SYMMETRIC AND ASYMMETRIC MULTILEVEL INVERTER TOPOLOGIES WITH REDUCING SWITCHES

Submitted by:

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SYMMETRIC AND ASYMMETRIC MULTILEVEL INVERTER TOPOLOGIES WITH REDUCING SWITCHES

A Project report

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BACHELOR OF TECHNOLOGY

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

by

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May, 2023

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This project report **SYMMETRIC AND ASYMMETRIC MULTILEVEL INVERTER TOPOLOGIES WITH REDUCING SWITCHES** done by **T.HARI KRISHNA (20955A0207)** is approved for the award of the Degree Bachelor of Technology in ELECTRICAL AND ELECTRONICS ENGINEERING

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With gratitude

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ABSTRACT

Key words: Multilevel inverter Symmetric multilevel inverter Asymmetric multilevel inverter Reduced switching devices.

To manage high voltage and power in flexible power systems, multilevel inverters have been designed. Compared to traditional 2-level inverters, these inverters come with a few built-in advantages. Among the most significant benefits of multilayer inverters is the high calibre of their output voltage.

There are new multilevel inverter topologies that are symmetric and asymetric suggested in this article. In compared to traditional other unconventional topologies, multilayer inverters, the suggested multilevel inverters require less switching components for a predetermined variety of output voltage levels. For use at higher voltage levels, hybrid topologies that are derived from the suggested topologies are suggested.

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LIST OF ABBREVIATIONS

MLI	Multilevel Inverter
IGBT	Insulated Gate Bipolar Transistor
EMI	Electromagnetic Interference
MCPWM	Multicarrier Pulse Width Modulation
THD	Total Harmonic Distortion
MATLAB	Matrix Laboratory

CHAPTER 1 INTRODUCTION

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INTRODUCTION

1.1 Introduction

Inverters are machines that use the available source to transform DC electricity into AC power. Multilevel inverters are tools used to convert high power from a readily available DC source. From the DC sources used as input, these inverters generate stepped output voltage.when the quantity of levels or steps grows, the output voltage's quality also improves. A multilevel inverter's level is frequently determined as the total of all the stages in the output voltage for a full cycle, plus the zero level.

Multilevel inverter topology is primarily illustrated using three fundamental structures: the cascaded multilayered inverter, multilevel inverter with a flying capacitor, and multilayer diode-clamped inverter. The cascaded multilevel inverter provides superior performance to the other two topologies attracted greater attention. because it is easy to expand the level of output voltage and has a basic structure and modular construction. The H-bridges in a simple cascaded multilevel inverter has four toggles, and generates three levels of output voltage, including +Vdc, 0Vdc, and -Vdc.Additional H-bridges can be added to raise output to the next level. However, The complexity of the system increases with the number of tiers.

Because separate DC sources (SDCS) andIt is necessary to use a lot of semiconductor devices,Application of cascaded multilevel inverters is restricted. Numerous topologies built on the fundamental cascaded multilevel inverter have been suggested recently to get around these restrictions .Depending on how large the DC voltage sources are, multilevel inverters divided into symmetric and asymmetric topologies.Additional H-bridges can be added to raise output to the next level.

However,The complexity of the system increases as the number of tiers does. Because separate DC sources (SDCS) and aThere is a demand for a lot of semiconductor devices, the application of cascaded multilevel inverters is restricted. Numerous topologies built on the fundamental cascaded multilevel inverter have been suggested recently to get around these restrictions .Depending on how large the DC

voltage sources are, There are two types of multilevel inverters: symmetric and asymmetric topologies.

1.2 Multilevel Inverter

A power electrical device called a multilevel inverter can use several to produce the necessary level of alternating voltage at the output, smaller DC voltages are used as inputs.The most common to convert DC voltage into AC voltage, an inverter is used is a two-level inverter. Now that we have a two-level inverter, the question of why use a multilayer inverter arises. We must examine the multilayer inverter concept before we can respond to this question.

Concept of Multilevel Inverter

First, let's look at an illustration of a two-level inverter. When we supply a With Vdc as the input, a two-level inverter will produce +Vdc/2 and -Vdc/2, which are two distinct voltages for the load. To form an AC voltage, these 2 freshly exchanged.Figure 2.1 illustrates the reference wave is depicted in the dashed blue line, and PWM is typically employed for switching.

This method of generating AC is effective, however it does have There are several drawbacks, such as greater dv/dt and harmonic aberrations in the output voltage than a multilayer inverter. Ordinarily, this strategy is effective, but in some instances, it results inspecifically those where low output voltage distortion is desired.

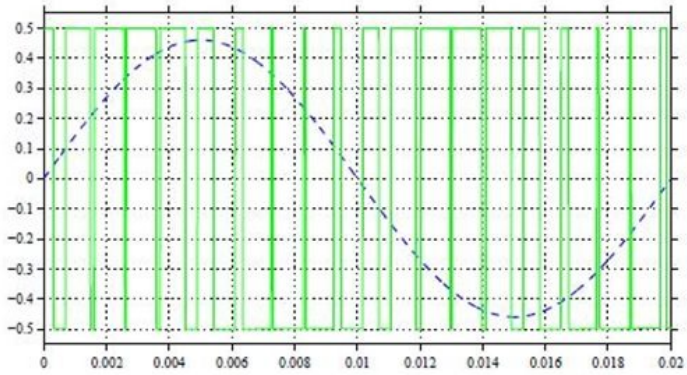


Fig:1.2.1 PWM voltage output of a two-level inverter

A two-level inverter is modified in some way by the idea of a multilayer inverter (MLI). Multilevel inverters combine multiple voltage levels to provide a smoother output waveform with less harmonic distortion and dv/dt.This is done in order to avoid dealing with the two-level voltage.

Voltage levels and waveform smoothness are negatively linked; as When voltage increases, the waveform becomesmore sophisticated as the controller circuit and its parts get more intricate. As the levels rise, the waveform becomes smoother, as can be seen inimage below shows the waveforms for the three, five, and seven level inverters.

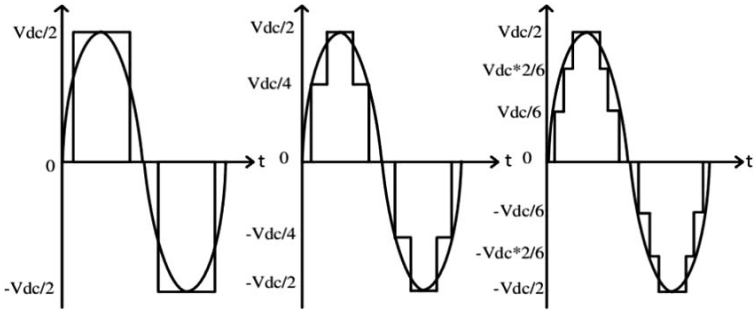


Fig:1.2.2 Three waveforms, one each at levels three, five, and seven, were swapped at the fundamental frequency

1.3 Multilevel Inverter Types

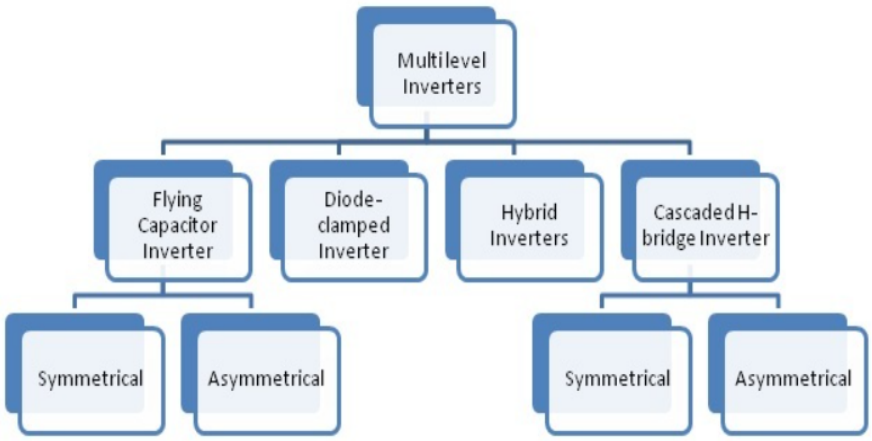


Fig:1.3.1 Multilevel inverter types

1.3.2 Multilevel Inverter Topologies

Multiple multilayer inverter topologies are available. The source of input and the switching process are different. To the multilayer inverters' voltage.

There are three main multilayer inverter topologies:

1. multilayer inverters with diode clapping.
2. multilayer inverters using flying capacitors.
3. H-bridge multilevel inverters in cascade.

1.4.1 DIODE CLAMPING MULTILEVEL INVERTER

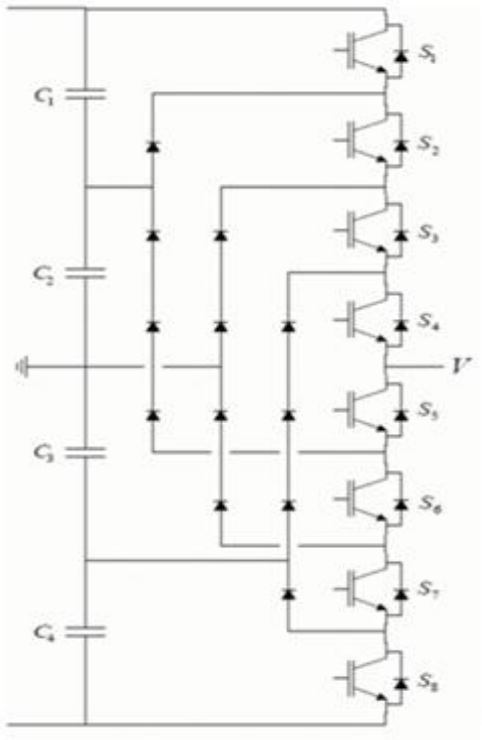
The fundamental idea behind an inverter the employment of diodes, which supply diverse voltage levels through various phases to series-connected capacitor bank connections. By transferring only a little amount of electricity, a diode eases the practice with different electrical parts.The DC input voltage is split in half at equivalent to the highest voltage output.

