INDUSTRIAL NETWORKS

Enabling IIoT and industry 4.0 Infrastructure
Seamless real-time communication is the core prerequisite for all Industry 4.0 and Industrial Internet of Things (IIoT) implementations. Renesas offers best-in-class communication components for all leading industrial communication protocols such as EtherCAT, EtherNet/IP, PROFINET, Modbus, IO-Link, and more. All of these silicon solutions come with comprehensive software support.
**Absolute Integration**

Industrial Ethernet is a big part of achieving 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.

**Renesas Industrial Networking**

Factories and production facilities today are becoming more advanced in order to improve productivity and safety. These advances are based on converting to open or Ethernet network communication.

Several technical requirements demanded by equipment used inside factories are:

1. Support for an open network communication protocol: PROFINET, EtherCAT, Modbus, and OPC UA
2. High-speed real-time performance and low power consumption to achieve high productivity: EtherCAT, PROFINET IRT, and TSN
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 provide ICs for Industrial Ethernet to easy to realize these functions.
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 Feature**

Due to the consistent communication API, developers can easily exchange various industrial Ethernet protocols while focusing on the application software. The portfolio consists three products that address wide application requirement: the RZ/N1D and RZ/N1S have respectively a dual or single core Arm® Cortex®. RZ/N1L is the smallest in this group and it includes only the communication block. Key three features are:

1. R-IN Engine with up to 5 port switch and multiprotocol support in HW for low power dissipation.
2. Powerful CA7 cores with embedded memory for a variety of applications.
3. Consistent communication API with OSAL for the simple exchange between protocols.

**Fast Evaluation and Prototyping**

The RZ/N1 Solution Kit is a complete development package that includes the hardware and software to enable faster prototyping of leading industrial Ethernet protocols such as EtherCAT, EtherNet/IP, PROFINET etc., thereby accelerating development and saving up to six months of industrial network protocol integration into customers’ applications.

In addition to three different CPU boards different (RZ/N1D, RZ/N1S and RZ/N1L), an expansion board enables you to evaluate various peripheral functions. You can choose which evaluation board to use according to your application. Experience the performance and function of the RZ/N1 through this CONNECT IT! ETHERNET RZ/N kit.

*For full version protocol stack, please contact your nearest stack supplier.
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 requires minimal latency and jitter, high speed operation providing excellent performance, and improved functionality for industrial equipment.

Some RZ/T1 products also incorporate the R-IN engine which allows for industrial ethernet communication.

Key Feature

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 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™, Tamagawa, 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.

- **Motion Control Solution Kit**: Reference solution. One stop evaluation of Servo and Motion controller development.
- **Renesas Starter Kit**: Perfect starter kit to evaluate RZ/T1 performance.
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 by using provided application software for EtherCAT and I/O Control.

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

### Key Feature

- **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

- **Kick-Start Kit for EC-1**
  - EtherCAT Communication evaluation environment platform.
  - Easy-to-use even for first-time users.
  - Easily confirm EtherCAT communication functions.
- **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.
- **Communication Module Solution for EC-1**
  - (Tessera Products: TS-EC-1-COM)
  - Easily upgrade to EtherCAT communication from existing Serial interfaces.
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 ◦.

Target products: PLC, remote IO, CNC, AC drive (inverter), robot, servo drive, servo motor

**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 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 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.

**TC/IP Communication**

The R-IN solution kit is an all-in-the-box package for fast evaluation and rapid prototyping of multiple industrial Ethernet protocols. It features a small R-IN32M3-EC board for evaluation of the industrial Ethernet interfaces, an evaluation version of IARs embedded workbench for Arm® Cortex® M3 JTAG debugger, as well as sample software including evaluation versions of several industrial Ethernet protocols like EtherCAT, PROFINET, EtherNet/IP and Modbus TCP.
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.

TPS-1 Block Diagram

TPS-1 Solution Kit Block Diagram
ERTEC: REALTIME ETHERNET CONTROLLER

Integrating Standard, Real Time and ‘Isochronous’ Real Time Ethernet

The ERTEC family of real time Ethernet controllers all include a dedicated hardware switch. It directs real time traffic around the standard Ethernet software stack when necessary, therefore making the response time for real time data packets very fast and deterministic. The hardware switch is fully PROFINET compliant and very robust for the highest PROFINET requirements.

Supporting Backwards Compatibility through Vertical Integration

The ERTEC device when running PROFINET can behave as a proxy so that standard fieldbuses can be integrated easily. Proxy operation includes support for DeviceNet, Interbus, PROFIBUS, HART, and Foundation Fieldbus. Moreover, ERTEC supports the integration of sensor/actuator communications. IO-Link enabled sensors/actuators can be encapsulated using ERTEC and PROFINET, giving visibility to the sensor network at the highest levels.

