International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-7 Issue-12, September 2018

Zigbee and RF Module based Solar Panel Monitoring System

Ajay Singh, M. P. S Chawla

Abstract: ***Solar energy is now accepted as an important source of renewable energy, thus real time information of a panel's system becomes a major concern. This paper illustrates about the hardware and software execution of continuous wireless monitoring system for solar panel located in remote areas. XBee module is used as a wireless sensor network which is low power consumption device. Short time delay characteristics and simple to develop, low cost leads to high data reliability. The proposed system has a sending end and another one as receiving end. This system monitors the Solar Panel Temperature, Humidity, Panel Current and voltage, as well the power. 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.***

Keywords: Sensors, Arduinoatmega2560 Microcontroller, X-bee s2 Module, Coordinator and Router, direct sequence spread spectrum XCTU, Postgre SQL Database.

I. INTRODUCTION

Solar photovoltaic power generation system is a multi-power system, which consists of the solar panels, batteries, power inverter components. Improvement in the maximum utilization of solar energy resources has become a challenge since long time. There are several factors that can affect on system's performance, such as a bad cabling (loose connectors or improper wiring), defects in inverters, variations on solar panel output, accidental damage, general manufacturing defects and environmental factors like weather [1]. Hence optimization in Solar Power measuring system is an important requirement for improving the utilization of Solar energy resources.

II. LITERATURE SURVEY

A literature review is that section which shows the various analysis and research being carried out in the field of the project and helps to discover research topics based on existing research. Some research work related with this project is described as follows: A research work presented by Souvanik Bandyopadhyay and M.P.S Chawla [1] described about solar panel ambient characteristic measurement from remote location by GSM technology. This system monitors Panel Temperature, Humidity, Current, voltage, light intensity, Power and then calculates the Panel Efficiency.

Manuscript published on 30 September 2018.
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At the receiving end, GSM module SIM900 receives the sensor data and stores it into Excel sheet software via Arduino to store the data in My SQL database. GSM module will also give readings of the Panel parameters through text messages. The Web page is used to see the Solar Panel data at any remote location.

Xihai Zhang, Jiali Du, Chengguo Fan, Dong Liu, Junlong Fang and Lingshu Wang [2] describes about an information monitoring system of an automatic tracking solar powered panel, in order to analyze, manage, visualize, and upload the real-time information of the paddy field.

Fang Chen, Linlin Qin, Xiaofeng Li, Gang Wu and Chun Shi [3] designed a control system with Zigbee used as a wireless sensor network. Control system used to maintain the temperature and humidity in greenhouse. The designed system is applicable to small greenhouse with better accuracy.

Kartik Rathod, Aesha Parikh, Prof. Vrushank Shah and Nilay Parikh [11] described the various strategies of ZigBee IEEE standards for making smart home environment. The proposed work dealt with fully functional smart wireless home automation network with the help of ZigBee and IEEE 802.15.4 protocols and to assess the applications in a sensor network.

Arbab Waheed Ahmad, Chankil Lee and Naeem Jan Saeed Iqbal [12] implemented ZigBee and GSM based Home Security Monitoring and Remote Control system. The proposed system consists of a control console interfaced with different sensors using ZigBee. The design has been implemented using XBee EM357 module, Atmega128 microcontroller and Sony Ericsson mobile phone.

Muthu Ramya.C, Prabakaran.R and Shanmugaraj.M [13] give brief description of ZigBee wireless standard (IEEE802.15.4). The IEEE standards utilize 64-bit and 16-bit addresses to support more than 65,000 connections per network. This paper also explains physical layers, media access control layers, ZigBee logical device types, Protocols stacks and topologies.

Purnima, Neetu Rout, Renuka Bhandari and Rahul Tiwary [10] developed a smart and an energy efficient patient monitoring system which send parameters of the patient in real time such as temperature, heartbeat, ECG etc. The Doctor obtained a data of a particular patient on his Personal Computer by accessing the database. All the recorded data is continuously updated through Zigbee receiver module.

