June 22, 2010

Freescale Solutions for Powertrain and Hybrid

FTF-AUT-F0553

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Powertrain and HEV Segment Marketing Manager

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Session Introduction

- This session aims:
  - To provide markets trends in automotive electrification regarding the powertrain
  - To address the emission reductions and standard regulations compliancy
  - To outline to the audience the technical challenges
  - To review Freescale solutions and how they can solve customer problems

Session Objectives

- After completing this session you will be able to:
  - Discuss the meaning of market trends
  - Compare the range of applications
  - Describe the high level electrical components
  - Compare Freescale's range of products
  - Identify the key players in the supply chain
  - Participate actively in further technical session

Agenda

- Powertrain & Hybrid Markets Environment
- Semiconductor Technology Review
- Freescale Controllers for Powertrain & Hybrid
- Battery Management Products
- Power Electronics Bricks
- Session Review and Wrap-up

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Powertrain & Hybrid Market Environment

Combustion Engine and Hybrid Vehicle

- Regulations are driving the industry innovation path
- Engine downsized for fuel consumption and efficiency
- Powertrain pulled by car electrification and affordable mobility in emerging markets

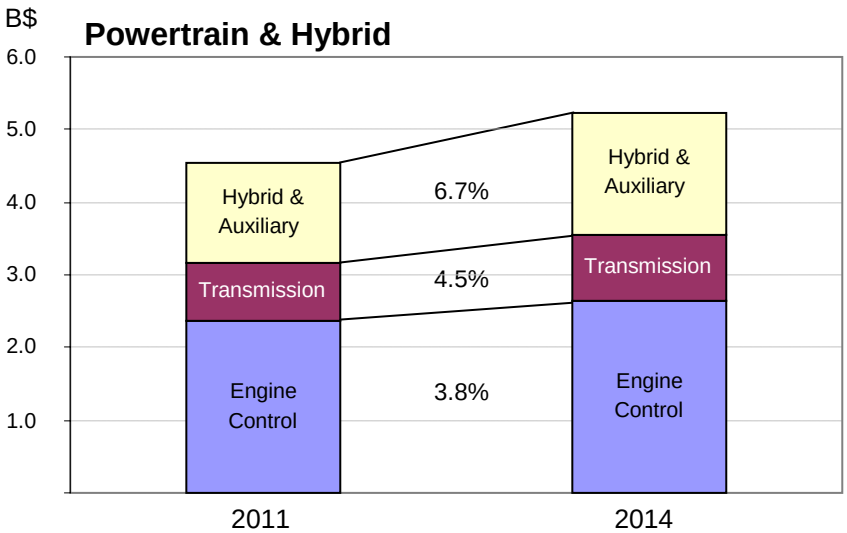
Automotive Semiconductor Demand (SAM)

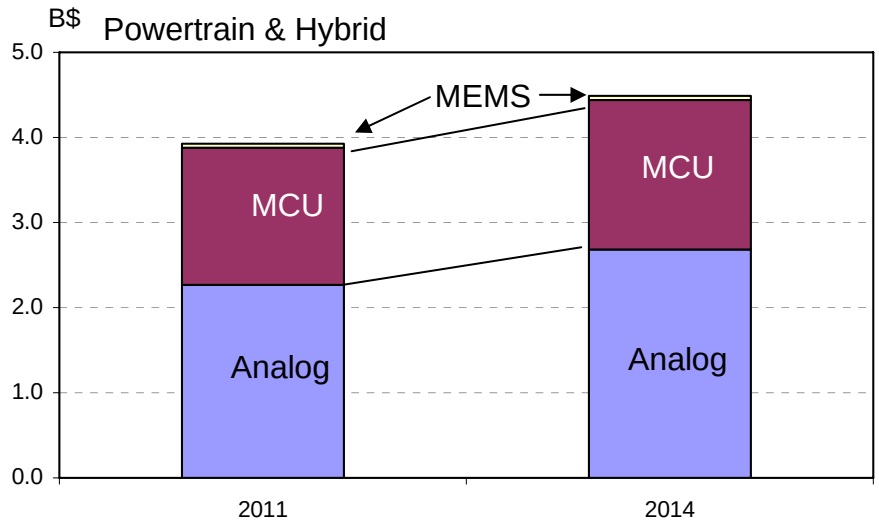
Source: Strategy Analytics Feb 2009

- $10.6 billion SAM (’09), growing at 10.4% CAGR through 2014 ($17.4B TAM)

  Excludes memory, discretes, optoelectronics

FSL Segment	2009	2010	2011	2012	2013	2014	CAGR09-14
Body & Security	2,413	2,586	2,925	3,204	3,513	3,809	9.6%
Chassis & Safety	3,730	3,975	4,459	5,004	5,561	6,014	10.0%
DIS	1,641	1,722	1,901	2,123	2,362	2,585	9.5%
Powertrain & Hybrid	2,864	3,187	3,659	4,139	4,606	5,034	11.9%
Grand Total	10,648	11,470	12,945	14,469	16,042	17,442	10.4%





Powertrain Electrification

Advanced ICE

- In Cylinder combustion control (pressure)
- High pressure on Common Rail
- Direct actuation
- Thorough Injector and ingnition control
- Air Charge and NOx trap

Micro Hybrid

- Start Stop system, belt driven or modified starter
- Electronic embedded system in the alternator
- On/Off cycle sustainable
- Torque assistance
- Regenerative energy

Hybrid / Electric

- High voltage battery
- Converter DC/DC
- Inverter module DC/AC
- Battery charger
- Smart grid

Anciliaries

- Oil/Water/Fuel Electric Pumps
- Low voltage Battery management
- HVAC compressor

Design Challenges

Combustion Control
Emission Monitoring
Exhaust Gas Treatment

Energy Management
High Power Efficiency
Multi Core MCU

Software Enablement
Functional Safety
Packaging Integration

Global Regulation Standards Summary

US

- The new CAFE standards must achieve by 2016 a combined average fuel-economy standard of 35.5 mpg—39 mpg for cars and 30 mpg for light trucks and SUVs—a 40 percent improvement over current standards.

China

- Emission standards are being adopted in China by the State Environmental Protection Administration (SEPA). Chinese standards are based on European regulations. Focus investment area-HEV and Fuel Cell.

Japan

- Japan' emissions standards in 2009 tightened further limits about NOx and PM to a level in-between the US 2010 and Euro 5 requirements.

Europe

- Europe emission concerns may provide short term an opportunity for low-priced start/stop gasoline-electric hybrid vehicles. Euro 6 standards effective from fall 2014, with a target to reach 95g CO2 by 2020.

