Design and Development of Solar Panel Testing Rig using LabVIEW

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Abstract- *Due to recent advancement in technology solar energy has become promising substitute for conventional energy source for production of electricity. Despite of all these, the efficiency of PV panel remains very low (maximum efficiency is less than 20% for commercial use). Also various physical parameters like Solar irradiation, Angle of tilt, Dust, Temperature, Humidity, wind speed etc. also affects the performance of PV panels. In this work design of Testing Rig is proposed using LabVIEW software and Arduino board to estimate the performance of PV panel under controlled condition (i.e. Solar irradiation, Angle of tilt, Dust, Temperature, Humidity, wind speed etc. is controlled for required condition.). So as to analyze and estimate the performance of PVpanel on field without actually installing them on field.*

Keywords- Solar irradiation, Angle of tilt, PVpanel efficiency, LabVIEW.

I. INTRODUCTION

Increase in energy demand, decline in fossil fuel, growth and development in manufacturing solar panels makes solar energy perfect solution for future energy demand. Although improvement in technology increases usage of solar panel, demand for low cost high efficiency still persists. Efficiency of PV panel is as high as 20% for commercial usage, prototypes are developed whose efficiency is as high as 25% to 30% but are yet to commercialized. In this work impact of above mentioned parameters on performance of PV panel is analyzed. Hence design of testing Rig is proposed which will replicate the changing profile of various mention physical parameters and accordingly performance of PV panel will be evaluated [1][2].

The paper is organized in following order, section 2 performance parameters of solar PV panel are described briefly. Section 3 describes hardware design of testing rig; it also explains LabVIEW (user interface) PC interface. Section 4 describe working of the whole assembly. Section 5 includes conclusion and finally section 6 contains references.

II. PERFORMANCE PARAMETERS OF SOLAR PV PANEL

Following are the performance characteristics of solar PV panel [3]:

1. Open Circuit Voltage:

When no load is applied across PV cell and cell is exposed to irradiation such that PV cell maximum voltage output, then voltage across the output terminals is defined as the *open-circuit voltage*. The open-circuit voltage *VOC* is:

$$V_{OC} \approx \frac{nkT}{q} \ln\left(\frac{I_L}{I_0} + 1\right).$$

Where k is the Boltzmann constant, T is the temperature in terms of Kelvin, q is Electric charge, V is output voltageof solar cell, I_L is light generated current, and I_0 is the reverse saturation current.

Short circuit current

When voltage across PV cell is zero i.e. the cell is operated at short circuit, *V = 0.*Maximum current *I* flowsthrough the terminals and this current is defined as the *short-circuit current*.

Fill factor

The fill factor (FF), is a parameter which, with respect to Voc and Isc, determines the maximum power from a solar cell. It is defined as the ratio of the maximum power from the solar cell to the product of Voc and Isc. Fill factor determines the utilization of PV panel.

Solar cell efficiency

PV Solar cell efficiency is the ratio of the electrical power output of a solar cell to the product of incident energy in the form of sunlight and the area of PV cell.

$$\eta = \frac{Pm}{G * Ac}$$

Parameters to be monitored are tabulated below:

III. HARDWARE DESIGN DETAIL

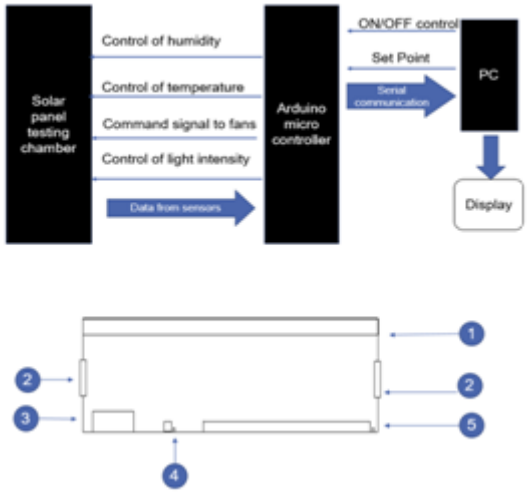


Fig No 1Block Diagram of Working of Solar Panel Testing Rig

Physical layout of solar panel Testing Chamber

1. Light source 3. Pyranometer
2. Exhaust Fan 4. Temperature
5. Solar Panel

1. Solar panel testing Chamber:

This chamber will host all the accessory required for testing of solar panel namely sensors for sensing physical parameters like solar irradiation, humidity, temperature, wind speed, angle of tilt etc. All lighting fixtures (LED and Halogen Lamps) will be attached to the ceiling of the chamber (shown in fig). Fans will be used to blow air over the solar panel. Also heaters will be deployed to heat the air inside the chamber so that, to increase the temperature inside the chamber. This will be useful in simulating real time situation.

