Web Server Based Solar Parameters Monitoring using Arduino

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ABSTRACT
Nowadays renewable energy systems are becoming best way to generate electricity. With advancement of technologies the cost of renewable energy equipment is going down globally encouraging large scale solar photovoltaic installations. Major part of renewable energy is solar energy. The implementation of new cost effective methodology based on technology to monitor a solar parameters for performance evaluation using open source tools and resources like Arduino and local Web Server which provides data on Web to monitor the parameters. Local Web provides all services for free of cost and monitoring can saves lot of investment on Web designing and maintenance. This focus on low cost system with easy interface so that common people who installs roof top solar plants also monitors easily without depending on service providing companies. This will facilitate preventive maintenance, fault detection of the solar panel in addition to real time monitoring. This research details the development of an open-source device to monitoring system for remote solar panel systems.

KEYWORDS: Solar; Arduino; Photovoltaic; Web Server

I. INTRODUCTION
Rising fossil fuel and burning fuel such as coal, global warming and severe weather condition have compelled many nations to look for alternative sources to reduce reliance on fossil based fuels. Solar energy is one of the most promising renewable sources that is currently being used worldwide to contribute for meeting rising demands of electric power.

Solar power is a conversion of sunlight into electricity, sunlight was collected either directly by using photovoltaic or indirectly using concentrated of solar energy.

Over the last decade, remote monitoring and controlling gained popularity in industrial and academic community also generating power using solar cells has been developed rapidly and in parallel of solar panel systems becoming widespread in power generation systems in all around the world.

This system is designed to monitor the solar panel parameters like the temperature, voltage, light intensity and current are monitored using Arduino UNO, Ethernet and web development. Environment temperature is measured by temperature sensor LM35.Voltage is sensed by voltage divider principle. The light intensity is monitored by using LDR sensor and load current is measured using ACS712 current sensor. The analog output of these sensors are fed into the ADC Channel of Microcontroller. After calculation all these data are displayed on Web Server interface that is a cross-platform on a device with web browsing capabilities like PC.

II. LITERATURE SURVEY
Author Kabalci, Ersan, Alper Gorgun, and Yasin Kabalci[1], introduces an instant monitoring infrastructure of a renewable energy generation system that is constituted with a wind turbine and solar panel arrays. The monitoring platform is based on current and voltage measurements of each renewable source. The related values are measured with the developed sensing circuits and processed by an 18F4450 microcontroller of Microchip. The processed parameters are then transmitted to a personal computer (PC) over universal serial bus (USB) to be saved in a database and to observe the system instantly. The coded visual interface of monitoring software can manage the saved data to analyze daily, weekly and monthly values of each measurement separately.

Suprita Patil, M. Vijayalashmi And Rakesh Tapaskar [2] describes the about iot that is used for solar power monitoring. The system has arduino and pi and others such as voltage and current sensing circuits. In the system, the arduino is used to measure the parameters. And these results are send to PI. It has Wi-Fi service to connect to cloud by using internet. So the solar power parameters reach the cloud. The user can be monitoring the data anywhere there has internet.

Bimal Aklesh Kumar[3] introduces about the web based system that can be applied in area of solar power system. The author describes about how to implement web server development. That have language to development of the web technology. The database is need to store the solar power system. And he also describes about the benefits of the web based monitoring system.

A. WEB BASED MONITORING
In order to make a web based monitoring system,the following technology must be used; HTML, Java and web server. In order to observe and control the system while

working one computer has been used and already present and LAN line is connected to the internet.

HTML - which stands for Hypertext Markup Language, is the predominant markup language for web pages. HTML elements are the basic building-blocks of webpages.HTML is written in the form of HTML elements consisting of tags, enclosed in angle brackets (like html>), within the web page content. HTML tags normally come in pairs like <h1> and </h1>. The first tag in a pair is the start tag, the second tag is the end tag (they are also called opening tags and closing tags). In between these tags web designers can add text, tables, images, etc.

