Vincotech

Motion Control Technology in the Industrial Sector

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1 Abstract

Vincotech offers a wide range of power modules featuring high level of integration and innovation aimed to fully support the Motion Control strategies for industrial applications, including general purpose VFDs as well as application-specific designs.

2 Motion Control Technology

Electric motors are all around us in appliances such as washing machines and refrigerators, and in transportation modes such as cars and in planes. We would not have many of the common modern conveniences we enjoy every day without electric motors. The first motors were invented in the early 19th century by historical figures and company founders such as Werner von Siemens, Thomas Alva Edison, Nikola Tesla and George Westinghouse. Without electric motors everyday life would be very difficult to imagine.

Motion control is an automation technology that has become a major part of the modern industrial machine design. It is about making a mechanism move under control. Therefore, it requires careful mechanical designing and incorporation of several motor control elements. In particular, motion control technology is advancing to ensure improved performance, ease of use and enable wider application of servo and motion controls.

Vincotech is the market leader in the design and manufacturing of energy conversion power electronics solutions which support motion control strategies for industrial applications, including industrial motor drives, embedded drives, heat pumps, HVAC systems, elevator and servo drives.

3 Industrial motor drives

In many industrial applications, motors need to be operated at different speeds and torques. These applications require a power conversion unit to be placed between the grid and the motor (*Figure 1*) that is usually known as a Variable Frequency Drive (VFD).

Figure 1: VDF

Usually the energy conversion process from a fixed AC voltage to a variable AC voltage is as depicted in *Figure 2*:

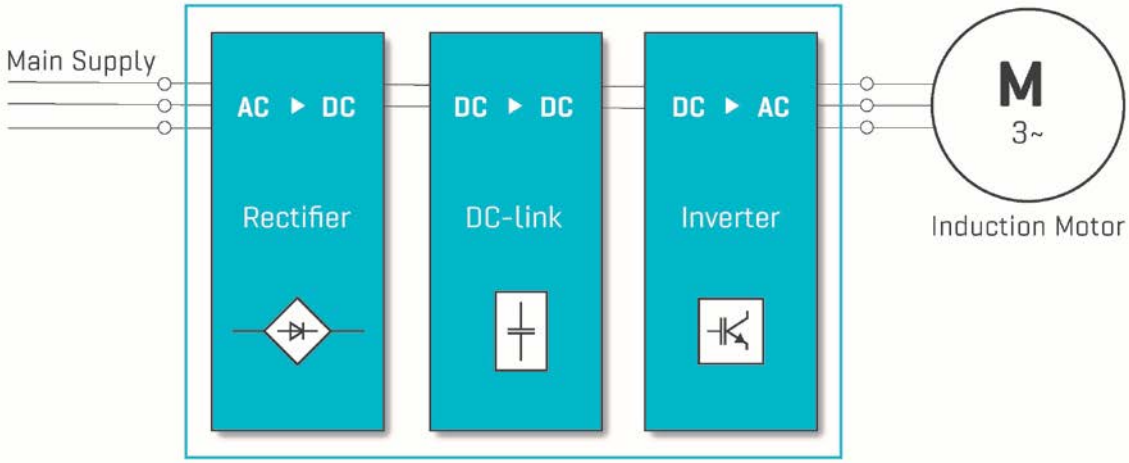

Figure 2: Energy conversion process

The most important advantage of a VFD is its ability to adjust the motor speed to the needs of the entire application. The second most important advantage is its ability to adjust the motor's torque. This feature protects the motor and the system driven by the motor from damage as the torque can be limited or precisely adjusted. Also, power savings can be considerable with

being able to control the motor's torque. For example, a VFD driven motor connected to a fan will only consume 1/8th of its rated power when operating at half speed, due to the cube root speed-to-power relationship of this system.

The controlled stopping or braking of a motor can be as important as its controlled acceleration. The greatest advantages of VFDs are realized in the braking of elevators and conveyors. This braking or reverse operation of motors is of great interest in many other applications, too. Reverse operation is possible by changing the rotary field in the motor by the VFD without having to change the order of the phase cables to the motor. VFDs also eliminate the need for valves, dampers and gear boxes. This leads to more compact systems, lower maintenance and lower operating costs.

