Development of the *SANMOTION G* 2-Axis Integrated AC Servo Amplifier

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1. Introduction

To help support a sustainable society, servo systems need to further reduce environmental impact and improve energy conversion efficiency.

Servo-driven equipment typically consumes a significant amount of power, raising demand for energy-efficient servo systems.

As equipment becomes smaller and more versatile, servo amplifiers—once installed in control panels—are increasingly being mounted inside equipment and on moving parts, driving the need for more compact, lightweight designs.

Moreover, servo systems are required to enhance equipment performance, simplify system startup, and enable quick troubleshooting.

To meet these market demands, we have developed a 2-axis integrated servo amplifier that is user-friendly and helps customers develop smaller, lighter, and more energy-efficient equipment.

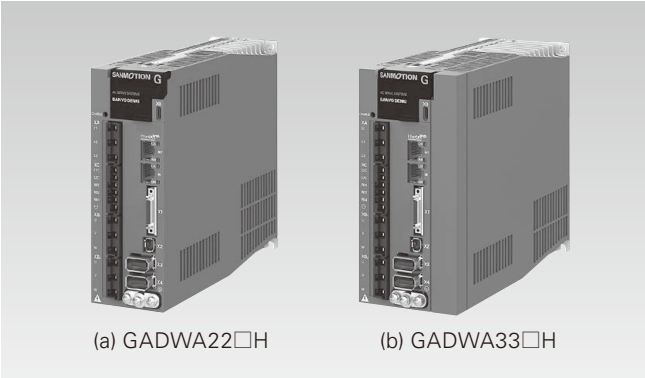
This article starts by introducing the specifications and appearance of the *SANMOTION G* 2-axis integrated AC servo amplifier (hereinafter, "new product")—the latest addition to the *SANMOTION G* servo systems lineup. Next, we'll introduce the features and the key development points of the new product.

2. Outline of the New Product

2.1 Appearance and dimensions

Figure 1 shows the new product. The lineup consists of four models: 20 A (Model No. GADWA22□H) and 30 A (Model No. GADWA33□H) output capacities, each available with or without a built-in regenerative resistor.

As shown in the outline drawing in Figure 2, the new product has a height of 160 mm, the same as a *SANMOTION G* single-axis servo amplifier,[1] and uses a standardized connector. This design allows both single-axis and 2-axis integrated servo amplifiers to be installed in the same equipment.



(a) GADWA22□H (b) GADWA33□H

Fig. 1 Appearance of the new product

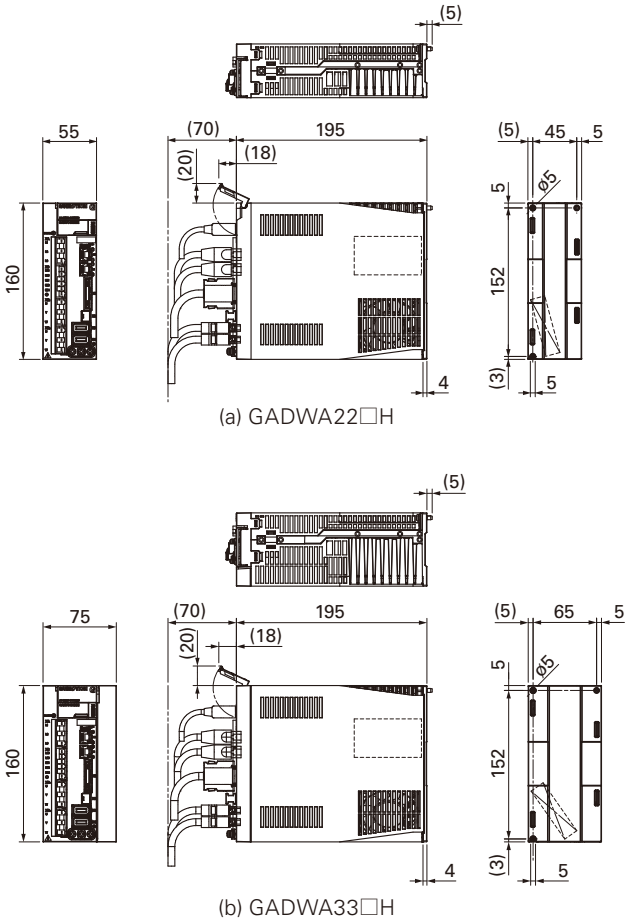


Fig. 2 Dimensions (Unit: mm)

2.2. Specifications

Table 1 shows the general specifications of the new product.

