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Performance of Solar PV System with Self Regulating Module for Micro DC Submersible Pump

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Abstract: ***Solar operated pumps are becoming the need of the hour, particularly in the remote areas where grid power is not available. Micro DC solar submersible pumps (less than 50 W) needed where water availability is less and the bore recuperation rate is very low. The available solar DC submersible pumps have capacities ranging from 400 watt to 15 kW with very high discharge rates. These pumps are therefore not suitable for bores with low recuperation rates. Further, these pumps use maximum power point tracking charge controller for their operation, adding to the system cost. Actual selection of the pump depends on the head and the discharge requirement. In the present work, a pump is coupled to a 35 watt DC motor. The Maximum operating voltage that the motor can sustain is around 14 Volts. The standard Solar PV Modules available in the market have V_{max} around 17.3 Volts which is much higher than the required operating voltage of the motor. These modules, if used, need charge controller to be placed in between the PV modules and the motor. Instead, Solar PV Modules having V_{max} suitable for the DC pump operation are designed and manufactured so that charge controller can be eliminated. Such modules are also called as self regulating PV modules. This paper describes the results of the experimentation carried out to study and compare the performance of the pump with standard as well as self regulating Solar PV Modules. The results obtained are encourageous as self regulating modules were found to perform better than the standard ones.***

Keywords: Solar PV module, Charge controller, Module utilization factor

1. Introduction

A conventional solar PV system consists of solar panels, a charge controller and the load. The load can be any electrical gadget suitable to the capacity of the solar modules. An inverter may be present if the load is an AC load. In the present study, the load is a pump coupled to a 35 W, 12 V DC motor. The solar PV Modules are the standard modules available in the market and usually have open circuit voltage VOC in the range of 21.2 Volts. These modules provide maximum power output when operated at around 17.3 Volts (Vmax). This voltage is much higher than the safe working of 12 volt DC motor and hence a DC to DC controller is used in between the panel and the load. The controller limits the charging voltage to 14.0 Volts by disconnecting the modules with the motor at higher voltage and thus protects the motor from any damage. The PV panels may be connected in series and/or parallel combinations depending upon the system power and the DC voltage required.

Generally charge controllers are used to control the voltage supplied to the pump motor within the safe operating voltage limit. These are placed in open area as these are to be placed as near to the solar PV module as possible to reduce the losses. These produce good amount of heat during DC to DC conversion. In due course of time these need lot of maintenance. Another important factor is the loss of power during the conversion.
Self-regulating PV module is one wherein the Voc or (Vmax)

is reduced by reducing the number of cells , keeping the wattage same and increasing the area of cells, because of the reduction in the Voc or (Vmax) elimination of the controller is easily possible.

Such modules increases the power output of the panel compared to the standard one of the same power rating. Secondly, this will eliminate the need of DC to DC controller and reduce size and cost of the Solar PV pumping system. We hereby propose Solar Photovoltaic modules with new specifications given in Table 1.

Table 1: Proposed wattage and Voc

Specifications			
	Self Regulating PV Modules		
	No.1	No.2	No.3
Type	Multi-Crystalline		
Nominal Peak Power	75 Wp	75 Wp	75 Wp
Short-circuit Current	4.68	5.1	5.98
Open-circuit Voltage	21.2	19.3	17.4
Current at Max power	4.24	4.68	5.35
Voltage at Max power	17.7	16	14.3
No. of cells	36	32	28
Area of cells (cm^2)	124.82	145.36	169.0
Area of Module(cm^2)	5360	5360	5360
Module efficiency	14	14	14

Very little information is found available on such self regulating PV modules, although reference to "self regulated solar panels" can be seen in the literature [4, 5, 6, 7]. To study how these self regulating modules perform with the solar DC motor pump system - this experimental work is undertaken.

2. Experimental Set Up

A schematic of the experimental set up is shown in Figure 1. It consists of a self regulating PV module, a submersible DC pump, Volt meter, Ammeter, over head tank, etc. all

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connected as shown. No DC to DC controller was used during the experimentation.