Java - is a programming language originally developed by James Gosling at Sun Microsystems (which is now a subsidiary of Oracle Corporation) and released in 1995 as a core component of Sun Microsystems' Java platform. The language derives much of its syntax from C and C++ but has a simpler object model and fewer low-level facilities. Java applications are typically compiled to byte code (class file) that can run on any Java Virtual Machine (JVM) regardless of computer architecture.

Java Server Pages (JSP) - JSP technology enables web developers and designers to rapidly develop and easily maintain, information-rich, dynamic web pages that leverage existing business systems.

Web Server - can refer to either the hardware (the computer) or the software (the computer application) that helps to deliver content that can be accessed through the Internet.

The most common use of web servers is to host web sites but there are other uses like data storage or for running enterprise applications. The primary function of a web server is to deliver web pages on the request to clients. This means delivery of HTML documents and any additional content that may be included by a document, such as images, style sheets and scripts.

Data Logger is an electronic device that records data over time or in relation to location either with a built in instrument or sensor or via external instruments and sensors. Increasingly, but not entirely, they are based on a digital processor (or computer). They generally are small, battery powered, portable, and equipped with a microprocessor, internal memory for data storage, and sensors. Some data loggers interface with a personal computer and utilize software to activate the data logger and view and analyze the collected data.

Database is an organized collection of data for one or more purposes, usually in digital form. The data are typically organized to model relevant aspects of reality (for example, the availability of rooms in hotels), in a way that supports processes requiring this information (for example, finding a hotel with vacancies). The term "database" refers both to the way its users view it, and to the logical and physical materialization of its data, content, in files, computer memory, and computer data storage.[3]

Tim Youngblood describes How to Use an Arduino as a Web Server. The author tells the basic requirement of the implementation of arduino based webserver. The hardware and software must be desired [4]. To implement this type of the system, the controller and network card are required.

III. THE PROPOSED SYSTEM
The figure 1 shows the proposed block diagram of Web Server based Solar Parameters Monitoring using Arduino. In this system the battery acts as load to monitor the voltage and current of rate of charging values. So this system has voltage and current sensing circuits which monitor the solar panel generate the power. the solar power that depends on the light intensity and temperature to get maximum power. So the values must be known and monitored in the solar power system. All sensing circuits of the solar parameters are directly connected to the controller. In this system, the arduino acts as the main controller. Sensing circuits are directly connect to analog input of Arduino. The pc and Arduino is attached using Ethernet cable via Ethernet shield of Arduino.

IV. IMPLEMENTATION OF THE PROPOSED SYSTEM
As shown in figure 1, the system is combined with software development and hardware installation. First of all choose the source what size of panel is needed by researching what watts of the device or devices are powering and then the battery is going to power of systems. The voltage stored in the battery is connected in parallel with the voltage divider. Voltage divider is usually use two resistors connected in series and the input voltage applied across the resistor pair and the output voltage emerging from the connection between them. Why use the voltage is to reduce the voltage from solar and the Arduino can stand 5V. Battery is then connect in series with current sensor (ACS712).
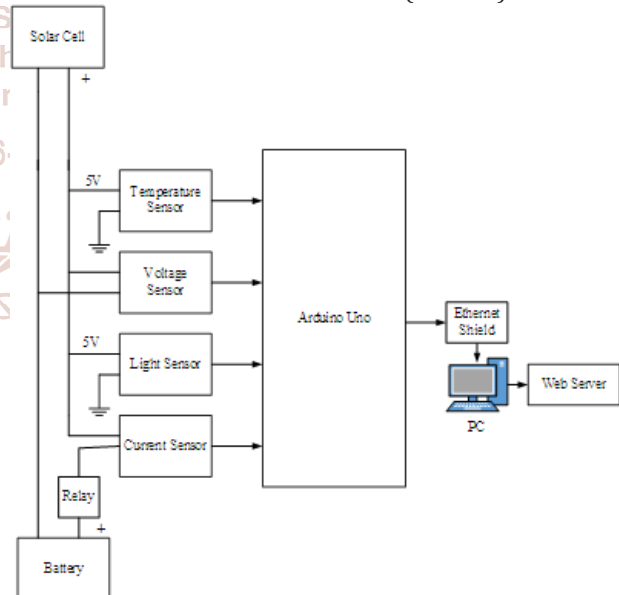
Figure1: The Proposed System of Web Server based Solar Parameters monitoring using Arduino.

