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Web Based Monitoring of Solar Power Plant Using Open Source IOT Platform Thingspeak and Arduino

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ABSTRACT

Now a days renewable energy systems are becoming best way to generate electricity. With advancement of technologies the cost of renewable energy equipments is going down globally encouraging large scale solar photovoltaic installations. Major part of renewable energy is solar energy. Due to its decentralized nature it is very difficult to monitor solar power plants with existing centralized SCADA(Supervisory Control And Data Acquisition) systems. We developed a prototype for implementation of new cost effective methodology based on IoT to monitor a solar photovoltaic plant for performance evaluation using open source tools and resources like Arduino and Thingspeak. Thingspeak is a SaaS (Software as a Service) platform which provides space on Web to monitor our parameters. Thingspeak provides all services for free of cost. Which saves lot of investment on Website designing and maintenance. We focussed 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, historical analysis of the plant in addition to real time monitoring.

I. INTRODUCTION

Photovoltaics were initially solely used as a source of electricity for small and medium-sized applications, from the calculator powered by a single solar cell to remote homes powered by an off-grid rooftop PV system. As the cost of solar electricity has fallen, the number of grid-connected solar PV systems has grown into the millions and utility-scale solar power stations with hundreds of megawatts are being built. Solar PV is rapidly becoming an inexpensive, low-carbon technology to harness renewable energy from the Sun. The aim of this system is to measure solar panel parameters through multiple sensor data acquisition. In this paper a solar panel is used which keeps monitoring the sunlight. Here different parameters of the solar panel like the light intensity, voltage, Current, Power and the temperature are monitored.

This system is designed using Arduino UNO Controller. The light intensity is monitored using an LDR sensor, voltage by voltage divider principle, Load Current is measured using ACS712 current Sensor. and temperature by temperature sensor LM35. The Analog Output from these sensors are fed into the ADC Channel of Microcontroller. After Calculation all these data are displayed on a 16X2 LCD interfaced to AVR micro controller

The main aim is to facilitate common small scale installations with cost effective and reliable monitoring system, with access from any where in the world. So that it drives all people to use this monitoring system so that their maintenance expenses are reduced significantly. And also recognizes dust and failures of panels due to different problem. And this causes timely maintenance and enhances power output from plant. Finally saves money for plant installers and saves lot of energy losses due to dust and temperatures and soiling of panels

II. INTERNET OF THINGS

The Internet of things (IoT) is interconnection of all machines, living things and non living things that are embedded with Sensors, actuators, electronics, software and network connectivity and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. The major part of IoT is HMI (Human Machine Interface). HMI The user interface (UI), in the industrial design field of human–computer interaction, is the space where interactions between humans and machines occur. The goal of this interaction is to allow effective operation and control of the machine from the human end, whilst the machine simultaneously feeds back information that aids the operators' decision-making process. interactive aspects of computer operating systems, hand tools, heavy machinery operator controls, and process controls are best examples if Human Machine Interaction. Our aim is to monitor power plant. It needs a Interface, Here we are considering Thingspeak as Interface because of its dedicated advantages, simplicity and free service.

III. THINGSPEAK - OPEN SOURCE IOT PLATFORM

ThingSpeak is a platform providing various services exclusively targeted for building IoT applications. It offers the capabilities of real-time data collection, visualizing the collected data in the form of charts, ability to create plugins and apps for collaborating with web services, social network and other APIs. We will consider each of these features in detail below. ThingSpeak was originally launched by ioBridge in 2010 as a service in support of IoT applications.

ThingSpeak is an application platform for the Internet of Things. ThingSpeak allows you to build an application around data collected by sensors. Features of ThingSpeak include: real-time data collection, data processing, visualizations, apps, and plugins. At the heart of ThingSpeak is a ThingSpeak Channel. A channel is where you send your data to be stored. Each channel includes 8 fields for any type of data, 3 location fields, and 1 status field. Once you have a ThingSpeak Channel you can publish data to the channel, have ThingSpeak process the data, and then have your application retrieve the data. 8 fields for storing data of any type - These can be used to store the data from a sensor or from an embedded device. 3 location fields - Can be used to store the latitude, longitude and the elevation. These are very useful for tracking a moving device. 1 status field - A short message to describe the data stored in the channel.

