Total Motion Control Solutions

Sensitron offers an extensive line of integrated COTS Motor Control products designed to meet your motor control needs, or to be tailored for your specific requirements while meeting your time-to-market and cost objectives. Sensitron’s brushless motor control expertise extends the usefulness of electronic technologies, bridging the gap between semiconductor devices and their system usage.
Motor Controller Product Integration

Sensitron has heritage in over two decades of motion, from packaged devices to hybrids and modules -

- 1990’s
  - Packaged Fets & IGBT Discretes
  - Dual MOSFET Modules
  - Hermetic Cryo Coolers
- 2000’s
  - IGBT and MOSFET Drives
  - 800A IGBT Module
  - Fully Integrated Hermetic Motor Controller
- 2010’s
  - Open Frame Module Controllers
  - 3-Phase Field Oriented Controller
  - Dual Axis Motor Control System
  - 3-Phase Half Bridge High Current Hermetic IGBT Module
  - Integrated heat sink H-Bridge

Markets
- Aircrafts, Helicopters
- UAV, UMG
- Ground Vehicles
- Off-Road Vehicles
- Ships
- Missiles

Applications
- Cooling Fans and Air Handlers
- Pneumatic and HVAC Compressors
- Position Control
- Elevation Position Control

Standards
- MIL-STD-1275
- MIL-STD-704
- MIL-STD-461
- MIL-STD-810

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Page 3
Digital Speed/Torque Controllers

Features/Benefits

- Sinusoidal Drive – lower distortion, smoother torque
- Field Oriented Control with Space Vector PWM
- Program for Speed, Torque, or Sensorless applications
- Top speed over 70,000 RPM (4 pole)
- Re-configurable firmware
- GUI Interface configures controller and motor parameters
- Isolated RS-232 Interface. Larger modules also have CAN, RS485/422
- Telemetry – reports current, speed, motor & bus voltages, baseplate temperature
- -55°C to +85°C baseplate, operating temp range
- 1500Vdc pin to case isolation
- Evaluation boards available for quick testing

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Operating DC Bus Supply Voltage</th>
<th>Absolute Peak DC Bus Voltage</th>
<th>RMS Output Motor Current</th>
<th>Peak Over Current Shutdown Protection</th>
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Configuration Utility

Utilizing the application information, this motor controller can be configured for specific motor control systems with little to no impact on hardware.

Features/Benefits

- Decreases design time by over 50%
- Excel-based software with motor drive GUI
- GUI controls motor and modifies parameters
- Built-in data logger
- Popup explanations for most fields

The Sensitron Advantage

Flexibility of this design allows for use of a single device/part number for multiple motor applications with few hardware changes.

Size 1 Pkg
Package Size: 3.10” x 2.10” x 0.385”
Weight: 3.0 oz

Size 2 Pkg
Package Size: 3.59” x 1.55” x 0.80”
Weight: 5.0 oz

Size 3 Pkg
Package Size: 3.70” x 2.90” x 0.80”
Weight: 13.0 oz

Open Frame Pkg
Package Size: 2.50” x 2.10” x 0.65”
Weight: 1.0 oz

Best used in high reliability military and industrial motor control applications.
3-Phase / BLDC Motor Controllers

Features/Benefits
- Tach output voltage with average output proportional to speed
- Direction input to control motor direction
- Programmable cycle by cycle current limiting
- Enable/Disable input and cycle-by-cycle current limit
- Analog, no software certification needed

The SMC6 Series is best used as two quadrant speed controller for fans, pumps, & motors

Speed/Velocity Controllers, SMC6 Series

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Operating DC Bus Supply Voltage</th>
<th>Absolute Peak DC Bus Voltage</th>
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**Integrated Motor Control Assemblies**

3-Phase Brushless DC Motor Controller with EMI Filter/Power Supply

**Features/Benefits**

Includes all features of the SMC or SMCV Series, plus:

- Fully integrated 3-phase BLDC motor controller
- EMI filter and auxiliary power supply
- Nominal 40A with maximum bus voltage of 50Vdc
- Small package: 3.84” x 4.19” max x 1.24” max
- Light weight: 20 oz.
- Intended for UAV, aircraft and military applications
- Rugged design intended to drive fans, pumps, compressors

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**Open Frame Module**

**Features/Benefits**

- Substantial weight and cost savings, easy connections
- SMC, SMCS, and SMCV types are available in this form factor
- P suffix option has 4x 0.050” pins for each power connection
- Small Package: 2.50” x 2.10” x 0.65”
- Very Lightweight: 1 oz

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**Intelligent Power Modules**

Sensitron’s SPM Series of Intelligent Power Modules feature MOSFET Drivers up to 600V/150A and IGBT Drivers up to 1200V/120A. These standard off-the-shelf modules have DC bus and control optical isolation, with sensing and shutdown features that surpass industry standard drivers.

