AGENDA

- Introduction
- Renesas xEV Solutions: Semiconductor for Traction Inverters
  - Microcontroller
  - Analog & Power
    - PMIC
    - High-Voltage Gate Driver
    - IGBT & FRD
    - Inductive Position Sensor
- BMS – Battery Management Solution
- Other Sessions
INTRODUCTION

Name: Peter Hogenkamp
Renesas affiliation: Joint Renesas in 1997
Position: Principle Engineer
    Automotive Technical Marketing
    Power Semiconductor Solutions

Name: Sam Gold
Renesas affiliation: Joint Renesas in 2008
Position: Senior Manager
    Automotive Digital Marketing
    Powertrain & xEV MCUs
xEV SYSTEM OVERVIEW - INVERTER -

Inverter
- Position sensor: IPS2xxx
- MCU: RH850/C1M-A
- Gate driver: RAA270000
- IGBT: R2A25110, ISL78434
- DC/DC: RH850/F1x, U2Ax

On-Board Charger
- MCU: ISL78714
- Gate driver: R2A25110

BMS
- Cell Monitor: RA270005
- MOSFET: RV1S2752Q
- Photocoupler: uPD16603x
- PMIC: RAJ28000x

Controller
- Gate driver: AE3/4 IGBT
- MOS Diode: AE4 IGBT
- PMIC: RAA270005
- MCU: ISL78714
- Photocoupler: uPD16603x
- PMIC: RAJ28000x
- MOSFET: RV1S2752Q
xEV INVERTER SOLUTION SYSTEM CONFIGURATION

Renesas Inverter kit covers all major semiconductor for Inverter

Inverter

- RH850/C1M-A2
- R2A25110KSP
- IGBT + FRD
- Temperature sensor diode
- Driver IC
- MCU
- Photocoupler
- RV1S2752Q
- RAA270000KFT
- PMIC
- Power Management IC
- RDC
- Power module
- Current Sensor
- IPS2550
- Inductive Position Sensor or optional Resolver

3.9L, 100kW
400V/800A (500A_{RMS})

External I/F

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FUTURE HEV/EV → INCREASE ELECTRICAL ANGLE VELOCITY

- Increased RPM level will be required for full HEV and PHEV/EV in future to achieve smaller form factors of xEV components, like the e-motor.
- Higher RPMs require high speed processing as the Inverter control feedback cycle becomes shorter.

Renesas is providing system control solutions to achieve high speed RPM ➔ cost down due to smaller system components.
RH850/C1M-A – HIGHLIGHTS & KEY FEATURES

Performance → Ideal Solution for Traction Motor Control
- Ideal for E-drive → control of 2 traction motors with 1 MCU
- 320MHz lock-step cores
- HW accelerator for E-Motor control Unit (EMU)
- Optimized system configuration with extremely fast memory access (flash, RAM)

Scalability & Flexibility
- C1M-Ax is the successor of C1H. Two memory/performance options available (2MB single core + 4MB dual core)
- Seamless upgrade to successor products: same architecture for motor control and re-use of SW

Technologies
- E-Motor position sensing → integrated Resolver-to-Digital-Converter (RDC) interface. Supporting as well REN inductive position sensor IPS2550
- FMONOS → extremely fast flash technology, reliable, proven, scalable

Safety & Security → ASIL-C and EVITA-light
- Motor-control error detection concept, lock-step cores, Self-diagnosis implemented
- SHE supporting

System Development Environment
- Comprehensive solution menu incl. all relevant 3rd-party tools, User Manual, various AppNotes, MCAL QM Starter kit + MCAL ASIL-C under preparation

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MCU Concept for EV/HEV
- Integration Concept -

1. High performance & Safety
   - Multi-core, 240/320 MHz
   - Enhanced diagnostic functions
   - Functional Safety

2. Integrated Resolver to Digital Converter (RDC3A)
   - Reduce System Cost with integrated RDC3A
   - Improvement of failure diagnosis

3. Integrated Motor Control Support (EMU3)
   - Built-in flexible, optional Hardware Logic for Motor Control
   - Able to control up to 2 motors independently in conjunction with the TSG3 timer
POWERTRAIN & XEV MCU ROADMAP

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<td>320MHz x (2+1), 8MB BGA304/252</td>
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<td>240/320MHz x (1+1), 4MB BGA304/252</td>
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<td>400MHz x (6+4), 16MB BGA468/373</td>
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<td>Gen 2</td>
<td>Gen 3</td>
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RH850/C1M-A MICROCONTROLLER

➢ Ideal solution for E-drive to control traction & generator motors with 1 MCU

▪ Control 2 motors with 1 MCU based on high performance multi core CPU
▪ Reduce CPU load with H/W-accelerator (EMU3) for high-speed motor control
▪ Reduce ECU BOM cost by an embedded Position sensor interface to connect either resolver- or inductive position sensors
▪ ISO-26262 ASIL-C compliant

