MOTOR DRIVE SOLUTIONS

Energy-efficient, Integrated and Discrete Semiconductor Solutions for Your Home Appliance and Industrial Applications
Improving Energy Efficiency and Reliability in Motor Control Applications

As the demands for energy efficiency, environmental responsibility and meeting government regulations are increasing, the need for highly efficient electronic systems becomes more and more important. Since electrical motors are the single largest consumer of electrical power and account for between 40 to 50 percent of total global energy consumption, it is essential that motor control solutions are both efficient and reliable.

Making the situation more complex is the fact that there is an extremely wide range of electric motor applications. Primary applications by sector include: residential—refrigerators, air conditioners, fans, pumps, kitchen appliances, washers and dryers, computers, tools, etc.; industrial/commercial—pumps and fans, air and liquid compression, heating and air conditioning (HVAC), large computers, escalators, elevators, hoists, cranes, industrial-grade laundry, cleaning and cooking equipment; transportation—electric trains, trucks, cars and motorcycles in related cooling/ventilation systems.

To accommodate the hundreds of applications, there are many types of electric motors from which to choose in order to get the highest efficiency and/or lowest cost. The most commonly used motors are AC Induction Motors (ACIM), brushed DC, stepper, brushless DC and Permanent Magnet Synchronous (PMSM). Once the motor has been chosen, it becomes extremely important to carefully choose the supporting components for the system. Critical design factors and challenges for motor control architectures are efficiency, reliability, noise reduction, thermal performance, reduced board space and ease of design.

For more information, use your smart phone to scan the QR code, or visit: www.fairchildsemi.com/applications/motor-control/
Fairchild’s Solutions for Successful Motor Control Applications

Our constantly expanding product portfolio—combined with manufacturing process enhancements—innovative topologies, and our systems expertise, allow circuit designers to develop the most advanced solutions to meet their needs. We offer a broad range of SPM®, IGBTs, Gate Drivers, PFC-PWM combos, MOSFETs, phototransistors and diodes for every motor control application. In addition, there are reference designs and evaluation boards to optimize your design success.

Examples From Our Portfolio Include:

- **Motion SPM® (Smart Power Module)**—integrated solutions that support low-power (20W) and high-power (7.5kW) designs
- **BLDC (Brushless DC/Permanent Magnet Synchronous Motor)**—mixed-signal ICs exclusively for motor control that replace complicated DSPs (Digital Signal Processors)
- **PFC (Power Factor Correction)**—PFC SPM® 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
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SPM 45H Series Modules

Designers who need to reduce board space, decrease manufacturing costs and speed time-to-market while increasing system reliability, have many options with Fairchild’s SPM 45H series. These modules can replace up to 25 discrete components by integrating 3 high-side drivers, 3 low-side drivers, 6 IGBTs, 6 FRDs, 3 bootstrap diodes, 1 thermistor, and numerous passives into a fully tested compact (39mm x 23mm) package.

Design Advantages:

• Built-in advanced NPT IGBTs provide optimal conduction loss and switching loss
• Advanced STEALTH™ Diode has low $t_i$ and $I_i$ characteristic (Figure 1)
• Full protective functions included; built-in NTC for OT protection, UVLO and SC
• Integrated bootstrap diode saves the PCB space and BOM cost
• Improved ruggedness due to advanced NPT IGBTs
• Built-in bootstrap diode and independent $V_S$ pin provides easy design and reduced board space

Applications:

• Air conditioners
• Washing machines
• Refrigerators
• Dishwashers
• Industrial inverters

Figure 1: $t_i$, Waveform Comparison Between Ultrafast Diode and Advanced STEALTH™Diode
### Motion SPM 45H Series Modules

#### Normal Speed Version

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*In Development

Note: Integrated Protection Functions Include Built-In NTC Thermistor and Built-In Over current (csc)

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### Typical Application Using the SPM 45H Module

![Typical Application Diagram](image)
SPM 5 Series Modules

The SPM 5 series module increases reliability, energy efficiency, lowers electromagnetic interference and saves PCB board space in low-power brushless direct current (BLDC) motor applications. These modules combine 6 MOSFETs (FRFET®, UniFET™) and 3 half-bridge HVICs in compact, thermally efficient, 29mm x 12mm packages. The FRFETs feature fast and soft recovery body diodes, offering a combination of lower switching losses, lower conduction losses at low current and a wider Reverse Bias Safe Operating Area (RBSOA), when compared to IGBTs. These body diodes are free-wheeling, eliminating the need for additional components.

