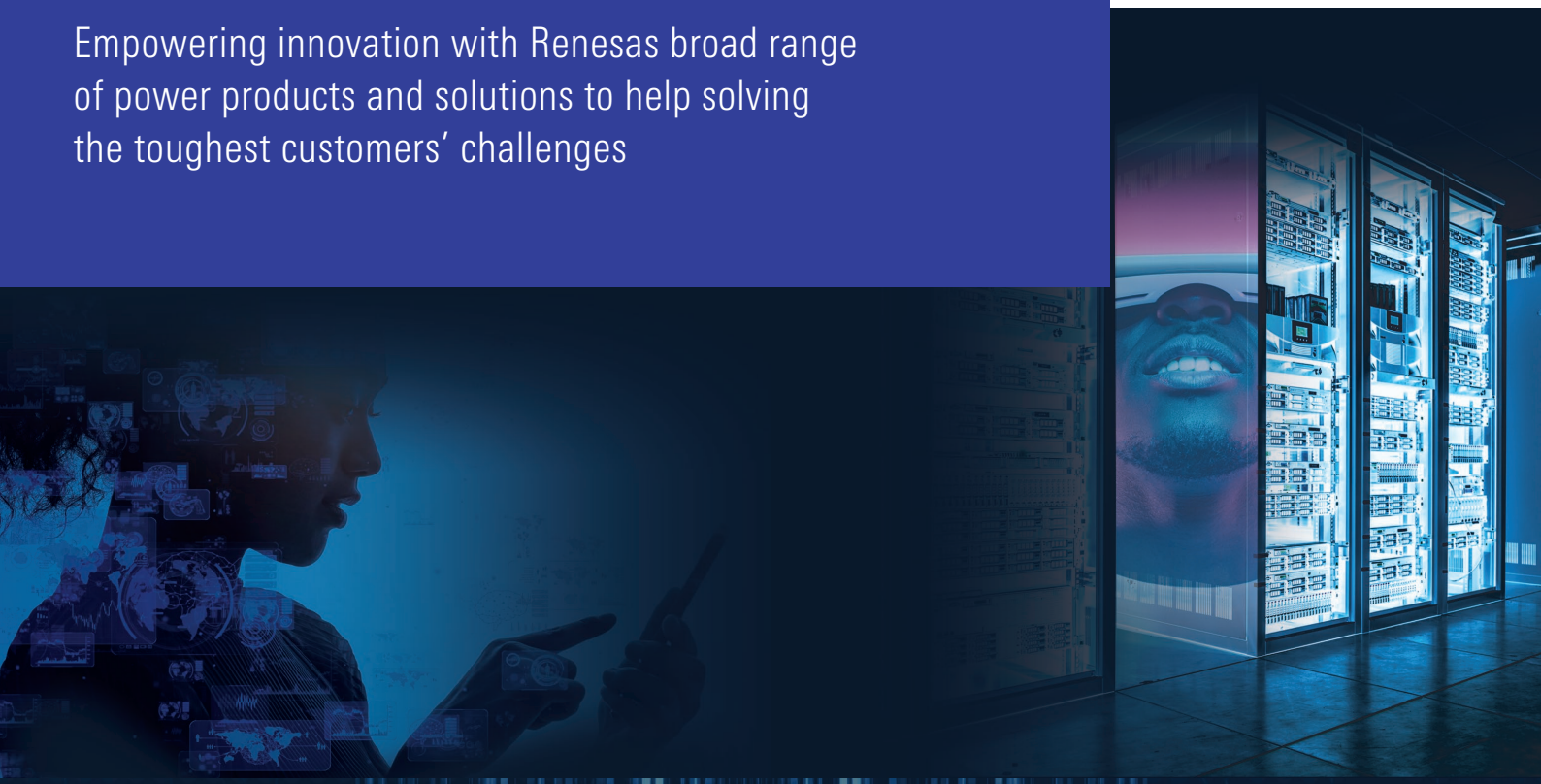
POWER PRODUCTS

Empowering innovation with Renesas broad range of power products and solutions to help solving the toughest customers' challenges



2025.06

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

PRODUCT PORTFOLIO

Discrete Power Devices

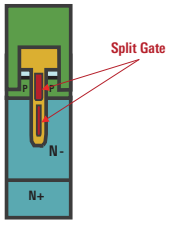
Renesas offers a comprehensive lineup of discrete and power devices tailored for today's industrial, automotive and consumers needs.
Our new REXFET Low and Medium Voltage MOSFET exploits Split-Gate technology to enhance both efficiency and power density in a cost-effective way, making them ideal for Motor Drive, Automotive 48V bus power delivery and conversion, server power supplies, and many other DC-DC related applications.
Our cutting-edge GaN devices take power density to new levels, offering outstanding switching speeds and reduced energy loss for infrastructure and computing market, e-Mobility applications, solar inverters, and Mass Market charging solutions.
Whether it's motor control, power conversion, or energy infrastructure, Renesas delivers the next generation of discrete that push the boundaries of performance and efficiency.

KEY PRODUCTS

Low and Medium Voltage MOSFET Families

Renesas new REXFET product family utilizing split gate technology achieve higher power density and efficiency and cost-effectiveness.

REXFET technology



- Split Gate (Shielded Gate) with narrow pitch technology
- Reduced gate-drain capacitance and gate resistance
- Higher power density and lower losses
- Improved long-term ruggedness and reliability
- Automotive AECQ and Industrial JEDEC qualified
- Suitable for both Motor Drive and Data Center / DC-DC applications
- Available in 3x3, 5x6, TOLL, TOLG packages

REXFET-1 100V/150V N-channel MOSFET in TOLL/TOLG/TOLT Package

Features

- AEC-Q101 Qualified product & PPAP support
- Automotive and industrial application
- 60% space reduction compared to D2PAK-7
- High current capability with TOLL/TOLG/TOLT packages options
- Standard Level gate threshold (VGS(th) = 2V - 4V)
- Best cost-performance combination with split gate technology

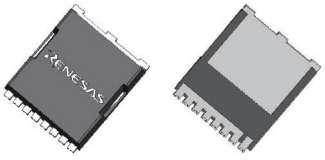
Benefits

- Standard package and pin out, allows for drop-in replacement
- TOLL w wettable flank for optical inspection
- TOLT for top-side cooling
- Enables higher power density designs

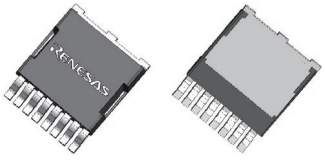
Typical Applications

- 36V, 48V, 72V, 96V system support
- Automotive:
  - 2- & 3-wheeler, E-bike, LEV, golf-cart, Forklift, OBC (DC-DC), etc.
- Industrial:
  - DC motor drive, gardening tool, drones, robotics, battery charger, telecom Battery Protection Unit, etc.

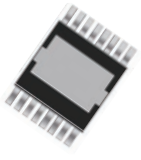
Part No.	Qualification	Package	VDSS	ID	Ron (max.)	Qg (typ.)
RBA300N10EANS-3UA02	Automotive	TOLL	100V	340A	1.5mΩ	170nC
RBA300N10EHPF-5UA02	Automotive	TOLG	100V	340A	1.5mΩ	170nC
RBE015N10R1SZQ4	Industrial	TOLL	100V	340A	1.5mΩ	170nC
RBE015N10R1SZPV	Industrial	TOLG	100V	340A	1.5mΩ	170nC
RBA200N15YANS-3UA03	Automotive	TOLL	150V	200A	3.4mΩ	96nC
RBA200N15YAPF-6UA03	Automotive	TOLT	150V	200A	3.4mΩ	96nC
RBA190N15YANS-3UA04	Automotive	TOLL	150V	190A	3.9mΩ	76nC
RBA190N15YAPF-6UA04	Automotive	TOLT	150V	190A	3.9mΩ	76nC
RBE034N15R1SZQ4	Industrial	TOLL	150V	200A	3.4mΩ	96nC
RBE034N15R1SZPW	Industrial	TOLT	150V	200A	3.4mΩ	96nC
RBE039N15R1SZQ4	Industrial	TOLL	150V	190A	3.9mΩ	76nC
RBE039N15R1SZPW	Industrial	TOLT	150V	190A	3.9mΩ	76nC



TOLL



TOLG



TOLT

KEY PRODUCTS

Low and Medium Voltage MOSFET Families

REXFET-1 100V N-channel MOSFET in SO8-FL Package

Features

- AEC-Q101 Qualified product & PPAP support
- Automotive and industrial application
- 80% space reduction compared to D2PAK
- Wettable flank for optical inspection
- Standard Level gate threshold (VGS(th) = 2V - 4V)
- Best cost-performance combination with split gate technology

Benefits

- Standard package and pin out, allows for drop-in replacement
- Increased power density with copper clip bonding
- Small footprint
- Outstanding package reliability

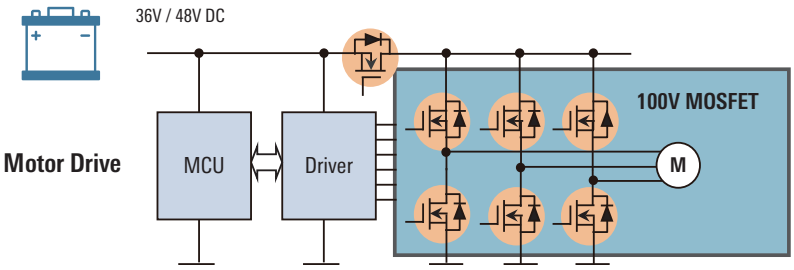
Typical Applications

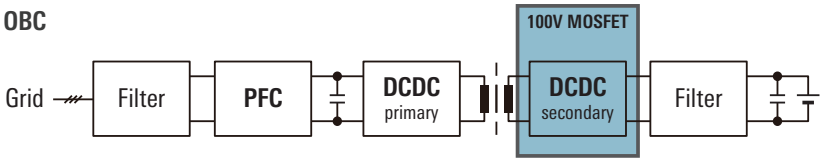
- 36V and 48V system
- Automotive:
  - Body electronics, DC-DC
- Industrial:
  - DC motor drive, gardening tool, drones, robotics, battery charger, telecom Battery Protection Unit, etc.

Part No.	Qualification	Package	VDSS	ID	Ron (max.)	Qg (typ.)
RBA160N10EANS-4UA03	Automotive	5x6 SO8-FL	100V	160A	2.9mΩ	90nC
RBA130N10EANS-4UA04	Automotive	5x6 SO8-FL	100V	130A	3.7mΩ	80nC
RBA80N10EANS-4UA07	Automotive	5x6 SO8-FL	100V	80A	6.7mΩ	43nC
RBA40N10EANS-5UA11	Automotive	3x3 µSO8-FL	100V	40A	11.1mΩ	28nC
RBA20N10EANS-5UA21	Automotive	3x3 µSO8-FL	100V	20A	21mΩ	18nC
RBE029N10R1SZN6	Industrial	5x6 SO8-FL	100V	160A	2.9mΩ	90nC
RBE037N10R1SZN6	Industrial	5x6 SO8-FL	100V	130A	3.7mΩ	80nC
RBE067N10R1SZN6	Industrial	5x6 SO8-FL	100V	80A	6.7mΩ	43nC
RBE111N10R1SZN2	Industrial	3x3 µSO8-FL	100V	40A	11.1mΩ	28nC
RBE210N10R1SZN2	Industrial	3x3 µSO8-FL	100V	20A	21mΩ	18nC

5x6 SO8-FL

3x3 SO8-FL





KEY PRODUCTS

Low and Medium Voltage MOSFET Families

ANL4 40V N-channel MOSFET in SO8-FL 5x6 Package

Features

- AEC-Q101 Qualified product & PPAP support
- Automotive and industrial application
- Small 5x6 SO8-Flat Lead package with copper clip
- Low Rds(on) to minimizing conduction loss
- Low input capacitance & Stable switching capability
- Standard Level gate threshold (VGS(th) = 2V - 4V)
- Lower surge and ringing voltage

Benefits

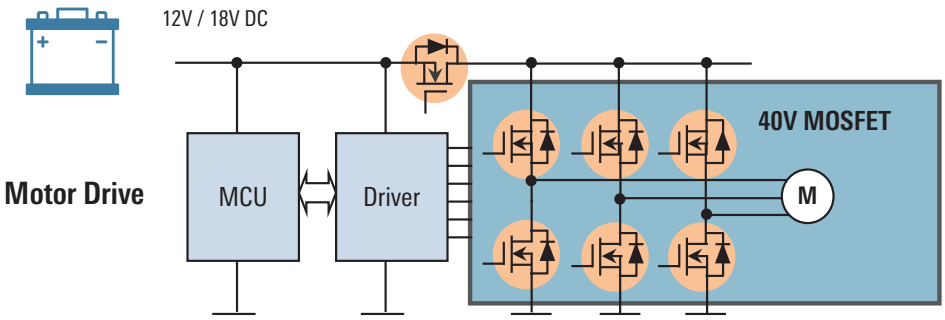
- Standard package and pin out, allows for drop-in replacement
- Easy to design, Easy to use
- High Efficiency, High Power, Low heat dissipation cost
- Easy to choose the best-fit for system needs

Typical Applications

- 12V and 18V system
- Automotive:
  - Electric Power Steering (EPS), Electric Braking (ABS), Injection system
  - Pump, Fans, Ventilation, Seat Adjustment, Sunroof, etc.
- Industrial:
  - DC motor drive, power tool, robotics, etc.

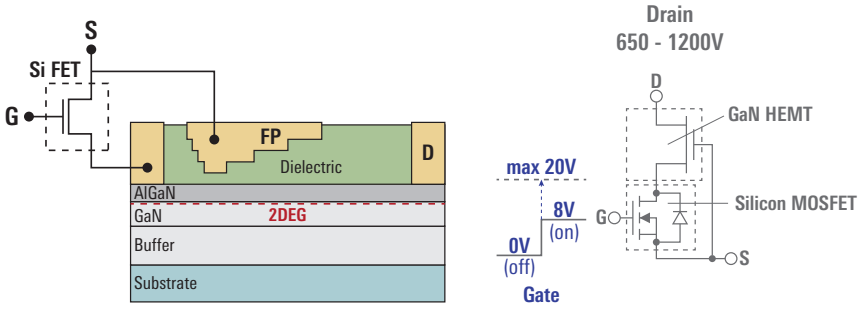
Part No.	Qualification	Package	VDSS	ID	Ron (max.)	Qg (typ.)
RBA100N04DANS-4UB02	Automotive	5x6 SO8-FL	40V	100A	2mΩ	83nC
RBA100N04DANS-4UA02	Automotive	5x6 SO8-FL	40V	100A	2.3mΩ	60nC
RBA80N04DANS-4UB03	Automotive	5x6 SO8-FL	40V	80A	3mΩ	56nC
RBA80N04DANS-4UA04	Automotive	5x6 SO8-FL	40V	80A	3.5mΩ	40nC
RBA50N04DANS-4UB05	Automotive	5x6 SO8-FL	40V	50A	5mΩ	34nC
RBA50N04DANS-4UA06	Automotive	5x6 SO8-FL	40V	50A	5.8mΩ	24nC
RBA30N04DANS-4UB10	Automotive	5x6 SO8-FL	40V	30A	10mΩ	19nC
RBE020N04R0SZN6	Industrial	5x6 SO8-FL	40V	100A	2mΩ	83nC
RBE023N04R0SZN6	Industrial	5x6 SO8-FL	40V	100A	2.3mΩ	60nC
RBE030N04R0SZN6	Industrial	5x6 SO8-FL	40V	80A	3mΩ	56nC
RBE035N04R0SZN6	Industrial	5x6 SO8-FL	40V	80A	3.5mΩ	40nC
RBE050N04R0SZN6	Industrial	5x6 SO8-FL	40V	50A	5mΩ	34nC
RBE058N04R0SZN6	Industrial	5x6 SO8-FL	40V	50A	5.8mΩ	24nC
RBE100N04R0SZN6	Industrial	5x6 SO8-FL	40V	30A	10mΩ	19nC

5x6 SO8-FL



KEY PRODUCTS
GaN

Renesas is at the forefront of semiconductor innovation with its advanced GaN (Gallium Nitride) HEMT power devices, delivering cutting-edge performance for next-generation applications. Our GaN solutions are engineered to offer ultra-fast switching speeds, dramatically increased power density, and lower energy losses, making them ideal for high-efficiency power conversion.

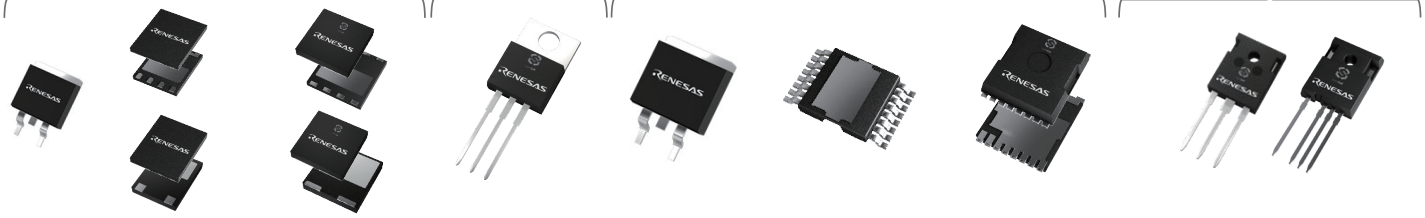


Renesas Cascode D-GaN: Cross-section and device structure

- Renesas D-Mode GaN (Depletion-mode Gallium Nitride) devices deliver unmatched performance while simplifying your design process.
- Pair seamlessly with standard MOSFET drivers, our GaN technology significantly reduces R&D time, accelerating your path to market.
- Built for reliability, Renesas GaN devices are rigorously qualified to meet JEDEC industrial standards and AEC-Q101 automotive certifications.
- Ensuring top-tier performance across a wide range of demanding applications.

