IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
Research Paper , **Journal Volume 11, Iss 07, 2022**

EXPLORING THE LITERATURE: BIDIRECTIONAL DC TO DC CONVERTERS

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ABSTRACT:

This research compares and contrasts the present practices with a bidirectional DC-to-DC converter. The suggested converter was designed from the ground up to work with closed-loop regulation. It is possible to get high output voltage and amplification by using a controller to adjust the duty cycle of switches. A buck-boost circuit, which acts as a buck circuit during charging and as a boost circuit during discharging, is used to construct the DC/DC converter. This allows us to utilize a variety of power-related technologies that improve efficiency, lessen losses, and boost performance.

Keywords: Bi-directional dc-dc converter, DC motor, Battery, Photovoltaic system, Controller .

1. INTRODUCTION

Bidirectional power transmission is not possible with DC-DC converters like buck and boost converters (and its variants). This limitation is due to the incorporation of diodes into their design, which impedes the flow of reverse current. To convert a unidirectional dc-dc converter into a bidirectional one, just swap out the diodes for a programmable switch.

When coupled with energy storage, the bidirectional dc-dc converter has emerged as a viable option for numerous power-related applications, such as hybrid cars, fuel cell vehicles, and renewable energy systems. It enhances system performance while cutting expenses and increasing efficiency.

In the context of electric vehicles, the regenerated energy returned by the electric machine is stored in a secondary energy storage battery. When starting the car, speeding up, or going uphill, the high-voltage bus's voltage needs to be amplified, hence a bidirectional dc-dc converter is required. The ability to switch the direction of current flow, and hence power, makes bidirectional dc-dc converters increasingly popular for power transmission between two dc power sources.

The multi-input bidirectional dc-dc converter can be used to combine numerous renewable energy sources into a single system. Benefits of this bidirectional dc-dc converter include galvanic isolation between the load and fuel cell, bidirectional power flow, matching multiple voltage levels, fast response to transient load demand, and more.

Recently, solar panels and wind turbines have become commonplace among renewable electric power generation technologies. When the voltage from the dc bus is not sufficient to power the load, a bidirectional dc-dc converter is used to move energy from the solar collectors to the capacitive energy source.

The circuit arrangement depicted in Figure 1 is used in the vast majority of modern bidirectional dc-dc converters. 1. marked by a specific amount of voltage or current being applied to one side. The location of the supplementary energy storage determines the type of bidirectional dc-dc converter. Energy is stored on the high voltage side in the buck design, and on the low voltage side in the boost configuration. The switch cell in bidirectional dc-dc converters must be able to

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transport current in both directions if the device is to enable bidirectional power transfer. Due to the impossibility of creating a power switch that allows current to flow in both directions, diodes are frequently employed in conjunction with unidirectional semiconductor power switches such power MOSFETs and IGBTs. Figure 1.2 depicts a double-sided current switch cell that can be used in place of the switch and diode in buck and boost DC-DC converters to enable bidirectional power flow.

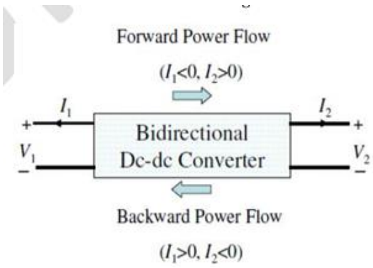

Figure 1 Illustration of bidirectional power flow

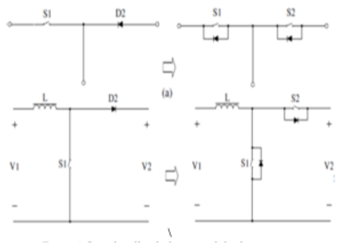

Figure.2 Switch cell in bidirectional dc-dc converter

Non-isolated converters and isolated converters are the two main types of converters. Each category is designed to address a unique set of operational requirements.

Non-isolated Bidirectional DC-DC Converters

If a power conversion system doesn't include a transformer or isolation, it will likely use a boost or buck DC-DC converter. The source and discharge sides can be kept completely isolated using a high frequency transformer-based method. In terms of efficiency, size, weight, and cost, the transformer-free variety is much preferred. Transformer-free alternatives are preferable where size and weight are critical, such as in high-power or spaceship power systems.

