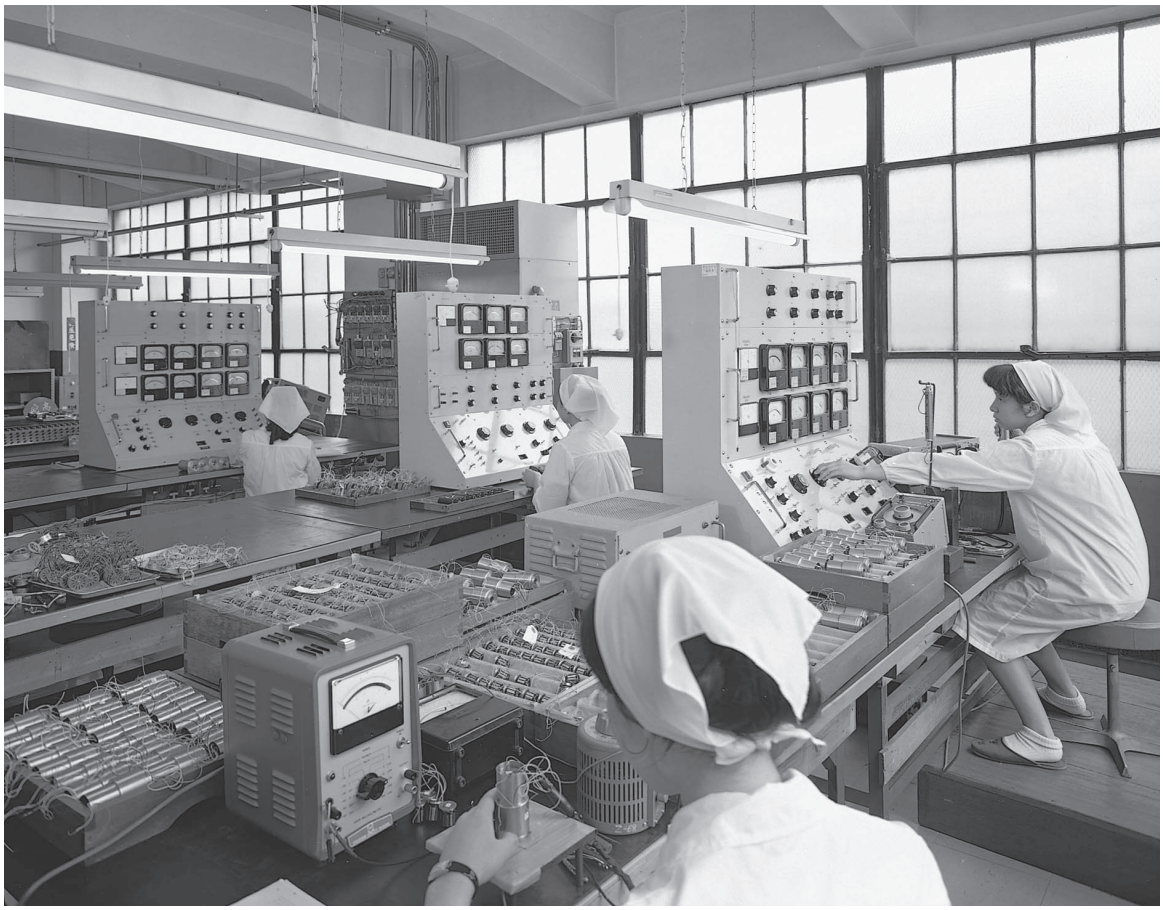
SANYO DENKI

Technical Report

Feature | Technical Developments in 2019



1968
Head Office and Tokyo Works

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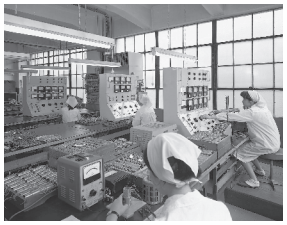
May 2020



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Head Office and Tokyo Works

1968

In 1964, the year of the Tokyo Olympics, SANYO DENKI revamped its management team with the founder Hideo Yamamoto stepping down to become chairman and Hiroshi Yamamoto becoming the second president. The goal of this personnel change was to facilitate the transition from the old to the new generation and indicated our strong determination to wager on our future development.

Following that, we developed the San Ace thin form-factor cooling fans that greatly boosted our position in the small-sized motor field, and small step-angle stepping motors that won large-volume orders from IBM Corporation of the United States for use in computers and peripheral devices, and took great strides toward a new era with the policy of "being a step ahead of the world's technology standards."

Tokyo Works supported our company's development through the production of these small-sized motors.

49 SANYO DENKI TECHNICAL REPORT
May 2020

C O N T E N T S

Monozukuri Working Closely with Customers Operating Officer Motoichiro Naruse 1

Features: Technical Developments in 2019 3

■ **Cooling Systems Division**

Highlights of 2019 and New Products Introduction Michinori Watanabe 3

Oil Proof Fans *San Ace 40WF*, *San Ace 60WF*, *San Ace 80WF*, and *San Ace 92WF* Atsushi Yanagisawa and Others 6

ø70 × 20 mm Centrifugal Fan *San Ace C70* 9TD type Koji Ueno and Others 14

■ **Power Systems Division**

Highlights of 2019 and New Products Introduction Naohiko Shiokawa 18

Expansion of the *SANUPS A11K-Li* Small-Capacity UPS Lineup Takeo Murai and Others 22

Development of the *LAN Interface Card* with Modbus Katsuhiro Yoshizawa and Others 28

■ **Servo Systems Division**

Highlights of 2019 and New Products Introduction Yasutaka Narusawa 35

Development of the *SANMOTION* 20 mm Wide Compact Cylinder Linear Servo Motor Yuqi Tang and Others 39

Development of *SANMOTION R 3E Model* Servo Amplifiers with Built-in Positioning Function Naohiro Ito and Others 43

List of Recipients and Nominees for the 69th JEMA Technological Achievement Award in 2020 49

Major Patents 50

Internal Recognition: Invention Grand Prize (Excellence Award) 52

Internal Recognition: Manufacturing Grand Prize (Excellence Award) 52

Technical Papers Published Outside the Company in General Technical Journals 53

Technical Papers Published Outside the Company 53

Monozukuri Working Closely with Customers

Motoichiro Naruse Operating Officer

SANYO DENKI Group's 8th Mid-term Management Plan, a 5-year plan started in April 2016, marks its final year in 2020.

"Continue to develop world-leading products in terms of quality, performance, and reliability" is one of the main initiatives of this plan.

"Continue to develop" expresses that, rather than merely engaging in product development, we emphasize the element of ceaselessness. To accomplish this initiative, enriching the design environment (both people and equipment) and securing R&D funding are essential. However, SANYO DENKI Group places the greatest emphasis on "Working closely with our customers and listening to their voices."

We also strongly value working closely with and hearing the views of our subcontractors and business partners who provide us with raw materials and parts. Through mutual factory tours and technology exchanges, we strive to forge relationships that enable us to stay abreast of the latest raw materials and parts technologies, and reflect this in product development in a timely manner.

Furthermore, to offer world-leading products, we do not focus our product development on sales volume. Rather, of the above-mentioned principles of "quality, performance, and reliability," we give our top priority to quality. This development policy of making quality our top priority helps distinguish our products in various markets.

In this volume of Technical Report, we will introduce the main new products and technologies released in 2019 in "Technical Developments in 2019."

Cooling Systems products, Power Systems products, and Servo Systems products all incorporate the results of manufacturing ("monozukuri" in Japanese) working closely with customers.

The *San Ace Controller* was developed in response to customers' requests for remote fan monitoring and preventative maintenance via the internet amid the rapid proliferation of IoT. With the fan automatic control function, excessive increase of speed can be prevented, thus significantly contributing to the realization of high energy efficiency and low noise in our customers' equipment.

Due to the frequent occurrence of typhoons, earthquakes, and other natural disasters in recent years, there has been a growing demand for UPSs as backup power supplies for outdoor ICT equipment, such as base stations and remote monitoring devices for disaster management. The *SANUPS N11B-Li* UPS equipped with lithium-ion batteries was designed to meet customer needs for an outdoor UPS that has a wide operating temperature range and require no battery replacement.

The *SANMOTION K* series is a new product in our lineup of DC servo motors, which have a 60-year long history of monozukuri. This product is an ideal example of our "Continue to develop" principle. In recent years, our products have often been used in precision measurement devices and medical equipment. To improve measurement accuracy, such applications require servo motors to have low speed fluctuation and temperature rise. Furthermore, as such devices are installed in quiet environments close to people, servo motors with low noise are essential. This product satisfies these needs of our customers.

A close look at the market environment reveals turbulent and accelerating change best represented by keywords such as AI, IoT, 5G, labor-saving, and disaster management. These changes are occurring on a global scale. The SANYO DENKI Group will ceaselessly pursue our principle of "monozukuri working with our customers" so we may skillfully handle these changes and contribute to our customers' value creation.

Cooling Systems Division

Michinori Watanabe

In our current world, amid a gradual transition to 5G, the next-generation of communication systems, the internet is an essential pillar, supporting our lives and public infrastructure, and has transformed our lifestyles and company activities dramatically.

Against this backdrop, more and more equipment today uses IoT that enables remote control and monitoring via the internet. Naturally, there has been a demand for IoT-ready products that allow easy remote control and monitoring of fans used in equipment to secure stable operation.

Also, as today's ICT equipment and digital signage used outdoors have higher performance and are becoming denser, fans are also required to offer high airflow, high static pressure and environmental durability. Meanwhile, fans used in industrial equipment and flat, thin form-factor equipment are required to be more compact while also achieving higher cooling performance.

To meet these market demands, we developed and launched an industry-first IoT product and fans with industry-leading performance and reliability.

Below are overviews of the products we developed in 2019.

■ IoT-ready Fan Controller

• *San Ace Controller*

Customers demanded products that can control fan speed in line with the operational status of their equipment to achieve higher energy saving, lower noise, and preventive equipment maintenance through remote fan status monitoring.

To meet such demands, we developed and launched *San Ace Controller*, the industry's first IoT-ready fan controller that can connect to a network and be remotely operated and monitored from an external terminal device.

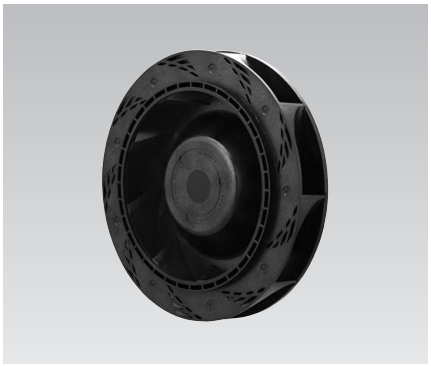
■ Splash Proof Centrifugal Fan

DC Fan

• ø150 × 35 mm *San Ace 150W* 9W2T type

In the quick EV charger, communication cabinet, and digital signage markets, where equipment is often installed outdoors, centrifugal fans are required to have higher splashproof performance.

To meet such market demands, we developed and launched the *San Ace 150W* 9W2T type ø150 × 35 mm Splash Proof Centrifugal Fan which offers the industry's highest(1) airflow and static pressure.



(1) Based on our own research as of March 12, 2019, conducted among equally-sized industrial splashproof centrifugal fans on the market.

■ Splash Proof Blower

DC Fan

• ø97 × 33 mm *San Ace 97W* 9W1B type

In recent years, there has been an increasing demand for blowers that can be used in the high static pressure range for products such as battery packs, ventilation systems, commercial kitchen equipment, and digital signage. This equipment is often used outdoors or in other harsh environments.

To meet such market demands, we developed and launched the *San Ace 97W* 9W1B type Splash Proof Blower that offers the industry's highest(2) airflow and static pressure among IP68-rated, equally-sized splashproof blowers on the market.

(2) Based on our own research as of March 26, 2019, conducted among equally-sized splashproof blowers on the market.

■ Oil Proof Fan

DC Fan

- 40 × 40 × 20 mm *San Ace 40WF* 9WFA type
- 60 × 60 × 20 mm *San Ace 60WF* 9WFA type
- 80 × 80 × 20 mm *San Ace 80WF* 9WFA type
- 92 × 92 × 32 mm *San Ace 92WF* 9WFA type
- 92 × 92 × 25 mm *San Ace 92WF* 9WFA type

The market of servo amplifiers and controllers, which are becoming increasingly high performance, primarily uses oil-proof fans. Therefore, the fans are also required to have higher cooling performance than before. Furthermore, such applications often require fans ranging in size from 40 × 40 mm to 92 × 92 mm.

In response to such demands, we developed and launched five models of 9WFA type Oil Proof Fans which offer the industry's highest(3) airflow and static pressure.

(3) Based on our own research at the time of product release, conducted among equally-sized oil-proof fans on the market.

■ Centrifugal Fan

DC fan

- ø70 × 20 mm *San Ace C70* 9TD type

With increased performance of compact or thin form-factor devices embedded in equipment such as graphics cards, cooling fans with higher cooling performance are demanded.

Also, customers want centrifugal fans to be compact so that they can effectively make use of the limited space inside equipment.

In response to such market demands, we developed and launched the *San Ace C70* 9TD type ø70 × 20 mm Centrifugal Fan which offers the industry's highest(4) airflow and static pressure.

(4) Based on our own research as of October 29, 2019, among equally-sized industrial centrifugal fans on the market.

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Oil Proof Fans *San Ace 40WF, San Ace 60WF, San Ace 80WF,* and *San Ace 92WF*

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Seiji Takeuchi Yoshihisa Yamazaki Yusuke Okuda Tatsuya Midorikawa

Yukihiro Nagatsuka Naoya Ozumi Masahiro Inukai Kwon Hyukjun

1. Introduction

Servo amplifiers and controllers are used to control machine tools and industrial robots, and fans are used to cool these devices. These devices are often located in environments exposed to oil mist, therefore oil-proof fans are used due to their high reliability. As today's high-performance devices generate more heat, the oil-proof fans used in these devices are also required to have higher performance.

To meet this demand, we developed and released four high-performance Oil Proof Fan models, the *San Ace 40WF*, *San Ace 60WF*, *San Ace 80WF*, and *San Ace 92WF* 9WFA types. This article introduces the features and performance of these products.

2. Product Features

Figures 1 to 4 show the appearance of the new models. The new *San Ace 40WF*, *San Ace 60WF*, and *San Ace 92WF* offer higher airflow and higher static pressure while maintaining size and mounting compatibility with our current models. The new *San Ace 80WF* achieves higher airflow and static pressure with a thickness of just 20 mm, thinner than any of our existing 80 × 80 mm Oil Proof Fans.

Fig. 1
40 × 40 × 20 mm
San Ace 40WF
9WFA type

Fig. 2
60 × 60 × 20 mm
San Ace 60WF
9WFA type

Fig. 3
80 × 80 × 20 mm
San Ace 80WF
9WFA type

Fig. 4
92 × 92 × 32 mm
San Ace 92WF
9WFA type

Below is a summary of the new models' structural features.

(1) Figure 5 shows the coating on electrical components. Electrical components (windings and circuits) are coated by a protective material with excellent oil resistance.
(2) Compared to standard fans, a wider clearance is provided between the blade tips and inner surface of the frame to prevent the fan from locking up due to oil or dust buildup.

Fig. 5 Coating of electrical components

3. Product Overview

3.1 Dimensions

Figures 6 through 9 show the dimensions of the new models.

The fans' external dimensions and mounting hole dimensions are unchanged and compatible with our current models.

3.2 Expected life

The new models have 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).

3.3 Characteristics

3.3.1 General specifications

Tables 1 shows the general specifications for the new models. We designed them with a rated voltage of 24 V to make them suitable for use in factory automation applications, where our Oil Proof Fans are mainly used.

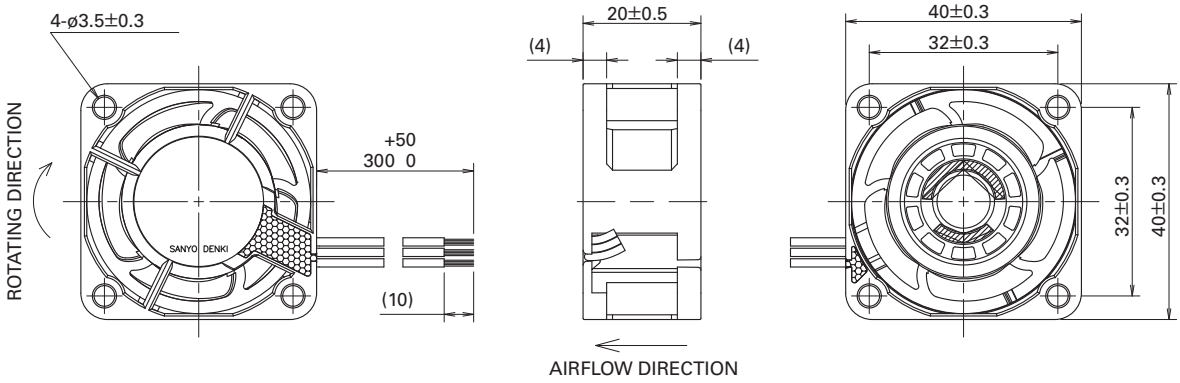

Fig. 6 Dimensions of *San Ace 40WF* (unit: mm)

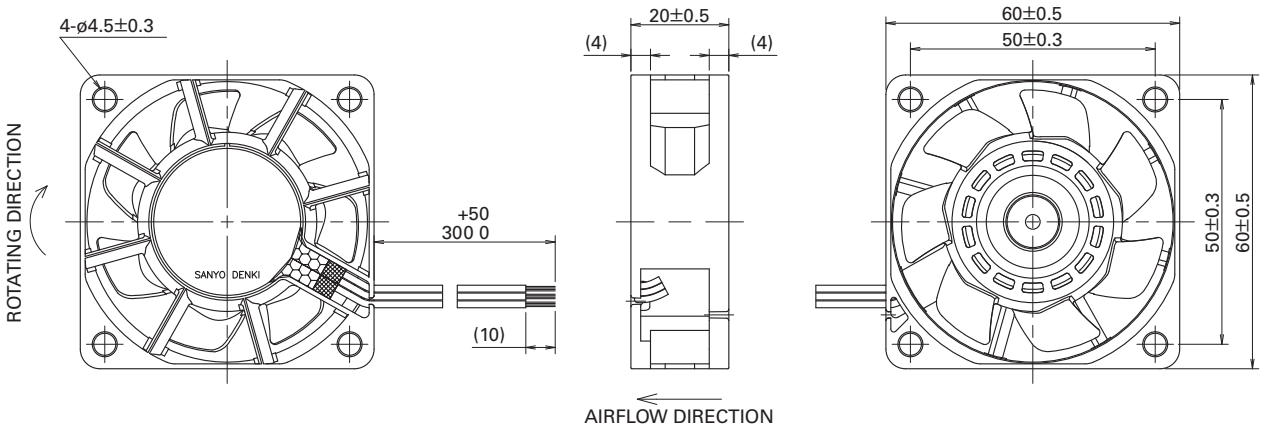

Fig. 7 Dimensions of *San Ace 60WF* (unit: mm)

