



# Analog Solutions for Automotive

## EU-ACC-T1573

Marc Osajda | Business Development Manager

JUNE . 2015



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# Agenda

- Introduction: Freescale Analog Automotive Solutions
- Power Management Solutions
- 24V eSwitches
- Programmable Solenoid Driver 12V & 24V
- Battery Sensors Solutions
- Conclusion & Q&A



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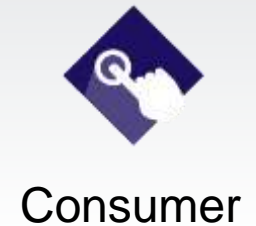
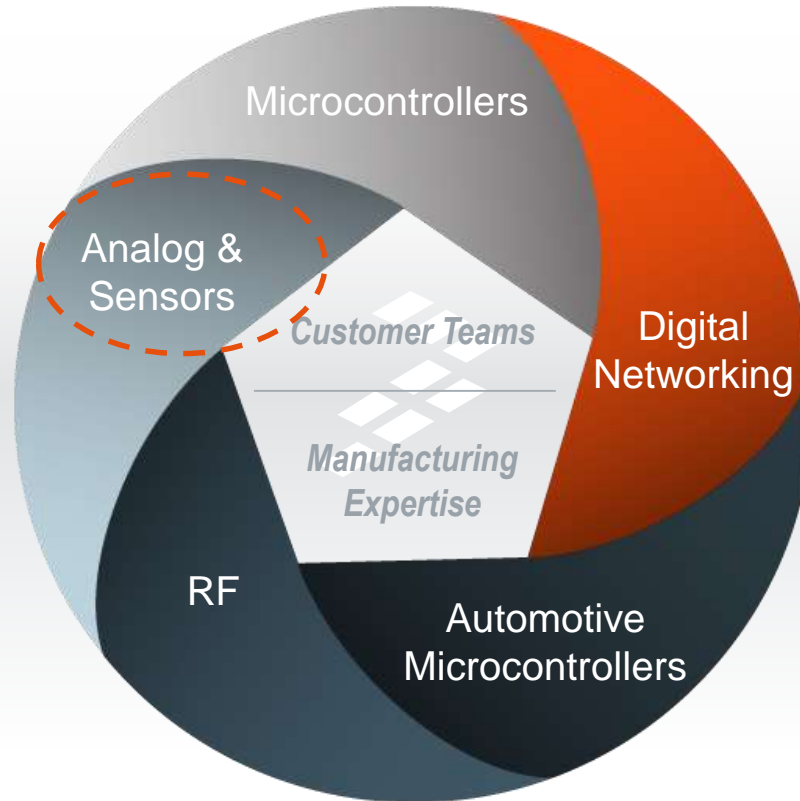
## Quick Introduction: Marc Osajda



- Freescale Semiconductor
  - Automotive Business Development Manager Analog & Sensor Group, EMEA
- 20+ years experience in MEMS sensors
  - Design, Application, Marketing, Business Development, Automotive
- MD from “Ecole National d’Arts et Métiers”, Paris, France
- Multiple publication and patents on Sensors



# We Are a Global Leader in Embedded Processing Solutions



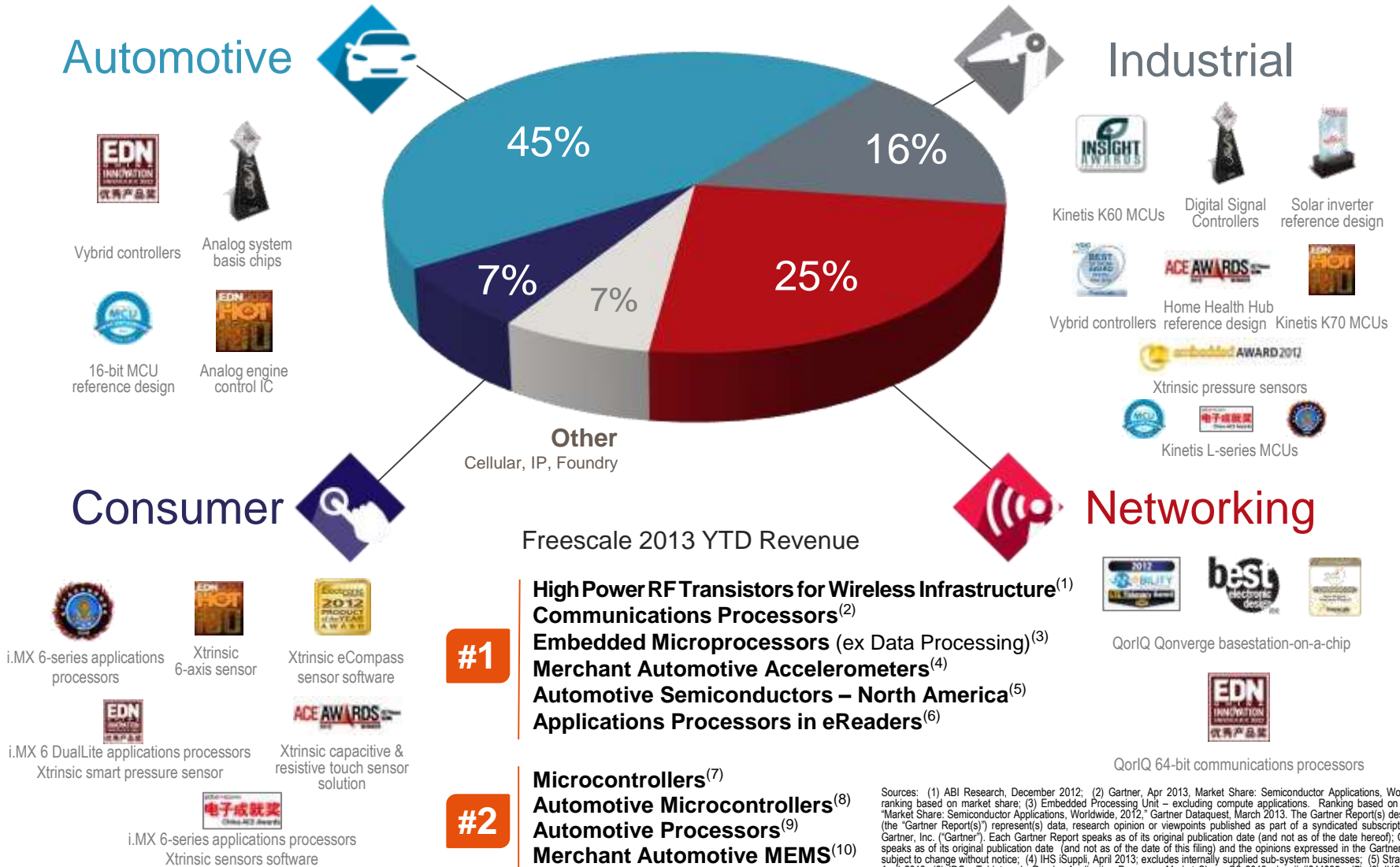
**Five** Core Product Groups

**>50** Year Legacy  
**>6,000** Patent Families\*

**Four** Primary Markets



# We Have a Significant Presence in All Segments



Freescale 2013 YTD Revenue

- #1** High Power RF Transistors for Wireless Infrastructure<sup>(1)</sup>
- #1** Communications Processors<sup>(2)</sup>
- #1** Embedded Microprocessors (ex Data Processing)<sup>(3)</sup>
- #1** Merchant Automotive Accelerometers<sup>(4)</sup>
- #1** Automotive Semiconductors – North America<sup>(5)</sup>
- #1** Applications Processors in eReaders<sup>(6)</sup>
- #2** Microcontrollers<sup>(7)</sup>
- #2** Automotive Microcontrollers<sup>(8)</sup>
- #2** Automotive Processors<sup>(9)</sup>
- #2** Merchant Automotive MEMS<sup>(10)</sup>

Sources: (1) ABI Research, December 2012; (2) Gartner, Apr 2013, Market Share: Semiconductor Applications, Worldwide, 2012; ranking based on market share; (3) Embedded Processing Unit – excluding compute applications. Ranking based on market share. "Market Share: Semiconductor Applications, Worldwide, 2012," Gartner Dataquest, March 2013. The Gartner Report(s) described herein, (the "Gartner Report(s)") represent(s) data, research opinion or viewpoints published as part of a syndicated subscription service by Gartner, Inc. ("Gartner"). Each Gartner Report speaks as of its original publication date (and not as of the date hereof). Gartner Report speaks as of its original publication date (and not as of the date of this filing) and the opinions expressed in the Gartner Report(s) are subject to change without notice; (4) IHS iSuppli, April 2013; excludes internally supplied sub-system businesses; (5) Strategy Analytics, April 2013; (6) IDC, Tablet and eReader Application Processor Market Share Q2 2013, doc # 244035; (7)-(8) IHS, March 2013, Competitive Landscape Tool – Annual - 2012; Gartner, March 2013; (9) Strategy Analytics, April 2013; (10) IHS, April 2013; excludes automotive MEMS supply internal sub-system businesses.



# SMARTMOS™ Technology Integration

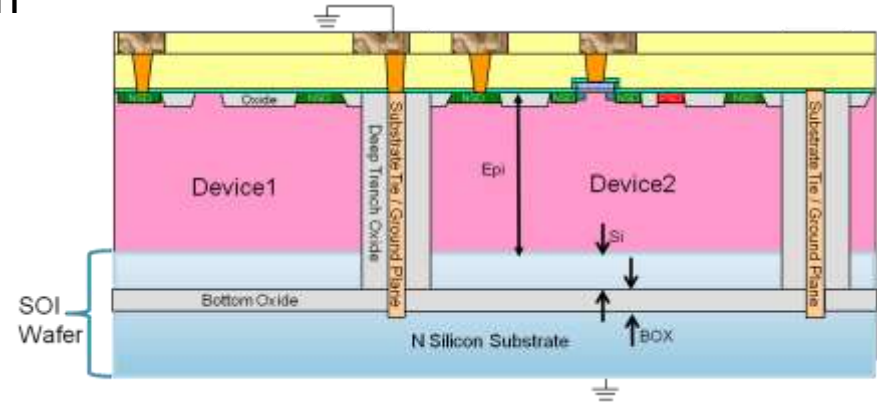
## More than driving loads

- Cost effective high voltage power analog embedded system process platform
- Low  $R_{dson} \cdot A$  for thermal efficiency in high current applications
- High Precision for sensor interface integrated with power applications
- Advanced Isolation capability and robust system transient ESD/EMC immunity
- Low-power devices to reduce overall system power consumption
- Extreme temperature operation for harsh application environments (-40 to +175°C)



# SMOS10HV Next Generation Technology

- SMOS10HV is Freescale's next generation high voltage Smartmos™ technology
- SMOS10HV features
  - 0.13um CMOS platform
  - SOI for superior noise isolation/ parasitic immunity
  - High density logic (100k gates/mm<sup>2</sup>)
  - High voltage capacity (90V)
  - Extensive suite of R & C for analog design
  - 4 layer fine pitch Cu metal + 2um Al "Mcap" (5LM)
  - Anti-fuse element for OTP
- SMOS10HV is aimed at highly integrated Automotive, Industrial and Power Management products



- Each component is surrounded on all sides by hard ground plane
- Each component or group of components is surrounded by oxide isolation
- No parasitic components to substrate
- Eliminates substrate injection and device cross-talk



# Freescale Product Programs

## SafeAssure™ Functional Safety Program

### Functional Safety Simplified

The Freescale SafeAssure functional safety program is designed to help simplify the process of achieving system compliance with functional safety standards in the automotive and industrial markets



## Energy-Efficient Solutions Program

### Energy Efficient by Design

The Energy-Efficient Solutions mark highlights selected products that excel in effective implementation of energy-efficient technologies



## Product Longevity Program

### Supply Assurance

For the automotive and medical segments, a broad range of products are made available for a minimum period of 15 years and 10 years for other market segments.



# ISO 26262 Certified Hardware Development Process for Analog/Sensors - Supplier Leadership in Meeting Functional Safety Requirements

- Certified by **SGS TUV Saar** – an independent accredited assessor
- Audit assessed the capability of **Freescale product development rules, processes and tools for analog and sensor devices** in our global NPI and manufacturing sites to satisfy the ISO 26262 functional safety standard (as applicable to a semiconductor supplier)
- Our **SafeAssure** functional safety development process for analog and sensor hardware has been **certified as compliant with ISO 26262 standard part requirements**, namely,
  - ISO 26262-2:2011 – Safety Management
  - ISO 26262-5:2011 – Hardware Development
  - ISO 26262-7:2011 – Production
  - ISO 26262-8:2011 – Supporting Processes
  - ISO 26262-9:2011 – Safety Analysis

**SGS TÜV SAAR**

CERTIFICATE NO.: FS/71/220/15/0078 PAGE 1/1

LICENCE HOLDER  
**FREESCALE SEMICONDUCTOR INC.  
ANALOG & SENSOR GROUP**  
2100 EAST ELLIOT ROAD  
TEMPE, ARIZONA 85284, USA

Project-No./ID: H0AE      LICENSED TEST MARK:       Report No.: H0AE0002

HOAE

Tested according to: ISO 26262 : 2011

Certified Product(s): SafeAssure™ companywide Analog & Sensors hardware development process for Functional Safety related components .

