To Study Electric Vehicles Using a Single Battery Pack and Active Filters

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Abstract: This paper is proposed to review the progress of active power filter (APF) technologies that are usually used to mitigate harmonics in utility power lines. Cascaded H-bridge (CHB) multilevel inverters have been conceiving as an option to decrease total harmonic distortion (THD) in medium-voltage drives. The reduced THD makes them useful for electric vehicle (EV) applications, but the main problem with the CHB is the large quantity of isolated power sources necessary to feed each of the H-bridges. An better variant known as the asymmetrical CHB (ACHB) inverter uses H-bridges of different sizes and then needs fewer isolated power sources than the CHB. However, in battery-powered EVs, simply one power supply (petroleum cell or battery pack) is attractive. This work presents a solution to solve the problem, in service some of the small H-bridges (Aux-bridges) as series active filters and using a small high-frequency link (HFL).With this result, only one dc basis is necessary to feed the inverter, and if the organize is adjusted to work at particular switching points, more than 98% of power is transferred throughout the larger H-bridges (MAIN bridges). An development for drive application has permitted to decrease the number of power supplies using floating capacitors, unidirectional power sources, and a pulse width modulator (PWM) that jumps some voltage steps. However, the number of self-determining power sources is only partially reduced. In electric vehicles battery pack is uses to provide power to electric motors. Battery is dc supply. Inverter is converted DC to contaminated AC supply having huge harmonics, these harmonics reduces the effectiveness of electric motor that as electric vehicle. This work shows some MATLAB imitation of inverter has done 21 levels. This imitation gives approximate output. As a result, THD decrease.

***Index Terms* - AC Motor Drives; Cascaded H-Bridges (CHBs); Electric Vehicles (EVs);**

I INTRODUCTION

In modern world electric vehicle is new up-and-coming trend, because cost of fuel is rising and air pollution as also increasing, electric vehicle is a new way to control the air pollution. Electric vehicle also gives less cost per kilometer. Electric vehicles can run up to 450 km in a single charge to achieve this distance usual fuel consume very great quantity of fuel give rise to expensive trip as well as increase in air pollution.

In electric vehicles battery packs are used to provide power to electric motors, battery gives DC provide this is to be converted to AC using inverter. Inverter gives very impure AC supply having large harmonics decrease the effectiveness of electric motor that as electric vehicle.

Cascaded H-bridge (CHB) multilevel drives have turn into very popular since they produce voltage waveforms with small distortion when compared with conventional machine drives based on two- or three- level inverters [1]. This characteristic looks nice-looking for applications in electric vehicles(EV) because it improve the efficiency of the traction motor (fewer harmonic currents) and reduce size (less isolation required) However, the great barrier for practical purpose of CHB in EVs is the large number of self-determining voltage supplies essential for its operation. An significant progress over the CHB is the "asymmetrical CHB"(ACHB) since it can produce the same number of levels with fewer power supplies[4].ACHBs use H-bridges fed with dc voltages of different magnitude. Where that which uses the better dc basis is called the MAIN Bridge. When the dc voltages are scaled in power of three, the MAIN Bridge carry more than 80% of the total power and works at basic frequency.[6]. These characteristics remarkable decrease the switching losses, improving the efficiency of the system. The rest of the H-bridges called Aux-bridges (auxiliary bridges) allow the generation of several voltage levels, dropping the total harmonic distortion (THD) and common-mode voltages. However ACHBs still need more that one isolated power source, and a result, the use of these technologies in EVs becomes difficult to implement [8].

In our project we are annoying to improve competence of motor of electric vehicle by adding a new filter circuit in electric drive train of electric vehicle. A filter circuit reduces harmonics in a great manner and gives output as almost clean sine wave.

Type Of Filters

Filter is of two types' passive filter and active filter. We are using Active filter as it has extremely good quality performance characteristics than passive filter. In our scheme we are using cascaded H-bridge inverter as an active filter. Here we are using cascade H-bridge inverter of 27 levels but using as of only 21 levels, since of this we can decrease the size of filter circuit as well as reducing power consumption from 20% to 2% of total power flow from battery to load through the filter. As a result, we are reducing harmonics from the provide.