Article published by Peter Wotton[15] describes the design of Home Networking System with wireless sensor network based on Zigbee standards. This paper emphasized on the communication reliability and security provided by Zigbee.

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This article concludes that Zigbee can be implemented easily with better security and very beneficial for the systems where cable based solutions can be difficult and expensive to install. Sahil Rajput, Dr S Vadivel and Sujala D Shetty [14] illustrate design and analysis of Patient Management system through web application and services. Java language is used for designing the application in NetBeans IDE. MySQL database is used to store the data.

III. PROJECT ARCHITECTURE

The proposed system architecture is classified into two parts. The first part is data acquisition node, which is connected to solar panel with the help of Arduino atmega2560 and second part is central computer system connected wirelessly with all devices via XBee module. The XBee module S2 connected to sensors must be in router mode configuration where as receiving side XBee module works in a coordinator mode configuration. Coordinator verifies with each node in a network to transfer their data before starting the communication and then particular devices in the network respond with obtained data. After this data is received by central system through coordinator, stores it internally on postgre SQL database and make available the data in web page.

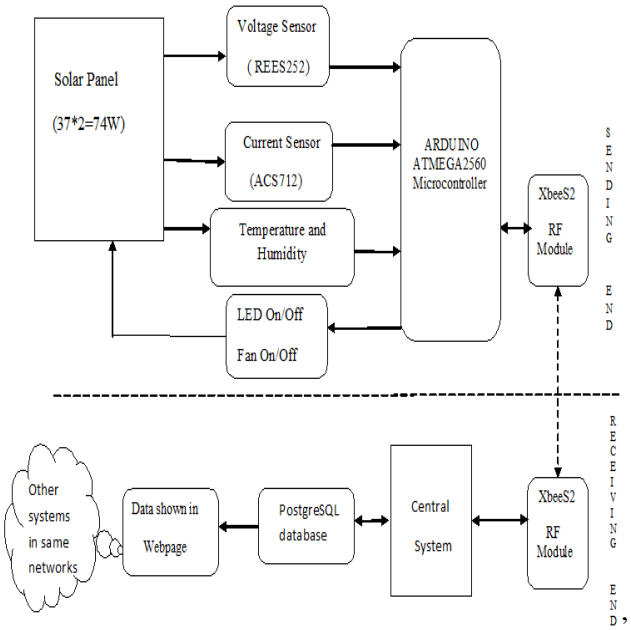

Fig1. Block Diagram of the Proposed System

3.1. DATA ACQUISITION NODE

The data acquisition node is consist of several sensors like voltage, current, temperature and humidity sensor. Arduinoatmega2560 contains 10 bit ADC channel, which means that input voltages are mapped between 0 to 5 volts into integer values between 0 and 1023.

3.1.1. Voltage Sensor

To measure the voltage in solar panel, REES252 voltage detection module is used. It operates at 5 volt dc input and fundamentally it is 5:1 voltage divide circuit using 30K and 7.5K ohm resistor and cannot measure above 25 volts. Voltage detection range for this module is DC 0.02445 to 25 volt and voltage analog resolution is 0.00489 volt.

3.2. Current Sensor (ACS712)

In this project, current is measured through ACS712 current sensor. The ACS712 used for cost effective and accurate measurement of DC or AC current. The ACS712 sensed the input current and converts it into an equivalent voltage value. The current value can be determined through sensor characteristic mention in datasheet. The PV current is measured through Arduino using the concept of 10 bit ADC by following equation.[5]

