INDUSTRIAL AUTOMATION
Enabling the Industry 4.0 infrastructure
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.

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What are Winning Combinations?

Winning combinations are comprehensive solutions that combine complementary Renesas products from our portfolio, such as analog + power + embedded processing devices. These winning combinations bring together products that work together optimally, enabling customers to speed up the design process and bring their finished products to market more quickly. With the focus on the industrial, infrastructure, and automotive fields, Renesas is working to provide an optimal portfolio of products to customers and partners worldwide.

Visit the website below to see examples of a variety of solutions for industrial equipment.

1. Provides optimized microcontrollers for a variety of industrial network applications
The three CPU types lineup and integrated 5-port gigabit Ethernet switch make it possible to provide the optimal microcontrollers for a wide range of industrial network applications.

— Lineup of three CPU types for excellent hardware scalability: Dual-core Cortex®-A7 (500MHz × 2), single-core Cortex®-A7 (500MHz), and R-IN engine only (125MHz).
— 5-port gigabit Ethernet switch and two independent MAC units support applications such as PLC devices and Ethernet switches. Integration of peripheral components helps reduce BOM cost.

2. Integrated R-IN engine (accelerator) supporting main industrial Ethernet protocols
The R-IN engine accelerator supports a wide range of protocols and enables high-speed processing. It reduces the load on the main CPU (Arm® Cortex®-A7) and contributes to highly efficient application control.

Protocol stacks
EtherCAT®, EtherNet/IP®, ETHERNET Powerlink®, PROFINET®, Sercos®, CANopen®, Modbus, TCP/IP

3. Redundant network configuration reduces network downtime to zero
Advanced redundant network configuration support helps eliminate network downtime.

— Redundant network connections: Parallel Redundancy Protocol (PRP)
— Looped network connections: HSR (High-availability Seamless Redundancy), DLR (Device Level Ring), RSTP (Rapid Spawning Trees)
Industrial Ethernet Module
R-IN32M3 Module

The new Industrial Ethernet Module (R-IN32M3 Module) is a certified hardware and software solution that allows an engineer to speed-up the development of a product and bring it fast to the market. Based on Renesas technology and quality standards, the module includes certified software of leading Industrial Ethernet protocols PROFINET® and EtherNet/IP™. Other industrial protocols such as EtherCAT® are in preparation and will be available soon. In addition, the module includes a high-speed SPI interface to communicate with the application controller. With Software Abstraction Layer, the device application can easily be connected to the module protocol software. This allows developers to easily implement various industrial Ethernet protocols and focus on developing their application software.

Key Features
- 2-port RJ45 connector with the support of the following Industrial Ethernet protocols:
  - PROFINET RT conformance class B
  - EtherNet/IP
  - EtherCAT (middle 2020)
- High speed SPI interface to connect the application CPU/MCU

Easy Setup for Faster Time to Market
Connect your Application with the Intelligent RJ45 to Industrial Ethernet fieldbus system

The Industrial Ethernet Protocol for the fieldbus communication runs inside the Renesas R-IN32M3 Module. With the corresponding API of the protocol library (Abstraction Layer) the communication is exported to the application MCU via the SPI interface. The application MCU has full control of the Industrial Ethernet protocol without investing in the CPU power to run the protocol. This relieves the application MCU from the often-crucial CPU load to run the real-time communication protocol. Renesas provides sample application and drivers for the application MCU in source code. This helps the saves development time and cost and enables a fast time to market. Via the Ethernet interface the module allows a software update of its own firmware as well as the application MCU.

Development Environment
Ready to evaluate and develop
Solution set
- [Kit.] R-IN32M3 Module + Adapter Board
- [soft] Synergy SK-S7G2 sample application*
- [FW] R-IN32M3 Module FW
- [tool] Management Tool
- [doc] Quick Start Guide
- [doc] Design Guide

Note: Need Synergy SK-S7G2 Starter Kit.

Target Application
The Industrial Ethernet Module solution comes in a size of a dual port RJ45 connector and is targeted to support various network topologies and industrial network slave applications like sensors and transmitters, gateways, operator terminals and remote I/O solutions.

Figure: Software Structure
Figure: Easy Connection Between Application
ASI4U-V5: Fully Compliant ASi-5 Transceiver ASSP

The ASI4U-V5 is the industry’s first silicon solution to fulfill the ASi-5 (Actuator-Sensor-Interface version 5) standard for industrial network equipment that enables comprehensive Industry 4.0 applications. The ASI4U-V5 ASSP comes with a completely verified and field-proven firmware that fully implements ASi-5. Hence, integration of ASi-5 into any application is very easy, as the complexity of the fieldbus is hidden by the chip and the firmware.

**Key Features**

- Fully compliant to the AS-i version 5 standard
- Fully compatible to the AS-i version 3 standard
- The solution consists of the ASSP and a self contained ASi-5 firmware
- 64-pin QFN package
- Support for simple slave applications (digital-IO connection)
- Support for complex slave applications (SPI/IF to the application)
- Operating temperature -40°C to +85°C
- Supply voltages: 5V and 3.3V
- Package dimensions: 9 × 9 mm, 0.5 mm pitch
- Part Number: R9J06G039UGNP

**ASi-5 Key Technology Advantages**

**Faster and more efficient for Industry 4.0 applications**

- ASi-5 supports 1.2ms cycle time with a jitter of less than 10ns vs 5ms of ASi-3
- ASi-5 allows for 96 devices being attached to the same cable vs 62 in ASi-3
- ASi-5 can run up to 200m cable vs 100m in ASi-3
- ASi-5 supports diagnostics and event handling needed for industry 4.0 applications

**Ease of integration**

- ASI4U-V5 is an ASi-5 silicon solution, which consists of the ASi-5 ASSP and a fully self-contained firmware image that handles all ASi-5 specific items. Hence, it is the easiest fieldbus integration option.
- ASI4U-V5 is fully backwards compatible to ASi-3
- ASI4U-V5 supports all bus topologies (line, star, tree)
- ASI4U-V5 supports and easy integration with IO-Link

**Robustness**

- ASI-5 is the most robust field bus due to its 3D redundancy concept, which ensures that all data reaches the destination in time without any errors. Robustness is a key asset in industrial communication.

**Application Examples**

Supports simple slave and complex slave applications

- Up to 22 digital I/Os for cyclic communication
- No software interface
- SPI I/F for up to 32 bytes for cyclic communication
- Software interface for diagnostic, parameter setting, local firmware update, time synchronization
R-IN32M4-CL3: Industrial Ethernet Controller with CC-Link IE TSN Support

The R-IN32M4-CL3 is a communication SoC with hardware support for CC-Link IE TSN. In addition to R-IN engine technology it implements a gigabit Ethernet compatible PHY, making it a one-chip solution for the latest in TSN communication.

Key Features

- Time synchronization accuracy between devices of ±1 µs or less (CC-Link IE TSN Class B support)
- 2-port gigabit Ethernet compatible PHY, CPU, and RAM (1.3MB) on an one-chip
- R-IN engine for same multi-protocol support as preceding product
- Compact package and on-chip PHY regulator for reduced mounting area
- Low power consumption (35% less than R-IN32M3-CL2)

Product Specifications

- CPU: Cortex-M4 (100MHz)
- RAM: 1.3MB ECC support
- Power supply voltage: 3.3V ±5%, 1.15V ±5%
- I/O: 106 channels (max.)
- 2 Ethernet ports (integrated 10/100/1000 PHY)
- Numerous peripheral functions
  - 32-bit external MCU interface
  - UART
  - I2C
  - CSI
  - Timer
- Operating temperature range
  - Tj = –40 to +125°C
  - Ta = –40 to +85°C

Development Environment

Verify your CC-Link IE TSN communication application within an hour of launching the development environment!

Solution set

- Startup manual
- Evaluation board mounted with R-IN32M4-CL3
- Sample software*
  - CC-Link IE TSN
  - CC-Link IE Field
  - Peripheral drivers
- Settings file for master station
- User’s manuals

Note: Supplied as IAR Embedded Workbench® for ARM projects.

Advantages of CC-link IE TSN

Time synchronization and time sharing among devices makes possible ultrahigh-speed, highly accurate motor control. It is also possible to seamlessly connect information technology (IT) networks and operational technology (OT) networks so they can interoperate with each other, enabling flexible support for multiproduct variable-quantity production in which models and manufacturing volumes can be changed in real time for higher plant productivity overall.
The crucial importance of functional safety is rising in the industrial field, aiming to maintain safety when malfunctions occur in order to prevent breakdowns and accidents during planned operation, adverse impacts from operator injuries, and associated economic losses. Today, not only the EU’s Machinery Directive but also the industrial safety and health laws in many countries require industrial machinery meets functional safety standards. As the scope of standards for functional safety expands in many industrial fields, Renesas provides IEC61508 certified functional safety software, documents, development tools, and verified reference kits to support our customers reduce the development task and time. Renesas been the 1st MCU supplier to complete the verification of the core self-test and been expanding safety solutions which is certified and compliant to IEC61508 by TÜV Rheinland.

**TUV Certified Solution**

Safety system development is very complexed process. Therefore it is very important to build up an application piece by piece considering functional safety standards in both hard and software modules. Ideally the parts should come with certification. While every application is different per usage for safety components, hard as well as software, Renesas provides less extensive workload for safety system developers. Renesas solutions covers certification process and will shortens customer’s actual development TAT. Renesas certified SW will do the functionalities safety diagnosis on MCU which means customer can focus more on application development.

