Performance of Conventional PV array configurations under Partial shadings

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***Abstract*— The main design objective of the solar photovoltaic (PV) systems is to extract the maximum power from the PV systems for a long time. The amount of power extracted from the PV array can be affected by temperature, solar irradiation, dust accumulation, wind speed, PV array configuration and shading pattern. Often, the PV arrays are completely or partially shadowed and has been recognized as a major challenging concern which can reduce the output power of PV arrays due to mismatching power loss between the PV modules and represents multiple Maximum Power Points (MPPs) in the electrical characteristics (I–V and P–V characteristics). The key objectives of this paper are to model, simulate and study the effects of PSCs on the electrical characteristics of Series (S), Series–Parallel (S–P), Bridge link(BL) and Honey- Comb (H-C) PV array configurations under various shading patterns such as, short and narrow, short and wide, long and narrow, long and wide, and diagonal shading patterns by using a MATLAB/Simulink simulation model. The performance analysis of the PV array configurations is carried out by considering the maximum power generated (P_{MP}), open-circuit voltage (V_{OC}), voltage at maximum power point (V_{MPP}), short-circuit current (I_{SC}), current at maximum power point (I_{MPP}), The simulation and performance analysis of PV array configurations is performed with 36 modules.**

***Keywords*— photovoltaic (PV) systems, Configurations, Maximum Power Points**

1. INTRODUCTION

The ever-growing demand for a low-cost energy and an in-creasing concern about environmental issues has motivated an enormous attention in the utilization of freely and abundantly available renewable energy sources such as solar, wind tidal energy etc. Among these renewable energy sources, solar Photovoltaic (PV) systems has attracted more attention due to the decrease in the price of PV modules, intentional government subsidies and innovative business models in the residential, commercial and utility power systems (The solar energy can be easily converted into electrical energy using PV cells/modules/arrays. The performance and efficiency of PV systems depend on many factors; such as solar irradiation, temper ature, aging effect, potential induced degradation effects etc. In general, the variations in solar irradiation and temperature will be considered as the most affecting factors of PV generation systems. The temperature has an enormous effect on aging of PV modules. If the PV modules are subjected to higher temperatures, it can lead to module delamination, creation of bubbles, corrosion etc. Under uniform irradiation condition (i.e., all the cells in a module or array receives the same irradiation), PV systems represents a unique Maximum Power Point (MPP) in the non-linear I–V and P –V characteristics. This MPP can be tracked by employing conventional Maximum Power Point Tracking (MPPT) techniques.

Under the Partial Shading Conditions (PSCs), commonly referred to as mismatching conditions, certain cells or modules in a PV array are shaded by passing clouds, trees, poles, buildings, bird droppings and some other objects Therefore, under PSCs PV modules represent multiple maximum power points (MPPs) in the non-linear I–V and P –V characteristics. The presence of multiple MPPs in the I–V and P –V characteristics and to track the global MPP, soft computing based MPPT techniques are efficient Due to PSCs, PV systems are prone to mismatching power losses, and hence the maximum power generation capability and efficiency of PV systems decreases. In addition, due to PSCs, the mismatching power losses in a PV system are also due to dust and soiling, defects of bypass diodes, different positioning of the PV modules in the same string with respect to solar irradiation, differences between the PV cells physical parameters, manufacturing tolerances etc. These mismatching power losses in a PV system can be reduced by employing various approaches; these are PV array configurations.

2. PV CONFIGURATIONS

• Begin with an overview of solar energy use globally and the role of photovoltaics in renewable energy. Discuss the basic principles of photovoltaic technology, including how solar cells convert sunlight into electricity.

- Provide a brief history of PV array configurations, detailing the evolution of different wiring schemes and layout designs.
- Discuss early challenges and technological advancements that have influenced the development of PV array configurations over time

2.1 Series PV configuration

All of the PV modules are wired together in a series connection in this setup. When PV modules are connected in series, the same amount of current passes through each one, thus their total current equals that of the PV array current. total voltage produced by a PV array, which is the same as the voltage across all modules in thearray added together

