High Side Intelligent Power Switches for Automotive Applications

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freescale™
Abstract

• Freescale’s intelligent high side switches are designed to control a wide variety of loads in automotive and industrial systems. This presentation describes Freescale’s high side switch portfolio and roadmap, device features, considerations for their use, potential applications and available design and support tools.
## Common Loads in 12V Systems

<table>
<thead>
<tr>
<th>Application</th>
<th>Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>Halogen &amp; incandescent lamps, LEDs, Xenon HID, …</td>
</tr>
<tr>
<td>DC motor</td>
<td>Fuel pump, wiper, fan, …</td>
</tr>
<tr>
<td>Solenoid</td>
<td>Xenon shutter, relay coil, …</td>
</tr>
<tr>
<td>Resistor</td>
<td>0² heater, seat heater, …</td>
</tr>
<tr>
<td>Power Distribution</td>
<td>Other modules or subcircuits</td>
</tr>
</tbody>
</table>

*Images of a fuse box, a fuel pump, and a body lighting module.*
What is an eXtreme Switch?

- A **SmartPower** device is a Power IC with some digital content. It interfaces between an MCU and a load.
- “eXtreme Switch” is Freescale’s brand name for high current “SmartPower”.
- The eXtremeSwitch limit of the load current is 2A-30A DC and 150A transient. Loads are mostly bulbs, but also DC motors, solenoids or submodules.
- eXtremeSwitch devices are available for:
  - **12V systems** (45V technology): Lighting, “Main switch”, DC motor control
  - **24V systems** (65V technology): General purpose switch for trucks, buses and special engines
- A **dual chip solution in a package is the most optimized (cost) for such current (so far)**.
- Technologies used are **SmartMOS (SM8MV) + Vertical Power MOSFET (HD5→Lfet) + Package (PQFN → SOICep)**

![32-pin SOICep](image1)

![12 mm by 12 mm PQFN](image2)
eXtreme Switch Composition

SMARTMOS™

- Protection and diagnostic
  - Short circuit
  - Reverse battery
  - Loss of ground/ Vbat
  - Energy discharge protection
  - Over temperature (175°C)
  - Over current shutdown
  - Over/under voltage

- SPI Interface
  - Easy connection to the uP
  - Programmability
  - Daisy chain using SPI
  - Programmable over current trip level
  - Watchdog
  - Embedded PWM module

Vertical Power stage

- Best-in-class Technology
  - Planar HD5 and TrenchFet LFET
  - 45V & 65V BV

- Protection in the power stage
  - Temperature sensor
  - Current sensor
  - Voltage sensor (Gen4)

Power package

- PQFN low cost power package
  - 0.5 mm thick lead frame
  - Die soldered attached
  - $R_{thj-c} < 0.5 \degree C/W$

- SOICeP32 and 54
  - Designed for high power
  - Large al wire capability
  - Pb-free compliancy
eXtreme Switch System Protection Features

- Load short-circuit (100mΩ)
- Over voltage
- Over temp
- Under voltage
- Load Shorted to Battery
- Open load OFF – ON – LED
- Current sense high precision
- Automatic PWM
- Up to 36V
- SPI
- Fault Mgmt.
- Simplified SW
- Overload

System Diagnostic
- Open load ON – OFF – LED
- Load Shorted to Battery
- Current sense

Switch Protection
- Over temp
- Ground loss
- Reverse Battery

System Protection
- Over-under voltage
- Module output short-circuit
- Load short-circuit
- Overload

Module output short-circuit (20mΩ)

