SANYO DENKI

Technical Report

Feature | Technical Developments in 2023

1988
SANYO DENKI EUROPE S.A.

57
May 2024

COLUMN

Cover image:

SANYO DENKI EUROPE S.A.

1988

In 1988, we founded our new Group Company, SANYO DENKI EUROPE S.A., in Villepinte, Paris, France, aiming to sell our products and explore new markets in France and neighboring countries.

It was originally located in a business district about 10 km north of central Paris, near Charles de Gaulle Airport. Conveniently located near metro and highway lines, it served as our vital hub in Europe.

In 2023, it was relocated to Goussainville, expanded with a stepping motor assembly factory next to it, aiming to expand our businesses in Europe further. Combining the assembly factory with the sales office has enabled us to deliver our products faster and make customizations more flexibly in Europe.

SANYO DENKI Group continues to strengthen its supply and logistics capabilities to swiftly deliver uniform, high-quality products and services to our customers worldwide.

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May 2024

C O N T E N T S

Moving Toward a New Era at SANYO DENKI

Shigeo Yamamoto Chairman of the Board & CEO

The history of SANYO DENKI is now almost a century long.

Over the last 100 years, the world has undergone major changes, with the last 20 years being particularly remarkable.

In the 2000s, the Internet took root as a communication tool. In the 2010s, demand for renewable energy grew considerably, and the 2020s are seeing an increasing interest in carbon neutrality.

Today, the inability to freely use computers or smartphones can be a major obstacle in daily life.

Amidst this landscape, our 9th Medium-term Management Plan, launched in April 2021, has entered its fourth year.

The primary goal of this plan is to “break the shell.”

In the initial phase of this break-the-shell initiative, a total of as many as 772 proposals were raised by the SANYO DENKI Group employees across the world.

Similar ideas have been grouped into a total of 389 initiatives, all of which have been set a timeline for implementation and are proceeding.

By the end of FY 2023, many of these initiatives had already come to fruition.

I am very proud of the way all the individual Group employees are breaking out of the shells they have built around themselves, as if to say, “That’s out of my responsibility,” “That’s not my style of doing things,” or “This is not our job,” and are standing tall in the face of change and progress in the world, and even trying to thrive on change.

We have now reorganized our formal 29-year-old business division-based system consisting of the Cooling Systems Division, Power Systems Division, and Servo Systems Division to establish a new system of three business companies: the San Ace Company, Electronics Company, and Motion Company.

The aim is to allow each business company to have its own management team and be more independent, and to make the management responsible not only for calculating the profit and loss of its business but also for the effective use of its assets.

"Management with responsibility" enables each business company to even conduct sales activities in its own way, in addition to the conventional way of selling products to customers through the sales department.

Once we establish a business style in which our business companies create new value using their technological capabilities, I believe that the SANYO DENKI Group as a whole will be able to perform to the best of its abilities.

This organizational change is our 390th initiative, added to the above-mentioned 389 "break-the-shell" initiatives.

In this issue, in the feature articles entitled "Technical Developments in 2023," we will introduce the major new products we released in 2023 and their technologies. These new products incorporate our specialty technologies that we have developed over the years and have been developed based on the "break-the-shell" initiatives.

SANYO DENKI's products and technologies contribute not only to industrial development and technological innovation but also to the preservation of the global environment, the effective use of energy, and the health and safety of people.

Based on the new business company-based system, we at the SANYO DENKI Group will continue to advance toward achieving happiness for all people through our three product brands *San Ace, SANUPS*, and *SANMOTION* as well as our business activities.

San Ace Products

Masato Murata

The use of generative AI such as ChatGPT has quickly become widespread through society and many companies are looking to adopt similar services. Such generative AI technologies are expected to advance fast, raising demand for more and more data centers to compute vast resources of information.

Although the COVID-19 infections have come to a halt and many businesses are returning to in-person operations, the efficient network-based business practices introduced during the pandemic—including telework, online meetings, and online training—have taken root.

As such, servers, routers, and storage devices that support such generative AI systems and information networks are required to perform better in speed, capacity, and reliability. Furthermore, today's equipment as a whole is becoming denser and generating more heat, demanding cooling fans with superior performance in airflow, static pressure, power consumption, and reliability.

In addition, with the Sustainable Development Goals (SDGs) becoming a global agenda, it is vital to develop products that consume less energy and last longer for carbon neutrality.

Against such a backdrop, we developed and launched cooling fans with industry-leading performance and reliability that can meet the market demand.

Below are overviews of the products we developed in 2023.

Note: The company names and product names listed in this article are the trademarks or registered trademarks of their respective owners.

■ Long Life Fan

DC Fan

• 40 × 40 × 28 mm *San Ace 40L* 9LG type

Our 40 × 40 × 28 mm Long Life Fans, primarily used in high-end servers and ICT equipment, are often installed in remote locations and therefore require high reliability and long expected life. Moreover, as equipment performance increases in general, our existing Long Life Fans are also required to provide higher cooling performance and lower power consumption than ever before.

In response to these needs, we developed and launched the *San Ace 40L* 9LG type Long Life Fan, which is designed for low power consumption while maintaining the same long life as our current model and offering the industry's highest(1) airflow and static pressure.

(1) Based on our own research as of May 25, 2023, conducted among axial DC fans of equivalent size and cooling performance on the market.

■ 120 × 120 × 25 mm ACDC Fan

• 120 × 120 × 25 mm *San Ace 120AD* 9AD type

For AC fans, there is increasing demand for PWM control to adjust fan speed based on the operating conditions of equipment, as well as for wide input voltage ranges to support use in various countries. To meet these requirements, we have expanded our lineup of ACDC fans, which have a built-in AC-DC conversion circuit to drive a DC motor.

Furthermore, today's control panels and industrial equipment are more compact and have less internal space, demanding thinner-profile cooling fans, including ACDC fans.

In response to such market demand, we developed and launched the *San Ace 120AD* 9AD type fan, which features a thickness of 25 mm, making it our slimmest ACDC fan, as well as the industry's highest(2) static pressure and airflow.

(2) Based on our own research as of June 26, 2023, conducted among ACDC fans of equivalent size on the market.

■ Low Noise Fan

DC Fan

• 92 × 92 × 38 mm *San Ace 92* 9RA type

Our 92 × 92 × 38 mm fans are often used in workstations, medical equipment, and servers. In consideration of environmental friendliness, demand for lower noise and lower power consumption is increasing for these applications as well.

To meet such market demand, we developed and launched the *San Ace 92* 9RA type fan, which has achieved both high performance and the industry's lowest(3) noise at the same time. It will be introduced in detail in a separate article in this issue.

(3) Based on our own research as of November 13, 2023, conducted among equally-sized axial DC fans on the market.

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92 × 92 × 38 mm *San Ace 92* 9RA Type Low Noise Fan

Masato Kakeyama Rogen Molino Jovelyn Villar Nerissa Quiroz

Jan Mison Sally Damasco Tetsuya Yamazaki

1. Introduction

The 92 × 92 × 38 mm 9G type fan we released back in 2003 still remains in high demand for use in workstations, medical devices, and rack-mounted/blade servers. However, as the SDGs (sustainable development goals) have quickly become a shared agenda of the global community, the above-mentioned equipment is increasingly pursuing better performance in quietness and energy efficiency. Cooling fans, in particular, are required to offer both low noise and low power consumption. To meet this changing market demand, we have developed and launched the *San Ace 92* 9RA type Low Noise Fan featuring the same airflow vs. static pressure characteristics as the current 92 × 92 × 38 mm 9G type fan.

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

2. Product Features

Figure 1 shows the new product.

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

Fig. 1 92 × 92 × 38 mm *San Ace 92* 9RA type

3. Product Overview

3.1 Dimensions

Figure 2 shows the dimensions of the new product. The new product was designed to be compatible with the current product in size and mounting.

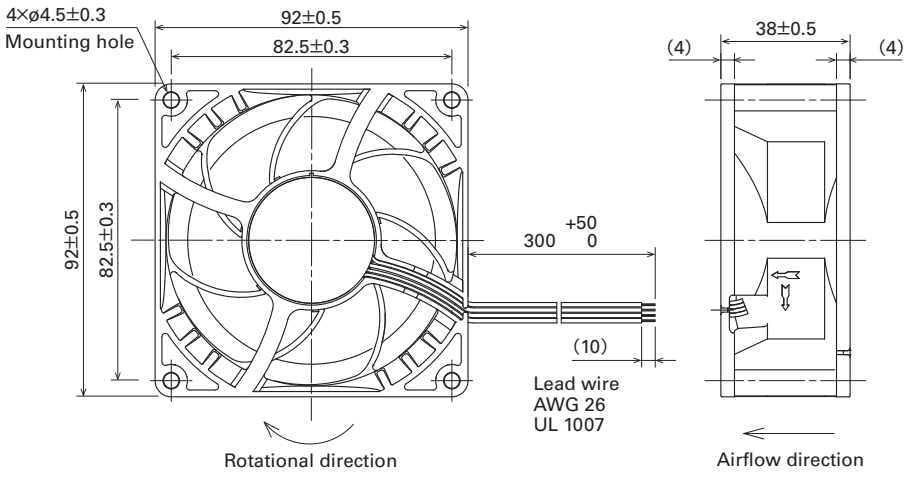


Fig. 2 Dimensions of the *San Ace 92* 9RA type (Unit: mm)

3.2 Specifications

3.2.1 General specifications

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

To support a wide range of markets and serve as a successor to the current product, we launched a lineup of models in three rated voltages of 12, 24, and 48 V and three high, medium, and low speeds.

