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# COMPARATIVE STUDY OF MULTILEVEL INVERTER TOPOLOGIES

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## ABSTRACT
Now a day's inverters are used by industrial areas because they provide reduced energy consumption, provides better system efficiency. Implementation of Multilevel Inverter-Fed Induction Motor Drive, there is some topologies like Diode-Clamped Inverter, Capacitor-Clamped Inverter, Cascaded Multicell Inverters, Generalized Multilevel Cells, etc are used. This paper gives comparison of topologies of multilevel inverter.

**KEYWORDS**: Diode-Clamped Inverter, Capacitor-Clamped Inverter, Cascaded Multicell Inverters, Generalized Multilevel Cells.

## INTRODUCTION
In the most of industries like oil sector, gas sectors, production plants and process industries Induction motor drive is used. Induction motors is a self starting constant speed AC motors and the speed of motor is depend upon the frequency of the supply and the no of windings. To control the speed of induction motor uses multilevel inverter drives. Because of its low cost and increased reliability Induction motor is the most widely used? The difficulty in using ac drives lies with the selection of suitable power electronic converter hence Pulse Width Modulation (PWM) is used for the control of the power electronic converter. Multilevel inverter could be a great choice for replacing the conventional voltage source inverters or current source inverters, it provides many advantages like reduced voltage stress, increased quality of output voltage and increased power rating [3].

## INVETER TOPOLOGIES
N. Mohan Teja et al. [1] proposed a system with Diode clamped Multi Level Inverter. An m-level diode-clamp converter typically consists of m - 1 capacitors on the dc bus. Figure 1 shows the Five Level Diode Clamped Inverter. This inverter consists of four capacitors C1, C2, C3, and C4. This type of inverter having some disadvantages or problems like dc link unbalance, turn-on snubbing of the inner dc rails, series association of the clamping diodes indirect clamping of the inner devices,. The problem like indirect clamping problem of the inner devices is solved by auxiliary resistive clamping network and discussed for both the new and conventional diode clamping inverter. Figure 2 shows the new diode clamping inverter, in which total of eight switches and twelve diodes of equal voltage rating is used for the five-level case. This is the same with the conventional diode clamping inverter with diodes in series.

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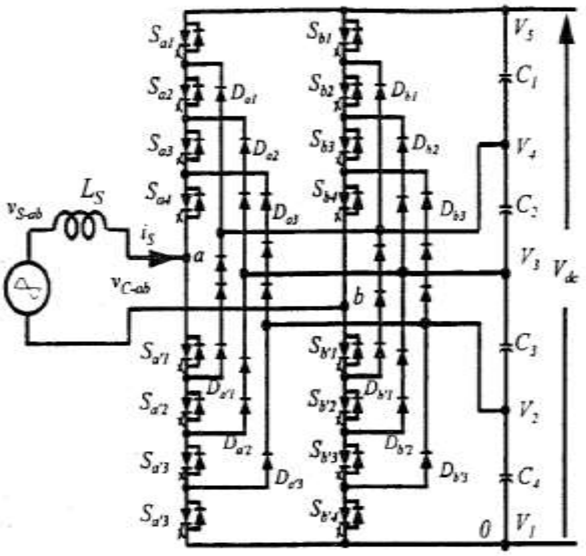


*Figure 1 Five Level Diode Clamped Inverter [1].*

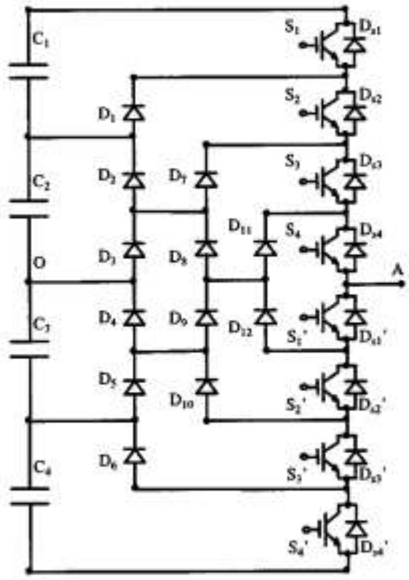


*Figure 2 Circuit Diagram of Five Levels New Diode Clamped Inverter [1].*

Jigar N. Mistry and Pratik H. Savsani [2], presents Performance of Variable Frequency Drive (VFD) using Flying Clamped Capacitor Multilevel Inverter (FCCMLI), in which conventional voltage source inverter-fed induction motor drive is modeled. Here simulation was done by using MatLab simulink. The capacitor clamped inverter alternatively known as flying capacitor and proposed by Meynard and Foch and it is alternative topology for the diode clamped inverter. Figure 3 shows the three-level flying capacitor inverter.

