RA8T1 GROUP INTRODUCTION

RENESAS RA FAMILY 32-BIT MCU

RENESAS ELECTRONICS CORPORATION
JANUARY 2024
VERSION 1.00

RENESAS 32-BIT MCU
PRODUCT & BRAND POSITIONING

Industry leading 32bit CPU performance based on Renesas' proprietary RX core

5.82 CoreMark/MHz, FPU, DSP

- Based on Renesas' proprietary RX "Renesas eXtreme" Core
- Industry leading 32bit performance.
- Huge line-up consisting of >1000 part numbers
- ASSP solutions for Motor control etc
- 100 µA/MHz, 350 nA standby

Integrated software and hardware platform based on Cortex-M with commercial software

Renesas Synergy™

- Cortex M0+/M4 based MCU's offered together with industry first commercial grade and warranted software package.
- Integrated Software, Development Tools, MCUs, Solutions

Industry leading IoT security with software flexibility based on Cortex-M with complete ecosystem from Renesas and our partners

Arm® Cortex®-M4/M23/M33/M85 MCU's

- Renesas Advanced: Innovative market-leading products based on Arm's Cortex-M cores
- Ultimate promise of IoT security by further enhancing Renesas' popular Secure Crypto Engine (SCE) IP
- Best-in-class peripheral IP provided by Renesas
- Easy development of IoT edge application using the new flexible software package

RENESAS 32-BIT MCU RA FAMILY

FEATURES AND VALUE PROPOSITIONS

Arm Core
High performance
Arm® Cortex®-M4/M23/M33/M85 cores

Scalability
48MHz to 480MHz operating
16KB to 2MB memory integration
16-pin to 224-pin package line-up

Security for IOT
Renesas' leading security engine with TrustZone®
Excellent ease-of use tools and offering

Advanced Technology
Best in class peripheral IPs, built on strong MCU heritage, such as Flash memory, digital features, HMI, connectivity, analogs

Software
Flexible Software Package (FSP)
Fast-start software for Security & Connectivity
Extensive third-parties ecosystem

TARGET MARKETS & APPLICATIONS

Industrial Automation

- Long product life
- 105°C support
- Industrial quality grade
- Strongest robustness

Security

- TrustZone support
- Integrated Crypto Module
- Key isolation and management
- True Random Number Generator (TRNG)

Connectivity

- Large On-chip RAM suitable for stacks
- CAN/USB/Ethernet
- Large amount on serial Interfaces
- QSPI and OCTA SPI Interfaces
- HW Crypto Module on-chip

Building Automation

- High On-Chip Flash/RAM memory ratio
- Wide range of connectivity: CAN/USB/Ethernet
- Rich analog features
- Small packages

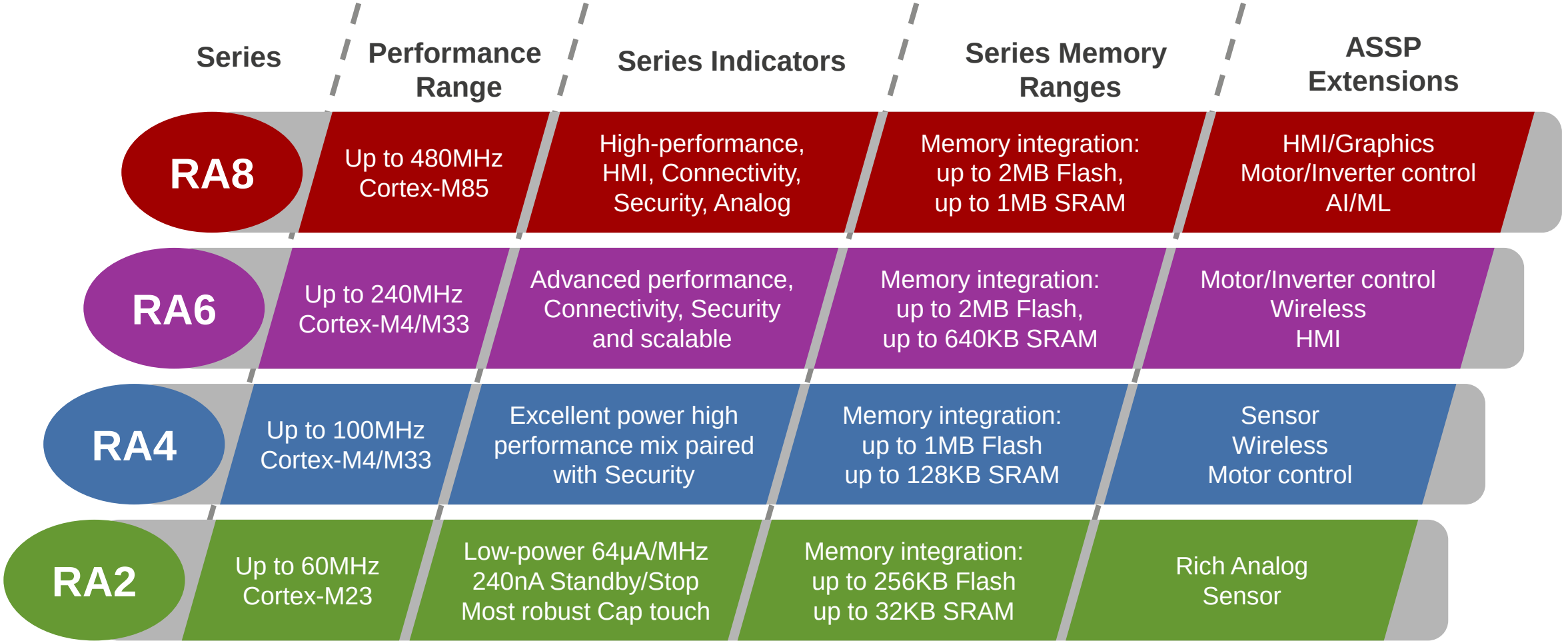
Metering

- Scalable lineup
- Industrial quality grade
- Long product life
- Encryption On-Chip

