RA FAMILY

Renesas 32-bit Arm® Cortex®-M Microcontrollers

2025.12

INTRODUCING THE RA FAMILY

Delivering the Ultimate Promise of IoT with Software Flexibility

CONTENTS

With the widespread adoption of IoT, the number of “connected devices” in our daily lives and industries continues to grow rapidly.
From smart homes and wearables to medical equipment, industrial automation, and social infrastructure monitoring,
today’s edge devices require designs built on security and reliability, ultra-low power performance that supports continuous operation, and flexible platforms that streamline increasingly complex system development.
To meet these evolving requirements, Renesas introduced the RA Family (Renesas Advanced) — a 32-bit MCU family built on the Arm® Cortex®-M core architecture.
True to the spirit of Renesas Advanced, the RA Family combines Renesas’ proven peripheral IP, created and enhanced through years of product development experience,
with advanced security expertise, integrating a hardware-based security engine and Arm TrustZone® isolation technology.
The RA Family has also obtained key industry certifications including SESIP and PSA Certified™,
and is designed to comply with the requirements of the EU Cyber Resilience Act (CRA),
providing a robust edge platform that addresses the rising global demand for cybersecurity.
Balancing low power consumption with high performance, the RA Family supports a wide range of applications—from battery-powered devices to continuously operating industrial systems.
In addition, the Flexible Software Package (FSP) from Renesas enables reuse of software assets, including key management and security functions, significantly enhancing development efficiency.
With its solid technological foundation and recognized security excellence, the RA Family continues to be adopted by leading manufacturers and design partners worldwide, earning a trusted reputation across diverse fields such as consumer electronics, industrial equipment, building automation, medical devices, and infrastructure systems.
Security, efficiency, and scalability — seamlessly integrated at the highest level,
the RA Family stands as a new foundation for securely connected embedded platforms in the IoT era.

Reliable. Agile. Advanced. — This is Renesas Advanced, the RA Family.

Positioning of the RA

Microcontrollers & Microprocessors, System-on-Chips (SoCs)

- **RZ** — High-end 32/64-bit MPUs
  High-resolution HMI, Industrial network & real-time control
- **RA** — Advanced 32-bit MCUs
  Arm ecosystem, Advanced security, Intelligent IoT
- **RX** — High Power Efficiently 32-bit MCUs
  Motor control, Capacitive touch, Functional safety, GUI
- **RISC-V products** — General-purpose 64-bit MPUs (RZ/Five Group)
  Application-specific 32-bit MCUs
- **RL78** — Ultra-low Energy 8/16-bit MCUs
  Bluetooth® Low Energy, SubGHz, LoRa®-based Solutions
  Automotive actuators & sensors, Low-end ECUs
- **RH850** — Automotive 32-bit MCUs
  Rich functional safety and embedded security features
- **R-Car** — Automotive SoCs
  Next generation of automotive computing

Analog and Power Devices

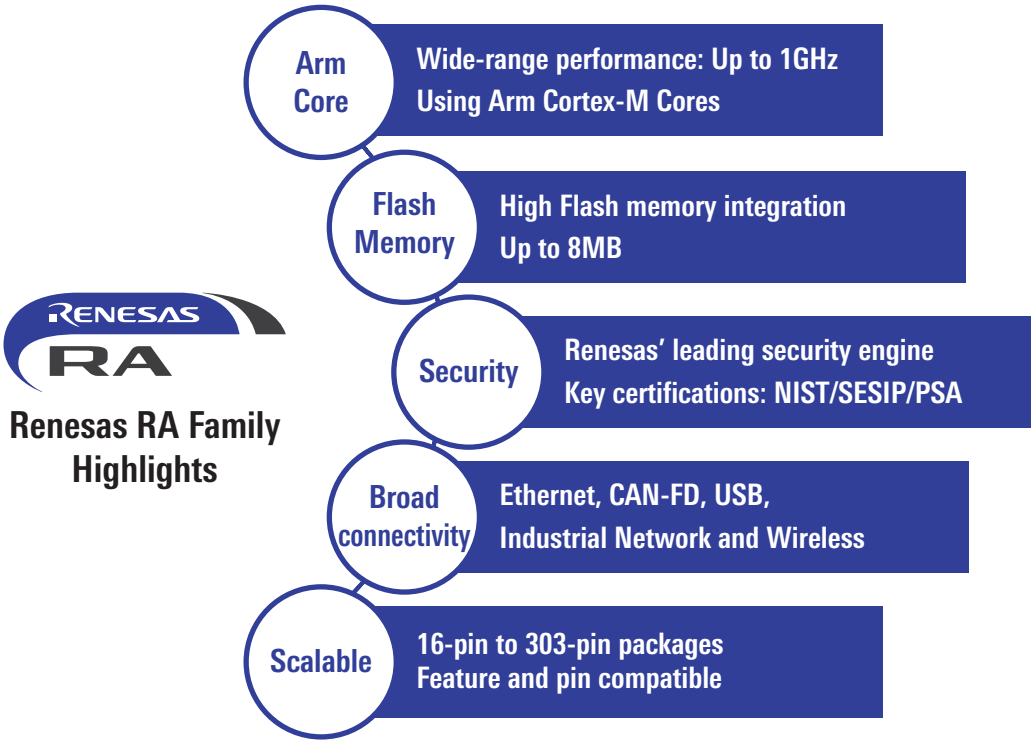
- Analog products
- Clocks & Timing
- Interface & Connectivity
- Memory & Logic
- Power & Power management
- Programmable Mixed-signal, ASIC, & IP products
- RF products
- Sensor products
- Space & Harsh environment

- Timing
- Wireless Power
- Battery Management
- Power Devices
- Power Management
- Sensors
- Video & Display

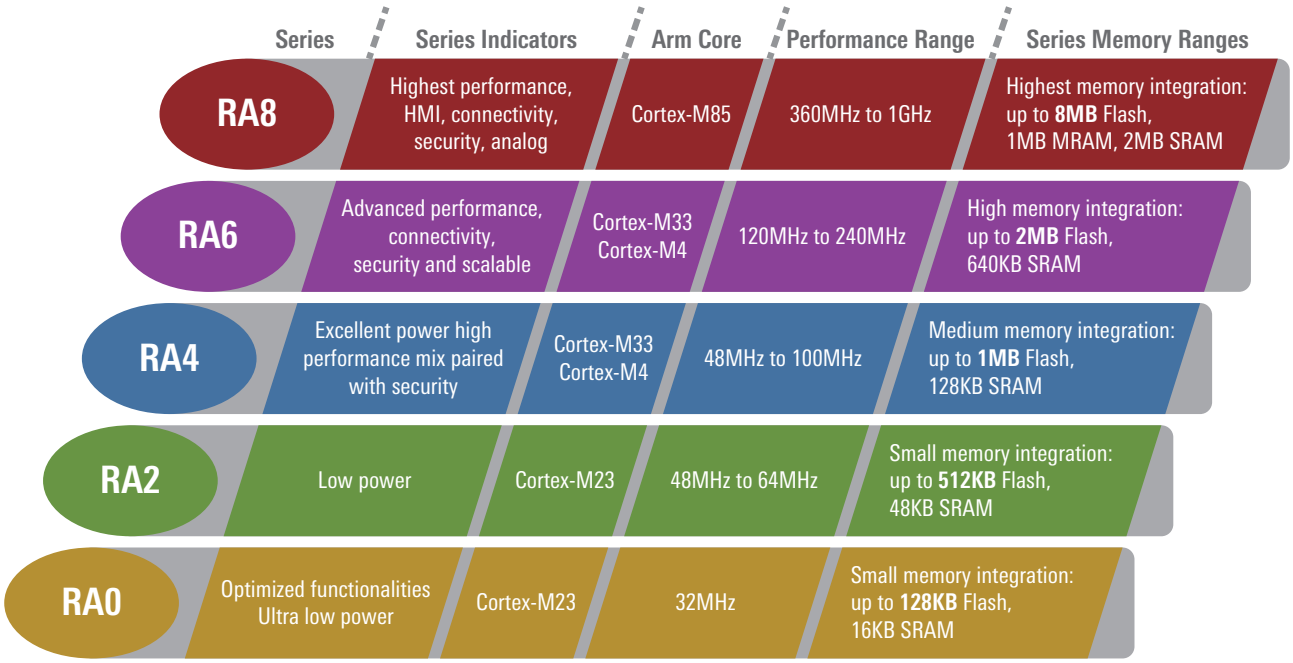
What is the Renesas RA Family?

The Renesas RA family is a high-performance 32-bit MCU series designed for a wide range of applications. It features Arm Cortex-M23, M33, M4, and M85 cores, along with Renesas' extensive and proven peripheral IP. For enhanced security, the RA family integrates a dedicated security engine and meets industry standards such as NIST, SESIP, PSA Certified, and compliance with the EU Cyber Resilience Act (CRA), addressing a wide spectrum of security requirements.

Additionally, with support for the Flexible Software Package (FSP), the RA family streamlines application development and accelerates time to market.



The RA Family offers five series optimized for performance, functionality, and cost: the RA8 series, delivering performance that covers the MPU range; the RA6 series, combining high performance with advanced features; the RA4 series, offering an optimal balance of performance and power efficiency; the RA2 series, focused on ultra-low power consumption; and the RA0 series, designed for cost-efficient applications.



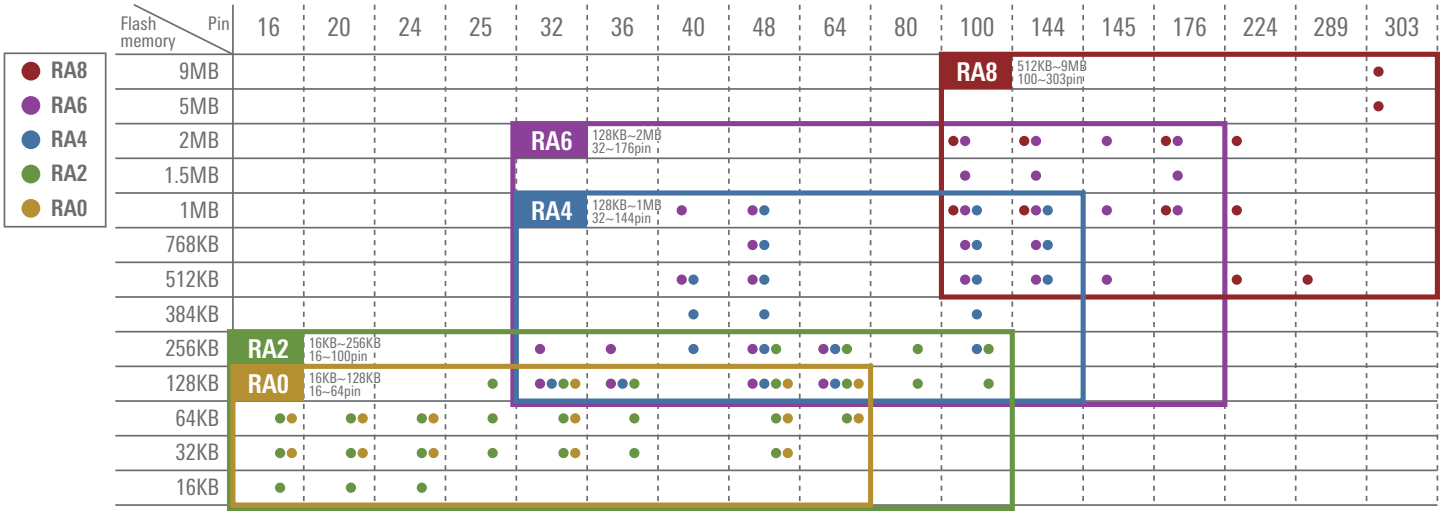
	Mainstream	Low Power	Entry	ASSP Motor & Analog	Wireless
RA8 Series	**RA8P1** 1GHz Cortex-M85, M33 Ethos-U55, 1MB/2MB **RA8D2** 1GHz Cortex-M85 8MB/4MB **RA8D1** 480MHz Cortex-M85 1MB/2MB **RA8M2** 1GHz Cortex-M85 8MB/4MB **RA8M1** 480MHz Cortex-M85 1MB/2MB		**RA8E2** 480MHz Cortex-M85 1MB/672KB **RA8E1** 360MHz Cortex-M85 1MB/544KB	**RA8T2** 1GHz Cortex-M85, M33 1MB/2MB **RA8T1** 480MHz Cortex-M85 2MB/1MB	
RA6 Series	**RA6M5** 200MHz Cortex-M33 2MB/512KB **RA6M4** 200MHz Cortex-M33 1MB/256KB **RA6M3** 120MHz Cortex-M4 2MB/640KB **RA6M2** 120MHz Cortex-M4 1MB/384KB **RA6M1** 120MHz Cortex-M4 512KB/256KB		**RA6E2** 200MHz Cortex-M33 256KB/40KB **RA6E1** 200MHz Cortex-M33 1MB/256KB	**RA6T3** 200MHz Cortex-M33 256KB/40KB **RA6T2** 240MHz Cortex-M33 512KB/64KB **RA6T1** 120MHz Cortex-M4 512KB/64KB	**RA6W1** 160MHz Cortex-M33 256KB/704KB
RA4 Series	**RA4M3** 100MHz Cortex-M33 1MB/128KB **RA4M2** 100MHz Cortex-M33 512KB/128KB **RA4M1** 48MHz Cortex-M4 256KB/32KB	**RA4C1** 80MHz Cortex-M33 512KB/96KB **RA4L1** 80MHz Cortex-M33 512KB/64KB	**RA4E2** 100MHz Cortex-M33 128KB/40KB **RA4E1** 100MHz Cortex-M33 512KB/128KB	**RA4T1** 100MHz Cortex-M33 256KB/40KB	
RA2 Series		**RA2L2** 48MHz Cortex-M23 128KB/16KB **RA2L1** 48MHz Cortex-M23 256KB/32KB	**RA2E3** 48MHz Cortex-M23 64KB/16KB **RA2E2** 48MHz Cortex-M23 64KB/8KB **RA2E1** 48MHz Cortex-M23 128KB/16KB	**RA2T1** 64MHz Cortex-M23 64KB/8KB **RA2A2** 48MHz Cortex-M23 512KB/48KB **RA2A1** 48MHz Cortex-M23 256KB/32KB	
RA0 Series		**RA0L1** 32MHz Cortex-M23 64KB/16KB	**RA0E2** 32MHz Cortex-M23 128KB/16KB **RA0E1** 32MHz Cortex-M23 64KB/12KB		

RA Family Memory vs. Pin Lineup

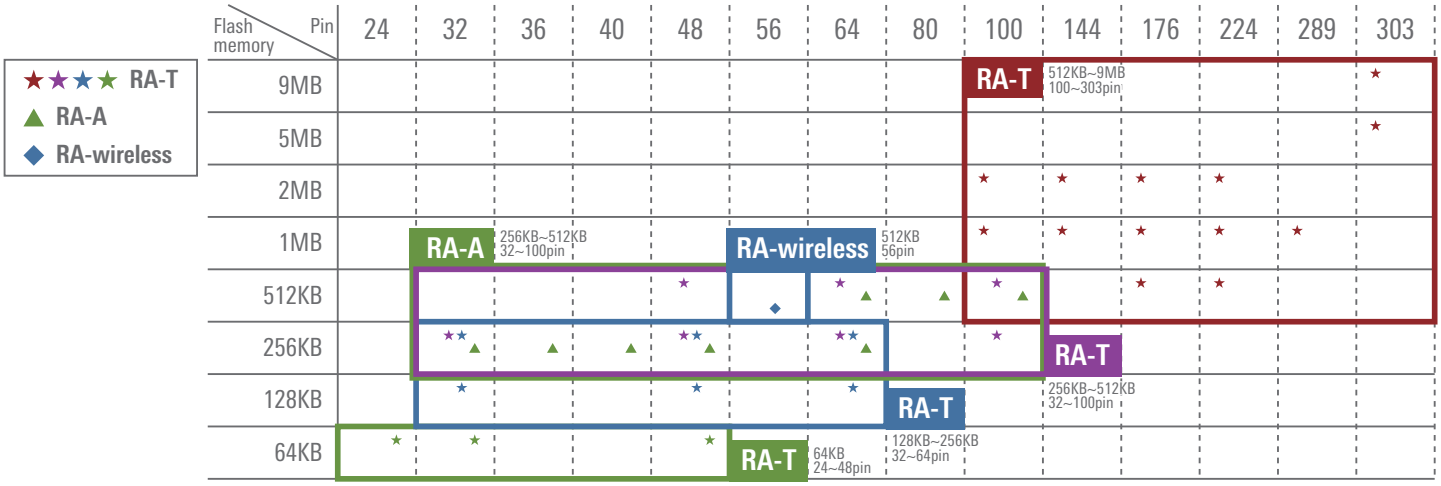
Pin and memory compatibility for smooth product migration

The design prioritizes package and pin layout compatibility, as well as memory capacity scalability, making future expansion and expansion to derivative products smooth, and also enabling the use of the same boards and software assets between microcontrollers with different functions and performance.

General Purpose

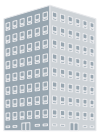


ASSP



RA Family Target Applications

The RA Family offers five series - RA8, RA6, RA4, RA2, and RA0 - designed to meet a wide range of application needs.
In addition, ASSP products such as Motor/Inverter (RA-T) and Rich Analog (RA-A) are also available, enabling the RA Family to be utilized in diverse fields.

	System Control		Drive (Motor/inverter control)		HMI (Capacitive touch LCD , etc)		Communications (Wired/Wireless/ Industrial network, etc.)		Measurement/ Sensing		AI/ML	
Industrial Automation  Robotics, Door Openers AC Drive, AC Servo UPS, Functional Safety, etc.	RA0	RA-T	RA0	**RA-T**	RA0	RA-T	RA0	RA-T	RA0	RA-T	RA0	RA-T
	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	**RA-A**	RA2	RA-A
	RA4		RA4		RA4		RA4		RA4		RA4	
	RA6		RA6		RA6		RA6		RA6		RA6	
	RA8		RA8		RA8		RA8		RA8		RA8	
Appliances  HVAC, Air Cleaners, Smoke Detectors, Wearable Devices, etc.	RA0	RA-T	RA0	**RA-T**	RA0	RA-T	RA0	RA-T	RA0	RA-T	RA0	RA-T
	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	**RA-A**	RA2	RA-A
	RA4		RA4		RA4		RA4		RA4		RA4	
	RA6		RA6		RA6		RA6		RA6		RA6	
	RA8		RA8		RA8		RA8		RA8		RA8	
Building Automation  Fire Panels, Vending Machines, Monitoring Systems, etc.	RA0	RA-T	RA0	**RA-T**	RA0	RA-T	RA0	RA-T	RA0	RA-T	RA0	RA-T
	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	**RA-A**	RA2	RA-A
	RA4		RA4		RA4		RA4		RA4		RA4	
	RA6		RA6		RA6		RA6		RA6		RA6	
	RA8		RA8		RA8		RA8		RA8		RA8	
Medical & Healthcare  Health Monitor Band, Wearable devices, Blood sugar meter, etc.	RA0	RA-T	RA0	**RA-T**	RA0	RA-T	RA0	RA-T	RA0	RA-T	RA0	RA-T
	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	**RA-A**	RA2	RA-A
	RA4		RA4		RA4		RA4		RA4		RA4	
	RA6		RA6		RA6		RA6		RA6		RA6	
	RA8		RA8		RA8		RA8		RA8		RA8	
Consumer Electronics  Home Entertainment, Power Adapters & Chargers, Wearables, etc.	RA0	RA-T	RA0	**RA-T**	RA0	RA-T	RA0	RA-T	RA0	RA-T	RA0	RA-T
	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	**RA-A**	RA2	RA-A
	RA4		RA4		RA4		RA4		RA4		RA4	
	RA6		RA6		RA6		RA6		RA6		RA6	
	RA8		RA8		RA8		RA8		RA8		RA8	
Metering & Energy  Electricity Meters, Automated Meter Reading, Network Cards, Flow Meters, Power Meters, etc.	RA0	RA-T	RA0	**RA-T**	RA0	RA-T	RA0	RA-T	RA0	RA-T	RA0	RA-T
	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	RA-A	RA2	**RA-A**	RA2	RA-A
	RA4		RA4		RA4		RA4		RA4		RA4	
	RA6		RA6		RA6		RA6		RA6		RA6	
	RA8		RA8		RA8		RA8		RA8		RA8	

RA0 Series

Features of the RA0 Series

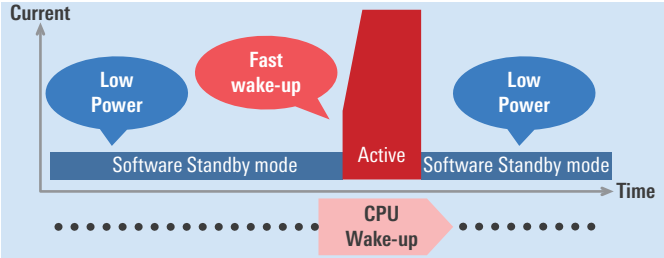
RA0 series is cost-efficient value line 32-bit MCU, offering ultra-low power consumption up to 32MHz and 128KB flash. And these devices have a feature set optimized for cost-sensitive applications.

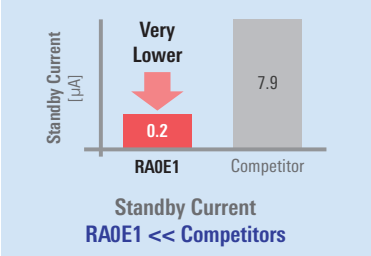
The RA0 MCUs integrate high-precision (±1.0%) on-chip oscillator (HOCO) improves baud rate accuracy and enables designers to forego a standalone oscillator to reduce customer BOM cost. They offer a wide operating voltage range of 1.6V to 5.5V so customers don't need a level shifter/regulator in 5V system. A wide range of packaging options is also available, including a tiny 3mm x 3mm 16-pin QFN.

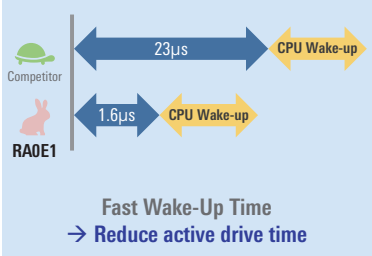
Low power consumption	Fast wake-up Operation	High accuracy internal osculator	Wide operating voltage range
2.5mA @ 32MHz operation 0.2µA @ Software standby mode	1.6µs from software standby mode	32MHz ±1% @ -40°C~125°C	1.6V ~ 5.5V

Ideal for intermittent operation

- Fast wake-up contributes to reduced current consumption by offering longer standby time.

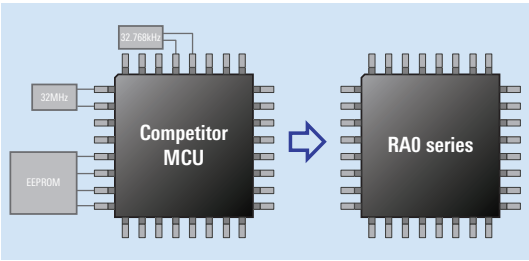


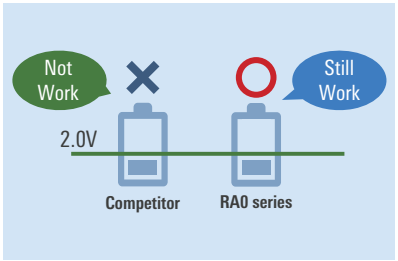


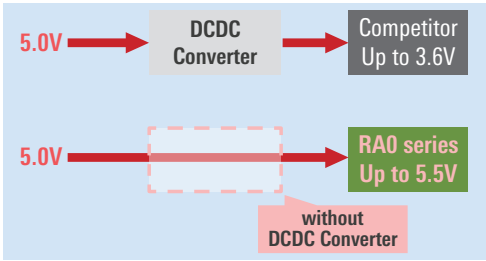


BOM cost reduction and Simplified Designs

- Integrated high-precision on-chip-oscillator, Data Flash
- RA0 series can work at Min 1.6V even when supply voltage drops.
- When using a 5.0V power supply, DCDC is not required and BOM cost can be reduced.







RA0 Series Lineup

Entry

RA0E1 — 32MHz, 64KB Flash, 12KB SRAM, 16/20/24/32-pin

Cortex-M23	12-bit ADC	UARTA	Data Flash	RTC	TRNG	ELC

RA0E2 — 32MHz, 128KB Flash, 16KB SRAM, 32/48/64-pin

Cortex-M23	12-bit ADC	UARTA	Data Flash	RTC	TRNG	ELC

Low power

RA0L1 — 32MHz, 64KB Flash, 16KB SRAM, 20/24/32/48-pin

Cortex-M23	12-bit ADC	UARTA	Data Flash	RTC	TRNG	ELC
Capacitive touch	Controlled Current Drive Port					

Common features

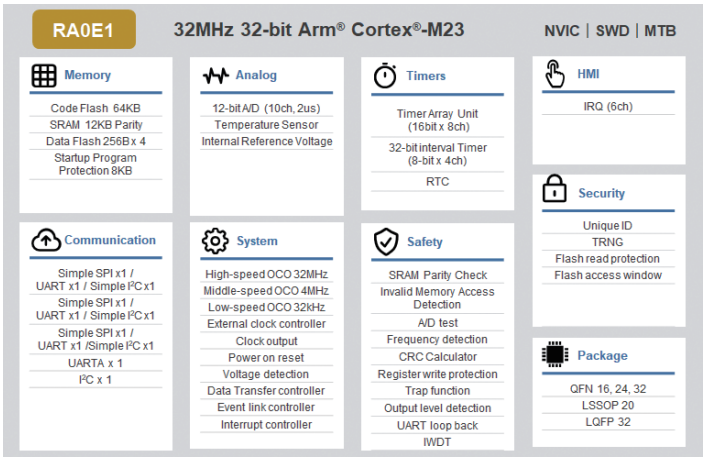
Low power process technology	DTC, LVD, CRC
Low Power Modes	FRP, Unique ID
SAU, IICA	Functional Safety Features
TAU, TML32, IWDT	

RA0E1 Group: 32MHz Arm Cortex-M23 Entry-Level MCU

The RA0E1 group is a basic, simple MCU in the entry line of the RA0 series, offering excellent cost effectiveness and ultra-low power consumption. It delivers up to 32MHz of CPU performance using an Arm Cortex-M23 core with up to 64KB of embedded flash memory and a wide supply voltage range from 1.6V to 5.5V. The RA0 series is ideal for cost-sensitive applications such as low power and lower cost for consumer electronics, system control for small appliances, industrial system control, and building automation.

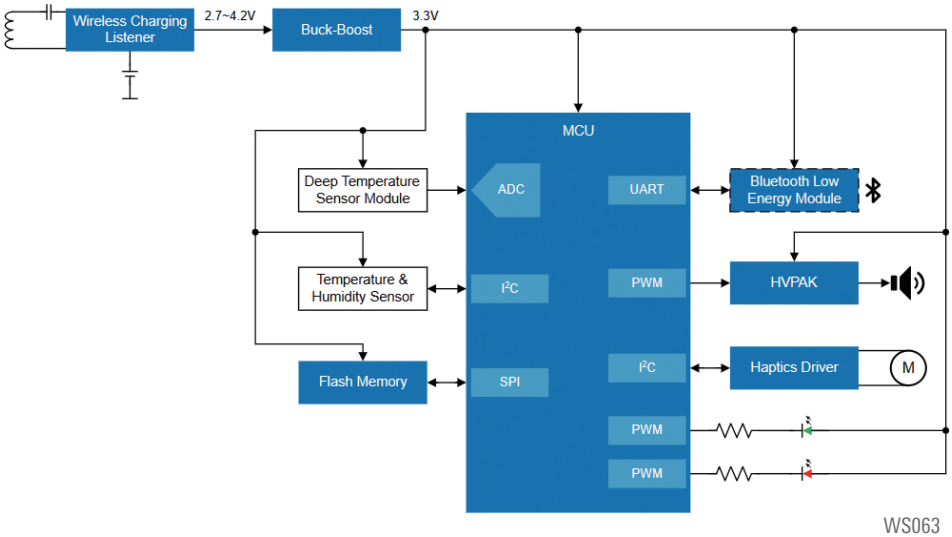
- 32MHz Arm Cortex-M23
- 32KB - 64KB Flash memory and 12KB SRAM
- Scalable from 16-pin to 32-pin packages
- Wide voltage range of 1.6V to 5.5V
- Various features: General PWM Timer, 32-bit Timer, RTC, 12-bit ADC, UART, Simple SPI, I²C
- ±1% high accuracy high-speed on-chip oscillator

Block Diagram



Use case: Heatstroke Prevention watch

This heatstroke prevention watch combines environmental sensors and deep body temperature monitoring to detect early warning signs of heatstroke. It prompts the wearer to take immediate action, such as hydrating or seeking shade. Designed with Renesas' industry-leading low-power technology, the watch enables continuous monitoring and delivers timely alerts through haptic feedback or a built-in speaker. NFC charging and optional Bluetooth connectivity enable convenient recharging and mobile integration for broader system use.



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System Benefits:

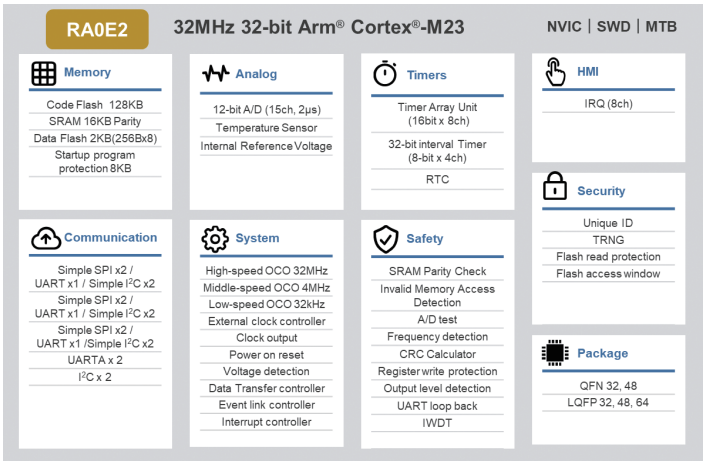
- Ultra-low power MCU enables continuous wear with fast wake-up and extended runtime between charges.
- Single-chip NFC charging simplifies system design, reduces external components, and enables a compact, low BOM design.
- Low-energy flash memory ensures fast reads and auto-interrupts, reducing polling overhead and conserving power.

RA0E2 Group: 32MHz Arm Cortex-M23 Entry-Level MCU with 128KB ROM

The RA0E2 group is a basic, simple microcontroller (MCU) in the entry line of the RA0 series, offering excellent cost-effectiveness and ultra-low power consumption. In addition, it is a ROM/PIN extension product of the RA0E1 group, with which it is highly compatible. It delivers up to 32MHz of CPU performance using an Arm Cortex-M23 core with up to 128KB of embedded flash memory, 16KB SRAM, and a wide operation temperature range from -40 to 125°C. The RA0 series is ideal for cost-sensitive applications such as low power and lower cost for consumer electronics, system control for small appliances, industrial system control, and building automation.

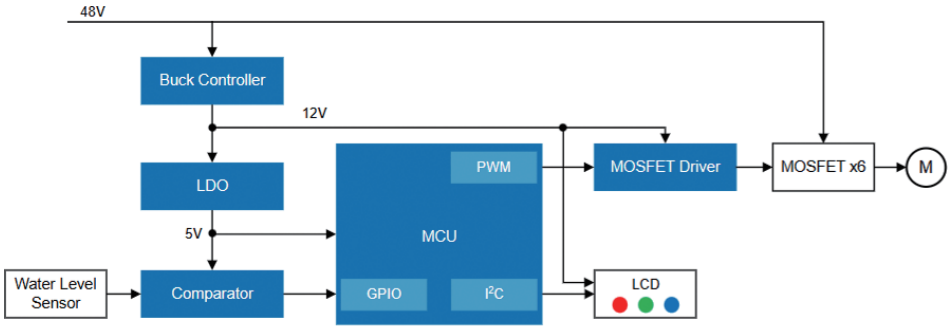
- 32MHz Arm Cortex-M23
- 64KB - 128KB Flash memory and 16KB SRAM
- Scalable from 32-pin to 64-pin packages
- Wide operating temperature range from -40 to 125°C
- Wide voltage range of 1.6V to 5.5V
- Various features, General PWM Timer, 32-bit Timer, RTC, 12-bit ADC, UART, Simple SPI, I²C
- ±1% high accuracy high-speed on-chip oscillator

Block Diagram



Use case: Household Water Pump

Household water pumps perform crucial functions, such as preventing flooding and water damage by removing excess water, and ensuring consistent water pressure and distribution by pumping water into storage tanks. This household water pump design features comparators that amplify signal data to an MCU from water-level sensors, driving the motor pump for a smart, responsive, and energy-efficient system.



System Benefits:

- Provides low power consumption and low noise for an energy-efficient water pump system.
- Photocouplers and gate drivers prevent high voltage damage, improving system safety and ensuring stable operation.
- Renesas' photocoupler and gate driver, combined with an inverter, offer a compact and high-efficiency design.

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RA0L1 Group: 32MHz Arm Cortex-M23 Ultra-Low Power Capacitive Touch MCU

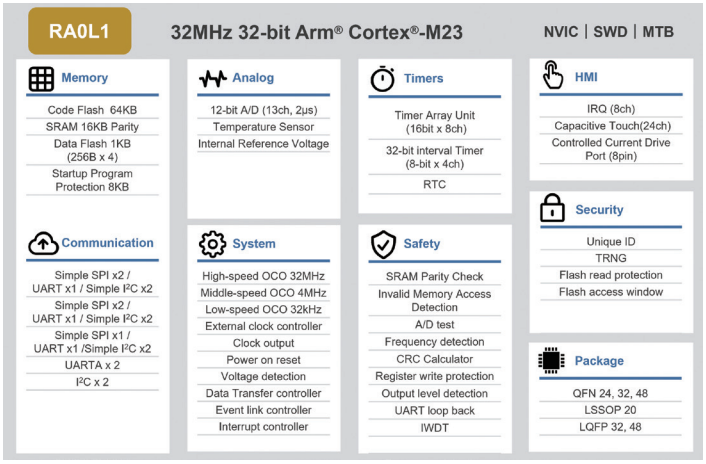
The RA0L1 group is the first product with capacitive touch functionality in the RA0 family MCU.

This product is implemented Arm Cortex-M23 core with low power and peripherals which are optimized for BOM cost reduction and simple design for the low-end MCU market. RA0L1 group supports up to 64KB code flash, 16KB SRAM memory, a wide operating voltage range of 1.6V to 5.5V, a wide operating temperature range of -40°C to 125°C.

The RA0 series is ideal for cost-sensitive applications such as low power and lower cost for consumer electronics, system control for small appliances, industrial system control and building automation.

- 32MHz Arm Cortex-M23
- 32KB - 64KB Flash memory and 16KB SRAM
- Scalable from 20-pin to 48-pin packages
- Wide operating temperature range from -40 to 125°C
- Wide voltage range of 1.6V to 5.5V
- Various features, General PWM Timer, 32-bit Timer, RTC, 12-bit ADC, UART, Simple SPI, I²C
- ±1% high accuracy high-speed on-chip oscillator
- Capacitive Touch Sensing Unit (CTSU2SLa)
- Controlled Current Drive Port

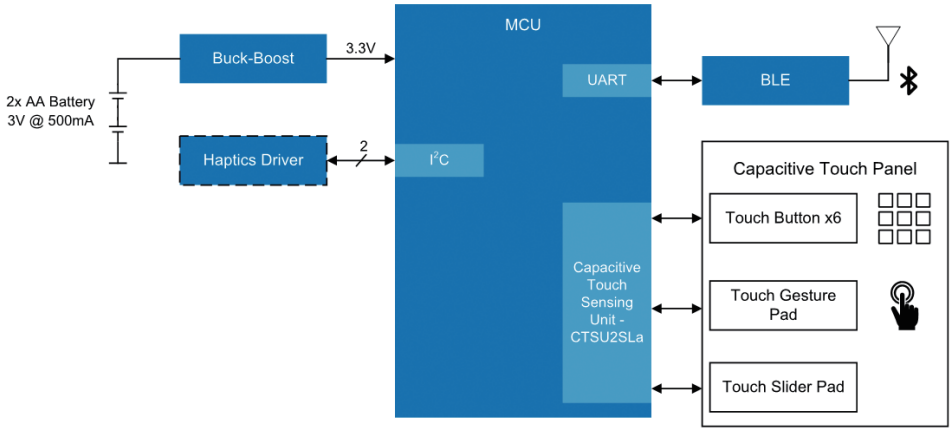
Block Diagram



Use case: Capacitive Touch Remote Controller

Slim, minimalist designs without physical buttons are increasingly appealing in consumer electronics and smart home applications. As households adopt more connected devices, an interoperable controller that can manage smart lights, TVs, sound systems, and more becomes essential.

This capacitive touch remote offers customizable gestures, swipes, and controls, consolidating multiple functions into one intuitive device. Its button-free design reduces mechanical points of failure, simplifies cleaning, and delivers versatile input through touchpads, sliders, and virtual buttons.



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System Benefits:

- Low-power system design extends battery life and usage time with energy-efficient components.
- Consolidated BOM minimizes external components (e.g., clocks, level shifters, regulators), enabling a compact form factor.
- Capacitive touch MCU supports flexible gesture inputs, including wheels, buttons, sliders, and swipes.
- Certified Bluetooth Low Energy (LE) modules ensure reliable connectivity and compliance with Bluetooth 5.1 and 5.3 standards.
- Optional haptics driver adds tactile feedback for a more intuitive and engaging user experience.

