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Comparative Study of Half Cut Solar Cell and Bifacial Solar Cell with Standard Solar Cell

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Abstract: *The main purpose of this thesis is to make comparative study of half cut solar cell and bifacial solar cell with standard solar cell. The main procedure of this thesis was divided into three parts. The first part presents the detailed explanation about the solar cell. The second part shows the information about half cut solar cell . The third part shows the information about bifacial solar cell. This part has included a carefully study in order to choose the most correctly and the financially modules and inverters for the systems. The last two part shows the comparative study of the different PV systems. This part has presented the necessary number of modules and inverters, the total necessary area and the economic analysis for each system. The simulation of the solar cell was done by the software MATLAB/SIMULINK. After the analysis of the results of the different solar cell, it was possible to see which cell technology will be preferable for this system.*

Keywords: Comparison between two solar cell i.e. half cut solar cell and bifacial solar cell with standard solar cell

I. INTRODUCTION

Solar cell is a key device that converts the light energy into the electrical energy in photovoltaic energy conversion. From the commercialization of the first solar cell in the 1954, researchers have modified the technology over the years in order to ensure improved efficiencies, lower cost and better reliability. For about two years, many PV modules manufacturers are converting their production lines to half-cut cell (HC) technologies. This new technology is claimed to have advantages over full cell (FC) modules: less resistive loss due to a reduced current; better shading behaviour because of the use of two strings connected in parallel within the module instead of one and less hot spot impact due to lower current within the module. This technology has still two drawbacks: much more soldering steps and a lower low light efficiency. Bifacial photovoltaic (BF PV) cells and modules are currently viewed as the next breakthrough in solar energy technology. Since BF PV modules use similar fabrication methods as monofacial PV cell modules, their implementation will not require significant changes to manufacturing equipment. Solar arrays of bifacial PV modules are expected to have lower operation and maintenance costs than samepower output monofacial PV modules arrays, given that less bifacial PV modules would be needed to match the desired power output. Most importantly, bifacial PV modules can capture direct and diffuse irradiance, resulting in a higher energy yield.

II. LITERATURE REVIEW

Solar radiation can be converted in various ways, such as thermal energy, chemical energy or electrical energy. This thesis will focus on converting solar energy into electrical energy by photovoltaic devices. Photovoltaic device or solar cell in other words, has two points of connection between the anode and the cathode so under the light irradiation (photons) the voltage is built between the two points. From this reason came the name PV. These cells are used the Photovoltaic effect for their operation. This effect was discovered by Edmond Becquerel in 1839 which researched the behavior of metals under light irradiation. After 50 years in 1883, produced Charles Fritt the first solar device which showed dependence between voltage and sun irradiance by a combination of metal and semiconductor. This solar

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device has shown efficiency of 1%. In pursuance of this study, the use of devices which are consist from metal and semiconductor have become potential materials to convert solar energy into electrical energy. Later, in 1905 was developed the photoelectric effect theory by Albert Einstein. He had discovered that when a photon hits the metal, the photon disappears and all its energy is transferred to one of the electrons in the metal.

III. METHODOLOGY

The standard model of PV Cell is designed in this paper using MATLAB / Simulink software using equivalent circuit of a Solar PV cell. The equivalent circuit contains a current source, a Diode, a series resistor and a shunt resistor as shown in below figure. The different I-V and P-V curves are studied by varying the parameters of the solar cell which are discussed in this paper later on.

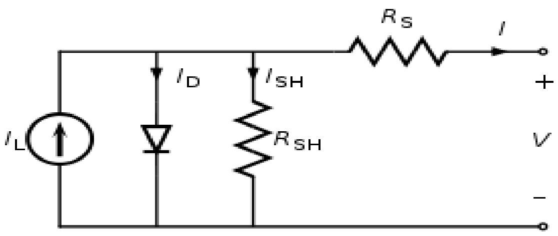


Figure: Equivalent circuit of solar cell

It is essential to understand the electronic behaviour of a solar cell and beneficial to design a model which is electrically equivalent, discrete electrical components based whose standard behaviour is well known. The characteristic equation of a solar cell is given by:

$$I = Iph - Io \left[\exp\left(q/\, nkT\, (V + IRs) \right) - 1 \right] - V + IRs\ Rsh$$

