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A Three-Phase Multilevel Hybrid Switched-Capacitor Pwm Pfc Rectifier For High Voltage Gain Applications

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ABSTRACT

To solve the problem that three-to-five-phase matrix converter (MC) cannot supply symmetrical voltages to unbalanced loads, a topology of five-phase six-bridge indirect MC and a carrier-based pulse-width modulation (PWM) method are proposed.

A midline bridge is added to the neutral point of five-phase loads in inverter stage. The neutral point voltage is analyzed and derived by space vector PWM (SVPWM) method for calculating the duty ratio of mid line bridge.

Calculations of other five-phase bridge duty ratios of SVPWM method remain unchanged. All of the duty ratios are used to calculate modulation waves of rectifier stage and inverter stage.

Driving signals of two-stage power switches are generated by comparing the modulation waves with a carrier, which are used to control the neutral voltage as corresponding zero-sequence voltage.

INTRODUCTION

The matrix converter (MC) has attracted much interest because of its many advantages such as four-quadrant running, bi-directional power flow, without intermediate storage element, sinusoidal input currents and output voltages and adjustable input power factor. Furthermore, due to the development of multi-phase (more than three phases) motors, the multi-phase drive system has also attracted much interest in recent years. The multi-phase system has been popularly applied in the fields of aerospace, ship propulsion and defence because of its high fault tolerance, low rotor harmonic current losses and low DC-

link current harmonics. Modulation methods of MC are complex and the complexity highly increases with the increasing number of phases. The space vector (SV) model of three-to-five-phase MC is presented. It is seen that the SV pulse-width modulation (SVPWM) method used for three-to-three-phase MC is extended to three-to-five- phase MC.

In this paper, a carrier-based PWM method of five-phase six bridges indirect MC (IMC) is proposed. The five-phase bridges are seen as a module separated from the midline bridge. Regardless of loads balanced or unbalanced, the five-phase bridges operate in the same way. When the loads are balanced, there are only five-phase bridges running with the midline bridge locked. The midline bridge is unlocked and put into operation when the loads are unbalanced. Moreover, the duty ratio of the midline bridge can be derived by the operation of five-phase bridges. This method can decrease the complexity by solving the problem in 2D coordinate system, and can be widely used with low switching loss.

PROPOSED SYSTEM

A topology of five-phase six-bridge indirect MC and a carrier-based pulse-width modulation (PWM) method are proposed. A midline bridge is added to the neutral point of five-phase loads in inverter stage.

The neutral point voltage is analyzed and derived by space vector PWM (SVPWM) method for calculating the duty ratio of Midline Bridge. Calculations of other five-phase bridge duty ratios of SVPWM method remain unchanged. All of the duty ratios are used to calculate modulation waves of rectifier stage and inverter stage.

Driving signals of two-stage power switches are generated by comparing the modulation waves with

a carrier, which are used to control the neutral voltage as corresponding zero-sequence voltage. Therefore, five symmetrical output voltage sinusoids are obtained under both balanced and unbalanced loads.

TOPOLOGY OF FIVE-PHASES SIX-BRIDGE IMC:

As can be seen, it is composed of the rectifier stage and inverter stage which consists of five bridges (*A*, *B*, *C*, *D* and *E*) and the newly added N-phase bridge. The N-phase Bridge is connected to neutral point (N) of five-phase loads. The rectifier stage is connected to sources through an inductance and capacitance (LC) filter and its each bridge contains bi-directional power switches. *u*a, *u*b, *u*c and *i*a, *i*b, *i*c are three-phase input voltages and currents. *L*f, *C*f are the inductance and capacitance of input filter, respectively. The inverter stage is connected to five-phase loads directly and its six bridges are constituted by insulated gate bipolar transistors and diodes. *u*A, *u*B, *u*C, *u*D, *u*E and *i*A, *i*B, *i*C, *i*D, *i*E are five-phase output voltages and currents. *u*N, *i*N are the N-phase output voltage and current. The rectifier stage and inverter stage are connected directly by DC link, *u*pn, *i*pn are the voltage and current of DC link.

SVPWM THEORY ANALYSIS OF FIVE-PHASES SIX-BRIDGE IMC:

The proposed carrier-based PWM method is on the basis of SVPWM method. Duty ratios of rectifier stage and five phases of the inverter stage are calculated by the theory of SVPWM. The voltages of the inverter stage are analyzed through the calculations of inverter five phases to obtain the modulation method of N-phase under unbalanced loads.

Vector	A^+	B^+	C^+	A^-	B^-	C^-	V_{AB}	V_{BC}	V_{CA}	
$V_0 = \{000\}$	OFF	OFF	OFF	ON	ON	ON	0	0	0	zero vector
$V_1 = \{100\}$	ON	OFF	OFF	OFF	ON	ON	$+V_{dc}$	0	$-V_{dc}$	active vector
$V_2 = \{110\}$	ON	ON	OFF	OFF	OFF	ON	0	$+V_{dc}$	$-V_{dc}$	active vector
$V_3 = \{010\}$	OFF	ON	OFF	ON	OFF	ON	$-V_{dc}$	$+V_{dc}$	0	active vector
$V_4 = \{011\}$	OFF	ON	ON	ON	OFF	OFF	$-V_{dc}$	0	$+V_{dc}$	active vector
$V_5 = \{001\}$	OFF	OFF	ON	ON	ON	OFF	0	$-V_{dc}$	$+V_{dc}$	active vector
$V_6 = \{101\}$	ON	OFF	ON	OFF	ON	OFF	$+V_{dc}$	$-V_{dc}$	0	active vector
$V_7 = \{111\}$	ON	ON	ON	OFF	OFF	OFF	0	0	0	zero vector

CONCLUSION

A topology of five-phase six-bridge IMC is proposed and is controlled by carrier-based PWM method. The five-phase six-bridge IMC can output symmetrical and sinusoidal voltages both under five-phase balanced loads and five-phase unbalanced loads.

This method can decrease switching loss under balanced loads. Furthermore, the method can solve the problem in 2D coordinate system which needs to be solved by the traditional method in the 2D coordinate system. This can reduce the complexity under unbalanced loads.

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