Enhancing Maximum Power with Switched PV Technology under Shading Condition for both AC and DC loads

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***Abstract*—This paper aims at extracting a maximum power from a PV array under different shading condition using switched PV technology. The proposed topology enhances power once there is less isolation due to shading. The methodology proposed here is cost effective, more economical throughout partial shading, simple, reduced in size and may be easily adopted for associate existing system. The simulated results explain that the proposed system is more efficient during partial shading conditions compared to conventional system for both AC and DC loads.**

Index Terms—Switched PV technology, Maximum power, Different shading, PV application, renewable energy.

I. INTRODUCTION

Currently, there is a rapid increase in electricity demand. To meet the power demand of every individual consumer, there is a wide usage of renewable energy sources. In present scenario, 30% of installed capacity are due to renewable energy sources. Solar power is one of the important and trending energy sources which can be implemented at consumer premises. The new invention and modification of PV module has helped in reducing size with greater output.

Extracting a maximum power from a solar PV module during shadowing condition is a significant measure. Foremost the P(V) and I(V) Characteristic response of solar PV modules to be analyzed for a varying isolation and temperature [1]. The effect of shading on power output and tracking maximum power point can be done using various Global power point Technique [2]. The different PV configuration, such as central inverter, string inverter, module integrated converter and differential power processing helps in extracting maximum power with their own advantages and disadvantages [3] [4]. String type of PV arrangement is more advantageous and cost effective compared to the other PV configuration with P & O MPPT control [5]. In this paper maximum power is extracted by using a string inverter configuration with switching technique. It is simulated for both AC and DC load at STC and compared with the traditional approach. The proposed scheme is more economical and efficient during partial shading condition with less investment and maintenance. The most significant advantage of the proposed topology is that, it can be implemented for an existing system. Figure 2 shows the general block diagram of the proposed topology.

II. PROPOSED SWITCHED PV ARRANGEMENT

In the proposed topology, each string has a converter and PV Panels in each string is exactly divided into 2 parts and connected to the diodes and switches as represented in the Figure 3. The proposed topology has 2 states of operation state 1 when the switch is in closed condition and state 2 when the switch is in an open condition.

When the switch is in a closed condition, we get maximum voltage of all the panels in a string, when the switch is open condition each segment will act as independent string contributing to the maximum voltage which is nearly twice that on stage 1. The Sepic converter is used because it performs the operation of Buck-Boost with non inverting output voltage. With a combination of H Bridge inverter of an AC load.

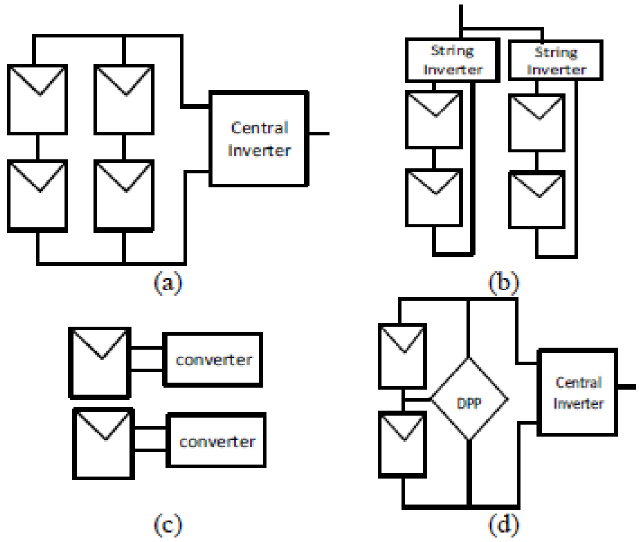

Fig.1. Types of PV Technology

III ANALYSIS OF PHOTOVOLTAIC CELL AT STC

A light energy from the sun is captured to produce electrical energy using PV cell. The mathematical modeling of PV cells is executed at STC (standard test conditions). The data considered for a PV cell is with respect to Table 1 provided by MITSUBISHI ELECTRIC - PVUD19MF5. The model developed in the MATLAB/Simulink environment is simulated for change in temperature with an STC of isolation and vice-versa. The P(V) and I(V) characteristics obtained stating that the output power decrease with increase in temperature above 25 degree Celsius and a decrease in isolation. These behaviors of PV cell for a change in temperature from 0-75 degree Celsius and change is isolation from 1000-250 can be seen in the graphs.(Figure 5-9)

