Power Modules for Charger Applications

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Abstract:
Semiconductors figure prominently in modern-day battery charging applications. This is why Vincotech has developed a wide range of power modules specifically for this purpose. H-bridges, half-bridges, as well as buck and boost modules, in combination with rectifier modules, convert a fixed voltage and frequency into a lower DC voltage suitable for batteries. They boost overall efficiency and improve the size-to-cost ratio. Another benefit over conventional designs is the controllability. What's more, custom topologies can easily implemented in Vincotech's power modules. These power modules make the most of the PCB and are very well suited for applications designed to leave a small footprint.

Introduction:
More and more engineers are optimizing the circuitry to recharge batteries in uninterruptable power supplies and back-up systems. Even conventional chargers have come to rely on semiconductors. Most chargers use PWM to this end. AC input voltage is first rectified into high DC voltage and then converted into high-frequency AC voltage. A high-frequency transformer brings the output voltage up to the level of the battery voltage through some fast rectifier diodes.

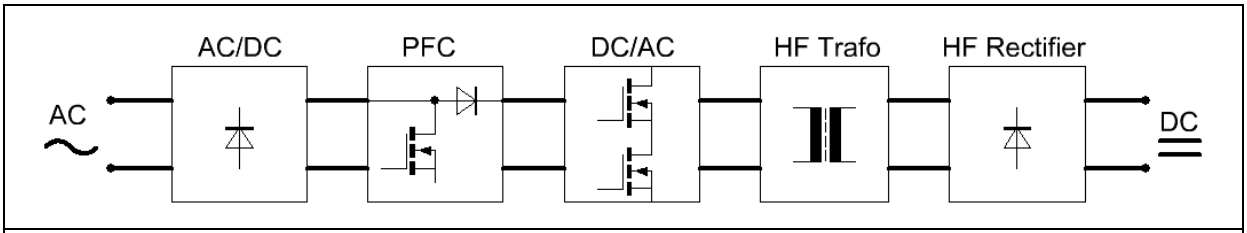

Figure 1: A look at the conversion chain

Two types of chargers are commonplace:
- Conventional battery chargers for indoor use
- Battery chargers for electrical vehicles

The big difference between the two is, of course, the environment in which they operate. Complexity is another differentiator. Chargers in electrical vehicles often have to replenish batteries not only when the vehicle is parked but also during braking. Therefore two different types of chargers come:
- Onboard chargers
- Off-board chargers

Each has its advantages and drawbacks. An onboard charger – that is, a unit installed in an electrical vehicle – can charge the battery wherever an electrical outlet is to be found. Some of these chargers also have a regenerating unit included. This means that the charger is not only used when the car is parked but also during travel. One drawback of this type of charger is its power capability, which is limited by size and weight. Off-board chargers, in turn, are theoretically unlimited when it comes to output power. However, the battery's ability to accept the charge certainly imposes a practical limit. Off-board versions charge batteries faster, but are less convenient for a lack of portability.

AC-to-DC conversion

Standard 50-Hz rectifier diodes serve to convert a fixed AC voltage into DC voltage. However, thyristors and MOSFETs may also be used for more demanding applications. Vincotech provides standard modules with a rectifier and additional PFC topology geared to obtain sinusoidal current from the grid.

The P98x family of modules features single-phase rectifier diodes as well as two PFC legs for interleaved control. Semiconductors of different sizes cover a power range of 3 to 8 kW. These modules employ fast-switching components, so additional capacitors are integrated to close the high-frequency loop. A shunt in the DC circuit is taken to measure the main current. Two external current transformers may be used to measure the current in each PFC leg. A reset diode for the transformer is also part of the package.

