Development of Small-Capacity UPS "SANUPS A11G-Ni"

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1. Introduction

With the remarkable advances in network technology, it has become essential to provide a constant supply of stable, high quality power to IT equipment that is sensitive to power supply variation. Therefore the rate of installation of uninterruptible power supply units (hereafter, "UPS") in network equipment such as servers, storage and routers is rising.

In addition, from the viewpoint of environmental measures, reductions in hazardous substances, reduction of power consumption, and longer life are increasingly becoming user requirements. With this background, we developed the UPS "SANUPS A11G-Ni" incorporating a nickel metal hydride battery, with the aim of providing the stable power supply and high efficiency of conventional products but with a smaller size, longer life of components, and fewer hazardous substances. This report presents an overview of the new product.

Fig. 1 "SANUPS A11G-Ni"

2. Background to development

2.1 Environmental measures

Batteries being the main component of UPS, lead storage batteries have typically been used from the viewpoints of cost and availability. However, lead, the principal constituent of lead storage batteries, is designated a hazardous substance in the RoHS directive (the European Parliament and Council directive restricting hazardous substances used in electrical and electronic equipment), and it is becoming a key issue in reducing the burden on the environment. Although a recycling system has been established for lead storage batteries and they are likely to be excluded from the RoHS directive, they are now targeted by many users as hazardous materials to be eliminated.

2.2 Smaller size and longer life

When a power outage occurs, network equipment such as servers, storage and routers increasingly tend to require more time to shut down, while additional batteries are needed to increase the power supply backup time during an outage, and these conditions conflict with the requirement for smaller size. Furthermore, lead storage batteries have a short service life at high temperatures, and maintenance was a key issue in long-term operation of lead storage batteries.

Therefore, in response to these problems and requirements, we developed the small capacity UPS "SANUPS A11G-Ni" with 1 kVA/1.5 kVA output capacity, a product that is based on technology used in earlier models but which can incorporate a nickel metal hydride battery.

3. Features

3.1 Incorporating a nickel metal hydride battery

(1) Selecting the battery

The energy storage sources for replacing lead storage batteries include nickel metal hydride batteries, lithium ion batteries, electric double layer capacitors and so on. Lithium ion batteries are widely used in portable devices and they have

Table 1 Comparison of the types and performance of batteries

	Lead storage battery	Nickel metal hydride battery	Lithium ion battery	Electric double layer capacitor
Environmental suitability	×(Lead)	○	○	○
Energy density	△	○	○	×
Small, light	△	○	○	×
Cost	○	△	×	×
Safety	○	○	△	○
Life expectancy	△	○	△	○
Large current discharge applications	○	○	△	○
Suitability for UPS	○	○	△	△

Fig. 2 Nickel metal hydride battery pack

high energy density, but it will be some time before they are ready for practical application in large capacity products. Electric double layer capacitors are effective for short-term backup, but they have low energy density, and they must be a larger volume than lead storage batteries. Nickel metal hydride batteries are used in the hybrid cars of major automakers, and with their large current discharge and their strong charge and discharge, they are also suitable for UPS. Furthermore, they have twice the energy density per unit volume of lead storage batteries, and about ten times the charge-discharge cycle lifetime making them suitable for longer life. For these reasons, nickel metal hydride batteries were chosen as the energy storage source to replace lead storage batteries in the "SANUPS A11G-Ni".

Table 1 is a comparison of the types and performance of batteries.

(2) Lifetime enhancing technology for nickel metal hydride batteries

In order to use nickel metal hydride batteries, it is not simply a matter of replacing the lead storage batteries. To make maximum use of the battery capacity, it is necessary to consider what sort of charging management is required. In particular, charge/discharge management is important, and nickel metal hydride batteries cannot be expected to last long with the method of charging used for lead storage batteries. For reliable, long term use of nickel metal hydride batteries, optimized charging technology is essential. The "SANUPS A11G-Ni" incorporates an optimal charging circuit developed jointly with Hitachi Computer Peripherals Co., Ltd., which achieves the longest battery life of 10 years at 25℃.