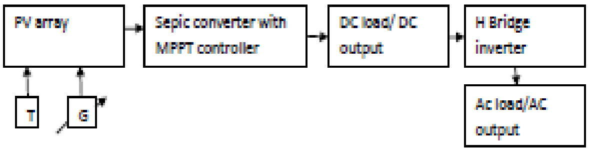

Fig.2. Block Diagram of a Proposed Topology

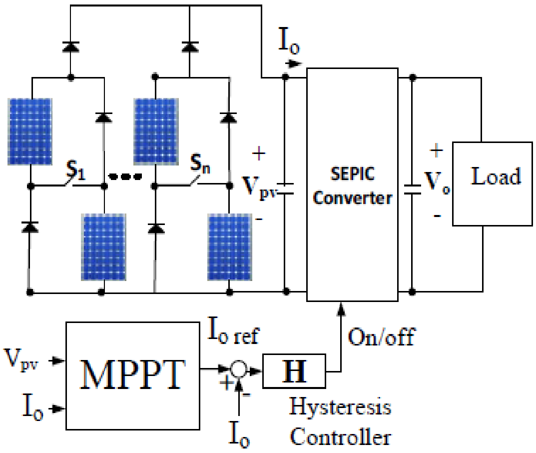

Fig.3. Proposed Switched PV Arrangement

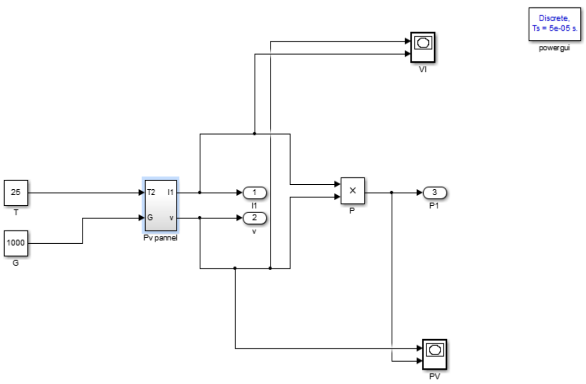

Fig.4. Subsystem Model of Solar PV cell

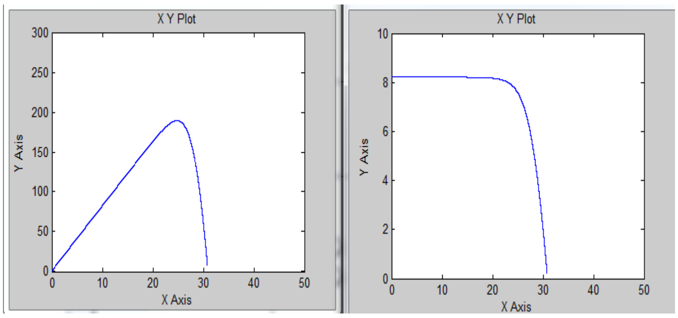

Fig.5. Plot of P(V) and I(V) at STC

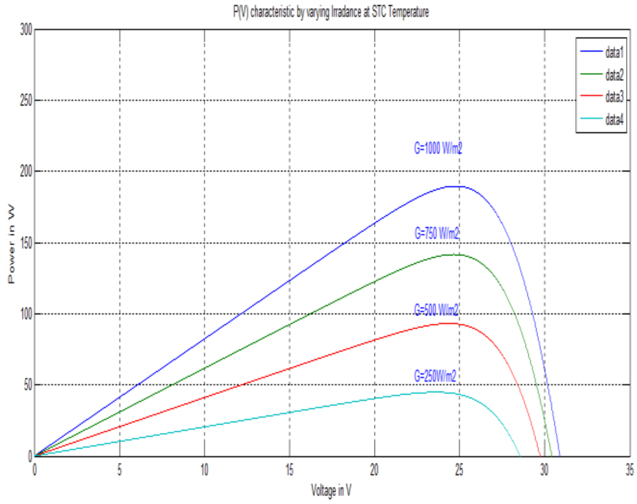

Fig.6. Plot of P(V) for Varying Isolation at STC of Temperature

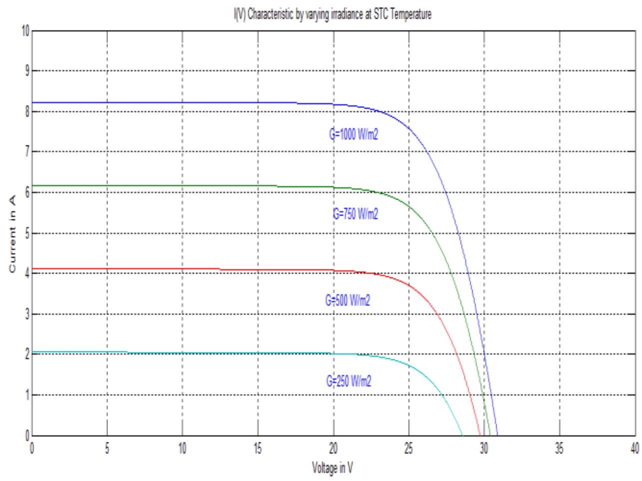

Fig.7. Plot of I(V) for Varying Isolation at STC of Temperature

IV LOAD CALCULATION

A load is an electrical component which consumes power. The generation capacity depends on the load present in a system. The load is either AC or DC. On a mean the residential users consume 5KW of power a day. Other loads like AC and