SANYO DENKI Technical Report

Feature | Technical Developments in 2020

1979
Shioda Works

51
May 2021

COLUMN

Cover image:

Shioda Works

1979

The 1970s was a time when office workers started using computers, word processors, and other computer devices in common, and the office automation market was on the rise as a promising market. These devices required many fans to cool them.

To meet this demand, we newly established a mass-production base of small-sized motors in Ueda City, Nagano Prefecture in April 1979.

Shioda Works was opened as a factory that specialized in producing the San Ace cooling fans, and its production capacity had steadily grown over time. In 1982, it underwent a major expansion to increase its capacity.

In 1990, however, to realize an even greater production capacity in the future, we established a new production base of the San Ace products, that is, the Fujiyama Works.

Since then, the Shioda Works has made contributions continuously by producing servo amplifiers and PV inverters, then currently stepping motors.

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Groundbreaking Ideas and Development Enhancement for 20% Faster Development

Koichi Uchibori Operating Officer

The year 2020 will be remembered as the year in which COVID-19 swept across the world, leaving no one unaffected by it.

In the Philippines, our group company, SANYO DENKI PHILIPPINES, INC. (hereinafter, "SDP") was ordered by the government to suspend its operations for about two months to prevent the spread of the infection. I was in the Philippines at the time and stayed there until production was restored. It was a challenging time that required us to perform measures through trial and error to satisfy the government's COVID-19 regulations and conditions.

Furthermore, our cooling fans and stepping motors were being used in medical equipment for treating patients with COVID-19. These equipment included ventilators and devices for pulmonary function testing, diagnostic blood testing, and therapeutic research. Since the timely supply of these products could help save lives, our first priority was to restart production once business operations resumed.

This experience made me further realize why high-quality, high-performance, and high-reliability products, such as ours, are being widely used in the field for medical equipment. Our mission is to continue to contribute to society by supplying the world with the various types of products it needs.

Our 8th Mid-term Management Plan started in April 2016 and ended in March 2021. It aimed to "continue to develop world-leading products in terms of quality, performance, and reliability." Over the past five years, our Cooling Systems Division, Power Systems Division, and Servo Systems Division released a total of 70 new products.

The Cooling Systems Division released 31 new products.

In particular, the division developed high airflow and high static pressure fans that achieve the industry's top* cooling performance. These fans were developed to enhance cooling capability in high-performance equipment with high component integration, such as servers, storage devices, and ICT equipment.

In addition to developing products for cooling applications, the division used customer feedback to develop a PWM controller that can regulate the rotational speed of fans externally and the industry's first* airflow tester that can easily measure system impedance and operating airflow when selecting cooling fans. In the future, the division plans to increase the number of products optimized for airflow.

The Power Systems Division released 22 new products.

In addition to developing compact and maintenance-free UPSs that use lithium-ion batteries to achieve long-term backup in various operating temperature ranges, the division has been developing power conditioners for power generation systems that use renewable energies such as photovoltaic power, wind power, and small- and medium-scale hydroelectric power sources.

The Servo Systems Division released 17 new products.

The division has been increasing the number of IoT-ready products. These include servo amplifiers that come with monitoring features for predicting equipment failure based on the operating status of amplifiers and motors, as well as products that can use smartphones and tablets to wirelessly monitor the status of robot and conveyor controllers.

Moving forward, we plan to continue developing products that contribute to customer productivity.

Our 9th Mid-term Management Plan started in April 2021 based on the concept of “breaking new ground.” One of the key policies of the plan is to “develop products that make new dreams come true.”

We aim to develop groundbreaking products and create new value by combining our cultivated technologies with new technologies, while pursuing increased development speeds of up to 20%.

To help achieve this goal, we opened a new building at our Technology Center in May 2021.

As a result, the center has laboratory space that is nearly twice the size of the previous one and provides a work environment that greatly facilitates design and development. By combining this center with our SDP Technology Center, which we opened in March 2019, we plan to accelerate global product development by breaking new ground and enhancing our development capabilities so that we can strengthen our brand name throughout the world.

* Based on our own research as of May 15, 2021.

Cooling Systems Division

Masato Murata

Remote work has been introduced at many companies as a measure to prevent the spread of COVID-19. As a result, the Internet and other types of ICT systems are playing a very important role in new lifestyles, business activities, and social activities.

Elements of ICT equipment such as servers, storage devices, and routers have been constantly improving in terms of speed, capacity, and performance, and they have been mounted in equipment with higher density. At the same time, the high density mounting of these types of equipment has increased heat buildup, which, in turn, has increased demand for fans with higher airflow and static pressure.

Also, equipment used outdoors such as base stations, PV inverters, and digital signage has increased performance, there has also been increased demand for water-resistant fans with higher cooling performance to accommodate the advanced features and performance of outdoor base stations, PV inverters, and digital signage.

To meet such market demands, we developed and launched fans with industry-leading performance and reliability.

Below is an overview of the products we developed in 2020.

■ High Static Pressure Fan

DC Fan

• 40 × 40 × 28 mm *San Ace 40* 9HVA type

40 × 40 × 28 mm fans are used in 1U servers and other ICT equipment. This equipment these days has higher performance than before, requiring more effective cooling. In addition, today's devices are required to be eco-efficient. This means that fans also need to operate with low power. To meet such demands, we developed and launched the *San Ace 40* 9HVA type fan. It offers the industry's highest[1] static pressure.

(1) Based on our own research as of May 28, 2020, conducted among equally-sized axial DC fans on the market.

• 80 × 80 × 38 mm *San Ace 80* 9HVB type

80 × 80 × 38 mm fans are used in high-density equipment such as 2U servers, storage devices, and routers. This equipment these days has higher performance than before, requiring more effective cooling.

In response to such market demands, we developed and launched the *San Ace 80* 9HVB type fan that features the industry's highest(2) airflow and static pressure.

(2) Based on our own research as of September 29, 2020, conducted among equally-sized axial DC fans on the market.

• 92 × 92 × 25 mm *San Ace 92* 9HV type

92 × 92 × 25 mm fans are being used widely in ICT and industrial equipment. Advancements in equipment performance and miniaturization have increased the heat generation inside equipment, requiring fans with higher cooling performance. In response to such market demands, we developed and launched the *San Ace 92* 9HV type fan that has the industry's highest(3) airflow and static pressure.

(3) Based on our own research as of March 10, 2020, conducted among equally-sized axial DC fans on the market.

■ Counter Rotating Fan

DC Fan

• 40 × 40 × 56 mm *San Ace 40* 9CRJ type

40 × 40 × 56 mm fans are being used in 1U servers and switching power supplies. This equipment these days has higher performance, calling for fans with higher cooling performance and lower operating power consumption. To meet such market demands, we developed and launched the *San Ace 40* 9CRJ type fan that has the industry's highest(4) static pressure with low power consumption.

(4) Based on our own research as of August 18, 2020, conducted among equally-sized axial DC fans on the market.

■ Splash Proof Fan

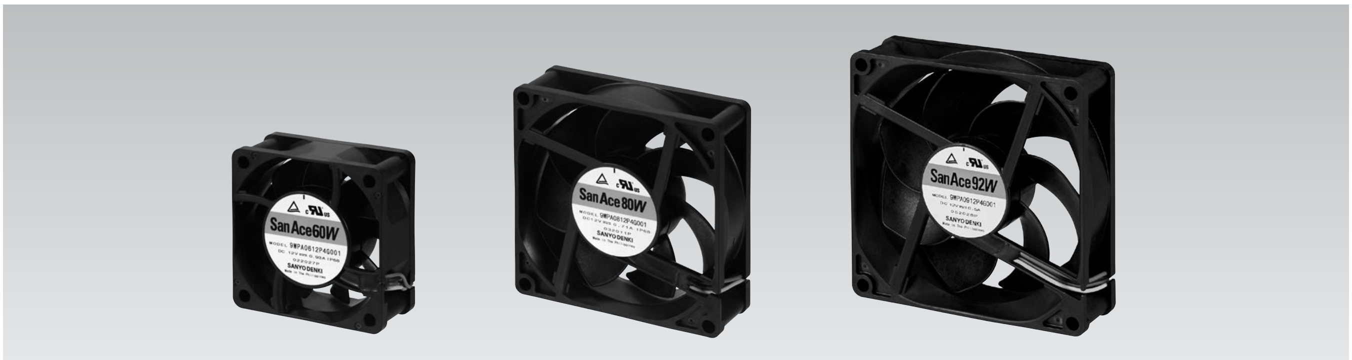
DC Fan

- 60 × 60 × 25 mm *San Ace 60W* 9WPA type
- 80 × 80 × 25 mm *San Ace 80W* 9WPA type
- 92 × 92 × 25 mm *San Ace 92W* 9WPA type

Our Splash Proof Fans have been used in outdoor equipment such as base stations, PV inverters, and digital signage. However, this equipment these days has higher performance and smaller sizes, and generates more heat, requiring more effective cooling than before.

In response to this demand, we developed and released the following high-performance Splash Proof Fans: *San Ace 60W*, *San Ace 80W*, and *San Ace 92W* 9WPA types. These fans offer the industry's highest(5) cooling performance (high airflow and static pressure) and IP68(6) protection.

(5) Based on our own research as of April 14, 2020, conducted among equally-sized waterproof axial DC fans on the market.
(6) IP68 ingress protection
The degree of protection (IP code) is defined by IEC (International Electrotechnical Commission) 60529 "Degrees of Protection Provided by Enclosures (IP Code)." (IEC 60529:2001)



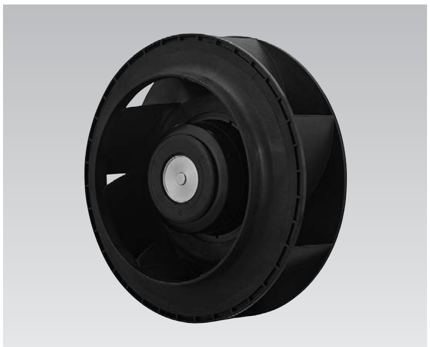
■ Centrifugal ACDC Fan and Splash Proof Centrifugal ACDC Fan

AC Fan

- ø190 × 88 mm *San Ace 190AD* 9ADTU type Centrifugal ACDC Fan
- ø190 × 88 mm *San Ace 190AD* 9ADW1TU type Splash Proof Centrifugal ACDC Fan

ø175 to ø250 mm AC centrifugal fans are being widely used in air conditioning systems, large inverters, and outdoor ICT equipment.

Advancement of this equipment has required cooling fans with higher cooling performance, lower power consumption, and higher water resistance. In response to such market demands, we developed and launched the *San Ace 190AD* 9ADTU type Centrifugal ACDC Fans and 9ADW1TU type Splash Proof Centrifugal ACDC Fans. These fans offer the industry's highest(7) static pressure.



(7) Based on our own research as of December 8, 2020, conducted among equally-sized waterproof or non-waterproof industrial centrifugal fans on the market.

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40×40×56 mm *San Ace 40* 9CRJ Type Counter Rotating Fan

Masaki Kodama　Toshiki Kobayashi　Toshiya Nishizawa

Ryo Shimizu　Hiromitsu Kuribayashi

1. Introduction

In the 1U server, ICT equipment, and power supply market, there has been increasing demand for high-performance and compact fans for cooling today's advanced and high-density equipment. As a cooling solution for this market, we have developed and offered 40×40×56 mm Counter Rotating Fans since quite a while. However, today's high-density equipment has required even higher cooling performance. Moreover, in recent years, many customers have also put an importance on eco efficiency for environmental conservation, which has become another target in our product development.

To meet these requirements, we developed and released the *San Ace 40* 9CRJ type Counter Rotating Fan (hereinafter, "new model"). It comes with a newly designed impeller and frame and features high performance and low power consumption.

This article will introduce the features and performance of the new model.

2. Product Features

Figure 1 shows the appearance of the new model.

The features of the new model are:

Fig. 1 40 × 40 × 56 mm *San Ace 40* 9CRJ type

(1) High static pressure
(2) High airflow
(3) Low power consumption

The new model achieves improved performance with the same size as the current model.

