



OpreX™ Control Devices

e-RT3 Plus

Industrial AI Platform

An industrial AI platform goes beyond the borders of IT and OT.

Our industrial AI platform enables you to develop applications using the Python machine learning libraries that are widely used in AI development. It can seamlessly connect from the local equipment to the higher level system and help you realize application development exceeding the boundary between IT and OT.

NEW

We have a new lineup of AI control learning services that use YOKOGAWA's reinforcement learning AI.

We provide an environment where customers can work with AI control themselves.



OS-free CPU module
F3RP70-2L

- Convenient Python libraries for AI application development
- AI control learning service using YOKOGAWA's reinforcement learning AI NEW
- Open Source Software to develop applications more efficiently
- A wide selection of I/O modules
- High environmental resistance
- Stable Supply



e-RT3 Plus



Industrial AI platform

Convenient Python libraries for AI application development

Supports Python, the indispensable programming language for AI development, statistics, web services, and data processing and analysis. You can add many AI related open source libraries and easily get started developing AI applications.



AI control learning service NEW

The industrial AI platform and YOKOGAWA's reinforcement learning AI are now available as a package. We provide an environment where customers can work independently on their own AI control. YOKOGAWA's Reinforcement Learning AI is characterized by being able to learn in a small number of trials and being resistant to disturbances. It frees you from adjustments that rely on intuition and experience, and contributes to process automation.



Leverage OSS to develop applications more efficiently

You can run Ubuntu, one of the most popular Linux distribution. By using OSS from around the world—such as network file sharing software and PC-less SCADA software—you can efficiently develop applications that meet your needs.

A wide selection of I/O modules

With a wide selection of I/O modules, you can easily reflect your program and application into the data acquisition and control level. Also, convenient Python libraries for AI application development come standard. Libraries that enable direct access from Python are also available.

High environmental resistance

Hardware that can withstand temperatures from 0°C to 55°C and fan-less design provide high environmental worthiness. Installs in a wide range of environments from factories and plants to outdoor panels.

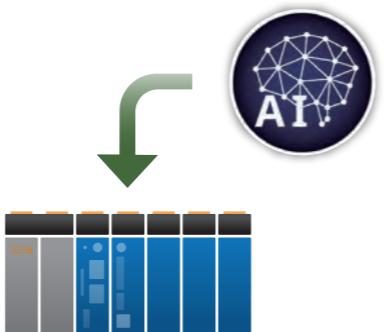
Stable Supply

We've kept the basic design consistent year after year. By maintaining compatibility while adding enhancements, we've made sure you can use e-RT3 with confidence in industrial applications with long life cycles.

Easy to add the AI model

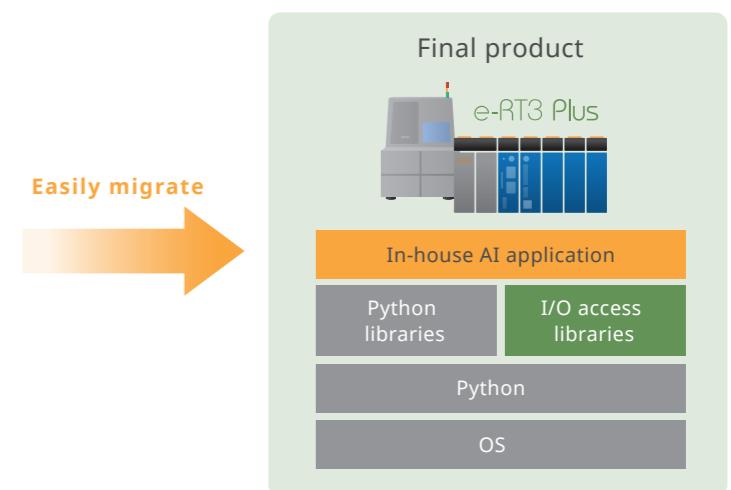
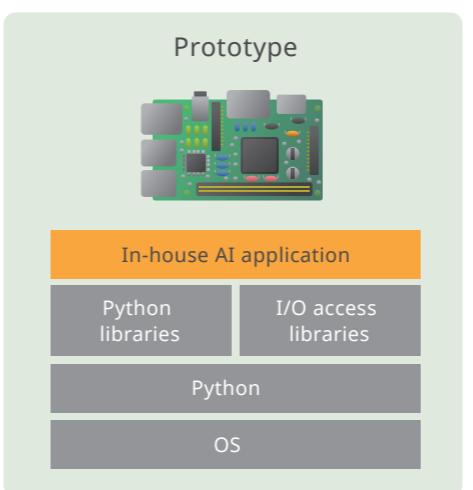
With Python, many standard AI libraries and external open source libraries are available to the public. You can use these to quickly develop AI applications, and easily incorporate them into a CPU module. By incorporating algorithms that determine pass/fail and customer knowledge into your AI model, you can use it on site as a determination device that can make real time determinations based on conditions.

