SANYO DENKI

Technical Report

Feature | Technical Developments in 2024

1997
R&D base in Ueda: Technology Center

59
May 2025

COLUMN

Cover image:

R&D base in Ueda: Technology Center

1997

After about a year of construction, our Technology Center—a research and development facility—was completed in September 1997. Surrounded by greenery in a quiet location, the new facility featured bright design rooms filled with natural light and well-equipped laboratories. It started operations with around 400 engineers filled with fresh anticipation. The stylish concrete-walled building offered state-of-the-art amenities for its time, including an advanced security system, a clean energy-powered system, a library stocked with extensive technical resources, and partitioned design rooms adjacent to labs, creating a dream work environment for engineers.

In 2023, it was expanded with a new wing named T2 added, further enhancing our research and development capabilities. Today, 352 employees work there, developing products using the latest technologies in close collaboration with our production sites in Japan and the Philippines. The facility continues producing products that contribute to society and make people's lives better and happier.

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May 2025

C O N T E N T S

Moving Forward in Step with Society's Growth

Yoshinori Kobayashi Operating Officer

Under our corporate philosophy to "aim to help all people achieve happiness, and work with people to make their dreams come true," SANYO DENKI operates businesses to contribute to society and people's lives with a focus on three core technologies: one for protecting the global environment, one for using new energy sources and saving energy, and one for protecting people's health and safety.

We go beyond simply supplying products and also put effort into developing and manufacturing eco-friendly, energy-efficient products by applying the technology we have built over the years.

Moreover, we also incorporate direct customer feedback into product development, enabling us to provide easy-to-use products and custom products tailored to address customer challenges.

In addition, we make it possible to deliver high-quality, reliable products that can be used with peace of mind even after long-term use by implementing failure-mitigation technologies and quality assurance from as early as the development stage.

In fiscal year 2024, alongside new product development, we launched a new business—Production Engineering Services—to help customers address their production challenges.By developing equipment and proposing systems, we deliver optimal solutions for our customers, helping them create new value.

In this issue's feature, "Technical Developments in 2024," we introduce the year's major new products and their technologies.

The lineup of San Ace products has been expanded with newly developed Long Life Fan, Counter Rotating Fan, and DC Fan, which are designed to deliver both high airflow and high static pressure, primarily for the cooling of servers and ICT equipment. Besides, we also developed a new Endurance Fan featuring superb water and dust protection for use in applications such as EV chargers and PV inverters.

For SANUPS, we developed a renewable energy inverter that can make full use of the power generated from diverse renewable energy sources. For UPS, the lithium-ion battery pack has been made compliant with international functional safety standards for increased safety.

As for SANMOTION products, the SANMOTION G servo system—which features powerful servo performance and user-/eco-friendliness with its compact, lightweight, and efficient design—has been expanded with new 1.8 to 5 kW models. Furthermore, we also developed a 2-axis integrated servo amplifier, which helps reduce equipment size, weight, and wiring.

These newly developed products are expected to help our customers address their challenges and aid their future innovations.

For example, with the recent rapid advancement of generative AI skyrocketing the use of supercomputers, San Ace cooling fans play an essential role in operating such systems stably. As digital technology further innovates, our cooling fans will continue to evolve to protect society through cooling.

SANUPS products accelerate the spread of renewable energy and contribute to the stabilization of grid power systems. With their high energy conversion efficiency, they reduce power loss and electricity costs, helping mitigate global warming and protect the environment.

SANMOTION products contribute to enhancing equipment productivity and quality through high-speed and high-precision servo control as factories and equipment become increasingly automated due to the recent labor shortages. Their high reliability also makes them suitable in medical and welfare fields.

SANYO DENKI's products and technologies contribute to protecting the environment, promoting the use of green energy, and supporting people's health and safety while sharing the joy of innovations and quality with our customers. We will continue to move forward in step with society's growth and endeavor to create new value.

San Ace Products

Tetsuya Yamazaki

AI technologies like generative AI and autonomous driving systems have been adopted by a wide range of industries. These AI-powered systems rely on GPU servers in data centers to process large volumes of data.

As remote work has become a new norm in recent years, cloud services are increasingly accessed from a network environment using a laptop or smartphone. Accordingly, communication equipment that supports cloud services, such as servers, storage devices, and routers, is advancing in speed and capacity.

As data centers and ICT equipment are becoming denser, they are generating more heat. To mitigate heat generation and reduce maintenance frequency, fans for cooling such equipment are required to provide higher cooling performance, reliability, and energy efficiency.

In addition, cooling fans with environmental durability are increasingly required for use in renewable energy systems installed outdoors, such as PV energy storage systems and rapid EV charging stations.

In this way, cooling fans are required to support a wide range of specifications, which requires constant, innovative advancement. To meet these market needs in a timely manner, we will remain committed to developing products that support people's lives.

Below are overviews of the products we developed in 2024.

■ Long Life Fan

DC Fan

• 60 × 60 × 76 mm *San Ace 60L* 9CRLB type

Our 60 × 60 × 76 mm Long Life Counter Rotating Fans are used in equipment that requires high reliability and long service life, such as high-end communication equipment and servers.

As equipment performance increases, Long Life Fans are required to provide higher cooling performance and lower power consumption than ever before.

In response to these needs, we developed and launched the *San Ace 60L* 9CRLB type Long Life Fan, which offers 100,000 hours of continuous operation and delivers the industry's highest(1) airflow and static pressure, all while maintaining the size of our current product.

(1) Based on our own research as of March 28, 2024, conducted among equally sized axial DC fans on the market.

■ High-Performance Fan

• 60 × 60 × 56 mm *San Ace 60* 9CRH type Counter Rotating Fan

Our 60 × 60 × 56 mm Counter Rotating Fans are widely used for cooling servers and communication equipment.

As equipment performance increases, some customers find the current product obsolete and have demanded a new Counter Rotating Fan with even higher cooling performance. In response to such market demands, we developed and launched the *San Ace 60* 9CRH type fan that features the industry's highest(2) airflow and static pressure.

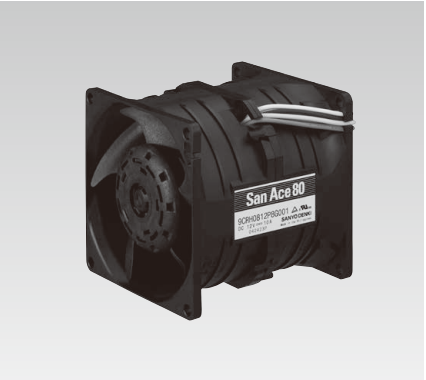
(2) Based on our own research as of June 12, 2024, conducted among equally sized axial DC fans on the market.

• 80 × 80 × 80 mm *San Ace 80* 9CRH type Counter Rotating Fan

Our 80 × 80 × 80 mm Counter Rotating Fans are mainly used in equipment requiring high cooling performance, such as high-performance communication equipment and GPU servers essential for generative AI.

As the performance of such equipment continues to increase, so does the demand for cooling capabilities beyond those of existing products.

In response to such market demands, we developed and launched the *San Ace 80* 9CRH type fan that features the industry's highest(3) airflow and static pressure.



(3) Based on our own research as of July 16, 2024, conducted among equally sized axial DC fans on the market.

• 38 × 38 × 28 mm *San Ace 38* 9HVA type fan

Our 38 × 38 × 28 mm fans are widely used primarily in high-density equipment such as 1U servers, switching power supplies, and communication equipment. Equipment of this size is in high demand and actively being developed.

As the performance of equipment is expected to advance further, higher cooling performance will be required of fans, beyond the reach of existing products.

In response to such market demands, we developed and launched the *San Ace 38* 9HVA type fan that features the industry's highest(4) airflow and static pressure.

It will be introduced in detail in a separate article in this issue.

(4) Based on our own research as of October 3, 2024, conducted among equally sized axial DC fans on the market.

■ Splash Proof Fan

DC Fan

• 120 × 120 × 25 mm *San Ace 120W* 9WPA type Splash Proof Fan

Our 120 × 120 × 25 mm Splash Proof Fans are extensively used in equipment that requires high water and dust protection, such as EV chargers, storage batteries, PV inverters, digital signage, and plant factories.

These types of equipment often require a compact size, low power consumption, and low noise.

In response to such market demand, we developed and launched the *San Ace 120W* 9WPA type Splash Proof Fan, which delivers the industry's highest(5) static pressure and airflow despite its slim form factor with a **25 mm** thickness.

It will be introduced in detail in a separate article in this issue.

(5) Based on our own research as of January 9, 2025, conducted among equally sized axial DC fans on the market.

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38 × 38 × 28 mm *San Ace 38* 9HVA Type DC Fan

Tatsuya Midorikawa Yo Muramatsu Hikaru Urushimoto

Sohta Ueno Toshiyuki Nakamura

1. Introduction

As the information society continues to evolve, communication devices are increasingly essential in supporting our society and economy. Servers and ICT equipment are becoming more compact and generating more heat, requiring smaller, higher-performance cooling fans.

To meet this demand, we have offered the 38 × 38 × 28 mm *San Ace 38* 9GA type DC Fan (hereinafter, "current product"), which has since become obsolete. Accordingly, we have recently developed and launched the *San Ace 38* 9HVA type DC Fan (hereinafter, "new product"), maintaining the same dimensions.

This article introduces the features and performance of the new product.

2. Product Features

Figure 1 shows the new product.

The new product delivers higher airflow and static pressure than the current product, without changing the dimensions.

It is also capable of cooling a wider range of applications, previously considered unfeasible.

Fig. 1 38 × 38 × 28 mm *San Ace 38* 9HVA type

3. Product Overview

3.1 Dimensions

Figure 2 shows the dimensions of the new product. The external dimensions and mounting hole dimensions are unchanged and compatible with the current product.

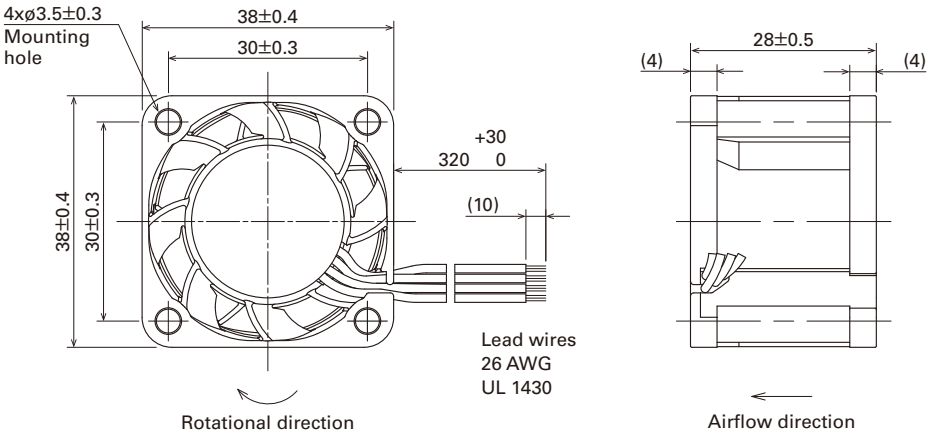


Fig. 2 Dimensions of 38 × 38 × 28 mm *San Ace 38* 9HVA type (Unit: mm)

3.2 Specifications

3.2.1 General specifications

Table 1 shows the general specifications of the new product.

