Industrial Automation

Be it for drives, control, sensor, and communication applications, Renesas accelerates application development with dedicated industrial automation solutions. Furthermore providing functional safety and security technology from Renesas pave the path to Industry 4.0 and Industrial Internet of Things applications.

What is R-IN Consortium?

The R-IN Consortium is a partner collaboration that makes factory more efficient and provides added value. It serves as a venue for creating platform solutions for Industry 4.0.

By providing supports needed to customers that develop industrial systems, the consortium solves various issues and encourages the early market penetration of new products.

Renesas offers optimized solution for each application such as Motor Control, Controllers, and Sensors. Also offers solutions for common technology such as Industrial Network, Functional Safety, and Security.

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- Application and Common Technology ___________________________________________ 2
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- For further information, visit our website: http://www.renesas.com/RinConsortium

Autonomous collaboration among partners gives industry systems (factory) more efficient, more added value and more market activation. The R-IN consortium aims more business creation w/ customers by offering valuable industrial solutions.
The Shortest Route to Industry 4.0
RZ/N Series Accelerate Development of Industrial Network Equipment

Provide Suitable LSI for various industrial network compatible applications
• Suitable for PLC and Ether switch with five Ports Gbit Ether switch and two independent GMAC unit.
BGM cost can be reduced by peripheral components integration.
• Provide three kinds of CPU lineup with Cortex®-A7 Dual Core (500MHzx2), Single Core (500MHz) and R-IN engine (125MHz)

Major industrial Ethernet protocol (Slave) can be realized with built-in R-IN engine
R-IN Engine can support a wide range of protocols and high-speed processing for communication processing.
Moreover, Cortex®-A7’s high CPU processing performance and large capacity memory can support various applications.

Slave protocol stacks
EtherCAT®, EtherNet/IP™, ETHERNET Powerlink®, PROFINET®, Sercos®, CANopen®

Implemented redundant network configuration to reduce network downtime to zero
• Duplicating Network : PRP (Parallel Redundancy Protocol)
• Looping Network : HSR (High-availability Seamless Redundancy)

RZ/N Series Product Lineup

The Shortest Route to Industry 4.0
RZ/N Series Accelerate Development of Industrial Network Equipment

Currently there are mainly two types of industrial network. First one is used in fieldbus networks to ensure real-time control for the various automates such as motors and I/Os. and the other network are used in the control networks in order to ensure reliability of the network for the managed server, controller and so on.

In existing networks, a clear separation between fieldbus net works and control networks exists. However, this divergence tends to become thinner as the industry networks evolve towards unified networks following the Industry 4.0 movement. RZ/N1 Series revolutionizes this approach as Industry’s one-chip solution that supports all major industrial protocol networks

Deployment of RZ/N Series

<table>
<thead>
<tr>
<th>RZ/N1D Group</th>
<th>RZ/N1S Group</th>
<th>RZ/N1L Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Port Ethernet and latest redundancy protocol supports Industrial Network Master application such as PLC</td>
<td>Having large size internal RAM will reduce peripherals to realize small PLC and HMI. Also built in R-IN Engine can realize Gateway and Sensor Hub</td>
<td>Supports main Industrial Ethernet Protocols by having dedicated HW (EtherCAT and Sercos III) and R-IN engine</td>
</tr>
</tbody>
</table>

RZ/N Series Target Application
Functional Safety Solutions to Bring Safety and Reassurance to Industrial Systems

The importance of "functional safety" in the industrial field, which aims to maintain safety even when malfunctions occur, is increasing to prevent the adverse effect of breakdowns and accidents inside plant operation, the adverse effect of injuries to operators, and the associated economic losses. The European Union’s Machinery Directive and workplace safety laws in many countries require equipment to meet functional safety standards.

To reduce the development burden on customers as the application of functional safety standards expands within many industrial fields, Renesas offers functional safety solutions: safety packages, safety reference kits, and development tools with safety support.

Supports developing safety systems

Safety analysis information on the microcontroller, self-diagnostic software, and system reference materials for industrial safety applications are provided, making it possible to develop safety equipment in shorter time.

Achieving higher level of safety

Microcontroller self-diagnostic software with a high diagnostic coverage to meet IEC 61508 SIL3 and dual microcontroller system will make it possible to achieve higher level of safety.

Third-party certified

The RX microcontroller’s self-diagnostic software and development tools with safety support have been certified by TÜV Rheinland.

Solution Roadmap

Safety package (microcontroller self-diagnostic library)
- Define safety manual and self-diagnostic software library.
- IEC 61508 SIL3 certified.
- Reference version and full product version available.

Safety reference kit
- Reference hardware (board), software, and documentation to assist application development

Development tools with safety support (IAR Systems)
- IAR Embedded Workbench for RX Functional Safety edition
- IEC 61508 SIL3 certified compiler environment

Development tools with safety support (Renesas original)
- CC-RX compiler V2.00.80
- IEC61508 SIL3 certified compiler environment

For further solution enhancement

Safety Package

- CPU, RAM, FlashROM

Certification Support

- Seminar: Seminar for understanding effectiveness of Renesas functional safety solution
- Design Consulting: Consulting of safety concept, designing, implementation and evaluation
- Software Development: Collaboration of the safety software to the specification of the customer

Certification Support

Reference Hardware

- Function and performance evaluation board with RX microcontroller
- Reference board
- User’s manual with design data (connection diagrams, parts list)

Reference Software

- Various diagnostic software for RX microcontroller peripherals
- Sample source code
- Evaluation application software, Middleware for MCU peripheral diagnosis, Peripheral driver (Self-diagnostic software is not included)
- API specification

Safety Reference Kit

- Safety-related documents, and documents covering diagnostic and control methods, required CPU performance, etc. (Total 18 documents)