Widest GaN package offering in the market – Multiple $R_{DS(ON)}$ ratings per package for scaling

30 W to 250 W | 0.2 kW to 2 kW | 1 kW to 3 kW | 1 kW to 10+ kW



DPAK	PQFN56	PQFN88	TO-220	D²PAK	TOLT	TOLL	TO-247-3	TO-247-4
480 mΩ*2	480 mΩ	480 mΩ	240 mΩ*2	50 mΩ	72 mΩ	85 mΩ	50 mΩ	50 mΩ
240 mΩ*2	240 mΩ	240 mΩ	150 mΩ		30 mΩ*2	72 mΩ	35 mΩ*1	35 mΩ
	150 mΩ	150 mΩ	85 mΩ			50 mΩ	30 mΩ	
		85 mΩ	72 mΩ			35 mΩ	15 mΩ	
		72 mΩ				30 mΩ*2		

*1: Includes AEC-Q101
*2: Sampling now

KEY PRODUCTS

GaN

TP65H070G4RS - 650V GaN FET

70mΩ, TOLT Package

Features

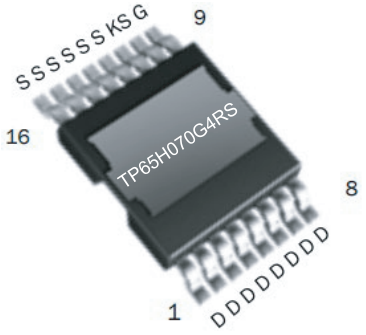
- Gen IV technology
- JEDEC-qualified GaN technology
- Robust design, defined by
  - Wide gate safety margin
  - Transient over-voltage capacity
- Very low Q_{RR}
- Reduced crossover loss
- Top-side cooling
- RoHS compliant, Halogen-free packaging

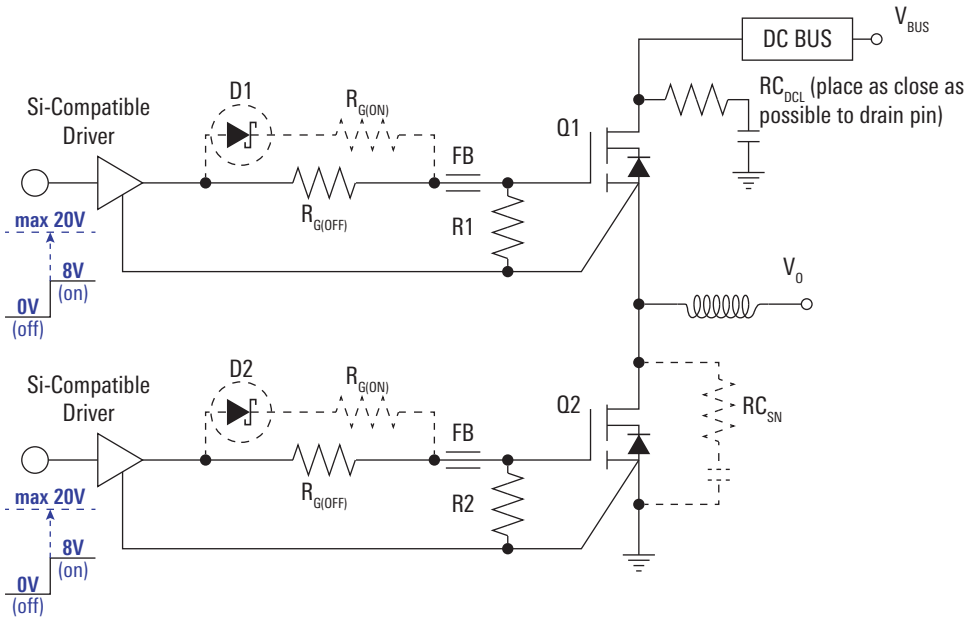
Benefits

- Achieved increased efficiency in both hard and soft – switching circuits
  - Increased power density
  - Reduced system size and weight
  - Overall lower system cost
- Easy to drive with commonly-used gate drivers
- GSD pin layout improves high speed design

Typical Applications

- Datacom
- Broad Industrial
- PV Inverter
- Servo motor
- Computing





KEY PRODUCTS

GaN

TP65H035G4QS, TP65H050G4QS, TP65H070G4QS - 650V GAN FET

35/50/70mΩ, TOLL Package

Features

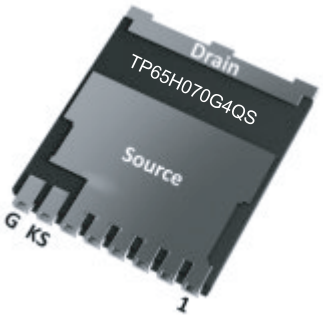
- JEDEC qualified GaN technology
- Dynamic $R_{DS(on)eff}$ production tested
- Robust design, defined by
  - Wide gate safety margin
  - Transient over-voltage capacity
- Very low Q_{RR}
- Reduced crossover loss
- Kelvin source for low inductance gate return path

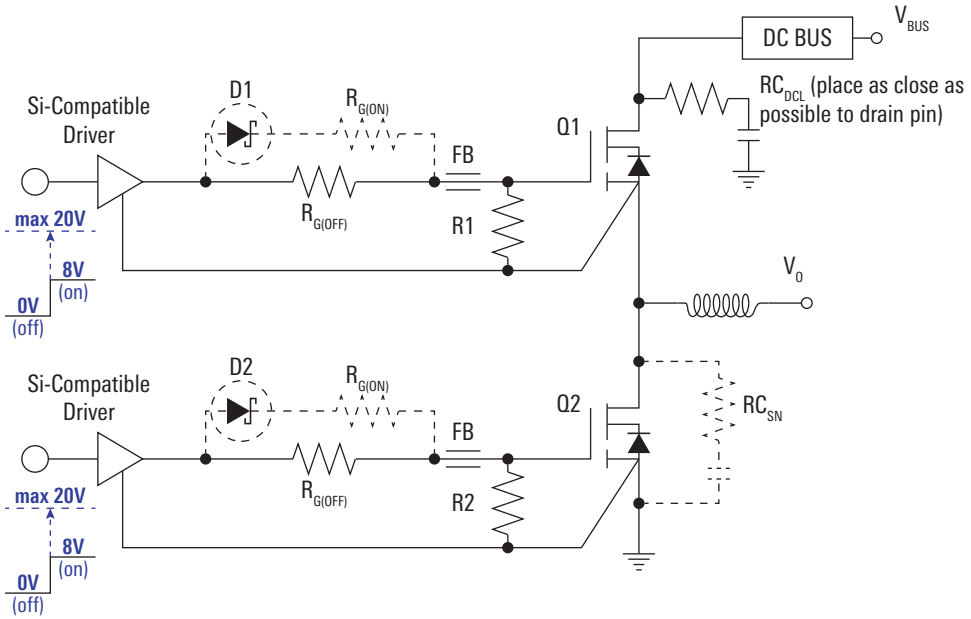
Benefits

- Enables AC-DC bridgeless totem-pole PFC designs
  - Increased power density
  - Reduced system size and weight
  - Overall lower system cost
- Achieved increased efficiency in both hard and soft – switching circuits
- Easy to drive with commonly-used gate drivers
- GSD pin layout improves high speed design
- Pin-to-pin drop-in with e-mode GaN

Typical Applications

- Infrastructure
- Broad Industrial
- PV Inverter
- Servo motor





KEY PRODUCTS

GaN

TP65H480G4JSGB - 650V GAN FET

480mΩ, 5x6 QFN

Features

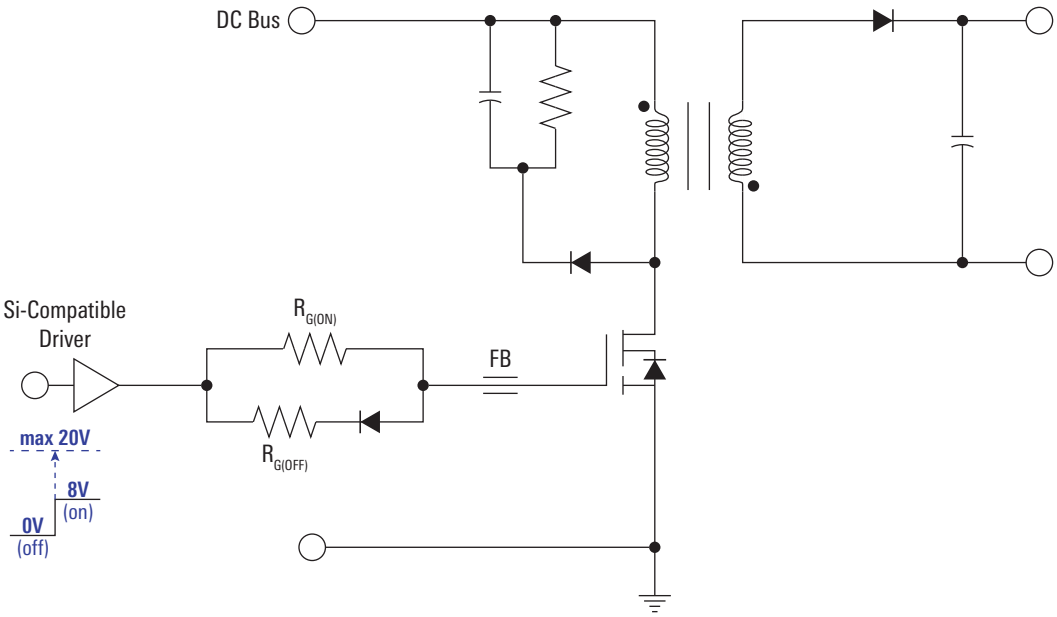
- Gen IV technology
- JEDEC-qualified GaN technology
- Robust design, defined by
  - Wide gate safety margin
  - Transient over-voltage capacity
- Very low Q_{RR}
- Reduced crossover loss
- RoHS compliant, Halogen-free packaging

Benefits

- Achieved increased efficiency in both hard and soft – switching circuits
  - Increased power density
  - Reduced system size and weight
  - Overall lower system cost
- Easy to drive with commonly-used gate drivers
- GSD pin layout improves high speed design

Typical Applications

- Consumer
- Power adapters
- Low Power SMPS
- Lighting

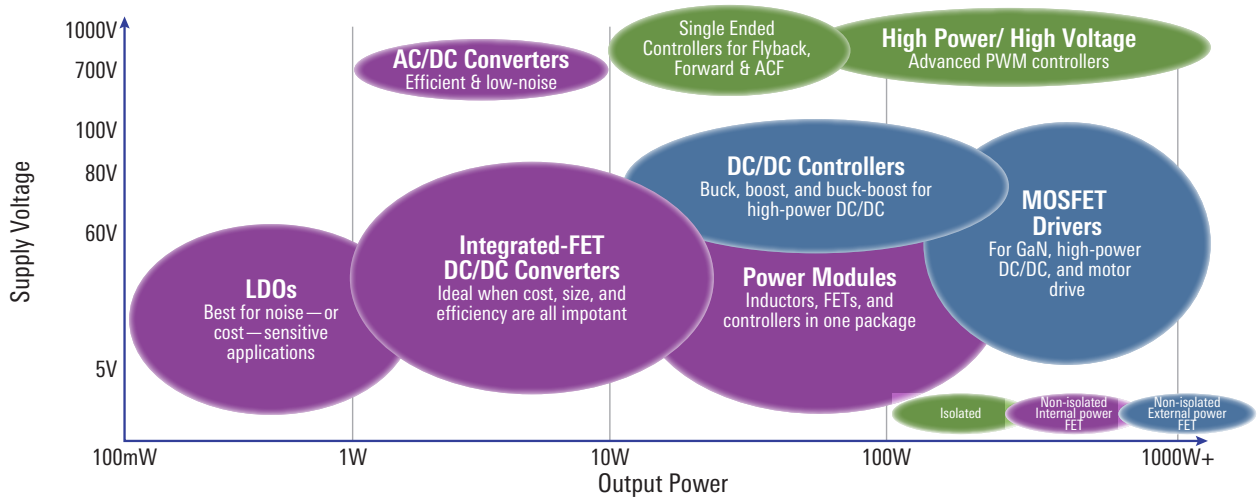


PRODUCT PORTFOLIO

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.

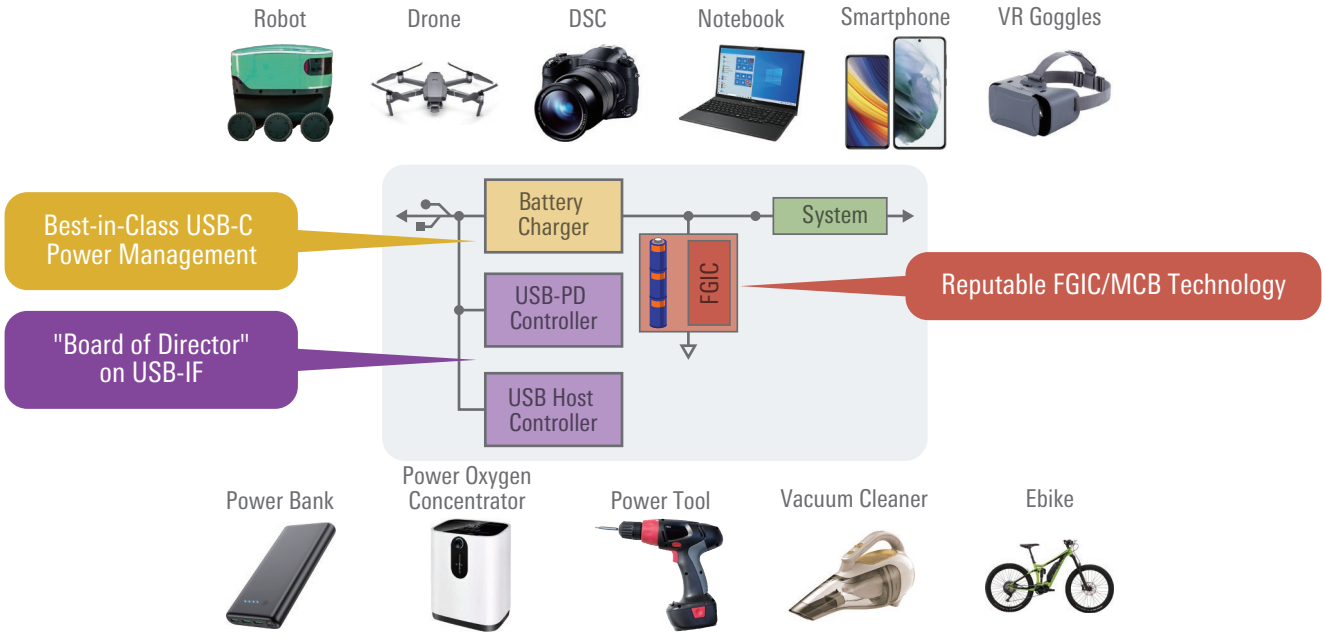
FROM MILLIWATTS TO KILOWATTS, WE CAN SUPPORT YOUR APPLICATIONS.



PRODUCT PORTFOLIO

Complete Industrial Battery Management Solutions

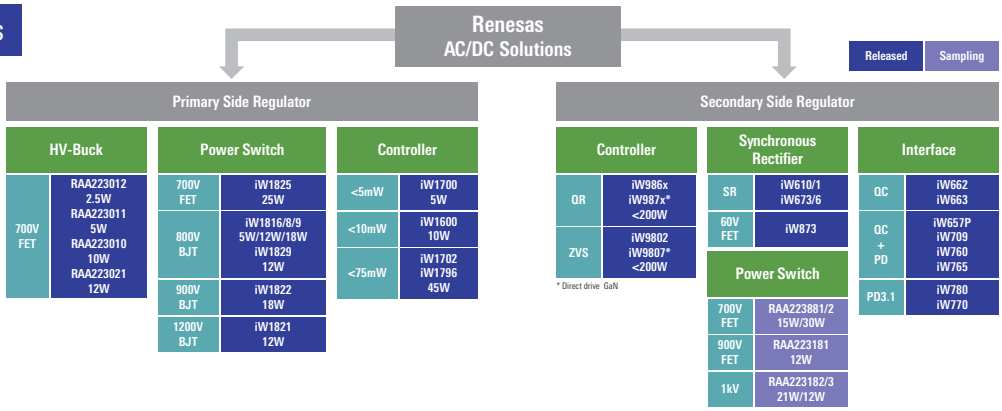
Renesas offers a full range of high-performance solutions for charger ICs, USB-PD applications, fuel gauge ICs, and battery frontend ICs to cover consumer, computing, and industrial applications using batteries from one cell to many cells. Renesas battery management solutions are backed by tested reference 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 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
- Renesas quiet light-load PFM mode
  - No audible noise, even at light load
- Low standby power: 5 to 30mW
- Low EMI (conducted and radiated)
- Supports 3.3V or 5V output directly.
  - No second-stage LDO needed.

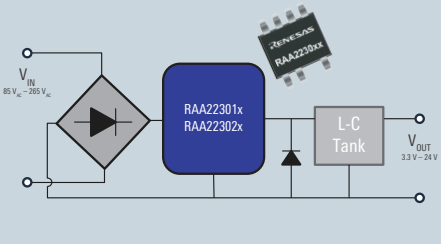
Features

- 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.

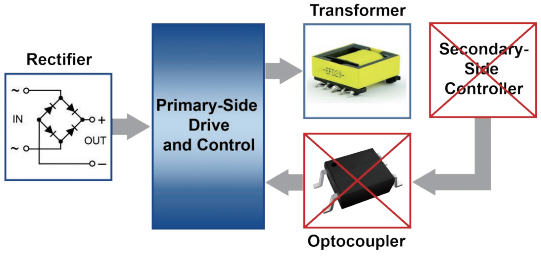
Block Diagram



Part No.	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.



KEY PRODUCTS

AC/DC Power Conversion

iW1702 – 45W *PrimAccurate™* Primary-Side Isolated Flyback Controller

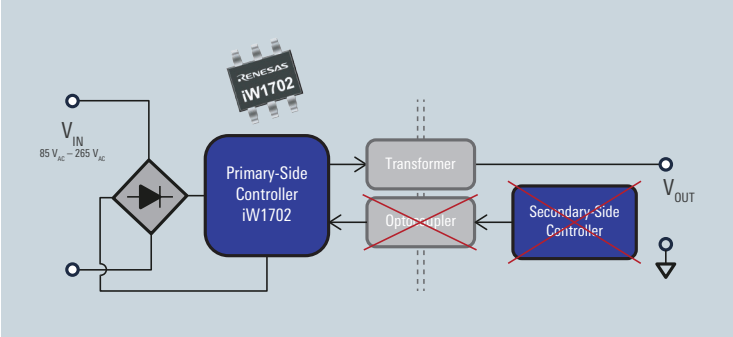
Features

- 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

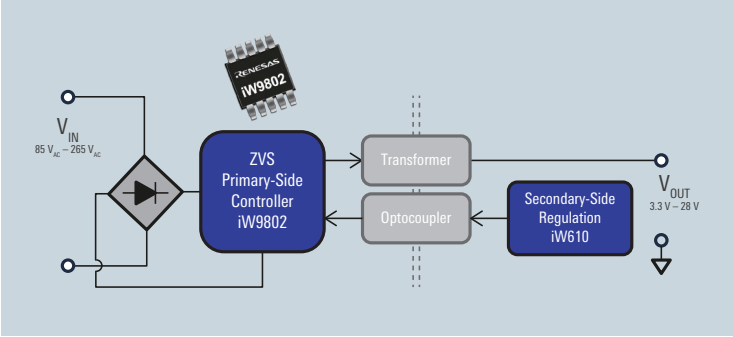
Features

- 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

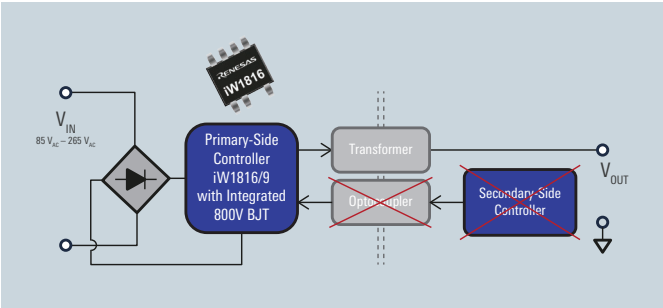
Features

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

Benefits

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

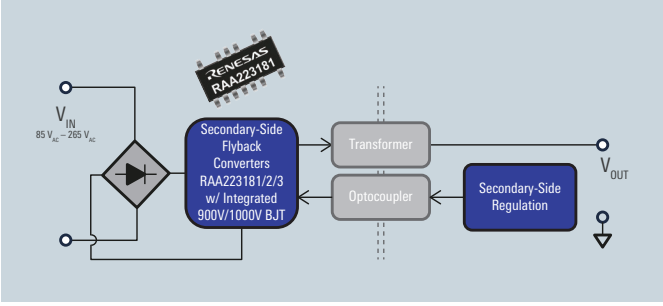
Features

- 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 CapSaver™ 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

