International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 14
October2016

Design of Integrated System For Bidirectional Power Flow Between the Electric Vehicle And DC or AC Grid

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ABSTRACT: This paper grants an built-in traction machineand converter topology that has bidirectional vigour flow abilitybetween an electric automobile and the dc or ac deliver or grid. Additionally paper offers a brand new motivation of bidirectional AC to DC converter or DC to AC inverter is proposed in this undertaking.Right here for bidirectional operation further boost converters and further converts are not wanted. A single three-segment converter is satisfactory to operate the AC traction motor, connect to AC grid, and to DC grid (as improve converter). Extra tripping switching are used here for these operations. The identical approach is operated for 5 states. These states will also be carried out in the simulation and a prototype is made to do the identical.

KEYWORDS-Bidirectional converter, electric vehicle, integrated converter, machine inductance.

I. INTRODUCTION

Several distributed energy (DE) systems are expected tohave a significant impact on the California energy market innear future. These DE systems include, but are not limited to:photovoltaic (PV), wind, micro turbine, fuel cells. Inaddition, several energy storage systems such as batteries andflywheels are under consideration for DE to harness excesselectricity produced by the most efficient generators duringlow loading. This harvested energy can be released onto thegrid, when needed, to eliminate the need for high-costgenerators. There are a number of applications for DC-to-DCsystems. These systems are used to convert the DC voltagemagnitude from one level to another with or without galvanicisolation. They take an uncontrolled, unregulated input DCvoltage and condition it for the specific load application. Anexample for such topology can be found in PV applications,where the dedicated DC-DC units are often designed toextract the maximum power output of the PV array.Photovoltaic (PV) technology involves converting solarenergy directly into electrical energy by means of a solar cell.A solar cell is typically made of semiconductor materialssuch as crystalline silicon and absorbs sunlight and produceselectricity through a process called the photovoltaic effect.The efficiency of a solar cell is determined by its ability toconvert available sunlight into usable electrical energy and istypically around 10%-15%. Therefore, to produce significantamount of electrical energy, the solar cells must have largesurface areas.

In this paper, an integrated motor converter is proposed thatcan be used as the traction motor drive, a battery charger, and apower converter to transfer energy from vehicle-to-grid (V2G)through reconfiguration of the inverter topology using relaysor contactors. The traction inverter with the proposed reconfiguration method can also transfer power from the vehicle toa dc grid and from a dc grid to the vehicle using the tractionmotor windings with the appropriate relay settings. The threephase machine windings and the three inverter phase legs canbe utilized with an interleaved configuration to distribute thecurrent and reduce the converter switching stresses. The batteryvoltage is increased in the boost mode to an output referencevoltage level within the limits of the machine ratings. A softstarter method using PWM control has been used to reduce thestarting current overshot when connecting to a dc grid. In a dcgrid connected mode, the voltage drop across the inductor willbe the difference between the inverter output voltage and the dcgrid voltage. The dc grid voltage provides more stable voltage tocounteract the rate of change of inductor current and the currentripple is controlled in a better fashion in a dc grid connectedmode.

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The proposed converter system can also be used for transferring power between a single-phase ac grid and the vehicle ineither direction without any extra component. The rated conditions of the motor and utility interface are quite similar. Theinverter is able to regulate the motor phase current in the entirespeed range. When changing from the motor control mode toac grid connected mode of operation, the back EMF voltageis replaced with the grid voltage. Considering the operatingconditions with the grid, motor inductance would be enoughto handle the grid connected modes of operation. Also, in theblocked rotor condition, motor magnetizing inductance dominates and contributes to the phase inductance significantly. Forhigh enough inductance required in case of ac grid, the rotorcan be locked which will give high inductance in the blockedrotor condition. In the charging mode, the machine is thermallystable with no electromechanical power flow through the airgapof the machine. The machine ratings are within limits in all theoperating modes as there is only electric loading, and no magnetic loading except during traction operation. The current limitis higher in converter modes compared to the traction modecurrent limit.

This paper presents the analysis, design, and experimentsof the integrated traction drive and power converter for electric/hybrid vehicle applications. The electric machine has beenanalyzed using coupled simulation of finite-element and dynamic analysis software. The power converter and controllerhave been modeled using MATLAB/Simulink. The proposedconverter reconfiguration method is advantageous for reducingthe size and component of the electric power train while providing bidirectional power flow capability with connections toeither dc or ac supplies.