High Performance Enabling High Local Intelligence

The ERTEC200 and ERTEC400 devices can deliver up to 200 MIPS of CPU performance and support up to 128 Mbytes of external memory allowing complex and highly intelligent applications to be designed for local level machines. The latest ERTEC200P device takes performance even further: A single ERTEC device can manage up to 150 axes and still leave 50 % of Ethernet bandwidth for standard traffic.

PROFINET Tool Kits with ERTEC

Two kits are available for the development of PROFINET applications. A fully featured version includes an IRT capable host controller while the simpler, lower cost kit allows real-time operation with a PC-based host controller.
### Efficiency

The RX Core marries the speed of a RISC architecture with the flexibility and code efficiency of a CISC architecture. The CPU interacts with the Flash and SRAM through an enhanced Harvard design. The RX Core leverages the industry’s fastest Flash memory, delivering up to 2.0 DMIPS/MHz and 4.62 CoreMark/MHz without wait states. Tightly coupled to the RX Core are the FPU, MAC, and RMPA (Repeat Multiply Accumulate), which are efficiently driven by DSP and floating point instructions to meet the growing demand of DSC (Digital Signal Controller) type applications.

### RX63N/RX65N: INDUSTRIAL COMMUNICATION MCU

**Benefits of the 32-bit RXv2 CPU Core as used on the RX65N/RX651/RX64M/RX71M**

**Comprehensive On-chip Peripherals**

RX631/RX63N/RX651/RX65N MCUs provide extensive communication peripherals with options for Ethernet, up to three CAN, and up to two USB-FS 2.0 channels, each operating as USB Host, USB Device, or USB OTG (On the Go). Additionally, they offer up to thirteen SCI, three SPI, and four I²C serial channels. Among their other peripherals are analog interfaces; timers; RTC and POR/LVD functions; and more.

**RX for Connectivity**

RX MCUs provide built-in hardware for implementing efficient communications with external peripherals, systems, test equipment and networks such as the Internet. The Ethernet, USB and CAN connectivity modules are well-proven, reliable designs.
RX64M/RX71M: SCALABLE MULTI-PROTOCOL SUPPORT MCU ARCHITECTURE

RX64M/RX71M – 32-bit High Performance Microcontroller Group

The high performing RX64M (120 MHz) /RX71M (240 MHz) family comprises more than 200 products that all include high-speed Flash memory clocked at 120 MHz. They are based on the new RXv2 CPU core, which is a trendsetter in its class with up to 4.55 CoreMark/MHz performance. These RX MCUs provides a universal platform for implementing leading field bus and communication technologies. It offers generous RAM of up to 512 kB, up to 4 MB of embedded Flash, up to three controller area network (CAN) interface channels and two integrated Ethernet MACs. Availability of CANopen, PROFINET (CCA/CCB RT1) and Ethernet/IP stacks make the RX64M and RX71M to a perfect choice for industrial networks with a daisy chain topology.

RX64M Industrial Support

- 2 channels of independent MAC
- Support for PROFINET, Ethernet/IP and CAN open Multi-Protocol Solution
- Time synchronous applied to IEEEE1588 Protocol
- HW switch (selectable Cut Through or Store & Forward internal frame propagation)
- HW multicast frame filter (all receive, all cancel, receive specific two frames)
- Up to 3 channels of CAN interface

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RX64M/RX71M Feature Overview

<table>
<thead>
<tr>
<th>Advanced Peripherals</th>
<th>Connectivity</th>
<th>Advanced Motor (optional)</th>
<th>Security (Option)</th>
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<td>CAN 2.0B</td>
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<td>Data Flash</td>
<td>AES/RSA/DES/HASH/TRNG (option)</td>
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<table>
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<tr>
<th>Memory</th>
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<th>Communication</th>
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<td>Report</td>
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<td>DAC 12-bit</td>
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<td>Event</td>
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</table>

Industry Ethernet Example using IEEE1588 Protocol on a Daisy Chain Topology
CANopen – Independent Fieldbus Technology

CANopen is a controller area network (CAN) based communication system for embedded systems used in automation. It was designed to allow microcontrollers and devices in motion-oriented machine control systems to communicate with each other in applications without a host computer. Today it is used in application fields such as medical equipment, off-road vehicles, maritime electronics, railway applications, or building automation. Based on the standardized profiles, devices of different manufacturers can be accessed via the bus in exactly the same manner, making devices of different manufacturers interoperable and exchangeable.