In this equation, I is the photoelectric, q is the charge of electron, I0 is the reverse saturation current of the Diode, V is the voltage across the diode, T is the temperature at junction, N is the ideality factor of the diode, K is the Boltzmann's constant, and Rs and Rsh are the series and shunt resistors of the PV cell, respectively

IV. SIMULATION MODEL OF STANDARD SOLAR CELL

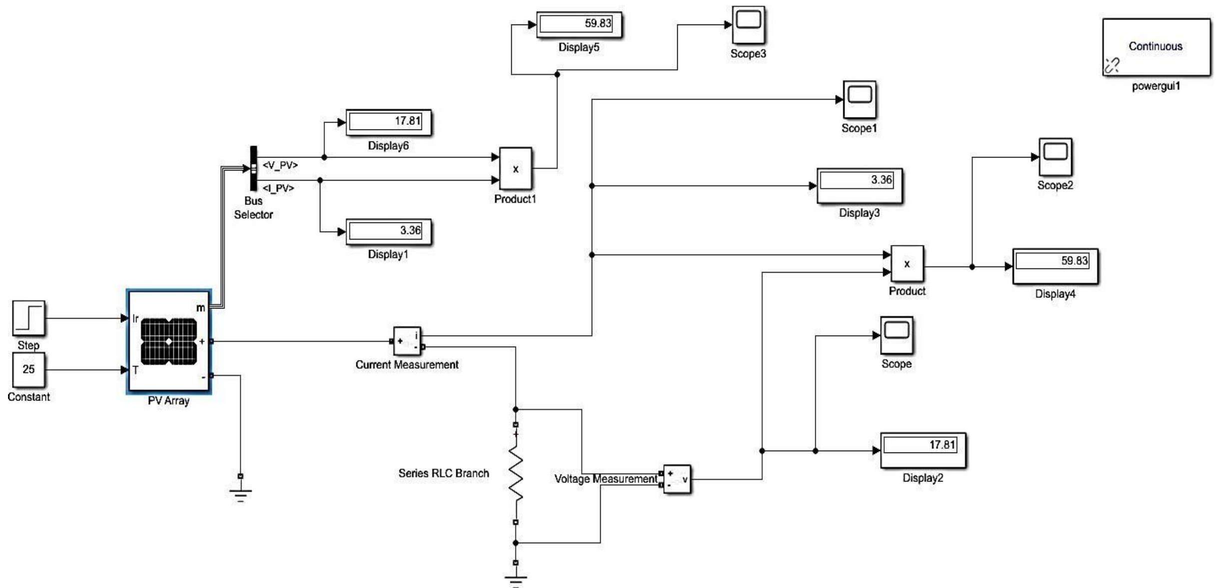
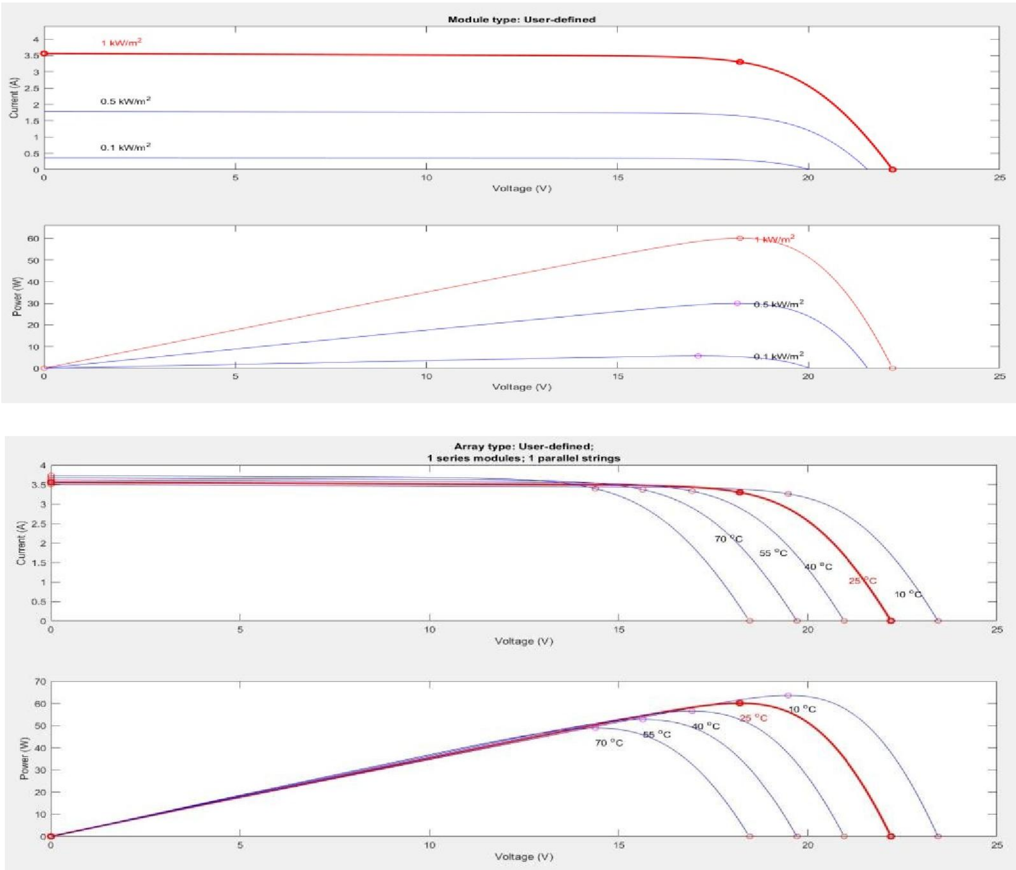


