様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９　（共通）

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研究課題名（和文）Novel High Reliability DC/DC Modular Multilevel Converter as a Power Router for Next Generation Medium Voltage DC Power Network

研究課題名（英文）Novel High Reliability DC/DC Modular Multilevel Converter as a Power Router for Next Generation Medium Voltage DC Power Network

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交付決定額（研究期間全体）：（直接経費）　　3,300,000円

研究成果の概要（和文）：将来の分散型電源における、中高電圧の直流マイクログリッドは、高効率と高信頼な配電システムと考えられています。本研究では、各直流マイクログリッドを接続する電力ルータとして双方向電力変換器を提案しました。 電力変換器の試作機では全体で 94% の高効率、DCリンクコンデンサーのゼロ電圧/電流リップル、および組み込みの EMI ノイズ フィルターを達成しています。 また、低電圧ストレス半導体によるマルチレベル構成により、高電圧変換が可能です。 したがって、提案した電力変換器は、将来の MVDC マイクログリッドで高い電力密度と信頼性を実現できます。

研究成果の学術的意義や社会的意義
A high voltage conversion and reliability converter is required for future MVDC microgrid. The proposed converter can use low voltage switches and number of modules to achieve flexible high voltage conversion. In addition, the ripple cancel function improved the lifetime of capacitors in converter.

研究成果の概要（英文）：Nowadays, it could discover that there are a lot of power conversion techniques around the world. According to the U.S. Energy Information Administration’s latest International Energy Outlook 2017 projects that the world energy consumption will grow by 28% between 2015 and 2040. The reduction of energy consumption become a significant task in power electronics.
Future medium voltage DC microgrid is considered as the high efficiency and reliability power distribution system. In this research, the bidirectional converters were proposed as a power router to connect each DC microgrid. The prototype of converters features high efficiency which overall 94 %, nearly zero voltage/current ripple on DC-link capacitors, and build-in EMI noise filter. In addition, the high voltage conversion can be achieved by the multilevel configuration with low voltage stress semiconductors. Accordingly, the proposed converters can achieve high power density and reliability in future MVDC microgrid.

研究分野：Power electronics

キーワード：DC-DC converter　MVDC　Power router　Energy management　Ripple Cancel　Embedded filter　Multi level converter　DAB

様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９（共通）

１．研究開始当初の背景

The DC power grid is regarded as a potential utility for future Internet of Things society due to high efficiency, stability, and reliability. Without additional AC/DC conversion in devices, the total efficiency could be improved by **17% to 20%.** In addition, it is easy and high efficient to integrate with the renewable energy and battery storage in a pure DC power system.

２．研究の目的

Future DC power grid is considered as shown in Fig. 1. Therefore, the **bidirectional DC/DC converters operated in high and different voltage conversion** for connecting each DC power grid.

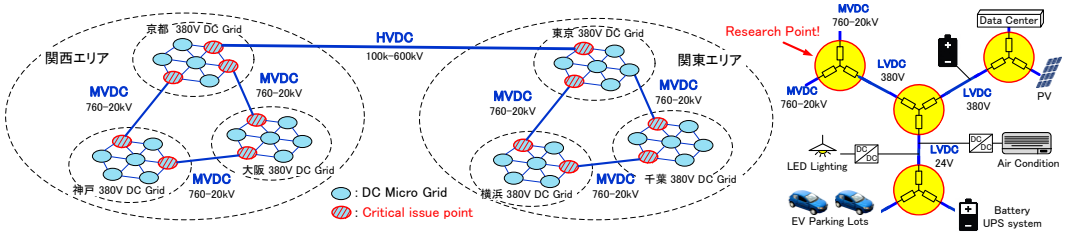
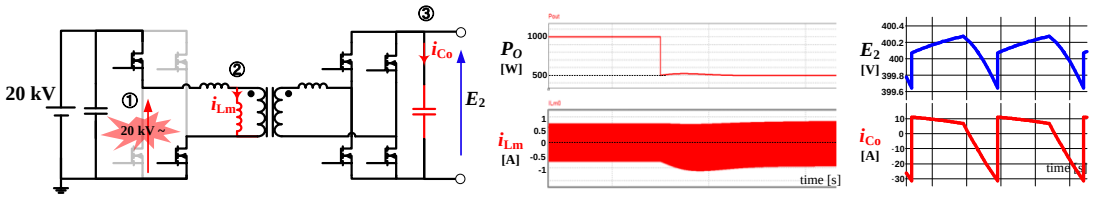


Fig. 1. Concept of next generation DC power grid.

