High Side Intelligent Power Switches for Automotive and Industrial Applications

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Abstract

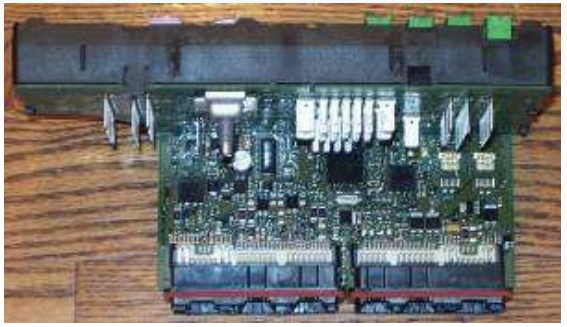
- Freescale's intelligent high side switches are designed to control a wide variety of loads in automotive and industrial systems. This presentation describes Freescale's high side switch portfolio and roadmap, device features, considerations for their use, potential applications and available design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

Outline

1. Low Voltage Loads and their System Requirements
2. Freescale's Technology Solutions
3. Freescale's Product Solutions for 12V and 24V Systems
4. Device Features
5. Ecosystem and Design Support

Common Loads in 12V Systems

Application	Loads
Lighting	Halogen & incandescent lamps, LEDs, Xenon HID, …
DC motor	Fuel pump, wiper, fan, …
Solenoid	Xenon shutter, relay coil, …
Resistor	0^2 heater, seat heater, …
Power Distribution	Other modules or subcircuits



Fuse Box

Body / lighting

Fuel Pump (MC33981)

4A / 36V eXtreme Switch Industrial Target Applications

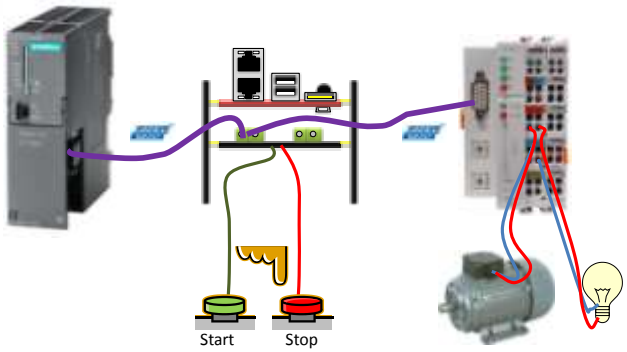
Up to 36V operating voltage

DC Motors

- Electric doors
- Wiper
- Washer pump
- Machine inspection
- Vending machines
- HVAC
- Hospital bed controller

Inductive loads

- Solenoids
- Water and fluid control app
- Valve controllers for thermostats
- Home Automation system



Factory Automation

- PLC
- Low end robotic
- Industrial printing systems
- POS terminals

Lighting loads

- Xenon
- Halogen
- Incandescent
- LEDs

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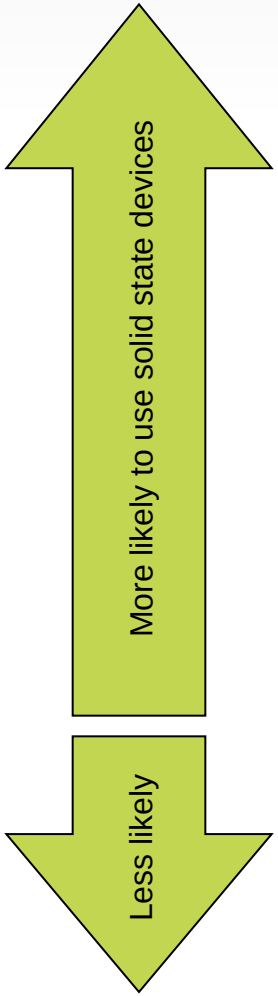
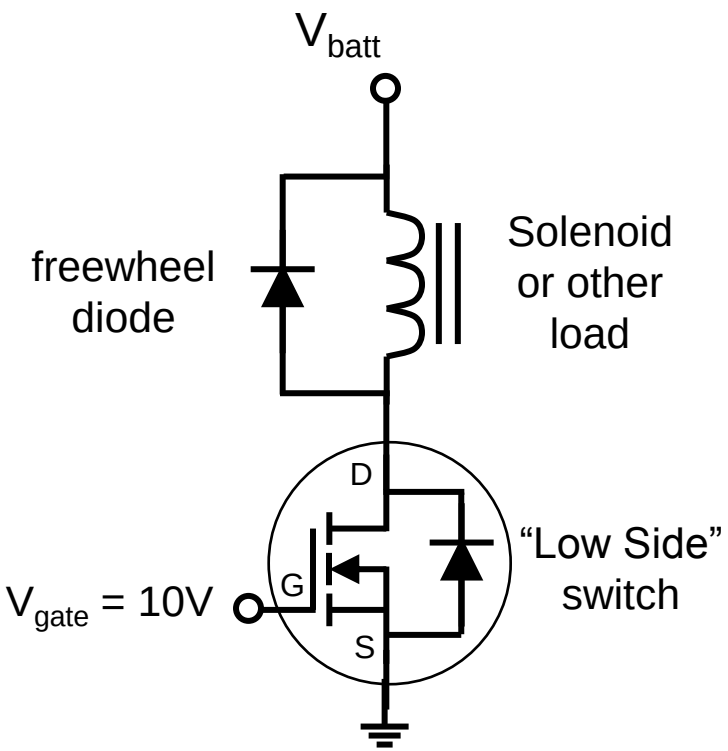
Relay Replacement Evolution

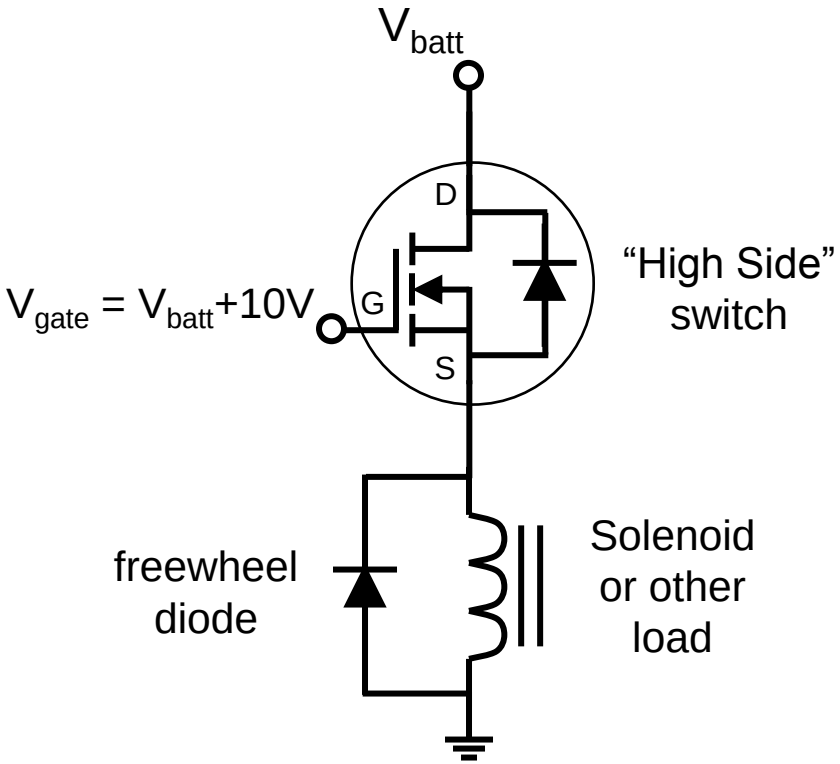


- Any load with currents < 1A
- Any load that requires PWMing
  - Bulb protection (against high voltage)
  - Dimming
  - Daytime running lamps
  - Soft-start
  - Motor speed control or back EMF detection
- Loads requiring sophisticated diagnostics
- Systems requiring careful over current management to protect wiring
- High side switched loads <20A
- 24V systems

- Loads that require blocking reverse battery current
- Low or high side switched loads with currents > 20A
- H-bridge or ½ H-bridge topologies > 10A

“Low Side” vs. “High Side” Switches





Design Challenges for Lighting

- Module cost
- Module size and weight
- Module mounting location and orientation
- Load variations with vehicle features
- Robustness
- Module manufacturability
- Quality
- Power density and thermal management
- Load/fuse assignment
- Harness protection
- Inrush currents much greater than operating current
- Short circuit management (retry strategy), especially at cold temperature
- FMEA (failure mode) considerations for headlamps and brake lamps
- Detecting an incorrect bulb size or a failure in paralleled lamps
- Diagnostics
- Module sleep state current
- Conducted and radiated emissions for PWMed loads; susceptibility

...ain Differences Between 12V and 24V Vehicular Systems

- Operating profile for trucks might be 300,000km/y
- Wire harness for 24V system is often much longer than in passenger vehicles
- Potentially up to 20 meters from module to load (up to 40m with a trailer)
- Potentially up to 20 meters from battery to module (for a distributed architecture)
- Increases wiring inductance and the possibility of wiring harness faults
- 24V systems have more loads than 12V systems and more of those loads are motors and solenoids
- motors are often PWMed @ ~1kHz from 5% to 100% whereas lighting is PWM-ed at 100 to 200Hz
- Vehicular transient specifications are more severe in 24V systems

	12V System	24V System	Comment
Load Dump (5b)	41V	58V	-600V at ECU level
Fast negative transient pulse (1)	-100V	-450V.. -600V*	-600V on Vpwr
Fast positive transient pulse (2a)	+100V	+50V*	Load required
Burst negative pulses (3a)	-150V	-200V	
Burst positive pulses (3b)	+100V	+200V	
Operating voltage range	4V to 20V	8V to 36V	
Under voltage	4.1V typ. (4.5V max)	7V	
Over voltage	32V typ. (28V min)	40V min*	input customer helpfull
Reverse battery	-16V	-28V	
Cranking (Pulse 4)	4.5 or 5.0V	8V*	
Supply voltage clamp	47V	60V	

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What is an eXtreme Switch ?

