

# New Control Strategy of Three-Phase Five-Level NPC Rectifier - Inverter System for Induction Machine Drive

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## Abstract

This paper proposes a control strategy of a three –phase five-level double converter for induction motor drives. The converter consists of the five-level NPC rectifier, DC link, and the five-level NPC inverter. In this control strategy, the DC link voltages are controlled by using a closed loop with an optimized stabilization system called clamping bridge. It provides a fast and flexible control of the converter capacitor voltage. This method will redress the imbalance of DC link voltage. This control strategy is completely independent from the load control, leading to a simpler implementation. The three-phase five-level NPC rectifier-inverter system is an ideal interface between a utility and renewable energy sources such as photovoltaic or wind generator.

**Keywords:** Five-level NPC converter, PWM strategy, DC link voltage, regulation voltage, unity power factor, stabilization system, induction machine, renewable energy.

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## 1. Introduction

In recent years, multilevel power converters for high power applications have been actively investigated [1-3]. In particular, three-level drive systems have been put to practical uses [1-2-3].

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The general function of the multilevel inverter is to synthesize a desired AC voltage from several levels of DC voltages. For this reason, multilevel inverters are ideal for connecting either in series or in parallel an AC grid with renewable energy sources such as photovoltaic or fuel cells or wind generator. Additional applications of multilevel converters include such uses as medium voltage adjustable speed motor drives, static var compensation, dynamic voltage restoration [3].....

Several topologies under serious consideration from industry are developed [3], however the Neutral Point Clamped (NPC) structure, proposed by Nabeba and al [2], remains the popular circuit due to its similarity to a conventional two-level voltage source inverter, and its ease of control [1-2-3].

The five-level inverter appears to offer interesting options for higher power drives without need for simultaneous device switching [2-3-4]. The output voltage waveform of the five-level NPC inverter is composed of intermediary voltage levels, which are typically obtained from capacitor voltage sources. However, the major problems with this configuration are in achieving four balanced voltage within the DC voltage source.

Different solutions have been proposed to overcome this problem [1-2-4-5-8]. A first approach [3] is to provide a single DC link voltage (from a three phase rectifier), and subdivide it into four equal voltage levels by using a split bank of capacitors [7]. The problem with the split capacitor arrangement is that during normal operation a net mean current is drawn from nodes **2** and **4** of the DC input voltage source by the load, and this will cause the link capacitors to charge or discharge, causing an imbalance in the DC input voltage source levels. During transient state, or if the PWM scheme and device switching characteristics are slightly unbalanced between the output phases, a net mean current may be drawn from the neutral point, node **3**, again leading to a capacitor voltage imbalance[3-5-6].

The easiest approach is to simply supply the DC link voltage with three-phase five-level NPC rectifier. We have proposed in [8] three-phase PWM five-level NPC rectifier as input stage of the three-phase five-level NPC voltage source inverter. We have shown in [8] that this first solution is not enough to maintain the equal voltage division mainly when a large load torque is applied.

In this paper, we propose a feed-back control, in dq rotating frame, of DC link voltage for five-level NPC rectifier-inverter system. The proposed control strategy uses closed loop with an optimized stabilization system called clamping bridge. It permits to have the capacitor voltage balancing with network unity power factor. In the first section, we elaborate the knowledge and control models of three-phase five-level NPC rectifier-inverter system. The second section presents the triangular-sinusoidal control strategy using four carriers. In the third section, we propose a control strategy of a three –phase five-level double converter for induction motor drives by using a closed loop with an optimized stabilization system called clamping bridge. The last section shows some important results of the proposed control strategy. As an application, we study the speed performances drive of the three-phase high power induction machine fed by this system.

## 2. Analysis of Five-level NPC Rectifier/Inverter System

### 2.1. Topology

Fig.1 shows the main circuit configuration of the three-phase five-level double converter. It consists of the five-level rectifier, the DC link, and the five-level inverter feeding the induction motor. The rectifier and inverter employ the neutral point clamping (NPC) structure. Each converter composed of three arms [6]. Each leg of this structure has six pairs of switching  $s_{is}$  devices in series and two in parallel. The diodes let to have zero voltage for  $V_{iM}$  ( $V_{iM}$  is the voltage of the phase relatively to the middle point  $M$ ).

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