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E-mail :
editor.ijpast@gmail.com
editor@ijpast.in

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Pwm Control Of Dual Induction Motor Fed With Differential Voltage Gains

Mr.P.Rajyalakshmi [1],G.Mounika [2], G.Vineetha [3],

Abstract

The primary goal of this project is to develop a 15-Level Asymmetric Cascaded H Bridge Multilevel Inverter with Less Number of Switches based on phase dispositionpulse width modulation (PDPWM) for electric vehicle applications. In this project, Asymmetrical MLI the DC source Magnitude are unequal and it is designed with binary form of voltage such as 50Vdc, 100Vdc & 200Vdc.Comparing both the MLI, Asymmetrical MLI generates a number of output voltage level with same number of Power semiconductor switches. The phase Disposition Pulse Width Modulation (PD-PWM) technique is used for controlling the Power semiconductor switches in MLI. The results are verified in both MATLAB.

INTRODUCTION

The multilevel inverter (MLI) topologies have beenintroduced to address different types of applications[1]–[3]. Generally, MLIs either rely on isolated dc power sourcesor split capacitors connected to a single dc power source tosynthesize its stepped output voltage levels. The first type ismore reliable but require as mentioned increasing number of dcpower sources and power switches such as cascaded H-bridgeMLI. On the other hand, split capacitor based MLIs such as neutralpoint clamped (NPC) MLI [4], flying capacitor (FC) MLI[5], and T-type MLI [6], [7] required lower number of powercomponents. Nonetheless, as the voltage across each capacitoris relaying on an ideal natural balance, their voltages in practical are susceptible for voltage drifting which leads tovoltage imbalance operations.In electric vehicle (EV) applications, the three-phase inverterin propulsion system is fed by a bidirectional dc–dc converter[8]–[10]. It controls the dc bus voltage by regulating its voltageto be at the level required to allow the power to flow to theelectric machine in motoring mode over the designed rangeof modulation index (*mi*). In breaking mode (regenerative),the bidirectional converter stepped the dc voltage to allow thepower to flow in reverse direction from the electric machineback to the utility grid or electrical storage units as in EV. Basedon the power source connected to the propulsion system, thebidirectional converter can be designed as boost converter inmotoring mode and buck converter in breaking mode, or viceversa.

Multilevel Inverter (MLI)has more advantages than conventional inverter because of less switching losses, less voltage stress across switch and less Electromagnetic Interference (EMI).Generally there are three basic types of MLI they are Neutral point Clamped (NPC MLI),Flying Capacitor (FC MLI) and

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Assistant Professor [1],
Department of EEE,

Cascaded H-Bridge (CHB MLI).The Figure 1.1 shows the classification of MLI. In NPCMLI it consists of clamping diodes which increases the voltage levels. The capacitor are connected in series for voltage balancing. This makes a huge problem for devices. In FCMLI more number of clamping capacitors are connected, so the voltage balancing is difficult. CHBMLI is suitable for high voltage applications because, each H bridge consists of 4 switch and one DC source. Clamping capacitors and diodes are not used here[5]. In CHBMLI Topology, depending upon DC source it consists of two types, 1.Single DC source and 2.Multiple DC source[4]-[3].In Single DC source the CHBMLI are connected in parallel and to the output of each H Bridge the low frequency transformer is connected .To increases the “n” number of levels the Transformer is increased for each H Bridge inverter, so that the efficiency of system will become less. In multiple DC Source the CHBMLI are connected in series.To increase the “n” number of output voltage levels the several H-Bridge and DC source are used. To reduce the switches in this topology the Symmetrical and Asymmetrical CHBMLI are utilized.[1]-[2].

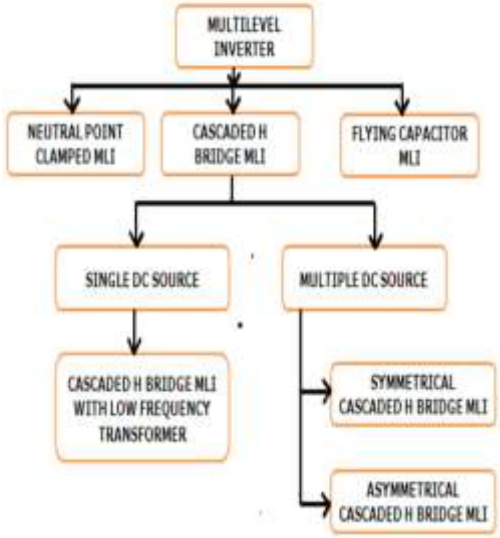

Fig. 1 Classifications of Multilevel Inverter

INDUCTION MOTOR

Historical Review

The history of electrical motors goes back as far as 1820, when Hans Christian Oersted discovered the magnetic effect of an electric current. One year later, Michael Faraday discovered the electromagnetic rotation and built the first primitive D.C. motor. Faraday went on to discover electromagnetic induction in 1831, but it was not until 1883 that Tesla invented the A.C asynchronous motor.