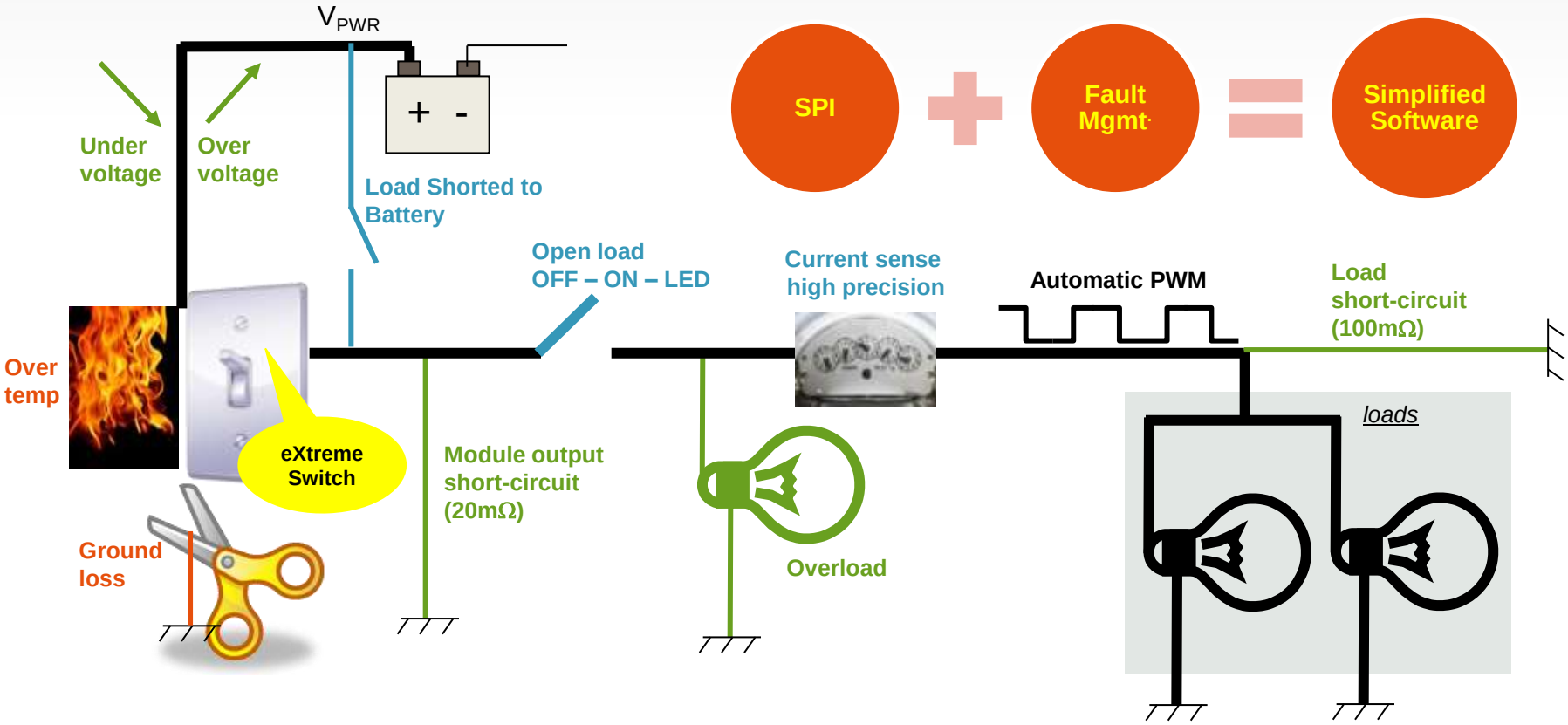
- *A SmartPower device is a Power IC with some digital content. It interfaces between an MCU and a load.*
- *"eXtreme Switch" is Freescale's brand name for high current "SmartPower".*
- *The eXtremeSwitch limit of the load current is 2A-30A DC and 150A transient. Loads are mostly bulbs, but also DC motors, 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

12 mm by 12 mm PQFN

- Control and protection circuitry includes:
  - Overload protection
  - Multi-step overcurrent detection
  - Short-circuit protection
  - Over-temperature protection
  - High-voltage survivability
  - Under-voltage and over-voltage shutdown with hysteresis

What are the primary eXtreme Switch features?



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

eXtreme Switch Product Family

12V Family Devices								
Part Number	**# of Outputs and On-Resistance**	**Total Outputs #**	**Package**	**Low Operating Voltage**	**High Operating Voltage**	**Pin to Pin Compatibility**	**Software Compatibility**	**Status / Launch**
MC07XS3200EK	Dual 7mΩ	2	32-pin SOICeP	6V	20V	-		In production
MC10XS3425EK	Dual 10mΩ, Dual 25mΩ	4	32-pin SOICeP	6V	20V	-		In Production
MC10XS3412DHFK	Dual 10mΩ, Dual 12mΩ	4	24-pin PQFN	6V	20V			In Production
MC10XS3435DHFK	Dual 10mΩ, Dual 35mΩ	4	24-pin PQFN	6V	20V		√	In Production
MC15XS3400DHFK	Quad 15mΩ	4	24-pin PQFN	6V	20V	√		In Production
MC35XS3400DHFK	Quad 35mΩ	4	24-pin PQFN	6V	20V			In Production
MC09XS3400AFK	Quad 9mΩ	4	24-pin PQFN	6V	20V			In Production
MC10XS3535HFK	Triple 10mΩ, Dual 35mΩ	5	24-pin PQFN	7V	20V			In Production
MC35XS3500HFK	Penta 35mΩ	5	24-pin PQFN	7V	20V	√	√	In Production
MC06XS3517AFK	Triple 6mΩ, Dual 17mΩ	5	24-pin PQFN	7V	20V			In Production
MC07XS6517EK	Triple 7mΩ, Dual 17mΩ	5	54-pin SOICeP	7V	18V	√	√	Launch Q3 2013
MC17XS6500EK	Penta 17mΩ	5	32-pin SOICeP	7V	18V			Launch Q3 2013

24V Family Devices								
Part Number	**# of Outputs and On-Resistance**	**Total Outputs #**	**Package**	**Low Operating Voltage**	**High Operating Voltage**	**Pin to Pin Compatibility**	**Software Compatibility**	**Status / Launch**
MC06XS4200FK	On-Resistance	2	23-pin PQFN	8V	36V			In production
MC10XS4200FK	Dual 10mΩ	2	23-pin PQFN	8V	36V	√	√	In Production
MC20XS4200FK	Dual 20mΩ	2	23-pin PQFN	8V	36V			In production

Main Switch Devices								
Part Number	**# of Outputs and On-Resistance**	**Total Outputs #**	**Package**	**Low Operating Voltage**	**High Operating Voltage**	**Pin to Pin Compatibility**	**Software Compatibility**	**Status / Launch**
MC33981ABHFK	Single 4mΩ, 60KHz	1	16-pin PQFN	6V	27V	-	-	In production
MC33982CHFK	Single 2mΩ	1	16-pin PQFN	6V	27V			In production
MC33984CHFK	Dual 4mΩ	2	16-pin PQFN	6V	27V	√	√	In production
MC33988CHFK	Dual 8mΩ	2	16-pin PQFN	6V	27V			In production

Extended operating voltage range:

In extended mode, the functionality is guaranteed but not the electrical parameters specified

- ➔ **12V Products: 4.0 to 28V (vs. 6.0 to 20V)**
- ➔ **24V Products: 6.0 to 58V (vs. 8.0 to 36V)**

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eXtreme Switch Product Family

Nickname

SP D 10 _24V

SELF PROTECTED

NUMBER OF OUTPUTS
- **S** = 1 OUTPUT (single)
- **D** = 2 OUTPUTS (dual)
- **Q** = 4 OUTPUTS (quad)
- **P** = 5 OUTPUTS (penta)

ON-RESISTANCE
- **06** = 6mΩ
- **10** = 10mΩ
- **20** = 20mΩ

Part Number

MC 10 XS 4 2 00 FK / R2

QUALIFICATION STATUS
- **PC** PRE-QUALIFICATION, ENGINEERING SAMPLES
- **MC** FULLY QUALIFIED
- **SC** CUSTOM DEVICE

ON-RESISTANCE
- **06** = 6mΩ
- **10** = 10mΩ
- **20** = 20mΩ

FAMILY
- **XS** = eXtreme SWITCH

FAMILY NUMBER
- **4** = 24V

NUMBER OF OUTPUTS
- **2** = 2 OUTPUTS (dual)
- **4** = 4 OUTPUTS (quad)
- **5** = 5 OUTPUTS (penta)

