Development of the *SANUPS E11B* Hybrid UPS

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1. Introduction

In recent years, the demand for uninterruptible power supplies (UPSs) has been increasing throughout the world. One of the reasons for this is because the spread of mobile devices and IoT-ready equipment has required more robust backup systems. As such, UPSs that can operate in regions with unstable power grids have been demanded.

Furthermore, there is also growing demand to reduce carbon footprints* as a countermeasure to global warming in order to help facilitate a sustainable society. As a result, the market is requiring products that can reduce CO_2 emissions and achieve energy savings over their entire service life.

It is against this backdrop that we have developed the *SANUPS E11B* as the successor series to our *SANUPS E11A* series, with an eye on overseas markets. This article will provide an overview of this series.

* A carbon footprint is the total amount of greenhouse gas emitted throughout its life cycle, including procurement of raw materials, production, use, disposal, and recycling, calculated in CO_2 equivalents. It can be one of the product parameters for product selection.

2. Development Background

Our current *SANUPS E11A* series makes use of a double conversion online topology to supply high-quality power, as well as a passive standby topology that prioritizes efficiency. It is available in output capacities of 1 kVA, 1.5 kVA, 2 kVA, and 3 kVA. Although this series comes with many desirable features, UPSs in this capacity range have, in recent years, been facing tough competition in terms of cost both in Japan and abroad.

At the same time, there has been greater urgency to address environmental issues on a global scale, thereby increasing demand for environmentally-friendly products.

Against such a backdrop, we developed the *SANUPS E11B* as an environmentally-friendly series that inherits the features of the *SANUPS E11A* series, while also significantly reducing costs and providing compatibility with the global market.

3. Features

Figure 1 shows the appearance of the 1 kVA model of the *SANUPS E11B*. The series lineup is available in output capacities ranging from 1 to 3 kVA. Its appearance and features are identical to the E11A series.

Fig. 1 *SANUPS E11B* 1 kVA model

3.1 UPS topology

The *SANUPS E11B* series comes with two modes, namely, a Double Conversion mode and Economy mode. The modes can be used differently depending on the settings. When the setting is fixed to Double Conversion mode, the inverter always supplies high-quality power. When set to automatic, the UPS will switch between the Double Conversion mode and Economy mode depending on the state of the input power, achieving both the high-quality power and energy savings. The modes are described below.

(1) Double Conversion mode (High-quality power mode)

Figure 2 shows the power supply path for the Double Conversion mode. First, the grid power is rectified and converted to a DC voltage. This is then converted by the inverter to a sinusoidal voltage and output. Therefore, even when the grid power fluctuates, the fluctuation is absorbed by the rectifier and inverter, enabling the UPS

to keep supplying high-quality power. The batteries are constantly float-charged by the charger so that they stay charged and ready for a power grid failure such as a power outage or voltage dip. If the grid frequency is within the frequency synchronization range (within ±1% when set to the Double Conversion mode fixed; when set to automatic, the range depends on the synchronization range setting), the UPS outputs a voltage with a frequency synchronized with the AC input frequency. If it is outside the range, it outputs a constant frequency of 50 Hz or 60 Hz and does not synchronize with the input voltage.

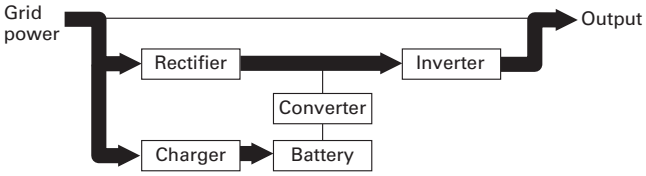

Fig. 2 The power supply path for the Double Conversion mode

(2) Economy mode (High-efficiency mode)

Figure 3 shows the power supply path for the Economy mode. When the grid power is stable, the inverter stops, allowing the grid power to be output as is. This eliminates the loss through the inverter and increases efficiency. The batteries are constantly float-charged by the charger so that they stay charged and ready for a power grid failure such as a power outage or voltage dip. When the grid power becomes unstable, the UPS automatically transfers to the Double Conversion mode described in the (1) above. This is done without interruption if the input frequency is within the synchronization range, or there will be an interruption within 8 ms if it is outside the range.

In the Economy mode, it is necessary to immediately detect abnormalities in the grid power. This is ensured by monitoring the input voltage waveform.