Table 1 General specifications of 38 × 38 × 28 mm *San Ace 38* 9HVA type

Model no.	Rated voltage [V]	Operating voltage range [V]	PWM duty cycle* [%]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow [m^3/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH$_2$O]	Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
9HVA0312P3K001	12	10.8 to 13.2	100	2.1	25.2	38,500	0.91	32.2	2,100	8.40	69	-20 to +70	30,000 at 60°C (53,000 at 40°C)
			20	0.06	0.72	6,000	0.14	4.9	51	0.204	29		
9HVA0312P3G001			100	1.1	13.2	30,000	0.71	25.1	1,300	5.20	64		40,000 at 60°C (70,000 at 40°C)
			20	0.05	0.60	5,000	0.11	3.8	35	0.140	25		

* PWM input frequency is 25 kHz. Speed is 0 min^{-1} at 0% PWM duty cycle only for models that have no speed ratings at 0% listed. When the control terminal is open, the fan speed is the same as the speed at 100% PWM duty cycle.

3.2.2 Airflow vs. static pressure characteristics

Figure 3 shows the airflow vs. static pressure characteristics of the new product.

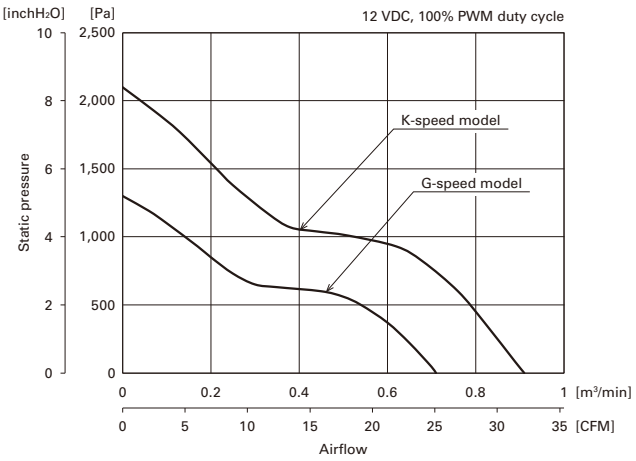


Fig. 3 Airflow vs. static pressure characteristics of the new product

3.2.3 PWM control

The new product comes with PWM control for controlling fan speed.

4. Key Points of Development

For the new product, we newly designed the highly efficient 3-phase motor driver as well as the impeller and frame shapes for increased aerodynamic performance.

Furthermore, increasing speed is one of the important factors for achieving high airflow and high static pressure.

The key points of development are as follows.

4.1 Motor and circuit design

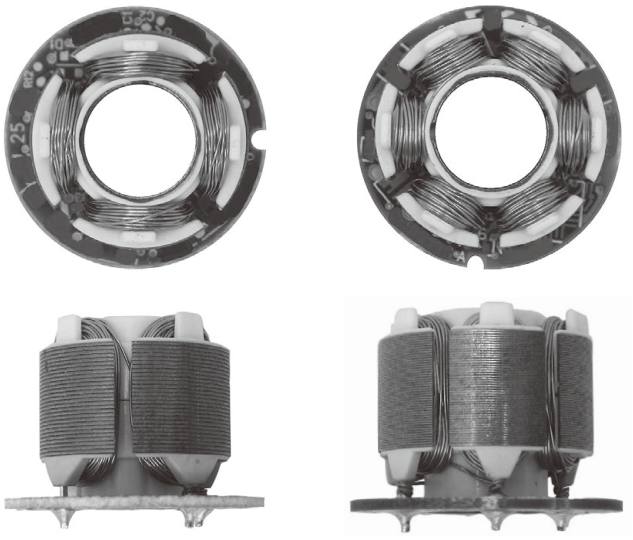
Figure 4 compares the motors of the new and current products.

To achieve a higher fan speed, it was necessary to develop a high-frequency motor current switching circuit and reduce motor vibration.

To achieve this, the new product uses a 3-phase motor driver instead of the predecessor's single-phase driver, reducing peak current during high-speed switching and enabling low-vibration operation due to lower cogging torque.

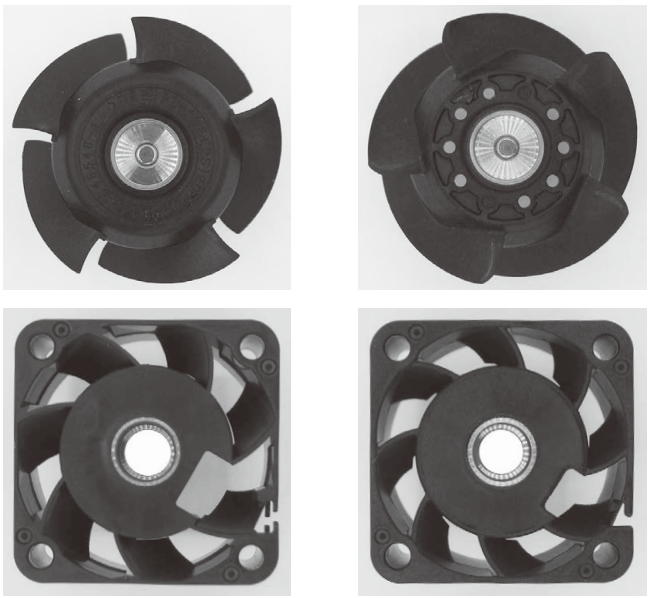
Also, increasing fan speeds generally leads to higher heat generated by electronic components, which can be a challenging issue to address because using a larger PCB narrows the vent area and negatively impacts the aerodynamic characteristics. Likewise, the use of multiple electronic components or large components with high current capacity is not applicable either.

To overcome these challenges, we optimized the component layout to maximize the passive cooling capability in combination with the impeller's vent holes. As a result, we achieved a high-speed fan circuit design while using the same PCB size as the current product.



Current product　　New product

Fig. 4 Motors of the new and current products



Current product　　New product

Fig. 5 Comparison of the impeller and frame shape for the new/current model

4.2 Impeller and frame design

Figure 5 shows a comparison of the impeller and frame shapes for the new and current products.

Faster fan rotation increases mechanical loads, including centrifugal force on the impeller and amplified vibration from rotating parts.

Therefore, we needed to newly design an impeller and frame shapes that offer both high durability and aerodynamic efficiency.

The impeller was designed so that the enlarged blades overlap as viewed from the inlet side, and the impeller boss shape was optimized to secure enough vent area, contributing to improved airflow and static pressure.

In addition, vent holes were introduced on the ceiling of the impeller boss to facilitate the motor's passive cooling, helping dissipate the heat generated by electronic components inside the motor.

The frame was also newly designed with vent holes, optimized thickness, and an adjusted number of stator blades to ensure sufficient rigidity for high-speed rotation.

In this way, the new impeller and frame designs enabled operation at high-speeds and enhanced aerodynamic performance.

5. Comparison of New and Current Products

5.1 Comparison of airflow vs. static pressure characteristics

Figure 6 compares the airflow vs. static pressure characteristics of the new and current products.

The new fastest model, 9HVA0312P3K001, has 1.5-times maximum airflow and 2.6-times higher maximum static pressure, compared to the current product.

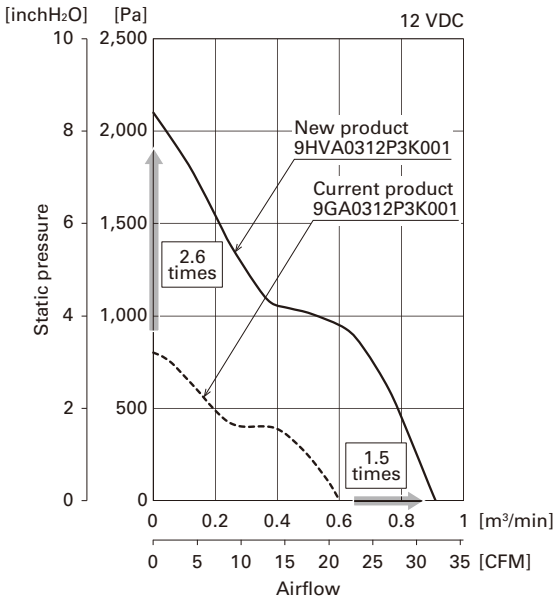


Fig. 6 Airflow vs. static pressure characteristics of the new and current products

5.2 Power consumption comparison

Figure 7 compares power consumption of the new and current products when operated to deliver the same airflow.

At the estimated system impedance (the ventilation resistance of equipment) shown in the figure, the new product consumes 10% less power than the current product.

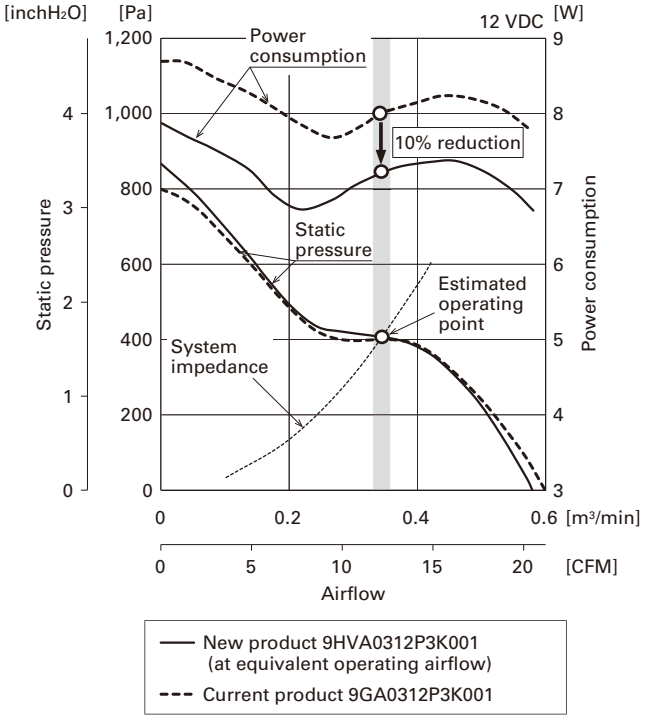


Fig. 7 Power consumption comparison between the new and current products

5.3 Environmental impact comparison

Figure 8 compares the CO_2 emissions of the new and current products over their life cycles.

Thanks to its reduced power consumption at the same operating airflow compared to the current product, the new product emits 10% less CO_2 over its product life cycle.

Compared to the current product, a single new product provides superior cooling performance than two current products operating in series, reducing the number of required cooling fans by 50%.

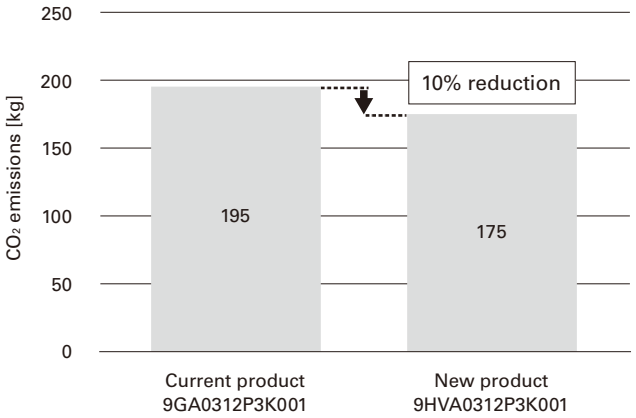


Fig. 8 CO_2 emissions comparison using an LCA calculation software (40,000 hours, when operated with the same operating airflow)

6. Conclusion

This article has introduced the features and performance of the newly developed 38 × 38 × 28 mm *San Ace 38* 9HVA type DC Fan.

The new product delivers higher airflow and static pressure than the current product while achieving lower power consumption when operated to deliver the same airflow.

It also contributes to saving space When mounted on equipment that requires high cooling performance, this fan saves space inside, giving flexibility to the equipment designer.

We will continue to help our customers create new value by swiftly meeting market demand and offering eco-friendly products.

