SANYO DENKI

Technical Report

Feature | Technical Developments in 2017

1945
Head Office and Tokyo Works relocated

45
May 2018

COLUMN

Cover image:

Head Office and Tokyo Works relocated

1945

Fifteen long years of war came to an end in August of 1945.

Domestic production capacity had declined rapidly due to a lack of raw materials and labor, in addition to damaged and evacuated factories following the late-war air raids.

However, the wartime economy had expanded the scale of the electric industry, and the radio communications sector in particular had achieved dramatic growth of both management scale and the level of technology.

During the war, we had established ourselves as a top domestic manufacturer of radio power generators.

In addition to specialized radio power generators, we had worked on many products in new advanced technology fields, and in so doing had built up our proficiency in a number of technologies.

In December of 1945, we established a new head office and factory in Tokyo's Sugamo district (now called Kita-Otsuka).

The structure had been damaged in air raids, leaving only the reinforced-concrete walls and floor. We repaired it and completed the factory.

While food shortages and a lack of supplies continued nationwide, causing many companies to suffer, we had taken our first step toward recovery.

We overcame the turbulent post-war period, and by 1951 the facility was running smoothly, with production lines in the basement and on the first floor, inspection and assembly lines on the second floor, storage and winding lines on the third floor, and a headquarters office on the fourth floor.

45 SANYO DENKI TECHNICAL REPORT

May 2018

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Satoru Onodera

Operating Officer

SANYO DENKI Continues Moving Forward with People

The SANYO DENKI Group's corporate philosophy is "We at SANYO DENKI Group Companies, aim to help all people achieve happiness, and work with people to make their dreams come true." Here, "people" refers to society and the natural environment, customers and users, suppliers and vendors, investors and financial institutions, competitors and the industry, and employees.

Working with these people, SANYO DENKI continues moving forward every day "to help achieve happiness, and make dreams come true." For example, we promote activities to create new value for our customers and users through technology, products, and services. For industry players and competitors, we engage in initiatives to build industrial and technical development through technical alliances and competition. For our employees, we take a management approach that will allow employees to feel motivated and achieve self-fulfillment through their work and company activities.

Presently, great changes are taking place in the world. Information and communications technology is connecting machines with machines, and machines with society, and it has become the norm for robots and automated equipment in factories to make products, and for AI (artificial intelligence) to process and use data.

With significant changes such as these taking place, let's return to the origin of *monozukuri*, so that we might understand the necessary approach to monozukuri that should be valued to "help achieve happiness, and make dreams come true" with "people."

The aim of monozukuri is the processing and assembly of materials and parts based on design information to create products with value. Creating this value quickly and easily is the essence and mission of monozukuri.

The following three organizational capabilities are necessary to "make value quickly and easily." Agility (speed and accuracy), flexibility (act according to the circumstances), and creativity (originality and ingenuity). "Agility" means acting swiftly and accurately, "flexibility" means taking action appropriate for the given circumstances in a constantly-changing environment, and “creativity” means being capable of originality and ingenuity.

To enhance the agility of monozukuri, it is extremely effective to use automated production lines with robots and ICT to connect components. Next, to enhance flexibility, the creativity of people is a key factor. To swiftly and easily make products with value the creativity of people in other words originality and ingenuity, is imperative.

In this issue, “Technical Developments in 2017” will introduce the main new products and technologies released in 2017.

Cooling Systems products, Power Systems products, and Servo Systems products all incorporate originality and ingenuity to create value for the customers who use them.

For example, our *G Proof Fan* can be used with peace-of-mind as it will not malfunction even in environments subjected to 75 G of centrifugal acceleration, commonly known as G-force. The *High Static Pressure Counter Rotating Fan* has a large cooling effect even in devices with high component density, so worry-free cooling design of devices is possible. On our PV inverter, *SANUPS W73A*, optimal input voltage - power characteristics can be set to suit wind power generators and hydroelectric power generators, therefore power generation systems can be built with peace-of-mind. Moreover, our servo amplifiers equipped with safety features and stepping motors with low acoustic noise and high efficiency can be used with peace-of-mind even for applications where humans and equipment come in close contact.

In this way, we, the SANYO DENKI Group, offer products packed with ideas to create new value and happiness for people in a swift and easy manner.

By leveraging robots and AI, monozukuri with high agility and flexibility has become a reality. Now it is essential to leverage the creativity of people. SANYO DENKI wishes to continue connecting people, valuing the connections between people, and moving forward together as one.

Cooling Systems Division

Honami Osawa

There is an unstoppable trend towards higher performance and integration in a wide range of markets. Prime examples include ICT equipment such as servers and storage systems, devices installed indoors such as power supplies, and devices installed outdoors such as the PV inverters, high-brightness LED lighting, and electric vehicle charging stations.

Cooling fans adopted in these devices are expected to offer higher airflow and static pressure than ever before.

Moreover, as a new application, there is increasing demand for fans with high reliability even in environments subjected to a large centrifugal acceleration or "G-force." One example is the fan used for the rotating parts of medical CT scanners.

SANYO DENKI responded to such demands in 2017 by developing and launching fans with industry-leading* performance and high reliability.

Below is an overview of the products developed by SANYO DENKI Cooling Division in 2017.

■ G Proof Fan

DC Fan

- 120 × 120 × 38 mm *San Ace 120GP* 9GP type
- ø172 × 150 × 51 mm *San Ace 172GP* 9GP type

There has been a growing demand for fans able to be used in environments subjected to centrifugal acceleration, commonly known as G-force.

One example is the fan used for cooling the interior of medical CT scanners. It is believed that devices such as this will offer even higher performance and higher reliability in the future, leading to greater demand for fans that can withstand environments with higher levels of G-force.

In order to meet such market requirements, SANYO DENKI has developed and released the *San Ace 120GP* and *San Ace 172GP* 9GP type G Proof Fans.

This fan's level of G-force tolerance is 75 G (first in the industry* to use this specification).

■ Blower

DC Fan

• 92 × 33 mm *San Ace B97* 9BMC type

The 92 × 33 mm Blower is used in various applications including servers, power supplies, and printers.

Its applications are broadening to air purifiers, household ventilation systems, fuel cells, etc. and, as such, requirements have emerged for even higher airflow and static pressure.

In order to meet such market requirements, SANYO DENKI has developed and released the *San Ace B97* 9BMC type Blower.

Compared to our current model (the 9BMB type), the new model has 1.15 times higher maximum airflow and 1.5 times higher maximum static pressure.

■ Counter Rotating Fan

DC Fan

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

More and more, cooling fans are required to have higher static pressure to match the increased density and heat generation of devices in the server and power supply markets.

Significantly higher cooling performance is required of 40 mm sq. fans, particularly for 1U servers, power supplies, and storage.

In order to meet such market requirements, SANYO DENKI has developed and released the *San Ace 40* 9CRH type Counter Rotating Fan.

Compared to our current model (the 9CRV type), the new model has 1.62 times higher maximum static pressure.

Details are introduced in the “New Product Introduction” article for this product.

■ Splash Proof Centrifugal Fan

DC Fan

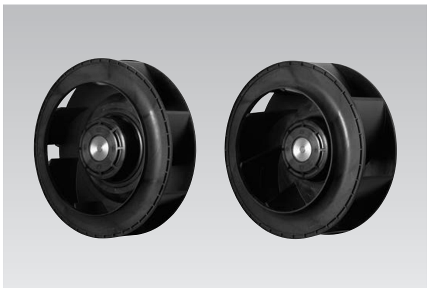
• ø221 × 71 mm *San Ace 221W* 9W2T type
• ø225 × 99 mm *San Ace 225W* 9W2T type

ICT equipment installed outdoors, PV inverters, large A/C equipment, industrial refrigerators, dust collectors, etc., are expected to offer high airflow and waterproof performance.

In response to market demands, SANYO DENKI has developed and released the *San Ace 221W* and *San Ace 225W* 9W2T type Splash Proof Centrifugal Fans which offer industry-leading* cooling performance.

Each model has a waterproof rating of IP56.

Details are introduced in the “New Product Introduction” article for this product.



■ Long Life Fan

DC Fan

- 140 × 140 × 38 mm *San Ace 140L* 9LG type
- 140 × 140 × 51 mm *San Ace 140L* 9LG type

140 mm sq. fans are used in a broad range of devices, including ICT equipment, industrial inverters, fuel cells, rapid chargers, and digital signage. The internal heat generation of these devices has increased, leading to demands for higher airflow and static pressure. At the same time, fans with a longer service life are in demand due to a shift towards maintenance-free devices with a longer lifespan.

In order to meet such market requirements, SANYO DENKI has developed and released the 140 × 140 × 38 mm and 140 × 140 × 51 mm *San Ace 140L* 9LG type Long Life Fans.

Compared to our current models of the 9L and 9LB types, the latest model boasts the following enhancements.

- 140 × 140 × 38 mm
  San Ace 140L 9LG type:
  1.7 times higher maximum airflow,
  5.2 times higher maximum static pressure
  1.8 times longer expected life (180,000 h at 60°C)
- 140 × 140 × 51 mm
  San Ace 140L 9LG type:
  1.1 times higher maximum airflow,
  2.7 times higher maximum static pressure
  3 times longer expected life (180,000 h at 60°C)

■ Long Life Splash Proof Fan

DC Fan

- 140 × 140 × 38 mm *San Ace 140W* 9WL type
- 140 × 140 × 51 mm *San Ace 140W* 9WL type

The 140 × 140 mm Splash Proof Fan is used on a wide-range of devices installed outdoors such as PV inverters, high-brightness LED lighting, and electric vehicle charging stations. To handle the increased heat generation from such applications, fans now not only need to be water resistant, but also demonstrate higher airflow and static pressure while lasting longer.

In response, SANYO DENKI has developed and released the *San Ace 140W* 9WL type Long Life Splash Proof Fan. The new model is based on the aforementioned *San Ace 140W* 9LG type, with the additional feature of being water resistant.

Compared to our current 9W and 9WB types, the latest model offers the following advantages:

- 140 × 140 × 38 mm
  San Ace 140W 9WL type:
  1.7 times higher maximum airflow,
  5.2 times higher maximum static pressure
  Equivalent expected life (100,000 h at 60°C)
- 140 × 140 × 51 mm
  San Ace 140W 9WL type:
  1.1 times higher maximum airflow,
  2.7 times higher maximum static pressure
  1.7 times longer expected life (100,000 h at 60°C)

* Based on our own performance comparison research at the time of release of each product, among equally-sized industrial DC fans on the market.

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High Airflow Splash Proof Centrifugal Fans *San Ace 225W* and *San Ace 221W*

Kakuhiko Hata Masashi Miyazawa Hayato Murayama Yukihiro Nagatsuka

Nozomi Manji Yuto Horiuchi Tetsuya Yamazaki

1. Introduction

In recent years, due to higher performance and functionality, there has been a constant increase in the amount of heat generated by outdoor equipment such as cellular base stations, ICT equipment, and PV inverters. Accordingly, greater demands have emerged for cooling fans that offer both water resistance and high airflow.

Moreover, there is an increasing demand for waterproof, high airflow fans for use in new applications such as large air conditioning equipment, commercial refrigerators, dust collectors, etc.

In response, SANYO DENKI has developed two high airflow Splash Proof Centrifugal Fans: *San Ace 225W* and *San Ace 221W*. This article will introduce the features and performance of the high airflow Splash Proof Centrifugal Fans *San Ace 225W* and *San Ace 221W* 9W2T type (hereinafter "new models").

2. Product Features

Figures 1 and 2 show the external views of the new models.

The features of the new models are as follows:

(1) High airflow
(2) Dustproof and waterproof performance with an IP56 ingress protection rating*
(3) PWM control function

* IP56 ingress protection rating
The degree of protection (IP code) is defined by IEC (International Electrotechnical Commission) 60529 "DEGREES OF PROTECTION PROVIDED BY ENCLOSURES (IP Code)" (IEC 60529:2001)

Fig. 1: ø225 × 99 mm *San Ace 225W* 9W2T type

Fig. 2: ø221 × 71 mm *San Ace 221W* 9W2T type

3. Product Overview

3.1 Dimensions

Figures 3 and 4 show the dimensions of the new models.

3.2 Specifications

3.2.1 General specifications

Tables 1 and 2 show the general specifications.

3.2.2 Airflow vs. static pressure characteristics

Figures 5 and 6 show the airflow vs. static pressure characteristics for the new models.

3.2.3 PWM control function

The new models have a PWM control function that enables external control of the fan speed.

By controlling the fan's speed to suit the device's heat generation state rather than operating it at full speed constantly, both the overall device power consumption and noise can be reduced.

3.3 Expected life

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

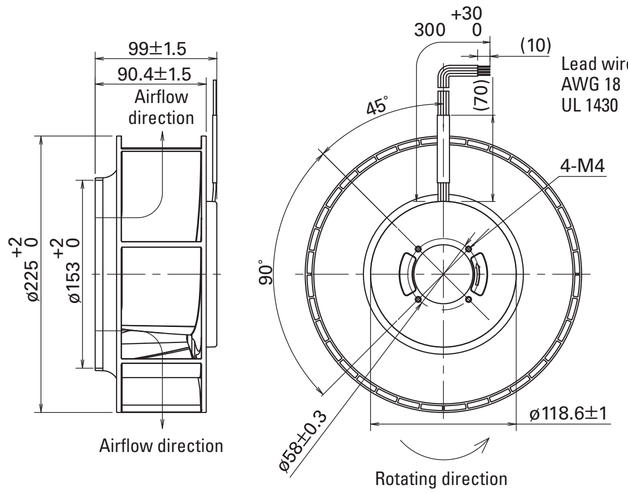

Fig. 3: Dimensions of the ø225 × 99 mm *San Ace 225W* 9W2T type (unit: mm)

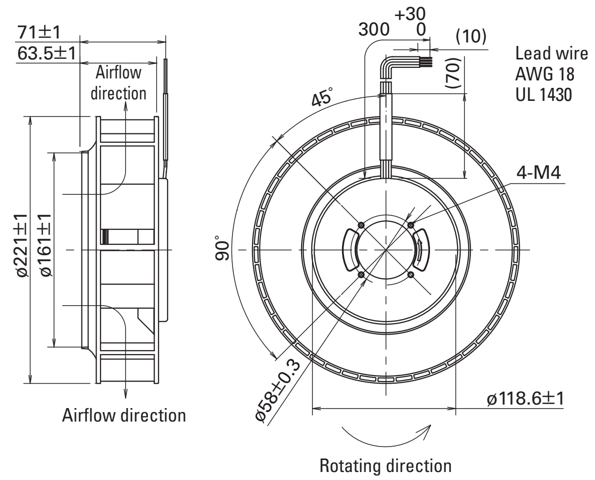

Fig. 4: Dimensions of the ø221 × 71 mm *San Ace 221W* 9W2T type (unit: mm)

Table 1: General specifications of the ø225 × 99 mm *San Ace 225W* 9W2T type

Model no.	Rated voltage [V]	Operating voltage range [V]	PWM duty cycle* [%]	Rated current [A]	Rated input [W]	Rated speed [min⁻¹]	Max. airflow [m³/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH₂O]	SPL [dB(A)]	Operating temperature [°C]	Expected life [h]
9W2TS48P0S001	48	36 to 72	100	2.45	117.6	3,000	23.5	830	635	2.55	72.0	-25 to +70	40,000 at 60°C (70,000 at 40°C)
			15	0.24	11.5	1,000	7.83	276	70.6	0.28	52.5		

* Input PWM frequency: 25 kHz. Speed is 0 min^{-1} at 0% PWM duty cycle.
When equipped with our inlet nozzle [separately sold (model no.: 109-1134H)]

Table 2: General specifications of the ø221 × 71 mm *San Ace 221W* 9W2T type

Model no.	Rated voltage [V]	Operating voltage range [V]	PWM duty cycle* [%]	Rated current [A]	Rated input [W]	Rated speed [min⁻¹]	Max. airflow [m³/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH₂O]	SPL [dB(A)]	Operating temperature [°C]	Expected life [h]
9W2TP24P0H001	24	16 to 36	100	3.35	80.4	3,050	17.6	621	530	2.13	71.5	-25 to +70	40,000 at 60°C (70,000 at 40°C)
			15	0.4	9.6	1,000	5.75	203	57.0	0.23	53.5		
9W2TP48P0S001	48	36 to 72	100	2.3	110.4	3,400	19.6	692	659	2.65	73.5		
			15	0.2	9.6	1,000	5.75	203	57.0	0.23	53.5		

* Input PWM frequency: 25 kHz. Speed is 0 min^{-1} at 0% PWM duty cycle.
When equipped with our inlet nozzle [separately sold (model no.: 109-1135H)]

