

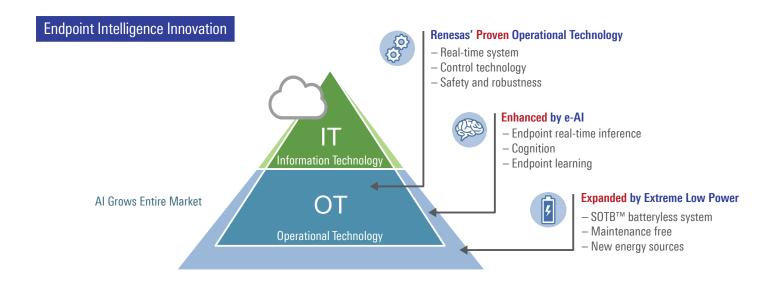
ENHANCING ENDPOINT INTELLIGENCE

With Embedded Artificial Intelligence (e-AI) from Renesas



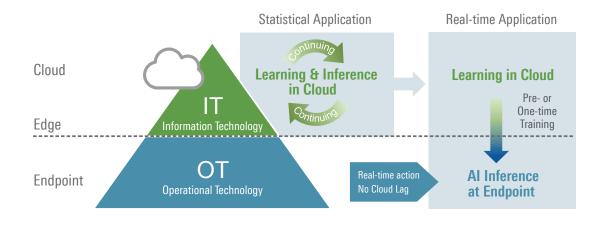
Real-time Intelligence without Cloud Lag

Artificial Intelligence is rapidly driving growth in the information technology (IT) and operational technology (OT) domains. For years, Renesas has been a leader in OT endpoint applications with microprocessor and microcontroller solutions. Leveraging that experience, Renesas' e-Al solutions are enhancing OT-based systems and products that we use around us every day by placing Al where it matters the most – at the endpoint – while decoupling dependency on the Cloud for real-time decisions and real-time action. Additionally, Renesas will expand e-Al application possibilities with the use of its exclusive extreme low-power process technology, Silicon On Thin Buried Oxide or SOTB[™], to enable batteryless solutions powered only by harvested ambient energy. Think of the possibilities.



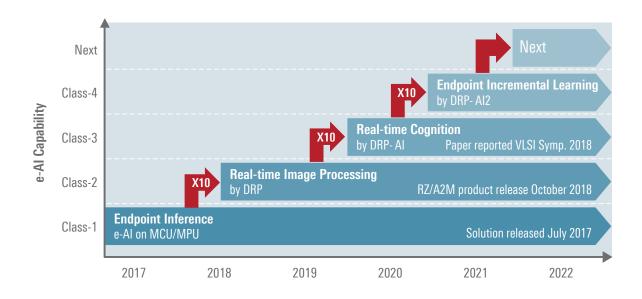
e-Al: Local Real-time Al by Inference

- Traditional statistical AI applications execute completely in the Cloud
- Real-time applications cannot tolerate cloud lag at the endpoint
- e-Al takes immediate action locally through inference from cloud-trained Al neural networks



e-AI Capability Advancements

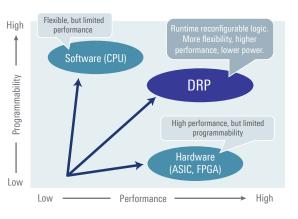
- Renesas is evolving e-Al. Classes 1 through 4, and beyond, increase capability incrementally at each step while keeping similar power consumption
- Exclusive Dynamically Reconfigurable Processor (DRP) technology and architecture accelerate image processing, object recognition, AI, and cognitive decision making
- Each evolution step represents 10 times the previous computing power due to DRP (see below) advancement
- Class 4 represents capability of incremental learning without connection to the Cloud to solve complex graphical problems and process multi-sensor inputs for robotics



Dynamically Reconfigurable Processor (DRP)

- DRP Reconfigurable Acceleration Hardware
 - Multi-application, massively parallel processor
 - Offloads main processor for specialized tasks
- Extreme Efficiency
 - Higher performance and lower power than use of CPU, GP-GPU, DSP, or FPGAs
 - Reduced memory requirements and memory access
- Flexibility
 - Run-time reconfigurable logic can execute different tasks as needed on each DRP processor cycle
 - Continuous new functions available to deployed products extend product life
- Acceleration
 - Image processing: edge detection, gray level, feature extraction, and more
 - Next: Al acceleration





Accelerate Video Processing with DRP

Process	Execution Time (ms)	
	DRP	CPU
Canny Edge Detection	9.3	138.3*
Harris Corner Detection	13.8	294.1*
QR Marker Detection	31.3	223.0**

* CPU: Using OpenCV (cv::medianBlur+cv::Canny) ** QR Marker detection: ZBar (cv::medianBlur+Zbar detection)

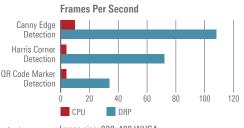


Image size: 800x480 WVGA Image color: Grayscale 8BPP CPU: RZ/A2M Cortex*-A9 @ 528 MHz DRP: Frequency 33 MHz ~ 66 MHz

