



## 19-Level Cross Switched Multilevel Inverter Fed Induction Motor Drive

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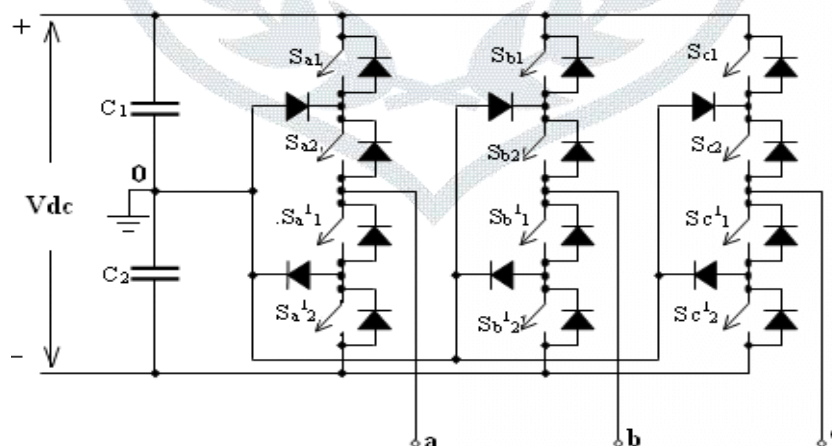
**Abstract :** Multilevel inverters have more prominent features than 2-level inverter due to various advantages like voltage quality, low EMI etc. The semi cross switched multilevel converter topology need less number of semiconductor switches compared to cascaded H-bridge multilevel inverter, and can be implemented to any number of voltage levels. The operating modes of 19-level semi cross switched multi level inverter are discussed. Three phase nineteen level inverter fed induction motor is implemented in MATLAB/SIMULINK.

