

# A SIMULATION AND ANALYSIS OF NEUTRAL POINT CLAMPED MULTILEVEL INVERTER

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**Abstract:** The fundamental utilization of multi-stage inverters is in medium voltage and high-strength applications. From all kinds of multi-stage inverters, proposed gadget makes use of Neutral Point Clamped Multilevel Inverter (NPCMLI) because of its robustness. The simulations of 3-stage, 7-stage and 9-stage are finished the use of the MATLAB surroundings and indicate suitable simulation end result of every stage. This paper additionally does dialogue approximately no. of switching device, clamping diodes in keeping with segment and DC bus capacitor which might be utilized in a 3-stage inverter. This paper additionally includes a simulation of MLI with an asynchronous device that is used to offer strong AC strength to the induction motor (asynchronous m/c) in the industry. In the end, we compare the THD% price of various stage NPCMLI.

**Keywords:** Neutral factor clamped multilevel inverter, Pulse width modulation, Total harmonic distortion (THD%), MATLAB.

## I. INTRODUCTION

Nowadays, excessive strength contraptions are required in nearly all industries. There are such a lot of business packages like induction cars which require excessive-strength and medium voltage in megawatt. It turns into tough to conjugate one semiconductor transfer at once in medium voltage grids. To remedy this problem, MLI shape has been developed. So that, the use of MLI turns into famous for excessive voltage and excessive-strength business packages in comparison to 2-degree inverters [2].

There are such a lot of blessings of multilevel inverters like development in output voltages and currents first-class as properly as development in voltage functionality alongside the same switching devices. MLIs are broadly utilized in packages like traction and strength systems, business drives, output waveform with low harmonic contents and with low switching frequency [6].

In easy terms, MLI is a strength digital factor that's capable of offer desired output voltage degree through the use of enter with a couple of low-degree DC voltages [8]. The concept of MLI is predicated on voltage ranges which might be introduced to provide clean AC signal [6].

From all types of topologies of MLI, NPC multi-degree inverter is broadly used which is likewise referred to as diode clamped MLI [4][6]. NPCMLI changed into based within the starting of 80's that's presently utilized in such a lot of business packages [6]. Many industries require pace manage of induction motor with much less harmonics. Less harmonics may be received through NPCMLI. The essential gain of NPC multilevel inverter is: content material of harmonics decreases consistent with the quantity of ranges. So that the want of filters may be avoided [2][5]. To manage strain of voltage, NPCMLI makes use of array of chains of conjugated switches consistent with degree of step. With little enhancement in steps of voltage, strength conversion may be earned in NPCMLI [2].

In the NPC multilevel inverter, additives are shifted at elemental frequency. So that, it calls for much less circuit safety as in comparison to the alternative multilevel inverters, has the greater

manage of switching, and it additionally will increase performance of inverter [1][2].

In paper, Simulation of NPC 3-degree, 7-degree and 9-degree inverters are completed through the use of sinusoidal pulse width modulation (SPWM) method in software program names MATLAB. This paper additionally is composed of dialogue approximately operation and operating method of NPCMLI. This paper consists of element analysis, evaluation amongst a lot of these NPC inverters.

**II. LITERATURE REVIEW**

From closing couple of years, there's development within side the importance of MLI. Due to potentiality to integrate waveforms with much less THD and with advanced harmonic spectrum, MLIs are broadly used for packages with excessive electricity and excessive voltage [2]. There are so many techniques which are used in improvement of multilevel inverter (i.e., impartial-point clamped MLI, cascaded H-bridge MLI, flying-capacitor MLI etc.). NPCMLI are implemented in huge place of commercial packages which covers medium voltage variety due to diverse benefits like low-harmonic contents, higher output waveforms, excessive-performance etc. [1][2][4][6], In NPCMLI, extraordinary DC supply may be translated into any no. of AC output stage. By the use of NPCMLI, nearly sinusoidal AC output may be received with the aid of using growing stage however THD may also lower at that time [3][7].

The most important difficulty with NPCMLI is the distinction in impartial -factor voltage [1]. The some other most important dangers of Neutral-Point-Clamped Multilevel Inverter (NPCMLI) are that there's problem in coping with real glide of electricity of each remoted converter in multi-stage converter and even as no. of degrees is excessive, it calls for excessive clamping diodes [2][6]. There are so many platforms which are used to broaden NPC topology like MATLAB, PSIM [5].

