

LabVIEW Based Modeling, Simulation and Monitoring of Solar Photovoltaic Module in Real Time

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ABSTRACT

This paper presents and discusses the performance analysis, monitoring and dynamic behavior of a stand-alone Photovoltaic (PV) module by using LabVIEW real-time interface capabilities. The actual generation of power using solar PV panel and its characteristics changes with change in temperature and irradiance. All the parameter testing and its analysis of photovoltaic module have been completed using simulation tool on the basis of PV module's behavior on change in weather conditions. The constructed LabVIEW software displays the electrical variables (voltage, current and power) on dedicated graph windows in a real time manner. The proposed technique also shows the integration of Digital Multimeter (DMM) in LabVIEW environment for data acquisition and processing in real time. User interface has also been developed to observe and record data in the form of chart, table and file (.lvm, .xlsx etc.) in real time. The proposed method is a low-cost solution to provide fast, secure and reliable system by making the system database-ready for performance analysis of PV systems. The analyzing process has been done in two ways- (1) OFF Line (Simulation) mode (2) ON Line (Real time) Mode simulation using Digital Multimeter (DMM). This whole system consists of personal computer with LabVIEW software, two DMMs, PV module, a variable resistive load. The results obtained from both the mode show that there is a good agreement between the measured and simulation results values. This Technique of monitoring and simulation data in real-time can be extended to study the fault diagnosis of a PV system.

Keywords—real time monitoring, LabVIEW, simulation, photovoltaic.

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INTRODUCTION

Due to the high demand of conventional energy resources like fuel, coal and natural gas etc the non-conventional energy resources like solar, wind and bio-gas etc are now used as regular energy resources. In the area of renewable energy the role of solar energy is important because of its unlimited availability and also the use of this energy is clean and eco-friendly. The well known MATLAB/Simulink is very useful to simulate off line but it cannot be used for on line or for real time simulation. In this proposed technique, the LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench) program has been used for both off line and on line simulation. LabVIEW is a graphical programming language by National Instruments that uses icons instead of lines of text to create applications. Nowadays this programming environment has found its application in many scientific fields and technical engineering, so in this work we propose an integral LabVIEW platform of monitoring, modeling and simulation tools for photovoltaic (PV) systems. The

LabVIEW platform is used not only for real time monitoring; it is useful for automation and controlling.

REFERENCE MODEL

The specification of Vikram solar make 40 W PV modules is given below in table 1, the same is used for simulation also.

Table 1: Electrical Parameters of Vikram Solar 40 W PV Modules

Sr. No.	Parameter	Value /Range
1	Rated Power	40W
2	Voltage at Maximum Power(V_{mp})	18.33 V
3	Current at Maximum Power(I_{mp})	2.39 A
4	Open circuit voltage (V_{oc})	22.25 V
5	Short circuit current(I_{sc})	2.53 A
6	Total no. of cell in series(N_s)	36
7	Total no. of cell in parallel (N_p)	1
8	Series Resistance (R_s)	0.92 ohm
9	Shunt Resistance (R_{sh})	194.42 ohm
10	Irradiance (G)	200-1000 W/m ²
11	Cell Temperature (T)	273-400 K
12	Reference Temperature (T_r)	298 K
13	Temp. Coefficient of Isc (K_i)	1.16E-5 A/K
14	Short circuit current at Ref. Temperature (I_{scr})	2.53

Experimental Set-Up

The developed system is used to monitor and analyze a stand-alone photovoltaic system located at COE Laboratory at College of Technology, Pantnagar, Uttarakhand, India. The entire system is monitored and analyzed by LabVIEW environment. Figure 1 shows the diagram of the stand-alone PV system experimental set-up. This entire set-up consist of PV module (40 W), two DMMs, display meter, connecting wires, variable resistor and a PC. The panels are installed and exposed to halogen light irradiation and inclined at a fixed angle of 0° from horizontal surface. The currents and voltages are channeled to LabVIEW environment through DMM.



Figure 1: The constructed PV system experimental set up

Offline Mode of Simulation Results

Figure 2 and 3 show the block diagram and front panel of LabVIEW simulation which is designed to simulate the solar panel as discussed before. The block diagram is designed according to photovoltaic basic equation.

