Seamless real-time communication is indispensable to Industry 4.0 and Industrial Internet of Things (IIoT) implementations. Renesas offers a variety of solutions for industrial networks to enable advancement and automation of industrial equipment, with support for protocols such as EtherCAT, EtherNet/IP, and PROFINET.
**Absolute Integration**

Industrial networks are a big part of achieving communication among devices from sensor to cloud. A common base technology serves to standardise and open the plant floor to the advantages of unbridled connectivity. Sensor data can be analyzed in the cloud to offer innovative services like preventative maintenance.

**Distributed Intelligence**

Manufacturing is being driven towards an increasing trend of individualised products requiring significant flexibility in the plant. This can only be achieved through distributed intelligence. More and more processing power is needed within individual plant components therefore driving the need for higher performance semiconductor products at all levels of the plant hierarchy.

**Vertical Transparency**

The cost of deployment and maintenance is related to the visibility of automation equipment in the plant. The ability to adjust parameters and configure individual machines, I/O devices, and processes is becoming a firm requirement. The ability to remotely configure the plant in real time is the ultimate goal of vertical transparency.

**Product Lineup**

<table>
<thead>
<tr>
<th>Motor Control</th>
<th>PLC, Gateway</th>
<th>Network Controller, Remote I/O</th>
<th>Module</th>
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</thead>
<tbody>
<tr>
<td>RZ/T2M Arm®Cortex®-R52 x2</td>
<td>RZ/T2L Arm®Cortex®-R52 x1</td>
<td>RX72M RX03 Core</td>
<td>Module TPS-1 PROFINET CPU</td>
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<tr>
<td>3 port GMAC w/ switch TSN switch EtherCAT slave</td>
<td>2 port EtherCAT slave</td>
<td>2 port EtherCAT slave</td>
<td>2 port w/ switch PHY EtherCAT slave</td>
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<td>RZ/T1 Arm®Cortex®-R4</td>
<td>RZ/N1 Arm®Cortex®-A7 v2 Arm®Cortex®-M3</td>
<td>R-IN32M3-CL Arm®Cortex®-M3</td>
<td>R-IN32M3 Module</td>
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<tr>
<td>3 port GMAC w/ switch EtherCAT slave</td>
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<td>2 port switch w/ switch CC-Link IE field and CC-Link IE TSN Class II</td>
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<td>RZ/N2L Arm®Cortex®-R52</td>
<td>R-IN32M4-CL Arm®Cortex®-M4</td>
<td>R-IN32M4-CL Module</td>
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<tr>
<td>2 port w/ switch RJ45x2 SPI for Application CPU</td>
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</table>

**Industrial Network Solutions from Renesas**

Factories and production facilities today are becoming more advanced in order to improve productivity and safety. These advances are based on communication via open industrial networks.

Several technical requirements demanded by equipment used inside factories are:
1. Support for an open network communication protocol: PROFINET, EtherCAT, and OPC UA
2. High-speed real-time performance to achieve higher productivity from protocols such as EtherCAT, PROFINET IRT, and TSN, as well as low power consumption.
3. Support for functional safety to realize safety operation equipment.

Industrial equipment vendors need to develop equipment that satisfies these requirements, and users will implement and use these equipment. Renesas provides products for industrial networks that make it easy to realize these functions.
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.

Industrial Network
## Recommended Devices for Industrial Networks

### For Master

<table>
<thead>
<tr>
<th>Type</th>
<th>R2/T2M</th>
<th>R2/T2L</th>
<th>R2/T1</th>
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* Under consideration. Contact a sales person for details.
The RZ/T2M combines fast and highly precise real-time motor control capabilities, together with the latest Industrial Ethernet system architecture on a single chip, while supporting functional safety operation.

**Key Features**

- Perform high-speed and high-precision real-time control by Cortex®-R52 CPU (Max 800MHz), implement large Tightly Coupled Memory (TCM:576KB) and Low Latency Peripheral Port (LLPP) bus.
- Integrates an Ethernet switch compatible with the TSN standard and supports major Industrial Ethernet protocols such as PROFINET IRT.
- Support functional safety processing with one of the dual CPU and dedicated peripheral functions used together with Functional Safety Software.
- On-chip peripheral functions (PWM, delta-sigma interface, encoder interface, etc.) support up to two-axis motor control.