Safety Manual Contents

- Description of self-diagnostic software library, indications of diagnostic coverage and failure rates

Certification

- IEC 61508 SIL3 certified by TÜV Rheinland

Safety Package

- For IAR: Product version RTK0005P000001SJ RTK501110P000001SJ
- For CC-RX: Product version RTK0004P000001SJ RTK501002P000001SJ

Reference Hardware

- RTK0005D0000101SJ RTK501110D0000101SJ
- RTK0005P0000101SJ RTK501110P0000101SJ

Reference Software

- All document set: RTK0008P0000101SJ
- Only for evaluation of self-diagnostic software on only RX32 board

Reference Documents

- Safety plan (SP), Verification and validation plan (V&V), Safety requirements specification (SRS), Safety concept (SC)
- Inter-MCU communication, Software error diagnosis, Power supply voltage diagnosis, Other circuits diagnosis
- FMEA, coverage computation and more

Time-efficiency by Functional Safety Solution

Reduced 3 years to 1 year

Conventional SIL certification phase

Certification Support

- Reference Kit: Safety reference kit
- Safety Package: Safety package

Main innovation

Adopt

Implementation Evaluation

Introduction

Concept

Imp. Est.

For further solution enhancement

Certification

Product List

RX631/63N RX111

RX631/63N RX111

Available now

Available now

Available now

Available now

RX631/63N Safety package

RX111 Safety package

RX631/63N Safety reference kit

RX111 Safety reference kit

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RX111 Safety package

RX631/63N Safety reference kit

RX111 Safety reference kit

RX631/63N CC-RX compiler

RX111 CC-RX compiler

For IAR: Product version RTK0005P000001SJ RTK501110P000001SJ

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Documents set for the concept phase extracted from the all documents set

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- For CC-RX: Product version RTK0004P000001SJ RTK501002P000001SJ

Reference Hardware

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- RTK0005P0000101SJ RTK501110P0000101SJ

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Product List

RX631/63N RX111

RX631/63N RX111

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Available now

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RX631/63N Safety package

RX111 Safety package

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RX111 Safety reference kit

RX631/63N CC-RX compiler

RX111 CC-RX compiler

For IAR: Product version RTK0005P000001SJ RTK501110P000001SJ

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Documents set for the concept phase extracted from the all documents set

All document set RTK0005P0000101SJ RTK501110P0000101SJ RTK0008P0000101SJ
Renesas Security Solution Contribute to Realize Safe and Secure Industry Automation

Industry 4.0 is gaining its speed. By ensured security into machines to machines network in the factory will maximize the value of connected factory. Renesas chip security technology and solution will be the root of trust of your product, contributing robust and securing the system.

Confidentiality
Visualization of the data is one of value brought by connected factory — The exchanged data between machines must be properly protected from eavesdropping.

Integrity
Availability of the factory machines are rely on the integrity of the program and data stored in silicon — must be protected from unauthorized tampering.

Authenticity/Availability
Is your installed machine or parts is the genuine? For connected factory management will require an authentication between machines to machine, main unit and replacement parts.

<table>
<thead>
<tr>
<th>Products</th>
<th>Functions</th>
</tr>
</thead>
</table>
| RZ/T1    | • JTAG connection lock / JTAG connection certification  
            • Secure Boot |
| RZ/A1    | • External ROM program tamper check  
            • Encryption of encrypted external ROM program and expansion to internal memory  
            • Hash copy detection of external ROM |
| RZ/G Series | • Secure Kernel Boot  
                  • Encrypted communication  
                  • Basic encryption library |
| RX231    | • Secure Boot  
                  • Encrypted communication  
                  • Secure update |

Our device solution contributes to secure the IA products

HMI
RZ/A Series:
• External ROM program tamper check  
• Encryption of encrypted external ROM program and expansion to internal memory  
• Hash copy detection of external ROM  
• Secure Kernel Boot  
• Encrypted communication  
• Basic encryption library

Controller/PLC
RZ/G Series:
• Secure Kernel Boot  
• Encrypted communication  
• Basic encryption library

Sensor/Actuator
RX231:
• Secure Boot  
• Encrypted communication  
• Secure update

Root of Trust — Protecting Customer’ Important Assets
Inside conventional MCU just with encryption accelerator, there is a risk that the customer key stored in flash memory without proper protection — can be tampered or stolen by attacker.

By having Renesas Trusted Secure IP, the key will be securely protected by access protection mechanism to the encryption engine itself and unique ID based proprietary mechanism to prevent from unauthorized access. Trusted Secure IP will contribute to secure your product as the root of trust.

General-purpose MCU with conventional crypto engine

CPU

Crypto engine

Unprotected storage of encryption key

Encryption key

Flash memory

General-purpose MCU with Trusted Secure IP (ex. RX231)

CPU

Trusted Secure IP

Secure storage of encryption key

Key generation information

Unique ID
Renesas Industrial Network Solution
Contribute to Realize Smart Society

There are various protocols for industrial network and there are made the best use of various features. However, coexist of various protocols is the challenge for realizing smart society that require interoperability. Renesas has various product/solution and overcomes challenges with customer.

Various products to solve any industrial protocols
Renesas can provide one protocol communication LSI and multi protocols communication LSI. One protocol communication LSI give benefits as small footprint and low cost for customer. Multi protocol communication LSI give benefits as unique environment for customer.

Usable for any layers/use cases in industrial
Renesas industrial ethernet LSI can realize standard ethernet products by customer. Further, Renesas industrial ethernet LSI supports redundancy network (HSR, PRP, DSR, MRP and so on). Furthermore, Renesas industrial ethernet LSI can use expanded communication LSI for MCU/MPU. So, Renesas LSI can solve/use any layer communication.