II. PROPOSEDCONVERTER TOPOLOGY

Dissimilar types of topologies have been established for electric vehicles for battery charging andbidirectional power flow between the battery and the power supply.However, the traction inverter uses the standard six-switch configuration that has elements of the variouspower converter topologies. The proposed converter topology utilizing the traction inverter along with theswitches used for reconfiguration is shown in Fig. 1(a) and (b) shows the detailed switch or relayarrangements required for different modes of operations. Several different configurations can be obtainedby appropriate positioning of the switches, which results in a novel methodology for bidirectional powertransfer between a vehicle battery and dc or ac grid. Including the use of the topology as the tractioninverter during vehicle operation this power converter can be operated in five different modes:

1) Power flow from the battery to the dc grid,

2) Power flow from the dc grid to the battery,

3) Traction mode,

4) Power flow from the battery to single-phase ac grid and

5) Power flow from a single-phase ac grid to the battery.

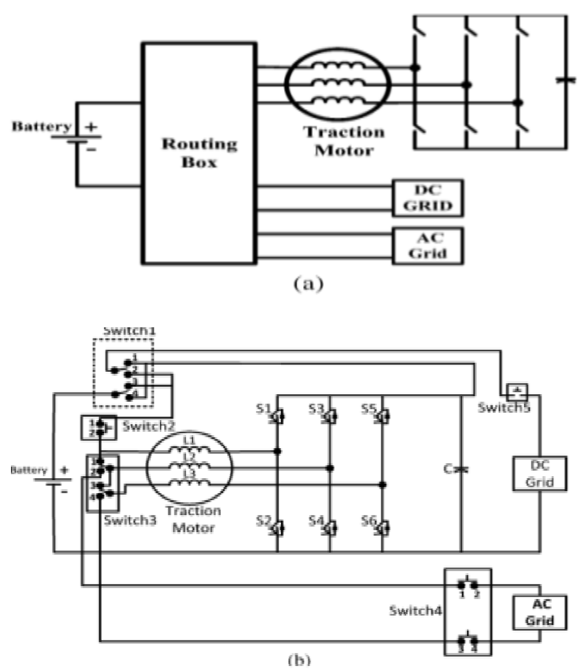

Fig.1. Converter with switches capable of interfacing with both ac and dc grid (a) combined and (b) details.Fig. 1(b) shows the details of the configuration in the routing

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Fig. 1. Converter with switches capable of interfacing with both ac and dc grid (a) combined and (b)details. Table I switch positions and converter states box with the switches which relates to the operationsof the switches according to table 1 The terminal numbers are shown in Fig. 1(b) inside the switches whichare changed to different positions for the different configurations.

Switch	State 1	State 2
Switch1	Pole positions: 1 and 3	Pole positions: 2 and 4
Switch2	1 and 2 disconnected Pole positions: 1 and 3	1 and 2 disconnected Pole positions: 1 and 3
Switch3	Pole positions: 1 and 3	Pole positions: 2 and 4
Switch4	1 and 2, and 3 and 4 disconnected	1 and 2, and 3 and 4 connected
Switch5	1 and 2 disconnected	1 and 2 connected

When the converter is to connect to a dc grid, Switch 4 will be in State 1 to isolate from the ac grid. Whenthe converter is to connect to an ac grid, Switch 5 will be in State 1 to isolate from the dc grid. Thus, thetraction converter can be connected to either a dc or an ac grid.

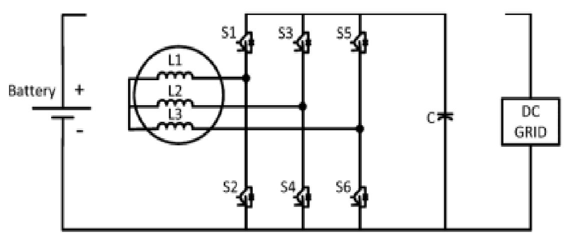

Fig 2. (OFF condition) Circuit with all switches in State 1.

Fig. 2 shows the OFF condition where all the switches are inState 1; in this situation, there will be no power transfer. If there is any fault in one or multiple phases inthe motor the converter configuration will be switched to State 1 as shown in Fig. 2, and there will be nopower transfer between the grid and the battery. The usual protection schemes for a traction inverter willtake over. The system has inherent fault protection capability, and extra protection is not needed.

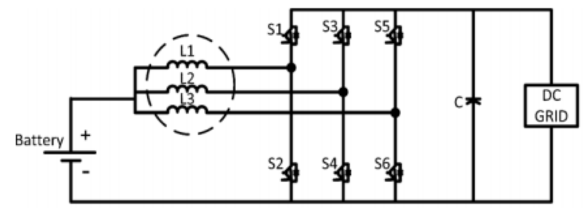

Fig. 3. Circuit with Switch 2 and Switch5 in State 2 for V2G boost or G2V buck operation with vehicle side inductors interleaved.

Fig. 3, operating mode 1 in Fig. 3 and operating mode 2 in Fig. 4 have been verified in simulation.Operating mode 1 is experimentally verified using two types of machines. Although, operating mode 2 inFig. 4 is different from operating mode 1, the converter is symmetrical for these two modes and forexperiments they are similar. Therefore, verifying operating mode 1 experimentally is sufficient for boththe modes.

