Development of the Small-Capacity UPS *SANUPS E11B-Li* and *SANUPS A11M-Li* Series

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1. Introduction

In recent years, the demand for uninterruptible power supplies (hereinafter, "UPS") 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 power backup systems. As such, there is a demand for UPSs that can operate in regions inside and outside Japan with unstable power grids.

Also, UPSs are being used in increasingly diverse situations, including in extreme temperature environments. We see this as a market need to address. Conventional lead-acid batteries can be charged only within a limited temperature range, and this can be problematic. For example, in high-temperature environments, these batteries can be discharged but cannot be charged. Customers have requested less frequent battery replacement maintenance as much as possible and UPSs that are easier to handle during installation and transportation.

In response, we developed the *SANUPS E11B-Li* series and *SANUPS A11M-Li* series to resolve these issues and meet these demands. These products make use of lithium-ion batteries (hereinafter, "LIB"). This article will provide an overview of these products.

2. Product Overview

The lineup of *SANUPS E11B-Li* series includes five models—1 kVA, 1.5 kVA, and 2 kVA for 100 V; 1 kVA and 2 kVA for 200 V—and the lineup of *SANUPS A11M-Li* series includes two models—for 100 V and 200 V. Figures 1 and 2 show the appearance of typical models of these series. Products in either series can be mounted in a 19-inch rack and horizontally or vertically on the floor.

Fig. 1 *SANUPS E11B-Li* 1 kVA model

Fig. 2 *SANUPS A11M-Li* 8 kVA model
(8 units in parallel)

3. Features

3.1 *SANUPS E11B-Li* series

This product uses a hybrid topology. The hybrid topology provides two operation modes: high-quality power mode (Double Conversion mode) and high-efficiency mode (Economy mode; standby topology). These modes can be used differently depending on the settings. When the setting is set 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 high-quality power and energy savings.

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

Figure 3 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 float-charged by the charger so that they stay charged and ready for a grid power 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; 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.

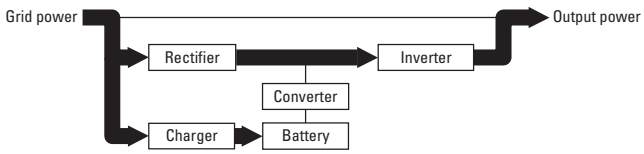

Fig. 3 The power supply path for the Double Conversion mode

(2) Economy mode (High-efficiency mode)

Figure 4 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 float-charged by the charger so that they stay charged and ready for a grid power 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 (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 constantly monitoring the input voltage waveform.

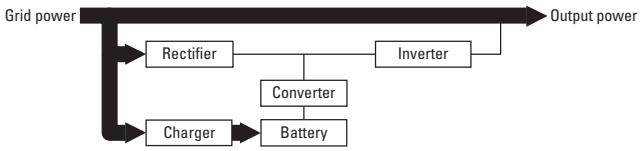

Fig. 4 The power supply path for the Economy mode

(3) In the event of a power grid failure

Figure 5 shows the power supply path during a power grid failure. If grid power 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.

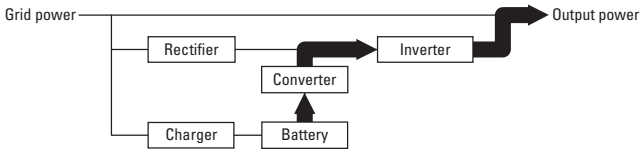

Fig. 5 The power supply path during a power grid failure

3.2 *SANUPS A11M-Li* series

(1) System diagram

Up to eight 1 kVA UPS units can be operated in parallel for increased reliability and expanded capacity. As shown in Figure 6, the product consists of up to eight UPS units and one power distribution unit.

