Intelligent Remote Monitor and Control Unit of Pv Plant Using Fuzzy Logic Controllerand IoT

G. Madhuri[1], A. Haritha[2], K. Ruchitha[3], P. Nanu [4]

[1]Assistant Professor, Department of Electrical and Electronics Engineering,
Vignan Institute of Technology and Science, Hyderabad, Telangana.
[2,3,4] UG Student, Department of Electrical and Electronics Engineering,
Vignan Institute of Technology and Science, Hyderabad, Telangana.

Abstract

Traditional solar power systems are frequently stand-alone units without any form of remote monitoring or management. These systems may not be able to adapt to changes in the environment since they are not optimised for efficiency. Remote monitoring and control can enable quick response in the event of system faults or underperformance, assisting in ensuring that the solar power system is operating at its best. The design and execution of an IOT are presented in this project. based smart solar photovoltaic remote monitoring and control system that, for optimum performance, makes use of fuzzy logic. A solar photovoltaic system can be remotely monitored and controlled with the help of the suggested system, enabling real-time analysis and adjusting of vital parameters including voltage, current, temperature, and irradiance. The system transmits thestable output to the MPPT while maintaining the stability of the PV plant's output voltage and currents using fuzzy logic. From the plant input, MPPT will deliver the highest output power, which it then transfers to the load. The suggested system offers an attractive alternative for both residential and commercial applications by offering an effective and dependable solution for remote monitoring and control of solar photovoltaic installations.

Keywords:

IOT, Fuzzy Logic, MPPT, Solar (PV)

1. INTRODUCTION

The energy not only has a significant impact on our daily lives but also on the national economy as a whole. Because of the industrial revolution, our everyday needs for energy are growing. The majority of energy generation in a growing nation like India relies primarily on non-renewable energy sources. The progressive depletion of natural resources, including fossil fuels, oils, and other energy sources, is causing civilisation in developing nations to become unsustainable. Additionally, the production of energy from conventional sources contributes to greenhouse gas emissions. To assure reliable, affordable, and clean energy, it has become a global issue to minimise the emission of greenhouse gases like CO2 and CO3[1] In contrast, renewable energy sources are the best way to produce clean and sustainable energy. Solar, wind, hydro, and other renewable energy sources are only a few examples [2].The most effective renewable energy source that has drawn the attention of researchers is the photovoltaic (PV) system. Because there are no moving parts, solar energy is a noise-free, clean, pollution-free, and maintenance-free energy source [3]. However, the use of solar energy is constrained by two significant considerations installation costs and insufficient energy conversion efficiency. The maximum power point tracking system (MPPT) of photovoltaic modules is one of the most efficient ways to boost the efficiency of the photovoltaic power system and gain control over these parameters, which include the cost of solar system installation[4].

To boost the PV module's efficiency, MPPT is utilised to extract the maximum power from it and provide it to the load. The output power of PV modules can be increased using a variety of methods. Constant voltage tracking is one of the techniques. This approach continually adjusts the duty cycle of the DC-DC converter to run the PV module at the predefined point near to the MPPT by comparing the measured PV module voltage with a reference voltage [5]. The CVT (Constant Voltage Tracking) Method is quite straightforward. It can keep track of the maximum power point even in a hazy situation. The P&O (Perturbation and Observation) Method is an alternative technique for determining the PV module's maximum power point.

The P&O Method can be used to measure the voltage, current, and power of the Module. The voltage is then jerked in order to shift towards the maximum voltage. This approach exhibits large oscillations around the MPPT and a sluggish tracking speed. In order to achieve maximum power point tracking, a new method-based MPPT controller is presented in this study. It is necessary to comprehend the properties of a solar module in order to develop a PV panel. The model characteristic of the module is described by an electrical equivalent circuit. There are two forms of resistance in the solar cell. Parallel resistance and series resistance are the two types of resistance. The losses in the current path caused by the metal grid and current connecting bus are linked to the resistance in series. The slight leakage of current along the resistive passage across the p-n junction is represented by other resistance, also known as parallel resistance.