In 1882, Nikola Tesla identified the rotating magnetic field principle, and pioneered the use of a rotary field of force to operate machines. He exploited the principle to design a unique two-phase induction motor in 1883. In 1885, Galileo Ferraris independently researched the concept. In 1888, Ferraris published his research in a paper to the Royal Academy of Sciences in Turin. Introduction of Tesla's motor from 1888 onwards initiated what is known as the Second Industrial Revolution, making possible the efficient generation and long distance distribution of electrical energy using the alternating current transmission system, also of Tesla's invention (1888).

Before the invention of the rotating magnetic field, motors operated by continually passing a conductor through a stationary magnetic field (as in homo polar motors). Tesla had suggested that the commentators’ from a machine could be removed and the device could operate on a rotary field of force. Professor Poeschel, his teacher, stated that would be akin to building a perpetual motion machine. This classic alternating current electro-magnetic motor was an induction motor.

In the inductionmotor, the field and armature were ideally of equal field strengths and the field and armature cores were of equal sizes. The total energy supplied to operate the device equaled the sum of the energy expended in the armature and field coils.

The power developed in operation of the device equaled the product of the energy expended in the armature and field coils. The main advantage is that induction motors do not require an electrical connection between stationary and rotating parts of the motor. Therefore, they do not need any mechanical commutates (brushes), leading to the fact that they are maintenance free motors. Induction motors also have low weight and inertia, high efficiency and a high overload capability. Therefore, they are cheaper and more robust, and less prone to any failure at high speeds. Furthermore, the motor can work in explosive environments because no sparks are produced.

3Induction motor general principle

As a general rule, conversion of electrical power into mechanical power takes place in the rotating parts of an electrical motor. In dc motor, the electrical power is conducted directly in armature the rotating part of the motor through brush or commutates and hence dc motor called as conduction motor but in case of induction motor the motor does not receive the electrical power by conduction but by induction in exactly same way as the secondary of a 2-winding transformer receives its power from the primary. That is why such motor known as induction motor.

In fact, an induction motor can be treated as a rotating transformer i.e. one in which primary winding is stationary but the secondary is free to rotate. Of all the a.c. motors, the poly phase induction motor is the one which is extensively used for various kinds of industrial drives.

When a three-phase supply is connected to the stator windings, a rotating magnetic field is produced. As the magnetic flux cuts a bar on the rotor, an e.m.f. is induced in it and since it is joined, via the end conducting rings, to another bar one pole pitch away, current flows in the bars.

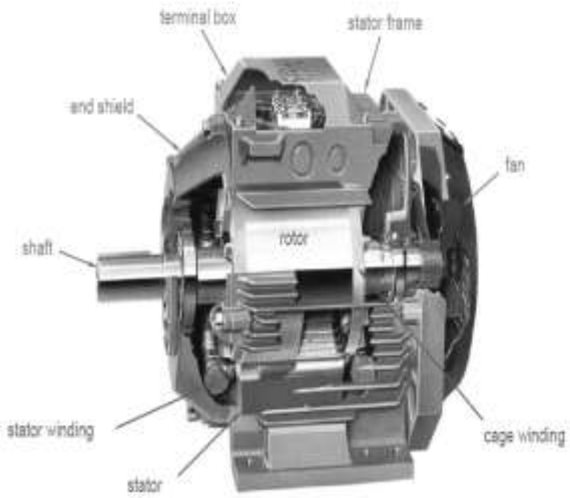

Figure 2 :Various parts of induction motor

The magnetic field associated with this current flowing in the bars interacts with the rotating magnetic field and a force is produced, tending to turn the rotor in the same direction as the rotating magnetic field. Similar forces are applied to all the conductors on the rotor, so that a torque is produced causing the rotor to rotate.

