SANYO DENKI

Technical Report

Feature | Technical Developments in 2022

1983
Advertisement with the 3C's mark

55
May 2023

COLUMN

Cover image:

Advertisement with the 3C's mark

1983

In 1983, SANYO DENKI put an advertisement bearing a large letter "C" to demonstrate our strong commitment to the fields of "computers," "control," and "communication." Under the slogan of "SANYO DENKI will take on high-tech challenges," all employees joined forces to face the fierce market competition.

Around that time, then - President Hiroshi Yamamoto was awarded the Medal with Blue Ribbon in recognition of his many years of service as a director of the Japan Electrical Manufacturers' Association. In the following year, then - Vice President Shinjiro Yokozawa was awarded the Japan Science and Technology Agency Award for his contribution to the industry through the development of servo mechanisms including stepping motors. This series of extreme honors contributed greatly to enhancing the company's brand image and reputation.

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May 2023

C O N T E N T S

SANYO DENKI's Technologies for Future Society

Yoshimasa Matsumoto Senior Executive Operating Officer

SANYO DENKI was founded in 1927 and will reach its 100th anniversary in four years.

Over the period of nearly 100 years, we have developed many products. Although our products are rarely seen by the general public, they have contributed to the development of society in many ways.

For example, we have developed systems that send air for cooling things, systems that convert and control energy, and systems for moving, manufacturing, and conveying things.

We have three business divisions: Cooling Systems, Power Systems, and Servo Systems.

Our cooling fans have been used in a wide range of fields, such as communication networks, PCs, and data centers.

Our power supply products, which are for converting and controlling electric power, have been used to provide power backup of communication carrier networks and computers.

Our servo system products, which is for moving and conveying things, have been used in automobile production lines, machine tools, copiers, printers, and hard disk drives.

Likewise, our products are used in numerous applications in various situations. In convenience stores, for example, they are used for air curtains in showcases, refrigerators, food warmer showcases, ATMs, POS systems, copiers, coffee makers, and surveillance cameras.
In hospitals, they are used in CT scanners, MRIs, mammography, blood analyzers, dialyzers, oxygen concentrators, fundus cameras, powder packing machines, and medical beds.

In the future, the world will see the emergence of even newer technologies such as IoT, AI, remote monitoring, and advanced automation.
Many of our products are used in ICT (information and communication technology) systems and communication networks, on which the above-mentioned new technologies are based.
Our products will also contribute to self-driving vehicles and hydrogen fuel-cell vehicles, which are expected to come to fruition in the future.

Due to the labor shortages and an aging population, robots will increasingly be used not only in industrial but also in many other fields such as agriculture, fishing, nursing care, home applications, advanced medical care, construction, automatic guided transport, and food services. The more robots become sophisticated and human-like, the more various types of motors are used in them to ensure safety. This is where our products can play an active role in their development.

For example, robots are in demand for automating the harvest of fruits and vegetables in agriculture and tasks that require craftsmen skills in the construction field.

AGVs (automated guided vehicles) and AMRs (autonomous mobile robots) will further evolve and be introduced into factories and our daily lives.

Equipment involving autonomous control uses a lot of fans.
LiDAR is a type of sensor that uses laser light and can precisely detect the position, shape, and distance of objects, which is essential for realizing self-driving vehicles in urban areas.
Roadside assistance radios are a generic term for a system that contains ICT equipment, sensors, and displays installed on roadsides. They help support safe driving using 5G communications. For such equipment, cooling fans are essential.

The energy sector is also facing a major turning point. To mitigate global warming, some energy control technologies are attracting attention, including those related to carbon neutrality, demand response, V2H (vehicle-to-home), and PPA (power purchase agreement). Our multi-function PV inverters and grid management systems are playing a major role in these fields.

In 2022, we released seven Cooling Systems products, such as air purifiers, low noise fans, and Splash Proof ACDC Fans; four Power Systems products, such as high-power UPSs; and four Servo Systems products, such as new AC servo systems and multi-axis linear servo motors.

With our new series of low noise fans, we achieved noise reduction, energy savings, and a longer service life. Our new servo series offers user-friendly, high-performance, and energy-saving features.

In 2021, we strengthened our development capabilities by opening a new wing at our Technology Center in Ueda.

In this issue, we will introduce some of our development achievements: San Ace 140 (low noise fans), San Ace 120AD (high-airflow Splash Proof ACDC Fans), LAN Interface Card, linear servo motor, and high-power stepping drivers.

We expect that the development of technology will be remarkable in the future and society will change along with it. Moving forward, SANYO DENKI Group will continue to develop new products that support society through technological advancement and aim to become the world's top brand as a global company.

Cooling Systems Division

Honami Osawa

Social environments have undergone major changes amid heightened awareness of infection control measures due to the spread of COVID-19. People are often restricted from working face-to-face, and remote work has become the new normal. ICT systems are now playing an extremely important role supporting this new mode of life. ICT equipment such as servers, storage devices, and routers have been constantly improved in speed, capacity, and performance becoming denser and generating more heat. This has raised demand for cooling fans with higher airflow, higher static pressure, and lower power consumption.

Furthermore, outdoor equipment such as base stations, PV inverters, and digital signage have increased in performance and functionality, requiring water-resistant cooling fans with higher cooling performance.

Also, the use of air purifiers in large spaces where many people gather is considered increasingly important in today's society.

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

Below is an overview of the products we developed in 2022.

■ Low Noise Fan

DC Fan

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

Our 80 × 80 × 38 mm fans are mainly used in 2U servers, and we have focused especially on increasing the performance. Meanwhile, power supply and measurement equipment industries are now demanding fans with lower noise and lower power consumption while maintaining the same cooling performance as the products currently in use.

To meet such demands, we developed and launched the *San Ace 80* 9RA type fan, which has the industry's lowest(1) noise and power consumption.

(1) Based on our own research as of June 10, 2022, conducted among equally-sized axial DC fans on the market.

• 120 × 120 × 38 mm *San Ace 120* 9RA type

Our 120 × 120 × 38 mm fans are used in a wide range of applications such as communication, medical, and measurement equipment. In these applications, there is now an growing demand for fans with lower noise and lower power consumption while offering the same cooling performance as the fans currently used.

To meet such market demands, we developed and launched the *San Ace 120* 9RA type fan, which has the industry's lowest(2) noise and power consumption.

(2) Based on our own research as of January 27, 2022, conducted among equally-sized axial DC fans on the market.

• 140 × 140 × 38 mm *San Ace 140* 9RA type

Our 140 × 140 × 38 mm fans are often used in equipment such as commercial air conditioners and medical equipment. Such equipment is used near people and thus requires quiet fans. Moreover, there is also high demand for reduced power consumption for environmental and running cost reasons.

To meet such market demands, we developed and launched the *San Ace 140* 9RA type fan that has the industry's lowest(3) noise and power consumption. Its details are covered in a separate article in this issue.

(3) Based on our own research as of October 27, 2022, conducted among equally-sized axial DC fans on the market.

■ Splash Proof Fan

DC Fan

• 40 × 40 × 20 mm *San Ace 40* 9WPA type
• 40 × 40 × 28 mm *San Ace 40* 9WPA type

In recent years, outdoor equipment such as base stations, quick EV chargers, and surveillance cameras is increasing in performance, and this has raised demand for compact water-resistant fans with higher performance.

To respond to such market demands, we developed and launched the *San Ace 40* 9WPA type Splash Proof Fan, which offers the industry's highest(4) airflow and static pressure, as well as IP68-rated protection(5).

(4) Based on our own research as of June 28, 2022, conducted among equally-sized water-resistant fans on the market.
(5) IP68-rated protection:
The IP Code, or Ingress Protection Code is defined by International Electrotechnical Commission (IEC) in the IEC 60529 standard "Degrees of Protection Provided by Enclosures (IP Code)".

■ 120 × 120 × 38 mm ACDC Fan

- 120 × 120 × 38 mm *San Ace 120AD* 9ADA type
- 120 × 120 × 38 mm *San Ace 120AD* 9ADAW type

An increasing number of customers have requested 120 × 120 × 38 mm ACDC Fans with even higher airflow than our current products (9AD type fans). Also, there has been increasing demand for durable fans with water and dust resistance for use in applications where AC fans are preferred, such as in plant factories and control panels used in factory equipment.

To meet such demands, we developed and launched two fans featuring the highest airflow and static pressure in the industry[6]: the *San Ace 120AD* 9ADA type fan; the *San Ace 120AD* 9ADAW type fan, which offers IP68-rated protection[5]. Their details are covered in a separate article in this issue.

(6) Based on our own research as of August 24, 2022, conducted among equally-sized ACDC fans and water-resistant ACDC fans on the market.

■ 160 × 160 × 51 mm ACDC Fan

- 160 × 160 × 51 mm *San Ace 160AD* 9AD type
- 160 × 160 × 51 mm *San Ace 160AD* 9ADW type

Our 160 × 160 × 51 mm AC Fans—designed in our proprietary size—are used in equipment such as control panels, industrial equipment, and air conditioners.

In these applications, there is an increasing demand for features such as low power consumption, low noise, water resistance, PWM control, and a wide input voltage range.

To meet such market demands, we developed and launched 160 × 160 × 51 mm *San Ace 160AD* 9AD type ACDC Fans and *San Ace 160AD* 9ADW type Splash Proof ACDC Fans with IP56-rated protection[7].

(7) IP56-rated protection:
The IP Code, or Ingress Protection Code is defined by International Electrotechnical Commission (IEC) in the IEC 60529 standard "Degrees of Protection Provided by Enclosures (IP Code)".

■ Air Purifier

• *San Ace Clean Air*

Against the background of increasing air pollution and the spread of COVID-19, there is now a greater public demand for clean air. It is expected that demand for large air purifiers will continue to grow as an infection control measure in facilities where many people gather.

To respond to such market demands, we have leveraged our accumulated cooling fan expertise and high-efficiency air flow channel design expertise to develop and launch the *San Ace Clean Air* Air Purifier capable of sanitizing and filtering the air in large rooms.

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120 × 120 × 38 mm *San Ace 120AD* 9ADA Type ACDC Fan and *San Ace 120AD* 9ADAW Type Splash Proof ACDC Fan

Masashi Murakami Noriaki Ogawa Izumi Onozawa

Toshiya Nishizawa Hidetoshi Oobayashi Masato Murata

1. Introduction

Our 120 × 120 × 38 mm ACDC Fans are primarily used in control panels of factory equipment. In recent years, control panels have become smaller and denser, requiring fans with higher airflow and higher static pressure. Environmental durability is also essential for ACDC fans for use in harsh environments such as dusty factory facilities and water-exposed plant factories.

In response to these market demands, we developed and launched new products featuring high airflow and high static pressure: a 120 × 120 × 38 mm *San Ace 120AD* 9ADA type ACDC Fan and a *San Ace 120AD* 9ADAW type Splash Proof ACDC Fan (hereinafter, "new product" for both).

This article introduces the performance and features of these new products, as well as the key points of development.

2. Product Features

Figure 1 shows the 9ADA type and Figure 2 shows the 9ADAW type.

The features of these new products are as follows:

(1) High airflow and high static pressure
(2) Wide AC input voltage range

In addition, the 9ADAW type is the first of our ACDC Fans to have the following feature.

(3) IP68-rated* dust and water protection

* IP68-rated protection:
The IP Code, or Ingress Protection Code is defined by International Electrotechnical Commission (IEC) in the IEC 60529 standard "Degrees of Protection Provided by Enclosures (IP Code)".

Fig. 1 120 × 120 × 38 mm *San Ace 120AD* 9ADA type

Fig. 2 120 × 120 × 38 mm *San Ace 120AD* 9ADAW type

3. Product Overview

3.1 Dimensions

Figures 3 and 4 show the dimensions of the 9ADA type and 9ADAW type, respectively. Both types are identical in external dimensions and mounting dimensions, and they are also designed to be compatible with our current products.

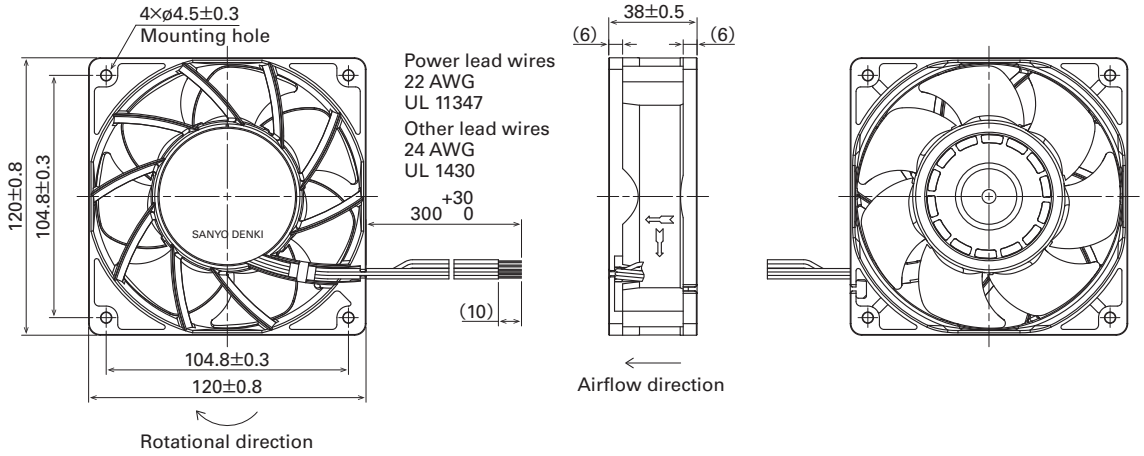

Fig. 3 Dimensions of 120 × 120 × 38 mm *San Ace 120AD* 9ADA type (Unit: mm)

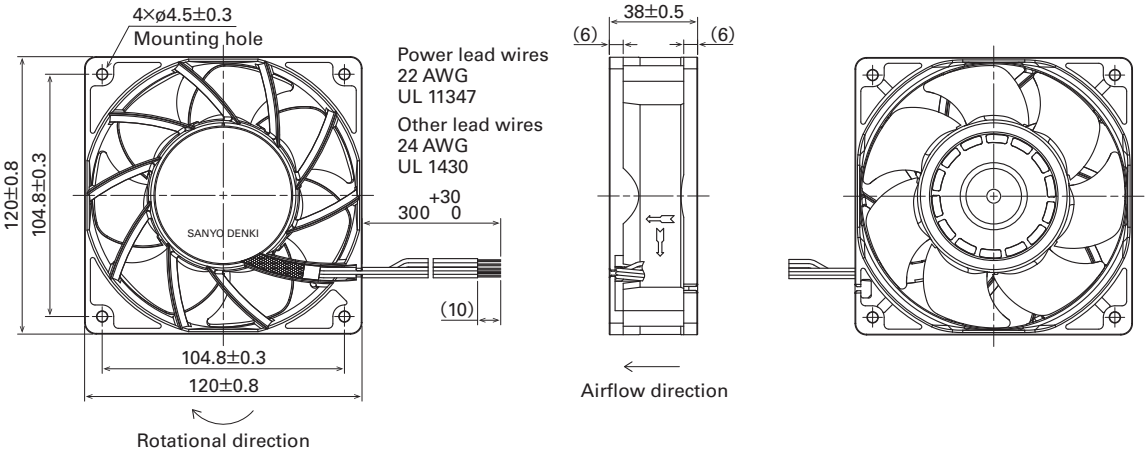

Fig. 4 Dimensions of 120 × 120 × 38 mm *San Ace 120AD* 9ADAW type (Unit: mm)

3.2 Specifications

3.2.1 General specifications

Tables 1 and 2 show the general specifications of the 9ADA type and 9ADAW type, respectively.

