iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 **Issue:** XII **Month of publication:** December 2016

DOI:

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

Volume 4 Issue XII, December 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Multilevel Inverter for Higher Output Voltage Levels

R.Bhavani[1], G.Swapna[2]
[1]M. Tech Student Department of Electrical Engineering, GRIET, Hyderabad-500072
[2]Assistant Professor in the Department of Electrical Engineering, GRIET, Hyderabad-500072

Abstract: ***This paper presents the multilevel inverter for higher output voltage levels by using asymmetrical cascaded H-bridge multilevel inverter. The general function of the multilevel inverter is to synthesize a desired high voltage from several levels of dc voltages that can be batteries, fuel cells, etc. In this paper, the proposed hybrid cascaded multilevel inverters are suitable for high voltage and high current applications of industrial drives and FACTS etc., In general control methods of these cascaded inverters are designed an assumption of having all dc source voltages same for all H-bridges, but with different input voltage ratios. The optimal structures of this topology are investigated for various objectives, such as minimum number of switches minimum standing voltage on switches for producing maximum output voltage steps. The proposed topology results in reduction of the number of switches, losses, installation area, and converter cost. The operation and performance of the proposed multilevel converter has been verified by the simulation result of 7-level, 23-level, and 27-level inverter.***
Keywords— asymmetrical cascaded multilevel inverter, pulse width modulation(PWM), IGBT.

I. INTRODUCTION

The concept of multilevel converters was introduced in 1975. The term multilevel began with the three level converter. A multilevel converter is a power electronic system that synthesizes a desired output voltage from several levels of dc voltages as inputs. With an increasing number of dc voltage sources, the converter output voltage waveform approaches a nearly sinusoidal waveform while using a fundamental frequency-switching scheme. Compared with the traditional two-level voltage converter, the primary advantage of multilevel converters is their smaller output voltage step, which results in high power quality, lower harmonic components, better electromagnetic compatibility, and lower switching losses.

Multilevel inverters have received added awareness for their ability on high-power and medium voltage function and because of former compensation such as high power quality, lower order harmonics, switching losses and improved electromagnetic interference. And also multilevel inverters are promising they have virtually sinusoidal output-voltage waveforms, Output current with improved harmonic profile, a lesser amount of stressing of electronic components owing to decreased voltages, switching losses that are inferior than those of predictable two-level inverters, a slighter filter size, and worse EMI, all of which make them cheaper, lighter, and more compact. Multilevel inverters make small Common mode voltage, consequently the stress in the bearings of a motor allied to a multilevel motor drive can be condensed. In addition CM voltages can be eliminated by using advanced modulation technique.

Multilevel inverters can draw input current with low distortion. These inverters can operate at equally fundamental frequency and high switching frequency PWM. It should be noted that lower switching frequency means lower switching loss and higher efficiency. These inverters make a stepped voltage waveform by means of a number of dc voltage sources as the input and a suitable arrangement of the power-semiconductor based devices.

Three major structures of the multilevel inverters have been presented: "diode clamped multilevel inverter," "flying capacitor multilevel inverter," and "cascaded multilevel inverter". The cascaded multilevel inverter is collected of a number of single-phase H-bridge inverters and is classified into symmetric and asymmetric groups based on the magnitude of dc voltage sources. In the symmetric types, all the dc voltage sources of cascaded H-bridges are having equal magnitudes, whereas in the asymmetric types, the values of the dc voltage sources of all H bridges are dissimilar.

In topical years, a number of topologies with various control techniques have been presented for cascaded multilevel inverters and diverse symmetric cascaded Multi level inverters have been presented. The foremost advantage of all these structures is the short variety of dc voltage sources, which is one of the most significant features in determining the cost of the inverter. On the other hand, because some of them utilize an elevated number of bidirectional power switches, a high number of insulated gate bipolar

©IJRASET: All Rights are Reserved

Volume 4 Issue XII, December 2016
ISSN: 2321-9653

transistors (IGBTs) are necessary, which is the major drawback of these topologies. Consequently, it increases control complexity, circuit size and cost.

The major advantage of this asymmetric topology and its algorithms is associated to its ability to create a substantial number of output voltage levels by using a low number of dc voltage sources and power switches but the high diversity in the magnitude of dc voltage sources is their most outstanding disadvantage.

Recently, asymmetrical and hybrid multistage topologies are becoming one of the most fascinated research area. In the asymmetrical configurations, the magnitudes of dc voltage supplies are uneven. These topologies diminish the cost and size of the inverter and get better reliability since lesser number of power electronic components, capacitors, and dc supplies are used.

The hybrid multistage converters consist of dissimilar multilevel configurations with uneven dc voltage supplies. Bidirectional switches with an suitable control technique can enhance the performance of multilevel inverters in terms of falling the number of semiconductor components, minimizing the withstanding voltage and achieving the required output voltage with higher levels. The magnitudes of the utilized dc voltage supplies have been selected in a way that brings the elevated number of voltage levels with an effective application of a fundamental frequency staircase modulation technique.

For a single-phase seven-level inverter, 12 power electronic switches are required in both the diode-clamped and the flying-capacitor topologies Asymmetric voltage technology is used in the cascade H-bridge multilevel inverter to allow more levels of output voltage, so the cascade H-bridge multilevel inverter is suitable for applications with increased voltage levels. Two H bridge inverters with a dc bus voltage of multiple relationships can be connected in cascade to produce a single phase seven-level inverter and eight power electronic switches are used. In this project a new asymmetric Bi-directional converter topology which uses contradictory ratios of dc voltage sources.

A. Cascaded H-Bridge Multi Level PWM Inverter

The cascaded multilevel inverter consists of a series of H-bridge inverter. The general purpose of this multilevel inverter is to synthesize a desired voltage from several separate dc sources, like batteries, fuel cells, solar cells, and ultra-capacitors.