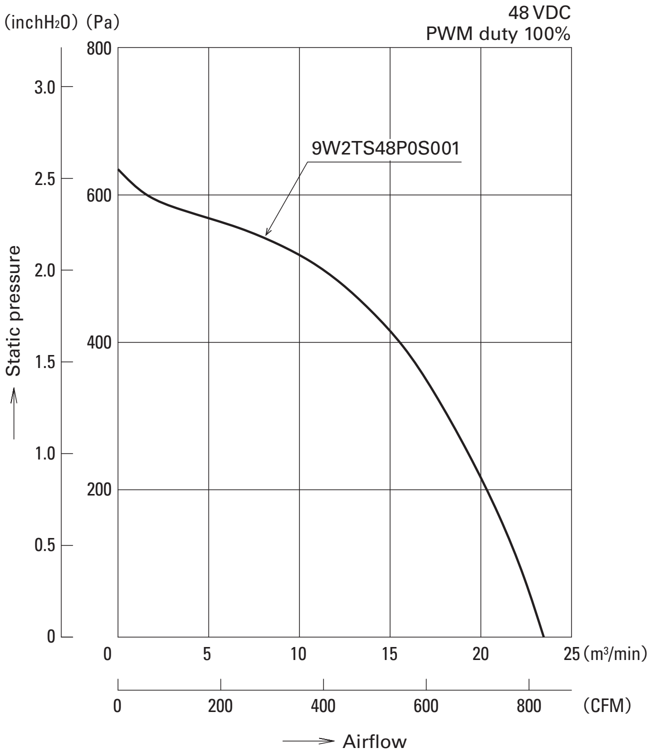

Fig. 5: Airflow vs. static pressure characteristics of the ø225 × 99 mm *San Ace 225W* 9W2T type

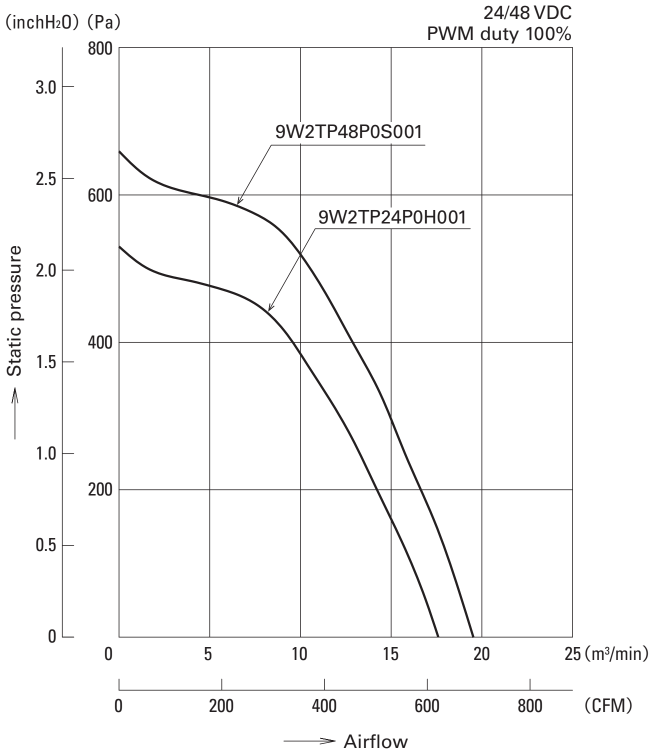

Fig. 6: Airflow vs. static pressure characteristics of the ø221 × 71 mm *San Ace 221W* 9W2T type

4. Key Points of Development

Based on the performance and structural components of our current High Airflow Centrifugal Fans *San Ace C225* and *San Ace C221*, the new models have adopted a structure never seen in our current Splash Proof Fans to achieve higher airflow.

The key points of development are explained below.

4.1 Waterproof design

Our current Splash Proof Fans are available in two types of structure. The first type covers the live parts (PCB, control circuit, motor) completely with epoxy resin, and the second type has a waterproof labyrinth structure to contain the live parts in its internal space.

The new models are large fans with high currents, therefore an electrolytic capacitor is used. As the pressure valve portion of the electrolytic capacitor must not be blocked, we couldn't employ the complete coverage with epoxy resin.

Due to the high current and high-heat generating control circuit components, we originally considered adopting a labyrinth sealing structure which allows enough space around the control circuit components for air ventilation as an alternative to covering the electrolytic capacitor in epoxy resin, etc. Studying various structures, we had a hard time achieving both internal air ventilation and waterproof performance because securing ventilation air space around the components always led to water ingress.

Consequently, we adopted a new structure where only the motor portion is covered in epoxy resin and the PCB and control circuit are contained in the space within the frame and top cover.

Figure 7 shows an external view of the live parts of the new models.

The frame and top cover are aluminum and painted for increased corrosion-resistance, improving reliability.

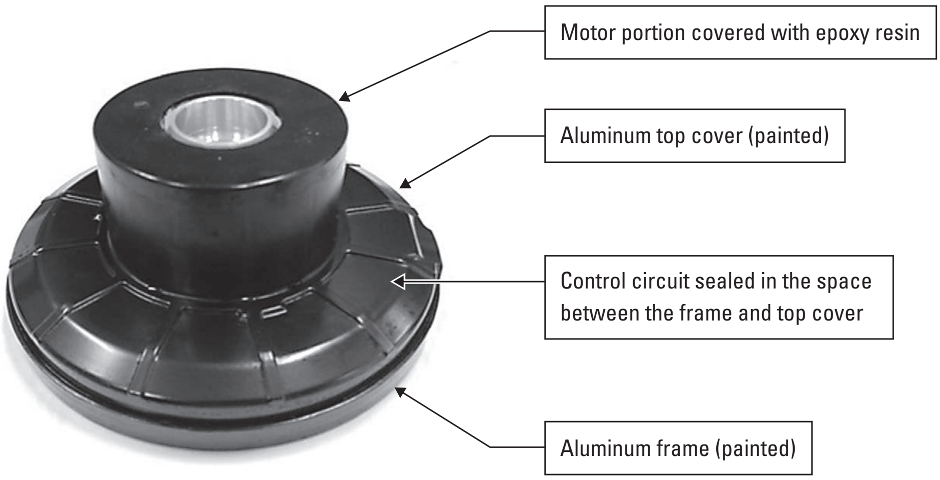

Fig. 7: External view of the live parts of the new models

4.2 Heat dissipation design to improve motor efficiency

Because the control circuit components of the new models are contained in a narrow space, the components cannot be directly air-cooled. It could shorten the life of the electrolytic capacitor if the temperatures of the control circuit components and the surrounding air rise. Therefore there is a need to reduce the temperature rise in a way other than air-cooling.

The new models achieved higher motor efficiency and reduced heat generation by revising the motor height, magnet height, and magnet material of the development base high airflow Centrifugal Fan. Moreover, by using a bigger PCB with no change in fan dimensions and optimizing the arrangement of the high-heat generating components, we could reduce the temperature rise, achieving high airflow and waterproof performance.

Table 3 compares motor efficiency of the current model and new model.

Table 3: Motor efficiency comparison

	Motor efficiency [%]	
	Base fan	New model
At minimum load (at maximum static pressure)	76	77
At maximum load	75	78

5. Comparison with our Current Model

Figure 8 compares the airflow vs. static pressure characteristics of 9W2TS48P0S001 (ø225 × 99 mm), the highest-airflow model among the new models and 9W1TG48P0H61 (ø175 × 69 mm), the highest-airflow model among our current Splash Proof Centrifugal Fans.

The new model features significantly improved 2.6 times higher maximum airflow and 1.7 times higher maximum static pressure.

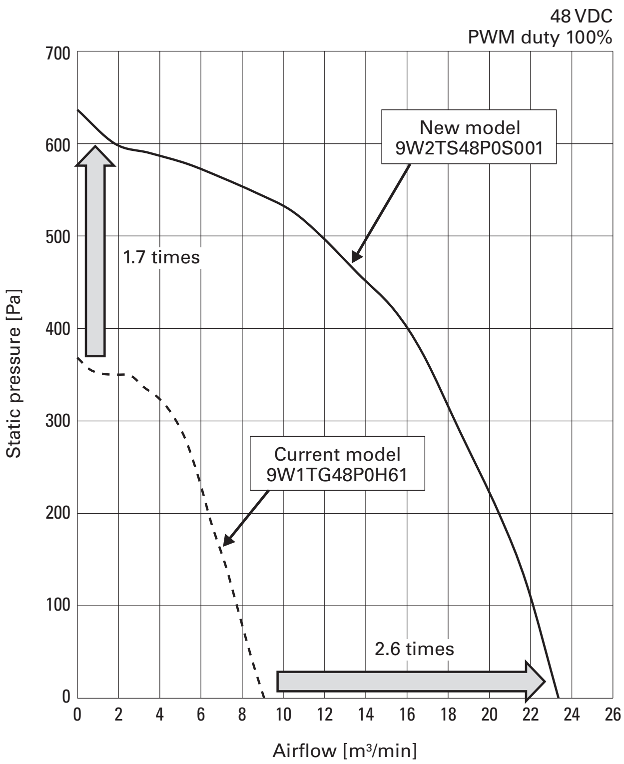

Fig. 8: Airflow vs. static pressure characteristics

6. Conclusion

This article has presented some of the features and performance of the high airflow Splash Proof Centrifugal Fans *San Ace 225W* and *San Ace 221W* 9W2T type we developed.

The new models achieved high airflow and an IP56 dust/waterproof rating by adopting a new water-resistant structure, improving motor efficiency, and optimizing the arrangement of high-heat generating components.

The ø225 × 99 mm sized fan has achieved the industry's highest* airflow as a splash proof centrifugal fan. The *San Ace 221W* 9W2T type fan is the first splash proof centrifugal fan of its size in the industry.*

It is predicted that outdoor equipment will be generating more and more heat and the demand for fans offering both high airflow and waterproof capability will continue to grow. It is also predicted that the demand for splash proof centrifugal fans will continue to grow for new applications such as air conditioning units and dust collectors.

By achieving both high airflow and dust/waterproof performance, we believe that the new models can help solve the issues our customers face.

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

* Based on our own research as of July 3, 2017.

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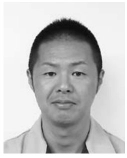

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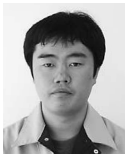

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High Static Pressure Counter Rotating Fan *San Ace 40* 9CRH Type

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1. Introduction

In recent years, the density and heat generation of servers and power supply devices have been increasing. Particularly for 1U servers, there is a requirement for 40 × 40 mm fans with significantly higher static pressure performance. SANYO DENKI has previously developed and released a 40 × 40 × 56 mm counter rotating fan, however there is a growing number of cases in which this fan cannot provide the required cooling performance. For this reason, there is increased demand for high static pressure fans that are capable of cooling even high-density environments. Power consumption and sound pressure level (SPL) are also important issues.

In order to meet these requirements, SANYO DENKI has developed and released the 40 × 40 × 56 mm high static pressure counter rotating fan *San Ace 40* 9CRH type (hereinafter, "new model") which features a newly-designed impeller, frame, motor, and circuit.

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

2. Product Features

Figure 1 shows an external view of the new model.

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

The features of the new model are:

(1) High static pressure
(2) Low power consumption
(3) Low SPL
(4) Optimal for 1U size units

3. Outline of the New Model

3.1 Dimensions

Figure 2 shows the dimensions of the new model.

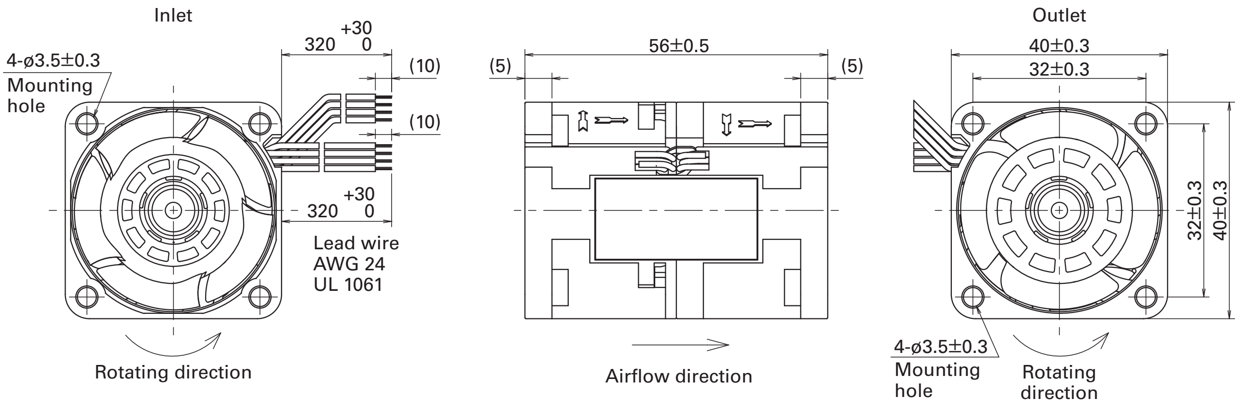


Fig. 2: Dimensions of the new model (unit: mm)

3.2 Characteristics

3.2.1 General specifications

Table 1 shows the general specifications for the new model.

The rated voltage is only 12 VDC, while the rated speed is 29,500 min^{-1} on the inlet side, and 25,500 min^{-1} on the outlet side.

Table 1: General specifications for the new model

Model no.	Rated voltage [V]	Operating voltage range [V]	PWM duty cycle [%]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]		Max. airflow		Max. static pressure		SPL [dB (A)]	Operating temperature [°C]	Expected life [h]
						Inlet	Outlet	[m^3/min]	[CFM]	[Pa]	[inchH_2O]			
9CRH0412P5J001	12	10.8 to 12.6	100	2.52	30.24	29,500	25,500	0.93	32.9	1,700	6.83	70	-20 to +70	30,000 at 60°C
			20	0.06	0.72	3,000	2,600	0.08	2.8	17	0.07	20		

3.2.2 Airflow vs. static pressure characteristics

Figure 3 shows the airflow vs. static pressure characteristics for the new model.

3.2.3 PWM control function

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

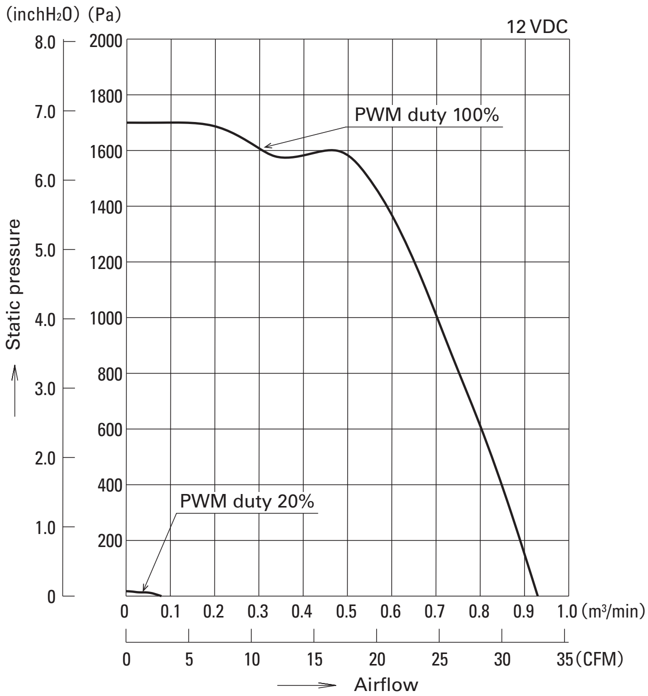


Fig. 3: Airflow vs. static pressure characteristics of the new model

4. Key Points of Development

The new model maintains a maximum airflow equivalent to that of the current model while offering significantly improved static pressure performance. High speed is essential to improving static pressure performance, so we redesigned the impeller, frame, motor, and circuit to achieve this.

Below, we explain the key points of development as well as the differences between the new model and the *San Ace 40* 9CRV type (hereinafter, "current model").

4.1 Impeller design

The impeller of the new model required sufficient strength to withstand a high speed of approximately 30,000 min^{-1}.

Based on the results of previous reliability evaluation tests, we used stress simulation technology and increased impeller blade thickness by approximately 1.4 times that of the current model to maintain sufficient strength.

Figure 4 shows the impellers of the inlet and outlet fans.

Figure 5 compares the blade thickness of the new and current models.

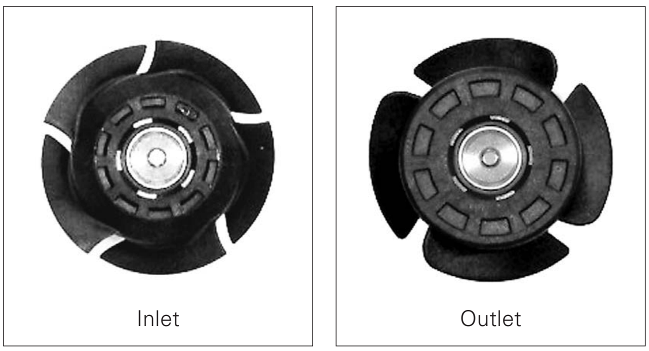


Fig. 4: Impellers of the inlet and outlet fans

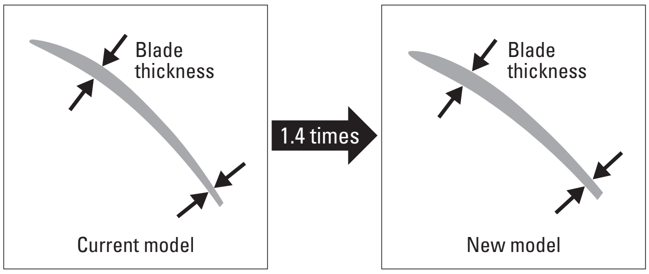


Fig. 5: Comparison of current and new model blade thicknesses

Increasing blade thickness has a significant impact on airflow vs. static pressure characteristics, power consumption, and SPL. However, by changing the inlet and outlet fans' impeller shape, mounting angle, and speed combinations, then repeatedly using 3D printing and performance evaluations for optimization, we successfully achieved the target performance.

4.2 Motor and circuit design

In order to increase fan speed, we redesigned the motor stator and changed the motor drive type from single-phase to 3-phase.