Their operating voltage range is 90 to 264 V, and thus they can be used both with 100 V and 200 V systems.

Table 1 General specifications of 120 × 120 × 38 mm *San Ace 120AD* 9ADA type

Model no.	Rated voltage [V]	Operating voltage range [V]	Frequency [Hz]	PWM duty cycle* [%]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow [m^3/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH$_2$O]	Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
9ADA1201P1G001	100 to 240	90 to 264	50/60	100	0.17	9.0	4400	3.9	138	170	0.683	52	-20 to +70	40000 at 60°C (70000 at 40°C)
				20	0.04	1.4	1050	0.93	32.8	15	0.06	25		
9ADA1201G1002				–	0.17	9.0	4400	3.9	138	170	0.683	52		
9ADA1201H1002					0.13	6.6	3800	3.36	119	128	0.514	48		60000 at 60°C (90000 at 40°C)

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

Table 2 General specifications of 120 × 120 × 38 mm *San Ace 120AD* 9ADAW type

Model no.	Rated voltage [V]	Operating voltage range [V]	Frequency [Hz]	PWM duty cycle* [%]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow [m^3/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH$_2$O]	Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
9ADAW1201P1H001	100 to 240	90 to 264	50/60	100	0.13	6.6	3800	3.36	119	128	0.514	48	-20 to +70	60000 at 60°C (90000 at 40°C)
				25	0.04	1.4	1050	0.93	32.8	15	0.06	25		
9ADAW1201H1002				–	0.13	6.6	3800	3.36	119	128	0.514	48		

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

3.2.2 Airflow vs. static pressure characteristics

Figure 5 shows the airflow vs. static pressure characteristics of the 9ADA1201P1G001 model, Figure 6 shows the characteristics comparison between the 9ADA1201G1002 and 9ADA1201H1002 models, and Figure 7 shows the airflow vs. static pressure characteristics of the 9ADAW1201P1H001 model. The airflow vs. static pressure characteristics of all models do not change over their input voltage range from 100 to 240 V.

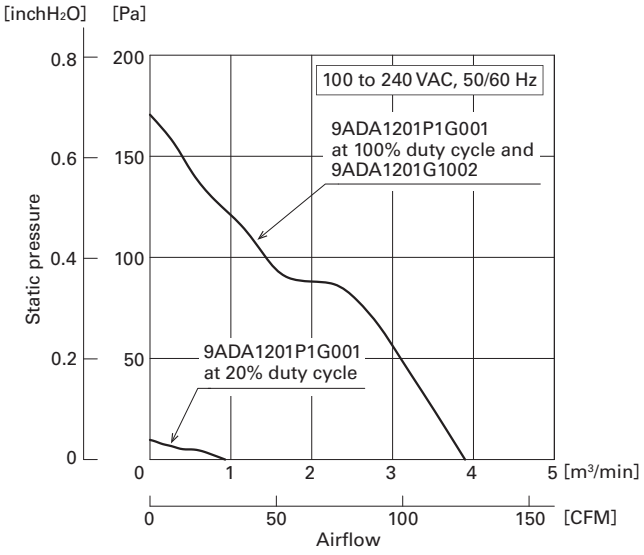

Fig. 5 Airflow vs. static pressure characteristics of 9ADA1201P1G001

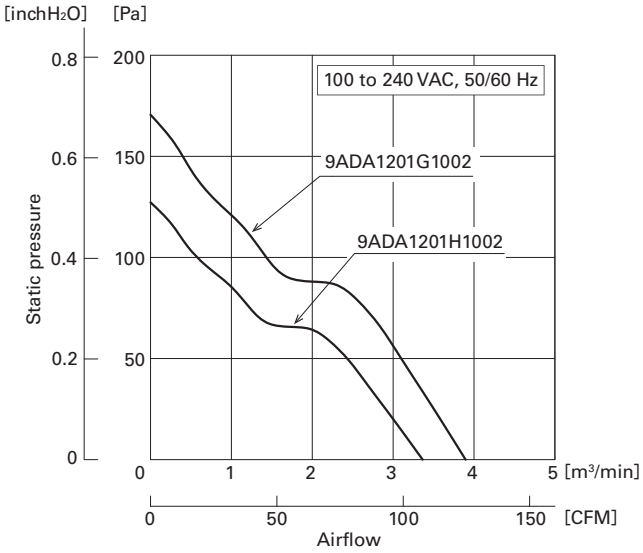

Fig. 6 Characteristics comparison between 9ADA1201G1002 and 9ADA1201H1002

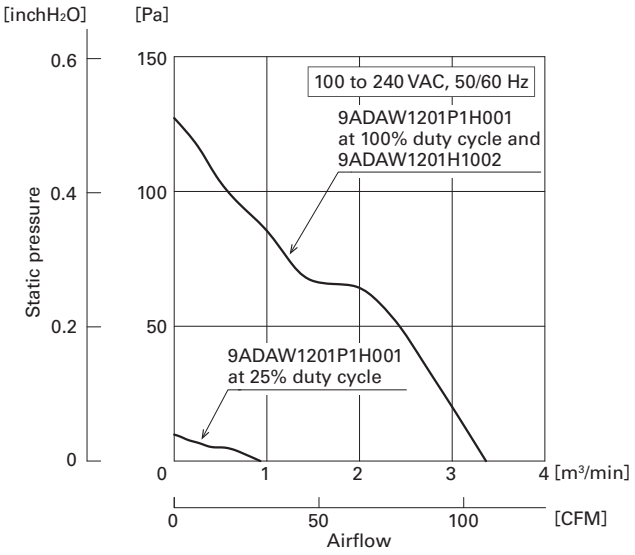

Fig. 7 Airflow vs. static pressure characteristics of 9ADAW1201P1H001

3.2.3 PWM control

The 9ADA1201P1G001 and 9ADAW1201P1H001 models come with PWM control for controlling the fan speed.

3.3 Expected life

The new products have an expected life of 40,000 hours for the 9ADA1201P1G001 model and 60,000 hours for the 9ADA1201H1002 and 9ADAW1201P1H001 models at 60°C (both have a survival rate of 90%, when run continuously at the rated voltage in free air and at normal humidity).

4. Key Points of Development

The new products achieve higher airflow and higher static pressure while maintaining the same size as our current ACDC fan. The 9ADAW type also offers dust and water protection.

The key features of the new products are described below.

4.1 Impeller and frame design

Figure 8 compares the impeller and frame shapes of the new *San Ace 120AD* fan and our current product.

We verified various combinations of parameters such as the number, length, and angle of impellers and the frame shape through simulations and evaluations on actual equipment to determine the optimal design for excellent airflow efficiency.

4.2 Circuit design

The key was to design a circuit that operates stably while providing high airflow, high static pressure, and a wide range of input voltages despite the size limitation of the PCB due to the impeller and frame shape.

The target specifications were achieved by improving the efficiency of the ACDC conversion circuit, optimizing the DC voltage that drives the motor, and selecting the best electronic components for the specifications.

4.3 Water-resistant design

Figure 9 shows the live parts of the 9ADAW type.

The 9ADAW type is our first Splash Proof ACDC Fan to achieve IP68-rated protection.

While many of our Splash Proof DC Fans have IP68, the best protection our existing Splash Proof ACDC Fans could offer was IP56. This was because enclosing a fan's motor and circuit portions completely with resin coating works for DC fans but not for ACDC fans since it would undermine the reliability and safety of components unique to ACDC fans in the event of abnormalities.

We resolved this challenge by devising a new structure that combined the structure of our Splash Proof DC Fan with that of our current Splash Proof ACDC Fan, ensuring the reliability and safety in the event of abnormalities and achieving IP68 protection.

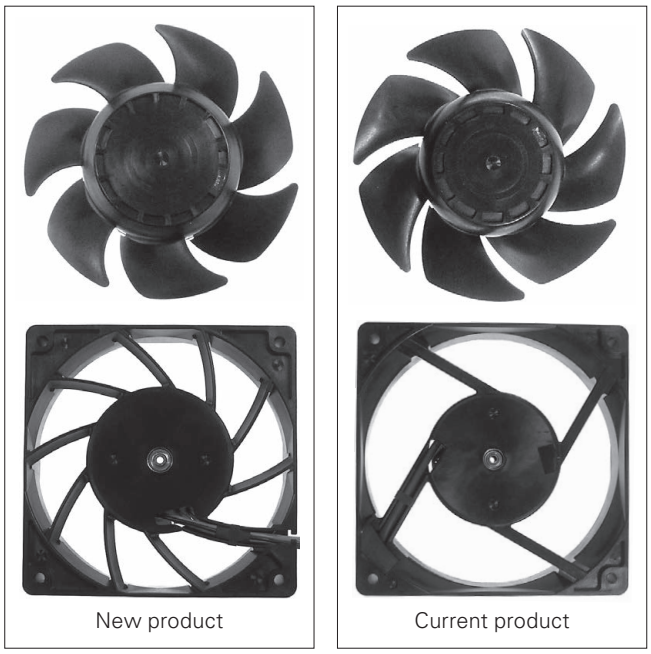

Fig. 8 Shape comparison between the new and current products

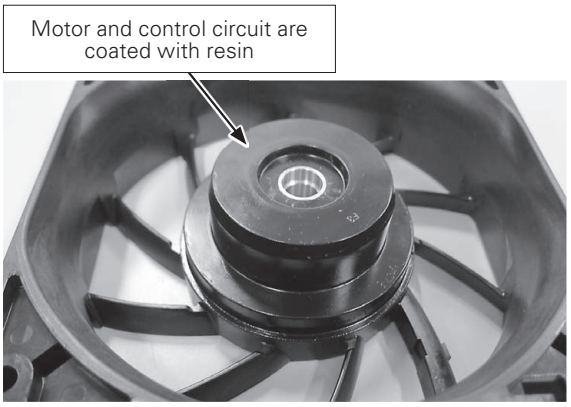

Fig. 9 Live parts of new product

5. Comparison of New and Current Products

5.1 Comparison of airflow vs. static pressure characteristics

Figure 10 compares the airflow vs. static pressure characteristics of the new 9ADA1201P1G001 and the current product. Compared to the current product, the maximum airflow and maximum static pressure have been improved by 30% and 102%, respectively.

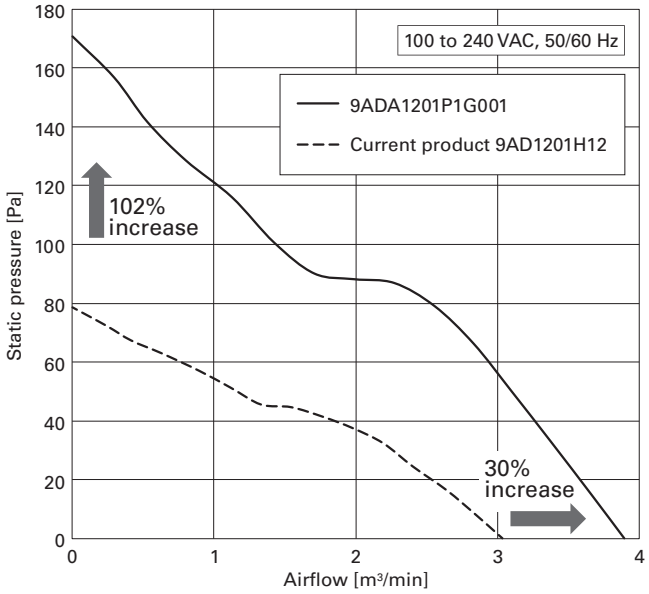

Fig. 10 Airflow vs. static pressure characteristics comparison between the current product and new 9ADA1201P1G001 (at 100 V, 60 Hz)

Figure 11 compares the airflow vs. static pressure characteristics of the new 9ADAW1201P1H001 and the current product. Compared to the current product, the maximum airflow and maximum static pressure have been improved by 12% and 52%, respectively.

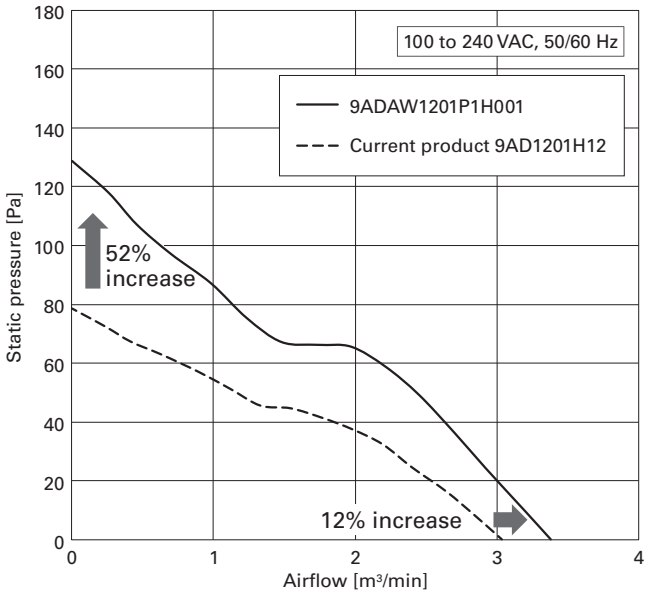

Fig. 11 Airflow vs. static pressure characteristics comparison between the current product and new 9ADAW1201P1H001 (at 100 V, 60 Hz)

6. Conclusion

This article presented some of the features and performance of the *San Ace 120AD* 9ADA type ACDC Fans and *San Ace 120AD* 9ADAW type Splash Proof ACDC Fans. Each of the new products achieves higher airflow and static pressure than the current products and can cool smaller and denser control panels. The 9ADAW type meets the requirement for use in harsh environments thanks to its dust and water protection.

We will continue to help our customers create new value by providing products that address market demand.

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140 × 140 × 38 mm *San Ace 140* 9RA Type Low Noise Fan

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Osamu Nishikawa Ryo Shimizu Hiromitsu Kuribayashi

1. Introduction

Equipment such as commercial air conditioners and medical equipment used near people requires particularly quiet fans. Also, energy conservation has become an important issue in recent years due to the worldwide trend toward CO_2 emissions reduction. We have offered a 140 × 140 × 38 mm 9P type fan (hereinafter, "current product") since 1999. However, this has become obsolete and is unable to meet recent customer needs, especially in noise and power consumption performance.

To meet such market demands, we have developed and launched a low-noise *San Ace 140* 9RA type fan (hereinafter, "new product").

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

2. Product Features

Figure 1 shows the new product. The new product has lower noise and lower power consumption than the current product while maintaining the same size and cooling performance.

Fig. 1 Appearance of 140 × 140 × 38 mm *San Ace 140* 9RA type

3. Product Overview

3.1 Dimensions

Figure 2 shows the dimensions of the new product.

