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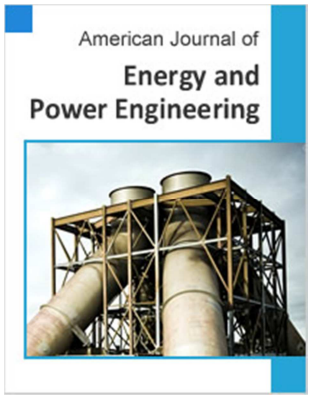

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Design, Implementation and Characterization of Homemade Solar Module

Anika Fariha Rashid, Shabnam Tahmin, Asma Haque, Nasheeta Nusrat Joarder, Saniat Rahman Zishan

Department of EEE, American International University-Bangladesh, Dhaka, Bangladesh

Email address

anikafariharashid@ymail.com (A. F. Rashid), shabnamtahmin@yahoo.com (S. Tahmin), haqueasma15@yahoo.com (A. Haque), nasheeta1990@gmail.com (N. N. Joarder), saniat@aiub.edu (S. R. Zishan)

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Abstract

Energy efficiency and conservation has been a heavily focused subject in recent years. With the advent of new technologies, as well as innovations to previous ones, using renewable sources of electricity widely and efficiently is gradually becoming a reality. This project attempts to harness the limitless energy of the sun and utilize it for the purpose of producing electricity. Using components like solar cells, resistor box, digital mustimeters, connecting wires, feasibility of this project is investigated. The process involves many steps such as, taking the simulated values of single solar cell for ideal condition, then taking the simulated results of a 3x4 solar module for ideal condition and after that this two steps are repeated practically after the hardware implementation. Finally, the simulated and practical results are compared. Moreover, cost of the module is quite less than manufacturers, so it is economically very much efficient. The result of this project shows that this technology has practical applications and can be implemented to face our energy crisis.

1. Introduction

Energy is becoming one of the most important terms throughout the world. There are many types of energy such as heat, kinetic or mechanical energy, light, potential energy, electrical, solar energy or other forms. All types of energies are running out of resources. To avoid and reduce energy crisis, it was intended to design a cost effective homemade solar module. Because solar energy is increasingly emphasized and regarded as an important resource of power energy in the future [1]. The energy from the sun not only is needed for life, but it also can be used as a renewable source of energy. Solar panels can be efficiently used in small power system such as charging up mobile phones, lighting small village-shops, or using in some small appliances [2]. Rather than implementing a homemade solar module, performance parameters of solar cells and module are also characterized. So that at first Ltspice simulation tool is used to simulate the single cell and solar module. The simulation has been done at the STC (Standard Test Condition, AM 1.5, irradiance=1000W/m^2). The value of single cell and module has been measured in dark laboratory using search light and under sunlight practically. Finally, the simulated and practical values have been compared to analyze the performance parameters. Also the cost effectiveness is the great advantage of this project as the homemade module cost is relatively less than the manufacturers.

2. Photovoltaic Cell

Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductor that exhibits the photovoltaic effect. Mainstream materials presently use for photovoltaic include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide. The solar cells that are also called photovoltaic (PV) cells, which as the name implies (photo meaning "light" and voltaic meaning "electricity") [3]. Using solar cells, the photovoltaic effect occurs when very short wavelengths of sunlight impact the matter and electrons become excited. The photovoltaic effect can also occur when two photons are absorbed simultaneously in a process called two-photon photovoltaic effect. The performance of PV cells are affected by many performance parameter of the cells like irradiance, fill factor, temperature etc.

3. Working Principle of Solar Cell

Light shining on the solar cell produces both a current and a voltage to generate electric power. When photon strikes a PV cell, some photon may be reflected or absorbed. The energy absorbed in photon is transferred to an electron in an atom of the cell. By getting new energy the electron is able to escape from its normal position and leaving this position, the electron causes a "hole" to form. Special electrical properties of PV cell, is an electric field thatseparates the electron hole pair and provides the voltage needed to drive the current through an external load [4].