The cascaded H-bridges multilevel inverter introduces the idea of using Separate DC Sources (SDCSs) to produce an AC voltage waveform. Each H-bridge inverter is connected to its own DC source Vdc. By cascading the AC outputs of each H-bridge inverter, an AC voltage waveform is produced. By closing the appropriate switches, each H-bridge inverter can produce three different voltages: +Vdc, 0 and -Vdc. It is also also possible to modularize circuit layout and packaging because each level has the same structure, and there are no extra clamping diodes or voltage balancing capacitors. The number of switches is reduced using the new topology.

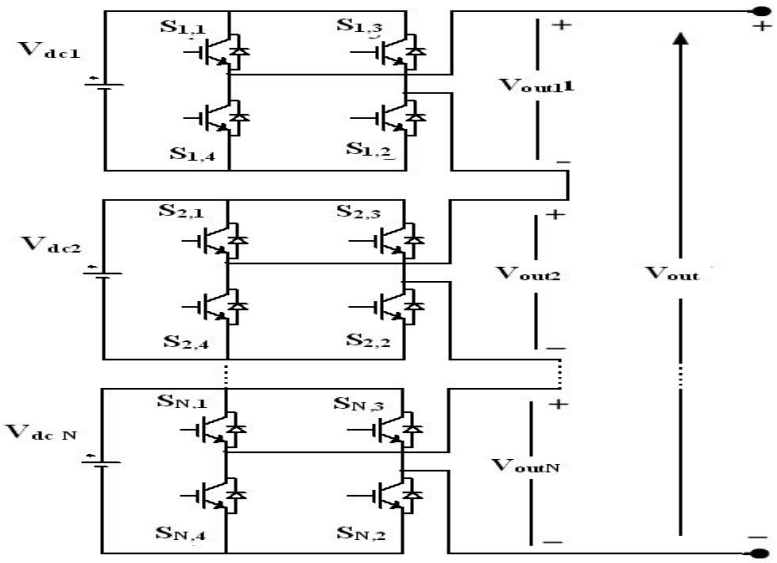


Fig.1.Configuration of cascaded inverter

©IJRASET: All Rights are Reserved

Volume 4 Issue XII, December 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

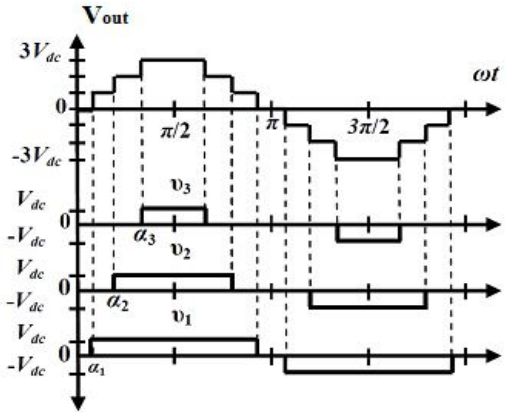


Fig.2.Output phase voltage waveform

The traditional two or three levels inverter does not completely eliminate the unwanted harmonics in the output waveform. Therefore, using the multilevel inverter as an alternative to traditional PWM inverters is investigated. In this topology the number of phase voltage levels at the converter terminals is 2N+1, where N is the number of cells or dc link voltages. In this topology, each cell has separate dc link capacitor and the voltage across the capacitor might differ among the cells. So, each power circuit needs just one dc voltage source. The number of dc link capacitors is proportional to the number of phase voltage levels .Each H-bridge cell may have positive, negative or zero voltage. Final output voltage is the sum of all H-bridge cell voltages and is symmetric with respect to neutral point, so the number of voltage levels is oddCascaded H-bridge multilevel inverters typically use IGBT switches. These switches have low block voltage and high switching frequency. Consider the seven level inverter; it requires 12 IGBT switches and three dc sources. A cascaded H-bridges multilevel inverter is simply a series connection of multiple H bridge inverters. Each H-bridge inverter has the same configuration as a typical single-phase full-bridge inverter..

B. Why Cascaded H-bridge multilevel inverter?

A seven-level cascaded converter, for example, consists of three DC sources and three full bridge converters. Minimum harmonic distortion can be obtained by controlling the conducting angles at different converter levels. Each H- bridge unit generates a quasi-square waveform by phase shifting its positive and negative phase legs" switching timings. Each switching device always conducts for 180° (or half cycle) regardless of the pulse width of the quasi-square wave. This switching method makes all of the switching devices current stress equal. In the charging mode, the cascade converters act as rectifiers, and power flows from the charger (ac source) to the batteries. The cascade converters can also act as rectifiers to help recover the kinetic energy of the vehicle if regenerative braking is used. The cascade inverter can also be used in parallel HEV configurations. This new converter can avoid extra clamping diodes or voltage balancing capacitors.

The combination of the 180° conducting method and the pattern-swapping scheme make the cascade inverters voltage and current stresses the same and battery voltage balanced Identical H-bridge inverter units can be utilized, thus improving modularity and manufacturability and greatly reducing production costs.

C. Features of CMLI

For real power conversions, (ac to dc and dc to ac), the cascaded-inverter needs separate dc sources. The structure of separate dc sources is well suited for various renewable energy sources such as fuel cell, photovoltaic, and biomass, etc. Connecting separated dc sources between two converters in a back-to-back fashion is not possible because a short circuit will be introduced when two back-to-back converters are not switching synchronously.

II. PULSE WIDTH MODULATION (PWM)

Output voltage of Inverter can also be adjusted by exercising a control within the inverter itself. The most efficient method of doing this is by pulse-width modulation control used within an inverter. In this method, a fixed dc input voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components. This is the most popular method of controlling the output voltage and this method is termed as Pulse width Modulation (PWM) control.

©IJRASET: All Rights are Reserved

Volume 4 Issue XII, December 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

A. Sinusoidal pulse width Modulation

In sinusoidal pulse width modulation several pulses per half cycle are used similar to multiple pulse width modulation but width of each pulse varies with amplitude of the sine wave. This is obtained by comparing the sine wave with high frequency triangular carrier wave.

When the modulating signal is a sinusoid of amplitude Am, and the amplitude of the triangular carrier is Ac, the ratio m=Am/Ac is known as the modulation index. Note that controlling the modulation index controls the amplitude of the applied output voltage.

