POWER PRODUCTS
Empowering innovation with Renesas broad range of power products and solutions to help solving the toughest customers’ challenges
GET POWERED BY RENESAS

Renesas offers a comprehensive portfolio of power management ICs and module solutions across the widest range of power requirements, making us the premier power partner for your most challenging design needs.

- Trusted, highly reliable, best-in-class power solutions
- Reference designs and tools that accelerate time-to-market
- Solutions that seamlessly connect to our industry-leading MCUs and MPUs

CONTENTS

Industrial
- Product Portfolio ................................................................. 3
- Key Products .................................................................... 4
- Application Solutions ...................................................... 19
- Look-up Table with Power Attached .............................. 26

Automotive
- Product Portfolio ................................................................. 28
- Key Products .................................................................... 29
- Application Solutions ...................................................... 33
- Look-up Table with Power Attached .............................. 42
PRODUCT PORTFOLIO

Complete Industrial Power Solutions

Renesas offers an extensive portfolio of high-performance power solutions for processors, controllers, DSPs, FPGAs, CPLDs, DDR memory, and other loads in your system. Whether you need standard linear regulators, highly flexible DC/DC converters, or fully integrated power modules, our products are tailored to meet your design challenges.

FROM MILLIWATTS TO KILOWATTS, WE CAN SUPPORT YOUR APPLICATIONS.

PRODUCT PORTFOLIO

Complete Industrial Battery Management Solutions

Renesas offers a full range of high-performance solutions for charger ICs, USB-PD applications, fuel gauge ICs, and battery frontend ICs to cover consumer, computing, and industrial applications using batteries from one cell to many cells. Renesas battery management solutions are backed by tested reference designs and strong application support. Our products can address your design challenges and increase your battery performance.
KEY PRODUCTS

AC/DC Power Conversion

AC/DC Non-Isolated High-Voltage Buck Converters

- Non-isolated buck makes AC/DC design easy
  - Eliminates power transformer
  - Also supports flyback topologies

- Features
  - Non-isolated buck makes AC/DC design easy by eliminating power transformer.
  - Also supports flyback topologies (isolated and non-isolated).
  - Pin-to-pin compatibility with most popular AC-DC parts
  - Low standby power (5 to 30 mW)

- Benefits
  - Improved performance compared to major competitors with respect to EMI, light-load mode power consumption, and low-voltage regulation
  - No audible noise
  - Low EMI (conducted & radiated)
  - Supports 3.3V or 5V output directly; no 2nd-stage LDO needed.

PrimAccurate™ Digital Primary-Side Regulation Technology

- Patented digital primary-side control technology
  - Provides highly accurate voltage and current control.
  - Uses digital compensation loop; no external compensation required.
  - Reduced BOM count enables higher MTBF.
  - Eliminates secondary-side feedback and regulation components.
  - Lower total BOM count yields higher reliability.
iW1702 – 45W PrimAccurate™ Primary-Side Isolated Flyback Controller

**Features**

- 79kHz switching frequency
- Adjustable light-load mode
  - Enables faster/slower transient response and higher/lower no-load power.
  - < 75mW with fast DLR, < 30mW with fast DLR using iW676 w/AVP
- Adaptive multi-mode control enables high efficiency across all load steps.
- Single-point fault protection against AC line voltage brown-out
- Output short-circuit and over-voltage protection

**Benefits**

- Compact BoM thanks to PrimAccurate™ technology for primary-side regulation
- Eliminates secondary-side regulation components:
  - Optocoupler, voltage reference, and passives
- Digital compensation loop: no external compensation required.
- No audible noise across entire operating range

**Block Diagram**

---

iW9802 – ZVS Primary-Side Controller

**Features**

- Switching frequencies up to 200kHz
- Renesas patented adaptive zero voltage switching (ZVS) technology reduces power loss and enables high power density solutions to 100W+.
- Adaptive multi-mode control enables high efficiency across all load steps.
- Multiple protection features for over-current, over-voltage and over-temperature
- Works with a wide variety of third-party controllers, including the industry-standard TL431, to implement fixed-voltage or adjustable output power supplies for RapidCharge applications.

**Benefits**

- Compact BoM enabled by high switching frequency
- Reduced transformer size
- Overall smaller solution size
- High power density
- <20mW no-load power capable

**Block Diagram**
KEY PRODUCTS

AC/DC Power Conversion

iW1816, iW1819: AccuSwitch™ AC/DC PWM ICs with Integrated High-Voltage Switch

- PWM controller and 800V BJT in one package
  - iW1816: 5W output; iW1819: 18W output
- Optimized to start into high capacitance loads up to 6,000μF.
- Meets stringent energy regulations
  - High light-load and active-mode efficiency
  - < 30mW no-load with fast dynamic load response
- Low-cost SOIC-7 package (iW1816), innovative 10-lead SOIC batwing package (iW1819) for high-voltage isolation, small footprint, and enhanced thermal performance

Features

PrimAccurate™ technology: Primary-side regulation eliminates secondary-side regulation components.
- Optocoupler, voltage reference, and passives
- Digital compensation loop: No external compensation required.

Benefits

- EZ-EMI™ technology
- Reduced EMI: Simplify input filtering for lower cost.
- Power BJT: Soft switching further reduces EMI.

Block Diagram

RAA223181/2/3 12W AccuSwitch™ Isolated Secondary-Side Flyback Converters

- 12W output power, integrated 900V MOSFET (RAA223181)
- 12W output power, integrated 1000V MOSFET (RAA223182/3)
- Highly accurate secondary-side regulation
- Programmable constant frequency DCM operation (recommended range 50kHz ~100kHz), suitable for PLC communication
- Frequency doubling for heavy load operation up to 12W, < 100ms
- Protection features: SCP, OLP, VinUV, VinOVP, VccOV, VccUV, OTP

Features

- Valley switching for best efficiency and EMI across full load range
- Low standby power < 150mW
- Renesas patent-pending CapSaver™ reduces cost and standby power.
- Built-in inrush current limiter
- Eliminates 450V input capacitor to reduce BOM cost.
- Eliminates cap balancing resistors.

Benefits

Block Diagram
KEY PRODUCTS

Analog Controllers

High Voltage/High Current for Today’s Power Demands

Dual-Output Analog Controllers

80V Dual Phase Buck Controllers for Si and GaN FETs  ISL81802 /ISL81806

Features

• Integrated CC/CV controller and driver
• Supports single or dual outputs.
• Supports multi-chip paralleling and phase interleaving.
• Wide switching frequency range: 100kHz to 2MHz
• Selectable among PWM/DE/Burst modes.
• Shoot-thru protection, OCP, OVP, OTP, UVP
• ISL81806 with optimized gate drive for GaN FETs

Benefits

• Wide input and output voltage range to address various application demands
• Flexible design with two independent outputs or one output with two interleaved phases
• Parallel operation to support high power applications; up to 6 interleave phases >1kW total power
• High side current sense enables accurate current monitoring and secure OCP and SCP.
• Current mode control for fast response
• High power density, high efficiency, lower-cost design with GaN

ISL81802 Evaluation Board

Evaluation Board with 2 cascaded ISL81802 (4-phase), 12V/40A Output

ISL81806 Evaluation Board

ISL81806 Demo Board 300W, 1/16 Brick
KEY PRODUCTS
Multi-Output and Multiphase Analog Controllers

**ISL8180x: Multi-Output and Multiphase Analog Controllers**

- **Industry’s first bidirectional 80V buck-boost controller**
  - CV/CC for both input and output
  - Wide programmable frequency range: 100kHz to 2MHz
  - Current sharing for parallel operation
  - Supports on-the-fly setting changes including the current flow.
  - High reliability with OVP, OCP, OTP, UVLO protection

**ISL81801 80V Bidirectional Buck-Boost Controller**

- **Features**
  - Wide $V_{IN}$ range: 4.5V to 40V/60V/80V
  - Wide $V_{OUT}$ range: 0.8V to 40V/60V/80V
  - Current sharing with cascade phase interleaving
  - External bias option for higher efficiency
  - Selectable PWM/DEM/burst mode operation
  - 32 Ld 5*5mm TQFN or 38 Ld 9.7*4.4mm HTSSOP

- **Benefits**
  - High-side current sensing for accurate input and output current monitoring and secure OCP and SCP
  - Current mode control for fast response
  - Bidirectional operation to manage energy flow in two directions
  - Supports customer supply chain management with P2P compatible product lineup from 40V to 80V.

