

Automotive **Analog and Sensor** Overview Featuring BCC and High Pressure Sensors

Eric Wu

M A R . 2 0 1 5



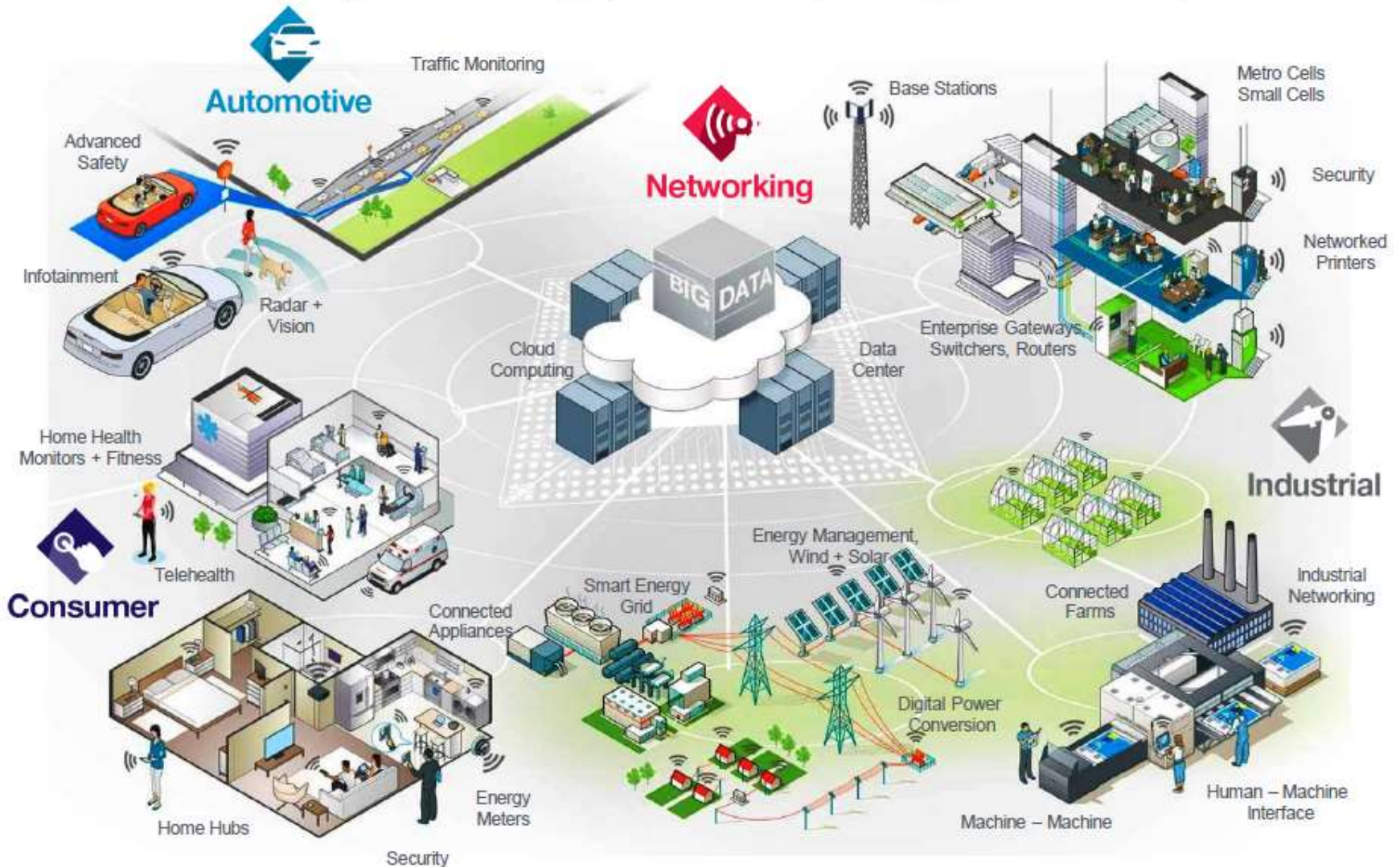
Agenda

- Gyro FXAS21002
- High pressure sensor FXTH87 series
- Sensor fusion
- SBC
- BMS



Freescale Products Power The Internet of Things

Microcontrollers | Digital Networking | Auto MCU | Analog and Sensors | RF



Freescal Sensor Target








Smart Sensors, smart digital networks



Micros & Sensors provide complete solutions for the secured IoT

Sensor Portfolio

	Pressure	Automotive, industrial, medical and consumer absolute and differential sensors <i>Flow, comfort management, HVAC, medical, engine control</i>
	Accelerometer	Consumer and industrial low-g sensors and tilt sensors Automotive medium- and high-g crash sensors <i>Vehicle stability, airbag, vibration monitor, tilt alignment</i>
	Magnetometer	Consumer and industrial magnetic field sensor and 3D compass <i>Orientation alignment, proximity detection, magnetic switch</i>
	Gyroscope	Consumer and industrial angular rate sensors and 6/9-DOF IMU Automotive roll sensor and IMU <i>Stabilization, motion and gesture HMI, inertial navigation, gaming</i>
	Sensing systems	Consumer and industrial MCU and sensor integrated platforms Automotive tire pressure monitoring system <i>Smart sensors, pedometer, anti-tamper, fault prognostication</i>



Motion sensor

Consumer and Industrial Accelerometer Family



MMA865x

- Digital Output
- Cost Efficient
 - 1mg/count sensitivity
- High Perf.
- Rich Features
 - P/L detection
 - High Pass Filter
 - Transient Detect
- 2x2 mm package



MMA845x

- Digital Output
- Extreme Perf.
 - .25mg/count sensitivity
- Extended Features
 - FIFO
 - Configurable P/L trip angles
 - High Pass Filter
 - Transient Detect



MMA8450

- Digital Output
- Low Voltage
 - 1.71-1.89V



MMA8491

- Digital Output
- Extreme Low Power
 - 0.35uA/Hz
- Cost Efficient
 - 1mg/count sensitivity
- Industrial Package

FXLN83xx

- Analog Output
- High Bandwidth
 - 4.9kHz
- Low Voltage
 - 1.71-3.6V
- Industrial Package
- Extended Temp Range: 105C

Consumer

Industrial



Xtrinsic FXAS21002 is in PRODUCTION !!

3 Axis Gyro with Market leading power consumption (over 40% better than the leading competitors)
Completes Freescale's 9-axis Sensor Fusion Solution.

Differentiating Points

- Best-in-class power performance: **2.6mA (Active), 1.6mA (Ready), 2uA (Standby)**
- Complete sensor fusion enablement suite

Product Features

- Enhanced Selectable Full Scale ranges: **+/-250, +/-500, +/-1000, +/-2000**
- Fast Transition from Standby to Active Mode (**60 ms**)
- Expanded Output data rates (ODR) from **12.5 Hz to 800Hz**
- Zero Rate Change over temperature: $\pm 0.3\text{dps}/^\circ\text{C}$
- Improved Noise: Angular Random Walk = **0.02 dps/rt(Hz)**.
- Angular velocity resolution $< 0.2^\circ/\text{s}$
- Programmable interrupts, Power saving features
- 1.95-3.6V supply voltage

Typical Applications

- Controllers: Remotes, Games
- Ruggedized Industrial and Medical Handhelds and Tablets
- Sports Monitoring, Remote control toys, Robots



Package

4x4x1mm QFN, 0.5mm pitch



Gyroscope Applications

What is a Gyroscope?

- Device for measuring angular rate / rotation rate (degs / sec)
- Enables user interface and navigation applications

Applications and Use Cases

- Robotics /Vaccum cleaner robots/ Gardening robots
- Internet of Things
 - Multiple applications for accurate positioning and advanced UI
 - Improved context awareness and control
- Remote Controls / Air mouse / Pointing Devices
 - Relative orientation, position, motion tracking of user interface device.
- Gaming
 - Life-like motion recognition human interface for higher fidelity gaming experience
- Industrial & Medical
 - Navigation assist, Asset Tracking
 - Activity Monitoring, Elderly monitoring, ... Apps based On Gesture Recognition
- Tablets / Mobile and LBS devices
 - Position extrapolation (Navigation Assist) during brief periods when GPS signal is lost
 - Mobile gaming – life like motion recognition
- Unmanned Arial Vehicles – UAV (Toys)
 - Active stabilization for remote control helicopters
- Wearables / Activity monitors
 - Higher accuracy motion and positioning for activity monitoring



Xtrinsic FXOS8700CQ

6DOF (3-axis Accelerometer, 3-axis Magnetometer)



Differentiating Points

- Pin compatible with Freescale accelerometers
- Lowest noise gcell and mcell
- Embedded Functionality to allow system fast response and power savings
- Vector Magnitude for mcell, gcell
- Award winning calibration and eCompass software
- 32 sample FIFO with burst read



Product Features

- 1.95V to 3.6V supply voltage, I/O 1.6V – 3.6V
- $\pm 2g/\pm 4g/\pm 8g$ accelerometer, ± 15 Gauss Field range
- Output data rate (ODR) from 1.563Hz to 800Hz , 400Hz hybrid
- 14-bit gcell data, 800 counts per Gauss
- Low Offset Drift: 0.1mG per deg
- 4 channel motion detection- FF, Pulse, Transient, HPF, Tap



