THE GENERALIZED DISCONTINUOUS PWM MODULATION SCHEME FOR THREE-PHASE VOLTAGE SOURCE INVERTERS

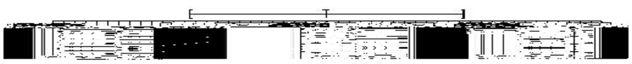
Olorunfemi Ojo, and Parag Kshirsagar
Department of Electrical and Computer Engineering
Laboratory for Electric Machines and Power Electronics/Center for Electric Power
Tennessee Technological University, Cookeville, TN 38505, USA
Phone : (931)-372-3869, Fax : (931)-372-3436, E-mail : jojo@tntech.edu

Abstract : This paper presents analytical techniques for the determination of the expressions for the modulation signals used in the carrier-based non-sinusoidal and generalized discontinuous PWM modulation (GDPWM) schemes for two-level, three-phase voltage source inverters. The resulting modulation schemes are applicable to inverters generating balanced or unbalanced phase voltages feeding either star or delta connected loads. The results presented in this paper analytically generalize the several expressions for the modulation signals already reported in the literature. Confirmatory experimental results are provided to illustrate some of the feasible modulation signals.

partitioning of the total time the devices in the two zero states are utilized [3]. It has been conclusively shown that changing the ratio by which the two zero states are applied in the direct digital implementation produces the same effect on the inverter performance as the classical sine-triangle intersection technique in which the modulation signals are augmented with an appropriate zero sequence signal [7-9]. It therefore follows that the same AC voltages with similar characteristics can be synthesized by either of

voltages, respectively. Equation (13) which first appeared in [9] and determined using a different method is what has given rise to what is known as the Hybrid PWM (HPWM) and later described as a non-sinusoidal PWM scheme [10-11]. In the implementation of this modulation scheme α can take any form (constant or time-varying) ranging between zero and unity. [9-11]. The choice of parameter α affects the neutral voltage between the load star-point and the inverter reference. In the conventional space vector modulation, α is general determined. In view of this indeterminacy, there is an infinite number of solutions which are obtained by various optimizing performance functions defined in terms of the modulation functions. For a set of linear indeterminate equations expressed as $AX = Y$, a solution which minimizes the sum of squares of the variable X is obtained using the Moore-Penrose inverse [14]. The solution is given as $X = A^T[AA^T]^{-1}$

(a)



(b)

(c)

Figure 3: Experimental results for three-phase inverter under GDPWM modulation feeding an induction motor on no-load. V_d

technique and the appropriate definition of the distribution or partition ratio of the times the zero (null) switching modes are used in the synthesis of a reference voltage. Some confirmatory experiments results have been provided to illustrate the various generalized carrier-based modulation signals possible. The methodology is extendable to the determination of discontinuous modulation schemes of other converters such as four-leg, multi-level, AC-AC and other variants.

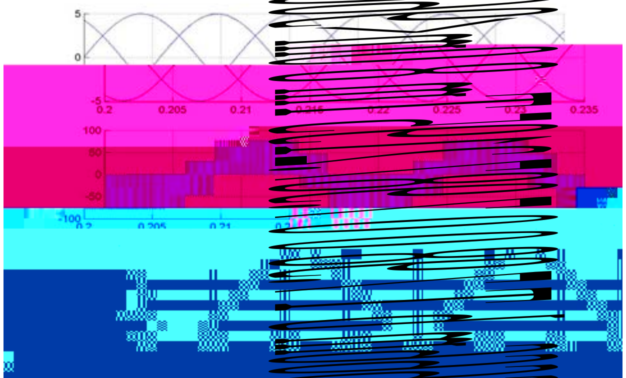


Figure 5: Balanced current in an unbalanced load. Reference peak current is 5A. (a) Balanced three phase actual currents (b) Phase a volatege, (c) Modulating signal.

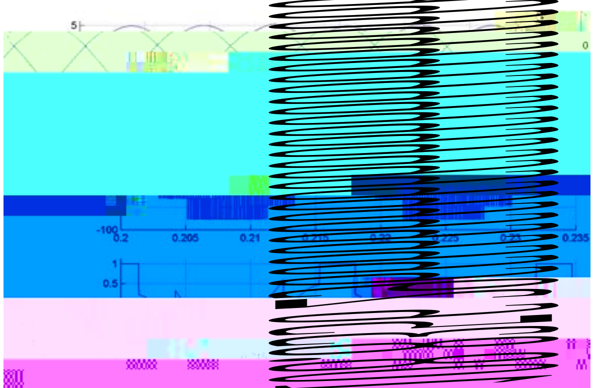


Figure 6 : Simulation results for unbalanced three-phase voltage under GDPWM. $\beta = 0.5[1 + \text{SgnCos } 3(\omega t + \delta)]$, $\delta = 0$, DPWM1,(a) Balanced three-phase current (b) phase a