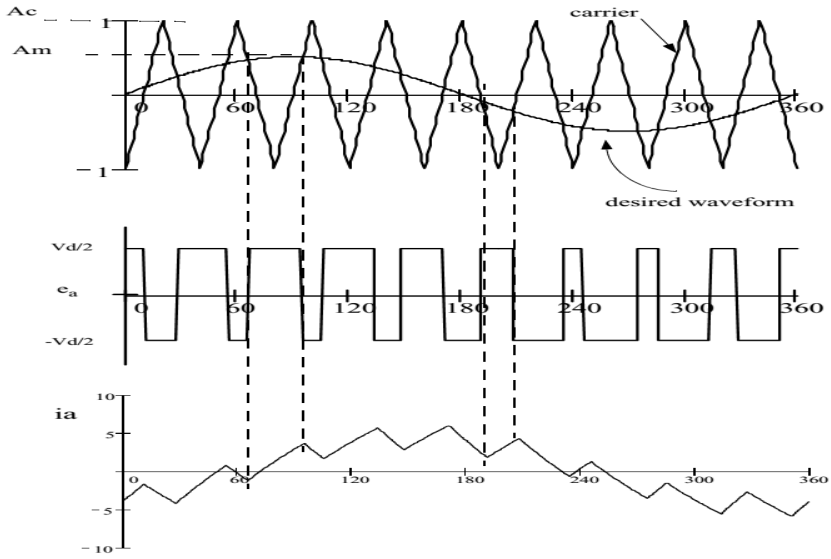


Fig.3.Sinusoidal pulse width modulation

III. PROPOSED CONCEPT

Hybrid Multilevel Inverter was introduced by means of all 3M possible output voltages, where M is the number of modules allied in series. Though this inverter uses extremely different DC voltage sources in the relation of 1:3:9 etc. In distinguish, the DC voltage sources consider in this paper are still exceptionally close to each other, they fluctuate only by ±20 %. The quantity of cells in sequence determines the number of output levels. 3M= 27 switching states S1, when M= 3 cells. With similar DC voltages, there are numerous switching states that create the same output voltages, resulting in 2.M + 1 = 7 different phase output voltage levels. Uneven DC source voltages direct to an improved number of different output voltage levels. The maximum number of levels is 3M = 27. With the DC source voltages distributed as Vi11:Vi12: Vil3= 1 Voc : 3Voc : 9Voc, all the dissimilar output voltage levels are consistently spaced. The aim of such an inverter (Hybrid Multilevel Inverter) has the disadvantage that the preliminary modularity is vanished. Each module must be intended for the equivalent voltage class. 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 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.

In order to consider the possible benefits of using unlike DC voltages, the 4:5:6 relation is used as an instance in the following part. For a first estimation it is abandoned if these differences are introduced by the moment behavior of the DC voltages, or if they are introduced by design and thus can be supposed to be stable. The second case is considered at this time for the sake of simplicity.

The figure shows the output wave forms the proposed asymmetrical converter. It is clearly seen that the level of inverter varies with the change in the ratios of input voltage. The inverter gives 7 level output voltage when the ratio is 1: 1: 1, while it gives 23 level output voltage when the ratio is 4:5:6 and it gives 27 level output voltage when the ratio is 1:3:9. 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.

©IJRASET: All Rights are Reserved

Volume 4 Issue XII, December 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

IV. CONTROL SCHEME

This section will discuss in detail a converter consisting of three modules with a DC voltage ratio of Vi11:Vi12:Vi13 = 4Voc: 5Voc: 6Voc. The results in a huge number of diverse output voltage levels with an incredibly good voltage resolution. This composition will be compared with the predictable approach with identical DC voltage sources, and with the Hybrid Multilevel Inverter using a 1:3:9 voltage relation. Two different control methods for a single phase converter are offered. Both algorithms imagine a steady sampling interval of the control, Ts. The first one uses a stable switching state during a full sampling interval (step or staircase method), whereas the second one is implemented with a Pulse Width Modulation (PWM method). Both methods receive that the DC source voltages are not steady but variable in time. The definite voltages on the capacitors are therefore calculated, and the phase voltage vector Vi1 is created. In order to compute all attainable output voltages Vol, the phase voltage vector is multiplied with all 3n possible switching states S1. This results in an unsorted vector containing all feasible output voltages.

V. SIMULATION

The name MATLAB stands for MATrixLABoratory. MATLAB was written originally to provide easy access to matrix software developed by the LINPACK (linear system package) and EISPACK (Eigen system package) projects..

MATLAB has many advantages compared to conventional computer languages (e.g.,C, FORTRAN) for solving technical problems. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. The software package has been commercially available since 1984 and is now considered as a standard tool at most universities and industries worldwide.

It has powerful built-in routines that enable a very wide variety of computations. It also has easy to use graphics commands that make the visualization of results immediately available. Specific applications are collected in packages referred to as toolbox. There are toolboxes for signal processing, symbolic computation, control theory, simulation, optimization, and several other fields of applied science and engineering.

Matlab is an interactive software system for numerical computations and graphics. As the name suggests, Matlab is essentially designed for the matrix computations such as

Solving systems of linear equations
Computing Eigen values and Eigen vector
Factoring matrices etc.

