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PERFORMANCE OF BI DIRECTIONAL DC DC USING CUK CONVERTER FOR ELECTRIC VEHICLE APPLICATION

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Abstract:
The inclusion of bidirectional DC-DC converter between the electric source and traction motor in Electric Vehicles facilitates the energy regeneration during braking and during motion along downhill slope. This inclusion can improve traction drive efficiency as much as by 25%, which improves the whole driving range. Now to reduce the weight, size and the cost of system, proper bidirectional DC-DC converter topology should be selected so as to optimize the design performance. This paper reviews and the study of the basic bidirectional DC-DC converter topology and presents the comparative advantages and disadvantages for arriving at the proper design decision for Electric Vehicle traction application.

Keywords: Regenerative braking, traction energy, Electric Vehicle.

1. INTRODUCTION

Bidirectional DC-DC converter can perform the stepping up and stepping down of voltage level with ability of power flow in both directions. Bidirectional DC-DC converters now have been used in various applications like Energy storage system of Electric vehicles, Fuel cell, Renewable energy and uninterrupted power supplies. Previously they were used only for speed control and regenerative braking of motor drives. The basic purpose of using bidirectional DC-DC converter is to achieve DC bus voltage regulation with ability of power flow in both directions.

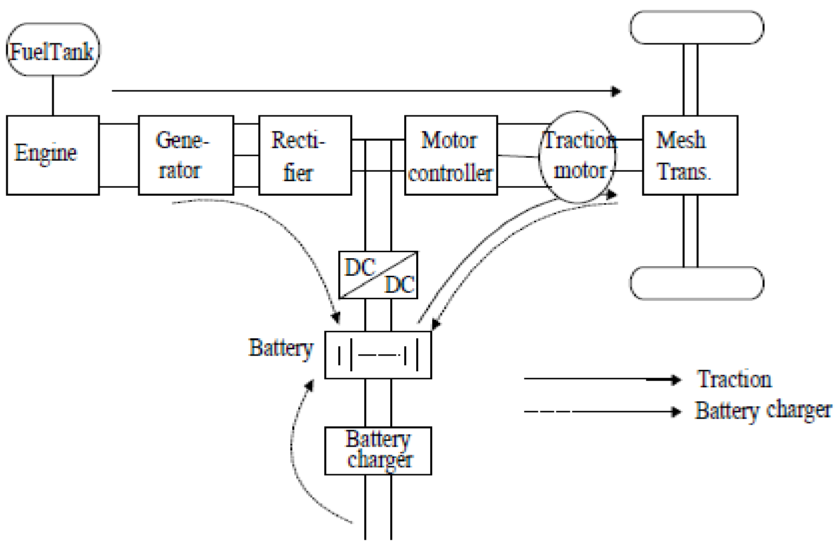

Fig.1. Series hybrid Drive Train employing a bidirectional DC-DC converter

For example power generated by Wind and Solar power plants with large ups and downs because energy supply by primary source to conversion unit (Wind turbines and PV panels) is uncertain. With large ups and downs it cannot be considered alone for power supply and always supported by secondary source like chargeable batteries or super capacitors. These secondary sources supply power whenever energy deficit and charge itself when system power is surplus. So now the bidirectional DC-DC converter function comes into play to allow power flow in both directions. 1Similarly in EV's, bidirectional DC-DC converter is used to link up energy storage system (battery or fuel cell with super capacitor) with DC bus as shown in Fig 1. Here they are used to regulate power supply to motor drive according to traction power demand.

2. CLASSIFICATION OF CONVERTER

Basically unidirectional DC-DC converter with bidirectional conducting switches used to derive the non-isolated bidirectional DC-DC converter. Basic Buck and boost converter circuit (Fig 2) consist of diode which doesn't allow bidirectional power flow. Problem will be solved when MOSFET or an IGBT having anti- parallel diode across them forms a bidirectional switch and allow bidirectional conduction.

