Interleaved Isolated Single PhasePHEV Charger

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Abstract: In the case of automotive industry onboard chargers are widely used because of its advantages. 3Kw chargers are on of the widely used chargers for plug in vehicle because of the availability of the power source. The interleaved boost AC-DC rectifier is one of the best topologies utilized for ac-dc conversion with better power factor. For the second stage, isolated full bridge DC-DC converter with the zero voltage switching is described. The proper zvs operation needs an accurate design of the resonant tank that adds extra complexity of the converter design.

***IndexTerms* - Electric vehicle, battery charger, frond end ac-dc converter, interleaved boost converter**

I. INTRODUCTION

Currently, energy efficiency is the peak priority to increase by a major concern with climatic changes and rising in fossil fuel price cost. Large portion of oil consumption is related with road vehicles. EV charging management requires the support of a corresponding communication structure. The interest on technologies for Electric vehicles (EV) and Plug- in Hybrid Electric Vehicle(PHEV) has significantly increased in the last years. A plug in hybrid electric vehicle includes rechargeable batteries. These batteries can be charged by using a external electrical power source. Battery chargers are another important component in PHEVs. Several manufactures are working world wide on the development of various types of battery modules for EVs and hybrid vehicles. However, the performance of battery modules depends on the design of the modules and how the modules discharged andcharged.

An onboard 3.3 KW charger can charge a 16KWh battery pack in PHEVs to 95% charge in about 4 h from a 240V supply. The charger architecture includes a first phase, an AC-DC converter with power factor correction and second stage is an isolated DC-DC converter. The important steps in the design and development of these battery chargers are selecting the optimal topology and evaluating the power loss in power semiconductor.

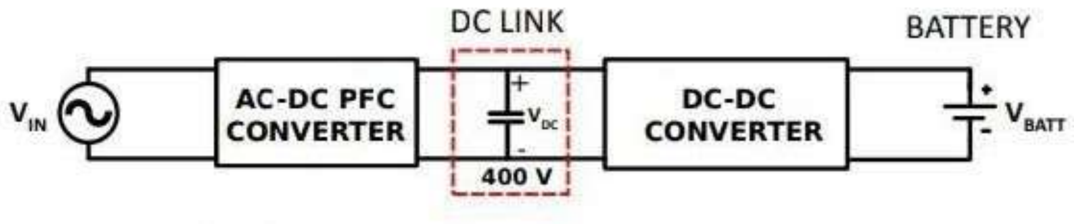
II. SPECFICATIONS OF THE CHARGER

The vehicle traction system energized by a battery that have a voltage level of 200-700V .For passengers cars a voltage levels like 700V can be utilized. For instance, the main specification of a 3.3 KW charger with a nominal battery voltage of 300V. Usually the power level is limited by the available power from the utility grid. The available power from a 230V/16A is 3520W.For charger with an efficiency level of 94% the output power is 3.3 KW.

The electro magnetic compatibility issue is another concern regarding the grid connected chargers. However, using a line filter to reduce EMC and transients is the main solution to full fill these requirements. The battery voltage in a passenger car lie between 300V or 700V.

Input voltage	85-270
Maximum value of the input current	16A
AC line frequency	47-70Hz
Power factor	94%
Total harmonic distortion less than	5%
Output DC voltage	200-470 V
Maximum output power	3.3KW
Charger efficiency	94%
Cooling	Liquid
Coolant temperature	40 to70
Ambient temperature	40 to105
Weight/Volume around	6Kg/5L

III. BLOCK DIAGRAM

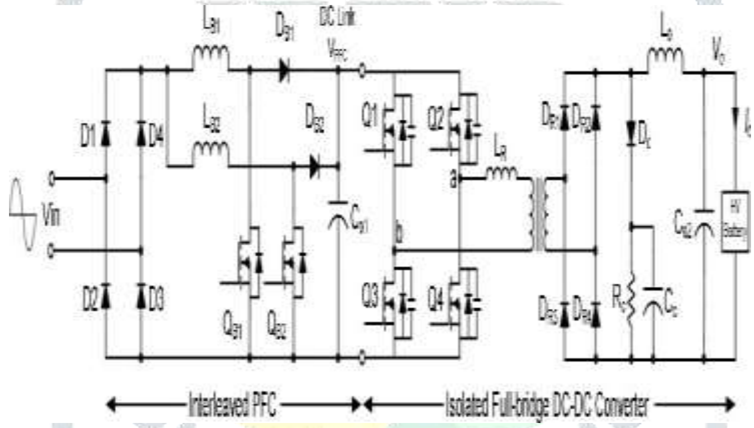


On board chargers for electric and hybrid vehicle is an indication of the new era in the field of power electronics. In both battery operated vehicle and in PHEV, a two stage converter connects the input grid voltage to the battery pack whose voltage varies from 100-500V, based on the vehicle size and range. A universal charger, which can address the wide range of battery pack voltage, is suitable for all vehicle architecture.