DC motor can be considered where farmer uses for the aim of irrigation. The Table 2-4 gives the standard AC, DC motor load details and power consumed by residential users. On an mean load is considered to be 5KW.

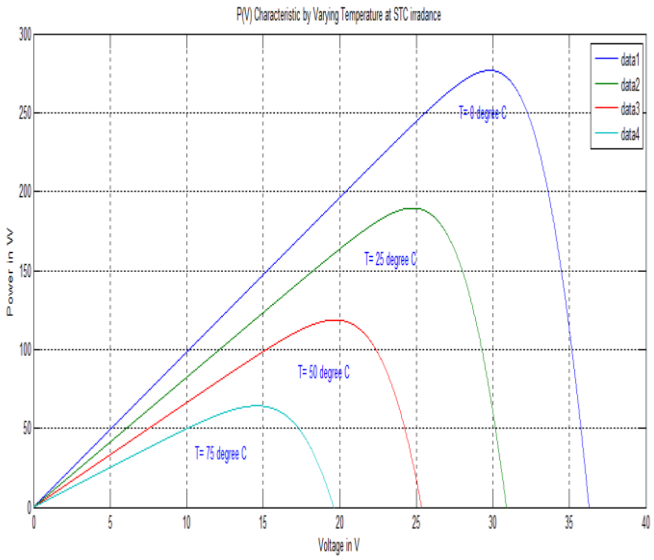

Fig.8. Plot of P(V) for Varying Temperature at STC of Isolation

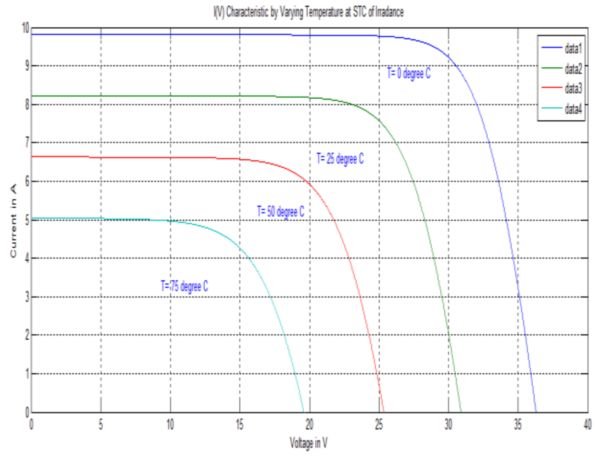

Fig.9. Plot of I(V) for varying Varying Temperature at STC of Isolation

Table.1. 190W PV Panel Data

Parameters	Values
Pmp(w)	190
Imp(A)	7.71
Vmp(V)	24.7
Isc(A)	8.23
Voc(V)	30.8
Rs(Ω)	0.20758
Rp(Ω)	975.6
µsc (k)	1.3e-3
Noct ℃	47.5
Ns	50

V. TECHNIQUE TO TRACK MAXIMUM POWER POINT AND SELECTION OF CONVERTER

To extract a most power throughout partial shading condition associate electronic controller is used known as MPPT controller.