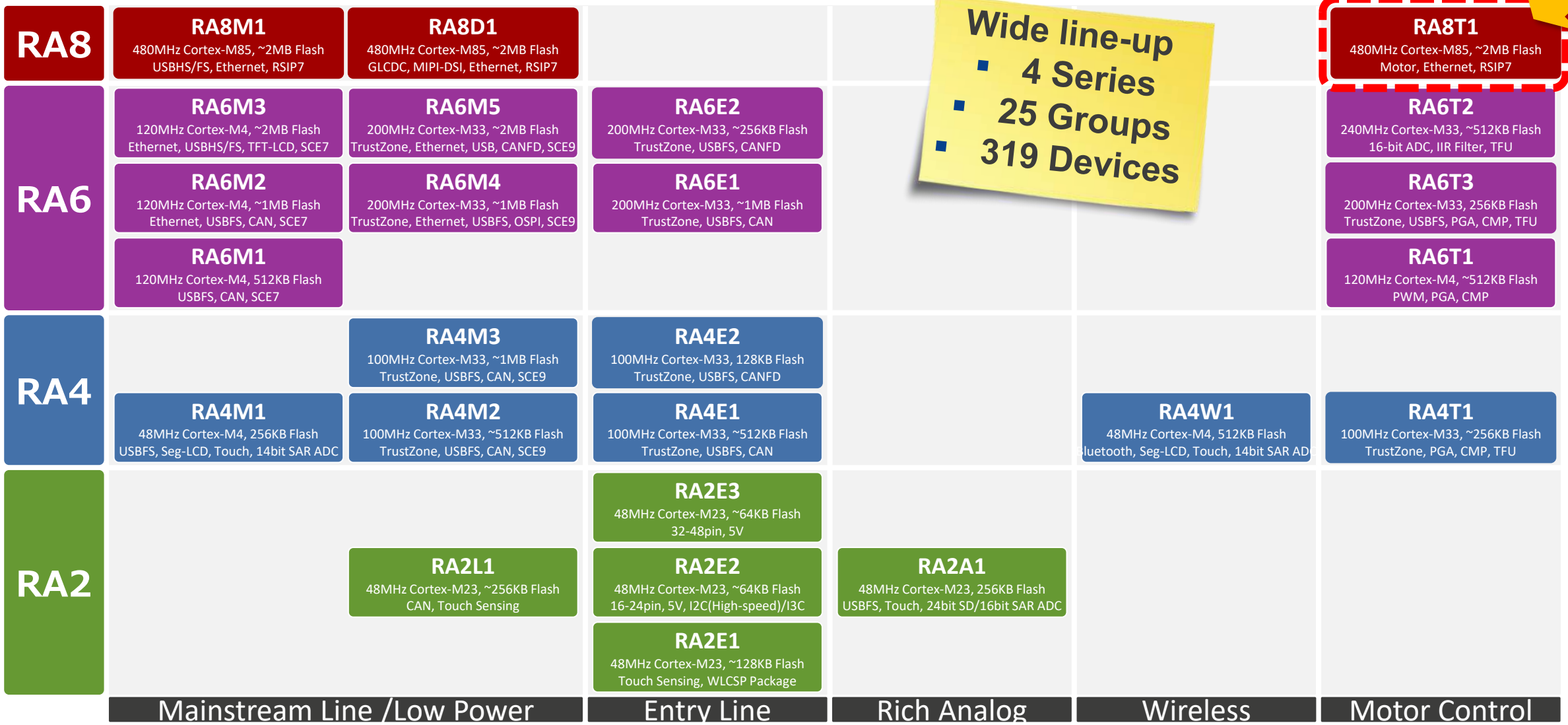
Home Appliance

- Temp up to 105°C
- Extensive family lineup
- Motor control solutions
- Capacitive Touch Interface

RENESAS RA FAMILY SERIES LINE-UP



RENESAS RA FAMILY PORTFOLIO

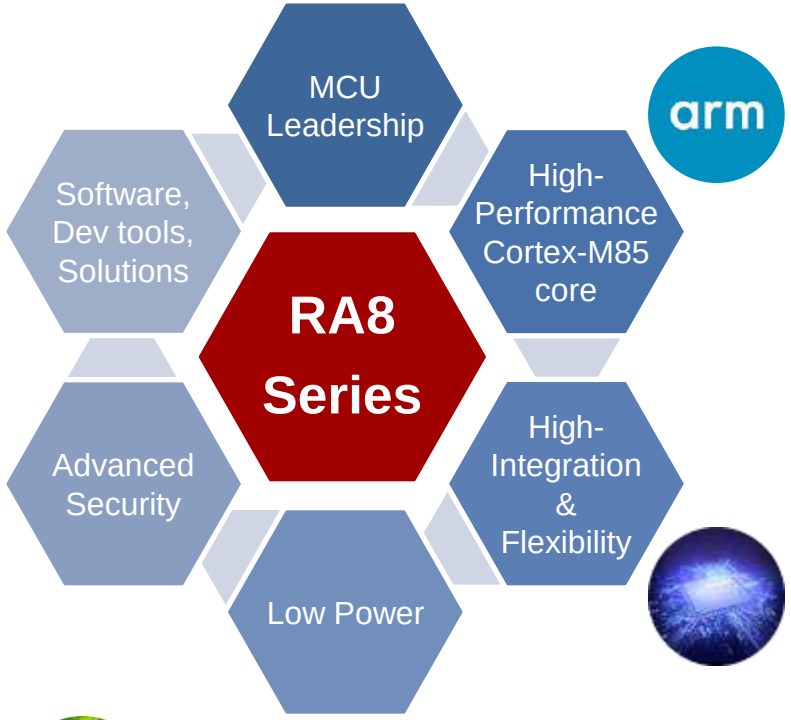


RENESAS RA FAMILY RA8 SERIES – KEY VALUES

- A world leader in MCUs, Renesas Electronics ships more than 3.5 billion units per year
- Industry's most advanced MCU process technology and vast network of more than 200 ecosystem partners