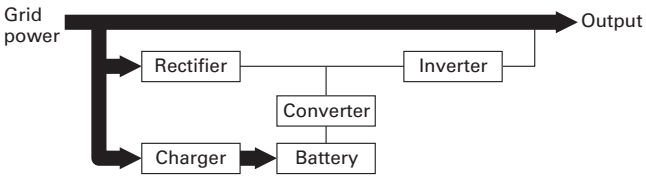

Fig. 3 The power supply path for the Economy mode

(3) In the event of a power grid failure

Figure 4 shows the power supply path during a power grid failure. If the power grid causes an interruption or power outage, the rectifier and charger will be stopped, then the converter will operate to supply power from batteries. If a grid failure occurs during the Double Conversion mode, battery power will be supplied to the load without interruption. If a grid failure occurs during the Economy mode, there will be an interruption within 8 ms until battery power will be supplied.

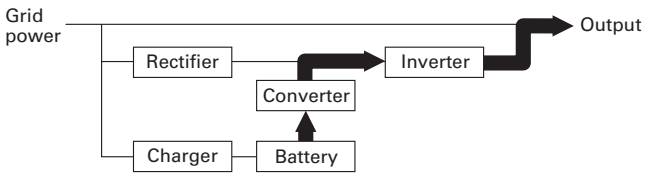

Fig. 4 The power supply path during a power grid failure

3.2 Wider input voltage and frequency ranges

We revised the converter's circuit type and control method to widen the operating input voltage range and frequency range.

The *SANUPS E11B* series support two voltage classes: 100 V and 200 V (1.5 kVA capacity is only available in the 100 V class). For the 100 V class, the E11A's 80 to 115 V input voltage range has been widened to 55 to 150 V. For the 200 V class, the previous 160 to 230 V range has been widened to 110 to 300 V. As for the input frequency range, the previous E11A's ranges of 46 to 54 Hz at 50 Hz and 55.2 to 64.8 Hz at 60 Hz have been widened to 40 to 120 Hz at 50/60 Hz.

This reduces the number of unnecessary transfers to battery power and prevents battery wear and degradation when the unit is used in areas with flactuating grid power.

3.3 Wider operating temperature range

To improve the cooling efficiency, we reduced the amount of wiring and revised the component layout to ensure sufficient air passage. We also selected components that can be used at low temperatures. These revisions have expanded the operating temperature range from 0 to 40°C to -10 to 55°C.

With a wider operating voltage range, the new product can be used in more harsh environments where the previous product could not be used.

3.4 Modular input and output

It was expected that there would be situations where it would be necessary to change the input plugs or power outlets when the product would be used in overseas markets.

To be prepared for this, we modularized the input and output part and gave it a structure that could be removed from the main UPS unit. This aimed to allow the input and output parts to be changed independently, which would be much faster and easier than redesigning the entire UPS. Figure 5 shows the rear view of the 1 kVA model of the *SANUPS E11B*, and Figure 6 shows its internal structure. The area enclosed by the border is the modularized input and output part.

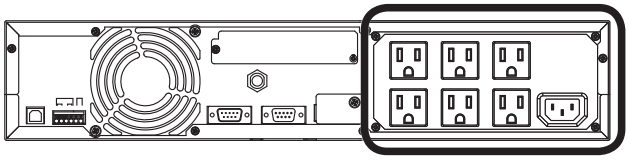

Fig. 5 Rear view of the *SANUPS E11B* 1 kVA model

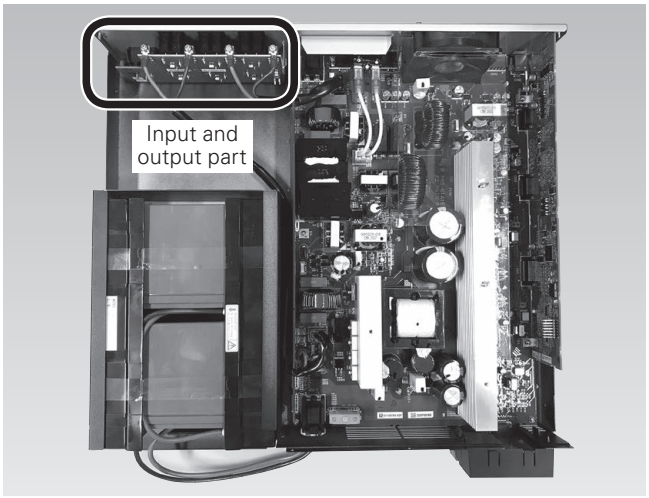

Fig. 6 The internal structure
of the *SANUPS E11B* 1 kVA model

3.5 Reduced internal wiring

As shown in Figure 6, we directly connected PCBs to each other using connectors and reduced the amount of wiring by replacing it with PCB patterns as much as possible. The reduction in wiring not only reduced assembly man-hours and material costs, but also secured internal clearances for air passage required for cooling.

This also aimed to make disassembly and recycling easier at the end of the product life, minimizing the impact on the environment.

