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学位論文題目	Transformer-Based Single-Stage Differential and Multilevel Converter Topologies and Its Control Techniques（変圧器を用いたシングルステージ差動およびマルチレベルコンバータの構成と制御）
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論文内容の要旨

In recent years, the world countries replaced the traditional energy sources with Renewable Energy Sources (RES) utilization to produce clean and efficient energy with global warming reduction. RES provides energy to a vast number of residential, industrial, commercial customers by utilizing the utility grid's transmission lines in the residential areas and separate lines in the remote areas from the utility grid. Among the different RESs, Photovoltaic (PV) has proven its effectiveness in different applications for many fundamental reasons. In addition, grid-integrated applications have become more popular due to the vast enhancement PV penetration and their emerging structures. As well, this success is encouraged by a considerable reduction in PV installation cost, storage batteries, inverters, and system controllers. Hence, PV structures form one of the most hopeful assets for creating required huge energy chunks for humankind, which paved the way for power electronics evolution.

DC-AC inverters form one of the most important parts of the PV system architectures. Different PV inverter structures have been presented for different purposes in the last decades. Microinverters offered an alluring solution for module integrated grid-tied operation under various climatic conditions, i.e.; module mismatch and partial shading conditions of solar arrays. Along these lines, numerous microinverter-type PV-inverters are introduced in the ongoing years that fulfill dependability requirements, compactness, ease, and decreased footprint. However, this solution has many severe problems, such as the double-line frequency component and its electrolytic capacitors. These issues disturb the

interconnection between the PV system and grid. Hence, three-phase microinverters are the most attractive topologies to mitigate double-line frequency issues as well as large electrolytic capacitor elimination.

This project surveys many of recent single-phase and three-phase inverters structures for grid-tied applications. Between these architectures, single-stage differential-based inverters have been selected., which replace the VSI legs with DC-DC converters. The configuration of these inverters provides many features such as; single-stage operation, voltage boosting-bucking capability, modularity, and galvanic isolation for grid protection requirements. In addition, it simplifies the power extension (scalability) by adding parallel converter modules utilizing the same control scheme.

This project proposes an isolated single-stage three-phase differential-based flyback inverter (DBFI) for grid-integrated PV applications. The proposed DBFI offers many features compared with existing converters such as; high power density, low cost, galvanic isolation, circuit structure and control simplicity. The proposed DBFI reduces the required number of low-side driven power MOSFETs and passive elements compared with the buck-boost based inverter topologies, which decreases the required compensator order for system stability that directly simplifies the controller specifications. Moreover, harmonic compensation strategy is utilized for second-order negative sequence harmonic compensation (SO-NSHC). The high-frequency transformer of the DBFI is presented based on nanocrystalline core for inverter compactness. In addition, a loss study is performed based on the derivation of the mathematical loss model for each component in terms of the time and the system parameters. The proposed DBFI has been validated by theatrical analysis, simulation, and experimental findings over a grid-tie closed-loop current control operation via 200 V, 1.6 kW, and switching frequency of 50 kHz laboratory prototype.

The project also proposes an isolated single-phase single-stage DC-AC cascaded transformer-based multilevel inverter (CTMLI) with its sinusoidal PWM switching technique considering minimum components count per output voltage level. The proposed CTMLI converts the input DC voltage to 19-level AC voltage at the output terminals using three full-bridge circuits and three cascaded transformers. Detailed mathematical model of the CTMLI is presented considering optimal transformer turn's ratio. Furthermore, cost estimation model for the MLI is introduced in details in order to investigate the cost reduction in the CTMLI. In addition, a detailed comparison with recent MLI is presented to confirm the CTMLI merits. The proposed CTMLI has been investigated experimentally using laboratory prototype (220V, 1.2kW) controlled with dspace DS-1103 digital controller in stand-alone grid-tied applications.