# Increase Efficiency of Solar Photovoltaic System by Data Acquisition Process

Sunil Parashar, Sunil Dhankhar

*Department of Computer Science & Engineering*

*SKIT, Jaipur, India*

Snlprshr5@gmail.com

*Abstract-* **In current scenario, renewable energy sources helps to make the environment greener and better. Currently, solar energy is the most available resource of renewable energy. This paper mainly represents the working principle of solar photovoltaic system and way to increase efficiency of the solar system using a method known as the data acquisition system. Data acquisition is a process to monitor changes in system, collect corresponding data and analyze data to make a decision. The data acquisition system has two parts, data acquisition board that contains Microcontroller Kit, ADC, and RS-232 and Zigbee communication modules. Another part is running on a host computer that has a set of software tools as Keil, Proteus, and Visual Basic 6.0 help to analyze and store data. Zigbee communication helps in wireless data transfer without any communication cost. Complete experiment and the result show the data acquisition designed is simple and stable.**

*Keywords*: **solar energy, green energy, photovoltaic cell, ADC, data acquisition, microcontroller, communication, serial communication, Zigbee communication.**

## I. INTRODUCTION

Electricity is the main factor for social, economic and industrial development. In the generation of electric energy, a generation can be possible in two ways renewable and non-renewable energy types that depend upon generation resources. Renewable energy sources are replenished automatically time to time means they may be natural and cannot be replaced as fast as they are being consumed. Example of renewable type is sun, wind, etc. Development and use of large scale solar energy is not only great style of utilization of energy resource in the future, but also efficient measures accommodating to energy resource frame and enhancing energy resource disaster. The data acquisition system is a process used to collect information that can be stored and processed by a computer to analyze some special phenomenon. To increase accuracy of solar energy resource data acquisition is very important, different instruments to obtain data on the solar energy resource can produce different results and have a significant impact on the large-scale solar energy development and utilization. Zigbee is IEEE international standard 802.15.4 based communication protocol for personal area network using small, low power, digital radios.

## II. STRUCTURE OF DATA ACQUISITION SYSTEM

Renewable energy sources provide a new area to generate energy by keeping the environment green. The solar energy system is most available and useful renewable resource today. Sun provides enough energy, but a mechanism needs to convert this solar energy into electric energy. The photovoltaic effect provides a way to use this solar energy in the best way by converting it into appropriate electrical form. Solar energy system mainly contains a set of solar cells or solar panel that takes sunlight as input and convert into electric type. Energy generated through photovoltaic system is not continuing because this system is affected by different environmental factors as dust, cloud, rain, etc. Charge controller used to regulate this discontinuous voltage; it can be said as a voltage regulator. Electricity generated by the photovoltaic panel is a DC type so it can be used directly for DC application, for AC application an inverter is used to convert generated DC power into AC power. The Ssorage system can be used to store energy for future use. Batteries are conventional storage of energy.

The data acquisition system is mainly divided into two parts; the first part is a data acquisition board that contains acquisition hardware modules as Analog-to-Digital converter (ADC), microcontroller and communication modules as RS-232 serial communication system and Zigbee wireless communication system. Another part of data acquisition is a host computer that mainly contains application software and database system. All decisions should be made in the host system.
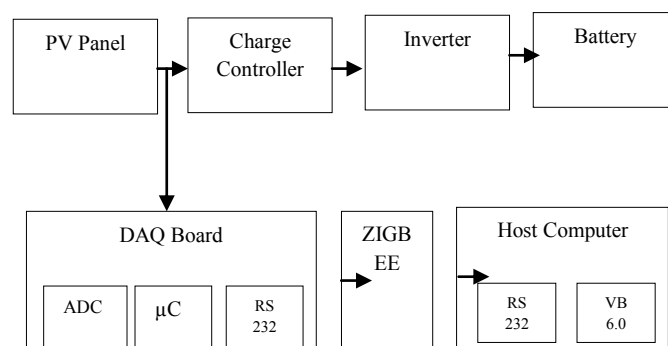