**The Sensitron Advantage**
*Standard off-the-shelf product with a wide voltage and current range containing sensing & shutdown features not widely available in industry standard drivers*

### Features/Benefits
- Module includes FETs/IGBTs and drivers, protection and monitoring
- 100V to 1200V Max voltage
- Current ratings from 20A to 150A
- -40°C to 150°C operating temp
- Most have isolated signal I/O
- Most report baseplate and dc link current with analog signals
- The high current modules (>100A):
  - Provide a differential signal for each phase current
  - Include a brake switch and pin for an external brake resistor

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<th>OCP</th>
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Power Bridges with Advanced Lightweight Packaging

Sensitron’s modules with advanced packaging have superior temperature cycling resistance and lower overall weight compared to traditional copper base plate modules. These composite materials are specifically engineered to have a coefficient of thermal expansion (CTE) that is similar to ceramic and silicon materials, which is commonly used in power modules, while maintaining a high thermal conductivity. These two desirable properties allow these modules to efficiently dissipate power losses over the entire lifetime of the module.

Three Phase IGBT or MOSFET Bridges with SiC diodes

Features/Benefits

- Lightweight, fully isolated package
- 600V & 1200V, 15A to 150A
- -65°C to 150°C or 175°C
- Options for integrated gate resistors, brake switches, brake resistors, thermistors
- Superior fatigue resistance & superior temperature cycling
- Integrated G-E & G-S resistors for higher ESD immunity
- Integrated brake resistor with direct heat transfer to base
- RTD to monitor module temperature

Three Phase IGBT Bridge with Brake IGBT plus Three Phase Bridge Rectifier with Inrush SCR

Features/Benefits

- 1200V, 150A, three-phase IGBT bridge
- 1200V, 133A SCR input bridge w/63A diodes (P/N: SCM1001)
- 1200V, 32A SCR for half-controlled bridge w/80A diodes (P/N: SHM1001)
- Upper and lower regenerative brake IGBT switches
- Use of latest 4th generation IGBTs & diodes to minimize total losses
- AlSiC baseplate for high temperature cycling capability
- Low profile, light weight package with near-hermetic construction
- Leapfrog device in the Bridge Market
Custom Assemblies

3-Phase Open Frame BLDC Motor Control w/ EMI Filter
- 400HZ 3 phase input driver, output to 10A peak
- Hall sensor commutation, with 6 pulse 3 phase output drive
- Locked rotor operation and protection, 25 RPM to 5000 RPM closed loop operation
- 12 Pole motor operation with internal tach
- MIL-STD-704 and MIL-STD-461 compliant

Power Conditioning Module & Motor Control, PCM Series
- 400HZ, 3 phase AC rectifier, available from 100V/80A to 1200V/42A
- 500V, 100 joules active bus voltage clamping
- Isolated 28V, 28W auxiliary converter with storage capacitors
- In rush current limiting
- MIL-STD-704 Compliant, EMI filter meets MIL-STD-461

3-Phase Bridge IGBT Hybrid
- 600V, 150Amps in a space qualified hermetic package
- Low CTE
- Moly/copper base plate
- Very large, 4.3” x 2.9” package
- MIL-PRF-38534 and MIL-STD-883 Compliant

High Current Half Bridge IGBT Module
- 600V, 1000A in a hermetic core construction
- Increased creepage and clearance distances for high altitude operation
- High frequency switching
- Operation at temperature extremes
- Internal layout with minimized stray inductances

High Performance Cryogenic Cooler Temperature Controller / Driver
- Designed to be compatible with a 1/3W cryogenic cooler
- Converts standard 28VDC aircraft power to AC out
- Operating input voltage 17VDC to 33VDC
- Operating temperature range -54°C to +100°C continuous operation case temperature
Evaluation Boards

Features/Benefits
- Fast product evaluation
- Rapid prototyping and system integration testing
- Offer Evaluation Boards and FAE support
- Offer higher level assemblies by leveraging on evaluation cards
- Stackable daughter boards for other communication options
- Evaluation board design information available to aid customers’ assembly design

Advanced Thermal Capabilities

Heat Sink Features/Benefits
- Passive and active heatsinks/exchangers
- Highly integrated baseplate for rugged environments
- Conduction and convection cooling schemes
- Numerical simulation methods and analysis-based design
- Electrical operations up to 175 degrees Celsius
- COTS and purpose-built options

