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Comparison of Isolated and Non-Isolated Bidirectional DC-DC Converter Fed PMDC Motor

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Abstract-This paper includes designing and implementation of a bidirectional DC-DC converter which is fed from permanent magnet DC motor which can also be used as traction system for hybrid electrical vehicle system. The major problem of HEV is the battery storage system, in order to overcome this we are using bidirectional converter; this improves the overall efficiency of HEV bidirectional converter works in either direction i.e. in regenerative mode or in motoring mode. In motoring mode the converter works as the boost converter, thus the voltage will be boosted, current will be less, the copper losses are negligible and efficiency of the system is more. In regenerating mode the system act as buck converter, in this mode the battery gets charged. And thus the efficiency of the system is high. In order to reduce the switching losses the ZVRT technique is used. Hybrid vehicle includes the benefits of engine, electric motor and batteries in order to provide fuel improvement economy. The necessity of converter in this for charging and discharging of batteries so the process of combining the charging and discharging in one circuit topology is known as bidirectional dc-dc converters.
Key words: Bidirectional converters, buck converter, boost converter, PMDC motor, Hybrid electric vehicle

I. INTRODUCTION

The voltage level of the electrical storage system can be increased by using the bidirectional DC-DC converters, thus results in decrease in current and losses. It promotes the improvement in conversion of power by providing the path for regenerative mode. This bidirectional DC-DC converter changes the energy transformation in HEV drive train. Half bridge non isolated bidirectional DC-DC converter has lower stress, less loss, it requiresless number of components contrasted with the bidirectional cascade BUCK-BOOST and CUK converters. Simultaneously half bridge non isolated bidirectional DC-DC converters are widely used. As we know that motoring converter operated at boost mode and regenerative converter at buck mode. For both stepping up and stepping down voltage bidirectional dc-dc converters are used. Where the output needs to be completely isolated from the input, isolated converters are employed. For high power applications, full bridge topology is used.[1].

II. BIDIRECTIONAL DC-DC CONVERTERS

Bidirectional DC-DC converters are used for both stepping up & stepping down the voltage level between its input and output and also on capability of power flow in both the directions. In Hybrid vehicles, renewable energy storage systems, uninterrupted power supplies applications bidirectional DC-DC converters are used. And for speed control and regenerative braking of motor drives they are traditionally used. There will be large fluctuations in the power generated by the wind or solar energy systems is caused due to the large variations and uncertainty of energy supply to conversion unit by the primary source. These systems are supported by auxiliary sources such as recharge batteries units or super capacitors as there will be a large fluctuations and thus these systems are always backed up. Therefore bidirectional DC-DC converters are needed to allow the power flow in both the directions at regulated level.

Hence HEV's, bidirectional DC-DC converters are employed to provide a link betweenhigh voltage DC bus to the hybrid vehicle system. Here they are used to regulate the power supply to motor drive to assist the traction power demanded.

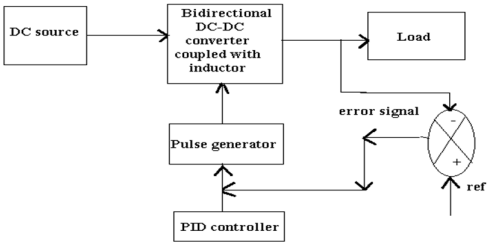


fig 1 Block diagram of bidirectional dc-dc converter

Fig shows the block diagram of PID controller based bidirectional dc-dc converter. The dc supply is used as a input to this converter. The output is given to the load. The output of this taken and is compared with reference signal by using comparator. The reference signal is previously set value. The error signal is the difference between output signal and reference signal then it is given as input for PID controller depending upon the duty cycle of the pulse generator the PID controller will be controlled. Finally we are getting high output voltage.[2].

