White Paper

Rapid and Easy Industrial Ethernet Development

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Abstract

The Industrial Ethernet R-IN32M3 Module, an embedded solution equipped with R-IN32M3-EC for multi-protocol support, offers high-speed real-time response and high-precision communication control. This compact module provides support for industrial networks while drastically minimizing development costs and reducing development time through use of hardware essential to industrial Ethernet communications, such as Ethernet PHY's and the RJ45 connector, along with a network stack of the three leading Ethernet protocols: PROFINET, EtherCAT® and EtherNet/IP™.

This white paper describes current trends in industrial networks, issues faced in the development environment, and the R-IN32M3 module solution, which is the answer to these development challenges.

Industrial Ethernet

Factory Networks

Communication networks used in factory production lines and equipment comprise three layers – the information network, the controller network, and the field network. Occupying the top layer, the information network is connected by Information Technology (IT); the control and field networks in the middle and lower layers are connected by Operational Technology (OT). This fusion of IT and OT communication technologies in factory networks is further evolving the Industrial Internet of Things (IIoT).

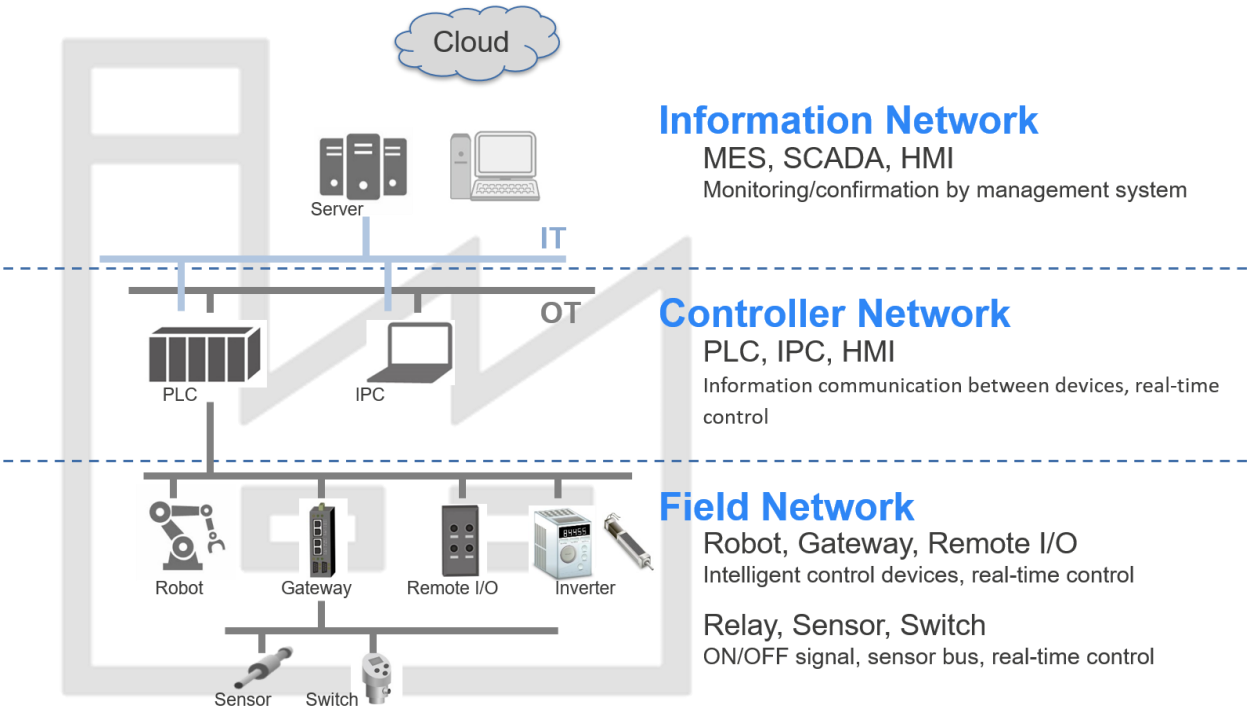

Figure 1: Factory Network Structure

The role of the information network is to optimize the entire manufacturing system with a structure of management systems such as Manufacturing Execution Systems (MES) and Supervisory Control and Data Acquisition (SCADA) System. These systems monitor, control, and acquire data throughout the factory, leading to improved productivity, enhanced manufacturing quality, and reduced labor requirements. As this network layer is not intended for controls, standard Ethernet TCP/IP is used for communications.

