ON Semiconductor

Is Now

To learn more about onsemi™, please visit our website at www.onsemi.com

Motor Drive Modules Support Rapid Design Cycles and Enhanced Efficiency and Reliability

Motor Drive Modules Support Rapid Design Cycles and Enhanced Efficiency and Reliability

The growth of motion control applications, coupled with environmental, commercial and legislative pressure to reduce energy consumption, means that efficiency is at the top of the design agenda for motor-based systems.

The International Energy Agency estimates that electric motors account for almost half (46%) of total global energy consumption, thus making them a focus for energy efficiency initiatives. Energy efficiency is sufficiently important that, in 2009, the European Union issued an energy-related products directive (ErP) 2009/125/EC. While the directive focused on multiple energy-consuming devices, EU regulation 640/2009 specifically relates to electric motors, whether they are sold as stand-alone devices or as part of larger equipment.

Making the situation more complex is the fact that there is an extremely wide range of electric motor applications covering multiple sectors, all of which require reliable, energy-efficient solutions.

In the home, motors are found in white goods such as refrigerators, kitchen appliances, washers and dryers. Cooling devices such as air conditioners and fans are also popular applications.

Industrial and commercial applications such as those found in factories and large offices also use motors for cooling and heating (HVAC). However, there are many more applications to be found including pumps and fans, air and liquid compression, large computers, escalators, elevators, conveyors, hoists, cranes, tools, industrial-grade laundry, cleaning and cooking equipment.

Electric vehicles use high voltage electric motors not only for traction but also for air-conditioning compressors, coolant circulation pumps and transmission oil pumps in hybrid electric vehicles.

Engineers can choose from many types of electric motors based on factors such as efficiency, power, size, reliability, ease of control, and cost. The most commonly used motors include AC induction motors (ACIM), brushed DC motors, stepper motors, brushless DC motors (BLDC) and permanent magnet synchronous motors (PMSM).

Critical Choices for Designers

Critical design factors and challenges for motor control architectures are efficiency, reliability, noise reduction, thermal performance, available board space, and ease of design. Once the optimum motor has been chosen, it becomes important to carefully select the approach for driving the system.

Many designers prefer using fully integrated, off-the-shelf solutions that reduce design time and risk. Leading semiconductor manufacturers are addressing this requirement by combining expertise in power semiconductor technology, advanced packaging techniques, and application knowledge to create dedicated, integrated solutions for motor control and industrial inverter applications. Integrating motor drive and protection circuitry into a single package, for example, creates a module that can significantly simplify and accelerate system design. These modules are 'pre-optimized' with important issues such as EMI already addressed. And by integrating all of the semiconductor devices into a single package, thermal issues are reduced and less PCB space is required.

Additional commercial advantages arise from the fact that, once the design enters the manufacturing phase, the lowered component count reduces assembly and inventory management costs.

When selecting a supplier, designers need to pay attention to the specific solution for the existing design but should also keep in mind other factors; for example, does the supplier offer a broad range of solutions that allow the design to be scaled up and down to meet future application requirements.

A Broad Range of Modular Motor Control Solutions

Figure 1 illustrates the elements of a high voltage motor control system. ON Semiconductor's broad product portfolio includes all of the key elements required for the key functional blocks:

- Motion Power Module − integrated solutions that support designs from low-power (20 W) to high-power (10 kW)
- BLDC Controller (Brushless DC/Permanent Magnet Synchronous Motor) − mixed-signal ICs exclusively for motor control that eliminate the need for complex and expensive DSPs (Digital Signal Processors)
- PFC (Power Factor Correction) − PFC modules that minimize input current distortion, reduce power loss, and save energy and cost
- Optocouplers − provide isolation from high-voltage devices in motor control designs
- SMPS (Switched Mode Power Supply) − power management devices used in Flyback converter designs

