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題目(和文)	大電力FTF システムへの応用のためのモジュラー・マルチレベル二重スター・チョッパセル形変換器の研究
Title(English)	Study of Modular Multilevel Double-Star Chopper-Cells Converters for High-Power Front-to-Front Applications
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	Firman Sasongko	指導教員（主）： Academic Advisor(main)	Prof. Hirofumi Akagi
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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

Wind energy is one of the most promising candidates for future decentralized renewable-energy-based power generation. In particular, offshore wind reserves an enormous potential for future large-scale sustainable energy resources. Future offshore wind farms are likely to be farther away from shore to increase the size and to reduce visual impacts. For a high-voltage ac transmission system, some of the electrical energy transmitted would be lost in the form of reactive power when a long distance cable is used. On the other hand, the transmissible power of high-voltage dc system is not limited by the transmission length. Moreover, dc power system offers higher reliability and flexibility than the conventional ac power system. Therefore, power collection and transmission system based on dc grids could be a better solution for future sustainable power generations.

This thesis proposes a high-power front-to-front (FTF) system based on three-phase modular multilevel double-star chopper-cells (DSCC) converters and three-phase medium-frequency ac-link transformers. The system provides an isolated dc-power-collection capability in addition to the three main functions of a dc-dc transformer: voltage stepping, voltage or power regulation, and fault isolation. The ac-link transformers step up the voltage from the power-collecting side voltage level to a higher voltage for power transmission. The use of medium frequency operation at the ac link results in reduction on the size of the transformers and passive components, which is very important in an offshore applications. Because the system is intended for high-power applications, the switching frequency of the DSCC converters should be set as low as possible. Therefore, a tradeoff between higher ac-link frequency and lower switching frequency should be made.

The proposed dc power collection offers a flexibility in terms of the number and rating of slave converters connected to the system, and scalability that allows connection of several clusters of FTF systems to form a larger dc-power-collection system. Moreover, the FTF system has a fast fault-blocking capability that can handle dc faults effectively by turning off the operation of all the DSCC converters connected to the same ac-link without the need of dc circuit breakers. A downscaled FTF system consisting of two three-phase DSCC converters rated at 400 Vdc and 10 kW is designed, constructed, and tested to verify its operation at low carrier frequency ratios with respect to the ac-link frequency.

The main objective of the research is on the investigation of practical feasibility of the FTF system for dc power collection and transmission systems. Three distinctive objectives can be divided as follows:

1. Performance and practicability verification of the FTF system through experimental implementation: Obtaining the operating performance of the downscaled FTF system under several conditions.
2. Performance and reliability verification of a dc power collection based on the FTF system using multiple DSCC converters: Obtaining the system performance and reliability for dc power collection under dynamic and fault conditions.
3. Investigation of a high-power DSCC converter using the phase-shifted-carrier pulsewidth modulation (PSC-PWM) at low-switching-frequency operation: Determining the constraints in the PSC-PWM method used in the DSCC converter at low-carrier-frequency ratios with respect to the ac grid frequency. From the obtained results, the research aims at proposing a modification to the PSC-PWM method to enable low-switching-frequency operation of the DSCC converter.

This dissertation contains seven chapters, and it is organized as follows:

Chapter 1 provides an introduction and background on the increasing trend of the offshore wind farms, and explains briefly the necessity of using more efficient and effective power collection and transmission system. This chapter also clarifies the research objectives, and explains the contents of the next chapters.

Chapter 2 reviews several options of power collection layouts for large offshore wind farms. Particular high-power dc-dc converter topologies applicable to dc power collections for future offshore wind farms are discussed. This chapter also provides a brief review on the current trend of modular multilevel converters along with their modulation methods.

Chapter 3 discusses the circuit configuration and operating principles of the DSCC converter.

Chapter 4 discusses an experimental verification of the downscaled FTF system consisting of two DSCC converters.

Chapter 5 discusses an application of dc power collection based on the FTF system. A simulation system of an FTF-based dc power collection rated at 10 MW and 13.2 kVdc is designed and utilized to verify its performance and reliability.

Chapter 6 presents a new carrier-based PWM method based on a modified PSC-PWM intended for low-carrier-frequency ratios with respect to the ac grid frequency. The new modulation method is discussed and verified through analytical approach and circuit simulation. This chapter also discusses the optimal carrier frequency of the new modulation method when the carrier frequency goes below double the ac grid frequency.

Chapter 7 provides the conclusions, and points out the contributions of this dissertation. This chapter also provides possible future research to improve the FTF system based on DSCC converters.