RESERVATION
- **00**

PACKAGE DESIGNATOR
- **FK** Pb FREE

TAPE AND REEL
- **R2** TAPE AND REEL

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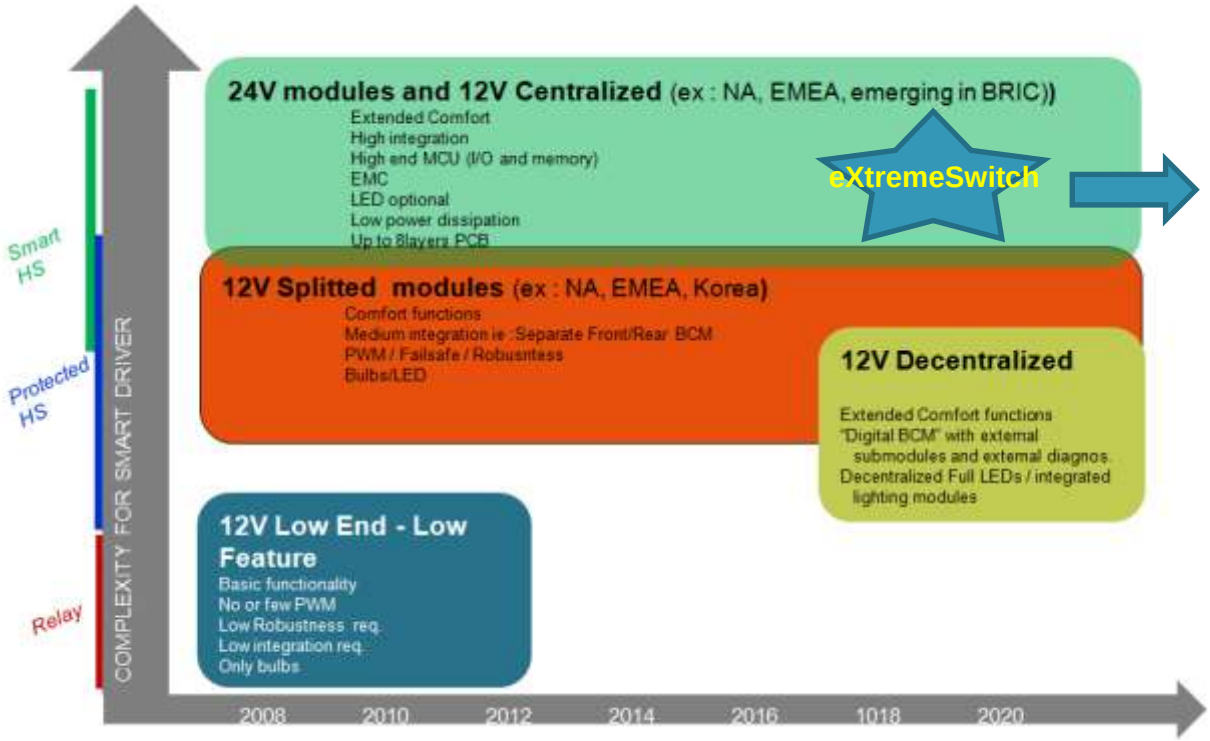
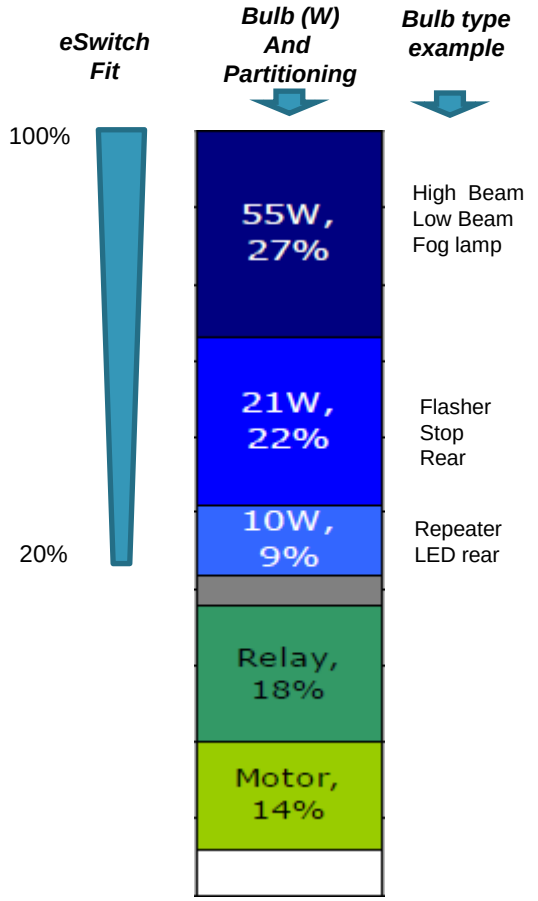
Target Applications for 12V Systems

eXtremeSwitch 12V are optimized for centralized modules and external lighting modules



eXtremeSwitch are optimized for High current loads starting from 15W



eXtreme Switch Target Applications

Auto External Lighting

- eXtremeSwitches are capable of driving from Xenon HID module (High current) to 10W or LED module (Low current).
- eXtremeSwitch Rdson is oversized for loads below 21W unless:

✓ 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 → Car options management

Car Application				Low & High beam Fog lights	Low & High beam Fog lights	Stop, Flasher Back drive lights	Stop, Flasher Back drive lights
Type of lamp				H1, H3, H4, H7, H9	Xenon HID	P27W, P21W P21W+R10W P21W+R5W	LED-arrays
Family	Product	Primary output	Secondary output				
Gen3	MC15XS3400	4*15 mΩ	-	√	√	√	X
	MC35XS3400	4*35 mΩ	-	X	X	√	√
	MC10XS3412	2*10 mΩ,	2*12 mΩ	√	√	√	X
	MC10XS3435	2*10 mΩ,	2*35 mΩ	√	√	√	√
	MC10XS3500	3*10 mΩ	2*35 mΩ	√	√	√	√
	MC35XS3500	5*35 mΩ	-	X	X	√	√
Gen3L	MC09XS3400	4*09 mΩ	-	√	√	√	X
	MC06XS3517	3*06 mΩ	2*17 mΩ	√	√	√	X
	MC10XS3200	2*10 mΩ	2*25 mΩ	√	√	√	X
	MC07XS3200	2*7 mΩ	-	√	√	X	X
Gen4	MC07XS6517	3*7 mΩ	2*17 mΩ	√	√	√	√
	MC17XS6500	5x17mΩ	-	X	X	√	√

eXtreme Switch – Intelligence and Safety

Protection Table		System Diagnostic				Switch protection				System Protection		
Product Family	Part Number	Open load ON-OFF-LED	Load Shorted to Battery	Temperature pre-warning Flag	Analog meas. I - T° - V	Overtemp hysteresis (w/ Flag)	Overtemp shutdown + time based retry (w/ Flag)	Ground loss - Reverse batt.	Load dump	Over / Under Voltage	ECU output short circuit latchoff	Load short circuit or overload latchoff
Main	MC33981ABHFK / R2	A - -	x	-	x - -	x	-	x x	41 V	x x	-	x
Main	MC33982CHFK / R2	A x -	-	-	x - -	x	-	x x	41 V	x x	-	x
Main	MC33984CHFK / R2	A x -	-	-	x - -	x	-	x x	41 V	x x	-	x
Main	MC33988CHFK / R2	A x -	-	-	x - -	x	-	x x	41 V	x x	-	x
12V	MC07XS3200EK	x x x	x	x	x - -	-	x	x x	41 V	x x	x	x
12V	MC09XS3400AFK / R2	x x x	x	x	x - -	-	x	x x	41 V	x x	x	x
12V	MC10XS3412DHFK / R2	x x x	x	x	x - -	-	x	x x	41 V	x x	x	x
12V	MC10XS3425EK	x x x	x	x	x - -	-	x	x x	41 V	x x	x	x
12V	MC10XS3435DHFK / R2	x x x	x	x	x - -	-	x	x x	41 V	x x	x	x
12V	MC15XS3400DHFK / R2	x x x	x	x	x - -	-	x	x x	41 V	x x	x	x
12V	MC35XS3400DHFK / R2	x x x	x	x	x - -	-	x	x x	41 V	x x	x	x
12V	MC06XS3517AFK / R2	x x x	x	x	x x -	-	x	x x	41 V	x x	x	x
12V	MC10XS3535HFK / R2	x - x	x	x	x x -	-	x	x x	40 V	x x	x	x
12V	MC35XS3500HFK / R2	x - x	x	x	x - -	-	x	x x	40 V	x x	x	x
24V	MC06XS4200FK / R2	x x x	x	x	x x -	-	x	x x	58 V	x x	x	x
24V	MC10XS4200FK / R2	x x x	x	x	x x -	-	x	x x	58 V	x x	x	x
24V	MC20XS4200FK / R2	x x x	x	x	x x -	-	x	x x	58 V	x x	x	x

A = available with analog current measurement

"X" Feature available
"-" Feature not available

- Protections, diagnostics SPI configurable
- In case of MCU failure, device protects all the system
- During system failure, Fail Safe mode can activate loads with full protection

eXtreme Product Features Evolution

Gen3

- ✓ SPI interface for programmability, full diagnostics
- ✓ Full diagnostic, no real time fault mgt needed
- ✓ High power density
- ✓ Extremely low sleep state current
- ✓ Multi-step over current strategy with auto-restart
- ✓ Robust and reliable solution with failsafe operation
- ✓ Specific configuration for bulbs, HID, LED
- ✓ Easy PWM management, EMC optimized
- ✓ Embedded PWM function with optimized slew rates
- ✓ Outputs under fully control and protected in case of MCU damage
- ✓ External or Internal watchdog with failsafe management.

