7-Level Semi Cross Switched Multilevel Inverter Fed Induction Motor Drive

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Abstract. Multilevel inverters have more prominent features than 2-level inverter due to various advantages like voltage quality, low EMI etc. The semi cross switched multilevel converter topology need less number of semiconductor switches compared to cascaded H-bridge multilevel inverter, and can be implemented to any number of voltage levels. The operating modes of 7-level semi cross switched multi level inverter are discussed. Three phase seven level inverter fed induction motor is implemented in MATLAB/SIMULINK.

1 Introduction

Now a day's multilevel inverters grab the attention of researchers due to the various advantages like quality output waveform, low EMI, low THD and are suitable for low and medium voltage industrial applications. Many multi-level inverter topologies are proposed and popular among them are the neutral point clamped [2], [3], flying capacitor [4], and cascaded H-bridge [5] structures, neutral point clamped and Flying capacitor multilevel inverters require complex circuitry with the increase in number of levels.

The main topologies of cascade H bridge is symmetrical with equal voltage sources and asymmetrical with unequal DC sources. The problem with asymmetrical topologies is that some switches have to process through main part of voltage so some high voltage switches are required.

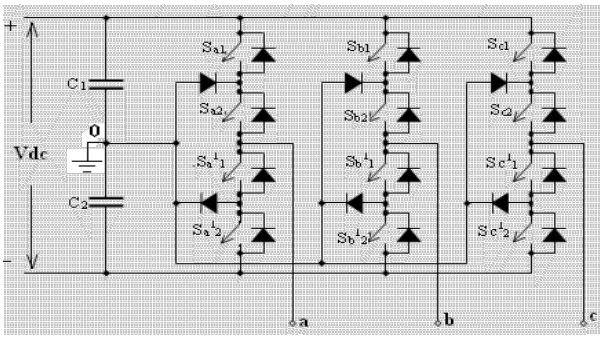

Fig. 1. 3-Phase 3-level Capacitor-Clamped MLI

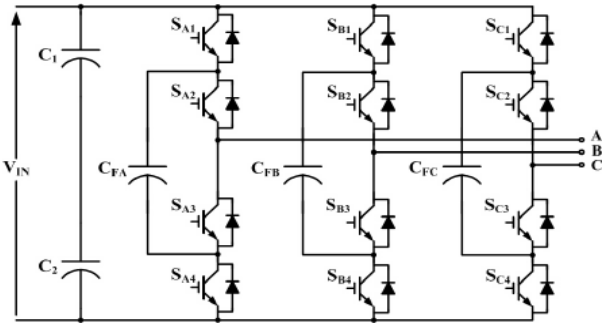

Fig. 2. 3-Phase 3-level Diode-Clamped MLI

2 Cascaded H-bridge Multilevel Inverter

The cascaded H-bridge(CHB) inverters are more interested due to the greater demand of medium-voltage high-power inverters. Full bridge strings are connected in cascaded form with separate dc sources to form CHB. Each full- bridge string generates three voltages at the output $+V_{dc}$, 0 and $-V_{dc}$.

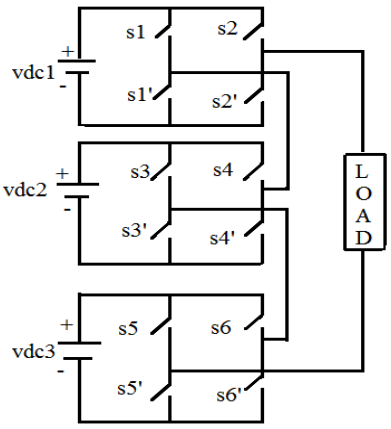

Fig. 3. Single Phase Cascaded H-bridge 7-level Inverter

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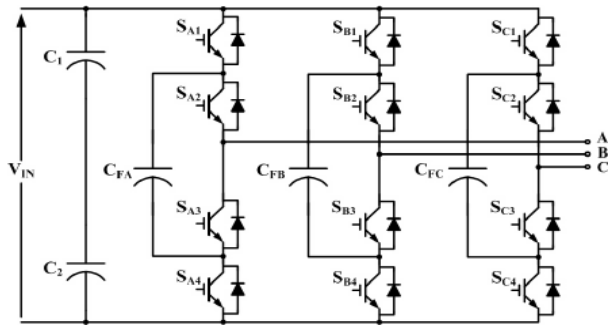


