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AN027
Brief description of bidirectionality in DC Converters and common applications

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Application Note - AN027

Bidirectional DC/DC Converters

Unidirectional DC/DC converters have traditionally been used to adapt voltage levels and supply low power devices (PLC, control boards, relays, peripherals...) from different voltage sources. As their name implies, the energy flow is unidirectional allowing the energy to flow from the power source to the load and not from the load to the power source.

When the power source and the load can supply and absorb energy the energy flow can happen in both directions and a bidirectional DC/DC converter should be found in between. With the development in the battery and energy storage field in the last decades and their use in an increasing amount of applications, such converters have been gaining more interest.

There are two main groups of DC/DC converters, isolated and non-isolated. The non-isolated, traditional main topologies such as buck or boost (and their derivatives) do not have bidirectional power flow capability. This limitation is caused by the presence of diodes in the topology that prevent reverse current flow, but in general these diodes can be replaced by switching devices to transform them into bidirectional converters as depicted in Fig. 1.

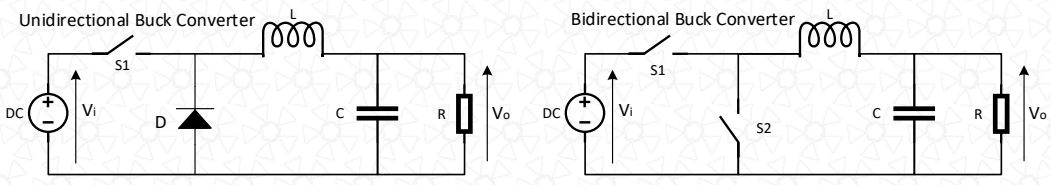

Fig. 1: Unidirectional and bidirectional non-isolated DC/DC Buck Converter

Isolated converters normally show a configuration that holds a high-frequency transformer between one side and the other. Each side of the transformer can be considered as an individual converter since they include independently controlled switching devices. There are different control strategies and topologies in the isolated converters currently on the market but all of them can be represented with the Fig. 2.

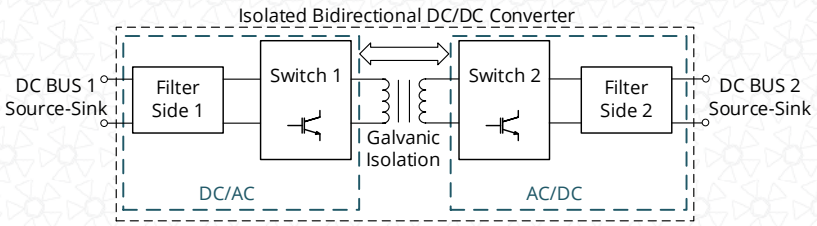

Fig. 2: General schematic isolated DC/DC converter

epic power designs and manufactures bidirectional non-isolated and isolated converters for different industrial markets. In recent years, the company has specialized in applications involving batteries, supercapacitors, and DC buses mainly in the market of elevation, intralogistics and microgrids. In such applications, epic power converters can work autonomously or commanded by an external controller.

Model	EPC 3k5 648i	EPC 5k5 648i	EPC 2k2 624i	EPC 2k2 348i	EPC 2k2 324i	EPC 4k8 6125i	EPC 8k 8380i
Peak power	4.2 kW	6.5 kW	2.6 kW	2.6 kW	2.6 kW	4.8 kW	10kW
Nominal power	3.5 kW	5.5 kW	2.2 kW	2.2 kW	2.2 kW	4.8 kW	8kW
High side voltage	510 to 848 Vdc			280 to 450 Vdc		430 to 830 Vdc	650 to-800Vdc
High side current (max)	6 A (7.5 A)	10 A (12 A)	4 A (5 A)	7 A (9.3 A)	7 A (9.3 A)	9 A	11 A (16 A)
Low side voltage	38 to 59 Vdc		19 to 30 Vdc	38 to 59 Vdc	19 to 30 Vdc	110 to 165 Vdc	280 to 600 Vdc
Low side current (max)	75 A (115 A)	115 A (180 A)	92 A (140 A)	50 A (70 A)	92 A (140 A)	40 A	21 A (33 A)

Fig. 3:Some of most popular epic power bidirectional isolated DC/DC converters

One of the most common autonomous applications can be found in the lift market where the ERS 2G product, including a bidirectional DC/DC converter and supercapacitors, monitors the DC link of the VF drive to absorb or provide energy. By doing so, it is possible to save and use all the braking energy that is normally wasted.