It is the primary of the diode clamped multilevel inverter flaw.Increasing the switches, diodes, and capacitors can solve this issue. These are constrained to the three stages due to capacitor balance problems owing to the same frequency that all switching devices employ and the straightforward back-to-back power transfer scheme, this type of inverter offers high efficiency.

Examples include a 5-level and a 9-multilayer inverter with level diode clamping.

A single capacitor, switches, and a five-level diode clamp are used in this circuit. multilevel an inverter, which produces an The generated voltage is halved using the DC input voltage.

In contrast to the 9-level and 5-level diode clamped inverter requires switches, diodes, and twice as many capacitors. Therefore, the output exceeds the input.



Fig;1.4.1 Multilevel inverter with diode clamping

Multilevel inverter with diode clamping Applications:

- Compensation for static VAR
- motor drives with variable speeds
- links between high-voltage systems
- high-voltage transmission cables for both DC and AC.

1.4.2 MULTILEVEL INVERTER FLYING CAPACITOR

Utilisation of The fundamental concept underlying this inverter is capacitors. It consists of switching cells with capacitor clamps connected in series.Electrical equipment receives the restricted energy coming from the capacitors. This inverter's switching states are similar to those of a diode clamped inverter. This particular style of multilevel Clamping diodes are not necessary for an inverter.

Half of Input voltage for DC is output. It is a problem with the flying capacitor multilayer inverter. The redundant switching inside the phase balances the capacitors in the air. The flow of power both active and reactive managed by it. Losses from switching will occur for the reason of the high-frequency switching, though.

Examples are the 5-level and 9-level flying capacitor multilevel inverters :

The multi-inverter with the diode clamp and this inverter are the same.

Only switches and capacitors are utilised in this inverter.

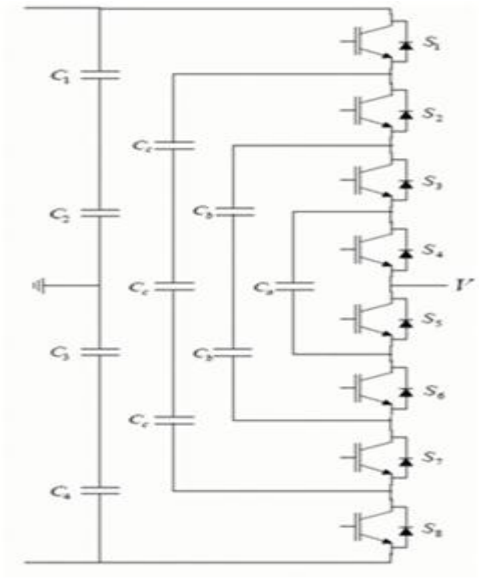


Fig:1.4.2. Multilevel inverter with flying capacitors

Multilevel Flying Capacitor Inverter Applications

Converters having the capacity to reduce harmonic distortion Using a DTC (Direct Torque Control) circuit, generate a static VAR for induction motor control.both AC-DC and DC-AC conversion applications rectifier for sinusoidal current.

1.4.3 Multilevel cascade H-Bridge inverter

Switches and capacitors are used by the cascaded H-bride multilevel inverter, and it requires fewer components per level. With this design, which has many power conversion cells, and power can quickly scaled up combining both of .

An H-bridge is a collection of switches and capacitors that each provide an alternative DC input voltage.One of the H-bridge cells that make up the device may create each of the zero, positive DC, and negative DC voltages. This type The advantage of a multi-level inverter over soaring capacitor and diode clamped inverters is that it uses fewer parts.

The inverter weighs more and costs less the other two, than. Soft switching is possible with some of the new switching methods.

The huge transformer needed by conventional Multi-phase inverters, flying capacitor inverters, clamping diodes for diode-clamped inverters, or diode-clamped inverters no longer essential with the introduction of multilayer cascade inverters. But to power each cell, these need a lot of independent voltages.

For instance, H-bridge clamped multilevel inverters (5 and 9) and multiple H-bridge inverters. This inverter and the multi-inverter diode clamped are both the same.

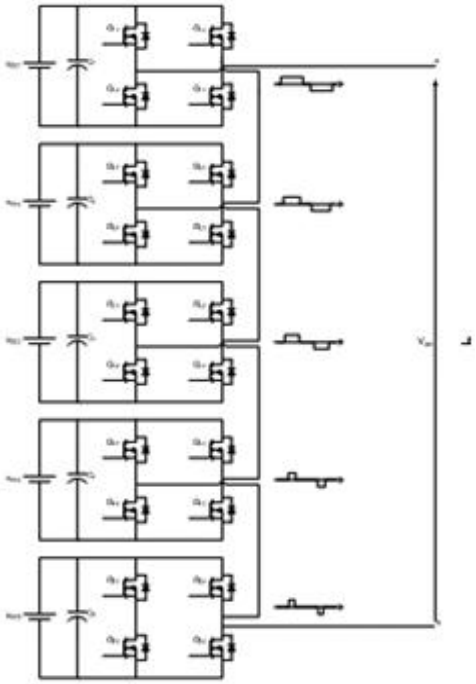


Fig: 1.4.3 Cascaded H-Bridge Multilevel Inverter

Applications for Multilevel Cascaded H-Bridge Inverters

- engine drives
- current filters
- DC power sources are used to power electric vehicles.
- compensators for power factor
- systems with back-to-back frequency links
- interacting with sources of renewable energy.

Symmetric and Asymmetric Multilevel Inverter

In this study, Hybrid and novel symmetric and asymmetric multilevel inverter topologies are suggested that are produced as a result of them and have fewer switches. The next section discusses the proposed multilevel inverters' basic functionality and power circuit topology.The proposed topologies are then contrasted with the other topologies. The investigation of hybrid topologies follows. To be able to

demonstrate the effectiveness of the suggested topology in producing the necessary output voltage, the modelling results, and the experimental data conclusion..

1.5 The proposed multilevel inverters

Both symmetric and asymetric multilevel inverters are given a new topology. There are significant differences between the suggested topologies for multilayer inverters that are symmetric and asymetric.The following subsections provide descriptions of them.

1.5.1.1 Proposed symmetric multilevel inverter

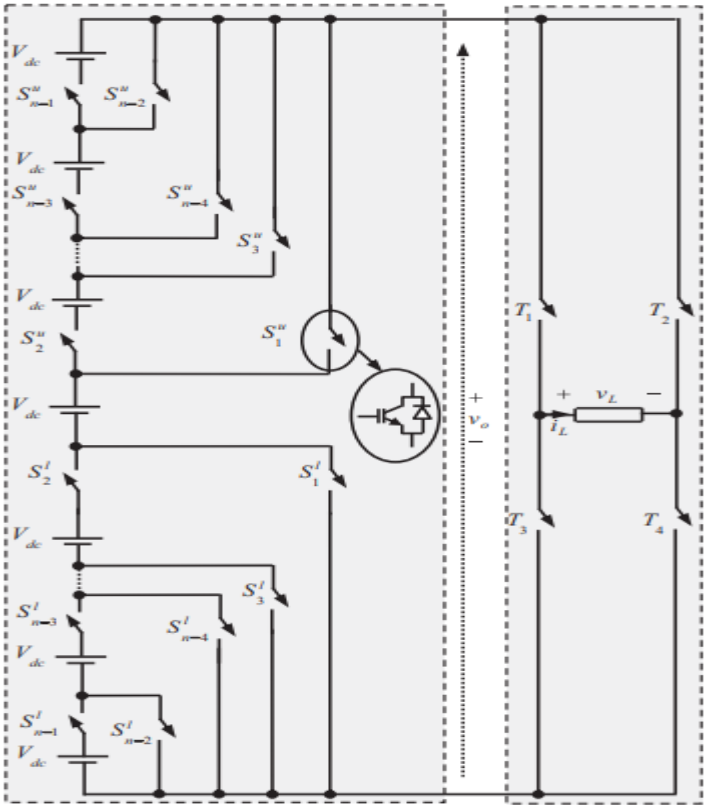


Fig:1.5.1.1 Proposed symmetric multilevel inverter

The symmetric multilayer inverter's suggested topology. The level creation component and the H-bridge make up the two halves of the multilevel inverter, as in the picture. The level maker component uses a particular configuration of power electronic switches and dc sources produce voltage levels.

The suggested topology's dc sources all have values that are equal to Vdc (symmetric topology). A switch separates the DC sources, allowing each one toa multilayer output voltage by being either conducted to the output or bypassed.. It is clear that the level generating component's positive voltage is always the output.

An H-bridge is employed a every half cycle, the level creator part's output should change the direction of the output voltage. In order to achieve zero voltage level, the H-bridge is further needed. Considering the states.

By properly switching between the switches, various output voltage levels are produced.For instance, based Depending on how the H-bridge switches are acting, the output voltage of Vdc is achieved if switches Su 1 and Sl 1 are switched on. Similarly, the switches Sl 1, Su 2, and Su 3 are activated to produce the output voltage of 2Vdc.

