

Multilevel Inverters Based On Space Vector Pulse Width Modulation Technique

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ABSTRACT: In this paper, a simplified space–vector pulse width modulation technique for multilevel inverters is proposed. This method is based on the simplification of the space–vector diagram of a five level inverter into that of a three level inverter. In turn, the three level inverter space vector diagram is simplified into that of two level inverter. Hence, the algorithm of five level space-vector pulse width modulation become very similar to that of conventional two level inverter. If simplified by the proposed method, all the remaining procedures necessary for the three-level and five level inverter SVPWM are done like conventional two-level inverter and the execution time is greatly reduced. The dc-link neutral-point potential control algorithms are implemented more easily. And the proposed method can be applied to the multi-level inverters above three and five level.

Keywords- Multilevel inverter, three level inverter, five level inverter, and space-vector PWM method

I. INTRODUCTION

A device that converts DC into AC at desired output voltage and frequency is called an Inverter. Phase controlled converters when operated in the inverter mode are called line commutated inverters. But line commutated inverters require at the output terminals an existing AC supply which is used for their commutation. This means that line commutated inverters can't function as isolated AC voltage sources or as variable frequency generators with DC power at the input. Therefore, voltage level, frequency and waveform on the AC side of the line commutated inverters can't be changed. On the other hand, force commutated inverters provide an independent AC output voltage of adjustable voltage and adjustable frequency and have therefore much wider application.

With increase of semi conductors technology, voltage source inverters have been extending its application in various area. Standard two level voltage source inverter consists of only one switching cell per phase. But in the field of high power driving systems, the level of direct current bus voltage constitutes an important limitation of the handled power. Another drawback is the very high dv/dt generated by the two level voltage source inverter. Multi level inverters have more advantages than the standard two level inverters. Voltage harmonics are lower due to the increase of output voltage levels. Performance of multilevel inverters depends on the PWM algorithm. The triangular-sinusoidal and the hysteresis PWM are dissuaded in the case of multilevel inverters because they cannot deal with the major drawback of multilevel inverters is the DC-link capacitor voltage balancing. The space vector pulse with modulation provides superior harmonics capacity, and permits to solves the problem of unbalanced capacitors voltages by using the redundant states in the space voltage vector plane

1.1 THREE LEVEL INVERTER

A device that converts DC voltage into AC voltage having three different level of output voltage is called as three level inverter.

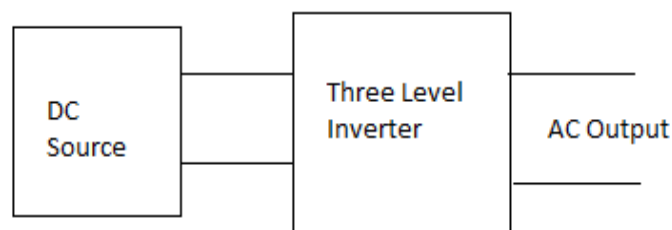


Fig.1. Block Dia. of three level inverter

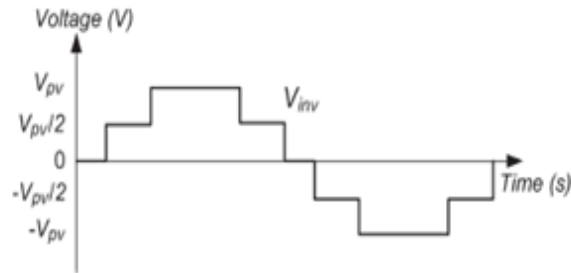


Fig.2. Waveform of three level inverter

1.2 FIVE LEVEL INVERTER

A device that converts DC voltage into AC voltage having five different level of output voltage is called as five level inverter.