RA2 Series

Features of the RA2 Series

The RA2 Series is the entry-level line of the Renesas RA Family of 32-bit MCUs, offering an excellent balance of cost, performance, and ultra-low power consumption. Featuring Arm Cortex-M23 core operating at up to 48 MHz, the RA2 Series is ideal for system control and user interface applications in home appliances, industrial automations healthcare devices, office equipment, and measurement instruments.

Extensive and advanced peripheral function

Capacitive Touch
12bit-DAC, LP Comparator
CAN, I3C, LPUART, I2S, USB FS, USB-C

High compatibility and Scalability

High compatibility between RA2 series
Scalable peripheral function between RA2,RA4,RA6 and RA8 series

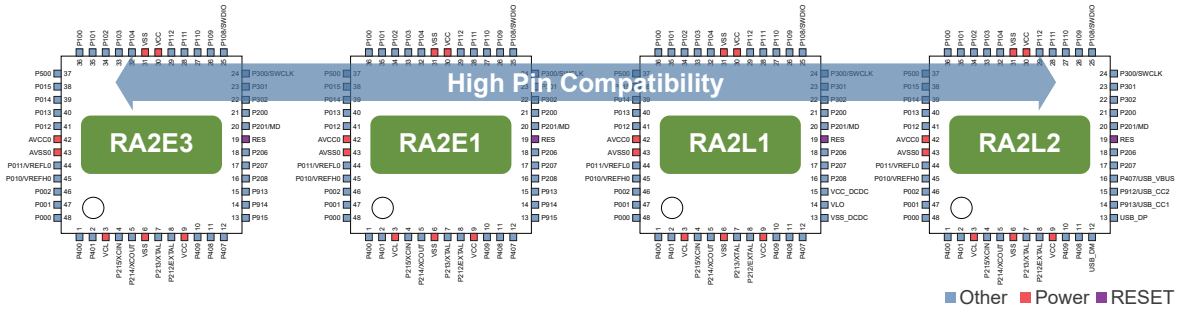
Low power consumption

87.5µA/MHz @ operation
0.25µA @ Software standby mode

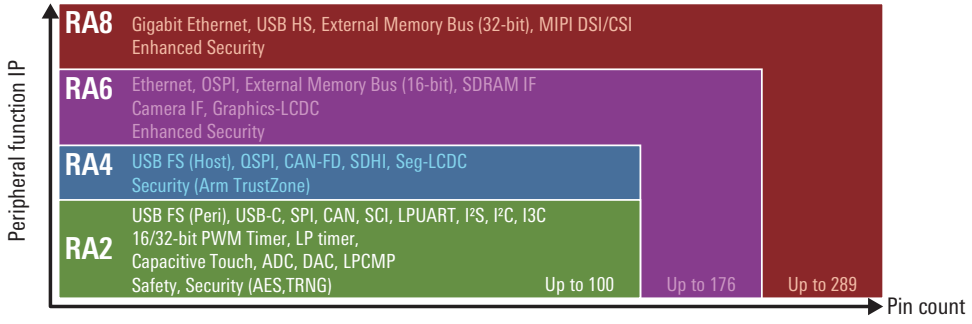
Very small package options

QFN, LGA, BGA, WLCSP

High compatibility within RA2 Series



Scalable peripheral functions across RA2, RA4, RA6 and RA8 Series



RA2 Series Lineup

USB

RA2L2 — 48MHz (Cortex-M23), 128KB Code Flash, 16KB SRAM, 4KB Data Flash, Security (Unique ID, TRNG)
32/48/64-pin

Cortex-M23	16-bit GPT	32-bit GPT	32-bit AGT	12-bit ADC	CAN	I3C	LPUART	I²S	USB FS	USB Type-C Interface

Capacitive touch

RA2L1 — 48MHz (Cortex-M23), 256KB Code Flash, 32KB SRAM (16KB ECC, 16KB Parity), 8KB Data Flash, Security (AES 128/256, Unique ID, TRNG)
48/64/80/100-pin

Cortex-M23	16-bit GPT	32-bit GPT	16-bit AGT	12-bit ADC	Capacitive touch	LP Comparator	12-bit DAC	CAN

RA2E1 — 48MHz (Cortex-M23), 128KB Code Flash, 16KB SRAM, 4KB Data Flash, Security (AES 128/256, Unique ID, TRNG)
25/32/36/48/64-pin

Cortex-M23	16-bit GPT	32-bit GPT	16-bit AGT	12-bit ADC	Capacitive touch	LP Comparator

Cost-effective

RA2E3 — 48MHz (Cortex-M23), 64KB Code Flash, 16KB SRAM, 2KB Data Flash, Security (Unique ID)
32/48-pin

Cortex-M23	16-bit GPT	32-bit GPT	16-bit AGT	12-bit ADC

RA2E2 — 48MHz (Cortex-M23), 64KB Code Flash, 8KB SRAM, 2KB Data Flash, Security (AES 128/256, Unique ID, TRNG)
16/20/24-pin

Cortex-M23	16-bit GPT	32-bit AGT	12-bit ADC	I3C

Common features

- Low Power Process Technology
- WDT, IWDT, RTC*1
- SCI, SPI, I²C*2
- Functional Safety Features
- Low Power Modes

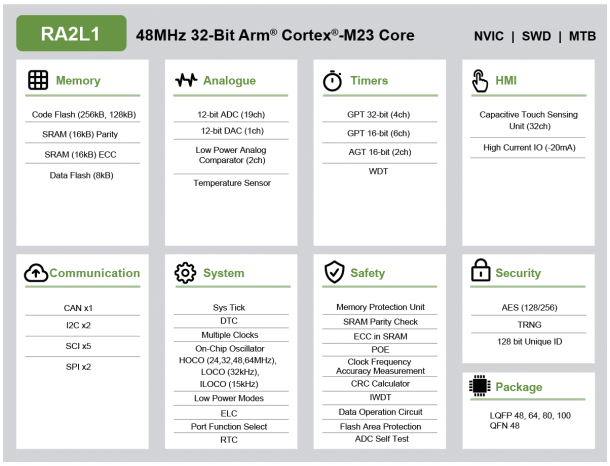
*1: RA2E2 not supported
*2: RA2L2, RA2E2 not supported

RA2L1 Group: 48MHz Arm Cortex-M23 Ultra-Low power General-Purpose Microcontroller

The RA2L1 group is based on the Arm Cortex-M23 core, the most energy-efficient CPU among Arm Cortex-M today. The optimized processing and Renesas' low power process technology makes it the industry's most energy-efficient ultra-low power microcontroller. The RA2L1 group supports a wide operating voltage range of 1.6V to 5.5V, and a maximum CPU clock frequency of 48MHz, lower active mode current, and standby mode current. The RA2L1 group also features an enhanced Capacitive Touch Sensing Unit (CTSU2), a set of serial communication interfaces, highly accurate converters, and timers. The products are available with pin counts ranging from 48-pin to 100-pin.

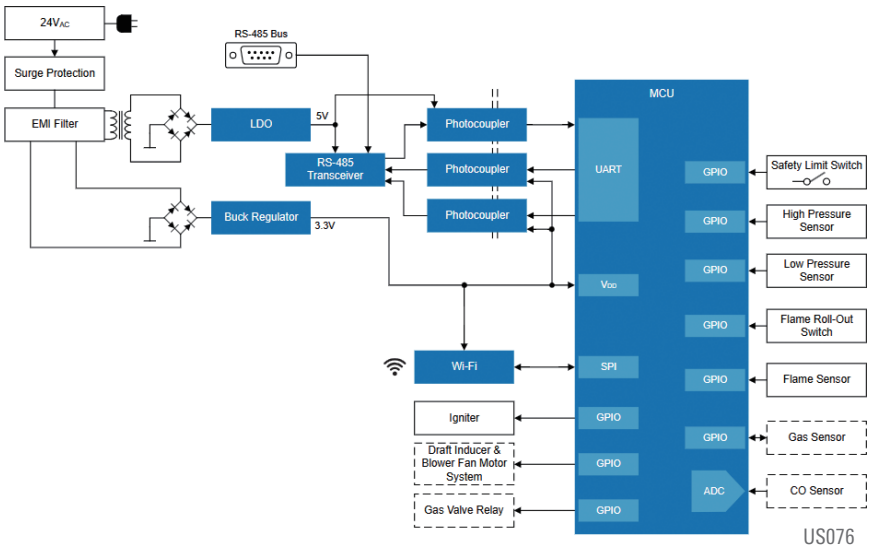
- 48MHz Arm Cortex-M23
- 128KB/256KB Flash Memory and 32KB SRAM with ECC
- 8KB Data Flash to store data as in EEPROM
- Scalable from 48-pin to 100-pin packages
- Internal voltage regulators
- Wide voltage range of 1.6V to 5.5V
- Enhanced Capacitive Touch Sensing Unit (CTSU2)
- 12-bit ADC, 12-bit DAC, LPACMP, temperature sensor
- 32-bit general PWM timer, 16-bit general PWM timer, 16-bit low power asynchronous general-purpose timer
- RTC
- SCI (UART, Simple SPI, Simple I²C)
- SPI/I²C multi-master interface and I²C bus
- CAN
- Safety
- Security and encryption
- 85/105°C operating temperature support

Block Diagram



Use case: Wi-Fi-Connected Furnace Controller

With the increasing adoption of smart homes, the demand for connected HVAC systems that can be remotely monitored and controlled via smart devices has grown. This allows for better energy efficiency and optimized heating schedules, enhancing the overall user experience.



US076

System Benefits:

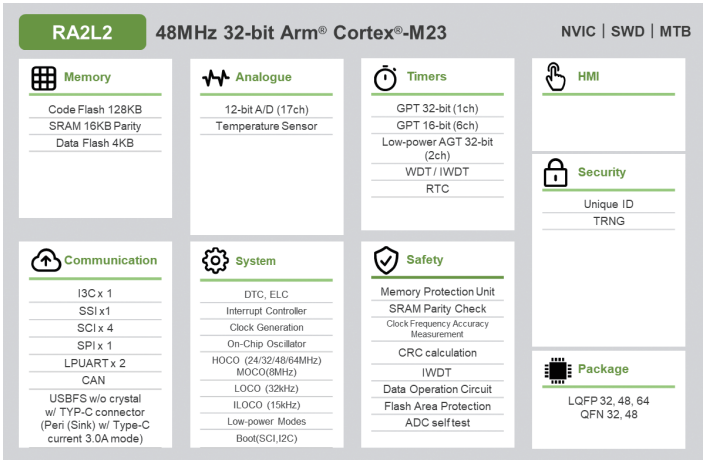
- The low-power characteristics help reduce power consumption during standby and low-load operation, improving the overall energy efficiency of the HVAC controller.
- Reduced external components enable smaller PCB size and lower BOM cost.
- 3Built-in security and safety features—such as AES, TRNG, and memory protection—support the design of highly reliable applications.
- A wide operating voltage range of 1.6–5.5 V allows flexible power-supply design.

RA2L2 Group: 48MHz Arm Cortex-M23 Entry-Level USB General-Purpose Microcontroller

The RA2L2 group is the RA Family's entry-level single-chip microcontroller based on the 48MHz Arm Cortex-M23 core and up to 128KB code flash and 16KB SRAM memory. The optimized processing and Renesas' low-power process technology make it the industry's most energy-efficient ultra-low power MCU. The RA2L2 group supports a wide operating voltage range of 1.6V to 5.5V, and it has rich serial communication functions such as I3C, SSI, low power UART, CAN, USB Full-Speed (FS) without crystal, and USB Type-C interface.

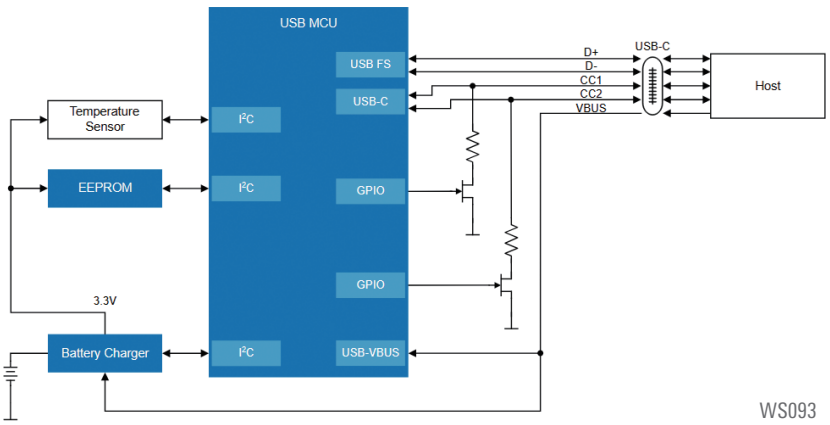
- 48MHz Arm Cortex-M23 core
- 64/128KB Flash Memory and 16KB SRAM with Parity
- 4KB data flash to store data as in EEPROM
- Scalable from 32-pin to 64-pin packages
- Wide voltage range of 1.6V to 5.5V
- 12-bit A/D converter, temperature sensor
- 32-bit general PWM timer, 16-bit general PWM timer, 32-bit low-power asynchronous general-purpose timer
- RTC
- SCI (UART, Simple SPI, Simple I²C)
- USB FS without crystal, USB Type-C interface
- Low-power UART
- I3C bus
- CAN
- SPI/I²C multi-master interface
- SSI (Serial Sound Interface)
- Safety
- Security
- 105/125°C operating temperature support

Block Diagram



Use case: USB Data Logger

Data loggers are essential for efficiently recording, storing, and transferring data across various industries. From cold chain monitoring in industrial applications to scientific research and environmental studies, capturing key metrics and transferring them to a computer is crucial for compliance and analysis. This low-power, cost-effective USB data logger integrates an MCU with built-in USB Type-C functionality, offering high accuracy, ease of use, and versatility. Data is stored in high-speed, low-power EEPROM and seamlessly transferred via USB Type-C, enabling plug-and-play functionality. Battery-operated for portability and extended operation, this logger is ideal for diverse applications.



System Benefits:

- Reliable, high-speed EEPROM with low power consumption and fast write times ensures efficient data logging.
- Cost-effective USB MCU supports USB Full-Speed (FS) and Type-C detection, enabling seamless connection and sink operation (up to ~3A at 5V).
- Highly integrated USB MCU with built-in RD termination and VBUS detection reduces external components, minimizing BOM costs.
- Optimized low-power design extends device battery life and improves power efficiency for long-term operation.

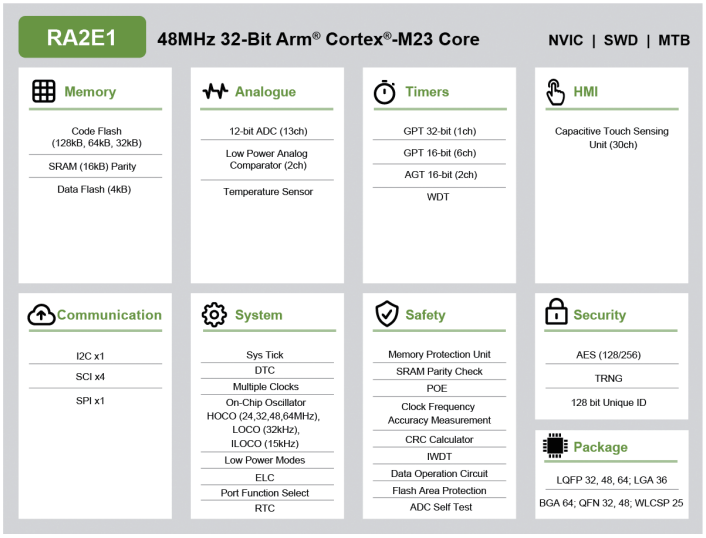
WS093

RA2E1 Group: 48MHz Arm Cortex-M23 Entry-Level General-Purpose Microcontroller

The RA2E1 group is the RA Family's entry-level single-chip microcontroller based on the 48MHz Arm Cortex-M23 core and up to 128KB code flash and 16KB SRAM memory. The optimized processing and Renesas' low power process technology make it the industry's most energy-efficient ultra-low power MCU. The RA2E1 group supports a wide operating voltage range of 1.6V to 5.5V and a large selection of packages such as LQFP, QFN, LGA, BGA, and WLCSP.

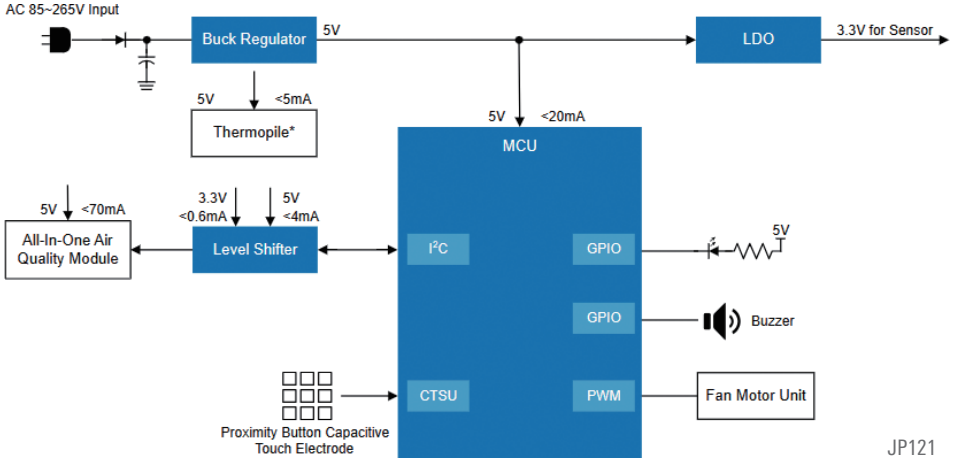
- 48MHz Arm Cortex-M23
- 32/64/128KB Flash memory and 16KB SRAM with Parity
- 4KB Data Flash to store data as in EEPROM
- Scalable from 25-pin to 64-pin packages
- Enhanced Capacitive Touch Sensing Unit (CTSU2)
- 12-bit ADC, LPACMP, temperature sensor
- 32-bit general PWM timer, 16-bit general PWM timer, 16-bit low power asynchronous general-purpose timer
- RTC
- SCI (UART, simple SPI, simple I²C)
- SPI/I²C multi-master interface and I²C bus
- Safety
- Security and encryption
- 85/105°C operating temperature support

Block Diagram



Use case: Smart Range Hood

As smart kitchens evolve, demand is shifting from traditional contact-type buttons to sophisticated touch-based interfaces that combine enhanced functionality with modern aesthetics. This system enables non-contact user interaction and system-level integration, delivering a more compact and refined design with improved performance.



JP121

System Benefits:

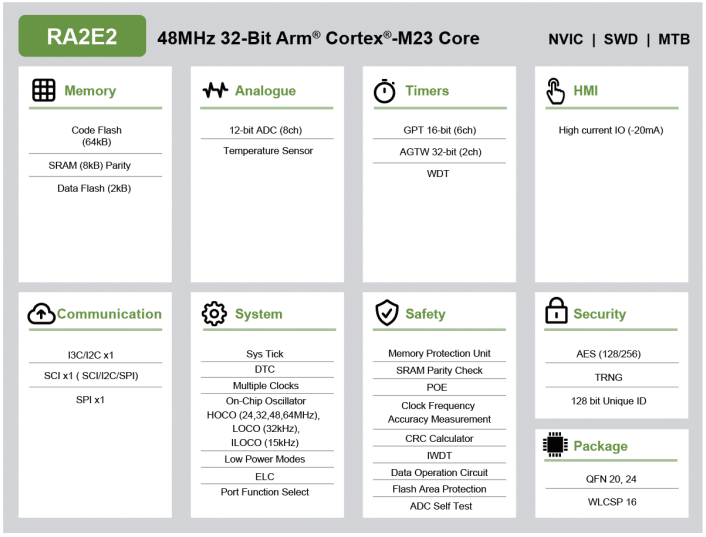
- The touch function has excellent noise resistance and responsiveness, enabling proximity detection and touch operation on a single chip.
- A wide operating voltage range (1.6V to 5.5V) allows flexible power design suitable for home appliances.
- IEC60730 safety standard for household appliances class B/C.
- Built-in security features (AES, TRNG) ensure reliability for future smart appliance integration and IoT connectivity.

RA2E2 Group: 48MHz Arm Cortex-M23 Ultra-Low Power General-Purpose Microcontroller

The RA2E2 Group is RA Family's entry-line single-chip microcontroller based on the 48-MHz Arm Cortex-M23 core with Renesas' innovative on-chip peripheral functions. RA2E2 Group offers ultra-low power operation and high-speed serial communication with the smallest package options of 20-pin and 24-pin QFN and 16-pin wafer-level CSP package, satisfying the needs of cost-sensitive and space-constrained applications. These RA2E2 Group microcontrollers enable extremely cost-effective designs for IoT sensor nodes, portable devices, industrial control, and any battery-operated application that requires developers to cut power consumption, cost, and space.

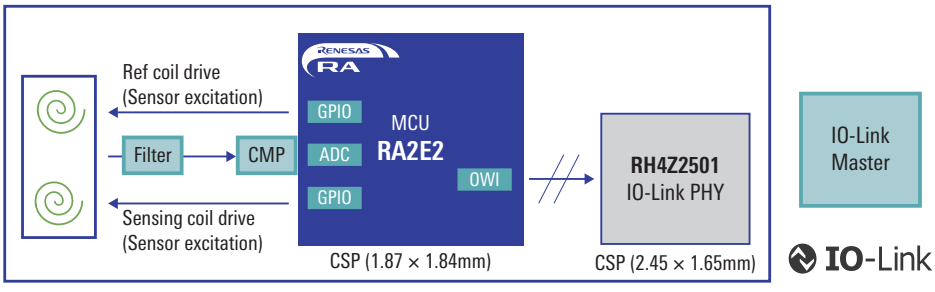
- 48MHz Arm Cortex-M23
- 16/32/64KB Flash memory and 8KB SRAM with Parity
- 2KB Data Flash to store data as in EEPROM
- Scalable from 16-pin to 24-pin packages
- 12-bit ADC, temperature sensor
- 16-bit general PWM timer, 32-bit low power asynchronous general-purpose timer
- I3C bus interface
- SCI (UART, Simple SPI, Simple I²C)
- SPI/I²C multi-master interface
- Safety
- Security and encryption
- 85/105/125°C operating temperature support

Block Diagram



Use case: IO-Link Sensors

IO-Link is a worldwide open standard protocol used for communication between devices in industrial settings. It facilitates bi-directional data exchange between a master device, actuators, and sensors.



JP174

System Benefits:

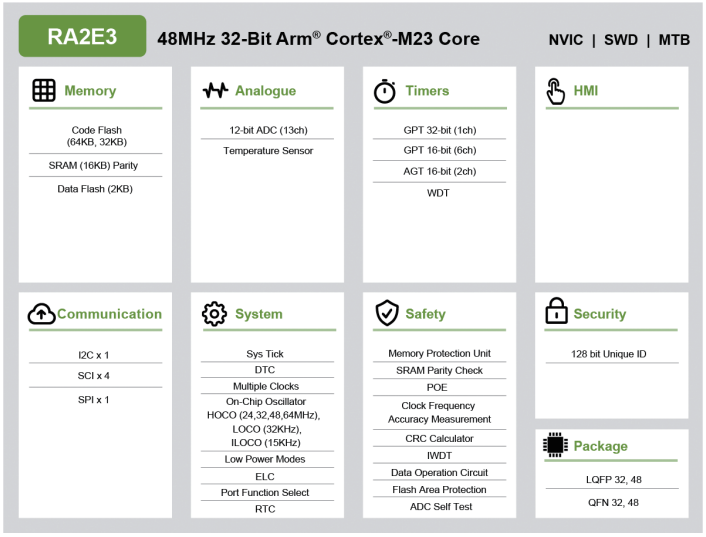
- The ultra-compact CSP package (1.87 × 1.84 mm) enables smaller sensor modules and greater design flexibility.
- The built-in high-precision ADC functions allow accurate detection and processing of sensor signals.
- Low-power design ensures reliable operation even in applications where continuous operation and energy efficiency are critical.

RA2E3 Group: 48MHz Arm Cortex-M23 Entry-Level, Ultra-Low Power General-Purpose Microcontroller

The RA2E3 group is an entry-line, single-chip microcontroller in the RA family based on the 48MHz Arm Cortex-M23 core with up to 64KB code flash and 16KB SRAM memory. RA2E3 MCUs provide an optimized feature set for cost-sensitive applications by supporting pin-to-pin and peripheral compatibility with RA2E1 MCUs. Ultra-low power consumption contributes to energy-efficient system design, required for IoT applications and battery-operated systems to achieve longer battery life.

- 48MHz Arm Cortex-M23 Core
- 32/64KB flash memory and 16KB SRAM with Parity
- 2KB Data Flash to store data as in EEPROM
- Package options of 32-pin and 48-pin
- 12-bit ADC, temperature sensor
- 32-bit general PWM timer, 16-bit general PWM timer, 16-bit low-power asynchronous general-purpose timers
- RTC
- SCI (UART, Simple SPI, Simple I²C)
- SPI/I²C multi-master interface and I²C bus
- Safety
- Security
- 85/105°C operating temperature support

Block Diagram

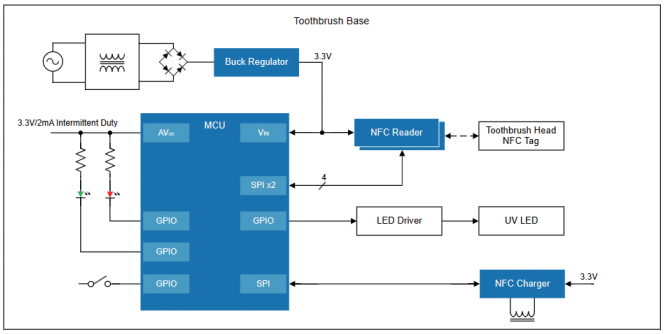


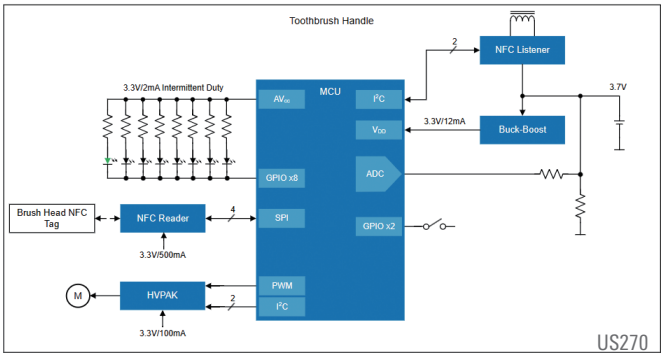
Use case: Electric Toothbrush with UV Sanitation

Driven by growing demand for hygiene, convenience, and advanced oral care, the electric toothbrush market continues to expand. This product combines a UV-sanitizing base with a battery-monitoring, NFC-enabled handle to ensure effective cleaning, hygiene, and peace of mind for health-conscious consumers.

System Benefits:

- The low power consumption of the RA2E3 extends the handle's battery life and reduces charging frequency.
- High-precision PWM enables efficient and smooth motor driving, enhancing user comfort.
- The built-in high-precision ADC can be utilized for battery voltage monitoring and feedback in motor control.





RA4 Series

Features of the RA4 Series

The RA4 series bridges the need for reasonable low power with the demand for connectivity and performance. These MCUs deliver up to 100MHz of CPU performance using an Arm Cortex-M33 core or M4 core with up to 1MB of embedded flash memory. The series offers a wide set of peripherals, including USB, CAN/CAN FD, I3C, ADC, capacitive touch, segment LCD controller, and additional security IP integration, making it suitable for IoT, industrial equipment, home appliances, office equipment, healthcare products, and meters.

High Performance with Low Power

On mainstream and entry line, achieves 81µA/MHz while running the CoreMark algorithm from flash @100MHz, delivering both speed and energy efficiency on active. On Lower Power line, provide good balance active current @80MHz and standby current for battery application.

Comprehensive Memory and Connectivity

Up to 1MB code flash with background operation and flash block SWAP, memory-optimized firmware updates.
Rich connectivity options include, USB 2.0 FS, CAN FD, SDHI, HDMI-CEC, and advanced analog features.

Secure Element Functionality

Provides enhanced performance, unlimited secure key storage, efficient key management, and reduced BOM cost by using on-chip security engine (SCE, RSIP).

Compact BGA Packages

Wide range of space-saving BGA packages and option to select open array ball grid type package for flexible adoption on several applications where board space is at a premium.

RA4 Series Lineup

Mainstream

RA4M1 — 48MHz (Cortex-M4), 256KB Code Flash, 32KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG, AES)
40/48/64/100-pin

Cortex-M4	16/32-bit GPT	16-bit AGT	CAN	I²C	SPI	I²S	USB FS	Capacitive touch	Segment LCD	14-bit ADC	12-bit DAC

RA4M2 — 100MHz (Cortex-M33), 512KB Code Flash, 128KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG, AES, RSA, ECC, SHA2)
48/64/100-pin

Cortex-M33 w TrustZone	16/32-bit GPT	16-bit AGT	CAN	I²C	SPI QSPI	I²S	USB FS	Capacitive touch	12-bit ADC	12-bit DAC

RA4M3 — 100MHz (Cortex-M33), 1MB Code Flash, 128KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG, AES, RSA, ECC, SHA2)
64/100/144-pin

Cortex-M33 w TrustZone	16/32-bit GPT	16-bit AGT	CAN	I²C	SPI QSPI	I²S	USB FS	Capacitive touch	12-bit ADC	12-bit DAC

Entry

RA4E1 — 100MHz (Cortex-M33), 512KB Code Flash, 128KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG)
48/64-pin

Cortex-M33 w TrustZone	16/32-bit GPT	16-bit AGT	CAN	I²C	SPI QSPI	USB FS	12-bit ADC	12-bit DAC

RA4E2 — 100MHz (Cortex-M33), 128KB Code Flash, 40KB SRAM, 4KB Data Flash, Security (Unique ID, TRNG)
32/48/64-pin

Cortex-M33 w TrustZone	16/32-bit GPT	32-bit AGT	CAN-FD	I3C	SPI	I²S	USB FS	12-bit ADC	12-bit DAC

Low Power

RA4L1 — 80MHz (Cortex-M33), 512KB Code Flash, 64KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG, AES, ECC, SHA2)
48/64/72/100-pin

Cortex-M33 w TrustZone	16-bit GPT	32-bit AGT	CAN-FD	I²C	I3C	SPI QSPI	I²S	USB FS	Capacitive touch	Segment LCD	12-bit ADC	12-bit DAC

RA4C1 — 80MHz (Cortex-M33), 512KB Code Flash, 96KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG, AES, ECC, SHA2)
64/100-pin

Cortex-M33 w TrustZone	16/32-bit GPT	32-bit AGT	CAN-FD	I²C	SPI QSPI	Segment LCD	12-bit ADC

Common features

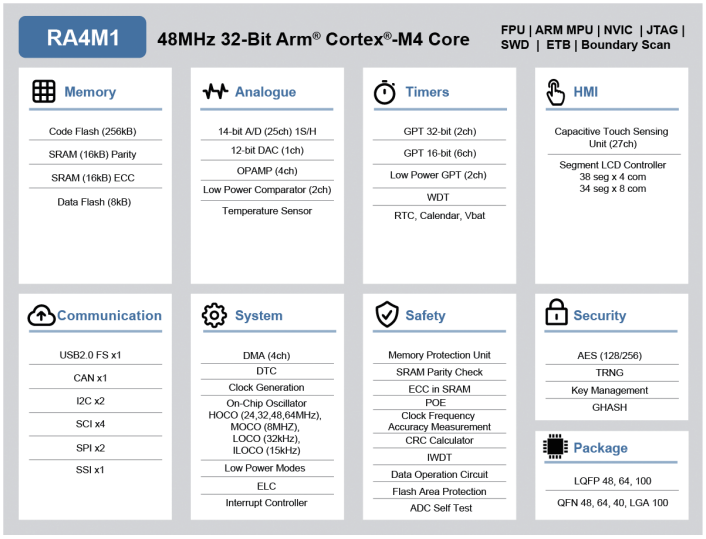
- DMAC, DTC
- RTC
- WDT, IWDT
- SCI (UART, Simple SPI/I²C)
- Functional Safety Features
- Low Power Modes/ Features

RA4M1 Group: 48MHz Arm Cortex-M4 and LCD Controller and Cap Touch for HMI

The Renesas RA4M1 group of microcontrollers (MCUs) uses the high-performance Arm Cortex-M4 core and offers a segment LCD controller and a capacitive touch sensing unit input for intensive HMI designs. The RA4M1 MCU is built on a highly efficient low power process and is supported by an open and flexible ecosystem concept—the Flexible Software Package (FSP), built on FreeRTOS—and is expandable to use other RTOSes and middleware.

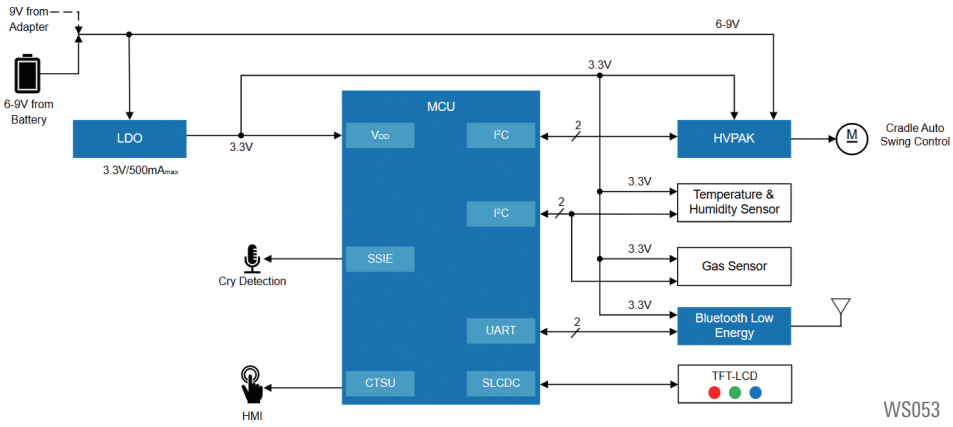
- 48MHz Arm Cortex-M4
- 256KB Flash Memory and 32KB SRAM
- 8KB DataFlash to store data as in EEPROM
- Scalable from 40pin to 100pin packages
- Segment LCD Controller
- 14-bit A/D Converter
- Capacitive Touch Sensing Unit
- USB2.0 Full Speed
- CAN 2.0B
- SCI (UART, Simple SPI, I²C)
- SPI/I²C Multimaster Interface

Block Diagram



Use case: Smart Cradle

This smart cradle and baby monitoring system is designed for use in homes and hospitals, offering essential safety features such as cry detection and real-time alerts. It includes a remote-controlled auto-swing function and a display for key information and notifications, which can also be sent to a mobile app via Bluetooth.



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System Benefits:

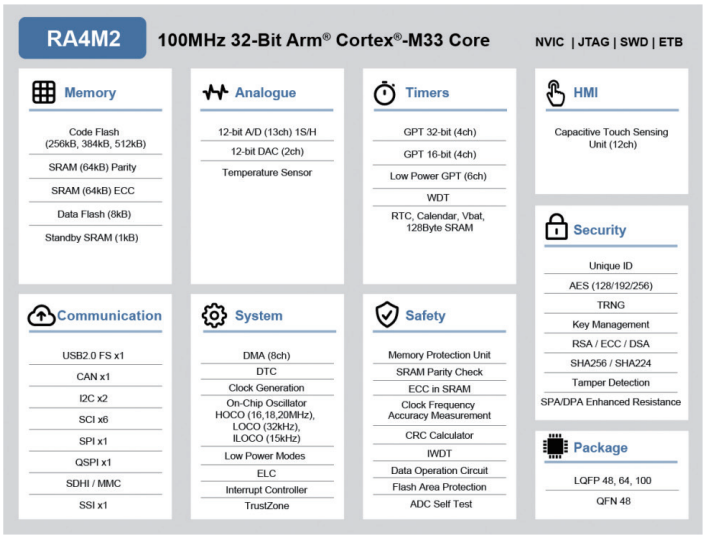
- Auto-swing feature with remote and mobile app control.
- Powered by an adapter or batteries for flexibility.
- Integrated display showing vital information like temperature.
- Cry detection integrated into auto-swing mode.

RA4M2 Group: 100MHz Arm Cortex-M33 TrustZone with Security enhancements

The Renesas RA4M2 group uses the Arm Cortex-M33 core with TrustZone. In concert with the secure crypto engine, it offers secure element functionality. The RA4M2 is built on a highly efficient 40nm process and is suitable for IoT applications requiring multiple communication options, future proof security, large embedded RAM, and low active power consumption down to 81µA/MHz running the CoreMark algorithm from Flash.

