

REDUCTION OF TOTAL HARMONIC DISTORTION IN POWER INVERTERS

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Abstract— The output voltage of PWM power inverters shows harmonic distortion due to several causes; the main ones are the modulation algorithm, nonlinearities in the output filter, dead times, voltage drops across the switches and modulation of the dc bus voltage. The distortion is more evident when using low dc bus voltages. As a result, motors driven by these inverters have important torque pulsations. This work proposes to reduce the distortion produced by dead times and voltage drops across the switches using a simple algorithm that recalculates the width of each PWM pulse, while preserving the ideal area. By simulation, the THD was reduced from 18% to 0.29% in a single-phase inverter. The proposed algorithm only needs products and sums, so it is suitable for being implemented on a DSP with a very low processing load.

Keywords — Power inverter, distortion, blanking time, THD.

I. INTRODUCTION

A single-phase PWM power inverter is shown in Figure 1. By turning on exclusively one switch in each leg (M1 and M4, or M2 and M3) a voltage difference is produced across points A and B. Simultaneous turning on of the two switches of either leg must be avoided to prevent a short circuit to ground on the dc-link. The natural turn-on and turn-off delays of the switches increase the possibility of producing the short circuit. A *delay time*, also called *dead time* (DT), is added before applying the turn-on pulse on any switch to minimize this risk; such that the previous conducting switch of the same leg has effectively turned off. Arbitrary waveforms can be synthesized between points A and B by adequate modulation of the turn-on pulse widths. The low-frequency spectrum of the synthesized waveform is similar to the desired one.

The most important sources of distortion in power inverters are: the kind of modulation used, nonlinearities in the output filter, dead times, the direct Voltage Drop across the Switches (VDS) and modifications of the voltage of the dc-link. The standard measure used to characterize distortion is the total harmonic distortion (THD).

Distortion due to DTs: The DTs are normally introduced at the beginning of each pulse, delaying the turning

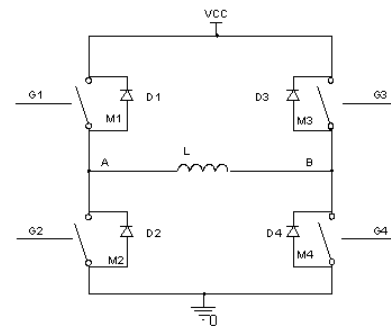


Figure 1. Full bridge inverter with inductive load.

on of the respective switch, to allow the other switch to effectively turn off (Mohan *et al.*, 1989). Distortion caused by the DTs has already been studied. In Mohan *et al.* (1989) and Mosely *et al.* (1999) a basic description of the problem and its influence over the THD of the output waveform can be found. Since during the DT both switches of the same leg are off, the sign of the output current dictates which of the freewheeling diodes conducts. In consequence, when the current is negative (positive current flows from point A to point B in Fig. 1 by convention) the average output voltage is higher than desired. On the contrary, when the current is positive the average output voltage is lower than desired. Then the output waveform is distorted, with low-order harmonic components that are difficult (or relatively expensive) to filter out.

According to Mosely *et al.* (1999), the ratio (Period/DT) must be > 15 or the DT $< 6.7\%$ of the period to keep the THD below 1%.

The problem has been extensively investigated (Ueda *et al.*, 1982; Chin, 1985 and Ueda *et al.*, 1989) with respect to the torque pulsations produced on the electric motors by the distorted waveforms. Several correction methods have been proposed to correct the distortion produced by the DTs; Murai *et al.*, 1987; Jeong & Park, 1991; Colby *et al.*, 1990; Choi *et al.*, 1994; Mohan *et al.*, 1989; Mutoh *et al.*, 1990 and Sukegawa *et al.*, 1991). Most of them are based on the mean value theory. The lost voltage is averaged along one switching interval and used to compensate the command voltage (Murai *et al.*,