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Model-Based Global Maximum Power Point Tracking at Photovoltaic String under Partial Shading Conditions Using Multi-Input Interleaved Boost DC-DC Converter

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Abstract : Solar energy is one of the remarkable renewable energy sources that have particular characteristics such as unlimited, no environmental pollution, and free access. Generally, solar energy can be used in thermal and photovoltaic (PV) types. The cost of installation of the PV system is very high. Additionally, due to dependence on environmental situations such as solar radiation and ambient temperature, electrical power generation of this system is unpredictable and without power electronics devices, there is no guarantee to maximum power delivery at the output of this system. Maximum power point tracking (MPPT) should be used to achieve the maximum power of a PV string. MPPT is one of the essential parts of the PV system which without this section, it would be impossible to reach the maximum amount of the PV string power and high losses are caused in the PV system. One of the noticeable challenges in the problem of MPPT is the partial shading conditions (PSC). In PSC, the output photocurrent of the PV module under the shadow is less than the PV string current. The difference between the mentioned currents passes from the module's internal parallel resistance and creates a large negative voltage across shaded modules. This significant negative voltage damages the PV module under the shadow. This condition is called hot-spot phenomenon. An anti-paralleled diode is inserted across the PV module to prevent the happening of this phenomenon. This diode is known as the bypass diode. Due to the performance of the bypass diode under PSC, the P-V curve of the PV string has several peaks. One of the P-V curve peaks that makes the maximum available power is the global peak. Model-based Global MPPT (GMPPT) methods can estimate the optimal point with higher speed than other GMPPT approaches. Centralized, modular, and interleaved DC-DC converter topologies are the significant structures that can be used for GMPPT at a PV string. there are some problems in the centralized structure such as current mismatch losses at PV sting, loss of power of the shaded modules because of bypassing by bypass diodes under PSC, needing to series connection of many PV modules to reach the desired voltage level. In the modular structure, each PV module is connected to a DC-DC converter. In this structure, by increasing the amount of demanded power from the PV string, the number of DC-DC converters that are used at the PV system will increase. As a result, the cost of the modular structure is very high. We can implement the model-based GMPPT through the multi-input interleaved boost DC-DC converter to increase the power extraction from the PV string and reduce hot-spot and current mismatch error in a PV string under different environmental condition and variable load circumstances. The interleaved boost DC-DC converter has many privileges than other mentioned structures, such as high reliability and efficiency, better regulation of DC voltage at DC link, overcome the notable errors such as module's current mismatch and hot spot phenomenon, and power switches voltage stress reduction.

Keywords : solar energy, photovoltaic systems, interleaved boost converter, maximum power point tracking, model-based method, partial shading conditions
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