Fig. 4. 3-Phase 3-level Diode-Clamped MLI

Table1: Switching table for 7-level CHB MLI

MODE	Switches ON	O/P Voltage
1	$S_1'S_2S_3S_4S_5S_6$	V_{dc}
2	$S_1'S_2S_3'S_4S_5S_6$	$2V_{dc}$
3	$S_1'S_2S_3'S_4S_5'S_6$	$3V_{dc}$
4	$S_1S_2S_3S_4S_5S_6$	$0V_{dc}$
5	$S_1S_2'S_3'S_4'S_5'S_6'$	$-V_{dc}$
6	$S_1S_2'S_3S_4'S_5'S_6'$	$-2V_{dc}$
7	$S_1S_2'S_3S_4'S_5S_6'$	$-3V_{dc}$

SEMI CROSS SWITCHED MULTI LEVEL INVERTER

In this topology the switches are connected as shown in figure5 and this topology requires less number of switches compared to CHB. For 7-level inverter the number of switches required is only seven i.e S1, S2, S3,S1', S2', S3', S4' Therefore, the complexity in driver circuit, number of switches required, number of switches conducting, THD and efficiency [1] reduces. So size and cost of the inverter is reduced compared to CHB multilevel inverter.

DC Voltage sources V1(100v), V2(100v), V3(100v) for one phase are connected as shown fig. 5. The switches switched as per requirement of voltage level.

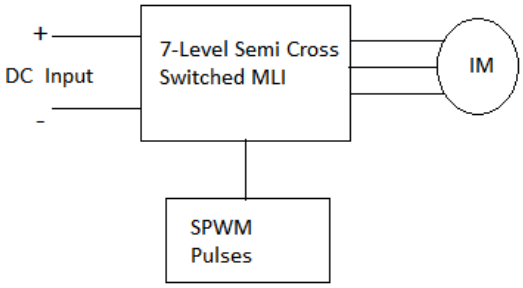


Fig.5. Block Diagram of 7-level semicross switched MLI fed induction motor drive

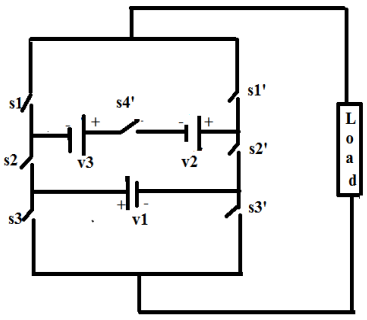


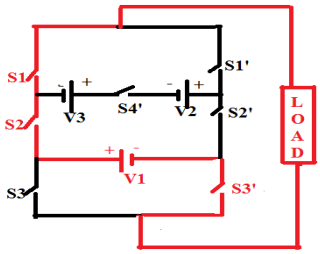
Fig.5. Single phase semi-cross switched multi level inverter

2.1 Modes of Operation

The switching operation of 7-level semi cross switched multilevel inverter shown below

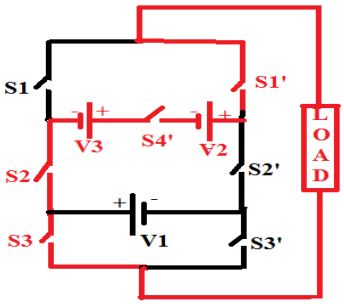
Mode-1:

- The switches s1, s2 and s3' are in ON state.
- The voltage across this load is +vdc.



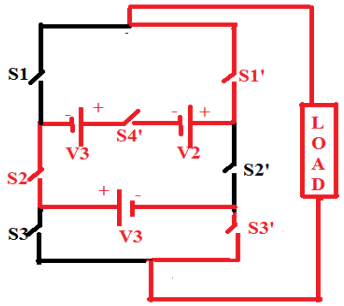
Mode-2:

- The switches s1, s2', s3' and s4' are in ON state.
- The voltage across the load is +2vdc.



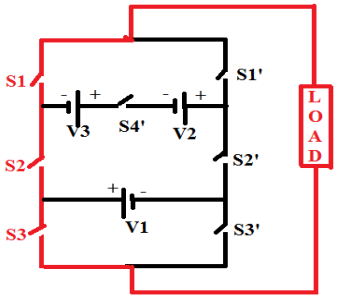
Mode-3:

- The switches s2 , s1',s3' and s4' are in ON state.
- The voltage across the load is +3vdc.



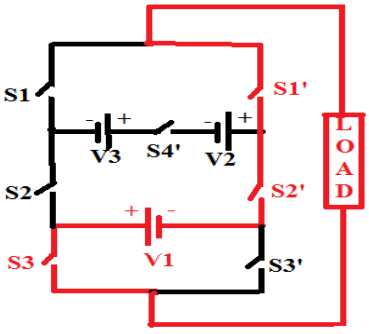
Mode-4:

- The switches s1, s2, and s3 are in ON state.
- The voltage across this load is 0.