Typical Applications

- Electronic Compass
- Scientific: Aurora Detection
- Industrial: Directional Drilling, mineral exploration
- GPS assist for Location Based Services



Package

3 x 3 x 1.2mm QFN





Pressure Sensors



Xtrinsic MPL3115A2

Precision Digital Altimeter



Differentiating Points

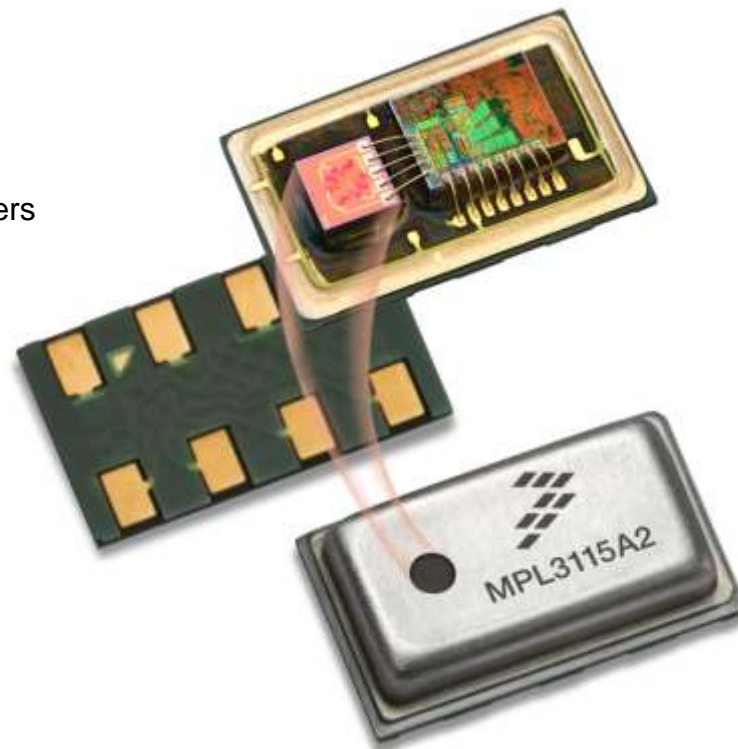
- Internally compensated, software is not needed
- Direct reading pressure in Pascals and altitude in meters
- On-board intelligence

Product Features

- Altitude resolution : < 1 foot / 0.3 m
- Pressure resolution: 1.5 Pa
- Pressure range: 20 – 110 kPa
- Calibrated pressure range: 50 – 110 kPa
- 1.95V to 3.6V supply voltage
- Variable output sampling rate (OST) up to 140 Hz
- Current Consumption:
 - Standby mode: 2 μ A
 - Low-power mode: 8.5 μ A at 1 Hz
- I²C digital interface

Typical Applications

- High Accuracy Altimeter
- Smartphones / Tablets
- GPS Enhancement for Location Based Services



Package

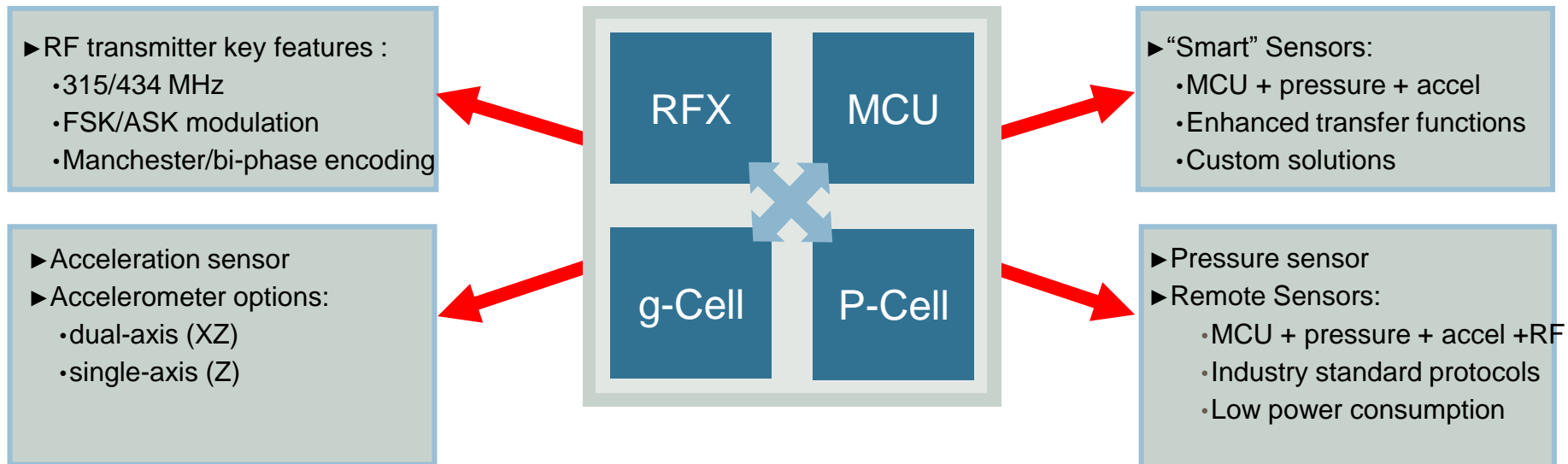
3 x 5 x 1.1 mm LGA



Remote Monitoring Systems

FXTH87 Series contains four devices:

- Pressure sensing device (P-Cell)
- Accelerometer device (g-Cell)
- 8-bit microcontroller (MCU)
- RF transmitter device (RFX)

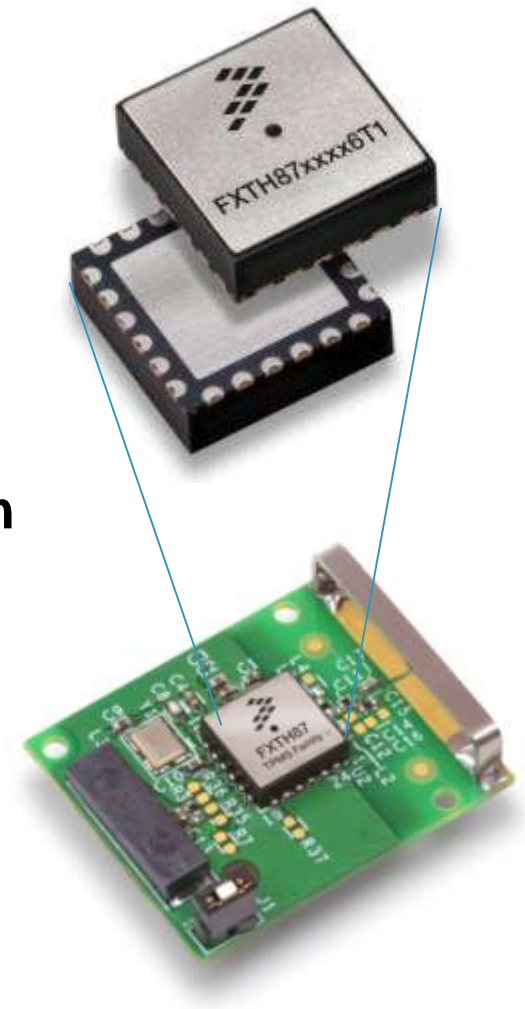


FXTH87 high pressure sensor

- **Smallest sensor on the market**
 - QFN 7x7x2.2 mm
- **Multiple pressure sensor ranges**
 - 450, 900 and 1500kPa
- Ultra low power consumption
- **Volume production now**
 - 450, 900kPa and 1500kPa version in production

Target Applications

- Engine management, including Turbo
- Small Engines, Motorcycles
- Autogas vehicles powered by green gases (LPG,CNG)
- Comfort Seating
- Industrial applications up to 15 bar abs
- **Investigating Oil pressure measurement**