The requirements is achieved by varying the AC/DC converter output voltage using the concept of variable DC link voltage , Which is one of the challenges in battery chargers for attaining universal output voltages. Lack of fast charging infrastructure deploys the automotive manufactures with on board battery chargers, which are feasible of charging from household power sockets.

Block diagram shows the typical layout of the battery chargers with a feature of isolation accepting the wide input voltages. A front end PFC converter is required at the input to maintain high power quality. In most PFC application, A boost converter with or without interleaved topology is preferred

IV. CIRCUIT DIAGRAM



The two stage battery pack is shown in the figure.

A. *Front end first stage ac-dc pfc rectifier*

The interleaved PFC consist of two continuous conduction mode boost converters in parallel , which operate 180 degree out of phase .The input current is the sum of the inductor currents in LB1 andLB2. Since the inductor ripple currents are 180 degree out of phase, then they cancel each other and reduce the input ripple current. The output capacitor current is the sum of two boost diode currents minus the DC output current. Interleaving reduces the output capacitor ripple current as a function of the duty cycle, the sum of the two diode currents approaches DC.

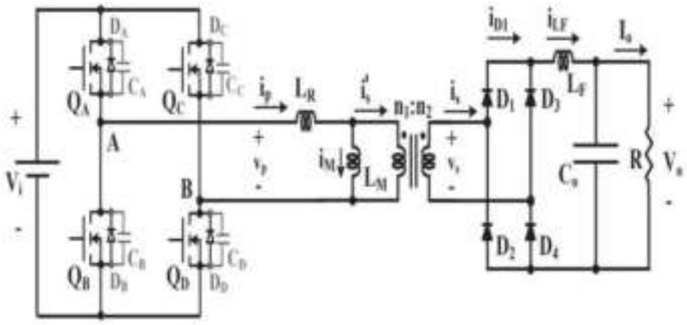
B. *Second stage zvs full bridge dc-dc converter*

ZVS for the switches is realized by using the leakage inductance of the transformer, in addition to the full bridge zvs converer presented here behaves similar to a traditional hard switched topology, but rather than simultaneously driving the diagonal bridge switches, the lower switches are driven at a fixed 50%duty cycle, and the upper switches are PWM on the trailing edge.

V. DESIGN OF INTERLEAVED BOOST COVERTER TDESIGN OF TYLE AND FONTS

There are different circuit topologies that can be utilized as the PFC pre regulator. There are different varieties and improvements to the basic boost converter to achieve a performance closer to the ideal AC-DC converter. The interleaved boost rectifier is an interesting configuration from the boost converter family providing some advantages over the basic topology. There are two energy storage inductors with two independent switches diodes that share the same bridge rectifier at the input side and the same dc bus capacitor. The switching functions are interleaved which significantly reduce the input line and output ripple can reduces. It simply can reduce the ripple to half when the duty cycle is half. In addition, interleaving provides the benefits for parallel converter operation for higher power application.

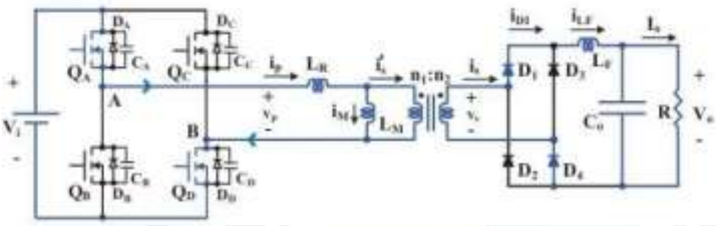
VI. DESIGN OF TRANSFORMER ISOLATED PHASE-SHIFTED FULL-BRIDGE CONVERTER WITHZEROVOLTAGESWITCHING OPERATION



Above fig. shows a schematic diagram of the full-bridge DC/DC converter with a phase-shifted control and zero voltage switching capability. The control is performed by a proper turn on/off of four switches (QA − QD) in the primary side bridge. Here it is assumed that the switches type is a power Mosfet. Moreover, inside each Mosfet there are an anti-parallel diode and a parasitic output capacitance that are utilized to perform the ZVS operation. However, those two components can also be external devices.

A. Initial condition t < t0

Suppose that QA and QD are conducting. Diodes D1 and D4 are conducting and charging the output inductor LF while transferring power to the load. The active part of the circuit is in blue color. For instance, parasitic diodes and capacitors of the primary bridge are not conducting. There is no stored energy incapacitor CD while capacitor CC is fully charged with input supply voltage Vi. The same holds for CA and CB. These capacitors in interaction with leakage inductance LR performs the ZVS operation. At full load, the transformer primary current is the maximum possible value which is the reflected load current to the primary and the magnetization current. The leakage inductance is usually much lower than the magnetization inductance, hence the voltage drop over the leakage inductance is negligible.



