SOLAR CELL UNDER VARIABLE TEMPATURE AND INSOLATION USING LABVIEW BASED SIMULATOR

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***Abstract*— Solar energy is the clean and eternal source of energy till the end of the world. Photo-voltaic (PV) cell is one of the best and efficient technologies to convert natural solar energy into electricity. Due to increasing in the cost and environmental factors, now solar photovoltaic is more focused in the research area. In this research area, main focus is on that how to improve the efficiency. Solar energy is variable depends upon the time and the atmospheric condition and hence output of the solar cell is directly proportional to the insolation level and inversely proportional to cell temperature and also the cell never operates at maximum power. In this report the characteristics of the sun power A-300 solar cell is simulated in a perfect way in LABVIEW. The output curves under insolation and temperature is checked graphically as well as numerically. The result of simulation in LABVIEW checks the data sheet values of parameters of sun power A-300 solar cell.**

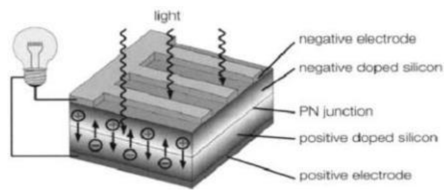
Keywords— Solar Photo Voltaic, Insolation, Labview

I. INTRODUCTION

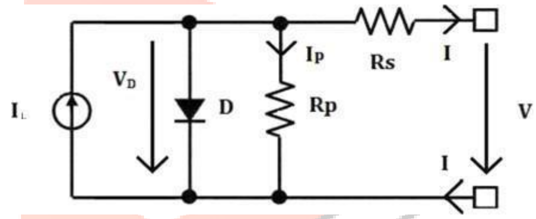
The sustainable power source utilization is expanding enormously as the current wellsprings of vitality like coal, petroleum products which give the vast majority of vitality to power age prior and even now are modest in nature. They will deplete with time in this nature. Fossil fuels being used continuously, continuously impacts the environment which leads to the cause of global warming. Renewable source of energy is efficient source of generating electricity if used wisely with appropriate technologies. The renewable energy comes from sun, wind, tides, geothermal and wind. These are clean and pollution free source of generating electricity unlike the traditional sources of generation and that is why it attracts the whole world to invest a huge capital in this field to generate more and more energy in a efficient way.

II. DESIGN OF PHOTOVOLTAIC CELL

The photovoltaic cells (solar cells) generate electricity through a process called photo-voltaic effect. They generally comprise of a PN junction, which is formed using certain semiconductor material. The cross-section of a general solar PV cell is similar to the figure below. The electric field is created at the junction due to the negative-positive doping in the semiconductor material. When sunlight is incident on the surface, the photon energy results the free charge carriers. The charge carriers are separated because of the electric field and a potential difference is generated at the external contacts. If the circuit is completed, a current called photocurrent flows depending on the light intensity.



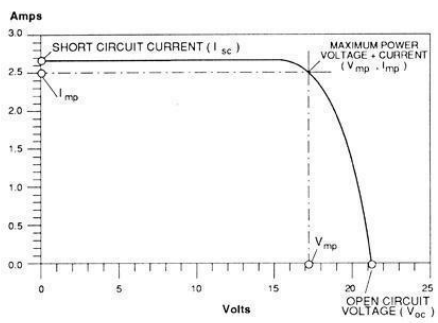
The solar panel simulator approximates the characteristics of a typical PV cell, through an equivalent circuit. The equivalent circuit for a typical PV cell is given below.



III. PERFORMANCE OF SOLAR CELL

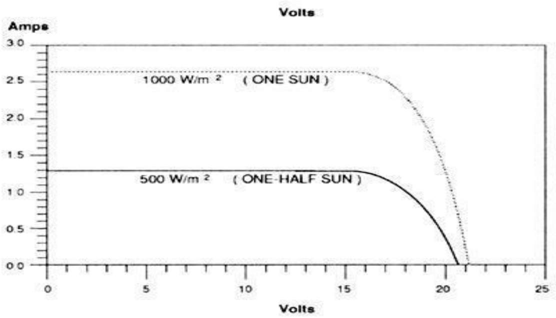
(a) V-I characteristic of PV Module

PV module has ability of maximum current when there is no opposition (resistance) in the circuit. In other words this is termed as short circuit between positive and negative terminals, hence this maximum current is called the short circuit current and is abbreviated I(sc). When the module is short circuited, then this voltage in the circuit will be zero. Also the voltage will be maximum when there is break in the circuit ,this is termed as open circuit voltage and is abbreviated as V(oc).Under this condition resistance is infinitely high and there will be no current in circuit. Here Current is expressed in amps and is plotted on vertical Y-axis. Voltage is expressed in volts and is plotted on the horizontal X-axis as in Fig.