**ISL81801 Evaluation Board**

- ISL81801 Evaluation Board, 80V Bi-Directional Buck-Boost controller with Current Sharing

<table>
<thead>
<tr>
<th>Output</th>
<th>Part No.</th>
<th>Status</th>
<th>$V_{IN}$ Range (V)</th>
<th>$V_{OUT}$ Range (V)</th>
<th>Package</th>
<th>Topology</th>
<th>Technical Highlights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual</td>
<td>ISL81802</td>
<td>Released</td>
<td>4.5 to 80</td>
<td>0.8 to 76</td>
<td>32 Ld 5x5 TQFN 38 Ld HTSSOP</td>
<td>Buck</td>
<td>MOSFET controller</td>
</tr>
<tr>
<td></td>
<td>ISL81806</td>
<td>Released</td>
<td>4.5 to 80</td>
<td>0.8 to 76</td>
<td>32 Ld 5x5 TQFN</td>
<td>Buck</td>
<td>GaN controller</td>
</tr>
<tr>
<td></td>
<td>ISL81805</td>
<td>Released</td>
<td>4.5 to 80</td>
<td>5 to 80</td>
<td>32 Ld 5x5 TQFN</td>
<td>Boost</td>
<td>MOSFET controller</td>
</tr>
<tr>
<td></td>
<td>ISL81807</td>
<td>Released</td>
<td>4.5 to 80</td>
<td>5 to 80</td>
<td>32 Ld 5x5 TQFN</td>
<td>Boost</td>
<td>GaN controller</td>
</tr>
</tbody>
</table>
KEY PRODUCTS

Switching Regulators

Wide \( V_{IN} \) Coverage

Benefits and Key Features

Robust & Reliable Performance
- \( \text{PGOOD} \), Enable function, adjustable soft start
- Extensive protection (OCP, OVP, OTP, SCP)
- External frequency synchronization

High Integration
- Integrated HS/LS FETs
- Internal compensation

Target Applications
- High-voltage single-board systems
- Industrial power systems
- Battery powered devices
- Telecommunication base stations
- POLs for high-performance DSPs, FPGAs, ASICs, and microprocessors

RAA211xxx New 24V to 75V Sync Buck Regulator Family – Wide \( V_{IN} \) Range

Common Features
- Integrated high-performance MOSFETs
- Programmable, fixed switching frequency up to 800kHz
- High-efficiency light-load operation
- IC can be biased from its own output to improve efficiency.
- Power Good, Soft Start, and Enable functions

<table>
<thead>
<tr>
<th>Part No.</th>
<th>( V_{IN} ) Range</th>
<th>( R_{dson} ) (High/Low)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAA211250</td>
<td>4.5V to 30V</td>
<td>70mΩ/25mΩ</td>
<td>5A</td>
</tr>
<tr>
<td>RAA211450</td>
<td>4.5V to 42V</td>
<td>75mΩ/25mΩ</td>
<td>5A</td>
</tr>
<tr>
<td>RAA211630</td>
<td>4.5V to 60V</td>
<td>110mΩ/40mΩ</td>
<td>3A</td>
</tr>
<tr>
<td>RAA211820</td>
<td>4.5V to 75V</td>
<td>155mΩ/80mΩ</td>
<td>2A</td>
</tr>
<tr>
<td>RAA211835</td>
<td>4.5V to 75V</td>
<td>155mΩ/NA</td>
<td>3A</td>
</tr>
</tbody>
</table>

Using 80V Sync Buck Regulator Family to Power MCUs

- Battery
- AC/DC
- 48V, 24V, 12V, 5V
- \( V_{IN} \) 80V
- Switching Regulators
- RX/RL/RZ MCUs
- 1.2V, 1.8V, 3.3V, 5V

E-meter System Diagram
**KEY PRODUCTS**

**Switching Regulators**

RAA211220/30/33 24V & 30V Pin Compatible Switching Regulators

### Features

- **Wide VIN range:** 4.5V to 24V/30V, 3A maximum output current
- **Low quiescent current:** 400μA
- **Protection features:** Low-side over-current (LSOC) limit, input under-voltage lockout (UVLO), over-temperature protection (OTP), output under-voltage protection (OUVP) with hiccup mode
- **Reference voltage (0.765/0.6V) output with 2% accuracy**
- **Current mode constant on-time (COT) control with internal compensation**
- **Package:** 6-lead SOT-23

### Benefits

- **Pin-compatible families**
  - RAA211230 24V input, 0.765 reference, 3A output 700 kHz operation
  - RAA211233 24V input, 0.6 reference, 3A output 1.4 MHz operation
  - RAA211320 30V input, 0.765 reference, 3A output 700 kHz operation
- **Reduced BoM:** Integrated HS and LS FETs plus internal control loop compensation
- **Excellent transient response and load regulation.**

### Block Diagram

- 24V/30V, 3A Synchronous Buck
- Current Mode COT
- RAA211220/33/20/32

### Part No. | VIN Range | IOUT | FB & Acc | Rdson (High/Low) | Fsw (Hz) | Control Mode | Package
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RAA211230</td>
<td>4.5V to 24V</td>
<td>3A</td>
<td>0.765V±0.015V</td>
<td>85mΩ/45mΩ</td>
<td>500K</td>
<td>COT</td>
<td>TSOT23-6</td>
</tr>
<tr>
<td>RAA211233</td>
<td>4.5V to 24V</td>
<td>3A</td>
<td>0.6V±0.012V</td>
<td>85mΩ/45mΩ</td>
<td>1.4M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAA211320</td>
<td>4.5V to 30V</td>
<td>2A</td>
<td>0.785V±0.015V</td>
<td>150mΩ/75mΩ</td>
<td>450K</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
KEY PRODUCTS

Low-Quiescent Current Switching Regulators

Renesas offers a tiny, easy-to-use, ultra-low quiescent current (IQ) buck regulator with a maximum input voltage of 40V (RAA21140x) or 80V (RAA21180x) and up to 300mA of output current with a fixed 3.3V or 5V output.

40V and 80V Low IQ Switching Regulator Family

Features

- Wide \( V_{\text{IN}} \) operation range: up to 40V/80V, 300 mA max. output current
- PFM control with internal compensation
- Multiple protection features: Over-current (OC) limit, input under-voltage lockout (UVLO), over-temperature protection (OTP), output over-voltage protection
- Ideal for linear regulator replacement
- Tiny TSOT23-5 package (2.9mm x 1.63mm)

Benefits

- Pin-compatible families of ultra-low quiescent current step-down regulators:
  - RAA211803 80V input with 3.3V output
  - RAA211805 80V input with 5V output
  - RAA211403 40V input with 3.3V output
  - RAA211405 40V input with 5V output
- IQ = 4/5.5μA at 40/80V, under no-load conditions, switching
- IQ = 2.5/4.5μA at 40/80V, under no-load conditions, switching

Block Diagram

40V/80V, 0.3A Low-IQ Buck Converter

- \( V_{\text{IN}} \) = 40V/80V
- \( V_{\text{OUT}} \) = 3.3V or 5V

- General Purpose or LDO Replacement
- Industrial Power Supplies
- Embedded Systems and I/O Supplies
- E-Bikes, Power Tools
- Industrial/Building Automation
KEY PRODUCTS

Low-Dropout Regulators (LDO)

High Performance LDOs

RAA214250 20V Wide Input Voltage Range, 500mA Linear Regulator

The RAA214250 is a cost-effective power device for Renesas RA, RL78, Synergy, and RX MCUs

Features

- Wide input voltage range: 2.5V to 20V
- Output current up to 150mA
- Low ground current
- Adjustable and accurate output voltage from 1.2266V to 18V
- Low dropout voltage: 225mV typical at 150mA load
- Excellent line and load regulation
- Stable with 1μF - 200μF MLCC output capacitor
- Integrated fault protections including thermal shutdown and current limit
- Available in compact and cost effective DFN or SOIC package.
- RAA214250 and RAA214290 are pin compatible.
- RAA214250: 500mA version
- RAA214290: 1A version

Benefits

- Battery-Powered Equipment
- MCU Power Supplies
- Electric Meters
- USB Devices
- Laptop Computers And Tablets
- Portable Modules And Appliances

Block Diagram
**RAA214020 Low-Noise LDO for Sensitive Circuits**

New ultra-low noise LDO minimizes phase noise & jitter in high-performance applications.

**Excellent Noise Performance**

**Features**

- Input voltage range: 2.7V to 5.5V
- Max. output current: 2A
- Max. dropout voltage: 540mV at 2A and 3.3 VOUT
- Low RMS output noise: 6.3μVRMS (10Hz to 100kHz)
- Output voltage adjustable: 0.9V to 5.5V-VDROPOUT
- Noise spectral density:
  - 184nV/√Hz at 10Hz
  - 79nV/√Hz at 10kHz
- High PSRR for VHEADROOM = 1.7V:
  - 100kHz: 64dB at 2A and 77dB at 500mA
  - 1MHz: 50dB at 2A and 55dB at 500mA

**Benefits**

- Operating quiescent current is typically 195μA.
- Stable with 22uF ceramic capacitor
- Built-in Power-Good feature
- RAA214020 Resistor network to set output.
- RAA214023 Output programed by connecting pins to ground or resistive divider network.

**Block Diagram**

- High-Speed ADCs/VCOs
- Clock and Timing
- RF and Connectivity
- IoT and Smart Utilities
- 4G and 5G Telecom
KEY PRODUCTS

Battery Management

Management and Protection of Lithium-ion Batteries

Protecting, Monitoring, and Balancing Rechargeable Battery Packs

Renesas lithium-ion battery pack monitoring, protection, and balancing ICs are specifically designed to meet the stringent safety, reliability, and performance requirements of portable and battery powered applications such as consumer, industrial, and medical products.

Battery Front End (BFE), Battery Management ICs

Benefits and Key Features

Protection and Cell Balancing
- Hot plug tolerant
- Over/under-voltage
- Charge/discharge current
- FET control when error detected
- Open-wire detection
- Auto-cell balancing

Host Controlled Features
- Current measurement
- Cell voltage measurement
- Pack voltage measurement
- Temperature measurement
- LED indication by GPIO
- Power supply for MCU

Features
- VCC = 12V to 59V for 4-16S with high-side FET drivers and 16b ADC
- Internal/external cell balancing
- Cell Measurement +/- 10mV across temperature range
- Low-side current measurement with timer
- 4 LED/GPIO pins
- 2 therm inputs

Benefits
- Robust, field proven solution for Ebikes and other mobility products
- High BOM integration, including LDO and LED inputs for cost reduction
- Low sleep current consumption

RAA489206 Industrial Battery Front End to Protect, Monitor, and Balance High-Voltage Battery Packs

- Up to 16 cell inputs
- Highly integrated: Includes charge pump, high side FET drivers, current measurement, LDO, wake-up logic, internal and external balancing circuits, and LED drivers.
- Hot plug tested and proven via random connection trials
- Reference circuit, sample code, and high degree of integration accelerate battery pack design, testing, and verification.
RAA489204

Features
- VCC = 10.0V to 65V
- Supports various functional safety features.
- Cell measurement: +/- 10mV
- Cell balancing with internal or external FETs
- Robust daisy chain communications
- Many autonomous functions relieve firmware and MCU load.
- Low power consumption while communicating and in sleep mode

Benefits
- Robust solution in noisy environments
- Easier safety certification
- Overall power budget can be met for High S, Low P applications

Battery Fuel Gauge ICs (FGICs)

Dedicated one-package solution with MCU and AFE provides an intelligent, programmable system for battery management that constantly monitors and protects the battery.