**Target Application**

- Industrial Motor Drives
- Safety Controllers
- Programmable Logic Controllers
- Safety Sensors

**Usage Example : Safe Motor Control**

Application and Safety Functionality separated
Two channel concept (1oo2 architecture)
Cross Monitoring
Standard Compliant
- IEC 61508 SIL3
- ISO 13849 Ple Cat4
- IEC 62061 SILCL3

Safety functions according to IEC61800-5-2 (e.g. STO, SLS, etc.)
Renesas Functional Safety Solution List

1. Self-test SW Kit*:
   Free package of MCU Self-diagnostics SW for diagnosing CPU, ROM, and RAM in MCU.

2. SIL3 System SW Kit*:

   SIL3 certified CC-Link IE Safety, and FSoE.

4. Reference Document*:
   Guidebook for safety system design following IEC61508 standard. Safety-related documents covering diagnostic, control methods, required CPU performance, system architecture reference, etc. This document is apart from MCU.

5. Reference Hardware Board:
   Evaluation board verified by certification body. Packed with functional safety know-how e.g. designed in diagnosis and monitoring circuit required by functional safety standard. Can immediately start prototype and SW development. Renesas Safety SWs can also be evaluated.

6. Safety certified compilers*:
   Renesas original certified compiler and certification kit. Certified IAR compiler also available from IAR.

Renesas Functional Safety Overview & Supporting Family

Based upon market requirement, Renesas have completed the supporting menu on RX Family from RXv1 core family also up to RXv3 core family today. This year Renesas have extended the supporting cores to RXv3 and released safety network protocol : FSoE (Functional Safety over EtherCAT).

New Solution of 2020

RXv3 Line-up Extension
- Self-test SW Kit*
- SIL3 System SW Kit*
- Safety Network Protocol*
- Reference HW Board
- Safety certified compilers*

Above kits will be supporting RXv3 core family from this year.

Safety Network Protocol
- FSoE*

Software kit of SIL3 certified stack included network communication i/f between safety and non-safety input. The stack runs on SIL3 System SW and Self-test SW which will do all the diagnosis task of safety monitoring of MCU.

Note: License agreement required beforehand. Please contact your local Sales office for further information.
Renesas Security Solution Contribute to Realize Safe and Secure Industrial 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/A2M            | • JTAG connection lock, JTAG connection certification  
|                   | • External ROM program tamper checking  
|                   | • Decryption of encrypted external ROM programs and deployment to external memory  
|                   | • External ROM dead copy detection                                      |
| RZ/G Series       | • Secure Kernel Boot  
|                   | • Encrypted communication  
|                   | • Basic encryption library                                               |
| RZ/N1D, RZ/N1S    | • Secure Boot  
|                   | • JTAG lock                                                              |
| RX231, RX651/N, RX66T, RX72T, RX72M, RX72N, RX66N | • Trusted Secure IP  
|                   | • Secure Boot  
|                   | • Encrypted communication  
|                   | • Secure update                                                         |
In recent years, the creation of new added value for the Internet of Things (IoT) has been gaining attention. On the other hand, since IoT devices connect to the Internet, they are exposed to risks such as eavesdropping, tampering, and viruses, and such harmful incidents are also seeing an increase in number. Consequently, the demand for security features is increasing for devices that previously didn’t need them.

**Robust Security with Trusted Secure IP**

RX security solutions implement Root of Trust for IoT devices using encryption by key data that is protected by a strong Trusted Secure IP and an authentication program using a memory-protection function. By implementing security functions using an RX microcontroller (MCU), you can easily and strongly protect IoT devices against threats.

The RX65N and RX231 with Trusted Secure IP are CAVP certified under the FIPS 140-2 standard of the National Institute of Standards and Technology (NIST) of the United States, so the encryption algorithm employed can be used with confidence.

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**Security Solutions**

Our device solution contributes to secure the IA products

- **HMI**
  - RZ/A
  - RZ/G

- **Controller/PLC**
  - RZ/N1D
  - RZ/G

- **Sensor/Actuator**
  - RZ/N1S
  - RX231, RX651/65N

- **Servo/Inverter**
  - RZ/T1
  - RX66T, RX72T

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**Threats**

- Eavesdropping
- Tampering
- Virus

**Security**

- Encrypted communication
- Secure updating
- Secure boot

Secure updating: Authentication for program updating detects and prevents tampering

Secure boot: Authentication for program execution detects and prevents tampering

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**Security Hardware Implementing Root of Trust**

**RX MCU**

- Trusted Secure IP
- Flash memory
- Memory protection

**CPU**

- Secure area
- Key data
- Encryption engine

**Update**

- Information leak
- Eavesdropping

**Illegal operation**

- Hijack
- Tampering

**Operate**

- Virus
Resolver Motor Control Solutions Featuring Superlative Cost and Performance Characteristics

Overview of Resolver Motor Control Solutions

These resolver-based motor control solutions are motor control systems for industrial and consumer applications realized by combining resolver-to-digital converter (RDC) ICs and RX Family microcontrollers (MCUs). It is possible to easily control a resolver-based stepping motor or brushless DC motor using the driver software of the microcontroller. Solution kits, sample code, development support tools, and application notes for motors with resolvers are available, and motor control using resolvers can be started immediately.

Key Features

- High-precision motor control is possible even in harsh environments with heat, dust, or vibration.
- Realize high-precision control at low cost using a new type of resolver control with superlative cost performance.
- Resolver signal gain, phase, and angle error are automatically corrected through the driver API that can be used in combination with an RX MCU to achieve high precision.

System Configuration

- In resolver-based motor control solutions, the RDC IC and RX MCU process signals from the resolver as angle information, and the RX MCU controls the motor. A dedicated driver for the RDC IC is provided on the RX MCU, and resolver processing can be easily performed using the API.
- Using a portion of the MCUs functionality makes it possible to simplify the RDC IC and thereby lower its cost.

Motor Control Solutions for Stepping Motors with Resolvers

- Stepping motors with resolvers and resolver motor control solutions developed by collaboration between MinebeaMitsumi Inc. and Renesas make possible servo control for stepping motors that are normally controlled by open loop control.
- These solution realize many advantages such as low noise, low vibration, low power consumption and maximization of motor torque.
- ICs, software, development kits, and development support tools for resolver control and motor control are available.

Solution Contents

Stepping motor with resolver: New motor manufactured by MinebeaMitsumi Inc.
RX24T: MCU for motor control
Resolver-to-digital converter: IC that converts resolver output into digital signal
Solution kit: All items necessary for controlling a stepping motor with resolver are provided
Support tool: Development support tool essential for motor control debugging
System Configuration and Our Recommendation

Overall
Applications such as industrial small robot are required motors with higher precision motor control, miniaturized form factors, and improved resistance to environmental influences. Customer can achieve high-precision motion even in harsh environments such as factory, while reducing costs and further miniaturizing industrial equipment by using smaller motors.

Recommended Products

Microcomputers

<table>
<thead>
<tr>
<th>Category</th>
<th>Products</th>
<th>Operating Frequency (MHz)</th>
<th>Operating Voltage (V)</th>
<th>On-Chip Memory (Max)</th>
<th>Features, etc.</th>
</tr>
</thead>
</table>
| System/Motor Control MCU | RX72M                  | 240                      | 2.7 to 3.6            | 4MB Flash 1MB RAM 32KB DataFlash | • High-performance RXv3 core and large memory capacity for high-precision motor control  
|                        | RX72T                  | 200                      | 2.7 to 5.5            | 1MB Flash 128KB RAM 32KB DataFlash | • High performance RXv3 core with various motor control function  
|                        | RX66T                  | 160                      | 2.7 to 5.5            | 1MB Flash 128KB RAM 32KB DataFlash | • Support for wide range of power supply voltages, all functions necessary for motor control on a single compact chip  
|                        | RX24T                  | 80                       | 2.7 to 5.5            | 512KB Flash 32KB RAM 8KB DataFlash | • Suits for single inverter control with a built-in FPU (floating-point processing unit) that enables it to easily program complex inverter control algorithms  
|                        | RX23T                  | 40                       | 2.7 to 5.5            | 128KB Flash 12KB RAM | • Simplify design in kit with RX24T  

Analog & Power Devices

<table>
<thead>
<tr>
<th>Category</th>
<th>Products</th>
<th>Main Specification</th>
<th>Features, etc.</th>
</tr>
</thead>
</table>
| RDC-IC                 | RAA3064002GF (85 degree) RAA3064003GF (105 degree) | Single-phase induced/two phase output Rectangle waveform 5/10/20kHz, 2.5Vp-p | Simplify design in kit with RX24T  
|                        | HIP4082                | 80V, 1.25A Peak Driver     | Winding error correction function  
|                        | RJK08542DP8            | Nch Single Power MOSFET 80V 25A 13mOhm LLPK | Low on-resistance, high-speed switching, and high-robustness  
|                        | ISLU8440               | 1A MOSFET gate driver 90µA start-up current, 125µA maximum 35ns propagation delay current sense to output | 30V operation, low operating current, 90µA start-up current, adjustable operating frequency to 2MHz, and high peak current drive capability with 20ns rise and fall times.  
|                        | ISLU85033              | Wide VIN Dual Standard Buck Regulator With 3A/3A Continuous Output Current | Wide input voltage range from 4.5V to 28V  
|                        | ISLU85050              | High performance 500mA LDO | ±1.8% VOUT accuracy guaranteed over line, load  
|                        | RMUV series            | RMUV series: Standby: 0.6µA (typ.), Access time 45ns (max.)  | Industry-leading Low standby current, suitable for battery-backup memory  
|                        | RMXV series            | RMXV series: Standby: 1.0µA (typ.), Access time 55ns (max.) | High reliability. Extremely low soft-error rate, less than 0.1 FIT / Mbit  
|                        | ISLU8485E              | ESD Protected to ±15V 5V Low Power High Speed Rate Limited, RS-485/RS-422 Transceivers | Data rates up to 10Mbps which features higher slew rates. Extended industrial temperature options (+125°C)  
|                        | ISLU8485E              | ESD Protected to ±15V 5V Low Power High Speed Rate Limited, RS-485/RS-422 Transceivers | Operate from a single +5V supply (10% tolerance)  

Power supply
RX72M, RX72N, RX66N Expands Equipment Control and Networking Portfolio with 32-Bit MCUs

Overview

Launched new product, RX72N, RX66N, built around RXv3 core. RX72N features a maximum operating frequency of 240 MHz and two Ethernet channels, and the RX66N features a maximum operating frequency of 120 MHz and one Ethernet channel. In addition to existing RX72M with EtherCAT® support, expands our MCU products portfolio by combining equipment control and networking just one chip.

