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Review on IoT Based Smart Solar Photovoltaic Plant Remote Monitoring and Control Unit

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Abstract— **The cost of renewable energy equipment's goes down globally with advancement of technologies encouraging massive scale solar photovoltaic installations. IoT leads the work quicker and smarter to implement in advanced growing technologies. The main vision for writing this review is each and every solar photovoltaic solar array should be monitored to know its current status because monitoring is very important for performance evaluation as well as controlling panels to work in a very good condition. The performance, monitoring and maintenance of the plant will highly enhance by using the IoT based Technology for observing solar photovoltaic plant. This will facilitate preventive maintenance, historical analysis of the plant in addition to real time observance moreover as controlling solar panels and this will conjointly helps for power generation by setting the equipment to induce maximum sunlight automatically. Once there's decrease in intensity of light, solar panels automatically changes its direction to get maximum intensity of light that the solar energy conversion efficiency are going to be improved.**

Keywords: *Remote monitoring, IoT*

I INTRODUCTION

The growth of solar market is leaving some technology companies in search of a form of wireless monitoring for increasing numbers of solar plants. Solar arrays also have a higher level of sophistication, in terms of optimizing its performance, extending their active life and increasing its residual value. Unfortunately, the technology to do this does not come with the basic package – but it is an option. Until recently most of new array owners have not been offered, or taken advantage of these new monitoring options. However, the effectiveness, affordability and availability of these technologies are becoming much more attractive. Two types of sources are available for electrical power generation, one is conventional and another is non-conventional. Today to generate many of electrical power conventional sources like gas, coal, nuclear power generators are used, but some of these conventional source are polluting the environment while generate the electricity. That's why nuclear energy is non preferable because of its harmful radiation effect on the mankind. After few years conventional sources will not be sufficient enough to fulfil the energy requirements of the mankind. So most of the electrical power must be generated by non-conventional energy sources like solar, wind, etc. With the day by day reducing cost of PV power generation and further intensification of energy crisis, PV power generation technology obtains more and more application. For collecting detail information about solar photovoltaic plant and to know how they actually work I have visited to "India One" solar thermal power plant. It really helps me to think on various factors and issues related to solar power Plant.

Figure 1: "India One" Solar Thermal Power Plant, Abu Road, Rajsthan

Power generation from the Solar Photovoltaic plants is variable due to changes in solar light intensity, temperature and other factors. Thus monitoring is essential, as we know local monitoring of solar power plant is very difficult hence monitoring remotely is essential. IoT (Internet of Things) approach will be taken for remote monitoring system for the solar photovoltaic power plant, which really envisions a near future where daily objects will be armed with raspberry pi

which is comprise of microcontrollers and transceivers for digital communication. The remote monitoring eliminate the disadvantages associated with the traditional wired systems, make data measurement and monitoring process easier, cost effective and IoT based systems take a giant leap towards monitoring by intelligent decision making from web as well as controlling solar panels.

Sunlight has two components, first is the direct beam which carries about ninety percent of the sun energy, and second is the diffuse sunlight in atmosphere that carries the remaining.

The diffused portion is the blue sky on a clear day which increases proportionately on cloudy days. As the majority of the energy from sunlight is in the direct beam, maximizing collection of energy requires the sun to be visible to the panels as long as possible. A typical solar panel converts only thirty to forty percent of the incident solar irradiation into electrical energy. To constantly rotate the solar panel towards the direction where the intensity of sunlight is maximum an automated system is required.

II LITERATURE SURVEY

As we are discussing about review on IoT based smart solar PV system its first step to collect literature about solar PV plant and other IoT based systems, one of them which is named as "*Pollution guard"*. It is Data acquisition based system, which is designed to collect as well as process atmospheric pollution data measured in several strategic points of a region. Practically the air pollution data being collected from every place in the country. E-mail alerts generated when the level of toxic substances exceeds some given values, chosen with regard to respiratory illness [8].

The discussion in this article is based on implementation of new methodologies to achieve energy efficiency via two way interaction in which the smart metering for next generation energy efficiency and conservation is used. Improved measurement technology by displaying all per phase information on LCD at the meter side, automatic meter reading, power quality and exported energy measuring capacity, energy as well as cost for better energy conservation are the key methodologies of this research. The digital meter was made using energy metering chip, PIC microcontroller and real time clock IC. The data are sent to a remote server via Short Message Service using SIM900 GSM module. The server handles the incoming messages [9].

System is required to be able to acquire, save, analyse, and process real time data. For changing those environment factors and monitoring in long distance it is essential to control related instruments so that it realizes modern, intelligent, and accurate control. This DACS system measures number of remote signals and controls the remote devices through communication network via internet. We can use GSM module for remote access [4].