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Future Architecture Challenges

- Lower cost of ownership
  - Lower ASPs!!!
  - Reduced development costs
  - Faster time to market

- Power consumption
  - Customers requesting 50% reduction in power over existing architecture
- Performance
  - Customers requesting up to 5x performance over existing architecture

- Functional Safety
  - ASIL-C or ASIL-D compliance for most applications
  - <4% cost adder for ASIL-D

Barriers are breaking down across application to avoid duplicating development :

- **Chassis, Motor control and powertrain to converge**
- **Interlock family of Body device**
- **Enabled by a common software**

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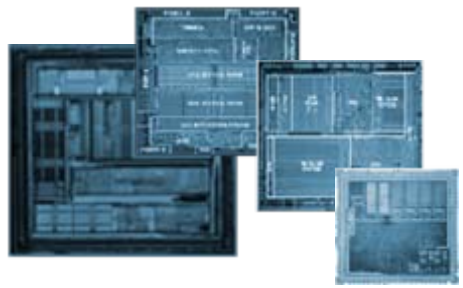
Semiconductor Technology Overview

Automotive Semiconductors Evolution

- Process node trails ‘industry leading’ by ~5-7 years and ~4-5 nodes
  - Volume production today mostly on 250nm, 180nm and 130nm
  - Logic ramping 90nm, next step on 55nm
  - Analog shipment in 0.25µm, foreseeing 0.13µm
  - Breakthrough power technologies: MOSFET, LFET
- More than 30 Years Automotive Leadership
  - 20K transistors integrated in 1980, 65M+ in 2008
- Zero Tolerance for Failure



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Freescale Power Technology Roadmap

eXtreme Switch product for automotive 45V/65V

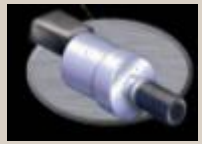
Migrating from HDTMOS -> LFET

Lighting

Window lift /Seat control

Electric Water Pump

Electric Assist Power Steering



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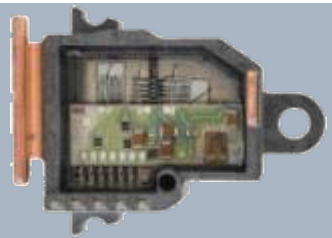

Very high power product for automotive

20V/400A

Micro-Hybrid

Start & Stop

85V/400A

Micro-Mild-Hybrid

Regenerative Braking

Mild-Hybrid

High Power

Full-Hybrid

Electric drive

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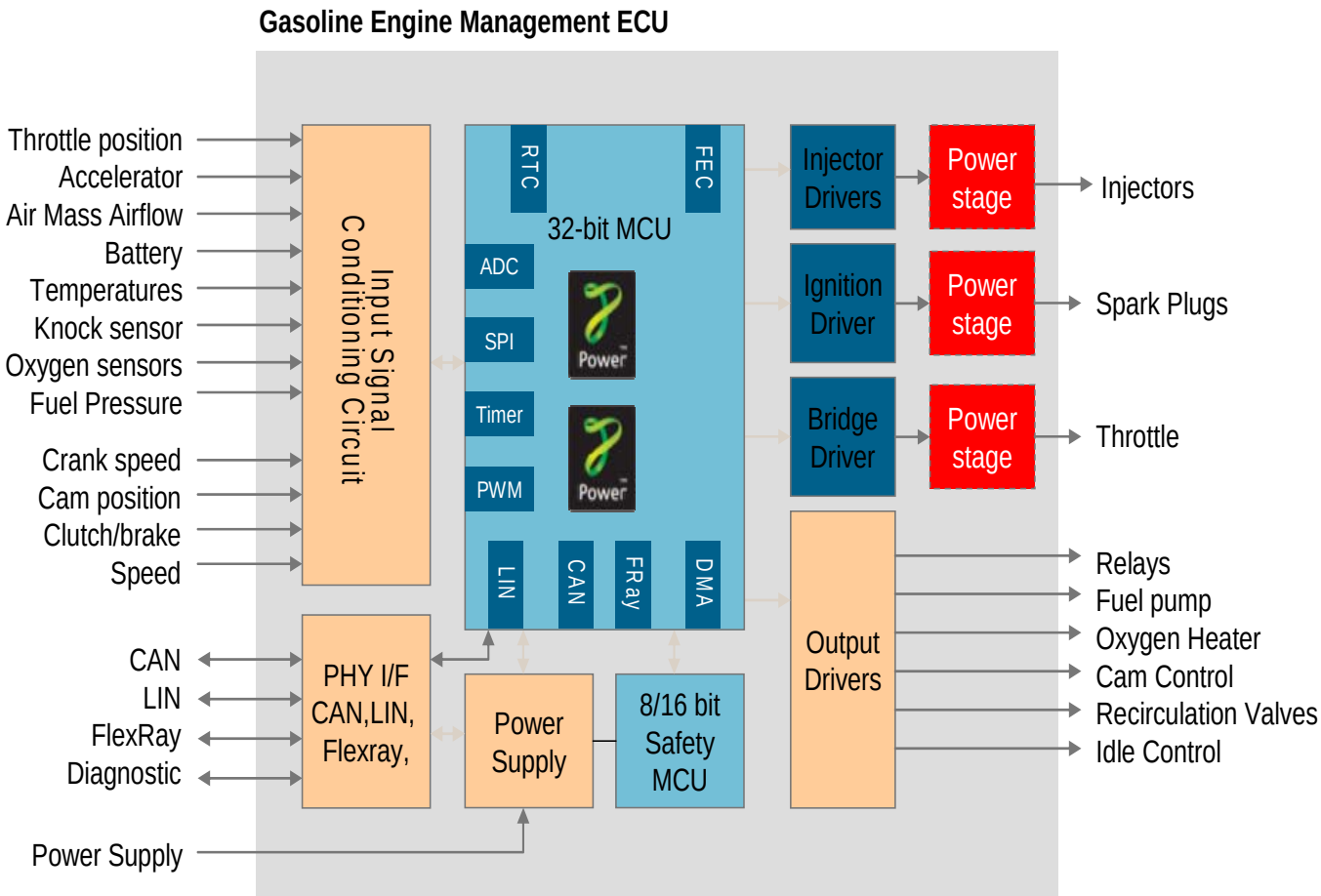
Freescale Controllers for Powertrain & Hybrid

Gasoline Engine Management



Main Requirements

- Increased fuel economy
- Reduced emissions (CO, Total hydrocarbons (HC), O3, and NOx particulates)
- Improve reliability
- Increase Performance
- Reduce Mechanical Content
- Increase Engine Efficiency

Freescale Products

Microcontroller:
- MPC55xx family
- MPC563xM, MPC5674F

Power Supply & interfaces:
- MC33730, MC339905
- *Integrated custom chipsets*

Switches:
- MC33800, MC33810, MC33812
- *Integrated custom chipsets*

CAN Interface: MC33902

HBridge:
- MC33899, MC33926, MC33931, MC33932

Pressure sensors:
- MPXHZ6115, MPXHZ6250

HEV / EV – Where Freescale Plays

HV Battery management S12(X),

LV Battery management MM912xxx IDC, S12(X)