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120 × 120 × 25 mm *San Ace 120W* 9WPA Type Splash Proof Fan

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Benjo Castillo Leslie Anne Culanding Katsumichi Ishihara

1. Introduction

Our 120 × 120 mm sized cooling fans are used in various applications, including EV chargers, storage battery systems, PV inverters, digital signage, and plant factories. These applications require highly durable fans that offer water and dust resistance to protect live parts from fine dust and humid environments. As these systems are often powered by renewable energy sources, fans are also required to be compact, energy-efficient, and low-noise.

To better meet these market demand, we have developed and launched the slim 120 × 120 × 25 mm *San Ace 120W* 9WPA type Splash Proof Fan, expanding the lineup of Splash Proof Fans.

This article introduces the features and performance of the new product.

2. Product Features

Figure 1 shows the new product.

The new product has a slimmer profile, lower noise, and lower power consumption than the current 120 × 120 × 38 mm 9WP type fan while maintaining the same 120 × 120 mm frame size and cooling performance.

Fig. 1 120 × 120 × 25 mm *San Ace 120W* 9WPA type

3. Product Overview

3.1 Dimensions

Figure 2 shows the dimensions of the new product. The new product is designed to be compatible with the current product in frame size and mounting while being slimmer.

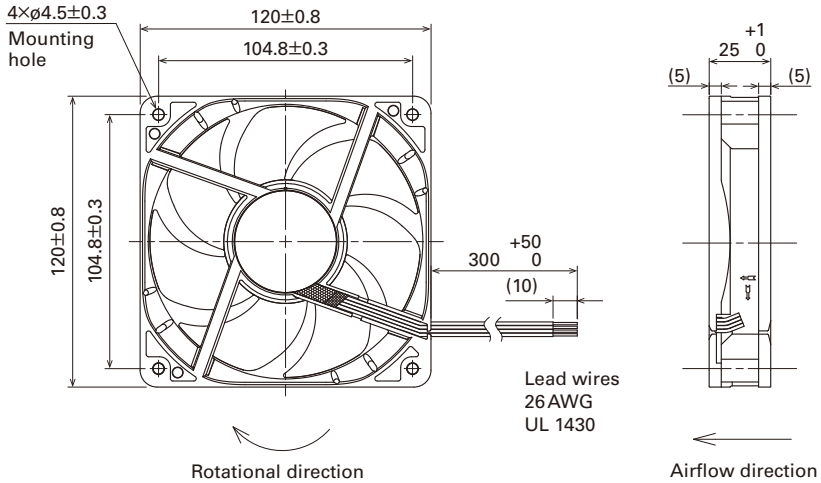


Fig. 2 Dimensions of the *San Ace 120W* 9WPA type (Unit: mm)

Table 1 General specifications of the *San Ace 120W* 9WPA type, models with pulse sensor and PWM control

Model no.	Rated voltage [V]	Operating voltage range [V]	PWM duty cycle* [%]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow [m^3/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH$_2$O]	Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
9WPA1212P4J001	12	10.8 to 13.2	100	1.0	12.0	5,400	4.20	148	210	0.84	53	-20 to +60	40,000 at 60°C (70,000 at 40°C)
			20	0.07	0.84	1,600	1.24	43.8	24.0	0.10	25		
9WPA1212P4G001			100	0.50	6.0	4,250	3.30	117	135	0.54	46	-20 to +70	
			20	0.06	0.72	1,300	1.00	35.3	16.0	0.06	20		
9WPA1224P4J001	24	21.6 to 26.4	100	0.50	12.0	5,400	4.20	148	210	0.84	53	-20 to +60	
			20	0.05	1.20	1,600	1.24	43.8	24.0	0.10	25		
9WPA1224P4G001			100	0.25	6.0	4,250	3.30	117	135	0.54	46	-20 to +70	
			20	0.04	0.96	1,300	1.00	35.3	16.0	0.06	20		

* The PWM input frequency is 25 kHz; the fan speed at 0% PWM duty cycle is 0 min^{-1}.
Note: The expected life at an ambient temperature of 40°C is for reference purposes only.

Table 2 General specifications of the *San Ace 120W* 9WPA type, pulse sensor models

Model no.	Rated voltage [V]	Operating voltage range [V]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow [m^3/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH$_2$O]	Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
9WPA1212J4001	12	7 to 13.2	1.0	12.0	5,400	4.20	148	210	0.84	53	-20 to +60	40,000 at 60°C (70,000 at 40°C)
9WPA1212G4001		7 to 13.8	0.50	6.00	4,250	3.30	117	135	0.54	46	-20 to +70	
9WPA1212H4001		10.2 to 13.8	0.12	1.44	2,400	1.85	65.0	47.0	0.19	30	-20 to +70	
9WPA1224J4001	24	14 to 26.4	0.50	12.0	5,400	4.20	148	210	0.84	53	-20 to +60	
9WPA1224G4001		14 to 27.6	0.25	6.00	4,250	3.30	117	135	0.54	46	-20 to +70	
9WPA1224H4001		20.4 to 27.6	0.06	1.44	2,400	1.85	65.0	47.0	0.19	30	-20 to +70	

3.2 Specifications

3.2.1 General specifications

Tables 1 and 2 show the general specifications of the new product.

To support a wide range of markets, we launched a lineup of models in two rated voltages of 12 and 24 V and three speeds of high, medium, and low.

3.2.2 Airflow vs. static pressure characteristics

Figure 3 shows the airflow vs. static pressure characteristics of the new product.

3.2.3 PWM control

The high-speed model and medium-speed model come with PWM control for controlling the fan speed.

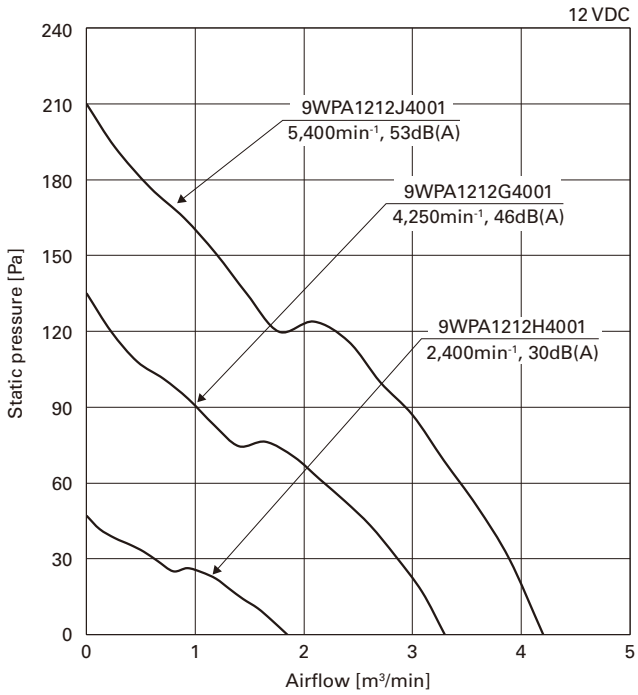


Fig. 3 Airflow vs. static pressure characteristics of the *San Ace 120W* 9WPA type

4. Key Points of Development

While being slimmer, the new product delivers greatly improved performance than the current product (120 × 120 × 38 mm 9WP type). It also achieves lower noise and lower power consumption when operated with the same cooling performance.

The key points of development are described below.

4.1 Motor and circuit design

To improve the cooling performance of the current product, we increased the fan's vent area by using a smaller, more efficient motor.

To that end, we replaced the unipolar motor driver with a more efficient bipolar one. Moreover, we used a stronger magnet to optimize the motor output against the impeller load, successfully reducing heat generation and power consumption.

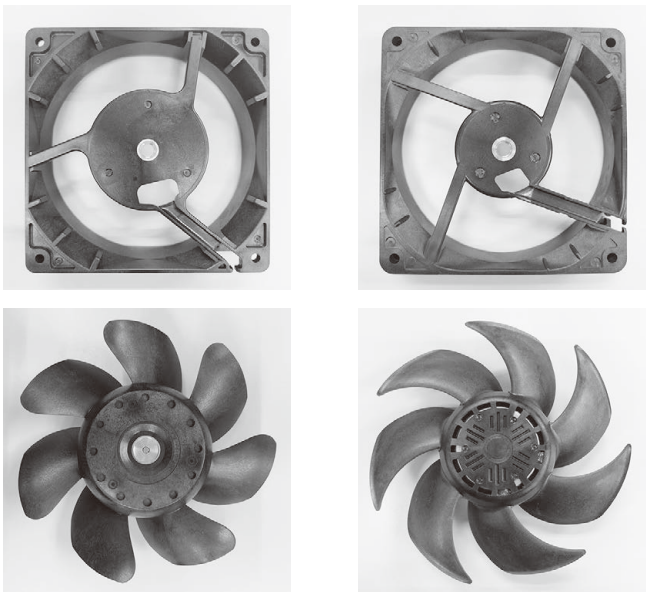
4.2 Structural design

We achieved IP68-rated water and dust protection by enclosing all live parts with a highly water-resistant resin coating. Figure 4 shows the coating on the live parts.

Fig. 4 Coating of live parts

The frame and impeller were designed to be rigid enough to support the increased fan speed while offering low power consumption and low noise. To mitigate motor temperature rise due to the increased fan speed, the frame and impeller shapes were optimized through simulations and evaluation on actual equipment, successfully completing the product development.

Figure 5 compares the shapes of the new and current products.



Current product　　New product

Fig. 5 Shape comparison of the new and current products

5. Comparison of New and Current Products

5.1 Comparison of the airflow vs. static pressure characteristics and noise levels of new and current products

Figure 6 compares the airflow vs. static pressure characteristics of the new and current products.

Compared to the current 120 × 120 × 38 mm 9WP type fan, the new product achieves 1.26 and 2.1-times greater maximum airflow and static pressure, respectively.

Figure 7 compares the airflow vs. static pressure vs. power consumption characteristics and load vs. noise characteristics of the new and current products at equivalent cooling performance. The new product achieves a 28% reduction in power consumption at the assumed operating point while maintaining the same airflow vs. static pressure characteristics as the current product. In addition, its noise level has been reduced by 6 dB(A).

