Development of UPS Products Equipped with Lithium-Ion Batteries Creating Change and Offering New Value

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1. Introduction

SANYO DENKI develops and releases uninterruptible power supplies (UPS) to protect important equipment such as servers and ICT equipment in the event of power outages.

Conventionally, lead-acid batteries have been used in UPSs due to their lower cost and ease of use. Lead-acid batteries are excellent in terms of availability, safety, and cost. However, lead-acid batteries and the UPSs which use them have the following problems.

(1) The characteristics and lifespan of lead-acid batteries are easily affected by operating temperature, so they need to be installed in temperature-controlled environments. For example, if the average operating temperature is 25°C, the lower the temperature falls below this, the smaller the battery capacity becomes, reducing UPS backup time. Moreover, in environments above 25°C, battery life shortens relative to the temperature.

(2) In the case of lead-acid batteries, generally the capacity at the end of battery service life is set at 50% of the initial value, so UPS backup time is shorter when a battery nears the end of its life. Moreover, service life is shortened if there is a high charge/discharge frequency. As such, the battery must be replaced at an early stage to ensure load equipment will be properly backed up in the event of a power outage.

(3) Lead-acid batteries have a relatively small energy density, so if a UPS requires prolonged backup time, the number of batteries must be increased, therefore a large installation space must be secured.

2. UPSs Creating Change in the Market

SANYO DENKI solved these problems of UPSs using lead-acid batteries by developing UPSs equipped with lithium-ion batteries (hereinafter LIBs) that can be installed in harsh environments that were previously impossible, broadening the scope of UPS utilization, creating change in the market, and offering new value.

The features of these UPS models are (1) a wide operating temperature range that can be used with peace of mind in both extremely cold and extremely hot regions, (2) significantly smaller size than SANYO DENKI's current models, and (3) reduced battery replacement costs by extending the battery replacement interval from five to ten years.

Moreover, the safety of these UPSs have been improved by monitoring LIB information on the UPS side, in addition to the management system on the LIB side. The following sections will introduce SANYO DENKI's LIB-equipped UPS product lineup.

2.1 *SANUPS A11K-Li* series

The *SANUPS A11K-Li* series are LIB-equipped UPSs which adopt the highly reliable double conversion online topology, and are suitable for backup of computers and production equipment. They are space-saving, and offer extended backup time.

The lineup is available with output capacities of 1.5, 3, and 5 kVA. Figure 1 is an external view of the *SANUPS A11K-Li* series. All models can be installed in 19-inch racks.

Fig. 1 *SANUPS A11K-Li* (1.5 kVA)

2.2 *SANUPS N11B-Li* series

In recent years, there has been an increasing demand for backup power for outdoor facilities such as base stations, traffic lights, paid parking lots, and surveillance cameras.

Hence, SANYO DENKI developed the *SANUPS N11B-Li* series, which can be used outdoors due to having a design where the UPS main unit and LIB are housed in a single enclosure with IP65* dustproof and waterproof protection.

This product is available with output capacities of 1, 1.5, and 3 kVA. Figure 2 is an external view of the *SANUPS N11B-Li* series.

This UPS adopts a passive standby topology to minimize power consumption and achieve high efficiency. This makes it possible to install the UPS outdoors where the ambient temperature is high, as well as helps to reduce running costs and save energy.

*The degree of protection (IP code) is defined by IEC (International Electrotechnical Commission) 60529 "DEGREES OF PROTECTION PROVIDED BY ENCLOSURES (IP Code)" (IEC 60529:2001)
IP65: No ingress of dust. Devices operate stably even when directly exposed to water from many directions.

Fig. 2 *SANUPS N11B-Li* series

2.3 *SANUPS N11C-Li* series

There is a demand for backup power for disaster management facilities such as floodgates, warning sirens, and emergency management radios as well as for the system power source that monitors them.