The important components inside a VFD are the power rectifier diodes, the brake chopper, and the power semiconductor switches. Power rectifier diodes are used to rectify the AC input voltage. The brake chopper is used to dissipate the regenerated energy from the motor during braking and it protects the DC link capacitor from damage. The power semiconductor switches are used to convert the rectified input voltage back to a controlled variable voltage and variable frequency output.

The Vincotech offer for industrial applications comprises power integrated modules (PIM/CIB – converter, inverter and brake), sixpacks (three-phase modules), half-bridges and rectifier modules engineered to support standard drive applications for industrial use and motor power ranges from 1 kW to 200 kW.

4 Embedded drives

Discrete drives are standard solutions designed to control a wide range of motion applications. Nevertheless, higher integration and more complex subsystems are some of the current trends in the industrial market, and more and more companies provide embedded drive systems with different level of customization.

Embedded drive systems integrate drives and electric motors to reduce the space occupancy thanks to their compact and hermetical design. Since they are dedicated to specific applications, design engineers can optimize them in order to reduce the size and cost of the final product and to increase the reliability and performance.

An embedded drive circuit consists of an input rectifier, PFC boost stage and a three-phase output inverter. Depending on the application, the best choice of a module for this circuit is a highly integrated IPM (Intelligent Power Module) or a very flexible PIM (Power Integrated Module). The IPM also has the logic components and gate drives required for power switches. The PIM provides just the power components, so the gate drive has to be mounted on the system's PCB (*Figure 3*).

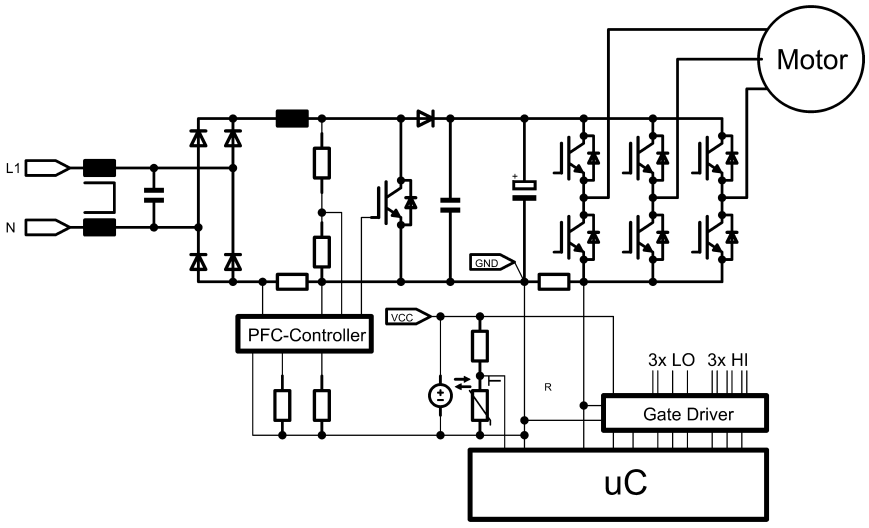

Figure 3: Power Integrated Module (PIM) with PCF

Two key requirements for electronically controlled motors embedded in pumps, compressors, fans and other such applications are:

- Power Factor Correction (PFC): PFC is mandatory for drives connected to the public power grid.
- Hermetic motor integration: A hermetically sealed, integrated motor requires a compact design and thermal management. Interior space is limited and a hermetic seal prevents any airflow from reaching components on the system's PCB board. The heat generated by gate drives, shunt resistors and the like has to be dissipated by a connected heat sink.

Vincotech's power module portfolio for embedded drives features 600V and 1200V IPMs as well as power integrated modules with PFC circuits (PIM+PFC) that achieve the highest level of integration of any power module available on the market today. That makes these modules the best solution for space-constrained mechanical environments. The overall system's size, cost,

and time-to-market can be reduced by integrating all of a motor drive's functional blocks, apart from the input filter, DC capacitor and microcontroller.