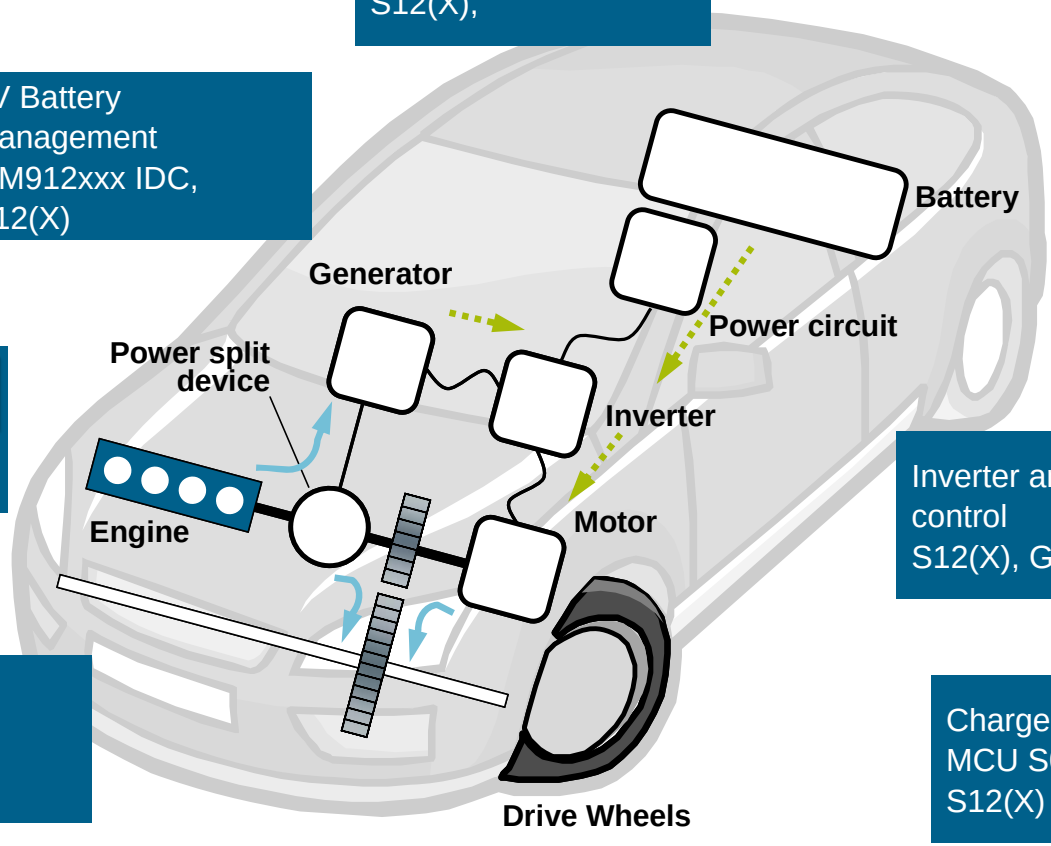
DC/DC converter S08, S12(X)

Engine control analog drivers, pressure sensor, S08, MOSFET

Inverter and motor control S12(X), Gate driver

µHybrid, S/Stop S08, S12(X), MOSFET

Charger MCU S08, S12(X)



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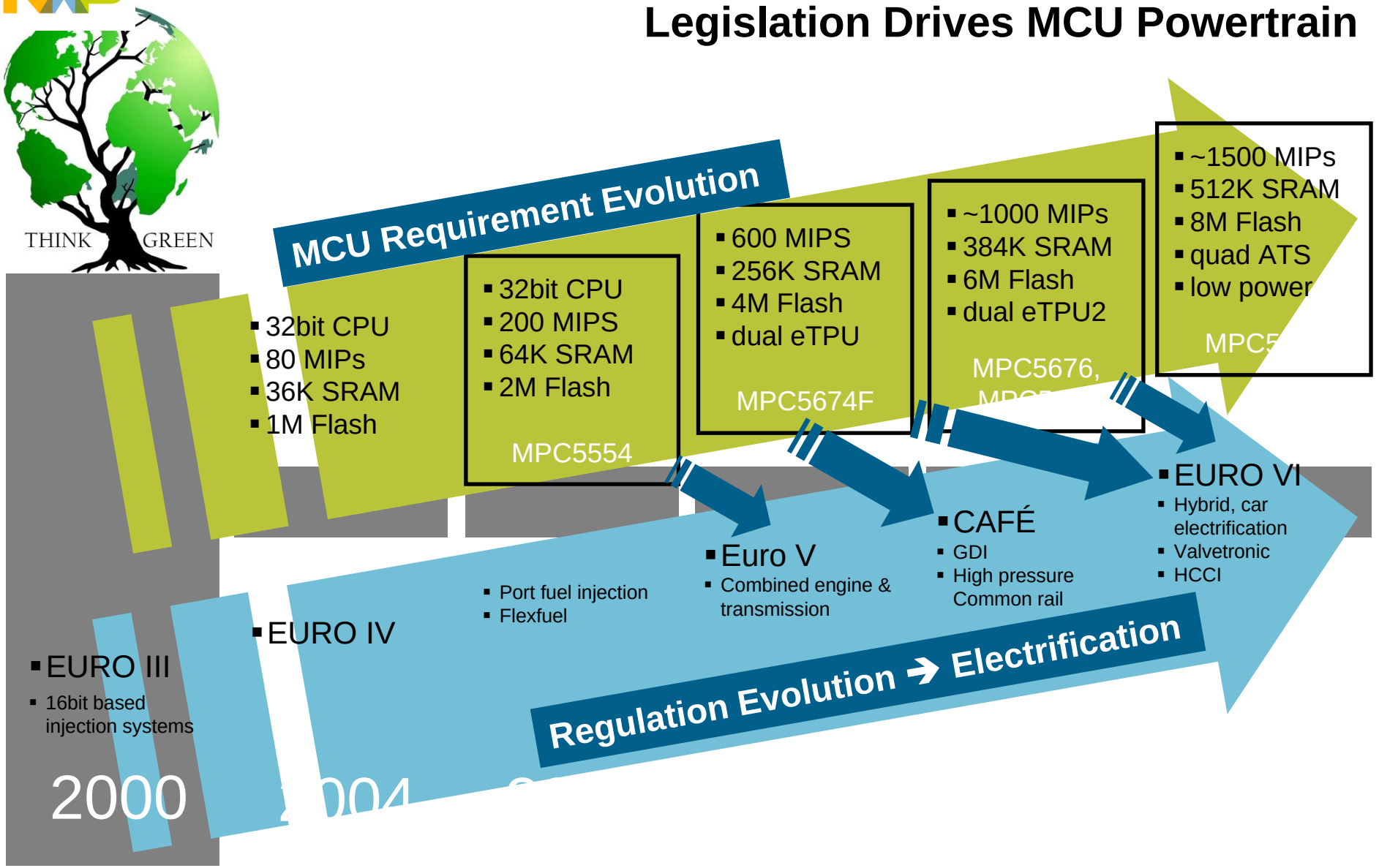
Legislation Drives MCU Powertrain



