



Recently, further productivity improvements, quality improvements in each specific application, and improved maintainability have been required of the industrial robots. Among such conditions, the E Controller was developed with the latest electronic and information technology so as to offer easier operation and maintenance, higher basic performance and enhanced safety features. This paper provides an overview of the E Controller.

Preface

It has now been 44 years since Kawasaki commenced production in 1969 of the first industrial robots in Japan. Industrial robots introduced a level of flexibility not seen in earlier automation equipment, reducing labor requirements in spot welding, arc welding, painting, handling, semiconductor and liquid crystal substrate transport, and other fields of application, and improving productivity at manufacturing sites in Japan and overseas. However, the role played by industrial robots at manufacturing sites has continued to increase in importance, and further improvements in productivity, quality in the respective application, and maintainability are demanded.

Meanwhile, there has been remarkable technological progress in the electronic and information sectors, and early incorporation of that progress into robot technology has been the determining factor in the evolution of industrial robots. With this background, it is essential that the latest hardware and software be incorporated into robot controllers to improve basic performance and functionality, together with timely provision of added values that respond to diverse user needs.

To meet these demands, we have developed the E series controller as a new offering in our line of robot controllers. In addition to improved operation performance, this controller delivers greater operability and maintainability as well as enhanced safety functions.

1 Development concepts

In developing the E controller, we placed particular emphasis on the following items based on demands from

users regarding existing controllers.

(i) Smaller size

Make the controller more compact to reduce the footprint for a leaner production line.

(ii) Improved basic performance

Use a powerful CPU to achieve more accurate trajectory control, faster program execution, and more convenient saving and loading, etc.

(iii) Improved maintainability

To reduce the maintenance time during operation and reduce the system setup time before operation, improve the replaceability of parts that require periodic replacement, and strengthen various monitoring functions.

(iv) State-of-the-art safety functions

Make full use of functional safety technologies to realize state-of-the-art safety functions such as software control of the robot's operating space.

2 Specifications

The specifications of the E controller are shown in Table 1.

Table 1 Specifications of controller

Item		Specifications
Enclosure structure		E2X/3X/4X Std/Ext, E7X: Enclosed structure E9X: Open structure
Size		E3X/4X Std: W550×D550×H1200 E2X Std: W450×D550×H950 E2X/3X/4X Ext: W500×D550×H1400 E7X: W500×D420×H259 E9X: W500×D580×H270
No. of control axes	Standard	6 axes

In particular, the E2X standard and explosion-proof specification enclosure enables the replacement of all components including the fan from the front, eliminating the need for maintenance space in the back and side areas. Also, the E7X and E9X use a compact enclosure and single-phase 200V power source, enabling installation in any environment.

The interior of the controller is divided largely into a card rack unit, a servo amplifier unit, and an MC unit (Fig. 1). The features of each unit are described below.

(1) Card rack unit

The card rack unit consists of a DC power source for supplying control power, a main CPU board for managing the execution of the operating system and user programs and generating position commands, a power sequence board for monitoring and controlling safety circuit conditions, and an I/O fieldbus board for sending and receiving signals with external equipment. In addition, use of a PC-based architecture forms a configuration for flexible functionality expansion.

(2) Servo amplifier unit

The servo amplifier unit consists of an amplifier for controlling the motor current driving the robot, and a servo CPU board for performing the servo control to track

the encoder values with the position commands sent 5.27139()-33(t42p

(2) Reduced check/repeat trajectory errors

In the past, there were large trajectory errors between check operations and repeat operations, and in some cases teaching correction was performed while monitoring the

Furthermore, Ethernet connection between controllers can enable connection to our vision device K-HIPE-R-PC, collaborative operation between multiple robots for handling heavy objects that cannot be handled by a single robot, and other high-performance system configurations.

We also support numerous fieldbuses that help to reduce wiring costs and increase system expandability (Table 1).

5 Expansion of safety functions

(1) Advanced safety functions

As an option for further expansion of safety functions, the E controller can be fitted with the robot motion monitoring safety function Cubic-S. Cubic-S takes its name from the three S's of "Supervise/Safety/Smart." It uses software to provide advanced safety functions that could not previously be achieved, enabling flexible, low-cost construction of production lines. Cubic-S offers eight safety functions: motion area monitoring, joint monitoring, speed monitoring, stop monitoring, tool orientation monitoring, protective stop, emergency stop, and safety state output.

These safety functions are given redundancy through the use of two CPUs, achieving the functional safety standard IEC61508 "SIL2" and ISO13849-1 "PLd/Category 3" safety performance, and obtaining certification from third-party certification authorities TÜV SÜD and UL.

(2) Application example

(i) Motion area monitoring function

In the past, a safety fence needed to be installed around the outside of the mechanically limited robot motion range. As shown in Fig. 5, application of Cubic-S enables installation of the safety fence around a smaller area, thus reducing the robot installation space.

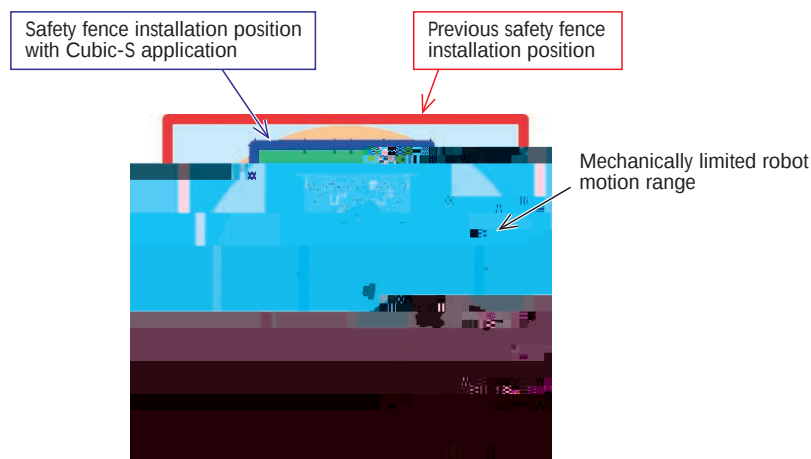
(ii) Function for selecting motion range to limit space

An example of selectable limitation on operating range is

In addition, we have added a maintenance support function that displays on the teaching pendant information useful for resolving errors. A display example of the maintenance support function is shown in Fig. 4. When an error occurs, possible causes are displayed, together with their respective probabilities, investigation methods, procedures, time required, and necessary tools, etc., to help shorten the system recovery time.

(3) Easy information handling—network functionality

The E controller is equipped with two Ethernet connectors. Data that can be used to trace products inside the controller, robot error information useful for maintenance planning, etc. can be retrieved via the network. This can be done using such methods as a library function compiling functions for accessing the controller from the computer to retrieve information, and a web server function for displaying information in the controller on the browser software of a remote computer, etc.



shown in Fig. 6. In this example, two robot operating areas exist, with the robot piling up on one side of the operating area workpieces brought in on a conveyor, while a completed pile of workpieces is carried out by forklift in the other operating area. In this case, the robot's motion range needs to be limited when the forklift is carrying out the workpieces so that the robot does not intrude into the forklift area. Previously, multiple light curtains for detecting forklift and robot intrusion and a safety PLC for their control