Key Features

RX72M, RX72N, RX66N

- Outstanding Real-Time performance: Industry’s fastest flash memory operating that RX72M and RX72N need only one wait cycle and No wait occurs for RX66N when a cache miss occurs.
- Multi-function and Small Footprint: Industry’s largest memory and General-purpose input/output contribute to shrink caches and reduce development time by integrating many functions into a single chip.
- Robust Security: Perfect application from various treats by Trusted Secure IP (TSIP), TSIP outputs key generation related unique ID, this avoids to use in other devices, even if the key generation is stolen.
- Advanced HMI without external RAM: LCD controller, 2D drawing engine, serial sound I/F, and 1MB SRAM realize lower barrier to adaption of HMI function.

RX72M

- Built-in EtherCAT slave controller: Adopted Beckhoff Automation’s “EtherCAT Slave Controller IP Core”, and advanced timers support three-phase complementary PWM outputs and encoder inputs, realize high-precision motor control through EtherCAT communication.
- Multi-Protocol support: Certified by major protocols of EtherCAT, Profinet RT and Ethernet/IP, Sample program of major protocols realize to reduce development time and cost.

New RX Portfolio

<table>
<thead>
<tr>
<th>Group</th>
<th>RX72M</th>
<th>RX72N</th>
<th>RX66N</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>240MHz RXv3 core</td>
<td>240MHz RXv3 core</td>
<td>120MHz RXv3 core</td>
</tr>
<tr>
<td>Memory</td>
<td>4MB flash memory (120MHz read access) 1MB SRAM</td>
<td>4MB flash memory (120MHz read access) 1MB SRAM</td>
<td>4MB flash memory (120MHz read access) 1MB SRAM</td>
</tr>
<tr>
<td>Network</td>
<td>2ch Ethernet</td>
<td>2ch Ethernet</td>
<td>2ch Ethernet</td>
</tr>
</tbody>
</table>

System Configuration

Multi-pin package:

Release restrictions on functionality selection due to tight program capacity and insufficient pins, and support to reduce number of components, small footprint, and development time.
Renesas Solution Starter Kit for High-Precision Sensing evaluation of RX23E-A MCU

**Kit Overview**

The RX23E-A Renesas Solution Starter Kit (RSSK) includes an RX23E-A mounted evaluation board with sensor measurement peripheral circuits. By using it with software downloadable from the website, users can start evaluating analog features right after unboxing. The kit helps users shorten development period and improve time-to-market.

**Sensor Signal Conditioning ICs for Industrial Sensing Applications**

**Product Family Overview**

Renesas Sensor Signal Conditioner (SSC) ICs facilitate design and production of sensor interfaces by providing programmable, highly accurate, wide gain and quantization functions combined with powerful, proven high-order digital correction and linearization algorithms, which are embedded in the device.

**SENSOR SIGNAL**
- Physical measure
  - Pressure
  - Torque
  - Temperature
  - Force
  - Weight/load

**SIGNAL CONDITIONING**
- Signal transducing
- Signal amplification
- Signal conditioning
  - (compensation of offset, non-linearity and temperature dependency)

**CONDITIONED OUTPUT**
- Linear analog
  - Ratiometric voltage, current loop
- Digital PWM, I2C, SPI and OWI output

See Product Portfolio on page 37.
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 IC and multi protocols communication IC.
One protocol communication IC give benefits as small footprint and low cost for customer.
Multi protocol communication IC give benefits as unique environment for customer.

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

Contribute to realize the interoperability for smart society
Some multi protocols communication IC can realize simultaneous operation for two industrial protocols. So, customer can develop the gateway between industrial ethernet protocols.
## Recommended Devices for Industrial Networks

### For Master

<table>
<thead>
<tr>
<th>Fieldbus</th>
<th>RX7M</th>
<th>RZ/N1D</th>
<th>RZ/N1S</th>
<th>RZ/N1L</th>
<th>RZ/T1</th>
<th>ASI4U-V5</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPCI UA</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
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<tr>
<td>PROFINET</td>
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<td>EtherCAT</td>
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<td>Sercos III</td>
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<tr>
<td>CC-Link IE TSN</td>
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<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
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<td>CC-Link IE Field</td>
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### For Slave

<table>
<thead>
<tr>
<th>Fieldbus</th>
<th>RX7M</th>
<th>RZ/N1D</th>
<th>RZ/N1S</th>
<th>RZ/N1L</th>
<th>RZ/T1</th>
<th>R-IN32(CL3)</th>
<th>R-IN32(CL)</th>
<th>R-IN32(EC)</th>
<th>EC-1</th>
<th>TPS-1</th>
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</tbody>
</table>

**Note:** Under consideration. Contact a sales person for details.
AC Servo System Configuration and Our Recommendation

Overview

• The AC servo system used in machine tools, industrial robots, and variety of other manufacturing machinery precisely controls the rotor position, rotation direction, rotation speed, and torque of servo motors. Features such as fast calculation, the ability to generate and output 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, combining fast real-time processing performance with extensive peripheral functions such as multifunction motor control timer, A/D converter, 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 power devices.

System Block Diagram

- Power supply
- DC/DC: 24V > 5V, 3.3V, 1.2V
- Inverter circuit
- IGBT drive photocoupler
- Tr-output photocoupler
- Encoder
- Display MCU
- Control MCU
- SRAM
- Industrial Ethernet: EtherCAT, EtherNet/IP, PROFINET, etc.
- External communication
- High-speed communication photocoupler
- SCI, CAN, USB
- Current monitor
- Isolation amplifier
- Temp. sensor
- Feedback
- Functional Safety MCUs

IGBT: Insulated Gate Bipolar Transistor
PFC: Power Factor Correction
PWM: Pulse Width Modulation
SCI: Serial Communication Interface
ADC: Analog to Digital Converter
## 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 (Max.)</th>
<th>Features, etc.</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tightly-coupled memory for fast real-time control</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R-IN Engine for fast, power-efficient communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Encoder interface to accommodate external FPGA functions</td>
</tr>
<tr>
<td>Control MCU</td>
<td>RZ/T1</td>
<td>600/450/300</td>
<td>3.3 (I/O) 1.2 (Core)</td>
<td>512KB + 32KB Extended RAM: 1MB</td>
<td>High-performance RXv3 core and large memory capacity for high-precision motor control</td>
</tr>
<tr>
<td></td>
<td>RX72M</td>
<td>240</td>
<td>2.7 to 3.6</td>
<td>4MB Flash 1MB RAM 32KB DataFlash</td>
<td>High-performance RXv3 core and large memory capacity for high-precision motor control</td>
</tr>
<tr>
<td></td>
<td>RX72N</td>
<td>240</td>
<td>2.7 to 3.6</td>
<td>4MB Flash 1MB RAM 32KB DataFlash</td>
<td>High-performance RXv3 core and large memory capacity for high-precision motor control</td>
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<tr>
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<td>RX72T</td>
<td>200</td>
<td>2.7 to 5.5</td>
<td>1MB Flash 128KB RAM 32KB DataFlash</td>
<td>High-performance RXv3 core and large memory capacity for high-precision motor control</td>
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<td>RX66T</td>
<td>160</td>
<td>2.7 to 5.5</td>
<td>1MB Flash 128KB RAM 32KB DataFlash</td>
<td>High-performance RXv3 core and large memory capacity for high-precision motor control</td>
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<td>Display MCU</td>
<td>RX651</td>
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<td>1MB Flash 256KB RAM 32KB DataFlash</td>
<td>High performance RXv3 core with various motor control function</td>
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<tr>
<td></td>
<td>RX65N</td>
<td>120</td>
<td>3.3</td>
<td>1MB Flash 256KB RAM 32KB DataFlash</td>
<td>High performance RXv3 core with various motor control function</td>
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<td>RX113</td>
<td>32</td>
<td>3.3</td>
<td>512KB Flash 64KB RAM 8KB DataFlash</td>
<td>High performance RXv3 core with various motor control function</td>
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<tr>
<td></td>
<td>RA6M3</td>
<td>120</td>
<td>3.3</td>
<td>2MB Flash 64KB RAM 32KB DataFlash</td>
<td>High performance RXv3 core with various motor control function</td>
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### Memory