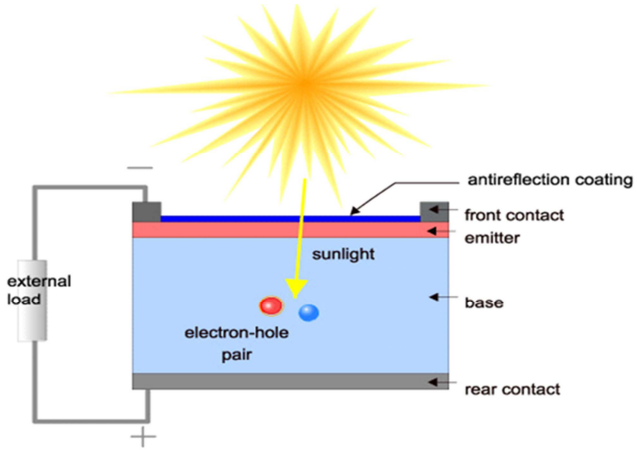

Figure 1. *Process of generating power of a PV cell [3].*

4. Simulation Concept

LTspice is a powerful, fast and free simulation tool, schematic capture and waveform viewer with enhancements and models for improving the simulation of switching regulator [5]. It also provides micro models for most of Linear Technology's switch-mode DC/DC converters, op amps, comparators, linear regulators. In theoretical portion LTspice simulation tool is used to find out the I-V and P-V characteristics curve.

4.1. Ideal Curve of a Solar Cell

Assuming that initially there is no load, the operating point will be at the far right at the open-circuit voltage, Voc, of the solar array with zero current. As the load increases further, it will reach the maximum power point (MPP), where the power drawn from the solar cell is maximized. The voltage at this point is denoted by the maximum-power voltage (Vmp), and the current by maximum-power current (Imp). Eventually, the operating point will reach the far left at the short-circuit current, Isc, with zero voltage output.

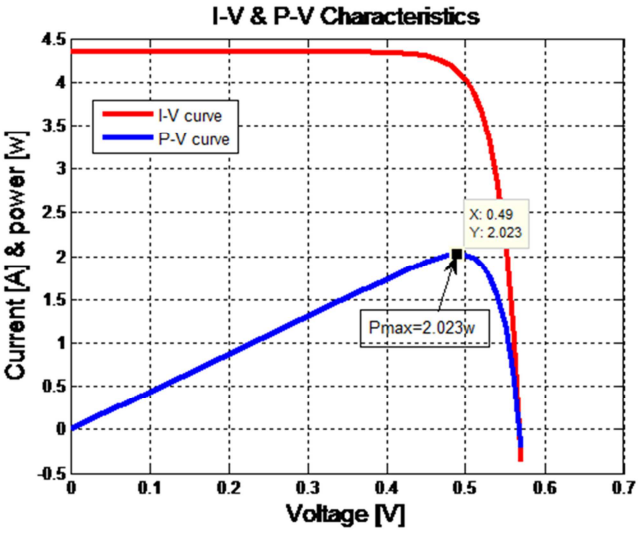

Figure 2. *I-V and P-V characteristics curve of single solar cell.*

4.2. Curve of a 3x4 Cells

In industrial practices 12 solar cells are connected in series to form one module of solar cell.

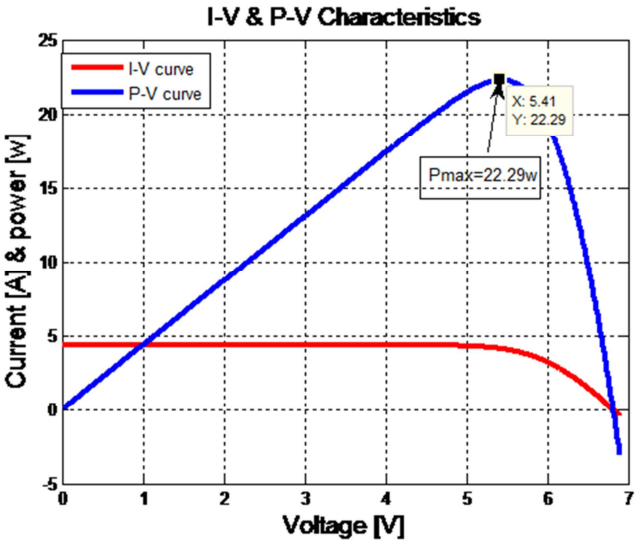

Figure 3. *I-V and P-V characteristics curve of 3x4 cells.*

4.3. Effects of Irradiance

The amount of sunshine reaching the solar cells at any moment is called irradiance. Irradiance is a measurement of solar power and is defined as the rate at which solar energy falls onto a surface and the unit is W/m² - that is Watts per square meter.

