# Development of the *SANMOTION R ADVANCED MODEL* 400 VAC Input Multi-axis Servo Amplifier

Takashi Kataoka Yoshihisa Kubota Hiroto Noguchi Akihiro Matsumoto

Keisuke Ishizaki Yasuo Nakamura Yasuhiro Wakui

## 1. Introduction

A variety of power supply voltages are used throughout the world, depending on the region. To use servo system products, products with input voltage specifications that suit factories in various regions are required. Most factories use either 200 VAC or 400 VAC as their main power supply voltage, with the latter being common in Europe and Asia, where there are many factories. As such, SANYO DENKI is enhancing its lineup of 400 VAC input servo amplifiers in the same way as its 200 VAC input products.

This paper will introduce the 400 VAC input multi-axis servo amplifier newly developed and added to the *SANMOTION R ADVANCED MODEL* lineup. This servo amplifier has a multi-axis configuration, which helps to save space and create a flexible system. Moreover, it is suitable for European and Asian customers, who use 400 VAC as the main power supply input.

Below is an overview of the new model covering performance and main functions, initiatives to achieve a configuration with optimal heat radiation, and so on.

## 2. Product Overview

### 2.1 External view and dimensions

Figure 1 shows external views of the newly developed *SANMOTION R ADVANCED MODEL* 400 VAC input multi-axis servo amplifier, and Figures 2 through 4 provide its dimensions. In order to make flexible system configuration possible, the new model is separated into three components; the control unit, power unit, and amplifier unit. They have an open-type structure intended to be installed in our customers' control panels. We have prepared two types of control units; the first being a 4-axis integrated type EtherCAT interface, and the second being a single-axis analog command interface, a 16 kW output power unit and four types of amplifier units; 25 A, 50 A, 75 A and 150 A. The height of the product is 380 mm, which is shorter than the 460 mm of the 200 VAC type.