Contribute to realize the interoperability for smart society
Some multi protocols communication LSI can realize simultaneous operation for two industrial protocols. So, customer can develop the gateway between industrial ethernet protocols.

---

Industrial Network

Redundancy network

Manufacturing Line

Field network

Control network

Management Server

Gateway

Protocols

 OPC UA
Ethernet/IP
Modbus
EtherCAT
Sercos
CC-Link IE
DeviceNet
IO-Link

Renesas Industrial Network Solution

Renesas, with partners, provides necessary solutions for development by customer.

Solution example

- RZ/N1D Solution Kit
- RemoteI/O Reference Kit
- RX64M and R-IN32M3 Connection Evaluation Kit
- IAR KickStart Kit
- Industrial Network Communication LSI Evaluation Kit
- CiA402 drive profile guide

Development environment
- OS
- Protocol stack
- Sample software
- Evaluation Board
- Schematic, Layout
AC Servo System Configuration and Our Recommendation

Overview
- To meet these needs, Renesas offers an extensive product lineup. The RZ/T1 is a microprocessor that is ideal for AC servo control applications.
- The AC servo system used in machine tools, industrial robots, and variety of other manufacturing machinery precisely controls the rotor power devices.

Encoder Interface, and R-IN Engine. Also with the RX Family, which comprises a wide range of product series, and an array of analog and combining fast real-time processing performance with extensive peripheral functions such as multifunction motor control timer, A/D converter, and synchronous processing.

- Also requires communication functions (industrial network support) for advanced motion control instructions, remote operation, multiple waveforms, and feedback control are necessary to achieve fast response to changes in load, improved stopping accuracy, and minimal vibration. Also requires communication functions (industrial network support) for advanced motion control instructions, remote operation, and synchronous processing.

- To meet these needs, Renesas offers an extensive product lineup. The RZ/T1 is a microprocessor that is ideal for AC servo control applications.
- The AC servo system used in machine tools, industrial robots, and variety of other manufacturing machinery precisely controls the rotor power devices.

Recommended Products

Microcontrollers and Microprocessors

<table>
<thead>
<tr>
<th>Block</th>
<th>Recommended Products</th>
<th>Operating Frequency (MHz)</th>
<th>Operating Voltage (V)</th>
<th>On-Chip Memory (Meg)</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control MCU</td>
<td>RZ/T1</td>
<td>600/450/300</td>
<td>3.3 (5V)</td>
<td>1.2 (3.3V)</td>
<td>Tightly-coupled memory for fast real-time control</td>
</tr>
<tr>
<td></td>
<td>RX11M</td>
<td>240</td>
<td>3.3</td>
<td>4MB Flash</td>
<td>High-performance firmware and large memory capacity for high-precision motor control</td>
</tr>
<tr>
<td>Display MCU</td>
<td>RX655/ RX656M</td>
<td>120</td>
<td>3.3</td>
<td>3.3 or 5</td>
<td>Multi-function timer and ADC for motor control and A/D connection via external bus</td>
</tr>
<tr>
<td></td>
<td>RX313</td>
<td>32</td>
<td>3.3</td>
<td>1.2</td>
<td>Ability to implement a variety of user interfaces using capacitive touch sensing and liquid crystal controller</td>
</tr>
</tbody>
</table>

Memory

<table>
<thead>
<tr>
<th>Block</th>
<th>Memory Size</th>
<th>Recommended Products</th>
<th>Access Time (ns)</th>
<th>Standby Current (μA)</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRAM</td>
<td>4M bits</td>
<td>RX02/4048E Series</td>
<td>4ns</td>
<td>0.4μA</td>
<td>Renesas’ original memory cell technology is more than 500 times as resistant to software errors as full CMOS memory cells, providing the high reliability for the industrial market.</td>
</tr>
<tr>
<td></td>
<td>8M bits</td>
<td>RX02/8088E Series</td>
<td>4ns</td>
<td>0.8μA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16M bits</td>
<td>RX02/1619A Series</td>
<td>4ns</td>
<td>1.2μA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32M bits</td>
<td>RX02/3216A Series</td>
<td>4ns</td>
<td>1.2μA</td>
<td></td>
</tr>
</tbody>
</table>

Analog and Power Devices

<table>
<thead>
<tr>
<th>Block</th>
<th>Category</th>
<th>Recommended Products</th>
<th>Main Specifications</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>DC-DC</td>
<td>RAA23015x</td>
<td>Input voltage range: 7 to 36V, output voltage: 0.8 to 36V, Max. output current: 3A</td>
<td>Simplify power supply design and shortening SAT in kits with Renesas microcontrollers.</td>
</tr>
<tr>
<td></td>
<td>DC-DC</td>
<td>RAA23002x</td>
<td>Input voltage range: 4.5 to 16V, output voltage: 0.8 to 6V, Max. output current: 3A</td>
<td></td>
</tr>
<tr>
<td>Current monitor</td>
<td>Isolation amplifier</td>
<td>PS8020A/PS8020A</td>
<td>10μA, 10μA, 10μA</td>
<td>Support for high temperature operation up to 110°C</td>
</tr>
</tbody>
</table>

Isolation

<table>
<thead>
<tr>
<th>Block</th>
<th>Category</th>
<th>Recommended Products</th>
<th>Main Specifications</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>DC-DC</td>
<td>PS8001</td>
<td>100ppm, compact, high voltage tolerance</td>
<td>Compact and high voltage tolerance</td>
</tr>
<tr>
<td></td>
<td>DC-DC</td>
<td>PS8020/PS8024</td>
<td>6900V isolation</td>
<td>Compact and high voltage tolerance</td>
</tr>
</tbody>
</table>