**III. PROPOSED METHODOLOGY**

The three-degree NPCMLI includes D1 to D6-six impartial factor clamping diodes and Sa1 to Sa12-twelve lively unidirectional switches. Central factor of C1 and C2 capacitors is impartial factor. The important benefit of this association is that simplest

one 1/2 of of DC hyperlink voltage need to be blocked via way of means of each transfer In order to fabricate 3levels, there's want to show on simplest 2 of the 12 switches at any time in each segment leg. Fundamental circuit configuration of three-degree NPCMLI Switching states for 3 - degree NPCMI is proven in TABLE1.

As visible in Fig.1, IGBT makes use of switching gadgets and here, pulse is given with identical constant term thru the IGBT. In first 1/2 of period, switches (Sa1, Sa2, Sa5, Sa6, Sa9, Sa10) are on, different switches are off and in 2d 1/2 of period, switches (Sa3, Sa4, Sa7, Sa8, Sa11, Sa12) are on, different switches are off. After making use of Voltage divider rule, First capacitor voltage to the primary 1/2 of cycle and Second capacitor voltage. Diode makes use of 1/3 1/2 of cycle and no related DC voltage source. The remaining country output voltage is zero volts due to the fact modern-day need to be exceeded thru diode (0A) with pass IGBT in step with segment (Sa2 and Sa3, Sa6 and Sa7, Sa10 and Sa11). So, output facet reached at solid AC energy (nearest to sinusoidal).

TABLE 1. SWITCHING STATES FOR A three-LEVEL NPCML.

| $v_0$ | $\frac{V_{dc}}{2}$ | 0 | $-\frac{V_{dc}}{2}$ |
|-------|--------------------|---|---------------------|
| s     | 1                  | 0 | 0                   |
| s     | 1                  | 1 | 0                   |
| s     | 0                  | 1 | 1                   |
| s     | 0                  | 0 | 1                   |

**A. OPERATION**

In three-degree NPCMLI one segment-leg is operated in three states:

First country

Second country = zero

Third country in first country, Output voltage.

In this country, switches and are 1 meaning those switches are closed (on) and all different switches are zero meaning those switches are open. Here, we're making use of an enter voltage and a voltage divider rule. Then we get output voltage. Current is passing thru diode, and switches to output terminal as proven in Fig 2.

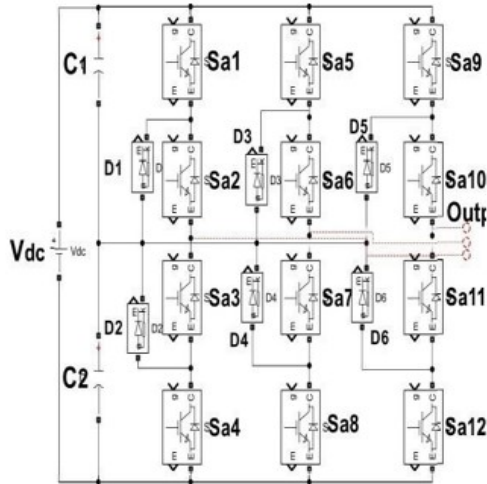


Fig.1 Simplified format of three-degree NPCMLI

In 2d country, Output voltage = zero.

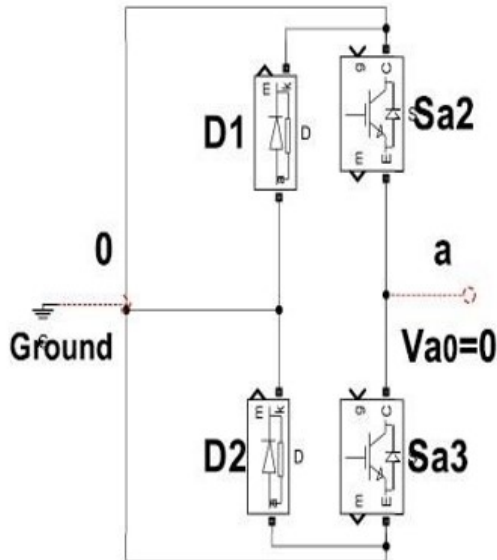


Fig. 2 Switching of first country Three-degree NPC MLI

In this country, switches and are 1 that approach those switches are closed(on) and all different switches are zero that approach those switches are open. Here, we're making use of an enter voltage and a voltage divider rule. Then we get zero output voltage. Current is passing through diode, and switchest output terminal proven in Figthree.