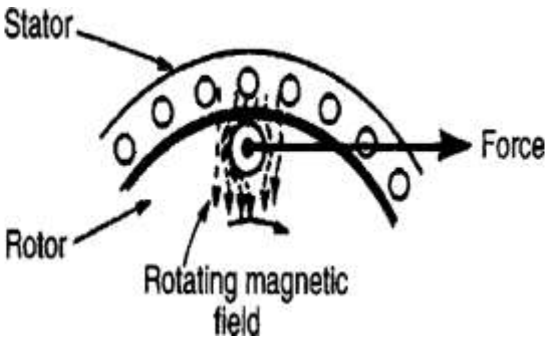

Figure 3. Production of magnetic field

They are widely used for different applications ranging from small induction motors in washing machines, household fans etc to vary large induction motors which are capable of tens of thousands of kW in output, for pipeline compressors, wind-tunnel drives and overland conveyor systems. Through electromagnetic induction, the rotating magnetic field induces a current in the conductors in the rotor, which in turn sets up a counterbalancing magnetic field that causes the rotor to turn in the direction the field is rotating. The rotor must always rotate slower than the rotating magnetic field produced by the polyphase electrical supply; otherwise, no counterbalancing field will be produced in the rotor. Induction motors are the workhorses of industry and motors up to about 500 kW (670 horsepower) in output are produced in highly standardized frame sizes, making them nearly completely interchangeable between manufacturers.

MULTILEVEL INVERTERS

An inverter is an electrical device that converts direct current (DC) to alternating current (AC); the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits.

Static inverters have no moving parts and are used in a wide range of applications, from small switching power supplies in computers, to large electric utilityhigh-voltage direct current applications that transport bulk power. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries.

The electrical inverter is a high-power electronic oscillator. It is so named because early mechanical AC to DC converters was made to work in reverse, and thus were "inverted", to convert DC to AC.

The inverter performs the opposite function of a rectifier

Cascaded H-Bridges inverter

A single-phase structure of an m-level cascaded inverter is illustrated in Figure 3.1. Each separate dc source (SDCS) is connected to a single-phase full-bridge, or H-bridge, inverter. Each inverter level can generate three different voltage outputs, $+V_{dc}$, 0, and $–V_{dc}$ by connecting the dc source to the ac output by different combinations of the four switches, S_1, S_2, S_3, and S_4. To obtain $+V_{dc}$, switches S_1 and S_4 are turned on, whereas $–V_{dc}$ can be obtained by turning on switches S_2 and S_3. By turning on S_1 and S_2 or S_3 and S_4, the output voltage is 0. The ac outputs of each of the different full-bridge inverter levels are connected in series such that the synthesized voltage waveform is the sum of the inverter outputs. The number of output phase voltage levels m in a cascade inverter is defined by m = 2s+1, where s is the number of separate dc sources. An example phase voltage waveform for an 11-level cascaded H-bridge inverter with 5 SDCSs and 5 full bridges is shown in Figure 31.2. The phase voltage $v_{an} = v_{a1} + v_{a2} + v_{a3} + v_{a4} + v_{a5}$.

For a stepped waveform such as the one depicted in Figure 3.1 with s steps, the Fourier Transform for this waveform follows

$$V(\omega t)=\frac{4V_{dc}}{\pi}\sum_{n}\left[\cos(n\theta_1)+\cos(n\theta_2)+\ldots+\cos(n\theta_s)\right]\frac{\sin(n\omega t)}{n},\quad \text{where } n=1,3,5,7,\ldots$$

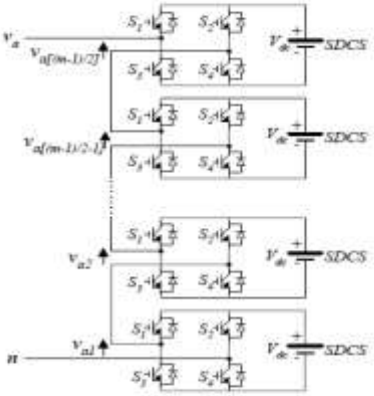

Fig 4 Single-phase structure of a multilevel cascaded H-bridges inverter

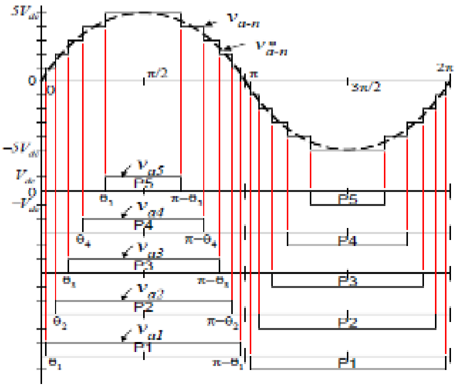

Fig. 5 Output phase voltage waveform of an 11-level cascade inverter with 5 separate dc sources.