Table 1 shows the transitioning between symmetric multilayer inverter states that is advised. It is obvious that discrepancies between the switch states in the output voltage's the two extremes of values are associated with the H-bridge switches' statuses.The column n in this table indicates how many sources DC voltages are present. The following is true for the equations of the symmetric multilayer inverter with n dc sources may be constructed:

On switches	Output vc
$T_2, T_3, S_2^u, S_2^l \ldots, S_{n-3}^u, S_{n-3}^l, S_{n-1}^u, S_{n-1}^l$	$-nV_d$
⋮	⋮
$T_2, T_3, S_2^u, S_2^l, S_3^u, S_3^l$	$-3V_d$
$T_2, T_3, S_1^l, S_2^u, S_3^u$	$-2V_d$
T_2, T_3, S_1^u, S_1^l	$-V_{dc}$
(T_1,T_2) or (T_3,T_4)	0
T_1, T_4, S_1^u, S_1^l	V_{dc}
$T_1, T_4, S_1^l, S_2^u, S_3^u$	$2V_{dc}$
$T_1, T_4, S_2^u, S_2^l, S_3^u, S_3^l$	$3V_{dc}$
⋮	⋮
$T_1, T_4, S_2^u, S_2^l \ldots, S_{n-3}^u, S_{n-3}^l, S_{n-1}^u, S_{n-1}^l$	nV_{dc}

N level = 2n + 1 (1)

NIGBT = 2n + 2 (2)

vo, max = nVdc (3)

where N level, NIGBT, and vo, max stand for, respectively, the quantity of IGBTs,the highest output voltage and the number of output voltage levels determining the connection between the N level .

The symmetric topology suggested allows for the following method for obtaining NIGBT:

N level = NIGBT − 1 (4)

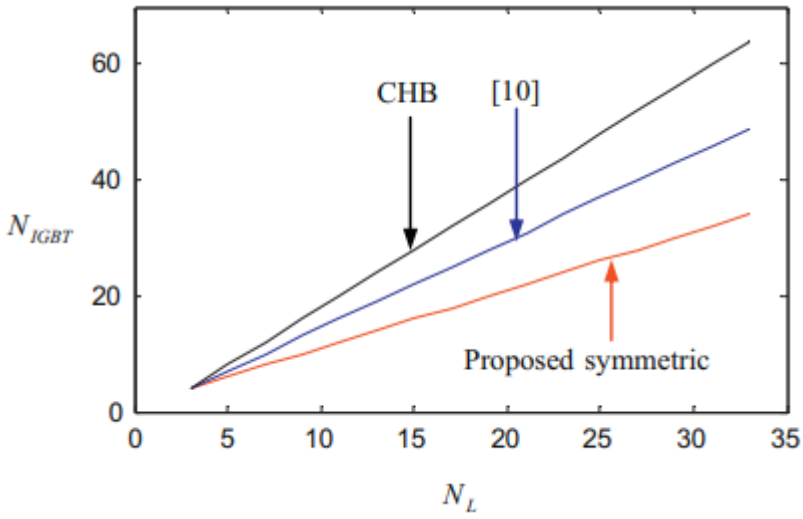


Fig:1.5.1.2. Comparison of the IGBTs utilised in the symmetric topologies corresponding to a given number of voltage levels

1.5.1.3 Asymmetric multilevel inverter being proposed

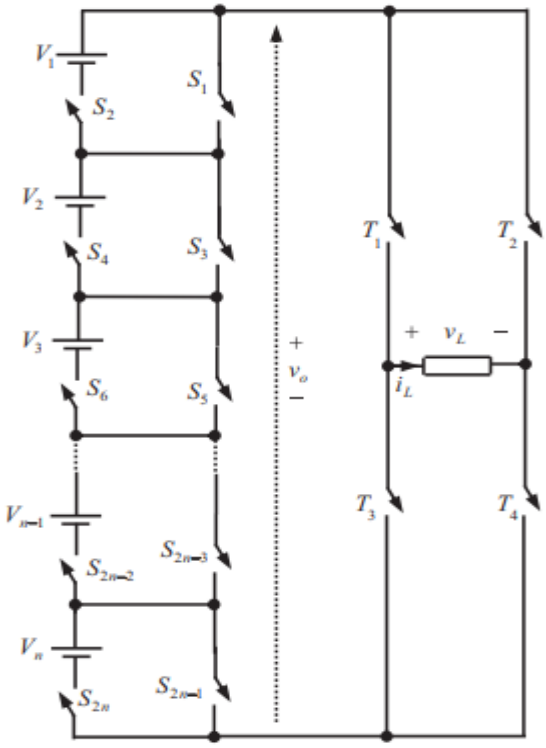


Fig:1.5.1.3 proposed asymmetric multilevel inverter

Asymmetric multilevel inverter that has been proposed.The H-bridge component and the level creator component two components that make up the asymmetric topology, just like the symmetric one. The H-bridge component shares identical to the symmetric topology.

However, the other portion is really distinct. The ability to bypass the dc voltage sources is required or conducted individually by the asymmetric architecture. from the symmetric topology. To produce all of the desired voltage values, this is required.

To accomplish the needs of an asymmetric multilevel inverter, two more switches are necessary. As an illustration, It is necessary to avoid the other sources of dc voltage when V2 is needed at the output. Table 2 lists the switch states needed to generate various output voltage values.

State	On switches	Output voltag
1	$T_1, T_4, S_2, S_4, S_6, \ldots, S_{2n-2}, S_{2n}$	$-\sum_{i=1}^{n} V_i$
⋮	⋮	⋮
$2n-5$	$T_1, T_4, S_2, S_4, S_6, \ldots, S_{(2n-3)}, S_{(2n-3)}$	$-(V_1+V_2+V_3$
$2n-4$	$T_1, T_4, S_1, S_4, S_6, \ldots, S_{(2n-3)}, S_{(2n-3)}$	$-(V_2+V_3)$
$2n-3$	$T_1, T_4, S_2, S_3, S_6, \ldots, S_{(2n-3)}, S_{(2n-3)}$	$-(V_1+V_3)$
$2n-2$	$T_1, T_4, S_1, S_3, S_6, \ldots, S_{(2n-3)}, S_{(2n-3)}$	$-V_3$
$2n-1$	$T_1, T_4, S_2, S_4, S_5, \ldots, S_{(2n-3)}, S_{(2n-3)}$	$-(V_1+V_2)$
$2n$	$T_1, T_4, S_2, S_3, S_5, \ldots, S_{(2n-3)}, S_{(2n-3)}$	$-V_1$
$2n+1$	$S_1, S_3, S_5, \ldots, S_{(2n-3)}, S_{(2n-3)}$	0
$2n+2$	$T_1, T_4, S_2, S_3, S_5, \ldots, S_{(2n-3)}, S_{(2n-3)}$	V_1
$2n+3$	$T_1, T_4, S_2, S_4, S_5, \ldots, S_{(2n-3)}, S_{(2n-3)}$	V_1+V_2
$2n+4$	$T_1, T_4, S_1, S_3, S_6, \ldots, S_{(2n-3)}, S_{(2n-3)}$	V_3
$2n+5$	$T_1, T_4, S_2, S_3, S_6, \ldots, S_{(2n-3)}, S_{(2n-3)}$	V_1+V_3
$2n+6$	$T_1, T_4, S_1, S_4, S_6, \ldots, S_{(2n-3)}, S_{(2n-3)}$	V_2+V_3
$2n+7$	$T_1, T_4, S_2, S_4, S_6, \ldots, S_{(2n-3)}, S_{(2n-3)}$	$V_1+V_2+V_3$
⋮	⋮	⋮
$4n+1$	$T_1, T_4, S_2, S_4, S_6, \ldots, S_{2n-2}, S_{2n}$	$\sum_{i=1}^{n} V_i$

The dc sources' values are connected in the following manner for the asymmetric multilevel inverter taken into account:

$$Vi = 2(i-1)Vdc \quad i = 1, 2, \cdots, n \qquad (5)$$

A binary increase in In Equation (5), the importance of DC sources is shown. These dc sources' settings enable the creation of any output voltage level that is conceivable. Following is a list of the output voltage levels and IGBT counts:

$$N\ level = 2(n+1) - 1 \qquad (6)$$

$$NIGBT = 2n + 4 \qquad (7)$$

The greatest output voltage that can be achieved may be stated according to the quantity of DC sources as follows:

$$vo, max = (2n - 1)Vdc \qquad (8)$$

Using (6)-(7), it is possible to determine the following relationship between N level and NIGBT for the suggested asymmetric topology:

N level = 2(NIGBT−2)/2 – 1 (9)

When (4) and (9 are compared, the asymmetric multilevel For a given IGBT count, the inverter either produces much more output voltage levels or utilises a significantly lesser IGBT At a certain output voltage level, count.

The asymmetric topology has this advantage across the topology that is symmetric. However, given that this particular type of multilevel dc voltage sources are necessary for the inverter. varied values, supplying them can be a difficult problem.

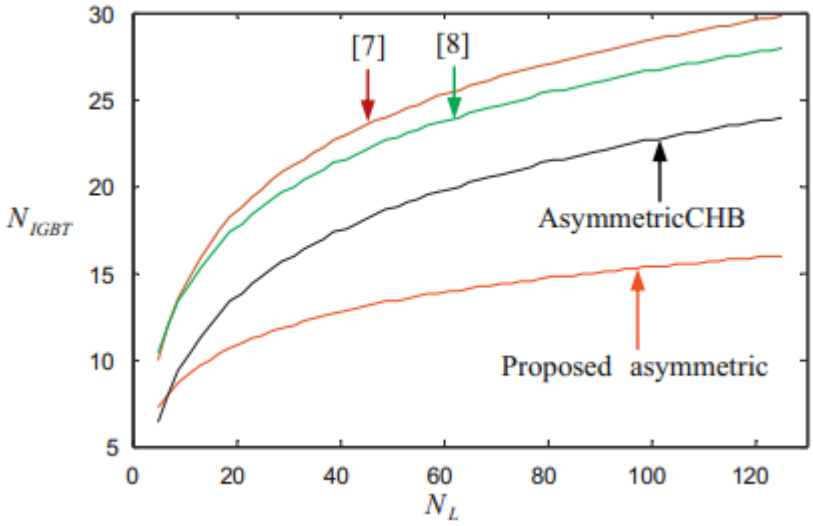


Fig:1.5.4 Comparison of the IGBTs utilised pertaining to the asymmetric topologies at a range of voltage levels

1.5.2.1 Comparison of the proposed multilevel inverters with other topologies

This section compares The number of voltage levels in the suggested topologies equals the number of IGBTs employed different topologies currently in use. Contrasted with the suggested symmetric topology traditional the symmetric topology of the CHB multilevel inverter and order to have the same criterion.