BUCK CONVERTER

The first bidirectional topology is derived from conventional buck boost topology with implementation of bidirectional conducting switches as shown in Fig 2. During step up operation Q2 remains switch off all the time and Q1 remains switch on at required duty cycle.

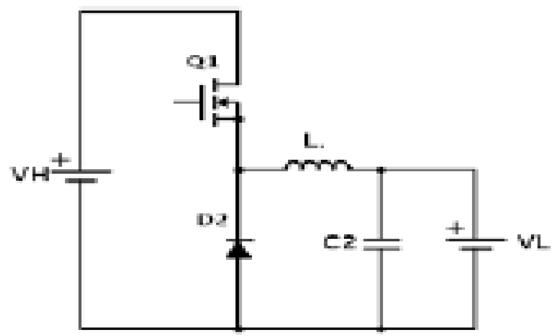

Fig.2.Buck converter

Similarly during step down operation Q1 remains switch off all the time and Q2 remains switch on at required duty cycle. To avoid cross conduction through switches and converter output capacitance, small dead time is provided during mode transitions.

BOOST CONVERTER

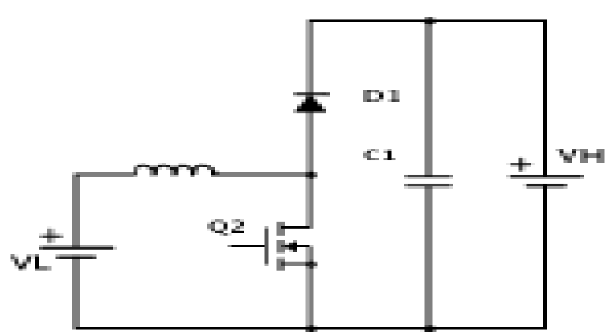

Fig.3.Boost converter

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The buck boost cascade converter can be obtained by cascading bidirectional boost converter with bidirectional buck converter . The switch combination and current direction in this topology allows output voltage to be higher or lower than the input voltage.conducting depending upon duty cycle. During forward step down operation switches S2, S3, S4 are always off whereas S1 is operated with required duty cycle. Diode D3 always remains forward biased whereas Diode D2 and D3 are always reverse biased. Diode D4 acts as freewheeling diode. During backward step up operation S4 is operated with required duty cycle and S3 is always on with diode D1 acting as freewheeling diode.

3. RESULT ANSLYSIS

If the converter circuit does not have any auxiliary components , then the switches operates under hard switching operation and this leads to the considerable amount of the power loss and high electrical stress within the switches during turn on and turn off condition because of very large values of the current and voltage simultaneously across it.