Benefits and Key Features

Safety and Protection Control
- Over/under-voltage
- Charge/discharge current
- FET control when error detected
- Chemical fuse control
- Cell balancing

Remaining Capacity Management
- Current/voltage detection
- Precise coulomb counter
- Deterioration detection
- Calculation and learning of battery capacity
- Current/voltage calibration
- Fault detection/history management

FGIC Battery Pack System Diagram
KEY PRODUCTS

Battery Management

FGIC Block Diagram

Voltage and Current Measurement by Independent A/D Converters
- Current detection: 153 μA/LSB resolution (18-bit ΔΣ, 5 mΩ shunt resistor)
  support for simultaneous measurement with virtually no temperature drift
- Voltage/temperature measurement: 15-bit ΔΣ ADC

High Reliability & High Integration
- Built-in FET protection for over-current or short circuit conditions
- Redundant fault detection by both MCU and AFE
- Ability to set lifecycle related limits and maintain battery parameter and operation history using data flash guaranteed for 100,000 erase/write cycles
- Integrated CAN interface and realtime clock (RTC) circuit for industrial apps: ICs can manage date and time in a single device (RAJ240090 and RAJ240100).

Few Parts, Low System Cost
- Supports large-current discharge with N-channel FET drivers.
- Integrated pull-up resistors for thermistor

Extended Battery Life
- Low-power mode with consumption of 25 μA or less and cell balance circuit to maximize battery capacity (RAJ240090 and RAJ240100)

Battery Fuel Gauge ICs

<table>
<thead>
<tr>
<th>Cells</th>
<th>Pack Voltage (V)</th>
<th>Part No.</th>
<th>Flash ROM</th>
<th>RAM</th>
<th>Charge/Discharge FET Control</th>
<th>Serial Interface</th>
<th>I/O</th>
<th>Features</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 to 5.5</td>
<td>RAA241200</td>
<td>64 KB</td>
<td>4.0 KB</td>
<td>Low side</td>
<td>PC, UART</td>
<td>7</td>
<td>Very compact package (1.871mm x 2.478mm) Very low power consumption (10 μA)</td>
<td>16WLBGA</td>
</tr>
<tr>
<td>2 to 4</td>
<td>2.2 to 25</td>
<td>RAJ240055</td>
<td>64 KB</td>
<td>4.0 KB</td>
<td>High side</td>
<td>PC, UART</td>
<td>12</td>
<td>Compact package (4mm x 4mm)</td>
<td>32QFN</td>
</tr>
<tr>
<td>2</td>
<td>4 to 25</td>
<td>RAJ240071</td>
<td>32 KB</td>
<td>1.5 KB</td>
<td>High side</td>
<td>PC, UART</td>
<td>11</td>
<td>Compact package (4mm x 4mm) 5-cell support</td>
<td>32QFN</td>
</tr>
<tr>
<td>3</td>
<td>4 to 50</td>
<td>RAJ240090</td>
<td>128 KB</td>
<td>7.0 KB</td>
<td>High/low side</td>
<td>PC, UART, CAN</td>
<td>31</td>
<td>High voltage tolerance, on-chip CAN, low power consumption (25 μA)</td>
<td>64QFP</td>
</tr>
<tr>
<td>3</td>
<td>4 to 40</td>
<td>RAJ240301</td>
<td>64 KB</td>
<td>5.5 KB</td>
<td>Low side</td>
<td>PC, UART</td>
<td>21</td>
<td>GPIO: I/O x 15, input x 2, NOD x 2, HVNOD x 2</td>
<td>48QFP</td>
</tr>
<tr>
<td>3</td>
<td>8 to 50</td>
<td>RAJ240310</td>
<td>64 KB</td>
<td>4.0 KB</td>
<td>Low side</td>
<td>PC, UART</td>
<td>15</td>
<td>Compact package (5mm x 5mm) 10-cell support</td>
<td>40QFN</td>
</tr>
</tbody>
</table>

* Specifications are subject to change without notice.
KEY PRODUCTS

Power Modules

Complete Power System

Renesas has over ten years of power module experience. Power modules reduce the design time, lower cost and save board space. With a small form factor, high power efficiency and robust features such as digital control, these modules get you to market faster with significantly less engineering effort.

**Benefits and Key Features**

**Easy to Use**

- Full integration means less complexity and easier design.
- First-pass success

**Highest Power Density**

- Power output up to 100W POL in a single package

**Thermally Enhanced Package Technology**

- Thermal molding compound allows for even heat distribution.
- Large copper pads transfer heat efficiently.
- Operates at full load across wide temperature range.
- Leaded package allows pin access.

**Real-Time Telemetry — Dynamic Configuration**

(Available in Digital Power Modules)

**PowerNavigator™ GUI**

Allows simple configuration and monitoring of multiple digital DC devices using a PC with a USB interface.

**Analog Modules**

A simple, effective DC/DC power supply solution that integrates necessary power elements in a single package.

**Digital Modules**

A high-performance DC/DC power supply solution that integrates all power elements in a single package and supports digital communication and configurability for advanced power management techniques. Digitally design with PowerNavigator™ GUI software.
# KEY PRODUCTS

## DC/DC Power Modules

### RRM20030

**Features**
- 3A complete power supply: Integrates controller, gate driver, MOSFETs, and inductor.
- 4.6V to 20V input voltage range
- Adjustable output voltage (0.6V to 5.5V)
- Current mode constant-on-time (COT) control operation with internal compensation
- Compact RoHS-compliant 3mm x 2.8mm x 1.7mm dual flat no-lead (DFN) package

**Benefits**
- Modules provide:
  - Ease-of-use
  - Fast time-to-market
  - First-pass success
  - Supports wide range of custom applications.
- High efficiency improves thermals and reduces operating costs.
- Reduced board space (3mm x 2.8mm)

**Block Diagram**

### RRM12120

**Features**
- PMBus1.3-compliant, controller + SPS
- Wide operating range
  - Wide VIN range: 4.75V to 15V
  - Programmable output voltage (0.45V to 3.3V)
  - Pin-selectable pre-programmed output voltage
  - 0.7% output voltage accuracy over temperature
  - 20A continuous output current
  - Up to 94% efficiency
  - Small 10mm x 13mm x 5.9mm size BGA package
  - “Black box” fault capture and recording

**Benefits**
- Modules provide:
  - Ease-of-use
  - Fast time-to-market
  - First pass success
  - Programmability allows customization.
- High efficiency improves thermals and reduces operating costs.
- Reduced board space (10mm x 13mm)
- Telemetry supports debug and fault investigation.

**Block Diagram**
APPLICATION SOLUTIONS
Three-Level (T-TYPE) DC AC Inverter

This solution is a digital control solution for photovoltaic power conditioners, uninterruptible power supply, and industrial three-phase DC/AC inverter power supply. The 3-level (T-type) circuit topology to a three-phase DC/AC inverter can improve system efficiency and reduce the size of the filter reactors.

- RX66T can simultaneously output 12 PWM gate signals required for a 3-level inverter by synchronously operating 6 channels of GPT timers.
- Gate driver and IGBT design provide efficiency to reduce switching losses.

BOM List for Reference Design

- RAA211250: Integrated FET 30V, 5A Synchronous Buck Regulator with Internal Compensation and Programmable Frequency
- RAA214250: 20V, 500mA Linear Regulator
- RVI9231A: 2.5 A Output Current, High CMR, IGBT Gate Drive, 5-PIN SSOP (LSS05 WITH 8.2mm Creepage Distance) Photocoupler
- RX66T: 32-bit Microcontrollers Optimal for Motor Control in Industrial, Home Appliance, and Robotics Applications
- PS8352AL2: Analog Output Type Optical Coupled Isolation Amplifier
- EL5220T: 12MHz Rail-to-Rail Input-Output Operational Amplifier
- RBN75H65T1FPO-A0: IGBT 650V 75A TO-247A Built-In FRD
- RBN75H125S1FP4-A0: IGBT 1250V 75A TO-247plus Built-In FRD

Reference Solution – System Benefits
APPLICATION SOLUTIONS

Smart Solar Battery Charger

Using the green energy of solar to charge a battery is a very popular application. Solar cells produce a challenge, however, due to the wide variability of the output voltage depending upon the amount of solar energy directed at the panel, temperature and the load on the panel. This solution helps overcome these challenges while protecting and maximizing battery life.

