Development of the Small-Capacity UPS *SANUPS A11M* Series

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1. Introduction

In addition to the advancement of ICT technology in recent years, the evolution of electronic equipment such as smartphones and tablets, which are high-performance information devices, has made global network systems essential in our daily lives for over a decade now. Such systems cannot afford even a split second of downtime, therefore uninterruptible power supplies (UPS) are used. When an abnormality such as a power outage occurs in the AC voltage supply, a UPS supplies power without interruptions to electronic equipment by converting the built-in battery power to AC power. As such, UPSs must be highly reliable.

SANUPS A11M, the newly developed small-capacity UPS series, is optimal for such applications requiring high reliability. This article will provide an overview of this product.

2. Development Background

From the late half of the 1990s, computers have been getting smaller, and requiring lower power consumption. Moreover, to minimize the risk of data loss the mainstream method was to connect a UPS to each piece of equipment. At that time, all high-reliability UPSs had high capacities of 100 kVA or higher and used either the working/spare switching system or the parallel redundant system. There were no high-reliability UPS in the small-capacity 1 kVA class.

In 2003, we developed the *SANUPS ASE-H* enabling the configuration of high-reliability redundant systems for the small-capacity UPS market. The *SANUPS ASE-H* has been used in situations requiring higher reliability for 10 kVA or less, such as backup operation of railway and expressway management systems.

As the successor of the *SANUPS ASE-H* (hereinafter “current product”), the *SANUPS A11M* (hereinafter “new product”), inherits the concept of supporting easy high-reliability and scalable capacity through parallel operation of multiple 1 kVA units, while increasing the number of units connectable in parallel from 5 to 8. Also, with SANYO DENKI’s original parallel operation control technology, stable operation, including backup operation in the event of a power outage, is possible even if communication lines are cut. Moreover, with a wider operating temperature range and input voltage/frequency range than the current product, the new product can minimize battery wear and enable stable operation by reducing the frequency of switching to battery operation, even in regions with unstable power sources.

3. Features

As mentioned above, the new product can connect a maximum of 8 units in parallel while the current product can connect up to 5 units. Figure 1 shows the appearance of the new product with 8 units mounted on a rack.

Fig. 1 *SANUPS A11M* (8 kVA rack mount type)

3.1 High reliability with autonomous method of parallel control

As the inverter output is AC voltage, when connecting inverter units in parallel, the voltage amplitude, frequency, phase, etc. of all units must be exactly the same or an electrical current called a "cross-current" occurs between units, and it is no longer possible to maintain current balance.

Examples of control methods of connecting inverters in parallel include the central control method and the master/slave method. These methods have many parts in common, such as control circuits and control/communication lines, so they are suitable for capacity expansion. However, they are not considered highly reliable.

In contrast, the new product does not have a central control unit, but rather features independent control circuits for each unit. This enables parallel operation of the inverters through individual control.

This control method detects input and output voltages, then calculates the momentary frequency and momentary phase and make adjustments.

The new product has communication lines between units for starting/stopping them and sharing measurement data. However, synchronization between units is performed at each unit without relying on inter-unit communication, so even if inter-unit communication is cut, parallel operation can be maintained not only during AC operation, but also during backup operation.

When 8 units are run in parallel as shown in Figure 2, for example, they can handle a load of up to 8 kVA. For a load capacity of 7 kVA or less, having one unit worth or excess capacity means there will be redundancy to maintain operation even if one unit fails. In this way, the new product achieves highly reliable redundancy through parallel operation control with a minimum of common parts.