<table>
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<th>Memory Density</th>
<th>Recommended Products</th>
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<th>Standby Current (Typ.)</th>
<th>Features, etc.</th>
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<td>4-Mbit</td>
<td>RMLV0408E Series</td>
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<td>0.4µA</td>
<td>Competitive differentiation:</td>
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<td></td>
<td>RMLV0414E Series</td>
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<tr>
<td>8-Mbit</td>
<td>RMLV0808E Series</td>
<td>45ns</td>
<td>0.45µA</td>
<td>Industry-leading Low standby current, suitable for battery-backup memory</td>
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<tr>
<td>16-Mbit</td>
<td>RMLV1616A Series</td>
<td>55ns</td>
<td>0.5µA</td>
<td>High reliability: Extremely low soft-error rate, – less than 0.1 FIT / Mbit</td>
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<td>32-Mbit</td>
<td>RMLV3216A Series</td>
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<td>32-Mbit</td>
<td>RMV3216A Series</td>
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<tr>
<td>64-Mbit</td>
<td>RMV6416A Series</td>
<td>55ns</td>
<td>1.2µA</td>
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### 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>
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<tbody>
<tr>
<td>Power supply</td>
<td>DC/DC</td>
<td>RAA230152</td>
<td>Input voltage range: 7 to 28V Max. output current: 3A</td>
<td>Auto PFM (low-load, low power operation) mode</td>
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<tr>
<td></td>
<td></td>
<td>RAA230153</td>
<td>Input voltage range: 7 to 28V Output voltage: 0.8 to 6V Max. output current: 3A</td>
<td>Auto PFM (low-load, low power operation) mode</td>
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<tr>
<td></td>
<td></td>
<td>RAA230231</td>
<td>Input voltage range: 4.5 to 16V Output voltage: CH1 3.3V, CH2 0.8 to 6V Max. output current: 3A</td>
<td>Dual channel DC/DC</td>
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<tr>
<td></td>
<td></td>
<td>RAA212422</td>
<td>Dual synchronous rectification DC/DC regulator CH1: Vin = 3 to 40V, 1.1A output CH2: Vin = 2.7 to 5.5V, 1.5A</td>
<td>Low-load mode</td>
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<tr>
<td>Current monitor</td>
<td>Isolation amplifier</td>
<td>PS8352A</td>
<td>1% precision, analog output, SDIP package</td>
<td>Compact package: 3mm x 6mm TDFN</td>
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<tr>
<td></td>
<td></td>
<td>PS9352A</td>
<td>1% precision, digital output, SDIP package</td>
<td>Support for high temperature operation up to 110°C</td>
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<tr>
<td>Inverter circuit</td>
<td>IGBT/IPM drive photocoupler</td>
<td>PS9402/PS9031</td>
<td>1% precision, analog output small package</td>
<td>Ability to select from wide range of functions to match IGBTs used</td>
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<td>PS9906/PS9905</td>
<td>IGBT protection circuit/2.5A output small package</td>
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<tr>
<td>Isolation</td>
<td>High-speed communication photocoupler</td>
<td>PS8901</td>
<td>10Mbps, compact, high voltage tolerance 600V isolation</td>
<td>Compact and high voltage tolerance</td>
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<tr>
<td></td>
<td>Tr-output photocoupler</td>
<td>PS8902/PS8924</td>
<td>Compact, high temperature tolerance</td>
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</table>
**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 one-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.

---

**Supports Industry Ethernet Communication**

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Supports</th>
<th>Provides Solution, Supports Partners</th>
</tr>
</thead>
</table>
JSI Technology (EtherCAT Slave) ([http://jsl.co.jp/](http://jsl.co.jp/))
Sherpa Inc. (EtherCAT Slave) ([https://www.Sherpa-tech.net/](https://www.Sherpa-tech.net/))
M2M craft Co., Ltd. (EtherCAT Slave) ([http://www.m2mcraft.co.jp/](http://www.m2mcraft.co.jp/)) |
| PROFINET | Sherpa Inc. ([https://www.sherpa-tech.net/](https://www.sherpa-tech.net/))
M2M craft Co., Ltd. ([http://www.m2mcraft.co.jp/](http://www.m2mcraft.co.jp/))
TMG Technologie und Engineering GmbH ([https://www.tmgte.de/](https://www.tmgte.de/))
Molex LLC ([https://www.molex.com/molex/home](https://www.molex.com/molex/home)) |
| EtherNet/IP | Sherpa Inc. ([https://www.sherpa-tech.net/](https://www.sherpa-tech.net/))
M2M craft Co., Ltd. ([http://www.m2mcraft.co.jp/](http://www.m2mcraft.co.jp/))
TMG Technologie und Engineering GmbH ([https://www.tmgte.de/](https://www.tmgte.de/))
Molex LLC ([https://www.molex.com/molex/home](https://www.molex.com/molex/home)) |
JSI Technology (EtherCAT Slave) ([http://jsl.co.jp/](http://jsl.co.jp/))
Sherpa Inc. (EtherCAT Slave) ([https://www.Sherpa-tech.net/](https://www.Sherpa-tech.net/))
M2M craft Co., Ltd. (EtherCAT Slave) ([http://www.m2mcraft.co.jp/](http://www.m2mcraft.co.jp/)) |

*Visit the website for configuration data for each encoder interface is available: ([https://www.renesas.com/ja-ja/products/microcontrollers-microprocessors/rz/rtz/rtz1.html#sampleCodes](https://www.renesas.com/ja-ja/products/microcontrollers-microprocessors/rz/rtz/rtz1.html#sampleCodes))*
**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
- Encoder interface (Nikon A-format™/BiSS-C/EnDat2.2/HIPERFACE DSL®/Tamagawa) (option)
  Note: 2ch encoder support depends on the combination of the selected protocol

- High Speed USB
- Secure boot (option)
- Safety functions
  - ECC memory
  - CRC (32-bit)
  - Independent WDT: Operating on dedicated on-chip oscillator
- ΔΣ interface
- 100Mbps EtherMAC (with Ethernet switch)
- Ethernet accelerator
- Power supply voltage: 1.2V, 3.3V

Package
- FBGA 320pin (17mm × 17mm, 0.8mm pitch)

---

**Power ICs (DC/DC)**

**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.

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**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 amplifiers, 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 (SDIP).
- The lineup of IGBT/IPM drive photocoupler includes products designed to accommodate 2.5A output. Products with integrated Desat or active mirror clamp functionality to prevent IGBT destruction.
- Products with high voltage tolerance and a compact LS05 package 14.5mm creepage products capable of accommodating 690V European industrial voltage.

---

**RZ/T1 Motion Control Solution Kit**

- Package includes all parts needed for motor control evaluation.
- Supports safe design and can be used for reference.
- Includes multifunction utility tool.
- Servo control software is available.
**General Purpose Inverter System Configuration and Our Recommendation**

- **Overview**
  - 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 worldwide, 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.
  - 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.

- **System Block Diagram**
### Recommended Products

#### Microcontrollers

<table>
<thead>
<tr>
<th>Block</th>
<th>Recommended Products</th>
<th>Operating Frequency (MHz)</th>
<th>Operating Voltage (V)</th>
<th>On-Chip Memory (Max.)</th>
<th>Features, etc.</th>
</tr>
</thead>
</table>
| Control MCU            | RX22M                | 240                      | 2.7 to 3.6            | 4MB Flash 128KB RAM 32KB DataFlash | • High-performance RX3 core and large memory capacity for high-precision motor control  
          | RX22N                | 240                      | 2.7 to 3.6            | 4MB Flash 128KB RAM 32KB DataFlash | • Arithmetic unit for trigonometric functions and collective register bank save function  
          | RX22T                | 200                      | 2.7 to 5.5            | 1MB Flash 128KB RAM 32KB DataFlash | • High performance RX3 core with various motor control function  
          | RX66T                | 160                      | 2.7 to 5.5            | 1MB Flash 128KB RAM 32KB DataFlash | • Large memory helps the complicated software development  
          | RX24T RX24U          | 80                       | 2.7 to 5.5            | 512KB Flash 8KB DataFlash      | • High-performance RX3 core and large memory capacity for high-precision motor control  
          | RX656 RX651          | 120                      | 3.3                   | 2MB Flash 64KB RAM             | • 2ch Ethernet  
          | RX113                | 32                       | 3.3                   | 512KB Flash 64KB RAM           | • Support for wide range of power supply voltages, all functions necessary for motor control on a single compact chip  
          | RA6M3                | 120                      | 3.3                   | 2MB Flash 64KB RAM             | • Arm® Cortex®-M4 core and offers a TFT controller with 2D accelerator and JPEG decoder.  
          |                      |                         |                       |                                | • Flexible Software Package (FSP), built on FreeRTOS—and is expandable to use other RTOSes and middleware.  

#### Display/Option MCU

<table>
<thead>
<tr>
<th>Block</th>
<th>Recommended Products</th>
<th>Operating Frequency (MHz)</th>
<th>Operating Voltage (V)</th>
<th>On-Chip Memory (Max.)</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX22M RX22N RX22T RX66T RX24T RX24U RX656 RX651 RX113 RX6M3</td>
<td>240 200 160 80 120 32 120</td>
<td>2.7 to 3.6 2.7 to 5.5 2.7 to 5.5 2.7 to 5.5 3.3 3.3 3.3</td>
<td>4MB Flash 128KB RAM 32KB DataFlash 1MB Flash 128KB RAM 32KB DataFlash 1MB Flash 128KB RAM 32KB DataFlash 2MB Flash 64KB RAM 512KB Flash 64KB RAM 2MB Flash 64KB RAM</td>
<td>• Recommended Products Features, etc.</td>
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### Industrial Communication Chip

<table>
<thead>
<tr>
<th>Block</th>
<th>Category</th>
<th>Recommended Products</th>
<th>Features, etc.</th>
</tr>
</thead>
</table>
| Industrial communication controller | Multi protocol | R-IN32M3-CL/EC, R-IN32M4-CL3, R-IN32M3-CL/EC | • Support CC-Link IE, EtherCAT, EtherCAT/IE, and PROFINET.  
          | Dedicated protocol | RZ/N1L | • Easy slave implementation with R-IN engine and specific hardware  
          | EC-1 | RZ/N1L | • Optimized for EtherCAT applications.  
          | EC-1 | RX72M | • Provide solutions with high reliability.  

