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AN OVERVIEW OF REMOTE MONITORING IN SOLAR PHOTOVOLTAIC SYSTEM

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Abstract- Solar energy is playing a vital role among the renewable energy re-sources used for electrification.As rooftop solar photovoltaic systems uses are continuously increasing for domestic as well as commercial uses and also are getting integrated into the existing grid, there is a growing need for monitoring of real time generation data obtained from solar photovoltaic plants[1].To optimize the overall performance of the solar power plantthere is needto develop an efficient solarphotovoltaic remote monitoring system.Using the Internet of Things Technology for supervising solar photovoltaic power generation can greatly enhance the performance, monitoring and maintenance of the plant.This study includeshere the overview of basic structure of solar Photovoltaic Systems, different remote monitoring methods &use of IoT for remote monitoring. This paper present an overview of the research going on in this area, focused on aspects mentioned above which will beuseful for further investigation to improve the system.

Key Words: Solar PV system,Remote monitoring Methods, IoT Technology

I. INTRODUCTION

As the global energy demand increases with the growth of world population, countries all over the world are putting more and more emphasis on the development of renewable energy. Among the many sources of renewable energy, solar energy is considered as the most promising and reliable energy source. [1]

Power generated from Solar Photovoltaic plants is variable in nature due to changes in solar irradiance, temperature and other factors[2]. Thus remote monitoring is essential. By monitoring this real time data obtained from solar photovoltaic plants, system performance can be optimized to a great extent. Remote monitoring processwill eliminate the hazards associated [1] with the traditional wiring systems and make data measurement and monitoring process much easier and cost effective.

Photovoltaic system in our day today life measures solar panel parameters like voltage and current and display these parameters on LCD Display. If user wants the status of this system remotely then he must send predefined message to the GSM module SIM card. But in this case there is no source to send the data to the web server [3].This approach for monitoring PV system suffers from problems like low automaticity and poor real-time [1]. These problems can be overcomed by an efficient remote environment monitoring and controlling system.
In this paper different related works for monitoring systems are discussed. Based on this review IoT (Internet of Things) approach is found more impressive.Using the Internet of Things Technology for supervising solar photovoltaic systems will greatly enhance the performance, monitoring and maintenance of the plant.This will improve preventive maintenance, fault detection, historical analysis of the plant in addition to real time monitoring.

II. SOLAR PHOTOVOLTAIC SYSTEM

Figure shows Basic Structure Solar System.Basic Solar Photovoltaic System consists of Solar Panel, Charge Controller, Battery and Inverter.Photovoltaic technology is used to convert solar energy into electricity. PV contains cells which are built from layers of semiconductor material. It reacts to sunlight and produce electricity.

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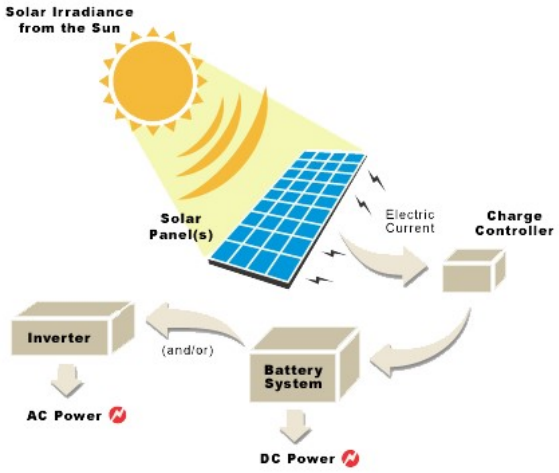

Figure1: Basic solar photovoltaic system

A charge controller is fundamentally a voltage or current controller to charge the battery and keep electric cells from overcharging.Battery System act as a storage for electric power.During night-time system uses battery because of unavailability of sunlight. Inverter is connected to battery for converting Direct Current into Alternating Current. [4]

III.RELATED WORKS FOR PV MONITORING SYSTEMS

With the aim of building an effective low cost monitoring system, numerous previous works on solar energy monitoring system have been reviewed. Earlier, both wired and wireless systems are used for transmitting data.