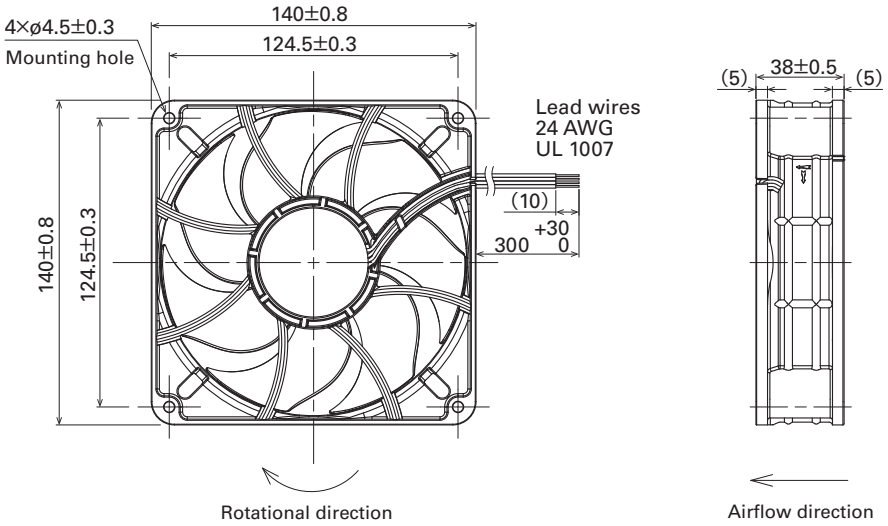

Fig. 2 Dimensions of 140 × 140 × 38 mm *San Ace 140* 9RA type (Unit: mm)

3.2 Specifications

Tables 1 and 2 show the general specifications of the new product, and Figure 3 shows the airflow vs. static pressure characteristics.

While the current product lineup offers only two different fan speeds (medium-speed and low-speed models), the new product lineup offers four fan speeds (fastest, high-speed, medium-speed, and low-speed models) for use in a wide range of markets.

Compared to the current medium-speed models, the new high-speed and fastest models have achieved an 18% and 33% increase in maximum airflow, respectively.

In addition, the fastest model comes with PWM control. The PWM control enables the external control of fan speed according to the amount of heat generated by equipment, contributing to reducing noise and power consumption of equipment.

Table 1 General specifications of 140 × 140 × 38 mm *San Ace 140* 9RA type fastest models

Model no.	Rated voltage [V]	Operating voltage range [V]	PWM duty cycle* [%]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow [m^3/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH_2O]	Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
9RA1412P1G001	12	10.8 to 13.2	100	1.10	13.2	4250	6.0	212	160	0.64	52	-20 to +70	40000 at 60°C (70000 at 40°C)
			20	0.09	1.1	1250	1.81	64.0	16.3	0.065	19		
9RA1424P1G001	24	21.6 to 26.4	100	0.53	12.7	4250	6.0	212	160	0.64	52		
			20	0.05	1.2	1400	2.17	76.7	21.5	0.086	22		
9RA1448P1G001	48	43.2 to 52.8	100	0.28	13.4	4250	6.0	212	160	0.64	52		
			30	0.04	1.9	1600	2.32	82.0	29.5	0.118	25		

* Input PWM frequency: 25 kHz. Speed is 0 min^{-1} at 0% PWM duty cycle.

Table 2 General specifications of 140 × 140 × 38 mm *San Ace 140* 9RA type high-speed, medium-speed, and low-speed models

Model no.	Rated voltage [V]	Operating voltage range [V]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow [m^3/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH_2O]	Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
9RA1412S1001	12	7 to 13.8	0.75	9.0	3750	5.3	187	130	0.52	49	-20 to +70	40000 at 60°C (70000 at 40°C)
9RA1412H1001			0.43	5.2	3050	4.3	152	92	0.37	43		
9RA1412M1001			0.19	2.3	2250	3.2	113	54	0.22	35		
9RA1424S1001	24	14 to 27.6	0.37	8.9	3750	5.3	187	130	0.52	49		
9RA1424H1001			0.22	5.3	3050	4.3	152	92	0.37	43		
9RA1424M1001			0.10	2.4	2250	3.2	113	54	0.22	35		
9RA1448S1001	48	40.8 to 55.2	0.21	10.1	3750	5.3	187	130	0.52	49		
9RA1448H1001			0.13	6.2	3050	4.3	152	92	0.37	43		
9RA1448M1001			0.06	2.9	2250	3.2	113	54	0.22	35		

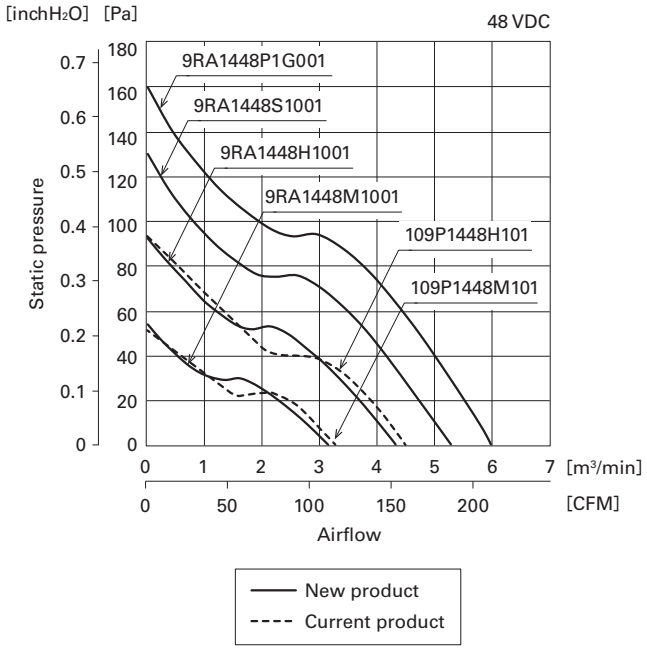

Fig. 3 Airflow vs. static pressure characteristics of 140 × 140 × 38 mm *San Ace 140* 9RA type fans

4. Key Points of Development

In order to reduce noise and power consumption, the new product has an optimally selected motor and new impeller and frame shapes designed with an innovative concept without being constrained by the current product shape.

The key points of development are described below.

4.1 Motor design

For the new product to achieve the target airflow vs. static pressure characteristics, we selected a motor with the optimal output out of the ones used in our existing fans. This enabled the downsizing of the motor, increasing the design freedom of the impeller and frame.

In contrast to the unipolar motor drive (two-phase half-wave) of the current product, the new product uses a highly efficient bipolar drive (single-phase full-wave).

4.2 Impeller and frame design

To achieve low noise and low power consumption, simulations were performed to find the optimal combination of various parameters such as impeller hub diameter, blade shape, number of blades, blade mounting angle, frame shape, and stator blade shape and number. Through evaluations on actual equipment with the selected combinations, the optimal shape was determined.

Figures 4 and 5 compare the impeller shape and frame shape, respectively, between the new and current products.

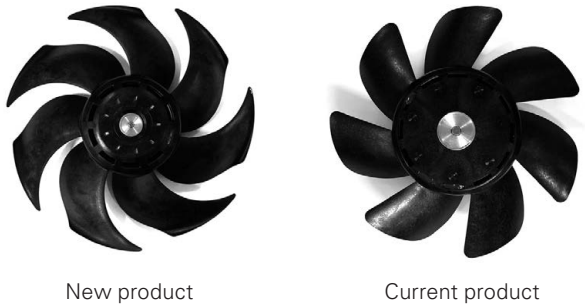

Fig. 4 Comparison of the impeller shape of the new and current products

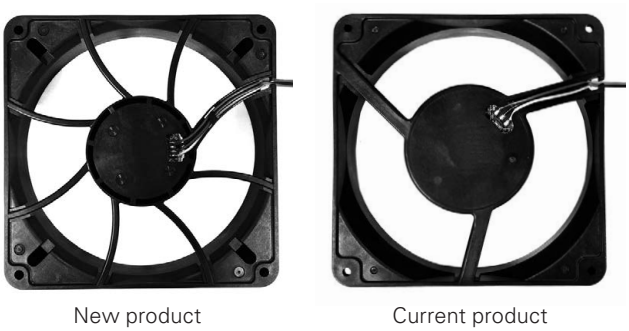

Fig. 5 Frame shape comparison of the new and current products

5. Comparison of New and Current Products

5.1 Noise level and power consumption comparison

Figure 6 compares the power consumption and noise level of the current and new products at equivalent cooling performance. At the estimated system impedance (equipment ventilation resistance) shown in the figure, the new product has 9.5 dB(A) lower noise and 24% lower power consumption compared to the current product.

5.2 Environmental impact comparison

Figure 7 compares the CO_2 emissions of the new and current products over their life cycles.

The new product produces 41% less CO_2 emissions over its product life cycle compared to the current product thanks to its greatly reduced power consumption. In addition, its motor has been downsized and its product weight has been reduced from 450 g to 360 g, contributing to waste reduction.

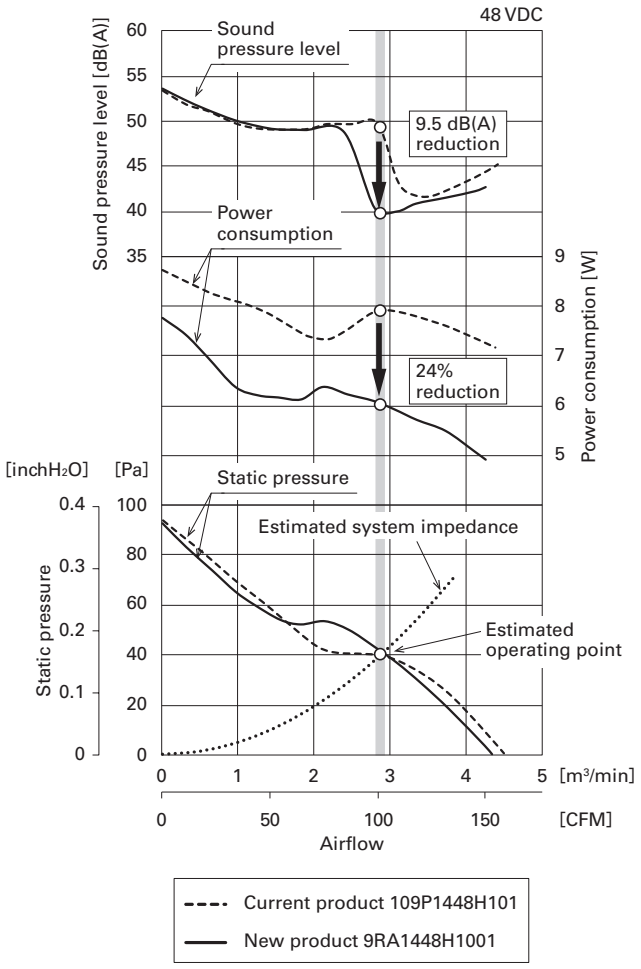

Fig. 6 Noise level and power consumption comparison

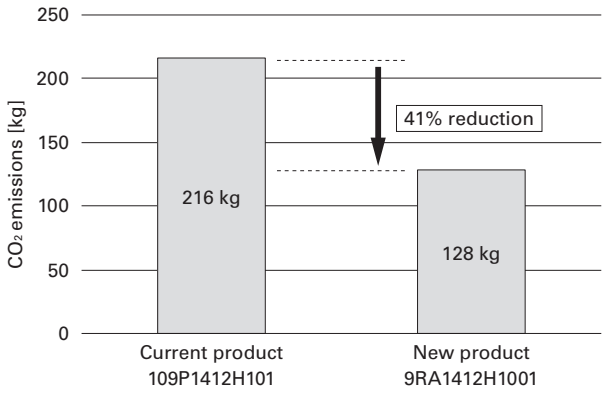

Fig. 7 CO_2 emissions comparison based on our life cycle assessment calculation software (40,000-hour continuous operation in free air)

6. Conclusion

This article introduced the features and performance of the low-noise *San Ace 140* 9RA type fan.

The new product has lower noise and lower power consumption than the current product while maintaining the same cooling performance. In addition, the lineup includes models with higher airflow and higher static pressure than the current product.

This contributes to reducing noise, saving energy, and improving the performance of equipment used near people such as commercial air conditioners and medical equipment. It also reduces total CO_2 emissions over the equipment life cycle, contributing to a reduction in environmental impact.

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

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Power Systems Division

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2022 saw the rapid spread of the Omicron variant of COVID-19 but was also a year when we implemented a new way of dealing with infection balancing infection control and economic activity. As society has grown accustomed to living with COVID-19, work-from-home and teleworking have become an accepted practice in many companies.

The manufacturing industry is observing a significant growth in smart factories leveraging digital technologies such as IoT and AI, exploring the use of data obtained from IoT devices and sensors.

Meanwhile, the Japanese government has announced its plan to achieve carbon neutrality, or net-zero greenhouse gas emissions, by 2050. This has raised demand for more efficient power supply devices.

It is against this backdrop that the Power Systems Division developed the following new products in 2022. For uninterruptible power supplies (UPSs), we developed a small-capacity online UPS *SANUPS A11N* and a medium-capacity online UPS *SANUPS A23D*.

For UPS management, we developed the 1-Gigabit Ethernet *LAN Interface Card* for UPSs.

This article provides an overview of each of these products.

■ Development of the *SANUPS A11N* online UPS

The *SANUPS A11N* is a double conversion online UPS capable of parallel redundant operation. The input/output voltage is single-phase 2-wire and can be set to either 200, 208, 220, 230, or 240 V.

It is available in two types. The single unit type has a single 5 kVA base unit with AC output outlets on the back of the unit, while the parallel connection type comes with a power distribution unit and is scalable up to 20 kVA by combining up to four base units in parallel.

The parallel connection type uses our "fully autonomous control" technology to control the parallel operation of each unit. As long as there is an unused capacity of one unit (5 kVA) extra for the load, the parallel redundant operation can be performed using one unit as a spare, further increasing reliability.

The product supports a wide input voltage range and can continue to supply power without switching to battery power even if the input voltage fluctuates within a range from -20 to +15% at full load level (or -40 to +15% at low load levels). This allows it to be used even in regions where the power supply is unstable.

It also uses a 3-level inverter for the inverter circuit to achieve an industry-leading(1) conversion efficiency of up to 95.1%.

Even when grid power is unavailable and the UPS is not operating, the battery cold start function allows the UPS to be started by battery to supply AC power, serving as an emergency power source during a natural disaster.

Fig. 1 *SANUPS A11N* parallel connection type, 20 kVA model

(1) Based on our own research as of June 30, 2022, conducted among online UPSs on the market.

■ Development of the *SANUPS A23D* online UPS

The *SANUPS A23D* is an online UPS with 3-phase 3-wire 200 V input/output voltage. The lineup is available in output capacities of 30, 50, 75, and 100 kVA. The product supports an input/output voltage of 210 and 220 V without a transformer (set at the time of shipment).

This UPS achieves a conversion efficiency of up to 95%, delivering a 2% increase from our current product. This suppresses power consumption and heat generation, reducing running costs and CO_2 emissions.

The product can also be operated within a wide AC input voltage range. This reduces transfers to battery power under unstable input power conditions, minimizing battery wear and degradation.