- FSP (Flexible Software Package) with RTOS to support faster development
- Out-of-the-box evaluation kit
- Quick and Effective tool solution, development support tools for various applications (QE)
- Fulfilling reference designs (winning combo)

- Immutable storage for hardware root-of-trust
- Advanced cryptography with industry leading, NIST compliant algorithms
- Secure firmware programming and Secure debug
- Secure interface to external memory (Octal SPI with Decryption-On-The-Fly)



- Lead partner with Arm and first to market with Cortex-M85 core based MCU
- New Armv8.1-M architecture brings both TrustZone for system partitioning and Helium Technology for DSP/ML acceleration
- High-performance and more energy-efficient than Cortex-M7 core

- 40nm process node
- Large Flash memory and SRAM integration, multiple memory configurations enable for diverse use cases
- Best-in-class peripherals, digital features, HMI, connectivity, analogs and safety

- 1.68 to 3.6V lower voltage operation with low active and standby current consumption
- Several modes/features to low power consumption while providing high-performance

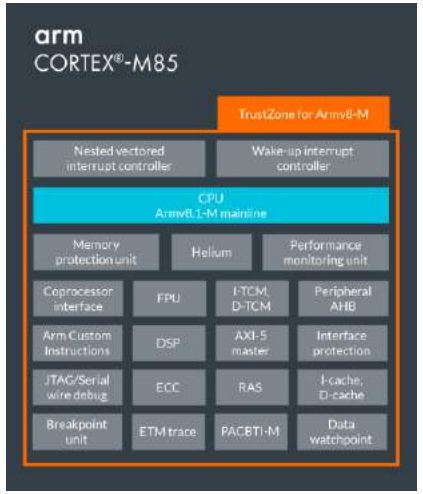
ARM CORTEX-M85 – HIGH-END M-CLASS CORE

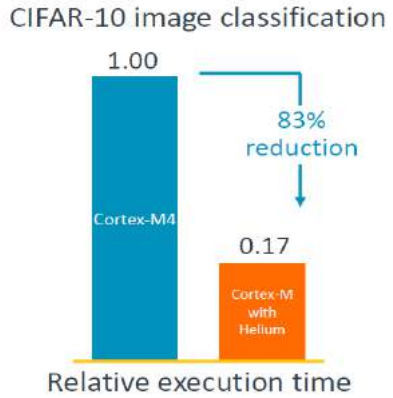
New Armv8.1-M Architecture Cortex-M85 Core
Delivering **6.39 CoreMark/MHz**

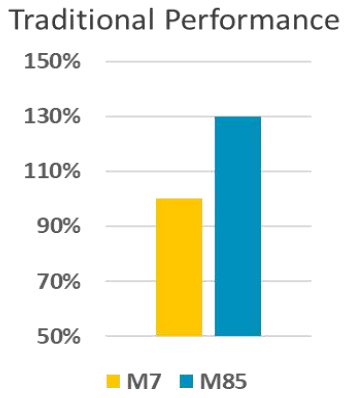
Helium Technology, M-profile Vector extension (MVE)
Accelerates DSP/ML Performance **x4** over Cortex-M7

Advanced Security with TrustZone and PACBTI

	Cortex-M7	Cortex-M85
Architecture	Arm v7-M	**Arm v8.1-M**
TrustZone	Not supported	**Supported**
Helium (MVE)	Not supported	**Supported**
HW floating point	Scalar DP/SP	**Scalar HP/SP/DP Vector HP/SP**
MACs per cycle	1 32bx32b	**8 8bx8b 4 16bx16b 2 32bx32b**
CoreMarks/MHz	5.29	**6.39**







MOTOR CONTROL PRODUCT LINE – FEATURE SET

- Wide range motor control MCU line-up from low-end to high-end with optimal feature-set.
- Keeps CPU and peripheral scalabilities, implements unique hardware IP.
- Supports motor control evaluation kits, tools and software.

Group	Core	Freq.	Code ROM	RAM Data ROM	PWM	Analog			Motor Accelerator	Communication			Pin Count
RA8T1	CM85	480MHz	1M-2MB Dual-bank Flash	1MB 12KB	PWM 28ch	12b ADC x2, 21ch	HSCMP x2		MVE	SCI x6 SPI x2 I2Cx2, I3Cx1	CANFD x2 USBFS x1 SDHI x2	Ethernet	100-224 pin
RA6T2	CM33	240MHz	256K -512KB Flash	64KB 16KB	PWM 20ch	16b ADC x2, 29ch	HSCMP x4	PGA x4	TFU IIR Filter	SCI x6 SPI x2 I2C x2	CANFD x1		48-100 pin
RA6T3	CM33	200MHz	256KB Flash	40KB 4KB	PWM 12ch	12b ADC x1, 12ch	HSCMP x3	PGA x3	TFU	SCI x2 SPI x2 I3C x1	CANFD x1 USBFS x1		32-64 pin
RA6T1	CM4	120MHz	256K -512KB Flash	64KB 8KB	PWM 26ch	12b ADC x2, 17ch	HSCMP x6	PGA x6		SCI x7 SPI x2 I2C x2	CAN x1		64-100 pin
RA4T1	CM33	100MHz	128K -256KB Flash	40KB 4KB	PWM 12ch	12b ADC x1, 12ch	HSCMP x3	PGA x3	TFU	SCI x2 SPI x2 I3C x1	CANFD x1		32-64 pin

RA8T1 GROUP CONCEPT AND VALUE PROPOSITION

High-end motor control MCU RA8T1 Group
Extreme high-performance CPU core and abundant peripheral functions bring advanced real-time control with additional values

Extreme Performance

- Armv8.1-M architecture Cortex-M85
- Helium Technology, M-profile vector extension (MVE)
- up to 480MHz operation

- High-efficiency motor control for suppressing power consumption
- Allows addition features to user system, such as functional safety, predictive maintenance and so on

High-Integration

- Up to 2MB Flash and 1MB SRAM, 100 to 224-pin package line-up
- various features such as PWM timers, ADC, high-speed comparator, Ethernet MAC/DMA, CAN FD, security, etc.

