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CONTENT

- Renesas in Automotive
- MCU for E-drive
- RH850 / C1M-A
- RH850 / C1M-A Motor Control Details
- RH850 FuSa Support Package
- RH850 / C1M-A ETS Concept
- Summary
AUTOMOTIVE
VEHICLE CONTROL / AUTONOMOUS DRIVING / ELECTRIC VEHICLE

Open, innovative and trusted solutions for the future of driving

▪ A leading MCU/SoC supplier
  W/W shipments reached over 1.3B units in 2018

▪ Best in quality
  Extremely low failure rate down to 0.1ppm

▪ Advanced process technologies
  16nm FinFET for SoC and 28nm for MCU

▪ Highly valued system
  Digital processor combined with analog solutions
## MARKET TREND

"CASE" CHANGES THE AUTO INDUSTRY

### Connected
- Accelerate expansion of Cloud Services
- Maintenance / Upgrade
- Cyber attack

### Autonomous
- Upcoming Level 4 AD car
- Driverless service trial
- AI computing

### Sharing
- New business model
- New players
- Centralized service car / Maintenance management

### Electrified
- High growth of EV market
- Zero emission regulation
- EV supplier in Emerging Markets
**World Class Automotive Solutions**

**Portfolio Overview**

<table>
<thead>
<tr>
<th>Customer Application</th>
<th>Customer Middleware, Stacks, Drivers</th>
<th>ARM Ecosystem</th>
<th>Analog &amp; Power Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renesas RL78</strong></td>
<td>True Low Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Renesas RH850</strong></td>
<td>Performance you can’t beat</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Renesas R-Car</strong></td>
<td>Simply Performance</td>
<td></td>
<td>High Efficiency</td>
</tr>
<tr>
<td>Designed to achieve best-in-class</td>
<td>World’s leading 32-bit MCU platform</td>
<td>Automotive High-Performance SoCs</td>
<td>PMIC, BMS, Power MOSFET, IPD &amp; IGBT, Automotive Analog IC, Motor Driver</td>
</tr>
</tbody>
</table>

- **True Low Power**
  - Wide package and memory scalability
  - H/W safety features
  - High temperature support

- **Performance you can’t beat**
  - First 40nm + 28nm Embedded Flash
  - High CPU performance
  - Lowest power consumption
  - Highest quality & reliability

- **Simply Performance**
  - Power-efficient H/W platform
  - Multi-core architecture
  - Impressing graphics capabilities
  - Extensive software support

- **High Efficiency**
  - PMIC, BMS
  - Power MOSFET
  - IPD & IGBT
  - Automotive Analog IC
  - Motor Driver

**World’s leading 32-bit MCU platform**
**Automotive High-Performance SoCs**

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Changing Industry Needs Driving Automotive MCUs

- Multi-Core (High Performance & Robustness)
- Low Power Consumption (Overheating Prevention)
- Increasing Program Capacity
- High Integration (Cutting-Edge Features)

Development & Production Partnership of Next-Gen World Standard 28nm MCU

130 nm
90 nm
40 nm
28 nm

1st Product sample announced at ISSCC 2015

Mass Production

March 2018

Green-Car
Autonomous Driving

*1: Announced on September 1, 2016
*2: ISSCC: International Solid-State Circuits Conference
**Microcontroller Quality – RH850 in 40nm**

40nm products (RH850 Series) have achieved 0.08ppm (43pcs / 551.6Mpcs)

![Graph showing RH850 shipping qty and failure rate with data points for 2015 to 2019, indicating a failure rate of 0.1PPM in 2019.](image-url)

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MICROCONTROLLER FOR E-DRIVE
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) position interface to strongly reduce BoM cost
- FMONOS → extremely fast flash technology, reliable, proven, scalable

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

System Development Environment
- Comprehensive solution menu including all relevant 3rd-party tools, User Manual, various Application Notes, MCAL (ASIL-C), MBD solution and Starter kit available
**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
   - Improvements for 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
RH850/C1M-A BLOCK DIAGRAMS
RH850/C1M-A2

### 32-bit CPU

- **2 + 1 RH850 G3MH Core**
  - @ 320 MHz, \( T_j = -40 \sim +150 \degree C \)
- 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