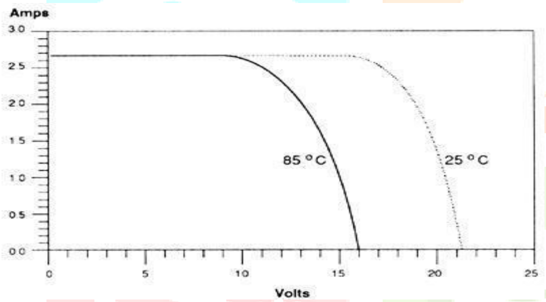
(b) V-I characteristic of PV Module showing the impact of solar radiation on module

As per the data the Standard sunlight conditions taken on a clear day is assumed to be 1000 watts of the solar energy per square meter i,e (1000 W/m2). This is also termed as "one sun," or a "peak sun." Where Less than one sun will reduce the current output of the module. Let us take an example, if only one-half sun (500 W/m2) is available, the amount of output current is roughly cut in half.



(c) V-I characteristic curve of PV Module and also Impact of temperature on it.

The effects of temperature on output voltage affect it inversely. If the temperatures increases this will reduce the voltage by an amount from 0.04 to 0.1 volts for every one degree Celsius rise in temperature (0.04V/0C to 0.1V/0C).



IV. PHOTOVOLTAIC DESIGN

MPPT is a technique used to obtain Maximum power of a PV Array at any time of the day at that irradiation so that the PV panel can be utilized efficiently. The Maximum Power Transfer hypothesis says that most extreme force can be separated from a source when the heap impedance is equivalent to the source impedance (the Thavenin's comparable impedance). As we all know irradiation is not a constant value and it keeps changing throughout the day, whenever there is a change in the irradiation, the operating point shifts and thus some algorithms are used to obtain MPPT. This provides variable duty cycle to the gate switch of the Boost converter and hence the output voltage is obtained at MPPT.

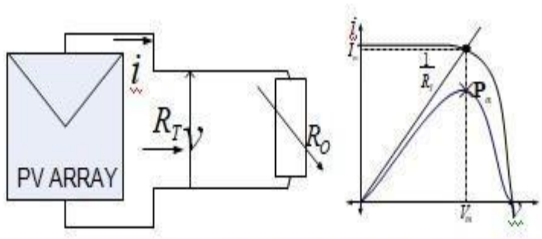


Figure 11: Maximum power point tracking

Hill climbing method

In this work, One of the Hill climbing method's technique has been used i.e. incremental conductance. It is a very popular and robust technique. Unlike other methods, it does not use derivative or resistance switches or reference cell or sampling. It just measures the PV current and voltage. Based on the power calculation, the operating point climbs the hill and tries to reach the top to provide maximum power. The methods are simple and require less computational power.

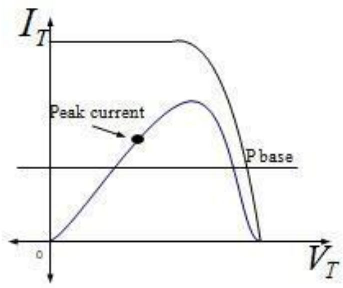


Figure 14: Hill climbing method

Power is the product of the current and voltage. Peak current is the current at the operating power point i.e. the most immediate point. P base is the average of all the previous powers. Both the powers are varying continuously but Power at peak current is rapidly changing and the base power is also moving but with a slow rate.

