

# Real Time Monitoring And Controlling Of Solar Panel Using Labview

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**Abstract:** This paper aims at the development of real time process to track the sun position and maintain maximum efficiency using Arduino UNO and LabVIEW. The parameters such as voltage, current, light intensity of solar panel are acquired continuously. Voltage is measured by using voltage divider, current is measured by using acs712 and light dependent resistors(LDR) is used for capturing maximum light source and the acquired data are processed in Arduino and send to LabVIEW. Arduino compares the value of two LDRs which are placed in the opposite sides of the solar panel and accordingly sends signal to the stepper motor. The stepper motor rotates the solar panel to the maximum light source location sensed by LDR with better resolution than servomotor. In software development, the Graphical User Interface (GUI) is constructed by using LabVIEW. The tracking process of sun is made in both automatic mode and manual mode by using an external switch in the circuit. When the switch is in ON position, it is in the manual mode and vice versa. The automatic mode is governed by Arduino-stepper motor interface. In manual mode, the desired step angle is entered manually in Arduino or LabVIEW. The energy from the solar panel is stored in battery. That stored energy is used to supply the arduino board and also load.

**Index Terms:** LabVIEW, MPPT, Arduino, Solar panel, LDR, Stepper motor, GUI.

## I. INTRODUCTION

DUE to increase in energy demand and the environmental problems, the natural energy sources have become alternative to the conventional energy sources. Renewable energies from natural resources such as sun, wind, tides, waves and geothermal heat are inexhaustible and clean. A range of technologies such as photovoltaic, thermal electricity, etc. is used to produce electrical energy from radiant light and heat from the solar energy. Solar panel use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The module use wafer-based crystalline silicon cells. Many approaches have been proposed to monitor solar panel parameters and Maximum Power Point Tracking of PV panel. As LabVIEW has high performance in communicating with several devices simultaneously, the proposed system is very simple, low cost and high reliable. The monitored data can be stored [1]. System has two stages i.e. hardware and software development. In hardware development, 4 LDRs has been used for capturing of maximum light. Sensing the LDR the two DC motors are used to move the solar panel to maximum light source location [2]. MPPT is developed with LM324 comparator with optocoupler. The results are taken from Bluetooth module and a display panel interfacing with Arduino UNO [3]. MPPT concentrates on maximum and efficient use of solar energy by real time tracking and using Arduino of the single axis solar tracker. It includes wind protection scheme considering effect of shielding on solar panel [4]. For high efficiency, maximum power must be harnessed from the solar panel [5]. Hence this proposed system aims at maximum power point tracking from the solar panel by the comparison of light intensity from the Sun. Tracking of solar panel helps to change their orientation throughout the day to follow the sun's path to maximize the energy capture and it helps to minimize the angle of incidence between the incoming sun light and the panel which increases the amount of energy. This paper uses single-axis solar tracker which rotate on one axis moving backward and forward in a single direction. As improved efficiency means improved yield, so that it makes a quite difference in the income from the large plant. This improved performance of solar panel is governed by the monitoring system continuously. The parameter under consideration such as voltage, current, light intensity has been acquired from solar panel and processed using the Microcontroller. This is then sent to LabVIEW for graphically representation. The

performance of the solar power system is monitored using Voltage versus Time and Current versus Time plot.

## II. BLOCK DIAGRAM

From the solar panel, the parameters like voltage, current, light intensity is acquired using sensors. Voltage is measured from the voltage divider circuit. Current is measured from the current sensor which is connected in between the solar panel and load. LDRs are placed in the opposite sides of solar panel. Then the acquired values are sending to the Arduino. The block diagram of proposed method is shown in Fig.1. In the Arduino the programming is done to control the solar panel and to send the solar panel values to the LabVIEW. In the LabVIEW, the acquired values are displayed as graph and in the meters. The battery is connected to the solar panel. The supply to the Arduino board is given from the battery. The LDR values are read by the Arduino and compared with the threshold value. If the LDR1 value is lesser than the threshold value and LDR2 is greater than threshold value then the panel moves in the forward direction. If the LDR2 value is lesser than the threshold value and LDR1 is greater than threshold value then the panel moves in the backward direction. If both are lesser than threshold value, then the panel moves to the centre position.