Above fig. Operation of the phase-shifted full-bridge converter with ZVS converter status in initial condition, t < t0.

B. Interval t0 < t < t1

The right leg transition is starting by turning off QD Assume that at t = t0 switch QD is commanded to the off state. The magnetization current is usually much less than the full load current. After t = t0 the stored energy in leakage inductance LR forces the current to continue to flow through CC and CD until they change status from fully charged to fully deployed and vice versa. The stored energy in the leakage inductance should be higher than the stored energy in the capacitors fora proper ZVS operation. For instance, at light loads in which the leakage inductance can not supply this energy level, the ZVS operation is lost. Usually the ZVS operation range is 50% of full load (decided by the designer). In this time interval the capacitors are charged and de-charged linearly over time consequently, the transformer primary voltage linearly decreases. The transformer secondary voltage also decreases and in a certain point the voltage value is equal to the output voltage. After this point, the voltage over the output inductor changes its polarity and there is no power transfer from the input supply to the load. Afterwards, the output inductor and the output capacitor supply the load. At the end of this interval the transformer primary voltage reaches zero voltage.

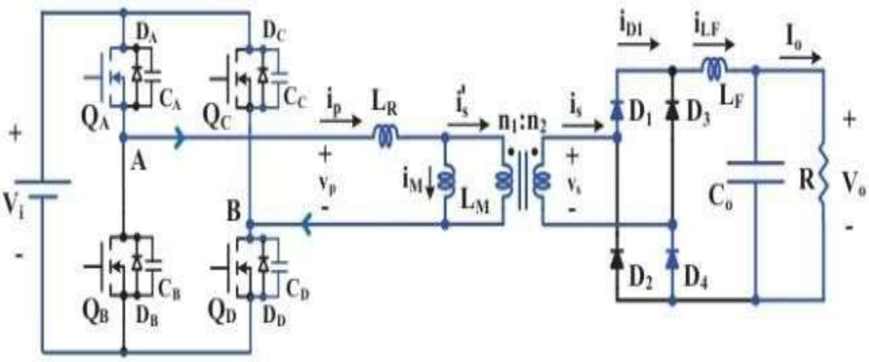


Fig shows Operation of the phase-shifted full-bridge converter with ZVS starting of the right leg transition, t0 < t < t1.

C. Interval t1 < t < t2

When CD is fully charged it will not take more current from the circuit. The capacitor CC is ideally fully de-charged, so the current flows through diode DC. This is the mechanism of the ZVS operation. If the gate signal of QC is activated by the controller, QC is turned on lossless because the anti parallel diode forces the switch's voltage to a value close to zero. However, one needs to make sure that the diode is conducting before the gate activation by a proper component and controller selection. After activation of QC the diode is still conducting. The two devices share the current that lowers the conduction loss. By turning on the Mosfet QC, the right leg transition is finished and the circuit is ready to perform the left leg transition under ZVS condition. The magnetization current is circulating through QA, QC and DC. When the right leg transition is finished, the transformer primary and secondary voltages are zero and there is no power transfer to the load from the input supply. The output inductor, LF, supplies the load and forces all diodes at the output bridge, D1 − D4, to conduct and share the current.

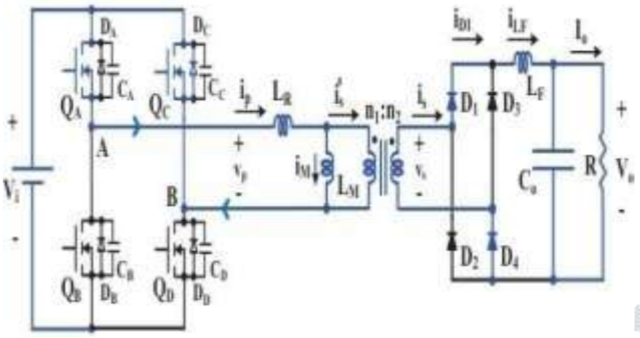


Fig shows Operation of the phase-shifted full-bridge converter with ZVS completion of the right leg transition, t1 < t < t2.

D. Interval t2 < t < t3

The left leg transition is initiated by the turning off of the QA gate signal at t = t2. It is desired to turn off QA and turn on QB with a zero voltage. In this moment the transformer primary current, ip(t2), is slightly less than the transformer initial current, ip(t0), because of the losses. At t = t2 the Mosfet channel stops to conduct the current and CA takes over the current flow. Capacitor CB starts to supply the current simultaneously. Consequently, the voltage at point A starts to decrease towards zero which is preparing for the ZVS operation of QB.