Drive

<table>
<thead>
<tr>
<th>Block</th>
<th>Category</th>
<th>Recommended Products</th>
<th>Main Specifications</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>DC-DC</td>
<td>PLH3527/18BEP-AD</td>
<td>1800V, compact, high voltage tolerance</td>
<td>Highly reliable (guaranteed short-circuit withstand time)</td>
</tr>
<tr>
<td></td>
<td>DC-DC</td>
<td>PS2301</td>
<td>1800V, compact, high voltage tolerance</td>
<td></td>
</tr>
</tbody>
</table>

Industrial Ethernet: EtherCAT, EtherNet/IP, PROFINET, etc.
Four Features of the RZ/T Series

- **High-performance, High-speed Real-time Control**
  - High-speed RAM connected directly to the CPU for fast processing and deterministic real-time responsiveness without the cache
  - ECC for enhanced reliability
  - Vectored interrupt controller (VIC) to ensure interrupt responsiveness suitable for embedded control applications

- **Integrated Peripheral Functions**
  - The integrated encoder interface (option) handles the functions previously performed by external FPGA or ASIC devices.
  - This single-chip AC servo solution reduces the component count and reduces the component count and board area.

- **On-Chip R-IN Engine**
  - The R-IN Engine accelerator for Industrial Ethernet communication performs standard Ethernet processing in hardware.
  - Network processing four times as fast as comparable conventional products.

- **On-Chip R-IN Engine**
  - RZ/T1 Motion Control Solution Kit
  - Supports Industry EtherCAT Communication
  - Provides Solution, Supports Partners

RZ/T1 (Support Multi Protocol)

High performance CPU (Arm® Cortex®-R4 Processor with FPU)
- Operating frequency: 450MHz/600MHz
- High-performance, high-speed real-time control
- Single-precision/double-precision floating point unit
- On-chip memory
  - Tightly Coupled Memory: 512KB (w/ECC) + 32KB (w/ECC)
  - R-IN engine instruction memory: 512KB (w/ECC) + data memory: 512KB (w/ECC)
- Features
  - Industrial Ethernet communication accelerator with multi-protocol support (R-IN engine)
  - EtherCAT Slave controller
  - PWM timers: MTU3a, GPT
  - Nikon A-format™/Biss-C/EnDat2.2/HIPERFACE DSL/Tamagawa (option)
  - High-speed USB
  - Secure boot (option)
  - Safety functions
    - ECC memory
    - CRC (32-bit)
    - Independent WDT: Operating on dedicated on-chip oscillator
    - 100Mbps EtherMAC (with Ethernet switch)
    - Ethernet frame size: 1.2V, 3.3V
  - Package
    - FBGA 320pin (17mm x 17mm, 0.8mm pitch)

Photocouplers (Isolation Amplifiers, IGBT/IPM Drive Photocouplers, High Speed Photocouplers)
Renesas photocouplers are based on technology that provides three benefits: high reliability even at high temperatures, high noise tolerance, and high voltage tolerance in spite of small package size. The lineup of photocoupler products is available to meet the requirements of each specific application.

- Isolation amplifier, IGBT/IPM drive photocoupler, and high-speed communication photocouplers can be used in combination to effectively isolate key portions of AC servo system.
  - The isolation amplifier lineup includes products offering analog or digital output at 1% precision and a compact package (ODP).
  - The lineup of IGBT/IPM drive photocouplers includes products designed to accommodate 2.5A output.
  - Products with integrated Oslate or active mirror clamp functionality to prevent IGBT destruction
  - Products with high voltage tolerance and a compact LQD5S package

RZ/T1 (Support Multi Protocol) Block Diagram

Power houses

Feature 1. Bundled with microcontrollers to simplify the power supply design process.
Renesas offers kit products comprising microcontrollers and power ICs to simplify the task of designing a power supply and shorten TAT.
Feature 2. Ideal for systems incorporating RZ, R-IN, and SoC devices requiring multiple power supplies.
The ability to deliver multiple power supplies from a single power IC reduces the board size and component count.
Renesas solution boards help simplify the task of designing complex power supplies and shorten TAT.
Feature 3. Web-based simulation environment
This service calculates the circuit characteristics (power conversion efficiency, output ripple voltage, and discharge time) based on the operating conditions supplied by the customer and provide graphs that can be referenced when selecting circuit characteristics and components.
General Purpose Inverter System Configuration and Our Recommendation

Overview
- In response to these varied requirements, Renesas offers a broad lineup of products that provide scalability. The RX Family provide an array of on-chip peripheral functions such as multifunction timers and A/D converters optimized for inverter control, Ethernet and USB interfaces, and serial interfaces. Also available with analog and power devices suitable for inverter applications.

- The general-purpose inverter is a variable-speed controller that precisely controls the shaft rotation speed, typically, an induction motor or synchronous motor. They are widely used in industrial machinery such as production line conveyors, cranes, elevators, fans, pumps, and compressors. As the need to save energy grows, there is widespread demand for an inverter control to boost energy efficiency. The performance and multifunctionality of inverters continue to improve. This is due to advances in simple controller functions, interfaces such as field networks of various types and USB, and display panels enhancing usability. At the same time, there is growing demand in emerging economies for inverters that are cheaper and more compact.

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- The RX Family is a family of microcontroller units (MCUs), developed by Renesas Electronics. They are based on the Power Architecture, offering a wide range of features and performance levels to suit various applications.

- The RX Family is designed to meet the needs of both general-purpose and special-purpose applications, featuring a high-performance core and a variety of peripheral functions.

- The RX Family offers flexibility in terms of performance, memory size, and peripheral features, allowing users to choose the right device for their specific needs.

- The RX Family is used in a wide range of applications, including automotive, industrial, consumer, and embedded systems.