A. 7-Level Inverter

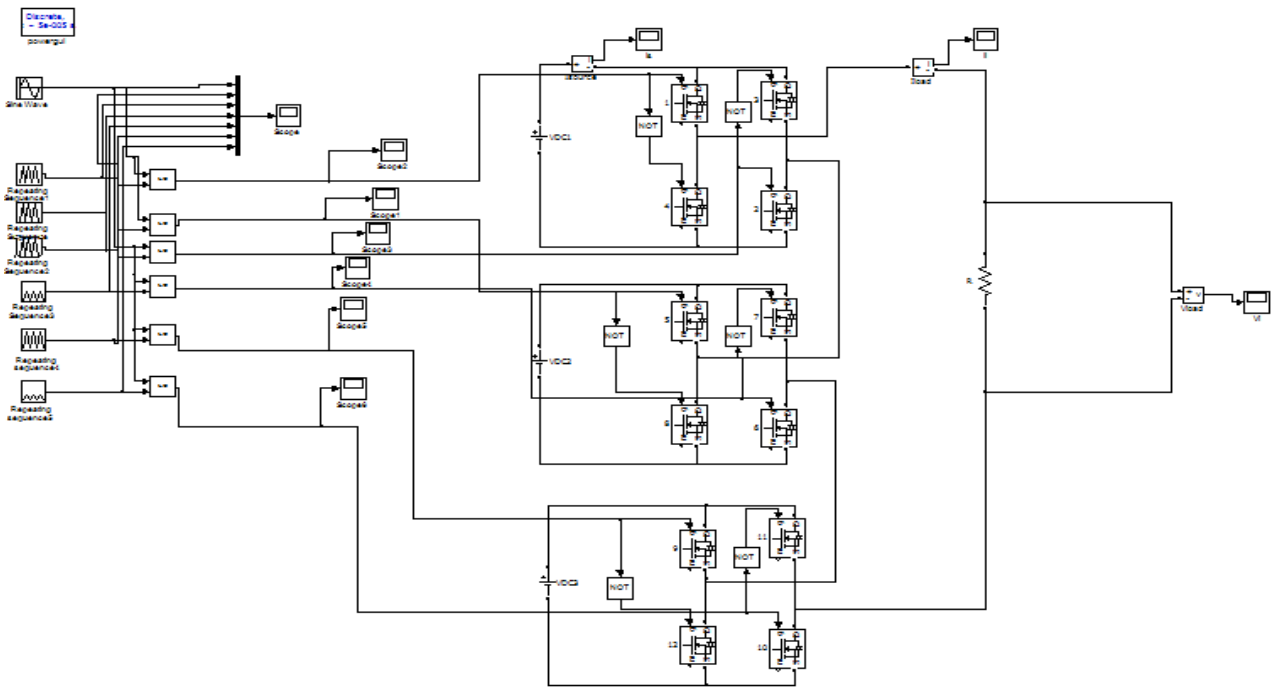


Fig.4..Simulation circuit 7-level cascaded H-bridge multilevel inverter

©IJRASET: All Rights are Reserved

Volume 4 Issue XII, December 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