The magnitudes of the Fourier coefficients when normalized with respect to V_{dc} are as follows:

$$H(n)=\frac{4}{\pi n}\left[\cos(n\theta_1)+\cos(n\theta_2)+\ldots+\cos(n\theta_s)\right],\quad \text{where } n=1,3,5,7,\ldots$$

The conducting angles, θ_1, θ_2, ..., θ_s, can be chosen such that the voltage total harmonic distortion is a minimum. Generally, these angles are chosen so that predominant lower frequency harmonics, 5th, 7th, 11th, and 13th, harmonics are eliminated. More detail on harmonic elimination techniques will be presented in the next section.

Multilevel cascaded inverters have been proposed for such applications as static var generation, an interface with renewable energy sources, and for battery-based applications. Three-phase cascaded inverters can be connected in wye, as shown in Figure, or in delta. Peng has demonstrated a prototype multilevel cascaded static var generator connected in parallel with the electrical system that could supply or draw reactive current from an electrical system.

The inverter could be controlled to either regulate the power factor of the current drawn from the source or the bus voltage of the electrical system where the inverter was connected. Peng [20] and Joos [24] have also shown that a cascade inverter can be directly connected in series with the electrical system for static var compensation. Cascaded inverters are ideal for connecting renewable energy sources with an ac grid, because of the need for separate dc sources, which is the case in applications such as photovoltaic's or fuel cells.

Cascaded inverters have also been proposed for use as the main traction drive in electric vehicles, where several batteries or ultra capacitors are well suited to serve as SDCSs. The cascaded inverter could also serve as a rectifier/charger for the batteries of an electric vehicle while the vehicle was connected to an ac supply as shown in Figure. Additionally, the cascade inverter can act as a rectifier in a vehicle that uses regenerative braking.

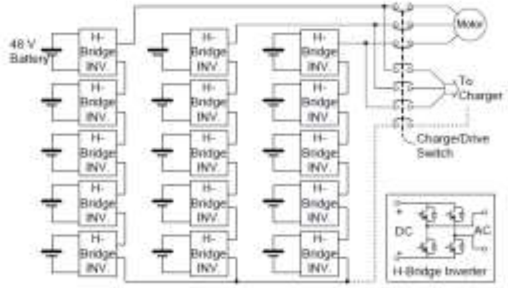

Fig 6 Three-phase wye-connection structure for electric vehicle motor drive and battery charging.

The main advantages and disadvantages of multilevel cascaded H-bridge converters are as follows

ELECTRIC VEHICLE

Electric Vehicle (EV) is an emerging technology in the modern world because of the fact that it mitigates environmental pollutions and at the same time increases fuel efficiency of the vehicles. Multilevel inverter controls electric drive of EV of high power and enhances its performance which is the reflection of the fact that it can generate sinusoidal voltages with only fundamental switching frequency and have almost no electromagnetic interference. This paper describes precisely various topology of EVs and presents transformer less multilevel converter for high voltage and high current EV. The cascaded inverter is IGBT based and it is fired in a sequence. It is natural fit for EV as it uses separate level of dc sources which are in form of batteries or fuel cells. Compared to conventional vehicles, Electric Vehicles (EVs) are more fuel efficient due to the optimization of the engine operation and recovery of kinetic energy during braking. With the plug-in option (PEV), the vehicle can be operated on electric-only modes for a driving range of up to 30–60 km. The PEVs are charged overnight from the electric power grid where energy can be generated from renewable sources such as wind and solar energy and from nuclear energy. Fuel cell vehicles (FCV) use hydrogen as fuel to produce electricity; therefore they are basically emission free. When connected to electric power grid (V2G), the FCV can provide electricity for emergency power backup during a power outage. Due to hydrogen production, storage, and the technical limitations of fuel cells at the present time, FCVs are not available to the general public yet. EVs are likely to dominate the advanced propulsion in coming years. Hybrid technologies can be used for almost all kinds of fuels and engines. Therefore, it is not a transition technology. In EVs and FCVs, there are more electrical components used, such as electric machines, power electronic converters, batteries, ultracapacitors, sensors, and microcontrollers. In addition to these electrification components or subsystems, conventional internal combustion engines (ICE), and mechanical and hydraulic systems may still be present. The challenge presented by these advanced propulsion systems include advanced power train components design, such as power electronic converters, electric machines and energy storage; power management; modeling and simulation of the power train system; hybrid control theory and optimization of vehicle control.