The controller network uses master devices such as Programmable Logic Controller (PLC) and Industrial PC (IPC) to connect control devices and production lines, and to communicate control data to/from slave devices in the field network in real time.

The field network is where various control and measuring devices (inverters, gateways, remote I/Os, etc.) are connected as slave devices to corresponding masters located in the upper layers. Conventionally, field network equipment consists of many serial fieldbus protocols, such as CANopen, CC-Link, DeviceNet™, Modbus and PROFIBUS. Since 2000, industrial Ethernet protocols have progressively replaced their fieldbus counterparts due to rapid digitalization and demands for high-speed, large capacity and real-time handling of data between components. Even by 2018, it was clear that the number of industrial Ethernet device nodes exceeded that of serial fieldbus.

Industrial Ethernet Protocol

Multiple industrial Ethernet protocol standards exist, each managed and operated by a corresponding support organization. The following are a few typical protocol standards.

EtherCAT®

EtherCAT® is an open field network developed by the German company Beckhoff Automation in 2003 and is managed and run by the EtherCAT Technology Group (ETG). Packet data is sent in order from the master to each slave connected via the Ethernet cable, and returned to the master to complete one cycle. Within one cycle, each slave processes EtherCAT frames “on the fly,” directly reading or writing data from/to a specified location in the packet data. The result is a protocol offering high-speed and highly efficient communications. Data processing is controlled within the slaves by an EtherCAT Slave Controller (ESC), eliminating dependency on MCU performance and ensuring speed and efficiency. The R-IN32M3 Module easily realizes EtherCAT® slaves using R-IN32M3-EC with a built-in ESC and protocol stacks.

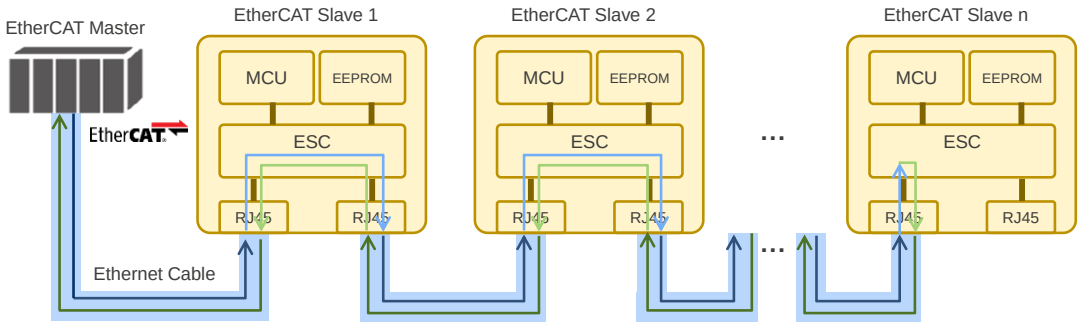

Figure 2: EtherCAT® Communications

PROFINET

PROFINET is an open field network developed by PROFIBUS & PROFINET International (PI) based on the TCP/IP Ethernet. PROFINET includes three different classes in addition to the communications cycle performance. PROFINET Class A (Non-Real-Time or “NT”), based on TCP/IP transfer with a cycle time of approximately 100ms, is used for reading and writing parameters that do not require real-time performance. PROFINET Class B (Real-Time or “RT”) introduces a software protocol stack, offers a cycle time of approximately 10ms, and is typically used for factory automation or process automation. PROFINET Class C (Isochronous Real-Time) requires a dedicated controller and has a specified cycle time of less than 1ms.

EtherNet/IP™

EtherNet/IP™ is an open field network developed by Rockwell Automation and is managed and run by Open DeviceNet Vendor Association, Inc. (ODVA). Common Industrial Protocol (CIP) is implemented as a control protocol on TCP/IP Ethernet, enabling priority control for integrating control data and information data using managed switches. As CIP is also used in DeviceNet™, porting to EtherNet/IP™ is relatively easy. The EtherNet/IP™ protocol is also operationally compatible with DeviceNet™ sensor level products.

