This application note provides an overview of the different IPM package families, to facilitate the module selection for a specific application and power range.

**ON Semiconductor’s IPM allows designers to:**
- Reduce system cost thanks to high integration in small footprint packages with excellent cooling performance
- Reduce assembly cost with simple assembly concept
- Reduce time to market with a power stage already optimized to meet the best trade-off between switching characteristics and EMI performance
- Improve reliability with short circuit rated IGBTs driven by rugged gate driver ICs with key protection features, in a rugged transfer mold package

**ON Semiconductor proposes different module topologies:**
- 3-Phase Inverter modules
- 3-Phase Inverter with PFC (Combo) modules
- Interleave PFC with Input bridge rectifier modules
- Single boost PFC with Input bridge rectifier modules
- Bridgeless PFC modules with built in shunt resistor

Reference designs and online simulation tool are available in ON Semiconductor website to facilitate the design and evaluation of IPMs.

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**Motor Development Kit (MDK) 4 kW Board with Intelligent Power Module SPM31 650 V**

**SECO-MDK-4KW-65SPM31-GEVB**

**Description**
The SECO-MDK-4KW-65SPM31-GEVB is a development board for three-phase motor drives, part of the Motor Development Kit (MDK). The board features the NFAM5065L4B Intelligent Power Module in a DIP39 package and is rated for 650 Vdc input, delivering continuous power in excess of 1 kW, with the capability of delivering up to 4 kW power for short periods. The board is fully compatible with the Universal Controller Board (UCB), based on the Xilinx Zynq-7000 SoC, which embeds FPGA logic and two Arm® Cortex®-A9 processors. As such, the system is fit for high-end control strategies and enables operation of a variety of motor technologies (AC induction motor, PMSM, BLDC, etc.).

**Features**
- 4 kW Motor Control Solution supplied with up to 650 Vdc
- Compatible with the Universal Controller Board (UCB)
- FPGA’s controller based on Xilinx Zynq-7000 SoC

**Applications**
- White Goods
- Industrial Fans
- Industrial Automation
- Industrial Motor Control

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**Motor Development Kit**

**Online Simulation**
3-Phase Inverter IPM

**SPM7 in PQFN for Up to 80 W Motors**
- MOSFET/IGBT module in small foot print 12.9 x 12.9 mm PQFN package
- Available in 250 V with \( R_{DS(ON)} \) from 0.8 Ω to 1.4 Ω
- Available in 500 V with \( R_{DS(ON)} \) from 1.85 Ω to 3.4 Ω
- Achieve high power density thanks to larger PCB land pattern with higher heat dissipation capability

**SPM5 in SMD and Through-Hole Packages for Up to 200 W Motors**
- MOSFET/IGBT module in SMD and Through-Hole package to drive motors up to 200 W
- Can be mounted with heatsink for enhanced heat dissipation (but no screw hole on the package)
- Available in 250 V using MOSFET with \( R_{DS(ON)} \) from 0.37 Ω to 1.10 Ω
- Available in 500 V using MOSFET with \( R_{DS(ON)} \) from 1.43 Ω to 5.50 Ω
- FSB50x50A version is optimized for applications running at switching frequency below 10 kHz, for which conduction losses are predominant
- FSB50x50B version is optimized for applications running at frequency above 10 kHz, for which switching losses are predominant
- FSB50x50BL version is slow down compared to the B version for better EMI
- Available in 600 V using:
  - RC IGBT, provide higher efficiency at higher current, with good tradeoff between low switching loss, good EMI performance and cost benefit.
  - Super Junction MOSFETs with \( R_{DS(ON)} \) from 0.45 Ω to 2.70 Ω for ultra-low conduction losses
- Used in various white good appliances such as dishwashers and washing machine drain pumps, refrigerators as well as in industrial motor drive such as fan, pumps.