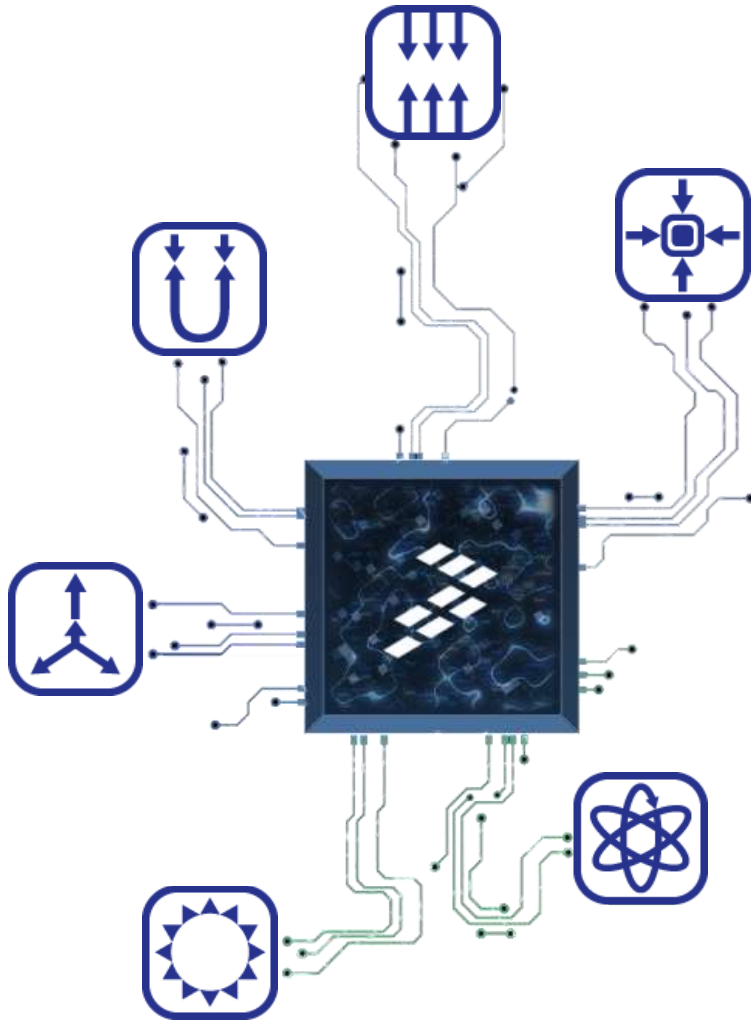




Sensor Fusion

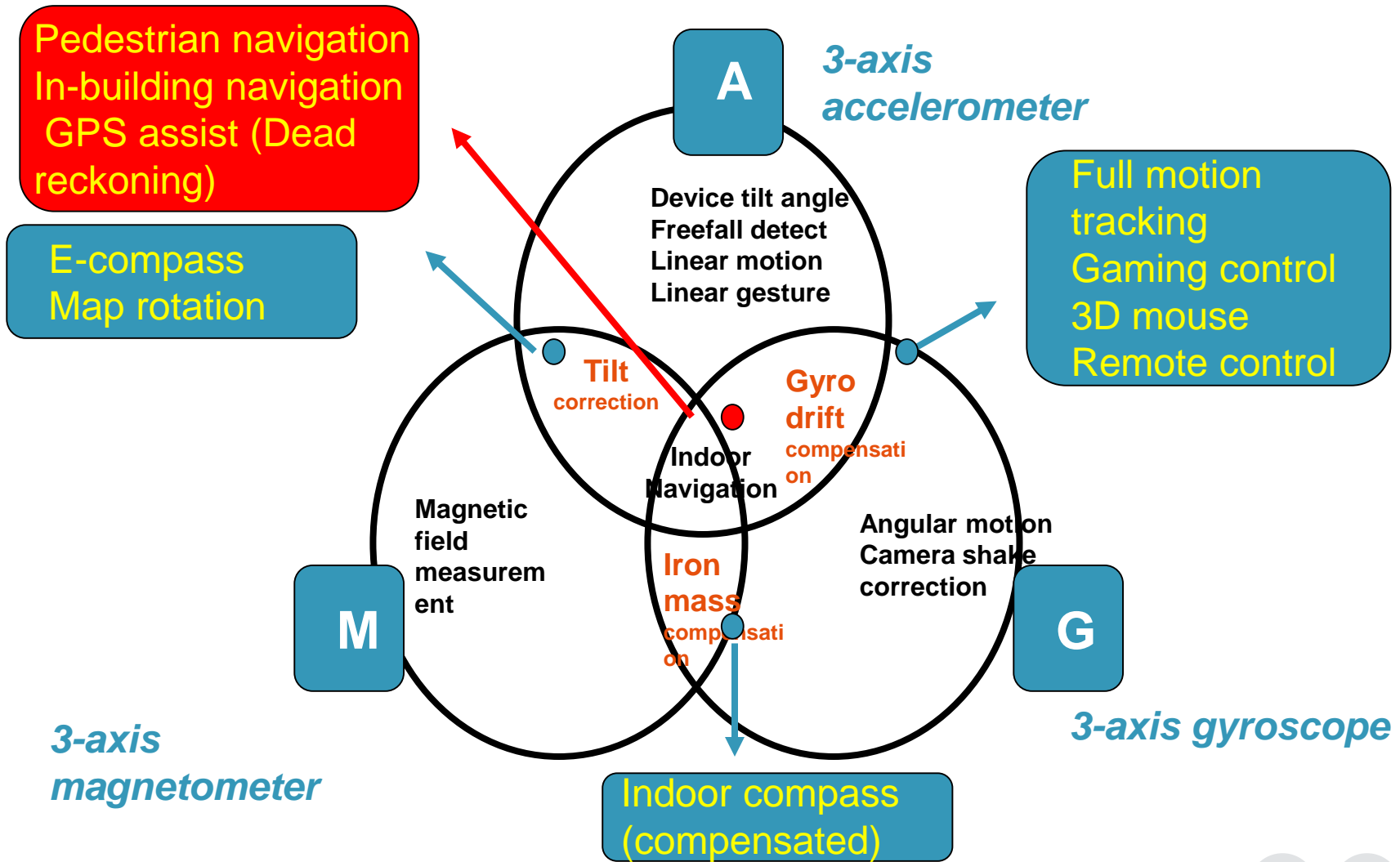
MEMS and Sensors Fusion

“The Whole Is Greater Than the Sum of Its Parts”

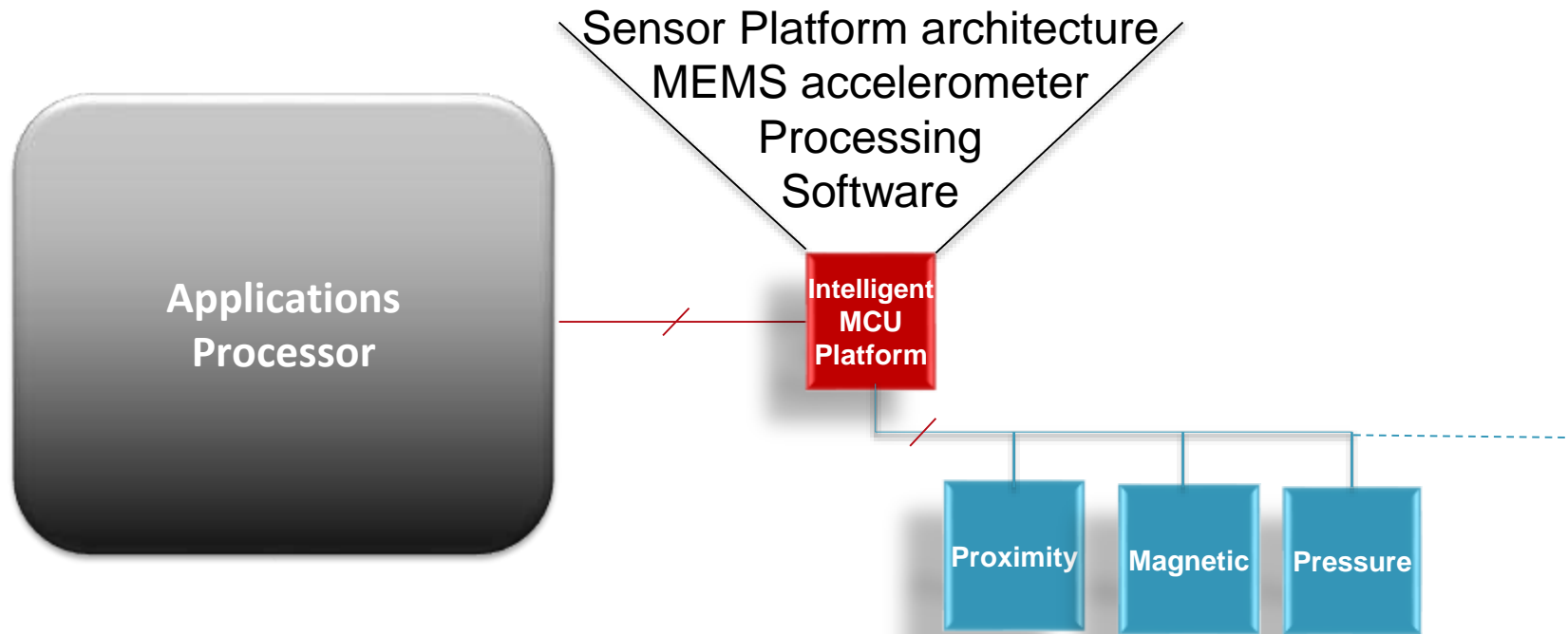


- Individual sensors have inherent limitations and/or errors that can be corrected or compensated for by complementary sensing nodes:
 - **Accelerometer:** x, y & z linear motion sensing - sensitive to vibrations
 - **Gyroscope:** pitch, roll & yaw rotational sensing - zero bias drift
 - **Magnetometer:** x, y & z axis magnetic field sensing - sensitive to magnetic interference
- Fused sensor information is more accurate and reliable than individual sensor data:
 - e.g. Gyros suffer from offset drifts over time. A companion accelerometer's data compensates for the offset drift

Smart Sensor Platform: Multiple Sensors Working Together



Intelligent Sensor Platform



The New Sensor Generation: Xtrinsic

Sensor Fusion Example



Wearables is Not Just Smart Watches...