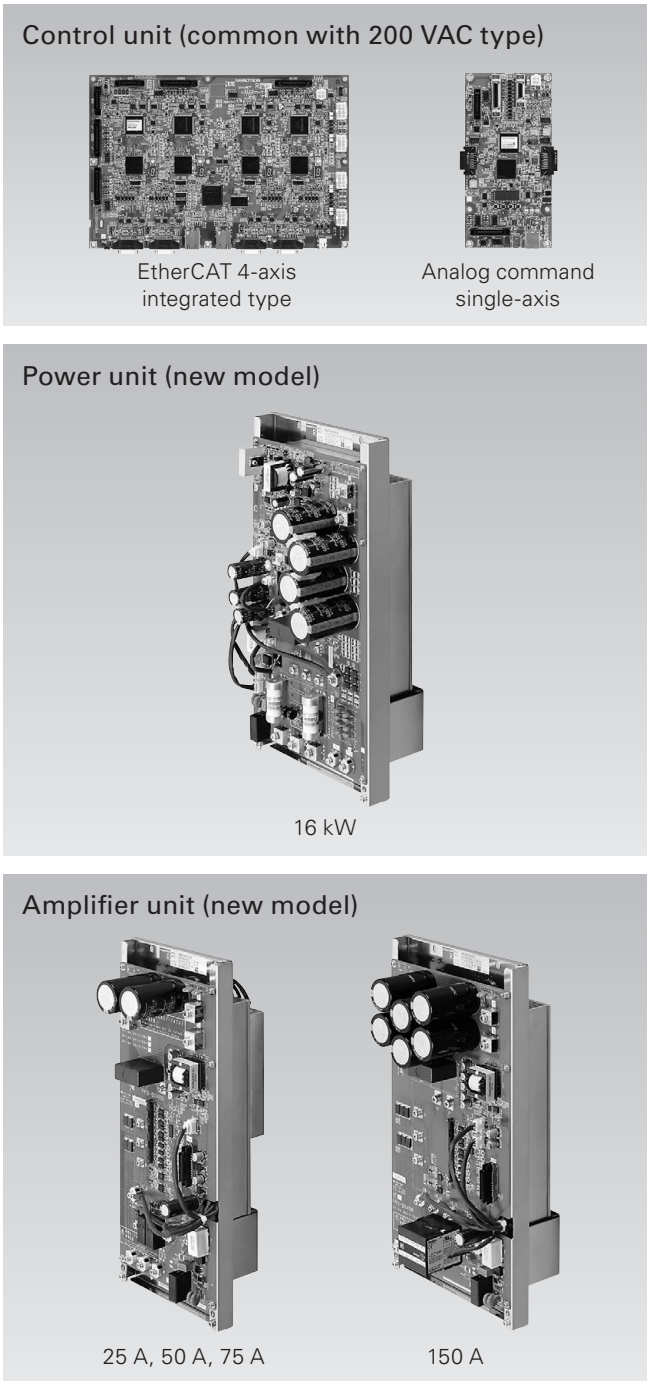



Fig. 1: External view

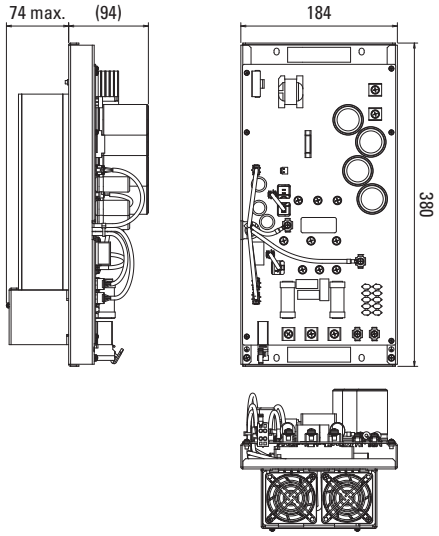



Fig. 2: Dimensions (Power unit 16 kW)

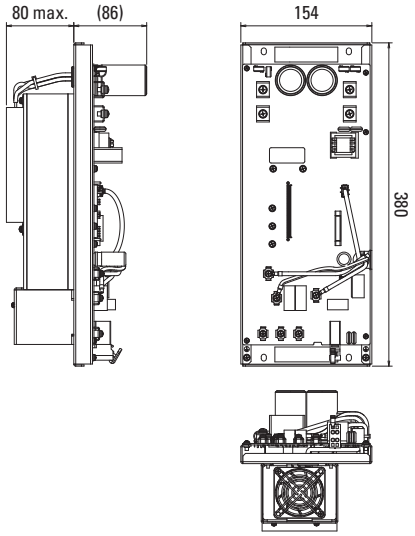



Fig. 3: Dimensions (Amplifier unit 75 A)

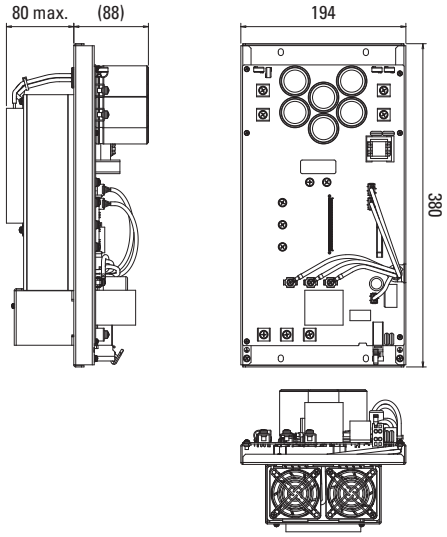



Fig. 4: Dimensions (Amplifier unit 150 A)

## 2.2 Main specifications

Table 1 and Table 2 show the main specifications for the power unit and amplifier units of the *SANMOTION R ADVANCED MODEL* 400 VAC input multi-axis servo amplifier.