**Index Terms –** Multilevel Inverter, Cross Sourced, CHB

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



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

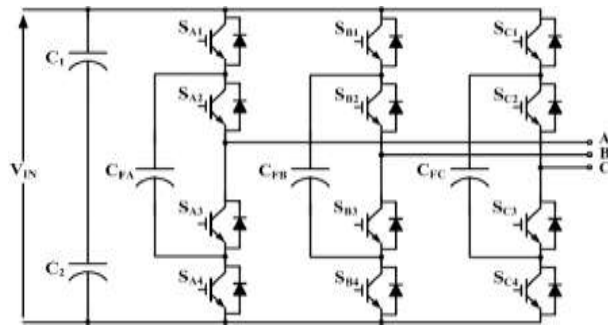


Fig. 2. 3-Phase 3-level Diode-Clamped MLI

II. 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<sub>dc</sub>, 0 and -V<sub>dc</sub>.

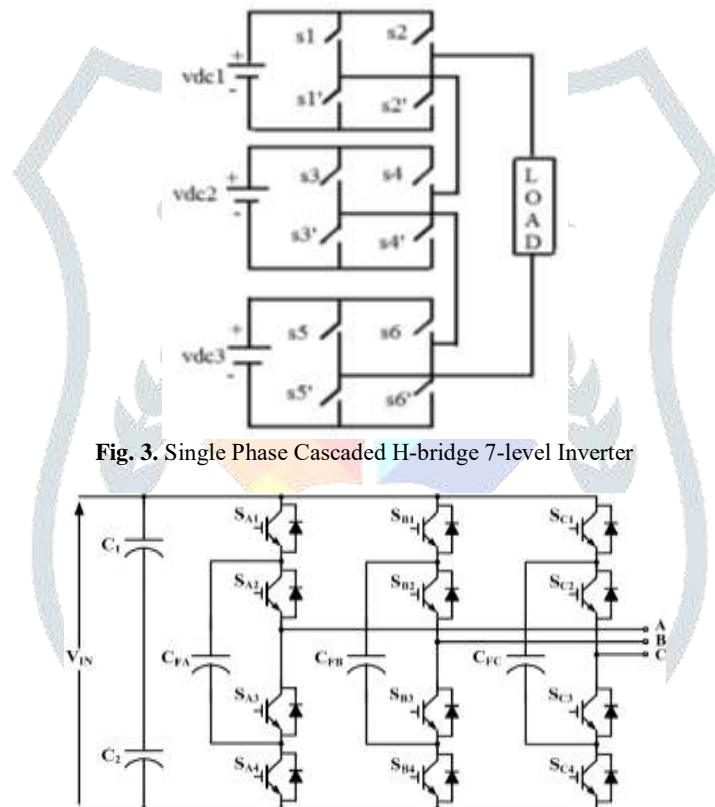


Fig. 3. Single Phase Cascaded H-bridge 7-level Inverter

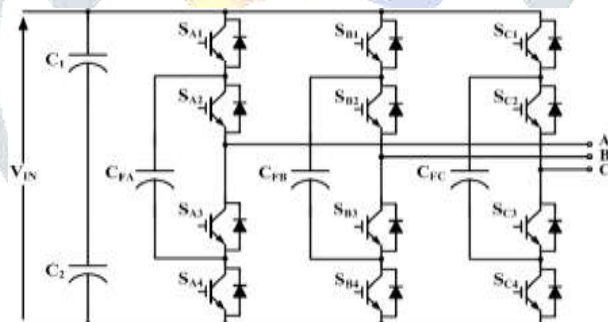


Fig. 4. 3-Phase 3-level Diode-Clamped MLI

Table1: Switching table for CHB MLI

MODE	Switches ON	O/P Voltage
1	$S_1' S_2 S_3 S_4 S_5 S_6$	$V_{dc}$
2	$S_1 S_2 S_3 S_4 S_5 S_6$	$2V_{dc}$
3	$S_1' S_2 S_3 S_4 S_5' S_6$	$3V_{dc}$
4	$S_1 S_2 S_3 S_4 S_5 S_6$	$0V_{dc}$
5	$S_1 S_2 S_3 S_4 S_5' S_6'$	$-V_{dc}$
6	$S_1 S_2' S_3 S_4 S_5 S_6'$	$-2V_{dc}$
7	$S_1 S_2 S_3 S_4 S_5 S_6'$	$-3V_{dc}$

## SEMI CROSS SWITCHED MULTILEVEL INVERTER

In this topology the switches are connected as shown in figure 5 and this topology requires less number of switches compared to CHB. For 19-level inverter the number of switches required is only seven i.e.  $S_1, S_2, S_3, S_1', S_2', S_3', S_4'$ . 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  $V_1(100v), V_2(100v), V_3(100v)$  for one phase are connected as shown fig. 5. The switches are switched as per requirement of voltage level.