CANopen Source Code Library and Design Tool

The CANopen library addresses several CAN networks (CAN lines), enabling the use of more than one CAN line in platforms without operating systems (OS) as well as in both systems with single- and multi-tasking OS with insufficient resource protection mechanisms. Gateways can be created between networks, whereby functionality (Master/Slave) can be different for each line.

The CANopen Design Tool facilitates the development of applications with the CANopen library and relieves developers from laborious and error-prone tasks. As a tool it generates and modifies device data bases that describes the interface to the CANopen network and contain information about the device. The function of CANopen Design Tool is to administer the data within the object directory data base and to create an object dictionary code for the CANopen library. Furthermore an Electronics Data Sheet (EDS) is generated and all implemented objects can be made available as HTML or text file for documentation purposes.

Supported Products

The CANopen technology is available for the following Renesas products:

- R-IN32M3 – The Industrial Ethernet Controller that supports a wide range of Industrial Ethernet protocols.
- RZ/N1 – Powerful Cortex®-A7 performance with multi-protocol industrial Ethernet support.
- RX63N/RX31N/RX651/RX65N – MCUs for the mid-range of performance requirements that feature an Ethernet Controller.
- RX64M/RX71M – High-speed, low consumption MCU with advanced real-time performance and large-capacity memory.
- The RL78 Family – MCU with low power consumption and high performance for Ultra Low Power systems.
- RX231 Group – MCU with an extreme energy efficiency for use in applications of home automation, healthcare, industrial, smart meter as well as generally the Internet of Things (IoT) and industry 4.0.
Standards

As the Industrial Internet of Things is gaining on popularity, there is a growing demand for communication controllers that support multiple Industrial Ethernet standards. The capability to cover multiple application scenarios with a single device simplifies the development process, decreases the time to market as well as both the production and the inventory costs. For this purpose, Renesas offers the R-IN32M3 family, with an Arm® Cortex®-M3 SoC and more than 1 MByte internal memory. It supports multiple Ethernet protocols and features a lot of port-multiplexed interfaces.

Unlike the universal electro-mechanical interfaces for the industrial Ethernet, there are numerous interface requirements for different applications. This means that there is no universal housing that can cover multiple application scenarios without changes. Consequently, in order to keep the cost structure for a family of automation devices at a low level, the design must be divided into several independent parts. This way all components that can be reused can be grouped in one section while the customizable interfaces and IO connectors are grouped in a different section.

REMOTE I/O TRIAL KIT

Renesas Design-Study

With the R-IN32M3-EC Remote IO Device Study Renesas developed a flexible housing concept for the industrial communication. It utilizes R-IN32M3 Multiprotocol capability for the network communication and offers a modular implementation for the interfaces on the application side. With this concept an automation device family can be either extended with additional IO modules or adapted to various application scenarios. The module consists of:

- Main board with the R-IN32M3-EC, flash memory, status LEDs and programming and configuration functions as well as device power supply.
- IO board for mechanical connectors and a 10-bit configuration switch to be mounted on top of the main electronic board.
- Lower housing with mechanical fixation for the two boards.
- Housing cover with specific holes for all IO interfaces, power supply, LEDs and switches.
- Internal LED light guide

The R-IN32M3 Remote IO Device Study can cover various IO scenarios with minor changes. It is only the less complex IO part with the respective housing cover that has to be developed for a new device. On the software side a simple driver takes over the connectivity of the various IOs with the module core software.

Products

You can easily develop a Remote IO product family for different application scenarios supporting multiple protocols and at low cost by your own. R-IN32M3 supports protocols such as EtherCAT, CC-Link IE, EtherNet/IP, PROFINET and has many different interfaces for all kind of applications. For a small PCB footprint the R-IN32M3-EC device already includes the required 100 Mbit Ethernet PHY and has a large internal memory for application and the protocol stack software.
## TOOL KITS

### TABLE OF AVAILABLE TOOL KITS

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<th>Available Kit</th>
<th>Order Number</th>
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<td>Solution Kit</td>
<td>YCONNECT-IT-RIN</td>
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<tr>
<td>R-IN32M3-EC</td>
<td>Evaluation Kit</td>
<td>Y-SK-RIN32M3-EC (EtherCAT)</td>
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<td>R-IN32M3-CL</td>
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<td>Y-SK-RIN32M3-CL (CC-Link IE)</td>
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<td><strong>EC-1</strong></td>
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<td><strong>Development Kit</strong></td>
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