**Reference Solution – System Benefits**

- MPPT Algorithm maximizes power usage from solar panel
- Buck-boost architecture charges the battery even when the solar panel’s voltage is below the battery voltage
- Programmable charge rates to support various modes such as fast-charge and trickle-charge
- Up to 60V input and adjustable output voltage of 0.8V to 60V
- Monitors battery status and protects battery from damage caused by over-charging

**BOM List for Reference Design**

- ISL28413 Quad General Purpose Micropower, RRIO Operational Amplifier
- RAA211820 Integrated FET 75V, 2A Synchronous Buck Regulator with Internal Compensation and Programmable Frequency
- ISL81601 60V Bidirectional 4-Switch Synchronous Buck-Boost Controller
- RL78/G23 New Generation RL78 General-Purpose Microcontrollers with Further Refined Low-Power Performance and Expanded Peripheral Functions

*Cell balancing and safety built into L-Ion Battery. Only algorithm changes.*
APPLICATION SOLUTIONS

AC Servo

This Renesas AC servo solution integrates motor control and EtherCAT design to support high-speed and high-precision motor control through synchronizing time-sensitive industrial Ethernet communications. This solution is composed of three blocks: system control, power drive and motor encoder, which are physically isolated while maintaining a high degree of interconnect. By utilizing the high-performance RZ/T2L, RZ/T2M or RZ/N2L microprocessor, this monolithic solution design outperforms traditional two-chip platforms on performance and cost.

- **Reference Solution – System Benefits**

  - Customers can easily implement motor control using the CiA 402 drive profile via EtherCAT and referring to this solution board.
  - 2-in-1 chip design, removes additional FPGA, optimized solution cost
  - Renesas offers over 50% of this solution’s BOM, alleviating delivery concerns in sourcing from multiple vendors

- **BOM List for Reference Design**

  
<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RZ/T2M</td>
<td>High-performance Multi-function MPU Realizing High-speed Processing and High Precision Control for Industrial AC Servos and Controllers</td>
</tr>
<tr>
<td>RZ/N2L</td>
<td>Integrated TSN-Compliant 3-Port Gigabit Ethernet Switch Enables Various Industrial Applications to Easily Implement Industrial Ethernet and TSN</td>
</tr>
<tr>
<td>DA9061</td>
<td>PMIC Designed for Applications Requiring up to 6A Continuous Current</td>
</tr>
<tr>
<td>RAA211650</td>
<td>60V 5A Integrated Switching Regulator</td>
</tr>
<tr>
<td>ISL32179E</td>
<td>Quad, ±16.5kV ESD Protected, 3.0V to 5.5V, RS-485/RS-422 Transmitters</td>
</tr>
<tr>
<td>ISL3172E</td>
<td>Quad, ±15kV ESD Protected, 3.3V, Full Fail-Safe, Low Power, High Speed or Slew Rate Limited, RS-485/RS-422 Transceivers</td>
</tr>
<tr>
<td>RV1S9213A</td>
<td>IPM Drive Photocouplers (Optocouplers)</td>
</tr>
<tr>
<td>RV1S9353A</td>
<td>Optically Isolated Delta-Sigma Modulator</td>
</tr>
<tr>
<td>R1EX24016A</td>
<td>Two-wire serial interface 16k EEPROM (2-kword × 8-bit)</td>
</tr>
<tr>
<td>PS2761B-1</td>
<td>4-PIN SOP Photocoupler Operating Ambient Temperature 110°C</td>
</tr>
<tr>
<td>PS2561DL-1</td>
<td>DIP Photocoupler Operating Ambient Temperature 110°C</td>
</tr>
<tr>
<td>PS8101</td>
<td>1 Mbps, High CMR Analog Output Type 5-PIN SOP (SO-5) Photocoupler</td>
</tr>
<tr>
<td>RV1S9061A</td>
<td>IPM Drive Photocouplers (Optocouplers)</td>
</tr>
<tr>
<td>iW673</td>
<td>Digital Green-Mode Synchronous Rectifier Controller</td>
</tr>
<tr>
<td>AT2SSF128A</td>
<td>128Mbit, 2.7V Minimum SPI Serial Flash Memory with Dual I/O Support</td>
</tr>
<tr>
<td>ISL844A</td>
<td>High Performance Industry Standard Single-Ended Current Mode PWM Controller</td>
</tr>
<tr>
<td>RZ/T2L</td>
<td>High-Performance MPU Realizing High-Speed and High-Precision Real-Time Control with EtherCAT</td>
</tr>
</tbody>
</table>

---

*Optional MPU’s: RZ/T2L or RZ/N2L*
APPLICATION SOLUTIONS

3-Phase Smart Electric Meter

An energy meter is a necessity for the Industrial and Green revolutions. The 3-phase or polyphase meter is used for heavy industrial and high electricity-consuming homes.

Despite the mechanical meter’s ruggedness, which led to market dominance even in modern times, the increasing demand for automatic meter reading (AMR) capability as well as the requirement of less susceptibility against tampering attempts drove the development of smart meters, electronic meters with enhanced, easier mechanisms for remote data acquisition and processing.

A tamper-proof and connected system provides a lot of advantages to users regarding information about their energy consumption.

- Magnetic tamper-proof
- High voltage operation
- Last gasp power source
- Remote data acquisition

### Reference Solution – System Benefits

### BOM List for Reference Design

- **iW1821**: 1200V AccuSwitch™ AC/DC Digital Primary-Side Converter for Three-Phase Industrial Applications up to 12W
- **RA2A2**: 48MHz Arm® Cortex®-M23 Ultra-Low Power General-Purpose Microcontroller with Rich Peripherals
- **RAA214020**: 5.5V 2A Ultra Low Noise, High PSRR, LDO
- **ISL91107**: High Efficiency Buck-Boost Regulator with 3.6A Switches
- **RYZ024A**: LTE Cat-M1 Cellular IoT Module for Global Deployment
- **PTX105R**: Mid-power, Multi-protocol NFC Forum Compliant Reader
- **PS2514L-1**: High-speed Switching/High Isolation Voltage Photocoupler Series
- **ISL8485**: 5V, Half Duplex, 5Mbps, RS-485/RS-422 Transceiver
APPLICATION SOLUTIONS

Wireless IIoT Gateway

This system depicts a high-performance wireless Industrial IoT gateway for Wi-Fi 6E low-latency networks. It provides both wired and wireless communication to transfer the sensor data to the cloud.

**Reference Solution – System Benefits**

- Optimized power supply using a single power management IC (PMIC)
- Tailored clock tree with real-time clock
- Dual power input via AC power and 12V DC
- Diverse options for connectivity
- GigE, Bluetooth, USB OTG, Wi-Fi 6E, LTE Cat-M1
- Support for various sensors and interfaces
- RS-232, RS-486, CAN, multiple analog input, 4-20mA input, and humidity and temperature

**BOM List for Reference Design**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISL85005</td>
<td>4.5V to 18V Input, 5A High Efficiency Synchronous Buck Regulator</td>
</tr>
<tr>
<td>iW1825</td>
<td>700V AccuSwitch™ AC/DC Digital Primary-Side Converter with Configurable Light Load Mode for Applications up to 25W</td>
</tr>
<tr>
<td>ISL80030A</td>
<td>3A Synchronous Buck Converter in 2x2 DFN Package</td>
</tr>
<tr>
<td>DA9217</td>
<td>Configurable, 6A Dual-Phase SubPMIC for high performance mobile processors and memory</td>
</tr>
<tr>
<td>SLG46535</td>
<td>GreenPAK™ Programmable Mixed-signal Matrix with Asynchronous State Machine and Dual Supply</td>
</tr>
<tr>
<td>AT25QL128A</td>
<td>128Mbit, 1.7V Minimum SPI Serial Flash Memory with Dual I/O, Quad I/O and SPI Support</td>
</tr>
<tr>
<td>SP35023</td>
<td>VersaClock™ 3S Programmable Clock Generator</td>
</tr>
<tr>
<td>ISL1208</td>
<td>1C Real Time Clock/Calendar, Low Power RTC with Battery-Backed SRAM</td>
</tr>
<tr>
<td>RYZ014A</td>
<td>LTE Cat-M1 Cellular IoT Module</td>
</tr>
<tr>
<td>ICL3221E</td>
<td>±15kV ESD Protected, +3V to +5.5V, 1μA, 250kbps, RS-232 Transmitters/Receivers</td>
</tr>
<tr>
<td>ISL32601E</td>
<td>1.8V to 3.3V, Micro-Power, ±15kV ESD, +125°C, Slew Rate Limited, RS-485/RS-422 Transceivers</td>
</tr>
<tr>
<td>HS3001</td>
<td>High-Performance Relative Humidity and Temperature Sensor</td>
</tr>
<tr>
<td>ISL28022</td>
<td>Precision Digital Power Monitor</td>
</tr>
<tr>
<td>DA14531</td>
<td>SmartBond™ Ultra-Low Power Bluetooth® 5.1 System-on-Chip</td>
</tr>
<tr>
<td>RZ/G2N</td>
<td>Ultra-high Performance Microprocessors with Dual-core Arm® Cortex®-A57 (1.5 GHz) CPUs, with 3D Graphics and 4K Video Encoder/Decoder</td>
</tr>
<tr>
<td>ISL9003A</td>
<td>Low Noise LDO with Low IQ, High PSRR</td>
</tr>
</tbody>
</table>
Hi-Speed & Long-Distance Power Line Communication Unit for AC Line/DC Line

Power Line Communication (PLC) is a communication method that uses power lines as the medium, so it is possible to build a system quickly at low cost. Using this method, communication data can be propagated through AC or DC power lines. For example, building automation can be realized using existing AC power lines in the building. Alternatively, DC power lines can be used for communication between devices, reducing device harnesses.

Renesas provides a narrow-band PLC modem IC, R9A06G061, which enables high-speed communication over 1Mbps and stable long-distance communication over 1km for peer-to-peer networks.

- The PLC unit can be configured using Renesas products, including the R9A06G061 PLC modem, line driver, and AC/DC and DC/DC regulators. For a DC line, the PLC unit can be configured in a small size of about 3cm square. The PLC unit actual schematics, BOM lists and Gerber data are also ready.
- Evaluation boards optimized for AC lines and DC lines are available. A “Performance Test Tool” and sample application software are available which run on the evaluation board. Customers can immediately develop and evaluate a PLC system. Renesas also prepares board schematics, BOM lists and PCB layout guides to support customer development.