Another monitoring is through LCD display. **LCD (Liquid Crystal Display)** screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. In our model it is also used to directly display parameters at plant control panel.

IV. METHODOLOGY AND PROTOTYPING

A. Block Diagram

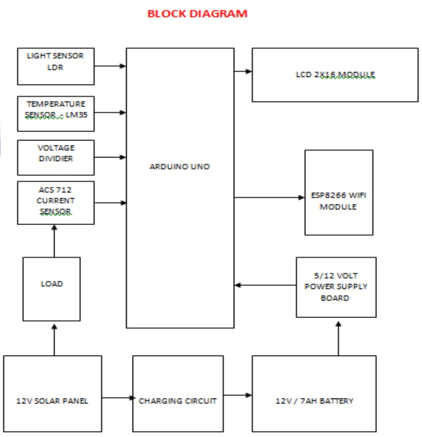


Fig. Block Diagram

B. ARDUINO UNO

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures kits for building digital devices and interactive objects that can sense and control the physical world.Arduino boards may be purchased preassembled, or as do-it-yourself kits, the Arduino project provides an integrated development environment (IDE) based on a programming language named Processing, which also supports the languages C and C++. The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

C. ESP8266 WIFI MODULE

The ESP8266 is a low-cost Wi-Fi chip with full TCP/IP stack and MCU (Micro Controller Unit) capability produced by Shanghai-based Chinese manufacturer, Espressif Systems.

The chip first came to the attention of western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer, AI-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at the time there was almost no English-language documentation on the chip and the commands it accepted. The very low price and the fact that there were very few external components on the module which suggests that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation.

V. SENSORS

A. ACS712 Current Sensor

A current sensor is a device that detects electric current (AC or DC) in a wire, and generates a signal proportional to it. The generated signal could be analog voltage or current or even digital output. It can be then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purpose.

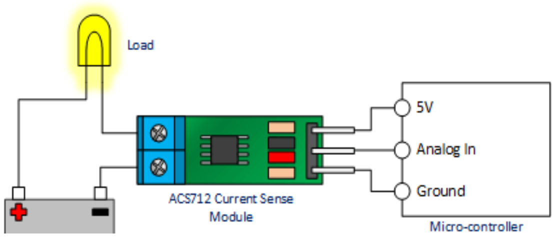


Fig. ACS Current sensor

Direct current input,
unipolar, with a unipolar output, which duplicates the wave shape of the sensed current
digital output, which switches when the sensed current exceeds a certain threshold ACS712 current sensor operates from 5V and outputs analog voltage proportional to current measured on the sensing terminals. You can simple use a microcontroller ADC to read the values. Provides up to 3000 VRMS galvanic isolation. The low-profile, small form factor packages are ideal for reducing PCB area over sense resistor op-amp or bulky current transformer configurations. The low resistance internal conductor allows for sensing up to 20 A continuous current. Providing typical output error of 1%.

B. LDR – Light Dependent Resistor

A photoresistor or light-dependent resistor (LDR) or photocell is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photoresistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits. LDR's are light dependent devices whose resistance decreases when light falls on them and increases in the dark. When a light dependent resistor is kept in dark, its resistance is very high.. So to know the light intensity level at solar power plant we are connecting this LDR by providing constant voltage through Arduino pins.

C. LM35

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in ºC). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a Thermistor. It also possess low self heating and does not cause more than 0.1 ºC temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every °C rise/fall in ambient temperature, *i.e.*, its scale factor is 0.01V/ °C. It is connected to the Arduino board.