The new model can be combined with motors of rated outputs ranging between 0.5 kW and 15 kW. The applicable encoders are SANYO DENKI's absolute encoder and wire-saving pulse encoder.

Regarding the control unit, a Safe Torque Off (STO) function is available when using an EtherCAT (maximum of 4 axes) interface. Moreover, as an IoT-related function, a power consumption monitoring function has been incorporated, and it is possible to examine optimization of operating patterns and operating status from the host device.

The new model also complies with international standards such as Europe's Low Voltage Directive, the EMC Directive, Functional Safety, the US's UL/cUL, and Korea's KC mark.

Table 1: Power unit main specifications

| | | |
|---|---|---|
| **Output capacity** | | 16 kW |
| **Input** | **Main circuit voltage** | 380 to 480 VAC +10%, -15% |
| | **Control voltage** | 24 VDC ±15% |
| **Dimensions (W × H × D)** | | 184 × 380 × 162 mm |
| **Interface** | | I/O between amplifier units (power supply detection, etc.) |
| **Display** | | Main power charging display, control power establishment display |
| **Inrush prevention circuit** | | Built-in (thyristor type) |
| **Regeneration function** | | Built into circuit (External resistor) |
| **Cooling method** | | Forced air cooling |
| **Safety standards** | **UL/cUL** | UL 61800-5-1 |
| | **Low voltage directive** | EN 61800-5-1 |
| | **EMC directive** | EN 61800-3, EN 61326-3-1 |
| | **KC mark** | KN 61000-6-2, KN 61000-6-4 |

Table 2: Main specifications of amplifier units

| Output capacity | | 25 A | 50 A | 75 A | 150 A |
|---|---|---|---|---|---|
| Input | Main circuit voltage | 457 to 747 VDC | | | |
| | Control voltage | 24 VDC ±15% | | | |
| Output | Continuous rated current | 4.8 Arms | 12 Arms | 18 Arms | 34 Arms |
| | Instantaneous maximum current | 14.1 Arms | 29.2 Arms | 45.5 Arms | 83 Arms |
| Dimensions | | W154 mm H380 mm D161 mm | | | W194 mm H380 mm D197 mm |
| Compatible motors | | 0.5 to 2.0 kW | 2.0 to 3.5 kW | 4.5 to 7.0 kW | 7.5 to 15 kW |
| Compatible encoders | | Absolute encoder, wire saving pulse encoder | | | |
| Interface | | EtherCAT (4-axis integrated control), analog (single-axis control) | | | |
| Dynamic brake | | Included (built-in resistors) | | | |
| Cooling method | | Forced air cooling | | | |
| Safety standards | UL/cUL | UL 61800-5-1 | | | |
| | Low voltage directive | EN 61800-5-1 | | | |
| | EMC directive | EN 61800-3, EN 61326-3-1 | | | |
| | KC mark | KN 61000-6-2, KN 61000-6-4 | | | |

## 3. Main Functions and Features

This section describes the functions and features of the new model.

### 3.1 System downsizing

Previously, it was necessary to use a step-down transformer, etc. to convert the power supply current from 400 VAC to 200 VAC in order to use a 200 VAC input servo system in a 400 VAC power supply environment. On the new model, however, a 400 VAC power supply can be directly supplied to the servo amplifier, eliminating the need for a step-down transformer and making it possible to reduce system size.

### 3.2 High response control

Based on a control system compatible with the *SANMOTION R ADVANCED MODEL* AC servo amplifier, the new model is equipped with functions to improve phase delay and increase integral gain, for higher feedback response. Moreover, with both speed and torque feed-forward compensation, an improvement in command responsiveness can also be expected.

### 3.3 Power consumption monitoring function

The new model features a power consumption monitoring function which estimates the power consumption of the servo motor and amplifier based on the speed and current of the motor. This makes it possible to easily estimate and monitor a device's power consumption.

