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Design And Implementation of Electric Vehicle Charger Using Hybrid Converter

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ABSTRACT

Over the recent years, the growing need for the integration of electric vehicles into the grid has been seen. Electric vehicles can be easily integrated into the conventional grid through the advancement of various topologies of power semiconductor devices and the development of power electronic converters. The interface provides the maximum power point for the electric vehicles to operate. The Hybrid LUO converter (HLC) implemented in this project is one of the most popular topology for integration renewable energy resources and electric vehicle. This configuration of bidirectional DC-DC converter provides galvanic isolation through a high frequency transformer and also provides bidirectional power flow. The HLC converter control is based on the modulation of phase shift control where the leading bridge supplies power to the lagging bridge. The closed loop control of the converter is implemented in this project.

Keywords—Hybrid Converter, LUO Converter

I. INTRODUCTION

Other than the integration of more renewable energy resources and the electric vehicles into the grid system for more energy production, the reduction in the usage Of fossil fuels and non-renewable energy resources is an important factor to consider for the efficient usage of power and reducing the environmental damage .The growing need for the integration of electric vehicles is also gaining importance today. The plug-in hybrid electric vehicles are capable of supplying power to the grid as they have bulk energy storage batteries. They can charge from the grid and also can produce energy From the conventional fuels and store it in their bulk batteries. The stored energy from the batteries of the vehicles can be supplied back to the grid during the off peak hours. This method of supplying to the grid system can be helpful in supporting the grid by giving the additional power when the grid is in need. This bidirectional power flow can be made possible only with help of power electronic converters. There are various converter topologies available. The most common topology that can be used for the integration of the electric vehicles is the Hybrid LUO topology of bidirectional DC-DC converter. This topology offers the bidirectional power flow from the grid to vehicle and vehicle to the grid. The topology also provides galvanic isolation with the help of a high frequency transformer. The centralized generation of the energy resources can be replaced by the complete distributed generation plants through this integration. The efficiency of the power transfer between the vehicles and the grid can be improved and regulated. The battery ratings also play an important role in this energy transfer. The electric and hybrid vehicle market has been growing over the years and continues to grow today. Influenced by both government regulations and consumer demand, auto manufacturers have continued to pursue technologies to improve efficiency and fuel economy. As the market progresses, continued research and development is needed to enable large-scale market penetration of electric and hybrid vehicles in the future. In particular, there are three main areas in which current research aims to improve the vehicle: electric motors, power electronics, and energy storage. This report describes the evolution of these technologies and the road map for future development and implementation in electric and hybrid vehicles.

II. OBJECTIVE

To improve the Charging Range by using the Proposed Hybrid Convertor model for an purpose of real time Electric Charging and Aging Applications

III. PROPOSED SYSTEM

The Hybrid LUO (HLC) converter using a bidirectional DC-DC converter implemented with a galvanic isolation on the two sides of the converter. The Hybrid LUO DC-DC converters has the advantages of the higher power density ,bidirectional power transfer capability of the converter ,modulated and symmetrical form of design and the control requirements are simple .The HLC converter can also be used for the multiport operation, which is a necessary characteristic for the integrating of the multiple DC sources and loads using a only one converter .this configuration of the specific bidirectional dc-dc converter is now becoming the widely used to interface on the residential premises with the distribution capacity of the grid to be (230 v.50hz grid) .The highly focused area of the application of this converter is the energy storage systems for the electric vehicle batteries and the fuel cells of the electric vehicles and the interface for the multiple renewable energy resources and the photovoltaic model and chargers for the plug in hybrid electric vehicle and the battery incorporated electric vehicles. Vehicle to grid (V2G) concepts, smart home concepts for the AC micro grids and the residential DC distribution system for the homes (DC Nano grids). The attractive features of the Hybrid LUO which acts as a core of the high frequency transformer are the higher power delivery and the high frequency applications such as low device stress, the transformer leakage inductance does not include any extra reactive component. The Hybrid LUO consists of two of the active bridges on its both sides and they brought together by using a transformer and the power is supplied from the leading bridge to the lagging bridge. The amount of the transfer of the power depends upon the bridgewhich is lagging or leading.