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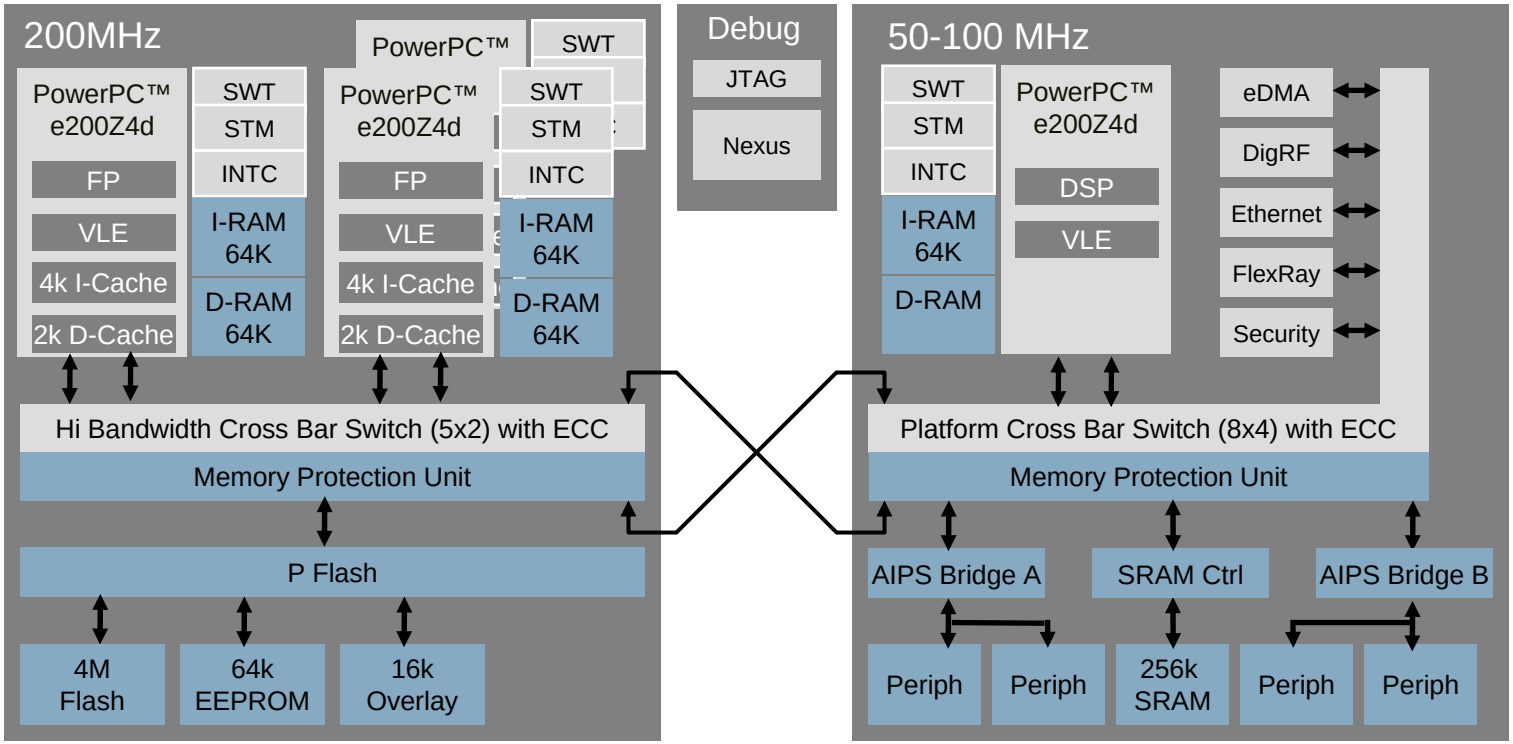
MPC57xx Device Proposal (Up to 200MHz)



- Permanent Lock-step for Safety.
- Third main core for increased performance. Computational Shell at max Frequency
- I/O processor for Timed Non safety-related functions.
- Peripheral Domain at max 50MHz
- Total SRAM >320K bytes
- Current Target: < 350 mA

Peripherals:
Same as Low end except:
ADC: 68 channels total
4xCAN
5xSCI
6xdSPI
Security module Including:
- Secure CPU, flash & RAM
- AES 128 Encryption/Decryption
- True Random number generator
- Secure keys

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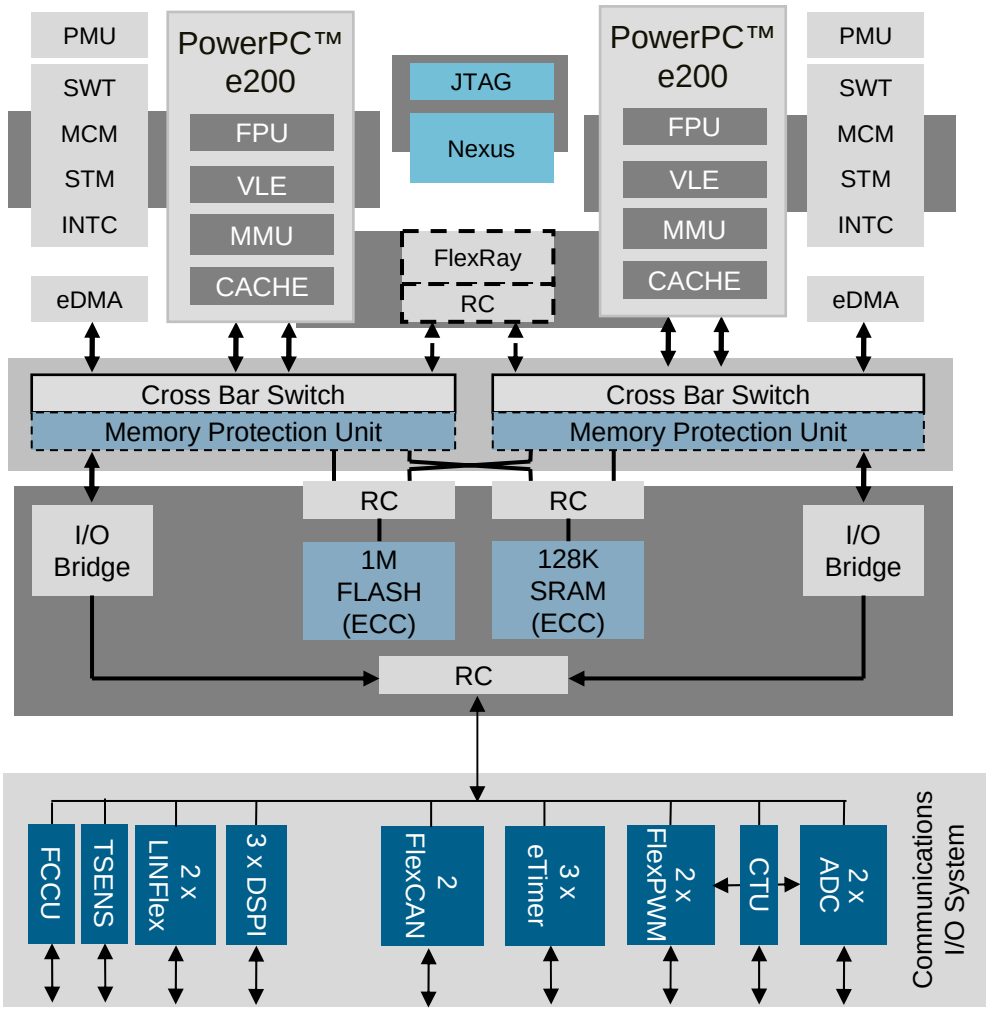
1MB - MPC5643L