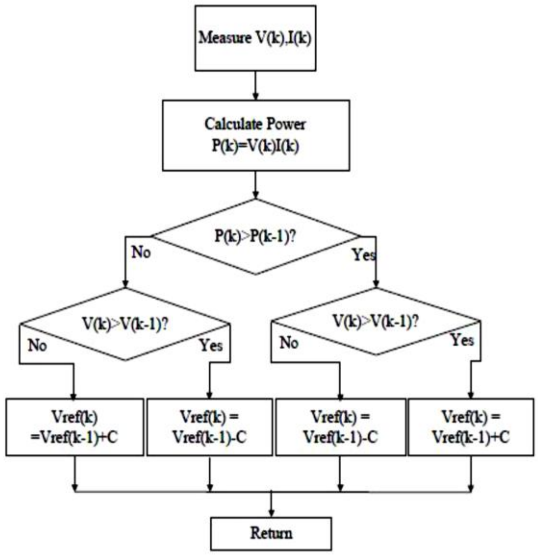

Fig.10. Flowchart Indicates the Operation of P&O MPPT Technique

Table. 2. Standard DC Motor Specification

Description	Motor 1	Motor 2	Motor 3	Motor 4
PV Array	1200Wp	1800Wp	3000Wp	4800Wp
Electronic controller	Can be adopted	Can be adopted	Can be adopted	Can be adopted
Dynamic Head	45 meters	45 meters	70 meters	70 meters
Water Pumped	42000 lts per day	63000 lts per day	63000 lts per day	100000 lts per day

Table. 3. Standard AC Motor Specification

Description	Motor 1	Motor 2	Motor 3	Motor 4
PV Array	1200Wp	1800Wp	3000Wp	4800Wp
Electronic controller	Can be adopted	Can be adopted	Can be adopted	Can be adopted
Dynamic Head	45 meters	45 meters	70 meters	70 meters
Water Pumped	38000 lts per day	57000 lts per day	57000 lts per day	91000 lts per day

MPPT controller operates in 3 steps initially it will calculate power /voltage output of a PV panel next it compares it with the Specified output and so optimizes power from the PV array to fulfill the load demand. There are many types of MPPT controller such as fuzzy logic, neural network, incremental conductance method, Perturb and Observe Technique etc.. Here we have adopted P & O method because it has more advantages such as, straight forward implementation, less power consumed, simple algorithm. The only disadvantage is that during rapid changes in a surrounding system, it takes the

Table. 4. Residential power consumed

Sl. No.	From Date	To Date	Up To Date Reading	Previous Reading	No of Units
1	18/1/16	18/2/16	2805	2708	97
2	18/2/16	2/3/16	2853	2805	48*2
3	18/11/15	18/12/15	2610	2519	91
4	18/12/15	1/1/16	2708	2610	98
5	18/10/15	18/11/15	2519	2417	102
6	2/3/16	2/4/16	2950	2853	97

wrong track in order to avoid this huge scale is taken into account. Figure 10 shows the Flow chart of a P&O method with controlling action of duty cycle in Table 5. For the change in surrounding temperature MPPT controller will adjust the duty cycle of the converter to optimize power for a given load can be seen in Figure 11. The duty cycle will increase or decrease to meet the global point. To track MPPT a code is written as per the flow chart using Matlab13 and called to the functional block of simulink. The inputs considered for an MPPT controller are MPPT enable, voltage and current of a panel and physical parameter.

A converter Chosen here is a Sepic converter because it can be used to vary the voltage easily to maintain constant output voltage required. The electrical stress on a deviceis is a smaller amount and it has reduced current ripple thus its additional economical than alternative converters. Together with this associate H Bridge inverter is employed to convert a power from DC to AC to fulfill AC load needs.

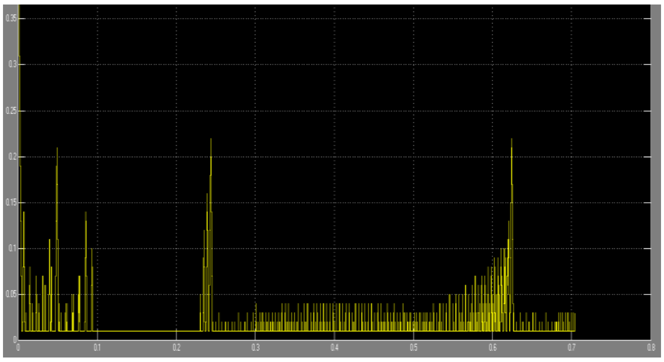

Fig.11. Change in Duty Cycle to Shift to Maximum Power Point

Table.5.Control Action of Duty Cycle

Case	Conditions	Position	Control Action
1	$\Delta pk > 0, v_k > 0$	Left of MPP	Increase δ
2	$\Delta pk > 0, v_k > 0$	Right of MPP	Decrease δ
3	$\Delta pk < 0, v_k < 0$	Right of MPP	Decrease δ
4	$\Delta pk < 0, v_k < 0$	Left of MPP	Increase δ

VI. PROPOSED SYSTEM SIMULATION AND RESULTS

MATLAB/SIMULINK-2013b is employed to create a Simulink model. The proposed system of State 1(Figure 12) and State 2(Figure 13) is compared with the conventional system (Figure 14) for various Shading condition as shown in Table 6. The total power output for every shading pattern is recorded.