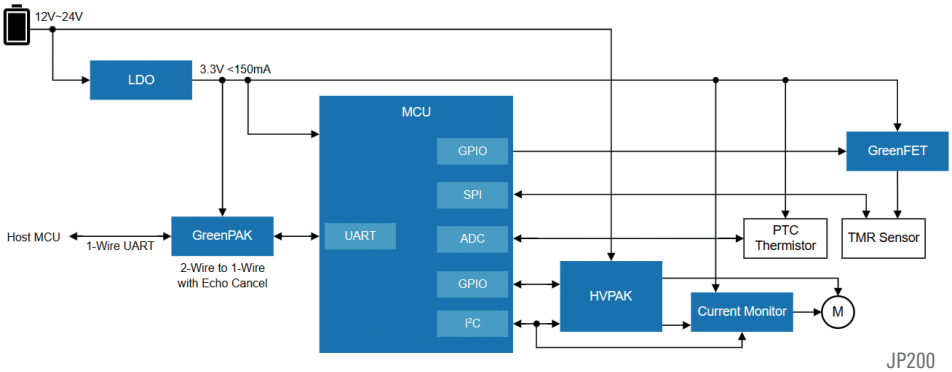
- 100MHz Arm Cortex-M33 with TrustZone
- 512KB Flash Memory and 128KB SRAM (64KB w ECC), 1KB Stand-by SRAM
- 8KB DataFlash to store data as in EEPROM
- Scalable from 48pin to 100pin packages
- Capacitive Touch Sensing Unit
- USB2.0 Full Speed, CAN 2.0B
- SCI (UART, Simple SPI, Simple I²C)
- SPI/I²C Multi-master interface
- SDHI/QSPI/SSI/Serial Sound Interface
- Secure Crypto Engine SCE9

Block Diagram



Use case: Server Motor Control

The ability to control robotic movements is crucial across various industries, including manufacturing, logistics, and healthcare. Precision movement is essential for meeting industry standards, enhancing operational efficiency, and ensuring safety.



System Benefits:

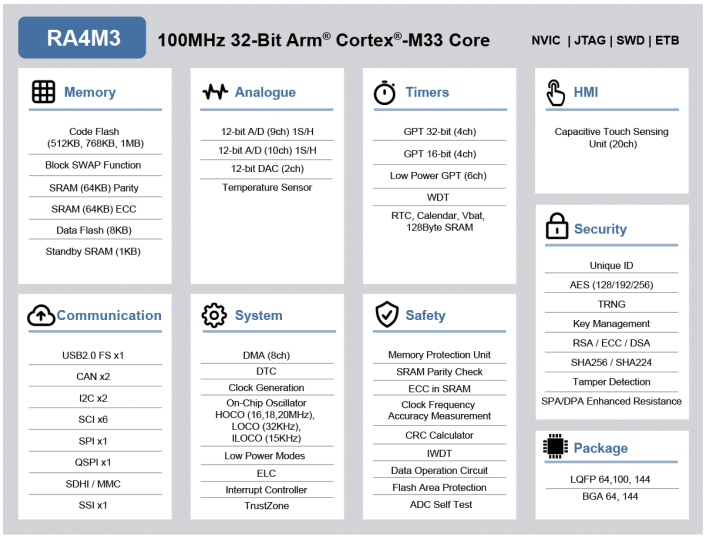
- Precision control for motor angles with adequate torque and speed by command, providing highly responsive and flexible functionality.
- The HVPAK programmable mixed-signal matrix features high-voltage H-bridge functionality in a tiny 2mm x 3mm QFN package which contributes to minimizing the size of the servo motor.
- Monitor status via 1-wire UART with echo cancel simplifies communication lines while ensuring signal integrity.
- Cascading multiple servos allows for harness reduction in a system, reducing BOM and system costs.
- Compact size for easy embedding into a robot.

RA4M3 Group: 100MHz Arm Cortex-M33 with TrustZone, Security and Memory enhancements

The Renesas RA4M3 group uses the Cortex-M33 core with TrustZone. In concert with the secure crypto engine, it offers secure element functionality. The RA4M3 is built on a highly efficient 40nm process and is suitable for IoT applications requiring vast communication options, future proof security, large embedded RAM, and low active power consumption down to 119µA/MHz running the CoreMark algorithm from Flash.

- 100MHz Arm Cortex-M4F with 1MB Flash Memory and 128KB SRAM (64KB wECC)
- 8KB Data Flash to store data as in EEPROM
- 1KB Stand-by SRAM
- Scalable from 64pin to 144pin packages
- Capacitive Touch Sensing Unit
- USB2.0 Full Speed, CAN 2.0B
- SCI (UART, Simple SPI, Simple I²C)
- SPI/I²C Multi-master interface, SDHI/QSPI/SSI/Serial Sound Interface
- Secure Crypto Engine SCE9

Block Diagram

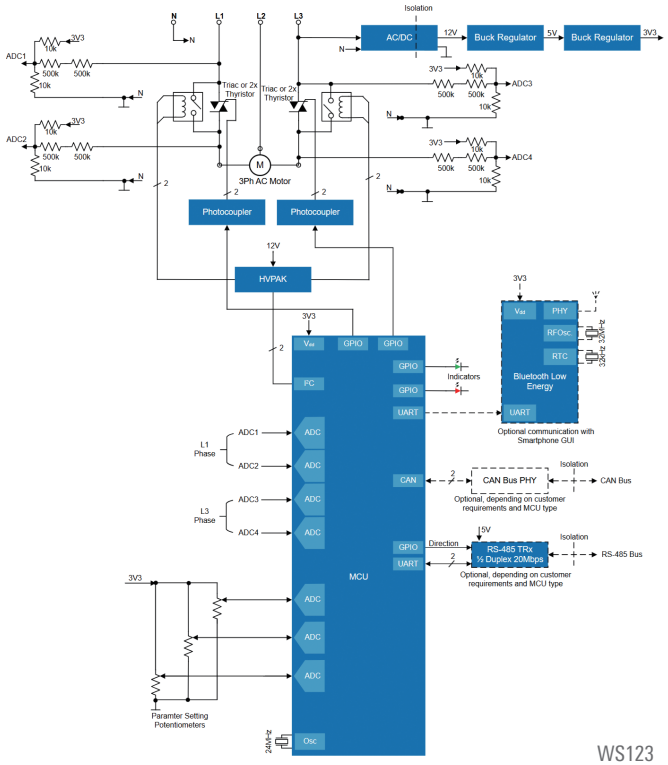


Use case: 3-Phase AC Motor Soft Start

Traditionally, 3-phase AC motors are started in a star configuration and then switched to a delta configuration to reduce inrush current and mechanical stress, thereby extending motor life. However, this method requires additional wiring and complex switching mechanisms. An alternative is the phase-cut technique on two phases, which soft-starts (and optionally soft-stops) the motor by reducing the phase cut from 360° to 0°. Relays are used to bypass the Triacs/Thyristors in run mode, eliminating losses and improving efficiency.

System Benefits:

- Simplifies wiring and reduces motor costs by eliminating the need for star-delta connections.
- Extends motor life by reducing mechanical stress.
- Significantly decreases inrush current and allows precise control over its duration.
- Enables easy parameter adjustment using simple potentiometers.
- Offers optional bus interfaces for control, such as RS-485 or CAN.
- Provides an optional user-friendly GUI accessible via Bluetooth on a smartphone.



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RA4L1 Group: 80MHz Arm Cortex-M33 with LCD controller and Cap Touch for HMI

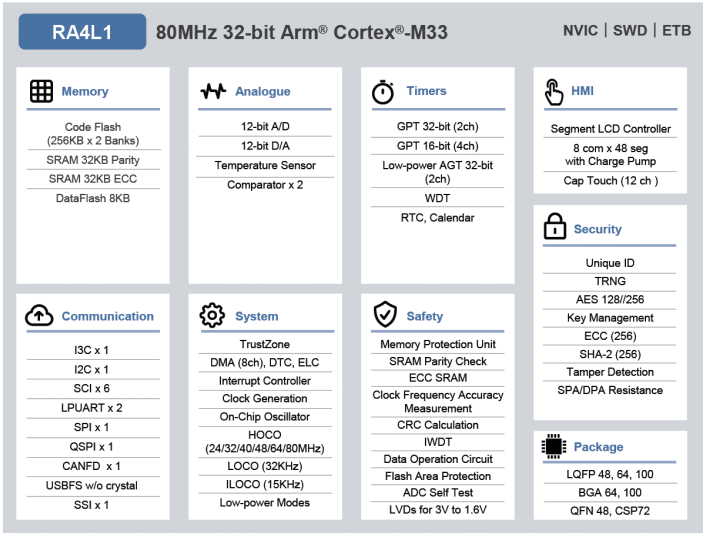
The RA4L1 MCU group is based on the Arm Cortex-M33 (CM33) core with TrustZone, delivering low voltage operation, low power consumption, and high performance operation. The RA4L1 offers operation down to 1.6V combined with a low-power standby current of as little as 1.65µA and a multitude of low-power features.

The RA4L1 include features such as segment LCD display drive and an advanced security engine, as well as RTC, ADC, and timers and communications interfaces such as CAN FD, USB 2.0 FS, I²C/I3C, and low-power UARTs.

The RA4L1 comes in a wide variety of standard LQFP and QFN package options as well as a range of space-saving BGA and CSP options and offers support for operating temperatures of -40°C to 125°C.

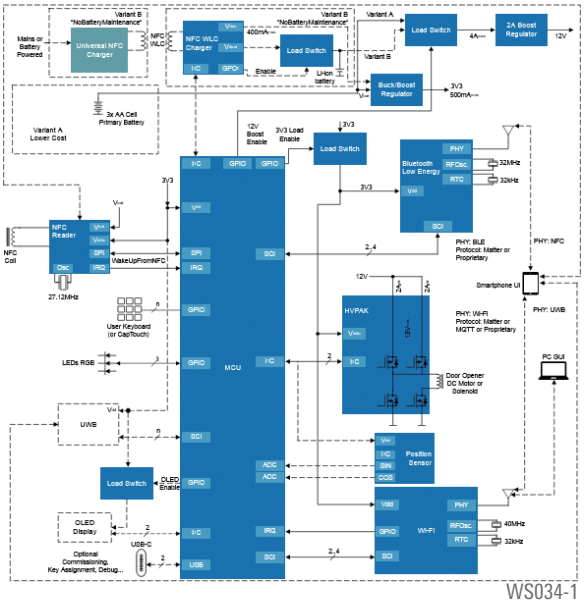
- 80MHz Arm Cortex-M33 with 512KB dual bank Flash, 64KB SRAM & 8KB Data
- Flash Active: 168µA/MHz Standby: 1.65µA with fast wake-up <3.5µS (from MOCO)
- Scalable from 48-pin to 100-pin, with QFN, LQFP, BGA & CSP Package options
- Segment LCD Controller & Capacitive Touch Sensing Unit
- 12-bit A/D Converter, 12-bit D/A Converter, temperature sensor and Comparators
- Low power timers and RTC
- USB2.0 Full Speed, CAN FD
- LPUARTS, SCI (UART, Simple SPI, Simple I²C), SPI/I²C/I3C/SSI/QSPI
- Renesas Secure IP (RSIP) supporting AES, ECC (256-bit), SHA, TRNG

Block Diagram



Use case: Smart Lock

The upcoming Aliro standard is advancing rapidly, driven by collaboration among Tier-1 mobile and smart lock OEMs to establish a unified framework for secure access and digital key management. Renesas, an active CSA member, is part of the development of the upcoming Aliro specification, contributing to the evolution of secure and interoperable smart locks. Renesas offers a comprehensive smart lock platform ready for compliance with the upcoming Aliro standard, equipping developers with all the tools needed to create high-performing, secure smart locks. These locks support full-feature functionality while optimizing power consumption at the system level.



WS034-1

System Benefits:

- This smart lock can be opened via NFC (tap with card or smartphone), Bluetooth, Wi-Fi, optional ultra-wideband (UWB) connectivity, or LTE (currently beyond the upcoming Aliro specifications).
- The platform can be powered by disposable primary cell batteries (three AA batteries) or a Li-ion battery rechargeable via NFC wireless charging, powered by DC or AC mains (e.g., in the door post/frame).
- Digital "door key" for access control can be securely transferred via Wi-Fi, Bluetooth, USB, or LTE-M/NB-IoT.
- The system offers optional precise hardware feedback on the door lock position.
- A comfortable GUI with a TFT graphic display and touch control is available.

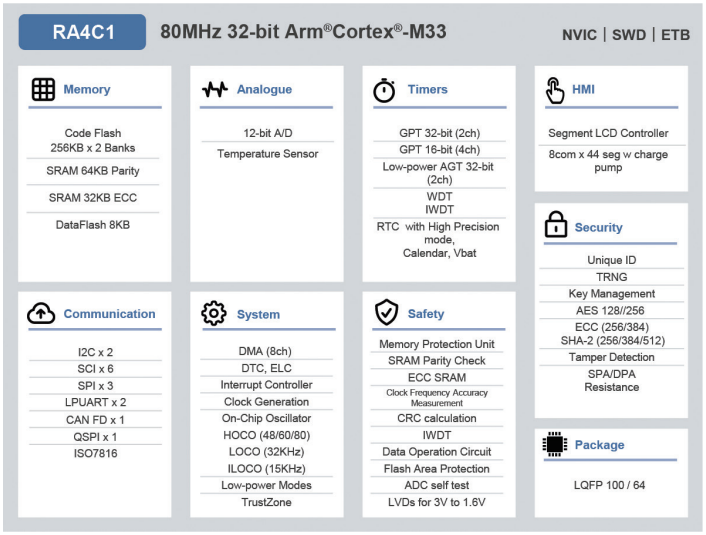
RA4C1: Group: 80MHz Arm Cortex-M33 with LCD and advanced security features

The RA4C1 32-bit MCU group features an Arm Cortex-M33 (CM33) core with TrustZone to deliver an ideal balance of low voltage operation, low power consumption, and high performance. The RA4C1 offers operation down to 1.6V, combined with a low-power standby current of as little as 1.73µA and a multitude of low-power features.

The RA4C1 integrates an advanced security engine and peripheral features such as segment LCD display drive, RTC with a high-precision mode, ADC, and timers, as well as integrated communications interfaces such as CAN FD, I²C, SPI, and low-power UARTs. The RA4C1 comes in a range of 64-pin or 100-pin LQFP packages and offers support for operating temperatures of -40°C to 105°C.

- 80MHz Arm Cortex-M33 with 512KB dual bank Flash, 96KB SRAM & 8KB Data Flash
- Active: 168µA/MHz Standby: 1.73µA with fast wake-up <3.5µS (from MOCO)
- Supports 64 and 100-pin LQFP packages
- 12-bit A/D Converter with temperature sensor
- Low power timers, RTC and Segment LCD Controller
- Low power UARTs, CAN FD
- SCI (UART, Simple SPI, Simple I²C), SPI/I²C Multi-master interface/QSPI
- Safety features including multiple WDT, ECC and parity, clock check circuit
- Renesas Secure IP (RSIP) supporting AES, ECC (384-bit), SHA, TRNG

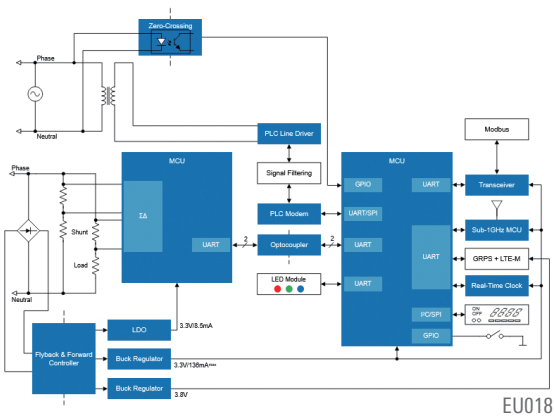
Block Diagram



Use case: Smart 1-Ph E-Meter

With increasing regulatory pressure, local utilities must adopt more efficient methods to monitor subscriber-level energy consumption, adjust conventional energy generation, and support flexible business models such as pre-paid and post-paid. These electricity meters will require reliable bidirectional communication, with system designs varying between wired and wireless approaches depending on local infrastructure.

This flexible metering system supports multiple current sensing methods, such as current transformers (CTs) and Rogowski coils, to meet diverse deployment needs. It is scalable to support 2G or 5G wireless connectivity for remote and rural areas, Sub-1GHz communication via a data logger, or wired connectivity through power line communication (PLC) for urban environments, enabling reliable performance across a wide range of metering scenarios.



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System Benefits:

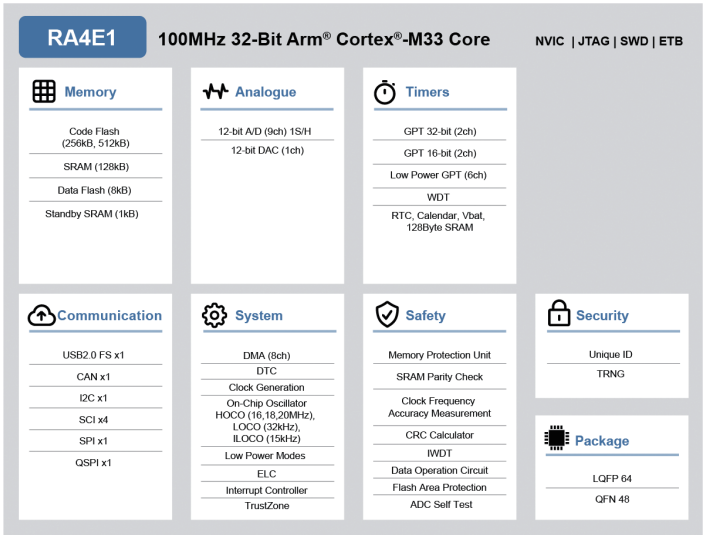
- Scalable system controllers offer high performance, rich connectivity, and integrated security engines with tamper detection and TrustZone support—ideal for efficient and secure smart metering.
- UART with optical isolation ensures reliable data transfer and protects the controller from high voltage transients, scalable for multi-line systems.
- LED/IrDA and RS-485 interfaces support reliable, bidirectional communication for contactless local access and long-range wired connectivity, supporting production, configuration, and field servicing.
- Galvanic isolation can be achieved via a dedicated LDO for metrology and an optional LDO for RS-485 with wireless modules operating at 3.8V (min. 3.3V) using a separate DC/DC supply, while other system components are powered by an independent 3.3V regulator.

RA4E1 Group: 100MHz Arm Cortex-M33 Optimized feature set

The RA4E1 is the perfect entry point into the RA Family of microcontrollers. The RA4E1 is suitable for entry IoT applications requiring value-optimized features and connectivity integration, total system cost reduction, and an optimized mixture of high performance with 100MHz Cortex-M33 core in combination with the lowest active power consumption down to 81µA/MHz running the CoreMark algorithm from Flash.

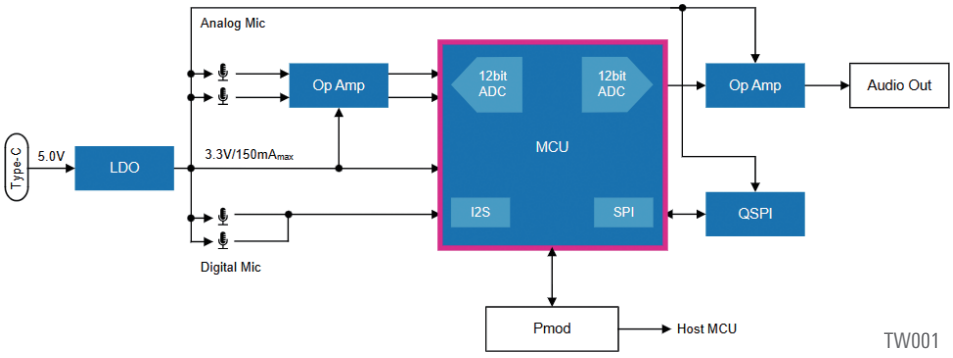
- 100MHz Arm Cortex-M33 with TrustZone
- 256KB - 512KB Flash memory and 128KB SRAM
- Scalable from 48-pin to 64-pin packages
- Various communication features, USB 2.0 FS, CAN, QSPI, SCI and SPI
- 12-bit ADC, 12-bit DAC, General PWM Timer

Block Diagram



Use case: Edge Voice User Interface

As consumers seek more intuitive and hands-free ways to interact with their devices, an edge voice user interface (VUI) allows users to control systems like TVs, speakers, and smart appliances without the need for a remote or smartphone. This platform offers VUI designs based on the RA family of 32-bit MCUs. The versatile design serves as the foundation for VUI systems within the Renesas Ready Partner Network, supporting local endpoint inference for voice recognition without requiring network connectivity.



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System Benefits:

- Powerful MCU allows for local endpoint inference, enabling voice recognition without network connectivity.
- Low-power Arm Cortex-M33 MCU ensures energy-efficient operation, ideal for battery-powered devices.
- Supports up to two digital microphones and two analog microphones.
- Accommodates multiple microphone types for flexible integration in various audio environments.
- External QSPI flash provides storage for voice samples and library data.
- Communication interfaces include Pmod interface (Type-2A/3A/6A), USB Type-C, and Micro-B.

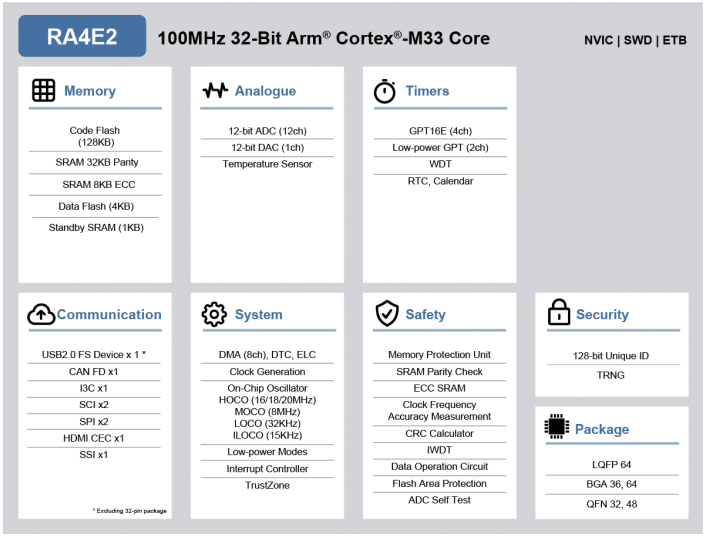
RA4E2 Group: 100MHz Arm Cortex-M33 with the smallest package options

The RA4E2 entry-line microcontroller is based on the 100MHz Arm Cortex-M33 core with TrustZone. The RA4E2 MCUs offer high-performance and optimized peripheral functions along with the smallest package options, including space-saving 36-pin BGA and 32-pin QFN packages. These satisfy the needs of both cost-sensitive and space-constrained applications.

The RA4E2 provides an entry point to the wider RA family due to its well-balanced performance, advanced peripheral functions, and scalability.

- 100MHz Arm Cortex-M33 with TrustZone
- 128KB Flash memory and 40KB SRAM
- Scalable from 32-pin to 64-pin packages
- Various communication features, USB 2.0 FS, CAN FD, I3C, HDMI CEC, SSI, SCI and SPI

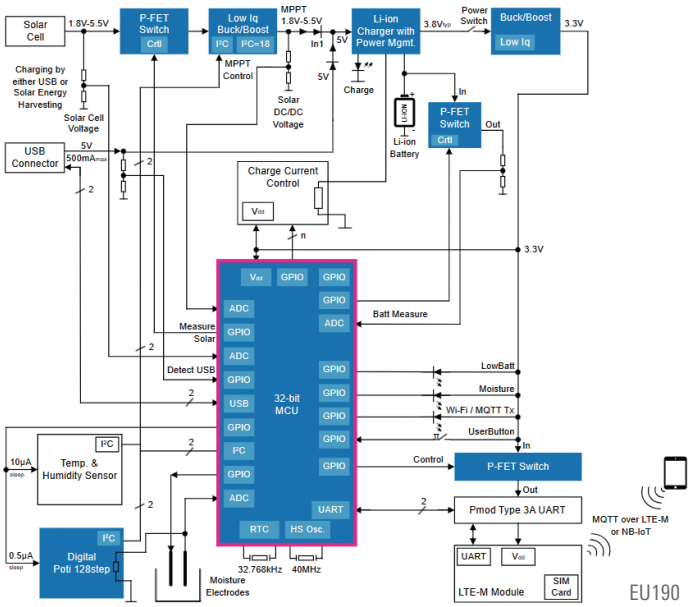
Block Diagram



Use case: Smart Water Monitoring System

This smart water monitoring system is designed for environments without Wi-Fi infrastructure. Using just two simple wires, it accurately detects humidity levels or water leakage and sends real-time alerts via LTE or NB-IoT using the MQTT protocol through a cloud-based MQTT broker (e.g., Adafruit, Amazon, or a customer-owned broker).

The system seamlessly integrates with and automatically controls shut-off valves, such as the smart water actuator, which subscribes to MQTT messages sent by the monitoring system.



System Benefits:

- Monitoring of autonomous, self-sustaining buildings and infrastructure.
- Operates almost anywhere with LTE-M/NB-IoT network coverage.
- Solar power/rechargeable battery enables self-contained operation.
- Detects high/low moisture levels or water spillage.
- Allows users to control water valves via the MQTT broker.
- Fully compatible with the smart water actuator.

RA6 Series

Features of the RA6 Series

The RA6 series offers the widest integration of communication interfaces as well as the best performance level. These MCUs aim for up to 240MHz of CPU performance using an Arm Cortex-M4 or M33 core and a memory range from 128KB to 2MB Flash. The series offers Ethernet, USB Full Speed and High Speed, ultra–Low Power Wi-Fi6, QSPI, OctaSPI, CAN/CAN FD, I3C, and TFT display driver integration. The embedded security engines are full of features you can leverage in your higher-level solutions with secure element services. The RA6 series addresses a broad range of applications for IoT endpoints such as white goods, meters, and other industrial and consumer applications.

High Performance with Low Power

Achieves 80µA/MHz while running the CoreMark algorithm from flash at 200MHz on Cortex-M33 CPU, delivering both CPU operating speed/performance and energy efficiency on active mode.

Comprehensive Memory and Connectivity

Up to 2MB code flash with background operation, Dual-bank, and flash block SWAP, memory-optimized firmware updates.
Rich connectivity options include Ethernet MAC controller, CAN FD, USB 2.0 HS/FS, ultra–Low Power Wi-Fi6, SDHI, HDMI-CEC, and advanced analog with three sample-and-hold per ADC, PGA, and high-speed comparators.

Secure Element Functionality

Provides enhanced performance, unlimited secure key storage, efficient key management, and reduced BOM cost by using on-chip crypto engine (SCE, RSIP).

Compact BGA Packages

Wide range of space-saving BGA packages and option to select open array ball grid type package for flexible adoption on several applications where board space is at a premium.

RA6 Series Lineup

Mainstream	RA6M1	120MHz (Cortex-M4), 512KB Code Flash, 256KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG, AES, RSA, ECC, SHA2) 64/100-pin	Cortex-M4	32-bit GPT	16-bit AGT	CAN	I²C	SPI QSPI	I²S	USB FS		Capacitive touch		12-bit ADC	12-bit DAC
	RA6M2	120MHz (Cortex-M4), 1MB Code Flash, 384KB SRAM, 32KB Data Flash, Security (Unique ID, TRNG, AES, RSA, ECC, SHA2) 100/144/145-pin	Cortex-M4	32-bit GPT	16-bit AGT	CAN	I²C	SPI QSPI	I²S	USB FS	Ethernet MAC	Capacitive touch		12-bit ADC	12-bit DAC
	RA6M3	120MHz (Cortex-M4), 2MB Code Flash, 640KB SRAM, 64KB Data Flash, Security (Unique ID, TRNG, AES, RSA, ECC, SHA2) 100/144/145/176-pin	Cortex-M4	32-bit GPT	16-bit AGT	CAN	I²C	SPI QSPI	I²S	USB FS		Capacitive touch	Graphic LCD	12-bit ADC	12-bit DAC
	RA6M4	200MHz (Cortex-M33), 1MB Code Flash, 256KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG, AES, RSA, ECC, SHA2) 64/100/144-pin	Cortex-M33 w TrustZone	16/32-bit GPT	16-bit AGT	CAN	I²C	SPI OctaSPI	I²S	USB FS	Ethernet MAC	Capacitive touch		12-bit ADC	12-bit DAC
	RA6M5	200MHz (Cortex-M33), 2MB Code Flash, 512KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG, AES, RSA, ECC, SHA2) 100/144/176-pin	Cortex-M33 w TrustZone	16/32-bit GPT	16-bit AGT	CAN-FD	I²C	SPI OctaSPI	I²S	USB HS/FS	Ethernet MAC	Capacitive touch		12-bit ADC	12-bit DAC
Entry	RA6E1	200MHz (Cortex-M33), 1MB Code Flash, 256KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG) 48/64/100-pin	Cortex-M33 w TrustZone	16/32-bit GPT	16-bit AGT	CAN	I²C	SPI QSPI	I²S	USB FS	Ethernet MAC			12-bit ADC	12-bit DAC
	RA6E2	200MHz (Cortex-M33), 256KB Code Flash, 40KB SRAM, 4KB Data Flash, Security (Unique ID, TRNG) 32/48/64-pin	Cortex-M33 w TrustZone	16-bit GPT	32-bit AGT	CAN-FD	I3C	SPI	I²S	USB FS				12-bit ADC	12-bit DAC
Wireless	RA6W1	160MHz (Cortex-M33), 256KB Code Flash, 704KB SRAM, 8KB Data Flash, Security (Unique ID, TRNG) 60/70-pin	Cortex-M33				I²C	SPI	I²S					12-bit ADC	Wi-Fi 6

Common features

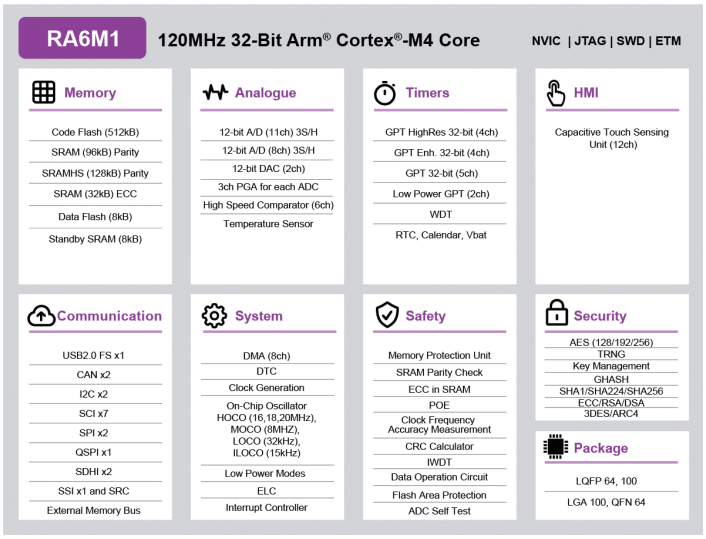
- DMAC, DTC
- RTC
- WDT, IWDT
- SCI (UART, Simple SPI/I²C)
- Functional Safety Features
- Low Power Modes/ Features

RA6M1 Group: 32-bit Microcontrollers with 120MHz Optimized Entry Point

The Renesas RA6M1 microcontroller is the entry point to the Renesas RA6 product series for applications that require a high-performance Arm Cortex-M4 core at a very attractive price point. The RA6M1 is suitable for IoT applications requiring security, large embedded RAM and low power consumption.

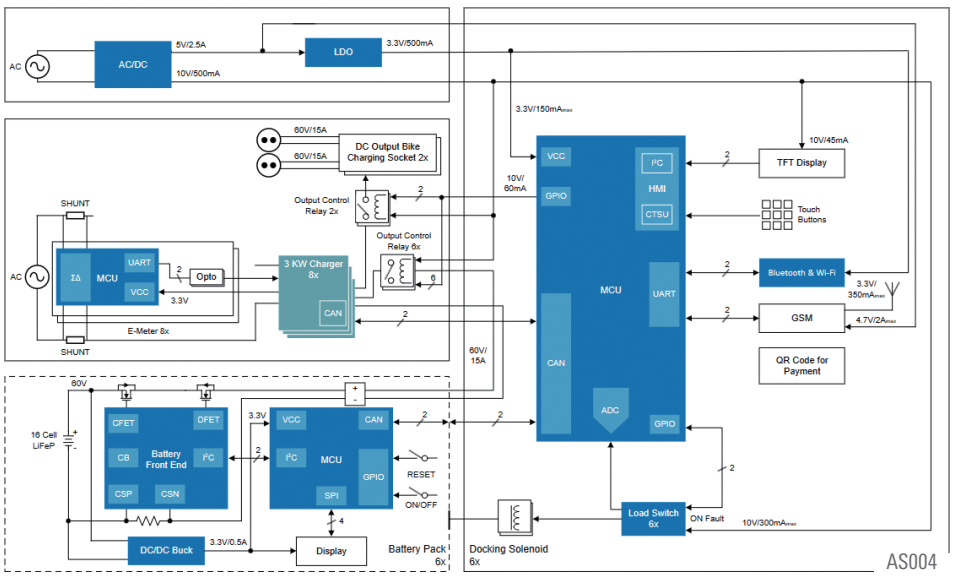
- 120MHz Arm Cortex-M4
- 512KB Flash Memory and 256KB SRAM
- 8KB DataFlash to store data as in EEPROM
- Scalable from 64-pin to 100-pin packages
- Capacitive Touch Sensing Unit
- USB2.0 Full Speed
- CAN 2.0B
- SCI (UART, Simple SPI, I²C)
- SPI/I²C Multimaster Interface
- SDHI
- SSI/Serial Sound Interface

Block Diagram



Use case: Swappable Battery Charging Kiosk

The swappable battery charging method represents the future of light electric vehicle (LEV) battery charging. This approach significantly reduces user wait time and simplifies operation, making it an attractive alternative to traditional charging station infrastructure, which demands substantial investment. Additionally, the kiosk offers emergency DC charging for non-standard battery-operated vehicles, enhancing its versatility and utility.



System Benefits:

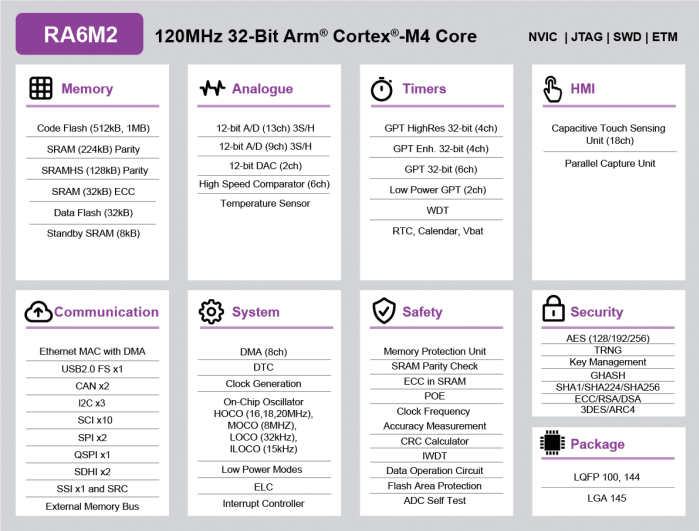
- Intuitive touch-based access to control the swapping process
- CAN-based communication between devices to monitor battery health and charging status
- Modular charging approach with 3kW AC/DC charger for flexible power management

RA6M2 Group: 32-bit Microcontrollers with 120MHz Medium Size Memory and Ethernet

The Renesas RA6M2 group of microcontrollers (MCUs) uses the high-performance Arm Cortex-M4 core and offers Ethernet MAC with individual DMA, to ensure high data throughput. The RA6M2 is suitable for IoT applications requiring Ethernet, security, large embedded RAM, and low active power consumption.

- 120MHz Arm Cortex-M4
- 512KB – 1MB Flash Memory and 384KB SRAM
- 32KB DataFlash to store data as in EEPROM
- Scalable from 100-pin to 145-pin packages
- Ethernet controller with DMA
- Capacitive Touch Sensing Unit
- USB2.0 Full Speed
- CAN 2.0B
- SCI (UART, Simple SPI, I²C)
- SPI/I²C Multimaster Interface
- SDHI

Block Diagram



Use case: Touchless Button Reference Design

The Touchless Button Reference Design can detect the approach of fingers and hands without physical contact using Renesas' capacitive touch solution. The electrode detects the proximity of the finger via self-capacitance and turns on the LED. The demo solution is compatible with all types of Renesas capacitive touch CPU boards.

System Benefits:

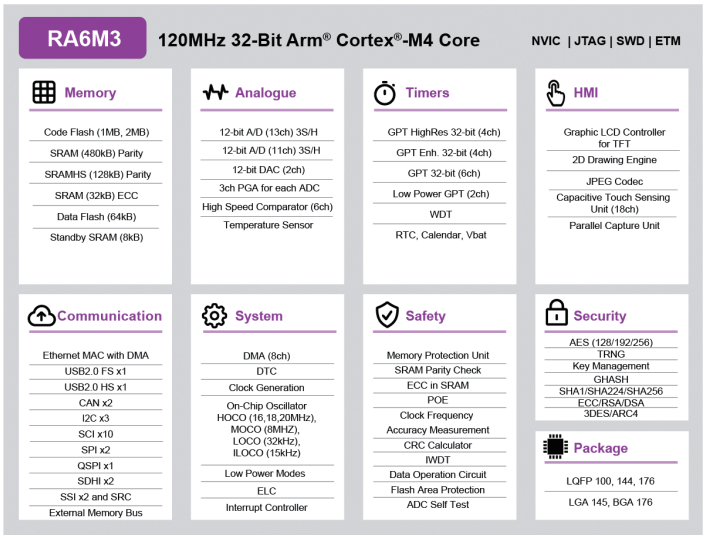
- When you don't want to or cannot touch a surface (elevator buttons, etc.)
- When your hands are occupied (vending machines, etc.)
- When your hands are wet (refrigerators)
- Other items that you don't want to touch (smart toilets)

RA6M3 Group: 32-bit MCUs with 120MHz with USB High-Speed, Ethernet and TFT controller

The Renesas RA6M3 group of microcontrollers (MCUs) uses the high-performance Arm Cortex-M4 core and offers a TFT controller with 2D accelerator and JPEG decoder. Additionally, the RA6M3 MCU offers Ethernet MAC with individual DMA and USB high-speed interface to ensure high data throughput. The RA6M3 is suitable for IoT applications requiring TFT, Ethernet, security, large embedded RAM, and USB High Speed (HS).

