Design of Multi-Staged Power Electronic Interface for Stand-alone Application Powered by Photovoltaic Module

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Satya Prakash ; Madhusmita Mohanty ; Subhransu Padhee **All Authors**

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Abstract:
This paper provides design details of a multi-staged power electronic interface (PEI) which is used to process the low output voltage of photovoltaic module and deliver power to stand-alone load. The PEI comprises of an active-clamp current-fed full-bridge isolated converter and a single-phase voltage source inverter. Active-clamp current-fed full-bridge isolated converter is used to step-up the low voltage of PV module to a desired DC-link voltage. Perturb and Observe maximum power point tracking is used to control the DC-DC converter and fixed-frequency sliding mode control technique is used to control the single-phase inverter because the said control technique reduces the chattering effect of classical sliding mode controller and provides good steady state as well as dynamic voltage regulation during sudden change of load profile.

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Satya Prakash
Department of Electrical Engineering, Motilal Nehru National Institute of Technology Allahabad, Prayagraj, India

Madhusmita Mohanty

Department of Electrical and Electronics Engineering, National Institute of Technology Puducherry, Karaikal, India

Subhransu Padhee
Department of Electrical and Electronics Engineering, Sambalpur University Institute of Information Technology, Burla, Odisha

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I. Introduction

Out of the different renewable energy sources PV is used widely across the globe because of its relatively moderate cost and abundant availability of solar power. The main limitation of PV system is its efficiency which can be defined using Shockley-Queisser limit [1]. To extract maximum amount of energy from PV module and process the power, power electronic interface (PEI) is used. In multi-stage PEI, the first stage comprises of a front-end DC-DC converter which steps-up the low voltage of PV module to an adequate DC-link voltage. The front-end converter should have (a) high conversion ratio, (b) low input current ripple injection, (c) high efficiency, (d) Compact size and (e) isolation of high-voltage DC bus from low voltage PV module. Due to the need of isolation between the low voltage PV module and high voltage DC-bus, galvanically-isolated DC-DC converters are preferred for design of PEI. Galvanically-isolated DC-DC converter comprises of either a half-bridge or full-bridge switching network, high frequency isolation transformer, rectifier stage and filter unit. Basically there are three types of galvanically-isolated converter configuration, i.e voltage-source, current-source and impedance-source [2]. The current source galvanically isolated converters are used for step-up operation and the said converter has short-circuit immunity but the control aspect of the converter is complicated [3]. One of the limitations of current-source isolated converter topologies are the problem caused by leakage inductor of the transformer which gives rise to high surge voltage during the turn-off of the switch. Therefore, to protect the circuit from breakdown, an active clamp circuit is used. Active-clamp circuit comprises of an auxiliary switch, clamp capacitor and transformer leakage inductor [4]. A comparative analysis of active-clamped ZVS current-fed half-bridge and full-bridge converter has been reported in [5].

Authors

Satya Prakash
Department of Electrical Engineering, Motilal Nehru National Institute of Technology Allahbad, Prayagraj, India

Madhusmita Mohanty
Department of Electrical and Electronics Engineering, National Institute of Technology Puducherry, Karaikal, India

Subhransu Padhee
Department of Electrical and Electronics Engineering, Sambalpur University Institute of Information Technology, Burla, Odisha

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