Development of the *SANUPS A22A* Modular Uninterruptible Power Supply

Hiroya Tokutake Hiroshi Hirata Yoshiko Kondo Yuzo Kubota Hiroyuki Kaneko

Toshifumi Nishizawa Yoshimi Sunohara Tomoharu Tanaka Yuta Abe Mika Takehara

1. Introduction

In recent years, due to the advancement of information and communications technology and the popularization of applied products, stoppages of 24/7 data centers and public infrastructure have an even greater impact on society. For this reason, uninterruptible power supplies (UPS) which provide backup power to load devices in those facilities must also be highly reliable.

SANYO DENKI has developed the *SANUPS A22A*, a modular double conversion online UPS, to back up devices requiring high reliability by using a parallel redundant operation system, which, in combination with modular 5 kVA units, also makes it possible to perform maintenance on individual UPS modules while supplying power to the devices.

This article describes the overview and features of the *SANUPS A22A*.

2. Product Overview

The *SANUPS A22A* was designed to provide backup power for mission-critical devices used in data centers and public infrastructure facilities which require high reliability. It consists of inverter modules, battery packs, and a cabinet. Up to twenty-one 5 kVA inverter modules can be paralleled in the cabinet.

The lineup includes a 3-phase 4-wire model with a maximum output capacity of 105 kVA, and a single-phase 2-wire model with a maximum output capacity of 50 kVA. With the modular configuration of the 5 kVA units, optimal output capacity can be selected by adjusting the number of inverter modules used. In addition, backup time can be extended by adding optional battery modules. As such, this UPS can be flexibly arranged in an optimal system configuration for the operating environment.

Moreover, the same inverter module is used for both the 3-phase 4-wire model and the single-phase 2-wire model, and cabinets are available in either 3-phase or single-phase output configuration.

Figure 1 shows the appearance of the cabinets, and Figure 2 shows the appearance of the inverter module and battery packs. The cabinets are available in two types: one which accommodates up to four inverter modules for output capacities up to 20 kVA, and one which accommodates up to seven inverter modules for output capacities up to 35 kVA.

Fig. 1 Cabinets

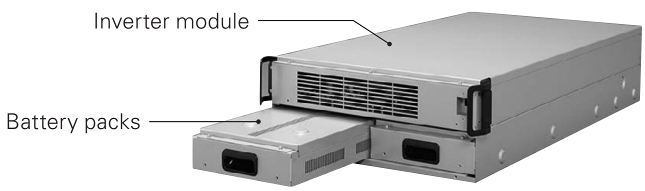


Fig. 2 Inverter module and battery packs

The circuit configuration features a double conversion online topology (3-level type) which supplies high-quality power unaffected by input voltage or input frequency, thereby achieving the highest efficiency in the industry.*

The output voltage setting options are 380 V, 400 V, and 415 V for the 3-phase 4-wire model, and 220 V, 230 V, and 240 V for the single-phase 2-wire model, making this device suitable for the various voltage standards of Asia and Europe.

Moreover, the cabinets have a user-friendly operating touch screen for intuitive operation.

3. Features

3.1 Parallel redundant operation

The *SANUPS A22A* features parallel redundant operation, and in the 3-phase output configuration, up to twenty-one 5 kVA inverter modules can be connected in parallel. Figure 3 shows a parallel redundant circuit diagram. With this feature, if you have at least one inverter module more than that which is required to cover the load capacity, even if one inverter module fails, inverter operation can continue with remaining inverter modules, offering a highly reliable power supply.

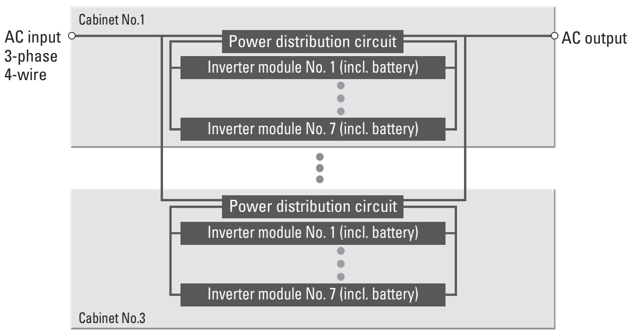


Fig. 3 Parallel redundant circuit diagram

3.2 Flexible system configuration

The modular design allows users to select the output capacity in 5 kVA increments depending on the number of inverter modules connected in parallel. The output capacity options are up to 105 kVA for the 3-phase 4-wire model, and up to 50 kVA for the single-phase 2-wire model. Also, backup time can be extended by adding optional battery modules. As such, this UPS can be flexibly arranged in an optimal system configuration to satisfy the needs of the operating environment.