EMU3 solution

Integrated RDC solution

CONVENTIONAL

External pos. sensor IF

Resident or Inductive pos. sensor IFS 2550

Redundant SW/IF for functional safety

RENESAS

Integrated pos. sensor IF for BOM cost reduction

Resident or Inductive pos. sensor IFS 2550
## RH850/C1M-A2

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Order code</th>
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<tr>
<td>RH850/C1M-A2</td>
<td>BGA252-17x17-0.8</td>
<td>R7F701275EABG</td>
</tr>
</tbody>
</table>

### 32-bit CPU
- **2 + 1 RH850 G3MH Core**
  - @ 320 MHz, \( T_j = -40 \text{~}+150 \, ^\circ \text{C} \)
- MPU: 16 regions, FPU: 2

### System, Safety & Security
- 16ch DMA + 128 DTS
- ICU-S (Security Module)
- Clock Monitor
- Error Control Module
- MISG
- Boundary scan
- 2 x DCRA

### Memory
- **4 MB Code Flash**
- Total: 320 KB RAM
  - Local: 64 KB / core
  - Global RAM: 128 KB
- **64KB Data Flash**

### Analog
- 3 x ADC
  - max. 48 ch (12-bit)
  - 6+6+4 T/H

### Interfaces
- **4 x RSCAN-FD**
- **4 x RSENT**
- **3 x RLG3**
- **4 x TAUD**
- **2 x TAUJ**
- **6 x TAPA**
- **3 x TSG3**
- **3 x SCI3**
- **2 x TSG**
- **2 x ENCA**
- **2 x TPBA**
- **2 x RDC3A**
- **4 x OSTM**
- **2 x WDTA**
- **2 x SWDT**

### Generic Timers
- **4 x TAUD**
- **3 x SCI3**
- **3 x CSIH**
- **4 x RSENT**
- **6 x TAPA**
- **3 x TSG3**
- **2 x ENCA**
- **2 x TPBA**

### Package & Power Supply
- **BGA252** (0.8 mm pitch)
- Dual voltage supply:
  - I/O: 4.5 .. 5.5 V / Core: 1.15 .. 1.35 V

### Motor Control IP
- **EMU3 2ch**
- **RH850 G3MH Core**
  - \( I/O: 4.5 \text{~}5.5 \, \text{V} / \text{Core: 1.15 \text{~}1.35 \, \text{V}} \)

### Dual voltage supply:
- I/O: 4.5 .. 5.5 V / Core: 1.15 .. 1.35 V

### Debug System
- NEXUS, AUD

### Device Package Order code
- RH850/C1M-A2
- BGA252-17x17-0.8
- R7F701275EABG
### RH850/C1M-A1

#### 32-bit CPU
- **1 + 1 RH850 G3MH Core**
  - @ 240 MHz, $T_j = -40 \sim +150 \, ^\circ C$
- MPU: 16 regions, FPU: 1

#### Memory
- **2 MB Code Flash**
- **64KB Data Flash**
- Total: 192 KB RAM
  - Local: 64 KB / core
  - Global RAM: 64 KB

#### System, Safety & Security
- 16ch DMA + 128 DTS
- Clock Monitor
- ICU-S Security Module
- Error Control Module
- MISG
- Boundary scan
- 2 x DCRA

#### Debug System
- NEXUS, AUD

#### Analog
- **3 x ADC**
  - max. 30 ch (12-bit)
  - 6+6+4 T/H

#### Interfaces
- **4 x RSCAN-FD**
- **3 x SCI3**
- **3 x CSIH**
- **3 x RLIN3**
- **4 x RSENT**

#### Generic Timers
- **2 x TAUD**
- **1 x TAUJ**
- **3 x SCI3**
- **4 x TAPA**
- **2 x TSG3**
- **2 x ENCA**
- **1 x TPBA**

#### Package & Power Supply
- **QFP176 (0.5 mm pitch)**
- Dual voltage supply:
  - I/O: 4.5 .. 5.5 V / Core: 1.15 .. 1.35 V

#### Motor Control IP
- **1 x RDC3A**
- EMU3 1ch

#### Device
- **RH850/C1M-A1**

#### Package
- QFP176-24x24-0.5

#### Order code
- R7F701278EAFP

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PMIC FOR RH850/C1M-AX MCU

- **RAA27000x PMIC for RH850**
  - Optimized power supply for RH850 and integrate monitor and diagnosis functions
  - Easy to develop and reduce external BOM cost and PCB area

- **Planning RH850 Next PMIC**
  - Support ISO26262 ASIL D
  - Support wide current supply range by changing external FET