D. Voltage Divider Circuit

A voltage divider (also known as a potential divider) is a passive linear circuit that produces an output voltage (V_{out}) that is a fraction of its input voltage (V_{in}). Voltage division is the result of distributing the input voltage among the components of the divider. A simple example of a voltage divider is two resistors connected in series, with the input voltage applied across the resistor pair and the output voltage emerging from the connection between them. By using appropriate resistors we can get Vout as fraction of Vin and connecting across the panel terminal we can sense the voltage of panel or power plant.

VI. EXECUTION & WORKING

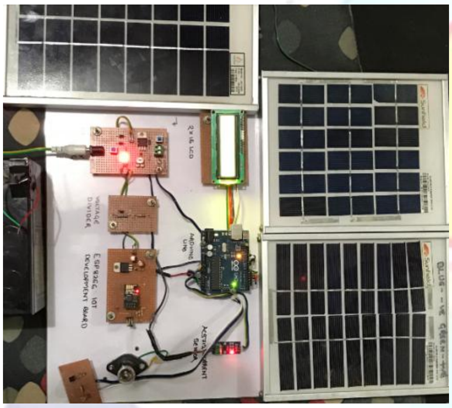
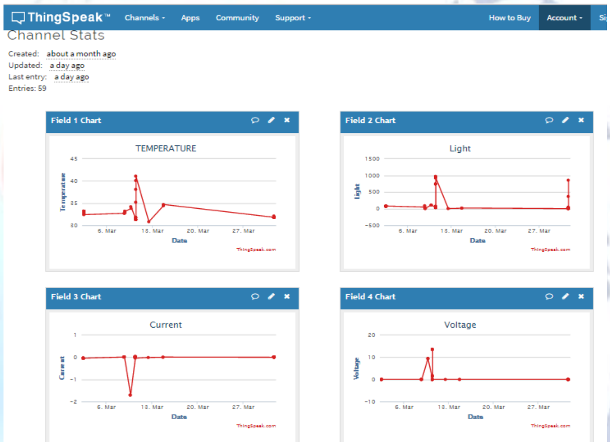


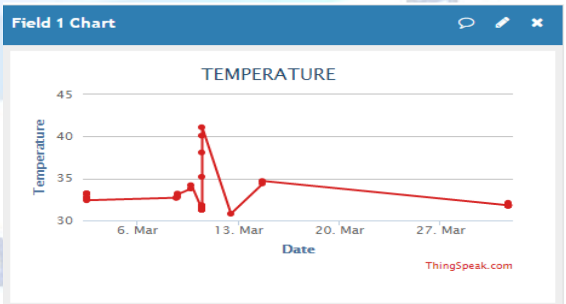
Figure: Monitoring system hardware assembly

When we switch on the system first Arduino and other components gets power from solar panel. Battery connected to solar panel is also charged as charging circuit will control the voltage. ESP8266 WIFI MODULE gets power and search for wifi network and connects to it. Three sensors Current sensor, LM 35 temperature sensor, LDR senses parameters and Voltage dividing circuit gives voltage values of panel to Arduino board. There data is processed and power is calculated As product of voltage and current and all five parameters Current, voltage, power, light, temperature are sent LCD display and also sent to Thingspeak server through Wifi. Same will be repeated for every 15 seconds. Thingspeak will show this data in form of graph as we can easily observe trends and values. When ever panel power is not sufficient or zero, then bettery will provide power to all circuits including Arduino. Potentiometers, Voltage regulators, resistors and diodes are used to give needed voltages to different components and also gives protection to device. As all these are small electronic components all need very less power and DC voltages ranging from 3 Volts to 12 Volts. We can manually switch power sources between solar panel and battery. We can monitor it using Thingspeak from anywhere and if any network problem arises then also we can see all parameters in LCD display. power consumed by the system to monitor power plant is very less compared to production. We keep voltage regulators and potentiometers to give stable voltages to all electronics components. Connected resistors to limit the voltages to safeguard all components.