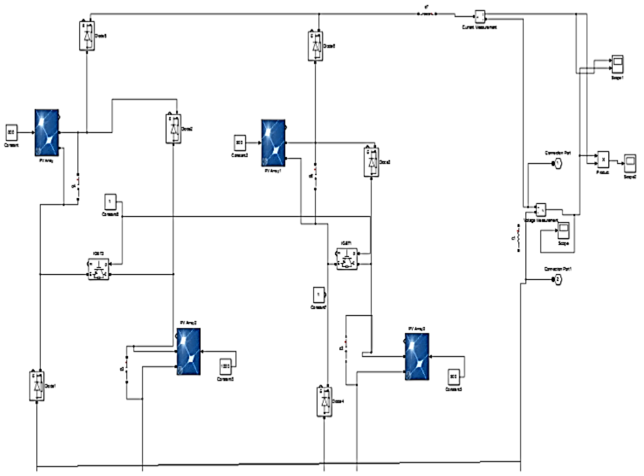

Fig. 12. Proposed State 1 switch connection

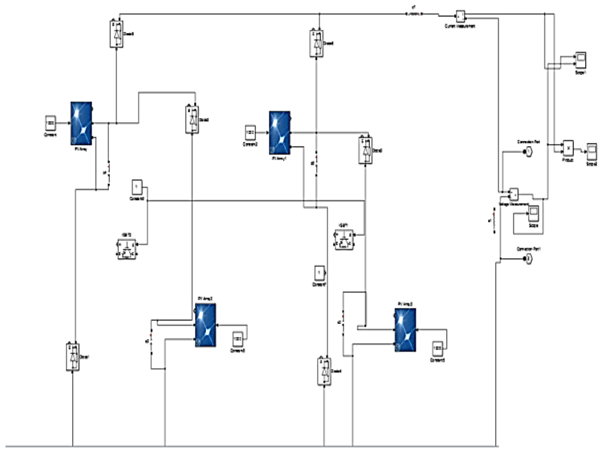

Fig. 13. Proposed State 2 switch connection

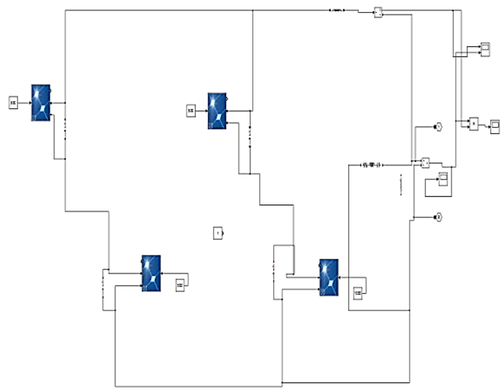

Fig. 14. Conventional System Simulation Block

Table.6 Shadowing Pattern

PV Module	No shading	10% shading	20% shading	30% shading	40% shading	50% shading
1	1000	900	800	700	600	500
2	1000	900	800	700	600	500
3	1000	900	800	700	600	500
4	1000	900	800	700	600	500