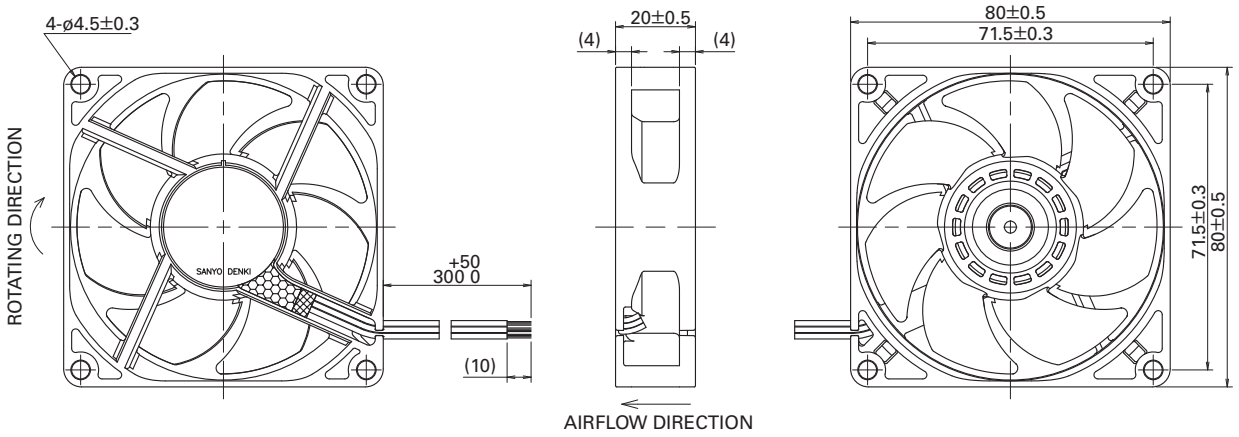

Fig. 8 Dimensions of *San Ace 80WF* (unit: mm)

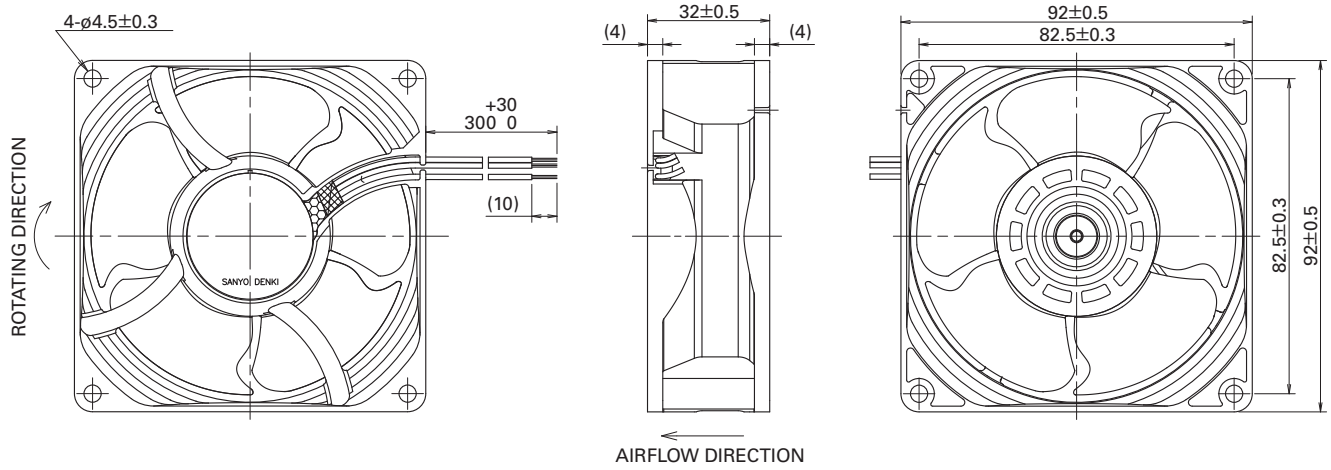

Fig. 9 Dimensions of *San Ace 92WF* (unit: mm)

Table 1 General specifications for the new models

Model no.	Rated voltage [V]	Operating voltage range [V]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow		Max. static pressure		SPL [dB(A)]	Operating temperature [°C]	Expected life [h]
						[m^3/min]	[CFM]	[Pa]	[inchH_2O]			
9WFA0424G6001	24	20.4 to 27.6	0.11	2.6	17,000	0.31	10.9	170	0.68	48	-20 to +70	40000 at 60°C (70000 at 40°C)
9WFA0624G6001		15 to 27.6	0.16	3.8	7,700	0.79	27.9	158	0.63	48		
9WFA0824G6001		15 to 27.6	0.15	3.6	6,000	1.44	50.8	105	0.42	48		
9WFA0924G2001		12 to 27.6	0.58	13.9	9,600	3.1	109.5	380	1.53	63		

Note: The expected life at an ambient temperature of 40°C is for reference purposes only.

3.3.2 Airflow vs. static pressure characteristics

The airflow vs. static pressure characteristics for the new models in Figures 10 through 13 show the respective upper and lower limits of their rated voltage and operating voltage range.

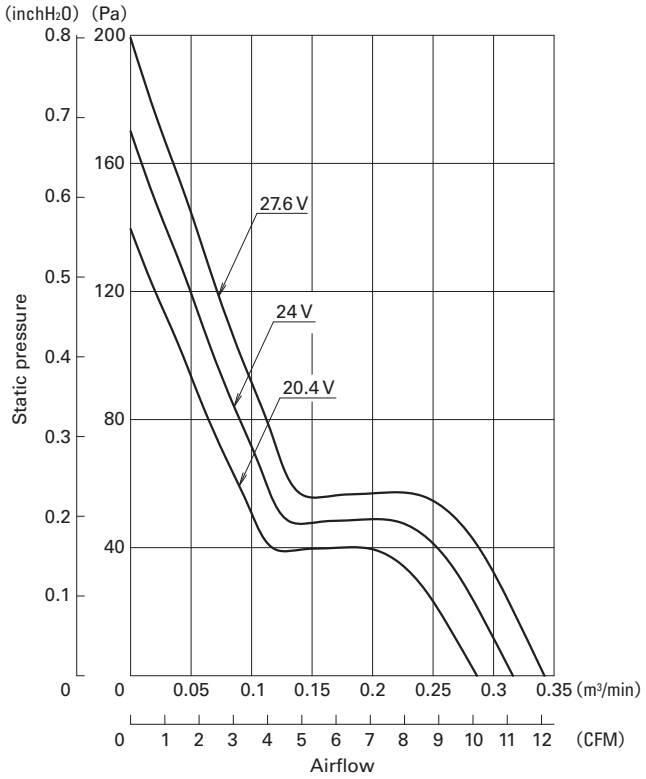

Fig. 10 Airflow vs. static pressure characteristics of *San Ace 40WF*

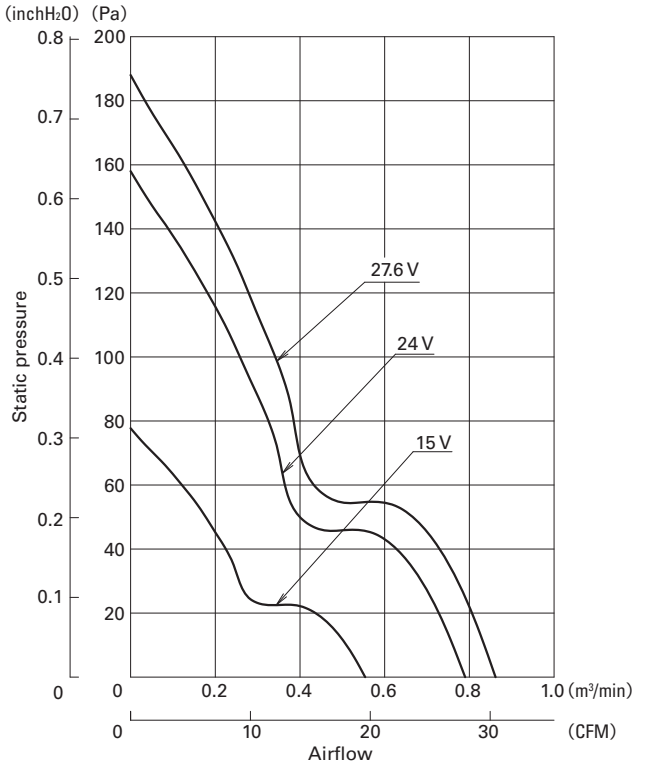

Fig. 11 Airflow vs. static pressure characteristics of *San Ace 60WF*

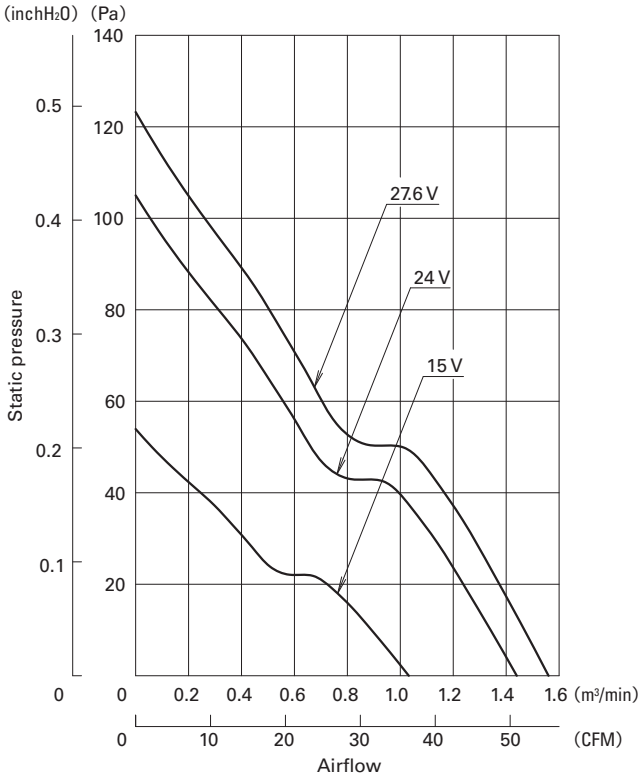

Fig. 12 Airflow vs. static pressure characteristics of *San Ace 80WF*

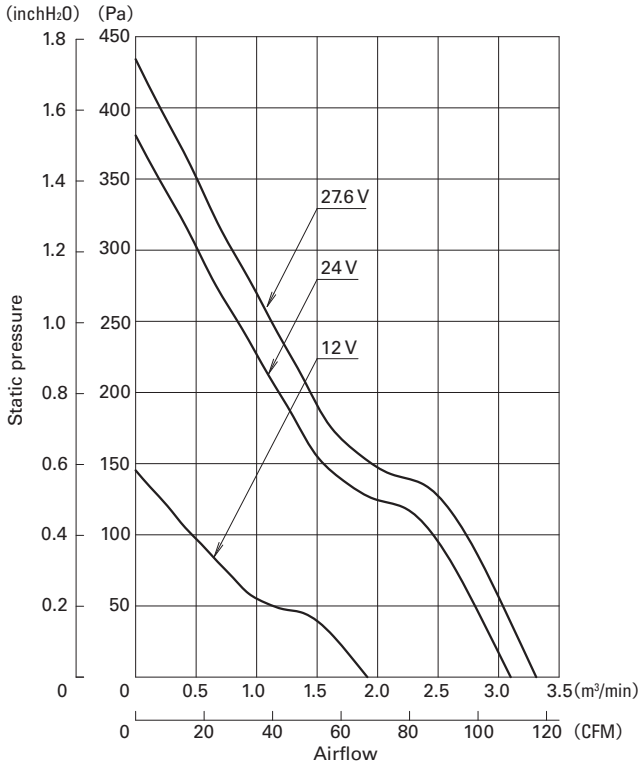

Fig. 13 Airflow vs. static pressure characteristics of *San Ace 92WF*

4. Comparison with Current Models

Figures 14 through 17 compare the airflow vs. static pressure characteristics of the new and current models. Compared to the current models, the new models have greater maximum airflow and maximum static pressure. Despite its 5 mm thinner frame size than the current 80 × 80 × 25 mm Oil Proof Fan, the new *San Ace 80WF* model has both greater maximum airflow and maximum static pressure.

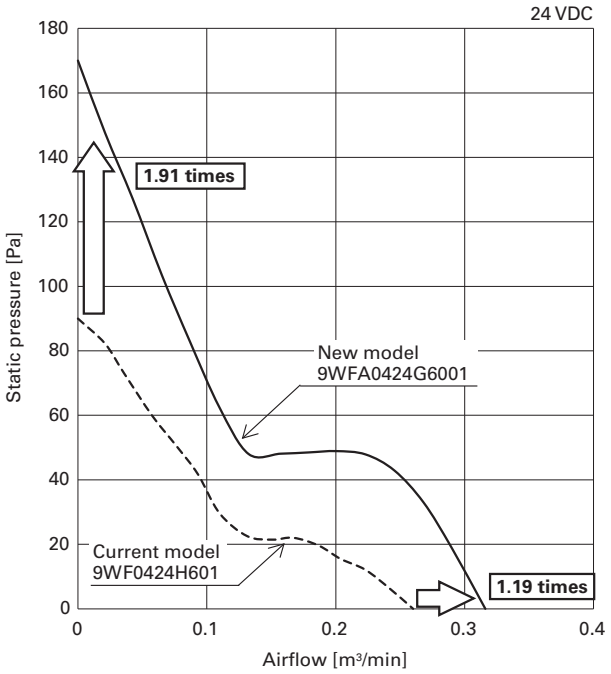

Fig. 14 Comparison of the airflow vs. static pressure characteristics for the new and current *San Ace 40WF* models

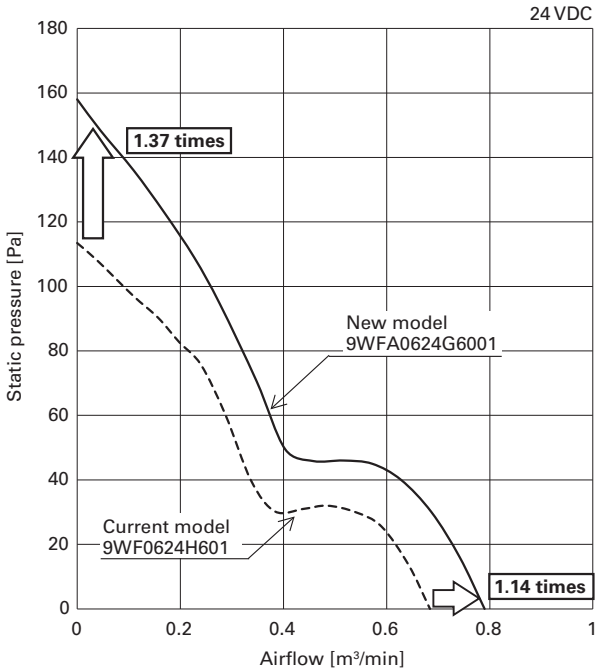

Fig. 15 Comparison of the airflow vs. static pressure characteristics for the new and current *San Ace 60WF* models

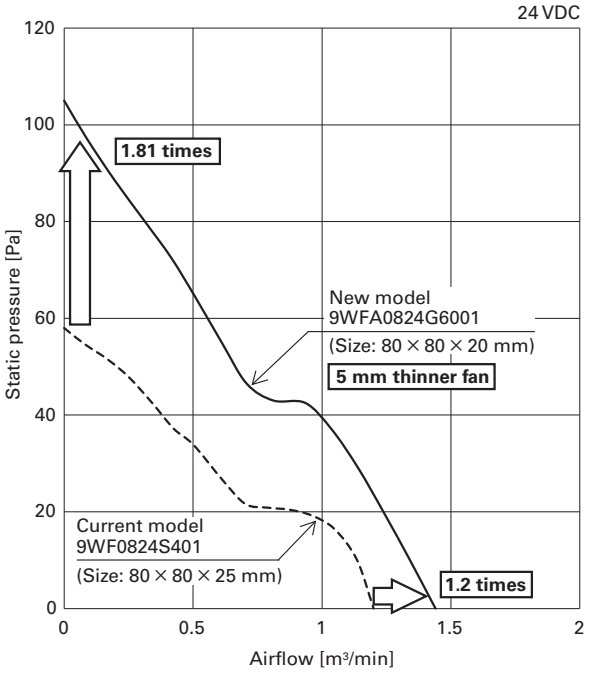

Fig. 16 Comparison of the airflow vs. static pressure characteristics for the new and current *San Ace 80WF* models

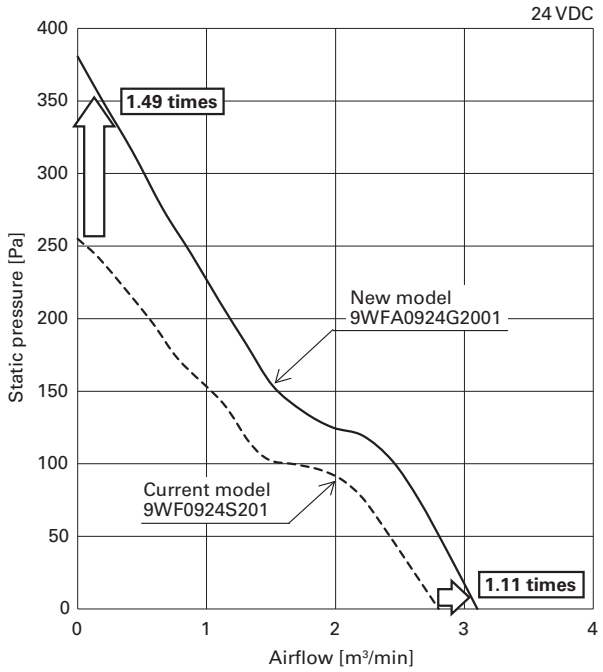

Fig. 17 Comparison of the airflow vs. static pressure characteristics for the new and current *San Ace 92WF* models

New model Current model

Fig. 18 Shape comparison of the new and current *San Ace 80WF* models

The new models offer higher airflow and higher static pressure than the current models while featuring good oil proof performance.

We redesigned the impeller and frame to achieve higher performance, and used a high-efficiency motor and drive method to reduce power consumption while increasing fan speed compared to the current models.

The key points of development are explained below.

4.1 Impeller and frame

When redesigning the impellers and frames of each new model, we conducted numerous simulations and practical evaluations for various combinations of parameters such as the number, length, and angle of blades, and the number and shape of frame spokes. In this way, we determined the optimal design for excellent airflow efficiency. Moreover, we increased the frame strength over the current models to suppress the increase in vibration caused by higher speeds.

The example in Figure 18 compares the shapes of the impellers and frames for the current and new *San Ace 80WF* models.

4.2 Motor and circuit

Regarding the motors of the new models, we reviewed the stator shape and used a motor core with greater efficiency than that of the current models, and revised the circuit components. This resulted in reduced power consumption and increased speed.

Figure 19 compares the power consumption and the airflow vs. static pressure characteristics between the new and current *San Ace 80* models at the same maximum airflow. This graph makes the comparison with the speed of the new model reduced to the point of equal maximum airflow. It demonstrates that static pressure is higher in most ranges and power consumption is lower in all ranges than the current model.

