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Body Control Module (BCM)

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Field Application Engineer - Automotive
Agenda

► Body Electronics Challenges
► BCM Overview
► Freescale Solutions
► Networking
► BCM Example
► Where can I find more information?
► Q&A
Body Electronics Challenges
Enabling More Integration

Benefits:
- Less modules, less cables
- Reduced weight, fuel efficiency
- Reduced manufacturing costs
- Better quality
- Lower total cost of ownership

Body Controller (interior features + lighting)
CAN Gateway
Fuses Box Replacement
Central Body Domain Controller
RF Receiver (key, tires)
Challenges of higher integration

► Increased performance needs
  • Use of I/O processor to offload interrupt handling (e.g. S12XE, MPC5510)
  • More sophisticated software architectures (e.g. AUTOSAR)

► Increased number of I/O (A/D and timer channels):
  • Use eSwitches using an SPI to save PWM channels and A/D inputs
  • Stay with cost effective QFP packages

► Development cycle of more complex modules
  • Rapid prototyping, use of model based design
  • Off-the-shelf low-level drivers (e.g. AUTOSAR MCAL Layer from FSL)
  • Initialization tools to help configure more complex MCUs (e.g. RAppID)

► Power Consumption in both run and sleep modes
  • Need advanced low-power modes (e.g. S12XE and MPC5510)
  • Use smart analog chips with wake-up features (e.g. MSDI, Romeo3)
Centralized vs Distributed

Centralized architectures refer to fewer modules with more functionality than distributed architectures featuring smaller modules with more communication interfaces.

Benefits as perceived by Freescale:

Centralized Architectures:
- Simpler networking
- More cost effective for low-end cars
- Optimized number of ECUs

Distributed Architectures:
- Greatest flexibility w/ car options
- Designed for reuse and scalability
- Facilitates power cables routing
BCM Overview
BCM Overview

- Body control electronics cover a wide range of comfort, security, lighting and access technologies, inside and outside the passenger cabin
Low End BCM - Block Diagram

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**IGN**
- Ignition Key Position

**Door**
- Central Lock Switch
- Door Ajar Status
- Driver Seat Belt indicator

**Window**
- Power Window Switch
- Power Window disable
- Rear Window Defrost Switch
- Current Protection

**Light**
- Exterior Light Switch
- Interior Light Switch

**Wiper**
- Wiper Switch
- Wiper intermittent adjust

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**Input**
- CAN SBC MC33742

**Output**
- RKE Receiver

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- +12V
- CAN
- +5V

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**MCU**
- S12XE Family

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**RKE**
- RKE Receiver

---

**Central Lock Relay**
- Power Window Relay
- Rear Defrost Relay
- Turn Lamp / Hazard
- Lo/Hi Beam & Side light
- Interior /Salute light
- Washer Motor
- Wiper Motor
- Alarm Beeper

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* Total IO - 55
Generic body control module – Communication and power supply

Factors to consider:

- Amount of physical layer communications channels required.
- PCB space available.
- Power supply partitioning on the module.
- Low power requirements of the module.
- Diagnostics required for the communication channels.
Communication + Power Supply (SBC – System Basis Chip)

Low power modes attributes

- Low consumption.
- Detection of “wake up events”
- Wake up time
- Periodic scan function (wake up event detection) prior to full network wake up

ECU: A & B

ECU: B (partial A & C)

Integrated transceiver and regulator with additional simplified functionality.

FSL CAN HS/LIN portfolio

Separated transceiver and regulator.

ECU: C, D (partial B)

Medium/high complexity CAN, LIN wake-up

Low/medium complexity CAN & local wake-up

No low power mode

High complexity. Multiple wake up
Periodic scan (wake up)

FSL CAN HS/LIN portfolio

Separated transceiver

Integrated transceiver

SBC CAN (33742)
SBC LIN (MC33910 – ‘912)
Generic body control module – handling inputs

Factors to consider:

- Amount of switches (switch to GND / VBatt)
- Amount of analog inputs
- Wakeup capable inputs (digital and analog).
- Wetting current characteristics.
- PCB space available.
- Power dissipation constrains
- Low power requirements of the module.
- Amount of components on the PCB.

Input / Output blocks

- Communication + power supply
  - Vreg
  - CAN P/L
  - Watchdog
  - Wakeup

Processing block

- S08 S12X MPC55XX MPC560X

Output blocks

- Motor drivers
- High side drivers
- Low side drivers
MSDI - Multiple Switch Detection Interface
33993 / 33972 / 33975

• The Multiple Switch Detection Interface is a monolithic silicon integrated circuit (IC) that performs switch monitoring functions. The device can be used to detect the closing and opening of up to 22 switch contacts.