In august 2010 Mohamed Zahran, YousryAtia implemented a Wired and Wireless Remote Control of PV System[5]. The Wired Monitoring systems were controlled on site by the operator himself. Analog and digitalsensors, microcontroller as Data logger, one serial cable and a computer equipped with LabVIEW software.All the data were collected by the microcontroller unit and transferred to the laptop via a serial cable.Visualization, system administration and further processing of the data was executed from user PC. They Implemented Wireless remote control in h7two different ways. One with Atmel microcontroller board which acts as data acquisition and system controller and second with compact reconfigurable input output (cRIO) Real-Time controller. In first option, the system sensors collect the physical parameters, variables, signals and send them to microcontroller board which convert the analog signals to digital form, then system makes necessary mathematical and logical processes, and send the signals to the front panel with the help of LabVIEW software monitor.Second option was used to assemble the data acquisition cards for both analog and digital signals.In this option, they usedmost popular thing in industrial field known as Programmable Automation Controllers (PAC).The PAC has the ruggedness of a PLCcombined with processing power of a PC.

Ravi Tejwaniand Girish Kumar proposed a remote monitoring technique described in journal Energy Procedia Nov 2013.This technique monitors Solar Photovoltaic Systems using GSM Voice Channel.The embedded remote monitoring systems was able to use Ethernet network, dial-up network or GSM modem for communication.They used GSM voice channel for the communication of data, in the form of analog signal between transmitter and receiver. In order to study and evaluate the performance of proposed technique, various experiments had beenperformed and impact of parameters like shape (sine, square and triangular), frequency (50 - 4000Hz) andamplitude (0 – 6 V) of analog signal had been studied.It was observed that sine wave of frequency from 300 Hz to 3300 Hz with 4.5 V maximum amplitude could be sent on voice channel of GSM network with less than 1% error.[11]

FarihahShariff, NasrudinAbd Rahim Implemeneted a PV remote Monitoring System Based on GSM in 2013 which was equipped with voltage sensor, current sensor, temperature sensor and irradiation sensor and GSM modem for data transmission[6]. The monitoring end was composed of PV module; data acquisition device and GSM modem 1 while the remote pc end was composed of GSM modem 2 and remote pc.PV module was monitored using data acquisition device. Microcontroller collects all the data from sensors in five minutes interval time. GSM modem 1 stores the received data and transmit it in short messages (SMS) to GSM modem 2. The second modem was connected to remote pc. The received data is filtered and categorized before saved to excel file.

In September 2018, Zigbee and RF Module based Solar Panel Monitoring System was implemented by Ajay Singh, M. P. S Chawla[7].XBee module was used as a wireless sensor network. Coordinator received the complete data from sensor nodes by a help of Router X-bee module which was connected to program Arduinoatmega2560 Microcontroller. The system had a sending end and another one as receiving end.At the receiving end, X-bee module receives the sensor data and sends it to the central system. Python language is used to stored continuous data in Postgre SQL database. The stored data in database can be observed in the Web Page through internet.

In 2016, Retno Tri Wahyuni and YusmarPalapaWijaya published a paper Solar Panel Performance Monitoring System in Sensor Node. This paper discusses a system which monitors the performance of photovoltaic power supply from sensor node in a WSN system. The observedparameters were temperature, irradiance, current and voltage. The system was divided into 3 main blocks which are, client, server, and communication system. The client hadsensors,RTC, local display, backup data logger, and microcontroller. The communication devices used was Xbee radio-frequency module.The server was a PC software developed using LabView software. But the drawback for this system was it has limited transmission range. Testing indicated the effective range without obstacles was 250m, but with obstacles present it was able to reach out only 60m. [12]

