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Solar Panel Efficiency Monitoring with Voltage & Current Sensing

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Abstract: *This project aims to develop a measurement of solar energy using Arduino Board technology. In this research, three parameters measured are voltage, current and Maximum Power Point Tracking. The voltage is measured using the voltage sensor because the voltage generated by the solar panel are large for the Arduino as receiver. The current is measured using the current sensor module that can sense the current generated by the solar panel. These parameters as the input value for the Arduino and the output is sent to Thingspeak. Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of producing. ThingSpeak is an IoT analytics platform service that permitsus to collect, visualize and analyze live data streams in the cloud. ThingSpeak gives instant visualizations of the information posted by our devices to the ThingSpeak. The main controlling device of the whole system is an Arduino microcontroller. Solar panel, voltage sensor, current sensor, ESP8266 Wi-Fi module are interfaced to Arduino*

Keywords: Arduino, ESP8266 Wi-Fi module, Solar Panel, Thing speak. Solar energy

I. INTRODUCTION

The impacts of global warming are being felt across the globe. We have to reduce our dependence on fossil fuels and start using clean energy instead. Solar energy is an example of promising renewable sources that is presently being used in the world for meeting rising demands of electric power. This power is the conversion of sunlight into electricity, sunlight is collected either directly by using photovoltaics or indirectly using concentrations of solar energy. In this project a solar panel is used which keeps monitoring the parameters of the solar panel like the voltage, current and Maximum Power Point Tracking. Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of. MPPT is not a mechanical tracking system that "physically moves" the modules to make them point more directly at the sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power. The main controlling device of the whole system is a Arduino microcontroller. Solar panel, voltage sensor, current sensor, ESP8266 Wi-Fi module are interfaced to Arduino. The microcontroller initially measures the voltage and current from solar panel and wind turbine without load connected. Also, the microcontroller measures the voltage and current from solar panel under load conditions. The Arduino microcontroller takes the decision of operating the load through PWM (Pulse Width Modulation) until the maximum voltage is obtained from solar panel without degrading the load performance. The values of voltage and current are to Thingspeak through WiFi module. To perform this intelligent task, Arduino microcontroller is loaded with an intelligent program written using embedded 'C'. An embedded system is a combination of software and hardware to perform a dedicated task. Some of the main devices used in embedded products are Microprocessors and Microcontrollers. Microprocessors are commonly referred to as general purpose processors as they simply accept the inputs, process it and

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give the output. In contrast, a microcontroller not only accepts the data as inputs but also manipulates it, interfaces the data with various devices, controls the data and thus finally gives the result.

Need of Project:

Solar energy is the best available option to solve the energy crises. Where as to enhance the generation capacity and frequent maintenance is very important to get uninterrupted power. Generation of solar panels affects due to dust which settle on panel surface, of any electrical fault. Since solar panels are costly, any damage in the structure or ground surface may cause to break panel or change the direction of panel which may reduce the amount of sunlight collected by panel. Electrical maintenance is also important for solar systems due to fluctuating amount sunlight throughout the day and year, solar panel generated wide range of voltages. With this, changing environmental conditions may damage the wiring. Since the solar energy generation is limited for day time, prediction of generating solar power may help to manage the consumption.

Objective:

- Since solar energy generation system is high cost investment, it must be run at full efficiency. In this project, an automation is performed with the help of sensors to make sure that solar farm run at full efficiency and detect situation in case of any maintenance. Objectives of the project are:
- Measure & monitor power (V*I) generation of each panel.
- Find the faulty panel by comparing generated power with panel capacity.
- Find faulty panel and provide maintenance alert.
- Show all the parameters & alert on webpage using IOT.

II. LITERATURE SURVEY

In “Monitoring Of Solar Panel Based On IOT”[1], panel surface temperature is measured along with voltage generated by panel. By measuring generated voltage panel is rotated into the direction where maximum output is obtained.

“Online multi-parameters electronic monitoring system for solar photovoltaic panel applications”[2] Here author studied effect of dust density, light intensity as well as ambient temperature on panel effectiveness through designing and implementing a simple and easy use electronic monitoring system.

“Design of Solar Panels Efficiency Monitoring System”[3] describes a software based on system architecture for continuous monitoring of solar panels efficiency. The system collects various data, including the surface temperature of the solar panels, degree of power charge, weather information, and other technical data.

