Architecture Trends
Body Electronics
Infineon Symposium, Sep. 2010

Li Shi Ming
Body Application Marketing Manager
IFCN, ATV Marketing Team, Shanghai
Agenda

Body Architecture Trends

• Centralized vs. Decentralized Architectures
• Typical System Block Diagrams
• Solutions for Decentralized Electronics
• Power Distribution System

Energy Efficient Networks

• Motivation
• Two Ways to Improve Energy Efficiency of ECUs
• Sample Calculation – How much Energy Can be Saved
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- Sample Calculation – How much Energy Can be Saved
Body Electronics / Body Control Module
Changing the Cost-Benefit Situation

In the Past

- Power BOM Device Cost
- System benefits

Limited system functionality
Focus on Power BOM / Device cost

In the Future

- Power BOM Device Cost
- System benefits

Increased complexity, More features
Focus on System cost

Trends

- Diagnostic & PWM
- Flexibility
- PCB space & Pdiss
- Unified BCM

August 2010
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High Sophisticated System Architecture

Backbone / Gateway

This Diagram does not reflect any specific OEM architecture.
The modular character of components and systems contributes to the success of automotive electronics.

The aim of modularisation is to standardise non-perceivable parts and to individualise perceivable parts.

The multiple utilisation of corporate modules leads to considerable advantages in both cost and quality. At the same time developmental periods become shorter.
Coexistence of Discrete and Integrated Power Drivers

Discrete implementation

Integrated approach

BCM with low complexity

BCM with high complexity

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Market Share</th>
<th>Added Features (SPI, Pdiss, PCB, …)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>30% (trend: ↑)</td>
<td>high value</td>
</tr>
<tr>
<td>Mid</td>
<td>40% (trend: ↑)</td>
<td>depends</td>
</tr>
<tr>
<td>Low</td>
<td>30% (trend: ↓)</td>
<td>hardly relevant</td>
</tr>
</tbody>
</table>
Wide Range of Scalability of Generic BCM Designs

One BCM/PCB design but multiple Variants to handle.

Low end car model
No LED, Bulbs only

Mid range car model
LED as option

High end car model
LED only
"Limp Home" Function
Functional Safety in Lighting Control

- Failure
  - µC not working
  - Vcc not working
  - Reset clamped

- LIMP Home activated by Hermes

TLE8264-2E

- SPI
- State Machine
- WD

Limp Home

- SPI, INT, RO, TxD, RxD (CAN, LIN)
- Vcc 5V

Micro Controller

Power Switch, e.g. SPOC

- LH
- LH_PL
- LH_SI

Backlight

Indicator

Brake

PWM

LH

TLE8264-2E

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# ASIL Compliant Requirements in Body Future Requirement – Arising Soon

<table>
<thead>
<tr>
<th>Function</th>
<th>ASIL (ISO 26262)</th>
<th>Failure Reaction Time (us)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGN Switch (Body Computer, Ignition key)</td>
<td>B</td>
<td>t.b.d.</td>
<td>Failure Critical Event: Unwanted switching off KL15 during driving</td>
</tr>
<tr>
<td>Lighting function: Low beam, Front &amp; Rear Turn signal light</td>
<td>B</td>
<td>t.b.d.</td>
<td>Failure Critical Event: Turn Signal need to be switched off, low beam need to be switched on</td>
</tr>
<tr>
<td>Lighting function: High beam, Parking light, Side marker</td>
<td>A</td>
<td>t.b.d.</td>
<td>Requirements not known</td>
</tr>
<tr>
<td>Lighting function: Stop light, Tail light</td>
<td>A ?</td>
<td>t.b.d.</td>
<td>Requirements not known</td>
</tr>
</tbody>
</table>
| Any motor load (window lift, seat, wiper, HVAC etc.)          | ??               | t.b.d.                    | No demand of ASIL so far
Centralized vs. Decentralized Architecture
LED for Exterior Lighting

