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Performance Improvement of Single Phase Seven Level Inverter using Coupled Inductors

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Abstract *– Multilevel inverter is a power conversion strategy in which the output voltage is obtained in steps thus bringing the output closer to a sine wave and reduces the total harmonic distortion. In conventional multilevel inverters, the problems such as dc capacitor voltage balancing, higher total harmonic distortion, higher switching losses and high electromagnetic compatibility are eliminated in this new topology .This paper deals with a single-phase seven level inverter using coupled inductors which is controlled by multicarrier PWM technique. It improves the efficiency by eliminating dc capacitor voltage balancing, reducing total harmonic distortion, better electromagnetic compatibility and lower switching losses. The inverter can generate seven voltage levels at its output terminals with only one dc source .The performance has been studied by the MATLAB/Simulink.*

Keywords: *Multilevel inverter, Total Harmonic Distortion, Pulse width modulation, Electromagnetic Compatibility*

INTRODUCTION

In recent years multi level inverters are used for high power and high voltage applications. Multilevel inverter output voltage produce a staircase output waveform, this waveform look like a sinusoidal waveform. The multilevel inverter output voltage having less number of harmonics compared to the conventional bipolar inverter output voltage. If the multilevel inverter output increase to N level, the harmonics reduced to the output voltage value to zero. The multi level inverters are mainly classified as Diode clamped, Flying capacitor inverter and cascaded multi level inverter. [1]

A multilevel inverter with only one dc source and no split capacitors may be the most desirable topology but unfortunately this type of inverter has yet to be discovered. Recently, multilevel inverters with coupled inductors have drawn some researchers' interest and a half-bridge three-level inverter has been proposed using two power switches, two diodes, and two coupled inductors [2]–[5].Whereas, as for single-phase seven-level cases, two such half-bridges, i.e., seven power devices (five power switches, two diodes) and four (two pairs of) coupled inductors will be needed [3], [4]. What is more, dc component exists in the inductor current in these of inverters, which is harmful to the full use of the magnetic cores. More recently, [6] presented a single-phase inverter called a five-level-active-neutral-point clamped with coupled inductor. The 5L-ANPLCI inverter uses eight power switches, and split of the dc-link capacitor is needed. Thus, the risk of unbalanced capacitor voltage exists if the inverter is not properly modulated. Several control and modulation strategies have been developed such as Multicarrier Pulse Width Modulation (PWM), Sinusoidal PWM, Space Vector PWM and Selective harmonic elimination [8-9].

This paper deals with a single-phase seven level inverter using coupled inductors which is controlled by multicarrier PWM technique. It improves the efficiency by eliminating dc capacitor voltage balancing, reducing total harmonic distortion, better electromagnetic compatibility and lower switching losses. The inverter can generate seven voltage levels at its output terminals with only one dc source .The performance has been studied by the MATLAB/Simulink.

2. BLOCK DIAGRAM OF THE PROPOSED METHOD

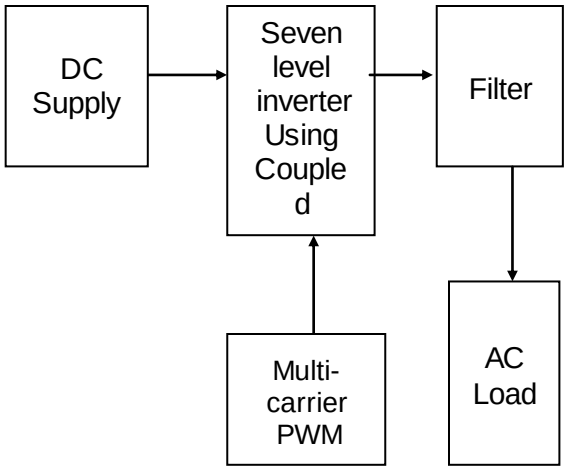

Figure 1: Block Diagram

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Figure.1 shows the block diagram of the proposed multilevel inverter .The dc supply is given to the seven level inverter using coupled inductors which converts DC power into AC power for AC load and it is controlled by multicarrier PWM technique. The inverter can generate seven voltage levels at its output terminals with only one dc source.