### 3.4 Energy saving

As multiple amplifier units have a common power unit, regenerative power from the motor can be used to power other motors, and it is possible to increase the energy-saving performance of equipment.

We have also achieved a low power consumption of 24 V by using unit internal temperature monitoring to perform two-stage speed control of a variable speed fan.

### 3.5 Lightweight

The servo amplifier's housing (sheet metal portion) is made from high-strength stainless steel (SUS). We performed fixed-value analysis and damping performance investigations of the sheet metal in order to secure a strength equivalent to that of the cold-rolled steel plate (SPCC/SECC) (hereinafter steel plate) used on current models, at the same time reducing the thickness and weight of the sheet metal.

Moreover, conventional steel plate was electroplated or painted as a means of rust prevention. Stainless steel, however, has excellent anti-rust performance even without being treated, and therefore offers an advantage for use in manufacturing.. Generally-speaking, stainless steel has a higher electrical resistance than steel plate, so we implemented innovative measures for reducing contact resistance, such as directly connecting a ground terminal and connecting the sheet metal via a tap. As a result, we achieved the same level of grounding continuity (conductivity) and noise resistance as current models.

### 3.6 Simple wiring

For the control power supply (24 VDC) wiring, we used the same connector as that used on the *SANMOTION R 3E MODEL* 400 VAC input single-axis servo amplifier and made single touch connection possible.

Moreover, as shown in Figure 5, the terminals (P, N) for the main circuit (457 to 747 VDC) bus power supply supplying power from the power unit to the amplifier unit have a standardized layout (height) between units, and can easily be wired to the copper bar.

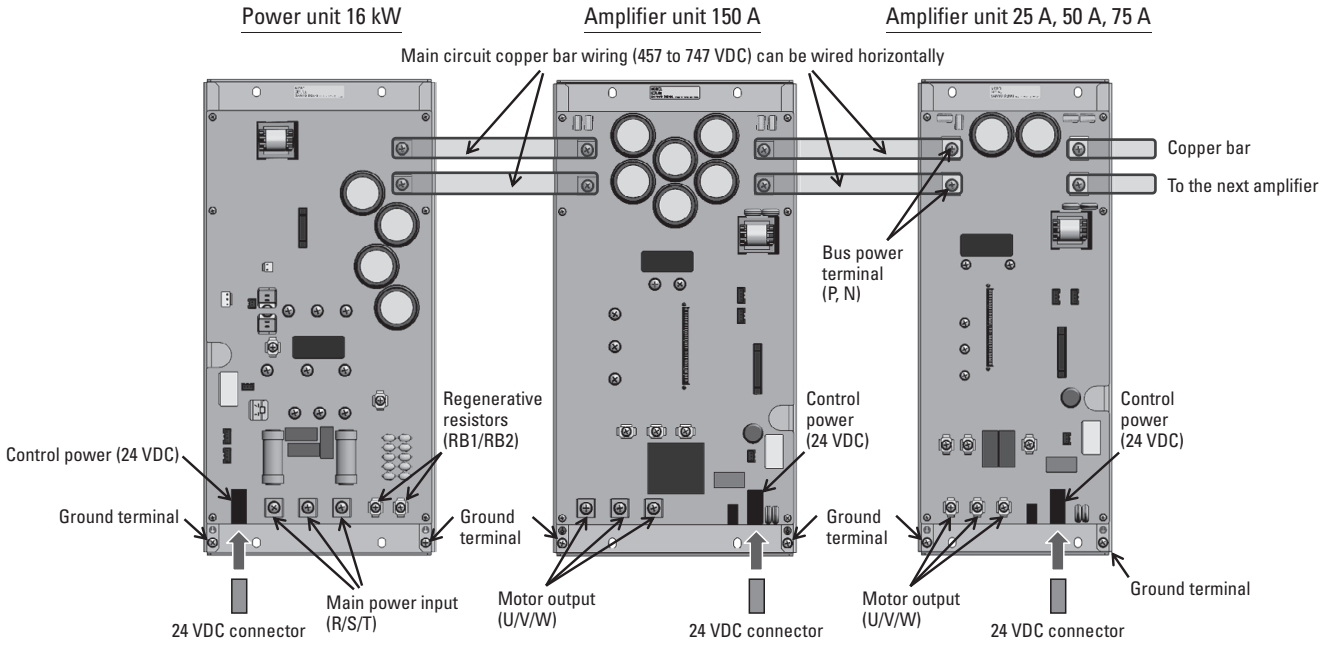
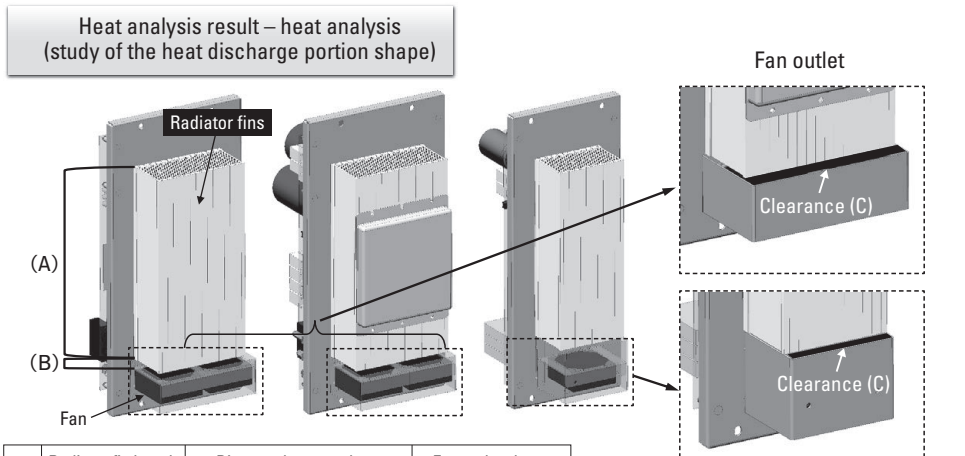