### Memory

<table>
<thead>
<tr>
<th>Block</th>
<th>Density</th>
<th>Recommended Products</th>
<th>Access Time (Max.) (Typ.)</th>
<th>Standby Current (Typ.)</th>
<th>Features, etc.</th>
</tr>
</thead>
</table>
| SRAM                   | 4-Mbit  | RMLV008BE Series     | 45ns                      | 0.4µA                  | Competitive differentiation:  
          | 8-Mbit  | RMLV008BE Series     | 45ns                      | 0.45µA                 | Industry-leading Low standby current, suitable for battery-backup memory  
          | 16-Mbit | RMLV1616A Series     | 55ns                      | 0.5µA                  | High reliability: Extremely low soft-error rate, ~ less than 0.1 FIT / Mbit  
          | 32-Mbit | RMLV3216A Series     | 55ns                      | 0.6µA                  | Competitive differentiation:  
          | 64-Mbit | RMLV6416A Series     | 55ns                      | 1.0µA                  | Industry-leading Low standby current, suitable for battery-backup memory  
          |         |                      |                           | 1.2µA                  | High reliability: Extremely low soft-error rate, ~ less than 0.1 FIT / Mbit  

### 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 DC/DC</td>
<td>RAA230152</td>
<td>Input voltage range: 7 to 28V Output voltage: 5.0V Max. output current: 3A</td>
<td>Auto PFM (low-load, low power operation) mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAA230153</td>
<td>Input voltage range: 7 to 28V Output voltage: 0.6 to 6V Max. output current: 3A</td>
<td>Auto PFM (low-load, low power operation) mode</td>
<td></td>
</tr>
</tbody>
</table>
|                        | RAA230231 | Input voltage range: 4.5 to 18V Output voltage: CH1 3.9V, CH2 0.8 to 6V Max. output current: 3A | Auto PFM (low-load, low power operation) mode  
          | RAA212422 | Dual synchronous rectification DC/DC regulator CH1: Vin = 3 to 49V, 1A output CH2: Vin = 2.7 to 5.5V, 1.5A | Low-load mode  
          | ISL80019  | Synchronous rectification regulator Vin = 2.7 to 5.5V, 1.5A | Low-load mode  
          |           |                      |                     | Compact package: 2mm × 2mm TDFN |
| Current monitor        | Isolation amplifier | PS3325A PS0350A | 1% precision, analog output, SDIP package | Support for high temperature operation up to 110°C |
| Inverter circuit       | IGBT/IPM drive photocoupler | PS9402/PS9501/PS9009/PS9005 | IGBT protection circuit/2.5A output small package IPM drive/690V insulation | Ability to select from wide range of functions to match IGBTs used  
          | Isolation | High-speed communication photocoupler | 10Mbps, compact, high voltage tolerance 690V insulation  
          |           | compact, high voltage tolerance 690V insulation | Compact, high voltage tolerance  

---
Our Recommended solutions for General Purpose Inverters

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></td>
<td></td>
<td></td>
<td>Up to 32MHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RX100</td>
</tr>
<tr>
<td>Brushless DC Motor</td>
<td>Vector control (120-degree continuity control)</td>
<td>PWM x6 Dead time generator PDE A/D converter (PWM link)</td>
<td>Compact motors</td>
</tr>
<tr>
<td>Square wave control (120-degree continuity control)</td>
<td>PWM x6 A/D converter</td>
<td>Refrigerator Fan Compact Robot</td>
<td>Industrial Pump</td>
</tr>
<tr>
<td>Induction AC Motor</td>
<td>Vector control</td>
<td>PWM x6 Dead time generator PDE A/D converter (PWM link)</td>
<td>Fan Refrigerator Washing machine Pump</td>
</tr>
<tr>
<td></td>
<td>V/f control</td>
<td></td>
<td>Air conditioner Pump</td>
</tr>
<tr>
<td>Stepper Motor</td>
<td>Vector control</td>
<td>PWM control</td>
<td>Printers / Multi-function printers / Surveillance cameras / Compact motors</td>
</tr>
<tr>
<td></td>
<td>Pulse output</td>
<td>Port control or PWM control</td>
<td></td>
</tr>
</tbody>
</table>

Motor Control Solutions

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.*

After purchase, you can download the software from the website and start evaluating immediately.

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.

Renesas provides various ready to use sample codes and application notes for each type of motor control.

Application Notes/Sample Code

Renesas provides ready to use sample codes and application notes for each type of motor control.

<table>
<thead>
<tr>
<th>Control method</th>
<th>Target MCU</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>120-degree conducting control with hall sensor</td>
<td>RX23T, RX24T</td>
<td>Available [by website]</td>
</tr>
<tr>
<td>Sensorless 120-degree conducting control</td>
<td>RX23T, RX24T</td>
<td>Available [by website]</td>
</tr>
<tr>
<td>Vector control with encoder</td>
<td>RX72T, RX66T, RX24T, RX24U, RX23T</td>
<td>Available [by website]</td>
</tr>
<tr>
<td>Sensorless vector control</td>
<td>RX72T, RX66T, RX24T, RX24U, RX23T, RX13T</td>
<td>Available [by website]</td>
</tr>
<tr>
<td>Induction AC motor sensorless vector control</td>
<td>RX72T, RX66T, RX13T (*uses partner inverter board)</td>
<td>Please contact us</td>
</tr>
<tr>
<td>Resolver vector control</td>
<td>RX24T</td>
<td>Available [by website]</td>
</tr>
<tr>
<td></td>
<td>RX24T, RX66T, RX23T</td>
<td>Please contact us</td>
</tr>
</tbody>
</table>
RX72M Group

Built around the RXv3, the third-generation RX CPU core, these high-performance MCUs (1396 coremark score) provide functions needed for the main applications for industrial machinery and EtherCAT communication functionality on an one-chip.

RX72M Group Block Diagram

RX66T Group

The RXv3 core offers the best performance at the same range MCU with 5V support. And the built-in motor control peripherals (pseudo-differential input PGA, comparator, etc.) contributes to BOM reduction. Feature hardware implementation of system safety functions, greatly reducing the load imposed by software.

RX66T Group Block Diagram

RX72T Group

RX72T Group offers high performance required for motor control in robots and other equipment by max 200 MHz operating frequency CPU core and dedicated accelerators. Built-in security and safety features also offer new added value for inverter control applications.

RX72T Group Block Diagram

RX24T Group

RX24T MCU are designed to ensure the highest noise immunity and operate in a voltage range from 2.7V to 5.5V and added operating ambient temperature 105 degree product line up, providing the highest reliability for any equipment using inverter.

RX24T Group Block Diagram
## PLC System Configuration and Our Recommendation

### 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, while block PLCs (CPU unit only) are used for small-scale 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, RX66N 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 RX66N but also fully optimized. 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

#### Module type PLC: CPU unit + peripheral units

- Backplane bus
- DC/DC
  - 24V > 5V, 3.3V, 1.0V
- ASIC
- Control SOC
- Control MPU
- Peripheral unit MCU
- USB PHY
- Ethernet PHY
- SD memory card
- Control MCU
- Photocoupler
- SRAM
- Flash ROM
- 24V > 5V, 3.3V, 1.0V
- Sensors/remote I/O
- Field network
- General-purpose inverter/servo

#### Block type PLC

- Wireless module
- Communication MCU
- Control MCU
- Photocoupler
- SRAM
- SD memory card
- Ethernet PHY
- USB PHY
- RS485 transceiver
- Field network

---

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, while block PLCs (CPU unit only) are used for small-scale systems.
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### Recommended Products

**Microcontrollers and Microprocessors**

<table>
<thead>
<tr>
<th>Block</th>
<th>Recommended Products</th>
<th>Maximum Operating Frequency</th>
<th>On-Chip Memory (Max.)</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCUs for peripheral units or Control MCUs/Control MPUs</td>
<td>RZ/A1</td>
<td>400MHz</td>
<td>2 to 10 MB RAM</td>
<td>Using the internal RAM, memory access is significantly faster and more stable compared to that of using external RAM. Furthermore, in case an one-chip solution is desired to handle both lag processes and network processes simultaneously, as well as provide support to multiple industrial network master protocols, our RX/N1D is the right product for you.</td>
</tr>
<tr>
<td></td>
<td>RZ/A2M</td>
<td>528MHz</td>
<td>4MB RAM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RZ/N1S</td>
<td>500MHz</td>
<td>6MB RAM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RZ/N1D</td>
<td>500MHz Dual</td>
<td>2MB (+DDR-iF)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RX72M</td>
<td>240MHz</td>
<td>4MB Flash 1MB RAM 32KB DataFlash</td>
<td>• High-performance RXv3 core and large memory capacity for high-precision motor control • Arithmetic unit for trigonometric functions and collective register bank save function • 2ch Ethernet</td>
</tr>
<tr>
<td></td>
<td>RX72N</td>
<td>240MHz</td>
<td>4MB Flash 32KB DataFlash</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RX65N</td>
<td>120MHz</td>
<td>2MB Flash 640KB RAM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RX651</td>
<td>120MHz</td>
<td>2MB Flash 640KB RAM</td>
<td></td>
</tr>
<tr>
<td>Peripheral unit MCU or Communication MCU</td>
<td>RX231</td>
<td>54MHz</td>
<td>512KB Flash 64KB RAM 8KB DataFlash</td>
<td></td>
</tr>
<tr>
<td>Peripheral unit MCU</td>
<td>RX111</td>
<td>32MHz</td>
<td>512KB Flash 64KB RAM 8KB DataFlash</td>
<td></td>
</tr>
</tbody>
</table>

