On-Board Charger (OBC) APM16
APM Solutions for Automotive xEV

- **OBC (On-Board Computer)**
  - APM16 (650V)

- **HV DC-DC Converter**
  - APM16 (650V)

- **Traction Inverter**
  - SSDC (750V/800A): DSC (750V):

- **HV E-Compressor**
  - ASPM27 (650V/50A)
  - ASPM34 (1200V/25A)
  - ASPM34 (1200V/35A)
  - ASPM34 (1200V/10A)
  - ASPM27 (600V/40A)
  - ASPM27 (600V/50A)
  - ASPM16 (750V/75A)
  - ASPM27 (600V/30A)

- **HV Supercharger**
  - ASPM27 (650V/50A):

- **EPS (Electric Power Steering)**
  - APM7, 11 (40V)
  - APM20 (40V)

- **48V BSG/ISG (Battery-Synchronous Generator/Intelligent Silent Generator)**
  - APM17M

- **Battery Cooling Fan**
  - ASPM27 (650V/50A)
  - SIP-23 (40V/20A)

- **BRAKING**
  - APM20 (40V)

- **HV Oil Pump**
  - ASPM27 (650V/50A)
  - SIP-23 (40V/20A)

- **48V DC/DC Converter**
  - APM19 (80V)

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**Public Information**

APM – Automotive Power Modules
ASPM – Automotive Smart Power Modules (Integrated Gate Driver)
APM Performance benefits

[ Thermal Performance ]

Lower Rthjs of APM => Lower Tj => Lower Rdson => Higher Power Density => Compact Size

Simulation Block Diagram

Highly optimized thermal performance  →  APM can reach Rthjs << 1 K/W

[ Electrical Performance ]

• Lower circuit resistance (i.e., double the number of wire bonds comparing with standard discrete package) allows customer to provide higher torque output
• Reduced stray inductances as a result of physical proximity of the devices
• Better dynamic and EMI performance
• High Isolation Voltage saving additional insulation layer
Benefits of ON Semiconductor Power Modules (APM)

Electrical Performance
- High Current Capability
- Low Inductance
- Low Resistance
- EMI performance by snubber
- HV Isolation inside

Proven Reliability

Power Density ——— Cost

Low Thermal Resistance Junction to Heat sink

Smaller foot print

System Cost
- APM
- Discrete
- Quality Cost
- Discrete / Passive Cost
- Metal PCB
- Performance Cost

Fab + Assembly Total Solution

Customer

Public Information
APM Performance benefits

[ Thermal Performance ]

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Simulation Block Diagram

Highly optimized thermal performance → APM can reach Rthjs << 1 K/W
APM Design benefits

- Smaller system, smaller housing
- More compact layout
- Thermistor, shunts, passive components and power interconnections inside of the module
- Higher current density
- Better utilization of MOSFET Die due optimized thermal path (~30%)
- Smaller PCB area possible
- Lower total resistance, high efficiency

- Fully tested and optimally matched power circuit.
- Minimize assembly points and defect rate.
- Reduced system failure rate at the end customer
- Reduced number of components – Quality control cost reduction
- Simplified assembly
- Bus bar saves high current on PCB

- Lower SYSTEM LEVEL COST
  - PCB, housing and system volume reduction.
  - No high currents on PCB
  - Integrated electrical isolation
  - Simplified and smaller thermal interface
  - Increased Yield and Productivity

Half the size of discrete solution
APM16 vs. 4x TO247!
HV OBC & DC/DC Modules

**Features**

- One package outline covers multiple circuit configurations
- Automotive qualified per AECQ101 and AQG324
- Ceramic substrate option - AlN or Al2O3: Low junction-sink thermal resistance
- Pb Free

**Specifications**

<table>
<thead>
<tr>
<th>Part number</th>
<th>Silicon</th>
<th>Voltage</th>
<th>Rating</th>
<th>Tj rating</th>
<th>Substrate</th>
<th>Config</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAM65HR51DS2</td>
<td>SFIII</td>
<td>650V</td>
<td>51mΩ max @25C</td>
<td>55C/150C</td>
<td>Al2O3</td>
<td>H-Bridge</td>
</tr>
<tr>
<td>FAM65CR51DZ2</td>
<td>SFIII</td>
<td>650V</td>
<td>51mΩ max, @25C</td>
<td>-55C/150C</td>
<td>Al2O3</td>
<td>PFC</td>
</tr>
<tr>
<td>FAM65RO30DS1/2</td>
<td>Si</td>
<td>650V</td>
<td>1.2V, 60ns and 30A @Tj=25C</td>
<td>-55C/150C</td>
<td>Al2O3</td>
<td>Bridge Rect.</td>
</tr>
</tbody>
</table>
Automotive Module Based OBC Demo

Design Features

- AQG324 Qualified APM to reduce PCB space and size.
- 2CH Interleaved PFC for higher efficiency and power density.
- Full bridge LLC to boost efficiency by high bus voltage usage.
- Flyback topology to supply auxiliary power.
- Hardware PFC and LLC control for improved fault modes.
- Fully functional solution including input/output current/voltage sensing and CC/CV PWM control interface.