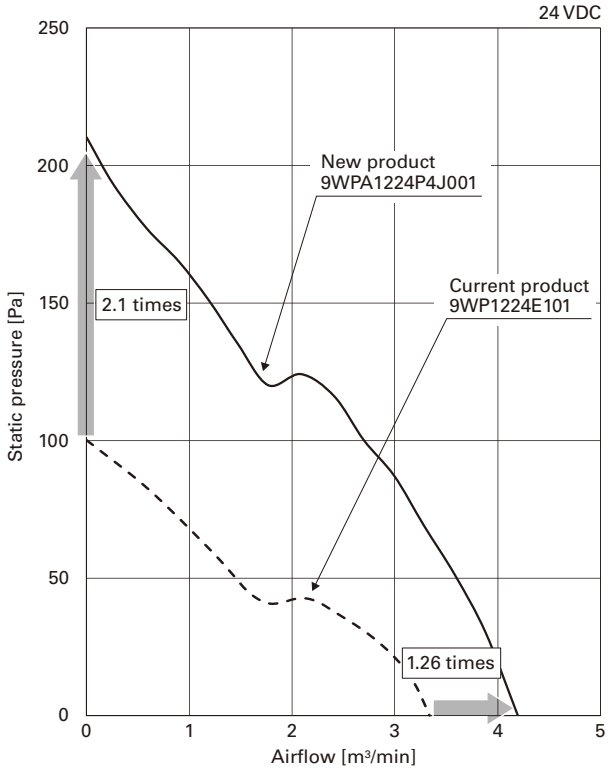


Fig. 6 Comparison of the new and current *San Ace 120W* products

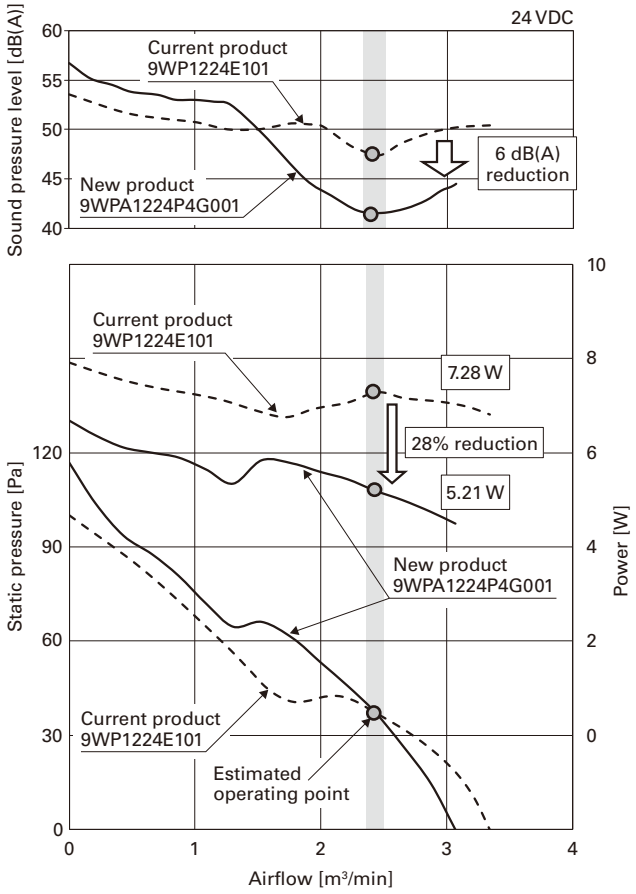


Fig. 7 Comparison of the new and current *San Ace 120W* products (at same cooling performance)

5.2 Environmental impact comparison

Figure 8 compares the CO_2 emissions of the new and current products over their life cycles.

The new product produces 26% less CO_2 emissions over its product life cycle compared to the current product, thanks to its reduced power consumption.

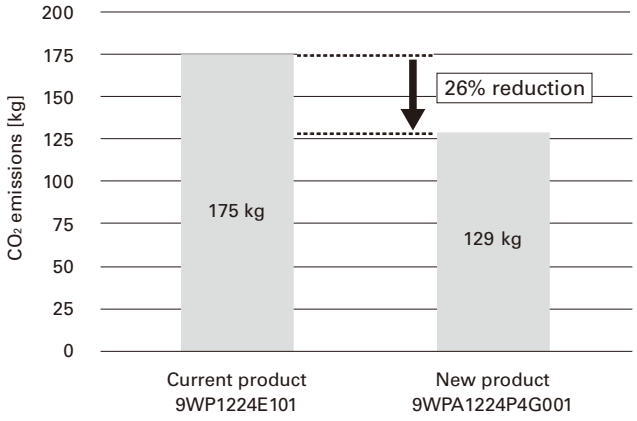


Fig. 8 CO_2 emissions comparison using an LCA calculation software (40,000 hours, when operated with the same operating airflow)

6. Conclusion

This article introduced the features and performance of the *San Ace 120W* 9WPA type fan.

The new product achieves lower noise, lower power consumption, and equivalent protection rating compared to the current product while also delivering significantly improved cooling performance. We expect it to contribute greatly to applications that require environmental durability, higher cooling performance, and improved energy efficiency over previous products.

We will continue developing products that promptly meet market demands to contribute to creating new value for our customers.

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SANUPS Products

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SANUPS is a brand name for our electrical energy and power conversion products, such as uninterruptible power supplies (UPSs), renewable energy inverters, and engine generators. We contribute to achieving the Sustainable Development Goals (SDGs) and a sustainable society by providing SANUPS products that are energy-efficient, compact, lightweight, low-noise, safe, and reliable. This article presents two SANUPS products developed in 2024.

We will first introduce the *SANUPS W83A* power conditioner, or renewable energy inverter.

This product supports power generation from various renewable energy sources, including solar, wind, hydro, biomass, and waste heat. It is equipped with an isolated operation function, which can supply power during emergencies such as power outages when combined with batteries, contributing to disaster management and business continuity planning (BCP) purposes.

It features wireless communication and supports mobile devices, allowing status monitoring and setting adjustments on intuitive screens. It also supports LAN-based network systems, enabling remote monitoring.

Moreover, this product has reduced switching losses and improved efficiency compared to our previous model. As a result, it has reduced power consumption and heat generation, helping reduce CO_2 emissions.

As described above, the *SANUPS W83A* contributes to realizing a low-carbon society.

Next, we will introduce the *SANUPS A11N-Li* UPS's new model that is compliant with international safety standards.

In applications like medical equipment, where battery malfunction or abnormal operation can cause serious accidents, compliance with functional safety standards—error detection and fail-safe—is required.

This UPS conforms to the "IEC 62040-1 UPS safety requirements" standard defined by the International Electrotechnical Commission (IEC). Its built-in lithium-ion battery pack also complies with IEC 60730-defined Class B safety.

As shown above, this product complies with international safety standards and therefore can be used safely with peace of mind.

Below are some of the features of these new products and their contribution to customers and society.

■ The *SANUPS W83A* Renewable Energy Inverter

In recent years, the adoption of renewable energy has been expanding as part of efforts to achieve a low-carbon society, resulting in increased demand for renewable energy inverters. Renewable energy sources such as solar, wind, hydro, and biomass require renewable energy inverters capable of converting power specific to each source. There is also a growing demand for renewable energy inverters that can connect to storage batteries to balance power supply and demand.

In response, we developed the *SANUPS W83A* renewable energy inverter to support diverse renewable energy generation systems and storage batteries.

Its features are as follows.

1. Compatible with various renewable energy sources and storage batteries

The product is easily configurable for use with various renewable energy sources, such as solar, wind, hydro, biomass, and waste heat, and it can also be used in combination with a storage battery.

2. Emergency management and BCP purposes

It is equipped with an isolated operation function, which can supply power during emergencies such as power outages, serving disaster management and BCP purposes.

3. High efficiency

Switching losses have been reduced by one-third and efficiency has been increased by 2.0% compared to its predecessor. Therefore, it has reduced power consumption and heat generation, helping reduce CO_2 emissions.

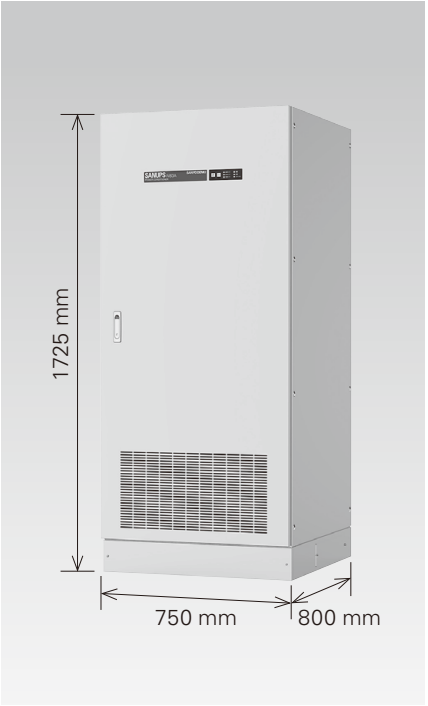
4. Compatible with the new Grid-Interconnection Code

It supports the frequency feedback method with step injection (Step 3.2) and features grid frequency tolerance detection. The product can be used with generators that connect to the grid at extra-high, high, or low voltages.

5. Improved operability and maintainability

It features wireless communication and supports mobile devices, allowing status monitoring and setting adjustments on intuitive screens. It also supports LAN-based network systems, enabling remote monitoring.

Consequently, the *SANUPS W83A* contributes to achieving a low-carbon and sustainable society and the SDGs.



Reference

(1) Takuya Ota and 12 others: "Development of the *SANUPS W83A* Renewable Energy Inverter" SANYO DENKI Technical Report, No.58, pp.27-34 (2024.11)

■ The *SANUPS A11N-Li* UPS's Safety Standard-Compliant Model

Lithium-ion batteries are increasingly used as storage batteries in UPSs due to their compact size, light weight, and long service life.

Moreover, in applications like medical equipment, where battery malfunction or abnormal operation can cause serious accidents, compliance with functional safety standards—lithium-ion battery pack's error detection and fail-safe features—is required.

This UPS conforms to the "IEC 62040-1 UPS safety requirements" standard defined by the International Electrotechnical Commission (IEC). Its built-in lithium-ion battery pack also complies with IEC 60730-defined Class B safety.

Its features are as follows.

1. Protection functions

The battery pack is designed to reduce the hazards and risks associated with lithium-ion batteries by activating protection functions in the event of a single failure.

For example, its Battery Management Unit (BMU) monitors all cells. It disconnects all battery modules from the main circuit if it detects an abnormality such as overcharge or overdischarge, ensuring safety.

2. Self-diagnosis

The battery pack consists of an input device, a logic unit, and an output device, with each equipped with a self-diagnosis function.

The self-diagnosis function with a fail-safe design ensures a safe shutdown even if a protection function fails.

3. Development process management

We adopted a V-model-based development process to manage the software lifecycle.

This provides clear traceability between functional safety requirements, software design, coding, and testing phases, making it easier to verify that requirements are met at each stage of development.

As described above, this UPS features a high-performance lithium-ion battery pack and conforms to international safety standards, making it a safe, highly reliable product for worldwide use.

Details on this product are covered in a separate article in this issue.

Horizontal

Vertical

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Development of a Safety Standard-Compliant Model of the *SANUPS A11N-Li* Online UPS with Long-Life Li-ion Battery

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1. Introduction

Due to their compact size, light weight, and long service life, lithium-ion batteries are in high demand for use as storage batteries in uninterruptible power supplies (UPSs). One characteristic of lithium-ion batteries is their high energy density, which necessitates safety measures for properly managing the charge/discharge and cell temperatures to prevent thermal runaway.

Accordingly, we have developed a new model that complies with international safety standards for the *SANUPS A11N-Li* UPS, which uses our lithium-ion battery pack. By meeting these standards, the new model offers a high level of safety, ensuring safe, reliable use for customers globally, including in Japan.

This article will provide an overview of the new model. It will then describe the requirements of international safety standards. Furthermore, it will discuss the method of ensuring functional safety, which is a requirement of these standards.

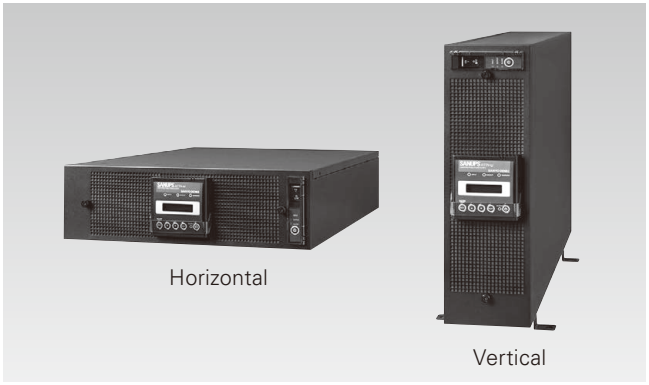


Fig. 1 Single-unit type 5 kVA model

2. Product Overview

This safety standard-compliant model is the latest addition to the existing lineup of the *SANUPS A11N-Li* UPS.[1]

Figure 1 shows the new model and Figure 2 illustrates its internal structure.

