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Multicarrier PWM Technique for the Performance Improvement of Single Phase Five Level Inverter with Coupled Inductors

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ABSTRACT

Multilevel inverter is a switching converter where the appropriate control of an arrangement of switching devices allows combining diverse input voltages to synthesize a sinusoidal output voltage waveform. In order to avoid the problems such as voltage balancing, higher total harmonic distortion and higher switching losses in conventional multilevel inverters, a new topology is proposed using coupled inductors. This paper deals with a single-phase five-level inverter using coupled inductors and the common three-arm power module. It improves the efficiency by avoiding voltage balancing, reducing total harmonic distortion and lower switching losses. Multicarrier pwm technique is being used in this proposed single phase five level inverter. The inverter can generate five 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, Single phase

I INTRODUCTION

A multilevel inverter is a power electronic converter that synthesizes a desired output voltage from several levels of dc voltages as inputs. With an increasing number of dc voltage sources, the converter output voltage waveform approaches a nearly sinusoidal waveform while using a fundamental frequency-switching scheme. The primary advantage of multilevel inverter is their small output voltage, results in higher output quality, lower harmonic component, better electromagnetic compatibility, and lower switching losses. [1] [2].

High magnitude sinusoidal voltage with extremely low distortion at fundamental frequency can be produced at output with the help of multilevel inverters by connecting sufficient number of dc levels at input side. There are mainly three types of multilevel inverters; these are a) diode- clamped, b) flying capacitor and c) cascade multilevel inverter (CMLI).Among these three, the two most common topologies are the cascaded H-bridge inverter and its derivatives [3], and the Diode-clamped inverter [4]. The main advantage of both topologies is that the rating of the switching devices is highly reduced to the rating of each cell. However, they have the drawback of the required large number of switching devices which equals 2(*k*-1) where *k* is the number of levels. This number is quite high and may increase the circuit complexity, and reduce its reliability and efficiency.Cascaded H-bridge inverter has a modularized layout and the problem of the dc link voltage unbalancing does not occur, thus easily expanded to multilevel. Due to these advantages, cascaded H-bridge inverter has been widely applied to such applications as HVDC, SVC, stabilizers, and high power motor drives. Diode clamped inverter needs only one dc-bus and the voltage levels are produced by several capacitors in series that divide the dc bus voltage into a set of capacitor voltages. Balancing of the capacitors is very complicated especially at large number of levels. Moreover, three-phase version of this topology is difficult to implement due to the neutral-point balancing problems. The output waveforms of multilevel inverters are in a stepped form, therefore they have reduced harmonics compared to a square wave inverter. To reduce the harmonics further, carrier-based PWM methods are suggested in the literature [5].

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

[14]–[17].Whereas, as for single-phase five-level cases, two such half-bridges, i.e., six power devices (four power switches, two diodes) and four (two pairs of) coupled inductors will be needed [15], [16]. 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, [18] 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.

This paper deals with a single-phase five-level inverter using coupled inductors and the common three-arm power module. It improves the efficiency by avoiding voltage balancing, reducing total harmonic distortion and lower switching losses. Multicarrier pwm technique is being used in this proposed single phase five level inverter. The inverter can generate five voltage levels at its output terminals with only one dc source .The performance has been studied by the MATLAB/Simulink.

II PROPOSED SINGLE PHASE FIVE LEVEL INVERTER

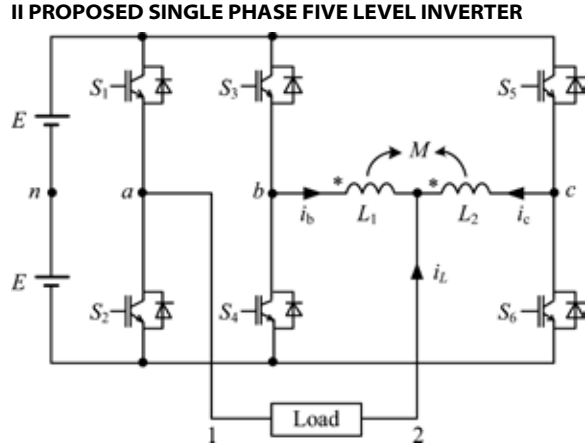


Fig.1. Proposed single-phase five-level inverter.