- Eliminates external parts such as memory, ADC, comparator and so on, for cost reduction
- Reduces board space for minimization of system

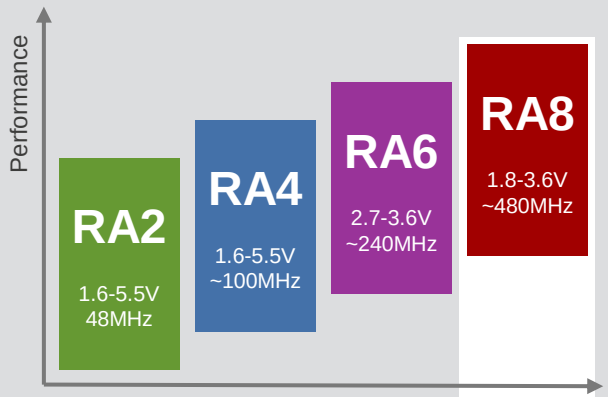
Ease-of-Development

- Flexible software package (FSP)
- Supports RTOS
- Motor control solutions; Evaluation kits, sample code, GUI tool

- Shortens development term by various sample codes, software drivers and support tools
- Allows utilization of software assets

RENESAS RA8T1 GROUP

480MHZ ARM CORTEX-M85 CORE WITH 1M/2MB FLASH & 1MB SRAM



- 480MHz, 32-bit Arm Cortex-M85 core with Helium Technology & TrustZone
- 40nm High-Performance Process
- Operating temperature range: Tj = -40 to 125°C
- Operating Voltage: 1.68V-3.6V

RA8T1

480MHz Arm Cortex-M85 Core, Armv8.1-M Architecture w/ Helium

FPU | ARM MPU | NVIC | JTAG | SWD | ETM | Boundary Scan

Memory

- Code Flash (2MB/1MB) Dual bank function
- Data Flash (12KB)
- SRAM (512KB) Parity
- SRAM (384KB) ECC
- TCM (128KB) ECC
- I/D Cache (32KB)
- Standby SRAM (1KB)

Analog

- 12-bit ADC (2units, 21ch, 3ch-S/H x1)
- 12-bit DAC (2ch)
- High-speed Comparator (2ch)
- Temperature Sensor

Timers

- GPT 32-bit (8ch)
- GPT 16-bit (6ch)
- Low Power GPT 16-bit (2ch)
- Ultra Low Power GPT 32-bit (2ch)
- WDT (1ch)

Communication

- Ethernet MAC w/ DMA (x1)
- USB2.0 FS (x1)
- CAN FD (x2)
- I3C (x1)
- I2C (x2)
- SCI (x6)
- SPI (x2)
- SD/MMC (x2)

System

- DMA (8ch)
- DTC
- Clock Generation
- On-chip Oscillator
- DC-DC Converter
- Low Power Modes
- ELC
- Interrupt Controller

Safety

- Memory Protection Unit
- SRAM Parity Check
- ECC in SRAM
- POE
- Clock Frequency Accuracy Measurement
- CRC Calculator
- IWDT
- Data Operation Circuit
- Flash Area Protection
- ADC Self Test

Security

- AES (128/192/256)
- TRNG
- RSA 4K, ECC
- SHA-2 (224/256/384/512)
- Secure Debug
- Immutable Storage
- TrustZone
- CMAC/HMAC/GMAC
- DPA/SPA Side Ch Protection

Package

- LQFP 100, 144, 176
- BGA 224

RENESAS RA8T1 GROUP PRODUCT LINE-UP

Flash/RAM	Tj	Max frequency				
2MB/1MB	-40 to 125 °C	480MHz				R7FA8T1AHECBD
		400MHz		R7FA8T1AHECFB	R7FA8T1AHECFC	
		360MHz	R7FA8T1AHECFP			
1MB/1MB	-40 to 125 °C	480MHz				R7FA8T1AFECBD
		400MHz		R7FA8T1AFECFB	R7FA8T1AFECFC	
		360MHz	R7FA8T1AFECFP			
Pin Count			100-pin	144-pin	176-pin	224-pin
Package type			LQFP	LQFP	LQFP	BGA
Package size (body)			14 x 14 mm	20 x 20 mm	24 x 24 mm	13 x13 mm
Pin pitch			0.5 mm	0.5 mm	0.5 mm	0.8 mm