(3) Smaller size

Compared with conventional lead storage batteries, the energy storage density by volume of nickel metal hydride batteries is more than twice as great. If a battery with the same capacity as a lead storage battery were used, its volume would be half, and its mass would be about half as well. In the "SANUPS A11G-Ni", twice the volume of nickel metal hydride batteries are held in the space for housing lead storage batteries, and where the earlier model, the "SANUPS ASE15S1" provided 5 minutes' backup, the "SANUPS A11G-

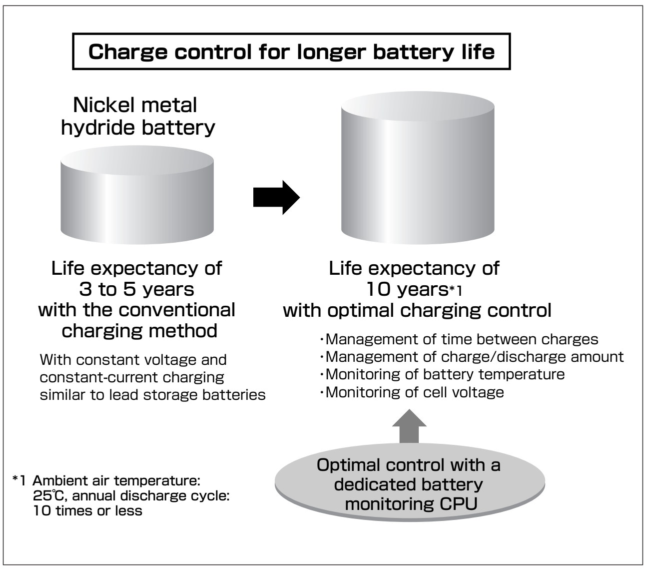

Fig. 3 Elements of optimal charging control.

Ni" can provide 18 minutes' backup with the same dimensions. Therefore it is not necessary to add space for more batteries, and smaller size and lower weight is achieved. With output capacity of 1.5 kVA and power outage backup time of 18 minutes or more, we achieved the industry's smallest size at W 410 mm × D 540 mm × H 86 mm. The unit can be placed horizontally, vertically or in 19-inch racks (2U).

3.2 RoHS directive compliance

The "SANUPS A11G-Ni" uses components that comply with the RoHS directive, and the printed circuit board is assembled with lead-free solder. Not only is the battery lead-free, the six hazardous substances*1 in the component parts are also rapidly being reduced.

3.3 High efficiency and stable power supply

(1) Operating efficiency

For the main circuit, this UPS uses the successful 3-arm*2 continuous inverter power supply system from the "SANUPS ASE", achieving high operating efficiency of a maximum 91%, from AC input to general output.

(2) Stable power supply

Since a continuous inverter power supply system is used, there is absolutely no output switching time when there is an input problem, which is an issue with the continuous commercial power supply systems. Also, it is possible to supply stable power to load equipment when other kinds of power supply trouble occur (power outage, instantaneous power outage, voltage fluctuation, high-frequency noise, or frequency fluctuation). In addition, the output voltage waveform is in the form of sine wave output which is best suited to load equipment.

3.4 Automatic battery diagnostics

The battery charging circuit includes a dedicated charge control CPU, which constantly monitors the amount of charge, the amount of discharge, battery voltage and battery temperature. In addition, it instantaneously measures the impedance and discharge capability of the battery at a constant frequency to check the normality of the battery. If the battery deteriorates or its discharge capability falls, or if the battery fails or the battery pack connector is disconnected, it can sound an alarm to prevent the system from going down in a power outage.

3.5 Output socket control

The firm output socket primary system (commercial power supply when the UPS stops) and system control function socket secondary system, used with good results in the "SANUPS ASE" are used again here, achieving both reliability for the power supply and simple management.

3.6 Network support

It is necessary to provide support for UPS management in a network environment, and to perform a range of communication with a computer. The "SANUPS A11G-Ni" is provided with RS-232C as standard, and a LAN interface card is available as an option. In combination with the UPS management software "SAN GUARD IV" developed by Sanyo Denki, powerful support is available for use in a network environment.