The application of electric vehicle is road vehicles and railways. There are three types of motors are used in electric vehicles are as follows:

- Brushless DC(BLDC) Motor
- Brushed DC Motor
- AC Induction Motor

The total harmonic distortion (THD) is a dimension of the harmonic distortion present in a signal and is exact as the ratio of the sum of the power of all harmonic mechanism to the control of the fundamental frequency.

II. LITERATURE REVIEW

- *High step Multistep Inverter Optimization Using a Minimum number of power Transistors, (2006)*

Multilevel inverters with a large quantity of ladder (more than 50 levels) can make high excellence voltage waveforms, high-quality enough to be considered as suitable voltage template generators. A lot of levels or steps can follow a voltage reference with accuracy, and with the advantages that the generated voltage can be modulated in amplitude in its place of pulse width modulation.

- *23-Level Inverter for Electric vehicles Using a Single Battery Pack and Series Active Filters, (2012).*

Cascaded H-bridge (CHB) multilevel inverters have been conceiving as an alternative to decrease total harmonic distortion (THD) in medium-voltage drives. The reduced THD makes them helpful for electric vehicle (EV) applications, but the main problem with the CHB is the great quantity of isolated power sources necessary to feed each of the H-bridges. An better alternative known as the asymmetrical CHB (ACHB) inverters uses H-bridges of different sizes and then needs fewer isolated power source than the CHB. though, in battery-powered EVs simply one control supply (fuel cell or battery pack) is desirable. This work present a solution to solve the difficulty, in service some of the small H-bridges (Aux-bridges) as series active filters and using a small high-frequency link (HFL).

- *Synthesis of Multilevel Converters based on single and/or Three-phase Converter Building Blocks, (2008)*

This document synthesizes a relations of multilevel converters that is construct by using multiply well-developed single-and/or three-phase converters structure blocks. The resultant compensation includes a modular structure that leads to suitable construction and preservation as well as easy extension to higher voltage level. One successful example from these relations is the cascaded H-bridge converter, which is now extensively used for Volt Ampere Reactive (VAR) recompense and motor drive application due to its many advantages.

III. BLOCK DIAGRAM AND COMPONENTS

A. *Block Diagram*

In Our study necessary Battery, Variable Voltage Supply, Main H-bridge Inverter, Cascaded H-bridge Inverter, Rectifier, Auxiliary H-Bridge Inverter, Toroidal Transformer, and Induction Motor.

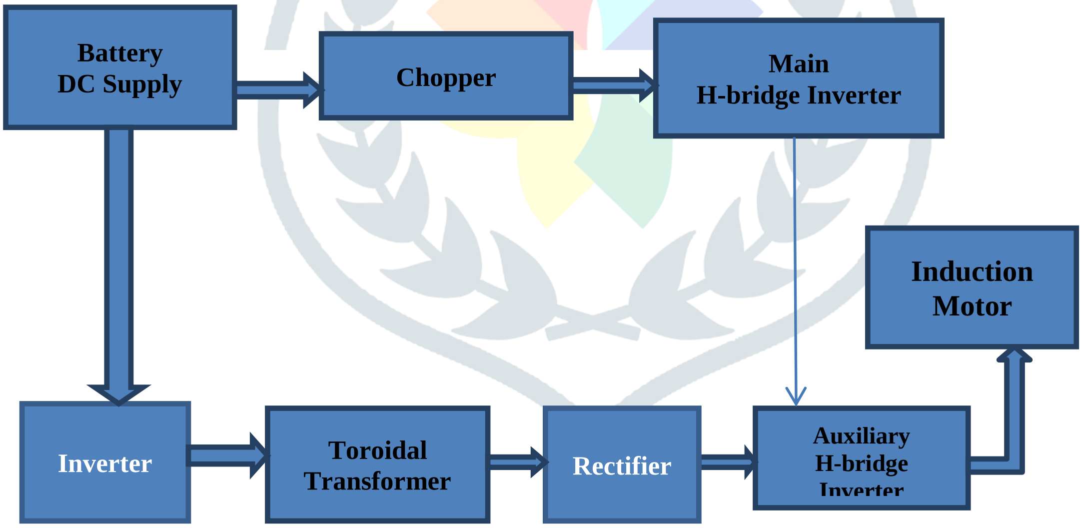

Fig 1- Block Diagram

B. ***Components***

- *DC Supply*

A DC supply is fed Variable dc source. The variable dc source act as a chopper.