Technical Data/Parameter: The audited SafeAssure development process for hardware product components complies with the ISO 26262 standard part requirements

ISO 26262-2:2011  
ISO 26262-5:2011  
ISO 26262-7:2011  
ISO 26262-8:2011  
ISO 26262-9:2011

Specific Requirements: The certificate is created for the purpose of providing conformity of the development and support process in accordance with ISO 26262. Changes which are not covered in the Audit Report have to be reconsidered.

Certification Body for Functional Safety: **SGS-TÜV Saar GmbH**      Munich, 26.01.2015  
Signature: *Marcus Rau*

The test mark regulation is an integral part of this certificate.  
SGS-TÜV Saar GmbH, Heisenstr. 61, D-81074 München, Deutschland / Germany  
WebSite: www.sgs-tuv-saar.com      E-Mail: fa@sgs.com



# Analog Portfolio

Bridging Real-World Physics to Connected Digital Intelligence



**System Power Management and Interface**



**Power Drivers and Switches**



**Battery Management**



**Analog System Solution**

**Power Management IC**

**System Basis Chip**

**Physical Layer Transceiver**

**Input Monitoring**

LDO – DC/DC  
Safety – Monitoring  
CAN – LIN – TPL – DSI

**Gate Driver**

**Power Driver**

**eXtreme Switch**

Low  $R_{DSon}$  – SPI  
High Side – Low Side  
Diag. & Protection

**Intelligent Battery Sensor**

**Battery Cell Controller**

**Li-Ion Battery Charger**

**Alternator Regulator**

System in Package  
800V – Balancing  
LIN – CAN – TPL

**77 GHz Radar**

**Airbag**

**Valve Controller**

**Programmable Solenoid Controller**

**Small Engine Controller**

System On Chip  
Safety  
Diag. & Protection



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- **Power Management Solutions**
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# System Power Management and Interface Key Products



**System Power Management and Interface**

**Power Management IC**

**System Basis Chip**

**Physical Layer Transceiver**

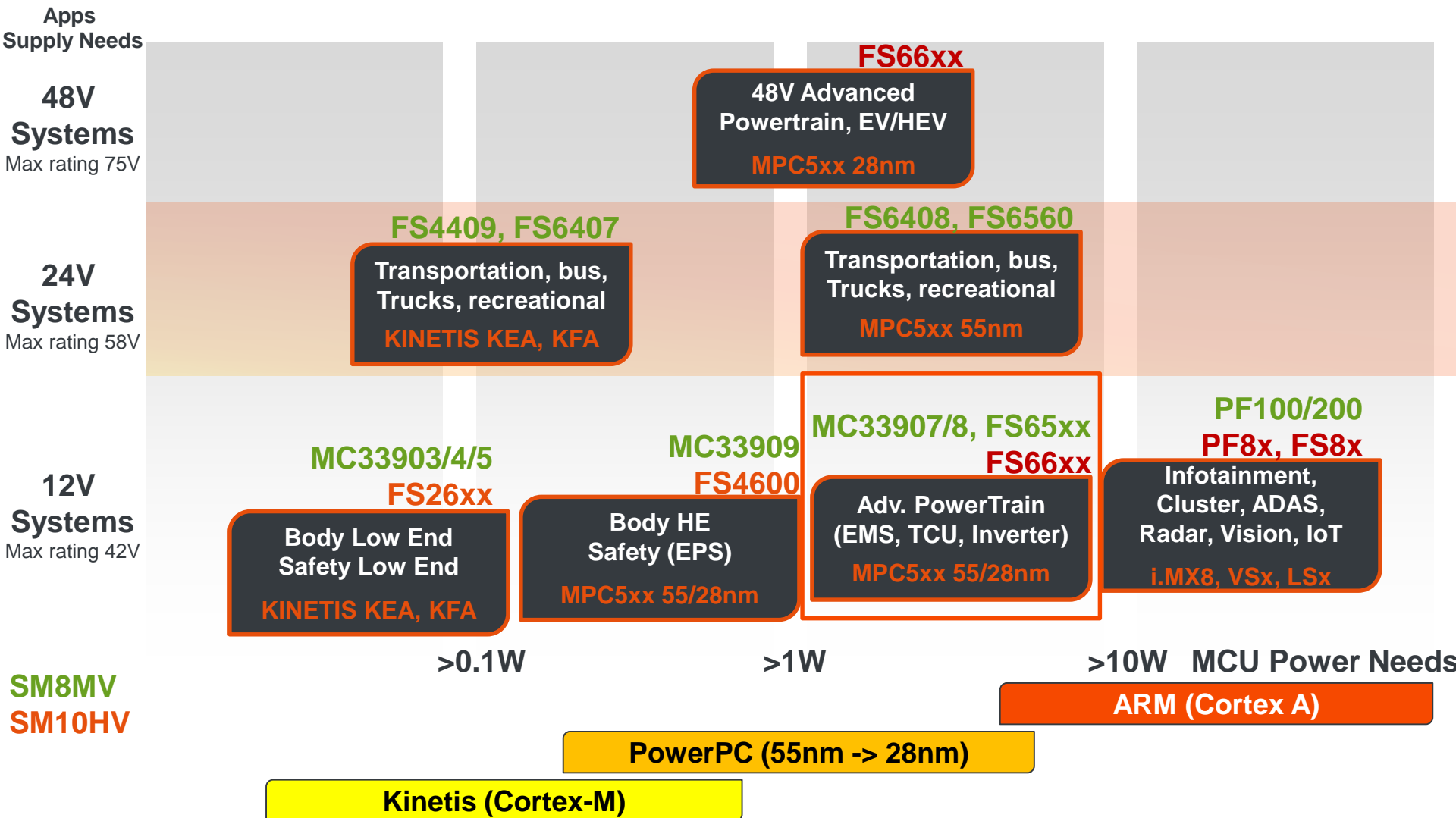
**Input Monitoring**

LDO – DC/DC  
Safety – Monitoring  
CAN – LIN – TPL – DSI

Power Management IC	Automotive	Industrial / Consumer
I.MX 6, 7 & FPGA	MMPF0100xxAZ MMPF0200xxAZ - -	MMPF0100xxAN MMPF0200xxAN MC32PF3000 MC34PF3000
QorIQ and LayerScape	-	MC34VR500
System Basis Chip	Automotive	Industrial / Consumer
LDO Based architecture	MC33910/11/ 12 MC33903/4/5	- MC34903/4/5
DC/DC Based architecture	MC33907 MC33908 MC33909	MC34FS6407 MC34FS6408 MC34FS4409
Physical Layer Transceiver	Automotive	Industrial / Consumer
CAN	MC33897 MC33901 MC33CM0902	- MC34901 MC34CM0902
LIN	MC33662/3	-
TPL	MC33664	-
DSI	MC33781/4 MC33AS0528	- -
ISOLINK	MC33660	-
Input Monitoring	Automotive	Industrial / Consumer
Switch Interface	MC33972/5/8	MC34972/5/8



# Global Power Management Portfolio Segmentation



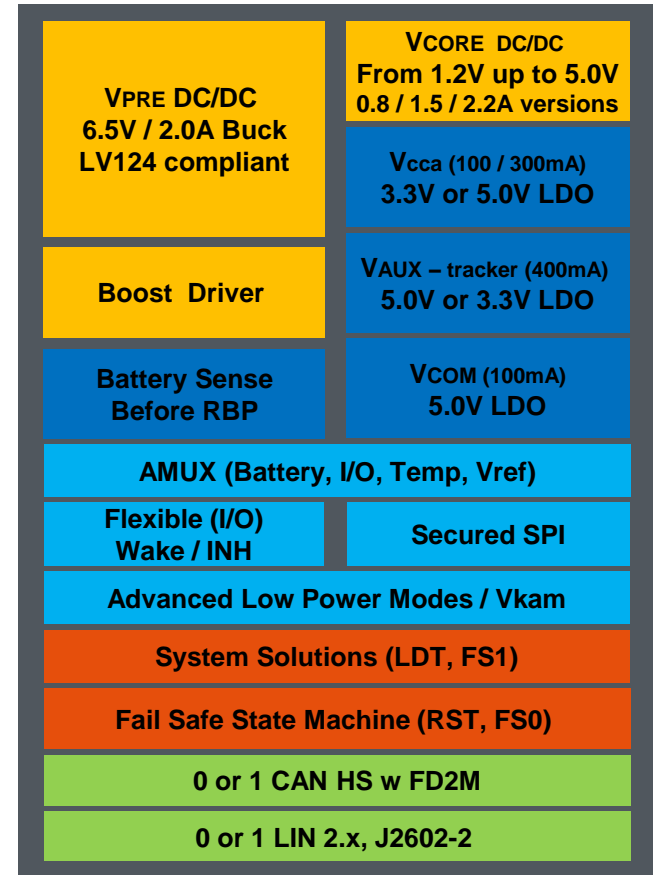
# SBC Portfolio Overview

Part Number Box & internal name	MC33910, 911, 912	MC33903 CANVAS32	MC33904/5 CANVAS	MC33909 CANopy	MC33907 PowerSBC10	MC33908 PowerSBC20
6.5 V Pre-regulator	N/A	N/A	N/A	2.0 A B/B 440kHz	2.0 A B/B 440 KHz	2.0 A B/B 440 KHz
VCore / (MCU core)	60 mA (Linear)	0.4 A (Linear) with ballast	0.4 A (Linear) with ballast	0.5 A (Linear)	0.8 A (B_2.4 MHz)	1.5 A (B_2.4 MHz)
VCCA (I/O / ATD)	N/A	N/A	N/A	N/A	100 mA (int) +/-1% 300mA (wPNP) +/-3%	100 mA (int) +/-1% 300mA (wPNP) +/-3%
Auxiliary Supply Vaux	N/A	N/A	Yes (ballast)	200mA (Tracker)	Up to 300 mA Tracker / Auxiliary	Up to 300 mA Tracker / Auxiliary
Can_5V Supply -- VCAN	N/A	100mA	100mA	200mA	100mA	100mA
CAN Interfaces	0	1	1	1	1	1
LIN Interfaces	1	0 / 1 / 2	0 / 1 / 2	0 / 1 / 2 / 3 / 4	0 / 1	0 / 1
IOs	4 W/U 2 LS drv (opt) Op Amp (opt)	2 / 4	2 / 4	6	6 (incl. F/S inputs)	6 (incl. F/S inputs)
Watchdog	Timeout Window	Timeout,window, random config.	Timeout,window, random config.	Timeout,window, random config.	Challenger	Challenger
Fit for ASIL	QM	B	B	B	D	D
LowQ LPOFF	32µA	15µA	15µA	<100µA	30µA	30µA
AMUX & Batt.Sense	Yes	Yes	Yes	Yes	Yes	Yes
Fail Safe	RST	Safe	Safe	Safe	Independ. I/O	Independ. I/O
Package	LQFP32	SOI32eP	SOIC32eP	LQFP48eP	LQFP48eP	LQFP48eP

# MC33907/08 – Key Features

- **Input Voltage 2.7V to 40V**
- **2.0A / 6.5V Buck Pre Regulator with optional Boost Driver LV124**
- **One high efficient buck converter, 2.4MHz (FS65xx series)**
  - Output Voltage from 1.2 to 5V
  - 1.5 A max at output @ 1.2V
- **3 LDOs :**
  - Vcca
  - 5V Vcom for embedded CAN interface
  - 1 Vaux Trackers, battery proof (additional tracker capable with Vpre output)
- **Lower Power Mode : 30µA in LPOFF with WU capability**
- **AMUX for I/O, Battery, voltage reference and Temp. Sensing**
- **Independent Fail Safe State Machine**
  - Safety Concept (RST and FS outputs)
  - Challenger Watch Dog to for for ASIL D applications
  - 6 Configurable I/Os, Safety capable
  - MCU and external IC monitoring
- **Communication Interface :**
  - CAN HS with FD 2M and LIN PHYs (P/N options without PHY)
  - SPI for MCU communication
- **Package : LQFP48eP**

## System Basis Chip



## Applications

- 12V ADAS, PowerTrain, BMS
- 55nm and 28nm MCU





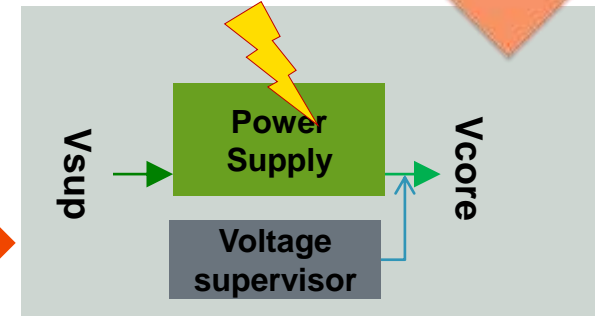
# MC33907/8: Functional Safety Strategy



## • Single Point Failure (SPF)

- Fail Safe State Machine as **Independent** checker
- Physical and electrical independence
- Own Reference, clock, Supply