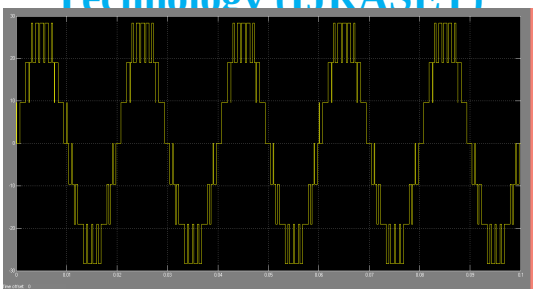


Fig.5.Output of 7-Level cascaded H-bridge multilevel inverter

B. 23- Level Inverter

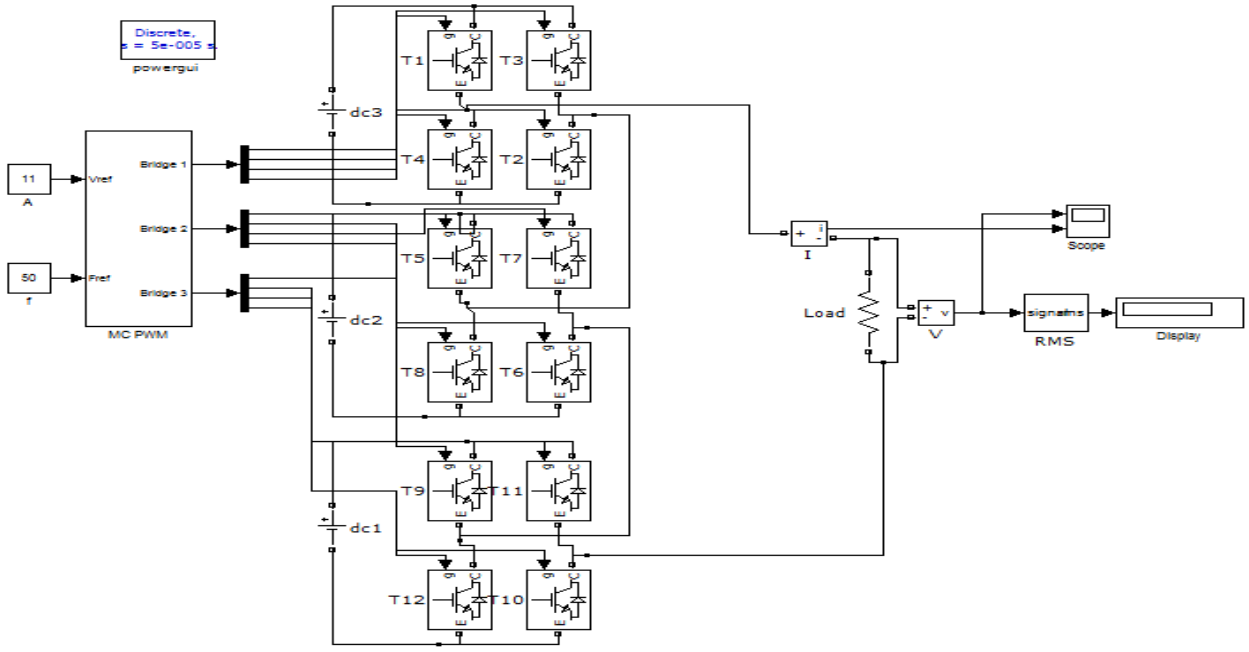


Fig.6.Simulation of 23-level inverter

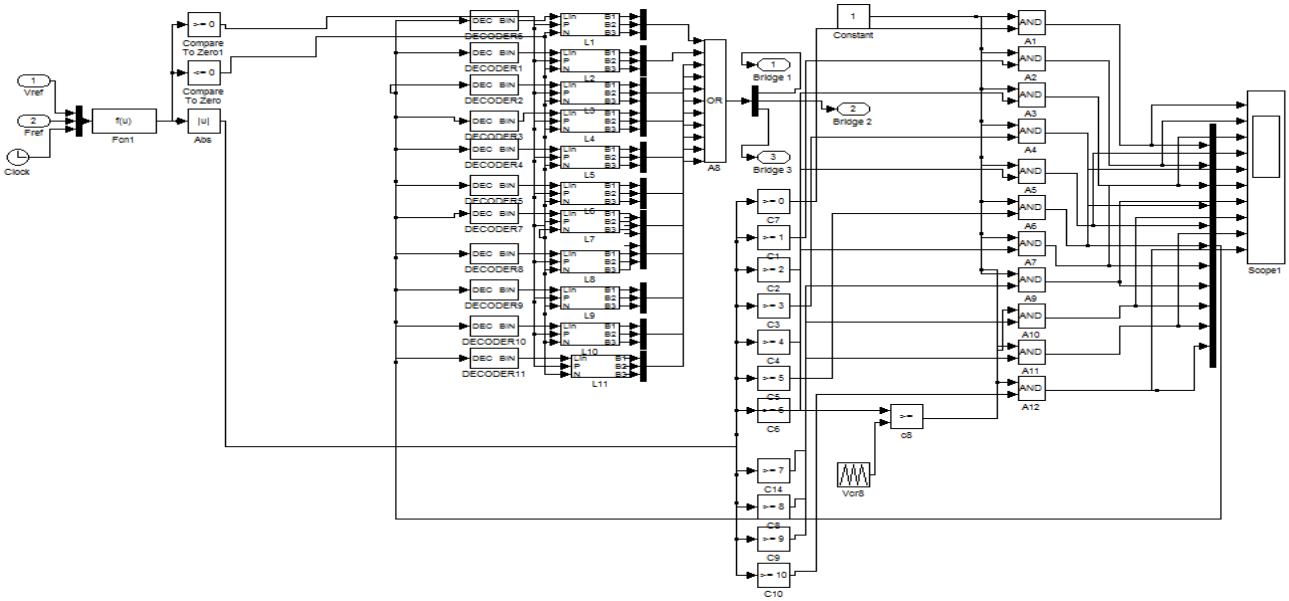


Fig.7.subcircuit of 23-level inverter

©IJRASET: All Rights are Reserved

Volume 4 Issue XII, December 2016
ISSN: 2321-9653

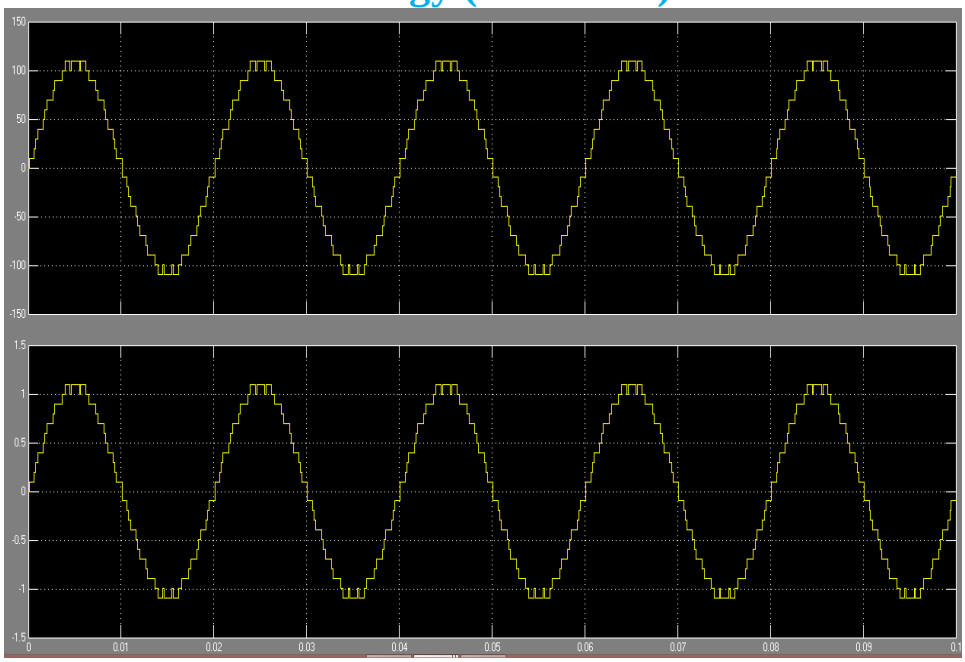


Fig.8.Output waveform of 23-level inverter

Voltage levels	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Vdc	1	0	1	0	0	0	1	1	1	1	0	0
2 Vdc	0	0	1	1	1	0	1	0	1	1	0	0
3 Vdc	1	1	0	0	1	1	0	0	0	0	1	1
4 Vdc	1	1	0	0	1	0	1	0	1	0	1	0
5 Vdc	1	0	1	0	1	1	0	0	1	0	1	0
6 Vdc	1	0	1	0	1	0	1	0	1	1	0	0
7 Vdc	0	0	1	1	1	1	0	0	1	1	0	0
9Vdc	1	1	0	0	1	1	0	0	1	0	1	0
10Vdc	1	1	0	0	1	0	1	0	1	1	0	0
11 Vdc	1	0	1	0	1	1	0	0	1	1	0	0
15 Vdc	1	1	0	0	1	1	0	0	1	1	0	0
0 Vdc	1	0	1	0	1	0	1	0	1	0	1	0
- Vdc	1	0	1	0	1	1	0	0	0	0	1	1
-2 Vdc	1	1	0	0	1	0	1	0	0	0	1	1
-3 Vdc	0	0	1	1	0	0	1	1	1	1	0	0
-4 Vdc	0	0	1	1	1	0	1	0	1	0	1	0
-5 Vdc	1	0	1	0	0	0	1	1	1	0	1	0
-6 Vdc	1	0	1	0	1	0	1	0	0	0	1	1
-7 Vdc	1	1	0	0	0	0	1	1	0	0	1	1
-9 Vdc	0	0	1	1	0	0	1	1	1	0	1	0
-10 Vdc	0	0	1	1	1	0	1	0	0	0	1	1
-11 Vdc	1	0	1	0	0	0	1	1	0	0	1	1
-15 Vdc	0	0	1	1	0	0	1	1	0	0	1	1