To monitoring of four parameters like temperature sensor, voltage divider, light sensor (LDR) and current sensor (LM35) are connected to the Arduino analog input pin. In this circuit, all parameters are in the analog form. The system need to convert them in digital form. The result values show in local website when the network connection is via Ethernet shield with LAN cable. An arduino received the data form sensing circuits and calculate these. And then these values are shown in web page on computer browser via Ethernet shied and Ethernet People who know the IP address, every can monitor the solar system.

A. Arduino

In the hardware portion, the main controller unit is Arduino. It is an open source microcontroller which can be easily programmed, erased and reprogrammed at any instant of time. Based on simple microcontroller boards, it is an open source computing platform that is used for constructing and programming electronic devices. It is also capable of acting as a mini computer just like other microcontrollers by taking inputs and controlling the outputs for a variety of electronics devices. It is also capable of receiving and sending information over the internet with the help of various Arduino shields, which are discussed in this paper. Arduino uses a hardware known as the Arduino development board and software for developing the code known as the Arduino IDE (Integrated Development Environment). Built up with the 8-bit Atmel AVR microcontroller's that are manufactured by Atmel or a 32-bit Atmel ARM, these microcontrollers can be programmed easily using the C or C++ language in the Arduino IDE.[5]

Figure2 Arduino Uno Board

The figure 2 shows the Arduno uno that is used in this system. It reads the signal from analog input pins. And data is caluated and the output singal is send to pc via Ethernet shild. The Arduno Ethernet shield is as shown in figure 3.

B. Ethernet Shield

The Arduino Ethernet Shield allows an Arduino board to connect to the internet. The Arduino Ethernet Shield is allowed to connect Arduino to the internet. This shield enables Arduino to send and receive data from anywhere in the world with an internet connection. It can also use to do fun stuff like control robots remotely from a website, or ring a bell every time get a new message. This shield opens up endless amounts of possibility by allowing to connect project to the internet in no-time flat.

It is based on the Wiznet W5100 ethernet chip (datasheet). The Wiznet W5100 provides a network (IP) stack capable of both TCP and UDP. It supports up to four simultaneous socket connections. Use the Ethernet library to write sketches which connect to the internet using the shield. The ethernet shield connects to an Arduino board using long wire-wrap headers which extend through the shield. This keeps the pin layout intact and allows another shield to be stacked on top. The latest revision of the shield adds a micro-SD card slot, which can be used to store files for serving over the network. It is compatible with the Arduino Duemilanove and Mega (using the Ethernet library coming in Arduino 0019). An SD card library is not yet included in the standard Arduino distribution. [6]