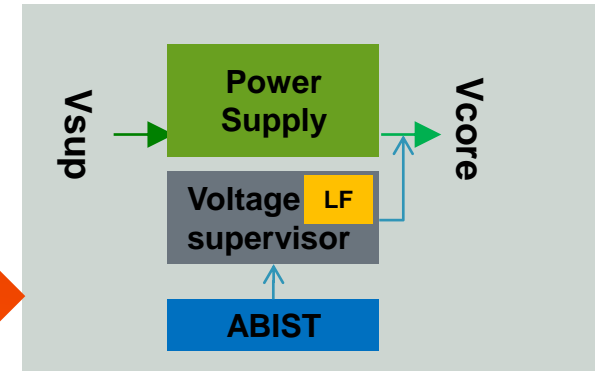
*Failure that results from a single point fault and leads directly to the violation of a safety goal"*  
**Requires a Quick detection**



## • Latent Failure (LF)

- Built-In Self Test
  - Analog (**ABIST**)
  - Logic (LBIST) – covering 90%
- Checker activated at each init phase

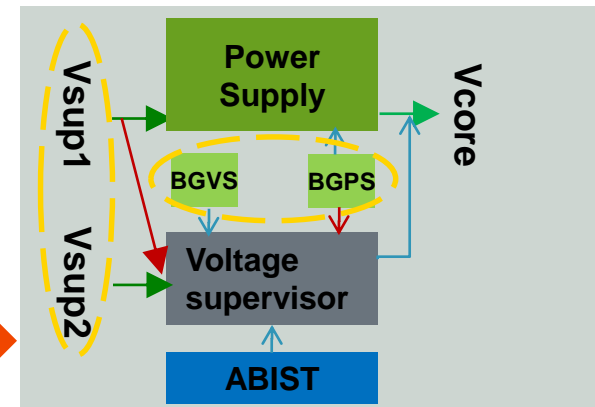
*"Failure, resulting from the combination of several independent faults, which leads directly to the violation of a safety goal" can become dangerous in conjunction with a second fault*  
**Periodic detection necessary**



## • Common Cause Failure (CCF)

- Independent Failure Monitoring Machine covering
  - **Independent Vsup, Reference Voltage and current, Clock**
  - Fail Safe Signal Monitoring
  - Fail Safe Output Management

*"Failure that results either in the loss of a safety function or in the loss of a Safety Detection Mechanism"*



# Advantage of this **Safety Integrated Solution**

- Your application implementation is **simplified** !
  - No need to implement a 2<sup>nd</sup> MCU to manage the safety in addition to the power supply.
  - Challenger / Watchdog implemented in the device
  - Voltage supervision available to track the regulators
  - No need to implement supply redundancy to satisfy fault management
- Power system Basis chip is the ideal **companion chip of your MCU**
  - Supervision of the MCU
  - Supervision of the system safety function
  - Capable to put your system in safe state if MCU falls in a wrong state
  - Flexible and configurable to fit with your application needs
- Comes with a set of **tools** and **documentations** to simplify its integration in your ASIL or SIL system assessment.

# MC33907 and MC33908 Industry Certification

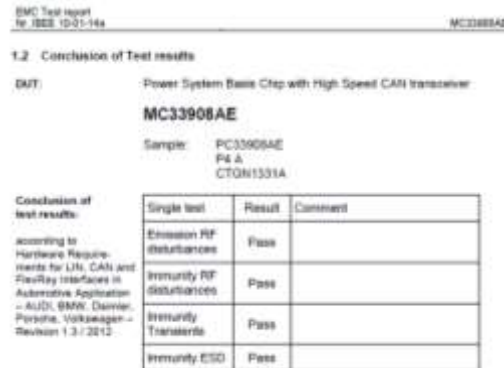
## CAN Elect. Conformance

- ❖ C&S **granted**
- ❖ Velio **granted**



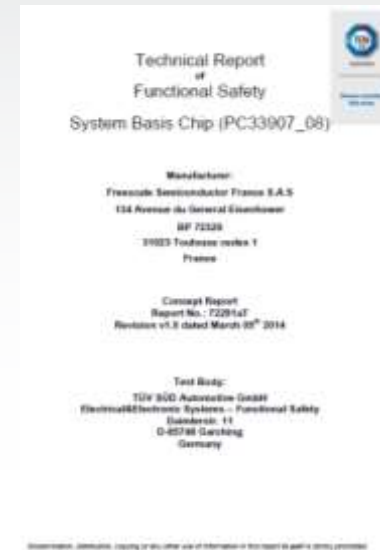
## EMC/ESD Conformance

- ❖ IBEE Zwickau **granted**
- ❖ J2962 **on going**
- ❖ PCB Design guideline Application note



## Safety Assessment

- ❖ Architecture and Concept **positively** Assessed by TUV SUD





# MC33907 / MC33908 EcoSystem

- **Quick performance Evaluation Board (EVB)**
  - Easy-to-use EVB for MC33907AE and MC33908AE
  - **KIT33908AEEVB and KIT33907AEEVB (with GUI) – 150\$**
- **Attach Strategy : Easy to Design Evaluation Module (EVM)**
  - Mother Board MC33908 - **KIT33908MBEVBE – 350\$**
  - Daughter Board MPC5643L - **KITMPC5643DBEVM (+ SW) – 150\$**
  - **Complete kit part number – KIT908-5643EVM (+ SW) – 550\$**
  - Panther Daughter board coming soon
- **Technical support**
  - Datasheet
  - EMC/ESD, compliance reports
  - Apps Notes (AN4442, AN4661, AN4843, AN4766, MPC5744PEV144UG)
  - SafeAssure Documentation (**FMEDA, Safety Manual**)
- **Tools:**
  - **Power Dissipation** prediction tool
  - Friendly **Graphical Interface**
  - SW example code
  - FAQ
  - Training
  - Complete support team here in Toulouse



Orderable on [www.freescale.com](http://www.freescale.com)



Freescale Semiconductor  
Safety Manual



Safety Manual for MC3390x

Devices Supported:

- + MC33907
- + MC33908

Table 1. Compliance Information

Compliance	MC33907 Safety Manual
RoHS	Yes
REACH	Compliant
RoHS 2.0	Compliant
RoHS 2.0 Annex 1	Compliant
RoHS 2.0 Annex 2	Compliant
RoHS 2.0 Annex 3	Compliant
RoHS 2.0 Annex 4	Compliant
RoHS 2.0 Annex 5	Compliant
RoHS 2.0 Annex 6	Compliant
RoHS 2.0 Annex 7	Compliant
RoHS 2.0 Annex 8	Compliant
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RoHS 2.0 Annex 13	Compliant
RoHS 2.0 Annex 14	Compliant
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RoHS 2.0 Annex 91	Compliant
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RoHS 2.0 Annex 93	Compliant
RoHS 2.0 Annex 94	Compliant
RoHS 2.0 Annex 95	Compliant
RoHS 2.0 Annex 96	Compliant
RoHS 2.0 Annex 97	Compliant
RoHS 2.0 Annex 98	Compliant
RoHS 2.0 Annex 99	Compliant
RoHS 2.0 Annex 100	Compliant

Device	Part Number	Package	Application
MC33907	MC33907AE	QFN	Automotive
MC33908	MC33908AE	QFN	Automotive
MC33907	MC33907AE	QFN	Automotive
MC33908	MC33908AE	QFN	Automotive

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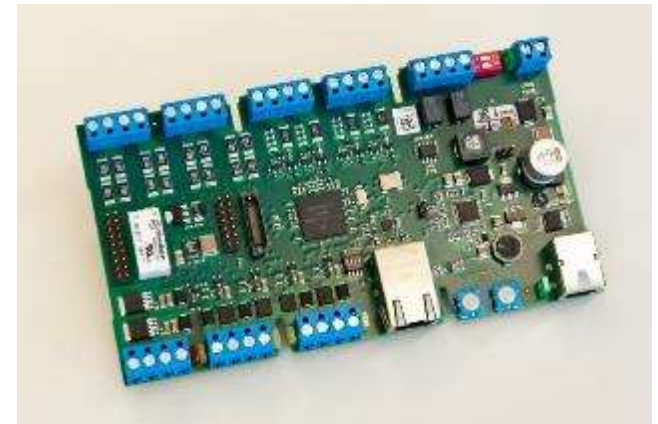
# SafeAssure KIT – EK5744

- Partnership by **Freescale** and **MicroSys**
- Based on Freescale Solutions
  - Qorivva **MPC5744P** MCU
  - **MC33907** System Basis Chip
- Safety Standards addressed
  - **IEC61508** (2010), **ISO13849** (2008), **IEC62061** (2005)
- **TUV Sud** will review the KITs and capabilities
- SafeAssure KIT
  - Will be orderable on Freescale.com (**miriac-EK5744**)
  - Support will be from **Freescale** (at MPC5744P and MC33907 level) and from **MicroSys** at system level
- **1<sup>st</sup> KIT** to provide an **industrial** safety solution using an MCU and SBC with an integrated safety architecture (MPC5744P and MC33907)

**Customer package information:** June 2015

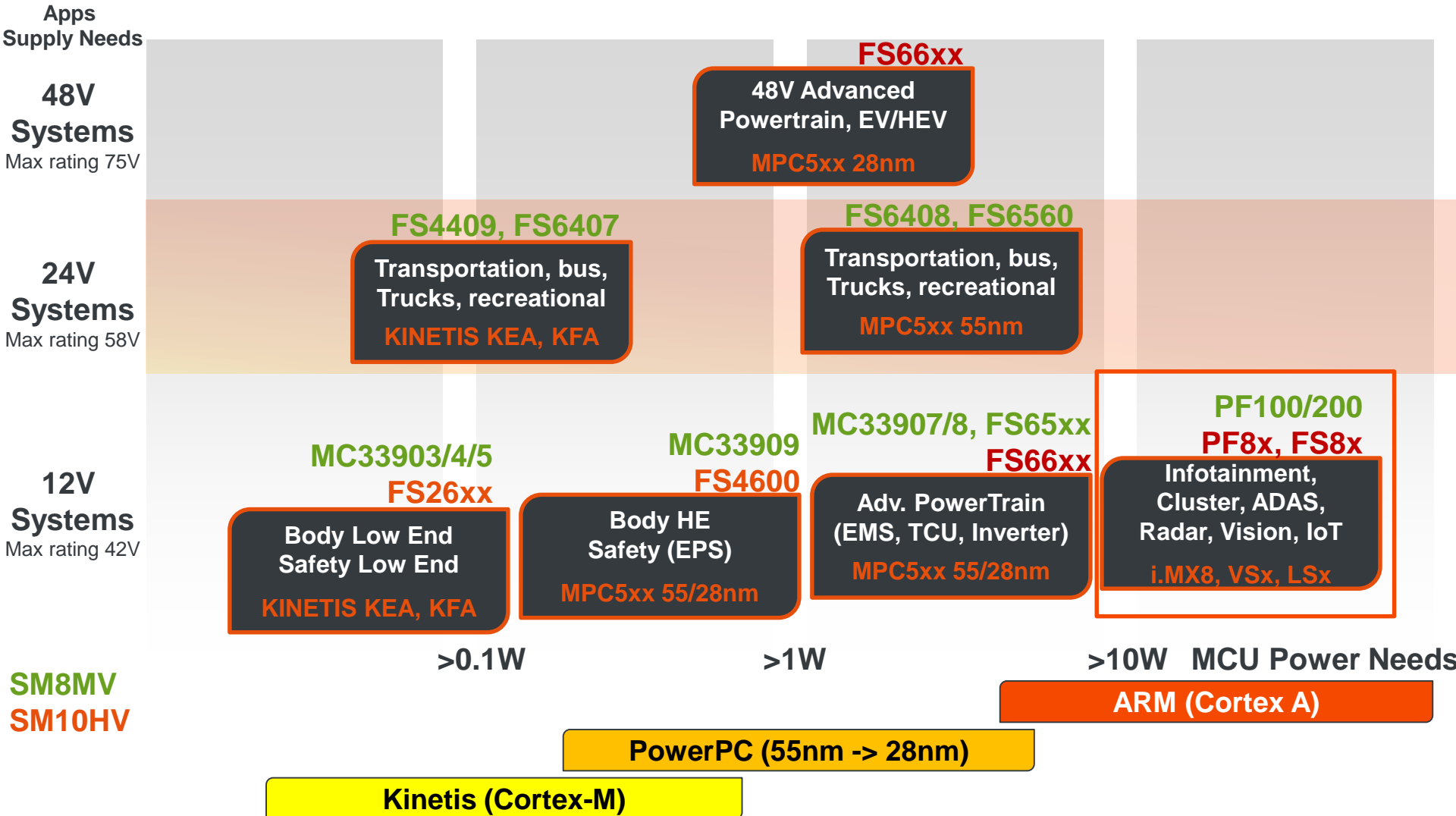
**SW development status:**

- HW concept: Assessed now
- Safety firmware → SW source by Q3 & SW assessed by Q4



