Design, Analysis and Development of a Modular Multilevel Converter (MMC) Sub-Module Power Circuit

Abstract

1. Introduction
Modular Multilevel Converters (MMCs) have emerged as the state-of-the-art topology for medium- and high-voltage applications due to their superior scalability, reduced harmonic distortion, fault management capability, and modular design. Each MMC arm comprises several sub-modules (SMs) that define overall system performance and reliability. The proposed project focuses on designing, analyzing, and developing a fully functional Full-Bridge Sub-Module (FBSM) using Silicon Carbide (SiC) MOSFETs, with integrated power, protection, control-supply, and thermal management features.

2. Objectives
The main objectives of this project are:
1. To design a full-bridge SiC MOSFET-based power circuit for an MMC sub-module.
2. To select and integrate a high-reliability DC-link capacitor suitable for high ripple current and fast transient operation.
3. To design isolated gate-drive circuits with protection features such as desaturation detection, under-voltage lockout, soft-turn-off, and gate clamping.
4. To integrate a compact onboard DC–DC converter to derive isolated control-supply rails directly from the DC-link voltage.
5. To implement a bypass switch mechanism enabling fault-tolerant operation.
6. To prepare full schematic design, PCB layout, and fabrication documentation for the sub-module.
7. To carry out testing and validation of the developed hardware under realistic electrical conditions.
3. Expected Outcomes
? A fully engineered MMC full-bridge sub-module with integrated power, control, and thermal systems.
? Experimental validation demonstrating switching performance, thermal stability, and fault-tolerant operation.

4. Conclusion
This project will develop a high-performance MMC sub-module .

Academic Project Requirements:

1) Required No. of student(s) for academic project: 2

2) Name of course with branch/discipline: B.E./B.Tech. Electrical

3) Academic Project duration:

(a) Total academic project duration: 24 Weeks
(b) Student's presence at IPR for academic project work: 3 Full working Days per week

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