Table 1 General specifications

Amplifier capacity		20 A + 20 A	30 A + 30 A
Control power supply voltage range		Single-phase 200 to 240 VAC (+10, -15%)	
Main circuit power supply voltage range		3-/single-phase 200 to 240 VAC (+10, -15%)	
Dimensions (H × W × D)		160 × 55 × 195 mm	160 × 75 × 195 mm
Mass		1.3 kg	1.6 kg
Continuous output current		3.1 Arms	5.2 Arms
Peak current		12.0 Arms	16.3 Arms
Compatible motors		Up to 800 W (in total)	Up to 1.5 kW (in total)
Compatible encoders		• Absolute encoder (battery-less, single-turn) • HEIDENHAIN's EnDat 2.2 encoder [2]	
Ratings and functions	Maximum resolution	• 134,217,728 steps/revolution (27 bit)	
	Control functions, compensation functions	• Tandem operation control (no external cable required) • Quadrant projection compensation • Friction compensation • Gravity compensation • Disturbance observer	
	Mechanical vibration, resonance suppression	• Model-following vibration suppression • FF vibration suppression • Adaptive notch filter • CP vibration control • Minor-vibration control • Torque command notch filter (variable width)	
	Servo tuning	• Frequency characteristics measurement • Advanced tuning • Auto tuning responsiveness (7 characteristics, 40 levels)	
	Start-up, monitoring, diagnosis	• Virtual motor operation • Drive recorder • Encoder/EtherCAT communication quality monitoring • Input power supply monitoring • Control power supply frequency monitoring • Regenerative resistor power consumption monitoring • Remaining electrolytic capacitor life • Remaining holding brake life • Relay counter • Encoder temperature monitoring • Amplifier temperature monitoring	
	Programmable operation	2-axis programmable operation	
	Operation trace	6 analog channels, 4 digital channels, operation check possible on a single screen	
	Touch probe	2 channels per axis (4 channels in total)	
	Safe Torque Off	1-input 2-axis control	
	Fully closed-loop control	Not supported	
	Regeneration function	Built-in	
	Dynamic braking	Built-in	
Input/Output	Interface	EtherCAT	
	EtherCAT shortest communication cycle	250 μs	
	PDO mapping number	40 objects and 160 byte in total for 2 axes	
	General-purpose input	10 inputs in total for 2 axes	
	General-purpose output	2 outputs per axis and 1 common output	
Compliance with standards	UL/CSA	UL 61800-5-1 / C22.2 No.274-13	
	Low Voltage Directive / EMC Directive	EN 61800-5-1 / 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	
	Other	UKCA Mark, RoHS Directive	

It uses EtherCAT[3] to communicate with host controllers, enabling high-precision synchronization and simplifying network configurations. It also provides the same functionality and complies with the same standards as the *SANMOTION G* single-axis servo amplifiers.

3. Features

The new product is the industry's smallest[4] 2-axis integrated AC servo amplifier. It employs a shared converter and regenerative unit, enabling efficient energy use for both axes. Furthermore, it comes with functions optimized for 2-axis integration, such as monitoring capabilities and high-precision synchronized and programmable operation.

The features of the new product are as follows:

3.1 Compact and lightweight

As shown in Figure 3, compared to the use of two single-axis servo amplifiers, the installation footprint has been reduced by 38% and the weight has been made 19% lighter. It is one of the smallest and lightest servo amplifiers in the industry thanks to its shared converter unit, compact components, and an innovative structural design. These features provide greater flexibility in equipment design for our customers, allowing installation in confined spaces such as inside equipment.

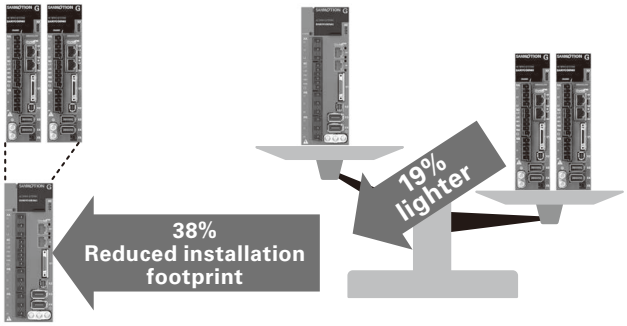


Fig. 3 Compact and lightweight design

3.2 Wiring and energy savings

(1)By adopting the EtherCAT multi-axis specifications and sharing power supplies and general-purpose I/O signals between the two axes, cable wiring has been reduced by 35%.