3. Product Outline

3.1 Dimensions

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

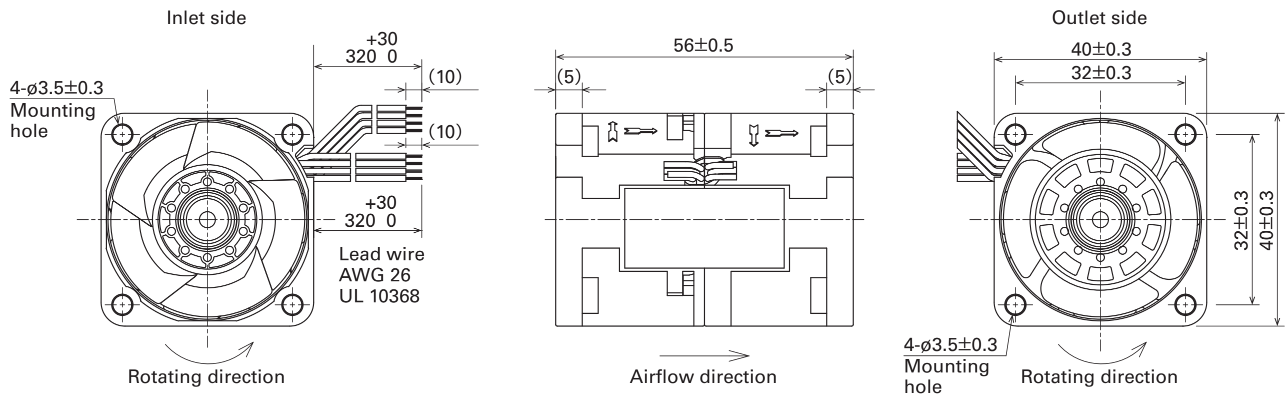

Fig. 2 Dimensions of the new model (unit: mm)

3.2 Specifications

3.2.1 General specifications

Table 1 shows the general specifications for the new model.

The rated speed is 36,200 min^{-1} on the inlet side and 32,000 min^{-1} on the outlet side.

Table 1 General specifications for the new model

Model no.	Rated voltage [V]	Operating voltage range [V]	PWM duty cycle* [%]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow		Max. static pressure		Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
							[m^3/min]	[CFM]	[Pa]	[inchH$_2$O]			
9CRJ0412P5J001	12	10.8 to 12.6	100	3.1	37.2	36,200/32,000	1.06	37.4	2,400	9.64	72	-20 to +70	30,000 at 60°C (53,000 at 40°C)
			20	1.2	1.2	4,500/4,000	0.11	3.9	40	0.16	28		

* 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.

3.2.2 Airflow vs. static pressure characteristics

Figure 3 shows the airflow vs. static pressure characteristics for the new model. Shown are examples at PWM duty cycles 100% and 20% at a rated voltage of 12 V.

3.2.3 PWM control function

The new model has a PWM control function that enables external control of fan speed.

3.3 Expected life

The new model has an expected life of 30,000 hours at 60°C (survival rate of 90%, run continuously at rated voltage and normal humidity in free air).

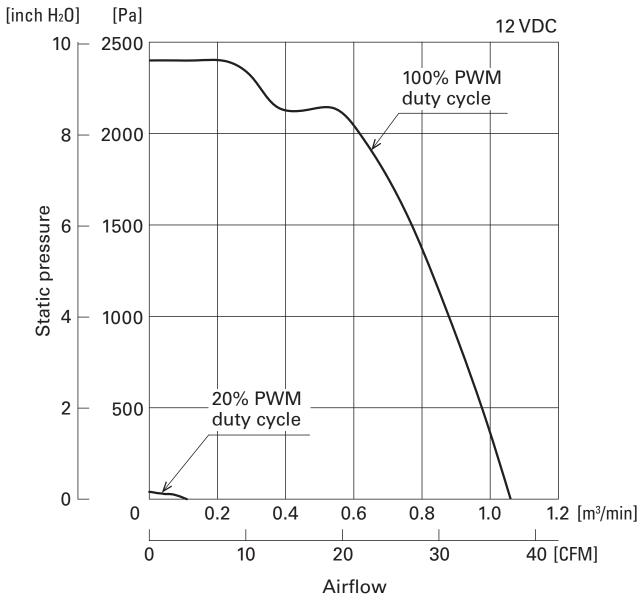

Fig. 3 Airflow vs. static pressure characteristics of the new model

4. Key Points of Development

The new model offers significantly improved airflow and static pressure. To achieve higher performance, we newly designed the impeller and frame.

In the following sections, we'll explain the key points of the development and the differences between the new model and the *San Ace 40* 9CRH type fan (hereinafter, "current model").

4.1 Impeller and frame design

A Counter Rotating Fan has an inlet fan and an outlet fan, and the combination of their shapes, blade angles, and rotational speeds significantly varies the product's airflow vs. static pressure characteristics. To achieve the target performance, we used 3D printing and simulations to optimize the blade angle and the shape of the impeller and frame

Figure 4 shows a comparison of the impeller shape for the new and current models.

We increased the blade surface area by 10% on the inlet side and 3% on the outlet side compared to the current model, thereby achieving high airflow and high static pressure. Although power consumption usually increases in proportion to the increase in blade surface area, we were actually able to reduce power consumption by optimizing the blade shape.

Fig. 4 Comparison of the impeller shapes for the new and current models

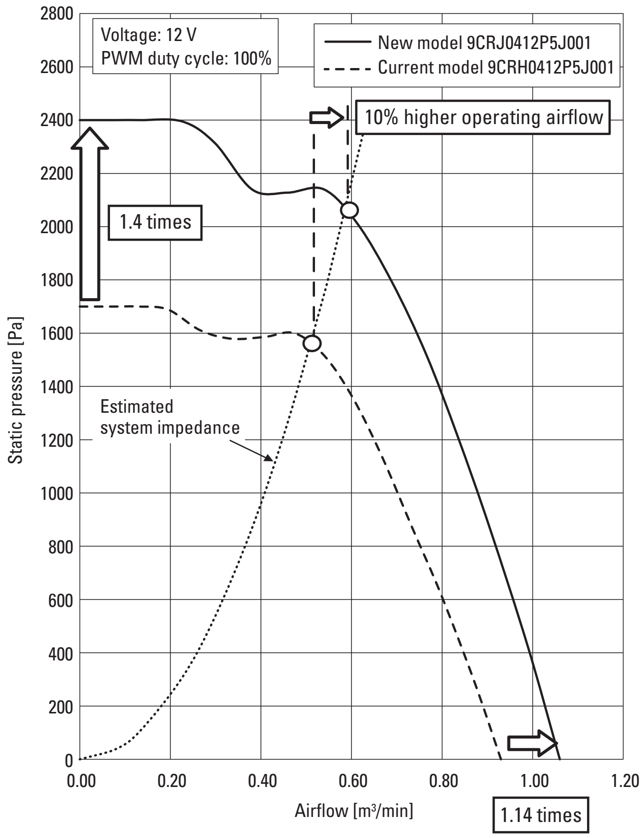

Fig. 5 Airflow vs. static pressure characteristics (Compared with the current model)

5. Comparison with Current Model

5.1 Comparison of airflow vs. static pressure characteristics

Figure 5 compares the airflow vs. static pressure characteristics of the new and current models. Maximum airflow and maximum static pressure are, respectively, 1.14 times and 1.4 times that of the current model. The figure shows that the operating airflow of the new model is 10% higher than that of the current model at the estimated system impedance (ventilation resistance) shown in the figure.

5.2 Power consumption comparison with the current model at equivalent performance

Figure 6 compares the power consumption between the new model and current model at the same maximum airflow. When the speed of the new model is lowered by PWM control and cooling performance is equivalent to that of the current model, the new model consumes up to 20% less power than the current model in the estimated operating range.

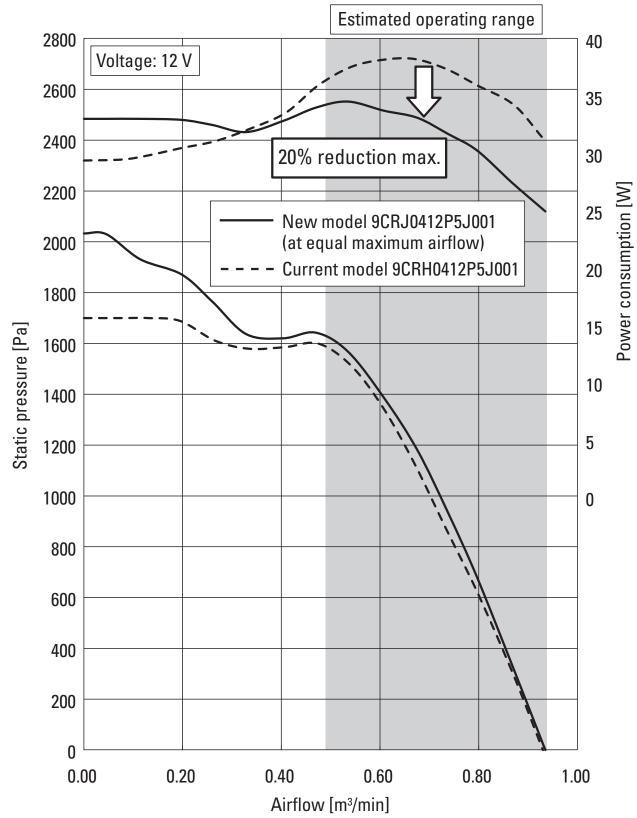

Fig. 6 Power consumption comparison with the current model

6. Conclusion

This article has introduced the features and performance of the 40 × 40 × 56 mm *San Ace 40* 9CRJ type Counter Rotating Fan with high performance and low power consumption.

The new model outperforms our current model. Furthermore, the new model consumes much less power than the current model when maximum airflow is equivalent to that of the current model.

We believe the new model's features will greatly contribute to the cooling of high heat-generating, high-density equipment that are expected to become increasingly common in the future.

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

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80 × 80 × 38 mm *San Ace 80* 9HVB Type High Static Pressure Fan

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Yuto Horiuchi　Honami Osawa

1. Introduction

In recent years, ICT equipment, such as servers, storage devices, and routers, have improved in terms of performance and functionality. However, these enhancements have required denser internal component mounting, leading to increased heat generation. As a result, higher cooling performance is being required for these types of applications. We released the 80 × 80 × 38 mm *San Ace 80* 9HVA high static pressure fan (hereinafter, "current model"), but there was increasing demand for a high static pressure fan capable of cooling equipment under higher density and higher heat generating environments.

To meet this demand, we developed and released the *San Ace 80* 9HVB High Static Pressure Fan (hereinafter, "new model"). It features a newly designed impeller, frame, and circuit.

This article will introduce the features and performance of the new model.

2. Product Features

Figure 1 shows the appearance of the new model.

The features of the new model are:

Fig. 1 80 × 80 × 38 mm *San Ace 80* 9HVB type

(1) High static pressure
(2) High airflow
(3) Size suitable for 2U units

The new model improves performance, while maintaining the same size of the current model.

3. Product Outline

3.1 Dimensions

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

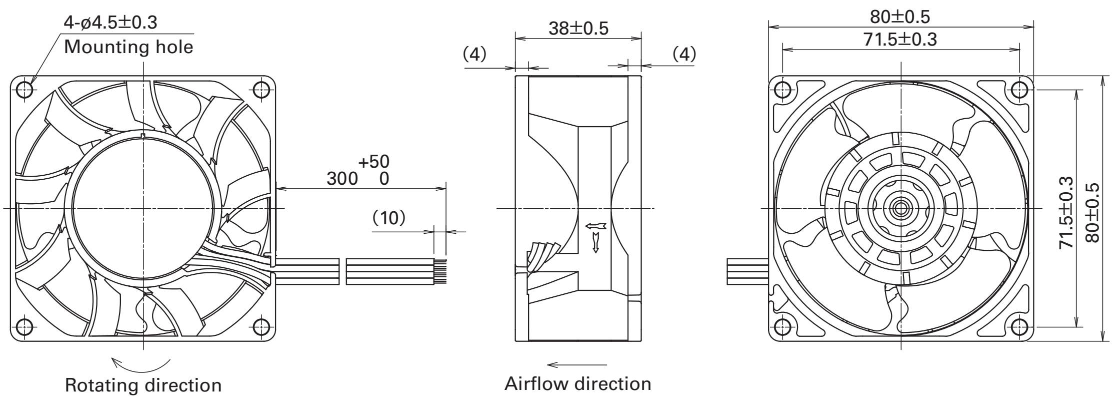

Fig. 2 Dimensions of the new model (unit: mm)

3.2 Specifications

3.2.1 General specifications

Table 1 shows the general specifications for the new model. It is available with a rated voltage of 12 VDC and has a rated speed of 18,300 min^{-1} (G speed).

Table 1 General specifications for the new model

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_2O]	Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
9HVB0812P1G001	12	10.8 to 12.6	100	4.8	58	18,300	4.0	141.3	1,600	6.42	75	-20 to +70	40000 at 60°C (70000 at 40°C)
			20	0.17	2.0	4,300	0.94	33.2	105	0.42	40		

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

3.2.2 Airflow vs. static pressure characteristics

Figure 3 shows the airflow vs. static pressure characteristics for the new model. Examples are shown for a PWM duty cycle of 100% and 20% at a rated voltage of 12 V.

3.2.3 PWM control function

The new model has a PWM control function that enables external control of fan speed.

3.3 Expected life

The new model has an expected life of 40,000 hours at 60°C (survival rate of 90%, run continuously at rated voltage and normal humidity in free air).