Wai Mar Myint Aung, Yadanar Win, Nay Win Zaw Implemented Solar Photovoltaic Data Monitoring System in August 2018.This system was designed by using the light sensor, temperature sensor, voltage sensor, and current sensor and Arduino Uno controller. In this system, Proteus ISIS was used for testing the code of this project before implementing on hardware. The goal for this system implementation was to measure solar panel parameters through multiple sensor data acquisition.[13]

Research paper by Santiago Manzano, Raúl Peña-Ortizpublished in Nov 2014 discusses detailed description of PV monitoring methods[8].The use of technology for communication between this network and the datalogger can cite wire, wireless distinguishes, GSM, ZigBee. In the data logger, the use of boards with National Instrument Technology, Arduino, Waspmote was found. Table I shows Historical Evolution and Technical Analysis of PV Monitoring Systems

Table I :Historical Evolution and Technical Analysis of PV Monitoring Systems

Experiences	**Year**	**Device**	**Comm^{n} Technologies**	**Data Logger**	**Data Transmission mode/range**	**Remote Monitoring Access**
GSM-based monitoring and control of photovoltaic power generation	2006	Multiple sensors	Gsm Cellular	Ni field Pointarchitecture:Fp-2000	Cellular Network	Lan
Design of a Remote Data Monitoring System for a Solar and Wind Based Renewable Energy Power Source: Application to a Water Delivery Project in a Rural Community.	2008	Ni-4060, 5 ½ digit digital multimeter	Wire	Ni-4060, 5 ½ digit digital multimeter	---	Web
Wired and wirelessremote control of PVsystem	2010	Multiple sensorsand Actuators	Wired and wireless	Atmrga16 Microcontroller	---	---
Wireless zigbee system	2011	Multiple sensors	Zigbee/ieee 802.15.4	ZigbeemcuCc2531 ti Soc	10-300 m	---
RemoteMonitoring System based on GSM	2013	Multiple sensors	Wire	Pic18f4550 Gsm	Cellular Network	---
Development of a Wireless Sensor Network for Individual Monitoring of Panels in a Photovoltaic Plant	2014	WSN	Xbee	Xbee-pro 802.15.4 Piccontoller	10-300 m	---
Internet of Things Application	2016	Multiple sensors	On board Wi-Fi,	CC3200 microcontroller with ARM	Cellular Network	Smartpone& Web
Photovoltaic Data Monitoring System	2018	Multiple sensors	Wire	Arduino Uno controller	---	---
Zigbee and RF Module	2018	Multiple sensors	Xbee	Arduinoatmega2560	Xbee Module (300-350 ft.)	Web

IV. INTERNET OF THINGS (IOT)

IoT is the network of physical objects, devices embedded with electronics, software sensors, and network connectivity. IoT enables these objects to collect and exchange data [9]. It is a futuristic technology by which an object could be sensed, monitored and controlled remotely using the cloud servernetwork [10].By using the IoT based remote monitoring system it will be easier to supervise the overall performance of a solar power plant by a web based approach.

V. TREND

Research trends are mainly focused on improving the reliability, efficiency, and power quality, reducing the cost. Artificial intelligence can be implemented in future development using various machine learning algorithms so that the system can become smart enough to take decisions about data and performance. Also A provision for advance remotely manage the Solar PV plants of various operations like remote shutdown, remote management can be incorporated with this system later.

VI.CONCLUSION

This paper discusses the background and necessity to develop remote monitoring Systems for Solar Photovoltaic Plants, Introduces a basic solar photovoltaic System, Various monitoring methods. Using Iot technology remotely monitored solar photovoltaic facilitates preventive maintenance, fault detection, historical analysis and real time monitoring. Thing speak an open source Internet of Things (IoT) application is used which allows user to collect, store, analyse, visualize and act on data from sensors. It is an application programming interface (API) to store and retrieve data from sensors.

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