

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

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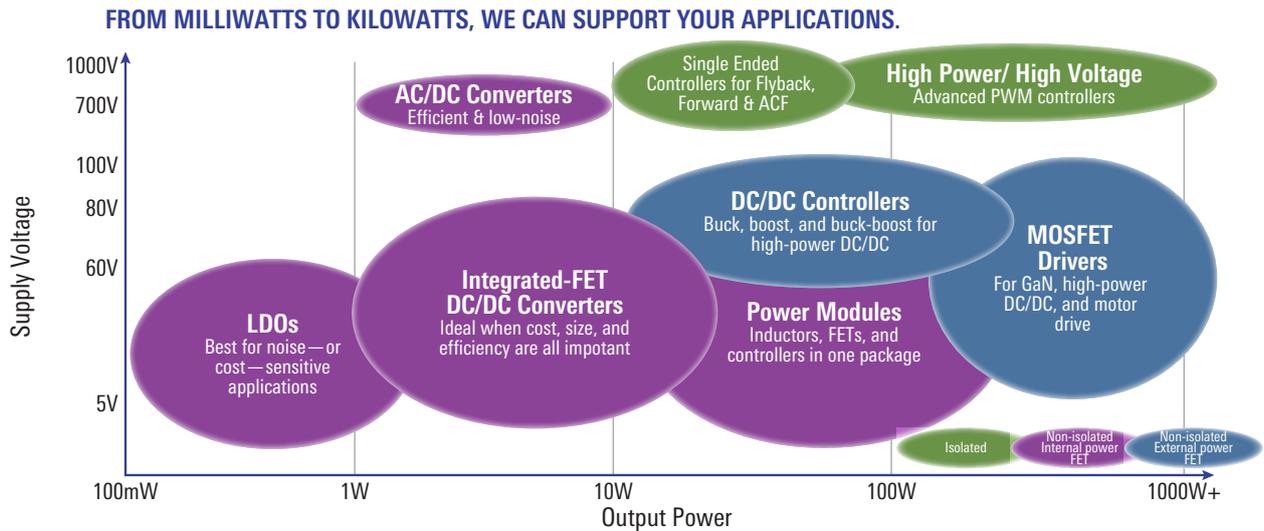
Automotive

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PRODUCT PORTFOLIO

Complete Industrial Power Solutions

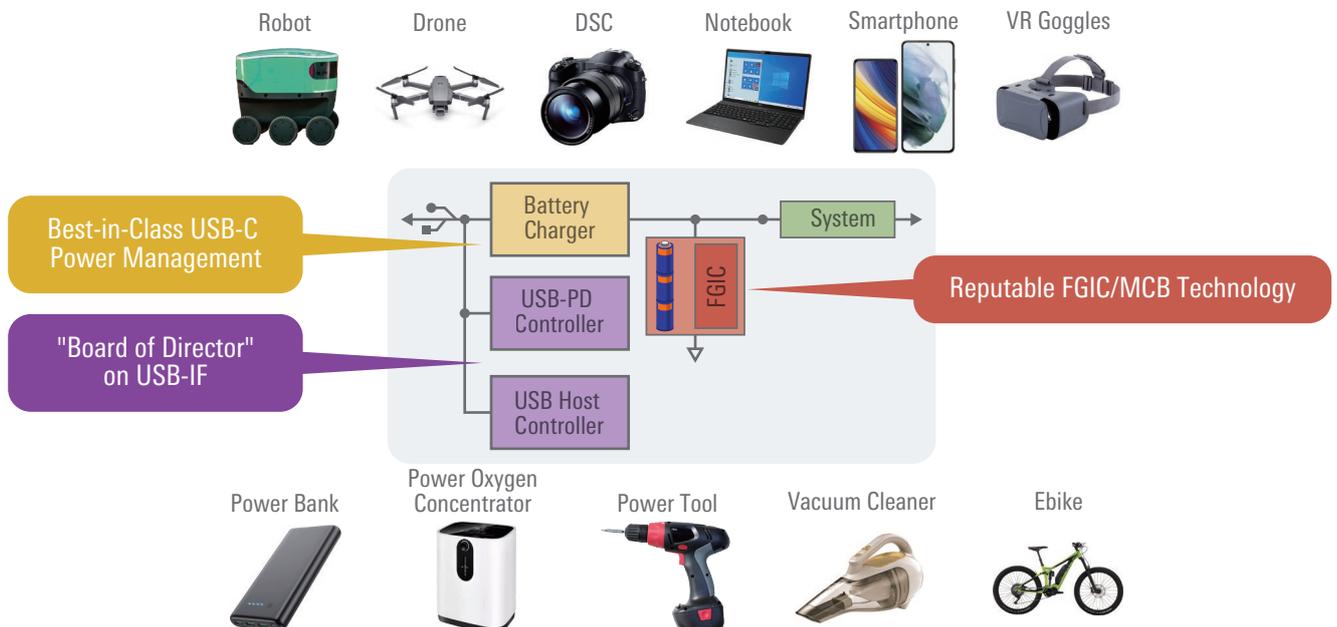
Renesas offers an extensive portfolio of high-performance power solutions for processors, controllers, DSPs, FPGAs, CPLDs, DDR memory, and other loads in your system. Whether you need standard linear regulators, highly flexible DC/DC converters, or fully integrated power modules, our products are tailored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



PRODUCT PORTFOLIO

Complete Industrial Battery Management Solutions

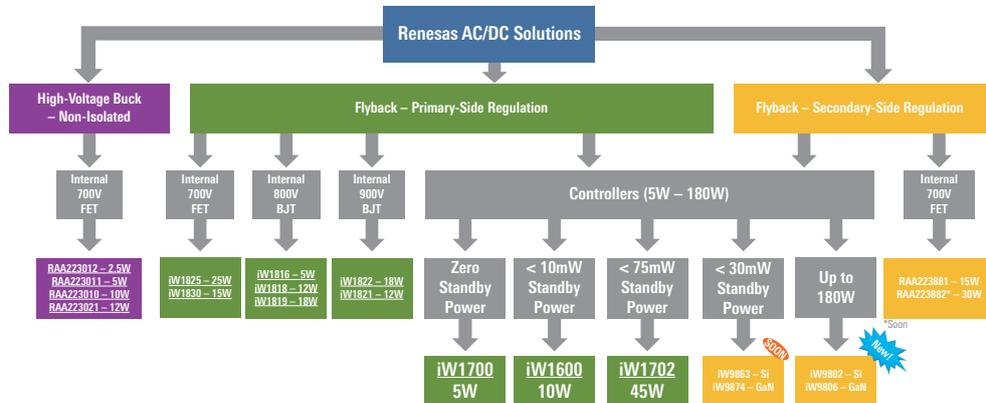
Renesas offers a full range of high-performance solutions for charger ICs, USB-PD applications, fuel gauge ICs, and battery frontend ICs to cover consumer, computing, and industrial applications using batteries from one cell to many cells. Renesas battery management solutions are backed by tested reference 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 Product Solutions



AC/DC Non-Isolated High-Voltage Buck Converters

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

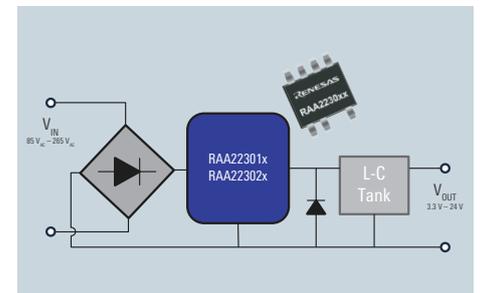
- Renesas quiet light-load PFM mode
 - No audible noise, even at light load
- Low standby power: 5 to 30mW

■ 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.

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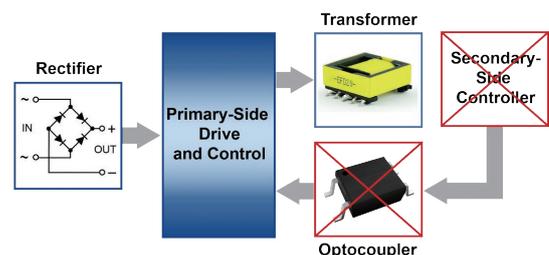
■ Block Diagram



Product	Typical Output Power (Max.)	Power Supply Topology	No-Load Standby Power	Driver Type	Key Features	Package
RAA223012	2.5W	Non-Isolated Buck & Flyback	< 10mW	Integrated 700V MOSFET	Low EMI, no audible noise, supports 3.3V or 5V output directly; no second-stage LDO needed.	TSOT23-5, SOIC-8
RAA223011	5W	Non-Isolated Buck & Flyback	< 10mW	Integrated 700V MOSFET	Low EMI, no audible noise, supports 3.3V or 5V output directly; no second-stage LDO needed.	TSOT23-5, SOIC8-7, SOIC-8
RAA223010	10W	Non-Isolated Buck & Flyback	< 15mW	Integrated 700V MOSFET	Low EMI, no audible noise, supports 3.3V or 5V output directly; no second-stage LDO needed.	SOIC8-7
RAA223021	12W	Non-Isolated Buck & Flyback	< 20mW	Integrated 700V MOSFET	Low EMI, no audible noise, supports 3.3V or 5V output directly; no second-stage LDO needed.	SOIC8-7

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*TM Primary-Side Isolated Flyback Controller

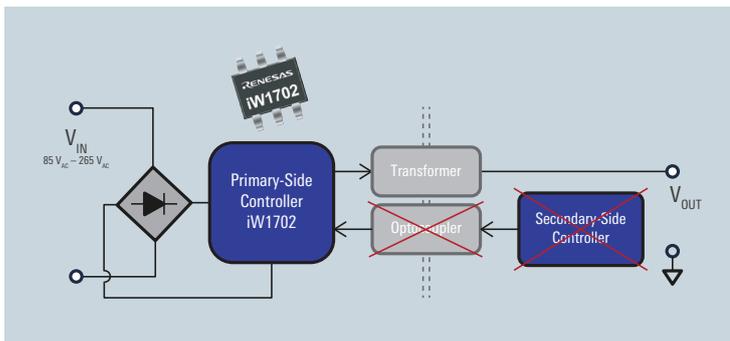
■ Features

- 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*TM 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

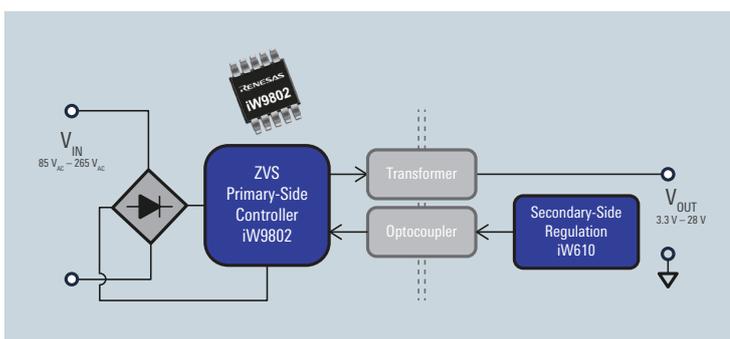
■ Features

- 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*TM AC/DC PWM ICs with Integrated High-Voltage Switch

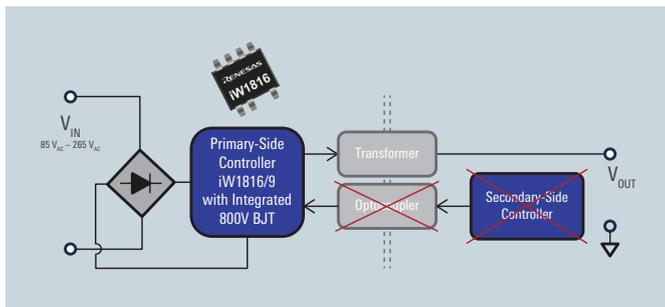
■ Features

- PWM controller and 800V BJT in one package
 - iW1816: 5W output; iW1819: 18W output
- Optimized to start into high capacitance loads up to 6,000 μ F.
- 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

■ Benefits

- *PrimAccurate*TM technology: Primary-side regulation eliminates secondary-side regulation components.
 - Optocoupler, voltage reference, and passives
 - Digital compensation loop: No external compensation required.
- EZ-EMITM technology
 - Reduced EMI: Simplify input filtering for lower cost.
 - Power BJT: Soft switching further reduces EMI.