### Memory

<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>4-Mbit</td>
<td>RMLV0408E Series, RMLV0416E Series</td>
<td>45ns</td>
<td>0.4µA</td>
<td>• Exclusive Renesas memory cell technology is more than 500 times as resistant to software errors as full CMOS memory cells, providing the extremely high reliability demanded in the industrial field.</td>
</tr>
<tr>
<td></td>
<td>8-Mbit</td>
<td>RMLV0808B Series, RMLV0816B Series</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16-Mbit</td>
<td>RMLV1616A Series</td>
<td>55ns</td>
<td>0.5µA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32-Mbit</td>
<td>RMV2216A Series</td>
<td></td>
<td>1.0µA</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>RAA230152</td>
<td>Input voltage range: 7 to 28V Output voltage: 5.0V Max. output current: 3A</td>
<td>• Auto PFM (low-load, low power operation) mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAA230153</td>
<td>Input voltage range: 7 to 28V Output voltage: 0.8 to 6V Max. output current: 3A</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAA230231</td>
<td>Input voltage range: 4.5 to 18V Output voltage: CH1 3.3V, CH2 0.8 to 6V Max. output current: 3A</td>
<td>• Auto PFM (low-load, low power operation) mode • Dual-channel DC/DC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RAA212422</td>
<td>Dual synchronous rectification DC/DC regulator • CH1: Vin = 3 to 40V, 1.1A output • CH2: Vin = 2.7 to 5.5V, 1.5A</td>
<td>• Low-load mode • Compact package: 3mm × 6mm TDFN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISL80019</td>
<td>Synchronous rectification regulator Vin = 2.7 to 5.5V, 1.5A</td>
<td>• Low-load mode • Compact package: 3mm × 2mm TDFN</td>
</tr>
<tr>
<td>Isolation</td>
<td>High-speed communication photocoupler Tr-output photocoupler</td>
<td>PS0001, PS0123, PS0124 PS2844-4</td>
<td>10Mbps, compact, high voltage tolerance Compact SOS package Common-lead package</td>
<td>• Compact and high voltage tolerance, ideal for compact systems</td>
</tr>
</tbody>
</table>
1. Reducing development resources by adopting this platform

The module type of PLC consist with peripheral units such as IO Unit, Network Unit, and Positioning Units where MCU performance differs within each units. 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 cost). 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 easy 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.


The newly added RX72M/RX72N are successor of RX71M with enhanced performance and function as flagship of RX family, 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.
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.

RZ/A1, RZ/A2M, 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 One-chip RZ/N1D provides high CPU frequency, large sized memory I/F, USB, SDIOs, to interface with PLC. Also Renesas provides not only an IC but evaluation model SW PLC kit supporting PROFINET, EtherNet/IP, EtherCAT, etc. This will shrink your development time-line for immediate evaluation of industrial Ethernet master communication processing and ladder process.

RZ/N1D Block Diagram

### RZ/N1D Block Diagram

- **System**
  - 400-pin LFBGA 17mm × 17mm/0.8mm pitch
  - 324-pin LFBGA 15mm × 15mm/0.8mm pitch
- **CPU**
  - Arm® Cortex®-A7 Core: 500MHz
  - Arm® Cortex®-M3: 125MHz
- **Memory**
  - L1 Cache: 16KB
  - D-Cache: 16KB
  - L2 Cache: 256KB
  - SRAM 2MB (with ECC)
- **R-IN Engine**
  - MPU: 125MHz
  - Ethernet: 10/100/1000 (IEEE802.3af)
  - USB2.0 HS
  - SPI
- **Evaluation Protocol Stack**
  - Master: PROFINET
  - EtherNet/IP
  - EtherCAT
  -Slave: PROFINET
  - EtherNet/IP DLR
  - EtherCAT

*For full version protocol stack, please contact your nearest stack supplier*
Remote IO 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.
### Recommended Products

#### Industrial Communication IC

<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>
|       | Factory Automation IC | R-IN32M3-EC | Cortex®-M3 | 100 | 3.3V (I/O) 1.0V (Core) | 1.3MB (ECC) | • Single-chip support for multiple industrial protocols, including EtherCAT.  
  • On-chip 100Mbps Ethernet PHY. |
|       |           | R-IN32M3-CL | Cortex®-M3 | 100 | 3.3V (I/O) 1.0V (Core) | 1.3MB (ECC) | • Single-chip support for multiple industrial protocols, including CC-Link IE Field. |
|       |           | R-IN32M4-CL3 | Cortex®-M4 processor with FPU | 100 | 3.3V (I/O) 2.5V (PHY) 1.15V (Core) | 1.3MB (ECC) | • Support for multiple protocols, including CC-Link IE TSN, EtherCAT, EPA, and PROFINET.  
  • Integrated 2-port gigabit Ethernet compatible PHY. |
|       | Industrial Communication Controller | EC-1 | Cortex®-R4 processor with FPU | 150 | 3.3V (I/O) 1.2V (Core) | | • A communication chip with support for EtherCAT, combining architecture with excellent real-time performance and an integrated EtherCAT slave controller. |
|       |           | TPS-1 | — | — | 3.3V (I/O) 1.6V (Core) | — | • A device conforming to the PROFINET IRT standard, one of the industrial Ethernet communication standard involved in growing adoption of open networks, is available. |
| RZ/N |           | RZ/N1S | Cortex®-A7 | 500 | 3.3V (I/O) 1.15V (Core) | 6MB (ECC) | • A device supports multiple protocols such as EtherCAT, EtherCAT/IP, PROFINET, SERCOS, POWERLINK, IO Link, Fieldbus. |
|       |           |         | Cortex®-M3 | 125 | 3.3V (I/O) 1.15V (Core) | 6MB (ECC) | • A device supports multiple protocols such as EtherCAT, EtherCAT/IP, PROFINET, SERCOS, POWERLINK. |
| RX700 | RX72M | RXv3 | 240 | 3.3V | 1MB + 32KB (ECC) | | • High-performance RXv3 core and large memory capacity for high-precision motor control  
  • Arithmetic unit for trigonometric functions and collective register bank save function  
  • On-chip EtherCAT slave controller. |

### 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>
</table>
|       | Power supply | DC/DC | RAA230152 | Input voltage range: 7 to 28V  
  Output voltage: 5.0V  
  Max. output current: 3A | • Auto PFM (low-load, low power operation) mode |
|       |           | RAA230153 | Input voltage range: 7 to 28V  
  Output voltage: 0.8 to 6V  
  Max. output current: 3A | | |
|       |           | RAA230231 | Input voltage range: 4.5 to 18V  
  Output voltage: CH1: 3.3V, CH2: 0.8 to 6V  
  Max. output current: 3A | • Auto PFM (low-load, low power operation) mode  
  • Dual channel DC/DC |
|       |           | RAA21422 | Dual synchronous rectification DC/DC regulator  
  • CH1: Vin = 3 to 40V, 1.1A output  
  • CH2: Vin = 2.7 to 5.5V, 1.5A | • Low-load mode  
  • Compact package: 3mm x 6mm TDFN |
|       | Isolation | Tr-output photocoupler | ISL80019 | Synchronous rectification regulator  
  Vin = 2.7 to 5.5V, 1.5A | • Low-load mode  
  • Compact package: 2mm x 2mm TDFN |
|       |           | PS2811-4 | SSOP package  
  LDV INPUT | • Compact and high voltage tolerance, ideal for compact systems |
|       |           | PS2801C-4 | SSOP package | |
Today, Industrial Ethernet is expanding rapidly in factories, and machines and modules are required to support it. Features in this high demand includes support for multiple Industrial Ethernet protocols and excellent real-time responsiveness to improve factory productivity. The importance of these two aspects cannot be overemphasized. 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 real-time responsiveness five to ten times that of a conventional software real-time OS. In addition, the fluctuation caused by inconsistencies in the operation time with conventional CPU processing is reduced substantially from one-fifth to one-tenth of the previous level.

2. Multi-protocol support (EtherCAT, EtherNet/IP, PROFINET, etc.)

The R-IN32M3 Series supports various industrial Ethernet protocols, including CC-Link IE Field and EtherCAT, and conventional open network protocols.

**Ethernet protocols:**
- EtherCAT*, EtherNet/IP, PROFINET (RT), Modbus TCP, and CC-Link IE Field*

**Open network protocols:**
- CANopen, DeviceNet, Modbus RTU/ASCII, and CC-Link

<table>
<thead>
<tr>
<th>Supports Industry Ethernet Protocol</th>
<th>Recommended Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC-Link IE TSN Class B</td>
<td>R-IN32M4-CL3</td>
</tr>
<tr>
<td>CC-Link IE TSN Class A</td>
<td>R-IN32M4-CL3, RZ/N1, RZ/T1, R-IN32M3-EC/CL, RX72M</td>
</tr>
<tr>
<td>CC-Link IE Field</td>
<td>R-IN32M4-CL3, R-IN32M3-CL</td>
</tr>
<tr>
<td>EtherCAT</td>
<td>RZ/N1S, RZ/N1L, RZ/T1, EC-1, R-IN32M3-EC, RX72M</td>
</tr>
<tr>
<td>EtherNet/IP</td>
<td>RZ/N1S, RZ/N1L, RZ/T1, R-IN32M3, R-IN32M4-CL3, RX72M</td>
</tr>
<tr>
<td>Modbus/TCP</td>
<td>RZ/N1S, RZ/N1L, RZ/T1, R-IN32M3, R-IN32M4-CL3, RX72M</td>
</tr>
<tr>
<td>PROFINET RT</td>
<td>RZ/N1S, RZ/N1L, RZ/T1, R-IN32M3, R-IN32M4-CL3, RX72M</td>
</tr>
<tr>
<td>PROFINET IRT</td>
<td>TPS-1</td>
</tr>
<tr>
<td>ETHERNET POWERLINK</td>
<td>RZ/N1S, RZ/N1L</td>
</tr>
<tr>
<td>Sercos III</td>
<td>RZ/N1S, RZ/N1L</td>
</tr>
<tr>
<td>OPC-UA</td>
<td>RZ/N1S, RZ/N1L, RZ/T1, R-IN32M3, R-IN32M4-CL3, RX72M</td>
</tr>
</tbody>
</table>

*1. Supported by R-IN32M3-EC only.
2. Supported by R-IN32M3-CL only.