Gen3L

- ✓ LFET technology introduction significantly reduces on-resistance
- ✓ Higher over current thresholds to accommodate newest lamps
- ✓ Option for dual in SOIC with exposed thermal pad (EVL compliant)

Gen4

- ✓ Intend for a complete and **scalable** family in term of software and footprint
- ✓ It provides diagnostics for light emitting diodes (LEDs) with an **enhanced current sense precision with synchronization pin**
- ✓ It combines flexibility through daisy chainable 5.0MHz SPI, extended digital and analog feedback, safety and **robustness**.
- ✓ It integrates an **enhanced PWM module** with 8 bits duty cycle capability and pre-scaler per output
- ✓ This family is packaged in a Pb-Free **power-enhanced SOICep** package with exposed pad and **ELV compliant.**

22A / 14V Gen4 Penta eXtreme Switches

MC07XS6517 / MC17XS6500

Scalable family of 22A/14V programmable penta high-side switches with wide range diagnostic current sensing and lowest Rdson for up to 30% smaller PCB and 50% lower component count

- **Differentiating Points**
  - **Robustness:** Unique over-current latch-off protection, full digital and accurate analog diagnostics, and protection features with embedded failsafe mode
  - **Integration:** 5 configurable low Rdson channels with daisy-chainable SPI
  - **Density:** Thermally enhanced package for affordable high switch count modules with up to 30% lower power, 30% smaller PCB footprint and 50% fewer components
  - **Accuracy**: Advanced current sensing over temperature and supply voltage range allowing accurate current monitoring from 25mA to 22A
  - **Scalability:** Pin and SW driver compatible family
  - **Best thermal efficiency:** Lowest Rdson in penta configuration

- **Product Features**
  - Penta 5x 17mW and penta 3x 7mW + 2x 17mW configurations
  - Operating voltage range from 6 - 18 V with sleep current < 5.0 µA
  - Flexible load management up to 11A, 22A with enhanced thermal management
  - Enhanced output current sense (down to 25mA) with programmable synchronization signal, ±5°C temperature and ± 1% battery voltage feedback
  - 5.0 MHz 16-bit daisy chainable SPI control
  - Full diagnostic and protection including over-current profiles, output-ON and –OFF open load detections, thermal shut-down, pre-warning, and fault reporting
  - Individually programmable internal/external PWM signals with 8 bit duty cycle control
  - Watchdog and failsafe mode
  - External smart power switch control

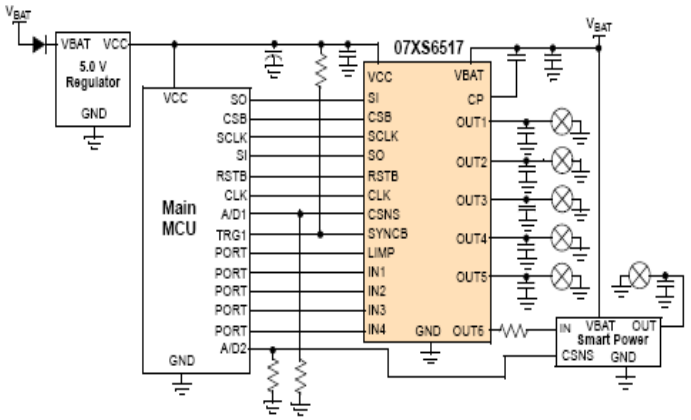


Figure 1. Penta High Side Simplified Application Diagram

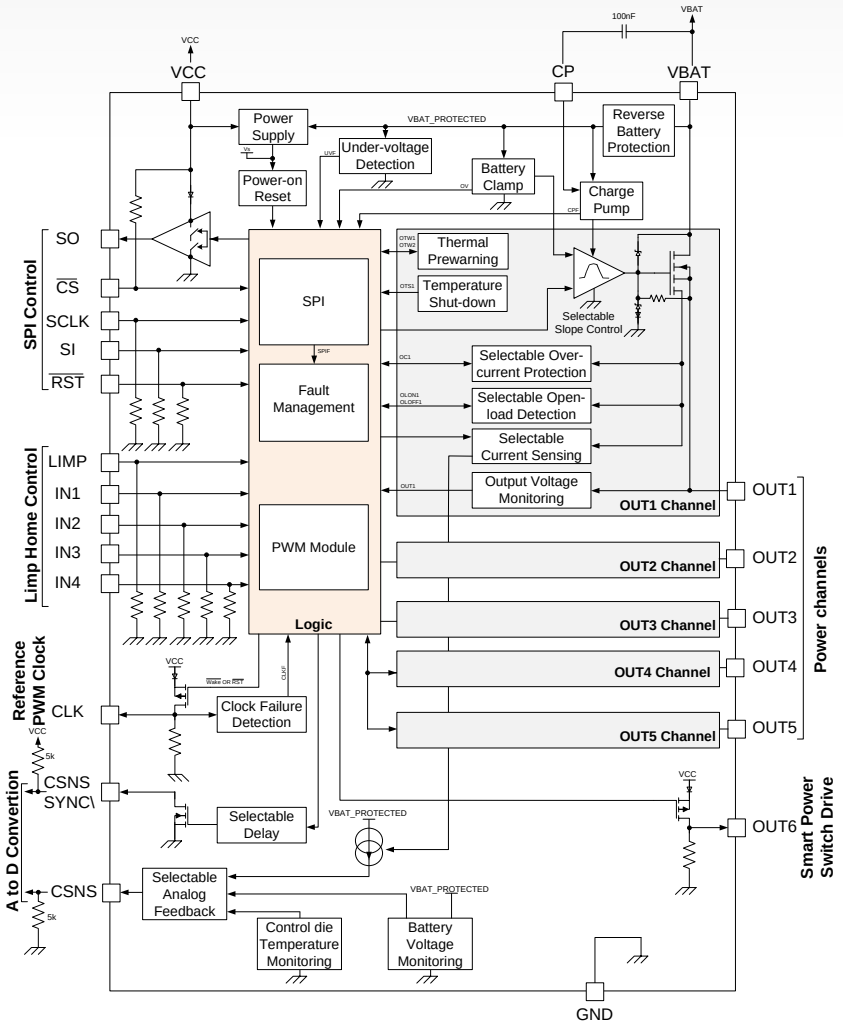
Typical Applications

Transportation
- 12V Lighting from High beam to LEDs
- Valves
- DC motors

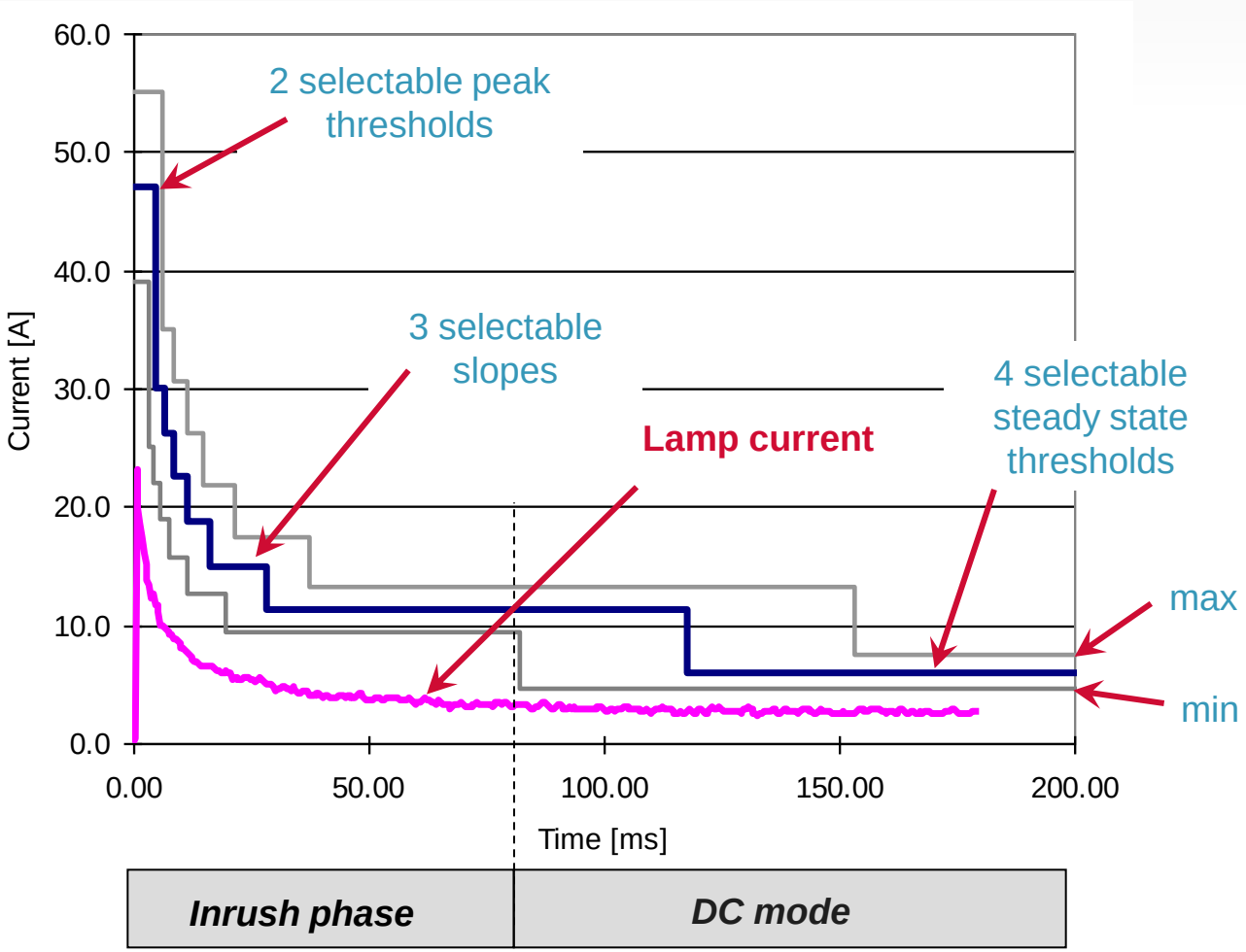
Industrial
- High current / highly inductive loads (solenoids)
- DC motor control
- Factory automation PLC

Product Block Diagram and Features (Gen4)