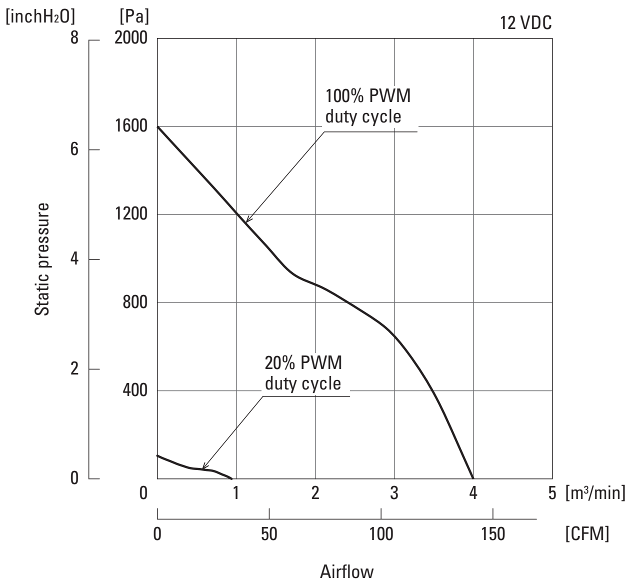

Fig. 3 Airflow vs. static pressure characteristics of the new model

4. Key Points of Development

The new model features a newly-designed impeller, frame, and circuit that improve static pressure and airflow performance.

Next, we explain the key development points and compare the new model with the current model.

4.1 Impeller and frame design

The new model uses a structural design that can withstand high speeds. This enables it to achieve higher static pressure and airflow performance than the current model.

Figures 4 and 5 show a comparison between the new model and current model in terms of impeller shape and frame shape, respectively.

To support higher speeds, the impeller and frame need to be strong enough to withstand the generated stress. To achieve this, we used our proprietary stress simulation technology to select optimal impeller and frame shapes and plastic strengths to maintain the needed strength.

Another challenge that we faced was the higher temperature rise of the motor. This was due to the increase in power consumption caused by the higher speed. We overcame this challenge by improving the cooling performance by optimizing the size, quantity, and location of the air vents on the impeller, especially the air vents on the outer periphery of the impeller. This enabled us to reduce the temperature rise of the motor.

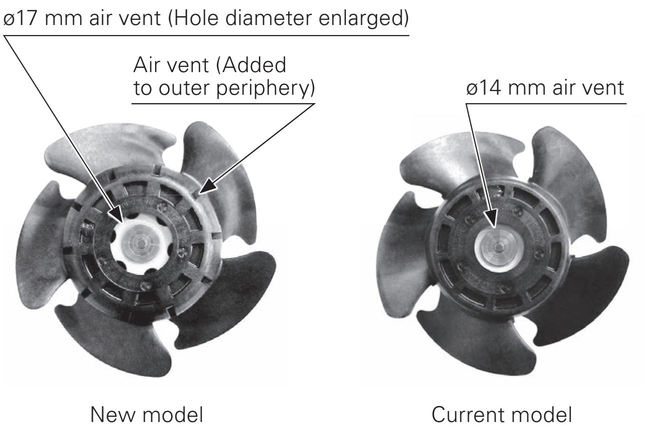

Fig. 4 Comparison of the impeller shapes for the new and current models

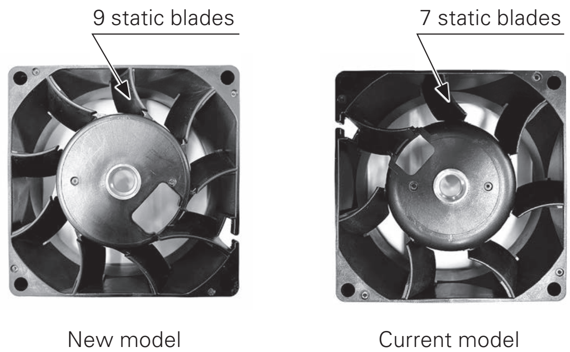

Fig. 5 Comparison of the frame shape for the new and current models

4.2 Circuit design

The new model has the highest maximum-load power consumption among all of our 80 × 80 mm products. In particular, it is 1.6 times higher than that of our current model. The heat generated by electronic components due to the increase in power consumption was a problem. We tried applying some conventional measures such as using multiple components or larger components with higher current capacities. These measures were effective, but not enough to suppress the heat generation.

In addition to selecting highly efficient electronic components, we implemented a pattern design that took into consideration heat dissipation. This enabled us to achieve a circuit design for high speed applications by optimally arranging the components so as to maximize self-cooling via the air vents based on the improved cooling performance of the impeller as described in Section 4.1.

5. Comparison with Current Model

5.1 Comparison of airflow vs. static pressure characteristics

Figure 6 compares the airflow vs. static pressure characteristics of the new and current models. Maximum airflow and maximum static pressure are, respectively, 1.07 times and 1.19 times that of the current model.

5.2 Power consumption comparison with the current model

Figure 7 provides a comparison of power consumption for the current and new models at equivalent cooling performance. When the speed of the new model is lowered by PWM control to have the same cooling performance as the current model, the new model consumes 5% less power than the current model.

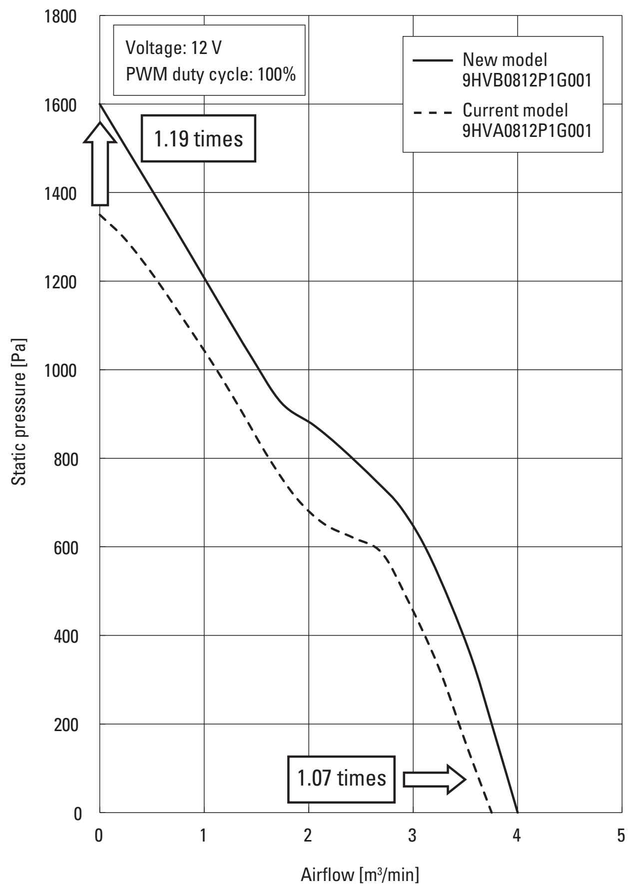

Fig. 6 Airflow vs. static pressure characteristics (Compared with the current model)

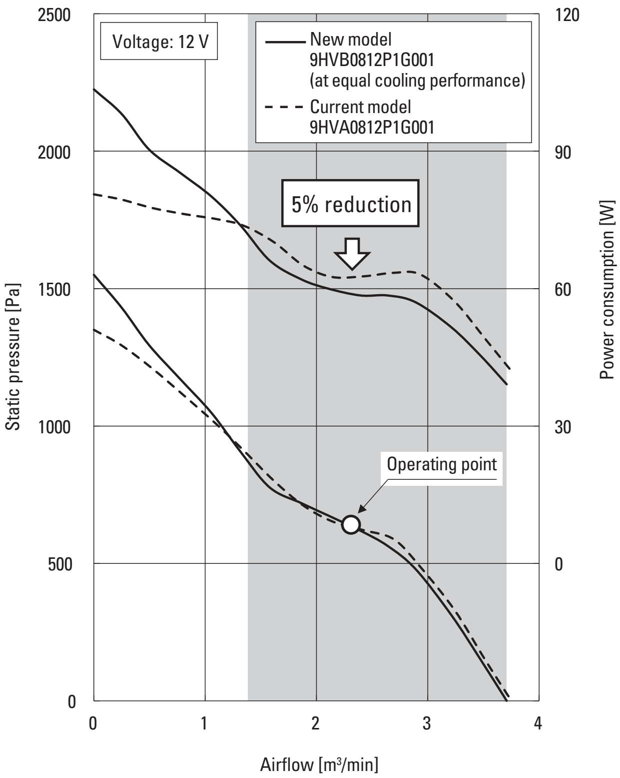

Fig. 7 Power consumption comparison with the current model

6. Conclusion

This article has introduced the features and performance of the 80 × 80 × 38 mm *San Ace 80* 9HVB type high static pressure fan.

The new model has higher static pressure and airflow than our current model.

With high static pressure and airflow, the new model can effectively cooling the equipment that has high density and high heat generation.

We will continue to develop the industry's best fans in terms of performance, reliability, and quality by using future-oriented technologies that enable us to quickly adapt to the demands of customers.

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Fifth-generation mobile communication system (hereinafter, "5G") services started in 2020. 5G is expected to advance IoT and AI by enabling "high-speed and large-capacity" data transmission, "low latency," and "multi-device connections." Edge computing will particularly benefit from the features of 5G and is expected to be increasingly deployed in a wide range of fields, including manufacturing, ICT, and medicine. Since edge computing enables servers to be distributed in areas in close proximity to user terminals, it is expected that there will be growing demand for uninterruptible power supplies (UPSs) with excellent environmental durability and maintainability.

Many world leaders believe that greenhouse gas emissions are the main cause of the increasingly severe natural disasters that are occurring throughout the world. As a result, environmental initiatives are being taken in earnest to achieve a "decarbonized society" that reduces greenhouse gas emissions to zero by 2050. These initiatives are expected to increase the deployment of renewable energy power generation systems, such as those that use hydroelectric, geothermal, and biomass sources. It is anticipated that these systems will be able to operate stably in all types of natural conditions despite environmental and installation site restrictions.

In the global market, an increasing number of equipment are being installed in locations where there is an unstable supply of power. To prevent equipment from being failed due to power outages and prevent harmonics generated by equipment from affecting utility power, these types of locations need to be provided with equipment that can prevent instantaneous voltage dips and harmonics. Furthermore, these types of equipment are increasingly required to meet European safety standards.

It is against this backdrop that the Power Systems Division released the following new products in 2020.

For starters, the division expanded its lineup of *SANUPS E11B* small-capacity hybrid UPSs to include a 3 kVA model. Furthermore, the division developed the *SANUPS E11B-Li* lithium-ion battery equipped hybrid UPS and the *SANUPS A11M-Li* parallel redundant double conversion online UPS.

In terms of products for renewable energy, the division developed the *SANUPS W75A* as a rectifier unit that converts the AC output of generators, such as those of wind power and hydro power generation systems of 10 kW or less, into DC power.

The division also expanded its lineup of *SANUPS C23A* voltage dip compensators to include models that comply with European safety standards.

This article provides an overview of each of these products.

Expanding the Lineup of the *SANUPS E11B* Hybrid UPS

The *SANUPS E11B* hybrid UPS constantly monitors the status of the input power source and automatically selects the optimal power supply mode to provide a stable supply of high-quality power. This UPS achieves both high-quality power supply and energy savings.

We added a 3 kVA model to our original lineup of 1 kVA, 1.5 kVA(1), and 2 kVA products.

Figure 1 shows the appearance of the *SANUPS E11B*.

The *SANUPS E11B* has a wider input range than previous models.

The input specifications include input voltage ranges of 55 to 150 V for the 100 V model and 110 to 300 V for the 200 V model. In addition, this product has an input frequency range from 40 to 120 Hz. This enables it to be installed in environments with unstable power conditions. This also reduces the amount of switching operations required during battery usage and prevents battery depletion and degradation.

Furthermore, its environmental temperature range of -10 to +55°C allows the unit to be installed in environments susceptible to large temperature changes.

A detailed introduction of the performance, functions, and features of the *SANUPS E11B* is provided in the New Products Introduction section of this Technical Report.

Fig. 1 *SANUPS E11B*

(1) 1.5 kVA model is available for 100 V only.

Development of the *SANUPS E11B-Li* Hybrid UPS and the *SANUPS A11M-Li* Double Conversion Online UPS

The *SANUPS E11B-Li* and *SANUPS A11M-Li* are UPSs that come equipped with lithium-ion batteries.

Figure 2 shows the appearance of the *SANUPS A11M-Li*.

The *SANUPS E11B-Li* is available in 1 kVA, 1.5 kVA(1), and 2 kVA products. The *SANUPS A11M-Li* can be expanded to 8 kVA by combining 1 kVA units. Moreover, by using one of the units as a backup unit, operators can configure a parallel redundant system capable of supplying highly reliable power.

The input voltage specifications include a lineup of single-phase 2-wire 100 V and 200 V products(1).

Since the expected life of lithium-ion batteries is 10 years, we simply revised the lead-acid battery specifications of the *SANUPS E11B* and *SANUPS A11M* to enable them to use lithium-ion batteries to achieve 10 years of maintenance-free operation. This means that these units contribute to both cost and labor savings.