- *Variable DC Source*

The PWM outline for all H-bridges must remain constant, which extremely simplify the tasks of the manager. For this reason, a variable dc source to control v has implement using a bidirectional chopper with one insulated gate bipolar transistor (IGBT) module. The most relevant part of this chopper is the inductance LDC, which needs to be small and light. To decrease weight, it uses a particularly designed output inductance “LSS”, with air core and aluminum coils. The design and conclusion of this inductance.

That paper also describes all the design criterion of the IGBT buck-boost converter, which at a switching frequency of 10 kHz. The size of L is approximated
20 X 20 X 35 cm3, and its total weight, including the container, is only 22 kg. For this new city car, with a traction motor of only 18 kW, a similar design will be measured but with and IGBT chopper working at 10 kHz. As the chopper will be lesser and its switch incidence will be larger, the inductance will be lesser, and its weight will be less than 15 kg.

- *H-Bridge Inverter*

The term H-bridge inverter is the graphical representation of such a circuit. H-bridge inverter is build with four switches (Solid-state or mechanical). When the switch S1 and S4 (according to the first figure) are stopped up up (and S2 and S3 are open) a optimistic voltage will be functional across the motor. By opening S1 and S4 switches and closing S2 and S3, this voltage is reversed; allow reverse operation of the motor. Using above fig., the switches S1 and S2 should never be closed at the same time, as this would cause a short circuit on the input voltage source. The same applies to the switches S3 and S4. This state is known as shoot-through.

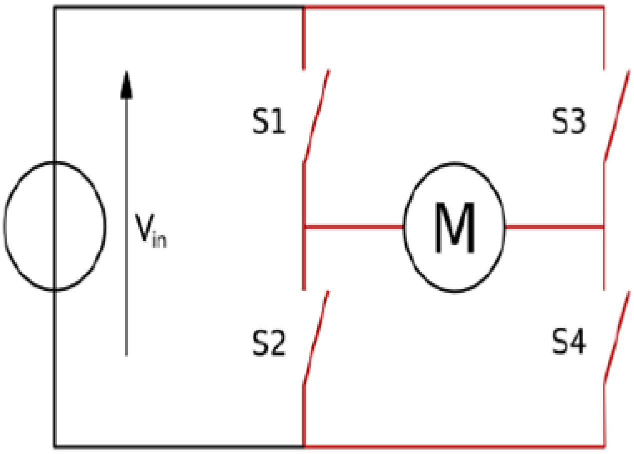

Fig 2- H-bridge Circuit

The H-bridge inverter agreement is usually used to reverse the polarity / direction of the induction motor, but can also be used to 'brake' the motor, where the induction motor comes to a rapidly stop, as the motors terminal are shorted, or to let the motor 'free run' to a stop, as the motor is efficiently disconnected from the circuit.

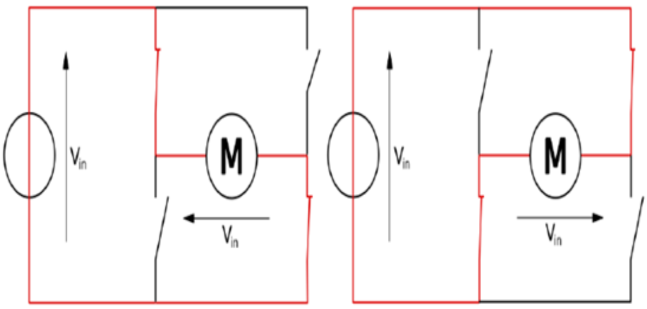

Fig-3 H-bridge Working

- *Motor*

A synchronous electric motor is an AC motor in which, at stable state, the rotation of the shaft is synchronized with the frequency of the provide present; the rotation period of the motor is accurately equal to an essential number of AC cycles. Synchronous motors contain multiphase AC electromagnets on the stator of the motor that create a magnetic field which rotates in time with the oscillations of the line current. The rotor with permanent magnets or electromagnets turns in step with the stator field at the same rate and as a result, provides the second synchronized revolving magnet field of any AC motor. A synchronous motor is termed doubly fed if it is supplied with separately keyed up multiphase AC electromagnets on both the rotor and stator.