**Industrial Communication IC**

Our Recommended Devices for Remote IO System
**Product list for R-IN engine**

<table>
<thead>
<tr>
<th>RZ/N1S</th>
<th>Cortex®-A7 + Cortex®-M3</th>
<th>4p GbE Switch + 1 MAC</th>
<th>EtherCAT Slave Controller</th>
<th>Senseon</th>
</tr>
</thead>
<tbody>
<tr>
<td>RZ/N1L</td>
<td>Cortex®-M3</td>
<td>4p GbE Switch + 1 MAC</td>
<td>EtherCAT Slave Controller</td>
<td>Senseon</td>
</tr>
<tr>
<td>RZ/T1</td>
<td>Cortex®-M4 Processor with FPU + Cortex®-M3</td>
<td>2p Ether Switch + 1 MAC</td>
<td>EtherCAT Slave Controller* (*Option)</td>
<td></td>
</tr>
<tr>
<td>R-IN32M3-EC</td>
<td>Cortex®-M3</td>
<td>2p Ether Switch</td>
<td>EtherCAT Slave Controller</td>
<td></td>
</tr>
<tr>
<td>R-IN32M3-CL</td>
<td>Cortex®-M3</td>
<td>2p GbE Switch</td>
<td>CC-Link IE Field Controller</td>
<td></td>
</tr>
</tbody>
</table>

**Industrial Ethernet Communication IC (R-IN32M4)**

The R-IN32M4-CL3 is an Ethernet communication SoC that makes possible ultrahigh-speed, highly accurate motor control by maintaining time synchronization accuracy between devices of 1 millionth of a second or less to enable support for CC-Link IE TSN networks. This lets customers achieve ultrahigh-speed, highly accurate motor control in their application devices, speeding up TSN response in application devices requiring fast and responsive control, such as AC servos, actuators, and vision sensors, as well as remote I/O applications with heavy network usage.

### R-IN32M4-CL3 Block Diagram

```
Real-time OS accelerator (HW-RTOS)

R-IN Engine

Arm® Cortex®-M4
Arm® Cortex®-M4 (32-bit RISC CPU running at 100MHz)
Real-time OS accelerator
Ethernet controller
Instruction RAM
Ethernet MAC
10/100/1000Mb Ethernet PHY

1.3MB ECC memory (instruction RAM, data RAM, buffer RAM)
Many peripheral functions
Serial flash memory interface for reduction in external ROM mounting area
SRAM interface support (ability to connect external MPU)
CAN × 2 channels, I²C × 2 channels
Up to 106 general ports
10-bit SAR ADC (8 channels)

Fast real-time processing
• R-IN Engine
  – Arm® Cortex®-M4 processor with FPU (32-bit RISC CPU running at 100MHz)
  – Real-time OS accelerator
• Ethernet controller
  – CC-Link IE TSN Controller
  – On-chip 10/100/1,000Mb Ethernet PHY
  – 1.3MB ECC memory (instruction RAM, data RAM, buffer RAM)
Many peripheral functions
  – Serial flash memory interface for reduction in external ROM mounting area
  – SRAM interface support (ability to connect external MPU)
  – CAN × 2 channels, I²C × 2 channels
  – Up to 106 general ports
  – 10-bit SAR ADC (8 channels)
```

**Industrial Ethernet Communication IC (R-IN32M3 Series)**

The R-IN32M3-EC has an integrated 10/100 Ethernet PHY and requires no external PHY. This allows for a more compact module board. On the other hand, the R-IN32M3-CL implements the CC-Link IE protocol in hardware, is equipped with a 1Gbps Ethernet MAC, and (when paired with an external 1Gbps Ethernet PHY) supports 1Gbps Ethernet communication.

- **R-IN32M3-EC: Supported protocols**
  - EtherCAT, EtherNet/IP, PROFINET(RT), ModbusTCP, CC-Link, CANopen, DeviceNet, Modbus RTU/ASCII

- **R-IN32M3-CL: Supported protocols**
  - CC-Link IE Field, EtherNet/IP, PROFINET(RT), ModbusTCP, CC-Link, CANopen, DeviceNet, Modbus RTU/ASCII

### R-IN32M3-EC/R-IN32M3-CL Block Diagram

```
Real-time OS accelerator (HW-RTOS)

R-IN Engine

Arm® Cortex®-M3
Arm® Cortex®-M3 Processor with FPU (32-bit RISC CPU running at 100MHz)
Real-time OS accelerator
Ethernet controller
Instruction RAM
Ethernet MAC
2-port Ethernet PHY

On-chip memory (RAM)
Instruction RAM
Ethernet MAC
Buffer RAM (64KB)

Many peripheral functions
Serial flash memory interface for reduction in external ROM mounting area
SRAM interface support (ability to connect external MPU)
CAN × 2 channels, I²C × 2 channels
Up to 96 general ports

Fast real-time processing
• R-IN Engine
  – Arm® Cortex®-M3 processor with FPU (32-bit RISC CPU running at 100MHz)
  – Real-time OS accelerator
• Ethernet controller
  – CC-Link IE TSN Controller
  – On-chip 2-port Ethernet switch (IEEE 1588, DLR, cut-through hub function, etc.)
  – 1.3MB ECC memory (instruction RAM, data RAM, buffer RAM)
Many peripheral functions
  – Serial flash memory interface for reduction in external ROM mounting area
  – SRAM interface support (ability to connect external MPU)
  – CAN × 2 channels, I²C × 2 channels
  – Up to 96 general ports
```
RZ/N1S Group

RZ/N1S housed Cortex®-A7 and a large size of built-in RAM in a small package. Since peripheral parts can be reduced, it can be used for small PLC, HMI, etc. In addition, since it has a proven R-IN engine as an accelerator for industrial Ethernet communication, it can be used for protocol gateway, sensor hub, etc.

PROFINET Communication IC (TPS-1)

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

RZ/N1L Group

RZ/N1L equipped with “R-IN engine” which is an accelerator for industrial Ethernet communication can be used for the communication parts of industrial network device where real-time responsibility is required. With integrated EtherCAT and Sercos III slave dedicated H/W, it is possible to handle a wide range of protocols.

EtherCAT Communication IC (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.
CONNECT IT! ETHERNET RZ/N

CONNECT IT! ETHERNET RZ/N is the perfect solution kit for developers new to developing for the RZ/N1. In addition to an evaluation board, it includes a JTAG emulator and various sample software projects. Just set up the board according to the startup manual and you can evaluate projects employing Linux OS or the R-IN Engine, as well as master and slave communication using EtherCAT or other protocols. In addition to versions with three different CPU boards (RZ/N1D, RZ/N1S, and RZ/N1L), an expansion board is also available that enables you to evaluate a variety of peripheral functions. Choose the evaluation board that best matches your application. This solution kit lets you experience the performance and functionality of the RZ/N1.

EC-1 Remote I/O Solution

To enable as many customers as possible to undertake development quickly, easily, and with peace of mind, Renesas offers this solution combining hardware, software, integrated development environment, and other necessary elements. The board has eight input and eight output channels and is designed to operate at 24V to simulate an actual remote I/O product. Since the board and sample software have already passed EtherCAT certification testing, using the circuit diagrams of the board for reference can greatly reduce the workload involved in developing a commercial product.

RX72M Solution

This solution consists of RX72M-based evaluation board along with sample software for the OS, middleware and industrial network communication protocols. Enables to cover 70% of the major industrial network communication protocols in the market, and it has been passed for conformance with the three major protocols (EtherCAT, PROFINET RT, EtherNet/IP).
Sensor Interface

Sensors are surely the fastest growing market among various factory sectors as the Industry is moving toward the adoption of Industrial Internet of Things.

Sensors, or so called Edge Applications, now play a vital role into Smart Factory visualization down to all sensor levels and big data gathering for analytics that improve manufacturing processes.

**Functional Blocks**

Functions of sensing systems can be classified with 3 functional blocks to take sensor signal accurately, to process the signal and to output the data. Requirements for each block vary widely over the applications from the simple function sensors such as small pressure sensors to PLC Analog modules that require the complicated and flexible signal processing.

Our solution using Sensor Signal Conditioners (SSC) and Microcontrollers with Sensor Interface analog functions to fit to wide range of market needs.

**Functional Block Diagram**
## Recommended Products

<table>
<thead>
<tr>
<th>Block</th>
<th>Recommended Products</th>
<th>Operating Frequency (MHz)</th>
<th>Operating Voltage (V)</th>
<th>On-Chip Memory (Max.)</th>
<th>Features, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCU for Sensor Controller (Featured Products)</td>
<td>RX23E-A</td>
<td>32MHz</td>
<td>1.8 to 5.5</td>
<td>256KB Flash, 32KB RAM, 8KB Data Flash</td>
<td>Incorporates an analog frontend with low-noise and low-ripple characteristics enabling measurement with an accuracy better than 0.1% without calibration. Ideal for sensors, controllers, or test equipment requiring sensing using minute analog signals representing temperature, pressure, flow, weight, distortion, etc. The RXv2 CPU core excels in DSP and FPU calculations. Enables implementation of high-precision measurement, control, or communication using an one-chip.</td>
</tr>
<tr>
<td></td>
<td>RA2A1</td>
<td>48MHz</td>
<td>1.6 to 5.5</td>
<td>256KB Flash, 32KB RAM, 8KB Data Flash</td>
<td>High-performance Arm® Cortex®-M32 core. Integrates numerous digital peripheral functions and analog functions such as 24-bit ΔΣ ADC and 16-bit SARADC that can be used to measure and process analog signals from sensors and also support human interface functionality such as USB and touch panels.</td>
</tr>
<tr>
<td></td>
<td>RL78/11E</td>
<td>32MHz</td>
<td>2.4 to 5.5</td>
<td>32KB Flash, 4KB RAM, 8KB Data Flash</td>
<td>Power-efficient RL78 MCU with 24-bit ΔΣ A/D converter ideal for high-precision measurement required by industrial devices, measurement of flow, pressure, weight, or distortion for applications in the environmental infrastructure field, or photometry for applications in the healthcare field; 12-bit D/A converter; and analog frontend with configurable amplifier. Compact (4mm × 4mm) package that enables design of space-efficient applications.</td>
</tr>
</tbody>
</table>