■ Block Diagram



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

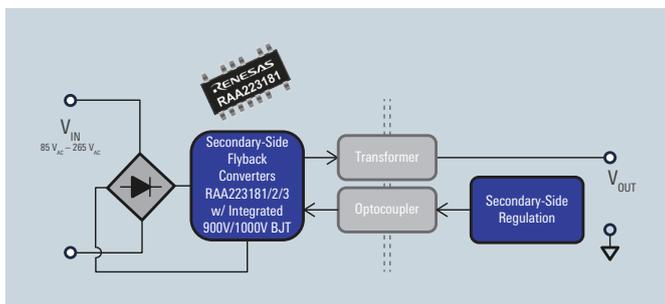
■ Features

- 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

■ Benefits

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

■ 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

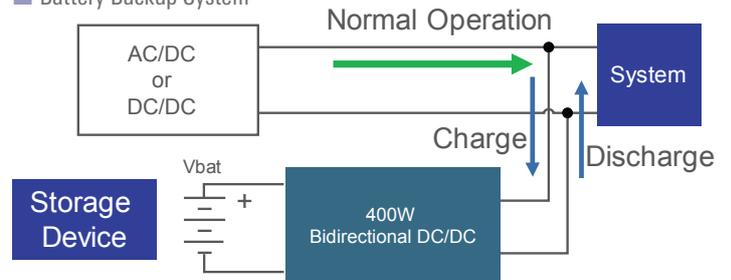
Multi-Output and Multiphase Analog Controllers

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

■ Battery Backup System



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

Output	Part No.	Status	V_{IN} Range (V)	V_{OUT} Range (V)	Package	Topology	Technical Highlights
Dual	ISL81802	Released	4.5 to 80	0.8 to 76	32 Ld 5x5 TQFN 38 Ld HTSSOP	Buck	MOSFET controller
	ISL81806	Released	4.5 to 80	0.8 to 76	32 Ld 5x5 TQFN	Buck	GaN controller
	ISL81805	Released	4.5 to 80	5 to 80	32 Ld 5x5 TQFN	Boost	MOSFET controller
	ISL81807	Released	4.5 to 80	5 to 80	32 Ld 5x5 TQFN	Boost	GaN controller

KEY PRODUCTS

Switching Regulators

Wide V_{IN} Coverage

Benefits and Key Features

Robust & Reliable Performance

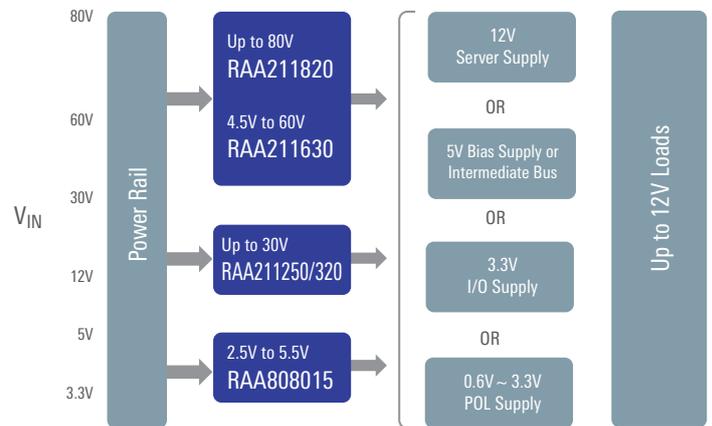
- P_{GOOD}, Enable function, adjustable soft start
- Extensive protection (OCP, OVP, OTP, SCP)
- External frequency synchronization

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



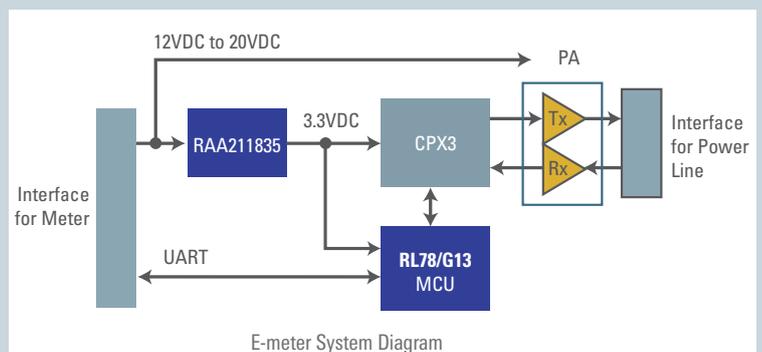
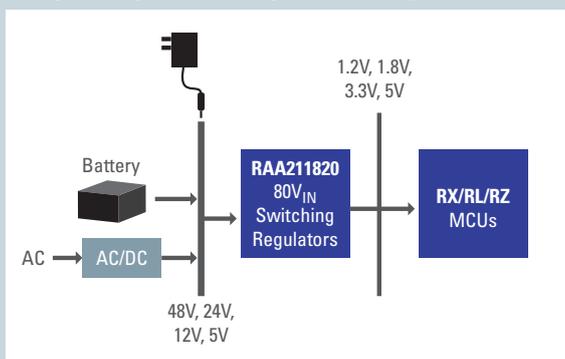
RAA211xxx New 24V to 75V Sync Buck Regulator Family – Wide V_{IN} Range

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

Part No.	V_{IN} Range	$R_{ds(on)}$ (High/Low) QFN	$R_{ds(on)}$ (High/Low) HTSSOP	I _{OUT}	Package
RAA211250	4.5V to 30V	70mΩ/25mΩ	115mΩ/40mΩ	5A	20 Ld 3.5x4 QFN 16 Ld HTSSOP
RAA211450	4.5V to 42V	75mΩ/25mΩ	115mΩ/40mΩ	5A	
RAA211630	4.5V to 60V	110mΩ/40mΩ	155mΩ/55mΩ	3A	
RAA211820	4.5V to 75V	155mΩ/80mΩ	200mΩ/95mΩ	2A	
RAA211835	4.5V to 75V	155mΩ/NA	200mΩ/NA	3A	

Using 80V Sync Buck Regulator Family to Power MCUs



KEY PRODUCTS

Switching Regulators

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

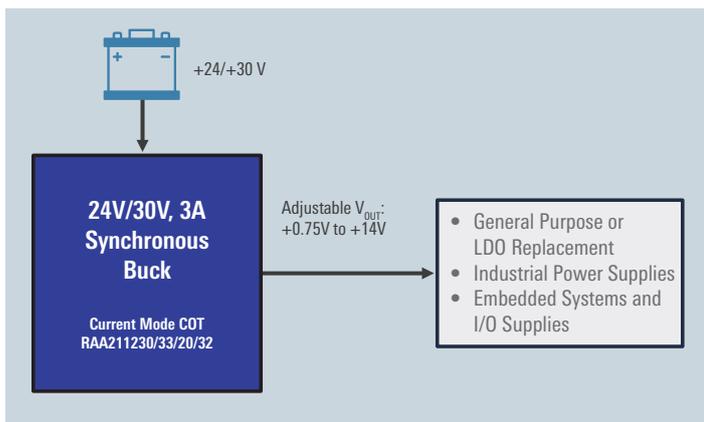
Features

- Wide V_{IN} range: 4.5V to 24V/30V, 3A maximum output current
- Low quiescent current: 400 μ A
- 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



Part No.	V_{IN} Range	IOUT	FB & Acc	R_{dson} (High/Low)	Fsw (Hz)	Control Mode	Package
RAA211230	4.5V to 24V	3A	0.765V \pm 0.015V	85m Ω /45m Ω	500K	CoT	TSOT23-6
RAA211233	4.5V to 24V	3A	0.6V \pm 0.012V	85m Ω /45m Ω	1.4M		
RAA211320	4.5V to 30V	2A	0.765V \pm 0.015V	150m Ω /75m Ω	450K		



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

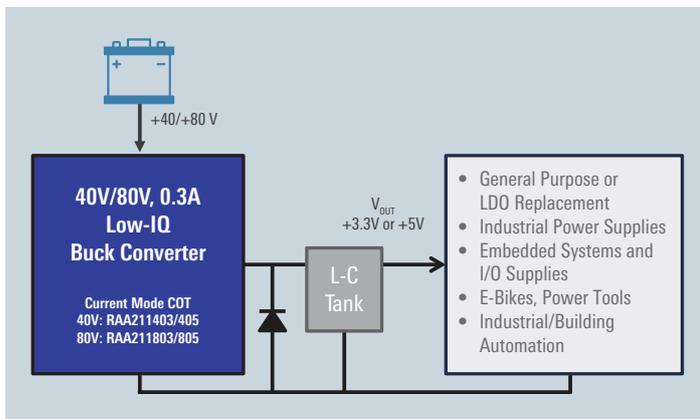
■ Features

- Wide V_{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 = 4/5.5 μ A** at 40/80V, under no-load conditions, switching
 - **IQ = 2.5/4.5 μ A** at 40/80V, under no-load conditions, switching

■ Block Diagram



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

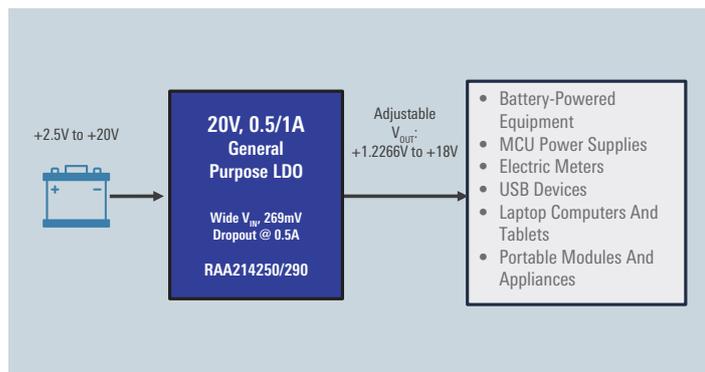
■ Features

- 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 1 μ F - 200 μ F MLCC output capacitor

■ Benefits

- 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

■ Block Diagram



RAA214020 Low-Noise LDO for Sensitive Circuitry

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

Excellent Noise Performance

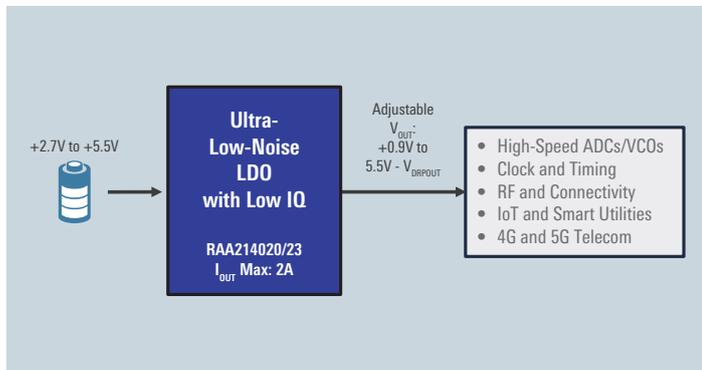
Features

- Input voltage range: 2.7V to 5.5V
- Max. output current: 2A
- Max. dropout voltage: 540mV at 2A and 3.3 V_{OUT}
- Low RMS output noise: 6.3μVRMS (10Hz to 100kHz)
- Output voltage adjustable: 0.9V to 5.5V-V_{DROPOUT}
- 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 22μF ceramic capacitor
- Built-in Power-Good feature
- **RAA214020** Resistor network to set output.
- **RAA214023** Output programmed by connecting pins to ground or resistive divider network.