2. BLOCK DIAGRAM

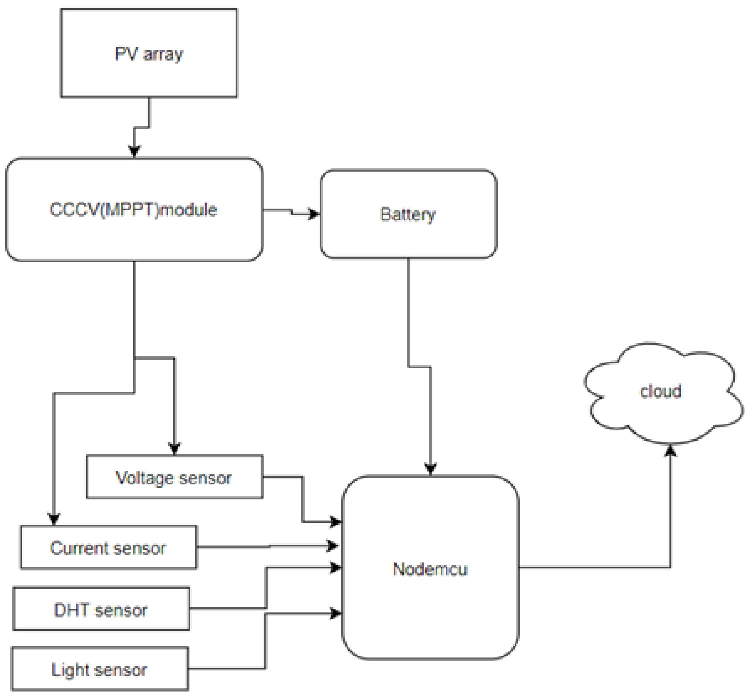

Fig 1 Block diagram

2.1. SOLAR PANEL

Solar cells, the primary component of solar panels, transform solar energy into electrical energy. In order for people to utilise this electrical energy, it must first be transformed and then stored in batteries. The part of solar panels that is most frequently used is crystalline silicon. It is common knowledge that these silicon crystals produce electrical energy (DC) when solar photons or light energy strike them. The solar panel has an output of 23W at 18V.

Fig 2.Solar Panel

2.2. The MPPT based Fuzzy logic controller

Fuzzy Logic Controllers (FLC) have many uses in relation to renewable energy sources. Due to its simplicity, FLC requirements have increased during the past ten years. FLC also handles erroneous input, therefore the controller doesn't require a precise mathematical model. To get the most power out of PV modules, nonlinearity situations are simply handled by FLC. It can operate in every type of weather, regardless of temperature changes or levels of irradiance.

Fuzzy logic controller process can be assorted into three categories:-

1. Fuzzification

2. Rule Evaluation

3. Defuzzification.

Fuzzification, the first category, uses sharp inputs such changes in input voltage levels. Following the receipt of Crisp Input, the stored membership function turns Crisp Input into Fuzzy Input. The first stage of FLC, or fuzzification, occurs after the fuzzy values are designed.

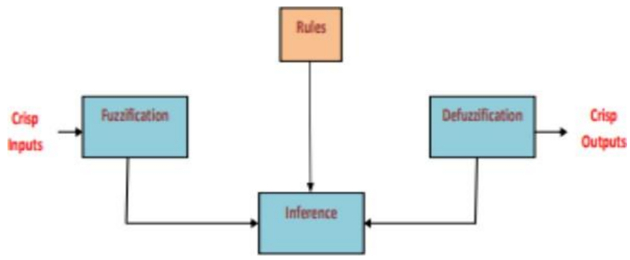

Fig:3 Fuzzy Logic Controller

2.3. DC-DC Buck-Boost converter

Using DC to DC An electrical circuit called a buck-boost converter is used to convert one level of DC to another level. Different types of DC to DC converters exist. The most widely employed DC to DC converter is the Buck-Boost model. By adjusting the switch duty ratios, it is possible to step up or step down the DC to DC voltage. the buck-boost converter's performance while operating in SMPS (Switching Mode Power Supply) Mode. When the duty ratio is less than 50%, the output voltage and vice versa are less than the input voltage. The DC to DC Buck-Boost converter functions as follows: Reverse-biased and not conducting, the diode is in a state when the T1 transistor is turned ON. During the 0 t DTS interval, the transistor T1's activation is investigated.

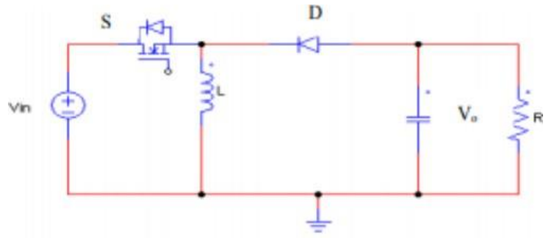

Fig:4 Circuit of Dc- Dc buck booster

The diode is in the conducting mode when the T1 transistor is switched off. It is renowned for operating in constant state. During a single switching cycle, the net charge in the current inductor should be zero. The transistor T1 is then checked during the DTS-t-TS period when it is turned on.