# Global Power Management Portfolio Segmentation

## Power Scalable Solutions (MCU Target and Power Level)



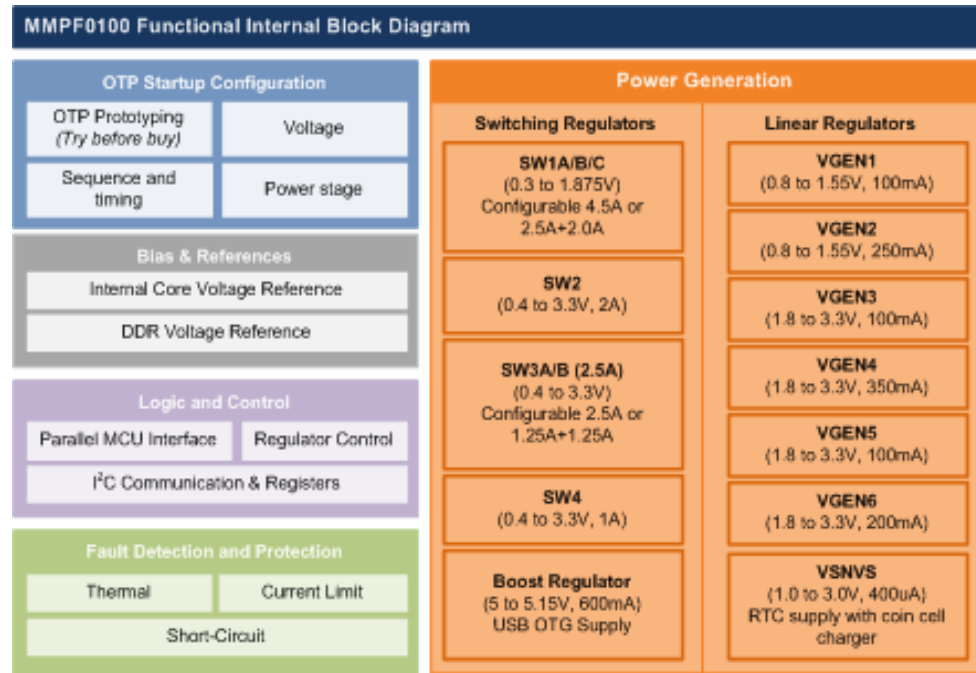
# MMPF0100: 14 Channel Configurable PMIC

## Differentiating Points

- Proven compatibility with i.MX 6 processor applications. Proven BSP's for IMX6S, SL, SLX, D, DL, Q.
- Boost regulator to 5.0 V out for USB
- OTP (One Time Programmable) memory to configure the device for field programming
- Custom pre-programmed output voltages, sequencing, and timing available
- Power control logic with processor interface and event detection

## Product Features

- Vin 2.8V to 4.5V Supply
- 4 to 6 Channel configurable buck converters\*\*
- 6 User programmable LDO
- Forced PWM or automatic PSM operation
- Boost regulator, Coin cell charger, DDR reference
- Programmable output voltage, current limit, soft-start, Fsw, OTP fault interrupt
- High power 8x8 mm, 56 E-QFN or WF-QFN



**\*\*MMPF0200 has 3/4 buck regulators instead of 5/6**

## APPLICATIONS

- Tablets, eReaders, Smartbooks, Navigation
- IPTV, IP Phone
- **Automotive infotainment**
- Human-machine interface, Home Automation
- Portable Medical







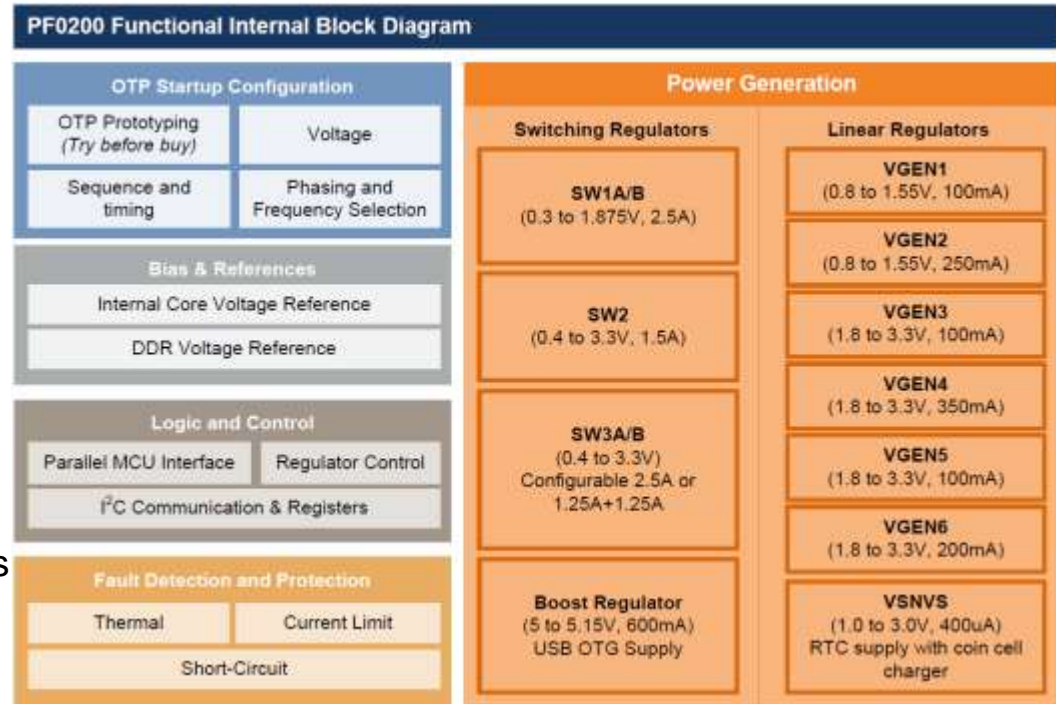
# MMPF0200 : 12 Channel Configurable PMIC

## Differentiating Points

- Proven compatibility with i.MX 6 processor applications. Proven BSP's for IMX6SLX.
- Boost regulator to 5.0 V out for USB
- OTP (One Time Programmable) memory to configure the device for field programming
- Custom pre-programmed output voltages, sequencing, and timing available
- Power control logic with processor interface and event detection

## Product Features

- Vin **2.8V to 4.5V** Supply
- 3 to 4 Channel configurable buck converters
- **6 User programmable LDO**
- Forced PWM or automatic operation
- Boost regulator, Coin cell charger, DDR reference
- Programmable output voltage, current limit, soft-start, Fsw, OTP fault interrupt
- High power 8x8 mm, 56 E-QFN or WF-QFN



Lower featured version of the PF0100. SW1C and SW4 regulators are removed in MMPF0200 and SW2's current rating is reduced to 1.5A

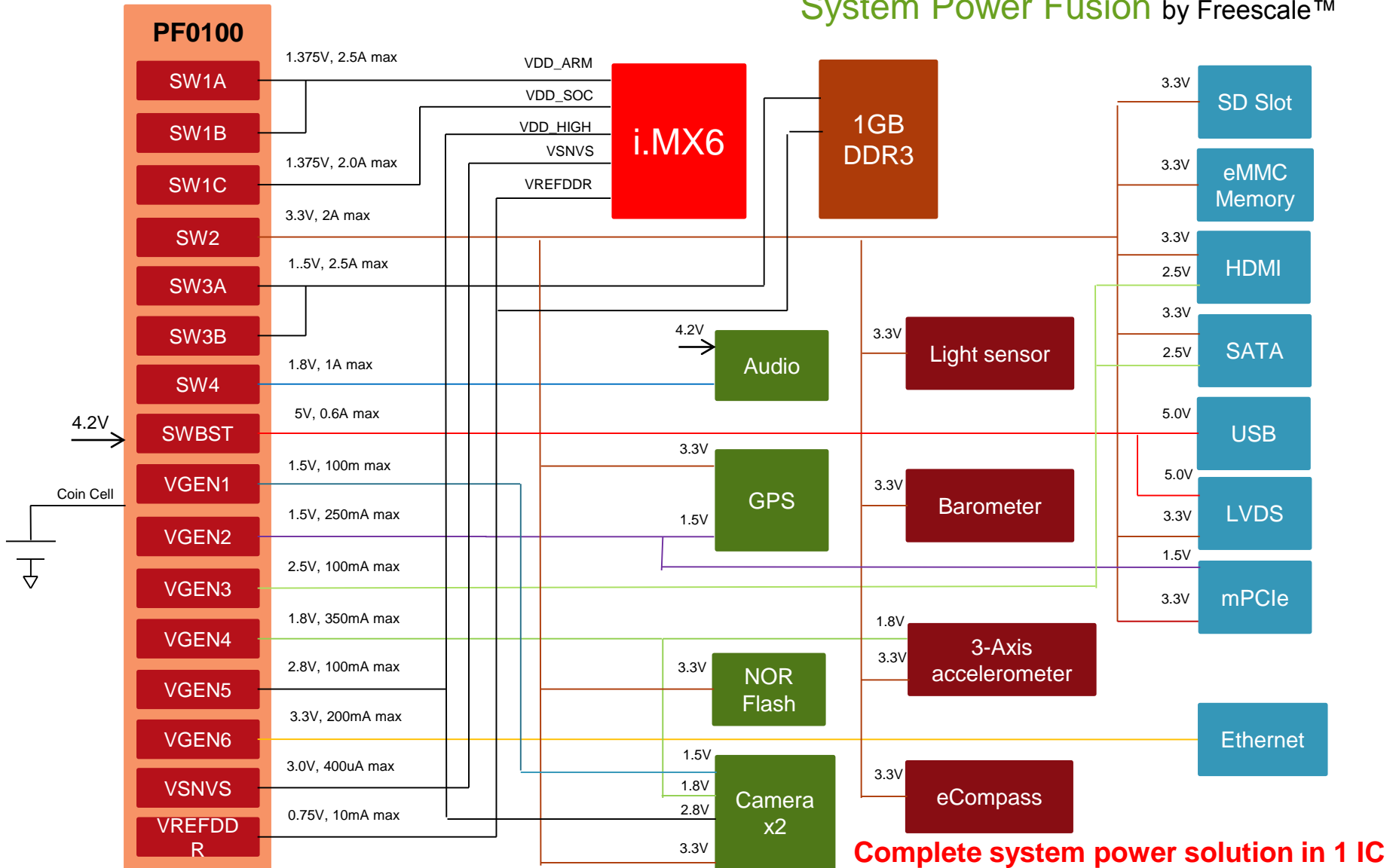
## Applications

- Tablets, eReaders, Smartbooks, Navigation
- IPTV, IP Phone
- **Automotive infotainment**
- Human-machine interface, Home Automation
- Portable Medical



# Example: PF0100 Power to Complete i.MX 6 System

System Power Fusion by Freescale™



Complete system power solution in 1 IC

# Reference Design

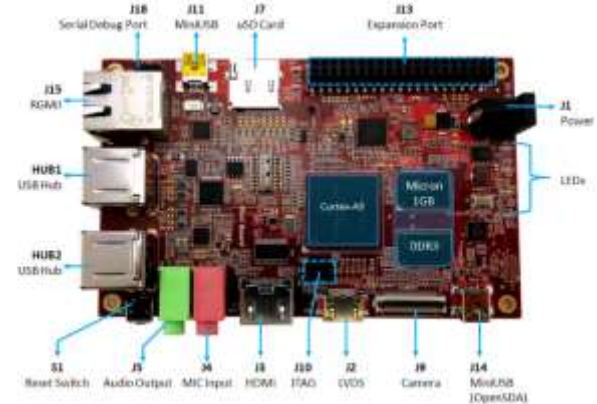
## SABRE for Automotive Infotainment



*i.MX 6SoloL EVK*



*R10Tboard*



# PMIC Reference Design

Board Name	i.MX	PMIC	Avail.	Market
SABRE Board for Smart Devices	i.MX6Q	MMPF0100F0AEP	now	Consumer/Industrial
SABRE Platform for Smart Devices	i.MX6Q i.MX6DL	MMPF0100F0AEP	now	Consumer/Industrial
SABRE For Automotive infotainment	i.MX6Q i.MX6DL	MMPF0100NPAZES	now	Automotive
SoloLite Evaluation Kit	i.MX6SL	MMPF0100F1AEP	now	Consumer/Industrial
SoloLite Evaluation Kit	i.MX6SL	MMPF0200F3AEP	now	Consumer/Industrial
MX 6SX Automotive	i.MX6SX	MMPF0100F6AZES	now	Automotive
MX 6SX SDB	i.MX6SX	MMPF0200F6AEP	now	Consumer/Industrial
RIoT board	i.MX6 S	MMPF0100NPAEP	now	Consumer/Industrial
SABRE SDB	IMX 7S/D	MC34PF3000	now	Consumer/Industrial
SABRE	IMX6 PLUS	MMPF0100F9AEP	3Q15	Automotive
EVK	IMX 6UL 9x9	MC34PF3000	4Q15	Consumer/Industrial