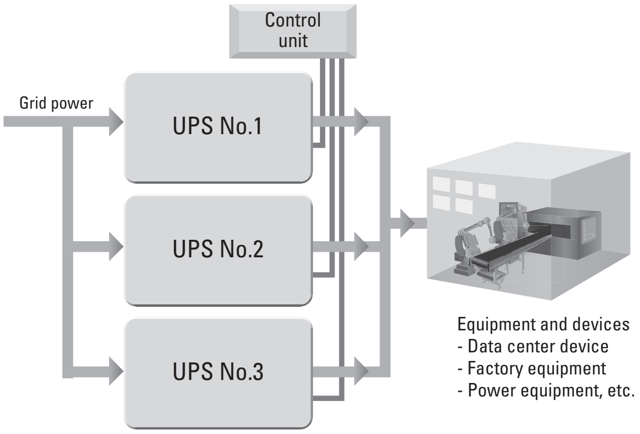
3.3 Fully autonomous control method

For this product, the inverter modules can operate in parallel using a fully autonomous control method.

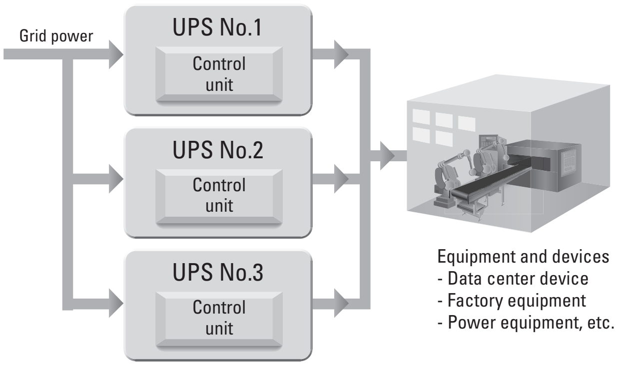
In general, when paralleling the inverters in UPS units, the output of each inverter is in alternating current, so it is necessary to synchronize their voltage amplitude, phase, and frequency. If the AC output from the inverter modules operating in parallel gets out of sync with each other, even slightly, this may cause a potentially damaging voltage disparity. Moreover, the output of each inverter is connected only with wiring, so the resistance between inverters is extremely small and even a slight voltage difference causes excess current (called cross-current) to flow between inverters as per Ohm's law, that is, "current = voltage difference/resistance." In such cases, an individual inverter would be unable to supply this excess current, causing the inverter to stop. To suppress this cross-current, there is a control unit, as shown in Figure 4 (a), which enables parallel operation. This form of parallel operation by distributing the same voltage command and phase/frequency command to each inverter is known as the "central control method."

However, if this central control unit fails, the whole system would stop. Even if the inverter module was very reliable, if the reliability of the central control unit was low, the reliability of the whole system would be low.

Therefore, this product uses a fully autonomous control method characterized by a control unit on each individual inverter module instead of a central control unit for the parallel operation. Parallel operation is achieved by each inverter module independently suppressing cross-currents. As a result, by individually controlling each inverter module and eliminating the risk brought by the central control unit, the reliability of the whole system is improved.



(a) Central control method



(b) Fully autonomous control method

Fig. 4 Control methods for parallel operation

3.4 Improved maintainability

The modular design makes service work such as replacing inverter modules and battery packs much easier. Figure 5 shows how the inverter module and battery packs are installed.

The inverter module and battery packs are plug-in types, allowing them to be installed and removed from the front of the UPS. Even in the unlikely event that one of the inverter modules fails during parallel redundant operation, it would be possible to hot swap (insertion/removal while connected to a load) it without interrupting the inverter power, enabling maintenance work to be performed swiftly.

