

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.

## 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.

## 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.

## 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.

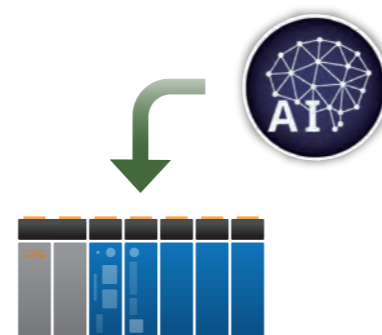
## Easy to add the AI model

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

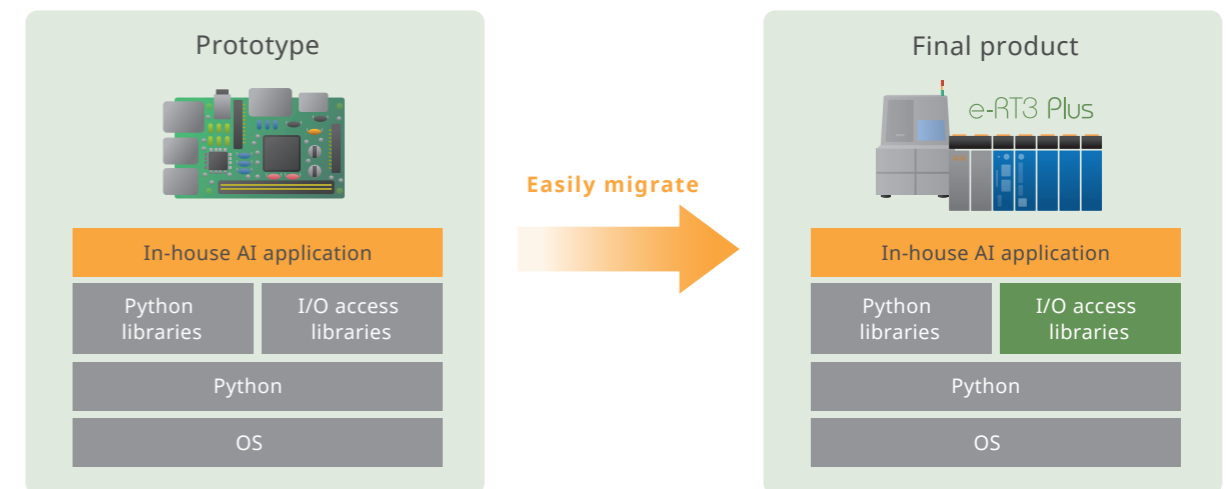
Category	Package
Package management	python3-pip
Machine learning	python3-sklearn
Numerical analysis	python3-numpy
	pandas
	python3-scipy
Drawing graphs	python3-matplotlib
Increased speed	cython3
Communication	python3-pymodbus
Development environment	jupyter-notebook
Remote debugger	ptvsd

※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.



## 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.



■ Uploaded on Yokogawa Partner Portal web site



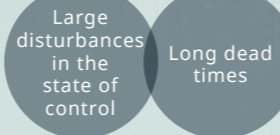
# AI Control Learning Service NEW

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.

### Common concerns



**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

\*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.

## 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.

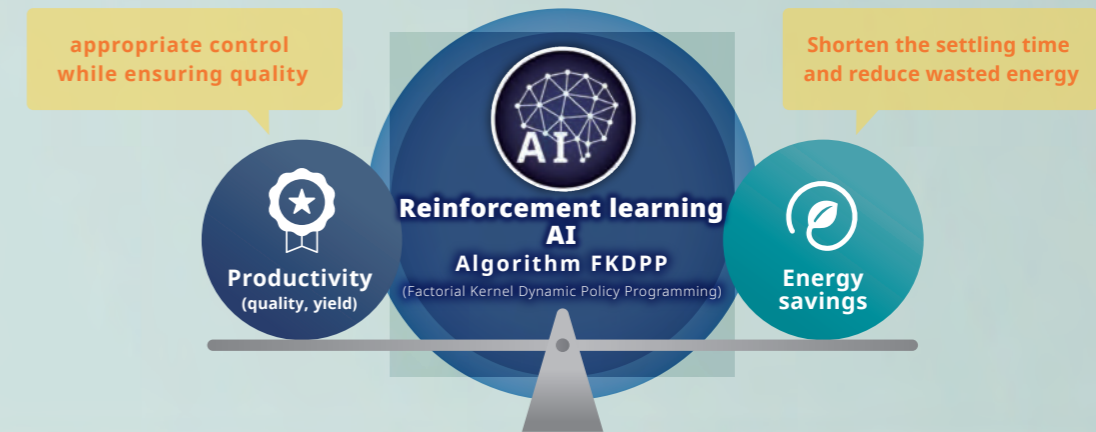
\* A process that relies on the intuition and experience of skilled engineers / A process that requires human adjustment every time a disturbance occurs