Python libraries	
Category	Package
Package management	python3-pip
Machine learning	python3-sklearn
	python3-numpy
Numerical analysis	pandas
	python3-scipy
Drawing graphs	python3-matplotlib
Increased speed	cython3
Communication	python3-pymodbus
Development environment	jupyter-notebook
Remote debugger	ptvsd



Easily migrate existing programs

Because you can easily migrate existing programs that were prototyped on a single-board computer, you can confidently incorporate developed AI applications into the final product.



※The above libraries are included in the Linux image provided by Yokogawa (as of April 2020).
※The contents of the libraries are out of the scope of the Yokogawa warranty.

Uploaded on Yokogawa Partner Portal web site

AI Control Learning Service NEW

Yokogawa Electric's reinforcement learning AI, which succeeded in autonomous control of plants using AI for the first time in the world^{*1}, can now be implemented with the e-RT3 Plus. The industrial controller and AI control are now available as a package so that customers can work independently on AI control.

Features of YOKOGAWA's reinforcement learning AI

With PID control which widely used in control, high-precision control can be achieved when conditions are straightforward, but becomes difficult when there is a large disturbance in the control state or when there is a long dead time. In many cases, adjustments must be made based on intuition and experience. AI easily utilizes empirical knowledge through learning, and can frequently derive answers even if a theory has not been established.

YOKOGAWA's reinforcement learning AI "Factorial Kernel Dynamic Policy Programming" (FKDPP)^{*2} is very practical because it requires fewer trials than general reinforcement learning.

Supports optimal control according to customer control objectives

Learns after a small number of trials

Applicable to variety of controls

Common concerns
Large disturbances in the state of control
Long dead times

Expected benefits of AI control

Securing the Future Workforce and Shifting to Automation

AI enables autonomous processes^{*} that previously required human adjustment, thereby eliminating labor shortages in the field.

* A process that relies on the intuition and experience of skilled engineers / A process that requires human adjustment every time a disturbance occurs

Contribute to improving controllability

Suppresses the overshoot, and lower load on equipment due to improved controllability.

Coexistence of productivity and energy savings (Contribute to sustainability)

The control to shorten the settling time ensures productivity (quality, yield, etc.) while reducing wasted energy.



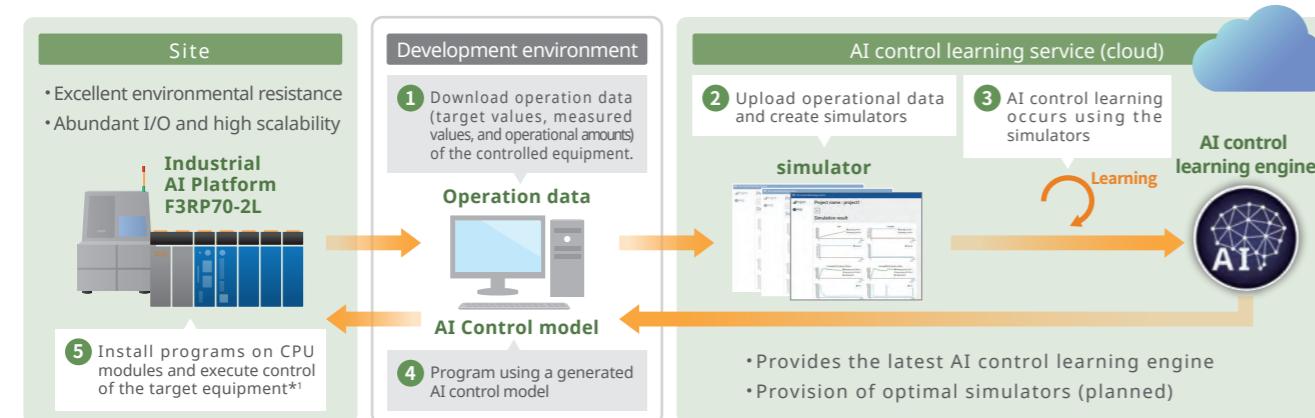
*1 Based on Yokogawa Electric survey conducted in February 2022 regarding AI that directly changes the manipulative variable in the chemical plant.