C. Arduino UNO and Ethernet Shield

The Arduino Ethernet Shield allows an Arduino board to connect to the internet using the Ethernet library and to read and write an SD card using the SD library. This shield is fully compatible with the former version, but relies on the newer W5500 chip. To use the shield, mount it on top of an Arduino board (e.g. the Uno). To upload sketches to the board, connect it to computer with a USB cable as normally would. Once the sketch has been uploaded, it can disconnect the board from computer and power it with an external power supply. Connect the shield to computer or a network hub or router using a standard Ethernet cable (CAT5 or CAT6 with RJ45 connectors). Connecting to a computer may require the use of a cross-over cable (although many computers, including all recent Macs can do the cross-over internally). [7]
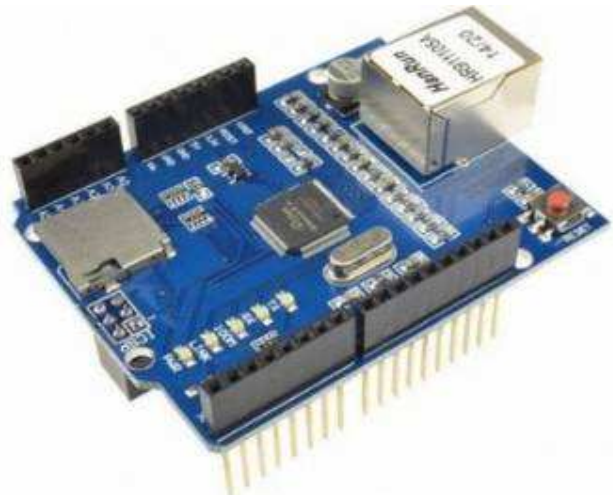

Figure 3 Ethernet Shield [6]

D. Network Settings

The shield must be assigned a MAC address and a fixed IP address using the Ethernet.begin() function. A MAC address is a globally unique identifier for a particular device. Current Ethernet shields come with a sticker indicating the MAC address you should use with them. For older shields without a dedicated MAC address, inventing a random one should work, but don't use the same one for multiple boards. Valid IP addresses depend on the configuration of the network. It is possible to use DHCP to dynamically assign an IP to the shield. Optionally, it can also specify a network gateway and subnet. [7]

E. Temperature Sensor (LM35)

In general, a temperature sensor is a device which is designed specifically to measure the hotness or coldness of an object. LM35 is a precision IC temperature sensor with its output proportional to the temperature (in °C). The operating temperature range is from -55°C to 150°C. LM35 is a precession Integrated circuit Temperature sensor, whose output voltage varies, based on the temperature around it. Power the IC by applying a regulated voltage like +5V (VS) to the input pin and connected the ground pin to the ground of the circuit. The LM35 has an output voltage that is proportional to the Celsius temperature. The scale factor is .01V/°C. Now, you can measure the temperate in form of voltage as shown below. If the temperature is 0°C, then the output voltage will also be 0V. There will be rise of 0.01V (10mV) for every degree Celsius rise in temperature. [8]
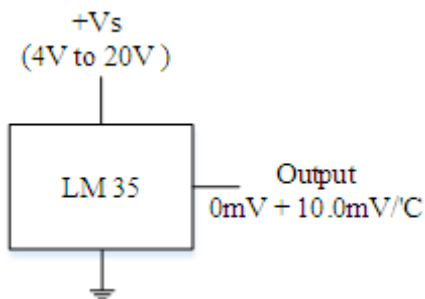
Figure4 LM35 Circuit Symbol [12Tar]

The voltage can converted into temperature using the below formulae

VOUT = 10mV/°C x T

Where; VOUT is the LM35 output voltage
T is the temperature in °C

F. Voltage Sensing Circuit

A voltage divider is a simple circuit which turns a large voltage into a smaller one. Using just two series resistors and an input voltage, it can create an output voltage that is a fraction of the input. Voltage dividers are one of the most fundamental circuits in electronics. [9]
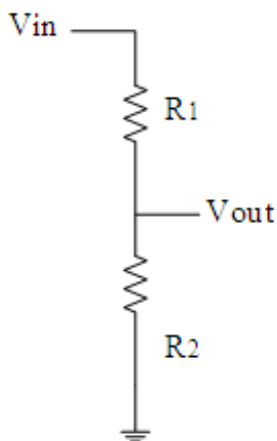

Figure 5 Voltage Divider by Resistor R_1 and R_2 [9]