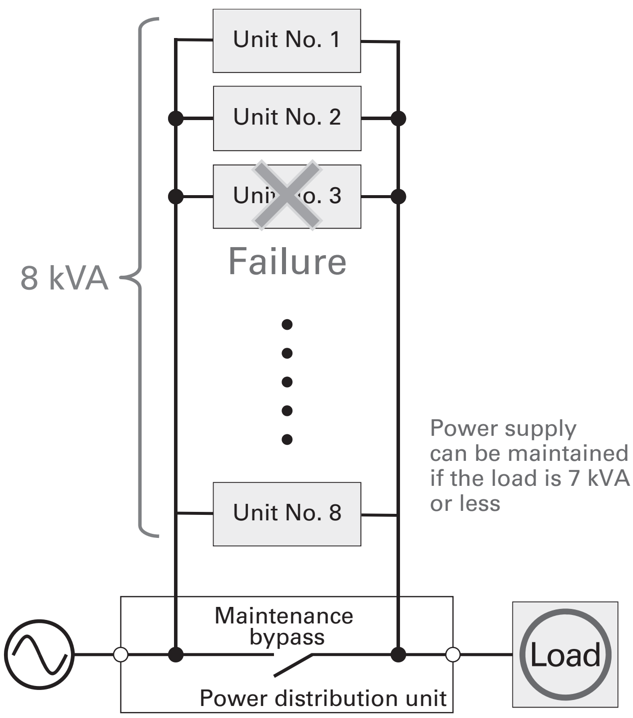

Fig. 2 Parallel redundant operation

3.2 Wider input voltage range

Some regions of the world have underdeveloped infrastructure and unstable power systems. Using conventional UPSs in such regions may lead to accelerated battery wear from frequent battery operation caused by voltage and frequency fluctuations.

We solved this issue by designing the new product to have wide input voltage and frequency ranges; the voltage range is 55 to 150 V for the 100 V model and 110 to 300 V for the 200 V model, and the frequency range is 40 to 120 Hz. This can reduce the number of transfers to battery operation even in regions where grid power is unstable and voltage and frequency fluctuate greatly. This means that stable power can be supplied to a load while battery wear is kept minimal.

3.3 Wider operating temperature range

Conventionally, UPSs were primarily used for backup of ICT equipment and servers, and often used in temperature-controlled environments. In contrast, recently an increasing number of UPSs are used in environments with little temperature control, such as factories, offices, and stores. Against this backdrop, we developed the new product to have an operating temperature range of -10 to 55°C. Battery charging stops at 40°C or above, however, the new product can be used at a higher ambient temperature than the current product as long as the battery lasts.

3.4 Support of high load power factors

Current electronic devices can provide power factor correction and have a high input power factor. Considering this, we designed the new product to have an increased rated output power factor of 0.8, while that of the current product is 0.7.

This led to the new product's increased active power of 4.0 kW, while that of the current product is 3.5 kW, when compared in a 5-unit parallel operation.

3.5 Battery management function

The new product has a function to automatically perform regular battery tests to ensure batteries are problem-free. Furthermore, the new product ensures increased reliability by offering battery management functions the current product does not. Such functions include a battery service life warning, total battery run time, battery state of charge, and estimated backup time.

3.6 Easy maintainability and serviceability

As Figure 3 shows, in the new product, batteries are built into a plastic tray for easy removal. This makes battery replacement easy.

Fig. 3 Front panel and battery

3.7 Reduced size and weight

With a volume of 15.19 liters, the new product is around 1% smaller than the current product, which has a volume of 15.34 liters. Moreover, by using high-capacity batteries, the number of batteries used has been reduced from 3 to 2. Also, by simplifying the internal structure, a significant weight reduction (from 19 kg to 15 kg) has been achieved.

3.8 Network functions

For simple UPS management, UPS management software *SANUPS SOFTWARE STANDALONE* can be downloaded free of charge. A serial cable for computer connection comes included as a standard accessory. Connection is also possible via a commercially-available USB cable. (USB and serial communications are mutually exclusive)

Moreover, we have an optional LAN Interface Card and *SANUPS SOFTWARE* available for advanced UPS management in a network. These can help users build a flexible, integrated network environment.

3.9 High performance interface

The new product comes with the following interfaces:

(a) Dry contact interface

Just as for the current product, combining with an optional Dry Contact Interface Card will enable dry contact output. Moreover, mounting compatibility is maintained, and the new product can replace the current product in customers' systems.