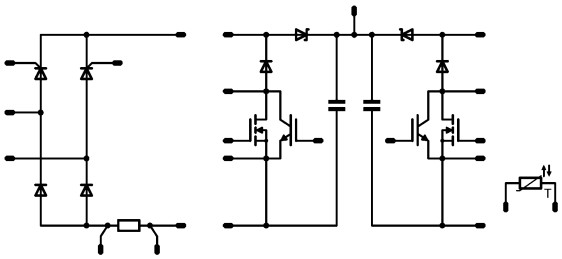

Figure 2: A diagrammed P98x module

The example in Figure 2 shows a half-controlled P98x module with a parallel switch and the possibility of current measurement in the drain. The parallel switch consisting of an IGBT and MOS offers the benefits of both technologies. On the one hand, MOSFET switching losses are very low. On the other, IGBT conduction losses are also low.
Variants of the P98x module with rectifier diodes in all positions as well as with fast IGBTs or MOSFETs only are also available. Each of these variants comes in open drain and open source versions, whereby current measurement may be floating or based on DC- potential.
This module enables engineers to achieve high efficiency while reducing the footprint of the heatsink. The integrated capacitors minimize stray inductance and reduce EMI.

The P38x is a cost-optimized module for applications with less demanding requirements.

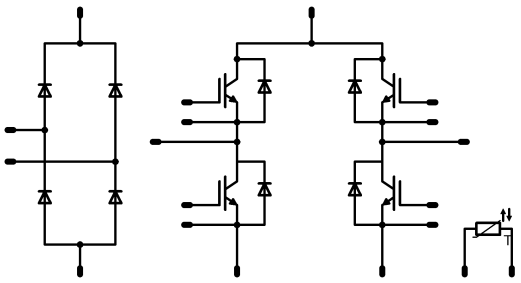

Figure 3: A diagrammed P38x module

Designed specifically to get the job done without shunts and capacitors, this module's integrated components are limited to usual 50 Hz rectifier diodes and a fast H-bridge with IGBTs. Higher efficiency can be achieved by using MOSFETs instead of IGBTs. The open emitter configuration allows independent current measurement for each leg.

DC-to-DC conversion

Conversion into high-frequency AC voltage takes place after rectification and power factor correction. Many chargers operate in hard-switching mode and are therefore based on an H-bridge topology. Generally four MOSFETs get the job done, but fast-switching IGBTs are also an option.
Vincotech also offers standard solutions for this type of application. The P72x family of modules features integrated fast switching IGBTs or MOSFETs, as well as capacitors to close the internal high-frequency loop.

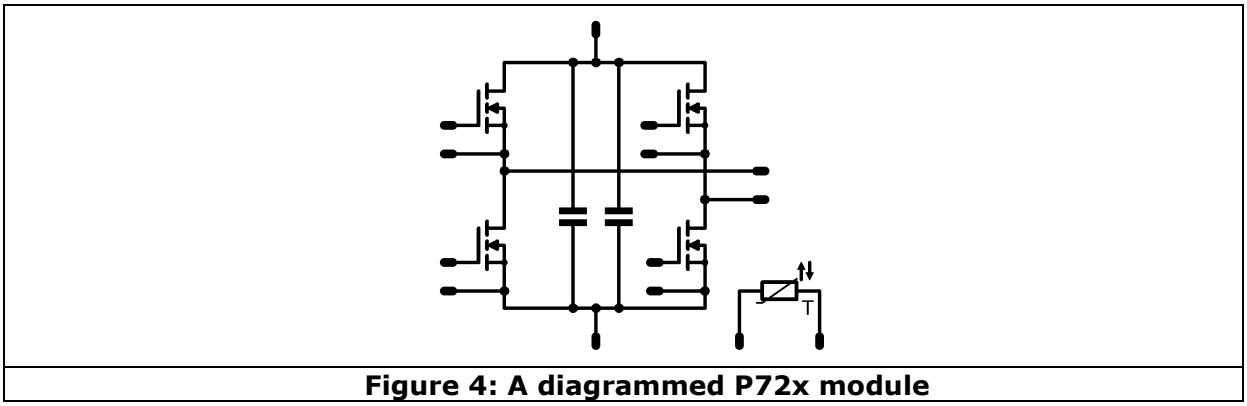

Figure 4: A diagrammed P72x module

This family is equipped with 600 V IGBTs or MOSFETs or with fast switching 1200 V IGBTs.

