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Original Article

Iot-Based Monitoring and Management System for Optimizing Solar Panel Performance

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Abstract: *This project introduces an IoT-based system for the monitoring and management of solar panel arrays within electrical systems. The solution utilizes IoT technologies to enable real-time tracking and control of solar panels, optimizing their performance and ensuring efficient energy generation. The system incorporates smart sensors to measure key parameters such as solar irradiance, panel temperature, and electrical output. Data is transmitted via wireless communication to a centralized platform where it is analyzed to provide insights into system performance and potential issues. Predictive analytics and automated alerts facilitate timely maintenance and adjustments, enhancing the reliability and longevity of the solar panels. This IoT-based approach not only improves the management of solar energy systems but also supports the broader goals of energy efficiency and sustainability by ensuring optimal operation and reduced operational costs.*

Keywords: *IoT Solar Monitoring. Solar Panel Optimization, Smart Solar Management. Real-Time Solar Analytics, Energy Efficiency, Solar Performance Tracking, IoT Energy Management.*

INTRODUCTION

Embedded physical devices, such as household appliances are becoming smarter and smarter. They are equipped with embedded microprocessors and wireless transceivers, offering limited communication capabilities and providing smart behaviour. Everyday objects are fitted with small, cheap mobile processors, sensors and actuators. Sensors and wireless sensor networks are being deployed in smart home solutions, measuring with precision the environmental conditions inside the home environment. Their advanced sensing functionalities and their increasing accuracy enable the development of smart home applications that offer advanced automation. Residences are transformed into smart homes, incorporating embedded sensors and actuators, and pervasive technology. This merging of computing with physical objects introduces the concept of information appliances, defined as devices or machines, designed to perform some specific functionality but are usable, at the same time, for the purposes of computing. Typical examples of computing devices include smart phones, embedded sensors and actuators. As Donald A. Norman points out, "the trend in computing is towards simplicity through specialization". This trend seems to justify Mark Weiser's vision of the Disappearing Computer, according to which "the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it". These augmented appliances, when interconnected, they can form wireless networks, extending residential areas into smart pervasive environments.

EXISTING SYSTEM

Internet of Things (IOT) has developed rapidly and has been applied to support applications in various fields such as environmental protection and military solar power monitoring. IOT nodes connect and communicate with each other through sensing and perception. In addition, they can combine into a large scale of IOT sensing networks. Generally, the collaboration and cooperation of IOT nodes sense the surrounding environment, which can effectively compensate for the shortcomings of current atmospheric environmental solar power monitoring technologies, and achieve real-time solar power monitoring in accident-prone areas, important industrial parks and densely populated areas.

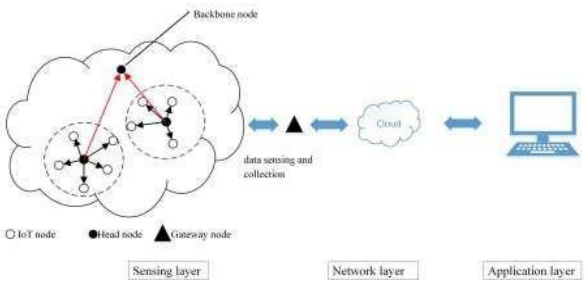

Figure .2.1. Internet of Things (IoT) architecture.

2.1 WIRELESS SENSOR SOLAR POWER MONITORING (WSM)

The nodes in the entire sensing networks are actived, and each node communicates with the backbone node in real time. When a leakage occurs, nodes can quickly detect the abnormal situation, and can quickly locate the dangerous area, then determine the dangerous boundary according to its own situation (abnormal or normal). In Fig. 2, the shaded are presents the abnormal region, the white circles represent the normal actived nodes, the green circles refer to abnormal nodes, and the orange circles represent the boundary nodes.

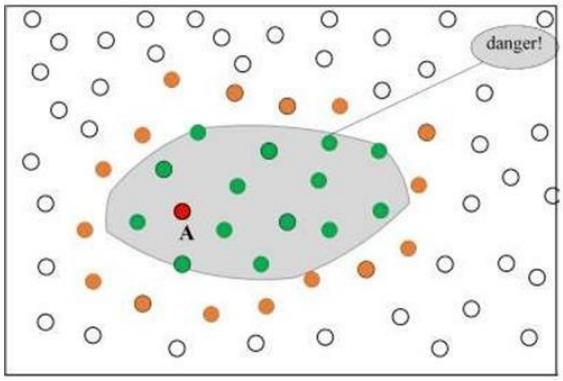

Figure.2. 2. Hazardous areas detected by the method of WSM.

Where, the boundary node is defined as a given node whose measured value is lower than the set threshold and there is at least one abnormal node in its one-hop neighbor nodes under the premise of missing node in the sensor network. These boundary nodes contain the whole dangerous area inside to ensure security. This method can identify the dangerous areas in a short time, but the network lifetime is short because the nodes are in the working state for a long period of time and the battery energy consumption is higher.