Modbus TCP

Modbus TCP is a field network developed by Modicon. Master-slave communications are started when a command is issued from the master. The master can issue commands by broadcasting to a specific slave or all slaves.

CC-Link IE

CC-Link IE is an open field network developed by the CC-Link Partner Association in 2007. CC-Link IE Control was developed for controllers, and CC-Link IE Field and CC-Link IE Basic were developed for field networks. CC-Link IE features a network based on Gigabit Ethernet, perfect for enabling high-speed communication.

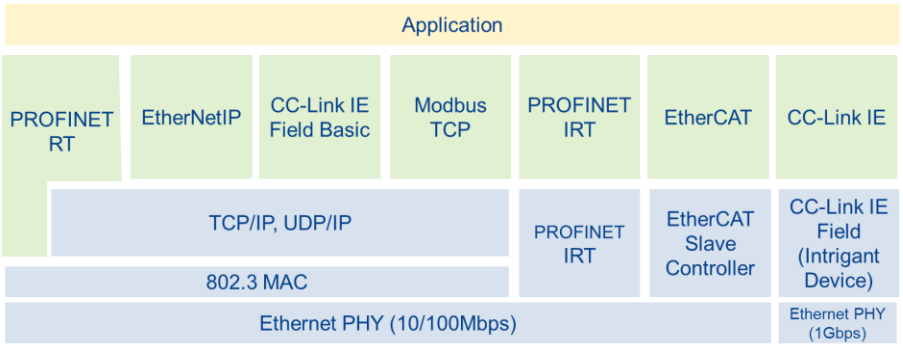

Figure 3: Industrial Network Classifications

Development-related Issues

Naturally, the transition of the field network communication method from conventional serial to Ethernet not only requires new hardware designs, but considerably complicates the software structure. In particular, industrial Ethernet differs from standard Ethernet communications, which mostly handle web and e-mail transmissions. This special communication method raises the development threshold for the lone engineer significantly, and implementation of industrial Ethernet introduces the following challenges.

(1) Support for Ethernet

Although Ethernet is a widely accepted technology, hardware design hurdles become even higher with the selection and availability confirmation of PHY and other components, as well as considerations regarding compliance with IEE802.3

(2) Support for Communication Protocols

The key is the implementation of protocol stacks. The most common question from engineers lacking protocol experience is: “Where to start?” It takes a considerable number of workhours to develop communication protocols in-house, and, of course, budget issues enter the decision-making process when purchasing from a protocol vendor. Additionally, there is the potential burden of supporting multiple protocols. These considerations entail insurmountable development costs, especially for small projects. In addition, protocol standards are usually revised about once a year which leads to maintenance effort and additional budget on the engineering end.

(3) Support for Evaluations and Verification Tests

In order to sell an industrial Ethernet-compatible product featuring logos of the protocols it supports, the product must pass the certification tests of each corresponding protocol association. A certain amount of know-how is required by the developer as preliminary tests are generally carried out by the product manufacturer.

R-IN32M3 Module Solution

Renesas has equipped the R-IN32M3 Module with the multi-protocol LSI R-IN32M3-EC, creating a solution for the many challenges faced when designing industrial Ethernet products. The following provides a detailed outline of the main features of the R-IN32M3 Module.

Features

1. Compact, all-in-one module
2. Equipped with 3 major protocols
3. Extensive development environment

Figure 4: R-IN32M3 Module

Name	R-IN32M3 Module
Product model name	RY9012A0000GZ00#001 RY9012A0000GZ00#002
Built-in CPU	R-IN32M3-EC
Supported protocols	EtherNet/IP PROFINET EtherCAT
Product size	50x34x12mm *Excl. pins
Power supply	3.3±0.15 VDC
Power consumption	Typical 1.3W / Max 2.0W
Operating temperature	- 40 ～ 70 ℃
Applicable standards	CE UL Pb RoHS

The R-IN32M3 module is ideal for developing succeeding products to existing lineups, such as visualizing devices using industrial Ethernet and collecting real-time device information.