---

**Reference Solution – System Benefits**

- High Speed Narrow Band Power Line Communication Modem IC
- DC Input/Single Transistor Output Photocouplers (Optocouplers)
- Single Port, PLC Differential Line Driver
- 700V AC/DC Regulator with Ultra-Low Standby Power and up to 5W Output Power
- Wide VIN 150mA Synchronous Buck Regulator

**BOM List for Reference Design**

- R9A06G061 High Speed Narrow Band Power Line Communication Modem IC
- RV1S2211A DC Input/Single Transistor Output Photocouplers (Optocouplers)
- ISL15102 Single Port, PLC Differential Line Driver
- RAA223011 700V AC/DC Regulator with Ultra-Low Standby Power and up to 5W Output Power
- ISL85412 Wide VIN 150mA Synchronous Buck Regulator
APPLICATION SOLUTIONS

Gigabit Industrial Ethernet System-on-Module

The industrial market highly appreciates “stamp-type” proven-to-work MPU system-on-modules (SoMs), where customers can build their own unique peripherals around them. Renesas provides such a module and carrier board for this type of solution, resulting in a massive reduction of time-to-market, development cost and risk on the customer side.

- Stamp-type SoM module
- Ready, proven-to-work, includes all needed components
- Can directly be soldered on customer carrier board as a “stamp” on a letter
- Single 3.3V supply by dedicated PMIC OTP settings for RZ/N2L and RZ/T2M MPUs
- Integrated memory 16MB QSPI flash + 32MB SDRAM, 2kx8 EEPROM, 2x industrial Ethernet Gigabit interface

### Reference Solution – System Benefits

- DA9083 Six-channel Configurable System Power Management IC
- SLG46117 GreenPAK™ Programmable Mixed-Signal Matrix with P-FET Power Switch with Discharge
- XL 1000fs Quartz-based PLL Oscillator
- AT25SF128A 128Mbit, 2.7V Minimum SPI Serial Flash Memory with Dual I/O Support
- RZ/N2L Integrated TSN-Compliant 3-Port Gigabit Ethernet Switch Enables Various Industrial Applications to Easily Implement Industrial Ethernet and TSN
- R1EX24016A Two-wire serial interface 16k EEPROM (2-kword × 8-bit)
### LOOK-UP TABLE WITH POWER ATTACHED

#### Industrial

**Power Attach for Industrial MCU Families: RL78, RX, RA**

### RL78 Family

<table>
<thead>
<tr>
<th>MCU Series &amp; Simplified MCU Requirements**</th>
<th>Input Source</th>
<th>Regulator Type</th>
<th>Part Number</th>
<th>CFP*2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RL78G (General Purpose)</strong></td>
<td>Coin Cell</td>
<td>Low IQ Boost</td>
<td>ISL9116B</td>
<td>NO</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 105°C: 17.6mA (Nominal VDD: 1.6-5.5V)</td>
<td>Li-Ion Cell</td>
<td>Buck-Boost</td>
<td>ISL9122A</td>
<td>NO</td>
</tr>
<tr>
<td>RL78L (LCD Driver)</td>
<td>USO or 5V Rail</td>
<td>Fixed Output Voltage LDO/Low Noise LDO</td>
<td>RAA214401/RAA214023</td>
<td>YES</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 85°C: 8.5mA (Nominal VDD 1.6-5.5V)</td>
<td>12 V Rail</td>
<td>Fixed Output Voltage LDO</td>
<td>RAA214401</td>
<td>YES</td>
</tr>
<tr>
<td>RL78/11E (ASSP Sensing)</td>
<td>24V Rail</td>
<td>Buck Converter</td>
<td>RAA214403</td>
<td>NO</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 125°C: 8.7 mA (Nominal VDD 2.4-5.5V)</td>
<td>48V Rail</td>
<td>Buck Converter</td>
<td>RAA211805</td>
<td>NO</td>
</tr>
<tr>
<td>RL78/11D (ASSP Detector)/RL78/H1D (ASSP Medical)</td>
<td>72V Rail</td>
<td>Buck Converter</td>
<td>RAA211803</td>
<td>NO</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 105°C: 8.7 mA (Nominal VDD 1.8-5.5V)</td>
<td>AC Outlet 120/240 V</td>
<td>AC-DC Converter</td>
<td>RAA223012</td>
<td>YES</td>
</tr>
</tbody>
</table>

*1 Simplified power requirements assume worst-case current consumption. Customers to verify actual use-cases
*2 CFP: Common Foot-Print with other parts available on the market

### RX Family

<table>
<thead>
<tr>
<th>MCU Series &amp; Simplified MCU Requirements**</th>
<th>Input Source</th>
<th>Regulator Type</th>
<th>Part Number</th>
<th>CFP*2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RX100/200</strong></td>
<td>Coin Cell</td>
<td>Low IQ Boost</td>
<td>ISL9116B</td>
<td>NO</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 85°C, All peripherals: 80mA (Nominal VDD 1.8-5.5V)</td>
<td>Li-Ion Cell</td>
<td>Buck-Boost</td>
<td>ISL9122A</td>
<td>NO</td>
</tr>
<tr>
<td>RX600 (Mainstream)</td>
<td>USO or 5V Rail</td>
<td>Fixed Output Voltage LDO/Low Noise LDO</td>
<td>RAA214401/RAA214023</td>
<td>YES</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 105°C, Full operation: 270mA (Nominal VDD 2.7-5.5V)</td>
<td>12 V Rail</td>
<td>Fixed Output Voltage LDO</td>
<td>RAA214401</td>
<td>YES</td>
</tr>
<tr>
<td>RX700 (Flagship)</td>
<td>24V Rail</td>
<td>Buck Converter</td>
<td>RAA214403</td>
<td>NO</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 105°C, Full operation: 319mA (Nominal VDD 2.7-5.5V)</td>
<td>48V Rail</td>
<td>Buck Converter</td>
<td>RAA211805</td>
<td>NO</td>
</tr>
<tr>
<td>AC Outlet 120/240 V</td>
<td>72V Rail</td>
<td>Buck Converter</td>
<td>RAA211803</td>
<td>NO</td>
</tr>
</tbody>
</table>

*1 Simplified power requirements assume worst-case current consumption. Customers to verify actual use-cases
*2 CFP: Common Foot-Print with other parts available on the market

### RA Family

<table>
<thead>
<tr>
<th>MCU Series &amp; Simplified MCU Requirements**</th>
<th>Input Source</th>
<th>Regulator Type</th>
<th>Part Number</th>
<th>CFP*2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RA2 (Arm® Cortex®-M23)</strong></td>
<td>Coin Cell</td>
<td>Low IQ Boost</td>
<td>ISL9116B</td>
<td>NO</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 85°C: 28.5mA (Nominal VDD: 1.6-5.5V)</td>
<td>Li-Ion Cell</td>
<td>Buck-Boost</td>
<td>ISL9122A</td>
<td>NO</td>
</tr>
<tr>
<td>RA4 (Arm® Cortex®-M4 or -M33)</td>
<td>USO or 5V Rail</td>
<td>Fixed Output Voltage LDO/Low Noise LDO</td>
<td>RAA214401/RAA214023</td>
<td>YES</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 85°C: 50mA/95mA (5.5V/3.6V) (Nominal VDD: 1.6-5.5V or 2.7-3.6V)</td>
<td>12 V Rail</td>
<td>Fixed Output Voltage LDO</td>
<td>RAA214401</td>
<td>YES</td>
</tr>
<tr>
<td>RA6 (Arm® Cortex®-M4 or –M33)</td>
<td>24V Rail</td>
<td>Buck Converter</td>
<td>RAA211320</td>
<td>YES</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 105°C: 150mA (Nominal VDD: 2.7-3.6V)</td>
<td>48V Rail</td>
<td>Buck Converter</td>
<td>RAA211805</td>
<td>NO</td>
</tr>
<tr>
<td>AC Outlet 120/240 V</td>
<td>72V Rail</td>
<td>Buck Converter</td>
<td>RAA211803</td>
<td>NO</td>
</tr>
</tbody>
</table>

*1 Simplified power requirements assume worst-case current consumption. Customers to verify actual use-cases
*2 CFP: Common Foot-Print with other parts available on the market

<table>
<thead>
<tr>
<th>MCU Series &amp; Simplified MCU Requirements**</th>
<th>Input Source</th>
<th>Regulator Type</th>
<th>Part Number</th>
<th>CFP*2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RA8 (Arm® Cortex®-M85)</strong></td>
<td>Coin Cell</td>
<td>Low IQ Boost</td>
<td>ISL91117</td>
<td>NO</td>
</tr>
<tr>
<td>High-Speed Operation Mode, Max VDD, 125°C: 632mA (Nominal VDD: 1.68-3.6V) (both in DCDC mode and External VDD mode)</td>
<td>Li-Ion Cell</td>
<td>Buck-Boost</td>
<td>ISL91127</td>
<td>NO</td>
</tr>
<tr>
<td>12 V Rail</td>
<td>USO or 5V Rail</td>
<td>Fixed Output Voltage LDO</td>
<td>RAA211250</td>
<td>YES</td>
</tr>
<tr>
<td>24V Rail</td>
<td>24V Rail</td>
<td>Buck Converter</td>
<td>RAA211450</td>
<td>NO</td>
</tr>
<tr>
<td>48V Rail</td>
<td>48V Rail</td>
<td>Buck Converter</td>
<td>RAA211630</td>
<td>NO</td>
</tr>
<tr>
<td>72V Rail</td>
<td>72V Rail</td>
<td>Buck Converter</td>
<td>RAA211835</td>
<td>NO</td>
</tr>
<tr>
<td>AC Outlet 120/240 V</td>
<td>AC Outlet 120/240 V</td>
<td>AC-DC Converter</td>
<td>RAA223012</td>
<td>YES</td>
</tr>
</tbody>
</table>