Design Advantages:

- Integrated thermal sensing unit (TSU) for real-time detection (Figure 1)
- Built-in bootstrap diode delivers a more simplified, compact design
- Higher reliability due to fully tested modules (HVICs and MOSFETs)
- High-active input signal logic resolves the startup and shutdown sequence constraint between the control supply and control input providing fail-safe operation with direct connection between the SPM® and a 3.3V CPU or DSP
- Single-grounded power supply and optocoupler-free interface due to built-in HVIC
- No need for any additional external sequence logic
- Three divided negative DC-link terminals for inverter current sensing applications

Applications:

- Washing machines
- Indoor/outdoor fans
- Pumps
- Dishwashers

Figure 1: 3V/5V CMOS/TTL Compatible Perfectly Linear Characteristics
### Typical Application of SPM 5 Series Modules

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* A: DIP, -AS: Surface Mount, AT: Extended Clearance DIP
SPM 3 Series Modules Optimize Wide Range (600V/3A to 30A) of Inverter Driver Applications

For increased design flexibility of a wide power range (from 0.15kW to 3kW), the SPM 3 series modules provide a range of 3A to 30A in a single package. Fairchild’s Direct Bonded Copper (DBC) technology with the product number prefix FSBB indicates this capability. The SMP 3 series consists of a suite of 17 IGBT inverter modules and 2 MOSFET modules offering excellent thermal resistance. Each module integrates 3 high-side drivers, 1 low-side driver, and 6 IGBTs with fast recovery diodes, or MOSFETs, in a compact 44mm x 26.8mm x 5.5mm package.

**Design Advantages:**

- Low-loss efficient NTP IGBTs, FRDs and bootstrap diodes are integrated in a single package to optimize motor driving performance
- Single-grounded power supply and optocoupler-free interface due to built-in HVIC
- Full protective functions; UVLO, SC and TSD
- Divided negative DC-link terminals for inverter current sensing applications
- Isolation voltage rating of 2500Vrms/min
- Very low leakage current due to ceramic and DBC substrate

**Applications:**

- Air conditioners
- Washing machines
- Refrigerators
- Dishwashers
- Industrial inverters

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### Motion SPM 3 Series Modules

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Note: Integrated Protection Functions Include Built-In Over current (CSC) and Built-In Over Temp (TSD)
SPM 2 Series Modules

The Motion SPM®2 series provides complete adjustable-speed motor drive control and fully-integrated circuit protection for AC motors found in applications such as washing machines and air conditioners. Compared to discrete IGBT solutions, the integrated SPM® module requires less than half the board space, while providing low-voltage control and high-voltage output stage rated at 10–30A at 220V AC. This series is available in a small (60mm x 31mm), ceramic-based transfer molded-type package that optimizes heat transfer from the IGBTs, achieving 27% higher power rating than conventional TO-220F packages.

Design Advantages:

- Built-in thermistor for temperature monitoring
- Adjustable short-circuit current protection using low-side sense-IGBTs
- Low-active input signal logic resolves the startup and shutdown sequence constraint between the control supply and control input providing fail-safe operation with direct connection between the SPM® and a 3.3V CPU or DSP
- Divided negative DC-link terminals for inverter current sensing applications
- Inverter power rating covering up to 7.5kW at 230V AC input within a single package
- Optimized IGBTs for low- and high-switching applications
- Isolation voltage rating of 2500V rms/min
- Low thermal resistance due to ceramic and DBC substrate

Applications:

- Air conditioners
- Industrial inverters

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<th>Part Number</th>
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Note: Integrated Protection Functions Include Built-In NTC Thermistor and Built-In Over Current (AC)
PFC SPM® Modules

For design flexibility, Fairchild offers both discrete and integrated PFC solutions. Our integrated Power Factor Correction Smart Power Modules (PFC SPM®) are also known in the industry as IPM (Intelligent Power Modules). These solutions are optimized for a wide power range (600V/3A to 30A) for inverter driver applications. PFC SPMs have the same advantages of the SPM Direct-Copper Bond (DCB) substrate packaging. For example, this packaging enables high voltage motor drivers; and now enables PFC for high-voltage motor control. Integrated into the PFC SPM family are a front-end rectifier circuit, partial switching converter circuit, and power factor correction circuit which can be controlled by an external controller; e.g. Fairchild’s BLDC/PMSM controller, third-party micro-controller (MCU), DSP controller, or FPGA (Field Programmable Gate Array).