The series and parallel connection The uses one of the sources of dc voltage multilevel inverter with symmetry.It is significant to note that the cascaded H-bridge cell of the topology is disregarded for the sake of this comparison to be able to

maintain the same comparison condition.However, using the suggested topology, if an H-bridge is cascaded, it will perform better than in terms of the quantity of IGBTs employed.

The suggested symmetric multilevel inverter's quantity of IGBTs, as well as the architecture and number of symmetric CHB multilevel inverters, appear in Fig. 3. The suggested symmetric multilayer inverter employs a lot fewer IGBTs than the other topologies, as seen in the image.

For example, the proposed design employs 18 For a 15-level inverter, IGBTs , compared to 24 and 28 IGBTs for the symmetric CHB multilevel inverter. From the perspective of how many Integrated circuits are always in the current path. Given moment, another comparison between the topologies has been conducted. In Fig. 4, this comparison is shown. Less devices are in the present path in the suggested topology. Than the current architecture, as seen in the picture.

The fewer minimal The number of devices in the current implies low conduction losses and low voltage drop across the devices route.

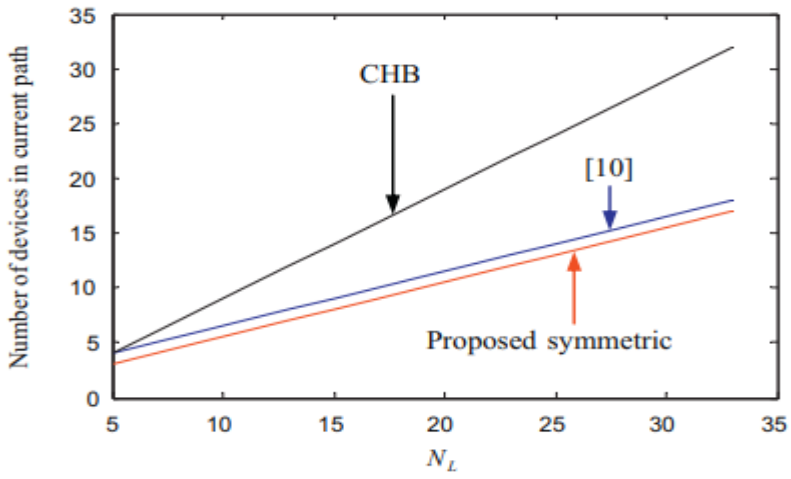


Fig:1.5.2.1 Relationship between the number of levels and the number of semiconductor devices in the current route at any one time for symmetric topologies

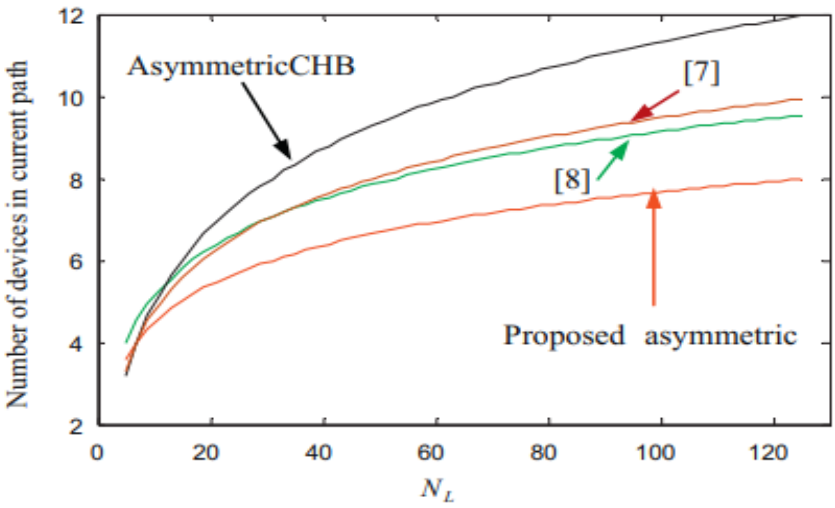


Fig:1.5.2.2 A comparison relation between the level count and the quantity of semiconductor devices used today route at any one time for asymmetric topologies

Two asymmetric multilevelCascaded basic units have been used in the introduction of inverters. The asymmetric CHB multilevel inverter and the proportion of the used IGBTs to the total number of voltage levels in the suggested asymmetric architecture are depicted in Fig. 1.5.2 The multilevel inverter that has been presented is asymmetric makes use of a lot fewer IGBTs.

The topology employs 20 IGBTs for a 21-level inverter, Taking the 31-level asymmetric inverter as an example, architecture in Ref. [8] uses 20 IGBTs to produce a 35-level output voltage. Figure 6 shows how many devices are on the current path at any given moment against the asymmetric topologies' voltage level count. This graph unequivocally demonstrates suggested asymmetric topology is significantly less than that in the various topologies. As previously mentioned, this lowers both the conduction losses and voltage drop on semiconductor devices.

1.6.1 IGBT (Insulated Gate Bipolar Transistor):

Power MOSFETs and bipolar transistors are combined into a single device to form IGBTs. This device's features include bipolar transistor output, MOSFET input, and output.

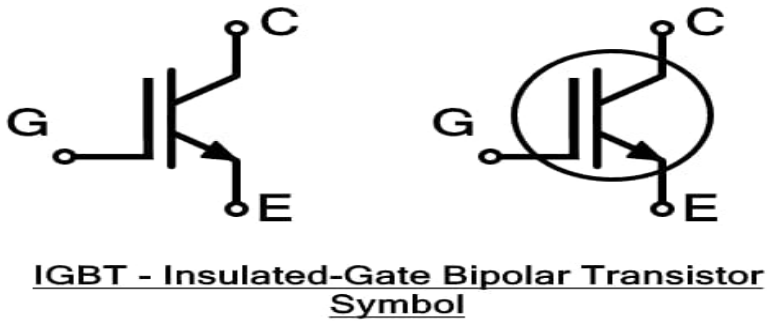


Fig:1.6.1. IGBT symbol

Similar to a power MOSFET in terms of voltage regulation, an IGBT has a somewhat longer turn-off time. • Isolated gate transistors (IGT) and conductively modulated field effect transistors (COMFET) are two types of field effect transistors (GEMFET), a bipolar mode MOSFET, and gain improved MOS field effect transistors (GEMOS).

An IGBT is also referred to as a bipolar MOS transistor,. IGBTs experience a rare phenomena known as latching up by regenerative action as a result of the existence of parasitic thyristor. IGBTs are semiconductor devices with four alternating layers (P-N-P-N), each of which is controlled by a non-regenerative MOS gate.

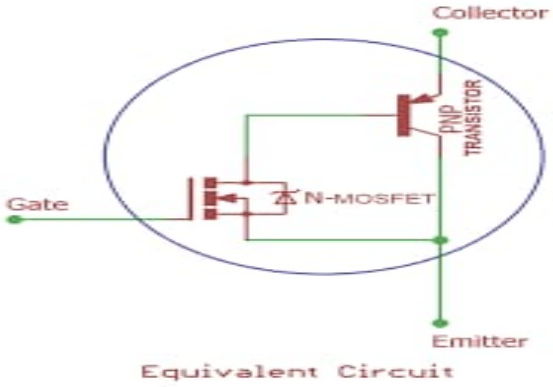


Fig:1.6.2 Equivalent circuit of IGBT

1.7 Harmonics

Frequencies that are multiples of one another are called harmonics. In music, they are referred to as octaves, and they are typically desirable. However, they are not welcome in the electrical energy distribution system of a building. Harmonics are a problem when paired with the main electric waveform. Harmonic frequencies may occur twice at 120 Hz, three times at 180 Hz, etc.

And soon because the harmonics of the 60 Hz vital energy frequency are multiples of that frequency. When harmonics are added, the sine wave is disrupted. Any defective or incomplete signal can be covered with an immense number of frequencies produced by the Fourier series.

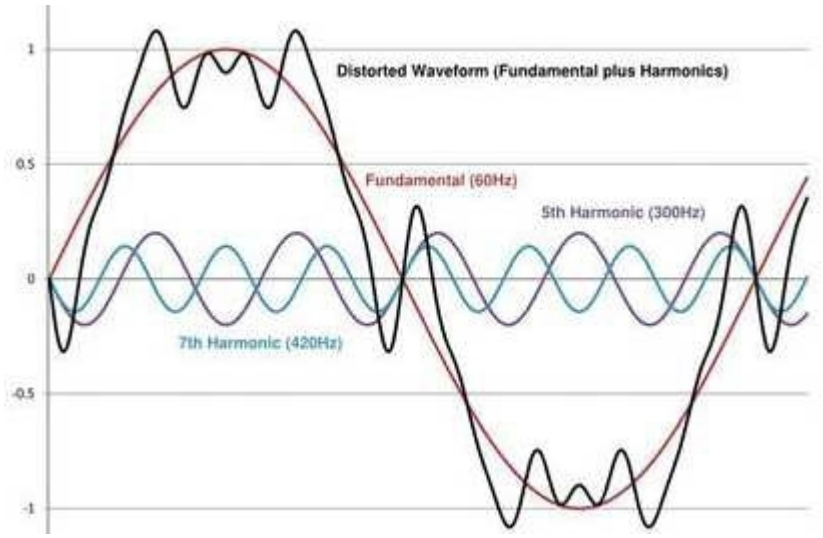


Fig:1.7.1 Harmonic distortion waveform

Electric powered voltages and currents called harmonics can cause serious issues with an electric power device. While harmonics might not stop a factory or workplace from running, their impact increases with their magnitude. Depending on how much power the device can handle and how susceptible it is to harmonic distortion.