- **Penta:** 3x7mΩ & 2x17mΩ or Penta 5x17mΩ
- Operating voltage range of **6.0 V to 18 V** with sleep current **< 5.0 µA**
- **Flexibility** Xenon / LED / Halogen
- Lighting: from 100Hz to 400Hz – DC motor: up to 1kHz
- **Individually** programmable internal/external **PWM** clock signals with **8-bit** PWM duty cycles.
- **Daisy chainable 16-bit 5MHz SPI** control of over-current profiles, channel control including PWM duty-cycles, output-ON and -OFF open load detections, thermal shut-down and fault reporting
- Channel round shaping for **excellent EMC behavior**
- Enhanced **output current sense (down to 25mA)** with programmable **synchronization signal, ±5°C temperature and ± 1% battery voltage feedback**
- Watchdog and **failsafe mode**
- **External** smart power **switch control**
- **Compatible** PCB foot print and SPI software driver among the family
- **Current sense precision resistor can be shared among many devices**



Programmable Overcurrent Profile
(MC10XS3412)



eXtreme Switch Features and Benefits (Gen4)

Features and Benefits

Features	Benefits
Lowest Rdson @ 7mΩ /17mΩ in thermally enhanced package	Best thermal efficiency for 30% smaller footprint and best module longevity with 30% lower power dissipation
Programmable dynamic threshold over-current and over-temperature detection limits	Optimized fault protection
Accurate temperature (±5°C) and synchronous / asynchronous current (±10%) sensing	Advanced load diagnostics
Compatible devices and flexible load management from high current (HID, 65W lamps) to low current LEDs	Hardware reuse across multiple applications and quick-turn flexibility for tuning designs with ambiguous load requirement
Programmable fault auto-retry	Auto recovery for transient faults
Watchdog and Protected output in failsafe mode	Ready for an SIL-B compliant module design
Selectable slew rate	Optimize EMI vs efficiency tradeoff
Individually programmable internal/external PWM signals	Offloads MCU for software design simplicity & PPM reduction
5.0 V compatible 16-bit daisy chainable SPI control	BOM component & cost savings by eliminating series SPI resistors between MCU and device

eXtreme Switches (Gen4)

Product Differentiation

Scalable family of 22A/18V programmable penta high-side switches with wide range diagnostic current sensing and lowest Rdson for up to 30% smaller PCB and 50% lower component count

Robustness	Integration	Flexibility
Embedded intelligence and safety	**Lighter-weight, smaller systems**	**Design re-use across multiple applications**
External or internal watchdog with fail safe management	Embedded PWM module simplifies MCU interface	Configurable over-current for different load types & sizes
Multi-step configurable over-current latch protection	Full diagnostics for multiple switches thru single SPI bus	Embedded diagnostics & fault management simplifies SW
Reduces wire harness size & increases protection	Thermal efficient design enables smaller package	Software & footprint compatibility family

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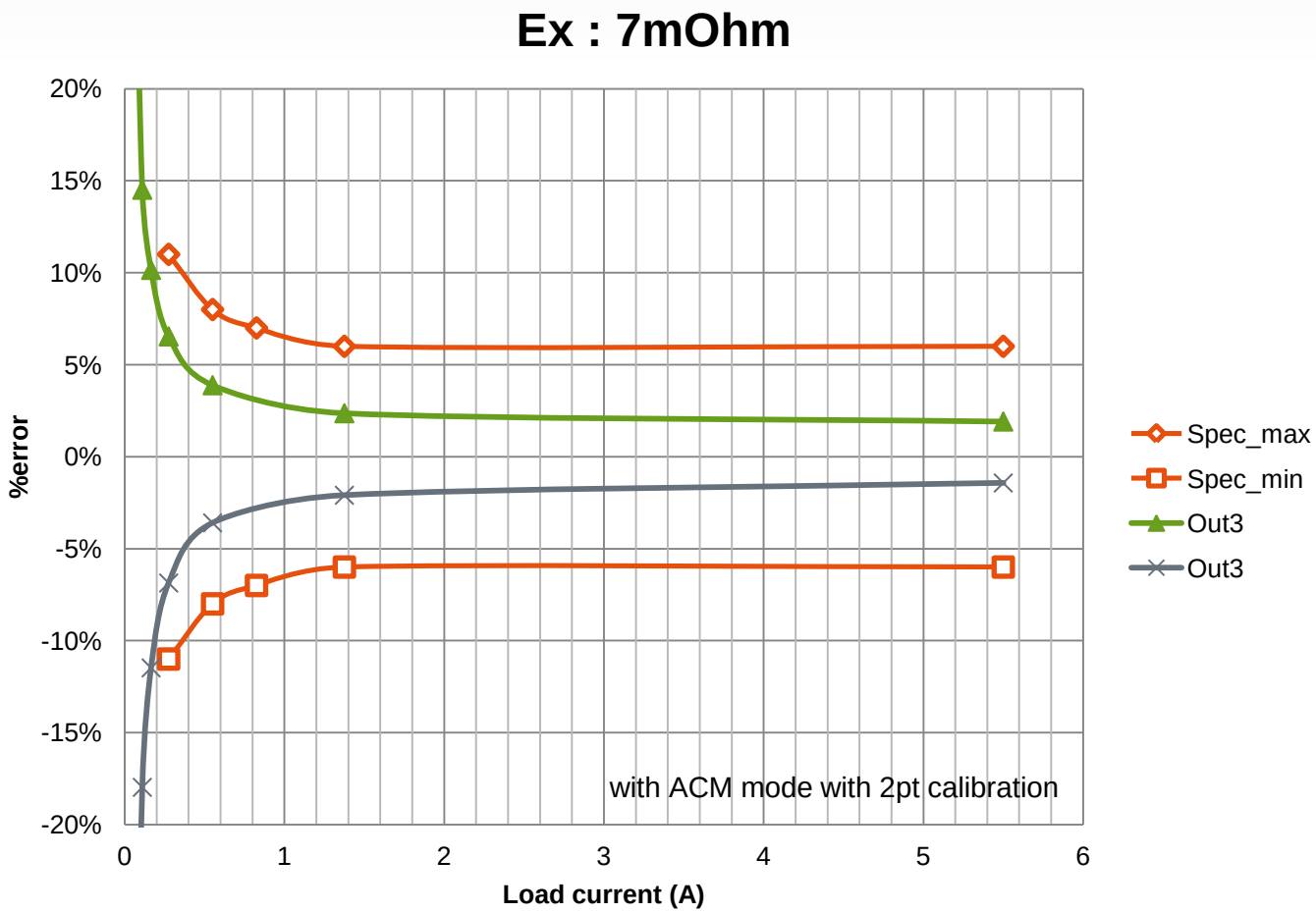
7mΩ output – Current sense precision



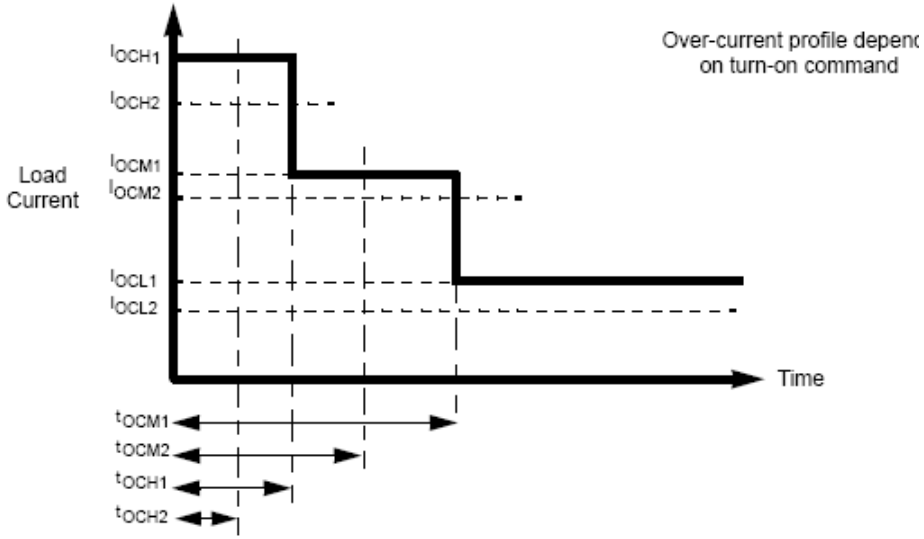
24A / 36V eXtreme Switch

Features and Benefits

Features	Benefits
Lowest Rdson @ 6/10/20 mΩ in thermally enhanced package	Best thermal efficiency for 30% smaller footprint and best module longevity with 30% lower power dissipation
3.3 / 5.0 V compatible 16-bit Daisy chainable SPI control	BOM component & cost savings by eliminating series SPI resistors between MCU and device
Compatible devices and flexible load management from 1 to 24A with possible parallel output operating modes	Hardware reuse across multiple applications and quick-turn flexibility for tuning designs with ambiguous load requirement
Programmable dynamic threshold over-current and over-temperature detection limits	Optimized fault protection
Programmable fault auto-retry	Auto recovery for transient faults
Full programmability and diagnostic capability through SPI	Off loads real-time interrupt fault management from MCU, simplifying system hardware and software
Accurate temperature (±5°C) and synchronous / asynchronous current (±10%) sensing	Advanced load diagnostics
Selectable slew rate	Optimize EMI vs efficiency tradeoff
Individually programmable internal/external PWM signals	Offloads MCU for software design simplicity & PPM reduction