Author defined certain problems in solar panel related to following factors 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. IoT technology and WSN are getting more fused to smart surroundings and our day to day life as they are being used for health, amenity and safety applications. Smart grid incorporates the newest improvements in information and communication technologies to subsidies to a more reliable and candid electricity system. The discussion in this paper, all the description given about an effective design and development of an intelligent system for administering, monitoring and controlling solar Photovoltaic (PV) system. To improve performance, monitoring and maintenance of the plant by integrating Internet of Things (IoT) and Machine to Machine (M2M) based technology using IPV6 over Low power wireless personal area network (6LowPAN) Wireless Sensor Network (WSN). Due to the massive development of technology the cost of solar systems is become low. That's why it is globally encourage in large-scale solar PV systems installations. This enormous scale of solar system requires an advanced system for monitoring and controlling the solar PV plant by the remote webserver are using Internet of thing and cloud computing. This system is based on the design of a new cost-effective smart system for monitoring and controlling the solar PV system in order to solve management problems, maintenance, fault detection and shortens the mean time to repair. The result of our demonstration shows that the system can monitor, manipulate data from solar PV system and control the operation of a system. Thus, the proposed Smart systems functions are realized in real-time [1].

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.. In this paper, we survey over one hundred IoT smart solutions in the marketplace and examine them closely in order to identify the technologies used, functionalities, and applications. More importantly, we identify the trends, opportunities and open challenges in the industry-based the IoT solutions. Based on the application domain, we classify and discuss these solutions under five different categories: smart wearable, smart home, smart, city, smart environment, and smart enterprise. This survey is intended to serve as a guideline and conceptual framework for future research in the IoT and to motivate and inspire further developments. It also provides a systematic exploration of existing research and suggests a number of potentially significant research directions. [2].

To overcome the drawbacks related to conventional and wired health monitoring systems this system helps 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. The health of the Solar PV systems should be monitored continuously for their better performance and maintenance. Based on this information, preventive maintenance can be carried out to improve the performance and life of the system, thereby reducing the overall operating cost. For rural application advantage and disadvantage of several monitoring systems is based on the techniques of communication, such as, computer to computer communication (Ethernet), embedded system to computer (GSM) and embedded system to embedded system (GSM, GPRS) are discussed. A new technique is proposed as a solution to overcome the limitations of other techniques. The proposed technique uses GSM voice channel for the communication of data, in the form of analogy signal between transmitter and receiver. In order to study and evaluate the performance of proposed technique, various experiments have been performed and impact of parameters like shape (sine, square and triangular), frequency (50 - 4000Hz) and amplitude (0 – 6 V) of analogy signal have been studied. It is observed that sine wave of frequency from 300 Hz to 3300 Hz with 4.5 V maximum amplitude can be sent on voice channel of GSM network with less than 1% error. This technique has low initial as well as operating cost. The GSM network is readily available in rural areas; this technique can be used easily [6].

This system is based on a small scale system which is implemented using assembly of PV polycrystalline modules connected to a single-phase utility grid through a commercial inverter. Then, a flexible, robust and reliable measurement and control system based on wireless sensor network (WSN) architecture is deployed. 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 on a digital signal processor (DSP) and a human-machine interface (HMI) is developed and it is use for interacting with managing remote sensor systems (RSSs)[3].

In advanced growing technologies IoT leads the work faster and smarter to implement. Each and every solar photovoltaic cell of a solar panel needs to monitor to know its current status as for this is concern monitoring as well as detecting in case of defect in solar cells of a panel and implement corrective measures to work in a good condition.

Using the Internet Of Things Technology for administering sun based photovoltaic power era can incredibly upgrade the execution, checking and support of the plant. With headway Of innovations the cost of renewable vitality types of gear is going down all around empowering extensive scale sunlight based photovoltaic establishments. This gigantic size of sunlight based photovoltaic sending requires advanced frameworks for robotisation of the plant checking remotely utilizing web based interfaces as dominant part of them are introduced in difficult to reach areas and in this way not able to be observed from a committed area. The talk in this paper depends on usage of new practical procedure in view of IoT to remotely screen a sunlight based photovoltaic plant for execution assessment. This will encourage preventive support blame recognition, chronicled investigation of the plant in expansion to constant checking [10].

The IoT (Internet of Things) allows objects to be sensed remotely over existing network infrastructure, creating opportunities for pure integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. This technology has many applications like Solar cities, Smart villages, Micro grids and Solar Street lights and so on. As Renewable energy grew at a rate faster than any other time in history during this period. The system we are discussing here refers to the online display of the power usage of solar energy as a renewable energy. This monitoring is done through raspberry pi module and smart Monitoring displays daily usage of renewable energy. Analysis impacts on the renewable energy usage and electricity issues [12].

Today conventional sources like coal, gas, nuclear power generators are used to generate most of electrical power. And nuclear energy is not preferable because of its harmful radiation effect on the mankind. After few years conventional sources will not be sufficient enough to fulfill the energy requirements of the mankind. With the continuously reducing cost of PV power generation and further intensification of energy crisis, PV power generation technology obtains more and more application [13].

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 [14].

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 [15].

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 [16].

In this paper they will analyse 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 behaviour. They studied delayed behaviour by using previous results. Once studied delay behaviour, dynamics related to the delay in the Internet are modelled 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 [18].