3.7 Maintainability and reduced maintenance cost

Systems in which networked computers run 24 hours a day are on the increase, as are situations where it is not possible to stop the power supply for maintenance and inspection of the UPS.

The "SANUPS A11G-Ni" uses a nickel metal hydride battery pack that can be removed easily. This makes the battery hot swappable, allowing it to be replaced without stopping the device. And although the battery is a consumable part, since it has a maximum life expectancy of ten years at 25℃, it is not necessary to change the battery before the end of the lifetime of the device, if it is installed in a good environment. Similarly, since the fan also has a long service life, it is not necessary to replace the fan before the end of the lifetime of the device,

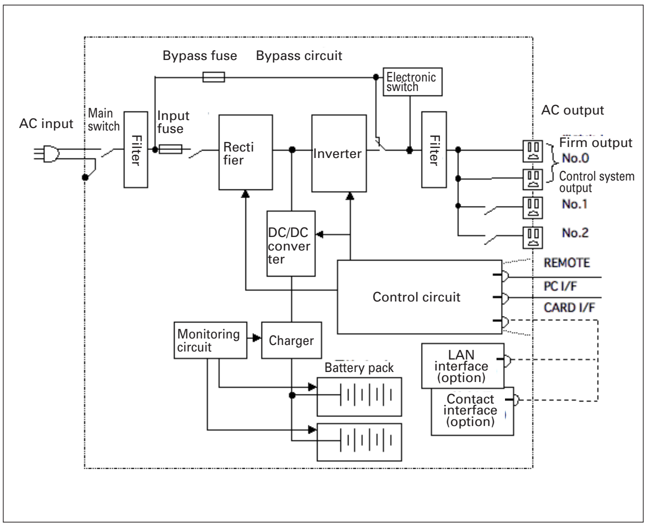

Fig. 4 "SANUPS A11G-Ni" circuit system diagram thereby reducing maintenance costs.

3.8 Wide input/output range

The input/output voltage can be switched between 100 V, 110 V, 115 V, and 120 V to match the equipment used.

3.9 Options

A full range of options are provided to meet all user needs. The following are examples of available options.

(1) Rack mounting tools
(2) LAN interface card
(3) Contact interface card
(4) Maintenance bypass unit

Table 2 "SANUPS A11G-Ni" standard specifications

Model number			A11GN102A001	A11GN152A001	Note
Output capacity			1kVA/0.7kW	1.5kVA/1.05kW	Apparent power/effective power (*1)
Systems	Operating system		Commercial synchronous online inverter power supply		
Systems	Input rectifier system		High power factor converter		IGBT PWM
Systems	Cooling system		Forced air cooling		
Systems	Inverter system		High frequency PWM		
AC input	Number of phase		Single-phase 2-line		(*2)
AC input	Voltage		100/110/115/120V±15% or less		The same as the output voltage
AC input	Frequency		50/60Hz		The amplitude range is the same as the output frequency accuracy
AC input	Required capacity		0.9kVA	1.3kVA	Maximum capacity when the battery undergoes recovery charging
AC input	Input power factor		0.95or more		When the input voltage waveform distortion factor is less than 1%
AC output	Number of phase		Single-phase 2-line		
AC output	Rated voltage		100/110/115/120V		Specify the voltage when ordering (The standard is 100 V)
AC output	Voltage setting precision		Within ±2% of rated voltage		
AC output	Rated frequency		50/60 Hz		Selected automatically
AC output	Frequency accuracy		Within ±1/±3/±5% of rated frequency (±3% at shipment)		The setting can be changed. When the battery is operating: Within ±0.5%
AC output	Voltage waveform distortion factor	With a linear load	3% or less		
AC output		With a rectifier load	7% or less		
AC output	Load power factor	Rating	0.7 (delay)		
AC output		Amplitude range	0.7 (delay) ~ 1.0		
AC output	Transient voltage fluctuation	For a sudden variation of load	Within ±5% of rated voltage		0〜100% change or output switching
AC output		For power recovery after power outage	Within ±5% of rated voltage		For rated output
AC output		For sudden variation of input voltage	Within ±5% of rated voltage		±10% change
AC output	Overcurrent protection action		Automatic switching to bypass circuit (with auto-return function)		(*3)
AC output	Overload capacity	Inverter	105% (200 ms)		
AC output		Bypass	200% (30 s), 800% (2 cycles)		
Battery		Type	Cylindrical sealed nickel metal hydride battery		Life expectancy 10 ten years (25℃) (*4)
Battery		Backup time	12 min (700 W)	18 min (1050 W)	Ambient 25℃ at the rated load
Operation		Battery start	Function available		(*5)
Noise			40 dB or less		1 m in front of the device, A characteristics
Calorific value			110 W	145 W	
Input leakage current			3 mA or less		
Applicable standards			UL1778, VCCI Class A		
Ambient conditions			Ambient air temperature: 0〜40℃ Relative humidity: 30 〜90% (no condensation)		