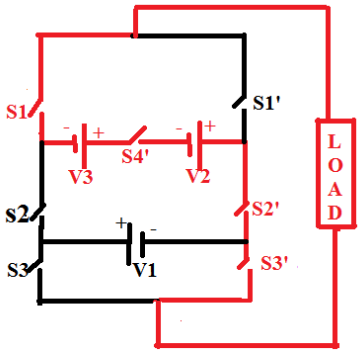
Mode-5:

- The switches s3,s1' and s2' are in ON state.
- The voltage across this load is –vdc.



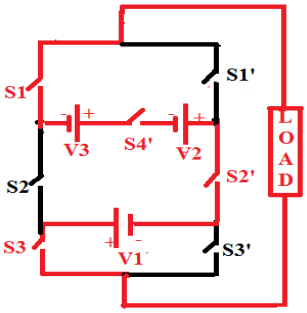
Mode-6:

- The switches s2, s3, s1'and s4'are in ON state.
- The voltage across this load is -2vdc.



Mode-7:

- The switches s1, s3, s2'and s4' are in ON state.
- The voltage across this load is -3Vdc.



3. Results

Simulation of three phase 7-level cascaded H bridge multilevel inverter and semi cross switched multilevel inverter induction motor is performed using MATLAB/SIMULINK environment.

3.1 Three phase 7-level cascaded H-bridge multilevel inverter fed IM

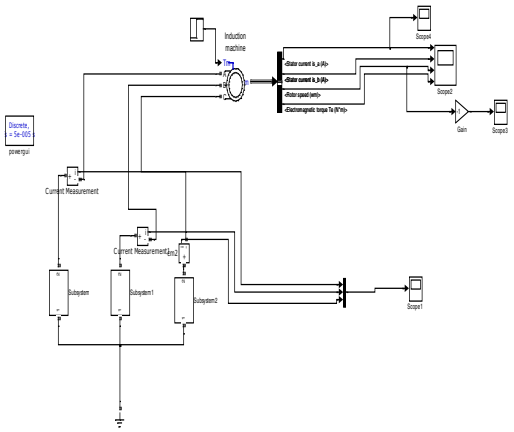


Fig.6. Simulink diagram of Three phase 7-level Cascaded H-bridge multilevel inverter fed IM