❖ *Operations:*

The process of introduction motor is due to the interaction of the magnetic fields of the stator and the rotor. Its stator windings, which consist of a 3 phase windings, is provide with a 3 phase supply, and the rotor is provided with a DC supply. The 3 phase stator windings carrying 3 phase currents produces 3 phase rotating magnetic flux (and therefore a rotating magnetic field). The rotor of the induction motor locks in with the rotating magnetic field and rotates along with it. Once the rotor locks in with the rotating magnetic fields, the motor is said to be in synchronization. A three phase (or six-phase derived from three phase) stator windings is potential, but in this case the direction of rotation is not defined and the machine may start in either direction unless prevented from doing so by the starting arrangements.

Once the induction motor is in operation, the speed of the motor is dependent only on the supply frequency. When the motor load is increased beyond the breakdown load, the motor falls out of synchronization and the field windings no longer follows the rotating magnetic field. Since the motor cannot produce (synchronous) torque if it falls out of synchronization, sensible synchronous motors have a partial or total squirrel-cage damper (amount issuer) winding to stabilize process and facilitate starting. Because this winding is smaller than that of an equal induction motor and can overheat on long process, and because large slip- incidence voltages are induced in the rotor excitation windings, synchronous motor protection devices sense this state and interrupt the power supply (out of step protection).

❖ *Application:*

A clock driven by an introduction motor is in principle as precise as the line frequency of its power source

- *Main Converter*

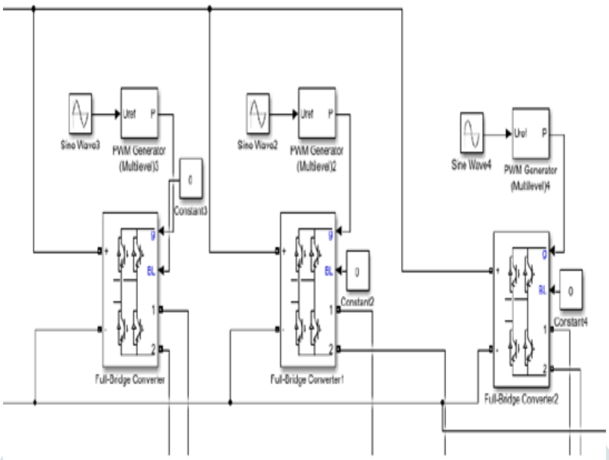

Fig4 -Main Converter

In this circuit DC provides is associated to DC link and the output of the DC link is associated to main converter. The key converter is the grouping of H-Bridge. There is three phase load for each phase one H-bridge is related. Output frequency obtain is 60HZ. The wave obtained is square wave. PWM method is used for triggering the IGBT circuit in imitation. Carrier frequency of PWM is 150HZ. Sinusoidal signal of PWM is also 60HZ.

- *Toroidal Transformer*

As the High Frequency Link (HFL) workings at high incidence (5-20 kHz), its size and weight becomes very small. For example, in a 100-kW machine drive for an EV, a 1.9-kW HFL is necessary [1.9% of the total power according with]. Working at a incidence of 10 kHz and with a flux density of 0.2 T, a core transformer of 4 cm (2 X 2 cm) with an internal diameter of 3 cm and an external diameter of 7 cm is suitable.