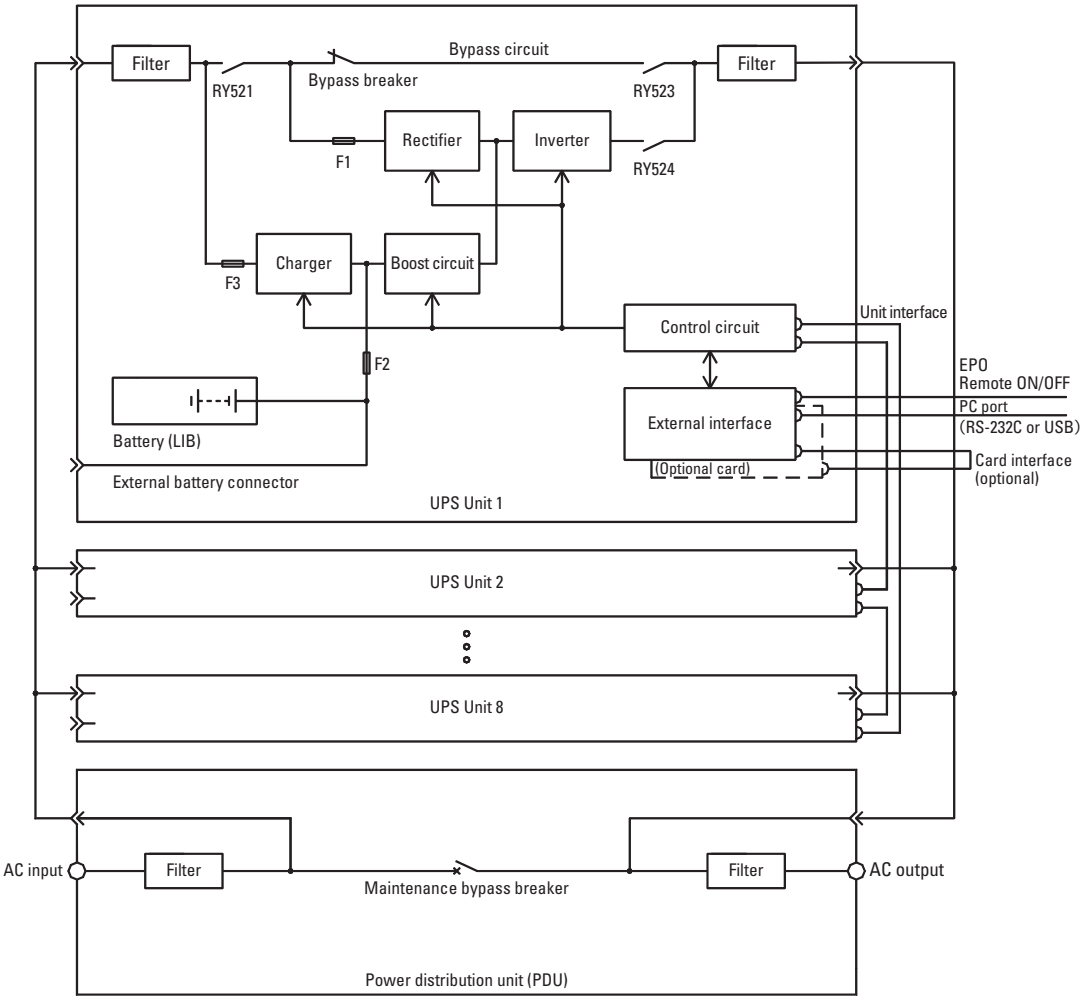

Fig. 6 A11M-Li system diagram

(2) Control method

The product uses the autonomous control method. Compared with the central control method and master/slave method, this method allows for independent control of each unit using each unit's control circuit doing control individually. This ensures high reliability and disconnectability of units if failure occurs. As shown in Figure 7, connecting eight units allows power to be supplied to a maximum load of 8 kVA. When the load capacity is 7 kVA or less, the UPS can have an extra capacity of one unit for redundancy to maintain operation even if one unit fails.