Block Diagram



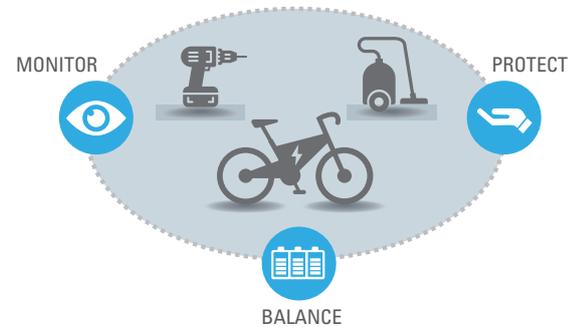
KEY PRODUCTS

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

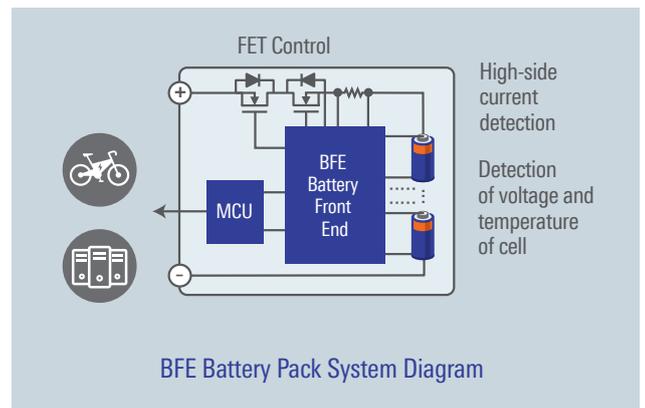
Benefits and Key Features

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



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.

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

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.

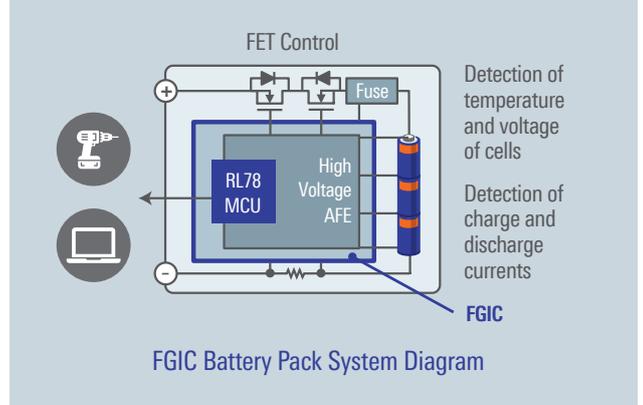
Benefits and Key Features

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



KEY PRODUCTS

Battery Management

FGIC Block Diagram

Voltage and Current Measurement by Independent A/D Converters

- Current detection: 153 $\mu\text{A}/\text{LSB}$ resolution (18-bit $\Delta\Sigma$ 5 m Ω shunt resistor) support for simultaneous measurement with virtually no temperature drift
- Voltage/temperature measurement: 15-bit $\Delta\Sigma$ ADC

High Reliability & High Integration

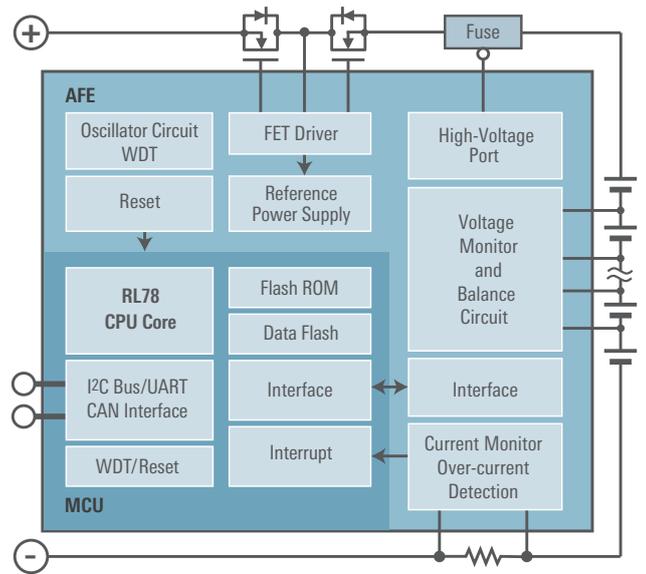
- Built-in FET protection for over-current or short circuit conditions
- Redundant fault detection by both MCU and AFE
- Ability to set lifecycle related limits and maintain battery parameter and operation history using data flash guaranteed for 100,000 erase/write cycles
- Integrated CAN interface and 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)



Internal Block Diagram of FGIC

* Specifications are subject to change without notice.

Battery Fuel Gauge ICs

	Cells	Pack Voltage (V)	Part No.	Flash ROM	RAM	Charge/Discharge FET Control	Serial Interface	I/O	Features	Package
NEW	1	2 to 5.5	RAA241200	64 KB	4.0 KB	Low side	I ² C, UART	7	Very compact package (1.871mm x 2.478mm) Very low power consumption (10 μA)	16WLPGA
NEW	2 to 4	2.2 to 25	RAJ240055	64 KB	4.0 KB	High side	I ² C, UART	12	Compact package (4mm x 4mm)	32QFN
			RAJ240057	128 KB	7.0 KB					
	2 to 5	4 to 25	RAJ240071	32 KB	1.5 KB	High side	I ² C, UART	11	Compact package (4mm x 4mm) 5-cell support	32QFN
			RAJ240075	64 KB	4.0 KB					
	3 to 8 3 to 10	4 to 50	RAJ240090	128 KB	7.0 KB	High/low side	I ² C, UART, CAN	31	High voltage tolerance, on-chip CAN, low power consumption (25 μA)	64LQFP
			RAJ240100							
NEW	3 to 7	4 to 40	RAJ240301	64 KB	5.5 KB	Low side	I ² C, UART	21	GPIO: I/O x 15, input x 2, NOD x 2, HVNOD x 2	48QFP
	3 to 10	8 to 50	RAJ240310	64 KB	4.0 KB	Low side	I ² C, UART	15	Compact package (5mm x 5mm) 10-cell support	40QFN

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.

Renesas Power Module

PWM
Controller

MOSFETs

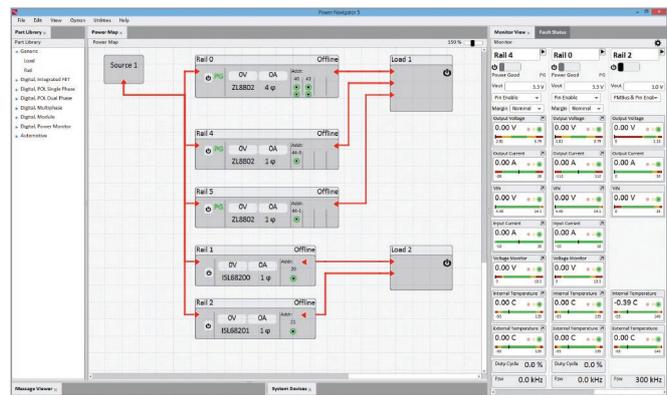
Inductor

Compensation

Real-Time Telemetry — Dynamic Configuration (Available in Digital Power Modules)



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

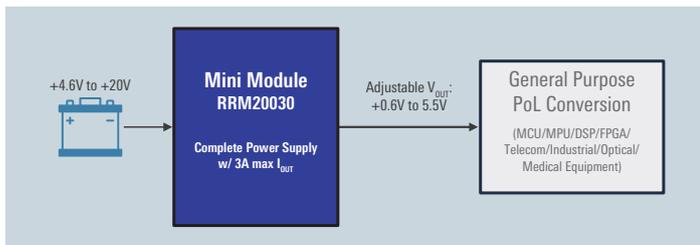
DC/DC Power Modules

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

■ Block Diagram



■ Benefits

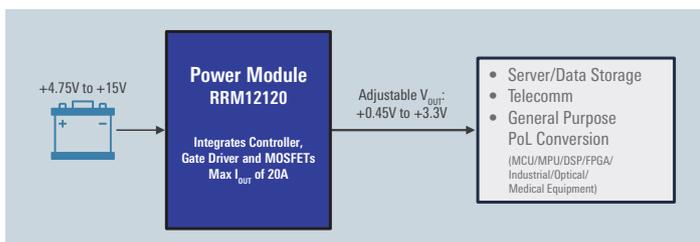
- Modules provide:
 - Ease-of-use
 - Fast time-to-market
 - First-pass success
- Supports wide range of custom applications.
- High efficiency improves thermals and reduces operating costs.
- Reduced board space (3mm x 2.8mm)

RRM12120

■ Features

- PMBus1.3-compliant, controller + SPS
- Wide operating range
 - Wide V_{IN} range: 4.75 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

■ Block Diagram



■ 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.

APPLICATION SOLUTIONS

Three-Level (T-TYPE) DC AC Inverter

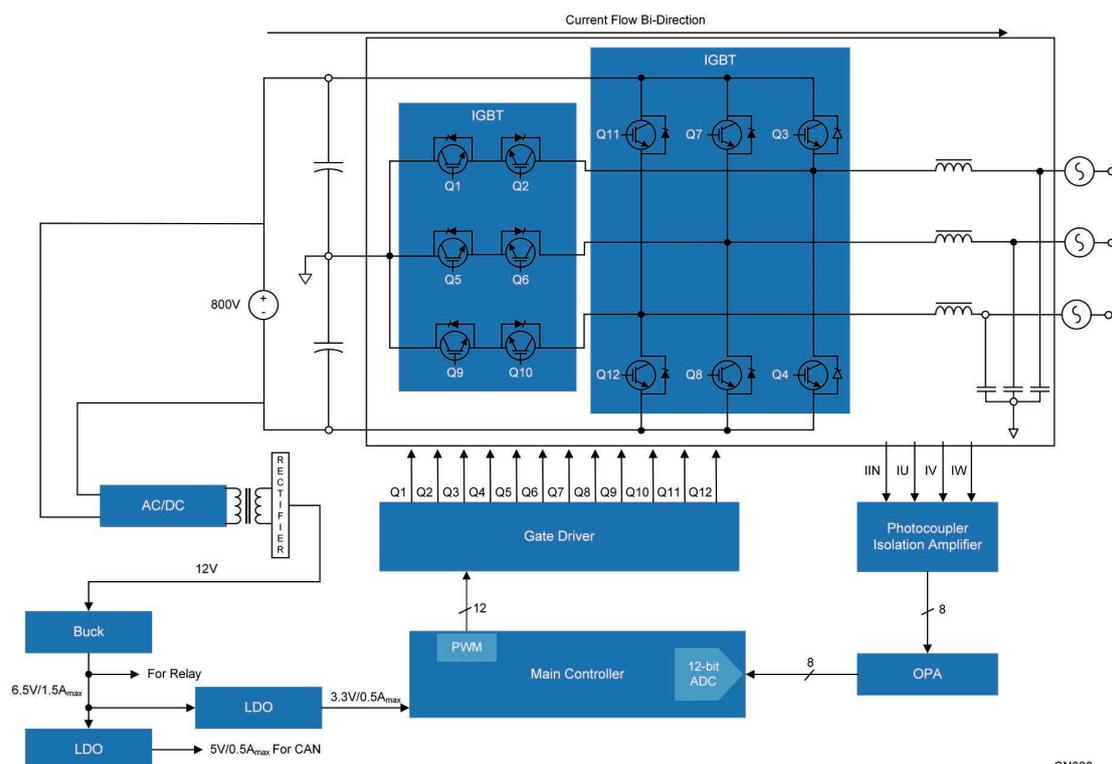
This solution is a digital control solution for photovoltaic power conditioners, uninterruptible power supply, and industrial three-phase DC/AC inverter power supply. The 3-level (T-type) circuit topology to a three-phase DC/AC inverter can improve system efficiency and reduce the size of the filter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

Reference Solution – System Benefits

- 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

ISL8844A	High Performance Industry Standard Single-Ended Current Mode PWM Controller
RAA211250	Integrated FET 30V, 5A Synchronous Buck Regulator with Internal Compensation and Programmable Frequency
RAA214250	20V, 500mA Linear Regulator
RV1S9231A	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
RBN75H65T1FPQ-A0	IGBT 650V 75A TO-247A Built-In FRD
RBN75H125S1FP4-A0	IGBT 1250V 75A TO-247plus Built-In FRD