Use of solar panel to convert sun's energy to electrical is very popular, but due to transition of the Sun from east to west the fixed solar panel may be able to generate optimum energy. With the impending scarcity of non-renewable resources, people are considering using alternate sources of energy. From all other available resources sun energy is the most abundant and it's comparatively easy to convert it to electrical energy. The proposed system solves the problem by an arrangement for the solar panel to track the Sun.[18]3

III BLOCK DIAGRAM OF IOT BASED SOLAR PV SYSTEM

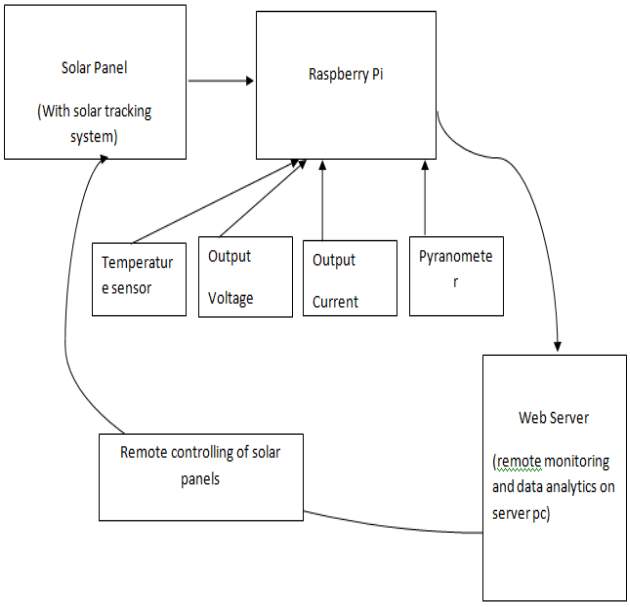

Figure 2: Conceptual IoT based Solar PV system

An IoT based smart solar PV plant basic schematic is shown in figure 2. It will work as smart IoT based data acquisition system as well as it will give smart data analytics on acquired data and it will control panels as per given conditions. The data acquisition system will capable of acquiring the values for PV voltage, PV current, solar intensity and temperature. The system will sense PV voltage by voltage divider circuit, PV current can sense by using shunt with differential amplifier. The solar intensity we can measure using pyrometer and temperature by using LM35 temperature sensor.

The system we are discussing here will use tracker to actively track solar radiation and according to that adjust solar panel to maximize the power output. The complete operation of solar tracking system will depend on light dependent resistor (LDR), which is used in electronics as sensor whose resistance decrease with increasing light intensity. The daily motion causes the sun to appear in east to west direction over the earth. In this conceptual system solar panel will consist of a pair of LDRs whose output compared with comparator and as per result solar panel movement will be done.

The Raspberry Pi is a low cost and it is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet, What's more, the Raspberry Pi has the ability to interact with the outside world, and has been used in a wide array of digital world. It plays very important role in IoT based smart solar PV system. All sensor mentioned earlier will give analogy output to Raspberry Pi, it has analogy to digital converter hence it converts analogy values I digital one. The decision of movement of solar tracking system will also depend on command from Raspberry Pi as per programming. As we discussing system is IoT based it is essential to connect data to web using internet for this reason Raspberry Pi module will use instead of microcontrollers because Raspberry Pi have inbuilt Wi-Fi module. Data will acquired on web server through cloud and then monitoring and data analytics will available on IP address. From server side system could control solar panels as per user need.

The conceptual system in this paper is to monitor the state of a photovoltaic system through an IoT based network in order to control it remotely. The information from the sensors is transmitted via the Wi-Fi network. IoT application schematic for the Solar Power Plant is shown in figure 2. The schematic diagram is three layered starting with the sensing layer at bottom which comprises of current sensors, voltage sensors, pyrometer for irradiance measurement and other sensors, this layer also includes Raspberry Pi based data processing of data acquired from the sensors. The Raspberry Pi communicates with wireless module to initiate and transmit data to server. Layer 2 as envisaged is the network layer where data logging from the plant for real time processing is done. Then after the network layer, this processed and stored data is used in the application layer. In this layer sophisticated web based services are designed based on the data collected, processed and stored. Graphical user interfaces will help to monitor the performance of the plant. By using the IoT based remote monitoring system it will be easier to supervise the overall performance of a solar power plant controlling panel by a web based approach.

IV CONCLUSION

Use of IoT for monitoring and controlling of a solar power plant is an important step as day by day renewable energy sources are getting integrated into utility grid. Thus automation and intellectualization of solar power plant monitoring and controlling will enhance future decision making process for large scale solar power plant and grid integration of such plants. IoT based remote monitoring will improve energy efficiency of the system by making use of low power consuming advanced wireless modules. IoT based remote monitoring will ensure comfortable plant monitoring and by controlling solar panels from web reduces human interaction with these type of systems as well as solar tracking will improve energy efficiency of the plant.

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