Monitoring systems for disaster management facilities are installed in confined spaces such as small-scale unmanned buildings or containers, with no form of air-conditioning; therefore, it is assumed that they will be required to operate in harsh environments. As such, UPSs are required to offer high-efficiency, long backup times, space-saving, low maintenance, and have a wide operating temperature range.

To meet these needs, SANYO DENKI developed the *SANUPS N11C-Li* series which features a small footprint and adopts the passive standby topology with minimal heat dissipation.

This product is available with output capacities of 1.5, 3, and 5 kVA.

With minimal heat dissipation and high-efficiency, it can be used in extreme temperature environments, such as outdoor cubicles without air-conditioning, and contributes to lower running costs and energy-saving.

Figure 3 is an external view of the *SANUPS N11C-Li* series. All models can be installed in 19-inch racks.

Fig. 3 *SANUPS N11C-Li* (5 kVA)

3. Common Features of the Newly Developed UPSs

The above-mentioned UPS products share common features that offer new value. These features are described below.

3.1 Low maintenance

Conventional lead-acid battery-equipped UPSs have to be replaced approximately every five years. The expected life of the LIBs used in these UPSs is ten years, which means no battery replacement work is required for approximately ten years. The expected life of the UPS main unit is also ten years, so no maintenance work, such as battery replacement, is required during this period, meaning that maintenance and operating costs are reduced.

3.2 Wide operating temperature range

LIB-equipped UPSs have an operating temperature range between -20˚C and +50˚C or 55˚C, which is wider than that of conventional models.

By widening the operating temperature range we have significantly expanded the scope of UPS application, so they can now be used in harsh temperatures, which was previously impossible with conventional UPSs.

3.3 Compact and lightweight

Compared to lead-acid batteries, LIBs have higher energy densities. When comparing products with equivalent backup times, LIB-equipped UPSs are around half the volume and mass of conventional UPSs. Figure 4 illustrates the configuration differences between UPSs using lead-acid batteries and UPSs using LIBs.

The LIB-equipped UPS occupies less space than the lead-acid battery UPS, contributing to efficient usage of space in the locations in which they are installed.

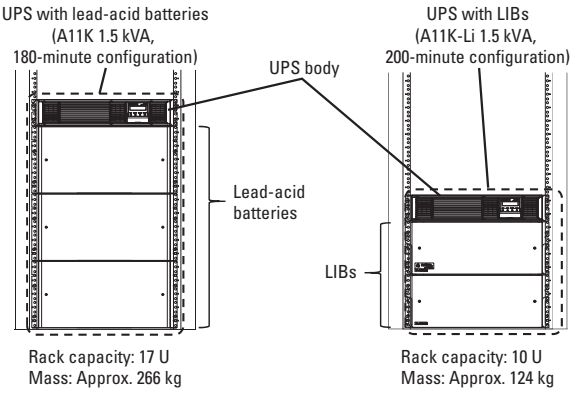

Fig. 4 Comparison of UPS configurations (when mounted in a 19-inch rack)

Table 1 compares the features of an LIB-equipped UPS with a conventional lead-acid battery-equipped UPS.

Table 1 Features of the newly developed UPS

	Conventional UPS (with lead-acid batteries)	**Newly developed UPS (with LIB)**
Expected battery life	5 years* (ambient temperature: 25˚C)	**10 years*** (ambient temperature: **30˚C**)
Operating temperature range	-10 to 40˚C	**-20 to 55˚C**
Volume, mass	1	**Approx. 1/2**

*: Assuming ten power outages a year

4. Technology Achieving High Safety and Offering Peace of Mind

4.1 LIB protection function

Due to the high energy density of LIBs, there is some concern about smoke and fire. But by carefully monitoring LIB status, they can be used safely.

SANYO DENKI's LIB-equipped UPSs feature safety management of LIB with a battery management system (BMS), as well as monitor the LIB on the UPS to protect the LIB in the event of an abnormality being detected. Overviews of these protection functions are as follows.