Wearable Ring Scanner



Headset Running Voice Recognition



Nymi, Heart-rate Based Password Authentication



Kiwi Wearables – Personal Tracker



Fitness/ Activity Monitors



Smart Glasses



Headset Computer



Angel – first open sensor for health and fitness

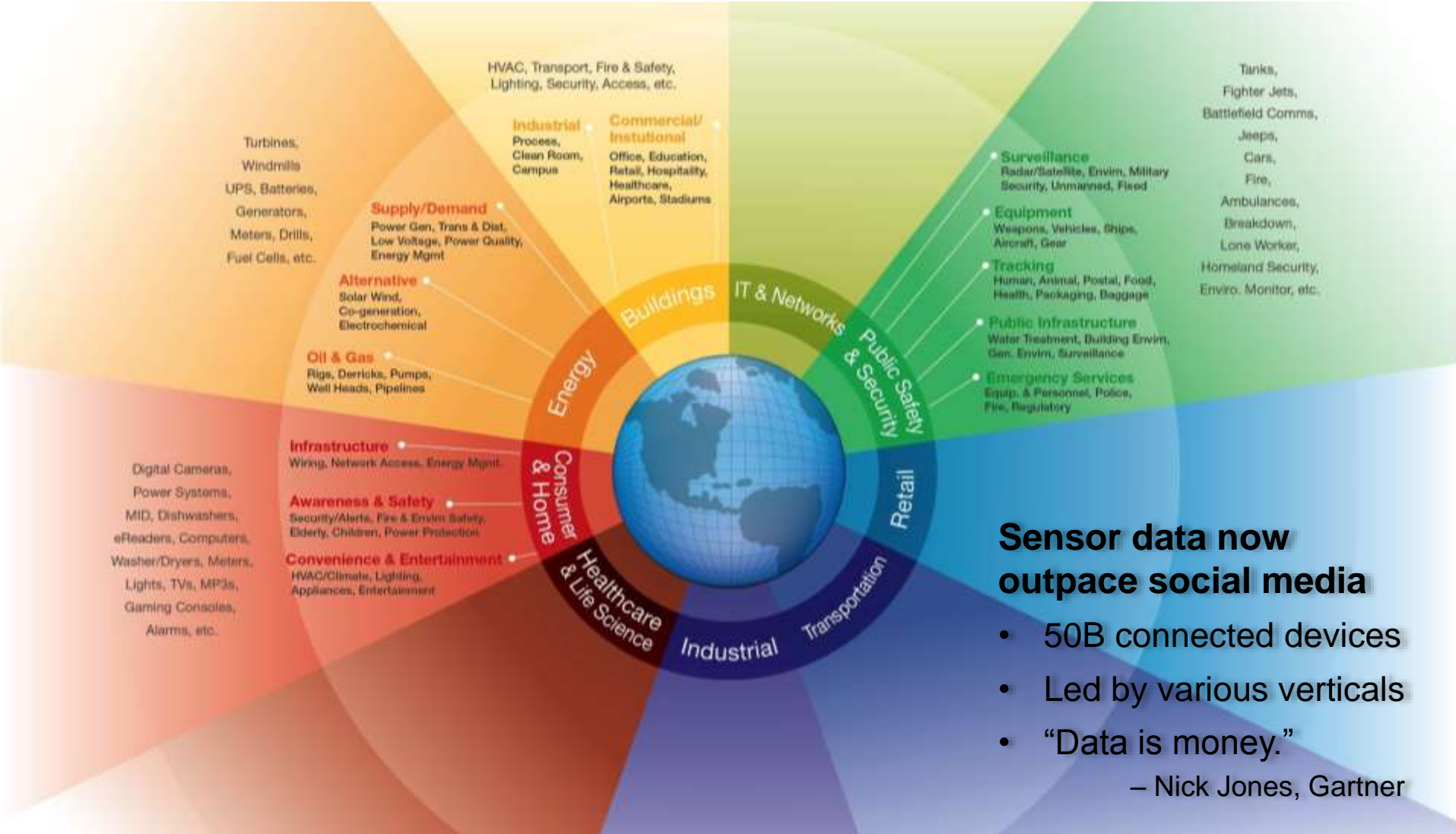


Bone Conduction Bluetooth headset cap



Virtual Reality Headset

Sensors provide a Primary Source of Data for the IoT



Sensor data now outpace social media

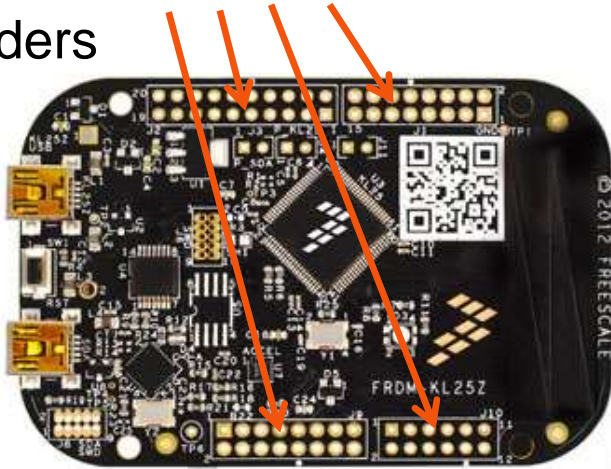
- 50B connected devices
- Led by various verticals
- “Data is money.”

– Nick Jones, Gartner



Freedom & Sensor Box Content

- The “Sensor Shield” parcel (e.g. FRDM-FXS-MULTI-B) includes...
 - 4 Connectors for FRDM-KL25Z I/O Headers



- As well as Jumpers needed for the Sensor Shield configuration:

- Sensors Interrupt Selection (J3 to J6)
- BT Module Supply (J7)
- Supply Freedom with Battery (J22)



Freescale Open Source Sensor Fusion Library

Product Features

- **Functionality**
 - 3-axis, 2-axis heading, 6-axis eCompass, 6-axis indirect Kalman filter, 3-axis relative rotation, and 9-axis indirect Kalman filter
 - Programmable sampling, fusion rates, and frame of reference
- **Included projects**
 - Kinetis K20, KL25Z, KL26Z, KL46Z, and K64F Freedom boards
 - Use of Freescale Multi sensor boards
 - CodeWarrior and Kinetis Design Studio IDEs
- **Additional commercial support and services available**

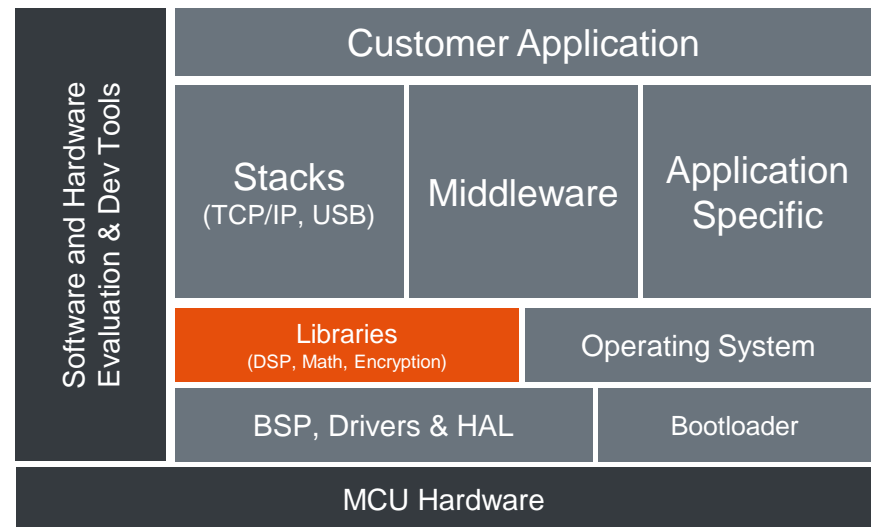
Learn more at: www.freescale.com/sensorfusion



Full featured sensor fusion library, including the award winning e-compass software



Fully open source, eliminating proprietary constraints, increasing flexibility, and decreasing time-to-market



