NCPRE NEWS

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National Centre for Photovoltaic Research and Education
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A Project of the Ministry of New and Renewable Energy at IIT Bombay

Design of a line-frequency zig-zag transformer employed in a unified AC-DC system, suitable to integrate photovoltaic (PV) with grid

NCPRE has research activities grouped in five major areas: Crystalline Silicon Solar Cells, Thin Film Materials and Devices, Energy Storage, Power Electronics and Module Reliability. **This month's Newsletter focuses on recent Power Electronics research activities on development of a line-frequency zig-zag transformer that helps integrate low voltage (LV) photovoltaic (PV) with ac grid.**

Continuous improvement in the domain of power electronics (PE) converter and photovoltaic technology has resulted in continuous improvement of hybrid micro grid architectures. A Hybrid micro grid consists of both ac and dc type of loads. Renewable dc sources like solar photovoltaic are preferably operated at low voltages to avoid mismatch losses. This necessitates use of high voltage boosting in order to interface PV to the high voltage dc bus of the system. Conventional dc-dc converters (eg. boost and buck-boost) offer high voltage gain at the cost of reduced efficiency. The work proposes use of zig-zag ac transformer to integrate low voltage PV to a high voltage dc bus. A Zigzag transformer has zigzag windings as compared to conventional transformer as shown in Fig. 1.

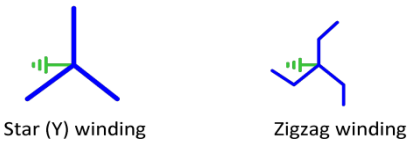

Fig.1 *Conventional Star transformer and Zigzag transformer*

NCPRE investigators have developed a novel line-frequency zig-zag transformer to achieve high performance of the system. A novel unified ac-dc topology is shown in Fig. 2, which employs a line-frequency zig-zag transformer to integrate two sources of different frequencies i.e. grid (ac) and PV (dc). In this scheme, since low voltage dc is riding over high voltage ac before feeding to rectifier, the boosting requirement is less. Winding leakage inductances of the zig-zag transformer are utilized as required boost-inductances for the PWM rectifier stage and thereby reduce the component count.

As additional line-frequency inductors are avoided, overall power density is also improved.

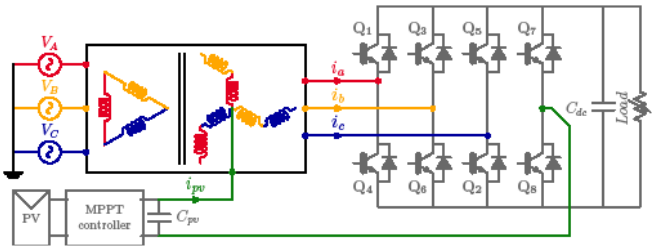

Fig.2 *Schematic of a unified ac-dc system showing the line-frequency zig-zag transformer used to interface photovoltaic (PV) and ac grid*

An experimental prototype of 1 kW, 415/130 V, 50 Hz, delta/zig-zag transformer is built, which is shown in Fig. 3. Its winding leakage inductances are measured using a Scientific 6018 LCQR bridge and compared with estimated values using analytical and FEM (2D) methods. The measured data is in good agreement with the analytical and FEM results.

(a) (b)

Fig.3 *Experimental prototype of 1kW, 415/130 V, 50 Hz delta/zig-zag transformer (a) Top view of winding assembly, showing its rectangular bobbin and spacer arrangement (b) Experimental setup to measure the winding leakage*

The work summarized in this newsletter was recently presented at the Tenth Annual IEEE Energy Conversion Congress and Exposition (ECCE 2018) in Portland, Oregon, USA.

For detailed information on NCPRE research on the topic, please contact bgf@ee.iitb.ac.in.