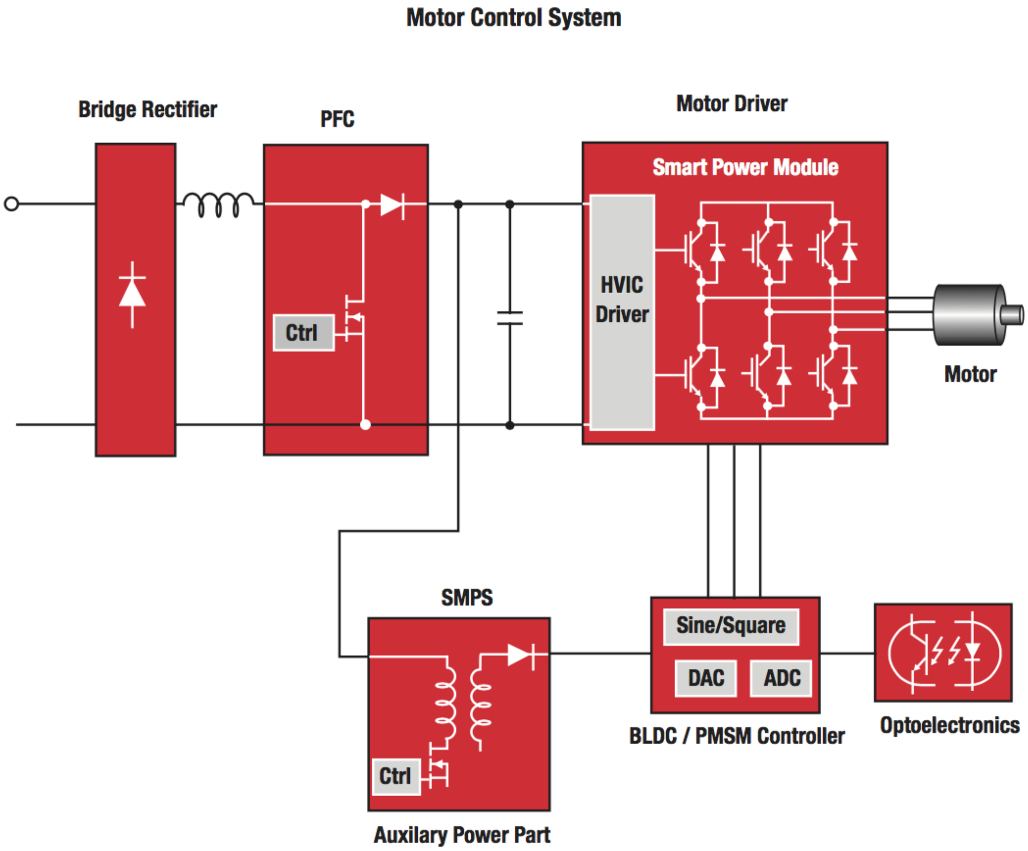

Figure 1. Motor Control Systems Contain Multiple Functional Blocks

The motion power modules provide a fully-featured, high-performance three-phase inverter output stage and optimized gate drive technology to minimize EMI and losses, and provide multiple on-module protection features.