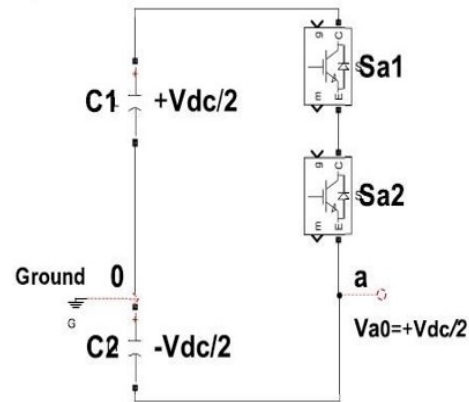


Fig.3 Switching of Second country Three-degree NPC MLI

In 1/3 country, Output voltage. In this country, switches and are 1 meaning those switches are closed(on) and all different switches are zero meaning those switches are open. Here, we're making use of an enter voltage and a voltage divider rule. Then we get - output voltage. Current is passing through diode, and switches to output terminal proven in Figfour.

Fig three Switching of Second country Three-degree NPC MLI

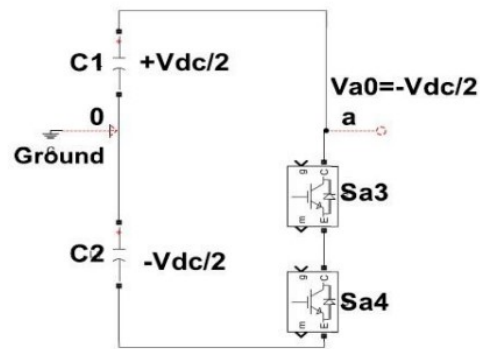


Fig.4 Switching of Third country Three-degree NPC MLI

IV.SIMULATIONRESULTS

In the proposed system, Simulation of NPCMLI is accomplished the use of platform named MATLAB. MATLAB is a one form of simulation software program to carry out matrix manipulation, plotting of capabilities and data, implementation of algorithms with applications written in C, C++, JAVA etc. It integrates computation, visualization, and programming environment. In easy term, MATLAB is a numerical computation package,

with the 'Symbolic' Toolbox. it could do additionally symbolicalgebra. These elements make MATLAB an incredible device for research. Given beneath simulation and effects of three-degree closed-loop, seven-degree and nine-degree NPCMLI.

**A. Single section three-degree NPC MLI closed loop simulation**

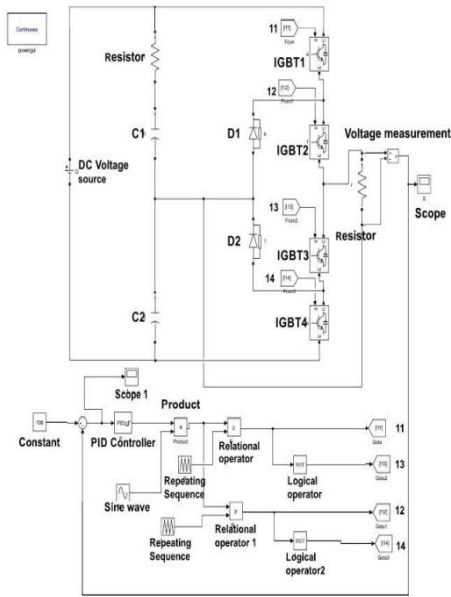


Fig. 5 Simulation of three-degree NPC MLI closed loop

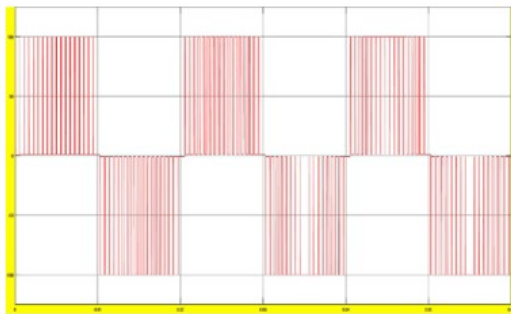


Fig 6. Simulation results of 3 level NPCMLI closed loop

Here, simulation enter is 200v DC, output facet voltage is 100v AC and resistor is used as a load. Closed loop simulation includes One PID controller, one sine wave, Two repeating sequence, relational operator and NOT logical operator. Simulation parameters which are used in unmarried

section three-degree NPCMLI are displayed in TABLE 2. As proven in Fig.5, at a time simplest switches are on and switches are off function according to section and simulate get end result that's proven in Fig.6.