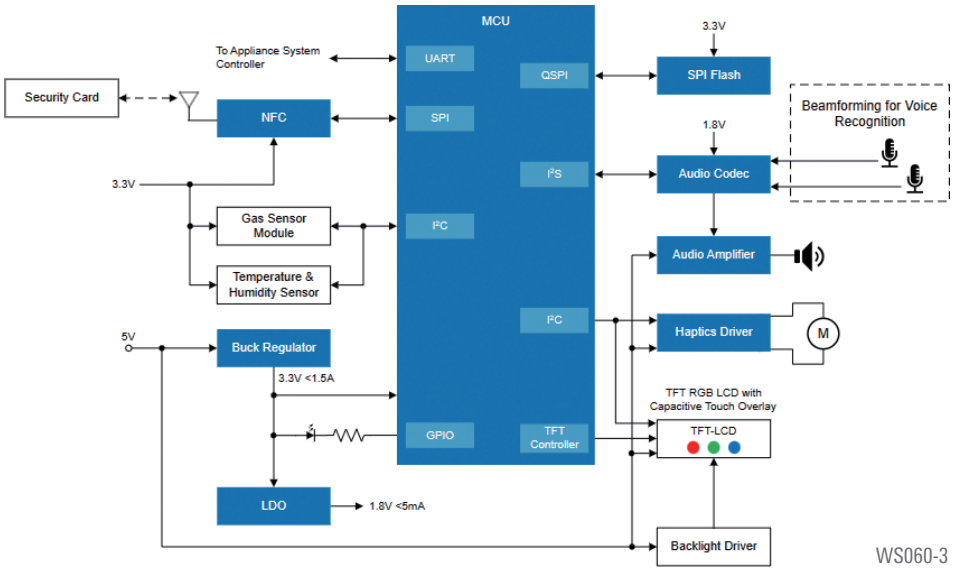
- 120MHz Arm Cortex-M4
- 1MB – 2MB Flash Memory and 640KB SRAM
- 64KB DataFlash to store data as in EEPROM
- Scalable from 100-pin to 176-pin packages
- Ethernet controller with DMA
- TFT Controller/2D Accelerator/JPEG Decoder
- Capacitive Touch Sensing Unit
- USB2.0 Full Speed/ USB High Speed
- CAN 2.0B
- SCI (UART, Simple SPI, I²C)
- SPI/I²C Multimaster Interface

Block Diagram



Use case: HMI for Appliances

Designed with support haptics-compatible touch panels, voice guidance, and multi-modal input, this system enables seamless interaction across a wide range of appliances. Integrated LCDs showcase rich GUIs and status screens, while high-end variants with Wi-Fi and Bluetooth Low Energy (LE) ensure effortless pairing with smartphones and integration into smart home ecosystems.



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System Benefits:

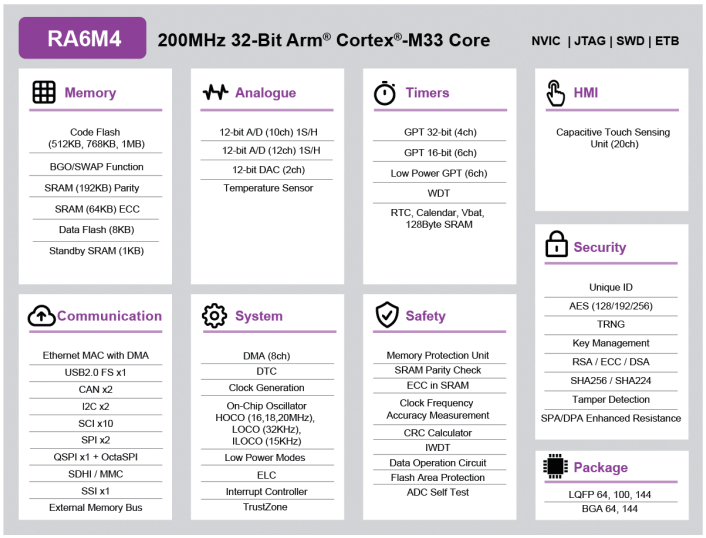
- High-resolution LCD operates without the need for external DRAM, simplifying PCB design and reducing BOM costs.
- Integrated PMIC consolidates power delivery from a single 5V input and includes advanced protections, such as undervoltage lockout (UVLO), overcurrent protection (OCP), and thermal protection.
- Mid-range variant includes NFC-based personal authentication for secure access, ideal for shared appliance environments.

RA6M4 Group: 200MHz Arm Cortex-M33 TrustZone, High Integration with Ethernet

The Renesas RA6M4 group of microcontrollers (MCUs) uses the high-performance Arm Cortex-M33 core with TrustZone. In concert with the Secure Crypto Engine it offers Secure Element functionality. The integrated Ethernet MAC with individual DMA ensures high data throughput. The RA6M4 is built on a highly efficient 40nm process and is suitable for IoT applications requiring Ethernet, future proof security, large embedded RAM, and low active power consumption down to 99µA/MHz running the CoreMark algorithm from Flash.

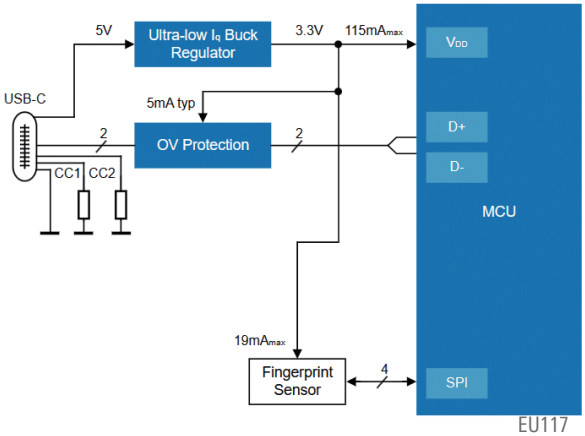
- 200MHz Arm Cortex-M33 with TrustZone
- Secure element functionality
- 512KB - 1MB Flash memory and 192KB SRAM with Parity and 64KB SRAM with ECC
- Dual-bank-Flash with background operation
- 8KB Data Flash to store data as in EEPROM
- Scalable from 64-pin to 144-pin packages
- Ethernet controller with DMA
- Capacitive touch sensing unit
- USB 2.0 Full Speed
- CAN 2.0B
- QuadSPI and OctaSPI
- SCI (UART, Simple SPI, Simple I²C)
- SPI/I²C multimaster interface
- SDHI and MMC
- LQFP and BGA package options

Block Diagram



Use case: Ultra small fingerprint module

As cybersecurity threats evolve, the demand for secure hardware-based authentication methods is rising to enhance the protection of sensitive data. In portable devices, traditional security methods struggle to balance compact design with high security, crucial for applications like USB dongles where space is limited but security is paramount. This compact design is tailored for a USB dongle fingerprint authentication module, enabled by the high performance and security features of the MCU. The MCU is provided in a very small package and ensures robust security through features like TrustZone and a secure crypto engine. Utilizing a modern USB Type-C in a cost-effective setup with USB 2.0 data bandwidth/power supply range, the fingerprint sensor application is condensed to a 12mm x 12mm footprint (plus 8mm x 8mm for the USB-C connector).



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System Benefits:

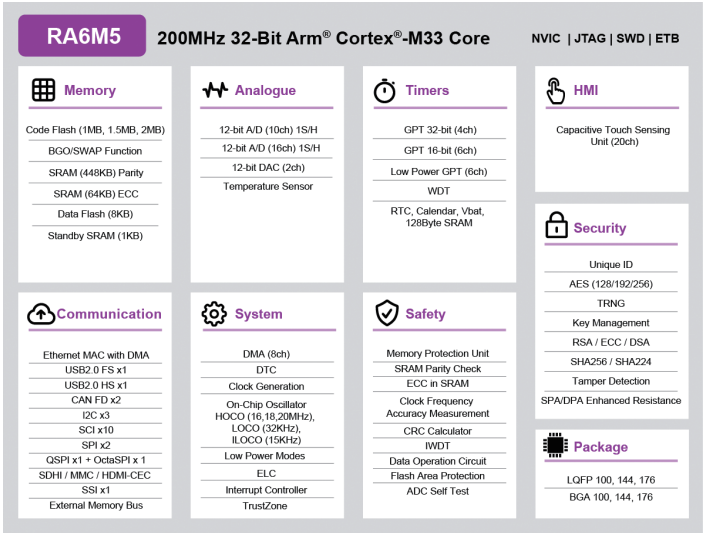
- Arm Cortex-M33 MCU with TrustZone and secure crypto engine provides robust security for fingerprint authentication, ensuring protection against unauthorized access.
- Optional expansion with galvanically isolated RS-485 bus connection allows integration into industrial automation systems.
- The ultra-compact footprint design allows for integration into space-constrained applications such as USB dongles.

RA6M5 Group: 200MHz Arm Cortex-M33, Highest Integration with Ethernet and CAN FD

The RA6M5 group uses the high-performance Arm Cortex-M33 core with TrustZone. In concert with the Secure Crypto Engine, it offers Secure Element functionality. The integrated Ethernet MAC with individual DMA ensures high data throughput. The RA6M5 is built on a highly efficient 40nm process and is supported by the FSP, built on FreeRTOS, and is expandable to use other RTOSes and middleware. The RA6M5 is suitable for IoT applications requiring Ethernet, future proof security, large embedded RAM, and low active power consumption down to 107µA/MHz running the CoreMark algorithm from Flash.

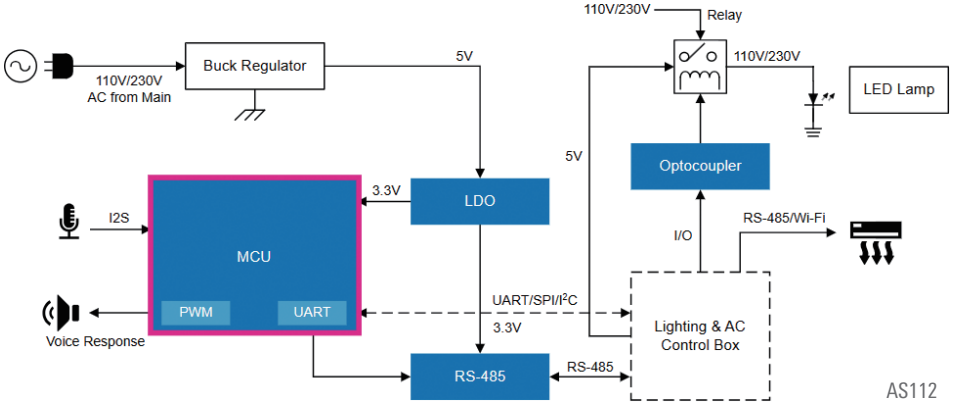
- 200MHz Arm Cortex-M33 with TrustZone
- 1MB - 2MB Flash memory and 512KB SRAM
- Scalable from 100-pin to 176-pin packages
- Secure element functionality, Capacitive touch sensing unit, Various communication features

Block Diagram



Use case: Smart Voice-Controlled Room Automation

Voice recognition is a key feature of today's digital lifestyle, enabling control of lighting, air conditioning, curtains, and appliances through voice commands. This hands-free capability improves hygiene by reducing the need to touch surfaces in hotels or offices. Renesas offers a design with an offline voice recognition algorithm for real-time control, utilizing a third-party voice recognition engine. The system supports advanced voice command recognition in two languages simultaneously, with 34 global languages available for integration into existing control systems.



System Benefits:

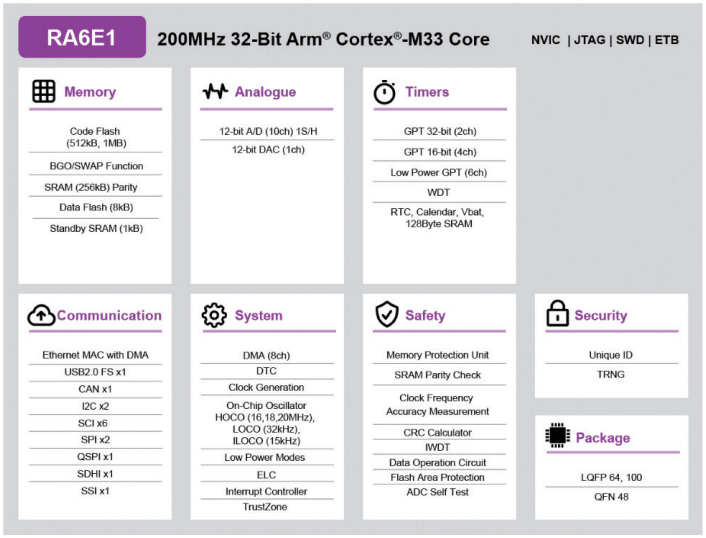
- Easily integrates into existing hotel air conditioning, lighting control systems, and home appliances.
- Customizable voice commands with an advanced recognition engine and algorithm.
- Supports dual languages and trigger commands.
- Cost-effective design for enhancing room automation.

RA6E1 Group: 200MHz Arm Cortex-M33 High performance and streamlined features

The RA6E1 group of 32-bit MCUs uses the high-performance Arm Cortex-M33 core with TrustZone. The RA6E1 is built on a highly efficient 40nm process and is supported by an open and flexible ecosystem concept, the Flexible Software Package, and is the perfect entry point into the RA Family of microcontrollers. The RA6E1 is suitable for entry IoT applications requiring streamlined features and connectivity integration including Ethernet, and unprecedented performance with a CoreMark of 790.27, which is 3.95 CoreMark/MHz.

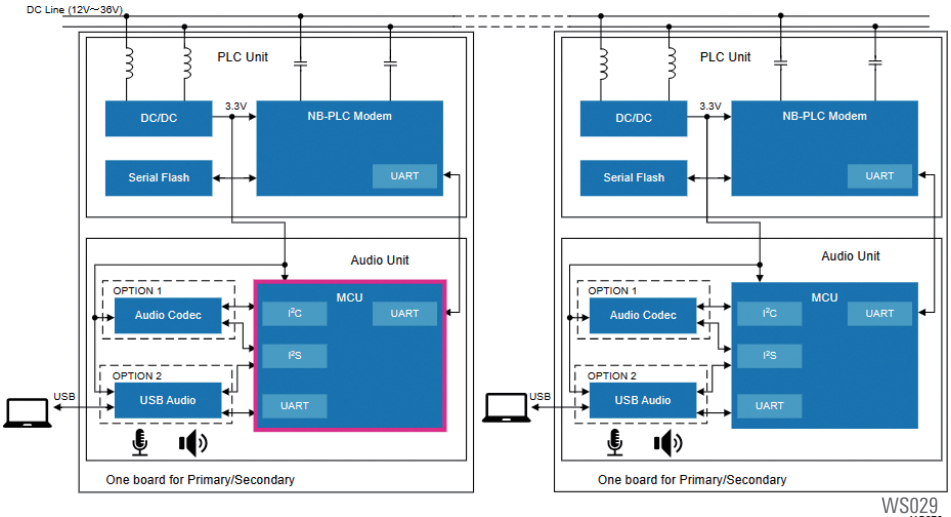
- 200MHz Arm Cortex-M33 with TrustZone
- 512KB - 1MB Flash memory and 256KB SRAM
- Scalable from 48-pin to 100-pin packages
- Various communication features, Ethernet MAC, USB 2.0 FS, CAN, QSPI, SDHI, MMC, SCI and SPI

Block Diagram



Voice Over PLC with High-Performance Audio Codec

This power line communication (PLC) audio system enables audio communication through existing power lines, making it ideal for applications like water heaters, doorbells, and in-house announcements. By eliminating the need for dedicated communication cables, the system reduces costs, simplifies construction and maintenance, and minimizes wiring errors.



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System Benefits:

- Enables audio communication between floors via PLC.
- Reduces costs by eliminating the need for additional wiring or physical deployment.
- Offers superior reliability, long-distance communication over 1km, and high-speed data transfer up to 1Mbps.
- Features a low BOM cost and supports a compact design.

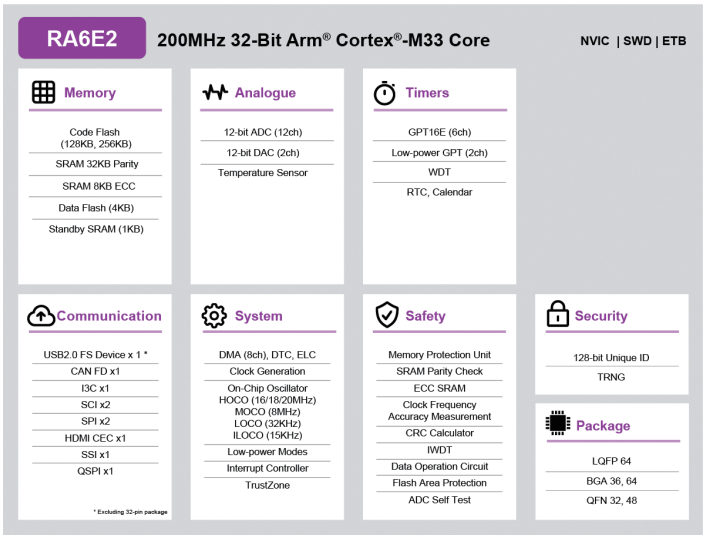
RA6E2 Group: 200MHz Arm Cortex-M33 Best-in class performance as entry-line MCU

The RA6E2 entry-line microcontroller is based on the 200MHz Arm Cortex-M33 core with TrustZone.

The RA6E2 MCUs offer best-in-class performance as an entry-line microcontroller while pursuing cost optimization. Pin and peripheral compatibility with the RA4E2 group make it ideal for applications requiring higher performance, small footprint, and lower pin counts.

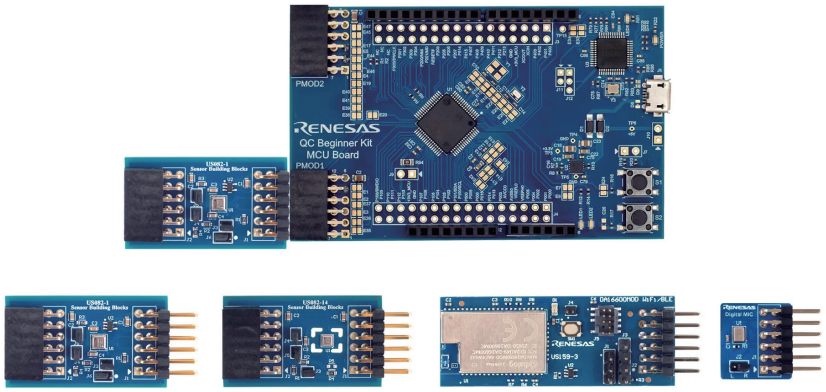
- 200MHz Arm Cortex-M33 with TrustZone
- 128KB - 256MB Flash memory and 40KB SRAM
- Scalable from 32-pin to 64-pin packages
- Various communication features, USB 2.0 FS, CAN FD, I3C, HDMI CEC, SSI, QSPI, SCI and SPI

Block Diagram



Use case: QuickConnect Beginners Kit

The QuickConnect Beginners Kit is designed to offer a user-friendly entry point into the QuickConnect Platform. All boards included in the kit are supported through QuickConnect Studio. Featuring a modular design with standard Pmod connectors, the kit includes the BGK-RA6E2 MCU board, a Wi-Fi connectivity module, and a variety of sensors—ideal for fast prototyping. This setup enables both rapid software development and easy hardware integration. Users can create projects using AWS MQTT sample applications and gather real-time data from sensors such as temperature, humidity, air quality, and audio.



Features:

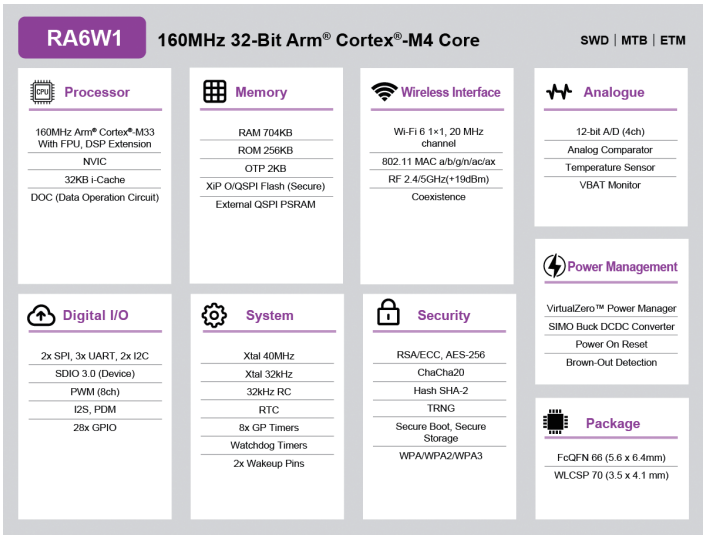
- Rapid prototyping using MCU, connectivity, and sensors.
- All boards are supported on QuickConnect Studio for system software development and customization.
- Samples of use cases for AWS connectivity are described in the user manual.
- Mobile app available for Wi-Fi provisioning on Android and iOS.
- QuickConnect Beginners kit V2.0 with Bluetooth Low Energy (LE) module can be used to complete the example projects available in the application manual for the kit.

RA6W1 Group: Wi-Fi6 MCU – 2.4/5GHz dual band ultra low power

The RA6W1 group is an ultra–Low Power Wi-Fi6 Wireless MCU that combines a 160MHz Arm Cortex-M33 core with Dual-band Wi-Fi6 integrating a comprehensive number of serial peripherals. The RA6W1 Wireless MCU integrates 2.4/5GHz Dual Band Wi-Fi6 functionality with large integrated RAM and optimized feature set this is suitable for a wide range of Wi-Fi IoT applications either as a standalone Wi-Fi MCU or connected to a host MCU. The RA6W1 group integrates unique low power capabilities enabling sleepy connected functionality enabling battery power Wi-Fi applications and fulfilling the latest low power regulations. RA6W1 group is fully scalable for any application with O/QSPI interface for Flash (XiP) and a QSPI interface supporting PSRAM for large application data like display buffers. RA6W1 is Matter ready with SDK certified for Matter 1.4 making RA6W1 the ideal choice for Smart home applications.

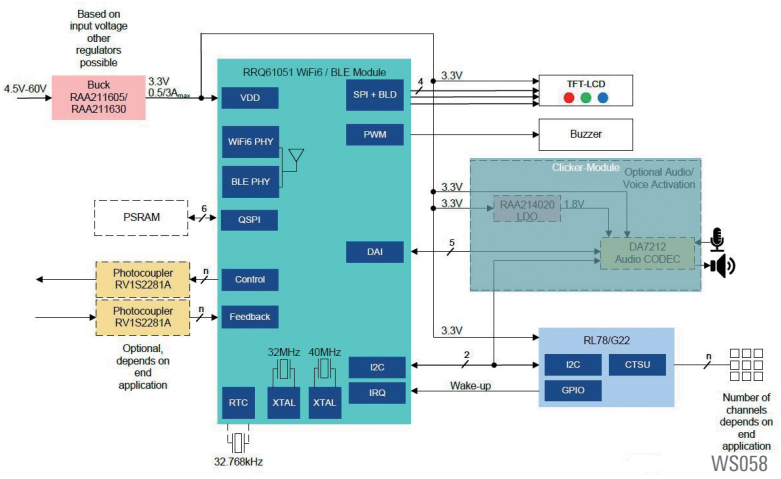
- 160MHz Arm Cortex-M33 core
- 704KB SRAM, 256KB ROM, 2KB OTP
- Packaged 66-pin FcQFN, 70-pin WLCSP
- Wi-Fi6 2.4/5GHz, IEEE 802.11a/b/g/n/ac/ax, 1x1, 20MHz channel
- 2x SPI, 3x UART, 2x I²C, 8 channel PWM, PDM/I²S, up to 28 GPIOs
- Security functions including ECC, AES, SHA256, secure key storage, TRNG

Block Diagram



Use case: Touch HMI interface for home appliances

This solution is for a Wi-Fi connected HMI interface for the smart home. Being based on the RA6W1 Wi-Fi6 MCU which is integrated into the RRQ61051 Wi-Fi/BLE combo module and the RA6W1 MCU is driving the LVGL based GUI on the SPI connected QVGA display. There is integrated low latency touch control with the RL78 touch controller and MQTT weather server providing continuous updates. RA6W1 implements Sleepy connection for ultra low power support with low latency for remote control of the Smart appliance.



RA8 Series

Features of the RA8 Series

The RA8 series provides the highest performance and the most advanced feature-set among the Renesas RA MCU Family portfolio, using the industry-leading Arm Cortex-M85 CPU core with Helium™ M-profile Vector Extensions to deliver unprecedented performance, with fully deterministic, low latency, real-time operation that enables customers' most demanding application needs.

The RA8 series MCUs are designed for increasing security demands. Renesas Security IP with advanced cryptographic acceleration, secure boot with FSBL in immutable storage and tamper protection work seamlessly with Arm TrustZone to realize robust security.

These are general-purpose MCUs and address diverse high-performance and compute-intensive applications in Industrial Automation, Home Appliances, Smart Home, Consumer, Building/Home Automation and Medical/Healthcare market segments.

Highest Performance

- Powerful Arm Cortex-M85 core, 6.39 CoreMark/MHz Demonstrated Performance
- Arm v8.1 architecture with Helium for DSP/ML acceleration

Advanced Security

- Hardware Root-of-Trust and Secure Boot
- Advanced cryptography for secure element functionality
- Arm TrustZone for isolation and system partitioning

Wide coverage of the target applications

- RA8P1: Voice/Vision AI/ML
- RA8E2, D1, D2: Graphics & Display
- RA8E1, M1, M2: System control, etc.

Arm Cortex-M cores

	M0+	M23	M4	M33	M55	M7		M85
Instruction Set Architecture	Armv6-M	Armv8-M Baseline	Armv7-M	Armv8-M Mainline	Armv8.1-M Mainline	Armv7-M		Armv8.1-M Mainline
DMIPS/MHz	0.99	1.03	1.26	1.54	1.69	2.31	+35%	3.13
CoreMark/MHz	2.46	2.64	3.54	4.10	4.40	5.29	+20%	6.39*
MVE	–	–	–	–	Helium	–	New	Helium
TrustZone	NA	(Yes)	NA	Yes	Yes	NA	New	Yes

* Measured by Renesas

RA8 Series Lineup

The RA8P1 is the Renesas' first AI accelerated MCU designed for Edge AI, with a focus on Voice and Vision AI applications.

The RA8D2, RA8D1, and RA8E2 MCUs are designed for graphics/HMI and display applications. These MCUs are highly scalable with increasing performance and capabilities to meet diverse application requirements.

RA8M2, RA8M1, and RA8E1 are general-purpose MCUs that support real-time control applications and combine high performance with a scalable set of peripherals.

The RA8E1 and RA8E2 are the entry-line MCUs in the RA8 series, delivering an optimized feature-set for cost sensitive applications.

AI / ML

RA8P1 — 1GHz (Cortex-M85), 250MHz (Cortex-M33), 1MB MRAM, 8MB Flash (Option), 2MB SRAM (TCM, ECC supported), 224/289/303-pin

Dual Core Cortex-M85 Cortex-M33	Ethos-U55 NPU	OSPI w/DOTF, XIP	32-bit External Memory Bus	USB HS SDHI	I3C	16-bit ADC	16-bit Camera I/F	MIPI DSI & CSI-2	GLCDC 2DRW	PDM I/F I²S	Gbit Ethernet TSN Switch	Crypto Engine

Graphics / Display

RA8D2 — 1GHz (Cortex-M85), 250MHz (Cortex-M33), 1MB MRAM, 8MB Flash (Option), 2MB SRAM (TCM, ECC supported), 224/289/303-pin

Dual Core Cortex-M85 Cortex-M33	OSPI w/DOTF, XIP	32-bit External Memory Bus	USB HS SDHI	I3C	16-bit ADC	16-bit Camera I/F	MIPI DSI & CSI-2	GLCDC 2DRW	PDM I/F I²S	Gbit Ethernet TSN Switch	Crypto Engine

RA8D1 — 480MHz (Cortex-M85), 2MB Flash, 1MB SRAM (TCM, ECC supported), 12KB Data Flash, 176/224-pin

Cortex-M85	OSPI w/DOTF, XIP	32-bit External Memory Bus	USB HS SDHI	I3C	12-bit ADC	16-bit Camera I/F	MIPI DSI	GLCDC 2DRW	I²S	10/100 Ethernet	Crypto Engine

RA8E2 — 480MHz (Cortex-M85), 1MB Flash, 672KB SRAM (TCM, ECC supported), 12KB Data Flash, 224-pin

Cortex-M85	OSPI w/ XIP	16-bit External Memory Bus	12-bit ADC	GLCDC 2DRW	I²S	TRNG Unique ID

System Ctrl. / Computing

RA8M2 — 1GHz (Cortex-M85), 250MHz (Cortex-M33), 1MB MRAM, 8MB Flash (Option), 2MB SRAM (TCM, ECC supported), 176/224/289/303-pin

Dual Core Cortex-M85 Cortex-M33	OSPI w/DOTF, XIP	32-bit External Memory Bus	USB HS SDHI	I3C	16-bit ADC	16-bit Camera I/F	PDM I/F I²S	Gbit Ethernet TSN Switch	Crypto Engine

RA8M1 — 480MHz (Cortex-M85), 2MB Flash, 1MB SRAM (TCM, ECC supported), 12KB Data Flash, 100/144/176/224-pin

Cortex-M85	OSPI w/DOTF, XIP	32-bit External Memory Bus	USB HS SDHI	I3C	12-bit ADC	16-bit Camera I/F	I²S	10/100 Ethernet	Crypto Engine

RA8E1 — 360MHz (Cortex-M85), 1MB Flash, 544KB SRAM (TCM, ECC supported), 12KB Data Flash, 100/144-pin

Cortex-M85	OSPI w/ XIP	12-bit ADC	8-bit Camera I/F	I²S	10/100 Ethernet	TRNG Unique ID

Common features

- Arm TrustZone
- Ultra Low-power Timer AGT Timer, RTC
- WDT, IWDT
- DAC, High-Speed Comparator
- SCI, SPI, I²C, USBHS/FS, CAN-FD
- Timers
- Functional Safety Features
- Low Power Modes/ Features

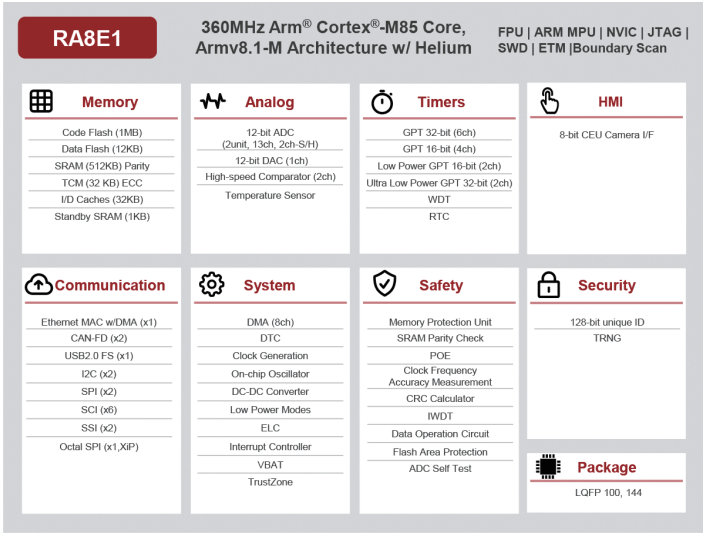
RA8E1 Group: 360MHz Arm Cortex-M85 Entry-Line Microcontroller with Helium

The RA8E1 MCU Group features entry-line 32-bit microcontrollers (MCU) based on the Arm Cortex-M85 (CM85) core with Helium and TrustZone, delivering breakthrough performance of 6.39 CoreMarks/MHz, with fully deterministic, low-latency, real-time operation that enables customers' most demanding application needs. These are general-purpose MCUs and address diverse high-performance and compute-intensive applications in industrial automation, home appliances, smart home, consumer, building/home automation, and medical/healthcare market segments.

The RA8E1 MCUs integrate the high-performance CM85 core with memory, multiple external interfaces and an optimized peripheral set that addresses the needs of price-sensitive applications. RA8E1 MCUs are available in 100 and 144-pin LQFP packages, to serve the needs of a broad range of high-performance applications.

- 360MHz Arm Cortex-M85 with Helium MVE, Armv8-M TrustZone
- 1MB Flash memory, 544KB of SRAM including TCM, and 32KB I/D Caches and 12KB Data Flash
- xSPI compliant Octal SPI with XIP & DOTF
- On-chip immutable ROM for First Stage Bootloader
- 8-bit CEU camera I/F for simple vision AI application
- 100-pin and 144-pin LQFP packages

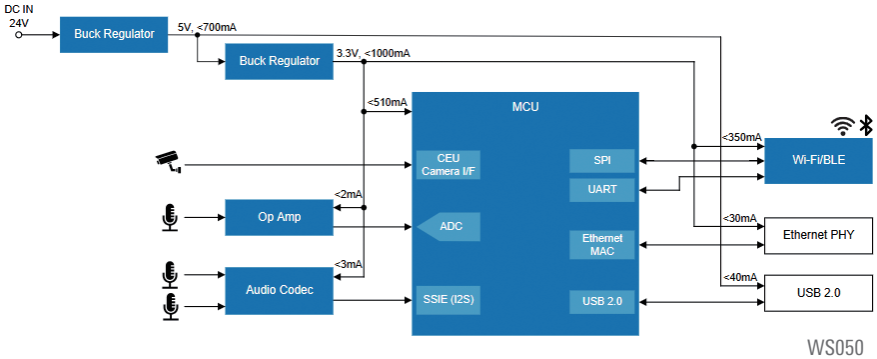
Block Diagram



Use case: Entry Level Voice & Vision AI System

The increasing demand for smart and secure environments, combined with advancements in AI technology, is driving the development of more affordable and accessible entry-level AI systems. These systems come with advanced security features and smart functionalities designed to integrate seamlessly with existing ecosystems.

This design offers a cost-effective, mid-range voice and vision AI system for voice and image recognition. It features a high-performance Arm Cortex-M85 core-based MCU with Helium Vector Extensions, providing a significant performance boost for AI/ML and DSP operations. This versatile design is suitable for various applications, including surveillance and voice assistants. It includes audio and image capture interfaces, as well as Wi-Fi and Bluetooth Low Energy (LE) connectivity, ensuring easy integration with existing home or infrastructure ecosystems.



WS050

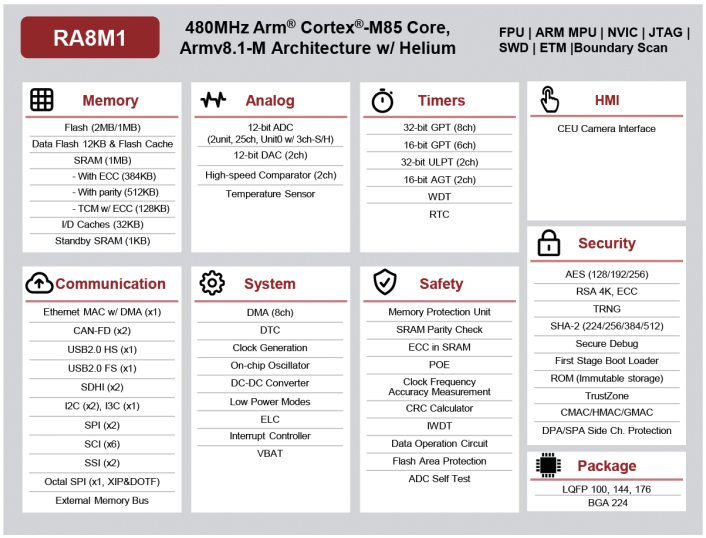
RA8M1 Group: 480MHz Arm Cortex-M85 MCU with Helium

The RA8M1 MCU Group has the Arm Cortex-M85 (CM85) core, delivering breakthrough performance of over 3000 CoreMark at 480 MHz, with fully deterministic, low latency, real-time operation that enables customers' most demanding application needs. These are general-purpose MCUs and address diverse high-performance and compute-intensive applications in Industrial Automation, Home Appliances, Smart Home, Consumer, Building/Home Automation and Medical/Healthcare market segments.

The RA8M1 MCUs integrate the high-performance CM85 core with large memory, multiple external interfaces, and a rich peripheral set optimized to address diverse application requirements, and are available in packages from 100 pins to 224 pins, to serve the needs of a broad range of high-performance applications. Secure element functionality is built-in with advanced cryptographic security IP, immutable storage, and tamper protection, for truly secure IoT.

