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Smart Solar Inverter with IoT

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A B S T R A C T

This Paper describe the design and develop of a solar inverter with efficient solar energy capturing using maximum power point tracking and load control using IoT. The battery charge level, health, electrolyte levels, and battery drain time, are measured using sensors and a potential divider circuit that is connected to an Arduino, and the information is displayed on an LCD display and a cloud website.

Keywords: Solar, IoT, Wi-Fi,, Arduino.

Introduction

In this paper an IOT enabled solar smart inverter is design concept is mentioned that uses Wi-Fi technology to involve e a two way communication with the user and equipment is used. The battery voltage of the inverter as well as utilization time of the loads which the user chooses to run will be communicated to the observer. The observer can control the loads without wiring by using smart communication device, thus will enable the efficient utilization of energy and also increases human comfort. So it is necessary to create an IoT-enabled solar smart inverter that uses Wi-Fi technology to engage a two-way communication with the user and equipment. The Battery State of Charge, electrolyte level, and run time of the load on the battery are communicated to the user. The user can control the connected load wirelessly employing a mobile application. This will enable the efficient utilization of energy and also upgrades human comfort. An Arduino Uno with Node MCU which runs on the ESP8266 Wi-Fi module is often used to implement the aforementioned objectives. The output power from solar panel can be maximized by making use of an MPPT system, to obtain high power.

1.1 Objectives

1. This paper gives the idea of design and develops a solar inverter with efficient solar energy capturing using maximum power point tracking and load control using IoT concepts.

2. The battery charge level, operating voltage, current, electrolyte levels, and battery drain time, are measured using sensors and a potential divider circuit that is connected to an Arduino controller, and the information is displayed on an LCD display and a cloud website.

2. Literature Survey

The Literature Survey is carried out by referring various standard papers.

Author **Gopal G Menon, et.al** proposes an IoT-based solar smart inverter. In this work, a single axis solar tracking mechanism is used to maximize efficiency. It uses a 12V battery for storing the generated voltage, which also consists of a battery charge indicator system using a potential divider circuit. For connecting the battery to the loads, a square wave inverter is used. Loads are controlled using Node MCU based on the ESP8266 wi-fi module [8].

Authors **M. G. Villalva, et.al** propose that "maximum power point tracking mechanism can increase the efficiency of the system by approximately 30% than overcharge controllers that do not implement MPPT. And the frequently used algorithm is the Perturb and Observe technique. The common reason is that the Perturb and Observe (P&O) algorithm is low cost digital device ensuring robust and good efficiency. [9]

Author **Hend Abd El-monem Salama, et.al** presents solar system development in a lab. In this paper system under study uses a hard and fast solar module and it's converted into a dual-axis tracking module. A dual-axis tracker can trace the sun vertically and horizontally through optimum light sensors connected to the system. Maximum power point tracking (MPPT) solar model has been incorporated to reduce the cost system of tracking the panel, when compared with other methods of solar - tracking systems. [12]

3. System Design

The proposed system for IOT enabled solar smart inverter is as shown in figure 1

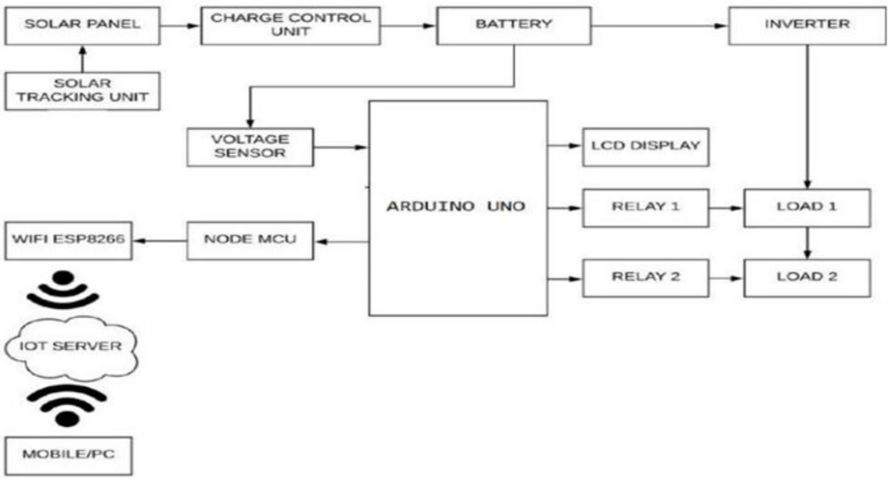

Fig 1 Proposed System design for smart solar inverter with IoT.