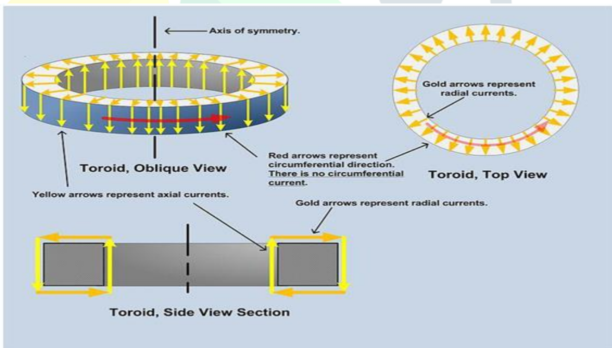

Fig-5 Toroidal Transforme r

- *Power Electronics Devices*

A. Power Diodes
B. Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET)
C. Insulated-Gate Bipolar Transistor (IGBT)
D. Thyristors (SCR, GTO, MCT)

Table 1. Comparison between Power Electronics Devices

Parameter	SCR	Power BJT	Power MOSFET	IGBT
Operating Frequency	400 to 500 HZ	10 KHZ	100KHZ	10 KHZ
On state Voltage drop	< 2 Volts	< 2 Volts	4-5 Volts	3 Volts
Trigger Circuit	Current controlled needs single pulse to turn on	Current controlled needs continuous base drive	Voltage controlled needs continuous gate drive	Voltage Controlled needs continuous gate drive
Maximum VI Rating	10Kv/5000A	2Kv/1000A	600v/200A	1500v/400A
Applications	DC motor drives, Inverter, rectifiers	UPS, Static VAR Systems, AC motor control	AC motor control	BLDC drives AC motor control UPS
Type of device	Minority carrier	Minority carrier	Minority carrier	Minority carrier
Voltage/Current Controlled	Current	Current	Voltage	Voltage
Communication circuit	Necessary	Not Necessary	Not Necessary	Not Necessary
Blocking capacity	Symmetrical	Asymmetrical	Asymmetrical	Asymmetrical
Temperature Coefficient	Negative	Negative	Positive	Flat
Thermal Runway	Possible	Possible	Not Present	Not Present
Parallel Operation	External equalizing circuit is necessary	External equalizing circuit is required	Easy To Parallel	Easy To Parallel

IV. CIRCUIT DIAGRAM AND OPERATION

A. Circuit Diagram Of Asymmetrical Cascade H-Bridge Inverter

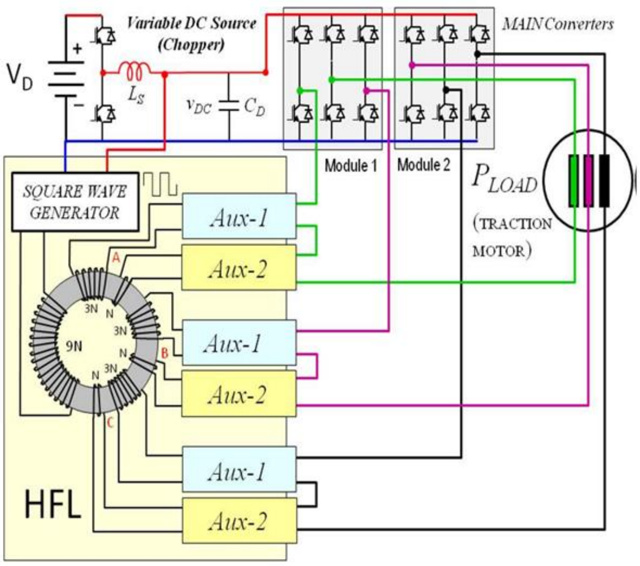

FIG:6- Circuit Diagram of asymmetrical Cascade H-Bridge Inverter

B. Working of asymmetrical Cascade H-Bridge Inverter:

The CHB is the "asymmetrical CHB" (ACHB) since it can produce the similar number of levels with less power provisions. ACHBs use H-bridges fed with DC voltages of dissimilar magnitudes, where that which uses the better dc source is called the main bridge. When the dc voltages are scale in powers of three, the MAIN bridge carrier more than 80% of the whole power and works at fundamental frequency. This characteristic remarkably reduces the switching losses, improving the competence of the system. The rest of the H-bridges called Aux-bridges (auxiliary bridges) allow the generation of several voltage levels, dropping the total harmonic distortion (THD) and common-mode voltages. However, ACHBs still require more than one isolated power source, and as a result, the use of these technology in EVs becomes not easy to implement.