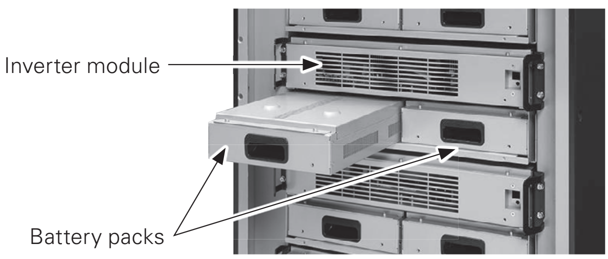


Fig. 5 Installation image

3.5 Industry's highest efficiency

By adopting the 3-level method for the rectifier and inverter conversion circuit, we have achieved the highest efficiency in the industry * (94.5%). This reduces running costs and contributes to energy saving.

3.6 Output power factor of 1.0

In recent years, an increasing number of power supplies for servers are equipped with an input current power factor correction function, meaning that load power factors are also increasing.

In light of such circumstances, we achieved an output power factor of 1.0 for this product. As such, it is possible to supply sufficient power even for load devices with high input power factors, which are predicted to increase in the future.

3.7 Wide input range

The allowable input voltage range is wide: -20 to +15% at a load level above 70%, and -40 to +15% at a load level 70% or below.

This wide input voltage range reduces the frequency of switching to battery operation even when the input power source is unstable, as well as minimizes battery drain and wear caused by frequent discharging.

3.8 Improved user experience

The *SANUPS A22A* features a vibrant touch screen user interface arranged in an intuitive, user-friendly screen layout. Figure 6 shows the UPS system's operation status screen. On the current model, operation status is displayed using LEDs, however, this product has a touch screen that vividly illustrates the status using easy-to-understand animations. Each menu is permanently displayed with tabs, and by pressing the desired menu tab, the operator can jump swiftly to another screen, making the UPS easier to navigate.

Furthermore, servicing has been simplified thanks to the intuitive user interface as maintenance personnel can operate the touch panel, for example, to set the output voltage of the UPS.

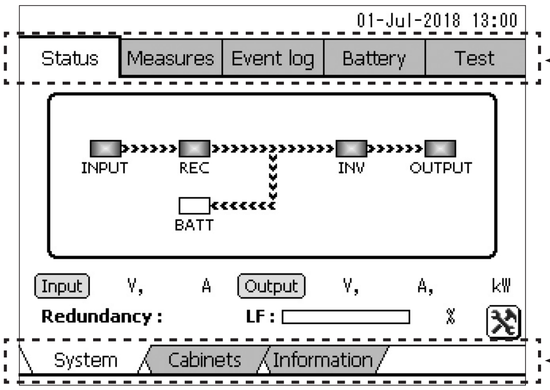


Fig. 6 UPS operation status screen

3.9 Battery management function

The product is equipped with self-diagnosis functions such as an automatic battery self-test and a battery service life management function to ensure reliable backup of load equipment during power outages. There are also battery management functions that improve reliability. Such functions include a battery service life warning, a display of total battery run time, and an estimated backup time.

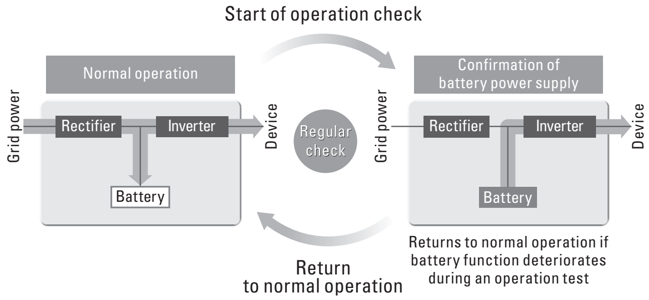


Fig. 7 Battery self-test

4. Circuit Configuration

Figure 8 shows the circuit diagram for this product.