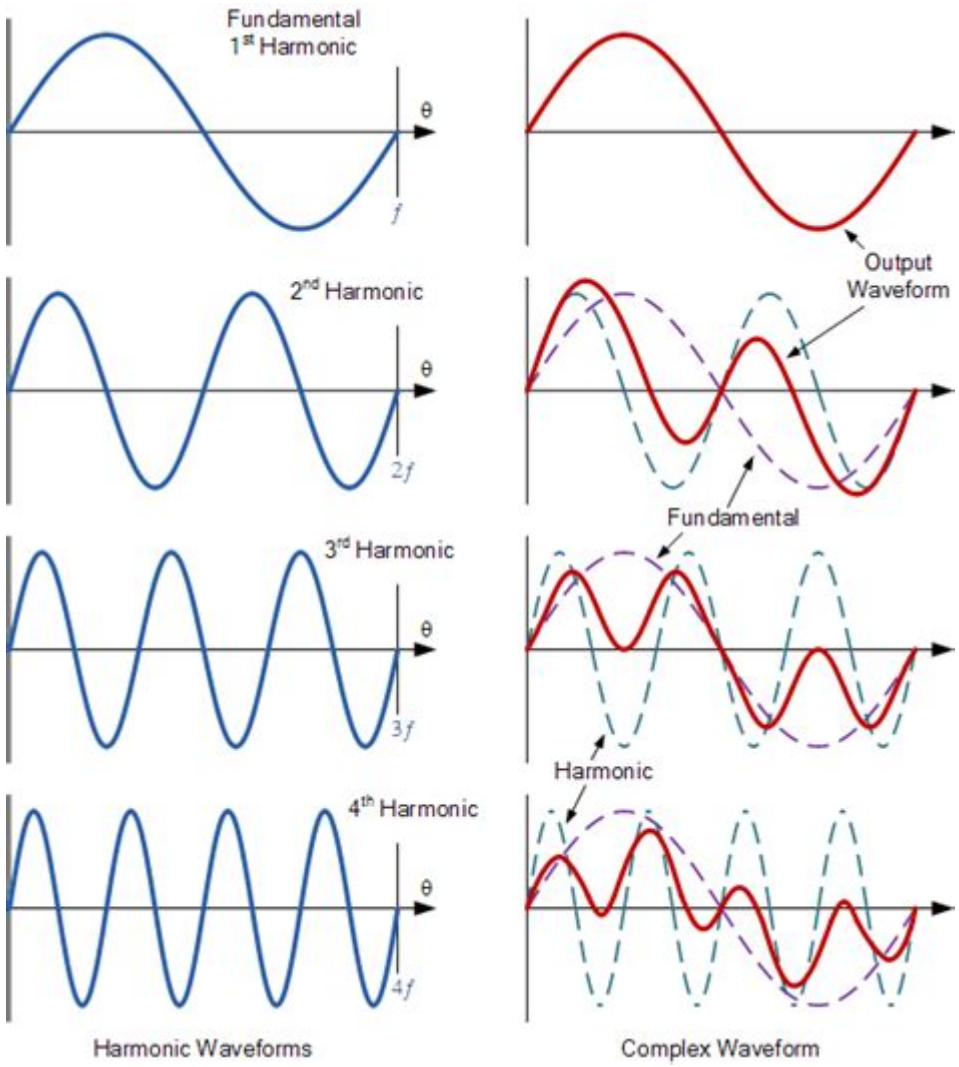


Fig:1.7.2 Harmonics and Complex waveforms

The values of the harmonics are E = Vmax(2t), while the fundamental frequency is E = Vmax(2t):

A second harmonic is:

E2 = V2(max)(2*2*t), V2(max)(4*t), and V2(max)(2*t).

E3 = V3(max)(3*2*t) = V3(max)(6*t), = V3(max)(3*t) for the third harmonic.

E4 = V4(max)(4*2*t) = V4(max)(8*t), = V4(max)(4*t) for a fourth harmonic.

As a result, the intricate waveform equation is as follows:

$$E_T = E_1 + E_2 + E_3 + \ldots\ldots E_{(n)} \quad \text{etc.}$$

$$E_T = V_{1max} \sin(2\pi f\tau) + V_{2max} \sin(4\pi f\tau) + V_{3max} \sin(6\pi f\tau) \ldots \text{etc.}$$

1.8 Total Harmonic Distortion

The existence of harmonics is displayed in the waveform of a voltage or current for each harmonic frequency as a percentage of the basic frequency's amplitude.Total harmonic distortion, or THD of a sign, is the ratio of the basic frequency powers of the total of all harmonic additive powers powers.

Both the linearity and nonlinearity of audio structures are indicated by THD. electrical energy structures' energy first class distortion component is occasionally carefully connected to time. As a synonym, it is employed in audio structures. technique to reduce THD natural modern way to reduce distortion additives employing a loud speaker amplifier, a microphone, or other tools, radio communications can generate a better copy of an audio recording.

(Square of amplitude of fundamental) X 100

$$\text{Distortion Factor}(THD) = \sqrt{\frac{\sum_{h=2}^{n} V_h^2}{V_1^2}} \times 100\%$$

Sources of Harmonics

Both the linearity and nonlinearity of audio structures are indicated by THD. electrical energy structures' energy first class distortion component is occasionally carefully connected to time. As a synonym, it is employed in audio structures. technique to reduce THD natural modern way to reduce distortion additives employing a loud speaker amplifier, a microphone, or other tools, radio communications can generate a better copy of an audio recording.

CHAPTER 2

LITERATURE SURVEY

This work introduces a new cascade topology for multilevel converters that involves serial coupling of a number of submultilevel units. Two novel techniques are provided for figuring out the magnitudes of the dc sources. The suggested topology is designed to generate any level with the fewest possible components and switch peak voltages. Due to the use of low voltage switches in the described design, it is possible to use it in high voltage applications rating. [1]

Harmonic Selection and Elimination The control of a five-phase, three-level NPC inverter is proposed using pulse width modulation (SHE-PWM) based on particle swarm optimisation. The goal of applying this technique is to improve the output voltage quality. The SHE-PWM is produced by the minimization of a restricted nonlinear objective function in order to satisfy this criterion, which includes a desired fundamental magnitude and the elimination of a certain number of low order harmonics.[2]

This research suggests a novel single-phase 15-level inverter with fewer components for solar PV applications. To extract energy from the solar PV modules, the suggested inverter is combined with a boost converter. This helps to produce fifteen stepped output voltage levels with decreased THD. The suggested inverter can increase efficiency while lowering system costs, complexity, and losses. The output voltage from Solar PV with MPPT(P&O) will be increased to its maximum voltage by the traditional boost converter.[3]

The most important traits of multilevel converters, to inspire potential solutions, and to demonstrate that we are at a turning point where energy businesses must count on multilayer converters as an effective alternative to traditional two-level converters.[4]

Voltage imbalance continues to be a problem with flying capacitor multilevel converters. The phase-shifted pulse width modulation (PS-PWM) technique has some self-balancing characteristics.[6]

a new multilayer converter topology that uses fewer power electronic switches and has several stages. The suggested circuit consists of blocks of sub multilevel converters that are connected in series. For a variety of goals, including a minimum amount of switches and capacitors and a minimum standing voltage on switches to produce a maximum amount of output voltage steps, the optimal topologies of this topology are examined. [7]

For both single-phase and three-phase medium-voltage high-power systems, brand-new symmetric hybrid multilevel topologies are presented. The topology concept is explained in depth, and the proposed converters' ancestry can be traced back to a three-level switching cell with a low component count and modulation pattern. Low output-voltage distortion and voltage sharing are accomplished. [8]

It is suggested to create a unique multilayer inverter using few switching elements. It consists of an H-bridge and an inverter that switch the dc voltage sources between series and parallel to produce multilevel voltage.[10]

A new multilevel converter topology, particularly network connections in power transmission and generation, that is ideal for very high voltage applications. It introduces the basic idea and the actual control system.[11]

A highly intriguing substitute for medium and high power drives are multilevel converters. The cascaded multicell converter is one of this type's more adaptable topologies. The usage of a single-phase reduction cell appropriate for cascaded multilevel converters is suggested in this research.[12]

A high sinusoidal output voltage can be created by developing a multilevel cascaded voltage source converter. Rectifiers fed from isolated generator coils balance the inverter modules' dc link voltages, and the inverter switching method balances the modules' power distribution. The dc link capacitors' size is constrained by the switching strategy's reduction of the low order harmonics. [13]

It is made up of several cascaded basic cells and is derived from the generalised multilevel inverter topology. The large transformer utilised in a traditional cascaded H-bridge converter is not required here because all of the dc capacitors are floating and the separate dc sources are not required. Additionally, it may actively balance each dc voltage level by utilising redundant switching states that are appropriate without the aid of any supporting circuitry. Additionally, it is easily expandable to higher levels.It is concluded that the novel topology that has been developed is very suitable for converters with a large number of levels by comparing it to the existing primary multilevel topologies. The voltage method and the operating concept are presented. [14]

The M2LC family of ac/ac modular multilevel converters will be a new addition. The modularity and improved control abilities of the new design make it unique. The rigid modularity produces a very affordable and adaptable converter structure. A variety of multiphase ac/ac converters are ideally suited to this novel Msup2LC design. A single-phase ac/ac converter that supports four-quadrant operation is described in full, along with its fundamental operating principle and both static and dynamic behaviour. It has been proven that this converter design successfully satisfies the stringent standards for ac-fed traction vehicles in the future.[15]