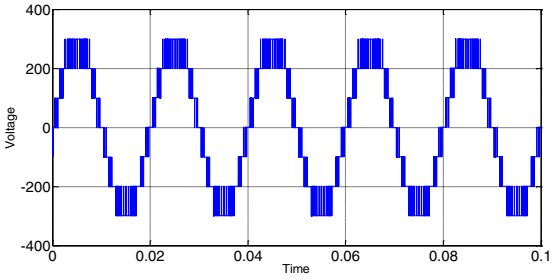


Fig.7. Phase Voltage

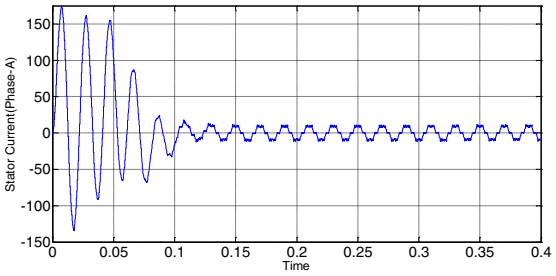


Fig.8. Stator current

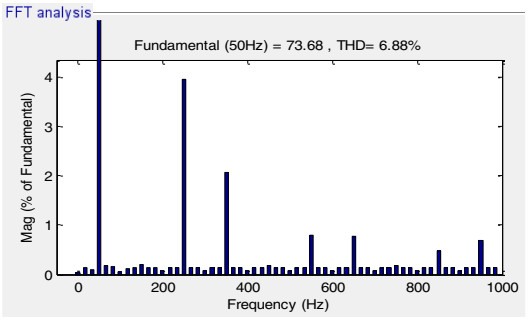


Fig.9. THD analysis of voltage

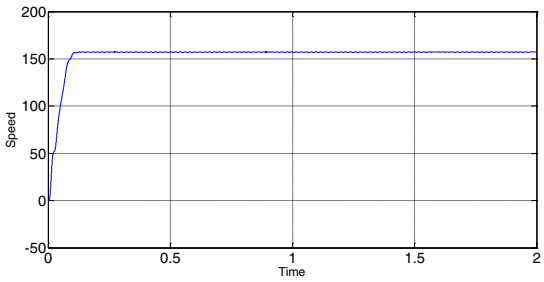


Fig.10. Speed of induction motor

3.2 Three phase 7-Level semi cross switched multilevel inverter

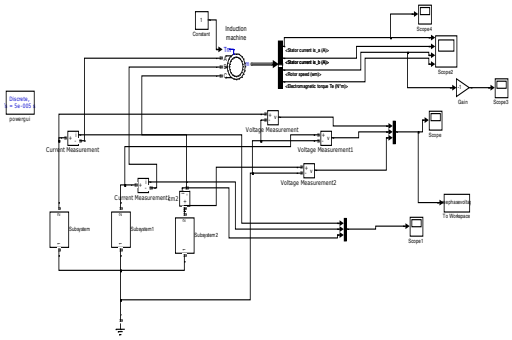


Fig.11. simulink diagram of three phase 7-level semi-cross switched multilevel inverter fed IM

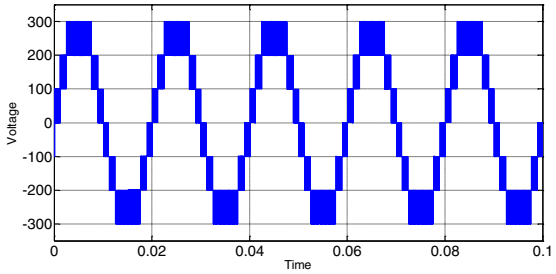


Fig.12. Phase voltage

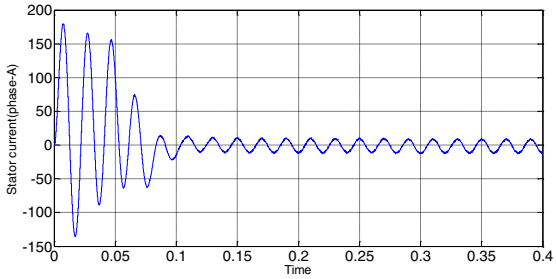


Fig.13. Stator current

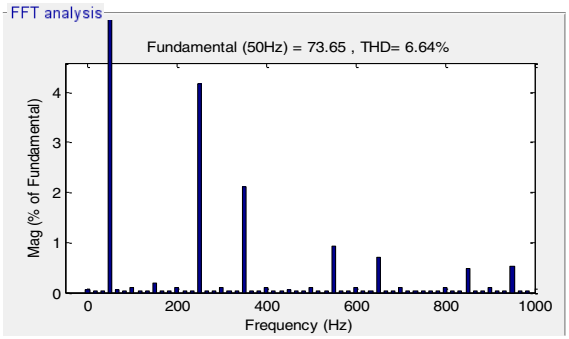


Fig.14. THD analysis of voltage

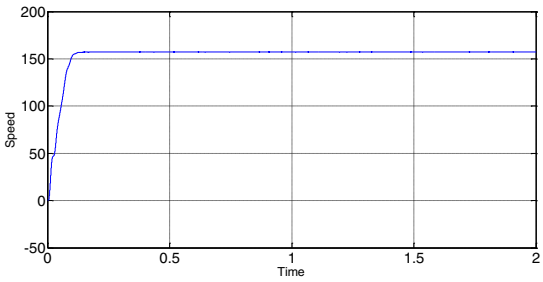


Fig.15. Speed of induction motor

Table 2. Comparison table for number of switching devices

OUTPUT VOLTAGE LEVELS	NUMBER OF SWITCHING DEVICES			
	Cascaded H-Bridge MLI		semi-cross switched MLI	
	1-Phase	3-Phase	1-Phase	3-Phase
7 LEVEL	12	36	7	21

Table 3. Comparison table for THD

OUTPUT VOLTAGE LEVELS	THD	
	Cascaded H-Bridge MLI	semi-cross switched MLI
7 LEVEL	6.68	6.64

Table 4. Comparison table for losses

OUTPUT VOLTAGE LEVELS	Losses/Phase(w)	
	Cascaded H-Bridge MLI	semi-cross switched MLI
7 LEVEL	7.34	4.28

4. Conclusions

The three phase 7- level cascaded H-bridge multilevel inverter and three phase 7-level semi cross switched multilevel inverter fed IM is simulated. From the analysis it clear that number of switches required, THD, and losses are also reduced for semicross switched multilevel inverter.

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