A. The need of bidirectional DC-DC converter in HEV

1) In this operating system, the power high voltage is low which makes the current to increase rapidly which results in high electrical and thermal stresses and also it increases the ohmic losses and hence efficiency will decreased.
2) The stress depends on the ratio of output to input, the variation in the input voltage increases the components ratings which are used.
3) The wide variation in the input voltage. May cause further increase in the voltage and current stresses.
4) Due to above 2 factor, component may cause EMI emission is order to avoid the proper shielding in provided. These factor makes the converter packaging bulky, heavy and expensive, in order to overcome this problem efficient DC-DC converter are used.
5) Bidirectional power flow in required to recharge the electricalenergy system during regenerative braking.[4].

B. Applications of bidirectional DC-DC converter in HEV are

1) High efficiency
2) Light in weight and compact ripple
3) Lower input and output current ripple
4) Lower electromagnetic interference

III. CLASSIFICATION OF BIDIRECTIONAL DC-DC CONVERTER

A. Non isolated bidirectional DC-DC converter

The basic DC-DC converter such as a buck and boost converter have bidirectional power flow capability; this is due to the presence of diode which prevents the reverse current flow. Bidirectional DC-DC converter derived from unidirectional converter by replacing the diode with the controllable switch due to the presence of diode in the buck-boost converter, they don't have property of bidirectional flow. This can be removed by using power MOSFET or IGBT connected anti parallel diode across them to form a bidirectional switch. This allows the current in both directions for bidirectional power flow accordance with controlled switching operation.

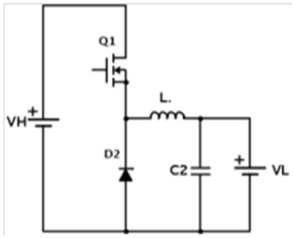
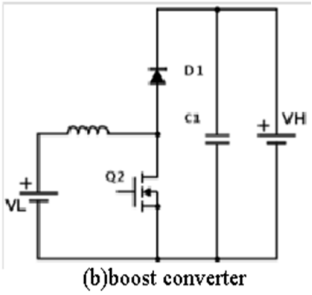


Fig 2.2 (a)Buck converter



(b)boost converter

B. Bidirectional buck-boost converter

Half bridge non isolated bidirectional DC-DC converter fed PMDC motor as shown in fig. Here boost mode is for motoring and buck mode for regenerative. Low voltage battery pack is installed on both side and on the other side PMDC motor is installed in order to limit the speed. It contains high frequency capacitor on motor side as the energy buffer and on the battery side smoothening capacitors are used.

During step up switch Q1 is conducting at the required duty cycle while Q2 is remains in off condition at all the time. Similarly during step down operation Q2 is conductive at required

Duty cycles where as Q1 is remains in off condition. in order to avoid cross conductance through two switches and converter output capacitance is controlled by providing small dead time during transitions mode.[3].

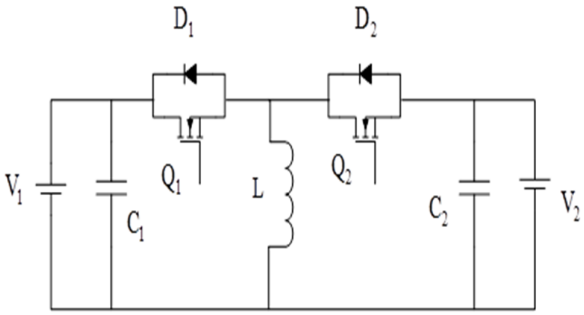


Fig 2.3 bidirectional DC-DC converters

Mode operation	Device activated
Buck	Q2,D1
Boost	Q1,D2

Buck-boost mode of operation

IV. CONVERTER OPERATIONS

A. Continuous conduction mode

A large valued filter inductor is required forcontinuous conduction mode of a bidirectional DC-DC converter. As the use of large valued inductor, mode transitioning and transient response will goes on decreasing.

B. Discontinuous conduction mode

In this case, the inductor value is less as compare to continuous conduction mode so that the response becomes faster this result in increasing power density. This operation allows zero turn on losses and thus low reverse recovery loss in diode[1]..

Advantages of NBDC

1) Structure is symmetrical.
2) Low ripple current on both side.

3) It has protection against short-circuit.