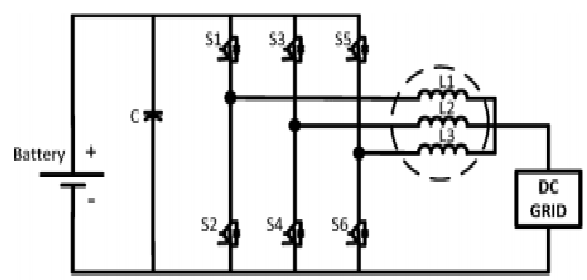

Fig. 4. Circuit with Switch 3 and Switch 4 are in State 1 for V2G buck or G2V boost operation with dc grid side inductors interleaved.

It can be observed that forV2G boost operation, the interleaved technique can be applied on the batteryside with the three inductances and three legs of the converter; for G2V boost operation, the interleavedtechnique can be applied on the dc grid side to reduce the switching stresses. The proposed converter canbe used for traction mode with Switch1 in State 2 and other switches in State 1 as shown in Fig. 5.

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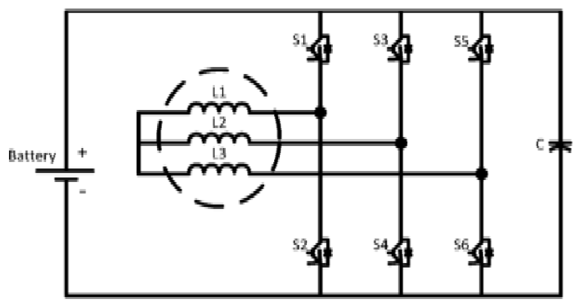

Fig. 5. Circuit with Switch 1 is in State 2 for traction mode operation.

This converter can be used for bidirectional power transfer between a single-phase ac grid and the vehiclebattery. For this configuration, Switch 1 and Switch 5 are kept in State 1, while all switches are to be inState 2. The two phases of traction motor windings are connected with the single-phase ac grid side andanother switch connects with the battery as shown in Fig. 6. Power can flow in either direction with buckor boost modes of operation.

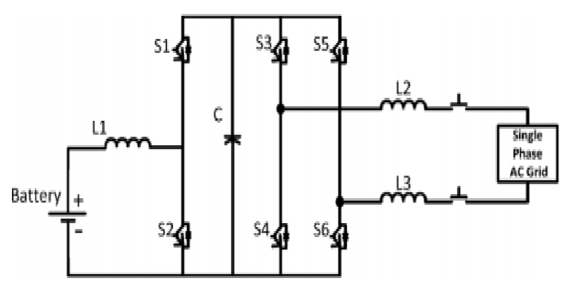

Fig. 6. Circuit configuration for bidirectional interface with a single-phase ac grid

Power can flow in either direction with buck or boost modes of operation. Operating mode 1 in Fig. 3 andoperating mode 2 in Fig. 4have been verified in simulation. Operating mode 1 is experimentally verifiedusing two types of machines. Although, operating mode 2 in Fig. 4 is different from operating mode 1, theconverter is symmetrical for these two modes and for experiments they are similar. Therefore, verifyingoperating mode 1experimentally is sufficient for both modes. The operation mode in Fig. 5 is the typicaltraction machine operation which is used in the motor drives of electric and hybrid vehicles.