**Solution Kit**

Renesas Starter Kit+ for RZ/T2M includes an on-board emulator, so you can start evaluation by simply connecting the bundled cable to your PC. An encoder library and a variety of sample programs for industrial network communication protocols are available on the Renesas website.
RZ/T2L: Outstanding Real-Time Performance and EtherCAT Communication Functionality

Target Applications
The RZ/T2L is ideal for high-speed, high-precision, real-time control applications and also supports EtherCAT communication.

Key Features
- Integrated Arm® Cortex®-R52 @ Max 800MHz, a tightly coupled memory (576KB) directly connected to CPU and Low Latency Peripheral port(LLPP) bus
- Integrated rich peripheral functions such as ∑Δ I/F, A/D converter and multi-protocol encoder I/F
- Seamless H/W architecture with RZ/T2M, and scalable & compatible S/W platform such as FSP with Renesas MPU and MCU
- Integrated EtherCAT slave controller and supports ECC for all internal RAM
- Supports security functions such as secure boot, JTAG authentication and unique ID
- Can be used as safety MCU in the functional safety S/W solution

Scalable System Solution (AC Servo/AC Drive)
Users can select the MPU suitable for their products from Renesas’ MPU lineup that is developed based on similar H/W architecture.
Also, users can use the compatible software platform between Renesas MPU and MCU to utilize existing S/W assets and easily scale their product development.

Block Diagram

Solution Kit
Renesas Starter Kit+ for RZ/T2L includes an on-board emulator, so you can start evaluation by simply connecting the bundled cable to your PC. An encoder library and a variety of sample programs for industrial network communication protocols are available on the Renesas website.
RZ/T1: Industrial Drives with Multi-Protocol Industrial Ethernet Controllers

**Target Applications**

RZ/T1 was specifically developed for Industrial Motors and AC Servos where time is critical, deterministic applications require minimal latency and jitter, high speed operation providing excellent performance, and improved functionality for industrial equipment. Some RZ/T1 products also incorporate the Renesas R-IN engine which allows for industrial ethernet communication.

**Key Features**

The RZ/T1 complements Renesas’ industrial smart factory solution portfolio.

- **High Performance and Real-Time Capability**
  The RZ/T1 Group has the Arm® Cortex®-R4 Processor with FPU core, which was designed for real-time processing, and is capable of high-speed operation at up to 600 MHz. Furthermore, tightly-coupled memory capable of definitive real-time response processing allows high-speed access from the CPU without passing through the cache memory.

- **Industrial Ethernet Network**
  RZ/T1 devices that are equipped with a built-in Renesas R-IN engine, which includes accelerator for industrial Ethernet communications, can perform industrial Ethernet processing without loss of real-time performance by Hardware RTOS (HW-RTOS).

- **Digital Encoder Interface**
  RZ/T1 devices that are equipped with a configurable absolute encoder interface are perfectly suited for precision motion control applications. The range of industry standards supported by configurable encoder interface includes EnDat2.2, BiSS*-C, A-format™, FA-CODER®, and HIPERFACE® DSL.

**Solution Kit**

The RZ/T1 solution kit provides full access to the single/dual core drive solution with easy access to multiple industrial Ethernet standards and encoder interface protocols. It is the perfect kit for developers who are new to the RZ/T1.

- **Renesas Starter Kit**: Perfect starter kit to evaluate RZ/T1 performance.
RZ/N2L: Industrial Ethernet Communication MPU for Adding Network Functionality to Industrial Equipment and Devices

Target Applications

The RZ/N2L is optimized as a dedicated networking companion chip that can easily implement industrial Ethernet communication and TSN in industrial equipment. The RZ/N2L is a single chip solution for both industrial network and application processing.

Key Features

- Arm® Cortex®-R52 operating at a maximum frequency of 400MHz and tightly-coupled memory (256KB).
- 3-port Gigabit Ethernet switch supporting next-generation network standard TSN and EtherCAT® slave controller.
- Host interface allows application CPU to directly connect to RZ/N2L, and access at high speed. Application CPU can directly access to the system RAM of RZ/N2L.
- ELC (Event Link Controller) can be operated without the support of CPU processing.
- Supports functional safety like a safety MCU.

Solution Kit

Renesas Starter Kit+ for RZ/N2L includes an on-board emulator, so you can start evaluation by simply connecting the bundled cable to your PC. A variety of sample programs for industrial network communication protocols are available on the Renesas website.