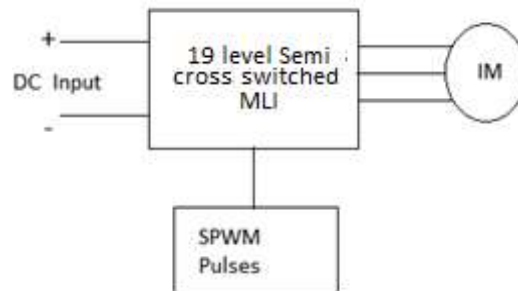


Fig.5. Block Diagram of semicross switched MLI fed induction motor drive

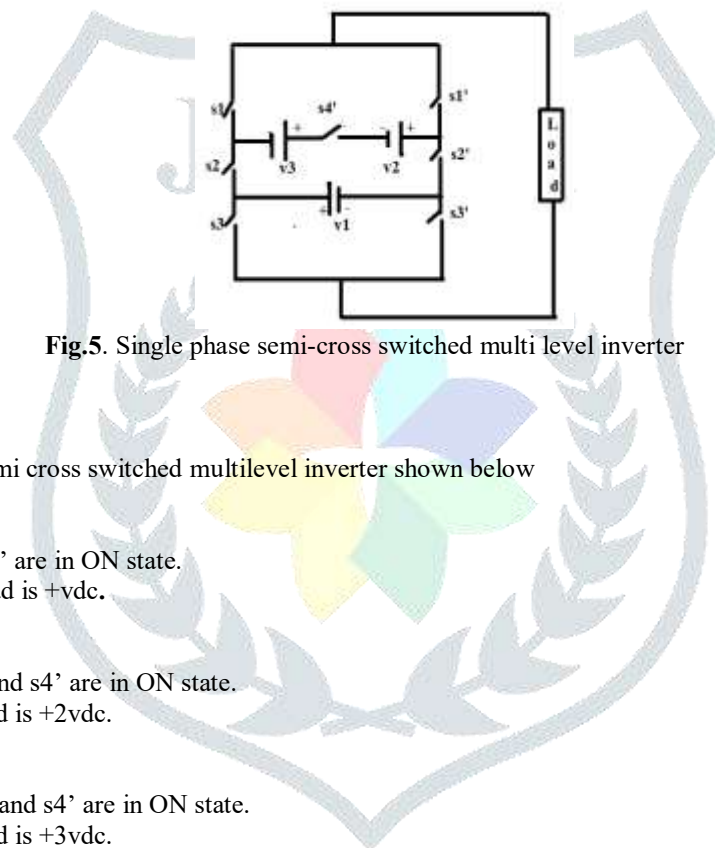


Fig.5. Single phase semi-cross switched multi level inverter

### 2.1 MODES OF OPERATION

The switching operation of semi cross switched multilevel inverter shown below

Mode-1:

- The switches  $s_1, s_2$  and  $s_3'$  are in ON state.
- The voltage across this load is  $+v_{dc}$ .

Mode-2:

- The switches  $s_1, s_2', s_3'$  and  $s_4'$  are in ON state.
- The voltage across the load is  $+2v_{dc}$ .

Mode-3:

- The switches  $s_2, s_1', s_3'$  and  $s_4'$  are in ON state.
- The voltage across the load is  $+3v_{dc}$ .

Mode-4:

- The switches  $s_1, s_2$ , and  $s_3$  are in ON state.
- The voltage across this load is 0.

Mode-5:

- The switches  $s_3, s_1'$  and  $s_2'$  are in ON state.
- The voltage across this load is  $-v_{dc}$ .

Mode-6:

- The switches  $s_2, s_3, s_1'$  and  $s_4'$  are in ON state.
- The voltage across this load is  $-2v_{dc}$ .

Mode-7:

- The switches  $s_1, s_3, s_2'$  and  $s_4'$  are in ON state.
- The voltage across this load is  $-3V_{dc}$ .