3.2.2 Airflow vs. static pressure characteristics

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

3.2.3 PWM control

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

Table 1 General specifications of the *San Ace 92* 9RA type with PWM control

Model no.	Rated voltage [V]	Operating voltage range [V]	PWM duty cycle* [%]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow [m^3/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH$_2$O]	Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
9RA0912P1J001	12	10.8 to 13.2	100	1.24	14.9	6400	3.28	116	192	0.77	50	-20 to +70	40000 at 60°C (70000 at 40°C)
			20	0.07	0.8	1600	0.82	29	12.0	0.05	12		
9RA0912P1G001			100	0.96	11.5	5800	2.97	105	158	0.63	47		
			20	0.06	0.7	1400	0.72	25	9.2	0.04	10		
9RA0924P1J001	24	21.6 to 26.4	100	0.62	14.9	6400	3.28	116	192	0.77	50		
			20	0.07	1.7	2200	1.13	40	22.7	0.09	19		
9RA0924P1G001			100	0.48	11.5	5800	2.97	105	158	0.63	47		
			20	0.05	1.2	2000	1.02	36	18.8	0.08	17		
9RA0948P1J001	48	43.2 to 52.8	100	0.31	14.9	6400	3.28	116	192	0.77	50		
			20	0.03	1.4	2000	1.02	36	18.8	0.08	17		
9RA0948P1G001			100	0.25	12.0	5800	2.97	105	158	0.63	47		
			20	0.03	1.4	1700	0.87	31	13.6	0.05	13		

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

Table 2 General specifications of the *San Ace 92* 9RA type constant-speed models

Model no.	Rated voltage [V]	Operating voltage range [V]	Rated current [A]	Rated input [W]	Rated speed [min^{-1}]	Max. airflow [m^3/min]	Max. airflow [CFM]	Max. static pressure [Pa]	Max. static pressure [inchH$_2$O]	Sound pressure level [dB(A)]	Operating temperature range [°C]	Expected life [h]
9RA0912J1001	12	7 to 13.2	1.24	14.9	6400	3.28	116	192	0.77	50	-20 to +70	40000 at 60°C (70000 at 40°C)
9RA0912G1001		7 to 13.8	0.96	11.5	5800	2.97	105	158	0.63	47		
9RA0912H1001		7 to 13.8	0.52	6.2	4650	2.36	83	102	0.41	40		
9RA0924J1001	24	14 to 26.4	0.62	14.9	6400	3.28	116	192	0.77	50		
9RA0924G1001		14 to 27.6	0.48	11.5	5800	2.97	105	158	0.63	47		
9RA0924H1001		14 to 27.6	0.26	6.2	4650	2.36	83	102	0.41	40		
9RA0948J1001	48	36 to 52.8	0.31	14.9	6400	3.28	116	192	0.77	50		
9RA0948G1001		36 to 55.2	0.25	12.0	5800	2.97	105	158	0.63	47		
9RA0948H1001		36 to 55.2	0.14	6.7	4650	2.36	83	102	0.41	40		

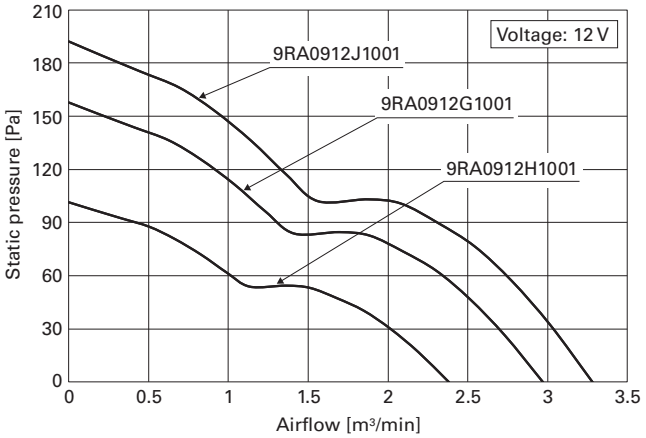


Fig. 3 Airflow vs. static pressure characteristics of the *San Ace 92* 9RA type

4. Key Points of Development

The new product achieves lower noise and lower power consumption than the current product while maintaining the same cooling performance.

The key points of development are described below.

4.1 Motor and circuit design

To reduce power consumption from the current product, the new product adopted a newly designed circuit, to which the high-efficiency bipolar drive was chosen over the unipolar drive used in the current product. Increasing the motor size is effective for reducing power consumption, but it makes noise reduction challenging. For this reason, we maintained the same motor size as the current product. We successfully reduced power consumption through the optimization of the motor output against the impeller load by increasing the motor winding fill factor.

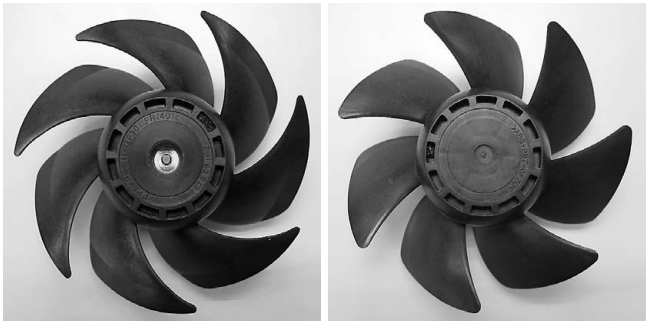
4.2 Impeller and frame design

Figure 4 compares the frame shapes, and Figure 5 compares the impeller shapes of the new and current products. Figure 6 shows an example of simulation-based sound source analysis.

While the current product has three spokes, the new product features four spokes for improved frame strength. However, adding spokes tends to increase the noise level. We have achieved lower noise and lower power consumption for the new product through simulation-based design optimization and evaluations on actual equipment by trying numerous combinations of parameters such as rotor hub diameter, impeller shape, number and mounting angle of blades, frame shape, and spoke shape and layout.

New product Current product

Fig. 4 Frame shape comparison of the new and current products



New product Current product

Fig. 5 Comparison of the impeller shape of the new and current products

Fig. 6 Simulation-based sound source analysis example

5. Comparison of New and Current Products

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

Figure 7 compares the airflow vs. static pressure vs. power consumption characteristics and airflow vs. noise characteristics of the current product and the fastest model of the new product. The new product has achieved a 13% reduction in power consumption at the assumed operating point while maintaining the same airflow vs. static pressure

characteristics as the current product. The noise level has been reduced by 3 dB(A). This means that, if the noise level of the current product can be tolerated, the new product offers much higher cooling performance equivalent to two units of the current product.

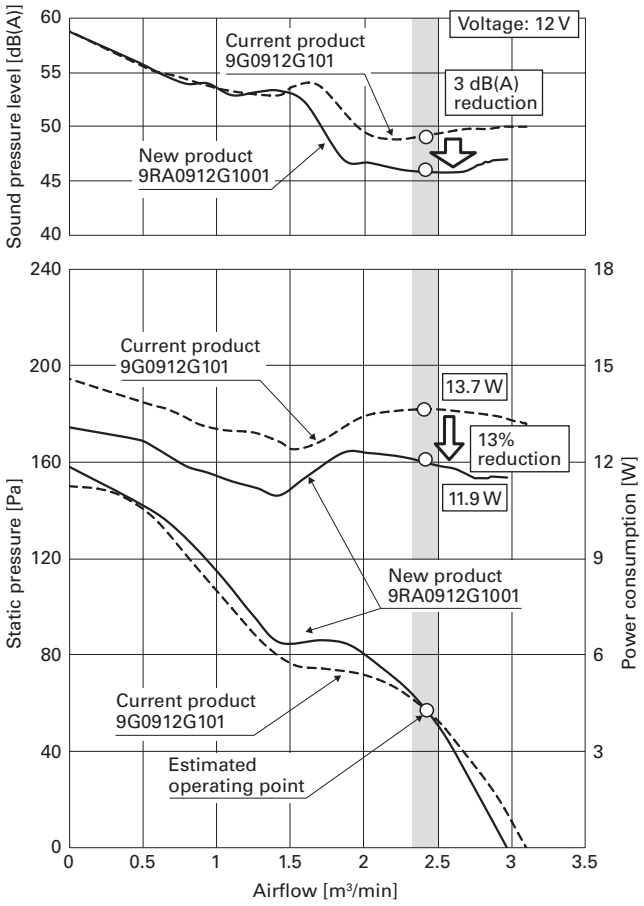


Fig. 7 Comparison of the *San Ace 92* new and current products

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

The new product produces 13% less CO_2 emissions over its product life cycle compared to the current product, thanks to its reduced power consumption.

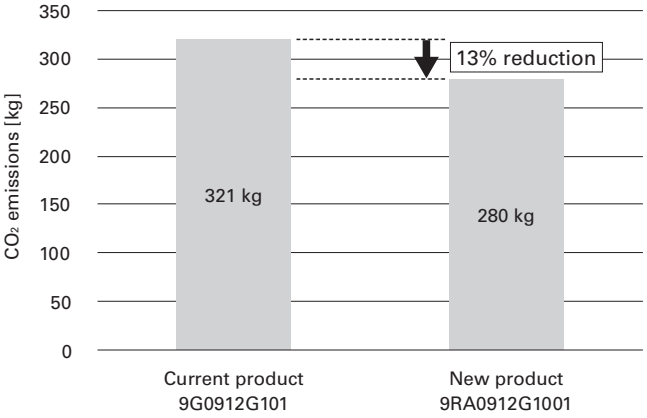


Fig. 8 CO_2 emissions comparison using our LCA calculation software (40,000 hours, when operated with the same operating airflow)

6. Conclusion

This article introduced the features and performance of the *San Ace 92* 9RA type.

The new product achieved lower noise and lower power consumption than the current product while maintaining the same cooling performance. This contributes to noise reduction and energy savings for equipment that is used near people, such as workstations, medical devices, and rack-mounted/blade servers.

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

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SANUPS Products

Naoya Nakamura

SANUPS is the brand name for our power-related products including uninterruptible power supplies (UPSs), PV inverters, and engine generators. These products are designed to ensure a stable power supply to customer equipment and effectively use electric power to reduce CO_2 emissions, benefiting both society and our customers.

This article briefs the features and innovations of the SANUPS products we developed in 2023 and describes how they benefit our customers and society.

We will first introduce the *SANUPS A13A* modular UPS. This UPS offers highly reliable power supply through parallel redundancy and enhanced maintainability with its hot-swappable module. These features minimize equipment downtime and provide stable equipment operation for our customers.

Next, we will introduce the *SANUPS A11N-Li*, a UPS featuring long-life lithium-ion batteries and parallel redundancy.

By combining up to four 5 kVA base units in parallel, this UPS offers scalable output capacities of 5, 10, 15, and 20 kVA. Its newly developed built-in lithium-ion battery pack provides high efficiency and high reliability while also offering compact and lightweight design, long service life, and wide operating temperature range.

This also helps reduce installation space and running costs.

Finally, we will introduce the *SANUPS LiB Pack*, a lithium-ion battery pack. It achieves a high level of safety by using iron phosphate battery cells and a fully redundant protection circuit. This compact, lightweight, and long-life storage battery can replace conventional lead-acid batteries, saving space and reducing the environmental impact.

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

■ Development of the *SANUPS A13A* Online UPS

The *SANUPS A13A* UPS is available in four output capacities ranging from 6.25 to 25 kVA by combining one to four 6.25 kVA 3-phase UPS modules in parallel.

Its features are as follows.

1. High conversion efficiency

It achieves a conversion efficiency of 92% through the use of the latest IGBT module as a power conversion device and optimized control.

2. Highly reliable UPS topology

The UPS module supports parallel redundant operation. For the three models (12.5, 18.75, and 25 kVA models) consisting of multiple UPS modules, even if one UPS module fails, the remaining modules continue supplying power through the inverter.