G. Light Dependent Resistor or a Photo Resistor

Photocells or LDR's are non-linear devices. There sensitivity varies with the wavelength of light incident on them. When light is incident on a photocell it usually takes about 8 to 12 ms for the change in resistance to take place, while it takes one or more seconds for the resistance to rise back again to its initial value after removal of light. This is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material. [10]

Figure6 Typical LDR [10]

H. ACS712 Current Sensor

Sensing and controlling current flow is a fundamental requirement in a wide variety of applications including, over-current protection circuits, battery chargers, switching mode power supplies, digital watt meters, programmable current sources, etc. This current module can accurately detect AC or DC current

Figure 7 ACS712 Current Sensor [11]

The maximum AC or DC that can be detected can reach 5A, and the present current signal can be read via analog I/O port of Arduino. In this system, the current is sensed by figure 7 ACS712 sensor. [11]

V. SOFTWARE DEVELOPMENT

First of all initiation parameter that are voltage, current, light and temperature sensor. These sensing circuits are connected to arduino. But there is no operation of the system. So the software of all operation of the proposed system is developed by arduino based software and web server function is included. Web server need the Ethernet that can be shoveled by using an Arduino with Ethernet shield as a web server.

The web servers in this paper is used to serve up web pages that can be accessed from a web browser running on any computer connected to the same network as the Arduino. Some of the Arduino web server pages allow access to the Arduino hardware – this allows hardware to be controlled.Very basic web server that serves up a single web page using the Arduino Ethernet shield. An SD card is not used in this as the web page forms part of the Arduino sketch.The software development of the system is as shown in figure 8. The is the flow chart of the system. And then check the network connection. If the connection approve display the data on Web Server. If the connection has problem return to check the connection. The process of data describe in Web Server are explain with flow chat in step by step.

VI. EXPERIMENTAL RESULTS AND CONCLUSION

This paper was designing an energy monitoring system and there were several important goals. The proposed system hardware circuit is assembled. And then software is downloaed to the arduino. The hardware model of the proposed system is as shown in figure 9 and 10. In this system, all sensor and relay are connected to Web Server program through Arduino board.All real data is sent to computer to real time monitor. In this system 20W solar panel is used. It has 21.4V of solar open circuit voltage.
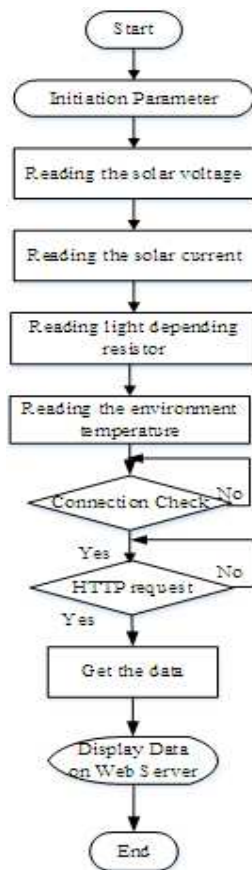
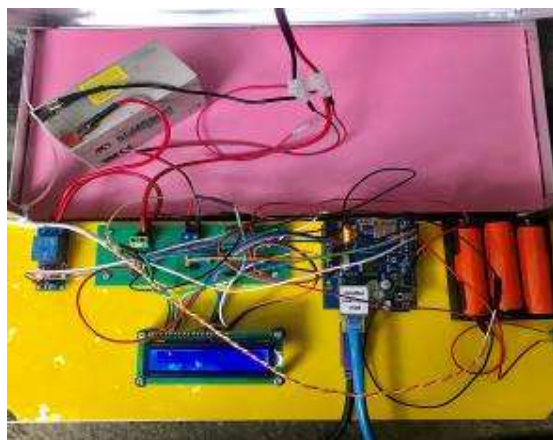**Figure8. Flow Chart of Software Development of the System.**