RA8T1 GROUP TARGET APPLICATIONS

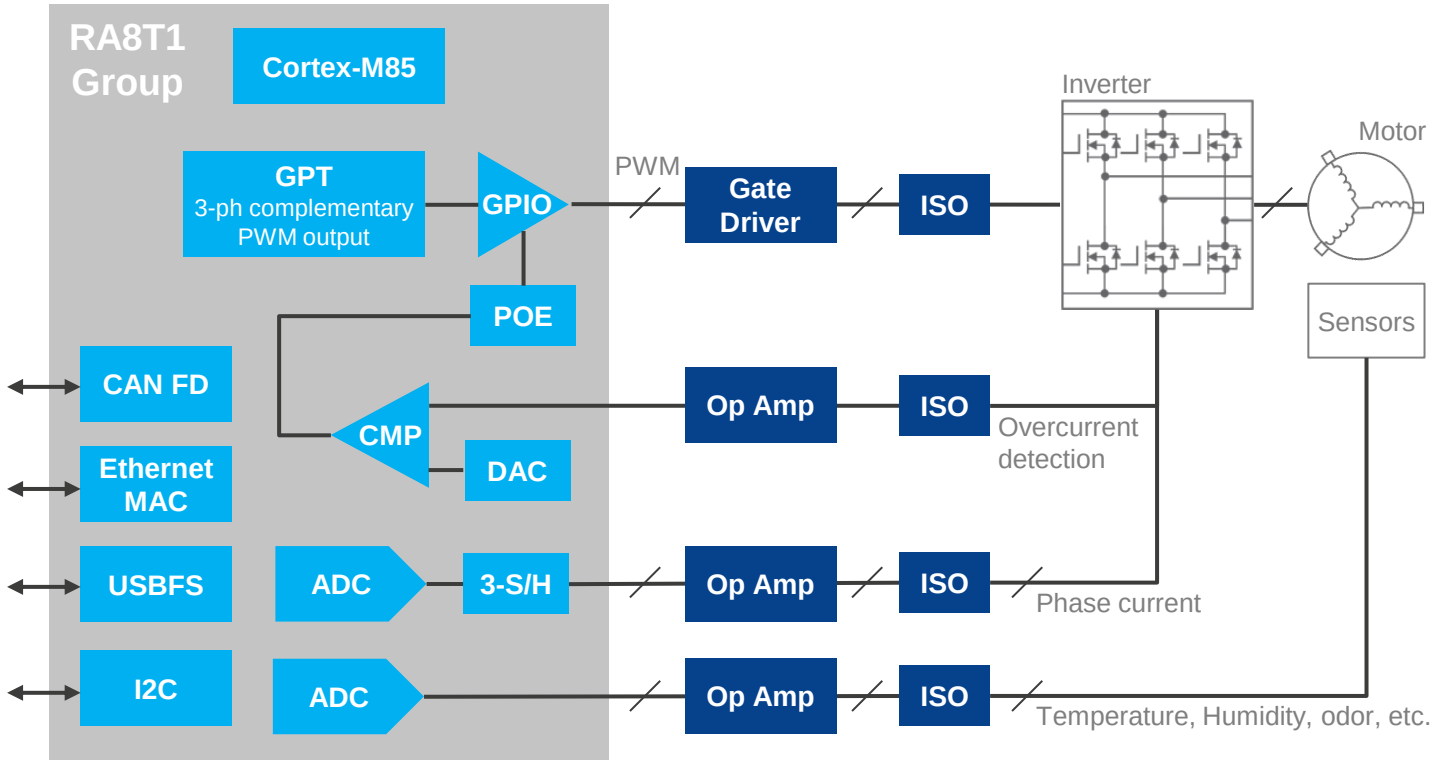
Industrial Automation	Building Automation	Smart Home	Consumer Products	Healthcare
▪ AC Drive/ GP Inverter ▪ Line Conveyor ▪ AGV/AMR ▪ Compressor	▪ HVAC ▪ Solar Inverter ▪ Elevator ▪ Pump ▪ Fan	▪ Air Conditioner ▪ Washing Machine ▪ Refrigerator ▪ Dish Washer ▪ IH Cooker ▪ Vacuum Cleaner	▪ Drone ▪ E-Bike ▪ Lawn Mower ▪ Power Tool	▪ CPAP Machine ▪ CT Scanner ▪ Clinical Equipment