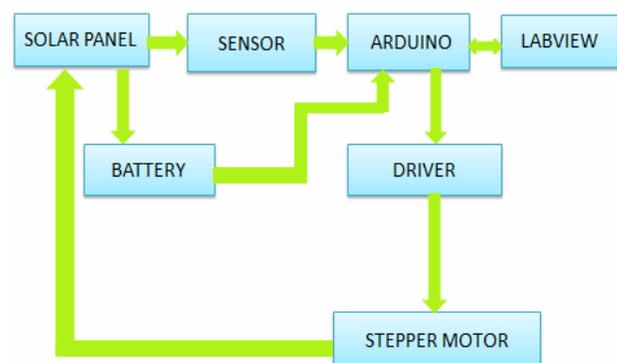
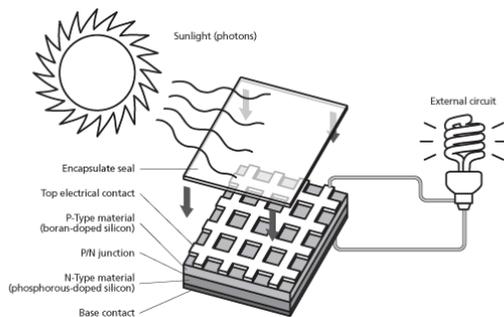


Fig.1. Block Diagram

In manual mode, the desired step angle is entered in the LabVIEW and sends to the stepper motor through driver module. Solar cell is the basic unit for energy generation. In this, electrical energy is extracted from the light energy directly. The working of solar panel depends on photovoltaic effect, hence solar cell also known as photovoltaic cell. Solar cell is basically a p-n junction device. It is formed by high concentration of holes (p type) and high concentration of electron (n type) semiconductor material. Movement of negative charges to the p-side exposes positive ion cores in negative side while movement of positive ions to the negative side exposes negative ion cores in positive side which causes electric field at the junction and forming the depletion region.

### A. Solar Panel

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**Fig.2. Working Principle of Solar Panel**

Generally a photovoltaic cell has negative front and positive back contact. A semiconductor p-n junction is in the middle of these two contacts like a battery. If these two sides are connected by an external circuit, flow of current occurs between positive to negative terminal of solar cell. To increase the utility of solar energy, solar cells are placed together and interconnected in a waterproof package called solar panel/array. A 12 volt panel consists of 36 cells connected in series and 24 volt panel consists of 72 cells connected in series.

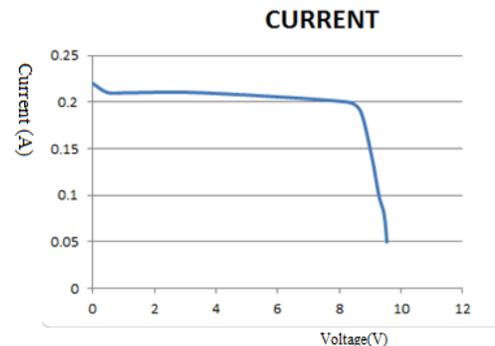
### B. Solar Panel Specification

The solar panel used in this paper has the following specification

Voltage and Watts	- 12V, 3W
Open circuit voltage ( $V_{OC}$ )	- 17V
Short circuit current ( $I_{SC}$ )	- 0.2A
Maximum power voltage	- 21.6V
Maximum power current	- 0.18

### C. I-V Characteristics

Solar cell I-V characteristics curve shows the current and voltage characteristics of photovoltaic cell which gives the detailed description of solar energy conversion ability and efficiency. This curve is the superposition of the I-V curves of the solar cell diode in presence and absence of light [7]. From this characteristic, several parameters like short circuit current, the open circuit voltage, fill factor and the efficiency of the solar panel can be determined. The short circuit current is the current through the solar cell when the voltage across the solar cell is zero (i.e. during short circuit condition of solar cell). The open circuit voltage  $V_{OC}$ , is the maximum voltage available from a solar cell, occurs at zero current (i.e. during open circuit condition). The fill factor is a parameter which in conjunction with  $V_{OC}$  and  $I_{SC}$ , determines the maximum power from a solar cell. The Fill Factor is defined as the ratio of maximum power from the solar cell to the product of  $V_{OC}$  and  $I_{SC}$ . The efficiency is defined as the ratio of energy output from the solar cell to input energy coming from the sun. It depends on the incident sunlight and temperature of solar cell. The span of solar cell I-V characteristics curve ranges from short circuit current ( $I_{SC}$ ) at zero output volts, to zero current at the full open circuit voltage ( $V_{OC}$ ). The point at which the cell generates maximum electrical power is called maximum power point (MPP). The short circuit current of solar panel is 0.22A. The current voltage characteristic of the solar panel is shown in the above graph. The current versus voltage graph is shown in the Fig. 3.



**Fig. 3. IV Characteristics**

### P-V Characteristics

The solar panel P-V characteristics is shown in Fig.4. This curve represents the power versus voltage of the solar panel. The maximum power point occurs where the voltage and current will be larger. Here the maximum power of the solar panel occurs at a voltage of 8.28V.