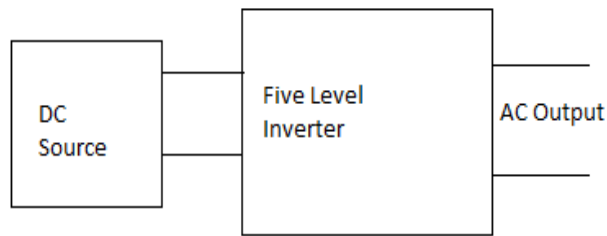


Fig.3. Block Dia. Of five level inverter

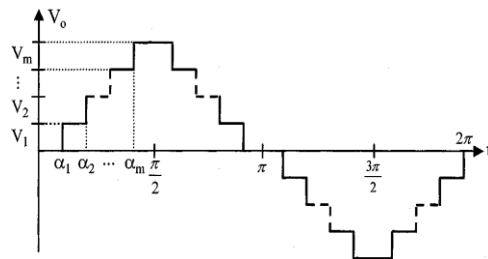


Fig.4. Waveform of five level inverter

II. SVPWM METHOD FOR THREE LEVEL INVERTER

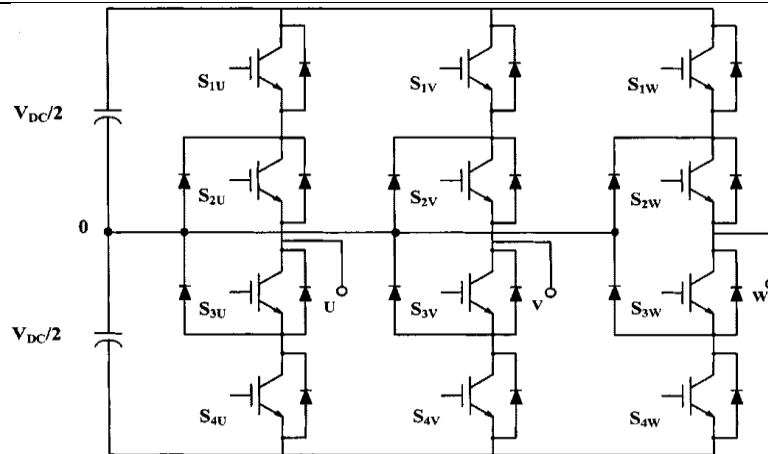


Fig.5.Circuit Diagram Three level inverter

Circuit diagram of a three-level inverter is as shown in fig 5. [1] And the switching states of each phase of the inverter are listed in Table I. There are three kinds of switching states P, O, and N in each phase, so there exist 27 switching states in three phase three level inverter. By using the space-vector diagram of a three-level inverter, the basic principle of the proposed SVPWM method can be easily explained. The space-vector diagram of a three-level inverter, shown in Fig.6, can be thought that it is composed of six small hexagons that are the space-vector diagrams of conventional two-level inverters. Each of these six hexagons, constituting the space-vector diagram of a three-level inverter, centres on the six apices of the inner small hexagon as is shown in Fig.7. So, if these six small hexagons are shifted toward the centre of the inner hexagon by $V_{dc}/3$, the space-vector diagram of a three-level inverter is simplified to that of a two-level inverter. To simplify into the space-vector diagram of a two-level inverter as explained above, the following two steps have to be taken. First, from the location of a given reference voltage, one hexagon has to be selected among the six hexagons. Secondly the original reference voltage has to be subtracted by the amount of the centre voltage vector of the selected hexagon. By these two steps, the three-level space-vector plane is transformed to the two-level space-vector plane.

Table.I. SWITCHING STATE AND TERMINAL VOLTAGE

Switching Indication	Switching Sequence				Voltage
	1	2	3	4	
P	1	1	0	0	$V_{dc}/2$
O	0	1	1	0	0
N	0	0	1	1	$-V_{dc}/2$