RA8T1 Group will suit for drive applications in wide market field

RA8T1 GROUP 3-PHASE INVERTER CONTROL EXAMPLE



Key components

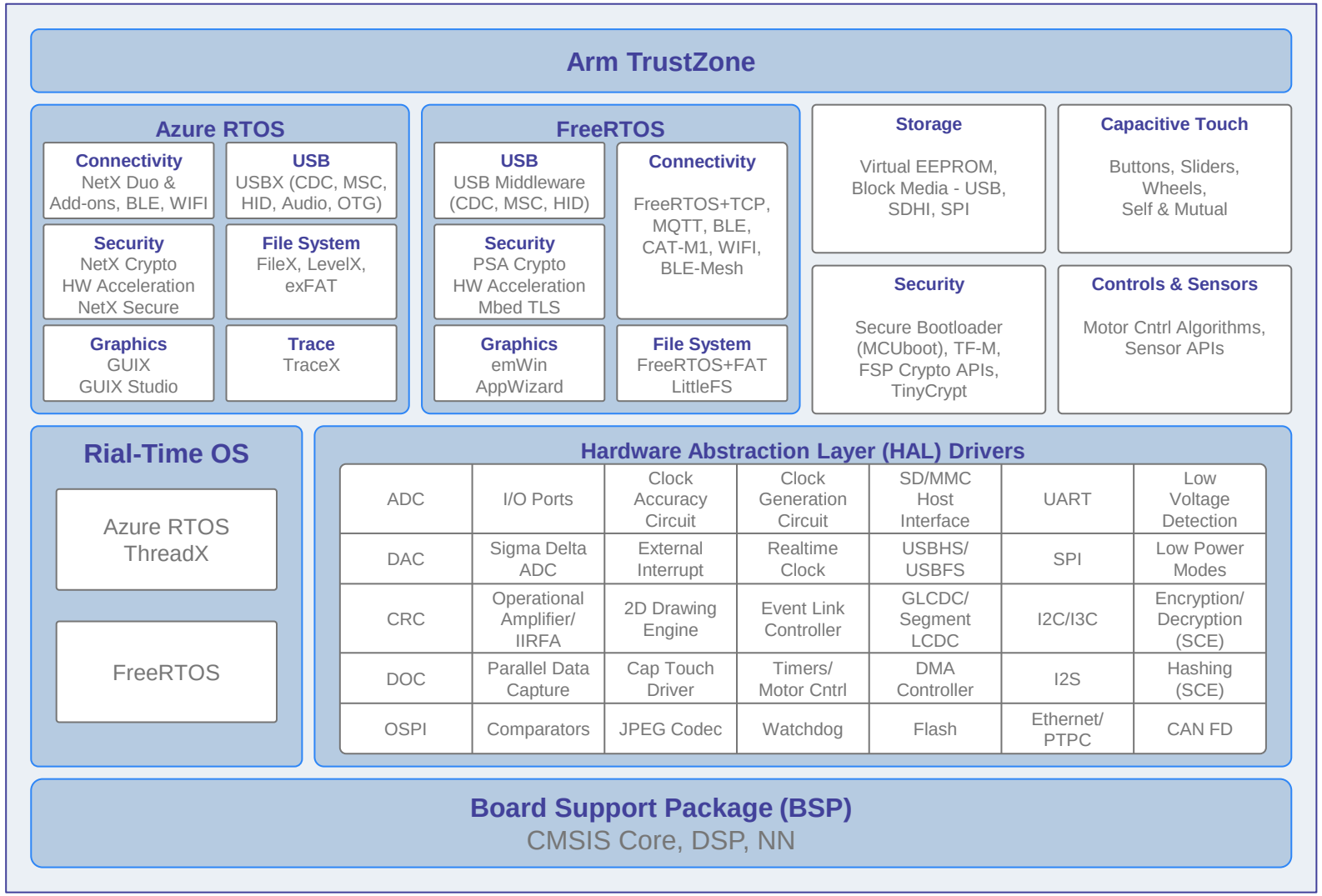
- **Calculation performance**
  - ✓ **Cortex-M85 core with Helium Technology**
  - ✓ **128KB TCM with ECC**
  - ✓ **Up to 480MHz operation**
- **3-phase inverter control**
  - ✓ **GPT** for 3-phase complementary PWM output
- **Process 3-phase current measurement**
  - ✓ **Simultaneous 3ch Sample and Hold**
  - ✓ **12-bit ADC**
- **Output protection for safety**
  - ✓ **Comparator** to detect overcurrent
  - ✓ **POE** to forcibly shut-off PWM output
- **Communications**
  - ✓ **Ethernet MAC**
  - ✓ **CAN FD**
  - ✓ **USBFS**
  - ✓ **I2C**
  - ✓ **…etc.**

DEVELOPMENT ENVIRONMENT OVERVIEW

The RA Family development environment offers flexibility in terms of different supported on-chip debuggers, IDEs, and compilers. Customer can use the Renesas e^2 studio, IAR Embedded Workbench and Keil MDK. All tools can use the RA Smart Configurator for FSP driver and middleware selection and configuration, in addition to pin mapping and clock-tree configuration.

	Renesas e^2 studio	IAR Systems Embedded Workbench for Arm	Keil Microcontroller Development Kit
Compilers	- GNU Compiler Collection - Arm LLVM - Arm Compiler 6* - IAR C/C++ *	- IAR C/C++	- Arm Compiler 6
Debugger probes	- Renesas E2/E2 Lite - SEGGER J-Link	- SEGGER J-Link - IAR I-Jet (limited support)	- SEGGER J-Link - Keil ULINK (limited support)
Smart Configurator	Built-in - BSP - Clock - Pin - Drivers - Interrupts	Supplied as RA Smart Configurator - BSP - Clock - Pin - Drivers - Interrupts	Supplied as RA Smart Configurator - BSP - Clock - Pin - Drivers - Interrupts
Application specific configurator	- QE for Motor - Renesas Motor Workbench - Embedded Target	N/A	N/A
Other	- Visual Studio Code Extension		

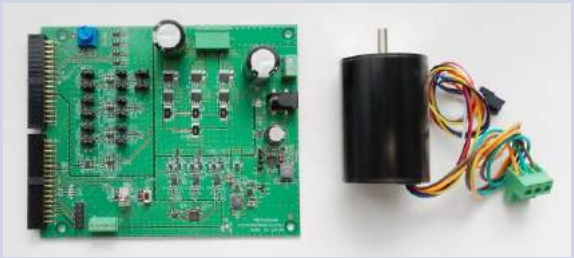
FLEXIBLE SOFTWARE PACKAGE (FSP)



Benefits

- Provides an easy-to-use, scalable, high-quality software for embedded system designs using the RA Family 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 e^2 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
- Complete source code available through GitHub