Circuit configuration

Control configuration
## OBC Design Details Description

<table>
<thead>
<tr>
<th>Component featured</th>
<th>Control features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part number</strong></td>
<td><strong>PFC Controller FAN9672</strong></td>
</tr>
<tr>
<td>FAN9672Q</td>
<td>• Continuous Conduction Mode with Average Current Mode Control</td>
</tr>
<tr>
<td></td>
<td>• Two-Channel Interleave Operation</td>
</tr>
<tr>
<td></td>
<td>• Programmable Operation Frequency Range: 18 kHz<del>40 kHz or 55 kHz</del>75 kHz</td>
</tr>
<tr>
<td></td>
<td>• Programmable PFC Output Voltage, UVLO, Soft-start</td>
</tr>
<tr>
<td></td>
<td>• Two Current-Limit Functions</td>
</tr>
<tr>
<td></td>
<td>• TriFault Detect™ Protects Against Feedback Loop Failure</td>
</tr>
<tr>
<td>FAN7688SJX</td>
<td><strong>LLC Controller FAN7688</strong></td>
</tr>
<tr>
<td>NCV3843B</td>
<td>• Secondary Side PFM Controller for LLC Resonant Converter with Synchronous Rectifier Control</td>
</tr>
<tr>
<td></td>
<td>• Charge Current Control for Better Transient Response and Feedback Loop Design</td>
</tr>
<tr>
<td></td>
<td>• Adaptive Synchronous Rectification Control with Dual Edge Tracking</td>
</tr>
<tr>
<td></td>
<td>• Closed Loop Soft-Start for Monotonic Rising Output</td>
</tr>
<tr>
<td></td>
<td>• Wide Operating Frequency (39 kHz ~ 690 kHz)</td>
</tr>
<tr>
<td></td>
<td>• Green Functions to Improve Light-Load Efficiency</td>
</tr>
<tr>
<td></td>
<td>• Protection Functions: OCP, OVP, OTP, VCC-UVLO, overload, all with Auto-Restart</td>
</tr>
<tr>
<td></td>
<td>• Wide Operating Temperature Range -40°C to +125°C</td>
</tr>
<tr>
<td>FAN3224TUMX-F085</td>
<td><strong>PWM Controller NCV3843</strong></td>
</tr>
<tr>
<td>NCV890100PDR2G</td>
<td>• Trimming Oscillator, Frequency Guaranteed at 250 kHz</td>
</tr>
<tr>
<td>NCV51460SN33T1G</td>
<td>• Current Mode Operation to 500 kHz</td>
</tr>
<tr>
<td>NCV210SQT2G</td>
<td>• Automatic Feed Forward Compensation</td>
</tr>
<tr>
<td>NCV2003SN2T1T</td>
<td>• Latching PWM for Cycle-By-Cycle Current Limiting</td>
</tr>
<tr>
<td>SC431AVSNT1G</td>
<td>• Internally Trimming Reference with Undervoltage Lockout</td>
</tr>
<tr>
<td>FODM8801C</td>
<td>• High Current Totem Pole Output</td>
</tr>
<tr>
<td></td>
<td>• Low-startup/operating current, UVLO with Hysteresis</td>
</tr>
</tbody>
</table>

### Part number
- **FAN9672Q** - PFC controller
- **FAN7688SJX** - LLC controller
- **NCV3843B** - PWM controller
- **FAN3224TUMX-F085** - Low-side gate driver
- **NCV890100PDR2G** - Buck mode switching regulator
- **NCV51460SN33T1G** - Precision voltage reference
- **NCV210SQT2G** - Current sense amplifier
- **NCV2003SN2T1T** - Precision operational amplifier
- **SC431AVSNT1G** - Precision voltage reference
- **FODM8801C** - Opto-coupler
### Vs discrete solution

<table>
<thead>
<tr>
<th>Vs discrete solution</th>
<th>APM Module</th>
<th>Discrete Components</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB Layout Design</td>
<td>✓ Simple</td>
<td>Complex</td>
<td>By using integrated power module;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Circuit design can be more compact</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Save the materials including device</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>housing, clip heat sinks, insulation materials and interconnections</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>wires resulting in overall cost reduction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Based on the excellent high thermal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>performance junction to sink, Optimum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>cooling route can be designed which</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>improve overall system efficiency than</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>the system based on the discrete.</td>
</tr>
<tr>
<td>Manufacturing Process</td>
<td>✓ Simple</td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td>Converter Size / Weight</td>
<td>✓ Smaller / Lighter</td>
<td>Larger / Heavier</td>
<td></td>
</tr>
<tr>
<td>Noise Immunity (EMC)</td>
<td>✓ Improved circuit pattern &amp; Snubber</td>
<td>Weak (Complex PCB pattern)</td>
<td></td>
</tr>
<tr>
<td>High voltage isolation</td>
<td>✓ HV isolation inside the module</td>
<td>Need additional isolation layer</td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance – junction to case</td>
<td>✓ Lowest</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td>Cooling Efficiency</td>
<td>✓ Low</td>
<td>Complex cooling route design required</td>
<td></td>
</tr>
</tbody>
</table>

### Vs Other Power modules

<table>
<thead>
<tr>
<th>Vs Other Power modules</th>
<th>APM Module</th>
<th>Case Module</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>✓ Highest (Thermal stress, Mechanical &amp; Vibration)</td>
<td>Lower than APM</td>
<td>• Transfer molded ON’s APM module solution whose high reliability</td>
</tr>
<tr>
<td>Converter Size / Weight</td>
<td>✓ Smallest / Lighter</td>
<td>Larger and Heavier</td>
<td>performance was proven in automotive field since 2008, can provide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>than APM</td>
<td>much lighter and compact solution than gel filled case module.</td>
</tr>
</tbody>
</table>