• One MSDI device can replace 66 SMD devices

• MSDI can handle multitude of common I/O needs in embedded systems (Analog mux, FETs, LEDs, power sensors)

<table>
<thead>
<tr>
<th>Customer Benefits</th>
<th>Discrete Switch Inputs</th>
<th>MC33972 Switch Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Dissipation</td>
<td>Poor (&gt;8W)*</td>
<td>Good (&lt;1W)*</td>
</tr>
<tr>
<td>Operating Voltage Range</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td>Board Space Utilization</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Number of Solder Joints</td>
<td>Poor (352 solder joints)</td>
<td>Excellent (138 solder joints)</td>
</tr>
<tr>
<td>Ground Offset Protection</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Quiescent Current with Wake up</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

* Considering the 22 switches closed.
Generic body control module - High side & Low side drivers

Factors to consider:
► Amount of high side and low side outputs
► Current profile of each of the outputs
► Protection and diagnostic requirements
► PWM requirements for each outputs.
► PCB space available.
► Power dissipation constrains
► Variability between the loads been driven.
► Reliability requirements
► Failsafe characteristics of the outputs.

Input / Output blocks
- Communication + power supply
- CAN
- CAN P/L
- Watchdog
- Wakeup
- LIN
- LIN P/L
- Switch inputs
- Analog inputs

Processing block
- S08
- S12X
- MPC560X
- MPC55XX
- SPI

Output blocks
- Motor drivers
- High side drivers
- Low side drivers
SMARTMOS™

**Protection and diagnostic**
- Over temperature
- Over current
- 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 overcurrent trip level
- Watchdog

HDTMOS™

**Best in Class MOSFET**
- 1.7 mOhm typ. at 25°C
- 2.9 mOhm typ at 150°C

**Protection in the power stage**
- Temperature sensor
- Current sensor

PQFN

**Low cost power package**
- 0.5 mm thick leadframe
- Die soldered attached
- Rthj-c < 0.5 °C/W

**Design Flexibility**
- Alu Power wires
  - Low series resistance
  - Current capability > 200A

**High reliability**

ADVANTAGES OF 2 DIE SOLUTIONS:
- Reduce temperature of control die
- Avoid parasitic substrate effects
- Use each techno at efficient level
- Reduce stand by current
eXtremeSwitch GenIII

- Low space, weight, full integration with minimum MCU required.
- 55W/65W or 21W/28W bulb, HID-Xenon and LEDs matrix compliant,
- PWM module self running with configurable duty-cycle and delay (reduction of MCU I/Os needed),
- Protections and Over-current profile dedicated to PWM bulb switching,
- EMC optimization,
- High reliability,
- Outputs under fully control and protected in case of MCU damage,
- Auto-retry,
- External or Internal watchdog with failsafe management.

Light weight & Fuel efficient
Intelligent & Safe
Lower system cost
No inventory cost for spare relay/fuse
Factors to consider:

- **Scalability & Flexibility:**
  - Platform approach
  - Compatibility (reuse)
  - Migration options
  - Peripherals
- **MCU selection:**
  - Flash, ROM, EEPROM
  - Pin-out
  - Package options
  - Functionality
  - Low Power
  - Development support
  - Cost
  - Quality
  - Software availability
Automotive Performance & Integration

Expanding Our 32-bit Power Architecture™ Family
Control and Communications

Building on Our 16-bit Strength S12-S12X
- Expanding on-chip peripherals with XGATE co-processor
- Extending flash memory sizes and CPU performance
- FlexRay™ integration

Cost Reducing Low-End S08
- Cents not dollars for automotive quality and control.

• First 32-bit MCUs with Integrated FlexRay™ for vehicle networking
• New low-cost solutions widen entry point
• New application areas for body, safety and gateway
Relative Performance/Features Positioning

- **32bit**
- **16bit**
- **8bit**

**Features, I/O functionality**

- **S08S/S08E**
- **S08D**
- **S12P**
- **S12XS**
- **S12XE** (S12X w/ XGATE)
- **MPC5510** (z1 + z0 dual-core)
- **MPC560xB** (z0 single core)
Highly Integrated BCM – MPC5510 or S12XE

Application Challenges

► Integration level depends on OEM needs
► Diversity of architectures
  • Distributed vs centralized
  • AUTOSAR or not
  • Networking requirements
► Low power management
► Reuse of legacy software and tools

Freescale Solutions

► Scalable product families
► I/O Processor support for maximum flexibility
► AUTOSAR MCAL available for both architectures
► High-performance AND low-power!
► Standard architectures supported by a strong ecosystem of tools and software partners
Freescale Automotive Multi-Core Architectures

I/O Processor Solutions
(In production today)
• CPU offloading of specific low-level tasks
• Peripheral emulation and flexibility
• Parallel Gateway communications processing

Hi-Performance Symmetric dual-core Processing
(In Development)
• Increased MIPS/MHz
• Simplified Application level tasks partitioning
• Improved current consumption and EMC performance

Integrated Safety Architectures
(In Development)
• Lockstep functionality
• Self test diagnostics
• Dual redundant systems with Error Correction
The Crossbar Architecture, a Turbo for Gateways