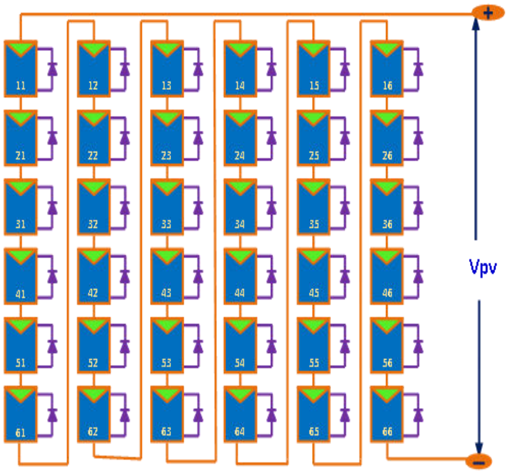

Fig. 1 Series configuration

2.2 Series-Parallel PV configuration

It the widely used popular topology for both stand-alone PV systems and systems that connect to the grid. The PV panels are linked together to form a string to get the desired output voltage and current. The output current of an S-P structure is equal to the total current of all the strings, and the output voltage is equal to the voltage across any one of the strings.

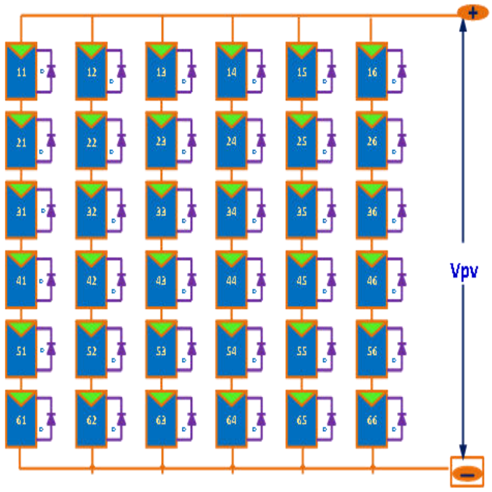

Fig. 2 Series-Parallel configuration

2.3 Bridge-Link configuration

In Bridge-Link PV array Configuration is formed by connecting each four PV modules such a manner that they form a bridge, after forming these bridges are connected with cross ties.

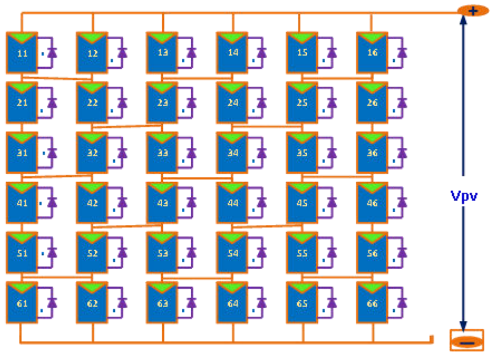

Fig. 3 Bridge-Link configuration

2.4 Honey-Comb PV configuration

The honey bee's home, a hexagon, served as inspiration for this layout. Honey bee hives take on a hexagonal shape when six modules are joined together, and in this arrangement, all hexagonal structures are held together using cross-ties.

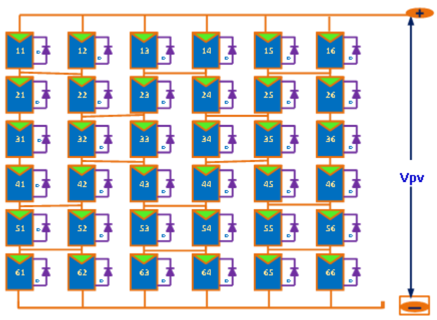

Fig.4 Honey-comb configuration

3 PARTIAL SHADING

Non-uniform shading on photovoltaic (PV) arrays can significantly impact their performance and efficiency. Shading can occur due to various factors, such as nearby trees, buildings, poles, and even accumulated dirt or debris on the panels themselves. simulation and study the effects of PSCs on the electrical characteristics of Series (S), Series–Parallel (S–P), Bridge link(BL) and Honey- Comb (H-C) PV array configurations under various shading patterns such as, short and narrow, short and wide, long and narrow, long and wide, and diagonal shading patterns by using a MATLAB/Simulink.

