International Journal of Modern Agriculture, Volume 10, No.2, 2021
ISSN: 2305-7246

Real Time Monitoring Of Hotspots In Pv Panels Using Iot Technologies

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Abstract :
In a world where energy demand is growing, it is important to find creative ways to minimise and save energy. There is a lot of interest in designing an environmentally sustainable device thatsavesmoneyonenergyand maximizes thesolarpanelcostreturnoninvestment.Anew data logger has been developed, installed, programmed, and tested using software & hardware and it has been mounted to be an experimental model in a variety of locations. In areas without connections to the electrical grid or conventional wired telecommunication networks, remote monitoringimprovesthedatalogger'seffectiveness.TheuseoftheInternetofThingsinsolar panel measurement systems which is used to allow the remote control of Photovoltaic (PV) systems, which increases system performance. We present a multifunctional, low-cost, and scalablesystemforPVpanelenvironmentalmonitoringandmeasurementofenergyfromthepanel andenergyconsumptioninthisproject.Thissystemusesanarduino-basedembeddedsystemwith IoTcommunicationforremotedevicemonitoring.Incaseanyproblemoccurredinanyoneofthe panels, it will be replaced by buffer technique. A web/PC based program can be used to track the proposed framework. When the quality parameters of solar power system generation deviate from a predetermined set of standard values, the device sends a warning to a remoteuser.

Keywords---*Photovoltaiccell-Monitoringsystem-Datalogging-Internetofthings-Thingspeak website-Datavisualization*

1. INTRODUCTION

Solar panels which absorbs the sun's light and transform them to electricity . A solarpanel consistsofaseriesofsolar(orphotovoltaic) cellsthatcanbeusedto produceelectricityusingthe photovoltaiceffect.TheInternetofThings(IoT)isanetworkofphysicalobjects that are loaded withsoftware applications,and some othertechnologiesso asto interact andswap data alongwithadditionaldevicesandsystemsoverthecloud.Amongthemanyadvantageofsolarpanels, the most prominent is that it is a fully renewable energy source. It has low maintenance costs. Control structures based on the sun presume pure, unadulterated vitality. Adding solar-powered boardstoyourhomehelpstodecrease the rate of emission ofgreenhousegas. Coal as well as natural gas are used to generate conventional electricity. Open health is also supported by renewablevitality.

The instruments that use electrical signals to calculate temperature measurement. The sensor is of two differenttypes ofmetals , when bare to a change in temperature, producevoltage.A humidity sensor (also known as a hygrometer) detects, monitors, and records moisture as well as air temperature. Humidity sensors track changes in electrical currents/temperature in the air to determine humidity levels. The Arduino used for solar panel is a small board which is used to power the board, allowing you to build a self contained customized board. Arduino comes with 3Watt solar panel and a 1100 mAhLiIon battery that provide 5Vto the Arduino. With a thousand hundred mAh Lithium Ion battery, 5V Regulator provides 5V to the Arduino board.By the examination of International Survey Agency(ISA), it has been predicted that PV will provide around 11% of worldwide electricity production[1]. For best energy conservation solar energy is used. The PV panel monitoring uses RFID[2][11] and communicate through SMTP. To monitor the PV panels with the combination of the wired and wireless sensors and programmable controllers in additional to system arrangement[3]. Here for monitoring PV panel used PLC[4][12] for cost reduction and monitoring information will be represent in graph model. To getmaximum efficiency and to prevent damage, it is important to maintain the PVpanels.

Data can beregularly stored and monitored at central station called HUB, data will be sent to server through ethernet. For visualization and monitoring process, to save data on excel file GUI using python is used[5]. To identify electrical and climatic parameters data logger[6] [14]is used, and monitored data will be communicatedbywebsiteormobileapplicationeventhoughanynetworkissuedatawillbestored in SD card. Due to increasing demand of electricity in the increasing population world, the photovoltaic(PV) power generation are very important and urgent in certain cases.Monitoring of PV panels is necessary to avoid the huge damage in the PV panel before it causes the highest rate ofadverseeffect.Hencemonitoringtheperformanceofsolarpanelscanbedoneusingsmartphone based microcontroller[7][15]. Here it monitor four parameter current, temperature, voltage, humidity, andalsoitwillbecontrolledusingsmartphones.Forevery30secondthedatawillbemonitored and transfer the data[8]. To detect

the formation of hotspot, cracks and damages in PV panels cells using Thermal Imaging i.e., using Infra Red(IR) cameras. For the efficient view of the images FLIR C2 (45 degree view), thermal camera is used. Designing the PV panels using MPPT controllers makes the overall PV panel setup to more efficient of robust[9]. Downslope wind generate are common in certain condition become dangerous wind storm. Solar panel and solar batteries to power meterological stations that covered by snow will affect the performance. After continuous usage of SD failures provides direction to develop a power methodical system based on embeddedcontroller[10].