PROPOSED SYSTEM

The AC load is given to the main system. This system contains the meter which receives the signal in continuous form. The controller is the heart or the brain of system; it coordinates the functionality of other parts of the system. It can be any of the microcontrollers; for this research an Arduino microcontroller was used for easy prototyping, implementation and emulation of embedded systems. Figure 3.1 Block Diagram of the Proposed Method. The power fluctuations are monitored using the current sensor and voltage sensor which is fed to the microcontroller. Relay is an electromagnetic switch which operates on small electric current that turn on or off a much larger electric current. The live reading is displayed on LCD. For transferring the data through Node Mcu. The authorized person continuously receives the notification regarding consumption of power on the smart app that power.

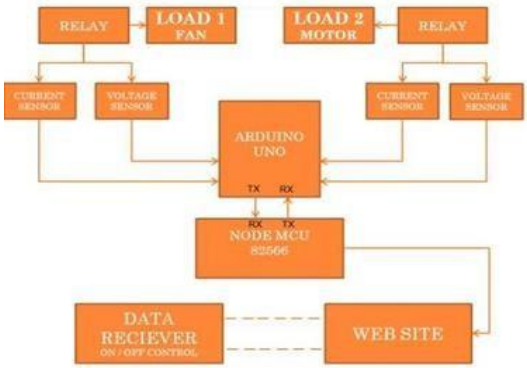

Figure 3.1 Block Diagram of the Proposed Method

HARDWARE MODULE-WISE DESCRIPTION

4.1 Arduino Microcontroller:

Arduino is an open-source gadgets stage dependent on simple to-utilize equipment and software. Arduino sheets can peruse inputs - light on a sensor, a finger on a catch and transform it into a yield turning on a LED. Through the Arduino board we can get a hint of what to do by sending a set of instructions to the microcontroller on the board and for this we use programming language which is basically a me as C programming and also we can use the Arduino Software (IDE), based on processing. This microcontroller can work with various communication technologies and sensors. Due to its simplicity and availability of number of hardware extensions, the board can be used with utmost efficiency.

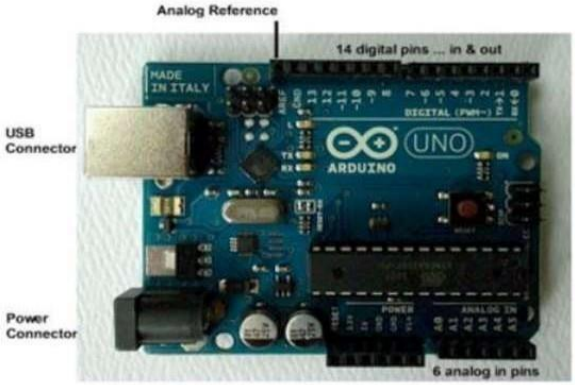

Figure 4.1 Arduino microcontroller

Pin Category	Pin Name	Details
Power	Vin, 3.3V, 5V, GND	Vin: Input voltage to Arduino when using an external power source. 5V: Regulated power supply used to power microcontroller and other components on the board. 3.3V: 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA. GND: ground pins.
Reset	Reset	Resets the microcontroller.
Analog Pins	A0 – A5	Used to provide analog input in the range of 0-5V
Input/Output Pins	Digital Pins 0 - 13	Can be used as input or output pins.
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data.
External Interrupts	2, 3	To trigger an interrupt.
PWM	3, 5, 6, 9, 11	Provides 8-bit PWM output.
SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication.
Inbuilt LED	13	To turn on the inbuilt LED.
TWI	A4 (SDA), A5 (SCA)	Used for TWI communication.
AREF	AREF	To provide reference voltage for input voltage.

Table 4.1 Pin description of Arduino

4.2 Wifi Module:

The Wifi module we are using in this model is Node Mcu. It is an open source IoT platform. It is a SoC(System on a chip) produced by Express-if Systems, and hardware which is based on the ESP-12 module. The meaning of

the term Node MCU by default refers to the firmware rather than the development kits. The Lua scripting language is used by the firmware. It can be programmed directly through USB port using LUA programming or Arduino IDE.

Figure 4.2 Wi-Fi module NodeMCU

4.3 Current Sensor:

ACS712 current sensor is used in power solar power monitoring system. It provides precise solutions for AC or DC current sensing which is suitable in industrial, commercial, and communications systems.

Figure 4.3 Current Sensor

4.4 Voltage Sensor:

A voltage sensor is a sensor used to calculate and monitor the amount of voltage in an object. Voltage sensors can determine the AC voltage or DC voltage level. The input of this sensor is the voltage, whereas the output is the switches, analog voltage signal, a current signal, or an audible signal.

Figure 4.4 Voltage Sensor

4.5 Internet Of Things (Iot):

IoT is an ecosystem of connected physical objects that are accessible through the internet. To transfer information wirelessly for power consumption solar power monitoring and controlling NodeMCU Wi-Fi module is used. The NodeMCU development board is a powerful solution to program microcontrollers and be part of the

Internet of Things (IoT). Here for solar power monitoring power the IoT ESP8266 modules take the calibration pulse from meter and perform necessary operations afterward it sends the required information like no. of units or power is on limit or not etc. in blynk server from there it continuously notified to the authorized person about the detail of consumption of power.