It shares the same appearance and internal structure as the current models, and its lithium-ion battery pack and inverter are modularized for plug-in connections.

The new model uses our lithium-ion battery pack, which is provided with functional safety to ensure a higher level of safety and reliability in accordance with international safety standards.

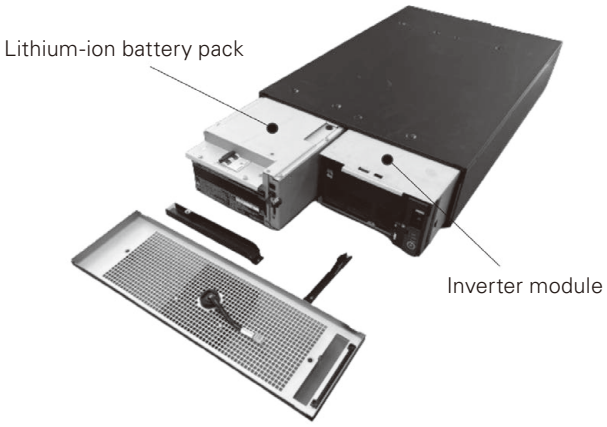


Fig. 2 Internal structure
(single-unit type 5 kVA model)

Table 1 shows the electrical specifications of the *SANUPS A11N-Li* single-unit type 5 kVA model compliant with international safety standards. Like the *SANUPS A11N* UPS, it features a reliable double conversion online topology and delivers a high conversion efficiency. The new model is equipped with a long-life lithium-ion battery and is also compliant with international safety standards.

Table 1 Electrical specifications of the *SANUPS A11N-Li* single-unit type 5 kVA safety standard-compliant model

Items			Ratings and characteristics	Remarks
Type	Model		A11NL502	
	Topology		Double conversion online	Grid synchronous
	Inverter		High-frequency PWM	
	Cooling system		Forced air cooling	
AC input	Rated voltage		200/208/220/230/240 V	Voltage range: Within -40% to +15% of rated voltage
	Rated frequency		50/60 Hz	
	No. of phases/wires		Single-phase 2-wire	
	Max. output capacity		5.5 kVA or less	Max. capacity during battery recovery charging
	Power factor		0.95 or greater	At rated output and when input voltage harmonic distortion < 1%
AC output	Rated capacity		5 kVA / 4.5 kW	Apparent power / Active power
	No. of phases/wires		Single-phase 2-wire	
	Rated voltage		200/208/220/230/240 V	User-selectable. Factory setting: 200 V
	Voltage waveform		Sinusoidal	
	Voltage regulation		Within ± 2% of rated voltage	At rated output
	Rated frequency		50/60 Hz	Auto-sensing or fixed frequency selectable
	Frequency regulation		Within ± 1/3/5% of rated frequency	In free (asynchronous) run: Within ± 0.5%
	Voltage harmonic distortion		3% / 7% or less	At linear load / rectifier load, at rated output
	Transient voltage fluctuation	Abrupt load change	Within ± 5% of rated voltage	For 10 ⇔ 100% load step changes
		Loss/return of input power		At rated output
		Abrupt input voltage change		For ± 10% abrupt changes
		Response time	5 cycles or less	Excluding when loads are removed
	Load power factor		0.9 (lagging)	Variation range: 0.7 (lagging) to 1.0
	Efficiency		94% or greater	For reference purposes only
	Overcurrent protection		110% or greater	Automatic transfer to bypass
	Overload capability	Inverter	110% / 118%	For 1 min / Instantaneously
		Bypass	200% / 800%	For 30 s / 2 cycles
Heat dissipation			287 W	At rated output after battery recovery charging
Acoustic noise			45 dB or less	1 m from front of UPS, A-weighting
			51 dB or less	1 m from front of UPS, A-weighting, at start of charging
Leakage current			5 mA or less	3 mA or less under the setting without asynchronous operation
Safety standards			IEC 62040 JISC 4411	For UPS
			IEC 62619, IEC 60730 JISC 8715, JISC 9730	For battery pack
EMC(Note 1) Directive			EN 55032, EN 61000 series VCCI	For UPS

3. International Safety Standards Requirements

For a LIB-based UPS to comply with international safety standards, it is required to meet both IEC safety requirements and EN-defined EMC(Note 1) Directive requirements. Listed below are the standards and requirements that have been satisfied.

3.1 Standards conformity

The product complies with the safety standards listed in Table 2.

Table 2 Standards conformity

Applicable parts and characteristics	Standards	Description
UPS unit	IEC 62040-1	Safety requirements of UPS
Lithium-ion battery pack	IEC 62619	Safety requirements for secondary lithium cells and batteries, for use in industrial applications
	IEC 60730 Annex H	Requirements for electronic controls General requirements
EMC Directive	EN 55032	Emission
	EN 61000 series	Immunity

Like the current *SANUPS A11N* lead-acid battery UPS,[2] the UPS unit is compliant with the safety requirements of IEC 62040-1.

For the lithium-ion battery pack, general safety requirements are defined in "IEC 62619: Safety requirements for secondary lithium cells and batteries, for use in industrial applications". These standards require battery system safety to be based on functional safety principles, as outlined in "Annex H: Requirements for functional safety of electrical/electronic/programmable electronic control systems" of "IEC 60730: Requirements for electronic controls." This model meets the Class B safety as defined in this standard.

3.2 Protection functions

In functional safety, hazardous conditions and events must be specified to determine the necessary protection functions to ensure safety. Table 3 lists the built-in protection functions of the lithium-ion battery pack of this model.

Table 3 Protection functions

Detection item	Use	Protective actions
Cell overvoltage	Prevents cell overcharge	Shuts off charging/ discharging circuit
Cell undervoltage	Prevents cell overdischarge	Shuts off charging/ discharging circuit Shuts down battery pack's power supply
Discharging overcurrent	Prevents cell overcurrent	Shuts off charging/ discharging circuit
Charging overcurrent	Prevents cell overcurrent	Shuts off charging/ discharging circuit
Overtemperature	Prevents cell overtemperature	Shuts off charging/ discharging circuit
Undertemperature	Prevents cell undertemperature	Shuts off charging/ discharging circuit
Communication error	Prevents unmonitored cell	Shuts off charging/ discharging circuit

These protection functions incorporate redundant detectors and protection mechanisms to maintain protection in the event of a single failure. This has enabled the product to meet the requirements of IEC 60730 Class B safety, ensuring a high level of safety.

4. Ensuring Functional Safety

Meeting the IEC 60730 Class B safety requires equipment to remain safe despite a failure of a single protection function. To meet this requirement, we incorporated the following design features into the product.

4.1 Circuit configuration and basic operations

Figure 3 shows the product's circuit configuration.

The battery pack consists of 24 V battery modules in an 8S2P (8-series 2-parallel) configuration, and each battery module contains multiple battery cells. A CMU (Cell Management Unit) measures the battery module's voltage and current, monitors cell voltages and temperatures, and performs cell voltage balancing.

Each CMU communicates battery module information to the BMU (Battery Management Unit). The BMU monitors all cells to detect abnormalities in the battery pack and provide protection. Information is exchanged between CMUs and between the BMU and CMUs through communication. If the BMU detects an abnormality, such as cell overcharge and overdischarge, it disconnects all battery modules from the main circuit to ensure safety.

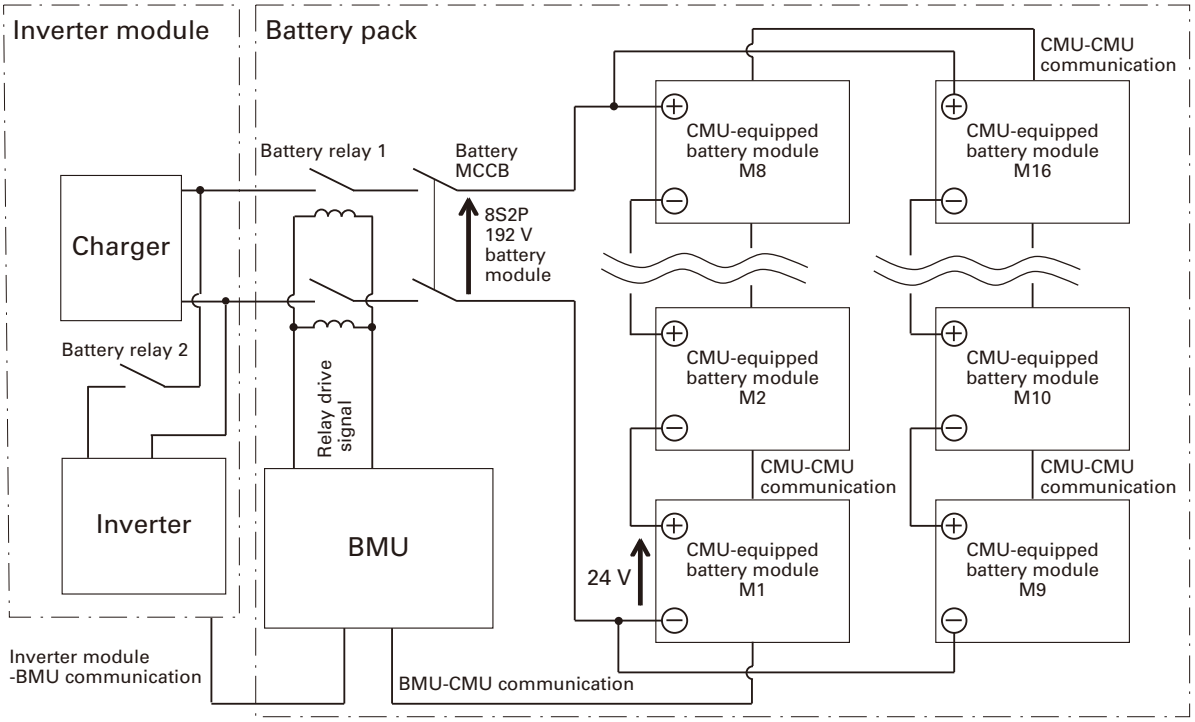


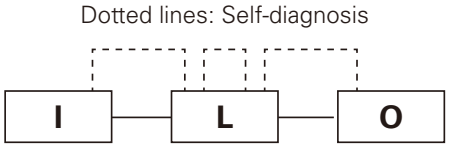
Fig. 3 Circuit configuration of the new model (5 kVA model)

4.2 Basic structure of functional safety

Functional safety is a set of principles and techniques for achieving a high level of safety by incorporating monitoring and protection functions into electrical, electronic, or software-based control systems.

The battery pack section of this model consists of the input device, logic, and output device blocks, as shown in Figure 4. Each block is independently configured and equipped with its own self-diagnosis function.

Figure 4 lists each block's self-diagnosis functions and the components they apply to. The logic block performs self-diagnosis on itself as well as on the input and output device blocks. The self-diagnosis must be performed regularly to ensure safety. These self-diagnosis functions are designed to be in accordance with IEC 60730 Annex H. In the event of a failure in an electrical, electronic, or software-based control system, the self-diagnosis detects it and switches the system to a safe state.



Block	Applicable component	Self-diagnosis functions
I: Input device	Communication	Communication diagnosis
L: Logic	CPU	Processor diagnosis Memory diagnosis Clock diagnosis, etc.
O: Output device	Battery relay 1	Output signal diagnosis

Fig. 4 Functional safety basic principles and self-diagnosis

4.3 Software design and testing processes

International safety standards require software design and testing processes to be structured systematically. In response, we adopted the V-model framework for the software design and testing processes for the lithium-ion battery pack used in this model. This approach helps prevent design flaws and testing misses, ensuring high product quality. Figure 5 illustrates the V-model framework.