(2)Compared to using two units of the *SANMOTION G* single-axis servo amplifier, it has 18% lower power loss at rated output. As shown in Figure 4, the regenerative energy generated by one axis can be effectively reused to power the other axis.

(3)By integrating the control circuits (CPU, FPGA, and power supply) for two axes into a single unit, standby power consumption has been reduced by 36%.

In this way, the new product has an improved energy efficiency and contributes to reduced installation time, lower wiring costs, and energy savings for the customers' equipment.

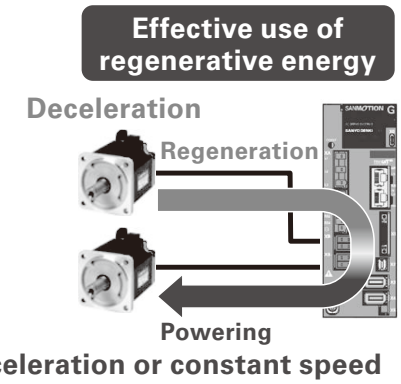


Fig. 4 Reuse of regenerative energy

3.3 Easy to use

3.3.1 Inter-axis synchronization and coordination

The new product can perform high-precision 2-axis synchronization without using a dedicated amplifier-to-amplifier communication cable. Furthermore, it can monitor the status of each axis internally and adjust the behavior of one axis depending on the status of the other. For example, when the first axis stops, the amplifier can switch the servo gain of the second axis in response. Moreover, newly added 2-axis shared output signals, such as a "2-axis servo-ready signal output," make it easier for the host controller to identify the status of the servo system.

3.3.2 2-axis programmable operation

The amplifier features 2-axis programmable operation for 2-axis positioning using simple commands. Figure 5 shows a conceptual flow of 2-axis programmable operation. Because the programmable operation is handled by the amplifier itself, each axis can be operated independently without the need for direct control from the host controller.

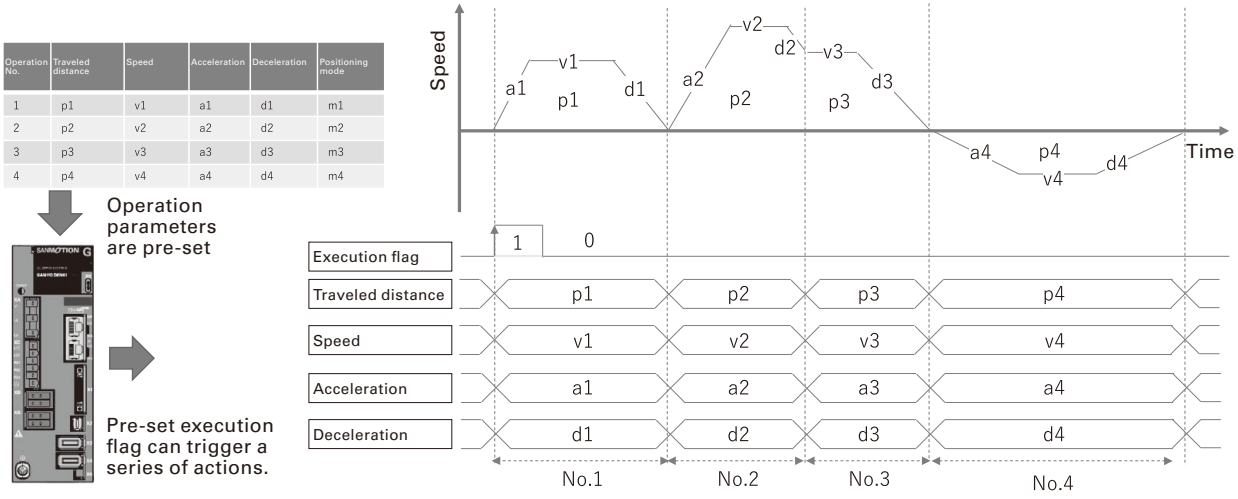


Fig. 5 2-axis programmable operation

3.3.3 Easy setup

Parameters of two axes can be adjusted with a single setup software program. In addition, it can trace the operation status of both axes on the same screen. Figure 6 shows traces of both axes displayed simultaneously. This allows for more efficient start-up and maintenance of equipment.

