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Maximising Solar Cell Efficiency with PERC Technology

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MAXIMISING SOLAR CELL EFFICIENCY WITH PERC TECHNOLOGY

Abstract— Recently new innovation and advance technology has been introduced in the field of solar technology, which allows feasible access in the area of solar applications. Solar technology achieved these impressive targets in order to provide multiple applications that have been possible with the help of a production line through many PV industries. After getting such a response of the whole world towards renewable field it become necessary to enhance eco-friendly technology. Indian government also proclaim the target of 100 GW by 2022. Therefore, accomplishment of few new projects proved to be a great start but the challenges faced by PV industries is still concerning, which can lower down the speed towards target. And the main factor is its efficiency.

Keywords— Solar Cell, Efficiency, PERC, MATLAB, Hardware setup etc.

I. Introduction

Passivated Emitter Rear Cell or Passivated Emitter Rear Contact both are the same things which related to PERC technology. It is the most efficient cell that is available in the current technology and when compared to the standard cells it is far better than conventional cell when it comes to the point of efficiency. They also have the advantage to work with low light condition i.e. in cloudy season and high temperature condition. While it's just a simple addition in the production line to convert the standard cell into PERC by adding one layer to its back surface, which provides multiple benefits to the production line in terms of cost and efficiency. PERC solar cell doesn't require many additional changes in the present manufacturing unit and machinery, although it's just simple addition of layer in the rear side of exciting standard cell and in this manner access to the higher efficient solar cell is complete. No much modification is required and even minimal changes can achieve the target and the manufacturer can produce the low cost higher efficient cell.

II. Structure of PERC

When it comes to the manufacturing of PERC cell, a minimal change in the production line is required and addition of few steps are required that can provide the back surface passivation and metallization to the standard mono-crystalline solar cell. Additional steps that are required for PERC cell manufacturing are :

- Formation of back surface passivation layer for rear contacts.
- Opening of the stack using laser or chemical etching.

By adding these required steps the capital cost of manufacturing remains unaffected while the remarkable higher efficiency can be achieved. Thus, few new innovative ideas and machinery required at the stage of production unit for upgrading the PERC cell and with the bulk production it will help lowering down the manufacturing cost.

Processing of PERC cell is basically the addition of passivation on rear side of the cell, it involves depositing of areas surface passivation film, which gives the formation of rear contact. There are two additional steps which is involved in the standard cell to convert it into the PERC cell. Chemical wet bench isolation step is twitched for rear polishing. The degree of polishing can vary accordingly to the case. Thus, in the standard cell two additional steps are introduced i.e. passivation film deposition system and film opening system. Film opening system can be done through laser or by chemical path.

Fig 1 Actual image of Standard solar cell

Fig 1 shows standard conventional cell having following specification :
Poly crystalline panel, SUNSTAR made, model no. 0605
9 volts, 10 watt, size 218*188 mm.

Fig 2 Actual image of PERC solar cell

Fig 2 shows PERC solar panel having following specification:
Poly crystalline panel, 9 volts, 10 watt
Size 218*188 mm with 1.6 gram AL paste in rear side.

III .Block Diagram

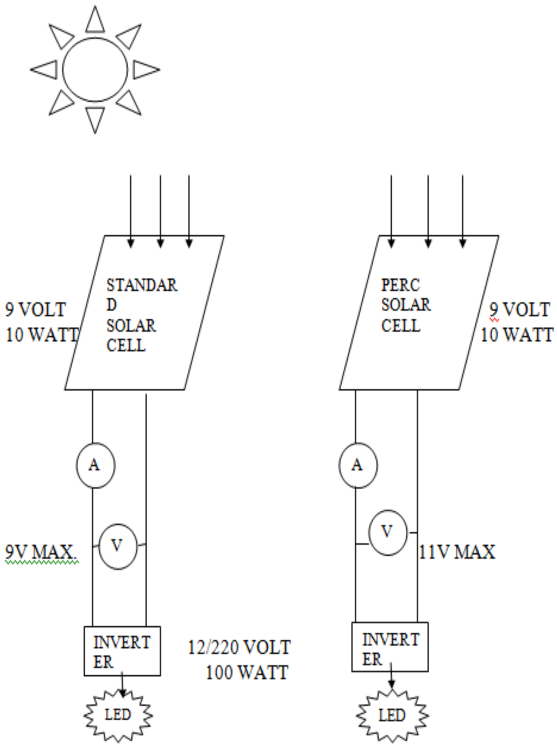

Fig. 3 Block Diagram to show the output of Standard and PERC solar cells

Fig 3 shows that when we use standard solar cell then the output voltage that we receive is 9V max while using PERC technology the output increases to 11 V with same input.

VI. MATLAB Simulation

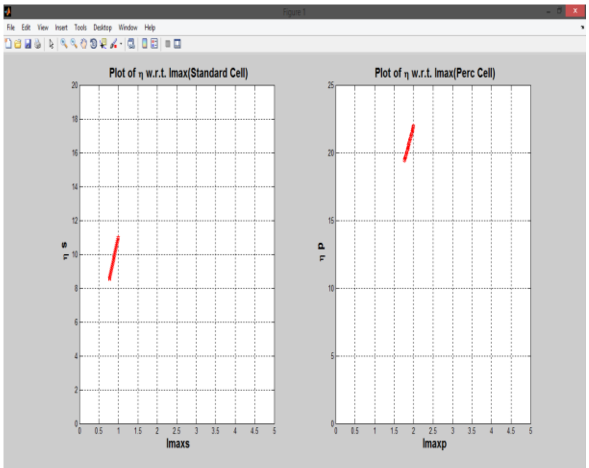

Fig. 4 Simulated result of conventional and PERC solar cell

Fig 4 shows the simulated output using MATLAB in which it is clearly shown that the output produced using PERC technology is higher than conventional cell.