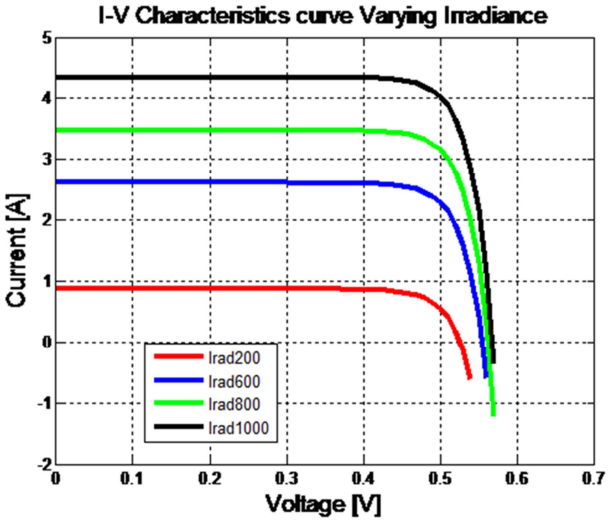

Figure 4. *I-V plots of solar cell varying irradiance.*

5. Hardware Implementation and Simulation

5.1. Description of the Connection

The project is basically based on making a homemade solar module and for establishing the project first of all photovoltaic cells are placed on a plastic white board for making the module. The module follows 3x4 model that means there are 3 rows and 4 columns and thus 12 cells are connected in series and by this process two opposite terminals are created so that the load can be connected. The cells which are placed on the board should maintain an equal distance from each other. As it is a series connection, positive side of one solar cell is connected with negative side of another solar cell and thus the whole module is connected through this process. A resister box is considered as load for the project and two digital mustimeters are used as ammeter and voltmeters.

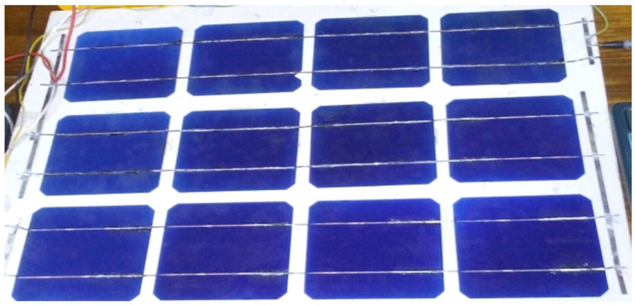

Figure 5. *Hardware implementation.*

5.2. I-V (Current versus Voltage) and P-V (Power versus Voltage) Curve of a 12 Cells

After implementation the single solar cell's values are taken varying resistance under the sunlight and in dark laboratory. For checking the homogeneity all the values of individual cell are measured.