Core
- Up to 120MHz PowerPC ISA Dual e200 zen4 core
- 4K 2-way / 4-way I-cache
- FPU
- Safety enhanced Cores + FPU + VLE + MMU
- Dual Parallel or Lock Step configuration + HW/SW monitoring

Memory
- Up to 1MByte RWW Flash with ECC
- Up to 128 KByte SRAM with ECC
- EE emulation
- Dual crossbar with MPUs

I/O
- 2 x FlexCAN (32 message buffers each)
- 1 x FlexRay (64 msg. buffers)
- 2 x LINFlex
- 3 x DSPI
- 1 x External clock output
- 2 x FlexPWM (2 x 12 channels)
- 3 x eTimer modules (3 x 6 channels)
- Dual ADC (16 channels each, 12bit), 1 S/H per ADC
- 1 x Cross-triggering unit for motor control

System
- 16 Channels eDMA
- Autonomous Fault Collection and Control Unit
- CRC computing unit
- Software watchdog timer (inc. window mode, flow monitoring)
- 2 x Junction temperature sensor
- Nexus debug interface (up to N3)
- FM-PLL + FlexRay PLL
- 3.3 V Single supply with external and internal ballast transistor
- 3.3 V I/Os (ADC 5 V capable)
- 144 LQFP / 257 MAPBGA
- Tj = 150°C

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Start/Stop Application

MCU:

MC9S08SG

MC9S12XS

MC9S12P

System Basis Chip:

MC33742, MC33905

LIN, CAN PHY/I:

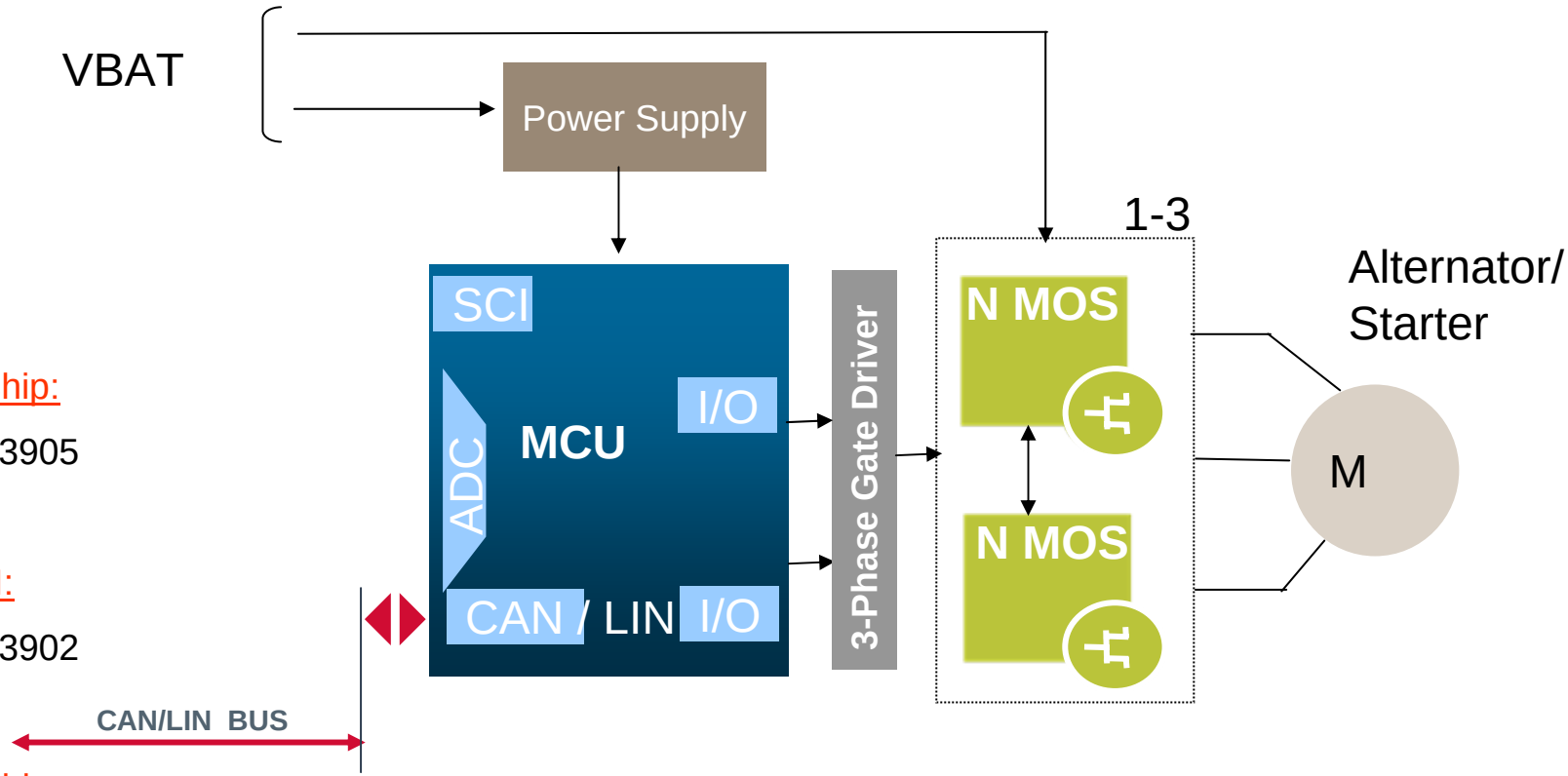
MC33661, MC33902

3-Phase Gate driver:

MC33937A

Power MOSFET:

Die – Consult Factory



- Multiple MOSFET at higher frequency to control Motor in multiple phases configuration
- “Sub-mΩ” devices , 0.6 mOhm at 550A
- Reverse mode using body diode at 400A
- Repetitive UIS : 60M cycles at 400A

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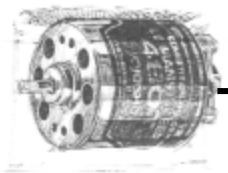
Battery Management Products