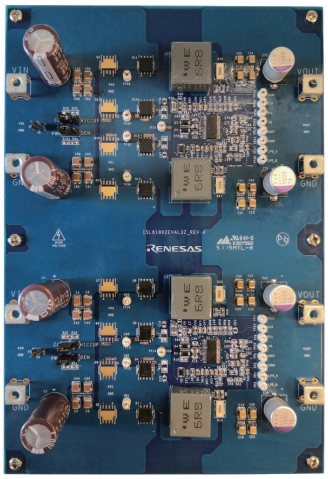
Features

- 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

KEY PRODUCTS

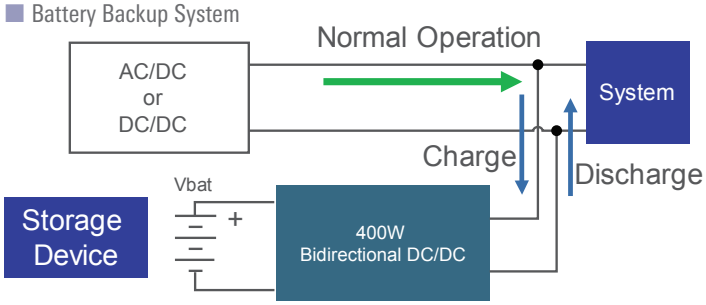
Multi-Output and Multiphase Analog Controllers

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

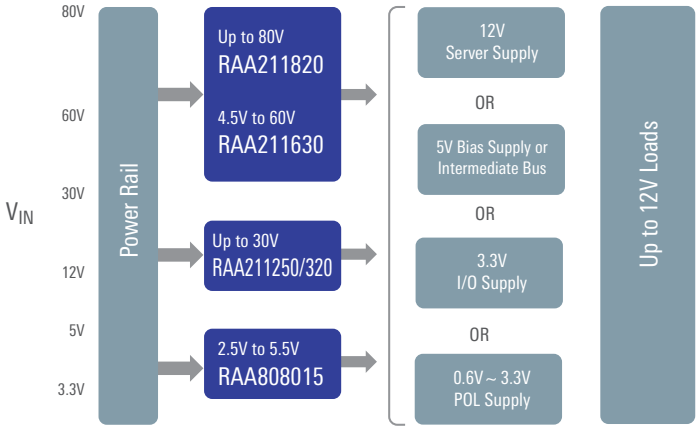
- P_{GOOD}, Enable function, adjustable soft start
- Extensive protection (OCP, OVP, OTP, SCP)
- External frequency synchronization

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



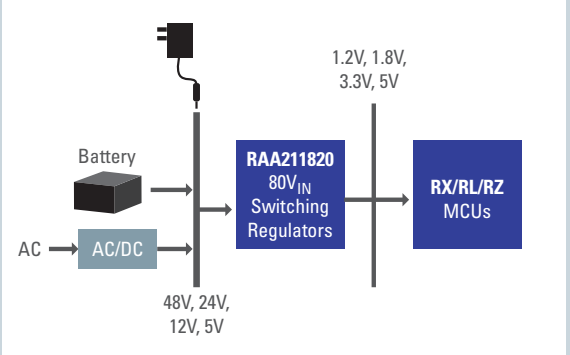
RAA211xxx New 24V to 75V Sync Buck Regulator Family – Wide V_{IN} Range

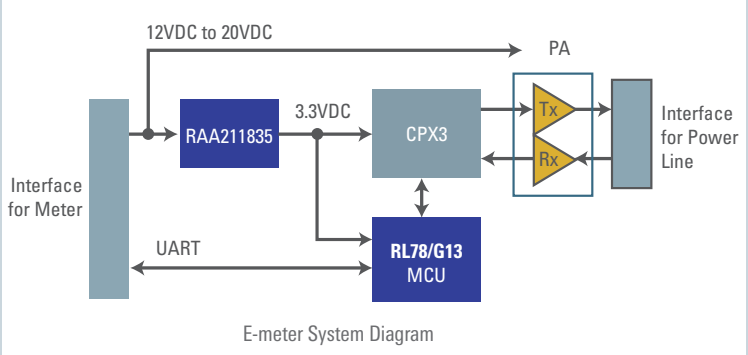
Common Features

- 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	Rdson (High/Low) QFN	Rdson (High/Low) HTSSOP	IOUT	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





E-meter System Diagram

KEY PRODUCTS

Switching Regulators

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

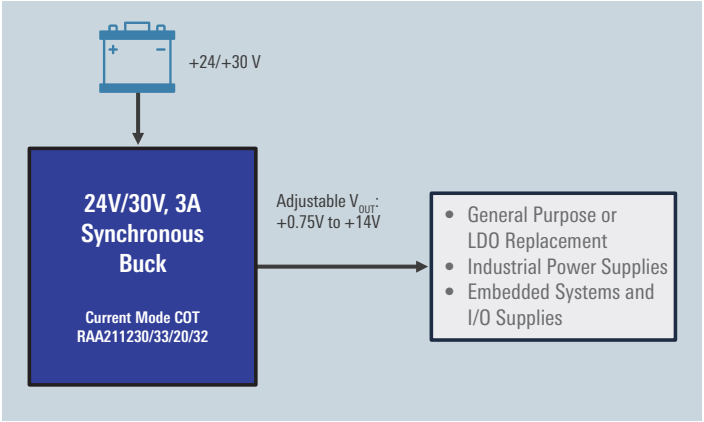
Features

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



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

TSOT23-6
2.9 x 2.8 mm

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

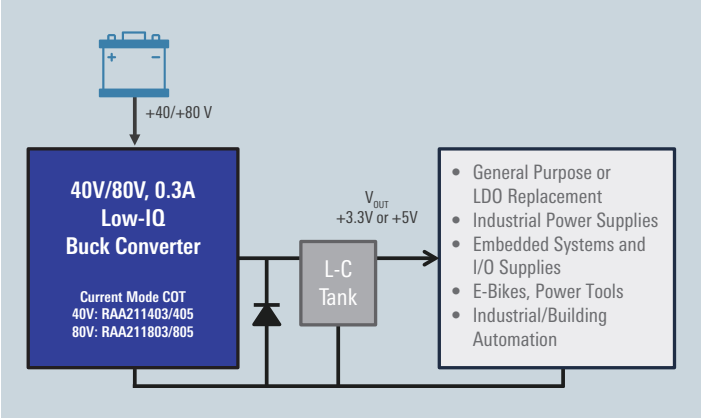
Features

- 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 = 4/5.5µA** at 40/80V, under no-load conditions, switching
  - **IQ = 2.5/4.5µA** 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

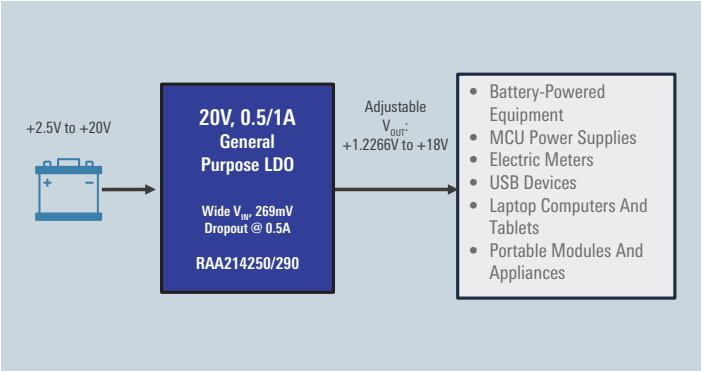
Wide input voltage range: 2.5V to 20V

- 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 1µF - 200µF 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



KEY PRODUCTS

Low-Dropout Regulators (LDO)

RAA214020 Low-Noise LDO for Sensitive Circuitry

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

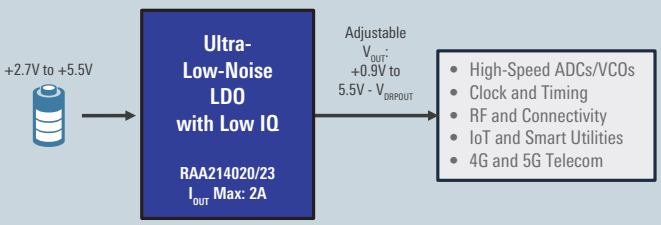
Features

- 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-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 restive divider network.

Block Diagram



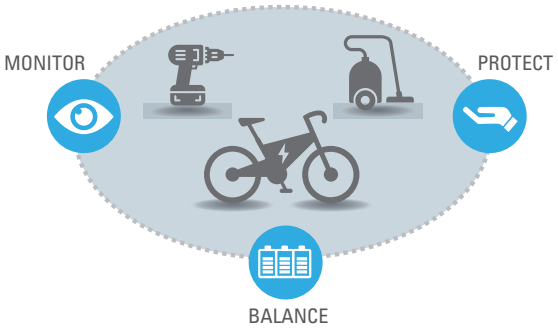
KEY PRODUCTS

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

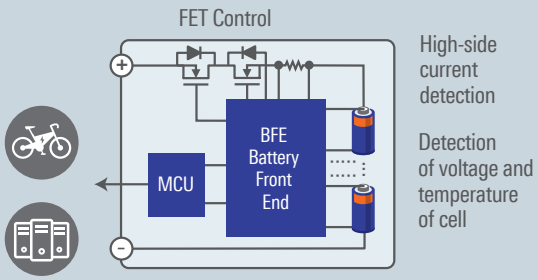
Benefits and Key Features

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



BFE Battery Pack System Diagram

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

KEY PRODUCTS

Battery Management

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.

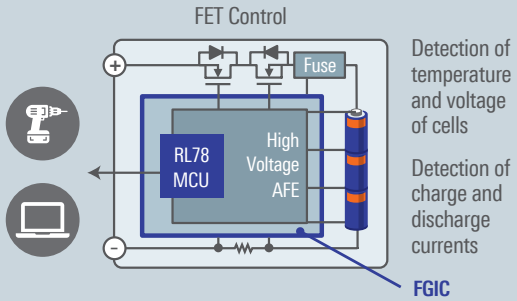
Benefits and Key Features

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

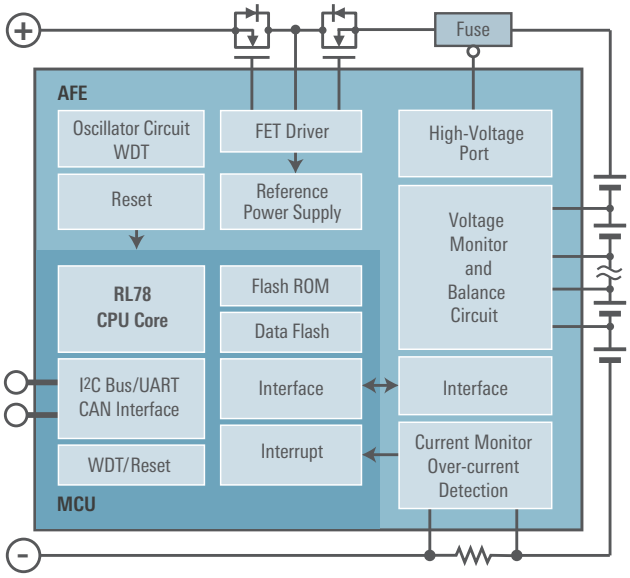
- Built-in FET protection for over-current or short circuit conditions
- Redundant fault detection by both MCU and AFE
- Ability to set lifecycle related limits and maintain battery parameter and operation history using data flash guaranteed for 100,000 erase/write cycles
- Integrated CAN interface and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



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
1	2 to 5.5	RAA241200	64 KB	4.0 KB	Low side	I²C, UART	7	Very compact package (1.871mm x 2.478mm) Very low power consumption (10 µA)	16WLBGA
2 to 4	2.2 to 25	RAJ240055	64 KB	4.0 KB	High side	I²C, 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	I²C, UART	11	Compact package (4mm x 4mm) 5-cell support	32QFN
		RAJ240075	64 KB	4.0 KB					
3 to 8	4 to 50	RAJ240090	128 KB	7.0 KB	High/low side	I²C, UART, CAN	31	High voltage tolerance, on-chip CAN, low power consumption (25 µA)	64LQFP
3 to 10		RAJ240100							
3 to 7	4 to 40	RAJ240301	64 KB	5.5 KB	Low side	I²C, 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	I²C, UART	15	Compact package (5mm x 5mm) 10-cell support	40QFN

APPLICATION SOLUTIONS

Smart Solar Battery Charger

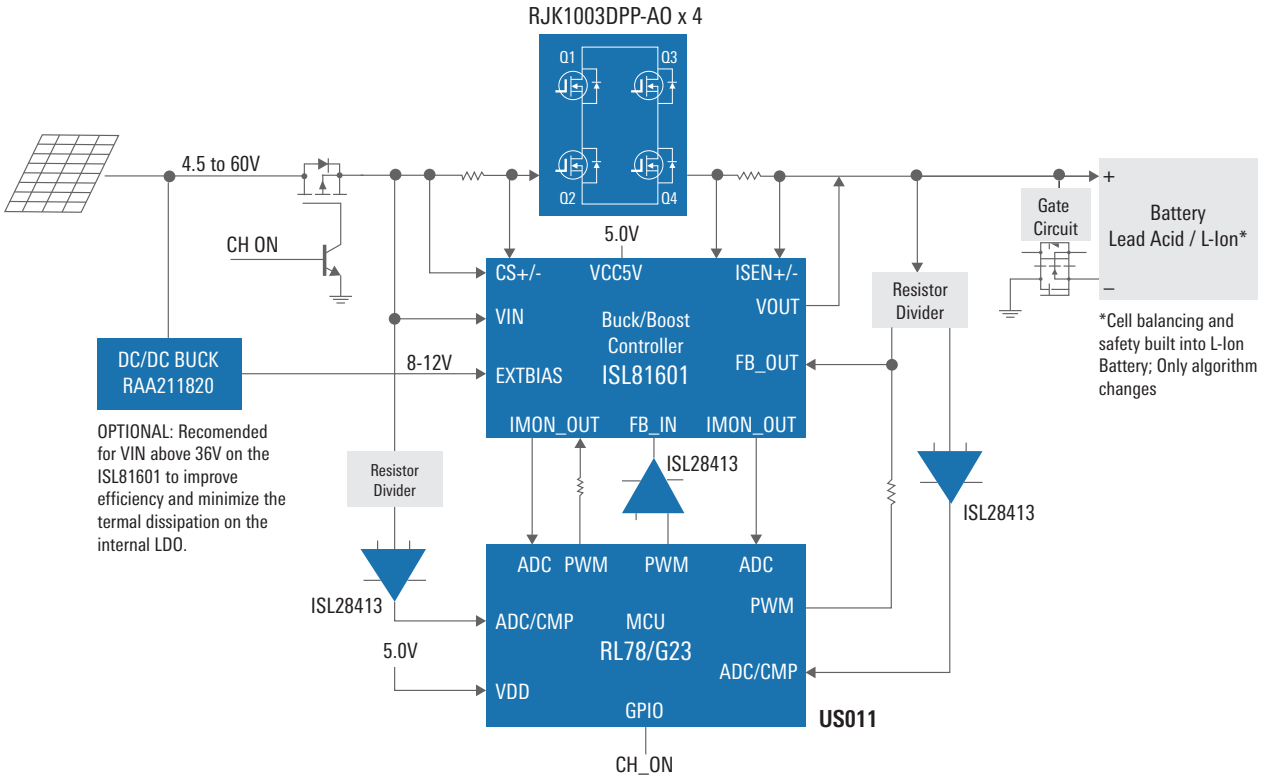
Using the green energy of solar to charge a battery is a very popular application. Solar cells produce a challenge, however, due to the wide variability of the output voltage depending upon the amount of solar energy directed at the panel, temperature and the load on the panel. This solution helps overcome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

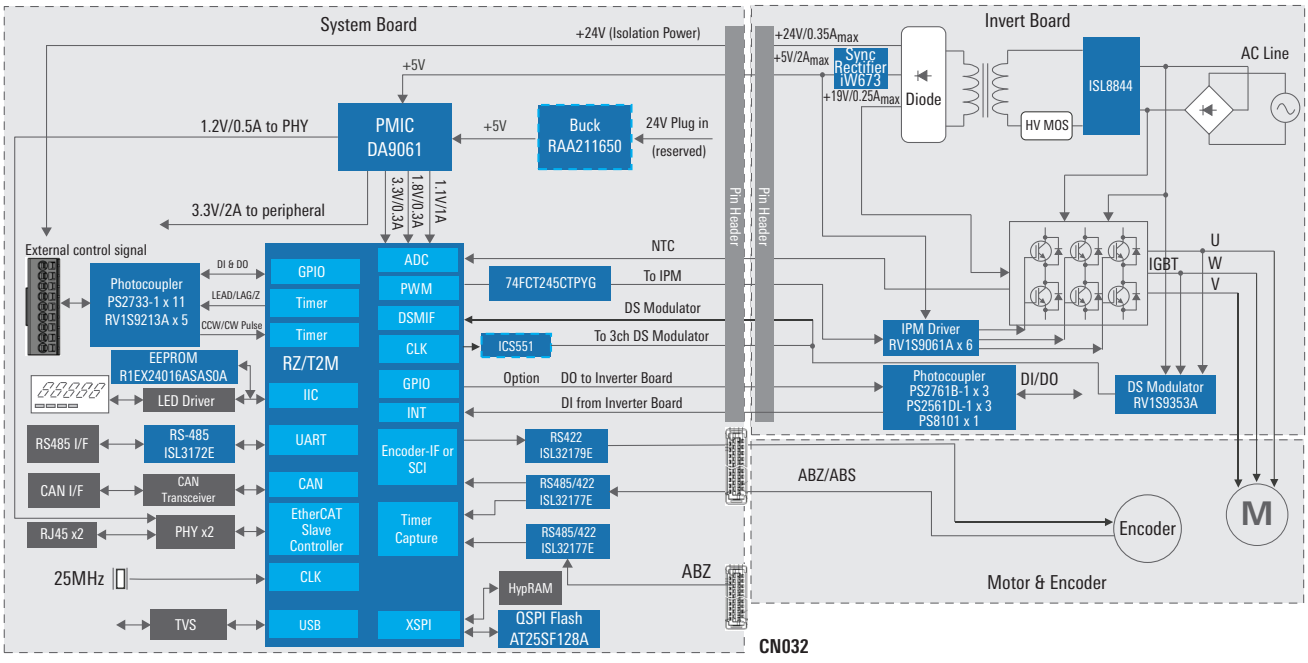
This Renesas AC servo solution integrates motor control and EtherCAT design to support high-speed and high-precision motor control through synchronizing time-sensitive industrial Ethernet communications. This solution is composed of three blocks: system control, power drive and motor encoder, which are 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



*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.

