Green Energy and Technology

Zhijun Peng *Editor*

Trends and Technological Challenges in Green Energy

Selected Papers from ICGET 2023

Springer

Green Energy and Technology

Climate change, environmental impact and the limited natural resources urge scientific research and novel technical solutions. The monograph series Green Energy and Technology serves as a publishing platform for scientific and technological approaches to “green”—i.e. environmentally friendly and sustainable—technologies. While a focus lies on energy and power supply, it also covers "green" solutions in industrial engineering and engineering design. Green Energy and Technology addresses researchers, advanced students, technical consultants as well as decision makers in industries and politics. Hence, the level of presentation spans from instructional to highly technical.

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Preface

The 2023 8th International Conference on Green Energy Technologies (ICGET2023) was successfully held during 17–19 August 2023 as physical conference finally after COVID-19.

The event was highlighted by keynote speakers including Prof. Dimitrios Karamanis from University of Patras, Greece, Prof. Kei Eguchi from Fukuoka Institute of Technology, Japan, and Prof. Hartmut Hinz from University of Applied Sciences, Germany. Researchers and students from Greece, Japan, Germany, Mexico, China, Ireland, UAE, Turkey, UK, Croatia, etc. have joined the conference and share their works through onsite oral sessions and online oral session.

ICGET has been an excellent forum for scientists and engineers throughout the world to present and discuss the latest technological advancements as well as future directions and trends in the field. All papers submitted to the Conference were peer-reviewed. Accepted papers are included in this volume, which comprises three chapters: (1) Solar Energy Technology and Photovoltaic Power Generation, (2) Wind Power Generation and Ocean Energy, and (3) Renewable Energy Systems and Thermal Engineering.

As this volume is published, we would like to express our sincere appreciation to all the individuals who have contributed to ICGET 2023 in various ways. Special thanks are extended to our colleagues in program committee for their thorough review of all the submissions, which is vital to the success of the conference, and also to the members in the organizing committee who had given their valuable time and efforts in planning, promoting, organizing, and helping the conference.

We warmly welcome you to join our conference next year!

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Part I
Solar Energy Technology and Photovoltaic Power Generation

Performance Analysis for Bidirectional DC/DC Power Converter for Photovoltaic Applications: Simulation Study

Sasa Sladic, Michele De Santis, Even Zivic, and Wojciech Giernacki

1 Introduction

Bidirectional power converters can be found in literature very often [1–12]. Bidirectional DC/DC power converters can be combined with bidirectional DC/AC converters, boosting the importance of DC/DC power converters both to AC and DC electrical networks (micrograms). Due to the large number of different DC/DC bidirectional converters, most of the authors limit their analysis to transformerless bidirectional DC/DC converters [1–6].

Others try to improve the performance of known bidirectional DC/DC power converters [7], improve their efficiency [8], or develop new topologies in order to compare them to known ones [9].

The most frequent topologies include buck–boost topology and symmetrical buck–boost topology [1–5]. Buck–boost topology consists of two power converters (single buck and single boost). Symmetric power converters consist of two power converters of the same type (e.g., buck–boost), which correspond to H-bridge topology [6]. More unusual combinations (e.g., zeta/SEPIC) mean that it is theoretically possible to combine all the power DC/DC converters [9]. Because of the importance of PV systems in the last 20 years, a huge effort was taken for the

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classification of DC/DC power converters for renewable energy source applications [10–12]. In this chapter, Luo [13] and flyback power converters have been combined. Their combination is expected to improve DC/DC bidirectional converter efficiency.

Most of the DC/DC power converters have been known for decades. However, Luo power converter has only been presented recently [13]. Basically, the main idea for the new class of step-up power converters was developed in the last 20 years. Luo converter is known for its computational complexities [14]. It could be said that it incorporates properties of basic (e.g., boost power converter) with the addition of switched capacitor converters (SCCs). This means that Luo converters are rich in complex behavior and difficult to analyze. However, it has numerous advantages, including a high step-up DC–DC conversion ratio and an increased efficiency compared to the boost power converter. In spite of the obvious advantages, its modified topologies are hard to recognize between the most used bidirectional power converters.