Limitations

1) It can only operate in buck mode in one direction and boost in another mode.
2) Structure becomes impractical, when the voltage ratio more.
3) Galvanic isolation is less between two sides.

C. Isolated bidirectional DC-DC converter

Most of IBDC have the same structure is as shown in fig. this structure consist of two high frequency switching DC-AC converter and high frequency transformer are primarily used to maintain the galvanic isolation between two sources. The transformers are used to match the voltage between different stages for the proper design and optimization of different stages. The galvanic isolation and voltage matching is obtained by using the transformer in a power electronic circuitry this provides ac link energy transformer basically most of the IBDC are the structure as shown in fig. in order to convert dc input to high frequency ac quantities. The system requires two switching dc-ac converter of high frequency. The transformer voltage matching between the source and load side thus the voltage ratio between them is very high therefore transformer with ac quantities. Hence DC-AC converters are required at both the temperature. Hence the system transfer the energy in both the directions this converter are similarly to the non isolated bidirectional DC-DC converter works in two modes i.e. in buck or boost.

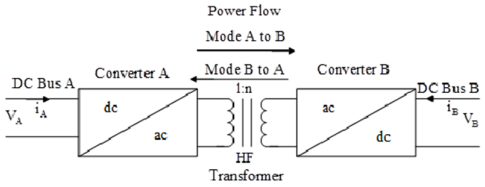


Fig 2.4 Basic structure of isolated bidirectional DC-DC converter

Advantages of IBDC

1) Current stresses of switches on both sides are equal.
2) For soft switching, there is no need of active or passive elements.
3) Transformer has simple structure that simplifies the designing and maintenance task.
4) Due to lack of additional passive elements, there will be fastdynamic behavior is another important feature.
5) This method includes average current mode controlor peak current mode control.

Limitations

1) The converter may lose soft switching in light load condition.
2) The currents flowing in dc buses contain high ripple content, this demands appropriate filtering circuits which makes the circuit complicated.
3) This control is sensitive to slight variation of flux, especially when bus voltages are high.

D. Bidirectional DC-DC converter fed PMDC motor

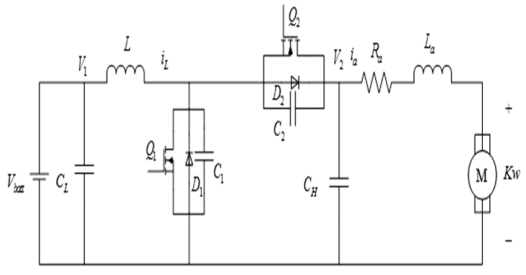


Fig 2.5 Bidirectional DC DC converter fed PMDC motor

Soft switching bidirectional dc-dc converter fed PMDC motor is as shown in fig. this converter is operated in boost mode for

forward motoring and in buck mode for regenerative braking of the PMDC motor. Battery pack is placed on the low voltage side and PMDC motor is placed on another side in order to control the speed. It contains the energy buffer of high frequency capacitor on motor side and on the battery side smoothening capacitors are installed.[5].

E. Comparison of isolated and non isolated bidirectional dc-dc converter

1) Isolated converters uses transformer for energy storage while other use separate inductor
2) There is isolation between input and output.
3) The input range for isolated converter is 5-600V.
4) This converter uses high frequency transformer.
5) Battery can withstand from few hundred volts to several hundred volts for medical applications.
6) The outputs of the isolated are either positive or negative.
7) Non isolated converters uses single inductor for energy storage hence these are simple in design.
8) Power limit ranges from less or equal to 42.4V peak 160V DC, 250VA.
9) There is no isolation between input and output.
10) Output voltage depends on input voltage which is also depends on user applications.
11) Low cost and simple in design.[4].

V. CONCLUSIONS

Bidirectional dc-dc converters are widely used converters; there will be increasing need of systems with the capability of bidirectional energy transfer between two buses and are used in dc motor drives, new applications of BDC includes energy storage in renewable energy systems, fuel cell energy systems, HEV and uninterrupted power supplies. The performance of hybrid vehicle system gives satisfactory results at different driving condition. For this electric drive, the proposed control technique with PI controller is suitable.

