# Development of the *SANMOTION C* Robot Motion Controller

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## 1. Introduction

In recent years, robots have been increasingly deployed in various industries to solve the labor shortage due to the declining birthrate and aging population in Japan. The robot introduction into production processes has automated production equipment and improved productivity through labor savings. To maintain high productivity with robots, it is important to quickly detect and respond to changes in the operating environment and production equipment with which robots are used. Therefore, robot controllers need to have advanced motion control functions as well as information communication functions that can grasp production status in real time and transform and transmit relevant data.

To meet this need, we have developed a robot motion controller that features various robot control functions, as well as enhanced capabilities for communicating with ICT equipment.

In this article, we describe the main functions and features of the new robot motion controllers added to the *SANMOTION C* lineup.

## 2. Product Overview

The product lineup was expanded with the addition of three models: a standard model 505 (hereinafter, "505") for single robot control, and mid-range model 507 (hereinafter, "507"), and high-end model 520 (hereinafter, "520") for multi-robot control.

### 2.1 Appearance and dimensions

Figure 1 shows the appearance of the 520, 507, and 505 robot motion controllers. Figure 2 shows the dimensions of the 520 model, while Figure 3 shows those of the 507 and 505 models.

These come with a DIN rail for easy installation to a control panel.


Fig. 1 520 (left), 507, and 505 (right)

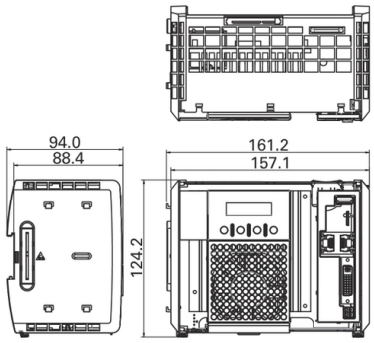


Fig. 2 Dimensions of the 520

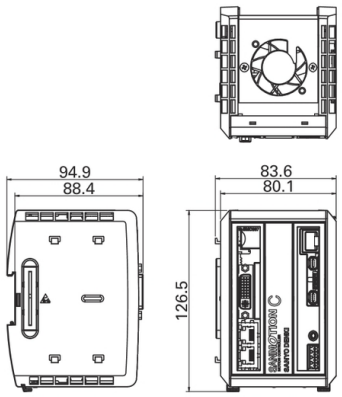


Fig. 3 Dimensions of the 507 and 505

## 2.2 General specifications

Table 1 shows the general specifications of the new models.

Each model comes standard with an EtherCAT industrial open network interface to support motion networks. The high-speed EtherCAT enables real-time monitoring of equipment status. These models have Ethernet, RS-232, RS-422, RS-485, and USB interfaces, and also support open protocols such as OPC-UA, Modbus TCP, HTTP, and MQTT, making them compatible with various devices.

These models comply with the following international standards: UL/cUL (North America), EMC Directive (Europe), UKCA (United Kingdom), and KC Mark (South Korea).

Table 1 General specifications

| Model | | High-end | Mid-range | Standard |
|---|---|---|---|---|
| Model no. | | SMC520 | SMC507 | SMC505 |
| Interface | | EtherCAT (100 Mbps) master function | | |
| | | Ethernet (10/100/1000 Mbps) × 2 ports<br>Protocol (Modbus TCP, OPC-UA) | | |
| | | – | RS-232/422/485 × 1 port | |
| | | USB 3.0 × 1 port<br>USB 2.0 × 1 port | USB 3.0 × 1 port | |
| Input voltage | | 24 VDC (19.2 to 30 VDC) | | |
| Power consumption (of controller) [W] | | 33.7 | 28.2 | 17.7 |
| Dimensions (W x H x D) [mm] | | 161.2 × 124.2 × 94 | 83.6 × 126.5 × 94.9 | |
| Mass [g] | | 900 | 515 | 500 |
| No. of controllable robots | | 4 | 2 | 1 |
| Control functions | | Sequence/motion/robot control | | |
| Compliance with standards | UL/cUL | UL 61010-1, UL 61010-2-201 | | |
| | EMC Directive | Directive 2014/30/EU | | |
| | RoHS Directive | Directive 2011/65/EU | | |
| | UKCA | BS EN 61131-2:2007 | | |
| | KC Mark | KN 61000-6-2, KN 61000-6-4 | | |

Note: "SMC" is omitted in the model no. in the running text.