# Power Management – Processor Attach Summary



MC33903/4/9

MC33907/8

FS45/FS65

FS66xx

PF100/200

PF8x

FS8x

VR5xx

59B4

MPC574xB

Others

KFA 256/2M

KGA 128

MPC5777C

MPC5746R

MPC5744P

MPC5643L

Others

MPC5775R

MPC5777M

MPC5777C

MPC5744P

59B4

MPC574xB

Others

59P8xx

59P6xx

59P4xx

i.MX 6 QPlus

i.MX 6 DPlus

i.MX 6 Quad

i.MX 6 Dual

i.MX 6 DL

i.MX 6S

i.MX 6SX

i.MX 6SL

S32V2 / V4

i.MX8 Q Max

i.MX8 Q+ 4/8

i.MX8 S/D/Q

S32V6 / V8

S32V2 / V4

i.MX8 Q Max

i.MX8 Q+ 4/8

i.MX8 S/D/Q

T1023

T1013

LS1043A

LS1023A

LS1024A

LS1022A

LS1021A

LS1020A



Competition



ARM® Auto



MPC5xxx



i.MX



QorIQ / LSx



# Agenda

- Introduction: Freescale Analog Automotive Solutions
- Power Management Solutions
- **24V eSwitches**
- Programmable Solenoid Driver 12V & 24V
- Battery Sensors Solutions
- Conclusion & Q&A

# Power Drivers and Switches Key Products



**Power Drivers  
and Switches**

**Gate Driver**

**Power Driver**

**eXtreme Switch**

Low  $R_{DSon}$  – SPI  
High Side – Low Side  
Diag. & Protection

Gate Driver	Automotive	Industrial / Consumer
H-Bridge Pre-Driver	MC33883	-
BLDC Pre-Driver	MC33937	MC34937 – MC34GD3000

Power Driver	Automotive	Industrial / Consumer
H-Bridge & DC Motor Driver	- MC33886 – MC33926 MC33931/2 MC33HB2000/1	MPC155xx – MC34933 - MC34931/2 MC34HB2000/1
BLDC Driver	-	MC34929
Low / High Side Switch	MC33882 MC33880 – MC33879 MC33996 – MC33999	- - -

eXtreme Switch Family	Automotive	Industrial / Consumer
Low $R_{DSon}$	MC33981/2/4/8	MC34981/2/4/8
Medium $R_{DSon}$	MC12XS6 MC24XS4	MC12XSF MC36XSD



# eXtreme Switch Composition

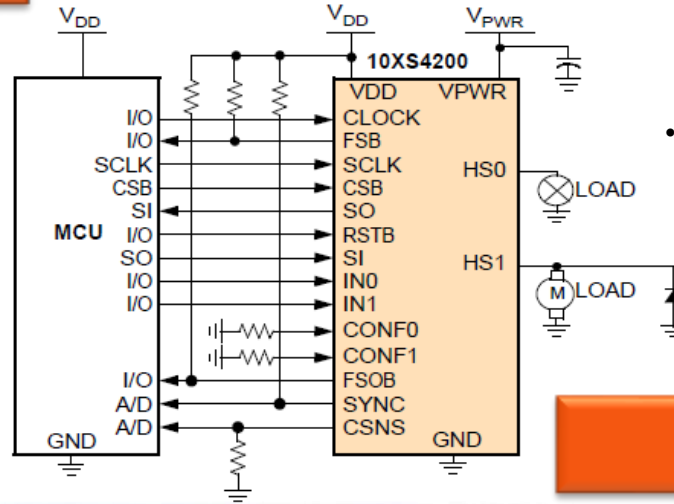
## SMARTMOS™

- **Protection and diagnostic**

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

- **SPI Interface**

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

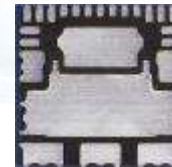


## Vertical Power stage

- **Best-in-class Technology**
  - Planar HD5 and TrenchFet LFET
    - 45 V & 65 V BV
- **Protection in the power stage**
  - Temperature sensor
  - Current sensor

## Power package

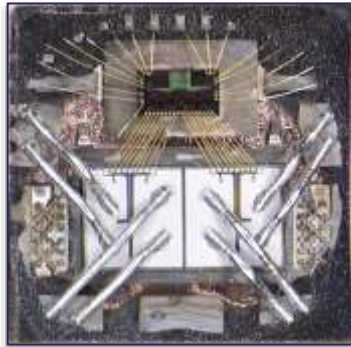
- **PQFN low cost power package**



- 0.5 mm thick lead frame
- Die soldered attached
- $R_{thj-c} < 0.5^{\circ}\text{C/W}$

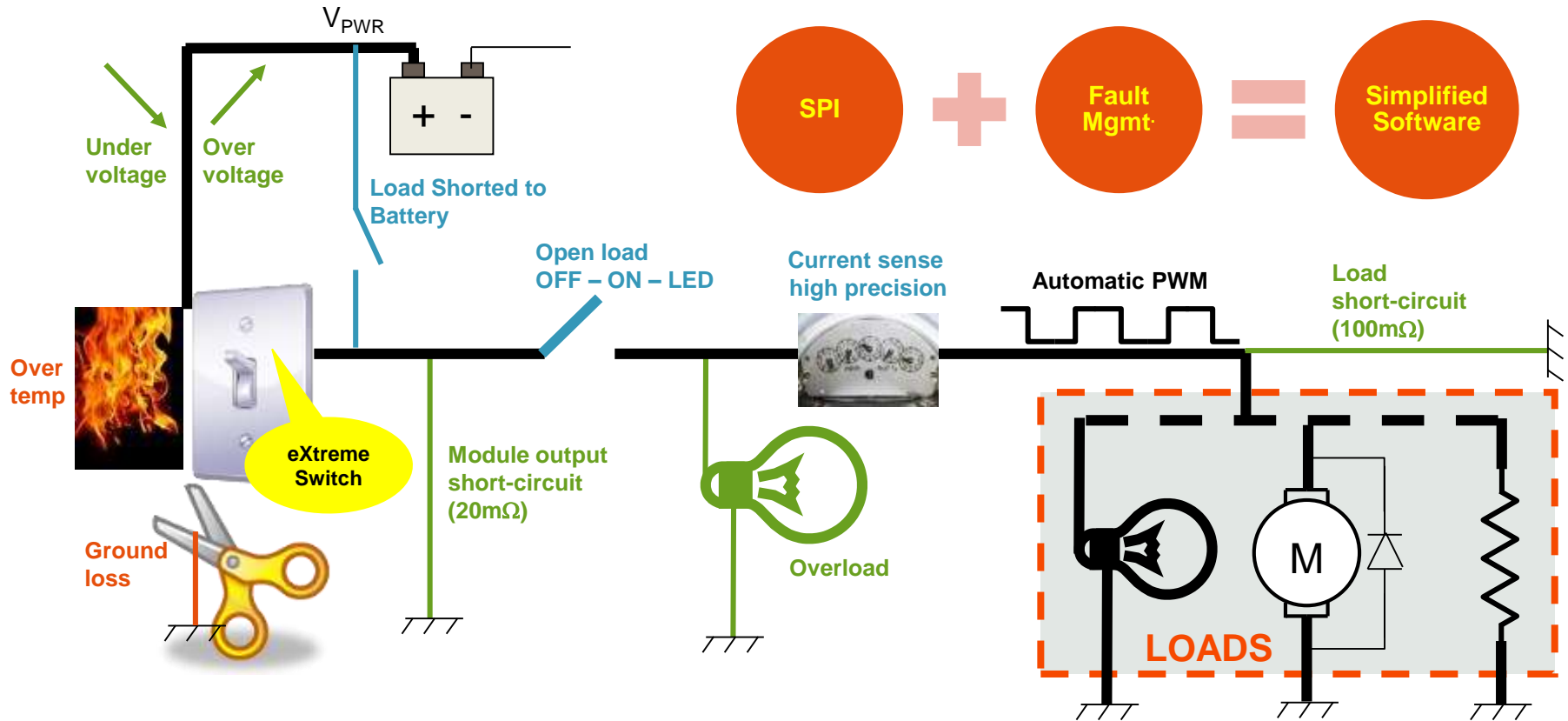
- **SOICeP32 and 54**

- designed for high power
- Large AL wire capability
  - Pb-free compliancy





# What Are the Primary eXtreme Switch Features?



SPI + Fault Mgmt = Simplified Software

## 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



# 24 A / 36 V eXtreme Switch

MC06XSD200 – MC10XSD200 – MC16XSD200 – MC22XSD200 – MC50XSD200

Dual 6mΩ

Dual 10mΩ

Dual 16mΩ

Dual 22mΩ

Dual 50mΩ

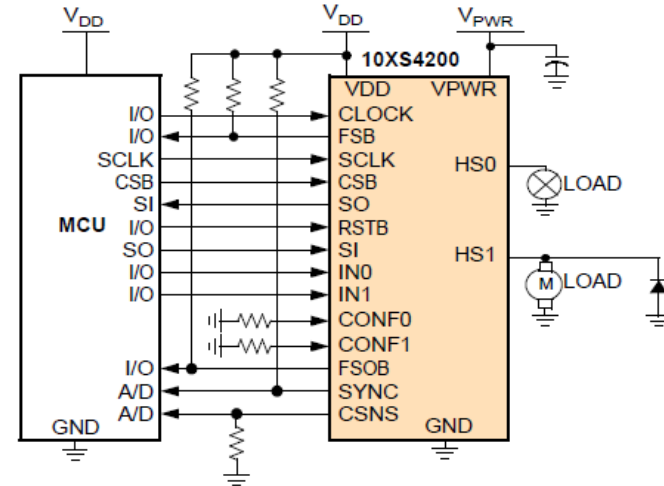
**Scalable, programmable family of 24 A/36 V SPI-driven, dual-channel, smart high-side switches with lowest RDSon for up to a 30% board reduction**

## Differentiating Points

- **Robustness:** Unique over-current latch-off protection, full digital & analog diagnostic and protection features with embedded failsafe mode
- **Integration:** Unique daisy-chainable SPI control for dual low RDSon channels in a single package
- **Accuracy:** 5X better current sensing accuracy over temperature & supply voltage range with unique accurate temperature sensing capability
- **Scalable:** Compatible PCB foot print and SPI software driver
- **Lowest RDSon in Dual Configuration:** 20% smaller PCB due to lower power dissipation when using 12 A/channel or 24 A/dual in a thermally enhanced package

## Product Features

- Dual 24 A/36 V high side switch with 6, 10, 16, 22 or 50 mW RDSon channels
- Normal operating range: **8.0 – 36 V**, extended range: **6.0 – 58 V**
- Flexible load management **1-24 A** with possible **parallel output** operating modes
- **Programmable dynamic threshold over current protection** and over-temperature protection with programmable auto-retry functions
- 3.3 V and 5.0 V compatible **16-bit Daisy chainable SPI control**
- $\pm 5^{\circ}\text{C}$  temperature and synchronous / asynchronous current ( $\pm 10\%$ ) sensing
- Individually programmable internal/external PWM clock signals



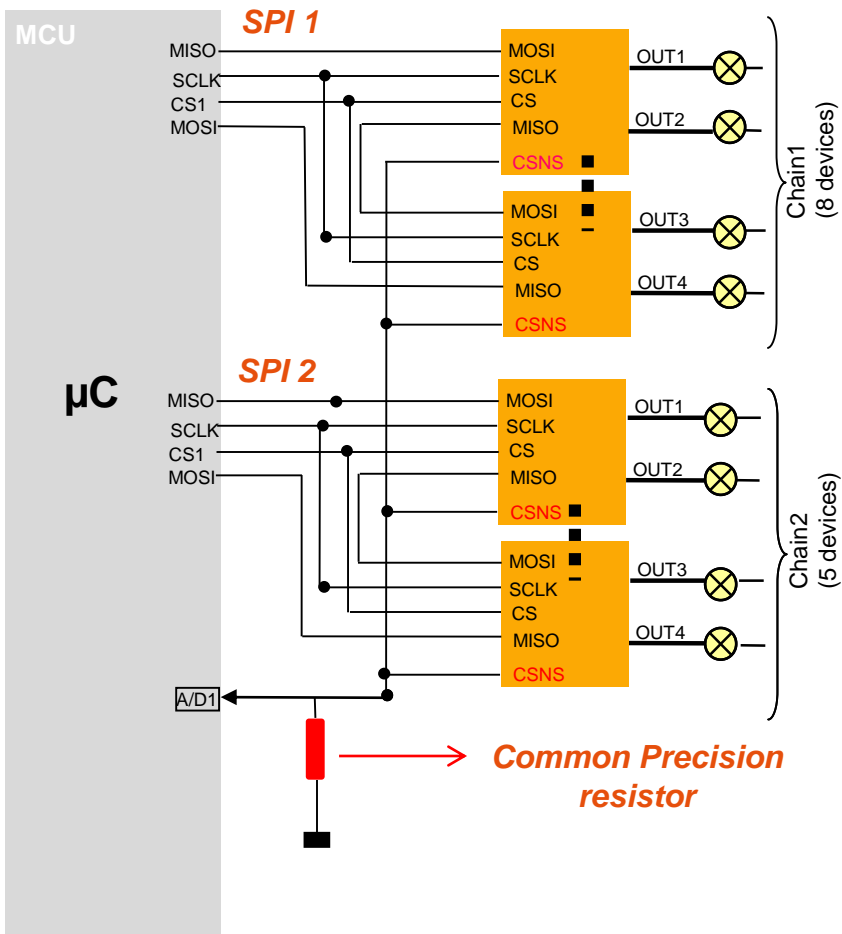
## Typical Applications

Transportation 12 / 24 V

- 24 V Lighting and capacitive loads
- Valves
- DC motors

Industrial 36V

# 24A / 36V eXtreme Switch Application Diagram



## • Application Needs

26 \* 2A loads with current sense

## • Freescale SPI Solution Requirement

All devices can be connected in Daisy Chain (2 in this example)

