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IJIEMR Transactions, online available on 10th Oct 2017. Link :http://www.ijiemr.org/downloads.php?vol=Volume-6&issue=ISSUE-9

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Volume 06, Issue 09, Pages: 16– 22.

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# ASYMMETRICAL MULTI LEVEL INVERTER FOR INDUCTION DRIVE APPLICATIONS

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**ABSTRACT:** In recent years multilevel inverters are much focused because of their ability to reduce losses and improved power quality. They produce virtually sinusoidal output voltage waveforms. Although there are numerous topologies of multilevel inverters in writing, prominent among them are cascaded multilevel inverter, this paper examines the capacities of cascaded multilevel inverter to deliver more output voltage levels with same number of H-bridges, however with various different voltage ratios. The increased levels with different voltage ratios reduces THD of multilevel inverter. The proposed inverter with PI controller in a closed loop is fed to induction motor and simulation results are shown.

**Keywords:** Asymmetrical Multilevel Inverter, Cascaded Multilevel Inverter, Pulse Width Modulation (PWM), THD, PI Controller, Induction Motor.

## I.INTRODUCTION

Multilevel inverters have received added awareness for their capacity on high-power and medium voltage capacity and on account of previous remuneration such as high power quality, lower order harmonics, minimum switching losses and moved forward electromagnetic impedance. Furthermore multilevel inverters are promising, they have for all intents and purposes sinusoidal output voltage waveforms, output current with enhanced symphonious profile, a lesser measure of pushing of electronic components owing to decreased voltages, switching losses that are substandard than those of unsurprising two-level inverters, a slighter channel size, all of which make them less expensive, lighter, and the sky is the limit from there conservative. These inverters make a ventured voltage waveform by method for various dc voltage sources as the info and an appropriate game plan of the force semi conductor-based devices. Three noteworthy structures of the multilevel inverters have been displayed: "diode clamped multilevel inverter," "flying capacitor multilevel inverter," and "cascaded multilevel inverter". The cascaded multilevel inverter is gathered of various single-phase H- bridge inverters and is grouped into symmetric and awry gatherings in light of the extent of dc voltage sources. In the symmetric sorts, all the dc voltage wellsprings of cascaded H-

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bridges are having parallel sizes, while in the uneven sorts; the estimations of the dc voltage wellsprings of all H bridges are divergent. In topical years, various topologies with different control procedures have been exhibited for cascaded multilevel inverters. Assorted symmetric cascaded multilevel inverters have been exhibited.The chief preferred standpoint of every one of these structures is the short assortment of dc voltage sources, which is one of the most huge elements in deciding the expense of the inverter. Then again, in light of the fact that some of them use a hoisted number of bidirectional power switches, a high number of protected entryway bipolar transistors (IGBTs) are essential. The significant favorable position of this lopsided topology and its calculations is related to its capacity to make a significant number of output voltage levels by utilizing a low number of dc voltage sources and power switches however, the high differing qualities in the greatness of dc voltage sources is their generally exceptional impediment. Recently, asymmetrical and hybrid multistage topologies are getting to be a standout amongst the most intrigued research range. In the lopsided designs, the extents of dc voltage supplies are uneven. These topologies reduce the expense and size of the inverter and show signs of improvement unwavering quality since lesser number of power electronic components, capacitors, and dc supplies are utilized. The half breed multiphase converters comprise of divergent multilevel designs with uneven dc voltage supplies. Bidirectional switches with an appropriate control strategy can upgrade the execution of multilevel inverters as far as falling the number of semiconductor parts, minimizing the withstanding voltage and accomplishing the required output voltage with more elevated amounts. The sizes of the used dc voltage supplies have been chosen in a way that brings the raised number of voltage levels with a successful use of an essential frequency staircase regulation system.

## II.PROPOSED CONCEPT

### A.System Topology

Hybrid Multilevel Inverter was introduced by method for each of the 3M possible output voltages, where M is the quantity of modules allied in series. In spite of the fact that this inverter utilizes to a great degree distinguish, DC voltage sources in the connection of 1:3:9 and so forth. In recognize, the DC voltages sources consider in this paper are still incredibly near each other, they fluctuate just by ±20 %. The amount of cells in succession decides the quantity of output levels. 3M= 27 switching states SI, when M= 3 cells. With comparative DC voltages, there are various switching states that make the same yield voltages, coming about in 2.M + 1= 7 diverse stage yield voltage levels. Uneven DC source voltages direct to an enhanced number of various output voltage levels. The maximum number of levels is 3M = 27. When the DC source voltages are uneven but only ±20 % unlike from each other, the number of different output voltage levels is also superior. As an instance, we believe a case where one cell has 100 % of its nominal DC voltage, other has 120% and the third one has 80%. The DC source voltages are in

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relation of 4:5:6 in this scheme. As can be seen, the voltage levels are approximately the same as in the 1:3:9 case, apart from some levels not there at high complete values of output voltage.