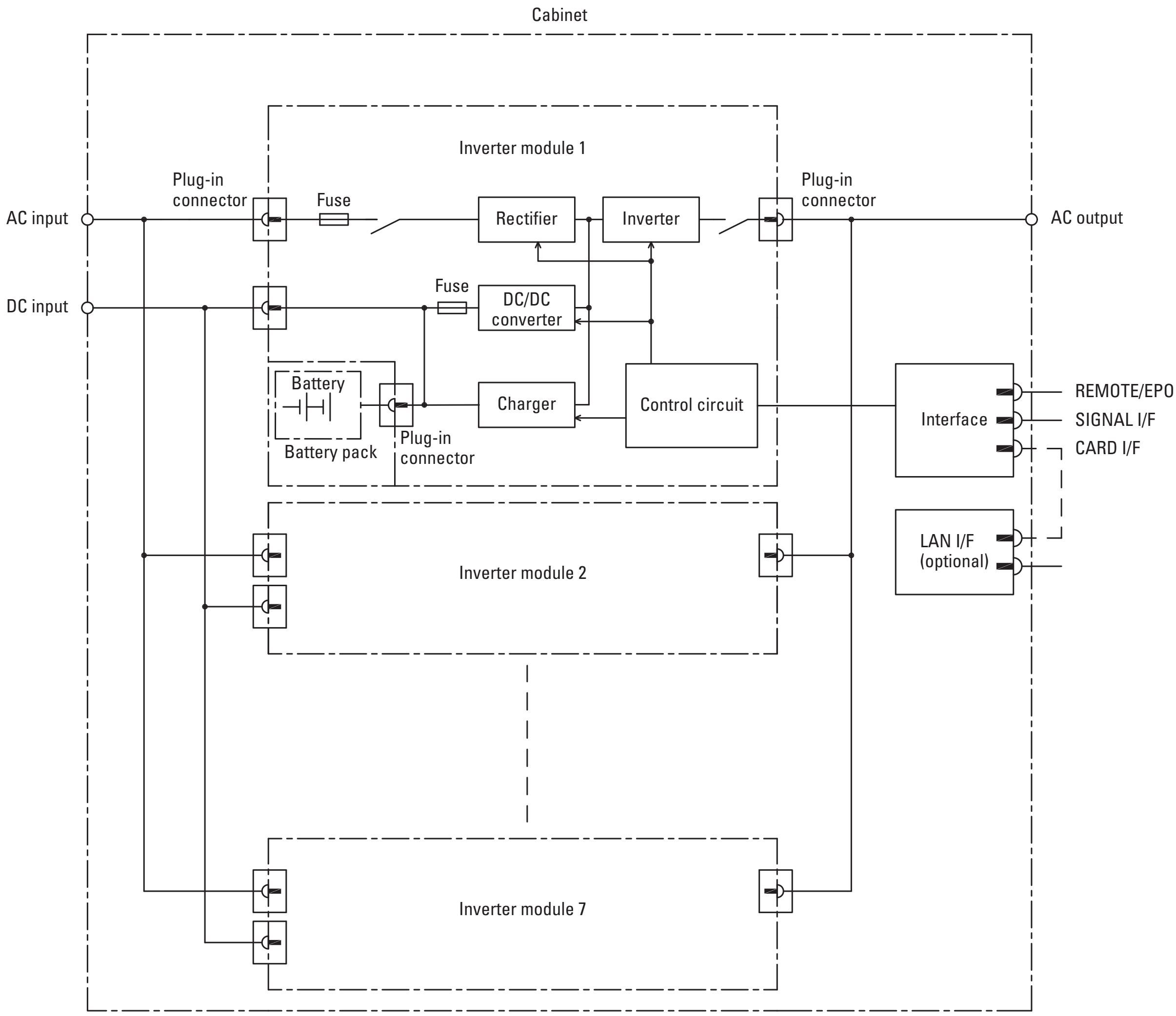


Fig. 8 Circuit diagram

4.1 Main circuit configuration

The *SANUPS A22A* consists of a cabinet and an inverter module.

The cabinet contains power distribution circuits for AC input and AC output, and an interface.

The inverter module contains components such as a rectifier, an inverter, a DC/DC converter, a charger, and battery packs. The rectifier and inverter use the 3-level method for high efficiency.

The inverter modules and battery packs are connected to the cabinet via a plug-in connection using plug-in connectors, and therefore can be hot-swapped (inserted/removed while connected to a load) from the front of the UPS.

4.2 Control circuit configuration

In contrast to the current model, the control circuit in the *SANUPS A22A* predominantly uses surface-mount components to create a smaller footprint.

The control power circuit adopts the quasi-resonant RCC method for high efficiency.

5. Specifications

Table 1 shows the specifications of this UPS and Figure 9 shows the dimensions.