3. PROPOSED SINGLE PHASE SEVEN LEVEL INVERTER

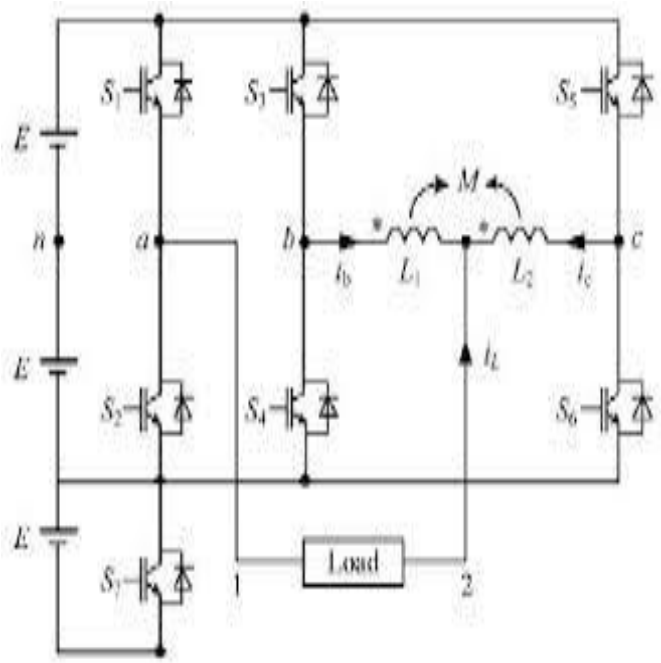

Figure 2: Proposed single-phase seven level inverter.

The Proposed single-phase seven level inverter consists of seven controlled power switches, two coupled inductors, dc link voltage and a load. In Fig. 1, *E* is the dc-link voltage and *L*1 and*L*2 are the two coupled inductors. The mutual inductance of the two inductors is *M* and the output terminals of this inverter are 1 and 2. Obviously, this topology is very simple and can be constructed simply by adding two coupled inductors to a conventional three-arm inverter bridge [7].

The power switches in one arm are assumed to switch complementarily. For instance, *S*2 must be turned OFF if *S*1 is turned ON and vice versa. The number "1" will be used to denote the ON state of one switch and "0" will be used to denote the OFF state. Obviously, the proposed inverter can generate seven voltage levels at its output terminals. From the table 1 the switching state of *S*1 must be 1 if voltage between 1 and 2 ≥ 0 and the switching state of *S*1 must be 0 if voltage between 1 and 2 ≤ 0. This means *S*1 and *S*2 will switch at the fundamental frequency of the reference signal. So, the switching losses of *S*1 and *S*2 will be very low in the proposed inverter [7].

Table.1 shows the switching states of seven level inverter.

Table 1: Switching Strategy

Voltage	S1	S2	S3	S4	S5	S6	S7
+2E	1	0	0	1	0	1	0
+2E	1	0	0	1	1	0	1
+E	1	0	1	0	0	1	0
+E	1	0	1	0	1	0	1
0	1	0	0	1	0	1	0
0	0	1	0	1	1	0	1
-E	0	1	1	0	0	1	0
-E	0	1	1	0	1	0	1
-2E	0	1	0	1	0	1	0
+2E	0	1	0	1	1	0	1

4. MULTICARRIER PWM TECHNIQUE

Several modulation strategies have been developed for multilevel inverters. The most commonly used is the multi carrier PWM technique. The principle of the multicarrier PWM is based on a comparison of a sinusoidal reference waveform with triangular carrier waveforms. m-1 carriers are required to generate m levels. The carriers are in continuous bands around the reference zero. They have the same amplitude A_c and the same frequency f_c. The sine reference waveform has a frequency f_r and A_r is the peak to peak value of the reference waveform. At each instant, the result of the comparison is 1 if the triangular carrier is greater than the reference signal and 0 otherwise. The output of the modulator is the sum of the different comparisons which represents the voltage level. The strategy is therefore characterized by the two following parameters called amplitude modulation index m_a and frequency modulation index m_f. Frequency modulation ratio is defined as the ratio of carrier frequency and modulating frequency. Amplitude modulation ratio is defined as the ratio of amplitude of modulating signal and amplitude of carrier signal.