### 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)

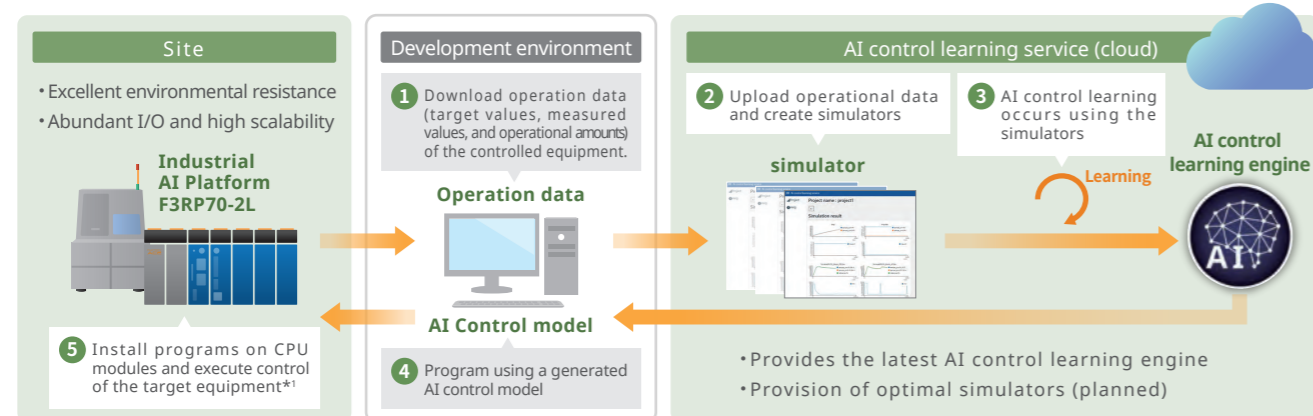
The control to shorten the settling time ensures productivity (quality, yield, etc.) while reducing wasted energy.



## 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

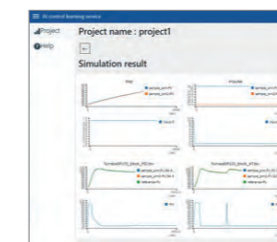
\*Purchase this product if you plan to use your existing OS-Free CPU module. For new purchases, we offer the F3RP70-2L/L09 OS-Free CPU module with an AI control license.



\*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.

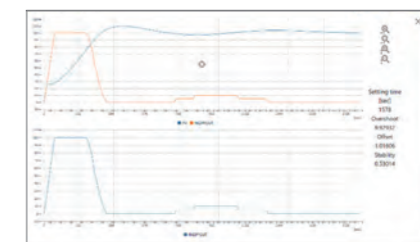
To use the AI control learning service, please apply\*2 at our dedicated website. After applying, a user account will be created in the cloud environment and you can begin using the service. The service is an annual subscription. To create an AI control model, you need to prepare either an actual machine 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

