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Five Level Cascaded H-Bridge Multilevel Inverter Using Multicarrier Pulse Width Modulation Technique

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Abstract* —The multilevel inverter utilization has been increased since the last decade. These new type of inverters are suitable in various high voltage and high power applications due to their ability to synthesize waveforms with better harmonic spectrum and faithful output. This paper presents an asymmetrical five level cascaded H-bridge multilevel inverter, using multicarrier pulse width modulation technique. And also comparison is made between multicarrier pulse width modulation and the embedded matlab function. The Simulation results are presented to prove that THD is reduced with the multicarrier modulation. This topology also reduces the number of switches and also the cost. From the results, the proposed inverter provides higher output quality with relatively lower power loss as compared to the other conventional inverters with the same output quality.

***Index Terms*— Cascaded H-bridge multilevel inverter (CHB), embedded matlab function, multicarrier pulse-width modulation, total harmonic distortion (THD).**

I. INTRODUCTION

Demand for high-voltage, high power converters capable of producing high-quality waveforms while utilizing low voltage devices and reduced switching frequencies has led to the multilevel inverter development with regard to semiconductor power switch voltage limits. Multilevel inverters include an array of power semiconductors and capacitor voltage sources, the output of which generate voltages with stepped waveforms. The commutation of the switches permits the addition of the capacitor voltages, which reach high voltage at the output, while the power semiconductors must withstand only reduced voltages.

The most attractive features of multilevel inverters are as follows:-

1) They can generate output voltages with extremely low distortion and lower dv/dt.
2) They draw input current with very low distortion.
3) They generate smaller common mode (CM) voltage, thus reducing the stress in the motor bearings. In addition, using sophisticated modulation methods, CM voltages can be eliminated.
4) They can operate with a lower switching frequency.

The multilevel inverter has been implemented in various applications ranging from medium to high-power levels, such as motor drives, power conditioning devices, also conventional or renewable energy generation and distribution. The different multilevel inverter structures are cascaded H-bridge, diode clamped and flying capacitor multilevel inverter [4]. Among the three topologies, the cascaded multilevel inverter has the potential to be the most reliable and achieve the best fault tolerance owing to its modularity, a feature that enables the inverter to continue operating at lower power levels after cell failure. Modularity also permits the cascaded multilevel inverter to be stacked easily for high power and high-voltage applications. The cascaded multilevel inverter typically comprises several identical single phase H-bridge cells cascaded in series at its output side. This configuration is commonly referred to as a cascaded H-bridge, which can be classified as symmetrical if the dc bus voltages are equal in all the series power cells, or as asymmetrical if otherwise. In an asymmetrical CHB, dc voltages are varied to produce more output levels. In this paper , we are using two modulations , one is the multicarrier phase shifted modulation and other is the embedded matlab function and THD level is compared.

II. FIVE LEVEL CASCADED H-BRIDGE MULTILEVEL INVERTER

A. Conventional cascaded H-bridge multilevel inverter

Fig.1 shows a five level cascaded H-bridge multilevel inverter. The converter consists of two series connected H-bridge cells which are fed by independent voltage sources. The outputs of the H-bridge cells are connected in series such that the synthesized voltage waveform is the sum of all of the individual cell outputs. The output voltage is given by

$$V=V_1+V_2$$

Where the output voltage of the first cell is labeled V_1 and the output voltage of the second cell is denoted by V_2. There are five level of output voltage ie 2V, V, 0, -V, -2V.The main advantages of cascaded H-bridge inverter is that it requires least number of components, modularized circuit and soft switching can be employed. But the main disadvantage is that when the voltage level increases, the number of switches increases and also the soures, this in effect increases the cost and weight. The cascaded H-bridge multilevel inverters have been applied where high power and power quality are essential, for example, static synchronous compensators, active filter and reactive power compensation applications, photo voltaic power conversion, uninterruptible power supplies, and magnetic resonance imaging. Furthermore, one of the growing applications for multilevel motor drive is electric and hybrid power trains.