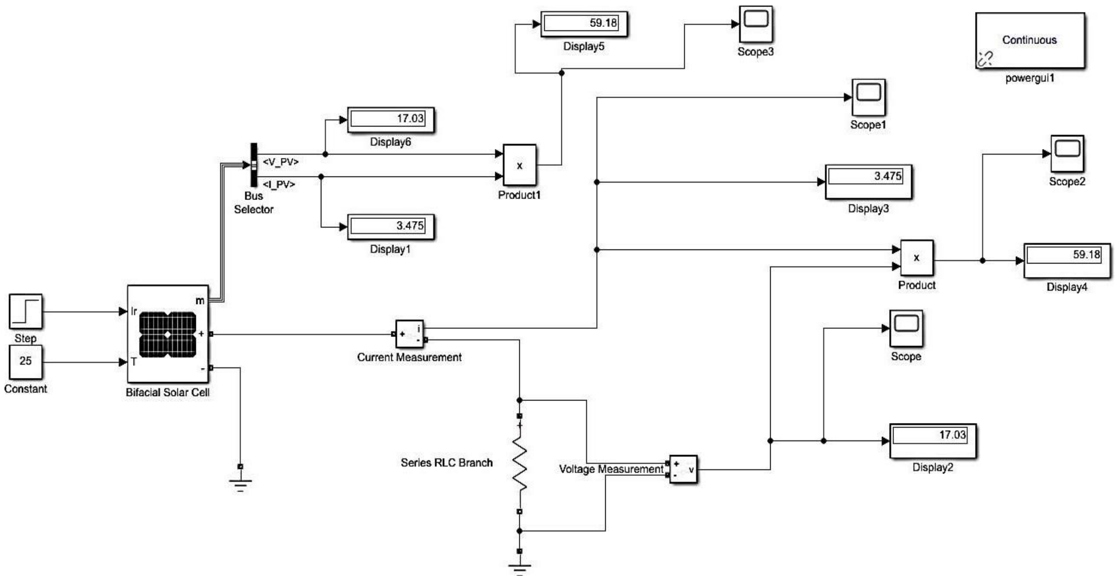
Figure: Circuit Diagram of IV and PV Characteristic of Standard Solar Cell

In this article, the basic PV Cell model is modelled using MATLAB/Simulink software using the analogous Solar PV cell circuit. The different I-V and P-V curves are investigated by varying solar cell parameters, as mentioned later in this paper. A solar cell's characteristic equation is given by:



