Development of the *SANMOTION R 3E Model* 400 VAC Input Servo Amplifier (150 A, 300 A)

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1. Introduction

The *SANMOTION R 3E Model* 200 VAC input servo amplifier developed in 2014 features a wide range of products able to drive motors with outputs of up to 30 kW, and is being used by customers in a variety of machinery. With the globalization of industry, a high demand for 400 VAC input servo amplifiers is emerging primarily in Europe and Asia, therefore SANYO DENKI has enhanced the lineup with new 400 VAC input models capable of driving motors with the same outputs as the 200 VAC models.

This article will introduce the two new models added to the *SANMOTION R 3E Model* 400 VAC input servo amplifier lineup:150 A and 300 A.

First, an overview of the new models will be provided. Next, the main performance, functions and development points will be introduced.

2. Product Overview

2.1 Appearance and dimensions

Figure 1 shows the appearance of the *SANMOTION R 3E Model* 400 VAC input servo amplifiers with 150 A and 300 A capacities (hereinafter 150 A and 300 A models), while Figures 2 and 3 show their dimensions.

In order to maintain compatibility with existing products, the new models were given the same width and height dimensions as the current models.

2.2 Main specifications

Table 1 shows the main specifications of the 150 A and 300 A amplifiers. The interface supports analog and pulse train inputs, as well as EtherCAT. We have also added a functional safety model to the lineup, allowing customers to choose the right one for their equipment's application.

Compatible motors are the R1 and R2 series 400 V input motors with 5.5 to 30 kW outputs.

Compatible encoders are our absolute encoders and wire-saving incremental encoders. Moreover, these models also support encoders manufactured by HEIDENHAIN (EnDat2.2 interface) for use with linear motors or fully closed-loop control systems.

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

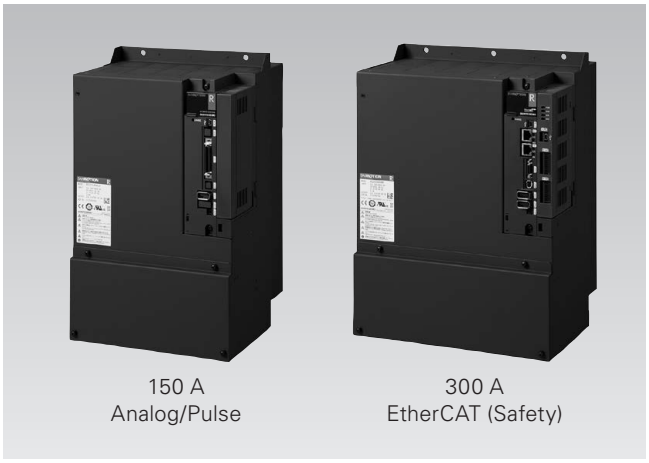


Fig. 1 Appearance

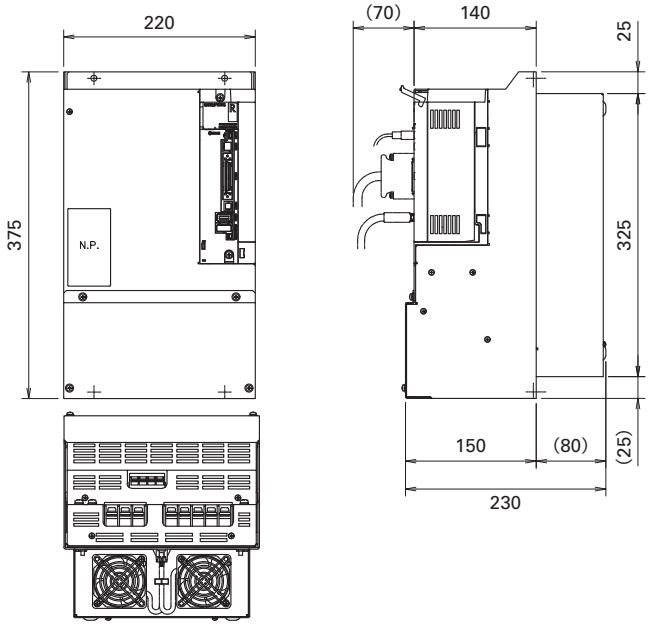


Fig. 2 Dimensions (150 A)

