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# Performance Evaluation of Carrier Based PWM Techniques for Hybrid Multilevel Inverters with Reduced Number of Components

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## Abstract

This paper presents an implementation of hybrid multilevel inverter employing fewer components and less carrier signals when compared to conventional multilevel inverters. In the hybrid topology, to increase the performance of multilevel inverter, first positive levels are generated by using switches having high frequency and then reverse the voltage component using low frequency switches. Due to this, the complexity and overall cost for higher output voltage levels are greatly reduced. Simulation of single phase 7-level, 9-level and 11-level hybrid inverter has been performed using sinusoidal pulse width modulation (SPWM) techniques i.e., APOD and CO. Also the two techniques are compared in terms of total harmonic distortion (THD) for various modulation indices and observed to be greatly improved when compared to conventional topologies. The performance of single phase eleven level hybrid inverter is analyzed for induction motor (IM) load. Simulation is performed using MATLAB/SIMULINK.

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**Keywords:** Hybrid inverter; SPWM; total harmonic distortion; induction motor; alternate phase opposition disposition; carrier overlapping.

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## 1. Introduction

The concept of power conversion in multilevel inverters has got several advantages [1]–[6]. A multilevel inverter is implemented with reversing voltage component that has some advantages as the levels increase when compared to conventional multilevel inverters [7]. The hybrid topology eliminates the diodes and capacitors that are used in diode clamped inverters, capacitors used in flying capacitor inverters and also reduces the switches and carrier signals required than in cascaded inverters, diode clamped, and flying capacitors inverters. An approach of utilizing high-power devices with low-switching-frequency reduces voltage distortion of output but has got current harmonics which is a major drawback [8]. There are asymmetrical methods of using different values of voltage source which requires more number of power switches and diodes with different rating [9, 10]. Some topologies suffer from the capacitor balancing problems [11]–[14]. Whereas in case of hybrid multilevel inverter, the voltage sources used have equal values and has many advantages compared with the methods discussed above. It uses less number of switches and carrier waves and also operates the switching devices at line frequency which results in more efficiency. In this paper, alternate phase opposition disposition (APOD) and carrier overlapping (CO) sinusoidal pulse width modulation techniques are utilized to drive the inverter.

## 2. Description of Seven Level Hybrid Multilevel Inverter

The hybrid MLI topology is a combination of level generation as well as polarity generation parts which is responsible for multilevel output voltage generation. Here, the level generation part that consists of high-frequency switches produce the positive levels. And the polarity generation part with low frequency switches is responsible to give output polarity. Hybrid multilevel inverter mainly eliminates higher number switches that are required to produce output levels. A single phase hybrid inverter for seven levels can be seen in Fig.1.

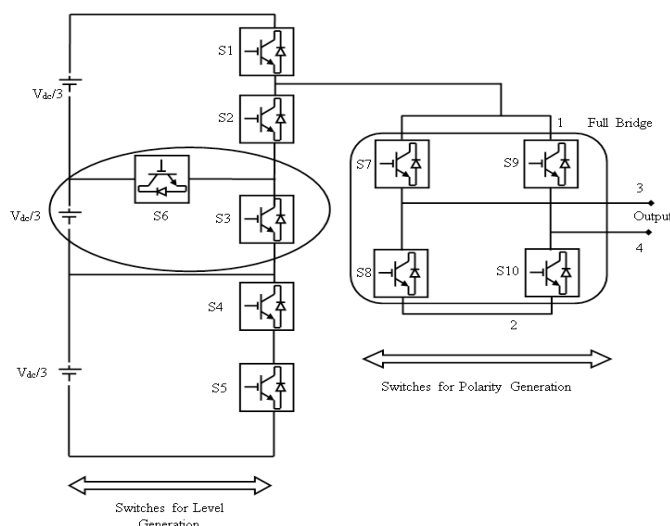


Fig. 1. Single phase seven level hybrid multilevel inverter.

It consists of 3 isolated sources and 10 switches. High frequency switches will generate the required output levels without polarity. Later, the output voltage polarity is decided by the switches that has low frequency which is a full bridge converter. This concept can be applied to any number of voltage levels just by duplicating the state that is represented in the middle of Fig.1. Moreover, conventional seven level multilevel inverters using sinusoidal pulse width modulation requires six carriers, but three carriers are sufficient for hybrid multilevel inverter.

The various switching modes for a seven-level hybrid inverter are shown in Table 1 for generating the required levels. There are 6 switching patterns to control seven level hybrid inverter.

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