CN028

APPLICATION SOLUTIONS

Smart Solar Battery Charger

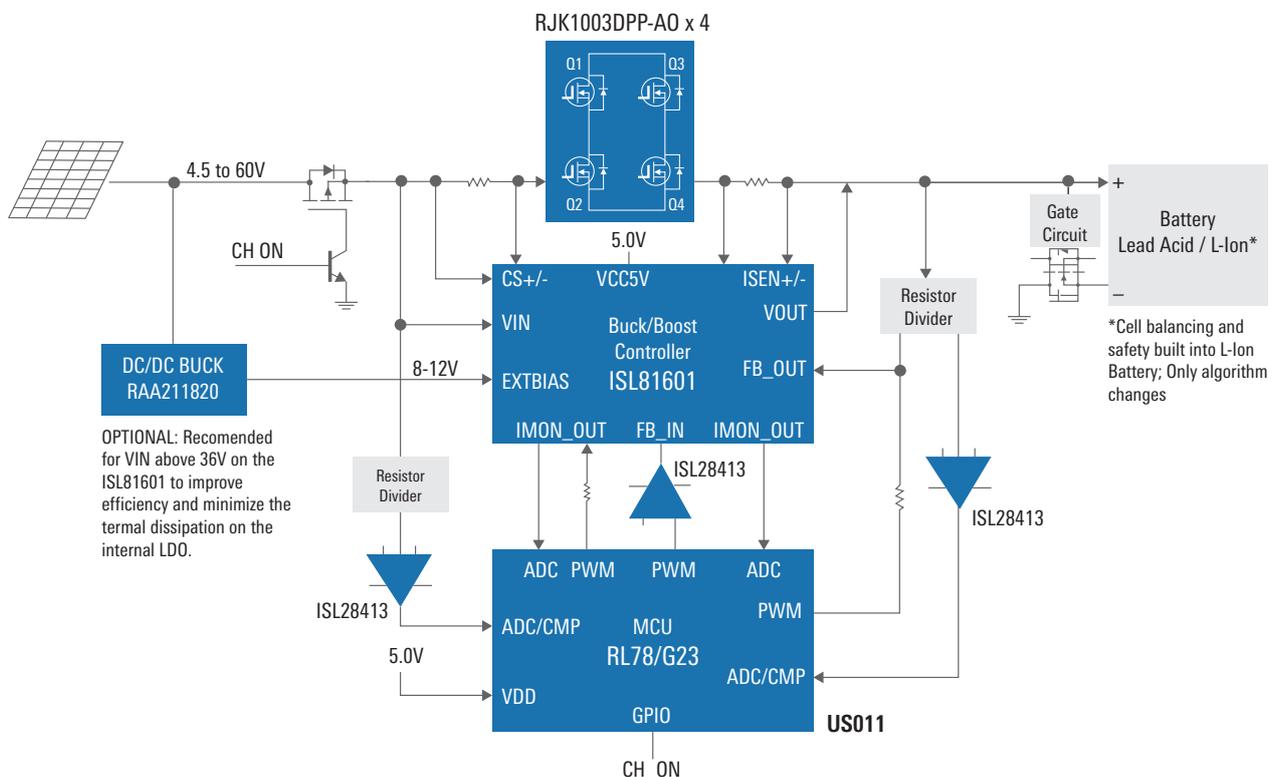
Using the green energy of solar to charge a battery is a very popular application. Solar cells produce a challenge, however, due to the wide variability of the output voltage depending upon the amount of solar energy directed at the panel, temperature and the load on the panel. This solution helps overcome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



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.

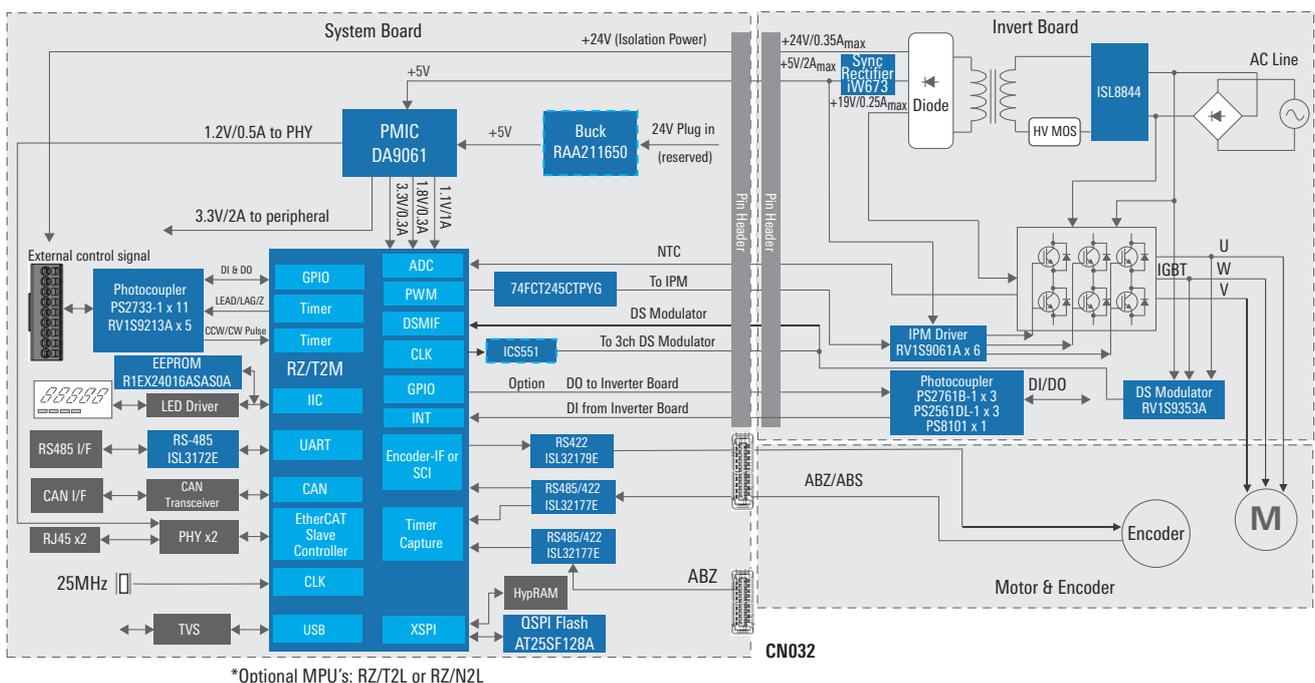
Reference Solution – System Benefits

- 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

RZ/T2M	High-performance Multi-function MPU Realizing High-speed Processing and High Precision Control for Industrial AC Servos and Controllers
RZ/N2L	Integrated TSN-Compliant 3-Port Gigabit Ethernet Switch Enables Various Industrial Applications to Easily Implement Industrial Ethernet and TSN
DA9061	PMIC Designed for Applications Requiring up to 6A Continuous Current
RAA211650	60V 5A Integrated Switching Regulator
ISL32177E	QUAD, ±16.5kV ESD Protected, 3.0V to 5.5V, RS-485/RS-422 Receivers

ISL32179E	Quad, ±16.5kV ESD Protected, 3.0V to 5.5V, Low Power, RS-422 Transmitters
ISL3172E	±15kV ESD Protected, 3.3V, Full Fail-Safe, Low Power, High Speed or Slew Rate Limited, RS-485/RS-422 Transceivers
RV1S9213A	IPM Drive Photocouplers (Optocouplers)
RV1S9353A	Optically Isolated Delta-Sigma Modulator
R1EX24016A	Two-wire serial interface 16k EEPROM (2-kword × 8-bit)
PS2761B-1	4-PIN SOP Photocoupler Operating Ambient Temperature 110°C
PS2561DL-1	DIP Photocoupler Operating Ambient Temperature 110°C
PS8101	1 Mbps, High CMR Analog Output Type 5-PIN SOP (SO-5) Photocoupler
RV1S9061A	IPM Drive Photocouplers (Optocouplers)
iW673	Digital Green-Mode Synchronous Rectifier Controller
AT25SF128A	128Mbit, 2.7V Minimum SPI Serial Flash Memory with Dual I/O Support
ISL8844A	High Performance Industry Standard Single-Ended Current Mode PWM Controller
RZ/T2L	High-Performance MPU Realizing High-Speed and High-Precision Real-Time Control with EtherCAT



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.

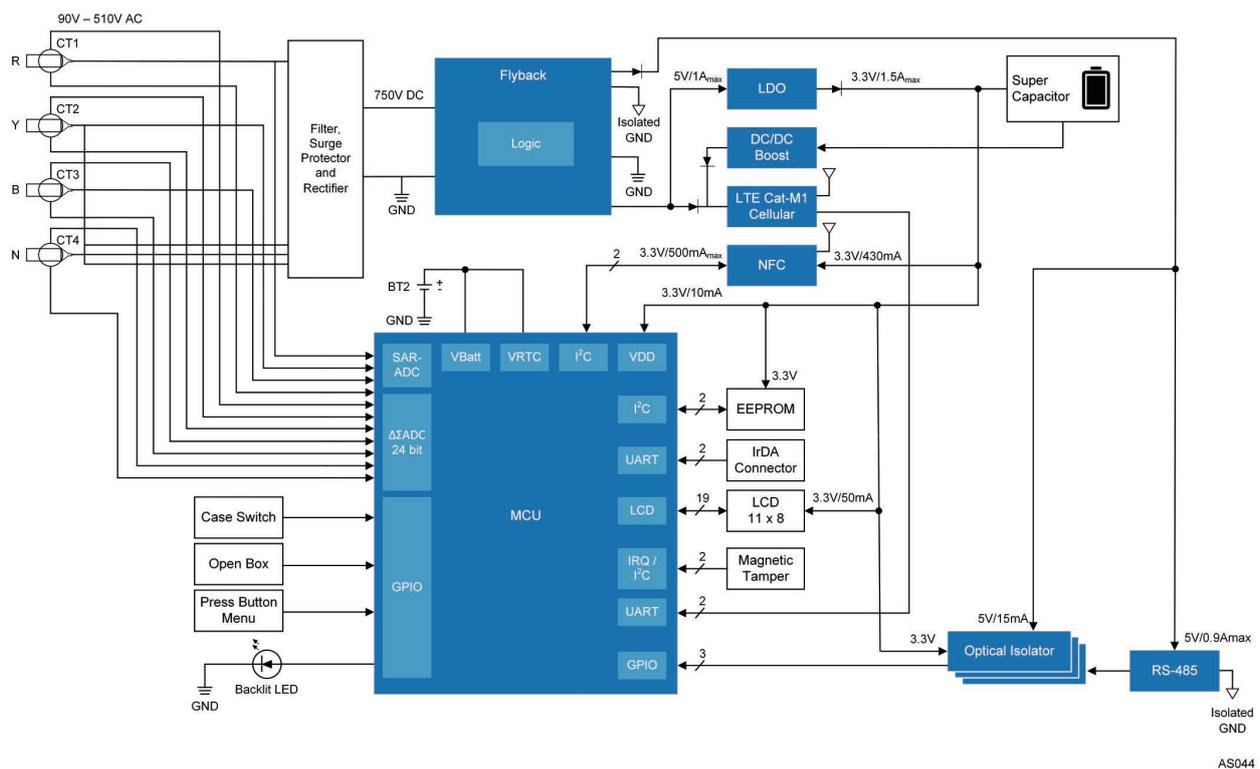
A tamper-proof and connected system provides a lot of advantages to users regarding information about their energy consumption.

Reference Solution – System Benefits

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

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.