1. Compact, All-in-One Module

The R-IN32M3 Module includes a 2-port RJ-45 connector and all of its peripherals in a compact 50 x 34 x 12 mm package. The 9-pin connector (header) for serial communication is solder-mounted on the board, requiring no special connector and making circuit design extremely easy. PROFINET, EtherNet/IP™, and EtherCAT® communications can be realized through a serial communication (SPI) connection with the host microcomputer via the 9-pin connector.

The module hardware was designed with compliance in mind; all reliability evaluations have been carried out based on Renesas' quality standards. Adherence to safety standards (CE and UL) and environmental regulations has been certified as well.

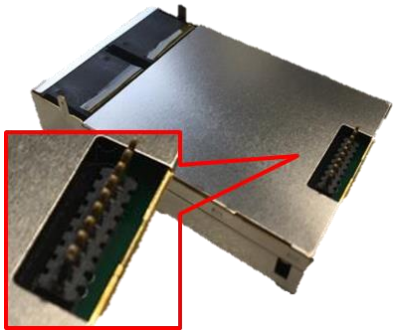

Figure 5: External Connection Terminal

2. Equipped with 3 Major Protocols

When the R-IN32M3 Module was launched in August 2020, it supported PROFINET and EtherNet/IP™, and with the recently added support for EtherCAT®, the module now supports the three top protocols that

account for approximately 75% of all industrial Ethernet protocols, as shown in Fig. 7. By updating your module with the latest firmware downloadable from the Renesas website, you can add EtherCAT® support without any changes to the module hardware.
The R-IN32M3 Module has acquired certification for each protocol based on a configuration which connects the YCONNECT-IT-I-RJ4501 Solution Kit to the Synergy SK-S7G2 Starter Kit as the host microcomputer using an Arduino connector. Each protocol must be certified again after your final product is ready, but the pre-certified R-IN32M3 Module makes final certification relatively easy to obtain.

Another benefit of using the Renesas R-IN32M3 Module is our free-of-charge firmware updates. The specifications of protocol standards are periodically subject to revisions, which usually come with a transition period of about half a year after announcement. To pass the post-revision compliance test, adjustments may have to be made to support the new specification. Renesas plans firmware updates that will be available for free to customers, thus reducing both maintenance costs incurred by protocol updates and total cost of ownership (TCO).

Figure 6: Protocol Certificates

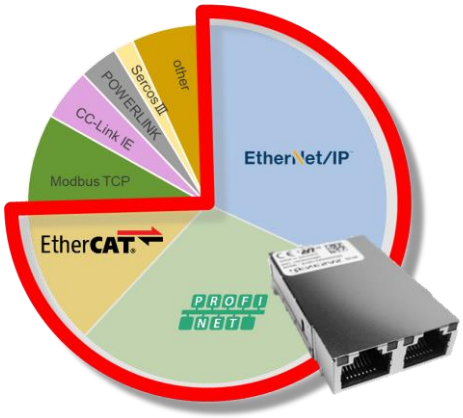

Figure 7: Protocol Usage Share

3. Extensive Development Environment

We are in the midst of creating various development environments for evaluation and product development are on-going using the R-IN32M3 Module, with even further plans for expansion in the future.

The development environment features the Management Tool, a convenient auxiliary tool for device configuration that includes an easy master function for each protocol, a module configuration function for setting IP addresses, etc., a firmware update function, and a log acquisition function. Using the Management Tool helps provide resources that reduce the implementation time for R-IN32M3 Module evaluation.

Renesas offers the YCONNECT-IT-I-RJ4501 Solution Kit, equipped with the R-IN32M3 Module, as an evaluation environment. Evaluation can be performed easily by connecting the development board to various evaluation boards with a general-purpose Arduino and P-mod connector. The sample software included with the host computer connected to the Synergy S7 Starter Kit SK-S7G2 comes with sample projects for various applications.