The input specifications and environmental temperature range are the same as those of the *SANUPS E11B* and *SANUPS A11M*. Therefore, they can be installed in environments with unstable power supply conditions or large temperature changes.

Fig. 2 *SANUPS A11M-Li*

(1) 1.5 kVA model is available for 100 V only.

■ Development of the *SANUPS W75A* Rectifier for Wind Power and Hydro Power Generation Systems

The *SANUPS W75A* is a rectifier for wind power and hydro power generation systems.

Figure 3 shows the appearance of the *SANUPS W75A*.

The *SANUPS W75A* has a rated output capacity of 11 kW.

The main circuit uses full-wave rectification to convert the AC power of the generator into DC power that can be input to the power conditioner. It achieves the industry's highest level of conversion efficiency(2).

The *SANUPS W75A* was developed to be used in combination with our three-phase 9.9 kW *SANUPS W73A* power conditioner for wind power and hydro power generation systems.

The main feature of this unit is its DC voltage rise control function (brake function). This function prevents voltage above the specification range from being applied to the power conditioner. With a sealed structure and fanless passive air cooling system, the *SANUPS W75A* achieves excellent environmental durability via IP65 water and dust protection.

Since it comes with a wide AC input voltage range and DC output voltage range, it can be flexibly used as a rectifier for renewable energy power generation systems that use generators, such as those that use biomass and geothermal power sources as well as wind and hydroelectric.

Fig. 3 *SANUPS W75A*

(2) Based on our own research as of January 29, 2020, conducted among 3-phase rectifiers for wind power and hydro power generation systems.

References

Ryu Yoshizawa and 3 others: Development of the *SANUPS W75A* Rectifier Unit for Wind Power and Hydro Power Generation Systems
SANYO DENKI Technical Report, No.50, pp.21-24 (2020.11)

■ Expanding the Lineup of the *SANUPS C23A* Voltage Dip Compensator

The *SANUPS C23A* voltage dip compensator is available in a lineup of 10 kVA, 20 kVA, 30 kVA, 50 kVA, 100 kVA, and 200 kVA products.

Figure 4 shows the appearance of the *SANUPS C23A* (200 kVA model).

The *SANUPS C23A* can supply stable power to equipment without interruption even when there are instantaneous voltage dips or momentary outages. Furthermore, it uses an active filter to prevent harmonics from affecting utility power. This power supply unit can use these features to supply highly efficient and high-quality power using a parallel processing topology (parallel inverter feed).

Our new lineup of 50 kVA, 100 kVA, and 200 kVA *SANUPS C23A* products complies with European safety standards, including the Low Voltage Directive, EMC Directive, and RoHS Directive.

This means that these products can be used as equipment power supplies not only in Japan, but in many countries throughout the world.

A detailed introduction of the performance, functions, and features of the *SANUPS C23A* is provided in the New Products Introduction section of this Technical Report.

Fig. 4 *SANUPS C23A* (200 kVA model)

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Development of the *SANUPS C23A* Voltage Dip Compensator with Compliance with European Standards

Hiroaki Miyoshi Yuji Wada Minoru Yanagisawa Yuzo Kubota

Naoya Nakamura Takuya Ota Satoshi Furihata Shohei Ohashi

1. Introduction

In recent years, an increasing number of industrial equipment manufacturers in Japan have introduced semiconductor manufacturing facilities in China and other Asian countries. Taking unstable local power environments, these facilities often need to be combined with a voltage dip compensator and harmonic solution equipment.

Our existing product, the *SANUPS C23A* voltage dip compensator, can be used for such needs to reduce the initial cost and installation man-hours because, with its active filter, it can solve the voltage dip problem and harmonics problem in one unit. (1)

Furthermore, the equipment installed in the factories in China and other Asian countries has been increasingly required to have CE markings to comply with European safety standards.

To meet this need, we newly developed CE-compliant models of the *SANUPS C23A* voltage dip compensator and added them to the lineup. This article introduces the features of this new model.

2. Product Overview

The new models of the *SANUPS C23A* have capacities of 50, 100, and 200 kVA.

Figure 1 shows the appearance of the 200 kVA model, and Figure 2 shows the basic circuit block diagram of the *SANUPS C23A*.

The *SANUPS C23A* features a parallel processing topology and uses an electric double-layer capacitor (EDLC) as an energy storage device. The parallel processing topology supplies power to loads mainly via an AC switch. When it does this, the bi-directional inverter configures redundancy in parallel with the grid power and charges the EDLC while the active filter suppresses harmonic currents and corrects the input power factor. In other words, the grid power supplies power to the load, while the bi-directional inverter supplies only the necessary power for the harmonic current suppression and input power factor correction. This significantly reduces power loss and makes a high-efficiency and high-quality power supply possible.

If the grid power fails, the C23A immediately isolates the grid power and continues supplying power from the bi-directional inverter without interruption. (1)

Fig. 1 *SANUPS C23A* (200 kVA model)

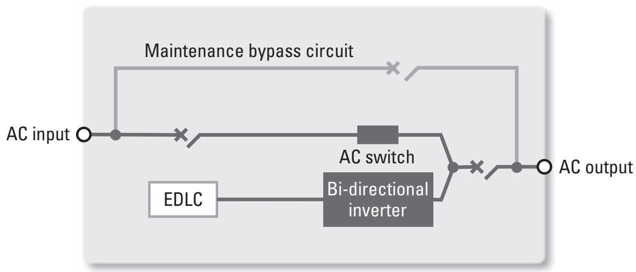


Fig. 2 Basic circuit configuration

3. Features

3.1 Compliance with international safety standards

The new models of the *SANUPS C23A* are compliant with European safety standards of the Low Voltage Directive

(2014/35/EU), EMC Directive (2014/30/EU), and RoHS Directive (2011/65/EU, (EU) 2015/863), with most of the features of the current models maintained. Therefore, they can be used in countries and companies that require CE marking.

In particular, the customers who have used the existing *SANUPS C23A* as a power supply for semiconductor manufacturing equipment in Japan can now use the same system overseas without the need to design or purchase a new power supply system.

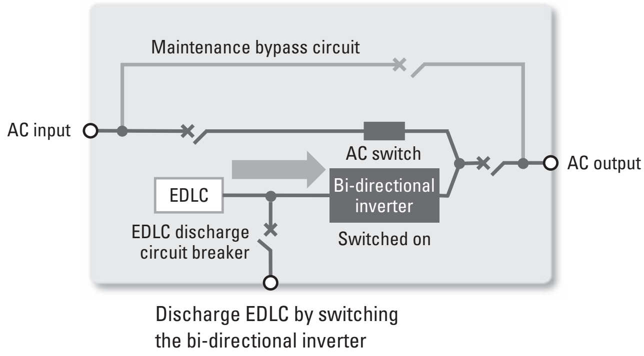
3.2 Extended expected life

The expected life of the current models of the *SANUPS C23A* is 10 years. However, the new models have a longer expected life of 15 years with a new electrolytic capacitor and other components used. Components that last less than 15 years, such as the EDLC, fans, fuses, and electromagnetic contactors, are classified as periodic replacement parts, specifying the maintenance cost for customers who intend to use the product for 15 years.

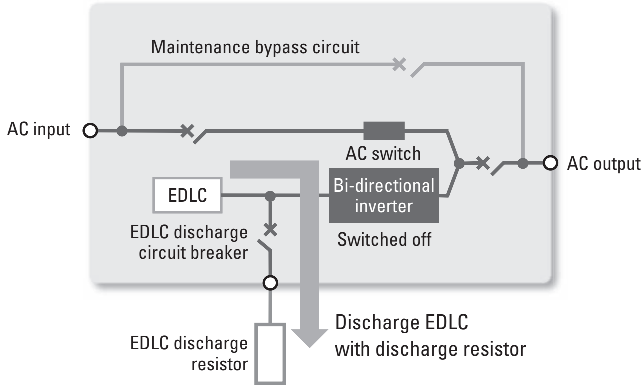
3.3 Improved maintainability

The new models have an expected life of 15 years. However, as described in Section 3.2, this requires that some components be replaced periodically. For easy replacement work, we have revised the layout of components and the mounting structure. In addition, we also revised the electrolytic capacitor in the bi-directional inverter unit so that it would last for 15 years and require no replacement. This helped reducing the replacement time and costs.

EDLCs have a service life of about 10 years, so they would be subject to replacement. However, similar to lead-acid batteries, an EDLC remains charged with a certain voltage stored even after the power is disconnected. Replacing the EDLC in this state could cause an electric shock or short circuit. To prevent this and ensure safe EDLC replacement, we added the new models with a new function for discharging the EDLC. The EDLC discharge proceeds in two steps. The first step is shown in Figure 3 (1). This requires consuming the charge that remains in the EDLC so that it falls below a dangerous level (60 VDC). This is done by using the bi-directional inverter's no-load loss that results from switching the bi-directional inverter. The second step is shown in Figure 3 (2). This requires connecting a resistor to the EDLC discharge circuit breaker after stopping the unit, and then turning on the circuit breaker to discharge the EDLC to almost no voltage. After these steps, technitians can safely and quickly replace EDLCs and perform necessary maintenance work.



(1) Step 1



(2) Step 2

Fig. 3 Self-discharge of EDLC

3.4 Dimensions

Table 1 compares the dimensions of the new *SANUPS C23A* models with current models. For the new models, we added a circuit to conform to the EMC Directive and secured insulation by providing more clearance between components to conform to the Low Voltage Directive. Although the new 200 kVA model has a 100 mm longer width than that of the current 200 kVA model, we managed to maintain the dimensions of our current models for 50 and 100 kVA capacities by revising the component layout and other efforts. This means that the current models can easily be replaced with the new models.

Table 1 Dimensions

Output capacity	Model no.	Size (width × depth × height) Unit: mm
50 kVA	C23A503C (New model)	750 × 700 × 1775
	C23A503 (Current model)	750 × 700 × 1775
100 kVA	C23A104C (New model)	1050 × 800 × 1950
	C23A104 (Current model)	1050 × 800 × 1950
200 kVA	C23A204C (New model)	1650 × 800 × 2075
	C23A204 (Current model)	1550 × 800 × 2075

4. Specifications

Table 2 shows the electrical specifications of the new product.

Table 2 Electrical specifications

Items		Model no.	C23A503C	C23A104C	C23A204C	Remarks
Rated output capacity	Apparent power		50 kVA	100 kVA	200 kVA	
	Active power		40 kW	80 kW	160 kW	
Enclosure type			Steel-sheet free-standing enclosure (Ingress protection rating: IP2X)			
Topology			Parallel processing			
Cooling system			Forced air cooling			
Energy storage device			Electric double-layer capacitor (EDLC)			
AC input	No. of phases/wires		3-phase 3-wire			
	Rated voltage		200/210/220 V			
	Rated frequency		50/60 Hz			
	Current harmonic distortion compensation	Compensation capacity	Within rated capacity			
		Harmonic current	85% or higher compensation			At 100% rectifier load
		Compensation order	2nd to 20th harmonics			
	Input power factor		0.98 or greater			At rated output
AC output	No. of phases/wires		3-phase 3-wire			
	Rated voltage		200/210/220 V			
	Voltage regulation	In grid operation	Within -8 to +10% of rated voltage			User-selectable
		In capacitor operation	Within ±2% of rated voltage			(1)
	Rated frequency		50/60 Hz			
	Frequency regulation	In grid operation	Within ±4% of rated frequency			
		In capacitor operation	Within ±0.1 Hz of rated frequency			(1)
	Load power factor	Rated	0.8 (lagging)			
		Fluctuation range	0.7 to 1.0 (lagging)			(2)
	Voltage harmonic distortion (In capacitor operation)	At linear load	2% or less			
		At rectifier load	5% or less			
	Voltage unbalance (In capacitor operation)		2% or less			With a load of 1/3 the total capacity on one line
	Transient voltage fluctuation (In capacitor operation)	Fluctuation	Within ±5%			
		Settling time	50 ms or less			
	Overload capability (Bypass circuit)		200% (for 30 s), 800% (for 0.5 s)			
	Overcurrent protection		The inverter shuts down at 110% of the rated output, then the grid power will be supplied by bypass. When the current falls equal to or below the rated current, the inverter will automatically start up for normal operation.			
	Transfer time to capacitor operation		0 s (No interruption)			
	Dip compensation time		1 s or more (At rated load)			(3)
	Initial charging time		Within 60 s			Capacitor voltage from 0 to 100%
	Recharging time		Within 10 s			After compensating for a 1-second voltage dip
Acoustic noise			65 dB or less			A-weighting, at 1 m from front of unit
Heat dissipation			2.6 kW	5.1 kW	10.2 kW	At rated output, after battery charging completed(4)
Operating environment			Ambient temperature: 0 to 40˚C Relative humidity: 30 to 90% (non-condensing)			
Standards			CE (Low Voltage Directive, EMC Directive): EN 62040-1, -2, RoHS Directive			

(1) When switched to the capacitor operation with the rated input voltage and rated frequency; indicates the performance of the inverter.
(2) In continuous operation
(3) At the rated load level, a load power factor of 0.8 lagging and 25˚C ambient temperature.
(4) Calculated with a load power factor of 0.8.