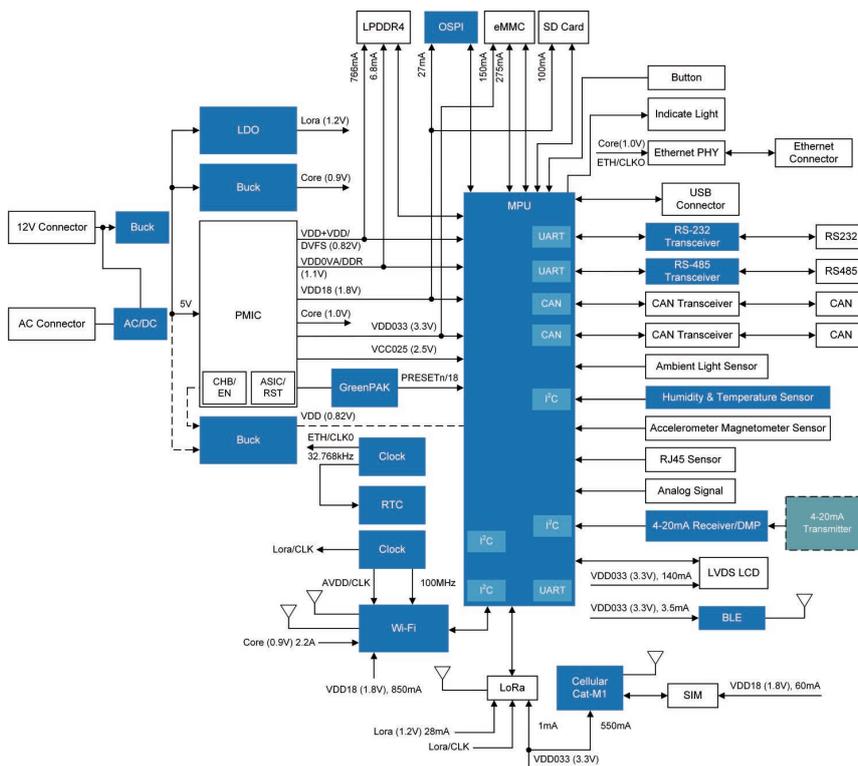
Reference Solution – System Benefits

- 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

ISL85005	4.5V to 18V Input, 5A High Efficiency Synchronous Buck Regulator
iW1825	700V AccuSwitch™ AC/DC Digital Primary-Side Converter with Configurable Light Load Mode for Applications up to 25W
ISL80030A	3A Synchronous Buck Converter in 2x2 DFN Package
DA9217	Configurable, 6A Dual-Phase SubPMIC for high performance mobile processors and memory

SLG46535	GreenPAK™ Programmable Mixed-signal Matrix with Asynchronous State Machine and Dual Supply
AT25QL128A	128Mbit, 1.7V Minimum SPI Serial Flash Memory with Dual I/O, Quad I/O and QPI Support
5P35023	VersaClock® 3S Programmable Clock Generator
ISL1208	I²C Real Time Clock/Calendar, Low Power RTC with Battery-Backed SRAM
RYZ014A	LTE Cat-M1 Cellular IoT Module
ICL3221E	±15kV ESD Protected, +3V to +5.5V, 1µA, 250kbps, RS-232 Transmitters/Receivers
ISL32601E	1.8V to 3.3V, Micro-Power, ±15kV ESD, +125°C, Slew Rate Limited, RS-485/RS-422 Transceivers
HS3001	High-Performance Relative Humidity and Temperature Sensor
ISL28022	Precision Digital Power Monitor
DA14531	SmartBond™ Ultra-Low Power Bluetooth® 5.1 System-on-Chip
RZ/G2N	Ultra-high Performance Microprocessors with Dual-core Arm® Cortex®-A57 (1.5 GHz) CPUs, with 3D Graphics and 4K Video Encoder/Decoder
ISL9003A	Low Noise LDO with Low IQ, High PSRR



APPLICATION SOLUTIONS

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.

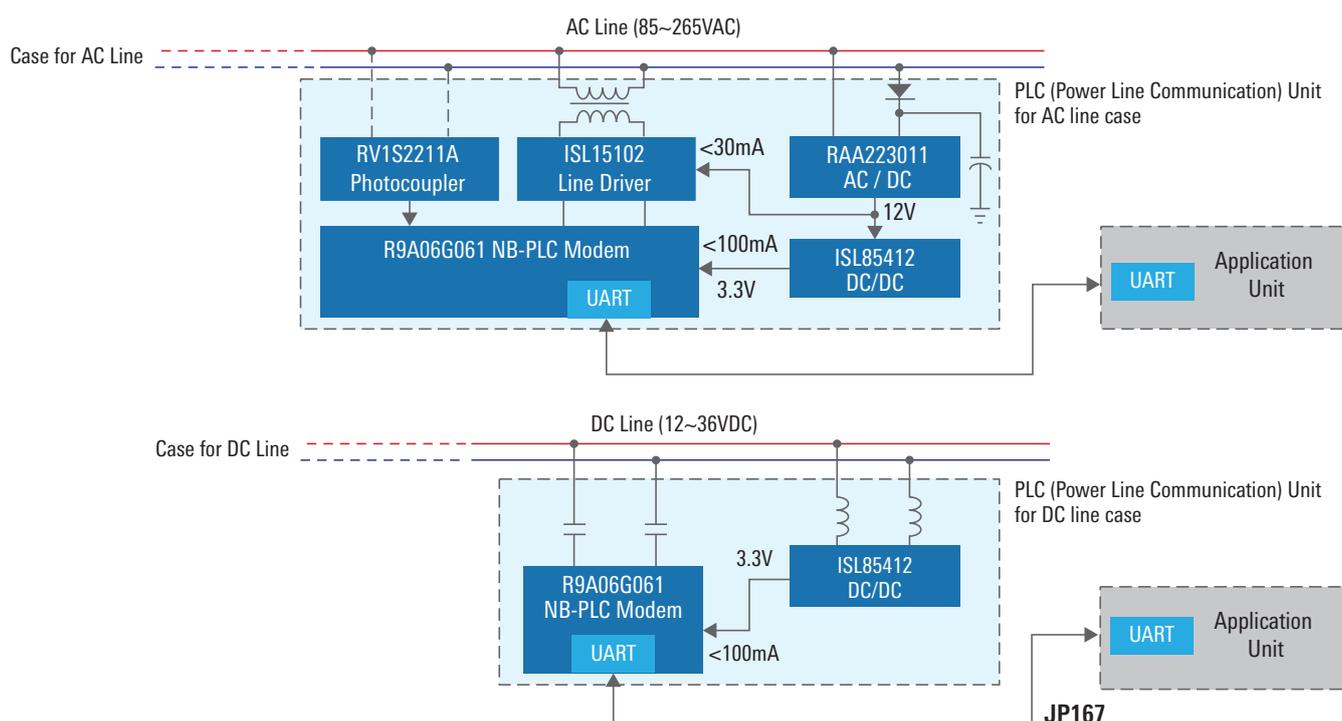
Renesas provides a narrow-band PLC modem IC, R9A06G061, which enables high-speed communication over 1Mbps and stable long-distance communication over 1km for peer-to-peer networks.

Reference Solution – System Benefits

- 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.

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



LOOK-UP TABLE WITH POWER ATTACHED

Industrial

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

RL78 Family

MCU Series & Simplified MCU Requirements*1	Input Source	Regulator Type	Part Number	CFP*2
RL78G (General Purpose) High-Speed Operation Mode, Max VDD, 105°C: 17.6mA (Nominal VDD: 1.6-5.5V)	Coin Cell	Low IQ Boost	ISL9116B	NO
	Li-ion Cell	Buck-Boost	ISL9122A	NO
RL78L (LCD Driver) High-Speed Operation Mode, Max VDD, 85°C: 8.5mA (Nominal VDD 1.6-5.5V)	USB or 5V Rail	Fixed Output Voltage LDO/Low Noise LDO	RAA214401/RAA214023	YES
	12 V Rail	Fixed Output Voltage LDO	RAA214401	YES
RL78/11E (ASSP Sensing) High-Speed Operation Mode, Max VDD, 125°C: 8.7mA (Nominal VDD: 2.4-5.5V)	24V Rail	Buck Converter	RAA214403	NO
	48V Rail	Buck Converter	RAA211605	YES
RL78/11D (ASSP Detector)/RL78/H1D (ASSP Medical) High-Speed Operation Mode, Max VDD, 105°C: 8.7 mA (Nominal VDD: 1.8-5.5V)	72V Rail	Buck Converter	RAA211803	NO
	AC Outlet 120/240 V	AC-DC Converter	RAA223012	YES

*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

MCU Series & Simplified MCU Requirements*1	Input Source	Regulator Type	Part Number	CFP*2
RX100/200 High-Speed Operation Mode, Max VDD, 85°C, All peripherals: 80mA (Nominal VDD 1.8-5.5V)	Coin Cell	Low IQ Boost	ISL9116B	NO
	Li-ion Cell	Buck-Boost	ISL9122A	NO
	USB or 5V Rail	Fixed Output Voltage LDO/Low Noise LDO	RAA214401/RAA214023	YES
	12 V Rail	Fixed Output Voltage LDO	RAA214401	YES
	24V Rail	Buck Converter	RAA214403	NO
	48V Rail	Buck Converter	RAA211605	YES
	72V Rail	Buck Converter	RAA211803	NO
RX600 (Mainstream) High-Speed Operation Mode, Max VDD, 105°C, Full operation: 270mA (Nominal VDD 2.7-5.5V) RX700 (Flagship) High-Speed Operation Mode, Max VDD, 105°C, Full operation: 319mA (Nominal VDD 2.7-5.5V)	AC Outlet 120/240 V	AC-DC Converter	RAA223012	YES
	Coin Cell	Low IQ Boost	ISL9116B	NO
	Li-ion Cell	Buck-Boost	ISL9122A	NO
	USB or 5V Rail	Buck Converter	RAA808013	YES
	12 V Rail	Buck Converter	RAA211230	YES
	24V Rail	Buck Converter	RAA211412	YES
	48V Rail	Buck Converter	RAA211605	YES
72V Rail	Buck Converter	RAA211820	NO	
	AC Outlet 120/240 V	AC-DC Converter	RAA223011	YES

*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

MCU Series & Simplified MCU Requirements*1	Input Source	Regulator Type	Part Number	CFP*2
RA2 (Arm® Cortex®-M23) High-Speed Operation Mode, Max VDD, 85°C: 28.5mA (Nominal VDD: 1.6-5.5V) RA4 (Arm® Cortex®-M4 or -M33) 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)	Coin Cell	Low IQ Boost	ISL9116B	NO
	Li-ion Cell	Buck-Boost	ISL9122A	NO
	USB or 5V Rail	Fixed Output Voltage LDO/Low Noise LDO	RAA214401/RAA214023	YES
	12 V Rail	Fixed Output Voltage LDO	RAA214401	YES
	24V Rail	Buck Converter	RAA214403	NO
	48V Rail	Buck Converter	RAA211605	YES
	72V Rail	Buck Converter	RAA211803	NO
RA6 (Arm® Cortex®-M4 or -M33) High-Speed Operation Mode, Max VDD, 105°C: 150mA (Nominal VDD: 2.7-3.6V)	AC Outlet 120/240 V	AC-DC Converter	RAA223012	YES
	Coin Cell	Low IQ Boost	ISL9116B	NO
	Li-ion Cell	Buck-Boost	ISL9122A	NO
	USB or 5V Rail	Buck Converter	RAA808013	YES
	12 V Rail	Buck Converter	RAA211320	YES
	24V Rail	Buck Converter	RAA211412	YES
	48V Rail	Buck Converter	RAA211605	YES
RA8 (Arm® Cortex®-M85) High-Speed Operation Mode, Max VDD, 125°C: 632mA (Nominal VDD: 1.68-3.6V) (both in DCDC mode and External VDD mode)	72V Rail	Buck Converter	RAA211820	NO
	AC Outlet 120/240 V	AC-DC Converter	RAA223011	YES
	Coin Cell	Low IQ Boost	ISL91117	NO
	Li-ion Cell	Buck-Boost	ISL91127	NO
	USB or 5V Rail	Buck Converter	RAA808013	YES
	12 V Rail	Buck Converter	RAA211250	YES
	24V Rail	Buck Converter	RAA211450	NO
48V Rail	Buck Converter	RAA211630	NO	
	72V Rail	Buck Converter	RAA211835	NO
AC Outlet 120/240 V	AC-DC Converter	RAA223021	YES	