The Proposed single-phase five-level inverter consists of six controlled power switches, two coupled inductors , dc link voltage and a load. In Fig. 1, 2*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.[13]

The power switches in one arm are assumed to switch complementarily. For instance, S2 must be turned OFF if S1 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 five voltage levels at its output terminals. From the table 1 the switching state of S1 must be 1 if voltage between 1 and 2 ≥ 0 and the switching state of S1 must be 0 if voltage between 1 and 2 ≤ 0. This means S1 and S2 will switch at the fundamental frequency of the reference signal. So, the switching losses of S1 and S2 will be very low in the proposed inverter.[13]

Table.1.Switching strategy

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

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

IV MULTICARRIER PWM TECHNIQUE

Multicarrier PWM technique is the widely adopted modulation strategy for multilevel inverter . It is similar to that of the sinusoidal PWM strategy except for the fact that several carriers are used. Multicarrier PWM is one in which several triangular carrier signals are compared with one sinusoidal modulating signal. The number of carriers required to produce m-level output is m- 1. All carriers have the same peak to peak amplitude Ac and same frequency fc except for VF. The reference waveform has peak to peak amplitude of Am and a frequency fm .The reference is continuously compared with each of the carrier signals and whenever the reference is greater than the carrier signal, pulse is generated.

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.

IV SIMULATION RESULTS

In this paper, the simulation model is developed with MATLAB/SIMULINK. The simulation result of the proposed five level inverter is shown in Fig.2 and the corresponding FFT analysis is shown in fig 3. The generated output pulses from the pulse generator is shown in the Fig. 4 and those pulses generated are to drive the devices in to ON for a five level inverter topology.

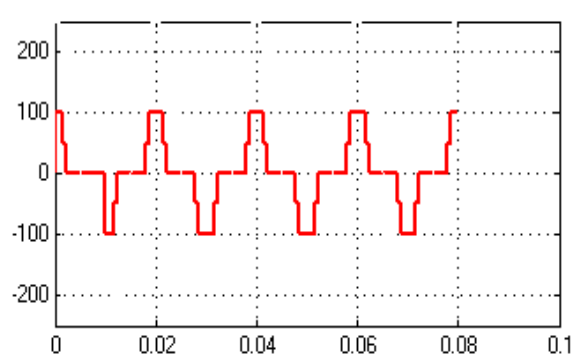


Fig. 3. Output Voltage for Five Level Inverter

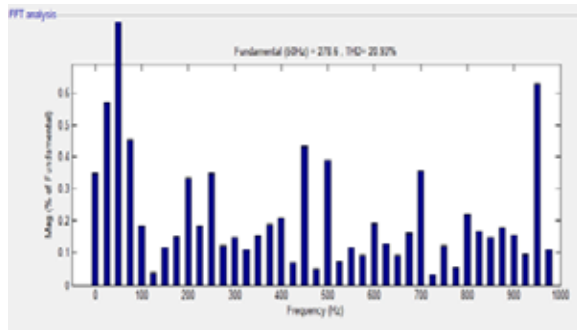


Fig. 4. FFT Analysis for Five Level Inverter

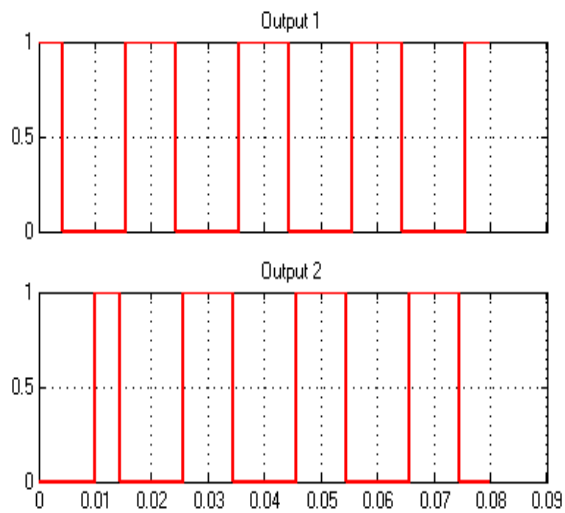


Fig.5.Generated gate pulses

V CONCLUSION

In the present work , deals with a single-phase five-level inverter using coupled inductors and the common three-arm power module. It improves the efficiency by avoiding voltage balancing, reducing the total harmonic distortion and lower switching losses. Multicarrier pwm technique is being used in this proposed single phase five level inverter. The performance has been studied by the MATLAB/Simulink. The output shows very low total harmonic distortion and is 20.93% .Hence we could achieve improved efficiency of the system.

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