1.CIRCUIT CONFIGURATION:

The HLC converter is made up of two controllable switching bridges and one high frequency transformer. In an H - bridge connection, each switching bridge has four high frequency active controllable switching devices which may be MOSFETs or IGBTs. These connection is similar to that used in dc - dc converters with full - bridge. However, the difference is that the bridging the other side of the transformer with uncontrollable switching devices (such as diodes) in the dc-dc converter, HLC converters use two active bridges formed by active controllable devices. Therefore it was called as Hybrid LUO. The galvanic isolation is produced by the high frequency linear transformer between two H - bridges of a HLC converter. The magnetic core's weight and volume is reduced by the operation of high - frequency transformer. HLC converters use more silicon semiconductor devices (whose price is continuously falling) while using less copper and smaller magnetic component (whose price is continuously rising). During normal transformer operation, there will be a certain amount of leakage inductance in the primary and secondary windings of the high frequency transformer. There are two purposes for the leakage inductance.1. It is used as an energy storage component.2. Reduces dv / dt voltage change over switching devices during switching transients, facilitates soft switching and reduces switching losses. Instead of MOSFETs, power IGBT can be used in the schematic. While using IGBT diode pair instead of MOSFET, there will be possible of Bidirectional current flow is possible. It is therefore capable of conducting bidirectional current. In addition, there is asymmetrical dual active H - bridge configuration in HLC converters which help to attain bidirectional flow of power. On the other hand, it can only block positive voltage from this setup. It is also possible to implement an AC-AC HLC converter using the same configuration method both polarities must be blocked by the switches in the transformer as the input and output voltages are dc. They also have to conduct current in both directions. Therefore, there are two anti-serial the inherent symmetry of the power circuit in a DAB converter ensures

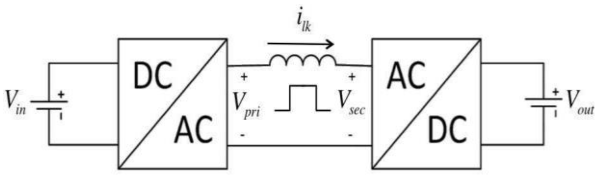


Fig.1 circuit configuration of Hybrid LUO Converter.

Each switch of each bridge is controlled using two level modulation with a 50 percent duty ratio. The operation of the HLC converter is controlled by phase shift modulation. The power flow of the converter is determined from left to right or right to left by controlling the phase difference between two bridges. If the value of the phase angle is more than zero, the power flows from left to right or the value of the phase angle is less than zero than the power flows from right to left through the transformer which has the same ratio of turns on both sides, primary and secondary. This control method is called modulation of the phase shift (PSM).Power flows from the leading bridge to the lagging bridge introduce two operating modes respectively, corresponding to two power flow directions of a HLC are Fig.2.3 Operation Modes (a) Positive power flow (b) Negative power flow converter.

IV. POWER FLOW ANALYSIS

Each of the two full-bridge consists of two set of the switching devices that are driven with square-wave pulses complimentary. The converter's switching frequency (fs) is referred by these complimentary devices switching frequency. The magnetizing inductance of the isolation transformer becomes negligible at high frequencies and the transformer can only be modelled by its inductance of leakage. The converter's power equation is derived by an equivalent circuit shown in the figure below. The Bridge waveforms are, represented as square waves Vpri and Vsec, and apply them to the HF - XFMR terminals.