When compared to isolated buck-boost DC-DC converters (IBDC), non-isolated NBDCs are simpler and more efficient. The transformer-free version is favored for uses that demand a lot of power. The current high power density bidirectional dc-dc converter has been improved with the development of a low inductance multiphase current interleaving approach for high power applications.

The NBDC's operation is shown in Figure 1. 1.1.1. Here it is laid out for your perusal. In this converter, the inductor is responsible for the bulk of the energy transmission. Ton=DT, where T=1/fsw is the switching period and D is the duty cycle, describes the amount of time that the charging process takes place via the active switch on the source side during each switching cycle. This power is transferred to the load when Toff is set to (1-D)T. Similar to the four-switch buck boost converter's (Figure 1.1.2) operational principle. While Q2 and Q3 are used for right-to-left power transmission, Q1 and Q4 are the active switches for left-to-right power. Synchronous rectification technology is used in this configuration to improve overall efficiency and allow for the inclusion of new features.

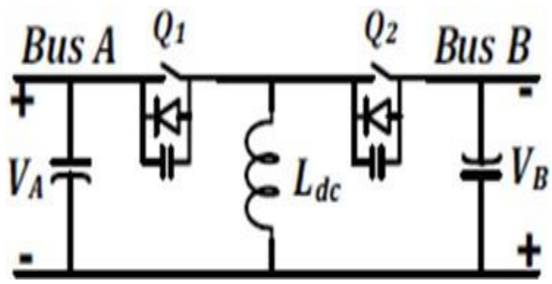

Figure 3 Bidirectional buck-boosts

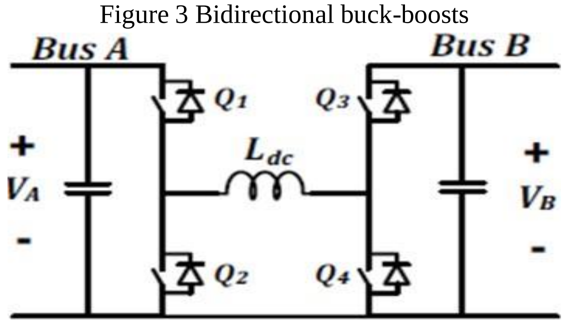

Figure 4 two back-to-back connected NBDC

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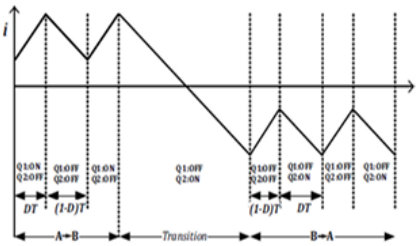

Figure5. Operating waveforms

Isolated Bidirectional DC-DC Converters

In complex systems with multiple inputs and outputs, galvanic isolation is required to meet regulatory standards. Protecting workers, lowering decibel levels, and keeping protection equipment running smoothly are the primary goals of galvanic isolation.

Several uses call for voltage matching to facilitate the efficient design and optimization of the voltage rating for various stages of a system. In power electronic systems that require an alternating current connection for efficient energy transmission, a magnetic transformer is typically used to provide both galvanic isolation and voltage matching.

In bidirectional dc-dc converters, isolation is typically provided via a transformer. Adding a second transformer increases expenses and decreases efficiency. In contrast, a transformer is a good option since it may isolate the two voltage sources and help with the impedance matching. To function as a current source, a conductor requires inductance. Many variations on the full-bridge, half-bridge, and push-pull topologies can be found in isolated bidirectional dc-dc converters. A high frequency isolation transformer half-bridge and a current-fed push-pull are used in one type of isolated bidirectional dc-dc converter. The battery gets charged whenever there's a direct current (dc) bus nearby, and it takes over completely if there isn't one. The circuits that charge and discharge direct current (DC) UPS batteries can benefit greatly from this converter. The advantages of this converter design include galvanic isolation between the two DC sources via a single transformer, a small number of components, and the reusability of the power components for bidirectional power transfer.

