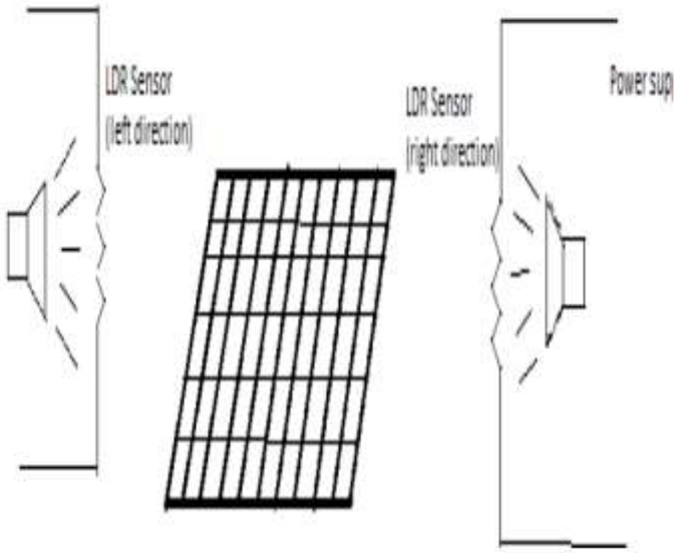

Figure: 4 Solar tracking sensor

4.2 ESP32 based controller

There's no need to buy separate microcontrollers for Wi-Fi or Bluetooth because the ESP32 has all of these features built into a single chip. As a result of its cost-effectiveness and high processing capabilities, this board was chosen. Tensilica's 32-bit dual-core CPU Xtensa and LX6 microcontroller power the ESP32 board. Many open-source platforms and languages are supported, making it an excellent choice for developers. Codes were written using the Arduino IDE and then uploaded straight to the Arduino board in this investigation. ESP32 DEVKIT V1 was utilised in this IoT project as shown in below Figure.

Figure: 5 The ESP32 DEVKIT V1 board used as controller

4.3 Modeling of IoT device

Interconnecting electronic items with computers, or "IOT," has been useful in a variety of fields. Communication or data transfer via a network is possible without the use of interfaces. Currently, the Internet of Things (IOT) is a resource for wirelessly enhancing real-world applications. It offers a better time-space connection while also delivering a better optimized outcome. Internet of Things (IoT) delivers a user-interface programme that eliminates errors and blind spots that could impair the system's accuracy. In addition to improving and enhancing consumer involvement, recent technology also enhances the performance of the product and aids robust development of automation technology. Users can all participate and utilize it at the same time, and the data is accurate and trustworthy. IoT provides real-time data that can be used to create a safe and secure environment in which resources can be collected.

V. Conclusion

IoT-based real-time solar charge controllers, including a microcontroller (Node MCU), a PV panel, sensors (INA219 current module, digital temperature sensor, and LDR), a Battery charger module, and battery, are discussed in this work. PV panels' voltage, current, temperature, and light intensity may all be monitored in real-time using a GUI on connected devices in remote locations or far from the control centre utilizing the system's remote monitoring capabilities. For the purpose of this article, research has been done on the current solar charge controller systems in use. A low-cost smart microcontroller can be used to create an IoT-based virtual solar energy monitoring system. Blynk, a cloud-based smartphone application, displays real-time measurements of solar parameters. Optimized results are shown in the monitored parameters, which roughly match the electrical ratings of solar modules tested under Standard Test Condition (STC).

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