**SPM8 for 300 W Range Motors**
- IGBT module in fully molded package with screw hole for easy mounting on heat sink
- Available with 600 V IGBTs, from 4 A to 15 A
- Used in in white goods appliances such as compressors for refrigerators and fans
SIP-K for Up to 1 kW Range Motors

- IGBT module in a Single-In-Line package for vertical mounting on the PCB
- It is based on an IMS substrate for high mounting density and good heat spreading, fully over molded for enhanced electrical isolation
- SIPK is pin compatible with SIP1A and SIP05F. It also has same mounting hole position with SIP05F
- SIPK available in 600 V 5 A and 10 A

Compact IPM in DIP-S6 and DIP-S for 1 kW Range Motors

- 600 V IGBT module in a compact 29.6 x 18.2 mm package
- 3 A device based on IMST and full mold package
- From 5 A to 15 A with exposed Al2O3 substrate for enhanced heat dissipation and reliability
- NFAQ0560R43T/NFAQ1560R43T are 5 A and 15 A modules based on FS4 RC IGBTs, enabling a higher power density in compact sized package with cost optimization
- Used in white good appliance such as washing machines and in industrial motor drive such as fans, with power ranging from 700 W to 1 kW

SPM45 for 1 kW to 3 kW Motors

- IGBT module with ceramic substrate for optimized heat dissipation and cost
- Available in 600 V, wide portfolio from 5 A to 30 A for scalable power class within the same footprint
- NFA41560R42 and NFA42060R42 are 15 A and 20 A modules based on FS4 RC IGBTs for cost optimization, good EMI performance
- Used in room air conditioning ranging from 1 horse power to 3 horse power

SPM31, SPM3V and ASPM27 for 7 kW Motors

- IGBT modules with Al2O3 and AlN substrates for best heat dissipation
- Available in 1,200 V from 5 A to 20 A
- Available in 600 V from 15 A to 50 A, 650 V from 20 A to 60 A
- Used in large range of industrial motor drives such as variable frequency drives, servo, pumps, HVAC with powers up to 7 kW
- SPM31 is pin to pin compatible with other suppliers in the market, offering dual source capability
- SPM31 with FS4 IGBT offers a more cost effective solution for high performance applications. It offers higher efficiency than SPM3V for switching frequencies above 10 kHz
- SPM3V is running at higher volume and offers a more cost effective solution for applications demanding less performance
- AQG324 Automotive version available under ASPM27 package family, for e-compressor and other auxiliary motor drives for EV/HEV
- ASPM27v3 based on FS4 IGBTs, optimized with lower switching losses for fast switching application with good EMI trade off:
  - NFV A33065L42 shows similar losses as NFV A33065L32 but better EMI
  - NFV A3-50/60-65L42 shows lower losses than the NFV A3-40/50-65L32, allowing faster switching or higher current rating for similar EMI performance

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SPM49, SPM34 and ASPM34 for 10 kW Motors

- IGBT modules with Al2O3 and AlN substrate for best heat dissipation
- Available in 1,200 V from 10 A to 50 A
- Available in 600 V from 30 A to 75 A, 650 V from 50 A to 75 A
- Used in large range of industrial motor drives such as variable frequency drives servo, pumps, HVAC with powers up to 10 kW
- AQG324 Automotive version available under ASPM34 package family, for e-compressor and other auxiliary motor drives for EV/HEV
- SPM49 is pin to pin compatible with other suppliers in the market, offering dual source capability
- SPM49 with FS4 IGBT offers a more cost effective solution for high performance applications. It offers higher efficiency than SPM34 for switching frequencies above 10 kHz

3-Phase Inverter with PFC Combo Module Overview

Application Diagram

SIP2A Combo Module

- IGBT inverter combined with PFC stage
- Available in 600 V 10 A with PFC based on Super Junction Mosfet and Silicon Carbide diode optimized for 100 kHz switching frequency range
- Available in 600 V 15 A with PFC based on IGBT and silicon diode, for 20 kHz ~ 40 kHz switching frequency
- In SIP2A Single In Line package is available with straight leads or 90deg bend leads for vertical and horizontal mounting on PCB
PFC Modules with/without Input Bridge Rectifier

Application Diagram

Interleave PFC with Input Bridge Rectifier
- SPM2V 32 with Al2O3 and AlN substrate for best thermal dissipation
- Available in 600 V from 30 A to 50 A
- Available with Silicon Carbide diode for enhanced thermal and EMI performance
- Optimized for 40 kHz ~ 60 kHz switching frequency

Single Boost PFC with Input Bridge Rectifier
- SPM45 with ceramic substrate and SPM3V with Al2O3 substrate for enhanced heat dissipation
- Available in 600 V, from 20 A to 30 A

Bridgeless PFC Module with Built-In Shunt Resistor
- SPM3V package with Al2O3 and AlN substrate for best heat dissipation
- Available in 600 V from 40 A to 60 A