# 3. Main Functions

In addition to robot control functions, the new models come equipped with sequence control and motion control functions, enabling you to develop a robot system with a single controller. In particular, a dedicated teaching pendant and robot commands allow for easy robot motion planning and teaching tasks. The details of each function are provided below.

## 3.1 Motion control functions

The new models not only feature a digital I/O-based sequence control, but also PTP positioning and electronic cam (for multi-axis synchronization) functions. As shown in Table 2, they can control up to 64 motor axes and support programming languages compliant with IEC 61131-3.

Table 2 General motion control specifications

| | |
|---|---|
| No. of controllable axes | Up to 64 |
| Communication cycle | 1 to 16 ms |
| Control system | Position control, speed control, torque control |
| Acceleration/ deceleration profile | Trapezoidal, sine squared, and trapezoidal with jerk limit |
| Unit for positioning control | Arbitrary (pulse, mm, inch, degree) |
| Programming languages | IL, ST, LD, FBD, SFC, and CFC as per IEC 61131-3 |
| Motion function block | Homing, incremental mode, absolute mode, constant speed mode, electronic cam, and electronic gear |

## 3.2 Robot control functions

As shown in Table 3, the new models are equipped with kinematics tailored to robot mechanisms, enabling a single controller to control up to four robots. The new models can perform robot jog operations and 3D interpolation control using a dedicated teaching pendant and robot commands. These functions make it possible to program robot motion in a short period.

Table 3 General robot control specifications

| | |
|---|---|
| **No. of controllable robots** | Up to 4 |
| **Communication cycle** | 1 to 16 ms |
| **Control system** | PTP motion, 3D linear interpolation, and 3D circular interpolation |
| **Control functions** | Conveyor tracking,<br>palletizing (without teaching)<br>Collision detection |
| **Teaching method** | Numerical input or through teaching |
| **Unit for positioning control** | Arbitrary (pulse, mm, inch, degree) |
| **Programming languages** | Original language |
| **Controllable robot mechanisms** | Cartesian coordinate, SCARA,<br>parallel link, palletizing,<br>and 6-/7-axis articulated robots |

## 3.3 Collision detection

To enhance the safety and reliability of robot systems, the new models are equipped with a function that detects robot collisions and performs robot emergency stops prior to any alarms such as servo amplifier overloading. The collision is detected by comparing joint torque values calculated from the robot's motion profile with the robot's torque sensor values. This function support SCARA robots.

## 3.4 Integrated development tool (*SANMOTION C* Studio)

The integrated development tool features a tree-style menu to centrally manage the configurations, programming, and 3D simulations required in robot development processes.

### 3.4.1 Configuration functions

Figure 4 shows the screen of the interactive user interface for setting the devices that configure the robot. Users can set system (controller and servo amplifier) parameters by simply selecting devices through dialogs. Figure 5 shows the configuration screen for setting robot mechanism parameters. This graphically displays robot mechanisms and enables you to set parameters intuitively.


Fig. 4 Dialog-based user interface

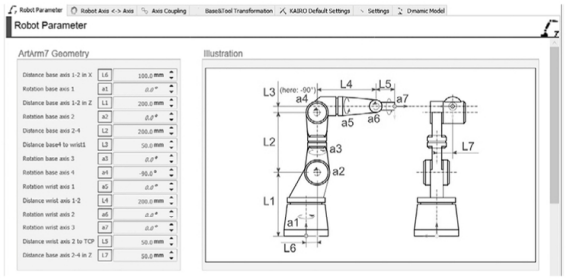


Fig. 5 Configuration screen

### 3.4.2 Programming functions

Figure 6 shows the screen for creating an application program for sequence and motion control. The tool provides programming languages that comply with the international standard IEC 61131-3, including IL (instruction list), LD (ladder diagram), ST (structured text), SFC (sequential function chart), FBD (function block diagram), and CFC (continuous function chart). You can create robot motion programs using a teaching pendant and the development tool shown in Figure 7. This environment makes it easy for PLC programmers and robot engineers to develop programs, and shortening the robot system development time.