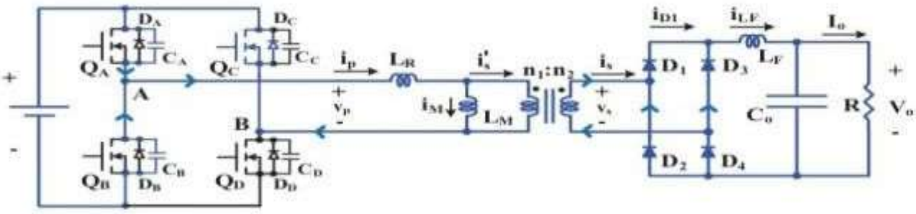
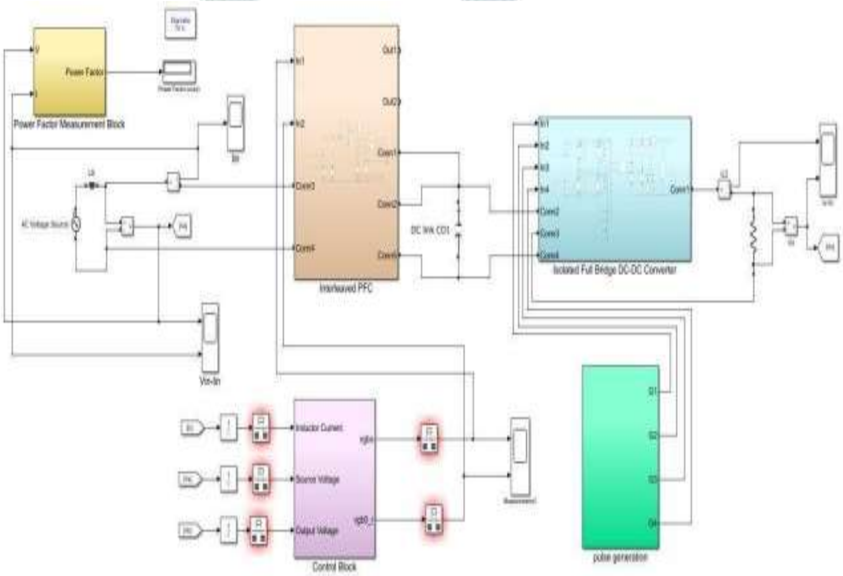


Fig shows Operation of the phase-shifted full-bridge converter with ZVS the left leg transition, t2 < t < t3.

VII. SIMULATION AND RESULTS



This is the simulink model of existing system. Mainly 2 parts are present in the system, interleaved PFC and isolated full bridge DC –DC converter. Two MOSFETS are present in the interleaved PFC block. The gate pulse for the proper working of MOSFET is given by control block. The input parameters to the control block are inductor current, source voltage and output voltage.

VII.CONCLUSION

The main specifications, design process, loss analysis and design examples of a 3.3 kW battery charger is presented and explained in this report. Usually there are two power conversion stages in a modern 3.3 kW battery charger used as an onboard vehicle charger: a Boost rectifier as the front-end pre-regulator and a transformer isolated DC/DC converter. The interleaved Boost rectifier is explained in this case. In addition, the regulatory standards regarding the utility grid are listed. It is shown that an efficiency level of 98% is feasible for this stage that provides a compact high power density AC/DC conversion.

The transformer isolated full-bridge DC/DC converter with a Phase-shift control and ZVS operation is considered as the second stage converter. The analysis results show that the designed DC/DC stage has a good design and performance, but the IL Boost converter stage can be improved by changing component selections.

REFERENCES

[1] "A wide input and output voltage range battery harger using buck-boost power factor correction converter", A.V.J.S.Praneeth, Student Member, IEEEand Sheldon S Williamson, Senior Member, IEEE, 2019.

[2] " Electric vehicle charging topologies , controlschemes for smart city application" Sanjeev K Nayak, Member, IEEE, 2019

[3] "Plug-in hybrid electric vehicle charging infrastructure review," K. Morrow, D. Karner, and J. Francfort, U.S. Dept. Energy–Veh Technol.Program, Washington, DC, INL/EXT-08-15058, 2008.

[4] " A high performance single phase bridgeless interleaved PFC converter for plug in hybrid electric vehicle battery charger" Fariborz Musavi , member of IEEE, William G Dunford , senior member IEEE., 2011.

[5] "An automotive onboard 3.3-kw battery charger for PHEV" application. Deepak S. Gautam, Student Member, IEEE, Fariborz Musavi, Senior Member, IEEE,Murray Edington, Member, IEEE, Wilson Eberle, Member, IEEE, and William G. Dunford, Senior Member, IEEE. 2012.

[6] "Single –phase on board integrated bi-directional charger with power factor correction for an EV", Upendra singh, dept of Electrical engineering, Yash pal, dept of electrical engineering, 2019.

[7] " An improved battery charger for ev with high power factor", Rdha Kushwaha , IEEE, 2018