3. Improved maintainability

Its modular design achieves improved maintainability.

Since the UPS module, display module, and bypass module are all plug-in types, the UPS module and battery module can be hot-swapped and replaced even during operation.

These parallel redundancy, modular design, and hot-swappable module features make front-side maintenance possible, improving product maintainability and minimizing equipment downtime.

4. Long service life

The expected life of the UPS is 15 years, which is much longer than the 10 years of conventional UPSs. Additionally, regular replacement parts such as a cooling fan and electrolytic capacitor last as long as the product, eliminating the need for replacement.

These features help reduce maintenance costs for our customers and also contribute to the realization of a sustainable society.

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

Fig. 1 The *SANUPS A13A* 25 kVA model

■ Development of the *SANUPS A11N-Li* Online UPS

The *SANUPS A11N-Li* is a UPS equipped with a specially developed lithium-ion battery pack.

Lithium-ion batteries have a high energy density and therefore require enhanced safety to prevent thermal runaway of battery cells. Therefore, the battery pack comes with a built-in BMU (Battery Management Unit) that detects and provides protection against battery malfunctions. In addition, the battery pack achieves a high level of safety, having passed the drop test and combustion test specified in JIS C 8715-2.(1)

Its features are as follows.

1. Long service life

Its long-life lithium-ion batteries can be expected to last 10 years. Conventional UPSs with lead-acid batteries would need to be replaced one to three times over 10 years. Featuring lithium-ion batteries, this product is free from replacement, reducing replacement costs.

2. Compact and lightweight

Compared to its predecessor, the new UPS is smaller and lighter, reducing volume and mass by 25% and 42%, respectively, without compromising backup time.

3. Wide operating temperature range

It has a wider operating temperature range of -10 to 55ºC over the 0 to 40ºC of our conventional UPS. This enables the UPS to be used under harsher temperatures in high-density servers and network devices.

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

Fig. 2 The *SANUPS A11N-Li* 5 kVA model

(1) Japanese Industrial Standards Committee: "JIS C 8715-2 (Secondary lithium cells and batteries for use in industrial applications—Part 2: Tests and requirements of safety)"

■ Development of the *SANUPS LiB Pack*, a Lithium-Ion Battery Pack

Lithium-ion batteries are smaller and lighter than lead-acid batteries due to their higher energy density. Moreover, lithium-ion batteries have a low environmental impact because they do not use heavy metals such as lead. Thanks to these features, lithium-ion batteries are increasingly being used to replace lead-acid batteries.

It is against this backdrop that we developed the *SANUPS LiB Pack*, a high-safety lithium-ion battery pack.

Its features are as follows.

1. High safety

The new battery pack conforms to UL 1973,(2) a safety standard for storage batteries. Having a high energy density, lithium-ion batteries require an enhanced level of safety because of their relatively high potential for serious accidents if mishandled.

To achieve a high level of safety, the new battery pack was designed with the following three features.

(1) Use of iron phosphate battery cells
(2) Protection circuits with a circuit breaker
(3) Full redundancy of each protection circuit

2. Enhanced environmental durability

The new battery pack has a wide operating temperature range of -20 to 60ºC and therefore can be used under harsh environments.

3. High performance

The new battery pack supports rapid charging and discharging. It can discharge with a maximum discharge current of 9C(3) (45 A) and charge with a maximum charge current of 2C (10 A), making it suitable for applications that require high current output.

4. Long service life

Since the new lithium-ion battery pack has a longer service life than lead-acid batteries, it reduces the man-hours and cost of battery replacement.

Fig. 3 The *SANUPS LiB Pack*

(2) UL 1973 is a safety standard for batteries for use in stationary and motive auxiliary power applications.
(3) The C-rate is a measure of the rate at which a battery is charged or discharged, with a 1C rate defined as the current that completes the charge/discharge of the entire battery in one hour.

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Development of the *SANUPS A13A* Online UPS

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1. Introduction

Uninterruptible power supplies (UPSs) are devices that protect customer equipment such as computers, servers, ICT equipment, and production facilities by providing backup power in the event of a power failure, and therefore a high level of reliability is required. Furthermore, since UPSs keep running all the time, achieving a high conversion efficiency is key to reduce CO_2 emissions.

Against this backdrop, we newly developed the *SANUPS A13A* modular UPS. This UPS features highly reliable power supply, high efficiency, high maintainability, and long service life thanks to its modular design.

In this article, we begin by introducing the appearance and specifications of the new product. Next, we will describe six features of the UPS, including its high conversion efficiency, highly reliable power supply, and superb maintainability.

2. Product Overview

Figure 1 shows the *SANUPS A13A* inverter panel. Main UPS functions of the *SANUPS A13A* are modularized into separate modules. The module types are as follows.

(1) UPS module
A power conversion unit with an output capacity of 6.25 kVA per module

(2) Display module
A module for displaying information on and controlling UPS

(3) Bypass module
A module for switching output to bypass during maintenance

(4) Battery module
A module combining multiple lead-acid batteries

Figure 2 shows the circuit diagram. The standard battery backup time is 8 minutes, and a battery module is built into the inverter panel. For longer backups of 30 or 60 minutes, an external battery panel is required.

Fig. 1 The *SANUPS A13A* inverter panel (25 kVA model)

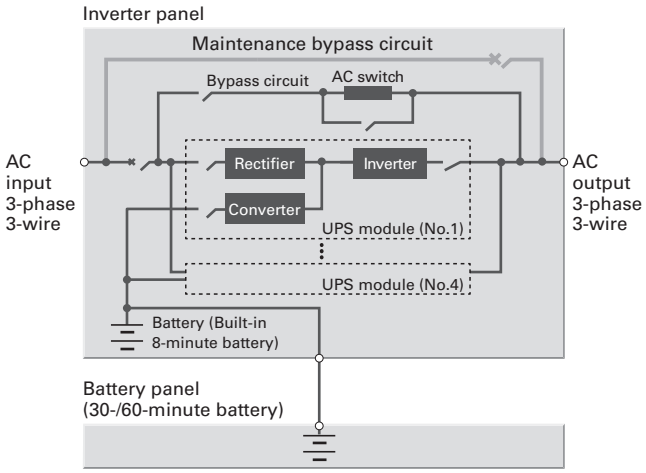

Fig. 2 Circuit diagram for the *SANUPS A13A*

Table 1 shows the electrical specifications. One unit of the UPS module has an output capacity of 6.25 kVA. The lineup is available in four different output capacities of 6.25, 12.5, 18.75, and 25 kVA, which consist of one to four UPS modules configured in parallel.

Table 1 Electrical specifications of the *SANUPS A13A*

Item \ Model			A13A622	A13A123	A13A183	A13A253	Remarks
Rated output capacity (Apparent power / Active power)			6.25 kVA/ 5 kW	12.5 kVA/ 10 kW	18.75 kVA/ 15 kW	25 kVA/ 20 kW	
Technology	**Topology**		Double conversion online				
	Cooling system		Forced air cooling				
	Rectifier		High power factor converter				
	Inverter		High-frequency PWM, instantaneous waveform control				
AC input	**No. of phases/wires**		3-phase 3-wire				
	Rated voltage		200/210/220 V				Same as AC output
	Voltage range		At load levels ≥ 80%: Within ±15% of rated voltage At load levels < 80%: Within -30% to +15% of rated voltage				
	Rated frequency		50/60 Hz				
	Frequency range		Within ±10% of rated frequency				Operation guaranteed within this range
	Current harmonic distortion		10% or less				At rated output
	Input power factor		0.98 or greater				At rated output
AC output	**No. of phases/wires**		3-phase 3-wire				
	Rated voltage		200/210/220 V				
	Voltage regulation		Within ±2% of rated voltage				In grid operation
	Rated frequency		50/60 Hz				Same as AC input
	Frequency regulation		Within ±0.5 Hz of rated frequency				In free run (asynchronous)
	Grid synchronized range		Within ±15% of 200/210/220 V Within ±1% of rated frequency (±1/3/5% selectable)				
	Voltage harmonic distortion	**At linear load**	2% or less				At rated input
		At rectifier load	5% or less				At rated input and 100% rectifier load
	Voltage unbalance		2% or less				At 100% unbalanced load
	Load power factor	**Rated**	0.8 (lagging)				
		Variation range	0.7 to 1.0 (lagging)				
	Transient voltage fluctuation	**Abrupt input voltage change**	Within ±2% of rated voltage				Outage ↔ Recovery
		Abrupt load change	Within ±5% of rated voltage				For 0 ↔ 100% load step changes
		Output transfer	Within ±5% of rated voltage				During bypass to inverter transfer at rated output
	Overload capability	**Inverter**	125% (for 10 min), 150% (for 1 min)				At rated input and rated load power factor
		Bypass	200% (for 30 s), 800% (for 2 cycles)				At rated input and rated load power factor
Overcurrent protection			Uninterrupted transfer to bypass at approx. 150% or more				Automatic retransfer after restored to normal condition (In synchronous run)
Acoustic noise			50 dB or less	50 dB or less	55 dB or less	55 dB or less	1 m from front of UPS, A-weighting (At linear load)
Battery type			Small-sized valve-regulated lead-acid (VRLA) battery				
Operating environment			Temperature: 0 to +40°C, humidity: 30 to 90% RH (non-condensing)				

Figure 3 shows the dimensions of the inverter panel.

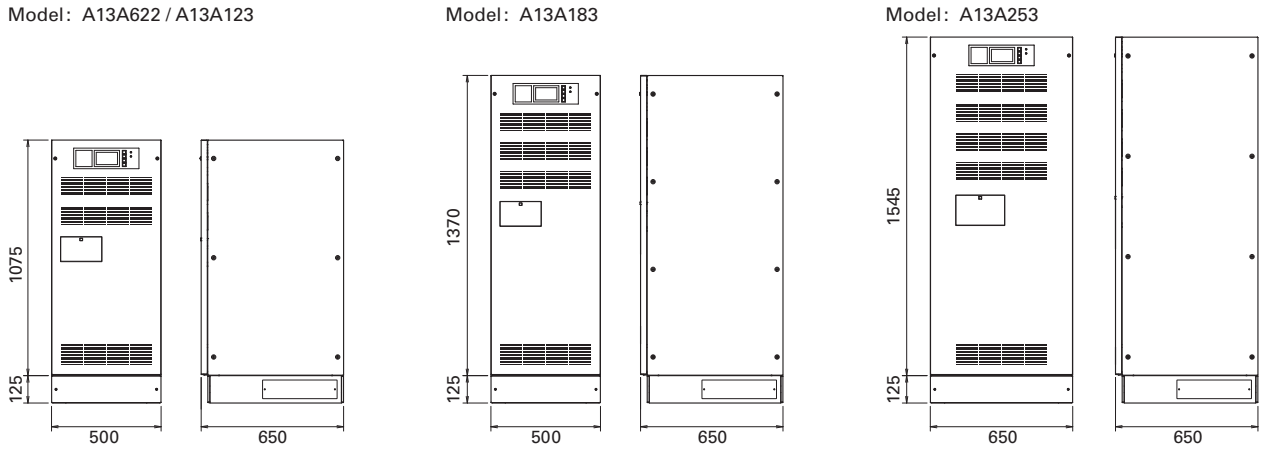

Fig. 3 Dimensions of inverter panel (Unit: mm)

3. Features

The UPS module uses a double conversion online UPS topology for power conversion. This ensures the delivery of high-quality power to equipment, unaffected by the voltage, frequency, or voltage harmonic distortion of AC input power.