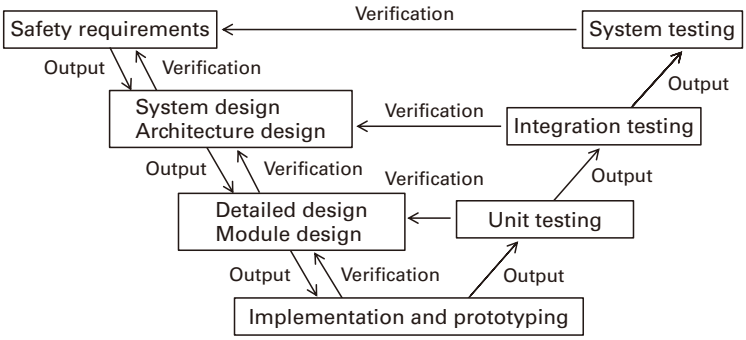


Fig. 5 V-model software development example

The V-model-based software design and testing processes are described below.

(1) To meet the safety requirements shown in the upper left of Figure 5, we proceeded with the design in the following order: system design, detailed design, implementation, and prototyping.

(2) At each phase, we conducted verification to ensure that individual high-level requirements were fully met.

(3) Outputs from high-level phases serve as inputs for the subsequent lower-level phases. The inputs to each lower-level phase determine that phase's specifications (outputs). To ensure the safety requirements are correctly met, these input-output relationships must be strictly managed. To comprehensively trace and manage these relationships throughout the entire process, we introduced a visualization document called "traceability matrix."

(4) On the right side of the V-model, we conducted verification testing at each design stage, verifying that the requirements, specifications, and test results were consistently traced and satisfied.

In this way, the V-model software design and testing processes offer the advantage of design phases well defined for the safety requirements and linked with their corresponding tests, thereby making it easier to verify whether the system meets all safety requirements.

This also facilitated the verification of whether the software protection functions, on which the safety performance of the lithium-ion battery pack depends, operate as intended, achieving high product quality and reliability.

4.4 Achieving the safety class

As described above, the basic structure, applied technologies, and development process of the lithium-ion battery pack were designed and evaluated as per IEC 60730, achieving the IEC 60730-defined Class B safety.

5. Conclusion

This article has introduced the new safety-compliant model added to the *SANUPS A11N-Li* UPS lineup.

The features of this model are as follows.

(1) In the event of a failure in an electrical, electronic, or software-based control system, each block's self-diagnosis detects it and transitions the system to a safe state.

(2) The protection functions are fail-safe and designed with redundant detectors and protection mechanisms, enabling continued operation even in the event of a single failure. This design satisfies the requirements of IEC 60730 Class B safety, achieving a high level of safety.

(3) The V-model-based software design and testing process prevents design and test flaws from being missed, realizing high product quality and reliability.

The lithium-ion battery pack used in this model is an excellent energy storage device that complies with the functional safety requirements of international safety standards. In addition, the UPS meets relevant international safety standards, offering a reliable and safe solution to users worldwide.

To contribute to a safer, more secure society, we will continue to develop and deliver safer, more reliable products to our customers.

(Note 1) Electromagnetic compatibility (EMC) refers to a device's ability to operate correctly without emitting or being affected by electromagnetic interference.

References

(1) Takeo Murai and 6 others: "The *SANUPS A11N-Li* Online UPS with Long-life Li-ion Battery"
SANYO DENKI Technical Report, No.57, pp.19-24 (2024.5)

(2) Makoto Kitazawa and 7 others: "Development of the *SANUPS A11N* Online UPS"
SANYO DENKI Technical Report, No.54, pp.29-35 (2022.11)

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SANMOTION Products

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SANYO DENKI Group contributes to society by developing environmentally friendly products that enhance the performance, quality, and reliability of our customers' equipment.

This article provides an overview of the SANMOTION products developed in 2024, highlighting their features and how they contribute to our customers and society.

First, we have expanded the lineup of the *SANMOTION G* servo system, which combines "powerful" performance and "friendly" features, by adding new motors with rated outputs of 1.8 to 5 kW and new amplifiers with output current capacities of 75, 100, and 150 A.

In terms of "powerful" features, the new models offer improved servo performance and environmental durability compared to the current models. This helps improve the performance of customers' equipment and ensures reliable operation even in harsh environments. Moreover, the servo motors and servo amplifiers have been made smaller, lighter, more efficient, and easier to use, making them "friendly" to both the environment and users.

Next, we developed the *SANMOTION G* 2-axis integrated AC servo amplifier to support equipment downsizing and energy savings.

The amplifier is available in four models: two output capacities, each available with or without a built-in regenerative resistor.

Compared to using two single-axis servo amplifiers, these models reduce size, weight, and wiring, offering a greater flexibility in equipment design. They also contribute to energy savings by reducing standby power consumption and effectively using regenerative energy. Moreover, they feature simplified high-precision 2-axis synchronized, programmable operation, making them easy to use for our customers.

Below is an overview of these new products and their features.

■ *SANMOTION G* Medium-Capacity AC Servo Systems

A servo system is an important element in equipment and has a great impact on the performance, quality, and reliability of equipment. Therefore, servo systems need to provide high responsiveness, precise command-following performance, and high reliability. They also need to be energy efficient to contribute to carbon neutrality.

In 2022, we initially launched the *SANMOTION G*, a servo system that combines "powerful" performance and "friendly" features, with a lineup of 30 W to 1.5 kW servo motors and 10 to 50 A servo amplifiers. Widely adopted by our customers, these models have contributed to reducing the size and weight of machines while enhancing functionality and performance.

To meet the growing demand for use in larger machines and equipment, we have recently expanded the lineup with new 1.8 to 5 kW servo motors and 75, 100, and 150 A servo amplifiers.

Their features are as follows.

1. Powerful servo performance

We increased the output area by 10% by optimizing the servo motor's electromagnetic field structure and windings, and by improving the servo amplifier's voltage utilization rate at high speeds—when voltage saturation occurs.

Also, the frequency response of the speed control has been increased by 1.4 times by speeding up the control cycle and improving the torque control. Furthermore, the positioning time was reduced to one-third by compensating for the effects of friction and gravity, which hinder settling.

In addition, we used structural and thermal simulations to improve rigidity and reduce operating temperature, further enhancing environmental durability. This enables use at altitudes of up to 2000 m. Moreover, compared to the current models, the motor's vibration resistance has been doubled to 50 m/s^2, making it suitable for use in harsher environments.

2. Strong reliability

We have added an overshoot suppression feature to the servo amplifier's speed control, improving the command-following performance.

We also subdivided the servo amplifier's alarms to better identify the causes of power device errors, enabling quicker troubleshooting and minimizing downtime.

Furthermore, we added an overload level monitoring feature. This makes it possible to determine how much margin is left before an overload alarm is triggered, maximizing the motor's performance by optimizing the operation cycle time.

3. Friendliness to the environment

Efficiency of the servo motor was improved by 3% through optimization of the electromagnetic field structure and windings. Also, by reducing the size and thickness of the encoder, the new motors are up to 9% shorter and 11% lighter.

By using a low-loss power device and a control circuit with reduced power consumption, the servo amplifiers achieve a 0.6% gain in efficiency with 12% increase in inverter switching frequency. In addition, the amplifier housing material has been changed from sheet metal to plastic, reducing the amplifier weight by up to 19%.

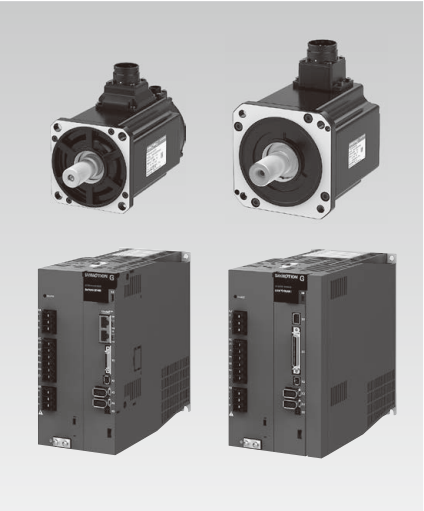
These improvements help make customer equipment more compact and energy efficient.

4. Friendliness to customers

We replaced the screw-fitting type power connectors of the servo motors with circular push-pull connectors, making cable attachment more user-friendly. Moreover, both the servo motors and amplifiers are designed to be dimensionally identical and mounting-compatible with our conventional products, making replacement with the *SANMOTION G* easy for customers.

Furthermore, the servo amplifier has a new function for adjusting the switching frequency at any motor speed. This feature allows users to tailor the low-noise mode to their device's operation, reducing unpleasant high-frequency noise during low-speed operation. This is especially beneficial in applications like collaborative robots and medical devices, ensuring safe and quiet operation near people.

As described above, this new AC servo system combines high performance and reliability, compact and lightweight design, and low noise. With its powerful yet environmentally and user-friendly features, it enhances the value of our customers' equipment while contributing to achieving the carbon neutrality.



■ *SANMOTION G* 2-axis Integrated AC Servo Amplifier

To contribute to the realization of a sustainable society, servo systems need to further reduce their environmental impact and improve their energy conversion efficiency. Additionally, ease of equipment startup and maintenance is becoming increasingly important.

To meet these needs, we developed the *SANMOTION G* 2-axis integrated AC servo amplifier—a user-friendly solution that contributes to equipment downsizing and energy savings.

This product is available in four models: 20 A and 30 A output capacities, each available with or without a built-in regenerative resistor. It comes with an EtherCAT* interface for connections with a host controller.

Its features are as follows.

1. Compact and lightweight

Compared to using two units of the *SANMOTION G* single-axis AC servo amplifier, the new amplifier has a 38% reduced installation footprint and 19% reduced weight. This provides a greater flexibility in equipment design, allowing installation in confined spaces or inside equipment.

2. Wiring and energy savings

With the new product, cable wiring and standby power consumption have been reduced by 35% and 36%, respectively. It also efficiently uses regenerative energy across both axes, improving overall energy efficiency and contributing to energy savings in customers' equipment.

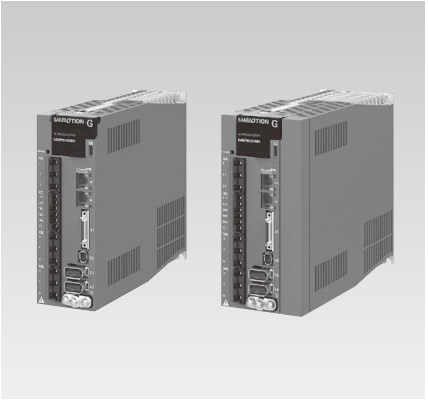
3. User friendliness

The new product comes with a function that simplifies synchronized and programmable operation of the two axes with high precision. This improves the performance of machinery while eliminating the need for complex control on customers' equipment.

Moreover, the setup software displays the servo amplifier's status and operation trace waveforms of two axes simultaneously, making equipment startup and maintenance easier.

In summary, the new 2-axis integrated servo amplifier features a compact, lightweight design with enhanced energy efficiency and ease of use, helping customers increase equipment value and reduce environmental impact.

Details on this product are covered in a separate article in this issue.



* EtherCAT is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

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

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Keisuke Ishizaki Yosei Hirano Shuhei Nakazawa

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.