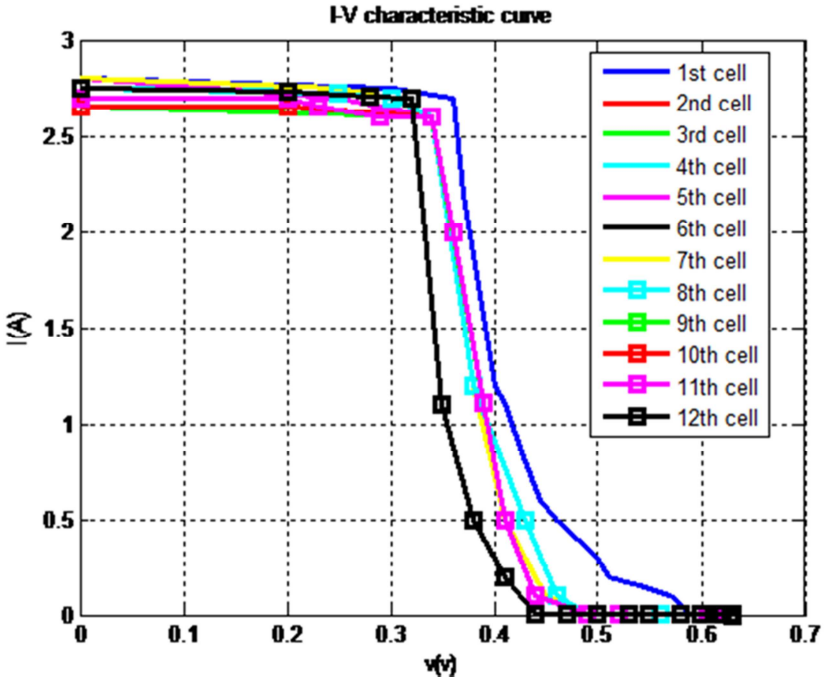

Figure 6. *I-V characteristics curve of 12 cells under sunlight.*

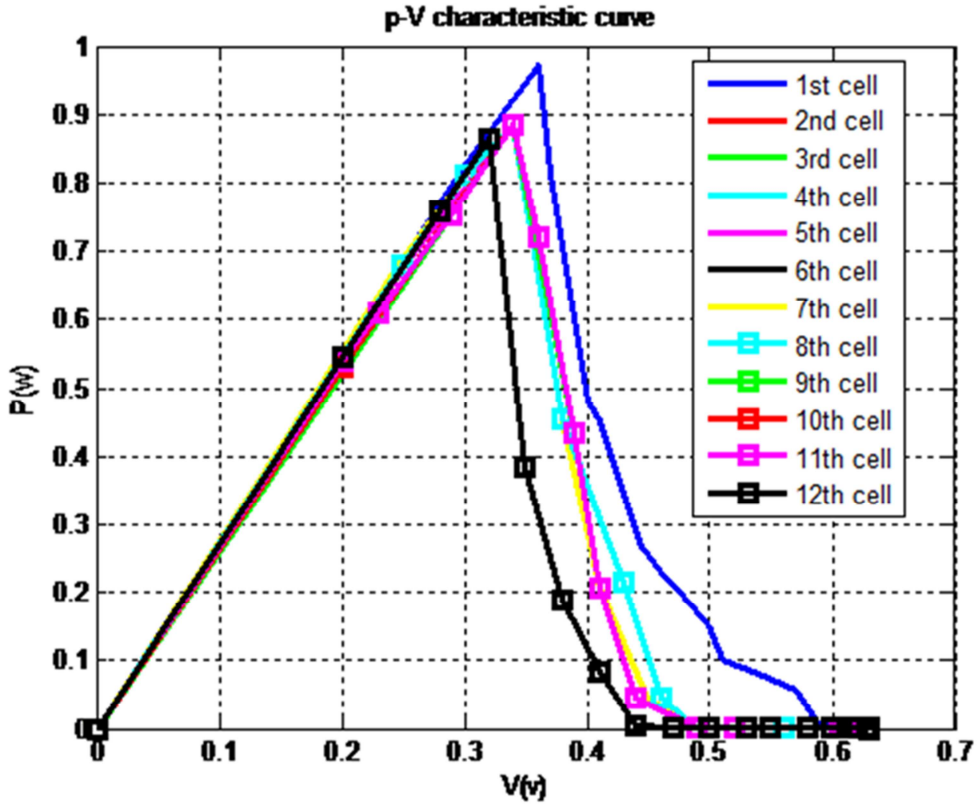

Figure 7. *P-V characteristics curve of 12 cells under sunlight.*

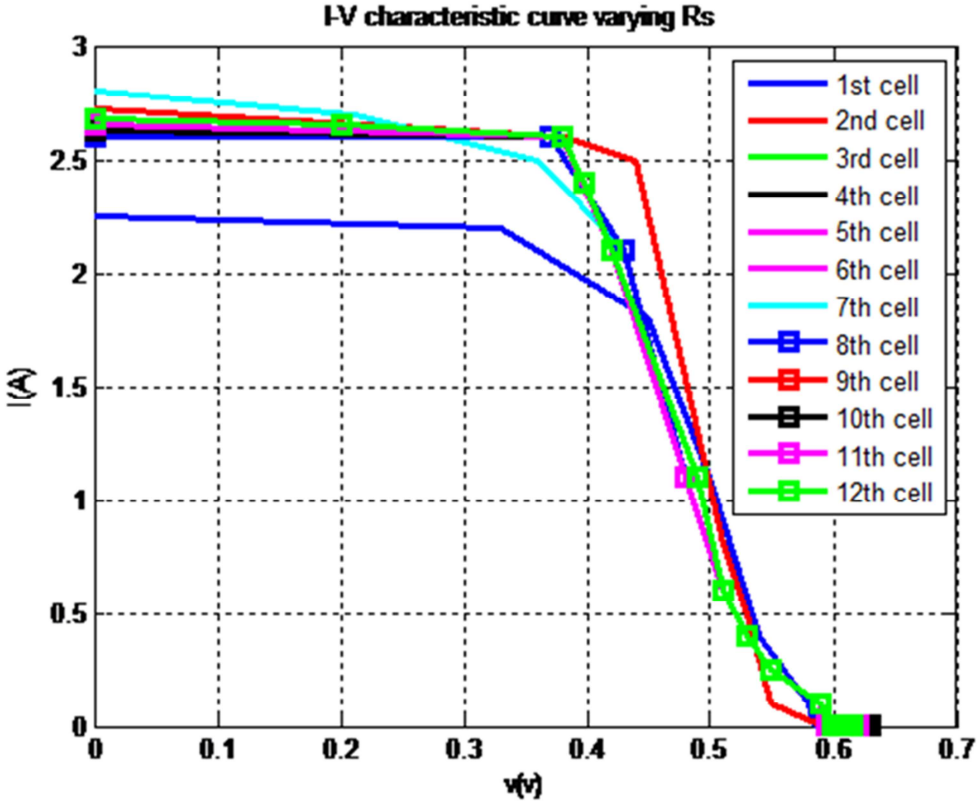

Figure 8. *I-V characteristics curve of 12 cells in dark laboratory.*