1.1. Operating system

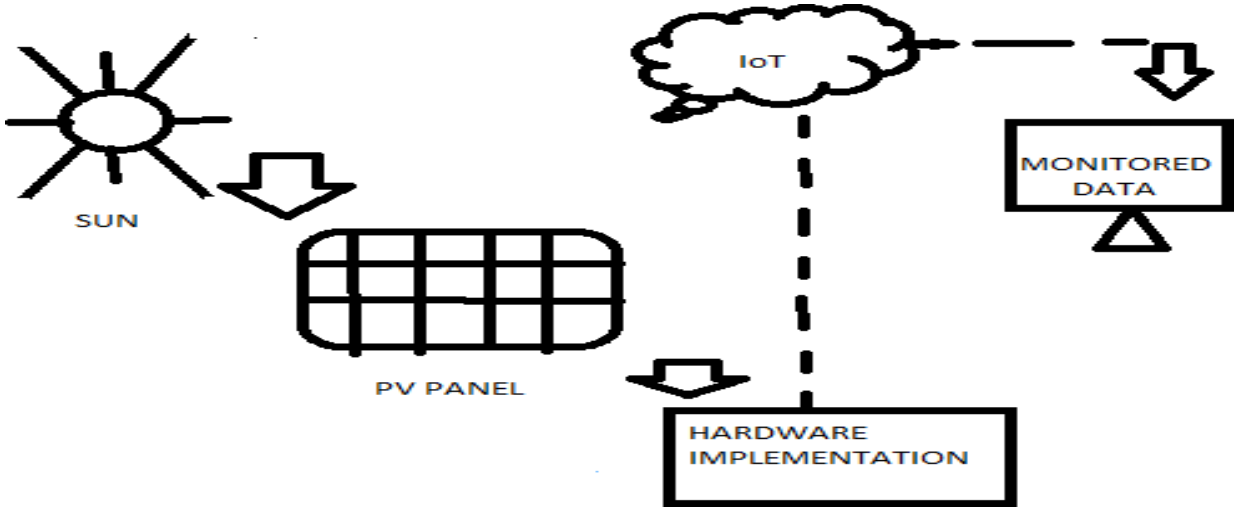


Fig 1. Basic implementation of PV panel monitoring

A solar panel is used to keep track of the amount of sunlight. Using IOT technology, various parameters such as voltage, current, and temperature are displayed on the LCD. Solar energy is the electricity produced by absorbing the sun's light and is used for commercial and residential purposes as shown in Fig.1.Here it is very low prospect of electrical fault ofseparate component or total failure of the system is impossible to monitor and control and communicateto centre station as the rate of the components are huge. Natural causes like rainfall, snow, dust, storm,lightningstrikes,oreveninsectscandamagethePVpanel.Overloadinginsupplygridwill affect the performance and cause power reduction. So it is necessary to monitor parameters like temperature, voltage, current, humidity if any of the function is not proper it will communicate information through website. Through logging the website at any where and at any place we can view the data of these parameters meanwhile how much energy is consumed everyday is also notified by the website and the rest of the energy is transferred to EB. Also if any dust occurs in the panel it may affect the performance. If any array of the panel is affected by birds remnants or if any shadow of the tree falls on the array of the panel it will affect the performance. Because of that, the particular array function will be low. To overcome these drawbacks additional panel is used , it will perform the function of the affected panel automatically and obtain the same measurement of other panel and also it monitors how much of voltage obtained before and after problemoccurred.AsaresultPVpanelwillbemonitoredandcontrolledanditsperformancewill be notified by the Thingspeak website. Data visualization of energy used can be viewed.We can view it from anywhere.