2. Arduino Micro-controller

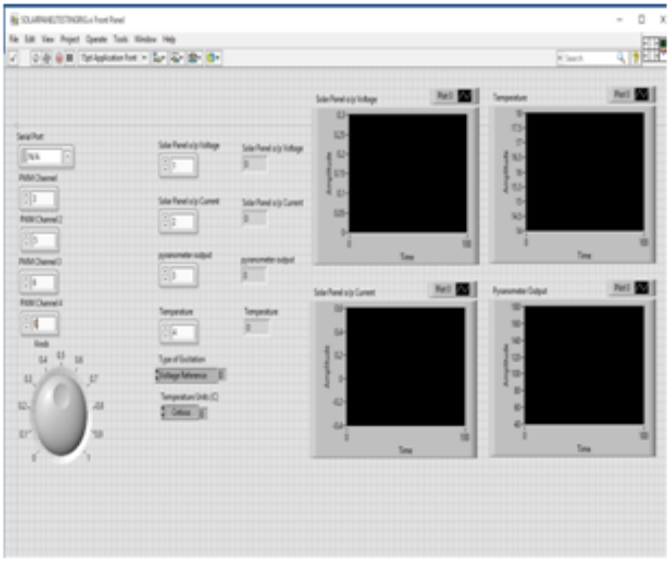
Arduino based micro-controller is used to connect the sensors and other controlling equipment to the PC. Here Arduino will accept the raw data from sensors and transfer it to the PC through the serial communication. User can send command signal to the controller through serial communication link to control speed of the fan, light intensity, humidity and temperature.

3. PC

The PC will be used to as HMI (Human Machine Interface). LabVIEW software is used to simulate the effects of physical parameters on solar panel. We can also Program Arduino Micro controller usingLabVIEW. All the real-time data will be displayed on the screen of the PC.

IV. WORKING MECHANISM

First Solar PV panel is placed inside the testing rig. Now the actual physical stimulation of the solar PV panel will begin by turning ON the halogen lamps inside the chamber. The number of halogen lamps and their intensity is adjusted so that they yield maximum power of 1000W/m^2 (which is standard operating condition).Also the temperature inside the chamber is measured using LM 35 IC which is integrated to



Arduino microcontroller. Also heaters are provided to increase the temperature of the chamber. Fans are provided for cooling purpose. Also there is arrangement for changing humidity. Above arrangement helps in developing real time condition in which solar PV panel actually operates on the field.

V. CONCLUSION

The micro-controller based system for PV simulation will help to simulate all types of solar panel for any given condition of temperature, irradiation, angle of incidence. With proposed simulator field testing of solar cells is not required.

REFERENCES

[1] Dhruv Kapoor, student member IEEE, Dipankar Deb student member IEEE, student member IEEE and Paloma Sodhi, “Solar Panel Simulation Using Adaptive Control” by 2012 IEEE International Conference on Control Applications (CCA).

[2] Zhang housheng, Zhao Yanle "Research on a Novel Digital Photovoltaic Array Simulator", 2010 IEEE DOI 10.1109/ICICTA.2010.141 2010 International Conference on Intelligent Computation Technology and Automation.

[3] MamtaSutar, G K Singh and R P Saini Krein, "Comparison of Mathematical Model of Photovoltaic Module and Effect of Various Parameters on its Performance", 2013 IEEE.

[4] TarakSalmi, MOunirBouzgeunda, Adel Gastli, "Matlab – Simulink based Modelling of Solar Photovoltaic Cell Tracker", International Journal of Renewable Energy Research TarakSalmi et al., Vol .2, No 2. 2012.

[5] Y. li, T. lee, F. peng and D. liu, "A Hybrid Control Strategy for Photovoltaic Simulator", in Applied Power Electronics Conference and exposition, 2009. APEC 2009. 24th Annual IEEE, Feb 2009, pp. 899-903.

[6] Ali. M. Bazzi, Zach Klein, Micah Sweeney, Kevin Kroeger, Pradeep Shenoy, and Philips T. Krein, "Solid State Light Simulator with Current Mode Control",2011 IEEE.