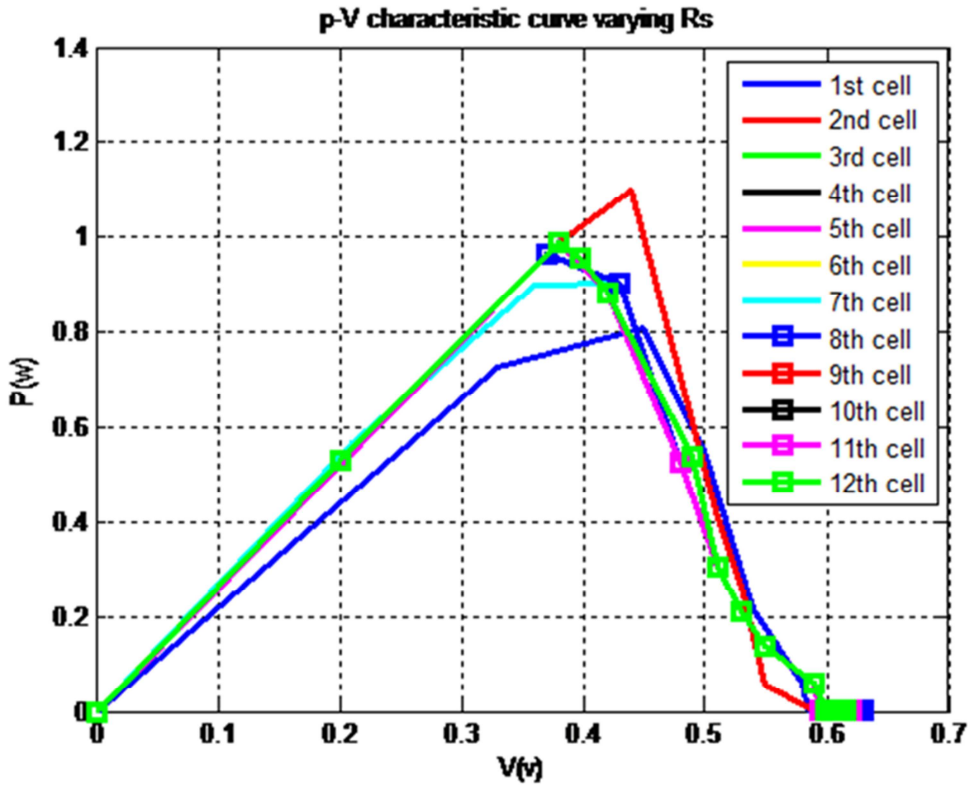

Figure 9. *P-V characteristics curve of 12 cells in dark laboratory.*

5.3. I-V and P-V Curve of a Module

After taking the values of single cell, the values of the implemented module are taken following the same procedure.