$$I = \left(\left(\frac{5}{1023}\right) * Vout - 2.5\right)/(0.185) \ldots (1)$$

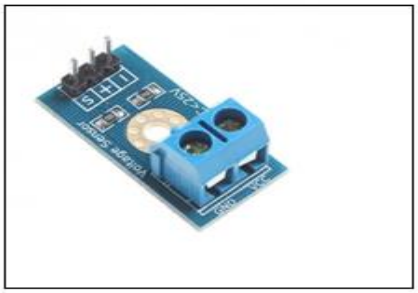

Fig2. Voltage Sensor

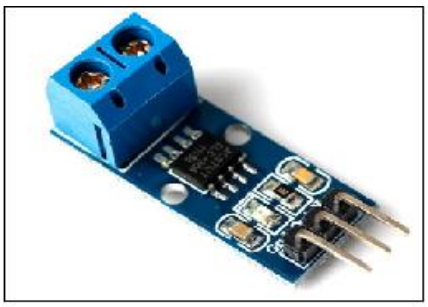

Fig 3. Current Sensor

3.2.1. Tempreture and Humidity Sensor

DHT11 being a composite sensor is commonly used as humidity and temperature measurement which gives a digital output for the humidity and temperature. This sensor includes a resistive assembly of wet components and NTC temperature measurement devices. Humidity is measured with the electrodes having moisture holding substrate between them. Hence, the value of humidity is inversely proportional to the resistance of substrate.

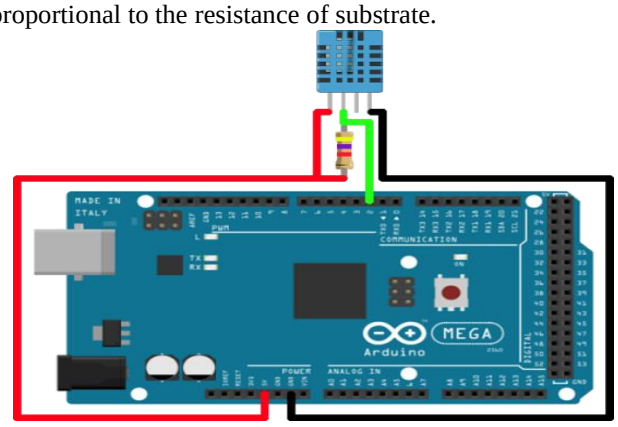

Fig 4. DHT11 Connection with Arduino

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3.2.2. Solar Panel

It consists of two set of solar panel, each panel with a rating of 37 W and these panels are mounted over a strong metal base with 1000W Halogen lamp of both sides. Normally the panel is placed 180° horizontally but the plates can be tilted. The power produced can be varied by tilting the plates to different angles. This simply represents the relation between angle of light beam that hits on the panel and the power produced. The power can also be varied by adjusting the stand of the halogen lamp. DC voltage is produced by the solar panel and the power produced from the two panels are taken from + and – terminals. The outputs of both the panels are connected in parallel and finally a single + and – terminals are taken from the panel through the wires.

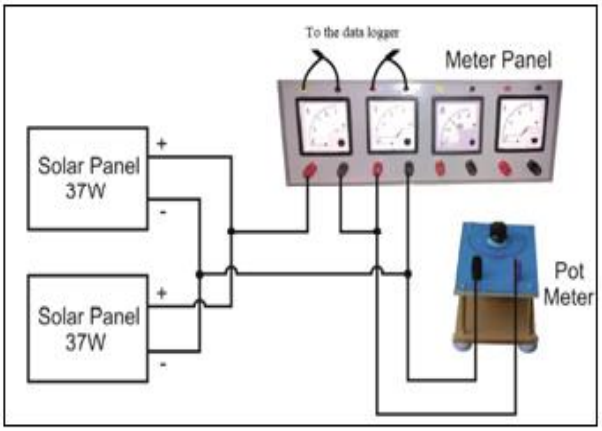

Fig 5. Solar Panel Setup (In Laboratory)

3.3. System Software Design

The drawback of a cable network is a challenge, which includes high initial cost and more installation time, thus a wireless communication medium is opted. The wireless communication link is developed using XBee radio modules and the device can work as a Coordinator, a Router or an End device depending upon its configuration. Zigbee is a small power consumption device which provides a range up to 400 feet in outdoor**.** It works under the various frequency ranges such as 868 MHz in Europe, 915 MHz in North America and Australia and 2.4 GHz available worldwide, ISM band ranges from 20kbps to 250 kbps. [11, 14]. Wave bands are generally different for the different wireless networks such as Wireless Fidelity, Wireless USB Bluetooth etc.