(b) Remote switch connector

In addition to having a contact input with an on/off function just as the current product, the new product can also use the functions shown in Table 1 with settings.

Table 1 Remote switch functions

Setting value	Function
ON/OFF Both are used	ON/OFF is operated using the respective switches. When both ON and OFF signals are input, OFF is given priority.
ON only (Positive logic) (OFF is disabled)	Turn ON/OFF with an ON-side switch. When the ON signal is input, the UPS starts up.
OFF only (Negative logic) (OFF is disabled)	Turn ON/OFF only with the ON-side switch. When the ON signal is input, the UPS shuts down.

(c) EPO (Emergency Power Off) connector

Connecting a switch to this connector and turning it on will enable the emergency stop of the UPS.

4. Circuit Configuration

Figure 4 shows the circuit configuration and system diagram for the new product UPS unit.

4.1 Main circuit configuration

The new product UPS unit is composed of a high input power factor converter, inverter, charger, battery boost circuit, output transfer switch, bypass circuit, filter, and control circuit.

With a power distribution unit, up to 8 UPS units can be connected in parallel.

For the high input power factor converter, we adopted a single-switch boost chopper. This chopper is composed of a bi-directional semiconductor switch and boosts AC voltage into DC voltage. At the same time, there is a function to condition input current waveform into a sine wave.

The inverter is of the half-bridge type and has a reduced number of elements, enabling us to eliminate the drive circuit and other peripheral circuits.

We have improved the efficiency of the battery charger by supplying the input power directly.

4.2 Control circuit

Through digitization of the control circuit, the new product achieves input and output waveform rectification, UPS operation sequence, and parallel operation control with a single CPU. Moreover, it has CAN for communicating information from each UPS unit. This makes high-speed data transfer possible, and unit-specific information such as measurement results and failure information can be shared. The number of connected units are managed automatically, and an alarm sounds when any of the UPS units stop.

4.3 Electrical characteristics

Table 2 provides the standard specifications of the new product (per UPS unit).