Recommended Products

- Microcontrollers
- Industrial Communication Chip
- Memory
- Analog and Power Devices
Our Recommended Devices for General Purpose Inverters

Brushless AC Motor
Stepper Motor

Recommended RX Series for Motor Application

<table>
<thead>
<tr>
<th>Motor Type</th>
<th>Control Method</th>
<th>Necessary Functions</th>
<th>Performance Required by Application and Recommended RX Microcontroller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector control</td>
<td>PVM6 A/D converter</td>
<td>Washing machine (1 Motor), Pump, Compressor, Fan</td>
<td>RX100, RX200, RX200 (RX23T), RX200, RX700, RX600</td>
</tr>
<tr>
<td>Square wave control</td>
<td>PVM6 A/D converter</td>
<td>Washing machine (1 Motor), Pump, Compressor, Fan</td>
<td>RX100, RX200, RX200 (RX23T), RX200, RX700, RX600</td>
</tr>
<tr>
<td>Induction AC Motor</td>
<td>PVM6 A/D converter</td>
<td>Washing machine (1 Motor), Pump, Compressor, Fan</td>
<td>RX100, RX200, RX200 (RX23T), RX200, RX700, RX600</td>
</tr>
<tr>
<td>Stepper Motor</td>
<td>PVM6 A/D converter</td>
<td>Washing machine (1 Motor), Pump, Compressor, Fan</td>
<td>RX100, RX200, RX200 (RX23T), RX200, RX700, RX600</td>
</tr>
</tbody>
</table>

Renesas provides various motor control solutions, including hardware supports such as motor control evaluation system, starter’s kits, as well as software tools such as vector control and other control methods, waveform display, automatic parameter adjustments etc.

Motor Control Starter Kit (Renesas Solution Starter Kit)
Just connect a power supply to get started checking your motor drive application. This kit consists of a motor and an inverter board. The provided “sample programs” are ideal for leaning about different control methods.

Motor Control Development Support Tool Renesas Motor Workbench
Analyzer function reduces the debugging workload. Tuner function enables simple vector control, even if you have no specialized knowledge.

Notes:
1. The above are supplied on a DVD-ROM with the RX62T kit.
2. Items printed in blue are not implemented on standard products.
3. Maximum specifications for the group are listed above.
Overview

Programmable logic controllers (PLCs) are used to control industrial machinery such as AC servos, general-purpose inverters, and sensors. They are widely used in factory automation systems for manufacturing and processing lines, machine tools, and industrial robots. To provide control capabilities tailored to each individual system, modular PLCs (CPU unit and various peripheral units) are used for large-scale and midsize systems.

Peripheral units of module type PLC includes a variety of products to match the specific requirements from end users, while the proliferation of development resources has become an issue. To solve this problem, Renesas offers a peripheral unit platform based on the RX Family, which covers a broad performance range (32MHz to 240MHz) and a multitude of peripheral functions. This helps reduce the amount of development resources needed.

For block type PLC, RX64M product provides a one chip solution with large capacity RAM, Ethernet, USB, SD Card I/O integrated, leading to both performance rise and BOM size reduction. In addition, our new lineup now also offers RX65N/RX651, not only pin-compatible with RX64M but also fully compatible. We can, therefore, provide an even larger selection of products, for our customers to expand their own series of products.

Furthermore, if RX family haven’t met the performance requirements, please consider as well our RZ/A and RZ/N series, both offer higher RAM capacity. By utilizing the extra large RAM, the memory access speed can be improved, which, in turn, leads to higher performance of the customer products.

System Block Diagram

Recommended Products

Microcontrollers and Microprocessors

<table>
<thead>
<tr>
<th>Block</th>
<th>Recommended Products</th>
<th>Maximum Operating Frequency</th>
<th>On-Chip Memory</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>RX211L</td>
<td>48MHz</td>
<td>64KB RAM</td>
<td>Using the internal RAM, memory access is significantly faster and more reliable compared to that of using external RAM. Furthermore, in case an on-chip solution is desired to handle both log and network processes simultaneously as well as provide support to multiple industrial network/machine protocols, our RX211L is the right product for you.</td>
</tr>
<tr>
<td></td>
<td>RX215</td>
<td>50MHz</td>
<td>64KB RAM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RX210</td>
<td>100MHz</td>
<td>2MB RAM Dual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RX51M</td>
<td>240MHz</td>
<td>64KB Flash 2MB RAM 2MB DataFlash</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RX64M</td>
<td>120MHz</td>
<td>64KB Flash 32KB RAM 1MB DataFlash</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RX65N</td>
<td>120MHz</td>
<td>1MB Flash 256KB RAM 32KB DataFlash</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RX651</td>
<td>120MHz</td>
<td>1MB Flash 256KB RAM 32KB DataFlash</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RX64N1</td>
<td>100MHz</td>
<td>256KB Flash 256KB RAM 32KB DataFlash</td>
<td></td>
</tr>
</tbody>
</table>

Peripheral unit microcontroller: Module type PLC
- Covering an RX-based platform for many types of peripheral units helps reduce the development resources (time and cost) required.

Control microcontroller: Block type PLC
- In addition to communication functions such as Ethernet and USB, the large memory capacity helps reduce the number of external components required.

Communication microcontroller
- The TSPI-1 function safely protects encryption keys, and the SDHI function enables fast data communication with the wireless communication module.