Table 1.switching sequence of 23-level CHB inverter

©IJRASET: All Rights are Reserved

Volume 4 Issue XII, December 2016
ISSN: 2321-9653

C. 27-level inverter

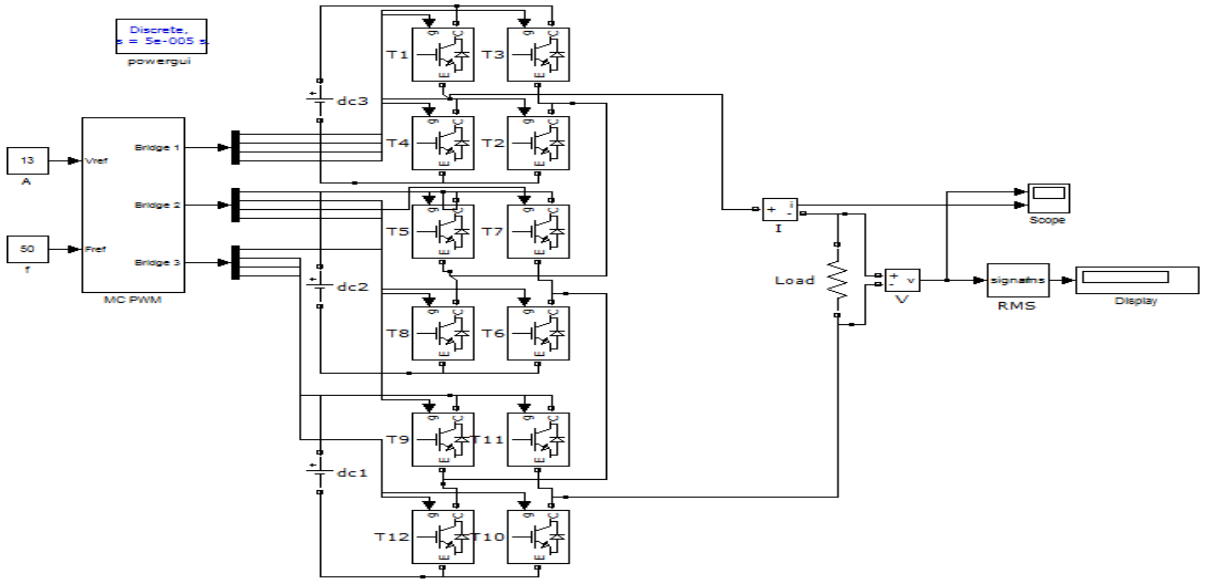


Fig.9.Simulation of 27-level inverter

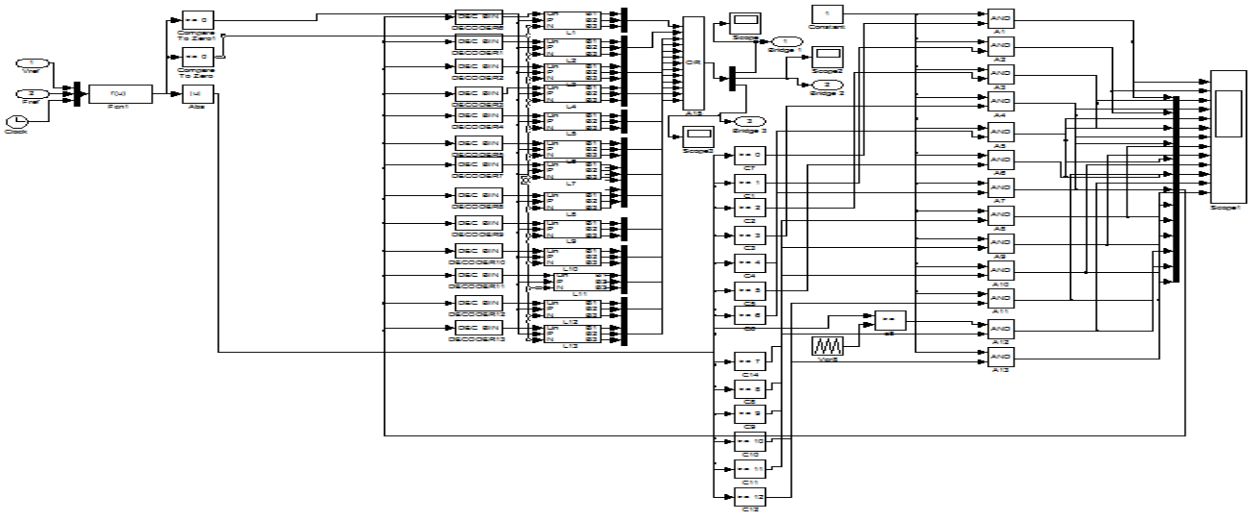


Fig.10.Subcircuit for 27-Level inverter

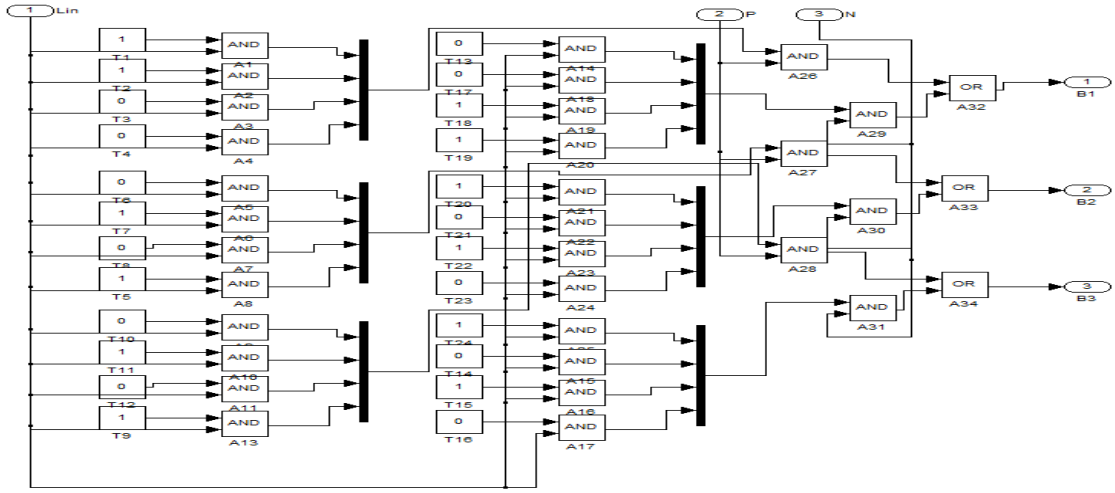


Fig.11.Subcircuit of 27-level switching states

©IJRASET: All Rights are Reserved

Volume 4 Issue XII, December 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

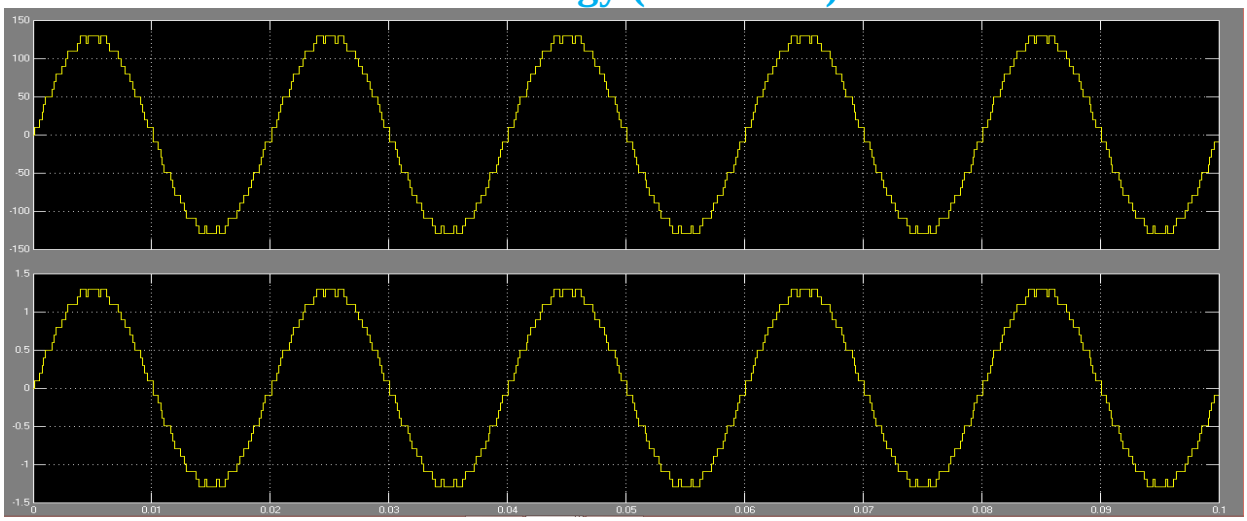


Fig.12.Output waveform of 27-level inverter

Votage levels	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Vdc	1	1	0	0	0	1	0	1	0	1	0	1
2Vdc	0	0	1	1	1	1	0	0	0	1	0	1
3 Vdc	0	1	0	1	1	1	0	0	0	1	0	1
4 Vdc	1	1	0	0	1	1	0	0	0	1	0	1
5 Vdc	0	0	1	1	0	0	1	1	1	1	0	0