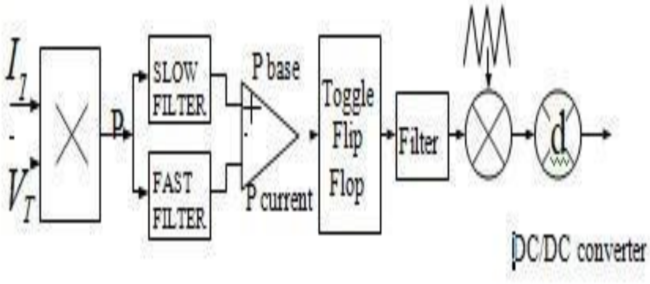
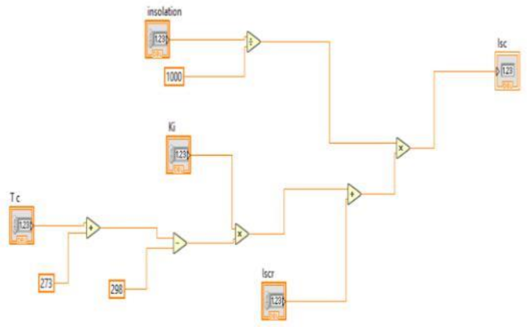


Figure 15: Hill climbing method process

The current and voltage of the solar PV module goes into the multiplier to give us the power, this power is passed on from filter. The slow filter whose time constant is large is responsible for P base and the fast filter whose time constant is less is responsible for P current. The range of Duty cycle is from 0 to 1. If D increases, the operating point shifts left and as it touches the P base it toggles, D reverses and moves right. If D decreases, the operating point shifts right and due to toggling effect, it reverses its direction. In this way it keeps hovering around the maximum power operating point and provides Varying Duty cycle to the gate of the converter.

V. SIMULATION OF PV CELL IN LABVIEW



To simulate the characteristics curves of a solar cell, its fundamental equations (1-6) are used. In LABVIEW, recreations of these conditions are as of now talked about in the writing by different writers and I have just planned by keeping them as reference. Below figure 19 shows the designing of the equation -4 in Labview. In Labview, we can easily build the different block diagrams which can be easily solved and observed. In the final block diagram, it is composed of different equations which are shown in the equations from (1-6). The result calculated from the simulation are verified with the data values.

VI. EFFECT ON PV PARAMETERS BY VARYING IRRADIATION

We know that output of the solar PV cell is directly proportional to the insolation means that if there is increment in insolation then the output of the solar PV cell increases and vice-versa. Solar energy is not a continuous form of the energy, it depends upon the time and the atmospheric conditions. Solar energy is good in summers as compared to winters and in summers, its high at the mid day time

G	Voc	I sc	V mpp	I mpp	P mpp	eff.
(w / m^2)	(V)	(A)	(V)	(A)	(W)	%
1000	0.67	5.9	0.5695	5.60425	3.19	20.4
800	0.66	4.72	0.56	4.47	2.52	20.16
600	0.65	3.54	0.55	3.34	1.85	19.82
400	0.63	2.36	0.54	2.22	1.20	19.34
200	0.61	1.18	0.52	1.10	0.57	18.

Table 3: simulation results at different insolation but at 25 degree centigrade

. Hence solar energy is variable. Those areas on the planet having great summers are unreasonably useful for the creation of power through the sun based cells.

By simulating the block diagram in LABVIEW, when we change the insolation at different levels but at a constant temperature (25 degree centigrade) we can easily observe the different IV and PV waveforms at the different insolation levels in fig(3) and the different values of Voc, Isc, Vmpp, Impp, Pmpp, efficiency and fill factor in table

VII. DATA SHEET VALUES FOR SUN POWER A- 300 SOLAR CELL

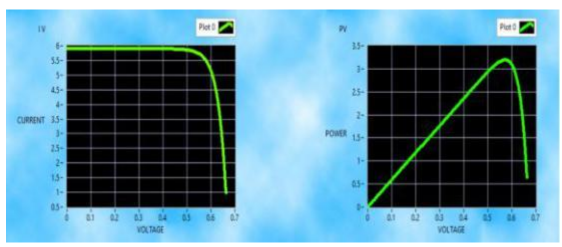
Parameters	data sheet values
V_os (V)	0.670
I_sc (A)	5.90
P_mpp (W)	3.10
V_mpp (V)	0.560
I_mpp (A)	5.54
Efficiency	21.5
Area (mm2)	125×125