<table>
<thead>
<tr>
<th>Block</th>
<th>Memory Size</th>
<th>Recommended Products</th>
<th>Access Time (Max.)</th>
<th>Standby Current (Typ.)</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRAM</td>
<td>4M bits</td>
<td>RA5W4400RAE Series RA4W4040E Series</td>
<td>15ns</td>
<td>64μA</td>
<td>Exclusively Renesas memory cell technology, 15ns access time; 25ns read latency. Powerful read, write, and high efficiency.</td>
</tr>
<tr>
<td></td>
<td>8M bits</td>
<td>RA5W88005 Series RA5W80208 Series</td>
<td>15ns</td>
<td>64μA</td>
<td>Exclusively Renesas memory cell technology, 25ns access time; 25ns read latency. Powerful read, write, and high efficiency.</td>
</tr>
<tr>
<td></td>
<td>16M bits</td>
<td>RA5W1650A Series</td>
<td>15ns</td>
<td>16μA</td>
<td>Exclusively Renesas memory cell technology, 25ns access time; 25ns read latency. Powerful read, write, and high efficiency.</td>
</tr>
<tr>
<td></td>
<td>32M bits</td>
<td>RA5W3216A Series</td>
<td>15ns</td>
<td>16μA</td>
<td>Exclusively Renesas memory cell technology, 25ns access time; 25ns read latency. Powerful read, write, and high efficiency.</td>
</tr>
</tbody>
</table>

Analog and Power Devices

<table>
<thead>
<tr>
<th>Block</th>
<th>Category</th>
<th>Recommended Products</th>
<th>Main Specifications</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>DC/DC</td>
<td>RA423015x</td>
<td>Input voltage range: 7 to 29V, output voltage: 0 to 6V Max. output current: 3A Auto-PFM (high load, high efficiency) mode</td>
<td>Available in kits with Renesas microcontrollers, simplifying power supply design and streamlining TAT.</td>
</tr>
<tr>
<td></td>
<td>DC/DC</td>
<td>RA423023x</td>
<td>Input voltage range: 4.5 to 36V, output voltage: 0.8 to 6V Max. output current: 3A Auto-PFM (high load, high efficiency) mode Dual-in-DIP</td>
<td>Available in kits with Renesas microcontroller, simplifying power supply design and streamlining TAT.</td>
</tr>
<tr>
<td>Isolation</td>
<td>High-speed communication photodetector/photodiode</td>
<td>PS0301, PS0212, PS0214</td>
<td>550Mbps, compact, high voltage tolerance, compact S6S package</td>
<td>Compact and high voltage tolerance, ideal for compact systems</td>
</tr>
<tr>
<td></td>
<td>High-speed communication photodiode</td>
<td>PS0312, PS0324</td>
<td>550Mbps, compact, high voltage tolerance, compact S6S package</td>
<td>Compact and high voltage tolerance, ideal for compact systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block</th>
<th>Block Category</th>
<th>Recommended Products</th>
<th>Main Specifications</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Block type PLC</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Peripheral Unit Platform Based on RX Family

1. Reducing development resources by adopting this platform

The module type of PLC consists of peripheral units such as ID Unit, Network Unit, and Positioning Units where MCU performance differs within each unit. When choosing the microcontroller for each peripheral unit, selecting products with different CPU architectures, peripheral functions, or development environments can make it difficult to reuse existing software and increase the development resources (development time and costs). As a solution, Renesas offers a unified platform based on the RX Family microcontrollers, which cover a wide performance range from 32MHz to 240MHz. This RX-based platform allows "reuse of software assets" together with "unified development environment," in order to reduce development resources and bring added value to user applications. Along with the reduction of required development resources, thanks to our RX platform, we are now preparing Firmware Integration Technology (FIT) to further support our customers to make up for the resource gap. FIT commonizes the configurations such as microcontroller initialization, file structure etc. of all sample codes for our RX family, making it easier to build the sample codes into the user application, since all the interfaces are also commonized, moving user applications among different RX-series microcontrollers is also stress-free, which in turn reduces the required development resources for our customers.

Illustration of Reduced Development Resource Requirements from Platform Adoption

<table>
<thead>
<tr>
<th>Platform adoption</th>
<th>Development time and cost</th>
<th>Reduced Development Resource Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>RXv1</td>
<td></td>
<td>Same</td>
</tr>
<tr>
<td>RXv2</td>
<td></td>
<td>Shorter</td>
</tr>
</tbody>
</table>

Function

RX CPUS

longitudinal development environment

Chip debugging emulator

Compiler

Core

Central IP

RX CPU

CPU

Reference RX651/RX65N: Reduce Development Work Labor when Expanding Product Series

In addition, we offer our customers great support such as FIT, specification-diff APN and Pin comparison documents, which further reduce the resource demand for our customers when expanding their own product series.

The newly added RX651/RX65N are pin & feature compatible with RX600 series products, which makes design upgrade/migration quite easy. The newly added RX-series microcontrollers is also stress-free, which in turn reduces the required development resources for our customers.

FIT commonizes the configurations such as microcontroller initialization, file structure etc. of all sample codes for our RX family, making it easier to build the sample codes into the user application, since all the interfaces are also commonized, moving user applications among different RX-series microcontrollers is also stress-free, which in turn reduces the required development resources for our customers.

RZ/A1 and RZ/N1 are released with rich line-ups of internal RAM size, CPU performance etc., offering our customer the best chance of finding the optimized one for their own product series.

Network Process and Ladder Process within the Single Chip

RZ/N1D provides high CPU frequency, large sized memory, I/F, USB, SDIOs, to interface with PLC. Also Renesas provides not only a LSI but evaluation model SW PLC kit supporting PROFINET, Ethernet/IP, EtherCAT, etc. This will shrink your development timeline for immediate evaluation of industrial Ethernet master communication processing and ladder process.