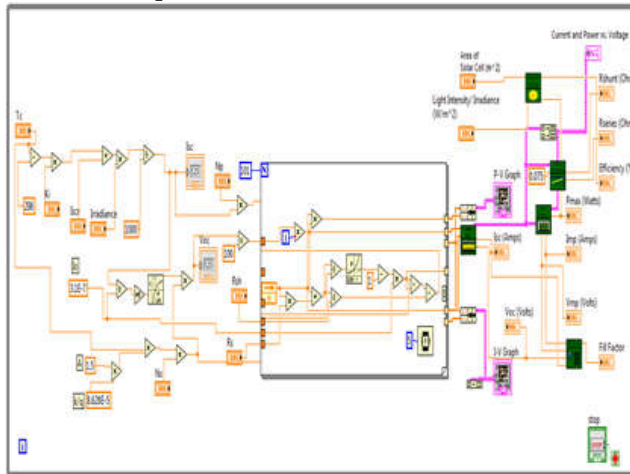


Figure 2: Offline Mode for PV Module (Block Diagram)

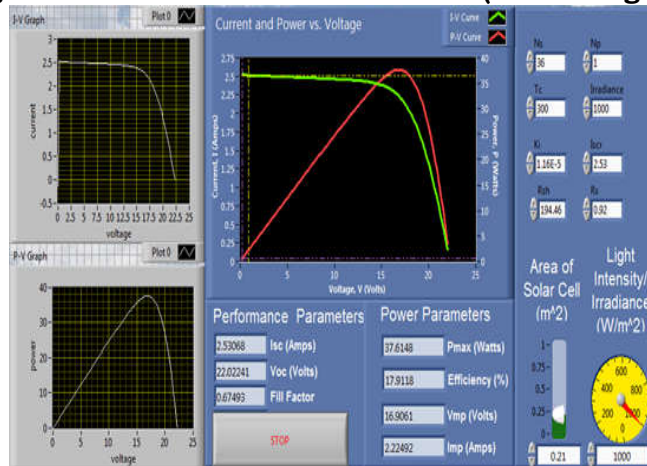


Figure 3: Offline Mode for PV Module (Front Panel)

I-V and P-V curve at constant Temperature and varying Irradiance

Here the cell temperature is set to 305K (constant value) and the irradiance is changing from 800 to 400 W/m² then according to I-V curve it can be noticed that the open circuit voltage (V_{oc}) and short circuit current (I_{sc}) values decrease. And according to P-V curve, it can be seen that the overall power decrease while decreasing irradiance.

At Irradiation(G)= 800W/m²& Temperature(T_c)= 305K

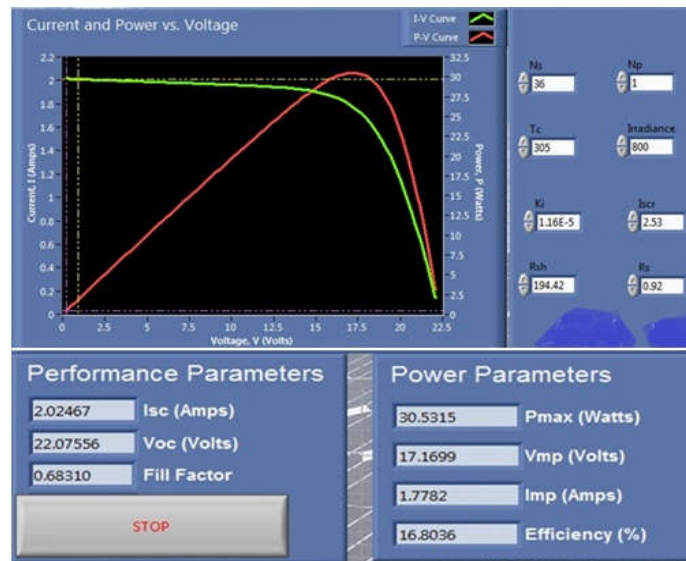


Figure 4: At Irradiance (G) = 800W/m² and Temperature (T_c) = 305K

From figure 4 it can observe that at this irradiance and temperature the V_{oc} is 22.07 V and I_{sc} is 2.02A.