6 Vdc	0	1	0	1	0	0	1	1	1	1	0	0
7 Vdc	1	1	0	0	0	0	1	1	1	1	0	0
8 Vdc	0	0	1	1	0	1	0	1	1	1	0	0
9 Vdc	0	1	0	1	0	1	0	1	1	1	0	0
10 Vdc	1	1	0	0	0	1	0	1	1	1	0	0
11 Vdc	0	0	1	1	1	1	0	0	1	1	0	0
12 Vdc	0	1	0	1	1	1	0	0	1	1	0	0
13 Vdc	1	1	0	0	1	1	0	0	1	1	0	0
0 Vdc	0	1	0	1	0	1	0	1	0	1	0	1
- Vdc	0	0	1	1	0	1	0	1	0	1	0	1
-2 Vdc	1	1	0	0	0	0	1	1	0	1	0	1
-3 Vdc	0	1	0	1	0	0	1	1	0	1	0	1
-4 Vdc	0	0	1	1	0	0	1	1	0	1	0	1
-5 Vdc	1	1	0	0	1	1	0	0	0	0	1	1
-6 Vdc	0	1	0	1	1	1	0	0	0	0	1	1
-7 Vdc	0	0	1	1	1	1	0	0	0	0	1	1
-8 Vdc	1	1	0	0	0	1	0	1	0	0	1	1
-9 Vdc	0	1	0	1	0	1	0	1	0	0	1	1
-10 Vdc	0	0	1	1	0	1	0	1	0	0	1	1
-11 Vdc	1	1	0	0	0	0	1	1	0	0	1	1
-12 Vdc	0	1	0	1	0	0	1	1	0	0	1	1
-13 Vdc	0	0	1	1	0	0	1	1	0	0	1	1

Table 2.Switching Sequence of 27-Level CHB Inverter

©IJRASET: All Rights are Reserved

Volume 4 Issue XII, December 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