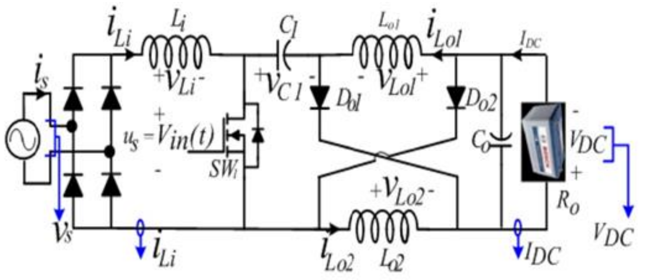
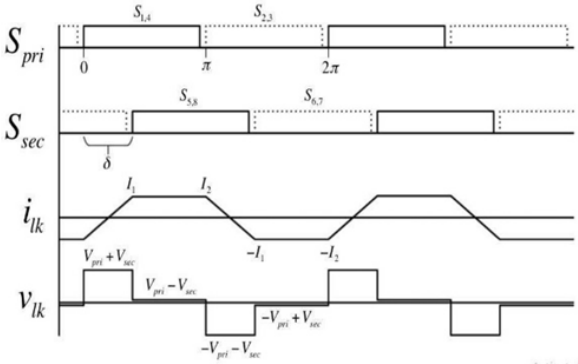


Fig.2 High frequency equivalent Dual Active Bridge

Hybrid LUO using a bidirectional DC-DC converter controls the power flow by phase shifting the pulses of one bridge to the other. This form of control is called as phase shift modulation (PSM) control of the Hybrid LUO circuit topology and it directs power between the two dc buses to provide power to the lagging bridge The square waves applied create a differential voltage across the leakage inductance and direct the stored energy. Taking into account the control pulses for switches S1,S4 of the primary bridge and S5,S8 of the secondary bridge, the pulses are shifted to the secondary side bridge by $+\delta$.Similarly, it causes power to be delivered to the primary bridge by shifted secondary bridge by $-\delta$, making it the leading bridge,



The final expression of the power shows a relationship between the supplied power to the output side as a function of the duty cycle (phase shift) among the two bridges, the switching frequency of the converter, and the inductance of energy transfer. Also the, (5) indicates that a negative duty cycle (or phase shift) between bridges will result in power being drawn from the output side and it is delivered to the dc bus input which is given as input for the design of functioning converter to meet out the needs of a necessary application, the required parameters must be balanced.

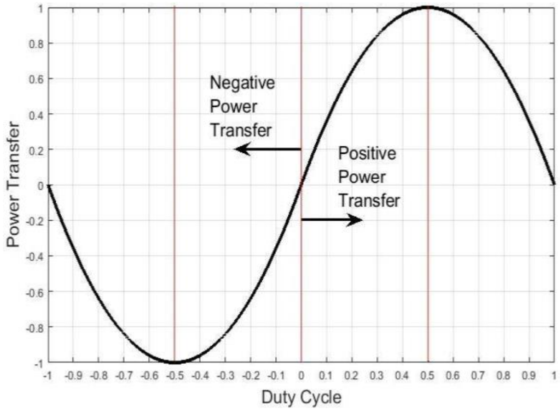


Fig.3 Hybrid LUO power transfer characteristics

C.CONTROL TOPOLOGY:

PEAK CURRENT MODE CONTROL:

Instantaneous current control within one switching cycle is offered by the analog current mode control which is a fast current mode. The Hybrid LUO converter's peak current mode is proposed in this chapter. The primary step is the master bridge in the peak current control mode, which switches with a constant 50 percent duty cycle. The transformer current is continuously monitored. Compared to the measured value of transformer, the reference generated by the voltage loop I0. The switching is done by using SR flip flop. Unlike the average control mode, there is no phase shift as such. The reference current generated by the voltage controller controls power flow.

V. EXISTING SYSTEM

1. History of Electric Vehicles:

In 1801, the steam-powered carriage was built, opening the era of horseless transportation. After thirty years of noise and dirtiness due to steam engines, the first battery-powered EV was built in 1834. Over fifty years later, the first gasoline- powered ICE vehicle was built in 1885. So, EVs are not new and already over 170 years old. With the drastic improvement in combustion engine technology, ICE vehicles showed much better performance and EVs were out of use from the 1930s to the 1950s.Interests in EVs started at the outbreak of energy crisis and oil shortage in the 1970s. The actual revival of EVs is due to the ever increasing concerns on energy conservation and environmental protection throughout the world as summarized below: EVs offer high overall energy efficiency over the ICE vehicles.