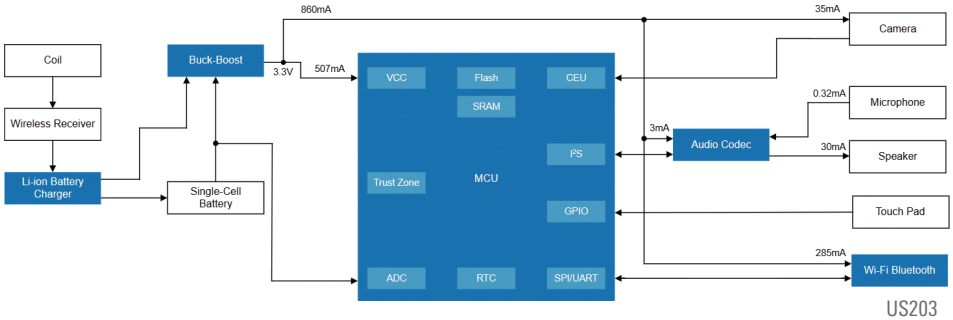
- 480MHz Arm Cortex-M85 with Helium MVE, Armv8-M TrustZone
- 1MB - 2MB Flash memory, 1MB of SRAM including TCM, and 32KB I/D Caches and 12KB Data Flash
- External memory interfaces (CS/SDRAM) and xSPI compliant Octal SPI with XIP & DOTF
- Renesas Secure IP (RSIP-E51A) & On-chip immutable ROM for First Stage Bootloader
- Scalable from 100-pin to 224-pin packages

Block Diagram



Use case: Smart Glasses

The smart glasses serve as an extension of the IoT system, which can be implemented directly on the glasses themselves. This system offers a range of functions, including taking pictures, playing music, making phone calls, voice commands, and danger alerts. It utilizes the machine learning capabilities of the Arm Cortex-M85 MCU for efficient audio and image processing on the edge. This enables quick identification of potential dangers, triggering alarms through the speaker.



US203

System Benefits:

- Edge machine learning capability.
- Secured by Arm TrustZone with support for Secure OTA.
- Active noise cancellation audio system with two microphone beamforming, ensuring clear audio in noisy environments.
- Low quiescent current power system for extended battery life.
- Waterproof system with no external connectors.

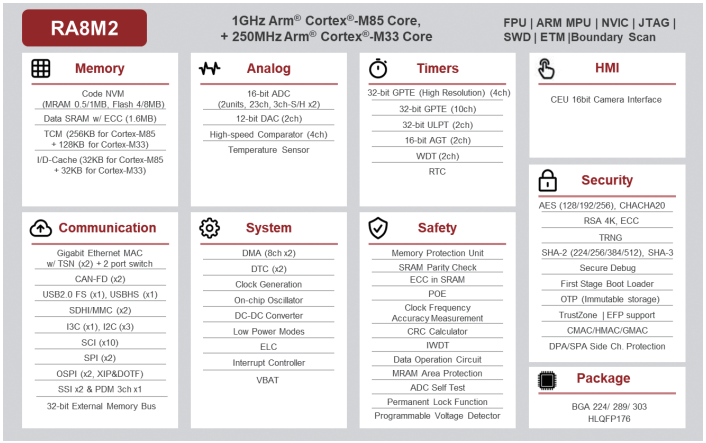
RA8M2 Group: 1GHz Arm Cortex-M85 & CM33 Dual-Core High-Performance MCU

The RA8M2 group features 32-bit general-purpose MCUs that combine 1GHz Arm Cortex-M85 with Helium Vector Extensions and 250MHz Cortex-M33 cores, delivering over 7300 CoreMark CPU performance to meet demanding application needs. These MCUs are ideal for compute-intensive applications in industrial automation, home appliances, smart home, consumer, building/home automation, and medical/healthcare market segments.

RA8M2 MCUs integrate large on-chip MRAM and SRAM memory, multiple memory interfaces, and a rich peripheral set, enabling efficient system design and lower costs. The MRAM provides non-volatile, high-reliability storage for critical data. Available in packages from 176 to 303 pins with junction temperature up to 125°C, these MCUs enable a wide range of industrial and IoT/consumer applications. Secure element functionality is built-in, with advanced cryptographic security IP, immutable storage, and tamper protection, to ensure data privacy and integrity.

- 1GHz Arm Cortex-M85 core with Helium Vector Extensions, 250MHz Cortex-M33 core
- 0.5/1MB MRAM, 4/8MB Flash (option), 2MB SRAM including TCM and 64KB caches
- 32-bit external memory I/F (CS/SDRAM) and xSPI compliant Octal SPI with XIP & DOTF
- Renesas Security IP, TrustZone, tamper protection, secure boot with immutable storage for first stage bootloader
- Gigabit Ethernet, TSN switch, USB 2.0 HS/FS, CAN FD, SDHI, SPI, I3C/I²C serial interfaces
- 176-pin HLQFP & 224, 289, 303-pin BGA packages

Block Diagram

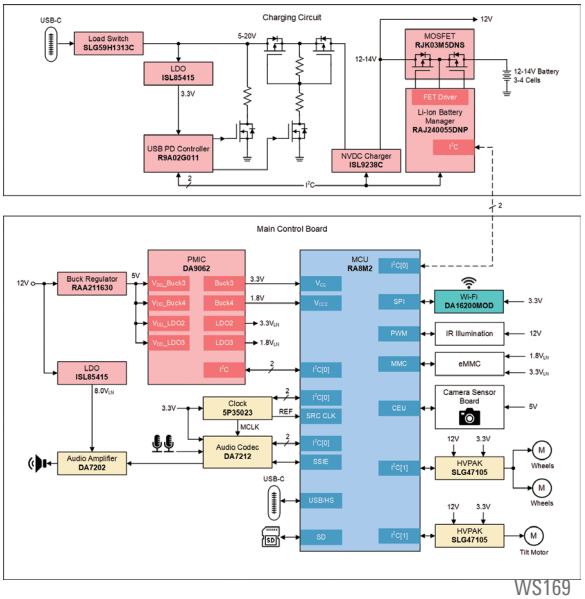


Use case: Pet camera robot

Mobile pet camera robot with real-time video, audio, and wireless control

As more households adopt pets, owners seek reliable ways to ensure their companions' safety, behavior, and well-being while they're away. Stationary cameras provide coverage, but are limited as pets move throughout the home, leaving blind spots. A mobile pet camera robot solves this by enabling control to move and follow pets around, reducing blind spots and enabling interaction opportunities for owners to engage with pets while being away.

This RA8M2 based Pet Camera Robot system is a mobile pet camera that provides video footage and two-way audio interaction to move around the house and allow owners to dynamically interact with their pets. Controlled by a phone app via Wi-Fi, users can see video feed, talk through the robot and control the robot to move around and follow their pets.



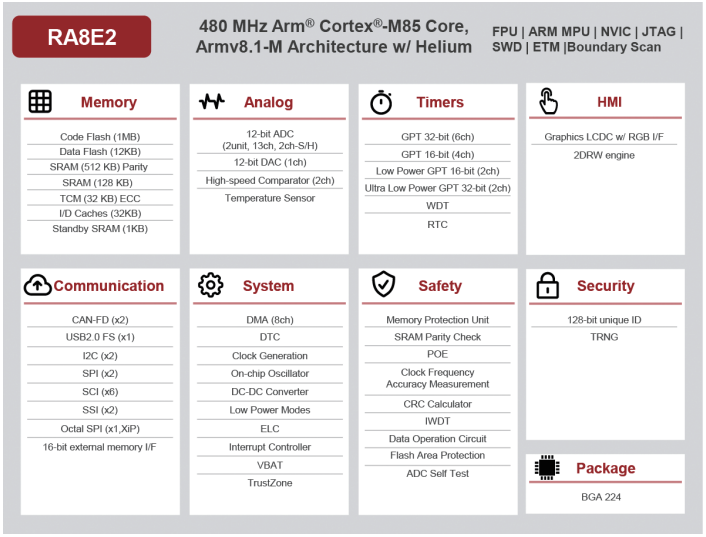
RA8E2 Group: 480MHz Arm Cortex-M85 Entry-Line Graphics/Display Microcontroller

The RA8E2 MCU group features entry-line graphics-enabled 32-bit microcontrollers (MCUs) based on the Arm Cortex-M85 (CM85) core with Helium and TrustZone, delivering breakthrough performance of over 3000 CoreMark points at 480 MHz, and graphics capabilities that drive TFT-LCD displays. These MCUs address diverse high-performance graphics applications in industrial automation, home appliances, smart home, consumer, building/home automation, and medical/healthcare market segments.

The RA8E2 MCUs integrate the high-performance CM85 core with large memory, and an optimized peripheral set including a graphics TFT-LCD controller with parallel RGB interface, 2D drawing engine, and multiple external memory interfaces, which addresses the needs of price-sensitive graphics applications. These MCUs are available in 224-pin packages.

- 480MHz Arm Cortex-M85 with Helium MVE, Armv8-M TrustZone
- 1MB Flash memory, 672KB of SRAM including TCM, and 32KB I/D Caches and 12KB Data Flash
- 16/8-bit external memory interfaces (CS/SDRAM), xSPI compliant Octal SPI with XIP & DOTF
- On-chip immutable ROM for First Stage Bootloader
- Graphics LCD controller with RGB I/F, 2D drawing engine
- 224-pin BGA packages

Block Diagram

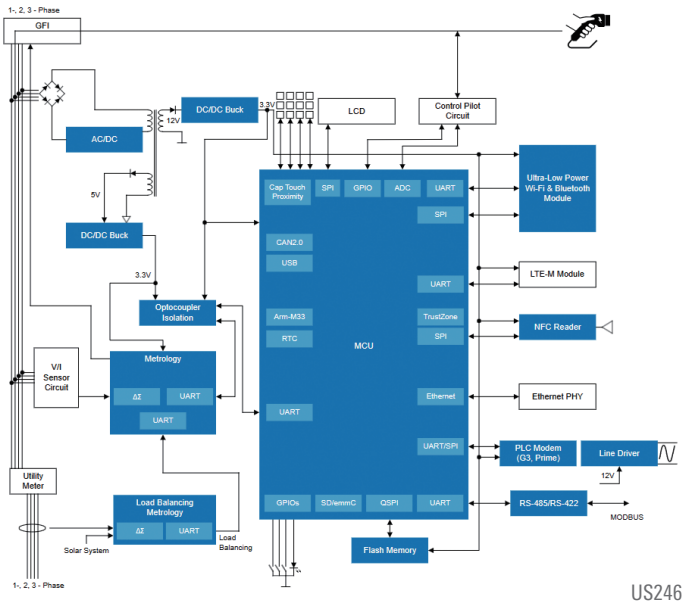


Use case: Level 2 EV Charger Wall Box

The EV charging station is designed for both consumer and business EV chargers. Its modular approach offers a variety of connectivity options, including Wi-Fi, LTE Cat-M1, or power line communication (PLC), with the possibility to add additional interfaces like Ethernet, Bluetooth Low Energy (LE), or wired communication via a Modbus interface. The station features an NFC reader for customized billing and access control and includes modular metrology for monitoring power consumption in a standard AC power environment. It also supports load balancing and incorporates safety features to ensure reliable operation.

The MCU supports dual-flash bank operation, permitting safe over-the-air (OTA) updates and fallback.

High voltage AC/DC design eliminates the need for optocouplers, simplifying the system architecture.



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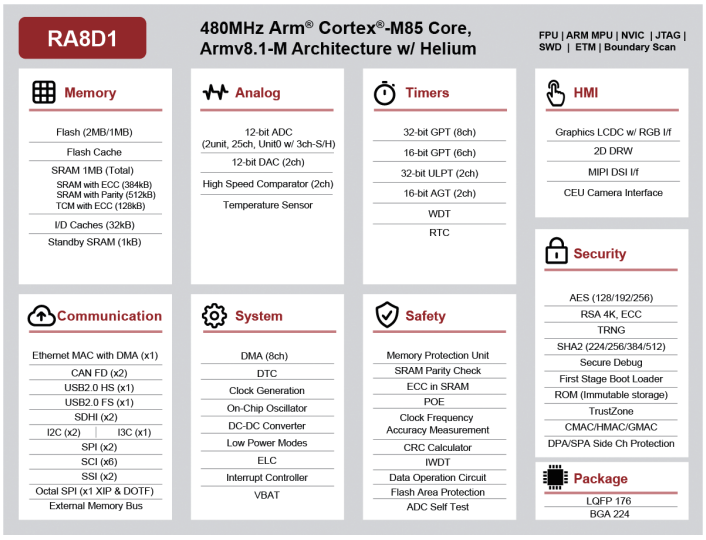
RA8D1 Group: 480MHz Arm Cortex-M85 Graphics/Display MCU with Helium

The RA8D1 MCU Group has the Arm Cortex-M85 (CM85) core, delivering breakthrough performance of over 3000 CoreMark at 480 MHz, and superior graphics capabilities that enable high resolutions display and Vision AI applications. These are general-purpose MCU devices and address diverse high-performance and compute-intensive applications in Industrial Automation, Home Appliances, Smart Home, Consumer, Building/Home Automation, and Medical/Healthcare market segments.

The RA8D1 MCUs integrate the high-performance CM85 core with large memory, and a rich peripheral set including a high-resolution TFT-LCD controller with parallel RGB and MIPI-DSI interfaces, 2D drawing engine, 16-bit camera interface, and multiple external memory interfaces, optimized to address the needs of diverse graphics and Vision AI applications. These MCUs are available in 176 and 224-pin packages. Secure element functionality is built-in with advanced cryptographic security IP, immutable storage, a true secure boot, and tamper protection, for truly secure IoT.

- 480MHz Arm Cortex-M85 with Helium MVE, Armv8-M TrustZone
- 1MB - 2MB Flash memory,1MB of SRAM including TCM, and 32KB I/D Caches and 12KB Data Flash
- 32/16/8-bit external memory interfaces (CS/SDRAM) and xSPI compliant Octal SPI with XIP & DOTF
- Graphics LCD Controller with RGB and MIPI-DSI I/Fs, 2D Drawing Engine, 16-bit CEU Camera I/F
- Renesas Secure IP (RSIP-E51A) & On-chip immutable ROM for First Stage Bootloader
- 176-pin LQFP & 224-pin BGA package

Block Diagram



Use case: High-End Feature-Rich HMI Platform

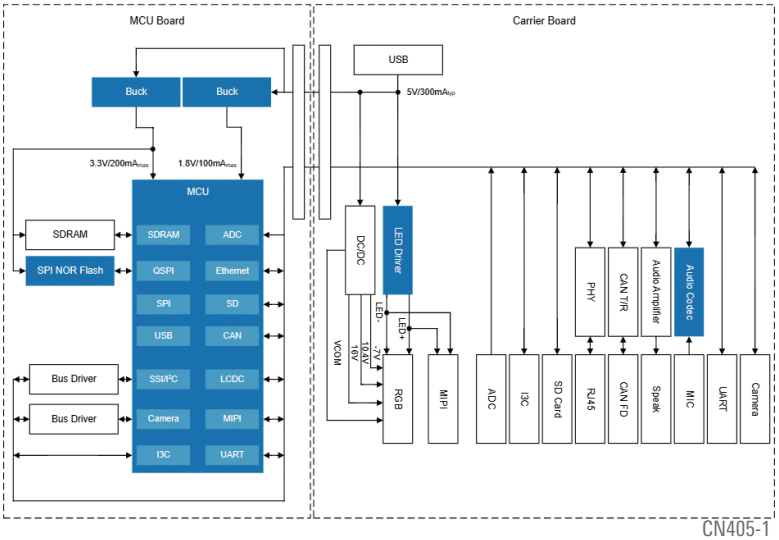
The demand for sophisticated human machine interfaces (HMIs) continues to grow, necessitating support for multiple display outputs like RGB and MIPI, flexibility in display resolutions, along with peripherals such as microphones, speakers, Ethernet, and CAN FD across various industries.

This feature-rich HMI platform integrates multiple peripherals, including microphones, Ethernet, and CAN FD, and is scalable to meet diverse application needs. It offers a system for single displays up to WXGA, providing flexibility for various end applications.

System Benefits:

- Rich HMI built-in functions support two video outputs, camera input, microphone interface, and audio output, offering enhanced multimedia capabilities and versatile input/output integration.
- MCU-based WXGA single display HMI platform supports RGB and MIPI video outputs with 2D graphics, powered by an Arm Cortex-M85 high-performance MCU.

WXGA Single Display HMI Platform (MCU-Based)



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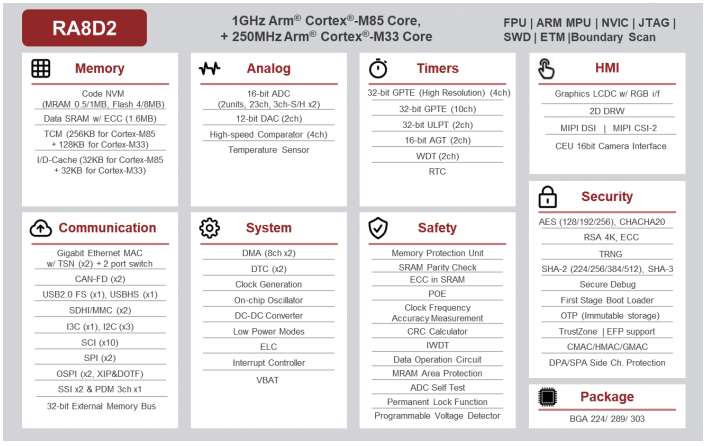
RA8D2 Group: 1GHz Arm Cortex-M85 & CM33 Dual-Core Graphics/Display MCU

The RA8D2 group comprises 32-bit single and dual-core graphics-enabled MCUs with 1GHz Arm Cortex-M85 with Helium Vector Extensions and 250MHz Cortex-M33 cores. These MCUs deliver ultra-high performance of over 7300 CoreMark and superior graphics capabilities that enable high-resolution TFT-LCD displays and vision AI applications.

Integrating the high-performance cores with large on-chip memory, multiple high-throughput memory interfaces, and a rich set of graphics peripherals – a high-resolution LCD controller with parallel RGB and MIPI DSI, 2D drawing engine, 16-bit parallel CEU, and MIPI CSI-2 camera interfaces – address the needs of demanding graphics/HMI and AI applications. Built on the advanced 22nm ULL TSMC process, these devices offer significantly lower active currents and have several low-power features developed to reduce the overall power consumption, while still providing high performance. Secure element functionality is built-in with new cryptographic security IP, secure boot, immutable storage, and tamper protection, enabling truly secure consumer/IoT applications.

- 1GHz Arm Cortex-M85 core with Helium Vector Extensions, 250MHz Cortex-M33 core
- 0.5/1MB MRAM, 4/8MB Flash (option), 2MB SRAM including TCM and 64KB caches
- 32-bit external memory I/F (CS/SDRAM) and xSPI compliant Octal SPI with XIP & DOTF
- Parallel and MIPI CSI-2 camera interfaces, I²S and PDM interfaces, GLCDC w/ RGB & MIPI DSI I/Fs
- Renesas Security IP, TrustZone, tamper protection, secure boot with immutable storage for first stage bootloader
- Gigabit Ethernet, TSN switch, USB 2.0 HS/FS, CAN FD, SDHI, SPI, I3C/I²C serial interfaces
- 224, 289, 303-pin BGA packages

Block Diagram

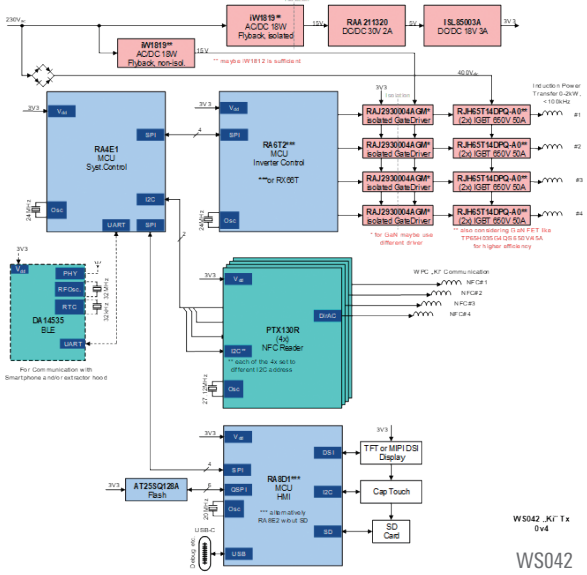


Use case: High-Efficiency Ki Wireless Power Transceiver System

A high-efficiency Ki Wireless Power Transceiver System (Tx) with NFC, smart control, and scalable design

This innovative Ki wireless power transceiver system (Tx) combines wireless power transfer and communication. Ki delivers up to 2kW of power with high-efficiency transfer, low-loss switching, minimal standby current, and dynamically adjusting power (0–2kW) for maximum energy efficiency. By eliminating appliance cables, Ki optimizes kitchen and home spaces, redefining convenience, safety, and performance for modern appliances.

Powered by Renesas' industry-leading NFC and MCU technology, this system features a capacitive touch display graphical user interface (GUI) and Bluetooth communication for monitoring and remote control. It enhances connectivity and user-friendly control by seamlessly integrating with appliances like extractor hoods. Designed for complete compatibility, the Ki wireless power transceiver system (Tx) interfaces directly with the Ki wireless power receiver system (Rx) for a fully integrated wireless power design.



WS042

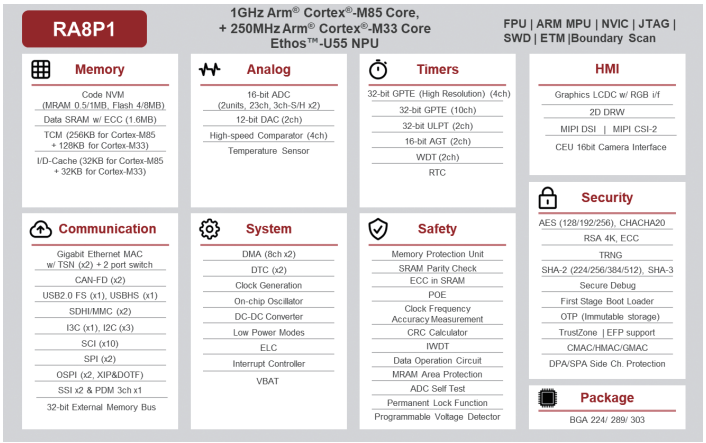
RA8P1 Group: 1GHz Arm Cortex-M85 and Ethos-U55 NPU Based AI Microcontroller

The RA8P1 group features 32-bit AI-accelerated microcontrollers (MCUs) powered by the high-performance Arm Cortex-M85 (CM85) with Helium MVE and Ethos-U55 NPU. It delivers 256GOPS of AI performance, a breakthrough CPU performance of over 7300 CoreMarks and advanced artificial intelligence (AI) capabilities enabling voice, vision, and real-time analytics AI applications on a single chip. The RA8P1 MCUs built on the advanced 22nm ULL process are available in single and dual-core options with a Cortex-M33 core embedded on the dual-core MCUs.

The RA8P1 MCUs integrate high-performance CPU cores with large memory, multiple external memory interfaces, and a rich peripheral set optimized for AI applications. Single and dual-core devices in 224 and 289 BGA packages are available, to address diverse use cases across broad markets. Secure element functionality is built-in with advanced cryptographic security IP, immutable storage, and tamper protection, to deliver truly secure Edge AI and IoT applications.

- 1GHz Arm Cortex-M85. 250MHz Cortex-M33 cores, and Ethos-U55 NPU, 256GOPS at 500MHz
- 0.5/1MB MRAM, 4/8MB Flash (option), 2MB SRAM including TCM and 64KB caches
- 32/16-bit external memory I/F (CS/SDRAM) and xSPI compliant Octal SPI with XIP & DOTF
- Renesas Security IP, TrustZone, tamper protection, secure boot with immutable storage for first stage bootloader
- Parallel and MIPI-CSI2 camera interface (I/F) for vision AI, I²S and PDM I/F for voice AI
- GLCDC w/ parallel RGB and MIPI-DSI I/Fs, Gigabit Ethernet, TSN switch, USB 2.0 HS/FS, CAN FD
- 224, 289, 303-pin BGA packages

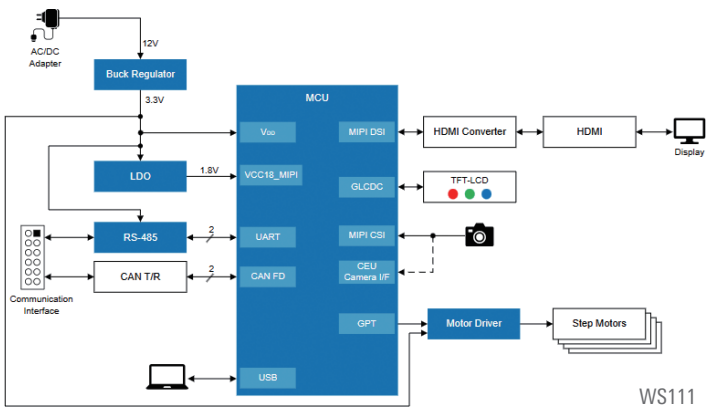
Block Diagram



Use case: AI Drawing Robot Arm

Designed for drawing applications, this AI drawing robot arm utilizes a camera for image capture. The system processes these images with advanced algorithms to generate patterns and translate them into precise, machine-readable instructions for controlling stepper motors. This innovative system serves diverse sectors—from industrial and manufacturing applications requiring accurate, repeatable patterns, logos, and identifiers for time savings and quality consistency, to educational and research environments that benefit from hands-on robotics learning.

Supports micro-ROS run on the MCU, enabling seamless integration with robotic systems and enhancing real-time communication capabilities.



WS111

RA-T Series

Features of the RA-T Series

The RA-T series is MCU for motor and inverter control built on Arm Cortex-M core architecture. These MCUs feature motor control timers, a rich set of analog functions such as analog-to-digital (A/D) converter, 3-channel simultaneous sample-and-hold circuit, programmable gain amplifier (PGA), and comparator, as well as multiple connectivity interfaces and advanced security features. RA-T MCUs deliver the performance and flexibility needed for applications ranging from basic motor control to high performance, high-precision real-time control in both consumer and industrial systems.

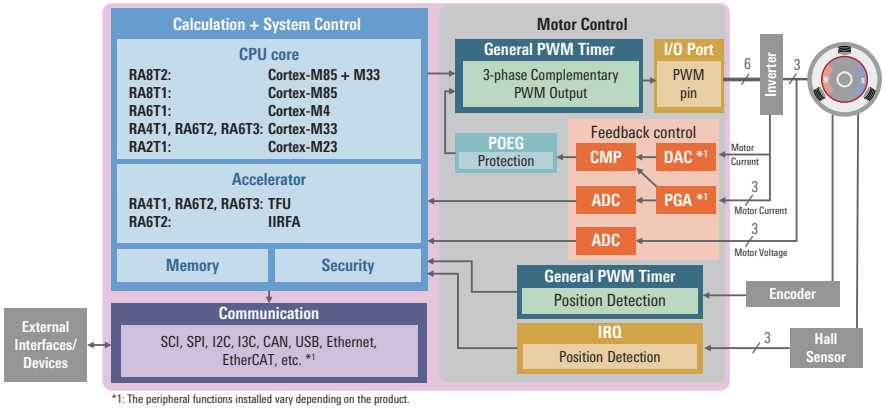
Broad lineup
64MHz ~ 1GHz
24 ~ 303-pin
Scalable peripherals

Specialized motor control functions
Three-phase complementary PWM output
PWM output emergency stop
Trigonometric function unit

Analog functions for enhanced performance
Three-channel simultaneous sample-and-hold circuit
PGA
Comparator

Various solutions
Motor/power control
Functional safety
Security
Industrial Automation network

Resources Specialized for Motor and Inverter Control



*1: The peripheral functions installed vary depending on the product.

RA-T Series Lineup

RA8T2 — 1GHz (Cortex-M85), 250MHz (Cortex-M33), 1MB MRAM, 2MB SRAM (TCM, ECC supported)
176/224/289/303-pin

Dual Core Cortex-M85 Cortex-M33	PWM Output pin 2	Double precision FPU	USB FS	SDHI	Gigabit Ethernet	EtherCAT	Security

RA8T1 — 480MHz, 2MB Flash (Dual Bank supported), 1MB SRAM (TCM, ECC supported), 12KB Data Flash
100/144/176/224-pin

Cortex-M85	PWM Output pin 28	Double precision FPU	USB FS	SDHI	Ethernet	Security

RA6T3 — 200MHz, 256KB Flash, 40KB SRAM (ECC supported), 4KB Data Flash
32/48/64-pin

Cortex-M33	PWM Output pin 12	PGA	Single precision FPU	Trigonometric Function Unit (TFU)	USB FS	Security

RA6T2 — 240MHz, 512KB Flash, 64KB SRAM (ECC supported), 16KB Data Flash
48/64/100-pin

Cortex-M33	PWM Output pin 20	PGA	Single precision FPU	Trigonometric Function Unit (TFU)	Security

RA6T1 — 120MHz, 512KB Flash, 64KB SRAM, 8KB Data Flash
64/100-pin

Cortex-M4	PWM Output pin 26	PGA	Single precision FPU	Security

RA4T1 — 100MHz, 256KB Flash, 40KB SRAM (ECC supported), 4KB Data Flash
32/48/64-pin

Cortex-M33	PWM Output pin 12	PGA	Single precision FPU	Trigonometric Function Unit (TFU)	Security

RA2T1 — 64MHz, 64KB Flash, 8KB SRAM, 2KB Data Flash
24/32/48-pin

Cortex-M23	PWM Output pin 8

Common features
- 16-bit or 12-bit ADC
- 12-bit DAC*
- Comparator
- SCI/SPI/I²C
- CAN FD or CAN*

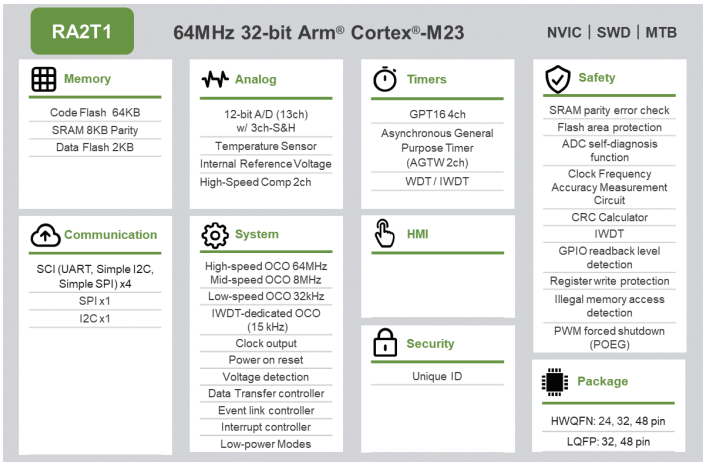
*: RA2T1 not supported

RA2T1 Group: 64MHz Arm Cortex-M23 Motor Control Microcontroller

The RA2T1 group microcontroller is optimized for single motor control applications. Featuring PWM timer and advanced analog, including 3 sample-and-hold circuits integrated in the A/D converter, it is suitable for efficient low-end motor control applications such as power tools, fans, and home appliances. Supporting a wide operating range of 1.6V to 5.5V and offered in a compact 24-pin QFN package, the RA2T1 meets the needs of cost-sensitive and space-constrained designs.

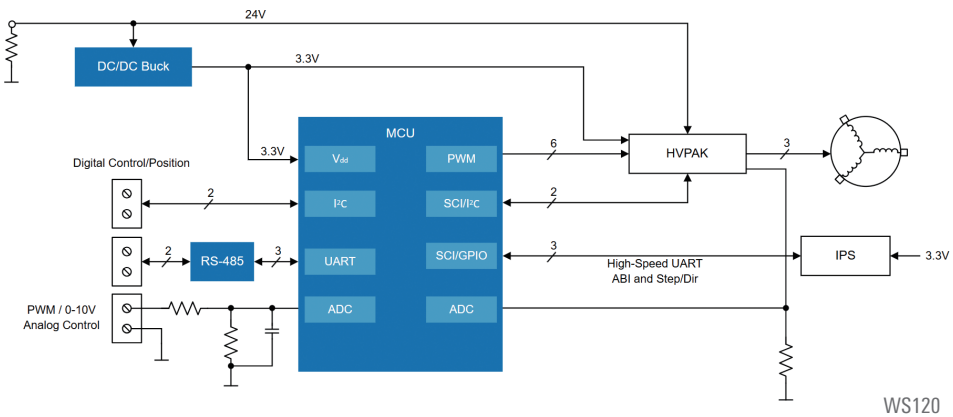
- 64MHz Arm Cortex-M23 core
- Integrated flash memory of 64KB and 8KB SRAM
- Package lineup from 24-to 48-pin including small 4x4mm QFN package option
- Integrated analog functions including 12-bit ADC with 3ch sample-and-hold circuit, high-speed analog comparator, programmable gain amplifier (PGA)
- Communication interface: SCI, SPI, I²C
- Wide voltage range of 1.6V to 5.5V
- Wide operating temperature range of -40°C to 125°C

Block Diagram



Use case: Mini BLDC Servo

The growing presence of robotic systems has increased the demand for small, precise, and cost-efficient BLDC servo applications. This trend drives higher integration, combining motor control with position sensing to enable advanced control algorithms. The system offers a low-power servo implementation capable of driving up to 75W BLDC motors with precise position control.



System Benefits:

- Flash-based MCU for reliable and efficient operation.
- Support for multiple control algorithms.
- High-accuracy speed control for precision applications.
- Low parts count for cost-effective designs.

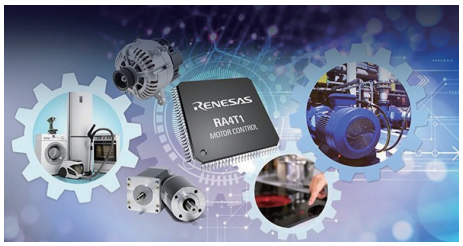
WS120

RA4T1 Group: 100MHz Arm Cortex-M33 Motor Control Microcontroller

Based on the 100MHz Arm Cortex-M33 core with TrustZone, the RA4T1 group offers an optimized peripheral for motor control and inverter control functions with small 32-pin QFN and LQFP package options. These satisfy the needs of high-performance, cost-sensitive, and space-constrained applications.

The RA4T1 integrates a wide range of communication interfaces, including CAN FD, I3C, SCI, and SPI, covering all the connectivity needs of a wide range of motor control and consumer applications.

- 100MHz Arm Cortex-M33 core with TrustZone
- 128KB to 256KB Flash memory and 40KB SRAM, 4KB Data Flash to store data as in EEPROM
- Scalable from 32-pin to 64-pin packages
- 16-bit PWM timer
- 12-bit A/D converter, Programmable gain amplifier, High-speed comparator, 12-bit D/A converter
- Trigonometric Function Unit
- CAN FD, I3C, SCI, SPI



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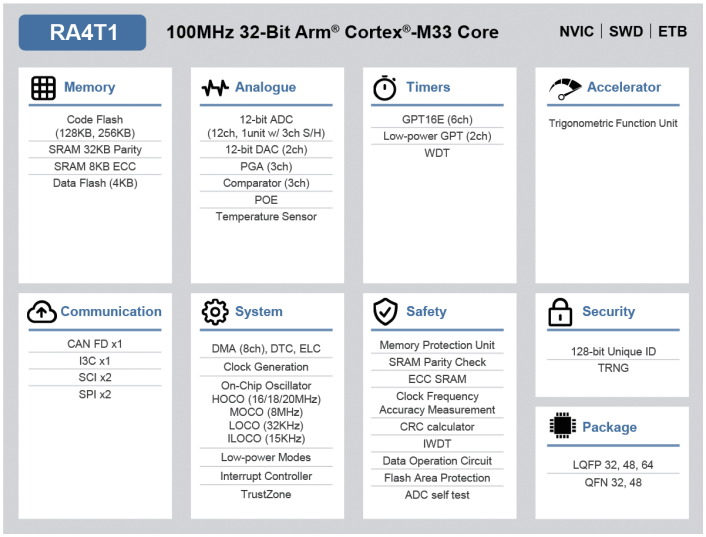
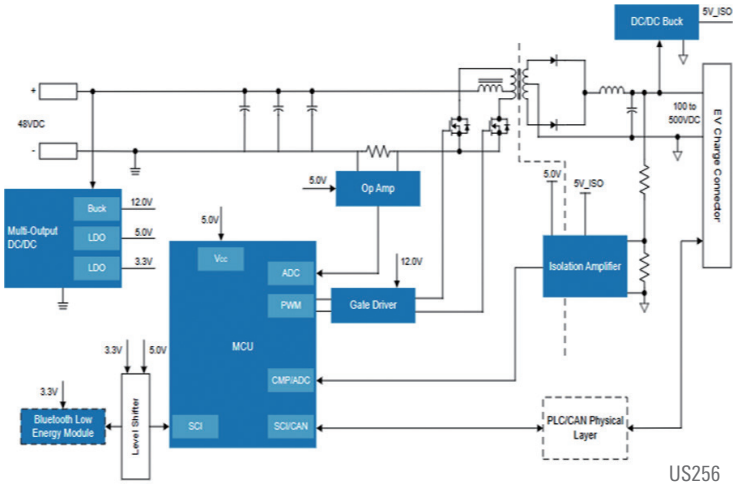


Use case: Portable EV Charger

This system is a versatile, battery-powered electric vehicle (EV) DC charger design for mobile charging. It serves as a "Virtual Gas Can," ideal for service companies and roadside assistance, enabling vehicle charging in locations without access to permanent charging stations. The charger can be powered by a 48V battery stack, and the optional Bluetooth feature eliminates the need for a control panel, reducing costs while providing charger status updates.