Renesas Starter Kit+ for RZ/N2L
(Product No.: RTK9RZN2L0S00000BE)
RZ/N1: Multi-Protocol Industrial Ethernet Controllers meet Performance

Target Applications

The scalable RZ/N1 family of Arm based communication devices was developed for applications like gateways, PLCs, industrial switches, sensor hubs, and remote I/Os.

Key Features

The products in the RZ/N1 Group provide single-chip solutions that make it possible to realize simultaneously a field network connected to devices requiring real-time control and a highly reliable control network employing a redundant structure. The group lineup comprises three products that can be utilized in a broad array of applications. The RZ/N1D and RZ/N1S are built around the Arm® Cortex®-A7 in dual- and single-core configurations, respectively, while the RZ/N1L consists of the communication block only. Each of these products features the Renesas R-IN engine, an accelerator that supports a wide variety of protocols and delivers fast processing performance. The major features are as follows:

1. Renesas R-IN engine, maximum 5-port gigabit Ethernet switch, and independent MAC unit provide support for multiple industrial Ethernet protocols.

2. Lineup of three CPU types to match a range of applications: Dual-core Cortex®-A7 (500MHz × 2), single-core Cortex®-A7 (500MHz), and Renesas R-IN engine only (125MHz).

Fast Evaluation and Prototyping

The RZ/N1 Solution Kit is a development package incorporating both hardware and software that implements the main industrial Ethernet protocols such as EtherCAT, EtherNet/IP, and PROFINET. This makes it possible to develop prototypes in less time. By using this kit customers can reduce the time needed to develop a product by up to six months.

In addition to three CPU boards (RZ/N1D, RZ/N1S, and RZ/N1L), expansion boards are available for evaluation of a variety of peripheral functions. Select the evaluation board that best matches your application. This kit is the ideal way to experience the performance and functionality of the RZ/N1.

*For full version protocol stack, please contact your nearest stack supplier
Industrial Ethernet Embedded Module
R-IN32M3 Module

The R-IN32M3 is a compact industrial Ethernet embedded module that supports the PROFINET, EtherNet/IP™, and EtherCAT® protocols. By using it in combination with a host MCU to control the user application, it enables users easily to develop supported products without worrying about the details of industrial Ethernet communication. It is also possible to deploy support for Modbus TCP by using the host MCU for control.

**Features**

- **An all-in-one solution that shortens time-to-market**
  - This embedded module implements the functionality required by industrial networks.
  - Reduces the burden of software development and component procurement.

- **Multi-protocol**
  - The protocol can be changed without overwriting the firmware.
  - No need to purchase a separate module for each protocol stack.

- **Ample selection of development tools**
  - Sample software is available for Renesas RA, RX, and RL MCUs.
  - Get started with evaluation right away using a simple master tool.

- **Easy-to-implement host interface**
  - SPI connection via pin header connector.
  - No need to mount additional connectors.

**Solution Kits**

Users can choose between two environments when selecting a solution kit to support development. Sample packages are available for download on the web, so you can get started right away with the development environment that best matches your application.

- **Adapter Board Mounted with R-IN32M3 Module**
  - [YCONNECT-IT-I-RJ4501](#)
  - Connects to an Arduino™ MCU development board for development work.
  - Ideal for customers who have already decided on the host MCU they plan to use.

- **CPU Card Mounted with R-IN32M3 Module**
  - [SEMB1320: Shimafuji Electric Incorporated](#)
  - Evaluation board with integrated module and mounted with RX66T host MCU.
  - Ideal for customers just getting started with evaluation of Industrial Ethernet applications.