4.6 Solar Panel Monitoring:

As the world now is turning towards renewable energy sources and countries like Iceland have obtained 100% renewable energy status and India has also started to lean towards renewable energy, moreover rooftop solar panels are becoming a trend nowadays but In order to know how efficiently the solar photovoltaic system is working and for performance evaluation there should be some monitoring system. Therefore here we propose a system using a microcontroller and internet of things technology using sensors to monitor the parameters of the solar photovoltaic system remotely from anywhere using smart phones and computers using web server. Some solar photovoltaic systems are located in inaccessible locations and it is difficult to monitor it and the solar panels are not utilized to its full efficiency all day ,in order to achieve the solar panel must absorb maximum sunlight every instant , in order to achieve it here we propose a sun tracking technology to control the solar panel and rotate it so it absorbs maximum sunlight every instant .The system is based on a new cost effective technology using a microcontroller and internet of things technology monitors and controls the solar photovoltaic system remotely from anywhere around the world.

4.8 Software Design:

Flowchart:

The flowchart in figure 4.4 has clearly defining the actual design steps for power consumption solar power monitoring and controlling system. Here, once the device is power ON all components will initialized. The system will check the connectivity interface is in proper working condition. If the connectivity interface is working properly, then the IoT ESP8266 WI-FI module continuously checks the availability of internet connection for transferring meter status wirelessly to the Blynk server. When the internet connection available matches to the default connection at that time the WI-FI module is ready for receiving the meter reading from the system and transferring meter status to the Blynk server. If internet connection does not match it retry again. After WI-FI module connected the continuous notification will generate on the Blynk application which is installed on the authorized person cell phone or in their PC .It helps to check meter status at any time.

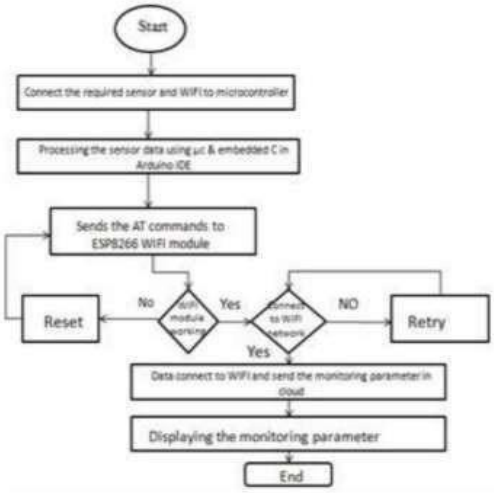

Figure 4.7 Process Flow for Sending Meter Status

The system constantly check if the power consumption occurred is on the limit of meter or not.

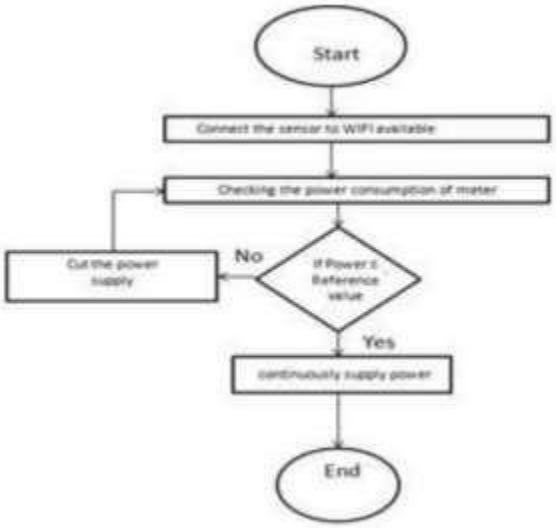

Figure 4.8 Flowchart for Disconnection and Reconnection

As shown in figure 4.8. If the power is beyond the limit of meter, the sensor will send a signal to the processor which in turn triggers the connectivity interface to send notification on the Blynk application to the authorized person of electricity board section that meter has been using high amount of power. At the same time it cut out the power supply of the whole colony. In this way the power solar power monitoring of the whole area will be monitored.

CONCLUSION

With the help of designed model power consumption of a customer is monitored. When the user exceeds his limit of power consumption the supply of power will cut off automatically. The usage of every consumer in the region or sector is sent to the blink server. Supplier will be notified about the power consumption of the entire region or sector. The supplier can monitor and control the power usage of the user as well as the entire region. The power consumption data sheet of the entire region is generated and analyzed using lab view. If the generated data is provided to the customers, they can compare their usage with the data sheet. So this will help to identify the fraudulent user who is stealing the user's power by direct hooking method. As the Indian Government has also proposed formation of Smart Cities which will have an effective energy management, transportation, waste disposal and resource conservation strategy using primarily Internet of Things. This wireless IoT based technique

is much useful to detect the stealing of the electricity worldwide. So in this work variable voltage and variable power will set according to electricity board section as well as it provide safety as the limit of meter will change by the authorized person.

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