Centralized Architecture Today

Partially Decentralized Architecture > 2012

Fully Decentralized Architecture > 2020

**LED as an option**
For **Certain** Car Models of One Platform

**LED-only**
For **Certain** Car Models of One Platform

**LED-only**
For **All** Car Models of One Platform

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Generic Decentralized Front Light Module

Decentralized Light Control Module

- System Basis Chip
  - TLE 8261E/-2E
  - TLE 8262E/-2E
- Communication
- Supply
- Optional: LIN Bus
- CAN Bus
- +12V from Battery

16/32-bit Microcontroller
- XC2200 Family

Motor Driver / Beam Control

LED Driver

- Power LED Driver
  - TLD 5095EL
  - TLD 5098EL
- Power LED Driver
  - TLD 5095EL
  - TLD 5098EL
- Power LED Driver
  - TLD 5085EJ

Curves Light

- Position Sensor
  - TLE 4906

Light Levelling

- Position Sensor
  - TLE 4906

Beam Control

- Daytime Running Light/Position Light
- Headlight Low Beam
- Headlight High Beam
- Turn Indicator

Further LED channels
Body Architectures BCM/Door Centralized Architecture

**Features:**
- Single Central BCM Module

**Benefits:**
- Fully scalable Functionality

**Drawbacks:**
- Heavy wiring effort or cars with high functionality

**Coverage:**
- Low End Cars
- Only few electronic functions
Body Architectures BCM/Door
BCM + Door Modules Using CAN/LIN

**Features:**
- Full Featured Door Modules
- CAN or LIN connection to BCM and between Front & Rear Door

**Benefits:**
- Low wiring harness effort
- Full functional network
- Automatic Door Functions

**Drawbacks:**
- Expensive
- High end Solution / Low Scalability

**Coverage:**
- Premium Brands

*Fewest Wiring Harness*

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Body Architectures BCM/Door Mixed Architecture (DCM + Central Lock)

Features:
- Door Modules without Door Lock
- CAN or LIN connection to BCM and between Front & Rear Door
- Smart Window Lift in Rear Door

Benefits:
- Kind of mixed architecture
- Partially scalable

Drawbacks:
- Low scalability @ Front Doors

Coverage:
- Mid Class and Premium Class Vehicles

Mixture of Door Module and Smart Window Lift
Decentralized Body Electronics
LIN Slave System IC

TLE98xx

VREG
Watchdog

LIN Bus

+12V from Battery

HV Inp
Timer

8-Bit MCU
8051 Core
MDU Coprocessor
24..40 MHz
32..64k Flash

GPIO

Power Driver

VQFN-48 7x7mm Footprint

+12V from Battery

LIN Bus

M
Small Body Control Module
Emerging Markets

- Single CAN connects to Powertrain Electronics
- Reduced Number of High Side Switch Loads (e.g. Indicators, Brake)
- Many High Current Loads still driven by relays
- Optional RKE functionality, interior LED, etc.
HVAC Control Module
Low to Mid End / Manual + Semi-Automatic

Key Features:
- Same Loads as in High-End Systems / Same Devices Applicable
- Low Cost Microcontroller

- 8-bit Microcontroller XC800 Family
- Optional: VREG TLE42xx
- LIN LDO TLE 8458
- CAN Transceiver TLE6254-3 TLE6250 TLE 6251-2G/DS
- Optional: CAN Bus
- LIN Bus
- +12V from Battery
- Motor Driver
- Power Half Bridge BTN 7960B
- NovalithIC™
- HITFET™ BTS 3405
- LS Driver
- SPI / Mirror Control
- Multi Half Bridges TLE 84106 EL (3 Flaps) ¹
- Multi Half Bridges TLE 84110 EL (5 Flaps) ¹

¹ In development

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Door Module
Full Door Functionality

System Basis Chip
TLE 8261E/-2E

LIN LDO
TLE 8458

8-bit Microcontroller
XC 800 Family

16/32-bit Microcontroller
XC2200 Family

Mirror Power IC
TLE 8203E

Multi Half Bridges
TLE 6208-3

PROFET™+
BTS 5120-2
BTS 5180-2

TrilithIC
BTM 7740G

NovalithIC™
Power Half Bridge
BTN 7960B

Mirror Heating

Mirror Position

Interior Light
Puddle Lamp
5W, 10W

Mirror Flap

Interior Light
Puddle Lamp
(Rear Door only)