It also comes with a new "walk-in feature." When used in an emergency power supply system that combines an emergency generator and UPS, this feature suppresses sudden output voltage fluctuations in the emergency generator during power restoration, allowing customers to build an economical emergency power supply system by not requiring an unnecessarily high capacity of a generator.

We revamped the part selection and improved efficiency so that the main replacement parts—electrolytic capacitors and cooling fans—do not need to be replaced for 15 years. This helps reduce part replacement costs.

Fig. 2 *SANUPS A23D*
100 kVA model

■ Development of 1-Gigabit Ethernet *LAN Interface Card* for UPSs

Our *LAN Interface Card* is a UPS management product used in a UPS for monitoring the UPS status in real time and managing the UPS remotely.

As IoT advances, there is a growing demand for server power management that supports faster communication and increased security. In response, the new model supports 1-Gigabit Ethernet for use in various network environments.

In addition to SSH(2), this card also supports REST API(3) as a communication protocol for shutting down servers. This protocol is simpler yet highly versatile and is capable of shutting down the latest servers and network devices that have enhanced security.

Wireless LAN support has also been added to enable users to monitor UPSs using their smartphones and tablet PCs even in environments without wired LAN support, greatly improving user convenience. Finally, this product also features automatic log storage capability that allows UPS operating information to be easily copied by simply plugging in a USB flash drive.

Details on the 1-Gigabit Ethernet *LAN Interface Card* for UPSs are covered in a separate article in this issue.

Fig. 3 *LAN Interface Card*

(2) SSH (Secure Shell) is a communication protocol secured by data encryption.
(3) REST API is a communication protocol used in web communication.

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Development of 1-Gigabit Ethernet *LAN Interface Card* for UPSs

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1. Introduction

Our *SANUPS LAN Interface Card* (hereinafter, "*LAN Interface Card*"), installed in uninterruptible power supplies (hereinafter, "UPSs"), has been used not only in the ICT equipment market but also in the industrial equipment market for UPS monitoring and automatic server shutdown in the event of an outage.

We have received various requests from customers regarding the use of such cards with UPSs. There have been demands in the ICT device field, for example, for UPSs to connect to Gigabit Ethernet and have advanced security features.

At the same time, we have received requests from the industrial equipment market, such as additional support for UPS monitoring via connections other than a wired LAN and UPS log acquisition that does not require a PC connection.

To meet these requests, we have developed a new model of the *LAN Interface Card* (hereinafter, "new model").

This article provides an overview of the new model and introduces its features.

2. Product Overview

The new model has the following new functions added to our current models to meet various requests from customers.

- 1-Gigabit Ethernet
- Wireless LAN communications
- Log storage on a USB flash drive
- Enhanced server shutdown

To realize these functions, the new model has all-new hardware, such as a faster CPU, increased on-board memory capacity, and additional interfaces.

At the same time, the new model has been designed with the same dimensions as those of the current models so that it can be installed in our current UPSs.

Figure 1 shows the new model (Model no.: PRLANIF031).

Fig. 1 *LAN Interface Card* (Model no. PRLANIF031)

The following functional enhancements have been made to the external interface of the new *LAN Interface Card*.

- The wired LAN communication supports 1-Gigabit network communications, which is faster than current models.
- A USB port has been added for the connection of USB devices. This allows the user to connect a Wi-Fi adapter and USB flash drive.
- An EXT port has been added for extension, which allows temperature/humidity sensors and Modbus RTU devices to be connected at the same time via an extension cable.
- A USB Type-C port has been added as a setup port to be used for direct configuration from a PC.

Figure 2 shows the external interface of the front panel.

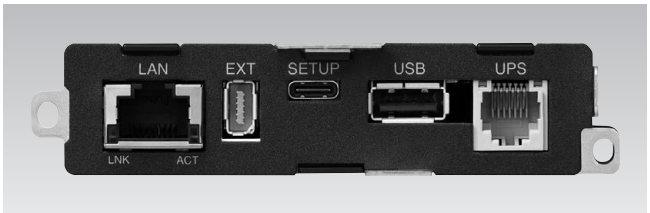

Fig. 2 *LAN Interface Card* front interface

In terms of software features, the new model complies with new security standards for ICT devices, for which a high level of security is required.

The current models have traditionally been equipped with the SSH (Secure Shell), a protocol to remotely operate network-connected devices through secure communications by encrypting network communications, to perform shutdown of servers and network devices.

The new model is equipped with the OpenSSH* with enhanced security over the current models and thus can be securely used even in customer environments requiring a high level of security.

* OpenSSH is an open source implementation of SSH.

3. Features

3.1 1-Gigabit Ethernet

The new model enables 1000 Mbps network communication, which was not supported by the current models.

This realizes to connect the *LAN Interface Card* directly to a network device through Gigabit Ethernet, enabling downloading of collected data and uploading of setting value data at high speeds.

Table 1 shows a comparison with the current models.

Table 1 Comparison of network communication support

Standards	Communication speed	Current model	New model
10Base-T	Max. 10 Mbps	✓	✓
100Base-TX	Max. 100 Mbps	✓	✓
1000Base-T	Max. 1000 Mbps	–	✓

(✓: supported, –: not supported)

3.2 USB port

The new model comes with a USB Type-A port to extend its functionality by connecting USB devices. By connecting a Wi-Fi adapter or USB flash drive to the USB port, wireless LAN communications and log storage on USB flash drives can be realized.

3.2.1 Wireless LAN communications

Connecting a Wi-Fi adapter to the USB port enables wireless LAN communications in either station mode or access point mode. Table 2 describes each mode of operation.

Table 2 Wi-Fi operation modes of *LAN Interface Card*

Operation mode	Description
Station mode	Connects a *LAN Interface Card* client device to a host device, such as a wireless LAN router.
Access point mode	Connects a smartphone or tablet client device to a *LAN Interface Card* host device.

When operating in station mode, you can remotely monitor the *LAN Interface Card* even in environments without LAN cables, as long as there is a nearby wireless LAN base station such as a Wi-Fi router.

When operating in access point mode, you can directly connect to the *LAN Interface Card* from a smartphone to check the UPS status or change the *LAN Interface Card* settings even in environments without a nearby wireless LAN base station such as a Wi-Fi router.

3.2.2 Log storage on a USB flash drive

In the case of abnormalities, it is essential to analyze information such as UPS and *LAN Interface Card* event logs as well as the measurement data of the UPS, temperature/humidity sensors, and Modbus-compatible devices.

With the current models, this information has been only obtained over a network using a PC.

However, the new model automatically creates a local backup of log and measurement data by simply connecting a USB flash drive to the USB port without using a PC.

Table 3 lists the obtainable data.

Table 3 Data that can be saved on a USB flash drive

Items to save	Description
Setting values	*LAN Interface Card* setting values
System log	*LAN Interface Card* event log
Aggregate data (daily)	Aggregate data of hourly mean values, minimum values, and maximum values
Aggregate data (monthly)	Aggregate data of daily mean values, minimum values, and maximum values
Aggregate data (yearly)	Aggregate data of monthly mean values, minimum values, and maximum values
Collected data (UPS)	Measurement data for up to one month (UPS)
Collected data (temperature/ humidity sensors)	Same as above (temperature/ humidity sensors)
Collected data (Modbus device)	Same as above (Modbus device)
Maintenance data	UPS event log, failure log, etc.

3.3 Temperature/humidity sensors and Modbus devices can be connected and monitored

With the current models, temperature/humidity sensor and Modbus RTU-compatible devices cannot be connected or monitored at the same time.

In contrast, the new model can connect to temperature/ humidity sensors and Modbus RTU-compatible devices at the same time thanks to the added EXT port via an extension cable.

This enables monitoring of the air conditioning in the area where a UPS is installed by detecting temperature and humidity conditions and capturing the operating status of a Modbus-compatible air conditioner.

3.4 Enhanced server shutdown

UPSs are widely used in server rooms and data centers to provide power backup for ICT equipment. In such applications, our *LAN Interface Card* plays a role in safely shutting down servers and network equipment in the event of a power failure or other abnormality.

Currently, ICT equipment has been used in highly secure network environments and the UPSs used for power backup of such equipment are also required to operate in highly secure environments.

In conventional server environments, servers, storage, network devices, and other network infrastructure had their own hardware. In recent years, however, there has been increasing use of virtual servers that integrate and run multiple operating systems within a single physical server and HCI* devices that virtualize network infrastructure in software. With virtual servers and HCI devices, shutting down computers require complex procedures, and UPSs are also used for power backup of these devices.

The new model provides extended functions for handling complex server shutdown procedures in high-security environments.

* HCI stands for Hyper-Converged Infrastructure. It integrates the functions of servers, storage devices, and network devices into a single machine using virtualization software technology.

3.4.1 Enhanced SSH functionality

The current models feature SSH (Secure Shell) for shutting down servers, which enables remote devices to be connected and shut down safely.

SSH encrypts communications with remote devices to prevent data tampering and eavesdropping, and efforts have constantly been made to enhance its security level by improving the encryption algorithm.

The current models use commercial SSH software, which usually takes a long time to import encryption algorithm updates.

The new model supports OpenSSH. OpenSSH is now the de facto standard implementation of SSH and widely used in servers where a high level of security is required.

When using SSH, there may be differences between the SSH encryptions supported by the *LAN Interface Card* and the customer's environment. In such a case, the current models require our customers to change their SSH encryption settings to match those of the *LAN Interface Card*.

In contrast, thanks to the OpenSSH support, the new model can be used without our customers having to change their settings or compromise the level of their security.

3.4.2 REST API-based server shutdown

Currently, many server manufacturers provide their REST APIs,* which are application programming interfaces that use the HTTP protocol. By using an API, users can remotely manage their servers.

The new model enables users to shut down their servers using the REST APIs of their respective server manufacturers. The new model offers more secure communication with servers because REST APIs use HTTPS, which is a more secure version of HTTP.

* REST API stands for REpresentational State Transfer Application Programming Interface. It defines the rules for exchanging data using the HTTP protocol.

Fig. 3 Setting screen of computer shutdown

3.4.3 Enhanced script execution

With virtual servers and HCI devices, shutting down or starting computers require users to follow a number of steps, making the settings on the current models complicated.

The new model provides an interface for configuring the required steps to shut down and start up computers. Users can configure up to 10 steps using a web tool.

Figure 3 shows the computer shutdown settings screen. In the screen, there are five computers registered for shutdown. It shows that the shutdown sequence is currently in progress.

The shaded squares indicate the step where a shutdown is performed. The 1st and 2nd devices from the top have their shutdowns set to Step 1. The 3rd device has it set to Steps 2 and 3. The 4th device and the 5th device have their shutdowns set to Step 3 and Step 4, respectively.

When a shutdown sequence starts, the action registered to Step 1 is executed first. When all Step 1 actions of each device are completed, it moves on to Step 2 and continues to execute in sequence up to Step 10.

With virtual servers and HCI devices, shutting down or starting computers require a number of steps to be performed in a specified order. The new model, with enhanced functions, allows users to manage shutdown settings with ease.

3.5 UPS linkage function

The new model features a UPS linkage function for synchronous/redundant control of multiple UPSs.

The UPS synchronous control synchronizes the stop/start timing for multiple UPSs. In other words, when one of the UPSs in synchronous control is stopped, the other UPSs are stopped at the same timing as well as the subsequent shutdown of devices.

The redundant UPS control is used in server environments where two UPSs are used for redundancy. The redundant UPS control shuts down the servers when power cannot be supplied normally from either of the UPSs due to power failure. With this function, UPS operation can continue without shutting down the servers if either of the UPSs is able to continue supplying power normally.

The current models also feature the UPS linkage function, but they use this control with *LAN Interface Cards* in UPSs communicating via a network. This is problematic because a linkage control cannot be performed normally when network devices such as hubs and network switches are stopped due to power failures.

In contrast, with the new model, the UPS linkage function does not rely on network-based communication. Instead, it uses CAN (Controller Area Network) communication by connecting multiple *LAN Interface Cards* directly with cables. This ensures synchronized and redundant operation of UPSs without being affected by external factors such as power failures.

3.6 IP address can be changed from UPS

When using the new model with our *SANUPS A23D* or *SANUPS A11N* UPS, its IP address (IPv4 address) and settings can be checked and changed from the UPS control panel.

This makes the introduction of the new model easy since the network settings can be done directly from the UPS control panel. It is also easy to check network information.

Figure 4 shows the IP address settings screen on the *SANUPS A23D*.

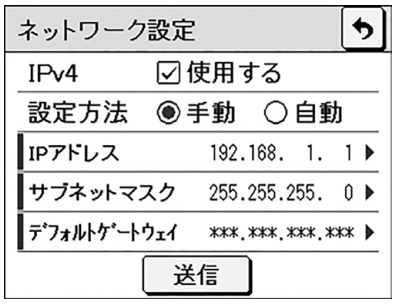

Fig. 4 Screen example of IP address settings for the *SANUPS A23D*

3.7 Card edge connector

Conventionally, it required a dedicated cable to connect a UPS and *LAN Interface Card*, however, the new model comes with a card edge connector. (Refer to Figure 5 to see the card edge connector of the *LAN Interface Card*.)

Fig. 5 Card edge connector of the *LAN Interface Card*

This makes it easy to connect the new model to a UPS that has a card edge connector; simply inserting it into the UPS's expansion slot will do it. From now on, all the UPSs we develop will be equipped with an card edge connector, eliminating the need for a UPS connection cable.

4. Specifications

Table 4 shows the specifications of the new model.

Table 4 Specifications of the *LAN Interface Card*

Items	Ratings and standards
Model no.	PRLANIF031
Dimensions	105 (W) × 125 (D) × 23.5 (H) mm
Operating environment	Temperature: -25 to 60°C Humidity: 0 to 90% RH (non-condensing)
LAN communication	Transmission speed: 1000/100/10 Mbps (auto-negotiation) Transmission method (full-duplex/half-duplex): Automatic Auto-MDIX feature
Functions	• Automatic start-up/shutdown of computers (SSH, REST API, Telnet) • Shutdown of computers in power redundancy • UPS synching (up to 5 UPSs) • Automatic computer startup at power restoration • Scheduled operation • UPS status display (supports our HTML-based Web Tool, SSH and Telnet) • SNMP agent (RFC1628, JEMA-MIB) • Sending/receiving emails • NTP (Network Time Protocol) • Downloading and uploading UPS setting values • Test functions (script execution, sending emails, sending SNMP traps, shutdown) • Notification of events to the syslog server • Measurement deviation monitoring (UPS internal information, Modbus measurements, temperature/humidity sensor measurements) • Statistical graph display (UPS internal information, Modbus measurements, temperature/humidity sensor measurements) • Modbus master/slave functions • Status measurement monitoring of Modbus slave devices (up to 16 items) • Environmental monitoring by temperature/humidity sensors (up to 16 items) • Daily/monthly/yearly report generation (UPS internal information, Modbus measurements, temperature/humidity sensor measurements) • Measurement data aggregation (UPS internal information, Modbus measurements, temperature/humidity sensor measurements) • Wireless LAN support • Log storage on a USB flash drive • Latest firmware update
External communication protocols	Modbus TCP, Modbus RTU*, 1-Wire*, CAN*
Supported protocols	TCP/IP, UDP, DHCP, SNMP (v1, v2c, v3), HTTP, HTTPs, Telnet, SSH, FTP, FTPs, SMTP (over SSL/TLS), POP3 (over SSL/TLS), NTP

* When the EXT connector is used

5. Conclusion

This article provided an overview of the new *LAN Interface Card* and introduced its features.