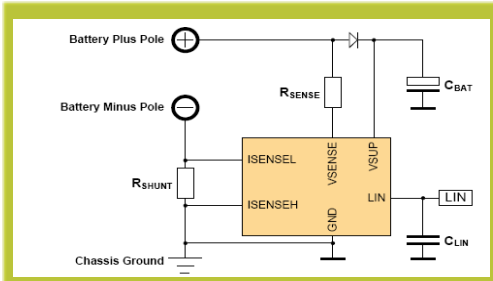
Freescale in HEV/EV – Low Voltage Battery



Inverter & Controller

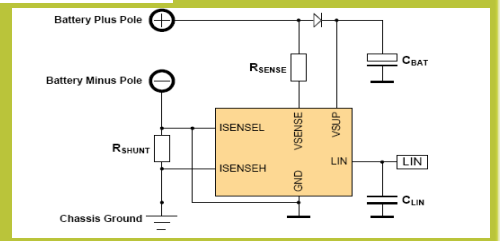
DC/DC Converter

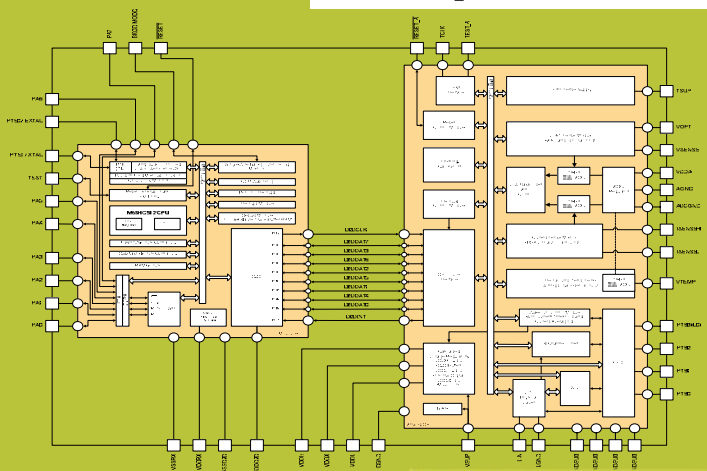
LV BMS



Device GND = Chassis GND

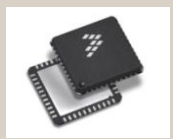
Device GND = Battery Minus

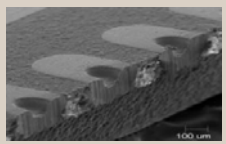


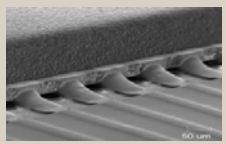


Package

- 7x7 QFN 48ld
- Optical Inspection capable through Wet-able Flanks / dimple leads
- No need for X-Ray at manufacturing



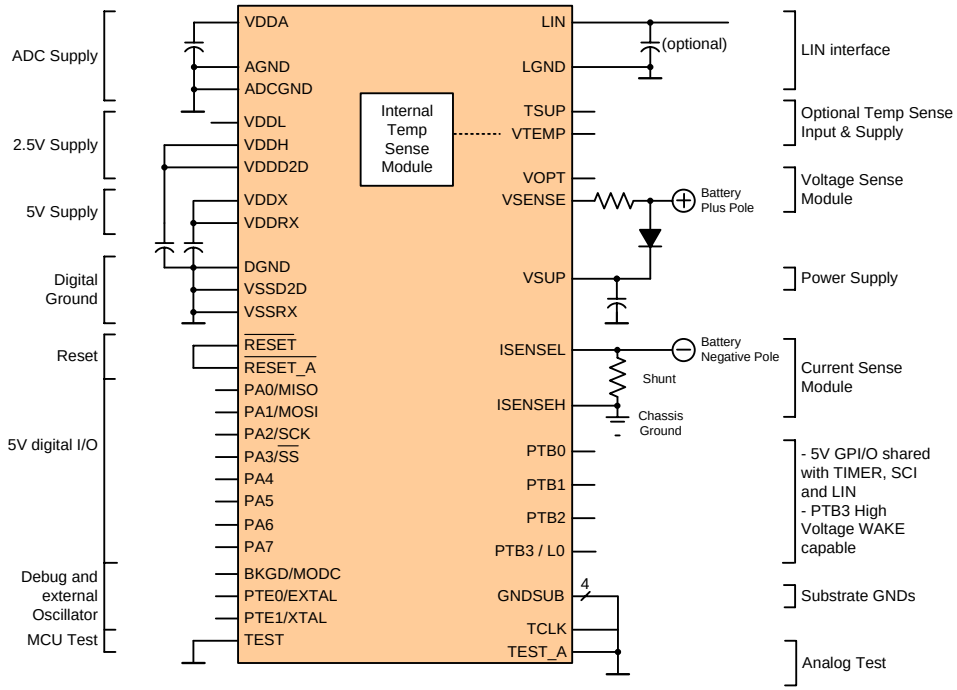




Intelligent Battery Sensor ASSP

Key Characteristics

- MCU S12 (16-bit)
- Flash 128k (Options: 32k/64k/96k)
- Data Flash 4k
- RAM 6k
- PL / WD LIN / YES
- Standby Current <100µA (1sec Isense)
- ESD 8kV LIN
- Operating Voltage 3.5..28V
- RAM Contents Guaranteed 2.5...3.5V (Option: Cranking Mode)
- Operating Temperature -40°C<Ta<125°C
- ADC (2nd Order Sigma Delta) 16bit
- Current Measurement Relative /Absolute Accuracy
- Voltage Measurement Relative /Absolute Accuracy
- Temperature Measurement Relative Absolute Accuracy



- **Battery Voltage Measurement**
- **Battery Current Measurement**
- **On chip temperature measurement**

Samples and evaluation board available

Key Features

- Normal and low-power modes (Stop/Sleep)
- Triggered wake-up from LIN, periodic wake-up from timer event
- PGA (programmable low-noise gain amplifier) with automatic gain control feature
- Accurate internal oscillator (external quartz oscillator for extended accuracy)
- Communication via LIN 2.1, LIN2.0 bus interface
- 2 independent high precision references
- Debug Mode
- Options:
  - External Temperature Sensor Option (TSUP, VTEMP)
  - Optional 2nd external voltage sense input (VOPT)

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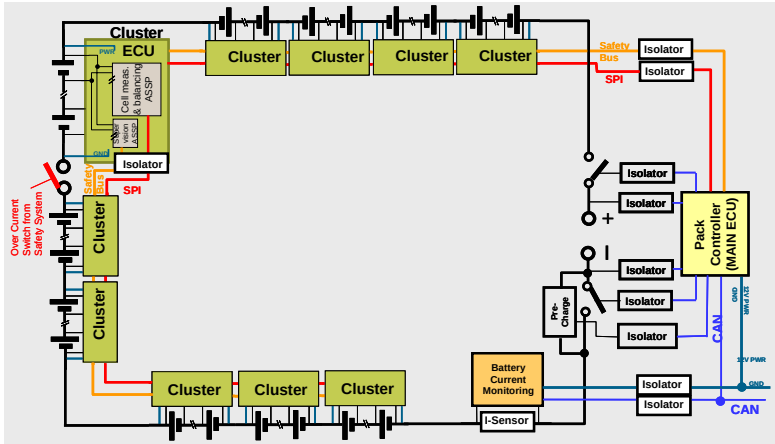
High Voltage Battery

- Topology under definition
- Cluster controller concept for each group of cells
  - Cluster control and passive cell balancing
  - Scalability with active cell balancing
  - Single package device
  - Safety function
- Inter cluster communication
- Current sense Application Specific Solution Product (ASSP)
  - IP re-use from MM912xxxx
- Pack controller supervision



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Power Electronics Bricks

Electric Car Concept – New Idea?