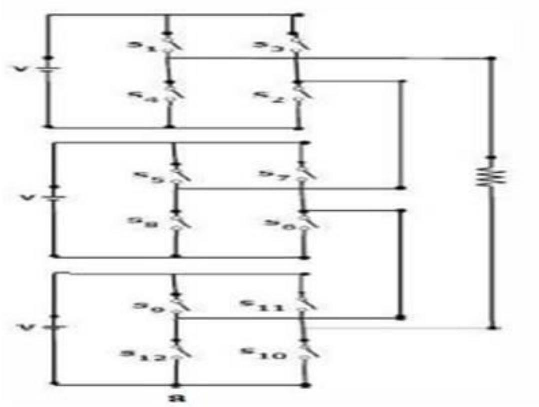


**Fig1. Asymmetrical cascaded multilevel inverter topology with different ratios of input voltages.**

This inverter having 3 bridges connected in series gives different levels of output voltages without changing the circuit except the ratios of input voltages. Switching of the converter is done by following the staircase control technique. Pulse width Modulation technique can also be applied by appropriate calculation of the switching time period. From the proposed cascaded asymmetrical multilevel inverter topology, it is clearly seen that the level of inverter varies with the change in the ratios of input voltage. The proposed topology with different voltage levels is compared and their THD values are observed. The inverter gives 7 level output voltage when the ratio is 1: 1: 1 and its THD is observed as 31.07% while it gives 23 level output voltage when the ratio is 4:5:6 and it has the THD of 23.85% and it gives 27 level output voltage when the ratio is 1:3:9 and its THD is observed as 7.11%. As we know as the levels increases the harmonics reduces and the system virtually produces sinusoidal output waveform. THD value of 27 level cascaded multilevel inverter is 7.11% which is less compared to other levels. The system with less THD is connected to induction motor for better performance of the system. In order to consider the possible benefits of using unlike DC voltages, the 1:3:9 relation is used as an instance in the following part.

**B.Advantages of Multilevel Inverter for Motor Drive Applications**

An induction motor is a paradigm of asynchronous AC machine, which consists of a stator and a rotor. This motor is extensively used because of its well-built features and sensible cost. Induction motors are used in many industrial applications such as heating, ventilation, air conditioning systems, waste water treatment plants, blowers, fans, textile mills, and in rolling mills, etc.. The induction motor synchronous speed is characterized by taking after condition, Ns= 120f/p

Where f is the frequency of AC supply, n is the speed of rotor, p is the quantity of posts per period of the motor.By adjusting the frequency of control circuit all through AC supply, the rotor pace will adjust. The induction motor speed variety can be easily accomplished for a short assortment by either stator voltage control or rotor resistance control. By keeping up a relentless Vlf proportion, the maximum torque of the motor gets to be consistent for evolving speed. Since voltage and

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frequency are the huge parameters to be considered for control the rate of impelling motor, consequently inverters are chosen as the front end converters for instigation motor, which can controlled together voltage and frequency. So, we use multilevel inverters for speed control of motor drives.

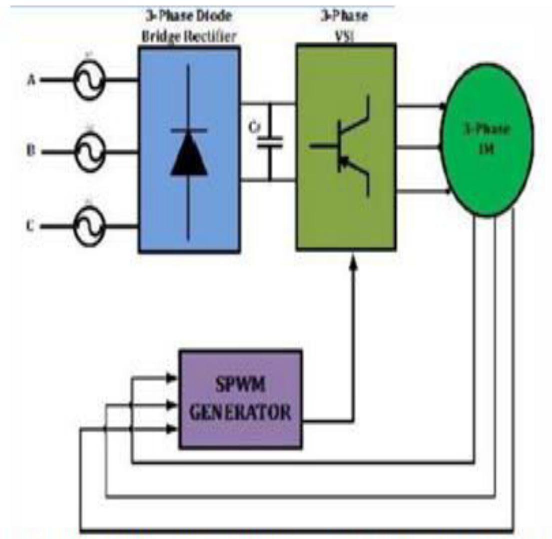


Fig2. Block Diagram Schematic of V/f control of VSI fed 3- phase Induction Motor Drive.