2. EXISTING SYSTEM

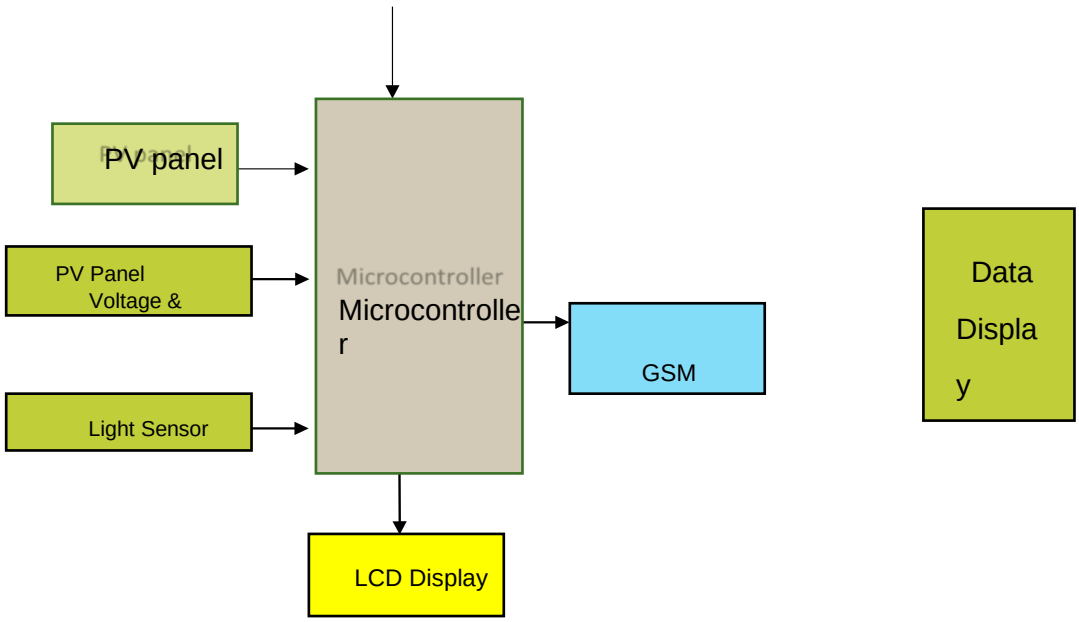


Fig 2. Existing System

A controller and current track the solar panels.Present and potential are used to sense current and voltage,transformers are a type of transformer. Solar monitoring isn't in place, and Solar panel regulation has not yet been implemented as a result.For any given moment, the solar panel is not being used to its full capacity.The existing framework incorporates various review of PV checking system throughout the final two decades. Many control systems which can be set up to support cellular networking, allowing to access system and data stored in the cloud from mobile devices without connecting to wireless network. While, even if personaluser internet connection fails, can quiet access solar monitoring unit. Depending on the basis of the interface set up, it may be able to access your tracking data, though internet connection was down. But, this is not the instance for microinverter monitoring systems.

The primary low-cost frameworks are calculated for solar radiation checking. On an eight-bit microcontroller, a verification framework was developed with four simple inputs.ThisDatalogger is appropriate for meteorological framework control at inaccessible stations.The attachment for thedatalogger to the personal computer was the most difficult part of this project. Another control system for long-term vitality sources was published in 2003.The datalogger is used as a Data Acquisition card positioned in a PC, a 12-bit precision AnalogtoDigitalconverter to handle 16 single channels of input. As an impediment, dependency on aPersonalComputerand the usage of commercialised computer applications increased the overall cost of the framework. For the purpose of monitoring a PhotoVoltaic plant. A system is developed for the purpose of controlling environmental factors in addition forensuring the proper operation for the PV solar power plant.

The precision electronic standard field point Input Output gadgets and a tall agility information procurement card were used to power the datalogger. The graphical approach based on the Labview™ software, the need of the Personal Computer inter relation with a assigned data procurement system administration for the further observing functioning of the PV appliance were the two major issues.The Internet of Things system for monitoring PV cell hot spots is focused on temperature and voltage sensors that are easily inserted. However, the datalogger had a number of flaws, including the need to reduce control usage, the display of an input voltage run, and the lack of an open interface. As it stands, the existing renewable energy collection system focuses solely on battery charging and buck boost transformation.

Also the existing framework on off the gadgets through Google assistant. The system controlled through 2G(GSM) and low bandwidth communication. They use a WiFi connection to keep a real-time eye on each panel. Monitoring systems have a variety of tools to assist you in better understanding your solar energy use. in addition to displaying energy consumption and generation results. Monitoring software tools can also recognize panel issues and faults, as well as repair recommendations.. Often, you can monitor historical data from your device aswell.