5. Conclusion

This article introduced the features of our new CE-marking compliant models of the *SANUPS C23A* voltage dip compensator.

Compared to the current models, the new models have the following added advantages:

(1) Compliance with the following European safety standards: the Low Voltage Directive, EMC Directive, and RoHS Directive

(2) Extended service life and improved maintainability

With these advantages, the new models can meet the needs of customers who require CE marking compliance for use in Asia and Europe. In addition, they can reduce the initial investment and maintenance costs for these customers.

Moving forward, we will continue to keep up with the needs of customers to swiftly develop products that can satisfy them.

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Development of the *SANUPS E11B* Hybrid UPS

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1. Introduction

In recent years, the demand for uninterruptible power supplies (UPSs) has been increasing throughout the world. One of the reasons for this is because the spread of mobile devices and IoT-ready equipment has required more robust backup systems. As such, UPSs that can operate in regions with unstable power grids have been demanded.

Furthermore, there is also growing demand to reduce carbon footprints* as a countermeasure to global warming in order to help facilitate a sustainable society. As a result, the market is requiring products that can reduce CO_2 emissions and achieve energy savings over their entire service life.

It is against this backdrop that we have developed the *SANUPS E11B* as the successor series to our *SANUPS E11A* series, with an eye on overseas markets. This article will provide an overview of this series.

* A carbon footprint is the total amount of greenhouse gas emitted throughout its life cycle, including procurement of raw materials, production, use, disposal, and recycling, calculated in CO_2 equivalents. It can be one of the product parameters for product selection.

2. Development Background

Our current *SANUPS E11A* series makes use of a double conversion online topology to supply high-quality power, as well as a passive standby topology that prioritizes efficiency. It is available in output capacities of 1 kVA, 1.5 kVA, 2 kVA, and 3 kVA. Although this series comes with many desirable features, UPSs in this capacity range have, in recent years, been facing tough competition in terms of cost both in Japan and abroad.

At the same time, there has been greater urgency to address environmental issues on a global scale, thereby increasing demand for environmentally-friendly products.

Against such a backdrop, we developed the *SANUPS E11B* as an environmentally-friendly series that inherits the features of the *SANUPS E11A* series, while also significantly reducing costs and providing compatibility with the global market.

3. Features

Figure 1 shows the appearance of the 1 kVA model of the *SANUPS E11B*. The series lineup is available in output capacities ranging from 1 to 3 kVA. Its appearance and features are identical to the E11A series.

Fig. 1 *SANUPS E11B* 1 kVA model

3.1 UPS topology

The *SANUPS E11B* series comes with two modes, namely, a Double Conversion mode and Economy mode. The modes can be used differently depending on the settings. When the setting is fixed to Double Conversion mode, the inverter always supplies high-quality power. When set to automatic, the UPS will switch between the Double Conversion mode and Economy mode depending on the state of the input power, achieving both the high-quality power and energy savings. The modes are described below.

(1) Double Conversion mode (High-quality power mode)

Figure 2 shows the power supply path for the Double Conversion mode. First, the grid power is rectified and converted to a DC voltage. This is then converted by the inverter to a sinusoidal voltage and output. Therefore, even when the grid power fluctuates, the fluctuation is absorbed by the rectifier and inverter, enabling the UPS to keep supplying high-quality power. The batteries are constantly float-charged by the charger so that they stay charged and ready for a power grid failure such as a power outage or voltage dip. If the grid frequency is within the frequency synchronization range (within ±1% when set to the Double Conversion mode fixed; when set to automatic, the range depends on the synchronization range setting), the UPS outputs a voltage with a frequency synchronized with the AC input frequency. If it is outside the range, it outputs a constant frequency of 50 Hz or 60 Hz and does not synchronize with the input voltage.

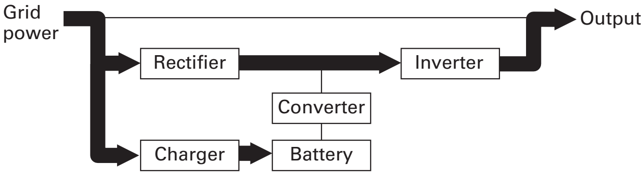

Fig. 2 The power supply path for the Double Conversion mode

(2) Economy mode (High-efficiency mode)

Figure 3 shows the power supply path for the Economy mode. When the grid power is stable, the inverter stops, allowing the grid power to be output as is. This eliminates the loss through the inverter and increases efficiency. The batteries are constantly float-charged by the charger so that they stay charged and ready for a power grid failure such as a power outage or voltage dip. When the grid power becomes unstable, the UPS automatically transfers to the Double Conversion mode described in the (1) above. This is done without interruption if the input frequency is within the synchronization range, or there will be an interruption within 8 ms if it is outside the range.

In the Economy mode, it is necessary to immediately detect abnormalities in the grid power. This is ensured by monitoring the input voltage waveform.

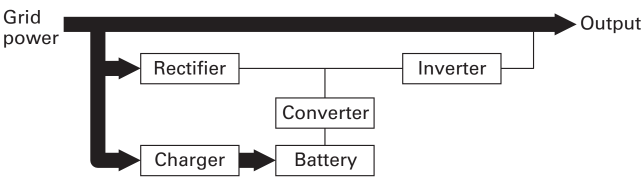

Fig. 3 The power supply path for the Economy mode

(3) In the event of a power grid failure

Figure 4 shows the power supply path during a power grid failure. If the power grid causes an interruption or power outage, the rectifier and charger will be stopped, then the converter will operate to supply power from batteries. If a grid failure occurs during the Double Conversion mode, battery power will be supplied to the load without interruption. If a grid failure occurs during the Economy mode, there will be an interruption within 8 ms until battery power will be supplied.

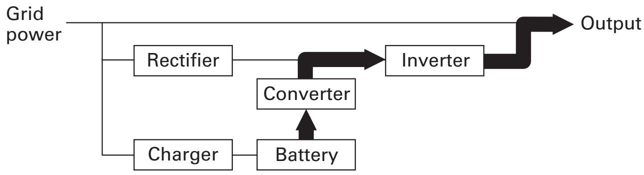

Fig. 4 The power supply path during a power grid failure

3.2 Wider input voltage and frequency ranges

We revised the converter's circuit type and control method to widen the operating input voltage range and frequency range.

The *SANUPS E11B* series support two voltage classes: 100 V and 200 V (1.5 kVA capacity is only available in the 100 V class). For the 100 V class, the E11A's 80 to 115 V input voltage range has been widened to 55 to 150 V. For the 200 V class, the previous 160 to 230 V range has been widened to 110 to 300 V. As for the input frequency range, the previous E11A's ranges of 46 to 54 Hz at 50 Hz and 55.2 to 64.8 Hz at 60 Hz have been widened to 40 to 120 Hz at 50/60 Hz.

This reduces the number of unnecessary transfers to battery power and prevents battery wear and degradation when the unit is used in areas with flactuating grid power.

3.3 Wider operating temperature range

To improve the cooling efficiency, we reduced the amount of wiring and revised the component layout to ensure sufficient air passage. We also selected components that can be used at low temperatures. These revisions have expanded the operating temperature range from 0 to 40°C to -10 to 55°C.

With a wider operating voltage range, the new product can be used in more harsh environments where the previous product could not be used.

3.4 Modular input and output

It was expected that there would be situations where it would be necessary to change the input plugs or power outlets when the product would be used in overseas markets.

To be prepared for this, we modularized the input and output part and gave it a structure that could be removed from the main UPS unit. This aimed to allow the input and output parts to be changed independently, which would be much faster and easier than redesigning the entire UPS. Figure 5 shows the rear view of the 1 kVA model of the *SANUPS E11B*, and Figure 6 shows its internal structure. The area enclosed by the border is the modularized input and output part.

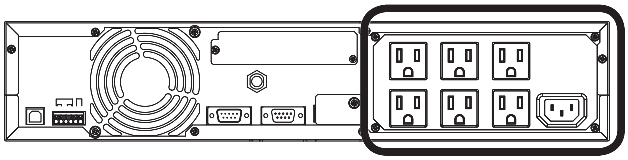

Fig. 5 Rear view of the *SANUPS E11B* 1 kVA model

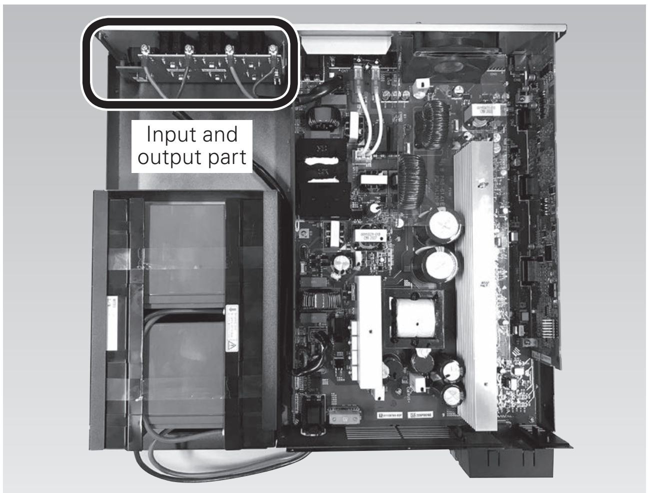

Fig. 6 The internal structure of the *SANUPS E11B* 1 kVA model

3.5 Reduced internal wiring

As shown in Figure 6, we directly connected PCBs to each other using connectors and reduced the amount of wiring by replacing it with PCB patterns as much as possible. The reduction in wiring not only reduced assembly man-hours and material costs, but also secured internal clearances for air passage required for cooling.

This also aimed to make disassembly and recycling easier at the end of the product life, minimizing the impact on the environment.

3.6 Environmentally friendly

Previously, we used to include a power management software CD-ROM with UPSs. However, CD-ROMs become no longer necessary after installation, so we decided not to include them and instead to have the latest software version downloaded from our website. This helps reduce the amount of plastic waste. As for the Instruction Manual, we used to provide a booklet with UPSs. However, we now only provide a simplified version that gives the minimum necessary instructions. Electronic versions of full Instruction Manuals have been made available for download from our website. This has the advantage of allowing customers to always download and use the latest version as needed without creating extra waste.

For the packaging, we changed the packaging material from styrofoam to corrugated cardboard to reduce the amount of plastic use for less impact on the environment.

4. Specifications

Table 1 shows the standard specifications of the *SANUPS E11B* 1 kVA model.

5. Conclusion

In this article, we introduced the *SANUPS E11B*, the successor series to our *SANUPS E11A* hybrid UPS series.

With widened input ranges, the new product can be used around the world with peace of mind even in areas with unstable power grids and in harsh operating environments.

Moreover, we reduced the amount of wiring for easier recycling, while also changing the packaging material and how we provide the software and Instruction Manual to make the product more environmentally friendly.

We will continue to develop products that can meet the needs of our customers by grasping their needs accurately in a timely manner and contribute to creating value for their businesses.

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Table 1 Standard specifications of the *SANUPS E11B* 1 kVA model

Items			Ratings and standards		Remarks	
Model			E11B102 100 V class	E11B102 200 V class		
Output capacity			1 kVA / 0.8 kW			
Cooling system			Forced air cooling			
AC input	Input plug		IEC 60320-C14			
	Number of phases/wires		Single-phase 2-wire			
	Rated voltage and range		55 to 150 V	110 to 300 V	When in Double Conversion mode The range varies by the load level.	
			Within ±8% of 100/110/ 115/120 V	Within ±8% of 200/208/220/ 230/240 V	When in Economy mode	
	Rated frequency		40 to 120 Hz			
	Required capacity		1.1 kVA or less		Max. capacity during battery recovery charging	
	Input power factor		0.95 or greater		At rated output	
AC output	Output outlet		NEMA 5-15R × 6	IEC 60320-C13 × 6		
	Number of phases/wires		Single-phase 2-wire			
	Rated voltage		100/110/115/120 V	200/208/220/ 230/240 V	User-selectable	
	Voltage regulation		Within ±2% of rated voltage		When in Double Conversion mode	
	Rated frequency		50 Hz or 60 Hz		Same as the input frequency (auto-select)	
	Frequency regulation		Within ±1% of rated frequency		In Double Conversion mode fixed setting	In battery operation: Within ±0.5%
			Within ±1, 3, or 5% of the rated frequency		In “automatic” setting	
	Voltage waveform		Sinusoidal			
	Voltage harmonic distortion		At linear load: 3% or less At 100% rectifier load: 8% or less		At rated output	
	Transient voltage fluctuation	For abrupt load change	Within ±5% of rated voltage		0 ⇔ 100% load step changes at rated input	
		Loss or return of input power			At rated output	
		Abrupt input voltage change			For ±10% changes	
	Response time		5 cycles or less			
	Load power factor		0.8 (lagging)		Variation range 0.7 (lagging) to 1.0	
	Overcurrent protection		Automatic transfer to bypass circuit at 105% or more		With automatic retransfer function	
	Overload protection	Inverter	105%		200 ms	
		Bypass	15 A (current protector)	8 A (current protector)	200% for 30 s, 800% for 2 cycles (reference values)	
Battery	Type		Small-sized valve-regulated lead-acid (VRLA) battery			
	No. of batteries		2		12 V per battery, serial	
	Rated capacity		68 W		15-minute rate, 34 W per battery	
	Backup time		3 min (800 W) 5 min (700 W)		At a 25˚C ambient temperature, using new, fully charged batteries.	
Heat dissipation			25 W		When in Economy mode	
			130 W		When in Double Conversion mode, after battery charging completed	
Input leakage current			3 mA or less			
Environment			Ambient temperature: -10 to +55˚C Relative humidity: 20 to 90%		Batteries stop charging at temperatures above 40˚C	
Acoustic noise			40 dB or less		When in Economy mode	1 m from front of UPS, A-weighting
			48 dB or less		When in Double Conversion mode	

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Works on the development and design of power supplies.