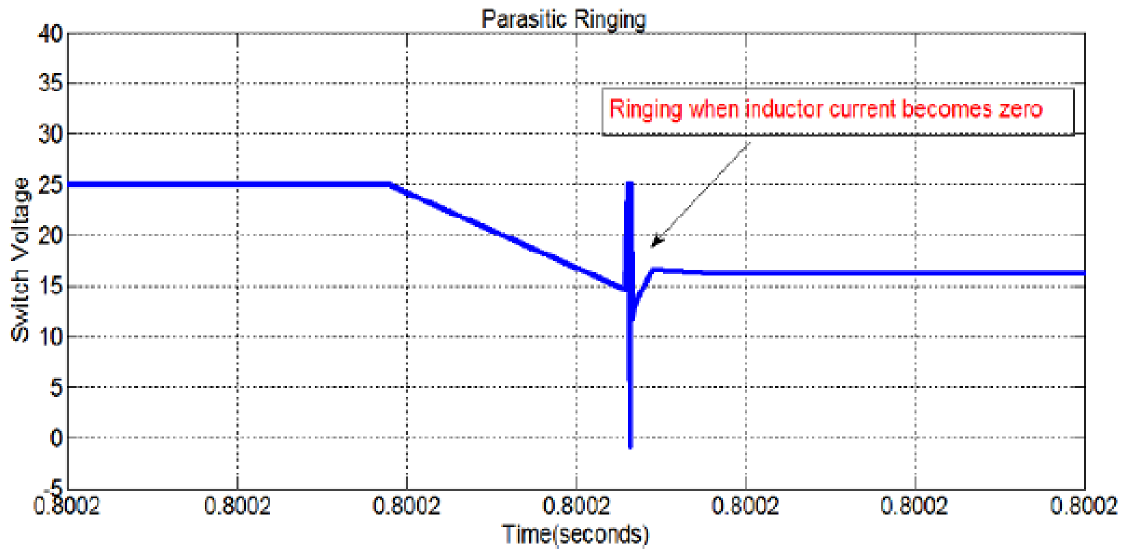

Fig.4.Motor speed

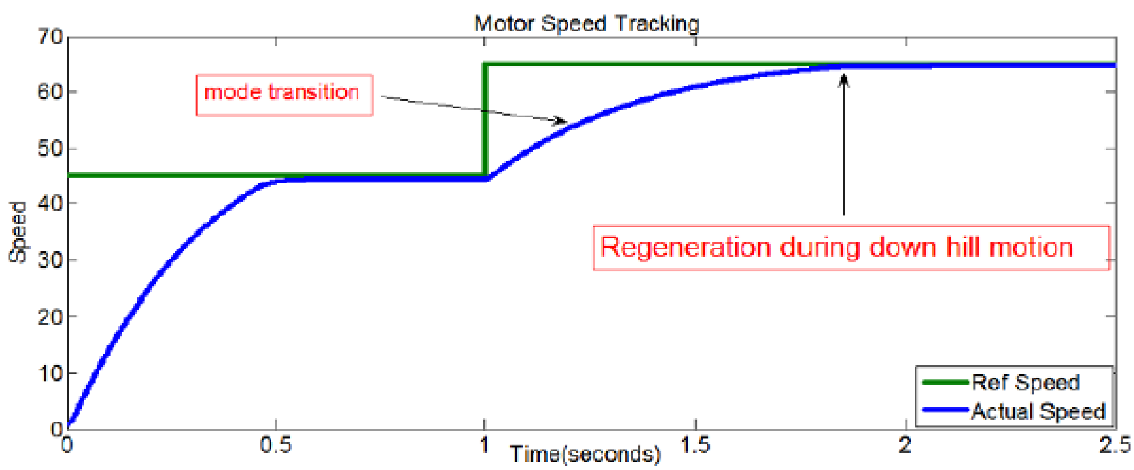

Fig.5.Waveform

Generally in all the converters operating under hard switching conditions and particularly in the high power converters, switching losses puts the major limitation on the increase of the switching frequency which is desired for the reduction in components values and hence the size cost and the compactness of the converter. Therefore a compromise is made with the value of the switching frequency in the practically acceptable range so as to achieve the high efficiency in the converter and at the same time to and limit its cost. The reduction in the value of the switching frequency increases the size of the passive components such as the capacitors, inductors, transformers etc and makes the DC DC converter heavier and bulky. Soft switching techniques when employed for the power converters, helps in increasing energy conversion efficiency , shifts up the upper limit for increasing switching frequency and thereby the reduction in the size ,weight and the cost of the passive components as well as the reduction of the electrical and thermal stresses along the switching devices and the EMI reduction during switching. Closed loop Simulation of the Bidirectional Converter fed PMDC Motor with the designed values was done in the Matlab Simulink. The simulation results were found satisfactory and as expected.

CONCLUSION

Since the structure of isolated bidirectional DC-DC converter is more complex, bulky, costlier due to presence of transformer and its overall efficiency is also less than non-isolated bidirectional DC-DC converter it is unfit for EV application. Therefore Non-Isolated Half Bridge Bidirectional DC-DC converter can be the most preferred option for EV drive train application.

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