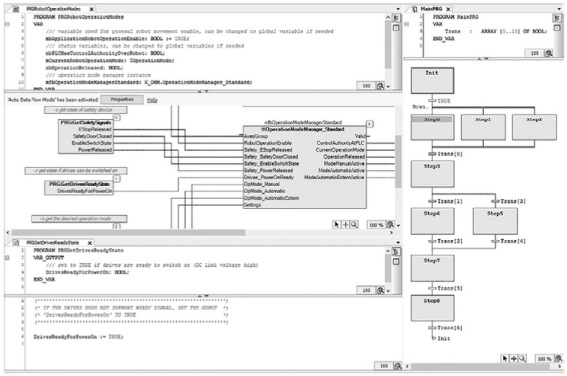

Fig. 6 Motion control programming screen

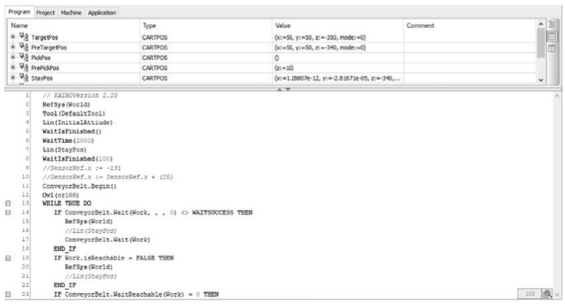

Fig. 7 Robot control programming screen

### 3.4.3 3D simulation functions

The tool comes with the 3D simulation function shown in Figure 8 that enables you to visually check the robot motion with its corresponding programs before putting them into actual use.

You can check how robots move under the set configuration parameters and programming logic on a computer. This greatly reduces the labor hours required for robot development.

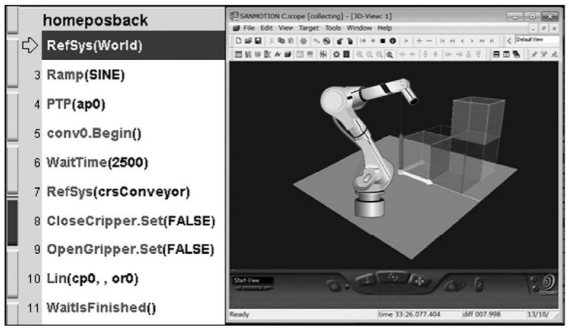


Fig. 8 3D simulation screen

## 4. Product Features

### 4.1 Size reduction

As shown in Table 4, the volume has been reduced by 70% compared to the current models by reducing the PCB size through high-density mounting of electronic components. This contributes to space savings in the control panel.

Table 4 Size comparison with the current product

| Item | New product | | Current product |
|---|---|---|---|
| **Model no.** | SMC520 | SMC507, SMC505 | SMC263X, SMC265X |
| **Dimensions (W x H x D) [mm]** | 161.2 × 124.2 × 94 | 83.6 × 126.5 × 94.9 | 270 × 120 × 100 |
| **Volume [cm$^3$]** | 1,882 | 1,004 | 3,240 |

Note: "SMC" is omitted in the model no. in the running text.

### 4.2 Abundant robot control

As shown in Figure 9, the new models can control 15 robot configurations, including the industry's cutting edge 7-axis articulated robots. The 7-axis articulated robots can move their arms like humans, avoid obstacles, and automate complex tasks in limited spaces. The new models enable users to perform various types of robot trajectory control and interpolated motions simply by setting robot mechanism parameters, contributing to in-house robot motion planning.

### 4.3 Enhanced network functions

Figure 10 shows a network configuration example.