Analog Portfolio Update



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



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



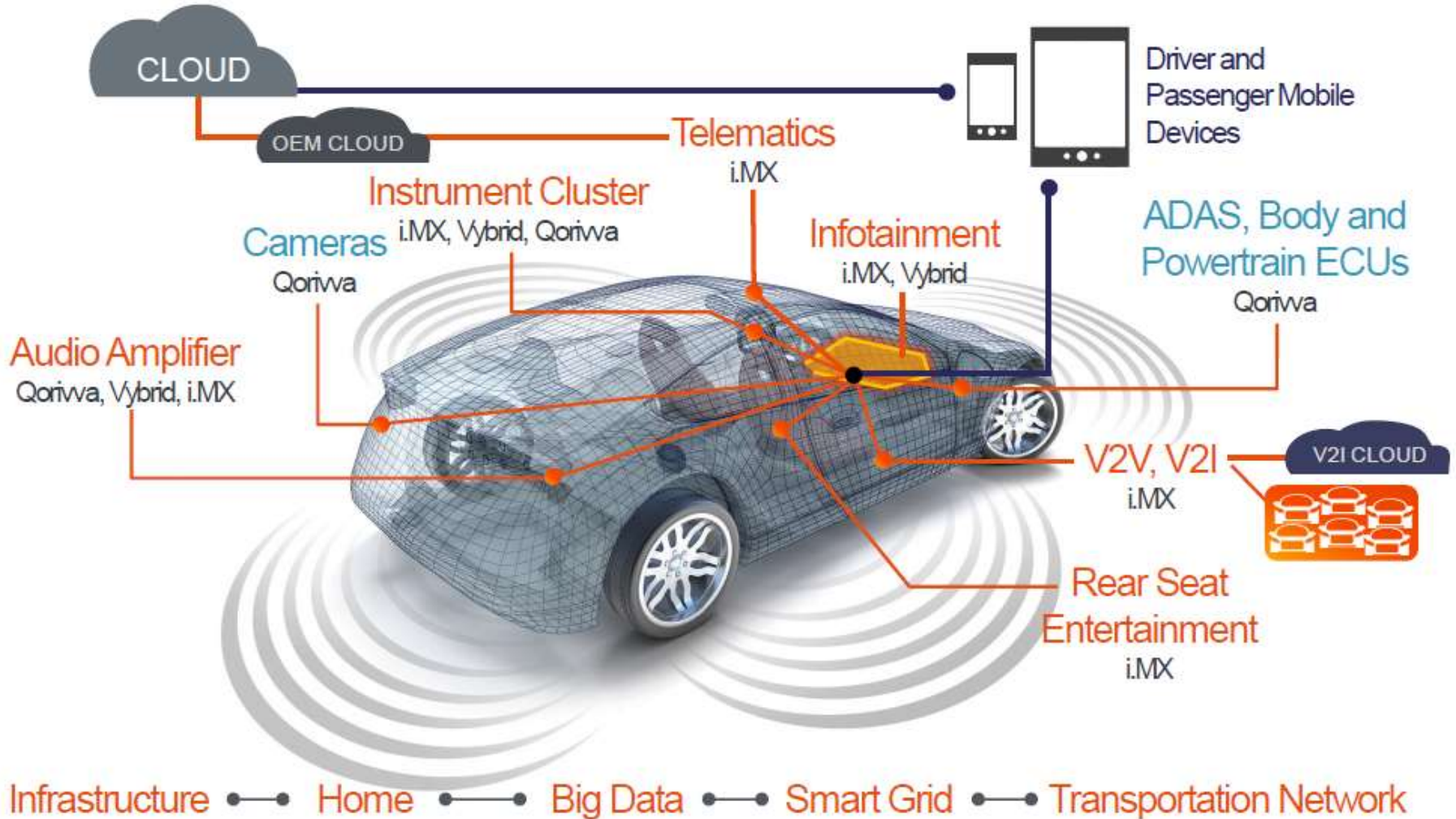
Product Longevity Program

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.



Tomorrow's Infotainment – Automotive IoT



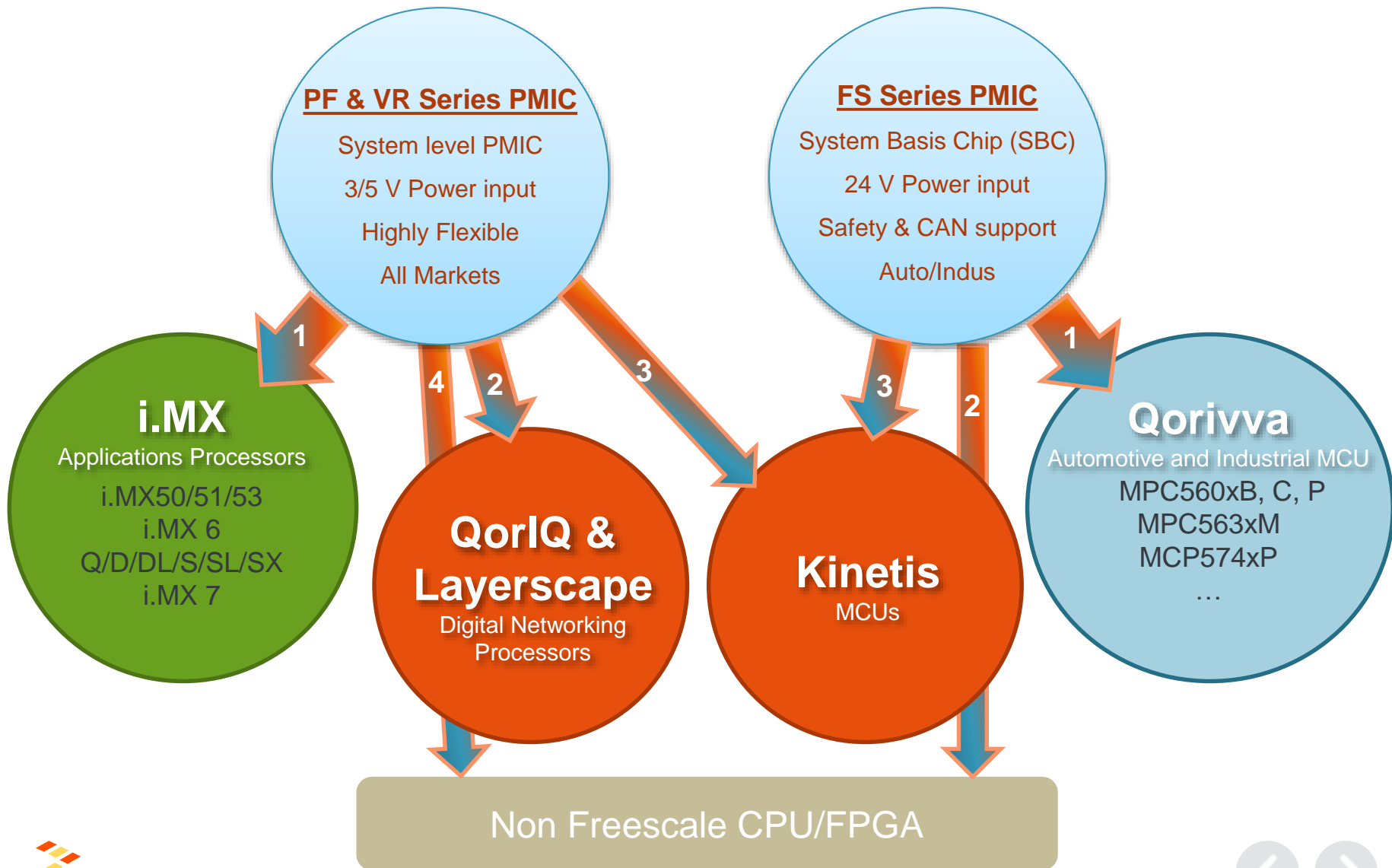
System Power Management Solutions

System power management solutions for Freescale processors and microcontrollers

		<i>Layerscape</i>	
SBCs with Functional Safety	PMICs	VR500 IoT Gateway	Battery Chargers
			



Freescale PMICs & Processors mapping





Safety Power Management Devices With Integrated Physical Layers

System Basis Chip – Power Management & Safety

embedded System Global Vision

Leverage standard automotive solutions **to support industrial** Market in terms of

- **Energy Efficient** Power Supply
- **Attach Strategy** with MCU
- Functional **Safety**
- **Communication**