IPMs are needed to achieve the functional integration and power density necessary for this type of design. The extent to which IPMs are integrated, varies. At minimum, a standard IPM features a simple three-phase inverter bridge with a compatible gate driver. With more extensive integrated modules, engineers can create more compact designs and take advantage of a proven combination of power components and gate driver circuit - the most critical elements in the inverter's design. This mitigates the risk associated with circuit design, speeds up development and slashes time to market.

Power semiconductors, integrated circuits, SMDs and resistors integrated into the substrate can all be combined with the benefit of thick-film technology, thereby maximizing functional integration of the new *flow* IPM 1B power modules (*Figure 4*). This design incorporates all active power components for a three-phase inverter with Active Power Factor Correction (APFC), including capacitors to compensate for inductive loops, shunts for sensing current, a PFC controller with its surrounding circuit to serve as a voltage divider, and DC capacitors.

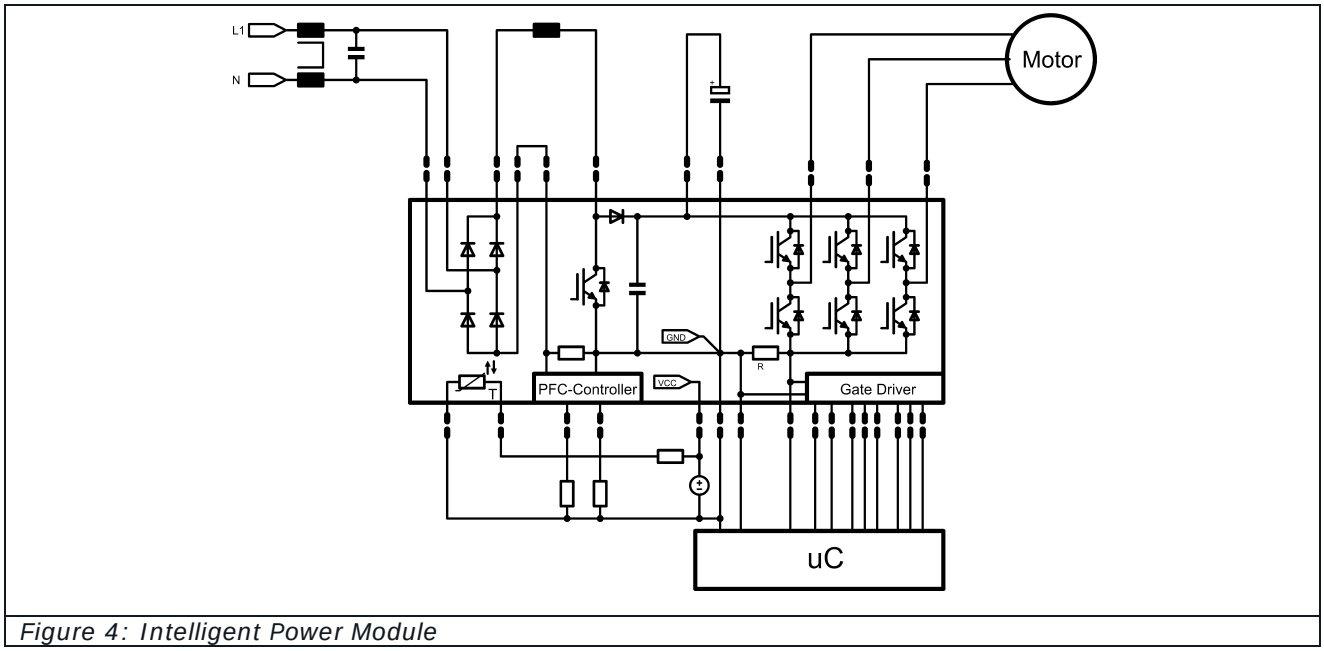

Figure 4: Intelligent Power Module

Only the power components – the input rectifier, PFC boost stage and three-phase output inverter – are integrated in PIMs. The gate drive circuit and other logic circuits have to be mounted on the external PCB. An integrated DC capacitor is provided to reduce inductance and enable ultra-fast turn-off for the PFC switch.