*1 Simplified power requirements assume worst-case current consumption. Customers to verify actual use-cases
*2 CFP: Common Foot-Print with other parts available on the market
MPU Family RZ: Maximum Performance for HMI, Industrial Network and AI applications

**Human Machine Interface**

**RZ/A Series**  
2D Graphics + RTOS

**RZ/G Series**  
Multimedia / 3D Graphics + Linux

**RZ/V Series**  
AI Accelerator + Linux

**RZ/N Series**  
Multi-protocol Industrial Ethernet with Redundancy + Linux/RTOS

**Industrial Realtime Control**

**RZ/T Series**  
Realtime Control + RTOS

---

### MPU Family RZ: Maximum Performance for HMI, Industrial Network and AI applications

<table>
<thead>
<tr>
<th>RZ MPU Series</th>
<th>MPU Target Application</th>
<th>Input Source</th>
<th>Regulator Type</th>
<th>Part Number</th>
</tr>
</thead>
</table>
| G2H, G2M      | General HMI, IoT Gateway (Linux) | 5 V (1S Battery, Pre-Regulator Output, 5V Supply Bus) | DA9092: 4xBucks, 4xLDO, RTC  
RAA215300: 6xBucks, 3xLDO, 1x1S CHRG  
DA9080: 4xBucks, 1xLDO, 1xGP ADC  
SLG51000 | DA9092 + RAA215300  
or  DA9092 + DA9080 + SLG51000 |
| G2N, G2E      | General HMI, IoT Gateway (Linux) | | DA9080: 4xBucks, 1xLDO, 1xGP ADC  
SLG51000: 6xLDO | DA9080 or DA9217 + SLG51000 |
| V2M, V2MA, V2L | Vision Artificial Intelligence | | DA9217: 1xDual-Phase Buck  
SLG51000: 6xLDO | DA9217 + SLG51000 |
| G2L, G2LC     | General HMI, IoT Gateway (Linux) | | DA9281: 4xBucks, 3xLDO, DDR VTT  
RAA215300: 6xBucks, 3xLDO, 1x1S CHRG | DA9215300 or DA9281 |
| G2UL, Five    | General HMI, IoT Gateway (Linux) | | DA9062: 4xBucks, 4xLDO, RTC  
RAA215310: 3xBucks, 4xLDO/LS | DA9062 or RAA215310 |
| A3UL          | General HMI (RTOS) | | DA9062: 4xBucks, 4xLDO, RTC  
RAA215310: 3xBucks, 4xLDO/LS | DA9062 or RAA215310 |
| T1, T2M, T2L  | Real Time Control | | PMIC: 4xBucks, 1xLDO, 1xGP ADC | DA9080 |
| A1LU, A2M     | General HMI (RTOS) | | PMIC: 4xBucks, 1xLDO, 1xGP ADC | DA9080 |
| N2L           | Industrial Network | | PMIC: 4xBucks, 1xLDO | DA9083 |
PRODUCT PORTFOLIO

Complete Automotive Power Solutions

By joining forces, Renesas, Intersil, IDT and Dialog, have become leaders in embedded solutions and analog mixed-signal products, uniquely positioned to help customers succeed in developing innovative applications in the automotive segment. Our combined portfolio will contribute to accelerating your development and enabling differentiation, while bringing predictability to your applications.

Power Product Lineup

Power products to cover an expanding range of application fields

<table>
<thead>
<tr>
<th>Application Domains</th>
<th>ADAS</th>
<th>Cockpit</th>
<th>E/E Architecture</th>
<th>Powertrain</th>
<th>xEV</th>
<th>Chassis &amp; Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Management ICs (PMICs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED Backlight Drivers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haptic Drivers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wireless Charging</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery Management ICs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate Drivers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IGBTs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOSFETs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Intelligent Power Devices
KEY PRODUCTS

Automotive Power Products

Power Management ICs

Renesas power management ICs are designed as complementary power solutions for Renesas MCUs and SoCs. Their optimized performance helps to reduce the system BOM cost, PCB mounting area, and system design development time.

**Features**
- Ideal power solution for Renesas MCUs and SoCs (e.g. RH850/E1x/C1x/P1x, R-Car Gen3, Gen4)
- Integrated fault diagnosis and monitor functions for ASIL applications

**Benefits**
- Optimized specifications help reduce system BOM cost and PCB area.
- Closely aligned MCU/SoC and PMIC solutions help shorten development time.

**Application Example Using RH850/E1x/C1x**

Battery Management ICs

Renesas battery management ICs have superior voltage measurement accuracy (initial accuracy: <±2.0mV) and long-term drift (<±6mV@6σ after 15 years on board). ASIL D Battery Management System (BMS) Design Solution available in combination with RH850/P1M.

**Features**
- Best-in-class on-board accuracy (±2.5mV ±3σ post soldering)
- ISO 26262 ASIL D support
- ±5V cell input measurement range (for fuel cells and bus bars)
- Low-power, high-security daisy chain (capacitor or transformer coupling)
- System-level software drivers/support (ASIL D complex device drivers)

**Benefits**
- BMS reference design with ISL78714 (BMIC) & RH850/P1M (MCU)
- Complex software drivers available.
- Reduced R&D burden.
- Lower BOM cost
- Excellent hot-plug performance
- Excellent long-term drift measurement accuracy
- Ability to balance all cells simultaneously

**BMS Reference Design**

Wireless Charging ICs

Qi-compatible wireless charging ICs for automotive applications deliver charging speeds that rival traditional plug-in charging.

**Features**
- Industry-first, flexible ARM® Cortex®-M0-based SoC architecture
- Industry-leading efficiency
  - >75% end-to-end
  - As fast as wired
  - Cool operation temperature
- Very low EMI
- Innovative and proven hardware and algorithm implementation

**Benefits**
- Wireless solution offering significant reduction of charging time, up to 20W.
- Design support
  - Reference design kits enable fast prototyping and time to market.
- Extensive documentation library
KEY PRODUCTS

Automotive Power Products

Gate Driver Units (GDUs)
Renesas GDUs are designed for use with xEV inverters. Their performance has been proven on Renesas reference boards, and they contribute to a reduction of BOM cost and the engineering development workload.

- **Features**
  - Low Ron (1 ohm max.), IGBT gate driver with 2.5k Vrms isolation
  - Support IGBT parallel connection
  - Built-in analog I/F can help to monitor the operation condition of secondary side (IGBT side)

- **Benefits**
  - Provides cost-effective solution (20% BOM Cost reduction expected)
  - Contributes to reduced engineering development workload

Example Solution
Inverter Reference Design with GDU

Haptic Drivers
Low-power, wide-bandwidth haptic drivers for vibrations and clicks in applications using eccentric rotating mass motors (ERM) and linear resonant actuators (LRAs)

- **Features**
  - Dynamic display control panels in the cabin that utilize haptics to provide immediate tactile feedback to the driver
  - Provides multiple feedback states — not just a simple click.
  - Applications include button replacement, rotary encoding, steering wheel fingertip feedback, etc.

- **Benefits**
  - 80% lower idle current than the competition
  - AEC-Q100 Grade 2, 3x3mm WFQFN package

LED Backlight Drivers
Advanced technology enables local dimming, high-contrast, high-quality, large displays.

- **Features**
  - 32 channels
  - Integrated current sink MOSFETs
  - External current sense resistors for flexibility and accuracy in broad range of LED applications
  - Comprehensive protection features

- **Benefits**
  - Patented BroadLED™ adaptive switch technology
  - Reduces power dissipation in the driver.
  - Maintains operation during LED short with minimal temperature increase.
  - Enables use of less costly, loosely binned LED arrays for lower BOM cost.
  - AnyMode™ technology reduces video motion blur.
  - 13-bit PWM dimming and 11-bit analog dimming improve dynamic range.
Renesas offers an extensive lineup of power MOSFET products covering a wide range of voltage and current ratings as well as different package types to enable customers building various types of electric equipment to select the optimal device for their specific application. We also supply bare-die IGBT products that enable customers to achieve an ideal match with the modules they design as well as intelligent power devices (IPDs).

### Power MOSFETs

**Features**
- World-top-class low Ron with super junction structure
- Extensive lineup for 12V / 48V battery applications
- Excellent quality
- Customized bare die support for pad layout & shipment format

**Benefits**
- High efficiency based on excellent Ron and switching performance
- Down-sizing by selecting optimized package from product line-up and bare die support options
- Robust design with high withstanding capability and sensing option

### IGBTs

Renesas supplies bare-die IGBT products that enable customers to achieve an ideal matching with the system and modules they design.

**Features**
- High performance & high quality IGBT bare die for HEV/PHV/EV
- World-top-level performance with low Vce (sat) and faster switching
- Voltage ratings ranging from 650V to 1200V
- Current and temperature sensing (optional)

**Benefits**
- High efficiency and low heat generation due to low power consumption
- Support for various mounting methods with top metal options
- High quality due to various testing options and qualification tests

### Intelligent Power Devices (IPDs)

Replaces mechanical relays for longer lifetime, smaller size, lighter weight, and extended functionality.