The 40 × 40 mm fan not only features a small PCB, but also adopts 3-phase motor, meaning it has a higher number of electronic components than the current model, and we were concerned that these could not all fit. As such, we were creative in the selection and arrangement of electronic components, which enabled us to build a new circuit without changing the size of the PCB from that of the current model.

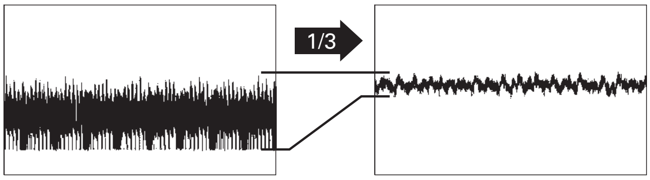
Figure 6 shows the motor portion of the current model and new model.

Current model (single-phase) New model (3-phase)

Fig. 6: Motors of the current model and new model

Due to its higher speed, the new model has a higher power consumption than the current model, however the change to a 3-phase motor has made it possible to reduce current waveform peak fluctuation to around one-third that of the current model.

Figure 7 is a comparison of current waveforms during steady operation.



Current model (single-phase) New model (3-phase)

Fig. 7: Current waveforms during steady operation (comparison with current model)

5. Comparison with Current Model

5.1 Comparison of airflow vs. static pressure characteristics

The new model maintains the same maximum airflow as the current model but achieves 62% higher maximum static pressure.

Figure 8 provides an example of the airflow vs. static pressure characteristics of the current model and the new model.

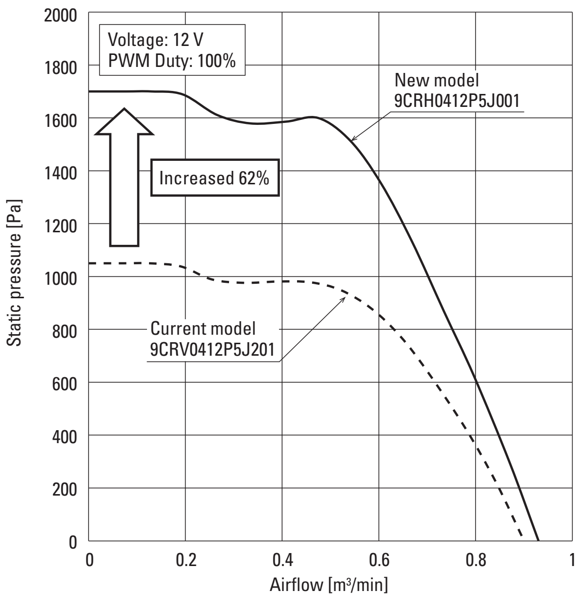


Fig. 8: Airflow vs. static pressure characteristics of current and new models

5.2 Power consumption comparison (when performance is equivalent to the current model)

Figure 9 provides a comparison of power consumption for the current and new models when their respective cooling performances are equivalent.

When the speed of the new model is lowered by PWM control and cooling performance at the assumed operating point is equivalent to that of the current model, the new model consumes 10% less power than the current model.

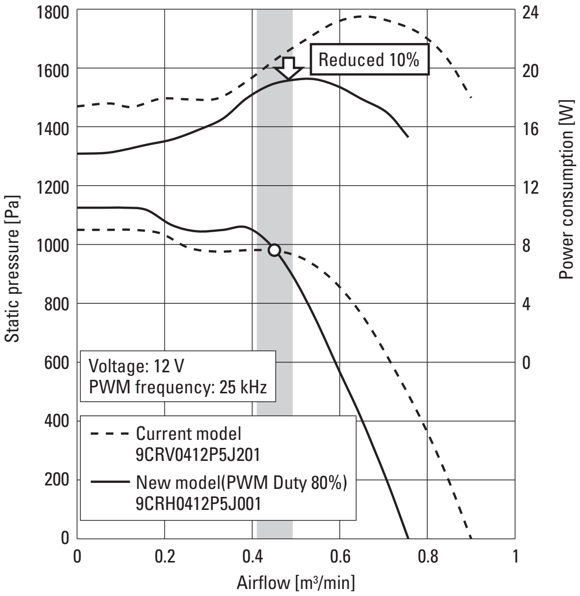


Fig. 9: Example of the airflow vs. static pressure characteristics (comparison with current model)

5.3 SPL comparison (when performance is equivalent to the current model)

Another focus when designing the new model was minimizing SPL and, as a result of innovative measures regarding inlet and outlet speed ratio and impeller shape, we succeeded in reducing SPL compared to the current model.

Figure 10 shows a comparison of SPL for the current and new model when cooling performances are equivalent.

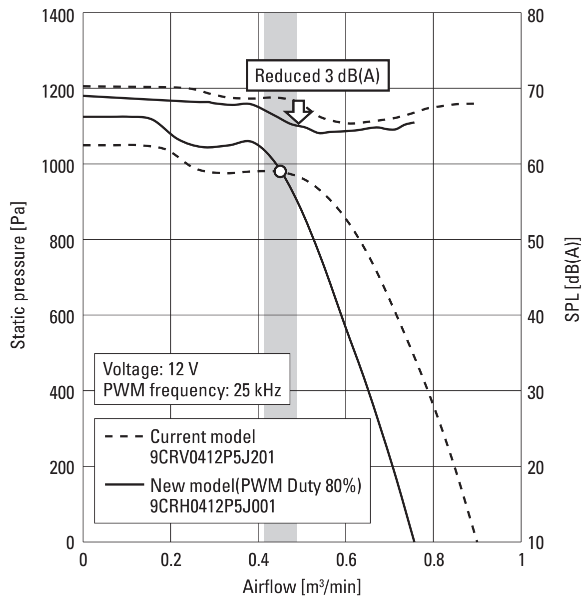


Fig. 10: Example of the airflow vs. static pressure characteristics (comparison with current model)

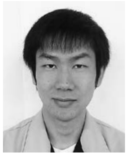
6. Conclusion

This article has introduced some of the features and performance of the 40 × 40 × 56 mm high static pressure counter rotating fan *San Ace 40* 9CRH type developed by SANYO DENKI.

The new model has significantly higher static pressure than our current model while maintaining equivalent maximum airflow. Furthermore, when cooling performance is equivalent to that of the current model, the new model offers reduced power consumption and SPL.

We believe these features of the new model will significantly contribute to the cooling of equipment that is forecast to have even higher density and heat generation in the future.

SANYO DENKI is committed to engaging in product development that helps to fulfill new dreams and offering products that earn our customers' satisfaction.



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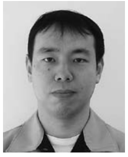

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In April 2017, the feed-in tariff (FIT) for renewable energy was significantly revised. The main point of the revision was the transition of focus from photovoltaic power generation to others to promote the installation of wind power, thermal power, small/medium-scale hydroelectric power, and biomass power generation systems. The FIT scheme was established 5 years ago, and now it has undergone a major overhaul.

Furthermore, in the UPS market, UPSs used as backup power for equipment operated outdoors (e.g. wireless base stations and paid parking lots) need to be able to withstand severe operating temperatures and require less maintenance.

To meet such market requirements, Power Systems Division developed and released the following products in 2017.

For the renewable energy market, we developed the PV inverter *SANUPS P73L*. The P73L can connect to batteries so that PV panel-generated power and battery power can be supplied during power outages. Furthermore, this product has a peak cut function and can store power during the night in its battery, which can be used together with the PV-generated power during the daytime.

Power Systems Division has also developed *SANUPS W73A*, a power conditioner for wind power and hydro power generation systems. The W73A allows arbitrary setting of the DC input voltage - power characteristics to suit the specific system so that the wind wheel or water turbine can generate power efficiently. This is Japan's first 3-phase power inverter for use in wind power and hydroelectric power generation systems that enables accurate and optimal power generation settings to suit the specific wind wheel or water turbine.*

For the UPS market, we have developed *SANUPS A11K-Li* and *SANUPS N11B-Li* as UPSs equipped with Li-ion batteries, which outperform lead-acid batteries in terms of environmental durability and service life. The A11K-Li and N11B-Li have operating temperature ranges of -20 to +55°C and -20 to +50°C, respectively. Both of these products are capable of withstanding harsh operating environments. Moreover, there is no need to replace the battery for ten years, making these UPSs maintenance-free.

This article will briefly describe the features of these new products.

* Based on our own research as of October 11, 2017, among power inverters for wind power and hydroelectric power generation systems.

■ *SANUPS P73L* - PV Inverter with Peak Cut Function

SANYO DENKI already offers *SANUPS P73K* as a PV inverter with a peak cut function supporting Li-ion batteries. However, in 2017, we developed *SANUPS P73L* based on the *SANUPS P73K* with new functions added to meet the latest market demands.

The *SANUPS P73L* is comprised of a 10 kW PV inverter unit, 10 kW charging unit, and I/O box, with the ability to add up to six 10 kW PV inverter units as a scalable system. This product comes in the "grid-connected, isolated, charging type" and "grid-connected, isolated type," with output capacities ranging from 10 to 60 kW.

Figure 1 shows the appearance of the *SANUPS P73L* grid-connected, isolated, charging type and grid-connected, isolated type.

The grid-connected, isolated, charging type supports peak power cut by supplying the power of its PV panel and storage battery to a general load via the isolated converter circuit and inverter circuit equipped in the PV inverter unit. Moreover, it can supply AC power to the isolated operation output during power outages on the grid.

The *SANUPS P73L* has the following four operation modes: grid-connected operation mode, peak cut operation mode, charging operation mode, and isolated operation mode. Figure 2 shows the switchover between these operation modes.

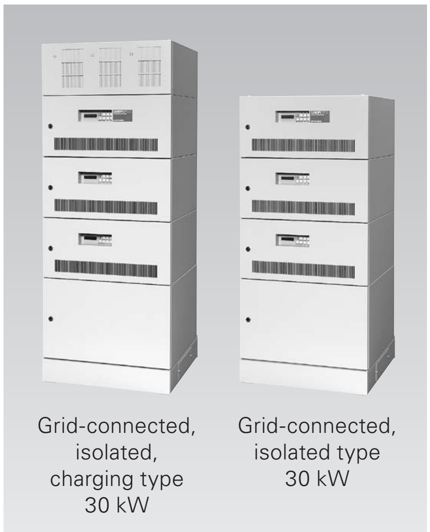

Fig. 1: *SANUPS P73L*

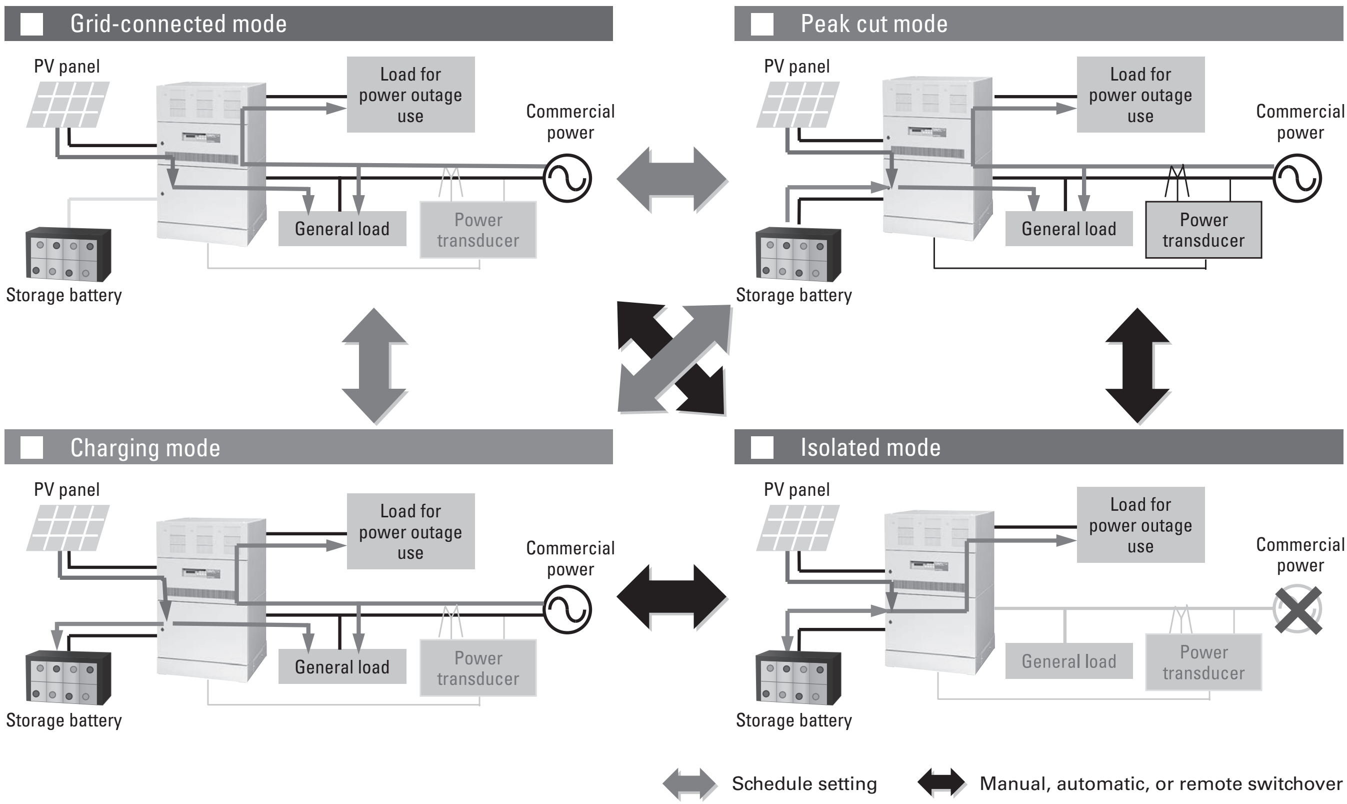

Fig. 2: Switchover between operation mode

■ *SANUPS W73A* - Power Conditioner for Wind Power and Hydro Power Generation Systems

As the next renewable energy following photovoltaic power generation, wind power and small/medium-scale hydroelectric power generation are expected to grow. The 10 kW class small wind power generation and small-scale hydroelectric power generation often use permanent magnet generators and, just as PV power generation, there is a demand for easy-to-use DC-AC power inverters.

In 2017, SANYO DENKI developed *SANUPS W73A*, a power conditioner for wind power and hydroelectric power generation systems which converts the generated DC power and allows arbitrary settings of DC input voltage - DC input power characteristics to suit the specific power generation system.

The *SANUPS W73A* has been equipped with a DC input voltage - DC input power characteristics setting function which can match the characteristics of wind power and hydroelectric power generation. Figure 3 shows the appearance of the *SANUPS W73A*.

It is possible to set a minimum of 2 and maximum of 32 power characteristic settings, and power characteristics set once can easily be added, changed, or deleted. Moreover, this product was designed presuming use on various systems, and the operation starting/stopping voltages can be set arbitrarily.

Fig. 3: *SANUPS W73A*

■ Small-Capacity UPS *SANUPS A11K-Li* and *SANUPS N11B-Li* Series

In recent years, there has been an increased demand for the backup power for outdoor facilities such as base stations, traffic lights, paid parking lots, and surveillance cameras. In addition to the ability to withstand temperatures and other harsh operating environment conditions, UPSs installed outdoors are required to have smaller footprint and extended backup time, and require less maintenance.

Conventionally, UPSs have used lead-acid batteries. However, they have a limited operating temperature range and short backup time towards the end of their life cycle, requiring replacing. Moreover, to achieve extended backup time, more batteries are needed, requiring more installation space.

As such, in 2017, SANYO DENKI developed *SANUPS A11K-Li* and *SANUPS N11B-Li* series as small-capacity UPS equipped with Li-ion batteries (LIB).

The *SANUPS A11K-Li* features the double conversion online topology, and is available in output capacities of 1.5 kVA, 3 kVA, and 5 kVA.

The *SANUPS N11B-Li* features the passive standby topology, and is available in output capacities of 1 kVA and 1.5 kVA. The *SANUPS A11K-Li* can be used as backup power for indoor equipment including servers while the *SANUPS N11B-Li* can be used as backup power for equipment installed outdoors.

Compared to UPSs with conventional lead-acid batteries, both of these series offer the benefits of operating in a wider temperature range, extended backup time in smaller installation space, and maintenance-free operation due to the eliminated need for battery replacement.

Figures 4 and 5 show the appearance of the *SANUPS A11K-Li* and *SANUPS N11B-Li* series, respectively.

Thanks to their LIB, the *SANUPS A11K-Li* has an operating temperature range of -20˚C to +55˚C, while the *SANUPS N11B-Li* has one of -20˚C to +50˚C, meaning that both products can be used with confidence even in extremely cold or hot regions.

The conventional UPSs with lead-acid batteries required battery replacement approximately every five years, but by adopting LIB, these new products can be used for up to ten years without battery replacement. Moreover, these products are approximately a half in volume than conventional UPSs, requiring less installation space.

The *SANUPS N11B-Li* adopts a sealed structure, therefore has excellent water resistance and protection against solid foreign objects including small insects and animals. This means it can be used outdoors with confidence.

Both series are equipped with a battery management unit and feature a data interface between the UPS and LIB. By monitoring detailed LIB data, and performing mutual protective operations and fault detections between UPS and LIB, the LIB can be used safely.