Design Advantages:
- Optimized IGBTs, diodes and gate driver for PFC applications
- High energy efficiency by eliminating one diode conduction loss
- Best thermal resistance due to adoption of DBC substrate
- Isolation voltage rating of 2500V\_rms/min
- Gate driving IC Under Voltage (UV) and Over Current (OC) protection
- Package designed to satisfy the basic creepage and clearance spacing – UL Certified No. E20920

PFC SPM devices have the same mechanical dimension as the motor driver SPMs; both can be installed on the same heat sink, enabling easy assembly and increased productivity.

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Interleaved PFC SPM Modules

An advanced 2-phase interleaved PFC Smart Power Module features a single-phase rectifier for AC input, 2-phase interleaved PFC, Control IC for gate driving and protection – UL Certified No. E209024.

Boost PFC SPM Modules

An advanced PFC Smart Power Module targeting high-power applications (3kW – 6kW).

Bridgeless PFC SPM Modules

An advanced PFC Smart Power Module targeting high-power applications (3kW – 6kW).
Fairchild Power Switch (FPS™) Controllers

The FSL1xx and FSL2xx series integrates PWM and SenseFETs, designed for high-performance Switch Mode Power Supplies (SMPS) with minimal external components.

Design Advantages:

- Avalanche rugged SenseFET (650V, 700V and 800V)
- Precision-fixed operating frequency and frequency jittering for attenuating EMI
- Advanced soft burst-mode operation for low standby power and lower audible noise
- No-load power consumption (FSL2xx):
  - <150mW at 265VAC without bias winding
  - <25mW or 50mW with bias winding
- Ultra-low operating current: 0.3mA (FSL2xx) and 1.8mA (FSL1xx)
- Protections: Over-Voltage Protection (OVP), Overload Protection (OLP), Output-Short Protection (OSP), Abnormal Over-Current Protection (AOCP) and Thermal Shutdown (TSD) with auto restart

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<th>( P_{\text{OUT}} ) (Max.) (W)</th>
<th>( R_{\text{DS(ON)}} ) (Max.) (( \Omega ))</th>
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AR: Auto Restart
Brushless DC/Permanent Magnet Synchronous Motor

With higher efficiency and reliability, lower acoustic noise and vibration as well as longer motor/battery life, the Brushless DC (BLDC) motor is being adopted in more and more designs. All of these motor enhancements are helping to meet consumer demands in motor applications. To align with this growing trend, Fairchild has developed the BLDC/PMSM controller—a mixed-signal integrated circuit to control variable speed, 3-phase (BLDC) and Permanent Magnet Synchronous Motor (PMSM) sensored motors.

Design Advantages:

- Fast implementation of BLDC and/or PMSM motor control without the burden of complicated software development
- Replaces complicated Digital Signal Processors (DSPs)
- Provides hardware implemented fault detection and protection features

FCM8201:
The FCM8201 has a SPI interface to allow greater configuration control via an MCU/DSP/FPGA; e.g. clock generator, PWM modes, DAC, ADC, OC timer, watchdog timer, dead time settings, error amp IP, etc.

FCM8202:
The FCM8202 is a stand-alone solution, no SPI port; therefore, no MCU/DSP/FPGA is required. The device configuration is controlled with the I/O pin settings; delivering the same external controls as the FCM8201.

Couple the BLDC/PMSM controller with the Smart Power Module (SPM®) motor driver for fast time-to-market and higher manufacturing reliability of your motor control designs.