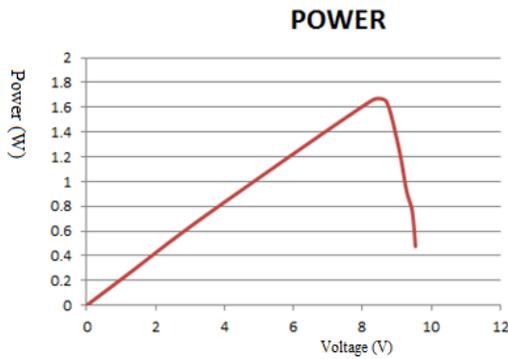


Fig.4. PV Characteristics

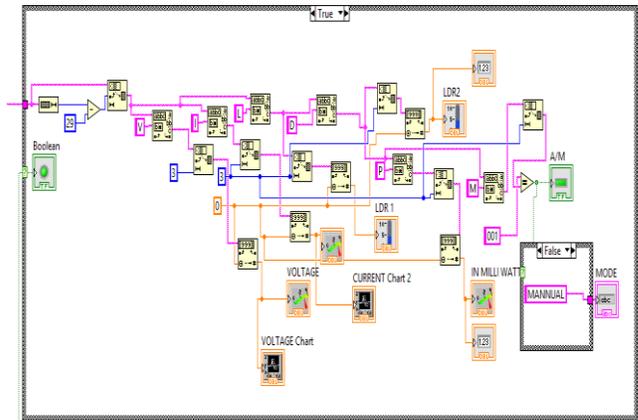


Fig.6. Block Diagram for Monitoring System in LabVIEW

**III. MONITORING SYSTEM**

The monitoring system governs the desired functioning of the solar panel. The parameters like voltage, current and light intensity of solar panel has been measured and graphically represented in LabVIEW. The performance of the solar power system is measured using Irradiance versus time plot, voltage versus time and current versus time plot which is displayed in LabVIEW front panel. The data to be monitored are acquired by using Arduino UNO. The data voltage, current and light intensity are measured by appropriate sensor and provided to Arduino. Voltage measured using voltage divider circuit, current measured using ACS712 and light intensity using LDR. The Arduino processes the input data and sends to LabVIEW in the format VxxxLxxxLxxxDxxxM00x.

**A. Front Panel**

The front panel is built using controls and indicators. Controls are inputs which allow the user to supply information to the VI. Indicators are outputs which indicate, or display, the results based on the inputs given to the VI. All objects are placed on the front panel will appear on the back panel as terminals. The front panel view of monitoring system is shown in the below Fig.5..



Fig.5. Front Panel in the LabVIEW

**B. Block Diagram**

After the front panel is built, add code using graphical representations of functions to control the front panel objects. The block diagram contains the graphical source code. Block diagram objects include terminals, sub VIs, functions, constants, structures and wires which transfer data among other block diagram objects. The block diagram of monitoring system is shown in the fig. 6.

**C. Voltage Display**



Fig.7. Voltage Display in LabVIEW

The 20 bit data from Arduino has been received by LabVIEW through serial communication port. This data contains first four bits for voltage information. This is separated from the other data. First the length of input data using string length function is calculated. The string subset function is used to return the substring of the input string beginning at offset which is 3 and containing length number of characters. This decimal string is converted into number and given to voltage display meter.

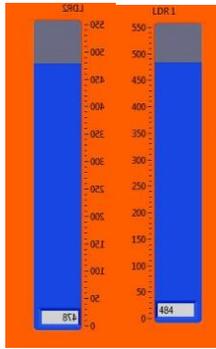
**D. Current Display**



Fig.8. Current Display in LabVIEW

The second four bit of data carries information about the current from solar panel. The process similar to that of voltage is done and the final number is provided to current display meter.

### E. LDR Value Display



**Fig.9. LDR Value Display in LabVIEW**

The third set of four bit of data carries information about the LDR value which is place on East side. The fourth set of four bit of data carries information about the LDR value which is place on West side. This information is extracted and represented in fill style.

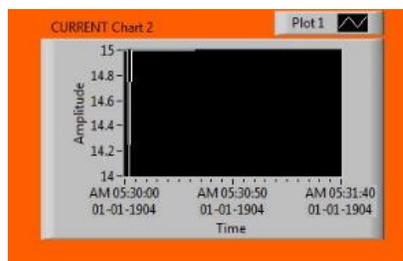
### F. Voltage versus Time Display



**Fig.10. Voltage versus Time Display**

The voltage value obtained after derivation from incoming data and processing is plotted against time continuously. The voltage is made at y-axis and time is scaled at x-axis.