Integrated Cross-Hatched Heatsink
- High transient power capability
- Very compact package
- Low thermal resistivity
- Multilayer structure capable
- Integrated, cross-hatched heat sink for greater efficiency and installation versatility

Integrated Module and Heatsink Assemblies
- Module operation temperature above 130°C
  - Pin fin heatsink base for silicone cooling
  - No-flow / start-up operation capability
- Integrated heat sink with membrane and gasket inserts
  - Uniformly distributed coolant flow
  - Light, multi-piece design
- Complete design analysis:
  - Computational Fluid Dynamics Analysis
  - Pressure Drop Computations
  - Conjugate Heat Transfer Analysis
  - Steady-State / Transient Thermal Computations
  - Stress Analysis (Thermal Stress and Burst Pressure)

Lightweight Packaging Technology
- Lower profile and light weight
- Lowest possible thermal resistance
- Higher temperature applications
- Lower cost
- Automation friendly
Lightweight Packaging Technology

Sensitron's Advanced Baseless Packaging Technology is a cost effective packaging solution that generates maximum weight savings with high thermal conductivity and fatigue resistance. Sensitron is positioned as a world leader in the advanced technology industry, with products that are designed, manufactured, tested, and qualified for high reliability applications where size, weight, and reliability are critical to mission success. From engineering design to finished product, our advanced simulation and modeling tools enable us to provide you with innovative product to meet your power solution requirements.

**Product Features**
- Lower profile and light weight
- Lowest possible thermal resistance
- Higher temperature applications
- Removes CTE mismatch between substrate & baseplate
- Higher reliability
- Lower cost
- Automation friendly

**Typical Applications**
- Aircraft Power Electronics
- Severe Environment
- Weight Sensitive Applications
- Long Cycle Life

**Performance Options**
- Low cost (Alumina)
- High thermal conductivity (Aluminum Nitride)
- High Strength (Silicon Nitride)

### Attribute Comparison by Compositon

<table>
<thead>
<tr>
<th></th>
<th>Advanced Baseless Packaging Technology</th>
<th>Copper Baseplate</th>
<th>AISIC Baseplate</th>
<th>Aluminum Baseplate</th>
<th>IMS Technology (Al)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal Performance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal resistance index</td>
<td>0.4</td>
<td>1.0</td>
<td>1.1</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Max usable temperature</td>
<td>200°C</td>
<td>150°C</td>
<td>150°C</td>
<td>150°C</td>
<td>150 °C</td>
</tr>
<tr>
<td>Fatigue resistance</td>
<td>superior</td>
<td>fair</td>
<td>good</td>
<td>poor</td>
<td>excellent</td>
</tr>
<tr>
<td>Flatness (per inch)</td>
<td>&lt;=0.003</td>
<td>&gt;=0.005</td>
<td>N/A**</td>
<td>&gt;= 0.005</td>
<td>&gt;= 0.005</td>
</tr>
<tr>
<td>Cost factor</td>
<td>$</td>
<td>$$$$</td>
<td>$$$$$</td>
<td>$$</td>
<td>$$</td>
</tr>
<tr>
<td>Weight index</td>
<td>0.2</td>
<td>1.0</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Typical package height (for a comparable module)</td>
<td>0.2 inch</td>
<td>0.325 inch</td>
<td>0.37 inch</td>
<td>0.325 inch</td>
<td>0.325 inch</td>
</tr>
</tbody>
</table>

**Bottom surface of AISiC baseplates is normally designed to have curvature.**
Product Development Equipment

- 4 Dual quadcore simulation workstations
- Dukane ultrasonic welder
- SST DAP sealer
- SSEC seam welder
- Sonix ultrasonic scanner
- BTU belt reflow furnaces
- Orthodyne 360 fully automatic wirebonder
- K&S 4526 semi-automatic wirebonder
- Dage bond pull tester
- Polaris percussion welder
- Trebor eutectic die bonder
- Trebor epoxy pick & place
- K&S semi-automatic pick & place
- ESPEC thermal cycling machine

Software Tools

- AutoCAD 2005
- Inventor 9
- Solidworks 2010
- Design Modeler
- ANSYS Mechanical v.13
- CFX v.13
- MTBF Computational Tool
- Relex Architect 2008

Mathematical Tools

- MathCAD 14
- Visual Basic
- APDL
- C++
- Origin 8.1
- Rapid Prototyping Tool
- ZCorp 3D Plus

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About Sensitron: Sensitron is a leading manufacturer of high reliability power electronic solutions including motor controllers, diodes, smart power management and conversion, voltage protection components and embedded boards, with over 40 years heritage serving space, aerospace, and defense markets.