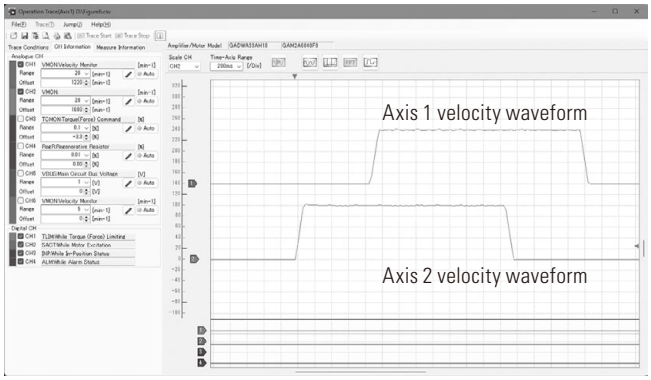


Fig. 6 Simultaneous trace display of two axes

These user-friendly features improve the equipment performance without complex control on the customers' equipment side. They also simplify adjustment, maintenance, and other engineering tasks, reducing equipment downtime.

4. Key Points of Development

This section outlines the key development efforts that enabled us to achieve high performance, quality, ease of use, the industry's smallest size, and improved noise immunity.

4.1 Challenge to achieve the industry's smallest size

To achieve a target size, we reduced the PCB size and used smaller components. In addition, we fine-tuned the balance between the signal pattern wiring and component layout. Furthermore, as shown in Figure 7, we optimized PCB component placement by creatively adding through-holes to the die-cast casing to avoid contact with components.

These efforts enabled us to achieve the industry's smallest size for the new product.

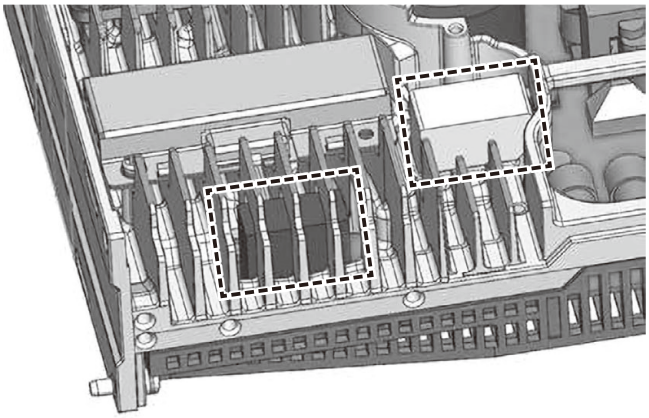


Fig. 7 Devised die-cast shape

4.2 Component standardization for both axes

Circuits common to both axes, such as converter circuits and safe torque off circuits, and components such as cooling fans were consolidated for sharing between the two axes. As a result, we reduced the number of components by 37% compared to two units of the *SANMOTION G* single-axis servo amplifier (see Figure 8).

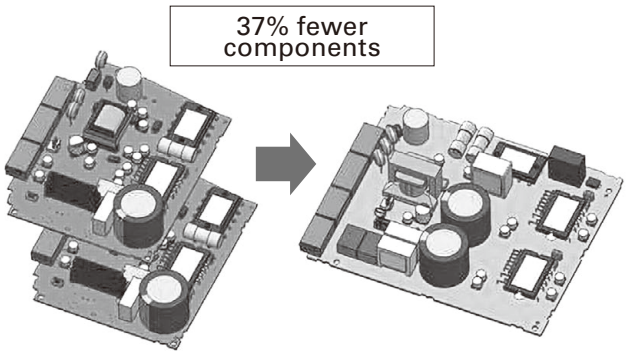


Fig. 8 Reduced number of components

4.3 Component standardization

4.3.1 Connector standardization

As shown in Figure 9, we standardized the connector with the *SANMOTION G* single-axis servo amplifier.