In recent years, research in Electric Vehicle (EV) development has been focused on various aspect of design, such as component architecture, engine efficiency, reduced fuel emissions, material for lighter components, power electronics, efficient motors and high power density batteries. To meet some of the aspect of EV cascaded multilevel inverter is used so as to meet high power demands. The multilevel voltage source inverters with unique structure allow them to reach high voltages with low harmonics without the use of transformers or series-connected synchronized switching devices. The general function of the multilevel inverter is to synthesize a desired voltage from several levels of dc voltages. For this reason, multilevel inverters can easily provide the high power required of a large electric drive. As the number of levels increases, the synthesized output waveform has more steps, which produces a staircase wave that approaches a desired waveform. Also, as more steps are added to the waveform, the harmonic distortion of the output wave decreases, approaching zero as the number of levels increases. As the number of levels increases, the voltage that can be spanned by summing multiple voltage levels also increases.

The structure of the multilevel inverter is such that no voltage sharing problems are encountered by the active devices. EV Configurations

Why EV’S, HV’S?

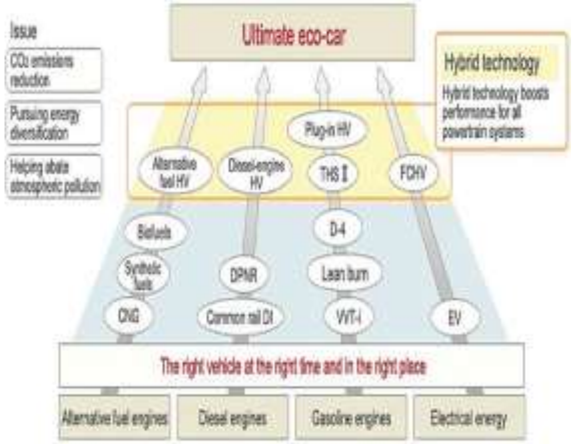

Fig.7 EV Configurations

Vehicles equipped with conventional internal combustion engines (ICE) have been in existence for over 100 years. With the increase of the world population, the demand for vehicles for personal transportation has increased dramatically in the past decade. This trend of increase will only intensify with the catching up of developing countries, such as China, India, and Mexico. The demand for oil has increased significantly. Another problem associated with the ever-increasing use of personal vehicles is the emissions. The green house effect, also known as global warming, is a serious issue that we have to face. There have been increased tensions in part of the world due to the energy crisis. Government agencies and organizations have developed more stringent standards for the fuel consumption and emissions. Nevertheless, with the ICE technology being matured over the past 100 years, although it will continue to improve with the aid of automotive electronic technology, it will mainly rely on alternative evolution approaches to significantly improve the fuel economy and reduce emissions. Battery-powered electric vehicles were one of the solutions proposed to tackle the energy crisis and global warming. However, the high initial cost, short driving range, long charging (refueling) time, and reduced passenger and cargo space have proved the limitation of battery-powered EVs. The EV was developed to overcome the disadvantages of both ICE vehicles and the pure battery-powered electric vehicle. The EV uses the onboard ICE to convert energy from the onboard gasoline or diesel to mechanical energy, which is used to drive the onboard electric motor, in the case of a series EV, or to drive the wheels together with an electric motor, in the case of parallel or complex EV. The onboard electric motor(s) serves as a device to optimize the efficiency of the ICE, as well as recover the kinetic energy during braking or coasting of the vehicle. The ICE can be stopped if the vehicle is at a stop, or if vehicle speed is lower than a preset threshold and the electric motor is used to drive the vehicle along. The ICE operation is optimized by adjusting the speed and torque of the engine. The electric motor uses the excess power of the engine to charge battery if the engine generates more power than the driver demands or to provide additional power to assist the driving if the engine cannot provide the power required by the driver. Due to the optimized operation of the ICE, the maintenance of the vehicle can be significantly reduced, such as oil changes, exhaust repairs, and brake replacement. In addition, the onboard electric motor provides more flexibility and controllability to the vehicle control, such as antilock braking (ABS) and vehicle stability control (VSC).

PROPOSED SYSTEM

Asymmetrical Cascaded H Bridge Multilevel Inverter

Figure 5.1 represents the Asymmetrical Cascaded H Bridge Inverter (ASCHB-MLI) topology. In this Inverter the DC source magnitude are unequal. The DC source magnitude are designed with binary form of voltage such as 25VDC, 50VDC, 100VDC respectively. Both the inverter consists of same number of Power semiconductor switches but the voltage level varies. In SCHBMLI the output voltage is 9level, where as in ASCHBMLI the output voltage is 15 level and they are 15Vdc, 30Vdc, 45Vdc, 60Vdc,75Vdc,90Vdc,105Vdc,0Vdc,-15Vdc, -30Vdc,-45Vdc,-60Vdc,-75Vdc,-90Vdc,-105Vdc respectively.[8]