✓ 8 I/Os pins used for 26 loads SPI control

## • Freescale Current Sense Resistor Requirement

All non active current sense pins can be tri-stated

✓ 1 Analog Input on µC used for current sensing

## • Freescale Solution Summary

✓ only 9 IOs of µC required

✓ only 2 Resistors for Fail Safe (Output and Status)

✓ only 1 High Precision Resistor

## Freescale Advantages vs. Competition

(2 outputs, 2 current sense & no SPI)

### ❑ SPI and Technology

✓ >30 IOs saved and >50 resistors saved !  
(no Resistors for MCU connection)

### ❑ Daisy Chainable and common Precision resistor

✓ 25 A/D saved and 25 high precision Resistors saved !  
(and/or external analog multiplexer)

**eXtreme Switch saves "Size – Weight – Cost" at module level**

# eXtreme Switch Product Family

12V Family Devices									
Generation	Part Number	Outputs # and On-Resistance	Total Outputs #	Package	Low Operating Voltage	High Operating Voltage	Max PWM frequency	Pin to Pin Compatibility	SW Compatibility
MC12XSC	MC07XSC200EK	Dual 7mΩ	2	32-pin SOICEP	6V	20V	1 kHz	-	√
	MC10XSC425EK	Dual 10mΩ, Dual 25mΩ	4	32-pin SOICEP	6V	20V	1 kHz	-	
MC12XSF	MC07XSF517EK	Triple 7mΩ, Dual 17mΩ	5	54-pin SOICEP	7V	18V	400 Hz	√	√
	MC17XSF500EK	Penta 17mΩ	5	32-pin SOICEP	7V	18V	400 Hz		
	MC40XSF500	Penta 40mΩ	5	32-pin SOICEP	7V	18V	400 Hz		
	MC08XSF421	Dual 08mΩ, Dual 21mΩ	4	32-pin SOICEP	7V	18V	400 Hz		
	MC17XSF400	Quad 17mΩ	4	32-pin SOICEP	7V	18V	400 Hz		

36V Family Devices									
Generation	Part Number	Outputs # and On-Resistance	Total Outputs #	Package	Low Operating Voltage	High Operating Voltage	Max PWM frequency	Pin to Pin Compatibility	SW Compatibility
MC36XSD	MC06XSD200FK	Dual 6mΩ	2	24-pin PQFN	8V	36V	1 kHz	√	√
	MC10XSD200FK	Dual 10mΩ	2	24-pin PQFN	8V	36V	1 kHz		
	MC16XSD200FK	Dual 16mΩ	2	24-pin PQFN	8V	36V	1 kHz		
MC36XSD	MC22XS4200BEK	Dual 22mΩ	2	32-pin SOICEP	8V	36V	1 kHz	√	√
	MC50XS4200BEK	Dual 50mΩ	2	32-pin SOICEP	8V	36V	1 kHz		

Main Switch Devices									
Generation	Part Number	Outputs # and On-Resistance	Total Outputs #	Package	Low Operating Voltage	High Operating Voltage	Max PWM frequency	Pin to Pin Compatibility	SW Compatibility
MC12XSB	MC34981ABHFK	Single 4mΩ	1	16-pin PQFN	6V	27V	60kHz	-	-
	MC34982CHFK	Single 2mΩ	1	16-pin PQFN	6V	27V	1 kHz	√	√
	MC34984CHFK	Dual 4mΩ	2	16-pin PQFN	6V	27V	1 kHz		
	MC34988CHFK	Dual 8mΩ	2	16-pin PQFN	6V	27V	1 kHz		

# Agenda

- Introduction: Freescale Analog Automotive Solutions
- Power Management Solutions
- 24V eSwitches
- **Programmable Solenoid Driver 12V & 24V**
- Battery Sensors Solutions
- Conclusion & Q&A

# Analog System Solution Key Products



**Analog System Solution**

- 77 GHz Radar
- Airbag
- Valve Controller
- Programmable Solenoid Controller
- Small Engine Controller
- System On Chip  
Safety  
Diag. & Protection

77 GHz Radar	Automotive	Industrial / Consumer
VCO, TX, RX Packaged chipset	MC33MR2001V/T/R	-

Airbag	Automotive	Industrial / Consumer
	MC33789 – MC33797	-
Reference Platform	RDAIRBAGPSI5	-

Valve Controller	Automotive	Industrial / Consumer
Octal SoC	-	MC34SB0800
Quad SoC	-	MC34SB0410

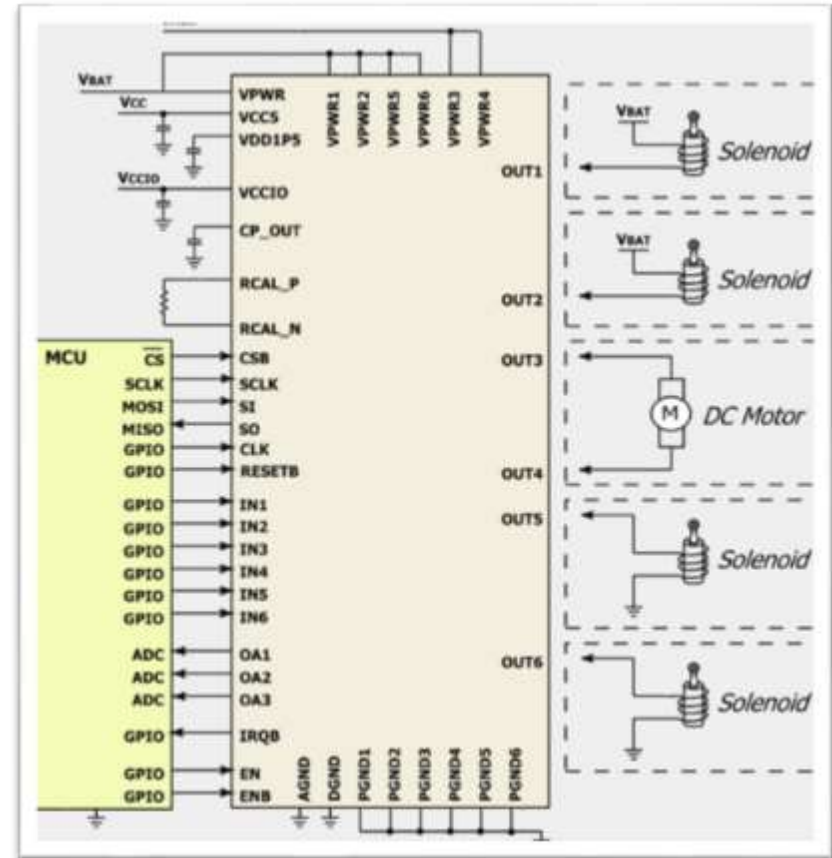
Programmable Solenoid	Automotive	Industrial / Consumer
Direct Fuel Injection up to 6-cyl.	MC33816	-

Small Engine Controller	Automotive	Industrial / Consumer
Engine control for 1-to-4 cylinder	MM912_812 MC33813 – MC33814	



# Programmable Solenoid Driver (PSD) Overview

- The PSD includes 6 half bridges to drive up to 6 loads like solenoid or DC motors.
- It will interface to MCU via
  - 6 direct control inputs, 3 analog outputs, 2 enablement and 1 resetb inputs, 1 interrupt output and a SPI interface for configuration and diagnosis.
- The logic interfaces are 5V and 3.3V compatible.
- Fully operational for 12V automotive systems & 24V truck/agricultural systems
- **Drive capability: 1 A typical, 1.5 A max**
- Functional and diagnostic features fully programmable via SPI
- Rich diagnosis features
- **Functional Safety**
- Package: 48LD LQFP-EP, 48LD QFN, KGD



# PSD Functional Block Diagram

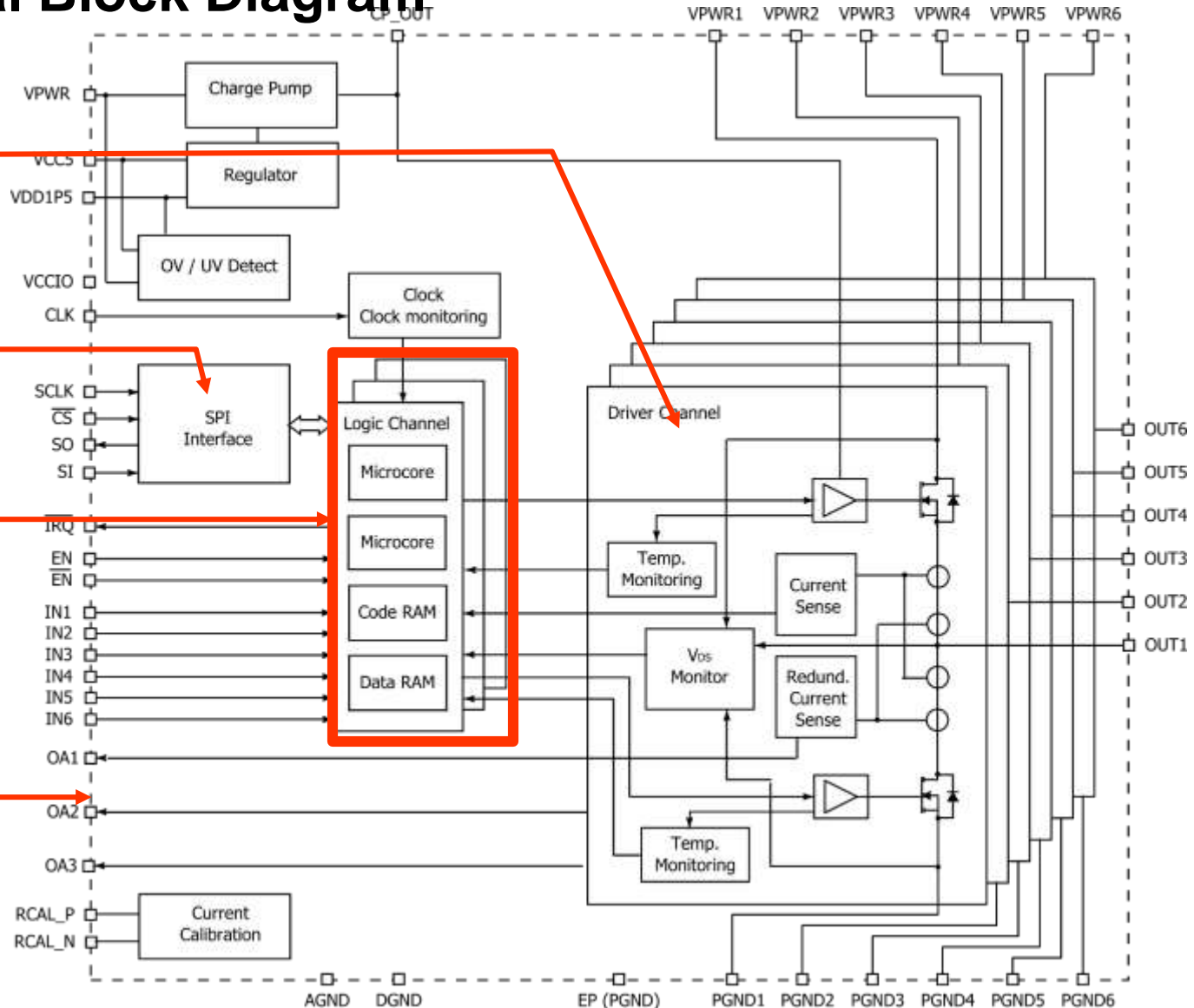
6 Driver Channels with integrated precision current sensor on each driver

16-bit SPI operating up to 10 MHz

3 Logic Channels with 2 Microcores embedded in each channel

One Microcore controls one Driver Channel

Three (3) analog current sense outputs





# Agenda

- Introduction: Freescale Analog Automotive Solutions
- Power Management Solutions
- 24V eSwitches
- Programmable Solenoid Driver 12V & 24V
- **Battery Sensors Solutions**
- Conclusion & Q&A