The new product supports 3-phase 3-wire input/output power, with the voltage to support being configurable from 200/210/220 V, covering a wide range of power systems. The features of the new product are given below.

3.1 Highly reliable UPS topology

The UPS module supports parallel redundant operation. For the three models (12.5, 18.75, and 25 kVA models) consisting of multiple UPS modules, even if one UPS module fails, the remaining modules continue supplying power as long as the UPS output capacity meets the load capacity requirement. This results in highly reliable power supply.

3.2 High conversion efficiency

The *SANUPS A13A* uses the latest IGBT module as the power conversion device for the rectifier and inverter. Moreover, by optimizing power conversion control, it achieves a conversion efficiency of 92%, marking an 8% improvement over our conventional *SANUPS AMB* UPS. The new product can contribute to reducing running costs and CO_2 emissions.

3.3 Improved maintainability

The new product uses a modular design to improve maintainability.

Current models require switching to bypass output for maintenance work or parts replacement. During maintenance, power is directly supplied from the grid to the load equipment, thereby stopping the functions of the UPS. In contrast, the new product offers the hot-swappable feature, allowing modules to be replaced without stopping UPS functions, thereby minimizing downtime.

Moreover, each module can be removed and installed from the front of the UPS for easy replacement. Figure 4 shows the structure inside the *SANUPS A13A* 25 kVA inverter panel.

Furthermore, since the UPS module and bypass module are both plug-in modules, they can be hot-swap replaced while the UPS continues running.

To sum up, the new product's parallel redundancy as well as the modular design and hot-swappable feature for front-side maintenance achieve improved maintainability and minimized equipment downtime.

3.4 Wide AC input voltage range

When the AC input voltage drops, UPSs switch to battery power to protect load equipment. However, frequent use of battery power can accelerate battery degradation.

To mitigate this, the new product features a wide rated input voltage range, extended from ±10% to ±15% of rated voltage compared to our conventional UPS, and the lower threshold can be further extended to -30% of the rated voltage when the load level is below 80%. This reduces the frequency of unnecessary transfer to battery power even in environments with unstable input voltage, preventing battery degradation and reducing the need for battery replacements.

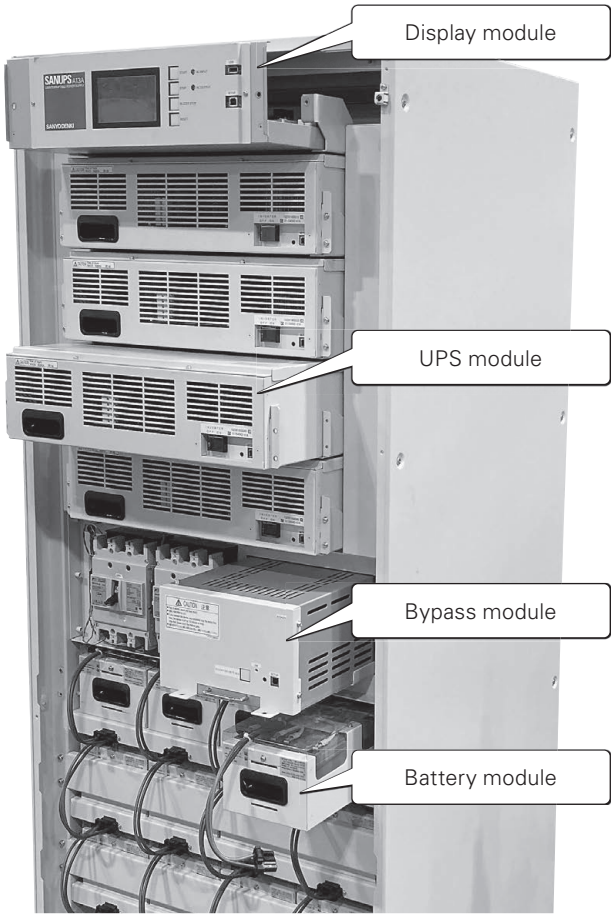

Fig. 4 Internal structure of inverter panel (25 kVA model)

3.5 Long service life

The expected life of the new product is 15 years, which is much longer than the 10 years of conventional UPSs. Additionally, regular replacement parts such as a cooling fan and electrolytic capacitor last as long as the product, eliminating the need for replacement.(1)

These features help reduce maintenance costs for our customers and contribute to the realization of a sustainable society.

(1) Regular replacement parts used: batteries and fuses.

3.6 Bypass circuit diagnostics

The new product can diagnose its bypass circuit while supplying power through the inverter. Figure 5 shows the bypass circuit. Diagnosis is performed by individually turning on and off the magnetic switches MC1 and MC2, and the AC switch, and checking the voltage at both ends of the switches.

Since the bypass circuit can be diagnosed before switching to bypass power, users can perform UPS maintenance with peace of mind.

Even if the diagnosis reveals an abnormality in the bypass circuit, the bypass module can be replaced without stopping the UPS functions.

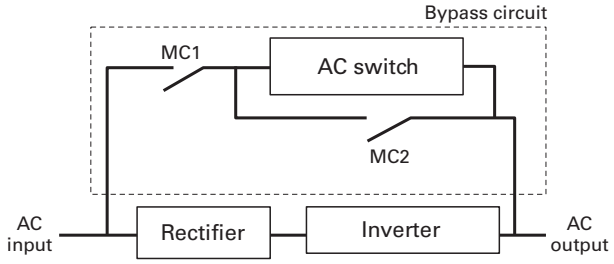

Fig. 5 Bypass circuit

4. Conclusion

In this article, we introduced the newly developed *SANUPS A13A* modular UPS.

It has the following six features.

(1) Realizes highly reliable power supply through modularized parallel redundant operation.
(2) Reduces running costs and CO_2 emissions thanks to its high conversion efficiency.
(3) Minimizes equipment downtime through improved maintainability.
(4) Helps prevent battery degradation and reduce battery replacement frequency thanks to its wide AC input voltage range.
(5) Helps reduce maintenance costs and contributes to the realization of a sustainable society through its long service life.
(6) Enables the bypass module to be replaced without stopping UPS functions via its bypass circuit diagnostic function.

The *SANUPS A13A* improves UPS reliability and ensures high maintainability and availability by combining modularization, parallel redundant operation, and a bypass circuit diagnostic function.

Going forward, we will continue to develop products that meet customer needs and contribute to the realization of a safe and secure society.

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The *SANUPS A11N-Li* Online UPS with Long-life Li-ion Battery

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Shota Ozawa Shogo Yoshinaga Nobuya Otsuki

1. Introduction

Uninterruptible power supplies (UPSs) are devices that ensure a stable power supply to servers, ICT equipment, and factory equipment and also protect against data loss and equipment damage in the event of a power outage by supplying power until the equipment can be safely stopped or shut down.

It has been demanded to offer a UPS with a longer service life, a reduction in size and weight, and a wider operating temperature range. However, since there has been no other battery option than the mainstream lead-acid battery, achieving these specification requirements has been difficult. In response, we recently started developing lithium-ion battery (LIB) UPSs, which use high-energy-density LIB in place of conventional lead-acid batteries.

In this article, we will introduce the *SANUPS A11N-Li* LIB UPS. We will begin by presenting its appearance and electrical specifications. Next, we will describe its features including safety features for ensuring safe use of lithium-ion batteries.

2. Product Overview

The *SANUPS A11N-Li* uses the same UPS unit as our conventional lead-acid battery UPS, the *SANUPS A11N*.[1] Therefore, it inherits the high conversion efficiency and highly reliable parallel redundancy of the conventional product.

The new product, however, features a newly developed dedicated LIB pack in place of the conventional product's lead-acid battery for improved performance. This change provided the new product with a longer service life, a smaller and lighter design, and a wider operating temperature range.

Figure 1 shows the *SANUPS A11N-Li* 5 kVA model. The battery pack and inverter come as plug-in modules. Figure 2 shows the internal structure of the *SANUPS A11N-Li* 5 kVA model.

The product lineup is available in four models with 5, 10, 15, and 20 kVA output capacities consisting of one to four 5-kVA base units connected in parallel. Figure 3 shows the *SANUPS A11N-Li* 20 kVA model.

Table 1 shows the electrical specifications of the *SANUPS A11N-Li* single-unit type 5 kVA model.

Mounted in a 19-inch rack

Fig. 1 The *SANUPS A11N-Li* 5 kVA model

Fig. 2 Internal structure of the *SANUPS A11N-Li* 5 kVA model

Fig. 3 The *SANUPS A11K-Li* 20 kVA model

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

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

3. Features

Table 2 compares the specifications of the conventional *SANUPS A11N* 5 kVA single-unit type using lead-acid batteries and the new *SANUPS A11N-Li* 5 kVA single-unit type.

Table 2 Specification comparison of the *SANUPS A11N* and *SANUPS A11N-Li*

Model	A11N single-unit type 5 kVA model	A11N-Li single-unit type 5 kVA model
Battery type	Small-sized valve-regulated lead-acid (VRLA) battery	Lithium-ion battery
Backup time [min]	10	10
Battery life (30ºC ambient temperature)	About 5 years	About 10 years
End-of-life capacity	50%	80%
Dimensions [W × D × H mm]	435 × 700 × 174.5	435 × 700 × 130
Required rack space*	4U	3U
Battery capacity [Wh]	940	1056
Mass [kg]	80	46
Operating temperature range	0 to +40ºC	-10 to 55ºC

* For EIA standard 19-inch racks. One rack unit (1U) occupies 44.5 mm of height.

In addition to the same features as the conventional product, the new product has the following additional features.

3.1 Long service life

Lithium-ion batteries have an expected life of 10 years, saving the man-hours and cost of replacing batteries. Moreover, the end-of-life capacity of lithium-ion batteries is 80%, while that of lead-acid batteries is 50%, offering longer backup times for extended periods of time.