Simulation 1 - Characteristics of IV and PV Standard Solar Cell

Simulation Model of Half-Cut Solar Cell



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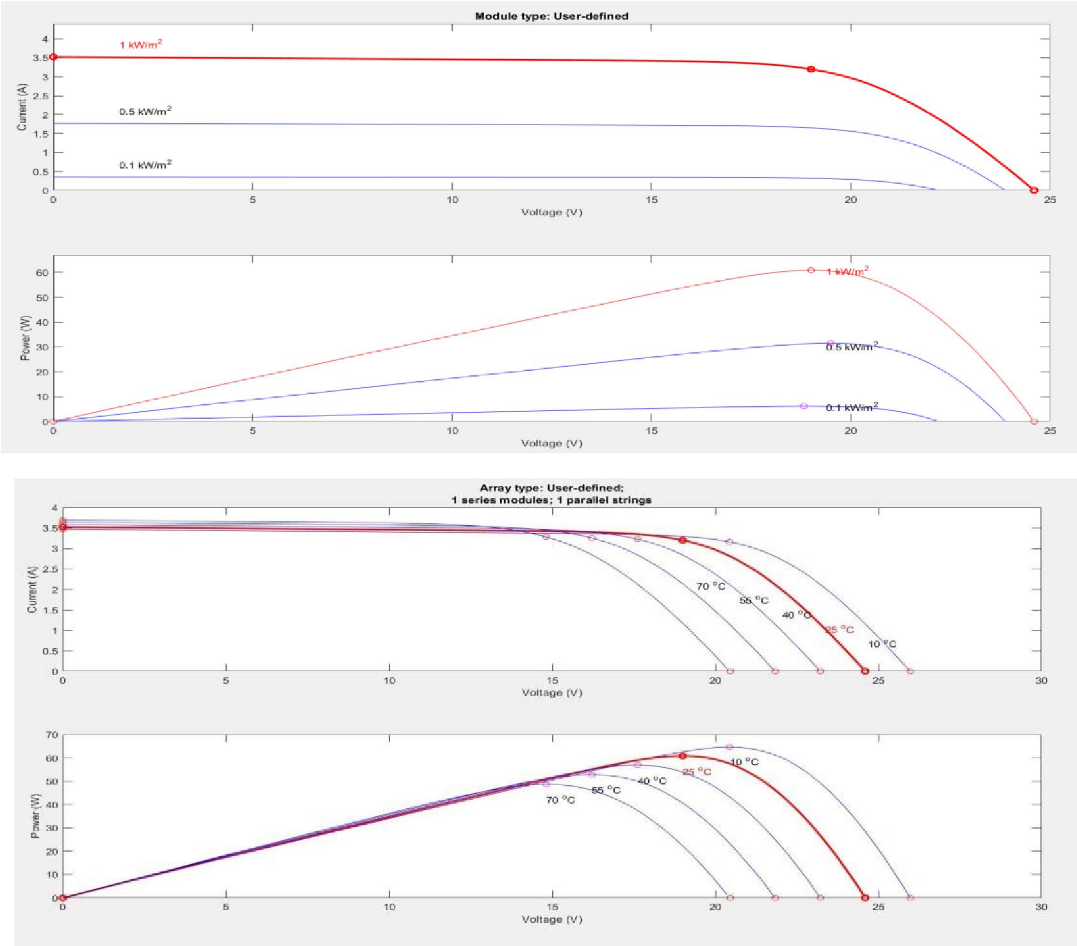
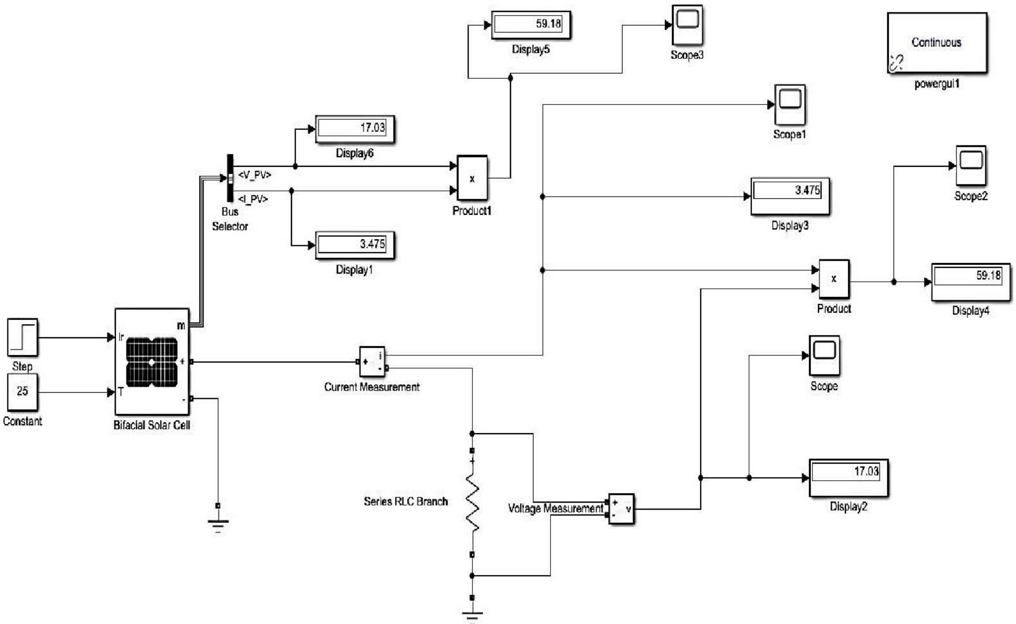