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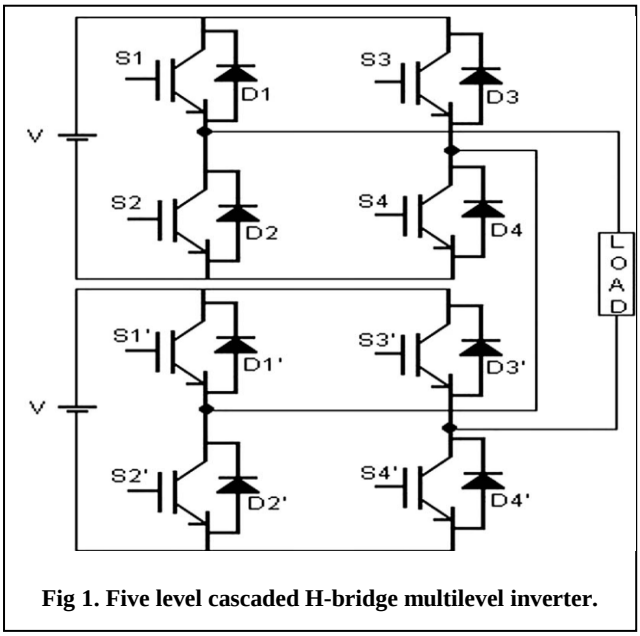

Fig 1. Five level cascaded H-bridge multilevel inverter.

B. Modified cascaded H-bridge multilevel inverter

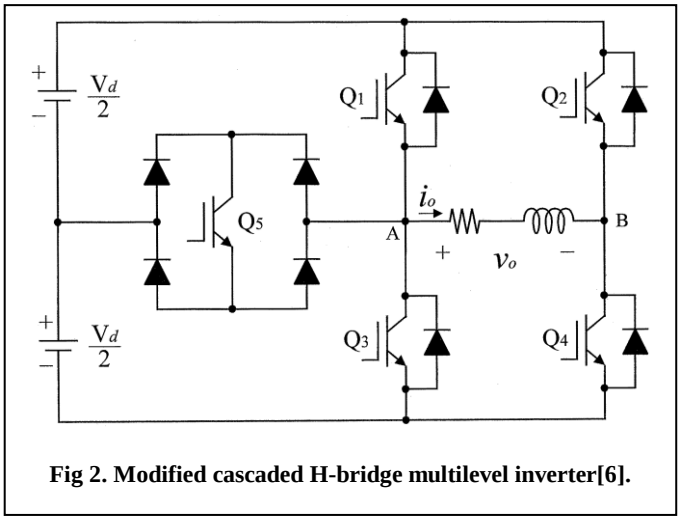

Fig 2. Modified cascaded H-bridge multilevel inverter[6].

Fig 2 shows the new cascaded five level H bridge multilevel inverter [6]. One switching element and four diodes added in the conventional full-bridge inverter are connected to the centre tap of dc power supply. Proper switching control of the auxiliary switch can generate half level of dc supply voltage. It has five output voltage levels that is V, V/2, 0, -V/2, -V. For getting the output voltage V the switches S_1S_4 need to be turned on. Similarly for output voltage V/2 switches S_4S_5 need to be turned on, for 0 either S_3S_4 or S_1S_2 need to be turned on; for –V/2 switches S_2S_5 need to be turned on; for –V switches S_2S_3 need to be turned on. The switching combinations are shown in Table1.

C. PWM modulation

In this topology, for generating the switching pulses multicarrier phase shifted pulse width modulation [3] and embedded matlab function are used. In the multicarrier modulation, the amplitude and frequency of all triangular carriers are the same as well as the phase shifts between adjacent carriers. Figure 3 and 4 shows multicarrier phase shifted pwm and embedded matlab function.

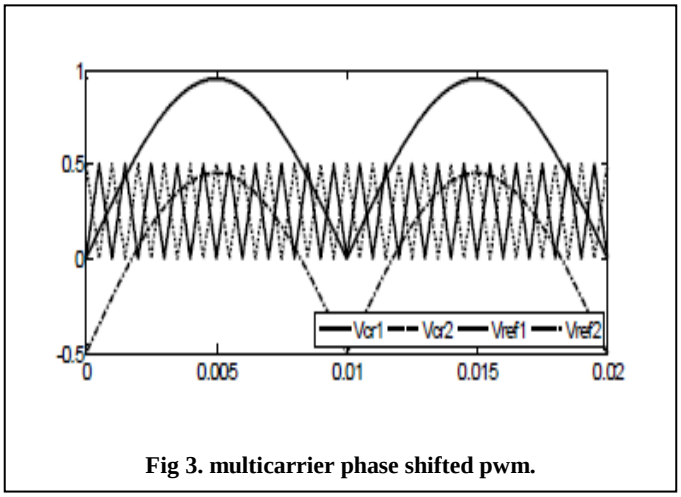

Fig 3. multicarrier phase shifted pwm.