Figure9. The hardware portion of the proposed system back view
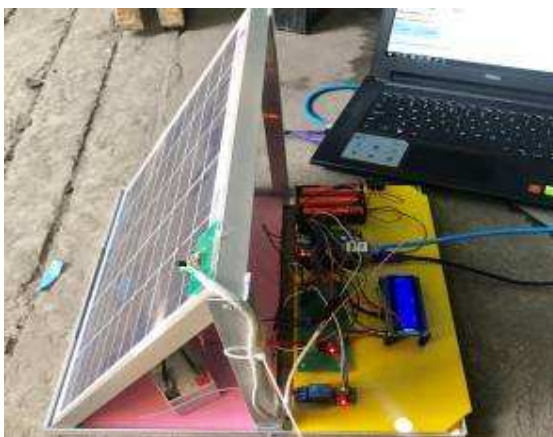

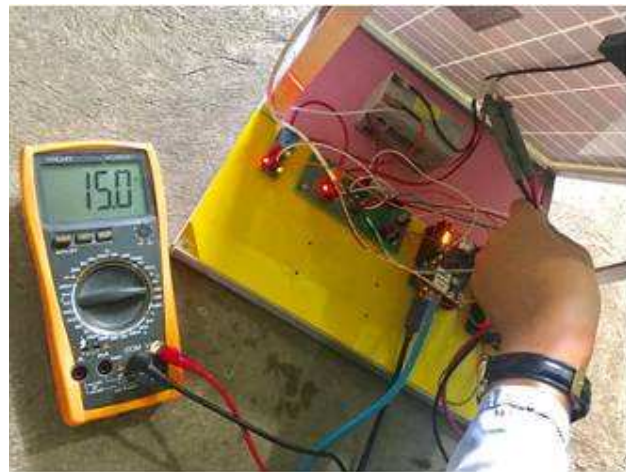**Figure10 the Complete Proposed System**

Figure11 Solar Voltage Measuring with Digital Meter

The developing software of HTML code with the Arduino programming into the Arduino UNO. The computer and UNO are link via Ethernet cable using Ethernet shield.The predefined IP address of the system is 192.168.0.111. This IP address is enter the browser. The HDML view of the system will be appear as shown in figure 12.

It shows the web view of the client server can exchange the design of page view in the program code. The Server program responds to HTTP request coming from client interface. Through Web Service client sends data and display the ddata to control and receive real time voltage, current, light and environment temperature. To use the web service, a client sends a request to remote system hosting the service, which then process the request sent back the response.

In this system the real voltage of solar is measured when getting the sunlight. Solar voltage can monitoring with the serial monitoring in arduino and also the IP address can check at the serial monitoring .The result of light intensity level 25.02%, the environment temperature is 28.84.degree Celsius and the output power with the solar panel is 15.29V. The current from the solar is not truth. It should have around 2A. This data are record in the morning with minimum sunlight.

Figure12 Final result on Web Page View of the Web Server

The solar pannel paremeters can be monitored by remotely using web server technology via Ethernet cable. By using this technology the solar power plant can be monitored by the status of the plant for user friendly. The user can't go to the plant. So this system can be applied to real application.

This paper is achieved all of the objective of solar parameters are: to measure solar panel parameter such as the temperature, light intensity, voltage and current.

The user of the automated intelligent monitoring system is capable of automatically identifying defects and monitoring parameters (temperature of panels, PV state, DC voltage and amperage) that can certainly enhance the efficiency of the PV system and reduce maintenance costs. The system has an advantage in flexibility, in the case of complementing the plant with more panels, and also shows the data for long periods of time without being interrupted by users.

It can also be monitored remotely via Ethernet cable. And it can be monitor web page of the system. No need to device to monitor. In this study the target is to monitor and control a developed solar panel by using available internet foundation. This web-enabled software will provide more flexibility over the system such as transmitting data from panel to the host computer and disseminating information to relevant stake holders barring any geographical barrier. The software would be built around web server with dynamic HTML.

Acknowledgment

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