**Features**
- Proven MOSFET and control chip technology in a single package
- Low ON-resistance and wide SOA
- Self-protection against short circuit, over-current, and over-temperature
- Self-diagnostic and monitoring functions
- High max operating temperature
- AEC-Q100 qualified and RoHS compliant

**Benefits**
- Mechanical relay replacement offering better lifetime, size, weight and functionality
- Switching of high currents of more than 30A
- Easy control by MCU with reduced power consumption
- Contributes to high system reliability with integrated smart protection
- Efficient drive of resistive, inductive, or capacitive loads

**Example Solution**
IPD outputs power supply and protects itself & loads.
The electrification of the powertrain is mandatory to comply with emission regulation. In addition to mild and full hybrid vehicles, the share of fully electric cars is increasing. Renesas’ robust, reliable and safe powertrain solutions help to manage efficient use of energy for the applications mentioned above. Renesas offers many xEV inverter reference solutions.

- Practical inverter specification for xEV 100kW class motors
- Reference solution kit including Inverter reference design, software, model based design, and calibration tool
- Functions and performance verified on Renesas dynometer test bench
- 3.9L compact volume due to highly integrated products and temperature management
- Superior power efficiency: 99% of maximum inverter efficiency
- Functions proven in real car demo

**BOM List for Reference Design**

- RH850/C1M-A2
- RAA270000
- R2A25110
- RJQ7031/RJU7032
- RV1S2752Q

- 32-bit microcontroller with embedded resolver interface and motor control IP
- Power management IC (PMIC)
- Gate driver IC
- IGBT and FRD
- Photocoupler

**Block Diagram and Reference Board**
APPLICATION SOLUTIONS
X-IN-1 System Integration

- Realizes cost savings to optimize MCU, PMIC, and peripheral component count.
- Model-based design with sufficient support capability can reduce R&D burden.
- Enables validation with actual motor load environment and combined operation of each unit.

**Reference Solution – System Benefits**

**Conventional System**
- Independent ECUs
- Many MCUs + PMICs are needed.

**X-in-1 System Integration**
- A single ECU (1 MCU + 1 PMIC), more compact
- Reduced BOM of MCU + PMIC, etc.
APPLICATION SOLUTIONS

Low-Voltage Inverter for 2/3-Wheeler Traction Motor Control

Renesas’ Low Voltage Inverter for 2/3 Wheelers Traction Motor Control solution is a reference design based on an MCU and analog products for high-power 48V motor control applications. The design includes inverter hardware design files (schematics and Gerber) and peripheral sample code (for the motor control unit and resolver-to-digital converter), allowing for fast evaluation and development based on real-life use cases.

- The power stage can drive up to a 10kW Motor.
- Support is available to scale the 48V power stage of the inverter as per customer requirements.
- Supports connection with vehicle I/O, brake sensor, accelerator, gear, and drive modes along with PWM output for the digital cluster.
- This reference design provides a complete inverter evaluation for motor control application using the RH850/C1M-A1 automotive MCU.
- Includes inverter hardware design files (schematics and Gerber) and peripheral sample code (for the motor control unit and resolver-to-digital converter), allowing for fast evaluation and development based on real-life use cases.

**Reference Solution – System Benefits**

**BOM List for Reference Design**

- RAA270000KFT: Power Management IC (PMIC) for Automotive RH850 MCUs
- RH850/C1M-Ax: Microcontroller with G3MH CPU Core Ideal for HEV / EV Motor Control
- ISL78434: 100V Boot, 4A Peak, Half-Bridge Driver with Single PWM Input and Adaptive Dead Time Control
- UPD166029T1J: Intelligent Power Device
- RBA250N10CHPF-4UA02: 100V – 250A – N-channel Power MOS FET
APPLICATION SOLUTIONS

Motor Generator System

This system is a high-performance xEV traction motor and regeneration control solution using the RH850/C1M-Ax automotive microcontroller (MCU), supporting ASIL C and incorporating lock-step CPU cores and sophisticated motor control IP (EMU3).

- Enhances diagnostic features and significantly reduces board area and BOM cost using an embedded resolver-to-digital (RDC) interface on the RH850/C1M-Ax MCU.
- Provides a proven system-design approach through a power management IC (PMIC) specifically designed for the RH850/C series of automotive MCUs, optimizing BOM cost and board space.
- Includes ready-to-start motor control software using the MCU EMU3 and embedded RDC.

Reference Solution – System Benefits

<table>
<thead>
<tr>
<th>BOM List for Reference Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP15P04SLG</td>
</tr>
<tr>
<td>RAA270000KFT</td>
</tr>
<tr>
<td>RH850/C1M-Ax</td>
</tr>
<tr>
<td>UPC842AMP</td>
</tr>
<tr>
<td>R2A25110KSP</td>
</tr>
<tr>
<td>IPS2550</td>
</tr>
</tbody>
</table>

Diagram showing the component layout and connections of the system.
APPLICATION SOLUTIONS

Automotive Communication Gateway Platform

This solution provides a complete reference design with hardware and software for automotive gateway applications to support the electrical/electronic (E/E) architecture. It provides an integrated system that controls an ever-increasing number of vehicle functions in all areas of vehicle control.

- Reduces the board size and BOM costs through MCU core integration into the system-on-chip (SoC) and uses a single board to control both the MCU domain and application SoC domain, which previously required separate devices.
- The reference board consists of a CPU board with a core SoC, power management IC (PMIC) and memory, and an interface board, enabling support for a variety of networks.
- Supports 16 channels of CAN FD (can be used as 16 channels of local interconnect network (LIN) and 8 channels of single edge nibble transmission (SENT) by multi-function), 2 channels of FlexRay, 2 channels of PCIe v4.0 x2 lanes, and 3 channels of 5G-USXGMII for Ethernet.
- The core system is realized by installing the R-Car S4 automotive SoC, LPDDR4x-3200 memory, and HyperFlash™ memory on the CPU board.
- Flexible clock generator capable of generating 12 outputs, PCIe Gen 1-4 clocks for automotive applications, and Universal Flash Storage (UFS) clocks to support multiple channels in a single device.

BOM List for Reference Design

- **RAA271041** Cold Crank Boost and Buck Controller with Drivers for ASIL-D Automotive Applications
- **RAA271005** Automotive 11ch Safe SoC PMIC with Extremely Low Quiescent Current
- **ISL78233** 3A Compact Synchronous Buck Regulator
- **ISL78310** High Performance 1A LDO
- **ISL78322** Dual 2A/1.7A Low Quiescent Current 2.25MHz High Efficiency Synchronous Buck Regulator
- **RC22112A** FemtoClock Clock Generator
- **R-Car-S4** Automotive System-on-Chip (SoC) for Car Server/Communication Gateway
APPLICATION SOLUTIONS

Solid State Automotive Power Distribution Module with E-Fuse

Renesas provides an efficient power distribution network solution based on Intelligent Power Device (IPD) technologies. The intelligent protection and diagnostic functions of the IPDs increase the safety level over mechanical relays. This solution optimizes wiring harnesses and improves reliability by adding current monitoring capabilities.

- Reduce the size and weight of a fuse box by integrating 10 output channels on a compact-sized board, aligning with the smart e-fuse concept.
- E-fuses offer maintenance-free load and wire protection that can be configured and adapted to a variety of cables. Significant higher accuracy of the e-fuses reduces the weight of the wire harness.
- The software-based e-fuse is activated from the current-sense feedback of the IPD to the MCU. The MCU is programmed to implement the fuse function.
- A safe parking mode*1 can be emulated by switching on the IPD and setting the MCU into a low-power mode.

---

*1 Parking mode represents a car parking situation where selected channels need to be active with minimum power consumption.

---

### Reference Solution – System Benefits

### BOM List for Reference Design

- **ISL78301** 40V, Low Quiescent Current, 150mA Linear Regulator for Automotive Applications
- **RL78/F14** Microcontrollers with Low Consumption Current for Automotive Applications
- **RAJ2800024H11HPF** Intelligent Power Device for automotive Application
- **UPD166033T1U** Intelligent Power Device
- **UPD166027T1J** Intelligent Power Device

---

**Diagram:**

- 12V Battery
- DC/DC LDO
- VCC
- Temp Sensor NTC
- UART
- CAN
- LIN
- MCU
- IPD (x2)
- IPD (x4)
- UART
- CAN
- GPIO
- Control
- Power Distribution Network for other ECUs
- AS234
Zone-ECU Virtualization Solution Platform

The RH850/U2x Zone-ECU Virtualization Platform is a development platform that provides a pre-integrated solution, including relevant software (SW) products and tools. This platform enables automotive customers to take a ready-to-go approach for individual Zone-ECU projects.

- Significantly reduced development effort based on a pre-built solution, resulting in less cost and reduced development risk.
- Combines the MCU hardware (HW) key features for Zone, such as hypervisor-support, safety, security, QoS, and more with the outstanding SW product portfolio and SW competence of ETAS, based on a collaboration between ETAS and Renesas.
- Provides a SW-first solution to enable the integration of multiple applications into a single ECU, that are safely and securely separated from each other to ensure the highest degree of freedom from interference.
- Provides a “ready-to-run” configuration showcasing different Virtual Machine (VM) configurations (single core, multi-core and multi-VM per core) by a PC-hosted application.

Reference Solution – System Benefits

BOM List for Reference Design

- **NP20P06SLG**  Power MOSFETs for Automotive
- **ISL78208**  Wide VIN Dual Standard Buck Regulator with 3A/3A Continuous Output Current
- **ISL78234**  4A Compact Synchronous Buck Regulator
- **RH850/U2A**  Zone/Domain Microcontroller Series

![Starter Kit or Piggy Board Diagram]

*1 RPP: Reverse Polarity Protection
Note: This block diagram shows the hardware portion of the Zone-ECU Virtualization Solution Platform. Download the relevant documentation for more details of the software.
APPLICATION SOLUTIONS

High-End Cockpit & Infotainment Solution

This combination of the R-Car (H3/M3/M3N) system-on-chip (SoC), power management IC (PMIC), and programmable clock generator allows for a versatile solution. They enable scalable cockpit and infotainment solutions that support high image quality, multiple video display outputs, and a wide variety of memory interfaces all in one design.