Servo Systems Division

Yasutaka Narusawa

SANYO DENKI contributes to society by developing new products that help enhance the performance and quality of our customers' equipment and create new value. This article will introduce the features and innovative points of the servo systems products we developed in FY2020, and describe how they are contributing to our customers and society.

In particular, we will discuss wireless communication products for motion controllers and servo amplifier products.

For starters, we developed the *Wireless Adapter 3A*. This device adds wireless features to the *SANMOTION C S100* motion controller (hereinafter, *S100*). It makes it easy to wirelessly communicate using a wireless LAN or smartphone in a factory by simply mounting it to the USB connector of the *S100* motion controller and setting a few minimal parameters. It also complies with the radio laws and regulations of many countries, so it can be used at various overseas production sites.

In recent years, IoT has been advancing at production sites with the aim of improving productivity and predictive maintenance of equipment. This product contributes to the advancement of IoT at production sites by making it easy to collect various types of data from machinery and servo control devices via wireless communication.

In the field of AC servo amplifier products, we enhanced our *SANMOTION R* 400 VAC input multi-axis servo amplifier lineup to support output capacities ranging from 20 kW to 37 kW. The new models are smaller and more lightweight, achieving a 61% reduction in volume and 60% reduction in mass compared to previous models. This was done by adopting a high-density component layout and optimizing the heat dissipation design.

We have also developed an EtherCAT interface type control unit based on our *SANMOTION R 3E Model* servo amplifier. The control unit can help improve the performance and processing quality of machinery.

By combining these products with our previously developed 15 kW system, we were able to create a 400 VAC multi-axis servo amplifier lineup of products capable of driving motors with output capacities ranging from 550 W to 37 kW. As a result, we were able to complete a lineup that supports the same outputs as that of our 200 VAC multi-axis servo amplifier. This gives customers an even greater choice of products to meet their various machinery needs.

Below are overviews of the new products and their features.

■ *Wireless Adapter 3A*

In recent years, factory networks have been switching to wireless LANs to enable flexible changing of production lines to accommodate the diverse needs of consumers. Furthermore, the use of IoT in factories has been accelerating as a method for collecting and analyzing information from production sites with the aim of improving productivity and predictive maintenance of equipment.

Against this backdrop, we developed the *Wireless Adapter 3A* as a product that can add wireless communication features to the *S100* motion controller and be used at various production sites overseas.

The features of this product are as follows.

1. Easy network connection

This product can connect to a wireless LAN in a factory by simply mounting it to the USB connector of the *S100* motion controller and setting a few minimal parameters. Since it also comes with an access point mode that enables it to act as a master station, it allows wireless devices to connect to each other even in areas where there is no available wireless network.

2. Compliance with regulations in various countries

This product complies with the IEEE802.11b/g/n wireless standard, allowing for faster and farther transmission. It can also be used at various overseas production sites, since it complies with the radio laws and regulations of many countries, including Japan, the United States, European nations, and China. This means that wireless equipment can be standardized without having to worry about replacing devices at each location.

3. Flexible modification of production lines

On production lines, various devices and equipment are wired together using cables to communicate information. When a production line changes, it can take a lot of time to perform the rewiring work. The use of this product eliminates the need to perform wiring, allowing for flexible changes to be made to production lines.

4. Improved maintainability

It can sometime be difficult for operators to access machinery due to their installation location. This product facilitates maintainability even in these types of environments by enabling operators to diagnose machine failures and adjust servo systems from remote locations.

As described above, this product is a wireless device that makes it easy to connect machinery to a wireless LAN in a factory. It can contribute to the construction of flexible production lines and improve maintainability.

■ *SANMOTION R* 400 VAC Input Multi-axis Servo Amplifier (37 kW, 300/600 A)

In recent years, the expansion of industrial globalization has increased the need for servo systems with 400 VAC input specifications, primarily in European and Asian regions. In response to this demand, we released the *SANMOTION R* 400 VAC input multi-axis servo amplifier in 2018 as a product that can support output capacities up to 15 kW. Since its release, it has gained much popularity among customers.

More recently, we have expanded our lineup by developing a 400 VAC input multi-axis servo amplifier that can support output capacities up to 37 kW, as well as a new EtherCAT communication type control unit.

The features of these products are as follows.

1. Expanded lineup

We developed a 37 kW power supply unit as well as 300 A and 600 A servo amplifier units capable of driving servomotors with output capacities ranging from 20 kW to 37 kW. By combining these products with our previously developed 15 kW system, we were able to create a 400 VAC input multi-axis servo amplifier lineup of products capable of driving motors with extensive output capacities ranging from 550 W to 37 kW.

As for control units, we released an EtherCAT interface type control unit based on our *SANMOTION R 3E Model*. This control unit can also be used with 200 VAC systems. This means that the host controller can be shared between 200 VAC and 400 VAC systems.

2. Downsizing and weight reduction

The products have achieved a smaller size by using the latest power modules and adopting an optimized thermal design and high-density component layout. They also use fewer components and achieve weight savings. In particular, the 600 A amplifier unit is much smaller and more lightweight, achieving a 61% reduction in volume and 60% reduction in mass compared to our previous model. Furthermore, we designed the structure of the heat sink to suppress component temperature change and increase product reliability, while also achieving a smaller size.

3. Increased control unit performance

The new EtherCAT control unit has better servo response and suppresses machine resonance and vibration better than previous products. It also comes with functions for monitoring the status of power consumption and communication quality and for estimating the remaining life of dynamic brake (DB) relays and holding brakes. These capabilities and features contribute to improving machinery productivity and processing quality and can also be used to perform various diagnostics and preventive maintenance.

Details on these new products are provided in the New Product Introduction section of this Technical Report.

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Development of the *SANMOTION R* 400 VAC Input Multi-axis Servo Systems (37 kW, 300/600 A)

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Satoshi Hiramitsu　Noriaki Kasuga　Shuhei Nakazawa

1. Introduction

The *SANMOTION R* 200 VAC input multi-axis servo system developed in 2013 is available in a wide range of models for driving servo motors with output capacities of 550 W to 37 kW. Since its release, it has gained much popularity among customers.

In recent years, the expansion of industrial globalization has increased the need for systems that support 400 VAC input power, primarily in European and Asian regions. In response to this demand, we released 400 VAC input multi-axis servo systems that support output capacities up to 15 kW in 2018.

We developed new models for the 400 VAC input multi-axis servo system for driving 20 kW to 37 kW large-output servo motors. As a result, we now offer an expanded lineup of 400 VAC multi-axis servo amplifiers that can drive 550 W to 37 kW output motors. Furthermore, to improve machinery processing quality and productivity, we developed an EtherCAT interface control unit that maintains the performance and features of our existing *SANMOTION 3E Model*.

In this article, we introduce the features and key development points of the new models: a single-axis EtherCAT control unit, 37 kW power supply unit, and 300 A and 600 A amplifier units.

2. Product Overview

2.1 Appearance and dimensions

Our *SANMOTION R* 400 VAC input multi-axis servo system consists of a control unit, power supply unit, and amplifier unit, allowing for flexible system configurations.

The units are shown in Figures 1 and 2, while their dimensional drawings are shown in Figures 3 to 5.

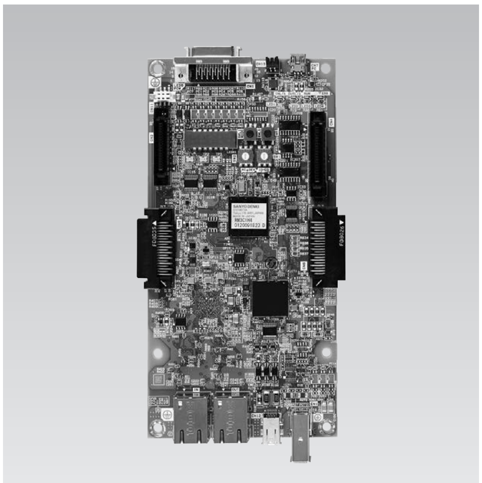

Fig. 1 Appearance
(Single-axis EtherCAT control unit)

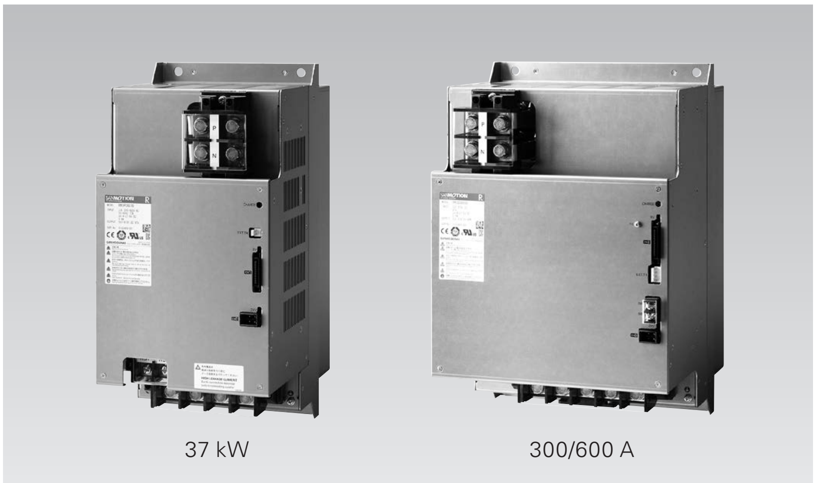

Fig. 2 Appearance
(Power supply unit and amplifier unit)

For the control unit, we added a new single-axis EtherCAT interface model designed based on our existing *SANMOTION R 3E Model* servo amplifier. We also released a 37 kW power supply unit as well as 300 A and 600 A amplifier units capable of driving servo motors with output capacities of 20 kW to 37 kW.

When using multiple control units, the units can be connected to each other with connectors, as shown in Figure 3, achieving both space and wiring savings. The power supply unit and amplifier unit both have a height of 380 mm, which is exactly the same as that of the existing 15 kW system for easy installation in the control panel.

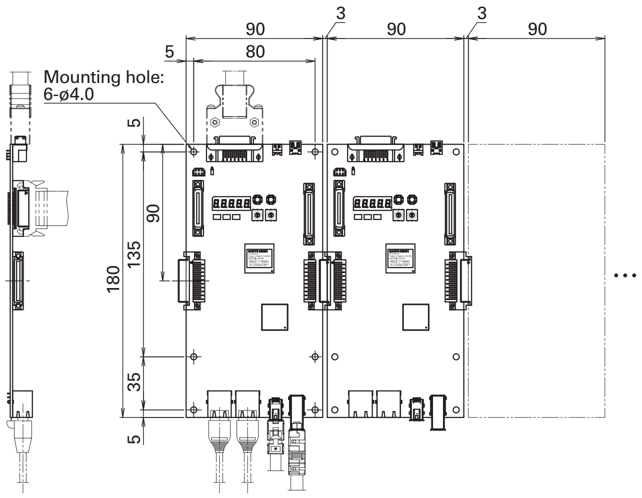

Fig. 3 Dimensions (Single-axis EtherCAT control unit)

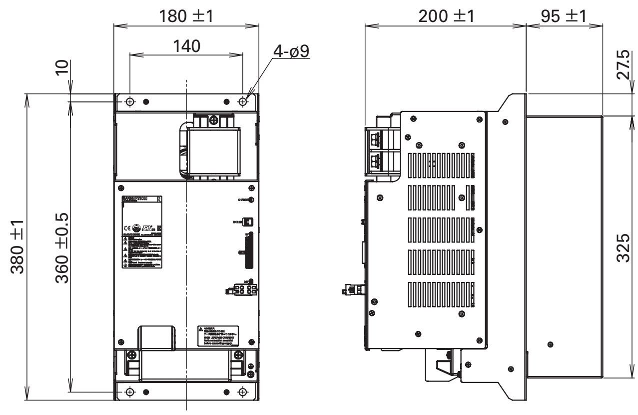

Fig. 4 Dimensions (Power supply unit 37 kW)

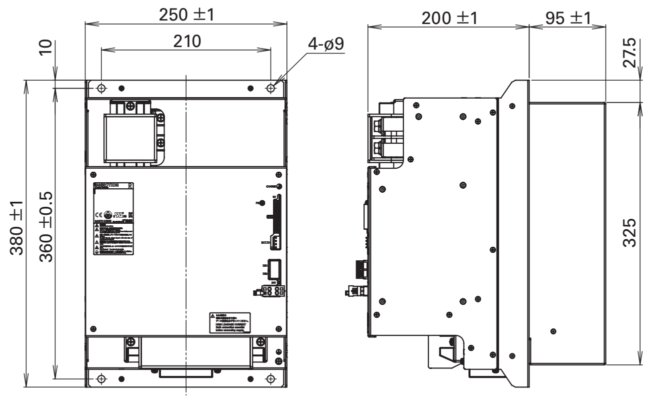

Fig. 5 Dimensions (Amplifier units 300 and 600 A)

2.2 Basic specifications

2.2.1 Basic specifications of units

Table 1 shows the specifications common to all units, and Table 2 to 4 show the basic specifications of individual units.

