Monitoring of Off-Grid Solar PV Power System

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Abstract*—The sustainability of standalone photovoltaic systems passes through an accompaniment of the systems installed in the field. Monitoring facility consists of the implantation of the voltage and current sensors, and temperature sensors, installation of the acquisition boards and development of the monitoring program. The results presented here will allow the development of a program of preventive maintenance of the photovoltaic systems. The system hardware consist of Arduino Uno, temperature sensor, AC/DC current and voltage sensors, so that system can sense power levels and temperature with the help of sensors and then will analyze it. Analyzed data will be displayed on Cloud platform as a result and actions can be taken.

***IndexTerms*— Monitoring System, Data-acquisition, Photovoltaic System.**

I. Introduction

As solar energy becomes more accepted as a viable source of renewable energy, quantitative information on a system's post install real performance becomes a major concern. There are many factors that can impact a system's real world performance such as a bad cabling (high resistance/impedance caused by loose connectors or improper wiring), defective inverters, inconsistencies on solar panel output, environmental factors like weather, accidental damage, as well as general manufacturing defects. The cost of ownership of a solar system is tied very tightly to the system's ability to produce a minimum quality of service over a period of time in order to accurately calculate the system's Return On Investment (ROI) period. Any one or combination of these complications can substantially impact the site's ability to achieve its planned ROI time-frame usually 5 to 25 years.The solar monitoring system composed of power meters, data loggers, string current sensors, inverter interface system, data logger, and weather stations is one of the most overlooked components of a Residential and Commercial sized site. The data logger-gateway is your central device for collecting this data and transforming it into useful information and alerts. Reliability issues to your data-logger gateway system can and will impact your ability to identify issues with your system, troubleshoot them, and resolve them in a cost effective manner.

II. Literature survey

There are several problems in solar PV power system related to following factors like mean time to repair, inflexibility, poor manageability and difficulty in maintenance. So they proposed an system model where gateway is embedded in solar panel with GPRS internet connection to update everything in a smart system using IoT[1]. It provides information related to survey on IOT in various fields such as home, city, environment and enterprise and also conveyed the existing level to IoT system. However to proposed it in some other efficient way [2]. In this paper they had defined problems related to management of solar panels and fields issues during power generation process so in order to overcome above issues they developed a model by using tiny OS. It also includes gateways, host computers and so on[3]. They based on timely manner and also includes data logging based on WSN(Wireless Sensor Nodes).The limit it can accept is 146V and 15.5A Systems. It can be further enhanced[4]. It uses ZigBee wireless communication for multi modal power converters between solar PV cells .It combines as a single host and perform monitoring process. According to MPPT(Maximum Power Point Tracking) algorithm each module collects its details and stores in an reference parameters accordingly. Hence the overall system is centralized [5]. In this paper they will analyze and study a solar power plant of a linear parabolic type after introducing it. They discuss the quality and effectiveness of each internet parameter in order to explain the Internet behavior. They studied delayed behavior by using previous results.

Once studied delay behavior, dynamics related to the delay in the Internet are modeled by using system recognition Technique and they used Wave Variable method is chosen as the best monitoring Method on remote monitoring methods. Finally solar power plants monitoring system via the Internet is finally designed [6]. In this paper they overcome the drawbacks by monitoring health of solar PV systems for their better performance and maintenance. Remote monitoring capabilities provide the information in advance when performance likely to fail. By using this information, preventive maintenance can be carried out to improve the life of the system, thus overall operating cost also reduced[7].In this paper they describe the implementation of a wireless remote monitoring and control system of a solar photovoltaic distributed generator (PVDG) for micro grids applications. The wireless communication technology utilizes a full duplex digital system using the ZigBee protocol, based on the IEEE 802.15.4 standard for Wireless Personal Area Network (WPAN). The supervisory control system is implemented by them on a digital signal processor (DSP) and human-machine interface (HMI) software is developed for interacting with and managing remote sensor systems (RSSs)[8]. In this paper they present performance results of middle scale grid-connected Photovoltaic (PV) system for monitoring periods.

The performance of PV system is quantitatively estimated and examined using calculation model with data which are monitored,so that various PV system technologies are development. Their aim is to develop reliable and valid evaluation method of Photovoltaic (PV) system performance such that maximum output is achieved over the system lifetime with performance improvement [9].

III. HARDWARE

A. Arduino:

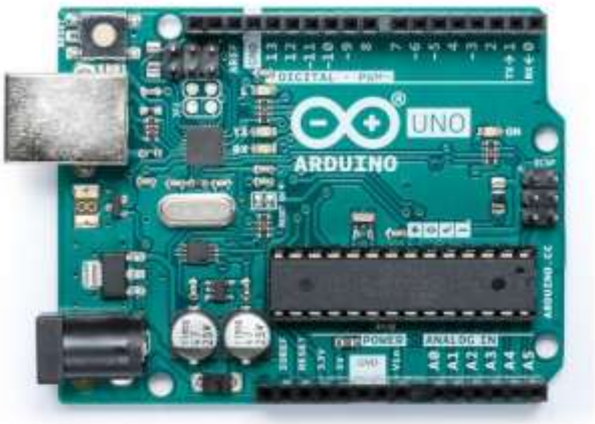

Fig.1 Arduino Uno R3 Development Board.