The new models feature Ethernet-based OPC-UA and Modbus TCP communications for sharing data with production management systems. OPC-UA is a communication protocol that is not manufacturer or device-dependent. Additionally, the built-in Modbus TCP, an open protocol, improves compatibility with touch panel displays, image processing equipment, and other peripheral devices. Also, using EtherCAT for the motion network enables to connect to all devices via an Ethernet cable, contributing to reducing system costs.

Furthermore, the new models can store data collected from production equipment on servers using HTTP and MQTT communications. By analyzing the stored data, you can predict degradation and errors in production equipment in advance and perform maintenance before failures or malfunctions occur.

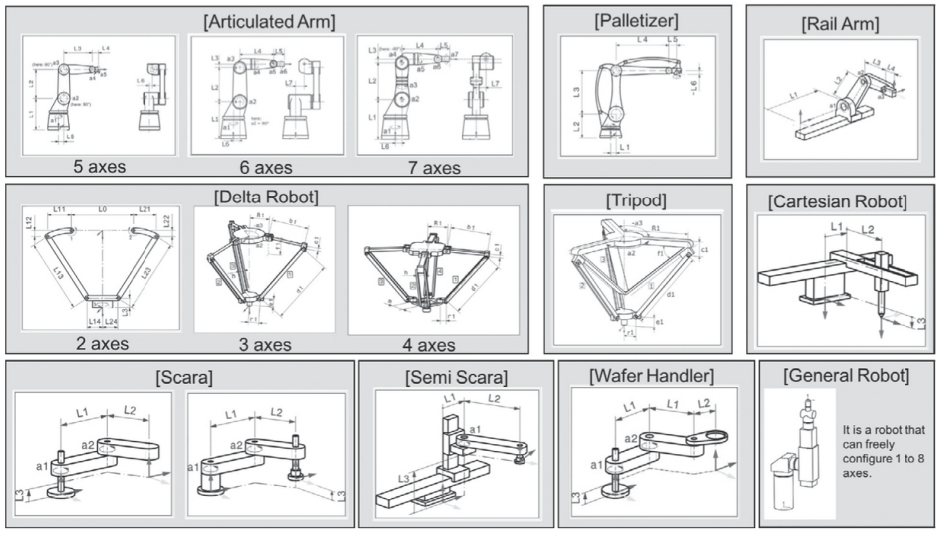


Fig. 9 Controllable robot mechanisms

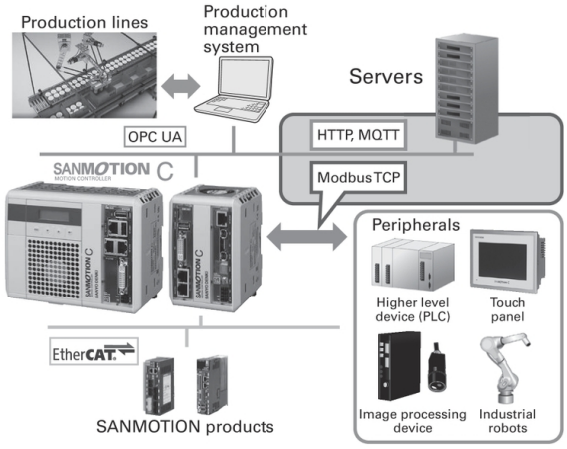


Fig. 10 Network connection configuration

## 5. Conclusion

In this article, we described the main functions and features of our new *SANMOTION C* lineup of robot motion controllers that contribute to automating production equipment and improving productivity through labor savings.

(1) The new models can control 15 robot configurations, including the industry's cutting-edge 7-axis articulated robots, contributing to the in-house robot motion planning for various industries.

(2) The new models support various communication protocols, such as Ethernet-based OPC-UA, Modbus TCP, HTTP, and MQTT, that improve compatibility with production management systems, peripheral devices, and servers.

(3) The new models come with enhanced network functions that enable real-time monitoring of production equipment operations. This enables users to detect changes in production equipment as quickly as possible and perform maintenance before failures or malfunctions occur.

The new models provide real-time monitoring of operations and contribute to high-quality manufacturing through their robot control functions and ICT equipment communication functions.

Going forward, we will continue to develop products with features that meet market demands so that we can create new value for our customers.

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