loads

Ground loss

Over temp

Under voltage

Load Shorted to Battery

Open load OFF – ON – LED

Current sense high precision

Automatic PWM

Load short-circuit (100mΩ)
# eXtreme Switch Features and Benefits

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest Rdson in thermally enhanced package</td>
<td>Best thermal efficiency for 30% smaller footprint and best module longevity with 30% lower power dissipation</td>
</tr>
<tr>
<td>Programmable dynamic threshold over-current and over-temperature detection limits</td>
<td>Optimized fault protection</td>
</tr>
<tr>
<td>Accurate temperature (±5 °C) and synchronous / asynchronous current (±10%) sensing</td>
<td>Advanced load diagnostics</td>
</tr>
<tr>
<td>Compatible devices and flexible load management from high current (HID, 65W lamps) to low current LEDs</td>
<td>Hardware reuse across multiple applications and quick-turn flexibility for tuning designs with ambiguous load requirement</td>
</tr>
<tr>
<td>Programmable fault auto-retry</td>
<td>Auto recovery for transient faults</td>
</tr>
<tr>
<td>Watchdog and protected output in failsafe mode</td>
<td>Ready for an SIL-B compliant module design</td>
</tr>
<tr>
<td>Selectable slew rate</td>
<td>Optimize EMI vs. efficiency tradeoff</td>
</tr>
<tr>
<td>Individually programmable internal/external PWM signals</td>
<td>Offloads MCU for software design simplicity &amp; PPM reduction</td>
</tr>
<tr>
<td>16-bit daisy chainable SPI control</td>
<td>BOM component &amp; cost savings by eliminating series SPI resistors between MCU and device</td>
</tr>
</tbody>
</table>
**SmartPower Benefits**

**SmartPower** device is a Power IC with some digital content. It interfaces between an MCU and a load.

“eXtreme Switch” is Freescale’s brand name for high-current “SmartPower”.

Why use SmartPower devices instead of relays?

- **Simple & Robust Design**: Self protection, diagnostic features
- **Switching Capability**: PWM capability, EMC, di/dt and dv/dt control
- **Power Dissipation**: Standby current few µA, No relay coil driver losses
- **Integration**: Lighter weight, smaller systems
Analog Power Operations Product Roadmap
24V & 12V eXtreme Switch Family

24V High-Side
Smart Switches
Trucks, Large Vehicles & Industrial
- SPD20B_24V Dual 20mΩ
- SPD10B_24V Dual 10mΩ
- SPD06B_24V Dual 6mΩ

Dual 22mΩ, eSOIC
Dual 50mΩ, eSOIC
Next Generation
Enhanced Features
Lower Cost

12V High-Side
Smart Switches
Automobiles
- MC10XS3425 Dual 10mΩ Dual 25mΩ
- MC07XS3200 Dual 7mΩ
- MC07XS6517 Triple 7mΩ, Dual 17mΩ
- MC17XS6500 Penta 17mΩ

Gen4 Portfolio Expansion
Quad 17mΩ
Dual 8mΩ, Dual 21mΩ
Penta 40mΩ
Triples 10, 25mΩ
Duals 10, 25mΩ

Released
2013
2014
2015
1Q 2Q 3Q 4Q 1Q 2Q 3Q 4Q 1Q 2Q 3Q 4Q

Proposal
Planning
Execution
Production
Left Edge: First Sample Date
Right Edge: Product Qualification
## eXtreme Switch Target Applications
### Auto External Lighting

<table>
<thead>
<tr>
<th>Family</th>
<th>Product</th>
<th>Primary output</th>
<th>Secondary output</th>
<th>H1, H3, H4, H7, H9</th>
<th>Xenon HID</th>
<th>P27W, P21W, P21W+R10W, P21W+R5W</th>
<th>LED-arrays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gen3</td>
<td>MC15XS3400</td>
<td>4.15 mΩ</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
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<td>MC35XS3500</td>
<td>5.35 mΩ</td>
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<tr>
<td>Gen3L</td>
<td>MC09XS3400</td>
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<td>MC10XS3200</td>
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<td>MC07XS3200</td>
<td>2.7 mΩ</td>
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<td>X</td>
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<tr>
<td>Gen4</td>
<td>MC07XS6517</td>
<td>3.7 mΩ, 2.17 mΩ</td>
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<tr>
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<td>5x17mΩ</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- The customer is looking for integration
- The customer is willing to have a single module capable of driving either LED (low current) or standard lamp (high current) on the same output
Gen4 Lighting Demo Board

Power supply

Switch

Fuse (30A/20A/10A)

55W/60W  21W/5W

10W

LED

Gen4

MC33903D

S12G128

RS232 communicated with PC
GUI Introduction

4 parts SO status

Select SO register and part ID

Turn on 4 parts by duty cycle

Reset 4 GEN4 parts

Auto display Select the IC number

Sending SPI manual

Click the round then Iout chart enable, it is better to display 1 chart. maybe wrong when more than 2 charts display enable