2PROPOSED SYSTEM

REAL TIME MONITORING OF PV PANELS USING IOT TECHNOLOGY

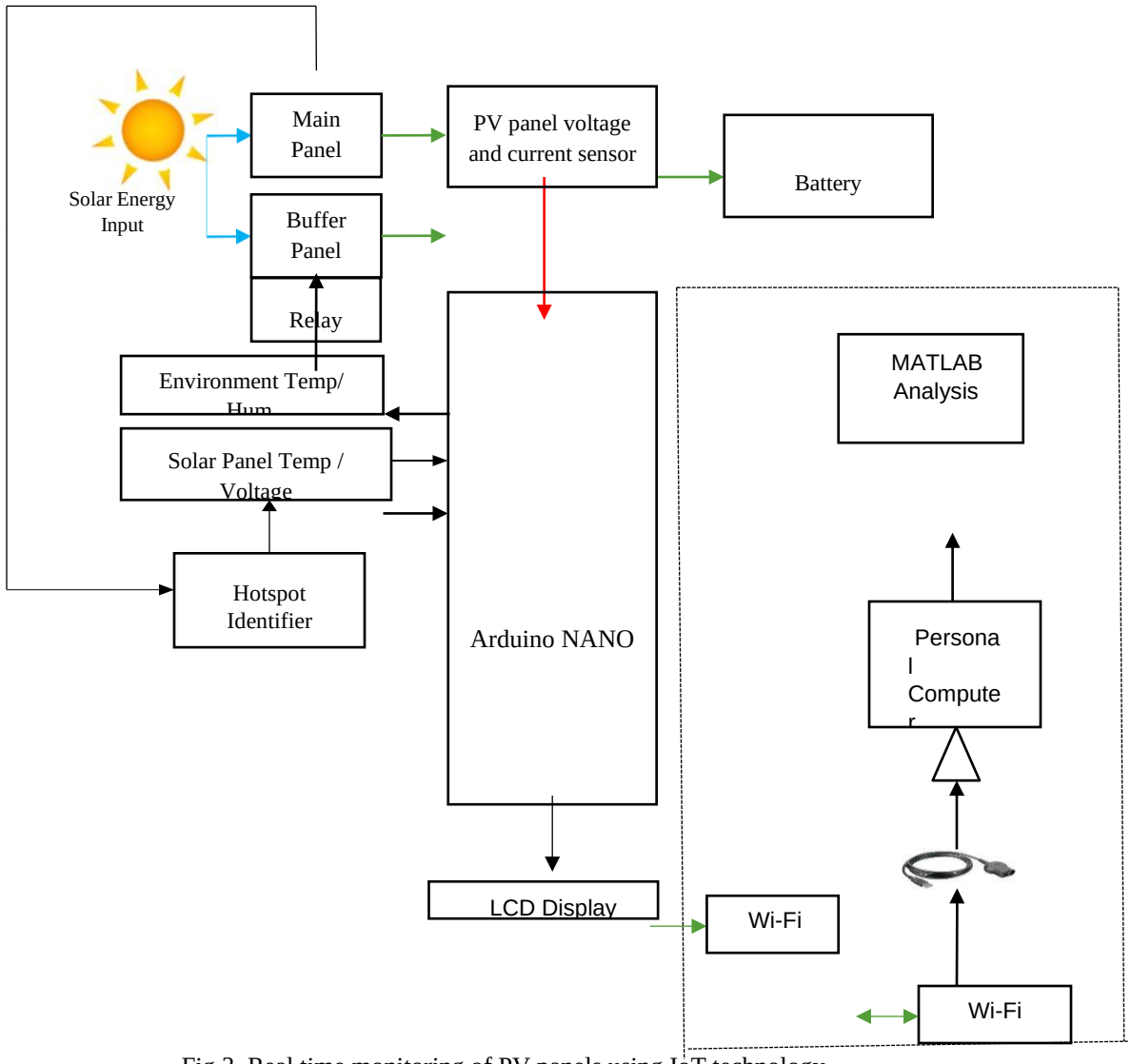


Fig 3. Real time monitoring of PV panels using IoT technology

Data logging block

Solar energy, a renewable source of energy which is obtained naturally by the sun acts as a source to the Photo Voltaic (PV) panels. A PV module is a pre-assembled system of photovoltaic cells that is ready for installation. Photovoltaic cells uses sunlight as a energysource to produce electricity. The PV Panel was a collection of PV modules, whereas an Array is a collection of them. Thephotovoltaic effect istheprocess of conversionofsunlightintoelectricity. The PV cells in the PV system have thisPhotoVoltaic effect. The photons in the light activates the electrons in semiconductors, allowing them forming the electron-hole pairs.A temperature sensor was an electronic equipment that used to measures the temperature of its environment and changes over the input data into electronic data to record,screen,or flag temperature changes.Avoltage sensormaybeasensorutilizedtocalculate and screen the sum of voltage in assert. Voltage sensors can decide the Alternate Currentvoltage or Direct Current voltage level. All these types of sensors senses and gives the information to the ArduinoNano.