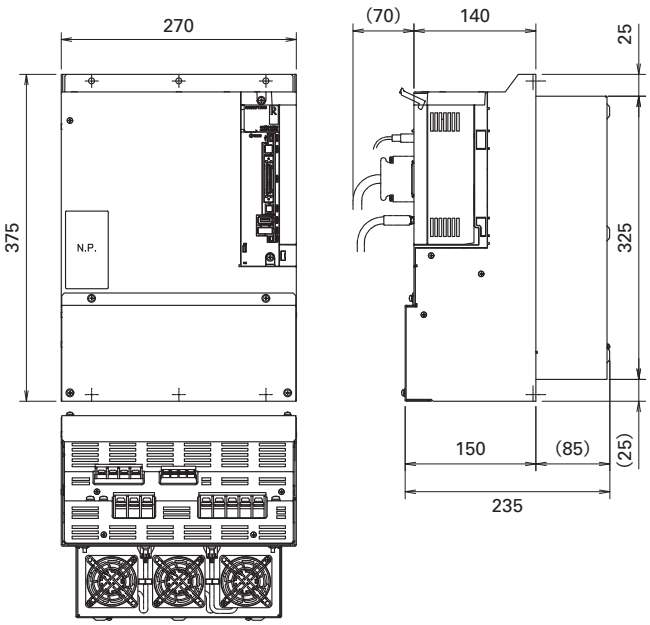


Fig. 3 Dimensions (300 A)

Table 1 Main specifications

Amplifier capacity		150 A	300 A
Control power supply voltage range		24 VDC ±10%	
Main circuit power supply voltage range		380 to 480 VAC +10%, -15%	
Dimensions		220 W × 375 H × 230 D	270 W × 375 H × 235 D
Continuous output current		34.0 Arms	66.0 Arms
Peak current		83.0 Arms	157.0 Arms
Compatible motor		5.5 to 15 kW	20 to 30 kW
Compatible encoder		· Absolute encoder (battery back-up, battery-less, single turn) · Wire-saving incremental encoder · HEIDENHAIN EnDat2.2 encoder	
Function	**Control function**	· Tandem operation control · Dual positioning feedback control	
	Mechanical vibration/ resonance suppression	· FF vibration suppression control (2-Step) · CP vibration suppression control · Adaptive notch filter	
	Servo tuning	· Auto tuning response 40 levels · Servo tuning support function	
	Start-up, monitoring, diagnosis	· Virtual motor operation · Power consumption monitoring · Drive recorder · Encoder temperature monitoring · Amplifier temperature monitoring · Service life diagnosis of holding brake · Monitoring of power consumption of regenerative resistor · Monitoring of encoder communication quality · Relay clicking counter	
Safety standards	**UL**	UL 61800-5-1	
	CSA	C22.2 No.274-13	
	Low Voltage Directive	EN 61800-5-1	
	EMC Directive	EN 61800-3, EN 61326-3-1	
	Functional safety	ISO 13849-1 PL=e, EN 61508 SIL3, EN 62061 SILCL3	
	KC mark	KN 61000-6-2, KN 61000-6-4	

3. Performance and Functions

The new models offer four new functions while maintaining the same performance and functions as the *SANMOTION R 3E Model* 200 VAC input servo amplifiers.

These functions acquire and analyze data relating to servo motors and servo amplifiers to improve the maintainability of equipment through preventive maintenance and environmental diagnosis. The details of each function are provided below.

3.1 Holding brake remaining life

A servo motor with a holding brake is a service life-limited component as repetitive braking causes wear, which in turn causes the gap to widen and, ultimately, prevents normal operation.

This function counts the number of the holding brake's braking rotation to estimate brake wear and monitor the remaining life of the holding brake. This enables customers to appropriately judge the timing of servo motor replacement and prevent equipment breakdown.

3.2 Monitoring of power consumption of regenerative resistor

We have added a function to monitor power consumption of regenerative resistor.

If the input voltage rises and the capacity of the electrolytic capacitor decreases, the regenerative power increases. By monitoring power consumption, it is possible to detect changes in the power source environment and device failures. Moreover, it also enables us to check the margin in relation to maximum absorbed power, therefore customers can choose the suitable regenerative resistor.

3.3 Monitoring of encoder communication quality

A function has been added to the new models to monitor communication error rate (bit error rate) and quantitatively check the quality of communication between the servo amplifier and encoder.

The error rate varies significantly if there is a problem with the servo amplifier-servo motor connection, grounding connection, or a problem with the shielded cables. With this monitoring function, you can perform the correct wiring, grounding, etc. at the device start-up, improving the device's noise resistance. Moreover, monitoring variations in the error rate during device operation helps in checking and improving communication quality.

3.4 Relay click counter

This function enables you to monitor the remaining life of components by counting the number of relay clicks produced in the inrush current limiting circuit, dynamic brake circuit, and holding brake output circuit. This enables systematic maintenance and prevents equipment breakdown.

4. Key Points of Development

4.1 Business continuity planning (BCP) initiatives

Our suppliers suffered extensive damage in the Great East Japan Earthquake in 2011 and Kumamoto Earthquake in 2016, which made our part procurement difficult, affecting our customers' production. For example, we failed in procuring intelligent power modules (IPM) that we used as the power module for servo amplifier inverters. We could not find an alternative to it due to the lack of compatibility of the package and functions which differ by manufacturer, and however, depending on the manufacturer, and a drastic design change was required.