Door Lock

Motor Driver

Lamp Driver

Motor Driver

8-bit
Microcontroller
XC 800 Family

+12V from Battery

CAN Bus

LIN Bus

Supply

Communication

Front Door Only

1) In development

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Main Wire harness of Power Distribution is getting more volume/weight and complex

We have seen these comparisons

**Harness 1949**
ca. 40 wires
ca. 60 connectors

**Harness 1999**
ca. 3 km cables
ca. 39 kg weight
ca. 1900 wires
ca. 3800 contacts

Dr. Wulf Bramesfeld
Freudenberg NOK Mechatronics GmbH & Co. KG
Electronica automotive conference, Munich 2008
Contribution of Smart Power Semiconductors
1990s Automotive Lighting Module Evolution

Body Control Module Evolution @ BMW
Vehicle Power Distribution Architecture
Split into Various Applications

Power Distribution architectures are the same in conventional, hybrid or electric vehicles 12 V Power Net part
SMART Power Distribution - Enabling Technology for Energy efficiency, Reliability and functionality

SMART Power Distribution is the enabler for

**Energy Efficiency**
- Material weight
  - device
  - module
  - wire harness
- Energy Consumption
  - Power dissipation
  - Driving current
  - idle mode

**Reliability**
- Stop – Start
  ( > 500 k cycles)
- On-board diagnostic
  (Short circuit detection)
- Reaction time
  (switch off speed)
- Robustness
  (vibration, shock)
- Secure disconnect

**Functionality**
- Maintenance Cycles
  (Including Reset Ability)
- Module volume
  (Space enabler)
- Module flexibility
  (Location)
- Module handling
  (Waterproof)
- Scalability/ Modularity

Cost down on system level under lifetime consideration
Relay + Fuse Replacement by Power PROFET™
Relay Replacement by Infineon® Connect FET

Lead Type (1.5 mΩ)
Engineering
Samples available

Power PROFET™
Replacement relay + fuse

Master: BTS 50015-1TAA  SOP Dec 2010

Chip-On-Chip Technology

Connect FET
Replacement of the relay only

Master: BTC 50010-1TAA  SOP Apr 2011

Lead Type (1.0 mΩ)
Engineering
Samples available

connect

switch
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- Sample Calculation – How much Energy Can be Saved
### Energy Efficiency and CO₂ Emission

**Impact of Electric Power and Weight**

<table>
<thead>
<tr>
<th>Electric Power</th>
<th>Equivalent Fuel Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 W (elektr.)</td>
<td>0.1 l/100km</td>
</tr>
<tr>
<td>50 kg</td>
<td>0.1 l/100km</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fuel Consumption</th>
<th>Equivalent CO₂ Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 l/100km Gasoline</td>
<td>23.6 g CO₂/km</td>
</tr>
<tr>
<td>1 l/100km Diesel</td>
<td>26.5 g CO₂/km</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CO₂ Emission</th>
<th>Equivalent Power or Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 g CO₂/km</td>
<td>40 W (elektr.) or 20 kg</td>
</tr>
</tbody>
</table>

*Source: VDI Conference „Elektronik im Kraftfahrzeug“, Baden-Baden 2007*
Semiconductors Contribute to Energy Efficiency in Nearly Every ECU

**Voltage Supply Efficiency**
Example: 5V, 200mA
60% less input power

\[
\text{IN} = \text{LOSS} + \text{OUT}
\]

- Linear Regulator:
  - IN = 0.2W
  - OUT = 1W
  - LOSS = 1W
  - \(-60\%\)

- DC / DC Regulator:
  - IN = 1W
  - OUT = 1W
  - LOSS = 2W
  - \(-60\%\)

**Power Switching Efficiency**
Example: 14V, 20A
70% less switching losses

\[
\text{IN} = \text{LOSS} + \text{OUT}
\]