Moreover, EVs can perform efficient braking by converting the kinetic energy back to electricity, virtually boosting up the energy efficiency by at most 25%. Moreover, while the maximum efficiency of the ICE vehicle can be 30-35 %, electric propulsion system drawing the power from battery can operate with a peak efficiency of around 90% [1]. EVs allow energy diversification. Electricity can be generated not only from thermal power using fossil fuels; coal, natural gas and oil, but also from hydropower, wind power, geothermal power, nuclear power, tidal power, wave power, solar power, chemical power and biomass power. EVs enable load equalization of power system.

By recharging EVs at night, the power generation facilities can be effectively utilized, contributing to energy saving and stabilization of power cost. EVs show zero exhaust emissions. EVs operate quietly and almost vibration-free, whereas ICE vehicles are inherently noisy and with sensible vibration. Thus, EVs are welcomed by drivers and appreciated by local residents. Nowadays, many governments actively promote the use of EVs by providing facilities such as financial subsidies and tax reduction, as well as enforcing regulations such as zero-emission zones and ultralow-emission vehicles. Apart from numerous advantages of EVs, they have some disadvantages like, large battery charging time, lower flexibility and limited dynamic performance. An important limitation is its limited operating range per cycle of battery charge which acts as bottleneck of the technology. To improve the dynamic performance and all electric range, advanced electric vehicles such as hybrid electric vehicles (HEV), plug in HEVs and fuel cell vehicles have been proposed. These advanced vehicles are not only capable to compete against the convention ICEVs in performance but are also able to give higher fuel economy and low emissions [1].

2. Types of Electric Vehicles:

The conventional ICE vehicle employs a combustion engine for propulsion. Its energy source is gasoline or diesel fuel. In contrast, the EV employs an electric motor and the corresponding energy sources are batteries, fuel cells, capacitors and/or flywheels. However the presently achievable specific energy of capacitors and flywheels precludes them from being the sole energy sources for EVs. The key difference between the ICEV and EV is the device for propulsion (combustion engine versus electric motor).

Currently, there are three categories of EV systems [2]: Battery EV (BEV) utilizes batteries as the sole energy source, and electric motors as the propulsion device. This BEV has been commercially available though not yet under mass production, and is mainly designed for commuter operation with the driving range of about 100 km per charge. 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 hybrid EV (HEV) incorporates both of the combustion engine and electric motor as the propulsion device. It adopts gasoline or diesel fuel as the main energy source, and utilizes batteries as the auxiliary energy source.

The HEV can offer the same driving range as the ICEV (over 500 km per refuel), while produces much lower emissions than those of the ICEV. This HEV has been commercially available and under mass production. The fuel cell EV (FCEV) adopts fuel cells as the main energy source, and the electric motor as the propulsion device. Since fuel cells cannot accept regenerative energy, batteries are generally adopted as the auxiliary energy source. Being fueled by hydrogen or methanol, the FCEV can provide a driving range comparable with the ICEV. Because of its high initial cost, this FCEV is not yet commercially available [2]. electricity through a chemical reaction. Fuel cell offers low emission and higher efficiency comparing to ICE. Today's fuel cells have achieved the power density suitable for vehicle applications A fuel cell uses hydrogen and oxygen to produce. The major challenges for fuel cell vehicles are cost and fueling infrastructure. Attempts are being made to reduce the manufacturing cost of a fuel cell. To address infrastructure issues, significant R&D effort is made in in-vehicle reformers which generates hydrogen-rich gas by reforming other fuels such as gasoline, methanol, or natural gas [3].