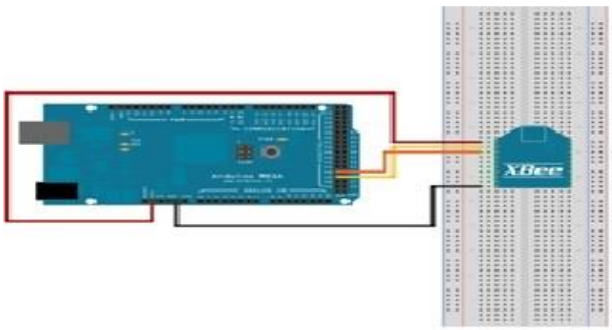

Fig 6. Arduino Connection with Xbee

For configuring XBee modules XCTU software tool is required. To create a wireless ad-hoc network using XBee modules, configuration is required first which is done by XCTU software tool.

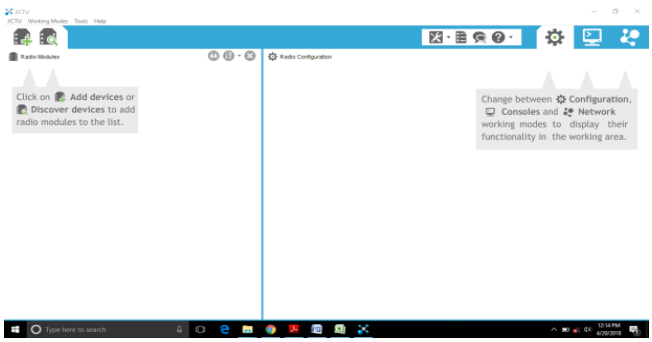

Fig 7. XCTU Software

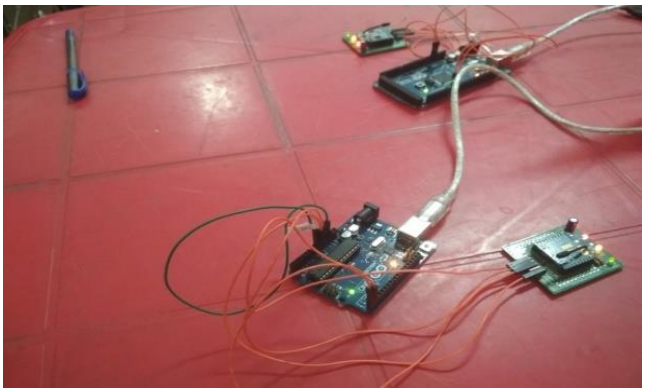

Fig 8 Configuration of XBee Modules

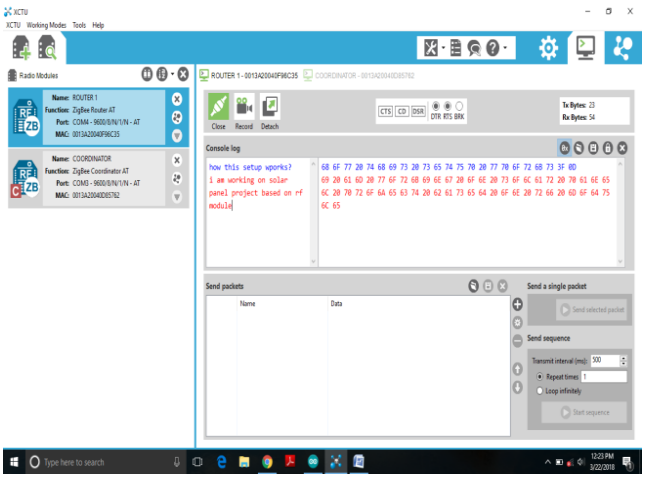

Fig 9. Communication between Two XBee

IV. WIRELESS NETWORK PROGRAMMING

The sequence of step required to set up the communication between two or more than two XBee are discussed below. First, the full function device becomes the coordinator to establish the ZigBee network. Then, the coordinator performs channel scanning, and selects a better channel from the channel list. Finally, the coordinator selects a unique PAN ID for the new network and waits for the router and terminal equipment to join. The terminal device first performs a series of initialization and looks for a network that can join, and if accomplished then, sends a request of joining network to the coordinator which will assign a 16 bits short address to the terminal device, if joined successfully, or continuing to find the network. After the router device joins the network successfully,

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it start the communication. The figure 9 and 10 shows the workflow of X-Bee module devices.