Among the bidirectional DC/DC converters, the H-bridge dual active bridge converter is the most general used solution. However, the H-bridge converter has three tasks need to overcome: ① **High voltage stress on switches,** ② **the DC bias current of transformer occurred during transient load,** and ③ **the high current ripple on DC-link capacitor** as shown in Fig. 2.



① High voltage stress ② DC bias current on transformer ③ High current ripple on DC-link capacitor

Fig. 2. Conventional H-bridge Dual-Active-Bridge (DAB) and Triple-Active-Bridge (TAB) converters.

３．研究の方法

To overcome the drawbacks of conventional H-bridge converters, two types of ripple cancel converters were developed in this researches:

(1) Basic unit of proposed multilevel module converter for low voltage DC microgrid as shown in Fig. 3.

(2) Proposed multilevel module converter for medium voltage DC microgrid as shown in Fig. 4.

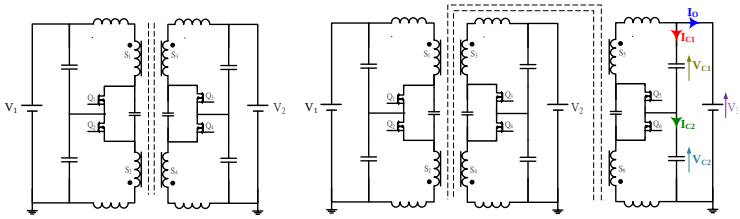


Fig. 3. 2 port and 3 port basic unit of proposed DC/DC MMC converters for 380 V DC applications.

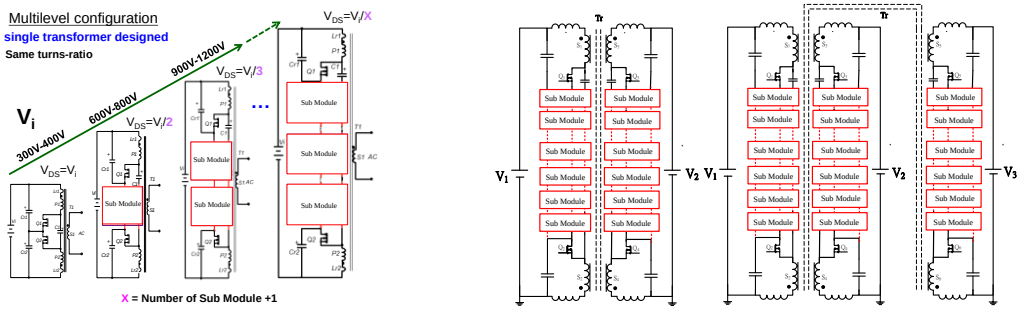


Fig. 4. DC/DC converters for high voltage (760 ~ 20 kV) DC applications.

４．研究成果

(1) Basic unit of proposed multilevel module converter for low voltage DC microgrid:

Compared with conventional DAB converter, the proposed circuit features:

① Number of switches and Voltage stress on switches: the proposed circuit has half number of switches and well-clamped voltage without voltage spike.

② No DC bias current on transformer: smaller transformer design can be used to avoid saturation occurred.

③ Ripple Cancelled on DC-link capacitors: the nearly zero ripple characteristic make electrolytic capacitors have better lifetime and reliability.

④ Better efficiency: the proposed circuit has better efficiency performance at light load condition.

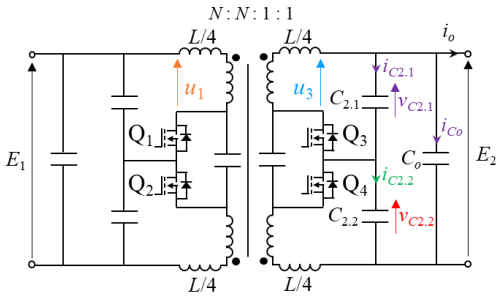


Fig. 5. DC/DC converters for 380 V DC applications.