The main object of this work is to find an HFL that is as small as likely for EV application, and this investigate has establish that, with good modulation change, the power rating of the Toroidal transformer (hence, the HFL) can be minimize. The future control plan reduces the size of the HFL. From 20% to less 2% of the machine. To achieve this, the situation voltage of the ACHB converter is adjusted to operate with a reduced number of levels. This paper demonstrates that, if a 27-levels ACHB converter mechanism with only 21 levels, some H-bridges will not transfer any power to the load, they behave like series active filters. The amplitude of the load voltage is controlled with a variable dc basis (chopper) that manages all the isolated provisions generate by the HFL. All the account of the new plan is explain in the following section.

The power source of each H-Bridge (V MAIN, V Aux-1, and V Aux-2) are replace by only one changeable dc source, which transfers to the minimum H-bridges (Aux-1 and Aux-2) through the HFL. This HFL connect the three H-bridges through a small Toroidal transformer with windings scaled in powers of 3, as shown in fig.1. This transformer is necessary to separate the power provisions of MAIN, Aux-1, and Aux-2 bridges. The traction motor can be either an foreword motor or a permanent- motor- machine (brushless dc or brushless synchronous) Aux-2 the converter uses the modulation called adjacent level control (NLC), which is one of the simplest modulation strategy for this kind of converter. The NLC consists of taking the level of voltage nearby to the position. The NLC permits to operate the H-bridges at very low switching incidence.

C. Connections

It uses a 27-level ACHB inverter (three H-bridges scaled in power of 3) with an HFL. All the power source of each H-bridges (V MAIN, V Aux-1, V Aux-2) are replace by only one variable dc sources, which transfer power to the lesser H-bridges (Aux-1 and Aux-2) from side to side the HFL. This HFL connect the three H-bridges through a small Toroidal transformer with windings scaled in powers of 3, as shown in circuit diagram. This transformer is necessary to isolate the power provisions of MAIN, Aux-1, and Aux-2 bridges. The traction motor can be also an introduction machine or a permanent motor machine (brushless dc or brushless synchronous). Aux-2 the converter uses the modulation called nearest level control (NLC), which is one of the simplest modulation strategies for this kind of converter. The NLC consists of taking the level of voltage closest to the position. The NLC permits to function the H-bridges at very low switch frequencies.

D. Operation characteristics of asymmetrical cascaded H-Bridge Inverter

Figure 1. Shows a complete three phase motor drive for an EV. The CHB is the "asymmetrical CHB" (ACHB) because it can produce the same number of levels with fewer power provisions. ACHBs use H-bridges fed with dc voltages of dissimilar magnitudes, where that which uses the larger dc basis is called as main bridge. When the dc voltages are scaled in powers of three, the MAIN Bridge carry more than 80% of the total power and works at basic frequency. This characteristic remarkably reduces the switching losses, improving the efficiency of the system. The rest of the H-bridges called Aux-bridges (auxiliary bridges) allow the generation of more than a few voltage levels, reducing the total harmonic distortion (THD) and common- mode voltages. However, ACHB's still need more than one isolated power source, and as a result, the use of these technology in EV's become hard to implement.

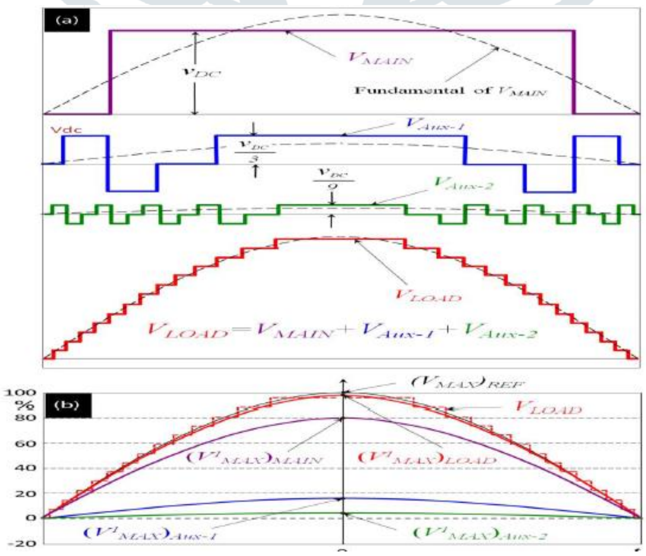

Fig-7 a) Voltage waveforms of each H-bridge using NLC modulation, with their fundamentals in dotted lines. (b) Fundamental of voltages at each bridge at load and reference voltage.