# Battery Management Key Products



## Battery Management

Intelligent Battery Sensor

Battery Cell Controller

Li-Ion Battery Charger

Alternator Regulator

System in Package  
800V – Balancing  
LIN – CAN – TPL

Intelligent Battery Sensor	Automotive	Industrial / Consumer
LIN-Based	MM912_637	-
CAN-Based	MM9Z1_638	

Battery Cell Controller	Automotive	Industrial / Consumer
14-Cell	MC33771	-
Isolated Physical Layer	MC33664	-

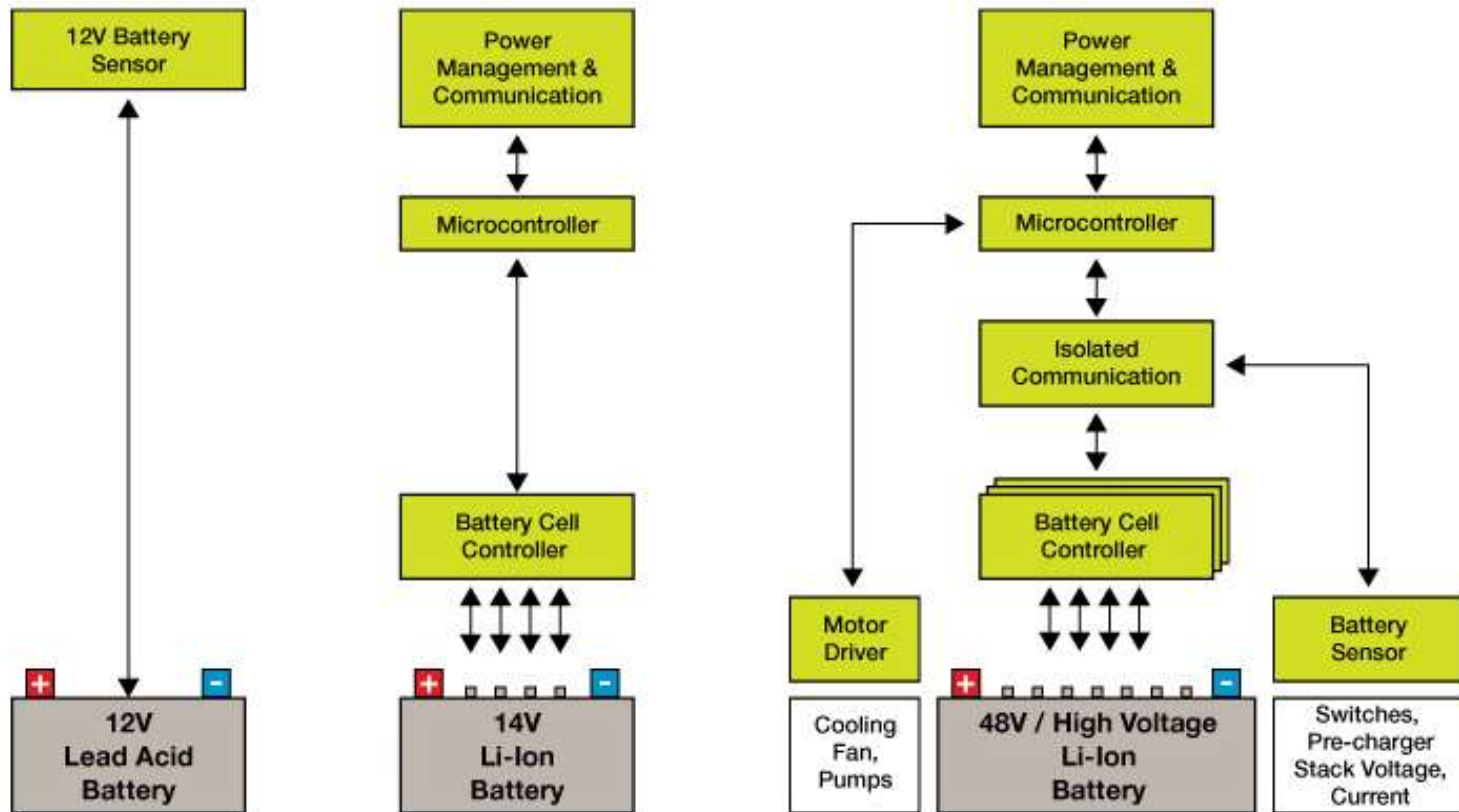
Li-Ion Battery Charger	Automotive	Industrial / Consumer
Linear Charger	-	MC34671/3/4/5
Switching Charger	-	MC32BC3770


Alternator Regulator	Automotive	Industrial / Consumer
No-Protocol	TC80500 (Die)	-
LIN-Based	TC80600 (Die & TO220)	-



# Freescale Battery Management System Solutions

## Battery Management



 Freescale Technology

# Intelligent Battery Sensors MM912J637 / MM9Z1J638

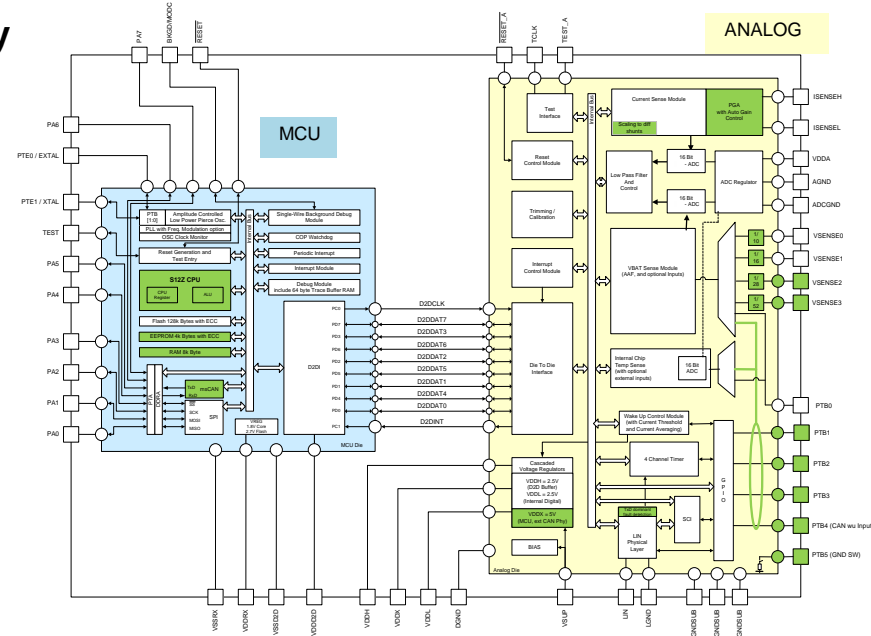
Precision battery monitoring solution enabling lower system power consumption with operating redundancy for mission-critical applications up to 52 V

## Differentiating Points

- LIN conformance and ESD/EMC robustness
- Configurable ADC HW filters reduce **Software complexity**
- Input voltage flexibility to address variety of applications  
Operating voltage redundancy with 3 ADC paths
- 70% stop duty cycle operation
- 20% lower system current consumption

## Product Features

- **Integrated MCU**, Flash, RAM, communication
- **3x 16-bit ADC** for **Current, Voltage and Temperature**
- Low-power features
- **Multiple wake-up** features (Current, temp, etc)
- Configurable HW filters (voltage and current SD ADC)
- Robust LIN physical layer
- MM912J637: 16-bit MCU targeting **lead acid battery management** over LIN interface
- MM9Z1J638: High-end 16-/**32-bit MCU** targeting a **wide range of battery applications** over **CAN** or LIN interface



## Typical Applications

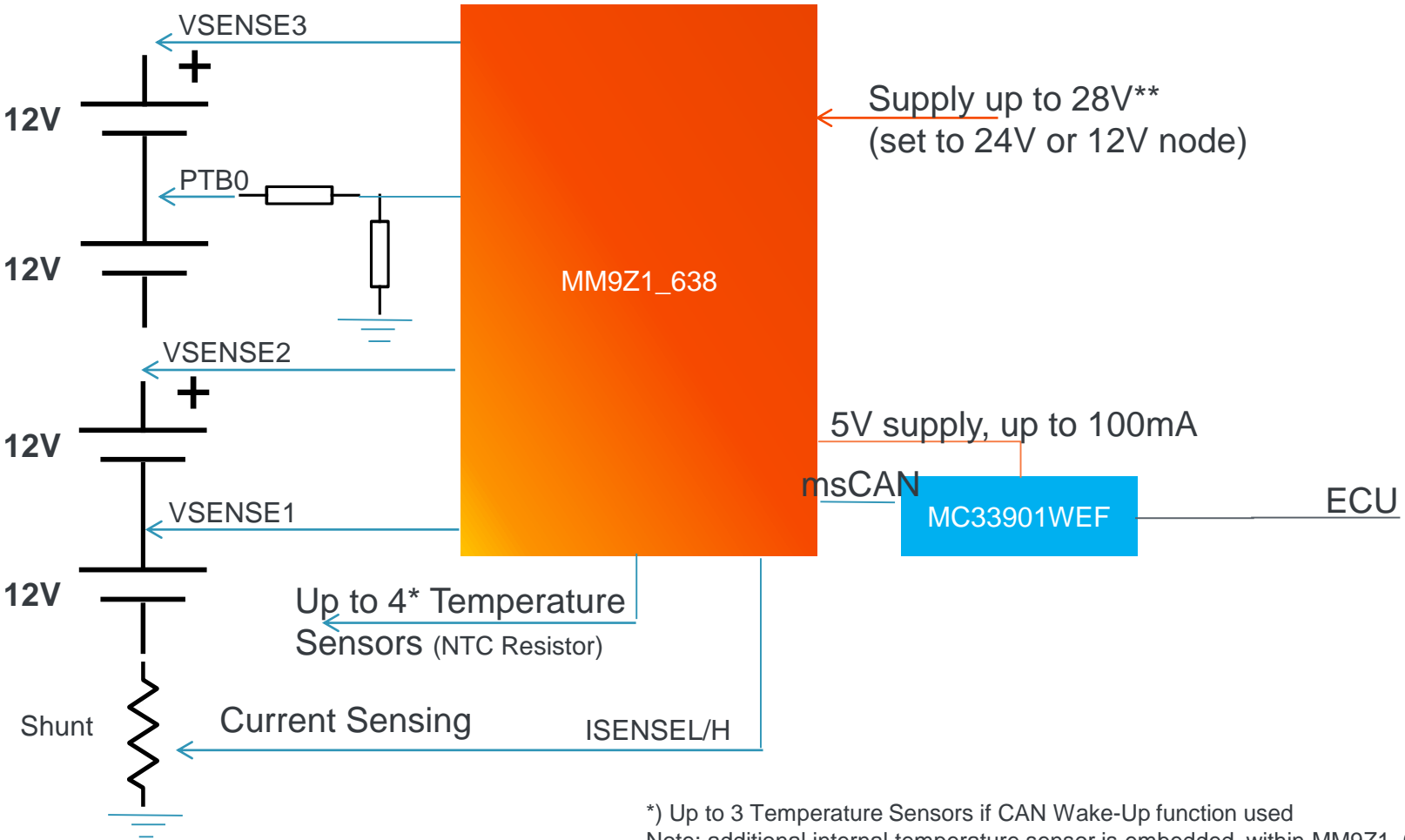
For mission critical battery operations:

- Automotive
  - 12 V Lead Acid, 14 V Li-Ion
  - 48 V HV BMS, Battery Junction Box
- Trucks & Utilities
  - 24 V Lead Acid





# 48V 4-Cell Monitoring application with MM9Z1\_638



# Battery Cell Controller (BCC) | Isolated Communication Overview



## Premium BCC

MC33771ASP (SPI comm)  
MC33771ATP (TPL comm)

- Precise differential cell voltage measurement
- Cell OV/UV, O/U temperature
- Synchronized current measurement
- Coulomb Count
- Cell balancing
- Temp measurement
- Functional verification and diagnostics
- Communication:
  - 2 MHz half duplex differential
  - SPI 4 MHz
- Package: 64-lead LQFP EP
- Temp range: -40 C to +105 C

## Advanced BCC

MC33771ASA (SPI comm)  
MC33771ATA (TPL comm)

- Precise differential cell voltage measurement
- Cell OV/UV, O/U temperature
- Cell Balancing
- Temp Measurement
- Functional verification and diagnostics
- Communication:
  - 2 MHz half duplex differential
  - SPI 4 MHz
- Package: 64-lead LQFP EP
- Temp range: -40 C to +105 C

## Basic BCC

MC33771ASB (SPI comm)  
MC33771ATB (TPL comm)

- Precise differential cell voltage measurement,
- Cell OV/UV
- Communication:
  - 2 MHz half duplex differential
  - SPI 4 MHz
- Package: 64-lead LQFP EP
- Temp range: -40 C to +105 C

Transformer  
Physical Layer  
MC33664ATL1

- Differential transformer driver / receiver
- Bus and MCU wake-up
- SAFE output (Fail-Safe implementation)
- Operating voltage down to 3.5 V (cranking)
- On-board oscillator
- Analog bit filter
- Package: 16-lead SOIC
- Temp range: -40 C to +105 C