*2 This is a reinforcement learning AI algorithm jointly developed by Yokogawa Electric and Nara Institute of Science and Technology (NAIST), and was recognized for the first time in the world as a "reinforcement learning technology that can be used in plant" at an IEEE international conference.

Product Specifications

Category	Name	Model
CPU module	OS-free CPU Module	F3RP70-2L
License	AI control learning service for F3RP70	SFRL18-MPC
	AI control license for F3RP70	SFRL19-MPC
Software Package	AI control software package for F3RP70	SFRM19-MDW

*Purchase this product if you plan to use your existing OS-Free CPU module. For new purchases, we offer the F3RP70-2L/L09 OS-Free CPU module with an AI control license.

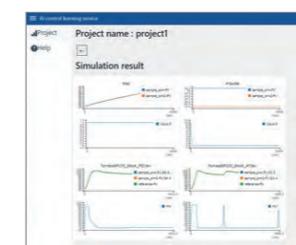


*1 AI control learning does not guarantee the generation of the best control model.

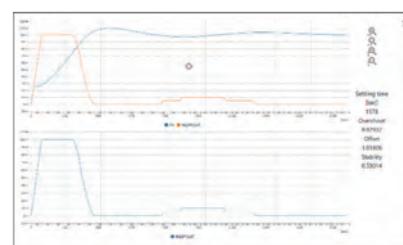
The performance of a control model varies depending on the characteristics of the equipment and the quality of the data provided.

To use the AI control learning service, please apply^{*2} at our dedicated website. After applying, a user account will be created in the cloud environment and you can begin using the service. The service is an annual subscription. To create an AI control model, you need to prepare either an actual machine or a simulator. If employing a simulator, you can create one using the simulator^{*3} function included with the AI control learning service.

AI control software package is provided from the Yokogawa Electric member site (Customer Portal).



Simulator
Conditions can be automatically set to easily generate control models



AI control learning
Generated control models are displayed graphically for review.

*2 Please apply at Yokogawa Electric's product introduction website. The product serial number shipped from the factory is required to apply. Please contact us for the sales area, as it is necessary to confirm the availability of the cloud service. It cannot be sold in China because it is not ready for sale.

*3 The simulator corresponds to single input and single output per the system identification method. If the controlled equipment has multiple inputs and outputs, it is necessary to prepare a separate simulator.