3.6 Environmentally friendly

Previously, we used to include a power management software CD-ROM with UPSs. However, CD-ROMs become no longer necessary after installation, so we decided not to include them and instead to have the latest software version downloaded from our website. This helps reduce the amount of plastic waste. As for the Instruction Manual, we used to provide a booklet with UPSs. However, we now only provide a simplified version that gives the minimum necessary instructions. Electronic versions of full Instruction Manuals have been made available for download from our website. This has the advantage of allowing customers to always download and use the latest version as needed without creating extra waste.

For the packaging, we changed the packaging material from styrofoam to corrugated cardboard to reduce the amount of plastic use for less impact on the environment.

4. Specifications

Table 1 shows the standard specifications of the *SANUPS E11B* 1 kVA model.

5. Conclusion

In this article, we introduced the *SANUPS E11B*, the successor series to our *SANUPS E11A* hybrid UPS series.

With widened input ranges, the new product can be used around the world with peace of mind even in areas with unstable power grids and in harsh operating environments.

Moreover, we reduced the amount of wiring for easier recycling, while also changing the packaging material and how we provide the software and Instruction Manual to make the product more environmentally friendly.

We will continue to develop products that can meet the needs of our customers by grasping their needs accurately in a timely manner and contribute to creating value for their businesses.

References

(1) Hiroyuki Hanaoka and 6 others: Development of the *SANUPS A11M* Small-Capacity UPSs
SANYODENKI Technical Report, No.48, pp.22-25 (2019.11)

(2) Hiroshi Sakaba and 5 others: Development of the Hybrid UPS *SANUPS E11A*
SANYODENKI Technical Report, No.21, pp.14-18 (2006.5)

Table 1 Standard specifications of the *SANUPS E11B* 1 kVA model

Items			Ratings and standards		Remarks	
Model			E11B102 100 V class	E11B102 200 V class		
Output capacity			1 kVA / 0.8 kW			
Cooling system			Forced air cooling			
AC input	**Input plug**		IEC 60320-C14			
	Number of phases/wires		Single-phase 2-wire			
	Rated voltage and range		55 to 150 V	110 to 300 V	When in Double Conversion mode The range varies by the load level.	
			Within ±8% of 100/110/ 115/120 V	Within ±8% of 200/208/220/ 230/240 V	When in Economy mode	
	Rated frequency		40 to 120 Hz			
	Required capacity		1.1 kVA or less		Max. capacity during battery recovery charging	
	Input power factor		0.95 or greater		At rated output	
AC output	**Output outlet**		NEMA 5-15R × 6	IEC 60320-C13 × 6		
	Number of phases/wires		Single-phase 2-wire			
	Rated voltage		100/110/115/120 V	200/208/220/ 230/240 V	User-selectable	
	Voltage regulation		Within ±2% of rated voltage		When in Double Conversion mode	
	Rated frequency		50 Hz or 60 Hz		Same as the input frequency (auto-select)	
	Frequency regulation		Within ±1% of rated frequency		In Double Conversion mode fixed setting	In battery operation: Within ±0.5%
			Within ±1, 3, or 5% of the rated frequency		In "automatic" setting	
	Voltage waveform		Sinusoidal			
	Voltage harmonic distortion		At linear load: 3% or less At 100% rectifier load: 8% or less		At rated output	
	Transient voltage fluctuation	**For abrupt load change**	Within ±5% of rated voltage		0 ⇔ 100% load step changes at rated input	
		Loss or return of input power			At rated output	
		Abrupt input voltage change			For ±10% changes	
	Response time		5 cycles or less			
	Load power factor		0.8 (lagging)		Variation range 0.7 (lagging) to 1.0	
	Overcurrent protection		Automatic transfer to bypass circuit at 105% or more		With automatic retransfer function	
	Overload protection	**Inverter**	105%		200 ms	
		Bypass	15 A (current protector)	8 A (current protector)	200% for 30 s, 800% for 2 cycles (reference values)	
Battery	**Type**		Small-sized valve-regulated lead-acid (VRLA) battery			
	No. of batteries		2		12 V per battery, serial	
	Rated capacity		68 W		15-minute rate, 34 W per battery	
	Backup time		3 min (800 W) 5 min (700 W)		At a 25˚C ambient temperature, using new, fully charged batteries.	
Heat dissipation			25 W		When in Economy mode	
			130 W		When in Double Conversion mode, after battery charging completed	
Input leakage current			3 mA or less			
Environment			Ambient temperature: -10 to +55˚C Relative humidity: 20 to 90%		Batteries stop charging at temperatures above 40˚C	
Acoustic noise			40 dB or less		When in Economy mode	1 m from front of UPS, A-weighting
			48 dB or less		When in Double Conversion mode	

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