- A versatile system that enables scalable cockpit and infotainment solutions that support high image quality, multiple video display outputs, and a wide variety of memory interfaces.
- Flexible clock generators can generate any clock frequency from 1MHz to 350MHz and allow a single device to replace several discrete clock circuits, saving BOM cost and reducing PCB area.
- A flexible power supply can support a wide range of multicore SoCs and integrate full power rail management with multiple sleep modes for an optimized solution.
- Reduces R&D cost and development time using PMICs verified for R-Car SoCs.

<table>
<thead>
<tr>
<th>BOM List for Reference Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA9063-A</td>
</tr>
<tr>
<td>DA9223-A</td>
</tr>
<tr>
<td>DA9224-A</td>
</tr>
<tr>
<td>9FGV0841</td>
</tr>
<tr>
<td>R-Car-H3e</td>
</tr>
<tr>
<td>R-Car-M3Ne</td>
</tr>
<tr>
<td>R-Car-M3e</td>
</tr>
<tr>
<td>5P49V60</td>
</tr>
</tbody>
</table>

![Diagram of system components and connections]
APPLICATION SOLUTIONS

ADAS Front Camera Solution

This open front camera solution features Renesas’ R-Car V3H System-on-Chip (SoC). This all-in-one scalable camera platform targets the latest Euro New Car Assessment Program (NCAP) and Chinese Car Safety Assessment Program (C-NCAP) requirements, such as automatic emergency braking, forward collision warning, lane keeping assist, and traffic sign recognition.

Reference Solution – System Benefits

- Turnkey end-to-end solution for NCAP on front camera application (ASIL B).
- Optimized solution offers low BOM and reduces the customer’s R&D effort.
- A variety of perception software is available from partners (Cartica, Phantom AI, and StradVision) which greatly reduces R&D turnaround time (TAT) and efforts.
- Other possible extensions include surround view, driver monitoring, augmented reality video, and radar fusion to enhance supported driving functions.
- Highest TOPS/Watt performance with deep learning engine for object detection, classification algorithms, and real-time AUTOSAR support.
- PMIC optimized for R-Car V3x with higher efficiency and functional safety (FuSa) features.

BOM List for Reference Design

- RAA271050 4A, High Efficiency Synchronous Buck Regulator for Automotive Applications
- RAA271000 General-Purpose SoC PMIC for Automotive Applications
- RAA271005 Automotive 11ch Safe SoC PMIC with Extremely Low Quiescent Current
- SP35023 VersaClock® 3S Programmable Clock Generator
- SP49V60 VersaClock® 6E Programmable Clock Generator for Automotive
- R-Car-V3H SoC Optimized for Automotive Application in Stereo Front Cameras
- R-Car V4H Best-in-Class Deep Learning at Very Low Power, System-on-Chip for Automated Driving Level 2+/Level 3

Multiple resolutions supported
100° HFOV, 1.7 MP (mid range)
120° HFOV, 8 MP (high end)
# LOOK-UP TABLE WITH POWER ATTACHED

## Automotive

### Power Attach for RH850 Family

<table>
<thead>
<tr>
<th>MCU</th>
<th>ASIL (MCU)</th>
<th>PMIC</th>
<th>ASIL (Power)</th>
<th>Input Source</th>
<th>Regulator Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH850/F1x</td>
<td>ASIL B</td>
<td>RAA271082</td>
<td>ASIL B</td>
<td>12V Rail</td>
<td>Buck Converter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coming Soon</td>
<td>ASIL D</td>
<td></td>
<td>Buck/Boost</td>
</tr>
<tr>
<td>RH850/P1x</td>
<td>ASIL D</td>
<td>RAA270005</td>
<td>QM</td>
<td>12V Rail</td>
<td>Buck Converter</td>
</tr>
<tr>
<td>RH850/C1x</td>
<td>ASIL D</td>
<td>RAA270000</td>
<td>QM</td>
<td>12V Rail</td>
<td>Buck Converter</td>
</tr>
<tr>
<td>RH850/U2x</td>
<td>ASIL D</td>
<td>Coming Soon</td>
<td>ASIL D</td>
<td>12V Rail</td>
<td>Buck/Boost</td>
</tr>
</tbody>
</table>

### Power Attach for R-Car Gen3

<table>
<thead>
<tr>
<th>SoC</th>
<th>ASIL (SoC)</th>
<th>PMIC</th>
<th>ASIL (Power)</th>
<th>Input Source</th>
<th>Regulator Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-Car E3e</td>
<td>ASIL B</td>
<td>RAA271050</td>
<td>ASIL D</td>
<td>12V Rail</td>
<td>Buck Converter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DA9224A</td>
<td>QM</td>
<td>5V Rail</td>
<td>Buck Controller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DA9063A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coming Soon</td>
<td>ASIL D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Car M3e</td>
<td>ASIL B</td>
<td>ISL78264</td>
<td>QM</td>
<td>12V Rail</td>
<td>Buck Converter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DA9214A</td>
<td>ASIL D</td>
<td></td>
<td>Buck Controller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DA9063A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAA271000</td>
<td>QM</td>
<td>5V Rail</td>
<td>Buck Converter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coming Soon</td>
<td>ASIL D</td>
<td></td>
<td>Buck Controller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coming Soon</td>
<td></td>
<td></td>
<td>Power Stage</td>
</tr>
<tr>
<td>R-Car H3e</td>
<td>ASIL B</td>
<td>ISL78264</td>
<td>QM</td>
<td>12V Rail</td>
<td>Buck Controller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAA271040</td>
<td>ASIL D</td>
<td></td>
<td>Buck Converter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DA9063A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DA9214A</td>
<td>ASIL D</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DA9213A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAA271000</td>
<td>Coming Soon</td>
<td>ASIL D</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coming Soon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coming Soon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Car V3M</td>
<td>ASIL B</td>
<td>RAA271050</td>
<td>ASIL D</td>
<td>12V Rail</td>
<td>Buck Converter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coming Soon</td>
<td>ASIL D</td>
<td>5V Rail</td>
<td></td>
</tr>
<tr>
<td>R-Car V3H</td>
<td>ASIL C</td>
<td>RAA271050</td>
<td>ASIL D</td>
<td>12V Rail</td>
<td>Buck Controller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAA271000</td>
<td>ASIL D</td>
<td>5V Rail</td>
<td></td>
</tr>
</tbody>
</table>

### Power Attach for R-Car Gen4

<table>
<thead>
<tr>
<th>SoC</th>
<th>ASIL (SoC)</th>
<th>PMIC</th>
<th>ASIL (Power)</th>
<th>Input Source</th>
<th>Regulator Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-Car S4</td>
<td>ASIL D</td>
<td>RAA271041</td>
<td>ASIL D</td>
<td>12V Rail</td>
<td>Buck/Boost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAA271005</td>
<td>ASIL D</td>
<td>5V Rail</td>
<td>Buck Converter</td>
</tr>
<tr>
<td>R-Car V4H</td>
<td>ASIL D</td>
<td>RAA271050</td>
<td>ASIL D</td>
<td>12V Rail</td>
<td>Buck Converter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAA271005</td>
<td>ASIL D</td>
<td>5V Rail</td>
<td>Buck Converter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coming Soon</td>
<td>ASIL D</td>
<td></td>
<td>Buck Controller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coming Soon</td>
<td></td>
<td></td>
<td>Power Stage</td>
</tr>
</tbody>
</table>
Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from the use of these circuits, software, or information.

2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement on any other claimed involving patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.

3. No licenses, express or implied, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

4. You shall be responsible for determining which licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products if required.

5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

6. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for such Renesas Electronics product depends on the product quality grade, as indicated below.

   “Standard”: Computer, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machin tools, personal electronic equipment, industrial robots, etc.

   “High Quality”: Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INDESTRUCTIBLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION (“Vulnerability Issues”). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

8. When using Renesas Electronics products, refer to the latest product information data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc., and ensure that usage conditions are within the voltage specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.

9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain-use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (life-critical life support devices or systems; surgical implants; etc.), or may cause serious property damage (locomotive systems; underwater repairs, nuclear power control systems; aircraft control systems; key plant systems; military equipment, etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.

10. You shall not incorporate any of the circuits, software, or information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples, into any product or systems unless such incorporation is specifically authorized in writing by Renesas Electronics. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.

11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, sale or use is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries governing the parties or transactions.

12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposposes of, or otherwise sells or transports the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.

13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.

14. Please contact a Renesas Electronics sales office for details on environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

15. Renesas Electronics and technologies shall not be used for or incorporated into any products or systems whose manufacture, sale, or use is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries governing the parties or transactions.

16. The buyer or distributor of Renesas Electronics products, or any other party which distributes, disposposes of, or otherwise sells or transports the product to a third party, shall notify such third party in advance of the contents and conditions set forth in this document.

17. “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

18. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.

19. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposposes of, or otherwise sells or transports the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.

20. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

21. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for such Renesas Electronics product depends on the product quality grade, as indicated below.

   “Standard”: Computer, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machin tools, personal electronic equipment, industrial robots, etc.

   “High Quality”: Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

22. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INDESTRUCTIBLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION (“Vulnerability Issues”). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

23. When using Renesas Electronics products, refer to the latest product information data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc., and ensure that usage conditions are within the voltage specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.

24. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain-use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fires, and/or to damage to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.

25. Please contact a Renesas Electronics sales office for details on environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

26. Renesas Electronics and technologies shall not be used for or incorporated into any products or systems whose manufacture, sale, or use is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries governing the parties or transactions.