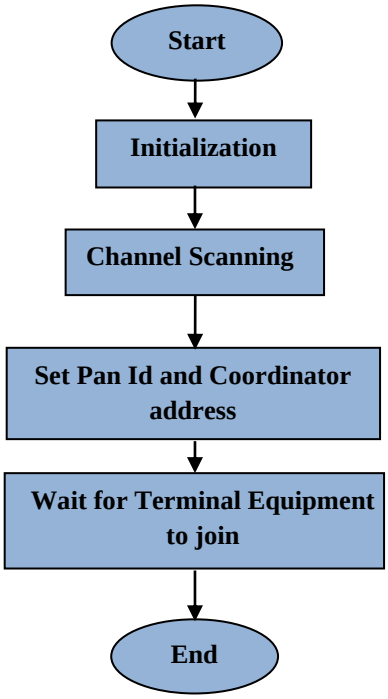

Fig. 10 Create Network

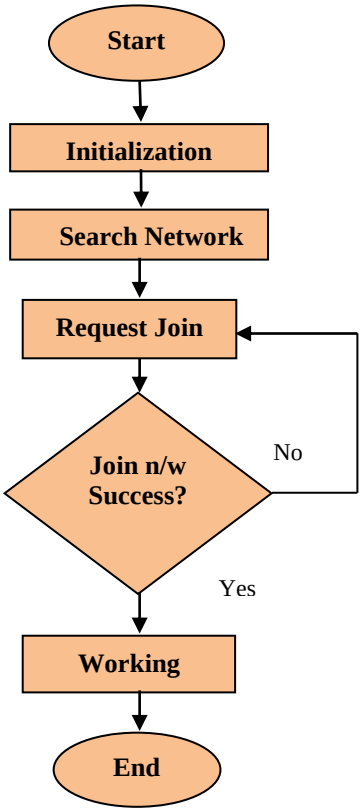

Fig 11 Connecting a Network

4.1. X-Bee Module System Range Testing

ZigBee communication distance for the IEEE802.15.4 standard designed is around 400 ft, but different RF chips and different circuit design will lead to differences in transmission distance [10]. Therefore, it is necessary to test the reliable transmission distance for better designing the network layout and meeting requirements of system communication distance and quality. Zig Bee communication distance is then tested in open environment for XBee s2 module. It works well for distance around 300-350 ft. above 350 ft discontinuity problem can occur in communication.

V. EXPERIMENT RESULTS

The design and development of a solar panel and measurements of ambient characteristics wirelessly is done from remote location. This system monitors the panel parameters such as Temperature, Humidity, Panel Current, Panel Voltage and Power with the help of sensor nodes. These data first comes to the database through XBee and then it is displayed on webpage.

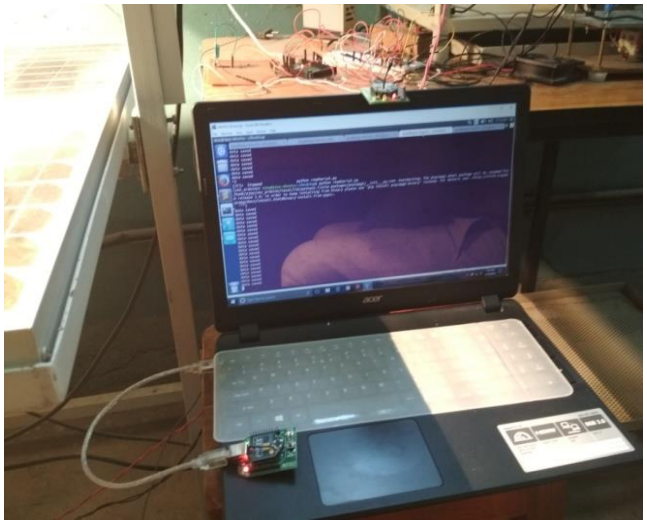

Fig12. Project Setup

Xbee modules communicate with each other without any wired connection with each other. Coordinator receives the complete data from sensor nodes by a help of Router X-bee module which is connected to program Arduino atmega2560. All data from field is sent to the Main System and is saved on postgre SQL database. Programming is done via python language as shown in Figs 13 and14.