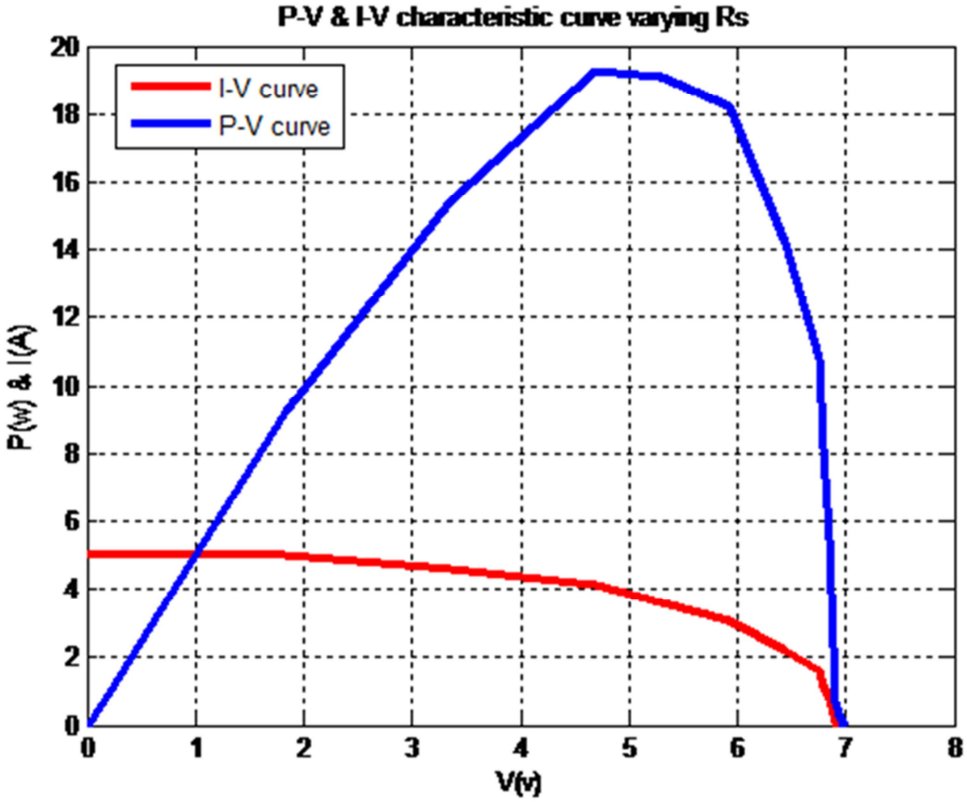

Figure 10. *I-V and P-V characteristics curve of a module under sunlight.*

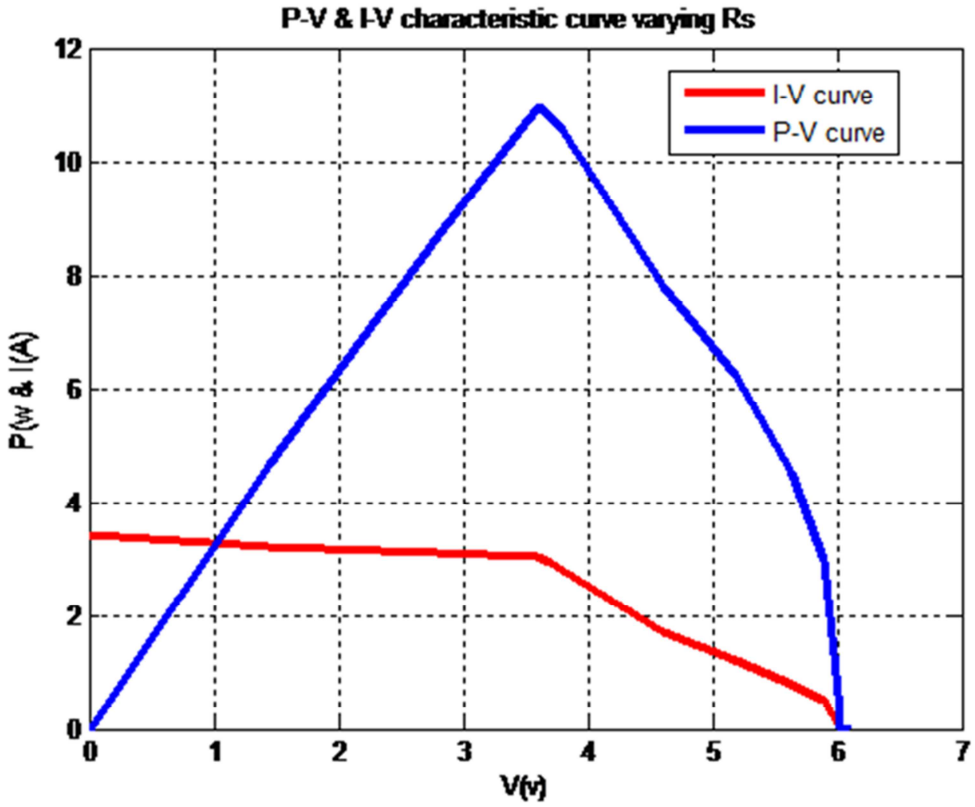

Figure 11. *I-V and P-V characteristics curve of a module in dark laboratory.*

Table 1. *Performance parameters of a module.*

Number	Value of a Module		
	Performance parameters	***Under sunlight***	***In dark laboratory***
1.	Isc	16.6 A	5.7 A
2.	Voc	7.42 V	7.22 V
3.	Vmax	4.93 V	6.67 V
4.	Imax	12.8 A	5.1 A
5.	Pmax	63.1 W	34.02 W
6.	Fill factor	0.548	0.524
7.	Efficiency	16.86%	9.33%

From above table, it can be understood that there is a huge variation between the two characteristics curve. The main reason for this variation is when a module is placed under the sunlight; it will absorb adequate solar energy that it would need. so the irradiance would be higher in this case and module will work more efficiently. But when a search light is injected over the module it will not be able to cover up the whole module. So that all the cells will not get the light energy equally, some portion of the module have high intensity whether some portion will not get the light properly. Thus the efficiency will be hampered and will be less than the previous one.

6. Discussion

The goal of this projectis to implement the homemade cost effective solar module. At first Ltspice simulation tool is used to simulate the single cell and solar module. The simulation is done at the STC (Standard Test Condition, AM 1.5, irradiance=1000W/m^2). Then before implementation, the value of single cell is collected in dark laboratory using search light as a source so that this can be compared with simulated value. Taking the values of single cell, which gives the better output, those are used to make the module. After completing the implementation, the values of single cell and module were taken at different sources which are search light and sunlight. Values of single cell are taken using shading process. After taking all the values of single cell and module, values are compared with the simulated values with different sources. Then analyzed that the performance parameter of the simulated values is greater than the practical values of a single cell before (before implementation) as the simulation is done in ideal condition. As mention earlier, measurement of PV cell and module are done under sunlight and in the dark laboratory, so it can be understood that under sunlight the single cell and module both of them give more output because sunlight is brighter and contains not only visible light but also UV and infrared light, which fluorescent light does not have. Finally, it also be seen that from practical value the maximum power of 3*4 modules is 19.27 Watt which can be used in many small applications. Last but not the least the module cost is relatively less than the manufacturers. So the cost effectiveness is the great advantage of this project.