S_1	S_2	S_3	S_4	S_5	Output voltage
ON	OFF	OFF	ON	OFF	V
OFF	OFF	OFF	ON	ON	V/2
OFF Or ON	OFF Or ON	ON Or OFF	ON Or OFF	OFF	0
OFF	ON	OFF	OFF	ON	-V/2
OFF	ON	ON	OFF	OFF	-V

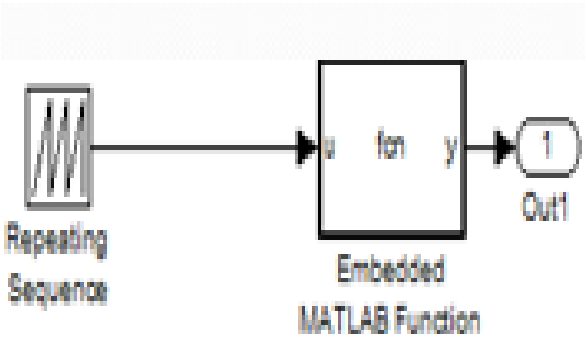

Fig 4. embedded matlab function for generating switching

III. SIMULATION AND RESULTS

The circuit was simulated with R load . Figure 5 shows the circuit arrangement with multicarrier modulation. Figure 6 and 7 shows the output waveform of five level cascaded multilevel inverter with multicarrier modulation and embedded matlab function. A THD analysis was done

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and the result obtained is as shown in figure 8 and 9. A comparison of the multicarrier modulation and embedded matlab function is presented in table 2.

TABLE 2: COMPARISON OF THD VALUES

Parameters	Multicarrier modulation	Embedded matlab function
THD (%)	28.83	30.05

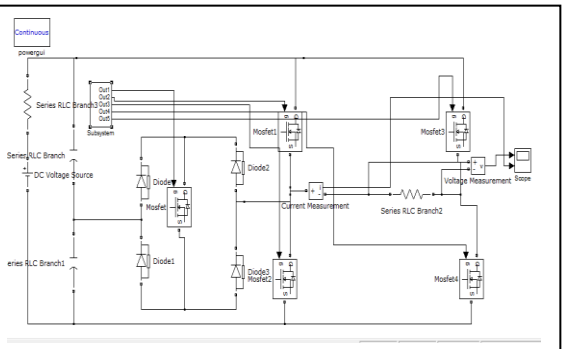


Fig 5 Five level cascaded H-bridge multilevel inverter.

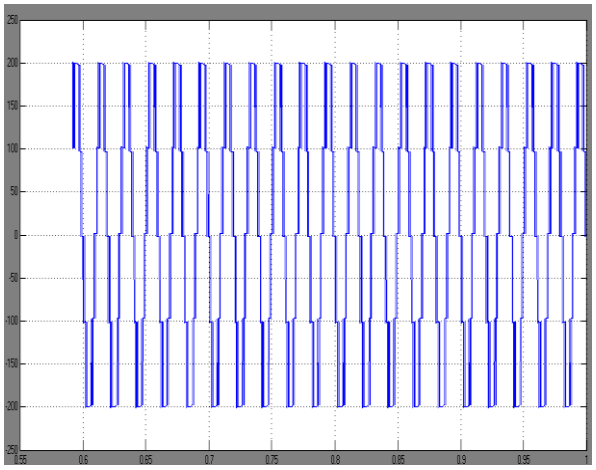
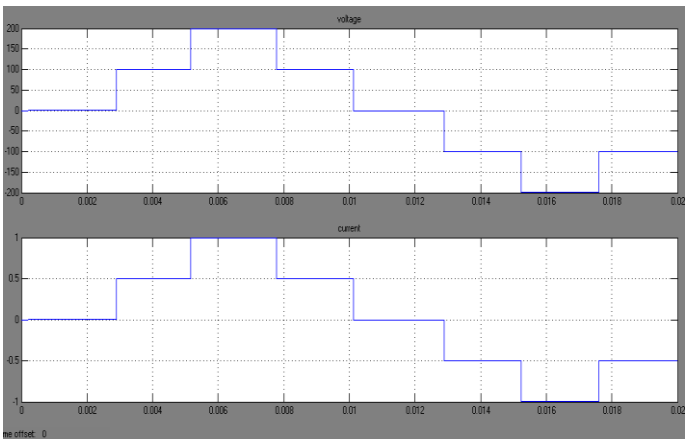


Fig 6 Five level cascaded H-bridge multilevel inverter, output voltage waveform using multicarrier modulation.