Fig. 4: *SANUPS A11K-Li* series

Fig. 5: *SANUPS N11B-Li* series

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Development of the *SANUPS W73A* Power Conditioner for Wind Power and Hydro Power Generation Systems

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1. Introduction

An outcome of the 21st yearly session of the Conference of the Parties (COP21) of the United Nations Climate Change Conference, held in late 2015, was the adoption of the Paris Agreement, whereby member states declared their commitment to suppressing temperature increase to less than 2°C above pre-industrial levels and ongoing efforts to limit the temperature increase to 1.5°C.

In response, the Japanese government passed a cabinet decision on the Plan for Global Warming Countermeasures in 2016. This plan states that renewable energy is an essential countermeasure against global warming and stressed it must be adopted to the maximum extent possible. (1)

Consequently, there is growing attention and heightened expectations not only for photovoltaic, but also for wind and hydroelectric power, as forms of renewable energy. SANYO DENKI has newly developed the *SANUPS W73A* power conditioner for wind power and hydro power generation systems, which enables the user to arbitrarily set the DC input voltage - DC input power characteristics to match a specific system. This article will introduce the features of this new product.

2. Background

Figure 1 shows an example of output characteristics for a typical wind power generator and output characteristics of SANYO DENKI's current PV inverter (hereinafter "current model").

As Figure 1 demonstrates, the output characteristics of the current model sometimes deviated from the maximum output characteristics of a wind power or hydroelectric power generator, therefore it was not possible to effectively generate power.

In order to solve this issue and use power more effectively than the current model, SANYO DENKI added a DC input voltage - DC input power characteristics setting function to the *SANUPS W73A* which enables the user to set power generation characteristics identical to the maximum output characteristics of wind and hydroelectric power generators.

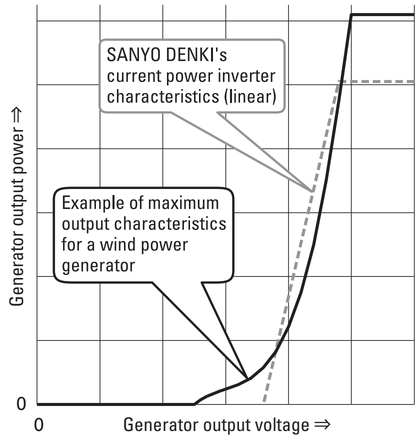

Fig. 1: Example of wind power generator output characteristics and the output characteristics of SANYO DENKI's current model

3. Overview and Specifications of the *SANUPS W73A*

Figure 2 shows the appearance of the *SANUPS W73A*, Figure 3 shows its basic circuit configuration, and Table 1 provides its specifications.

The *SANUPS W73A* adopts a high-frequency isolation type converter and is capable of direct connection not reliant on the grid-side electrical mode.

Fig. 2: *SANUPS W73A*

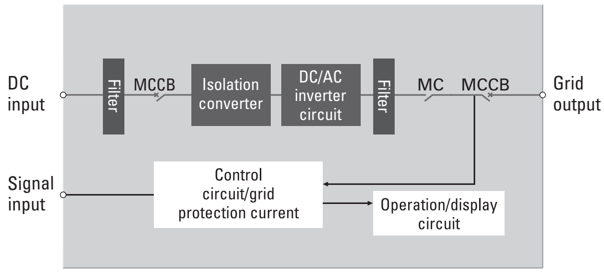

Fig. 3: Basic circuit configuration

Table 1: Specifications of the *SANUPS W73A*

Item		Model	Grid-connected type W73A992R	Remarks
Output capacity			9.9 kW	
Main circuit type			Self-commutated voltage type	
Switching method			High-frequency PWM	
Isolation method			High-frequency isolation type	
Cooling method			Forced air cooling	
Grid-connected operation	**DC input**	**Rated voltage**	400 VDC	
		Maximum allowable input voltage	570 VDC	
		Input operating voltage range	150 to 570 VDC	Rated output range 250 to 540 VDC
		No. of input circuits	1 circuit	
	AC output	**No. of phases/wires**	3-phase 3-wire	
		Rated voltage	202 VAC	
		Rated frequency	50 Hz / 60 Hz	
		Rated output current	28.3 AAC	
		AC output current harmonic distortion	Total current: 5% or less, individual harmonic order: 3% or less	Rated output current ratio
		Output power factor	0.95 or greater	At rated output with a power factor setting of 1.0 Power factor setting range: 0.8 to 1.0 (in increments of 0.01)
Efficiency			93%	Efficiency measurement method in accordance with JIS C 8961 With a power factor setting of 1.0
Grid protection			Overvoltage relay (OVR), undervoltage relay (UVR), overfrequency relay (OFR), underfrequency relay (UFR)	Overvoltage ground relay (OVGR) shall be externally connected and normally-closed dry contact input shall be the standard
Islanding detection		**Passive method**	Voltage phase jump detection	
		Active method	Frequency feedback method with step injection	
Communication			RS-485	
Noise			Up to 50 dB	A-weighting, 1 m from front of unit
Operating environment		**Ambient temperature**	-25 to +60°C	Output is derated above 40°C
		Relative humidity	Below 90% (non-condensing)	
		Altitude	2000 m max.	
Paint color			Munsell 5Y7/1 (semi-gloss)	
Heat dissipation			745 W	
Mass			64 kg	

4. Features of the *SANUPS W73A*

4.1 DC input voltage - DC input power characteristics setting function

Figure 4 shows an example of DC input voltage - DC input power characteristics (hereinafter "power characteristics") settings.

Power characteristics can be set to match the output characteristics of a specific wind power generator or hydroelectric power generator. It is possible to set from 2 to 32 power characteristics settings, and once set power characteristics can easily be added, changed, or deleted.

DC input voltage can be set in increments of 1 V within the range of 150 to 540 V and DC input power can be set in increments of 10 W within the range of 0 to 11,000 W.

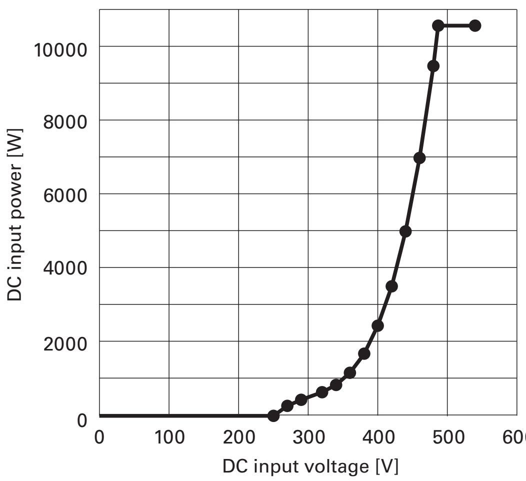

Fig. 4: Example of power characteristics settings

4.2 Function for setting operation-start voltage and operation-stop voltage

Based on the assumption that the *SANUPS W73A* will be used with a variety of systems, SANYO DENKI has made it possible for the user to arbitrarily set the operation start and stop voltages.

Operation-start and operation-stop voltages can be set within the setting ranges shown below. However, the upper limit setting of the operation-stop voltage range has to be at least 10 V lower than that of the operation-start voltage.

- Setting range for operation-start voltage: 230 to 400 VDC (Set in increments of 1 V)
- Setting range for operation-stop voltage: 150 to 320 VDC (Set in increments of 1 V)

4.3 Remote monitoring service

The *SANUPS W73A* can be connected to SANYO DENKI's *SANUPS PV Monitor* for remote monitoring and data collection/analysis via a network.

Furthermore, by using the *SANUPS NET* condition monitoring service, *SANUPS W73A* system status can be monitored via the internet from devices such as computers or smartphones.

SANUPS NET users can select either a power visualization service or system information management service, depending on their needs.

The power visualization service displays the power generation status and collects data. In addition to visualization, the system information management service provides notifications of operational status, the occurrence of trouble or alarms, and equipment fault recovery. It also displays a chronological history of alarms and fault recovery for reference.

Figure 5 shows an example of a remote monitoring connection using the *SANUPS PV Monitor* and *SANUPS NET*.

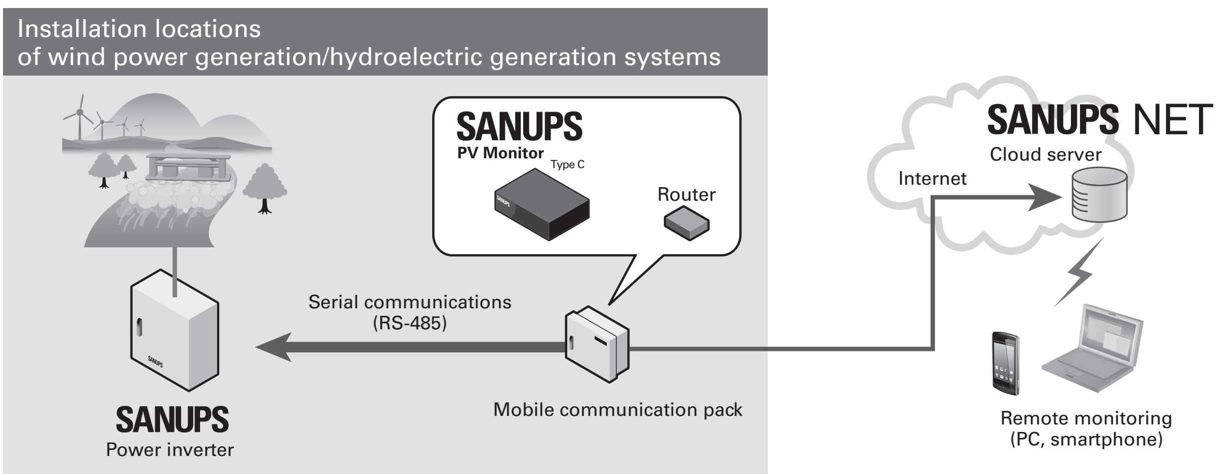

Fig. 5: Example of remote monitoring connection

4.4 Adoption of a frequency feedback method with step injection

As an active islanding detection method, the *SANUPS W73A* uses a frequency feedback method with step injection (hereinafter "new active method") which involves changing the AC voltage frequency and detecting frequency change by injecting the reactive power calculated from the frequency deviation that occurs when there is a power outage.

In principle, the new active method is characterized by not causing interference with other active methods, and is useful when connecting multiple power inverter units.

4.5 Power factor correction function

As a countermeasure to the problem of increased electrical voltage in the power distribution grid due to the large-scale introduction of renewable energy, the *SANUPS W73A* has the ability to change the power factor during grid-connected operation. This makes it possible to change the output power factor during grid-connected operation to a value between 0.8 and 1.0, which means increases in grid voltage can be minimized without the need to install special-purpose equipment or reinforce wiring.

4.6 Dustproof/waterproof performance

The *SANUPS W73A,* as a power inverter for outdoor use, has a protection rating of IP65 and a sealed structure with excellent dustproof and waterproof properties. This protects equipment from the ingress of rain, dust, small insects, and so on, and makes for a highly-reliable product that can be used with greater peace of mind.

4.7 Weather shelter

A weather shelter is an optional enclosure for the *SANUPS W73A* to serve as a heat shield, enabling it to be installed in locations exposed to direct sunlight.

Since weather shelters are assembled onsite, and do not require modifications to the unit, the IP65 protection performance of the *SANUPS W73A* is maintained.

5. Conclusion

This article has briefly provided an overview and introduced the features of the *SANUPS W73A* power conditioner for wind power and hydro power generation systems. This device helps to conserve the environment by promoting the introduction and effective utilization of renewable energy.

For future product development in related fields, SANYO DENKI will strive to alleviate the problems that come with large-scale deployment of renewable energy. We will achieve our goal of realizing new dreams together with our customers by quickly bringing products to market in addition to incorporating smart grid technologies and other innovative technologies. Furthermore, we will contribute to the creation of a low carbon society by offering products compatible with all renewable energy forms.

Reference

(1) Ministry of Environment's Plan
for Global Warming Countermeasures
http://www.env.go.jp/press/files/jp/102816.pdf (Japanese only)

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Development of the *SANUPS N11B-Li (3 kVA)* Uninterruptible Power Supply

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1. Introduction

Conventionally, SANYO DENKI has offered UPSs for indoor use as backup power for servers and ICT equipment or in combination with industrial devices. However, in recent years, there has been a growing demand for UPSs as backup power for outdoor ICT equipment, such as base stations and remote monitoring devices for disaster prevention.

Equipment for outdoor use is installed in harsh environments with large variation in temperature as well as exposure to water, dust and the like. For this reason, the UPSs for outdoor use need to be capable of operating in a wide temperature range, have water and dust resistance, and require less maintenance.

To date, UPSs have used lead batteries; however, these have a limited operating temperature range, short backup time towards the end of their life cycle, and require replacing.

By adopting lithium-ion batteries (hereinafter "LIB"), UPSs can be used in a wider operating temperature range compared to conventional lead batteries and require less maintenance, as battery replacement is required much less frequently.

SANYO DENKI has already developed the water/dust-resistant *SANUPS N11B-Li* series UPS equipped with LIB in output capacities of 1 kVA and 1.5 kVA. However, we have newly added a 3 kVA output model to the lineup to provide backup power for large capacity applications such as outdoor ICT equipment. This article will introduce the features of this new product.

2. Overview and Features of the Product

2.1 Product overview

Figure 1 shows the appearance of the *SANUPS N11B-Li (3 kVA)*.

Fig. 1: *SANUPS N11B-Li (3 kVA)*

2.2 Features

2.2.1 Wide operating temperature range

The wide operating temperature range of -20 to +50°C is achieved through the adoption of an LIB. This means this product can be used with confidence in extremely hot or cold environments.

2.2.2 Low maintenance

Lead batteries require replacement approximately every five years, but by adopting LIB, the new model can be used for up to ten years without needing to replace the battery. This reduction in maintenance work means battery replacement costs can also be reduced.

2.2.3 Improved maintainability

Tasks such as battery replacement have been made easy through the modularization of the inverter. Figure 2 shows an image of the *SANUPS N11B-Li (3 kVA)* equipped with an inverter module and battery modules.

This product has a maintenance bypass circuit, therefore modules can be replaced without the need to interrupt power supply from the grid.

Fig. 2: Inverter module and battery modules (*SANUPS N11B-Li (3 kVA)*)

2.2.4 Enhanced functionality

An LCD panel is used on the operation panel to improve user-friendliness and visibility.

2.2.5 High energy-saving and reduced heat dissipation

With the passive standby topology, the *SANUPS N11B-Li (3 kVA)* suppresses power consumption and achieves a conversion efficiency of 96%. This reduces running costs and contributes to energy-saving.

2.2.6 Outdoor installation

The *SANUPS N11B-Li (3 kVA)* adopts a sealed structure. This makes it possible to use the new model as backup power for ICT equipment installed outdoors.

2.2.7 Water and dustproof performance

This device adopts a sealed structure, therefore has excellent water resistance and protection against dust. As such, it can be used outdoors with confidence.

The new model achieved an IP rating of IP65* in a protection performance test.

* The degree of protection (IP code) is defined by IEC (International Electrotechnical Commission) 60529 "DEGREES OF PROTECTION PROVIDED BY ENCLOSURES (IP Code)." (IEC 60529:2001)
IP65: No ingress of dust. Devices operate stably even when directly exposed to water from many directions.

3. Circuit Configuration

Figure 3 shows the circuit diagram for the *SANUPS N11B-Li (3 kVA)*.

The *SANUPS N11B-Li (3 kVA)* integrates an "inverter module" consisting of a main circuit and a control circuit, and an "I/O portion" consisting of a communication interface circuit, input/output circuit, and battery management unit (BMU), and battery modules.

3.1 LIB monitoring circuit configuration

Equipped with a BMU, this product features a data interface between the UPS and LIB. By monitoring detailed LIB data, and having the UPS and LIB perform mutual protection operations and fault detections, the LIB can be used safely.

(1) UPS error detection

When a UPS error occurs, notification is sent from the UPS to the BMU via CAN communication. Once the BMU receives notification, it trips the battery breaker.

(2) LIB error detection

When an LIB error occurs, notification is sent from the BMU to the UPS via CAN communication. In response, the UPS stops the charger's output. Moreover, as soon as the BMU detects an LIB error, it trips the battery breaker.

(3) Monitoring LIB cell voltage and cell temperature

Cell voltage and temperature are measured in the battery module and the BMU is notified of the measurement values through CAN communication. If the cell becomes over-charged, over-discharged, or reaches an abnormal temperature, the BMU determines that an LIB error has occurred and, as mentioned in section (2) above, trips the battery breaker and separates the UPS from the LIB.

Users can check the measured values for battery voltage, cell temperature, and state of charge on the LCD panel.