### Functional Block

#### Sensor Signal Conditioner (Featured Products)

- **RX23E-A**
  - Resistive
  - 2.7 to 5.5 V
  - Digital
  - 14 bit ADC
  - SOIC, Wafer
  - Industrial/IC Sensors
- **RA2A1**
  - Resistive
  - 2.7 to 40 V
  - Analog/Digital
  - 16 bit ADC
  - Wafer
  - Consumer/White Goods
- **RL78/11E**
  - Capacitive
  - 2.3 to 5.5 V
  - Digital, PDM
  - 14 bit ADC
  - TSSOP, Wafer
  - Industrial
- **NEW**
  - **S1JA**
    - Resistive
    - 2.1 to 10 V
    - Digital
    - 14 bit ADC
    - SSOP, Wafer
    - Industrial/IC Sensors
- **NEW**
  - **ZSC31014**
    - Resistive
    - 2.7 to 5.5 V
    - Digital
    - 14 bit ADC
    - SOIC, Wafer
    - Industrial/IC Sensors
- **ZSC31050**
  - Resistive
  - 2.7 to 40 V
  - Analog/Digital
  - 16 bit ADC
  - Wafer
  - Consumer/Current Loop
- **ZSSC3026**
  - Resistive
  - 2.7 to 5.5 V
  - Digital
  - 16 bit ADC
  - SOIC, Wafer
  - Consumer/White Goods
- **ZSSC3224**
  - Resistive
  - 2.7 to 3.6 V
  - Digital
  - 24 bit ADC
  - QFPN, Wafer
  - Industrial/Consumer
- **ZSSC3240**
  - Resistive
  - 2.7 to 48 V
  - Analog/Digital
  - 24 bit ADC
  - TSSOP, Wafer
  - Industrial/Current Loop
- **ZSSC3123**
  - Capacitive
  - 2.3 to 5.5 V
  - Digital, PDM
  - 14 bit ADC
  - TSSOP, Wafer
  - Industrial
- **ZSSC3230**
  - Capacitive
  - 2.6 to 3.6 V
  - Digital, PDM
  - 18 bit ADC
  - QFN, Wafer
  - Industrial/Consumer

#### PHY for Field Communication

- **ZIOL2401**
  - IO-Link Line Driver
  - Dual Channel
  - The ZIOL2x01 is a line driver/level shifter IC that provides HV I/O channels with a wide range of configurable system features. It addresses the physical layer of sensor/actuator systems in factory automation applications and is specifically designed to support the communication standard IO-Link.
- **ASI4U**
  - AS-I 3 PHY
  - ASI V3 Compliant
  - The ASI4U is used as a part of a master or slave node and work as an interface to the physical bus. The device realize power supply, physical data transfer and communication protocol handling. All products are fully compliant with AS-Interface Complete Specification V3.0.
- **SAP5**
  - AS-I 3 PHY
  - ASI V3 Compliant
  - The SAP5 is a dedicated ASI V3.0 device supporting AS-I safety functions.
- **ASI4U-V5**
  - AS-I 5 PHY
  - ASI V5 Compliant
  - The ASI4U-V5 is the industry’s first silicon solution to fulfill the ASI-5 (Actuator-Sensor-Interface version 5) standard for industrial network equipment that enables comprehensive Industry 4.0 applications.
- **ISL32704E**
  - RS485 Driver
  - RS-485/RS-422 Compliant
  - The ISL32704E is a galvanically isolated, differential bus transceiver designed for bidirectional data transmission and meeting the RS-485 and RS-422 standards for balanced communication.

### Sensor Interface Lineup

#### Sensor Interface lineup

**MCU**

- **RX23E-A**
  - Dual Low noise 24bit DSADC
  - Max ENOB 23.6bit
  - FPU/DSP
- **RA2A1**
  - 24bit DSADC + 12bit SAR ADC
  - ARM® Cortex® M32
  - Security
- **RL78/11E**
  - Resistive
  - 24bit AFE
  - Embedded SSC math
  - PC/SPV/ON/1-P in flex. AOUT
  - Tiny chip of 1sqmm
- **ZSC310xy**
  - Low pin count
  - 24bit DSADC, Flexible AFE
- **ZSC3123**
  - 24bit DSADC + 12bit SAR ADC
  - ARM® Cortex® M32
  - Platform solution
- **ZSSC320**
  - 24bit DSADC + 12bit SAR ADC
  - ARM® Cortex® M32
  - Security
- **ZSSC3240**
  - Flex. resistive 24bit AFE
  - Embedded SSC math
  - PC/SPV/ON/1-P in flex. AOUT
  - Tiny chip of 1sqmm

**ASSP MCU**

- **ASSP Gen1-4**
  - ASSP Application Specific Standard Products
RX Family Development Tools

Renesas supports all stages of development phase in RX by supplying integrated development environments, real-time OSes, middleware, and programming tools that dramatically enhance the development process. Renesas integrated development environments will enable you to accomplish coding, building, and debugging tasks quick and easy, helping to reduce system development time. In addition, a variety of software (middleware modules, peripheral function modules) introduced by a new concept called Firmware Integration Technology (FIT) is available for the RX Family. This software code can be incorporated into user applications and simplifies the process of migration among RX microcontrollers, thereby realizing microcontroller platform for general-purpose inverters needed in the development of a wide variety of products.

RA Family Development Environment

The Renesas RA Family is a new family of 16-bit microcontrollers based on the ARM® Cortex®-M core architecture. It leverages robust security and flexible software solutions to meet the expandability, power efficiency, and performance requirements of embedded system end products.

Integrated Development Environment (IDE)

- Renesas e2 studio
- Keil MDK

Compiler

- GNU, Arm Compiler version 6

Emulator

- Segger J-Link
- Renesas E2 emulator, E2 Lite emulator

Flash Memory Programmer

- Renesas PG-FP6
- Third party solutions

Evaluation Kit

- Full MCU evaluation including on-chip debugger
- Individual kits for several products of each Renesas RA Series are available
### RZ/T, RZ/N Series Development Tools

**RZ/T, RZ/N Series: Development Environments (Integrated Development Environments)**

<table>
<thead>
<tr>
<th>Support Series</th>
<th>RZ/T</th>
<th>RZ/T, RZ/N</th>
<th>RZ/T</th>
<th>RZ/T, RZ/N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Development environments</strong></td>
<td>• DS-5</td>
<td>• IAR Embedded Workbench® for Arm®</td>
<td>• eBinder</td>
<td>• e² studio*3</td>
</tr>
<tr>
<td><strong>Compilers</strong></td>
<td>• Arm CC*1</td>
<td>• IAR C/C++ compiler*2</td>
<td>• Arm CC*1</td>
<td>• GNU tool*4</td>
</tr>
<tr>
<td><strong>ICEs</strong></td>
<td>• DSTREAM™</td>
<td>• J-Link®, J-Link Trace™ for Arm® Cortex®-A/N/M</td>
<td>• PARTNER-Jet2 from Kyoto Microcomputer</td>
<td>• J-Link Lite from Segger*5</td>
</tr>
</tbody>
</table>

**Notes:**
1. Arm CC is available in a free evaluation version that provides full functionality but is limited to 30 days of use. Contact a DS-5 sales agent for details.
2. A free evaluation license is available provided the 30-day time-limited evaluation or the permanent 32KB size-limited evaluation. (www.iar.com/EWARM)
3. Eclipse-based development environment from Renesas (http://www.renesas.com/e2studio)
4. GNU TOOLS & SUPPORT Website (https://gcc-renesas.com)
5. Renesas does not handle ICEs from Segger. Contact a sales agent for details.

### RZ/T, RZ/N Series Development Tools (Debuggers, ICEs)

| Debuggers | • PARTNER-Jet2 |
| ICEs | • microVIEW-PLUS |
| Compatible compilers | • exGCC from Kyoto Microcomputer |

**Notes:**
1. GNU TOOLS & SUPPORT Website (https://gcc-renesas.com)
2. Arm CC is available in a free evaluation version that provides full functionality but is limited to 30 days of use. Contact a DS-5 sales agent for details.
3. A free evaluation license is available provided the 30-day time-limited evaluation or the permanent 32KB size-limited evaluation. (www.iar.com/EWARM)

### e² studio: Integrated Development Environment Based on Eclipse (RZ/T Series)

E² studio is an integrated development environment based on the Eclipse open source integrated development environment and CDT plug-ins supporting development in C/C++. The version of e² studio that is compatible with the RZ/T series provides support for a code generation plug-in.

• C/C++ perspective: code generation plug-in

A code generation plug-in is available that enables the user to generate device driver programs for peripheral functions of Renesas microcontrollers (timers, UART, A/D converter, etc.) by entering settings in a graphical user interface. It is possible to specify the processing of multiplexed pins in a pin table and view a pin assignment diagram to confirm the settings.

### AP4: Code Generation Support Tool (RZ/T Series)

AP4 is a standalone tool that automatically generates peripheral function control programs (device driver programs) based on settings entered by the user. The build tool (compiler) is selectable. This makes it possible to generate peripheral function control program code to match a specific build tool and enables interoperability with integrated development environments. The version of AP4 that is compatible with the RZ/T series can generate compatible source code for IAR Embedded Workbench® for Arm® from IAR Systems, Development Studio (DS-5™) from Arm®, and e² studio (GNU Tools).