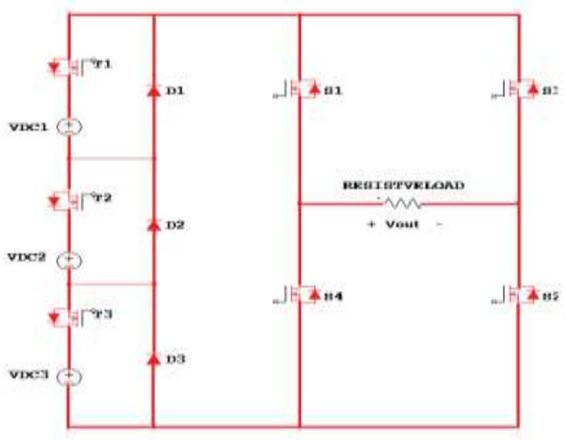

Fig. 8 Asymmetrical multilevel inverter

In ASCHMLI the number of switches and number of levels are represented as follows

$$N_{level}=2^{(n+1)}-1$$

$$N_{MOSFET}=n+4$$

PROPOSED SYSTEM

The below figure 5.17 shows 15-Level Asymmetric Cascaded H Bridge Multilevel Inverter with phase disposition pulse width modulation (PDPWM) for electric vehicle. The system contains three phase asymmetrical Cascaded H Bridge Inverter (ASCHB-MLI) topology. In this Inverter the DC source magnitude are unequal. The DC source magnitude are designed with binary form of voltage such as 25VDC, 50VDC, 100VDC respectively. The ASCHB-MLI is fed induction motor drive as shown in figure. ASHB-MLI is controlled by PD-PWM technique.

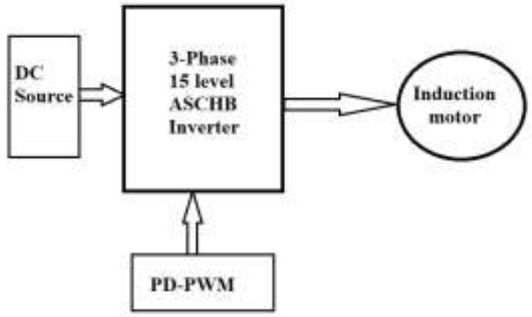

Fig 9 15-Level Asymmetric Cascaded H Bridge Multilevel Inverter with phase disposition pulse width modulation (PDPWM) for electric vehicle

PD-PWM

The Modulation Control Scheme is divided into two types they are fundamental switching (low switching) frequency and (High switching Frequency) PWM. In this ACHMLI the Phase Disposition Technique PWM is utilized with switching frequency of 2Khz.This PD-PWM technique is used to control the Switches in the inverter. Figure 5.17 shows the generation of PD-PWM technique for ASCHBMLI. In this technique it consists of 14 carrier signal (2KHz) and sine wave fundamental frequency (50Hz).Using logical circuits the switching pulse are generated [9].