4.3.2 PCB standardization

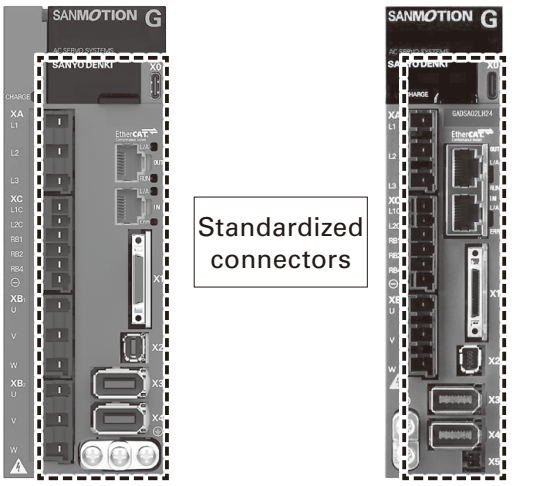
We standardized the PCB design for both the GADWA22□H and GADWA33□H models. This was made possible by altering PCB-mounted components—such as power devices—and structural parts like die-cast casings and plastic covers.

4.3.3 Cooling fan stalndardization

We used the same cooling fan for the GADWA22□H and GADWA33□H models by appropriately designing the shape and size of the heat sink.

By using the same connectors for the whole product series, we also standardized the connectors the customers need to prepare. In addition, the component standardization simplified manufacturing processes and inventory management.

In this way, we improved both customer usability and production efficiency.

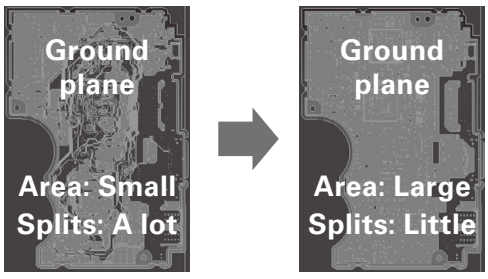


(a) New product (b) Single-axis servo amplifier

Fig. 9 Connector standardization

4.4 Improved noise resistance

To maintain a stable ground potential across the board and improve noise immunity, PCBs are generally designed to have a large ground plane. However, when a small PCB size limits the wiring space, the wiring pattern may need to be routed over the ground plane. This may cause the ground plane to be divided into smaller planes, resulting in lower noise immunity. As a countermeasure, we optimized the PCB component placement and routing layout to minimize ground plane divisions and preserve a large continuous ground plane, as shown in Figure 10. We also applied simulation techniques such as plane resonance analysis to further reduce noise. As a result, we were able to significantly improve noise immunity.



(a) Before improvement (b) After improvement

Fig. 10 PCB pattern layout improvement

5. Conclusion

In this article, we introduced the features and key development points of our new *SANMOTION G* 2-axis integrated AC servo amplifier.

The features of the new product are as follows.

1) Compact and lightweight

Compared to using two single-axis servo amplifiers, the installation footprint has been reduced by 38% and the weight has been made 19% lighter, contributing to downsizing and weight reduction of equipment.

2) Wiring and energy savings

The new product reduces cable wiring by 35%, simplifying equipment assembly for our customers.

It also reduces power loss at rated output by 18% and standby power consumption by 36%. Furthermore, integrating the two axes enables efficient mutual use of regenerative energy.

These enhancements contribute to energy savings for customers' equipment.

3) Easy to use

The servo amplifier supports 2-axis synchronized operation and 2-axis independent programmable positioning operation, enhancing equipment performance without complex control on the equipment side.

In addition, users can configure both axes and monitor their operational status using a single setup software program. It also simplifies engineering and maintenance work, reducing equipment downtime.

The *SANMOTION G* AC servo amplifiers offer high performance, functionality, and reliability. The new 2-axis integrated servo amplifiers offer greater design flexibility and ease of use through their energy-saving, compact, and lightweight design.

Going forward, we will continue to develop environmentally friendly, compact, lightweight, highly efficient, low-noise products that are optimized for our customers' equipment.

(1) For models with 50 A or less amplifier capacity.
(2) The company names and product names listed in this article are the trademarks or registered trademarks of their respective owners.
(3) EtherCAT is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.
(4) Based on our own research as of March 2025, conducted among AC servo amplifiers of equivalent capacity on the market.

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