A voltage-fed bridge is used on both sides of the isolation transformer in the dc-dc converter's dual active bridge design. Power is transmitted and stored via the transformer's leakage inductance, allowing current to flow in both directions.

IBDC structure

Almost without exception, medium-power IBDCs look like the one depicted in Figure. In order to provide galvanic isolation between the two power sources, a high-frequency transformer and two high-frequency bidirectional DC-AC converters are utilized here. This transformer is used to align voltages between two sources when there is a large gap in voltage between them. The terminals of the transformer are supplied with alternating current by DC-to-AC converters located on both ends of the device. The system's need for bidirectional energy transmission necessitates that each dc-to-ac converter be capable of such transfer in both directions. Equally important is the fact that the dc buses used in this setup can generate or use power.

A low value for the Thevenin impedance indicates that the dc buses displayed here exhibit stiff-voltage characteristics. These buses are in fact connected to a battery, ultracapacitor, or dc-link capacitor, which supplies direct current or an active load. These generators are modeled after a theoretical voltage source with constant output. The converters depicted in Figure 1.2.1 for renewable power generation are expected to incorporate the essential components to maintain a stable current, resulting in decreased fuel (electrical) expenses..

2. LITERATURE SURVEY

The use of a bidirectional DC-DC converter in a hybrid electric vehicle (HEV) was studied by Hua Bai et al. This high-capacity DC-DC converter joins a low-voltage high-voltage (HV) battery to a DC bus operating at high voltage. A normal battery cell has a voltage between 300 and 400 volts. For optimal performance of a motor and inverter, a voltage range of around 600 volts is

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recommended. The voltages of the battery and the motor can be matched thanks to this converter. This DC-DC converter's other jobs include improving the power train's efficiency, reducing battery current variations, and keeping the DC link's voltage stable, all of which make it possible to run a high-capacity power train.

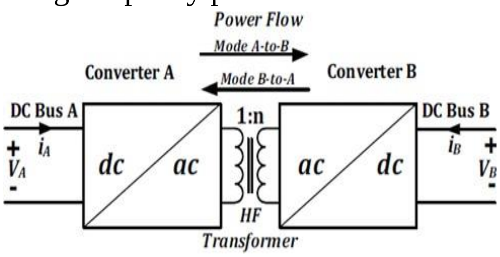

Figure 6 Basic structure of an IBDC

in terms of the Figure. One of the most important characteristics of an IBDC is the type of converters used on both ends. Switching converters can be split into two distinct categories. Common examples of current-type (or current-fed) structures are boost converters, which use an inductor with a constant current characteristic at its terminals to provide the input circuit with current. To mimic the input terminals of a standard buck converter, a voltage-fed arrangement uses a capacitor with a set voltage characteristic at its terminals.

Applications

Nearly 62% of the crude oil consumed today in the United States is refined into gasoline. This fuel is mostly employed in the transportation sector. Consistent energy production and lower carbon emissions are two challenges that are generally acknowledged. Hybrid electric vehicles (HEVs) provide a practical solution to these issues by boosting fuel efficiency by optimizing ICE performance, recapturing energy lost while braking, and turning off the ICE when the vehicle is idling. Plug-in hybrid electric vehicles (PHEVs) are defined as follows by the IEEE-USA Energy Policy Committee: (1) PHEVs have a battery storage system with a capacity of 4kWh or greater that is used to propel the vehicle; (2) PHEVs can recharge their battery system from an external source of electricity; (3) PHEVs can also charge their battery system from an external source of electricity. Plug-in hybrid electric vehicles (PHEVs) are becoming increasingly popular since there are now over a million HEVs on the road.

ability to travel at least 10 miles on electric power alone (i.e., without needing any gasoline). Multiple energy sources, including novel and emerging technologies, can power plug-in hybrid electric vehicles (PHEVs).