2.4. IOT / Wi-Fi MODULE

This project will be able to connect to Wi-Fi or the internet thanks to the ESP8266 Wi-Fi module. It is a gadget that will give your projects a lot of strength and is cheaply priced. It serves as the interface for any microcontroller and enables wireless projects. It is one of the top gadgets in the ranking of IOT platforms. It will be damaged if you give it 5V because it requires 3.3V to function. The VCC and CH-PD on the 8-pin, 27-ESP8266 must be connected to 3.3V in order to activate the wi-fi. The ESP8266 and Arduino will communicate through the TX and RX pins.

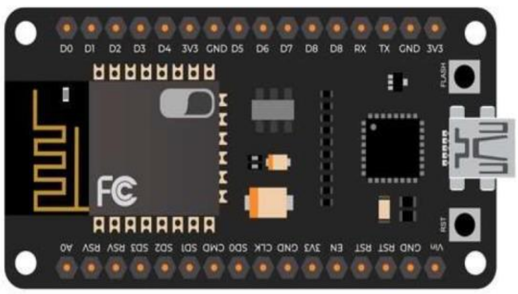

Fig:5 ESP8266 Wi-Fi MODULE

2.5. BATTERY

Batteries are composed of one or more cells, each of which generates an electron flux in a circuit due to chemical reactions. The three primary components of any battery are an anode (the "side"), a cathode (the "side"), and some sort of electrolyte (a material that chemically reacts with the anode and cathode). When the cathode and anode of a battery are connected to a circuit, a chemical reaction takes place between the anode and the electrolyte. This reaction causes the electrons to return to the cathode and experience a different chemical reaction. When the cathode or anode material is exhausted or no longer functional in the reaction, the battery is unable to generate power. As a result, your battery is regarded as "dead." Batteries classified as primary must be disposed of after usage. Rechargeable batteries are referred to as secondary batteries.

Fig: 6 Batteries in a variety of shapes, sizes, and chemistries.

2.6. LOAD

Through the incorporation of IoT, the intelligent control unit can collect and analyse real-time data in order to optimise the output of the fan. For instance, the system can modify the fan's speed or output level to maintain a comfortable environment based on temperature sensors and occupancy sensors. The fan's speed can be changed to give more cooling if the temperature rises, and less cooling if the temperature falls within the required range. This optimisation aids in lowering energy usage and raising system effectiveness as a whole.

2.7. VOLTAGE SENSOR

An object's voltage level can be determined and monitored via a voltage sensor. Voltage sensors can be used to measure both the DC and AC voltage levels. Voltage can be used as this sensor's input, and its output can be in the form of switches, analogue voltage signals, current signals, audio signals, etc.

Fig: 7 Voltage Sensor

2.8. CURRENT SENSOR

A device called a current sensor monitors electric current flowing through a wire and produces a signal corresponding to that current. A digital output or an analogue voltage or current could both constitute the generated signal.

Fig: 8 Current Sensor

2.9 LIGHT SENSOR

sensors for light. Light energy is transformed into an electrical signal by the light sensor, a passive device. Because they transform light energy (photons) into electronic signal (electrons), light sensors are more frequently referred to as photoelectric devices or photo sensors.

2.10 DHT SENSOR

The DHT11 is a serially-connected, single-wire digital humidity and temperature sensor that outputs humidity and temperature measurements. Temperature measurements are provided by the DHT11 sensor in degrees Celsius and relative humidity values in percentages (20 to 90% RH).

3. WORKING OF PROPOSED SYSTEM

In order to maximize the effectiveness and performance of the PV system, an intelligent remote monitoring and control unit of a photovoltaic (PV) plant employing a fuzzy logic controller and the Internet of Things (IOT) combines a number of different technologies. Here is a general description of how such a system may operate Integration of sensors: Sensors are installed in the PV plant to keep an eye on a number of metrics, including solar irradiance, outside temperature, PV panel temperature, voltage, current, and power production. Real-time information regarding the plant's operational state is provided by these sensors. Data collection: Using Internet of Things (IOT) communication protocols like MQTT (Message Queuing Telemetry Transport) or HTTP

(Hypertext Transfer Protocol), the sensor data is gathered and sent to a central monitoring system. Through the data collecting procedure, a central control unit may remotely monitor the PV facility. Fuzzy Logic Controller (FLC): To analyze the gathered sensor data and reach wise conclusions, the central control unit uses a fuzzy logic controller. A mathematical technique called fuzzy logic can handle ambiguous or unclear data and imitate human decision-making. The FLC transforms the sensor data into control actions by applying a set of predefined rules and membership functions. Decision-Making: When making judgments on how to operate the PV plant, the FLC takes into account a number of variables, including solar irradiance, temperature, and power output. For instance, based on the weather, it can choose the best power output level, the best tilt angle for solar panels, or when to turn on cooling systems. Control signals are created from the FLC's decisions and sent back to the PV plant as control signals. These signals can change variables such as solar tracking system positioning, inverter power output, or cooling system activation.