7. Conclusion

The sun is a source of renewable energy, and it is abundant freely throughout the globe. In order to harness this source of

energy efficiently, more research has to be done to make it cheaper, more efficient and reliable, to convince more people to switch to green energy to create power with as little pollution as possible produced as a by-product. Every form of energy collection will result in some pollution, but those that are green are known to cause less than those that are not. Most people who advocate greener sources of energy claim that the result of worldwide use of green energy will result in the ability to preserve the planet for a longer time. Greenhouse gases, a by-product of traditional sources of energy such as fossil fuels are thought to be causing global warming, or the process of the Earth heating up at an accelerated pace [16]. So that people should switch on to the solar energy.

In this project, there are some problems but it can be implemented properly without any error occurs. Moreover, cost of the module is quite less than manufacturers, so it is economically very much efficient. The result of this project shows that this technology has practical applications and can be implemented to face our energy crisis. If the solar cell becomes more available throughout the country, hopefully this project can provide many benefits and gains to consumers where they can save the cost and get available energy. In conclusion the homemade solar module is very simple, cost effective and efficiently used in small power appliances.

References

[1] S. Silvestre and A. Chouder, "Effects of shading on Photovoltaic Module performance," Progress in Photovoltaics: Research and Applications, no. 16, p. 141-149, 2008.

[2] Shruti Sharma, Kamlesh Kumar Jain, Ashutosh Sharma, "Solar cells: In research and applications- A Review", Materials Sciences and Applications, 2015, 6, 1145-1155.

[3] P/N Junctions and band gaps [Online] Available: thttp://solarcellcentral.com/junction_page.html

[4] Askari Mohammad Bagher, Mirzaei Mahmoud Abadi Vahid, Mirhabibi Mohsen, "Types of Solar cells and Application", American Journal of Optics and Photonics, 2015; 3 (5): 94-113.

[5] Modelling Photovoltaic Systems Using PSpice by Luis Castaner & Santiago Silvestre [Online] (Accessed on September 2002) Available: http://as.wiley.com/WileyCDA/WileyTitle/productCd-0470845279.html

[6] S. O. Kasap, "Principles of Electronic Materials and Devices", the 3rd edition, published by McGraw-Hill, International Edition, 2006 [Online] (Accessed on 21.10.2010) Available: http://www.amazon.com/Principles-Electronic-Materials-Devices-Kasap/dp/0073104647

[7] Series resistance [Online], Available: http://pveducation.org/pvc HYPERLINK "http://pveducation.org/pvcdrom/solar-cell-operation/series-resistance"drom/solar-cell-operation/series resistance

[8] Solar energy [Online] (Accessed on February 2014) Available: http://www.sciencedirect.com/science/article/pii/S0038092X13005240

[9] Energy efficiency [Online] (Accessed on 03.06.2013) Available: http://www.genesys-project.e HYPERLINK "http://www.genesys-project.eu/category/solar-panels"u/category/solar-panels

[10] Effect-of-parasitic-resistances [Online] Available: http://pveducation.org/pvcdrom/solar-cell-operation/effect-of-parasitic-resistances

[11] Solar Energy Information [Online] Available: http://www.makeitsolar.com/solar-energy-information/01-solar-history.htm

[12] Open circuit voltage [Online] Available: http://www.pveducation.org/pvcdrom/solar-cell-operation/open- circuit-voltage

[13] Short-circuit-current [Online] Available: http://pveducatio HYPERLINK "http://pveducation.org/pvcdrom/solar-cell-operation/short-circuit-current"n.org/pvcdrom/solar-cell-operation/short-circuit-current

[14] Fill-factor [Online] Available: http://pveducation.org/pvcdrom/solar-cell-operation/fill-factor

[15] Qi-Xun Zhang, Hai-Ye Yu, Qiu-Yuan Zhang, Zhong-Yuan Zhang, Cheng-Hui Shao and Di Yang, "A Solar Automatic Tracking System that Generates Power for Lighting Greenhouses", Energies 2015, 8, 7367-7380.

[16] Angel A. Bayod-Rújula, Alessandro Burgio, Zbigniew Leonowicz, Daniele Menniti, Anna Pinnarelli, and Nicola Sorrentino, "Recent Developments of Photovoltaics Integrated with Battery Storage Systems and Related Feed-In Tariff Policies: A Review", International Journal of Photoenergy, 2017.