- Platform = cores + crossbar + system support functions (INTC, debug, timers, semaphores…)

- The crossbar switch allows concurrent accesses between masters and slaves resources

- Widening the memory bottleneck:
  - Separate SRAM blocks
  - Flash controller with separate page buffers to emulate dual-ported flash

- Peak data bandwidth of the MPC5668G crossbar architecture is 3.5 Gbytes/sec at 116 MHz clock speed

Example of the MPC5668G Platform with a 6Mx6S crossbar configuration:
XGATE
- 16-bit 100Mhz Co-Processor to offload main CPU

Benefits
- Higher Throughput: Dual core drives higher performance without increased bus speed
- Low-EMC, Low-Power: main CPU can run lower frequency - reduces overall emission

Applications - existing XGATE applications include:
- IO Coprocessor
- Interrupt Processor
  - Interrupt nesting capability
- Smart DMA controller
  - Manipulate data or change memory source before storing to memory
- Virtual peripheral driver
  - Build LIN protocol layer, virtual PWM, SCI, SPI, etc.
- TFT Driver
  - Drive TFT Display directly from XGATE
- Onboard Safing Micro
  - Monitor main CPU with XGATE
- Manchester Decoding

Flexibility
- What can the XGATE do for you?
Networking
1990’s : The Birth of Networking into Cars

- CAN, VAN or J1850 depending on car makers
- Proprietary communication, K-line

The Challenge: Get to some consistency, Reuse

- Immobilizer
- Body Controller
- Instrument Cluster
- Engine Management
- Radio
- Airbag
- Anti-lock Braking
- Lighting
- Window lift
- Air conditioning
- Alarm
- Trailer Connection
2000’s : CAN and LIN Standards Dominate

The Challenge: Manage the complexity, limited bandwidth and non-determinism
2010’s : Hierarchical Networks

The Challenge : Overcome the complexity of “super nodes” through new design methodologies, standard software…

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Freescale is a leader in defining next generation communications specifically for Automotive

- Freescale is a founding member of the LIN Consortium
- Freescale is a founding member of the FlexRay Consortium

<table>
<thead>
<tr>
<th>Channels</th>
<th>LIN</th>
<th>CAN</th>
<th>FlexRay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>Single</td>
<td>Single/Dual</td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>20 Kbit/s</td>
<td>&lt;= 1 Mbit/sec</td>
<td>10 Mbits/sec</td>
</tr>
<tr>
<td>Time triggered</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Arbitration</td>
<td>Master</td>
<td>CSMA</td>
<td>TDMA</td>
</tr>
<tr>
<td>Devices available from Freescale today</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
BCM Example
Light Control Module

- Controls all exterior lighting, up to 16 channels
- CAN interface
- 55A current capability at 85°C
- Very small size (business card) and high power density
- Efficiency of about 99%
- Small footprint allows it to be used as a sub-module
- Uses wiring harness for heatsinking
- Wiring harness protection allows
  - the reduction of wiring harness gauge
  - omission of fuses
- Adds new features such as
  - PWM control for lamp dimming and protection
  - wiring, lamp and harness diagnostics
Light Control Module
Power Distribution Module

- 4.25” x 5.0” board
- High Power Outputs - 18 outputs, 80A total @ 85°C
- 22 switch inputs
- High Speed CAN and J-1850 Communications
- PC Master GUI Interface
Power distribution module Building Blocks

- CPU Block
- PC Master I/F Block
- eXtreme Switch Output Blocks
- SBC Power Supply Block
- J1850 Block
- MSDI Block
- Power Input & Protection Block
Where can I find more information?
www.freescale.com/training

Learning Centers
Training and other helpful content organized around a topic to provide orientation and support learning
- 8-bit
- 16-bit
- 32-bit
- DSP/DSC
- Sensors
- RF
- ZigBee
- Analog & Power Management
- CodeWarrior Development Tools

eLearning Quick Searches
- Industries
  - Automotive
  - Industrial
  - Network Communication
  - Consumer
- Design Topics
  - Low Power
  - Scalability
  - Motor Control
  - USB

Virtual Labs
- ColdFire 32-bit Processors
  - Flexis JM Badge Board
  - Flexis QE128
  - MCF5485E
- RS08 8-bit Processors
  - MC9RS08KA2

Features Videos
- Example: EEPROM emulation using flash
  Video outlines the basic concept of using Freescale Flash memory to emulate EEPROM. (Video - 2:36)
- Demonstration: View a simulation of eTPU
  set2 crank, cam, spark and knock window
  Automotive Functions
  (Video - 3:22)

Software & Hardware for this Virtual Lab:
- Target Control
- Windows PC
- RDDSP56F8BLDCE: 3-Phase BLDC Motor Control with Encoder using 56F8300 DSC
- CodeWarrior™ 56800/E Hybrid Controllers v6.1
- DSP56F805 Digital Signal Controller

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