Some versions of these modules provide a shunt resistor to sense current for PFC or inverter control. The emitter structure in the low-side switches is open, so three external shunt resistors may be connected for vector control-based inverter designs. A temperature sensor provides the heat sink temperature at the module's position.

5 Heat Pumps and HVAC

Increasing the power density is one of the main goals in the design of heat pump and HVAC systems. This goal can be achieved by:

- moving towards more compact designs
- increasing the efficiency of the energy conversion
- integrating more cost-effective solutions

Vincotech's PIM with interleaved Power Factor Correction (PFC) circuit is a unique and innovative topology for power modules featuring a high level of integration as well as improved energy conversion efficiency.

Interleaved configuration offers several benefits, including:

- ease of PCB design
- higher efficiency of the energy conversion
- better heating distribution
- smaller components on the PCB
- easier design of EMI filtering
- reduced output RMS current

Vincotech's new 600V *flow*PIM+PFC family is composed of three different sub-families featuring two-leg interleaved PFC circuit with and without an integrated input rectifier, and three-leg interleaved PFC without an input rectifier, respectively (*Figure 5*). All of them are equipped with both a three-phase motor inverter and a temperature sensor.

Products with two-leg interleaved PFC feature also shunt resistors in the motor inverter as well as a PFC circuit. The common and leg shunts in the PFC allow a perfect balancing of the current in the PFC circuit that leads to an increased lifetime of the chipset. The integrated shunt resistors in each leg of the inverter result in vastly improved motor control.

Furthermore, the DC-link voltage overshoot is dramatically reduced thanks to the on-board capacitors.

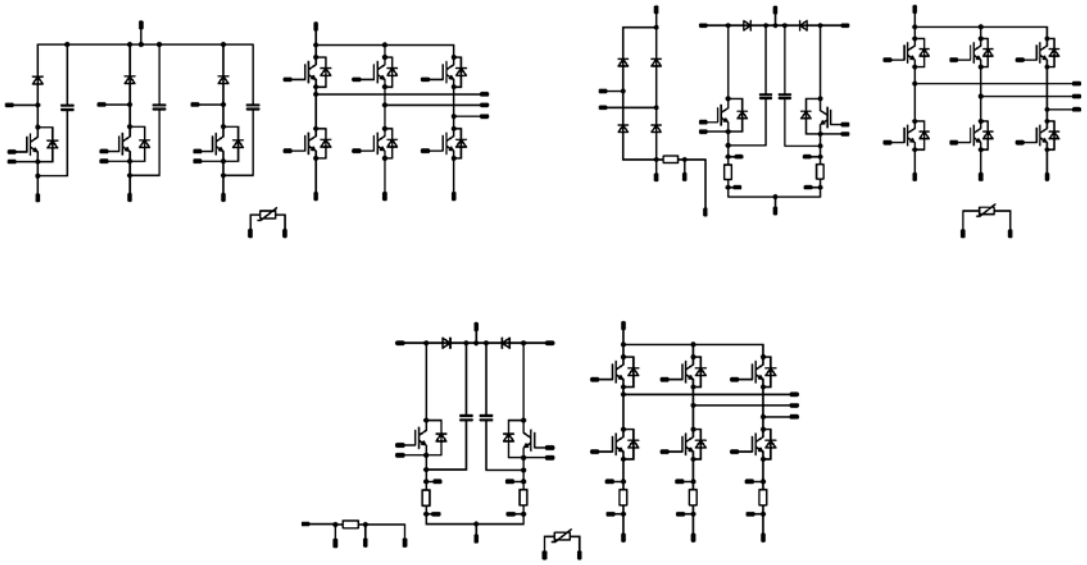

Figure 5: PIM with interleaved PFC

Special care is paid to the layout of the products in order to offer the best compromise between cost and performance. The power pins on the edge of the power modules result in a simplified and more cost-effective PCB design. The thermal design is also optimized thanks to separation of inverter and PFC parts.