### Debug System

- NEXUS, AUD

### Memory

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

### Interfaces

- 4 x RSCAN-FD
- Total: 4 x SCI3
- 3 x CSIH
- 3 x RLIN3
- 4 x RSENT

### Generic Timers

- 4 x TAUD
- 3 x TSG3
- 2 x ENCA
- 2 x TPBA

### Analog

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

### 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

- 2 x RDC3A
- EMU3 2ch
- RH850 G3MH Core
  - 1+0 @ 320 MHz
RH850/C1M-A1

32-bit CPU

1 + 1 RH850 G3MH Core
@ 240 MHz, Tj = -40 ~ +150 °C

MPU: 16 regions, FPU: 1

System, Safety & Security

16ch DMA + 128 DTS
ICU-S Security Module

Clock Monitor
Error Control Module
MISG
Boundary scan
2 x DCRA

Debug System
NEXUS, AUD

Memory

2 MB Code Flash
Total: 192 KB RAM
Local: 64 KB / core
Global RAM: 64 KB
64KB Data Flash

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

RH850 G3MH Core
1+0 @ 240 MHz

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

Motor Control IP

1 x RDC3A

EMU3 1ch

RH850 G3MH Core
1+0 @ 240 MHz

3 x ADC
max. 30 ch (12-bit)
6+6+4 T/H
## RH850/C1M-Ax Part Names

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Order code</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH850/C1M-A2</td>
<td>BGA252-17x17-0.8</td>
<td>R7F701275EABG</td>
</tr>
<tr>
<td>RH850/C1M-A1</td>
<td>QFP176-24x24-0.5</td>
<td>R7F701278EAFP</td>
</tr>
</tbody>
</table>
INTEGRATED RESOLVER-TO-DIGITAL CONVERTER (RDC)

→ BOM COST AND SPACE REDUCTION

- Input abnormality detection and double structure tracking loop → Redundant RDC can be removed

**External RDC**

**RH850**

**Contributing to ECU downsizing by reducing number of components**

**External RDC**

- Redundant for functional safety

**RH850/C1M-A**

**Integrated RDC**

(1) Detecting failure of input paths
- Resolver signal abnormality
- Disconnection abnormality
- Sum of squares amplitude abnormality

(2) Detecting failure of tracking loop
- Redundant tracking loop
- Conversion abnormality
- 2-path conversion abnormality

(3) BIST function
- BIST for each abnormality detection
Motor Control can be managed in parallel to the CPU (PE1/PE2).
Perform motor control with reduced CPU load by using a combination of ADC, RDC, and TSG3.
Selectable IPs for calculation.
MOTOR CONTROL IP (EMU)
HW ACCELERATOR FOR MOTOR CONTROL THAT REDUCES CPU LOAD

- Equipped with a HW accelerator that assists with motor control calculations, two motors can be controlled independently.
- Also supports various PWM modulation outputs.

Conventional 2-motor control

2-motor control with RH850/C1M-A

EMU: Enhanced Motor control Unit

Not only math processing acceleration, but also various types of complex modulation is supported by hardware.
CPU Load Comparison

CPU load for benchmark (1 motor / CPU)

- High-performance CPU can accelerate motor control
- EMU further accelerates motor control and significantly reduces CPU load

➔ C1M-A shows the capability of an advanced inverter system.

(Motor control Process)

- Input Processing
- 3–2 Phase Conversion
- Feedback Calculation
- 2-3 Phase Conversion
- Waveform Modulator, Others

(Diagram: Devices: G3MH@C1M-A (320MHz, 90nm) // Compiler: GHS, v2018.1.5 MULTI (IDE) Ver 7.1.6 // Application: Motor control No.2)
Renesas’ Functional Safety Activities

→ Long Experience in Functional Safety for Automotive

Compliance of ISO26262 in a company organized manner

- Establishment of safety life cycle
- Involvement of safety activities in internal standardized development flow

Establishment of internal assessment organization

- Independent (I3 level) internal organization
- Confirmation measures at appropriate development stages
- Active members of ISO26262/ ISO19451 / IEC61508 expert in internal assessment organization

MCUs that comply to ISO26262 and evolution to SoC, A&P

- Worldwide No. 1 experience in semiconductor devices for automotive applications
- Safety technologies reviewed and accepted by worldwide customers
- Efficient and sufficient safety mechanisms with company-owned technology

Strong influence in relevant standards

- ISO26262 WG08* / ISOPAS 19451 (UK / Germany / Japan)
- SAE (Germany), JSAE (Japan), Jaspar (Japan)