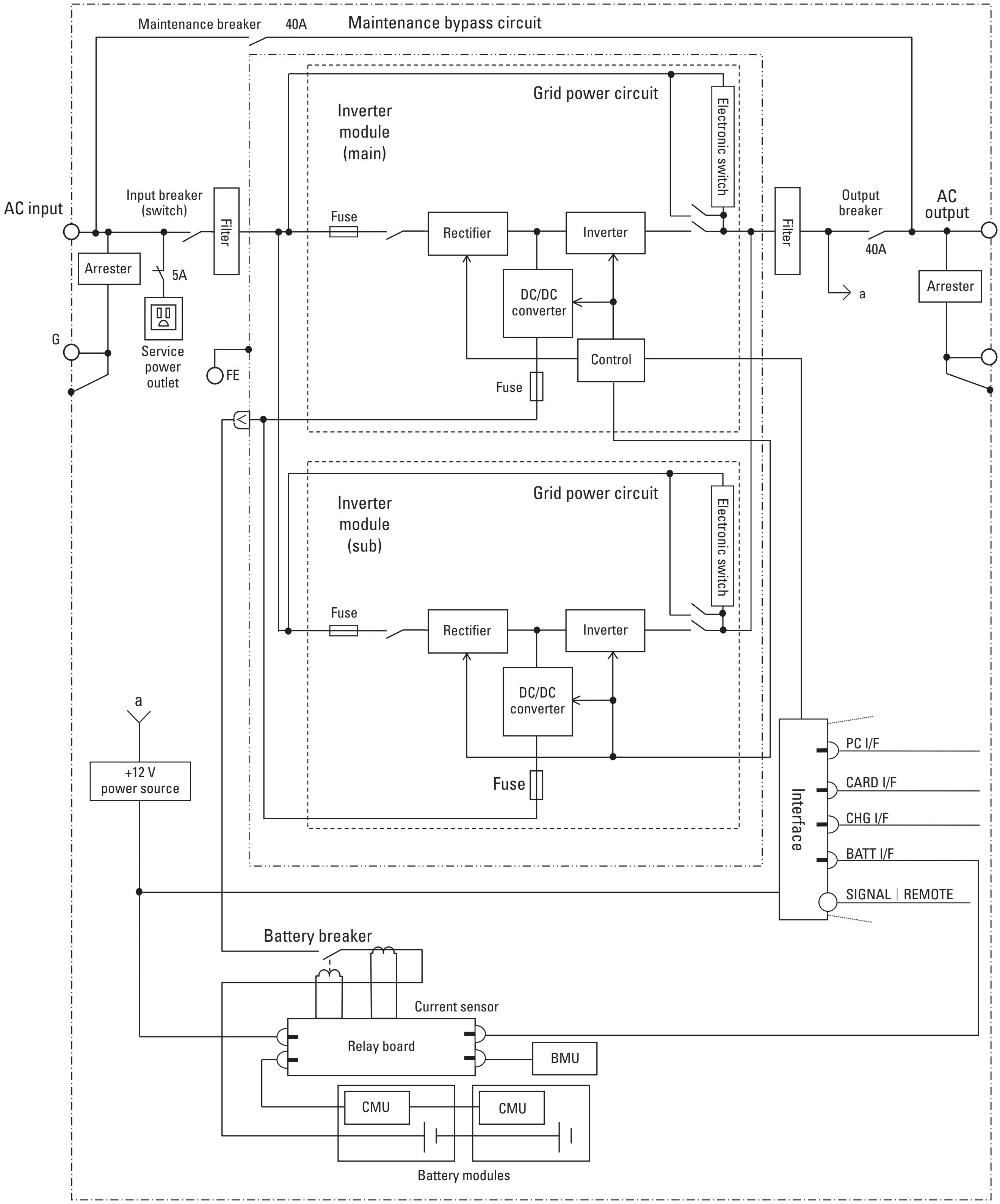

Fig. 3: Circuit diagram for the *SANUPS N11B-Li (3 kVA)*

4. Specifications

Table 1 shows the standard specifications of the *SANUPS N11B-Li (3 kVA)*.

Table 1: Specifications of the *SANUPS N11B-Li (3 kVA)*

Item			Unit	Ratings and characteristics	Remarks
Model			–	N11BL302	
Rated power capacity			kVA/kW	3/2.4	Apparent power/Active power
Type	**UPS topology**		–	Passive standby	
	Cooling method		–	Forced air cooling	
	Inverter system		–	High-frequency PWM method (during battery operation)	Commercial synchronous online double conversion
AC input	**No. of phases/wires**		–	Single-phase 2-wire	
	Rated voltage		V	100, 110, 120	Same as output voltage
	Voltage range		%	Within ±10 of rated voltage	
	Rated frequency		Hz	50/60	Frequency is automatically detected
	Frequency range		%	Within ±1, 3, 5, or 7 of rated frequency	(The fluctuation range is the same as the selected output frequency regulation)
	Required capacity		kVA	4 or less	Max. capacity during battery recovery charging
AC output	**No. of phases/wires**		–	Single-phase 2-wire	
	Rated voltage		V	100, 110, 120	Voltage waveform during battery operation: Pure sine wave
	Voltage regulation		%	During grid operation: Same as input voltage range	
				During battery operation: Within ±2 of rated voltage	At rated output
	Rated frequency		Hz	50/60	Same as input frequency
	Frequency regulation		%	During grid operation: Same as input frequency range	
				During battery operation: Within ±0.5	At rated output
	Voltage harmonic distortion		%	3 or less / 7 or less	During battery operation, at rated output
	Transient voltage regulation	**Rapid load change**	%	Within ±7 of rated voltage	During battery operation, for 0⇔100% load step changes / output switch
		Loss or return of input power	%	Within ±5 of rated voltage	During battery operation, at rated output
	Power factor		–	0.8 (lagging)	Variation range: 0.7 (lagging) to 1.0
	Overcurrent protection		%	Output breaker trip	
	Overload capability	**During grid operation**	%	200/800	30 s / 2 cycles
		During battery operation	%	105 or greater	200 ms
Battery		**Type**	–	Lithium-ion battery (LIB)	
		Backup time	Minute	30	Ambient temperature 25°C, at rated output, under factory conditions
Noise			dB	43 or less	1 m from front of device, A-weighting
IP rating			–	IP65	
Operating environment		**Ambient temperature**	°C	-20 to +50	*
		Relative humidity	%	10 to 90	Non-condensing
Storage environment			°C	-20 to +55	**

* Battery charging should be stopped when battery temperature exceeds 55°C.
** To prolong battery life, avoid use or storage for extended periods of time in environments exceeding +30°C. If the UPS is stored without being operated for a long period, the batteries may require recharging once a year.

5. Advantage for Customers

Below is a list of customer advantages gained by adopting this device.

(1)Broader selection of applications and installation environments due to a wider operating temperature range

(2)Reduced maintenance costs thanks to low-maintenance batteries

(3)In the unlikely event of a problem, maintenance work can be performed without interrupting power supply to the load equipment.

(4)Able to backup ICT equipment and outdoor equipment even in harsh environments.

(5)Sealed structure enables use in environments exposed to dust and rain.

6. Conclusion

Moving forward, information and communication technologies will undergo even further sophistication and play an even more important role in society. UPSs are used in a variety of applications and environments, and it is believed that the demand for environmental durability will continue to intensify. To satisfy these market requirements, SANYO DENKI will enhance our lineup of UPS equipped with LIB.

It is our goal to develop products that create value for our customers by responding to the diversifying needs of the UPS market.

Reference

Yuhei Shoyama and others: "Development of the Small-Capacity UPS *SANUPS A11K-Li* and *SANUPS N11B-Li* Series" SANYO DENKI Technical Report No. 44

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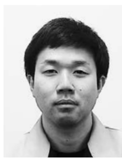

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The applications and requirements for servo systems are diversifying in line with changes in society and industrial structure, such as a declining birth rate, aging society, and globalization. Against this backdrop, SANYO DENKI develops products which solve our customers' issues and contribute to society.

This article will outline the features of our new products from 2017: one stepping motor and three servo amplifiers, telling how they can contribute to customer value.

First, as for stepping motor products, we released the *SANMOTION F series* 42 mm sq. 2-Phase 1.8° stepping motor featuring low noise and eco-efficiency. In the development of this product, we not only strived to achieve higher performance, but also put an effort to automate the production process, resulting in increased productivity.

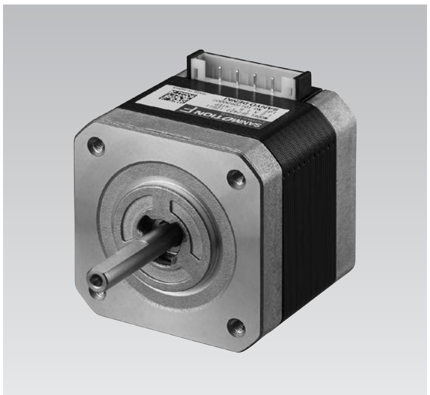
Next, regarding servo amplifier products, we added a 400 VAC input multi-axis servo amplifier to the *SANMOTION R ADVANCED MODEL* series. The addition of multi-axis 400 VAC input servo amplifiers to the current single-axis servo amplifier lineup significantly expands customer options, enabling the selection of the best servo system for customer equipment.

Moreover, we added an EtherCAT-enabled servo amplifier to the *SANMOTION R 3E Model* series. This product achieves an industry-leading minimum communication cycle of 62.5 μs (a half compared to conventional), and contributes to further improving the processing quality. In addition, the amount of data transfer in one communication cycle has increased to 1.6 times. A large amount of data can be collected in real-time, which contributes to the visualization of equipment operating status, as well as the IoT system with applications such as equipment failure prediction.

We also released *SANMOTION R 3E Model* Safety servo amplifiers with diverse safety functions and high safety performance. In recent years, in an increasing number of cases, machinery is required to have a safety system integrated conforming to international functional safety standards. This product enables users to build a safety system that offers high safety performance and flexibility, reducing the initial cost for startup.

This article will describe an overview of each new product and their respective features.

■ *SANMOTION F Series* 42 mm sq. 2-Phase 1.8° Stepping Motor



SANMOTION F series 42 mm sq. 2-Phase 1.8° stepping motor achieves higher torque, lower noise, and higher efficiency than our current model. Besides, it was designed for automated production to improve productivity.

The features of this product are introduced below.

1. High torque

To increase torque, we optimized the shape of stator core magnetic circuit with magnetic circuit simulation, and widened the stator core winding space. Also, by adopting a magnet with high residual magnetic flux density, we have successfully achieved 10 to 15% higher torque with the motor length maintained.

2. Low noise

In addition to increasing torque, we also improved the noise level by increasing the rigidity of the stator core. Furthermore, by revising the fit tolerance and clearance for stator, flange, and end cap, the motor rigidity after assembly has been increased. As a result, compared with the current model, the noise level in the operating zones has decreased by 3 to 5 dB.

3. Eco-efficient

Iron loss has been reduced due to the abovementioned optimized design of the stator core. Moreover, copper loss has been reduced by expanding winding space. These loss reductions have resulted in up to 2% higher motor efficiency. Equivalent torque performance can be obtained with a smaller input current than the current model, which contributes to minimal heat generation and better eco-efficiency of equipment.

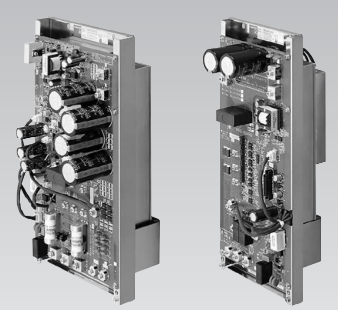
4. Increased productivity

For efficiently producing this product, we adopted an automated production line. In early stages of development, we designed a motor structure suited to automated production; that is, we designed the product and production process in parallel. Regarding the connection of the stator winding previously performed by hand, we designed a motor structure that performs both winding process and connection process simultaneously inside the winding machine.

As described above, compared to the current model, this product has achieved higher torque, lower noise, and better eco-efficiency. Particularly for applications where motors are operated in close proximity to patients or workers, such as medical devices, noise and heat generation can be reduced, which contributes to reduced noise and higher safety of equipment.

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

■ *SANMOTION R ADVANCED MODEL* 400 VAC Input Multi-axis Servo Amplifier



Power unit   Amplifier unit

In line with the globalization of industry, there are greater needs for servo systems with 400 VAC input specifications from not only our customers in Europe, China, and Southeast Asia, but also Japan. As such, SANYO DENKI has added a 400 VAC input multi-axis servo amplifier to the *SANMOTION R ADVANCED MODEL*.

The features of this product are introduced below.

1. Downsizing of the system

Previously, it was necessary to use a step-down transformer to convert power voltage to use a 200 VAC input servo system in a 400 VAC environment. However, in the case of this product, 400 VAC can be directly supplied, eliminating the need for a step-down transformer, thus achieving downsizing of the system. Moreover, the arrangement (height) of the main circuit's terminals for DC bus power supplied from the power unit to the amplifier unit is standardized between units, therefore wiring at the copper bar is simple.

2. High response control

Based on the control performance of AC servo amplifier *SANMOTION R ADVANCED MODEL*, we added a phase delay improvement function and torque feed-forward function. This has further improved response to commands, and contributed to better machining quality and productivity.

3. Eco-efficient

This is a servo system that can have multiple amplifier units sharing a single power unit. The eco-efficiency of the equipment is improved as the motor regenerative current that occurs in one motor can be used as power to drive a separate motor (powering). Furthermore, we added a power consumption monitoring function that estimates power consumption based on the speed and current of the motor. The visualization of power consumption makes it possible to assess the energy usage status and operating status of equipment and production facilities, thus we can expect that this model will better overall eco-efficiency of a factory and reduce energy costs.

4. Lightweight

For the housing (sheet metal) we have adopted stainless steel, which maintains equivalent strength as the conventional material (cold-rolled sheet metal) while being thinner, thus reducing weight. Moreover, stainless steel has high anti-corrosion properties, therefore this product can be used with peace-of-mind, even in environments with major temperature and humidity fluctuations.

Details of this product are provided in the "New Products Introduction" section of this report.

■ *SANMOTION R 3E Model* EtherCAT Servo Amplifier

Since SANYO DENKI released the EtherCAT servo amplifier of the *SANMOTION R ADVANCED MODEL* in 2009, we have enhanced our lineup with low-voltage input and multi-axis models, and these are used by many of our customers. In 2017, we developed the latest series *SANMOTION R 3E Model* EtherCAT servo amplifier. This product not only offers the strong control performance and support for abundant functions of the *SANMOTION R 3E Model*, it also features improved EtherCAT communication performance and function.

1. Shortest communication cycle in the industry

At 62.5 μs, this product achieves the shortest minimum communication cycle in the industry (in speed/torque control mode). This maximizes servo potential, making smooth operations possible and contributing to high quality processing by equipment.

2. Increased amount of data transfer

The maximum amount of data transfer in one communication cycle has increased from 20 objects on the current model to 31 objects on the new model, which is an increase of around 1.6 times. This makes it possible to obtain monitoring and diagnosis information from many servo amplifiers and motors in real-time, which in turn contributes to visualization of servo device and equipment operating statuses, as well as the IoT system with applications such as equipment failure prediction.

3. Improved convenience

The new models feature a scaling function enabling users to select the unit of measurement used for commands and feedback data to suit the structure of the particular piece of equipment. In the past, there was a need for the host controller to convert position command into encoder pulse units to perform control. By using this scaling function, it is possible to directly handle positional data using the original units of [mm] for linear-driven components, and [degree] for rotating components, thus alleviating the computing burden of the host controller and improving convenience.

■ *SANMOTION R 3E Model* Safety Servo Amplifier

Recent years has seen the rise of a demand for the servo systems used in equipment to have various safety functions conforming to international safety standards. Against this backdrop, we have released a safety servo amplifier with diverse safety functions and high safety performance in the *SANMOTION R 3E Model* series. This product is of a structure whereby an expansion board (safety function expansion board) to control safety functions is mounted to the servo amplifier side, and it can be applied to all products in the *SANMOTION R 3E Model* lineup.

The features of this product are introduced below.

1. Safety function

This product supports five types of safety functions demanded of many types of equipment to "stop the motor safely," and "rotate the motor safely." These are the "Safe Torque Off (STO)," "Safe Stop 1 (SS1)," "Safe Stop 2 (SS2)," "Safe Operating Stop (SOS)," and "Safely-Limited Speed (SLS)."

2. Safety performance

By newly developing a diagnosis function that detects encoder failure, even if this product is combined with a standard encoder that does not comply with the functional safety standard, it achieves the below safety performance, which is the highest in the industry (based on our own research as of April 2017).

[Standard compliance and safety performance level]

- EN 61508: SIL3, IEC 62061: SILCL3
- ISO 13849-1:2015 PL=e

This reduces the cost for introducing a safety system.

3. Safety input

Equipped with five safety inputs, this model enables users to select the safety function suitable for the control status of a certain application or piece of equipment. Moreover, up to 31 types of Safely-Limited Speed values are available to select from.

4. Safety output

With two types of safety output functions [Safe Brake Control (SBC) and Safe Speed Monitor (SSM)], and three types of status outputs (functional safety input status, safety function execution status, Safe Torque Off status), this product can monitor safety status, malfunction of safety functions.

As described above, by using this product, customers can minimize their start-up costs (product cost, costs for obtaining safety standard certifications) and build a safety system offering high safety performance and flexibility.

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Development of the *SANMOTION F* Series 42 mm sq. 2-Phase 1.8° Stepping Motor

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1. Introduction

As stepping motors are capable of performing high-accuracy positioning control in a simple system, they are used in a broad range of applications and fields, including OA devices, general industrial devices, and semiconductor manufacturing equipment. SANYO DENKI has focused product development on higher functionality and customization and has expanded the application scope of stepping motors for general industrial devices to the extent replacement of AC servo motors is possible.

Meanwhile, there is a growing demand for 2-phase stepping motors in applications where stepping motors have traditionally been used; namely, money-handling equipment such as automatic teller machines, biochemical analysis equipment, and medical devices such as artificial dialysis machines. The features required in these markets are low torque, low noise, and eco-efficiency. Also, emphasis is placed on compatibility with current models.

To satisfy these market requirements, SANYO DENKI developed the *SANMOTION F* 42 mm sq. 2-Phase 1.8° stepping motor. This article describes the new model's specifications and features, as well as the technologies behind them.