Many researchers have contributed to the development of multilevel power converters, which offer more than two levels of voltage to enable smoother and less distorted AC-to-DC, DC-to-AC, and DC-to-DC power conversion. A generalised multilevel inverter (converter) structure with self voltage balancing is presented in this study. The generalised inverter architecture can be used to derive the existing multilevel inverters, such as diode-clamped and capacitor-clamped multilevel inverters.Furthermore, the generalised multilevel inverter topology offers a genuine multilevel structure that can automatically balance each DC voltage level without the aid of other circuits, thus, in theory, offering a full and genuine multilevel topology that includes the existing multilevel inverters.[16]

CHAPTER 3

METHODOLOGY

3.1 11 level Symmetric Multilevel Inverter

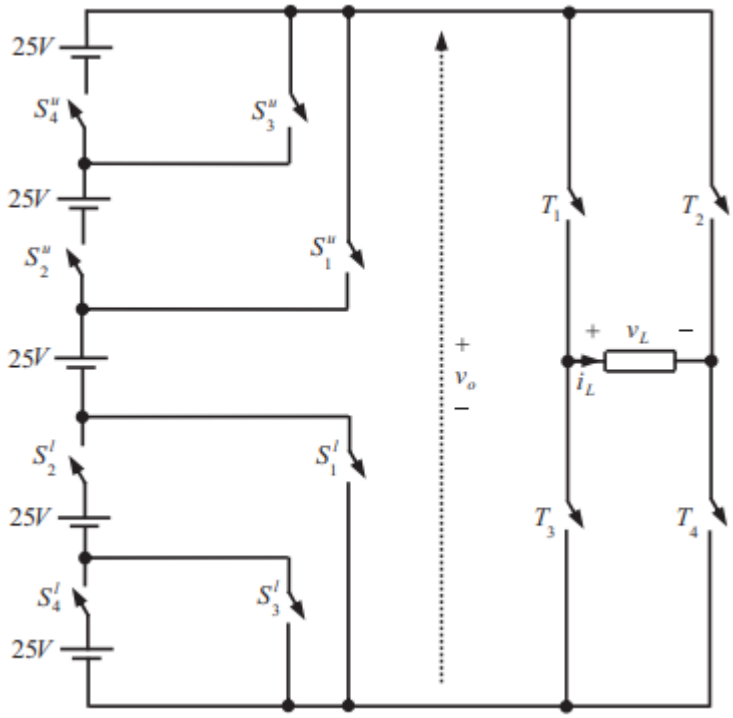


Fig:3.1 11 Level Symmetrical Multilevel inverter

In this number of voltage sources used are 5

Therefore, n=5

N level = 2n + 1 (1)

= 2(5)+1

N level =11

N IGBT = 2n + 2 (2)

= 2(5)+2

N IGBT =12

Vo max = nVdc (3)

= 5(25)

Vo max = 125v

3.2 15 Level Asymmetric Multilevel Inverter

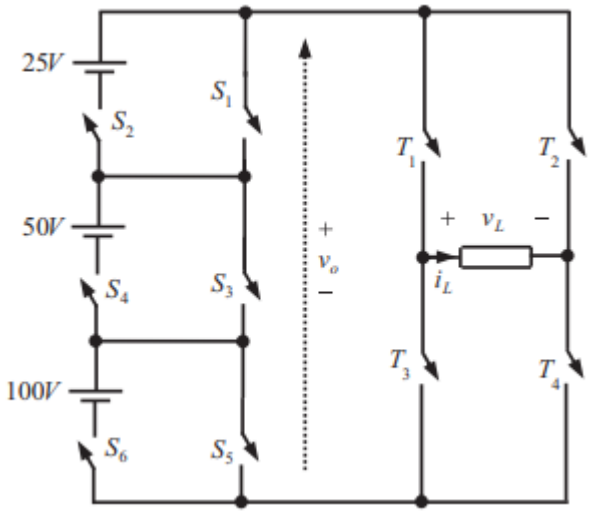


Fig:3.2 15 level Asymmetric multilevel inverter

Vi = 2(i−1)Vdc i = 1, 2,· · ·, n (5)

Here,

Vdc = 25

For i = 1,

V1 = 2(1-1)25 = 0

For i = 2,

V2 = 2(2-1)25 = 50

For i = 3,

V3 = 2(3-1)25 = 100

N level = 2^(n+1) – 1 (6)

= 2^(3+1) – 1

= 2^4 – 1

N level = 15

NIGBT = 2n + 4 (7)

= 2(3)+4

NIGBT = 10

Vo max = (2n − 1)Vdc (8)

= (2^n – 1)Vdc

= (2^3 – 1)25

= (8-1)25

Vo max = 175v

3.3 Comparison of THD and THDW for proposed multilevel inverter and 2-level H-bridge inverter

MI	Switching Frequency=1 kHz								Switching Frequency=5 kHz							
	9-Level MLI		13-Level MLI		17-Level MLI		2-Level H-bridge		9-Level MLI		13-Level MLI		17-Level MLI		2-Level H-bridge	
	T*	WT*	T*	WT*	T*	WT*	T*	WT*	T*	WT*	T*	WT*	T*	WT*	T*	WT*
1	11.3	0.45	10.19	0.66	7.02	0.31	53.01	1.59	13.97	0.22	9.43	0.18	7.12	0.21	52.41	0.37
0.75	19.66	0.99	13.46	0.69	10.13	0.68	84.34	2.57	18.34	0.49	13.39	0.19	9.38	0.4	84.14	0.51
0.5	27.15	0.96	19.95	0.7	11.85	0.69	124.30	3.82	27.14	0.34	18.51	0.87	14.22	0.51	124.34	1.34
0.25	52.67	1.73	40.77	0.9	27.15	0.96	203.41	4.88	53.28	0.81	40.42	0.43	27.14	0.84	203.65	1.23
T*= THD (%) WT*= THD_W(%)																

3.4 Reduced harmonic distortion

The filter circuit is not required since the output waveform has low total harmonic distortion thanks to the selective harmonic elimination approach and the multi-level structure.

3.5 Advantages

1.Common Mode Voltage is produced by the multilayer inverters., which lowers the motor's stress and prevents motor damage.

2. Input Current: Multilevel inverters have a low distortion input current capability.

3. Switching Frequency: The multilayer inverter may function at both fundamentally Both greater and lower switching frequencies are used.It ought to be emphasised that better efficiency and reduced switching loss are obtained with lower switching frequency.

4. Lessened harmonic distortion: The lack of a filter circuit results in output waveform exhibits low overall harmonic distortion thanks to the selective harmonic elimination approach and the multi-level structure.

3.5 Disadvantages

The following drawbacks apply to multilevel inverters:

1. The quantity of switching devices has significantly increased. The circuit becomes more expensive and complicated as a result. Additionally, there have been cases where dependability has been compromised.

2. Multiple gate pulses must be produced due to the numerous switches in multilevel inverters, which again necessitates the usage of sophisticated PWM-based digital signal processors.

3. A few designs for multilayer inverters call for more than one isolated DC supply. Due to the rising system costs, this is a serious problem. The absence of a DC supply is also a problem.

4. Creating numerous DC sources frequently calls for multi-winding transformers. As a result, the system increases in price.

3.6 Applications

- Active filters and motor drives.
- DC power sources are used to power electric vehicles.
- Compensators for power factor.
- Systems with back-to-back frequency links.
- Interacting with sources of renewable energy.

CHAPTER 4

IMPLEMENTATION OF SIMULINK MODEL

4.1 Introduction

To model electrical, mechanical, and control systems, Simulink software works in conjunction with SimPowerSystems software and other Physical Modelling product family members.

Simulink is the environment in which the SimPowerSystems programme runs. Therefore, familiarise yourself with the Simulink documentation before beginning this user's manual. You might also refer to the documentation for the Signal Processing Block set if you work on communications and signal processing jobs rather than control system design duties.

4.2 The Role of Simulation in Design

Electromechanical systems make up electrical power systems components like motorsand electrical circuits, as well as generators. The performance of the systems is always being enhanced by engineers in this field. Electrical engineers have been compelled by demands for much higher efficiency to utilise sophisticated control systems and powerful electronic gadgets ideas that strain conventional analytical tools and procedures. The regularity with which the system operates nonlinear that modelling is the only method to comprehend it further complicates the analyst's job.

There are other applications for power systems than the production of electricity on land using hydroelectric, steam, or other technologies. These systems have the trait of using power electronics and control systems in order to meet their performance goals.

Modern design tools like SimPower Systems software make it simple and quick for engineers and scientists to create models that replicate power supply. It utilises the Simulink environment, allowing you to develop models with only a few clicks and drags. You may quickly sketch the circuit topology, and you can determine how the circuit interacts with mechanical, thermal, among other fields, control. Here it

is feasible because the broad Simulink modelling library interacts with all the electrical components of the simulation.Designers can also employ Simulink block sets and MATLAB toolboxes since Simulink makes use of the MATLAB computational engine. SimPowerSystems software utilises a similar block and connection line interface and is a member of the Physical Modelling product family.

4.3 Power simulation libraries

Typical power equipment models,including Power electronics, lines, equipment, and transformers are available in Sim Power Systems libraries.The Hydro-Québec École de Technology Supérieure and Université Laval's a sizable North American utility called Power Systems Testing and Simulation Laboratory with its headquarters in Canada, experiences, are used to validate these models, which are validated ones taken from textbooks.

Demonstration files show the software SimPowerSystems' capacity to model a typical electrical system. Additionally, there are self-learning case studies available for those who want to brush up on their understanding of power system theory.Building blocks in SimPowerSystems' primary library, Powerlib, are organised into libraries based on how they operate. Powerlib's library pane displays the names and icons for the block libraries. Double-clicking The library is opened using a library icon where you may to get to the blocks. The Powergui block, which starts a graphical user interface for electrical circuit steady-state analysis, is also present in the main powerlib library window.