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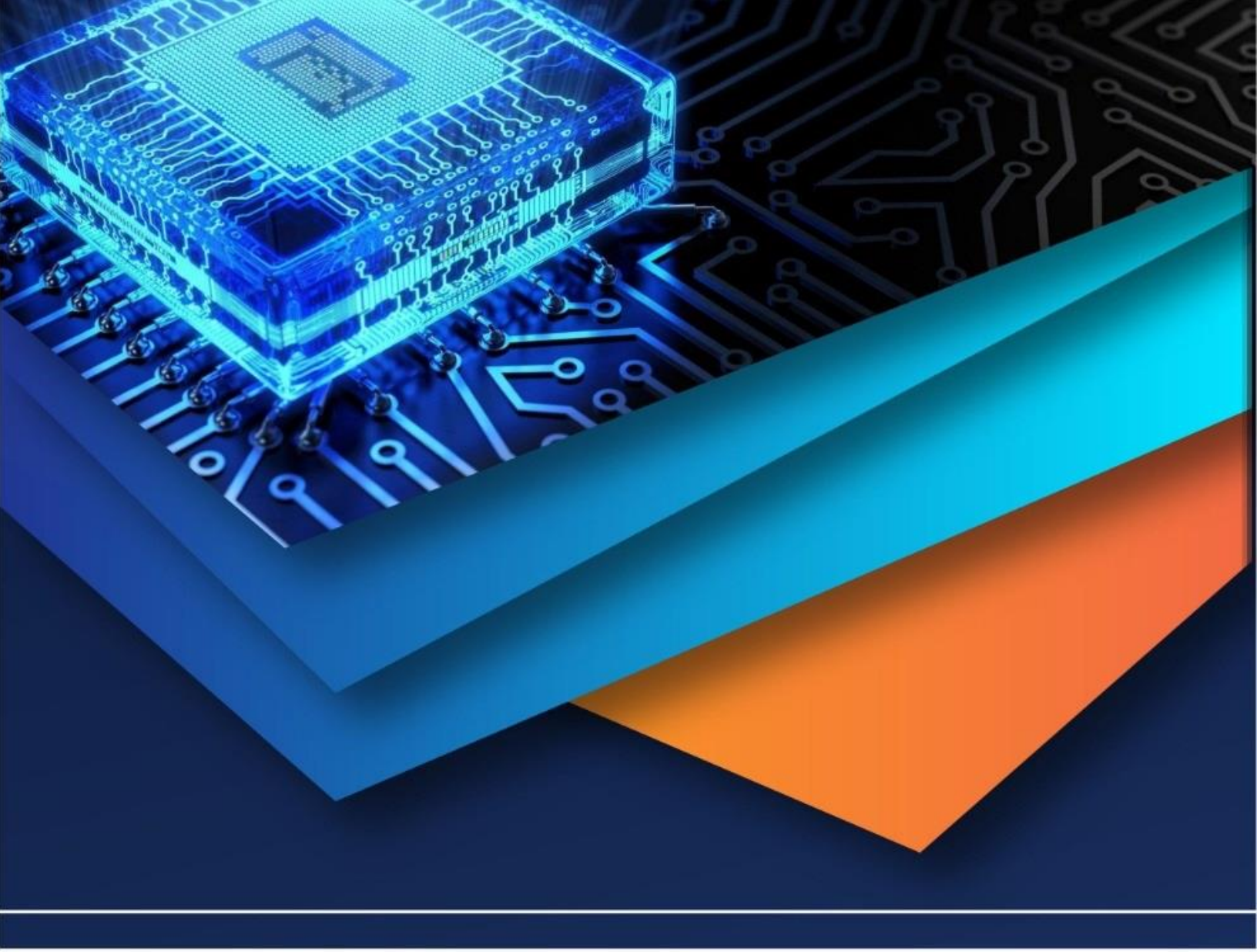

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