

## **Data Acquisition and Analysis of Solar Photovoltaic System**

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### **Abstract**

Solar energy is most useful resource of renewable energy. Using data processing and applying computer algorithms it can be possible to make this energy system more efficient. This paper represents the principle of on-grid photovoltaic cell system and characteristics of its components. A microcontroller based data acquisition system used to collect data from panel. The system comprises of data acquisition system, Zigbee and RS-232 communication modules and computer that permit user to collect data wirelessly. 8-bit 40-pin Atmel AT89C51 type microcontroller used to monitor. After collecting data wireless communication module Zigbee and serial communication module RS232 used to transmit collected data to user computer. Characteristics and operation of setup complete system provided and result of this experiment show that data acquisition is simple and stable.

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

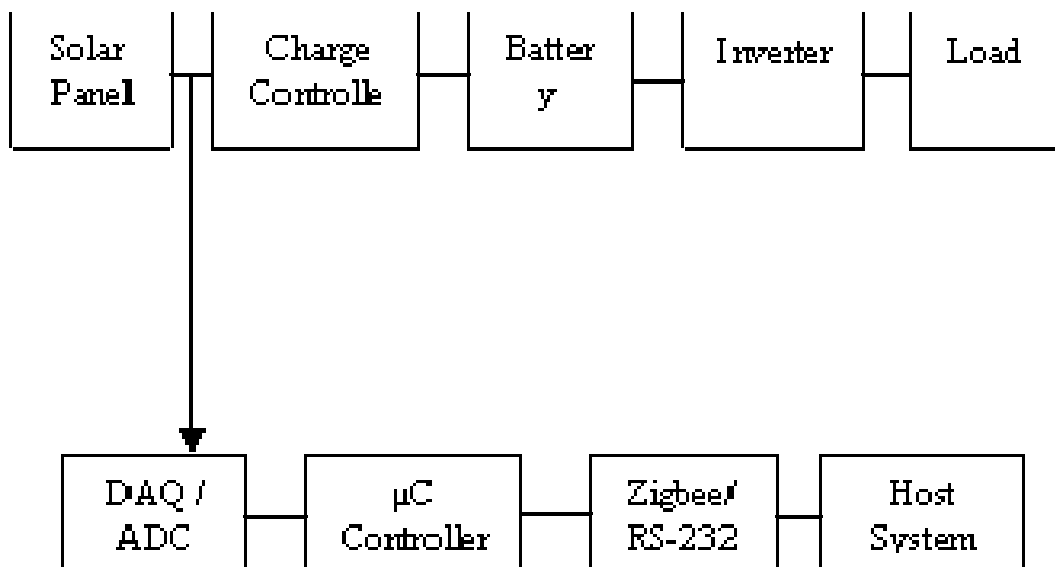
### **Introduction**

Renewable energy resources are becoming one of primary sources of energy due to its abundance. Today, as civilization grows rapidly various challenges are occur in front of energy structure. Because of interest regarding pollution and global warming demand of renewable energy resources are increased. Solar energy is most promising source of renewable energy sources because of its abundance, versatility and environmental friendly nature. Evolution and utilization of this energy not only provide way to use of these resources but also produce efficient assessment to adjust resources in better way to overcome energy resource crisis. There are different environmental and geographical factors that affect resources, so measurement of solar resources under these factors make system cost effective and enhance usage rate of renewable solar energy. Data acquisition helps to measure status of solar systems under these factors. Accuracy of data acquisition system is also important because

various instruments are used to obtain data from system and may produce different results that cause a serious impact on a large scale solar system. Usually, this data acquisition system uses a controller AT89C51, Analog to Digital converter ADC0831, and various communication modules. Some software modules also used to make data acquisition efficient and flexible.

### Structure of Solar Photovoltaic System

Solar energy is main part of renewable energy sources. Sun is an infinite source of solar energy that reduces the need of electric energy. To use this energy there is a list of components that provide a better way to generate and use of this solar energy, as photovoltaic cells, charge controller, inverter and any storage methods as battery. Photovoltaic cells also known as solar cells convert this solar energy into electricity by the photovoltaic effect. Solar cell or photovoltaic cells are constructed from material that uses to convert solar light into electric form. PV cells are made of composition of layers of any semiconductor material as silicon. When sun generated photons of light strikes a solar cell, energy generated that are then absorbed by semiconductor component. Generated power from a solar cell is much low as one or two watts. So to enhance system power a number of cells are group together over a plate also known as solar panel.