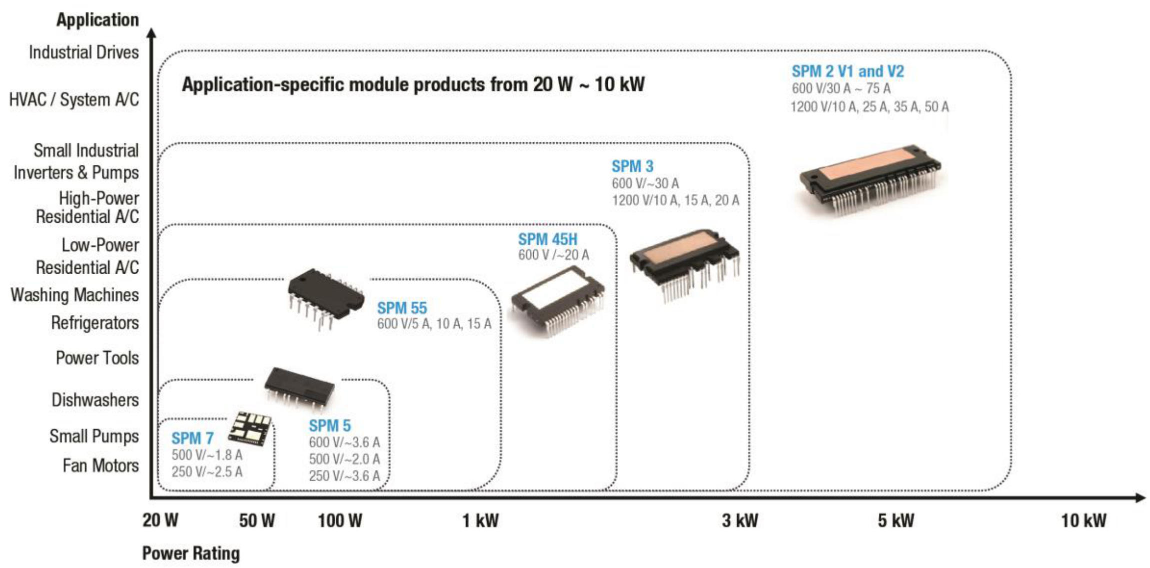

Figure 2. Board Power Module Range Covers Multiple Applications up to 10 kW

While the power module range offers key benefits such as UL certification (UL1557), improved thermal performance due to direct-bond copper (DBC), and better reliability with higher noise / surge immunity across the range, each device is optimized to suit a specific application set.

SPM 2 Series

Typically used in HVAC, industrial inverters, servomotors, pumps or fan motors, the 600 V and 1200 V SPM 2 module series addresses three-phase inverter based motor drive applications up to 10 kW. Reliability is reinforced by using low-loss NPT and field-stop trench IGBTs with DBC package technologies that achieve greater than 10% reduction in module losses, with longer short-circuit rating capabilities and embedded protection circuits.

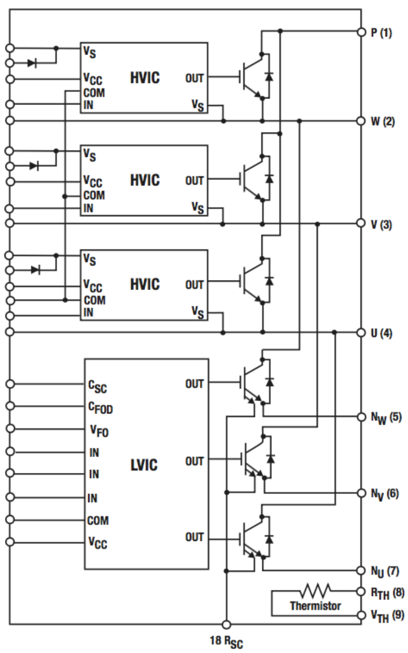

Figure 3. SPM 2 Block Diagram

SPM 3 Series

Supporting a broad range of applications including HVAC, commercial air conditioners, compact industrial level inverters, servo-drivers, fan motors and pumps, the 500 V, 600 V, and 1200 V SPM 3 module series covers a wide range of power applications up to 3 kW. This solution is compatible with AC induction, BLDC, and PMSM motor types. Separate open emitter terminals are available for each phase to support the widest variety of control algorithms. SPM 3 modules are offered in very low thermal resistance packaging AL2O3 DBC, ceramic substrate, and FullPAK options.

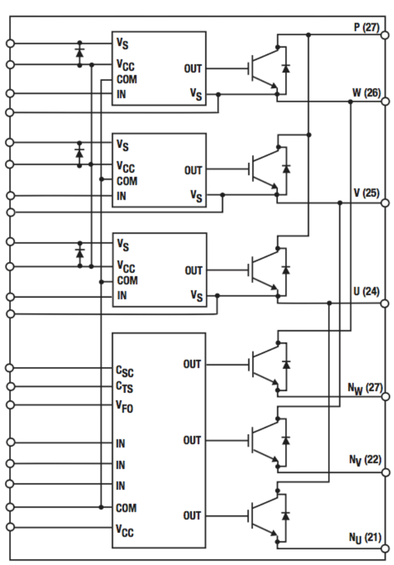

Figure 4. SPM 3 Block Diagram

SPM 45 Series

Aimed primarily at residential applications including appliance inverters (such as residential A/C), washing machines, refrigerators, pumps, industrial fans and compact inverters, the 600 V SPM 45 module series provides compact and high-performance inverter solutions for AC motor drives in lower power applications up to ±2 kW. The series targets cost-sensitive applications below 30 A, offering ceramic substrate packaging with built-in bootstrap diodes. System reliability is further enhanced by a built-in NTC for temperature monitoring, integrated under-voltage lock-out (UVLO) function and over-current protection input.