WP: Work Products
A&P: Analog & Power
* WG08 is the former WG16
FUNCTIONAL SAFETY
- SCOPE OF SUPPORT PROGRAM -

System safety concept & Design information

Functional safety support program

- Assumed safety requirements
- Safety application note
- Verified SW driver
- SW work product
- HW work product
- Consulting

Renesas device safety analysis data base

FMEDA tool (CAR Tool)

System SW

System safety analysis report
**Functional Safety**  
**- Summary of Support Model -**

- **Workshops** (optional)
- **Technical Support**  
  - Technical hotline support (optional, but recommended)
- **CAR Tool**  
  - Customisable and time limited FMEDA database
- **Standard FuSa deliverables**  
  - DIA, Safety requirement spec, Safety application note, Static FMEDA, Safety case, FuSa assessment report

- Workshops in agreement with customer per request
- Safety Technical Support per a window person in a project
- • Additional license  
  • License extension
- Part of “Standard FuSa Deliverables” or enhanced by “Special FuSa Support Service”
## SAFETY RELATED DELIVERABLES & SERVICE

<table>
<thead>
<tr>
<th>Standard FuSa deliverables *1</th>
<th>(Free of charge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ DIA template</td>
<td></td>
</tr>
<tr>
<td>❑ Safety requirement specification</td>
<td></td>
</tr>
<tr>
<td>❑ Safety application note (HW SW interface)</td>
<td></td>
</tr>
<tr>
<td>❑ Static FMEDA *2</td>
<td></td>
</tr>
<tr>
<td>❑ Safety case *3 (List of work products and status)</td>
<td></td>
</tr>
<tr>
<td>❑ Functional safety assessment report *4</td>
<td></td>
</tr>
</tbody>
</table>

*1 This is delivered along with hardware product if required.
*2 RH850: Static FMEDA is delivered by static CAR tool
*3 List of Work Products and status
*4 Summary version is provided. It shows completion of the activity and its summary of the results.
MCU IP CONTENTS FOR MILS AND PILS

Semiconductor IP application to MILS (Model In the Loop Sim) and PILS (Processor in the Loop Simulation)

MCU IP Model

Requirements
System design
Module design
Implementation
Product test
System test
Module test
System

Real ECU

sPILS
vHILS

MILS

OS
Windows platform
Operation Environment
MathWorks tool version R2015aSP1
- Model Development Environment
MATLAB®
Simulink®
- Simulation Execution Environment
Simscape™
SimPowerSystems™
WEB SITE:  www.renesas.com

How to use website

▪ Use link to Automotive Products


▪ Scroll down to Featured Automotive Products

▪ Select one device Family and click on the provided link: RH850/C1M-Ax Design Support Resources | Renesas

▪ Check content
  – Design Support & Documents
  – Hardware Tools
  – Software Tools
  – Third-Party Support
  – Boards & Kits
RH850/C1M-A EASY TO START WEBSITE CONCEPT (2/2)

Document area
- Direct download or request button
- User Manual
- Application Notes
- Workshops
- Security & FuSa

Device website
- All content to start on a single page

Tools area
- Download of necessary tools or option to buy direct via Renesas or distribution
- Starter Kits
- Programmer
- MCAL
- MBD solution

Support area
- Direct help from Renesas and experienced users
- E-mail contact
- FAQ
- Forum

Design & Support Resources
- Website

Start banner
- RH850/C1M-Ax Design Support Resources

Partner area
- Link to eco-system partner programs
- Autosar BSW
- Security
- Support

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xEV SYSTEM ARCHITECTURE AND RENESAS SOLUTION OFFERING

**Inverter**
- Position sensor: IPS2550
- MCU: RH850/C1M-A, RAA270000, RAA271086
- Gate driver: R2A25110-next, ISL78434
- IGBT/MOS: AE4/5 IGBT ANM2 MOS

**On-Board Charger**
- MCU: RH850/F1x, U2Ax
- Gate driver: R2A25110
- IGBT/MOS Diode: ISL78714

**DC/DC**
- Controller: RH850/F1x, U2Ax, ISL78226
- Gate driver: R2A25110, ISL784x4
- IGBT/MOS Diode: AE4/5 IGBT ANM2 MOS

**BMS**
- Cell Monitor
- MOSFET
- PMIC: RAA270005, RAA271086
- MCU: RH850/C1M-A
- Photocoupler: RAV28000x uPD16603x, RV1S2752Q