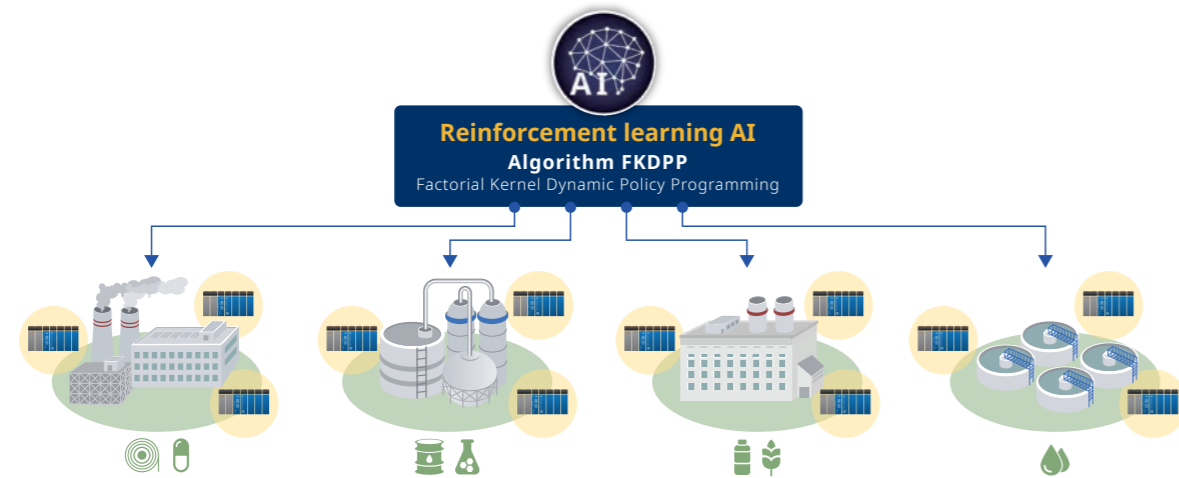
## AI control learning service

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

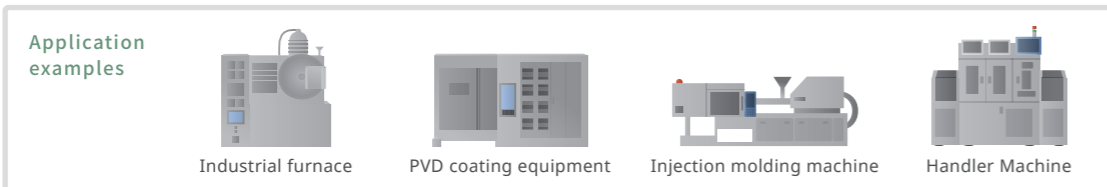
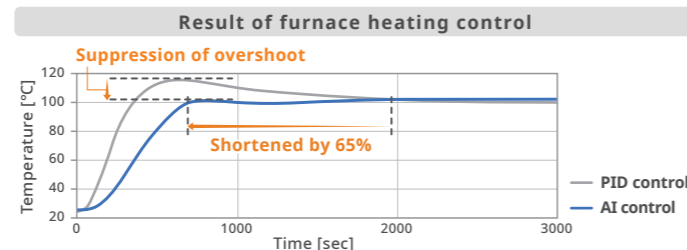
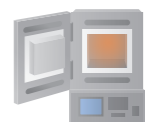
- Resources and energy (petroleum, chemical, natural gas, electric power, renewable energy, etc.)
- Materials (textiles, pulp and paper, paints, etc.)
- Electronic equipment (semiconductor manufacturing equipment, etc.)
- Food and agriculture,
- Pharmaceuticals
- Water and sewage systems



### Application examples

Temperature, pressure, water level/flow control etc.

- Demonstration: Furnace heating control
- Comparison of auto-tuning PID control with AI control



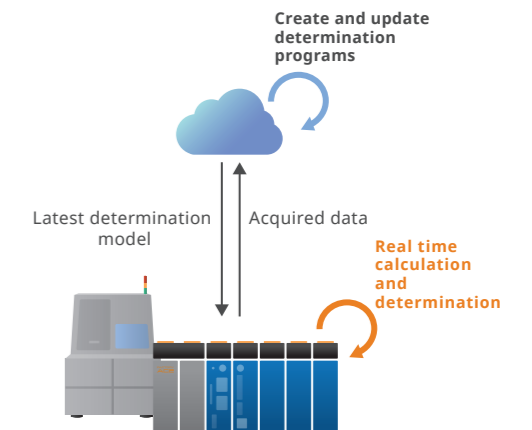
- While ensuring quality, overshoot (which is difficult to adjust) is suppressed while reducing dead time
- Contributes to energy saving by improving efficiency
- Improvement of transient characteristics prevents unnecessary load on the heater and contributes to extending the life of the equipment

## 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.

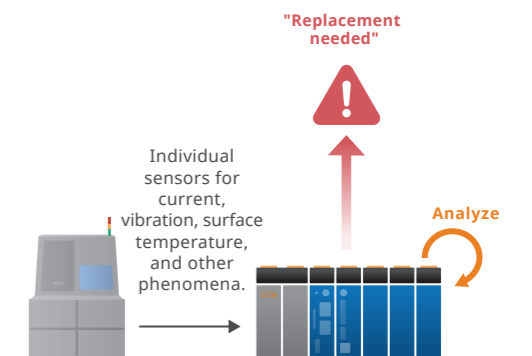


## Predict the lifespan of machine parts

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.

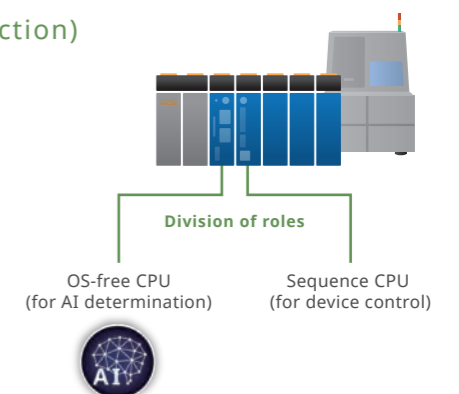


## AI determination and High speed control in a single unit

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  
Distributed processing means distributed development for increased efficiency





# 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.



## Digital Input / Output module

### [ F3XD\*\* / F3YD\*\* ]

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



## 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.



## 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.



## 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.



## OS-free CPU module

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

Item	Specifications
CPU	Cortex-A9 MPCore (Dual 866MHz)
Boot loader	U-boot 2019.04
Endian type	Little endian
Memory	ROM:256MB, RAM:1GB, SRAM:8MB
Interface	Ethernet:10BASE-T / 100BASE-TX / 1000BASE-T (2ch) RS-232C:9.6kbps~115.2kbps dedicated connector Storage : SDHC memory card (2slot) PCI : For utility module (32bit)
Biggest mounting module count	4 module / 1 unit
Current consumption	1200mA
Outer dimensions	28.9 (W) × 100 (H) × 83.2 (D) mm
Masses	220g

※ OS image details are posted on the website.

## 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	Calculation method	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	Digital input	F3XD32-□□ / F3XD64-□□ / F3WD64-□□
	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)

Unit: mm

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

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



e-RT3 Plus Website



Caution



- 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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