Application

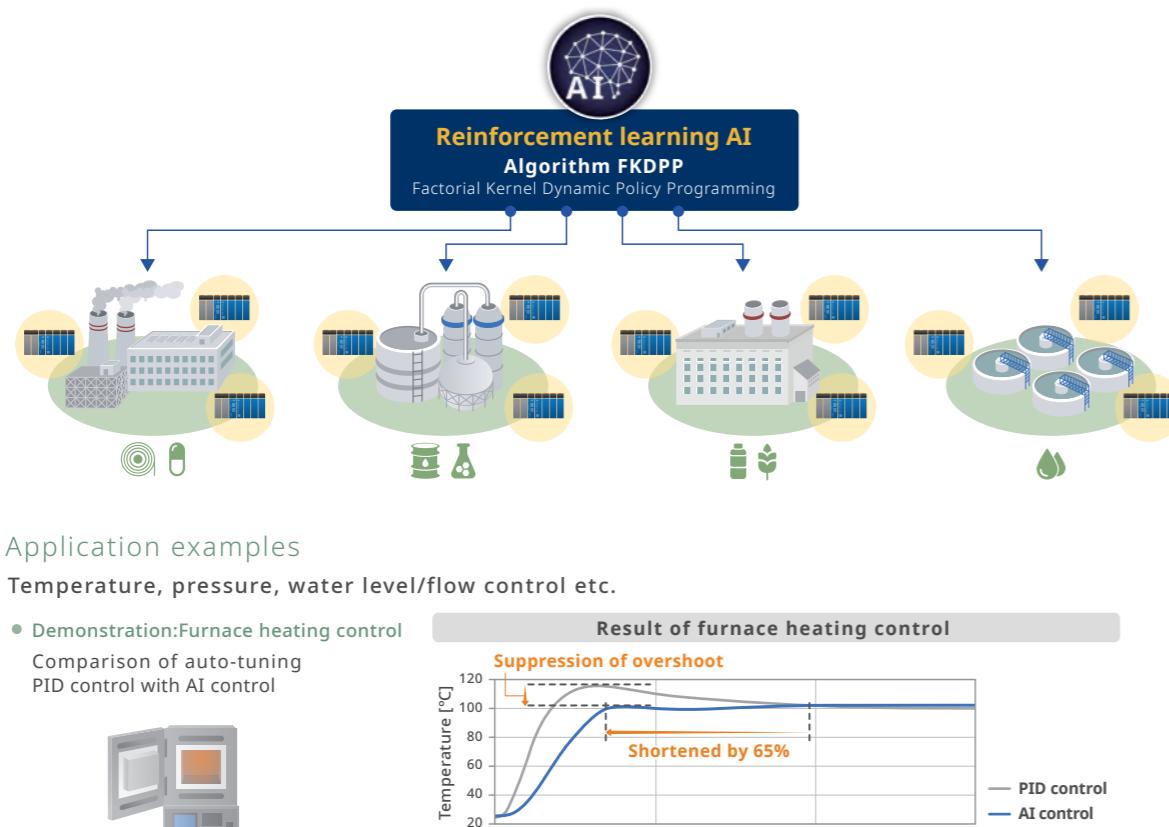
AI control learning service

In combination with proven industrial controllers, our AI control can be used in a wide range of applications, including plant and machine control.

- Supports control periods from 0.01 seconds, and equipment control that requires high speed
- Multiple control loops can be processed in a single controller
- Hybrid control that takes advantage of the features of PID and other conventional control methods

Main markets

- Resources and energy (petroleum, chemical, natural gas, electric power, renewable energy, etc.)
- Materials (textiles, pulp and paper, paints, etc.)
- Electronic equipment (semiconductor manufacturing equipment, etc.)
- Food and agriculture,
- Pharmaceuticals
- Water and sewage systems

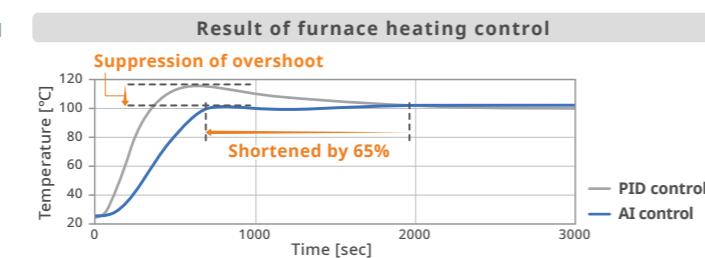


Application examples

Temperature, pressure, water level/flow control etc.

- Demonstration: Furnace heating control

Comparison of auto-tuning PID control with AI control



Application examples



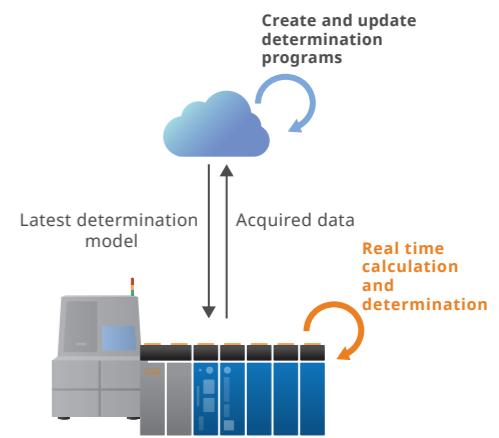
- While ensuring quality, overshoot (which is difficult to adjust) is suppressed while reducing dead time
- Contributes to energy saving by improving efficiency
- Improvement of transient characteristics prevents unnecessary load on the heater and contributes to extending the life of the equipment