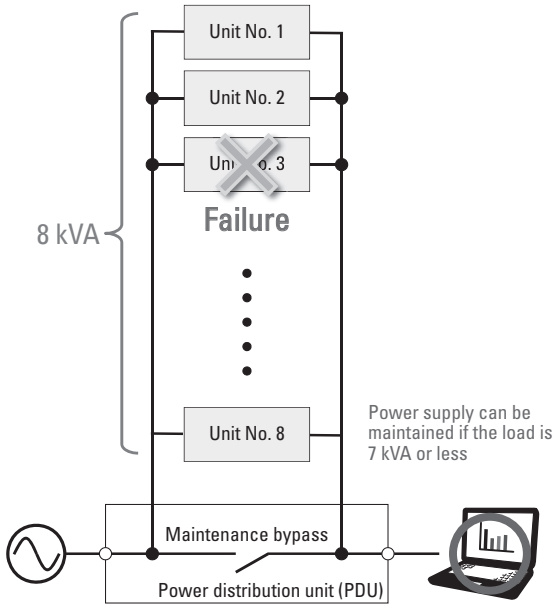

Fig. 7 Parallel redundant operation

3.3 Wide input ranges

We designed the *SANUPS E11B-Li* and *SANUPS A11M-Li* to have wide input voltage and frequency ranges. The voltage range is 55 to 150 V for 100 V models and 110 to 300 V for 200 V models, and the frequency range is 40 to 120 Hz. This can reduce the number of transfers to battery operation even in regions where input 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.

3.4 Wide operating temperature range

In an ambient temperature of 40°C or higher, lead-acid batteries can be discharged but cannot be charged. LIBs can be both charged and discharged throughout a wide operating temperature range of -10°C to +55°C. They can be used in extremely hot and cold regions, or inside small unmanned buildings without air-conditioning.

3.5 Reduced maintenance

While our current UPSs that use lead-acid batteries require battery replacement about every five years, the UPSs with LIBs allow for operation for roughly ten years (at an ambient temperature of 30°C) without battery replacement. We revised the product service life based on the LIB's longer battery service life, increasing it from seven years of the current product to 10 years. This reduces maintenance work and battery replacement costs. Figure 8 shows the product's front panel and LIB.

Fig. 8 Front panel and LIB

3.6 Reduced weight

LIBs weigh only one-third of lead-acid batteries, reducing the product weight significantly. This makes the handling of the product easier when the product is transported, installed, and mounted in a 19-inch rack.

3.7 LIB monitoring function

The LIB itself provides safety protection functions. When a protection function is activated, the LIB shuts down the LIB battery circuit. Connection then recovers automatically once the error is resolved. Following are the major protection functions.

- OCP (over-current protection)
- OTP (over-temperature protection)
- OVP (over-voltage protection)
- UVP (under-voltage protection)

The UPS checks the battery circuit for connection every 24 hours to confirm whether an LIB protection function is activated. If an error is confirmed, it outputs a minor failure alarm.

4. Specifications

(1) Table 1 shows the standard specifications of the *SANUPS E11B-Li* 1 kVA model.

(2) Table 2 shows the standard specifications of the *SANUPS A11M-Li*.

5. Conclusion

This article introduced the *SANUPS E11B-Li* and *SANUPS A11M-Li*.

The *SANUPS E11B-Li* can be used with peace of mind even in regions with unstable power grids and in harsh operating environments. It offers benefits such as a longer product life and lightweight thanks to the LIB's high energy density. It can therefore be proposed to customers all over the world.

The *SANUPS A11M-Li* offers the same benefits as the *SANUPS E11B-Li*, and is also capable of parallel redundant operation. It can be proposed to customers who require a small-capacity, high-reliability UPS.

We will continue to accurately identify the needs of our customers and quickly develop products that can meet these needs.