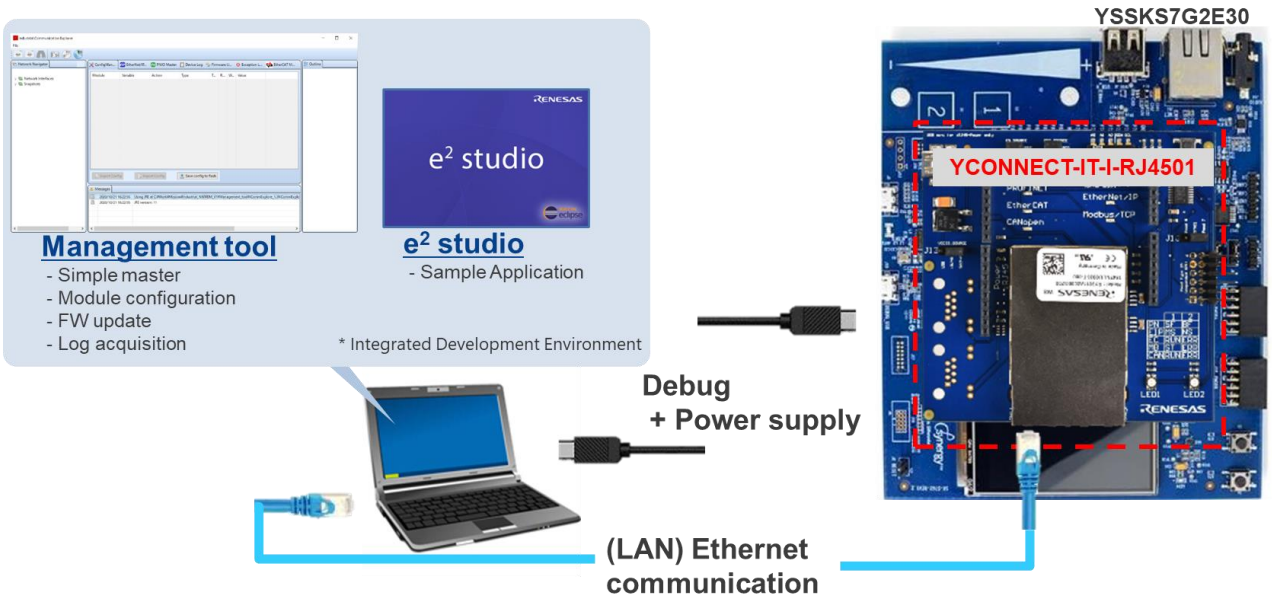

Figure 8: Development Environment

	Host MCU	Development Environment
Development Board	Synergy S7	Renesas Electronics • YCONNECT-IT-I-RJ4501 with YSSKS7G2E30
	RX66T	Shimafuji Electronics Incorporated SEMB1320

Conclusion

This white paper described the progressive switch of industrial networks to Ethernet communications and the R-IN32M3 Module solution, which advances the development of industrial Ethernet products.

The compact R-IN32M3 Module package is an all-in-one solution offering all of the hardware required for industrial Ethernet communications, as well as three built-in protocol communications stacks. This package allows engineers, regardless of industrial network expertise, to focus on application development by significantly reducing product development burdens such as hardware design, communication protocol implementation, and conformance test implementation.

The R-IN32M3 Module contributes to the digitalization of factory networks, such as visualization of internal data in manufacturing equipment and data replacement via fieldbuses, though its support of industrial Ethernet real-time communications.

Learn More

- R-IN32M3 Module: Hardware and software solution for industrial Ethernet, equipped with protocol stacks for PROFINET®, EtherCAT®, and EtherNet/IP™.
- R-IN32M3 Module Solution Kit [YCONNECT-IT-I-RJ4501]: Solution board embedded with R-IN32M3 module.
- SK-S7G2 Starter Kit [YSSKS7G2E30]: Starter kit equipped with Synergy S7 and development environment.
- CPU Card With R-IN32M3 Module RX66T Solution Kit SEMB1320: Includes R-IN32M3 module, RX66T, and development environment.
- Industrial Ethernet Products: Explore Renesas products that support the advancement of industrial Ethernet usage.

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