3.2 Reduced size and weight

Compared to the conventional product, the new product has been made smaller and lighter, reducing volume and mass by 25% and 42%, respectively, without compromising backup time.

3.3 Wide operating temperature range

The new product has a wider operating temperature range of -10 to 55ºC, extended from the 0 to 40ºC of the conventional product, enabling use in harsher environments

4. Key Points of Development

Lithium-ion batteries have a high energy density and require enhanced safety measures to prevent thermal runaway of the cells. Therefore, the battery pack comes with management functions to detect and protect against battery malfunctions. It features a robust housing and cell layout that suppresses smoke and fire from cells, if one occurs.

Figure 4 shows the circuit configuration of the *SANUPS A11N-Li* single-unit type 5 kVA model.

A battery pack consists of 24 V battery modules in an 8S2P (8-series 2-parallel) configuration, and each battery module consists of multiple battery cells. A CMU (Cell Management Unit) measures the battery module's voltage, current, cell voltage, and cell temperature, and controls the cell voltage balance accordingly. Each CMU communicates battery module information to the BMU (Battery Management Unit). The BMU monitors all the cells to detect and protect against battery pack abnormalities. It also calculates the battery capacity and communicates measured values and fault information to the inverter module. If the BMU detects an abnormality such as cell overcharge or overdischarge, it disconnects all the battery modules from the main circuit to ensure safety.

Given below are the new product's fault detection and protection functions and its safety design.

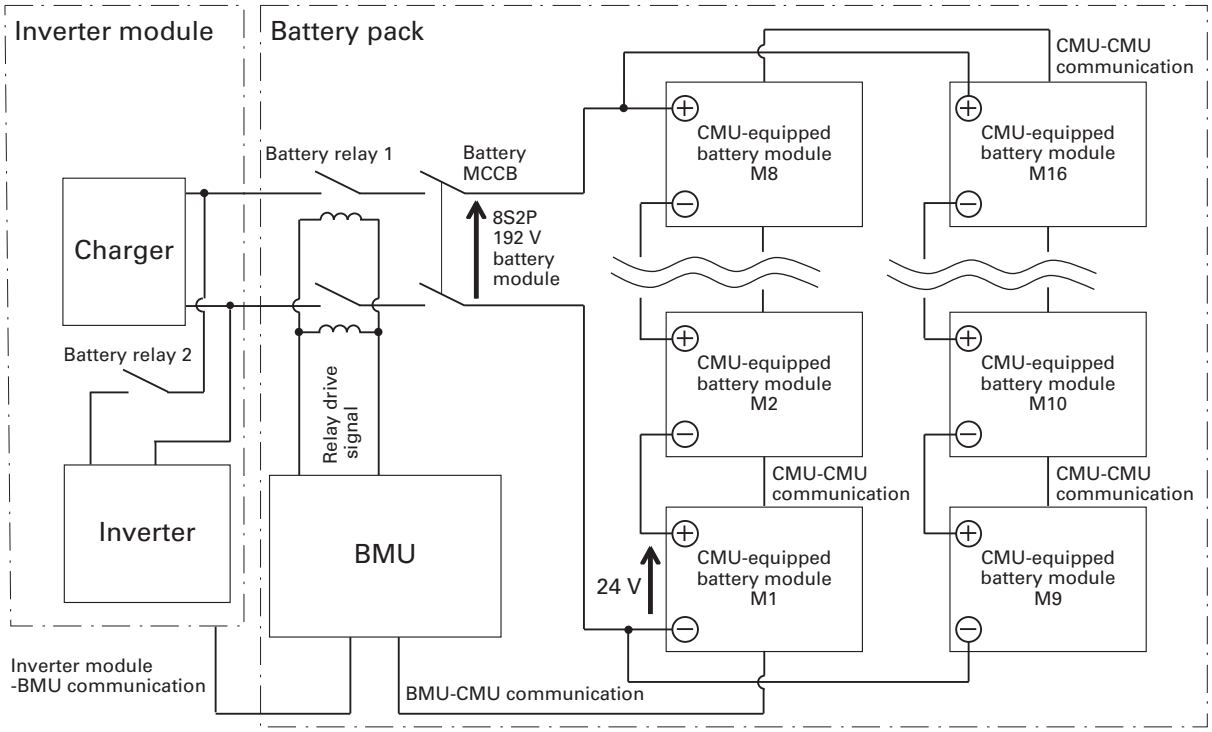

Fig. 4 Circuit configuration of the *SANUPS A11N-Li* single-unit type 5 kVA model

4.1 Fault detection and protection

If the BMU detects any of the following faults (1) through (5), the BMU turns off the battery relay 1 and quickly disconnects all the battery modules from the main circuit. The inverter module, upon receiving fault information from the BMU, shuts down the charger. If a fault is detected during battery operation, the inverter module will also turn off the battery relay 2 and disconnect the main circuit. This ensures the protection of both the inverter module and the battery pack.

(1) Overcharge/Overdischarge voltage detection

The BMU detects overcharge and overdischarge by monitoring the battery module voltage and cell voltage measurement data sent from the CMU.

(2) Cell imbalance detection

The BMU monitors all the cell voltage information sent from the CMU to detect excessive imbalances in cell voltages based on their maximum and minimum values.

(3) Charging/Discharging overcurrent detection

The BMU detects overcurrent by monitoring the charge and discharge current data measured by the CMU using a current sensor.

(4) Over/Under-temperature detection

The BMU detects over-/under-temperatures in the cells by monitoring the cell temperature measured by the battery module's temperature sensor. In addition, the inverter module stops charging and discharging for protection by detecting a rise or drop in ambient temperature.

(5) Communication error detection

The BMU monitors CMU-CMU and CMU-BMU communications. The BMU and inverter module monitor communications between the BMU and inverter module. A communication error is detected whenever any of the communications are interrupted.

Even if a relay cannot be disconnected through (1) to (5) above, the UPS ensures protection against overcurrent and short circuits for safe use by blowing the fuse of each CMU and turning off the battery MCCB connected in series to the battery relay 1.

4.2 Structural safety

The battery pack is protected by a steel plate enclosure to withstand external shocks. Figure 5 shows the battery pack.

In a battery module, eight battery cells are laid out in a way so that they do not interfere with each other. Therefore, even if a cell catches fire, heat transfer to surrounding cells is reduced, thereby suppressing the spread of fire. Figure 6 shows the cell configuration of the battery module.

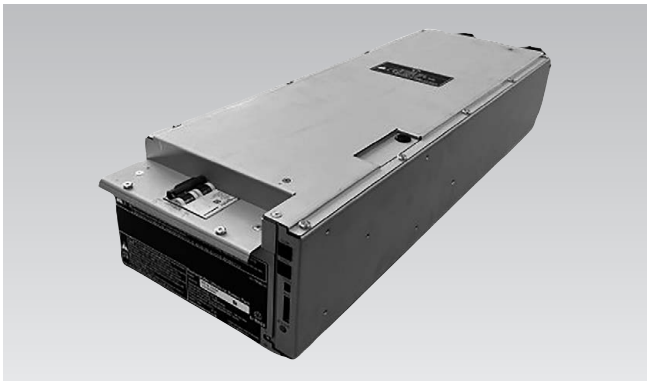

Fig. 5 Battery pack

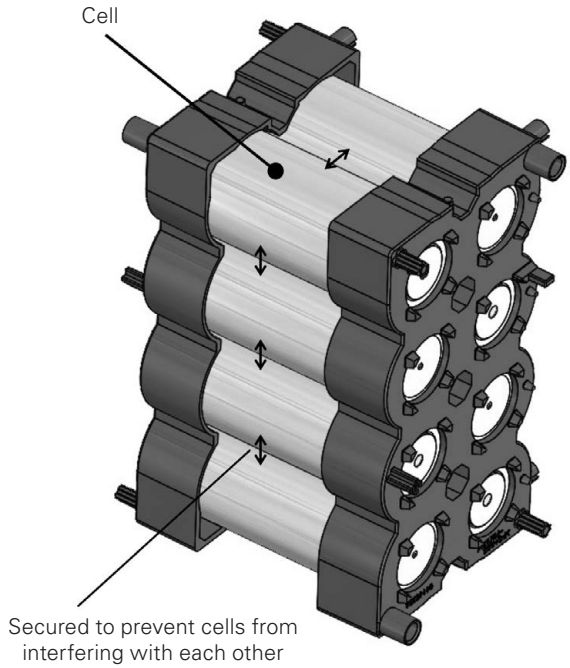

Fig. 6 Cell configuration of battery module

The battery pack ensures a high level of safety, having passed the drop test and combustion test specified in JIS C 8715-2 (Secondary lithium cells and batteries for use in industrial applications—Part 2: Tests and requirements of safety).[(2)]

5. Conclusion

In this article, we introduced the *SANUPS A11N-Li* LIB UPS. The new product offers the following features and ensures the safety required when using lithium-ion batteries.

(1) Uses lithium-ion batteries to achieve a long service life, a small and lightweight design, and a wide operating temperature range.
(2) Safety features to ensure a high level of safety: battery management functions for detecting and protecting against battery faults and a battery design that prevents cell smoke or fire, if one should occur, from spreading.

Looking ahead, we plan to expand our lineup of lithium-ion battery UPSs based on these achievements.

References

(1) Makoto Kitazawa and others: "Development of the Online UPS *SANUPS A11N*", SANYO DENKI Technical Report No.54
(2) Japanese Industrial Standards Committee: "JIS C 8715-2 (Secondary lithium cells and batteries for use in industrial applications—Part 2: Tests and requirements of safety)"

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SANMOTION Products

Tsuyoshi Kobayashi

We at the SANYO DENKI Group aim to create new value and address social issues by developing and providing products and services that have never been seen before. In line with the increasing awareness of the SDGs in recent years, we have been developing new products that enhance the performance, quality, and reliability of our customers' equipment while also considering societal and environmental impacts.

This article presents the SANMOTION products developed in 2023.

Firstly, we have added a new power regeneration model to the lineup of the *SANMOTION R* power supply units. This model feeds the regenerative power generated during servo motor deceleration back to the power grid.

When a motor decelerates, it acts as a generator and produces regenerative power. Through this technology, the unit efficiently feeds the energy back to the power grid, reducing power consumption in equipment and factories. In addition, it accurately measures the current and voltage of the converter, allowing users to check the amounts of power consumed by their servo system and saved by reusing it.

The product contributes to making equipment more energy-saving with its power regeneration technology and power condition visualization.

Next, we developed the *SANMOTION C S200* motion controller with technology for managing equipment operation featuring functions for equipment status monitoring and troubleshooting.