5. SIMULATION RESULTS

In this paper, the simulation model is developed with MATLAB/SIMULINK. The simulation circuit and result of the proposed seven level inverter using coupled inductors is shown in Fig.3 & 4 and the corresponding FFT analysis is shown in fig 5. The

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generated output pulses are to drive the devices in to ON for a seven level inverter topology.

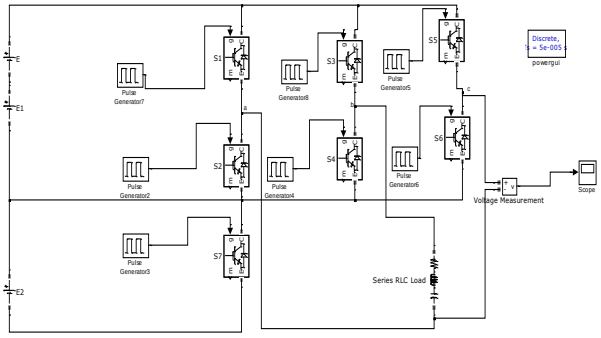

Figure 3: Simulation circuit of the proposed method

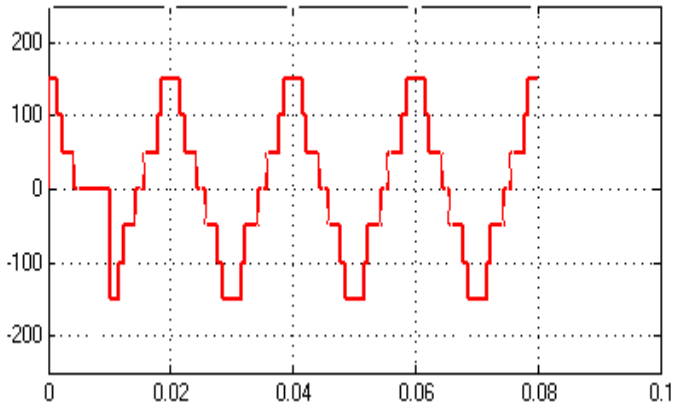

Figure.4. Output Voltage for Seven Level Inverter

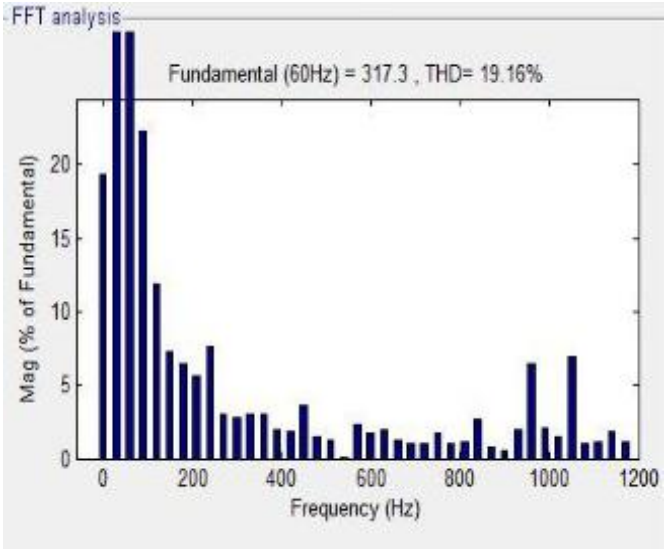

Figure 5: FFT Analysis for Seven Level Inverter

6. CONCLUSION

In the present work , deals with a single-phase seven level inverter using coupled inductors which is controlled by multicarrier PWM technique. The performance has been studied by the MATLAB/Simulink. The output shows very low total harmonic distortion and is 19.16% when compared to five level inverter using coupled inductors. Hence we could achieve the improved efficiency of the system.

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