## III.CONTROL SCHEME

The 27 output voltage levels are obtained if a voltage ratio of modules is 1:3:9. To get a voltage of Vdc switches S1, S2, S6, S8, S10, S12 should be turned ON. Switches S1, S2 are turned ON to get a voltage of Vdc. Switches S6, S8, S10, S12 are turned ON to short circuit and get voltage of 0. So that the resultant voltage will be Vdc. By switching of different switches we can get different voltage level. In order to compute all attainable output voltages Vol, the phase voltage vector is multiplied with all $3n$ possible switching states S1

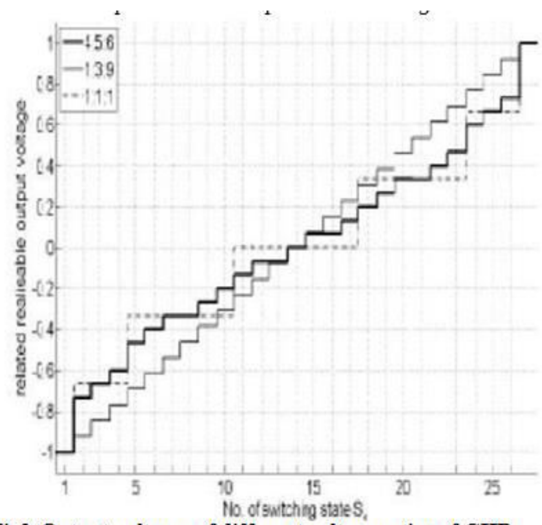


Fig3. Output voltages of different voltage ratios of CHB.

Table 1. Switching Sequence of 27-Level Multilevel Inverter.

| VOLTAGES | SWITCHES | | | | | |
|---|---|---|---|---|---|---|
| Vdc | S1 | S2 | S6 | S8 | S10 | S12 |
| 2Vdc | S3 | S4 | S5 | S6 | S10 | S12 |
| 3Vdc | S2 | S4 | S5 | S6 | S10 | S12 |
| 4Vdc | S1 | S2 | S5 | S6 | S10 | S12 |
| 5Vdc | S3 | S4 | S7 | S8 | S9 | S10 |
| 6Vdc | S2 | S4 | S7 | S8 | S9 | S10 |
| 7Vdc | S1 | S2 | S7 | S8 | S9 | S10 |
| 8Vdc | S3 | S4 | S6 | S8 | S9 | S10 |
| 9Vdc | S2 | S4 | S6 | S8 | S9 | S10 |
| 10Vdc | S1 | S2 | S6 | S8 | S9 | S10 |
| 11Vdc | S3 | S4 | S5 | S6 | S9 | S10 |
| 12Vdc | S2 | S4 | S5 | S6 | S9 | S10 |
| 13Vdc | S1 | S2 | S5 | S6 | S9 | S10 |
| 0Vdc | S2 | S4 | S6 | S8 | S10 | S12 |
| -Vdc | S3 | S4 | S6 | S8 | S10 | S12 |
| -2Vdc | S1 | S2 | S7 | S8 | S10 | S12 |
| -3Vdc | S2 | S4 | S7 | S8 | S10 | S12 |
| -4Vdc | S3 | S4 | S7 | S8 | S10 | S12 |
| -5Vdc | S1 | S2 | S5 | S6 | S11 | S12 |
| -6Vdc | S2 | S4 | S5 | S6 | S11 | S12 |
| -7Vdc | S3 | S4 | S5 | S6 | S11 | S12 |
| -8Vdc | S1 | S2 | S6 | S8 | S11 | S12 |
| -9Vdc | S2 | S4 | S6 | S8 | S11 | S12 |
| -10Vdc | S3 | S4 | S6 | S8 | S11 | S12 |
| -11Vdc | S1 | S2 | S7 | S8 | S11 | S12 |
| -12Vdc | S2 | S4 | S7 | S8 | S11 | S12 |
| -13Vdc | S3 | S4 | S7 | S8 | S11 | S12 |

At present, the PI controller is most broadly received in mechanical application because of its straightforward structure, simple to outline and minimal effort.. PI controller will dispense with

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constrained motions and steady state error resulting about operation of on-off controller and P controller individually. Be that as it may, presenting indispensable mode negatively affects rate of the reaction and general strength of the system. In this manner, PI controller won't expand the pace of reaction. PI controllers are all the time utilized as a part of industry, particularly when rate of the reaction is not an issue. Along these lines, the PI controller has the accompanying focal points:

- The PI controller helps in reducing steady state error, in this way making the system more steady.
- It makes the system to react speedier.