**Specifications**

<table>
<thead>
<tr>
<th>Product No.</th>
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* Each protocol is network certified, but the customer’s system still needs to be certified as a finished product.
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 Renesas 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
- Renesas 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 (SBEV-RIN32M4CL3, manufactured by Shimafuji Electric Incorporated)**
- **IAR Embedded Workbench integrated development environment (evaluation version)**
- **I-jet Lite (JTAG-ICE)**
- **Sample software**
  - CC-Link IE TSN
  - CC-Link IE Field
  - Peripheral drivers
- **Settings file for master station**
- **User’s manuals**

**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.
R-IN32M3: Industrial Ethernet Controllers

Target Applications

The R-IN32M3 Series is suitable for use in the communication unit of slave devices in field networks and motion networks indicated by 

Characterized by Innovation

R-IN32M3 is an Industrial Network Controller with multiprotocol support for industrial applications like Remote IOs, Sensors, Actuators, PLCs, Drives, Motion Controllers or robots. The design philosophy is characterized by three design rules:

- Low power dissipation despite the highest level of integration
- Perform time sensitive and process intensive tasks in hardware
- Support all major industrial Ethernet standards

The Renesas R-IN engine also features a Hardware Accelerator for both the real-time operating system and higher layer network frame processing.

The new Dimension of Real-Time

The Renesas R-IN engine is an integrated processor subsystem that includes hardware Ethernet and RTOS accelerators, developed for high speed and real-time communication under very low power consumption. These mechanisms do not just reduce the number of cycles needed to process one Ethernet frame drastically, but they also provide an unmatched determinism with response times beyond the capabilities of pure CPU based systems. The device supports industrial Ethernet protocols like EtherCAT, PROFINET, EtherNet/IP and CC-Link IE. Some variants also include an integrated Ethernet PHY.

Effects on Ethernet Frame Processing: Drastic Reduction of Overhead Processing

Target products: PLC, remote IO, CNC, AC drive (inverter), robot, servo drive, servo motor
EC-1: High Performance EtherCAT® Controller

Target Applications

EC-1 is a dedicated device with a built-in EtherCAT slave controller. This is an optimal solution to design high performance EtherCAT protocol in Industrial automation and manufacturing.

1. Remote IO
   EC-1 handle both EtherCAT communication and I/O control at the same time thus, eliminating the need for additional external CPU for I/O control. Get started quickly using provided application software for EtherCAT and I/O Control.

2. Communication Module
   Can easily upgrade to EtherCAT communication from existing serial interfaces.

Key Features

Solution certified by EtherCAT Test Center (ETC) conformance testing
• Software environment and evaluation board are certified by official conformance test based on BECKHOFF’s EtherCAT slave stack code.

Easy transition from low-speed serial communication to EtherCAT
• Customer can easily change communication protocol to legacy serial interfaces, allowing user to focus on their end application.
• Sample software is provided that targets various devices with different profiles :
  √ CiA402 drive profile for motor driving devices.
  √ ETG.5003 profile for semiconductor manufacturing equipment.

Optimized for EtherCAT applications. Best suited for designing slave devices with High-Speed connectivity.
• Integrated Arm® Cortex®-R4F Core @ 150MHz with double and single precision floating point unit. The Tightly Coupled Memory (TCM), EtherCAT slave controller is ideal for deterministic high-speed connectivity.
• Compatibility has been verified with master devices from more than ten manufacturers. This is a proven solution and significantly reduces the development time for EtherCAT slave applications.

Fast Evaluation

Remote I/O Solution for EC-1 (Tessera Products: TS-EC-1)
Solution kits packaging the hardware, software and integrated development environment necessary for enabling many users to start evaluation and development safely, quickly and easily.
TPS-1: Single Chip for PROFINET RT and IRT

Certified RT/IRT Functionality for PROFINET V2.3

The PROFINET Device Chip TPS-1 is designed for easy and cost-efficient implementation of PROFINET interfaces for automation devices. It is a highly integrated single chip solution that complies with the PROFINET Conformance Class C.

The internal structure is designed to fulfill the requirements of the IRT protocol and the time-critical PROFINET protocols are supported by hardware.

The configurable interfaces facilitate the flexible realization of different use cases like direct connection of an external host CPU or digital I/Os without additional circuitry. Special synchronization signals allow to lock the host application program to the PROFINET I/O cycle. To support line topologies in PROFINET networks, the TPS-1 is equipped with two integrated PHYs and an integrated IRT switch.

Efficiency - Sustainable Low Cost

For the complete implementation of a PROFINET device interface, only the TPS-1, a serial Flash device, an oscillator, and the physical adaptations for the Ethernet interface (transformers and connectors) are needed. The serial flash component contains the individual chip configuration and the PROFINET stack firmware.

Due to the low space requirement (just 260 mm²) and low power dissipation (0.8 W) of the TPS-1, a PROFINET interface can also be integrated into automation devices with special requirements regarding housing size and protection classes. Conductor routing between the balls is still possible in order to keep down PCB cost.

