Design, Analysis and Development of Modular Multilevel Converter (MMC) Sub-Module On-Board Control, Sensing and Interface Circuit

Abstract

Introduction
Modular Multilevel Converters (MMCs) have emerged as the preferred topology for medium- and high-voltage applications such as HVDC transmission, STATCOMs, renewable integration, and high-power drives. The performance, reliability, and protection capability of an MMC heavily depend on the design of its sub-modules, particularly the on-board control, sensing and interface electronics. The proposed project aims to design, analyze, and develop a compact and robust sub-module electronic circuit incorporating voltage and current sensing with digital isolation, thermal monitoring, gate-drive interface, and CPLD-based local logic control and protection.
2. Objectives
The major objectives of this project are:
1. To design an integrated sensing and protection circuit for each MMC sub-module.
2. To develop isolated voltage and current sensing circuits suitable for high-voltage floating operation.
3. To incorporate thermal sensing and module-level protection mechanisms.
4. To design and implement on-board sub-module logic using a low-power CPLD for gate drive coordination, fault detection, and communication.
5. To prototype, test, and validate the developed circuits under representative operating conditions.
A low-power CPLD will be designed to perform real-time sub-module logic including:
• Gate signal sequencing for the half-bridge switches
• On-board capacitor voltage balancing support
• Over-voltage, over-current, and over-temperature protection
• Fault latching and communication to the central controller
• High-speed interfacing with isolated gate drivers
The CPLD implementation ensures deterministic timing, reduced latency, and high reliability.
Conclusion:
• Development of CPLD based control circuit for MMC Sub module operation.

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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