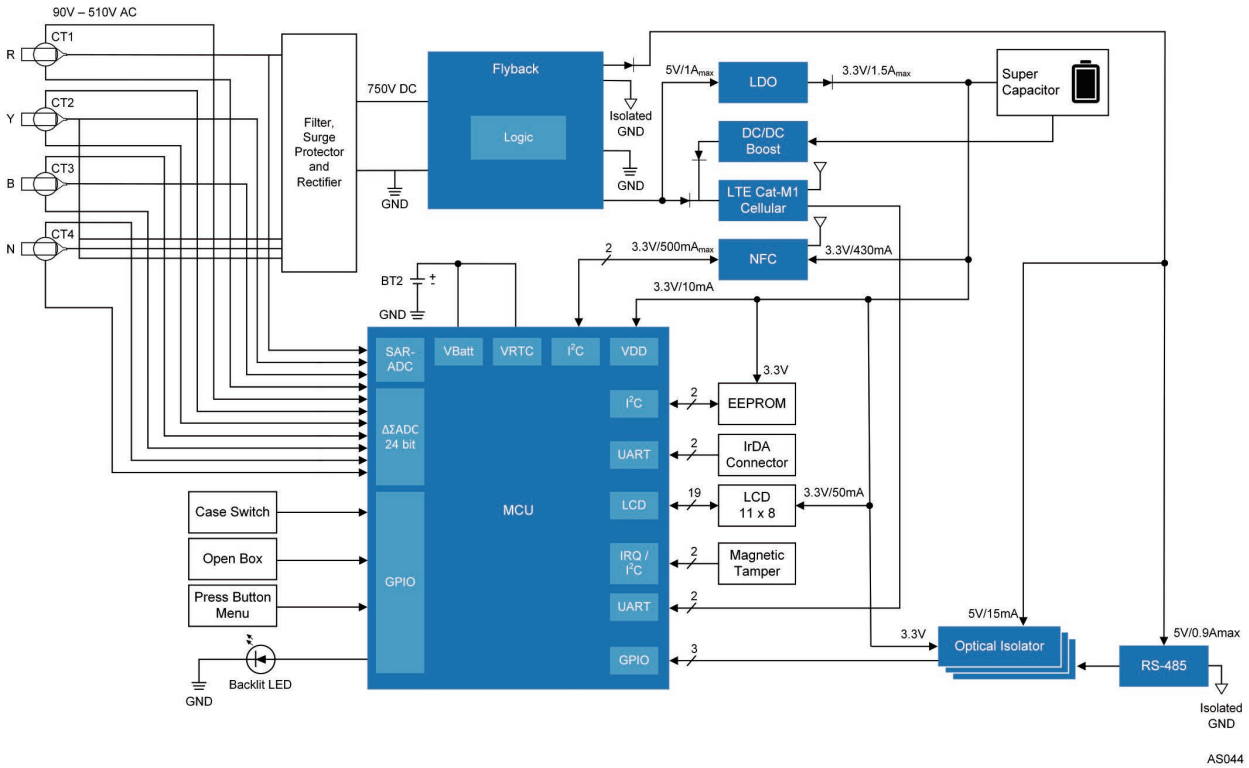
A tamper-proof and connected system provides a lot of advantages to users regarding information about their energy consumption.

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

Industrial Gateway with Wi-Fi 6

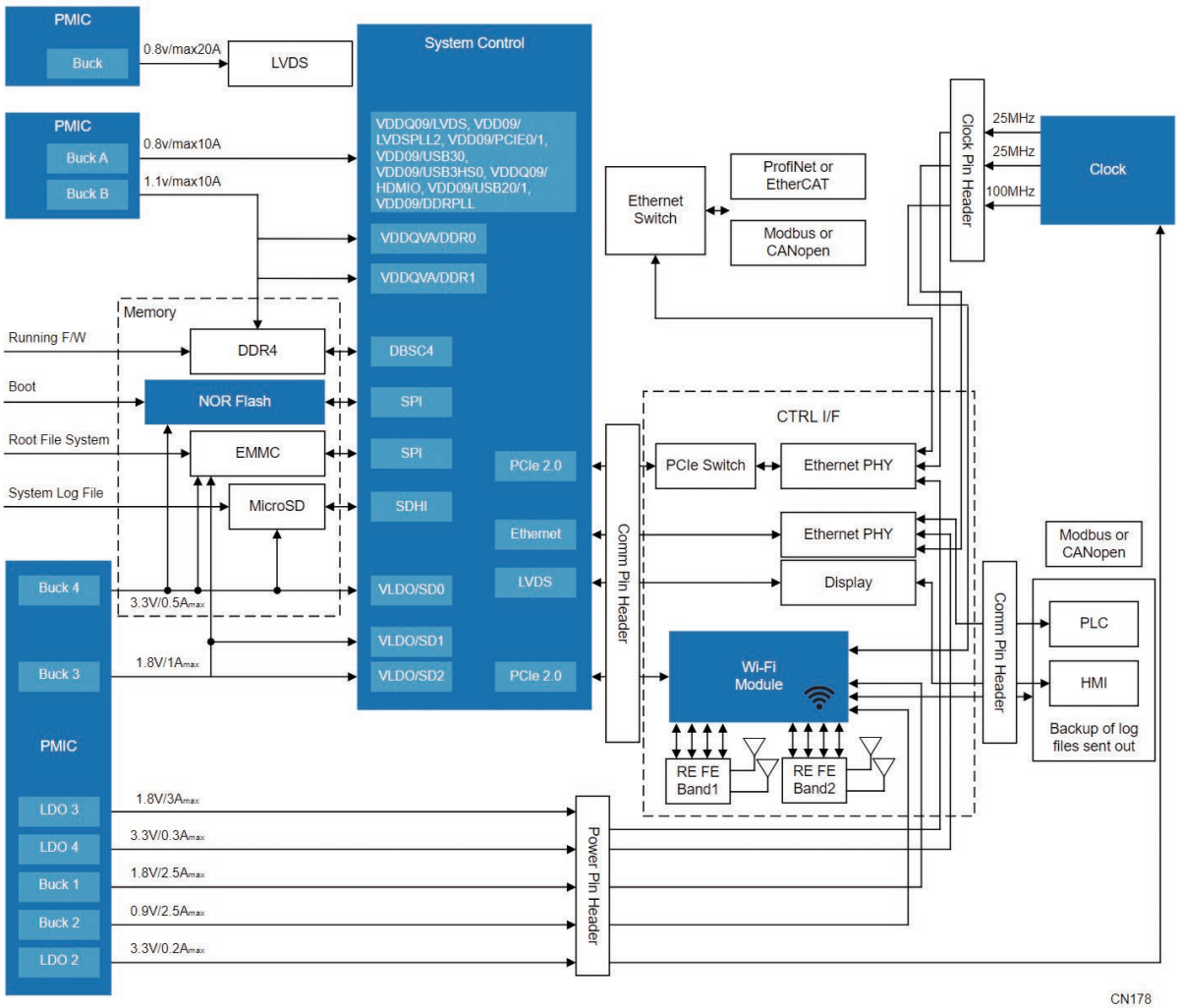
This solution shows the capability and features of an ultra-high performance MPU with quad-core Arm® Cortex®-A57 and quad-core Arm® Cortex®-A53 CPUs, rich peripheral supports LVDS, PCIe, and memory I/F like Gigabit Ethernet, DDR, USB 3.0, SD, etc. Power and clock design is simple and saves on PCB size. High-performance, highly integrated Wi-Fi 6 (802.11ax) R2 single PCIe chip delivers the best Wi-Fi network with flexibility and reliability.

Reference Solution – System Benefits

- On-field data processing: Super strong MPU + Wi-Fi 6 module connect; meanwhile, an RZ/G2H MPU supports memory bandwidth performance exceeding 50GB/s, able to realize fastest data transmission for on-field programmable logic controller (PLC) application. The Wi-Fi chip can drive up to 4.8Gbps PHY/data link speed.
- High integration PMIC: Simplified system power design and PCB size, 3-chipset covers all power tree.
- High integration clock: Simplified system clock design and limited time jitter.

BOM List for Reference Design

DA9213	Multiphase 20A Output Current
DA9214	Multiphase 2x 10A Output Current Synchronous Dual Step-Down Converter
DA9062	PMIC Designed for Applications Requiring up to 8.5A
AT25SF128A	128Mbit, 2.7V Minimum SPI Serial Flash Memory with Dual I/O Support
RZ/G2H	Ultra-High Performance Microprocessors with Quad-Core Arm Cortex-A57 and Quad-Core Arm Cortex-A53 CPUs, with 3D Graphics and 4K Video Encoder/Decoder
CL8040	Wi-Fi 6 Concurrent Dual Band 4T4R PCIe Chip
5X1503	MicroClock Programmable Clock Generator with Embedded Crystal



APPLICATION SOLUTIONS

Hi-Speed & Long-Distance Power Line Communication Unit for AC Line/DC Line

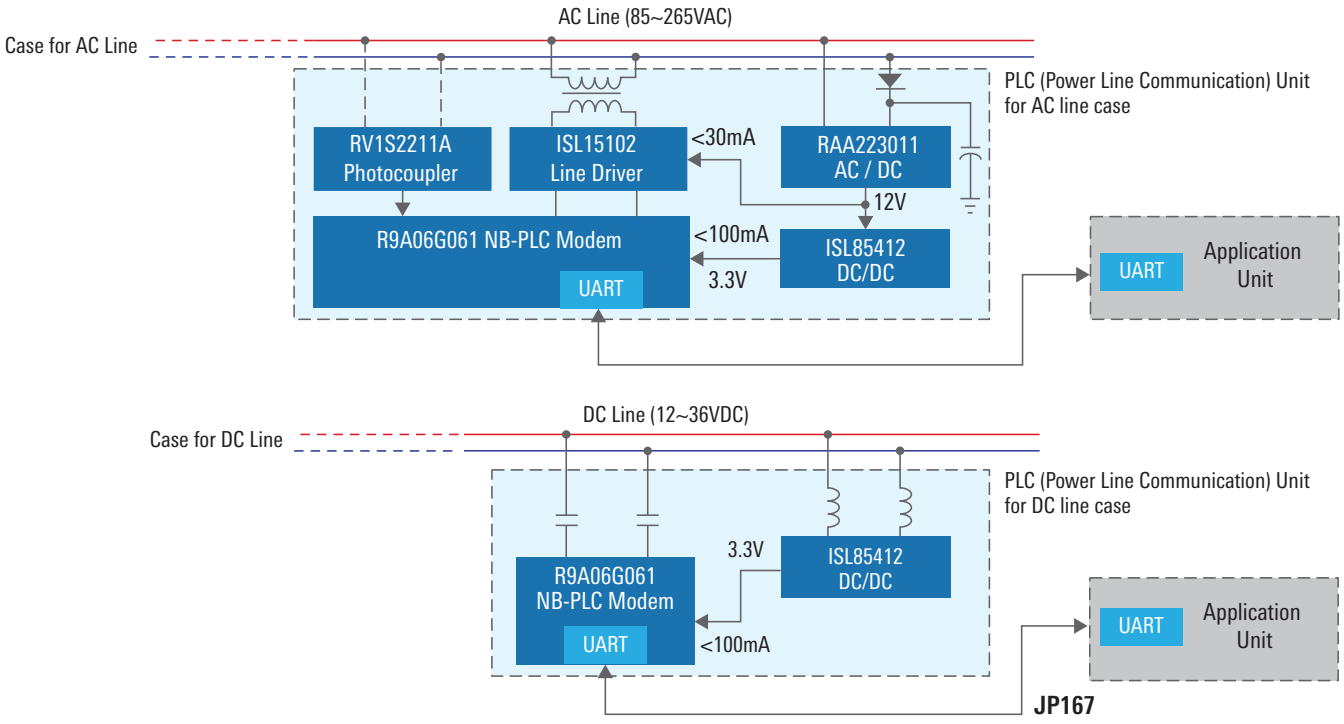
Power Line Communication (PLC) is a communication method that uses power lines as the medium, so it is possible to build a system quickly at low cost. Using this method, communication data can be propagated through AC or DC power lines. For example, building automation can be realized using existing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



APPLICATION SOLUTIONS

Gigabit Industrial Ethernet System-on-Module

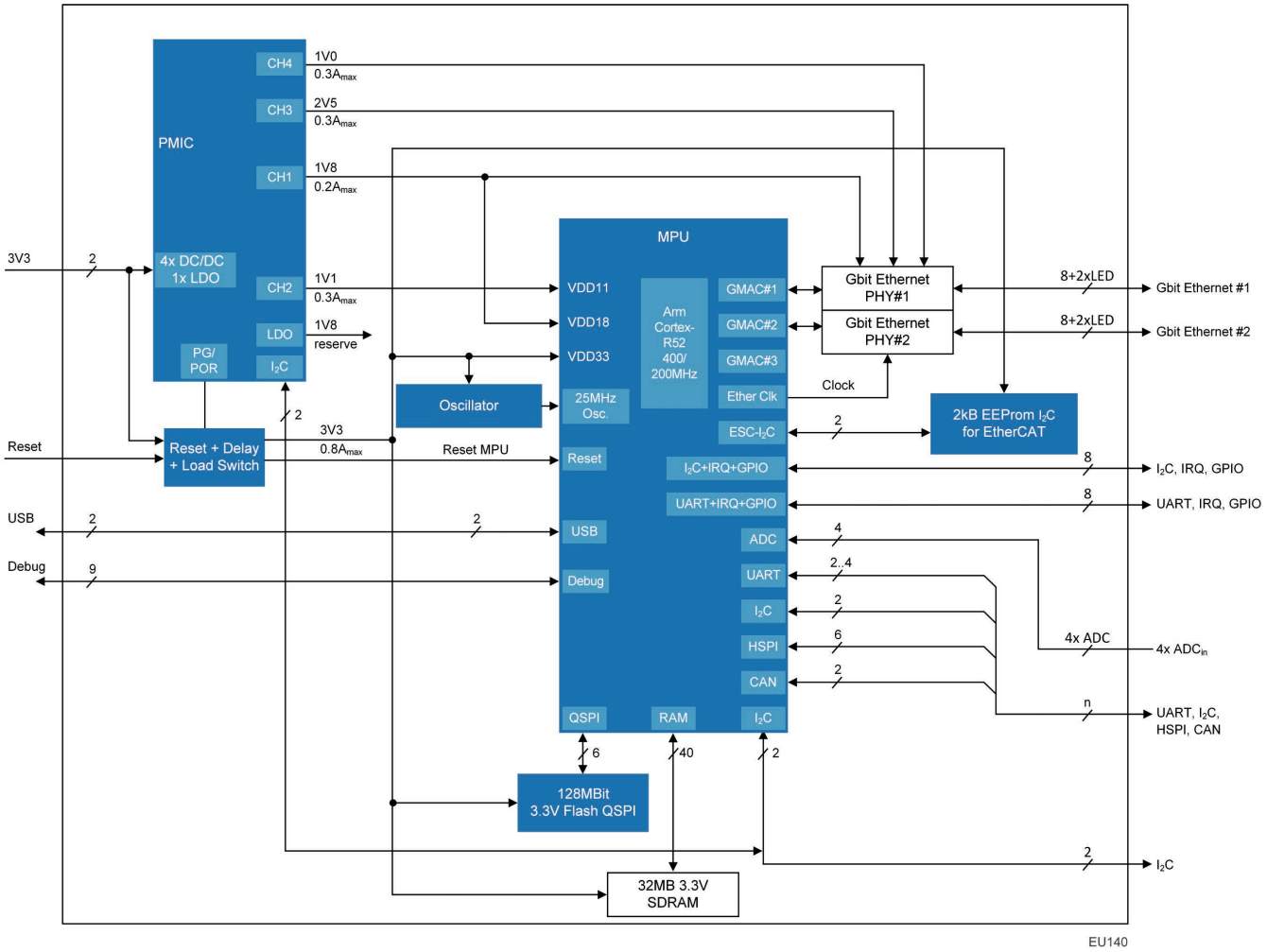
The industrial market highly appreciates “stamp-type” proven-to-work MPU system-on-modules (SoMs), where customers can build their own unique peripherals around them. Renesas provides such a module and carrier board for this type of solution, resulting in a massive reduction of time-to-market, development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

Reference Solution – System Benefits

- 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

BOM List for Reference Design

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)



APPLICATION SOLUTIONS

240W 48V Extended Power Range AC/DC Adapter

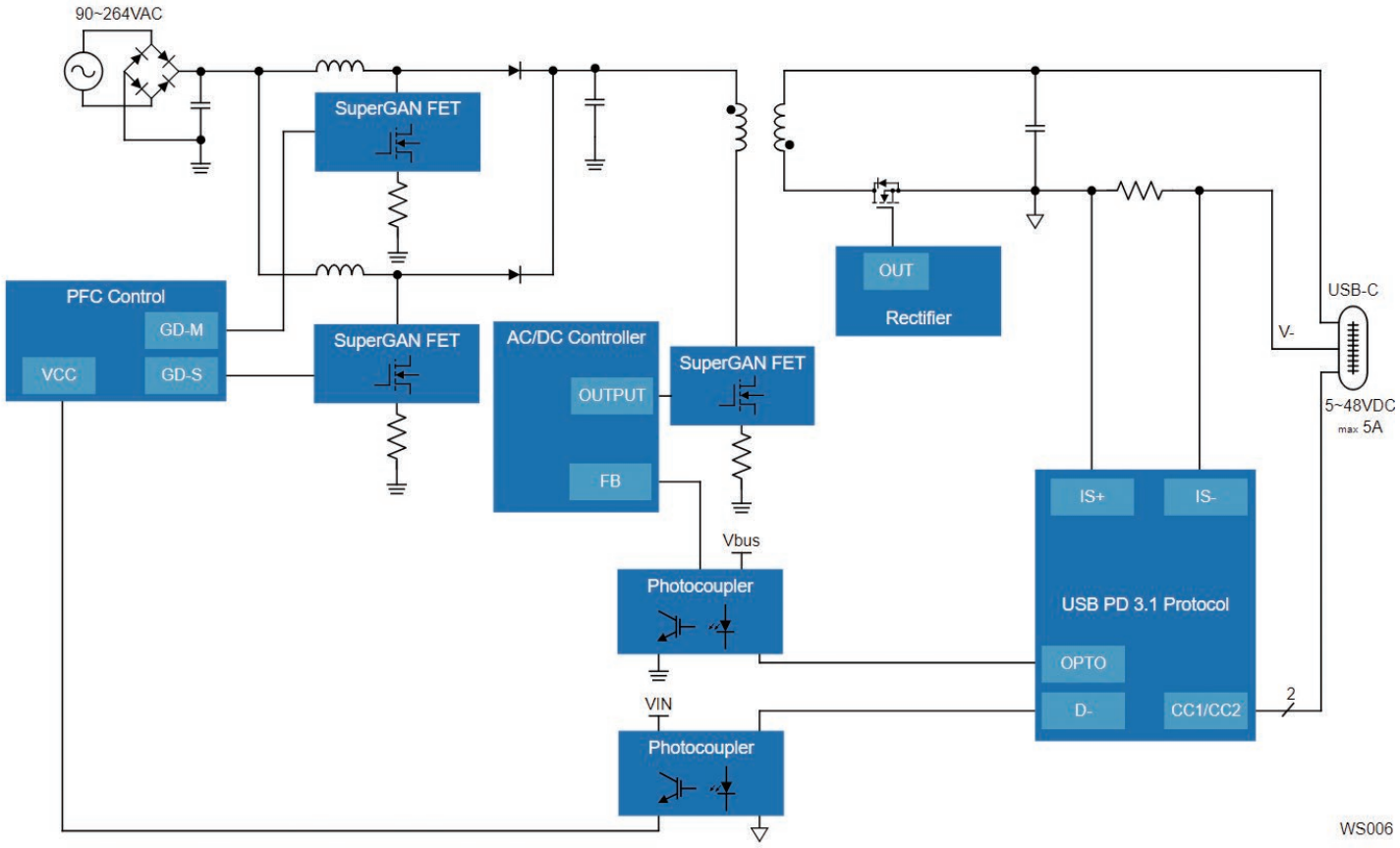
This power supply design delivers a robust 240W output in alignment with the USB Power Delivery (PD) 3.2 extended power range (EPR) standard, catering to diverse power supply requirements and adhering to European regulations mandating the use of USB Type-C universal chargers for various portable electronic devices.