Use the BLDC/PMSM controller in discrete motor drive implementations along with Fairchild's HVIC (High-Voltage Integrated Circuits) gate drivers, IGBTs (Insulated Gate Bipolar Transistors) and MOSFETs.
High-Voltage Gate Drivers (HVIC)

Fairchild’s HVICs improve system reliability with an innovative noise canceling circuit that provides excellent noise immunity. HVIC solutions save at least 50% PCB area compared to commonly used optocoupler-based or pulse transformer-based solutions. The industry-leading, high-side driver operation with negative $V_s$ swings, of up to -9.8V (at $V_{BS} = 15V$), protects the HVIC against negative noise. Competitive products must use an additional diode to provide this protection. These HVIC products feature the industry’s lowest quiescent currents for extremely low-power consumption, as well as the market’s lowest temperature dependency of electrical characteristics, guaranteeing stable operation in a wide range of applications.

**Design Advantages:**
- Variety of topologies: low-side, high-side, half-bridge and complete 3-phase in one package
- Full protection function with high ruggedness
- Shoot-through protection, over current protection, fault out, under voltage, etc.
- High noise immunity
- Better performance on positive, negative $V_B$ and positive, negative noise on $V_B$
- Wider $V_{IN}$ voltage range over competitor solutions

**Applications:**
- 3-phase motor inverter drivers
- Air conditioners, washing machines, refrigerators, dishwashers
- Industrial inverters – sewing machines, power tools

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Topology</th>
<th>$V_O$ Offst</th>
<th>$I_{O+}$/$I_{O-}$ (mA)</th>
<th>Input</th>
<th>Protection Functions</th>
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<td>350/650</td>
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<td>250/500</td>
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<td>2500/2500</td>
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<td>High-Side and Low-Side</td>
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<td>350/650</td>
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<td>UVLO ($V_{cc}/V_{dd}$)</td>
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<td>4500/4500</td>
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<td>UVLO ($V_{cc}/V_{dd}$)</td>
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<td>SOP-28</td>
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Short Circuit Rated IGBTs

For demanding applications where there is a possibility that the device will be subject to a short circuit condition, Fairchild offers a family of high-voltage driver IGBTs capable of withstanding a 10µsec output short circuit, under worst case power supply (V_{BB} = 150V, V_{CC} = 15V) and junction temperature, 150°C. These devices also feature low conduction loss and switching loss characteristics, making them ideal for high-speed applications. The SMD packages allow for IR reflow and wave solder assembly without delamination.

Design Advantages:
- Proven IGBT and FRD technology (whole adopting silicon is used in SPM® Modules)
- Support short circuit withstand time with high ruggedness (Figure 1)
- Included co-pack diode for free-wheeling path
- SMD packages require no delamination
- Fairchild’s IGBTs guarantee IR reflow and wave solder assembly

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<tr>
<th>Part Number</th>
<th>V_{CES}</th>
<th>I_{p} @ T_{C} = 100°C</th>
<th>V_{CES,Sat} @ T_{J} = 25°C</th>
<th>V_{p} @ T_{J} = 25°C</th>
<th>Co-pack Diode</th>
<th>Short Circuit Withstand Time** (µs)</th>
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* In Development
** Condition: V_{DS} = 350V, V_{CC} = 15V, R_{g} = 100Ω, T_{J} = 150°C

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<th>V_{p} @ T_{J} = 25°C</th>
<th>Co-pack Diode</th>
<th>E_{j} Typ. (mJ/A)</th>
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<td>√</td>
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** Field Stop II Technology
Note: For complete product portfolio visit http://www.fairchildsemi.com/search/tree/power-management/igbts/discrete-igbts/
Optocoupler Isolation for IGBT/MOSFET Gate Drivers

These IGBT/MOSFET gate driver optoelectronics complement Fairchild’s well-established offering in the discrete power IGBT/MOSFET line of products. Fairchild offers one-stop shopping for most integrated and discrete motor control devices. This combined solution of optocouplers and IGBTs/MOSFETs converts the mW to kW providing electrical isolation between the primary and secondary circuits.