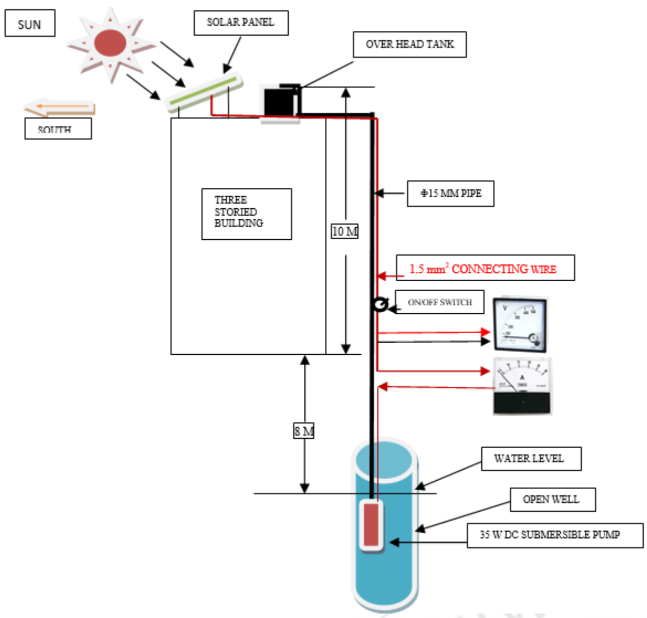

Figure 1: Experimental Setup

Three such setups, with different self-regulating modules, were prepared for direct comparison. Schematic diagram of the experimental setup shown in Figure 1.

3. Experimental procedure

1. All the three self-regulating PV modules were mounted in open, shadow free area facing south with an angle of 23^0 with horizontal.
2. The solar submersible pumps connected to the panels through an ON/OFF switch. The length of the pipe, diameter of the pipe, length of the wire, wattage of the pump and the PV module kept same for all the three sets.
3. The delivery head maintained 18 m from the free water level.
4. An ammeter and a voltmeter provided for current and the voltage measurement respectively.
5. Experiment started in the morning at 8 am. Hourly readings of current and the voltage manually recorded.
6. The trial taken for seven days.

4. Results and discussion

Figure 2, 3 shows the current drawn by the pump from the self-regulating PV module of Voc 17.4 V and the corresponding hourly variation in flow respectively during day time operation. Figure 4,5 show the current drawn by the pump from the self-regulating PV module of Voc 19.3 V and the corresponding hourly variation in flow respectively during day time operation. Figure 6,7 show the current drawn by the pump from the self-regulating PV module of Voc 21.2 V the corresponding hourly variation in flow respectively during day time operation. The figures also show the voltages attained by the respective panels. The testing being done simultaneously, there is no variation in the solar radiation for all the three pumps.

4.1 Self-regulating PV module V_{oc} 17.4 volt

It can be seen from figure 2 that for the self-regulating PV module V_{oc} 17.4

1. The operating voltage does not cross 14.2 volt throughout the day operation. Hence this module is quiet safe for the pump operation.
2. The developed voltage slowly increases from zero and attains 14 V by around 8.30 hours and remains constant till 15.0 hrs. The current drawn during this period is also constant and is around 2.5 A.
3. Both, the voltage and the current start decreasing thereafter.

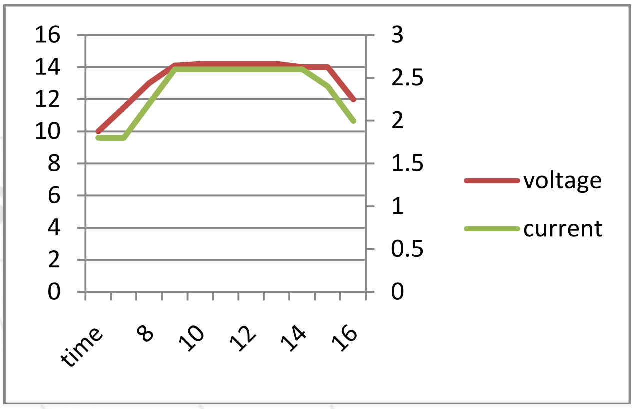

Figure 2: Voltage and Current Self-regulating PV module V_{oc} 17.4

Hourly flow Voc = 17.4 Volt

It can be seen from figure 3 that for the self-regulating PV module having V_{oc} 17.4 Volt

1. The flow of water through pump stars around 7 Am in the morning. The flow is very less because of the weak radiation and is about 60 lit per hour.
2. The flow slowly increases to about 100 lit/hour by 8 am and reaches to 250 lit / hour by 9 am.
3. This flow of 250 lit / hour is constant for next 5 hours and then starts dropping in the evening to 80 lit/hour.