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

Items			Ratings and standards		Remarks	
Model			E11BL102 100 V class	E11BL102 200 V class		
Output capacity			1 kVA / 0.8 kW			
Topology			Hybrid		Interruption occurs when transferring to battery power from Economy mode	
Cooling method			Forced air cooling			
AC input	**Input plug**		IEC 60320-C14			
	Number of phases/wires		Single-phase 2-wire			
	Rated voltage		100/110/115/120 V	200/208/220/230/240 V		
	Voltage range		At load levels < 40%: 55 to 150 V At load levels < 70%: 68 to 144 V At load levels ≥ 70%: 80 to 144 V	At load levels < 40%: 110 to 300 V At load levels < 70%: 136 to 288 V At load levels ≥ 70%: 160 to 288 V	When in Double Conversion mode	
			Within ±8% of rated voltage		When in Economy mode	
	Rated frequency		50/60 Hz		(auto-sensing)	
	Frequency range		40 to 120 Hz			
	Required capacity		1.1 kVA or less		Max. capacity during battery recovery charging	
	Input power factor		0.95 or greater		In Double Conversion mode, at rated output	
AC output	**Output outlets**		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		50/60 Hz		Same as the input frequency (auto-select)	
	Frequency regulation		Within ±1% of rated frequency		In fixed Double Conversion mode	During battery operation: Within ±0.5%
			Within ±1/3/5% of 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	
		For loss/ return of input power			At rated output	
		For abrupt input voltage change			For ±10% changes When in Double Conversion mode	
	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**		Lithium-ion battery			
	No. of batteries		2		Serial connection	
	Capacity		40 Ah·cell			
	Backup time		4 min		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 and batteries fully charged	
Environment			Ambient temperature: -10 to +55°C Relative humidity: 20 to 90% (non-condensing)		Battery charging stops when outside the ambient temperature range	
Acoustic noise			41 dB or less		When in Economy mode	1 m from front of device, A-weighting
			51 dB or less		When in Double Conversion mode	

Table 2 Standard specifications of the *SANUPS A11M-Li*

Items			Ratings and standards		Remarks
Model			A11ML102 100 V class	A11ML102 200 V class	
Rated output capacity		**N configuration**	1.0 to 8.0 kVA / 0.8 to 6.4 kW		Depends on the no. of units in parallel
		N+1 configuration	1.0 to 7.0 kVA / 0.8 to 5.6 kW		
Topology			Double conversion online		
Cooling method			Forced air cooling		
AC input	**Number of phases/wires**		Single-phase 2-wire		
	Rated voltage		100/110/115/120 V	200/208/220/230/240 V	Depends on the output voltage settings
	Voltage range		At load levels < 40%: 55 to 150 V At load levels < 70%: 68 to 140 V At load levels ≥ 70%: 80 to 140 V	At load levels < 40%: 110 to 300 V At load levels < 70%: 136 to 280 V At load levels ≥ 70%: 160 to 280 V	
	Rated frequency		50/60 Hz		
	Frequency range		40 to 120 Hz		
	Required capacity	**N configuration**	1.1 to 8.2 kVA		Depends on the no. of units in parallel Max. capacity during battery recovery charging
		N+1 configuration	1.2 to 7.2 kVA		
	Input power factor		0.95 or greater		At rated output
AC output	**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		
	Rated frequency		50/60 Hz		Same as the input frequency (auto-select)
	Frequency regulation		Within ±1/3/5% of rated frequency		
	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 ±10% of rated voltage		0⇔100% load step changes at rated input
		For loss/return of input power			At rated output
		For 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	200% (for 30 s), 800% (for 2 cycles)		
Battery	**Type**		Lithium-ion battery		
	No. of batteries		2		Per unit. Serial connection
	Capacity		40 Ah·cell		Per unit
	Backup time		4 min		At a 25˚C ambient temperature, using new, fully charged batteries, with N units used
Heat dissipation			130 to 1040 W		Depends on the no. of units in parallel When batteries are fully charged
Environment			Ambient temperature: -10 to +55˚C Relative humidity: 20 to 90% (non-condensing)		Battery charging stops when outside the ambient temperature range
Acoustic noise			54 to 59 dB		Depends on the no. of units in parallel 1 m from front of device, A-weighting

References

(1) Hiroyuki Hanaoka and 6 others: Development of the Small-Capacity UPS *SANUPS A11M* Series
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(2) Akihiro Tsukada and 7 others: Development of the *SANUPS E11B* Hybrid UPS
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