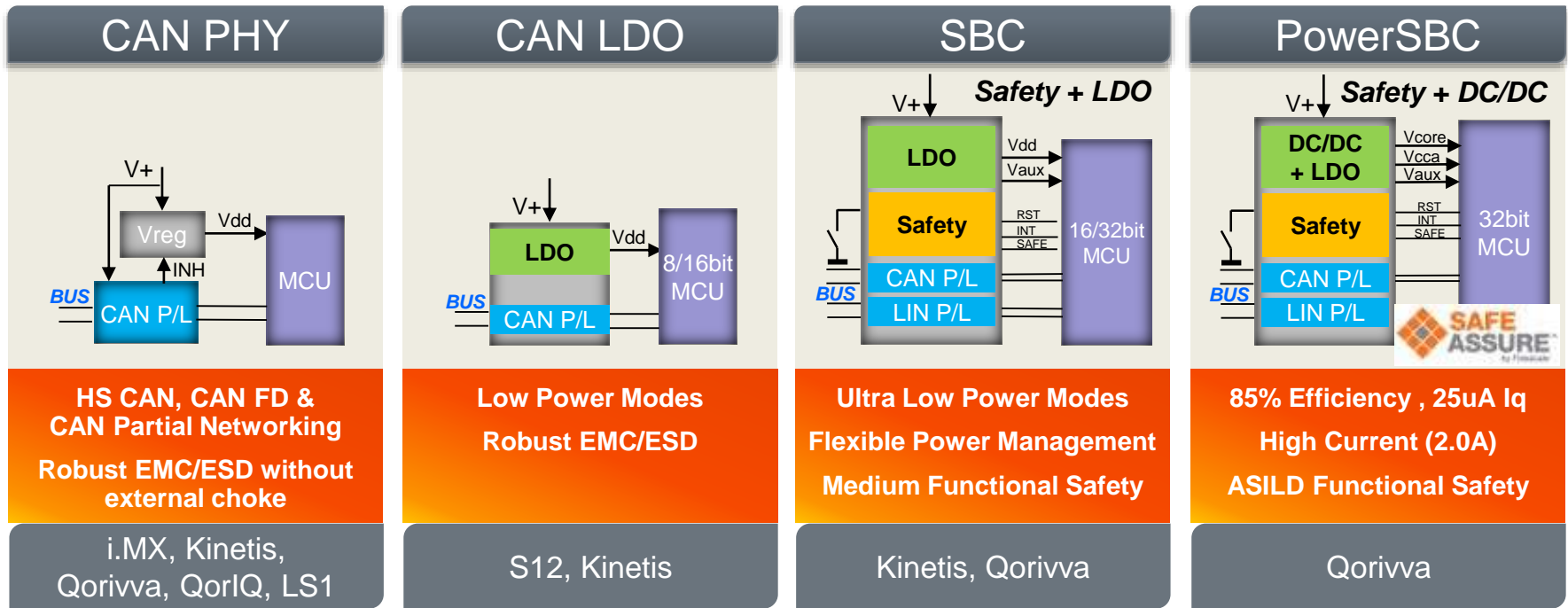
SBC Industrial Focus on

- **Transportation** Systems
- **Energy Conversion & Distribution (Inverters & Battery Management** Safety Critical)
- **Motor Control** Safety Critical (Robotics)
- Factory & Building **Automation**



System Basis Chip Segmentation

Different Solutions for Different System Needs



Scalable family of products supporting a wide range of MCU and power segmentation architectures

MC33907/8 Safe SBC with Buck/Boost Regulator

System Basis Chip (SBC) family providing energy efficient DC/DC power conversion and low voltage operation with advanced functional safety mechanisms



Differentiating Points

- **Availability** : Ultra low voltage operation **down to 2.7V**
- **Efficiency** of a Dual DC/DC converter topology
- **Safety** : Innovative architecture allowing **independent** monitoring of safety critical parameters
- **Scalable** family of products supporting a wide range of MCU and power segmentation architectures

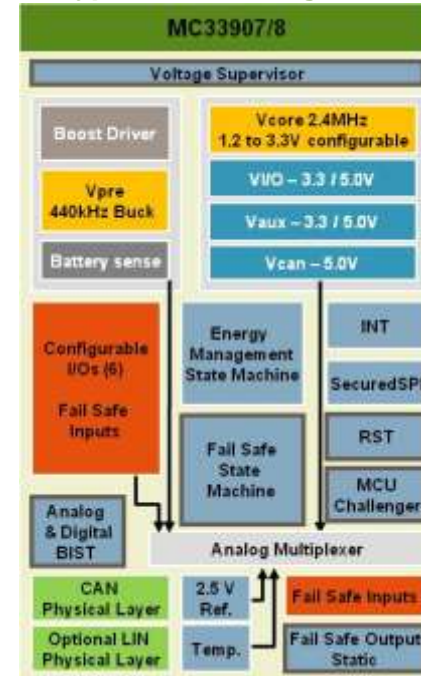


Product Features

- Flexible DC/DC Buck pre regulator with optional Boost to fit with **LV124**
- Multiple supplies up to **1.5 A**
- Low Power Modes (**30µA**), -50% versus competition
- Analog Multiplexer & Battery sensing
- **Independent fail safe state machine** supporting functional safety standards
- Secure SPI interface
- Robust physical layers with superior EMI/ESD performance



Typical Block Diagram



Typical Applications

- Power management
- Functional safety integration
- Safety Critical Motor Control

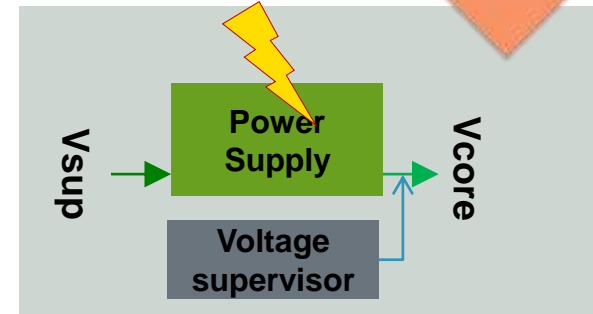


MC33907_8: Functional Safety Strategy



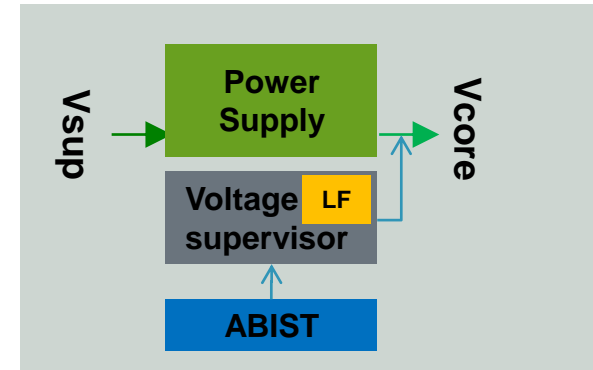
Single Point Failure (SPF)

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



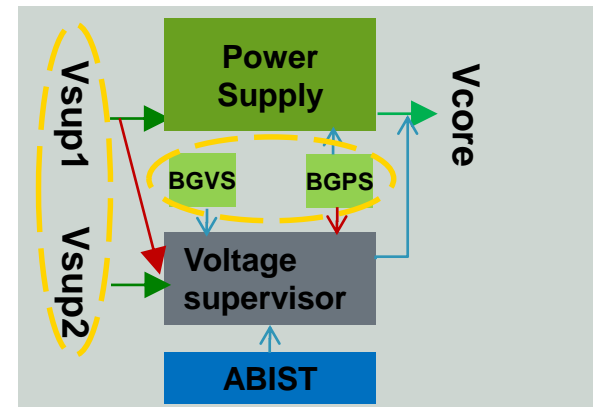
Latent Failure (LF)

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



Common Cause Failure (CCF)

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



MC33907_8: Functional Safety Concept



4 Power SBC Main Safety Functions implemented :

1 – Power supply and Supervisor

- Over-voltage detection
- Under-voltage detection
- Voltage supervisor provides independent supervision of power supply

2 – Failsafe inputs

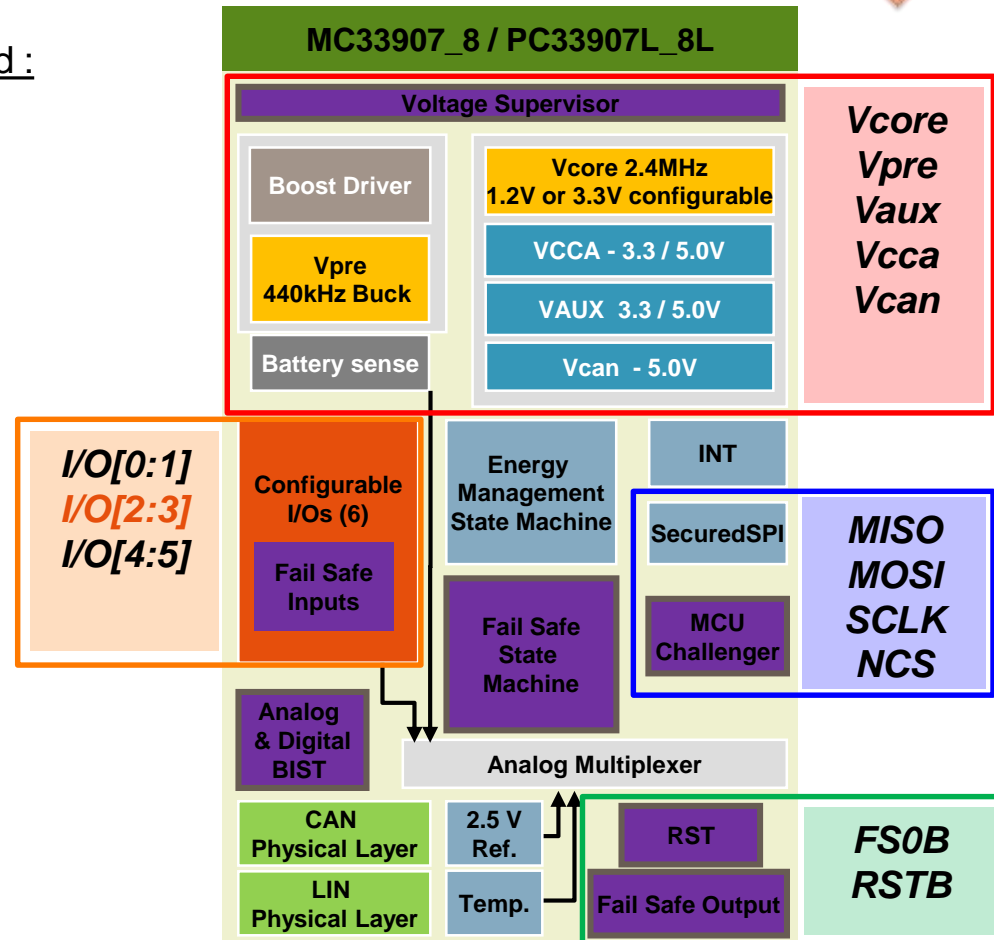
- MCU error signal monitoring
- Analog IC error signal handling

