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A novel PV sub-module-level power-balancing topology for MPPT under partial shading and mismatch conditions

Key words: Sub-module-level MPPT, Differential power processing (DPP), Distributed power converters, Switched-capacitor (SC) converters

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Motivation/Main ideas

Motivation

Partial shading and mismatch conditions among the series-connected modules/sub-modules suffer from a nonconvex power curve with multiple local maxima and decreased peak power for the whole string.

Main ideas

Energy transfer between the sub-modules brings them to the same operating voltage, and this collective operation produces a convex power curve, which results in increased peak power for the string.

Method

- Use switched capacitor converter to transfer energy between sub-modules to obtain convex power curves with increased peak value.

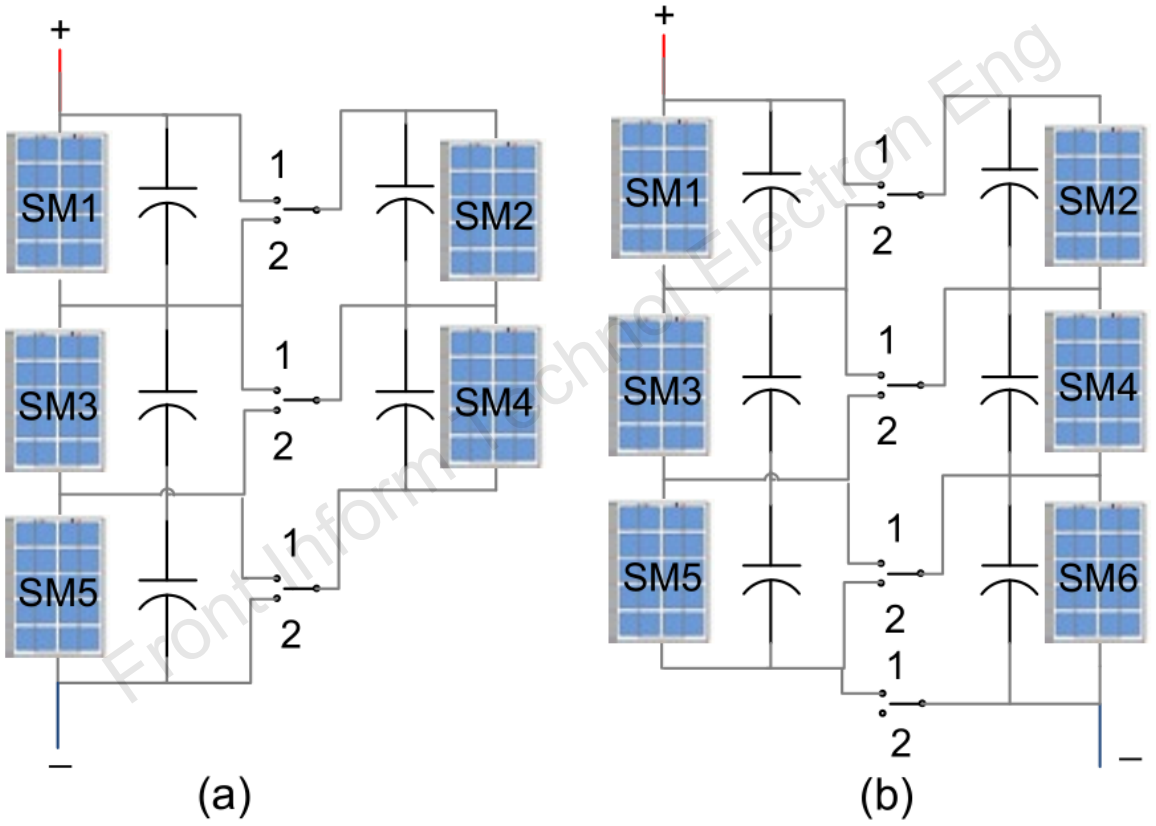

Fig. 1 Proposed ladder-connected sub-modules (SMs) topology that requires continuous switching (a) and allows stopping the switching process (b)

Major results (I)

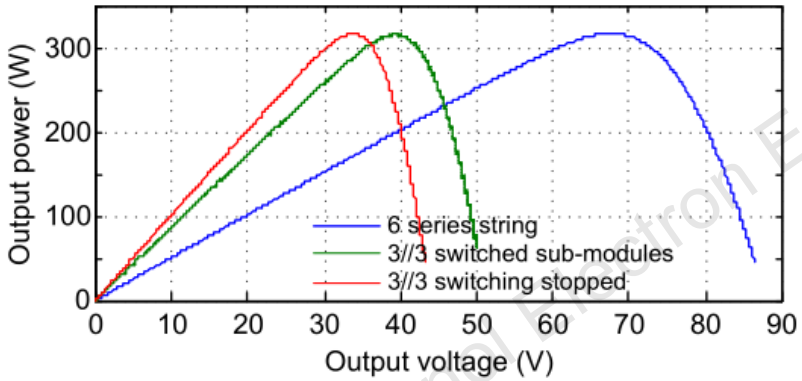

Fig. 4 Comparisons of power versus output voltage (P-V) curves for uniform irradiation conditions (references to color refer to the online version of this figure)

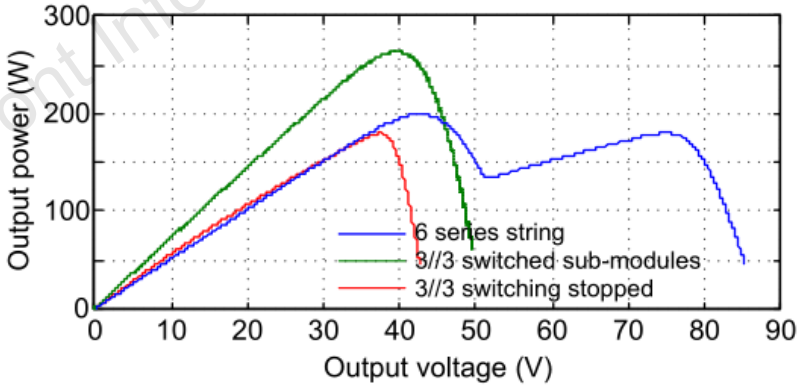

Fig. 5 Comparisons of power versus output voltage (P-V) curves for partially shaded condition (references to color refer to the online version of this figure)

Major results (II)

Table 1 Comparison for maximum powers and efficiencies in simulations

Configuration	Maximum power (W)		CE (%)	EPE (%)
	UR	16% OS		
6 series+by-pass	318.06	199.47	100	62.71
3//3 sw stopped	317.55	179.98	99.84	56.67
3//3 sw sub-module	316.41	264.18	99.48	83.49

UR: uniform radiation; OS: overall shading; CE: conversion efficiency; EPE: extracted power efficiency

Conclusions

- The switching process between the SMs enables the array to act as a single ideal PV module.
- The parallel-ladder configuration of the SMs requires n capacitors and *n*+1 switches for the power balancing of *n* SMs, while the switched capacitor topology proposed by the similar literature.
- This advantage results in reduced power electronics losses, less cost, and smaller size of the converter circuit.
- The results proved that, with the proposed topology, it is possible to extract almost all the power available on the partially shaded string and transfer it to the load side.