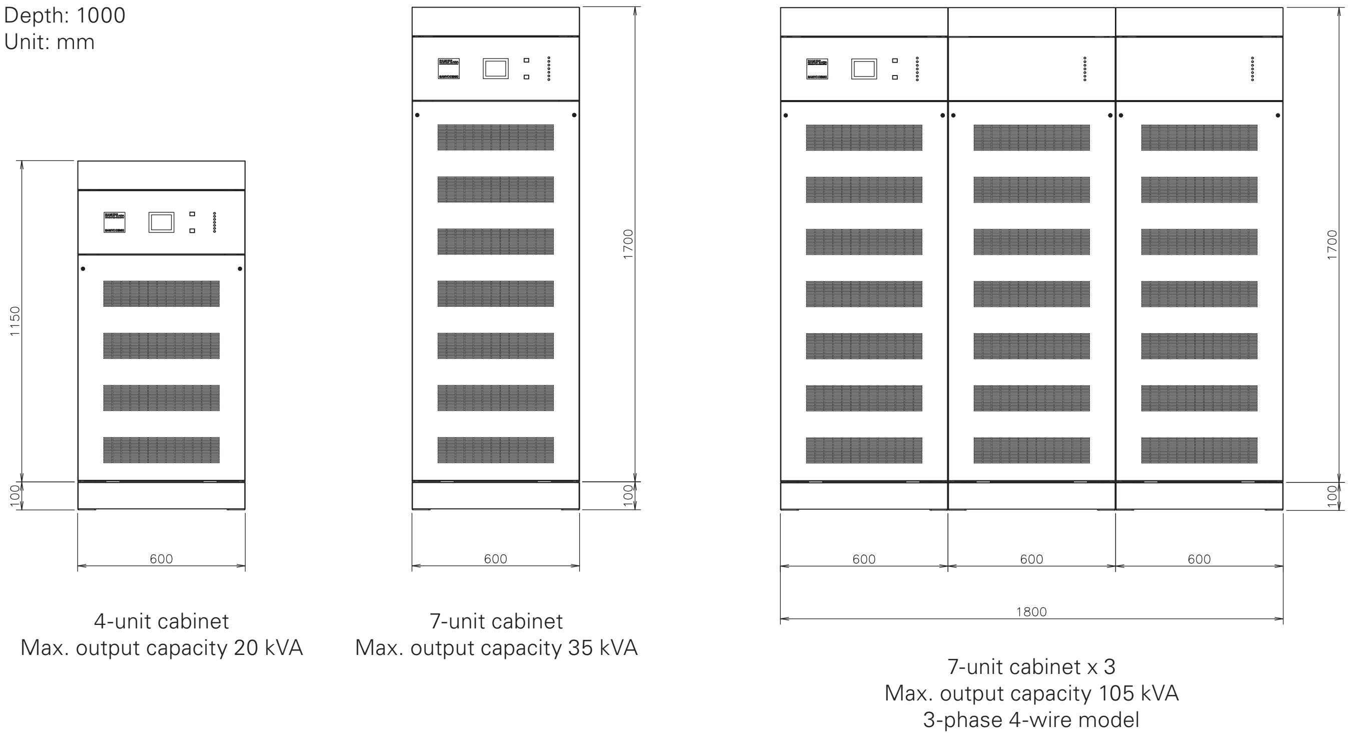


Fig. 9 Dimensions

Table 1 Specifications

Item			3-phase 4-wire model	Single-phase 2-wire model	Remarks
Type	UPS topology		Double conversion online	Double conversion online	
	Cooling method		Forced air cooling	Forced air cooling	
	Inverter system		High-frequency PWM	High-frequency PWM	
	Inverter structure		Modular	Modular	Hot-swappable
	Battery structure		Modular	Modular	Hot-swappable
AC input	No. of phases/wires		3-phase 4-wire	3-phase 4-wire	
	Rated voltage		380 V, 400 V, 415 V	380 V, 400 V, 415 V	
	Voltage range		Within -40% to +15% of rated voltage	Within -40% to +15% of rated voltage	At load level < 70% Recovery voltage is -20% of rated voltage or more
			Within -20% to +15% of rated voltage	Within -20% to +15% of rated voltage	At load level ≥ 70%
	Rated frequency		50/60 Hz (auto-sensing)	50/60 Hz (auto-sensing)	
	Frequency range		Within ± 8% of rated frequency	Within ± 8% of rated frequency	
	Power factor		0.97 or more	0.95 or more	When input voltage harmonic distortion is less than 1%
AC output	Rated capacity		5 kVA / 5 kW	5 kVA / 5 kW	Apparent power / active power
	No. of phases/wires		3-phase 4-wire	Single-phase 2-wire	
	Rated voltage		380 V, 400 V, 415 V	220 V, 230 V, 240 V	
	Voltage regulation		Within ± 2% of rated voltage	Within ± 3% of rated voltage	At rated output
	Rated frequency		50/60 Hz	50/60 Hz	Same as input rated frequency
	Frequency regulation		Within ± 1, 3, 5% of rated frequency	Within ± 1, 3, 5% of rated frequency	Configurable
			Within ± 0.5%	Within ± 0.5%	During battery operation
	Voltage harmonic distortion		2% or less / 5% or less	3% or less / 7% or less	At linear load / rectifier load, rated output
	Transient voltage fluctuation	For abrupt load change	Within ± 3% of rated voltage	Within ± 5% of rated voltage	For 0 ⇔ 100% load step changes
		Loss or return of input power			At rated output
		Input voltage during rapid change			For ± 10% rapid voltage changes
	Load power factor		0.7 (lagging) to 1.0	0.7 (lagging) to 1.0	
	Overload capability		120% (30 min)	120% (30 min)	
			150% (1 min)	150% (1 min)	
Overcurrent protection			Drop (instantaneous), inverter shutdown	Drop (instantaneous), inverter shutdown	
Efficiency			94.5%	94.5%	At rated output
Acoustic noise			55 dB or less	55 dB or less	1 m from front of device, A-weighting
Operating environment	Ambient temperature		0 to +40°C	0 to +40°C	During operation
			-15 to +40°C	-15 to +40°C	During storage, transportation
	Relative humidity		10 to 95% (non-condensing)	10 to 95% (non-condensing)	During operation, storage, transportation