DETROIT ELECTRIC CARS

J. F. HAYDEN, Agent

High Point, N. C.

Since gasoline automobiles are being made more complicated every year, and still many inherent difficulties not yet overcome, and with the cost of gasoline advancing, I am forcibly convinced that with the recent improvement in storage batteries the Electric Automobile will largely supersede the gas cars.

The Electric Car has never had any problem except the weight of the storage battery. Do you know that the weight of the battery has recently been reduced to one-half, and that the "Detroit Electric" will now run 80 miles on one charge? This is as far as you will want to run in one day. When you go home at night, if your battery is getting low, you simply throw a switch in your garage and your car will be fully charged next morning. When you pay your house lighting bill you will also pay your power bill. At the High Point rate of 6c. per k. w. hour, you will pay about 1-3/4c. per mile. You know the price of gasoline has doubled recently. Do you know that only 15% of the oil wells produce any gasoline at all, and that after a certain time the supply will be exhausted?

With the "Detroit Electric" you have absolutely no starting troubles, even at zero temperature. You have no complicated machinery to keep in repair, no water to freeze, no vibrating parts (such as engine pistons, valves and cranks), no clutch, no transmission gears. There are only two moving parts--the revolving motor shaft and the revolving rear axle.

The "Detroit" will climb a steeper hill than a gasoline car, and yet is as noiseless as a shadow. It will last several times as long as a gas car because there are no high speed parts to wear; no vibration whatever; no excessive strain such as engine explosions, throwing in of clutch, etc. It can be driven by any member of the family. Where other cars have from six to twelve levers to operate, this has only two. One is used for steering and the other starts, gives five speeds, stops, backs, and applies brakes. The speeds are 6, 9, 13, 17 and 21 miles.

There is no chauffeur to pay, no cylinder oil to buy, no grease to soil your car, no tire punctures, no unsightly extra tires or wheels to carry, no inner tubes, repair kits, pump or jack to carry, and practically no troubles of any nature.

The same battery operates motor, lights, brakes, horn and everything. The absence of machinery should appeal to every one. The riding qualities greatly excel those of any gas car. The passengers ride midway between the wheels. There is entire freedom from all vibration such as from engine&gears; no noise; no odors such as from gasoline and burning grease, and there in not the usual nerve strain on the driver.

Do not fail to investigate the "Detroit Electric." Let me know when and a demonstration will be arranged for you.

Very truly,
J. F. HAYDEN, Agent.

CENTURY ADVERTISEMENTS—AUTOMOBILES 53

FOR your bride-to-be—or your bride of many Junes ago—a Detroit Electric.

No other bridal present means so much—expresses so perfectly all that you want it to say.

For the Detroit Electric is the standard of value—the highest compliment in selection that you can pay—the most *considerate choice* for her permanent happiness, comfort, luxury, safety.

The Detroit Electric is simple of control—responsive. Gives automatic protection in emergencies.

Our "Chainless" Direct Shaft Drive—a straight path of power—reduces number of parts and simplifies construction. No concealed chains. Pneumatic or Mota cushion tires.

Batteries optional—Edison, nickel and steel, Ironclad, Detroit or Exide.

Anderson Electric Car Company
Dept. 9. Detroit, Mich.

The Detroit Electric Chainless

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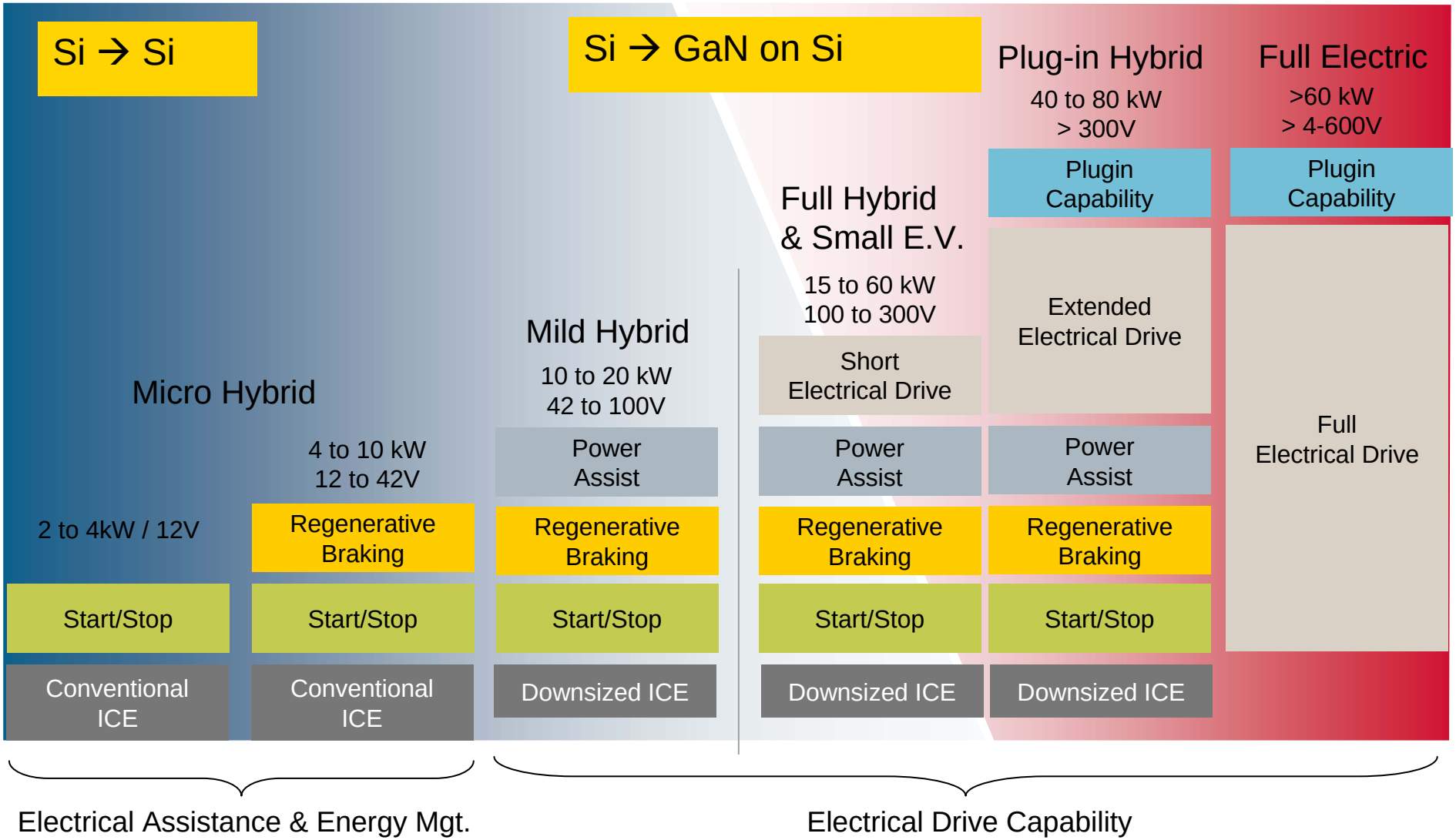
Market Outlook