This product can remotely monitor equipment conditions and send production status notifications by email, enabling maintenance from any location.

It also records servo system information and camera images on memory cards over long periods, enabling users to check equipment operating conditions and quickly address errors for reduced downtime.

To sum up, the power regeneration model of the *SANMOTION R* power supply unit contributes to reducing customer power consumption and preserving the global environment through the use of power regeneration technology and energy-saving useful functions.

The motion controller uses email notifications, remote monitoring, and image recording to improve equipment productivity and contribute sustainable production.

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

■ The *SANMOTION R* power supply unit, power regeneration model

Recently, efforts have been underway toward the realization of an eco-friendly, sustainable society through the effective use of renewable energy and further energy savings. In this context, servo systems are required to use energy more efficiently and contribute further to energy savings.

To meet these expectations, we have added a newly developed power regeneration model to the lineup of the *SANMOTION R* power supply units, which feeds the servo motor's regenerative power back to the power grid. Its features are as follows.

1. Reuse of regenerative power

When equipment decelerates, the servo motor acts as a generator and produces regenerative power. Our current regenerative resistor model, with its resistor, consumes the regenerative power as heat. The existing power supply unit lineup has been expanded with the addition of the new power regeneration model, which feeds the regenerative power back to the power grid for reuse.

The new model enables the regenerative power to be reused to power other equipment, reducing the total power consumption of a factory.

2. Power supply and power consumption monitoring

The voltage, current, frequency, and power consumption during the new model's power running and regeneration can be checked via an EtherCAT-connected controller. The function helps users reduce electricity costs by enabling them to review the operating conditions and manage the power consumption of their entire factory based on this information. Such detailed operational data helps review the operating conditions of equipment and manage factory power consumption, reducing electricity costs.

3. Remaining component life estimation

The product estimates the remaining lifespan of regular replacement parts, enabling users to plan a replacement for components such as the main circuit electrolytic capacitor and cooling fan. This helps planned maintenance such as inspections, repairs, and parts replacements, ensuring the productivity of production lines.

Additionally, a drive recorder logs the power regeneration model's operating conditions, power supply status, and load conditions as waveforms, helping identify changes and alarm causes to reduce recovery time.

In this way, the power regeneration model added to the *SANMOTION R* power supply unit lineup facilitates energy management for customer equipment and entire factories, contributing to reduced electricity costs and environmental preservation.

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

Note: The company names and product names listed in this article are the trademarks or registered trademarks of their respective owners.

■ The *SANMOTION C S200* Motion Controller

In recent years, IoT technologies have been increasingly used in various industries to improve production productivity and quality. To ensure efficient, stable production, motion controllers must detect changes in the operating conditions and the ambient environment of equipment to promptly respond to these changes. There is also a demand to collect and record equipment data in real time to quickly resume operations in the event of a shutdown.

Accordingly, we developed the *SANMOTION C S200* motion controller, which accurately monitors equipment operating conditions for easy maintenance. Its features are as follows.

1. Real-time monitoring of equipment conditions

This controller features SMTP protocol-based email notification to promptly inform the administrator when equipment errors are detected. It can also send notification emails regarding production information such as when the planned production volume is reached. This enables users to quickly understand the equipment status and production conditions, helping maintain stable, efficient production.

2. Remote monitoring and maintenance

Remote monitoring of the operating conditions, including axis positions and error information, has been achieved by connecting the device to Automation Server(1) and using the web-based data visualization.(2) Furthermore, users can test and modify programs by connecting to a VPN(3). This function enables equipment to be maintained from any location at any time, reducing the time required for maintenance and inspection.

3. Quick root cause analysis

The new controller can collect and record time-series data on connected servo systems, digital input/output signals, and environmental conditions such as temperature and humidity. It can store the collected data in its built-in storage or a microSD card, enabling users to check equipment operating conditions over long periods of time. The new controller can also record the equipment status as an image when connected to a webcam. For example, when an error occurs, the new product records images before and after the error, enabling prompt identification of the root cause.

In this way, the motion controller is designed to detect changes in the operating conditions and ambient environment of the equipment, promptly notifying users of the status. If an error occurs, users can analyze the recorded data to promptly identify the cause, reducing the time needed to restore normal operational status.

Furthermore, it contributes to improving the productivity of equipment by enabling users to remotely monitor the operating status of equipment and perform maintenance when necessary.

(1) The name of the cloud service provided by CODESYS for remotely operating controllers.
(2) A drawing tool feature for designing screens on a web browser.
(3) VPN, or Virtual Private Network, is a technology for connecting locations with dedicated virtual lines and securely exchanging information.
Note: The company names and product names listed in this article are the trademarks or registered trademarks of their respective owners.

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Development of the *SANMOTION R* Power Supply Unit, Power Regeneration Model

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1. Introduction

Curbing global warming, which is causing widespread climate change, requires sustainable initiatives focused on environmental conservation and enhancing energy efficiency.

In the field of servo systems, there is a growing demand for products that offer energy savings, low carbon emissions, and enhanced maintainability, in addition to improved servo performance.

In response, we have added to the *SANMOTION R* power supply unit lineup a new power regeneration model that features energy savings, reduced CO_2 emissions, and improved maintainability.

This article provides a product overview and introduces the features of the power regeneration model of the *SANMOTION R* power supply unit (hereinafter, "new model").

Fig. 1 New model

2. Product Overview

2.1 Appearance

Figure 1 shows the new model and Figure 2 shows its dimensions.

2.2 Product lineup

The *SANMOTION R* multi-axis servo system is configured by combining a power supply unit, amplifier unit(s), control board(s), and servo motor(s) according to the customer's equipment, as shown in Figure 3. To expand the power supply unit lineup, we have added the power regeneration model (200 VAC, 37 kW).

When using the new model, an AC reactor is to be installed to mitigate the current and voltage distortions, as shown in Figure 4.

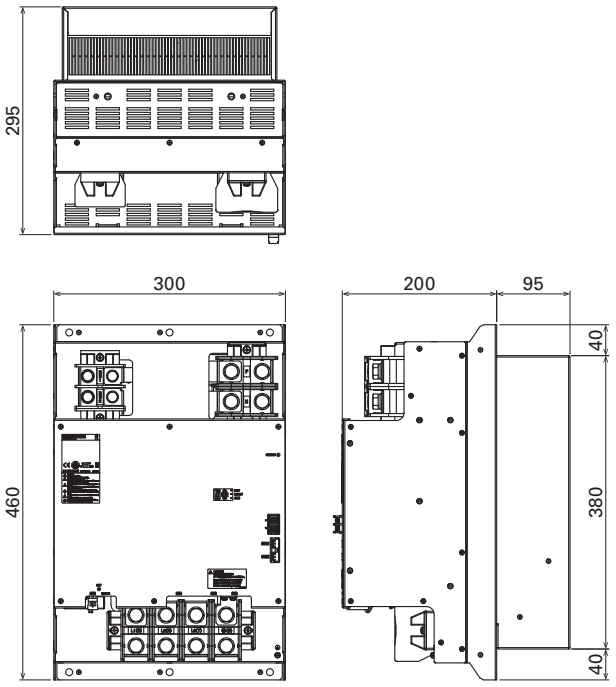

Fig. 2 Dimensions of new model (Unit: mm)

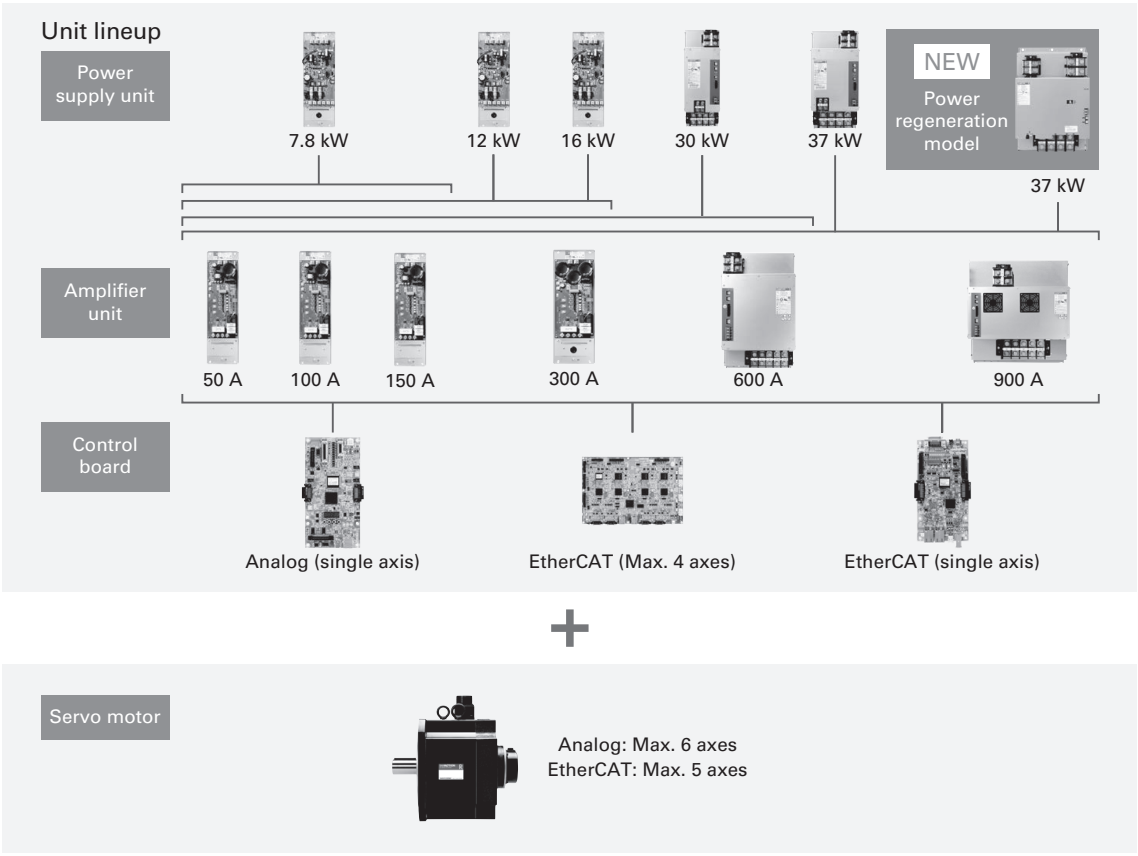

Fig. 3 Lineup of the *SANMOTION R* multi-axis servo systems

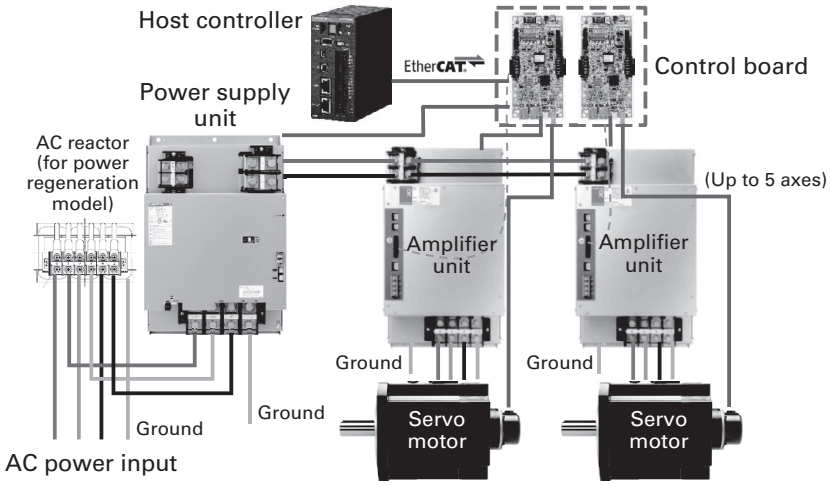

Fig. 4 System configuration for new model

2.3 Specifications

The new model supports a 200 VAC input voltage and can output and regenerate a rated power of 37 kW. Table 1 shows the general specifications.