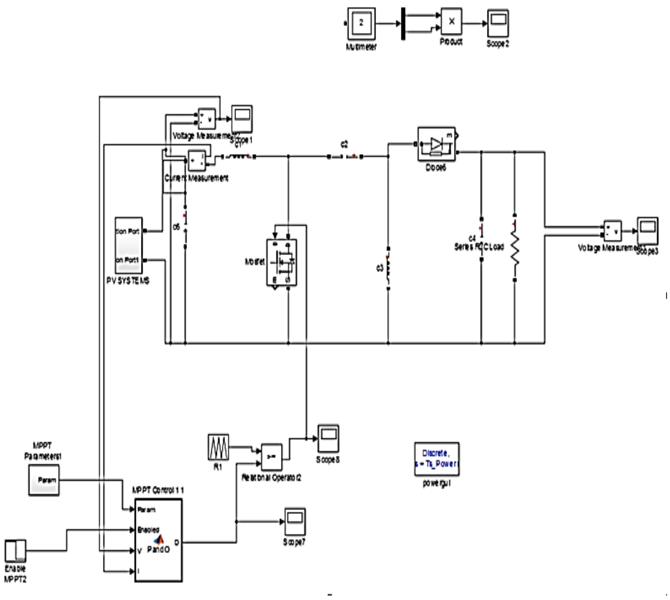

Fig. 15. Proposed System Simulation Block Fed to DC load

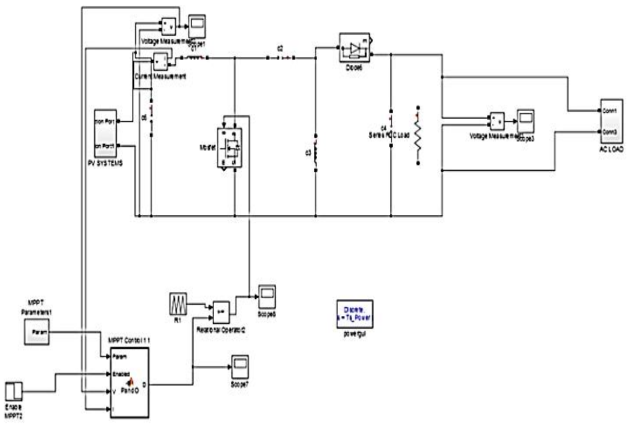

Fig. 16. Proposed System Simulation Block Fed to AC load

Figure 15-16 are the complete Simulink block of a proposed system fed to AC and DC load. Figures 17-22 show the plot of power output in watts for all shading condition fed with AC and DC load. The Simulink result recorded is tabulated in the Table 7-8. The power output is same for all the case when there is no shadow. Proposed state 1 is comparable to conventional system where in state 2, the output power obtained for different shadowing condition is greater compared with other condition. The power obtained in state 2 is more than twice the power of state 1 and as well as of conventional system during 40% and 50% of shading condition.

Table. 7. Power Output of DC load in watts

PV Module	No shading	10% shading	20% shading	30% shading	40% shading	50% shading
Con	5100	4200	3350	2500	1900	1250
State 1	5000	4270	3400	2600	1900	1330
State 2	5300	4950	4627	4320	4050	3750

Table. 8. Power Output of AC load in Watts

PV Module	No shading	10% shading	20% shading	30% shading	40% shading	50% shading
Con	5000	4100	3200	2500	1800	1250
State 1	5000	4250	3400	2550	1900	1300
State 2	5000	4700	4555	4416	4150	3800

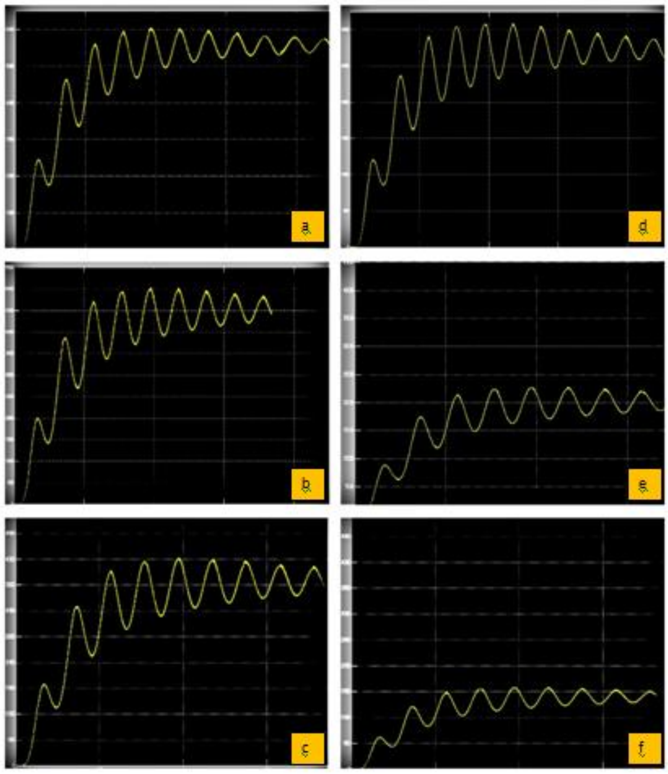

Fig. 17 (a – f) Power output of different shading Pattern in Watts of a Conventional System Fed to DC Load