Boost + H-Bridge

The P89x combines a boost stage for PFC and an H-bridge. This module is used for applications where budgetary concerns rule out integrated components. Instead, the rectifier diodes have to be installed on a printed circuit board. However, this module is equipped with fast-switching MOSFETs.

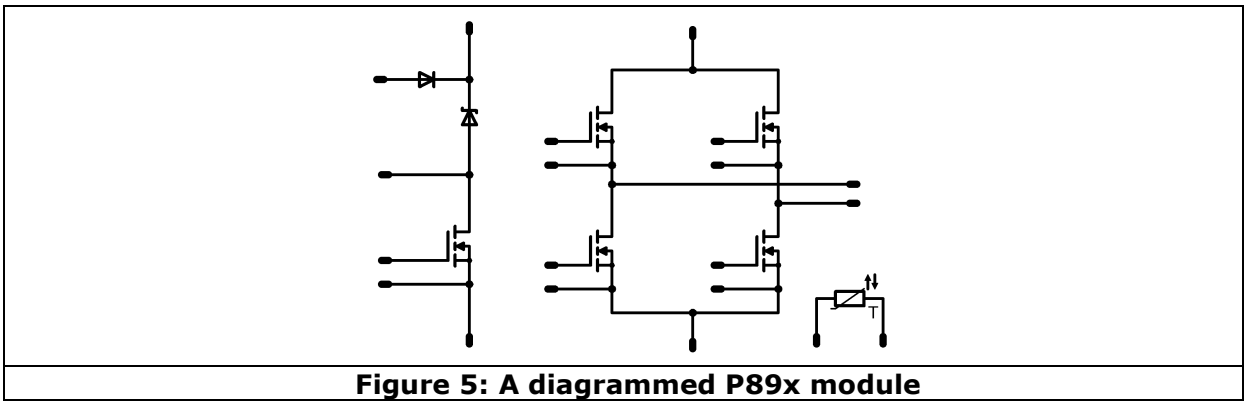

Figure 5: A diagrammed P89x module

Buck-Boost / Boost-Buck module

Another option is the M30x module, which may be used as a buck-boost or boost-buck module. It has two independent stages so different topologies can be realized. Standard modules in this configuration are available with various current ratings starting at 30 A and based on pure IGBTs or 41 mΩ with pure MOSFETs. High-performance and high-efficiency designs can be created using parallel switches with IGBTs and MOSFETs.

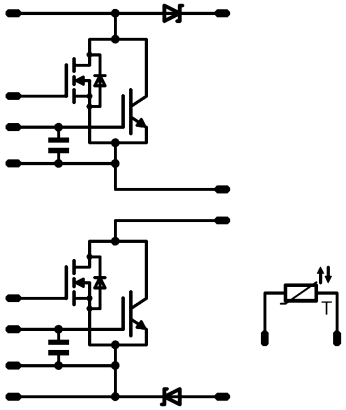

Figure 6: A diagrammed M30x module

A sensor in each of these modules serves to detect the heatsink temperature so that adjustments can be made when necessary.

Conclusion:

This paper touched on the features of various topologies. Vincotech has addressed the various issues with a selection of power modules designed specifically for charger applications. A rectifier plus interleaved PFC in half-controlled or uncontrolled configuration, with or without parallel switch, can serve to convert AC to DC. The standard product line also encompasses cost-optimized modules with a rectifier and H-bridge, as well as modules with a PFC and H-bridge. To make the portfolio round modules with Boost-Buck or Buck-Boost configuration are available in different power ranges.

Modifications such as swapping out switches and diodes are routinely performed. All modules are available with solder pins or Press-fit pins. Another option is a pre-applied layer of thermal interface material.

Featuring a dedicated pin-out and integrated capacitors, these modules provide the means to achieve higher efficiency, a smaller footprint and deeper integration.