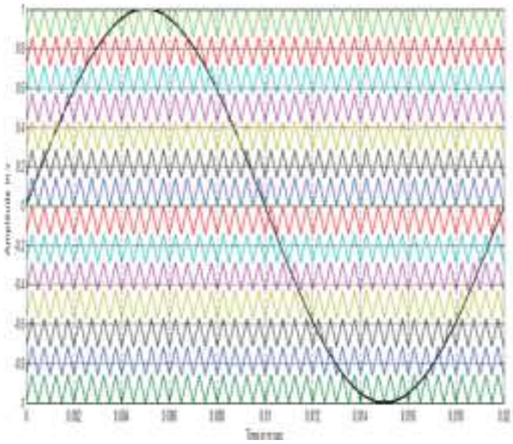

Fig. 10 PD-PWM Switching signal Generation

SIMULATION RESULTS

EXISITNG RESULTS

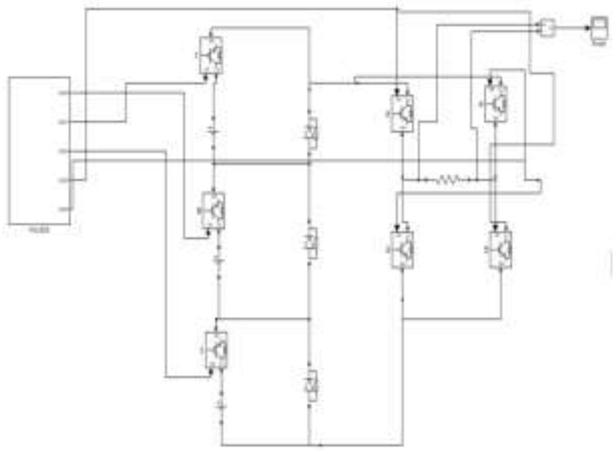

Fig. 11 MATLAB/SIMULINK circuit diagram of 15 level ASCHB Inverter with pulses

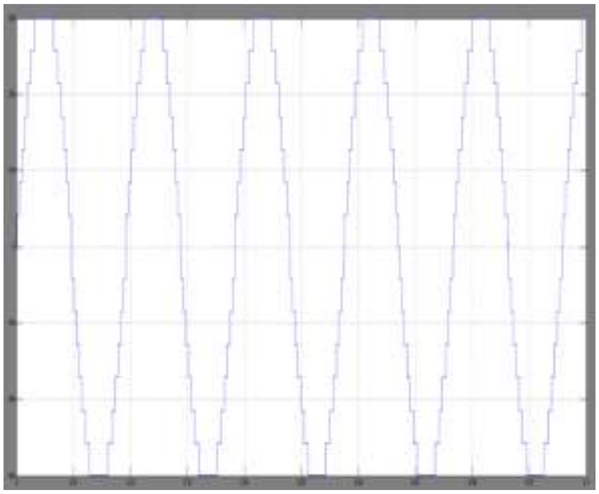

Fig. 12 Output Voltage for Asymmetric 15 level CHB Inverter

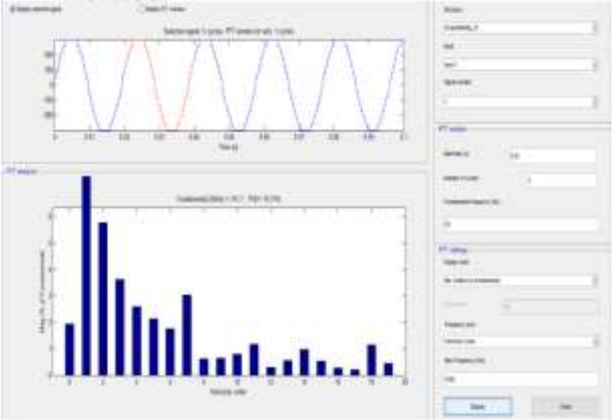

Fig. 13 THD Analysis for Asymmetric 15 level CHB Inverter using pulse

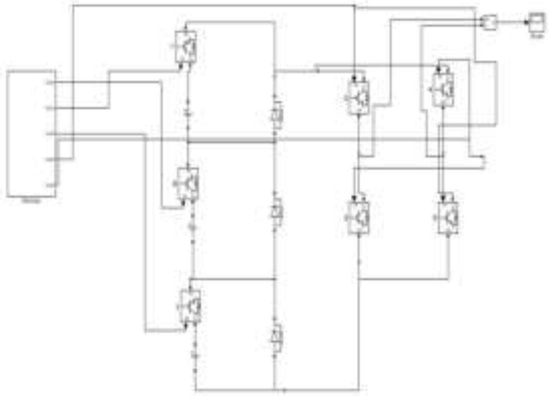

Fig. 14 MATLAB/SIMULINK circuit diagram of 15 level ASCHB Inverter with PD-PWM