Three separate open-emitter pins for low-side IGBTs enable three-leg current sensing. Built-in bootstrap diodes and dedicated V_S pins simplify PCB layout.

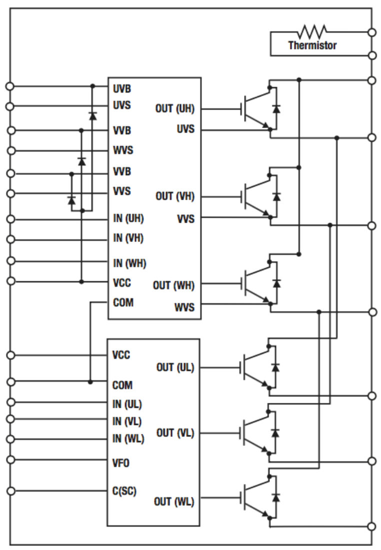

Figure 5. SPM 45 Block Diagram

SPM 55 Series

Also intended for residential use – including appliance inverters (such as residential A/C), washing machines and refrigerators – the 600 V SPM 55 modules provide a fully-featured, high-performance inverter output stage for lower power AC Induction, BLDC, and PMSM motors up to 1 kW. The built-in, high-speed HVIC requires only a single supply voltage and translates the incoming logic-level gate inputs to the high-voltage, high-current drive signals required to properly drive the modules' robust short-circuit-rated IGBTs. Separate negative IGBT terminals are available for each phase to support the widest variety of control algorithms.

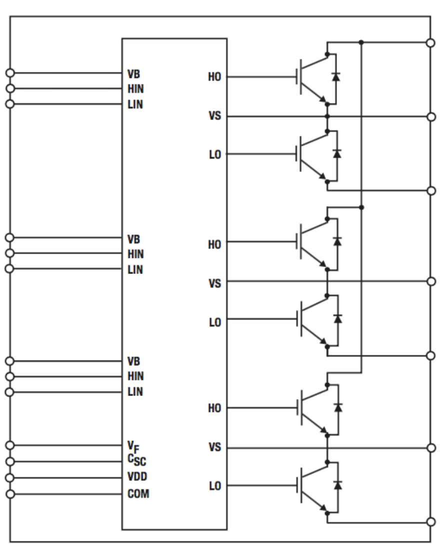

Figure 6. SPM 55 Block Diagram

SPM 5 Series

Serving a broad application set including dishwashers, ceiling fans, pumps and fans for lower power air conditioners, the 250 V, 500 V, and 600 V SPM 5 module series provides optimized gate drive to minimize EMI and losses for three-phase motor drive applications below 200 W. Modules are offered in package options of DIP, double DIP and SMD. Separate open-source MOSFET terminals for each phase support the widest variety of control algorithms.

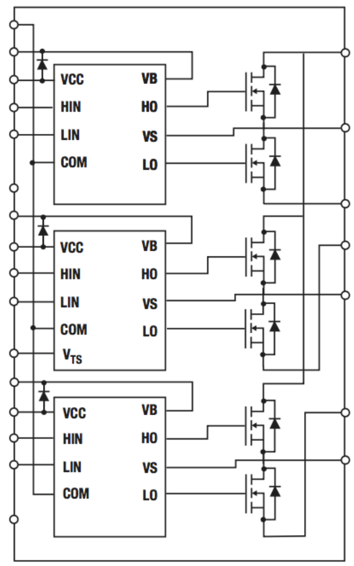

Figure 7. SPM 5 Block Diagram

SPM 7 Series

Intended for lower power applications such as small pumps, pedestal and ceiling fans below 100 W, the advanced SPM 7 (250 V, 500 V, 600 V) modules provide a fully-featured, high-performance three-phase inverter output stage for AC induction, BLDC and PMSM motors. These modules integrate the optimized gate drive of the built-in MOSFETs to minimize EMI and losses, while also providing multiple protection features. The built-in HVIC translates incoming logic-level gate inputs to the high-voltage, high-current drive signals required to properly drive the internal MOSFETs. Separate open-source MOSFET terminals are available for each phase to support the widest variety of control algorithms. The PQFN package can deliver board space savings of up to 50%, while minimizing EMI and losses.