US256

System Benefits:

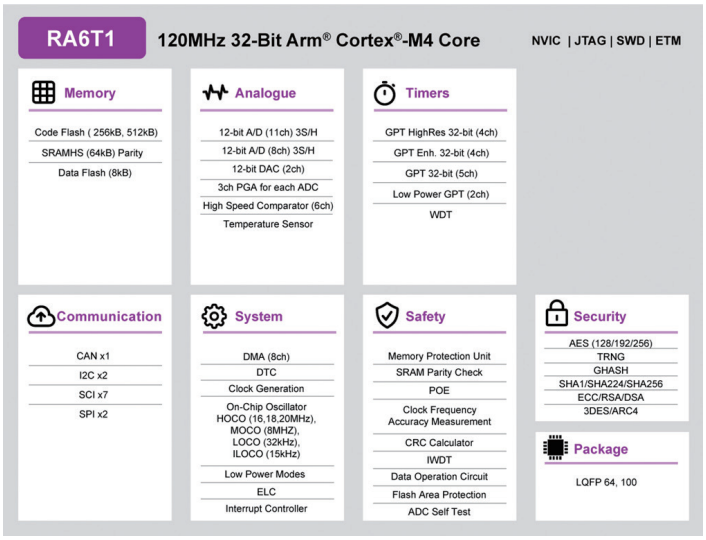
- Level 2 support for faster remote charging time per mile.
- Bluetooth interface for smartphone/tablet connectivity to monitor status.
- Compact and portable design for easy transportation.

RA6T1 Group: 120MHz Arm Cortex-M4 Motor Control Microcontroller

The Renesas RA6T1 Group, as part of the wide scalable RA6 Series, is optimized for enhanced motor control. The RA6T1 is built on a highly efficient 40nm process and equipped with various peripherals and memory suitable for motor control applications. To make engineers' application design easy, RA6T1 is supported by the Flexible Software Package (FSP) including a motor control specific control code algorithm, which makes the RA6T1 a perfect choice for quick time to market.

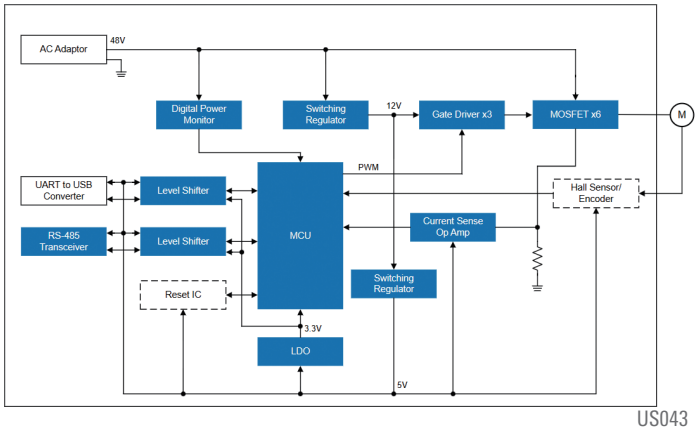
- 120MHz Arm Cortex-M4
- 256KB – 512KB Flash memory and 64KB SRAM
- 8KB Data Flash to store data as in EEPROM
- Scalable from 64-pin to 100-pin packages
- General PWM Timer - Enhanced High Resolution
- 12-bit A/D Converter
- High-Speed Analog Comparator
- Programmable Gain Amplifier
- CAN 2.0B

Block Diagram



Use case: 48V BLDC Motor Position Control

BLDC motor applications have been increasing rapidly due to the demand for smaller, high-efficiency products. The core of a BLDC motor design is a robust and reliable motor control circuit paired with a versatile MCU for a safe control algorithm. Key components of a motor control circuit include a MOSFET driver, versatile MCU, voltage regulators, cell balancer, and battery charger. This 48V position control system integrates these components to deliver precise and efficient motor control for various industrial applications.



US043

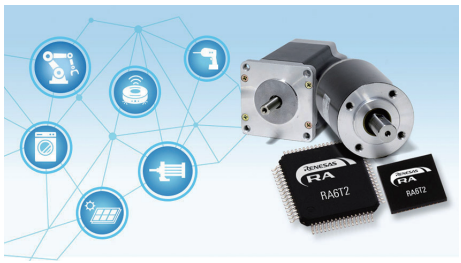
System Benefits:

- Utilizes an ultra-low power MCU for energy efficiency.
- Offers a fast wake-up time of 4µs for responsive control.
- Features an integrated 12-bit ADC with an op amp and comparator.
- Provides accurate cell balancing and monitoring with customer-programmable EEPROM for customization.

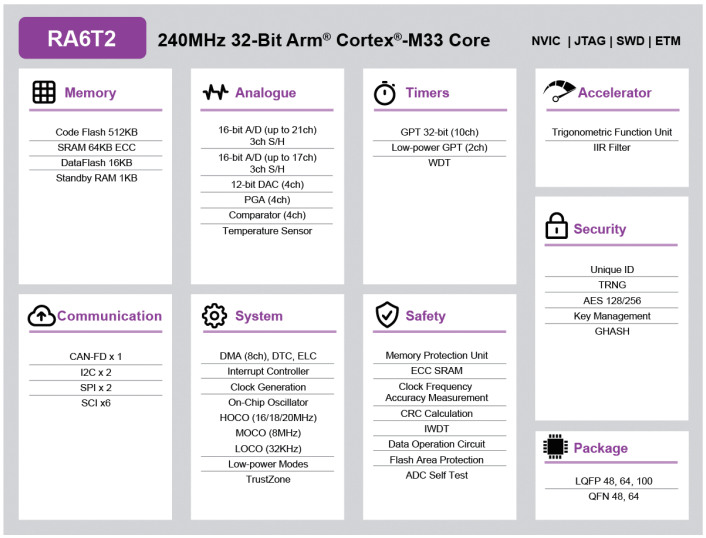
RA6T2 Group: 240MHz Arm Cortex-M33 Motor Control Microcontroller

The Renesas RA6T2 Group is the second RA ASSP product targeting motor and inverter control solutions. The RA6T2 combines an Arm Cortex-M33 with a hardware accelerator for motor control and high-speed flash memory for high-speed real-time performance at 240MHz. It can also realize next-generation high-speed, high-response motor algorithms and improve parallel processing performance such as other communication processing. In total, we have 20 different part names using 5 different package types. The Flexible Software Package (FSP) and the Arm Partner Ecosystem ensure an easy-to-use solution for highly efficient and accurate motor and inverter control.

- 240MHz Arm Cortex-M33 with TrustZone
- 256KB -512KB Flash memory and 64KB SRAM with ECC
- 16KB Data Flash to store data as in EEPROM
- Scalable from 48-pin to 100-pin packages
- HW accelerators for motor control calculation
- 16-bit ADC
- 12-bit DAC
- Programmable Gain Amp
- High-speed comparator
- PWM timer
- CAN FD (option)
- SCI (UART, Simple SPI, Simple I²C)
- SPI/I²C multi-master interface

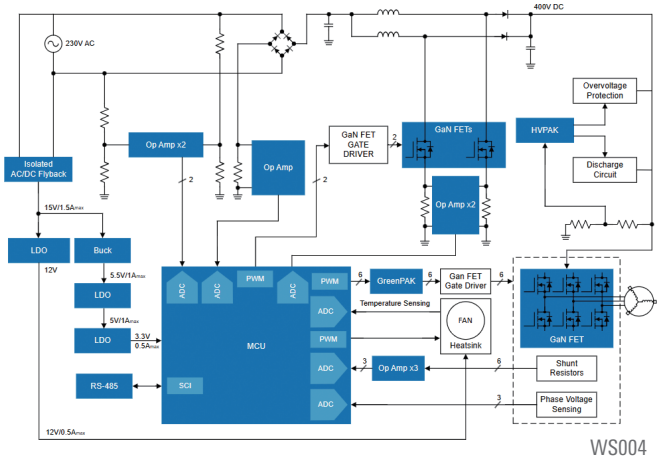


Block Diagram



Use case: 1.2kW High-Voltage GaN Inverter

Industrial applications often demand small and efficient high-voltage inverters for motor drives, leading engineers to develop innovative energy-saving solutions. This design features a high-voltage inverter combined with a power factor correction (PFC) circuit utilizing the latest GaN FET technology for high efficiency. A powerful MCU provides precision motor control, while GreenPAK and HVPAK devices ensure hardware-based circuit protection. The result is a low-cost, highly efficient industrial motor drive.



WS004

System Benefits:

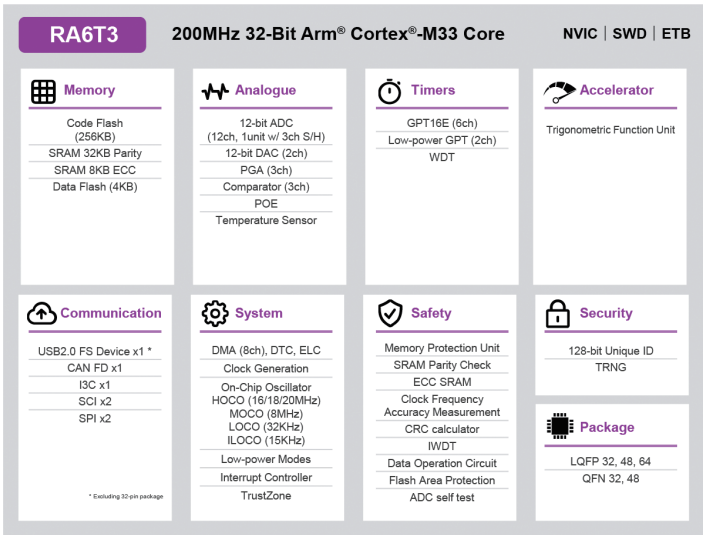
- 240MHz MCU provides high-resolution PWM to achieve precision motor control.
- GaN FETs enable highly efficient power factor correction (PFC) and 3-phase inverter.
- GreenPAK enables hardware PWM shoot-through protection.
- HVPAK ensures overvoltage protection and high-voltage discharge.

RA6T3 Group: 200MHz Arm Cortex-M33 Motor Control Microcontroller

The RA6T3 group is the microcontroller, designed for an optimum balance of peripheral functions and cost suitable for motor/inverter control, based on the 200MHz Arm Cortex-M33 core with TrustZone. This MCU is pin and function compatible with the RA4T1 group and can be seamlessly upgraded, making it an ideal solution for motor control and inverter control applications requiring higher performance.

- 200MHz Arm Cortex-M33 CPU core with TrustZone
- Integrated flash memory of 256KB and 40KB SRAM
- Package options from 32- to 64-pin including Small 5x5mm QFN package option
- Integrated advanced analog functions including 12-bit ADC, Programmable gain amplifier, Comparator, and 12-bit DAC
- Integrated communications options including USB 2.0 Full-Speed Device, CAN FD, I3C, SCI, and SPI

Block Diagram

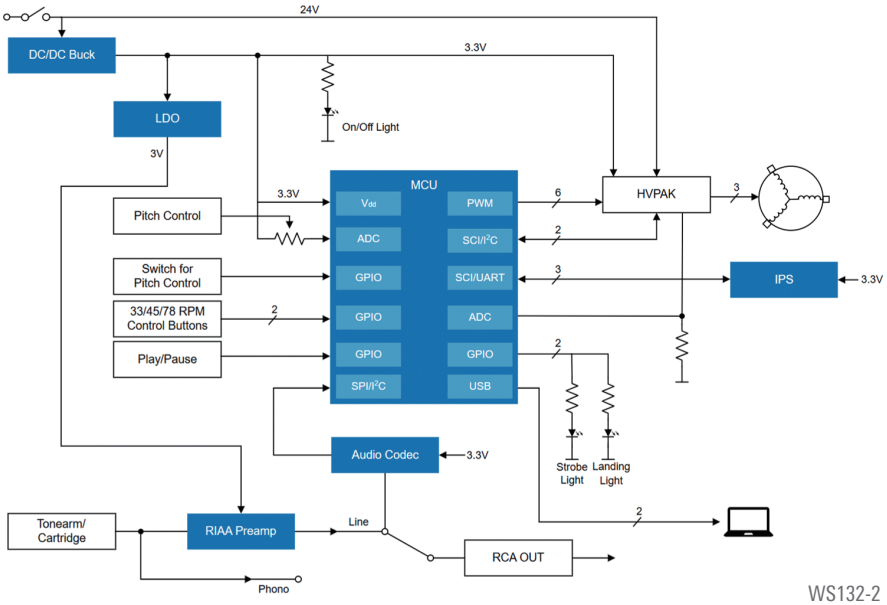


Use case: Turntable System with USB Output

Music lovers seek the authentic warmth of vinyl paired with the convenience of digital playback and archiving. This turntable system delivers smooth motor control, clean power, and precise audio processing for rich sound quality and effortless USB connectivity. An ultra-low power motor control MCU ensures accurate rotation speeds, while user-adjustable switches allow for personalized playback control. A synchronous buck regulator efficiently steps down 24V to 3.3V, with an LDO minimizing noise for pristine audio performance. The op amp-driven RIAA preamplifier reproduces analog sound, delivering warm audio to amplifiers or powered speakers via RCA connections. With USB output, users can digitize vinyl playback for custom playlists, effects, or recording.

System Benefits:

- User-configurable settings via switches for personalized playback experiences.
- Enhanced audio quality with op amps, minimizing noise and distortion.
- Clean and stable power delivery to sensitive audio components.

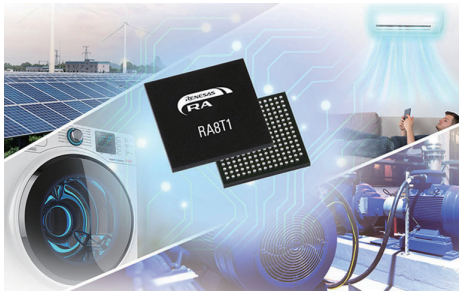


WS132-2

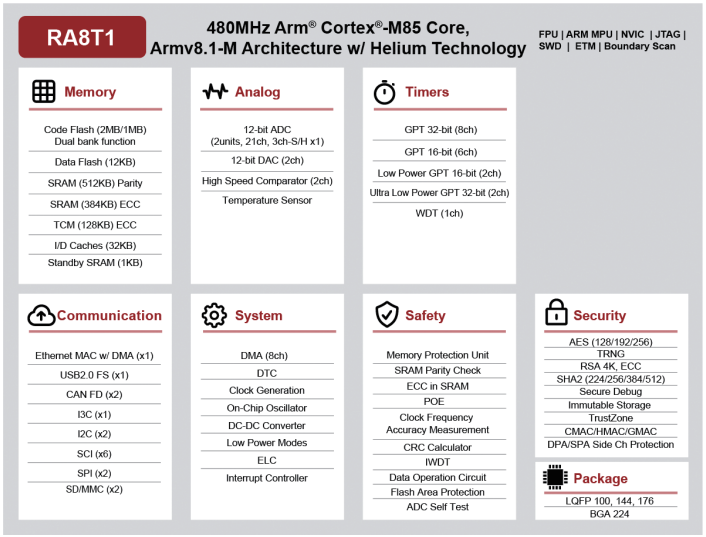
RA8T1 Group: 480MHz Arm Cortex-M85 Based MCU with Helium and TrustZone

The RA8T1 Group 32-bit microcontroller (MCU) is based on an up to 480MHz Arm Cortex-M85 core with Helium Technology and TrustZone and offers peripheral features optimized for motor or inverter controls. The RA8T1 Group integrates up to 2MB large Flash memory, 1MB SRAM including TCM, PWM timers, analog features, and multiple connectivity features, and also supports advanced security features and safety functions. The RA8T1 Group enables advanced motor control or additional functions on user systems through its high performance and abundant integrated features. The RA8T1 Group supports the Flexible Software Package (FSP) and partner ecosystems, as well as motor control evaluation kits, software, and tools.

- 480MHz Arm Cortex-M85 with Helium Technology and TrustZone
- 1MB - 2MB Dual-bank Flash memory and 1MB SRAM including TCM
- Scalable from 100-pin to 224-pin packages
- 12-bit A/D Converter with 3-ch Sample and Hold, 12-bit D/A Converter and High-speed Analog Comparator
- Integrated communications options including Ethernet MAC with DMA Controller, USB 2.0 Full-Speed, CAN FD, I3C, SCI, and SPI, SD/MMC Host Interface
- Renesas Secure IP (RSIP-E51A)



Block Diagram

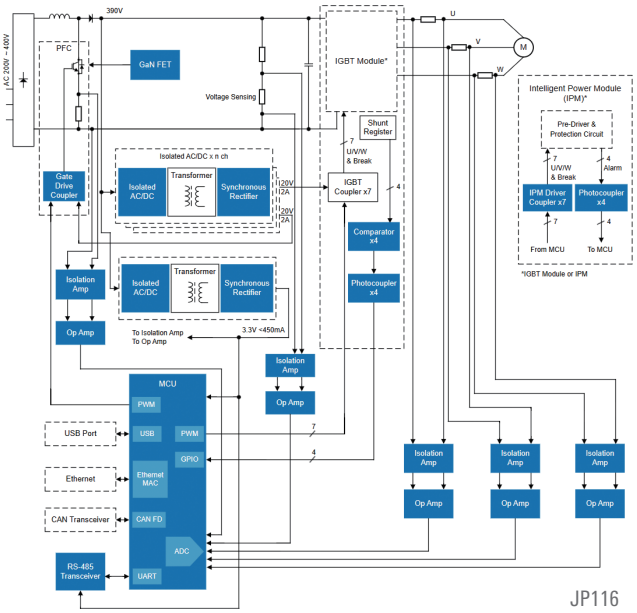


Use case: AC Drive & General Purpose Inverter System

This system provides a basic configuration and essential components for AC drives and general purpose (GP) inverters, serving as a variable-speed controller to precisely regulate shaft rotation speed in induction and synchronous motors. It is widely used in industrial machinery such as conveyors, cranes, elevators, fans, pumps, and compressors. Due to its versatile application scenarios, the system supports multiple optional functions to meet diverse industrial requirements, ensuring adaptability and efficiency in various settings.

System Benefits:

- Customers can easily fulfill major IC specification requirements of AC drives and GP inverter systems.
- Provides a high-accuracy motor control system with high-performance MCU and integrated analog devices.
- High-performance MCU supports motor control and communication in one MCU.



JP116

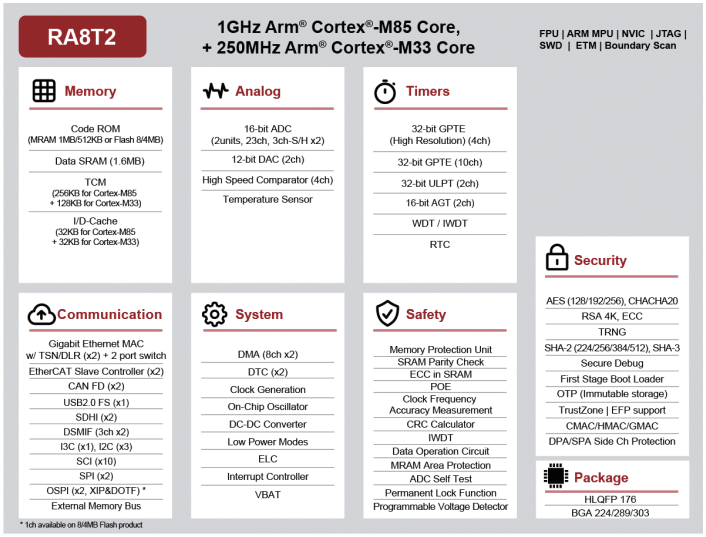
RA8T2 Group: 1GHz Arm Cortex-M85 Microcontroller Optimized for Motor Control

The RA8T2 is an ASSP microcontroller (MCU) featuring a 1GHz Arm Cortex-M85 processor, engineered for industrial motor control applications that require high real-time performance and high-precision control. Built on the advanced 22nm ULL process, the RA8T2 is available in both single and dual-core options. The dual-core variant is embedded with a Cortex-M33 core to efficiently separate real-time processing from the other processing tasks to further enhance the system performance.

The RA8T2 ASSP MCU combines high-speed operation, large-capacity memory, a PWM timer for motor control, and analog functions – all on a single chip. A dual-channel Gigabit Ethernet controller with switch function and an optional EtherCAT slave controller enables synchronous networks in industrial fields. The RA8T2 is available in three package types: BGA-224, 289, and HLQFP-176.

- 1GHz Arm Cortex-M85 and 250MHz Cortex-M33 cores
- 0.5/1MB MRAM
- 2MB SRAM including TCM and 64KB caches
- 32-bit PWM timer, high-resolution timer
- 16-bit A/D converter with 3 sample-and-hold circuits, 12-bit DAC
- High-speed comparator
- SCI (UART, Simple SPI, Simple I²C), SPI, Octal SPI, I²C, I3C, CAN FD
- Gigabit Ethernet, TSN switch, EtherCAT slave controller
- Delta-sigma modulator interface
- Renesas Secure IP, TrustZone, tamper protection
- Safety functions

Block Diagram



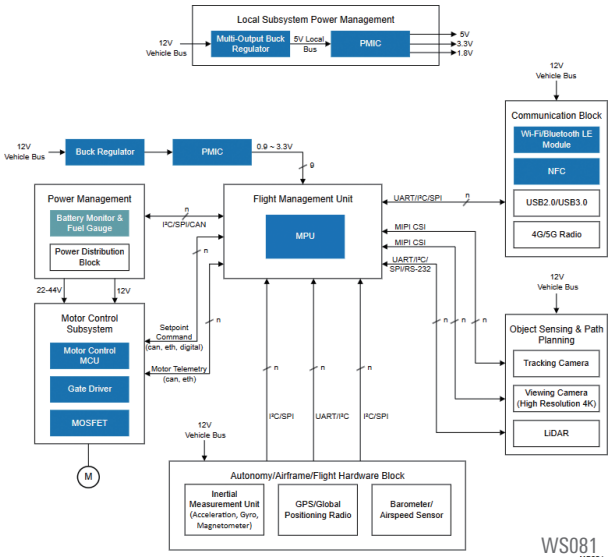
Use case: Unmanned Aerial Vehicle (UAV)

The growth of autonomous systems and mobile robotics is driving demand for efficient, intelligent, and reliable unmanned aerial vehicle (UAV) designs. This UAV system leverages Renesas' advanced processing, motor control, and battery management to deliver seamless operation, high-precision control, and extended operational time. With robust motor control, and scalable battery management, the design supports a wide range of applications, industrial inspection, agriculture, and logistics.

In this design, an advanced motor control electronic speed controller (ESC) can be built with an MCU, which simultaneously accepts a commanded setpoint and streams motor control data (e.g., phase currents, RPM, voltage) to the Flight Management Unit.

System Benefits:

- AI-powered vision processing accelerates real-time image recognition, obstacle avoidance, and autonomous decision-making, enhancing safety and performance.
- Supports multi-sensor integration and system monitoring.
- Ultra-high speed hardware AI inference (DRP-AI) with up to 80 TOPS meets the needs of vision AI applications.



RA-A Series

Features of the RA-A Series

The RA-A series is low power MCU with 24-bit Sigma-Delta A/D converter & rich analog feature set on Arm Cortex-M core architecture. The RA2Ax group supports a wide range of operating voltages from 1.6 V ~ 5.5 V, it is also possible to communicate with devices operating at 5V without a level shifter, which contributes to BOM reduction. The RA-A is suitable for industrial sensor applications and energy meters.

Rich analog function	AFE tool Support	Wide operating voltage range
24-bit Sigma-Delta A/D converter	QE for AFE	1.6V ~ 5.5V

24-bit Sigma-Delta A/D converter and Analog Front End

RA2A1

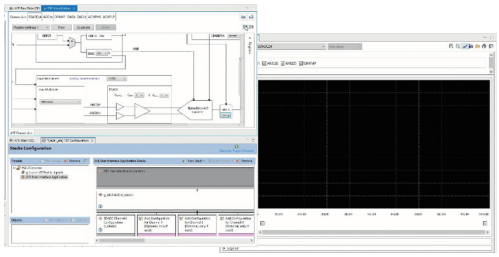
RA2A1 has up to 8ch of 24-bit Sigma-Delta A/D converter & rich analog feature set.
The input voltage range is 0.2 to 1.8 V, and oversampling is possible at up to 1MHz.
The 24-bit Sigma-Delta A/D converter has an instrumentation amplifier and a calibration function. The functions allow high-precision A/D conversion by calculating the offset error correction value and gain error correction value under the conditions of use.
In addition, RA2A1 has analog functions that 16-bit SAR A/D converter, 12-bit D/A converter, 8-bit D/A converter, operational amplifiers and two types of compilators.

RA2A2

RA2A2 has up to 7ch of 24-bit Sigma-Delta A/D converter.
The input range is -0.5 to 0.5 V and can be oversampled up to 3MHz. The 24-bit Sigma-Delta A/D converter is implemented with PGA that can amplify signals up to 32 times. It has phase adjustment function for the acquired voltage and a low-pass filter specifically for 50/60Hz, making it ideal for measuring AC power.

Easy for development start

RA2Ax offers a QE for AFE Tool and evaluation board to help with evaluation of analog functions. QE for AFE allows you to configure and acquire data for the analog peripheral functions installed in each product, including the 24-bit sigma-delta A/D converter.
This makes it possible to proceed with the initial device consideration easily and smoothly.



RA-A Series Lineup

RA2A1 48MHz, 256KB Flash, 16KB SRAM, 8KB Data Flash
32/36/40/48/64-pin

Cortex-M23	24-bit SDAD	16-bit SAR ADC	12-bit DAC 8-bit DAC	OPAMP	ACMPHS	ACMPLP	USB2.0 FS	CAN	Touch driver

RA2A2 48MHz, 512KB Flash, 48KB SRAM, 8KB Data Flash
64/80/100-pin

Cortex-M23	24-bit SDAD	12-bit SAR ADC	Digital Filter	LCD driver	Dual bank/ MMF	Independent WDT

Common features

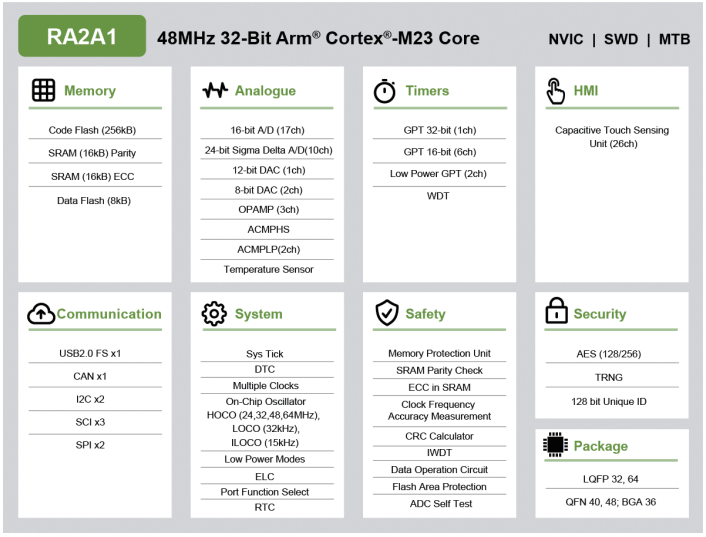
- SCI/SPI/I²C
- AES (128/256)
- TRNG

RA2A1 Group: Analog and peripheral function rich MCU

The RA2A1 group is a high-performance, low-power analog microcontroller based on an Arm Cortex-M23 core with a 48MHz clock frequency and a wide range of analog front ends, including two types of A/D converters. This group supports a 16-bit SAR A/D converter, a 24-bit sigma-delta A/D converter, a 12-bit D/A converter, comparators, and operational amplifiers. These functions are suitable for applications that measure and adjust sensor signals with high accuracy. In addition, UART, I²C, simple SPI, CAN, and USB 2.0 Full-Speed are also integrated as peripheral functions, enabling easy communication with other devices. The RA2A1 supports a wide operating voltage range of 1.6V to 5.5V, enabling communication with devices operating at 5V without level shifters. The RA2A1 MCU targets industrial sensor applications with low power consumption and low-cost advantage.

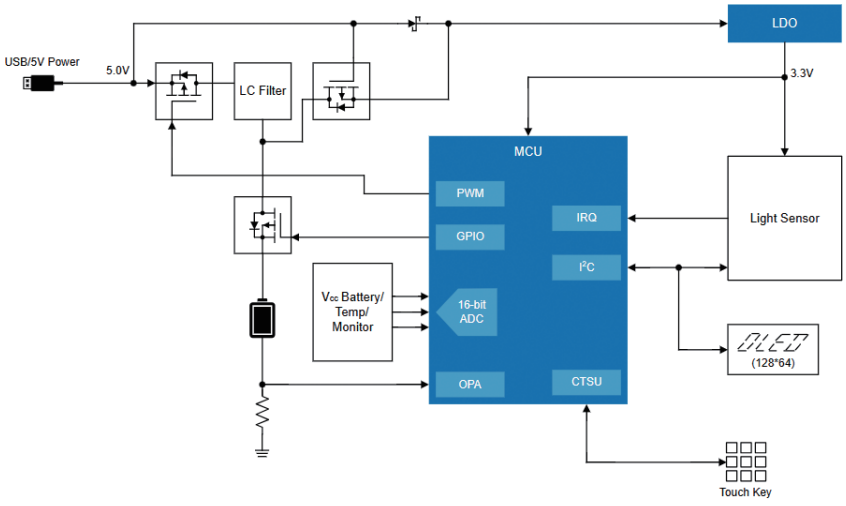
- 48MHz Arm Cortex-M23
- 256KB Flash memory and 32KB SRAM, 8KB Data Flash to store data as in EEPROM
- Scalable from 32-pin to 64-pin packages
- Capacitive touch sensing unit
- 16-bit SAR A/D, 24-bit SD A/D, 12-bit D/A, 8-bit D/A, OPAMP (3ch), ACMP-HS/LP
- USB 2.0 Full Speed, CAN 2.0, SCI (UART, Simple SPI, Simple I²C)

Block Diagram



Use case: Digital illuminance meter

RA2A2 has variety analog front-ends and communication functions, in addition it has LCD drivers and touch sensors. So it can be used as a digital illuminance meter.



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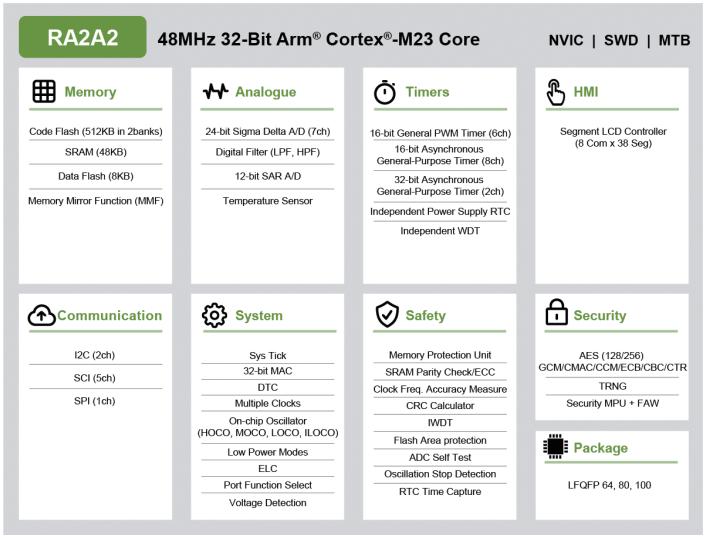
RA2A2 Group: NILM Compatible Smart Electric Meter On a Single Chip

The RA2A2 group is a low-power microcontroller that combines a 48MHz Arm Cortex-M23 core and a rich set of peripheral functions. The RA2A2 MCU provides an optimized feature set suitable for a wide range of applications by supporting segment LCD and high-precision analog sensing functionalities while reducing power consumption, system cost, and overall footprint. Furthermore, the RA2A2's dual bank flash and security features make firmware updates easy and increase system reliability.

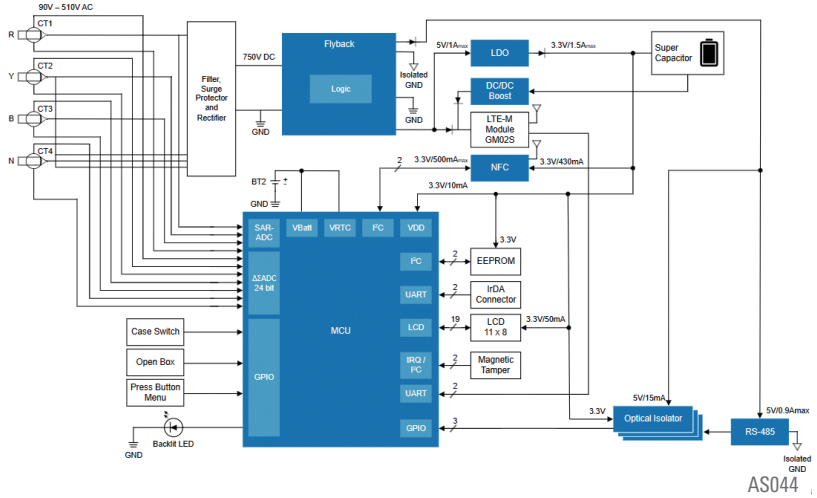
- 48MHz Arm Cortex-M23 core
- 512KB flash memory (dual bank) and 48KB SRAM, 8KB data flash memory (100,000 program/erase (P/E) cycles)
- 64-pin, 80-pin, and 100-pin LFQFP package options
- 24-bit Sigma-Delta A/D converter, 12-bit A/D converter and temperature sensor
- 16-bit general-purpose timers, 32-bit and 16-bit low-power AGT timers, and independent power supply RTC
- SCI (UART, Simple SPI, Simple I²C), SPI and I²C bus
- Segment LCD controller (8com x 38seg)
- Security functions including AES, Security MPU, Flash Access Window, TRNG

Block Diagram



Use case: Smart Energy Meter supporting NILM

RA2A2 MCUs contribute to the digitalization of conventional systems with key features including high-level analog sensing and AES hardware accelerator functions. When the end-systems are digitalized, it is possible to analyze individual systems status seamlessly for further energy-efficient, streamlining system operation. For example, next generation smart electricity meters with Non-Intrusive Load Management (NILM) technology enable energy consumption monitoring based on detailed analysis of the current and voltage of the total load. The adoption of smart meters with NILM is the most cost-effective and scalable solution for increasing energy efficiency and lowering energy consumption.

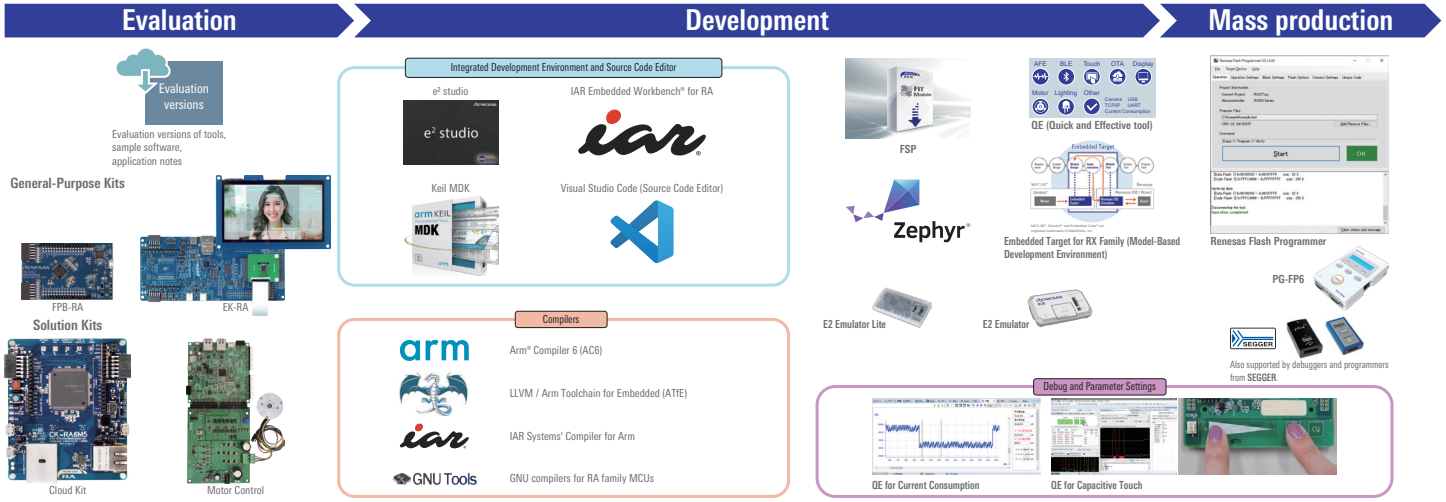


AS044

Development Environment

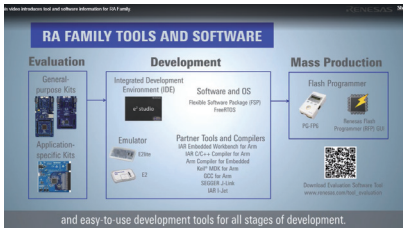
Development Tools Designed to Maximize the Attractions of the RA Family

Renesas supports customers through all stages of the development of their applications by supplying integrated development environments, RTOS, middleware, and programming tools that dramatically enhance the development process. These development tools, combined with evaluation kits and assistance tools specifically for the RA Family, enable you to accomplish coding, building, and debugging tasks quickly and easily, while helping to reduce system development time.