Simulation 2 - Characteristics of IV and PV Half-cut Solar Cell

Simulation Model of Bifacial Solar Cell



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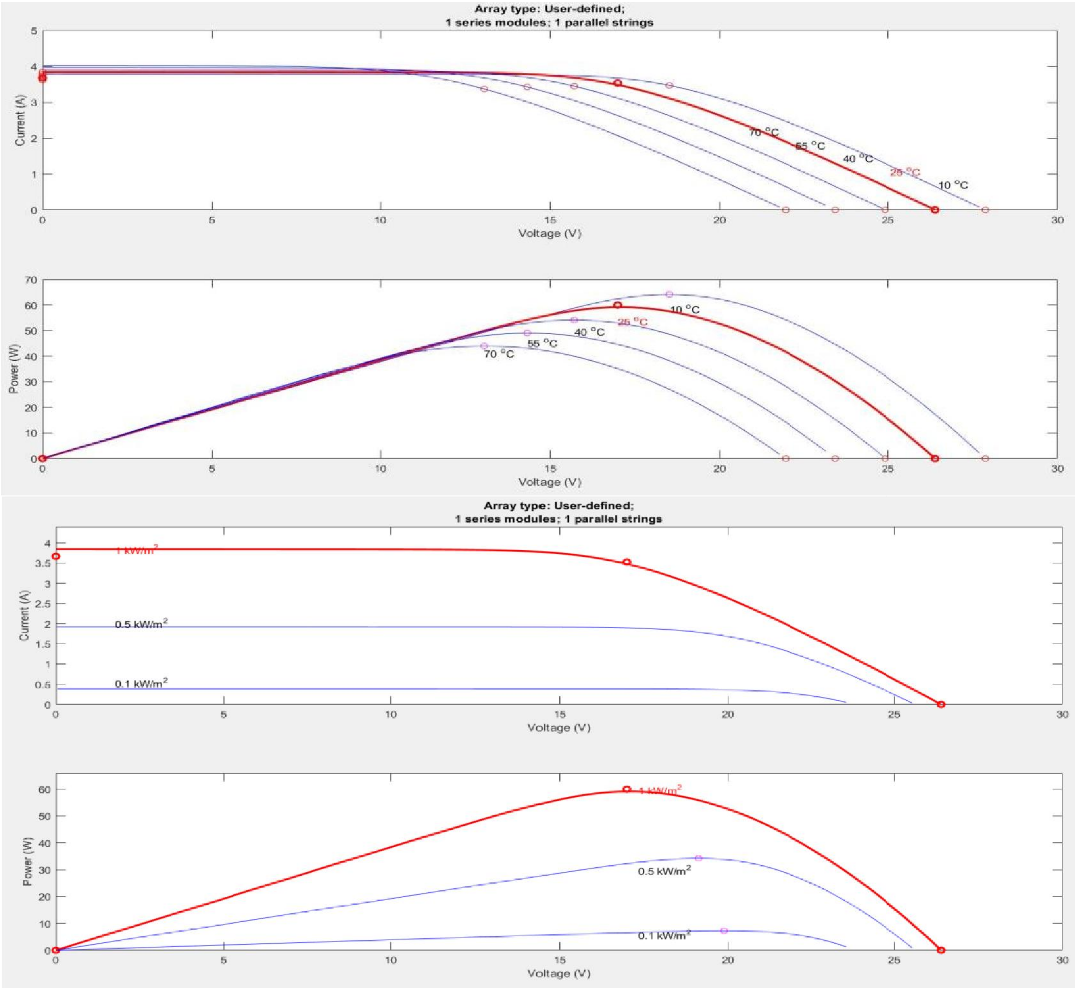