(1) Protection by BMS

BMS monitors LIB current, cell voltage, and cell temperature, and turns the switch off to disconnect and protect the LIB if it detects an overcurrent, overcharge, or excessive temperature.

(2) Protection by UPS

A UPS communicates with the BMS and monitors LIB status during operation. If a communication error occurs, the UPS stops charging to protect the LIB. Also, if the LIB's charging voltage or cell voltage increases, the UPS stops the charger to protect the LIB. Furthermore, the UPS stops charging or discharging if the LIB's cell temperature becomes too high.

If any other abnormality occurs in the UPS or LIB, the circuit is disconnected on both UPS and LIB-side switches for protection. Moreover, in the event of a short circuit, the LIB is isolated via a fuse to protect wiring.

Figure 5 shows how the UPS and LIB configure the protection.

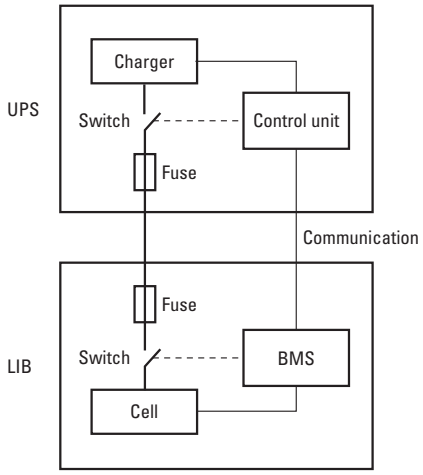

Fig. 5 LIB protection functions

4.2 Optimal device internal layout

Conventionally, UPSs are mostly installed indoors. However, as described above, we designed the *SANUPS N11B-Li* to be used outdoors, which required a protection as high as IP65.

The heat generated within an IP65 rated enclosure cannot directly escape to the outside. If heat is trapped inside the UPS and becomes concentrated in one area, it may raise the temperature of the electronic components or LIB, which in turn could hasten component deterioration or trigger a malfunction. In such cases, the UPS may not reach its expected life, possibly leading to a fail in backing up load equipment properly.

With consideration to this aspect, in designing the UPS, SANYO DENKI used a thermal fluid analysis simulation to verify internal heat flow, and optimized the structure and layout design to effectively circulate and discharge heat to the outside by using the entire enclosure. Figure 6 shows one example of thermal fluid analysis.

As a result, we succeeded in designing an enclosure with an IP65 protection without reducing UPS performance and reliability by preventing heat from concentrating in particular spots, thus developing a UPS with high reliability capable of operating outdoors.

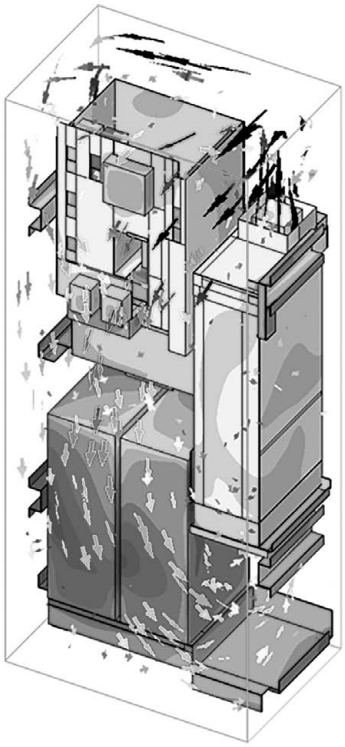

Fig. 6 Thermal fluid analysis model of the *SANUPS N11B-Li* (3 kVA)

5. Conclusion

This article has introduced new UPS products equipped with LIBs and the technologies that we used to realize their performance.

These products and technologies broaden the scope of UPS application as they enable UPSs to back up equipment in harsh environments, which was previously impossible with conventional products. Moreover, by not requiring battery replacement for approximately ten years, these products help to reduce maintenance costs.

We will continue to pursue technologies that broaden UPS applications and create major market changes, and develop products that offer our customers new value.

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