Configurable & Programmable Overcurrent Detection Profiles

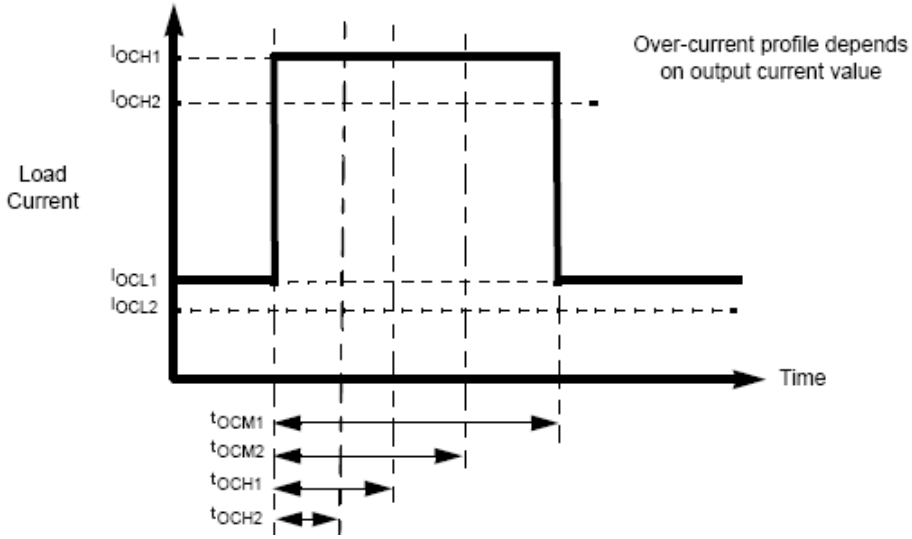
CONF bit = 0
Static Bulb lamp over-current protection profile activated



Static multi-stage over current protection profile protects lamps without shutting down the supply during inrush current

Activation by a turn-ON event

CONF bit = 1
Dynamic DC Motor over current protection profile activated



Dynamic over current protection window protects DC motors without shutting down the supply during short stall-periods

Activation by I(load) > I(OCL)

24A / 36V eXtreme Switch

Product Differentiation

Thermally efficient ultra-low Rdson 24A/36V dual high side switch family in a small package footprint with programmable fault protection

Robustness	Integration	Flexibility
Embedded intelligence and safety	**Lighter-weight, smaller systems**	**Design re-use across multiple applications**
External or internal watchdog with fail safe management	Embedded PWM module simplifies MCU interface	Configurable over-current for different load types & sizes
Multi-step configurable over-current latch protection	Full diagnostics for multiple switches thru single SPI bus	Embedded diagnostics & fault management simplifies SW
Reduces wire harness size & increases protection	Thermal efficient design enables smaller package	Software & footprint compatibility family

For Additional Information

Freescale's External Web Site
http://www.freescale.com/

Freescale's Analog Web Site (useful pdf's plus links to other sites)
http://www.freescale.com/webapp/sps/site/homepage.jsp?code=ANALOGHOME

- *About Freescale Analog*
- *Analog Technology Brochure (pdf)*
- *Analog Packaging Brochure (pdf)*
- *Analog Applications Brochure (pdf)*
- *Automotive Solutions Brochure (pdf)*
- *Analog Selector Guide (pdf)*
- *Automotive Selector Guide (pdf)*
- *SafeAssure Functional Safety*
- *Thermal Analysis of Semiconductor Systems (pdf)*

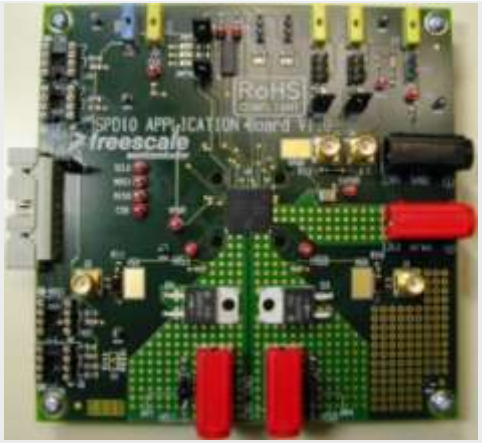
High Side Switches, including eSwitches (parametric search & datasheets)
http://www.freescale.com/webapp/sps/site/taxonomy.jsp?nodeId=01435979968459

Analog Toolbox (Evaluation Kits, SPIGEN software, reference designs)
http://www.freescale.com/zh-Hans/webapp/sps/site/overview.jsp?code=ANALOGTOOLBOX

SPI Generator (SPIGen) Software
http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=SPIGEN

24A / 36V eXtreme Switch
EcoSystem

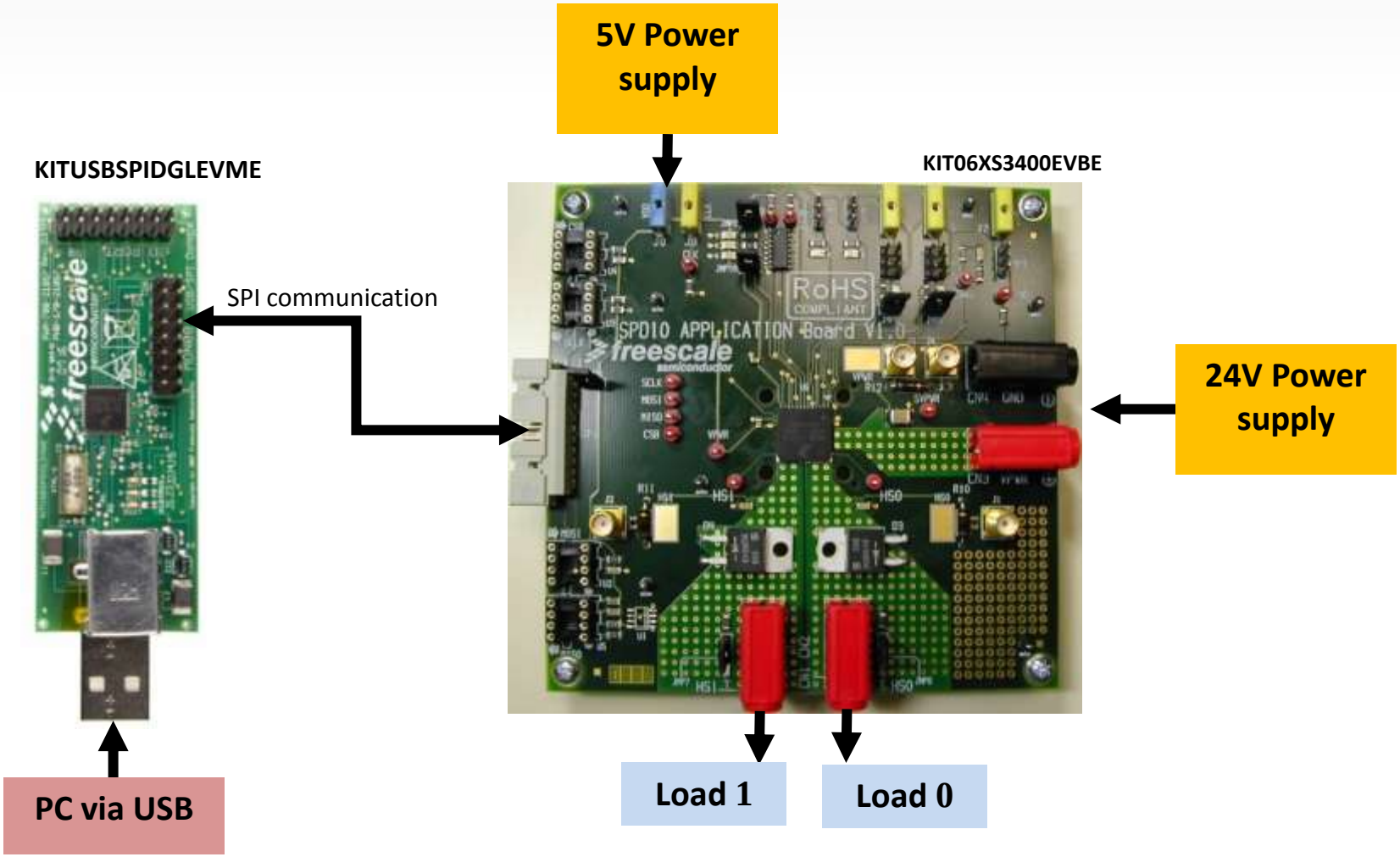
- **Evaluation kit (EVB kit)**
  - KIT06XS4200EVBE for the Dual 6 mOhm device
  - KIT10XS4200EVBE for the Dual 10 mOhm device
  - KIT20XS4200EVBE for the Dual 20 mOhm device



- **Reference design**
  - 16-bit MCU S12G, 4 eXtreme Switch devices, CAN Physical Laye

- **Application notes and tools**
  - MC06XS4200 / MC10XS4200 / MC20XS4200 Datasheets
  - AN2467: Power Quad Flat No-Lead (PQFN) Package
  - AN3298: Solder Joint Temperature and Package Peak Temperature
  - AN4516: IBIS Model File for Dual 24V High Side
  - AN4474: EMC and Fast Transient Pulses Performances for Dual 24 V High
  - AN4473: Compact Thermal Model for Dual 24V High Side Switch
  - AN4515: Lifetime Computation for Dual 24V High Side
  - AN4542: Repetitive Short-Circuit Performances for Dual 24V High Side
  - Microsoft Excel© Thermal Calculator
  - Cadence Orcad© Behavioral models

Typical eSwitch EVB Kit Connected to SPIGEN Dongle



Power Dissipation Calculator (Excel based)