At Irradiance(G)= 600W/m²& Temperature(T_c)= 305K

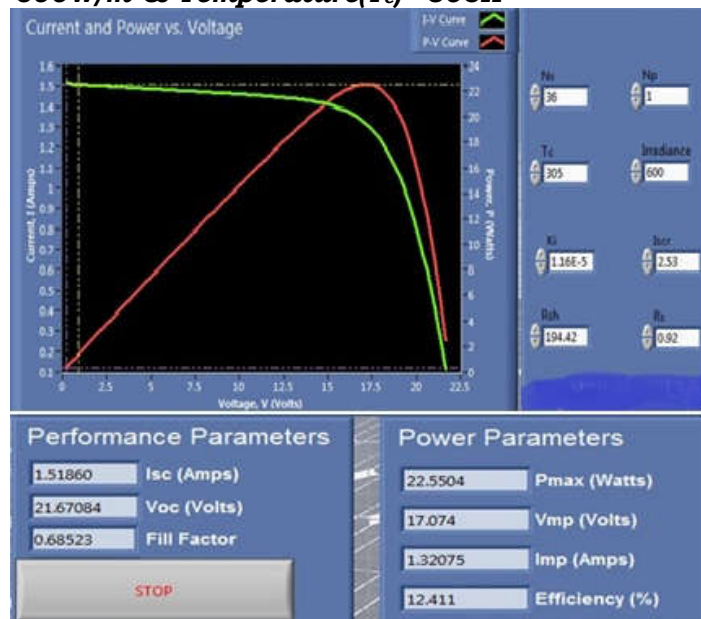


Figure 5: At Irradiance (G) = 600W/m² and Temperature (T_c) = 305K

From figure 5, on decreasing irradiance from 800 W/m² to 600 W/m², I_{sc} also decreases from 2.02 A to 1.518 A and V_{oc} 22.07 V to 21.67 V. Hence the overall power also decreases.

I-V and P-V curve Varying Temperature and constant Irradiance

Here the irradiance is set to 800W/m² (constant value) and the cell temperature is changing from 305 to 330 K then according to I-V curve it can be noticed that on increasing cell temperature the open circuit voltage (V_{oc}) decreases while short circuit current (I_{sc}) increases slightly. And according to P-V curve, it can be seen that the overall power decrease while increasing the cell temperature.

At Irradiance(G)= 800W/m²& Temperature(T_c)= 305K

From figure 4, it can observe that at this irradiance and temperature the V_{oc} is 22.07V and I_{sc} is 2.02A.

At Irradiance (G) = 800W/m² and Temperature (T_c) = 318K

From figure 6, on increasing temperature from 305K to 318K, I_{sc} is negligibly increased but V_{oc} decreases from 22.07 V to 21.67 V. Hence the overall power also decreases.

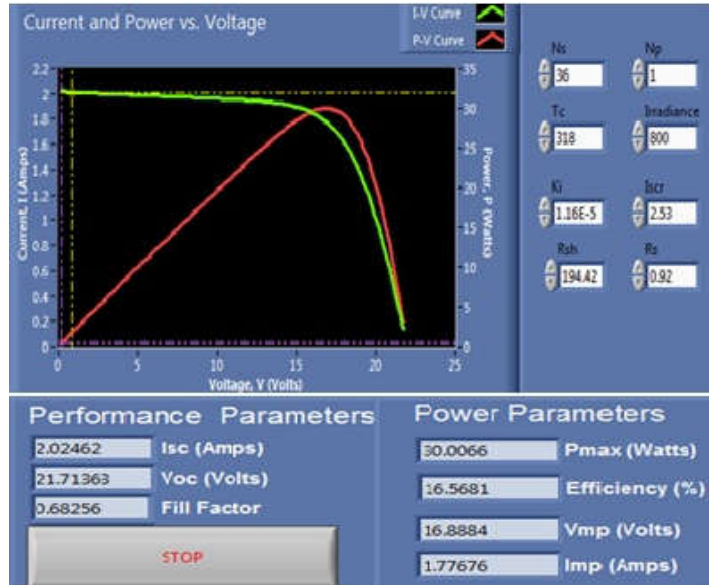


Figure 6: At Irradiance (G) = 800W/m² and Temperature (T_c) = 318K Real Time (On-Line) simulation Using DMM in LabVIEW

To perform the online experiment on the photovoltaic the LabVIEW program has been developed, figure 7 and 8 show the block diagram and front panel of program respectively. The currents and voltages are channeled to LabVIEW environment through DMM.