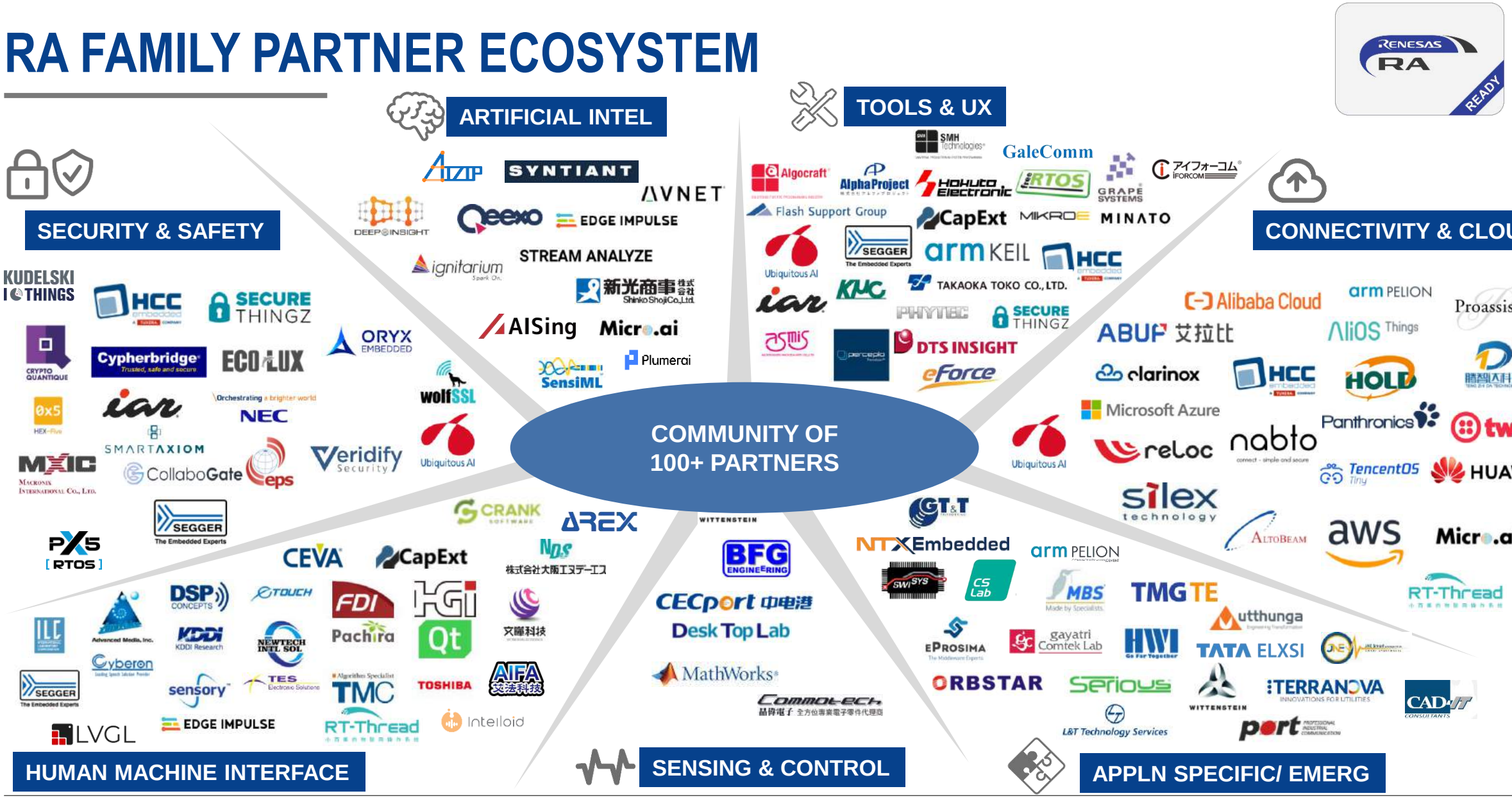
MOTOR CONTROL EVALUATION KIT

	CPU board	Inverter board	Communication board
Appearance			
Description	Evaluation board which equipped the target device. Enables the motor control evaluation by connecting inverter boards, and the MCU evaluation by sole as well.	3-phase Motor control inverter board with brushless DC motor. Enables motor control evaluation by combining with a compatible CPU board.	Serial communication board to connect to the target MCU. Enables safe of motor control evaluation or debug by electrical isolation for communication signals.
Features	• Inverter board connector (x2) • PMOD Type 2A/3A/6A (x2) • USBFS connector • Ethernet(10/100M) connector • SD micro slot • CAN I/F (T/H) • J-Link OB w/ USB connector • 20-pin T/H for Arm debugger • UART connector for MC-COM • LEDs/Reset button • T/H for unused MCU pins	• 48V/10A_{RMS} capability • 1-shunt/3-shunt current sensing • Overcurrent detection • Supports Hall sensors, encoders and inductive position sensors • Potentiometer/Push switch • LEDs • Including BLDC motor (36V/1.67A)	• Supports the GUI tool ‘Renesas Motor Workbench’ • Connected to CPU board via an isolator • Sampling period min 20µs/4ch • Enables connection to user board
Kit name: P/N	MCB-RA8T1: RTK0EMA5K0C00000BJ	MCI-LV-1: RTK0EM0000S04020BJ	MC-COM: RTK0EMXC90S00000BJ
	MCK-RA8T1 (combined kit): RTK0EMA5K0S00020BJ		

MOTOR CONTROL APPLICATION NOTE & SAMPLE CODE

MCU	Motor control sample code	Document Number	Supported Kit
RA8T1	Hall sensor 120-degree conducting control	R01AN6843	MCK-RA8T1 (RTK0EMA5K0S00020BJ) MCI-LV-1 (RTK0EM0000S04020BJ)
	Sensor-less 120-degree conducting control	R01AN6844	
	Sensor-less vector control (1-shunt)	R01AN6840	
	Sensor-less vector control	R01AN6839	
	Sensor-less vector control (2-motors drive)	R01AN6421	
	Hall sensor vector control	R01AN6466	
	Encoder vector control	R01AN6841	
	Induction sensor vector control	R01AN6842	