Gen3, GEN3L, GEN4 and 24V eXtremeSwitch Partitioning and Thermal Estimates

Date	########
Vehicle	TBD
Module	TBD
Revision	template
Editor	K. Gauen

Conditions Table	Value	Unit
Ambient temperature, Ta	85	[C]
Battery voltage, Vbatt	16	[V]
PQFN Rthja*	20	[C/W]
Module Thermal Resistance	3	[C/W]
Total e-Switch Power Dissipation	2,2	[W]
Power Dissipated in other Drivers	1,0	[W]
Misc. Module Power	0,0	[W]
Total Module Power	3,2	[W]
Module Temp Rise	9,5	[C]
Reverse Battery Voltage	14,0	[V]

USER INPUT
Other cells are locked, no password

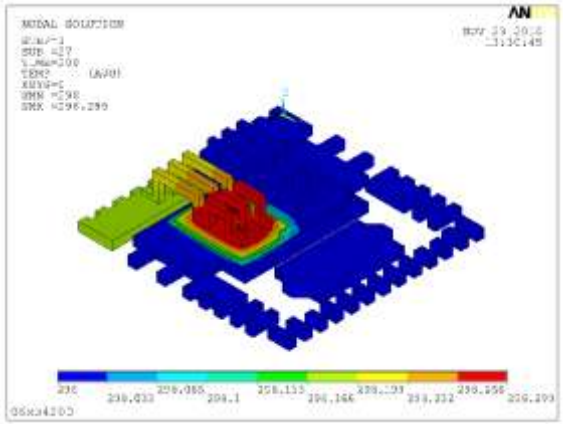
* for a single package

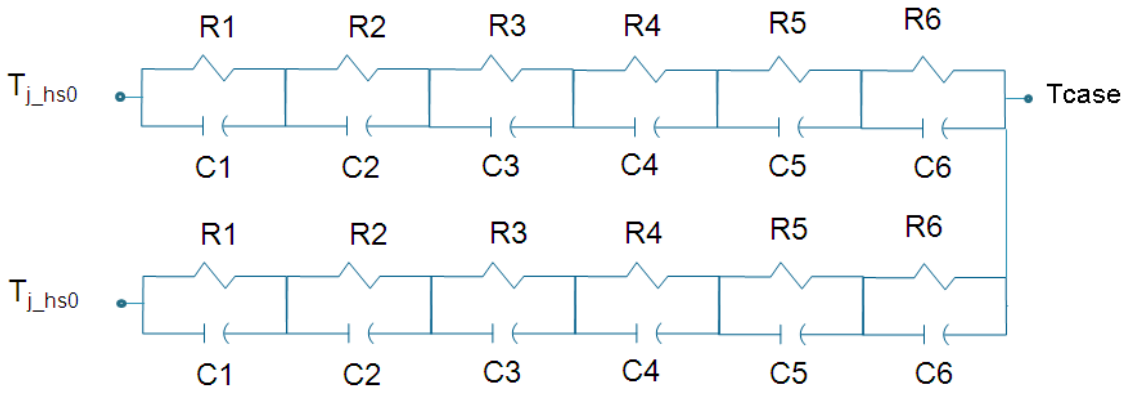
Typical Rds(on) % of max rating	90%
Vpwr Current	6,5mA
Idd	2mA
Typ. Rev Batt Rds(on) multiplier at 25C	1,00
Typ. Rev Batt Rds(on) multiplier at 150C	1,45

						User Inputs											
Output Channel Name	Batt or Fuse	Proposed Device	Device channel #	Max Rds @25C [mOhms]	Channel's Min inrush current limit [A]	Load's Peak Inrush Current [A]	Max Load @16V [A]	Load Duty Cycle [%]	PWM Freq [Hz]	PWM Duty Cycle [%]	Slew Rate Setting	Slew Rate [v/µs]	Load ON	PWM ON	RMS Current @16V [A]	Estimated Tj [C]	Rds@ Estimated Tj [mΩ]
Load =	=	MC20XS4200	1	20	27,5	0,0	5,00 A	100%	100 Hz	100%	Low	0,20	0	0	0,00 A	120	27,576
Load =	=	#1	2	20	27,5	0,0	5,00 A	100%	100 Hz	100%	Low	0,20	0	0	0,00 A		27,576
															0,00 A		
Load =	=	MC10XS4200	1	10	55,0	0,0	5,00 A	100%	100 Hz	100%	Low	0,20	0	0	0,00 A	120	13,788
Load =	=	#2	2	10	55,0	0,0	5,00 A	100%	100 Hz	100%	Low	0,20	0	0	0,00 A		13,788
Load =	=	MC06XS4200	1	6	91,7	0,0	0,00 A	100%	100 Hz	100%	Low	0,30	0	0	0,00 A	120	8,273
Load =	=	#3	2	6	91,7	0,0	0,00 A	100%	100 Hz	100%	Low	0,30	0	0	0,00 A		8,273

Compact Thermal Models

AN4473 presents compact thermal models per each 24V device





IBIS Model

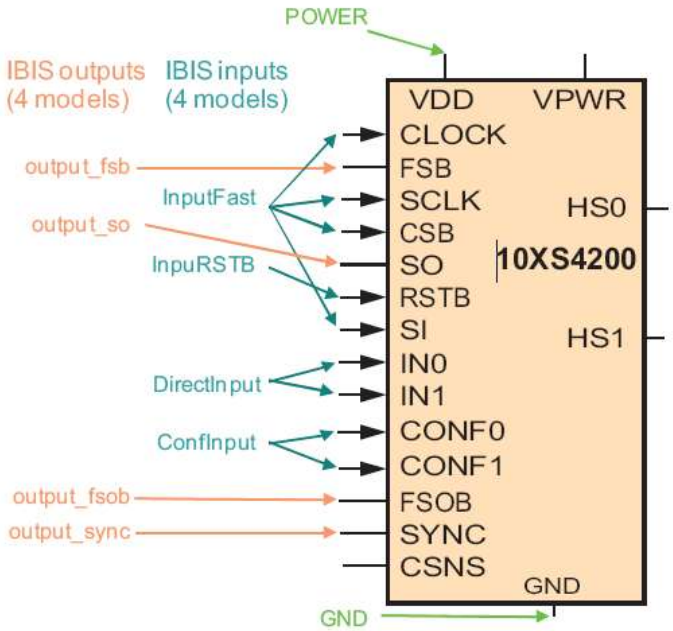
AN4516 presents the Input/Output Buffer Information Specification (IBIS) model

IBIS file contains the basic signal models for each type of signal of device:

- For input buffers: Input's capacitance and static pull-up/down currents
- For output buffers: Output's capacitance, static/dynamic pull-up/down currents, propagation delay

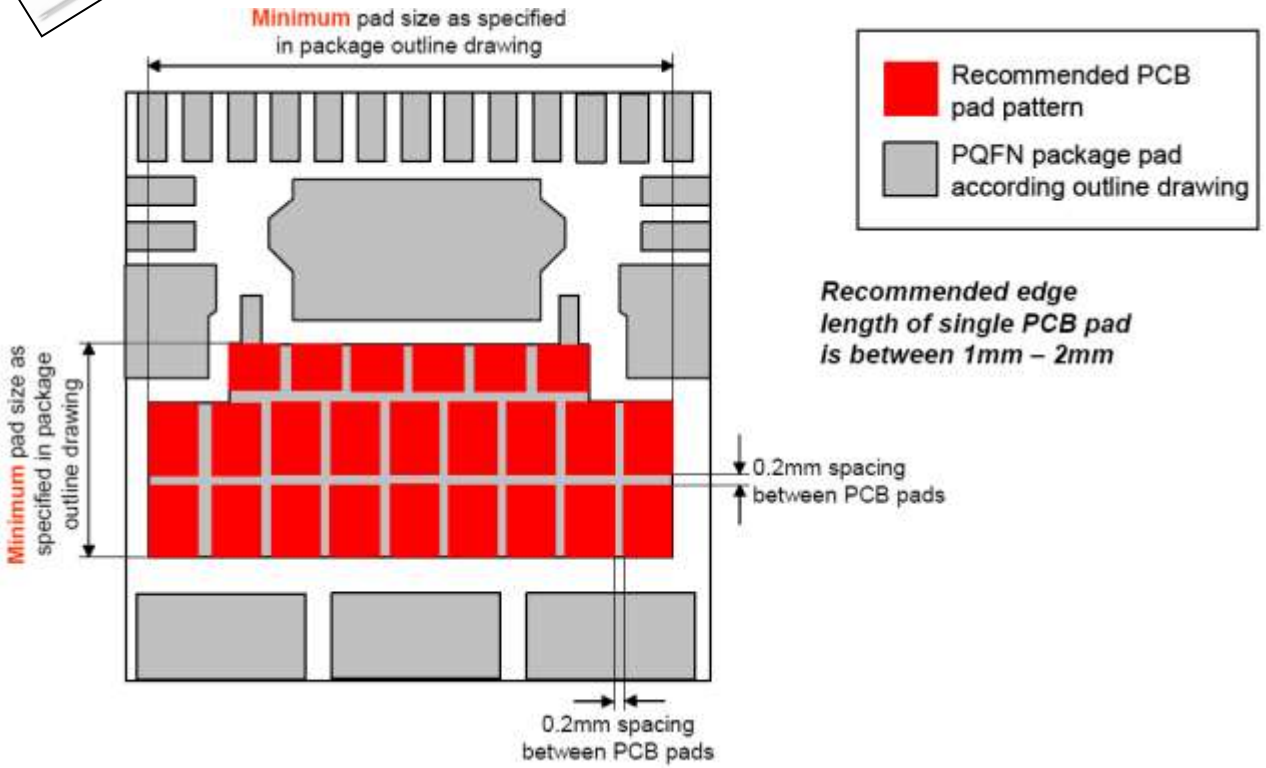
For Dual 24 V High Side Switch, the IBIS model contains descriptions of