Installation location			Indoors	Indoors	
Operating altitude			2000 m or less	2000 m or less	
Battery	Battery type		Small-sized valve-regulated lead-acid (VRLA) battery	Small-sized valve-regulated lead-acid (VRLA) battery	
	Battery configuration		12 V, about 9 Ah	12 V, about 9 Ah	
	Batteries per inverter module		16	16	
	Backup time		10 min	10 min	At 25°C ambient temperature, load power factor of 0.75, using new, fully charged batteries.

6. Conclusion

This article has introduced the overview and features of the *SANUPS A22A* modular uninterruptible power supply.

This device, with its adaptable modular design and resilient parallel redundant operation, can meet the power supply requirements of mission-critical applications that demand high reliability and availability. Furthermore, it offers a wide output capacity range and backup time to achieve a flexible and optimal system configuration for our customers' operating environments.

We will continue to quickly develop products to meet these market demands and provide products that fulfill our customers' needs.

* Based on our own market research as of August 7, 2018, conducted among double conversion online UPSs on the market with equivalent voltage and capacity.

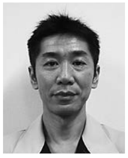
Hiroya Tokutake
Joined SANYO DENKI in 2012.
Power Systems Div., Design Dept.
Works on the development and design of UPS.

Hiroshi Hirata
Joined SANYO DENKI in 1985.
Power Systems Div., Design Dept.
Works on the development and design of UPS.

Yoshiko Kondo
Joined SANYO DENKI in 1989.
Power Systems Div., Design Dept.
Works on the development and design of UPS.

Yuzo Kubota
Joined SANYO DENKI in 1983.
Power Systems Div., Design Dept.
Works on the mechanism and design of UPS.

Hiroyuki Kaneko
Joined SANYO DENKI in 1993.
Power Systems Div., Design Dept.
Works on the development and design of UPS.



Toshifumi Nishizawa
Joined SANYO DENKI in 1997.
Power Systems Div., Design Dept.
Works on the development and design of UPS.

Yoshimi Sunohara
Joined SANYO DENKI in 2011.
Power Systems Div., Design Dept.
Works on the mechanism and design of UPS.

Tomoharu Tanaka
Joined SANYO DENKI in 2015.
Power Systems Div., Design Dept.
Works on the development and design of UPS.

Yuta Abe
Joined SANYO DENKI in 2016.
Power Systems Div., Design Dept.
Works on the development and design of UPS.

Mika Takehara
Joined SANYO DENKI in 2017.
Power Systems Div., Design Dept.
Works on the development and design of UPS.