Fig 7 Five level cascaded H-bridge multilevel inverter, output voltage and current waveform using embedded matlab function



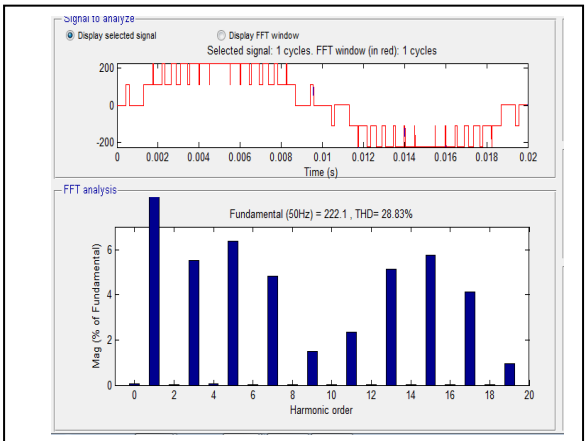


Fig 8. Five level cascaded H-bridge multilevel inverter with multicarrier modulation, THD=28.83%.

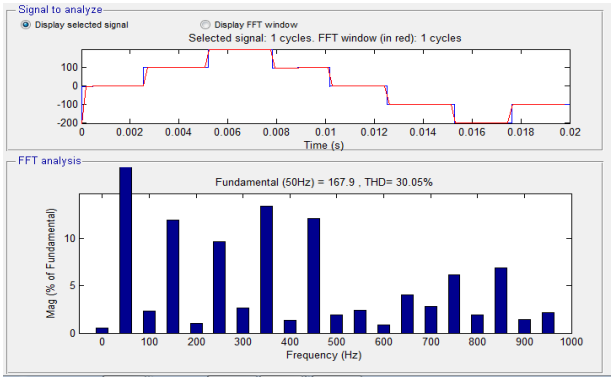


Fig 9. Five level cascaded H-bridge multilevel inverter with embedded matlab function, THD=30.05%.

IV. CONCLUSION

In this paper, a five level cascaded H-bridge multilevel with multicarrier pulse width modulation and embedded matlab function, is presented. The simulation results show that the total harmonic distortion is low for multicarrier modulation method. The total harmonic distortion can be further reduced by using filter circuit. This circuit also reduces the number of switches and sources.

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REFERENCES

[1] Nasrudin Abd. Rahim, Mohamad Fathi Mohamad Elias, Wooi Ping Hew, IEEE transaction. Industry Electronics, "Design of filter to reduce harmonic distortion in industrial power system", Vol. 60, No: 8, 2943-2956, August 2013.

[2] J. Selvaraj and N. A. Rahim, "Multilevel Inverter For Grid-Connected PV System Employing Digital PI Controller," IEEE Trans. Ind.Electron., vol. 56, pp. 149-158, 2009.

[3] Naderi and A. Rahmati, "Phase-Shifted Carrier PWM Technique for General Cascaded Inverters," IEEE Trans. Power Electron. vol. 23, pp. 1257-1269, 2008.

[4] J. Rodriguez, J.-S. Lai, and F. Z. Peng, ―Multilevel inverters: A survey of topologies, controls, and applications,‖ IEEE Trans. Ind. Electron., vol. 49, no. 4, pp. 724–738, Aug. 2002.

[5] M. Malinowski, K. Gopakumar, J. Rodriguez, and M. A. Pérez, ―A Survey on cascaded multilevel inverters,‖ IEEE Trans. Ind. Electron., vol. 57, no. 7, pp. 2197-2206, July 2010.

[6] S. J. Park, F. S. Kang, M. H. Lee, and C. U. Kim, ―A new single-phase five-level PWM inverter employing a deadbeat control scheme,‖ IEEE Trans. Power Electron., vol. 18, no. 18, pp. 831–843, May 2003.

[7] N. A. Rahim, and J. Selvaraj, ―Multistring five-level inverter with novel PWM control scheme for PV application,‖ IEEE Trans. Ind. Electron., vol. 57, no. 6, pp. 2111-2123, June 2010.