3 – Watchdog

- Windowed watchdog (1ms to 1024ms)
- SPI refresh → Question / Answer principle

4 – Failsafe outputs

- RSTB → MCU reset (active Low)
- FS0B → System “deactivation” (active Low)



SBC Portfolio Overview

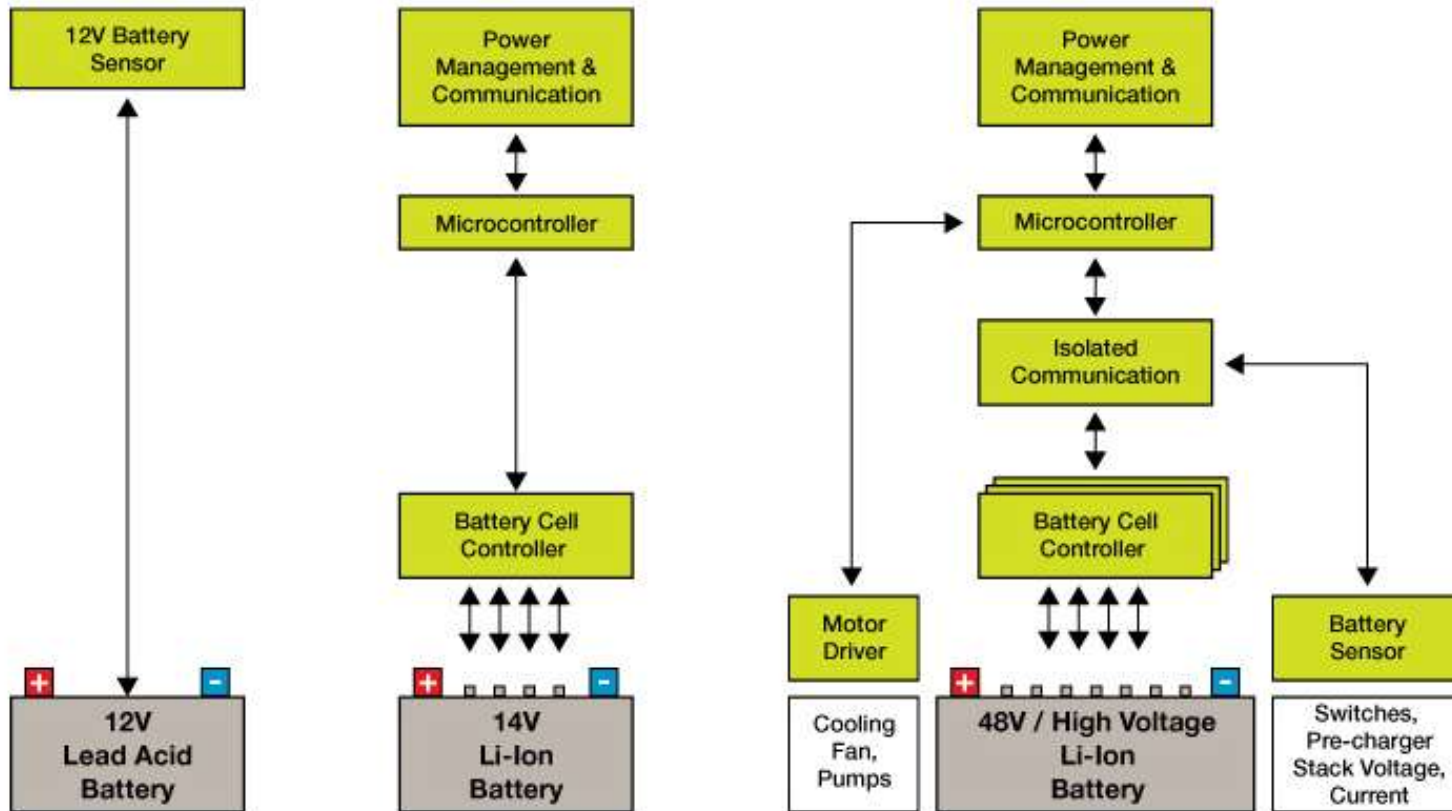
Part Number Box & internal name	MC33910, 911, 912	MC33903 CANVAS32	MC33904/5 CANVAS	MC33909 CANopy	MC33907 PowerSBC10	MC33908 PowerSBC20
Product Status	Production	Production	Production	Dev June 2014	PPAP	PPAP
6.5V Pre-regulator	N/A	N/A	N/A	2.0A B/B 440kHz	2.0A B/B 440kHz	2.0A B/B 440kHz
VCore / (MCU core)	60mA (Linear)	0.4A (Linear) with ballast	0.4A (Linear) with ballast	0.5A (Linear)	0.8A (B_2.4MHz)	1.5A (B_2.4MHz)
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




Battery Management Solution

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

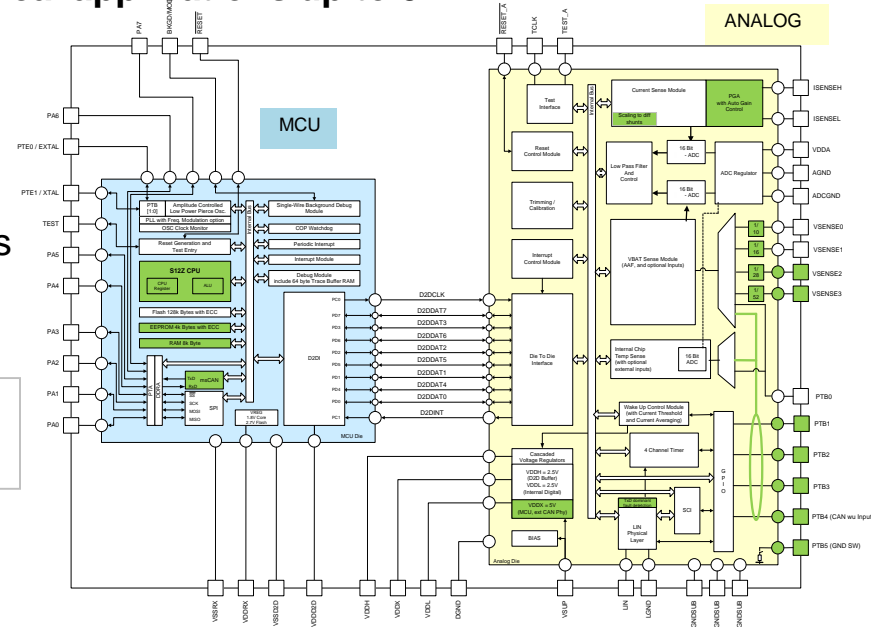
Differentiating Points

- 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



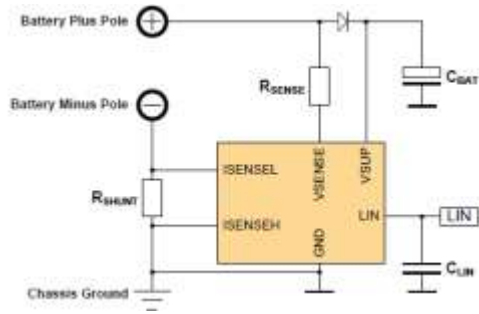
Typical Applications

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
- Industrial
 - Energy Storage Systems (ESS), UPS
 - Industrial Automation precision monitor
 - Cordless tools & appliances



MM912J637 / MM9Z1J638 Intelligent Battery Sensor Lead Acid Battery Applications

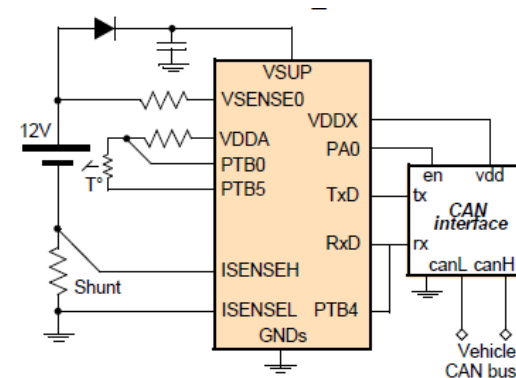


12V Pb Battery (LIN)

Product Function

- Measurement of battery Voltage, Current and Temperature
- Determination of key battery characteristics:
 - State of Charge (SoC)
 - State of Health (SoH)
 - State of Function (SoF)
- Communication to Host
- ECU Power management

SAM [2017]: \$30M



12V Pb Battery (CAN)

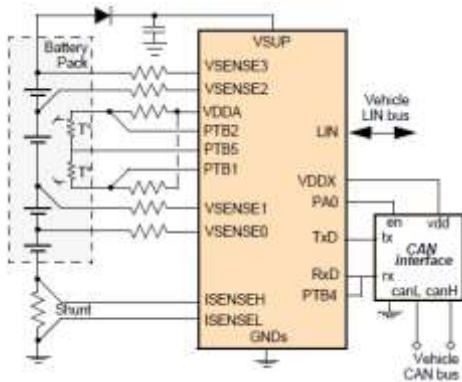
Product Function

- Measurement of battery Voltage, Current and Temperature
- Determination of key battery characteristics:
 - State of Charge (SoC)
 - State of Health (SoH)
 - State of Function (SoF)
- Communication to Host
- ECU Power management