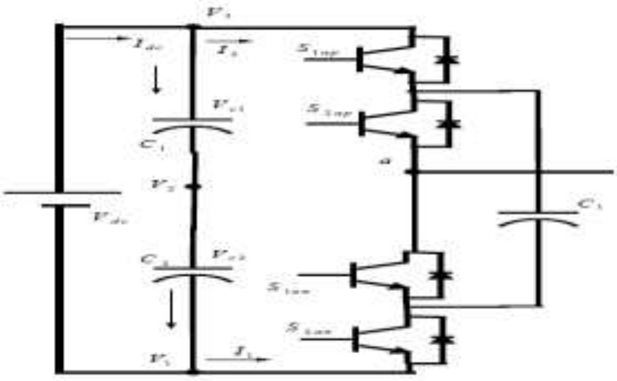

*Figure 3 One Leg of 3 level FCC Inverter [2].*

Each flying capacitor is charged to one-half of the dc voltage and can be connected in series with the phase to add or to subtract this voltage i.e. each phase node (a, b, or c) can be connected to any node in the capacitor bank (V3, V2, V1), also when S1ap and S2ap are turned on positive node V3 occurs and to the neutral point voltage when S2ap and S1an are turned and the negative node V1 is connected when S1an and S2an are turned on. When S1ap and S1an are turned on then capacitor C1 is charged and when S2ap and S2an are turned on then capacitor C1get discharged.

Fang Zheng Peng [4] presents a generalized multilevel inverter (converter) topology with self voltage balancing. This method provides a true multilevel structure that can balance each dc voltage level automatically without any assistance from other circuits. This topology can balance each voltage level by itself regardless of inverter control and load characteristics. Diode-clamped and capacitor-clamped multilevel inverters are derived from the generalized inverter topology. Figure 4 shows the generalized multilevel inverter topology per phase leg. Fig. 4 shows generalized topology, where two-level inverter phase leg can be obtained by cutting off at the “2-level line,” three-level inverter leg by cutting off at the “3-level line,” and so on.

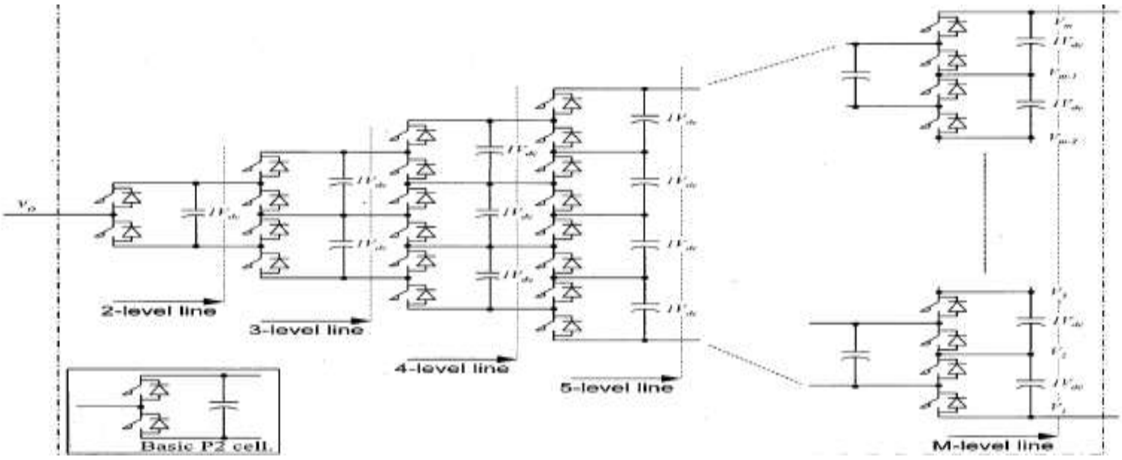


***Figure 4 Generalized multilevel inverter topology (M-level, one phase leg). Inset: basic P2 cell [4].***

Application of Diode clamped multilevel inverter, flying capacitors multilevel inverter and Cascaded H- bridge multilevel inverter are given in table 3 and Table 4 compares the power component requirements per phase leg among the three multilevel voltage source inverter mentioned below. It shows that the number of main switches and main diodes, needed by the inverters to achieve the same number of voltage levels [5].