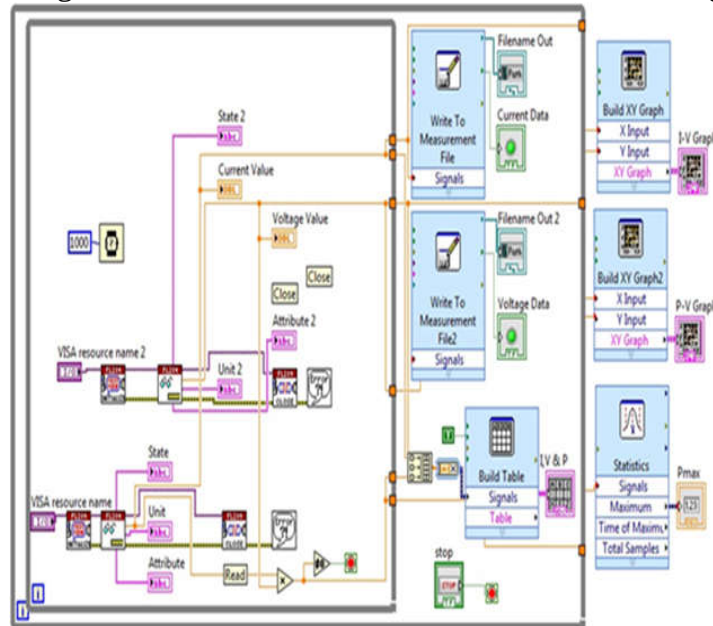


Figure 7: Real Time Simulation Mode for P-V module (Block Diagram)

The readings of current, voltage, power and the corresponding I-V, P-V curve on changing the resistance from zero to maximum is shown in front panel (figure 8).

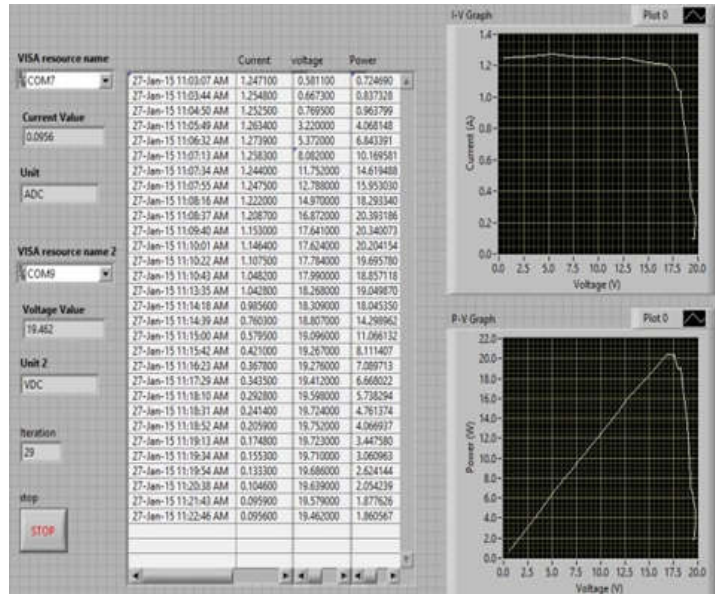


Figure 8: Real Time Simulation Mode for P-V module (Front Panel)

**I-V and P-V curve at constant Temperature and varying Irradiance
At Irradiance (G)= 800W/m² and Temperature (T_c) = 305K**

From figure 9, it can be seen that at this irradiance and temperature the real time measured V_{oc} is 20.94 V and I_{sc} is 1.37 A.

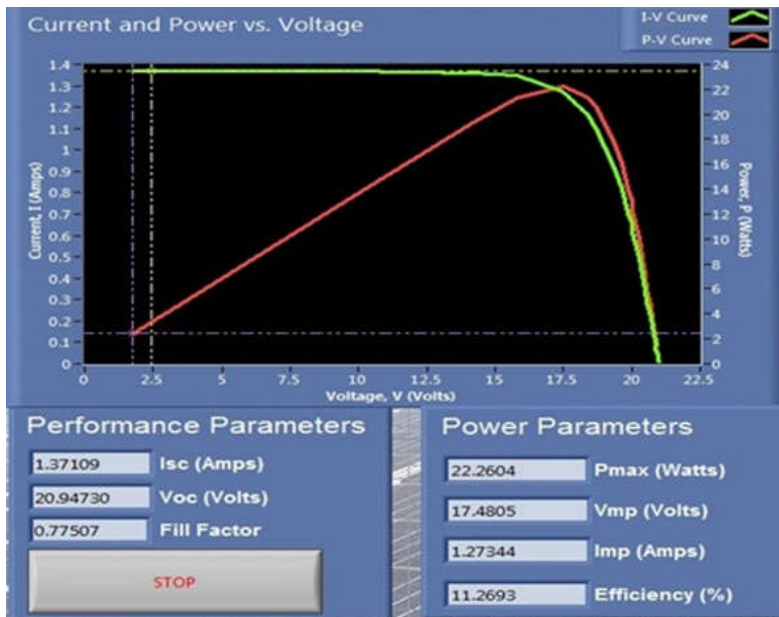


Figure 9: At Irradiance (G) = 800W/m² and Temperature (T_c) = 305K

At Irradiance (G)= 600W/m² and Temperature (T_c) = 305K

From figure 10, on decreasing irradiance from 800 W/m² to 600 W/m², I_{sc} also decreases from 1.37 A to 1.17 A and V_{oc} from 20.94 V to 20.89 V. Hence the overall power also decreases.