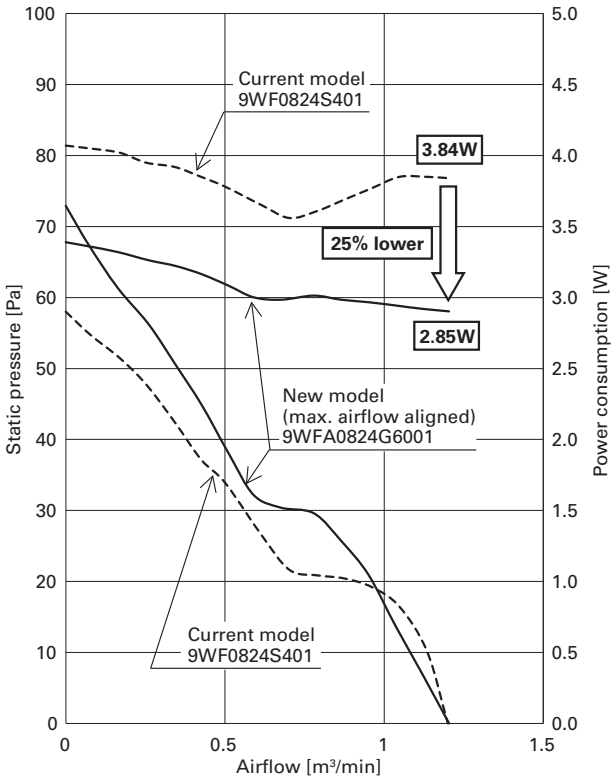

Fig. 19 Airflow vs. static pressure characteristics and power consumption comparison of the new and current *San Ace 80WF* models

5. Conclusion

This article introduced the features and performance of four new models of high-performance Oil Proof Fans: the *San Ace 40WF*, *San Ace 60WF*, *San Ace 80WF*, and *San Ace 92WF* 9WFA types.

Compared with our current models, the four new models offer higher airflow and higher static pressure. As such, we believe they can contribute to the cooling of today's high-performance, heat-generating equipment such as servo amplifiers and controllers.

We wish to continue developing products that meet market needs and contribute to the creation of our customers' new value, and help customers achieve happiness and make their dreams come true.

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ø70 × 20 mm Centrifugal Fan *San Ace C70* 9TD type

Koji Ueno Takashi Kawashima Masaki Kodama Hiromitsu Kuribayashi

1. Introduction

In recent years, equipment has been becoming smaller and thinner, and the cooling fans used inside it are also required to be smaller and thinner.

There is a particularly strong demand for higher cooling performance in compact, thin profile devices like graphics cards embedded in equipment that is becoming increasingly high performance.

Centrifugal fans are suitable for these applications, and there is a need for smaller and thinner centrifugal fans with higher cooling performance.

To meet this demand, we developed the ø70 × 20 mm *San Ace C70* 9TD type Centrifugal Fan (hereinafter "new model") that is compact and thin profile in a size which is a first for the market.

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

2. Product Features

The features of the new model are:

(1) New size
(2) High airflow and static pressure
(3) Low power consumption and sound pressure level (SPL)

Figure 1 shows the appearance of the new model. It has an outer diameter of 70 mm and a thickness of 20 mm.

Fig. 1 ø70 × 20 mm Centrifugal Fan *San Ace C70* 9TD type

3. Product Overview

3.1 Dimensions

Figure 2 shows the dimensions of the new model. The outer diameter of the impeller is 70 mm, and the thickness from the bottom surface of the frame to the top surface of the impeller is 20 mm. It has three M3-threaded mounting holes on the bottom surface.

3.2 Specifications

3.2.1 General specifications

Table 1 shows the general specifications for the new model. It has a rated voltage of 12 V, rated speed of 9,200 min^{-1}, and a PWM control function.

Figure 3 illustrates an installation example of an inlet nozzle 109-1106 for the new model, and Figure 4 demonstrates the installation dimensions. The specifications and characteristics shown are with an inlet nozzle installed. Three M3 screws are used to secure the fan, and four sets of M4 screws and nuts are used to install the inlet nozzle.

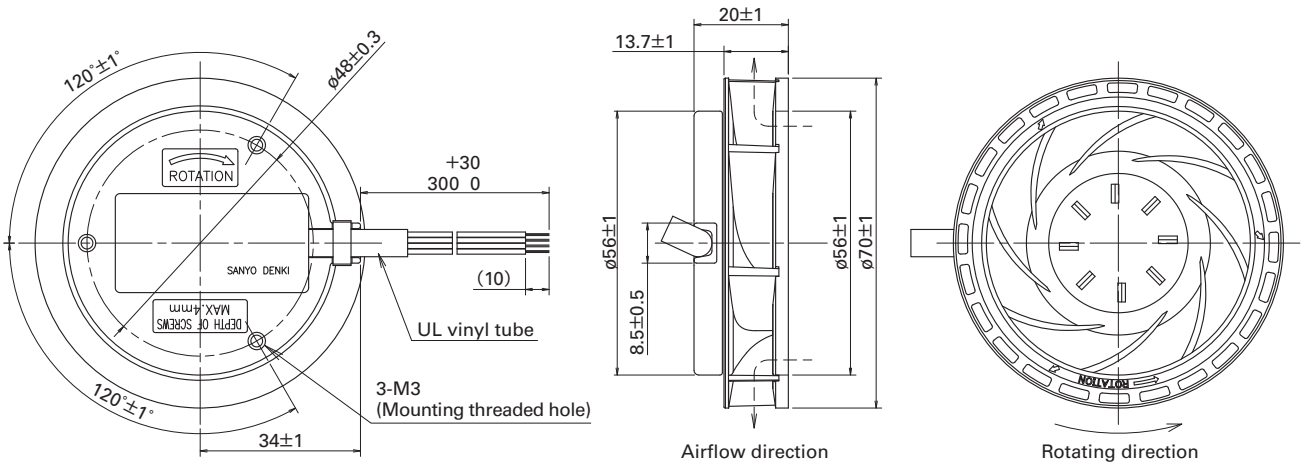

Fig. 2 Dimensions of the new model (unit: mm)

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		SPL [dB(A)]	Operating temperature range [°C]	Expected life [h]
							[m^3/min]	[CFM]	[Pa]	[inchH_2O]			
9TD12P6G001	12	10.8 to 13.2	100	1.0	12	9,200	1.13	39.9	560	2.24	61	-20 to +70	40,000 at 60°C (70,000 at 40°C)
			20	0.1	1.2	2,000	0.23	8.1	25	0.10	30		

* Speed is 0 min^{-1} at 0% PWM duty cycle. Input PWM frequency: 25 kHz
Note 1: When equipped with our inlet nozzle (model no.: 109-1106).
Note 2: The expected life at an ambient temperature of 40°C is for reference purpose only.

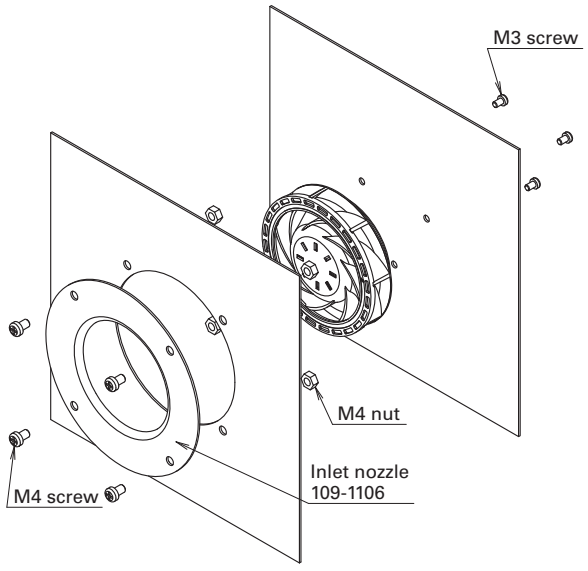

Fig. 3 Installation of inlet nozzle on new model

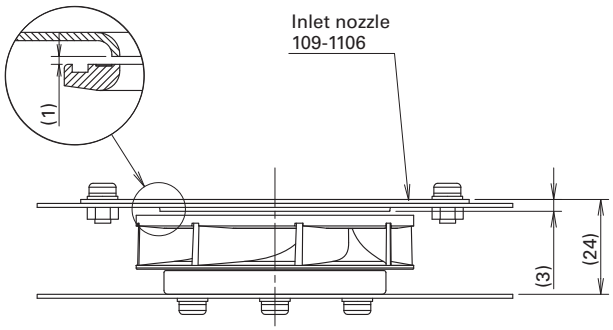

Fig. 4 Dimensions of new model with inlet nozzle installed (unit: mm)

3.2.2 Airflow vs. static pressure characteristics

Figure 5 shows the airflow vs. static pressure characteristics for the new model. The curves demonstrate the PWM duty cycle at 100%, 50%, 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. See Figure 5 for the airflow vs. static pressure characteristics at different PWM duty cycles.

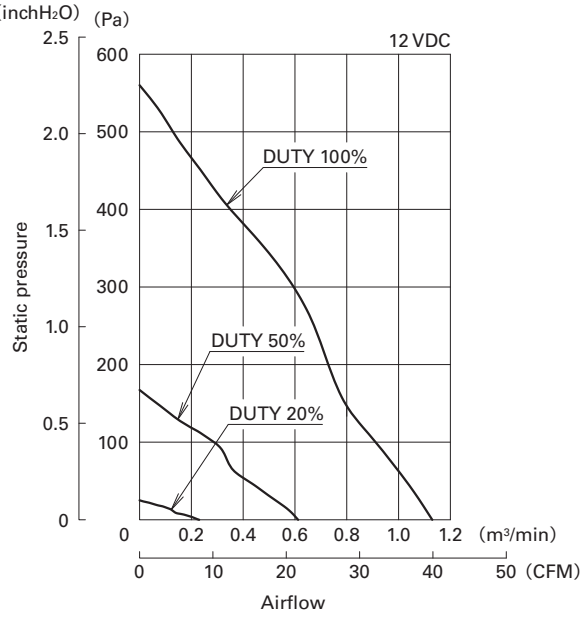

Fig. 5 Airflow vs. static pressure characteristics of new model

3.2.4 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).

4. Key Points of Development

The new model achieves high airflow and high static pressure despite the compact and thin profile.

The key points of development are explained below.

4.1 Compact and Thin Profile

To make the fan smaller and thinner, the motor needed to be made smaller. However, motor heat generation and motor torque issues arose. We solved these issues and achieved a thickness of 20 mm by taking the following measures.

(1) Solution for motor heat generation

We successfully suppressed the motor's temperature rise due to heat generation by using a die cast aluminum frame with excellent heat dissipation and establishing a self-cooling structure with vents on the rotor's intake face. Figure 6 shows the cooling structure of the new model.

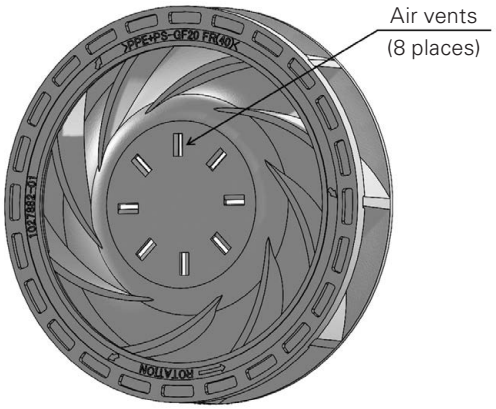

Fig. 6 Cooling structure of the new model

(2) Solution for motor torque

Motor torque can be improved by increasing the motor's diameter. However, as the ratio of the motor diameter to impeller size becomes larger, the air flow path narrows and the airflow vs. static pressure characteristics decreases. As such, we set the motor diameter to minimize the airflow vs. static pressure characteristic reduction and raised motor efficiency by designing a new circuit, achieving the necessary motor torque.

4.2 Impeller and inlet nozzle design

We optimized the impeller design by using fluid simulation with the motor size for the necessary torque and maximum flow path. Figure 7 shows a fluid simulation.

Moreover, we prepared a dedicated inlet nozzle, which is shown in Figure 3, for the new model. With the shape and mounting position optimized, as shown in Figure 4, the new model achieves high airflow and static pressure as well as lower SPL and power consumption.

Fig. 7 Fluid simulation example

5. Comparison with the Current Model

Figure 8 shows a comparison of the airflow vs. static pressure characteristics for the new model and a 76 × 20 mm Blower (hereinafter "current model") of similar size with the same impeller structure as a Centrifugal Fan.

Compared with the current model, the new model's maximum airflow has increased 3.9 times and maximum static pressure has increased 1.9 times.

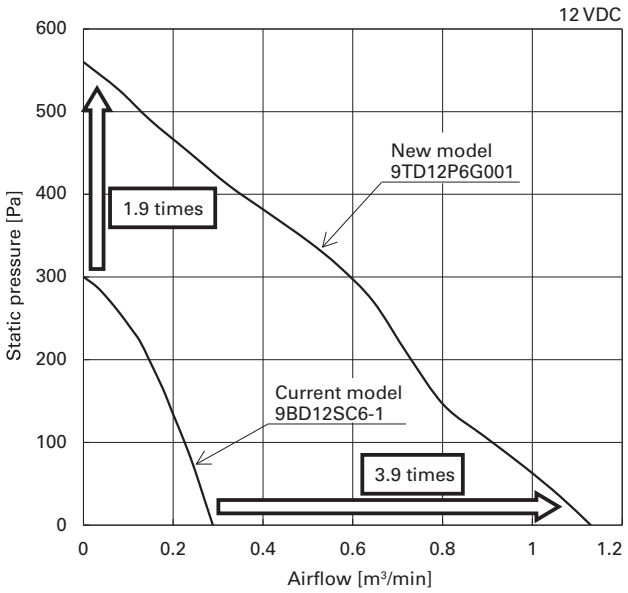

Fig. 8 Airflow vs. static pressure characteristics for the new model and the current model

6. Conclusion

This article introduced some of the features and performance of the ø70 × 20 mm Centrifugal Fan *San Ace C70* 9TD type.

With a higher-efficiency motor and optimized structure, the new model realized high cooling performance despite the compact and thin profile.

In the future, it is expected that equipment in the market will become smaller and thinner. Accordingly, there will be limited component installation space inside equipment, and the resulting higher density will make it more difficult to secure an airflow path.

The new model is the most compact of our Centrifugal Fans, and with its high airflow and static pressure, we believe it will greatly contribute to solving our customers' issues.

We will continue to stay ahead of the diversifying market and develop products that create value for our customers.

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2019 was the year in which real-world examples of smart factories leveraging IoT and AI emerged. Smart factories use IoT equipment and ICT to gather and analyze data to significantly improve energy efficiency and productivity. In addition to the ongoing advance of 5G communication and the predicted further growth in popularity of AI technology, countries around the world are advancing their respective initiatives,(1) and it is expected that this will bring innovative change to the manufacturing and logistics industries in the 2030s.

Meanwhile, 2019 was also a year in which uneasiness toward climate change intensified considerably. In the past five years, the highest average global temperatures ever recorded(2) have been reached. In addition, the sea rise forecast for the year 2100 increased significantly over previous forecasts.(3) In Japan, a number of large-scale typhoons damaged critical infrastructure and heavily impacted individuals' lives and corporate activities.

Power supply equipment and related products offered by the Power Systems Division include uninterruptible power supplies (UPS) and emergency power supplies supporting factories and critical infrastructure, power conditioners for renewable energy generation systems helping to prevent global warming, and networking products. Many of our customers have high expectations for such products as essential equipment to maintain factory production and critical infrastructure. In 2019, the Power Systems Division released the following new products.

Starting with UPSs, we developed the *SANUPS A11M* highly-reliable parallel redundant UPS, which can be used all over the world. In addition, we added new models to our *SANUPS N11B-Li* and *SANUPS A11K-Li* lineups of UPSs equipped with lithium-ion batteries, which we have been aggressively expanding in recent years.

In terms of renewable energy-related products, we enriched the lineup of our *SANUPS W73A* power conditioner for wind power and hydro power generation systems, adding a grid-connected isolated type that can be used during power outages.

For networking products, we developed the *SANUPS LAN Interface Card*, which is equipped with a Modbus(4) TCP/RTU communication function.

This article provides an overview of each of these products.

(1) Some examples include the German government's Industry 4.0, GE America's Industrial Internet, the Chinese government's Made in China 2025, and Connected Industries advocated by Japan's Ministry of Economy, Trade and Industry (METI).
(2) According to a report by the WMO (World Meteorological Organization).
https://public.wmo.int/en/media/press-release/wmo-seasonal-update-indicates-above-average-temperatures (2019.9.2)
(3) According to a report published by IPCC (Intergovernmental Panel on Climate Change).
https://www.ipcc.ch/2019/09/25/srocc-press-release/ (2019.9.25)
(4) A standard communication protocol for data transfer between industrial equipment.

■ Development of the *SANUPS A11M* Double Conversion Online UPS

The *SANUPS A11M* is a double conversion online UPS that easily achieves high reliability and increased capacity through parallel operation of multiple units. The *SANUPS A11M* uses our own parallel operation control technology that controls each unit individually to enable stable operation, including backup operation at power outages, even when a communication error occurs between units. This product has a single-phase 2-wire output and comes in 100 V and 200 V models, and can be expanded up to 8 kVA by combining multiple 1 kVA units. The *SANUPS A11M* is a highly reliable UPS that can be used all over the world.

Figure 1 shows the appearance of the *SANUPS A11M*.

The *SANUPS A11M* has a wider operating temperature range than our current product and can be used in environments between -10˚C and +55˚C. Furthermore, with wider input voltage and frequency ranges than the current product, the *SANUPS A11M* limits transfers to battery operation even in regions with unstable power supplies to prevent battery wear and achieve stable output.

By eliminating the built-in battery and simplifying the internal structure, we have reduced the mass of the *SANUPS A11M* to 15 kg compared to the 19 kg of the current product.

Fig. 1 *SANUPS A11M*

■ Expanding the Lineup of *SANUPS A11K-Li* LIB-Equipped Double Conversion Online UPS

We have been selling UPS products equipped with lithium-ion batteries (LIB) since 2017. The *SANUPS A11K-Li* is a double conversion online UPS for indoor use equipped with LIBs. The *SANUPS A11K-Li* is used in applications that demand high reliability, such as data centers and production plants, thanks to features including a wide operating temperature range, wide input range, high power factor output, and good maintainability.

In 2019, we added models offering 19 minutes of backup power to our *SANUPS A11K-Li* series. These are available in output capacities of 1.5 and 3 kVA.

Figure 2 shows the appearance of the *SANUPS A11K-Li* (1.5 kVA).

A detailed introduction of the performance, functions, and features of the *SANUPS A11K-Li* is provided in the New Products Introduction section of this Technical Report.

Fig. 2 *SANUPS A11K-Li* (1.5 kVA)

■ Expanding the Lineup of *SANUPS N11B-Li* LIB-Equipped Outdoor UPS

The *SANUPS N11B-Li* is an LIB-equipped passive standby UPS for outdoor use. Due to its wide operating temperature range, high energy efficiency, and the convenience of outdoor use, the *SANUPS N11B-Li* is used as backup power for outdoor equipment such as base stations, traffic lights, and metered parking.