Pritam Pokhra[4] deals with the design & analysis of the Automatic Sun Tracking Solar Panel based on open loop concept. The main objective of the project is to harnesses the maximum amount of sunlight from sun and converting it to electricity so that it can be easily used and transferred. This can be done by aligning the solar panel perpendicular to sun rays so that maximum sunlight can be converted into electrical form. As this system give maximum efficiency. The main feature of this tracker is that it is independent of the intensity of sunrays. It directly takes the coordinate of the sun according to its position and align itself according to that. As well as it gives higher efficiency, high reliability. The advantage of this project is to provide access to an everlasting and pollution free source of energy. This project can be used in form of decentralized generation. And when connected to big battery banks then can independently fulfill the needs of local areas.

In Solar Panel Cleaning Robot[5] its stated that the dust particles accumulating on the solar panels will prevent the solar energy from reaching the solar cells, thereby reducing the overall power generation. Power output is reduced as much as by 50%, if the module is not cleaned for a month. In order to regularly clean the dust, an automatic cleaning system which removes the dust on the solar panel is developed. In this paper, the problem is reviewed and the method for dust removal is discussed. A robot cleaning device is developed and it travels the entire length of the panel. A PIC microcontroller is used to implement robots control system. The robot provided a favorable result and proved that such a system is viable by making the robotic cleaning possible, thus helping the solar panel to maintain its efficiency.

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"Solar Energy Monitoring System by IOT"[6] shows that the Internet of Things has a vision in which the internet extends into the real world, which incorporates everyday objects. The IoT allows objects to be sensed or controlled remotely over existing network infrastructure, creating opportunities for pure integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. This technology has many applications like solar cities, smart villages, micro grids and solar street lights and so on. As Renewable energy grew at a rate faster than any other time in history during this period. The proposed system refers to the online display of the power usage of solar energy as a renewable energy. This monitoring is done through raspberry pi using flask framework. Smart Monitoring displays daily usage of renewable energy. This helps the user to analysis of energy usage. Analysis impacts on the renewable energy usage and electricity issues.

III. Methodology

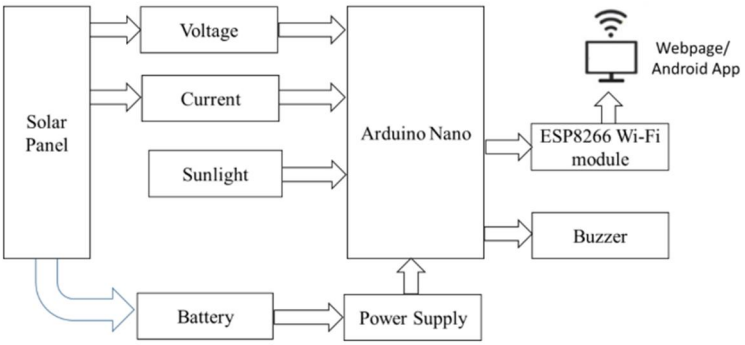

Fig. 1: Block Diagram of System

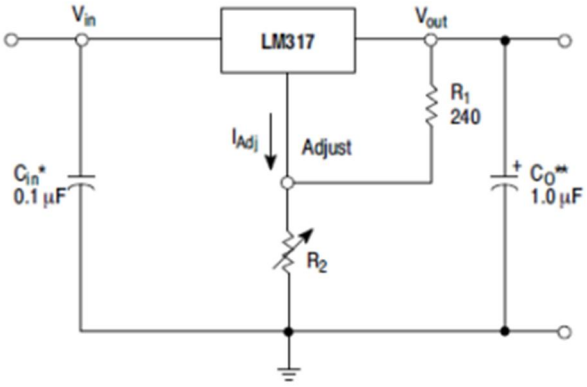

Fig. 2: LM317 Basic Configurations

A current and voltage sensors will be used to measure generating power from solar panel. By detecting generation deficiency, we can found defective panels & improve the generation by completing maintenance on-time. With the help of WIFI module all the parameters & alert will be shown on webpage. All operation will be controlled by arduino Nano. Complete system will be powered through solar panel.