*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

Industrial Network



RZ/N Series

Multi-protocol Industrial Ethernet with Redundancy + Linux/ RTOS

Vision AI



RZ/V Series

AI Accelerator + Linux



Industrial Realtime Control



RZ/T Series

Realtime Control + RTOS

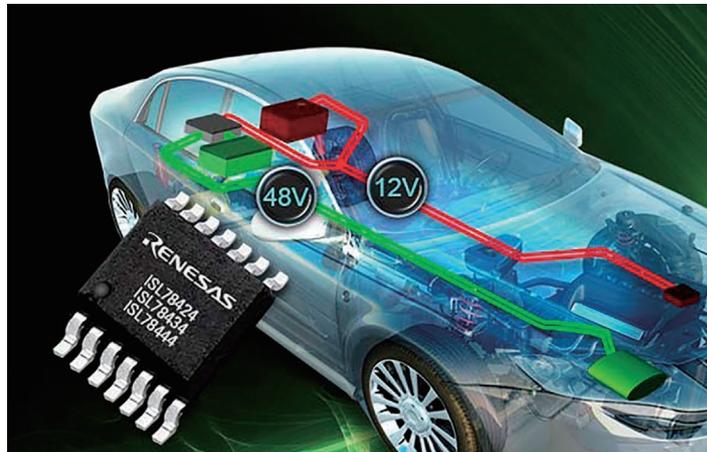
RZ MPU Series	MPU Target Application	Input Source	Regulator Type	Part Number
G2H, G2M	General HMI, IoT Gateway (Linux)	5 V (1S Battery, Pre-Regulator Output, 5V Supply Bus)	DA9092: 4xBucks, 4xLDO, RTC RAA215300: 6xBucks, 3xLDO, 1x1S CHRG DA9080: 4xBucks, 1xLDO, 1xGP ADC SLG51000	DA9092 + RAA215300 or DA9092 + DA9080 + SLG51000
G2N, G2E	General HMI, IoT Gateway (Linux)		RAA215300: 6xBucks, 3xLDO, 1x1S CHRG DA9080: 4xBucks, 1xLDO, 1xGP ADC DA9217: 1xDual-Phase Buck SLG51000: 6xLDO	RAA215300 or DA9080 + DA9217 + SLG51000
V2M, V2MA, V2L	Vision Artificial Intelligence		DA9281: 4xBucks, 3xLDO, DDR VTT RAA215300: 6xBucks, 3xLDO, 1x1S CHRG	RAA215300 or DA9281
G2L, G2LC	General HMI, IoT Gateway (Linux)		DA9281: 4xBucks, 3xLDO, RTC RAA215300: 6xBucks, 3xLDO, 1x1S CHRG	RAA215300 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

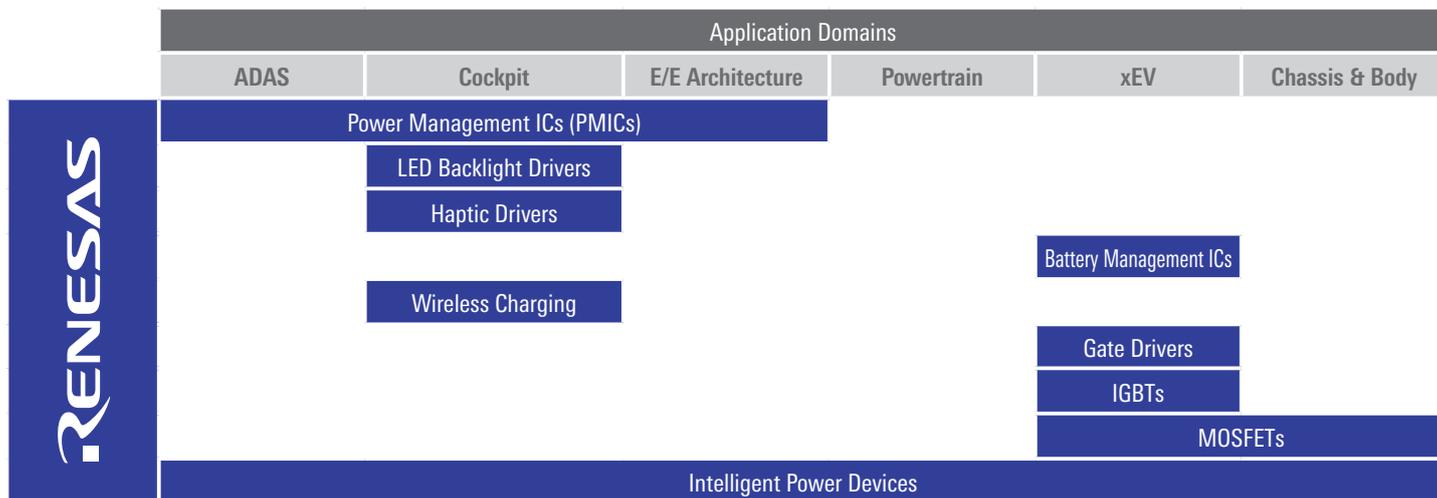
By joining forces, Renesas, Intersil, IDT and Dialog, have become leaders in embedded solutions and analog mixed-signal products, uniquely positioned to help customers succeed in developing innovative applications in the automotive segment.

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



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.

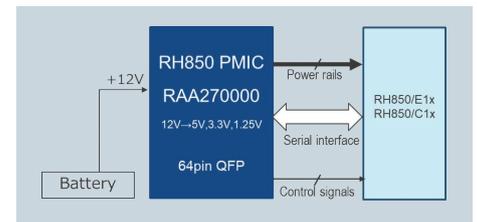
■ Features

- 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: $<\pm 2.0\text{mV}$) and long-term drift ($<\pm 6\text{mV}@6\sigma$ after 15 years on board). ASIL D Battery Management System (BMS) Design Solution available in combination with RH850/P1M.

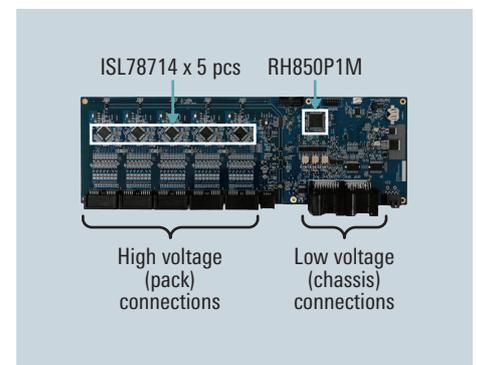
■ Features

- Best-in-class on-board accuracy ($\pm 2.5\text{mV} \pm 3\sigma$ post soldering)
- ISO 26262 ASIL D support
- $\pm 5\text{V}$ 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.

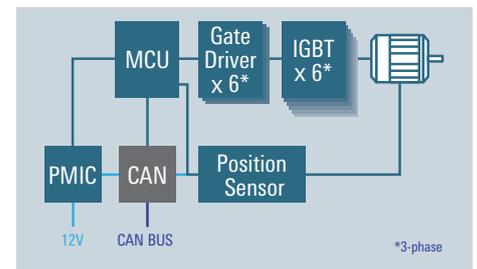
■ Features

- 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 WFOFN 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

Focusing on performance-driven applications to contribute to system innovation (high efficiency, down-sizing, robust design).

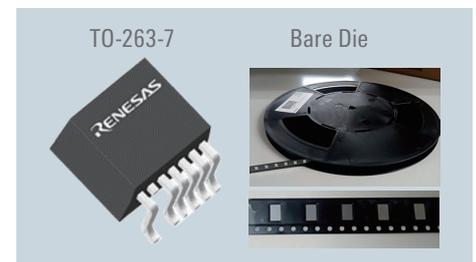
■ Features

- 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

■ Low Ron Package Tape & Reel



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

■ Thin Wafer Technology



Intelligent Power Devices (IPDs)

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

■ Features

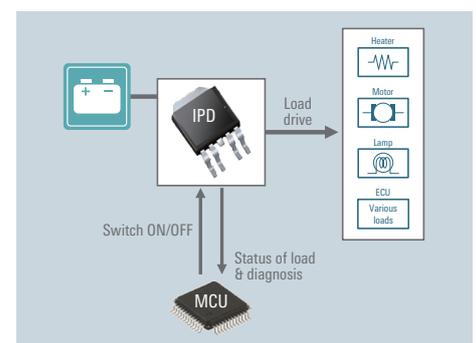
- Proven MOSFET and control chip technology in a single package
- Low ON-resistance and wide SOA
- Self-protection against short circuit, over-current, and over-temperature
- Self-diagnostic and monitoring functions
- High max operating temperature
- AEC-Q100 qualified and RoHS compliant

■ 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.



APPLICATION SOLUTIONS

EVs/HEVs



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.

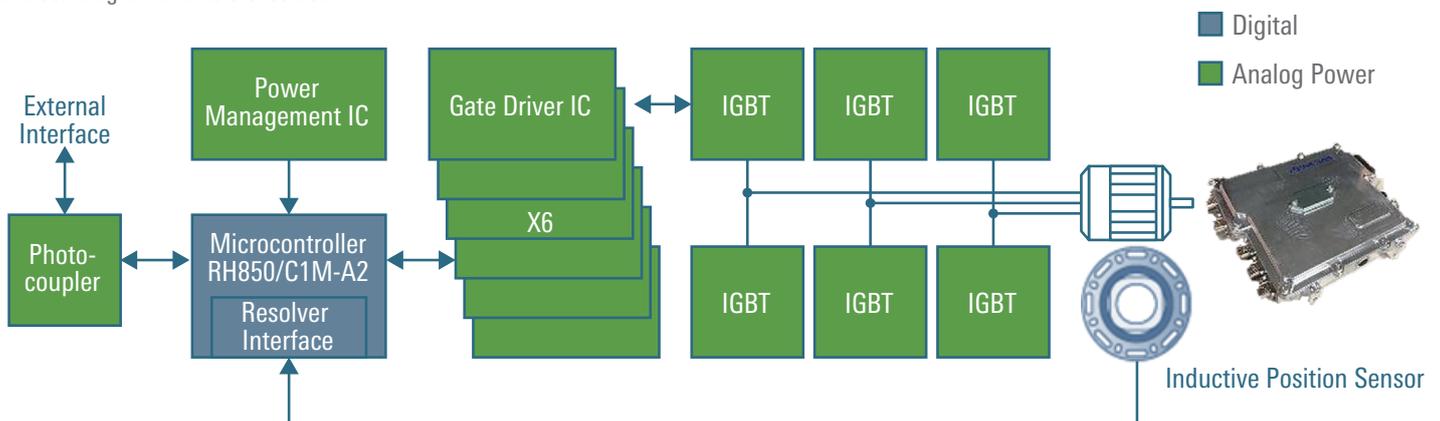
Reference Solution – System Benefits

- 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 dynamometer 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	32-bit microcontroller with embedded resolver interface and motor control IP
RAA270000	Power management IC (PMIC)
R2A25110	Gate driver IC
RJQ7031/RJU7032	IGBT and FRD
RV1S2752Q	Photocoupler

Block Diagram and Reference Board



APPLICATION SOLUTIONS

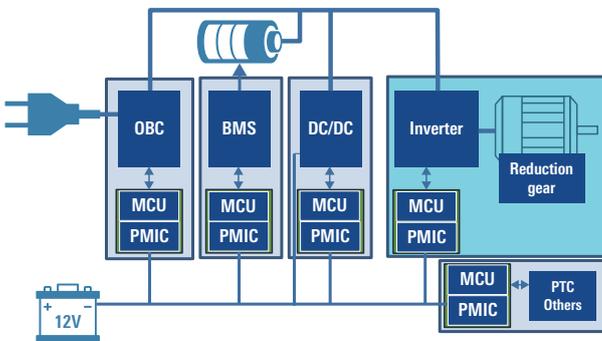
X-IN-1 System Integration

Reference Solution – System Benefits

- 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.