3. Electric Vehicle Technology:

The technologies involved in EVs are diversified and include electrical, electronic engineering, mechanical, automotive engineering, and chemical engineering. Specialists in these disciplines of engineering must work together in the main areas that must be integrated: body design, batteries, electric propulsion, and intelligent energy management. Concerns in this work will be directed towards electric part in the vehicles and its associated issues. Fig. 1 shows the general electrical configuration of EVs, including the BEV, HEV and FCEV. It consists of three major subsystems— electric propulsion, energy source, and auxiliary. The electric propulsion subsystem comprises the electronic controller, power converter, electric motor, mechanical transmission, and driving wheels. The energy source subsystem involves the energy source, energy management unit, and energy refueling unit. The auxiliary subsystem consists of the power steering unit, temperature control unit, and auxiliary power supply. Based on the control inputs from the brake and accelerator pedals, the electronic controller provides proper control signals to switch on or off the power devices of the power converter which functions to regulate power flow between the electric motor and energy source. The backward power flow is due to regenerative braking of the EV and this regenerative energy can be stored. The most available EV batteries as well as capacitors and flywheels accept regenerative energy. The energy management unit cooperates with the electronic controller to control regenerative braking. It also works with the energy refueling unit to control refueling and to monitor usability of the energy source. The auxiliary power supply provides the necessary power with different voltage levels for all EV auxiliaries, especially the temperature control and power steering units [2].

4. Electric Propulsion System:

Electric propulsion is to interface electric supply with vehicle wheels, transferring energy in either direction as required, with high efficiency, under control of the Fig. 4 "General Electrical Configuration of EVs"driver at all times. From the functional point of view, an electric propulsion system can be divided into two parts—electrical and mechanical. The electrical part includes the motor, power converter, and electronic controller. On the other hand, the mechanical part consists of the transmission device and wheels. Sometimes, the transmission device is optional. The boundary between electrical and mechanical parts is the air- gap of the motor, where electromechanical energy conversion is taking place. Electric propulsion, a major power electronics area, plays a very important role in EVs. Sometimes, it is described as the heart of EVs [4]. Fig. 2 illustrates the functional block diagram of a typical EV propulsion system where the arrow-headed thick and thin lines represent the power and signal flows, respectively. Due to the availability of regenerative braking, the power flow is reversible. Depending on the motor control strategy, driver's command, and data obtained from the EMS, the electronic controller provides proper control signals to the power converter. These signals are amplified via a driving circuitry to switch proper power devices. Thus, the power converter regulates power flow between batteries and the motor during motoring and regenerative braking. Finally, the motor interfaces with wheels via the transmission device.

V.SIMULATION AND RESULTS:

The simulation of the proposed converter was done using MATLAB Software. The simulation diagram of the proposed converter was depicted

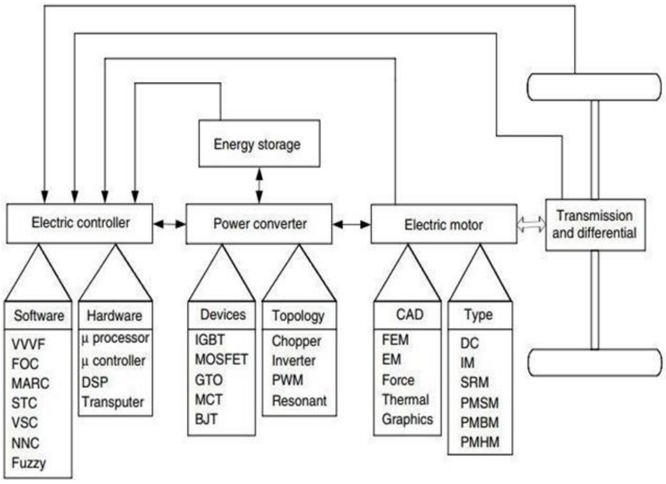


Fig.5 "Functional block diagram of a typical electric propulsion system"

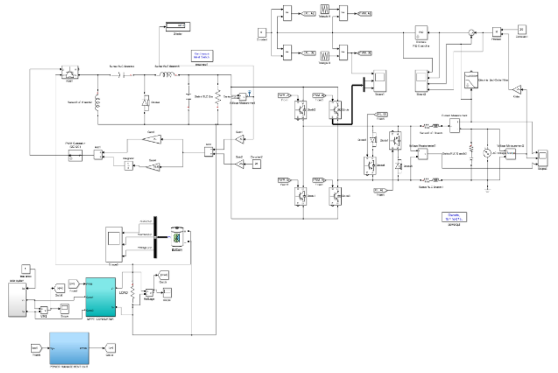


Fig.6 Simulation of HLC (Open Loop)

1. INPUT SOURCES:

In this project, a 12V DC source is considered as input source for Hybrid LUO converter.