**Fig. 1. Solar System with Data Acquisition Model**

It is not possible to use solar energy in direct way because of its discontinuous nature or other environmental factors as dust, cloud, rain, etc. So there is a need of a mechanism to control the charge and storage that has capability of absorbing and delivering power. Charge controller works between battery and solar panel and maintains voltage of both components. If generated voltage through panel is higher

than battery allow battery to charge and if voltage through panel becomes lower than cutoff panel from battery. So it protects system from overcharge and reverse leakage.

Battery energy storage methods can be used that abate solar power generation issues as ramp-rate, frequency or voltage issue. A number of batteries are used through serial or parallel, this choice depends upon capacity of the components of solar cells. A DC-AC inverter used to convert DC power produced by panel into AC power to allow for electrical appliances.

The data acquisition system consists of a microcontroller AT89C51 and some of its peripheral equipments as ADC analog to digital converter ADC0831, LCD (Liquid Crystal Display), and some communication modules as Zigbee and RS-232. Zigbee allows system to transmission of data wirelessly. RS-232 makes a bridge of communication between host computer and data acquisition modules. Host system contains some software modules as keil, proteus and visual basic 6.0 to allow collecting data and creating chart to take decisions.

### **Hardware and Software in Data Acquisition System**

#### ***Microcontroller AT89C51:***

AT89C51, Atmel designed 8-bit microcontroller that has 4K bytes of flash programmable and erasable read only memory (PEROM). This microcontroller is compatible with MCS-51 instruction set and pinout. Operation frequency varies from 0 to 24MHz. 11.0592MHz crystal frequency set to currently so timing delay is 1.085µsec.

#### ***Analog to Digital Converter ADC0831:***

ADC0831 is 8-bit serial data output 8 pin analog to digital converter IC that converts continuous analog signal to a digital number form. ADC0831 converter used with microcontroller to convert analog data received from solar panel to digital form to display or store.

#### ***Communication Modules Zigbee and RS232:***

Zigbee is an IEEE 802.15 standard based communication protocol used to create wireless personal area network between solar panel and host computer to transmit data to host system. RS232 is a serial communication standard used for transmission of data between data terminal equipment as host computer and data circuit terminating or communication equipment Zigbee. MAX232 IC used to complete these actions and it use only a 5V voltage can be TTL level converter for RS232.

#### ***KEIL:***

The µvision integrated development environment (IDE) from keil provides support for embedded software development. To instruct microcontroller AT89C51, this one used to decide controls. It provides facility to editing source code, debug programs and also complete simulation in powerful environment.

**Proteus:**

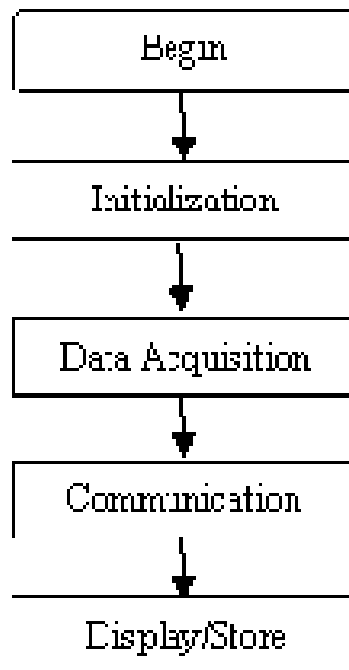
Proteus virtual system modeling is simulation tool that is a combination of SPICE circuit simulation, different animated components and various microprocessor based design, used to simulate and test design before create physical prototype. Complete acquisition model designed into this environment to check its complexity level. Availability of serial communication allows it to transmission of data to other modules.

**Visual Basic 6.0:**

Visual basic is an event driven language with an integrated development environment allow it to perform some special functionality as rapid application development (RAD) of graphical user interface, database access and remote data objects etc. It helps to gather data in database and create a graph or chart to make comparison easy and understandable.