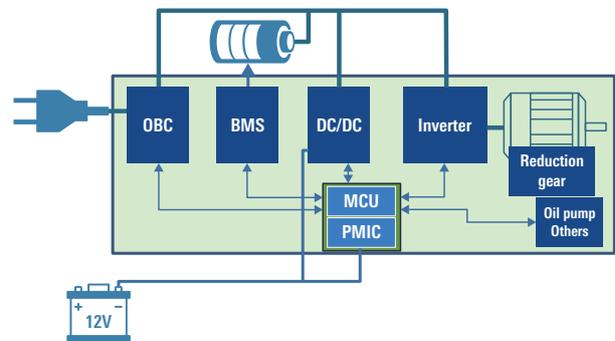
Conventional System

- 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

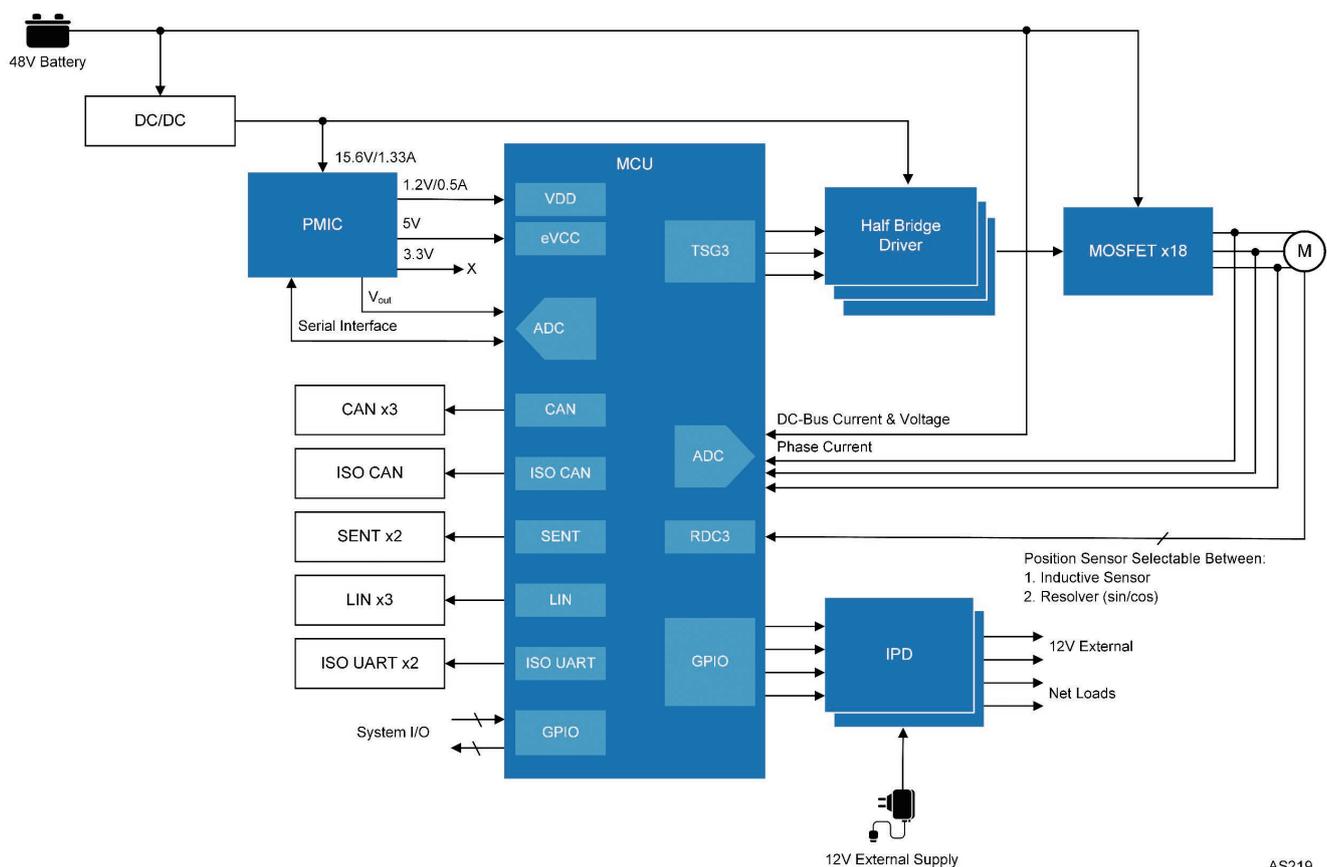
Renesas' Low Voltage Inverter for 2/3 Wheelers Traction Motor Control solution is a reference design based on an MCU and analog products for high-power 48V motor control applications. The design includes inverter hardware design files (schematics and Gerber) and peripheral sample code (for the motor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

Reference Solution – System Benefits

- 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.

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

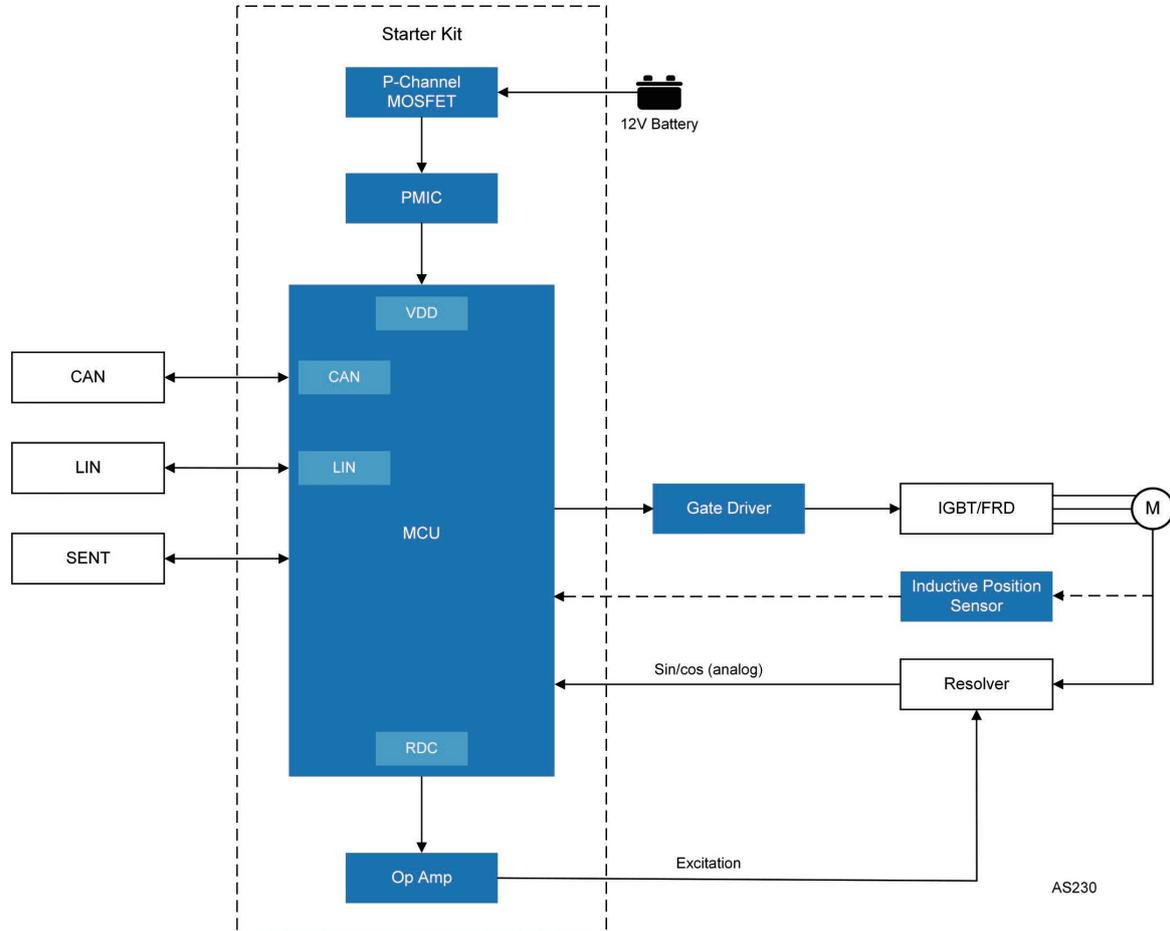
This system is a high-performance xEV traction motor and regeneration control solution using the RH850/C1M-Ax automotive microcontroller (MCU), supporting ASIL C and incorporating lock-step CPU cores and sophisticated motor control IP (EMU3).

Reference Solution – System Benefits

- 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.

BOM List for Reference Design

NP15P04SLG	Power MOSFETs for Automotive
RAA270000KFT	Power Management IC (PMIC) for Automotive RH850 MCUs
RH850/C1M-Ax	Microcontroller with G3MH CPU Core Ideal for HEV / EV Motor Control
UPC842AMP	Single Power Supply, High-speed, Wide Band, Dual Bipolar Operational Amplifier
R2A25110KSP	Gate Driver for HEV/EV
IPS2550	Inductive Position Sensor for High-Speed Motor Commutation (Automotive)



APPLICATION SOLUTIONS

Automotive Communication Gateway Platform

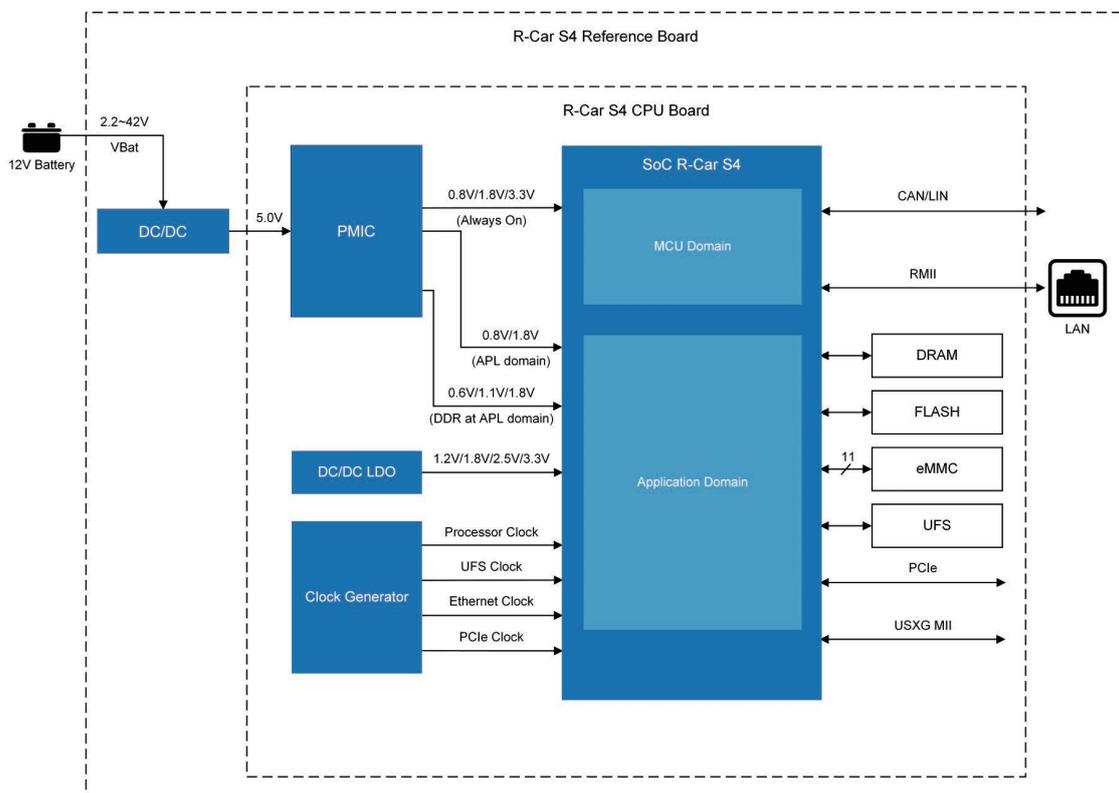
This solution provides a complete reference design with hardware and software for automotive gateway applications to support the electrical/electronic (E/E) architecture. It provides an integrated system that controls an ever-increasing number of vehicle functions in all areas of vehicle control.

Reference Solution – System Benefits

- 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.