Fig. 5: Terminal layout drawing

## 4. Optimal heat radiation configuration

Figure 6 shows the heat radiation configuration of the newly developed *SANMOTION R ADVANCED MODEL* 400 VAC input multi-axis servo amplifier.

On the power unit and amplifier unit, the heat-generating portions of the diode module and power module are located above the radiator fins. For the fan to cool these hot portions efficiently, important factors to consider are the distance between the radiator fins and cooling fan, as well as the




| No. | Radiator fin length (A portion) | Distance between heat radiator fins and fan (B portion) | Fan outlet shape (C portion) |
|---|---|---|---|
| (1) | Long fins | Short distance | Clearance |
| (2) | Long fins | Short distance | No clearance |
| (3) | Short fins | Long distance | Clearance |
| (4) | Short fins | Long distance | No clearance |

Fig. 6: Distance between radiator fins and cooling fan

clearance of the cover over the cooling fan.

As shown in Figure 6, to optimize cooling efficiency of the new model, SANYO DENKI changed conditions for the length of the radiator fins (A), the distance between the radiator fins and the cooling fan (B) and the outlet clearance (C), then performed heat analysis to determine the optimal layout.

As shown in Figure 7, even if the radiator fins are short, as per condition No. (4), by securing space between the fins and fan, and eliminating the fan outlet clearance, it was possible to optimize the heat radiation effect.