In 2019, we added models offering 24-hour backup power to our *SANUPS N11B-Li* series. These can be used in projects for Japan's Ministry of Land, Infrastructure, Transport and Tourism's "Fundamental Plan for National Resilience." They come in output capacities of 70 W and 140 W. Figure 3 shows the appearance of the *SANUPS N11B-Li* (70 W). At an ambient temperature of -20˚C, this product can provide 24-hour backup power to 70 W and 140 W devices.

Fig. 3 *SANUPS N11B-Li* (70 W)

■ Grid-Connected Isolated Type Added to the Lineup of *SANUPS W73A* Power Conditioners for Wind Power and Hydro Power Generation Systems

In 2017, we released the *SANUPS W73A*, a grid-connected type power conditioner (renewable energy inverter) for wind power and hydro power generation systems. In recent years, there has been a greater need to secure power supplies during emergencies and stronger demand for independent power supplies in non-electrified areas such as remote islands. In 2019, we expanded the lineup of *SANUPS W73A* by adding a grid-connected isolated type, Japan's first(5) power conditioner with an isolated operation function.

Figure 4 shows the appearance of the *SANUPS W73A* grid-connected isolated type.

Using the existing grid-connected type as a base with dimensions unchanged, the *SANUPS W73A* grid-connected isolated type was made capable of isolated operation through the addition of components and modification of component layout and control program. The output electrical system is 3-phase 3-wire 202 VAC, and the maximum output is 9.9 kVA. The *SANUPS W73A* grid-connected isolated type can provide electric power as an independent power source on remote islands and in other non-electrified areas, and also as an emergency power source during power outages.

The product offers startup method and time options, which enable it to perform isolated operation with the motor starting current suppressed regardless of the load connected.

Fig. 4 *SANUPS W73A* grid-connected isolated type

(5) Based on our own research as of March 27, 2019, among power inverters for wind power and hydroelectric power generation systems on the market.

■ Addition of a Modbus Protocol Communication Function to the *SANUPS LAN Interface Card* UPS Option Product

In recent years, it has become common practice to use ICT for monitoring production equipment in factories and other manufacturing sites. In 2019, we added a Modbus protocol communication function to our *SANUPS LAN Interface Card* UPS option product. The Modbus protocol is an industry-standard communication protocol widely used in industrial equipment. Figure 5 shows the appearance of the *SANUPS LAN Interface Card*.

The *SANUPS LAN Interface Card* can be used with both the Modbus RTU and Modbus TCP protocols. Moreover, this product has both Modbus master and Modbus slave functions, and both functions can be used simultaneously. For example, it is possible to read measurement values from an instrument and transfer these to a host master device together with UPS information.

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

Fig. 5 *SANUPS LAN Interface Card*

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Expansion of the *SANUPS A11K-Li* Small-Capacity UPS Lineup

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1. Introduction

General servers, compact ICT equipment, and FA equipment often require an uninterruptible power supply (UPS) that can provide backup power for around 10 minutes.

We already offer *SANUPS A11K-Li* series equipped with lithium-ion batteries (LIB) that are capable of providing 30 to 400 minutes of backup time. These models use large-capacity LIBs to provide a long backup time, and are bigger than lead-acid battery-equipped models that provide 10 minutes of backup time. As such, there is a demand for UPSs that are equivalent in size to the *SANUPS A11K* series, which use lead-acid batteries, but are equipped with LIBs to offer benefits such as a long service life, maintenance-free, and a wide operating temperature range.

Furthermore, with hyper-converged infrastructure (HCI) systems becoming increasingly popular as next-generation virtualization platforms, servers need more time to shut down than before. To shut down safely during power outages, UPSs are required to provide at least 15 minutes backup time even at the end of the battery life.

To satisfy these requirements, we developed the two UPSs models described below.

- Short backup time (around 10 minutes) models with a compact LIB built into the UPS main unit that is equivalent in size to and lighter than the lead-acid battery-equipped *SANUPS A11K* series.
- Intermediate backup time models with 19 minutes of backup time suited to new-generation servers.

This article introduces the new model lineup, as well as their main specifications and appearance. The following section will explain the features of the new models, as well as techniques for LIB monitoring and protective operations.

2. Main Specifications of the New Models

This time, we enhanced our *SANUPS A11K-Li* series with models offering around 10 minutes of backup time in 1 kVA, 1.5 kVA, 2 kVA, 3 kVA, and 5 kV output capacities (short backup time models) and models offering 19 minutes of backup time in 1.5 kVA and 3 kVA output capacities (intermediate backup time models). Table 1 shows the main specifications of the new models.

Figure 1 (1) through (3) shows the appearance of the new models. These are *SANUPS A11K-Li* short backup time models with output capacities of 1 kVA, 3 kVA, and 5 kVA.

Fig. 1 *SANUPS A11K-Li* series

Table 1 Main specifications of the *SANUPS A11K-Li* series new models

Item			Unit	Ratings and characteristics							Remarks
Model			—	A11KL102	A11KL152	A11KL202	A11KL302	A11KL502	A11KL152 (19 min)	A11KL302 (19 min)	
Rated output capacity			**kVA/kW**	1/0.8	1.5/1.2	2/1.6	3/2.4	5/4	1.5/1.2	3/2.4	Apparent power / Active power
Technology	**Topology**		—	Double conversion online							
	Cooling system		—	Forced air cooling							
	Inverter system		—	High-frequency PWM							Grid synchronous
AC input	**Number of phases/wires**		—	Single-phase 2-wire							
	Rated voltage		**V**	100, 110, 120							Same as output voltage
	Voltage range		**%**	Within ±20 of rated voltage							At load level ≥ 70%
				Within -40 to +20 of rated voltage							At load level < 70% The -40% becomes -20% for recovery voltage(1)
	Rated frequency		**Hz**	50/60							Auto-sensing(2)
	Frequency range		**%**	Within ±1, 3, 5, or 7 of rated frequency							(The fluctuation range is the same as the selected output frequency regulation)
	Required capacity		**kVA**	1.1 or less	1.5 or less	2.0 or less	3.0 or less	5.3 or less	1.5 or less	3.0 or less	Max. capacity during battery recovery charging
	Power factor		—	0.95 or more		0.97 or more			0.95 or more	0.97 or more	When input voltage harmonic distortion is less than 1%
AC output	**Number of phases/wires**		—	Single-phase 2-wire							
	Rated voltage		**V**	100, 110, 120							Factory setting. Voltage waveform: pure sine wave
	Voltage regulation		**%**	Within ±2 of rated voltage							At rated output
	Rated frequency		**Hz**	50/60							Same as input frequency
	Frequency regulation		**%**	Within ±1, 3, 5, or 7 of rated frequency (Default setting: ±3)							Frequency regulation setting can be changed (±1, 3, 5, or 7%). Within ±0.5% during battery operation(2)
	Voltage harmonic distortion		**%**	3 or less / 7 or less							Linear load / rectifier load, at rated output
	Transient voltage fluctuation	**For abrupt load change**	**%**	Within ±5 of rated voltage							For 0⇔100% load step changes or at output switching
		Loss or return of input power	**%**								At rated output
		For abrupt input voltage change	**%**								For ±10% changes
		Response time	**Or less**	5 cycles							
	Load power factor		—	0.8 (lagging)							Variation range: 0.7 (lagging) to 1.0
	Overcurrent protection		**%**	105 or greater							Automatic transfer to bypass(2)
	Overload capability	**Inverter**	**%**	105 or greater							200 ms
		Bypass		200/800							30 s / 2 cycles
Battery		**Type**	—	Lithium-ion battery (LIB)							
		Backup time	**min**	13	8	15	9	11	19	19	Ambient temperature 25°C, at rated output, using new, fully charged batteries
Acoustic noise			**dB**	41 max.	45 max.		46 max.		45 max.	46 max.	1 m from front of device, A-weighting (Where the ambient temperature is 40°C or lower)
				51 max.		55 max.			51 max.	55 max.	1 m from front of device, A-weighting (Where the ambient temperature exceeds 40°C)
Operating environment	**Ambient temperature**		**°C**	-20 to +55							(3)
	Relative humidity		**%**	10 to 90							Non-condensing

(1) When the low input voltage detection value setting is variable (setting can be changed). Fixed setting is ±20% of rated voltage.
(2) The inverter synchronizes operation with AC input and allows uninterrupted transfer to a bypass circuit provided that the AC input frequency is within ±3% of the rated frequency (1, 3, 5, or 7% selectable) and the AC input voltage is within ±20% of the rated voltage (if the setting of the low input voltage detection value is variable and the load level is less than 70%: within -40% to +20% of the rated voltage).
Note that operation changes to battery operation when the AC input frequency exceeds the setting range.
(3) Charging stops when battery temperature exceeds 55°C.

3. Features

3.1 Maintainability and backup time after aging deterioration

While *SANUPS A11K* series UPSs with lead-acid batteries require battery replacement approximately every five years, the new models, thanks to the LIB, can operate for roughly ten years without battery replacement. This maintenance-free operability reduces maintenance work and battery replacement costs.

Furthermore, an LIB has less capacity reduction due to aging deterioration compared to a lead-acid battery. This means that, when we compare the backup time at the end of battery life, the backup time for the lead-acid battery is approximately half the initial value. By contrast, the backup time for LIBs only drops 10%, meaning that the change in backup time due to aging deterioration for the latter is extremely minimal.

3.2 Operating temperature range

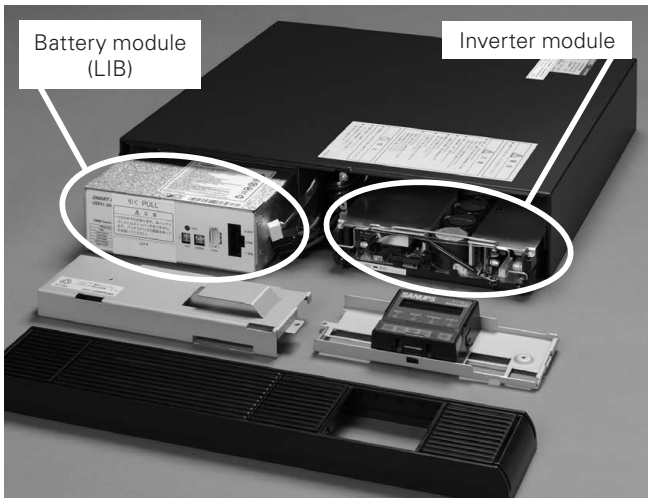
The operating temperature range of the *SANUPS A11K* series equipped with lead-acid batteries is -10˚C to +55˚C (charging stops at +40˚C to protect the battery). By contrast, the operating temperature range of the new models is -20˚C to +55˚C, making them suitable for both extremely cold and extremely hot environments.

3.3 Equipment size and mass

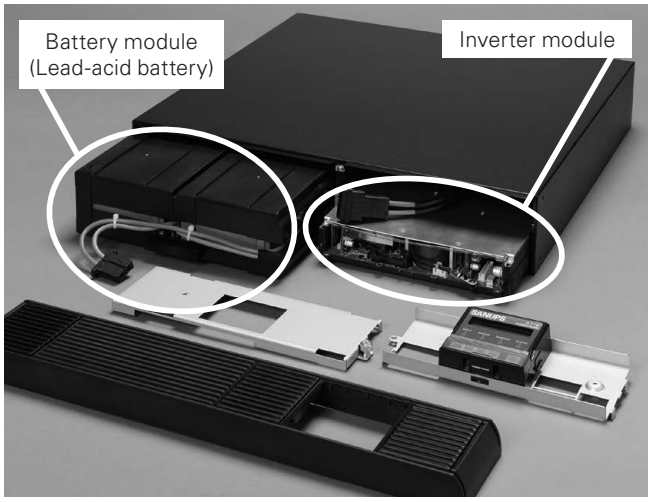
Figure 2 (1) and (2) show the interiors of *SANUPS A11K-Li* (1 kVA) and *SANUPS A11K* (1 kVA), respectively. Table 2 shows a comparison of the volume and mass for the new short backup time models and the current models.

Figure 2 (1) shows that, for the new short backup time models, we were able to fit the LIB in the space occupied by the lead-acid battery without changing the size or shape of the current housing. LIBs are lighter than lead-acid batteries, therefore, as demonstrated in Table 2, the new short backup time models are up to 44.8% lighter than current models of equivalent size.

Table 3 shows a comparison of the volume and mass for the new intermediate backup time models and the current models. As Table 3 shows, the new intermediate backup time models are smaller and lighter than the current models. On the current models, an external battery unit is necessary to provide 19 minutes of backup time. Therefore, volume, mass, and space occupied on a rack are all greater. For the new intermediate backup time models, the depth of the main unit has been extended, so the battery can be contained internally and an external battery unit is not required.



(1) New model *SANUPS A11K-Li* (1 kVA)



(2) Current model *SANUPS A11K* (1 kVA)

Fig. 2 Interior of new model and current model

Table 2 Volume and mass comparison between *A11K-Li* and *A11K* series short backup time models

Output capacity	Model	Backup time	Dimensions (Width × depth × height)	Volume ratio	Mass	Mass ratio
1 kVA	**A11KL102 (new model)**	13 min (0.8 kW/power factor 0.8)	435 mm × 440 mm × 86 mm	±0%	17 kg	-22.7%
	A11K102 (current model)	10 min (0.8 kW/power factor 0.8)		—	22 kg	—
1.5 kVA	**A11KL152 (new model)**	8 min (1.2 kW/power factor 0.8)	435 mm × 440 mm × 86 mm	±0%	18 kg	-37.9%
	A11K152 (current model)	10 min (1.2 kW/power factor 0.8)		—	29 kg	—
2 kVA	**A11KL202 (new model)**	15 min (1.6 kW/power factor 0.8)	435 mm × 625 mm × 86 mm	±0%	27 kg	-32.5%
	A11K202 (current model)	8 min (1.6 kW/power factor 0.8)		—	40 kg	—
3 kVA	**A11KL302 (new model)**	9 min (2.4 kW/power factor 0.8)	435 mm × 625 mm × 131 mm	±0%	32 kg	-44.8%
	A11K302 (current model)	8 min (2.4 kW/power factor 0.8)		—	58 kg	—
5 kVA	**A11KL502 (new model)**	11 min (4 kW/power factor 0.8)	435 mm × 690 mm × 175 mm	±0%	49 kg	-38.7%
	A11K502 (current model)	8 min (4 kW/power factor 0.8)		—	80 kg	—

Table 3 Volume and mass comparison between *A11K-Li* and *A11K* series 19-minute backup time models

Output capacity	Model	Backup time	Dimensions (Width × depth × height)	Volume ratio	Mass	Mass ratio
1.5 kVA	**A11KL152 (new model)**	19 min (1.2 kW/power factor 0.8)	435 mm × 625 mm × 86 mm	-35.9%	27 kg	-60.8%
	A11K152 (current model)	30 min (1.2 kW/power factor 0.8) (1)	435 mm × 488 mm × 86 mm 435 mm × 488 mm × 86 mm External battery unit	—	69 kg	—
3 kVA	**A11KL302 (new model)**	19 min (2.4 kW/power factor 0.8)	435 mm × 690 mm × 175 mm	-10.9%	47 kg	-56.0%
	A11K302 (current model)	30 min (2.4 kW/power factor 0.8) (1)	435 mm × 625 mm × 131 mm 435 mm × 625 mm × 86 mm External battery unit	—	108 kg	—

(1) When used in an ambient temperature of 25˚C, the backup time at the end of the lead-acid battery life (after 5 years) is 19 minutes. LIBs maintain 90% or more backup time after 5 years.

4. Technique for Monitoring LIB

Figure 3 shows the circuit diagram for the new models. The new models comprise a main circuit, control circuit, communication interface circuit, LIB, and a battery management system (or BMS) that monitors the LIB.

4.1 LIB monitoring circuit configuration

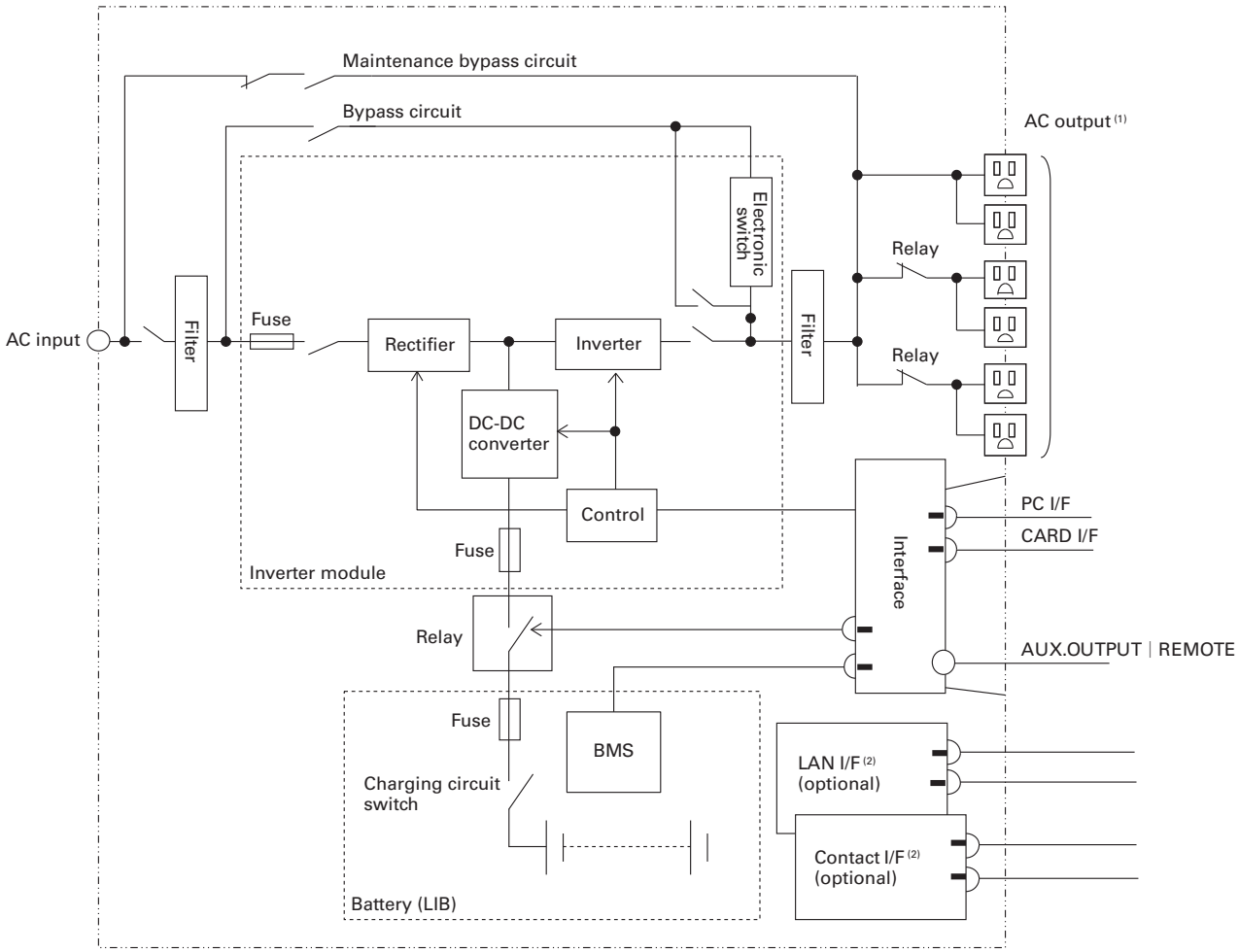
The BMS is installed inside the LIB and manages the battery's status. The UPS communicates with the BMS and gathers information on the LIB. As such, both the BMS and UPS monitor the LIB and improve safety through their respective roles of fault detection and protection.