The development of this product involved full-scale upgrading of hardware and software, and therefore it will serve as a base for our future power management products and monitoring products of the Power Systems Division. Moving forward, this will enable us to respond flexibly to new requirements when developing products.

In the future, we expect that advanced security measures will be required not only for ICT systems but also for industrial systems. In this regard, we are confident that our customers will be able to use this product with peace of mind.

Server management technologies in ICT systems are rapidly advancing today. With the development of our new *LAN Interface Card*, we will continue to work to keep pace with the tide of technological innovation, swiftly develop products to meet market demands, and continue offering products that satisfy customers.

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SANYO DENKI contributes to society by developing products that enhance the performance, quality, and reliability of customer equipment, while optimally solving customer challenges and creating new value.

In this article, we present the new products we developed in 2022: an AC servo system product, a linear servo motor product, and stepping driver product, with their features and their contributions to our customers and society.

To begin with, we developed the *SANMOTION G* AC servo systems with rated outputs ranging from 30 W to 1.5 kW. This new servo system is an all-new upgrade of the conventional *SANMOTION R* servo system with a new motor, holding brake, encoder, and servo amplifier, based on the concept of being "powerful" and "friendly."

The "powerful" refers to its high performance and high reliability. While featuring greatly improved servo performance and reliability, the new product can be used with confidence even in harsh environments. In addition to being compact, lightweight, and highly efficient, it is also "friendly" by being both user-friendly and eco-friendly.

Next, for linear servo motor products, we developed the new *SANMOTION* linear servo motor that offers high acceleration and energy savings.

The new product achieves high acceleration motion by improving its thrust characteristics and offers better efficiency by reducing motor loss. Therefore, it contributes to improved productivity by increasing the speed of equipment and the high precision of equipment by reducing the temperature rise of equipment.

With our stepping driver products, we have developed two new stepping driver models (high-power model and basic model) for 2-phase and 5-phase stepping systems, for a total of four new models. The high-power models can drive motors with high torque and contribute to shortening equipment cycle times. The basic models were designed to be an easy replacement for our current models and to be more compact and lightweight. Both models feature significantly reduced vibration during motor rotation.

The new products contribute significantly to higher performance and lower vibration of equipment.

Below are the overviews of these new products and their features.

■ *SANMOTION G* AC servo system

Servo systems are an important element in equipment that have a great impact on the performance, quality, and reliability of the equipment. The role is becoming more important in industrial development to resolve challenges for the global environment, such as improved efficiency and resource conservation of electric equipment to mitigate global warming.

In response to these expectations, we developed the new *SANMOTION G* AC servo system. This new servo system is an all-new upgrade of the conventional *SANMOTION R* servo system, with everything upgraded including the servo motor, holding brake, encoder, and servo amplifier based on the concept of being "powerful" and "friendly."

The "powerful" refers to its high servo performance and high reliability for use with peace of mind in various regions and environments. What we mean by "friendly" is that the product is designed to be energy-efficient, compact, lightweight, environmentally

friendly, and ease of use for customers.

Its servo motor lineup comprises a total of 37 models: 13 low-inertia models ranging from a 40 mm sq., 50 W model to a 100 mm sq., 1.5 kW model, and 24 medium-inertia models ranging from a 40 mm sq, 30 W model to a 130 mm sq., 1.2 kW model. Its servo amplifier lineup comprises a total of 21 models: three 100 V models with output current capacities of 10, 20, and 30 A, four 200 V models with that of 10, 20, 30, and 50 A, and the rest are other models with variations in servo motor combinations and host controller interface.

Their features are as follows.

1. Powerful servo performance

The servo motor has achieved downsizing and higher outputs. Downsizing was achieved by optimizing the electromagnetic field structure of the motor and reducing the size of the encoder. In addition to being compact and lightweight, the motor winding was optimized, increasing the maximum speed to 6500 min^{-1} and achieving higher output power.

The servo amplifier has an improved voltage utilization rate at high speed, which extended the output range of the servo motor.

We also increased the frequency response of the speed control to 3.5 kHz by speeding up the control cycle and improving the torque control. Furthermore, we greatly reduced the positioning time by compensating for the effects of friction and gravity, which hinder settling.

The high-resolution battery-less absolute encoder with a maximum 27-bit resolution provides stable, repeatable motion and high-precision positioning.

2. High environmental durability

The vibration resistance was tested under harder acceleration conditions than before: 50 m/s^2 for the servo motor and 6 m/s^2 for the servo amplifier. We also developed a highly reliable holding brake that has less friction material wear and maintains holding torque even in high-temperature and high-humidity conditions. In addition, the operating altitude of the product has also been extended to 2000 m.

3. Enhanced maintainability

This product offers functions that are convenient for preventive maintenance of components including holding brakes, electrolytic capacitors, cooling fans, and relays. Based on this information, users can plan overhauls.

We also added functions to help diagnose the operation environment of the servo system, such as main circuit rectification voltage monitoring and control power supply frequency monitoring. By investigating the operating environment, these functions can help our customers diagnosing their environment and identify the cause of abnormalities.

4. Friendliness to the environment

The servo motor has up to 9% higher efficiency and up to 48.3% lower CO_2 emissions over the current products thanks to its optimized electromagnetic field design, improved winding fill factor, and use of low-loss materials.

The servo amplifier features a mode that reduces noise from the switching frequency. It is suitable for use in environments that require low noise such as hospitals so that patients would not feel anxious by the operating noise.

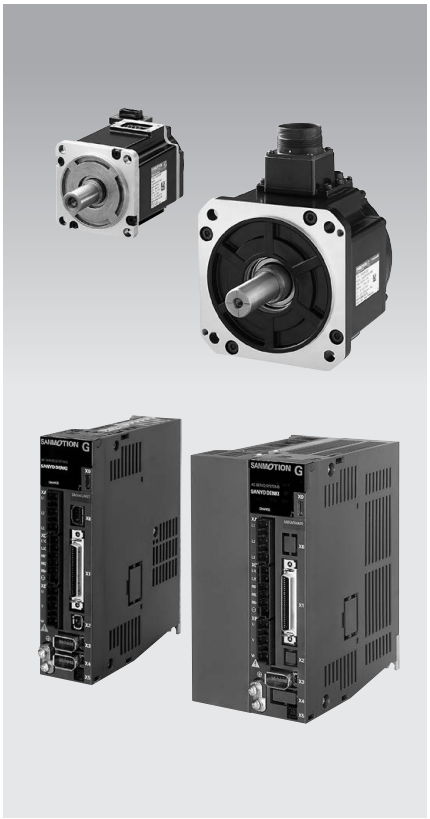
5. Friendliness to operators

It provides high-precision system analysis measurements for frequency analysis with sinusoidal commands.

Its advanced tuning function, which measures machine characteristics and adjusts parameters based on the application, provides optimal adjustments and reduced start-up time.

6. Friendliness to customers

The servo motor's flange size, mounting dimensions, and output shaft shape, as well as the servo amplifier's dimensions and mounting dimensions are highly compatible with those of our current products. This makes replacement of our products currently used in customers' equipment with the *SANMOTION G* very easy.



■ High-acceleration, energy-saving *SANMOTION* linear servo motor

Linear servo motors provide linear motion without using a ball-screw based “rotation-to-linear conversion” mechanism, greatly helping make equipment faster and more precise. Our linear servo products are also used in lithography equipment and chip mounters where the above-mentioned strength can be leveraged.

We developed this new product aiming to help make customer equipment faster and more precise. The features of this product are as follows.

1. High-acceleration motion

The newly designed mover structure and optimized magnetic circuit led to improved thrust characteristics, enabling high-acceleration motion. Compared to our current models, no-load acceleration has been increased by 9%. Capable of high-speed drive, the new product can shorten the cycle time of customer equipment and improve its productivity.

2. Energy savings

The newly designed mover structure and improved winding fill factor led to reduced motor losses and improved efficiency. Furthermore, the reduced motor losses reduce the motor’s heat generation, which in turn, lowers the temperature customer equipment. The reduced motor temperature minimizes thermal expansion in the motor mounting mechanism in the equipment, keeping the high precision of the equipment.

These features make this product ideal for semiconductor manufacturing equipment, lithography equipment, and conveying machines, helping make them faster and more precise.

For more information, refer to the “New Product Introduction” section of this Technical Report.

■ High-output *SANMOTION F* stepping drivers

It is not possible to make industrial equipment faster and more precise without improving its motor system. Therefore, to contribute to shorter cycle time and smoother operation of customer equipment, we developed compact, high-power stepping drivers featuring high-speed drive and small speed variations.

The new stepping drivers are available in a total of four models: a high-power model and a basic model for both 2-phase and 5-phase. The high-power models feature high-torque drive of a motor. The basic models maintain compatibility with our current models.

Their features are as follows.

1. Compact, high power, and low vibration

Both models can drive motors with high torque while being compact and lightweight. In particular, the high-power models have 1.5 to 2.7 times higher torque at high speeds than our current models, greatly speeding up the equipment.

Also, both models have smaller speed variations during rotation, demonstrating improved efficiency over the current models. Therefore, they can contribute to smoother operation and energy savings of equipment.

2. Easy replacement

The drivers come with a new function that allows control of both 2-phase and 5-phase motors with the same resolution (step resolution compatibility). This function enables easy replacement between 2-phase and 5-phase systems without changing the program of the host controller.

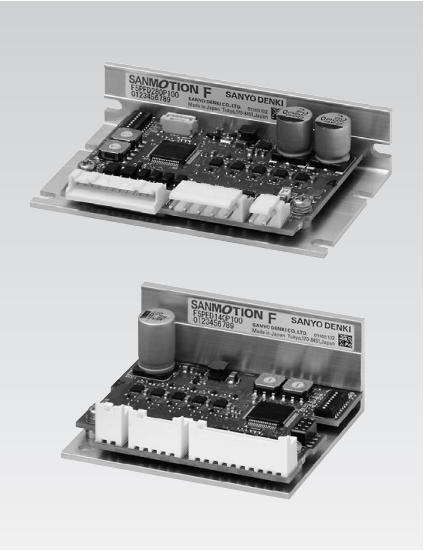
3. Various useful safety functions

The new drivers are equipped with an enhanced self-diagnosis at power-on and status monitoring during operation to ensure safe use. When an abnormality is detected, the drivers will issue a warning and stop the system. In addition, they can also display warnings at the first sign of power supply voltage and temperature issues.

4. PC-based functions

The high-power models are equipped with PC-based functions. When connected to a PC via a dedicated tool, users can set advanced operation parameters, monitor the internal status, use a preventive maintenance function, and check alarm logs. These functions enable users to easily customize the functions to suit their equipment and check the operating status.

For more information, refer to the "New Product Introduction" section of this Technical Report.



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Development of High-Acceleration, Energy-Saving SANMOTION Linear Servo Motor

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1. Introduction

Linear servo motors are increasingly demanded in applications that require high-speed operation and high-precision positioning, such as surface mounters and lithography equipment. In recent years, they are growingly used in medical devices for higher precision. The advantage of using them is that they can easily achieve high speed and high precision by directly driving equipment linearly without using a rotary-to-linear motion conversion mechanism such as a ball screw.(1)

To improve the speed and precision of customer equipment, it is essential to improve the thrust characteristics of the linear servo motor that drives the equipment while also reducing the motor size, weight, and energy usage (loss reduction). In addition, the motor size affects the size and mass of the parts used in the motor mounting mechanism. Furthermore, the motor's heat generation causes thermal expansion in the motor mounting mechanism in equipment, which undermines the precision of the equipment.

To overcome these challenges, we developed a compact, high-acceleration, energy-saving linear servo motor. The new product is a flat type linear motor with core.

In this article, we begin by showing the specifications and appearance of the new product. Next, we describe its structure and characteristics and present its features taking an example of an XY cartesian robot.

2. Specifications and Appearance of New Product

Figure 1 shows the new linear servo motor, and Table 1 shows its specifications.

The new product consists of a magnet rail (stator) of permanent magnets and a laminated armature coil (mover) facing each other across an air gap.

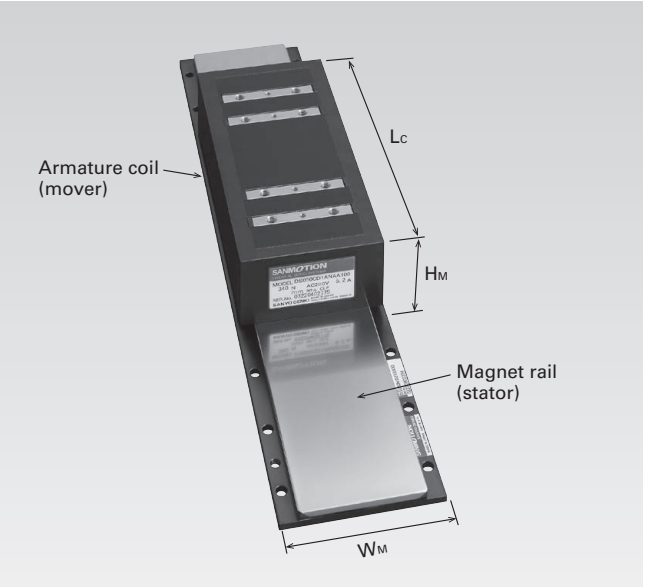

Fig. 1 Appearance of new product

Table 1 Specifications of new product

Items	Symbol	[Unit]	Flat type with core	
			Current product	New product
Coil model no.	—	—	DS045CC1AN	DS050CD1AN
Magnet rail model no.	—	—	DS045MC	DS050MD
Rated thrust	F_C	[N]	260	340
Maximum thrust	F_P	[N]	500	630
Coil length(1)	L_C	[mm]	130	145
Motor width	W_M	[mm]	65	71
Motor height	H_M	[mm]	48.5	48.5
Coil mass	M_C	[kg]	1.8	2.15
Magnet rail mass	M_{mr}	[kg/m]	3	3.5

(1) Excluding the hall sensor

3. Specifications of the New Product

3.1 Structure and features

3.1.1 Improved thrust

Figures 2 and 3 show examples of a linear servo motor installed in equipment. The thrust of a linear servo motor is produced in the area (thrust area S) where the armature coil (mover) and magnet rail (stator) face each other. Our current product secured high thrust by increasing the thrust area S in the direction of the motor width W_M.

However, the increased motor width resulted in an increase in the size and mass of the equipment as well as the amount of motor materials.

Therefore, as shown in Figure 3, the new product secured high thrust by increasing the thrust area S rather in the direction of the motor motion (coil length L direction) not in the motor width W_M direction. This reduces the motor installation width W_A to W_B, resulting in increased thrust without significantly increasing the size of the equipment.

Figure 4 shows a comparison, between the current and new products, of the equipment volume required to install a linear servo motor to produce the same thrust. Compared to the current product, the new product requires 10% less space of customer equipment.