4.4 Models for Simpower systems using nonlinear Simulink blocks

The powerlib library's blocks of nonlinear Simulink are kept in a unique block library called powerlib models. SimPowerSystems software creates an identical Simulink model of your circuit using these masked Simulink models. For further information on the powerlib models library, see to Improving Simulation Performance

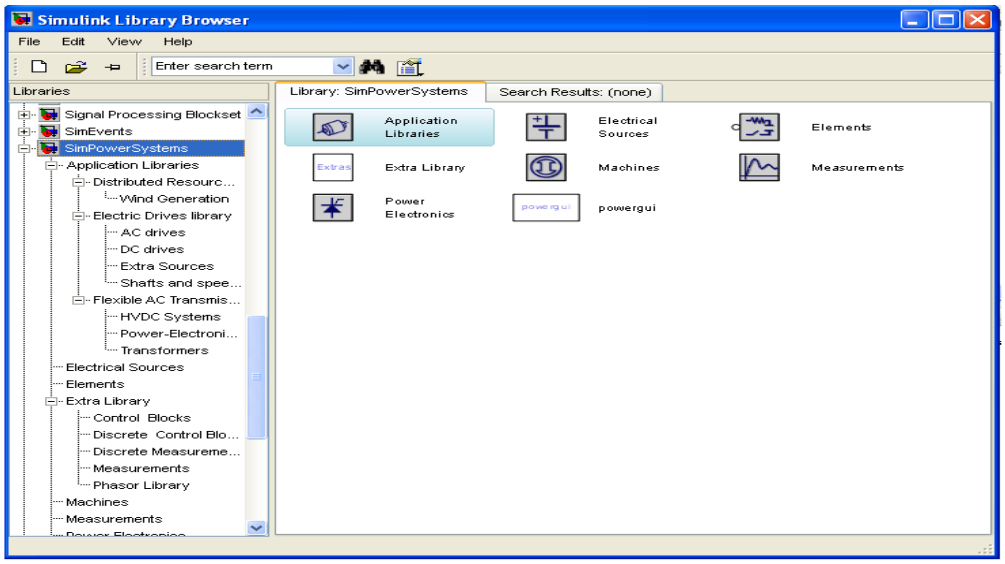


Fig:4.4 Diagram of simpower system

4.5 Applications of Matlab

With the help of pre-built functions and user-created programmes, data may be analysed and visualised using the software package MATLAB. A programming language and environment for numerical computations are called MATLAB. Easy Matrix manipulation, function, and data are possible using MATLAB visualisation, implementation of algorithms, design of user interfaces, and communication with programmes written in different tongues.Despite its focus on number computation, Maple may be integrated into a complete computer algebra system thanks to a separate toolbox that communicates with the Symbolic engine for Maple.

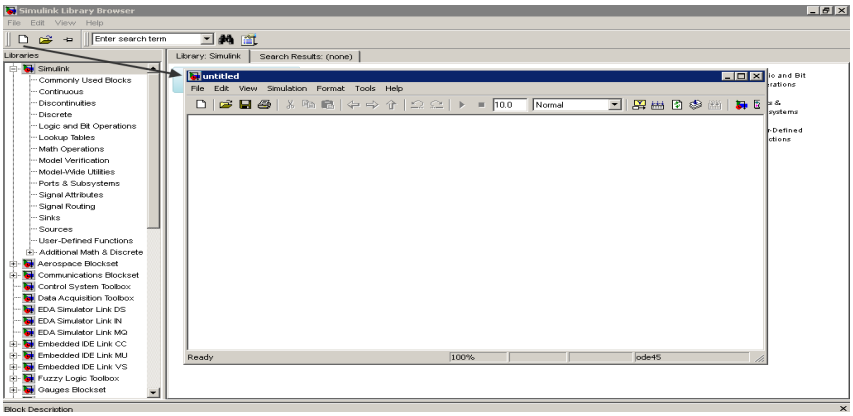
among the applications for the math lab are:

- ➢ Multiplexing using splitting of frequencies orthogonally
- ➢ data mining with genetic algorithms
- ➢ utilising the VQ approach for speech recognition
- ➢ Analysis of multi-user and iterative channel estimation identification in multiple route channels in DS-CDMA DS-CDMA radio waves
- ➢ detection of time-domain signals

- ➢ Time-domain signal detection for mimo-OFDM systems based on second-order statistics
- ➢ Block coding in time and space
- ➢ Channel block codes for mimo in space-time
- ➢ channel estimate in the dark.

Basic circuit design and outcome analysis:

A file will appear after you click the file and choose "new model file":



The block will now show in the new model file (untitled) when you right-click it.

Consider a sine wave as an example. Place the scope block in the source block to receive or examine the output. Connect the two blocks. Now that a basic circuit is prepared, you may simulate it by selecting the simulation icon (the "PLAY BUTTON") and setting the simulation time (the default setting is 10.0 seconds). Now that the simulation is finished, you may see the results by double-clicking the scope.When you select auto scale, the output is displayed in clear detail.

4.6. Model execution phase

Simulink calculates the system's performance using data provided by the model during the simulation model execution phase. Time steps, or discrete time intervals, are used to determine the states and outputs. Step size is the measure of the interval between each step. The software that was used to identify the continuous states of the system, whether those continuous states contain discontinuities, and the

fundamental sampling time (Zero Crossing Detection) all have an impact on the step size. The model specifies the state of the simulated system before that and its outputs at the start of the test. The new values, states, and outputs are then included into the model. The final inputs, states, and outputs of the system are shown by the model somewhere close to the simulation's conclusion.

The model's outputs are updated in blocks using the Matlab programme at regular intervals in a sorted order. Simulink computes the block's outputs using the block's transformation matrix. Since the block's imports and states may be required at the structure's end, Simulation software additionally keeps track of the current time for the output function. Simulink uses the block's integral sampling moment to modify the output of a separate block if this step is a multiple of the step preceding it.

- Sorts and modifies the block states of the model. Simulink computes each block's discrete states based on the decision variable problem or issue being addressed. Simulink uses a dynamic average of the temporal derivatives of the current states to determine the block's unbroken states.
- Simulink finds singularities in uninterrupted environments using a technique known as slowly changing detection, and it uses the continuing derivatives function of the structure to compute the states' temporal derivatives.
- Determines the time for the subsequent timing step.

4.7 Block Sorting Rules

Before these streaming servers travel across these blocks, each block must also be updated. This rule makes sure that the inputs are still valid when updates are made to direct-feed through blocks. As long as they push any direct-feed via blocks that need to be updated first, non-direct-feed via blocks can be used in any type of sequence. To comply with this requirement, move every semi fed via the blocks in whatever order to the head of the current line. Simulink can reject - anti pass through blocks even during the filling process as a simple consequence.Reorganise the list of non-direct-feed through blocks as a consequence of putting these recommendations into effect. seem to be at the peak Without regard to order, direct feed blocks are listed

first.It is instantly supplied via the block connected or laterally to at least one of the inputs to the block in the sequence necessary to create valid inputs in a nursing instantaneous. Since Simulink's conception, a similar stalemate has demanded the entry of a block that instantly feeds through data. The mathematical circle will symbolise a collection of current. The block's input and output are both pure mathematical equations with unknown variables, thus the name. Additionally, the solutions from these equations are always precise.As a result, Simulation software tries to prevent rings with direct feeding algebra equations from being formed whenever feasible.

11 level symmetric multilevel inverter block diagram

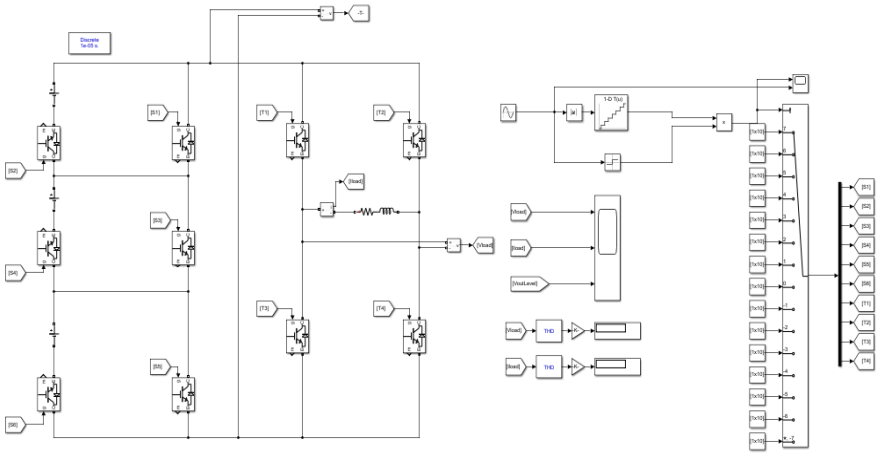


Fig:4.7.1 11 level symmetric multilevel inverter

15 level asymmetric multilevel inverter block diagram

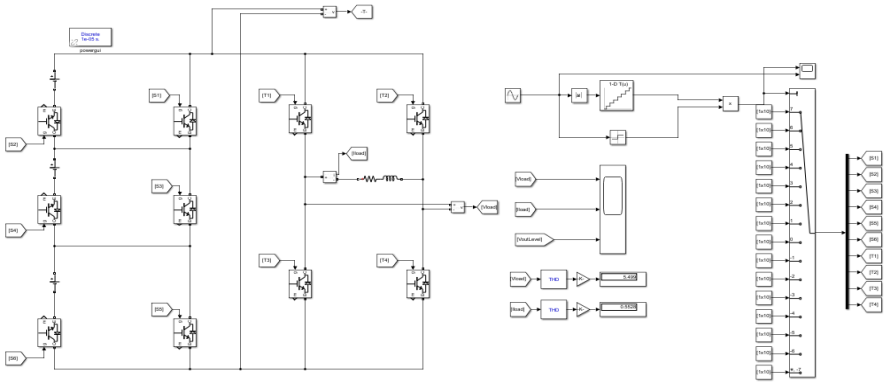


Fig:4.7.2 15 level asymmetric multilevel inverte

CHAPTER 5

SIMULATION RESULTS OF MODEL

The modelling and The suggested multilevel inverters are symmetric, asymmetric, and hybrid have undergone experimental study are covered in this part. The PSCAD/ EMTDC programme is utilised for simulation. All of the switches are regarded as perfect in the simulations. an inductance and resistance coupled in series with values of 35 and 55 mH, make up the load.