(1)Protection by BMS

The BMS monitors cell voltage, battery current, and cell temperature. If it detects overcharging, overcurrent, or excessive temperature rise, it will disconnect the LIB from the charging circuit for protection.

(2)Protection by UPS

The UPS stops charging to protect the LIB when a fault occurs on the BMS, or a communication fault occurs between the UPS and BMS. The UPS stops charging if the LIB's charging voltage or cell voltage increases. The UPS stops charging and discharging if the cell temperature becomes too high.



(1) For the *SANUPS A11K-Li* 2 kVA, 3 kVA, and 5 kVA models, output power is available from both the outlet and terminal block.
(2) Connect to CARD I/F connector (either one).

Fig. 3 Circuit diagram for the *SANUPS A11K-Li* (1 kVA)

5. Conclusion

This article introduced the new lineup for the LIB-equipped *SANUPS A11K-Li* series.

The newly-developed UPS has the following advantages over a conventional UPS using lead-acid batteries.

(1) Maintenance-free, requiring no battery replacement
(2) Wide operating temperature range enables use in extremely hot and cold environments
(3) Weight reduction achieved for the short backup time models, and the 19-minute backup time models are more compact and lightweight

Moreover, we designed an LIB monitoring system by the UPS and BMS for fault detection and protection.

UPSs are becoming increasingly important to society. As their applications and installation environments diversify, it is likely that demand will grow for models with various specifications. We will expand our product lineup of UPSs with LIB to meet these market needs, aiming to develop products that can provide our customers with new value.

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Development of the *LAN Interface Card* with Modbus

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1. Introduction

IoT has been incorporated in production lines at an ever-increasing pace, and it has become common practice to monitor the operating status of industrial equipment remotely.

In such an environment, demand is increasing for a single monitoring system that can batch monitor industrial equipment and uninterruptible power supplies (UPS) used for backing up this equipment.

We developed the *SANUPS LAN Interface Card* (hereinafter, *LAN Interface Card*) as a UPS optional product. It is used for monitoring UPSs remotely, and for shutting down computers in data centers and server rooms automatically during power failures. However, with the increased popularity of virtual servers, there is growing demand to use LAN Interface Cards in equipment with comparatively complicated shutdown procedures.

To respond to the above demands, we have added or enhanced the following features in the newly developed *LAN Interface Card*.

- We added Modbus, a widely used communication protocol between industrial equipment, to enable use in industrial environments.
- We enhanced functions to enable use in information systems environments for automatic shutdown of virtual servers that require complex suspension procedures.

This article provides an overview of the newly developed *LAN Interface Card* (new model) and introduces its features.

2. Product Overview

The new models maintain all functions of our current product and feature an additional Modbus communication function.

There are two forms of Modbus communication: the Modbus TCP protocol, which communicates over networks, and the Modbus RTU protocol, which uses serial communication.

The new models are divided into two groups: one that supports the Modbus TCP protocol, and another that supports both Modbus TCP and Modbus RTU protocols.

Figure 1 shows PRLANIF021A, which only supports the Modbus TCP protocol.

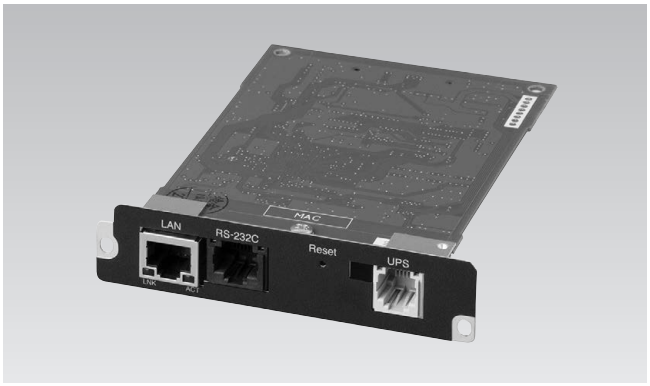

Fig. 1 PRLANIF021A

Figure 2 shows PRLANIF023A, which supports both Modbus TCP and Modbus RTU protocols. When connecting to a device that uses the Modbus RTU protocol, a communication cable is connected to the EXT port on the front panel.

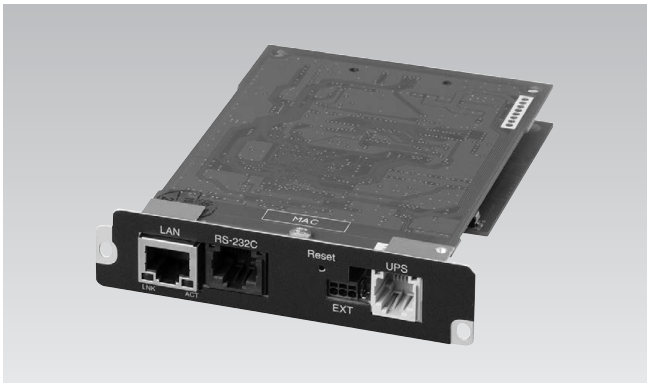

Fig. 2 PRLANIF023A

We also added a model with a cover around the PCB that protects from impacts so the *LAN Interface Card* can be transported while mounted.

Figure 3 shows PRLANIF024A, a model that supports both Modbus TCP and Modbus RTU protocols and has a protective cover.

Fig. 3 PRLANIF024A

3. Features

3.1 Modbus master/slave functions

The Modbus protocol uses a master/slave communication method whereby the master issues a request to the slave, which then returns a response.

The new models support both Modbus master and Modbus slave communication methods.

Figure 4 shows a visualization of the Modbus communication method.

When installing a UPS in an environment with a PLC or a monitoring control system such as a supervisory control and data acquisition (SCADA) operating as a Modbus master, the *LAN Interface Card* is set to Modbus slave communication. The UPS can be remotely managed from Modbus masters, enabling users to check UPS operating status and control the UPS (battery test, UPS stop, UPS start).

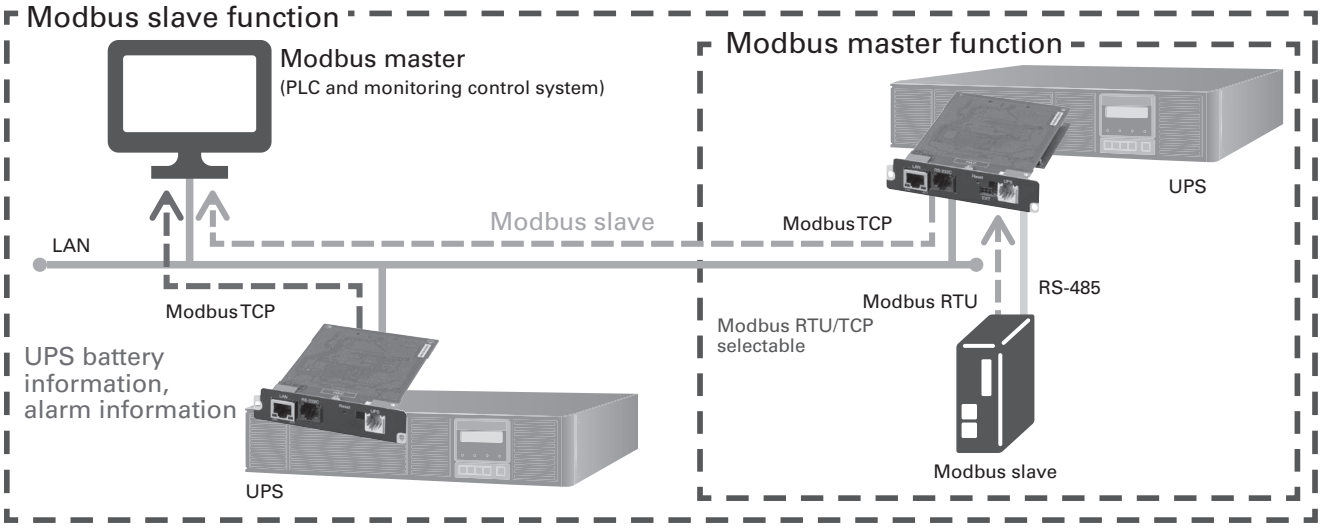

Fig. 4 Visualization of Modbus communication method

When connecting a UPS to measuring instruments such as wattmeters or I/O units via Modbus slave communication and reading measurement data or status information, the *LAN Interface Card* is set to Modbus master communication.

Modbus-related settings are performed using the Web Management Tool, the same as for our current models.

Figure 5 depicts the Web Management Tool screen for setting the Modbus connection method.

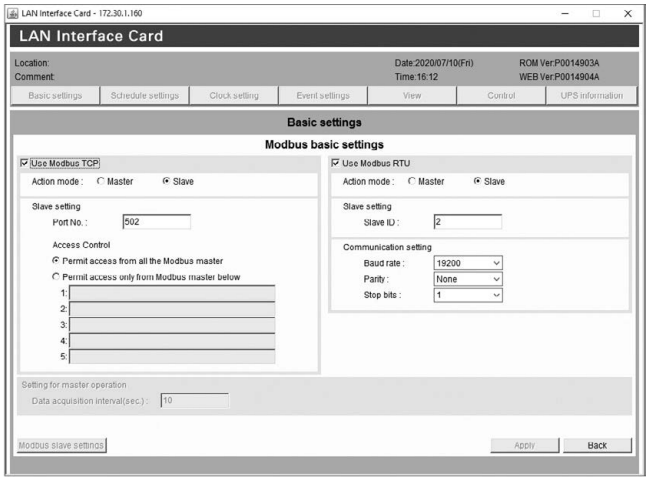

Fig. 5 Modbus basic settings screen

3.1.1 Modbus master/slave settings

On the new models, users can select either master or slave communication method for each communication protocol. For new models that support both Modbus TCP and Modbus RTU protocols, users can combine communication methods, such as slave for Modbus TCP and master for Modbus RTU. However, master cannot be set for both Modbus TCP and Modbus RTU at the same time.

Table 1 shows available communication method combinations.

When using Modbus master and slave communications together, as shown in Figure 4, the Modbus RTU protocol can be used as a Modbus master connection to gather information from Modbus slave units, and then pass that information to a host Modbus master unit via Modbus slave communication.

Table 1 Available communication method combinations

By product type/ combination pattern		Modbus TCP		Modbus RTU	
		Master	Slave	Master	Slave
Modbus TCP model	1	○	-		
	2	-	○		
Modbus TCP/RTU model	1	○	-	Disabled	Disabled
	2	-	○	Disabled	Disabled
	3	Disabled	Disabled	○	-
	4	Disabled	Disabled	-	○
	5	○	-	-	○
	6	-	○	○	-
	7	-	○	-	○

(○: Can be set, Disabled: Function is set as disabled)

3.1.2 Modbus slave function

If used with the Modbus slave function enabled, the new models can manage the UPS from the system's Modbus master unit in the same way as other Modbus slave devices.

UPS operational information can be checked and UPSs can be controlled from Modbus master units monitoring customers' production equipment, such as PLCs and SCADA systems. As such, there are expectations toward applying this technology to production line management and monitoring.

Table 2 shows UPS information and control functions available from Modbus master units.

Table 2 Acquirable information and UPS control functions

Major acquirable information	· UPS status information · UPS measurement value information · UPS output status · UPS battery information · UPS profile information (serial numbers, product names, rated capacities, etc.) · LAN Interface Card event log (up to 10 recent events) · Alarm status · LAN Interface Card connection unit information · Measurement deviation information · Modbus slave unit information
UPS control functions	· Battery test (start/cancel) · UPS stop · UPS start · UPS reset (UPS stop → start)

Note: Information that can be acquired differs by UPS model.

3.1.3 Modbus master function

When connected to a Modbus slave unit such as an I/O unit or measuring instrument, the new models can monitor status and measurement data of up to 16 points.

When importing status data, the user can set the UPS to treat a situation as abnormal when the signal status changes from off to on, or vice-versa.

When acquiring measurement data from Modbus devices, measurement values may include decimal numbers or be several digits long, depending on the device. The new models can be set to import measurement value data from a variety of devices. Moreover, a threshold can be set for the measurement values being imported. If readings deviate from the threshold value, an email notification is sent to a preset email address and the event is recorded in the data log.

Figure 6 is an example of a screen for registering a Modbus slave unit to acquire measurement values.

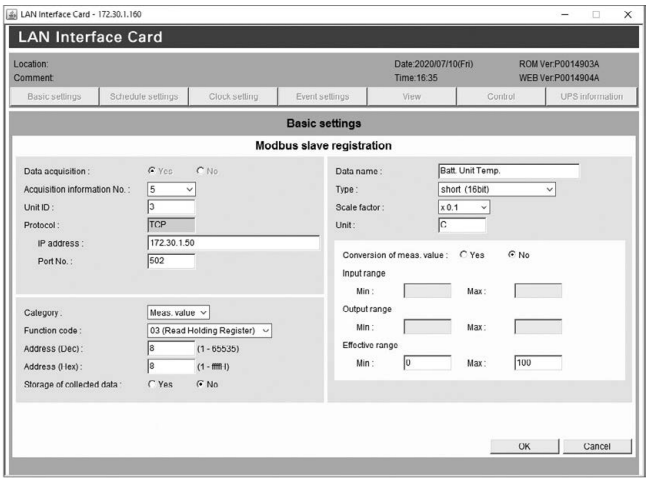

Fig. 6 Example screen
for registering Modbus slave units

Status information and measurement values retrieved from the Modbus slave unit can be checked from the Web Management Tool.

Figure 7 depicts an example of a screen for displaying status and measurement values from the Modbus slave unit.

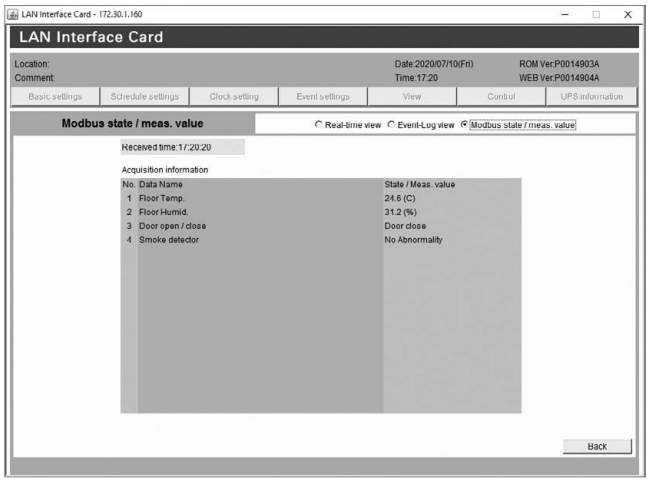

Fig. 7 Example screen
for displaying Modbus slave unit information

3.2 Enhanced shutdown functions

With the WScript function, even our current LAN Interface Cards models can safely shut down computers that are backed up by UPSs in the event of a power failure.

When a server needs to shut down in a power outage, with server shutdown commands registered to the *LAN Interface Card*, this function uses the SSH/Telnet protocol to remotely operate the server, log in, and then use the registered commands to shut down the server.

In conventional server environments, servers, data storage devices, network devices, and other infrastructure all used dedicated hardware. But in recent years, there has been an increasing use of virtualized servers that integrate and operate multiple OSs within a server and hyper-converged infrastructure (HCI) that virtualizes infrastructure in software.

For the new models, we have enhanced the shutdown function of virtualization platforms such as virtualized OSs and HCI.

3.2.1 Expansion of WScript function setting capacity

When shutting down virtualization platforms, several operations such as shutting down the guest OS, disabling the storage function, and disabling the management controller must be performed in a certain order.

With current models, there was a limit to the registration capacity for WScript commands, and sometimes it was not possible to set all of the procedures necessary to shut down virtualization platforms.

On the new models, the command registration capacity was increased from 598 to 10,238 bytes: sufficient space for complex virtualization platform shutdown procedures.

3.2.2 Additional commands to the WScript function

Table 3 lists the commands of the current models' WScript function that can be used to shut down a server.

When shutting down a virtualization platform, all guest OSs must shut down before disabling the storage function.

The current models lack a command to check whether or not a guest OS has shut down, so after the operation to shut down a guest OS executes, they must wait the maximum time for a guest OS to shut down using the sleep command. As such, even if the guest OS shuts down early in the wait period, the storage function will only stop after waiting for the set period. Therefore, it sometimes took longer than necessary to shut down systems.

Table 4 shows a list of the commands newly added to the WScript function.

We have prepared a wait_dev command and delay_dev command to proceed to the next process even within the stop/start wait time of the guest OS without waiting for the set wait time to finish if it can be confirmed that the designated unit has either stopped or started.

Furthermore, some virtualization platform administrators expressed a desire to use script files they had prepared themselves to stop or start a system.

With the latest development, if the user sets a shell script they have prepared together with our commands, the contents of that shell script will be sent to a server and directly executed on the server side.

Using the new commands, it is now possible to shut down even complex systems such as virtualization platforms within the UPS battery backup time, satisfying our customers' requests.

Table 3 List of commands used with the current model

Command	Description
Send	Set the character string (command) to be sent to the WScript side. Example: send=shutdown
Wait	Set the character string (such as a prompt) to be received on the UPS side. Example: wait=login
sleep	Set the wait time until the next process. Unit: Seconds Example: sleep=90
delay	Delay script start by the designated time. Unit: Seconds Example: delay=120

Table 4 List of additional commands of the new models

Command	Description	Example
wait_dev_on	Designate name (address) of devices to check activation status and have script processing wait until all devices are activated.	wait_dev_on=[192.168.1.1 192.168.1.2]
wait_dev_off	Designate name (address) of devices to check shutdown state and have script processing wait until all devices are shut down.	wait_dev_off=[192.168.1.1 192.168.1.2]
delay_dev_on	Designate registered device names (addresses) and delay running of the script until all devices are activated.	delay_dev_on=[192.168.1.1 192.168.1.2]
delay_dev_off	Designate registered device names (addresses) and delay running of the script until all devices are shut down.	delay_dev_off=[192.168.1.1 192.168.1.2]
<begin_shell_script> <end_shell_script>	Execute shell script created by user. When shell script file content is entered between "<begin_shell_script>" and "<end_shell_script>," that content is sent to the server to be executed.	<begin_shell_script> #!/bin/sh ⋮ <end_shell_script>

3.3 UPS measurement storage function

The *LAN Interface Card* acquires measurement data from the UPS approximately every 10 seconds.

The new *LAN Interface Card* models can store up to seven days' worth of measurement data.

If a fault occurs on the UPS, the stored measurement data can be used to analyze the cause of the fault.