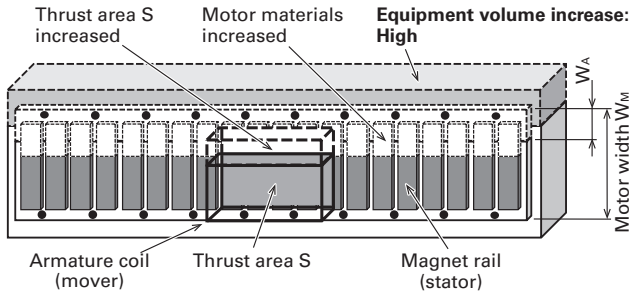

Fig. 2 Installation example of current linear servo motor

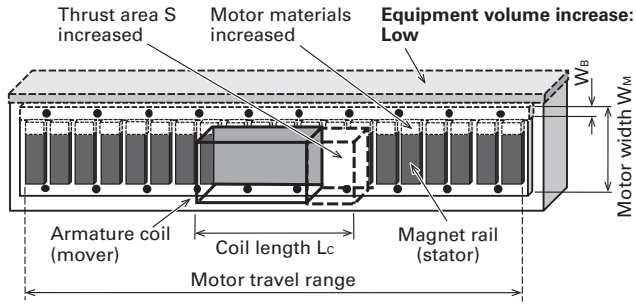

Fig. 3 Installation example of new linear servo motor

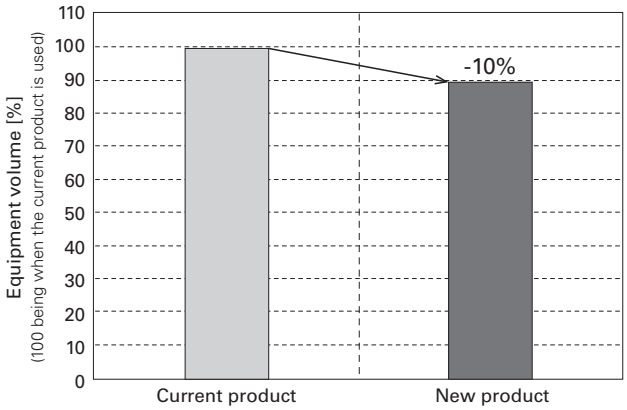

Fig. 4 Equipment volume required for linear servo motor installation (with the same thrust)

3.1.2 Improved energy efficiency (reduced losses)

Figure 5 shows the thrust area of the armature coil (mover) of an iron-core linear servo motor. Compared to the current product, the new product has a reduced end-winding, which is irrelevant to thrust, height H_A by redesigning the winding around the iron core. This reduces the end-winding volume to whole winding ratio while simultaneously reducing copper losses by increasing the ratio of the coil conductor area over the total slot area (slot fill factor).

Figure 6 shows a comparison of the end-winding volume to whole winding ratio. In the new product, the end winding occupies 11% less volume of the whole winding volume than the current product.

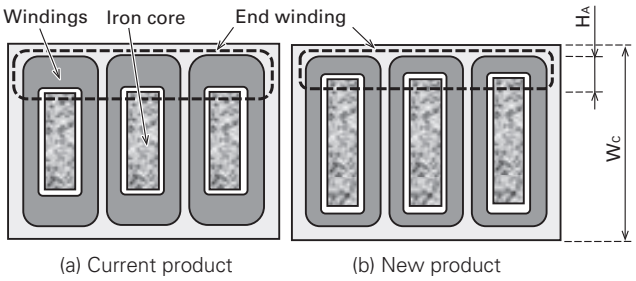

Fig. 5 Comparison of winding structure (reduced end winding)

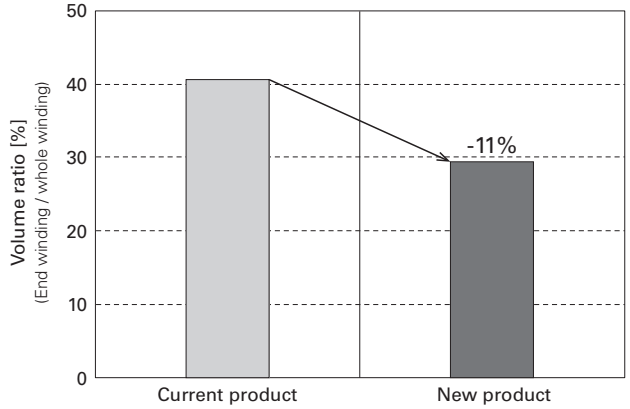

Fig. 6 Comparison of winding volume

3.2 Thrust density and maximum acceleration

3.2.1 Thrust density

Figure 7 shows a comparison of thrust density. Thrust density is the thrust per unit volume, and the greater the value, the higher the thrust and the more compact the linear servo motor.[1] The new product has a redesigned motor structure that optimizes the magnetic circuit and winding layout. As a result, compared to the current flat type linear servo motor with core, the new product achieves a 12% higher rated thrust density and 8% higher maximum thrust density.

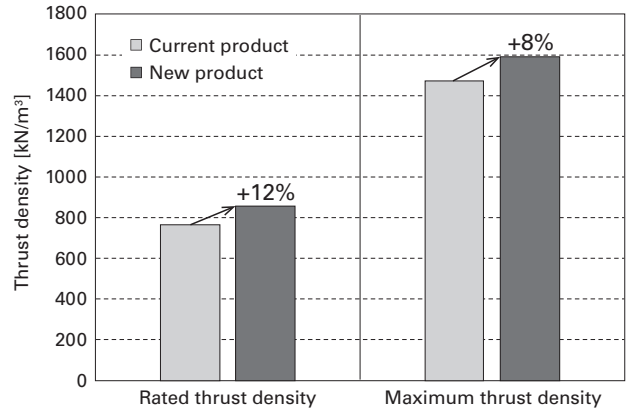

Fig. 7 Comparison of thrust density

3.2.2 Maximum acceleration

Figure 8 shows the relationship between load mass and maximum acceleration. Acceleration is expressed as the equation (1) below using the motor thrust and mass (mover coil mass + load mass). The new product has achieved size and weight reductions through its improved thrust and thrust density. As a result, it has a higher maximum acceleration assuming that the load mass is constant. This can contribute to improving equipment productivity.

$$A_{MAX} = F / (M_L + M_C) \quad \ldots (1)$$

F : Thrust [N]
M_L : Load mass [kg],
M_C : Coil mass [kg]

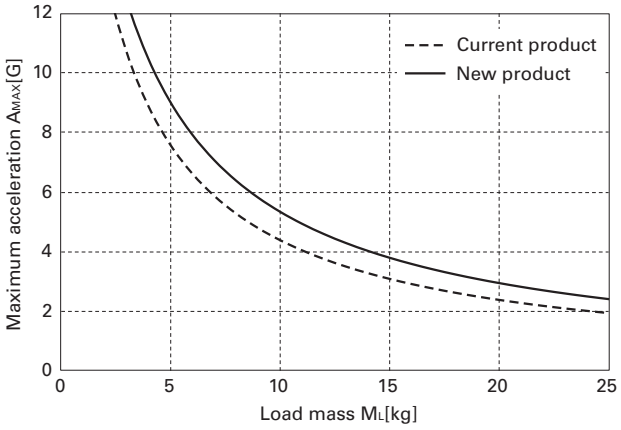

Fig. 8 Comparison of maximum acceleration

3.3 Improved energy efficiency (reduced losses)

Figure 9 is the copper loss comparison between the new and current products. The new product, with its reduced end winding volume and increased space factor, reduces losses by more than 15% compared to the current product.

This reduction in losses reduces the temperature rise of the motor, which suppresses thermal expansion in equipment, contributing to improving the equipment precision.

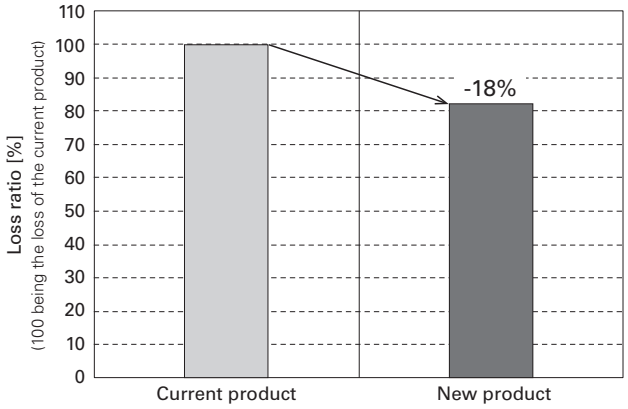

Fig. 9 Comparison of losses (copper losses)

3.4 Thrust vs. speed characteristics

Figure 10 compares the thrust F versus speed V characteristics. The new product improves thrust in all operating ranges from low speed to high speed compared to the current product thanks to the optimized windings

and improved thrust density. In particular, compared to the current product, the new product improves thrust in the continuous zone, resulting in higher acceleration and reduced downtime during continuous operation. This can contribute to shortening equipment cycle times.

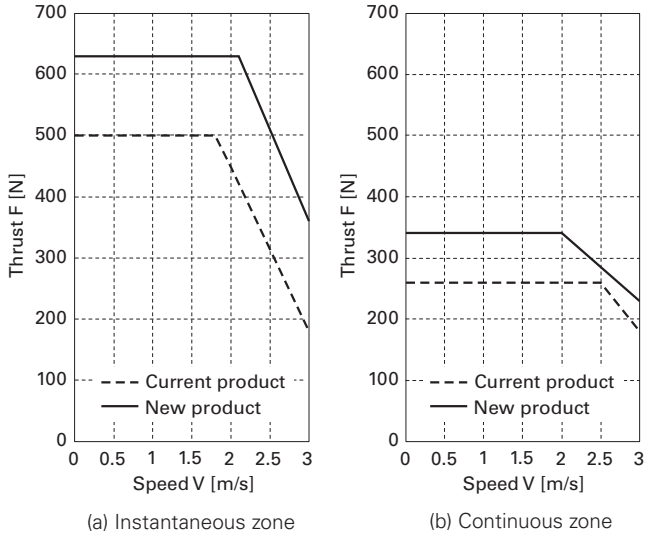

Fig. 10 Thrust vs speed characteristics (at 200 V input)

4. Configuration Example

Figure 11 shows the new product applied to the upper X-axis of an XY cartesian robot as an application example.

In the current product, the thermal expansion in the upper X-axis moving slider due to the motor heat undermined the positioning precision of the equipment.

The new product suppresses heat generated from the motor by reducing motor loss. This reduces the amount of thermal expansion that occurs in the moving slider.

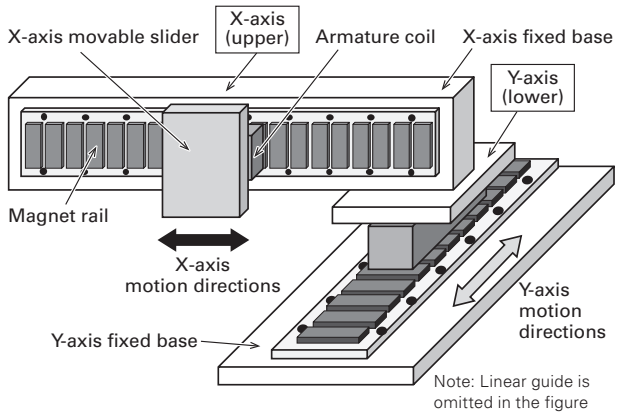

Fig. 11 Illustration of XY cartesian robot mechanism

Figure 12 compares the thermal expansion in the upper X-axis moving slider when the motor generates heat. When the new product is used, the upper X-axis moving slider thermal expansion can be reduced to about 1/2 of that of the current product.

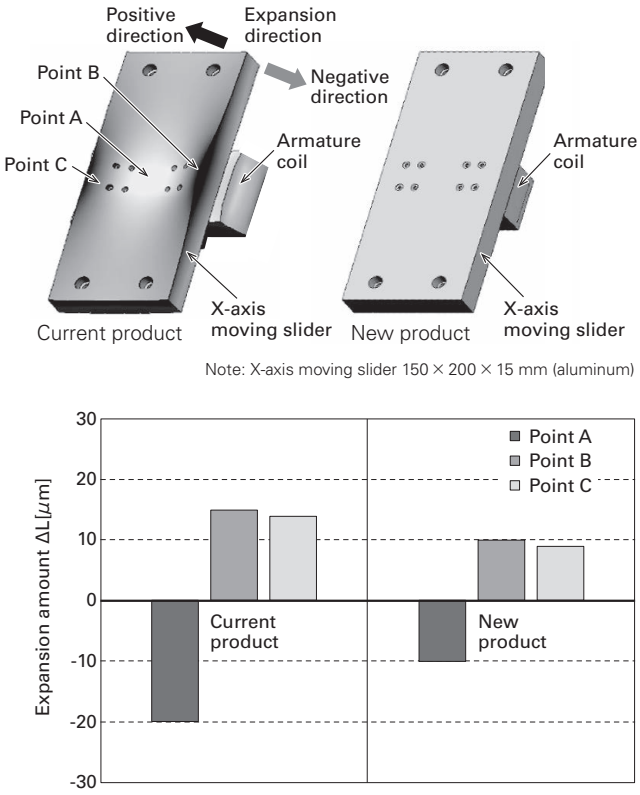

Fig. 12 Thermal expansion in moving slider (analyzed results)

Figure 13 compares, between current and new products, the effect on the lower Y-axis when the upper X-axis moving slider is driven at the same acceleration. Compared to the current product, the new product improves the acceleration of the lower Y-axis by reducing the volume and mass of the upper X-axis fixed base. This reduces the overall size of the XY cartesian robot system and improves its productivity without increasing the size of the motor for the lower Y-axis. Table 2 shows the effect of using the new product to an XY cartesian robot system.

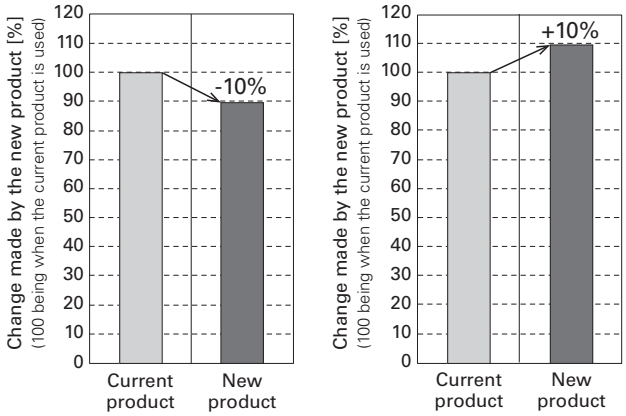

Fig. 13 Weight reduction in X-axis fixed base and effect on Y-axis

Table 2 Benefits when new product is used in XY cartesian robot

	Current product	New product
X-axis (moving slider)	Thermal expansion: High	Thermal expansion: Low
X-axis (fixed base)	Mass/volume: High	Mass/volume: Low
Y-axis	Acceleration: Low	Acceleration: High

5. Conclusion

In this article, we introduced the structure and features of our newly developed high-acceleration, energy-saving *SANMOTION* linear servo motor, as well as an example of its application example. The features of the new product are as follows.

(1) High thrust while being compact and lightweight (Increased thrust density)

By optimizing the motor structure and winding layout, we improved the rated thrust density and the maximum thrust density by 12% and 8%, respectively (compared to the current product).