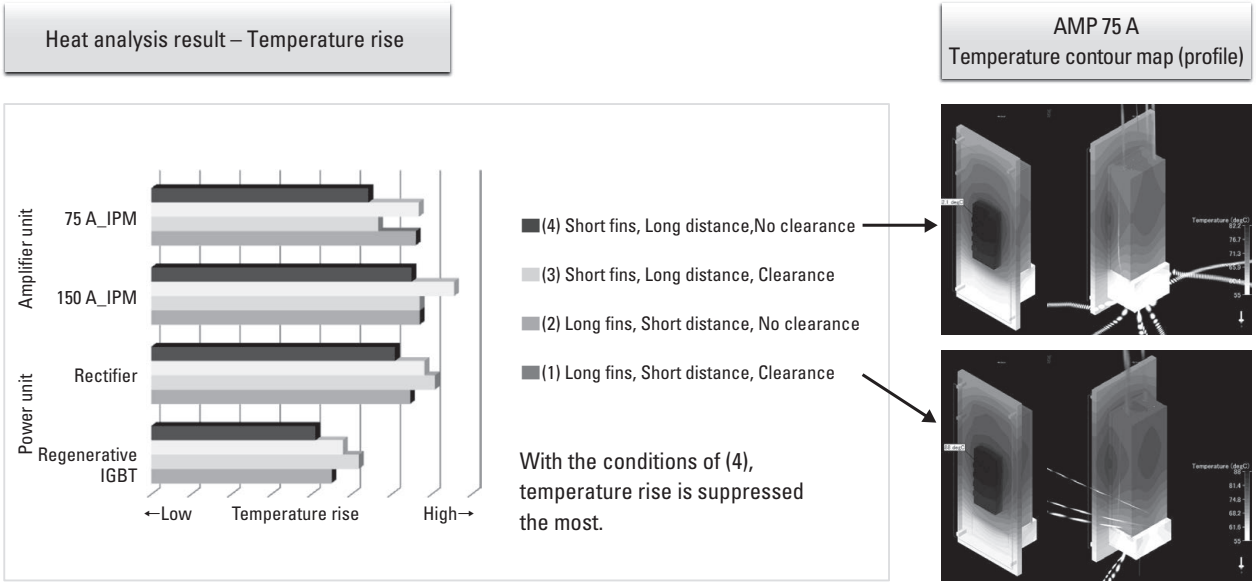



Fig. 7: Heat analysis results

## 5. Conclusion

This article has introduced the performance and main functions of the *SANMOTION R ADVANCED MODEL* 400 VAC input multi-axis servo amplifier and initiatives regarding adopting new structural materials and achieving an optimal heat radiation configuration.

The new model makes it possible to directly supply 400 VAC, the common power supply in European and Asian factories, to a servo amplifier without the need for a step-down transformer. Moreover, the multi-axis servo amplifier shares a common power unit, so regenerative power from the motor can be used to drive other motors, which we believe will help to improve the energy-saving performance of our customers' equipment.

Amidst ever-changing markets, SANYO DENKI is committed to developing servo systems that help to solve our customers' problems and create new value.

**Takashi Kataoka**
Joined SANYO DENKI in 1988.
Servo Systems Div., Design Dept. 2
Works on the development and design of servo amplifiers.

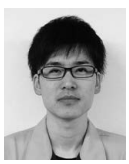
**Yoshihisa Kubota**
Joined SANYO DENKI in 1989.
Servo Systems Div., Design Dept. 2
Works on the development and design of servo amplifiers.

**Hiroto Noguchi**
Joined SANYO DENKI in 2016.
Servo Systems Div., Design Dept. 2
Works on the development and design of servo amplifiers.

**Akihiro Matsumoto**
Joined SANYO DENKI in 1990.
Servo Systems Div., Design Dept. 2
Works on the development and design of servo amplifiers.

**Keisuke Ishizaki**
Joined SANYO DENKI in 2008.
Servo Systems Div., Design Dept. 2
Works on the development and design of servo amplifiers.

**Yasuo Nakamura**
Joined SANYO DENKI in 2009.
Servo Systems Div., Design Dept. 2
Works on the development and design of servo amplifiers.



**Yasuhiro Wakui**
Joined SANYO DENKI in 2012.
Servo Systems Div., Design Dept. 2
Works on the development and design of servo amplifiers.