3.1 Software Requirement

Arduino IDE:

Arduino IDE is open source software that is mainly used in coding. It is official software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process. The main code, also known as a sketch that is created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board. The IDE environment consists of two main parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module.

3.1.1Thing Speak:

Thing Speak™ is an IoT analytics service that allows user to collect, observes, and analyze real data streams in the cloud. Thing Speak provides real mode of data posted by your devices to Thing Speak. With the ability to execute MATLAB® code in Thing Speak, the user can perform online analysis and process data as it comes in. Also beside this, Thing Speak is often used for prototype model design..

The user can send data from any internet-interface device directly to Thing Speak using a Rest API or MQTT.

3.2 Hardware Requirements

3.2.1 Arduino UNO Board

The Arduino UNO is one of the most used microcontrollers in the industry and telecommunication Sector. This device is very easy to handle compact and user friendly. The coding of this device is very simple. The programing of this microcontroller is very easy and code can embedded easily. The applications of this microcontroller in various fields like security, home appliances, remote sensors, and industrial automation. This microcontroller has interface adaptability with the internet and perform as a server function ..

3.2.2Processor Node MCU ESP 8266

Node MCU is an Internet of Things (IoT)-consist of open-source Lua-based firmware and development board. This device includes software for Systems ESP8266 Wi-Fi module as well as hardware for the ESP-12 . The major advantage for choosing this device is that it has low cost and includes a built-in Wi-Fi module. Because it is similar to Arduino, it can be programmed using the Arduino software. It has ten General Purpose Input-Output pins for connecting to external devices.

The ESP8266 Wi-Fi Module is Embedded SOC with integrated TCP/IP protocol stack that can give any microcontroller interconnectivity to given Wi-Fi network. The ESP8266 is capable of either performing an application or connecting all Wi-Fi networking functions from another application processor.

3.2.3 Wi-Fi Module –

The ESP8266 Wi-Fi Module is a self-contained SOC embedded TCP/IP protocol stack that can give any microcontroller access to available Wi-Fi network. The ESP8266 is capable of either hosting an application to all Wi-Fi networking functions from another application processor. Node MCU is an Internet of Things (IoT)-based open-source Lua-based firmware with development board. This Device includes software for Systems' ESP8266 Wi-Fi SoC as well as hardware for the ESP-12 module. The main objective for selecting this device is that it has low cost and includes a built-in Wi-Fi module. As it functions as Arduino; it is programmed using the Arduino IDE software. It has ten General Purpose Input-Output pins for connecting to peripherals.

3.3 Sensors used in System

3.3.1 Temperature and Humidity Sensor (DHT11):

The DHT11 is a mostly used Temperature and humidity sensor in electronic measuring system. The sensor comes with a inbuilt Negative Temperature coefficient thermistor to measure temperature and produces serial output data for eight bit microcontroller. The sensor is calibrated with standards and easy to connect with other microcontrollers.

3.3.2 Voltage Sensor:

A voltage sensor is a transducer used to calculate and monitor the amount of voltage in an invertor . This sensor determines the AC voltage or DC voltage level. The input of this sensor is the voltage, And it has capacity to sense the voltage up to 25 volts.

3.3.3 Relay:

The relay is Electromechanically Device. The relay is a hardware device used for remote device switching. It has capacity to perform remote control of devices over a network. Devices are often remotely powered on or off, when a pulse is provided to the relay module. In this proposed model the a Single channel isolated 5V, 10A relay module is used. The processors like Arduino, AVR, PIC, ARM can easily interfaced with the relay and control the on-off operation of sensors and devices. It can also control various appliances and other equipment generally works on electromagnetic principle which requires high current.

Storage and Conversion of Energy: This consists of a charge controller for charging the battery at a normal voltage and an Inverter performs conversion of voltage from DC to AC voltage.. For indication purpose it contains a LCD display connected with arduino for observing battery charge status in terms of percentage volt..