- 4 input buffers: CLOCK, SCLK, CSB, RSTB, SI, IN[0:1], CONF[0:1] pins
- 4 output buffers: FSB, SO, FSB, SYNC pins
- Package parasitic elements



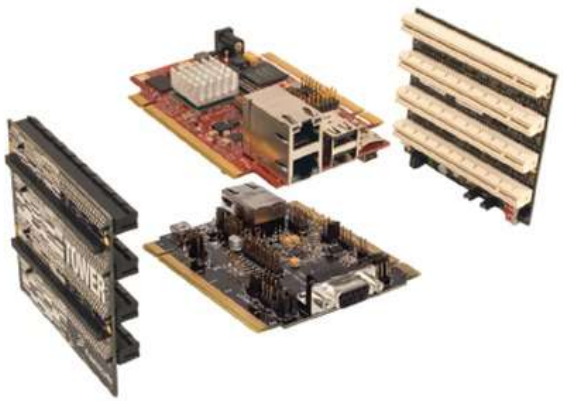
PQFN PCB Guidelines

AN2467 presents guidelines for printed circuit board design and assembly



24A / 36V eXtreme Switch

Analog Tower System development KIT Plan



Available Nov 2013

Development KIT under study for devices compatible with 24V industrial applications requirements

- 12V Intelligent High Side Switches
- 24V Intelligent High Side Switches

Interact, Explore, Create with Tower Geeks Online Community (www.towergeeks.org)

Supported Software Design Resource: Processor Expert (MCU Driver Suite)

24A / 36V eXtreme Switch

Analog Freedom development KIT Proposal

Available Nov 2013

Development KIT under study for devices compatible with 24V industrial applications requirements

- Voltage regulator with advanced functional safety features

Join KINETIS channel partners strategy
Avnet with WiGo
Future with Intersil
Arrow with Cloud Connect

Supported Software Design Resource: Processor Expert (MCU Driver Suite)

freescale™

Processor Expert: Key Concepts

Available Nov 2013

- Processor Expert
  - Provides features that fully support design time configuration
- Configuration of Whole Device
  - Configuration of targeted MCU / MPU / DSC
  - Configuration of **components** selected by user needed in application
- Code Generator
  - Able to generate both:
    - MCU **Component** Drivers code for any given configuration
    - MCU **Initialization** code (application specific)
- Basic Element of the Processor Expert is Embedded Component
  - Components are seen as objects for customer fast enablement and ease-of-use

AN2467 - Layout Considerations

Freescale Semiconductor
Application Note

AN2467
Rev. 4.0, 4/2007

Power Quad Flat No-Lead (PQFN) Package

1 Purpose

This document provides guidelines for Printed Circuit Board (PCB) design and assembly. Package performance attributes such as Moisture Sensitivity Level (MSL) rating, board level reliability and Thermal Resistance data are included as reference.

2 Scope

This document is written to generically encompass several different Power Quad Flat No-Lead (PQFN) packages assembled at Freescale internal assembly sites and external subcontractor sites. It should be noted that device specific information is not provided. This document serves only as a guideline to assist in the development of user specific solutions. Development effort will still be required by end users to optimize PCB mounting processes and board design.

Contents

freescale semiconductor

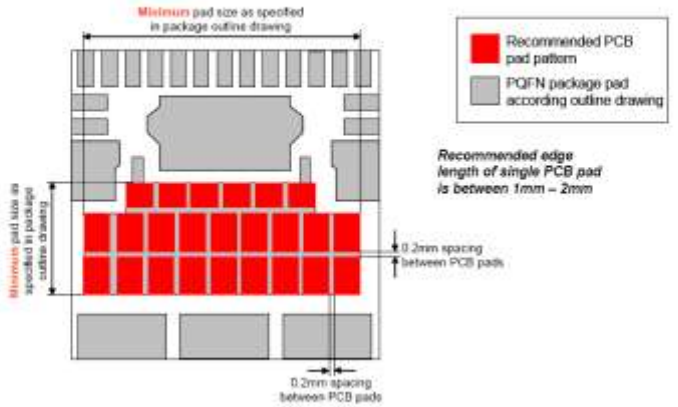
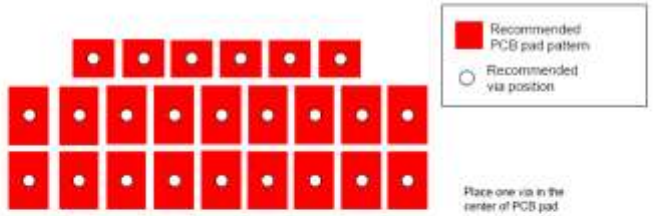


Figure 13. PCB Pad Design



Recommended via diameter is 0.5mm.
PTH (plated through hole) via must be plugged/ filled with epoxy or solder mask in order minimize void formation and to avoid any solder wicking into the via.

Figure 14. Via Design

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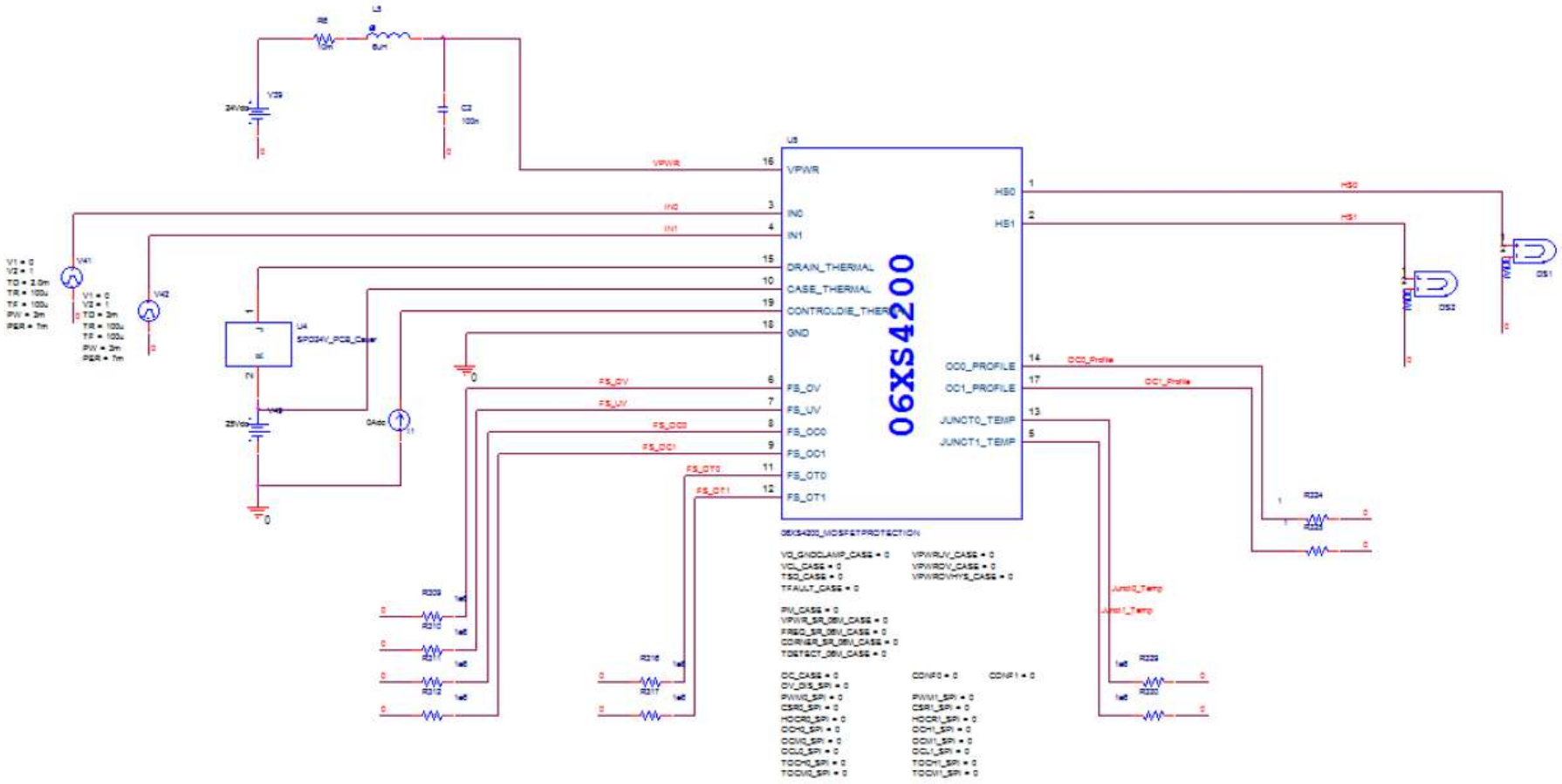
Cadence Orcad© Behavioral Model

The behavioral model manages **concurrently the electrical and thermal aspects.** It allows evaluation of a device's thermal performance under various conditions:

- Supply voltage
- PCB design layout
- Ambient temperature
- eXtreme Switch device type changes
- Parametric range steps (over-current level , under-voltage threshold)

The prediction of junction temperature elevation is based on the computation of transient power dissipation on dedicated channel. The reciprocal influence of junction temperature and on-state resistance of channel is modeled.

Cadence Orcad© Behavioral Model (cont'd)



Cadence Orcad© Behavioral Model (cont'd)

What is NOT included in the model?

- Digital SPI control and diagnostic
- Analog diagnostic
- Reverse battery protection
- EMC emission > 1MHz and susceptibility
- Parasitic and second order effects
- Aging

Each model is flexible and ready for integration of models developed by final user, like loads, PCB, etc.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