Table 1 General specifications

Items		Specifications and functions
Main power supply voltage (3-phase)		200 to 230 VAC +10%, -15%
Power supply frequency		50/60 Hz ± 3 Hz
Allowable power voltage imbalance		±2%
Control power (power supply unit)		24 VDC ±15%
Control power (amplifier unit)		200 to 230 VAC +10%, -15%
Rated power		37 kW
Maximum instantaneous power		74 kW
Power factor (during power running) **Power factor (during regeneration)**		92.0% (at 100% load) 88.0% (at 100% load)
Regenerative capacity		Continuous at 100%, 20 s at 200%
Regeneration control		Combination of power regeneration and regenerative resistor*
Dimensions		300 (Width) × 460 (Height) × 295 (Depth) [mm]
Mass		24.5 kg
Compliance with standards	**UL/cUL**	UL 61800-5-1
	Electrical safety	IEC 61800-5-1 EN 61800-5-1
	EMC	EN 61000-6-2 IEC 61800-3 EN 61800-3
	KC Mark	KS C 9610-6-2 KS C 9610-6-4
	RoHS Directive	IEC 63000:2018 EN 63000:2018

* External regenerative resistor required separately.

With a maximum regenerative capacity of up to 200% of the rated output for 20 seconds, the new model is available for equipment that generates large amounts of regenerative power instantaneously. If a momentary outage occurs during regeneration, however, regenerative power cannot be fed back to the power supply. In such cases, the new model switches to the built-in regenerative resistor, ensuring reliable use.

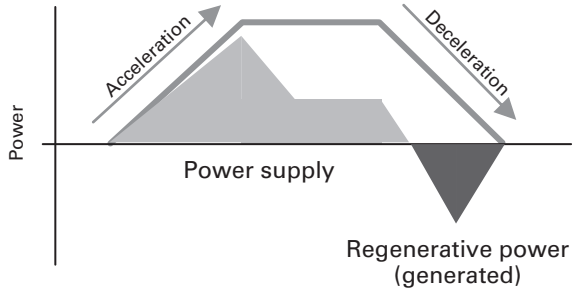

Fig. 5 Illustration of regenerative power produced during servo motor operation

3. Features

The main features of the new model are as follows.

3.1 Reuse of regenerative power

Servo motors are powered by the power supply during acceleration and constant-speed operation. During deceleration, on the other hand, they act as generators and produce regenerative power. Figure 5 illustrates how regenerative power is produced during servo motor operation.

The *SANMOTION R* multi-axis servo system's main circuit power supply can be shared through the system and the regenerative power can be used to drive servo motors on the other axes.

With the current regenerative resistor model, any excess regenerative power is only consumed as heat in the resistor, instead of powering other axes. By replacing the current

regenerative resistor model with the new model, the regenerative power can be fed back to the power supply for reuse in other devices within the same equipment or elsewhere in the factory.

Figure 6 illustrates the flow of power during power running and regeneration.

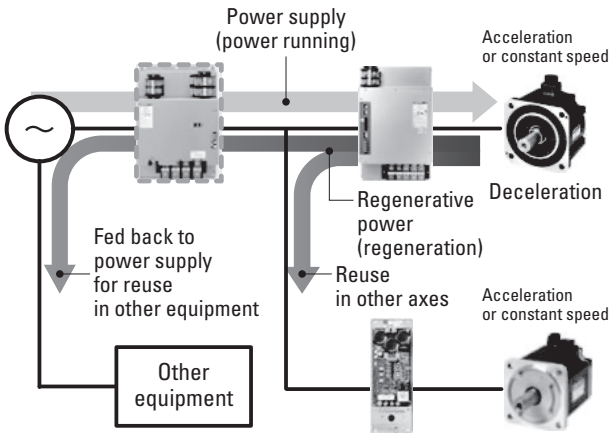

Fig. 6 Flow of power during power running and regeneration

The new model reduces the electricity usage in machinery and entire factories, also reducing CO_2 emissions. For example, if a servo motor runs in a cycle of operating at 100% of its rated output and then switches to regeneration at 50%, the new model reduces CO_2 emissions by 43% compared to the regenerative resistor model. This reduction contributes to mitigating global warming.

3.2 Power supply and power consumption monitoring

As shown in Figure 7, the new model is equipped with feature-rich monitoring that allows users to check power supply conditions such as voltage, current, and frequency, as well as the power consumption during power running and regeneration.

No.	Power supply condition and power consumption monitoring
1	Main circuit input voltage effective value monitor
2	Average current monitor
3	Main circuit power frequency monitor
4	Main circuit DC voltage monitor
5	Average power monitor
6	Power running monitor
7	Power consumption integration monitor
8	Power regeneration power monitor
9	Power regeneration power amount integration monitor
10	Power regeneration status monitor

Fig. 7 List of monitored power supply and power consumption items

The new model is equipped with a device designed to detect power supply voltage and current for controlling regeneration. This device measures the actual power supply voltage and current, providing high-precision power monitoring.

These monitoring features help assess input power quality, enabling efficient electricity usage management across equipment and the entire factory.

3.3 Improved maintainability (preventive maintenance)

The remaining life of the relays, electrolytic capacitors, and cooling fans used in the new model can be monitored using EtherCAT communication and setup software. Figure 8 shows the remaining life monitoring screen.

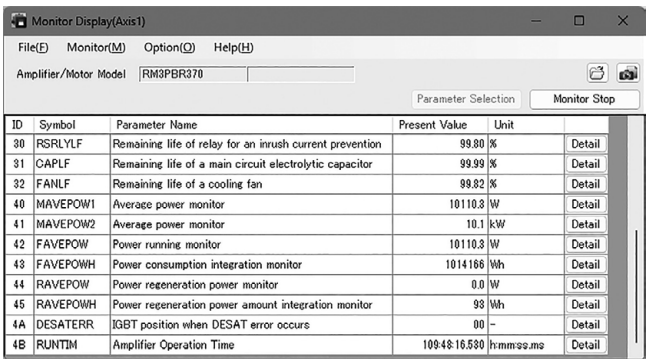

Fig. 8 Viewing monitored items using the setup software

Based on the remaining life of individual parts, the power supply unit can be maintained systematically.

3.4 Enhanced troubleshooting analysis (drive recorder)

The current lineup of the *SANMOTOR R* multi-axis servo system offers a drive recorder on the control board, which is useful for analysis during troubleshooting. The new model offers a drive recorder as well, enabling it to collect data, which was not the case for the current regenerative resistor model.

Figure 9 lists the data that can be stored by the drive recorder.

No.	Data stored by drive recorder
1	Main circuit power frequency monitor
2	Main circuit rectifier voltage monitor
3	Main circuit input voltage effective value monitor
4	R-phase current monitor
5	S-phase current monitor
6	Average current monitor
7	Internal temperature monitor
8	Average power monitor
9	Power running monitor
10	Power consumption integration monitor
11	Power regeneration power monitor
12	Power regeneration power amount integration monitor
13	IGBT monitor on overcurrent condition
14	Power regeneration status monitor

Fig. 9 Data stored by drive recorder

By integrating two drive recorders—one for the control board and another for the new model—more extensive data can be analyzed. This ensures prompt troubleshooting, minimizing downtime and speeding up recovery.

4. Conclusion

In this article, we presented an overview of the power regeneration model of the *SANMOTION R* power supply unit (200 VAC, 37 kW) and described some of its features.

The significance of the new model is as follows.

- Energy savings

  Power regeneration technology has been adopted to efficiently reuse regenerative power in other axes of the same equipment or other equipment within the factory, reducing overall power consumption throughout the facility.

- Visualization of power supply conditions and power consumption

  Users can check the input power supply voltage and current of the power supply unit, as well as the power consumption of the servo system. This contributes to monitor of quality of the input power source and manage the electric energy consumption within the equipment and factory.

- Improved maintainability

  The power supply unit can be maintained systematically based on the remaining life of relays, electrolytic capacitors, and cooling fans, minimizing equipment downtime.

- Enhanced troubleshooting analysis

  Equipped with a drive recorder, the new model swiftly identifies and resolves issues that may arise.

Overall, the new model offers increased energy efficiency, reduced carbon emissions, and enhanced maintainability. Going forward, we will continue to develop products that help create new value for our customers.

References

(1) Masaaki Mizusawa and 6 others: "Development of the *SANMOTION R* 400 VAC Input Multi-axis Servo Systems (37 kW, 300/600 A)"
SANYO DENKI Technical Report, No. 51, pp. 27-31 (2021.5)

(2) Takashi Kataoka and 7 others: "*SANMOTION R ADVANCED MODEL* 400 VAC Input Multi-axis Servo Amplifier"
SANYO DENKI Technical Report, No. 45, pp. 34-38 (2018.5)

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List of Awarded and Nominated Engineers for the 72nd JEMA Technological Achievement Award in 2023

Heavy Electrical Category			
Prize	**Title**	**Department**	**Name**
Encouragement Award	Development of the *SANMOTION G* AC Servo Motor	Public Relations Sect., Corporate Planning Dept.	Hiroki Sagara
		Design Dept. 1, Servo Systems Div.	Mai Ishikawa, Takuya Saito
		Design Dept. 2, Servo Systems Div.	Kazuhiro Makiuchi, Tetsuya Okazaki
	Development of the *SANMOTION G* AC Servo Amplifier	Design Dept. 2, Servo Systems Div.	Yuuki Nakamura, Toshio Hiraide, Masaki Miyashita, Masanao Somemiya, Hideaki Nishizawa
	Development of High-Precision Disk Module Assembly Technology	Production Engineering and Development Sect., Production Engineering Dept., Servo Systems Div.	Takahiro Yoneta
		Subsect. 1, Production Engineering and Development Sect., Production Engineering Dept., Servo Systems Div.	Hideyuki Ayuzawa, Yuki Matsubara, Tomoe Kodama, Jun Matsuzaka
	Establishment of Automatic Weighing Method for Epoxy Resin Using Load Cells	Subsect. 1, Production Engineering Sect., Production Dept., Cooling Systems Div.	Yuki Kanbayashi

Department names are those at the time of nomination.