Table 1 Common specifications for 400 VAC multi-axis servo systems

Environment	**Operating/storage temperature**	0 to +55˚C / -20 to +65˚C
	Operating/storage humidity	Below 90% RH (non-condensing)
	Operating altitude	Below 1,000 m
	Vibration/impact	4.9 m/s² / 19.6 m/s²
Standards	**UL/cUL**	UL 61800-5-1 / C22.2 No274-13
	Low Voltage Directive	EN 61800-5-1
	EMC Directive	EN 61800-3, EN 61326-3-1
	Functional safety*	ISO 13849-1: PL=e EN 61508 SIL3, EN 62061 SILCL3
	KC Mark	KN 61000-6-2, KN 61000-6-4

* Models with Safe Torque Off function

Table 2 Basic specifications of control unit

Interface			EtherCAT
Size			90 (W) × 180 (H) × 21 (D) mm
Mass			0.12 kg
Compatible equipment	**Motors**		*SANMOTION R* rotary motors
	Encoders	**Standard**	Battery-less absolute encoder
			Absolute encoder for incremental systems
		Options	Battery-backup absolute encoder
			Wire-saving incremental encoder
Functions	**Safety functions**		STO (Safe Torque Off)
	EtherCAT communication		• Touch probe • Homing • Firmware update via FoE (File access over EtherCAT) • Parameter upload/download via FoE
	General-purpose I/O		Input: 7, output: 2
	Mechanical vibration/ resonance suppression		• Feedforward (FF) vibration suppression control (2 levels) • Vibration control for track control • Adaptive notch filter
	Servo tuning		• Auto tuning response 40 levels • Servo tuning support function
	Start-up,monitoring, diagnosis		• Virtual motor operation • Driver recorder • Encoder/amplifier temperature monitoring • Power consumption monitoring • Encoder communication quality monitoring • Service life diagnosis (Relay and holding brake)

Table 3 Basic specifications of power supply unit

Output capacity		**37 kW**
Input voltage	**Main circuit**	380 to 480 VAC +10%, -15%
	Control circuit	24 VDC ±15%, 4.6 A (When 5 axes of amplifier units connected)
Size		180 (W) × 380 (H) × 295 (D) mm
Mass		16 kg
Mounting		Wall-mounted
Cooling system		Forced air cooling (ducted cooling)

Table 4 Basic specifications of amplifier unit

Amplifier capacity		**300 A**	**600 A**
Input voltage	**Main circuit**	457 to 747 VDC	
	Control circuit	24 VDC ±15%, 2.2 A	24 VDC ±15%, 2.6 A
Output current	**Rated output**	66 Arms	89 Arms
	Maximum	157 Arms	250 Arms
Compatible motors		Up to 30 kW	Up to 37 kW
Size		250 (W) × 380 (H) × 295 (D) mm	
Mass		20 kg	21 kg
Mounting		Wall-mounted	
Cooling system		Forced air cooling (ducted cooling)	

2.2.2 Unit configurations

This system allows multiple amplifier units and control units to be connected to a single power supply unit.

Table 5 shows the series lineup, and Figure 6 shows various system combinations.

Table 5 System lineup

Control unit	Single-axis analog		4-axis EtherCAT		Single-axis EtherCAT	
+						
Power supply unit	16 kW				37 kW	
+						
Amplifier unit	25 A	50 A	75 A	150 A	300 A	600 A
Compatible motors	Up to 2 kW	Up to 3.5 kW	Up to 5.5 kW	Up to 15 kW	Up to 30 kW	Up to 37 kW

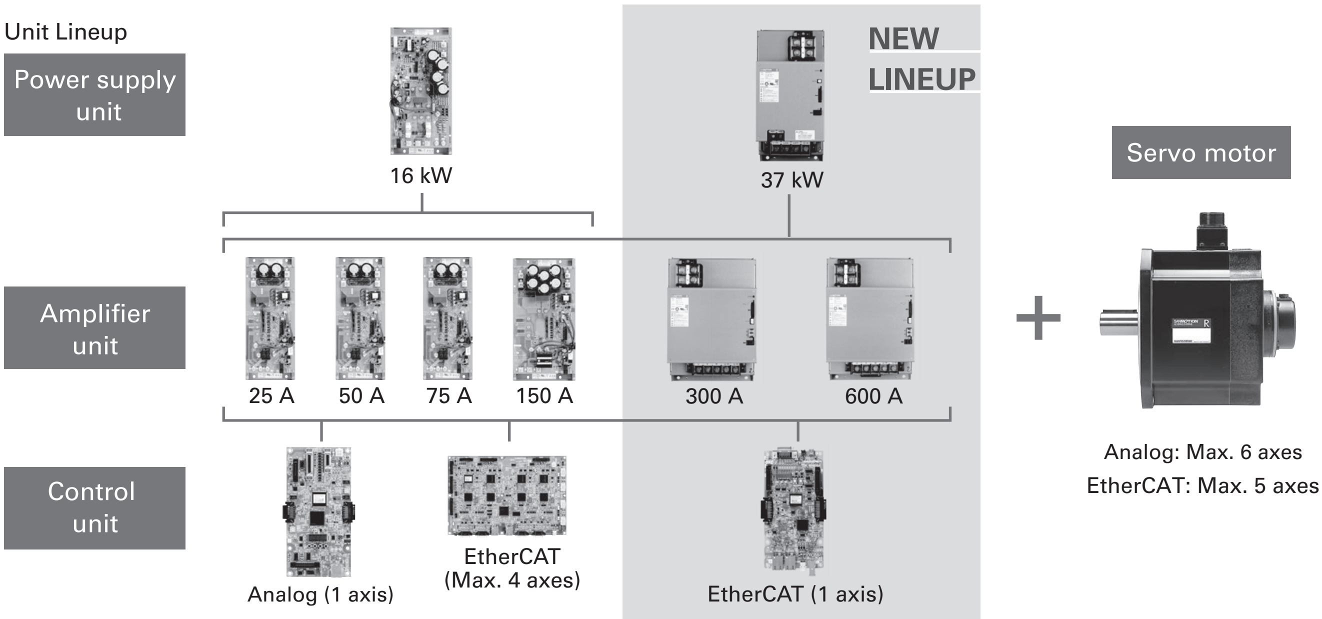

Fig. 6 System unit configurations

3. Features

3.1 Expanded lineup

By adding the 37 kW system to the lineup, we expanded the 400 VAC input multi-axis system lineup to support output capacities ranging from 550 W to 37 kW. The 37 kW power supply unit can also be combined with the existing 25 to 150 A open-frame amplifier units, as shown in Figure 7. As a result, the 400 VAC lineup is now available in comparable output variations to that of our 200 VAC multi-axis servo amplifier.

In addition, the control unit is compatible with both 200 VAC and 400 VAC systems, allowing the 200 VAC system to be replaced without changing the host controller.

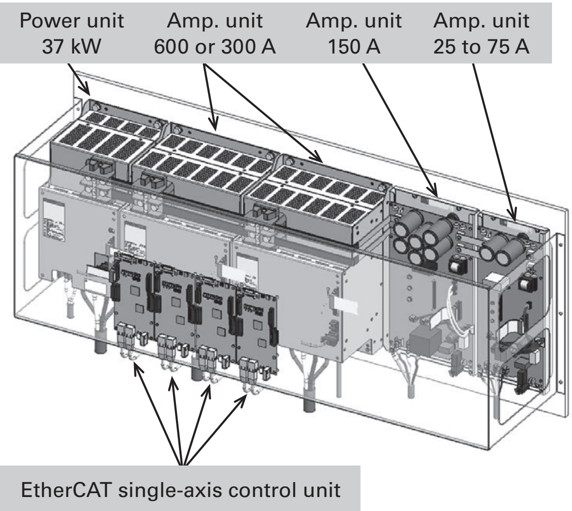

Fig. 7 System illustration

3.2 Downsizing and weight reduction

We used latest power modules in the power supply unit and amplifier unit to reduce power loss. They also use a high-performance heat sink to optimize heat dissipation. Furthermore, we achieved downsizing by using a high-density component layout.

We also reduced the number of components to reduce weight by using an integrated copper bar structure for the unit's internal wiring.

As a result, the new 600 A amplifier unit has been made smaller and lighter, achieving a 61% volume and 60% weight compared to the previous model. This realized the industry's smallest size* as a servo system to be combined with a 37 kW motor.

The downsizing and weight reduction help reduce its occupancy in customer equipment, and build more flexible layouts and downsize customer equipment.

3.3 Increased control unit performance

We newly developed a control unit designed based on the *SANMOTION R 3E Model* servo amplifier. It has better servo responsiveness and suppresses machine resonance and vibration better than the previous model, while also improving machinery productivity and processing quality. It also comes with functions for monitoring the status of power consumption and encoder communication quality and for estimating the remaining life of dynamic braking (DB) relays and holding brakes. These rich features contribute to the environmental diagnosis and preventive maintenance of machinery.

* Based on our own research as of February 2021.

4. Key Points of Development

As mentioned above, the size of the new models has been made much smaller than that of our previous models. The thermal design of a product is a key for downsizing. Also, large-capacity servo amplifiers require larger electrolytic capacitors and other components. These components must be secured with silicone rubber to suppress vibration Conventionally, it had been difficult to automate this process and often needed to be done manually. We will now introduce the key points of development and the technique we used to solve this automation challenge.

4.1 Optimal heat-dissipating structure

These servo systems are often used in the injection axis of injection molding machines.

Injection axes involve a process where melted plastic is cooled and solidified in a mold, which requires the motor to perform above its rated torque to apply pressure for over 10 seconds.

The repetition of this process significantly changes the temperature of the power module (IGBT) used in the amplifier unit, and reduces the life of the component (thermal cycle life).

As a solution to this, we optimized the heat-dissipating structure of the new models to suppress this temperature change. In particular, the thermal cycle life is significantly affected by the thermal capacity of the power module's copper base and heat sink. Recognizing this, we determined the optimal base thickness through the analysis of the temperature change in power modules by modifying the heat sink base thickness using the thermal analysis simulation shown in Figure 8. As a result, we were able to substantially reduce the size, while also securing sufficient component service life and improving the product reliability.

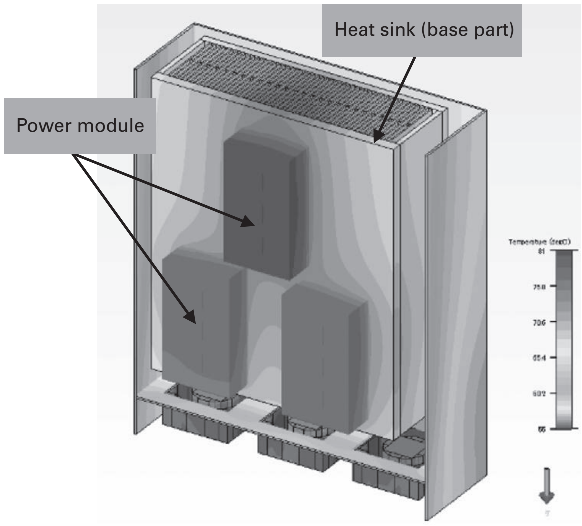

Fig. 8 Heat analysis with heat dissipation fin thickness varied

4.2 Improved fan cover

To achieve higher component density, we equipped the 600 A amplifier unit and 37 kW power supply unit with built-in cooling fans.

We also designed a new fan cover made from sheet metal as a countermeasure against intrusion of foreign objects. Compared to conventionally used filter kits, we were able to improve the airflow vs. static pressure characteristics and reduce noise levels. Moreover, since filter replacement is no longer necessary, they can be used for a long time with peace of mind.