SAM [2017]: \$15M

MM912J637 / MM9Z1J638 Intelligent Battery Sensor

Growth Applications



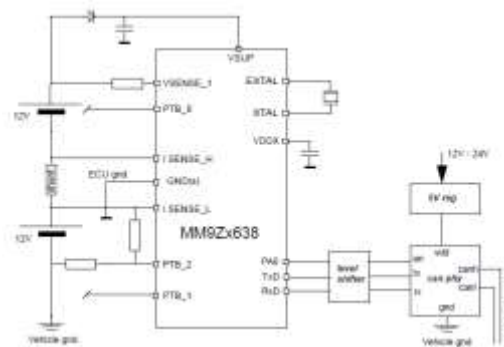
Multiple Cells

Product Function

- Measurement of battery Voltage, Current & Temperature
- Determination of key battery characteristics:
 - State of Charge (SoC)
 - State of Health (SoH)
 - State of Function (SoF)
- Cell Measurement
- Control of Balancing & Motor driver circuitry
- Safe Communication to Host
- ECU Power management

Application Examples:

- 4 cell Li-Ion Battery



Multi- Battery

Product Function

- Measurement of battery Voltage, Current and Temperature
- Determination of key battery characteristics:
 - State of Charge (SoC)
 - State of Health (SoH)
 - State of Function (SoF)
- Communication to Host
- ECU Power management

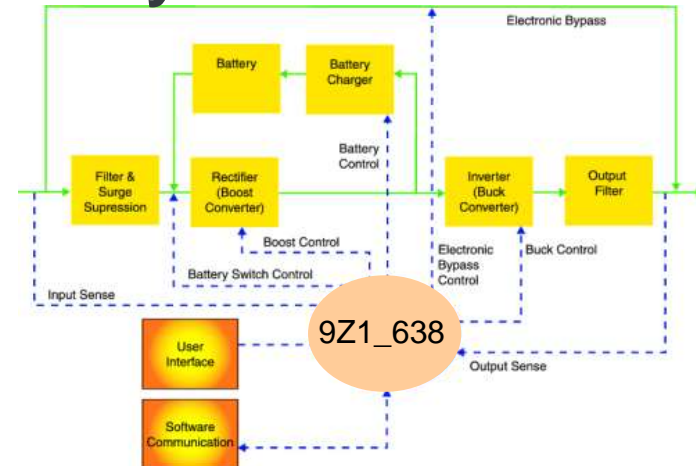
Application Examples:

- Truck/ light vehicles
- Forklifters



Forklift

SAM [2017]: \$20M



UPS

Product Function

- Input Sensing
- Battery Switch Control
- Boost Control
- Battery Control
- Buck Control
- Output Sense



UPS

SAM [2017]: \$20M





MM912_637 and MM9Z1_638 EcoSystem

Fast Evaluation of Device performance

- EVBs for MM912_637 and MM9Z1_638
 - Friendly Graphical Interface
 - Easy to use debugging tool
 - Codewarrior compiler
 - ProgsS12 P&E

Complete Technical Documentation available to ease Design

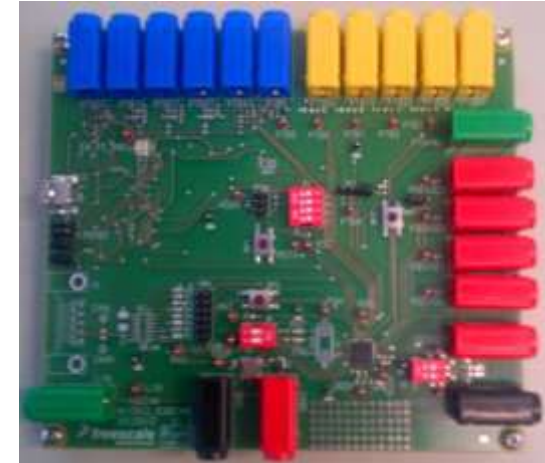
- Datasheets, EVB contents
- Safety Assessment / FMEDA in development for MM9Z1_638
- Official EMC reports from external laboratories

Reference Designs

- MM912_637 **Reference design** in development
 - 12 V PB Battery (LIN)
- MM9Z1_638 **Reference designs** in development
 - 12 V PB Battery (LIN)
 - 12 V PB Battery (CAN)
 - 14 V 4-cells Li-ion Battery (CAN and LIN)

Easy to Use tools: Support design wins

- Technical Training and hands on training on demand
- FAQ and other technical marketing presentations



12 V PB Reference Design



4 Cells Li-Ion Reference Design





MC33771 - Connectivity

SPI based solution

MC33771 Battery Cell Controller

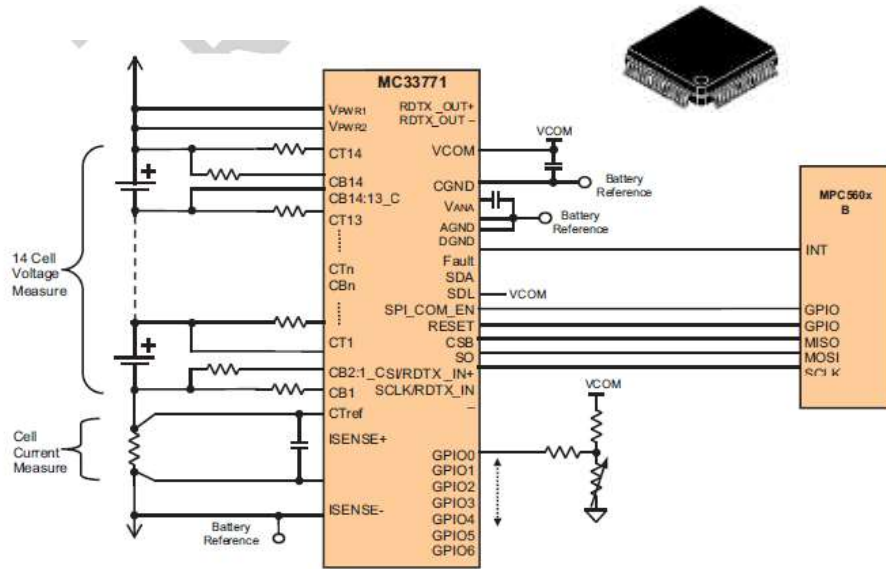


Figure 1. Low Voltage Simplified Application Diagram

Daisy Chain solution

MC33771 Battery Cell Controller + MC33664 Physical Layer

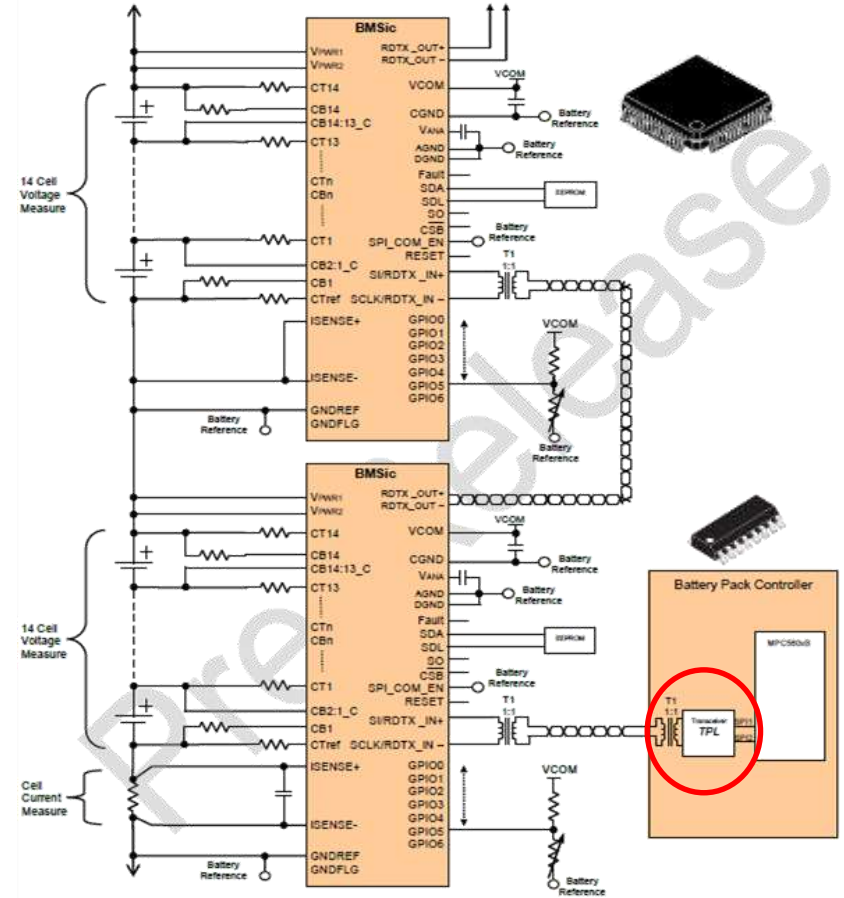


Figure 2. High Voltage System Application Diagram





www.Freescale.com