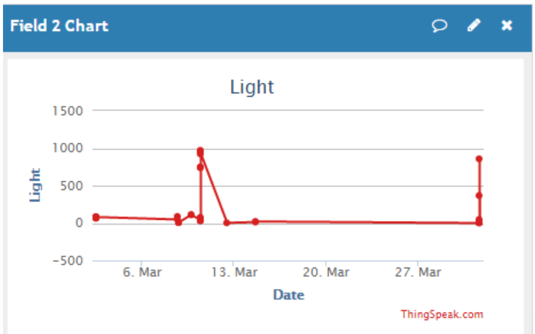
VII. MONITORING



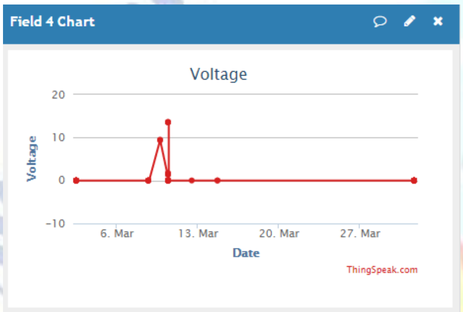
This is web interface in which all parameters are displayed. By opening this website we can monitor our power plant. These parameters are visualized using bar graphs or tables or histograms.



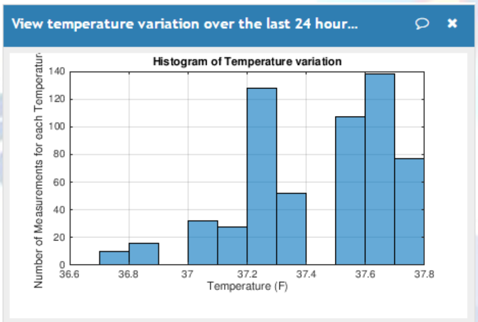
This is picture of individual field. This field shows temperature versus date graph. LM 35 will sense this temperature. Fed to this channel for every 15 seconds.



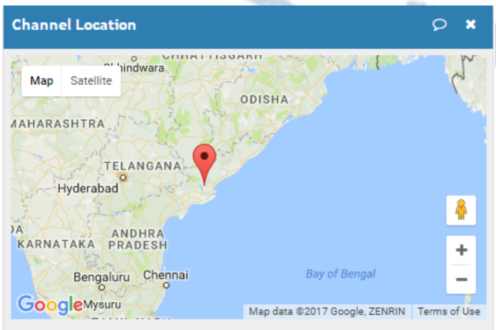
This graph is LDR values versus date. This will show level of sun light intensity at solar power plant.



This is voltage curve. Voltage of power plant or panel versus date. This is sensed using voltage divider circuit. In the same way Current and power also monitored.



In this data is not only shown directly. We can analyze data for particular time period and trends of data. This field shows temperature variations for lasr 24 hours.



Here we can find three location channels which we can show the plant location with longitude and latitudes. Here our plant is shown on roof of our college.

VIII. CONCLUSION

With this paper we made an attempt to solve the problem of monitoring of solar power plants that users are facing today. For this purpose we used the tools of newer technologies. We applied the concepts of IoT and tried to monitor solar panel parameters and other parameters related to solar power plant operation and maintenance with the help of IoT and Thingspeak open source IoT platform. Our low cost monitoring device has lot of scope because monitoring and maintenance plays key role in solar power plants. Appropriate monitoring improves efficiency of plant and operating conditions. It has some disadvantages like loss of privacy and cyber security and also this project requires Internet connectivity as well. This may not be available at all conditions and server may breakdown sometimes. Open source platforms may not be good for large scale plants monitoring. However it is very useful for small installations and remote location plants. A provision of advance remotely manage the Solar PV plants of various operations like remote shutdown, remote management is to be incorporate with this system later. For machine learning algorithms implementation reliable data is obtained. Real time data is readily available to study the load patterns and power generation patterns. Power system scheduling becomes easy and load predictions will be most accurate. This will also facilitate preventive maintenance, fault detection, historical analysis of the plant in addition to real time monitoring.

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