## COMPARISON OF DIFFERENT MULTILEVEL INVERTER

***Table 3. Applications of different inverter.***

| Diode clamped multilevel inverter | Flying capacitors multilevel inverter | Cascaded H- bridge multilevel inverter |
|---|---|---|
| • Static var compensation<br>• Variable speed motor drives<br>• High voltage system interconnections<br>• High voltage DC and AC transmission lines | • Induction motor control using DTC (Direct Torque Control) circuit<br>• Static var generation<br>• Both AC-DC and DC-AC conversion applications<br>• Converters with Harmonic distortion capability<br>• Sinusoidal current rectifiers | • Motor drives<br>• Active filters<br>• Electric vehicle drives<br>• DC power source utilization<br>• Power factor compensators<br>• Back to back frequency link systems<br>• Interfacing with renewable energy resources. |

***Table 4 Comparison of Power Component Requirements Per Phase Leg Among Three Multilevel Inverters [5]***

| Inverter Configuration | Diode Clamped | Flying – Capacitors | Cascaded– inverter |
|---|---|---|---|
| Main switching devices | 2 (m–1) | 2(m–1) | 2(m–1) |
| Main diodes | 2 (m–1) | 2(m–1) | 2(m–1) |
| Clamping diodes | (m–1) (m–2) | **0** | **0** |
| DC bus capacitors | (m – 1) | (m – 1) | (m – 1)/2 |
| Balancing Capacitors | **0** | (m – 1) (m – 2)/2 | **0** |

Table 5 provides the advantages and disadvantages of the Cascaded H-Bridge Multilevel Inverters, Diode Clamped Inverters and Capacitor Clamped Inverters [6].

**Table 5. Advantages and Disadvantages of different inverters.**

| | Cascaded H-Bridge Multilevel Inverters | Diode Clamped Inverters | Capacitor Clamped Inverters |
|---|---|---|---|
| Advantages | 1. We get same switching frequencies for all the switches.<br>2. Modular structure is easier to analyze. | 1. Low cost and less components due to less number of capacitors.<br>2. Can be operated on SDCS. | 1. Each branch can be analyzed independently |

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| | | | |
|---|---|---|---|
| Disadvantages: | 1. Separate DC sources are required. | 1. For more than three levels, the charge balance gets disturbed.<br>2. Output voltage gets limited. | 1.Pre-charging capacitors is difficult. |

T.Porselvi and Ranganath Muthu at [7] presents the comparison of Cascaded H-Bridge (CHB), Neutral Point Clamped (NPC) and Flying Capacitor (FLC) multi-level voltage source inverters. All inverters are simulated in MATLAB using multi carrier sine pulse width modulation (MCSPWM) at same input voltage, the output voltages obtained with the Cascaded H-Bridge (CHB) inverter is twice the voltage with Neutral Point Clamped (NPC) or Flying Capacitor (FLC) inverters. Table 6 shows the output voltage levels for the three MLIs.

***Table 6 Input and Output Voltages of Three Inverters [7].***

| Name of the Inverter | Input voltage | Output voltage levels |
|---|---|---|
| Cascaded H-bridge (CHB) Inverter | 200V | +200V, +100V, 0V.-100V, -200V |
| Neutral Point Clamped (NPC) Inverter | 200V | +100V, +50V, 0V.-50V, -100V |
| Flying-capacitor (FLC) Inverter | 200V | +100V, +50V, 0V.-50V, -100V |

## CONCLUSION

The single phase inverter requires its own isolated DC supply typically derived from a multi-winding low frequency transformer or high frequency DC-to-DC converter clamped structure is unsuitable because of difficulty of balancing the series DC capacitor voltage. To solve this problem hybrid inverter topology has been proposed.

As compared to other topologies cascade H-Bridge has some advantages. This is easily extensible to high number of level & easy to implement. It can distribute the switching signals correctly in order to minimize switching losses. It also provides the facility to compensate unbalance DC source. It reduces harmonic distortion & enhanced the fundamental output voltage.

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