<table>
<thead>
<tr>
<th>CPU Unit</th>
<th>Peripheral Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU Unit</td>
<td>Peripheral Unit</td>
</tr>
</tbody>
</table>

CPU Unit

Peripheral Unit

No need to access external RAM

<table>
<thead>
<tr>
<th>Series</th>
<th>CPU Core</th>
<th>CPU freq. (MHz)</th>
<th>Internal RAM (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RZ/A1</td>
<td>Cortex®-A9</td>
<td>400</td>
<td>128MB</td>
</tr>
<tr>
<td>RZ/A1L</td>
<td>Cortex®-A7</td>
<td>590</td>
<td>64MB</td>
</tr>
<tr>
<td>RZ/N1</td>
<td>Cortex®-A7</td>
<td>590</td>
<td>64MB</td>
</tr>
<tr>
<td>RZ/N1D</td>
<td>Cortex®-A7 Dual</td>
<td>590/590</td>
<td>256MB + DDR (F)</td>
</tr>
</tbody>
</table>

A Proposal for Units Demanding Large RAM Capacity

By storing peripheral data in internal RAM instead of external RAM, the data access speed can be dramatically increased, which, in turn, improves the performance of the customer system.

Features

- Improved RAM access
- Enhanced performance
- Reduced development costs

General Features

- 64-bit CPU
- Enhanced features
- CoreConnect® ( integrates communication, etc.)

Operating System

- Linux

Evaluation Version Protocol Stack

Master

Software PLC

PROFINET, EtherCAT, EtherCAT, etc.

Slave

PROFINET, EtherCAT, EtherCAT, etc.

For full version protocol stack, please contact your nearest stock supplier

<table>
<thead>
<tr>
<th>Network Process and Ladder Process with the Single Chip</th>
</tr>
</thead>
<tbody>
<tr>
<td>RZ/N1D provides high CPU frequency, large sized memory</td>
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</tbody>
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<table>
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<tr>
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CPU Unit

Peripheral Unit

Download

Serial Flash

RZ/A1 & RZ/N1

<table>
<thead>
<tr>
<th>Series</th>
<th>CPU Core</th>
<th>CPU freq. (MHz)</th>
<th>Internal RAM (MB)</th>
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<td>400</td>
<td>128MB</td>
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<td>RZ/A1L</td>
<td>Cortex®-A7</td>
<td>590</td>
<td>64MB</td>
</tr>
<tr>
<td>RZ/N1</td>
<td>Cortex®-A7</td>
<td>590</td>
<td>64MB</td>
</tr>
<tr>
<td>RZ/N1D</td>
<td>Cortex®-A7 Dual</td>
<td>590/590</td>
<td>256MB + DDR (F)</td>
</tr>
</tbody>
</table>


The newly added RX651/RX65N are pin & feature compatible with RX600 series products, which makes design upgrade/migration quite easy. In addition, we offer our customers great support such as FIT, specification-diff APN and Pin comparison documents, which further reduce the resource demand for our customers when expanding their own product series.

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<tr>
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</tr>
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CPU Unit

Peripheral Unit

Download

Serial Flash

RZ/A1 & RZ/N1

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<td>Cortex®-A7 Dual</td>
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</tr>
</tbody>
</table>
## Remote I/O System Configuration and Our Recommendation

### Overview
- Remote I/O enables master devices such as PLCs to control the input and output of data from a remote location via network. The input and output signals can be either digital or analog.
- Customers are increasingly transitioning from older industrial protocols based on RS-485/RS-232 serial communication to Ethernet-based industrial protocols. The R-IN32 Series is a single-chip device that supports both types of industrial networks.

### System Block Diagram

![System Block Diagram](image)

### Recommended Products

#### Industrial Communication LSI

<table>
<thead>
<tr>
<th>Block</th>
<th>Category</th>
<th>Recommended Products</th>
<th>CPU</th>
<th>Operating Frequency (MHz)</th>
<th>Operating Voltage (V)</th>
<th>On-Chip RAM (Max.)</th>
<th>Features, etc.</th>
</tr>
</thead>
</table>
| R-IN32M3-EC | Factory Automation LSI | Cortex®-M3 | 90 | 3.3V (IO) 1.0V (Core) | 1.2MB (ECC) | • Single-chip support for multiple industrial protocols, including EtherCAT.  
• On-chip 100Mbps Ethernet PHY. |
| R-IN32M3-CL | Cortex®-M3 | 90 | 3.3V (IO) 1.0V (Core) | 1.2MB (ECC) | • Single-chip support for multiple industrial protocols, including CC-Link IE Field. |
| R-IN32M4-CL2 | Cortex®-M4 with FPU | 100 | 3.3V (IO) 1.0V (PMM) 1.0V (Core) | 1.2MB (ECC) | • Single-chip support for multiple industrial protocols, including CC-Link IE Field.  
• On-chip 1000Mbps Ethernet PHY. |
| EC-1 | Cortex®-A9 with FPU | 110 | 3.3V (IO) 1.0V (Core) | 1.3MB (ECC) | • A communication chip with support for EtherCAT, combining architecture with excellent real-time performance and an integrated EtherCAT slave controller. |
| EPS-1 | — | — | — | — | • A device conforming to the PROFINET IO standard, one of the industrial Ethernet communication standards involved in growing adoption of open networks, is available. |
| RZ/N1S | Cortex®-A7 | 400 | 3.3V (IO) 1.2V (Core) | 6MB (ECC) | • A device supports multiple protocols such as EtherCAT, EtherCAT / PROFINET, SERCOS III, PROFINET, PROFINET IO Link Master. |
| RZ/N1L | Cortex®-A9 | 125 | 3.3V (IO) 1.2V (Core) | 6MB (ECC) | • A device supports multiple protocols such as EtherCAT, EtherCAT / PROFINET, SERCOS III, PROFINET, PROFINET IO Link Master. |