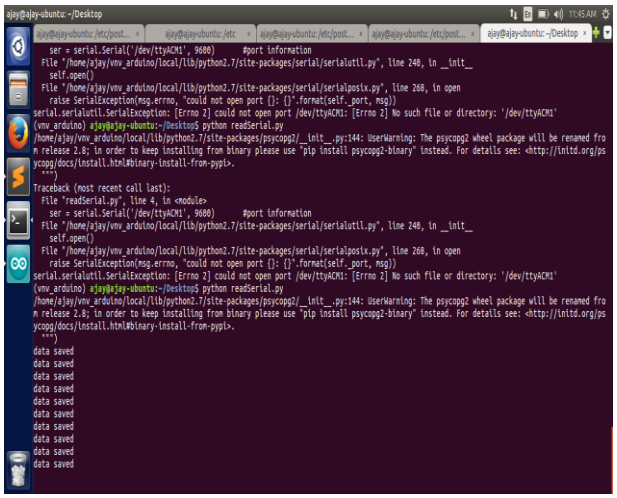

Fig13. Data Saved From Arduino to Database

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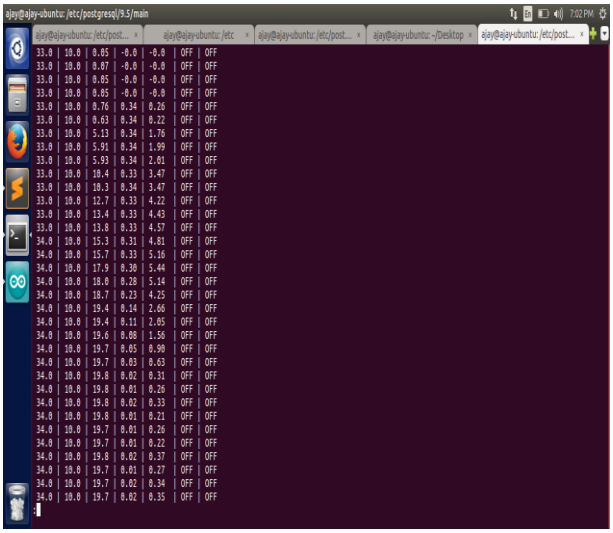

Fig14. Data Shown on Database

Fig. 15 describes about, how the web page fetches the data from database. This web page data can be accessed by all the other systems which are connected with the same internet network.

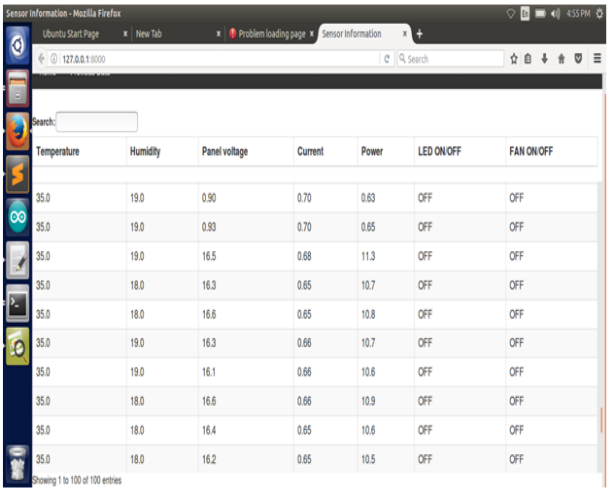

Fig 15. Data Shown in Webpage

5.1. Graphical Analysis of Voltage, Current & Pv Measurement

Figs. 16 & 17 are show voltage and current measurement of existing lab setup and via arduino.