AI determination device

Install a determination model on the CPU module, and make real-time determinations on site

- Upload data acquired on site to the cloud, and create a program that can determine pass/fail
- Load a determination model into the CPU module, and make real-time pass/fail determinations on site
- Sequentially upload acquired data to the cloud, and update the determination model as needed

Point! While making real-time determinations on site, link to the cloud and update the determination model as needed to increase determination accuracy.

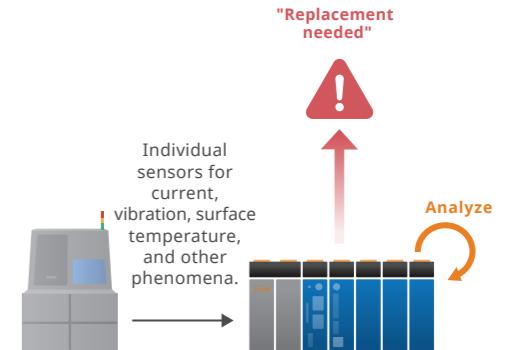


Predict the lifespan of machine parts

Maintenance based on equipment condition to avoids machine downtime

- Compares the equipment's optimal condition with its current condition
- From vibration, temperature, load current, and other phenomena, calculates the likelihood of a malfunction (in-house knowledge)
- Transition from TBM (time based maintenance) to CBM (condition based maintenance) to identify the ideal part replacement timing and reduce loss
- Replace parts before they malfunction, and avoid machine downtime

Point! Use Python to easily compare data and perform complex calculations.

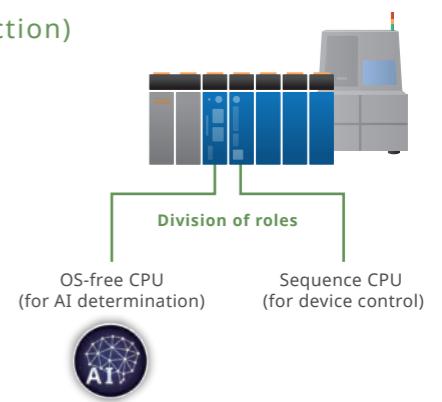


AI determination and High speed control in a single unit

Spreads processing across two CPUs (multi-CPU function)

- Process AI determination on the Python compatible CPU
- A sequence CPU provides high-speed device control
- IT engineers manage the AI component
- OT engineers manage the device control component

Point! Achieves device control (OT) and AI determination (IT) on a single platform



Lineup

OS-free CPU module

[F3RP70-2L]

A CPU module with boot loader. By inserting an SDHC card containing a OS image file provided by Yokogawa Partner Portal Website, you may launch Linux Ubuntu by starting the module.



OS-free CPU module

Name	Model
OS-free CPU module	F3RP70-2L
OS-Free CPU Module with AI control license	F3RP70-2L/L09

Digital Input / Output module

[F3XD** / F3YD**]

Various types of Digital input module and Digital Output module are available for use according to your application.



Analog Input / Output module

[F3AD** / F3DA**]

These Analog Input module and Analog Output module provide high-speed conversion, high precision, advanced functionality, and excellent noise immunity. They come with high (16-bit) resolution.



High-speed data acquisition module

[F3HA**]

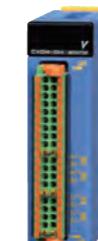
Analog data acquisition and analysis modules that deliver high speed and high accuracy. They also include A/D conversion and FFT calculations synchronized with a counter.



Temperature monitoring module

[F3CX04]

Monitor temperature on up to 4 channels. Input conditions and other data needed for temperature monitoring is saved in the module, so you don't have to reconfigure parameters every time you start operation.



Base module

[F3BU**]

We offer four types of base module for 5, 9, 13, and 16 slots.



Power supply module

[F3PU**]

Install one power supply module for each base module.