#### Analog and Power Devices

<table>
<thead>
<tr>
<th>Block</th>
<th>Category</th>
<th>Recommended Products</th>
<th>Main Specifications</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>DC/DC</td>
<td>RA223015x</td>
<td>Input voltage range: 7 to 28V, output voltage: 0.6 to 5V, Max. output current: 3.2A, Ultra-PFM (light load, high efficiency) mode</td>
<td>• Available in kits with Renesas microcontrollers, simplifying power supply design and shortening TAT.</td>
</tr>
<tr>
<td>Isolation</td>
<td>Tri-output photo-coupler</td>
<td>PS2801-4</td>
<td>SSDP package (LVM INPUT)</td>
<td>• Compact and high voltage tolerance, ideal for compact systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PS2801C-4</td>
<td>SSDP package</td>
<td></td>
</tr>
</tbody>
</table>
Our Recommended Devices for Remote IO System

Today, Industrial Ethernet is expanding rapidly in factories, and machines and modules are required to support it. Features in this high demand include support for multiple Industrial Ethernet protocols and excellent real-time responsiveness to improve factory productivity. The importance of these two aspects cannot be overemphasised. The R-IN32M Series from Renesas Electronics provides the above-mentioned functionality to help boost manufacturing productivity and reducing costs on the manufacturing line.

Advantages of the R-IN32M

1. Integrated real-time OS accelerator (HW-RTOS) and Ethernet accelerator

One of the most distinctive features of the R-IN32M3 is the high-speed operation with the basic function of the real-time OS in hardware to implement high-speed real-time response and high-precision communication control for industrial Ethernet communication. Because the hardware in the new R-IN32M3 Series covers heavy load operations for the CPU, the combination of the CPU and HW-RTOS result in ultra-high-speed operation time with conventional CPU processing is reduced substantially from one-fifth to one-tenth of the previous level.

Fast System Call (API execution time)

This figure shows how conventional RTOS processing time changes with internal status changes. The API being measured is the Flag Set API execution time. With conventional RTOS, as the number of tasks waiting for the event flag increases, API execution time increases, whereas with HW RTOS the API execution time is essentially fixed. The ability of HW RTOS to maintain a relatively stable processing time is a truly important feature. In conventional RTOS, API execution time increases as events increase. HW RTOS is particularly helpful when running real time applications on embedded systems.

Quick interrupt response

As mentioned before, HW RTOS does not simply implement a real-time OS in hardware, Hardware Interrupt Service Routine. The HW ISR is a hardware implemented function which invokes an API which is related to each interrupt signal and the user can register in advance. This means that whenever an interrupt is received, it goes directly to the task, not the ISR in software. The result is that for interrupt processing, which rarely needs high speed real time handling, we can speed up the interrupt process, decrease context switches, stabilize task processing time, and decrease CPU load.

As described above, HW RTOS provides not only fast API execution time but also short interrupt disable period, quick interrupt response and processing time stability. This graph shows interrupt response of both conventional RTOS and HW RTOS. We measured two values; one is the time between an interrupt occurring and the ISR activating, and the other is the time between an interrupt and next task. From this graph, we can see that not only is the interrupt response time for HW RTOS faster than conventional RTOS, but it never fluctuates, another key feature. We think it’s clear this makes HW RTOS perfectly suited to high precision real time control.
R-ZINM4-CL: Supported protocols

- EtherCAT, EtherCAT IP, PROFINET (RT), Modbus TCP, CANopen, DeviceNet, Modbus RTU/ASCII, CC-Link

R-ZINM4-CL: CL-IE Field, CANopen, DeviceNet, Modbus RTU/ASCII, CC-Link

Fast real-time processing
- R-ZINM4-CL: On-chip Cortex™-M4 processor with FPU (32-bit RISC CPU) running at 100MHz
- R-ZINM3: On-chip Cortex™-M3 processor with FPU (32-bit RISC CPU) running at 100MHz

Support for Industrial Ethernet
- 2 × UTP/STP 10/100M/1G Ethernet PHY

Many peripheral functions:
- 10-bit SAR ADC (8 channels)
- 2 × SPI
- 2 × SDIO/eMMC
- 2 × USB 2.0 HS
- 1 × Ethernet

PROFINET Communication LSI (TPS-1)

This is an industrial networking ASIC targeted at providing a complete hardware solution for PROFINET IO Device. It integrates dual port PHY and PROFINET IR switch with bridge delay of less than 3µs.

Ethernet Communication LSI (R-ZINM4-CL)

R-ZINM4-CL is an efficient solution that is simple to implement, yet have the processing power to handle the I/O as well as the network interface.

HeartCat Communication LSI (EC-1)

EC-1 is an efficient solution that is simple to implement, yet have the processing power to handle the I/O as well as the network interface.
No matter the requirements of an IoT application, there is a Synergy MCU that can meet them.

The capabilities provided by S7, S5, S3, and S1 Series MCUs readily handle a wide range of applications, from ultra-small mobile devices to calculation-intensive industrial systems, medical equipment, and more. The rigorously enforced compatibilities expand system design flexibility and help conserve development resources.
Purchasing Renesas Microcontrollers Online

Renesas microcontrollers can be purchased online at our website. It can be accessed 24 hours a day from your work or home PC and supports direct orders and purchases in quantities as small as one unit. Renesas provides strong support through its sales presence to each and every customer engaged in product development.

You can also purchase Renesas Electronics microcontrollers from the websites.

http://www.renesas.com/

Simply enter the products you wish to purchase, the quantity, and the shipping address, and we'll ship your order directly to the specified address. We can also accommodate requests for expedited shipping.
**Renesas on the Web**

- **RZ/T**

- **RX Family**

- **LSI for Factory Automation**
  - [https://www.renesas.com/products/factory-automation](https://www.renesas.com/products/factory-automation)

- **Functional Safety Solution for Industrial Automation**

- **AC Servo System**
  - [https://www.renesas.com/solutions/factory/common-technologies/ac-servo-system](https://www.renesas.com/solutions/factory/common-technologies/ac-servo-system)

- **General-Purpose Inverter**