2. Specifications of the New Model

2.1 External view

Figure 1 shows an external view of the new model. The connector type of the new model is common to the entire series, and is designed to be inserted from the top of the stepping motor. Compared to the current model, where the connector is inserted from the direction of the output axis, the new design makes it easier to route the lead wire. Moreover, there is no need to secure space for looping back the lead wire cabling, which allows the customer greater freedom when designing equipment. Lead wire customization is done via the conventional method of using a terminal harness.

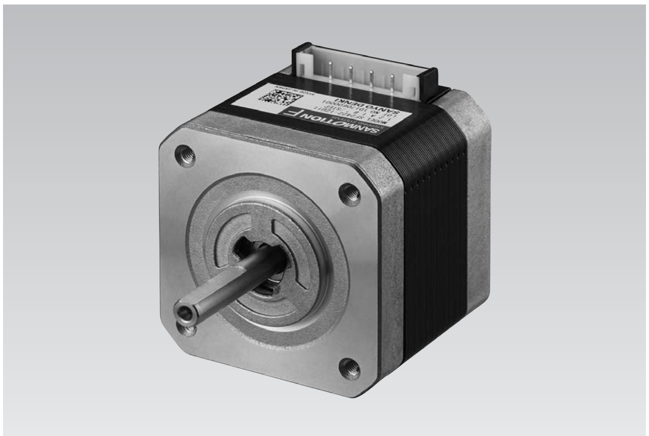

Fig. 1: External view of the new model (SF2422 type)

2.2 External dimensions

Figure 2 shows the new model's main external specifications. The flange size is 42 mm sq., with the same mounting pitch and mounting pilot dimensions as the current model. This means there is mounting compatibility between the new and current models, which makes for easy replacement. As with the current model, shaft specifications can be customized.

2.3 Lineup and main specifications

Table 1 and Table 2 show the lineup and main specifications for unipolar and bipolar type stepping motors, respectively. SANYO DENKI has prepared a total of 16 standard models to choose from, including the four different motor lengths of 33 mm, 39 mm, 48 mm and 59.5 mm, unipolar models and bipolar models with differing torques, and single shaft and double shaft models. As the new models are the same length as the current model, replacement is possible without the need for customers to change their equipment specifications.

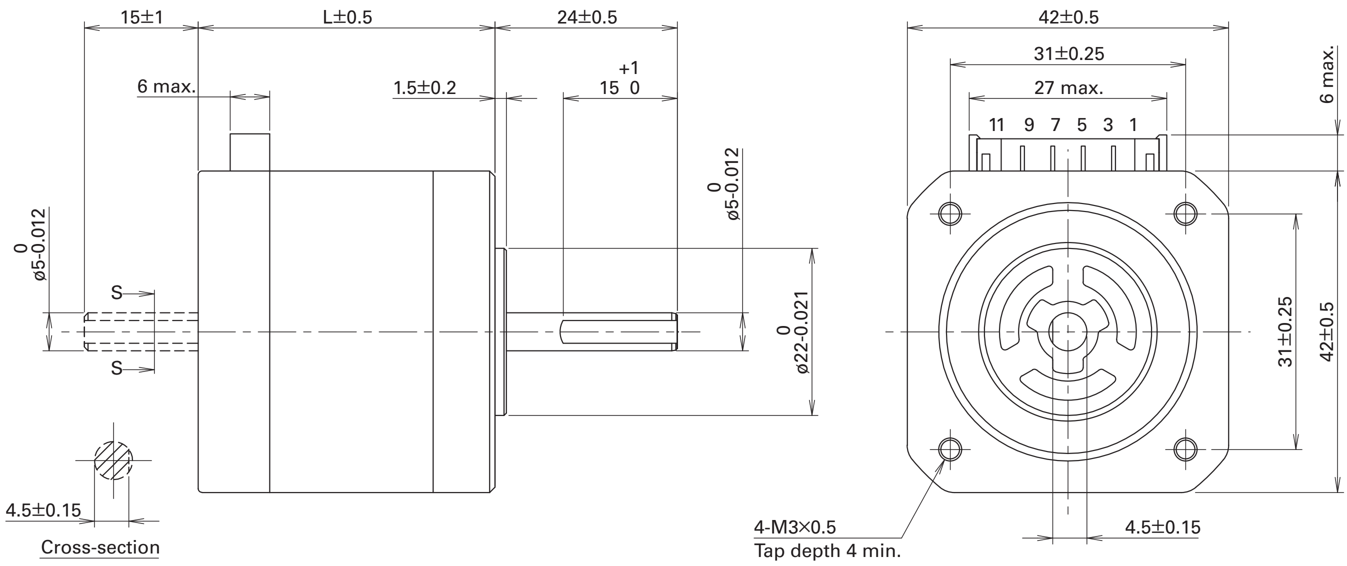

Fig. 2: External dimensions of the new model

Table 1: Lineup and main specifications for the unipolar type

Model no.		Holding torque at 2-phase excitation [N · m] MIN.	Rated current [A/phase]	Winding inductance [mH/phase]	Rotor inertia [× 10^{-4} kg·m^2]	Mass [kg]	Motor length L [mm]
Single shaft	Double shaft						
SF2421-12U41	**SF2421-12U11**	0.22	1.2	2.4	0.031	0.23	33
SF2422-12U41	**SF2422-12U11**	0.33	1.2	3.3	0.046	0.3	39
SF2423-12U41	**SF2423-12U11**	0.4	1.2	3.9	0.063	0.38	48
SF2424-12U41	**SF2424-12U11**	0.58	1.2	5.4	0.094	0.51	59.5

Table 2: Lineup and main specifications for the bipolar type

Model no.		Holding torque at 2-phase excitation [N · m] MIN.	Rated current [A/phase]	Winding inductance [mH/phase]	Rotor inertia [× 10^{-4} kg·m^2]	Mass [kg]	Motor length L [mm]
Single shaft	Double shaft						
SF2421-10B41	**SF2421-10B11**	0.29	1	7	0.031	0.23	33
SF2422-10B41	**SF2422-10B11**	0.43	1	9.6	0.046	0.3	39
SF2423-10B41	**SF2423-10B11**	0.56	1	12.5	0.063	0.38	48
SF2424-10B41	**SF2424-10B11**	0.8	1	16	0.094	0.51	59.5

3. Product Features

3.1 High torque

Figure 3 shows a comparison of pull-out torque characteristics. The new model has 10 to 15% higher torque than the current model. To achieve this higher torque, we incorporated the following innovative ideas.

(1) Optimal stator core magnetic circuit design

Figure 4 is a schematic of the stator core profile. The stator core is comprised of a back yoke and poles, which act as magnetic circuits, and the teeth at the tip of the poles. We optimized the stator core magnetic circuit by systematically analyzing the shapes of the above-mentioned components and using magnetic circuit simulation. This has not only increased torque, but also reduced iron loss.

(2) Larger winding space

By identifying the areas where magnetic flux density easily became saturated, and adjusting the widths of the back yoke and poles to prevent magnetic flux from concentrating, we widened the winding space to the greatest extent possible. This has the effect of minimizing the increase in copper loss without reducing torque.

(3) Adoption of a magnet with high residual magnetic flux density

By adopting a magnet with high residual magnetic flux density, higher torque has been achieved without increasing the overall motor length.

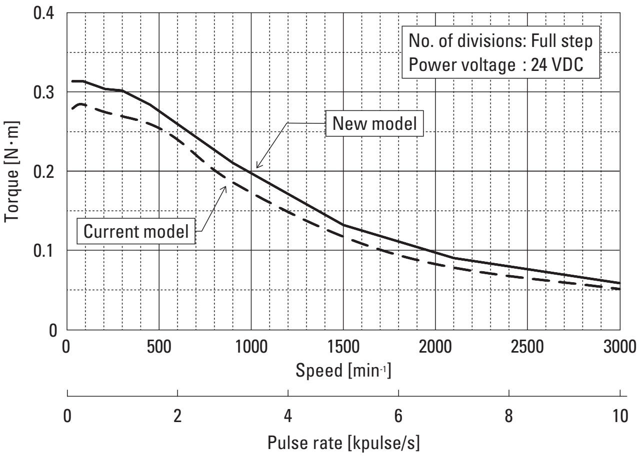

Fig. 3: Pull-out Torque characteristics comparison (SF2422-12U41)

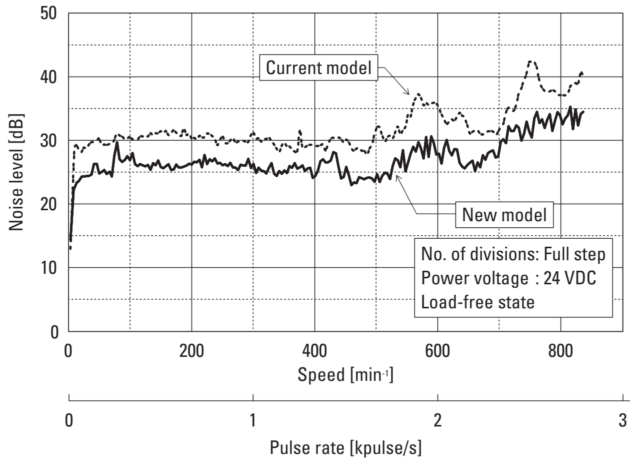

Fig. 5: Noise characteristic comparison (SF2422-12U41)

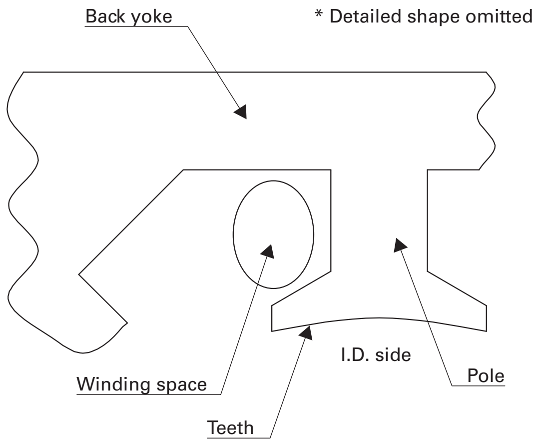

Fig. 4: Stator core profile schematic

3.2 Low noise

Figure 5 shows a noise characteristic comparison. Compared with the current model, the noise level of the new model in its operating range has been reduced by between 3 and 5 dB. Medical devices in which stepping motors are used are often operated in close proximity to patients, therefore minimal noise is preferable. To achieve low noise, we incorporated the following innovative ideas.

(1) High-rigidity stator core

We analyzed the structure of the back yoke and poles and obtained the dimensions that would increase both rigidity and torque, which resulted in higher stator core rigidity.

(2) High-rigidity motor

We revised the tightening allowance between the stator and the flange/end cap as well as the engagement length to increase post-assembly motor rigidity and, ultimately, reduce noise.

3.3 Higher eco-efficiency through increased motor efficiency

Compared to the current model, the new model has 2% higher efficiency. We reduced iron loss through the above-mentioned optimization of the stator core design. Furthermore, copper loss was reduced by expanding the winding space. The reduction of these losses made it possible to achieve equivalent torque to the current model with less input current, therefore, taking SF2422-12U41 as an example, the following is achieved.

- 10°C or higher reduction in motor temperature increase
- 10% reduction in input current

This results in low heat generation and better eco-efficiency of equipment, the former point making it a safer motor to use particularly in medical devices that operate in close proximity to patients.

3.4 Motor structure design suitable for automatic production line

An automatic production line was adopted for the new model to eliminate variations caused by manual work and improve both quality and productivity. From the initial development phase, we designed the motor structure to suit automatic production and devised creative ways to eliminate processes that had conventionally been performed manually. For the current model, the wiring and connection processes are performed separately, with the latter in particular being performed by hand. In the new model a pin is set in the insulator, and by tying the beginning and the end of the winding it is possible to simultaneously perform both winding and connection automatically in a winding machine. By adopting this structure, we have secured pin strength and winding nozzle space, as well as established a structure for easily connecting the winding to the pin.

Moreover, the new product was designed so it could easily be manufactured automatically through measures such as using a rotor with the least possible amount of machining cost, and enabling easy determination of orientation and direction by establishing assembly standards for each component, etc.

These structural design components make the new model well-suited to an automatic production line, thereby achieving improved quality and productivity, as well as a constant stable supply of high-quality products.

4. Conclusion

This paper has introduced the specifications and features of the *SANMOTION F* series 42 mm sq. 2-Phase 1.8° stepping motor.

The new model improves upon those characteristics required in applications where stepping motors are increasingly being demanded, such as money-handling equipment and medical devices. The new model can easily replace the current model because of mounting and size compatibility. Moreover, SANYO DENKI has established an optimal structural design for automatic production and product specifications which improve productivity. Through this development, we are able to offer our customers greater safety and peace of mind, as a stable supply of a high-quality product is ensured. This stepping motor can be proposed both as a new product in a broad market or as a replacement to update older models at the same time as offering optimal specifications for money-handling equipment and medical devices.

SANYO DENKI intends to apply the technologies used for this development to stepping motors other than the 42 mm sq. size, and prepare a lineup that satisfies the ever-changing and diverse needs of the market to offer products that create new value for our customers.

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Development of the *SANMOTION R ADVANCED MODEL* 400 VAC Input Multi-axis Servo Amplifier

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Keisuke Ishizaki   Yasuo Nakamura   Yasuhiro Wakui

1. Introduction

A variety of power supply voltages are used throughout the world, depending on the region. To use servo system products, products with input voltage specifications that suit factories in various regions are required. Most factories use either 200 VAC or 400 VAC as their main power supply voltage, with the latter being common in Europe and Asia, where there are many factories. As such, SANYO DENKI is enhancing its lineup of 400 VAC input servo amplifiers in the same way as its 200 VAC input products.

This paper will introduce the 400 VAC input multi-axis servo amplifier newly developed and added to the *SANMOTION R ADVANCED MODEL* lineup. This servo amplifier has a multi-axis configuration, which helps to save space and create a flexible system. Moreover, it is suitable for European and Asian customers, who use 400 VAC as the main power supply input.

Below is an overview of the new model covering performance and main functions, initiatives to achieve a configuration with optimal heat radiation, and so on.

2. Product Overview

2.1 External view and dimensions

Figure 1 shows external views of the newly developed *SANMOTION R ADVANCED MODEL* 400 VAC input multi-axis servo amplifier, and Figures 2 through 4 provide its dimensions. In order to make flexible system configuration possible, the new model is separated into three components; the control unit, power unit, and amplifier unit. They have an open-type structure intended to be installed in our customers' control panels. We have prepared two types of control units; the first being a 4-axis integrated type EtherCAT interface, and the second being a single-axis analog command interface, a 16 kW output power unit and four types of amplifier units; 25 A, 50 A, 75 A and 150 A. The height of the product is 380 mm, which is shorter than the 460 mm of the 200 VAC type.

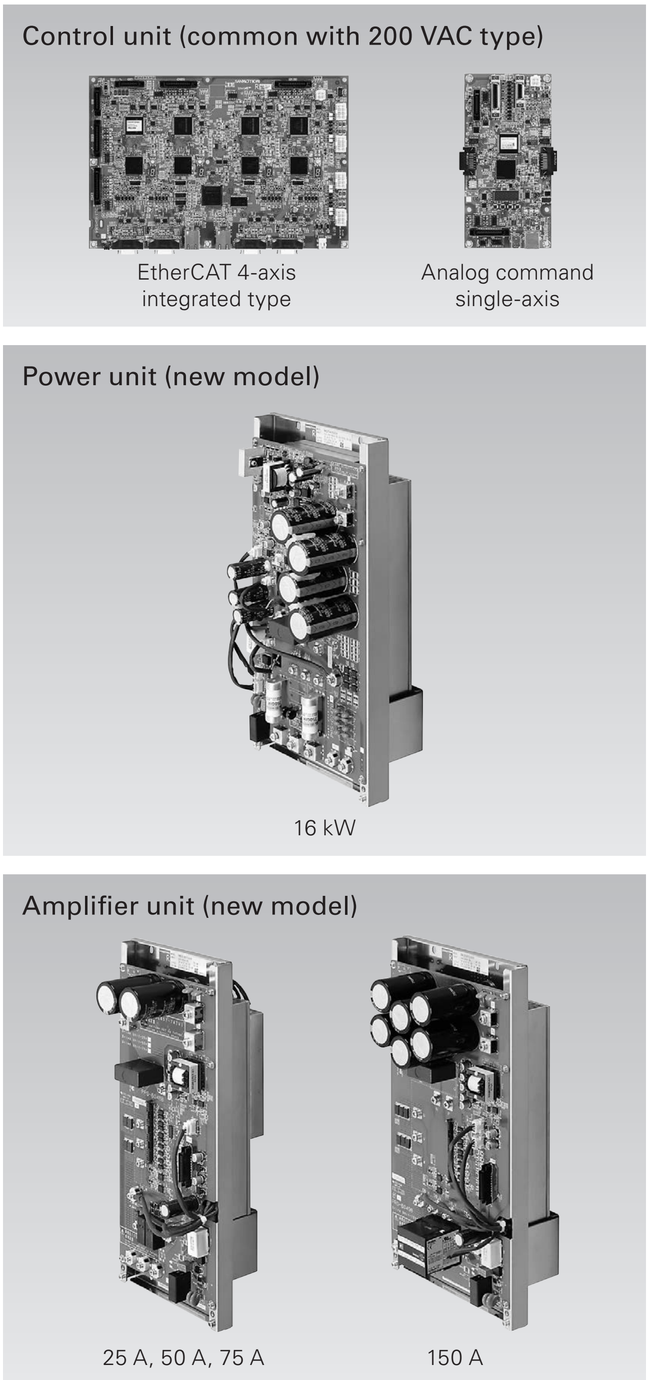


Fig. 1: External view

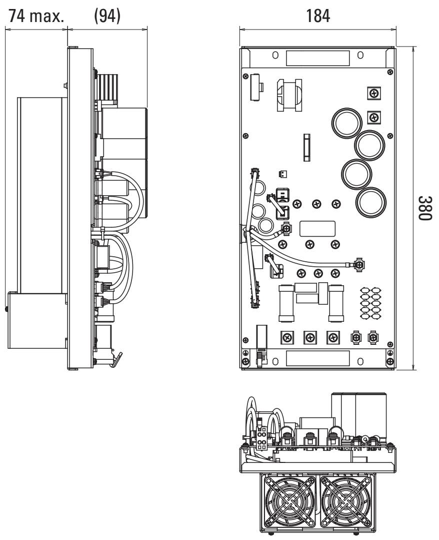


Fig. 2: Dimensions (Power unit 16 kW)