Reference Solution – System Benefits

- Delivers maximum power per USB specifications (48V/5A)
- Zero voltage switching (ZVS) minimizes switching loss for high efficiency (>94% at 28V, 5A)
- Enhanced power density reduces size and weight while achieving improved thermal management

BOM List for Reference Design

R2A20132SP	Critical Conduction Mode Interleave PFC Control IC
TP65H150G4LSG	650V 150mΩ SuperGaN® FET in PQFN88
iW9801	100W+ Digital Zero Voltage Switching RapidCharge™ AC/DC Controller, Compatible with Transphorm GaN
TP65H070G4PS	650V 70mΩ SuperGaN® FET in TO-220
PS2381-1	4-PIN LSOP Photocoupler Operating Ambient Temperature 115°C
iW676	Digital Synchronous Rectifier
iW780	Secondary-Side USB Power Delivery 3.1 Protocol and Interface IC for Single and Multi-port Adapters up to 240W



APPLICATION SOLUTIONS

Low-Cost USB-C & USB PD 100W Power Supply with Multiple Outputs

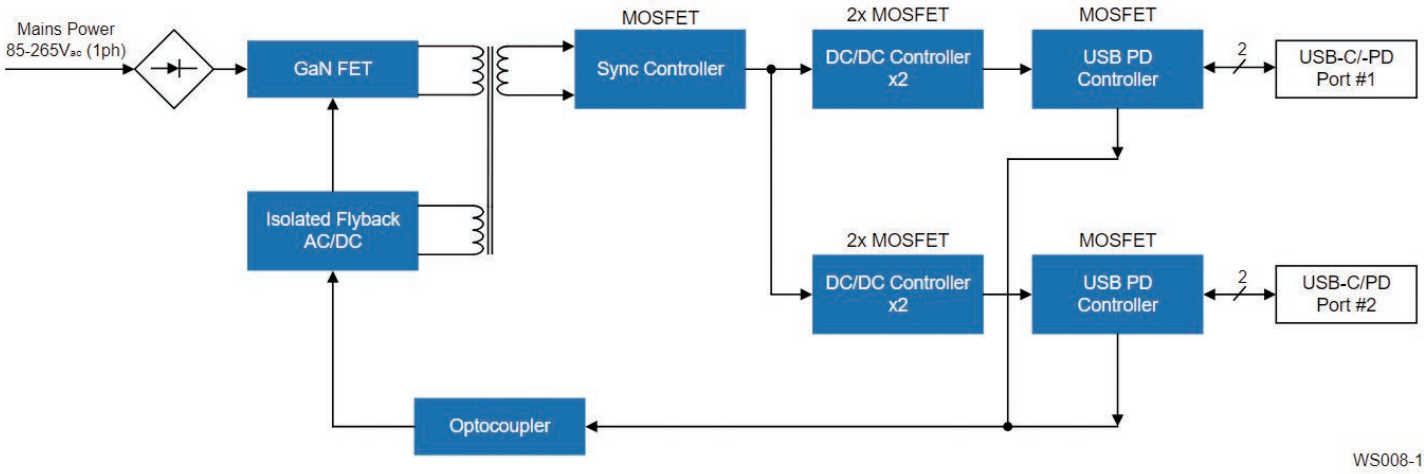
USB-C and USB Power Delivery (PD) became the standard for power supply of mobile devices. These designs implement low-cost single and dual port USB-C and USB PD 3.1 power adapters with 5-20V/5A 100W dual outputs or a 5-28V/5A 140W single output. The designs feature BOMs optimized for cost and power efficiency to minimize the size and price of the adapter.

Reference Solution – System Benefits

- Works with any USB-C sink
- Supports USB PD 3.1 automatic voltage/power negotiation
- AC Input Range: 90-264V_{AC}
  - Integrated power factor control
- 100W Dual DC Output Variant: 5V/3A, 9V/3A, 15V/3A, 20V/3.25A/5A
- 140W DC Output Variant: 5V/3A, 9V/3A, 15V/3A, 20V/5A, 28V/5A
- Standby Power <300mW
  - Meets DOE Level VI requirement for dual port operation
- Max Ripple <200mV_{PP}
- Low cost chargers and/or power source for Mobile Phones and Tablets and any USB-C sink

BOM List for Reference Design

TP65H150G4LSG	650V 150mΩ SuperGaN® FET in PQFN88
iW3627	Digital Constant-Voltage Offline PWM Controller with Power Factor Correction for 100W+ Applications
PS2381-1	4-PIN LSOP Photocoupler Operating Ambient Temperature 115°C
iW610	Digital Synchronous Rectifier Controller Works in High-Side and Low-Side Rectification Configurations to Optimize Magnetics
ISL8117	Synchronous Step-Down PWM Controllers
iW780	Secondary-Side USB Power Delivery 3.1 Protocol and Interface IC for Single and Multi-port Adapters up to 240W



APPLICATION SOLUTIONS

Low-Cost USB-C & USB PD 140W Power Supply with Multiple Outputs

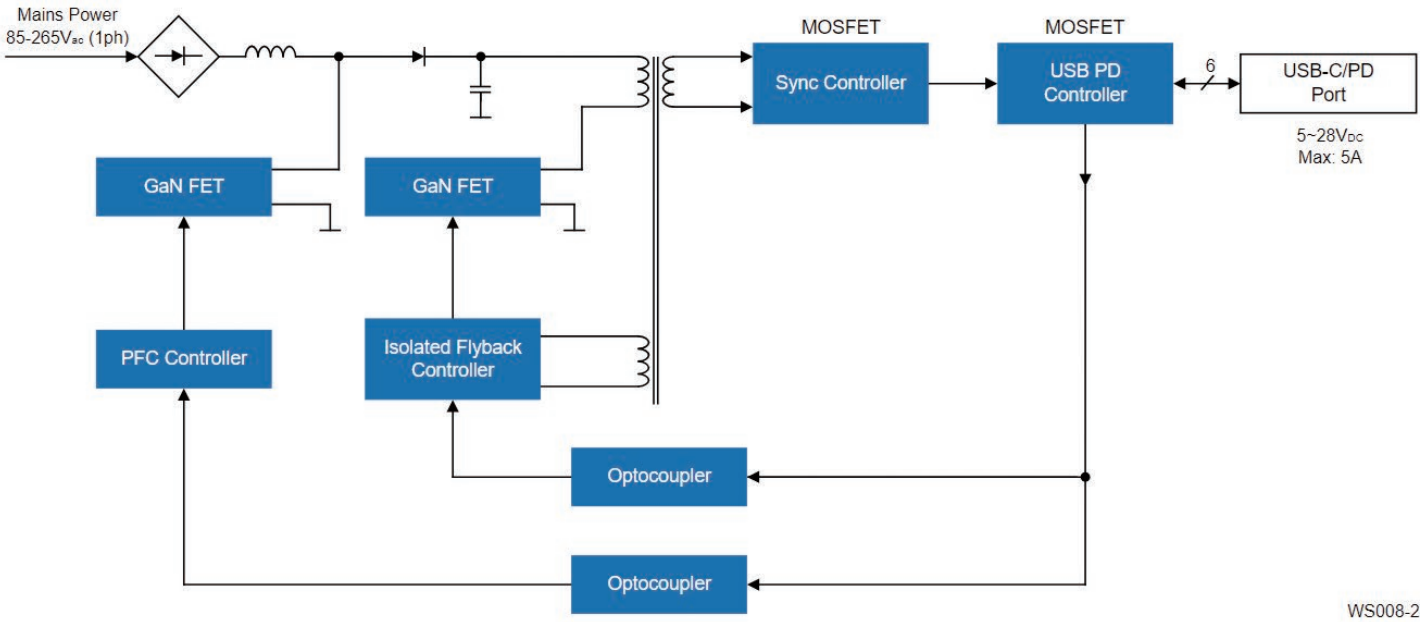
USB-C and USB Power Delivery (PD) became the standard for power supply of mobile devices. These designs implement low-cost single and dual port USB-C and USB PD 3.1 power adapters with 5-20V/5A 100W dual outputs or a 5-28V/5A 140W single output. The designs feature BOMs optimized for cost and power efficiency to minimize the size and price of the adapter.

Reference Solution – System Benefits

- Works with any USB-C sink
- Supports USB PD 3.1 automatic voltage/power negotiation
- AC Input Range: 90-264V_{AC}
  - Integrated power factor control
- 100W Dual DC Output Variant: 5V/3A, 9V/3A, 15V/3A, 20V/3.25A/5A
- 140W DC Output Variant: 5V/3A, 9V/3A, 15V/3A, 20V/5A, 28V/5A
- Standby Power <300mW
  - Meets DOE Level VI requirement for dual port operation
- Max Ripple <200mV_{PP}
- Low cost chargers and/or power source for Mobile Phones and Tablets and any USB-C sink

BOM List for Reference Design

TP65H150G4LSG	650V 150mΩ SuperGaN® FET in PQFN88
R2A20133DSP	Critical Conduction Mode PFC Control IC
iW9801	100W+ Digital Zero Voltage Switching RapidCharge™ AC/DC Controller, Compatible with Transphorm GaN
PS2381-1	4-PIN LSOP Photocoupler Operating Ambient Temperature 115°C
iW610	Digital Synchronous Rectifier Controller Works in High-Side and Low-Side Rectification Configurations to Optimize Magnetics
iW780	Secondary-Side USB Power Delivery 3.1 Protocol and Interface IC for Single and Multi-port Adapters up to 240W



APPLICATION SOLUTIONS

Zero Standby Power 65W USB-C Adapter with Single and Dual Output

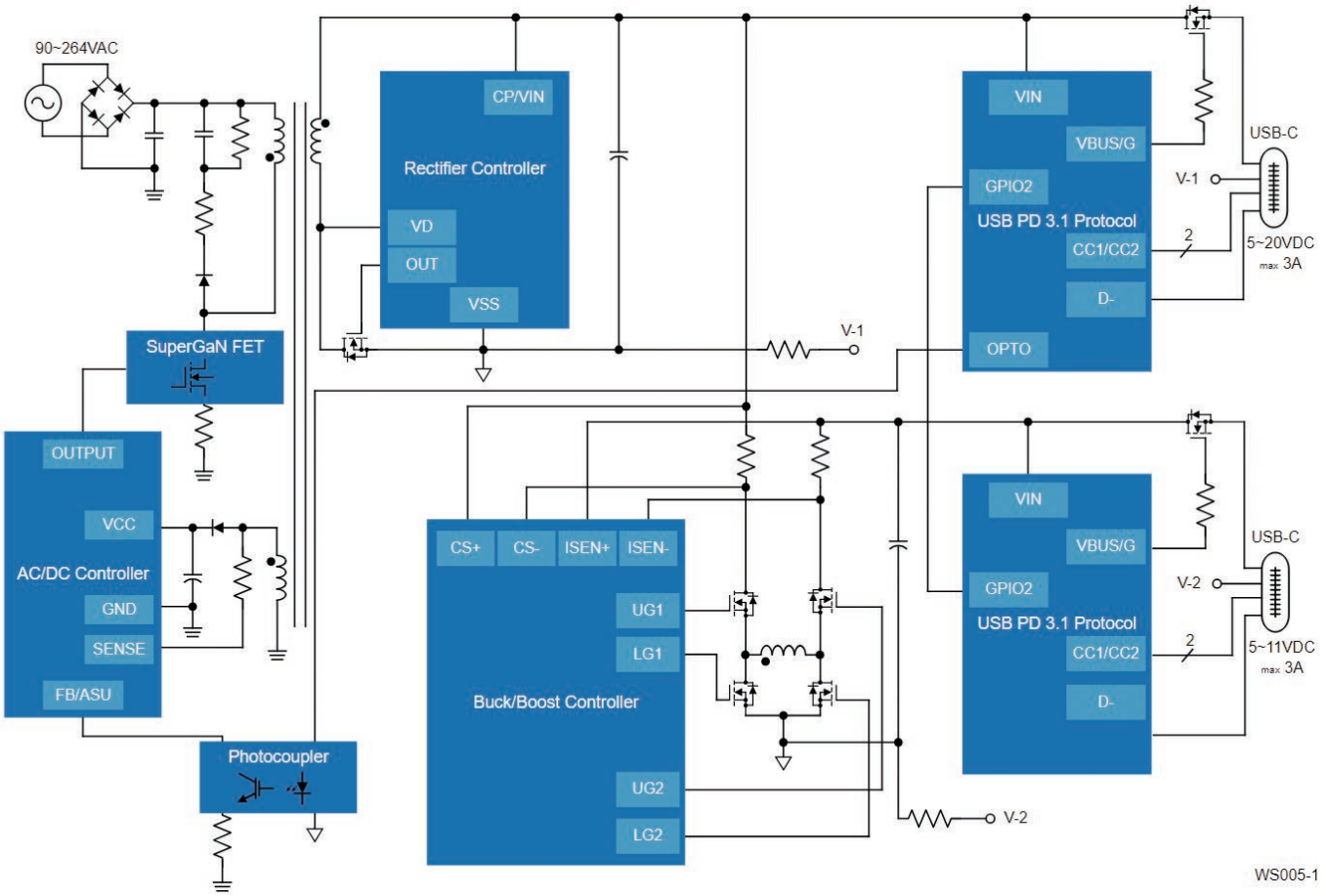
Designed with USB PD 3.1 technology, this ultra-compact USB Type-C adapter delivers 65W of power using adaptive quasi-resonant (QR) operation and multi-mode control to enhance size, efficiency, and EMI performance. Ideal for travel adapters requiring a lightweight and small form factor, its dual-port capability enables the simultaneous charging of two devices, reducing the need for multiple chargers while on the go. The Zero Standby Power (ZSP) design allows users to leave the charger plugged in without power consumption during idle periods.

Reference Solution – System Benefits

- Zero Standby Power (ZSP)
- Optional dual-port USB-C output
- Ultra-compact size
- Low system cost
- Adaptive quasi-resonant (QR) operation and multi-mode control
- Low cost chargers and/or power source for Mobile Phones and Tablets and any USB-C sink

BOM List for Reference Design

iW9870	GaN Digital Quasi-Resonant AC/DC Flyback Controller for Zero Standby Power RapidCharge Power Supplies up to 140W
TP65H150G4LSG	650V 150mΩ SuperGaN® FET in PQFN88
PS2381-1	4-PIN LSOP Photocoupler Operating Ambient Temperature 115°C
iW610	Digital Synchronous Rectifier Controller Works in High-Side and Low-Side Rectification Configurations to Optimize Magnetics
ISL81401A	40V Unidirectional 4-Switch Synchronous Buck-Boost Controller
iW780	Secondary-Side USB Power Delivery 3.1 Protocol and Interface IC for Single and Multi-port Adapters up to 240W



APPLICATION SOLUTIONS

3.6kW Bi-directional Digital Power System

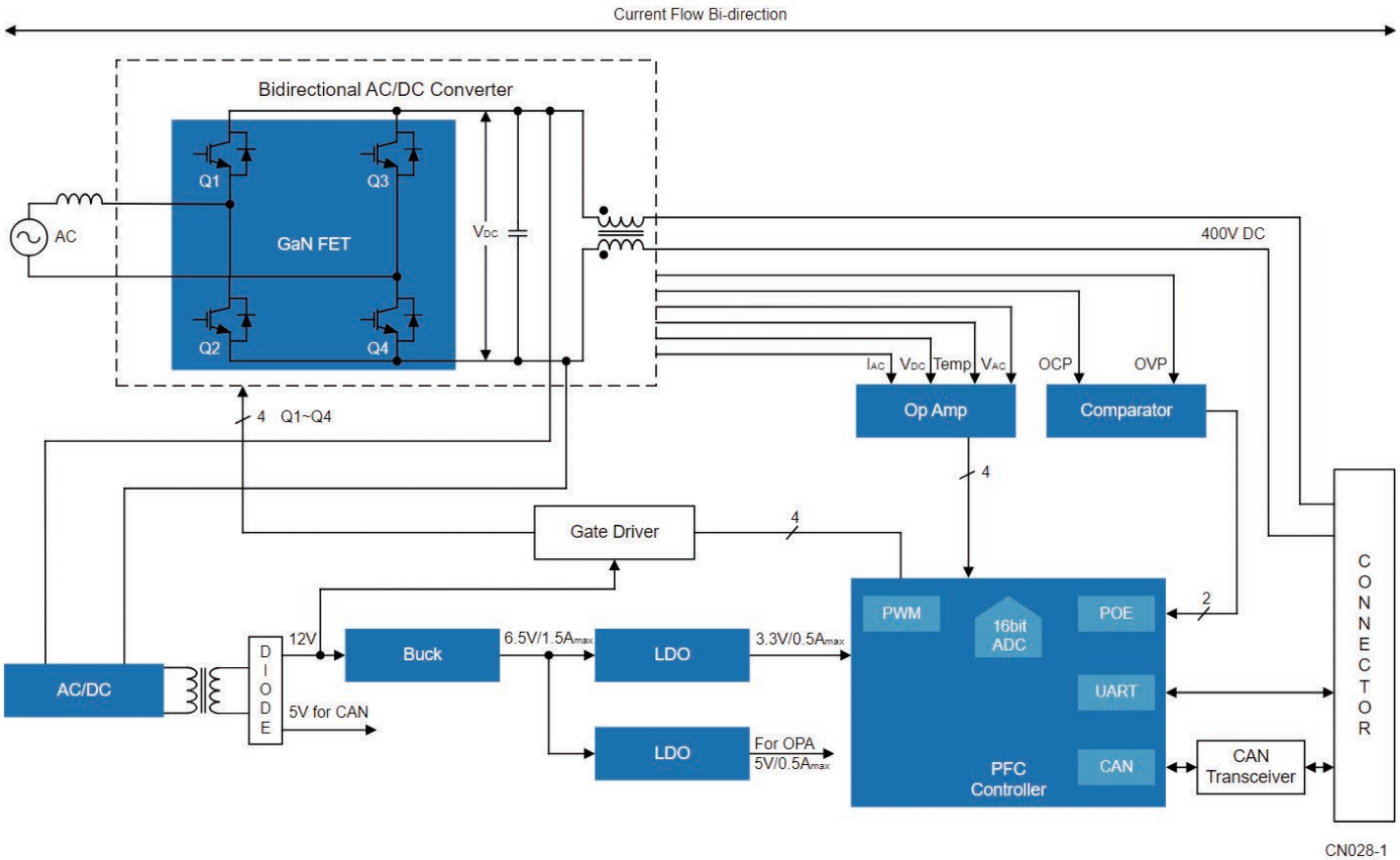
This system, utilizing Renesas high-performance Arm® Cortex®-M33 MCU and 650V GaN FET, achieves 3.6kW bi-directional power conversion through two designs: totem-pole bridgeless power factor correction (PFC) topology to realize bi-directional digital AC/DC power conversion. The PFC is followed by a Dual-Active Bridge (DAB) isolated DC-DC converter described in the next page.