III. SIMULATION AND EXPERIMENTAL RESULTS

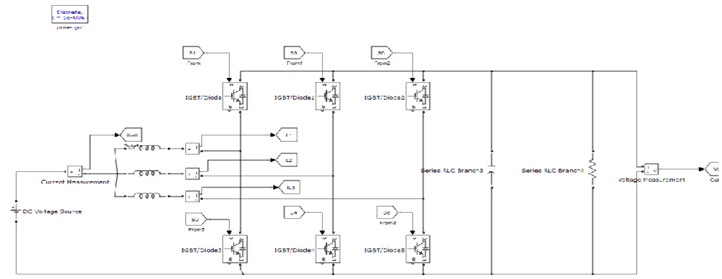

Fig. V2G Boost Converter or G2V Buck

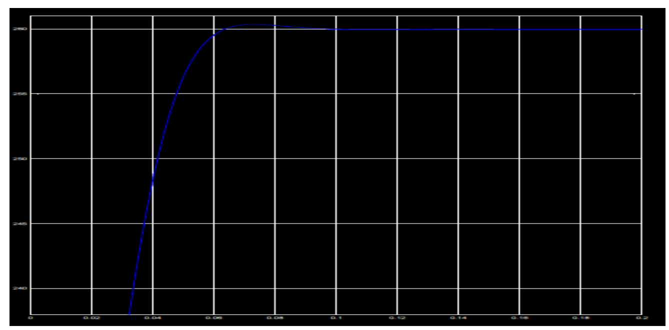

Fig: Output voltage for boost converter

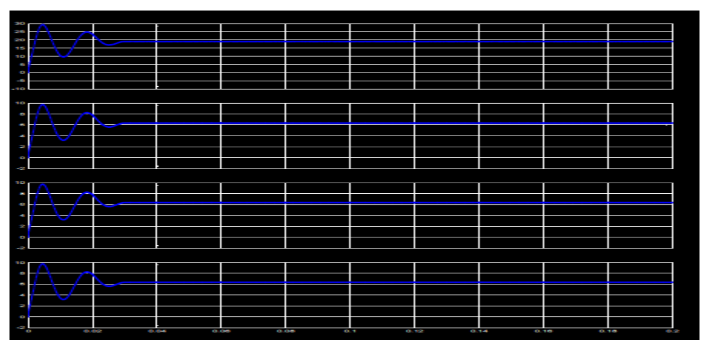

Fig. Currents iL1, iL2 , iL3

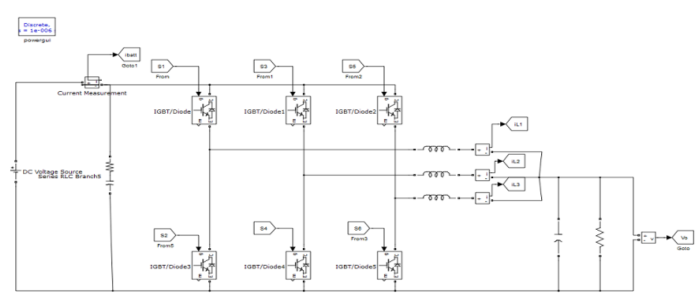

Fig. V2G Buck Converter

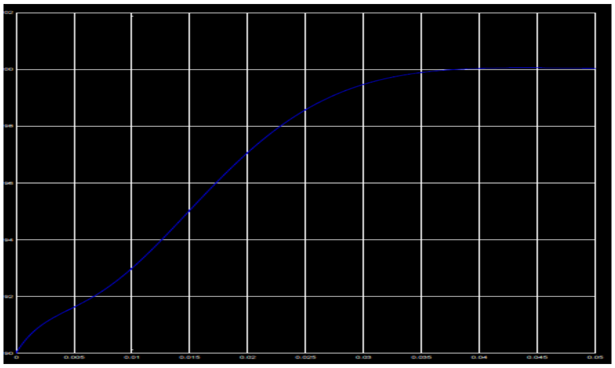

Fig: output voltage for buck converter

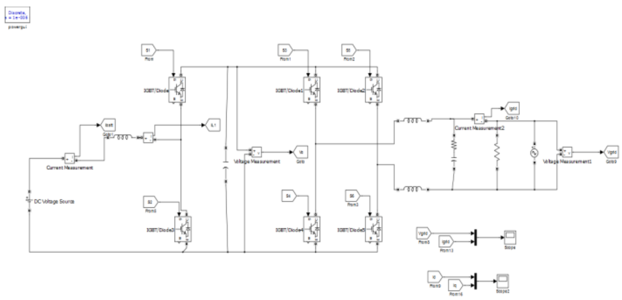

Fig. Vehicle to AC Grid

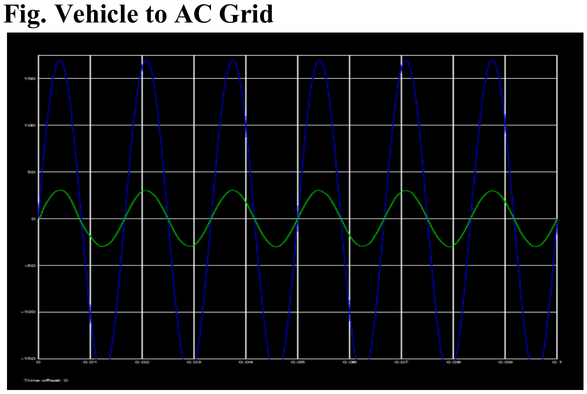

Fig. Ac grid Voltage and Current

IV. CONCLUSION

An built-in integrated-converter topology and reconfiguration method had been proposed in this paper, where tractioncomputing device windings can be used as the inductors of the converter to switch vigour between a automobile battery and both dc or acgrid. The converter reconfiguration thought is useful in minimizing the scale and elements in the powertrain of an electrical car.The experimental results verified that the proposed built-in converter can work in each instructions for V2G and G2V;moreover, it has the benefits of making use of the interleaving technique in each V2G and G2V modes of operations.

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