The Arduino Nano is a closely packed, full featured, and suited to breadboardand is based on the ATmega328 (Arduino Nano 3) microcontroller. Arduino have more common features as the ArduinoDuemilanove, but it comes in a separate

kit. It has only a DC power socket and uses a Mini-B USB cable rather than a usual one. All these information will be displayed in the LCD display. A liquid-crystal display(LCD)maybe a horizontal-panelshow or other electronically tweaked optical equipment that employs the light-modulating properties of fluid gems which is combined with polarizers. In case any problem occurred in any of the panels, the voltage level will get decreased, then the relay will give intimation to the bufferpanel. To compensate the problem occurred in the main panel, buffer panel will substitute the work of themainpanel.ArelaydriverIntegratedCircuitisanelectro-magneticswhich thatisusedifalow voltagecircuitisusedtoturnonandoffalightbulbthatisattachedtoa220Vmainssupply.Relays have special properties and are being phased out in favour of solid-state switches, which aremore durable than solid-state machines.

Togetthemostpoweroutofthesolarpanel,changetheloadtomatchthecurrentandvoltage.All these information will be logged into the specific log in(Thingspeak website). Through that website we can open and view what are all the problems occurred and we can monitor how much amountofvoltageisobtained.Ifsuddenlytheproblemoccurredinthepanelmeansautomatically the buffer panel compensates the work of the main panel and the problem occurred information will be received to the user e-mail id as notification, so that the user can immediately open the website and view theproblem.

Data will be stored in the memory of the inverter or in data loggers. On the market, there are a range of choices. Some manufacturers still sell memory expansion or upgrades. The data loggers provide monitoring features for a range of environmental and other device-related parameters, providingtheuserwithacomprehensiveoverviewoftheentiresystem.Additional parameters that can be monitored include solar radiation, solar irradiation, wind speed, and, in some cases, air pressure and air humidity. Temperature sensors such as the PT100 or PT1000 are commonly used. The controlequipment's analogue inputs are usually 4-20mA or 0-10V, with solar inputs.

Radiationwillbemeasuredwithreferencesolarcells(Si-mono). There are also digital inputs. It can also be used to attach net meters and other control equipment.

3. HARDWARE IMPLEMENTATION

A.PV PANEL

Solar cells, also known as photovoltaic cells, are devices that turn sunlight intoelectricity. Photovoltaics (often abbreviated as PV) gets its name from the photovoltaic effect, which is the process of converting light to electricity . The PV cells in a PV system have this effect. As an internalelectricfield,for constructing a P-N structure,thesemi conductor materials were doped. The p-type (positive) silicon tends to gain holes rather than electrons, while the n-type (negative) silicon prefers to gain electrons.As photons in light strike the cell, they excite electrons in semiconductors, resulting in the formation of electron-hole (negative-positive) pairs.Thesepairswerepromptoseparateduetotheexistinginternalelectricfield.Consequently, Electrons gravitate towards the negative electrode, meanwhile holes gravitate towards the positive electrode. The negative electrode, load, and positive electrode are all connected in series forming a circuit. Resulting an electric current is produced, providing the power to the external load. The PV effect in the solar cell works in same way. Three primary types of the solar panels are monoand polycrystalline, and thin-film.Eachtypehasitsownsetofbenefitsanddrawbacks,andthebestsolarpanel type for your installation will be determined by factors unique to your home and desired device characteristics. Even though if we install the most effective solar panel installation, there are certain conditions where the solar panel efficiency reduces. Those conditions are bird’sremnants, tree’s shadow on the panel, dust layer on the PhotoVoltaic panel, etc…and these conditions are called as PartialShading.

Fig 3. PV Panel

B.PARTIALSHADIN

When the PV array is partially shaded, the unshaded modules receive a certain amount of solarirradiation,whiletheshadedmodulesreceiveless.Theshadingfactorandnumberofshaded modulesdefinethepartialshadingoperatingstate.Yes,solarpanelscanbeusedinshadyareas and on cloudy days, but their output power potential is reduced due to less sunlight exposure.