**Design Advantages:**
- Wide operating voltage range: 10V to 30V
- High output current capability
- 5000V isolation voltage rating
- High common mode immunity, 3.5kV/us min.
- Low supply current (ICCH, ICCL)
- >8mm creepage and clearance distance
  - Lead spacing option “T”, through-hole, DIP packaging
  - Lead spacing option “TS”, surface mount, DIP packaging

### Optocoupler Isolation for IGBT/MOSFET Gate Drivers

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<th>$I_{UH}$ (Max.) (mA)</th>
<th>$I_{UU}$ (Min.) (A)</th>
<th>$I_{UH}$ (Max.) (mA)</th>
<th>PWD (Max.) (ns)</th>
<th>$V_{UVLO}$ (Typ.) (V)</th>
<th>$V_{UVHI}$ (Typ.) (V)</th>
<th>CMR (Min.) (kV/µs)</th>
<th>$V_{ISO}$ (Min.) (V)</th>
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Optocoupler Isolation for SPMs and HVICs

To prevent catastrophic failure of the motor drive and to meet safety regulatory standards, Fairchild offers 3.3V/5V high-speed logic gate optocouplers that provide isolation to Smart Power Modules (SPM®).

**Design Advantages:**
- Excellent noise immunity characterized by Common Mode Transient Immunity (CMTI) and Power Supply Rejection (PSR) specifications
- High bandwidth up to 25Mbps and 6ns pulse width distortion
- Dual supply voltages, 3.3V and 5V, enabling CMOS and level translation capabilities
- Electrical characteristics guaranteed beyond the full industrial temperature range (–40°C to +110°C)
- UL1577 (3,750 VAC RMS for 1 min) and DIN EN/IEC60747-5-2 certified for increased reliability

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Note: For complete product portfolio visit http://www.fairchildsemi.com/search/tree/optoelectronics/high-performance-optocouplers/high-speed-logic-gate/
Motion Control Design Tool Easily Calculates Power Losses and Temperature Changes

The Motion Control Design Tool assists in the selection of the optimum Fairchild Motion SPM® module for a specific application. This tool addresses three-phase inverter sinusoidal modulation for variable speed drive applications powering permanent magnet synchronous motor (PMSM) and AC induction motors. Part selection is based on a detailed entry of application specific I/O information. The program output includes module component losses, junction temperature increases, cooling requirements and junction temperature ripple at the motor/output frequency.

Flyback Design & Simulation in Minutes — at No Expense

Faster power supply designs—whether you are a power supply expert or not—are now a reality with Fairchild’s Power Supply WebDesigner (PSW). This online design and simulation tool takes your specifications and provides a complete Primary-Side Regulated (PSR) Flyback Converter or Secondary-Side Regulated (SSR) Flyback Converter design. You get a schematic, simulated verification, and bill of material in minutes. Fine-tune design parameters without a bench prototype, swap component choices and perform detailed simulations and analyses—all with the ability to confidentially save your design for future reference.

Fairchild’s Global Power Resources™ supports your designs with automated tools. For more information, visit www.fairchildsemi.com/design_tools
### PRODUCTS