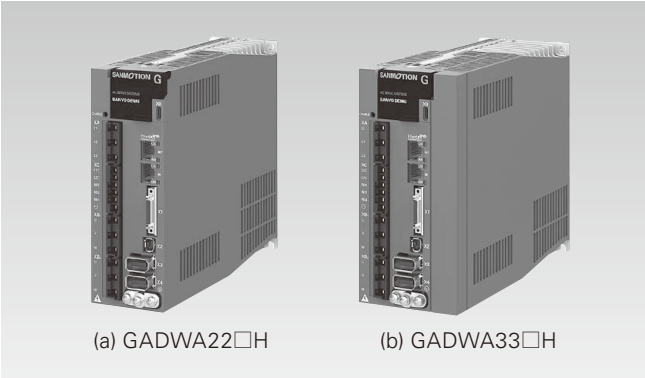
This article starts by introducing the specifications and appearance of the *SANMOTION G* 2-axis integrated AC servo amplifier (hereinafter, "new product")—the latest addition to the *SANMOTION G* servo systems lineup. Next, we'll introduce the features and the key development points of the new product.

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

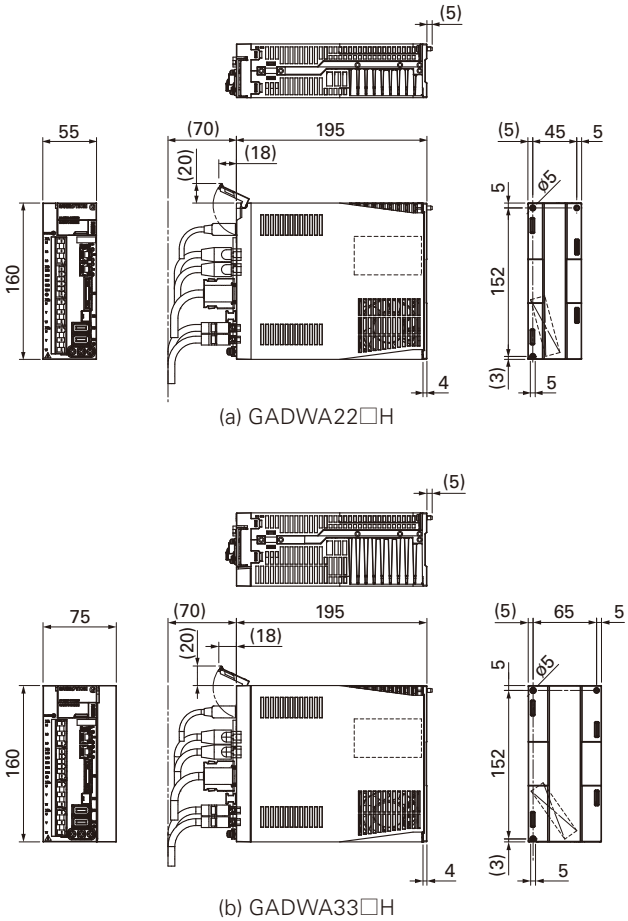


Fig. 2 Dimensions (Unit: mm)

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.

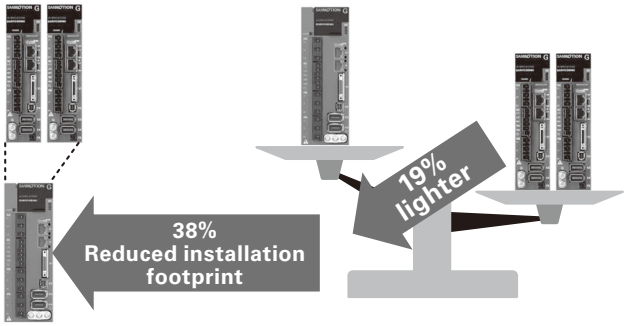


Fig. 3 Compact and lightweight design

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.

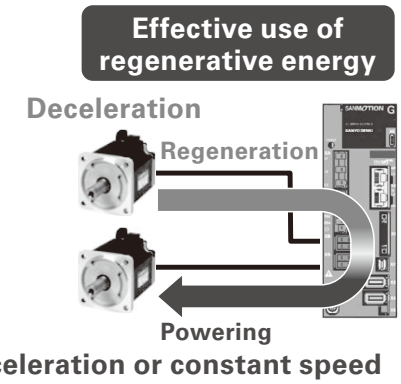


Fig. 4 Reuse of regenerative energy

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.

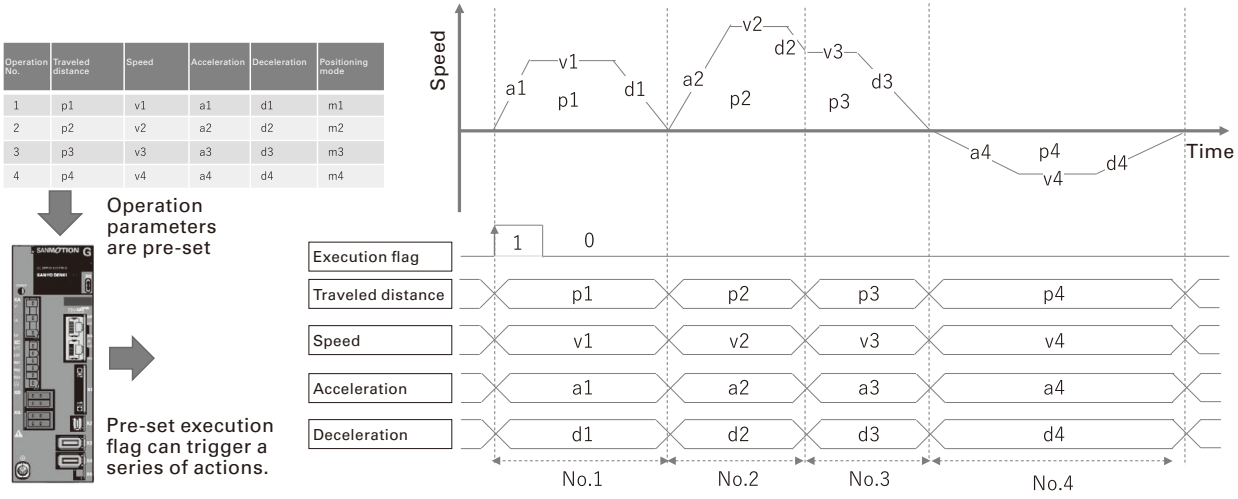


Fig. 5 2-axis programmable operation

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.

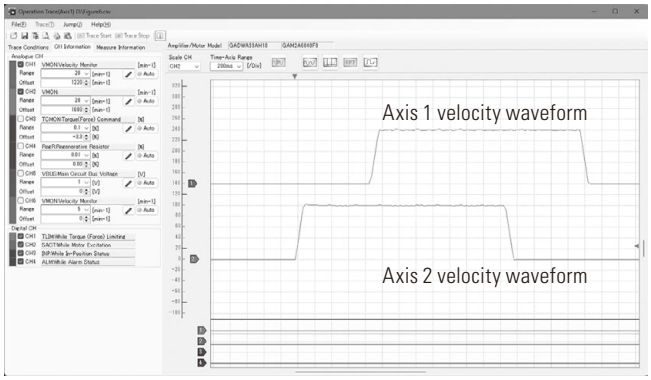


Fig. 6 Simultaneous trace display of two axes

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.

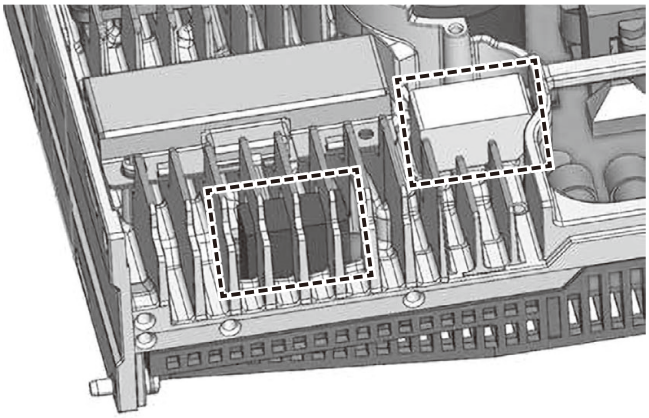


Fig. 7 Devised die-cast shape

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).

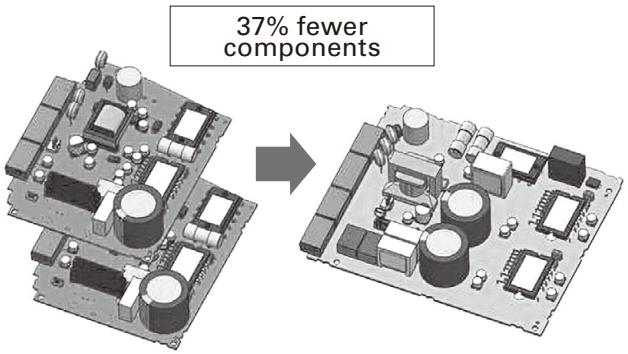


Fig. 8 Reduced number of components

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

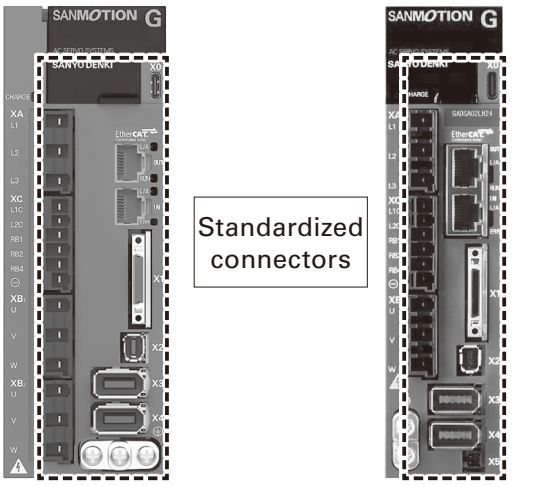
We standardized the PCB design for both the GADWA22□H and GADWA33□H models. This was made possible by altering PCB-mounted components—such as power devices—and structural parts like die-cast casings and plastic covers.

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.

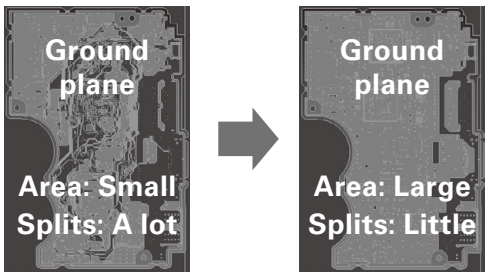


(a) New product (b) Single-axis servo amplifier

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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List of Awarded and Nominated Engineers for the 73rd JEMA Technological Achievement Award in 2024

Heavy Electrical Category			
Prize	**Title**	**Department**	**Name**
Encouragement Award	Development of *SANMOTION G* AC Servo Systems (1.8 to 5 kW servo motors, 75 to 150 A servo amplifiers)	Design Dept., Electronics Company	Yasuhiro Wakui, Yuta Imai, Kazuki Fujita
		Design Dept., Motion Company	Takuya Saito, Tomohiro Harada
	Development of *SANUPS A11N-Li* Lithium-Ion Battery Online UPS	Design Dept., Electronics Company	Takuya Ozawa, Shota Ozawa, Nobuya Otsuki, Shogo Yoshinaga
	Development of the *SANUPS A13A* Modular Uninterruptible Power Supply	Design Dept., Electronics Company	Hiroyuki Kaneko, Hiroya Tokutake, Yoshimi Sunohara, Mika Takehara, Mieko Oi
	Development of Lithium-Ion Battery Pack Production Line and Quality Control System	Subsect. 1, Production Engineering Sect., Production Dept., Electronics Company	Shigeo Ichikawa, Mizuka Takahashi, Hiroto Aoki, Hiroaki Sakata, Yuki Sato
	Development of Magnetization Control for Permanent Magnets Used in Battery-less Encoders	Production Engineering and Development Sect., Production Engineering Dept., Motion Company	Takahiro Yoneta, Hideyuki Ayuzawa, Jun Matsuzaka

Department names are those at the time of nomination.