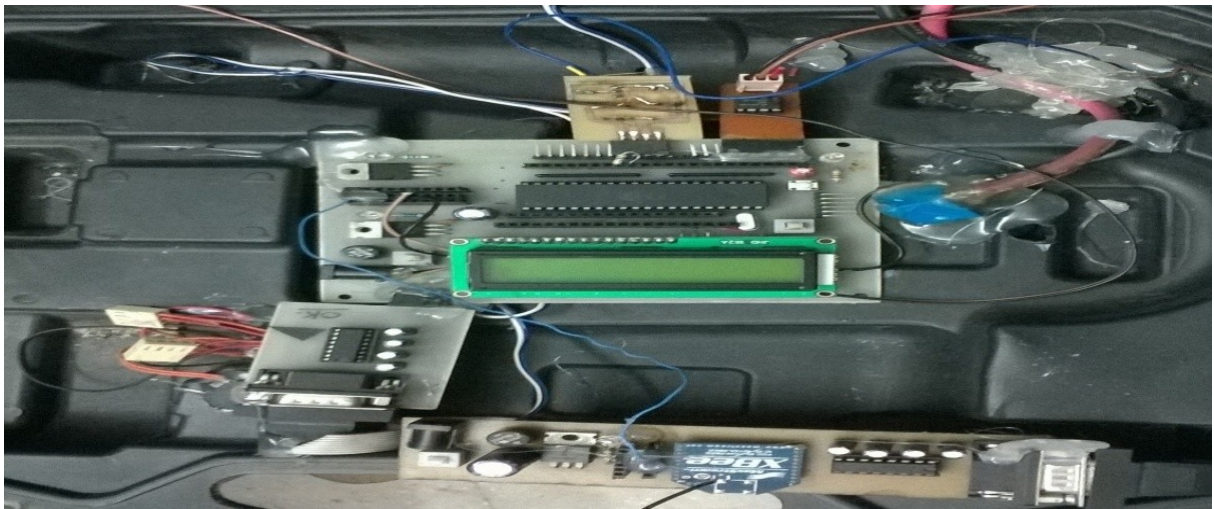Figure 1. Photovoltaic Cell Power Generation Structure

Figure 2. Data Acquisition Board

## III. HARDWARES AND SOFTWARES IN DATA ACQUISITION SYSTEM

Data acquisition board comprises a set of electronic components used to control data acquisition process. Data acquisition board mainly contains Microcontroller, Analog-to-Digital Converter, and liquid crystal display (LCD), Zigbee and RS-232 serial modules. The figure 2 shows all components and connections of the data acquisition board.

### A. Microcontroller AT89C52:

AT89C52, Atmel designed 8-bit microcontroller with 4K bytes of flash programmable and erasable read only memory (PEROM). The operating frequency of this controller varies from 0 to 24MHz and 11.0592MHz crystal frequency is set to currently. To make compatible with other peripheral devices as ADC, LCD or serial communication module it has 32 programmable I/O lines with 4 ports and 16-bit timer/counter with 6 interrupt sources. Figure 2 shows the peripheral device (LCD) connection with microcontroller.

### B. Analog to Digital Converter ADC0831:

ADC0831 is 8 pins, 8-bit serial data output IC used to convert the continuous analog signal into a digital data.
It accepts incoming analog data from panel and converts it into an appropriate digital form and sends this data to microcontroller port.
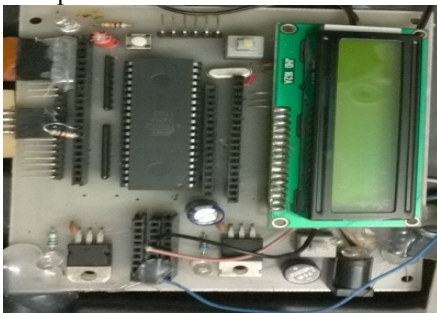


Figure 3. Microcontroller Kit in DAQ Board

### C. Zigbee and RS232:

Zigbee is an IEEE 802.15 standard based communication protocol used to create a wireless personal area network between solar panel and host computer to transmit data from the data acquisition board to the host system. Zigbee works better in a small geographical area without any communication cost.