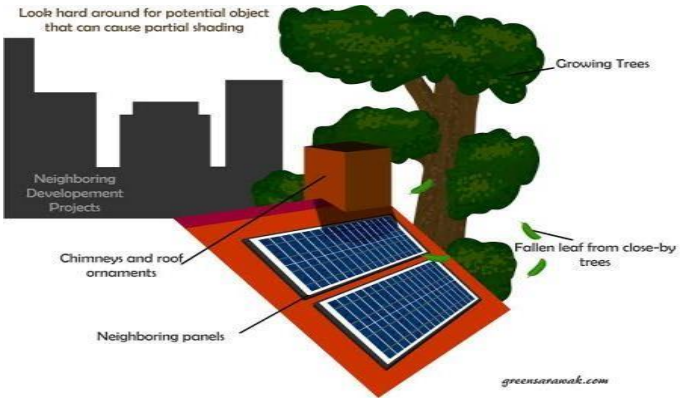


Fig 4. Partial shading condition.

Solar panel design and roof orientation, for example, can help avoid unnecessary power loss due to reducedsunlightexposureevenifonlyonepanelisshaded,everypanelinyoursystemisaffected. This implies that only a small amount of shading can intensely reduce the output of an entire PV system. Shade is something the blocks that flow in traditional solar panel strings. If a tree or a chimney casts shade on even one of the panels in the string, the output of the entire string will be reduced to practically zero for the duration of theshadow.

When a photovoltaic (PV) panel is exposed to partial shade, its power efficiency is reduced as shown in Fig4.Intheworst-casescenario,itcouldproduceahotspot,whichcouldlead toafire hazard. Bypass diodes are wired across a group of PV cells in a series-parallel (SP) configuration toaddressthisproblem. Due to the placement of bypass diodes in the PV column, it may avoid unshaded areas. The PV panel's positioning by pass diodes helps it to avoid unshaded PV cells.To mitigate the impact of partial shading, topologies such as complete cross-tied (TCT), bridge connection (BL), and honeycomb (HC) for PV panels have been suggested in addition toSP.

Each configuration outperformed the SP topology in terms of efficiency. Many of these configurations,however,lackamechanismtoisolatePVcellsthatarehotspot-affected.Inaddition to effectively coping with shading conditions, a recently established complementary metal oxide semiconductor (CMOS)-embedded PV panel has been shown to provide several other benefits.In our project we are using extra panel to overcome partial shading. It does the performance of the partially shaded panel and obtain the same parameter measurements like otherpanel.

C.DATALOGGING

In case of collecting and storing data over time, so to examine particular patterns or record data-actions of a device, network, or IT environment is known as data logging. It allows for the recording of all interactions involving the collection, access, or modification of data, files, or applications on a storage device or application. Data logging allows you to keep track of what you're doing with data or file objects or sets. Data logging usually documents events or actions such as the size of the data, the most recent update, the username of the person who changed the data. Data logging makes it easier to store and collect information from a personal computer or device.Datalogging,forexample,canmonitorprocessortemperatureandmemoryuseovertime, inadditiontonetworkbandwidthuse.Thisdataisusedbysystem/networkmanagerstoanalyse systemornetworkoutputovertime.DataloggingalsoenablesISandauditingpersonneltoreview device access information and evaluate audit trails in order to track down viruses and detect suspiciousactivity.

The data logger differentiate solar energy with the DC electrical output of the device, and is specifically designed for logging data from PV installations for performance evaluation. A time and date stamp is applied to all of the details. The data logger has an IP65 rating and can run in temperatures ranging from 10 to +40 degrees Celsius. When recording, the data logger takes a measurement 800 times per second and then saves the average, minimum, and maximum of voltage, current, and irradiance over the storage interval which can range from 1 second to 60 minutes. A time and date stamp is

applied to all of the details.

D.BUFFERPANEL

When the main panel functioning is not normal due to some conditions such as snowfall, harshweatherconditions,tree'sshadowonthepanel,dustformationonthepanel,birdsremnants, etc. Due to these conditions it affects the output parameters such as voltage, current, humidity levels. Hence the output levels of current, voltage are reduced than the normal panel functioning. So, the additional buffer panel is used for the partially shaded panel. The parameters such as voltage,currentareconstantlysensedthroughsensors.Thesemeasurementsarestoredinarduino. When these parameter measurements are lower or different than the normal panel, the arduino sends the indication to the relay driver. Hence the relay driver makes the buffer panel to work automatically to perform the same function as of the normalpanel.