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

B. AC Current Sensor (Split-core)

The Yhdc current transformer is manufactured by Beijing YaoHuadechang Electronic Co., Ltd and is widely available from many stockists as Non-invasive AC current sensor (100A max), Model SCT-013-000. It has no internal burden resistor, but a transient voltage suppressor limits the output voltage in the event of accidental disconnection from the burden. It is capable of developing sufficient voltage to fully drive a 5 V input.

Fig.2 Split-core AC current Sensor.

C. DHT11 Temperature and Humidity Sensor

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness. The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). Its fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds, so when using our library, sensor readings can be up to 2 seconds old.

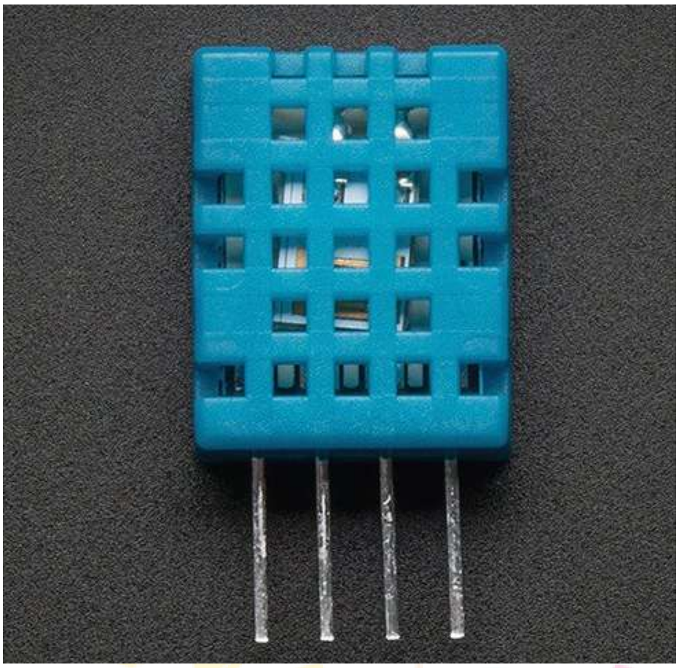

Fig.3 DHT11 Temperature and Humidity Sensor.

IV. SYSTEM DESIGN

1. **IoT Device:** Each IoT device has atemperature sensor, AC current and voltage sensor, two DC current and voltage sensing circuit. The device takes the sensor data periodically after every minute. The interfaces of IoT devicce consist of: Sensor Interface, power relay interface. These interfaces work in on board designed using Atmega328 microcontroller. The Sensor Inter- face receives data from the sensor already converted into voltage equivalent, sensor signals in Volts are read via Analog Input pin. We can convert the sensor values in Volt into corresponding actual measurement unit.
2. **Communication module:** IoT was selected for this battery operated sensor network because of its low cost, low power consumption, and greater useful range in comparison with other wireless technologies. The devices operate in industrial, scientific, and medical 2.4-GHz radio band. The ESP8266-01 is an RF modem with integrated chip antenna, 8-pins.. It can operate up to a distance of 100 m with 70 mA current draw at 3.3 V. The ESP8266-01 radio modem is powered at 3.3 V through a voltage regulator and interfaced to the host microcontroller through its serial port, a logic-level asynchronous serial, and voltage compatible UART configured at 9600 baud rate, no - parity, 1 - start bit, 1 - stop bit, 8 - data bits. This communication module provides internet connectivity to the IoT device to transmit the sensor data to the IoT platform for remote viewing.
3. **IoT platform:** In existing monitoring system we saw that user has to present at the field to know the status of current and voltage data on the inverter LCD. To over-come to existing system graphical user interface (GUI) is developed to monitor the current status of Solar PV system. This application permits the user to see the status of the sensors remotely by using any Internet access devices. All the information is stored in the database online, so it can be accessed from anywhere. The IoT platform provides data visualization of the sensor values real time.

V. CONCLUSION AND FUTURE SCOPE

Thus the monitoring system has been designed and tested successfully. The monitoring of an Off-Gird Solar PV power system will reduce the operation and maintenance cost of the system with the help of preventive maintenance. Sensor data obtained provides the essential data for analysis of the overall system efficiency of the plant. Using this system a solar installer or consumer can get better ROI (Return on Investment).

A monitoring system allows detection of system performance issues that might be very difficult to detect otherwise. For example, imagine there is a nearby building demolition and the surface of many PV modules suddenly becomes dirty. With a monitoring system, the effect will be noticed within one day - energy production will show a drastic decrease in performance from one day to another, the issue can be investigated and the affected modules can be cleaned. Without a monitoring system, an entire month can go by without the system owner noticing the problem. This works has demonstrated the potential of monitoring photovoltaic systems to performance evaluation and fault identification, increasing, in this way, the sustainability of standalone photovoltaic systems applied to rural electrification.

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