Chapter 25

Modelling and Realisation of a Three-Level PWM Inverter Using a DSP Controller to Feed an Asynchronous Machine

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ABSTRACT

Multilevel inverters have seen an increasing popularity in the last few years for medium- and high-voltage applications. The most popular has been the three-level neutral clamped inverter. Multilevel inverters synthesize output voltage from more than two voltage levels. Thus, the output signal spectrum is significantly improved in comparison with the classical two-level converters. This chapter discusses modelling and control of a Neutral Point Clamped (NPC) inverter which operates with the PWM switching pattern using a DSP. The mathematical model of the NPC inverter is carried out using conversion and connection functions for an easier understanding of the system operation. Simulation results using MATLAB program are reported, and it is shown that the performances obtained for driving an asynchronous motor using this inverter are very promising. Finally, analysis of the theoretical and the experimental results is carried out in order to validate the effectiveness of the proposed control solution.

1. INTRODUCTION

The three level inverters often referred to as Neutral Point Clamped (NPC) inverters offer several advantages over the more common two level inverters. As compared to two level inverters, three level

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inverters have smaller output voltage steps that mitigate motor issues due to long power cables between
the inverter and the motor. These issues include surge voltages and rate of voltage rise at the motor ter-
ninals and motor shaft bearing currents. In addition, the cleaner output waveform provides an effective
switching frequency twice that of the actual switching frequency. Should an output filter be required,
the components will be smaller and less costly than for an equivalent rated two level inverter. Most often
the NPC inverter is used for higher voltage inverters. Since the IGBTs are only subjected to half of the
bus voltage, lower voltage IGBT modules can be used.

Figure 1 shows the circuit configuration of the NPC inverter. Each leg has four IGBTs connected in
series. The applied voltage on the IGBT is one-half that of the conventional two level inverters. The bus
voltage is split in two by the connection of equal series connected bus capacitors. Each leg is completed
by the addition of two clamp diodes.

This topology has been used traditionally for medium voltage industrial applications. In addition to
the capability of handling higher voltages, the NPC inverter has several favorable features including lower
line-to-line and common mode voltage steps and lower output current ripples for the same switching
frequency as that used in a two level inverter.

An attempt is made to present the most common multilevel (three-level) inverters and briefly describe
their advantages and disadvantages based on a literature survey. The literature survey is intended to
compare the inverters based on their performance aspects and the challenges and restrictions they could
impose for application in a given area.

The fundamental purpose of considering multilevel inverters instead of the popular two-level inverters
is due to the high value of DC-link voltage that needs to be employed in future developments. With the
increase in the DC-link voltage, it is aimed that the performance of the inverter in use does not degrade
and hence, multilevel inverter options have been considered.

The increase in power-handling capabilities of the power electronic switches has made the use of
multilevel inverters feasible for high-power applications. For high voltage and high power systems, instead
of using switches with high voltage ratings, it is beneficial to connect the switches having low-voltage
ratings in series (Tolbert et al., 1997). This allows the latter to be switched faster than the switches hav-
ing higher voltage ratings, thus resulting in switching harmonics of higher frequencies which can be
filtered easily.
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