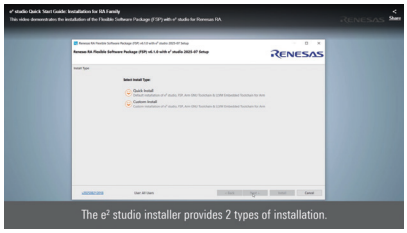


RA Family Software & Tool Course

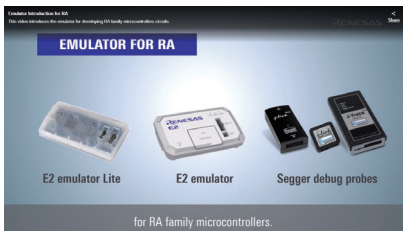
In these videos, you will learn about solutions, software and tools for the Renesas RA Family of MCUs. These videos introduce the Renesas development environment in an easy-to-understand manner to start your development.



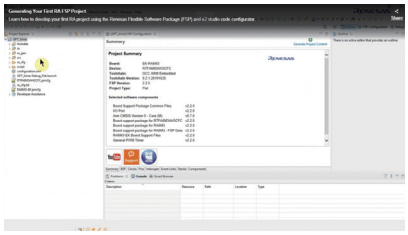
[Quick Start Guide - Tool & Software Introduction for RA | Renesas]



[e² studio Quick Start Guide: Installation for RA Family | Renesas]

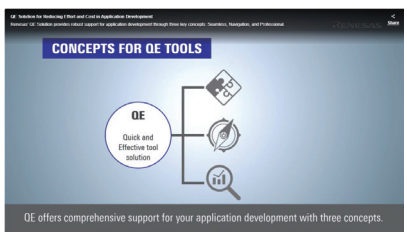


[Emulator Introduction for RA | Renesas]



[Generating Your First RA FSP Project | Renesas]

[Connecting Renesas Flash Programmer with RA Devices | Renesas]



[QE Solution for Reducing Effort and Cost in Application Development | Renesas]

General-Purpose Kits

The RA Family general-purpose kits enable users to effortlessly evaluate the features of different RA MCU Groups and quickly develop sophisticated IoT & embedded systems prototyping. A wide range of line-up from entry, basic kit to full-evaluation offer numerous options suitable for various needs. All are supported by the RA Family Flexible Software Package (FSP) and IDEs including Renesas's "e2studio", IAR's "Embedded Workbench", and Arm's "Keil MDK".

High Expandability

Access to all MCU signal pins and board ecosystem compatibility, making functional expansion and application development easy.

Flexible Application Development

Compatible with Renesas sensors and communication modules, enabling quick proof-of-concept assembly of a wide range of applications such as IoT and industrial equipment.

Reference Design Data

Circuit diagrams, BOM lists, and design data are available as reference for customization and application development.

Extensive Development Support

Comprehensive documents and samples, from basic settings to application examples, supporting evaluation and development smoothly.

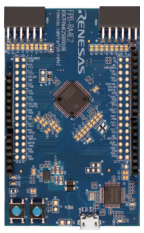
Product Lineup

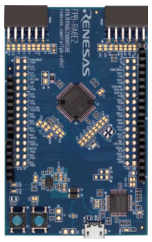
RA Kits Portfolio	RA8 Series	RA6 Series	RA4 Series	RA2 Series	RA0 Series
Fast Prototyping Board (FPB) ■ Limited functionality ■ All MCU pin access ■ On-board debugger (J-Link OB)/External debugger connector ■ 2 Pmods/Arduino Uno R3	FPB-RA8E1	FPB-RA6E1 FPB-RA6E2 FPB-RA6T3	FPB-RA4E1 FPB-RA4E2 FPB-RA4T1	FPB-RA2E1 FPB-RA2E2 FPB-RA2E3 FPB-RA2T1	FPB-RA0E1 FPB-RA0E2 FPB-RA0L1
Evaluation Kit (EK) ■ Differentiated functionality ■ Broad ecosystem compatibility ■ Multiple debugging modes ■ Feature scalability and expansion across RA MCU Series	EK-RA8D1 EK-RA8D2 EK-RA8E2 EK-RA8M1 EK-RA8M2 EK-RA8P1	EK-RA6E2 EK-RA6M1 EK-RA6M2 EK-RA6M3 EK-RA6M3G EK-RA6M4 EK-RA6M5	EK-RA4C1 EK-RA4E2 EK-RA4L1 EK-RA4M1 EK-RA4M2 EK-RA4M3 EK-RA4W1	EK-RA2A1 EK-RA2A2 EK-RA2E1 EK-RA2E2 EK-RA2L1 EK-RA2L2	

Board Image

• Fast Prototyping Board


FPB-RA0L1

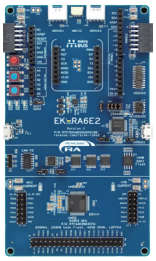

FPB-RA4E2

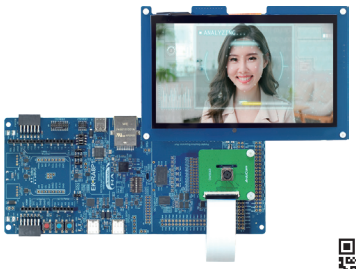

FPB-RA6E2


FPB-RA8E1

• Evaluation Kit


EK-RA2L2


EK-RA6E2


EK-RA8P1

Click here for detail lineup of RA evaluation kits

Integrated Development Environment

Renesas have prepared an integrated development environment that strongly supports the entire embedded system development. You can choose from an open source-based environment with various expansion functions, an original Renesas development environment, or a partner-made environment according to your usage scenario.

e² studio

This development environment based on Eclipse provides a large number of functions and is a popular choice amongst users developing for RA the world over. A variety of compilers and supported, and you can create projects using simple operations.

IAR Embedded Workbench for Arm

This is the C/C++ integrated development environment most broadly used internationally as a high-performance and highly reliable commercial tool for embedded software development. All functions are integrated seamlessly to maximize development efficiency. The static response analysis and dynamic response analysis add-ons provide a low-cost way for developers to dramatically increase the quality of their code.

IAR Embedded Workbench for Arm

Visual Studio Code from Microsoft, available on Microsoft Visual Marketplace, provides build and debug functions (extensions) for developing applications using Renesas MCUs.

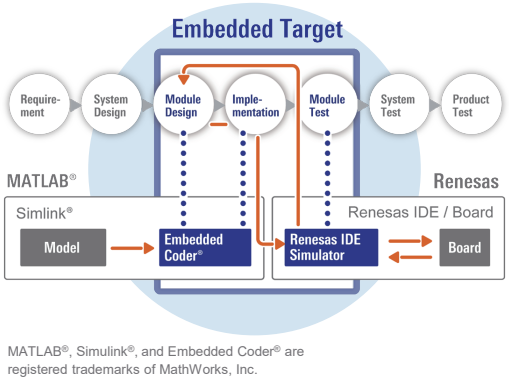
Arm Keil® MDK

A comprehensive software development solution for Arm-based microcontrollers, including RA Family MCUs, containing all the components that you need to create, build, and debug embedded applications.

RA Smart Configurator (RASC)

Works in conjunction with FSP. Desktop application designed to generate projects and configure device hardware such as clock set up and pin assignment as well as initialization of FSP software components for a Renesas RA microcontroller project when using a 3rd-party IDE and toolchain.

QE (Quick and Effective tool)



MATLAB®, Simulink®, and Embedded Coder® are registered trademarks of MathWorks, Inc.

Embedded Target for RA Family (Model-Based Development Environment)

Links e² studio with MATLAB or Simulink to assist customers with model-based development

Compilers

Renesas is preparing a range of compilers to maximize the performance of RA, from its own compilers to open source compilers from its partners.

Arm Compiler 6 (AC6)

Co-developed alongside the Arm architecture, Arm Compiler 6 is tuned to generate highly efficient code. It combines optimized tools and libraries from Arm, with a modern LLVM-based compiler framework.

LLVM / Arm Toolchain for Embedded (ATfE)

LLVM based bare-metal toolchain that can target the Arm architecture family from Armv6-M and newer. The toolchain follows the ABI for the Arm Architecture provides typical features needed for embedded and realtime operating systems.

Original compilers from IAR Systems generate code that leads the industry in speed and compactness.

GNU compilers are available for RA Family MCUs.

Debug Probes

E2 Emulator Lite

Entry-level model recommended for new users.

E2 Emulator

This model provides high functionality for enhanced development efficiency, with support for fast downloads and external trigger I/O.

SEGGER J-Link

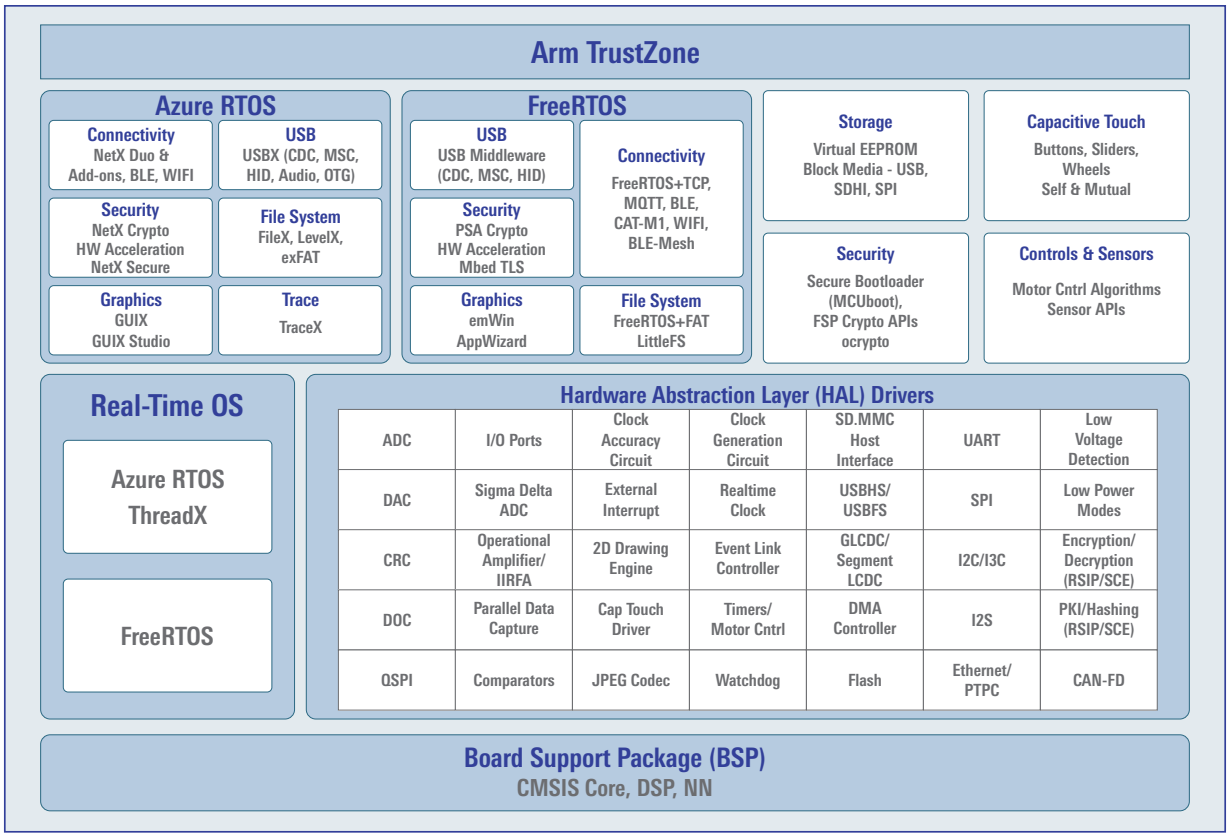
Providing outstanding performance and ease of use, J-Link debug probes can be with any of the promoted IDEs for RA development. J-Link OB (on-board) probes are also implemented on many RA evaluation boards, allowing easy debug out of the box.

IAR I-jet

IAR debug probes work natively with IAR Embedded Workbench, providing an intuitive interface and powerful debug, trace and analysis tools.

Flexible Software Package (FSP)

The Renesas Flexible Software Package (FSP) is an enhanced software package designed to provide easy-to-use, scalable, high-quality software for embedded system designs using Renesas RA Family Microcontrollers. With the support of Arm TrustZone and other advanced security features, FSP provides a quick and versatile way to build secure, connected IoT devices using production-ready drivers, Azure RTOS, FreeRTOS, and other middleware stacks. FSP uses an open software ecosystem and provides flexibility in using bare-metal programming, included Azure RTOS or FreeRTOS, your preferred RTOS, legacy code, and third-party ecosystem solutions. The combination of the flexible open architecture of the FSP plus the wide choice of 3rd party solutions as part of the Arm ecosystem increases the range of choice for application development. This means that developers can choose the software model that best suits their needs while utilizing Renesas's excellent Arm-based silicon solutions as well as speed up the implementation time of complex areas like connectivity and security.



Benefits

- Provides an easy-to-use, scalable, high-quality software for embedded system designs using the Renesas RA Family of Arm microcontrollers.
- Includes best-in-class HAL drivers with high performance and low memory footprint.
- Middleware stacks with Azure RTOS and FreeRTOS integration are included to ease the implementation of complex modules like communication and security.
- The e² studio IDE provides support with intuitive configurators and intelligent code generation to make programming and debugging easier and faster.
- Uses an open software ecosystem and provides flexibility in using bare-metal programming, included Azure RTOS and FreeRTOS, your preferred RTOS, legacy code, and third-party ecosystem solutions.
- Integrated package with all required components for easy setup and starting development (single installer with e² studio, CMSIS packs, tool chain and SEGGER J-Link drivers).
- Complete source code available through GitHub.

QE (Quick and Effective) Tools Tailored for Many Application Types

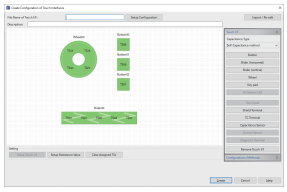
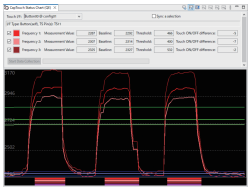
Renesas Solutions and Tools that Lighten the Application Development Workload

QE (Quick and Effective tool)

QE development support tools add development knowhow (functionality) to applications within the integrated development environment, helping to minimize the application development workload.

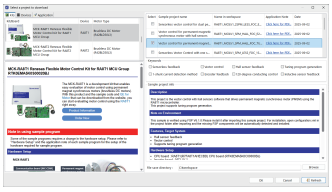
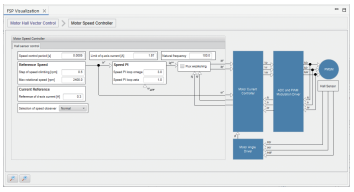
QE for Capacitive: Touch Development Support Tool for Capacitive Touch Sensor Applications

This tool simplifies making initial touch interface settings and tuning sensitivity, reducing the time required for development.

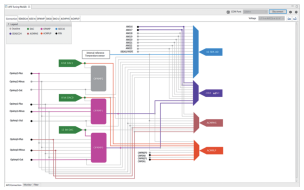
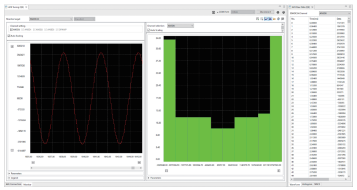
QE for Motor: Development Support Tool for Motor Applications

This tool works in conjunction with Renesas Motor Workbench and uses its Analyzer function to monitor the operation status of motor control programs, enabling verification of motor control systems.

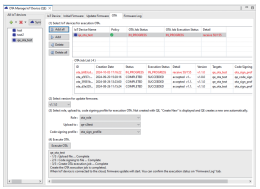
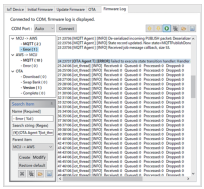
QE for AFE: Development Support Tool with Analog Frontend Support

This tool lets you perform high-precision sensing adjustment while viewing circuit diagrams of the AFE configuration and make adjustments to analog signals without the need for an oscilloscope.

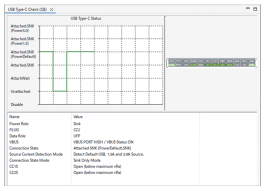
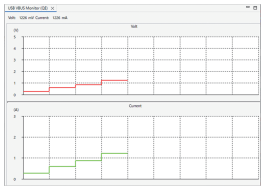
QE for OTA: Development Assistance Tool for Firmware Update

This tool lets you easily try out the over the air (OTA) functions of leading cloud services such as AWS. You can use it to evaluate everything from creating firmware updates, uploading them to the cloud, and executing OTA updates.

QE for USB: Development Assistance tool for USB developments

This tool is an embedded software development solution designed to facilitate the development of USB systems. By utilizing the “USB Type-C Check (QE)” and “USB VBUS Monitor (QE)” features, users can significantly streamline the debugging process for USB systems.

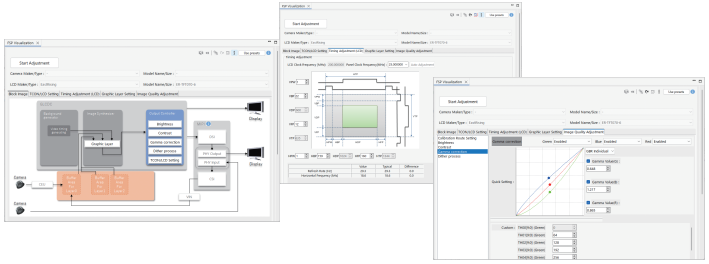



QE for BLE: Bluetooth LE Development Support Tool

This tool provides support for system development using the Bluetooth Low Energy(Bluetooth LE) protocol stack, allowing you to try out its communication functions immediately and shortening the development time until deployment.

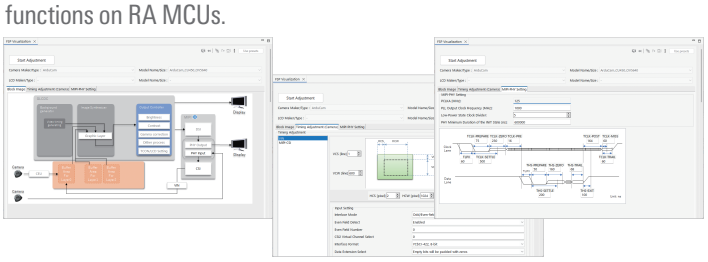
QE for Display: Development Support Tool for Display Applications

This tool simplifies initial screen calibration of the display when using the MCU’s on-chip LCD controller, reducing the time required for development.



QE for Camera: Development Assistance tool for Camera applications

This tool is a dedicated software solution designed to streamline the evaluation and debugging of camera modules and image-capture functions on RA MCUs.



Embedded Target for RA family (Model-Based Development Environment)

Implementation from model to Renesas MCU is automated to streamline software development

Embedded Target verifies algorithms to aid customers' model-based development by linking a Renesas integrated development environment e² studio with MATLAB or Simulink from MathWorks.
Software development can be streamlined by automatically porting code for an embedded MCU and ensuring the state in which buildand debug is performed in order to perform Processor-In-the-Loop simulation. The advanced analysis function of the Renesas integrated development environment is also useful for improving a model.

Seamless development, from building an environment to verifying a model's performance

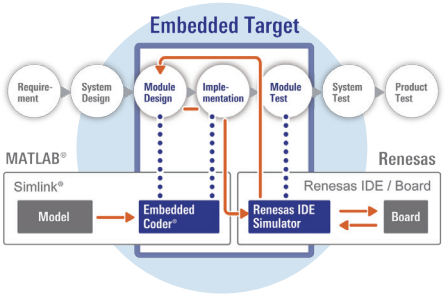
Automatically building a PILS* environment

*Processor In the Loop Simulation

Generate models for PILS from Simulink models with one click.
A channel for communication between MATLAB and the Renesas integrated development environment is built automatically.

Automatically generating a projectfor the Renesas integrated development environment

Embedded Coder incorporates code generated from a verification model and automatically generates buildable/debuggableprojects for e² studio.



MATLAB®, Simulink®, and Embedded Coder® are registered trademarks of MathWorks, Inc.

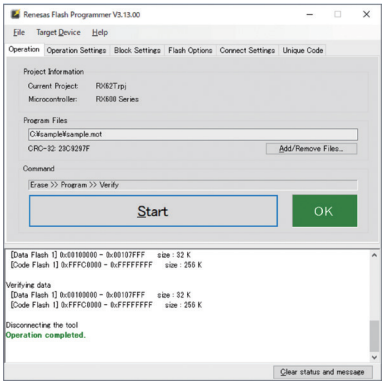
Verifying a model's performance using a Renesas MCU or simulator

The actual equipment debugger or simulator function of e² studio can be used for PIL simulation, and the analysis functions of e² studio can be used for model performance verification.

Programming Tools

You can choose the model that best suits your needs, from development, prototyping, and small-scale programming to mass production.

Programming tools, including products from Renesas partner vendors



Renesas Flash Programmer
flash memory programming software

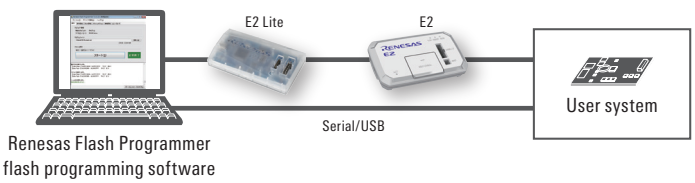
PG-FP6
standalone flash programmer

SEGGER

Also supported by debuggers and programmers from **SEGGER**.

Programming controlled by a PC [Renesas Flash Programmer flash programming software]

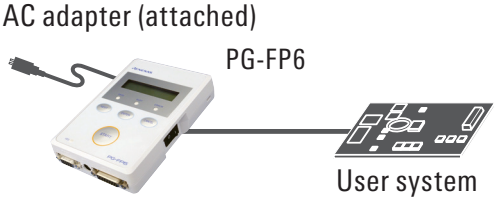
- Simple GUI specialized for programming
- Batch processing efficiently for programming large quantities at mass production
- PC-controlled programming using E2 emulator, E2 emulator Lite or serial/USB
- Ability to embed unique code



Renesas Flash Programmer
flash programming software

Programming controlled by a PC or stand-alone programming [PG-FP6 flash programmer]

- Stand-alone programming
- Programming controlled by a PC using a dedicated GUI
- Ability to store settings for up to eight environments
- Ideal for use on the production line (command control, remote control)
- Ability to embed unique code



Winning Combinations

Speeding Up Application Design for Customers

More Than 400 Winning Combinations for a Variety of Applications

Renesas offers comprehensive full-system solutions, featuring Winning Combinations of devices across our embedded processing, power, analog, and connectivity portfolios, to meet your application needs. With these engineering-vetted designs, you can take advantage of an elevated platform for your design ideas, accelerate your product development cycle, and lower overall risk to bring your designs to market.
Renesas continues to make available new Winning Combinations, including many featuring RA Family MCUs, one after another.

Key Technologies

Artificial Intelligence (AI)
Functional Safety
Gallium Nitride (GaN) Power
Human Machine Interface (HMI)
Motor Control
Security
Tracking & Locationing
USB

Industrial

Appliances
Building Automation
Industrial Automation
Medical & Healthcare
Metering
Motor Drives & Robotics
Renewable Energy & Grid
Retail, Automation & Payment

Consumer Electronics

Cameras
Computing
Home Entertainment
Power Adapters & Chargers
Wearables

Communications Infrastructure

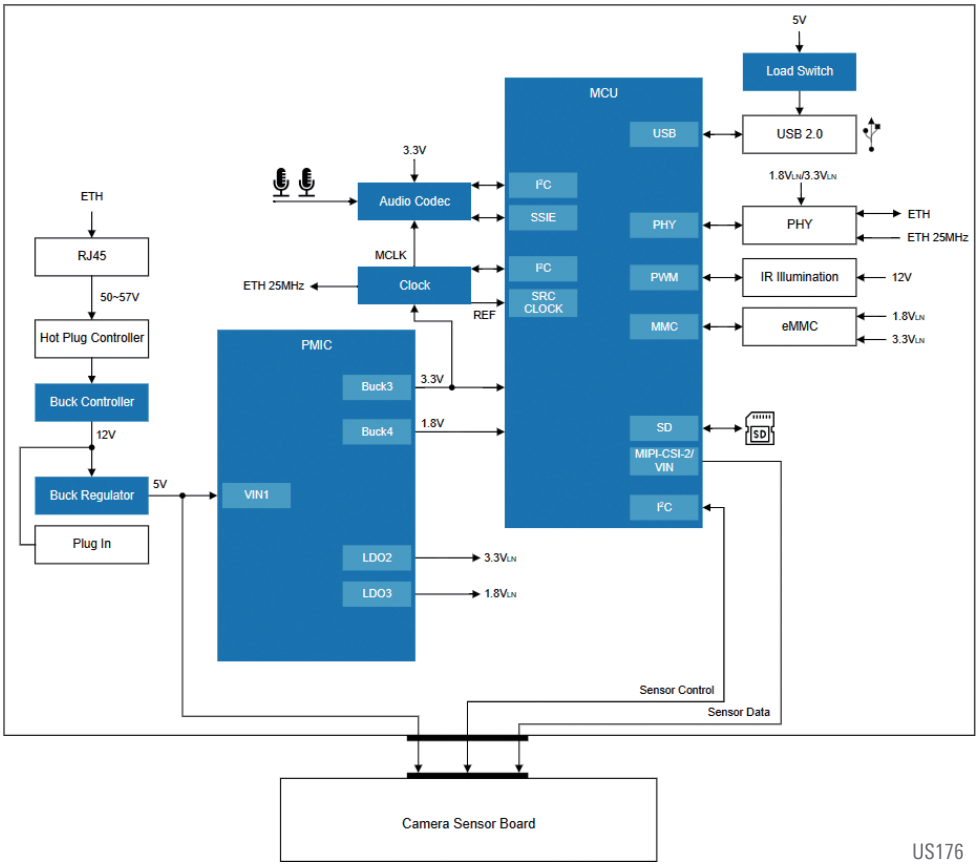
Cloud & Enterprise
Memory
Networking & Fixed Access
Wireless Infrastructure

Example Winning Combination: AI-Enabled Surveillance Camera

Easy-to-understand explanation of benefits

Easy-to-read block diagram

Easy access to related Renesas product pages



US176

Renesas Enabling Intelligence from the Cloud to the Edge and Endpoint Sustainably

Our comprehensive AI/ML developer stack transforms Vision, Voice, and Real-time Analytics applications. The extensive portfolios in sensing, connectivity, computing, and actuation, we cover all IoT layers. Our rich software, tools, solution offerings, and partner ecosystem provide the essential elements to accelerate your AIoT designs.

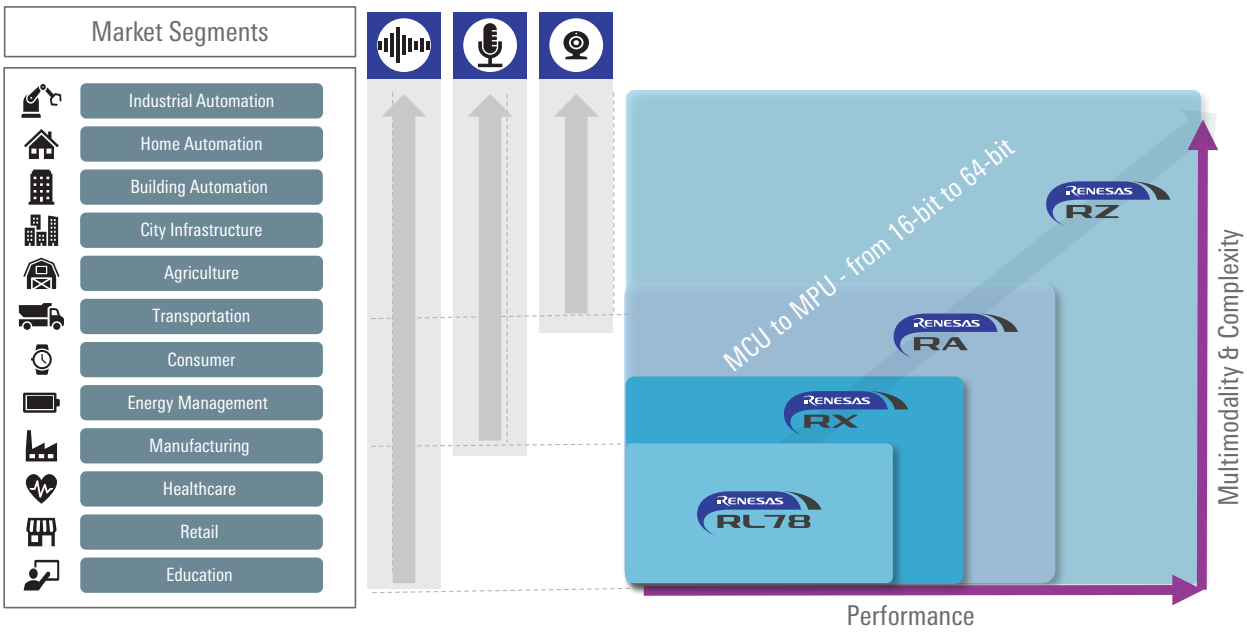
Why Choose Renesas?

Comprehensive AI/ML developer stack for vision, voice, and real-time analytics use cases. Tools and workflows for multiple developer journeys (bring-your-own-model, transfer learning, bespoke consulting and more). Rich library of easy-to-find solutions (application examples, toolboxes, solution suites, hardware reference kits). Broad ecosystem of trusted partners offering commercial-grade building blocks.

SIDE NOTE: Why Decentralize Intelligence?

Traditionally, the IoT has been built on a cloud-centric intelligence architecture. To truly scale and enable intelligence at all levels of the network, a decentralized intelligence architecture is needed. This means running cloud-independent inference engines on power-efficient or tiny computers within the edge and endpoints.

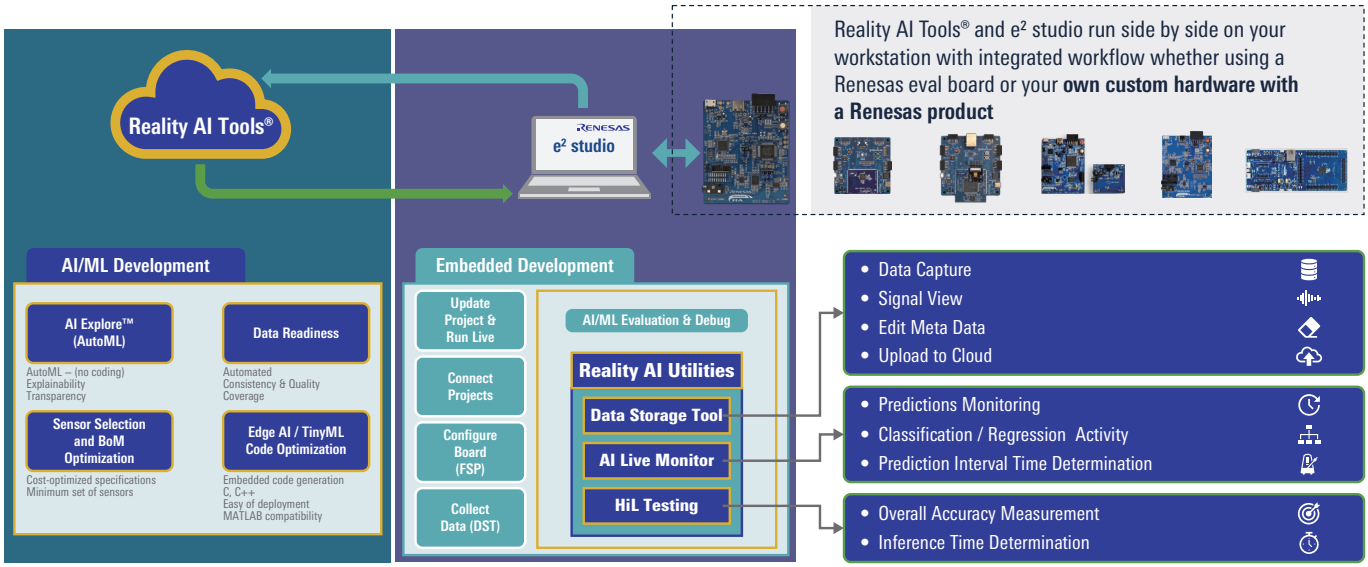
Renesas Ready Partner Network **Partner Ecosystem**	**RA Ready** RA Arm Cortex-M MCUs	**RX Ready** RX 32-bit Performance / Efficiency MCUs	**RL78 Ready** RL78 Low Power 8 & 16-bit MCUs	**RZ Ready** RZ 32 & 64-bit MPUs
Application Support	**Solution Suite**	**Toolbox**	**Application Example**	**Reference Design**
AI/ML Software	**Real-time Analytics** Reality AI Tools Reality AI Toolboxes RUHMI Framework	**Vision** e-AI Translator DRP-AI Translator DRP-AI TVM AI Navigator RUHMI Framework	**Voice** Cyberon DSpotter Cyberon DSpotterNLU RUHMI Framework	
Embedded Software	**Packages** Flexible Software Package (MCU) Firmware Integration Technology (MCU) CIP Linux (MPU) AI SDK (RZ/V2L) AI SDK (RZ/V2H) AI SDK (RZ/V2N)	**Tools** e² studio		
Hardware Portfolio	**AI at the Core** Timing Power Memory Inteface	**AI at the Edge** MPU Timing Power Memory Inteface	**AI at the Endpoint** MPU/MCU Power Connectivity AMS & CMIC	



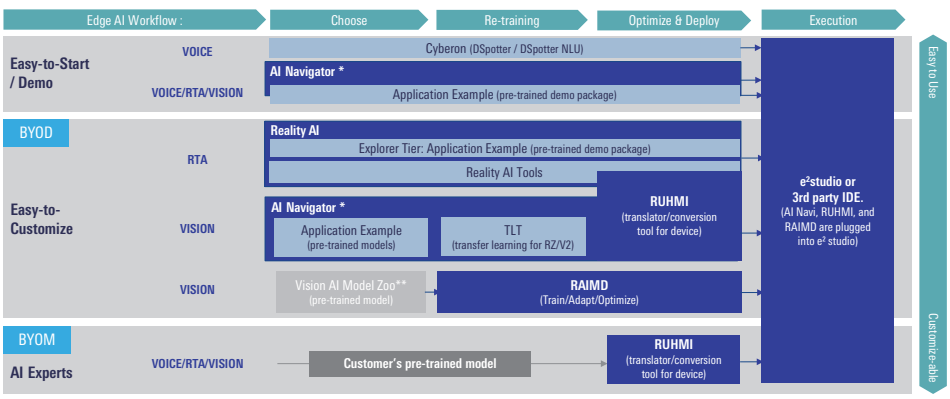
Application Zoo

Real-life application examples supported across the wide range of Renesas MCU/MPU and reference/demonstration kits. Pretrained models for vision, voice and realtime analytics.

Reality AI Tools



Renesas AI Tools Map



*AI Navigator: plugin tool inside e²studio. Wrapper GUI to available AI Tools
**Vision AI Model Zoo: Object Detection w/DetectNet, Image Classification w/MobileNet
Supported Product Families: [Cyberon] RX600, RX700, RA2/4/6/8 · [Reality AI] RL78, RX, RA, RZ · [RUHMI] RA8P1 · [RAIMD] RA8D1, RZ/V2H, RZ/V2L

Reference Kits and Development Boards

AI/ML	Motor Control	Cloud
AIK-RA8D1	MCK-RA8T1	CK-RA6M5
AIK-RA6M3	MCK-RA6T2	CK-RX65N
AIK-RA4E1	MCK-RX26T	HMI
AI/ML-Voice	RSSK-RX72T	CAP-TOUCH RX671
VK-RA8M1	RSSK-RX66T	
Voice-RA6E1	RSSK-RX23T	
Voice-RA4E1	RSSK-RX13T	
Voice-RA2L1		

Security Solutions

In the rapidly growing area of IoT and highly-connected devices, increasing consumer awareness and government legislation is forcing embedded device manufacturers to take the topic of security seriously. Already under the constraints of needing to create cost- and energy-efficient solutions, developers nowadays are required to design and implement security with limited additional time and budget.

Let Renesas simplify your path to product security and regulatory compliance.

Integrated Hardware-based Security Features

The RA Family was designed with security in mind, with scalable hardware-based security features including:

Functions	RA8D2 RA8M2 RA8P1 RA8T2	RA8D1 RA8M1 RA8T1	RA6M4 RA6M5 RA4M2 RA4M3	RA6M1 RA6M2 RA6M3 RA6T1	RA6T2	RA4C1	RA4L1	RA4M1 RA4W1	RA2 Series	RA0 Series
Identity										
Chip Unique ID	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Isolation										
Arm TrustZone	✓	✓	✓	–	✓	✓	✓	–	–	–
MPU	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
Security Engine	RSIP-E50D	RSIP-E51A	SCE9	SCE7	SCE5_B	RSIP-E31A	RSIP-E11A	SCE5	–	–
Cryptography and Key Handling										
AES	✓	✓	✓	✓	✓	✓	✓	✓	✓	–
SHA	✓	✓	✓	✓	–	✓	✓	–	–	–
RSA and ECC	✓	✓	✓	✓	–	ECC	ECC	–	–	–
PQC Ready	✓	–	–	–	–	–	–	–	–	–
TRNG	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Secure Key Handling	✓	✓	✓	✓	✓	✓	✓	✓	–	–
Code Protection and Lifecycle Management										
Flash Protection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Decrypt On-The-Fly	✓	✓	–	–	–	–	–	–	–	–
Device Lifecycle Mgmt	✓	✓	✓	–	✓	✓	✓	–	–	–
Debug/Program Protect	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Secure Boot (FSBL)	✓	✓	–	–	–	–	–	–	–	–
Physical Protection										
Passive Tamper Pins	✓	✓	✓	✓	–	✓	✓	✓	–	–
SPA/DPA Resistance	✓	✓	✓	–	–	✓	✓	–	–	–

Software and Tools

The RA Family Flexible Software Package (FSP) contains APIs for using the powerful cryptographic features of the Renesas Security Engines (RSIP and SCE):

- PSA Certified Crypto APIs, for Arm Ecosystem alignment
- FSP Crypto APIs, for compatibility with other Renesas MCU/MPU Families

The easy-to-use Security Key Management Tool, combined with the Renesas Key Wrap Service, provides support for secure key injection and update for prototype development and over the lifetime of the product.