It is expected that 50 Hz is the output voltage frequency. It is important to remember that just the asymmetric topology's experimental data are provided. The simulation studies' dc voltage sources are distinct dc sources.In reality, distributed energy supplies like solar panels may make these dc voltage sources accessible.

References [24, 25] , another way to supply the necessary multiple dc voltage sources is provided. Combining the use between line-frequency and high-frequency transformers is the foundation of this technique. This approach divides the multilevel inverter into two sections, the main section and the auxiliary sections. The primary component, which employs a line-frequency transformer, is in charge the bulk of the output power.

The available dc power supply is first converted to an incredibly high-frequency pulse in the auxiliary sections. a secondary winding high-frequency transformer with several passes the high-frequency waveform.

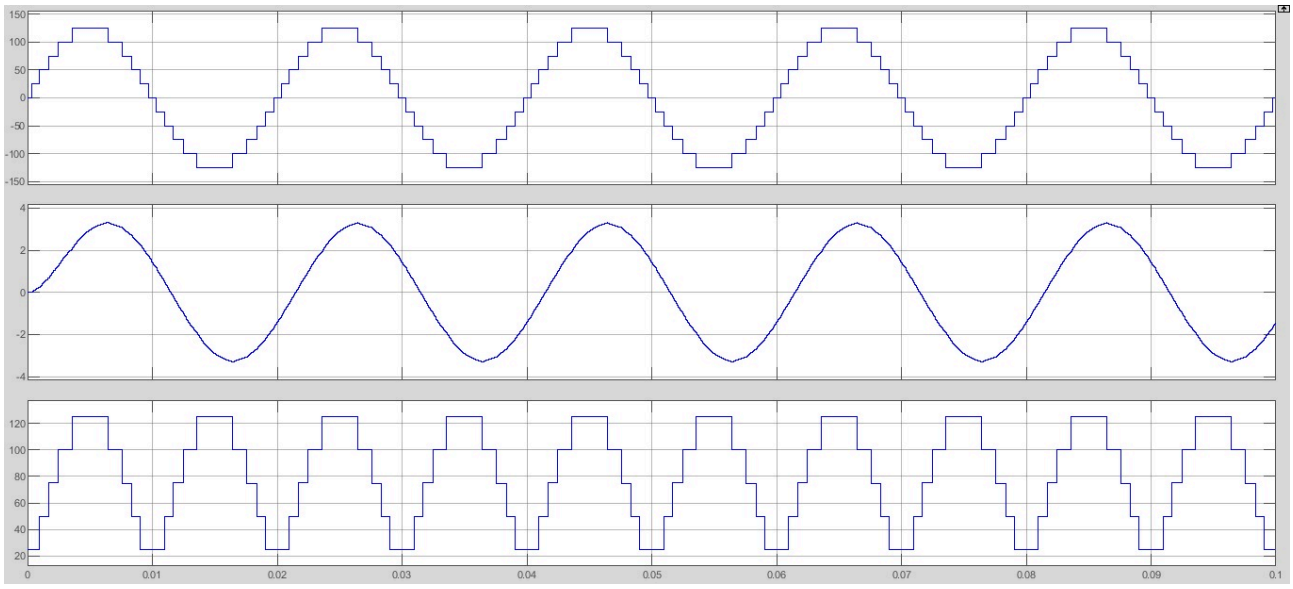


Fig5.1 Simulation The 11-level symmetric topology that is proposed has outcomes

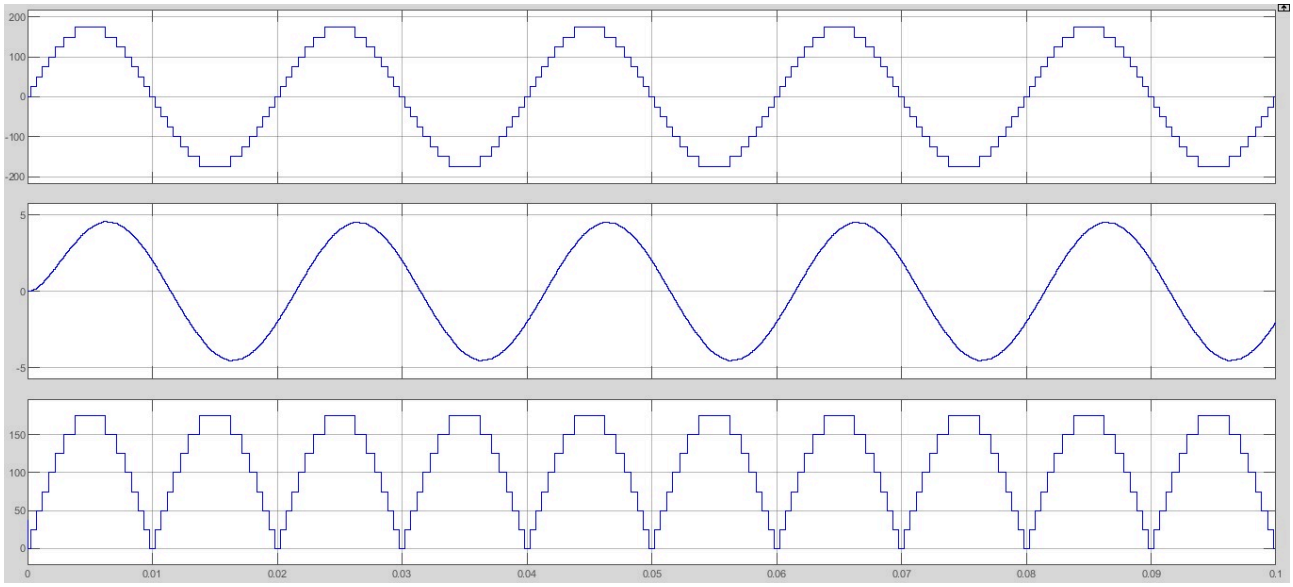


Fig5.2 Simulation The 15-level asymmetric topology that is proposed has outcomes

Figure 5.1 shows output voltage, current and DC link wave forms of 11-level symmetric multilevel inverter with the THD values 7.582 and 0.8862 of voltage and current.

Figure 5.2 shows output voltage, current and DC link wave forms of 15-level asymmetric multilevel inverter with the THD values 5.499 and 0.5528 of voltage and current.

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

Two innovative multilevel inverter topologies are put forth in this study. Asymmetric symmetric multilevel inverter and multilevel inverter are two of the topologies that have been suggested. Comparing the proposed multilevel inverters to existing topologies, fewer switching devices are used.

For instance, 28 IGBTs are used in the CHB multilevel inverter. but a 15-based on the level inverter suggested symmetric design uses 18 IGBTs. Ten IGBTs are used in an 11-based on the level inverter suggested asymmetric architecture.Twelve IGBTs are employed in a multilevel CHB inverter. with 11 levels of asymmetry. Additionally, based on the suggested topologies, two hybrid topologies that are better suited for higher voltage applications have been shown. Both simulation and evidence from experiments is presented to support the suggested topologies.

6.2 Future scope

To manage Multilevel inverters with high voltage and power, as well as dynamic power systems, been designed. Compared to traditional 2-level inverters, these inverters come with a few built-in advantages. Among the most significant benefits of multilayer inverters is the high calibre of their output voltage. There are new multilevel inverter topologies that are symmetric and assymetric.Suggested in this article.

In compared to standard multilevel inverters and other unconventional topologies, the suggested multilevel inverters require less switching components for a certain several levels of output voltage.To be utilised at higher voltage ranges, hybrid topologies that are derived from the suggested topologies are suggested. The simulation's outcomes using software PSCAD/EMTDC and the experimental findingsThe proposed topologies are validated by results from a lab prototype.

APPENDIX

An outstanding performance system for scientific computing is called as MATLAB. It adds computation, visualisation, and programming in an environment that is user friendly, with problems and solutions presented using conventional mathematical notation.

Typical uses of MATLAB include:

- ➢ Maths and computational work
- ➢ Algorithm designing
- ➢ Data collection and conversion
- ➢ Modelling and creating new simulation
- ➢ Data Analysing, exploration, and visualization
- ➢ Industrial and scientific illustrations.

In the computer programme MATLAB, a dimension-free array serves as a basic data component. This enables for quick and efficient resolution of several technical computing issues, particularly those involving vector, matrix formulations, comparison to time required to build a Use a scalar, pseudo-interactive programming language, such as C or FORTRAN

There are three key components to the MATLAB system:

- **Environment of MATLAB used for development**

These are the tools and resources that make it easier to use the features of MATLAB and files. User interfaces with graphics are used by several of these technologies. MATLAB workspace and Window command, a command line history, an editor and debugger, as well as browsers for examining the workspace, files, help, and the search path are all included.

- **MATLAB Library for different functions**

This includes a wide range of diverse computing methods, from elementary ones like sum, sine, and cosine to more intricate ones like matrices inverse, vector Eigen values, Bessel functions, and quick Fourier transformations.

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