Major Patents

■ **Patents registered in FY 2023**

Patent Number	Title	Inventor(s)
Philippines - 1-2010-500073	COUNTER-ROTATING AXIAL-FLOW FAN	Toshiyuki Nakamura, Atsushi Yanagisawa, Katsumichi Ishihara
Germany - 03064904	MEASUREMENT DEVICE	Katsumichi Ishihara, Takahisa Toda, Yo Muramatsu
Europe - 03064904	MEASUREMENT DEVICE	Katsumichi Ishihara, Takahisa Toda, Yo Muramatsu
France - 03064904	MEASUREMENT DEVICE	Katsumichi Ishihara, Takahisa Toda, Yo Muramatsu
U.K. - 03064904	MEASUREMENT DEVICE	Katsumichi Ishihara, Takahisa Toda, Yo Muramatsu
Germany - 03085962	BIDIRECTIONAL AXIAL FAN DEVICE	Satoshi Fujimaki, Toshiya Nishizawa, Takashi Kawashima
Europe - 03085962	BIDIRECTIONAL AXIAL FAN DEVICE	Satoshi Fujimaki, Toshiya Nishizawa, Takashi Kawashima
Finland - 03085962	BIDIRECTIONAL AXIAL FAN DEVICE	Satoshi Fujimaki, Toshiya Nishizawa, Takashi Kawashima
France - 03085962	BIDIRECTIONAL AXIAL FAN DEVICE	Satoshi Fujimaki, Toshiya Nishizawa, Takashi Kawashima
U.K. - 03085962	BIDIRECTIONAL AXIAL FAN DEVICE	Satoshi Fujimaki, Toshiya Nishizawa, Takashi Kawashima
Japan - 07228949	POWER CONVERSION EQUIPMENT	Minoru Yanagisawa
China - ZL201711429557.7	MOTOR CONTROL APPARATUS	Yuji Ide, Toshio Hiraide, Michio Kitahara
Germany - 03415831	COOLING FAN AUTOMATIC CONTROL SYSTEM AND COOLING FAN AUTOMATIC CONTROL DEVICE	Naoki Murakami, Masashi Murakami
Europe - 03415831	COOLING FAN AUTOMATIC CONTROL SYSTEM AND COOLING FAN AUTOMATIC CONTROL DEVICE	Naoki Murakami, Masashi Murakami
Finland - 03415831	COOLING FAN AUTOMATIC CONTROL SYSTEM AND COOLING FAN AUTOMATIC CONTROL DEVICE	Naoki Murakami, Masashi Murakami
France - 03415831	COOLING FAN AUTOMATIC CONTROL SYSTEM AND COOLING FAN AUTOMATIC CONTROL DEVICE	Naoki Murakami, Masashi Murakami
U.K. - 03415831	COOLING FAN AUTOMATIC CONTROL SYSTEM AND COOLING FAN AUTOMATIC CONTROL DEVICE	Naoki Murakami, Masashi Murakami
China - ZL201810783296.7	SHAFT ROTATION LINEAR MOTOR	Yuqi Tang
Korea - 102583198	SHAFT ROTATION LINEAR MOTOR	Yuqi Tang
Taiwan - I791565	SHAFT ROTATION LINEAR MOTOR	Yuqi Tang
Korea - 102566943	STATOR OF ROTATING ARMATURE AND ASSEMBLY METHOD THEREOF	Mitsuaki Shioiri, Koji Nakatake, Yasushi Yoda, Hong Zhang, Kazuhiro Yoda, Shogo Yoda
Taiwan - I798377	FAN MOTOR APPARATUS AND PROTECTION COVER OF FAN MOTOR APPARATUS	Yusuke Okuda, Haruhisa Maruyama, Yoshihisa Yamazaki
China - ZL201910659887.8	FAN CONTROL APPARATUS AND FAN CONTROL METHOD	Naoki Murakami, Honami Osawa, Soma Araki, Masashi Murakami
Taiwan - I819042	FAN CONTROL APPARATUS AND FAN CONTROL METHOD	Naoki Murakami, Honami Osawa, Soma Araki, Masashi Murakami
U.S. - 11662117	FAN CONTROL APPARATUS AND FAN CONTROL METHOD	Naoki Murakami, Honami Osawa, Soma Araki, Masashi Murakami
Taiwan - I819151	ARMATURE MOLDED STRUCTURE	Manabu Horiuchi, Hiroki Sagara, Jun Kitajima, Mai Shimizu, Takashi Matsushita
Taiwan - I818138	WATERPROOF BLOWER FAN	Masaki Kodama, Toshiya Nishizawa, Kakuhiko Hata

Patent Number	Title	Inventor(s)
Japan - 07394532	MOLDED STRUCTURE OF BRUSHLESS FAN MOTOR AND METHOD FOR MOLDING BRUSHLESS FAN MOTOR	Munenori Takakuwa, Kakuhiko Hata, Yukihiro Nagatsuka
U.S. - 11735963	POLYGONAL FRAME STRUCTURE WITH ARMATURE CORE WITH CONNECTED AND OPEN CORE SHEETS INSIDE THE FRAME	Manabu Horiuchi, Yasushi Misawa, Jun Kitajima, Mai Shimizu
Japan - 07316186	MOTOR CONTROL DEVICE AND INSULATION RESISTANCE DETECTION METHOD OF SAME	Yuji Ide, Keigo Kikuchi, Toshio Hiraide
Japan - 07394603	LINEAR MOTOR AND METHOD FOR MANUFACTURING IT	Yuqi Tang
Japan - 07386145	MOTOR CONTROL DEVICE AND INSULATION RESISTANCE DETECTION METHOD OF SAME	Yuji Ide, Keigo Kikuchi, Michio Kitahara, Toshio Hiraide
Japan - 07394669	MOTOR CONTROL APPARATUS	Yuji Ide, Michio Kitahara, Toshio Hiraide
U.S. - 11784520	ROTOR STRUCTURE OF SYNCHRONUS MOTOR	Manabu Horiuchi, Keisuke Nagata
U.S. - 11804766	LINEAR HEAD MODULE	Satoshi Inaba, Yuki Onda, Yasushi Misawa
U.S. - 11572883	REVERSIBLE FAN	Yoshihisa Yamazaki
U.S. - 11764660	LINEAR HEAD MODULE	Satoshi Inaba, Yuki Onda, Yasushi Misawa
U.S. - 11808271	AXIAL FAN	Yoshihisa Yamazaki

Internal Recognition: Invention Excellence Award

Awarded in May 2023

Prize	Title	Department	Name
Excellence Award	Motor Controller Mounting Structure	Design Dept. 2, Servo Systems Div.	Yuji Ide, Takao Oshimori, Hiroaki Koike
	Control and Magnetic Bias Suppression for Grid-connected PV Inverter	Design Dept., Power Systems Div.	Makoto Ishida, Minoru Yanagisawa
	Rotary Electric Motor Stator and Its Assembly	Design Dept. 1, Servo Systems Div.	Koji Nakatake, Yasushi Yoda, Mitsuaki Shioiri, Kazuhiro Yoda, Shogo Yoda, Hong Zhang
	Automatic Encoder Identification Device	Design Dept. 2, Servo Systems Div.	Masao Mizuguchi, Ryuichi Yanagisawa
	Detection of Motor Insulation Resistance	Design Dept. 2, Servo Systems Div.	Yuji Ide, Toshio Hiraide, Masakazu Sakai
		Under Operating Officer for Technical Development	Keigo Kikuchi

Internal Recognition: Manufacturing Excellence Award

Awarded in May 2023

Prize	Title	Department	Name
Excellence Award	In-Mold Gate Cutter Design for Large Fan Molds	Subsect. 2, Production Engineering Sect., Production Dept., Cooling Systems Div.	Yoichi Yamada, Taiki Kato
	Manual Insertion Line for Improving Productivity and Reducing Defects	SANYO DENKI PHILIPPINES, INC.	Rooks Estamo, Marlon Ico, Joseph Mella

Technical Papers Published Outside the Company in General Technical Journals

January to December 2023

Title of Paper	Authors	Name of Journal	Issued on	Published by
Feature: Product and Technology Development of Member Companies and the Results of 2023	SANYO DENKI CO., LTD.	*Denki* (Electrical Appliances)	2022.02	The Japan Electrical Manufacturers' Association (JEMA)
Development of Compact UPS Series *SANUPS E11B-Li* and *SANUPS A11M-Li*	Hiroshi Sakaba, Akihiro Tsukada, Kazuya Nishizawa	*Smart Grid*	2023.01	Taiga Publishing Co., Ltd.
SANMOTION Servo Systems - Features, Technical Development, and Application Examples	Yasushi Misawa, Tsuyoshi Kobayashi	*Machine Design*	2023.11	Nikkan Kogyo Shimbun

Technical Papers Published Outside the Company

January to December 2023

Title of Paper	Authors	Name of Journal	Issued on	Published by
Simultaneous Temperature Estimation of Winding and Magnet of PMSM by High-Frequency-Injection into Static Coordinate (Second Report)	Yuji Ide, Daigo Kuraishi, Akihiko Takahashi, Michio Kitahara (Joint-author: Nagaoka University of Technology)	IEEJ Technical Meeting Papers	2023.01	IEEJ Joint Technical Meeting on Semiconductor Power Converter and Motor Drive Linear Drive Technology That Meets Diversifying Needs
Linear Drive Technology That Meets Diversifying Needs	Satoshi Sugita (Joint author: Investigating R&D Committee on Technology for Utilizing Industrial Linear Drives)	IEEJ Technical Report	2023.04	IEEJ (D), Industrial Applications Category
Redefining the Instantaneous Maximum Power of Motors Required for Service Robots	Satoshi Sugita (Joint author: Technical Investigation Expert Committee for Defining Suitable Motors for Service Robots)	IEEJ Industrial Applications Category Conference	2023.08	IEEJ (D), Industrial Applications Category

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