Low-cost Solution Kit for TPS-1 “Y-CONNECT-IT-TPS-1L”

The new TPS-1 low-cost Solution Kit allows a simple and efficient PROFINET IRT design with the TPS-1 PROFINET IRT device chip. Beside the TPS-1 board, the kit features a passive adapter board that allows a simple connectivity to almost any MCU, a DVD with software and several cables.

The TPS-1 board runs the latest PROFINET IRT software and features only the basic circuitry needed for a PROFINET IRT network. Due to the optimized hardware there is a significantly lower entry cost to the PROFINET world and not at the expense of the usability. All the GPIOs and additional control signals are available on the connector and can be easily accessed.
RX72M Industrial Network Solutions

Industrial networks often involve multiple protocols operating side-by-side and coexisting with each other, with each being utilized for the specific features it provides. Renesas offers solutions incorporating the RX72M that support multiple protocols to assist customers with their development work.

RX72M Network Solutions
Sample software is available that supports EtherCAT® and other major industrial network communication protocols covering 70% of the market. In collaboration with partner vendors, Renesas enables customers to reduce the development time required for protocol implementation. By utilizing the excellent performance and large memory capacity of the RX72M operating at 240MHz (CoreMark score: 1461), these solutions concentrate system functions on a single chip, reducing the development BOM cost and contributing to more compact products.

RX72M Network Solution Boards
Renesas offers RX72M evaluation boards ideal for initial evaluation of network devices, along with OSes, middleware, and sample software.

RX72M CPU Card with RDC-1C (RTK0EMXDE0C00000B)
- Can be used to control BLDC motors and stepping motors when used in combination with a compatible inverter board.
- A variety of sample code is available.

TS-RX72M-COM *
- EtherCAT and 2-channel Ethernet port (MII)
- RS485 and CAN transceiver (field network support)
- Conformance tested on three major protocols (EtherCAT®, PROFINET RT, and EtherNet/IP).

* The TS-RX72M-COM board is available from Tessera Technology Inc. For details, contact a Renesas sales agent.

- Encoder vector control for permanent magnet synchronous motors
  Encoder vector control software is programmed onto the RX72M, enabling implementation of EtherCAT® communication and encoder brush motor control using a single chip.

- Vector control of stepping motors with resolvers
  Resolver vector control software is programmed onto the RX72M, enabling implementation of EtherCAT® communication and control of stepping motors with resolvers using a single chip.
RX72N, RX66N, RX65N
Expands Equipment Control and Networking Portfolio with 32-Bit MCUs

Outstanding real-time performance and one-chip solutions

Overview

Delivered more than one billion microcontrollers from the RX Family of 32-bit MCUs, and enable to pick up the the Ethernet supported MCU that best suits the application from a large selection of line-up. In addition to CPU performance from 120MHz to 240MHz, a wide range of memory options is available such as on-chip flash memory is from 512KB to 4MB and on-chip SRAM is from 256KB to 1MB. Other features include multiple communication interfaces, cloud connections, security, and HMI functions.

Key Features

RX72N, RX66N
- Outstanding Real-Time performance: With the fastest flash memory operation in the industry, even if the cache miss occurred, program instructions execute promptly no wait cycles for the RX66N and with only one wait cycle for the RX72N.
- Multiple Functions and Small Footprint: The largest memory of industry’s and general-purpose I/O interface enable to implement many functions, it contributes space saving and shorter development time.
- Robust Security: Perfect application from various threats by Trusted Secure IP (TSIP), as TSIP outputs key generation related unique ID, this avoids to use in other devices, even if the key generation is eavesdropped.
- Advanced HMI function: LCD controller, 2D drawing engine, serial sound I/F, and 1MB SRAM realize HMI functions without external RAM.

RX65N
- A variety of communication interfaces are implemented on-chip, including Ethernet (1 channel), USB, CAN, SD host/slave, and quad SPI.
- 2MB flash memory and 640KB SRAM relate to downsizing and large-capacity memory, suitable for a variety of applications.
**IO-Link**

Toward realization the smart factory that is at the core of Industry 4.0., the market trend shifted from general Ether to Industrial Ether. The challenge is to “Connect” all product devices from upper layers such as PLCs to lower layers such as sensors and actuators and common network communication is required in the market. IO-Link supports bidirectional communication and gather attention as a key technology to realize the goal of bringing IoT to the factory.