VI. Hardware Setup

Fig.5 Actual Image of Physical Model

Fig 5 shows Physical model consists of Standard poly-crystalline cell, modified PERC cell, inverter, LED bulb, focus light and multi-meter.

VII.SCADA ANIMATION

SCADA Animation to represents the different stages of cell working with the output voltage gain in comparison of standard cell with the PERC cell.

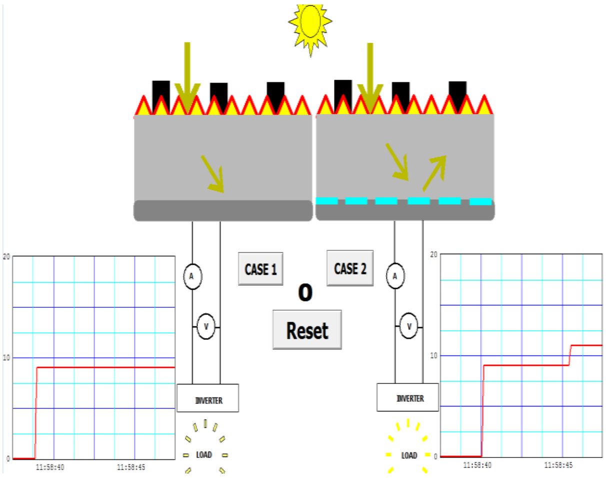

Fig 6 Scada combined cell performance

Fig 6 shows in combined cell performance, analysis of both the cells i.e. standard and PERC can be visualizes, determining the output voltage gain. The graphs represent the output voltage gain of both the cell, including the power gain with the intensity of load connected in output i.e. LED.

In CASE 1 Standard cell gain the output that is constant i.e. 9 volt maximum as light is absorbed in the BSF with less efficiency while the intensity of LED is low in comparison to PERC cell.

In CASE 2 PERC cell gain the output that is variable, which is 9 volt maximum at initial stage and in later rear stage working gains an additional gain to 11 volt maximum as the light is reflected back to the BSF to generates more additional current with more efficiency while the intensity of LED is high in comparison to standard cell.

VIII Formula Used

SOLAR PANEL USED:

1.STANDARD CONVENTIONAL PANEL

Poly crystalline panel, SUNSTAR made, model no. 0605
9 volt, size 218*188 mm.

2.PERC SOLAR PANEL,

Poly-crystalline panel, 9 volts, size 218*188 mm with 1.6 gram AL paste in rear side.

3. FORMULA USED

SOLAR CELL EFFICIENCY FORMULA

Solar Cell Efficiency = (P (max.)/ E*Ac) *100%
Where,
P(max.) = maximum power output in watt
E = incident radiation flux in watt/m^2
Ac = area of collector in m^2

SOLAR CELL FILL FACTOR FORMULA

FILL FACTOR = P(max)/(Voc*Isc)

Solar cell fill factor = (solar cell efficiency *Ac*E)/ (Voc*Isc)
Where,
Voc = open circuit voltage
Isc = short circuit current

SOLAR CELL OUTPUT GENERATED ENERGY

E= A*r*H*PR
Where,
E= energy in KWH
A= total surface panel area in m^2
r= solar panel yield or efficiency in %
H= annual average solar radiation on tilted panel
PR= performance ratio, coefficient for losses range between 0.5 and 0.9, default value= 0.75

OBSERVATION:

STANDARD CELL,
Voc= 9 volt
Line Voltage= 6 volt
Isc= 1 ampere
P(max.)= 7 watt
Fill Factor= 77.3%

PERC CELL,
Voc= 9 volt
Line Voltage= 9 volt
Isc= 2 ampere
P(max.)= 16 watt
Fill Factor= 88.8%

MATHEMATICAL CALCULATION:

STANDARD CELL EFFICIENCY,

EFFICIENCY (ηMAX.) = (7/(2000*0.0409))*100
= 8.55%

PERC CELL EFFICIENCY,

EFFICIENCY (ηMAX.) = (16/(2000*0.0409))*100
= 19.5%

Here, the whole mathematical formulas ultimately shows how the efficiency of solar cell is increased using PERC technology as compared to the conventional solar cell.

EQUIVALENT EFFICIENCY OF PERC CELL

To determine the equivalent efficiency of PERC cell, separate efficiency of front module and rear module are calculated, further addition of both efficiencies with reference of 0.1 to rear taken to determine the equivalent efficiency.

	V_{oc} (VOLT)	I_{sc} (AMPERE)	F.F. (%)	EFFICIENCY (η_{max}) (%)
18 CELL PERC, FRONT	9	2	88.8	19.5
MODULE FRONT	9	1.9	88.8	18.5
MODULE REAR	9	1.6	88.8	15.6

Table.1 Observation taken from front and rear module of PERC cell

$\eta_{eq,0.1} \equiv \eta_{front} + 0.1^* \eta_{rear}$

=18.5+0.1*15.6

=20.06%

IX .Conclusion

As commercialization of the technology is taking speed, record efficiencies are quickly being broken for PERC, reaching 22.13% for mono and 21.28% for multi. It is true that there are several other promising technologies being developed, but moving to PERC is rather simple- cell makers only need to add 2 machines (aluminum oxide deposition and laser system).Although the PERC cell constructed is quite different to what Chinese companies has introduced in the market due to the unavailability of raw material required at the manufacturing stage but still with the help of polycrystalline cell the rear module is assembled and connected electrically to achieved the record efficiency of 19.5%.

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