RS-232 is a serial communication standard used to make the communication link between data terminal equipment as host computer and data circuit terminating or communication equipment Zigbee. Figure 4 shows Zigbee and RS-232 communication boards. MAX232 IC used to make communication more convenient.
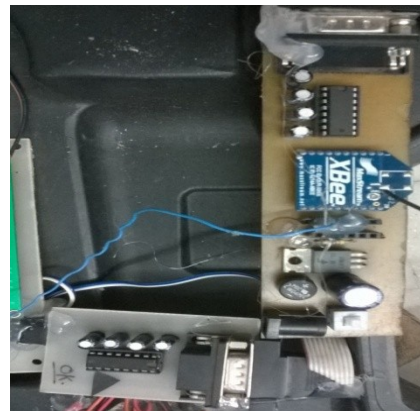


Figure 4. Zigbee and RS-232 in DAQ Board

### D. KEIL:

The Keil µvision integrated development environment (IDE) from Keil provides support for embedded software development. It provides a way to instruct microcontroller AT89C51. By using this tool, it can be easy to edit source code, debug programs and allow complete simulation with more options. To start with, on startup select appropriate controller type, then set all parameters of it as crystal frequency. .Hex type file is created through this tool and uploaded to a microcontroller that instructs microcontroller.

*E. Proteus*:

Proteus virtual system modeling (VSM) is a simulation tool that includes all electronics and electrical components. It allows a developer to design a virtual prototype and simulate it as real. It also provides facility to interact with code written in Keil and VB. It has a serial communication option that enhances its simulation and communication capability.

*F. Visual Basic 6.0*:

Visual basic has an integrated development environment that provides some special functionality as rapid application development, remote object access and database access. It is an event driven language means on any event there is an option defined in it. It helps to monitor any changes in the solar system by gathering data. To make data comparison more understandable different graph and charts can be created. Microsoft Excel tables used to store incoming data.

To test data acquisition system Eltima software is used to make the communication link between Proteus VSM tool and Visual Basic program.

## IV. DESIGN OF DATA ACQUISITION SYSTEM

*A. Zigbee Communication Module:*

Zigbee is IEEE international standard 802.15.4 based wireless communication protocol works over 2.4 GHz operating frequency. Networks in Zigbee are as personal area networks so each network has a unique identification as PAN identifier. 64-bit and 16-bit type IDs used in Zigbee network, where 64-bit ID used to join and remove any conflicts and 16-bit ID for data transmission. So 16-bit address is required for packet transmission in Zigbee network and 64-bit addresses for module identification. Figure 5 shows X-CTU application to connect Zigbee devices.
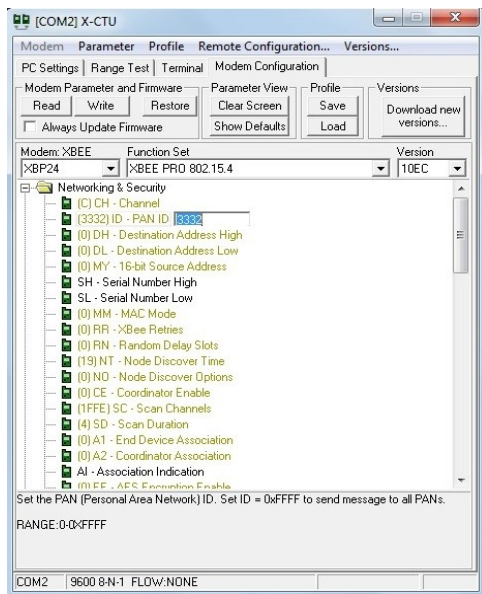


Figure 5. X-CTU Application for Zigbee Communication

Before starting communication needs to configure Zigbee devices in a proper way. Figure 5 shows different properties of modem configuration.