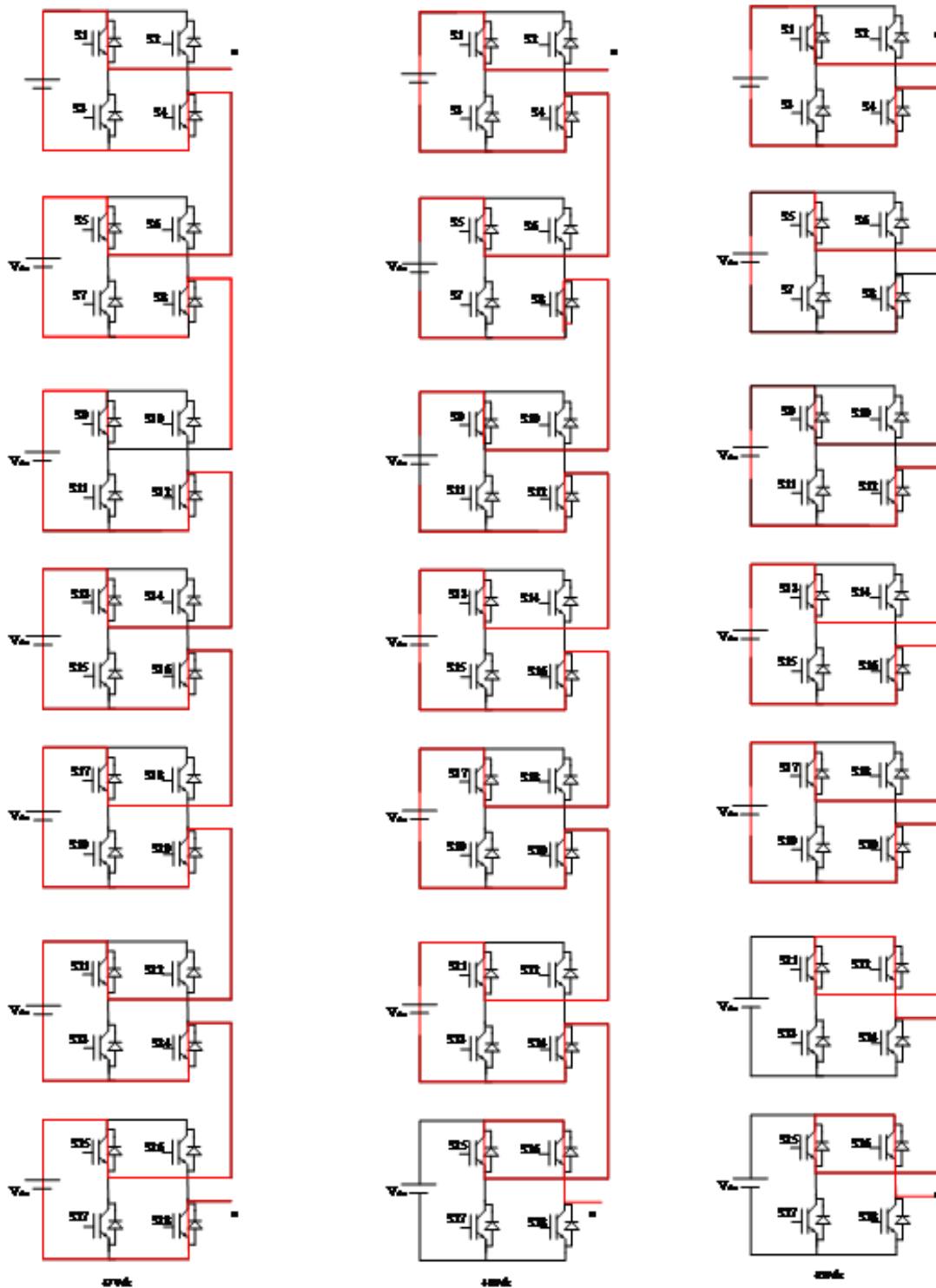


Fig. 6. Modes of Operation

**3. RESULTS**

Simulation of three phase 19-level cascaded H bridge multilevel inverter and semi cross switched multilevel inverter induction motor is performed using MATLAB/SIMULINK environment.