In light of the accompanying points of interest the unbalanced fell multilevel inverter with PI controller is utilized as a part of shut circle to enhance the execution and reduce THD of the system.

## IV.SIMULATION RESULTS

In the proposed system we use PI controller in closed loop. At present, the PI controller is most widely adopted in industrial application due to its simple structure, easy to design and low cost. As we know the gain will be improved in closed loop operation as compared to open loop operation. So the cascaded multilevel inverter with PI controller is used for closed loop operation for the proposed system. The closed loop system performance is better than open loop because the gain will be improved of the system and the parameters of the system can be easily varied and controlled. So, the open loop 27 level cascaded multilevel inverter is operated with PI controller for better performance and the THD value is 6.08% which is better than 27 level multilevel inverter with open loop whose THD is 7.11%. The output is given to induction motor and the speed, torque, current characteristics are observed through simulation results.

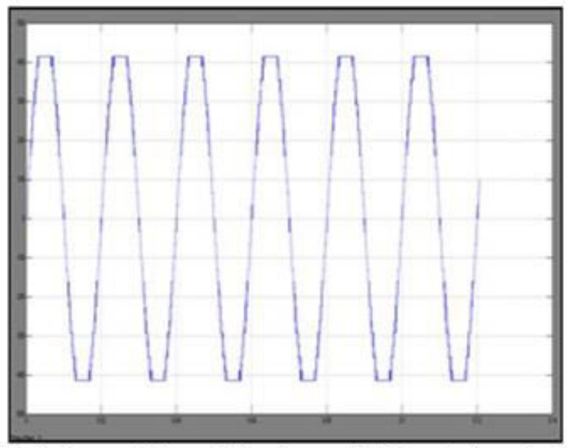

**Fig4. Output Voltage Waveform of 27 Level Cascaded Multilevel Inverter.**

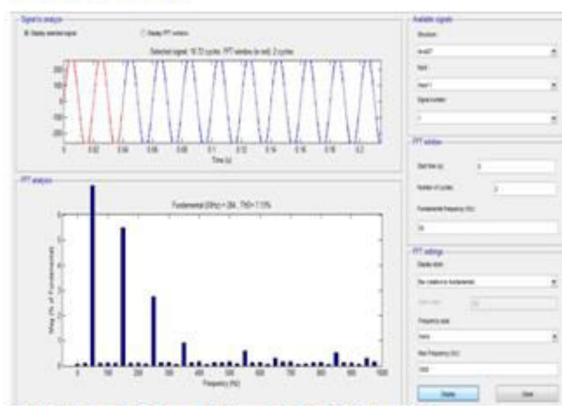

**Fig5. THD of 27 level Cascaded Multilevel Inverter.**

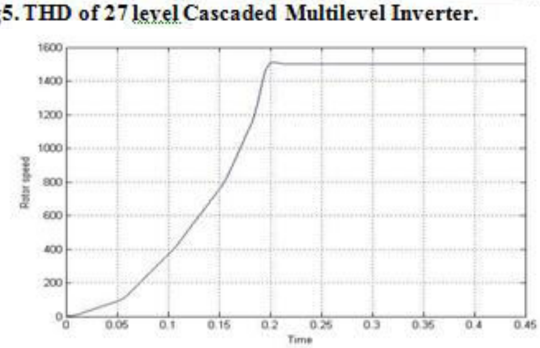


**Fig6. Speed Characteristics of Induction Motor For 27 Level Cascaded Multilevel Inverter.**

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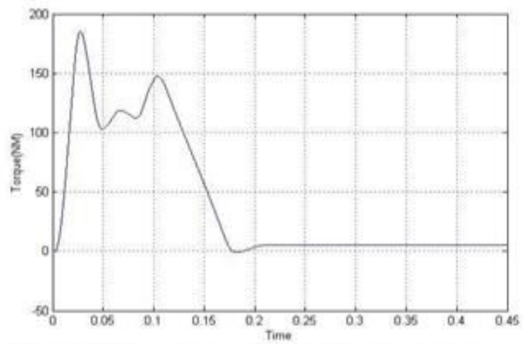


Fig7. Torque Characteristics of Induction Motor For 27 Level Cascaded Multilevel Inverter.

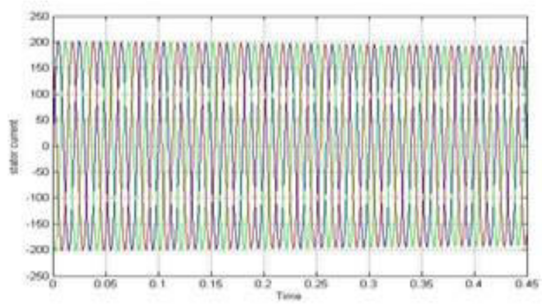


Fig8. Stator currents of Induction Motor For 27 Level Cascaded Multilevel Inverter.