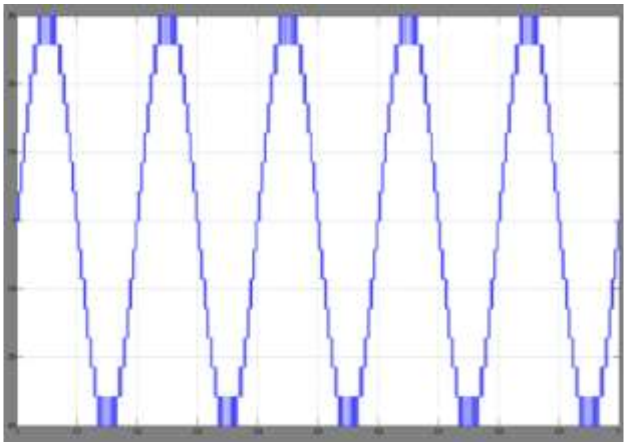

Fig. 15 Output Voltage for 15 level ASCHB Inverter using PD-PWM

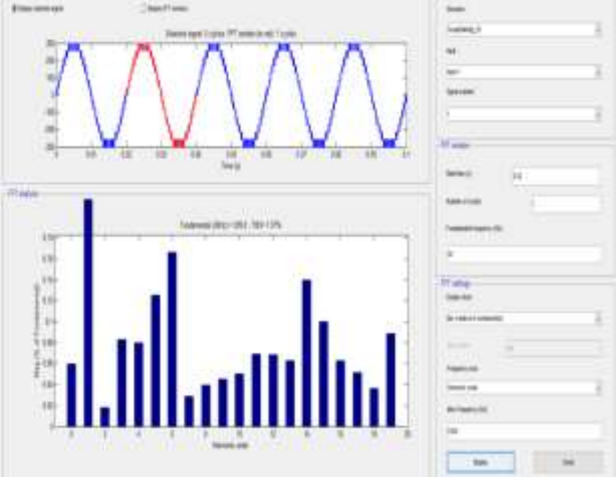

Fig. 16 THD Analysis for 15 level ASCHB Inverter using PD-PWM

EXTENSION RESULTS

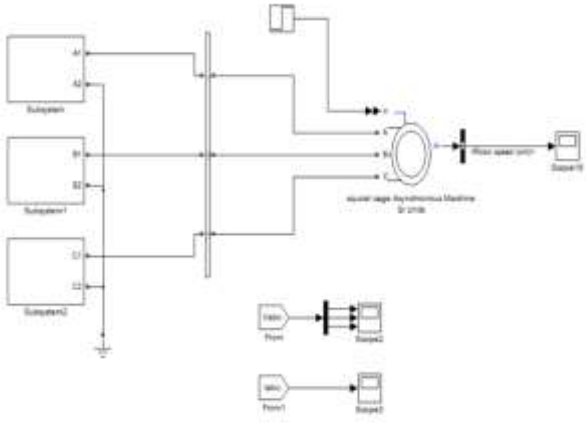

Fig. 17 MATLAB/SIMULINK circuit diagram of proposed three phase 15 level ASCHB Inverter for EV

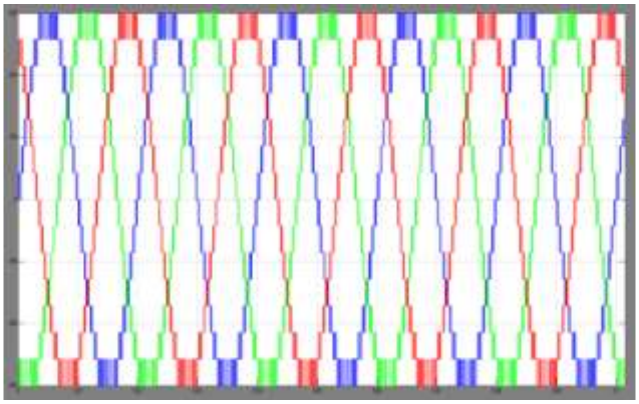

Fig. 6.8 Output Voltage

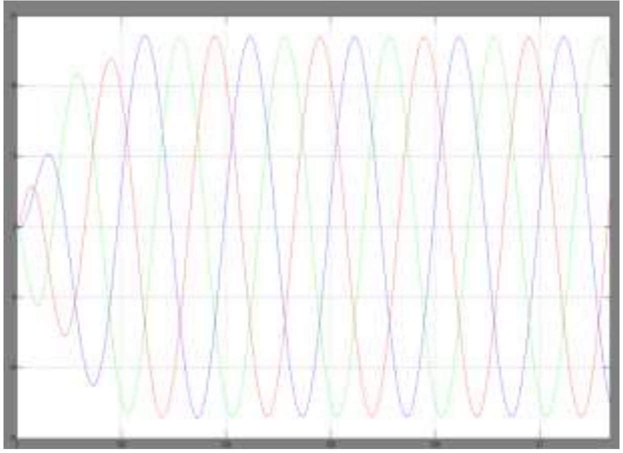

Fig.18 Output current

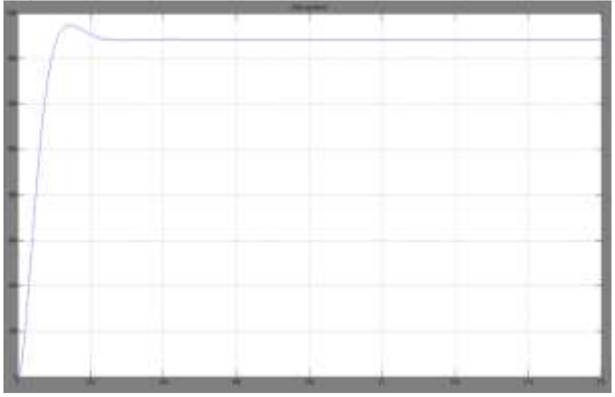

Fig 6.9 Speed of the motor

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