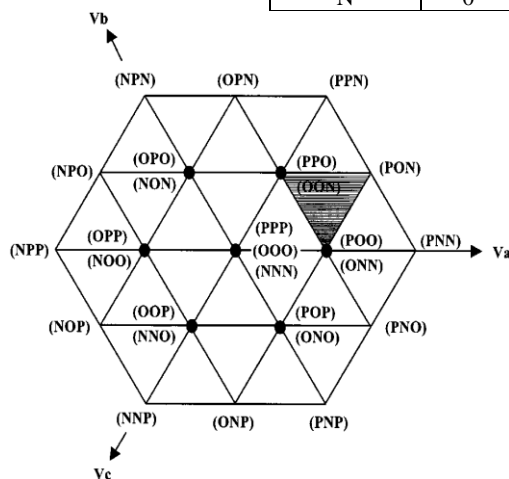


Fig.6. Space vector diagram of

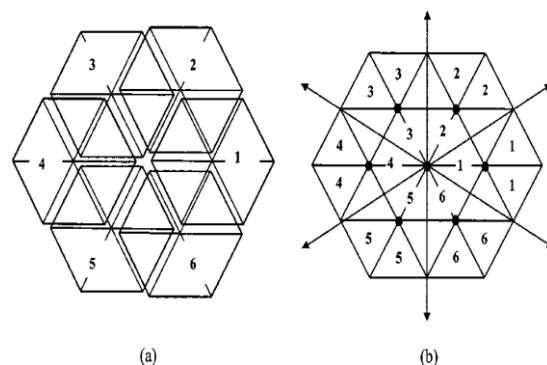


Fig.7. Simplification of three level Space

III. SVPWM METHOD FOR FIVE LEVEL INVERTER

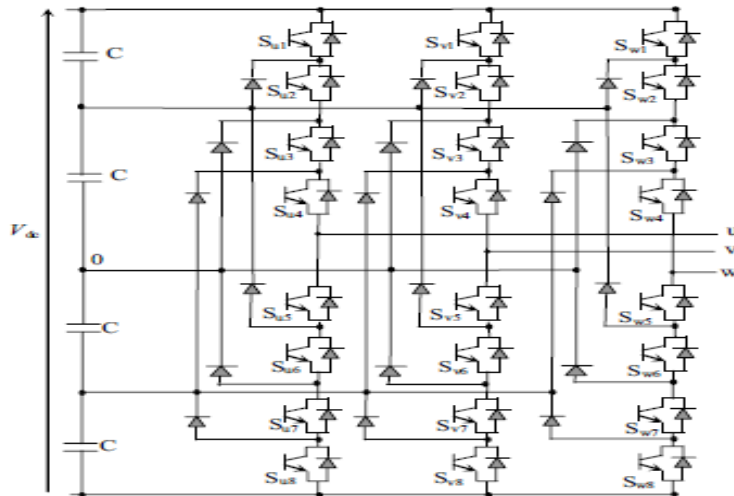


Fig.8.Circuit Diagram Five level inverter

Circuit diagram of a five-level inverter is as shown in fig 8. [2]The space vector diagram of a five level inverter can be thought that is composed of six small hexagons that are the space vector diagrams of the three level inverters. Each of these six hexagons, constituting the space vector diagrams of the three level inverters, centres on the six apexes of the medium hexagon as shown in fig.10. To simplify into the space vector diagram of a three level inverter, two steps have to be taken. Firstly, from the location of a given reference voltage, one hexagon has to be selected among the six hexagons. Secondly, we substrate the amount of the center voltage of the selected hexagon from the original reference voltage. By these two steps, the five level space vector planes is transformed to the three level space vector plane. In turn, the space vector diagram of the three level inverter can be thought that it is composed of six small hexagons that are the space vector diagram of conventional two level inverter. These hexagons are centred on the six apexes of the inner hexagon as shown in fig.10. To simplify into the space vector diagram of a two level inverter, we have to take the two steps mentioned above. After these simplifications, the determination of switching sequence and the calculation of the voltage vector duration time are done as conventional two level space vector PWM methods.

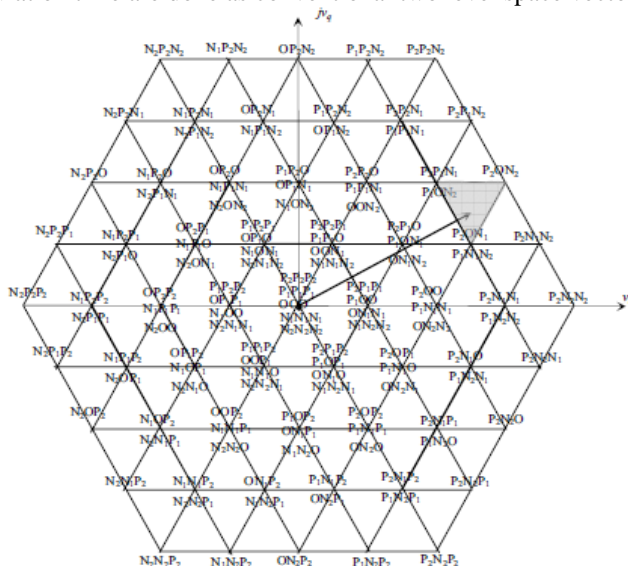


Fig.9. Space vector diagram of five level inverter

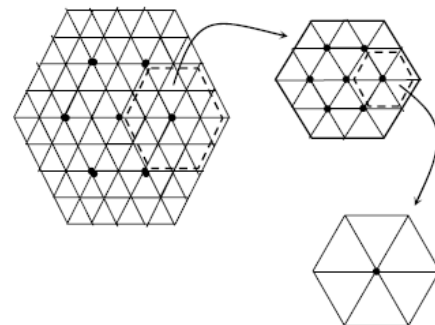


Fig.10. Simplification of five level Space vector diagram

Table.II SWITCHING STATE OF FIVE LEVEL INVERTER

Mode	States							
	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈
P ₂	1	1	1	1	0	0	0	0
P ₁	0	1	1	1	1	0	0	0
O	0	0	1	1	1	1	0	0
N ₁	0	0	0	1	1	1	1	0
N ₂	0	0	0	0	1	1	1	1

IV. CONCLUSION

In this paper, a simplification of the SVPWM applied for multilevel inverter is studied. To make this simplification, the SVPWM for five level inverter is reduced into SVPWM for three level inverter. In turn, the SVPWM for three level inverter is reduced to SVPWM for two level inverter. This simplification reduced considerably the computation time. The balancing of the capacitances voltages in the input side of the inverter can be made by rearranging the time distribution of the redundant voltage vectors. We can generalize this method to high order multilevel inverters.

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