### 3.1 THREE PHASE 19-LEVEL CASCADED H-BRIDGE MULTILEVEL INVERTER FED IM

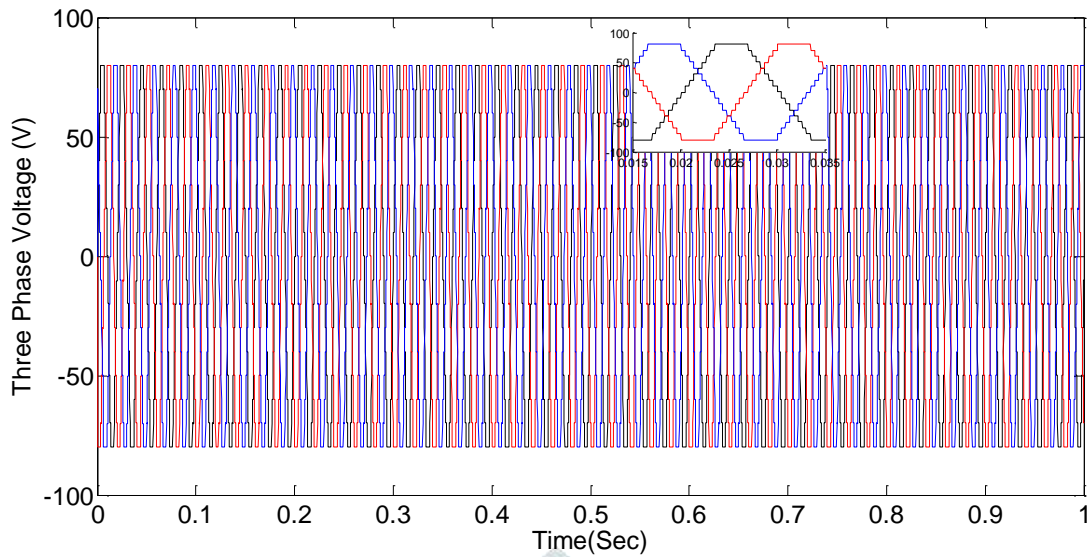


Fig.7. Phase Voltage

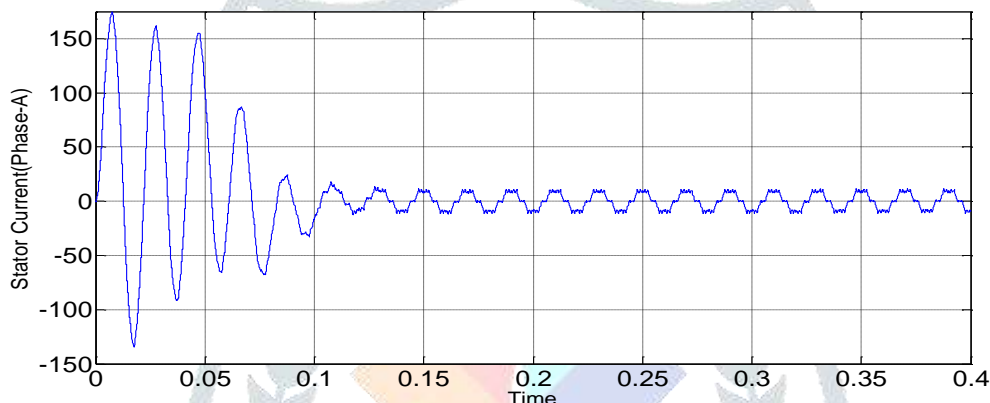


Fig.8. Stator current

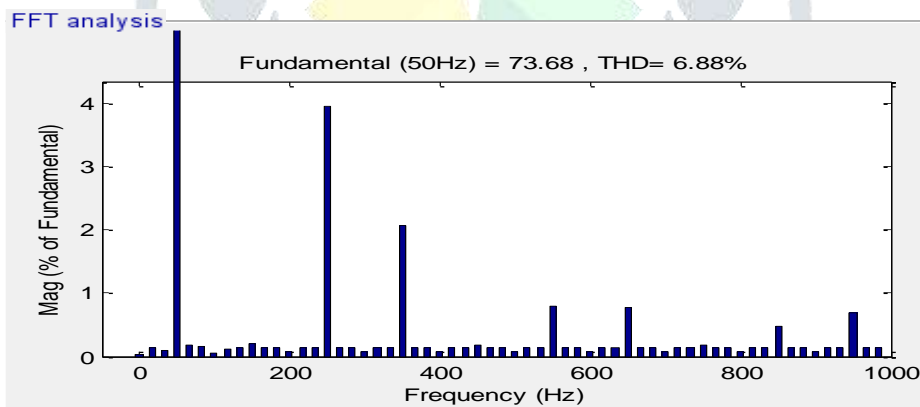


Fig.9. THD analysis of voltage

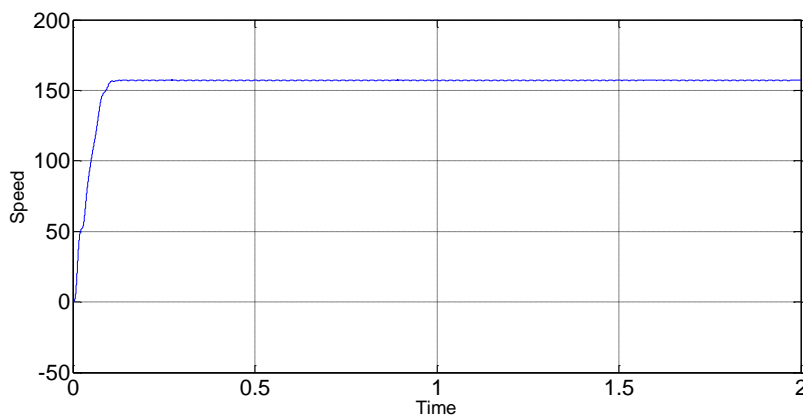


Fig.10. Speed of induction motor

3.2 THREE PHASE 19-LEVEL SEMI CROSS SWITCHED MULTILEVEL INVERTER

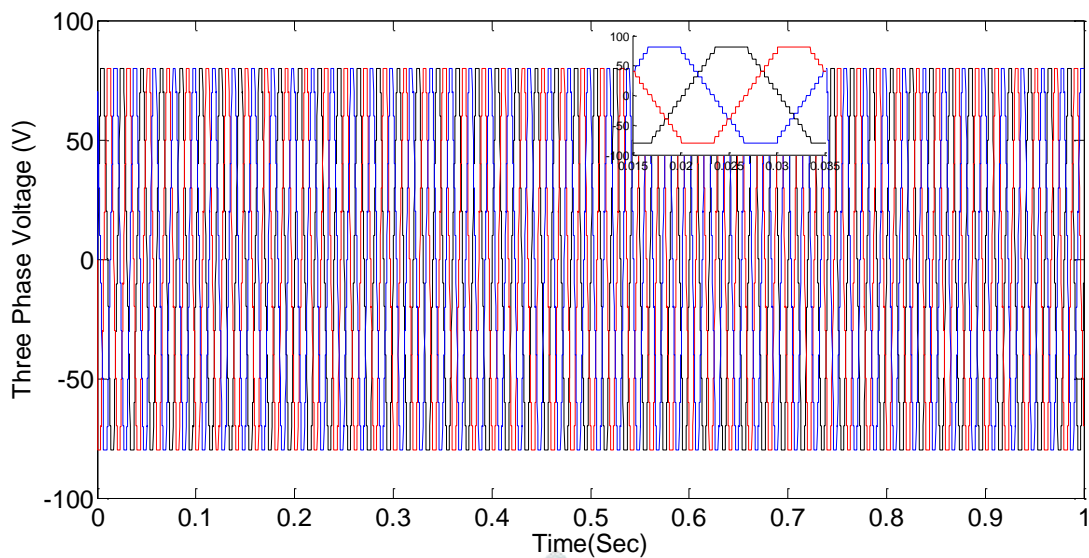


Fig.11. Phase voltage

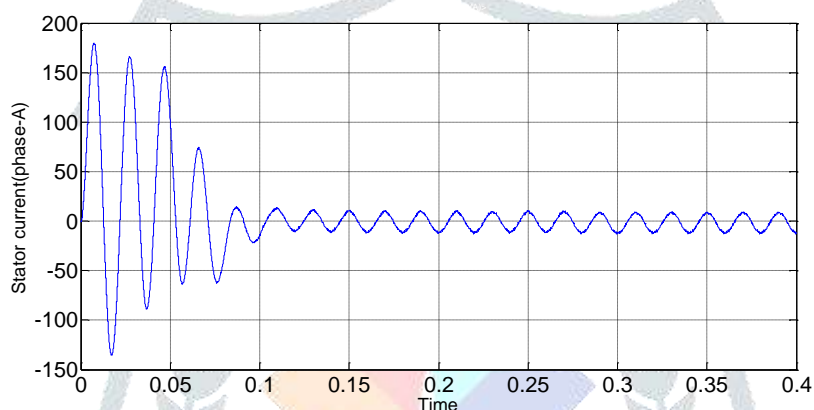


Fig.12. Stator current

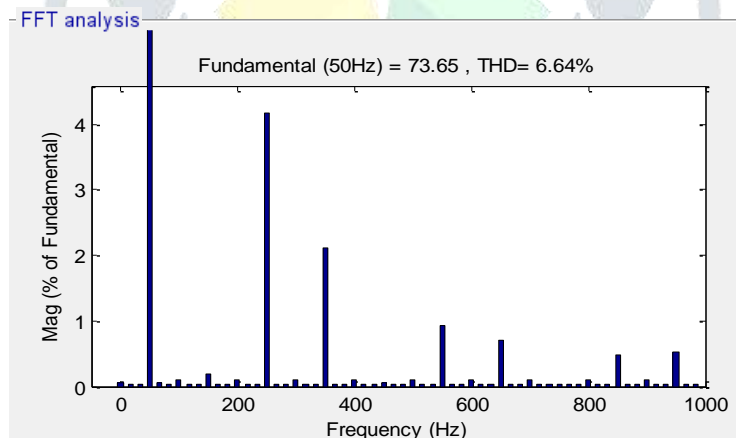


Fig.13. THD analysis of voltage

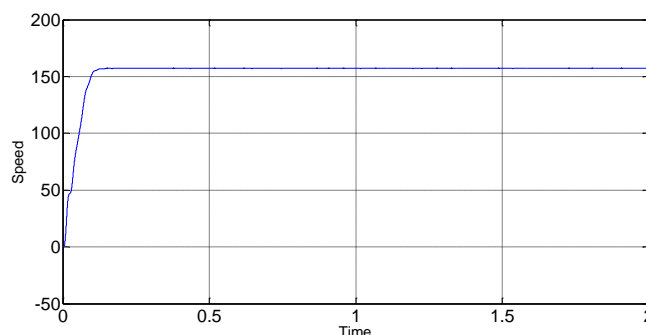


Fig.14. Speed of induction motor

**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
19 LEVEL	12	36	7	21

**Table 3.** Comparison table for THD

OUTPUT VOLTAGE LEVELS	THD			
	Cascaded H-Bridge MLI		semi-cross switched MLI	
19 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	
19 LEVEL	7.34		4.28	

#### IV. CONCLUSIONS

The three phase 19- level cascaded H-bridge multilevel inverter and three phase 19-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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