Reference Solution – System Benefits

- High-performance RA6T2 MCU and GaN FET to achieve high-performance Bi-direction power conversion
- Renesas basic digital power software algorithm package to helps customers easily develop their solutions
- Renesas total solution helps customer get their products to market faster
- Target Application: Energy storage, EV/HEV OBC, Power conversion

BOM List for Reference Design

R7FA6T2BD3CFP	240MHz Arm® Cortex®-M33 for motor and inverter control solutions
RAA211250	4.5V to 30V input voltage range and adjustable output voltage, 5A Buck
RAA214250	20V, 500mA Linear Regulator
iW9864	Digital Quasi-Resonant AC/DC Controller for Zero Standby Power RapidCharge™ Power Supplies up to 140W
TP65H035G4WS	650V, 35 mΩ gallium nitride (GaN) FET
UPC277G2	Comparators Utilizing CMOS Process Suitable for Low Voltage, Low Power Consumption, and Fast Response
READ2302G	High Drivability & High Slew Rate Operational Amplifier



APPLICATION SOLUTIONS

3.6kW Bi-directional Digital Power PFC System

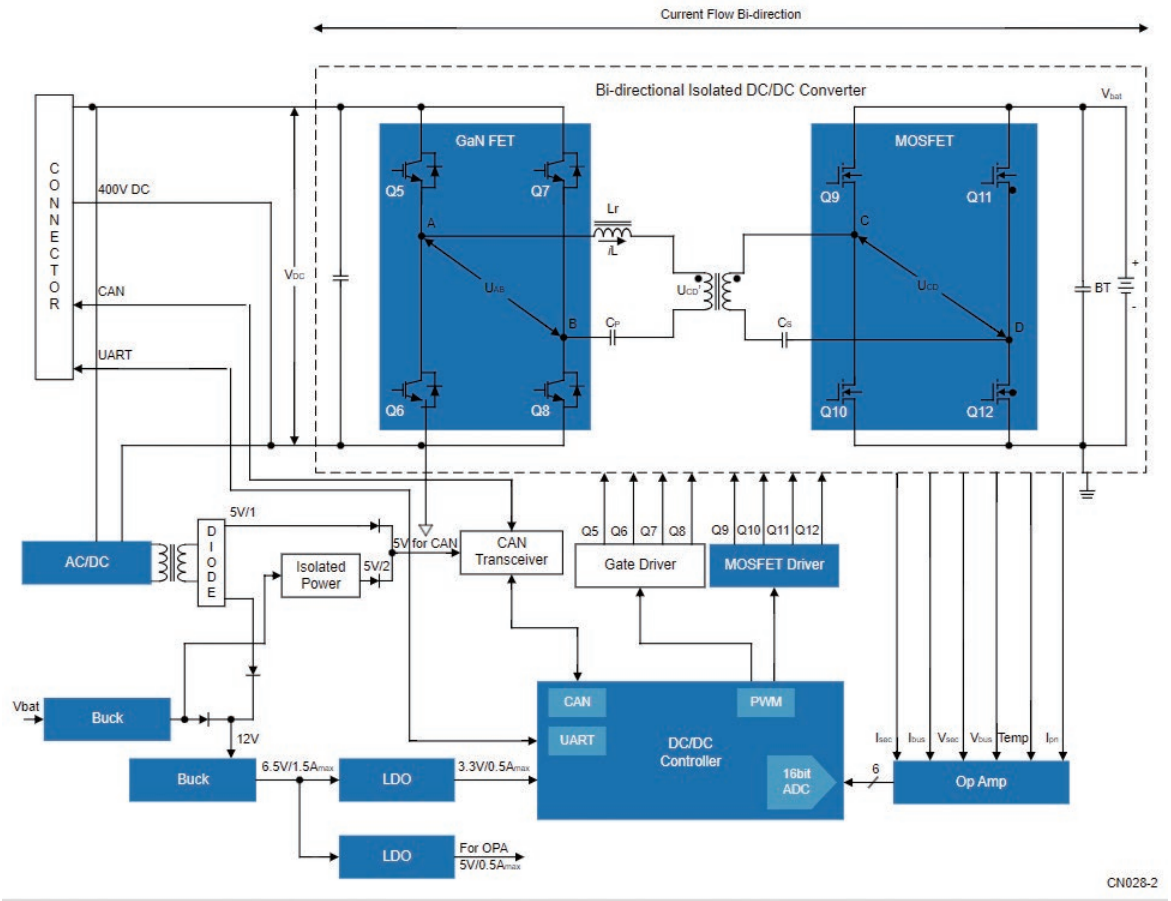
This system is based on Renesas high-performance RA6T2 ARM core MCU and 650V GaN FETs to achieve bi-directional power conversion. The Dual-Active Bridge (DAB) topology realizes bidirectional digital isolated DC/DC conversion.

Reference Solution – System Benefits

- High-performance RA6T2 MCU and GaN FET to achieve high-performance Bi-direction DC/DC power conversion
- Renesas basic digital power software algorithm package assists the customer to easily develop their solution
- Renesas provides a total solution to help customers with a reference design
- Target Application: Energy storage, EV/HEV OBC, Power conversion

BOM List for Reference Design

R7FA6T2BD3CFP	240MHz Arm® Cortex®-M33 for motor and inverter control solutions
RAA211820	Integrated FET 4.5V to 75V, 2A Buck
RAA211250	4.5V to 30V input voltage range and adjustable output voltage, 5A Buck
RAA214250	20V, 500mA Linear Regulator
ISL8843A	Single-Ended Current Mode PWM Controller with 3% Current Limit and Military Temp Grade Option
HIP2211	100V, 3A Source, 4A Sink, High Frequency Half-Bridge Drivers
RJK1001DPP-A0	N-Channel Mosfet 100 V, 80 A
TP65H035G4WS	650V, 35 mΩ gallium nitride (GaN) FET
READ2302GSP	High Drivability & High Slew Rate Operational Amplifier



APPLICATION SOLUTIONS

100W USB Power Delivery (PD) Source

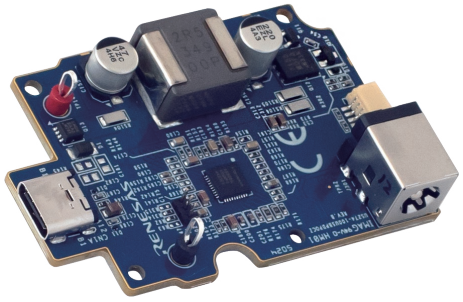
The US274-100USBPDPOCZ is a USB Power Delivery (PD) evaluation board designed to support DC input and USB PD output. It features the RAA489000, a digitally configurable buck-boost battery charger equipped with a USB-C® Port Controller (TCPC).
This board supports USB PD 2.0, USB PD 3.1, and USB-C specifications. It functions as a USB-C Standard Power Range (SPR) power source, capable of delivering up to 100W (20V, 5A) from a DC power source to a USB-C interface. The RAA489000 TCPC integrates TCPC PHY, CC logic, and VCONN switches, enabling reverse buck, boost, and buck-boost operations. The USB-C Port Manager (TCPM) functionality is implemented via I²C using the RL78/F14 series MCU (R5F10PBE).

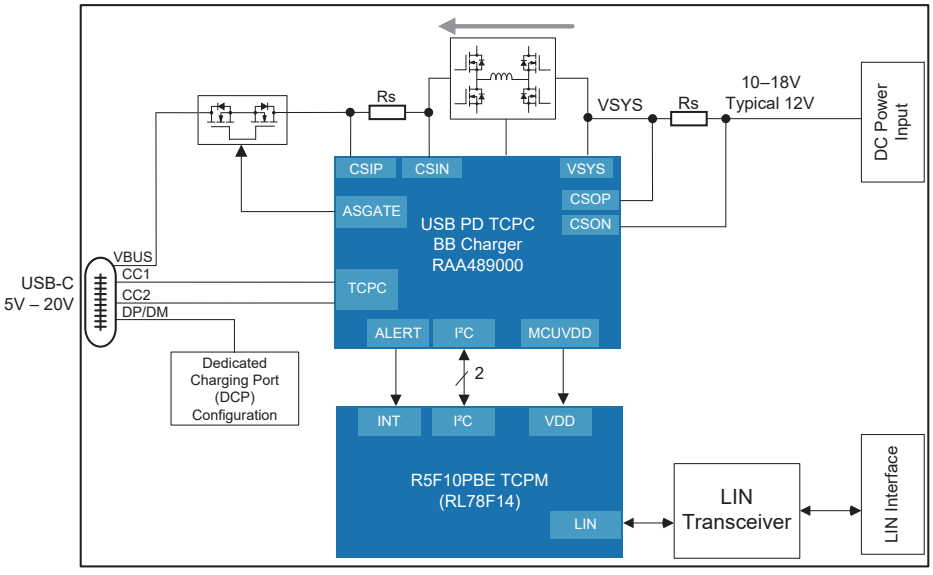
Reference Solution – System Benefits

- Highly integrated ICs allow for a space-efficient and compact design
- Provides efficient power delivery for USB-C SPR Range
- Certified for USB PD 3.0 and Programmable Power Supply (PPS)
- Built-in LIN module for automotive interfaces ensures seamless integration, allowing the charger to communicate with other modules in the vehicle
- Target Application: Automotive personal electronics charging, USB Type-C power sourcing device

BOM List for Reference Design

RAA489000	Integrated TCPC PHY, CC-Logic, and VCONN switches and supports reverse buck, boost, or buck-boost operation
R5F10PBELNA	RL78/F14 MCU with low level of consumption current and built-in LIN module for automotive interfaces, operating as TCPM
ISL80410	High voltage, adjustable VOUT, low quiescent current linear regulator





APPLICATION SOLUTIONS

USB PD 140W Charger Battery Management

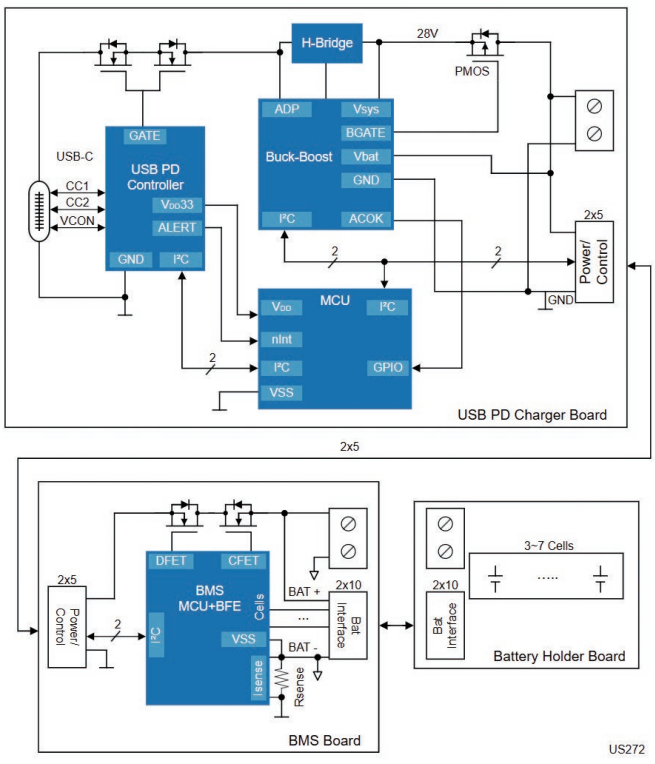
This USB Power Delivery (PD) charger battery management system is designed to deliver up to 140W of power for a 7-cell battery pack. It features a USB Type-C® Port Controller (TCPC) that is compliant with USB Type-C Port Controller Interface (TCPCi) revision 2.0 with Extended Power Range (EPR) and USB Power Delivery revision 3.1 specifications. The Type-C Port Manager (TCPM) function is integrated into the MCU via I²C communication. Additionally, a 30V buck-boost charger supports USB PD EPR, while the 3- to 10-cell battery front-end (BFE) controller and fuel gauge IC is utilized for system health monitoring and status updates.

Reference Solution – System Benefits

- Renesas provides USB PD, Battery Charger, MCU, and FGIC ALL-IN-ONE solution to meet various battery system requirements
- Up to 140W USB-C® battery system reference design can set battery configuration and max charging current for 2 to 7 cell battery pack
- Renesas provides GUI tool and user manual to accelerate software and hardware development process
- USB Type-C® Port Controller integrates high-power protection that is proven succesful in EPR range up to 48V design in the industry
- Offers complete Buck-Boost charger and MCU product protfolio to help selecting the most suitable product solution
- Target Application: Power tools, hand-held electronics, light protable electronic devices

BOM List for Reference Design

RAA489400	USB Type-C® Port Controller (TCPC) with integrated TCPC PHY, CC-Logic, supports Extended Power Range (EPR). (TID:10147)
RAA489118	Buck-Boost charger that supports a 30V input and 30V battery, compatible with any USB-C interface platform
R9A02G015	Implemented TCPM – USB PD Policy Engine function that is compliant with USB PD 3.1 Specification, in cooperation with muliti-Type-C Port Controller (TCPC) in USB PD system
RJK0853DPB	N-channel Power MOSFET supports up to 80V 40A
RAJ240090	3 to 10 Series Li-ion Battery Fuel Gauge IC
RAA211630	Integrated FET 60V, 3A Synchronous Buck Regulator
ISL80101	High Performance 1A LDO for system and Type-C port VCONN source power supply



APPLICATION SOLUTIONS

100W USB Type-C Battery System

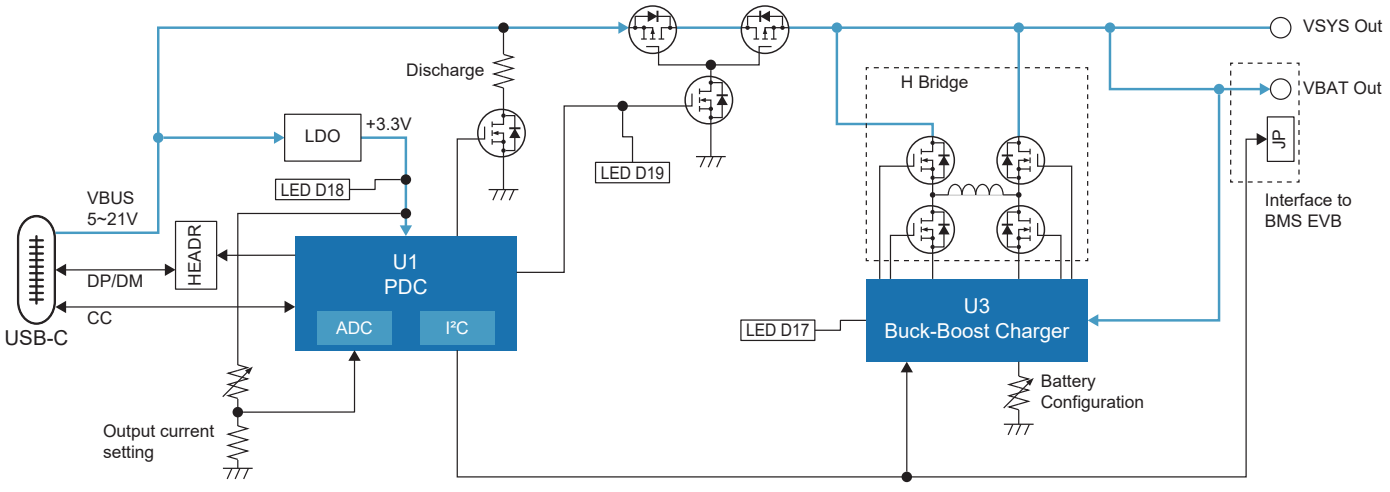
This is a single Type-C port reference design for implementing battery systems with 2 to 4 cells connected in series. This reference design supports a mode where power is only supplied from the USB Type-C® port and a mode that enables a power bank in combination with a lithium-ion battery with Battery Management System.
The reference board provides configurable number of batteries and the charging current, that the software can also be generated by an instruction tool called VIDWriter.
This evaluation board may be combined with an Evaluation Module of the Battery Fuel Gauging IC (FGIC) RAJ2400100 with Filefish to realize a complete Battery Management System (BMS).

Reference Solution – System Benefits

- Renesas provides simple design and high-performance reference to make the delevopement easier
- The power role of the USB Type-C® port supports Sink only or Dual Role Power
- On-board configuration switches allows switching charging modes and number of batteries instantly
- Renesas offers muliple software programming options of the USB PD controller, including GUI tools, SDK, and reference example code
- Target Application: standalone battery charging for power tools, portable vacuums, battery-powered lawn mowers, drones

BOM List for Reference Design

R9A02G011	USB Power Delivery (PD) controller that is based on Universal Serial Bus (USB) Power Delivery Specification Revision 3.1 and USB Type-C® Cable and Connector Specification Revision 2.1
RRB96838	Bidirectional 20V Buck-Boost Battery Charger with lower cost than legacy products (ISL9238C)



APPLICATION SOLUTIONS

240W USB Type-C Battery System

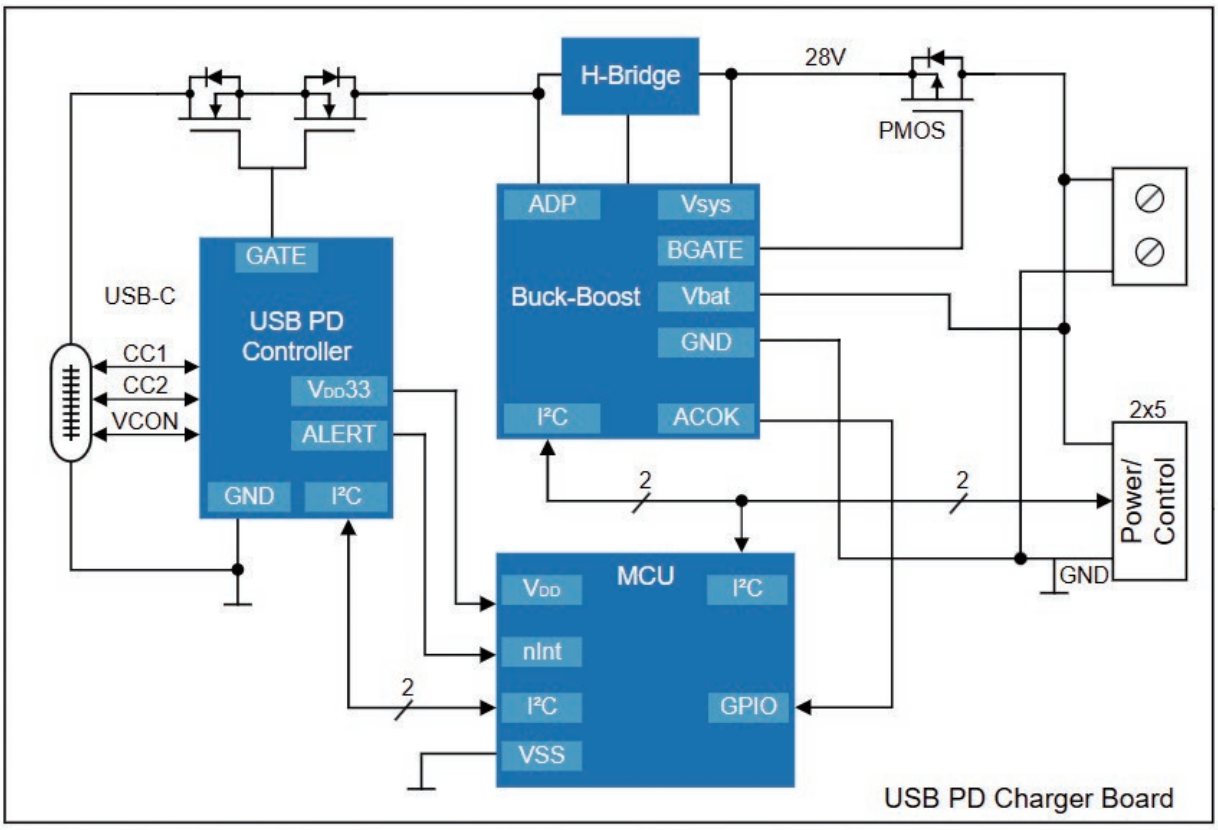
This is a Universal Serial Bus Power Delivery (USB PD) evaluation board that supports 6 to 12 battery cells in series configuration. This evaluation board is designed with a 48V USB-C Port Controller (SPR/EPR TCPC) RAA489400, USB-C Port Manager (TCPM) R5F10PGJ, and uses the RRB86848 as an On-Board Charger. The board will support up to 48V/240W USB Type-C® EPR. The RTKR868EPRDE0000BU supports the USB PD 2.0, USB PD 3.2, and USB Type-C® Specifications, working as a USB Type-C® EPR power sink charger or an EPR power bank.
This evaluation board may be combined with an Evaluation Module of the Battery Fuel Gauging IC (FGIC) RAJ2400100 with Filefish to realize a complete Battery Management System (BMS).