*B. Data Acquisition System Model:*

Figure 6 shows a flow chart of the data acquisition process. Data acquisition starts by initializing all components at begin level. Analog data are received at ADC to convert it into digital form. If conversion is failed need to convert again else send data to the controller and then move data to a host system to store. Zigbee and RS-232 help to move data from microcontroller to the host system.
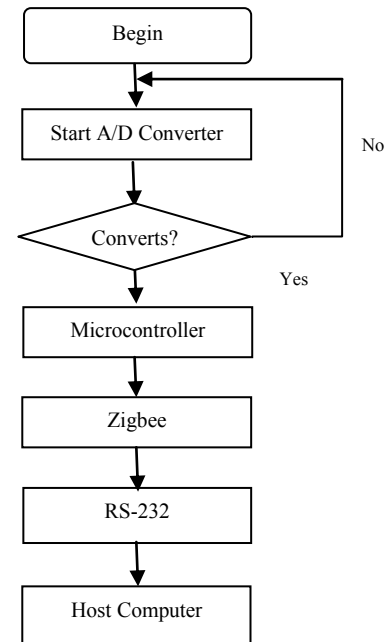


Figure 6. Block Diagram of Data Acquisition Process

## V. SIMULATION AND EXPERIMENT RESULT

The completed solar energy system is working with some predefined values. To understand complete working, some basic calculation needed as

The number of solar panels used = 10 (connected parallel)

Solar cells in each panel = 36 cells (connected serially)

The potential of each cell = 1V

So potential of a solar panel = 36V (shown in figure 4.15)

Current of each panel = 4A

Potential of complete solar systems = 36V

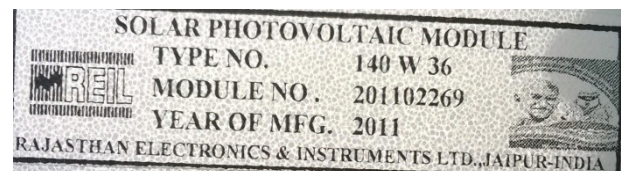Current of completed solar system = 4×10 = 40A