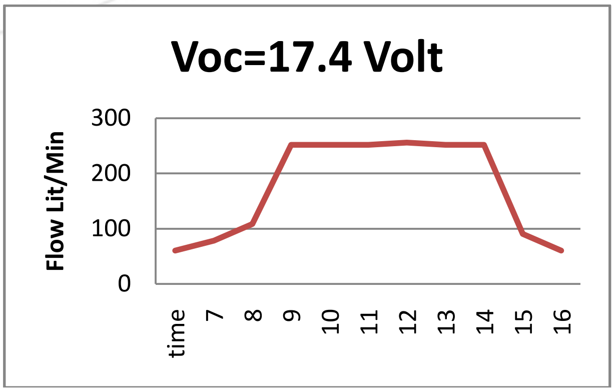

Figure 3: Flow Vs time Self-regulating PV module V_{oc} 17.4

4.2 Self-regulating PV module V_{oc} 19.3

Figure 4 shows variation in voltage and current for self-regulating PV module V_{oc} 19.3

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1. It can be seen in the graph that in the morning hours around 7 AM, the voltage is 11 volts and the current is around1.5 Amp. After 8.30 hours the voltage is 14.5 volt and current is 2.2 Amp. After 13 hours, the voltage is 16 volt and constant till 15 hours. After then current and voltage starts dropping, till 16 hours and then drops to 12 volt.
2. It can be seen that the voltage is 16 volt, which is above 14.2 volt throughout the day.

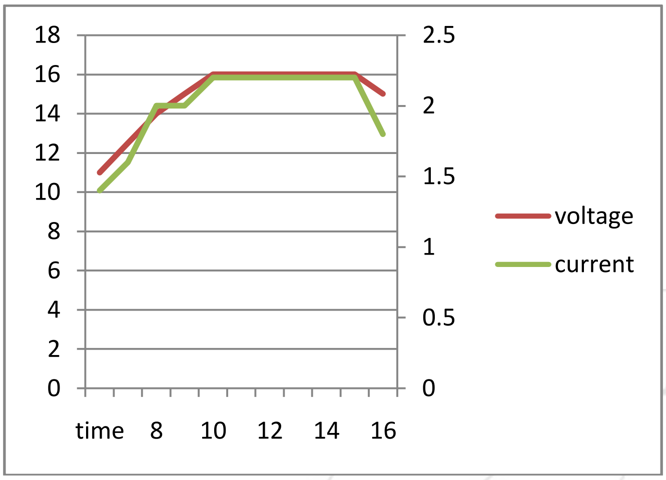

Figure 4: Voltage and Current Self-regulating PV module V_{oc} 19.3

Hourly flow Voc = 19.3 Volt

It can be seen from figure 5 that for the self regulating PV module having V_{oc} 19.3 Volt

1. The flow of water through pump stars around 7 Am in the morning. The flow is very less because of the weak radiation and is about 60 lit per hour.
2. The flow slowly increases to about 100 lit/hour by 8 am and reaches to 240 lit / hour by 9 am.
3. This flow of 240 lit / hour is constant for next 5 hours and then starts dropping in the evening to 80 lit/hour.
4. Pump stops working by 17.30 hours because of insufficient power from the PV module.