**B. Three section Seven-degree NPC MLI open loop simulation**

Here, simulation enter is 600v DC, output facet voltage is 100v AC and resistor is used as a load. In simulation, subsystem includes one sine wave, six repeating sequence, relational operator and NOT logical operator. Simulation parameters that's utilized in three section 7-degree NPCMLI are displayed in TABLE three. In simulation, at a time simplest six switches are on and 6 switches are off function according to section and simulate get end result that's proven in Fig.7.

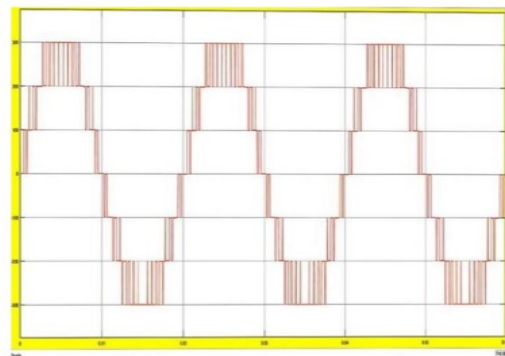


Fig.7 Simulation end result seven-degree open loop.

Here additionally, Simulation enter is 400v DC, output facet voltage is 50v AC and as a load used Resistor. In simulation, every subsystem includes one sine wave, 8 repeating sequence, relational operator and NOT logical operator. parameters that's utilized in three section nine-degree NPCMLI open loop are displayed in TABLE four. In simulation, at a time 8 switches are on and 8 switches are off function according to section and simulate get end result Fig.8.

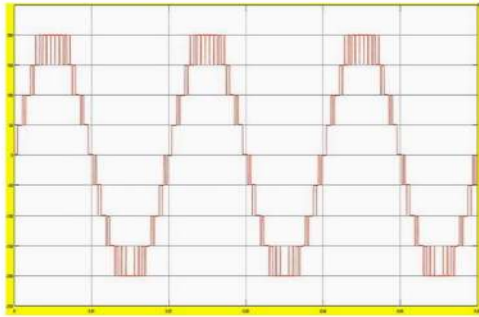


Fig 8. Simulation results 9 level NPCMLI open loop.

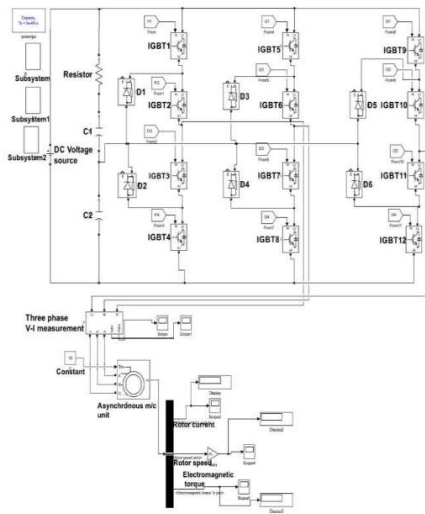


Fig 9. Simulation of 3 level NPCMLI with asynchronous motor.

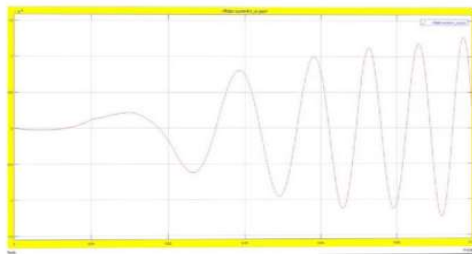


FIG. 10 Simulation result Rotor current Asynchronous motor

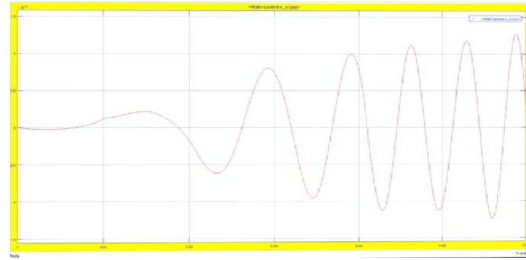


FIG. 11 simulation result rotor speed Asynchronous motor

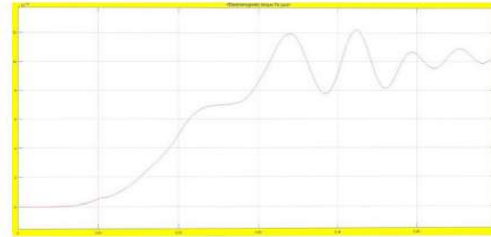


FIG.12 Simulation end result Electromagnetic torque Asynchronous motor.