This stored data can be acquired using the email function or FTP function.

Moreover, when using the Modbus master function to acquire measurement data from the Modbus slave unit, it is possible to save up to seven days' worth of measurement data in the same way as UPS measurement data. This stored data can also be acquired using the email function or FTP function.

4. Specifications

Figure 5 shows the specifications of the new models. PRLANIF021A and PRLANIF022A support only Modbus TCP, while PRLANIF023A and PRLANIF024A support both Modbus TCP and Modbus RTU.

Table 5 Specifications

Items	Ratings and standards			
Model	PRLANIF021A	PRLANIF022A (With cover)	PRLANIF023A	PRLANIF024A (With cover)
Dimensions	105 (W) × 125.5 (D) × 23.5 (H)			
Mass	80 g	120 g	110 g	150 g
Operating environment	Temperature: -25 to +60˚C Humidity: 0 to 90% RH (non-condensing)			
Power consumption	1.4 W		2.1 W	
LAN communication	Transmission speed: 100/10 Mbps (automatically detected) Transmission method (full-duplex/half-duplex): auto Auto-MDIX			
Function	· Automatic computer shutdown (multi-platform) · Shutdown of computers with redundant power supplies · Automatic computer startup at power restoration · Scheduled operation · UPS status display (Web Management Tool, Web Display Tool, SSH or Telnet) · SNMP agent (RFC1628, JEMA-MIB, SANYO DENKI private MIB) · Sending/receiving emails · NTP (Network Time Protocol) · Downloading and uploading UPS setting values · Test function (script execution, sending emails, sending SNMP traps, shutdown) · Notification of events to the Syslog server · Measurement deviation monitor (UPS internal information, Modbus measurements) · Statistical graph display function (UPS internal information) · Modbus master function / slave function · Status measurement of Modbus TCP slave device (max. of 16 points) · Storage of collected UPS/Modbus measurement data			
Modbus protocol	Modbus TCP		Modbus TCP, Modbus RTU	
Protocol	TCP/IP, UDP, DHCP, SNMP (v1, v2c, v3), HTTP, HTTPs, Telnet, SSH, FTP, FTPs, SMTP (over SSL/TLS), POP3 (over SSL/TLS), APOP, NTP			

5. Conclusion

This article has provided an overview of the *LAN Interface Card* with Modbus functions and introduced its features.

With the development of this product, UPSs can be managed in industrial networks, where demand has emerged recently, through the use of this *LAN Interface Card*.

Moving forward, we anticipate this product will be widely used not only for information systems, but also for industrial systems.

Moreover, with this development, we have enhanced the ability to shut down virtualization platforms, which are predicted to become even more widespread. Server management technology in information systems is rapidly advancing. For the *LAN Interface Card*, we will work to keep pace with the tide of technological innovation, swiftly develop products to satisfy market demands, and continue offering products that satisfy customers.

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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 developed in FY2019, and describe how they are contributing to our customers and society.

We will cover a DC servo motor product, a cylinder linear servo motor product, and a servo amplifier product.

First, we developed and released the *SANMOTION K* series DC servo motors. Compared with our current product series, these motors feature significantly reduced cogging torque and loss that minimizes temperature rise.

Moreover, we have devised the brushes and body structure to successfully reduce noise. These improvements in performance and characteristics make *SANMOTION K Series* motors ideal for use in coordinate measuring machines (CMMs) and other precision measurement equipment, and medical devices used in close proximity to people.

Next, we expanded the lineup of compact cylinder linear servo motors with the addition of a new 20 mm wide model. We increased thrust by optimizing the magnetic circuit and the combination of the number of coils and the number of poles while achieving a 14% increase in the motor's maximum acceleration over our current model by reducing the weight of moving elements. Maintainability has also been improved thanks to a self-lubricating linear guide. With improved acceleration and maintainability, this product can help improve the performance and reliability of semiconductor manufacturing equipment and other machinery.

Regarding AC servo amplifiers, we have added models with a built-in positioning function to the lineup of our *SANMOTION R 3E Model* series. The built-in positioning function provides customers a high degree of freedom, allowing positioning control for up to 254 points, continuous operation, and simple program operation. This product allows customers to build systems easily without using a dedicated positioning controller, contributing to downsizing and wire-saving of customers' equipment. For interfaces with host controllers such as PLCs, we have prepared the following two types: a parallel type with contact inputs and outputs, and a serial communication type (RS-485, Modbus RTU) to allow customers to choose the one best suited to their systems.

Below are overviews of the new products and their features.

■ *SANMOTION K Series* DC Servo Motors

The *SANMOTION K Series* DC servo motors achieve reduced cogging torque, loss, and noise compared to our current series. The new series lineup has the same flange sizes as the current series (42 mm, 54 mm, 76 mm, and 88 mm). The features of this product series are as follows.

1. Reduced cogging torque

We optimized magnet and armature core shapes to minimize cogging torque while maintaining torque characteristics. In addition, we devised manufacturing techniques for laminating electromagnetic steel plates and automating magnet attachment to reduce cogging torque stably. Thanks to these techniques, we successfully reduced cogging torque by more than half compared to the current series.

2. Reduced loss

For the new product, we devised a control method for our coil winding machine, and reduced copper loss by using thick windings with a high fill factor. By optimizing the number and material of brushes, we have also reduced mechanical loss from friction between brushes and commutators while maintaining equivalent brush life to the current series. For the 42 × 42 mm 60 W model, we reduced loss by 31% compared to the current series. This reduced the motor frame temperature rise by 25% and increased motor efficiency by around 10%. This means customer equipment is less affected by the motor temperature, contributing to energy saving.

3. Less noise

DC servo motors have a mechanical sliding portion consisting of a brush and commutator, and the vibrations generated by the contact between the brush and commutator is one of the main causes of noise during motor rotation. For this product, vibrations and noise caused by brush and commutator contact have been suppressed to reduce noise levels by up to 8 dB by optimizing the number of brushes and improving the rigidity of the bracket that supports the brushes.

As described above, this product features reduced cogging torque, loss, and noise compared to current products. With these superb performance levels, the *SANMOTION K Series* DC servo motors are suitable for use in CMMs and other precision measurement equipment that require speed stability in ultra-low-speed ranges, and medical devices used in close proximity to people.

■ *SANMOTION* 20 mm Wide Compact Cylinder Linear Servo Motor

In recent years, there has been a growing need for compact cylinder linear servo motors in semiconductor manufacturing equipment and various automatic assembly equipment for the purposes of downsizing equipment and increasing productivity. In response to this, we developed the *SANMOTION* 20 mm wide compact cylinder linear servo motor which offers improved thrust density and acceleration that result from its increased thrust, and excellent maintainability. The features of this product are as follows.

1. Higher thrust

By creatively arranging magnets and using magnet spacers, we succeeded in both increasing the interlinkage magnetic flux of windings and reducing the amount of magnet used.

We employed creative techniques for both the arrangement and processing of windings and leads to secure maximum winding space, and increased the effective winding volume. Because of these improvements, we successfully increased the motor thrust and reduced loss.

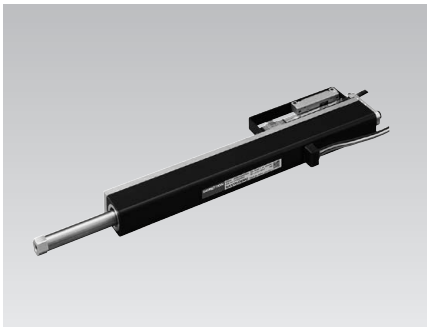
2. Improved thrust density and acceleration performance

As mentioned above, we improved thrust density (thrust per unit armature volume) by increasing the thrust. Compared to our current 12 mm wide model, both continuous and maximum thrust densities have been improved by approximately 40%. Furthermore, the lightened moving elements make it possible to drive heavier load weights at greater accelerations.

3. Improved maintainability

This product is equipped with an optical linear encoder. By devising a linear guide mounting method that ensures encoder detection and using a self-lubricating linear guide, we realized long-term stable motor operation and improved maintainability.

Details of this new product are provided in the "New Product Introduction" section of this Technical Report.



■ *SANMOTION R 3E Model* Servo Amplifiers with Built-In Positioning Function

Over the past few years, in response to the rapidly increasing performance and speed of machines, we have released several controller and servo amplifier products equipped with high-speed motion network functions, best represented by EtherCAT. These products have been used in a wide range of applications, including machine tools and articulated robots.

Meanwhile, in conveying machine and indexing applications that perform PTP positioning control, there is a demand for systems that enable easy positioning control from a PLC using contact signals or universal serial communication. To meet these needs, we added new built-in positioning function models to the lineup of the *SANMOTION R 3E Model* AC servo amplifiers. The features of this product are as follows.

1. Positioning control with a high degree of freedom

Positioning for up to 254 points can be performed according to the preset point data simply by designating point numbers from a host controller. This amplifier is able to reduce the burden on host controllers through continuous operation, simple program operation, and shortest path control, thus realizing positioning control with a high degree of freedom. This product allows systems to be built easily without using a dedicated positioning controller, contributing to downsizing and wire-saving of customers' equipment.

2. Startup support function

With the *SANMOTION MOTOR SETUP SOFTWARE* setup tool, point data can be edited and registered from a computer. Compared with our conventional *SANMOTION R* AC servo amplifiers with a built-in positioning function, startup has been made more convenient with an editing function for point data registration and a support function for easily checking motor and equipment motion.

3. Rich lineup

For interfaces with host controllers, we have prepared the following two types: a parallel type with contact inputs and outputs, and a serial communication type (RS-485, Modbus RTU) to allow customers to choose the one best suited to their systems.

Moreover, in addition to the standard "Safe Torque Off (STO)," the lineup also includes Safety models that are equipped with a variety of safety functions such as "Safe Stop (SS1, SS2)" and "Safely-Limited Speed (SLS)."

Details of this new product is provided in the "New Product Introduction" section of this Technical Report.

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Development of the *SANMOTION* 20 mm Wide Compact Cylinder Linear Servo Motor

Yuqi Tang Satoshi Sugita

1. Introduction

Most workpiece conveyance and machining operations of semiconductor manufacturing equipment, mounters, and machine tools move linearly. As such, linear motors that are capable of linear motion without using a ball screw or other linear motion conversion mechanism are widely used in these applications. The performance and functional requirements (thrust, speed, acceleration, positioning accuracy, etc.) for the linear motors used in this equipment differ depending on the application and axis motion direction.(1)

In 2014, we released a 12 mm wide compact cylinder linear servo motor, and it has been used in a wide range of equipment and applications. This linear motor is a moving magnet type (MM-Type) that has a permanent magnet on the mover that does not require power, reducing the mover weight. It is particularly suitable for short-stroke, high-acceleration applications such as vertical axes (Z-axes) of pick-and-place machines. By leveraging these features of the 12 mm model, we developed the *SANMOTION* 20 mm wide compact cylinder linear servo motor with a higher thrust and longer stroke.

This article introduces the performance, functions, and characteristics of the new 20 mm wide model in comparison with the current 12 mm wide model.

2. Development Background

Semiconductor manufacturing, inspection, and various assembly equipment (FPC bonders and lens mounters) has multiple axes to perform (vertical) pick-and-place operations. Compact cylinder linear servo motors can help downsize this equipment, simplify mechanisms, and improve productivity. To respond to greater market needs, however, the current 12 mm wide model needed a higher thrust and longer stroke. The following are the specification requirements for cylinder linear servo motors for use as vertical axes in semiconductor manufacturing, inspection, and various assembly equipment.

1) Compact, lightweight, high thrust, long stroke
2) All-in-one structure with a built-in linear encoder and linear guide
3) Multiple axes can be placed side-by-side

The 20 mm wide compact cylinder linear motor that we developed satisfies these requirements.

3. Specifications of the New Model

3.1. Appearance and composition

Figure 1 shows the appearance of the new 20 mm wide compact cylinder linear servo motor while Figure 2 shows its composition and dimensions.

The new model has an all-in-one structure with a built-in linear encoder and linear guide despite its 20 mm width. The motor consists of a mover with magnets built in a stainless steel pipe and a stator (armature) that integrates back yoke, windings, and aluminum housing.

The mover moves linearly, guided by linear bushings on both sides of the stator. By providing a back yoke on the outside of the cylindrical stator winding, we increased the magnetic flux interlinking with the coil to effectively increase thrust. This also prevents magnetic interference between axes when using multiple motors side-by-side.

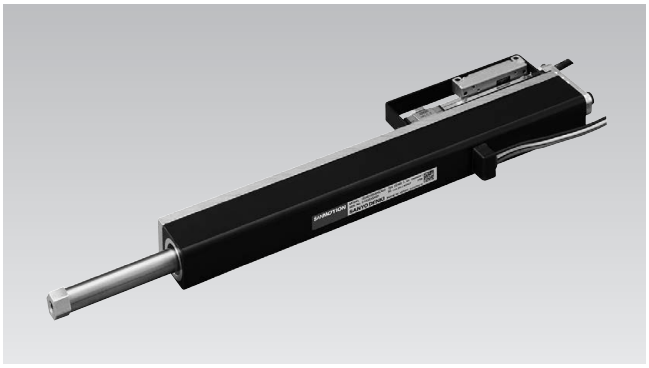

Fig. 1 Appearance of the 20 mm wide compact cylinder linear servo motor

Regarding the linear encoder, by connecting a detection scale to the mover through the anti-rotation linear guide, we ensured that the signal cable of the linear encoder does not move during operation, the same as the motor power cable. Moreover, by devising a mounting method for the linear guide, we stabilized the detection of the linear encoder. Also, with a self-lubricating linear guide used, the new model realized maintenance-free and long-term stable operation.

3.2 Performance and functions

Table 1 compares the specifications of the new and current compact cylinder linear servo motor models. Both the rated and maximum thrusts of the new model are around 3.0 times greater than those of the current 12 mm model. Furthermore, the new model has a 50 mm stroke, which is 20 mm longer than the current model's 30 mm stroke, and a 14% higher no-load maximum acceleration.

With its high thrust and long stroke in a compact body, the new model can contribute to simplifying customers' equipment and increasing its productivity. Moreover, multiple motors can be used side-by-side at intervals of 20 mm because mutual interference does not occur. This allows multiple motors to be placed side-by-side inside customers' equipment, providing customers with a greater freedom in designing high-density equipment.

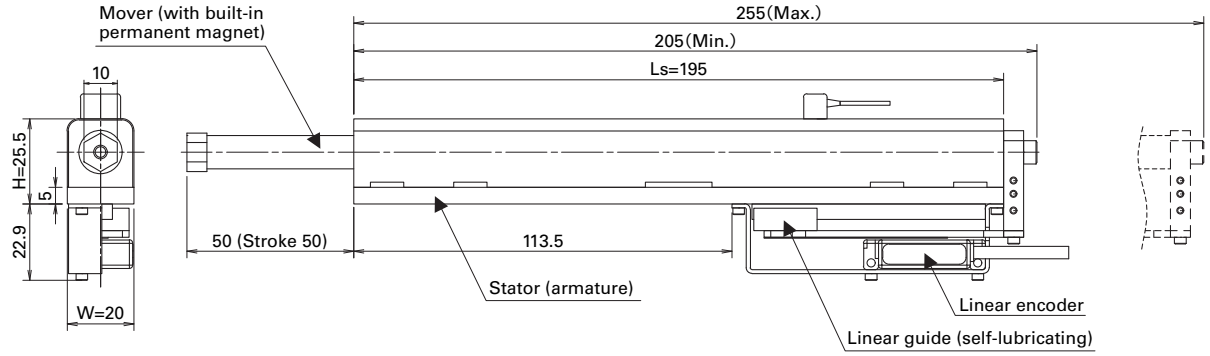

Fig. 2 Composition and dimensions of the 20 mm wide compact cylinder linear servo motor

Table 1 Specifications comparison of the new and current compact cylinder linear servo motors

Item	Symbol	Unit	Specifications	
			New model (20 mm wide cylinder linear servo motor)	Current model (12 mm wide cylinder linear servo motor)
Motor model no.	–	–	DE0BC005A05CX00	DE0AC001A03CX00
Driving method	–	–	Sinusoidal	
Excitation method	–	–	Permanent magnet (of mover)	
Magnetic pole pitch (N to N)	τ_p	mm	27	24
Armature dimensions (W × L × H)	W × L_S × H	mm	20 × 195 × 25.5	12 × 170 × 17
Rated thrust	F_R	N	15.0	5.1
Max. thrust	F_P	N	50.0	16.5
Rated speed	V_R	m/s	0.7	1.0
Maximum speed	V_{max}	m/s	1.4	2.0
Stroke	S	mm	50	30
Mover mass	M_C	g	120	45
Motor mass	M_W	g	450	192
No-load maximum acceleration	a_{max}	G	42.5	37.4
Minimum placement interval	W_p	mm	20	12
Linear encoder	–	–	Optical incremental linear encoder	
Linear encoder resolution (when multiplied by 4)	–	μm	1	

4. Product Features

4.1 Higher thrust and lower loss

To achieve a higher motor thrust and reduced loss, we increased magnetic flux, or magnetic loading, and the effective volume of coil windings, or electric loading.[2]

1) We creatively arranged mover magnets with magnetic spacers inserted between magnets, and succeeded in both increasing magnetic flux from the magnets and reducing the amount of magnets used.
   - We increased the magnetic flux interlinking with the coil by arranging the same poles of the permanent magnets to face and repel each other, and inserting magnetic spacers between magnets.
   - To maximize the magnetic flux interlinking with the coil, we optimized the dimensions of the magnets and magnetic spacers.
2) We maximized winding space by creatively arranging and processing the windings and leads. Moreover, we reduced copper loss by improving winding alignment and increasing the fill factor.

Figure 3 compares the current (I) versus thrust (F) characteristics of the new and current models. This shows that the new model generates a higher thrust than the current 12 mm model at the same electrical current. Moreover, it demonstrates excellent linearity of the characteristics.

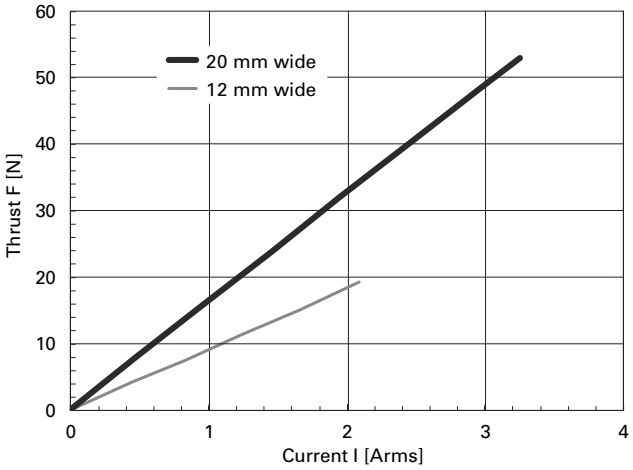

Fig. 3 Comparison of electrical current (I) vs. thrust (F) characteristics

Figure 4 compares the speed (V) versus thrust (F) characteristics of the new and current models (Instantaneous region). Compared with the current 12 mm model, the new model has a lower maximum speed. However, the new model can generate approximately 2.5 times greater thrust in the 1 m/s or less speed zone, which is its operating zone.