**POWER MANAGEMENT**
- Advanced Load Switches
  - Advanced Current Limited Load Switches
  - Slew Rate Controlled Load Switches
- Backlighting Unit (BLU)
  - CCFL Inverter ICs
  - LED BLU Driver ICs
- Battery Management
  - Battery Charger ICs
  - Current Sensing
- Diodes & Rectifiers
  - Bridge Rectifiers
  - Diacs
  - Rectifiers
  - Schottky Diodes & Rectifiers
  - Small Signal Diodes
  - Transient Voltage Suppressors (TVS)
  - Zener Diodes
- Ground Fault Interrupt (GFI) Controllers
  - Ground Fault Interrupt (GFI) Controllers
- IGBTs
  - Discrete IGBTs
- MOSFET and IGBT Gate Drivers
  - All Drivers
  - 3-Phase Drivers
  - Half-Bridge Drivers
  - High-Side Drivers
  - Low-Side Drivers
  - Synchronous Rectifier Drivers
- MOSFETs
  - Discrete MOSFETs
  - Integrated Load Switches
  - MOSFET/Shottky Combos
- Motion Control
  - BLDC/PMSM Controller
  - SPM™ (Smart Power Modules)
  - PFc SPM™ (Smart Power Modules)
- Non-Isolated DC-DC
  - Charge-pump Converters
  - DiMOS FET plus Driver Multi-Chip Modules
  - Step-down Controllers (External Switch)
  - Step-down Regulators, Non-Synchronous (Integrated Switch)
  - Step-down Regulators, Synchronous (Integrated Switch)
  - Step-up Regulators (Integrated Switch)
- Off-Line & Isolated DC-DC
  - AC-DC Linear Regulators
  - Flyback & Forward PWM Controllers
  - Flyback & Forward PWM Controllers with Integrated MOSFET
  - LLC Resonant & Asymmetric Half Bridge PWM Controllers
  - LLC Resonant & Asymmetric Half Bridge PWM Controllers with Integrated MOSFETs
  - Primary-Side Regulation CV/CC Controllers
  - Primary-Side Regulation CV/CC Controllers with Integrated MOSFETs
  - Standard PWM Controllers
  - Supervisory/Monitor ICs
- Power Factor Correction
  - Continuous Conduction Mode (CCM) PFC Controllers
  - Critical/Boundary Conduction Mode (CBM/BCM) PFC Controllers
  - Interleaved PFC Controllers
  - PFC + PWM Combination (Combo) Controllers
- Transistors
  - BJTs
  - Darlings
  - Digital/Bias-Resistor Transistors
  - JFETs
  - RF Transistors
  - Small Signal Transistors
- Voltage Regulators
  - LDOS
  - Positive Voltage Linear Regulators
  - Negative Voltage Linear Regulators
  - Shunt Regulators
  - Voltage Detector
  - Voltage Stabilizer
  - Voltage to Frequency Converter
- ANALOG & MIXED SIGNAL
  - Amplifiers & Comparators
  - Comparators
  - Operational Amplifiers
  - Audio Amplifiers
  - Audio Subsystems
  - Audio Headphone Amplifiers
  - Audio Speaker Amplifiers
  - Digital Microphone Amplifiers
  - Battery Protection ICs
  - Battery Protection ICs

**APPLICATIONS**

**POWER MANAGEMENT**
- Advanced Load Switches
- Backlighting Unit (BLU)
- Battery Management
- Diodes & Rectifiers
- Ground Fault Interrupt (GFI) Controllers
- IGBTs
- MOSFET and IGBT Gate Drivers
- MOSFETs
- Motion Control
- Non-Isolated DC-DC
- Off-Line & Isolated DC-DC
- Power Factor Correction
- Transistors
- Voltage Regulators
- ANALOG & MIXED SIGNAL

**APPLICATIONS**

**POWER MANAGEMENT**
- Advanced Load Switches
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**OTHER PRODUCTS**

**LIGHTING ICs**
- Fluorescent Lamp ICs
  - HID ICs
  - LED Lighting ICs
  - Portable LED Drivers

**OPTOELECTRONICS**
- High Performance Optocouplers
  - High Speed Logic Gate
  - High Performance Transistor
  - Low Voltage, High Performance
  - Specific Functions

**IGBT/MOSFET Gate Drivers**
- IGBT/MOSFET Gate Drivers

**INFRARED**
- Ambient Light Sensors
  - Emitting Diodes
- Optical Interrupt Switches
  - Photo Sensors
  - Photo Sensor – Transistors
- Reflective Sensors

**Phototransistor Optocouplers**
- Isolated Error Amplifier
  - Photo Darlington Output
  - Phototransistor Output - DC Sensing Input
  - Phototransistor Output - AC Sensing Input

**TRIAC Driver Optocouplers**
- Random Phase TRIAC Driver
  - Zero Crossing TRIAC Driver

**AUTOMOTIVE PRODUCTS**
- Automotive Discrete Power
  - Automotive Ignition IGBTs
  - Automotive IGBTs
- Automotive N-Channel MOSFETs
  - Automotive P-Channel MOSFETs
  - Automotive Rectifiers

**AUTOMOTIVE Gate Drivers**
- High Voltage Gate Drivers
  - Automotive Smart Power Switches

**CIRCUIT PROTECTION**
- Reverse Polarity Protection
  - Blocking Diodes
  - Reverse Bias Protection Switches
  - Schottky diodes

**Transient Voltage Suppressors (TVS)**
- Mid Power TVS
  - Power TVS (≤ 400W)