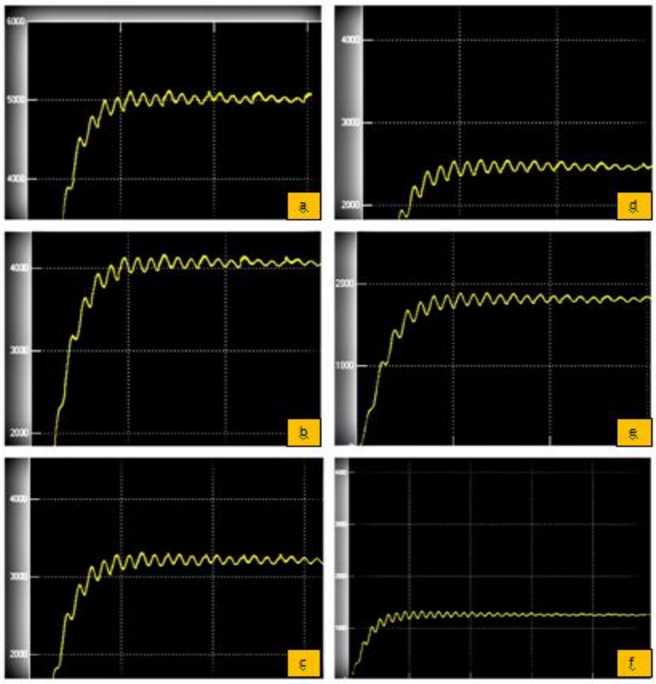

Fig.18. (a – f) Power output of different shading Pattern in Watts of a Conventional System Fed to AC Load

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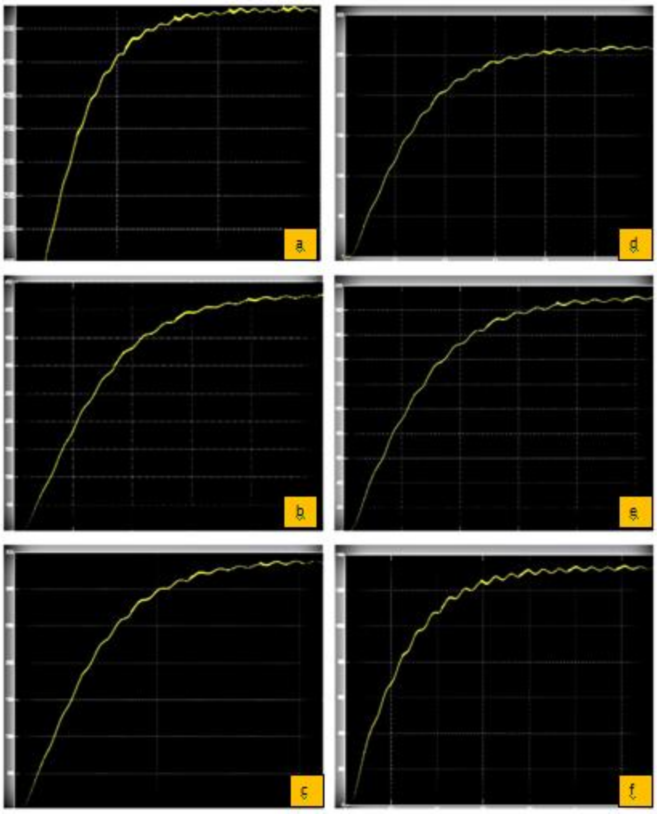

Fig.19. (a – f) Power output of different shading Pattern in Watts of a Proposed State 1 Fed to DC Load

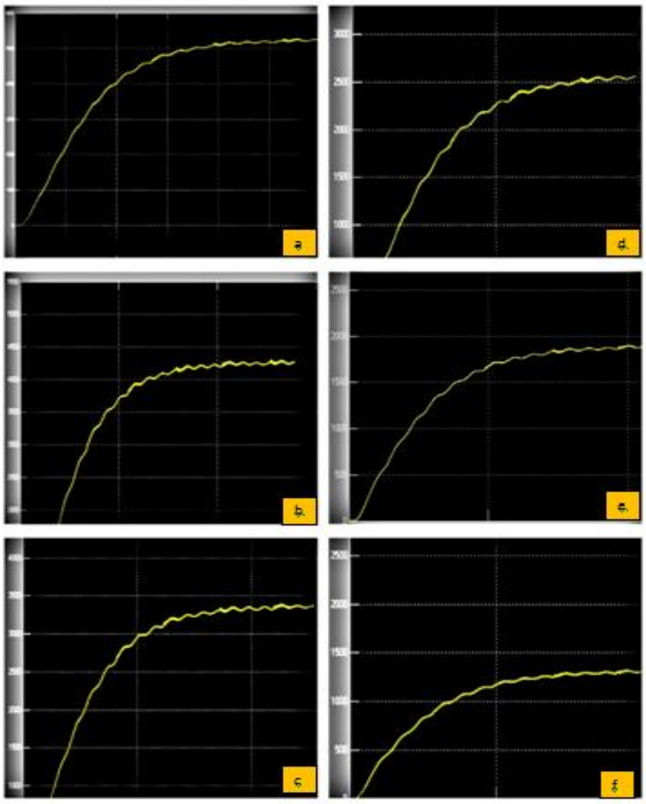

Fig.20. (a – f) Power output of different shading Pattern in Watts of a Proposed State 1 Fed to AC Load