2. PULSE GENERATION:

The switches are controlled by Phase Shift Modulation (PSM) technique. These switches are operated at 50% duty cycle with an operating frequency of 10 kHz. The gate pulses for inverter circuit are generated with zero delay and 180 delay and provided for the switches S1, S4 and S2, S3 respectively. Similarly, the gate pulse for the rectifier circuit was generated and provided for the switches S5, S8 and S6, S7 respectively. The gate pulse for inverter and rectifier circuit is shown in Fig. The delay provided for the gate pulse for rectifier side is considered as 25% of total time period of conduction. The switches are shifted by Phase Shift Modulation technique. Fig. shows how the rectifier gate pulse shifted from inverter gate pulse.

2. RESULT:

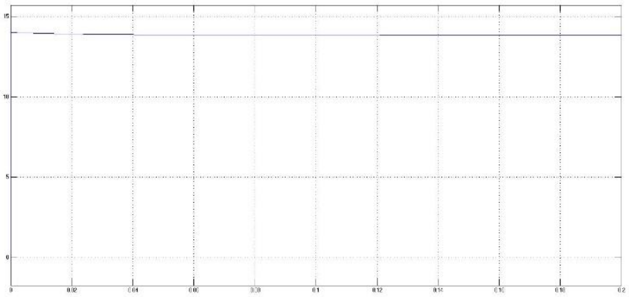


Fig.7 Simulation design of LLC resonant DC-DC converter

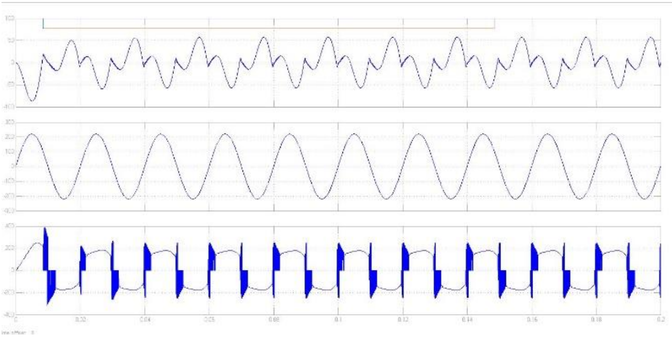


Fig.8 Scope 3

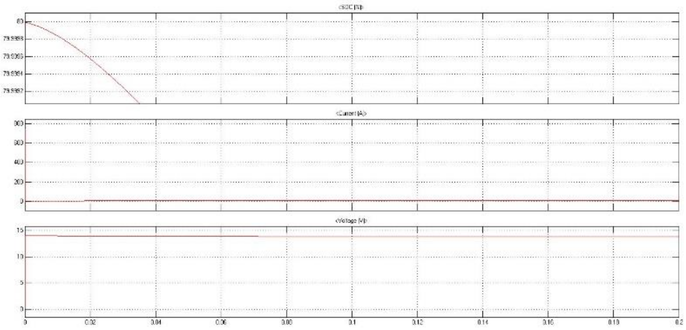


Fig.9 Scope 6

VI. CONCLUSION

The Hybrid LUO Hybrid converter based improved power quality AC-DC converter is proposed for Electric Vehicle battery charging application. The design, simulation and hardware implementation of proposed converter are carried out. The simulation results are obtained under various loading conditions and results demonstrate that the proposed converter is able to provide regulated output voltage irrespective of supply and load variations.

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