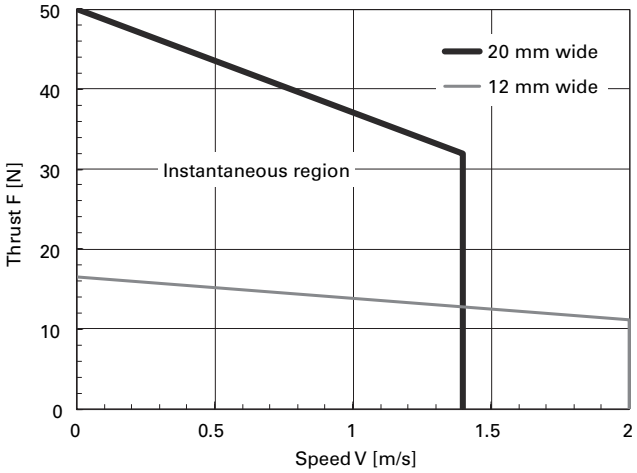

Fig. 4 Comparison of speed (V) vs. thrust (F) characteristics

4.2 Improved thrust density and maximum acceleration

We optimized the current model's magnetic circuit, magnetic pole pitch, and the combination of the number of coils and the number of poles to improve thrust, which increased the thrust density and maximum acceleration of the new model.

The thrust density (thrust per unit armature volume) is an indicator used when evaluating linear motor characteristics.[3] In the following, we define the armature volume as the volume of the magnetic circuit part (where thrust is generated) excluding the linear motion guiding apparatus (shaft guide).

Thrust density K_v can be expressed as

$$K_v = F / V_s = F / (W \times L \times H)$$

where F : thrust (continuous thrust or maximum thrust) [N]
V_s : Armature volume (magnetic circuit part) [mm^3]
W : Armature width [mm]
L : Armature length (excluding the linear motion guiding apparatus) [mm]
H : Armature height [mm]

Figure 5 shows a thrust density comparison of the new and current models Compared to the current 12 mm model, the new model has a 39.4% greater continuous thrust density and 43.7% greater maximum thrust density.

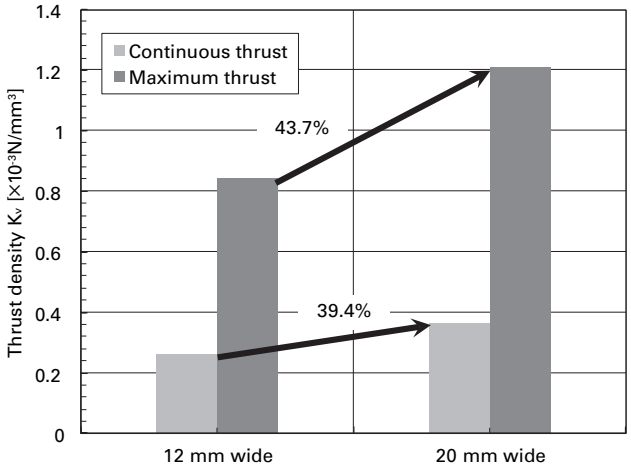

Fig. 5 Thrust density comparison of the new and current compact cylinder linear servo motors

Figure 6 shows a maximum acceleration comparison of the new and current models. The maximum acceleration was calculated using the following: Maximum thrust / mass of moving elements (mover mass + load mass). With its improved thrust density and lighter mover weight, the new model can drive heavier loads at a higher acceleration.

The maximum acceleration with zero load mass is 42.5 G for the new model and 37.4 G for the current 12 mm model. An improvement of approximately 14% was achieved.

Moreover, even with a heavier load mass, the maximum acceleration of the new model can be greater than that of the current model. The maximum load mass that the new model can move at a maximum acceleration of 1 G is 5 kg, while the current 12 mm model can only move a 1.6 kg load. In other words, the new model can drive loads approximately three times heavier than the current model.

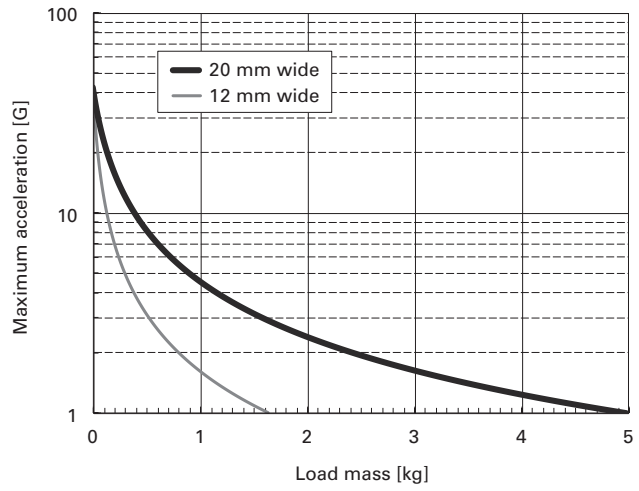

Fig. 6 Maximum acceleration comparison of the new and current compact cylinder linear servo motors

5. Conclusion

This article introduced the performance, functions, and characteristics of the *SANMOTION* 20 mm wide compact cylinder linear servo motor suited to vertical axes (Z-axes) of semiconductor manufacturing, inspection, and various assembly equipment (FPC bonders and lens mounters).

Compared to the current 12 mm model, the new model achieves a higher thrust, higher acceleration, and longer stroke.

- Rated/maximum thrust : 3 times greater
- No-load maximum acceleration : 1.14 times greater
- Stroke : 1.7 times greater

Furthermore, just like the current 12 mm model, the new model has an all-in-one structure with a built-in linear encoder and linear guide and can be used not only in single-axis applications but also in applications where multiple motors are placed side-by-side. This provides customers with a greater degree of freedom.

We believe the new and current models can be widely used in our customers' semiconductor manufacturing and inspection equipment, mounters, bonders, and wafer probers, and greatly contribute to improving performance and productivity.

References

(1) Investigating R&D Committee on Application Development of Linear Drives Technology and Industry Applications: Latest Situation of Linear Motor Application 2015, IEEJ Technical Report, No. 1368, pp.14-27 (2016.3)

(2) Yuqi Tang and another: Development of Compact Cylinder Linear Servo Motor "SANMOTION", SANYO DENKI Technical Report, No.38, pp.42-45 (2014.11)

(3) Satoshi Sugita and three others: Introduction of Industrial Linear Servo Motors, The 2014 Annual Meeting of the Institute of Electrical Engineers of Japan (IEEJ), 5-S24-2, p.3 (2014.3)

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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

1. Introduction

In recent years, industrial machinery and automation equipment have been actively introduced in many manufacturing fields with the aim of enhancing productivity and production quality. In light of this, we have developed and released many motion controllers and servo amplifiers that support EtherCAT and other high-speed motion networks. These products are primarily used in machine tools, articulated robots, and other equipment that requires synchronized control of multiple axes.

On the other hand, conveying equipment and indexing applications that perform PTP (point to point) positioning control require systems that allow simple positioning from a PLC using contact signals or universal serial communication. This article will introduce the *SANMOTION R 3E Model* servo amplifiers with a built-in positioning function, and discuss the features and key points of their development.

2. Product Overview

2.1 Appearance and dimensions

The new servo amplifiers are available in two types of interface: a parallel type with I/O contacts and a serial type (RS-485, Modbus RTU) for different interfaces.

Figure 1 shows a parallel type with a 200 VAC input and 150 A amplifier capacity, while Figure 3 shows its dimensions.

Figure 2 shows a serial type with a 200 VAC input and 30 A amplifier capacity, while Figure 4 shows its dimensions.

For all input power and amplifier capacity variations, the dimensions of the new models are the same as those of the *SANMOTION R 3E Model* analog/pulse train interface type and EtherCAT interface type amplifiers, maintaining mounting compatibility.

In addition, the new lineup includes Safety models equipped with functional safety specifications, and models with 400 VAC input.

Fig. 1 Appearance of the parallel type (I/O) 200 VAC, 150 A model

Fig. 2 Appearance of the serial type (RS-485 compliant) 200 VAC, 30 A model

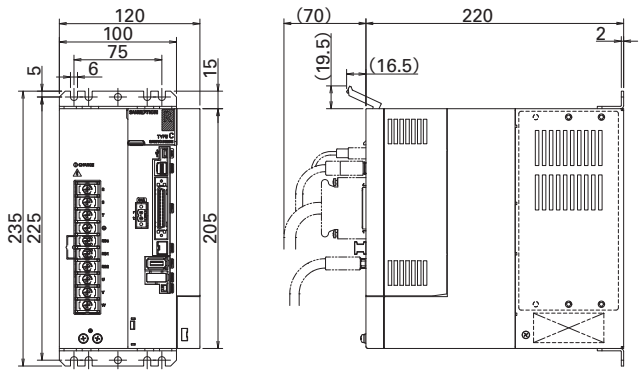

Fig. 3 Dimensions of the parallel type 200 VAC, 150 A model

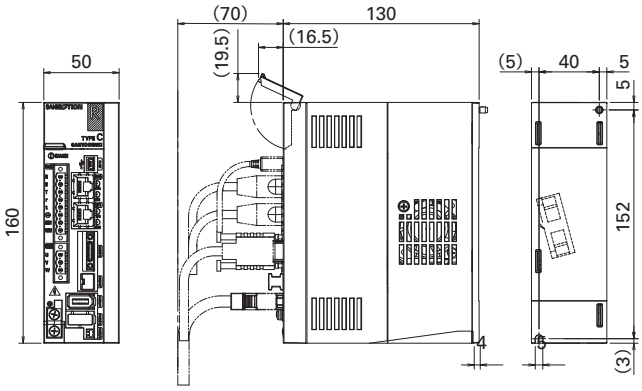

Fig. 4 Dimensions of the serial type 200 VAC, 30 A model

2.2. Basic specifications

1) Servo amplifier specifications

Table 1 shows the basic servo amplifier specifications.

Table 1 Basic specifications

Items			Specifications
Compatible	Input power supply		200 to 240 VAC
			100 to 120 VAC
			380 to 480 VAC
	Compatible motors		SANMOTION R series rotary motors
			SANMOTION DD, DS series linear motors
	Compatible encoders	Standard	Battery-less absolute encoder
			Absolute encoder for incremental systems
		Options	Battery-backup absolute encoder
			Wire-saving incremental encoder
			EnDat2.2 encoder (HEIDENHAIN)
Environment	Operation and storage temperature		0 to +55˚C, -20 to +65˚C
	Operating and storage humidity		Below 90% RH (non-condensing)
	Operating altitude		Below 1,000 m
	Vibration/impact		4.9 m/s^2 / 19.6 m/s^2
Safety functions	Amplifier		STO (Safe Torque Off)
	Functional safety module		STO, SS1, SS2, SLS, SOS, SSM, SBC
Function	Mechanical vibration/resonance suppression		· 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
	Setup software		Start-up, monitoring, diagnosis · Virtual motor operation · Encoder/amplifier temperature monitoring · Power consumption monitoring · Drive recorder · Service life diagnosis (Relay and holding brake) · Encoder communication quality monitoring
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

2) Positioning function specifications

Table 2 shows the specifications of the positioning function.

Table 2 Positioning function specifications

Number of controllable axes	1 axis	
Number of points	254 max.	
Command range	-2,147,483,648 to +2,147,483,647	
Command unit	mm, deg, pulse	
Acceleration/ deceleration	Linear/S-curve can be switched	
Point data setting	Numerical input with *SANMOTION Motor Setup Software* or by teaching	
Point number setting	Parallel 8 bit (binary code)	Serial 8 bit (binary code)
Torque limit	0 to 799% (With 100% being the rated value. Peak torque cannot be exceeded)	
Software limit	Available	
Operation modes	Point specification	
	Homing	
	Manual (Jog)	
	Manual (1 step)	
Zone signal	8 zones max.	

2.3 Interface specifications

We have developed two types to interface with host controllers; a parallel type (I/O) and a serial type (RS-485, Modbus RTU). Users can choose the optimal interface for their device's system. Table 3 shows the interface specifications.

Table 3 Interface specifications

Interface		Parallel type (I/O)	Serial type (RS-485 compliant)
Input	**General-purpose input**	None	7ch
	Dedicated input	20ch	None
	Point specification	8ch	Via communication
Output	**General-purpose output**	None	2ch
	Dedicated output	17ch	None

1) Parallel type (I/O)

The parallel type allows easy positioning using only contact I/O signals. For servo amplifier output signals, this parallel type supports both sinking and sourcing type controller input signals.

2) Serial type (RS-485, Modbus RTU)

The serial type uses the RS-485 Modbus RTU protocol developed for communication with PLCs and peripheral devices to connect to a variety of controllers. Users can easily check positioning control, parameter settings, and servo amplifier/motor status simply by using the respective coil and register read and write commands. Table 4 shows the communication specifications of the serial type.

Table 4 Serial type communication specifications

Items	Details	Initial value	Remarks
Protocol	Modbus RTU	—	Fixed to binary mode
Interface	RS-485 (1 to N)	—	8 axes max.
Transmission speed (bps)	4800, 9600, 19200, 38400, 57600, 115200	115200	
Start bit	1	1	Fixed
Data length (bit)	8	8	Fixed
Parity	None, even number, odd number	Even number	
Stop bit	1, 2	1	
Electrical specifications	RS-485 compliant (half-duplex communication)	—	Fixed
Connector	RJ-45	—	

3. Features

3.1 Positioning control with a high degree of freedom

The features of the new models' positioning control function are summarized as follows.

1) Basic functions

A maximum of 254 points of positioning can be set according to preset point data by simply specifying point numbers from a host controller. Profile data such as speed and S curve acceleration/deceleration, servo gain switchover selection, and current limit values can be set for each point to achieve fine-tuned control tailored to machine conditions.

2) Continuous operation

In addition to positioning to single points, continuous operation between points is also possible. There are two forms of continuous operation, "punctuated speed change operation" in which the motor stops and changes speed at each point (Figure 5), and "continuous speed change operation" in which the motor changes speed while passing through points (Figure 6). Users can select the operation type suited to their application.

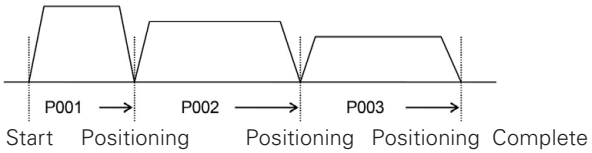

Fig. 5 Punctuated speed change operation

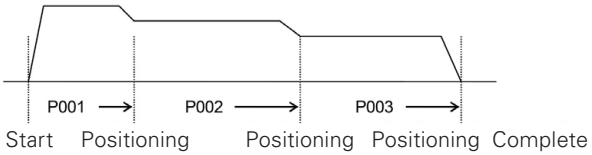

Fig. 6 Continuous speed change operation

3) Shortcut control

Positioning coordinate ranges can be set to arbitrary values to suit machine conditions in applications in which motors continue rotating without limit in a certain direction, such as machine tool indexing equipment. This makes it possible to perform positioning with coordinates matching the machine's position even when the motor is constantly rotating. Moreover, as shown in Figure 7, the shortcut control function automatically detects the shortest path to the target destination, thereby improving cycle time.

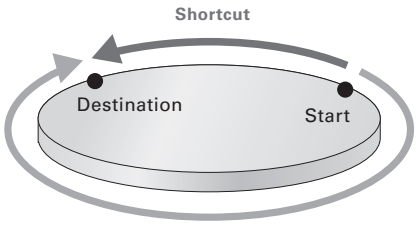

Fig. 7 Illustration of shortcut control

4) Simple program operation

As Figure 8 shows, the new models have a simple program function to perform an unconditional jump to a specified point after moving to a certain point, or perform the same operation a specified number of times. This reduces the burden on the host controller.

These abundant functions can help easily build flexible positioning control systems with a high degree of freedom without using special-purpose positioning controllers, reducing wiring and saving space.

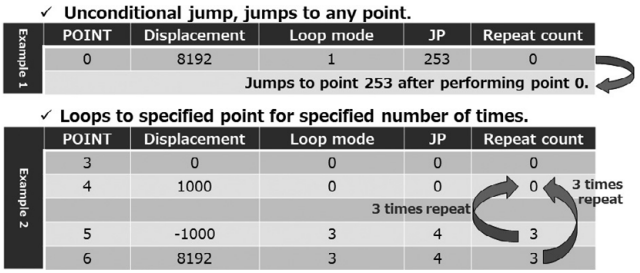

Fig. 8 Simple program operation

3.2 Safety functions

The new lineup also includes Safety models that have a variety of functional safety features such as "Safe Torque Off (STO)," "Safe Stop (SS1, SS2)," and "Safely-Limited Speed (SLS)." This makes it possible to safely stop and rotate the motor, and easily build safety systems for equipment. Also, to remove motor torque in an emergency with conventional servo amplifiers, it has been necessary to isolate the amplifier's power from the motor with a magnet switch. Now, thanks to the STO function, there is no need to isolate power, so equipment restart time can be shortened.

3.3 Startup support function

Point data necessary for positioning control can be set from a computer with the *SANMOTION MOTOR SETUP SOFTWARE* (hereinafter "setup software"). This setup software has an editing function for straightforward point data registration, as well as support functions such as point movement and trial operation to easily check motor and equipment movement. These functions simplify equipment startup.

Figure 9 shows the screen for setting and editing point data. When the row of the point to be set is clicked, an easy to understand point data editing screen displaying those items required for setting appears, and users can easily set point data.

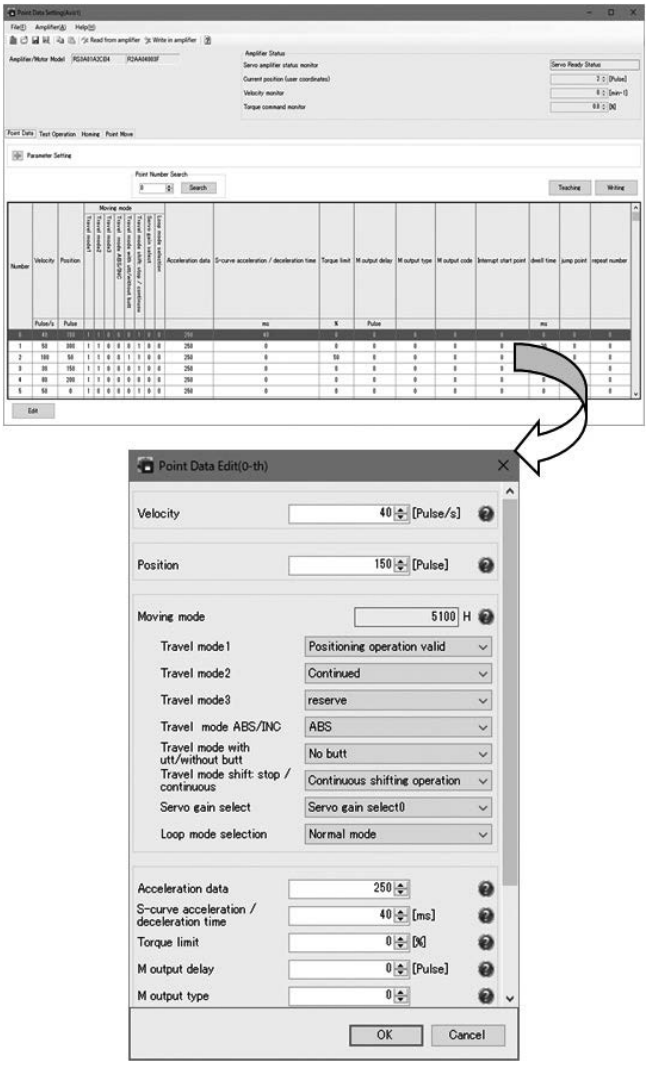

Fig. 9 Point data setting/editing screen

4. Key Points of Development

These new models maintain compatibility with the current models' positioning functions, and expand on the existing lineup with the addition of multiple versions, such as 400 VAC models, high-capacity models, and Safety models. In this section we will introduce some of the key points of development, such as our efforts to simplify replacement of the current models, and our efforts to simultaneously add a wide variety of products to our lineup.