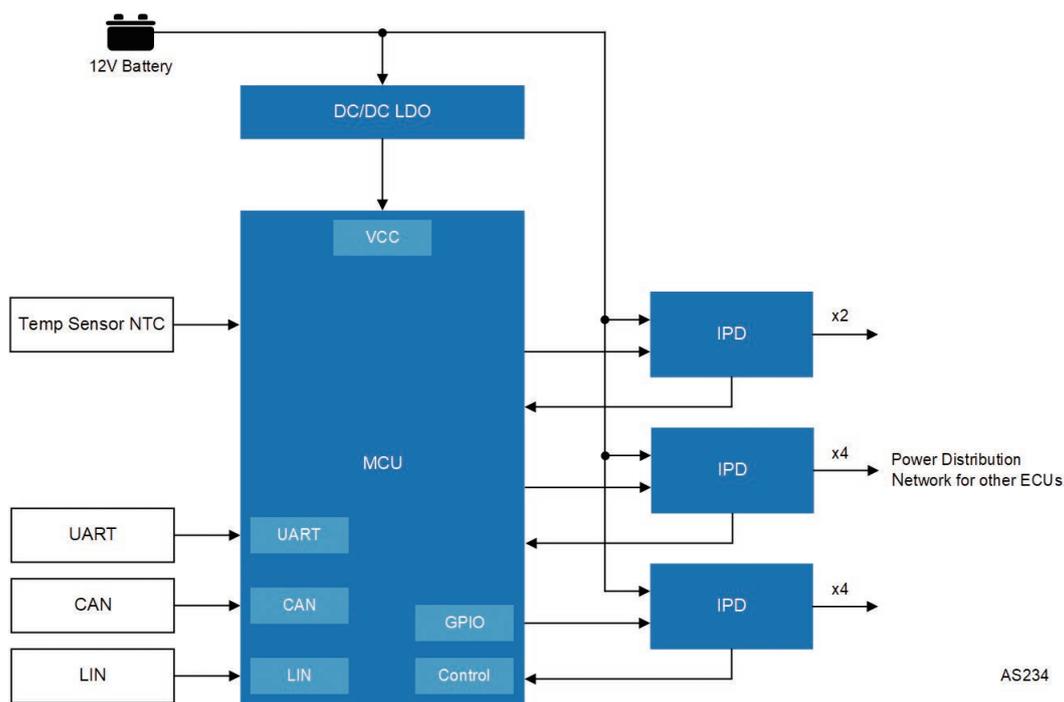
Reference Solution – System Benefits

- 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.

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

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



AS234

APPLICATION SOLUTIONS

Zone-ECU Virtualization Solution Platform

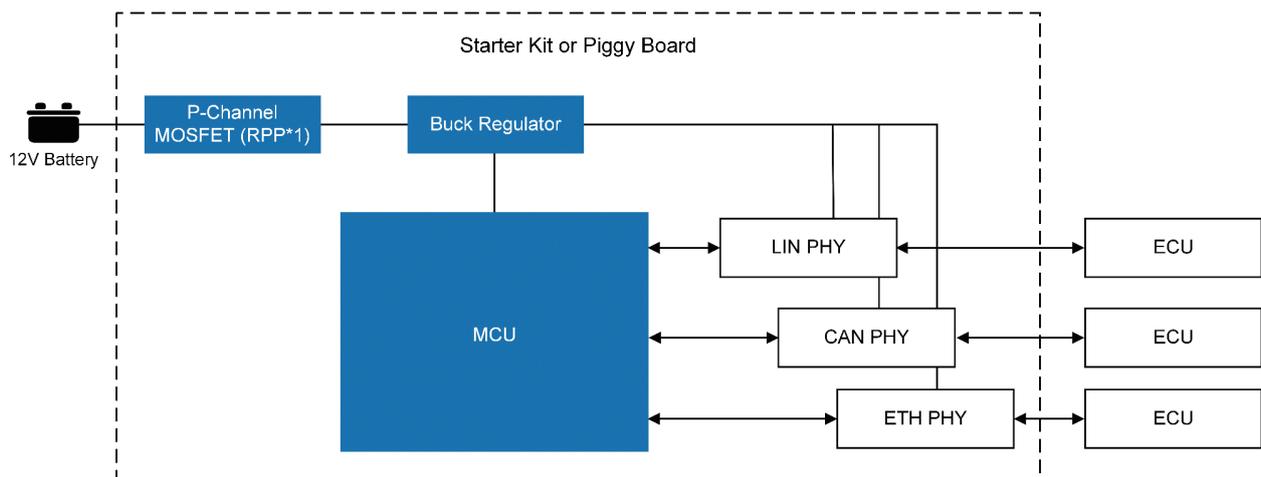
The RH850/U2x Zone-ECU Virtualization Platform is a development platform that provides a pre-integrated solution, including relevant software (SW) products and tools. This platform enables automotive customers to take a ready-to-go approach for individual Zone-ECU projects.

Reference Solution – System Benefits

- 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.

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



*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.

AS248

APPLICATION SOLUTIONS

High-End Cockpit & Infotainment Solution

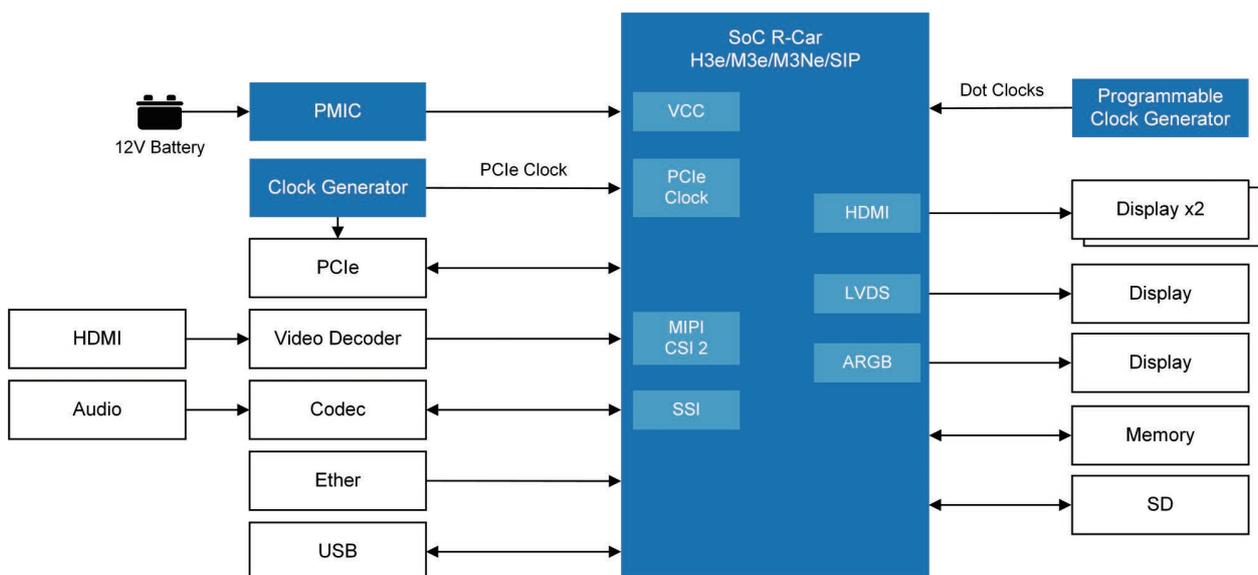
This combination of the R-Car (H3/M3/M3N) system-on-chip (SoC), power management IC (PMIC), and programmable clock generator allows for a versatile solution. They enable scalable cockpit and infotainment solutions that support high image quality, multiple video display outputs, and a wide variety of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

Reference Solution – System Benefits

- 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.

BOM List for Reference Design

DA9063-A	PMIC for Quad-Core Application Processors
DA9223-A	Automotive-Grade 0.8mm Pitch Multiphase Buck Converter
DA9224-A	Automotive-Grade 0.8mm Pitch Multiphase Buck Converter
9FGV0841	8-output 1.8 V PCIe Gen1–4 Clock Generator with $Z_0=100$ ohms
R-Car-H3e	R-Car H3/H3e/H3e-2G High-end Automotive System-on-Chip (SoC) for In-vehicle Infotainment and Integrated Cockpit
R-Car-M3Ne	R-Car M3N/M3Ne/M3Ne-2G Automotive System-on-Chip (SoC) Ideal for Medium-Class Automotive Computing Systems
R-Car-M3e	R-Car M3/M3e/M3e-2G Automotive System-on-Chip (SoC) Ideal for Medium-Class Automotive Computing Systems
5P49V60	VersaClock® 6E Programmable Clock Generator for Automotive



AS202

APPLICATION SOLUTIONS

ADAS Front Camera Solution

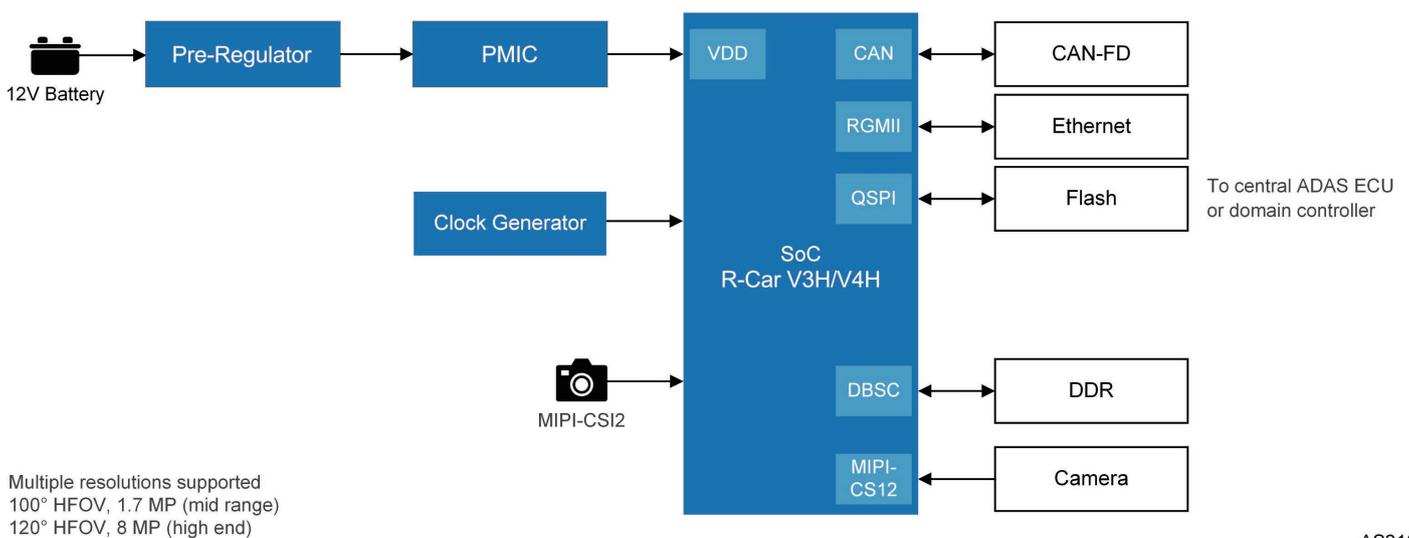
This open front camera solution features Renesas' R-Car V3H System-on-Chip (SoC). This all-in-one scalable camera platform targets the latest Euro New Car Assessment Program (NCAP) and Chinese Car Safety Assessment Program (C-NCAP) requirements, such as automatic emergency braking, forward collision 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
5P35023	VersaClock® 3S Programmable Clock Generator
5P49V60	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



LOOK-UP TABLE WITH POWER ATTACHED

Automotive

Power Attach for RH850 Family

MCU	ASIL (MCU)	PMIC	ASIL (Power)	Input Source	Regulator Type
RH850/F1x	ASIL B	RAA271082	ASIL B	12V Rail	Buck Converter
		Coming Soon	ASIL D		Buck/Boost
RH850/P1x	ASIL D	RAA271082	ASIL B	12V Rail	Buck Converter
		Coming Soon	ASIL D		Buck/Boost
RH850/C1x	ASIL D	RAA271082	ASIL B	12V Rail	Buck Converter
		Coming Soon	ASIL D		Buck/Boost
RH850/U2x	ASIL D	RAA271082	ASIL B	12V Rail	Buck Converter
		Coming Soon	ASIL D		Buck/Boost

Power Attach for R-Car Gen3

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

Power Attach for R-Car Gen4

SoC	ASIL (SoC)	PMIC	ASIL (Power)	Input Source	Regulator Type
R-Car S4	ASIL D	RAA271041	ASIL D	12V Rail	Buck/Boost
		RAA271005	ASIL D	5V Rail	Buck Converter
R-Car V4H	ASIL D	RAA271050	ASIL D	12V Rail	Buck Converter
		RAA271005 Coming Soon Coming Soon	ASIL D	5V Rail	Buck Converter Buck Controller Power Stage

Renesas Electronics Corporation TOYOSU FORESIA, 3-2-24 Toyosu, Koto-ku, Tokyo 135-0061, Japan

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