4 PERFORMANCE ANALYSIS

This section discussing the performance of SP, BL, HC PV array configurations under various PSCs. All the configurations' performances are evaluated by simulating them in Matlab/Simulink environment. The analysis of all configuration's performances are carried out under uniform insolation and then it can be extended under various PSCs

Paramerters	PV Configuration											
	S			SP			BL			HC		
Shade	Uniform	Row	Column	Uniform	Row	Column	Uniform	Row	Column	Uniform	Row	Column
Voc (V)	1181.35	1177.32	1178.76	193.96	196.1	196.24	196.75	196.55	196.75	197.11	196.25	196.59
Isc (A)	8.21	8.227	8.209	49.26	49.25	47.61	49.25	49.25	47.6	49.26	49.25	47.59
Peak Voltage (V)	935.38	779.58	792.85	158.39	131.21	157.42	158.03	132.03	159.26	155.66	130.55	159.67
Peak Current (A)	7.693	7.652	7.518	45.48	45.47	41.37	45.59	45.15	41.42	46.21	45.7	41.05
Peak Power (W)	7196.2	5965	5961.2	7204	5967	6514	7205	5962	6598	7194	5967	6555
No of Peaks	0	3	3	0	3	0	0	2	2	0	1	2
% Efficicency	14.14	12.56	12.55	14.15	12.56	13.71	14.15	12.55	13.89	14.13	12.56	13.80

Table 1: Parameters under Uniform, Row, Column shading conditions

Paramerters	PV Configuration											
	S			SP			BL			HC		
Shade	Diagonal	Center	SAN	Diagonal	Center	SAN	Diagonal	Center	SAN	Diagonal	Center	SAN
Voc (V)	1176.84	1178.03	1175.1	196.42	195.95	196.1	196.45	196.65	196.31	196.56	196.18	195.84
Isc (A)	8.209	8.208	8.208	49.23	49.13	49.23	48.37	49.22	49.23	49.22	49.23	49.24
Peak Voltage (V)	785.98	807.27	835.35	130.86	145.29	144.3	159.95	163.03	165.06	163.5	163.17	164.74
Peak Current (A)	7.59	7.206	6.41	45.59	40.95	37.98	41.95	37.5	33.03	38.98	37.32	32.66
Peak Power (W)	5967	5817	5355	5967	5950	5482	6710	6114	5454	6374	6090	5381
No of Peaks	6	4	3	2	3	4	2	2	4	2	4	4
% Efficicency	12.45	12.32	11.34	12.45	12.60	11.61	14.00	12.95	11.55	13.30	12.90	11.39

Table 2: Parameters under Diagonal, Center and Short and Narrow(SAN) shading conditions

Paramerters	PV Configuration											
	S			SP			BL			HC		
Shade	SAW	LAN	LAW	SAW	LAN	LAW	SAW	LAN	LAW	SAW	LAN	LAW
Voc (V)	1171.05	1174.4	1160.54	195.42	195.95	193.62	195.6	195.81	193.8	195.73	196.32	194.11
Isc (A)	8.204	8.207	8.18	49.22	47.58	40.2	49.22	47.53	40.2	49.23	47.54	40.22
Peak Voltage (V)	769.91	832.26	857.09	166.72	158.28	163.68	169.44	161.43	164.94	167.99	162.01	164.47
Peak Current (A)	6.38	6.41	3.986	28.4	36.85	26.32	28.31	37.16	26.55	28.44	36.8	26.49
Peak Power (W)	4912.5	5337	3417	4736	5833	4309	4798	6000	4380	4779	5962	4358
No of Peaks	4	4	5	4	4	1	2	3	2	2	3	1
% Efficicency	11.35	11.76	9.71	10.95	12.85	12.24	11.09	13.22	12.44	11.05	13.14	12.38

Table 3: Parameters under Short and Wide(SAW), Long and Narrow (LAN) and Long and Wide(LAW) shading conditions

5. CONCLUSION

• A detailed investigation on 6x6 conventional Solar PV array configurations such as Series, Series- Parallel, Bridge-Link, Honey-Comb under different shading conditions is done also finding the Peak power and efficiency.

• This research article has investigated the performance of S, S–P and H- C PV array configurations by changing the electrical connections between the PV modules in a PV array

• that impacts the maximum power generation capability under different partial shading conditions; uniform, short and narrow, short and wide, long and narrow, long and wide and diagonal shading condition. • The H-C PV array configuration generates the maximum power under all above mentioned shading conditions except in short and narrow shading condition. Therefore, from the MATLAB/ SIMULINK simulation results on S, S–P and H- C PV array configurations, it is concluded that in most of the partial shading conditions, the H-C PV array configuration is the most appropriate PV array configuration for the generation of maximum power compared to Series S and S–P PV array configurations

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