4.1 Easy replacement

To simplify replacement of the current models with the new models, we focused on the following measures.

(1) Compatibility

By maintaining compatibility with the current models for each positioning function, there is no longer a need to reprogram the host controller. Moreover, compatibility is maintained with point data files prepared for current models so they can be used on the new models without changing or recreating point data.

(2) Parameter conversion tool

While servo gain and other parameter files are not compatible, we have prepared a tool that automatically converts parameter files prepared for the current models so they can be used on the new models.

4.2 Standardized design

To support the rich *SANMOTION R 3E Model* lineup, we focused on standardizing design, thereby shortening the development period.

(1) Standardized output circuit

The current models have different output circuits for different controller input specifications (sinking or sourcing). The new models, however, have standardized output circuits that support both.

(2) Standardized components

As far as possible, components have been standardized with those of analog/pulse train and EtherCAT models (such as resin cases and die castings) to improve structural design efficiency.

(3) Integrated software

We have shortened the software development period by innovating software configuration and module design, and integrating the software for parallel and serial types.

(4) Reduced number of product models

By standardizing output circuits and making Safe Torque Off (STO) a standard feature, the total number of models have been reduced to one-quarter of that of the analog/pulse train interface models. This helps reduce our customers' management labor.

5. Conclusion

This article has provided an overview and discussed the features and key development points of the new lineup of *SANMOTION R 3E Model* AC servo amplifiers with a built-in positioning function.

The new models feature:

(1) Rich positioning functions such as a maximum of 254 positioning points, continuous operation, and simple program operation.

(2) Available in two interface types, a parallel type (I/O) and serial type (RS-485, Modbus RTU). Users can select the optimal interface for their controller specifications.

(3) We also have a lineup of Safety models, making it easier to build safety systems in equipment and contributing to machine safety.

(4) Enhanced setup software functions such as functions for

straightforward registration/editing of point data and easy check of motor movement, which are more user-friendly than the current models.

(5) Compatibility with the positioning functions and point data files used in our current models, making model replacement easy.

(6) Standardized output circuit (sinking/sourcing types), standard Safe Torque Off (STO) feature, and reduced number of product models to reduce customers' management labor.

We believe these servo amplifiers will help significantly improve cost performance by contributing to downsizing and wire-saving in devices as they enable easy system construction in PTP positioning applications without the need for a special-purpose positioning controller. Moving forward, we will continue developing and proposing new products embedded with IoT functions to help customers improve the quality of their operations.

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List of Recipients and Nominees for the 69th JEMA Technological Achievement Award in 2020

Heavy Electrical Category			
Prize	**Title**	**Division**	**Name**
Encouragement Award	Development of IoT-enabled Fan Controller	Cooling Systems Div., Design Dept. Cooling Systems Div., Design Dept. Cooling Systems Div., Design Dept.	Naoki Murakami Soma Araki Masashi Murakami
Encouragement Award	Development of DC Servo Motor Offering Reduced Speed Fluctuation, Energy-saving, and Low Noise	Servo Systems Div., Design Dept. 1 Servo Systems Div., Design Dept. 1 Servo Systems Div., Design Dept. 1	Hidetoshi Hayashi Daigo Kuraishi Yuji Yamamoto
	Development of IoT-enabled Emergency Diesel Generator	Power Systems Div., Design Dept. Power Systems Div., Design Dept. Power Systems Div., Design Dept.	Tetsuya Kobayashi Mamoru Tomioka Masayuki Shibata
	Development of Parallel Redundant Double Conversion Online UPS	Power Systems Div., Design Dept. Power Systems Div., Design Dept. Power Systems Div., Design Dept.	Hiroyuki Hanaoka Akihiro Tsukada Kazuya Nishizawa
	Development of 97 x 33 mm Splash Proof Blower	Cooling Systems Div., Design Dept. Cooling Systems Div., Design Dept. Cooling Systems Div., Design Dept.	Toshiya Nishizawa Masaki Kodama Koji Ono
Manufacturing Category			
Prize	**Title**	**Division**	**Name**
Encouragement Award	Innovation in In-house Injection Molding Machine	Servo Systems Div., Production Engineering Dept., Process Engineering Sect. 1 Servo Systems Div., Production Engineering Dept., Process Engineering Sect. 1 Servo Systems Div., Production Engineering Dept., Process Engineering Sect. 1	Masaki Musha Tetsuya Narusawa Manabu Takizawa

Division names are those at the time of nomination.

Major Patents

■ **Patents registered in 2019**

Registration Number	Name	Inventor(s)
Japan - 06465282	LINEAR MOTOR	Yuqi Tang, Takashi Matsushita, Kazuhito Yamaura
Japan - 06480316	MOTOR CONTROLLER	Yuji Ide, Toshio Hiraide
Japan - 06480849	INTERCONNECTION POWER SUPPLY SYSTEM	Makoto Ishida, Minoru Yanagisawa
Japan - 06489746	MAGNETIC SHIELD COVER FOR ENCODER OF MAGNETIC DETECTION TYPE AND ENCODER OF MAGNETIC DETECTION TYPE	Kazuhiro Makiuchi, Yoshihiro Shoji
Japan - 06489842	MOTOR CONTROLLER	Yuji Ide, Takao Oshimori, Hiroaki Koike
Japan - 06491497	MOTOR CONTROL DEVICE	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi, Toshio Hiraide
Japan - 06498087	MEASUREMENT DEVICE	Masahiro Koike, Tomoaki Ikeda, Takahisa Toda, Yo Muramatsu, Katsumichi Ishihara, Hikaru Urushimoto
Japan - 06498541	MEASUREMENT DEVICE	Katsumichi Ishihara, Takahisa Toda, Yo Muramatsu
Japan - 06518515	SENSOR FOR MOTOR	Takayoshi Seki
Japan - 06529894	CORELESS LINEAR MOTOR	Yuqi Tang
Japan - 06570783	MEASUREMENT DEVICE	Yo Muramatsu, Takahisa Toda, Katsumichi Ishihara, Hikaru Urushimoto
Japan - 06601788	MOTOR ROTATOR, MOTOR DEVICE, AND METHOD FOR MANUFACTURING THE MOTOR ROTATOR	Koji Nakatake, Masaaki Ohashi
Philippines - 1-2015-000337	MOTOR CONTROL UNIT	Yuji Ide, Takao Oshimori, Hiroaki Koike
Philippines - 1-2016-000071	MOTOR CONTROL DEVICE	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi, Toshio Hiraide
Europe - 02107669	MOTOR WITH AN ELECTROMAGNETIC BRAKE	Toshihito Miyashita, Masahiro Yamaguchi
Europe - 02169812	MOLDED MOTOR	Toshihito Miyashita, Hiroshi Hioki, Junichi Chiku
Europe - 02199620	AXIAL FLOW FAN	Katsumichi Ishihara
Europe - 02295818	CENTRIFUGAL FAN	Kevin Yen, Hiromitsu Kuribayashi
Europe - 02381111	FAN WITH REDUCED NOISE	Naoya Inada, Toshiyuki Nakamura, Toshiki Ogawara, Yoshinori Miyabara
Europe - 02644902	AXIAL FLOW FAN	Naoya Inada, Jiro Watanabe
Europe - 02662571	FAN FRAME	Masahiro Koike, Soma Araki, Toshiki Ogawara
Europe - 02706243	AXIAL FLOW FAN	Atsushi Yanagisawa
Europe - 02913912	LINEAR MOTOR	Akihiko Takahashi
Europe - 03141764	MEASUREMENT DEVICE	Masahiro Koike, Tomoaki Ikeda, Takahisa Toda, Yo Muramatsu, Katsumichi Ishihara, Hikaru Urushimoto
Korea Patent 101952145	SHAFT ROTARY TYPE LINEAR MOTOR AND SHAFT ROTARY TYPE LINEAR MOTOR UNIT	Yuqi Tang, Satoshi Sugita
Korea - 101967926	MOTOR CONTROLLER	Yuji Ide, Michio Kitahara, Satoshi Yamazaki
Korea - 101971691	GROUND WIRE CONNECTION STRUCTURE FOR MOTOR	Toshihito Miyashita, Manabu Horiuchi
Korea - 101992818	MOTOR STRUCTURE	Toshihito Miyashita, Manabu Horiuchi
Korea - 101993174	LINEAR MOTOR	Yuqi Tang, Takashi Matsushita
Hong Kong - HK1199559	LINEAR MOTOR	Yuqi Tang, Satoshi Sugita
Hong Kong - HK1204716	LINEAR MOTOR UNIT	Yuqi Tang, Kazuhito Yamaura
Hong Kong - HK1204717	LINEAR MOTOR	Yuqi Tang, Takashi Matsushita
Taiwan - I649942	LINEAR MOTOR	Yuqi Tang, Takashi Matsushita

Registration Number	Name	Inventor(s)
Taiwan - I649957	CONTROL DEVICE OF FAN MOTOR	Takahisa Toda, Takashi Kaise, Jiro Watanabe
Taiwan - I657645	LINEAR MOTOR UNIT	Yuqi Tang, Kazuhito Yamaura
Taiwan - I661179	MAGNETIC SHIELD COVER FOR ENCODER OF MAGNETIC DETECTION TYPE AND ENCODER OF MAGNETIC DETECTION TYPE	Kazuhiro Makiuchi, Yoshihiro Shoji
Taiwan - I661654	STATOR CORE AND PERMANENT MAGNET MOTOR	Toshihito Miyashita, Manabu Horiuchi
Taiwan - I661657	GROUND WIRE CONNECTION STRUCTURE FOR MOTOR	Toshihito Miyashita, Manabu Horiuchi
Taiwan - I666853	STATOR, METHOD FOR MANUFACTURING STATOR, AND MOTOR	Toshihito Miyashita, Masashi Suzuki, Manabu Horiuchi, Masaki Musha
Taiwan - I667616	PRODUCT SPECIFICATION SETTING APPARATUS AND FAN MOTOR HAVING THE SAME	Tetsuya Yamazaki, Takahisa Toda
Taiwan - I671614	MOTOR CONTROLLER	Yuji Ide, Michio Kitahara, Satoshi Yamazaki
Taiwan - I673434	WATERPROOF AXIAL FLOW FAN	Katsumichi Ishihara, Akira Nakayama, Tatsuya Midorikawa, Masato Kakeyama
Taiwan - I675965	HOUSING OF FAN MOTOR	Toshiya Nishizawa, Haruka Sakai, Jiro Watanabe, Masashi Yokota
Taiwan - I677631	STRUCTURE FOR ATTACHING COOLING FAN	Daigo Kuraishi
Taiwan - I678065	MOTOR CONTROLLER	Yuji Ide, Michio Kitahara, Satoshi Yamazaki, Toshio Hiraide
China - ZL201410443216.5	COIL INSULATING STRUCTURE / Bobbin with Grooves for Inserting Insulating Slot Closer (OF ELECTROMAGNETIC MOTOR STATOR)	Koji Nakatake, Yasushi Yoda, Masaaki Ohashi
China - ZL201410459216.4	HOUSING OF FAN MOTOR	Toshiya Nishizawa, Haruka Sakai, Jiro Watanabe, Masashi Yokota
China - ZL201410468768.1	CONTROL DEVICE OF FAN MOTOR	Takahisa Toda, Takashi Kaise, Jiro Watanabe
China - ZL201410730354.1	WATERPROOF AXIAL FLOW FAN	Katsumichi Ishihara, Akira Nakayama, Tatsuya Midorikawa, Masato Kakeyama
China - ZL201410745918.9	MOTOR CONTROLLER	Yuji Ide, Michio Kitahara, Satoshi Yamazaki
China - ZL201510023115.7	STATOR CORE AND PERMANENT MAGNET MOTOR	Toshihito Miyashita, Manabu Horiuchi
China - ZL201510042487.4	STATOR, METHOD FOR MANUFACTURING STATOR, AND MOTOR	Toshihito Miyashita, Masashi Suzuki, Manabu Horiuchi, Masaki Musha
China - ZL201510063992.7	MOTOR STRUCTURE	Toshihito Miyashita, Manabu Horiuchi
China - ZL201510088131.4	LINEAR MOTOR	Akihiko Takahashi
China - ZL201510105596.6	STRUCTURE FOR ATTACHING COOLING FAN	Daigo Kuraishi
China - ZL201510217658.2	MOTOR CONTROLLER	Yuji Ide, Michio Kitahara, Satoshi Yamazaki, Toshio Hiraide
China - ZL201510528340.6	STEPPER MOTOR	Yasushi Yoda, Koji Nakatake, Masaaki Ohashi
China - ZL201510572450.2	MOTOR CONTROLLER	Yuji Ide, Satoshi Yamazaki, Masahisa Koyama
China - ZL201510612683.0	MOTOR CONTROL UNIT	Yuji Ide, Takao Oshimori, Hiroaki Koike
U.S. - 10170970	STEPPER MOTOR	Yasushi Yoda, Koji Nakatake, Masaaki Ohashi
U.S. - 10193431	LINEAR MOTOR	Akihiko Takahashi
U.S. - 10224797	LINEAR MOTOR	Yasushi Misawa, Hiroyuki Sato, Akihiko Takahashi, Satoshi Sugita
U.S. - 10236732	INDUCTOR TYPE ROTARY MOTOR	Satoshi Sugita, Yuqi Tang, Yasushi Misawa, Shigenori Miyairi
U.S. - 10260519	BIDIRECTIONAL AXIAL FAN DEVICE	Satoshi Fujimaki, Toshiya Nishizawa, Takashi Kawashima
U.S. - 10274341	MAGNETIC SHIELD COVER FOR ENCODER OF MAGNETIC DETECTION TYPE AND ENCODER OF MAGNETIC DETECTION TYPE	Kazuhiro Makiuchi, Yoshihiro Shoji

Registration Number	Name	Inventor(s)
U.S. - 10312763	STATOR, METHOD FOR MANUFACTURING STATOR, AND MOTOR	Toshihito Miyashita, Masashi Suzuki, Manabu Horiuchi, Masaki Musha
U.S. - 10344764	AXIAL BLOWER AND SERIES-TYPE AXIAL BLOWER	Toshiyuki Nakamura, Shuji Miyazawa
U.S. - 10367393	MOTOR ROTATOR, MOTOR DEVICE, AND METHOD FOR MANUFACTURING THE MOTOR ROTATOR	Koji Nakatake, Masaaki Ohashi
U.S. - 10393127	HOUSING OF FAN MOTOR	Toshiya Nishizawa, Haruka Sakai, Jiro Watanabe, Masashi Yokota
U.S. - 10465692	FAN MOTOR	Naruhiko Kudo, Munenori Takakuwa, Tatsuya Midorikawa

Internal Recognition: Invention Grand Prize (Excellence Award)

Awarded in May 2019

Prize	Title	Division	Name
Excellence Award	Drainage Structure of Splash Proof Blower	Cooling Systems Div., Design Dept.	Masaki Kodama, Toshiya Nishizawa, Kakuhiko Hata

Internal Recognition: Manufacturing Grand Prize (Excellence Award)

Awarded in May 2019

Prize	Title	Division	Name
Excellence Award	Injection Mold Technology which Realized Both Miniaturization and High Quality Product Appearance	Cooling Systems Div., Production Dept. Production Engineering Sect. 2	Yoichi Yamada Rikiya Niimura
Excellence Award	Automation of Plate Processing for Linear Servo Motors	Human Resources Dept. (On secondment from SANYO DENKI Techno Service Co., LTD.)	Takashi Miyasaka, Toru Kamimura
		SANYO DENKI Techno Service CO., LTD.	Hideaki Kobayashi
		Servo Systems Div., Production Engineering Dept., Process Engineering Sect. 1, Subsect. 1	Yoshiaki Hirabayashi

Technical Papers Published Outside the Company in General Technical Journals

January to December 2019

Title of Paper	Authors	Name of Journal	Issued in	Publisher
Feature: Product and Technology Development of Member Companies and the Results of 2018	SANYO DENKI CO., LTD.	Denki (Electrical Appliances)	2019.2	The Japan Electrical Manufacturers' Association (JEMA)
Development of UPS Products Equipped with Lithium-Ion Batteries Creating Change and Offering New Value	Masahiko Nagai	Monthly JETI	2019.6	Nippon Syuppan Seisaku Center Inc.
Development of the *SANUPS G53A* Emergency Diesel Generator	Masayuki Shibata	Smart Grid	2019.10	TAIGA Publishing Co., Ltd.
Development of the *SANUPS A22A* Modular Uninterruptible Power Supply	Hiroya Tokutake, Hiroshi Hirata, Yoshiko Kondo, Yuzo Kubota, Hiroyuki Kaneko, Toshifumi Nishizawa, Yoshimi Sunohara, Tomoharu Tanaka, Yuta Abe, Mika Takehara	Monthly JETI	2019.11	Nippon Syuppan Seisaku Center Inc.
Development of the *SANMOTION C* Motion Controller SMC100	Hideaki Kodama, Tomonobu Tazaki, Shigeki Sato, Hiroto Endo, Manabu Nakamura, Naoto Miura, Masayuki Mizutani, Ryunosuke Murakami	Monthly JETI	2019.11	Nippon Syuppan Seisaku Center Inc.

Technical Papers Published Outside the Company

January to December 2019

Title of Paper	Authors	Name of Journal	Issued in	Publisher
Study of a microgrid using a private power generator during a utility grid failure	Takuya Ota, Hiroaki Miyoshi (Co-authors: Aichi Institute of Technology, Southeast University, NTT FACILITIES, INC.)	Conference paper collection	2019.5	The 3rd IEEE ICDCM (International Conference on DC Microgrids)
Component analysis of estimated voltage disturbance in temperature estimation method robust to parameter variation	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi (Co-author: Nagaoka University of Technology)	The papers of Technical Meeting on Semiconductor Power Converter, IEEJ	2019.1	Joint Technical Meeting on Semiconductor Power Converter and Motor Drive, IEEJ
Temperature Estimation Method Considering Zero Speed Operation of SPMSM	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi (Co-author: Nagaoka University of Technology)	2019 IEEJ Industrial Applications Category Contest Lecture paper collection	2019.8	IEEJ Industrial Applications Category

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