論文 / 著書情報
Article / Book Information

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著者(和文)	羅天
Author(English)	TIAN LUO
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種別(和文)	論文要旨
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	電気電子 電気電子	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（ 学術 ）
学生氏名： Student's Name	LUO TIAN		審査員主査： Chief Examiner	萩原 誠	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Due to the rapid development of photovoltaic and wind power, a significant amount of RES has been integrated into the grid. Globally, as of 2023, the world's total electricity generation was 30,000 TWh, with PV and wind power generating a total of 3935 TWh, accounting for 13.4% (3422 TWh, 11.9% in 2022). It is reasonable to believe that there will be more and more renewable energy sources (RES) installed and integrated into the grid in the future. However, the penetration of renewable energy resources (RES) is decreasing the resilience of current power grid due to their intermittent nature. In addition, the growth of RES is decreasing the inertia of our power grid, because the RES is based on inverters instead of rotating generators. Thus, the power grid could be unstable and uneconomic if no measures are taken.

To address these issues, it is necessary to equip RES with corresponding capacities of energy storage systems (ESS). ESS typically involves a quantity of batteries that can convert electrical energy into chemical energy for storage. ESS can not only store excess generated energy but also release energy during overload conditions to reduce the pressure on the grid. This helps mitigate the reduction in grid inertia caused by the integration of RES, then helping enhance the resilience (or stability) of the power grid. Under this background, a high-performance power conversion system can increase energy utilization and ensure the stored energy can be released correctly to rectify the fluctuation in power grids.

Meanwhile, increasing research suggests that using DC as the electricity carrier for local grids and microgrids may be more advantageous. Compared to AC, DC offers several benefits due to the absence of PLL and harmonic distortion issues. These advantages include the elimination of the skin effect, higher transmission efficiency, and greater flexibility in distributed power systems. Under this background, a high-performance power conversion system can increase energy utilization and ensure the stored energy can be released correctly to rectify the fluctuation in power grids.

In this context, this dissertation proposes a three-phase isolated bidirectional DC-DC power converter based on three-phase dual-active-bridge (TP-DAB) converter and multilevel cascaded converters. The proposed converter is suitable for battery energy storage systems in DC microgrids or other kilo-voltage DC power grids.

In the first part, a three-phase cascaded converters DC-DC converter using cascaded choppers, Yn-Y transformer, and neutral point wire is introduced (Chapter 3). Compared with the TP-DAB converter, it has advantages such as low RMS current, low peak current, and high conversion efficiency especially under light-load conditions. In addition, an improvement method applying variable duty ratios to the two three-phase bridges in the proposed converter is discussed (Chapter 4). The variable-duty method can almost eliminate the zero-sequence current component and then further reduce the RMS and peak currents possibly flowing in the circuit. All the verifications of this part are based on mathematical calculations and downscale experimental results.

Furthermore, the cascaded converters DC-DC converters can be categorized into four types based on the presence or absence of a neutral point wire of the Yn-Y transformer and the type of cascaded converters used. The first part of this dissertation discusses the simplest, basic type cascaded converters DC-DC converter. However, the basic type suffers from overmodulation issues, which limit the voltage conversion ratio and output current. In another part of this dissertation (Chapter 5), other types of three-phase cascaded converter DC-DC converters will be discussed. These converters utilize floating voltage, full-bridge converters, or both to overcome overmodulation issues, thereby eliminating the limitations on the voltage conversion ratio and

current. Finally, this dissertation provides a cost index approach to evaluate the remaining three types of converters.

In the final of the dissertation (Chapter 6), some challenges of the proposed cascaded-converters DC-DC converter, such as optimizing the operating frequency and dynamically switching operating mode with semiconductor breaker, are discussed. These discussions can provide guidance and inspiration for future work.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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