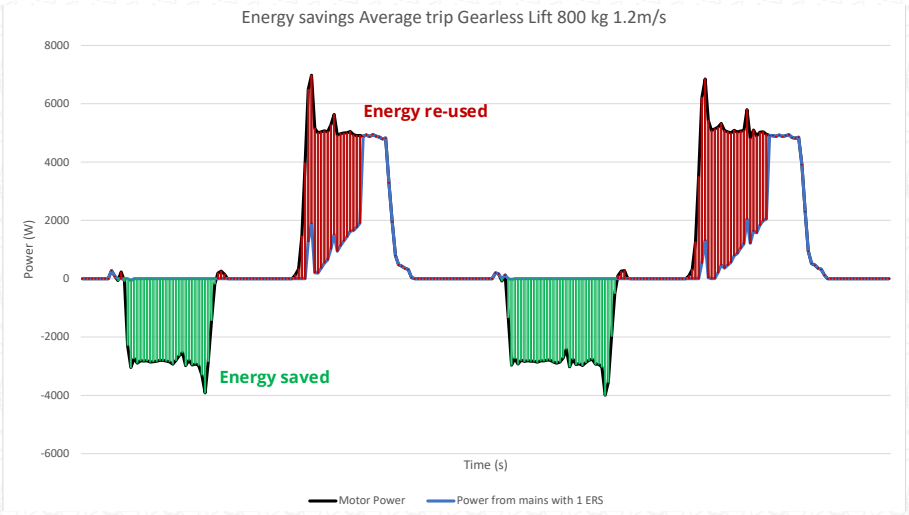

Fig. 4: Energy saved or re-used in lift application by monitoring the VFD/VVVF DC bus

One market that combines both autonomous and commanded operation of the converters is intralogistics. Shuttles and Autonomous Guided Vehicles, known as AGV, need, in general, free movement in warehouses to maximize flexibility, operability, and purpose. To do so, they generally extract energy from batteries which will discharge over the time and use then charge them when the machine has finished its work or there is a shift change. To charge the batteries, an external charger must be installed somewhere in the warehouse. However, these are normally bulky, expensive and take up space. Also, batteries normally show low voltages of operation which has traditionally led to the use of low-voltage DC motors.

By using bidirectional DC/DC converters in intralogistics vehicles it is possible to use standard AC drives, to save energy from the braking and extend the time between charges and avoid the installation of an external charger.

The DC/DC converter in autonomous mode transforms the low voltage from the batteries to a higher voltage to feed a standard drive directly in the DC bus. To do so, the DC/DC converter regulates the DC bus of the drive at a specific level in order to extract energy from or inject it back to the batteries during the operation of the vehicle. The energy flow when the AGV is moving can be seen in Fig. 4.

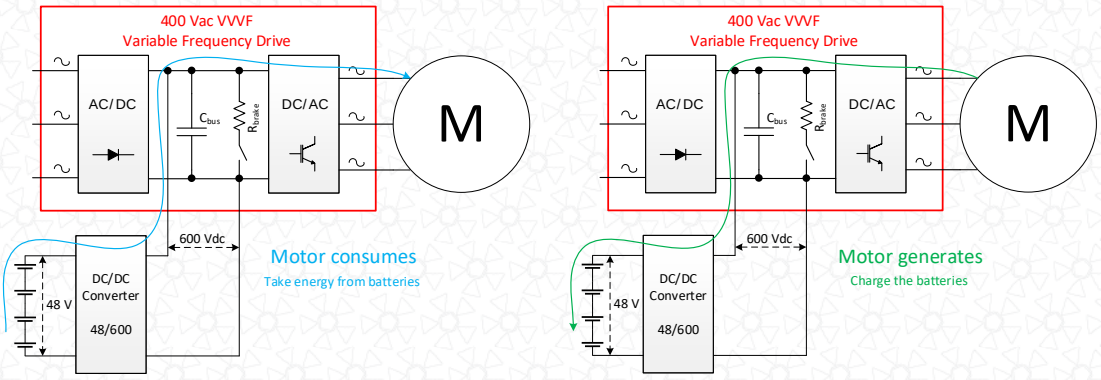

Fig. 5: Isolated DC/DC Converter working in an AGV application

When the batteries must be charged, the DC/DC converter can make use of its bidirectionality to act as a battery charger by simply receiving a command from the controller. The diode bridge of the AC drive is used to rectify the AC mains to DC and the DC/DC converter starts to work as a current source to charge the battery as in Fig. 5.

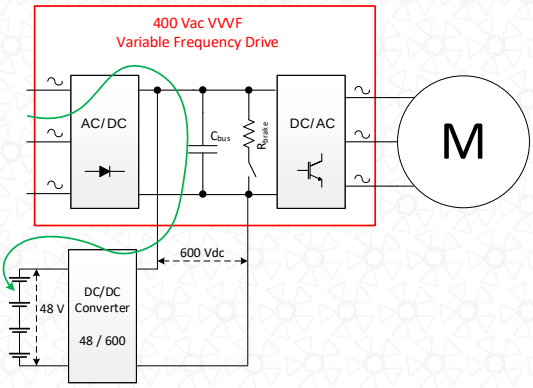

Fig. 6: Isolated DC/DC Converter used as a battery charger