Reference Solution – System Benefits

- Renesas has sophisticated technology background that continues to support up-to-date USB PD 3.2 and system integration with Battery Chargers
- Up to 240W USB-C® battery system reference design can set battery configuration and max charging current for 2 to 10 cell battery pack
- Renesas offers solutions for USB PD Alternate mode support, including USB3 Data and DisplayPort, which can combine with USB3 host controllers and MUX/ Redrivers
- Target Application: E-Bike, Automotive Car Charging module, In-vehicle Infotainment System (IVI), Power tools, Battery back-up system, Docking

BOM List for Reference Design

RAA489400	USB Type-C® Port Controller (TCPC) with integrated TCPC PHY, CC-Logic, supports Extended Power Range (EPR). (TID:10147)
RRB86848	Bidirectional 48V Buck-Boost Battery Charger with high efficiency and wide DC power range, that supports pass-through, OTG, reverse mode
R5F10PGJ	RL78/F14 MCU with low level of consumption current and built-in CAN module for automotive interfaces, operating as TCPM
ISL80101	High Performance 1A LDO for system and Type-C port VCONN source power supply



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 No.	CFP*2
RL78G (General Purpose) High-Speed Operation Mode, Max VDD, 105°C: 17.6mA (Nominal VDD: 1.6-5.5V) RL78L (LCD Driver) High-Speed Operation Mode, Max VDD, 85°C: 8.5mA (Nominal VDD 1.6-5.5V) RL78/I1E (ASSP Sensing) High-Speed Operation Mode, Max VDD, 125°C: 8.7mA (Nominal VDD: 2.4-5.5V) RL78/I1D (ASSP Detector)/RL78/H1D (ASSP Medical) High-Speed Operation Mode, Max VDD, 105°C: 8.7 mA (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
	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 No.	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
	AC Outlet 120/240 V	AC-DC Converter	RAA223012	YES
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)	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 No.	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
	AC Outlet 120/240 V	AC-DC Converter	RAA223012	YES
RA6 (Arm® Cortex®-M4 or –M33) High-Speed Operation Mode, Max VDD, 105°C: 150mA (Nominal VDD: 2.7-3.6V)	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
	72V Rail	Buck Converter	RAA211820	NO
	AC Outlet 120/240 V	AC-DC Converter	RAA223011	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)	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

LOOK-UP TABLE WITH POWER ATTACHED

Industrial

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

RENESAS RZ

Industrial Realtime Control

RZ/T Series

Realtime Control + RTOS

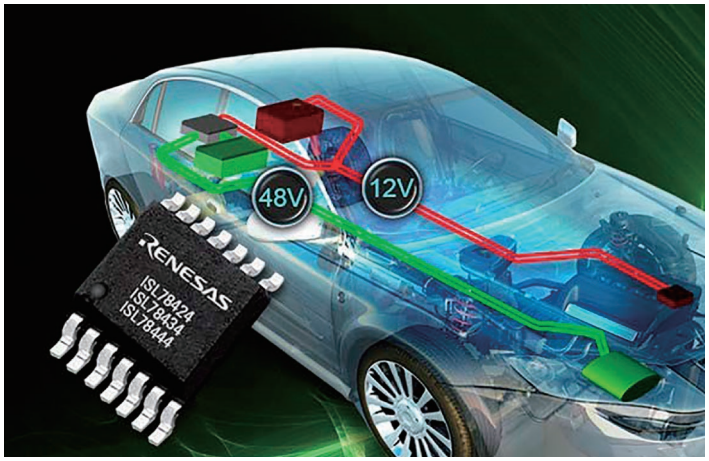
Family	Device	Target Application	System PMIC	Sub-PMIC
RZ/G	G1E	General HMI, IoT Gateway (Linux)	RAA215300A2GNP#HA5	–
RZ/G	G2L/V2L/G2LC	General HMI, IoT Gateway (Linux)	RAA215300A2GNP#HA0 RAA215300A2GNP#HA1	–
RZ/G	G2L/V2L	General HMI, IoT Gateway (Linux)	DA9281-01ATx	–
RZ/G	G2UL/A3UL/Five	General HMI, IoT Gateway (Linux)	DA9062-52/53/55/56AMx	–
RZ/G	G2H	General HMI, IoT Gateway (Linux)	DA9080-68FCBx	DA9292-ANOVx DA9121-C4V72
RZ/G	G2M/G2N	General HMI, IoT Gateway (Linux)	DA9080-68FCBx	DA9292-ANOVx
RZ/G	G3S	General HMI, IoT Gateway (Linux)	RAA215300A2GNP#HA3	–
RZ/G	G3S	General HMI, IoT Gateway (Linux)	DA9062-5DAMx	–
RZ/G	G3S	General HMI, IoT Gateway (Linux)	RAA215310AGNP#HA2	–
RZ/V	V2H	Vision Artificial Intelligence	RAA215300A2GNP#HA2	DA9141-08F72
RZ/V	V2H SOM	Vision Artificial Intelligence	RAA215300A2GNP#HA7	DA9215-8DUP6
RZ/V	V2N	Vision Artificial Intelligence	RAA215300A2GNP#HA2	DA9130-08RT2
RZ/TN	T1	Real Time Control	DA9279-48M7x	–
RZ/TN	N2H	Industrial Network	RAA215310AGNP#HA0	DA9217-17V7x
RZ/TN	N2H	Industrial Network	DA9080-66FCBx	DA9220-61V7x
RZ/TN	T2H	Real Time Control	RAA215310AGNP#HA0	DA9217-17V7x
RZ/TN	T2H	Real Time Control	DA9080-66FCBx	DA9220-61V7x
RZ/TN	T2L/N2L/T2M	Real Time Control/Industrial Network	DA9080-61FCBx	–
RZ/TN	T2M/N2L	Real Time Control	DA9080-64FCBx	–
RZ/TN	N2L SOM	Industrial Network	DA9083-31UUx	–
RZ/TN	T2M	Real Time Control	DA9061-16AMx	–
RZ/TN	T2L/N2L/T2M	Real Time Control/Industrial Network	DA9279-45M7x	–

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

	Application Domains					
	ADAS	Cockpit	E/E Architecture	Powertrain	xEV	Chassis & Body
RENESAS	Power Management ICs (PMICs)					
		LED Backlight Drivers				
					Battery Management ICs	
					Gate Drivers	
					MOSFETs	
	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.

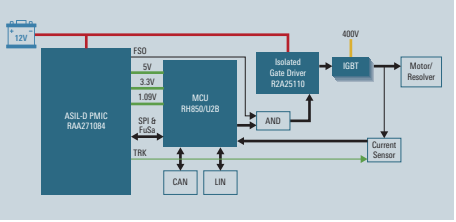
Features

- Provides unmatched scalability for High Performance Microcontrollers MCUs like RH850/U2A and RH850/U2B
- Integrated Support for ASIL D applications including the safety requirements of Renesas MCUs

Benefits

- Supports broad range of MCU and Applications without redesign effort/ risk
- Closely aligned with MCU and Application requirements to shorten design time

Application Example Using RH850/U2x



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.

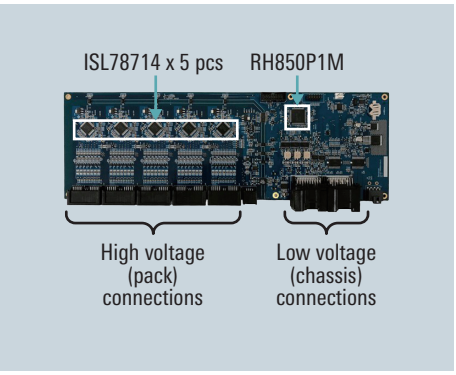
Features

- 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



Gate Driver Units (GDUs)

RAJ2930004AGM is designed for use with xEV inverter. It can be used together with both IGBTs and SiC MOSFETs. Built-in 3.75kVrms isolator can support power devices with a withstand voltage of up to 1200V.

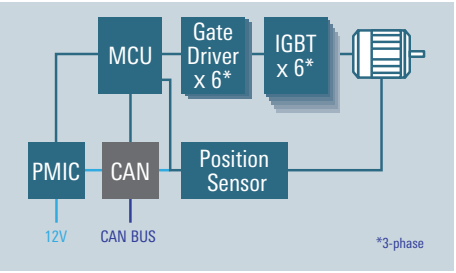
Features

- High Withstand Isolation voltage with Built-in 3.75kVrms isolator
- High CMTI performance at 150 V/ns or higher
- Built-in Protection and fault detection functions: DESAT, UVLO, Fault feedback

Benefits

- Basic functionality achieved with SOIC16 package making it ideal for cost-effective inverter systems.
- High CMTI providing reliable communication and increased noise immunity while meeting the high voltages and fast switching speeds required in inverter systems.

Example Solution
Inverter Reference Design with GDU



KEY PRODUCTS

Automotive Power Products

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.
- 12-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 intelligent power devices (IPD) that power and protect electrical loads throughout a vehicle to enable safer, more robust power distribution.

Intelligent Power Devices (IPDs)

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

Features

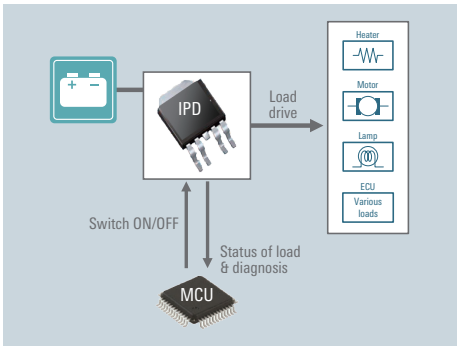
- Proven MOSFET and control chip technology in a single package
- Low ON-resistance and wide SOA
- Self-protection against short circuit, over-current, and over-temperature
- Self-diagnostic and monitoring functions
- High max operating temperature
- AEC-Q100 qualified and RoHS compliant

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.

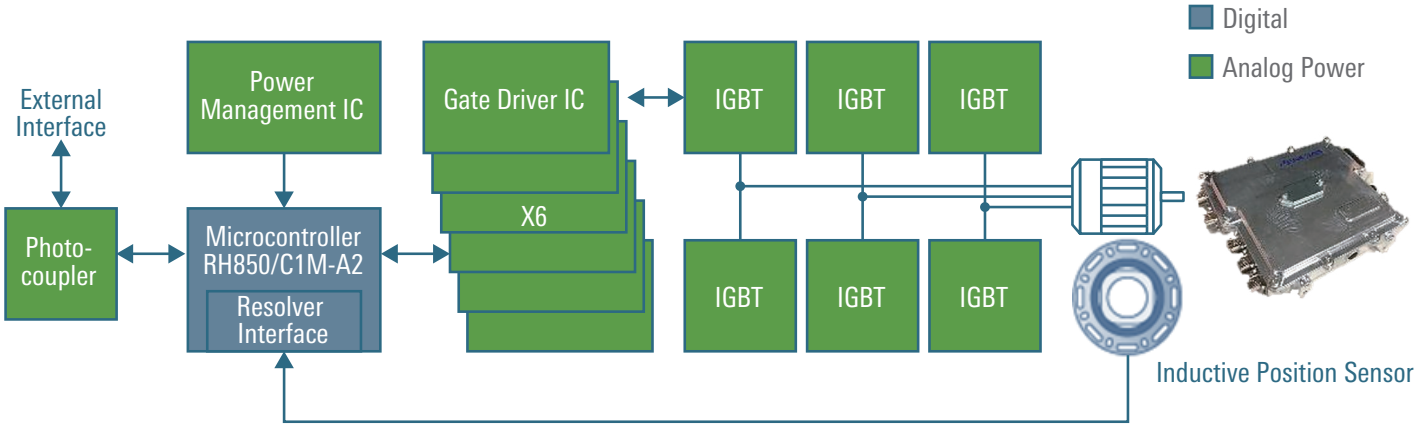
Reference Solution – System Benefits

- 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 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	32-bit microcontroller with embedded resolver interface and motor control IP
RH850/U2B	32-bit Vehicle Motion Microcontroller Series
RAA270000	Power management IC (PMIC)
RAA271084	General-Purpose Power Management IC for Automotive Applications
R2A25110	Gate driver IC
RV1S2752Q	Photocoupler
RAJ2930004AGM	Gate driver IC

Block Diagram and Reference Board



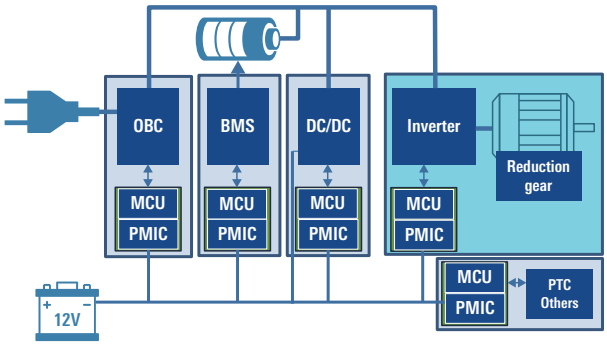
APPLICATION SOLUTIONS

X-IN-1 System Integration

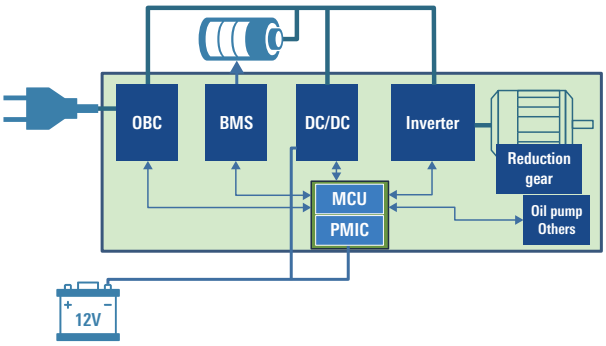
■ Reference Solution – System Benefits

- 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

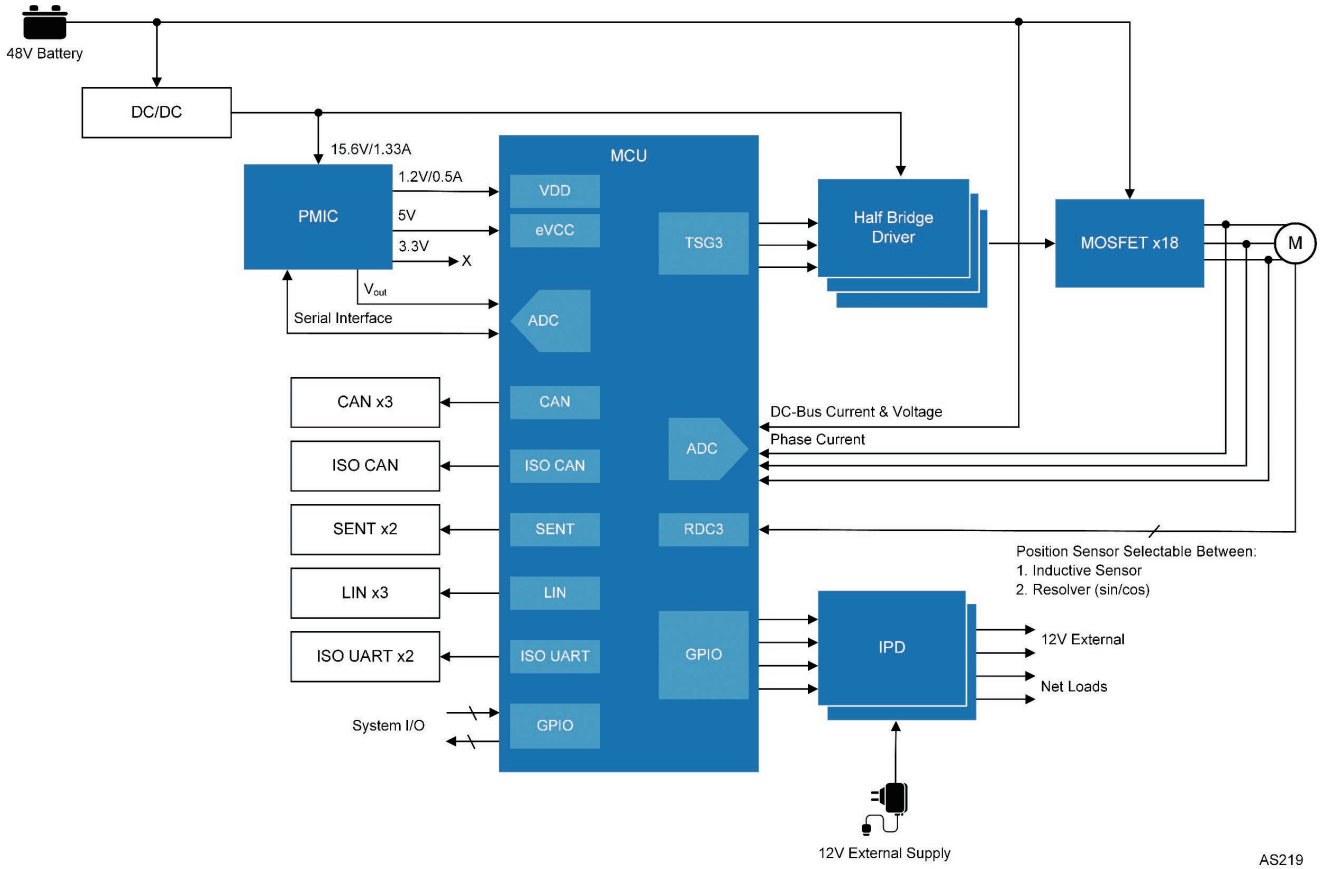
Renesas' Low Voltage Inverter for 2/3 Wheelers Traction Motor Control solution is a reference design based on an MCU and analog products for high-power 48V motor control applications. The design includes inverter hardware design files (schematics and Gerber) and peripheral sample code (for the motor 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

