報告番号	甲　第　14683　号

主 論 文 の 要 旨

論文題目　Study on Common-Mode Noise Reduction Methods in Non-Isolated DC-DC Converters
(非絶縁 DC-DC コンバータ向けコモンモードノイズ低減手法に関する研究)

氏　　名　佐々木　守

論 文 内 容 の 要 旨

This paper discusses common mode (CM) noise reduction methods in non-isolated DC-DC converters.

Recently, the demand for switched-mode power supplies (SMPSs) has been increasing because of increasing power generation in renewable energy generations and increasing power consumption in electrified transportation and data centers. Especially in SMPSs, non-isolated DC-DC converters are employed in various applications. But, on the other hand, the electromagnetic noise emitting from SMPSs becomes problematic.

SMPSs are demanded to have high power density. Therefore, the operation frequency of SMPSs is increasing to achieve higher power density. Wide band gap (WBG) devices utilizing silicon carbide and gallium nitride are employed in SMPSs for high-frequency operation because of the high dv/dt and di/dt ratio. However, the high-frequency operation and the high dv/dt and di/dt ratio increase electromagnetic noise. Especially, CM noise that flows through the ground is difficult to suppress. Therefore, many studies have been made on CM noise reduction methods.

Thus, the purpose of this paper is to propose CM noise reduction methods in non-isolated DC-DC converters for high-power density. First, CHAPTER 1 and 2 explain the social background of increasing demand for SMPSs and the technical background of increasing noise in SMPSs. The purpose of the dissertation and the research subject area are also explained at the end of CHAPTER 2. Then, three CM noise reduction methods are proposed in CHAPTER 3, 4, and 5. The summaries of the chapters are described below.

In CHAPTER 3, the CM noise reduction method with an auxiliary winding is proposed for a multiphase interleaved DC-DC converter with a coupled inductor. The proposed method decreases CM noise by adding an auxiliary winding and a capacitor not to degrade the power density. In this chapter, the CM noises in the conventional multiphase interleaved DC-DC converter and the proposed circuit are compared mathematically. Then the limitation of the CM noise reduction performance and the design guidelines for the auxiliary winding is indicated. Finally, the experiment verifies that the proposed circuit shows the CM noise reduction performance as expected.

In CHAPTER 4, the CM noise reduction method with reversed circuit configuration is proposed for the non-isolated boost DC-DC converter. The circuit components do not change, but the circuit configuration changes in the reversed circuit configuration. In this chapter, the CM noises in the conventional non-isolated boost DC-DC converter and the proposed circuit are compared, and the CM noise reduction performance is analyzed mathematically. Then, the implementation method to verify the CM noise reduction effect is explained. Lastly, the CM noise reduction effect is verified in the circuit simulation and the experiment. Additionally, the conditions where the proposed circuit configuration is effective are discussed.

In CHAPTER 5, the combination of thermal pads in switching devices is proposed to reduce the CM noise in the non-isolated DC-DC converter. The proposed method increases the impedance of the CM noise propagation path and decreases the CM noise by arranging the thermal pads of switching devices. In this chapter, the CM noise in the non-isolated DC-DC converter is first analyzed, and the impedance of the CM noise propagation path is clarified. Additionally, the influence of the thermal pad of the switching device on the CM noise is discussed. Then, the circuit implementation method to compare the influences of thermal pads on the CM noise is explained. Finally, the circuit simulation and the experiment verify that the combination of thermal pads reduces the CM noise.

CHAPTER 6 compares the strong and weak points of the abovementioned methods and summarizes this dissertation.