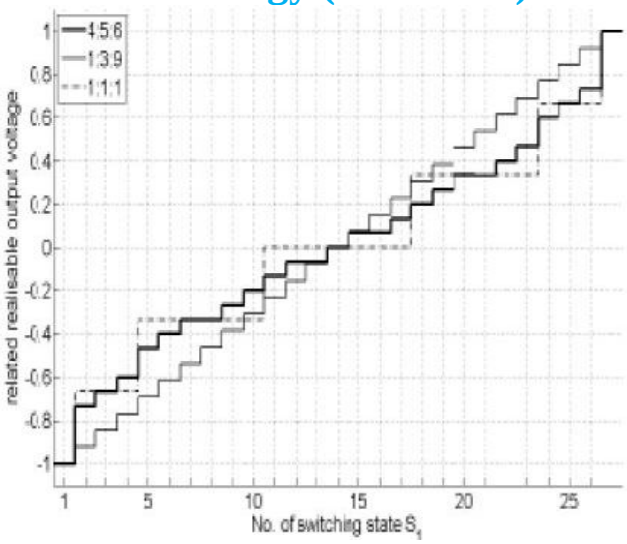


Fig.13.0utput voltages of different voltage ratios of CHB

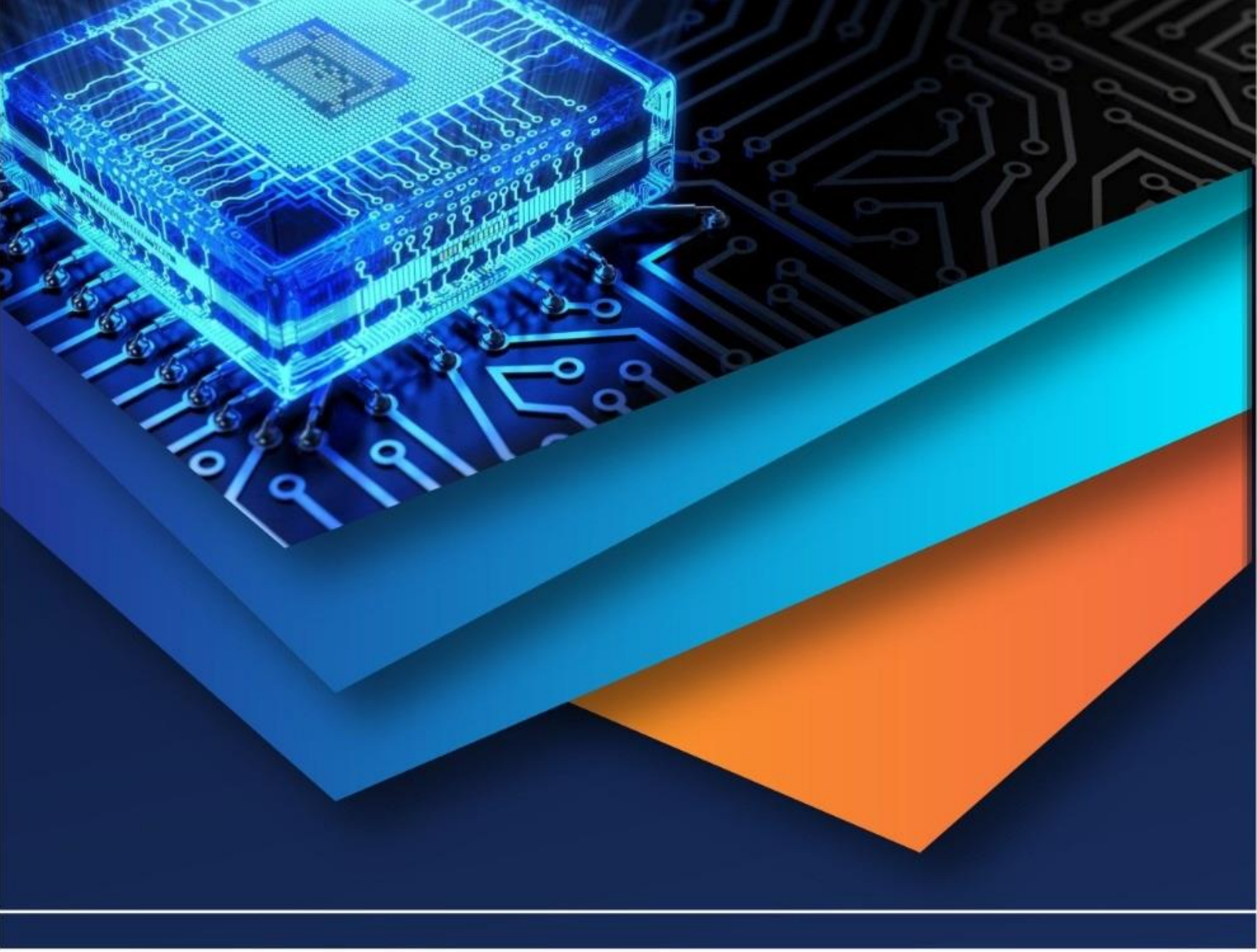
VI. CONCLUSION

The simulation results show that in this paper 23-level and 27-level asymmetrical cascaded H-bridge inverter are studied. The output of 23-level and 27-level asymmetrical cascaded H-bridge multi-level inverter functioning is realized virtually using MATLAB SIMULINK. A detailed multi-level inverter presented from which we concluded that the harmonic content is greatly reduced in multi-level inverter

REFERENCES

[1] Rashid, M.H., Power Electronics, Prentice Hall of India, New Delhi,1993
[2] Z. Du, L. M. Tolbert, J. N. Chiasson, and B. Ozpineci, "A cascade multilevel inverter using a single dc power source," in Proc. IEEE APEC, 2006,pp. 426–430
[3] E. Babaei, "A new cascaded multilevel inverter topology with minimum switches," IEEE Trans.PowerElectron. Vol 23, no.6, pp. 2657- 2664, Nov. 2008
[4] L.M Tolbert, F. Z.Peng and T. G Habelter, "Multilevel Converter for large electric drives," IEEE trans.lnd.Appl.VoI35, no. I, pp. 36-44, Jan/Feb.1999.
[5] Modern Power Electronics and AC Drives, by Bimal K. Bose. Prentice Hall Publishers.
[6] Power Electronics by Dr. P.S. Bimbhra. Khanna Publishers, New Delhi.

©IJRASET: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)