6 Elevator drives

A long life cycle and high switching frequency in the converter stage are the main requirements for power modules used in drives for elevator and escalator systems. Vincotech's offer comprises standard sixpack as well as sixpack equipped with high speed components.

Special topologies, integrating two sixpacks for both the converter stage and the motor stage, are also available in order to provide a more compact solution and meet the aforementioned specifications.

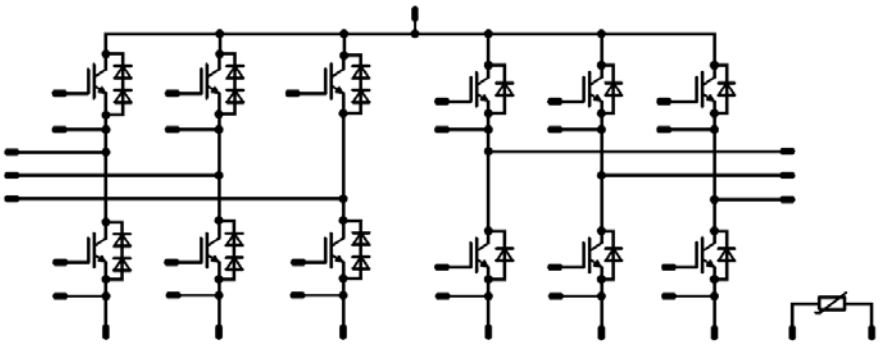

Figure 6: Twin-pack with tandem diode

Twin-packs are typically equipped with standard as well as high speed components. A tandem diode solution is also used to reduce power losses and then enhance the life cycle of the module even further (*Figure 6*).

7 Servo drives

Servo drive systems typically require switching frequencies in the range 10 kHz ÷ 16 kHz and output current overload up to 130% of the nominal current value.

Vincotech offers a full comprehensive product portfolio comprising input rectifier modules as well as sixpack power modules for the motor stage. Sixpacks are equipped with high speed components in order to mitigate the overall power losses while operating at high switching frequencies. A tandem diode solution is also offered in order to reduce power losses even further and assure a long life cycle of the products (*Figure 7*).

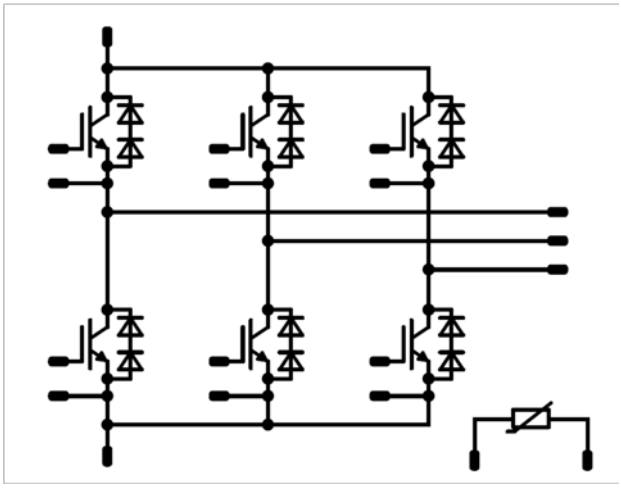

Figure 7: Sixpack with tandem diode

8 Conclusion

Modern life is unthinkable without the benefits provided by electric motors in the industrial sector. Power conversion devices are a pivotal part of the motion control in industrial applications. With these devices, the speed and the torque of the electric motors can be adjusted within a wide range to meet the needs of different applications.

Vincotech's product portfolio provides the functional integration and power density that engineers need to support the motion control strategies for industrial applications. The outstanding level of integration and innovation of Vincotech's products help system engineers to come up with more compact designs and to take advantage of a proven combination of power components and gate drive circuits. This mitigates the risk associated with circuit design, speeds up development, and dramatically reduces time to market.