4.3 Increased productivity and production quality

To improve productivity and quality, we have been developing production techniques using automation technology and robots.

As an anti-vibration measure, the new models use silicone rubber to secure their large snap-in aluminum electrolytic capacitors. Conventionally, the application of silicone rubber has been done by workers, resulting in inconsistencies in regard to the application area and amount of silicone rubber. For the new models, we devised a method that uses robots to do the application. By automating this process, we successfully reduced the inconsistency for improved productivity and quality.

5. Conclusion

In this article, we introduced the features and key development points of our new *SANMOTION R Model* 400 VAC input multi-axis servo systems.

(1) A 37 kW power supply unit and 300 and 600 A amplifier units were added to the lineup. Together with our previous models, we now offer an expanded lineup of 400 VAC multi-axis servo amplifiers that can drive 550 W to 37 kW output motors.

(2) We achieved significant downsizing and weight reduction by optimizing their heat-dissipating structures, adopting layouts with higher component density, and reducing the number of components. Therefore, we achieved the industry's smallest* servo system that can drive 37 kW motors.

(3) We released a control unit designed based on our *SANMOTION 3E Model* that can help achieve a higher servo responsiveness and suppress mechanical resonance and vibration better than previous products.

(4) The new models come with functions for monitoring the status of power consumption and encoder communication quality and for estimating the remaining life of components, allowing them to be used for environmental diagnosis and preventive maintenance of machinery.

We expect that the new models will help achieve space and wiring savings in machinery, while also improving productivity and processing quality.

With the addition of new models, the 400 VAC lineup now covers motor outputs ranging from 550 W to 30 kW, which is comparable to our 200 VAC multi-axis servo amplifier lineup, providing customers with an even greater choice of products for their various machinery needs.

Moving forward, we will continue developing and proposing new products that can improve customers' equipment and create value for our customers.

* Based on our own research as of February 2021.

Author

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Shuhei Nakazawa
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Internal Recognition: Invention Excellence Award

Awarded in May 2020

Title	Department	Name
Motor Controller Mounting Structure	Design Dept. 2, Servo Systems Div.	Yuji Ide, Takao Oshimori, Hiroaki Koike
Control and Magnetic Bias Suppression for Grid-connected PV Inverter	Design Dept., Power Systems Div.	Makoto Ishida, Minoru Yanagisawa

Internal Recognition: Manufacturing Excellence Award

Awarded in May 2020

<table>
<tr><th>Title</th><th>Department</th><th>Name</th></tr>
<tr><td>Mold Structure for Improved Releasability</td><td>Engineering Sect. 2, Production Dept.
Production, Cooling System Div.</td><td>Yoichi Yamada,
Shinsuke Okubo</td></tr>
<tr><td rowspan="3">High-Precision Assembly Technique
for the Light-Emitting Module
of Incremental Encoders</td><td>Subsect. 2, Process Engineering Sect. 1,
Production Engineering Dept., Servo Systems Div.,</td><td>Ikuo Takeshita</td></tr>
<tr><td>Production Engineering and Development Sect.,
Production Engineering Dept., Servo Systems Div.</td><td>Hideyuki Ayuzawa</td></tr>
<tr><td>SANYO DENKI Techno Service CO., LTD.</td><td>Daiki Kobayashi,
Yoshihiro Kojima</td></tr>
</table>

Major Patents

■ **Patents registered in 2020**

Registration Number	Title	Inventor(s)
Europe - 02458223	AXIAL-FLOW FAN WITH DOUBLE IMPELLERS	Honami Osawa, Katsumichi Ishihara, Toshiyuki Nakamura, Takashi Kaise, Yoshihiko Aizawa, Seiji Nishimura
Europe - 02173022	BRUSHLESS MOTOR STATOR	Izumi Onozawa, Masashi Miyazawa
Europe - 02355309	ELECTRIC FAN	Naruhiko Kudo, Tomoaki Ikeda, Haruhisa Maruyama
Europe - 02685625	MOTOR CONTROLLER	Takahisa Toda
Europe - 02814167	FAN MOTOR CONTROL UNIT	Yo Muramatsu, Takahisa Toda, Kenta Nishimaki
Europe - 02811627	FAN MOTOR, INLINE TYPE FAN MOTOR AND ASSEMBLY METHOD OF THE SAME	Katsumichi Ishihara, Masashi Nomura, Tomoko Hayashi
China - ZL201410443400.X	THREE−PHASE ELECTROMAGNETIC MOTOR	Toshihito Miyashita, Manabu Horiuchi
Korea - 102073801	STATOR, METHOD FOR MANUFACTURING STATOR, AND MOTOR	Toshihito Miyashita, Masashi Suzuki, Manabu Horiuchi, Masaki Musha
U.S. - 10666108	STATOR, METHOD FOR MANUFACTURING STATOR, AND MOTOR	Toshihito Miyashita, Masashi Suzuki, Manabu Horiuchi, Masaki Musha
Taiwan - I687028	MOTOR STRUCTURE	Toshihito Miyashita, Manabu Horiuchi
Europe - 02996230	STEPPER MOTOR	Yasushi Yoda, Koji Nakatake, Masaaki Ohashi
Hong Kong - HK1216945	STEPPER MOTOR	Yasushi Yoda, Koji Nakatake, Masaaki Ohashi
Taiwan - I682610	STEPPER MOTOR	Yasushi Yoda, Koji Nakatake, Masaaki Ohashi
China - ZL201510772342.X	MOTOR CONTROL APPARATUS	Yuji Ide, Masahisa Koyama, Shintaro Koichi
Taiwan - I691159	MOTOR CONTROL APPARATUS	Yuji Ide, Masahisa Koyama, Shintaro Koichi
China - ZL201511023274.3	FAN CASING AND FAN APPARATUS	Naoya Inada, Honami Osawa
Taiwan - I712357	FAN CASING AND FAN APPARATUS	Naoya Inada, Honami Osawa
Taiwan - I688325	MOTOR CONTROL DEVICE	Yuji Ide, Takao Oshimori, Hiroaki Koike
China - ZL201610079626.5	MOTOR CONTROL APPARATUS	Yuji Ide, Michio Kitahara, Toshio Hiraide
Taiwan - I703809	MOTOR CONTROL APPARATUS	Yuji Ide, Michio Kitahara, Toshio Hiraide
Taiwan - I696808	MEASUREMENT DEVICE	Katsumichi Ishihara, Takahisa Toda, Yo Muramatsu
Taiwan - I683196	MOTOR CONTROL APPARATUS	Yuji Ide, Michio Kitahara, Toshio Hiraide
China - ZL201610087797.2	MOTOR CONTROL DEVICE	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi, Toshio Hiraide
Taiwan - I705657	MOTOR CONTROL DEVICE	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi, Toshio Hiraide
Taiwan - I703270	IMPELLER AND FAN DEVICE	Jiro Watanabe, Masashi Miyazawa, Akira Nakayama
U.S. - 10781819	IMPELLER AND FAN DEVICE	Jiro Watanabe, Masashi Miyazawa, Akira Nakayama
China - ZL201610232262.X	BIDIRECTIONAL AXIAL FAN DEVICE	Satoshi Fujimaki, Toshiya Nishizawa, Takashi Kawashima
Taiwan - I699484	BIDIRECTIONAL AXIAL FAN DEVICE	Satoshi Fujimaki, Toshiya Nishizawa, Takashi Kawashima
China - ZL201610329511.7	SENSOR FOR MOTOR	Takayoshi Seki
China - ZL201610649891.2	LINEAR MOTOR	Yasushi Misawa, Hiroyuki Sato, Akihiko Takahashi, Satoshi Sugita

Registration Number	Title	Inventor(s)
Korea - 102178178	LINEAR MOTOR	Yasushi Misawa, Hiroyuki Sato, Akihiko Takahashi, Satoshi Sugita
China - ZL201610649582.5	AXIAL BLOWER AND SERIES-TYPE AXIAL BLOWER	Toshiyuki Nakamura, Shuji Miyazawa
Europe - 03133292	AXIAL BLOWER AND SERIES-TYPE AXIAL BLOWER	Toshiyuki Nakamura, Shuji Miyazawa
Taiwan - I702340	AXIAL BLOWER AND SERIES-TYPE AXIAL BLOWER	Toshiyuki Nakamura, Shuji Miyazawa
Japan - 06745661	MOTOR CONTROL APPARATUS	Yuji Ide, Michio Kitahara, Toshio Hiraide
Japan - 06653542	MOTOR CONTROL APPARATUS	Yuji Ide, Michio Kitahara, Toshio Hiraide
China - ZL201610676324.6	MEASUREMENT DEVICE	Masahiro Koike, Tomoaki Ikeda, Takahisa Toda, Yo Muramatsu, Katsumichi Ishihara, Hikaru Urushimoto
China - ZL201611177833.0	MOTOR	Manabu Horiuchi, Toshihito Miyashita
Korea - 102192221	MOTOR	Manabu Horiuchi, Toshihito Miyashita
U.S. - 10848019	MOTOR	Manabu Horiuchi, Mai Shimizu, Jun Kitajima
Japan - 06764670	POWER CONVERTER	Kazuya Nishizawa, Takuya Ozawa
Japan - 06680648	MOTOR CONTROL APPARATUS	Yuji Ide, Toshio Hiraide, Keigo Kikuchi
Japan - 06734752	AUTOMATIC ENCODER DETERMINING DEVICE	Ryuichi Yanagisawa, Masao Mizuguchi
China - ZL201710785510.8	REVERSIBLE FLOW FAN	Yoshihisa Yamazaki
Europe - 03301305	REVERSIBLE FLOW FAN	Yoshihisa Yamazaki
U.S. - 10662973	REVERSIBLE FLOW FAN	Yoshihisa Yamazaki
Europe - 03301306	BLAST FAN	Yoshihisa Yamazaki, Satoshi Fujimaki, Takashi Kawashima, Soma Araki
Japan - 06802022	BLAST FAN	Yoshihisa Yamazaki, Satoshi Fujimaki, Takashi Kawashima, Soma Araki
U.S. - 10837345	BLAST FAN	Yoshihisa Yamazaki, Satoshi Fujimaki, Takashi Kawashima, Soma Araki
U.S. - 10712041	COOLING FAN AUTOMATIC CONTROL SYSTEM AND COOLING FAN AUTOMATIC CONTROL DEVICE	Naoki Murakami, Masashi Murakami
Japan - 06766024	ORDER MANAGEMENT SYSTEM, ORDER MANAGEMENT APPARATUS AND ORDER MANAGEMENT PROGRAM	Shigejiro Miyata, Keigo Kikuchi
Japan - 06676133	ARMATURE MOLDED STRUCTURE	Manabu Horiuchi, Hiroki Sagara, Jun Kitajima, Mai Shimizu, Takashi Matsushita
Japan - 06694500	BOBBIN STRUCTURE OF ARMATURE	Manabu Horiuchi, Hiroki Sagara, Jun Kitajima, Mai Shimizu, Takashi Matsushita
Japan - 06764921	ARMATURE STRUCTURE OF THREE-PHASE MOTOR	Manabu Horiuchi, Hiroki Sagara, Mai Shimizu, Jun Kitajima
Japan - 06643519	MOTOR CONTROL APPARATUS AND INSULATION RESISTANCE	Yuji Ide, Keigo Kikuchi, Toshio Hiraide, Masakazu Sakai

Technical Papers Published Outside the Company in General Technical Journals

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Title of Paper	Authors	Name of Journal	Issued in	Publisher
Feature: Products and Technology Development of Member Companies and the Results of 2020	SANYO DENKI CO., LTD.	Denki (Electrical Appliances)	2020.2	The Japan Electrical Manufacturers' Association (JEMA)
Specialty Technologies for Efficiently Producing Servo Systems Products	Shusaku Magotake, Kazuhiro Makiuchi	Monthly JETI	2020.3	Nippon Syuppan Seisaku Center Inc.
Development of the *SANUPS W73A* Grid-connected Isolated Type	Makoto Ishida, Hirofumi Nishizawa, Tetsuya Fujimaki, Katsutoshi Tanahashi	Monthly JETI	2020.4	Nippon Syuppan Seisaku Center Inc.
Development of *SANMOTION R 3E Model* Servo Amplifiers with Built-in Positioning Function	Naohiro Ito, Hiroyuki Kosuge, Kenichi Fujisawa, Keisuke Ishizaki, Naoki Kubo, Hideaki Nishizawa	Monthly JETI	2020.12	Nippon Syuppan Seisaku Center Inc.

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Title of Paper	Authors	Name of Journal	Issued in	Publisher
Robust Estimation Method for Stator Temperature Based on Voltage Disturbance Observer Autotuning Resistance for SPMSM	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi (Joint-author: Nagaoka University of Technology)	IEEJ Journal of Industry Applications	2020.7	IEEJ

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