**Design of Data Acquisition System****Data Acquisition System Model:**

The data acquisition system software developed using embedded C language. Compiler tool to compile this code is keil C51 compiler and block diagram of system software shown in figure 2. Initialization of complete system by sending control or data bits, process data acquisition means access data and forward to host system or storage media through any communication modules as Zigbee and RS-232.



**Fig. 2. Software System Block Diagram**

Data acquisition system is a process used to collect information that can be stored and processed by a computer to analyze some special phenomenon. Two main aspects are essential for this system: transmission type in system (serial or parallel) and information exchange mode between system devices. The acquisition system is essentially based on Atmel AT89C51 and ADC0831 components.

When system start first of all continuous analog data send to analog to digital converter that accept data over VIN(+) pin and generates data in digital form from pin DO. This generated data is now sending to any pin of controller to allow controller to perform action according incoming value. After processing, data is transmitted to host system through wireless communication module Zigbee and serial communication RS-232. Now data is collected at host system in a database and graph created in Visual basic module to understand changes.

### Simulation and Experiment Result

Simulation of complete acquisition in software system is designed in Proteus virtual system modeling tool as shown in figure 4. This model comprises a microcontroller and its peripherals circuit. Input is applied at VIN(+) pin of ADC and output send to controller's P2 ports 1 pin. LCD is added at P1 port of controller that shows current status of solar system. RS-232 communication terminal is also added to transmit data to other terminal point as visual basic to draw a graph or chart. To get result to prove the system's condition for experiment are described as 4 solar panels are connected in parallel, where each panel has 36 cells in series. Open circuit voltage VOC of panel is 36V and short-circuit current ISC is 4A. So, total generated voltage through 4 panels are 36V maximum and current is maximum 8A. Through this calculation voltage of a single cell in a panel is 1V.

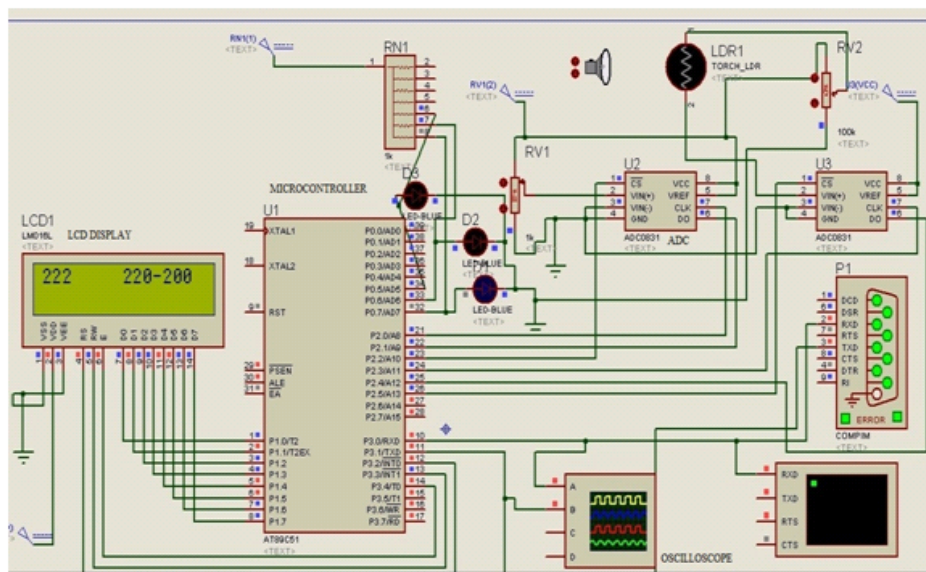


Fig. 3. Circuit of Data Acquisition in Proteus

Voltage and current measurement values are measured through device and acquisition is:

**TABLE 1 MEASURED VALUE VERSUS ACTUAL VALUE**

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

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

After collecting data from acquisition system it is proved that data collected through it meet the requirement of accuracy as: voltage error < 1V and current error < 1A. therefore the designed system meets to all requirements of a data acquisition system.

### **Conclusion**

This data acquisition system makes use of microcontroller hardware and software modules so it can be easier to reduce complexity of entire system in terms of hardware and software designs. Maintenance cost and upgradation cost of system is also reducible because of use of software. Compared to other implementations, this 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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