V. RESULT AND DISCUSSION

A. Simulation Model

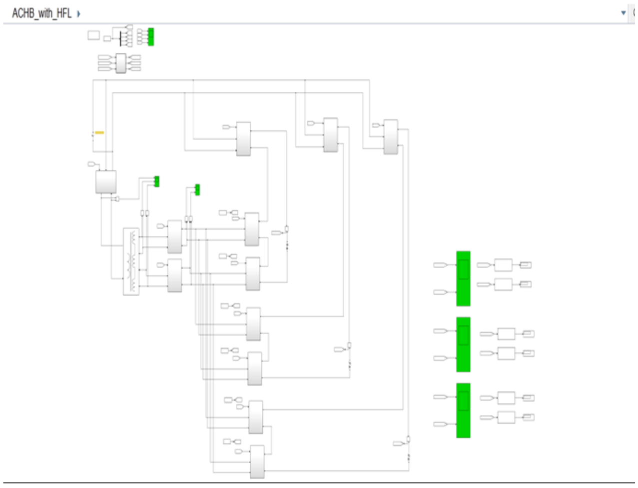

Fig-8 Simulation Model

By imitation this circuit to profitably to get estimated output of each block of this circuit and this product are as shown in fig.8 by implement imitation of DC link we get predictable output of steady voltage. Main converter gives frequency of 60 Hz. High frequency link creates 10 kHz output which is fed to auxiliary circuit. Outputs of all converters are super compulsory to get final power supply.

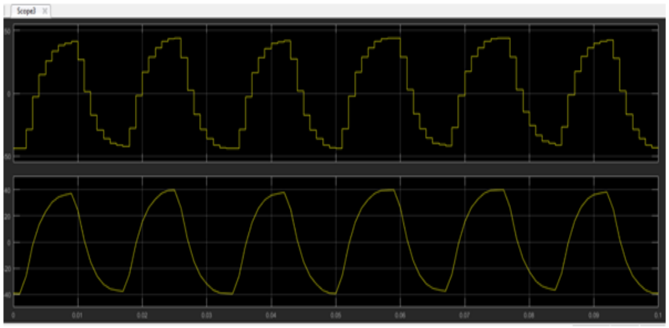

Fig-9 Simulation Output

Fig.9 shows the main mechanism of the 21-level multilevel inverter. This has been build two dissimilar topologies. A) Using four entity voltage source of each module [4]. B) Using one single voltage source for all unit and voltage escalation through output transformer [4]. The first topology is appropriate for machine drives application and the last configuration is useful for steady frequency purpose. This arrangement has been productively implement.

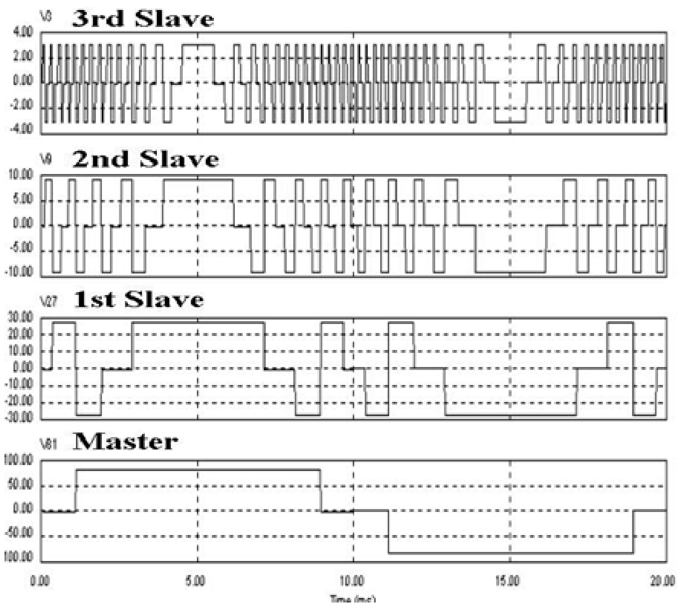

Fig-10Frequency Modulation of each converter

One significant character of multilevel inverter using voltage growth is that electric power distribution and switch frequency present advantages for the completion of these topologies. Fig.6.1.3.shows frequency allocation of each one of the four bridges used for execution of 21-level multilevel inverters [4].