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**RX23E-A Temperature Sensor Solution**

- This solution uses 32-bit MCU RX23E-A built-in a high-precision analog front-end (AFE) to measure temperature, process sensing and signals, and realizes IO-Link communications via ZIOL2401 IO-Link PHY chip.
- IO-Link tool on user’s PC enables to provide data check, monitor the value of temperature measurement, and set parameter.
- With IO-Link Teach In, enables to control LED on/off based on the temperature measurement.

**RA2E1 Pressure Sensor Solution**

- The combination of RA2E1 ultra-compact (CSP package) with low-power and ZSSC3240 kit (sensor + sensor signal conditioner) realize pressure measurement, signal processing, and IO-Link communication, suitable for space-constrained applications.
- IO-Link tool on user’s PC enables to provide data check, monitor the value of pressure measurement, and set parameter.
- With IO-Link Teach In, enables to control LED on/off based on the pressure measurement.

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**RA2E2 Proximity Sensor Solution**

- Ultracompact, power-efficient RA2E2 32-bit MCU with Arm Cortex-M23 core running at 48MHz and available in a variety of wafer chip scale package (WCSP) versions contributes to reduced BOM cost.
- We recommend using the one-wire interface (OWI) of the RH4Z2501 IO-Link PHY from Renesas to eliminate the need to use pins to connect to the MCU.
- Metal is detected by sensing the electrical resistance between two coils on the partner vendor board (IO-Link Inductive Sensor Solution Board), causing an LED on the board to illuminate. This can also be controlled and monitored using a GUI software tool that runs on a PC.

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* Renesas offers two types of sensor PHY to be selectable depending on users’ system requirements.
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/I/F 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
IEC16508 Certified Functional Safety Solutions for Industrial Applications

Renesas’ functional safety solutions provide the core technologies needed to obtain IEC 61508 SIL* certification. Certified software, kits, and reference boards, backed by reference documentation, ensure that the process of building a functional safety system is a smooth one. These solutions can dramatically shorten the time required for development and help you realize functional safety systems that perform appropriate processing when malfunctions occur.

* SIL: Safety Integrity Level. Designates the safety level under functional safety standards.

**TÜV 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 vs Certification Process**

Renesas solutions covers certification process and will shortens customer’s actual development TAT.

Renesas’ certified SW will complete the functional safety diagnosis on MCU so customer will be able to focus more on their own application development.

**Target Application**

- AC servos/drives
- Remote I/O
- Programmable logic controllers
- Sensors/actuators

**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 Solution Overview

Software

Self-Test Software Kit*
Diagnostic software for permanent failure of CPU, ROM, RAM inside the MCU/MPU.
Available for web download with certificate

SIL3 System Software Kit*
Functional Safety Platform software for dual MCU/MPU system equipped with MCU/MPU diagnosis, scheduler, and partitioning function.
Free evaluation version available via web download

Safety Protocol Application Software Kit*
FSoE and PROFiSafe for slave devices.
Free evaluation version available via web download

Software Kit for Compiler

IEC61508 Certification Kit for RX Compilers*
Document set certifying functional safety compliance of Renesas compiler “CC-RX”.

Document

Reference Document*
Guideline document to obtain IEC61508 certification, including:
- Sample documents to submit to certification body
- Preparation guide
- Technical documents, necessary for safety part development such as input/output circuit diagnosis —, and power-supply monitoring
Free digest version available via web download

Evaluation

Reference Hardware
- Reference board (dual MCU configuration eval board)
  - RX111-RX111 (RXv1 core version)
  - RX71M-RX851 (RXv2 core version)
  - RX72N-RX72N (RXv3 core version)
- FSoE reference kit with RX MCU*
  - RX72M – RX23T dual MCU configuration eval board comes with sample software to realize safety Remote I/O

Solution Portfolio

<table>
<thead>
<tr>
<th>Product</th>
<th>Family</th>
<th>RX</th>
<th>RA</th>
<th>RZ</th>
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<td>Core</td>
<td>RXv1 (RX111, 113, 130)</td>
<td>RXv2</td>
<td>RXv3</td>
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* Acceptance beforehand of a license agreement, or payment of a license fee when using the free evaluation version, is required.