RZ/A2M Microprocessor with DRP – Hardware Acceleration for e-AI

New in RZ/A2I

Performance and Flexibility

- Ideal for Human Machine Interface (HMI)
 - Multiple video output standards
 - Multiple graphics engines
- Accelerate Image Recognition
 - Boost image processing x10 with DRP
 - MIPI CSI camera interface
- Advanced Security
 - Secure boot, communication, and update

Software Package for AI+HMI

- RTOS, drivers, and middleware
- DRP tools, libraries, and application layer
- Smart configurator for SDK
- Quick and efficient camera/display graphical configuration with real-time feedback
- Seamless integration with TES Guiliani GUI framework

RZ/A2M Evaluation Platform

- Supports DRP evaluation
- MIPI Camera Module (MIPI CSI)
- HyperMCP with HyperFlash[™] and HyperRAM[™]
- RGB conversion board for HDMI display
- 2ch Ethernet communication
- Other peripheral functions, such as SDHI and USB

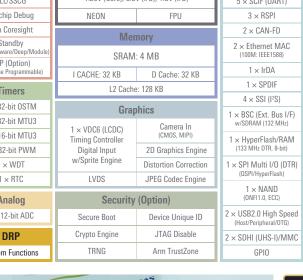
Kit Part Number: RTK7921053S00000BE

Learn more: https://www.renesas.com/RZA2M

RZ/A2M Microprocessor Block Diagram

System	C	PU	Interfaces
16 × DMAC	Arm Co	Arm Cortex [®] -A9 528 MHz (1320 DMIPS)	
Interrupt Controller			
PLL/SSCG		1.20V (Core), 3.3V (I/O), 1.8V (I/O)	
On-chip Debug	NEON	FPU	3 × RSPI
Arm Coresight	Ma	Momory	
Standby (Sleep/Software/Deep/Modu	2)	Memory SRAM: 4 MB	
OTP (Option) (One Time Programmable)	I CACHE: 32 KB	D Cache: 32 KB	$1 \times IrDA$
Timers		L2 Cache: 128 KB	
2 × 32-bit OSTM			
	Grap	Graphics	
1 × 32-bit MTU3	1 × VDC6 (LCDC)	Camera In	w/SDRAM (132 MHz)
8 × 16-bit MTU3	Timing Controller	(CMOS, MIPI)	1 × HyperFlash/RAM (133 MHz DTR, 8-bit) 1 × SPI Multi I/O (DTR)
8 × 32-bit PWM	Digital Input	2D Graphics Engine	
$1 \times WDT$	w/Sprite Engine	Distortion Correction	
$1 \times RTC$	LVDS	JPEG Codec Engine	(QSPI/HyperFlash)
Analog	Security	Security (Option)	
8×12 -bit ADC	Secure Boot	Device Unique ID	2 × USB2.0 High Speed (Host/Peripheral/OTG)
DRP	Crypto Engine	JTAG Disable	2 × SDHI (UHS-I)/MMC
Custom Functions	TRNG	Arm TrustZone	GPIO

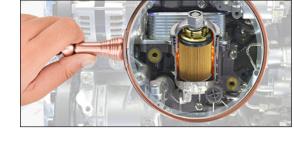




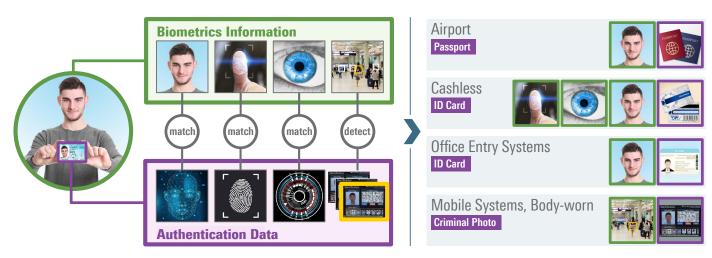
e-AI Use Cases

Class 1: e-AI Failure Prediction for Motors

- Detects previously invisible faults in real time by minutely analyzing oscillation waveforms from motors through current, vibration, or sound
- Predicts failure before it occurs to enable early warning
- Improves service quality, avoids downtime, and reduces maintenance costs



Classes 2 and 3: e-Al Multimodal Biometrics Authentication by Image Recognition



e-AI Deployed at Renesas Semiconductor Factory

Smart Factory moves from Preventive Maintenance to Predictive Maintenance

- Successfully detected defective wafers using e-AI, same as human experts could do
- Reduced false alarms from 50 incidents per month to ZERO
- Anomaly detection rate improved by 6x
- Reduced engineering resources required to respond
- Eliminated requirement to set statistical thresholds

Renesas installed over **150 AI units** into one of its own semiconductor factories, with **3,000** more AI units on the way



Learn more about Renesas e-AI solutions at:

https://www.renesas.com/e-ai

Renesas Electronics Corporation www.renesas.com

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