### G. Current versus Time Display



**Fig.11. Current versus Time Display**

The current value obtained after derivation from incoming data and processing is plotted against time continuously. The current is made at y-axis and time is scaled on x-axis.

## IV. MAXIMUM POWER POINT TRACKING SYSTEM

The tracking system includes the following components:

1. Circuit for sensing and controlling through microcontroller (Arduino)
2. Stepper Motor Driver
3. Stepper Motor

The principle of maximum power point tracking system is done by the Light Dependent Resistor (LDR). Two LDRs are placed in the opposite sides of the solar panel. The outputs of the LDRs are given to the Arduino at the analog pins (A0-A5). The variations in the values of LDRs are compared and appropriate step angles are given to the stepper motor driver (L298N) which drives the stepper to the appropriate angle. The voltage from the solar panel is given to the Arduino board using Voltage Divider circuit (as the input voltage range of Arduino board is less than 5 volts) at the analog pin A3 and current to the load is measured using current sensor ACS712 and the output of the current sensor is given to the analog pin A5. Two LDR values are given to the analog pins A0 and A1. There is a switch to change over from manual to automatic mode which is connected to the analog pin A3. The acquired analog values are converted into digital using the equation (1).

$$\text{OUT} = (\text{IN} * 5.0) / 1024 \quad (1)$$



**Fig.12. Tracking System**

The tracking system of the project is shown in the Fig.12. Each parameter acquired by the Arduino is converted into digital by calling the function. The LDR values are read by the Arduino and compared with the threshold value. During automatic mode, depending on the LDR values the microcontroller (Arduino) sends the appropriate step angle to the driver to correctly positioning of stepper motor. If the LDR1 value is lesser than the threshold value and LDR2 is greater than threshold value then the panel moves in the forward direction. If the LDR2 value is lesser than the threshold value and LDR1 is greater than threshold value then the panel moves in the backward direction. If both are lesser than threshold value, then the panel moves to the centre position. In manual mode, the desired step angle is entered in the LabVIEW and sends to the stepper motor through driver module. Then the acquired data has to be displayed in the LabVIEW, for that the data is send to the LabVIEW in the specific format like VxxxLxxxLxxxDxxxPxxxMxxx. The values are sent to the LabVIEW at delay of 1 second. The four pins of the stepper motor are connected to the digital pins 8, 9, 10, 11, 12 via stepper motor driver and the signal to the stepper motor is given through the pins.

### A. Automatic Mode

In automatic mode, depending on the LDR values the solar panel is adjusted to capture maximum light from the sun.

1) During Morning: LDR1 value is lesser than the threshold value and LDR2 value is greater than the threshold value, so the panel is adjusted to the morning side at an angle of 45 degrees. The position of solar panel in the morning time is shown in the Fig. 13.



**Fig.13. During Morning**

2) During Afternoon: Both the LDR values are lesser than the threshold value, so panel is adjusted to mid position at angle of 90 degrees. The position of solar panel in the afternoon time is shown in the Fig. 14.



**Fig.14. During Afternoon**

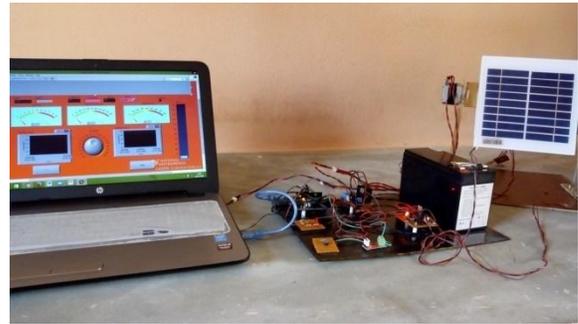
3) During Evening: LDR2 value is lesser than the threshold value and LDR1 value is greater than the threshold value, so the panel is adjusted to the evening side at an angle of 135 degrees. The position of solar panel in the evening time is shown in Fig. 15.



**Fig.15. During Evening**

## V. HARDWARE MODEL

The overall hardware model of the project is shown in fig.16.



**Fig.16. Hardware Assembly**

From the solar panel, the output voltage is given to the LED (through the voltage divider circuit) which is acting as load. The current to the LED is measured by current sensor. Switch is provided for the control of charging and discharging of battery. Pushbutton is used for change over from manual to automatic mode and vice versa. Driver L298N is used for driving stepper motor. Battery is used for supplying power to the Arduino board.

## VI. CONCLUSION

The system thus monitors the real time electrical parameters like voltage, current and light intensity of solar panel continuously and is displayed in the LabVIEW as graphical representation. The performance of solar panel is thus improved by maximum power point tracking using the measured parameters. As the efficiency is improved, yield is improved. This makes quite difference in the income. The future scope of the project is higher production of electricity from large solar power plant.

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