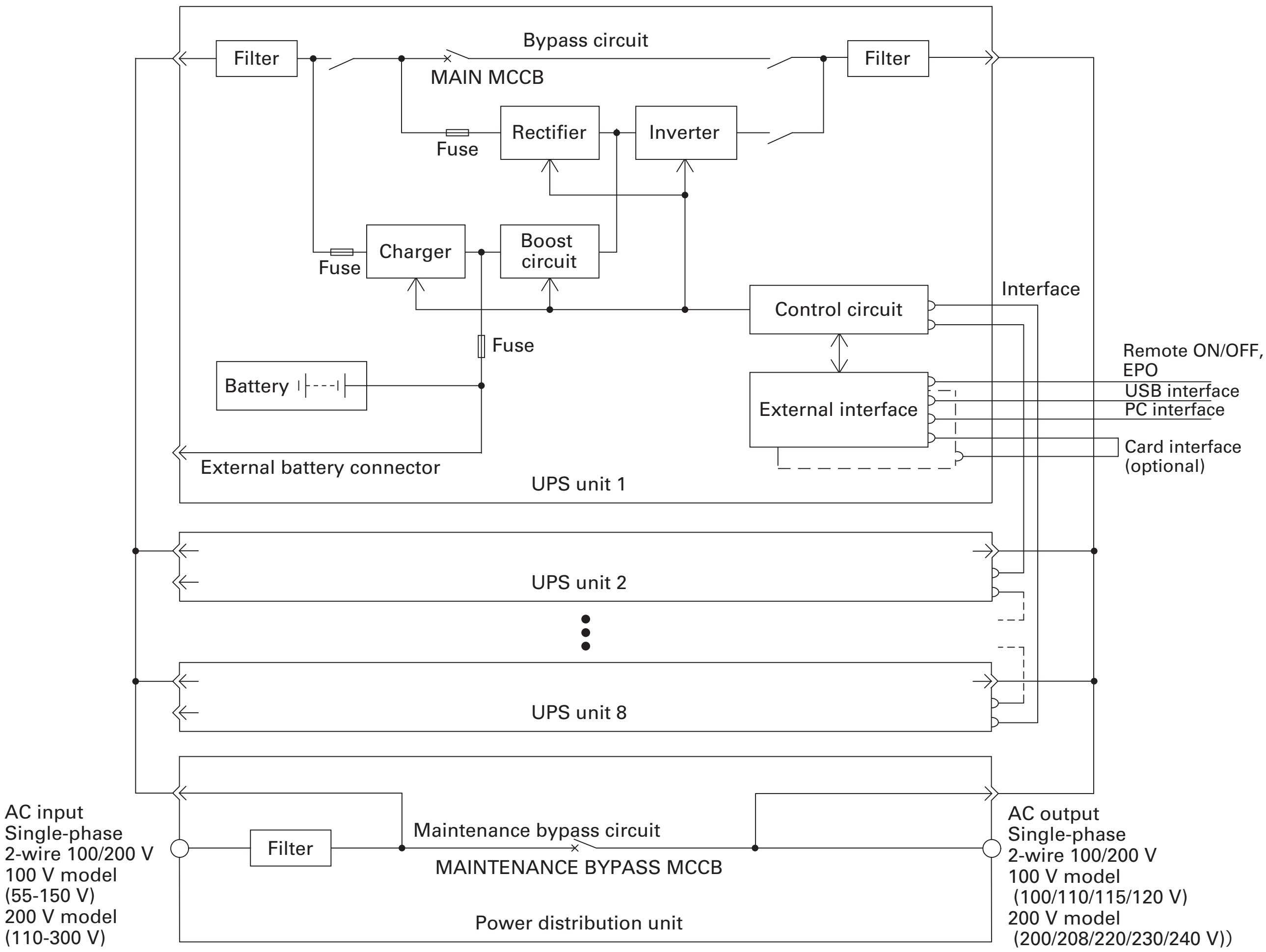

Fig. 4 System diagram

Table 2 Specifications

Items		Specifications
Output capacity		1 kVA / 0.8 kW
System	**Topology**	Double conversion online
	Rectifier	High input power factor converter
	Cooling method	Forced air cooling
	Inverter	High-frequency PWM
AC input	**No. of phases/wires**	Single-phase 2-wire
	Input voltage range	55 to 150 V (100 V model) 110 to 300 V (200 V model)
	Input frequency range	40 to 120 Hz
	Required capacity	1.1 kVA
	Power factor	0.95 or greater (at rated output)
AC output	**No. of phases/wires**	Single-phase 2-wire
	Rated voltage	100/110/115/120 V (100 V model) 200/208/220/230/240 V (200 V model)
	Voltage regulation	Within ±5% of rated voltage
	Rated frequency	50/60 Hz
	Frequency regulation	±1, 3, 5% of rated frequency (Factory setting: ±3%)
	Voltage harmonic distortion	3% or less (With a linear load) 8% or less (With a rectifier load)
	Rated load power factor	0.8 (lagging)
	Transient voltage fluctuation	Within ±10% (For abrupt load change) Within ±10% (Loss or return of input power) Within ±10% (For abrupt input change)
	Overcurrent protection	Uninterrupted transfer to bypass
	Overload capability	105% (Inverter)
Battery type		Small-sized valve-regulated lead-acid (VRLA) battery
Backup time		5 min (When the power factor is 0.7)
Acoustic noise (at 1 m from the front of unit)		45 dB or less
Operating environment		Ambient temperature: -10 to 50˚C Relative humidity: 10 to 90% (non-condensing)

5. Conclusion

This article has introduced the *SANUPS A11M* UPS capable of parallel operation of up to 8 kVA by combining 1 kVA UPS units (a maximum of 7 kVA in redundancy). This product supports high-reliability and scalable capacity, adopts SANYO DENKI's original parallel operation control technology, and features an expanded operating temperature range and input voltage/frequency range.

Worldwide, there are not many UPSs in the small-capacity few kVA class capable of performing parallel redundant operation. As such, we are confident this product can contribute to customers requiring small capacity and high reliability.

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