Output of solar panel depends on amount of sunlight fall on it. More sunlight gives more voltage whereas less sunlight cause reduction in output voltage. Maximum output voltage of panel we are using is 18V. Whereas as per the battery requirement, we need constant 13V dc to charge the battery. To satisfy this requirement, an variable voltage regulator IC as shown in figure bellow. A current and voltage sensors will be used to measure generating power from solar panel. By detecting generation deficiency, we can found defective panels & improve the generation by completing maintenance on-time. With the help of WIFI module all the parameters & alert will be shown on webpage. All operation will be controlled by arduino Nano. Complete system will be powered through solar panel In above figure, Cin is required if

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regulator is located an appreciable distance from power supply filter. Co is not needed for stability, however, it does improve transient response. Since $IAdj$ is controlled to less than 100 uA. The error associated with this term is negligible in most applications. As per the requirement of 13V output, consider R1=240 ohm.

A. Solar Panel

A solar panel is actually a collection of solar (or photovoltaic) cells, which can be used to generate electricity through photovoltaic effect and convert them into electricity or heat. A 12V Solar panel is interfaced to the Arduino.

Fig. 3: Solar Panel

B. Voltage Sensor:

A voltage sensor is a device that detects and measures AC or DC electrical pressure (voltage) in a circuit, commonly using a resistive divider to convert high voltages into manageable, proportional analog signals for microcontrollers. Common applications include battery monitoring, power supply testing, and industrial control, with 0-25V DC modules widely used in DIY projects

Fig. 4: Voltage Sensor

C. Current Sensor:

In most of the IoT based projects, SMPS and battery management systems, measuring how much current is flowing in the circuit is paramount. It decides the capacity of the battery to be used and predict the run time. It is also crucial in design of safety systems or any circuit to ensure the correct rating of the components to be selected. The ACS712 20A Current Sensor Module is a Hall Effect based sensor module to determine the current flowing in a given line. It can measure both AC and DC current upto 20A in both directions. Its output when no current is flowing through it is 2.5V and its scale factor is 100mV/A i.e if 10A current is flowing through it then its output will be 3.5V. It also provides isolation from the load so you don't need to worry about putting extra load in the circuit to measure current. . You should select the current sensor module according to maximum current you want to measure. You can also check the 20A Current Sensor and 30A Current Sensor.

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Fig. 5: Current Sensor

D. Arduin Uno :

The Arduino Uno R3 CH340G with USB Programming Cable Combo is a versatile and beginner-friendly development kit widely used for learning, prototyping, and building electronics projects. Powered by the ATmega328P microcontroller and integrated CH340 USB-to-Serial interface, this board allows easy programming without the need for an external programmer. The included USB Type-A to Type-B cable ensures stable data transfer and power supply, making this combo ideal for DIY, robotics, automation, and IoT applications.

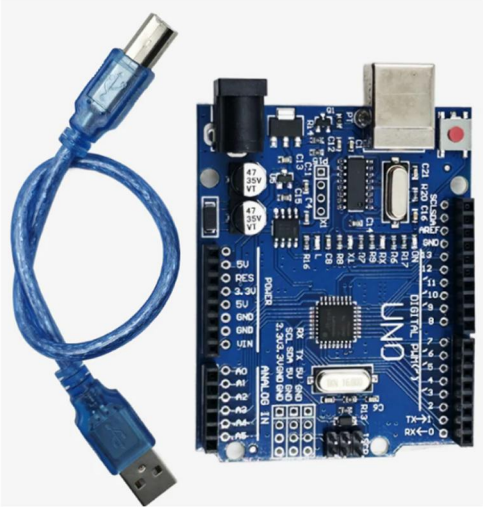

Fig. 6: Arduino Uno

IV. CONCLUSION

We believe that this project will be extremely helpful for increasing the efficiency and maintenance alert for solar power plants. This will ultimately reduce the troubleshooting time and manpower needed for maintenance work. Also with the features of energy generation prediction and cleaning time prediction, it will be easy to manage things. Due to use of IOT, a remote monitoring is possible. In this project by considering all the situations and possibility, we decided the objectives for project and chosen components which are helping to achieve the desire target. Though, design of circuit is critical due to non-availability of some of module in Protius software. Whereas due to the use of Arduino development tools, reduce difficulties during programming & troubleshooting was reduced.

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