This enables high acceleration (high response) for the equipment.

(2) Improved energy efficiency (low losses)

By reducing the end winding volumecoil end and improving the space factor, we reduced losses by more than 15% (compared to the current product).

This reduces the thermal expansion that occurs in the equipment due to the heat generated by the motor heat, contributingand contributes to higher precision of equipmentoperations.

(3) Contribute to downsizing and improved productivity of customer equipment

With the reduced motor size and weight and the increased thrust, the new product contributes to improving the productivity of equipment while minimizing the size of the equipment's motor-mounting mechanism.

We believe that the new product will contribute significantly to the improved productivity and precision of customer equipment.

Reference

(1) Yasushi Misawa and 2 others: "Development of Compact, Core-equipped SANMOTION Linear Servo Motors" SANYO DENKI Technical Report No. 37, pp. 35-38 (2014.5)

(2) Hiroyuki Sato and 3 others: "Development of a compact, large thrust, low magnetic attractive force linear servo motors" SANYO DENKI Technical Report No. 41, pp. 35-39 (2016.5)

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Development of High-Output *SANMOTION F* Stepping Drivers

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Ryuta Sugiyama Yasuyuki Katoh Haruki Nakagawa Yuya Kamimura

1. Introduction

SANMOTION F series stepping systems provide high-torque, high-precision operation and are used in a wide range of applications, especially for semiconductor manufacturing equipment and medical equipment. To achieve higher speeds and micromachining of equipment, it is essential to improve the performance of motor systems. In recent years, it has become important to save energy by improving equipment efficiency to protect the environment.

It is against this background that we developed new models of compact stepping drivers with dramatically improved overall performance. The new models are available in a high-power model with high output and high functionality and a basic model compatible with our current drivers for both 2-phase and 5-phase motors.

The high-power model is smaller and lighter than the current model but has much higher torque at high speeds. It also reduces speed variations, which enables the smooth operation of equipment at high speeds. In addition, it has PC-based functions that allow advanced parameter settings and status monitoring.

The basic model improves torque and reduces speed variations while maintaining interface and function compatibility with the current model. It can improve the equipment performance simply by replacing the driver thanks to the compatibility with the motors of the current model.

In this article, we begin by showing the appearance and specifications of the new models. Next, we introduce the performance and functions of the new models.

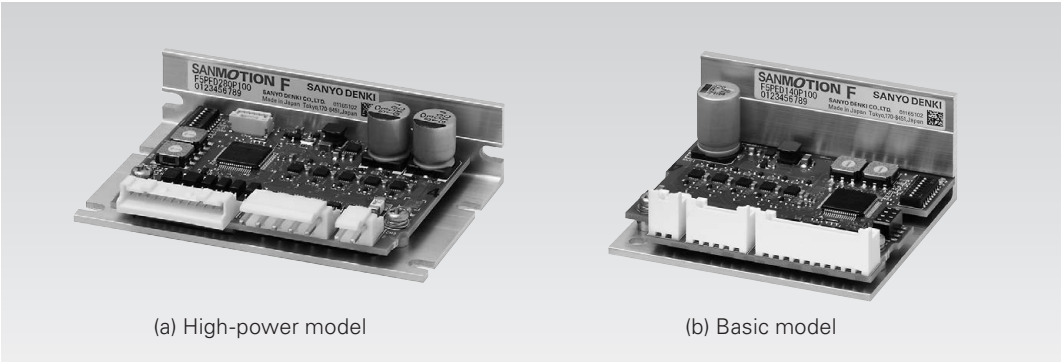
2. Product Overview

2.1 Appearance

Figure 1 shows the new models and Figure 2 shows their external dimensions.

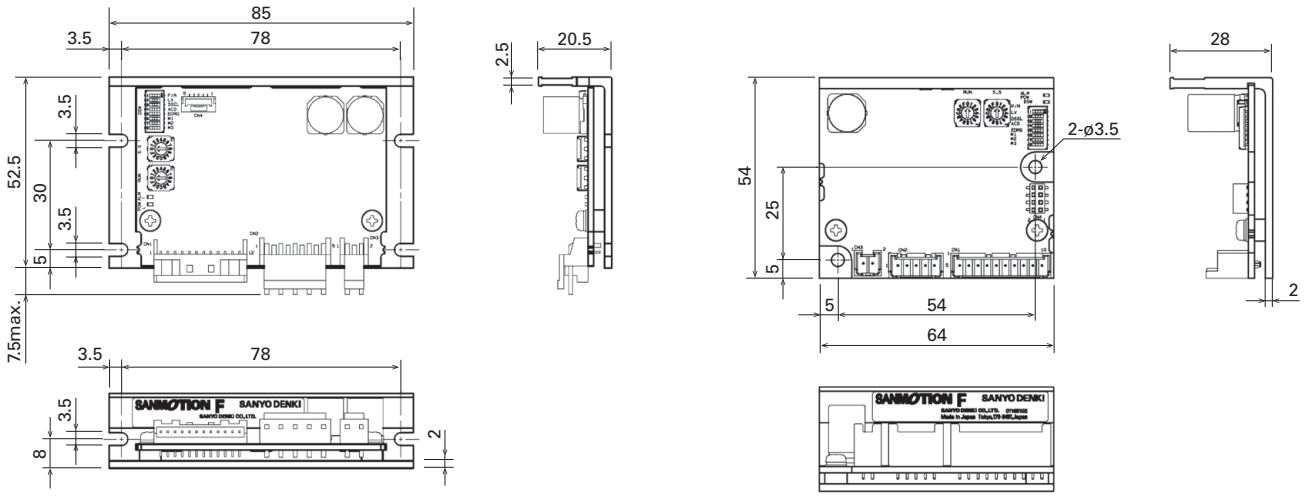
The high-power model has a thin profile and its volume and mass are 63% and 73% smaller, respectively, than the current model of the equivalent output. Since it can be mounted from either the back or the bottom, it provides high flexibility, for example, it can be installed in narrow spaces or the heat-dissipating surface can be attached closely for efficient heat dissipation.

The basic model has the same mounting dimensions for easy replacement of the current model. Through the use of low-loss electronic components to reduce heat generation and make heat sinks thinner, it achieved a 7% reduction in volume and 39% reduction in mass while maintaining almost the same shape as the current model.



(a) High-power model (b) Basic model

Fig. 1 Appearance of new models



(a) High-power model (b) Basic model

Fig. 2 Dimensions of new models (unit: mm)

2.2 Specifications

Table 1 shows the product lineup and specifications. Each model has the same specifications for 2-phase and 5-phase motors, except for the maximum output current and microstepping resolution.

Compared to the basic models, the high-power models feature higher output current and a variety of functions. The high-power model has a higher output current and can operate at higher speeds than the basic model. The high-power model also has PC-based functions, a preventive maintenance notification function, and a function to notify a host controller of alarms.

Table 1 Product lineup and specifications

Items		High-power model		Basic model	
		2-phase	5-phase	2-phase	5-phase
Maximum output current		4.0 A/phase	2.8 A/phase	2.0 A/phase	1.4 A/phase
Input voltage		24 VDC			
Input/Output signal		4/2		3/2	
Product size [mm]		85 × 20.5 × 52.5		64 × 28 × 54	
Mass [g]		60		55	
Microstep		1/256	1/250	1/256	1/250
Compatible motor (flange) size		56 mm sq. 86 mm sq.	60 mm sq.	42 mm sq. 56 mm sq. 60 mm sq. 86 mm sq.	28 mm sq. 42 mm sq. 60 mm sq. 86 mm sq.
Functions	Low vibration mode	✓		✓	
	Excitation phase memory	✓		✓	
	Step resolution compatibility	✓		✓	
	PC-based functions	✓		–	
	Preventive maintenance notification	✓		–	
Protection functions	Voltage monitoring	✓		✓	
	Overcurrent protection	✓		✓	
	Overheat detection	✓		✓	
	Wire breakage detection	✓		✓	
	Alarm notification signal	✓		–	

3. Features

Table 2 shows the features of the new models. The values in the table are the performance improvement ratios compared to the current models as well as the newly implemented functions. Further details on the implementation are described in the subsequent subsections.

Table 2 Product features

Items	High-power model(1)	Basic model(2)
Shape	Thin profile, mountable on two sides	Mounting and size compatibility
Volume	Reduced by 63%	Reduced by 7%
Mass	Reduced by 73%	Reduced by 39%
High-speed torque	1.5 to 2.7 times higher	1.05 to 1.1 times higher
Speed variation(3)	Reduced to 1/4 or less	Reduced to 1/3 or less
Efficiency(4)	8.7% increase	5.5% increase
Preventive maintenance notification	Yes	No (same as previously)
Other advantages	PC-based settings and status monitoring supported	Interface and functional compatibility with current product maintained

(1) Comparison with current model F5PAE140P100
(2) Comparison with current model BS1D200P10
(3) Comparison of the average of speed variations
(4) Comparison of the maximum combined efficiency of driver and motor

3.1 Improved overall performance

The new models can smoothly control the current passing through the motor, achieving high torque and low vibration. They monitor the current of the entire motor and optimally compensate it to improve the voltage utilization ratio to realize higher torque. In addition, they control to balance the current flow in the windings of each phase to reduce speed variations.

3.1.1 Improved high-speed torque

Figures 3 and 4 show the pull-out torque characteristics of the high-power model and basic model, respectively. Compared to the current models of the same output, the pull-out torque at high speeds has been increased up to 2.7 times for the high-power model and up to 1.1 times for the basic model.

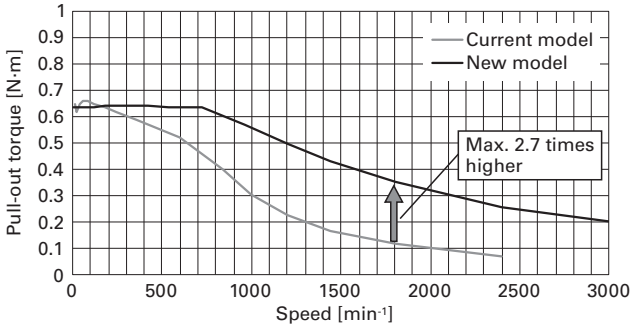


Fig. 3 Pull-out torque characteristics of high-power model

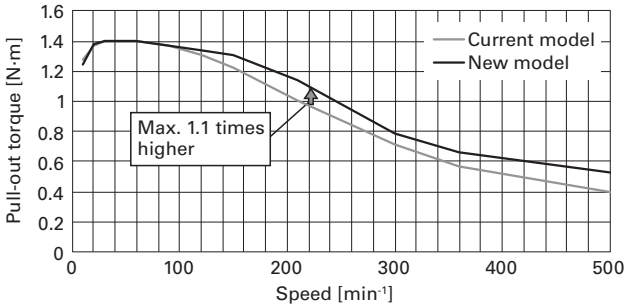


Fig. 4 Pull-out torque characteristics of basic model

3.1.2 Reduced speed variation

In general, stepping motors are prone to large speed variations during low-speed rotation below 150 min^{-1} or during high-speed rotation after voltage saturation. This is because the winding current fluctuates and resonates at the natural frequency of the motor and equipment due to phase switching at low speeds and due to interference between phase switching and the current control cycle at high speeds.

The new models have a well-balanced current flow in each phase winding that smoothen out current variations during phase switching to suppress resonance and reduce speed variation.

Figure 5 compares speed variations of the same motor when it was operated using the basic model and a current driver. It shows that the basic model reduces speed variations at both low and high speeds.

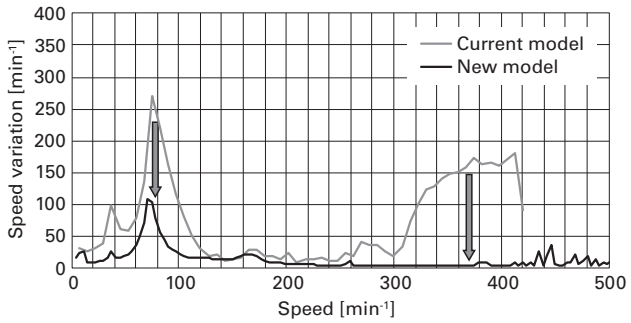


Fig. 5 Comparison of motor speed variation characteristics

3.1.3 Improved efficiency

Reducing speed variations also improves motor efficiency because less power is required which does not contribute to torque. Furthermore, by using low-loss components, the overall efficiency of the driver and motor has been increased by up to 8.7% for the high-power model and 5.5% for the basic model.

3.2 Basic functions

The new models also inherit the low-vibration mode and excitation phase memory functions of the current models. Low-vibration mode performs smooth control by interpolating between command pulses in micro-steps, which helps suppress speed variations at low speeds. The excitation phase memory function automatically saves the motor excitation phase at power shutdown to prevent shaft vibration at the next start of excitation.

In addition to the above functions, the new models possess 2-phase and 5-phase step resolution compatibility to facilitate the replacement of motor systems. This function enables control with a standard 2-phase motor command resolution of 200 P/R while using a 5-phase driver and motor. This allows, for example, users to change from a 2-phase system to a 5-phase system without changing the program on the host controller. This is useful for improving the equipment performance.

3.3 Enhanced protection and monitoring capabilities

The new models have greatly enhanced monitoring and protection functions that ensure safe and reliable use.

3.3.1 Various monitoring items

At power-on, a self-diagnosis function checks the driver's internal power supply voltage, sensor circuit, and motor power cable status. If it detects an abnormality, it issues an alarm before exciting the motor.

During operation, the system constantly monitors for excessive or insufficient input power supply voltages, driver overheating, motor overcurrent, and command speed errors. In particular, it monitors motor overcurrents not only for shorts between power cables but also for ground faults in the equipment housings. When it detects an abnormality, it instantly cuts off the output current.

When an alarm occurs, it stops the motor, notifies the host device with an output signal, and indicates the alarm factor by the number of times the LED blinks.

3.3.2 Warning feature

Current models do not have a function to alert users of abnormalities in input power supply voltage and other conditions. Therefore, it was difficult to detect abnormalities even when using the product at low margins and there were instances of alarms after shipping due to environmental changes or individual differences.

To resolve these issues, the new models are designed to display a warning as insufficient margins of power supply voltage and temperature before an alarm occurs. Normally, warnings are indicated only by LEDs, but the high-power model can also notify host devices using output signals. Since the motor can continue to operate during a warning, host devices can take measures before an alarm occurs.

3.4 PC-based functions

High-power models are equipped with PC-based functions. The driver is to be connected to a PC using a dedicated communication converter. In addition, SANMOTION MOTOR SETUP SOFTWARE, which has a proven track record with our servo amplifiers, is provided as PC software.

Connected to a PC, users can use the following functions.

- Settings of operation parameters
- Internal status monitoring
- Preventive maintenance assistance
- Reading alarm logs

3.4.1 Settings of operation parameters

Users can set parameters related to input/output signal functions, motor control, and preventive maintenance. Since the parameter settings are stored in the driver's nonvolatile memory, once they are set, they are retained and automatically used the next time the power is turned on. Table 3 shows some examples of setting parameters and their functions.