Simulation 3- Characteristics of IV and PV Bifacial Solar Cell

4.1 Comparison of Solar Cell

	Solar Cell		Half Cut Solar Cell		Bifacial Solar Cell	
Parameters	Theoretical Value	Experimental Value	Theoretical Value	Experimental Value	Theoretical Value	Experimental Value
Output Power	60 Watt	60 Watt	60 Watt	60 Watt	60 Watt	60 Watt
Operating Voltage	12 Volt	12 Volt	14 Volt	14 Volt	12 Volt	12 Volt
Maximum Voltage	18.2 volts	17.81 Volts	20 Volts	19.73 Volts	17 Volts	17.03 Volts
Maximum Current	3.3 Amps	3.36 Amps	3.00Amps	3.03 Amps	3.53 Amps	3.475 Amps
Voc	22.2 Volt	22.2 Volt	24.6 Volts	24.6 Volts	26.4 Volts	26.4 Volts
Isc	3.56 Amps	3.56 Amps	3.52 Amps	3.52 Amps	3.67 Amps	3.67 Amps
Series resistance	5.3 Ohm	5.3 Ohm	6.5 Ohm	6.5 Ohm	4.9 Ohm	4.9 Ohm
No. of Cell	60	60	120	120	60	60

Dimension	630*670*30	630*670*30	670*540*30	670*540*30	620*530*30	620*530*30
Weigh t	5.1 Kg	5.1 Kg	4.8 Kg	4.8 Kg	5.3 Kg	5.3 Kg
Efficiency	14.22%	14.22%	16.5 %	16.5 %	20.1 %	20.1 %

V. CONCLUSION

Introduction of Half cut cell has reduced the current flow in a standard solar cell by half, intandem the resistive loses in the cells have also reduced. Less resistance between cells and strings due to introduction of Half Cut cell and lower ampere current flow in the cells has increased the overall power output of the modules. Half Cut cell technology is integrated with PERC technology and use of backside of solar cells through introduction of bi-facial technology makes the overall solar panel highly cost effective as compared to the traditional solar modules. Half Cut solar technology with PERC technology and Mono Crystalline cells increase the solar cell efficiency as high as 22% which is a significant gain in the solar panel efficiency. If the solar module is bi-facial the power generation further increases by 10% and the comprehensive efficiency of bi-facial, Mono Crystalline, Half Cut cell, PERC technology based solar panel reaches to as high as 24%. Advantages of the Half Cut solar modules:

- **Higher Power Output:** The increase efficiency of Half Cut cell leads to the higher power output and increased energy yield of your solar power system.
- **Less Space Requirement:** With a increase power output per module the solar PV installation with Half Cut cell technology requires lesser space specially in case of rooftop solar system and you can do more panels installations on your rooftop.
- **Early Payback Period:** With lesser capital cost and higher energy yield, adopting Half Cut Mono Crystalline solar PV PERC technology panels makes your payback period shorter and yields to the early return of your capital invested in the solar project.

From this parameters we can conclude that the efficiency of standard solar panel is 14.22% and its fill factor is 75.9%. The efficiency of half-cut solar panel is 16.5% and its fill factor is 69.9%. And the efficiency of bifacial solar panel is 20.1% and its fill factor is 61.1%.Thus from this comparison of the parameters of half-cut solar panel, bifacial solar panel and the standard solar panel we can conclude that the efficiency is inversely proportional to the fill factor

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