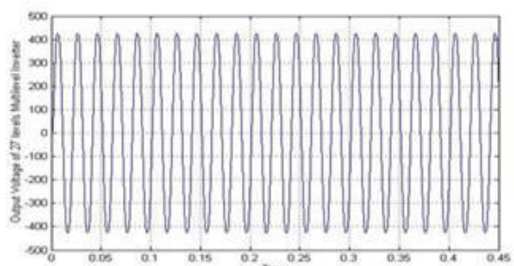


Fig9. Output Voltage Waveform of 27 levels Multilevel Inverter with PI controller.

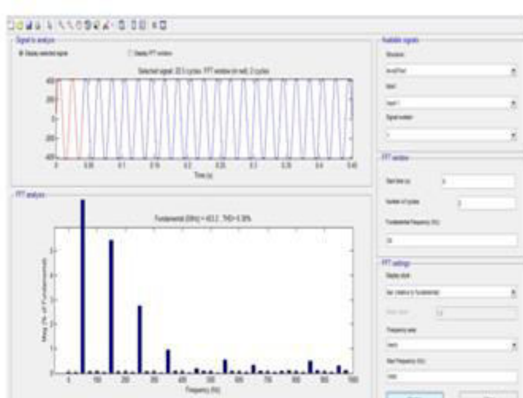

Fig10. THD of 27 level Cascaded Multilevel Inverter with PI controller.

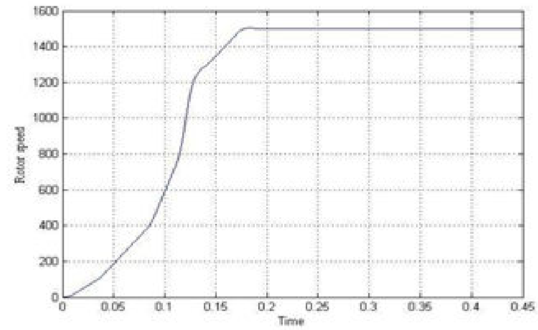


Fig11. Speed Characteristics of Induction Motor For 27 Level Cascaded Multilevel Inverter with PI controller.

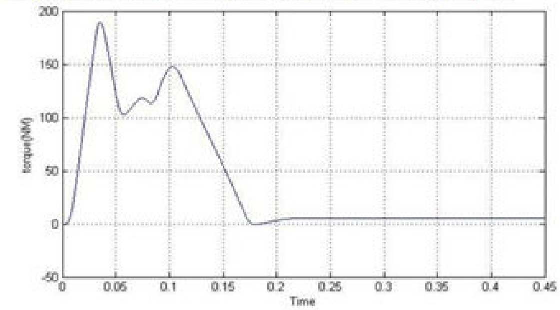


Fig12. Torque Characteristics of Induction Motor For 27 Level Cascaded Multilevel Inverter with PI controller.

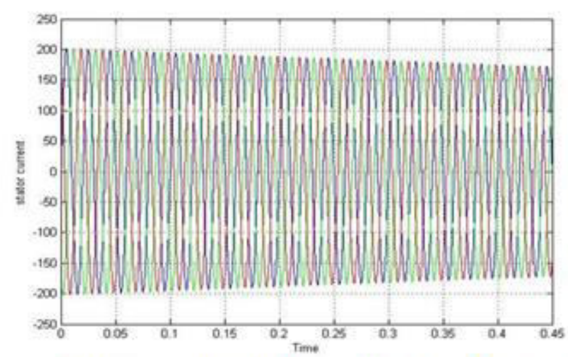


Fig13. Stator Currents of Induction Motor For 27 Level Cascaded Multilevel Inverter with PI controller.

## VI.CCONCLUSION

In this paper a 3 phase cascaded multilevel inverter with asymmetrical voltage technology is proposed. As we know that as the levels increases the harmonics reduces and the system virtually produces sinusoidal output waveform. THD value of 27 level cascaded multilevel inverter is 7.11% which is less than lower output voltage levels. The output voltage is given to induction motor

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and its characteristics are observed through simulation. The closed loop system performance is better than open loop, so the open loop 27 level cascaded multilevel inverter is operated with PI controller for better performance and the THD value obtained is 6.08% which is better compared to 27 level multilevel inverter with open loop. The output is given to induction motor and the speed, torque, current characteristics are observed.

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