R.Goutham Govind Raju et al.,

A zero voltage switching (ZVS) bidirectional isolated DC-DC converter was developed. This is used in fuel cell cars, electric vehicle propulsion systems, and power generation, all of which require a high power density. Power semiconductor devices (such MOSFET and IGBT) and their packaging, as well as the integration of the complete system, have a significant impact on the performance of standalone DC/DC converters in hybrid and fuel cell vehicles.

Young-Joo Lee et al.,,

This study presents a novel integrated converter that incorporates an ac/dc charger and a dc/dc converter into a single circuit. The PHEV and hybrid/plug-in hybrid conversions are optimized for usage with the integrated converter. The integrated converter can function as an ac/dc battery charger in addition to facilitating energy transfer between the battery pack and the electric traction system's high-voltage bus.

Lisheng Shi et al.,

Bidirectional ac-to-dc converters for PHEVs were defined, along with the necessary criteria and factors for their construction. Plug-in hybrid electric vehicles (PHEVs) typically use either a standalone configuration or a combination design where the inverter is used for the drive motor. Both converter topologies are evaluated, and their relative merits are carefully analyzed. Because of its potential to significantly reduce PHEVs' price, size, and weight, combination topology analysis has been given a lot of attention.

Tanmoy Bhattacharya et al.,

High amplification, wide load variations, reduced

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output current fluctuations, and the flexibility to use parallel battery energy are all properties of the proposed modular structure that imply a topology that can manage several power sources while keeping simplicity. This technique makes use of winding the transformer in such a way that the leakage inductance of the associated inductor is drastically reduced.

João Silvestre et al.,

For a small electric car, a bidirectional DC-DC converter was developed. The built and tested DC-DC converter can increase the nominal voltage (96V) of the battery pack to the required 600V for operating the Variable Frequency Drive that regulates the induction motor. This converter can be operated in reverse (from 600V to 96V) to harvest kinetic energy during coasting and downhill driving.

Hyun-Wook Seong et al.,

This article describes boost integrated technique (BIT) and light-load frequency modulation (LLFM) controlled high step-up non-isolated DC-DC converters. A parallel input, series output (PISO) design is proposed for the ZVS BIT, which incorporates a bidirectional boost converter and a series output module. **Zhe Zhang et al.,**

For the fuel cell hybrid energy system, a bidirectional isolated DC-DC converter is developed, with phase shift and duty cycle controls. Incorporating two high frequency transformers that combine a half-bridge circuit and a full-bridge circuit on the primary side, as proposed, reduces the number of switches and gate driver elements required.

Problem formulation

Most modern bidirectional dc-dc converters use a standard circuit design in which one terminal provides either current or voltage.

A bidirectional DC-DC converter provided the energy for the DC motor's drive. This architecture's boost converter capacity is realized via modulation of Q2 and use of the anti-parallel diode D1 as the boost-mode diode. By modulating Q1, the topology functions as a buck converter when the power flow direction is reversed, with the antiparallel diode D2 playing the role of the buck converter's diode. It's worth noting that the inductor current directions are different for the two modes. To facilitate both motor drive and regenerative braking, a novel control model is developed employing a state-of-the-art controller. This model used a Lithium-ion battery to test the motor's performance in driving and regeneration modes. This controller efficiently carries out multiple speed-related instructions, resulting in desirable consequences.

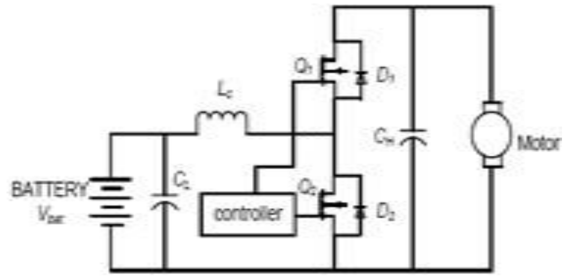

Figure 7 Bidirectional dc-dc converters with battery and dc motor

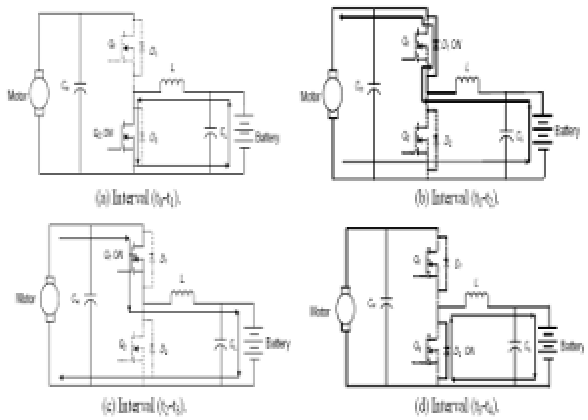

Figure 8 Converter operating modes.