4. SOFTWARE IMPLEMENTATION

A.ARDUINO IDE

For Windows, macOS, and Linux, the Arduino Integrated Development Environment (IDE) is a C and C++-based window-platform architecture. It's used to programmeArduino-compatible boards as well as third-party development boards with the rest of the third-party cores. An IDE source code was protected by the GNU which means General Public License of version 2. ArduinoIDEassistslanguages such asC, C++withspecialcodestructuringprotocols. The Wiring project includes the software library in the Arduino IDE that includes a variety of standard input procedures and output procedures. Anavrdude software is used by the Arduino IDE to convert implementation code into a text formatted file in a hexadecimal encoding, which was then loaded into Arduino board firmware for the loader programme. For flashing user code into official Arduino boards, Avrdudeistheuploadingmethod by default. As seen in fig, the Arduino IDE is a fork of the Processing IDE, but starting with version 2.0, the Processing IDE will be replaced by the Eclipse Theia IDE platform, which is based on Visual StudioCode.

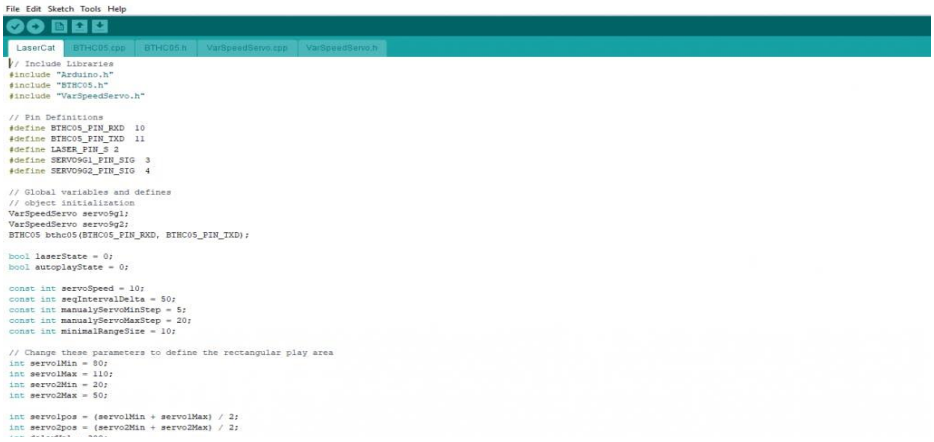


Fig 5. TheArduino

The Arduinosoftware IDE which was expanded as Integrated Development Environment (IDE) was a cross-platform system for Windows software, macOperatingSystem, and Linux software tool written in C, C++ functions. With the assistance of third-party centre, it can write and dump programmes to Arduino-compatible boards. The source code of the IDE waslicensed under the General Public License, version 2.To aid the C &C++ languages, the Arduino IDE employs code structuring protocols. Wiring project uses the software library which comes with the Arduino IDE and includes a number of regular input & output procedures. Two basic functions are used in user-written code for starting the sketch and the main programmeloop, that are compiled and linked into a possible cyclic programme using the GNU tool chain, included with the IDE distribution. The software is used by the Arduino IDE to convert possible code into a hexadecimal text format, which was then dumped into the Arduino board firmware for the loader programme.

B.THINGSPEAKWEBSITE

ThingSpeakTM is a Windows-based IoT analytics programme that aggregates, visualises, and analyses live data streams. ThingSpeak includes real-time visualisations of data that the computers send to it. In ThingSpeak, run MATLAB® code,

analyse, and the process data as it arrives in the real time. ThingSpeak is used for the IoT software prototyping &proof-of-concept analytics. The diagram (fig.3) below can be used to describe many IoT systems at a high level. The InternetofThings (IoT) is a relatively recent development that entails connecting a huge number of embedded devices to the Internet.The interconnected device sends data to cloud storage, cloud computing services, where it was processed and examined for useful perception. Low-cost cloud computing power and increased mobile connectivity are assisting this trend. Just a few of the vertical applications for IoTsolutions include monitoring and control of environment, health, vehicle fleet, industries and home automation.