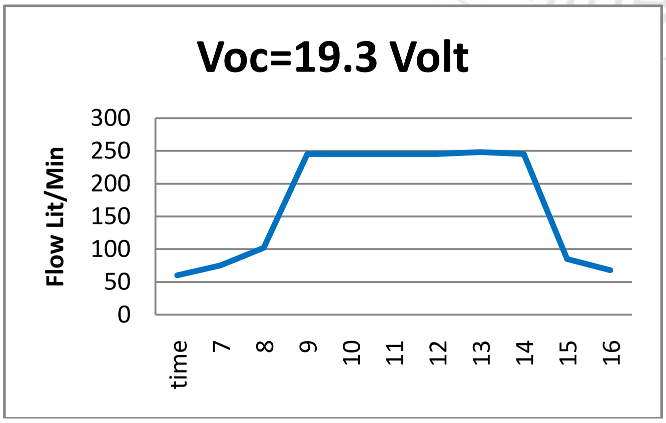

Figure 5: Flow Vs time Self-regulating PV module V_{oc} 19.3 Volt

4.3 Self-regulating PV module V_{oc} 21.2

Figure 6 shows the variation in voltage and current for Self-regulating PV module V_{oc} 21.2

It can be seen in the graph that in the morning hours around 7 AM, the voltage is around 13 volts and the current is around1.8 Amp. After 8.30 hours the voltage is 17.0 volt and current is 2.0 Amp. This is almost constant for the whole day. After 15 hrs the voltage current starts dropping, till 16 hours and then drops to 12 volt.

It can be seen that the voltage is above 14.2 volt throughout the day

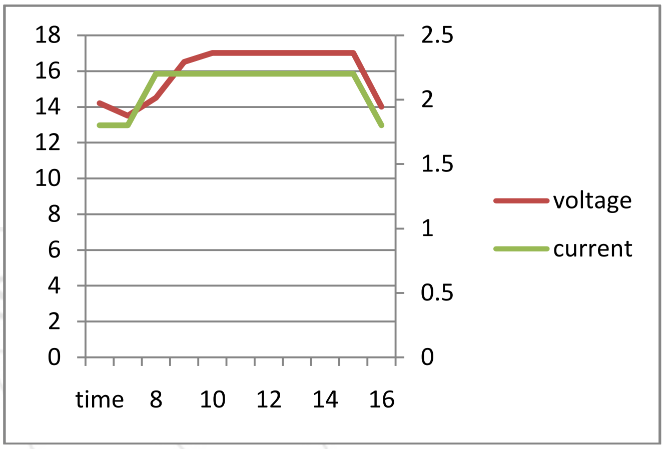

Figure 6: Voltage and Current Self-regulating PV module V_{oc} 21.2

Hourly flow Voc = 21.2 Volt

It can be seen from figure 7 that for the self-regulating PV module having V_{oc} 21.2 Volt

1. The flow of water through pump stars around 7 Am in the morning. The flow is very less because of the weak radiation and is about 60 lit per hour.
2. The flow slowly increases to about 110 lit/hour by 8 am and reaches to 230 lit / hour by 9 am.
3. This flow of 230 lit / hour is constant for next 5 hours and then starts dropping in the evening to 90 lit/hour.
4. Pump stops working by 17.30 hours because of insufficient power from the PV module

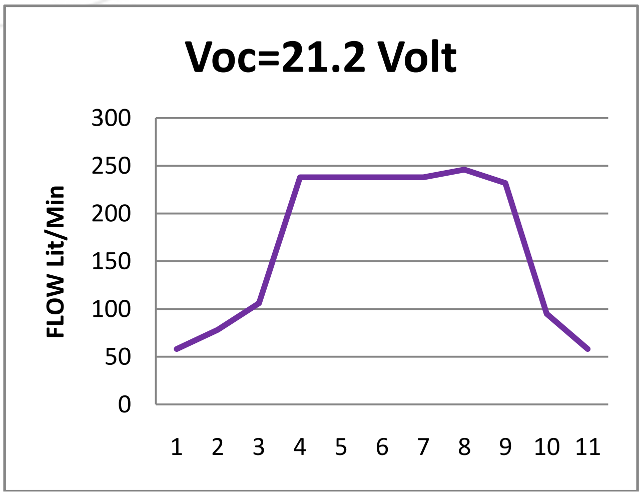

Figure 7: Flow Vs time Self-regulating PV module V_{oc} 21.2

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4.4 Comparison of daily flow

Figure 8 shows the comparison of daily flow of all the three pump set with self-regulating PV module having V_{oc} 17.4, 19.3 and 21.2 Volt

1. The daily flow of water through pump having self-regulating PV module of V_{oc} 17.4 Volt is 1910 lit/day, V_{oc} 19.3 Volt is 1865 lit/day and V_{oc} 21.2 Volt is 1830 lit/day.
2. Variation in flow is not much i.e. within 5%.