Table 3 Setting parameters

Setting parameters	Function	Benefit
Input signals	Select from excitation off signal, step angle switching signal, current limiter signal, limit sensor signal, etc.	Optimizes the system
2 step resolution modes	Enables switching the command resolution by an input signal.	Advanced motor operation
Speed command filtering	Alleviates shocks caused by acceleration and deceleration.	
Electronic gear	Sets the command resolution more finely than usual.	
Current-limiting value setting	Limits motor current according to the input signal to suppress heat generation.	
Traveled distance for maintenance notification	Issues a warning and prompts for maintenance and inspection when the set travel distance is reached.	Helps preventive maintenance

3.4.2 Internal status monitoring

When developing equipment and troubleshooting problems in the field, it is more efficient if the input status of commands and the operation status of drivers can be easily checked.

The new models provide internal status monitoring to facilitate device debugging. Table 4 shows some examples of the monitored items by this function. As shown in Figure 6, some of the monitored information can be displayed as an operation trace waveform. Users can check the timing of changes and the correlation with the other monitoring results. By using this function, users can check driver input and output and its internal status without measuring instruments. This greatly facilitates analysis and troubleshooting.

Table 4 Monitored items

Monitored items	Function
Command pulse counter	Displays the input pulse accumulative count value (command position).
Speed	Displays the motor speed.
Input power supply voltage	Displays the driver's input power voltage.
Driver internal temperature	Displays the driver's internal circuit temperature.
Output current	Displays the motor's output current.
Input signal monitoring	Displays the ON/OFF status of input signals.

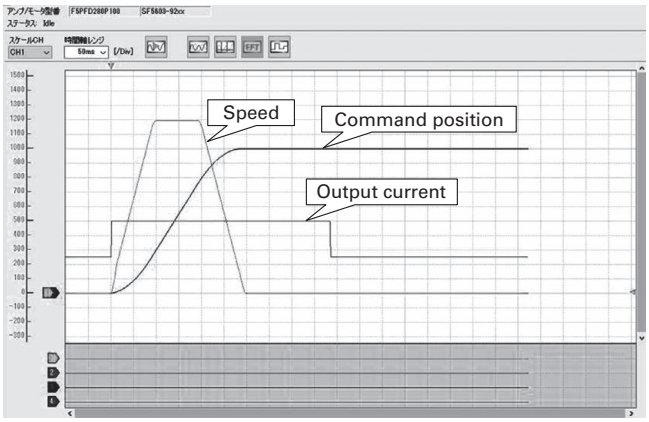


Fig. 6 Graph of motor operation monitoring

3.4.3 Preventive maintenance assistance

Mechanical parts such as ball screws require periodic maintenance to ensure quality. However, this work can be inefficient because even when the mechanical parts are in the same device, the amount of their usage will differ depending on the axis. If maintenance is performed all at once, even axes that do not require maintenance will be checked, which consumes time.

Therefore, the new models come with an accumulative travel distance monitor to manage the preventive maintenance periods. The monitor counts the number of motor rotations and shows the total travel distance actually commanded for the applicable axis. The count value is retained even if the driver's power is cut off. In such a case, it will be automatically restored at the next startup. From the user's perspective, it functions as simple accumulative travel distance information.

When a preset distance is reached, it can issue a warning and notify the user of the need of maintenance.

It enables performing maintenance based on the amount of usage of each axis, minimizing the amount of work required to maintain the quality of equipment.

3.4.4 Reading alarm history

Users can read the log of both past and present alarms. The alarm log records up to 15 alarms with time stamps in milliseconds. Alarms are saved even if the driver's power is cut off. Therefore, users can investigate the causes of past alarms by using the time stamp as a starting point.

4. Conclusion

In this article, we gave an overview of our new *SANMOTION F* stepping systems and described some of their main features.

- The high-power model has a thin profile and reduces volume and mass by 63% and 73%, respectively, compared to our current model of the same power output. Torque at high speeds was increased by 1.5 to 2.7 times, speed variations were reduced to 1/4 or less, and motor efficiency was improved by up to 8.7%.
  It also comes with PC-based functions, allowing users to set parameters according to their equipment and check the operating status.
- The basic model reduces volume and mass by 7% and 39%, respectively, while maintaining installation compatibility with the current model.
  When replacing a current model with the new model using the same motor, torque at high speeds is increased by 1.05 to 1.1 times, speed variations are reduced to 1/3 or less, and motor efficiency is improved by up to 5.5%.
- Both models have greatly enhanced protection and monitoring functions for safer use.

Both models are smaller and lighter than the current models but have increased torque at high speeds and higher power output. They have reduced speed variations compared to the current models, contributing to smaller and lighter equipment, shorter cycle times, and smoother operation. They are also environmentally friendly since they reduce CO_2 emissions during use and transport thanks to their energy-saving improved efficiency and their compact size and lightweight.

Looking ahead, we will leverage the technology we cultivated in these new models to provide faster, smoother, easier-to-use, and more efficient products that create new value for our customers.

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List of Awarded and Nominated Engineers for the 71st JEMA Technological Achievement Award in FY 2022

Heavy Electrical Category			
Prize	**Title**	**Department**	**Name**
Encouragement Award	Development of the High-Torque, High-Efficiency, Low-Noise *SANMOTION F* 2-Phase 56 mm sq. Stepping Motors	Design Dept. 1, Servo Systems Div.	Koji Nakatake, Yasushi Yoda, Shogo Yoda, Ryo Matsuo, Fumiharu Yamazoe
	Development of ø172 × 150 × 51 ACDC Fan and Splash Proof ACDC Fan	Design Dept., Cooling Systems Div.	Naoki Murakami, Koji Ueno, Naoya Ozumi, Takashi Kawashima
	Development of Safe, Reliable Holding Brake (for AC Servo Motors)	Design Dept. 1, Servo Systems Div.	Takeshi Miura, Ryota Hara, Rie Matsuyama
	Development of Compact Multi-Axis Integrated Linear Servo Motor Unit	Design Dept. 1, Servo Systems Div.	Yuki Onda, Satoshi Inaba, Yoshiki Kaneko
	Establishment of Automatic Gate Cutter Technology for Servo Motor Resin Molding	Subsect. 3, Process Engineering Sect. 1, Production Engineering Dept., Servo Systems Div.	Naoki Sakai, Tetsuya Narisawa, Manabu Takizawa

Department names are those at the time of nomination.

Major Patents

■ **Patents registered in FY 2022**

Patent Number	Title	Inventor(s)
Germany - 02733826	SPLIT-CORE TYPE MOTOR AND METHOD OF MANUFACTURING ARMATURE OF SPLIT-CORE TYPE MOTOR	Toru Takeda, Shintaro Koichi, Kenta Matsuhashi
Europe - 02733826		
Germany - 02848815	HOUSING OF FAN MOTOR	Toshiya Nishizawa, Haruka Sakai, Jiro Watanabe, Masashi Yokota
Denmark - 2848815		
Europe - 02848815		
Finland - 02848815		
France - 02848815		
U.K. - 02848815		
Japan - 07049754	MOTOR CONTROL APPARATUS	Yuji Ide, Michio Kitahara, Toshio Hiraide
Philippines - 1-2016-000156	BIDIRECTIONAL AXIAL FAN DEVICE	Satoshi Fujimaki, Toshiya Nishizawa, Takashi Kawashima
Philippines - 1-2016-000322	MEASUREMENT DEVICE	Masahiro Koike, Tomoaki Ikeda, Takahisa Toda, Yo Muramatsu, Katsumichi Ishihara, Hikaru Urushimoto
China - ZL201611048797.8	MOTOR CONTROL APPARATUS	Yuji Ide, Toshio Hiraide
Korea - 102381230	MOTOR	Manabu Horiuchi, Mai Shimizu, Jun Kitajima
Taiwan - I764894		
China - ZL201710560832.2	MOTOR CONTROL DEVICE	Yuji Ide, Toshio Hiraide, Keigo Kikuchi
Taiwan - I762510	BLAST FAN	Yoshihisa Yamazaki, Satoshi Fujimaki, Takashi Kawashima, Soma Araki
Philippines - 1-2018-000005	MOTOR CONTROL APPARATUS	Yuji Ide, Toshio Hiraide, Michio Kitahara
Taiwan - I783961		
Philippines - 1-2018-000167	COOLING FAN AUTOMATIC CONTROL SYSTEM AND COOLING FAN AUTOMATIC CONTROL DEVICE	Naoki Murakami, Masashi Murakami
Taiwan - I770194		
Japan - 07092471	ROTATING SHAFT LINEAR MOTOR	Yuqi Tang
Japan - 07108394	MOTOR HOLDING BRAKE SERVICE LIFE DETERMINATION SYSTEM, MOTOR HOLDING BRAKE SERVICE LIFE DETERMINATION DEVICE, AND MOTOR HOLDING BRAKE SERVICE LIFE DETERMINATION METHOD	Hideki Netsu, Yoshiyuki Murata
China - ZL201811345092.1	STATOR OF ROTATING ARMATURE AND ASSEMBLY METHOD THEREOF	Mitsuaki Shioiri, Koji Nakatake, Yasushi Yoda, Zhang Hong, Kazuhiro Yoda, Shogo Yoda
Japan - 07039264		
Japan - 07080644	POWER STORAGE SYSTEM	Hiroshi Yamada
Germany - 03540238	FAN MOTOR APPARATUS WITH PROTECTION COVER	Yusuke Okuda, Haruhisa Maruyama, Yoshihisa Yamazaki
Europe - 03540238		
Finland - 03540238		
France - 03540238		
U.K. - 03540238		
Italy - 03540238		
Japan - 07105584		
Japan - 07062512	PARALELL REDUNCANT UPS SYSTEM AND SYSTEM MONITORING METHOD USING THE SAME	Mieko Oi
U.S. - 11239711	ARMATURE MOLDED STRUCTURE	Manabu Horiuchi, Hiroki Sagara, Jun Kitajima, Mai Shimizu, Takashi Matsushita

Patent Number	Title	Inventor(s)
Austria - 03675326	BOBBIN STRUCTURE OF ARMATURE	Manabu Horiuchi, Hiroki Sagara, Jun Kitajima, Mai Shimizu, Takashi Matsushita
China - 03675326		
Germany - 03675326		
Europe - 03675326		
Spain - 03675326		
France - 03675326		
Italy - 03675326		
U.S. - 11489392		
U.S. - 11218035	ARMATURE STRUCTURE OF THREE-PHASE MOTOR	Manabu Horiuchi, Hiroki Sagara, Mai Shimizu, Jun Kitajima
Japan - 07199220	WATERPROOF BLOWER FAN	Masaki Kodama, Toshiya Nishizawa, Kakuhiko Hata
U.S. - 11286949		
Germany - 03713060	MOLDED STRUCTURE OF BRUSHLESS FAN MOTOR AND METHOD FOR MOLDING BRUSHLESS FAN MOTOR	Munenori Takakuwa, Kakuhiko Hata, Yukihiro Nagatsuka
Europe - 03713060		
U.S. - 11522410		
Taiwan - I768609	ROTARY ELECTRIC MOTOR	Manabu Horiuchi, Mai Shimizu, Takashi Matsushita, Yasushi Misawa (and Tomoyuki Suzuki from Japan Aviation Electronics Industry, Ltd.)
Japan - 07013540	ROTOR STRUCTURE OF SYNCHRONOUS MOTOR	Manabu Horiuchi, Keisuke Nagata

Internal Recognition: Invention Excellence Award

Awarded in May 2022

Prize	Title	Department	Name
Excellence Award	Encoder Automatic determination Device	Design Dept. 2, Servo Systems Div.	Masao Mizuguchi, Ryuichi Yanagisawa
	Reversible Flow Fan Frame Structure	Design Dept., Cooling Systems Div.	Takashi Kawashima, Soma Araki, Yoshihisa Yamazaki, Satoshi Fujimaki
	Detection of Motor Insulation Resistance	Design Dept. 2, Servo Systems Div.	Yuji Ide, Toshio Hiraide, Masakazu Sakai
		Under Operating Officer for Administration	Keigo Kikuchi
	Motor Controller Mounting Structure	Design Dept. 2, Servo Systems Div.	Yuji Ide, Takao Oshimori, Hiroaki Koike

Internal Recognition: Manufacturing Excellence Award

Awarded in May 2022

Prize	Title	Department	Name
Excellence Award	Introduction of Automatic PCB Coating Machine and Electronic Work Procedure	1st Subsect., Production Sect., 4th Production Dept., SANYO DENKI Techno Service	Taichi Kobayashi, Shimpei Kobayashi, Kai Suzuki
		Production Engineering Sect., Production Dept., Power Systems Div.	Mizuka Takahashi, Masahiro Hoyano
	Establishment of Automatic Gate Cutter Technology for Resin Molding	Subsect. 3, Process Engineering Sect. 1, Production Engineering Dept., Servo Systems Div.	Naoki Sakai, Akihiko Saito, Masahiro Seki

Technical Papers Published Outside the Company in General Technical Journals

January to December 2022

Title of Paper	Authors	Name of Journal	Issued in	Published by
Feature: Product and Technology Development of Member Companies and the Results of 2022	SANYO DENKI CO., LTD	*Denki* (Electrical Appliances)	Jan. 2022	The Japan Electrical Manufacturers' Association (JEMA)
Development of Compact UPS Series *SANUPS E11B-Li* and *SANUPS A11M-Li*	Hiroshi Sakaba, Akihiro Tsukada, Hiroyuki Hanaoka, Kazuya Nishizawa, Yuhei Shoyama, Takuya Ozawa, Hidenori Takizawa, Yuki Takayama	*Monthly JETI*	Apr. 2022	Nippon Syuppan Seisaku Center Inc.
Development of the *SANUPS E11B* Hybrid UPS	Akihiro Tsukada, Hiroshi Sakaba, Kazuya Nishizawa	*Smart Grid* (Technical Journal)	Apr. 2022	TAIGA Publishing Co., Ltd.
How to use linear motors effectively	Satoshi Sugita Joint author: Investigating R&D Committee on Technology for Utilizing Industrial Linear Drives	IEEJ Technical Report No. 1535	Sep. 2022	IEEJ (The Institute of Electrical Engineers of Japan)

Technical Papers Published Outside the Company

January to December 2022

Title of Paper	Authors	Name of Journal	Issued in	Published by
PMSM temperature estimation method using high frequency current controller including sine tracking control	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi, Michio Kitahara (Joint author: Nagaoka University of Technology)	The papers of Technical Meeting on Semiconductor Power Converter, IEEJ	Jan. 2022	IEEJ Joint Technical Meeting on Semiconductor Power Converter and Motor Drive
Simultaneous Realization Of High-Frequency-Current-Injection-Based Winding Temperature Estimation And Rotor Speed Control Using Dual Sinusoidal Waveform Tracking Current Control For PMSM		IEEJ Industrial Applications Category Conference lecture paper collection	Aug. 2022	IEEJ Industrial Applications Category
Simultaneous Temperature Estimation of Winding and Magnet of PMSM by High-Frequency-Injection into Static Coordinate		IEEJ Joint Technical Meeting on Semiconductor Power Converter and Motor Drive	Sep. 2022	IEEJ Joint Technical Meeting on Semiconductor Power Converter and Motor Drive

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