*1: The rated output capacity for A11GN152A001 in the UL standards is as follows. (The maximum output capacity is 1.5 kVA/1.05 kW at each setting voltage.)
Output voltage: 1.25 kVA/1.05 kW when set to 100 V; 1.35 kVA/1.05 kW when set to 110 V; 1.45 kVA/1.05 kW when set to 115 V; 1.5 kVA/1.05 kW when set to 120 V
*2: When grounded, set the input/output ground phase to match the designation of the device.
*3: When the AC input frequency is in the range of the AC output frequency accuracy, and the AC input voltage is within a ±15% range of the rated voltage, the inverter performs a synchronizing operation with the AC input and no-break transfer is possible.
*4: Life expectancy with ambient air temperature: 25°C, annual discharge cycle: 10 times or less.
*5: Even if there is a problem with the AC input (power outage, voltage drop), inverter output can be obtained using the battery provided.

4. Circuit configuration

Fig. 4 is a system diagram for the "SANUPS A11G-Ni".

4.1. Main circuit configuration

The "SANUPS A11G-Ni" consists of a high power factor converter, inverter, charger, output select switch, bypass circuit, battery charge/discharge monitoring circuit, battery and so on.

(1) Using a 3-arm continuous inverter system achieves high efficiency and reduces the number of components.

(2) The battery is boosted with a high-frequency transformer to achieve a smaller size.

(3) The charge/discharge monitoring circuit performs detailed charge control based on feedback from the temperature sensor and voltage sensor.

4.2. Control circuit configuration

As with the "SANUPS ASE", the "SANUPS A11G-Ni" uses a DSP*3 for UPS control, and sequence control is performed by a control CPU. Also, a dedicated monitoring CPU has been added to the charge/discharge monitoring circuit.

(1) Control

Converter control, inverter control, DC/DC control (battery booster control), and the various sensor and protection operations are performed by a single DSP.

(2) Sequences

Sequences have been changed to status transition sequences from the logic sequences used in earlier models. By using a dedicated CPU for monitoring the charge/discharge circuit it was possible to eliminate the concern over operational lag in the logic sequences, as well as enabling detailed charge control.

4.3. Electrical characteristics

Table 2 shows the standard specifications of the "SANUPS A11G-Ni".

5. Conclusion

Henceforward, with advances in the reliability and sophistication of network devices that will replace older technologies with the new developments in network technology, the requirements for more reliable, longer-lasting UPS which place a lower burden on the environment are expected to increase.

In response to these market requirements, we will carry out rapid development in order to provide products with environmental performance that can satisfy users.

We would like to express our gratitude to Hitachi Computer Peripherals Co., Ltd. for their tremendous cooperation in the development and commercialization of the "SANUPS A11G-Ni", and to the many other parties who gave their help and advice.

Reference

SANYODENKI Technical Report No.12
Yoshihiro Wada et al. ''Development of the small capacity UPS ''SANUPS ASE''

Footnotes

*1: The relevant hazardous chemical substances are lead, hexavalent chromium, mercury, cadmium, as well as the two types of brominated flame retardants polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) for a total of six substances.

*2: A system that performs AC→DC→AC power conversion using three sets of switching devises.

*3: Abbreviation of Digital Signal Processor.

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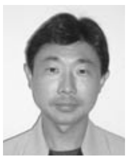

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