Transmission of Energy to the loads: This device consists of the IoT module for operating and controlling various loads like lamp sensors motors switches etc. using Relays, also called Home Automation.

4. Working

The working of the proposed system is briefly disused as follows.

The Photovoltaic voltage generated by solar module is a variable voltage. This output is then given to a Charge controller circuit to give a constant DC output voltage of approximately 15 V. The 12V battery is charging with this voltage if the input voltage is in the range of 12.7 V to 14 V. for calculating battery voltage a potential divider (Resistance array divider)is used and that is connected to an Arduino followed by the Node MCU ESP8266 which is used as a Wi-Fi Module to obtain output from the Invertor system and transmit this output to the cloud servers. The figure 2 shows the Smart Solar Invertor with IoT.

The specification of solar panel used is 100W and 230V inverter converts the DC voltage to AC voltage of frequency 50 Hz. This output is connected to a 5V relay which in turn is connected to processor based on ESP8266 Wi-Fi module. The observer or reader can select which loads to be working with the help of a mobile app connected to the IOT server. When the observer r selects the load to be run, the relay operates and the load get connected to system.

The inverter used in this design concept is a 100W inverter. It converts 12V DC to 230V AC. The output wave obtained is an alternating square wave of frequency 50Hz.The type of wire used in transformer winding is SWG.

The inverter, is connected to the 12V battery. This 12V is directly applied to the center tap of the primary (12-0-12) side of the transformer with 2 Amp and gives a maximum output of 5 W. IC4047 acts as pulse width modulation circuit and also it is a Voltage Regulated IC.The RC tank circuit connected to the IC is used for setting the desired frequency of the output. In this case the desired frequency is 50Hz. The variable resistor in RC tank circuit is varied for attaining the desired frequency.

Fig.2 Working Diagram of IoT Enabled Solar Smart Inverter

5. Results

As per mentioned in system the brief discussion about the results are as follows. The inverter's battery is charged using a solar panel, making it an eco-friendly power generator. Since the definition of a smart inverter is that it is a new generation of inverter using renewable energy, the inverter is a smart inverter having a wireless operating system with which a user can control home devices and appliances without wiring connection able to display the battery parameter like voltage, current, temperature as well as inform the operator about threshold levels of the various electric parameters.. The battery voltage value and run time of the loads are known to the operator which helps the operator to select particular loads that to be switch on. And thus loads were connected and controlled without any wiring connection. The mobile app with various data monitoring was used to control the loads wirelessly and monitor the battery voltage and run time of the loads.

The ESP8266 Wi-Fi Module is embedded with other wireless smart devices such as Smart phones with real time monitoring.

AT commands are executed to control the devices and various connected load. The executed result is displayed on the display with Thing Speak website and the electrolyte level in battery is displayed in percentage in a gauge meter.

5.1 Working Model-

The fig 3 shows the working model of Smart solar invertor

Fig 3 Smart Solar Inverter with IoT Working Model

6. Conclusion

From the design and implementation of proposed work it is concluded that IoT based Smart controlled inverter is implemented by considering new concept with existing inverter with bidirectional (Duplex) communication with the operator and thus by managing power the power can save with intelligent technology . Based on the requirement point of view, operator can control appliance

at the time of mains power failure, simultaneously operator can monitor the load current of the inverter. This prototype model idea gives deep insight into working of a self-sustaining and reliable system for monitoring and controlling loads using existing load current. This works on green energy principle that requires only few investment in solar panel and the smart controlled inverter system is developed at low cost with reliable operation. A consumer generates enough energy for himself and uses it accordingly with an environment friendly system. Hence in the work, Eco-friendly IoT based smart controlled inverter is proposed to control the various appliances in the home or Industry as per load condition and get information of all parameter on cloud through Wi-Fi.

6.1 Future work

This prototype gives idea about working of a self- sustaining and low cost system for home automation and monitoring power consumption of household appliances. Hence for future prospect the implementation of this work is possible with large scale and its data can available on cloud so it is possible to analyse with various parameter. This system requires only initial stage investment in solar panel and the smart inverter system is developed at low cost.

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