VIII. COMPARISON OF DATA SHEET VALUES AND SIMULATION VALUES

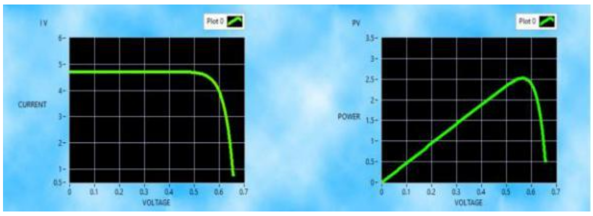
Parameters	Data Sheet Values	Simulated Results
V_os (V)	0.670	0.670
I_sc (A)	5.90	5.90
P_mpp	3.10	3.19
V_mpp (V)	0.560	0.56
I_mpp (A)	5.54	5.60
Effieiency%	21.5	20.4

IX. WAVEFORMS OF THE ABOVE OBSERVATIONS

G = 1000 w/m^2



G = 800 w/m^2



X. EFFECT ON PV PARAMETERS BY VARYING TEMPERATURE

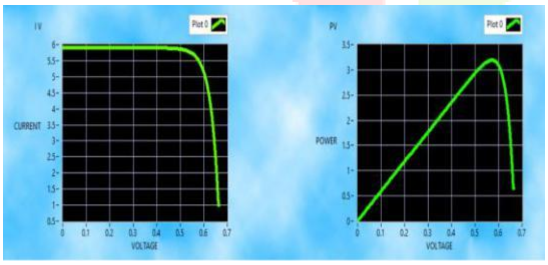
In this type of experiment in which ,we kept the solar cell at a constant insolation level but at the different temperatures and observe the reading at different temperatures in TABLE 4 and the waveforms in figure(24).

TABLE: SIMULATION RESULTS AT DIFFERENT TEMPERATURES BUT AT 1000 W/M^2 INSOLATION

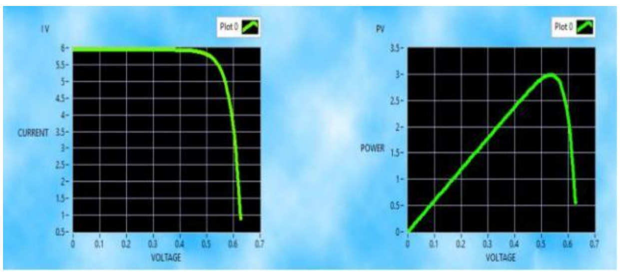
Tc (C^0)	Voc (V)	Isc (A)	V mpp (V)	Impp (A)	P mpp (W)	efficiency %	fill factor
25	0.67	5.90	0.5695	5.60425	3.19	20.4	0.8073
40	0.63	5.94	0.52	5.60985	2.98	19.10	0.79
60	0.58	6.00	0.48	5.58	2	17.32	0.77
80	0.53	6.066	0.43	5.52	2.42	15.51	0.74

WAVEFORMS OF THE ABOVE OBSERVATIONS

T c = 25 degree centigrade



T c = 40 degree centigrade



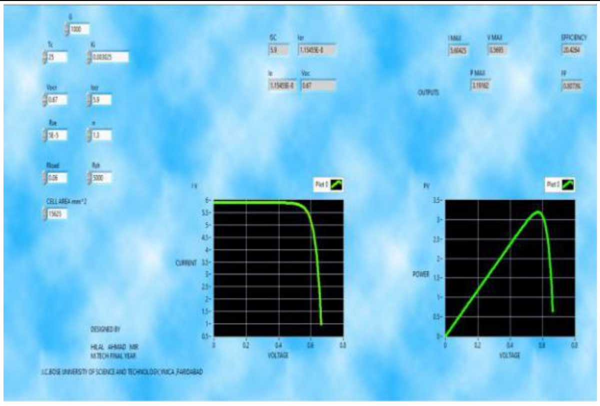


Figure 25: front panel of the simulator

XI. CONCLUSION

In this thesis, we have checked the output characteristics of solar cell at different insolations and temperatures in the LABVIEW through the mathematical modeling and also found the peak values of current, voltage and power as well as efficiency and fill factor.

Now I am preceding this work in my future that I will use the different algorithms to find the peak values automatically and I m right working on the incremental conductance algorithm in the Labview.

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