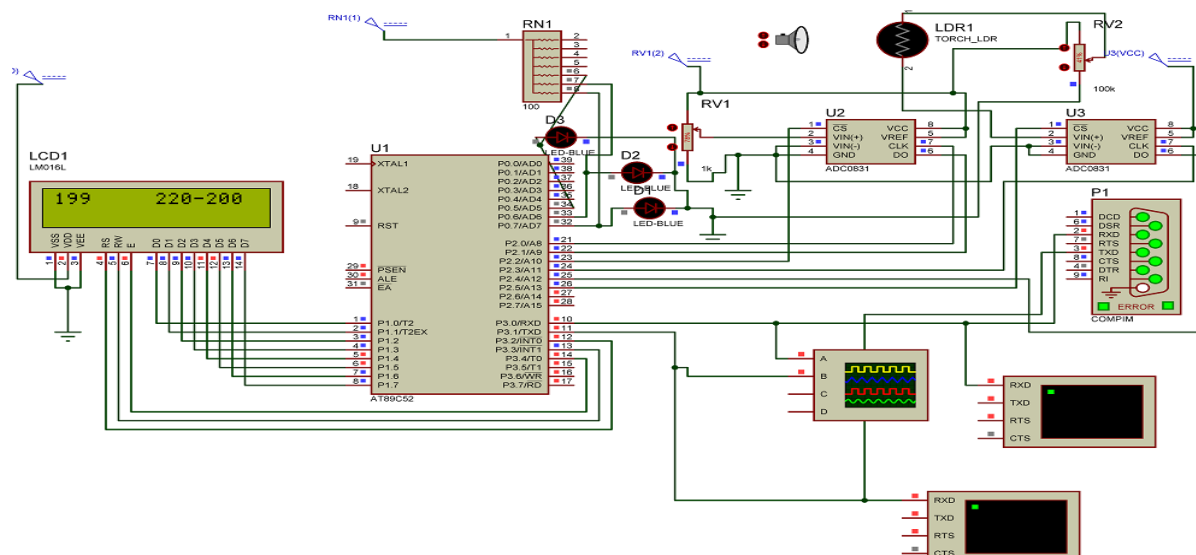

Figure 7. Solar Photovoltaic Module
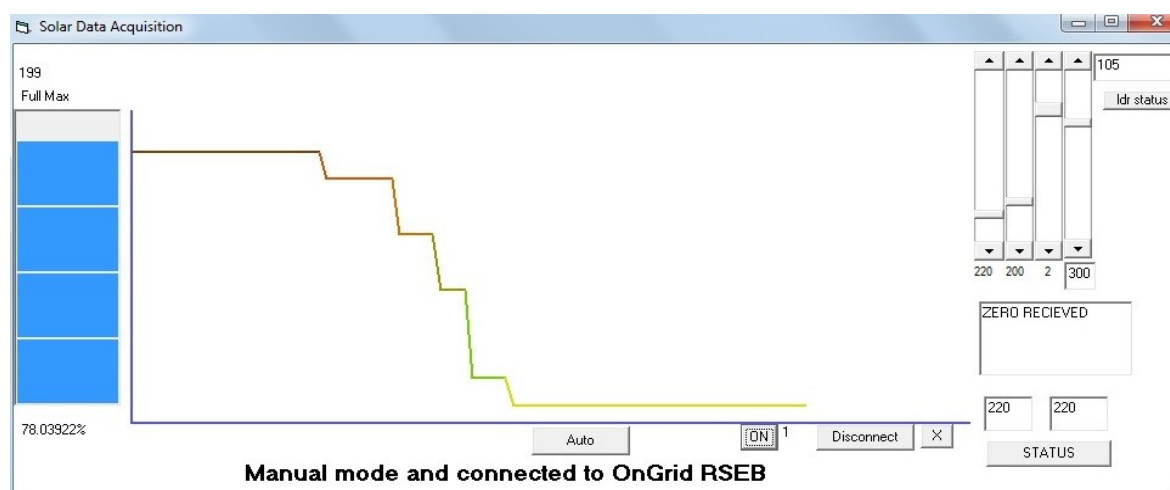
Figure 8. Simulation of DAQ in Proteus VSM



Figure 9. Data Acquisition Data Chart in Visual Basic at Host System

Simulation of complete data acquisition process is designed in Proteus virtual system modeling tool as shown in figure 8. This virtual system comprises a microcontroller AT89C52, ADC0831 and LCD and other circuit elements. An LDR (light dependent resistor) is also added to the model to check status of the environment. Input coming from RV1 is applied at VIN (+) pin of ADC0831 (U2) and output send to microcontroller's    1 pin of P2 port. To display the  current status of solar system, an LCD is added at P1 port of the microcontroller. RS-232 communication terminals are also in circuit (P1) to transmit data to another terminal point as visual basic to draw a graph or chart. By getting data, system trigger between two modes, auto mode and manual mode with options for off-grid solar system or on-grid RSEB connected. Figure 9 shows the manual mode with on-grid RSEB connected and status of complete solar systems with chart of incoming data. Complete experiment is simulated at TISHITU research center, Jaipur (26.8533, 75.8113 positions).

To check the reliability of data acquisition system a comparison table between the actual reading (taken using a multimeter) and DAQ system reading provided in table 1.

TABLE 1
EXPERIMENTED VALUE VERSUS ACTUAL VALUE

| Time (PM) | 12:15 | 1:15 | 2:15 | 4:15 | 6:35 |
|---|---|---|---|---|---|
| Voltage (Measured) | 31.2 | 32.0 | 31.6 | 29.0 | 19.0 |
| Voltage (Actual) | 31.5 | 32.2 | 31.5 | 29.1 | 19.3 |
| Current (Measured) | 15.1 | 15.5 | 15.3 | 11.4 | 4.3 |
| Current (Actual) | 15.2 | 15.7 | 15.3 | 11.8 | 4.5 |

*Note: All voltage values in Volts and current values in Ampere.*

After collecting data from data acquisition system, it can be shown that the data collected through a data acquisition system meets the requirement of accuracy as: voltage error < 1V  and  current  error  <  1A.  So it can be proved that the designed DAQ system meets with all requirements.

## VI.    CONCLUSION

This designed data acquisition system makes use of the microcontroller based data acquisition board hardware, software modules and communication modules as Zigbee. So it can be easier to reduce complexity of the entire system in terms of hardware, software and communication. Maintenance cost and upgradation cost of the system are also reducible because of the use of software.

Zigbee provides a new way of wireless communication by reducing communication cost in a small geographical area. Compared to other implementations, this data acquisition  model is more reliable and uses less energy and meets the goal of data acquisition system as high speed, real time calculation.

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