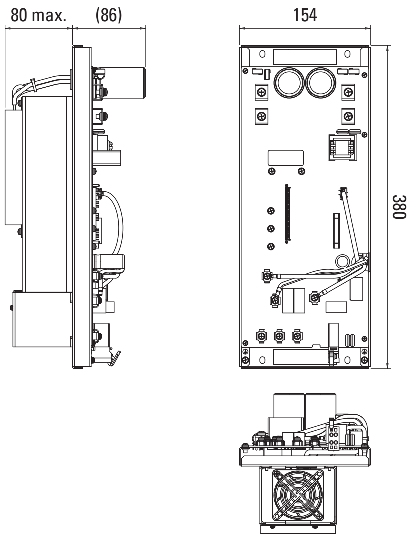


Fig. 3: Dimensions (Amplifier unit 75 A)

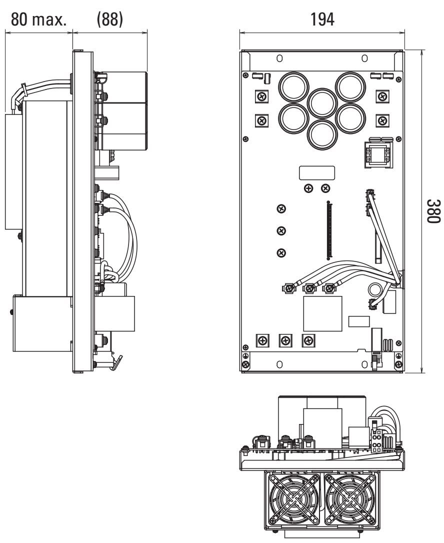


Fig. 4: Dimensions (Amplifier unit 150 A)

2.2 Main specifications

Table 1 and Table 2 show the main specifications for the power unit and amplifier units of the *SANMOTION R ADVANCED MODEL* 400 VAC input multi-axis servo amplifier.

The new model can be combined with motors of rated outputs ranging between 0.5 kW and 15 kW. The applicable encoders are SANYO DENKI's absolute encoder and wire-saving pulse encoder.

Regarding the control unit, a Safe Torque Off (STO) function is available when using an EtherCAT (maximum of 4 axes) interface. Moreover, as an IoT-related function, a power consumption monitoring function has been incorporated, and it is possible to examine optimization of operating patterns and operating status from the host device.

The new model also complies with international standards such as Europe's Low Voltage Directive, the EMC Directive, Functional Safety, the US's UL/cUL, and Korea's KC mark.

Table 1: Power unit main specifications

Output capacity		16 kW
Input	**Main circuit voltage**	380 to 480 VAC +10%, -15%
	Control voltage	24 VDC ±15%
Dimensions (W × H × D)		184 × 380 × 162 mm
Interface		I/O between amplifier units (power supply detection, etc.)
Display		Main power charging display, control power establishment display
Inrush prevention circuit		Built-in (thyristor type)
Regeneration function		Built into circuit (External resistor)
Cooling method		Forced air cooling
Safety standards	**UL/cUL**	UL 61800-5-1
	Low voltage directive	EN 61800-5-1
	EMC directive	EN 61800-3, EN 61326-3-1
	KC mark	KN 61000-6-2, KN 61000-6-4

Table 2: Main specifications of amplifier units

Output capacity		25 A	50 A	75 A	150 A
Input	Main circuit voltage	457 to 747 VDC			
	Control voltage	24 VDC ± 15%			
Output	Continuous rated current	4.8 Arms	12 Arms	18 Arms	34 Arms
	Instantaneous maximum current	14.1 Arms	29.2 Arms	45.5 Arms	83 Arms
Dimensions		W154 mm H380 mm D161 mm			W194 mm H380 mm D197 mm
Compatible motors		0.5 to 2.0 kW	2.0 to 3.5 kW	4.5 to 7.0 kW	7.5 to 15 kW
Compatible encoders		Absolute encoder, wire saving pulse encoder			
Interface		EtherCAT (4-axis integrated control), analog (single-axis control)			
Dynamic brake		Included (built-in resistors)			
Cooling method		Forced air cooling			
Safety standards	UL/cUL	UL 61800-5-1			
	Low voltage directive	EN 61800-5-1			
	EMC directive	EN 61800-3, EN 61326-3-1			
	KC mark	KN 61000-6-2, KN 61000-6-4			

3. Main Functions and Features

This section describes the functions and features of the new model.

3.1 System downsizing

Previously, it was necessary to use a step-down transformer, etc. to convert the power supply current from 400 VAC to 200 VAC in order to use a 200 VAC input servo system in a 400 VAC power supply environment. On the new model, however, a 400 VAC power supply can be directly supplied to the servo amplifier, eliminating the need for a step-down transformer and making it possible to reduce system size.

3.2 High response control

Based on a control system compatible with the *SANMOTION R ADVANCED MODEL* AC servo amplifier, the new model is equipped with functions to improve phase delay and increase integral gain, for higher feedback response. Moreover, with both speed and torque feed-forward compensation, an improvement in command responsiveness can also be expected.

3.3 Power consumption monitoring function

The new model features a power consumption monitoring function which estimates the power consumption of the servo motor and amplifier based on the speed and current of the motor. This makes it possible to easily estimate and monitor a device's power consumption.

3.4 Energy saving

As multiple amplifier units have a common power unit, regenerative power from the motor can be used to power other motors, and it is possible to increase the energy-saving performance of equipment.

We have also achieved a low power consumption of 24 V by using unit internal temperature monitoring to perform two-stage speed control of a variable speed fan.

3.5 Lightweight

The servo amplifier's housing (sheet metal portion) is made from high-strength stainless steel (SUS). We performed fixed-value analysis and damping performance investigations of the sheet metal in order to secure a strength equivalent to that of the cold-rolled steel plate (SPCC/SECC) (hereinafter steel plate) used on current models, at the same time reducing the thickness and weight of the sheet metal.

Moreover, conventional steel plate was electroplated or painted as a means of rust prevention. Stainless steel, however, has excellent anti-rust performance even without being treated, and therefore offers an advantage for use in manufacturing.. Generally-speaking, stainless steel has a higher electrical resistance than steel plate, so we implemented innovative measures for reducing contact resistance, such as directly connecting a ground terminal and connecting the sheet metal via a tap. As a result, we achieved the same level of grounding continuity (conductivity) and noise resistance as current models.

3.6 Simple wiring

For the control power supply (24 VDC) wiring, we used the same connector as that used on the *SANMOTION R 3E MODEL* 400 VAC input single-axis servo amplifier and made single touch connection possible.

Moreover, as shown in Figure 5, the terminals (P, N) for the main circuit (457 to 747 VDC) bus power supply supplying power from the power unit to the amplifier unit have a standardized layout (height) between units, and can easily be wired to the copper bar.

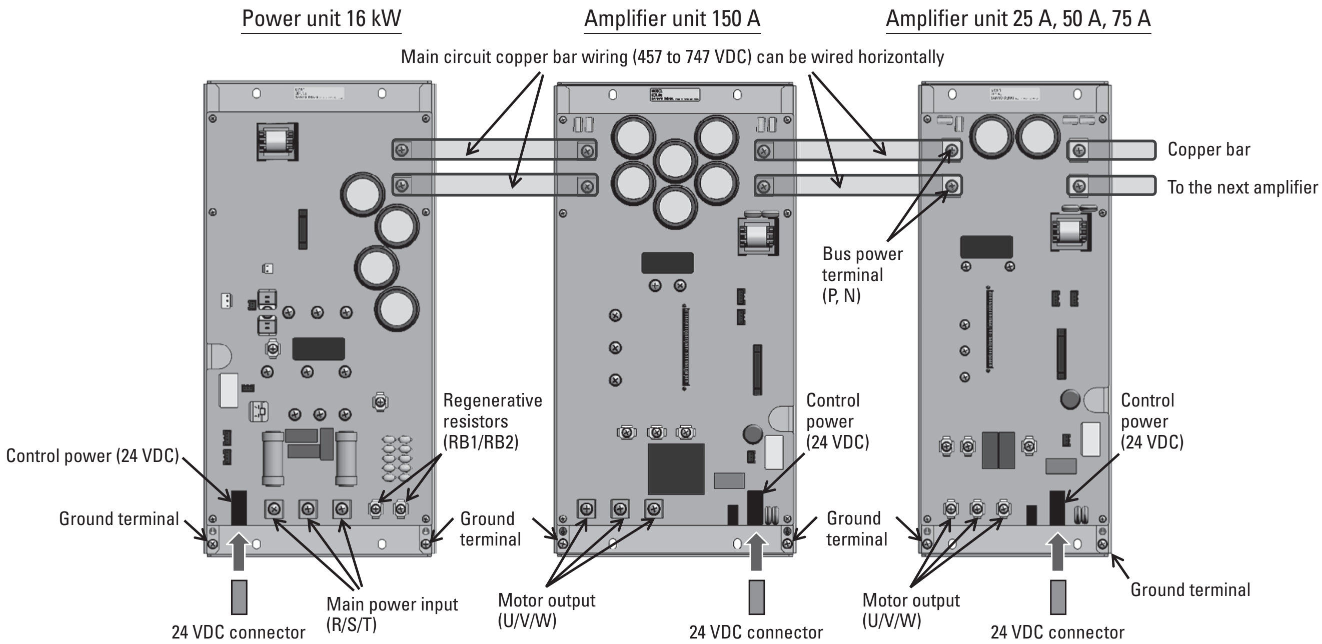
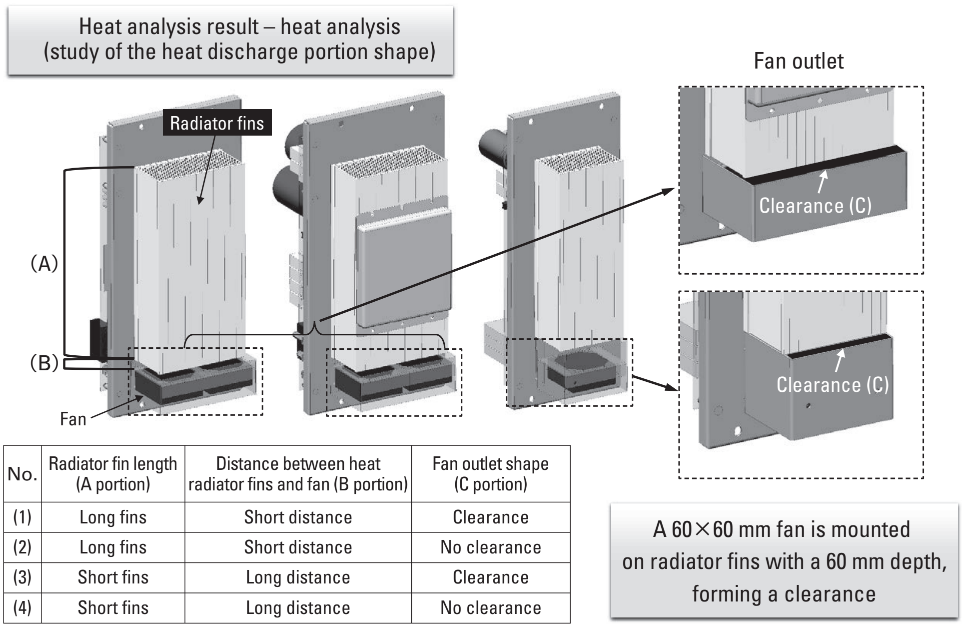


Fig. 5: Terminal layout drawing

4. Optimal heat radiation configuration

Figure 6 shows the heat radiation configuration of the newly developed *SANMOTION R ADVANCED MODEL* 400 VAC input multi-axis servo amplifier.

On the power unit and amplifier unit, the heat-generating portions of the diode module and power module are located above the radiator fins. For the fan to cool these hot portions efficiently, important factors to consider are the distance between the radiator fins and cooling fan, as well as the



No.	Radiator fin length (A portion)	Distance between heat radiator fins and fan (B portion)	Fan outlet shape (C portion)
(1)	Long fins	Short distance	Clearance
(2)	Long fins	Short distance	No clearance
(3)	Short fins	Long distance	Clearance
(4)	Short fins	Long distance	No clearance

Fig. 6: Distance between radiator fins and cooling fan

clearance of the cover over the cooling fan.

As shown in Figure 6, to optimize cooling efficiency of the new model, SANYO DENKI changed conditions for the length of the radiator fins (A), the distance between the radiator fins and the cooling fan (B) and the outlet clearance (C), then performed heat analysis to determine the optimal layout.

As shown in Figure 7, even if the radiator fins are short, as per condition No. (4), by securing space between the fins and fan, and eliminating the fan outlet clearance, it was possible to optimize the heat radiation effect.

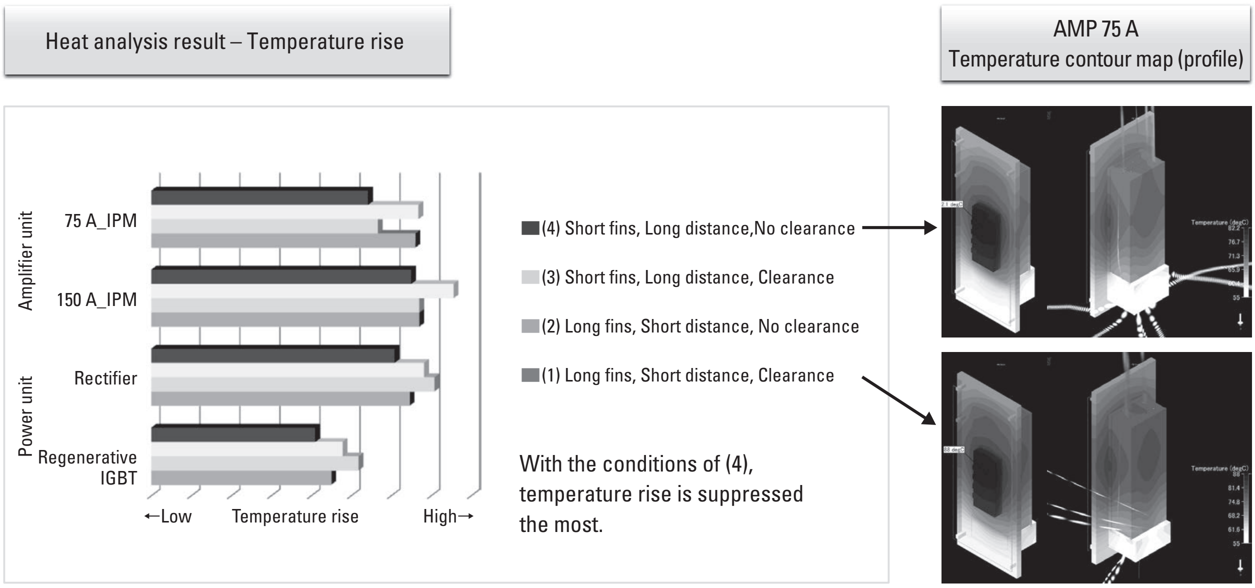


Fig. 7: Heat analysis results

5. Conclusion

This article has introduced the performance and main functions of the *SANMOTION R ADVANCED MODEL* 400 VAC input multi-axis servo amplifier and initiatives regarding adopting new structural materials and achieving an optimal heat radiation configuration.

The new model makes it possible to directly supply 400 VAC, the common power supply in European and Asian factories, to a servo amplifier without the need for a step-down transformer. Moreover, the multi-axis servo amplifier shares a common power unit, so regenerative power from the motor can be used to drive other motors, which we believe will help to improve the energy-saving performance of our customers' equipment.

Amidst ever-changing markets, SANYO DENKI is committed to developing servo systems that help to solve our customers' problems and create new value.

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Works on the development and design of servo amplifiers.