- 4.5W
  - Loss = 3W
  - \(-70\%\)
  - OUT = 1.5W
Motivation

How To Enhance Vehicle Efficiency when Car Drives

**Partial Node Deactivation**

Complete Deactivation of unused ECU’s

**Scalable Functionality**

Dynamical Adaptation of ECU Performance

---

**IGN off – Car in Sleep Mode**

- Target: Sleep mode current <100 µA per ECU
- No Bus traffic, Wakeup events possible
  - Remote Keyless Entry
  - Inquiry of Switch Panels

**Total Car Current Consumption:**

~ 5..20 mA

---

**IGN on – Car runs**

- Target Parameter Performance / Functionality
- Current Consumption – Not Yet a Constraint
- Permanent Network Traffic

**Total Car Current Consumption:**

~ > 10 Amps
(without any loads)
Energy Efficient Networks

Different Ways to Save Energy

Partial Node Deactivation

Affected Products
- Standalone CAN Transceiver
- System Basis Chip

Challenge
- Standardization of Wakeup CAN message

Market
- Mid-/high end vehicles, world-wide

Scalable Functionality

Affected Products
- Microcontroller

Challenge
- Implementation across µC families

Market
- Mid-/high end vehicles, world-wide

![Diagram of microcontroller and components]

- CAN TRX
- VREG
- Logic
- Power Supply
- CAN-Controller
- INT Handling
- SCI
- SPI

Function
Local Wakeup
Current ECU Operating Modes
No Energy Efficiency while Car is Driving

- **ECU in Normal Mode**
  - Microcontroller runs with full speed/performance
  - max operation: 100mA
- **ECU in Standby Mode or off (KL30 on / KL15 off)**
  - No Function, No Communication, Wakeup Possible
  - standby: 1mA
  - passive stop over: 10mA
  - active stop over: 100µA
  - slow down: 100mA

- **off**: 100µA
New Operating Modes
Reducing Energy Consumption

100mA
max operation

ECU in Normal Mode
Microcontroller runs with full speed/performance

10mA
slow down

Reduced (Scalable) Performance
No ECU Function, Communication active
No Loss of Bus Messages

1mA
active stop over

No ECU Function, Communication in Standby
Wakeup message Required

Fast Wakeup, if µC standby

ECU in Standby Mode or off (KL30 on / KL15 off)
No Function, No Communication, Wakeup Possible

passive stop over

Slow Wakeup, if µC off

off
Scalable Current Consumption Example: XC228xM Family

Current (mA)

- CPU: ON
- Flash: ON
- Peripherals: ON
- Pads: ON
- CPU: ON
- Flash: ON
- Peripherals: OFF
- Pads: OFF
- IDLE: ON
- MultiCAN Only
- IDLE: OFF
- MultiCAN Only
- IDLE: OFF
- MultiCAN Only
- IDLE: OFF
- MultiCAN Only

Theoretische Kurve: $I_{SACT} [mA] = 10 + 0.6 \times f_{sys}$ (ohne Pads)

Chart based on measurements
Example Calculation / Use Case Analysis
Total Current Consumption

**Status Quo**
All ECU run w/ full performance

**30% Partial Network**
- **Capable ECU**
  - (µC off)

**30% Partial Network**
- **Capable ECU**
  - (µC in STOP or IDLE mode)

**30% Scalable Performance**
(half average consumption)

Assumptions:
- Network with 40 ECUs. Average Current Consumption per ECU 200mA. ECUs with scalable performance save 50% (half average current consumption).
- Partial Network Mode: Capable ECUs remain 95% of run time in partial network mode with a current consumption of 1mA (µC off) resp. 10mA (µC in STOP or IDLE).

Assumptions: Network with 40 ECUs. Average Current Consumption per ECU 200mA. ECUs with scalable performance save 50 % (half average current consumption). Partial Network Mode: Capable ECUs remain 95% of run time in partial network mode with a current consumption of 1mA (µC off) resp. 10mA (µC in STOP or IDLE).