Software/License

Category	Name	Model	Description
License	AI control learning service for F3RP70	SFRL18-MPC	License to use content provided as a cloud service
Software Package	AI control license for F3RP70	SFRL19-MPC	License to download/execute AI control model (/unit)
	AI control software package for F3RP70	SFRM19-MDW	Software required to create and use AI control applications

AI control software package specifications

Execution library specifications

Item	Specifications
Library type	C language static library
	C language shared libraries
Control function	AI control / PID
Input	Analog value*1
Output	Analog value*2 / Time proportional DO value*3

*1: An analog input module can be used for analog input of current and voltage, and a temperature monitor module or PID control module can be used for temperature input.

*2: Analog output modules and PID control modules can be used for analog output of current and voltage.

*3: An output relay module and PID control module can be used for time-proportional numeric output.

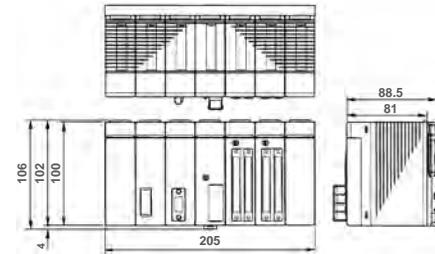
Data acquisition application specifications

Item	Specifications						
Operating CPU modules	OS-Free CPU Module						
Supported OS	Ubuntu 18.04 (Supplied with Ubuntu image)						
Available I/O modules	<table border="1"> <tr> <td>Digital input</td> <td>F3XD32-□□ / F3XD64-□□ / F3WD64-□□</td> </tr> <tr> <td>Analog input</td> <td>F3AD04-5R / F3AD08-6R / F3AD08-4R</td> </tr> <tr> <td>Temperature input</td> <td>F3CX04-0H / F3CU04-□H</td> </tr> </table>	Digital input	F3XD32-□□ / F3XD64-□□ / F3WD64-□□	Analog input	F3AD04-5R / F3AD08-6R / F3AD08-4R	Temperature input	F3CX04-0H / F3CU04-□H
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Analog input	F3AD04-5R / F3AD08-6R / F3AD08-4R						
Temperature input	F3CX04-0H / F3CU04-□H						
Minimum scan interval	1 msec						
Maximum acquisitions	100000						
Output file	Proprietary format (TSV)						

External Dimensions (For F3BU05-0D)

Base module	Number of slots	Number of I/O slots*	Total width
F3BU05	5	4	205
F3BU09	9	8	322
F3BU13	13	12	439
F3BU16	16	15	527

Unit: mm



* The number of available I/O slots is indicated assuming that one CPU module is installed.

e-RT3 Plus Website



- For proper and safe use of this product, read the instruction manual thoroughly.
- If faults of this product are expected to result in accidents or losses, install additional external protection and/or safety circuits.
- If the product is to be used in applications which may directly affect or threaten human lives and safety, such as railway facilities, aviation and space navigation, medical equipment or transport equipment, please contact Yokogawa's sales office.

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OpreX™ Yokogawa achieves operational excellence by providing products, services, and solutions based on the OpreX comprehensive brand that cover everything from business management to operations.

YOKOGAWA ELECTRIC CORPORATION

World Headquarters

9-32, Nakacho 2-chome, Musashino-shi, Tokyo 180-8750, Japan
<http://www.yokogawa.com/>

YOKOGAWA CORPORATION OF AMERICA

2 Dart Road, Newnan, Georgia 30265, U.S.A.
<http://www.yokogawa.com/us/>

YOKOGAWA EUROPE B.V.

Euroweg 2, 3825 HD Amersfoort, The Netherlands
<http://www.yokogawa.com/eu/>

YOKOGAWA ENGINEERING ASIA PTE. LTD.

5 Bedok South Road, Singapore 469270, Singapore
<http://www.yokogawa.com/sg/>

YOKOGAWA CHINA CO., LTD.

3F Tower D, Cartelo Crocodile Building,
No.568 West Tianshan Road, Shanghai 200335, China
<http://www.yokogawa.com/cn/>

YOKOGAWA MIDDLE EAST & AFRICA B.S.C.(c)

P.O. Box 10070, Manama Building 577,
Road 2516, Busaiteen 225, Muharraq, Kingdom of Bahrain
<http://www.yokogawa.com/bh/>

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