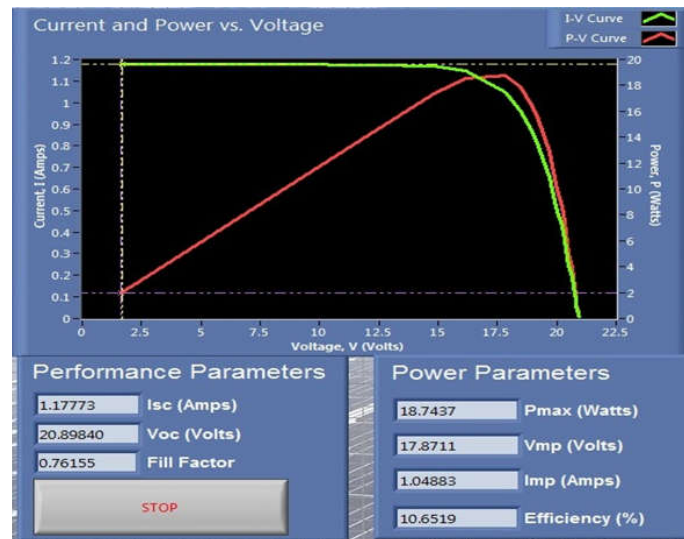


Figure 10: At Irradiance (G) = 600W/m² and Temperature (T_c) = 305K

I-V and P-V curve at Varying Temperature and constant Irradiance

At Irradiance (G)= 800W/m² and Temperature (T_c) = 305K

As discussed earlier, at this irradiance and temperature the real time measured V_{oc} is 20.94 V and I_{sc} is 1.37 A also shown in figure 9.

At Irradiance (G)= 800W/m² and Temperature (T_c) = 318K

Figure 11 shows, on increasing temperature from 305K to 318K, I_{sc} is negligibly increased but V_{oc} decreases from 20.94 V to 20.50 V. Hence the overall power also decreases.

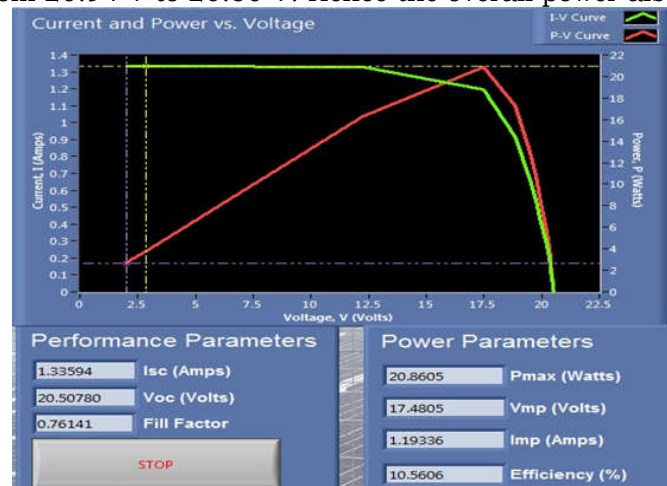


Figure 11: At Irradiance (G) = 800W/m² and Temperature (T_c) = 318K

CONCLUSION

All the results obtained for a 40W solar photovoltaic module in both on-line and off-line mode. In both cases the results obtained shows similar results matching with the data sheet. In the proposed work use of digital multi meter (DMM) and LabVIEW makes it possible to obtain the results automatically in real time. From the experimental data of this paper it can be concluded that the generated power of a PV module increases with increase in irradiance but decrease with increase in temperature, i.e. the performance of PV module is directly proportional to irradiance and inversely proportional to temperature. The developed system allows the acquisition and monitor of all necessary data from the PV module. The currents and voltages are channeled to LabVIEW environment through DMM which gives us accurate results. Hence, the proposed technique of PV parameter extraction is verified by the experimental set-up shown in fig. 1.

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