Clear, full-featured Application Notes and Application Projects provide customizable demonstrations of the RA Family Security Features and Solutions. (www.renesas.com/iot-security)

Valuable Certifications

The RA Family targets compliance with meaningful certification schemes:

- PSA Certified Level 1 for holistic system security
- PSA Certified Level 3 and SESIP3 for Root of Trust protection
- NIST Cryptographic Algorithm Verification Program (CAVP) for assurance of cryptographic correctness
- NIST FIPS 140-3 Levels 2 and 3

IoT Cloud Over-the-Air (OTA) Solutions

Issues and Requirements Related to IoT Devices

- ✓ Utilize **AI/ML on AWS cloud services**
- ✓ Develop **S/W with minimum costs**
- ✓ Expand **Network (Wired, Wireless)**
- ✓ Realize **Remote monitoring and remote control**
- ✓ Realize **OTA (Over the Air), FW update**
- ✓ Strengthen **Security feature**

Enhancing product's value proposition
Creating a comprehensive solution suite

Data collection
Remote operation
Remote monitoring

Monitoring health status and health management

Cost Optimization
Reducing work load and time to market

Connected Cities

Process optimization
Inventory tracking

Strengthening security
Security alerts and over-the-air updates

Anomaly and fault detection
Predictive Maintenance

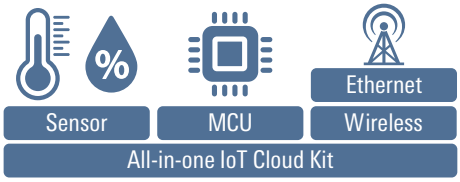
Software and security updates

IoT Cloud Over-the-Air (OTA) Solutions to Support IoT Development

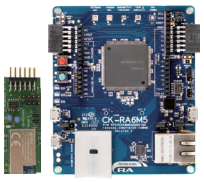
Development Platforms for Cloud (IoT) Devices

Expedite solution development with quick evaluation and proof of concept development.

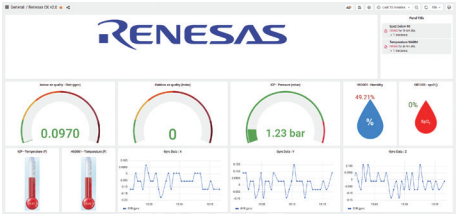
AWS Certified Hardware Environment



AWS device certified
Evaluation kit for IoT equipment development CK-RA6M5



Sample Software Ideal for Use with IoT Devices



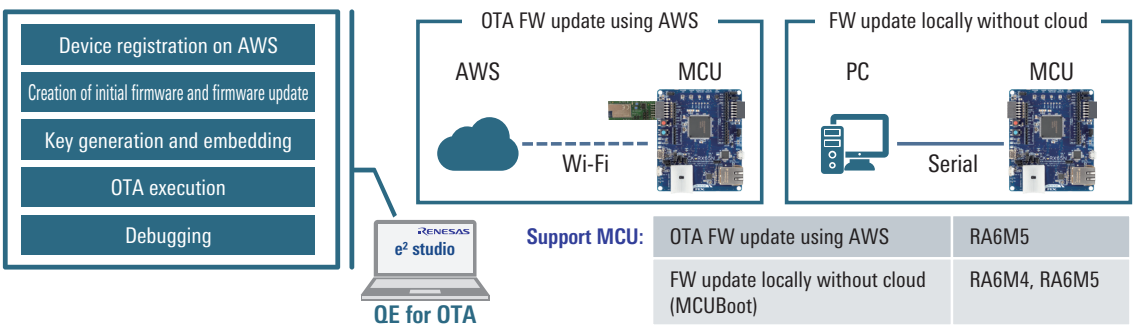
Application note which support development
- Sensor data visualization demo program
- AWS FreeRTOS OTA implementation procedure
- Secure Crypto Engine and Hardware Acceleration

Development Environment that Simplifies and Facilitates IoT Development

e² studio integrated development environment from Renesas
- Smart Configurator
  - Setting configuration for FreeRTOS
  - Setting configuration for peripheral functions and pins
- FSP Software Package
- QE for OTA development support tool

"QE for OTA" Development Assistance Tool for Firmware updates

QE for OTA is development assistance tool that is available free of cost to the developers implementing over-the-air (OTA) firmware updates with a simple and easy graphical user interface. It reduces the OTA execution time by 90% as compared to manually configuring the settings. QE for OTA supports firmware updates for MCUs that are locally without cloud.



Support MCU:		
	OTA FW update using AWS	RA6M5
	FW update locally without cloud (MCUBoot)	RA6M4, RA6M5

HMI Display Solutions

Displays play a crucial role in countless systems, delivering vital status updates and feedback to users in an intuitive way. From simple segment displays to feature-rich 3D applications with touch interfaces, we provide a comprehensive portfolio to meet diverse requirements. With a range of processors from entry-level microcontrollers (MCUs) to the highest-performance microprocessors (MPUs), our solutions are engineered to support a wide variety of display technologies, making them ideal for industrial or commercial applications.

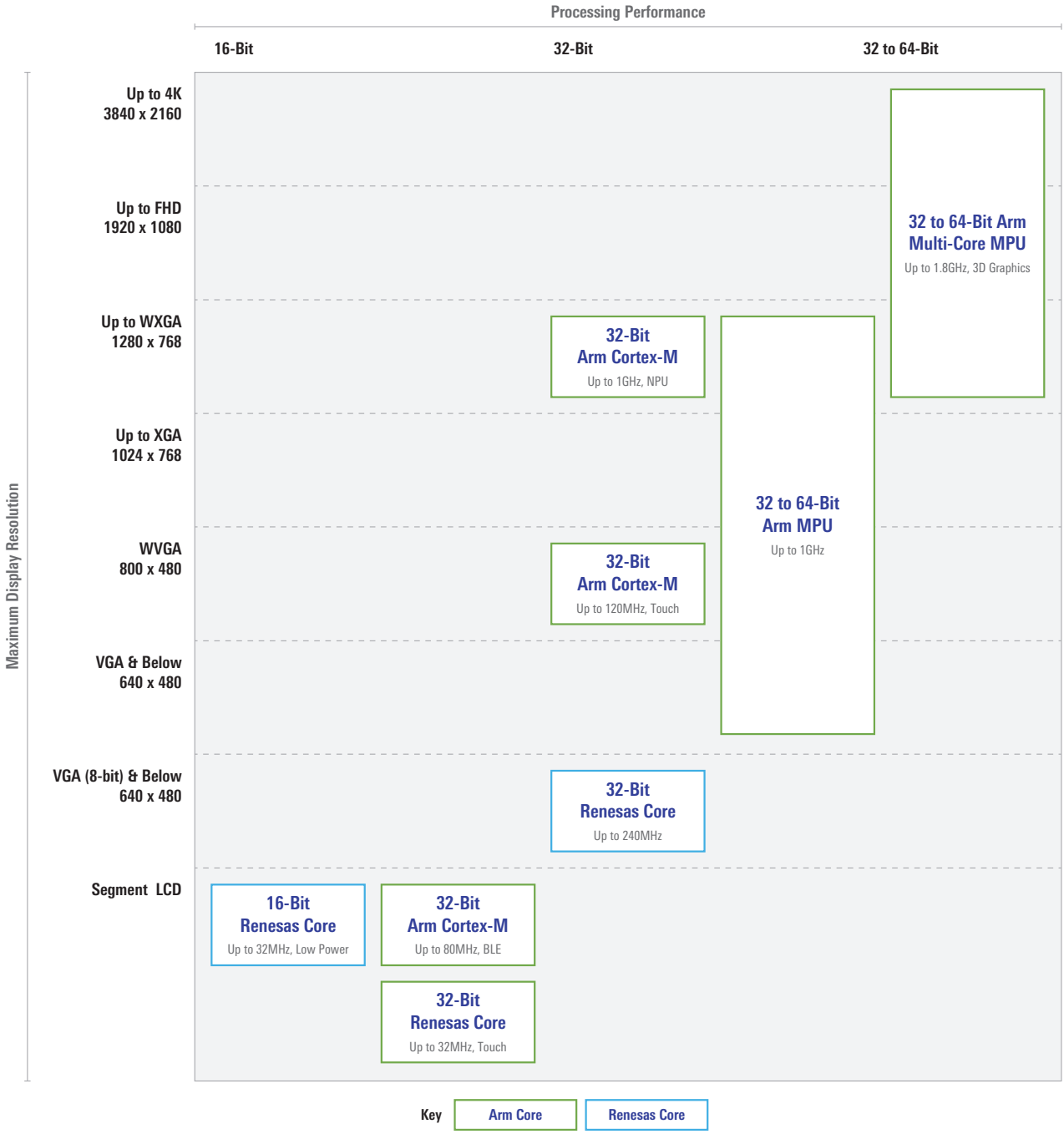
Scalable Graphics Portfolio

Whether requiring a low-power segment display or full-blown 3D graphics, we provide multiple devices servicing different needs.

Flexible Core Choices

From our low-power core MCUs to ultra-high performance multi-core Arm MPUs, designers can choose the right processing speed for their system.

MCUs & MPUs with Graphics Support



Extensive Partner Network

With graphical user interfaces (GUIs), users can rely on our robust partner network offering design tools and global support.

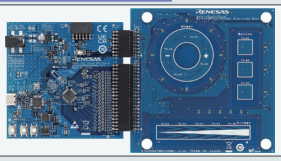
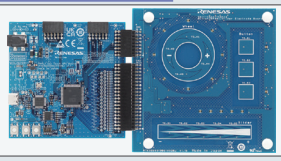
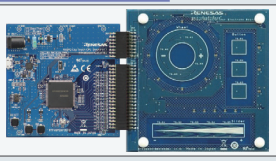
Partner	Solution	Description	RA Arm Cortex-M	RX 32-Bit Performance / Efficiency MCUs	RZ 32 & 64-Bit MPUs
Candera	CGI Studio	A powerful design tool for your embedded human machine interfaces (HMI). It enables the creation of HMIs and UIs of all kinds for automotive, white goods, medical, or industrial customers.			✓
Crank | AMETEK	Storyboard	An embedded graphical user interface (GUI) development framework for creating engaging HMI applications with exceptional user experiences.	✓		✓
Envox	EEZ Studio	A powerful solution for rapid development of embedded and desktop GUIs, offering seamless remote control of multiple devices and test & measurement (T&M) automation.	✓	✓	✓
LVGL	LVGL Embedded UI Library	A free and open-source embedded graphics library to create beautiful User Interfaces (UIs) for any MCU, MPU and display type. It makes UI development easier with 30+ built-in widgets, anti-aliasing, and more.	✓	✓	✓
Qt	Qt for MCU	Qt for MCUs is a complete graphics framework and toolkit with everything you need to design, develop, and deploy GUIs on RA 32-bit MCUs.	✓		
	Qt Device Creation	Develop a single cross-platform code base using one integrated toolset and target embedded, desktop, and mobile platforms.			✓
	Qt Design Studio	An easy-to-use 3D-capable design tool that bridges the gap between design and development. It allows prototyping within minutes and converts the design into production-grade code.			✓
SEGGER	emWin	A flexible, professional GUI platform, enabling the creation of highly efficient, high-quality, interactive GUI for the Renesas RA and RX Family MCUs on any display.	✓	✓	
SquareLine Ltd	SquareLine Studio	A visual drag-and-drop UI editor that enables individuals and businesses to design and create stunning GUIs quickly and effortlessly.	✓	✓	✓
Tara Systems	Embedded Wizard	A GUI technology that enables the customer to create platform-independent and high-performance GUI, even on resource-constrained microcontrollers.	✓	✓	✓
TES Electronic Solutions	Guiliani - Graphic Solutions	A powerful, yet easy-to-use, modern, object-orientated, and customizable software for creating stylish GUI quickly.	✓		
	Guiliani - Graphical UI Framework	A modern and powerful C++ software for creating stylish GUI on a wide range of embedded hardware such as the RZ/A MPU family.			✓

Capacitive Touch Sensor Solution

Renesas offers a capacitive touch solution that supports creating an user-friendly environment to lower hurdles in capacitive touch sensor application development, proposing revolutionary designs for switching devices and equipment.

The capacitive touch evaluation system includes a CPU board and a self-capacitance evaluation board for use as a touch application board. It has everything you'll need to get started evaluating applications incorporating buttons, sliders, and wheels.

Capacitive Touch Evaluation Systems

MCU	RA0L1	RA2L1	RA4L1	RA6M2
Product ID	RSSK-RA0L1	RSSK-RA2L1	RSSK-RA4L1	RSSK-RA6M2
Kit Name	Capacitive Touch Evaluation System for RA0L1	Capacitive Touch Evaluation System for RA2L1	Capacitive Touch Evaluation System for RA4L1	Capacitive Touch Evaluation System for RA6M2
Part No.	RTK0EG0065S01001BJ	RTK0EG0022S01001BJ	RTK0EG0057S01001BJ	RTK0EG0021S01001BJ
Board Image				
MCU P/N	R7FA0L1074CFL	R7FA2L1AB2DFP	R7FA4L1BD4CFP	R7FA6M2AF3CFB
Package	48-pin LQFP	100-pin LQFP	100-pin LQFP	144-pin LQFP
ROM/RAM	64KB/16KB	256KB/32KB	512KB/64KB	1MB/384KB
Number of Touch pins	24	32	12	18
Bundled items	■ Evaluation board ■ RA0L1 Cap Touch CPU board ■ Self-capacitance electrode board (buttons, sliders, wheels) ■ First Step Guide	■ Evaluation board ■ RA2L1 Cap Touch CPU board ■ Self-capacitance electrode board (buttons, sliders, wheels) ■ First Step Guide	■ Evaluation board ■ RA4L1 Cap Touch CPU board ■ Self-capacitance electrode board (buttons, sliders, wheels) ■ First Step Guide	■ Evaluation board ■ RA6M2 Cap Touch CPU board ■ Self-capacitance electrode board (buttons, sliders, wheels) ■ First Step Guide

QE for Capacitive Touch: Development Assistance Tool for Capacitive Touch Sensors

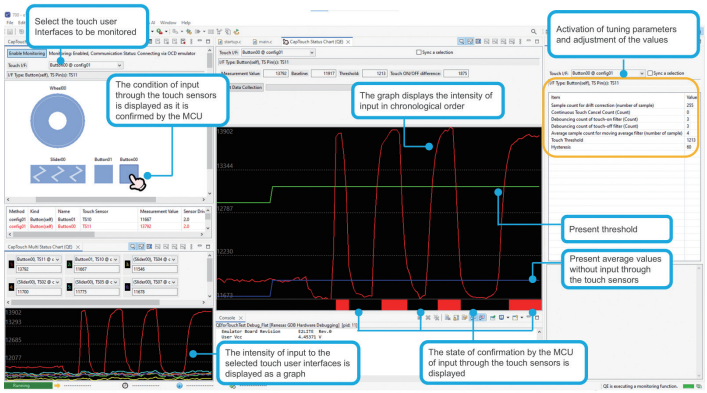
QE for Capacitive Touch is a solution toolkit for assisting in the development of embedded systems that include the use of capacitive touch. It supports the initial settings of the touch user interface and the tuning of the sensitivity. Software can be developed with a simple GUI according to the workflow.

Monitoring Function:

- This function displays waveforms of measurement values as capacitance changes over time.
- You can adjust a variety of tuning parameters while monitoring the capacitance waveforms.
- Supports saving displayed waveforms to a log.

Tuning Function:

- Automatic tuning performs configuration of parameter settings to match the board under development.
- Manual tuning and advanced mode tuning allow fine-grained customization.



Monitoring and parameter adjustment functions

Tutorial videos will help you develop the touch sensor function.

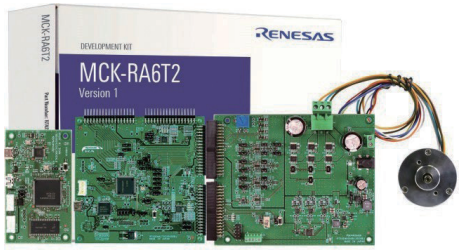
- QE for Capacitive Touch Tutorial –Step 1 Configuration for RA–
- QE for Capacitive Touch Tutorial –Step 2 Tuning for RA–
- QE for Capacitive Touch Tutorial –Step 3 Monitoring for RA–

Motor Control Solution

MCK-XXXXX are development kits that enable easy evaluation of motor control using Brushless DC (BLDC) Motors/Permanent Magnet Synchronous Motors (PMSM). These kits are configured to run the sample code that can be downloaded from the homepage. In addition, development support tools such as Renesas Motor Workbench, which can analyze and tune motors, and QE for Motor are available, so you can immediately start evaluating motor control using RA-T series MCUs.

MCK-XXXXX –Features–

- Includes an inverter board for 3-phase BLDC motor
- Supports 1-/3-shunt current sensing
- Overcurrent detection function
- Supports Motor Control Development Support Tool Renesas Motor Workbench and QE for Motor
- High voltage motor control evaluation using a separately sold High Voltage Inverter Board for RA6T2 (MCB-RA6T2)



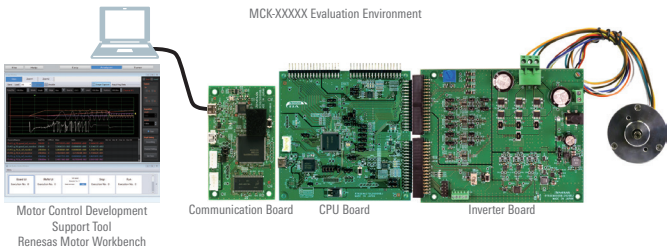
MCK-RA6T2 (RTK0EMA270S00020BJ)

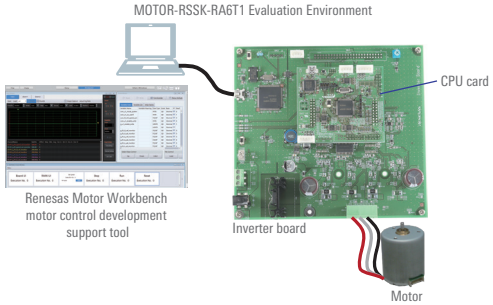
Items		RA8T2	RA8T1	RA6T2	RA6T3	RA4T1	RA2T1
Product ID		MCK-RA8T2	MCK-RA8T1	MCK-RA6T2	MCK-RA6T3	MCK-RA4T1	MCK-RA2T1
Kit Name		Renesas Flexible Motor Control Kit for RA8T2 MCU Group	Renesas Flexible Motor Control Kit for RA8T1 MCU Group	Renesas Flexible Motor Control Kit for RA6T2 MCU Group	Renesas Flexible Motor Control Kit for RA6T3 MCU Group	Renesas Flexible Motor Control Kit for RA4T1 MCU Group	Renesas Flexible Motor Control Kit for RA2T1 MCU Group
Part No.		RTK0EMA6L0S00020BJ	RTK0EMA5K0S00020BJ	RTK0EMA270S00020BJ RTK0EMA270S00021BJ	RTK0EMA330S00020BJ	RTK0EMA430S00020BJ	RTK0EMA810S00020BJ
Bundled Items	Inverter board	MCI-LV-1 (RTK0EM0000B12020BJ)					
	CPU Board	MCB-RA8T2 (RTK0EMA6L0C00000BJ)	MCB-RA8T1 (RTK0EMA5K0C00000BJ)	MCB-RA6T2 (RTK0EMA270C00000BJ or RTK0EMA270C00002BJ)	MCB-RA6T3 (RTK0EMA330C00000BJ)	MCB-RA4T1 (RTK0EMA430C00000BJ)	MCB-RA2T1 (RTK0EMA810C00000BJ)
	Communication Board	MC-COM (RTK0EMXC90S00000BJ)			–	–	MC-COM (RTK0EMXC90S00000BJ)
	Motor	R42BLD30L3 (MOONS')					
Inverter Specification		■ Rated voltage: 48V ■ Rated current: 10A (continuous) ■ Protect functions: Overcurrent detection, etc.					
Compatible High Voltage Inverter board		–	–	■ MCI-HV-1 ■ MCI-HV-2-3PH ■ MCI-HV-2-1PH	–	–	–
Resources		■ MCK-RA8T2 User's Manual ■ Design Package ■ MCK-RA8T2 Quick Start Guide	■ MCK-RA8T1 User's Manual ■ Design Package ■ MCK-RA8T1 Quick Start Guide	■ MCK-RA6T2 User's Manual ■ Design Package ■ MCK-RA6T2 Quick Start Guide	■ MCK-RA6T3 User's Manual ■ Design Package ■ MCK-RA6T3 Quick Start Guide	■ MCK-RA4T1 User's Manual ■ Design Package ■ MCK-RA4T1 Quick Start Guide	■ MCK-RA2T1 User's Manual ■ Design Package ■ MCK-RA2T1 Quick Start Guide

MOTOR-RSSK-RA6T1 –Features–

The Motor Control Evaluation System for RA6T1 is an evaluation kit for RA6T1.
The CPU Card is compatible with Motor CPU Cards for RX and RL78 Family MCUs.

Items	RA6T2
Product ID	MOTOR-RSSK-RA6T1
Kit Name	Motor Control Evaluation System for RA Family - RA6T1 Group
Part No.	RTK0EMA170S00020BJ
Bundled Items	■ Inverter board for BLDC motor (RTK0EM0000B10020BJ) ■ RA6T1 CPU Card ■ BLDC motor (TG-55L-KA)
Inverter Specification	■ Rated voltage: 48V ■ Rated current: 5A (continuous) ■ Protect functions: Overcurrent detection, etc.
Resources	■ Motor Control Evaluation System for RA Family - RA6T1 Group User's Manual ■ Design Package ■ Motor Control Evaluation System for RA Family - RA6T1 Group Quick Start Guide



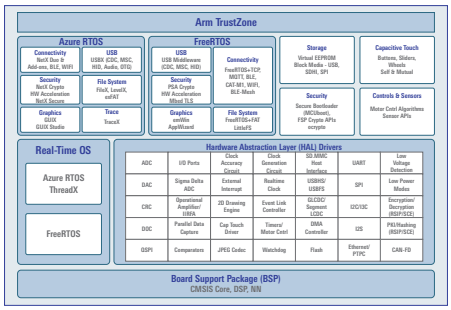


Flexible Software Package (RA Family)

The Renesas Flexible Software Package (FSP) is an enhanced software package designed to provide easy-to-use, scalable, high-quality software for embedded system designs using Renesas RA Family Microcontrollers. With the support of Arm TrustZone and other advanced security features, FSP provides a quick and versatile way to build secure, connected IoT devices using production-ready drivers, Azure RTOS, FreeRTOS, and other middleware stacks.

FSP uses an open software ecosystem and provides flexibility in using bare-metal programming, including Azure RTOS or FreeRTOS, your preferred RTOS, legacy code, and third-party ecosystem solutions.

The combination of the flexible open architecture of the FSP plus the wide choice of third party solutions as part of the Arm ecosystem increases the range of choice for application development. This means that developers can choose the software model that best suits their needs while utilizing Renesas's excellent Arm-based silicon solutions as well as speed up the implementation time of complex areas like connectivity and security.



Benefits

- Provides an easy-to-use, scalable, high-quality software for embedded system designs using the Renesas RA Family of Arm microcontrollers.
- Includes best-in-class HAL drivers with high performance and low memory footprint.
- Middleware stacks with Azure RTOS and FreeRTOS integration are included to ease the implementation of complex modules like communication and security.
- The e² studio IDE provides support with intuitive configurators and intelligent code generation to make programming and debugging easier and faster.
- Uses an open software ecosystem and provides flexibility in using bare-metal programming, including Azure RTOS and FreeRTOS, your preferred RTOS, legacy code, and third-party ecosystem solutions.
- Integrated package with all required components for easy setup and starting development (single installer with e² studio, CMSIS packs, tool chain and SEGGER J-Link drivers).
- Complete source code available through GitHub.

Renesas Motor Workbench

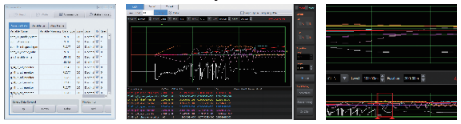
Renesas Motor Workbench is a development support tool for debugging, analyzing, and tuning motor control programs. With its user-friendly GUI, Renesas Motor Workbench delivers a visually engaging experience and enables real-time waveform monitoring of variables.

Features

- Testing and confirming operation of the motors included in Motor Control Kits.
- Measuring motor specific parameters for various motors as well as debugging and adjusting.
- Confirming operation of motors embedded in final applications.

Supported MCUs: RA2T1, RA4T1, RA6T1, RA6T2, RA6T3, RA8T1 and RA8T2

Analyzer Tool

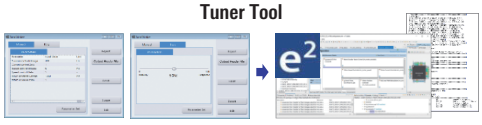


- Dynamic access to variables in the MCU
- Displays changes in variables as waveforms in real-time
- Trigger settings and zoom analysis

Easy GUI Tool

- Intuitive operations enable you to control speed and position of the motor easily
- You can check the drive status at a glance with meters and graphs

Tuner Tool

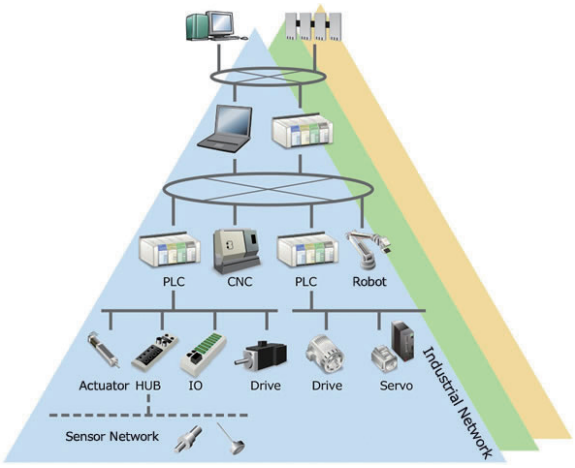


- Automatically obtains and tunes the parameters necessary for vector control
- Enables fine tuning by means of the manual tuning function
- Outputs the tuning results (header file, PDF)

Servo Tool

- Inertia Estimation: Estimates the load inertia and the inertia of the rotor and the shaft connected with the motor-axis while driving the motor
- Servo Tuning: Configures the settings for servo operation such as position control method and control parameters
- Return to Origin: Sets the method for return to origin and the return speed, etc.
- Point to Point: Performs PTP (Point to Point) operation for one axis

Industrial Network Solutions



Industrial Networks

Industrial networks are the backbone of modern industrial automation, enabling seamless connectivity and communication between machines, sensors, controllers, and software systems. These networks ensure real-time data exchange, improved process efficiency, and robust system security, allowing operators to monitor, control, and optimize production with high reliability. By supporting rapid decision-making, predictive maintenance, and integration of diverse components, industrial networks are vital for achieving productivity, quality, and safety goals in automated facilities.

Industrial Networks and RA MCUs

Many Renesas RA microcontrollers, particularly the RA6 and RA8 series, offer integrated Ethernet support and are specifically designed to enable connectivity for leading industrial protocols such as EtherCAT, PROFINET, EtherNet/IP, and Modbus TCP. Additionally, these devices facilitate implementation of non-Ethernet fieldbus protocols like CANopen, PROFIBUS, and DeviceNet via suitable external transceivers or protocol stacks, thus covering major industrial communication requirements for modern automation systems. This extensive protocol support allows RA devices to be flexibly deployed across a wide range of industrial networking and control scenarios.

EtherCAT® PROFINET® EtherNet/IP™
DeviceNet™ CANopen® PROFIBUS®
Modbus® TSN Time Sensitive Networking OPC UA

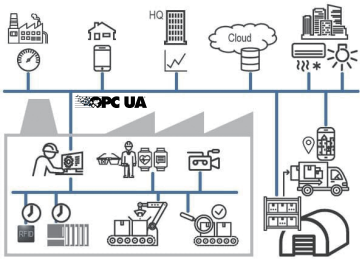
Time Sensitive Networking (TSN)

TSN Time Sensitive Networking™ Powered by IEEE 802

Renesas RA series devices increasingly offer support for Time-Sensitive Networking (TSN), enabling deterministic, low-latency Ethernet communication suitable for real-time industrial automation. TSN features such as time synchronization, traffic scheduling, and prioritization ensure reliable and predictable data transfer, making RA devices well-suited for advanced automation networks that require guaranteed response times and robust integration of safety-critical applications.

OPC UA

OPC UA FX (Field eXchange) is becoming increasingly important for seamless, secure, and real-time communication between industrial controllers. Renesas RA devices are designed to support OPC UA FX, enabling interoperable, flexible, and scalable automation networks that enhance connectivity and diagnostics in modern factories.



OPC UA

IEC61508 Functional Safety Solution

The importance of functional safety is increasing in order to prevent hazards and risks to people, machinery, and the environment from failure or error at the manufacturing site. However, designing the system and being certified under functional safety standards such as IEC 61508 requires a great deal of effort and time, which increases cost and could delay the product release significantly compared to non-safe development.
Renesas offers a one-stop functional safety solution comprised of general-purpose 32-bit microcontrollers (MCUs) with software solution components.

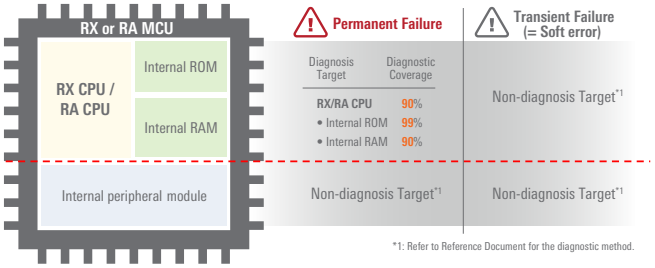
Solution Introduction

The Self-Test Software Kit provides a self-diagnostics software library for microcontroller, a complete safety manual, user guide and IEC61508 SIL3 Certificate test report certified by TÜV Rheinland Industrie Service GmbH (Germany). For safe system development, developers can use the information they require from the safety manual and make use of the self-diagnostics software library to alleviate the burden on microcontroller-level development to conform to functional safety.

Functional Safety
TÜVRheinland CERTIFIED
www.tuv.com ID 0600000000

This Kit diagnoses the permanent failure of CPU, internal ROM, and internal RAM.

* Please refer to the reference document for permanent failure diagnosis of other modules and transient failure diagnosis.



Target Application

Safety System for:

- AC Servo & Drive
- Remote IO
- Programmable Logic Controller
- Sensor and Actuator

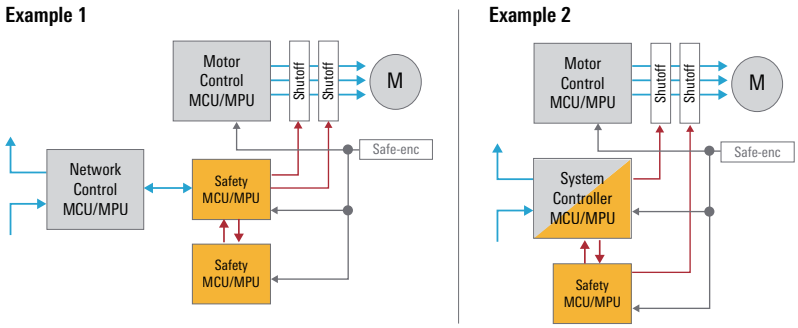

Industrial Robot Arm


PLC


AC Drive, Inverter


Light Curtain, Sensor

Target Safety System Example (Motor Control + Network Control + Safety)



IEC 60730 Safety Classes Support

The IEC/UL 60730 is the harmonized safety standard for household appliances.
It describes requirements for automatic controls including heating and air-conditioning applications. Renesas offers for the RA Family a self-test library to fulfill Class B requirements of the IEC 60730 standard, as this is the most commonly used requirement.
The related Appendix H lists all the specific faults that must be tested and details the need to place the equipment into a safe state for any single point failure.
In response to the need of designing IEC/UL 60730 certified applications, Renesas provides an RA Family IEC 60730 Self-Test Library designed to reduce the burden on customers developing their own solutions. The package comes with the sample code and the certification done by VDE.

RA Family Ecosystem Partners

Renesas is enabling a comprehensive partner ecosystem to deliver an array of software and hardware building blocks that will work out-of-the-box with Renesas RA Family MCUs. The Renesas RA ecosystem will help accelerate the development of IoT applications, including core technologies such as security, safety, connectivity, and HMI among others.

Expansive Third Party Solutions Portfolio

- 200+ partners, 300+ solutions and growing
- Coverage across all key IoT technologies
- Robust GTM and strong digital drumbeat

Commercial Grade Building Block Solutions

- Commercial grade software
- Work out-of-box with Renesas products
- Bundling options for select solutions

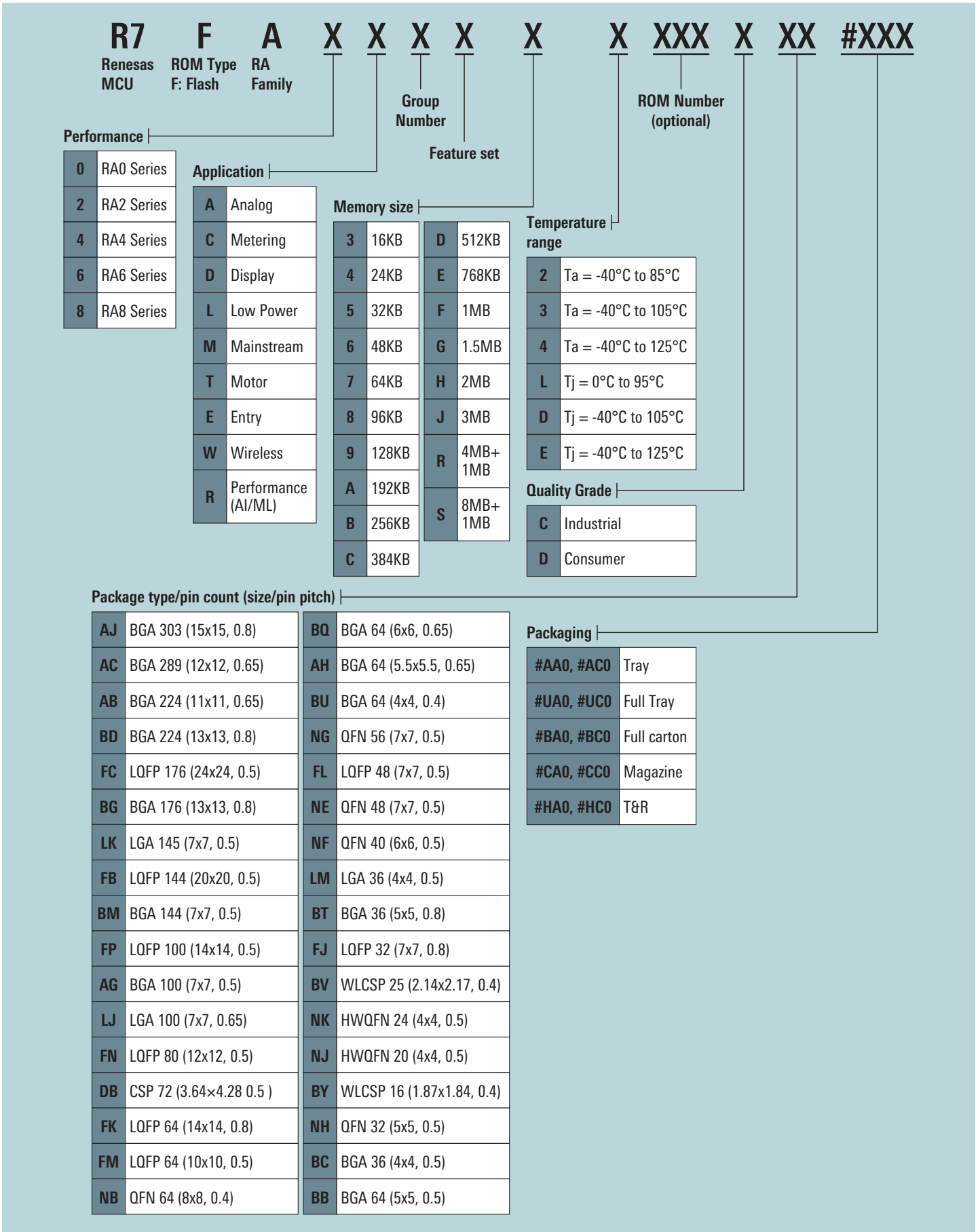
Problem Solving at Heart

- Address specific design problems
- Address specific skill-set gaps
- Customer-centric approach

Partner Overview

The partner overview shown might not be complete since the partner network is extending almost daily. For best reference and latest data, we recommend checking our webpage at: www.renesas.com/ra-partners

Explanation of Orderable Part Numbers



MEMO

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