

Losses Comparison Among Carrier-Based PWM Modulation Strategies in Three-Level Neutral-Point-Clamped Inverter



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Abstract. This paper investigates the power losses in semiconductors for a three-phase, three level neutral point clamped (3L-NPC) inverter. Analytical expressions for the switching and conductor losses are derived. Three different modulation strategies are analyzed: sinusoidal modulation (SPWM); sine modulation with injection of the third harmonic (THIPWM); carrier based space vector modulation (CB-SVPWM). Based on these strategies, the inverter losses are estimated through computational simulation under different operating conditions. The influence of these strategies on the losses is also analyzed.

Key words

Power Switch Losses, NPC Inverter, SVPWM, THIPWM, CB-SVPWM.

1. Introduction

Among the multilevel topologies, the most well know is the 3L-NPC inverter [1], which the power stage that can be seen in Figure 1. The main disadvantage of this structure is the imbalance in the distribution of loss in its semiconductor devices, leading to poor thermal distribution. Losses in power semiconductor depend on the PWM strategy adopted. This paper calculates and compares the losses in the inverter for three different PWM strategies: SPWM, THIPWM e CB-SVPWM. The operation limits of the converter, critical cases are determined and analyzed as show in Table I [2]. Operating under these limits the losses in the inverter have their maximum imbalance, limiting the switching frequency and the phase current of the converter.

Initially a mathematical approach for the inverter losses is developed, which allows to compare the losses in the NPC inverter for different modulation techniques. Then, the three techniques used will be presented and compared.

Table I. Critical operation cases for the 3L-NPC inverter for maximum loss imbalance among the power switches

3L-NPC	Power Factor	Modulation index	More losses
Case 1	1	max.	S_{11}, S_{14}
Case 2	1	min.	DC_{11}, DC_{12}
Case 3	-1	max.	Df_{11}, Df_{14}
Case 4	-1	min.	S_{12}, S_{12}

Losses in the inverter are estimated by computer simulations, taking into account different operating conditions.

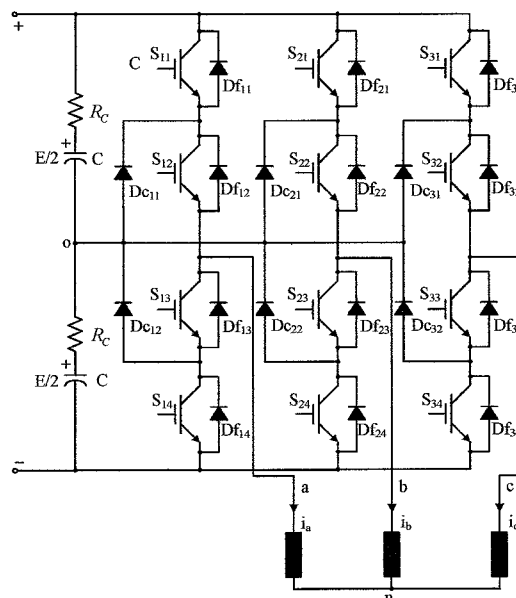


Fig. 1. Three-level NPC inverter.