*: Although the example describes using RX MCUs, it can be used for other MCUs as it is a technical document for the functional safety standard itself and not dedicated to a specific MCU/MPU Family.
**: EWARM from IAR Systems ready
## Winning Combinations

### 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.

### Winning Combinations

Analog + Power + Embedded Processing + Connectivity

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<tr>
<th>Application</th>
<th>Title</th>
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<tr>
<td>Network</td>
<td>Gigabit Industrial Ethernet System-on-Module (SoM) Solution</td>
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<tr>
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<td>Multi-Protocol Industrial Ethernet Switch</td>
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<td>CC-Link IE TSN Solution</td>
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<td></td>
<td>Real-Time Industrial Ethernet Switch (Low Cost) with RZ/N1S</td>
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<td>Industrial Automation Solution with Industrial Ethernet Module</td>
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<td>Motor</td>
<td>Motor Control System with Industrial Network and Functional Safety</td>
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<td>AC Servo Solution</td>
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<td>Functional Safety Network with Safety Drive System</td>
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<td>Sensor</td>
<td>Industrial Ether Connectable IoT Sensor Hub</td>
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<td>Time of Flight (ToF) Sensor Module</td>
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<td>Industrial Sensor Network Solution</td>
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<td>Industrial Ethernet Connected Sensor</td>
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Visit the website below to see examples of a variety of solutions for industrial equipment.

[https://www.renesas.com/winning-combinations](https://www.renesas.com/winning-combinations)

The easy way to discover Winning Combinations:

Type the ID number into the search bar on the Renesas website (www.renesas.com) to view the corresponding page.
### Notable Winning Combinations

**AC Servo Solution (CN032)**

- **System Board**
  - UART
  - USB
  - CAN
  - QSPI Flash
  - GPIO
  - IIC
  - PMIC
  - Encoder-IF
  - SPI
  - Timer
  - HypRAM
  - ADC
  - Photo-Coupler
  - Photo-Coupler
  - DS Modulator
  - To IPM
  - RV1S9213A x 5
  - EEPROM
  - LED Driver

**Invert Board**
- 24V to peripheral
- +24V Isolated Power
- 1.2V/0.5A to PHY
- 3.3V/2A to peripheral
- External control signal

**Motor & Encoder**
- +5V
- 24V Plug-in

**Overview**

This Renesas AC servo solution integrates motor control and EtherCAT design to support high-speed and high-precision motor control through synchronizing time-sensitive industrial Ethernet communications. This solution is composed of three blocks: system control, power drive, and motor encoder, which are physically isolated while maintaining a high degree of interconnect. By utilizing the high-performance RZ/T2M or RZ/N2L microprocessor, this monolithic solution design outperforms traditional two-chip platforms on performance and cost.

**Industrial Automation Solution with Industrial Ethernet Module (JP205)**

- **Node Device (1)**
  - MCU RA6M4 / RX651
  - DS Modulator
  - R-IN32M3 Module
  - Module
  - Motor & Encoder
  - Sensor (Others)
  - LDO
  - 3.3V < 600mA

**Node Device (2)**
- R-IN32M3 Module
- Ethernet

**Overview**

Previous industrial automation solutions used conventional bus connections such as RS-485 between master and node devices. This solution using the Renesas R-IN32M3 module allows ease of migration from an industrial field bus system to an industrial Ethernet system. It supports three major industry standard protocol stacks: PROFINET, EtherNet/IP, and EtherCAT. This enables customers to develop industrial Ethernet systems easily.
<Overview>
This is a total solution for an industrial motor control system composed of a variety of devices such as MPUs, MCUs for cross monitoring, power ICs, and delta-sigma modulators. Combining these devices makes it possible to implement a variety of functions required for motor control, industrial networks, and functional safety (FuSa) in a manner that delivers both high performance and simplicity.

• Gigabit Industrial Ethernet SoM (EU140)

<Overview>
There is increasing demand in the industrial equipment market for MPU-based system on module (SoM) products that offer advanced functionality and compact size, enabling customers to build their own peripheral devices. This solution, which includes an SoM and carrier board, is designed to substantially reduce the time, development cost, and risk for customers bringing products to market.
## Tool Kits

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**EtherCAT**

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**TPS-1**

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**IO-Link**

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**RA**

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