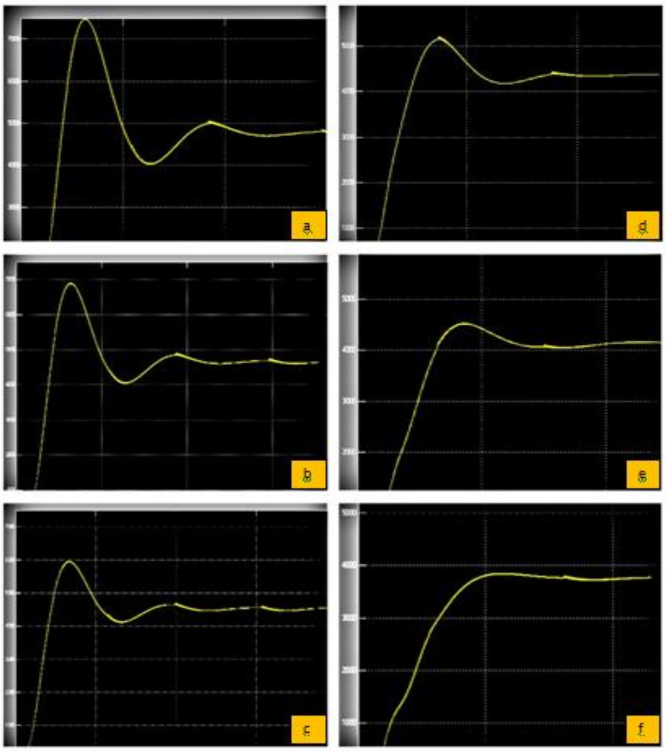

Fig.19. (a – f) Power output of different shading Pattern in Watts of a Proposed State 2 Fed to DC Load

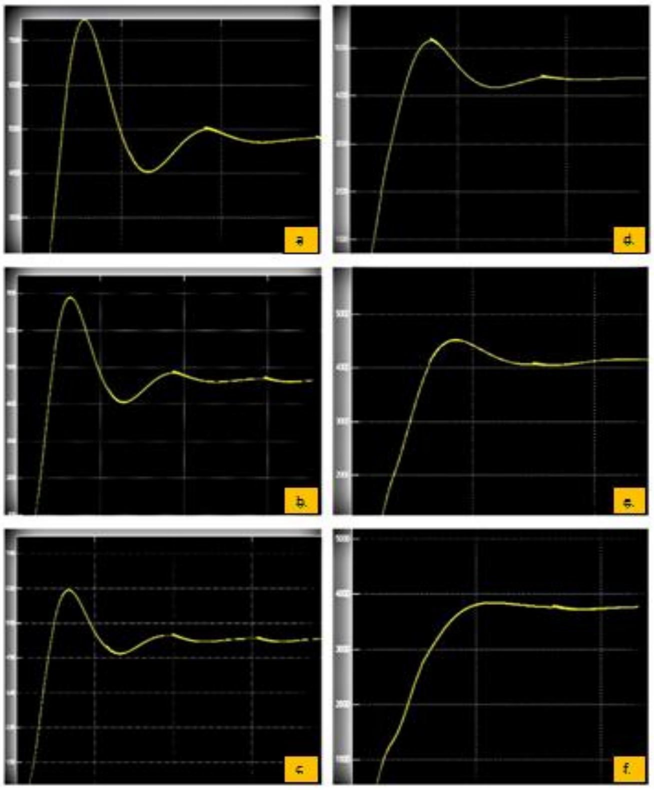

Fig.22. (a – f) Power output of different shading Pattern in Watts of a Proposed State 2 Fed to AC Load

VII. CONCLUSIONS

The Simulink model of a PV array with different shading conditions were implemented for AC and DC loads and the comparative results for conventional and proposed system were tabulated. From the simulation results obtained it can be observed that the power output of the proposed system varies between 4 - 200% for DC loads for no shading to 50% shading condition, whereas for AC loads, it varies between 0 – 204%. Hence it can be concluded that the proposed system is more efficient than the conventional system during partial shading to obtain maximum power with low investment cost.

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