Remote observation: The PV plant provides feedback to the central control unit on a continual basis to assess the efficacy of the control signals. The plant's performance is tracked using this feedback data, which also aids in finding any errors or anomalies. Performance Optimization is Based on past and current data, the FLC continuously learns and modifies its control rules. By taking into account the altering environmental conditions and plant parameters, the system is able to optimize the performance and efficiency of the PV plant over time. User Interface: A user interface, such as a web-based dashboard or a mobile application, can be used to access the intelligent remote monitor and control unit. Real-time data visualization, performance statistics, and the option to change system settings or overrule control choices are all provided via this interface. An intelligent remote monitor and control unit for a PV plant can boost energy production, improve fault detection and maintenance procedures, and improve overall plant performance by integrating IOT connectivity, sensor integration, fuzzy logic control, and remote monitoring.

5. ADVANTAGES

1. Monitoring of solar plant is easy.
2. Maximum power point can be tracked easily.
3. Solar panels can be continuously monitored.

4. Constant output voltage can be maintained.

4. COMPARISION BETWEEN EXISTING AND PROPOSED SYSTEMS

EXISTING SYSTEM	PROPOSED SYSTEM
Traditional solar power system do not have mechanism for remote monitoring and control	The proposed system is a IoT-based solar photovoltaic remote monitoring and control system that utilizes fuzzy logic controller
This system is not optimizer and may not be able to adapt to changes in environmental conditions.	The system can adapt to environmental changes as we use fuzzy algorithm to maintain the required output irrespective to the atmospheric conditions
The data analysis cannot be done using the data acquired through wifi module	The acquired data through the wifi module is analysed and provides the characteristics of the different parameters over a period of time.

6. RESULT

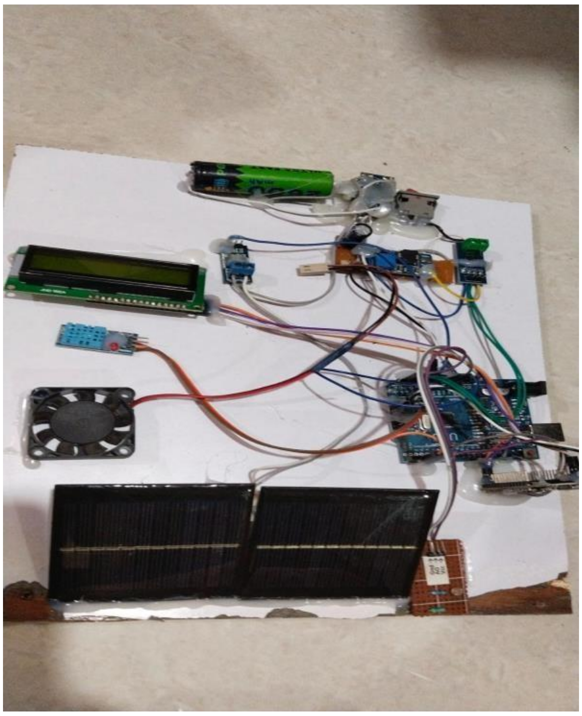

Fig: 9 Output model of the project

Fig: 10 Output Parameters of IOT

7. CONCLUSION

In conclusion, a photovoltaic (PV) plant's intelligent remote monitoring and control unit can profit from the combination of a fuzzy logic controller, the Internet of Things (IOT), and Maximum Power Point Tracking (MPPT) technology. With the help of this cutting-edge equipment, the PV plant can be remotely monitored, its performance is optimised, and its energy efficiency is increased. The IoT connection enables remote access and sophisticated analytics, the fuzzy logic controller optimises numerous settings based on input data, and the MPPT technology assures maximum power extraction from the solar panels. Additionally, the system offers proactive maintenance alerts, problem detection and diagnostics, and flexibility for future expansions. Overall, this intelligent remote monitoring and control unit equips operators with the knowledge they need to make informed decisions, maximise energy output.

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