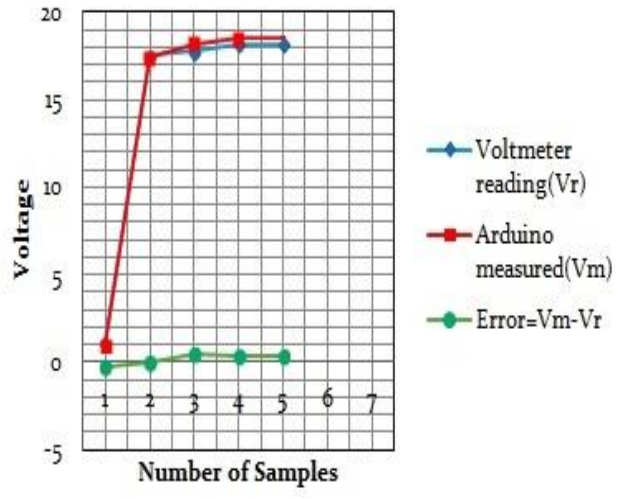

Fig 16. Voltage Measurement

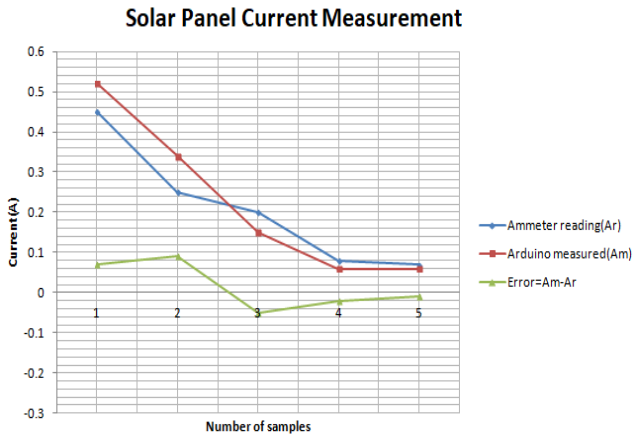

Fig 17. Current Measurement

When the value of resistance is minimum then the Panel produces maximum current in the circuit. Conversely, the maximum voltage occurs when the resistance is maximum. The P-V Curve is used to locate the maximum power output which is called as Maximum Power Point (MPP).

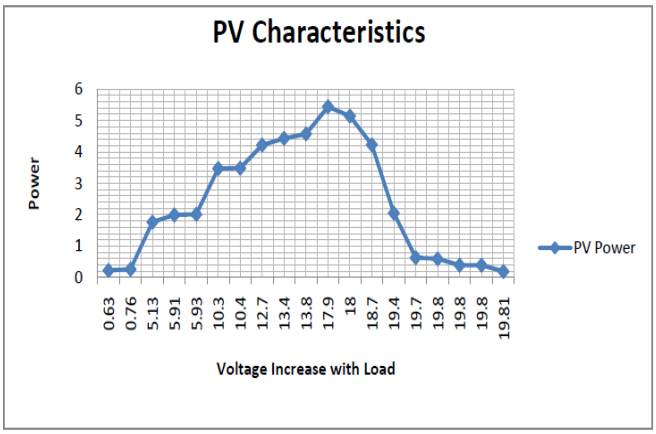

Fig 18 P-V Characteristics of Solar Panel

VI. CONCLUSION AND FUTURE WORK

The proposed system gives the Solar Panel Ambient Characteristics Wireless Monitoring and the controlling system is an efficient system in which user can monitor the real time electrical parameters of the solar panel from remote location at any time and can control the devices. This paper describes that the proposed wireless automation with ZigBee standards are quite advantageous in the field of the industries, being reliable and secure communication even when supporting 65000 nodes at a time. The developed components and the system can be improved for better performance. Some features that can be added to the present system in future are listed below:-

I. This system can also be applied for measuring the solar radiation of a particular area wirelessly as well this project can also implement weather forecasting mechanism for measurements.
II. XBee-PRO version module can be used in a proposed system, to eliminate the need for a separate processor.
III. A Weather forecasting system can be implemented with proposed system.

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