BCC Samples: Now

Production: Q4 2015

TPL Samples: Now

Production: Q4 2015



# MC33771 14 Cell Li-ion Battery Cell Controller

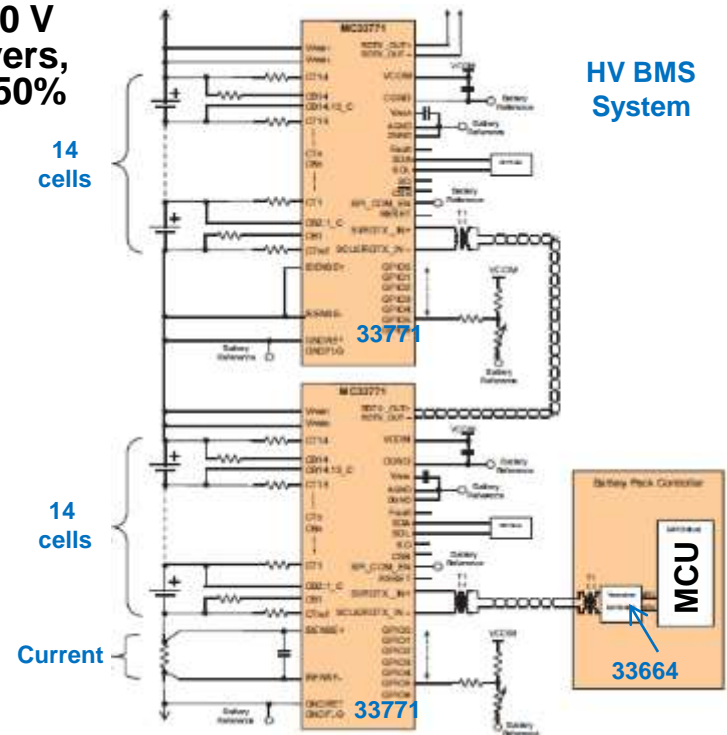
Scalable ISO26262 ASIL-C compliant controller for 48 to >1000 V packs with 2 Mbps transformer coupled daisy chain transceivers, cell balancing FETs and current sensors reducing BOM cost 50%

## Differentiating Points

- **Single chip** 48 V battery control scalable to > 1000 V
- **ASIL-C** functional safety compliant at 50% system BOM cost
- **300 mA** cell balancing transistors and **0.5%** current sensors
- **2 Mbps** differential communication transceiver
- >2.5x higher transformer coupled daisy chain isolation (3750 V)
- Companion communication interface IC for MCU SPI isolation
- **2 mV** voltage measurement accuracy
- 65µs one shot synchronized cell impedance determination
- **Fast data acquisition**: 3.6 ms for 96 cells, 4.5 ms for 112 cells
- Functional verification & **diagnostics** supporting ISO26262
- Automotive robustness: ESD, EMC, **Hot plug**, AEC Q-100

## Product Features

- **9.6 V ≤ VPWR ≤ 61.6 V** operation, 70V transient
- **14x** differential cell voltage + stack voltage measurement
- **7x** ADC + GPIO + temperature sensor Inputs
- Low power modes
- 64 pin QFP package
- Low-level drivers to simplify SW development

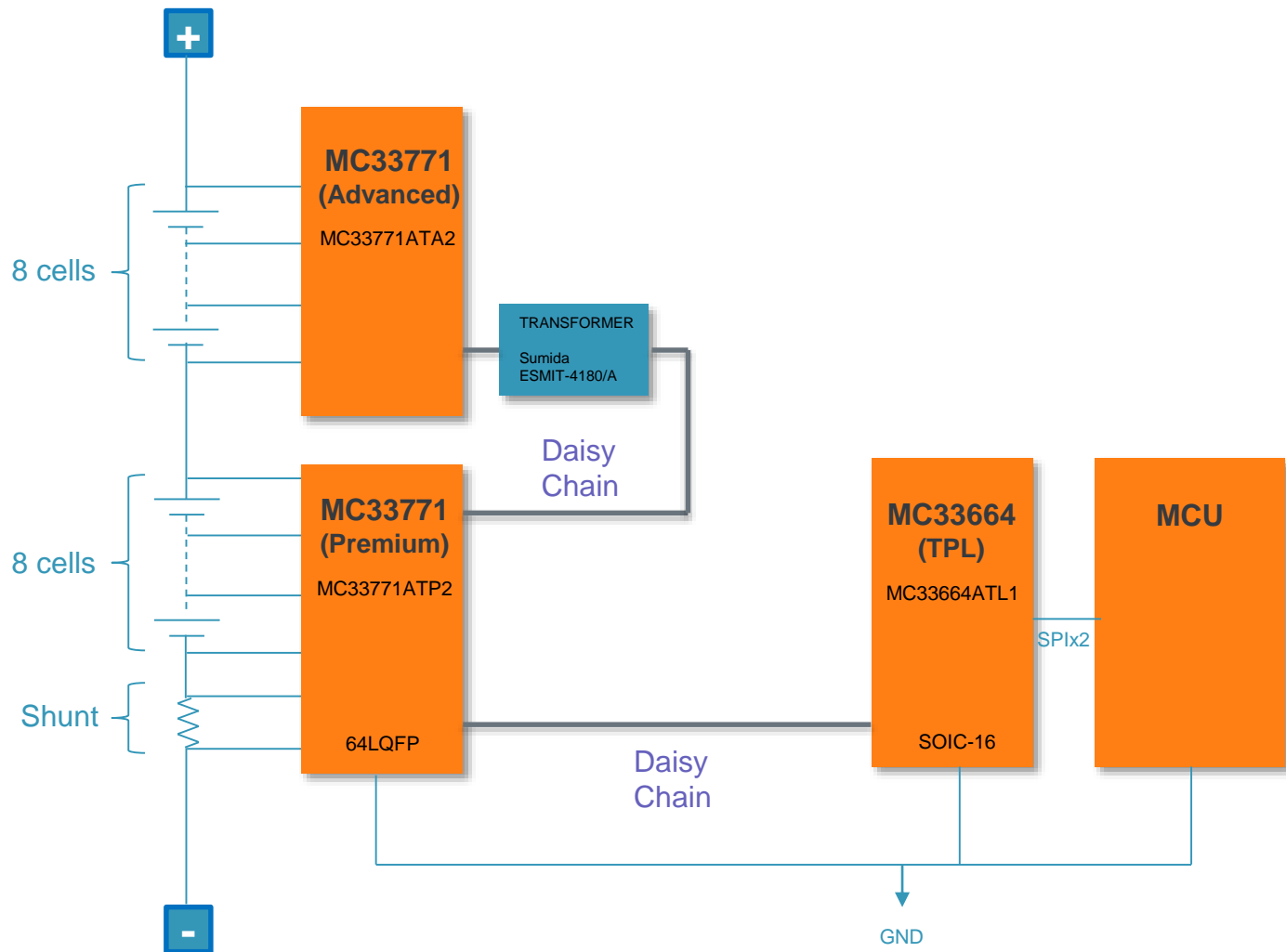


## Typical Applications

- Automotive hybrid and electric vehicles
- 48 V BMS and HV BMS (>1000V)
  - E-bikes, E-scooters



# 16-Cell Solution – Reduced BOM Example

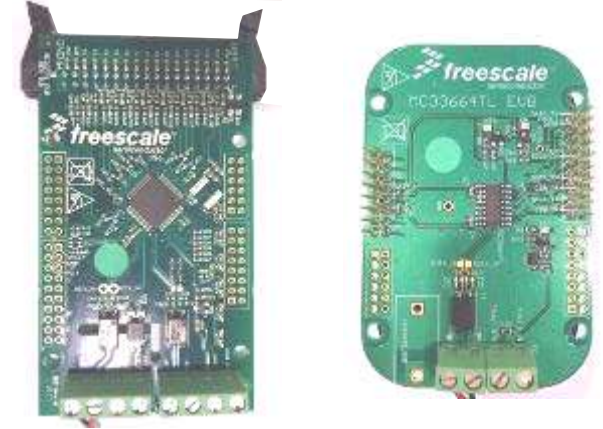


# MC33771 | MC33664 Battery Cell Controller Enablement

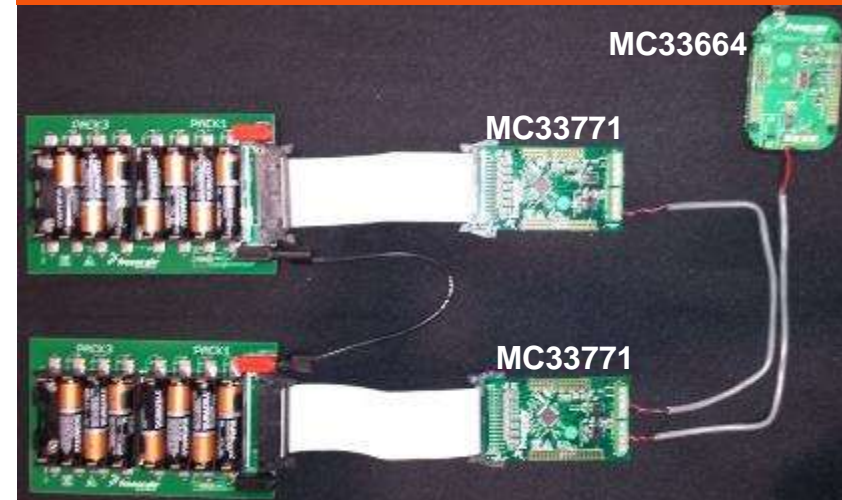
- **Fast Evaluation of device performance**
  - Evaluation boards for MC33771 and MC33664
    - KIT33771ASP1EVB
    - KIT33664EVB
- **Evaluation Kit**
  - 48 V battery management systems (BMS)
- **Technical Documentation for ease with design**
  - Data sheets
  - EVB user guide content
  - Safety assessment / FMEDA in development
  - EMC/DPI reports

Orderable at [freescale.com/analogtools](https://www.freescale.com/analogtools)

KIT33771ASP1EVB and KIT33664EVB



High voltage battery management system  
Freedom Platform + MC33664 + daisy chain MC33771



# Agenda

- Introduction
- Power Management Solutions
- 24V eSwitches
- Programmable Solenoid Driver
- 77 GHz Radar Solutions
- Battery Sensors
- Conclusion & Q&A

# Summary: Growing Analog Leadership in Automotive

## Powertrain & Hybrid

Alternator regulators  
Stop/Start MOSFETs  
Intelligent battery sensors & cell controller  
DFI Solenoid Controller  
System Basis Chip  
H-Bridge DC & BLDC motor drivers

## Driver Infotainment

Power Management IC  
CAN Transceiver

## Chassis

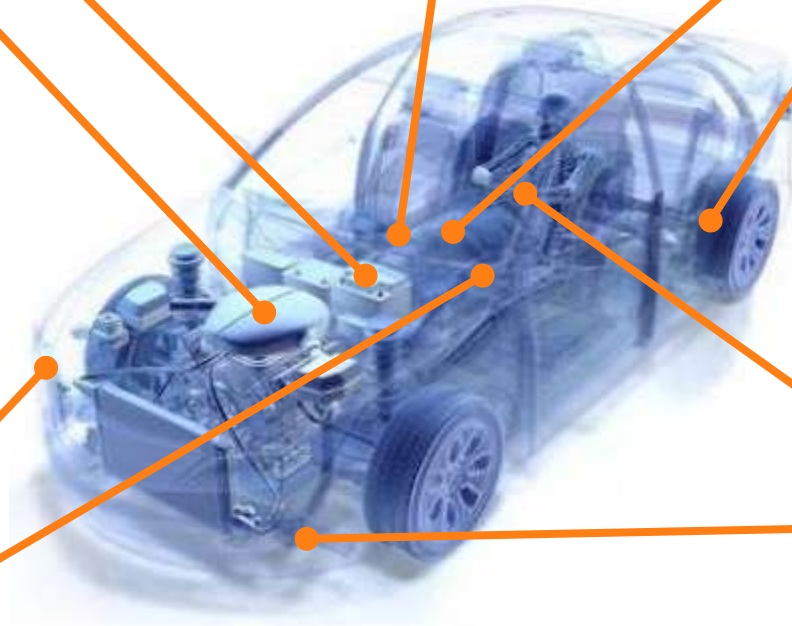
Braking: ABS, ESC, WSS control  
System Basis Chip  
BLDC motor pre-drivers  
CAN Transceiver

## Body Electronics

eXtreme power switches  
CAN / LIN transceivers  
System Basis Chip  
I/O switch detectors  
H-Bridge DC motor drivers  
BLDC motor pre-drivers  
IDC/MagniV relay drivers

## Safety

ADAS 77GHz radar transceivers  
Airbag SBC & Squib Driver  
System basis chip  
CAN / DSI transceivers



# Secure, embedded processing solutions for the Internet of Tomorrow





[www.Freescale.com](http://www.Freescale.com)