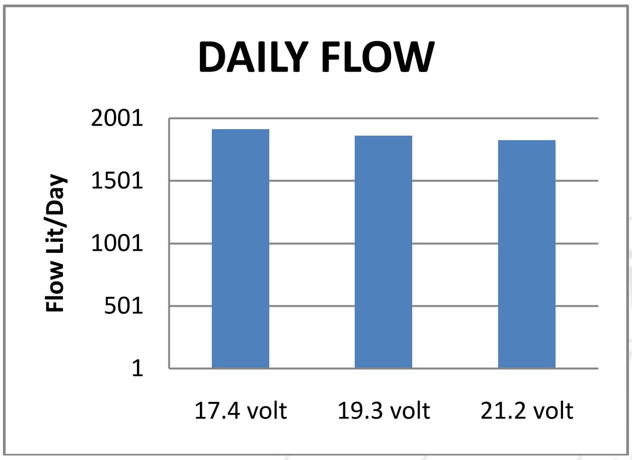

Figure 8: Comparison of daily flow Self-regulating PV modules

Table 2

Sr. No.	Self-regulating PV module Voc	Daily flow in lit	Difference in lit with Voc 17.4 volt pump	Varia-tion %
1	17.4	1910	--	--
2	19.3	1865	45	-2.3
3	21.2	1825	85	-4.45

5. Conclusions

1. Maximum voltage attained by the Self-regulating PV module V_{oc} 17.4 is 14.2 volts, by Self-regulating PV module V_{oc} 19.3 is 16 Volts and that of Self-regulating PV module V_{oc} 21.2 is 17 volts without DC to DC controller.
2. Maximum operating voltage of Self-regulating PV module V_{oc} 21.2V and 19.3V is much higher than the safe operating voltage of the pump motor. Hence DC to DC controller is necessary for above mentioned Self-regulating PV modules.
3. The operating voltage of self-regulating PV module having V_{oc} = 17.4 Volts, reaches up to 14.2 Volts. This is well within the safe operating voltage. Hence, DC to DC controller is not necessary.
4. Since the cost of DC to DC controller is eliminated, installation cost of the solar PV pumping system gets reduced also maintenance problems associated with DC to DC controllers are avoided .
5. DC to DC controller needs regular maintenance, this is also avoided.
6. Useful power generated by PV module is higher than the standard PV module under same test conditions as DC to DC controller loses are avoided.
7. Solar system cost also reduced because of higher power gain. Lesser power PV module can be used for the same operation
8. If V_{oc} (open circuit voltage) is reduced to a suitable & safe value, the DC to DC controller can be avoided and the safe operation of pump motor can also be ensured.
9. The daily flow for self-regulating PV module having V_{oc} = 17.4V Volts is maximum amongst the three self-regulating PV modules.
10. The comparison of daily flow of all the three mentioned self-regulating PV modules show that the flow of V_{oc} 21.2V and 19.3V is less by2.3 % and 4.45 % respectively as compared to V_{oc} = 17.4V , hence self-regulating PV module having V_{oc} = 17.4 Volts can be recommended to operate without DC to DC controller and it is safe.

References

[1] Photovoltaics-Wikipedia
[2] Photovoltaics: Solar Electricity and Solar Cells in Theory and Practice http://www.solarserver.com/knowledge/basic-knowledge/photovoltaics.html
[3] Performances of solar power plants in India, Central Electricity Regulatory Commission New Delhi, February 2011
[4] Byers, T.J, SciTech Journal Article, Photovoltaics; (United States); Volume: 1:3,1983-01- 01, "Self-regulating PV modules eliminate the charge controllers"
[5] Might Google 'self-regulating solar panels' May 19, 2010
[6] Solar online Australia-www.solaronline.com.au
[7] Solar Photovoltaic Technology and systems, A Manual for Technicians. Chetan Singh, Solanki

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