The Automotive Hybrid Electric Family



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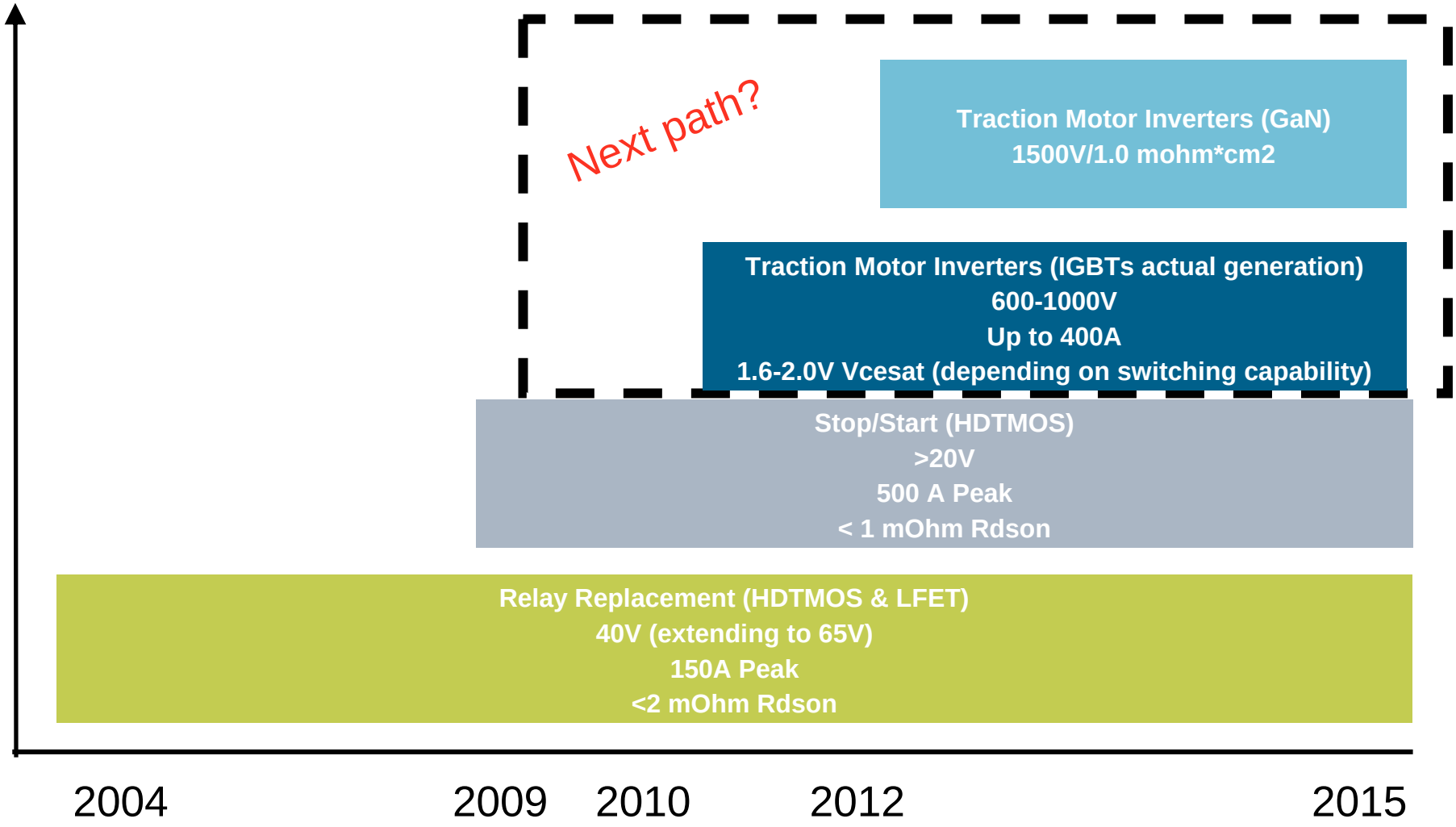
Freescale Power Technology Outlook



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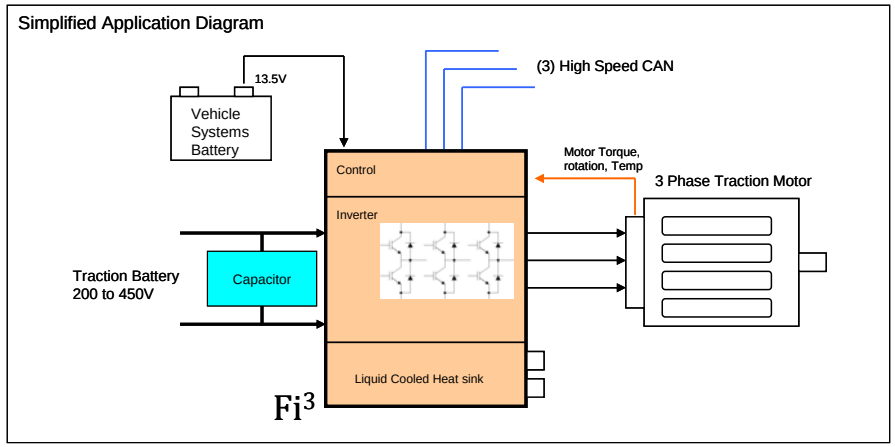
Freescale Intelligent Integrated Inverter Evaluation Kit

- The Fi3 , Freescale Intelligent Integrated Inverter building block, provides the vehicle designer with an automotive fully integrated reference platform, liquid cooled 3-phase induction or permanent magnet motor drive system requiring only housing and capacitor to complete. This system is designed to propel fully electric or hybrid electric vehicles.
  - **Power Module** Definition includes IGBT and Diodes
  - **Integrated Power Module** includes Power module + Analog Silicon integration (drivers, PS, interfaces, TIV sensors)
  - **Intelligent Integrated Inverter** includes **the Integrated Power Module with the controller board and low level drivers**



Session Review and Wrap-up

Summary

- Freescale is the top automotive microcontroller supplier
- Freescale is a technology leader with Power Architecture and its scalable core family
- Freescale is engaged in powertrain electrification with stop/start, battery management and motor control expertise
- High power electronics adopted extensively

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