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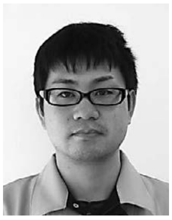
List of Technical Award Engineers of 67th JEMA of 2018

Heavy Electrical Category			
Prize	**Subject**	**Division**	**Name**
Encouragement Award	Development of *G-Proof Fan* with high G-force tolerance	Cooling Systems Div., Design Dept. Cooling Systems Div., Design Dept. Cooling Systems Div., Design Dept.	Naoya Inada Masato Kakeyama Masaki Kodama
Encouragement Award	Development of an AC servo amplifier with various safety functions and high safety performance	Servo Systems Div., Design Dept. 2 Servo Systems Div., Design Dept. 2 Servo Systems Div., Design Dept. 2	Yoshiyuki Murata Hideki Netsu Yuuki Nakamura
Encouragement Award	Development of Power Conditioner for Wind Power and Hydro Power Generation Systems	Power Systems Div., Design Dept. 1 Power Systems Div., Design Dept. 1 Power Systems Div., Design Dept. 1	Hirofumi Nishizawa Masahiro Inukai Tetsuya Fujimaki
	Development of a UPS equipped with lithium-ion batteries	Power Systems Div., Design Dept. 2 Power Systems Div., Design Dept. 2 Power Systems Div., Design Dept. 2	Shinichiro Yamagishi Kazuya Yanagihara Shota Ozawa
	Development of a 2-phase hybrid stepping motor that achieves high performance and automated assembly	Servo Systems Div., Design Dept. 1 Servo Systems Div., Design Dept. 1 Servo Systems Div., Design Dept. 1	Koji Nakatake Mitsuaki Shioiri Hong Zhang
	Development of *ø221 and ø225 Splash Proof Centrifugal Fans*	Cooling Systems Div., Design Dept. Cooling Systems Div., Design Dept. Cooling Systems Div., Design Dept.	Kakuhiko Hata Yukihiro Nagatsuka Nozomi Manji
Manufacturing Category			
Prize	**Subject**	**Division**	**Name**
Encouragement Award	Automation of magnet wire insulation film peeling	Servo Systems Div., Production Engineering Dept., Production Engineering and Development Sect. Servo Systems Div., Production Engineering Dept., Production Engineering and Development Sect. Servo Systems Div., Production Engineering Dept., Process Engineering Sect. 1	Kazuhiro Makiuchi Gang Xu Atsushi Endo

Division names are those at the time of nomination.


Naoya Inada


Masato Kakeyama


Masaki Kodama


Yoshiyuki Murata


Hideki Netsu


Yuuki Nakamura


Shinichiro Yamagishi


Kazuya Yanagihara


Shota Ozawa


Hirofumi Nishizawa


Masahiro Inukai


Tetsuya Fujimaki


Koji Nakatake


Mitsuaki Shioiri


Hong Zhang


Kakuhiko Hata


Yukihiro Nagatsuka


Nozomi Manji


Kazuhiro Makiuchi


Gang Xu


Atsushi Endo

Major Patents

■ **Patents registered in 2017**

Registration Number	Name	Inventor(s)
Patent 6163037	Terminating Resistor Connector	Koichi Machida
Patent 6074346	Switchboard Apparatus	Yuzo Kubota
Patent 6082689	Isolated Operation Detector and Method of Detecting Isolated Operation	Hiroyuki Hanaoka, Akihiro Tsukada, Kazuya Nishizawa
Patent 6109050	Parallel-Off Controller, Method of Controlling Parallel-Off and Power Conditioner	Hiroyuki Hanaoka, Akihiro Tsukada, Kazuya Nishizawa
Patent 6190550	Linear Motor and Magnetic Shielding Structure for Linear Motor	Yu Qi Tang
Patent 6128872	POWER TRANSMISSION DEVICE	Satoshi Sugita, Yu Qi Tang, Yasushi Misawa, Shigenori Miyairi
Patent 6125267	INTERIOR MAGNET LINEAR INDUCTION MOTOR	Satoshi Sugita, Yu Qi Tang, Yasushi Misawa, Shigenori Miyairi
Patent 6117574	INDUCTOR TYPE ROTARY MOTOR	Satoshi Sugita, Yu Qi Tang, Yasushi Misawa, Shigenori Miyairi
Patent 6118157	MOTOR SPEED CONTROL APPARATUS	Yuji Ide, Satoshi Yamazaki
Patent 6166926	LINEAR MOTOR	Yu Qi Tang, Satoshi Sugita
Patent 6082646	SHAFT ROTARY TYPE LINEAR MOTOR AND SHAFT ROTARY TYPE LINEAR MOTOR UNIT	Yu Qi Tang, Satoshi Sugita
Patent 6207870	FAN MOTOR	Naruhiko Kudo, Munenori Takakuwa, Tatsuya Midorikawa
Patent 6140037	POWER CONVERTER	Minoru Yanagisawa
Patent 6106568	POWER CONVERTER	Masahiko Nagai
Patent 6131144	WINDING INSULATION STRUCTURE OF STATOR OF ELECTROMAGNETIC MOTOR	Kazuhiro Yoda, Masaaki Ohashi, Shogo Yoda
Patent 6140035	THREE-PHASE ELECTROMAGNETIC MOTOR	Toshihito Miyashita, Manabu Horiuchi
Patent 6104134	HOUSING OF FAN MOTOR	Toshiya Nishizawa, Haruka Sakai, Jiro Watanabe, Masashi Yokota
Patent 6154704	CONTROL DEVICE OF FAN MOTOR	Takahisa Toda, Takashi Kaise, Jiro Watanabe
Patent 6106582	MOTOR CONTROLLER	Yuji Ide, Michio Kitahara, Satoshi Yamazaki
Patent 6126984	WATERPROOF AXIAL FLOW FAN	Katsumichi Ishihara, Akira Nakayama, Tatsuya Midorikawa, Masato Kakeyama
Patent 6204847	GROUND WIRE CONNECTION STRUCTURE FOR MOTOR	Toshihito Miyashita, Manabu Horiuchi
Patent 6093817	MOTOR CONTROL DEVICE	Yuji Ide, Satoshi Yamazaki, Masahisa Koyama
EP Patent 2091131	MOTOR ROTOR AND MANUFACTURING METHOD THEREOF	Toshihito Miyashita, Takashi Matsushita, Norihito Tanaka
EP Patent 2508760	COUNTER-ROTATING AXIAL FLOW FAN	Atsushi Yanagisawa, Honami Osawa
EP Patent 2916109	MAGNETIC SHIELD COVER FOR ENCODER OF MAGNETIC DETECTION TYPE AND ENCODER OF MAGNETIC DETECTION TYPE	Kazuhiro Makiuchi, Yoshihiro Shoji
EP Patent 2439415	LEAD WIRE ENGAGING STRUCTURE AND ELECTRIC APPARATUS	Yen Junchieh, Jiro Watanabe, Hiromitsu Kuribayashi, Shigekazu Mitomo
U.S. Patent 9613740	MOVING MAGNETIC FIELD GENERATING APPARATUS	Satoshi Sugita, Yasushi Misawa, Yu Qi Tang, Shigenori Miyairi
U.S. Patent 9581174	FAN FRAME	Masahiro Koike, Soma Araki, Toshiki Ogawara
U.S. Patent 9714659	AXIAL FLOW FAN	Naoya Inada, Jiro Watanabe
U.S. Patent 9660490	PERMANENT MAGNET TYPE MOTOR AND METHOD FOR MANUFACTURING PERMANENT MAGNET TYPE MOTOR	Toshihito Miyashita, Manabu Horiuchi
U.S. Patent 9634534	BRUSHLESS MOTOR	Yoshinori Miyabara, Haruhisa Maruyama, Kei Sato, Haruka Sakai
U.S. Patent 9601956	THREE-PHASE PERMANENT MAGNET TYPE MOTOR	Toshihito Miyashita, Masahiro Yamaguchi
U.S. Patent 9551345	AXIAL FLOW FAN	Atsushi Yanagisawa
U.S. Patent 9614405	WIRING STRUCTURE OF STATOR COIL	Yukio Miura, Masaaki Ohashi, Koji Nakatake
U.S. Patent 9742258	ROTATIONAL-LINEAR MOTION CONVERTER	Satoshi Sugita, Yu Qi Tang, Yasushi Misawa, Shigenori Miyairi
U.S. Patent 9712030	SHAFT ROTARY TYPE LINEAR MOTOR AND SHAFT ROTARY TYPE LINEAR MOTOR UNIT	Yu Qi Tang, Satoshi Sugita
U.S. Patent 9748814	ASSEMBLY METHOD OF AN INLINE TYPE FAN MOTOR	Katsumichi Ishihara, Masashi Nomura, Tomoko Hayashi

Registration Number	Name	Inventor(s)
U.S. Patent 9837884	Multi-phase Linear Motor with Continuously Wound Coils in Each Phase	Yu Qi Tang, Takashi Matsushita
U.S. Patent 9853530	LINEAR MOTOR UNIT	Yu Qi Tang, Kazuhito Yamaura
U.S. Patent 9698634	STATOR CORE AND PERMANENT MAGNET MOTOR	Toshihito Miyashita, Manabu Horiuchi
U.S. Patent 9742245	GROUND WIRE CONNECTION STRUCTURE FOR MOTOR	Toshihito Miyashita, Manabu Horiuchi
U.S. Patent 9705385	PRODUCT SPECIFICATION SETTING APPARATUS AND FAN MOTOR HAVING THE SAME	Tetsuya Yamazaki, Takahisa Toda
Korea Patent 10-1767527	LINEAR SYNCHRONOUS MOTOR	Yu Qi Tang, Satoshi Sugita
Korea Patent 10-1778119	ELECTRIC FAN	Naruhiko Kudo, Tomoaki Ikeda, Haruhisa Maruyama
Korea Patent 10-1738670	MOTOR CONTROLLER	Yuji Ide, Satoshi Yamazaki
Korea Patent 10-1788772	MOTOR CONTROLLER	Toshiyuki Nakamura, Yo Muramatsu
Korea Patent 10-1807787	MOTOR CONTROLLER	Yuji Ide
Korea Patent 10-1810638	MOTOR CONTROL SYSTEM INCLUDING ELECTRICAL INSULATION DETERIORATION DETECTING SYSTEM	Yuji Ide
Korea Patent 10-1810639	MOTOR CONTROL SYSTEM INCLUDING ELECTRICAL INSULATION DETERIORATION DETECTING SYSTEM	Yuji Ide, Masahisa Koyama, Yoshihisa Kubota
Korea Patent 10-1799957	MOTOR CONTROLLER	Yuji Ide, Satoshi Yamazaki
Korea Patent 10-1799544	MOTOR CONTROLLER	Yuji Ide, Masakazu Sakai
Korea Patent 10-1724646	MOTOR CONTROLLER	Yuji Ide
Taiwan Patent I565217	MOTOR CONTROLLER	Yuji Ide, Masakazu Sakai
Taiwan Patent I581556	MOTOR CONTROLLER	Yuji Ide, Satoshi Yamazaki
Taiwan Patent I594566	MOTOR CONTROLLER	Toshiyuki Nakamura, Yo Muramatsu
Taiwan Patent I606675	SPLIT-CORE TYPE MOTOR AND METHOD OF MANUFACTURING ARMATURE OF SPLIT-CORE TYPE MOTOR	Toru Takeda, Shintaro Koichi, Kenta Matsuhashi
Taiwan Patent I575863	MOTOR CONTROLLER	Yuji Ide
Taiwan Patent I594565	MOTOR CONTROLLER	Takahisa Toda
Taiwan Patent I596868	PERMANENT MAGNET TYPE MOTOR AND METHOD FOR MANUFACTURING PERMANENT MAGNET TYPE MOTOR	Toshihito Miyashita, Manabu Horiuchi
Taiwan Patent I584573	MOTOR CONTROL SYSTEM INCLUDING ELECTRICAL INSULATION DETERIORATION DETECTING SYSTEM	Yuji Ide
Taiwan Patent I582446	MOTOR CONTROL SYSTEM INCLUDING ELECTRICAL INSULATION DETERIORATION DETECTING SYSTEM	Yuji Ide, Masahisa Koyama, Yoshihisa Kubota
Taiwan Patent I600269	MOTOR CONTROL DEVICE AND MOTOR CONTROL METHOD	Yo Muramatsu, Takahisa Toda
Taiwan Patent I593215	THREE-PHASE PERMANENT MAGNET TYPE MOTOR	Toshihito Miyashita, Masahiro Yamaguchi
Taiwan Patent I583104	PERMANENT MAGNET-EMBEDDED MOTOR AND ROTOR THEREOF	Toshihito Miyashita
Taiwan Patent I589782	AXIAL FLOW FAN	Atsushi Yanagisawa
Taiwan Patent I568169	MOTOR CONTROLLER	Yuji Ide, Satoshi Yamazaki
Taiwan Patent I604683	WIRING STRUCTURE OF STATOR COIL	Yukio Miura, Masaaki Ohashi, Koji Nakatake
Taiwan Patent I597931	MOTOR CONTROLLER	Yuji Ide, Shunichi Miyazaki
China Patent ZL201310342099.9	PERMANENT MAGNET TYPE MOTOR AND METHOD FOR MANUFACTURING PERMANENT MAGNET TYPE MOTOR	Toshihito Miyashita, Manabu Horiuchi
China Patent ZL201310325466.4	MOTOR CONTROL SYSTEM INCLUDING ELECTRICAL INSULATION DETERIORATION DETECTING SYSTEM	Yuji Ide
China Patent ZL201310325069.7	MOTOR CONTROL SYSTEM INCLUDING ELECTRICAL INSULATION DETERIORATION DETECTING SYSTEM	Yuji Ide, Masahisa Koyama, Yoshihisa Kubota
China Patent ZL201310464531.1	THREE-PHASE PERMANENT MAGNET TYPE MOTOR	Toshihito Miyashita, Masahiro Yamaguchi
China Patent ZL201310397858.1	AXIAL FLOW FAN	Atsushi Yanagisawa
China Patent ZL201310425260.9	MOTOR CONTROLLER	Yuji Ide, Satoshi Yamazaki
China Patent ZL201310606923.7	POWER LINE CONNECTING STRUCTURE OF STATOR	Yukio Miura, Kazuyoshi Uchiyama, Kazuhiro Yoda
China Patent ZL201410167990.8	SHAFT ROTARY TYPE LINEAR MOTOR AND SHAFT ROTARY TYPE LINEAR MOTOR UNIT	Yu Qi Tang, Satoshi Sugita
China Patent ZL201310031221.0	MOTOR CONTROL DEVICE AND CONTROL METHOD OF THE SAME	Noriaki Taniguchi, Takahisa Toda, Yo Muramatsu
China Patent ZL201310159567.9	FAN FRAME	Masahiro Koike, Soma Araki, Toshiki Ogawara

Internal Recognition: Manufacturing Grand Prize (Excellence Award)

May 2017 Commendations

Prize	Subject	Division	Name
Excellence Award	Surface Treatment Technology for Improving the Appearance of Plastic Parts	Cooling System Div., Production Dept. Production Engineering Sect. 2 Cooling System Div., Production Dept. Production Engineering Sect. 2 Human Resources Dept. (On secondment from SANYO DENKI Techno Service CO., LTD.)	Yoichi Yamada Shoji Kanai Masahiko Nomura
Excellence Award	Automation of the 20 mm sq. R series servo motor rotor assembly	Servo Systems Div., Production Engineering Dept., Production Engineering and Development Sect. Servo Systems Div., Production Engineering Dept., Process Engineering Sect. 1, Subsect. 1 Human Resources Dept. (On secondment from SANYO DENKI Techno Service CO., LTD.) Human Resources Dept. (On secondment from SANYO DENKI Techno Service CO., LTD.)	Kazuhiro Makiuchi Kei Tanaka Atsushi Handa Daiki Kobayashi

Technical Papers Published Outside the Company in General Technical Journals

January to December 2017

Title of Paper	Authors	Name of Journal	Issued on	Publisher
Feature: Product and Technology Development of Member Companies and the Results of 2016	SANYO DENKI CO., LTD.	Denki (Electrical Appliances)	2017.2	The Japan Electrical Manufacturers' Association (JEMA)

Technical Papers Published Outside the Company

January to December 2017

Title of Paper	Authors	Name of Journal	Issued on	Publisher
Robust Positioning Control Using α-β Stationary Frame Current Controller and Disturbance Torque Hybrid Observer	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi and others	IEEJ Journal of Industry Applications Vol.6 No.2	March	IEEJ Industrial Applications Category
Estimation of Stator Resistance Variation Based on Stator Flux Linkage Estimation for Permanent Magnet Synchronous Motor.	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi and others	Research materials	March	Joint Technical Meeting on Motor Drive and Home and Consumer Appliances
Study on control operation in a system introducing power storage device	Takuya Ota, Hiroaki Miyoshi and others	Contest research paper collection	March	2017 IEEJ National Conference
Usual Application Example using Linear Motor Precision Positioning, High Speed, High Frequency	Satoshi Sugita and others	2017 IEEJ Industrial Applications Category Contest Lecture paper collection	August	IEEJ Industrial Applications Category
Experimental Study on Estimation of Stator Resistance Variation Based on Stator Flux Linkage Estimation for Permanent Magnet Synchronous Motor	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi and others	2017 IEEJ Industrial Applications Category Contest Lecture paper collection	August	IEEJ Industrial Applications Category
Control methods for power storage devices in distributed power system	Hiroaki Miyoshi and others	Contest research paper collection	October	INTELEC2017 (International Telecommunications Energy Conference 2017)
A Consideration on Current Noise Measurement in Distributed Power Supply Introduction System	Hiroaki Miyoshi and others	Contest research paper collection	October	INTELEC2017 (International Telecommunications Energy Conference 2017)

SANYO DENKI
Technical Report 45
May 2018
https://www.sanyodenki.com

Published in Japan in May 15, 2018 by SANYO DENKI CO.,LTD.
Published semi-yearly

3-33-1 Minami-Otsuka, Toshima-ku, Tokyo 170-8451, Japan
Phone +81 3 5927 1020
Publisher Shigeo Yamamoto