3. CIRCUIT DESCRIPTION

As shown in Figure 1, a dc-dc converter can be employed for both forward propulsion and regenerative braking of a dc motor in continuous conduction mode. To keep the converter in a steady condition, Q1 and Q2 MOSFETs are switched back and forth. To do this, we break the process into four intervals: the first (t0-t1), the second (t1-t2), the third (t2-t3), and the fourth (t3-t4). Keep in mind that V1 represents the low voltage side of the battery, while V2 represents the high voltage side of the load. The gate actuators in charge of operating the Q1 and Q2 switches are shown in Figure 3. In the following paragraphs, we will discuss the many times that the circuit was in continuous operation.

As shown in Figure 2(a), at time t0, the upper switch Q1 is OFF and the bottom switch Q2 is ON. During this period, the converter operates in boost mode, increasing the current through the inductor by supplying additional energy.

Both Q1 and Q2 are turned off for the time period 2(t1-t2). Figure 2(b) depicts the upper switch Q1 in its conducting condition, where the body diode D1 is conducting. The converter's output voltage is sent into the motor. This converter can boost battery voltage sufficiently to power the forward motor because it operates in boost mode.

At time t3, during period 3 (t2-t3), the upper switch Q1 is turned on while the lower switch Q2 is turned off. Figure 2(c) illustrates this point. In addition, diodes D1 and D2 are biased in the opposite direction. The converter operates in buck mode during this time.

During the fourth time period (t3-t4), both Q1 and Q2 valves are in their closed positions. The bottom switch Q2's body diode D2 begins conducting, as seen in Figure 2(d).

The input supply voltage and output voltage requirements are calculated by the bidirectional converter in order to propel the electric vehicle at the desired speed. To regulate the DC motor's current, the converter's power architecture employs a half bridge circuit.

4. OBJECTIVE

When coupled with energy storage, the bidirectional dc-dc converter has emerged as a viable option for a wide range of power-related applications, such as hybrid automobiles, fuel cell vehicles, renewable energy systems, and industrial settings. A closed-loop control system was considered during the design phase of the proposed converter. When compared to open loop control, closed loop control is far more effective. With a modern controller, we can adjust the switches' duty cycles to boost the output voltage and gain significantly. This results in lower levels of switching current, output frequency, and voltage. The valves' useful life can be significantly extended if heat loss is kept to a minimum. It improves efficiency and productivity while decreasing expenses.

- concerning the framework.
- In order to increase the amount of energy that can be stored by renewable energy sources.
- Construct an electric car using solar panels, a bidirectional converter, batteries, and other components.
- The goal is to reliably and cheaply generate electricity for use in an electric vehicle.
- Optimal duty cycle management control selection requires
- For an electric car to go great distances without needing to recharge at a charging station.
- This method reduces energy waste while facilitating the creation of a pollution-free setting.

5. METHODOLOGY

The following procedures must be carried out in order to create a Bidirectional converter for use in renewable energy systems. Make a thorough circuit schematic that includes a list of all parts and where to get them. Acquiring, inspecting, and storing parts. Building the breadboard prototype from the schematic and evaluating its performance. Layout, interconnection diagram (which is derived from the circuit diagram), machining specifications, and laminate cutting to exact dimensions are all generated. Making holes in the board and coloring the board's tracks in accordance with the components' placement and connection layouts. Eliminating unnecessary copper from the track area by etching the circuit board. To prevent the copper tracks from rusting or oxidizing due to moisture, you should first wash the circuit board in water and then solder them. Complete equipment integration, component integration, and testing. Making ready for a show-and-tell presentation.

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