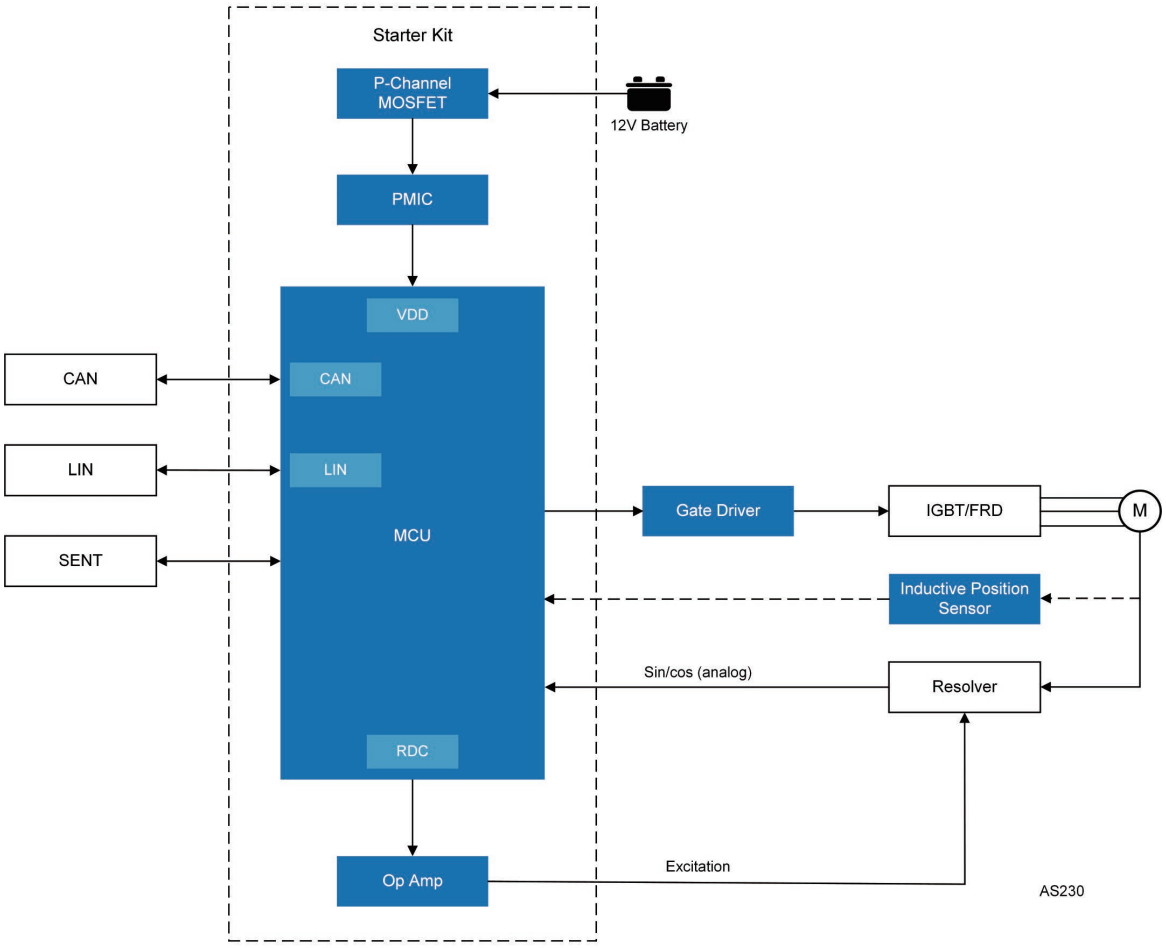
This system is a high-performance xEV traction motor and regeneration control solution using the RH850/C1M-Ax automotive microcontroller (MCU), supporting ASIL C and incorporating lock-step CPU cores and sophisticated motor control IP (EMU3).

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
RAA271084	General-Purpose Power Management IC for Automotive Applications
RH850/C1M-Ax	Microcontroller with G3MH CPU Core Ideal for HEV / EV Motor Control
RH850/U2x	32-bit Vehicle Motion Microcontroller Series
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)
RAJ2930004AGM	Gate driver IC



APPLICATION SOLUTIONS

Automotive Communication Gateway Platform

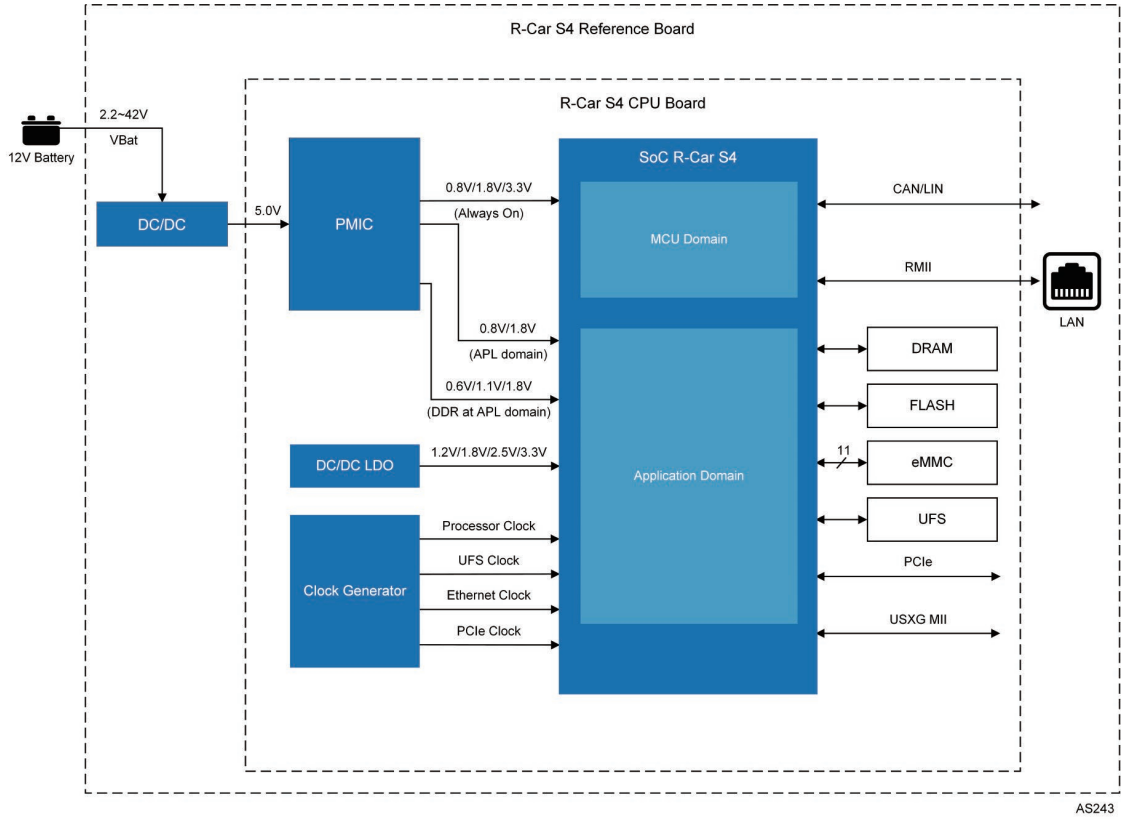
This solution provides a complete reference design with hardware and software for automotive gateway applications to support the electrical/electronic (E/E) architecture. It provides an integrated system that controls an ever-increasing number of vehicle functions in all areas of vehicle control.

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.

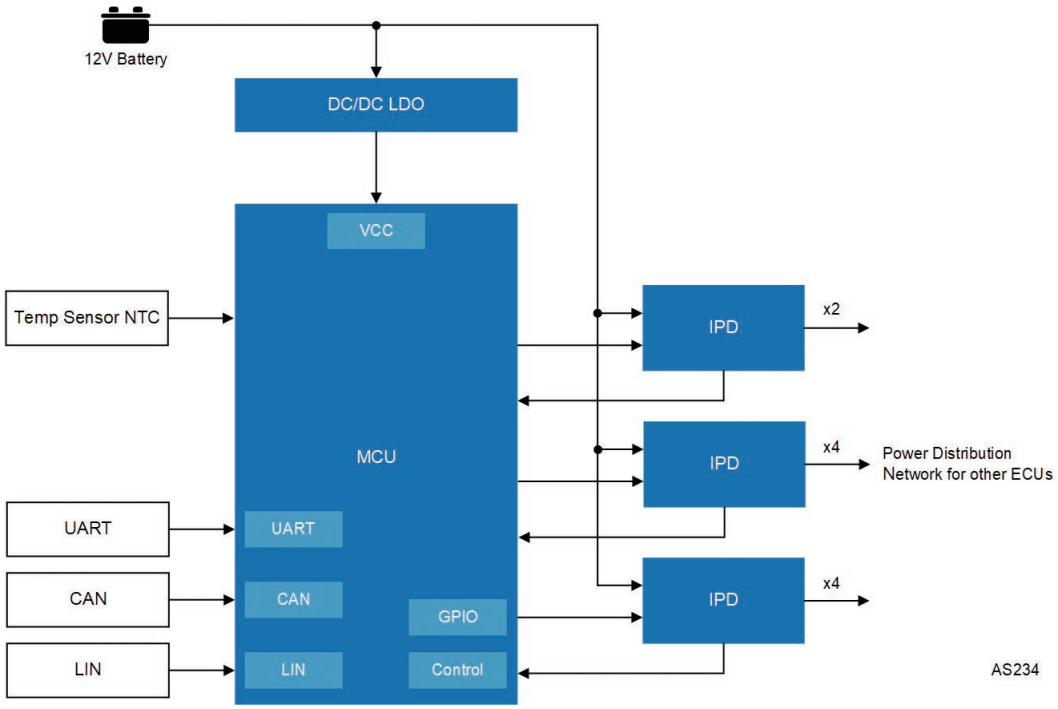
Reference Solution – System Benefits

- 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.

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

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
RAJ2810024H12HPD	Intelligent Power Device



APPLICATION SOLUTIONS

Zone-ECU Virtualization Solution Platform

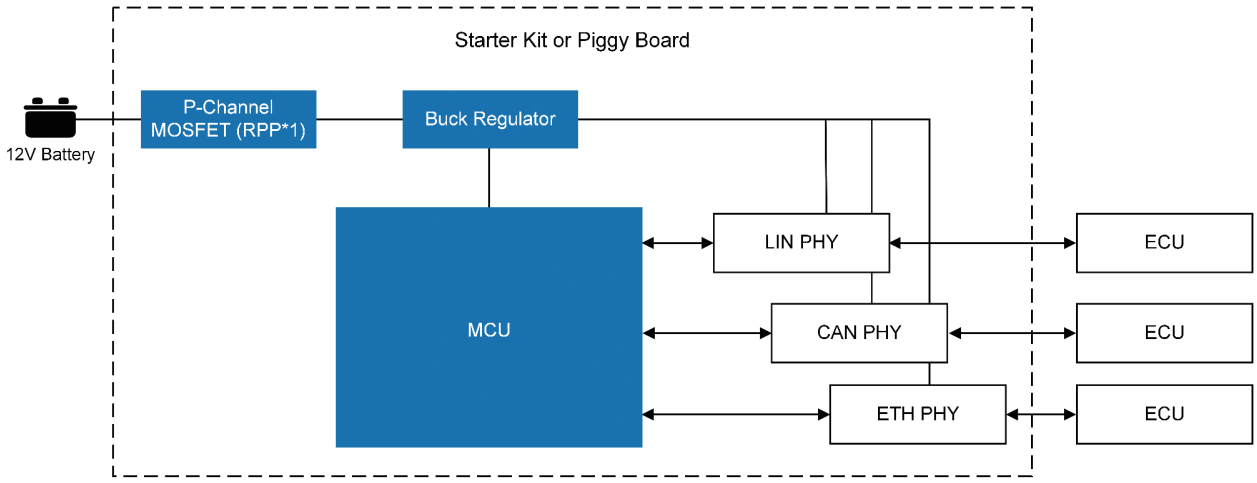
The RH850/U2x Zone-ECU Virtualization Platform is a development platform that provides a pre-integrated solution, including relevant software (SW) products and tools. This platform enables automotive customers to take a ready-to-go approach for individual Zone-ECU projects.

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
RAA271084	General-Purpose Power Management IC for Automotive Applications
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

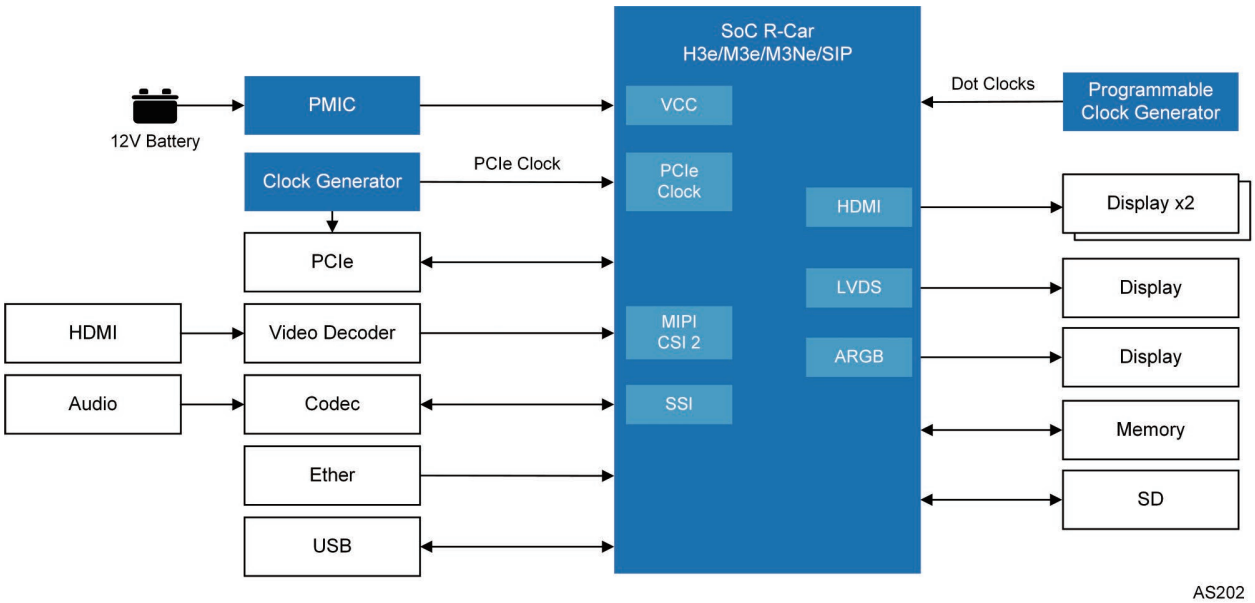
This combination of the R-Car (H3/M3/M3N) system-on-chip (SoC), power management IC (PMIC), and programmable clock generator allows for a versatile solution. They enable scalable cockpit and infotainment solutions that support high image quality, multiple video display outputs, and a wide variety of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



APPLICATION SOLUTIONS

ADAS Front Camera Solution

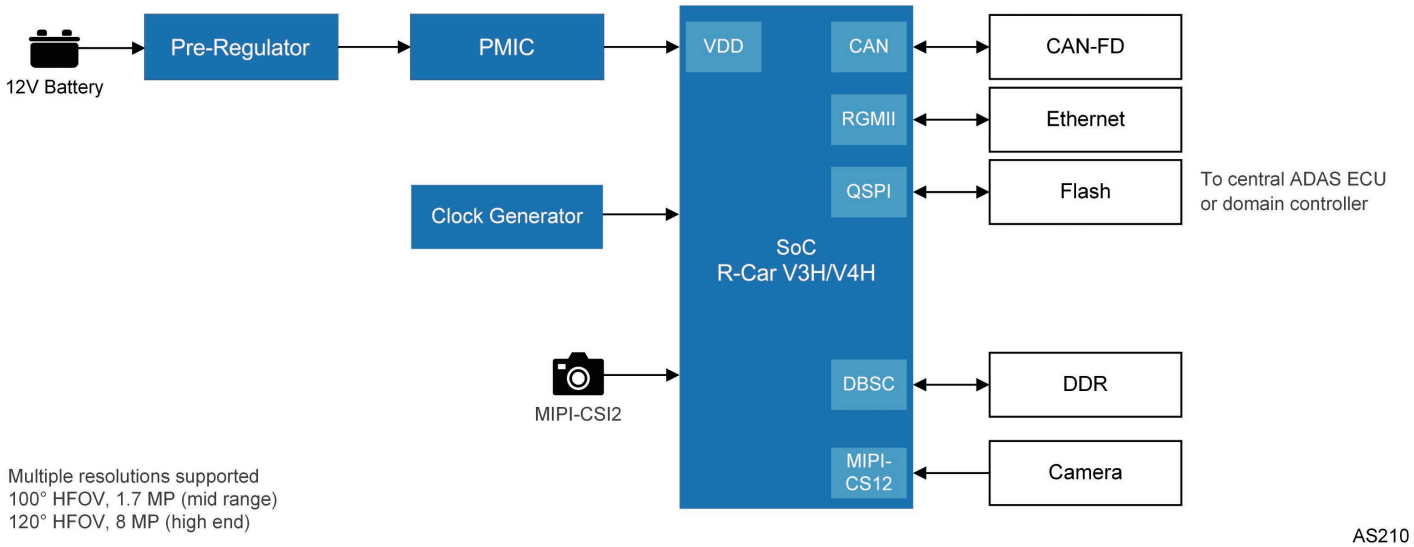
This open front camera solution features Renesas' R-Car V3H System-on-Chip (SoC). This all-in-one scalable camera platform targets the latest Euro New Car Assessment Program (NCAP) and Chinese Car Safety Assessment Program (C-NCAP) requirements, such as automatic emergency braking, forward collision 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
		RAA271084	ASIL D		Buck/Boost
RH850/P1x	ASIL D	RAA270005	QM	12V Rail	Buck Converter
RH850/C1x	ASIL D	RAA270000	QM	12V Rail	Buck Converter
RH850/U2x	ASIL D	RAA271084	ASIL D	12V Rail	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

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 and 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 or any other claims 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 license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what 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 each Renesas Electronics product depends on the product's quality grade, as indicated below.
   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine 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.
   Unless expressly 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 (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; 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.
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 INVULNERABLE 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 ranges 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 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 fire, and/or danger 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.
10. Please contact a Renesas Electronics sales office for details as to 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.
11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale 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 asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers 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 if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 2020.10)

■Contact Us
https://www.renesas.com/contact-us

Renesas Electronics Corporation

www.renesas.com

Document No. R16CP0005EJ0400