Cascaded H-Bridge Inverter with Reduced Number of Switches and A Single Dc Source

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ABSTRACT

This paper presents topology for a seven-level cascaded H-bridge multilevel inverter. The proposed topology uses reduced number of switches and requires only one DC source. The new topology results in reduced cost and can be enforced for any number of levels. The switching angles are generated using a new technique of selective harmonic elimination technique. The simulated waveforms of output voltage have reduced total harmonic distortion.

Introduction

Multilevel inverters (MLIs) are used in renewable energy applications for boosting low source voltage to higher voltage for transmitting power to loads and/ or to grid. They have higher efficiency, lower electromagnetic interference effects, lower switching losses, reduced output dv/dt, higher voltage capability and better power quality as compared to conventional inverters [1-3]. There are mainly three configurations of MLIs namely Cascaded H-Bridge, Neutral Point Clamped and Flying Capacitor. Of these the Cascaded H Bridge (CHB) Inverter has proven to be a better for high power applications as it does not require any clamping diodes or capacitors. It achieves the high voltage by cascading multiple single-phase inverter modules and requires the least number of components [4-6]. The main disadvantage of the CHB inverter is that it requires a separate DC source for each level. This paper proposes a new topology for CHB MLI, which uses only two switches per level and a single DC source. There must be a separate DC source for every individual H-bridge [7]. Fig. 1 shows the conventional single- phase seven-level CHB. The inverter uses three separate DC sources. Each DC source has a single-phase H-bridge inverter with four switches resulting in twelve switches for the seven-level inverter. Fig. 2 shows the output voltage waveform of the seven-level inverter. The seven levels of voltages are 0, ±VDC, ±2VDC and ±3VDC.

Proposed Multi-Level Inverter Fig. 3 shows the proposed topology of the CHB multi-level inverter. It requires only one DC source. It uses 3 three winding transformers with two primary windings and one secondary winding. The DC source is connected to the primary side of the transformer through the switches. The secondary windings are connected in series and the load is connected to the series connected secondary windings. The switching states to get the seven levels of output voltages are given in Table 1.

Switching Signals for the Inverter using Selective Harmonic Elimination Method The multi-level output AC voltage is obtained by switching ON and OFF the semiconductor switches in such a way that the desired fundamental is obtained with less harmonic distortion. The commonly used technique for switching is the selective harmonic elimination (SHE) method at fundamental frequency. In this technique, the switching angles are computed by solving transcendental equations characterizing harmonics [8-9]. For a seven-level inverter, three switching angles are to be generated by solving three transcendental equations. This method solves the transcendental equations with initial approximate values [10].

The output voltage waveform of the seven-level inverter is shown in Figure 4 for a half-cycle. Where θ1, θ2, and θ3 are the switching angles for the seven-level inverter, and 0< θ1< θ2< θ3< π/2. From Eqn.1 the fundamental voltage is given by Eqn. 2

The maximum value of the fundamental voltage is □ DC m V V 4 □1 , i.e., the value of the fundamental voltage when all the switching angles are zero. Modulation index M I is the ratio of fundamental voltage to maximum fundamental voltage. m1 DC I V V □M . Three equations can be formed to eliminate third and fifth harmonics Solving these equations by Newton -Raphson method, the switching angles are found to be θ1= 0.2923 rad, θ2=0.5542 rad, θ3=1.377 rad for M I = 2. Hence the third and fifth harmonics are eliminated, while higher order harmonics are present. This paper considers a new technique for the minimisation of seventh harmonic in addition to the elimination of third and fifth harmonics. This is implemented by considering seventh harmonic equation along with the third and fifth harmonic equations and ignoring the fundamental one. Seventh harmonic cannot be completely eliminated but can be minimised by equating Eqn. 6 to a minimum value. By solving Eqns. 4-6 by Newton-Raphson method, the values of switching angles are found to be θ1= 0.2037 rad, θ2=0.4701 rad, θ3=0.9784 rad

Result:

Fig. 5 Output voltage and FFT analysis of proposed CHB inverter with the conventional SHE technique

Comparison of Various Parameters of Seven-Level Conventional and Proposed CHB inverter

Conclusion

This paper presented a new topology for CHB inverter which uses less number of switches compared to conventional multi-level inverter. The proposed inverter uses only (m-1) switches whereas the conventional inverter uses 2(m-1) switches, for an m-level inverter. In addition, the proposed topology uses only one DC source irrespective of the levels but the conventional one uses (m-1)/2 DC sources for multilevel resulting in reduced cost of the proposed inverter. This paper also presented a new technique for SHE, which involves the elimination of third and fifth and reduction of seventh harmonics resulting in lower THD value.

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