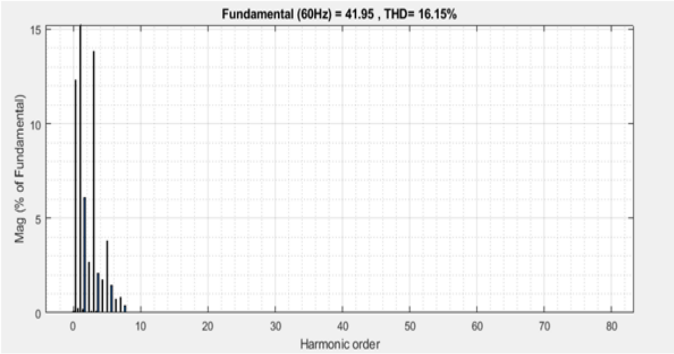

Fig-11 Total Harmonic Distortion

Cascaded H-Bridge inverter can function not only with Pulse Width Modulation method but also with amplitude modulation (AM), improving considerably the excellence of the output voltage. Waveform, with the use of amplitude modulation, small frequency, and voltage harmonics are perfectly eliminate. Generate almost ideal sinusoidal waveform, with a total harmonics distortion lower than 5%. Another significant characteristic is that each inverter operates at lower switching frequency reducing the semiconductor stress, and so reducing switch losses. [4]

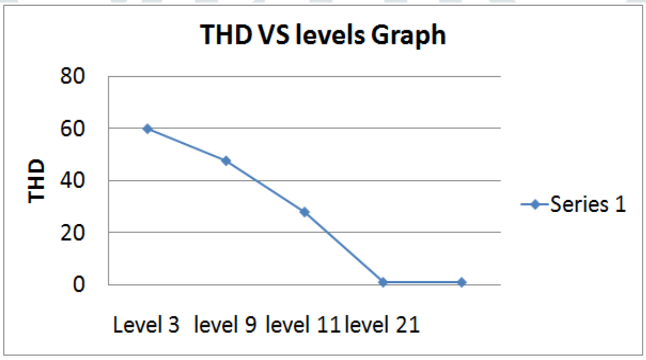

Fig-12 THD vs. Levels Graph

Fig. 12 is graphical representation of Total Harmonics Distortion Vs. Levels of cascaded H- Bridge Inverter. This there when levels are greater than before that form THD are reduced and to give sinusoidal wave.

VI. CONCLUSION & FUTURE SCOPE

In this paper, H-bridge inverter has been study and a implement simulation in MATLAB software. It has possibility of using ACHB multilevel inverter in electric vehicle. With an proper plan and adjustment of the ACHB, only less amount of power is transfer through the small H-bridges of the ACHB (AUX bridges). The topology and the switching approach make some of the Aux- bridges work as series active filter. Therefore, the circuit works efficiently to reduce harmonics of final output voltage and increase power quality of supply and development of competence of electric vehicle.

The MAIN bridges work at basic frequency (only two switch actions per cycle) and since they direct more than 98% of the power. The switching losses of the overall converter become very small. On the other hand, as the Aux-1 bridges move no power, they behave as series active power filters. The HFL is bidirectional, and then, the ACHB can work at full regenerative braking. The work is focused on electric traction drives, but the idea can be extensive to other application and in the series of megawatts.

VII FUTURE SCOPE

Until now we have designed and analyze in inverter and filter circuit. In future, we can design organizer circuit to control voltage, manage frequency of inverter, and filter. This circuit can be farther developed for electric sports car. By using specific electrical and mechanical designed topologies we can reduce size, cost, and weight.

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