So, for the new 300 A servo amplifier, we selected an IGBT module which is compatible with multiple manufacturer packages. An IPM has many built-in functions such as overload protection, over-heat protection, protection against control circuit low voltage, and software isolation in the case of overloads, while the IGBT module does not offer these functions.

As such, we newly designed a common circuit as a periphery protection function of the IGBT module, achieving the same safety level as the IPM. By establishing these technologies, it became possible to purchase core parts from multiple suppliers without changing the printed circuit board and continue production even in unforeseen circumstances by minimizing damage.

This achieves one element of business continuity planning (BCP) strategy, enabling us to stably deliver our products to customers.

4.2 Reduction of servo amplifier heat generation

In order to reduce internal heat generation, we optimized the electrolytic capacitor of the main circuit. By performing FFT analysis on the ripple current derived through circuit simulation then calculating the heat generation amount from the electric current value of each frequency band, we selected the optimal specifications for the electrolytic capacitor.

Table 2 shows a comparison of the new and current models' main circuit electrolytic capacitors. By increasing the main circuit electrolytic capacitor's allowable ripple current by 35.8% compared to our conventional model (SANYO DENKI's RS1 series), temperature rise has decreased by 38.1%, thereby reducing heat generation.

Moreover, by providing feedback of evaluation results and considering the worst conditions for product specifications and parts in the design phase, we have developed a product that offers greater safety, greater security and higher quality.

Table 2 Comparison of main circuit electrolytic capacitors

Item	Current model (RS1) 150 A	New models 150 A	Difference with current model
Temperature rise	13.9 K	8.6 K	-38.1%
Static electricity capacity	2,000 μF	2,180 μF	9.0%
Allowable ripple	9.0 Arms	12.3 Arms	35.8%
Volume	628,319 mm^3	461,814 mm^3	-26.5%
Surface area	7,854 mm^3	7,697 mm^3	-2.0%

4.3 Downsizing

As Figure 4 shows, the new models are installed within the control panel on the front side, and inside the duct on the back side. Table 3 gives a comparison of depth dimensions with current models. For the current models, the front side depth dimension (which previously differed depending on amplifier capacity) has been standardized to 150 mm, and the overall size has been reduced by up to 10%. Moreover, the safety function expansion board can be completely built into the main unit, therefore it is possible to switch to the *SANMOTION R 3E Model Safety*, which complies with functional safety standards, without changing amplifier mounting positions within the control panel, or increasing space occupancy.

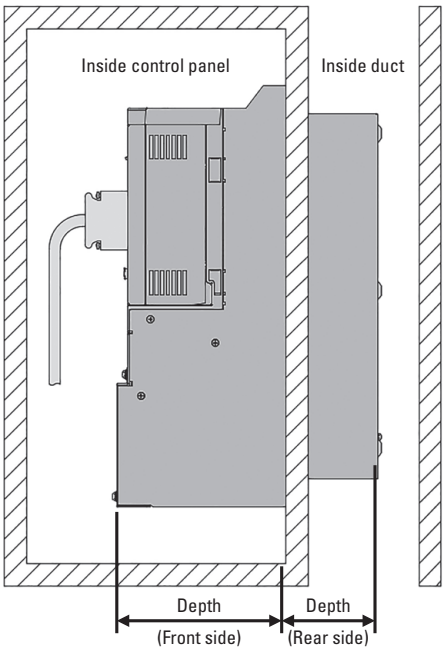


Fig. 4 Amplifier depth

Table 3 Comparison of depth and volume with current model

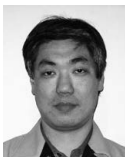
Capacity	Model number	Depth (Front side)	Depth (Duct side)	Volume Reduction rate
150 A	RS3C15 (New model)	150 mm	80 mm	-2%
	RS1C15 (Current model)	155 mm	80 mm	
300 A	RS3C30 (New model)	150 mm	85 mm	-10%
	RS1D30 (Current model)	160 mm	100 mm	

5. Conclusion

This article has introduced the main performance, functions, and development points of the new models added to the *SANMOTION R 3E Model* 400 VAC input servo amplifier lineup: the 150 A amplifier and the 300 A amplifier.

With the addition of these new models it is now possible to combine supporting motors of up to 30 kW outputs, which is equivalent to the *SANMOTION R 3E Model* 200 VAC input servo amplifiers. Furthermore, through newly added IoT functions, these models contribute to improved equipment maintainability, failure prediction, and preventive maintenance.

Moving forward, amidst market change and fluctuation, SANYO DENKI will continue to constantly assess the servo system requirements of our customers and develop products which create new value. Moreover, so that our customers may use our products safely and securely, we will further our efforts to improve design quality.



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