Major Patents

■ **Patents registered in FY 2024**

Patent Number	Title	Inventor(s)
Japan - 07431764	MOTOR ARMATURE WINDING STRUCTURE AND MOTOR ARMATURE WIRE WINDING METHOD	Mai Shimizu, Takashi Matsushita
Japan - 07441778	LINEAR MOTOR	Yuqi Tang
Japan - 07489312	MOTOR STATOR AND METHOD FOR MANUFACTURING MOTOR STATOR	Yasushi Yoda, Koji Nakatake, Shogo Yoda
Japan - 07532074	MOTOR CONTROL APPARATUS	Yuji Ide, Michio Kitahara, Toshio Hiraide
Japan - 07532207	MOTOR CONTROL APPARATUS AND MOTOR CONTROL METHOD	Yuji Ide, Toshio Hiraide, Michio Kitahara
Japan - 07586631	ARMATURE OF ROTARY ELECTRIC MACHINE AND INSULATION METHOD FOR THE SAME	Daigo Kuraishi, Naoki Sakai, Masashi Suzuki, Kazuhito Yamaura, Toshihiro Kurosaki
Japan - 07591427	MOTOR CONTROL APPARATUS	Yuji Ide, Michio Kitahara, Masahisa Koyama, Masakazu Sakai
Philippines - 1-2017-000272	BLAST FAN	Yoshihisa Yamazaki, Satoshi Fujimaki, Takashi Kawashima, Soma Araki
Philippines - 1-2019-000189	PARALLEL REDUNDANT UPS SYSTEM AND SYSTEM MONITORING METHOD USING THE SAME	Mieko Oi
Philippines - 1-2019-000497	WATERPROOF BLOWER FAN	Masaki Kodama, Toshiya Nishizawa, Kakuhiko Hata
Philippines - 1-2020-050396	MOTOR CONTROL APPARATUS AND INSULATION RESISTANCE DETECTION METHOD FOR SAME	Yuji Ide, Keigo Kikuchi, Toshio Hiraide
Philippines - 1-2020-050539	MOTOR CONTROL APPARATUS AND MOTOR CONTROL METHOD	Yuji Ide, Toshio Hiraide, Michio Kitahara
Europe - 03604960	FAN CONTROL APPARATUS AND FAN CONTROL METHOD	Naoki Murakami, Honami Osawa, Soma Araki, Masashi Murakami
Europe - 03657633	ARMATURE MOLDED STRUCTURE	Manabu Horiuchi, Hiroki Sagara, Jun Kitajima, Mai Shimizu, Takashi Matsushita
Europe - 04060695	ELECTROMAGNETIC SOLENOID AND METHOD FOR MANUFACTURING ELECTROMAGNETIC SOLENOID	Manabu Horiuchi, Keisuke Nagata, Rie Matsuyama
Europe - 04060876	ROTATING ELECTRIC MACHINE	Manabu Horiuchi, Mai Shimizu, Takashi Matsushita, Yasushi Misawa Co-invented with: Japan Aviation Electronics Industry, Ltd.
Europe - 04083436	WATERPROOF FAN	Naoki Murakami, Koji Ueno, Takashi Kawashima, Naoya Ozumi
Europe - 04089285	REVERSIBLE FAN	Yoshihisa Yamazaki
Europe - 04089286	REVERSIBLE FAN	Yoshihisa Yamazaki
Korea - 102690237	BOBBIN STRUCTURE OF ARMATURE	Manabu Horiuchi, Hiroki Sagara, Jun Kitajima, Mai Shimizu, Takashi Matsushita
Korea - 102696912	ARMATURE MOLDED STRUCTURE	Manabu Horiuchi, Hiroki Sagara, Jun Kitajima, Mai Shimizu, Takashi Matsushita
Taiwan - I841653	BOBBIN STRUCTURE OF ARMATURE	Manabu Horiuchi, Hiroki Sagara, Jun Kitajima, Mai Shimizu, Takashi Matsushita
Taiwan - I851639	ARMATURE STRUCTURE OF THREE-PHASE MOTOR	Manabu Horiuchi, Hiroki Sagara, Jun Kitajima, Mai Shimizu

Patent Number	Title	Inventor(s)
Taiwan - I851837	MOTOR CONTROL APPARATUS AND INSULATION RESISTANCE DETECTION METHOD FOR SAME	Yuji Ide, Keigo Kikuchi, Toshio Hiraide
Taiwan - I853984	MOTOR CONTROL APPARATUS AND INSULATION RESISTANCE DETECTION METHOD FOR SAME	Yuji Ide, Keigo Kikuchi, Toshio Hiraide, Masakazu Sakai
Taiwan - I855185	MOTOR CONTROL DEVICE AND INSULATION RESISTANCE DETECTION METHOD OF SAME	Yuji Ide, Keigo Kikuchi, Michio Kitahara, Toshio Hiraide
Taiwan - I865701	FRAME STRUCTURE OF MOTOR AND METHOD FOR MANUFACTURING FRAME AND ARMATURE OF MOTOR	Manabu Horiuchi, Yasushi Misawa, Jun Kitajima, Mai Shimizu
China - ZL201910187481.4	FAN MOTOR APPARATUS WITH PROTECTION COVER	Yusuke Okuda, Haruhisa Maruyama, Yoshihisa Yamazaki
China - ZL201911292558.0	WATERPROOF BLOWER FAN	Masaki Kodama, Toshiya Nishizawa, Kakuhiko Hata
U.S. - 11869712	ELECTROMAGNETIC SOLENOID AND METHOD FOR MANUFACTURING ELECTROMAGNETIC SOLENOID	Manabu Horiuchi, Keisuke Nagata, Rie Matsuyama
U.S. - 11933315	AXIAL FAN	Yoshihisa Yamazaki
U.S. - 11979077	MOTOR STATOR AND METHOD FOR MANUFACTURING MOTOR STATOR	Yasushi Yoda, Koji Nakatake, Shogo Yoda
U.S. - 11988225	AXIAL FAN	Yoshihisa Yamazaki
U.S. - 12006943	WATERPROOF FAN	Munenori Takakuwa, Hyukjun Kwon
U.S. - 12027936	LINEAR MOTOR AND LINEAR HEAD MODULE	Satoshi Inaba, Yuki Onda, Yasushi Misawa
U.S. - 12055150	REVERSIBLE FAN	Yoshihisa Yamazaki
U.S. - 12062913	INPUT POWER MONITORING CIRCUIT	Takashi Kataoka, Noriaki Kasuga, Masaki Miyashita
U.S. - 12071953	AXIAL FAN	Yusuke Okuda, Hiromitsu Kuribayashi
U.S. - 12074501	MOTOR-SPECIFIC ELECTROMAGNETIC BRAKING DEVICE	Masahiro Yamaguchi
U.S. - 12095329	MOTOR ARMATURE WINDING STRUCTURE AND MOTOR ARMATURE WIRE WINDING METHOD	Mai Shimizu, Takashi Matsushita
U.S. - 12101014	ROTATING ELECTRIC MOTOR	Manabu Horiuchi, Mai Shimizu, Takashi Matsushita, Yasushi Misawa, Co-invented with: Japan Aviation Electronics Industry, Ltd.
U.S. - 12104604	AXIAL FAN	Yoshihisa Yamazaki
U.S. - 12126296	MOTOR CONTROL APPARATUS	Takashi Kataoka

Internal Recognition: Invention Excellence Award

Awarded in May 2024

Prize	Title	Department	Name
Excellence Award	Fan Motor Protection Cover	Design Dept., San Ace Company	Yusuke Okuda, Haruhisa Maruyama, Yoshihisa Yamazaki
	Detection of Motor Insulation Resistance	Design Dept., Electronics Company	Yuji Ide, Toshio Hiraide, Masakazu Sakai
		Environmental Technology Implementation Dept.	Keigo Kikuchi
	Motor Controller Mounting Structure	Design Dept., Electronics Company	Yuji Ide, Takao Oshimori, Hiroaki Koike
	Rotary Electric Motor Stator and Its Assembly	Design Dept., Motion Company	Koji Nakatake, Shogo Yoda, Mitsuaki Shioiri, Yasushi Yoda
		Application Engineering Dept.	Hong Zhang
	Automatic Encoder Identification Device	Design Dept., Electronics Company	Masao Mizuguchi, Ryuichi Yanagisawa
	Control and Magnetic Bias Suppression for Grid-connected PV Inverter	Design Dept., Electronics Company	Makoto Ishida, Minoru Yanagisawa

Internal Recognition: Manufacturing Excellence Award

Awarded in May 2024

Prize	Title	Department	Name
Manufacturing Excellence Award	Development of Lithium-Ion Battery Pack Production Line and Quality Control System	Subsect. 1, Production Engineering Sect., Production Dept., Electronics Company	Shigeo Ichikawa, Mizuka Takahashi, Hiroto Aoki, Yuki Sato, Hiroaki Sakata
	In-house Development of Automatic Winding and Soldering Machine for Improved Productivity and Enhanced Safety	SANYO DENKI PHILIPPINES, INC.	Angelo Calingasan, Joseph Mella

Technical Papers Published Outside the Company in General Technical Journals

January to December 2024

Title of Paper	Authors	Name of Journal	Issued on	Published by
Feature: Product and Technology Development of Member Companies and the Results of 2023	SANYO DENKI CO., LTD.	*Denki* (Electrical Appliances)	2024.2	The Japan Electrical Manufacturers' Association (JEMA)
Products and Technology for a Low-Carbon Society	Masahiko Nagai	*Monthly JETI*	2024.4	Nippon Syuppan Seisaku Center Inc.
Fan Utilization Basics and Recent Trends in Products and Technologies	Toshiyuki Nakamura, Naoki Murakami	*Machine Design*	2024.4	Nikkan Kogyo Shimbun
The Development of the *SANUPS LiB Pack*, a Lithium-Ion Battery Pack	Mai Saito, Tetsuya Yamazaki, Hidenori Takizawa, Naoya Nakamura, Kazuya Kudo	*Monthly JETI*	2024.6	Nippon Syuppan Seisaku Center Inc.

Technical Papers Published Outside the Company

January to December 2024

Title of Paper	Authors	Journal / Conference Name	Issued on	Organizing Body
Technologies to Define Suitable Motors for Service Robots	Satoshi Sugita (Joint author: Investigating R&D Committee on Technologies to Define Suitable Motors for Service Robots)	IEEJ Technical Report	2024.1	IEEJ (D), Industrial Applications Category
Proposal of Variable Reluctance IPM Motor Achieving Increased Torque and Improved Efficiency in Medium and High-Speed Rotation Ranges	Manabu Horiuchi (Joint-author: Shinshu University)	IEEJ Joint Technical Meeting on Rotating Machinery/ Linear Drives/Home and Consumer Appliances	2024.8	IEEJ (D), Industrial Applications Category
Improved Performance of Variable Magnetic Reluctance IPM Motors Using d-Axis Flux Barriers	Manabu Horiuchi (Joint-author: Shinshu University)	IEEJ Joint Technical Meeting on Magnetics, Motor Drive, and Linear Drive	2024.12	IEEJ (A), Fundamentals and Materials IEEJ (D), Industrial Applications Category

Memo

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