



Title of Tutorial

Neutral Point Clamped Converters: Control solutions and reliability

Abstract

The three-level neutral-point-clamped (3L-NPC) converters have been widely applied in several applications including motor drives and grid integration such as wind and solar energy systems. Key performance metrics of the 3L-NPC converters like power quality, efficiency, and reliability are strongly affected by the used control methods. Therefore, several control methods have been proposed for the 3L-NPC topology to address certain aspects.

This tutorial aims to address basic concepts and design challenges of NPC converter applications. It will start with basic operating principles of the topology and their control challenges such as neutral point voltage balancing and thermal stress distribution. Then, two different control approaches will be presented: 1) carrier-based PWM techniques and 2) model predictive control techniques. For each control techniques, basic concept and step-by-step implementation guideline will be provided.

Then, an approach to analyze the reliability of power electronics converters will also be introduced, which includes thermal stress modeling, lifetime prediction, and reliability evaluation (Monte Carlo simulation). It will be demonstrated that control algorithm selection has a major impact on the reliability of semiconductor devices and DC-link capacitors in NPC converters.

Outline of Tutorial

Part I: Introduction

- Evolution of multi-level converter topologies
- NPC converter topology and operating principles
- Overview of the modulation methods
- Advantages and challenges of 3L-NPC converters
- Practical applications of 3L-NPC converters

Part II: Carrier based modulation methods for 3L- NPC converters

- Basic concept of carrier-based PWM for NPC converter
- Different PWM methods and their zero-sequence voltage
- Application-specified PWM methods: LVRT, Thermal balancing

Part III: Model predictive control methods for 3L- NPC converters

- Basic concept of FCS-MPC method for NPC converter
- Basic concept of CCS-MPC method for NPC converter
- Design and implementation challenges: weighting factors, computational burden
- Application-specified MPC methods: Grid-connected, UPS

Part IV: Reliability of 3L-NPC converters

- Tools for lifetime and reliability prediction
- Impact of the control algorithm on the device reliability
- Impact of the control algorithm on the capacitor reliability

Part V: Conclusion

- Outlook and future trend
- Final Q&A and feedback

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