Here additionally, Simulation enter is 840v DC and output load face voltage is 420v AC. parameters that's utilized in three section three-degree NPC MLI With Asynchronous gadget are displayed in TABLE five. In simulation, subsystem includes one sine wave, repeating sequence, relational operator and NOT logical operation and as a load used Asynchronous motor proven in Fig.9 and simulate get effects display in Fig.10, Fig.11, Fig.12. This is a one form of utility of NPC MLI in actual time.

**ANALYSIS**

Fig. nine Simulation of Three-degree NPC MLI with Asynchronous m/c THD % analysis of NPC MLI. we will almost show that THD% cost decreases in accordance increment in degree. So that we will say that there's much less harmonic to be had in high-degree impartial Fig. 10

Simulation end result Rotor present day Asynchronous motor factor clamped multilevel inverter.

**CONCLUSION**

Multilevel inverters are used for excessive electricity and low voltage kind application. NPCMLI is higher than different MLIs like flying-capacitor and cascaded H-bridge MLI. Neutral

factor clamped multilevel inverter has better efficiency.

Mostly, it's far used to lessen the stress & harmonics. Previous outcomes of THD (%) cost from the papers and above desk are as compared with received cost via way of means of this simulation & the no. of degrees techniques to  $\infty$  and the THD of output reaches to 0. Levels are extended to lower THD (%) cost in impartial factor clamped multilevel inverter. In future, we are able to amplify this mission via way of means of making Actual running version at the topologies for Simulation verification withinside the lab, evaluating NPC MLI with distinctive topologies in MLI. We also can use NPCMLI as adjustable pace manipulate power in industries.

#### REFERENCES:

- [1] S. [ K. Giri, S. Mukherjee, S. Kundu and S. Banerjee,"An altered PWM strategy for overmodulation operation of three-level NPC inverter with capacitor voltage balancing," 2017 IEEE Transportation Electrification Conference (ITEC- India), Pune, 2017, pp. 1-5.
- [2] N. F. Mailah et al., "Harmonics reduction of three phase five- level Neutral-Point-Clamped Multilevel Inverter," 2012 IEEE International Conference on Power and Energy (PECon), Kota Kinabalu, 2012, pp. 13-17. Ned Mohan, Underland. "Power Electronics and Drives";MINPERE,2003
- [3] T. Ahmadzadeh, M. Sabahi and E. Babaei, "Modified PWM control method for neutral point clamped multilevel inverters," 2017 14th International Conference on Electrical Engineering/Electronics, Computer Telecommunications and Information Technology (ECTI- CON), Phuket, 2017, pp. 765-768.
- [4] S. K. Bisoyi and N. K. Agarwal, "SHE PWM technique for three phase three level voltage source inverter," 2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI), Chennai, 2017, pp. 1742-1746.
- [5] H. Dallagi, "Study, analysis and simulation of three phase three- level, five-level and seven-level neutral-point-clamped inverters by PSIM," 2014 15th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA), Hammamet, 2014, pp. 654-660.
- [6] M. Swamy, K. Anuradha and B.G. Babu, "DC level stabilization in Neutral Point Clamped multilevel inverters," 2015 Conference on Power, Control, Communication and Computational Technologies for Sustainable Growth (PCCCTSG), Kurnool, 2015, pp. 211-216.
- [7] K. Anuradha and G. R. Krishna, "Neutral point voltage level stabilization and DC link capacitors voltage balance in neutral point clamped multilevel inverters," 2016 11th International Conference on Industrial and Information Systems (ICIIS), Roorkee, 2016, pp. 838- 843.
- [8] Syed Zain Nasir, "Introduction to Multilevel Inverters"  
[online]. Available: <https://www.theengineeringprojects.com/2014/12/introduction-multilevel-inverters.html>