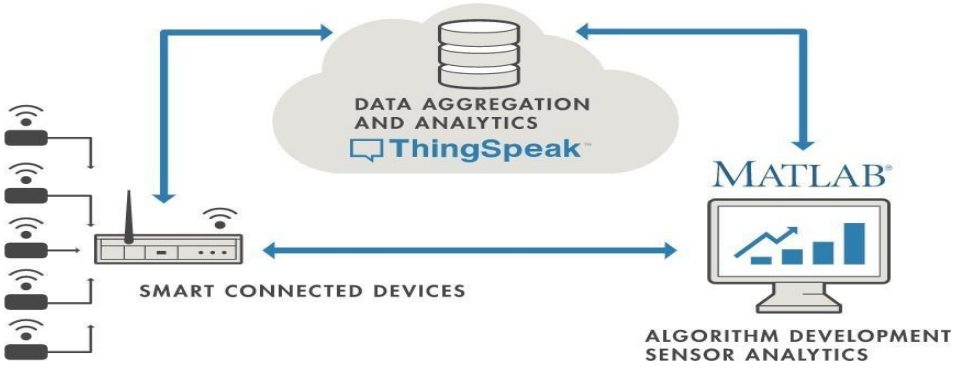


Fig 6. Thingspeak Overview

On the left, you can see the smartdevices are located at the network side. Data collection systems include wireless temperature sensors, heart rate monitors, hydraulic pressure sensors, factory floor machines. The cloud in the middle, which aggregates and analyses data in real time from a number of sources, often using an IoT analytics platform which was designed specifically for the purpose.On the right of the diagram, the algorithm construction for the application of IoT is depicted. In IoT system, all of these elements are included. ThingSpeak is a website for quickly gathering and analysing data from internet-connected sensors, and it's located in the cloud portion of the diagram.

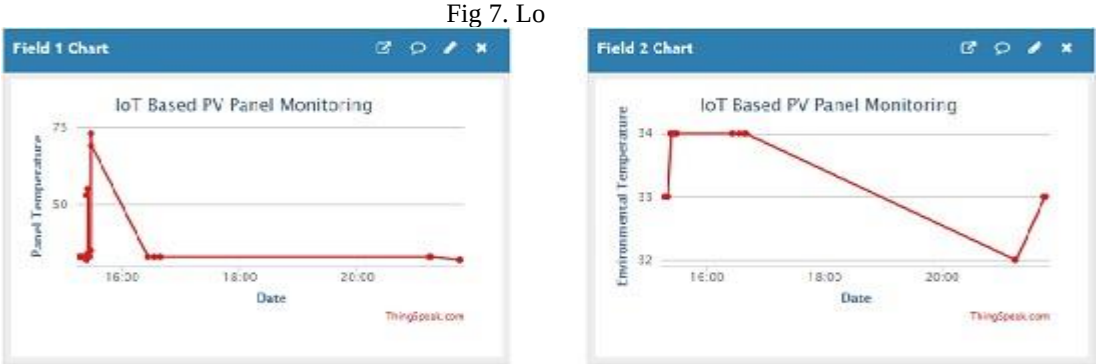
COLLECTED DATA IN THINGSPEAK

ThingSpeak allows sensors and websites to send data to the cloud (Internet of Things), where it can be stored in a private channel. Though ThingSpeak defaults to storing data in private channel medium, public channel medium which also can be used to exchange data with others. As shown in the Fig. 7, once data is storedin a ThingSpeak channel, able to analyse and visualise it, measure newly logged data, and communicate with the web services, and other devices.

ANALYZE DATA AND VISUALIZATION INTHINGSPEAK

- ThingSpeak gives you access to MATLAB, which can assist you in decipheringdata.
- Visually recognize the correlation in data using built-in plottingfunctions
- Visually recognize the correlation in data using built-in plottingfunctions
- Create a more sophisticated analysis by combining data from differentsources.

Fig 7. Lo



gged data in ThingSpeak

THINGSPEAK KEY FEATURES

ThingSpeak is a cloud-based service. This software enables to aggregate, visualize &analysedata live streams. ThingSpeak has a range of key features, such as:

- Simply form devices to submit data to through ThingSpeak using IoTprotocols.
- Real-time visualisation of sensordata
- Gather data from third-party sourceson-demand.
- Be clear of IoT data with the help ofMATLAB.
- Automate IoT analytics which is based upon events or schedules.
- Create IoT prototypes & systems without creating servers or develop webapps.

5. RESULT AND DISCUSSION

HARDWARE RESULTS

Solar energy is a good choice as a source of energy because it is renewable and plentiful, with the only disadvantages being the high cost of harnessing solar energy and its variable nature. The cost of devices is steadily declining as a result of technological advances. As a consequence, all we need is a fine, up-to-date monitoring system that can perform major tasks without human interference and provide data to the user whenever and wherever it is necessary

Fig 8. Hardware setup

6. CONCLUSION

The clean and abundant solar energy is a good alternative as a source of energy with the only problems of cost of harnessing solar energy, and its variable nature. With technological advancements, cost of devices is decreasing with a rapid rate. Hence all we need is a good, up-to-date monitoring system which can perform major tasks automatically without human intervention and can provide data to the user whenever and wherever needed.

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