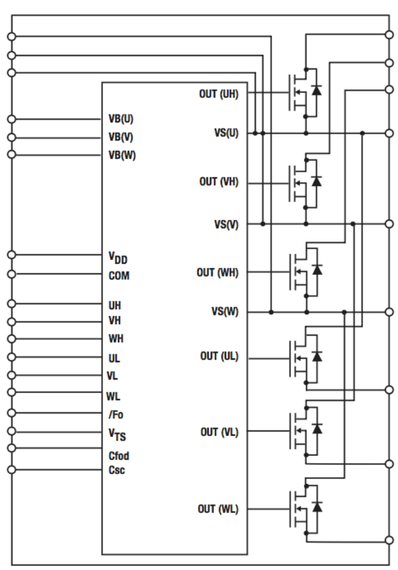

Figure 8. SPM 7 Block Diagram

Packaging Considerations

The complete SPM range comprises multiple packaging options including dual-in-line package (DIP) and surface-mount (SMD). Each of these is optimized to minimize PCB area, yet provide a simple method for adding additional cooling for high-power applications. The devices offer a far simpler mechanical and thermal arrangement than a discrete solution that would contain multiple ‘hot spots’.

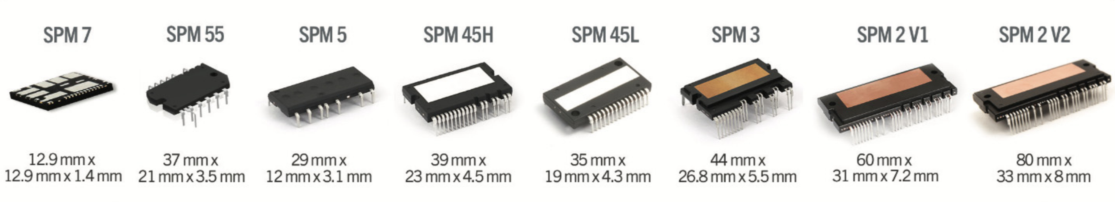

Figure 9. The SPM Range Offers a Wide Variety of Packaging, Including SMD

By following a few simple guidelines, designers can easily create a thermally efficient solution that meets the required safety spacing guidelines. This can be illustrated with a more detailed examination of the SPM 2 package.

Creepage and clearance distances ensure safety and compliance with all relevant safety standards. The package itself defines the distances for the power and control terminals (as shown in the table below); the designer needs to ensure that the PCB layout maintains these distances.

Location	Clearance [mm]	Creepage Distance [mm]
Between Power Terminals	7.80	8.00
Between Control Terminals	3.05	6.85
Between Terminals & H/S	3.8	6.06

Figure 10. Recommended Spacings for SPM 2 Module

When mounting a module to a heatsink, adhering to simple procedures will ensure success. The heatsink should have a flatness not exceeding −50/+100 μm, and a 150 μm layer of thermally conductive grease should be applied evenly across the contact surface, ensuring there is no dust or debris present.

Excessive and / or uneven fastening force must be avoided as this could apply stress to the silicon, thereby damaging the device. The correct procedure involves using M4 SEMS screws with a plain and spring washer and pre-tightening both screws to approximately 25% of the final torque, before final tightening with a torque-controlled screwdriver.

Summary

Motor control can be challenging for the less-experienced designers, not least due to stringent efficiency and reliability targets as well as standards-driven safety requirements. A modular approach is an obvious choice for newcomers to motor control, yet many experienced designers also value the multitude of benefits that modules offer. These include a pre-optimized design, reduced size, reduced BOM cost and component count, and assurance that reliability, safety, and efficiency targets will be met.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA
Phone: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910

ON Semiconductor Website: **www.onsemi.com**

Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative