RENESAS RA8D1 GROUP INTRODUCTION

RENESAS ELECTRONICS CORPORATION
NOVEMBER 2023
V1.0

INTRODUCING RENESAS 32-BIT RA FAMILY

HIGH-PERFORMANCE, ADVANCED SECURITY, BROAD CONNECTIVITY AND WIDE DEVICE LINE-UP

RENESAS RA

MCU Solutions & Open Ecosystem

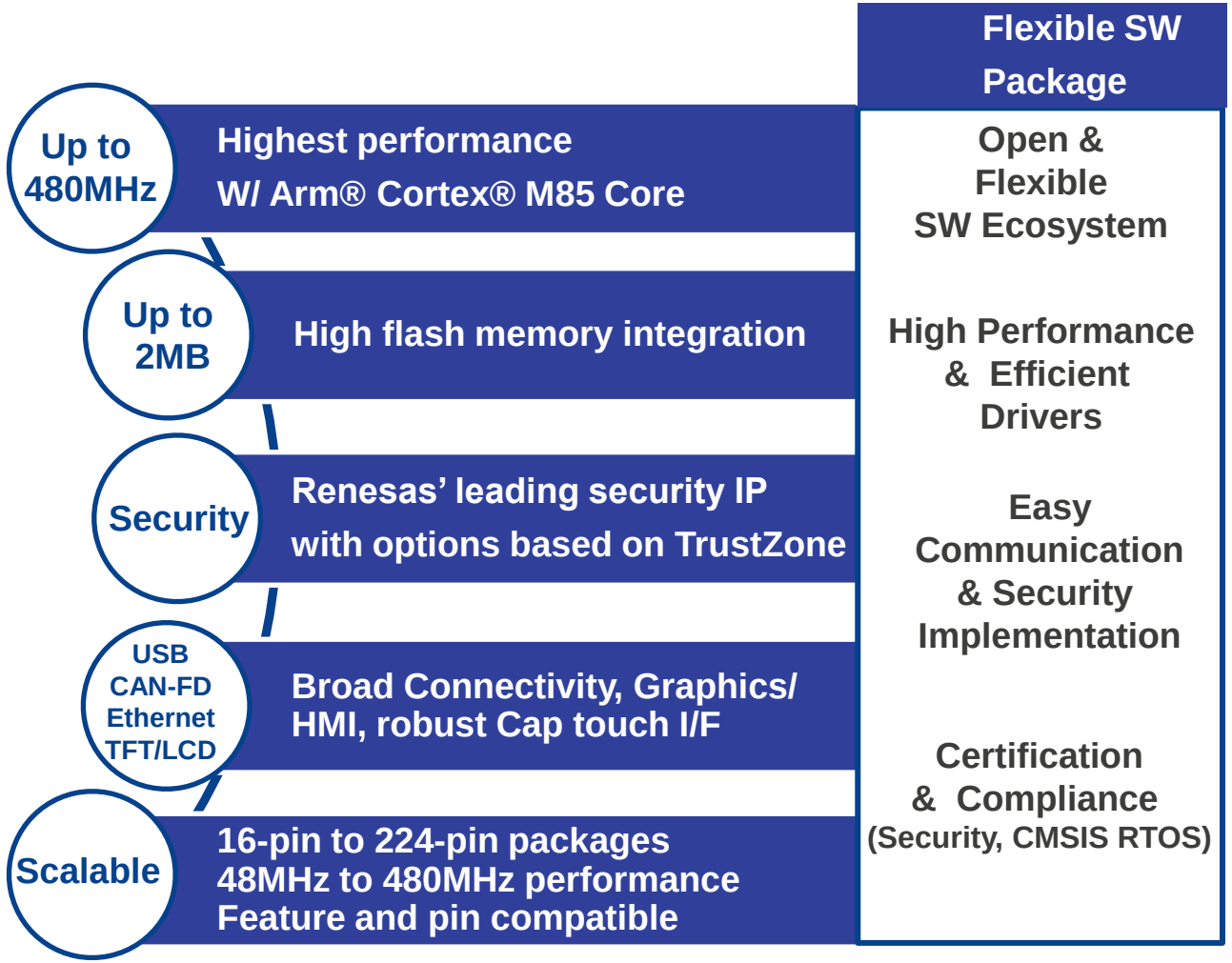
Arm® Cortex® M4, M33, M23 & M85 Cores

Efficient FSP Software, HAL drivers

Enhanced Security & Trustzone Technology

HMI/Graphics

Robust Capacitive Touch



INTRODUCING THE RENESAS RA8D1 GRAPHICS MCUS

INDUSTRY'S FIRST GRAPHICS MCUs BASED ON THE NEW ARM® CORTEX® -M85 CORE

Highest Performance Ideal for Vision AI Applications

- Powerful **Arm® Cortex® -M85** core with AI/ML capability
- **6.39 CoreMark/MHz** Demonstrated Performance

Advanced Graphics peripherals for high resolution displays

- Integrated Graphics capabilities support high resolution displays and camera applications
- Strong ecosystem partner network for Graphics and Vision AI

Advanced security for truly secure IoT

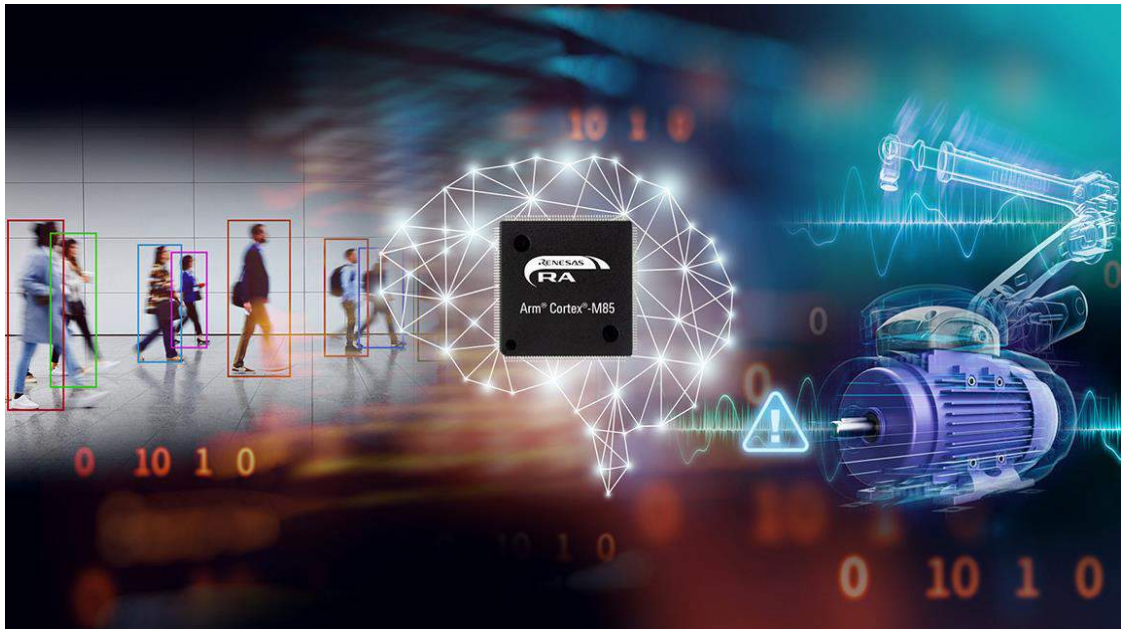
- **Hardware Root-of-Trust** and Secure Boot
- Advanced cryptography for secure element functionality
- **TrustZone** for isolation and system partitioning

Lower overall system power consumption

- Multiple low power modes & features
- 1.68-3.6V operating voltage

Ease of Development with comprehensive Software and Tools

- Flexible software package with RTOS
- Open architecture supports legacy code
- Robust partner ecosystem



INDUSTRY'S FIRST MCUS WITH NEW ARM® CORTEX® -M85 CORE!

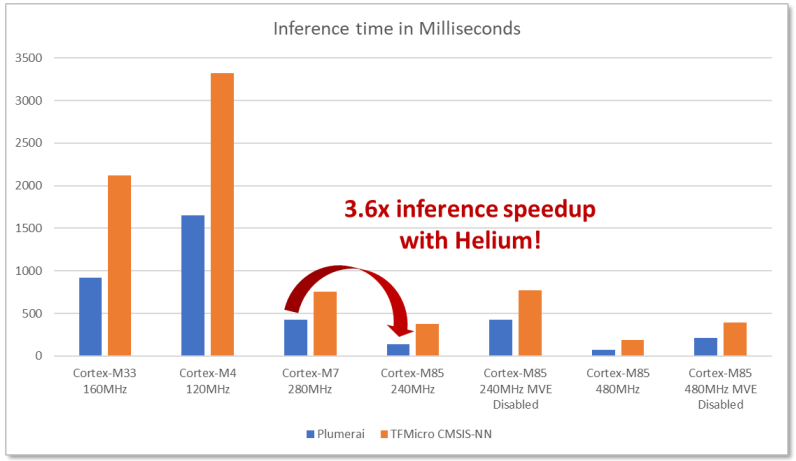
The new RA8 MCUs …

Bridge the gap between MCUs and MPUs

Enable compute-intensive applications with the lower power consumption and ease of use of an MCU

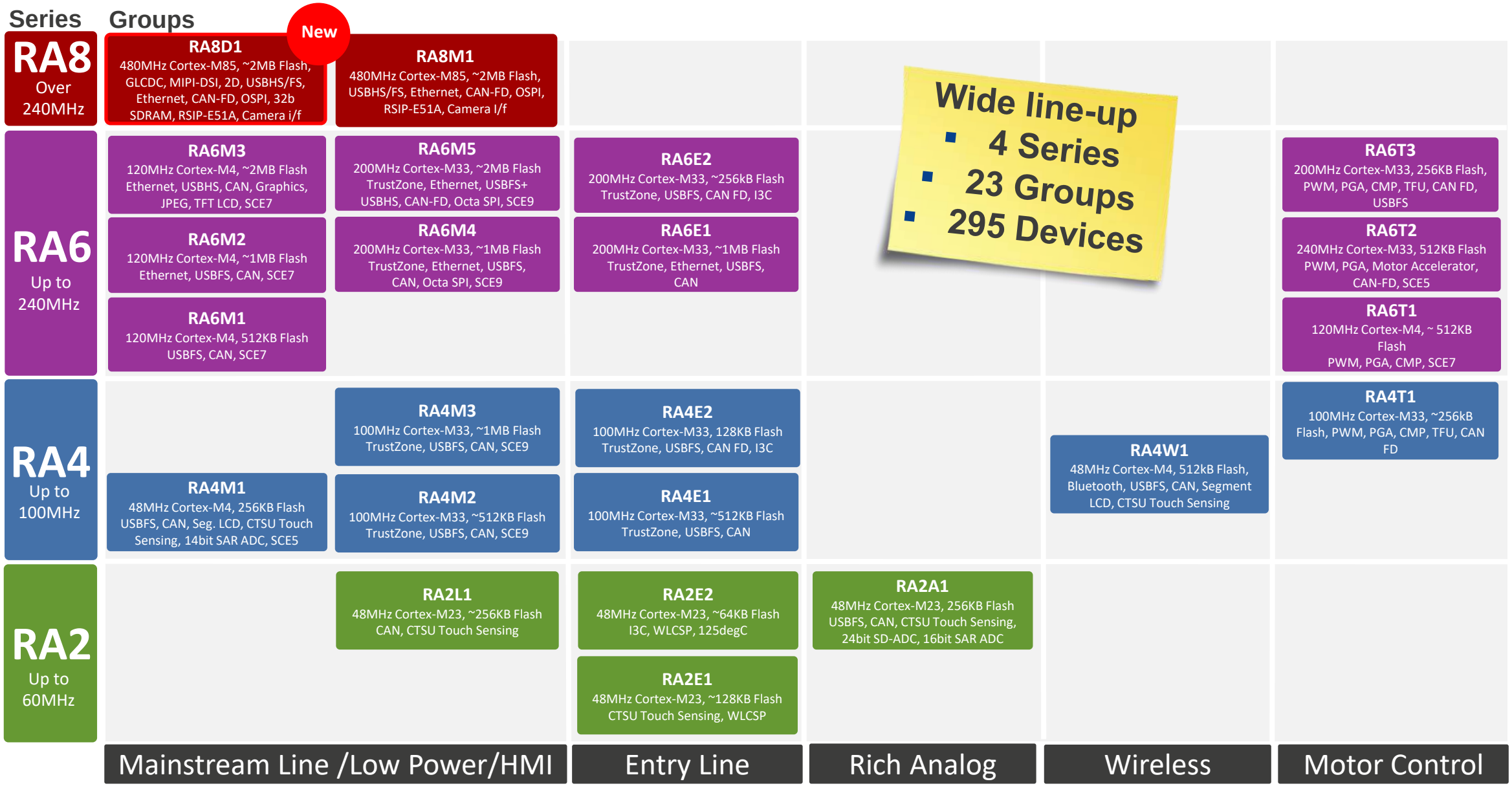
- First MCU with Arm® Cortex® -M85 Core Delivering **6.39 CoreMarks/MHz**
- Latest Arm v8.1-M Architecture with **Helium** accelerates DSP & AI/ML tasks
- Unprecedented **4X** DSP/ML & **30%** Higher Scalar Performance over Cortex-M7
- **Advanced security** with TrustZone and PACBTI

	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 32bit x 32bit	**2 32bit x 32bit 4 16bit x 16bit 8 8bit x 8bit**
CoreMark/MHz	5.29	**6.39**



Demonstrated Performance Uplift with Helium

RA FAMILY PORTFOLIO UPDATE



Status: 30th of May 2023

THE PRODUCT

RA8D1 MCU KEY VALUES
ENABLES GRAPHICS AND VISION AI APPLICATIONS

Industry's First MCU with new Cortex-M85 Core

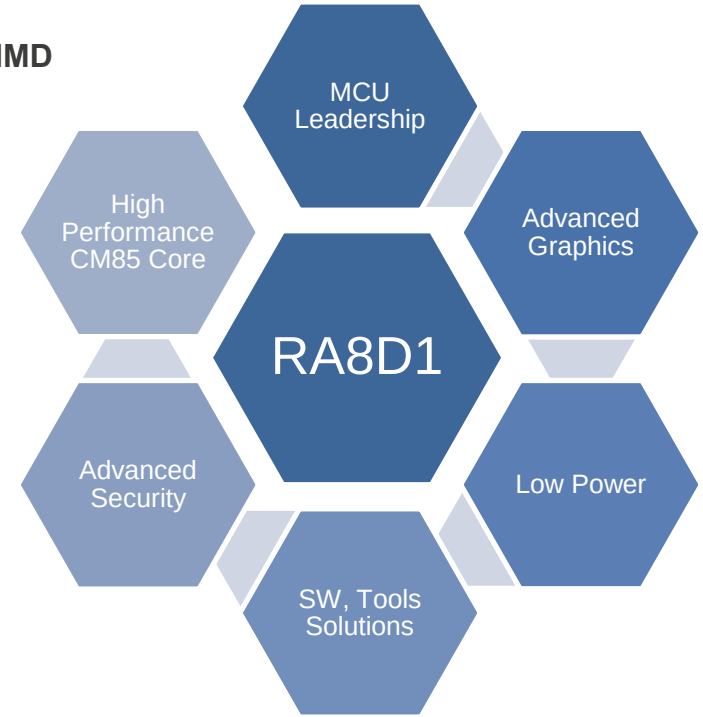
- Lead partner with Arm and first to market with Cortex-M85 core based MCU

Highest Performance

- **Powerful Cortex®-M85 core with Helium, Arm's SIMD Vector Extension**
- **Over 150 new scalar and vector instructions** for DSP/ML acceleration
- Higher performance and more energy-efficient than Cortex-M7 core

Advanced security

- Immutable storage for hardware Root-of-Trust
- Advanced cryptography with industry leading, NIST compliant algorithms
- Secure firmware programming, Secure debug
- TrustZone for isolation and system partitioning
- Secure interface to external flash (OctalSPI w/ Decryption-on-the-fly)



Advanced Graphics Integration

- High resolution Graphics LCD Controller w/ parallel RGB and MIPI-DSI Interfaces
- 2D Graphics Drawing Engine
- 16bit Camera Interface
- 32bit SDRAM for graphics frame buffers
- Embedded flash and SRAM
- OSPI interface to external flash for graphics assets
- Comprehensive graphics solution package with emWin and GUIX native support + Ecosystem partners

Low power consumption

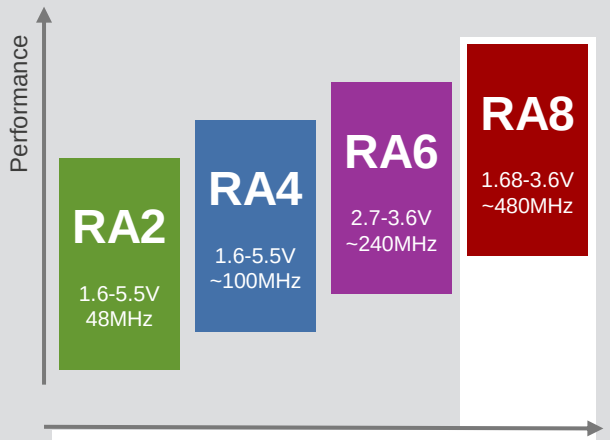
- 40nm process for low active and standby current
- 1.68-3.6V lower voltage operation
- Several low power modes/features to lower power consumption while providing high performance

Comprehensive Software and Tools

- Flexible software package with RTOS for faster development
- Open architecture supports legacy code and strong ecosystem
- Excellent industry standard tools to ease software development
- Advanced solutions for motor control, graphics & AI

RENESAS RA8D1 GROUP

ARM CORTEX-M85 CORE @ 480MHZ WITH 2MB/1MB FLASH, 1MB SRAM



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

RA8D1

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

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

Memory

- Flash (2MB/1MB)
- Flash Cache
- SRAM (1MB)
- - With ECC (384KB)
- - With parity (512KB)
- - TCM w/ ECC (128KB)
- I/D Caches (32KB)
- Standby SRAM (1KB)

Analog

- 12-bit ADC (2unit, 25ch, Unit0 w/ 3ch-S/H)
- 12-bit DAC (2ch)
- High-speed Comparator (2ch)
- Temperature Sensor

Timers

- 32-bit GPT (8ch)
- 16-bit GPT (6ch)
- 32-bit ULPT (2ch)
- 16-bit AGT (2ch)
- WDT
- RTC

HMI

- Graphics LCDC w/ RGB i/f
- 2D DRW
- MIPI-DSI I/f
- CEU Camera Interface

Communication

- Ethernet MAC w/ DMA (x1)
- CAN-FD (x2)
- USB2.0 HS (x1)
- USB2.0 FS (x1)
- SDHI (x2)
- I2C (x2), I3C (x1)
- SPI (x2)
- SCI (x6)
- SSI (x2)
- Octal SPI (x1, XIP&DOTF)
- External Memory Bus

System

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

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)
- RSA 4K, ECC
- TRNG
- SHA-2 (224/256/384/512)
- Secure Debug
- First Stage Boot Loader
- ROM (Immutable storage)
- TrustZone
- CMAC/HMAC/GMAC
- DPA/SPA Side Ch Protection

Package

- LQFP176
- BGA 224

RA8D1 GROUP FEATURES OVERVIEW

Performance	▪ **Unprecedented performance of 6.39 CM/MHz** with the Arm Cortex-M85 based on the **Arm v8.1-M** architecture, w/ superscalar 7-stage pipeline ▪ Helium, IEEE754-compliant Arm®v8.1-M Vector Extension accelerates DSP and AI/ML tasks ▪ **30% scalar performance and up to 4x DSP and AI/ML performance uplift** as compared to the Cortex-M7 core
Advanced Security	▪ **Advanced Renesas Security IP RSIP-E51A** for leading-edge cryptographic accelerators; **TrustZone and PACBTI** with the new CM85 core ▪ **Strong hardware root of trust** with **first stage bootloader in immutable storage providing a true Secure Boot**; Octal SPI with DOTF ▪ Secure debug, secure factory programming, secure FW updates, DLM support; Tamper and DPA/SPA side channel attack protection
Rich Graphics Peripherals	▪ **Graphics LCD Controller with parallel RGB and MIPI-DSI interfaces support resolutions up to WXGA**, ideal for high resolution displays ▪ 2D drawing engine offloads CPU for graphics rendering tasks and 16bit camera interface supports up to 5MP camera sensors ▪ Multiple external memory interfaces such as 32bit SDRAM interface and Octal SPI available for frame buffers and storage of graphics assets
Multiple memory options/ interfaces	▪ **Large 2MB/1MB embedded flash, 1MB SRAM enable graphics resolutions up to VGA resolution without external memory** ▪ **32bit SDRAM interface** provides high throughput interface to external SDRAM and **supports higher resolutions up to WXGA** ▪ Multiple memory interfaces provide flexibility – **xSPI compliant Octal SPI with XIP & DOTF** for secure interface to external memory + SDRAM i/f
Low Power Features	▪ **Multiple low power modes**, low active mode currents, low-speed active modes and fast wake-up time lower overall system power ▪ Low power features such as CPU sleep states, multiple power domains, power and clock gating, DCDC converter, state retention ▪ Wide voltage range of **1.68-3.6V**; **Vcc/Vcc2 domains** enable connection to 1.8V external components while rest of the MCU operates at 3.3V
Comprehensive SW & Tools	▪ **Flexible Software Package (FSP) with RTOS** provides comprehensive and highly flexible software and enables AI/ML, cloud connectivity, graphics and motor control solutions ▪ Industry standard Development Tools fully optimized for Cortex-M85 and Helium; Evaluation Kits for ease of development and debug

RA8D1 GROUP PRODUCT LINEUP

Flash/RAM	Tj			
2MB/1MB	-40 to 125 °C	w/o MIPI-DSI	R7FA8D1AHECFC	R7FA8D1AHECBD
		w/ MIPI-DSI	R7FA8D1BHECFC	R7FA8D1BHECBD
1MB/1MB	-40 to 125 °C	w/o MIPI-DSI	R7FA8D1AFECFC	R7FA8D1AFECBD
		w/ MIPI-DSI	R7FA8D1BFECFC	R7FA8D1BFECBD
Pin Count			176-pin	224-pin
Package type			LQFP	BGA
Package size (body)			24 x 24 mm	13 x13 mm
Pin pitch			0.5 mm	0.8 mm

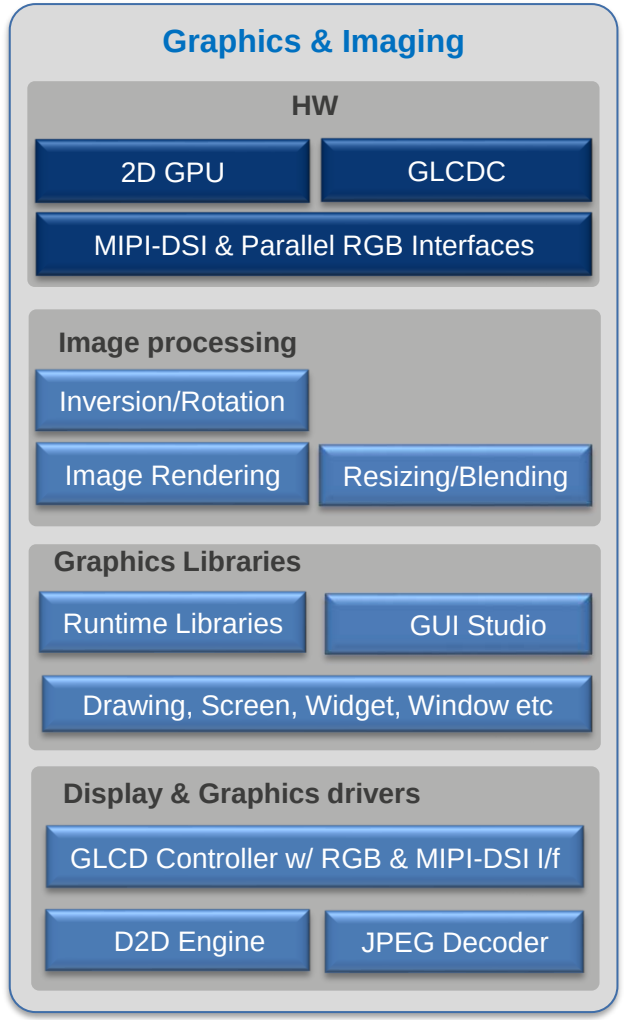
RA8D1 PART NUMBER LIST

Orderable Part Number	Flash	RAM	Data Flash	Operation Temperature Tj (°C)	Package		MIPI-DSI	Package dimensions (mm x mm)	Pin Pitch (mm)	Description
R7FA8D1AFECBD	1MB	1MB	12KB	-40 - 125	BGA	224	No	14x14	0.8	MCU RA8D1 ARM CM851M/1M BGA224
R7FA8D1BFECBD	1MB	1MB	12KB	-40 - 125	BGA	224	Yes	20x20	0.8	MCU RA8D1 ARM CM85 1M/1M BGA224
R7FA8D1AFECFC	1MB	1MB	12KB	-40 - 125	LQFP	176	No	24x24	0.5	MCU RA8D1 ARM CM85 1M/1M LQFP176
R7FA8D1BFECFC	1MB	1MB	12KB	-40 - 125	LQFP	176	Yes	13x13	0.5	MCU RA8D1 ARM CM85 1M/1M LQFP176
R7FA8D1AHECBD	2MB	1MB	12KB	-40 - 125	BGA	224	No	14x14	0.8	MCU RA8D1 ARM CM85 2M/1M BGA224
R7FA8D1BHECBD	2MB	1MB	12KB	-40 - 125	BGA	224	Yes	20x20	0.8	MCU RA8D1 ARM CM85 2M/1M BGA224
R7FA8D1AHECFC	2MB	1MB	12KB	-40 - 125	LQFP	176	No	24x24	0.5	MCU RA8D1 ARM CM85 2M/1M LQFP176
R7FA8D1BHECFC	2MB	1MB	12KB	-40 - 125	LQFP	176	Yes	13x13	0.5	MCU RA8D1 ARM CM85 2M/1M LQFP176

Part number	Title	Description
RTK7EKA8D1S01001BE	EK-RA8D1	Evaluation Kit for RA8D1 MCU Group

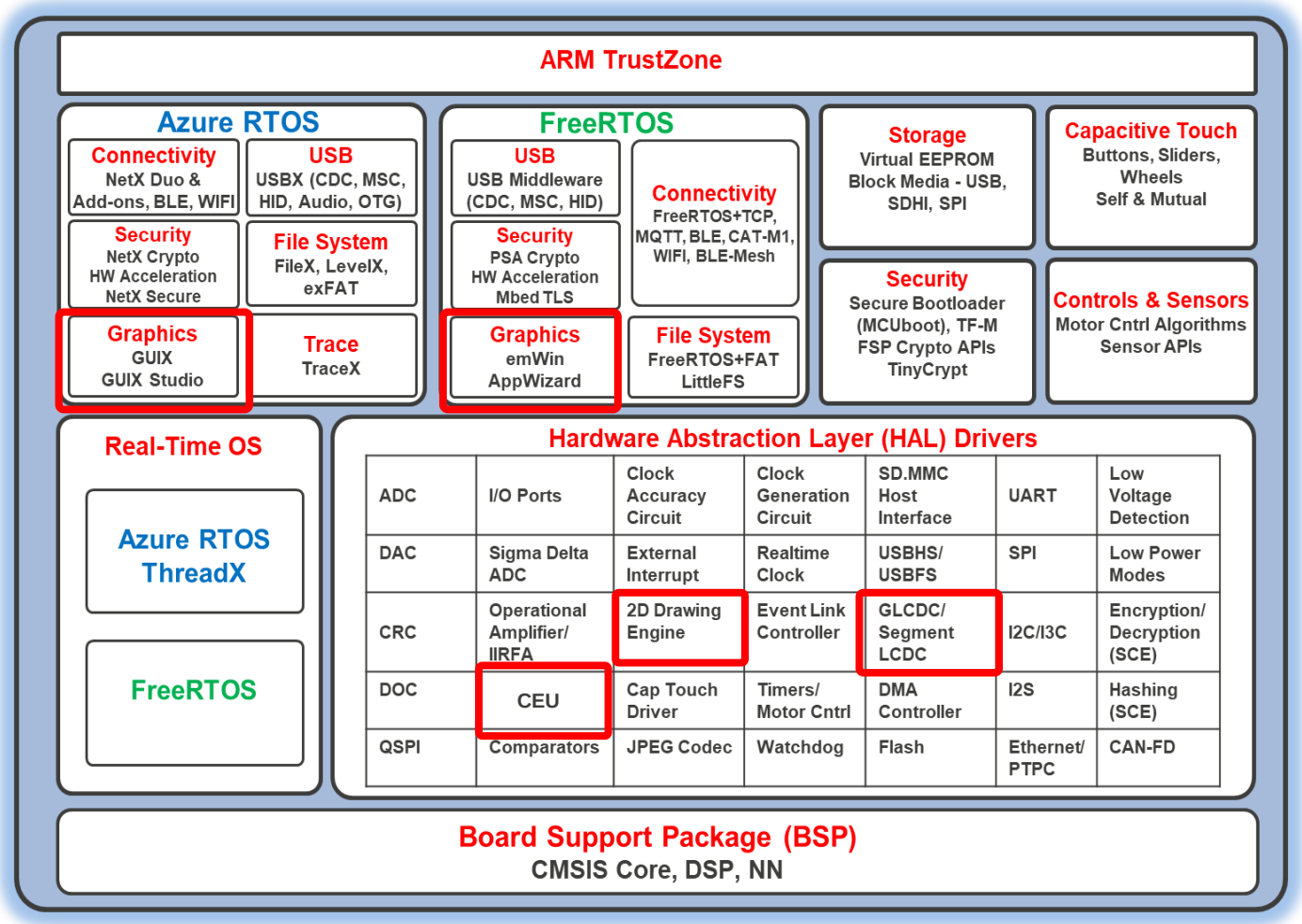
RA8D1 HMI SOLUTION

- **RA8D1 MCU**
  - Graphics LCD Controller with RGB Parallel and MIPI-DSI Interfaces
    - Highly configurable LCD Controller to drive a variety of TFT LCDs without CPU intervention
    - Support for panel resolutions up to WXGA
  - MIPI DSI Interface Option
    - High speed serial interface for low pin-count interface to MIPI DSI compliant displays
    - One clock lane and two data lanes; Up to 720Mbps per lane
  - 2D Drawing Engine to offload the CPU
  - 8/16bit Camera Interface (CEU)
  - Large flash and SRAM – 2MB Flash, 1MB SRAM support low resolution displays without ext. memory
  - 32bit SDRAM and OSPI interfaces to external memory
- **RA8D1-EK Graphics Kit**
  - RA8D1 graphics kit featuring TFT-LCD panel and camera module
- **Flexible Software Package with Graphics support**
  - Full featured emWin and GUIX graphics libraries including image processing, 2D acceleration, rotation/scaling, alpha blending etc.
  - Graphics peripheral drivers
  - Helium accelerated SW JPEG Decoder
- **Rich ecosystem partner support**
  - Native support for SEGGER emWin and Microsoft GUIX graphics stacks
  - Strong Graphics partner network



FLEXIBLE SOFTWARE PACKAGE GRAPHICS SUPPORT

- **Comprehensive graphics support integrated with FSP**
  - SEGGER emWin
  - Microsoft GUIX
- **Enhanced SEGGER emWin library using Helium instructions**. Integrated with FSP 5.0.0 and later!
  - **Enhanced JPEG decoder with Helium** to boost decoding performance - up to 27 fps end to end graphics performance
  - Enhanced graphics components in the emWin library
  - Easy to use APIs and GUI tools
  - Supports image processing, 2D acceleration, window manager, event processing, rotation/scaling etc.
  - Easy tool configurators to configure graphics modules
- HAL drivers for all graphics IP



RA8D1 TARGET APPLICATIONS

Industrial Applications	Consumer Products	Smart Home and Building Automation	Office Automation	Healthcare
▪ Industrial HMI ▪ Machine Vision	▪ Smart Appliances ▪ Video Doorbells ▪ Security cameras ▪ Robotic Vacuum Cleaners ▪ Exercise equipment ▪ Drones	▪ Security Panels ▪ Smart Thermostats ▪ Lighting Control ▪ Home Hubs/Gateways	▪ Barcode Scanners ▪ Fingerprint scanners ▪ QR Code readers ▪ Printer displays	▪ Patient Monitors ▪ BP Monitors ▪ Clinical equipment ▪ CPAP Machines
				

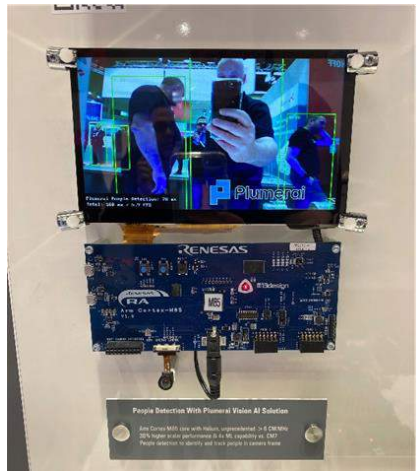
RA8D1 is ideally suited for HMI/Graphics and Vision AI applications

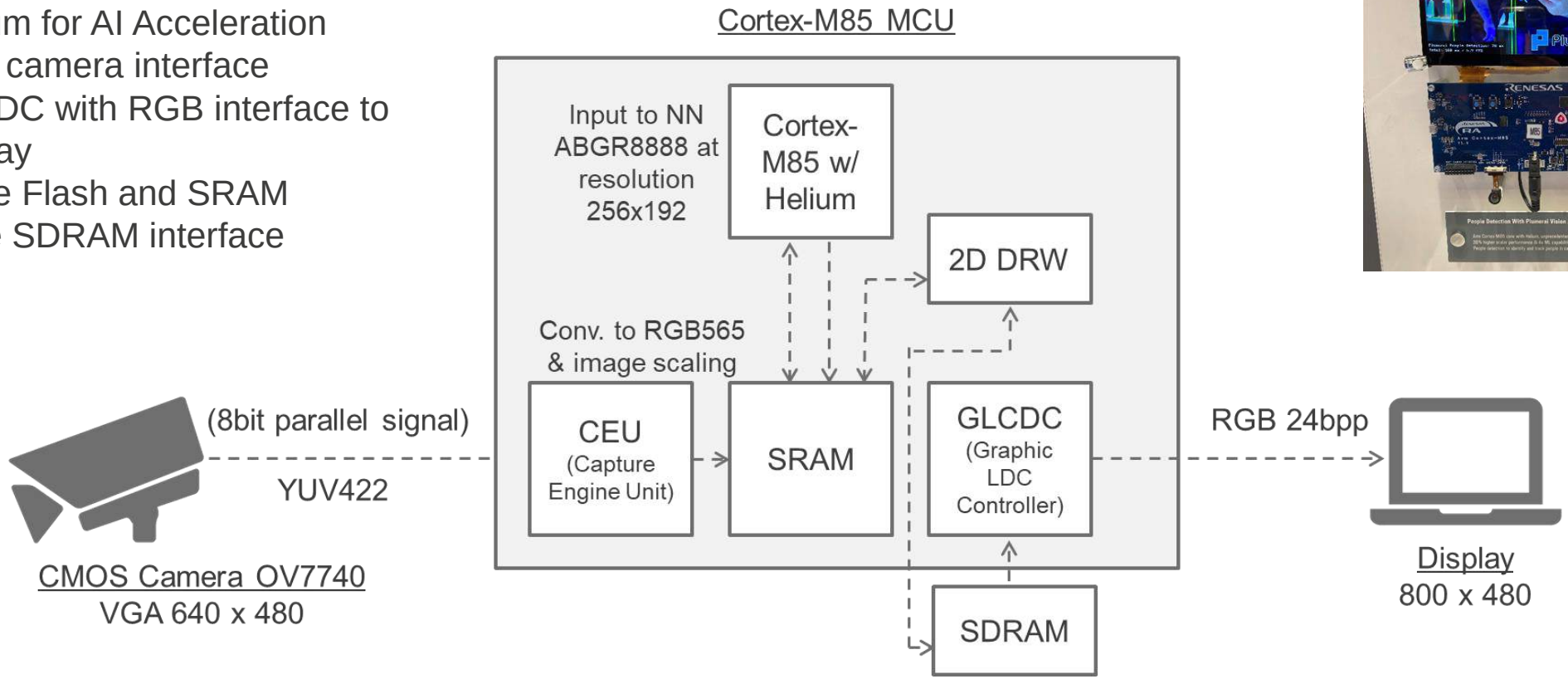
RA8D1 APPLICATION: PEOPLE DETECTION VISION AI

3.6x inference speedup over Cortex-M7 and 13.6fps inference performance, with Helium!

People Detection Vision AI

- Key Application Requirements:
  - Performance: 480MHz
  - Helium for AI Acceleration
  - CEU camera interface
  - GLCDC with RGB interface to display
  - Large Flash and SRAM
  - Wide SDRAM interface



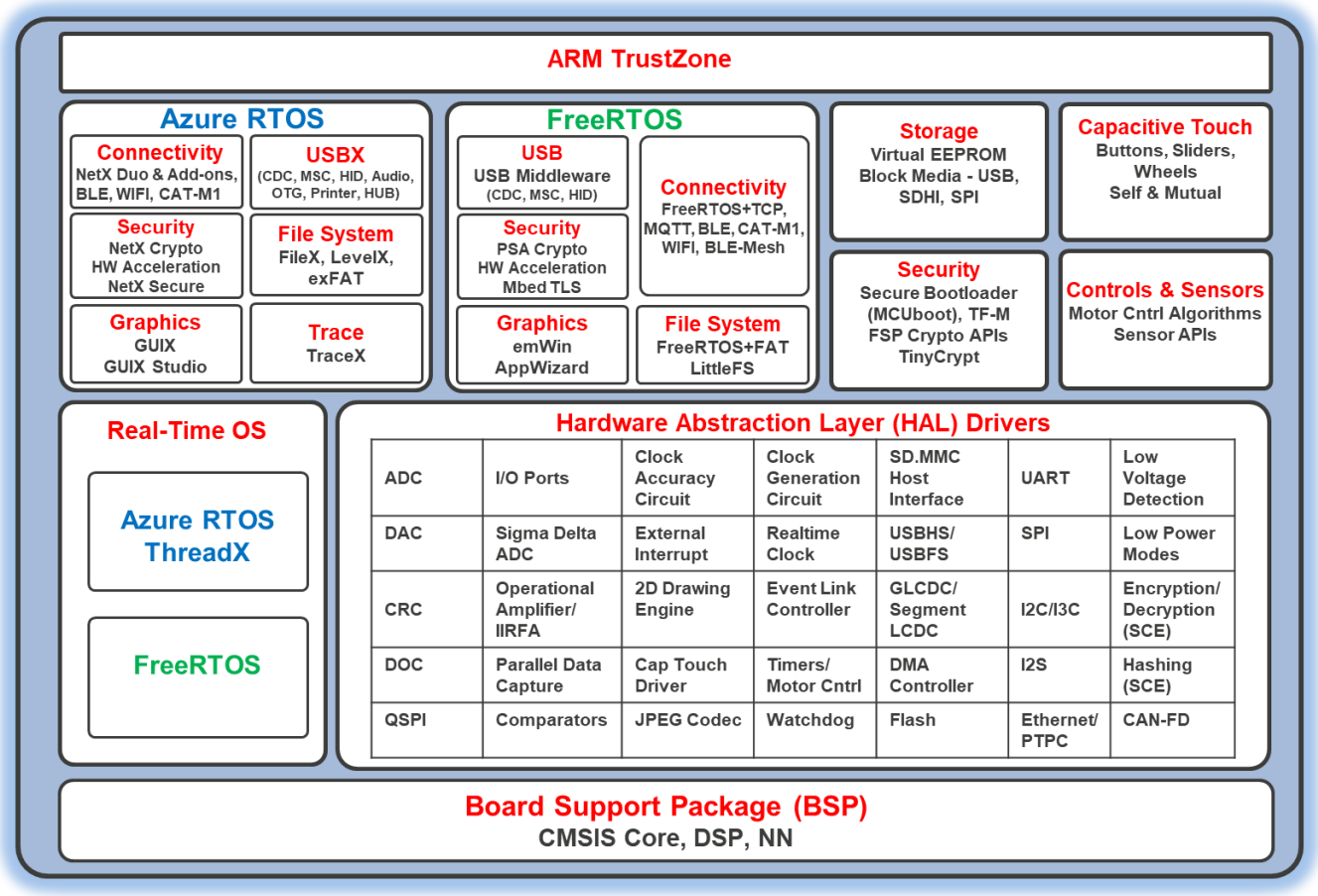


RA8D1 ENABLEMENT

FLEXIBLE SOFTWARE PACKAGE (FSP)

MIDDLEWARE AND DEVICE DRIVERS TO REDUCE TIME TO PRODUCTIZATION

Production Ready Peripheral Drivers	▪ HAL APIs to access all MCU peripherals ▪ ARM TrustZone Enabled ▪ Intuitive configurator and code generator ▪ Unit and system tested ▪ Static and dynamic analysis with industry standard tools
Uses RTOS Microsoft Azure aws	▪ Azure RTOS and FreeRTOS integrated with Flexible Software Package ▪ Tool configurable RTOS resources (Threads, mutexes, etc…) ▪ Bare metal support included
With Connectivity	▪ Includes Azure RTOS NetX Duo & add-ons, FreeRTOS TCP/IP stack, Secure Sockets, Cellular (CAT-M1), Wi-Fi & BLE/Mesh ▪ Includes MQTT and TLS ▪ Supports connectivity with all major Cloud Platform ▪ USB middleware for CDC, MSC, HID, Audio and OTG
And Security	▪ Cryptographic APIs based on Arm Mbed PSA, NetX Crypto and FSP Crypto APIs ▪ Crypto hardware acceleration supported ▪ PSA Level 2 and CAVP Certified ▪ Secure debugging



RA FAMILY DEVELOPMENT ENVIRONMENT
EASY TO USE AND FLEXIBLE

On-Chip Debug

- Renesas E2 & E2 Lite

- Segger J-Link

IDE

- Renesas e²studio

- Keil MDK

KEIL™ Tools by ARM

- IAR Embedded Workbench

Compiler

- GNU

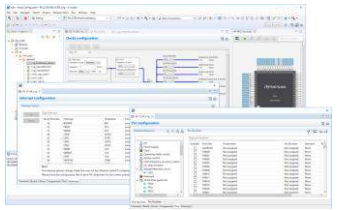
- Arm Compiler V6

KEIL™ Tools by ARM

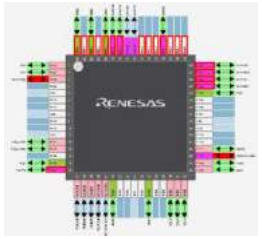
- IAR ARM Compiler
- Arm LLVM

Support Tools

- FSP driver selection and configuration



- Intelligent pin mapping



- Flash programmer
  - PG-FP6
  - RFP
  - A wide choice of 3rd party solution

Kits and Boards

- Evaluation Kits
  - EK-RA2A1
  - EK-RA2L1
  - EK-RA2E1
  - EK-RA2E2
  - EK-RA4W1
  - EK-RA4M1
  - EK-RA4M2
  - EK-RA4M3
  - EK-RA8M1
  - EK-RA4E2
  - EK-RA6M1
  - EK-RA6M2
  - EK-RA6M3
  - EK-RA6M3G
  - EK-RA6M4
  - EK-RA6M5
  - EK-RA6E2
  - **EK-RA8D1**
- Fast Prototyping Boards
  - FPB-RA2E1
  - FPB-RA2E2
  - FPB-RA4E1
  - FPB-RA6E1
  - FPB-RA4E2
  - FPB-RA6E2
- Solution Kits
  - RSSK-RA6M2
  - RSSK-RA6T1
  - MCK-RA4T1
  - RSSK-RA2L1
  - MCK-RA6T2
  - MCK-RA6T3

EK-RA8D1

EVALUATION KIT FOR RA8D1 MCU GROUP

Key Features

Special Feature Access

- MIPI DSI & Parallel Graphics Expansion Ports
- Camera Expansion Port
- Ethernet
- USB High Speed Host & Device
- 64 MB SDRAM
- 64 MB External Octo-SPI Flash

MCU Native Pin Access

- R7FA8D1BHECBD MCU
- 480 MHz, Arm Cortex®-M85 core
- 2 MB Code Flash, 1 MB SRAM
- 224 pins, BGA package
- Native pin access
- MCU & USB current measurement
- DC/DC mode configuration

Ecosystem & System Control Access

- USB Full Speed Host & Device
- 5 V input through USB (Debug, FS, HS) or external power supply
- Debug on-board (Segger J-Link®)
- Debug in (ETM, SWD & JTAG)
- Debug out (SWD)
- 3 User LEDs & 2 User buttons
- 2 SeeedGrove® system (I2C & analog)
- 2 Digilent Pmod™ (SPI & UART)
- Arduino™ (Uno R3)
- MikroElektronika™ mikroBUS
- SparkFun® Qwiic® (I2C)
- MCU boot configuration jumper

renesas.com/ra/ek-ra8d1

(User manual, quick start guide, development tools, schematics, design files & example projects)

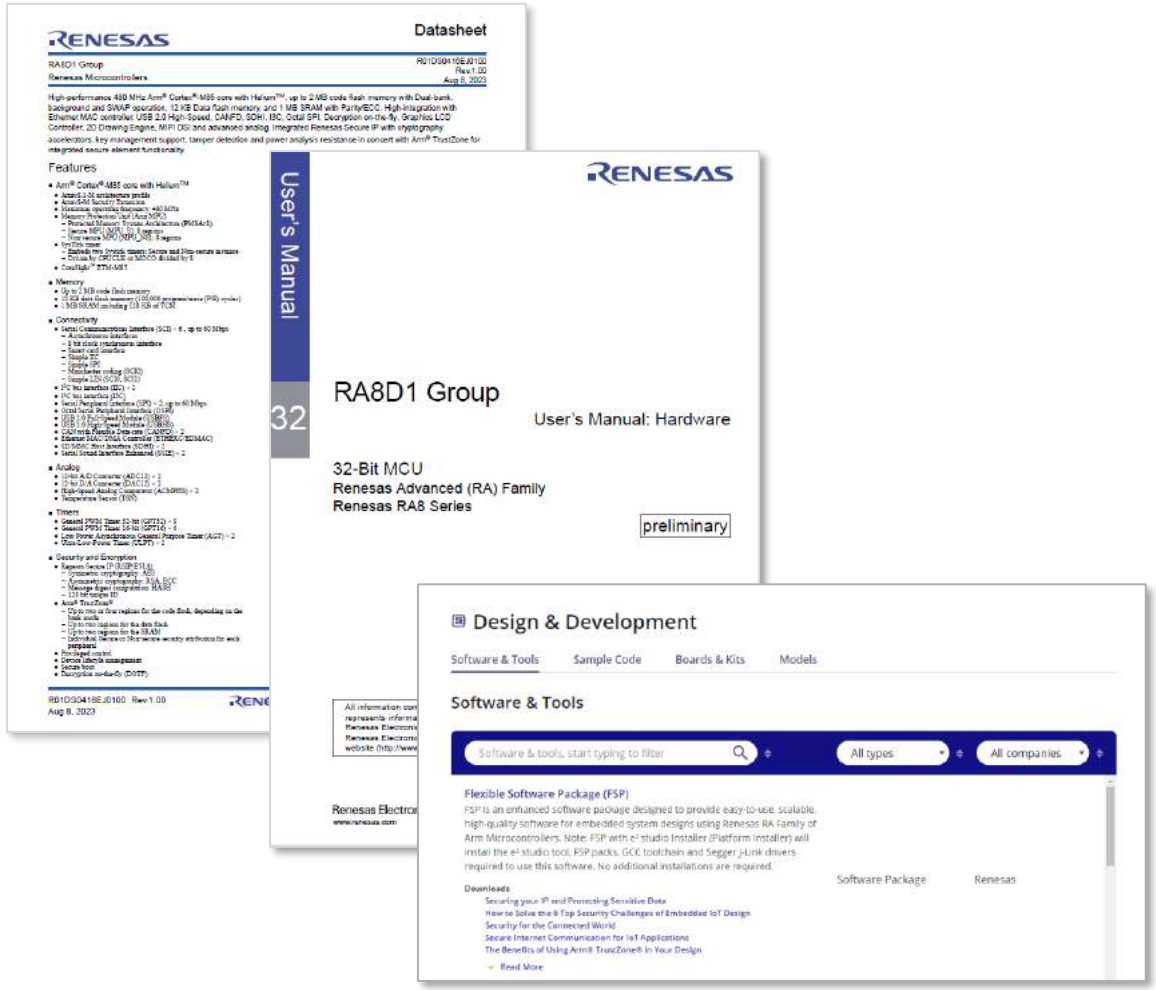
RTK7EKA8D1S01001BE

(Orderable part number)

RA8D1 COLLATERAL

Please visit: renesas.com/ra8d1

- **Product Documentation**
  - RA8D1 Group Flyer
  - RA8D1 Hardware User Manual v1.x
  - RA8D1 Datasheet v1.x
  - EK-RA8D1 Quick Start Guide
  - EK-RA8D1 User Manual
  - FSP v5.0 GA Release
  - FSP User Manual
  - Development Tools w/ CM85 support
  - RA8D1 Application Notes
  - RA8D1 Example Projects



EXPANSIVE 3RD PARTY SOLUTIONS PORTFOLIO

RENESAS RA READY

NEW Solution page released

Under preparation

AI/ML

AIZIP, SYNTIANT, AVNET, DEEPINSIGHT, Qeexo, EDGE IMPULSE, ignitarium, STREAM ANALYZE, 新光商事 Shinko Shoji Co.,Ltd., AISing, Micro.ai, SensiML, Plumerai

TOOLS & UX

SMH Technologies, GaleComm, Algocraft, AlphaProject, HOKUTO ELECTRONIC, RTOS, GRAPE SYSTEMS, アイフォーコム IFORCOM, Flash Support Group, CapExt, MIKROE, MINATO, Ubiquitous AI, SEGGER The Embedded Experts, arm KEIL, HCC embedded, iar, KHC, TAKAOKA TOKO CO., LTD., PHYTEC, SECURE THINGZ, DTS INSIGHT, eForce

SECURITY & SAFETY

KUDELSKI IOT THINGS, HCC embedded, SECURE THINGZ, ORYX EMBEDDED, CRYPTO QUANTIQUE, Cypherbridge Trusted, safe and secure, ECO-LUX, 0x5 HEX-Five, iar, Orchestrating a brighter world, NEC, SMARTAXIOM, MXIC Macronix International Co., Ltd., CollaboGate, eps, Veridify Security, wolfSSL, Ubiquitous AI, PX5 RTOS, SEGGER The Embedded Experts

CONNECTIVITY & CLOUD

Alibaba Cloud, arm PELION, Proassist, ABUP 艾拉比, AliOS Things, clarinox, HCC embedded, HOLD, 腾恺科技, Microsoft Azure, Panthronics, twilio, reloc, nabto connect - simple and secure, Ubiquitous AI, TencentOS Tiny, HUAWEI, silex technology, AltoBeam, aws, Micro.ai, RT-Thread

COMMUNITY OF 100+ PARTNERS

HUMAN MACHINE INTERFACE

CRANK SOFTWARE, AREX, WITTENSTEIN, CEVA, CapExt, NDS 株式会社大阪エヌデーエス, DSP CONCEPTS, eTOUCH, FDI, HGI, Pachira, Qt, 文曄科技, Advanced Media, Inc., KDDI KDDI Research, NEWTECH INTL SOL, Cyberon, SEGGER The Embedded Experts, sensory, TES Electronic Solutions, Algorithm Specialist TMC, TOSHIBA, AIFA 艾法科技, EDGE IMPULSE, RT-Thread, Intelliod, LVGL

SENSING & CONTROL

BFG ENGINEERING, CECport 中电港, Desk Top Lab, MathWorks, COMMOTECH 晶像電子 全方位專業電子零件代理商

APPLN SPECIFIC/ EMERG

GT&T, NTX Embedded, arm PELION, SWISYS, CS Lab, MBS Made by Specialists, TMG TE, RT-Thread, ePROSIMA The Middleware Experts, gayatri Comtek Lab, HWI Go For Together, utthunga, TATA ELXSI, JNet, ORBSTAR, Serious, WITTENSTEIN, TERRANOVA INNOVATIONS FOR UTILITIES, CAD-IT CONSULTANTS, L&T Technology Services, port PROFESSIONAL INDUSTRIAL COMMUNICATION

RENESAS

SUMMARY: RA8D1 KEY MESSAGES

- **Graphics enabled 32bit MCU based on the new ARM® Cortex®-M85 core** demonstrated at Embedded World 2022/2023
- **Highly integrated MCUs with rich graphics features** that enable vision AI and high-resolution graphics applications and simplify customers' design and development process
- **Bridge the gap between MCUs and MPUs** and enable compute-intensive applications with the lower power consumption and ease of use of an MCU
- **Significant step up in performance**, based on Arm v8.1-M architecture
  - >6 CoreMarks/MHz
  - 30% uplift in scalar performance and 4x ML performance compared to CM7
  - 20% vector performance uplift compared to the CM55 and features
  - Helium enables advanced DSP/ML capabilities for compute intensive applications such as endpoint AI
  - Brings TrustZone to highest performance M-class cores
- **Comprehensive solution** with FSP, tools, kits and solutions