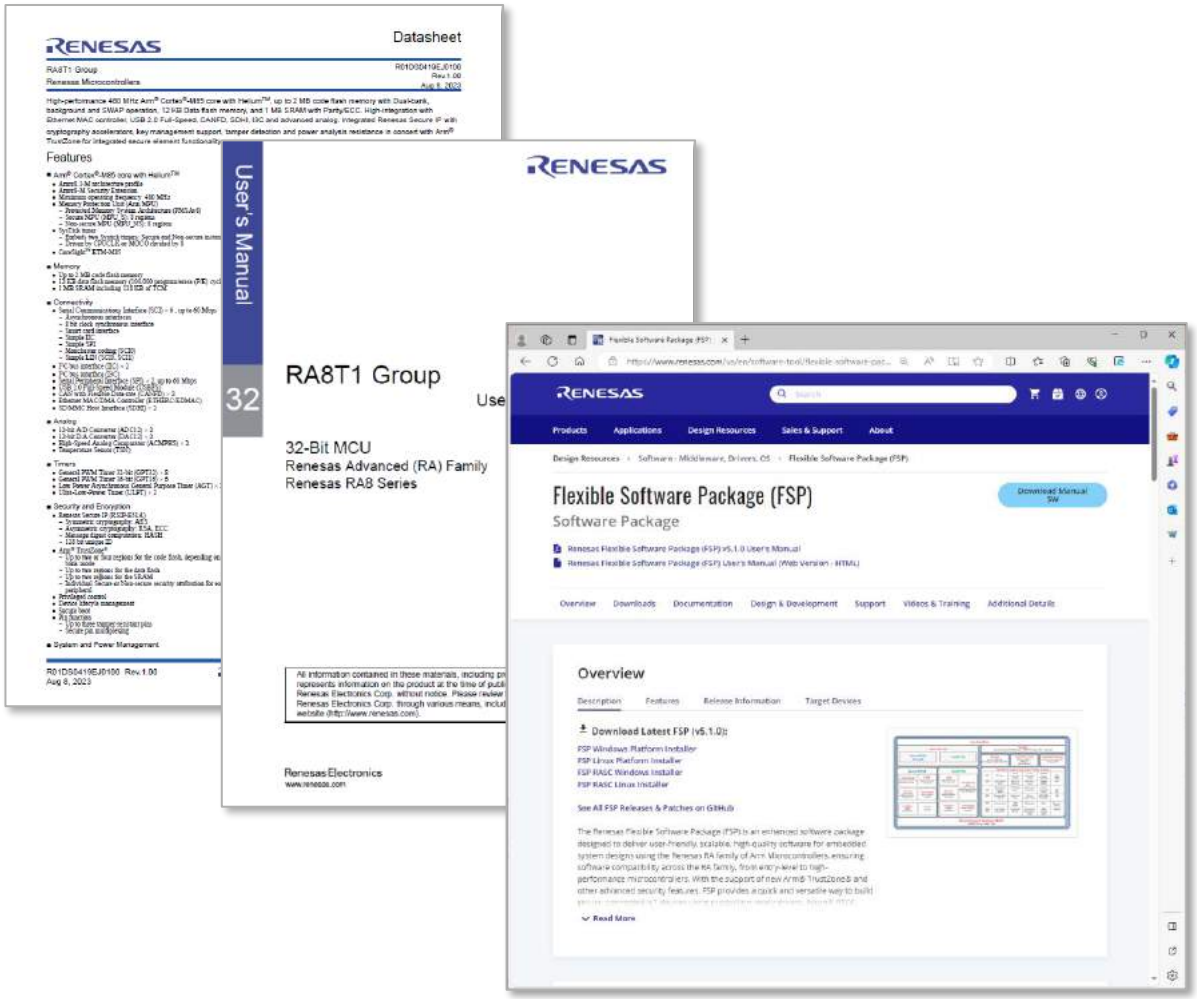
RA FAMILY PARTNER ECOSYSTEM



RA8T1 GROUP COLLATERAL

Please visit: renesas.com/ra8t1

- **Product Documentation**
  - RA8T1 Group Flyer
  - RA8T1 Hardware User's Manual v1.1
  - RA8T1 Datasheet v1.1
  - MCK-RA8T1 Quick Start Guide
  - MCK-RA8T1 User's Manual
  - FSP v5.1 GitHub Release
  - FSP User's Manual
  - Development Tools
  - RA8T1 Application Notes
  - RA8T1 Example Projects



PART NUMBER LIST

Device

Renesas Part Number	Memory Size			Temperature Range (Tj)	Package				Max Frequency
	Flash	SRAM	Data Flash		Pin	Type	Body size	Pin pitch	
R7FA8T1AFECFP	1MB	1MB	12KB	-40 to 125 °C	100-pin	LQFP	14 x 14 mm	0.5 mm	360MHz
R7FA8T1AFECFB	1MB	1MB	12KB	-40 to 125 °C	144-pin	LQFP	20 x 20 mm	0.5 mm	400MHz
R7FA8T1AFECFC	1MB	1MB	12KB	-40 to 125 °C	176-pin	LQFP	24 x 24 mm	0.5 mm	400MHz
R7FA8T1AFECBD	1MB	1MB	12KB	-40 to 125 °C	224-pin	BGA	13 x 13 mm	0.8 mm	480MHz
R7FA8T1AHECFP	2MB	1MB	12KB	-40 to 125 °C	100-pin	LQFP	14 x 14 mm	0.5 mm	360MHz
R7FA8T1AHECFB	2MB	1MB	12KB	-40 to 125 °C	144-pin	LQFP	20 x 20 mm	0.5 mm	400MHz
R7FA8T1AHECFC	2MB	1MB	12KB	-40 to 125 °C	176-pin	LQFP	24 x 24 mm	0.5 mm	400MHz
R7FA8T1AHECBD	2MB	1MB	12KB	-40 to 125 °C	224-pin	BGA	13 x 13 mm	0.8 mm	480MHz

Kit

Part Number	Kit Name	Title	Includes
RTK0EMA5K0S00020BJ	MCK-RA8T1	Renesas Flexible Motor Control Kit for RA8T1 Group	CPU board, COM board, Inverter board, Motor
RTK0EMA5K0C00000BJ	MCB-RA8T1	CPU Board for RA8T1 MCU Group	CPU board
RTK0EM0000S04020BJ	MCI-LV-1	Renesas Flexible Motor Control Inverter Board - Low Voltage 48V/10A for three-Phase BLDC/PMSM Motor	Inverter board, Motor
RTK0EMXC90S00000BJ	MC-COM	Renesas Flexible Motor Control Communication Board	COM board

Renesas.com