### Product roadmap

**Solution example**

<table>
<thead>
<tr>
<th>Year</th>
<th>RAA2700000 For RH850/E1x, C1x 64QFP (10x10*)</th>
<th>RAA2700005 For RH850/P1x 40QFP (7x7*)</th>
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<tbody>
<tr>
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<td>MP</td>
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</tr>
<tr>
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<td>Highly efficient Buck/Boost</td>
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**Cut-down Boost DCDC**

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A key analog component associated with the controller in these HV traction motor systems is an isolated HV gate driver (HV GDU). HV GDUs connected to the controller drives the power switches such as IGBTs. They convert PWM signals from the controller into gate pulses for the power switches to turn on and off.

Typical Functional Block Diagram with HV GDU (R2A25110)
IGBTs and FRDs

Provide high performance/robust IGBT for xEVs

- W/W Top switching loss performance
- High quality Bare chip
- 600~1200V, ~500A

![Diagram showing IGBT performance metrics](image)

- **AEnext** (Under dev.): Reduce -10%Vce(sat) against AE4
  - Improve conductivity modulation by fine pitch cell design

**Benchmark at the same current density**

- **AE3**: 20% less
- **AE4**: 10% less
- **Company A**: Benchmark
- **Company B**: Benchmark

- **Sw-loss**: Total switching loss \(E_{ON} + E_{OFF}\) [mJ]
- **Vce(sat)**: [V]
- **On-loss**: Better Performance
INDUCTIVE POSITION SENSOR - IPS2550 -

- Detect the position of a target metal based on electromagnetic induction of a coil
- Thinner, Lighter, High magnetic field immune
- Flexible multiplier, flexible mounting

- Easy-to-Use
- Thin, Light
- High magnetic field immune

Flexibility

Flexible to different pole pairs

1 pole pair
2 pole pair
4 pole pair

Flexible mounting

On-axis (end of shaft)
Off-axis (through shaft)
Off-axis (side shaft)
**xEV Inverter Reference Solution**

**System Benefits**
- Practical inverter specification for xEV 100kW class motor
- Reference solution kit including Inverter reference design, software, model base design and calibration tool
- Function and performance verified in Renesas motor bench
- 3.9L compact volume by highly integrate products and temperature management
- Superior power efficiency, achieved 99% maximum inverter efficiency
- Function is already proven in real car demo

**BOM List**
- **RH850/C1M-A2** 32bit Microcontroller
- **RAA270000** Power management IC
- **R2A25110** Gate driver IC
- **RJKxxx/RJUxxx** IGBT / FRD
- **RV1S2752Q** Photo Coupler
- **IPS2550** Inductive Position Sensor

**Block Diagram**

**Reference Board**

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BMS SOLUTION
**xEV SYSTEM OVERVIEW**

**Inverter**
- Position sensor
- MCU
- Gate driver
- IGBT
- R2A25110
- ISL78434
- AE3/4 IGBT

**DC/DC**
- Controller
- Gate driver
- IGBT MOS Diode
- R2A25110
- ISL78434
- AE4 IGBT
- ANM2 MOS

**On-Board Charger**
- MCu
- Gate driver
- IGBT MOS Diode
- R2A25110

**BMS**
- Cell Monitor
- MOSFET
- ISL78714
- RAA270005
- PMIC
- RAJ28000x
- uPD16603x
- RV1S2752Q

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RENESAS BATTERY MANAGEMENT SYSTEM SOLUTION

Contribute to maximizing battery capability, Safety and system cost reduction with high accurate voltage measurement, FUSA support and scalability of H/W & S/W.

Maximize Battery Capability
Best Voltage Measurement Accuracy

Safety
ASIL D system support with BMIC and MCU

Scalability
Pin-compatible product family (8cell, 12cell, 14cell, 16cell) supports battery packs with various number of cell
SUMMARY

✓ xEV Inverter
  • Renesas Inverter solution covers all major semiconductor for BOM optimized high performance traction inverter
  • Available Hardware and Software solutions support customer’s development
  • Advanced, BOM cost optimized motor position detection by Inductive Position Sensor

✓ Battery Management System
  • Reference solution using Renesas MCU + PMIC + BMIC
  • Accurate voltage measurement, functional safety support, and H/W and S/W scalability to maximize battery performance, safety, and reduce system development costs
OTHER SESSIONS AT EMBEDDED WORLD

Session:
• Power Management and Timing Solutions for Microprocessor/SoCs
• Winning Combinations, Analog & Digital
• Analog & Power portfolio overview

Flyer:
• IPS2550 - Inductive Position Sensor
• R-Car SoC V3x Camera Solutions
• R-Car SoC Gateway Solutions