Besides, Luo converter has a larger ratio between input and output voltage, which is useful in PV systems [15]. During the last 15 years, battery voltage in electric vehicles has increased, so a large step-up ratio ha become important in vehicle chargers [16]. Similar topologies can be found in the literature [17], which means Luo converter is still being explored widely.

2 Luo-Based Topology

The Buck–boost bidirectional power converter shown in Fig. 1 has been used most frequently. This type of power converter can connect two energy storages (e.g., supercapacitor and batteries).

Its alternative is the Luo-based bidirectional DC/DC power converter (Fig. 2). This type of power converter has an additional capacitor C, two diodes (D_3 and D_4), and an additional transformer. However, this bidirectional power converter has both transistors on the low potential. This means that low potential (boost) driver can be used for switching of both transistors. Furthermore, Luo converter step-up ratio brings to this converter a higher ratio between input and output voltage (both inputs could be input and output) and increased efficiency. Numerous simulations were taken.

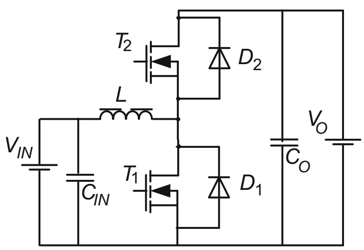

Fig. 1 Buck–boost (standard) bidirectional DC/DC power converter

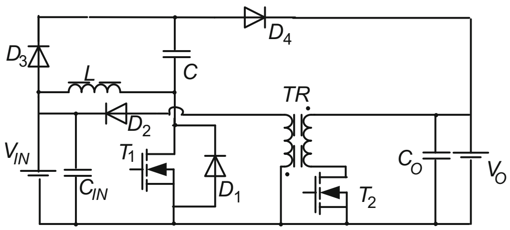

Fig. 2 Luo-based (proposed) bidirectional DC/DC power converter

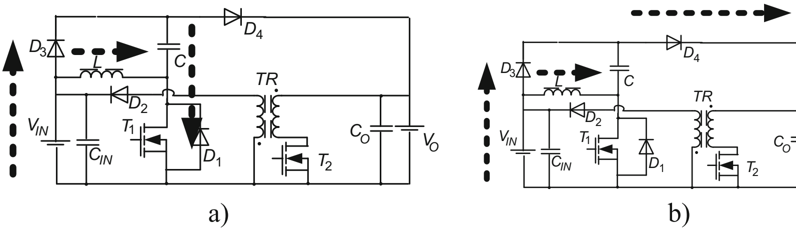

Fig. 3 Luo converter operation in the frame of bidirectional Luo-based converter: (**a**) T_1 ON; (**b**) T_1 OFF

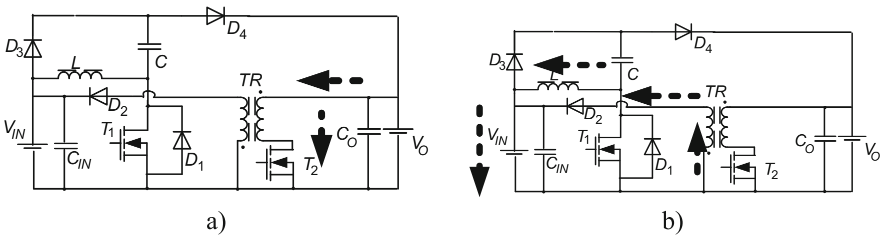

Fig. 4 Flyback converter operation in the frame of bidirectional Luo-based converter: (**a**) T_2 ON; (**b**) T_2 OFF

In this power converter, input voltage V_{IN} was increased via action of boost converter (V_{IN}, L, T_1, D_2). This means that the energy stored in L has to be released after the switching of the transistor T1 (Fig. 3). The input voltage supported with induced voltage on inductance L is charging output capacitor CO. In this case, energy from the input battery and input capacitor (C_{IN}) is transferred to the output.

In order to obtain the opposite energy direction (C_O to C_{IN}), flyback converter (T_2) action should occur (Fig. 4). After switching ON the transistor T_1, magnetic field increases in transformer TR. This means that after turning OFF the switch T_1, magnetic field energy is released and diode D_2 conducts current, which is charging capacitor C_{IN}.