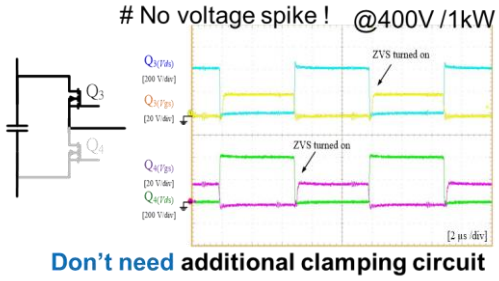


Fig. 6. Voltage stress on switches.

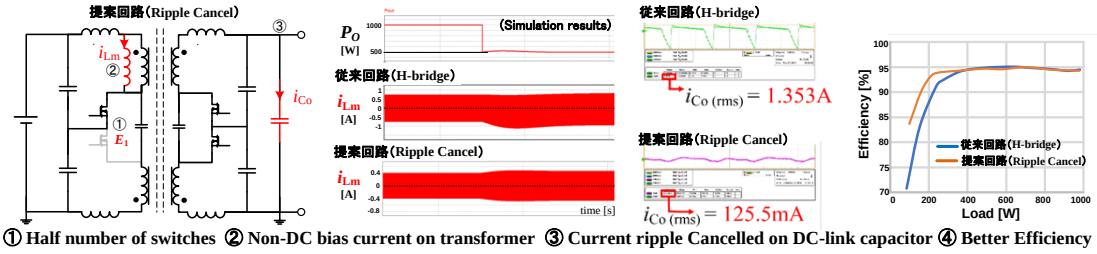
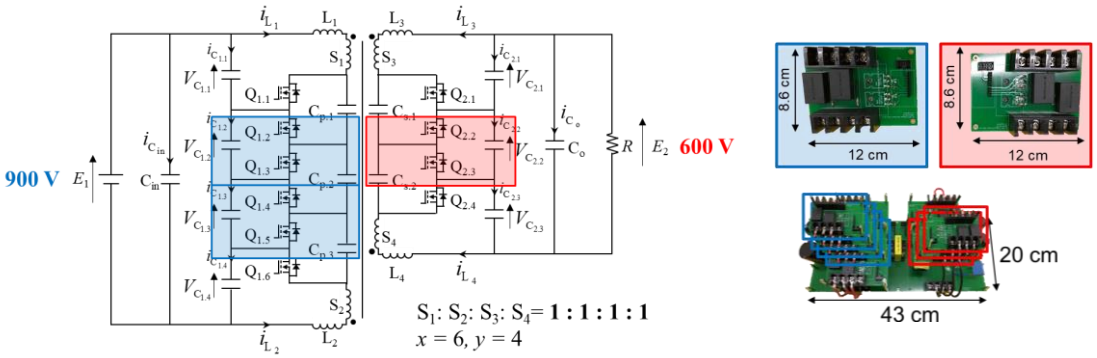


Fig. 7. Proposed bidirectional ripple cancel DC/DC converter..

(2) Proposed multilevel module converter (MMC) for medium voltage DC microgrid:

The proposed MMC inherit above four characteristics from basic unit circuit. In addition, the voltage automatic balanced in the series-connected switches.



(a) A 900V to 600V prototype (b) Hardware demonstration

Fig. 8. DC/DC converters for high voltage (760 ~ 20 kV) DC applications.

In summary, the proposed circuits have higher efficiency at light load condition, and the low voltage stress semiconductors can be used for high voltage application, and the nearly zero ripple of DC-link capacitor makes the volume of capacitor reduce and lifetime improve. The proposed circuit can be expected as a high efficiency, reliability, and low cost solution for future MVDC microgrid.

５．主な発表論文等

〔雑誌論文〕　計0件

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2021年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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６．研究組織

	氏名 （ローマ字氏名） （研究者番号）	所属研究機関・部局・職 （機関番号）	備考

７．科研費を使用して開催した国際研究集会

〔国際研究集会〕　計0件

８．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関